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A. Edward Scherer
Director
Nuclear Regulatory Affairs

February 15, 2008

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Subject: **Docket No. 50-361 and 50-362**
Comprehensive Demonstration Study for Clean Water Act Section 316(b)
San Onofre Nuclear Generating Station, (SONGS) Unit 2 and Unit 3

Reference: "Submittal of the Comprehensive Demonstration Study for the San Onofre Nuclear Generating Station in compliance with NPDES Permit Nos. CA0108073 and CA0108181," dated January 7, 2008, from Mary Jane Johnson, SCE, to John Robertus, California Regional Water Quality Control Board, San Diego Region.

Gentlemen:

Appendix B, Section 3.2, of Operating License Nos. NPF-10 and NPF-15 for San Onofre Unit 2 and Unit 3 respectively, requires that the Clean Water Act Section 316(b) Demonstration Study shall be provided to the NRC at the same time that it is submitted to the permitting agency. Accordingly, a copy of the Comprehensive Demonstration Study and the transmittal letter to the California Regional Water Quality Control Board, San Diego Region is attached.

If you require additional information, please contact Kathleen Yhip at (949) 368-7633.

Sincerely,

Attachments as stated

cc: E. E. Collins, NRC Regional Administrator, Region IV
N. Kalyanam, NRC Project Manager, SONGS Units 2 and 3
C. C. Osterholtz, NRC Senior Resident Inspector, SONGS Units 2 and 3
S. Y. Hsu, California Department of Health Services

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January 7, 2008

Mr. John Robertus, Executive Officer
California Regional Water Quality Control Board
San Diego Region
9174 Sky Park Ct. Suite 100
San Diego, California 92123

RE: Submittal of the Comprehensive Demonstration Study for the San Onofre Nuclear Generating Station in compliance with NPDES Permit Nos. CA0108073 and CA0108181.

Dear Mr. Robertus

Southern California Edison Company (SCE) is submitting the enclosed Comprehensive Demonstration Study (CDS) in compliance with the San Onofre Nuclear Generating Station (SONGS) NPDES permits (Permit Nos. CA0108073 and CA0108181). The purpose of this submittal is two-fold. The first is to comply with the requirements in the Special Provisions Section 1.a.ii. of the NPDES permits that stipulate a CDS must be submitted by January 9, 2008. The second is to provide information to Regional Board Staff to initiate Best Professional Judgment (BPJ) discussions to demonstrate compliance during the development of a state policy and a revised federal rule pursuant to Section 316(b) of the federal Clean Water Act.

The CDS has determined that owing to the design, location and operation of the cooling water intake structures, impingement mortality at SONGS is reduced by an estimated 94.2% in terms of finfish numbers and 97.7% by weight. These reductions are accomplished by existing intake design features and operational measures to reduce fish mortality. Based on evaluations of reduction technologies, cost-cost tests, and suggested evidence of entrainment reduction, the CDS determined that the existing cooling water system represents the Best Technology Available (BTA) for minimizing adverse environmental effects. The detailed analyses of impingement and entrainment impacts, as well as technologies to reduce them are included in the CDS.

All required components, as listed in the NPDES permits, were included in the CDS. These include the Source Waterbody Flow Information, Impingement Mortality and Entrainment Study, Technology and Compliance Assessment Information, Information to Support Site-Specific Determination of BTA, and a Verification Monitoring Plan. A Restoration Plan for the San Dieguito Wetlands, although developed and approved by the California Coastal Commission, was not included owing to the U.S. Second Circuit Appeals Court Decision that questioned restoration under Section 316(b).

The Second Circuit Court Decision on January 25, 2007, remanded the 316(b) Rule back to the Environmental Protection Agency (EPA). As a result, EPA withdrew the Rule entirely and encouraged regulatory agencies to use BPJ to determine compliance with NPDES permits. Additionally, the State Water Resources Control Board (SWRCB) has not developed a state policy for implementation of 316(b) requirements. Therefore, the CDS provides information and discussion relevant to determining BPJ for SONGS. SCE believes that a BPJ decision for no additional structural or operational requirements is appropriate and is supported by:

- Consistency with previous NPDES 316(b) compliance determinations,
- SONGS is currently at the upper end or exceeding of the remanded federal performance standards for impingement, and
- The need to maintain status quo in the interim period while EPA reconsiders its Phase II rule and the State develops its own policy.

SCE desires to meet with Regional Board staff to discuss the results of the CDS and BPJ. Once adequate time has been provided for review of the CDS, SCE will schedule a meeting with Regional Board staff. In the mean time, if you have any questions regarding the CDS, please contact Robert Heckler at (949) 368-3816, or Patrick Tennant at (626) 302-3066.

Sincerely,

Mary Jane Johnson
Manager, Site Support Services

bcc: J. Reilly
D. W. Kay
T. Gross
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David Asti (w/o encl.)

Comprehensive Demonstration Study for Southern California Edison's San Onofre Nuclear Generating Station

Final Report, January 2008

SOUTHERN CALIFORNIA
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San Onofre Nuclear Generating Station

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EXECUTIVE SUMMARY

This Comprehensive Demonstration Study (CDS) is submitted by Southern California Edison (SCE) in compliance with the San Onofre Nuclear Generating Station (SONGS) NPDES Permits (Permit numbers CA0108073 and CA0108181). The permit requirements for Best Technology Available (BTA) were based on the Federal Phase II §316(b) Rule issued in 2004. The Federal Rule authorized use of five different compliance alternatives and a number of compliance options.

SONGS has existing technologies currently in place that reduce impingement mortality by an estimated 94.2% in terms of finfish numbers and 97.7% by weight. These reductions are at the high end of the 80%-95% reduction range required by the Phase II Rule. Impingement mortality reduction is achieved through the use of an offshore intake with a velocity cap combined with an on-shore fish return system (FRS). In addition to modifications to the intake structures, SCE has committed to restore 150 acres of coastal wetland, costing $86 million. This acreage was determined by the California Coastal Commission (CCC) to be sufficient to offset entrainment losses of Units 2 and 3. The Second Circuit §316(b) ruling stated that restoration measures could not be used for compliance, therefore the SCE CDS does not include a Restoration Plan. However, a restoration plan has been developed and approved by the CCC in compliance with conditions stated in the Coastal Development Permit for the facility.

Alden Research Laboratory, Inc. (Alden) identified six potential structural and/or operational alternatives for more detailed evaluation to meet the entrainment reduction performance standard (i.e. 60%-90% reduction) of Federal Phase II Rule. Three of these alternatives were identified as infeasible for the following reasons:

- Reduced Cooling Water Pump Use – This option was determined not to be feasible because SONGS is a baseloaded facility with cooling water pumps in operation on an almost continuous basis. Times that flow reduction could occur are extremely limited and at unpredictable times.

- Aquatic Filter Barrier – Due to the amount of filter fabric material that would be needed and the harsh hydraulic conditions that occur in the California Coastal Pacific Ocean, especially during storm events, this option was determined to be infeasible for structural reasons.

- Relocation of the Cooling Water Intake Structure – The option was determined to be infeasible for a number of reasons that included lack of a clear entrainment reduction benefit and associated benthic habitat impacts. The SONGS Marine Review Committee

(MRC), an independent scientific review committee, reached the same conclusion in their evaluation of this option.

Cursory review suggested three technologies and operational measures that were potentially feasible and warranted further evaluation. In the context of this study, feasibility was determined based on the ability to engineer and theoretically apply such technologies. Numerous assumptions were made on the complete feasibility of these technologies. The study did not include the potential for environmental impacts, impacts to the California power system, or permitting and regulatory issues. SCE believes that these issues would likely affect the overall feasibility of the technologies. For purposes of this document, the estimated biological performance and cost associated with these alternatives are summarized as follows:

- Fine-mesh Traveling Screens – This was the lowest cost technology with an estimated capital cost of approximately $11 million and an annual operation and maintenance (O&M) cost of $663,000/yr. However, this option also had the lowest entrainment reduction benefit estimated to be less than 16%.

- Narrow-slot Wedgewire Screens – This technology had an estimated capital cost of $59 million and an O&M cost of approximately $1.5 million/yr. This option would automatically meet the Federal Phase II Rule impingement mortality reduction standard by reducing the through-screen velocity to less than 0.5 fps. The estimated reduction in entrainment is approximately 76%.

- Retrofit with Closed-cycle Cooling – This alternative had the highest cost with an estimated capital cost of $676 million and an annual O&M cost of $46 million/yr. However, this alternative would meet the performance standards for both impingement mortality and entrainment reduction.

Based on this analysis, SCE elected to comply with the permit using a combination of Compliance Alternative 2 (i.e., demonstrating existing measures in place) for impingement and Compliance Alternative 5 (use of site-specific standards) for entrainment. For impingement, SCE has provided the necessary CDS documents to demonstrate that the combination of the offshore velocity cap combined with the fish return system (FRS) meet the impingement mortality reduction performance standard for Units 2&3. For entrainment, SCE is demonstrating that based on technically sound site-specific cost estimates, the costs of potentially feasible entrainment reduction alternatives are significantly greater than those considered by EPA. The necessary CDS documents for use of Site-specific Standards using the cost-cost test are provided for reducing entrainment for Units 2&3. Additionally, the Impingement Mortality and Entrainment Report, as well as past studies, suggest that the off-shore, mid-water intake offers some degrees of reduction. This value is proposed to be quantified at a later date. However, based on the cost-cost test results and the suggested evidence of entrainment reduction, the existing cooling water intake structure should be determined to represent the Best Technology Available (BTA) for minimizing environmental effects of the cooling water intake structure (CWIS).

The Second Circuit Court Decision on the §316(b) Phase II Rule on January 25, 2007, remanded to the EPA the use of the cost-cost test, as well as other key elements of the rule. As a result, EPA has withdrawn the Phase II Rule in its entirety. EPA then issued a Federal Register Notice that until a revised final Rule is issued, §316(b) should be administered in individual NPDES permits on a Best Professional Judgment (BPJ) basis. SCE believes it is important that the final decision regarding requirements for any additional fish protection technologies for SONGS should be consistent with both the California State Policy and the revised Federal Phase II Rule. Work is currently in progress at both agencies to issue a proposed Rule/Policy in 2008. An interim BPJ decision for no additional structural or operational requirements is supported by:

- Consistency with previous NPDES §316(b) determinations issued for SONGS.
- SONGS is currently reducing impingement mortality sufficient to meet the upper end of the performance standard range and restoration measures are being implemented to offset entrainment losses for Units 2&3.
- It is currently unclear what technology(ies) will be considered BTA. Based on estimates, only two potentially feasible entrainment reduction technologies can meet the original performance standard range: narrow-slot wedgewire screens and closed-cycle cooling. While closed-cycle cooling achieves a higher level of entrainment reduction, it has not yet been determined if it will be identified as BTA in the revised Rule/Policy. It has an estimated cost of $676 million and a number of potential feasibility issues including the resulting environmental and permitting issues, social impacts, impacts to the California electrical system, and space constraints. In addition, wedgewire screens are unproven in California for use in an open ocean environment and have never been deployed in a high biofouling open ocean environment.
- Both EPA and the California State Water Resources Control Board (SWRCB) are working on a revised §316(b) draft Regulation/Policy for issuance in 2008.
- Petitions have been filed to the Supreme Court to review the Second Circuit Court Decision.

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1 INTRODUCTION

1.1 CDS Submittal Objectives

Although the 316(b) Rule has been suspended, the Comprehensive Demonstration Study (CDS) documents are being submitted for two key purposes:

1. To satisfy the requirements of Special Provisions 1(a)(ii) of Order Nos. R9-2005-05 and R9-2005-006 of NPDES Permit Numbers CA0108073 and CA0108181 for SONGS Units 2 and 3 respectively, and
2. To inform regulators in compliance decision making under Best Professional Judgment (BPJ).

The rationale for these dual objectives is based on the original Phase II Rule, the SONGS NPDES permit, the Second Circuit Court Decision, EPA's withdrawal of the Rule and the California State Water Resource Control Board's (SWRCB) efforts to develop a State §316(b) Policy.

1.2 The Phase II Rule Regulatory Requirements

EPA signed into regulation new requirements for existing electric power generating facilities for compliance with Section 316(b) of the Clean Water Act on July 9, 2004 (the Rule). These regulations became effective on September 7, 2004 and were based on numeric performance standards[1]. The Rule at 125.94(a) (1-5) provided facilities with compliance flexibility by incorporating five compliance alternatives as follows:

1. *A facility can demonstrate it has or will reduce cooling water flow commensurate with wet closed-cycle cooling and be determined to be in compliance with all applicable performance standards. A facility can also demonstrate it has or will reduce the maximum design through-screen velocity to less than 0.5 ft/s in which case it is deemed in compliance with the impingement mortality (IM) performance standard (the entrainment standard still applies).*
2. *A facility can demonstrate that it has in place technologies and/or operational measures and/or restoration measures in place that will meet the applicable performance standards.*
3. *A facility can propose to install new technologies and/or operational measures and/or restoration measures to meet applicable performance standards.*

[1] Performance standards are found at 125.94(b)

4. *A facility can propose to install, operate and maintain an approved design and construction technology.*
5. *A facility can request a site-specific determination of BTA [Best Technology Available] by demonstrating that either the cost of installing technologies and/or operational measures and/or restoration measures are significantly greater than the cost for the facility listed in Appendix A of the rule or that the cost is significantly greater than the benefits of complying with the applicable performance standards.*

All facilities that use compliance alternatives 2, 3, and 4 were required to demonstrate a minimum reduction in impingement mortality (IM) of 80% (125.94(b) (1)). Facilities with a capacity factor that is greater than 15% that are located on oceans, estuaries or the Great Lakes or on rivers and have a design intake flow that exceeds more than 5% of the mean annual flow must also reduce entrainment by 60% to 90% (125.94(b)(2)).

The Rule further required that facilities using compliance alternatives 2, 3, and 5 prepare a Comprehensive Demonstration Study (CDS) as described at 125.95(b) of the Rule. There were seven components of the CDS:

1. Proposal for Information Collection (PIC),
2. Source Waterbody Information (required only if facility is located on a river or reservoir),
3. Impingement Mortality and Entrainment Characterization Study
4. Technology and Compliance Assessment Information (consists of a Design and Construction Technology Plan and a Technology Installation and Operation Plan)
5. Restoration Plan
6. Information to Support Site-Specific Determination of BTA
7. Verification Monitoring Plan,(required if technologies or operational measures were used for compliance).

Facilities using compliance alternative 1 were not required to submit a CDS and those using compliance alternative 4 were only required to submit the Technology Installation and Operation Plan (TIOP) and Verification Monitoring Plan. All facilities that used compliance alternatives 2, 3, and 5 were required to prepare and submit components 1, 2, 3, and 7, but depending on the compliance alternative(s) selected, the facility would submit a 4) Design and Construction Technology Plan and Technology Installation and Operation Plan (TIOP), Restoration Plan, and/or information to support a site-specific BTA determination. Also facilities could choose to base the CDS on one or any combination of components 5–7.

The first CDS document required for submittal is the PIC. SCE submitted their PIC for SONGS to the San Diego Regional Water Quality Control Board (SDRWQCB) and other agencies for review in October 2005, and a revised edition in November 2006 (See discussion below). The Rule at 125.95(b) (1) required that the PIC include:

1. *A description of the proposed and/or implemented technologies, operational measures, and/or restoration measures to be evaluated in the Study.*

2. *A list and description of any historical studies characterizing impingement mortality and entrainment (IM&E) and/or the physical and biological conditions in the vicinity of the cooling water intake structures (CWIS) and their relevance to this proposed Study. If you propose to use existing data, you must demonstrate the extent to which the data are representative of current conditions and that the data were collected using appropriate quality assurance/quality control procedures.*
3. *A summary of any past or ongoing consultations with appropriate Federal, State, and Tribal fish and wildlife agencies that are relevant to this Study and a copy of written comments received as a result of each consultation.*
4. *A sampling plan for any new studies you plan to conduct in order to ensure that you have sufficient data to develop a scientifically valid estimate of IM&E at your site. The sampling plan must document all methods and quality assurance/quality control procedures for sampling and data analysis. The sampling and data analysis methods you propose must be appropriate for a quantitative survey and include consideration of the methods used in other studies performed in the source waterbody. The sampling plan must include a description of the study area (including the area of influence of the CWIS(s)), and provide a taxonomic identification of the sampled or evaluated biological assemblages (including all life stages of fish and shellfish).*

An important feature of the Rule was use of the calculation baseline. The calculation baseline was defined as follows:

> *Calculation baseline means an estimate of impingement mortality and entrainment that would occur at your site assuming that: the cooling water system has been designed as a once-through system; the opening of the cooling water intake structure is located at, and the face of the standard 3/8-inch mesh traveling screen is oriented parallel to, the shoreline near the surface of the source waterbody; and the baseline practices, procedures, and structural configuration are those that your facility would maintain in the absence of any structural or operational controls, including flow or velocity reductions, implemented in whole or in part for the purposes of reducing impingement mortality and entrainment. You may also choose to use the current level of impingement mortality and entrainment as the calculation baseline. The calculation baseline may be estimated using: historical impingement mortality and entrainment data from your facility or another facility with comparable design, operational, and environmental conditions; current biological data collected in the waterbody in the vicinity of your cooling water intake structure; or current impingement mortality and entrainment data collected at your facility. You may request that the calculation baseline be modified to be based on a location of the opening of the cooling water intake structure at a depth other than at or near the surface if you can demonstrate to the Director that the other depth would correspond to a higher baseline level of impingement mortality and/or entrainment.*

The calculation baseline is especially significant in the case of SONGS, because the facility significantly deviates from the baseline conditions. Therefore, the baseline had to be calculated in order for SONGS to claim credit for any deviations from the baseline that offered reductions in fish or shellfish losses.

1.3 SONGS 316(b) NPDES Permit Requirements

As a result of EPA's issuance of the Rule, the SDRWQCB included Special Provisions 1(a)(ii) of Order Nos. R9-2005-05 and R9-2005-006 respectively into the SONGS Unit 2 (Permit Number CA0108073) and Unit 3 (Permit Number CA0108181) NPDES Permits. These provisions required SCE to comply with the Rule by submitting CDS Documents by January 7, 2008 for SONGS Units 2 and 3 including:

- An Impingement Mortality and Entrainment Characterization Study,
- A description of the SONGS cooling water intake structures, and
- Confirmation of technologies, operational measures, and/or restoration measures selected and installed, or planned for installation to meet applicable requirements of 40 CFR §125.94.

The PIC was submitted to SDRWQCB in October 2005 with a transmittal letter. SCE also requested comments from the California Coastal Commission, the California Department of Fish and Game, the National Marine Fisheries Service, and the U.S. Fish and Wildlife Service. Verbal authorization was given by the SDRWQCB, and SONGS began the IM&E sampling in March 2006. The SDRWQCB issued comments on the PIC in a letter dated May 23, 2006. As a result, SCE met with the SDRWQCB on September 26, 2006 and agreed to modify the PIC studies in response to the comments, and in November 2006 revised the original PIC. The PIC modifications were summarized in a letter to the SDRWQCB dated December 22, 2006.

1.4 Second Circuit Court Decision

Shortly after the final Rule was issued, a number of States and Stakeholders (including environmental organizations and industry) filed lawsuits on various aspects of the new regulations. The Second Circuit Court issued its §316(b) Phase II Rule decision (Decision) on January 27, 2007. The Decision remanded significant portions of the Phase II Rule (Rule) to EPA. The Court determined that use of neither restoration measures nor the cost-benefit test could be used as compliance options. Two Rule provisions, the cost-cost test and the Technology Installation and Operation Plan (TIOP) were remanded to EPA for failure to provide adequate opportunity for public review and comment. The Court also remanded to EPA the determination of BTA, and specifically raised several issues that EPA will have to address in the promulgation of a revised Phase II Rule. These issues include:

- Closed-cycle Cooling as BTA – The Court said that EPA, in determining that closed-cycle cooling was not BTA for existing Phase II facilities, may have based that decision, at least in part, on the cost of the technology relative to the benefits. The Court pointed out that any consideration of the environmental benefits is not allowed and remanded this determination to EPA for clarification. The Court stated that EPA could consider factors such as the industry's ability to bear the cost, impacts to energy production and supply, and adverse impacts associated with retrofits as a basis to determine that closed-cycle cooling was not BTA.

- Use of "Best Performing" Technology – The Court upheld EPA's use of performance standard ranges. However, the Court determined that facilities must be required to use the "best performing" technology in the performance standard range rather than the most cost-effective technology.
- Consideration of Cost – The Court ruled that EPA could consider the cost of technologies to a limited extent in the BTA determination. The first cost consideration is whether or not facilities can reasonably bear the cost of the technology. The second is the limited use of cost-effectiveness. On this point the Court ruled that if there was an overlap in the expected environmental performance range of two best performing technologies, the facility could select the most cost-effective option rather than the one that had the potential for higher performance.

1.5 EPA Withdrawal of the §316(b) Phase II Rule

In response to the Decision, EPA issued a memorandum to EPA's Regional Offices dated March 20, 2007 announcing withdrawal of the §316(b) Phase II Rule. This was followed by a notice in the Federal Register on July 9, 2007. Specifically, the memorandum and Federal Register Notice stated the withdrawal of the Rule was a result of the Decision's impact on the overall compliance approach. With so many of the Rule's provisions affected by the Decision, the overall approach was no longer suitable for compliance. The memorandum and Federal Register notice further directed EPA Regional Offices and delegated States to implement §316(b) in NPDES permits on a "Best Professional Judgment" (BPJ) basis until the Decision issues are resolved. EPA is now proceeding to revise the Rule and a proposed Phase II Rule is expected to be issued by the end of 2008. This could result in a revised final Phase II Rule as early as 2009.

In response to the March 2007 EPA memorandum, SCE submitted a letter to SDRWQCB (letter dated March 23, 2007) requesting that the SONGS Units 2 and 3 requirements to comply with the Rule be withdrawn from the permit. SDRWQCB issued a letter dated May 31, 2007 stating it considered the Phase II Rule requirements in the permit to be suspended until such time that either EPA or the SWRCB provided further direction for compliance with §316(b). However, SCE continued with the CDS process for two reasons: the first was that information developed in the CDS would be helpful to inform state and federal agencies, and the second was it would facilitate BPJ discussions.

1.6 California SWRCB §316(b) Policy Development

After holding public stakeholder meetings for input, the California State Water Resources Control Board (SWRCB) issued a proposed Statewide §316(b) Policy in June 2006 (Draft Policy). The Draft Policy proposed requirements for 316(b) for California's Phase II facilities that were substantially more stringent than the Federal Rule. There were a number of significant deviations that included:

- Requiring facilities to meet the Rule's maximum performance standards for reduction of impingement mortality and entrainment rather than the performance standard range provided for in the Rule
- Consideration of zooplankton as an entrainable life stage
- Only allowing the use of restoration measures for achieving the maximum 90% entrainment reduction after reducing entrainment by a minimum of 60% from the calculated baseline by any combination of operational or structural controls
- Not allowing facilities to use restoration measures for compliance with the impingement reduction performance standard
- Using actual average flow and including reference stations as part of the calculation baseline
- Not allowing facilities to use the Rule's Compliance Alternative 5 by demonstrating that the cost of meeting the performance standard would be significantly greater than the benefit or costs considered by EPA
- Requiring that facilities use the "habitat production foregone" method to determine appropriate restoration for compliance
- Requiring facilities to conduct studies to evaluate cumulative impacts
- Requiring detailed monitoring studies including:
    - Quantification of all species and life stages
    - Quantification of impacts to zooplankton in addition to fish and shellfish
    - Requiring use of specific performance assessment models based on life history and population impacts on fish (Fecundity Hindcasting, Adult Equivalent Loss and Empirical Transport Method)

The SWRCB has not yet finalized the California Policy. However, it is SCE's understanding that SWRCB is working on a revised State §316(b) Policy and that such a Policy may be forthcoming in 2008.

1.7 Supreme Court Review of Second Circuit Decision

The Utility Water Act Group, Entergy Corporation and Public Service Gas and Electric Company filed a timely petition for Certiorari with the Supreme Court. At this point it is not yet know if the Court will hear this case. The Court has extended the deadline for filing responses to the three petitions to February 1, 2008.

1.8 Comprehensive Demonstration Study Organization

As a result of the §316(b) federal and state regulatory developments the nature of SCE's CDS approach for SONGS has shifted from that proposed in the PIC. The CDS is designed to facilitate BPJ discussions and assist in informing state and federal agencies. Section 2 provides a description of SONGS and the current compliance approach is discussed in Section 3. Section 4 provides a summary of the results of the Impingement Mortality and Entrainment Characterization Study. Section 5 provides a summary of compliance for impingement, while Section 6 provides a summary of compliance for entrainment. Section 7 provides an overall summary of compliance for the CDS and important considerations for the final SONGS BPJ determination.

2 FACILITY DESCRIPTION

SONGS is located on the coast of the Pacific Ocean in north San Diego County, approximately 2.5 miles southeast of San Clemente, California. The facility consists of two nuclear-fueled generating units (Unit 2 & Unit 3) each rated at 1,087 MW. SONGS is considered a baseloaded facility and has a capacity utilization of 85% and 84%, for Units 2 and 3 respectively, during the period 2001 through 2006. Each unit utilizes once-through cooling technology and withdraws approximately 1,200 million gallons a day (mgd). SONGS is located on the Pacific Ocean, withdraws more than 50 mgd, and has a capacity factor in excess of 15%, it is therefore subject to both the impingement mortality and entrainment reduction performance standards.

The design of the Cooling Water Intake Structures (CWIS) deviates significantly from the Rule's calculation baseline. Modifications to the intake that provide reductions in fish losses include the use of an offshore, submerged intake with a velocity cap in combination with a fish collection and return system (FRS). Units 2 and 3 each have submerged intakes located 3,183 ft offshore with the cooling water intake located at a depth of −32 ft MLLW. A schematic of this layout is shown in Figure 1. Condenser cooling water for each unit flows through a 49-foot diameter velocity cap at 1.8 feet per second (fps) into an 18-foot internal diameter, submerged pipe to the CWIS located onshore within the facility. Inside the CWIS onshore the cooling water passes through a series of vanes and angled louvers located in front of the traveling screens. The louvers and vanes are designed to guide fish to a quiet water area at the end of the intake where the FRS is located. There is a fish lift located in front of the traveling screens. The lift consists of a large tray that rests on the bottom of the intake and can be raised via a belt to collect fish in the water column in front of the screen. The tray is then tilted to transfer fish and shellfish collected to the fish return system which transfers them offshore in the Pacific Ocean. The louvers also function as bar racks designed to prevent large debris from entering the CWIS. The FRS is operated daily and returns fish to the ocean through a common conduit for both units.

In addition to the louvers, a "fish chase" procedure has been implemented that uses elevated temperatures to further guide fish into the FRS collection area prior to heat treatments. Heat treatments are conducted at approximately six-week intervals to control biofouling in the intake tunnels. This is done by manipulating gates to allow the discharge tunnel to act as the intake tunnel and the intake tunnel as the discharge. By maintaining water heated to 105°F through the intake tunnel for up to one hour, biofouling organisms are killed. SONGS is unique in using the FRS to remove fish from the intake screen wells and return them back to the ocean.

The cooling water for each of the two units, after passing through the bar racks, passes through six traveling screens. It is then is pumped through each Unit's four 202,750 gpm circulating water pumps into to the condensers. The through-screen water velocity of the traveling screens is 3.0 fps.

SONGS has installed a diffuser at the end of each the discharge tunnels to rapidly diffuse the thermal discharge plume and comply with thermal water quality standards. These diffusers extend to approximately 8,350 feet offshore for Unit 2 and 6,020 feet offshore for Unit 3. The fish return system discharges into a common pipe that extends approximately 1,312 feet offshore.

Further details on SONGS design and operations are provided in the Impingement Mortality and Entrainment Characterization Study (Attachment 2), the 122.21(r)(2)(3)&(5) Information (Attachment 1) and the Comprehensive Cost Evaluation Study (Attachment 4).

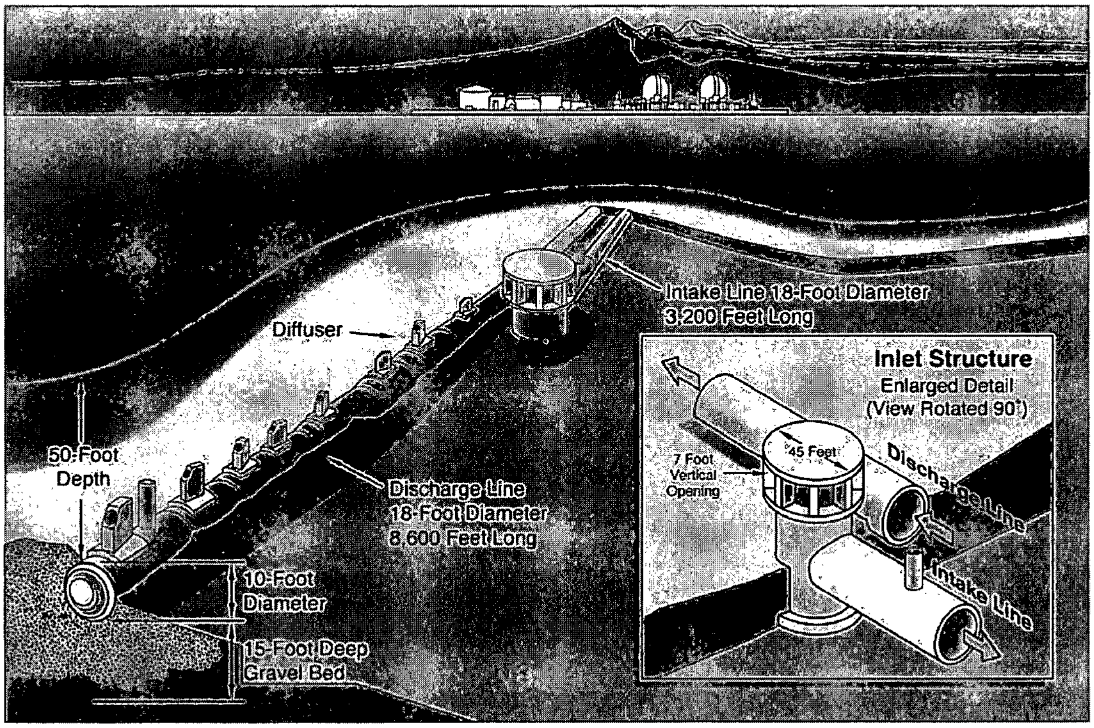


Figure 1. Schematic of SONGS cooling water intake and discharge.

3 §316(b) COMPLIANCE APPROACH FOR SONGS

As discussed in the introduction, EPA has suspended the Rule in its entirety. The result is that, from a federal perspective, the requirements to meet specific numeric performance standards, to submit a CDS, to submit the 122.21(r)(2)(3) and (5) information, and associated schedules are no longer applicable. As a result of EPA's action and the other §316(b) regulatory developments discussed in the introduction, SCE has modified its §316(b) approach for SONGS in a manner that meets the requirements of Special Provision 1(a)(ii) of the NPDES permit, is consistent with the overall Decision, and provides information to the SDRWQCB relative to BPJ compliance. The effect of the modification is that some of the CDS documents are submitted as originally proposed in the PIC, while others have been modified to be consistent with the Court Decision and/or BPJ. The approach used in this CDS and changes to the approach in the PIC are discussed in the section below.

3.1 Formation of Technical Oversight Team

SCE established a technical oversight work group to provide technical review and comment on the impingement and entrainment study and approach for estimating the calculation baseline. The Team consisted of the following organizations and individuals:

Southern California Edison

Robert Heckler – *Manager, Environmental Compliance*

Mary Jane Johnson – *Manager, Site Support Services*

David Kay – *Manager Corporate Environment, Health, and Safety*

Patrick Tennant - *Biologist*

State Water Quality Control Board – San Diego Region

John Odermat – *Senior Engineering Geologist*

Charles Cheng – *Engineering Geologist*

California Department of Fish and Game

William Paznokas – *Staff Environmental Scientist, Marine Region*

National Marine Fisheries Service

Bryant Chesney – *Southern California Habitat Coordinator*

California State Parks

Dave Pryor – *Resource Ecologist*

MBC Applied Environmental Sciences (IM&E Study Consultant)

Shane Beck – *Vice President*

EPRI (CDS – Consultant)

Dave Bailey – *Senior Project Manager*

Tenera Environmental (IM&E Study Consultant)

John Steinbeck – *Vice President*

ACT Environmental (SCE Marine Biology/316(b) Support)

Kevin Herbinson – *Senior Marine Biologist*

Subject Matter Experts

Andy Jahn, PhD – *Environmental and Statistical Consultant*

Peter Raimondi, PhD – *Associate Professor, University of California, Santa Cruz, Department of Ecology and Evolutionary Biology*

Dr. Raimondi is also a member of the California Coastal Commission's Scientific Advisory Panel for SONGS, and reviewed the draft Impingement Mortality and Entrainment Study.

3.2 Source Waterbody Information

The Source Waterbody Information CDS document is only required for facilities located on freshwater rivers or reservoirs. Since SONGS withdraws its condenser cooling water from the ocean, this CDS document is not required.

3.3 Impingement Mortality and Entrainment Characterization Study

This document was prepared in a manner consistent with the studies described in the revised PIC and the associated letter to SDRWQCB dated December 22, 2006. Section 4 provides a summary of the impingement and entrainment study results, and the complete Impingement Mortality and Entrainment Characterization Study Report is provided as Attachment 2. The approach used in the study and CDS is consistent with the requirements of §125.95(b)(3) of the Rule.

3.4 Use of Compliance Alternative 2 to Meet the Impingement Mortality Reduction Performance Standard

Compliance with impingement mortality reduction performance standard will be based on the approach discussed in the revised PIC. SCE has installed a combination of impingement mortality reduction technologies and operational measures at SONGS that meet the Rule's performance standard. The Rule at §125.94(a)(2) allows facilities to take credit for existing design and construction technologies to meet the performance standards. The specific fish protection technologies and operational measures installed at SONGS include a velocity cap and FRS installed on each of the two units. They are discussed in Section 5 of this document and the calculation baseline section of the Impingement Mortality and Entrainment Characterization Study (Attachment 2, Chapter 6). Use of existing technologies and operational measures for compliance (other than use of Compliance Alternatives 1 and 4 technologies) requires submittal of a Design and Construction Technology Plan, Technology Installation and Operation Plan (TIOP) and Verification Monitoring Plan. These CDS documents are also summarized in Section 5 and provided as Attachment 3.

3.5 Use of Site-specific Standards to Meet the Entrainment Performance Standard

Section 6 provides the SONGS compliance analysis for the entrainment performance standard based on use of Compliance Alternative 5 (Site-specific Performance Standards) using the cost-cost test. SCE had originally intended to submit a Restoration Plan for entrainment compliance based on SCE's agreement with the California Coastal Commission. The agreement includes restoration of 150 acres of coastal wetland as part of the overall San Dieguito River Valley Regional Open Space Park project for an estimated cost of $86 million. An April 1977 amendment to the Coastal Development Permit authorized a credit of 35 acres of wetlands if SCE provided continuous tidal flow maintenance in the San Dieguito Lagoon. The construction of this coastal wetland project was initiated in August 2006 and completion is expected in December 2009. Consistent with requirements for the use of restoration measures, the agreement includes funding of monitoring to ensure that the project goals are attained. Other restoration/mitigation programs included partial funding of a white sea bass fish hatchery. The agreement was specifically designed to offset losses of mid-water fish species based on an IM&E analysis conducted in the 1980s. As a result of the Second Circuit Decision, SCE is not proposing to use restoration measures for CDS compliance or submit a Restoration Plan for SONGS. However, a restoration plan has been submitted and approved by the California Coastal Commission and funding for construction of the wetlands to offset entrainment losses will continue.

SCE is submitting the CDS Documents required at §125.95(a)(6) of the Rule for compliance based on site-specific determination of BTA. Specifically, SCE is using the cost-cost test compliance option as authorized at Section §125.94(a)(5)(i) of the Rule. The specific CDS documents required for this approach include a Comprehensive Cost Evaluation Study, Site-specific Technology Plan, and a Verification Monitoring Plan. These CDS documents are provided as Attachment 4 and are summarized in Section 6.

3.6 BPJ Compliance Considerations

Because EPA has withdrawn the Rule and directed EPA Regions and States to implement §316(b) in individual NPDES permits on a BPJ basis, SCE provides a discussion of key factors for consideration by the SDRWQCB in developing its final BPJ determination for SONGS. These factors include a summary of the previous BPJ determination based on the MRC studies and recommendations, the information provided in the CDS, and EPA and SWRCB rulemaking efforts currently in progress. A discussion of these considerations is provided in Section 7.

4 IMPINGEMENT MORTALITY AND ENTRAINMENT CHARACTERIZATION STUDY

4.1 Summary of Regulatory Requirements and Studies

§125.95(b)(3) of the Rule requires submittal of an Impingement Mortality and Entrainment Characterization Study for the purpose of providing information to support the development of the calculation baseline and for characterizing current levels of impingement mortality and entrainment. The following components are required in support of the overall CDS:

1. Taxonomic identifications of all life stages of fish, shellfish, and protected species in the vicinity of the CWIS that are susceptible to impingement and entrainment;
2. Characterization of all life stages of fish, shellfish, and protected species identified in Item 1. The characterization must include a description of the abundance and temporal and spatial characteristics of species in the vicinity of the CWIS based on sufficient data to characterize annual, seasonal, and diel variations in impingement mortality and entrainment (e.g., related to climate and weather differences, spawning, feeding and water column migration); and
3. Documentation of the current impingement mortality and entrainment of all life stages of fish, shellfish, and any protected species in Item 1 and an estimate of impingement mortality and entrainment to be used as the calculation baseline. The documentation may include historical data if the data are representative of the current facility operation and current biological conditions at the site. Samples must be collected during periods of representative operational flows for the cooling water intake structure and the flows associated with the samples must be documented.

While SCE conducted extensive impingement and entrainment sampling at SONGS beginning in 1979 under the direction of the Marine Review Committee (MRC), SCE initiated new studies in 2006–2007 to ensure that the data were representative of current biological conditions. The most recent studies were conducted as required by NPDES permits (CA0108073 and CA0108181) that were based on the Federal Phase II Rule.

The studies included both in-plant and offshore field surveys. The initial sampling plan was submitted in the SONGS PIC in October 2005, and was modified as described in an amendment to the PIC submitted in November 2006. Impingement and FRS sampling were conducted from March 2006 through May 2007, and entrainment and source water sampling were conducted from March 2006 through April 2007. As discussed in the introduction, SCE formed a technical review committee consisting of fishery biologists and Federal and State Agencies to review study results, and additional experts to review the draft Impingement Mortality and Entrainment Characterization Study.

4.2 Summary of Entrainment and Source Water Sampling Results

Bi-weekly entrainment sampling was conducted in the onshore intake bays in 2006 and 2007. The dominant species collected were:

- northern anchovy (*Engraulis mordax*; 39% of the total larvae collected);
- unidentified anchovies (Engraulidae; 20%);
- queenfish (*Seriphus politus*; 6%);
- clinid kelpfishes (*Gibbonsia* spp.; 6%);
- combtooth blennies (*Hypsoblennius* spp.; 5%);
- gobies (Gobiidae; 5%); and
- white croaker (*Genyonemus lineatus*; 4%).

These seven taxa comprised over 84% of the larvae collected. The dominant species of fish eggs in the samples could not be identified to family due to current limitations in taxonomic knowledge of fish eggs in southern California. Total annual entrainment based on in-plant collections was estimated to be 1.1–1.4 billion larvae per unit, and 13–14 billion fish eggs per unit. The highest densities of eggs and larvae occurred in spring, and were relatively low throughout the remainder of the year. An exception was sea bass (*Paralabrax* spp.) when larvae peaked in summer (July and August 2006). Larvae were generally entrained in higher numbers at night but fish eggs exhibited no clear diel pattern of entrainment.

Thirteen offshore surveys were conducted during 2006–2007 concurrently with the in-plant entrainment sampling. Results of offshore sampling determined that there were greater concentrations of larvae offshore than at the in-plant entrainment stations, particularly for anchovies. During paired in-plant and offshore surveys, concentrations of fish larvae were higher in-plant during 5 of 13 surveys, while fish egg concentrations were higher in-plant during 11 of 13 surveys. Cropping by fouling organisms between offshore and in-plant sampling locations did not appear to be a major factor in the differences between the two sites. The highest concentrations of larvae occurred in April and June 2006 resulting in 34% of the annual entrainment occurring in April and 46% in June. Thus entrainment during these two months accounted for 80% of the estimated annual entrainment. During these two months the fish densities collected offshore were approximately three times higher than in-plant estimates for larvae, but only about 40% higher than the in-plant estimates for fish eggs.

Vertical distributions of eggs and larvae offshore followed previously recorded patterns for SONGS. Larvae were most abundant just above the bottom and in the surface waters. The lowest larval densities were found in the mid-water column. Fish egg concentrations at the surface were four times higher than in the mid-water column and were thirteen times higher than at the bottom of the water column. Crab megalopae (a larval stage) were most abundant at the bottom of the water column. It was also determined that fish egg and fish larvae densities were 10.1 and 3.6 times higher in the nearshore surface waters than in the water column near the intakes. However, the reverse was true for target invertebrate larvae (i.e., 50% higher near the intakes than in nearshore surface waters). Midwater offshore larval fish concentrations in the study were similar to those recorded during the MRC studies in 1978–1986. However, in-plant larval fish concentrations in this study were much lower than those found in the MRC study.

High year-to-year variability in densities of fish eggs and larvae has been documented by the California Cooperative Oceanic Fisheries Investigations (CalCOFI) in southern California. It is therefore not known if the differences between concentrations measured in 2006-2007 and studies conducted 20–30 years ago represent a true long-term decline in larval densities. However, conclusions from other studies suggest that the productivity of southern California waters declined with the onset of an ocean temperature regime shift of 1977.

4.3 Summary of Impingement Mortality Studies

An estimated 1,353,000 fish weighing 28,742 lbs were estimated to be impinged during the one-year study. This estimate is based on the cooling water flow for each unit during that period. The dominant species collected during the study were:

- queenfish 52.7% by number and 26.6% by weight;
- northern anchovy 29.3% by number and 2.6% by weight;
- Pacific sardine (*Sardinops sagax*) 7.9% by number and 9.8% by weight;
- deepbody anchovy (*Anchoa compressa*) 1.7% by number and 1.5% by weight;
- white seaperch (*Phanerodon furcatus)* 1.4% by number and 0.5% by weight;
- topsmelt (*Atherinops affinis)* 0.8% by number and 2.4% by weight;
- white croaker (*Genyonemus lineatus)* 0.7% by number and 0.5% by weight; and
- yellowfin croaker (*Umbrina roncador)* 0.7% by number and 25.2% by weight.

Together these eight species made up 95.2% by number and almost 70% by weight of the total annual impingement. SONGS impingement consists of two components. One component is the impingement resulting from daily operation of the cooling water intake structure. During normal operations fish and shellfish impinged on the screens are removed as screens are rotated to prevent the screen blockage from impeding cooling water flow to the condensers. This is accomplished by rotating the screens once per shift. The second component of impingement is the loss of fish and shellfish living in the intake bays that suffer mortality during periodic heat treatments to control biofouling in the intake tunnels. Each of these components and the methods used to reduce impingement mortality at the traveling screens is discussed separately.

4.3.1 Impingement During Normal Cooling Water Intake Operations

As discussed in Section 2, SONGS is equipped with a fish lift to collect and transfer fish and shellfish in front of the traveling screens to the FRS for transport back to the Pacific Ocean. The fish lift is operated at least once each 12-hr shift to remove fish from the area in front of the screens prior to screen operation. Normal screen rotation operations accounted for 97% of the fish impingement by number and 63% of the biomass. An estimated 118,000 shellfish weighing 2,886 lbs were also impinged. The dominant impinged shellfishes were rock crabs (*Cancer* spp.), swimming crab (*Portunus xantusii*), and blackspotted bay shrimp (*Crangon nigromaculata*). Normal screen rotation operations accounted for 71% of invertebrate impingement and 89% of the impingement biomass. Fish impingement peaked in summer and winter. Northern anchovy was the most frequently impinged fish in June 2006, while impingement of queenfish and bay anchovies (*Anchoa* spp.) peaked in November and December 2006. Invertebrate impingement showed a strong seasonal peak with highest numbers impinged in winter (November 2006 through January 2007). Impingement was generally higher during nighttime than during daytime.

4.3.2 Impingement Resulting from Heat Treatments

There are six generating facilities (including SONGS) in California with offshore intakes and velocity caps similar to SONGS. Each uses heat treatments conducted approximately every six weeks to control biofouling. Studies at the other five facilities indicate that impingeable-sized fish losses during heat treatments exceed impingement losses during normal operations on an annual basis (e.g., Huntington Beach Generating Station heat treatment losses accounted for approximately 75% of annual losses). SONGS is unique among these facilities in its use of a FRS and associated operational procedures to minimize fish mortality during heat treatments.

The SONGS FRS is designed to reduce fish mortality by guiding fish to a removal area where they are subsequently lifted and transported back to the source water body. Quantification of the FRS impingement mortality reduction was a component of the present study. The most abundant fishes collected in the FRS samples in 2006–2007 included northern anchovy, queenfish, Pacific sardine, and salema (*Xenistius californiensis*). Annual return estimates for fishes were 72% based on abundance and 89% based on biomass. For invertebrates, return estimates were much lower: 4% based on abundance and 40% based on biomass. Fish return was highest from June through August 2006, corresponding primarily to high return of northern anchovy, queenfish, and Pacific sardine. Bay anchovies occurred primarily in winter (November and December 2006). Invertebrate return was highest in spring and early summer, though return of spiny lobster occurred year-round, with peaks in July 2006 and February–March 2007. Consistent with normal operations, fish return was generally higher at nighttime than daytime for fishes, while there was no consistent diel pattern with respect to invertebrates. Fish return was higher than documented in previous studies, although species-specific return rates of common fishes were similar to those measured previously. Almost all of the fish taxa returned in highest abundance had slightly higher return efficiencies based on biomass, indicating that larger individuals were returned with greater efficiency than smaller individuals. This was particularly evident with queenfish, Pacific sardine, white seaperch, and white croaker.

Overall, the abundance of fish impinged both in terms of numbers and biomass was below the long-term annual averages since monitoring began in 1982. However, annual impingement estimates from 2005 were the highest on record, and resulted from the impingement of relatively high numbers of Pacific sardine and northern anchovy in normal traveling screen operation impingement sampling. Over the years there has been high year-to-year variability in fish impingement at SONGS, with peaks every four or five years. Analysis of the previously collected data indicates the impingement totals at SONGS are driven by the impingement of three species, including northern anchovy, Pacific sardine, and queenfish. When compared with commercial and recreational fishery losses, SONGS impingement totals are relatively low (1.0% or less for most species).

4.4 Calculation Baseline Estimate

The calculation baseline was a component of the Phase II Rule intended to provide a credit toward compliance for those facilities such as SONGS that have already installed design construction technologies and/or operational measures to protect fish and shellfish from impingement and/or entrainment. The calculation baseline was defined in the Phase II Rule as the level of impingement mortality and entrainment that would occur assuming a shoreline intake, 3/8-inch traveling screens oriented parallel to shore near the water surface, and the baseline practices and procedures of the facility (see introduction for full definition). The cooling water intake systems at SONGS deviate from the Rule's definition for the following reasons:

- the intakes are submerged;
- the intakes are located more than 3,000 ft offshore;
- the traveling screens are not oriented parallel to the shoreline;
- both intake designs include a velocity cap; and
- both cooling water intakes are designed with fish return systems.

At SONGS, calculation baseline estimates were made for both impingement mortality and entrainment assuming (1) there were no velocity caps on the intakes, and (2) all juvenile/adult fishes and invertebrates entrained at SONGS were subsequently impinged (i.e., no FRS, fish guidance systems, or fish chases). Since a site-specific analysis of velocity cap effectiveness is not possible at SONGS due to the configuration of the diffuser-port discharge structure, determination of the level of fish protection provided by the velocity caps at SONGS was made through analysis of previous laboratory and field studies in southern California at facilities with similar structures. This is entirely consistent with the Rule's definition of the calculation baseline that states: "*The calculation baseline may be estimated using historical impingement mortality and entrainment data from your facility or another facility with comparable design, operational, and environmental conditions*".

A statistical analysis of velocity cap efficacy data from El Segundo, Huntington Beach, Ormond Beach and Scattergood Generating Stations was performed. The analysis projected that impingement mortality at SONGS is reduced by an estimated 88.2% as a result of the velocity cap design presently in place.

The determination of fish and invertebrate return rates through the FRS was made by direct measurement throughout the study. Previous estimates of survival upon return were used to estimate the number and weight of fishes that would survive return through the FRS. The combined reduction in impingement mortality afforded by the velocity caps and FRS (taking into account return survival) at SONGS was 94.2% based on abundance and 97.7% based on biomass. These estimates were slightly lower than those calculated assuming all returned fish survived transit through the FRS (96.6% based on abundance and 98.7% based on biomass). No adjustments to annual entrainment estimates were made for purposes of the calculation baseline, although there was evidence during offshore sampling in 2007 that the offshore location of the intake and the depth of withdrawal could decrease entrainment relative to a shoreline, near-surface intake.

The complete SONGS Impingement Mortality and Entrainment Characterization Study is provided as Attachment 2.

5 USE OF COMPLIANCE ALTERNATIVE 2 TO MEET THE IMPINGEMENT MORTALITY REDUCTION PERFORMANCE STANDARD

The Rule at §125.94(2) allows facilities to demonstrate that they have currently installed and properly operate and maintain design technologies and operational measures that meet the performance standards. The combination of the installed offshore velocity cap and FRS result in an estimated 94.2% reduction in impingement mortality by number and a 97.7% reduction by weight. This level of reduction meets the upper end of the 80% to 95% reduction required by the Federal Phase II Rule and the impingement reduction standard proposed in the Draft California §316(b) Policy. Because SCE has installed, operates and maintains such technologies and operational measures at SONGS, SCE is using the Rule's Compliance Alternative 2 for impingement mortality reduction compliance. Use of Compliance Alternative 2 requires submittal of the technology and compliance assessment information as specified at §125.94(b)(4) and a Verification Monitoring Plan as specified at §125.94(b)(7) of the Phase II Rule.

The technology information required consists of two components that include a Design and Construction Technology Plan (DCTP) and a Technology Installation and Operation Plan (TIOP). For SONGS, these CDS components are based on the currently installed design and operational measures that have already been summarized in this document. These CDS documents are provided as Attachment 3. SCE is proposing two years of biological verification monitoring for SONGS as required by the Rule. This monitoring will continue to include monitoring during each heat treatment, as well as monthly impingement monitoring during normal operations. The details of the proposed impingement verification monitoring are also provided in Attachment 3

6 USE OF SITE-SPECIFIC STANDARDS TO MEET THE ENTRAINMENT REDUCTION PERFORMANCE STANDARD

The Rule at §125.94(a)(5)(i) allows facilities to comply by demonstrating that they have or will install technologies and operational measures based on a comparison of site-specific cost estimates to those considered by EPA in the Rule (i.e. cost-cost test). The CDS requirements for this compliance alternative are provided at §125.95(b)(6) of the Rule. EPA included SONGS as one of the facilities listed in Appendix B of the Rule and a cost estimate was provided in Attachment A of the Rule for comparison with SONGS detailed site-specific estimates. This Section provides a description of the screening process used to identify potential entrainment reduction alternatives (6.1), a discussion of alternatives evaluated as not feasible (6.2), a discussion of potentially feasible alternatives (6.3), a discussion of the costs for these alternatives (6.4), the cost-cost test analysis (6.5), and an entrainment compliance summary (6.6).

The determination of "feasibility" is only based on an engineering and cost analysis of the technology. The actual feasibility of the technology would need to incorporate not only the engineering and costs analyses, but also an environmental impact analysis. This analysis would take into concern environmental, social, potential impacts to the California power system, potential permitting issues, and nuclear safety analysis.

6.1 Entrainment Reduction Technology Screening Process

Alden conducted an analysis of alternative entrainment fish protection technologies and operational measures to reduce entrainment at SONGS. The details of the process used to identify the alternatives are provided in the Comprehensive Cost Evaluation Study (Attachment 4, Appendix A). Additionally, Dr. John Maulbetsch conducted an evaluation of closed-cycle cooling for SONGS (Attachment 4, Appendix C). The following eight alternatives were evaluated:

1. Reduced circulating pump flow using variable frequency drives;
2. Aquatic filter barrier;
3. Relocation of the intake further offshore to a point below the thermocline;
4. Fine-mesh modified traveling screens;
5. Offshore narrow-slot cylindrical wedgewire screens; and
6. Aquatic filter barrier
7. Offshore narrow-slot cylindrical wedgewire screens

8. Reduced circulating pump flow using variable frequency drives
9. Relocation of the intake further offshore to a point below the thermocline
10. Closed-cycle cooling.

6.2 Entrainment Reduction Options Evaluated as Not Feasible

6.2.1 Reduced Use of Cooling Water Pumps

The Rule assumed a proportional relationship between flow and entrainment. SONGS is a baseloaded nuclear facility and routinely requires use of all circulating water pumps for Units 2 and 3 to meet energy demands. A reduction in flow is expected to result in a reduction in generation capacity due to decreased plant efficiency and could ultimately increase the temperature of the discharge. Flow is only reduced during scheduled outages. Because flow reduction opportunities for SONGS are very limited and unpredictable this option is not considered feasible for use at SONGS.

6.2.2 Aquatic Filter Barrier (AFB)

The aquatic filter barrier (AFB) is a relatively new fish protection technology and has only been deployed on a full-scale basis at the Lovett Generating Station in New York on the Hudson River. The technology consists of two layers of fabric with 0.5 mm perforations and an integral air burst backwash system. The AFB would be installed around the cooling water intake structure. The surface area for passage of cooling water flow is such that the through-net fabric velocities are in the range of 0.02 feet per second (fps). At these low velocities, ambient water current can carry entrainable organisms away from the net. After several years of development, structural issues with the fabric and clogging were resolved and the most recent AFB entrainment reduction performance results indicate that the technology is capable of meeting the performance standards.

For impingeable-sized organisms this option would eliminate the benefit of the velocity cap and the FRS. Since this option has a maximum through-filter velocity that does not exceed 0.5 fps, it would automatically comply with the impingement mortality reduction standard in the Phase II Rule and no CDS would be required for impingement. An AFB deployed at SONGS would be expected to achieve a relatively high level of entrainment reduction if it could be designed to withstand the hydraulic forces and debris loading conditions that exist at SONGS. In order to ensure egg and larval fish protection, the AFB is designed to have a flow rate of 10 gpm/ft^2 providing a through-fabric velocity of approximately 0.02 fps. The offshore SONGS intakes are at a depth of approximately 30 ft MLLW, and 2,820 ft length of AFB material (i.e., over a half mile) would be required to maintain the design flow rate. The AFB could be deployed in the shape of a square with 725 ft on each side and would surround both intakes. Substantial intermediate support structures would be required to hold the AFB fabric in place. The installation would also require a storm-proof shelter to house the air burst system required to dislodge debris from the fabric. An AFB installation of this size would encompass 12 acres of ocean bottom habitat.

If the AFB could be successfully deployed, it would also require substantial operation and maintenance efforts, including the periodic use of divers to maintain it in a clean condition. As designed, the system uses an air burst system to control debris and biofouling buildup on the filter fabric. A compressed air hose is installed at the bottom of and in between the two layers of fabric that make up the AFB. When tension builds up on the outer fabric a tension sensor cord releases a blast of compressed air that moves up through the fabric to dislodge accumulated debris that is then carried away by ocean currents. However, an AFB has never been tested in a high biofouling marine environment such as that which exists in the vicinity of SONGS. Consequently, its ultimate efficacy cannot be determined. It is therefore expected that divers would be required to periodically conduct manual cleaning of the net and conduct other repairs and maintenance, and that such manual maintenance could be required many times a year.

The most significant concern for an ocean deployment is the ability of the system to withstand the severe hydraulic forces associated with major storm events that occur each year. Such storms have destroyed concrete piers and velocity caps at power plants (e.g., Scattergood Generating Station). The major difference in the AFB deployment at Lovett Generating Station and the one proposed for SONGS is that the area around Lovett is relatively calm compared to the open Pacific Ocean conditions during major storm events at SONGS.

Another impact would be the hindrance to vessel traffic in the area. The area surrounding the SONGS intake is open to public navigation, and the area is often used by recreational and commercial fisherman. An exclusion zone would have to be designated.

A final issue is the potential for impact to migrating marine mammals and sea turtles. The significance of this potential issue is not known at this time.

In conclusion, the AFB has never been tested in the marine environment. The potential for damage to the AFB due to storms is significant and the maintenance required due to fouling would be substantial. As a result of structural and other issues the AFB was determined infeasible for use at SONGS.

6.2.3 Relocation of the Intake Further Offshore

The Marine Review Committee (MRC) previously conducted an evaluation of the benefit in moving the SONGS cooling water intake structures to a location that could reduce overall entrainment. It was estimated that relocating the intakes 3,000 ft further offshore to a 60 ft depth would impact some 192,000 ft^2 of benthic habitat. At this distance consideration would be necessary to avoid interaction with the thermal discharge which also extends to this distance offshore. It was determined that the species composition of entrained organisms would be altered by reducing entrainment of forage species at the expense of increasing entrainment of recreational and commercial species.

The MRC concluded that relocating the intakes to a different location along the coast would result in no consistent differences in species composition and total abundances and as a result there was not a clear benefit to relocating the intake. With no clear evidence that a significant entrainment reduction would be achieved this option, it was dismissed from further consideration. Based on the current entrainment study results and the prior MRC evaluation there is no technical basis to support reconsideration of the prior MRC conclusion.

6.3 Feasible Entrainment Reduction Options

A summary and discussion of the three remaining options and the estimated fish protection benefit of each is provided below with a discussion of how the technology functions, proposed design for use at SONGS, expected performance and potential issues. More detailed discussion is provided in the Comprehensive Cost Evaluation Study (Attachment 4) and Attachment B of that document.

Again, it should be noted that the term "feasibility" is an engineering and cost analysis of the technology based on numerous assumptions. The actual feasibility of the technology would need to incorporate not only the engineering and costs analyses, but also an environmental impact analysis. This analysis would take into concern environmental, social, potential impacts to the California power system, potential permitting issues, and nuclear safety analysis.

6.3.1 Fine-mesh Traveling Screens

How It Protects Fish – This technology is designed to reduce impingement mortality and entrainment by collecting fish off fine-mesh screens and transporting them back to the ocean offshore in a manner that maximizes survival. This is achieved by use of design components that include:

- Low-pressure Screen Spraywash – A low-pressure screenwash spraywash system is installed to gently wash larvae off screens into a return trough.
- Fish Collection Buckets – Buckets are installed at the bottom of each screen panel to hold collected fish and shellfish in water for release into the return trough.
- Continuous Screen Rotation – The screens are rotated continuously to minimize the time that eggs and larvae are exposed to the system and increase survival.
- Fish Return – A return pipe or sluice is installed to transport collected fish and shellfish back to the Pacific Ocean. The SONGS has already installed the FRS so the capability to return fish is currently in place. There a currently approximately a half dozen such systems in use across the U.S. Depending on the location, species and life stages present and other factors these systems have been found to be effective in reduction entrainment.

Proposed Design for SONGS – The effectiveness of a fine-mesh screening system is measured in terms of both exclusion and survival. The exclusion component is based on whether the mesh size proposed can retain (exclude) eggs and larvae of fish and shellfish being entrained in the cooling water. Fine-mesh screens are often designed to meet a 0.5 fps approach velocity. However, expanding the intake to meet a 0.5 fps velocity is a relatively costly option and SONGS should first conduct a pilot study to determine if replacing the existing screens with fine-mesh screens without intake expansion will provide acceptable survival. To meet a 0.5 fps screen approach velocity a new larger intake would be required to accommodate 32 screens.

Fish and debris removed from the screens would have to be transported back to the ocean. This would be accomplished by combining the new troughs into the existing return pipe for release offshore.

Replacing the existing screens with fine-mesh Ristroph screens would cost $11,089,000 and could be completed during a scheduled outage. Construction of a new expanded screenhouse for the 32 new screens is estimated to exceed $60,000,000 and would require the plant to be shut down for a minimum of 1 year to connect the new structure. Due to space limitation on site, a new intake would need to be built out into the ocean. Detailed costs for replacing the existing screens are provided in the following section.

Expected Entrainment Reduction Performance – Currently SONGS is meeting the impingement mortality reduction standard with the existing velocity cap and FRS. Adding the fine-mesh system would be expected to result in a further reduction in impingement mortality. For entrainment, the fine-mesh screen system was evaluated to determine the likely entrainment reduction that could be achieved. The determination of the collection efficiency of 0.5 mm screens was estimated based on head capsule depth of the fish larvae. The details of this estimation method are provided in Appendix B of the Comprehensive Cost Evaluation Study (Attachment 3). The retention of dominant species such as anchovy and queenfish was relatively high at 81.3% and 89.8% respectively (Table 1). However survival was relatively low resulting in an overall estimated efficiency of 9.9% and 16.7% for these two species (Table 1). Overall performance for this option would be well below the minimum 60% entrainment reduction standard in the Phase II Rule.

Potential Issues – The requirement for continuous rotation may result in biofouling problems for these screens. Therefore, the system would require a biofouling control method as part of the overall design.

Although the system is designed to minimize stress to aquatic organisms, the process of collection and transfer will impart a stress to the organism that would not be experienced if they were not impinged. This is especially true for the earliest life stages (e.g., yolk-sac larvae). Generally, as fish grow survival will increase. For those fish that do come in contact with the screen, collecting them on a fine-mesh screen and returning them to the ocean rather than allowing them to be entrained should result in some reduction in losses.

Expanding the intake is not considered feasible based on preliminary engineering. A large screen structure would need to be built on the shoreline extending out into the ocean requiring the plant to be shut down for at least 1 year. Due to the impacts to the shoreline and cost associated with replacement power, expanding the intake should only be evaluated further if the results from the pilot study indicate it is worthwhile.

A detailed discussion of this technology option is provided in the Comprehensive Cost Evaluation Study (Attachment 4).

6.3.2 Narrow-slot Wedgewire Screens

How it Protects Fish - This technology provides fish protection through a combination of exclusion from the cooling system and low through-slot water velocities. The system effectiveness improves with ambient current sweeping velocities particularly when those velocities are greater than the velocities passing through the wedgewire slots. EPRI in a jointly funded project with EPA has conducted both laboratory and field studies on the performance of these screens. While widely deployed in freshwater and estuarine systems, experience with these systems is very limited in marine environments and there are no existing installations for electric generating stations in marine waters. A nuclear safety analysis review would also need to be conducted to determine feasibility.

Proposed Design for SONGS – Alden's design for this option proposes that 68 T-120 (10 ft diameter) screens with 0.5 mm slot openings would be required for the total flow for both units. One extra screen per intake was included in the design. This was done to allow for one screen to be removed for maintenance without increasing the velocity over manufacturer's design velocity (0.5 fps through-slot). To reduce the effects of bio-fouling a 70-30 copper-nickel alloy would be used. The screens would be mounted on six, 14-ft diameter intake pipes located beneath a large offshore work platform. The platform would provide:

- housing for compressors for the air backwash system,;
- a mechanical cleaning system; and
- a work deck from which to remove and maintain the screens.

Each of the intakes would include an emergency bypass to ensure an uninterrupted condenser cooling water flow in the event of extreme fouling event or other obstruction on the screen face. These gates would allow heat treatments to continue to control fouling in the intake tunnels.

Expected Entrainment Reduction Performance – The installation of wedgewire screens would eliminate the velocity cap and need for the FRS. It is important to consider performance in terms of reducing impingement mortality. The narrow-slot wedgewire screen through-slot design velocity does not exceed 0.5 fps and therefore it would qualify for use of Compliance Alternative 1. In the Phase II Rule for impingement mortality reduction no CDS would be required under this compliance alternative. Since there are no biological efficacy data with wedgewire screens for the species entrained at SONGS, head capsule depth data fish larvae was also used to estimate exclusion effectiveness for this option (see Appendix B of Attachment 4).

Performance is expected to be variable depending on species with reductions ranging from a high of almost 90% for queenfish to no protection for sea basses. However, the overall efficacy of this technology is estimated to reduce entrainment by 76.2% for all entrainable life stages combined. The estimated performance of narrow-slot wedgewire screens is shown in Table 1 below.

Potential Issues – The installation of narrow-slot wedgewire screens is feasible from an engineering stand point; however, it would require extensive civil structure, disturbance to the sea bottom in the area of the CWIS, create a public exclusion zone offshore, and down-time for construction. In addition, there is considerably greater operation and maintenance (O&M) cost associated with them compared to the existing O&M. A major concern is ensuring that marine biofouling can be controlled. Narrow-slot wedgewire screens should be effective at excluding some life stages of ichthyoplankton at SONGS. The ultimate efficacy is dictated by species-specific life stages and abundance of those life stages in the entrained population.

As with the previously discussed technologies, there are a number of ancillary issues that would need further study prior to full-scale deployment. A key technological issue would be quantification of performance and ensuring marine biofouling can be controlled.

Other issues that could affect the overall feasibility of this technology would be the environmental impacts and permitting associated with construction and long-term operations of the maintenance deck. This would require approval from several state agencies. Further impacts to offshore kelp forests and bottom habitat may require substantial mitigation.

6.3.3 Closed-cycle Cooling

How It Protects Fish – The Rule used the assumption of proportionality between entrainment and cooling water flow. Because wet closed-cycle cooling systems can achieve a level of reduction in excess of 90% they would automatically achieve a level of entrainment reduction at the upper end of the 60–90% performance standard range. Therefore, the Rule allowed use of Compliance Alternative I for closed-cycle cooling. While the Rule did not use the assumption of proportionality for impingement, EPA indicated a "substantial" reduction in impingement would be achieved such that closed-cycle cooling qualified for use of impingement as well.

Proposed Design for SONGS – SCE participated in a study conducted by EPRI to evaluate the cost of retrofitting each of the eighteen once-through cooling power plants in California with closed-cycle cooling. This study generated an evaluation for retrofitting SONGS with wet closed-cycle cooling.

Expected Entrainment Reduction Performance – A wet closed-cycle cooling system would be expected to reduce entrainment at SONGS by 90% as a result of the reduction in cooling water flow that would be achieved.

Potential Issues – There would be significant issues associated with a wet closed-cycle cooling retrofit at SONGS. One of the major issues is existing space constraints which are discussed in the EPRI report (Appendix C of Attachment 4). The space issues are particularly problematic as SONGS is surrounded by State Parks and Federally owned land. This option would be expected to result in significant environmental and social impacts. Such impacts could include:

- human health impacts associated with increased emissions of fine particulates;
- terrestrial impacts to nearby wetlands or structural impacts to materials due to salt drift;
- potential water quality issues due to concentration of ambient source water pollutants in blowdown;

- public safety issues due to fogging and nearby roads;
- noise; and
- aesthetics.

There are likely to be permitting issues associated with these issues that could delay or prevent permitting of this option. These include issues resulting from the construction and operation of the towers. Towers will increase particulate matter and relocation of employee parking will increase traffic in the area, requiring new air quality permits. Reductions in energy generation will force fossil fueled plants to increase generation, resulting in additional greenhouse gas emission. Development on the coast will require permission from the California Coastal Commission, U. S. Fish and Wildlife, California Department of Fish and Game, and the Regional Water Quality Control Board. Blowdown material will require landfill disposal since disposal through the outtakes will not meet water quality requirements. The construction of cooling towers at SONGS would result in expanding the security measures to include these towers as they would be required for the nuclear safety of the plant. This would result in significant costs that were not included in this report.

Table 1. Estimated entrainment reductions for fine-mesh and narrow-slot wedgewire screens.

		Fine-mesh screens				Narrow-slot wedgewire	
Species	**Percent of Total Entrainment**	**Retention (1)**	**Survival (2)**	**% Reduction in Entrainment (3)**	**% Reduction in Total Entrainment (4)**	**% Reduction in Entrainment (5)**	**% Reduction in Total Entrainment (4)**
northern anchovy	58.6	81.3	12.2	9.9	5.8	81.3	47.6
queenfish	6.0	89.8	18.6	16.7	1.0	89.8	5.4
white croaker	3.9	60.7	18.0	10.9	0.4	60.7	2.4
Paralabrax spp.	0.4	0.0	95.5	0.0	0.0	0.0	0.0
Gibbonsia spp.	6.0	81.7	95.5	78.0	4.7	81.7	4.9
Hypsoblennius spp.	4.9	21.8	95.5	20.8	1.0	21.8	1.1
gobies	4.9	64.1	0.0	0.0	0.0	64.1	3.1
California grunion	1.6	78.4	59.0	46.3	0.7	78.4	1.3
Totals	**86.3**				**13.7**		**65.8**
Totals Relative to Total Entrainment					**15.8**		**76.2**

(1) Percent of entrained organisms expected to be collected on the traveling screens
(2) Expected survival off screens of those collected
(3) Combined percent reduction based on retention and survival
(4) Percent reduction in entrainment based on the percent of each species comprising overall entrainment
(5) Percent each species is expected to be excluded from entrainment

6.4 Technology Costs

For two of the feasible alternative fish protection technologies, Alden prepared cost estimates based on deployment designs for SONGS. Cost estimates for a closed-cycle cooling retrofit were estimated by Dr. John Maulbetsch as part of an EPRI retrofit study. Table 2 provides cost estimates for each of the three feasible alternatives. Again, it should be cautioned that these estimates rely on many of assumptions. Costs are based on the costs estimated to retrofit the plant with these technologies if all permitting were in place. They also do not include potential mitigation costs, or any ancillary modifications to the plant (e.g., replacing the condenser system to fully maximize cooling towers) needed to support the equipment.

Table 2. Estimated costs of feasible entrainment reduction technologies.

Technology	Capital Cost	Capital Cost with Replacement Power Needed During Installation	O&M Cost	Total Annualized Cost (Capital & O&M)
Fine-mesh Traveling Screens	$11,090,000 (1)	$0	$663,000	$2,242,000
Narrow-slot Wedgewire	$59,000,000	$277,436,000	$1,534,000	$41,035,000
Closed-cycle Cooling	$676,384,000	$0(2)	$46,293,000	$177,825,000

(1) Note that the capital cost for fine-mesh traveling screens assumes installation of fine-mesh screens onto the existing screens.
(2) A $0 cost is assumed for replacement power due to uncertainty regarding the time period to connect the closed-cycle cooling system to the condenser water box. However, a significant outage lasting anywhere from a month to six months, or more, may be required per unit.

Retrofitting SONGS with closed-cycle cooling had the highest estimated cost. SCE participated in a study conducted by EPRI to estimate retrofit costs for all once-through cooling facilities in California. That final report titled "Issues Analysis Associated with Retrofitting Once Through Cooling Plants with Closed-Cycle Cooling" included a site-specific cost estimate for SONGS as Attachment B-15. That attachment is provided as Appendix C of the Comprehensive Cost Evaluation Study (Attachment 4). Peer reviewers for this report included the California Energy Commission and Tetra Tech which is performing a similar project for the Ocean Protection Council. The report pointed out that major system components of SONGS could not operate with dry cooling and therefore dry cooling was not feasible for SONGS.

The details of the technology designs used and their associated costs and assumptions are provided in Comprehensive Cost Evaluation Study (Attachment 4) of the CDS.

6.5 Analysis

The Rule at §125.94(a)(5)(i) allows facilities to demonstrate that if the costs considered by EPA in the Phase II Rule for that facility are significantly greater than the facility site-specific costs (based on reliable, scientifically sound cost estimates) then that technology would fail the test. SCE believes the peer reviewed closed-cycle cooling estimate generated in the EPRI study and the fine-mesh and narrow-slot wedgewire screen estimates prepared by Alden meet the Phase II Rule as reliable and scientifically sound, although the estimates are likely to underestimate the total costs due to the exclusion of the issues mentioned above.

EPA provided a cost estimate for SONGS in the Phase II Rule. SONGS is identified in Appendix B as facility number AUT0573. The costs for specific facilities are listed in Appendix A, and in that Appendix SONGS is assigned an n/a cost. EPA in the preamble of the Phase II Rule clarifies facilities assigned an "n/a" cost estimate were projected to already meet the applicable performance standards. EPA stated that "These facilities should use $0 as their value for the costs considered by EPA for a like facility in establishing the applicable performance standard." This point was discussed with EPA after the final Rule was issued and EPA said that as long as the EPA Phase II Questionnaire on which the determination was based was properly filled out, a $0 cost should be used in the cost-cost test. SCE has reviewed its questionnaire responses and determined they were properly filled out.

While EPA did not define or issue guidance on what costs would be considered "significantly greater", the estimated annualized costs for fine-mesh screen, narrow-slot wedgewire screens and closed-cycle cooling at $2.2 million, $41 million and $143 million, respectively, would all reasonably be considered significantly greater than $0.

6.6 Entrainment Compliance Summary

Based on the results of the cost-cost test analysis, each of the three potentially feasible entrainment reduction technologies was determined to have a cost significantly greater than the cost considered by EPA for SONGS in the Phase II Rule. Therefore, the existing cooling water intake structures are considered BTA for entrainment. CDS documents required for use of site-specific standards based on the cost-cost test are a Comprehensive Cost Evaluation Study, Site-specific Technology Plan and Verification Monitoring Plan which are provided in Attachment 4.

7 BEST PROFESSIONAL JUDGMENT COMPLIANCE CONSIDERATIONS

SCE has prepared this CDS in conformance with the NPDES permit and the Rule. SCE has provided documentation for the impingement mortality reduction achieved by the velocity cap and FRS which is estimated to reduce impingement mortality at the upper end of the performance standard range. SCE has used a site-specific standard cost-cost test analysis to demonstrate that the costs of achieving a 60% to 90% reduction to meet the entrainment reduction performance standard are significantly greater than EPA's estimated cost for SONGS. These were based on a technically sound site-specific evaluation of entrainment reduction structural and operational controls.

SCE is fully aware that the Second Circuit Court of Appeals remanded use of the cost-cost test to EPA for failure to allow adequate opportunity for public review and comment. SCE further recognizes that additional fish protection technologies and operational measures may be required to reduce entrainment, but point out a number of important considerations for the Board in making the final BPJ compliance determination for SONGS.

1. SONGS is an important source of reliable baseload generation in California. Since SONGS is a nuclear-fueled facility, the 2,174 MW of electricity generated does not directly result in air emissions and does not contribute to global warming as does fossil fuel power generation.

   SONGS also contributes to the local economy and the quality of life in Southern California by providing employment for more than 2,000 people and a source of $200 million in direct economic benefits to local communities, with an additional $20 million in property tax revenue.

2. Precedence has been set in past determinations that SONGS has been in compliance under BPJ guidelines. Prior to the issuance of the Rule, SONGS was determined to be in compliance with Section §316(b) based on an independent review of 316(b) demonstrations (from Units 2 and 3 in 1987, and an earlier demonstration in 1983 from the now-decommissioned Unit 1) by Science Applications International Corporation. This report was submitted to the EPA in 1993.

3. Impacts associated with entrainment at SONGS are currently being mitigated. SCE is spending an estimated $86 million for the construction, maintenance and monitoring for restoration of coastal wetlands specifically designed to offset Units 2&3 entrainment losses. These wetlands will continue to provide benefits to entrainable life stages long after the facility is decommissioned.

4. SONGS is in compliance with 316(b) reduction requirements for impingement. The level of impingement mortality reduction achieved is estimated to be 94.22% in terms of finfish numbers and 98.7% by finfish weight which is at the high end of the range specified in the Rule performance standard.

5. The decision remanding the Rule is still being litigated. An appeal to the Supreme Court has been filed regarding the Second Circuit Court Decision (Decision) that could alter the Decision. In addition, the Decision does not over rule and is inconsistent with the prior §316(b) Decision by the First Circuit Court in Seacoast Antipollution League vs. Costle. In that Decision the First Circuit Court ruled that cost and benefits could be considered using the wholly disproportionate standard. It is therefore up to the Board to determine whether or not this interpretation is appropriate unless and until authoritative action is taken by EPA or the SWRCB.

6. No rules or policies have been developed in place of the remanded rule, and are not expected until at least mid-2008. EPA has initiated work to revise the Rule in a manner that addresses issues raised by the Second Circuit Court. EPA's schedule calls for issuing a proposed Rule by the end of 2008. At this point it is anticipated that the Rule will be limited to use of technologies and operational measures, and if performance standard ranges are used, the use of the best-performing technology in the performance standard range will be required.

   Although much attention has been placed on closed-cycle cooling, it is not clear whether or not this technology will be identified as Best Technology Available. The Second Circuit Court determined that EPA could consider three factors as a basis for not identifying closed-cycle cooling as BTA. These three factors included:

   - the Industry cannot reasonably bear the cost of retrofits;
   - impacts to energy production and supply; and
   - adverse impacts associated with retrofits.

   The feasibility and the impacts of closed-cycle cooling are being thoroughly studied. SCE is one of 25 companies currently funding a $2.5 million dollar EPRI research project to provide technical information relative to closed-cycle cooling retrofits. The scope of the EPRI project will provide quantitative estimates of:

   - the national cost of retrofits;
   - the reduction in generation as a result of generation unit retirements and energy penalties associated with retrofits;
   - environmental and social impacts resulting from retrofits; and
   - impacts to electric system reliability.

   Additionally, SCE will be funding a complete analysis of the environmental impacts of closed-cycle cooling at SONGS. Thus, the subject is still being investigated, and critical data are still being developed. Therefore, deferring decisions to a later date will allow for a better informed decision.

7. The EPRI research project is national in scope and will provide information for California's facilities including SONGS. EPRI has met with EPA Staff working on the Rule to discuss the schedule, scope and approach for the research program, and EPA has expressed a strong interest in making use of this information in developing the proposed Rule.

8. The California State Water Resources Control Board continues to consider development of a State §316(b) Policy that is expected to be issued in 2008.

9. Due to points 2, 3, 4, 5, 6, and 7, it is important that the final determination of BTA for SONGS be consistent with both the revised Rule and the final State §316(b) Policy.

For these reasons SCE believes that a final BTA determination that requires additional technologies should be deferred until after the revised Rule or final State §316(b) Policy are issued. This CDS, MRC reports, and prior 316(b) demonstrations suggest that SONGS is in compliance with the intent of the §316(b) rule. Since EPA and SWRCB rule/policy making efforts are underway, additional analyses and implementation of technologies should not be required until they are finalized, to ensure consistency. Additionally, the design of the existing CWIS coupled with ongoing restoration projects have been demonstrated to significantly reduce some impacts and mitigate for others. This suggests that there is no urgency for modifications to SONGS and the existing CWIS should be considered BTA under BPJ.

A1 ATTACHMENT

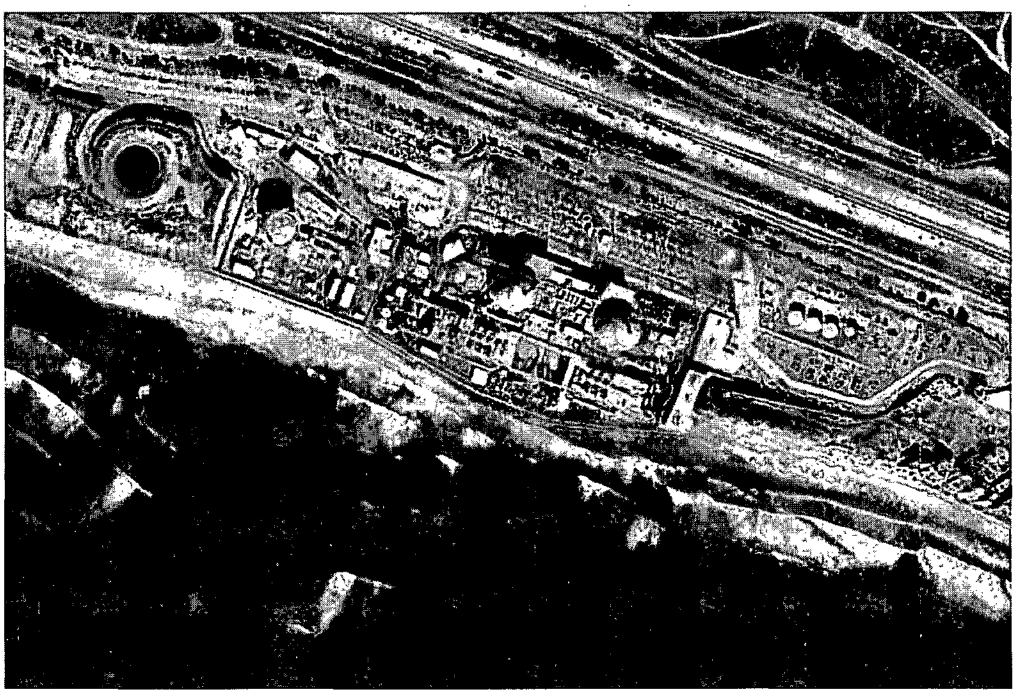
122.21(r)(2),(3), and (5) Information

ALDEN

Solving Flow Problems Since 1894

ATTACHMENT 1

§122.21 (r) (2), (3), (5) Information for San Onofre Nuclear Generating Station



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INTRODUCTION

This report is submitted in response the requirements of 40 CFR §122.21(r)(2), (3), and (5) (EPA 2004) by providing the Source Water Physical data, the Cooling Water Intake Structure (CWIS) data, and the Cooling Water System (CWS) data, respectively.

A. §122.21 (r) (2) SOURCE WATERBODY PHYSICAL DATA

The following source water physical data are being provided to characterize the waterbody in the vicinity of San Onofre Nuclear Generation Station (SONGS) CWIS. This information is used, in part, to evaluate the various measures being considered for reducing impingement mortality and entrainment at SONGS. The following sections describe the waterbody's key physical and chemical characteristics in the vicinity of SONGS and provide figures and maps for reference.

A.1 Narrative Description of Source Waterbody

SONGS is located on the coastline of the Southern California Bight approximately 2.5 miles southeast of San Clemente, California in northern San Diego County (Figure 1). The station is located on an exposed shoreline of the Pacific Ocean. SONGS' intake source waterbody is therefore an ocean intake. The immediate area around the station is primarily beach with some low bluffs.

A.2 Aerial Dimensions

For reference, an aerial view of SONGS is shown in Figure 2.

A.3 Depths

The water depth at the SONGS intakes, which are located approximately 3,150 ft offshore, is about 30 ft. Depths in the vicinity of the SONGS vary from about 4 ft along inshore areas to 118 ft two miles offshore. A steep drop-off occurs to the west of the SONGS intakes, after which depths exceed 200 ft in some areas. A depth chart for the marine area surrounding the intakes is shown in Figure 3.

A.4 Flow (currents)

The current velocities offshore of SONGS typically range from 0.1 ft/sec to 0.7 ft/sec in most seasons. The current flows predominantly in a south to southeasterly direction. Some localized upwelling and eddies can form off the primary current (SCE 1982). The existing alongshore drift is variable with tidal cycles. Wind conditions, geography, and bathymetry significantly affect the conditions in the area of SONGS (SAIC 1994). Velocities are generally stronger near the bottom than the surface (MRC 1976).

A.5 Salinity

Salinity in the southern California region of the Pacific Ocean where SONGS is located ranges from 32.1 ppt to 35.3 ppt with a mean of 33.8 ppt (Operational Oceanography Group 2006).

A.6 Seawater Temperature

Seawater temperatures in the vicinity of SONGS are coolest during the winter months (November – March) and warmest in the summer (June – August). Temperatures range from approximately 57° F in January to 68° F in August. The increase in ocean temperatures from January to August is relatively slow, whereas temperatures drop more rapidly from the fall to early winter (Southern California Edison 1983).

A.7 Geomorphological Features

SONGS is located on the coastline of the Southern California Bight (Bight) approximately 2.5 miles southeast of San Clemente and approximately 12 miles northwest of Oceanside (Figure 1). This region experiences a Mediterranean climate regime that is characterized by short, mild winters and warm, dry summers. Annual precipitation near the coast averages about 18 inches, of which 90% occurs between November and April (Southern California Edison 1983).

The general orientation of the coastline in the region tends to be from northwest to southeast. The Bight has slowly emerged over a long geological period, resulting in a coastline with numerous cliffs that are broken by coastal plains. The region has many small streams that normally flow only during rain events. These streams, along with cliff erosion, produce a considerable amount of sediment that enters the nearshore environment. The net transport of this sediment along the coast is toward the south.

The ocean floor in the vicinity of SONGS is an extensive shelf of soft sediments consisting of coarse and fine sands that are interrupted occasionally by areas of hard substrate. Three notable beds of giant kelp (*Macrocystis pyrifera*) occur on hard substrate located in the SONGS vicinity.

A.8 Area of Influence (AOI)

Defining the AOI at the CWISs requires an understanding of the design and operation of the CWIS and the hydrology and geomorphology of the surrounding waterbody. Several basic and common assumptions were made to define the approximate AOI using simplified, calculations. These assumptions are:

- Ocean bottom around the velocity caps is horizontal and level and the intake riser is elevated off the bottom;
- Ocean currents do not affect flow patterns into the velocity caps; and,

- Flow fields expand at approximately 60 degrees in both the horizontal and vertical direction from the entrance of the velocity caps.

Descriptions of the geometry of the velocity caps and bathymetry in the CWIS vicinity are based on information presented in the Proposal for Information Collection (Southern California Edison 2007).

The basic approach for estimating the AOI of an intake is to calculate the approximate area extending from the intake that would have minimum approach velocities of 1.0, 0.5, and 0.1 ft/sec. Using normal water depths and maximum plant cooling water flow, the distance from the intake opening with these minimum velocities was calculated and plotted as velocity contours on a sketch of the intake structure (Figure 4). To be conservative in determining the maximum AOI, these calculations assume that ocean currents do not affect flow patterns into the intake.

B. §122.21 (r) (3) COOLING WATER INTAKE STRUCTURE DATA

The SONGS offshore intake structure is comprised of two separate intakes; one each for Units 2 and 3. The Unit 2 intake is located at latitude N 33°21.633' and longitude W 117°33.743' and the Unit 3 intake is located at latitude N 33°21.852' and longitude W 117°33.632'. A topographic map showing geographical features in the vicinity of SONGS is presented on Figure 5. SONGS is primarily a base-load facility that uses a once-through cooling water system for its two nuclear-fueled units.

SONGS has separate and identical CWISs for Units 2 and 3. The two submerged intakes are located approximately 3150 ft offshore, 650 ft apart, at an approximate water depth of 30 ft. The depth in the area of the discharge structures range from 36 ft to 48 ft for Unit 3 and Unit 2, respectively.

Each CWIS includes an offshore intake with an on shore intake structure. Each cap is supported 7 ft above the intake riser by columns and located 12 ft below MLLW. A detailed schematic of the intakes and velocity caps is provided on Figure 6. The cooling water flow of 1,849 cfs per unit is conveyed to the onshore intake structures through 18 ft diameter concrete pipes at a velocity of 7.3 ft/sec. As water enters the onshore intake structure, it passes through a series of guide vanes to distribute the flow uniformly, 12 traveling bar racks, 14 traveling water screens, and 2 fish collection areas with an elevator and a common fish return system.

Each onshore intake structure has traveling bar racks angled about 20 degrees to the incoming flow. The bars are 0.25 in. wide with 1.0 in. clear spacing. As fish enter the onshore intakes the bar racks guide them into a 14 ft x 16 ft x 26 ft deep concrete holding chamber, which is isolated from the circulating water pumps by a traveling water screen (Figure 7). Fish within the holding chamber are removed and transferred to a fish bypass pipe by an elevator apparatus consisting of a manually operated, mechanized bucket lift. The watertight elevator bucket sits within the chamber at the end of the traveling bar racks. When operated, the bucket is raised; collecting most of the fish within the holding chamber, and at the top of its travel is tipped to transfer collected fish into a sluice channel. The process of collecting fish with the elevator bucket is repeated until the majority of fish in the holding chamber are removed. Water is added to the sluice channel and collected fish are discharged into a common 4 ft diameter bypass pipe. The conduit discharges fish 1,900 ft offshore in 19.5 ft of water. This system is normally operated at least twice daily.

Each unit has four circulating water pumps, two screenwash pumps, and four seawater cooling pumps which are located downstream of the screens and supply seawater to the steam turbine condensers, the auxiliary equipment, and spraywash water for the screens.

The eight circulating water pumps (four per unit) are located in separate pump bays in a common plenum which is 45 to 65 ft downstream of the traveling water screens (Figure 8). Each pump is a vertical, mixed-flow diffuser unit rated at a capacity of 461 cfs (207,500 gpm). The total Unit 2 and Unit 3 cooling water pumping capacity is 3,690 cfs (1,656,000 gpm). The monthly flow volumes from 1982-2006 for Unit 2 and Unit 3 are provided on Figure 9.

Each unit has a generating capacity of 1,087 MW. The average yearly capacity for 2001-2006 is provided in Table 1. The plant maintains an average capacity factor of 85%.

A summary of pertinent plant data is included in Table 2 and a summary of the velocity conditions through the system is provided in Table 3.

C. §122.21 (r) (5) COOLING WATER SYSTEM

The CWIS are unique to each unit. That is, they are isolated and changes in operation at either unit do not affect the other unit. Refueling outages of approximately 38 days are scheduled every 22 months. With this exception, the circulating water pumps are operated continuously. There are no seasonal shut-down of pumps.

The heated cooling water is discharged through two outfalls. Each outfall incorporates a diffuser system to dissipate the heat. The Unit 2 discharge outfall is 8,350 ft offshore in 49 ft of water and the Unit 3 discharge is 6,020 ft offshore in 35 ft of water. Each of the two 18 ft diameter concrete discharge conduits has 63 discharge nozzles. The nozzles are designed to direct the discharge flow away from the bottom at a 20 degree angle to provide mixing. The diffuser design is shown on Figure 10.

The intake water is conveyed by the circulating water pumps through the condenser to a common discharge conduit. The combined flow passes over a weir which maintains a constant lower limit for the hydraulic grade-line. This prevents a siphon occurring during extreme low tides.

The flow then enters a crossover box on the main discharge line. The crossover box has gates allowing the discharge flow to be reversed for heat treatment of the intake system for biofouling control. The gates are normally closed, but during the heat treatment the gates are manipulated allowing heated water to pass though the intake side of the cooling water intake system.

Heat treatment is conducted on an as-needed basis based upon a biofouling model and operational requirements of the plant

The fish return discharges 1,900 ft offshore in 19.5 feet of water. The discharge is sloped upwards to reduce the effects of pressure change on the returned organisms.

A flow distribution and water balance diagram is provided in Figure 11.

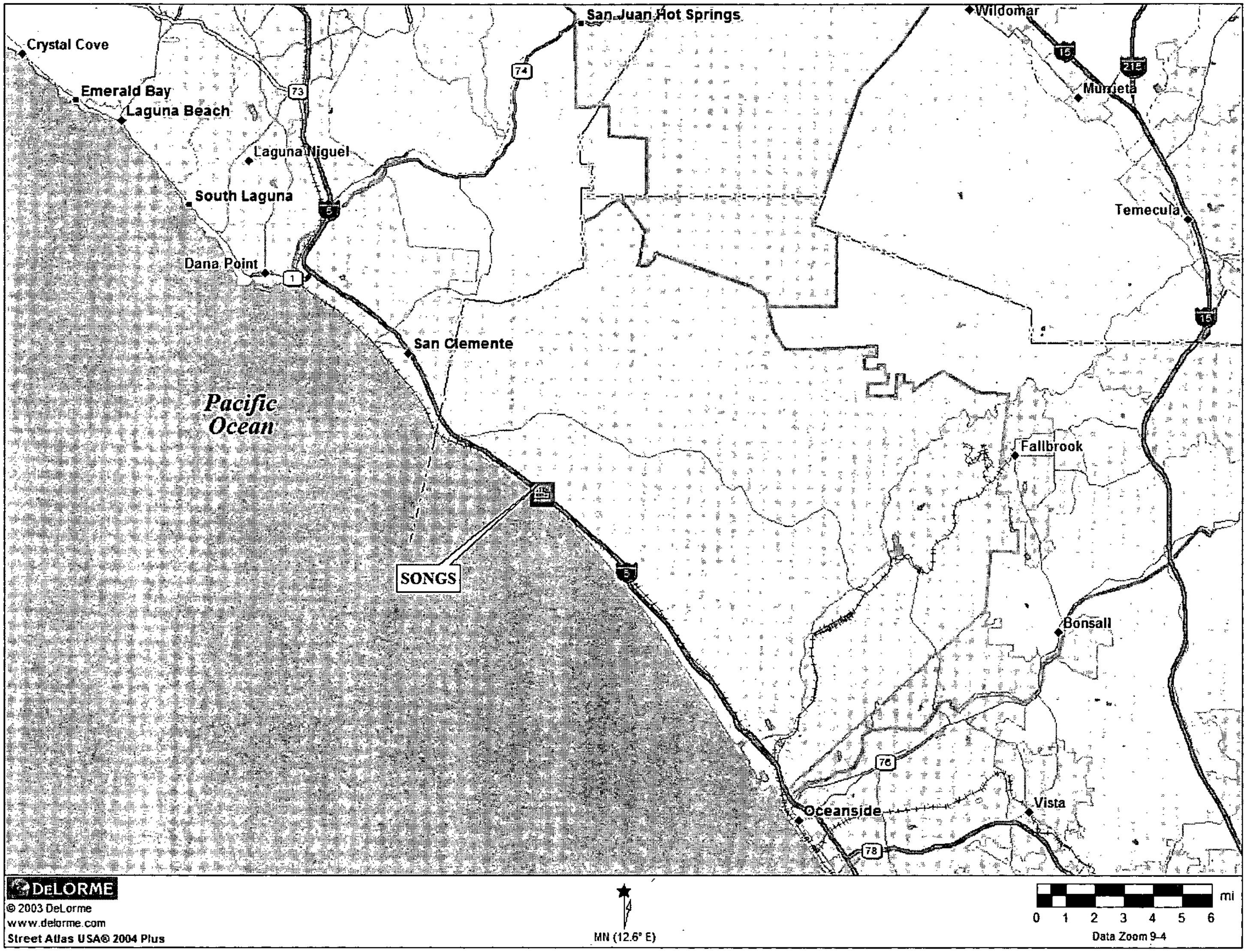


Figure 1 SONGS Vicinity Map

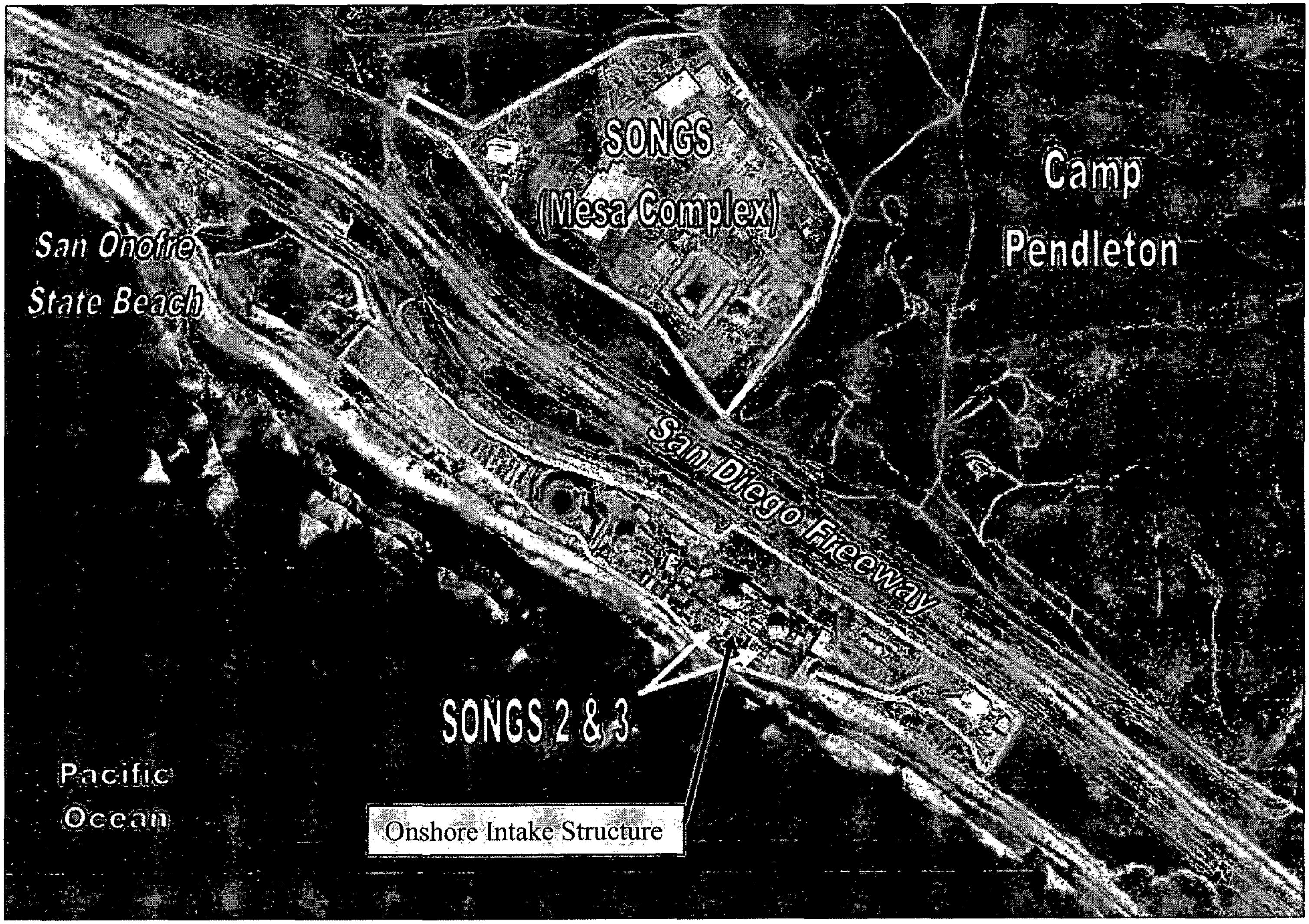


Figure 2 SONGS Aerial View (TTI 2007)

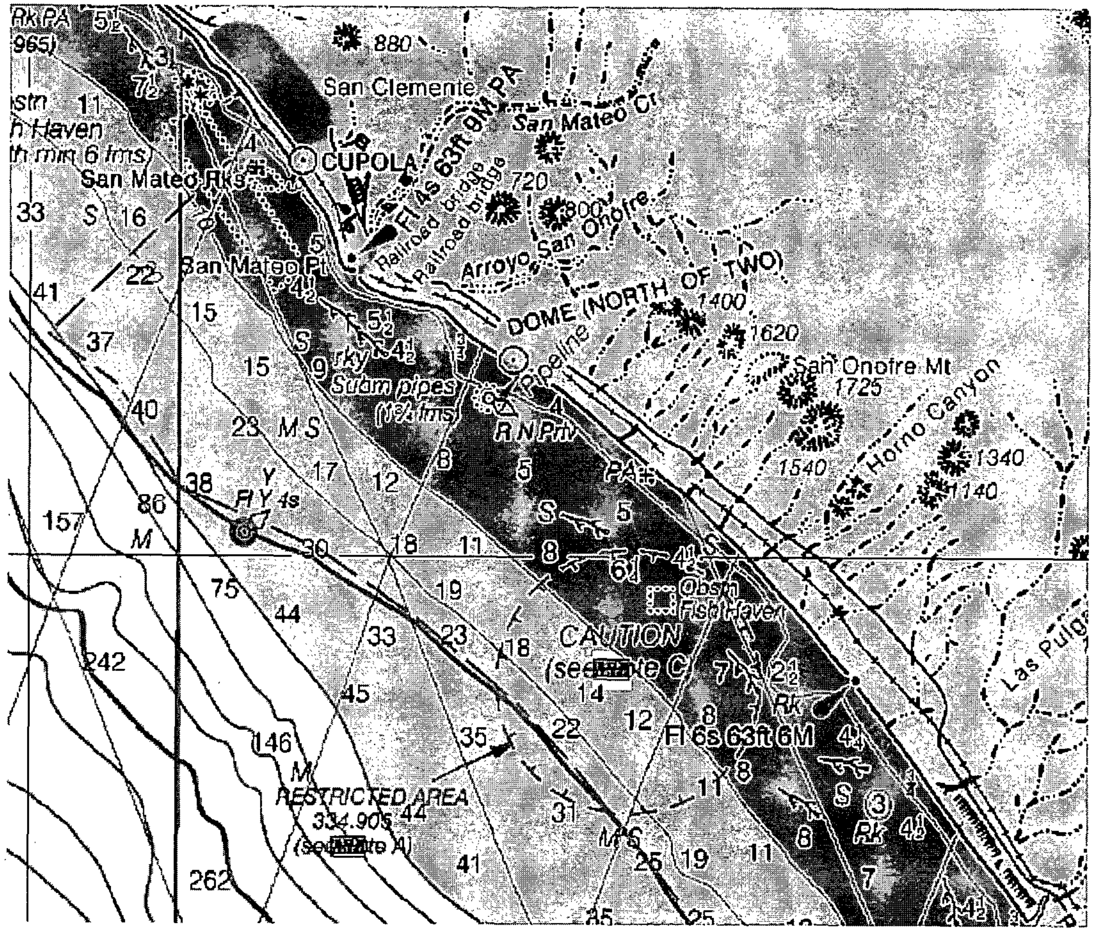


Figure 3 Navigation Map Showing Depths in the vicinity of SONGS
(Source: NOAA, San Diego to Santa Rosa Island)

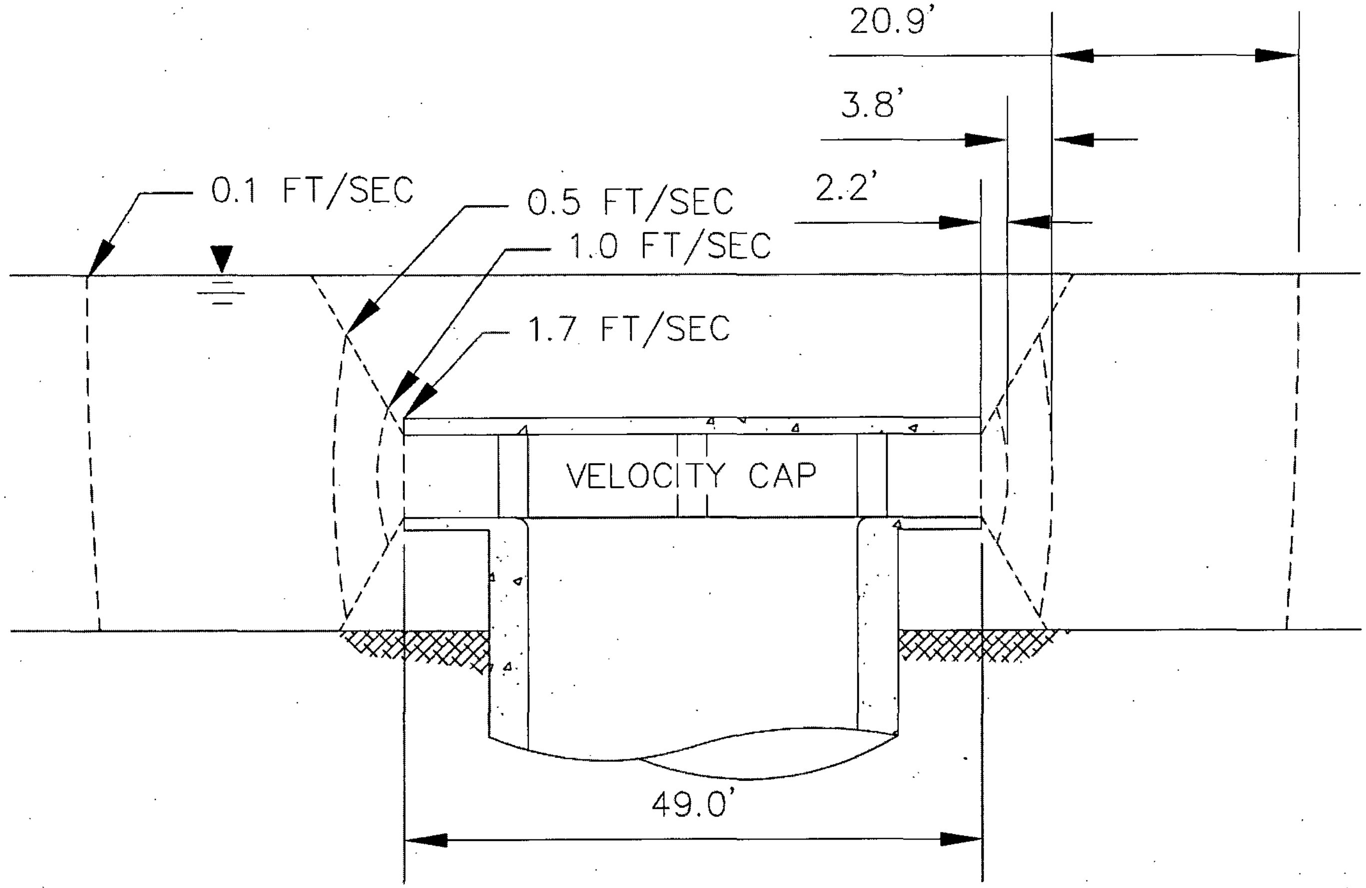


Figure 4 SONGS – Hydraulic Zone of Influence

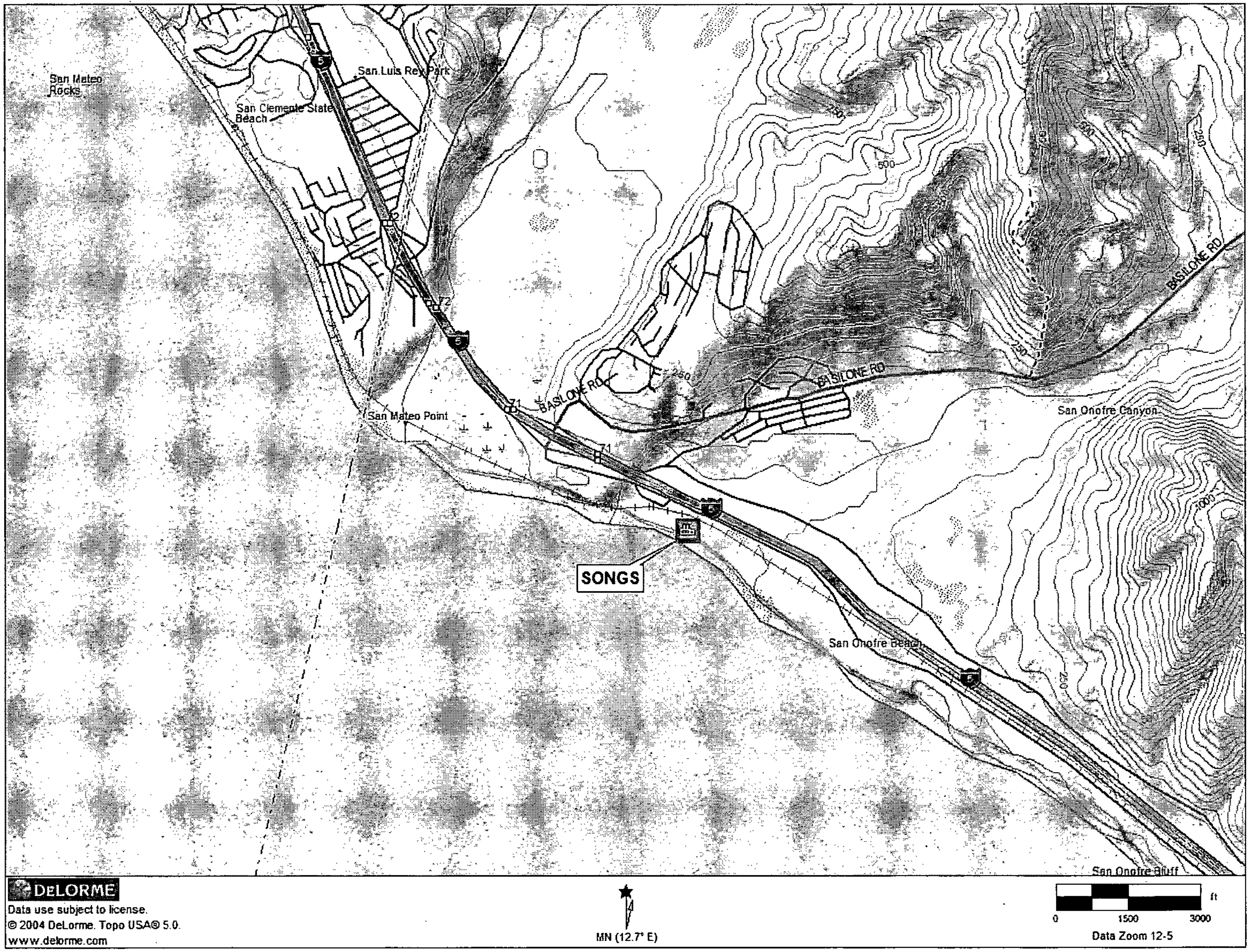


Figure 5 Topographic Vicinity Map for SONGS

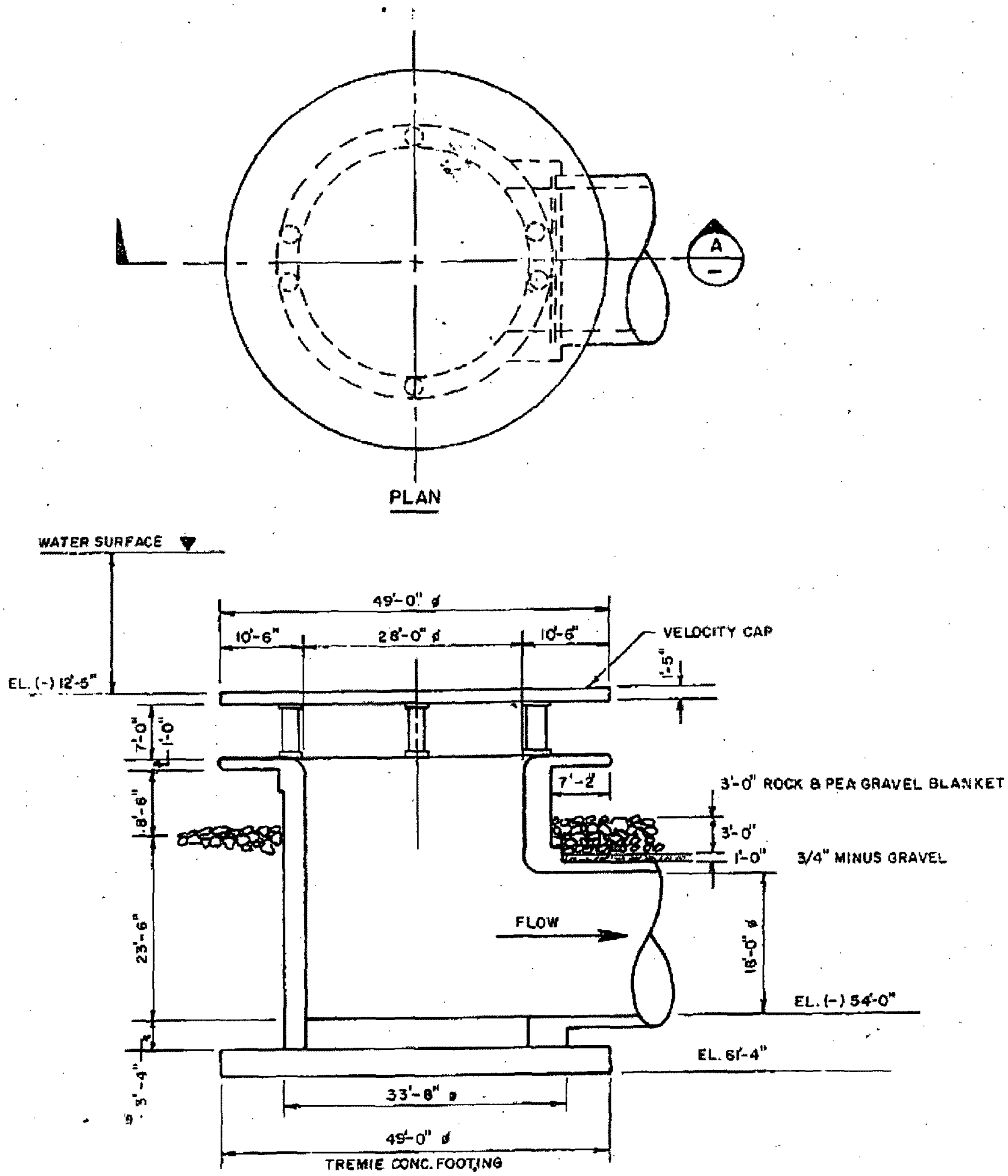


Figure 6 SONGS Velocity Cap – Plan & Section (typical)

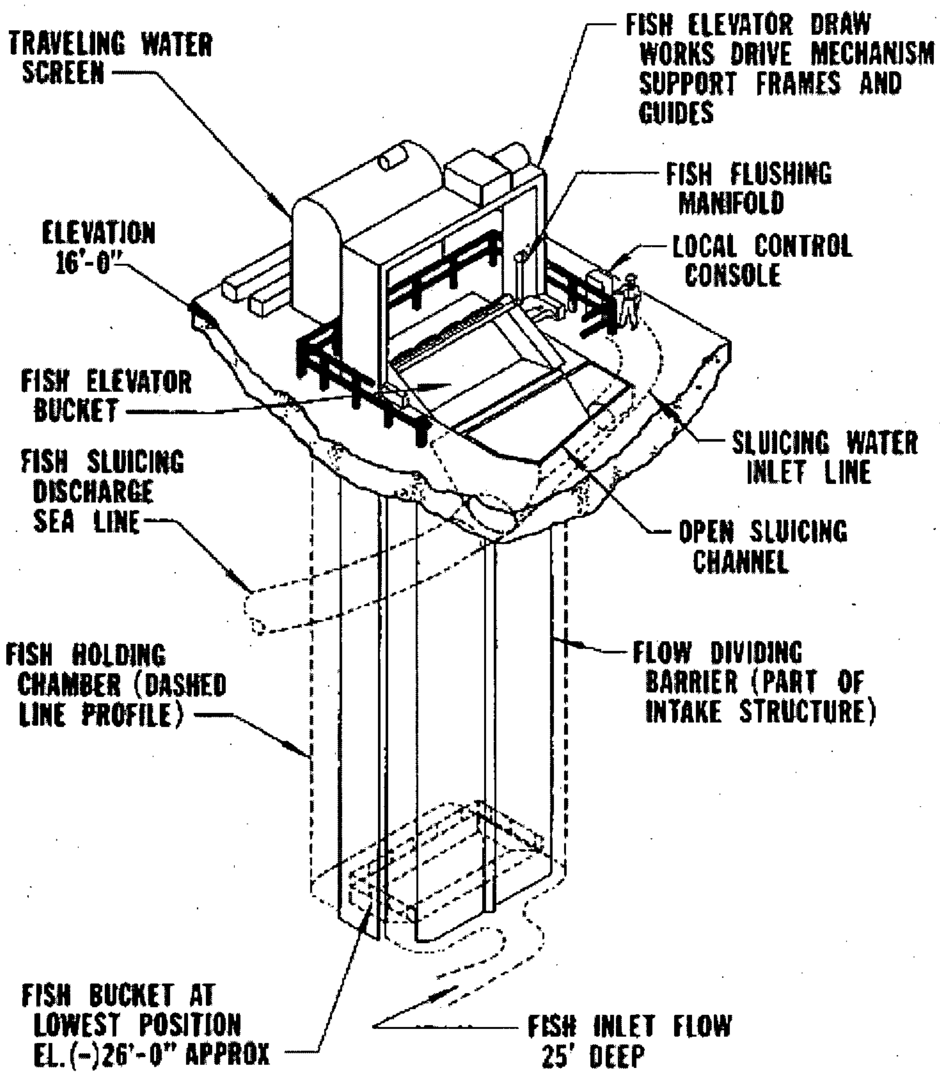


Figure 7 SONGS Fish Collection Elevator

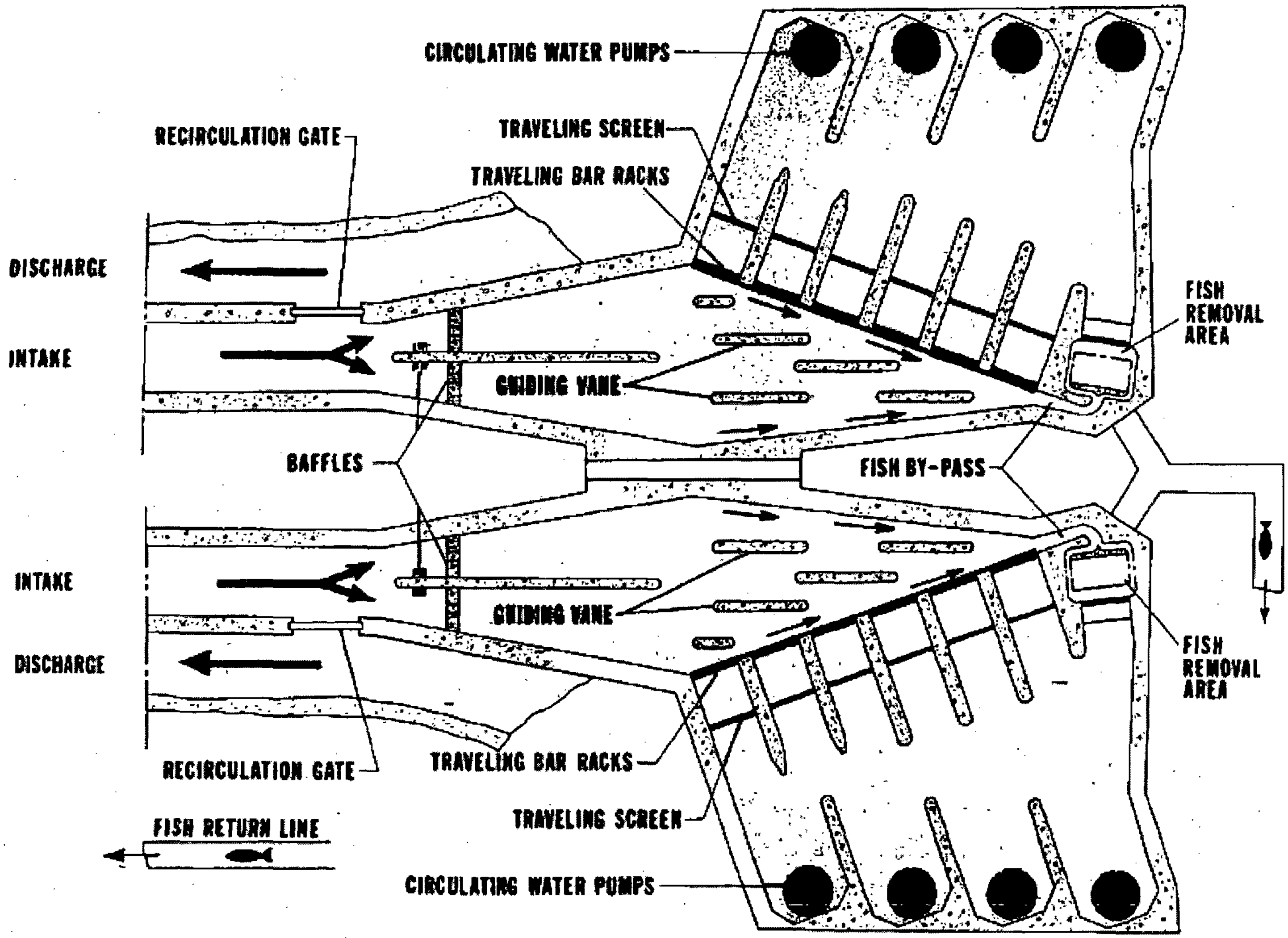


Figure 8 SONGS Intake Structure – Plan (Love et al. 1989)

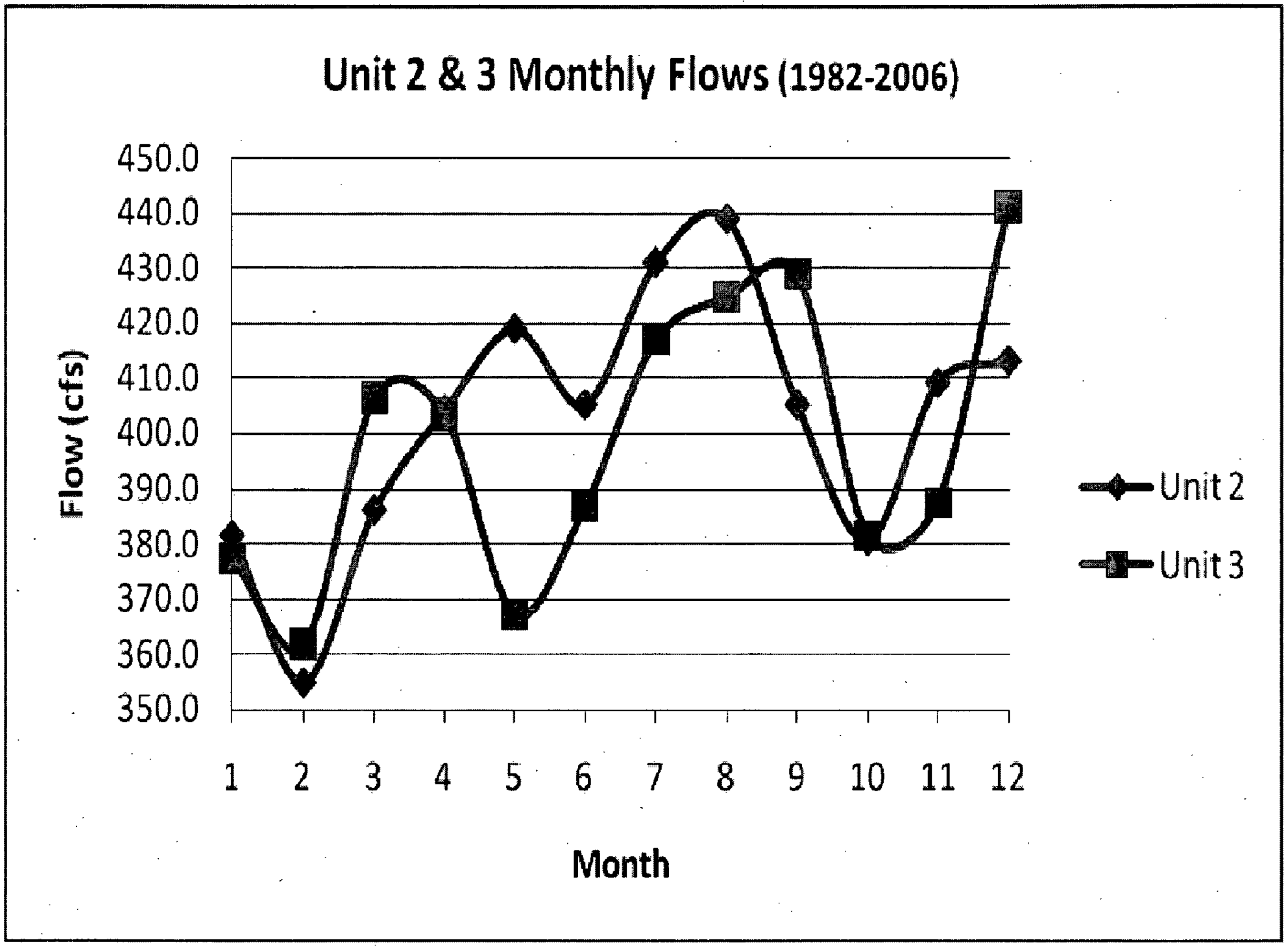


Figure 9 Monthly Unit Flows (1982 – 2006) – Unit 2 & 3

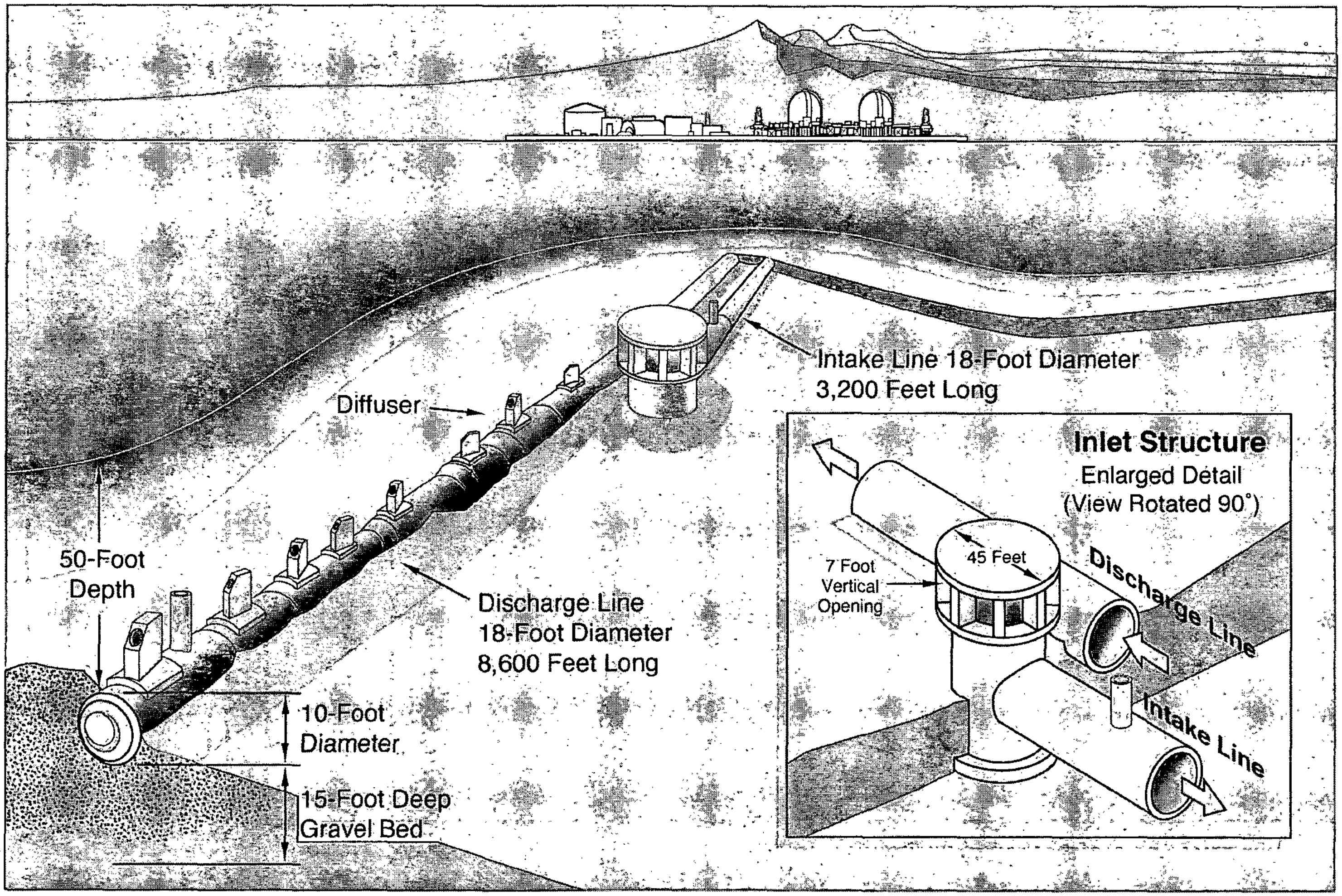
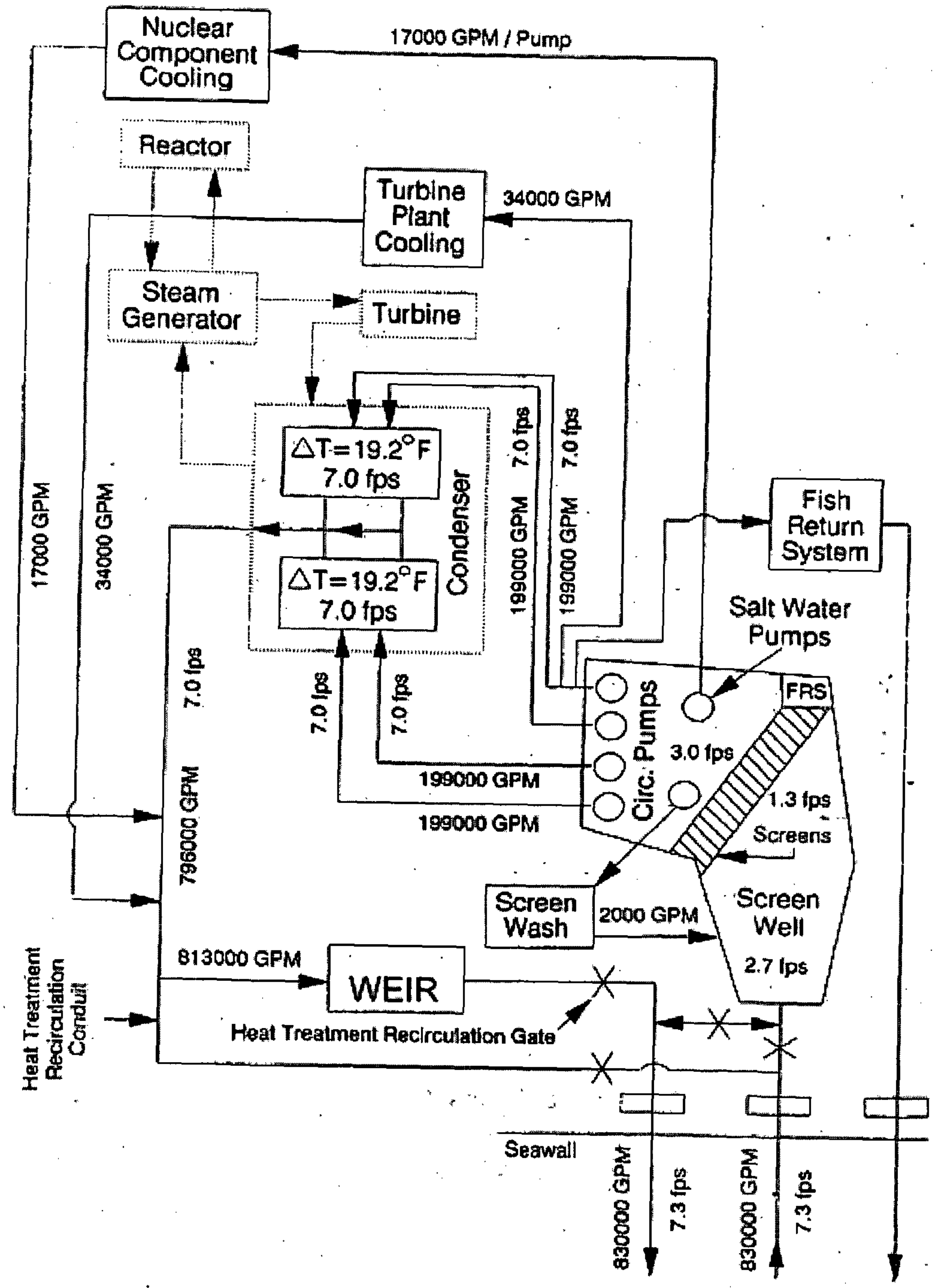


Figure 10 SONGS Discharge



Note: All flows are approximate.

Figure 11 SONGS Flow Distribution and Water Balance Diagram

Table 1 Average Yearly Capacity Factor (2001-2006)

Unit	MW (net)	Capacity Factor (%)[1]						
		2001	2002	2003	2004	2005	2006	Average
2	1127	96.1%	86.1%	98.4%	81.6%	90.5%	68.4%	85%
3	1127	57.2%	96.7%	87.1%	70.7%	95.9%	69.0%	84%

1. Capacity factor varies due to routine maintenance and scheduled refueling outages.

Table 2 Summary of CWIS Data

Location

San Clemente, California
Latitude: 33°22'07" N
Longitude: 117°33'18" W
Waterbody: Pacific Ocean

NPDES permit number: CA0108073, CA0108181
NPDES permit expiration date: March 9, 2010
Estimated project intake flow
Maximum
Units 2 & 3: 1,849 cfs per unit (52.4 m^3/sec each)
Intake velocities
Through-screen: 3.0 ft/sec

Project Structures (Unit 2)

Intake structure
Location: 3150 ft (960 m) offshore
Type: velocity cap
Bottom depth: 27 ft (8.2 m) (MLLW)
Intake pipe: 18 ft ID
Invert: El. -54 ft
Top elevation: El. -12.5 ft
Opening height 7.0 ft
Size: 49 ft diameter
Riser pipe: 28 ft diameter
Open area: (~1077.5 ft^2)

Trash racks/ Louvers
Location: Onshore Intake structure
Upstream of traveling water screens
Invert: El. -26.0 ft
Bar screen size: 1/4 in. wide 2.5 in. deep and 2 ft high
bars spacing: 1.5 in. apart
Louver angle: 20° to the incoming flow
Cleaning: louvers are rotated when initiated by differential pressure, high-pressure spray wash
Traveling water screens
Trash track: ~3220 ft downstream of opening
Traveling screen: ~13 ft downstream of trash rack
Number: 7
Bay width: 11.2 ft
Invert: El. -26.0 ft
Top: El.15.0 ft
Rotation speeds: 10 ft/min
Width: 10 ft
Mesh size and geometry: 3/8" square
Trash rack: 1 in. openings
Fish return: none

Table 2 (Continued)

Fish return System:

Louvers in front of the screens direct fish to a collection area with an elevator mechanism that lifts fish to a return sluice
Louver size: 1/4 in. wide
bars spacing: 1.0 in. apart
Water collection area: is 16 ft x 14 ft area with a rectangular slits in the bottom
Basket removal: dependant on the number of fish; can be lifted several times a shift
Basket speed; ~1 ft/sec
Fish sluice: 1900 ft

Circulating water pumps

Number of pumps: 4
Type of pumps: vertical, mixed-flow diffuser type
Inlet floor, pump chamber: El. -22.7 ft
Pump rating: 462 cfs (207,500 gpm)

Cooling water discharge

Location: 8350 ft offshore
Depth: 49 ft
Delta T: 20°F
Discharge pipe: 18 ft diameter
Type: diffusers (63, 2 ft diameter)

Project Structures (Unit 3)

Intake structure

Location: 3150 ft (960 m) offshore
Type: velocity cap
Bottom depth: 27 ft (8.2 m) (MLLW)
Intake pipe: 18 ft ID
Invert: El. -54 ft
Top elevation: El. -12.5 ft
Opening height 7.0 ft
Size: 49 ft diameter
Riser pipe: 28 ft diameter
Open area: (~1077.5 ft^2)

Trash racks/ Louvers

Upstream of traveling water screens
Invert: El. -26.0 ft
Bar screen size: 1/4 in. wide, 2.5 in. deep, and 42 ft high Approximate
bars spacing: 1.0 in. apart
Louver angle: 20° to the incoming flow
Cleaning: louvers are rotated once a shift cleaned by high pressure spray wash
Debris discharge: collected in bin

Table 2 (Continued)

Traveling water screens
- Location: Onshore Intake structure
- Trash track: ~3220 ft downstream of opening
- Traveling screen: ~13 ft downstream of trash rack
- Number: 7
- Bay width: 11.2 ft
- Invert: El. -26.0 ft
- Top: El.15.0 ft
- Rotation speeds: 10 ft/min
- Width: 10 ft
- Mesh size and geometry: 3/8" square
- Trash rack: 1 in. openings
- Spray nozzle configuration: high pressure front wash
- Operation: every rotate at regular intervals or when there is heavy debris
- Fish return: none, collected in a bin an hauled to landfill

Fish return System:
- Have louvers in front of the screens to direct fish to a collection area with an elevator mechanism the lifts fish to a return sluice
- Louver size: 1/4 in. wide
- bars spacing: 1.0 in. apart
- Water collection area: is 16 ft x 14 ft area with a rectangular sits on the bottom
- Basket removal: dependant on the number of fish can lift-several times a shift
- Basket speed; ~1 ft/sec
- Fish sluice: 1900 ft

Circulating water pumps
- Number of pumps: 4
- Type of pumps: vertical, mixed flow diffuser type
- Inlet floor, pump chamber: El. -22.7 ft
- Pump rating: 462 cfs (207,500 gpm)

Cooling water discharge
- Location: 6020 ft offshore
- Depth: 35 ft
- Delta T: 20°F
- Discharge pipe: 18 ft diameter
- Type: diffusers (63, 2 ft diameter)

Fuel Type: Nuclear

Plant output:
- Unit 2 & 3: 1,087 MW each

Operating mode: base loaded

Plant capacity factor: 85%

Table 3 Velocity Summary through System

Location	Calculated Velocity (ft/sec)
Velocity Cap	1.8
Intake Pipe	7.3
Approaching Trash Rack and Traveling Screen	1.3
Through screen Velocity	3.0

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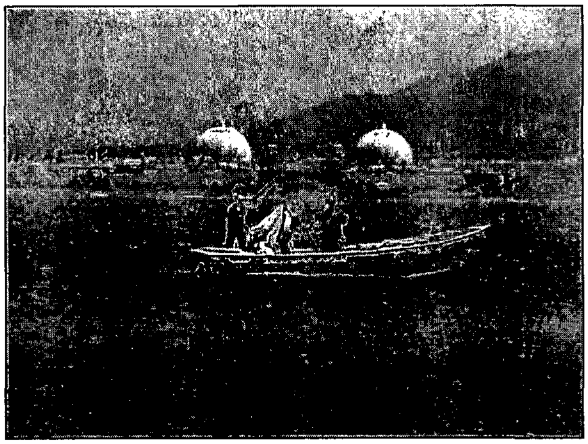
A2 ATTACHMENT

Impingement Mortality and Entrainment Characterization Study

FINAL REPORT

SAN ONOFRE NUCLEAR GENERATING STATION



CLEAN WATER ACT
SECTION 316(b) IMPINGEMENT MORTALITY AND ENTRAINMENT CHARACTERIZATION STUDY

Prepared by

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for

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P.O. Box 128
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December 11, 2007

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LIST OF ACRONYMS

BACIP	Before-After/Control-Impact Paired (sampling design)
BTA	Best Technology Available
CalCOFI	California Cooperative Oceánic Fisheries Investigations
CCC	California Coastal Commission
CDFG	California Department of Fish and Game
CDS	Comprehensive Demonstration Study
cfs	cubic feet per second
CL	carapace length
cm	centimeters
CPFV	Commercial passenger fishing vessel
CW	carapace width
CWA	Clean Water Act
CWIS	cooling water intake structure(s)
EFH	Essential Fish Habitat
EMDAS	Environmental Monitoring Database Access System
EPA	Environmental Protection Agency
ESGS	El Segundo Generating Station
ETS	Environmental Technical Specifications
FMP	Fishery Management Plan
fps	feet per second
FRS	Fish Return System
ft	feet
gpm	gallons per minute
GPS	Global Positioning System
HBGS	Huntington Beach Generating Station
ID	inside diameter
IM&E	Impingement Mortality and Entrainment
in	inch
kg	kilogram
km	kilometer
L	length
lbs	pounds
m	meter
mgd	million gallons per day
mi	miles
MLLW	Mean Lower Low Water
mm	millimeter
mps	meters per second
MRC	Marine Review Committee
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission Pacific Fisheries Management Council
OBGS	Ormond Beach Generating Station
oz	ounce
PFMC	Pacific Fisheries Management Council
PIC	Proposal for Information Collection
QA/QC	Quality Assurance/Quality Control

re:	reference
s	second
SCCWRP	Southern California Coastal Water Research Project
SCE	Southern California Edison
SCOR	Scientific Committee on Oceanic Research
SDG&E	San Diego Gas and Electric
SDRWQCB	San Diego Regional Water Quality Control Board
SGS	Scattergood Generating Station
SL	standard length
SMK	San Mateo Kelp
SOK	San Onofre Kelp
SONGS	San Onofre Nuclear Generating Station
TL	total length

1.0 EXECUTIVE SUMMARY

This report presents data from in-plant and offshore field surveys performed for the San Onofre Nuclear Generating Station (SONGS) 316(b) Impingement Mortality and Entrainment Characterization Study. This study was performed to satisfy conditions in the SONGS Units 2 and 3 National Pollutant Discharge Elimination System (NPDES) permits (CA0108073 and CA0108181). Sampling plans were submitted with the SONGS Proposal for Information Collection (PIC) in October 2005, and in a revised PIC submitted in November 2006. The requirements in the NPDES permits were based on requirements in the U.S. Environmental Protection Agency's (EPA) 316(b) Phase II regulations published in 2004, which have since been suspended. Impingement and fish return system (FRS) sampling was conducted from March 2006 through May 2007, and entrainment and source water sampling was performed from March 2006 through April 2007. This report presents entrainment, source water, impingement, and FRS data collected as part of the study, and a determination of the calculation baseline to be used in determining the entrainment and impingement mortality reductions as required. While certain aspects of the 316(b) Phase II regulations were subject to litigation, the IM&E Characterization Study and calculations baseline were not contested items.

Entrainment and Source Water

The most abundant larval fish taxa collected in biweekly, in-plant entrainment samples in 2006-7 included northern anchovy (*Engraulis mordax*; 39% of the total larvae collected), unidentified anchovies (Engraulidae; 20%), queenfish (*Seriphus politus*; 6%), clinid kelpfishes (*Gibbonsia* spp; 6%), combtooth blennies (*Hypsoblennius* spp; 5%), gobies (Gobiidae; 5%), and white croaker (*Genyonemus lineatus*; 4%). Combined, these taxa comprised 84.4% of the larvae collected. The most abundant fish eggs in entrainment samples could not be identified to family, a result of the present limitations in taxonomic knowledge of fish eggs in southern California. Total annual entrainment based on in-plant collections were approximately 1.1 to 1.4 billion larvae per unit, and 13 to 14 billion fish eggs per unit. Egg and larval concentrations peaked in spring, and were relatively low throughout the remainder of the year. Sea bass (*Paralabrax* spp) larvae peaked in summer (July and August 2006), however. There was no clear diel pattern of entrainment with fish eggs, although larvae were generally entrained in higher numbers at nighttime.

During 13 surveys in 2006-7, offshore entrainment samples were collected concurrently with in-plant entrainment samples. During these surveys, greater concentrations of larvae were measured at the offshore entrainment station than the in-plant entrainment stations, particularly of anchovies. During paired in-plant and offshore surveys, concentrations of fish larvae were higher in-plant during 5 of 13 surveys, while fish egg concentrations were higher in-plant during 11 of 13 surveys. Cropping between offshore and in-plant sampling locations did not appear to be a major factor in the differences between the two sites. Relatively high concentrations of larvae measured in April and June 2006 resulted in relatively high entrainment estimates; 34% of the annual entrainment was estimated to occur in April, with another 46% in June. Estimated annual entrainment based on offshore samples was approximately three times higher than the estimates from in-plant samples for larvae, but only about 40% higher than the in-plant estimates for fish eggs.

Vertical distribution of eggs and larvae offshore followed patterns previously recorded off SONGS. Larvae were most abundant in the suprabenthos (just above bottom) and in the neuston (surface waters), with lowest densities recorded in the water column. Fish egg concentrations were highest in the neuston, with densities about four times lower in the water column, and about 13 times lower in the suprabenthos. Crab megalopae were most abundant in the suprabenthos. Densities of larvae and eggs off SONGS were 10.1 and 3.6 times higher in the nearshore surface waters than in the water column near the intakes; however, concentrations of target invertebrate larvae, were 50% higher near the intakes than in nearshore surface waters.

Midwater concentrations of fish larvae measured from offshore samples in the present study were similar to those recorded during the Marine Review Committee (MRC) investigations (1978-1986). However, larval fish concentrations from in-plant samples were much lower. High year-to-year variability in densities of fish eggs and larvae has been documented by the California Cooperative Oceanic Fisheries Investigations (CalCOFI) in southern California, and it is unknown if the differences between concentrations measured in 2006-7 and those from 20-30 years ago represent a decline in larval densities. However, conclusions from other studies suggest that the productivity of southern California waters declined with the onset of the regime shift of 1977.

Impingement

A total of approximately 1,353,000 fishes weighing 13,037 kg was estimated to be impinged during the study year (52 weeks of cooling water flow at each unit). Queenfish was the most abundant species impinged, followed by northern anchovy, Pacific sardine (*Sardinops sagax*), and deepbody anchovy (*Anchoa compressa*). Normal operations accounted for 97% of fish abundance and 63% of the biomass. A total of approximately 118,000 macroinvertebrates weighing 1,309 kg was also impinged, with the most abundant taxa including rock crabs (*Cancer* spp), Xantus swimming crab (*Portunus xantusii*), and blackspotted bay shrimp (*Crangon nigromaculata*). Normal operations accounted for 71% of invertebrate abundance and 89% of the biomass. Fish impingement peaked in summer and winter; northern anchovy was most abundant in June 2006, while queenfish and anchovy (*Anchoa* spp) abundance peaked in November and December 2006. Invertebrate abundance showed a strong seasonal peak with highest numbers impinged in winter (November 2006 through January 2007). Impingement was generally higher during nighttime than during daytime.

Fish impingement abundance and biomass were below the long-term annual averages since monitoring began in 1982. Annual estimates from 2005 were the highest on record, and resulted from the impingement of relatively high numbers of Pacific sardine and northern anchovy in normal operation impingement samples. There has been high year-to-year variability in fish impingement at SONGS, with peaks every four or five years. Analysis of the previously collected data indicates the impingement totals at SONGS are driven by the impingement of three species, either singly or in combination:

northern anchovy, Pacific sardine, and queenfish. When compared with commercial and recreational fishery losses, impingement totals at SONGS were relatively low (1.0% or less for most species).

Fish Return System

The SONGS fish return systems are designed to reduce impingement by guiding fishes to a removal area where they are subsequently lifted and transported back to the source water body. This represents a reduction in impingement mortality that was quantified during the present study. The most abundant fishes in fish return system (FRS) samples in 2006-7 included northern anchovy, queenfish, Pacific sardine, and salema (*Xenistius californiensis*). Annual return estimates for fishes were 72% based on abundance and 89% based on biomass. For invertebrates, return estimates were much lower: 4% based on abundance and 40% based on biomass. Fish return was highest from June through August 2006, corresponding primarily to high return of northern anchovy, queenfish, and Pacific sardine. Anchovies (*Anchoa* spp) occurred primarily in winter (November and December 2006). Invertebrate return was highest in spring and early summer, though return of spiny lobster occurred year-round, with peaks in July 2006 and February-March 2007. Return was generally higher at nighttime than daytime for fishes, while there was no consistent diel pattern with respect to invertebrates. Fish return was higher than documented in previous studies, although species-specific return rates of common fishes were similar to those measured previously. Almost all of the fish taxa returned in highest abundance had slightly higher return efficiencies based on biomass, indicating that larger individuals were returned with greater efficiency than smaller individuals. This was particularly evident with queenfish, Pacific sardine, white seaperch (*Phanerodon furcatus*), and white croaker.

Calculation Baseline

The calculation baseline is designed to represent the level of impingement mortality and entrainment that would occur assuming a shoreline intake, 3/8-inch traveling screens oriented parallel to shore near the water surface, and the baseline practices and procedures of the facility. The cooling water intake systems at SONGS deviate from EPA's assumed configuration since (1) the intakes are submerged, (2) the intakes are located more than 3,000 ft offshore, (3) the traveling screens are not oriented parallel to the shoreline, (4) both intake designs include a velocity cap, and (5) both cooling water systems are designed with fish return systems. At SONGS, calculation baseline estimates were made for both impingement mortality and entrainment assuming (1) there were no velocity caps on the intakes, (2) all juvenile/adult fishes and invertebrates entrained at SONGS were subsequently impinged (i.e., there were no FRSs, fish guidance systems, or fish chases). Since a site-specific analysis of velocity cap effectiveness is not possible at SONGS due to the configuration of the diffuser-port discharge structure, determination of the level of fish protection afforded from the velocity caps at SONGS was made through analysis of previous laboratory and field studies in southern California at facilities with similar structures. The estimated efficiency of the SONGS velocity caps in reducing entrapment/impingement mortality is 88.17%. The determination of fish and invertebrate return rates through the FRSs was made by direct measurement throughout the study. Previous estimates of survival upon return were used to estimate the number and weight of fishes that would survive return through the FRSs. The combined impingement reduction afforded by the velocity caps and FRSs (taking into account return survival) at

SONGS was 94.22% based on abundance and 97.65% based on biomass. These estimates were slightly lower than those calculated assuming all returned fishes survived transit through the FRSs (96.64% based on abundance and 98.72% based on biomass). No adjustments to annual entrainment estimates were made for purposes of the calculation baseline, although there was evidence during offshore sampling in 2007 that the offshore location of the intake and the depth of withdrawal could decrease entrainment relative to a shoreline, near-surface intake.

2.0 INTRODUCTION

The San Onofre Nuclear Generating Station (SONGS) is a nuclear-fueled electric generating station owned by Southern California Edison (SCE), San Diego Gas and Electric (SDG&E), and the cities of Anaheim and Riverside, and is operated solely by SCE. SONGS is located approximately mid-way between Los Angeles and San Diego in southern California. The plant uses a once-through cooling water system for both of the operational units, Units 2 and 3. The two units withdraw a maximum of approximately 9,225,771 m^3 per day (2,437 million gallons per day [mgd]) of ocean water for cooling purposes, with each unit utilizing separate intake and discharge systems.

Cooling water systems are regulated under §316(b) of the Clean Water Act (CWA). In July 2004 the U.S. Environmental Protection Agency (EPA) established new regulations for §316(b) applicable to large existing power plants with daily cooling volumes in excess of 50 mgd. Due to the design, location, and operating characteristics for SONGS it was subject to these new regulations. The studies presented in this report were done in partial fulfillment of the requirements of the new regulations. The new regulations were challenged by a coalition of environmental groups that was heard by the Second U.S. Circuit Court of Appeals. The court rendered a decision in January 2007 that remanded many key components of the regulations back to the EPA. In March 2007, the EPA issued a memorandum suspending the rule and directing that all permits for Phase II facilities implement 316(b) on a case-by-case basis using "best professional judgment" (BPJ). The language of the memorandum was expanded and published in the Federal Register in July 2007 (Volume 72, 130:37107-37109).

2.1 BACKGROUND AND OVERVIEW

On July 9, 2004, the EPA published the second phase of new regulations under §316(b) of the CWA for cooling water intake systems (CWIS) that applied to existing facilities (Phase II facilities). The Phase II Final Rule went into effect in September 2004, and applied to existing generating stations with CWIS that withdraw at least 189,271 m^3 per day (50 mgd) from rivers, streams, lakes, reservoirs, oceans, estuaries, or other waters of the United States.

SONGS was classified as a Phase II existing facility, and was therefore subject to the 316(b) Phase II final regulations. The Phase II regulations (40 CFR 9, 122-125) established national performance standards that required reducing impingement mortality by 80 to 95% and entrainment by 60 to 90%. With the implementation of the final regulations, EPA intended to minimize the adverse environmental impact of cooling water intake structures by reducing the number of aquatic organisms lost as result of water withdrawals associated with those intake structures. The Phase II regulations became effective on September 7, 2004, and provided facilities with five compliance alternatives:

1. Demonstrate the facility has reduced flow commensurate with a closed-cycle recirculating system (only applies to the entrainment performance standard) or has reduced design intake

velocity to less than 15 cm/s (0.5 ft/s) (only applies to the impingement mortality performance standard);

2. Demonstrate that existing design and construction technologies, operational measures, and/or restoration measures meet the performance standards;
3. Demonstrate that the facility has selected design and construction technologies, operational measures, and/or restoration measures that will, in combination with any existing technologies, operational measures, and/or restoration measures, meet the performance standards;
4. Demonstrate that the facility has installed and properly operates and maintains an approved technology;
5. Demonstrate that a site-specific determination of BTA is appropriate.

Pursuant to the Phase II Final Rule, SCE submitted the SONGS Proposal for Information Collection (PIC) to the San Diego Regional Water Quality Control Board (SDRWQCB) in October 2005. The PIC included: a summary of fish protection technologies and operational measures proposed for evaluation, a summary of relevant physical and biological information, the proposed sampling plan to document impingement mortality (IM) and entrainment (E), and a schedule for information collection. The Study Plan was initiated in March 2006. After consultation with the SDRWQCB, a revised Study Plan dated November 2006 was submitted to the SDRWQCB. The revised PIC outlined some of the quality assurance/quality control (QA/QC) guidelines used during the studies, provided additional diagrams of the SONGS cooling water intake systems, detailed additional efforts to quantify fish egg entrainment, and provided answers to additional questions posed by the SDRWQCB.

Section 316(b) of the CWA requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available (BTA) to minimize adverse environmental impacts due to the impingement mortality of aquatic organisms (i.e., fish, shellfish, and other forms of aquatic life) on intake structures and the entrainment of eggs and larvae through cooling water systems. The 2004 316(b) Phase II regulations established performance standards for CWISs of existing power plants that withdraw more than 189,271 m^3 per day (50 mgd) of surface waters and use more than 25% of the withdrawn water for cooling purposes. The regulations required all large existing power plants to reduce impingement mortality by 80–95% and to reduce entrainment of smaller aquatic organisms drawn through the cooling system by 60–90% when compared against a "calculation baseline". The water body type on which the facility is located, the capacity utilization rate, and the magnitude of the design intake flow relative to the waterbody flow determined whether a facility was required to meet the performance standards for only impingement or both impingement and entrainment.

The 2004 regulations provided power plants with five options for meeting the performance standards, but unless a facility could show that it met the standards using the existing intake design or was installing one of the approved EPA technologies for IM&E reduction, it was required to submit information documenting its existing levels of IM&E. This information could be derived from existing data that may have previously been collected at the facility or a similar facility nearby. The data were then required to be submitted in an Impingement Mortality and Entrainment (IM&E) Characterization Study that was one component of the §316(b) Comprehensive Demonstration Study (CDS) required under the Phase II regulations. The impingement mortality component of the studies was not required if the through-screen intake velocity was less than or equal to 15 cm/s (0.5 ft/s). The entrainment characterization component was not required if a facility:

(a) Has a capacity utilization rate of less than 15%;

(b) Withdraws cooling water from a lake or reservoir, excluding the Great Lakes; or

(c) Withdraws less than 5% of the mean annual flow of a freshwater river or stream.

Based on previously collected intake velocity measurements and plant operating characteristics, both the IM&E components of the study were required at SONGS. Extensive entrainment and impingement studies were conducted at SONGS prior to operation, during construction, and after start up as part of the Marine Review Committee (MRC) requirements (Murdoch et al. 1989c). A 316(b) demonstration was previously performed for SONGS Unit 1 (SCE 1983a), which is no longer in operation and is in the process of decommissioning. A summary of the previous IM&E studies at Units 2 and 3 is provided in subsequent sections of this report. As described in the PIC that SCE submitted to the SDRWQCB in October 2005, SCE proposed to use the 2006-7 entrainment and impingement data for the IM&E Characterization Study, and to supplement it with previous data where appropriate.

2.1.1 Development of the Study Plan

The 2004 §316(b) regulations required that the plan for the IM&E Characterization Study include sufficient data to develop a scientifically valid estimate of IM&E including all methods and quality assurance/quality control procedures for sampling and data analysis. The sampling and data analysis methods must be appropriate for a quantitative survey and include consideration of the methods used in other studies performed in the source waterbody. The sampling plan was also required to include a description of the study area (including the area of influence of the CWIS), and provide for taxonomic identifications of the sampled or evaluated biological assemblages (including all life stages of fish and shellfish) that are known to be relevant to the development of the plan.

The 2004 regulations also required that the PIC include summaries of any previous studies characterizing impingement mortality and entrainment, and/or the physical and biological conditions in the vicinity of the cooling water intake structures and their relevance to the proposed studies. These were required to assist the SDRWQCB in reviewing and commenting on the IM&E study plan. If the data from previous studies were to be used in characterizing the existing levels of IM&E then the PIC must demonstrate that the data were representative of current conditions and were collected using appropriate QA/QC procedures.

The entrainment and impingement study was designed to estimate losses of fishes and shellfish due to operation of the cooling water system of SONGS. For the SONGS entrainment study, the numbers of fishes and target invertebrates entrained by the generating station were estimated from plankton samples collected inside the intake structure of each unit, as well as from near the offshore intake structures. Additional samples were collected monthly at stations located adjacent to the intake structures in the Pacific Ocean, and downcoast and inshore of the intake structures. An additional station line 8.6 km (5.4 mi) downcoast was added to collect information for calculation baseline information. For the impingement and fish return system (FRS) studies, impingement and fish return samples were collected from the respective screening and return facilities within the generating station.

2.1.2 Study Plan Objectives and Approach

Under the 2004 §316(b) regulations, the IM&E Characterization Study must include the following (for all applicable components):

1. Taxonomic identifications of all life stages of fish, shellfish, and any species protected under federal, state, or tribal law (including threatened or endangered species) that are in the vicinity of the CWIS and are susceptible to impingement and entrainment;
2. A characterization of all life stages of fish, shellfish, and any species protected under federal, state, or tribal law (including threatened or endangered species) identified in the taxonomic identification noted previously, including a description of the abundance and temporal and spatial characteristics in the vicinity of the CWIS, based on sufficient data to characterize the annual, seasonal, and diel variations in the IM&E;
3. Documentation of current IM&E of all life stages of fish, shellfish, and any protected species identified previously; and
4. An estimate of IM&E to be used as the calculation baseline.

The objectives of the SONGS IM&E Characterization Study are to provide the SDRWQCB with the necessary information to satisfy the four requirements listed above. Item 1 was satisfied by collection of in-plant entrainment and impingement samples, and offshore entrainment and source water samples. Seasonal and diel variations in IM&E were analyzed by sampling IM&E throughout the year during daytime and nighttime. Annual variations in IM&E were analyzed by comparing results from 2006-7 with results from previous studies at SONGS. The year-long IM&E study quantified the current levels of IM&E required by Item 3, and this estimate was further utilized to estimate the calculation baseline as required by Item 4.

The 2004 §316(b) regulations provided the SDRWQCB with considerable latitude in determining the level of detail necessary in meeting these objectives and states that "while the taxonomic identification in item 1 will need to be fairly comprehensive, the quantitative data required in items 2 and 3 may be more focused on species of concern, and/or species for which data are available." If the CDS was based on a given technology, restoration or site-specific standards, the level of detail in terms of the quantification of the baseline could be tailored to the compliance alternative selected and does not have to address all species and life stages. There was agreement with the SDRWQCB that the impingement sampling would identify, count, weigh, and measure all collected fishes, crabs, lobsters, shrimp, squid and octopus following the procedures in Section 5.3. This approach was taken to include all of the impingeable 'shellfish' that are recreationally or commercially important and a large number of species that are not fishery species. It was also agreed that the entrainment sampling would identify and count all fish eggs and larvae, megalops stage larvae for crabs, California spiny lobster phyllosoma larvae, and market squid hatchlings.

As required by Item 4, the data collected during the year-long study were utilized in estimating the SONGS calculation baseline. The calculation baseline was defined in the 2004 §316(b) regulations as follows:

> *"Calculation baseline means an estimate of impingement mortality and entrainment that would occur at your site assuming that: the cooling water system has been designed as a once-through system; the opening of the cooling water intake structure is located at, and the face of the standard 3/8-inch mesh traveling screen is oriented parallel to, the shoreline near the surface of the source waterbody; and the baseline practices, procedures, and structural configuration are those that your facility would maintain in the absence of any structural or operational controls, including flow or velocity reductions, implemented in whole or in part for the purposes of reducing impingement mortality and entrainment. You may also choose to use the current level of impingement mortality and entrainment as the calculation baseline. The calculation baseline may be estimated using: historical impingement mortality and entrainment data from your facility or another facility with comparable design, operational, and environmental conditions; current biological data collected in the waterbody in the vicinity of your cooling water intake structure; or current impingement mortality and entrainment data collected at your facility. You may request that the calculation baseline be modified to be based on a location of the opening of the cooling water intake structure at a depth other than at or near the surface if you can demonstrate to the Director that the other depth would correspond to a higher baseline level of impingement mortality and/or entrainment."*

As presented in the PIC, the SONGS CWIS does not match the definition of the calculation baseline. Deviations from the definition of calculation baseline are:

- The intakes are submerged rather than at, or near, the surface;
- The intakes are located offshore, away from the shoreline;
- The intake structures are fitted with velocity caps;
- There are fish guidance systems consisting of louvers and vanes which guide fish into collection and return systems; and
- Prior to heat treatments, an operational 'Fish Chase' procedure is utilized to remove organisms entrained in the cooling water systems.

The 2004 regulations allowed facilities to take credit for deviations from the calculation baseline if it could be demonstrated that these deviations provide reduced levels of IM&E. The approach taken for calculating baseline levels of IM&E is presented in Section 8.0.

The IM&E studies at SONGS were designed to examine losses resulting from both impingement of juvenile and adult fish and shellfishes on traveling screens at the intake during normal operations and from entrainment of larval fishes and shellfishes into the cooling water intake system. The sampling methodologies and analysis techniques were designed to collect the data necessary for compliance with the §316(b).

Impingement sampling has been conducted at SONGS Units 2 and 3 since 1982. The recent National Pollutant Discharge Elimination System (NPDES) permit for SONGS required impingement sampling on a quarterly basis and during heat treatments. Heat treatments are performed approximately every six weeks in the summer and approximately every nine weeks in the winter at each unit at SONGS. The impingement sampling methods used in the IM&E study were similar to those used in the NPDES monitoring program, but normal operations samples were collected biweekly, and with the addition of concurrent sampling at the FRS. Three of the 24-hour surveys were divided into two 12-hour cycles to document diel variation in impingement.

2.2 REPORT ORGANIZATION

The report is organized by study element and all pertinent findings associated with a particular element are addressed in the appropriate section. Section 3.0 includes a detailed description of SONGS and the CWIS. Data on circulating pump flows from the study period are presented and discussed as these are the data used in calculating estimates of impingement mortality and entrainment in other sections of the report. Section 3.0 also includes a description of the characteristics of the source water body. The information presented in Section 3.0 is required as part of 122.21(r)(2)(3) and (5), and was used in the estimation of the calculation baseline.

The methods and results for the entrainment and source water sampling are presented in Section 4.0. This data fulfills objectives 1 through 3 as outlined in Section 2.1.2. The methods and results for the impingement sampling are provided in Section 5.0, and this data also fulfills objectives 1 through 3 as presented in Section 2.1.2. The results from FRS sampling are presented in Section 6.0, and these same data are used for the Calculation Baseline levels of IM&E that will be used in other components of the SONGS Comprehensive Demonstration Study. This fulfills objective 4 as presented in Section 2.1.2. The results from the entrainment and impingement sampling are integrated into an overall discussion in Section 7.0. The references used in the report are presented in Section 8.0. Appendices include detailed summaries of cooling water flow, entrainment, and impingement data.

2.3 CONTRACTORS AND RESPONSIBILITIES

The IM&E Study was designed by ASA Analysis & Communication, Inc. Sampling was performed by MBC *Applied Environmental Sciences* (Costa Mesa, California) and Tenera Environmental. (San Luis Obispo, California). The roles of each of the respective firms were as follows:

- ASA Analysis & Communication, Inc
  - Study design
- MBC *Applied Environmental Sciences*
  - Study design
  - Field Sampling
  - Impingement and FRS Mortality data and analysis
  - Entrainment data analysis
  - Field sampling Quality Assurance/Quality Control (QA/QC)

    - Reporting

- Tenera Environmental

    - Entrainment sample sorting, identification, and QA/QC

    - Entrainment data entry

Each contractor was responsible for ensuring that all data were verified prior to computer entry, and that appropriate QA/QC measures were employed during data entry and analysis.

3.0 DESCRIPTION OF THE GENERATING STATION AND CHARACTERISTICS OF THE SOURCE WATER BODY

The following section describes SONGS and the surrounding aquatic environment. A description of the generating station and its cooling water intake system is presented in Sections 3.1 and 3.2. A description of the physical and biological environments in the vicinity of SONGS is presented in Section 3.3.

3.1 DESCRIPTION OF THE GENERATING STATION

SONGS is located on the coast of the Pacific Ocean on Camp Pendleton, a United States Marine Corps Base, approximately 2.5 miles southeast of San Clemente in north San Diego County, California (Figure 3.1-1). The facility currently consists of two nuclear-fueled generating units (Unit 2 & Unit 3). Unit 1, currently decommissioned, was operational from 1968 to 1992. Units 2 and 3 each have four cooling water pumps which provide a maximum of 3,203.4 m^3 per minute (846,240 gallons per minute [gpm]) of cooling water at full load. The total plant output is 2,174 megawatts (MW), with each unit rated at 1,087 MW. SONGS is considered a baseload facility, and from 2000 through 2006, the average capacity factor of the generating station was 88.7% (91.3% for Unit 2 and 86.0% for Unit 3). Each unit undergoes a refueling outage approximately every 18 months that typically requires 45 days; during these outages additional maintenance work is also performed. During 2006, both units underwent refueling outages, with Unit 2's occurring between January 5 and March 13, and Unit 3's between October 16 and November 28. Field studies started after the completion of the Unit 2 outage.

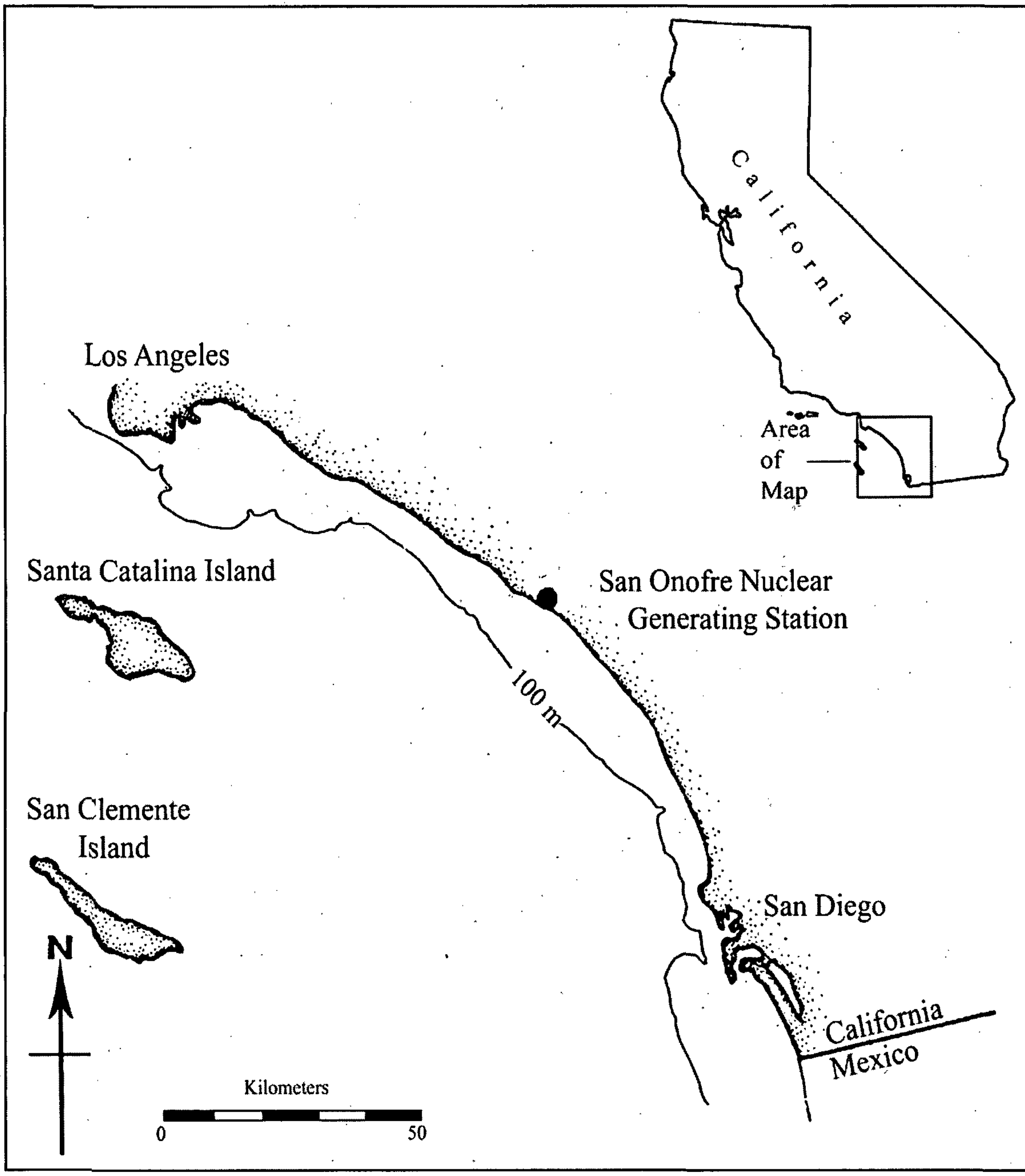


Figure 3.1-1. Location of San Onofre Nuclear Generating Station.

3.2 DESCRIPTION OF THE COOLING WATER INTAKE SYSTEM

The offshore intake structures for Units 2 and 3 are both identical in design and construction. They are located 960.1 m (3,150 ft) from shore at a bottom depth of 9.1 m (30 ft). (Figure 3.2-1) The intakes are about 198.1 m (650 ft) apart. A velocity cap that is 14.9 m (49 ft) in diameter is supported 2.1 m (7.0 ft) above each of the 8.5 m (28 ft) diameter intake risers (Figure 3.2-2). The velocity cap is 3.7 m (12.0 ft) below mean lower low water (MLLW). The water enters the velocity caps at an average velocity of 0.5 mps (1.7 fps) and enters the 5.5 m (18.0-ft) diameter intake pipes at a velocity of 2.2 mps (7.3 fps). The velocity cap redirects the intake flow from a vertical direction to a horizontal direction. The extended lip from the top of the riser, matched by the extended diameter of the cap, was designed to minimize turbulent flow that develops along the edges of the concrete structure and to create equal approach velocities (Schuler and Larson 1975).

The onshore intake structures are a mirror image of each other, and the following description is representative of both units. Water enters the plant and travels through a series of guiding vanes that serve to channel fish to the fish removal area (Figure 3.2-3). After the guiding vanes, the water then passes through a series of angled louvers that act as traveling bar racks and have an opening of 2.5 cm (1 in). The racks are used to remove larger debris from the flow. Once the water passes through the louvers, it approaches the 9.5-mm (3/8-in) traveling screens at a velocity of 0.4 mps (1.3 fps) with a through-screen velocity of 0.9 mps (3.0 fps). From here, the water is pumped through each unit's four 800.8 m^3 per minute (211,560 gpm) circulating water pumps where it flows to the condensers. Water is discharged from the plant primarily from two ocean outfalls. Each outfall is designed with diffusers to dissipate the heat load from the discharge. The outfall diffuser line for Unit 2 begins 1,795 m (5,888 ft) offshore and extends out to 2,545.1 m (8,350 ft), with discharge depths ranging from 11.9 m (39 ft) out to 14.9 m (49 ft) of water (Figure 3.2-1). The Unit 3 outfall diffuser line extends from 1,084.5 m (3,558) out to 1,834.9 m (6,020 ft) offshore, with discharge depths ranging from 9.8 m (32 ft) to 11.6 m (38 feet) of water. Each diffuser line consists of 63 ports spaced 12.2 m (40 ft) apart, and spread over a distance of 750.4 m (2,462 ft). The ports are 0.5 m diameter and 2.2 m above the bottom; each port is directed offshore with a tilt of 20° upward, and are alternately angled between 25° upcoast and 25° downcoast.

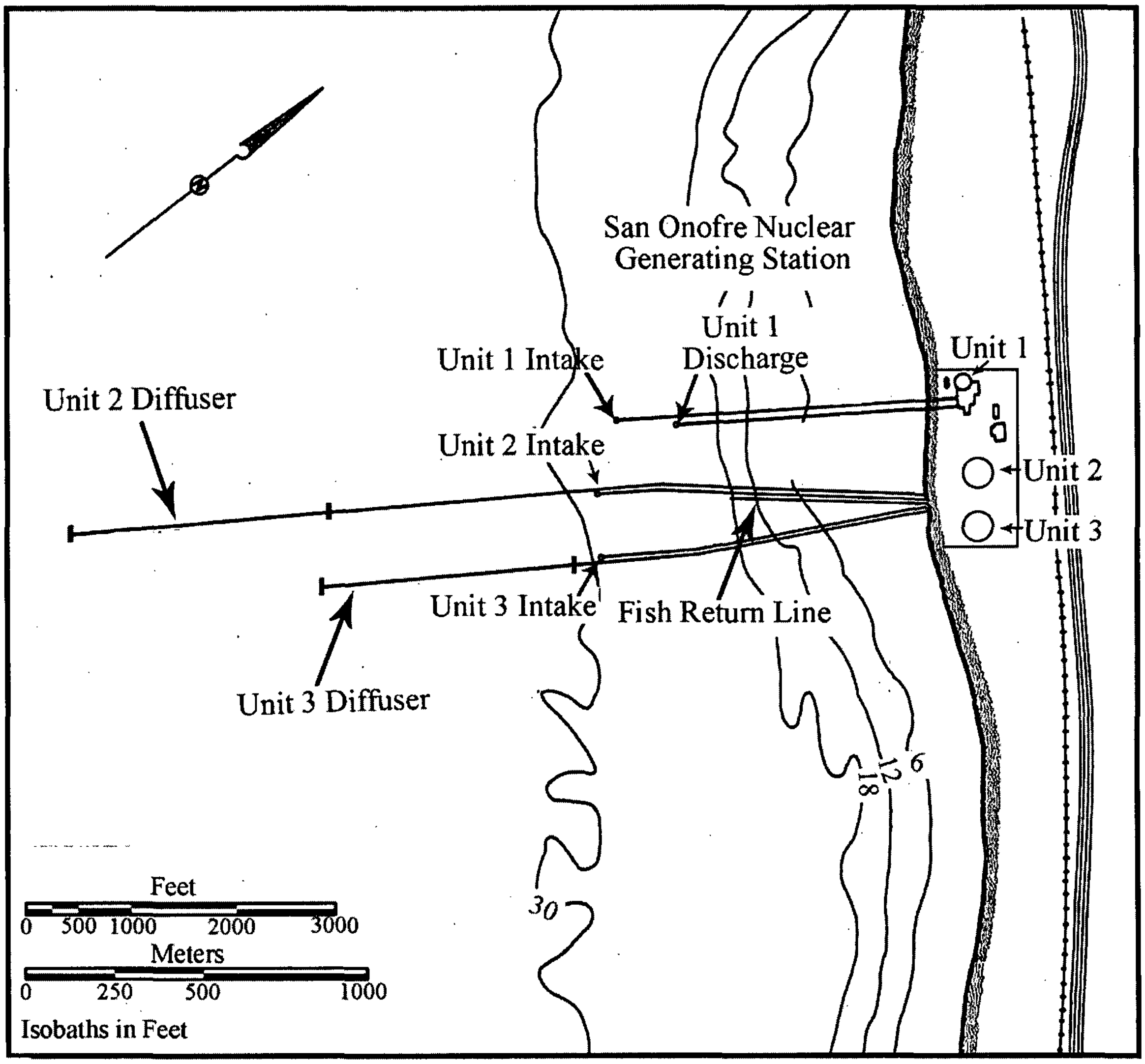


Figure 3.2-1. Configuration of San Onofre Nuclear Generating Station.

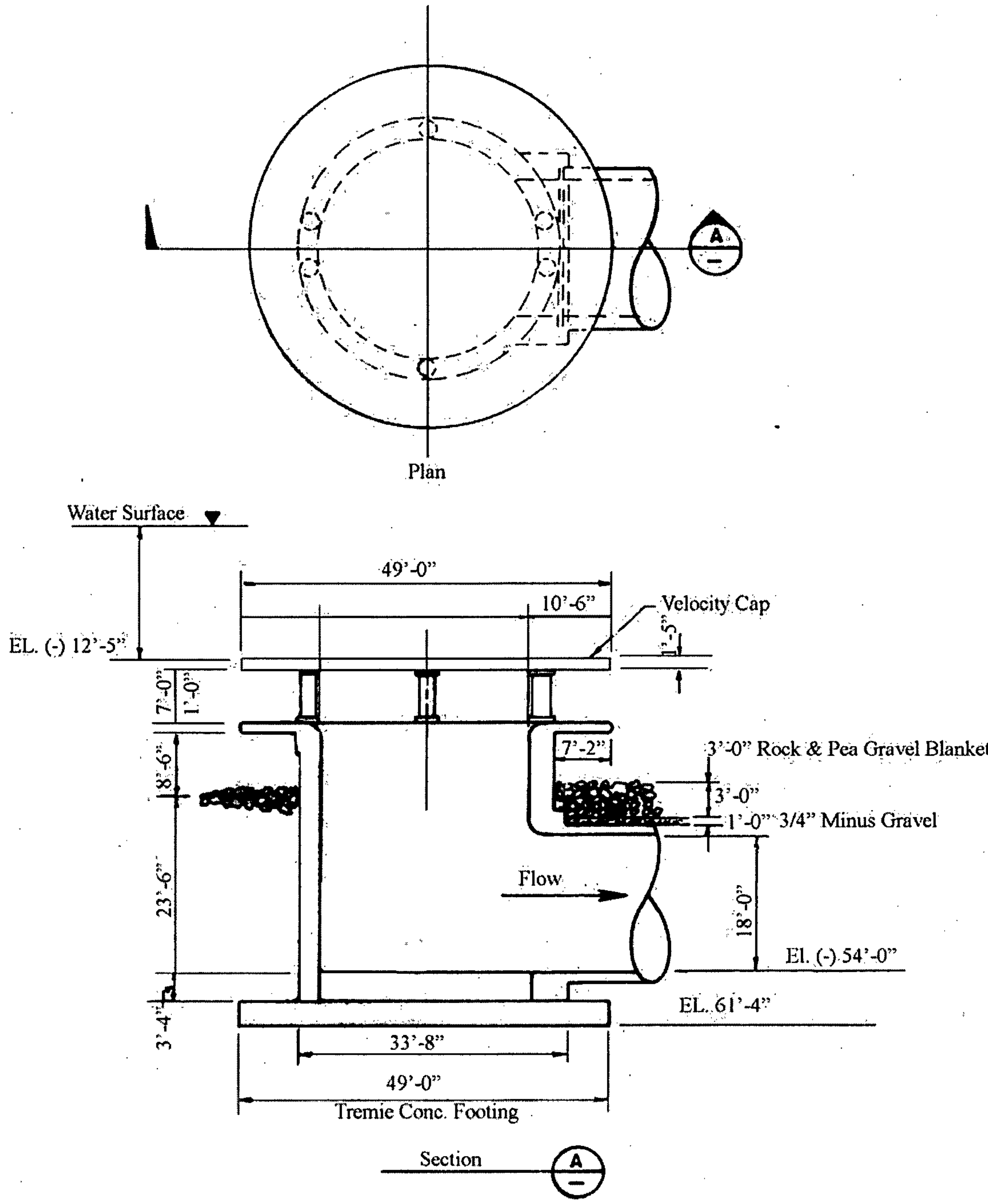


Figure 3.2-2. Diagram of one of the SONGS offshore intake structures and velocity caps.

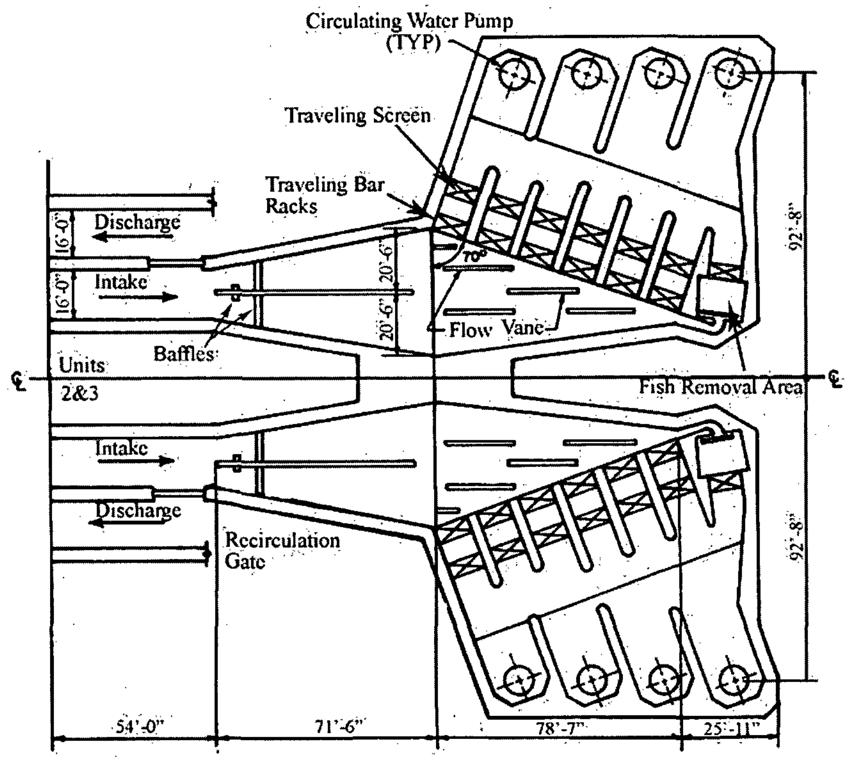


Figure 3.2-3. Diagram of the intake screenwell structure and fish removal area.

The circular intake conduit transitions to a square shape approximately 48.8 m (160 ft) seaward of the screenwell area. The screenwells are an elongated diamond shape, approximately 12.8 m (40 ft) wide in the center, and approximately 45.7 m (150 ft) from the seaward edge of the first guiding vane to the entrance of the bypass which diverts fish to the fish removal area (Figure 3.2-3). The screenwell bottom is at an elevation (El. [all elevations refer to mean sea level]) of -7.9 m (-26.0 ft) (Figure 3.2-4). The top of the intake pipe is at El. -3.0 m (-10.0 ft) when water enters the screenwell. There are six paired *traveling louver and screen combinations prior to the fish bypass*, with a seventh traveling screen behind the fish removal area. Louvers are aligned at an angle to the flow of water, with water then passing perpendicular through the screens to the pumps. The first louver and screen pair is located about 21.8 m (33.5 ft) downstream from where the intake conduit enters the screenwell, with the last pair an additional 23.9 m (78.5 ft) in distance to where the fish bypass begins. The louvers and screens are 3.0 m (10 ft) wide and extend from the bottom of the screenwell to the top deck. Screens are positioned 5.8 m (19 ft) downstream of the louvers. Debris is impinged on the louvers and screens, and when activated the louvers and screens rotate and the debris is washed off by spray nozzles, where it falls into a trough and is then carried to separate screen baskets. The mesh size on the traveling screens and on the screen baskets is 9.5 mm (3/8 in). When activated, two adjacent pairs of louvers and screens operate together, each set of pairs operating in succession, with the seventh screen behind the fish removal area operating concurrent with the last paired sets of louvers and screens. Each paired set rotates and is washed for six minutes, with a thirty second pause between pairs, taking approximately 19 minutes to complete the entire sequence. The screens are rotated once during every 12-hour shift, and in addition are self-activated by a pressure differential switch in case greater debris loads occur between scheduled operations. A backwash system providing up to 7.6 m^3 per minute (2,000 gpm) of cleaning water at 70 pounds per square inch (gauge) (psig) is used to remove debris from the screens. Fish and debris accumulate for disposal in two screen baskets situated in a rectangular sump, one each for the louvers and screens. Over flow water from either basket (if the mesh is blocked by debris) is returned to the screenwell in front of the screen adjacent to the sump.

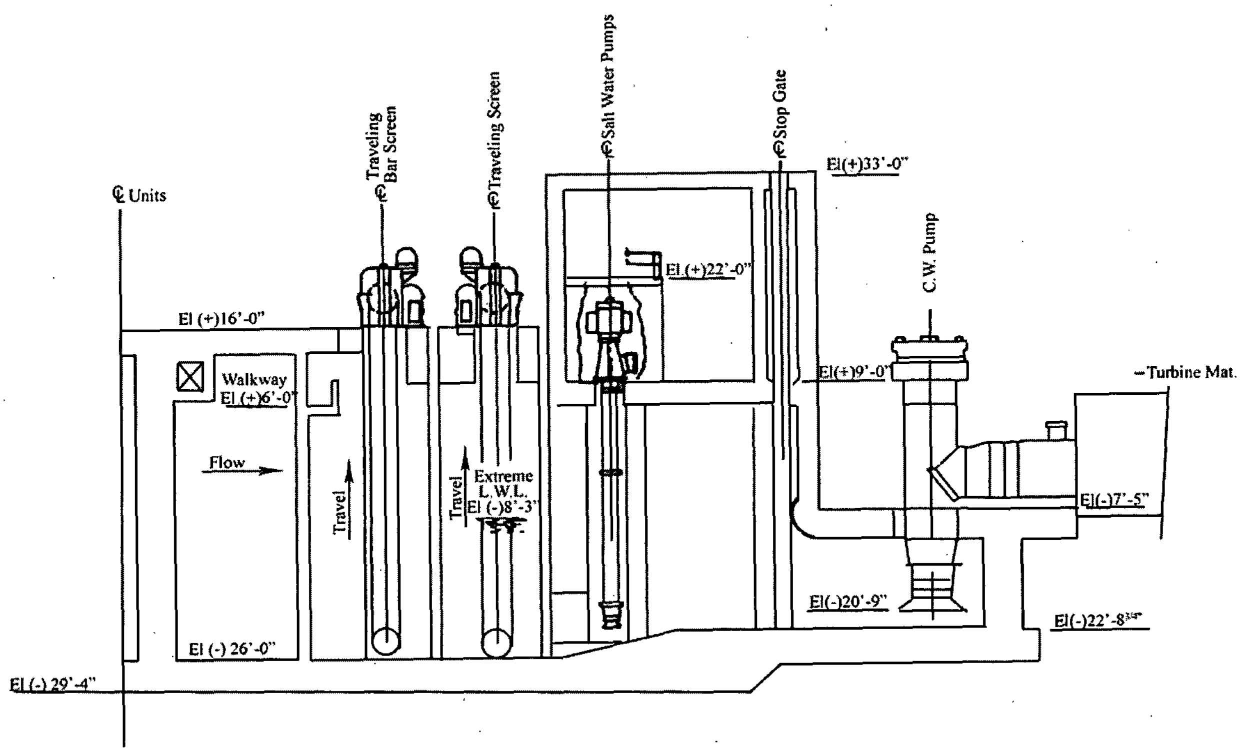


Figure 3.2-4. Sectional view of the SONGS screenwell.

Water passes through the louvers at an angle of 20°, determined to be an optimal angle to create the pressure differential to allow the fish to move to the fish removal area (Schuler and Larson 1975). The fish bypass is a smoothly curved channel that redirects flow and organisms into the fish removal area. Just before the fish bypass channel enters the fish removal area, a baffle wall is placed to split the flow in half and redirect it along the outside walls of the fish removal area. This flow re-direction creates a low flow area immediately behind the baffle, where fish aggregate. The fish removal area measures 4.9

by 4 m (16 ft by 13 ft) (Figure 3.2-5). The fish removal area contains a large elevator basket that raises fish and other entrained organisms to a return sluiceway. The watertight elevator basket, open at the top, sits inside the fish removal area. When activated, the elevator ascends and collects most of the fish; after reaching its maximum height, the elevator tips and spills the fish into the fish return sluiceway. This procedure is repeated several times until most fish in the area are removed. Simultaneously, additional water flushes through the sluiceway channel and is discharged through a 1.1-m (4-ft) diameter conduit that discharges 579.1 m (1,900 ft) offshore (Figure 3.2-1). The fish return conduit is common to both Units 2 and 3, with the two sluice channels merging approximately 9 m (30 ft) seaward of the fish removal area (Figure 3.2-6, inset). The entire system is referred to as the Fish Return System (FRS). Operationally, the FRS for each unit is operated once per shift to remove accumulated organisms, typically during the interval while the louvers and screens are running through their debris clearing cycle.

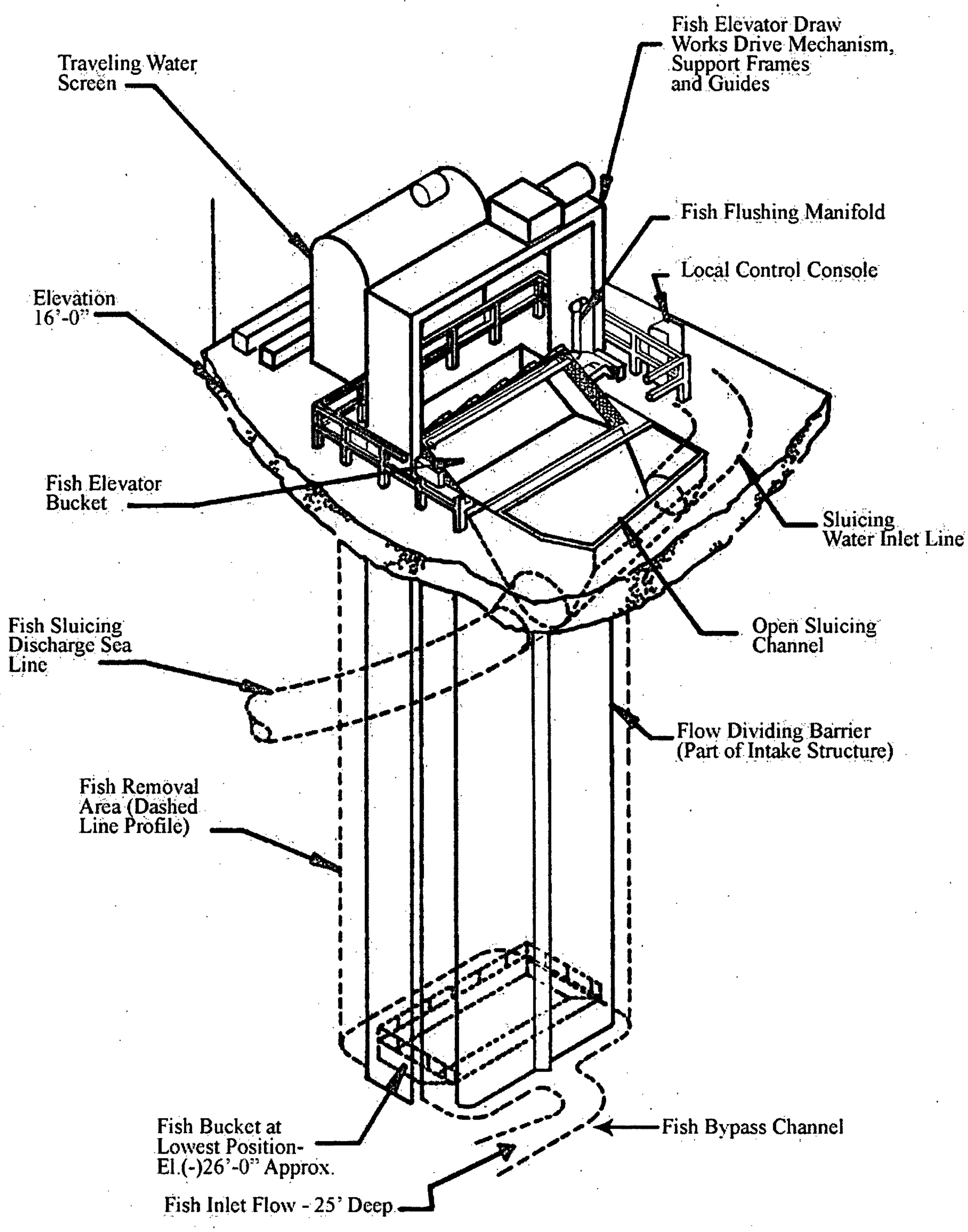


Figure 3.2-5. Diagram of one of the SONGS Fish Return Systems.

Approximately every six to nine weeks each unit conducts a heat treatment procedure to remove biofouling organisms from the conduit walls of the intake system. A heat treatment is done by reversing flow through the intake and discharge conduits and recirculating warmed cooling water through the system. A diagram of gate positions during reversed flow is shown in Figure 3.2-7. In normal flow configuration, Gates 3 and 6 are open, and Gates 4 and 5 are closed (see Figure 3.2-6). During a heat treatment, Gate 5 open and Gate 3 closed sends discharge water out through the intake conduit, Gate 4 open allows water flow in through the discharge conduit, and Gate 6 partially open allows recirculation of heated effluent to increase temperature to the desired level. The circulated water is maintained at a temperature of 40.5°C (105°F) for approximately one hour before returning to the normal configuration. For additional bacterial biofouling control in the condensers, each CWIS is also injected with sodium hypochlorite (liquid chlorine) for 65 minutes three times per 12 hour shift. Chlorine levels in the discharge water are kept within the limits of the SONGS NPDES permit.

Prior to every heat treatment, a "fish chase" procedure is performed. The fish chase procedure is utilized to remove any fish which have not accumulated in the fish removal area, but are present in the screenwell area in front of the louvers and screens. Some fish species are stronger swimmers and are able to maintain position along the concrete walls of the screenwell, and it is desirable to remove them prior to a heat treatment. By recirculating a portion of the heated effluent, the elevated temperature is used to force fish present in the screenwell area upstream of the fish removal area into the FRS collection area. During the fish chase, the temperature is raised at approximately 0.3°C (0.5°F) per minute by manipulating Gate 5 (Figure 3.2-6) between the discharge and intake tunnels. As the water is slowly heated, the fish in the screenwell move downstream into the fish removal area. During this process, the elevator is operated continuously, removing fish as they accumulate in the removal area. The water temperature is raised to a temperature of between 13.6 to 15.2°C (82 and 85°F) depending on the ambient seawater temperature. The duration of the fish chase varies from about two to three hours, depending on the densities of fish present in the screenwell and observations of the attending biologist. Highest densities are usually recorded during the summer months. More information on the fish chase is presented in Section 6.0.

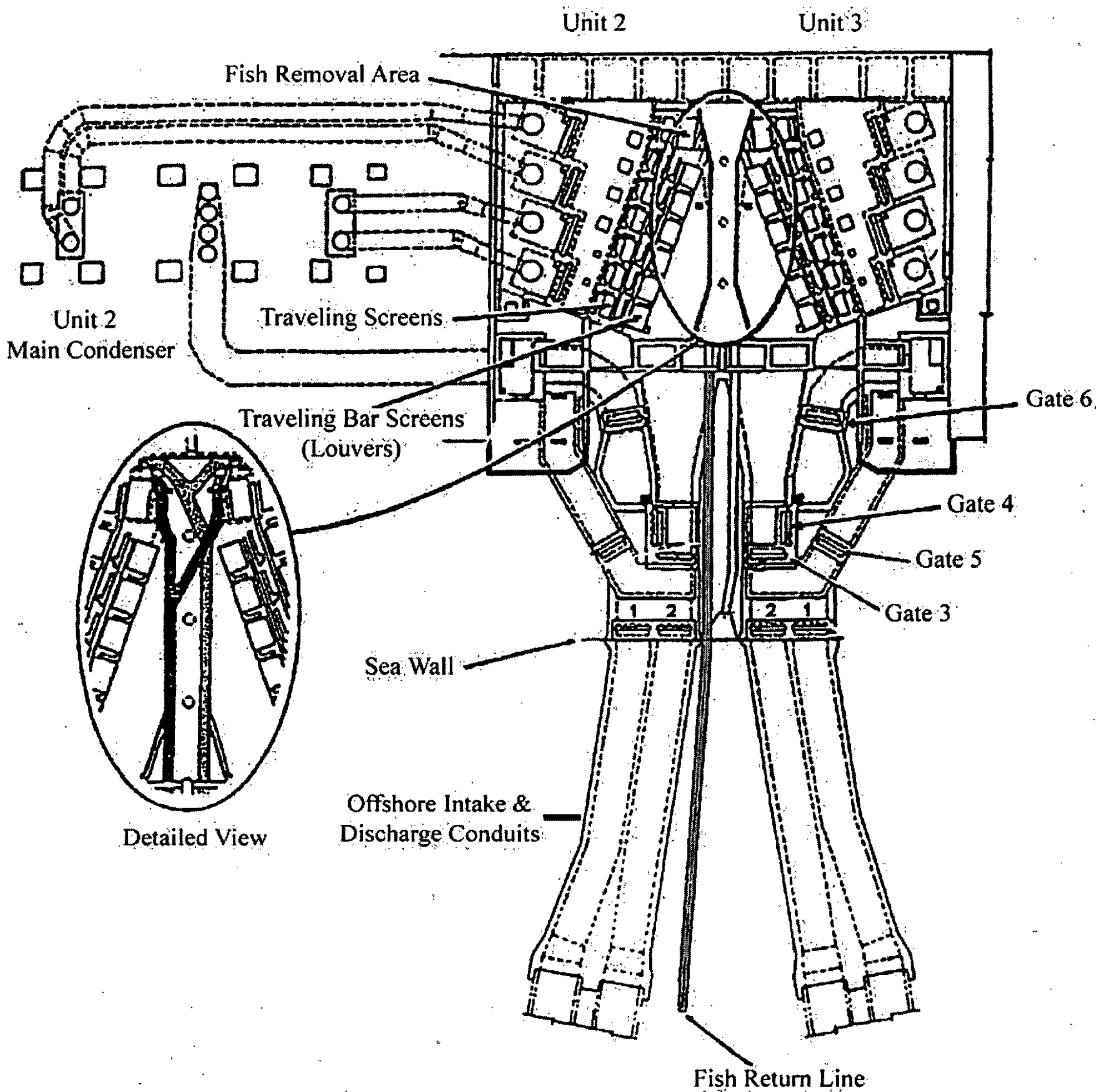


Figure 3.2-6. Plan view of the SONGS cooling water intake systems.

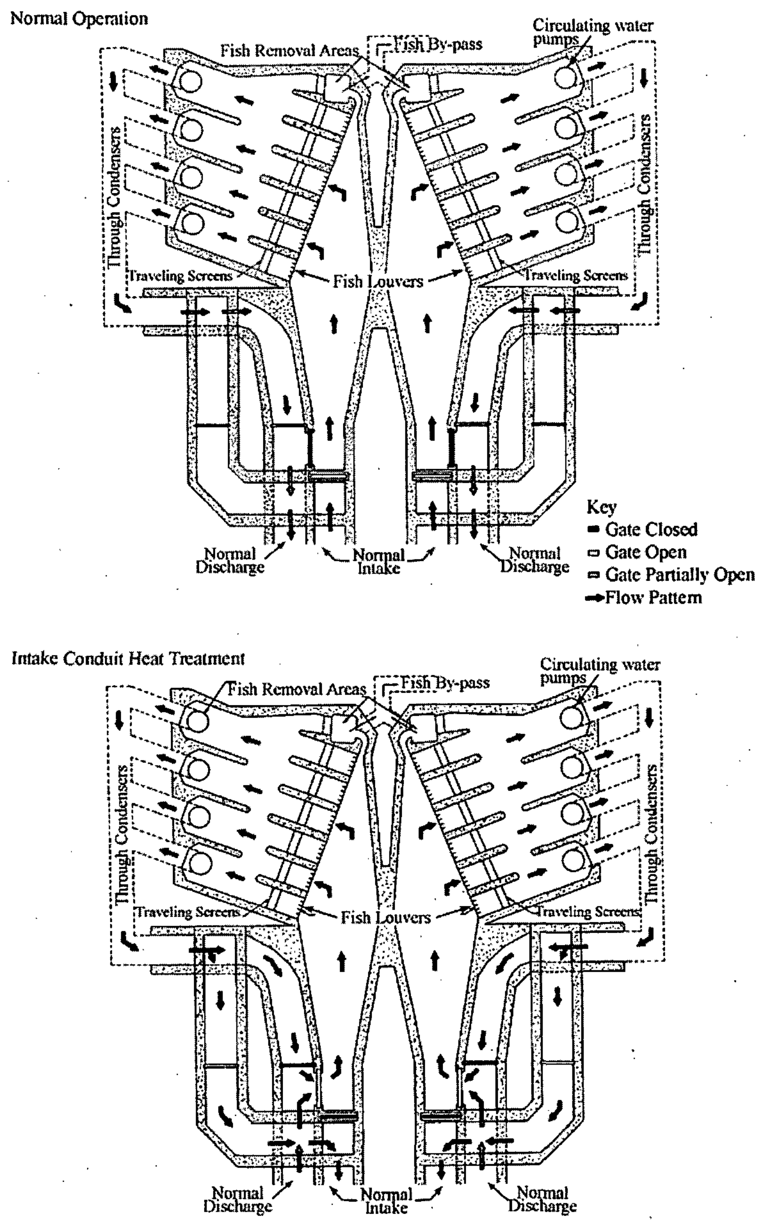


Figure 3.2-7. Plan view of SONGS gate positions during normal operation and intake heat treatment.

3.2.1 Circulating Water Pump Flows

Each of the CWIS's for Units 2 and 3 at SONGS withdraws a maximum of 4,612,850 m^3 per day (1,218.6 mgd) of cooling water from the Pacific Ocean. Velocities inside the circulating water system were calculated using the design flow of the facility. The water velocity in the intake pipes is calculated at 2.2 mps (7.3 fps), enters the screenwell and approaches the louvers at 0.4 mps (1.3 fps), then passes through the screens at 0.9 mps (3.0 fps) (SCE and EPRI Solutions 2006).

Daily cooling water flow volumes at SONGS during the study period (March 2006 to May 2007) are depicted for Units 2 and 3 in Figure 3.2-8. Flow at each unit was almost uniform, except for the refueling outage at Unit 3. Daily cooling flow at Unit 2 from 1 March 2006 to 30 April 2007, the completion of the 26 bi-weekly samples, averaged 1,476,619 m^3 per day (1,211.7 mgd), or about 99% of maximum design flow. Daily cooling flow at Unit 3 from 1 March 2006 to 30 May 2007 averaged 1,375,772 m^3 per day (1,129 mgd), or about 93% of maximum design flow.

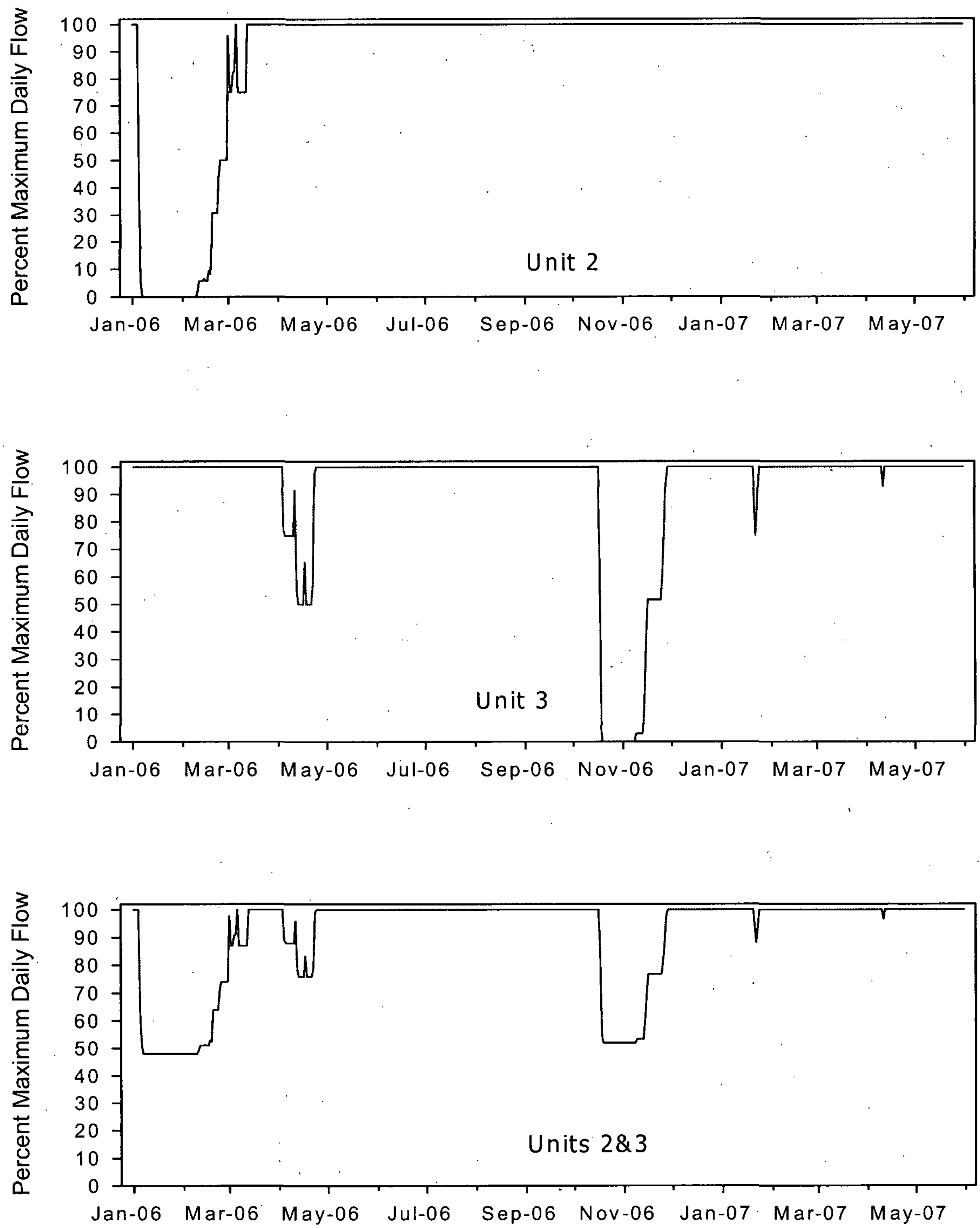


Figure 3.2-8. Daily cooling water flow volumes (percent of maximum) at SONGS from January 2006 through May 2007. Unit 2 (top), Unit 3 (middle), and Units 2&3 combined (bottom).

3.3 Environmental Setting

The following section describes the physical and biological environments in the vicinity of SONGS. SONGS withdraws cooling water from, and subsequently discharges cooling water to, the Pacific Ocean.

3.3.1 Physical Description

SONGS sits along an open, sandy stretch of coastline dominated by a coastal bluff along a stretch of the Pacific Ocean labeled as the Gulf of Santa Catalina on nautical charts. It is situated 4.0 km (2.5 mi) southeast of the city of San Clemente and approximately 19 km (12 mi) northwest of the city of Oceanside in southern California. Coastal waters are influenced by a complex interaction of oceanographic, biological, and meteorological elements which have short- and long-period cyclical variations and non-periodic trends. Winds, tides, and currents are particularly important since they exert the greatest effect on water body movements in coastal waters.

3.3.1.1 Physical Features

The general orientation of the coastline in the area runs from northwest to southeast. The generating station sits on a narrow coastal plain that extends from the coastline to a range of low hills 3.2 km (two mi) inland that have a maximum elevation of 526 m (1,725 ft) above sea level (EQA-MBC 1973). The plain terminates at the beach in a line of wave-straightened cliffs that extend 18 to 25 m (60 to 80 ft) above a narrow sandy beach. Numerous ravines are cut into the cliffs as a result of erosion from storm runoff from the coastal plain, and the coastal hills are broken by inland extending plains north and south of the area. To the northwest lies Dana Point, a large rocky headland approximately 17 km (10.6 mi) distant, and closer and less pronounced is San Mateo Point, approximately 3.8 km (2.4 mi) distant. There are two vernal creeks, San Onofre and San Mateo, which flow into the ocean just downcoast of San Mateo Point; flow from these creeks averages 355,279 and 1,470,120 m^3 (290 and 1,200 acre-feet) per year, respectively. The coastal bluff in the immediate area of the generating station slowly becomes lower until it becomes an inland coastal plain near the City of Oceanside. Beyond the surf zone, a gently sloping bottom reaches a depth of 15.2 m (50 ft) approximately 2,743 m (9,000 ft) offshore.

There are marinas located at Dana Point Harbor and at the City of Oceanside. Both marinas provide berths for commercial sportfishing vessels as well as private boat slips; Dana provides berths for approximately 1,500 vessels, and Oceanside provides approximately 950 berths. There is a pier in San Clemente extending 366 m (1,200 ft) into the Pacific Ocean

Two artificial reefs were installed in the nearby waters by SCE as mitigation for kelp losses due to increased turbidity in the area of San Onofre Kelp as a result of operations at SONGS (Ambrose 1990). The first, Pendleton Artificial Reef, is approximately 5.5 km (3.4 mi) downcoast on a sandy bottom in 13 to 15 m (43 to 50 ft) depth MLLW. It consists of 8 modules of quarry rock about 1.3 hectares (3.2 acres) total, with an average distance of 30 m (98 ft) between modules (DeMartini et al 1989). There is approximately 4 m (13 ft) of relief above the bottom (Ambrose and Swarbrick 1989). The second, Wheeler North Artificial Reef, is located on a sandy bottom upcoast of San Mateo Point about 4.9 km

(3.0 mi) from SONGS. It is currently comprised of 56 modules of quarry rock, each approximately 40 by 40 m (130 by 130 ft), for a total of about 9 hectares (22.4 acres), with a relief of 1-2 m (3-6 ft). It is scheduled for expansion in 2008, and upon completion will cover 60.7 hectares (150 acres).

3.3.1.1.1 Climate and Weather

Southern California lies in a climatic regime defined as Mediterranean, characterized by short, mild winters and warm, dry summers. Annual precipitation near the coast ranges between 25 and 38 cm (10 and 15 in), with most precipitation occurring from October through April.

A subtropical high-pressure system offshore the Southern California Bight (SCB) produces a net weak southerly/onshore flow in the area (Dailey et al. 1993). Wind speeds are usually moderate, and are on the order of 10 km/hr, with average speeds recorded at SONGS 11.3 km/h (7 mph). Wind speeds diminish with proximity to the coast, averaging about one-half the speeds offshore. Coastal winds in southern California are about one-half those found off central and northern California. However, strong winds occasionally accompany the passage of a storm. A diurnal land breeze is typical, particularly during summer, when a thermal low forms over the deserts to the east of the Los Angeles area. On occasion, a high-pressure area develops over the Great Basin in Utah, reversing the surface pressure gradient and resulting in strong, dry, gusty offshore winds in the coastal areas. These Santa Ana winds are most common in late summer, but can occur any time of year.

3.3.1.2 Physical Oceanography

Astronomical tides in southern California are classified as mixed, semi-diurnal, with two unequal high tides (high water and higher high water) and two unequal low tides (low water and lower low water) each lunar day (approximately 24.5 hr). Between 1997 and 2002, water level extremes in Outer Los Angeles Harbor, the nearest United States Geological Survey tidal gauge, ranged from -0.6 m to +2.35 m (-1.97 ft to + 7.71 ft) above MLLW. In the northeastern Pacific Ocean, the tide wave rotates in a counterclockwise direction such that flood tide currents flow upcoast and ebb tide currents flow downcoast.

The oceanic water mass adjacent to the southern California coast is primarily affected by the waters transported south by the California Current, which is modified by a countercurrent (Davidson Current) and upwelling. The California Current flows southward along the coast of California and is relatively close to the coast north of Point Conception. At Point Conception, the coastline makes an abrupt change to an east-west orientation and the flow of water departs the coastline. South of Tanner and Cortes Banks the main portion of the California Current curls toward land, and separates into two branches; one branch, known as the Southern California Countercurrent, turns back to the north between Santa Catalina Island and the Tanner-Cortes bank area. North of Santa Catalina Island, the Southern California Countercurrent turns towards shore and then flows south along the Continental Shelf. Along the coast, surface circulation is complicated by the predominantly southern flow, a northerly flow from the San Diego offshore region, coastal geometry, and bottom topography: The long term average current flow in the SONGS area is 3 cm/s downcoast (Ambrose and Swarbrick 1989).

As measured in the morning at the San Clemente pier from 1966 to 2004, the daily surface water temperature in the area generally fluctuates gradually up and down with the season, reaching a maximum in August. Maximum variation for that 38-year period ranges from 9.8°C in the winter to 26.2°C in the summer (SCCOOS 2007). Daily temperatures from Station C2S, just downcoast from SONGS, during 2006 are presented in Figure 3.3-1. Water temperatures during much of the first four months of 2006 were cooler than normal, but from May through July temperatures were mostly warmer than average. From August through October, temperatures fluctuated above and below average, and from November through year's end, temperatures were above average.

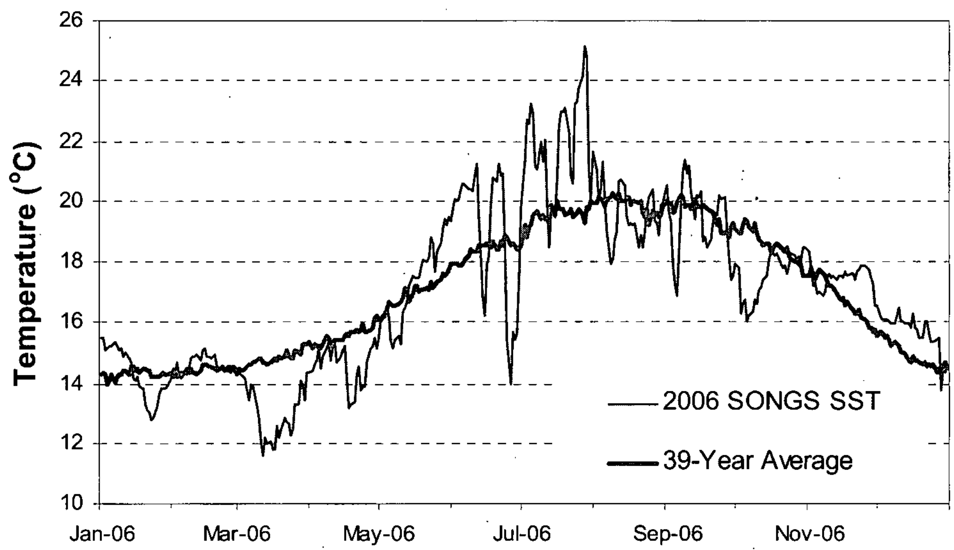


Figure 3.3-1. Daily sea surface temperature (SST; °C) off SONGS during 2006, and 39-year average from the San Clemente Pier, San Clemente, California.

Upwelling occurs when storms or strong offshore winds blow from the west or northwest. These winds induce surface currents which flow offshore. In nearshore coastal waters, cooler bottom water rises through the water column to replace the surface waters which have been displaced offshore, resulting in a breakdown of thermal stratification of receiving waters and reducing surface and bottom temperatures.

3.3.2 Biological Resources

The following sections describe the aquatic biological habitats and communities in the vicinity of SONGS, including both invertebrate and fish communities.

3.3.2.1 Habitat Variation

Organisms found in the pelagic habitat include a myriad of planktonic organisms (phytoplankton, zooplankton, and ichthyoplankton) that have minimal ability to resist ocean currents, and nektonic organisms, such as fishes and sharks that are freely mobile in local and oceanic currents. The pelagic habitat also supports large numbers of pinnipeds (including Pacific harbor seal [*Phoca vitulina richardsi*] and California sea lion [*Zalophus californianus californianus*]), cetaceans (such as gray whale [*Eschrichtius robustus*], bottlenose dolphin [*Tursiops truncatus*], and common dolphin [*Delphinus delphis*]), and birds, including California brown pelican (*Pelecanus occidentalis californicus*), terns, and gulls.

Intertidal habitat in the vicinity of SONGS is comprised of sandy, cobble, and rocky habitats. The rocky habitat in the area is restricted to the two closest headlands, Dana Point and San Mateo Point, with the remainder of the shoreline composed of a mixture of sandy beaches and sand/cobble beaches. The mouths of the two creeks have a small riparian habitat and closed embayment except during storm runoff.

The richest area for marine productivity in the immediate vicinity of the plant site is the shallow subtidal zone approximately 400 m (1,300 ft) upcoast of the facility (EQA-MBC 1973). This area supports a biological community dominated by surfgrass (*Phyllospadix*) and a brown alga (*Egregia*), which are the chief producers of organic matter. Further offshore, rocky bottom communities in the cobble areas are either absent or poorly developed. Much of the cobble in less than 10 m (33 ft) depth is exposed and buried periodically by waves and longshore sand transport, which limits biological productivity.

The habitat available offshore of the generating station consists of a mixture of sand, cobble, and isolated areas of exposed rock and sandstone (Duffy 1970). These types of bottom are generally less productive, biologically, than solid substrate outcroppings, but more productive than sand bottoms. There is a general change in bottom consistency from the San Mateo Point area, which is mostly stable cobble and boulders, to mostly sand at Don Light, which has isolated patches of cobble and rocky bottom. Most cobble in the San Onofre area is less than 30 cm (12 in) diameter, with occasional areas with boulders up to 60+ cm (24 in).

Sand in the area varies from fine sand with small ripples to coarse sand with large ripples. High proportions of soft-bottom benthos live most of their lives permanently in the sediments and are termed 'infauna'; those which live on the surface of the seafloor are called 'epifauna'. The soft-bottom habitat also supports several species of algae, macrofauna/megafauna (including crabs, snails, sea stars, urchins, and sea cucumbers), and fishes, including California halibut (*Paralichthys californicus*).

There are several large areas of cobble and boulders offshore of the SONGS area which provide habitat for the attachment and growth of giant kelp (*Macrocystis pyrifera*). The nearest, San Onofre Kelp bed (SOK), is 200 m (656 ft) downcoast of the Unit 2 diffusers in about 12.2 to 15.2 m (40 to 50 ft) depth. The areal extent of the SOK canopy has varied from none to 76.3 hectares in 1990, averaging 11.7 hectares since 1966 (MBC 2007). Another large boulder and cobble substrate exists at San Mateo Point, supporting attachment and growth of San Mateo Kelp bed (SMK), with depths ranging from 6.1 to 15.2 m (20 to 50 ft). This kelp bed canopy has varied from none to 87 hectares in 1990, averaging 15.0 hectares since 1966. In December 2006 both kelp beds had no visible canopy, and both are in a recruitment phase at the present time (MBC 2007). Kelp beds support a relatively varied and abundant marine biota (Dayton 1985). The extent of both kelp beds has varied greatly over the past 90 years, influenced by oceanographic conditions such as ocean temperatures, nutrient availability, and storm effects (e.g. surge, sand movement causing substrate inundation, and cobble displacement), as well as biological conditions (e.g. urchin densities).

3.3.2.2 Nursery Grounds

It is unknown to what extent the area around SONGS serves as a nursery for fish and invertebrate species; however, it can be assumed that the variety of habitat types are likely used by numerous species for such purposes. On the open coast, recruitment to the mainland shelf occurs year-round, but is greatest from winter to spring (Cross and Allen 1993).

Reefs and kelp beds provide habitat for a wide variety of fishes and invertebrates. Most commonly, passive drift carries late larval stages to the vicinity of these habitats where settlement takes place (Cowen 1985). In other species (possibly including chubs and giant kelpfish [*Heterostichus rostratus*]), actively swimming late larval stages may follow gradients in perceptual cues or internal waves to reefs. In still other species, larvae produced on a reef may have behavioral mechanisms to retard drift processes, keeping them in the local area for settlement (Stephens et al. 2006).

On the soft-bottom substrata of the southern California mainland shelf, Allen (1982) found that 45% of the 40 major fish community members had pelagic eggs and larvae, 18% (all rockfishes) were ovoviviparous with pelagic larvae, 15% had demersal eggs and pelagic larvae (such as combfishes, sculpins, and poachers), 12% were viviparous (bearing live young -- all surfperches), and 10% had demersal eggs and larvae (including midshipman and eelpouts). Southern California is located at the edge of the geographic range of many cool- and warm-water fish species, and recruitment of juveniles is episodic and species dependent (Allen and Pondella 2006). Coastal settlement is more variable than in bays, and interannual variation is probably primarily due to oceanic conditions that affect transport and survival of larvae, along with spawning success and availability of suitable benthic habitat for settling juveniles. In 1989, Allen and Herbinson (1991) surveyed bay, open coast, and protected coastal habitats in southern California with fine-mesh beam trawls. In general, fish densities were higher in bays than on the open coast, densities decreased with increasing depth, and highest densities were recorded in spring (May). On the inner shelf (6 to 15 m, or 20 to 49 ft), speckled sanddab (*Citharichthys stigmaeus*) was the most frequent juvenile fish taxa encountered, but queenfish (*Seriphus politus*) was most abundant.

3.3.2.3 Fish Diversity (All Life Stages)

Studies to document fish offshore of SONGS and adjacent areas have been conducted since 1963 using gill nets (Hickman 1973), otter trawls, which target demersal (epibenthic) fish (DeMartini and Allen 1986; Love et al 1986; SCE 2007), lampara nets (Allen and DeMartini 1983) to sample pelagic and mid-water fish; visual and cine-transects by SCUBA divers in nearby kelp beds (Larson and DeMartini 1984; DeMartini et al 1989); and visual surveys at nearby natural and artificial reefs (Ambrose and Swarbrick 1989). These surveys have collected or observed over 105 species of fish, with 40 to 50 of those species commonly occurring.

The long-term annual NPDES monitoring program for SONGS has been used to track fish populations offshore of the generating station and adjacent areas since 1979. At least 94 species of fish have been collected since 1987, although about 51 species are collected annually. Abundance has been dominated by queenfish, northern anchovy (*Engraulis mordax*), white croaker (*Genyonemus lineatus*), and speckled sanddab (*Citharichthys stigmaeus*), which combined account for 77% of the long-term trawl caught abundance. Requirements for the NPDES trawl program have changed over the years. Currently, surveys are conducted quarterly each year. Samples are collected at three depths at each of San Mateo Point, San Onofre, and Don Light, with two replicate tows at each depth. In 2006, 53 species of fish were collected by otter trawl off SONGS along the 6-, 12- and 18-m (20-, 40-, and 60-ft) isobaths. Abundance and species richness were both highest in spring. In 2006, speckled sanddab was most abundant in winter, white croaker was most abundant in spring, and northern anchovy was the most abundant species during both fall and winter. This program has noted variability in populations from year to year, with a general decline in offshore densities occurring until 1991, but with a subsequent increase in 1997 to the highest densities observed at SONGS, and in 1998 at Don Light, since monitoring began.

Video transect surveys off SONGS in 1985 and 1986 examined the fish assemblages of the San Onofre Kelp (SOK) bed (Kastendiek and Parker 1989). The kelp bed was split into upcoast and downcoast beds for analysis purposes. The most abundant water column (canopy) species were señorita (*Oxyjulis californica*), salema (*Xenistius californica*), halfmoon (*Medialuna californiensis*), kelp bass (*Paralabrax clathratus*), jack mackerel (*Trachurus symmetricus*), Pacific barracuda (*Sphyraena argentea*), and kelp perch (*Brachyistius frenatus*). Average densities ranged from 0.8 fish per 1,000 m^3 (barracuda at the downcoast SOK bed), to 39 fish per 1,000 m^3 (señorita at the upcoast SOK bed). The most abundant bottom fishes were señorita, rock wrasse (*Halichoeres semicinctus*), kelp bass, black perch (*Embiotoca jacksoni*), barred sand bass (*Paralabrax nebulifer*), pile perch (*Rhacochilus vacca*), white seaperch (*Phanerodon furcatus*), and California sheephead (*Semicossyphus pulcher*). Average densities ranged from 0.8 fish per 337 m^3 (sheephead at the downcoast SOK bed) to 11 fish per 337 m^3 (señorita at both SOK beds).

4.0 ENTRAINMENT STUDIES

4.1 INTRODUCTION

The purpose of the entrainment studies is to determine the extent of potential impacts from the operation of the cooling water system of SONGS on fish eggs and larvae and selected invertebrate larvae (target species). Entrainment refers to the withdrawal of aquatic organisms from the source water body into the cooling water intake structure of the generating station. The entrainment studies focused on larval life stages, while the impingement study focuses on juvenile and adult forms. The entrainment sampling plan was designed to characterize the composition and abundance of those organisms both 1) entrained by the generating station, and 2) present offshore in the vicinity of the intake structures and potentially at risk of entrainment.

4.1.1 Discussion of Species to be Analyzed

Several types of organisms are susceptible to entrainment by the generating station. The intent of this study is to estimate entrainment effects on two types of organisms: (1) fish eggs and larvae, and (2) larvae of the following invertebrate species: rock crabs (*Cancer* spp), market squid (*Loligo opalescens*), and California spiny lobster (*Panulirus interruptus*). Assessment of entrainment effects included species identified in the SONGS PIC as representative species:

- northern anchovy
- Pacific sardine
- queenfish
- white croaker
- kelp bass
- barred sand bass
- California spiny lobster

In addition, clinid kelpfishes (*Gibbonsia* spp, or kelp blennies) were also assessed due to their relative abundance in entrainment samples; this taxon ranked third in abundance at Unit 2 and fourth in abundance at Unit 3.

In the Phase II regulations, EPA defined entrainment as "*the incorporation of all life stages of fish and shellfish with intake water flow entering and passing through a cooling water intake structure and into a cooling water system.*" Planktonic organisms in the source water body that are smaller than the CWIS screening system mesh (3/8 in) are susceptible to entrainment. These include species that complete their entire life cycle as planktonic forms (holoplankton) and those with only a portion of their life cycle in the plankton as eggs or larvae (meroplankton). This study estimated entrainment effects on meroplanktonic species including all fish eggs and larvae, and the advanced larval stages of several shellfish species including all crabs, market squid, and California spiny lobster. None of the holoplanktonic forms (such as copepods) were enumerated because these populations are typically widespread, the species have short generation times, and the small population-level impacts would be difficult to estimate. All target taxa in the samples were identified to the lowest practical taxonomic level, but some specimens were combined into broader taxonomic groups because the morphological characteristics of some species are not distinct at smaller stages, descriptions are lacking for some of the larvae (particularly for many of the crab megalops), or specimens were damaged and could not be positively identified. Although all target taxa specimens were enumerated in the samples, including uncommon species and those with no direct fishery value, detailed impact analysis was only applied to a few of the more abundant species or species-groups, in addition to the specific shellfish taxa (spiny lobsters, market squid) regardless of abundance.

4.1.1.1 Fish

Many of the marine fishes in the vicinity of the CWIS produce free-floating larvae as an early life stage, with notable exceptions being surfperches and most sharks and rays which bear well-developed live young. Planktonic larval development promotes dispersal of the population but also puts larvae at risk of entrainment. Some groups (e.g., croakers, flatfishes, anchovies) broadcast eggs directly into the water column where they develop in a free-floating state until hatching into the larval form. In this case both eggs and larvae are potentially susceptible to entrainment. For groups that deposit adhesive eggs onto the substrate (e.g., gobies, cottids) or brood eggs internally until larvae are extruded (e.g., rockfishes, pipefishes), only the larvae and not the eggs are potentially at risk of entrainment.

4.1.1.2 Shellfish

"Shellfish" is a general term to describe crabs, shrimps, lobsters, clams, squids and other invertebrates that are consumed by humans, and it is used to differentiate this group of fishery species from "finfish" which includes bony fishes, sharks and rays. In the present study, rock crabs, spiny lobster, and market squid were selected as representative of the shellfish species at potential risk of entrainment, some of which have direct fishery value and others that are primarily important only as forage species for higher trophic levels. The inclusion of certain shellfish larvae as target species, and the enumeration of only the later stages such as megalops and phyllosomes, was a compromise between attempting to characterize the abundance of all planktonic organisms entrained into the CWIS (a nearly impossible task) and only a few species with commercial fishery value. In addition, only a few species have complete larval descriptions which makes accurate identifications problematical, and impact analyses based on broad taxonomic groups are subject to a great deal of uncertainty. Nevertheless, by including the megalops stage of rock crabs in the sample identifications there is some measure of the relative effects of entrainment on source populations of some of the more abundant but lesser-known species that have planktonic larvae.

4.1.1.3 Protected Species

Some fish and invertebrate species (abalone) in California are protected under California Department of Fish and Game regulations although few marine species are listed as either threatened or endangered.

Special status fish species that could occur in the vicinity of the power plant and that have planktonic larvae potentially at risk of entrainment include garibaldi (*Hypsypops rubicundus*), giant sea bass (*Stereolepis gigas*), tidewater goby (*Eucyclogobius newberryi*), and California grunion (*Leuresthes tenuis*).

The garibaldi, designated as the California state marine fish, is a bright orange shallow-water species that is relatively common around natural and artificial rock reefs in southern California. Because of its territorial behavior it is an easy target for fishers and could be significantly depleted if not protected. Garibaldi spawn from March through October, and the female deposits demersal adhesive eggs in a nest that may contain up to 190,000 eggs deposited by several females (Fitch and Lavenberg 1975). Larval duration ranges from 18–22 days (mean of 20 days) based on daily incremental marks on otoliths in recently settled individuals (Wellington and Victor 1989). The larvae are susceptible to entrainment, particularly in summer months when spawning is at its peak.

The giant sea bass is a long-lived species that can grow to over 7 ft in length and weigh over 500 lbs (Love 1996). Giant sea bass were once a relatively common inhabitant of Southern California waters, yet in the 1980s it was facing the threat of local extinction off the California coast due to overfishing. Actions were taken by CDF&G, resulting in protection from commercial and sport fishing that went into effect in 1982. Although the larvae are potentially susceptible to entrainment from coastally-sited power plants in southern California, no giant sea bass larvae have been identified from entrainment samples.

The tidewater goby is a fish species endemic to California and is listed as federally endangered. The tidewater goby is threatened by modification and loss of habitat resulting primarily from coastal development. It appears to spend all life stages in lagoons, estuaries, and river mouths (Swift et al. 1989) but may enter marine environments when flushed out of these preferred habitats during storm events. Adults or larvae may not survive for long periods in the marine environment but larval transport over short distances may be a natural mechanism for local dispersal.

California grunion is a special status species not because the population is threatened or endangered, but because its spring-summer spawning activities on southern California beaches puts it at risk of overharvesting, and CDFG actively manages the fishery to ensure sustainability. Spawning occurs only three or four nights following each full or new moon, and then only for 1–3 hours immediately after the high tide, from late February to early September (Love 1996). The female swims onto the beach, digs tail-first into the wet sand, and lays her eggs which are then fertilized by the male. After the eggs hatch, the larvae are carried offshore and can be susceptible to entrainment for approximately 30 days as they develop in the plankton.

4.2 PREVIOUSLY COLLECTED DATA

A summary of previously collected entrainment data from SONGS is presented in Section 7.2 (*Discussion*).

4.3 METHODS

4.3.1 Field Sampling

4.3.1.1 Entrainment sampling

4.3.1.1.1 In-Plant Entrainment Sampling

Composition and abundance of ichthyoplankton and shellfish larvae entrained by SONGS was determined by sampling directly inside the plant at each of the two screenwells (Stations E2 [Unit 2] and E3 [Unit 3]) every two weeks from March 2006 through April 2007. Both screen wells are located inside separate enclosed structures with an entryway and catwalk systems located below a concrete deck. From these catwalk systems, a series of steel cables were attached with clamps to create a junction in-between the cooling water system guiding vanes where a pulley system could directly lower the net. The 0.5-m (1.6-ft) diameter conical plankton net with 333 µm (0.013 in) mesh was lowered to just below the surface with a lead salmon ball attached to the bottom. The net was deployed just below the water surface for approximately three minutes until a minimum volume of 35 m^3 (9,247 gal) was filtered. The net was equipped with a calibrated General Oceanics 2030R flowmeter, allowing the calculation of the amount of water filtered. Each 24-hr survey was divided into four 6-hr periods (cycles). During each cycle, two replicate samples were collected at each unit.

At the end of each deployment, the net was retrieved and the contents were gently rinsed into the cod-end with seawater. Contents were washed down from the outside of the net to avoid the introduction of plankton from the wash-down water. The cod end was removed and the sample was then carefully transferred to a prelabeled jar with preprinted internal label. Each sample was preserved in 4–10% buffered formalin-seawater and returned to the laboratory for transfer to ethanol and sorting.

4.3.1.1.2 Offshore Entrainment/Source Water Sampling

The configuration of the source water study area was selected to 1) characterize the larvae of ichthyoplankton and shellfish potentially entrained by the SONGS cooling water intake, and 2) represent larval forms present in the nearshore habitats in the vicinity of the SONGS intake.

To determine composition and abundance of ichthyoplankton in the source water, sampling was done monthly on the same day that the entrainment station was sampled. Source water (offshore entrainment) was sampled in-between the Units 2 and 3 intake structures (O1) for 10 months, then shifted slightly downcoast for an additional 3 months (O2) (Figure 4.3-1). The reasoning behind this shift is explained further in this section. One more offshore station at Don Light (O3) was also sampled for 3 months, and two nearshore stations (S2 and S3) were sampled for three months in 2007 near the intakes and downcoast at Don Light.

Offshore entrainment samples were collected monthly near the SONGS intake structures during simultaneous in-plant entrainment sampling. Offshore entrainment samples were collected using a 60-cm diameter wheeled bongo frame fitted with 333-µm plankton nets, similar to the nets used by the

California Cooperative Oceanic Fisheries Investigations (CalCOFI). Each net was fitted with a Dacron sleeve and a cod end retainer to retain the organisms. Each net was equipped with a General Oceanics 2030R flowmeter, allowing the calculation of the volume of water filtered. Coordinates were determined using a global positioning system (GPS). Entrainment samples were collected using an oblique tow through the water column at a station located just inshore from the intake structures. The samples were collected using an oblique tow that sampled the water column from approximately 13 cm (6 in) off the bottom to the sea surface. This was not a stepped oblique tow that was used in some previous ichthyoplankton studies. With the vessel stationary, the bongo was lowered to the bottom. The vessel then moved forward slow ahead, and the cable was slowly retrieved until the bongo reached the sea surface. Two replicate tows were taken at the intake with a target volume of 35 m^3 per net. The net was redeployed if the target volume was not achieved during the initial tow. Sampling was conducted four times per 24-hr survey; sampling cycles were initiated at approximately 1200 hr, 1800 hr, 2400 hr, and 0600 hr. The offshore sampling methodology was the same as that used in recent 316(b) and CEC-mandated studies in California, including those at Diablo Canyon Power Plant, Morro Bay Power Plant, Huntington Beach Generating Station, and South Bay Power Plant.

In February 2007, the offshore sampling program was modified to collect additional information on spatial variability and vertical distribution of plankton in the SONGS source waters. This was done in response to a request from the SDRWQCB to collect more information on spatial variability. The following changes were made to the offshore sampling conducted in February, March, and April 2007:

1. The offshore entrainment station (Station O1) was moved approximately 400 m downcoast (Station O2) (Figure 4.3-1). The reason for this was to allow collection of inshore samples using a Manta net, and epibenthic samples in an area clear of obstructions;

2. An additional offshore station (at the same depth of the entrainment station) was sampled approximately 9 km downcoast off Don Light (O3).

3. Inshore of both offshore stations, surface waters were sampled using a Manta net (Stations S2 and S3);

4. At both offshore stations, sampling included oblique tows through the water column with a wheeled bongo, an epibenthic (suprabenthic) tow with a wheeled bongo, and a surface tow with a Manta net.

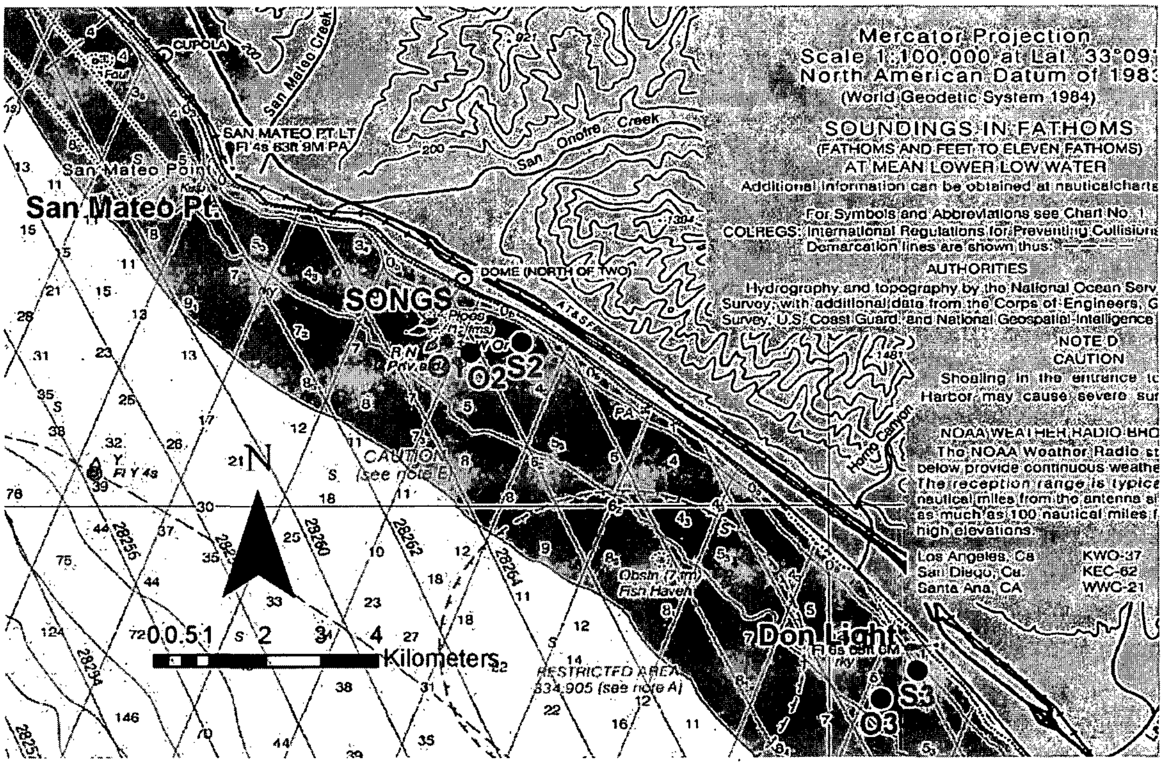


Figure 4.3-1. Location of SONGS offshore plankton sampling stations.

The Manta net was towed on the side of the boat to ensure that the boat wake or propeller wash did not have an effect on the incoming sample. To ensure the bottom tows stayed on the sea floor and sampled appropriately, the length of line deployed and angle of the line were constantly used to track the bongo depth. The wheeled bongo was lowered vertically prior to the tow to prevent introduction of plankton into the net. At the end of the tow, however, the bongo was brought to the surface, and plankton could have been introduced into the nets during this time. The target volumes were the same as that for the entrainment sampling (35 m^3 per net).

Samples were processed using the same procedures described for entrainment sampling in Section 4.3.2. During each source water survey, the source water stations were sampled four times per 24-hr period at 6-hr intervals. This interval allowed adequate time for one vessel and crew to conduct all source water and entrainment sampling while also partitioning samples into day-night blocks for analysis of diel trends. With the addition of the extra sample site, the order in which the stations were sampled from cycle to cycle was varied to avoid introducing a systematic bias into the data.

4.3.2 Laboratory Analysis

Samples were returned to the laboratory and transferred from formalin to 70% ethanol after approximately 72 hours. Samples were examined under a dissecting microscope and all fish eggs (entrainment samples only) and larvae were removed and placed in labeled vials, in addition, the following shellfish larvae were also removed:

- rock crab megalopa
- California spiny lobster phyllosoma
- market squid paralarvae

The samples from the two nets were preserved in separate 400 ml (13.5 oz) jars and processed separately, but the data from the two nets were combined for analysis. If the quantity of material in the two samples was very large then only one of the two samples was processed and analyzed. However, if the quantity of material exceeded 200 ml (6.8 oz), then the sample was split into multiple jars to ensure that the material was properly preserved. In some cases the collection of ctenophores, salps, and other larger planktonic organisms resulted in samples with large volumes of material, but these could be separated from other plankton with little difficulty and were generally not split, depending upon the final volume of the material.

Specimens were enumerated and identified to the lowest practical taxon. A representative sample of up to 50 larvae from each species for each survey (100 during the first two surveys) was measured from the entrainment samples using a dissecting microscope and image analysis system. If fewer than 50 individuals from a species were collected during the survey then all of the larvae from the survey were measured. Total length was measured to an accuracy of at least 0.1 mm (0.004 in).

4.3.3 QA/QC Procedures and Validation

A quality control (QC) program was implemented for the field and laboratory components of the study. Quality control surveys were completed on a quarterly basis to ensure that the field sampling was conducted properly. Prior to the start of the study the field survey procedures were reviewed with all personnel and all personnel were given printed copies of the procedures.

A more detailed QC program was applied to all laboratory processing. The first ten samples sorted by an individual were resorted by a designated quality control (QC) sorter. A sorter was allowed to miss one target organism if the total number of target organisms in the sample was less than 20. For samples with 20 or more target organisms the sorter was required to maintain a sorting accuracy of 90%. After a sorter completed ten consecutive samples with greater than 90% accuracy, the sorter had one of their next ten samples randomly selected for a QC check. If the sorter failed to achieve an accuracy level of 90% then their next ten samples were resorted by the QC sorter until they met the required level of accuracy. If the sorter maintained the required level of accuracy random QC checks resumed at the level of one sample check per ten sorted.

A similar QC program was conducted for the taxonomists identifying the samples. The first ten samples of fish or invertebrates identified by an individual taxonomist were completely re-identified by a designated QC taxonomist. A total of at least 50 individual fish or invertebrate larvae from at least five taxa must have been present in these first ten samples; if not, additional samples were re-identified until this criterion was met. Taxonomists were required to maintain a 95% identification accuracy level in these first ten samples. After the taxonomist identified ten consecutive samples with greater than 95% accuracy, they had one of their next ten samples checked by a QC taxonomist. If the taxonomist maintained an accuracy level of 95% then they continued to have one of each ten samples checked by a QC taxonomist. If one of the checked samples fell below the minimum accuracy level then ten more consecutive samples were identified by the QC taxonomist until ten consecutive samples met the 95% criterion. Identifications were cross-checked against taxonomic voucher collections maintained by MBC and Tenera Environmental, and specialists were consulted for problem specimens.

4.3.4 Data Analysis

4.3.4.1 Entrainment Estimates

Estimates of daily larval entrainment for the sampling period from March 2006 through April 2007 at SONGS were calculated from data collected at the entrainment station and data on daily cooling water flow from the power plant. Estimates of average larval concentration for the day when entrainment samples were collected were extrapolated across the days between surveys to calculate total entrainment during the days when no samples were collected. The total estimated daily entrainment for the survey periods and across the entire year where then summed to obtain estimates of total survey and annual entrainment, respectively.

The mean density and variance for each entrainment sampling station (Unit 2 in-plant, Unit 3 in-plant, and offshore [O1 and O2]) was calculated for each sampling day. Repetitions within a cycle were included. Unit-specific entrainment estimates based on offshore densities were derived by multiplying the survey density by the unit-specific cooling water flow. Total estimated entrainment for the sampling period (E) was calculated by multiplying the mean density by the total cooling water flow recorded for the sampling period. The estimated variance was calculated by the equation:

$$\text{Est. Variance} = (\text{Var}/n) * E^2$$

Annual estimates were derived by summing all entrainment and variance estimates. Standard error represents the square root of the total annual estimated variance.

4.3.4.2 Entrainment Impact Assessment

To put the entrainment results in context, losses were compared to (1) known population estimates where available, (2) commercial fishing landings for those species harvested commercially, and (3) sport fishing landings for those species targeted by recreational anglers. Commercial landing data were derived from three potential sources: (1) the Pacific Fishery Information Network (PacFIN), which summarized all commercial landings in the Los Angeles Area for the last seven years, (2) California Department of Fish and Game landing reports originating from Los Angeles area ports from 2005, and (3) California Department of Fish and Game catch block data from Orange and San Diego County area catch blocks in 2006. The five catch blocks in this analysis included: 737, 756, 757, 801, and 802

(Figure 4.3-2). Sport fishing landings were derived from the Recreational Fishery Information Network (RecFIN), which included all marine areas in southern California.

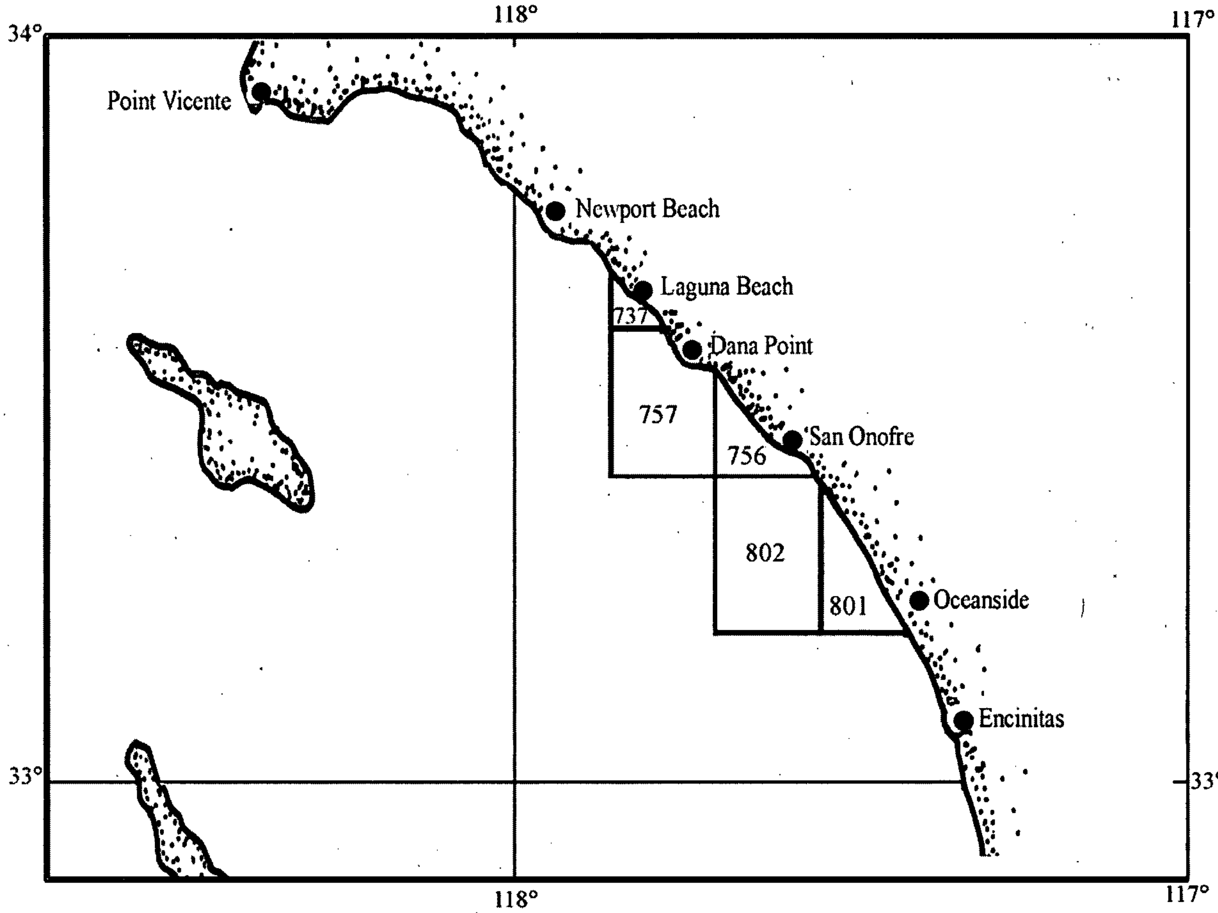


Figure 4.3-2. Location of the five CDFG catch blocks used in the SONGS impact analysis.

4.4 DATA SUMMARY

4.4.1 Summary of Processed Samples

Twenty-six entrainment surveys were completed between March 29, 2006 and April 26, 2007 at each of the in-plant entrainment stations (Table 4.4-1). Thirteen offshore sampling efforts were completed during that same time period. During the last three offshore sampling efforts, the sampling stations were altered to provide additional information on the spatial variability of entrainable organisms in the waters off San Onofre.

Table 4.4-1. Summary of SONGS entrainment/source water sampling effort.

Start Date	Unit 2 in-plant	Unit 3 in-plant	Offshore entrainment (O1)	Offshore entrainment (O2) and source water (O3, S2-3)
3/29/06	X	X		
4/12/06	X	X	X	
4/26/06	X	X		
5/10/06	X	X	X	
5/24/06	X	X		
6/07/06	X	X	X	
6/21/06	X	X		
7/06/06	X	X	X	
7/19/06	X	X		
8/02/06	X	X		
8/16/06	X	X		
8/30/06	X	X	X	
9/13/06	X	X	X	
9/27/06	X	X		
10/11/06	X	X	X	
10/25/06	X			
11/08/06	X			
11/21/06	X		X	
12/06/06	X	X	X	
12/20/06	X	X		
1/03/07	X	X		
1/17/07	X	X	X	
1/31/07	X	X		
2/14/07	X	X		X
2/28/07	X	X		
3/14/07	X	X		X
3/28/07		X		
4/11/07		X		
4/25/07		X		X

4.5 RESULTS

4.5.1 In-Plant Entrainment Summary

4.5.1.1 Fish

The most abundant larval fish taxa collected in in-plant entrainment samples at Unit 2 were northern anchovy, unidentified anchovies, clinid kelpfishes, and queenfish (Table 4.5-1). These same four taxa were most abundant at Unit 3, but queenfish were slightly more abundant than clinid kelpfishes. The most abundant fish egg taxa collected in in-plant entrainment samples at Units 2 and 3 were unidentified fish eggs and anchovy eggs. Total annual entrainment was estimated to be approximately 1.1 billion larvae at Unit 2 and 1.4 billion larvae at Unit 3, and 13 billion fish eggs at Unit 2 and 14 billion fish eggs at Unit 3 (Table 4.5-2).

Larval concentrations peaked in abundance in early-April 2006 at Unit 2 and in late-May 2006 at Unit 3 (Figure 4.5-1). Concentrations were highest from April through July 2006 at both units, and were relatively low from August 2006 through April 2007. A similar pattern was apparent for fish eggs at both units, although concentrations peaked in late-April 2006 (Figure 4.5-2).

Larval fish concentrations were generally higher at nighttime at Unit 2 (Figure 4.5-3), but during the first four months of sampling this was not necessarily the case at Unit 3 (Figure 4.5-5). (Note: Disregard negative symbols with nighttime concentrations in all figures depicting diel variation). During the last nine months of the study period, nighttime entrainment of fish larvae was generally higher than daytime entrainment. There was no clear diel pattern of entrainment with respect to fish eggs at either unit (Figures 4.5-4 and 4.5-6).

Table 4.5-1. Average concentration (No. per 1,000 m^3) of larval fishes and fish eggs collected from in-plant entrainment samples at SONGS in 2006-7.

Taxon	Common Name	Avg. Conc. (per 1,000 m^3) Unit 2	Unit 3	Mean	Percent
Larval Fish					
Engraulis mordax	northern anchovy	285.28	280.53	282.90	38.52
Engraulidae unid.	anchovies	48.50	249.13	148.82	20.26
Seriphus politus	queenfish	45.56	40.68	43.12	5.87
Gibbonsia spp	clinid kelpfishes	45.94	39.86	42.90	5.84
Hypsoblennius spp	combtooth blennies	34.06	36.72	35.39	4.82
Gobiidae unid.	gobies	38.67	31.56	35.11	4.78
Genyonemus lineatus	white croaker	24.07	39.76	31.91	4.34
Typhlogobius californiensis	blind goby	22.17	21.08	21.63	2.94
Leuresthes tenuis	California grunion	11.01	12.04	11.53	1.57
Gobiesox spp	clingfishes	10.71	8.94	9.83	1.34
Sciaenidae unid.	croakers	4.71	12.72	8.72	1.19
larvae, unidentified yolksac	unidentified yolksac larvae	6.73	10.34	8.53	1.16
Heterostichus rostratus	giant kelpfish	5.55	3.79	4.67	0.64
Labrisomidae unid.	labrisomid blennies	5.95	3.31	4.63	0.63
Atherinopsis californiensis	jacksmelt	4.80	4.08	4.44	0.60
larval fish fragment	unidentified larval fishes	4.84	3.58	4.21	0.57
Roncador stearnsii	spotfin croaker	3.90	3.32	3.61	0.49
Paralichthys californicus	California halibut	3.37	3.72	3.54	0.48
Paralabrax spp	sand bass	2.34	4.08	3.21	0.44
Atherinopsidae unid.	silversides	2.78	2.92	2.85	0.39
Rimicola spp	kelp clingfishes	0.54	4.05	2.30	0.31
Sphyraena argentea	Pacific barracuda	2.55	1.99	2.27	0.31
larval/post-larval fish unid.	larval fishes	1.92	2.32	2.12	0.29
Stenobrachius leucopsarus	northern lampfish	0.80	2.85	1.82	0.25
Perciformes unid.	perch-like fishes	0.48	2.42	1.45	0.20
Menticirrhus undulatus	California corbina	1.64	0.77	1.20	0.16
Gobiesocidae unid.	clingfishes	1.59	0.44	1.01	0.14
larval fish - damaged	unidentified larval fishes	0.78	1.17	0.97	0.13
Pleuronichthys guttulatus	diamond turbot	0.85	0.99	0.92	0.12
Sardinops sagax	Pacific sardine	0.91	0.90	0.90	0.12
Ophidiidae unid.	cusk-eels	0.42	1.31	0.86	0.12
Cheilotrema saturnum	black croaker	0.74	0.78	0.76	0.10
Haemulidae unid.	grunts	0.10	1.26	0.68	0.09
Clinidae unid.	kelp blennies	0.84	0.31	0.57	0.08
Peprilus simillimus	Pacific butterfish	0.51	0.41	0.46	0.06
Triphoturus mexicanus	Mexican lampfish	0.20	0.68	0.44	0.06
Diaphus theta	California headlight fish	0.30	0.54	0.42	0.06
Pleuronichthys spp	turbots	0.00	0.72	0.36	0.05
Ruscarius creaseri	roughcheck sculpin	0.34	0.21	0.27	0.04
Oxyjulis californica	senorita	0.22	0.32	0.27	0.04
Syngnathus spp	pipefishes	0.10	0.42	0.26	0.04
Paralichthyidae unid.	sand flounders	0.10	0.40	0.25	0.03
Pleuronichthys verticalis	hornyhead turbot	0.11	0.32	0.22	0.03
Citharichthys stigmaeus	speckled sanddab	0.10	0.32	0.21	0.03
Pleuronichthys ritteri	spotted turbot	0.00	0.38	0.19	0.03
Oxylebius pictus	painted greenling	0.00	0.33	0.16	0.02
Chaenopsidae unid.	tube blennies	0.29	-	0.15	0.02
Parophrys vetulus	English sole	0.24	-	0.12	0.02
Xystreurys liolepis	fantail sole	0.00	0.23	0.12	0.02
Citharichthys sordidus	Pacific sanddab	0.00	0.22	0.11	0.02
Gillichthys mirabilis	longjaw mudsucker	0.12	0.10	0.11	0.01
Semicossyphus pulcher	California sheephead	0.00	0.19	0.09	0.01
Lepidogobius lepidus	bay goby	0.00	0.12	0.06	0.01
Hypsypops rubicundus	garibaldi	0.00	0.12	0.06	0.01
Oligocottus / Clinocottus	sculpins	0.12	-	0.06	0.01
Acanthogobius flavimanus	yellowfin goby	0.11	-	0.06	0.01
Anchoa spp	anchovy	0.11	-	0.05	0.01

(*table continued*)

Table 4.5-1. (Cont.). Average concentration (No. per 1,000 m^3) of larval fishes and fish eggs collected from in-plant entrainment samples at SONGS in 2006-7.

Taxon	Common Name	Avg. Conc. (per 1,000 m^3) Unit 2	Unit 3	Mean	Percent
Larval Fish					
Pleuronectiformes unid.	flatfishes	0.00	0.11	0.05	0.01
Pleuronectidae unid.	righteye flounders	0.00	0.11	0.05	0.01
Umbrina roncador	yellowfin croaker	0.00	0.10	0.05	0.01
Anisotremus davidsonii	sargo	0.00	0.10	0.05	0.01
Atherinops affinis	topsmelt	0.00	0.10	0.05	0.01
Sebastes spp	rockfishes	0.00	0.10	0.05	0.01
Halichoeres semicinctus	rock wrasse	0.10	-	0.05	0.01
Atractoscion nobilis	white seabass	0.00	0.10	0.05	0.01
Paralabrax clathratus	kelp bass	0.10	-	0.05	0.01
Rimicola eigenmanni	slender clingfish	0.09	-	0.04	0.01
Xenistius californiensis	salema	0.00	0.09	0.04	0.01
Scorpaenichthys marmoratus	cabezon	0.09	-	0.04	0.01
Artedius lateralis	smoothhead sculpin	0.09	-	0.04	0.01
		628.54	**840.50**	**734.52**	**100.00**
Fish Eggs					
Engraulidae unid.	anchovy eggs	2,769.34	4,321.15	3,545.24	42.82
fish eggs unid.	unidentified fish eggs	3,392.55	2,805.08	3,098.81	37.43
Sciaen./Paralichth./Labridae	fish eggs	1,122.49	1,219.50	1,170.99	14.14
Paralichthyidae unid.	sand flounder eggs	162.35	171.16	166.70	2.01
Sciaenidae unid.	croaker eggs	116.93	90.47	103.70	1.25
Citharichthys spp	sanddab eggs	69.13	61.45	65.29	0.79
Pleuronichthys spp	turbot eggs	54.89	67.48	61.19	0.74
Atherinopsis californiensis	jacksmelt eggs	47.46	26.21	36.83	0.44
Labridae unid.	wrasse eggs	14.36	8.81	11.58	0.14
Sphyraena argentea	Pacific barracuda eggs	7.58	4.66	6.12	0.07
Paralabrax spp	sand bass eggs	4.70	4.38	4.54	0.05
Pleuronectidae unid.	righteye flounder eggs	2.25	3.15	2.70	0.03
Atractoscion nobilis	white seabass	1.25	1.10	1.17	0.01
Sardinops sagax	Pacific sardine eggs	0.67	1.16	0.92	0.01
Blenniidae	blenny eggs	0.36	1.07	0.71	0.01
Pleuronichthys guttulatus	diamond turbot eggs	0.55	0.60	0.58	0.01
Labridae / Serranidae	fish eggs	1.08	0.00	0.54	0.01
Merlucciidae / Sphyraenidae	hake / barracuda eggs	0.33	0.48	0.41	0.00
Atherinopsidae unid.	silverside eggs	0.47	0.23	0.35	0.00
Leuresthes tenuis	California grunion eggs	0.00	0.57	0.28	0.00
Bathylagidae	blacksmelt eggs	0.32	0.11	0.21	0.00
Atherinops affinis	topsmelt eggs	0.00	0.12	0.06	0.00
Carangidae	jack eggs	0.00	0.10	0.05	0.00
Hippoglossina stomata	bigmouth sole eggs	0.10	0.00	0.05	0.00
		7,768.78	**8,789.04**	**8,278.91**	**100.00**

Table 4.5-2. Total annual entrainment of larval fishes and fish eggs based on in-plant entrainment samples and actual cooling water flow volumes at SONGS in 2006-7.

		Unit 2 Annual Entrainment		Unit 3 Annual Entrainment	
Taxon	**Common Name**	**No.**	**Standard Error**	**No.**	**Standard Error**
Larval Fish					
Engraulis mordax	northern anchovy	479,007,401	68,988,831	434,342,517	53,641,744
Engraulidae unid.	anchovies	81,430,734	14,405,619	416,667,363	53,641,744
Seriphus politus	queenfish	76,505,225	13,786,845	68,249,022	5,669,608
Gibbonsia spp	clinid kelpfishes	77,130,359	4,537,232	66,286,861	1,591,190
Hypsoblennius spp	combtooth blennies	57,195,189	1,445,425	61,551,467	1,109,347
Gobiidae unid.	gobies	64,936,382	807,196	52,179,237	1,552,430
Genyonemus lineatus	white croaker	40,408,936	861,044	53,612,958	1,680,864
Typhlogobius californiensis	blind goby	37,232,896	728,449	33,319,355	819,732
Leuresthes tenuis	California grunion	18,492,455	2,772,680	20,218,496	2,607,047
Gobiesox spp	clingfishes	17,982,919	309,631	14,733,192	291,750
Sciaenidae unid.	croakers	7,915,558	123,437	21,254,568	522,291
larvae, unidentified yolksac	unidentified yolksac	11,302,128	74,565	17,358,885	725,133
Heterostichus rostratus	giant kelpfish	9,318,234	146,043	6,331,092	32,320
Labrisomidae unid.	labrisomid blennies	9,985,990	190,110	5,560,975	39,770
Atherinopsis californiensis	jacksmelt	8,064,738	125,842	6,782,274	69,337
larval fish fragment	unidentified larval fishes	8,133,839	186,820	5,903,338	45,807
Roncador stearnsii	spotfin croaker	6,554,214	63,617	5,580,349	74,659
Paralichthys californicus	California halibut	5,659,783	21,382	5,628,546	26,831
Paralabrax spp	sand bass	3,924,521	23,739	6,849,344	86,290
Atherinopsidae unid.	silversides	4,674,293	53,074	4,873,972	40,741
Rimicola spp	kelp clingfishes	911,868	3,449	6,804,784	196,908
Sphyraena argentea	Pacific barracuda	4,278,418	32,147	3,340,072	36,253
larval/post-larval fish unid.	larval fishes	3,230,932	15,358	3,892,231	75,341
Stenobrachius leucopsarus	northern lampfish	1,342,616	8,615	4,730,034	51,148
Perciformes unid.	perch-like fishes	800,791	9,926	4,065,305	127,899
Menticirrhus undulatus	California corbina	2,749,166	35,120	1,292,244	6,804
Gobiesocidae unid.	clingfishes	2,667,796	18,809	733,628	2,367
larval fish - damaged	unidentified larval fishes	1,301,285	3,570	1,890,686	3,963
Sardinops sagax	Pacific sardine	1,534,418	3,878	1,503,420	5,479
Pleuronichthys guttulatus	diamond turbot	1,420,112	2,024	1,545,857	2,134
Ophidiidae unid.	cusk-eels	707,150	2,198	2,194,425	40,827
Cheilotrema saturnum	black croaker	1,235,414	8,949	1,309,035	6,592
Haemulidae unid.	grunts	175,012	475	2,122,096	31,671
Clinidae unid.	kelp blennies	1,402,675	4,116	514,443	1,969
Peprilus simillimus	Pacific butterfish	856,975	4,321	691,309	1,297
Triphoturus mexicanus	Mexican lampfish	329,357	595	1,146,293	10,859
Diaphus theta	California headlight fish	511,473	1,834	913,160	4,448
Gillichthys mirabilis	longjaw mudsucker	198,260	608	1,100,262	411
Ruscarius creaseri	roughcheek sculpin	570,886	2,845	350,023	671
Oxyjulis californica	senorita	365,522	731	539,242	1,351
Syngnathus spp	pipefishes	175,012	475	685,125	970
Paralichthyidae unid.	sand flounders	169,845	447	663,236	1,919
Pleuronichthys verticalis	hornyhead turbot	191,802	570	530,847	842
Citharichthys stigmaeus	speckled sanddab	171,137	453	529,555	862
Pleuronichthys ritteri	spotted turbot	-	-	580,451	855
Oxylebius pictus	painted greenling	-	-	547,638	3,287
Chaenopsidae unid.	tube blennies	487,578	1,651	-	-
Parophrys vetulus	English sole	395,229	951	-	-
Xystreurys liolepis	fantail sole	-	-	390,708	1,549
Citharichthys sordidus	Pacific sanddab	-	-	375,855	461
Semicossyphus pulcher	California sheephead	-	-	311,921	1,508
Lepidogobius lepidus	bay goby	-	-	201,489	628
Hypsypops rubicundus	garibaldi	-	-	199,552	617
Oligocottus / Clinocottus	sculpins	193,094	579	-	-
Acanthogobius flavimanus	yellowfin goby	187,928	546	-	-
Anchoa spp	anchovy	184,053	523	-	-

(*table continued*)

Table 4.5-2. (Cont.). Total annual entrainment of larval fishes and fish eggs based on in-plant entrainment samples and actual cooling water flow volumes at SONGS in 2006-7.

		Unit 2 Annual Entrainment		Unit 3 Annual Entrainment	
Taxon	**Common Name**	**No.**	**Standard Error**	**No.**	**Standard Error**
Larval Fish					
Pleuronectiformes unid.	flatfishes	-	-	184,053	523
Pleuronectidae unid.	righteye flounders	-	-	176,303	481
Umbrina roncador	yellowfin croaker	-	-	175,012	474
Anisotremus davidsonii	sargo	-	-	174,366	469
Atherinops affinis	topsmelt	-	-	171,783	458
Sebastes spp	rockfishes	-	-	170,491	449
Halichoeres semicinctus	rock wrasse	169,845	447	-	-
Gillichthys mirabilis	longjaw mudsucker	-	-	162,741	411
Atractoscion nobilis	white seabass	-	-	161,903	406
Paralabrax clathratus	kelp bass	159,512	394	-	-
Rimicola eigenmanni	slender clingfish	150,471	350	-	-
Xenistius californiensis	salema	-	-	150,471	351
Scorpaenichthys marmoratus	cabezon	146,596	333	-	-
Artedius lateralis	smoothhead sculpin	142,722	314	-	-
		1,055,370,747	**109,819,182**	**1,354,505,858**	**124,894,547**
Fish Eggs					
Engraulidae unid.	anchovy eggs	4,649,934,983	104,603,451,976	6,507,702,844	310,326,916,208
fish eggs unid.	unidentified fish eggs	5,696,345,721	14,936,219,301	4,664,735,156	12,045,795,708
Sciaen./Paralichth./Labridae	fish eggs	1,884,744,389	3,358,962,952	2,046,332,962	4,548,589,518
Paralichthyidae unid.	sand flounder eggs	272,605,324	15,478,112	285,869,922	27,868,854
Sciaenidae unid.	croaker eggs	196,332,586	80,974,293	150,512,932	25,708,317
Citharichthys spp	sanddab eggs	116,070,102	3,582,008	102,371,375	2,047,917
Pleuronichthys spp	turbot eggs	92,172,309	15,478,112	109,272,586	1,667,795
Atherinopsis californiensis	jacksmelt eggs	79,680,619	96,295,510	43,801,805	26,826,771
Labridae unid.	wrasse eggs	24,110,906	659,474	14,788,797	342,038
Sphyraena argentea	Pacific barracuda eggs	12,732,573	414,138	7,830,313	344,770
Paralabrax spp	sand bass eggs	7,899,413	307,745	7,351,776	162,931
Pleuronectidae unid.	righteye flounder eggs	3,785,674	525	5,296,198	4,970
Atractoscion nobilis	white seabass	2,016,830	63,003	1,841,173	52,502
Sardinops sagax	Pacific sardine eggs	1,119,170	7,837	1,954,834	27,765
Blenniidae	blenny eggs	602,530	2,545	1,796,217	12,056
Pleuronichthys guttulatus	diamond turbot eggs	928,659	6,935	1,013,904	10,671
Labridae / Serranidae		1,806,300	50,524	-	-
Merlucciidae / Sphyraenidae	hake / barracuda eggs	561,199	3,440	803,374	9,995
Atherinopsidae unid.	silverside eggs	794,333	9,768	387,435	828
Leuresthes tenuis	California grunion eggs	-	-	951,032	7,571
Bathylagidae	blacksmelt eggs	533,430	2,157	181,470	510
Carangidae	jack eggs	-	-	163,543	414
Hippoglossina stomata	bigmouth sole eggs	163,387	414	-	-
Atherinops affinis	topsmelt eggs	-	-	126,018	263
		13,044,940,439	123,111,970,769	13,955,085,664	327,006,398,372

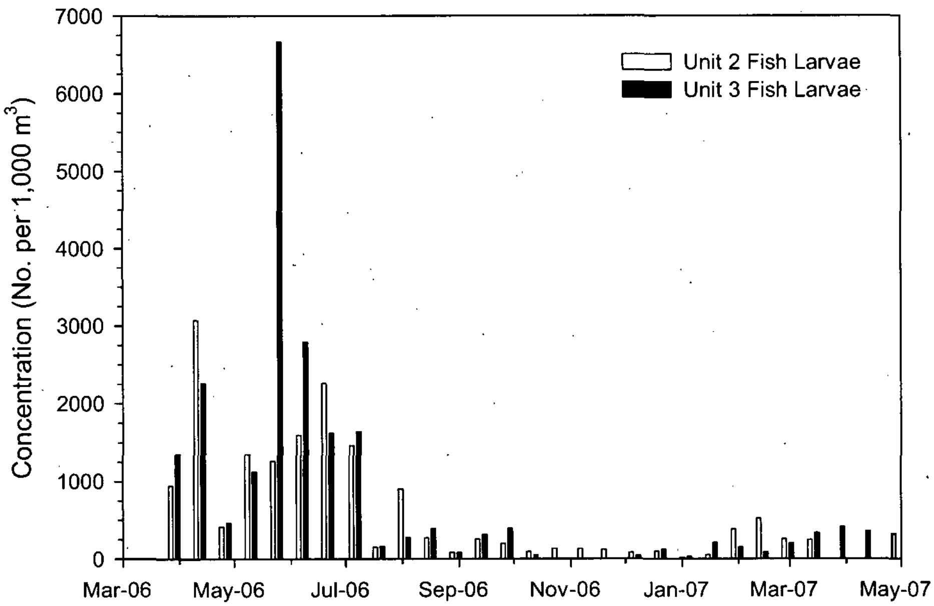


Figure 4.5-1. Mean concentration (# / 1,000 m^3 [264,172 gal]) of all larval fishes collected at SONGS in-plant entrainment stations, March 2006 through April 2007.

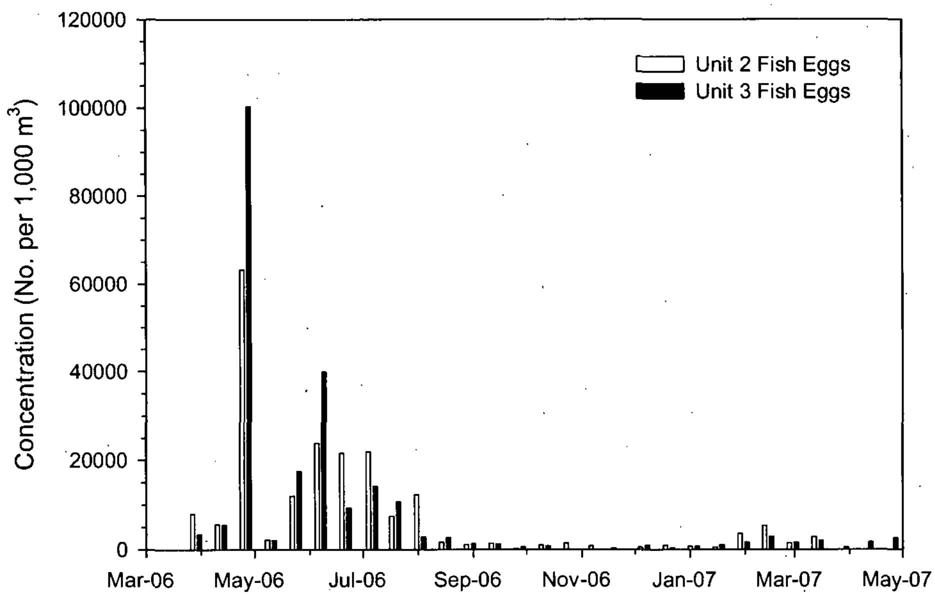


Figure 4.5-2. Mean concentration (# / 1,000 m^3 [264,172 gal]) of all fish eggs collected at SONGS in-plant entrainment stations, March 2006 through April 2007.

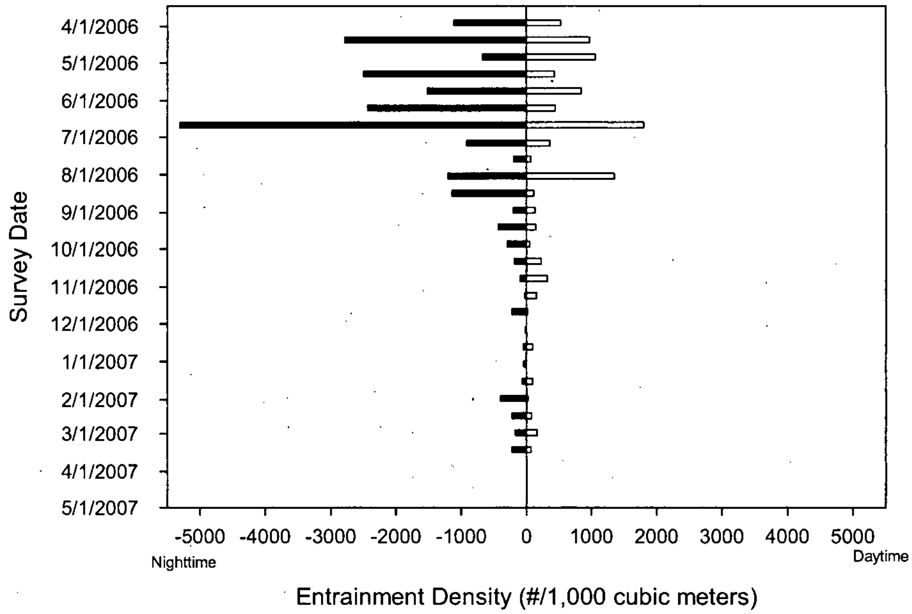


Figure 4.5-3. Mean concentration (# / 1,000 m3 [264,172 gal]) of all larval fishes collected at SONGS Unit 2 during night (Cycle 3) and day (Cycle 1) sampling.

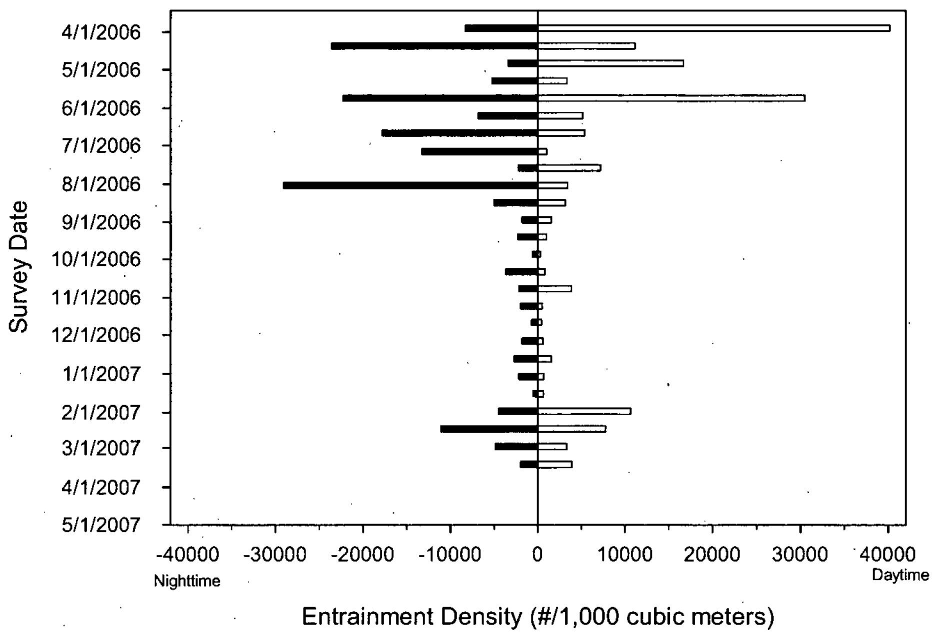


Figure 4.5-4. Mean concentration (# / 1,000 m3 [264,172 gal]) of all fish eggs collected at SONGS Unit 2 during night (Cycle 3) and day (Cycle 1) sampling.

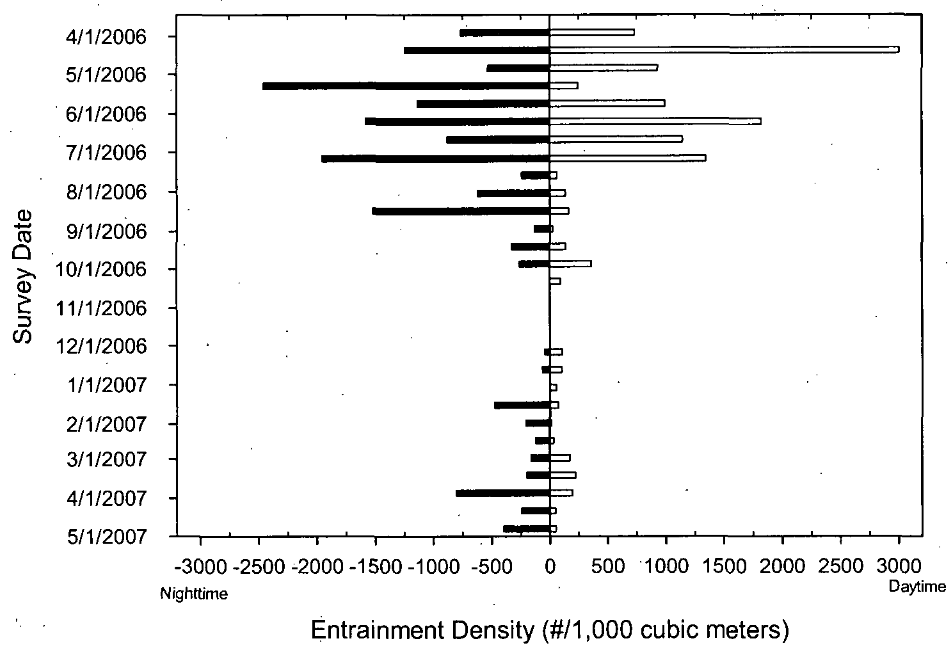


Figure 4.5-5. Mean concentration (# / 1,000 m3 [264,172 gal]) of all larval fishes collected at SONGS Unit 3 during night (Cycle 3) and day (Cycle 1) sampling.

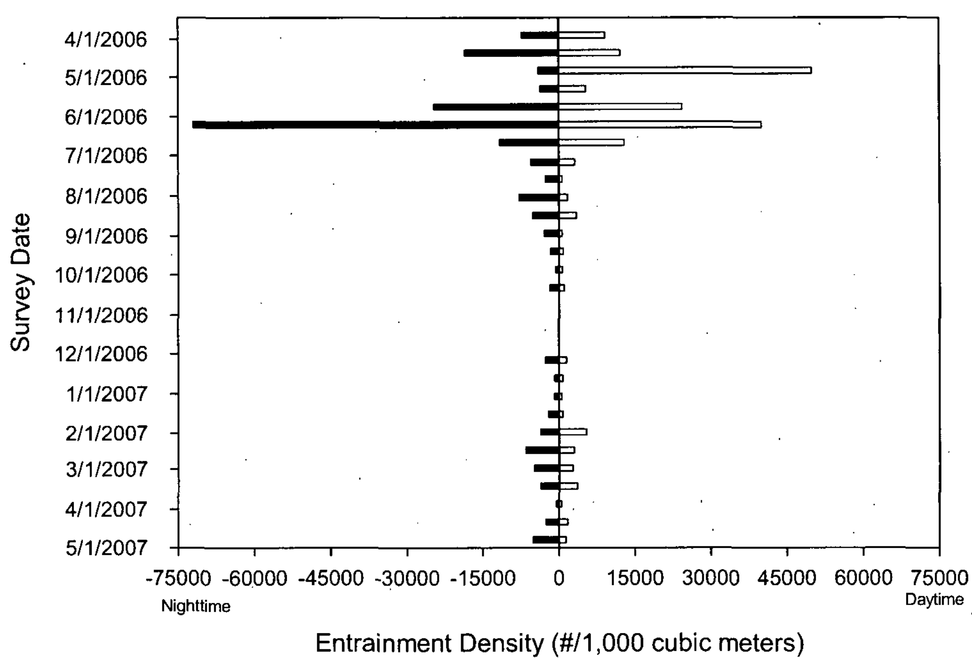


Figure 4.5-6. Mean concentration (# / 1,000 m3 [264,172 gal]) of all fish eggs collected at SONGS Unit 3 during night (Cycle 3) and day (Cycle 1) sampling.

4.5.1.2 Target Shellfishes

The most abundant target shellfish larvae collected in in-plant entrainment samples at Unit 2 were brown rock crab megalops (*Cancer antennarius*), yellow crab megalops (*Cancer anthonyi*), and slender crab megalops (*Cancer gracilis*) (Table 4.5-3). The most abundant taxa at Unit 3 were California spiny lobster phyllosoma, brown rock crab, and yellow crab. Total annual entrainment of target invertebrate larvae was estimated at 7.0 million larvae at Unit 2 and 10.5 million larvae at Unit 3 (Table 4.5-4).

Table 4.5-3. Average concentration (No. per 1,000 m^3) of target shellfish larva collected from in-plant entrainment samples at SONGS in 2006-7.

		Avg. Conc. (per 1,000 m^3)			
Taxon	**Common Name**	**Unit 2**	**Unit 3**	**Mean**	**Percent**
Cancer antennarius (megalops)	brown rock crab megalops	1.27	1.62	1.44	27.80
Panulirus interruptus (phyllosome)	California spiny lobster (larval)	0.75	1.95	1.35	26.05
Cancer anthonyi (megalops)	yellow crab megalops	1.25	1.37	1.31	25.19
Cancer gracilis (megalops)	slender crab megalops	0.79	1.13	0.96	18.56
Cancer productus (megalops)	red rock crab megalops	0.06	0.19	0.12	2.40
		4.13	6.26	5.19	100.00

Table 4.5-4. Total annual entrainment of target shellfish taxa based on in-plant entrainment samples and actual cooling water flow volumes at SONGS in 2006-7.

		Unit 2 Annual Entrainment		Unit 3 Annual Entrainment	
Taxon	**Common Name**	**No.**	**Standard Error**	**No.**	**Standard Error**
Cancer antennarius (megalops)	brown rock crab megalops	2,127,262	26,516	2,721,909	7,130
Panulirus interruptus (phyllosome)	California spiny lobster (larval)	1,265,120	5,025	3,277,430	92,479
Cancer anthonyi (megalops)	yellow crab megalops	2,100,138	7,836	2,293,098	6,347
Cancer gracilis (megalops)	slender crab megalops	1,334,221	1,317	1,903,170	3,654
Cancer productus (megalops)	red rock crab megalops	100,745	157	317,733	556
		6,927,486	**40,851**	**10,513,340**	**110,166**

4.5.2 Offshore Entrainment Summary

4.5.2.1 Fishes

The most abundant larval fish taxa collected offshore SONGS near the intake structures were northern anchovy, unidentified anchovies, unidentified yolksac larvae, and combtooth blennies (Table 4.5-5). The most abundant fish egg taxa collected offshore Units 2 and 3 were unidentified fish eggs, and fish eggs comprised of the complex Sciaenidae (croakers)/Paralichthyidae (sand flounders)/Labridae (wrasses). Total annual entrainment was estimated to be approximately 3.6 billion larvae at Unit 2 and 3.3 billion larvae at Unit 3, and 18 billion fish eggs at Unit 2 and 18 billion fish eggs at Unit 3 (Table 4.5-6).

Offshore larval concentrations peaked in abundance in April and June 2006 (Figure 4.5-7), while fish egg concentrations were highest in June and July 2006 (Figure 4.5-8). Concentrations of both eggs and larvae were relative low from August 2006 through April 2007.

Table 4.5-5. Average concentration (No. per 1,000 m^3) of larval fishes and fish eggs collected from offshore entrainment samples (Stations O1 and O2) at SONGS in 2006-7.

Taxon	Common Name	Avg. Conc. (per 1,000 m^3)	Percent
Larval Fish			
Engraulis mordax	northern anchovy	920.72	46.86
Engraulidae unid.	anchovies	364.66	18.56
larvae, unidentified yolksac	unidentified yolksac larvae	115.12	5.86
Hypsoblennius spp	combtooth blennies	108.78	5.54
larval fish fragment	unidentified larval fishes	82.41	4.19
Sciaenidae unid.	croakers	71.68	3.65
Seriphus politus	queenfish	42.83	2.18
larval/post-larval fish unid.	larval fishes	39.03	1.99
Genyonemus lineatus	white croaker	31.47	1.60
Perciformes unid.	perch-like fishes	26.70	1.36
Typhlogobius californiensis	blind goby	24.70	1.26
Sphyraena argentea	Pacific barracuda	22.05	1.12
Haemulidae unid.	grunts	21.54	1.10
Paralabrax spp	sand bass	15.68	0.80
Paralichthys californicus	California halibut	13.36	0.68
Roncador stearnsii	spotfin croaker	10.04	0.51
Gibbonsia spp	clinid kelpfishes	9.92	0.50
Leuresthes tenuis	California grunion	7.81	0.40
Labrisomidae unid.	labrisomid blennies	5.08	0.26
Gobiidae unid.	gobies	3.74	0.15
Pleuronichthys guttulatus	diamond turbot	3.02	0.15
Atherinopsidae unid.	silversides	2.90	0.15
larval fish - damaged	unidentified larval fishes	2.31	0.12
Oxyjulis californica	senorita	1.66	0.08
Pleuronichthys spp	turbots	1.54	0.08
Menticirrhus undulatus	California corbina	1.14	0.06
Heterostichus rostratus	giant kelpfish	1.08	0.06
Semicossyphus pulcher	California sheephead	0.95	0.05
Pleuronichthys verticalis	hornyhead turbot	0.92	0.05
Paralichthyidae unid.	sand flounders	0.77	0.04
Symphurus atricaudus	California tonguefish	0.68	0.03
Gobiesox spp	clingfishes	0.67	0.03
Atherinopsis californiensis	jacksmelt	0.61	0.03
Peprilus simillimus	Pacific butterfish	0.60	0.03
Sardinops sagax	Pacific sardine	0.58	0.03
Diaphus theta	California headlight fish	0.58	0.03
Pleuronichthys ritteri	spotted turbot	0.55	0.03
Triphoturus mexicanus	Mexican lampfish	0.54	0.03
Citharichthys stigmaeus	speckled sanddab	0.53	0.03
Xystreurys liolepis	fantail sole	0.47	0.02
Stenobrachius leucopsarus	northern lampfish	0.46	0.02
Gillichthys mirabilis	longjaw mudsucker	0.45	0.02
Citharichthys spp	sanddabs	0.45	0.02
Pleuronectiformes unid.	flatfishes	0.39	0.02
Labridae unid.	wrasses	0.36	0.02
Cottidae unid.	sculpins	0.33	0.02
Citharichthys sordidus	Pacific sanddab	0.33	0.02
Ophidiidae unid.	cusk-eels	0.28	0.01
Citharichthys sordidus	Pacific sanddab	0.26	0.01
Sarda chiliensis	Pacific bonito	0.24	0.01
Rhinogobiops nicholsii	blackeye goby	0.22	0.01
Cheilotrema saturnum	black croaker	0.21	0.01
Atractoscion nobilis	white seabass	0.21	0.01
Lepidogobius lepidus	bay goby	0.17	0.01
Anisotremus davidsonii	sargo	0.13	0.01
Halichoeres semicinctus	rock wrasse	0.13	0.01
Girella nigricans	opaleye	0.13	0.01

(*table continued*)

Table 4.5-5. (Cont.). Average concentration (No. per 1,000 m^3) of larval fishes and fish eggs collected from offshore entrainment samples (Stations O1 and O2) at SONGS in 2006-7.

Taxon	**Common Name**	**Avg. Conc. (per 1,000 m^3)**	**Percent**
Larval Fish			
Hypsoblennius jenkinsi	mussel blenny	0.13	0.01
Orthonopias triacis	snubnose sculpin	0.11	0.01
Myctophidae unid.	lanternfishes	0.10	0.01
Umbrina roncador	yellowfin croaker	0.10	0.01
Blennioidei unid.	blennies	0.10	0.00
Rimicola spp	kelp clingfishes	0.10	0.00
Merluccius productus	Pacific hake	0.07	0.00
Clinidae unid.	kelp blennies	0.06	0.00
Clupeidae unid.	Clupeidae unid.	0.00	0.00
Lyopsetta exilis	slender sole	0.00	0.00
Ruscarius creaseri	roughcheek sculpin	0.00	0.00
		1,964.94	**100.00**
Fish Eggs			
fish eggs unid.	unidentified fish eggs	6,678.05	66.76
Sciaen./Paralichth./Labridae	fish eggs	1,875.11	18.75
Engraulidae unid.	anchovy eggs	549.90	5.50
Paralichthyidae unid.	sand flounder eggs	295.59	2.96
Sciaenidae unid.	croaker eggs	237.21	2.37
Citharichthys spp	sanddab eggs	123.82	1.24
Pleuronichthys spp	turbot eggs	72.70	0.73
Labridae unid.	wrasse eggs	63.05	0.63
Sciaenidae unid	croaker eggs	42.38	0.42
Sciaenidae / Paralichthyidae	fish eggs	36.18	0.36
Paralabrax spp	sand bass eggs	20.57	0.21
Sphyraena argentea	Pacific barracuda eggs	7.63	0.08
Sardinops sagax	Pacific sardine eggs	0.94	0.01
		10,003.13	**100.00**

Table 4.5-6. Total annual entrainment of larval fishes and fish eggs based on offshore entrainment samples (Stations O1 and O2) and actual cooling water flow volumes at SONGS in 2006-7.

		Unit 2 Annual Entrainment		Unit 3 Annual Entrainment	
Taxon	**Common Name**	**No.**	**Standard Error**	**No.**	**Standard Error**
Larval Fish					
Engraulis mordax	northern anchovy	1,657,143,781	1,544,885,912	1,442,956,757	1,400,824,288
Engraulidae unid.	anchovies	656,466,119	344,981,993	598,035,710	338,620,320
larvae, unidentified yolksac	unidentified yolksac larvae	213,879,959	56,390,027	213,469,870	56,390,027
Hypsoblennius spp	combtooth blennies	197,522,574	30,939,026	196,889,524	30,939,026
larval fish fragment	unidentified larval fishes	149,666,272	13,251,445	145,105,502	13,235,129
Sciaenidae unid.	croakers	132,869,228	17,253,822	132,713,000	17,253,822
Seriphus politus	queenfish	77,329,425	7,347,726	77,296,847	7,347,726
larval/post-larval fish unid.	larval fishes	70,243,005	8,145,668	70,156,278	8,145,668
Genyonemus lineatus	white croaker	56,237,945	776,498	51,160,517	710,529
Perciformes unid.	perch-like fishes	49,631,868	4,747,091	49,631,868	4,747,091
Typhlogobius californiensis	blind goby	44,809,440	775,576	40,417,011	630,728
Haemulidae unid.	grunts	40,039,539	4,968,603	40,039,539	4,968,603
Sphyraena argentea	Pacific barracuda	39,763,460	3,882,499	39,763,460	3,882,499
Paralabrax spp	sand bass	29,039,275	879,451	29,039,275	879,451
Paralichthys californicus	California halibut	24,506,903	214,298	23,032,660	213,934
Roncador stearnsii	spotfin croaker	18,064,843	687,924	18,064,843	687,924
Gibbonsia spp	clinid kelpfishes	17,707,644	61,077	16,889,831	60,608
Leuresthes tenuis	California grunion	14,436,585	331,039	14,435,587	331,039
Labrisomidae unid.	labrisomid blennies	9,309,423	36,899	9,250,457	36,898
Gobiidae unid.	gobies	6,846,382	22,773	6,577,839	22,629
Atherinopsidae unid.	silversides	5,319,161	26,143	5,001,832	26,111
Pleuronichthys guttulatus	diamond turbot	5,447,412	8,285	4,382,370	6,842
larval fish - damaged	unidentified larval fishes	4,236,075	8,103	4,070,904	8,051
Oxyjulis californica	senorita	3,058,320	16,227	3,058,320	16,227
Pleuronichthys spp	turbots	2,799,889	10,324	2,565,138	10,311
Menticirrhus undulatus	California corbina	2,085,193	9,635	2,085,193	9,635
Heterostichus rostratus	giant kelpfish	1,868,073	5,145	1,842,336	5,145
Semicossyphus pulcher	California sheephead	1,758,880	4,358	1,758,880	4,358
Pleuronichthys verticalis	hornyhead turbot	1,669,613	2,258	1,535,065	2,064
Paralichthyidae unid.	sand flounders	1,412,178	4,785	1,336,922	4,763
Symphurus atricaudus	California tonguefish	1,231,862	4,435	1,231,862	4,435
Gobiesox spp	clingfishes	1,212,903	1,050	1,151,330	1,027
Sardinops sagax	Pacific sardine	1,083,442	3,153	1,083,442	3,153
Peprilus simillimus	Pacific butterfish	1,077,891	4,810	1,075,365	4,799
Diaphus theta	California headlight fish	1,067,921	3,310	1,067,921	3,310
Atherinopsis californiensis	jacksmelt	1,096,308	1,593	811,423	1,226
Citharichthys sordidus	*Pacific sanddab*	1,041,560	897	973,604	862
Triphoturus mexicanus	Mexican lampfish	988,580	1,115	803,957	831
Xystreurys liolepis	fantail sole	866,570	2,441	866,570	2,441
Citharichthys stigmaeus	speckled sanddab	974,915	950	745,762	620
Pleuronichthys ritteri	spotted turbot	988,320	625	710,367	466
Citharichthys spp	sanddabs	812,323	3,613	812,323	3,613
Gillichthys mirabilis	longjaw mudsucker	824,086	991	791,182	987
Stenobrachius leucopsarus	northern lampfish	818,774	554	760,459	518
Pleuronectiformes unid.	flatfishes	726,847	1,048	686,536	1,041
Labridae unid.	wrasses	662,082	1,088	662,082	1,088
Cottidae unid.	*sculpins*	603,777	479	599,975	476
Ophidiidae unid.	cusk-eels	507,367	768	434,718	617
Sarda chiliensis	Pacific bonito	431,763	926	431,763	926
Rhinogobiops nicholsii	blackeye goby	399,934	729	399,934	729
Cheilotrema saturnum	black croaker	397,535	1,041	397,535	1,041
Atractoscion nobilis	white seabass	390,386	1,050	390,386	1,050
Lepidogobius lepidus	bay goby	290,038	269	264,302	262
Anisotremus davidsonii	sargo	245,957	378	245,957	378
Halichoeres semicinctus	rock wrasse	245,957	478	245,957	478

(table continued)

Table 4.5-6. (Cont.). Total annual entrainment of larval fishes and fish eggs based on offshore entrainment samples (Stations O1 and O2) and actual cooling water flow volumes at SONGS in 2006-7.

		Unit 2 Annual Entrainment		Unit 3 Annual Entrainment	
Taxon	**Common Name**	**No.**	**Standard Error**	**No.**	**Standard Error**
Larval Fish					
Hypsoblennius jenkinsi	mussel blenny	234,517	437	234,517	437
Girella nigricans	opaleye	228,336	349	228,336	349
Orthonopias triacis	snubnose sculpin	204,955	304	204,474	303
Myctophidae unid.	lanternfishes	194,478	263	194,478	263
Umbrina roncador	yellowfin croaker	184,053	219	184,053	219
Blennioidei unid.	blennies	174,366	244	174,366	244
Rimicola spp	kelp clingfishes	174,366	200	174,366	200
Merluccius productus	Pacific hake	127,315	105	97,343	80
Clinidae unid.	kelp blennies	109,325	83	83,588	64
		3,555,787,272	**2,040,714,605**	**3,261,783,562**	**1,890,059,979**
Fish Eggs					
fish eggs unid.	unidentified fish eggs	12,254,081,802	44,136,890,603	12,078,087,071	44,136,840,883
Sciaen./Paralichth./Labridae	fish eggs	3,425,485,808	2,980,117,671	3,404,894,229	2,980,117,581
Engraulidae unid.	anchovy eggs	996,448,660	88,134,424	856,085,621	68,658,112
Paralichthyidae unid.	sand flounder eggs	541,680,730	13,964,865	507,995,947	13,935,858
Sciaenidae unid.	croaker eggs	404,867,993	82,093,623	404,823,965	82,093,153
Citharichthys spp	sanddab eggs	227,373,988	2,654,146	211,500,022	2,645,205
Pleuronichthys spp	turbot eggs	131,025,626	1,054,150	117,313,844	1,036,453
Labridae unid.	wrasse eggs	116,636,098	6,243,148	116,636,098	6,243,148
Sciaenidae unid	croaker eggs	78,034,062		65,291,417	
Sciaenidae / Paralichthyidae	fish eggs	60,751,604	7,143,678	60,751,604	7,143,678
Paralabrax spp	sand bass eggs	37,915,090	606,329	37,915,090	606,329
Sphyraena argentea	Pacific barracuda eggs	14,175,427	236,336	14,175,427	236,336
Sardinops sagax	Pacific sardine eggs	1,743,150	3,129	1,743,150	3,129
		18,290,220,040	**47,319,142,102**	**17,877,213,485**	**47,299,559,865**

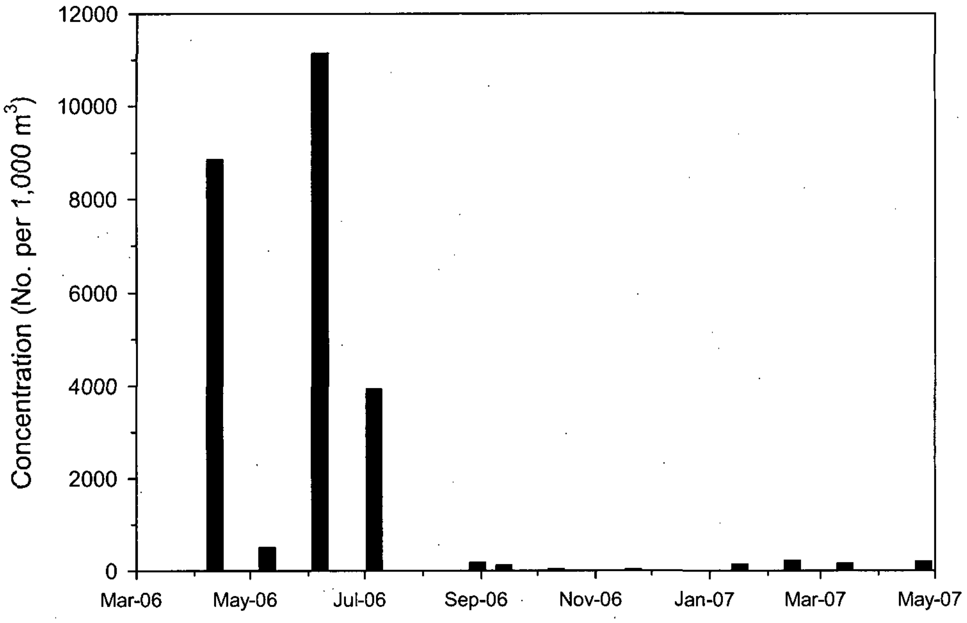


Figure 4.5-7. Mean concentration (# / 1,000 m3 [264,172 gal]) of all larval fishes collected at SONGS offshore entrainment stations (O1 and O2), March 2006 through April 2007.

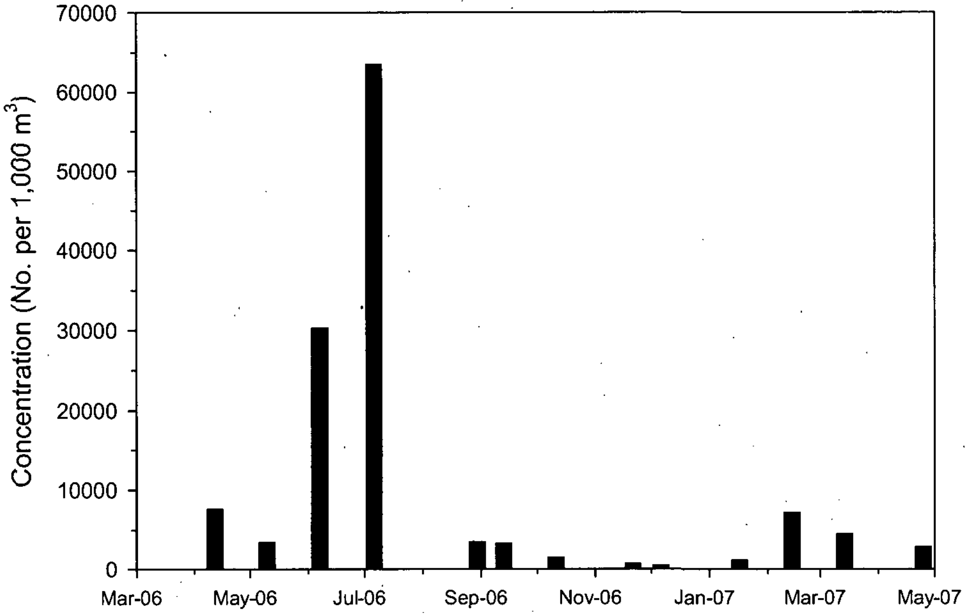


Figure 4.5-8. Mean concentration (# / 1,000 m3 [264,172 gal]) of all fish eggs collected at SONGS offshore entrainment stations (O1 and O2), March 2006 through April 2007.

4.5.2.2 Target Shellfishes

The most abundant target shellfish larvae collected offshore SONGS at the entrainment stations were California spiny lobster phyllosome, brown rock crab megalops, and yellow crab megalops (Table 4.5-7). Total annual entrainment of target invertebrate larvae based on offshore collections was estimated at 21.1 million larvae at Unit 2 and 20.8 million larvae at Unit 3 (Table 4.5-8).

Table 4.5-7. Average concentration (No. per 1,000 m^3) of target shellfishes collected from offshore entrainment samples (Stations O1 and O2) at SONGS in 2006-7.

Taxon	Common Name	Avg. Conc. (per 1,000 m^3)	Percent
Panulirus interruptus (phyllosome)	California spiny lobster (larval)	5.36	46.80
Cancer antennarius (megalops)	brown rock crab megalops	2.19	19.11
Cancer anthonyi (megalops)	yellow crab megalops	2.13	18.63
Cancer gracilis (megalops)	slender crab megalops	1.71	14.93
Cancer productus (megalops)	red rock crab megalops	0.17	1.47
		11.46	**100.00**

Table 4.5-8. Total annual entrainment of target shellfish larvae based on offshore entrainment samples (Stations O1 and O2) and actual cooling water flow volumes at SONGS in 2006-7.

		Unit 2 Annual Entrainment		Unit 3 Annual Entrainment	
Taxon	Common Name	No.	Standard Error	No.	Standard Error
Panulirus interruptus (phyllosome)	California spiny lobster (larval)	9,965,555	300,388	9,798,015	300,387
Cancer antennarius (megalops)	brown rock crab megalops	3,946,670	42,371	3,817,613	42,370
Cancer anthonyi (megalops)	yellow crab megalops	3,870,273	18,062	3,870,273	18,062
Cancer gracilis (megalops)	slender crab megalops	3,069,096	23,462	3,066,250	23,462
Cancer productus (megalops)	red rock crab megalops	290,038	269	264,302	262
		21,141,633	**384,522**	**20,816,453**	**384,543**

4.5.3 Offshore Source Water Summary

This section summarizes the results of plankton samples collected at four stations offshore SONGS (O2, O3, S2, and S3) during three surveys in 2007. During each of the surveys, three strata were sampled at the two offshore stations (O2 and O3): surface by Manta net, and water column and suprabenthos by wheeled bongo. At each of the shoreline stations (S2 and S3) only the surface waters were sampled by Manta net.

The most abundant larval taxa collected in the source water samples were northern anchovy, California grunion, unidentified silversides, and jacksmelt (*Atherinopsis californiensis*) (Table 4.5-9). Shoreline surface samples (collected at Stations S2 and S3) were dominated by grunion, silversides, jacksmelt, and clinid kelpfishes. Surface samples collected offshore were dominated by grunion, jacksmelt, silversides, and northern anchovy, but densities were two to three times lower than surface densities inshore. Water column densities were dominated by white croaker, northern anchovy, and unidentified anchovies, with densities about four times lower than surface densities at the same stations. Larval taxa most abundant in the suprabenthos were northern anchovy, unidentified gobies, white croaker, and bay goby (*Lepidogobius lepidus*). Densities in the bottom layer were about twice as high as larval densities at the surface, and about eight times higher than water column densities.

The most abundant fish egg taxa collected in the source water samples were unidentified fish eggs, Sciaenid (croaker) eggs, Engraulid (anchovy) eggs, and sand flounder (Paralichthyidae) eggs (Table 4.5-9). Shoreline and offshore surface samples (collected at Stations S2 and S3) were dominated by the same four egg groups, with inshore densities about 9% lower than those recorded offshore. Eggs of the same four taxa were also most abundant in the water column, with densities about 75% lower than those at the surface. Egg densities in the bottom layer were lowest, equal to only about one-third of the densities in the water column and about 8% of those recorded at the surface.

Temporal density patterns were similar between fish eggs and larvae (Figures 4.5-9 and 4.5-10). Suprabenthic densities were highest in February and March 2007, water column densities were highest in February, and surface densities peaked in April 2007.

The most abundant target invertebrate larvae collected offshore were slender crab megalops, yellow crab megalops, and brown rock crab megalops (Table 4.5-9). Densities were very low compared with fish eggs and larvae, and there was no clear distributional pattern.

Table 4.5-9. Average concentration (No. per 1,000 m^3) of larval fishes, fish eggs, and target invertebrates collected from source water samples by strata off SONGS in 2007.

		Shoreline (S2-3)	Offshore (02-3)		
Taxon	Common Name	Surface	Surface	Water Column	Suprabenthos
Larval Fish					
Engraulis mordax	northern anchovy	42.03	53.97	43.58	689.56
Leuresthes tenuis	California grunion	472.51	223.61	0.77	0.52
Atherinopsidae unid.	silversides	446.34	125.51	1.16	1.54
Atherinopsis	jacksmelt	406.48	138.62	0.72	-
Gibbonsia spp	clinid kelpfishes	305.07	20.70	5.81	38.01
Genyonemus lineatus	white croaker	8.86	18.73	48.23	201.79
Gobiidae unid.	gobies	-	4.72	1.74	228.94
Lepidogobius lepidus	bay goby	-	0.91	1.84	92.52
Engraulidae unid.	anchovies	9.35	30.34	33.52	10.25
Seriphus politus	queenfish	-	-	0.20	43.85
Atherinops affinis	topsmelt	24.08	12.95	-	-
Paralichthys californicus	California halibut	1.76	12.63	6.99	1.69
larvae, unidentified	unid. yolksac larvae	1.63	9.45	5.70	0.82
Heterostichus rostratus	giant kelpfish	-	-	1.52	14.89
larval fish fragment	unid. larval fishes	6.38	2.08	0.50	5.93
Pleuronichthys guttulatus	diamond turbot	1.76	1.40	6.72	2.41
Clinidae unid.	kelp blennies	5.22	5.18	-	1.44
Sardinops sagax	Pacific sardine	4.27	3.36	1.99	1.90
larval fish - damaged	unid. larval fishes	5.98	1.96	0.46	2.31
Scorpaenichthys	cabezon	-	8.73	-	-
Citharichthys stigmaeus	speckled sanddab	0.74	2.97	0.77	-
Sciaenidae unid.	croakers	1.86	0.46	2.07	-
Typhlogobius	blind goby	1.01	0.56	1.22	0.75
Hypsoblennius spp	combtooth blennies	-	0.55	1.25	1.27
Pleuronectiformes unid.	flatfishes	2.38	0.56	-	-
Stenobrachius	northern lampfish	1.12	-	0.65	1.12
Paralichthyidae unid.	sand flounders	-	1.42	0.23	0.44
Peprilus simillimus	Pacific butterfish	-	-	1.49	0.39
Gobiesox spp	clingfishes	-	-	-	1.71
Citharichthys sordidus	Pacific sanddab	-	0.99	0.71	-
Pleuronichthys spp	turbots	-	0.58	0.67	0.40
Pleuronichthys verticalis	hornyhead turbot	-	-	1.24	0.37
Pleuronectidae unid.	righteye flounders	0.96	-	-	0.44
Pleuronichthys ritteri	spotted turbot	-	0.46	0.48	0.31
Labrisomidae unid.	labrisomid blennies	-	-	-	0.77
Clupeidae unid.	Clupeidae unid.	-	-	0.22	0.36
Syngnathus spp	pipefishes	-	-	-	0.38
Gillichthys mirabilis	longjaw mudsucker	-	-	-	0.38
Leptocottus armatus	Pacific staghorn sculpin	-	-	-	0.32
Bathylagus ochotensis	popeye blacksmelt	-	-	-	0.31
Cottidae unid.	sculpins	-	-	0.26	-
Ruscarius creaseri	roughcheek sculpin	-	-	0.26	-
Orthonopias triacis	snubnose sculpin	-	-	0.25	-
Lyopsetta exilis	slender sole	-	-	0.23	-
		1,749.77	**683.42**	**173.43**	**1,348.09**

(table continued)

Table 4.5-9. (Cont.). Average concentration (No. per 1,000 m^3) of larval fishes, fish eggs, and target invertebrates collected from source water samples by strata off SONGS in 2007.

		Shoreline (S2-3)	Offshore (02-3)		
Taxon	**Common Name**	**Surface**	**Surface**	**Water Column**	**Suprabenthos**
Fish Eggs					
fish eggs unid.	unid. fish eggs	10,130.71	12,040.02	2,666.95	862.92
Sciaenidae unid.	croaker eggs	2,102.52	2,667.39	1,107.59	223.22
Engraulidae unid.	anchovy eggs	2,066.99	1,334.88	224.03	128.64
Paralichthyidae unid.	sand flounder	1,637.31	1,438.33	429.37	141.27
Pleuronichthys spp	turbot eggs	1,174.07	1,328.43	93.32	53.65
Citharichthys spp	sanddab eggs	357.81	419.18	196.23	77.98
Sciaenidae / Paralichthyidae	fish eggs	-	-	78.39	16.87
Sciaen. / Paralichthy. / Labri.	fish eggs	-	61.17	-	-
Sardinops sagax	Pacific sardine	0.95	4.58	2.48	3.09
Labridae unid.	wrasse eggs	5.95	3.07	-	-
Atherinopsis californiensis	jacksmelt eggs	-	-	-	2.16
Atherinopsidae unid.	silverside eggs	-	-	-	0.80
Carangidae	jack eggs	-	-	0.32	-
		17,476.31	**19,276.66**	**4,798.69**	**1,510.58**
Target Invertebrates					
Cancer gracilis (megalops)	slender crab meg.	-	3.00	1.40	5.07
Cancer anthonyi (megalops)	yellow crab meg.	-	1.45	0.41	3.21
Cancer antennarius (megalops)	brown rock crab	-	1.61	0.24	2.76
Cancer productus (megalops)	red rock crab	1.97	-	0.68	0.77
Cancer spp (megalops)	cancer crabs	-	-	-	0.37
		1.97	**6.06**	**2.73**	**12.18**

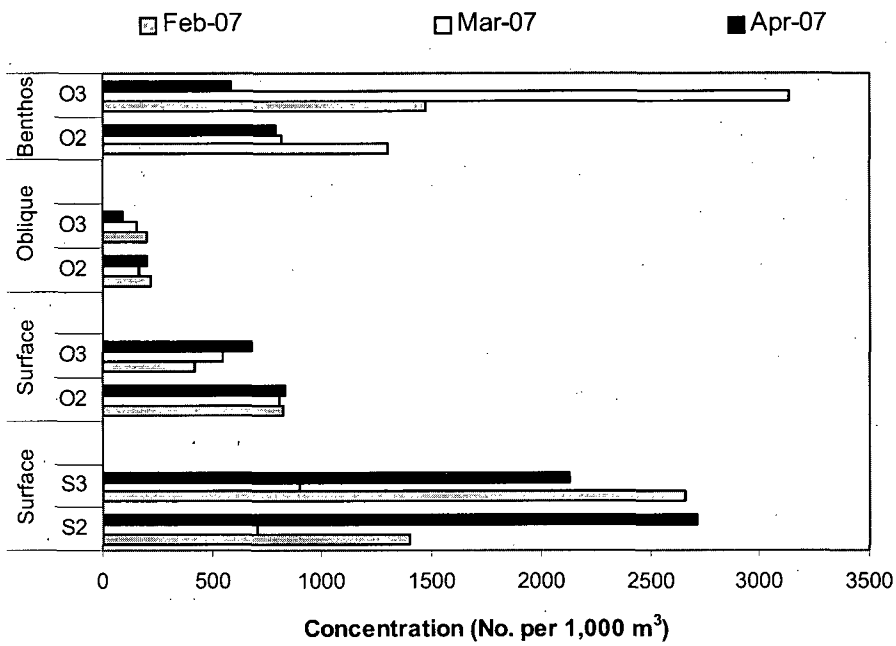


Figure 4.5-9. Mean concentration (# / 1,000 m3 [264,172 gal]) of all larval fishes by strata and station collected offshore SONGS, February – April 2007.

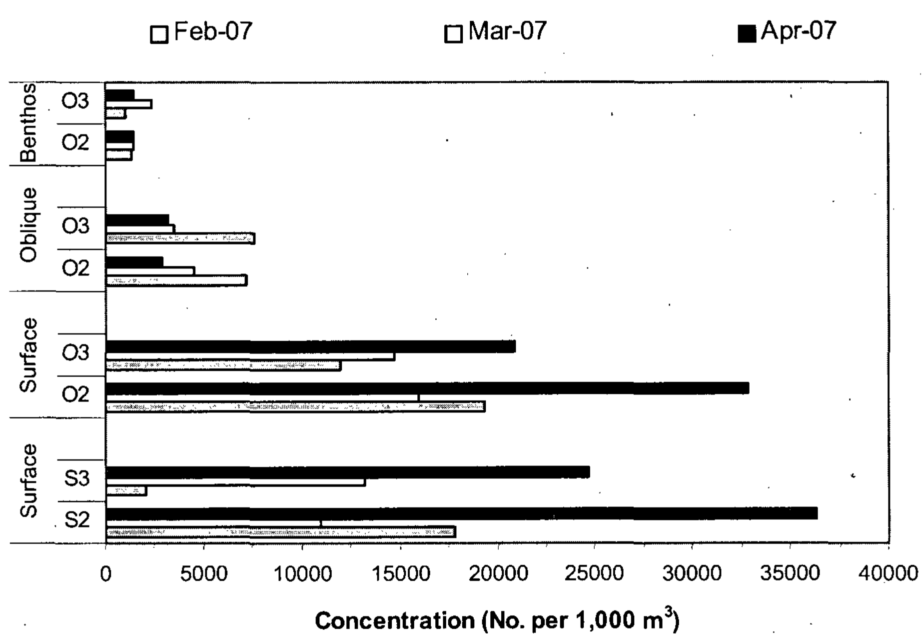


Figure 4.5-10. Mean concentration (# / 1,000 m3 [264,172 gal]) of all fish eggs by strata and station collected offshore SONGS, February – April 2007.

4.5.4 Entrainment Results by Species

The following sections present entrainment results by species. In addition to the taxa listed in the SONGS Proposal for Information Collection (PIC), clinid kelpfishes (or kelp blennies, *Gibbonsia* spp) were included in the analysis based on their relative abundance in entrainment samples.

4.5.4.1 Anchovies (Engraulidae)


Mark Conlin

Three species of anchovy (Family Engraulidae) inhabit nearshore areas of southern California: northern anchovy, deepbody anchovy (*Anchoa compressa*) and slough anchovy (*Anchoa delicatissima*). This analysis of entrainment effects on anchovies will concentrate on life history aspects of the northern anchovy because almost all of the Engraulid larvae collected that were large enough to be positively identified were northern anchovies. The remainder was very small specimens still in their recently-hatched yolk-sac stage and some that were damaged to an extent that they could not be positively identified to the species level.

Northern anchovy range from Cabo San Lucas, Baja California to Queen Charlotte Island, British Columbia (Miller and Lea 1972), and the Gulf of California (Hammann and Cisneros-Mata 1989). They are most common from Magdalena Bay, Baja California to San Francisco Bay within 157 km (98 mi) of shore (Hart 1973; MBC 1987). Three genetically distinct subpopulations are recognized for northern anchovy; (1) Northern subpopulation, from northern California to British Columbia; (2) Central subpopulation, from central California to northern Baja California; and (3) Southern subpopulation, off southern Baja California (Emmett et al. 1991).

4.5.4.1.1 Life History and Ecology

The reported depth range of northern anchovy is from the surface to depths of 310 m (1,017 ft) (Davies and Bradley 1972). Juveniles are generally more common inshore and in estuaries. Eggs are elliptical and occur from the surface to depths of about 50 m (164 ft), while larvae are found from the surface to about 75 m (246 m) in epipelagic and nearshore waters (Garrison and Miller 1982). Northern anchovy larvae feed on dinoflagellates, rotifers, and copepods (MBC 1987).

Northern anchovy spawn throughout the year off southern California, with peak spawning between February and May (Brewer 1978) although this may vary annually and geographically. Most spawning takes place within 100 km (62 mi) of shore (MBC 1987). On average, female anchovies off Los Angeles spawn every 7–10 days during peak spawning periods, approximately 20 times per year (Hunter and Macewicz 1980; MBC 1987). Most spawning occurs at night and is completed by dawn

(Hunter and Macewicz 1980). Anchovies are all sexually mature by age two, and the fraction of the population that is sexually mature at one year of age can range from 47 to 100% depending on the water temperature during development (Bergen and Jacobsen 2001). Love (1996) reported that they release 2,700–16,000 eggs per batch, with an annual fecundity of up to 130,000 eggs per year in southern California. Parrish et al. (1986) and Butler et al. (1993) stated that the total annual fecundity for one-year old females was 20,000–30,000 eggs, while a five-year old could release up to 320,000 eggs per year.

The northern anchovy egg hatches in two to four days, has a larval phase lasting approximately 70 days, and undergoes transformation into a juvenile at about 35–40 mm (Hart 1973; MBC 1987; Moser 1996). Larvae begin schooling at 11–12 mm (0.4–0.5 in) SL (Hunter and Coyne 1982). Northern anchovy on average reach 102 mm (4 in) in their first year, and 119 mm (4.7 in) in their second (Sakagawa and Kimura 1976). Larval survival is strongly influenced by the availability and density of phytoplankton species (Emmett et al. 1991). Storms and strong upwelling reduce larval food availability, and strong upwelling may transport larvae out of the SCB (Power 1986). However, strong upwelling may benefit juveniles and adults by increasing food resources. Growth in length is most rapid during the first four months, and growth in weight is most rapid during the first year (Hunter and Macewicz 1980; PFMC 1998). They mature at 78–140 mm (3.1–5.5 in) in length, in their first or second year (Frey 1971; Hunter and Macewicz 1980). Maximum size is about 230 mm (9.1 in) and 60 g (2.1 oz.) (Fitch and Lavenberg 1971; Eschmeyer et al. 1983). Maximum age is about seven years (Hart 1973), though most live less than four years (Fitch and Lavenberg 1971).

Northern anchovy are very important in the trophic ecology of marine food webs. They are random planktonic feeders, filtering plankton as they swim (Fitch and Lavenberg 1971). Juveniles and adults feed mainly at night on zooplankton, including planktonic crustaceans and fish larvae (Fitch and Lavenberg 1971; Hart 1973; Allen and DeMartini 1983). Numerous fish and marine mammal species feed on northern anchovy. Elegant tern and California brown pelican reproduction is strongly correlated with the annual abundance of this species (Emmett et al. 1991). Temperatures above 25°C are avoided by juveniles and adults (Brewer 1974).

4.5.4.1.2 Population Trends and Fishery

Northern anchovy are one of four coastal pelagic species managed by the Pacific Fisheries Management Council (PFMC)—the other species include Pacific sardine, Pacific mackerel (*Scomber japonicus*), and jack mackerel. Northern anchovy in the northeastern Pacific is divided into three subpopulations, or stocks: northern, central, and southern. Since 1978 the PFMC has managed northern anchovy from the central and northern subpopulations. The central subpopulation includes landings from San Francisco to Punta Baja, Baja California.

Three separate commercial fisheries target northern anchovy in California and Mexico waters: 1) the reduction fishery, 2) the live bait fishery, and a 3) non-reduction fishery (Bergen and Jacobson 2001). In the reduction fishery anchovies are converted to meal, oil, and protein supplements while the non-reduction fishery includes fish that are processed for human consumption, for animal food, or frozen for use as fishing bait.

Northern anchovy populations began to increase following the collapse of the Pacific sardine fishery in 1952. Landings remained fairly low throughout the 1950s but increased rapidly in the mid 1960s when reduction of anchovy without associated canning was permitted (Bergen and Jacobson 2001). The demand for this fishery was highly linked to the production and price of fish meal worldwide (Mason 2004). A drastic decline of 40% in fish meal prices worldwide during the early 1980s (Durand 1998) and the decline in anchovy abundance nearly ended anchovy reduction by 1983.

Estimates of the central subpopulation averaged about 359,000 tons from 1963 through 1972, increased to over 1.7 million tons in 1974, and then declined to 359,000 tons in 1978 (Bergen and Jacobsen 2001). Anchovy biomass in 1994 was estimated at 432,000 tons. The stock is thought to be stable, and the size of the anchovy resource is largely dependent on natural influences such as ocean temperatures related to a cold regime in the Pacific Decadal Oscillation (Chavez et al. 2003).

A total of 30 inner shelf and 16 bay and harbor stations were sampled during 2003 within the SCB by the Southern California Coastal Water Research Project (SCCWRP) (Allen et al. 2007). Species abundance was 25 fish per station for northern anchovy at bay and harbor stations during 5-10 minute trawls, while this species was not present at inner shelf stations.

The California commercial fishery for northern anchovy varies substantially by region and year. There have not been any landings of northern anchovy recorded from San Diego County since 1996 when 144,242 kg (318,000 lbs) were landed (PacFIN 2007). In 2004 there were 147,417 kg (325,000 lbs) landed in the Los Angeles area as compared to 2.75 million kg (6.07 million lbs) in the Santa Barbara area, and 3.89 million kg (8.58 million lbs) in the Monterey area for a total value of $750,000. Annual landings in the Los Angeles region since 2000 have varied from a high of 3.9 million kg (8.6 million lbs) in 2001, to a low of 0.14 million kg (0.3 million lbs) in 2004, with an average of 1.4 million kg (3 million lbs) annually (Table 4.5-10). In the five California Department of Fish and Game (CDFG) catch blocks off San Onofre, the 2006 catch totaled 33,207 kg (73,221 lbs) at an estimated value of $15,266 (CDFG 2007).

Table 4.5-10. Annual landings and revenue for northern anchovy in the Los Angeles region based on PacFIN data.

Year	Landed Weight (kg)	Landed Weight (lbs)	Revenue
2000	1,279,437	2,820,677	$145,579
2001	3,656,509	8,061,223	$319,628
2002	1,205,307	2,657,247	$100,716
2003	327,468	721,944	$37,750
2004	147,003	324,087	$35,699
2005	1,979,989	4,365,130	$185,579
2006	865,971	1,909,139	$75,104

During the MRC studies, the mean cross-shelf abundance of northern anchovy during the preoperational period ranged from 396 larvae per m^3 at the control site to 543 larvae per m^3 off SONGS (MEC 1987). During the operational period, densities ranged from 353 larvae per m^3 off SONGS to 476 larvae per m^3 at the control site. In the cooling water intake block sampled off SONGS (Block A), which was 0.5 to 1.1 km offshore at a depth of 6 to 9 m, preoperational densities averaged 15 larvae per m^3 in the neuston, 3,356 larvae per m^3 in the midwater, and 565 larvae per m^3 in the epibenthos (Kastendiek and Parker 1988). During the operational period, densities of northern anchovy averaged 12 larvae per m^3 in the neuston, 1,900 larvae per m^3 in the midwater, and 211 larvae per m^3 in the epibenthos. Data from MEC (1987) and Kastendiek and Parker (1988) are presented here for a species-specific historical comparison. The authors of this report have reason to believe that these previous species-specific estimates were calculated erroneously, and may actually represent the number of larvae per 100 m^3 or per 1,000 m^3. This contention is supported by statements in the "MRC Data Base User's Guide" (Green 1989). Larvae of northern anchovy were most abundant offshore of the intakes, with the number of larvae under 100 m^2 of sea surface ranging from 970 larvae at the intake isobath to 10,264 larvae at depths of 45 to 75 m (Barnett et al. 1984). Larvae of northern anchovy were abundant year-round, but were found in highest concentrations in winter and spring (Walker et al. 1987).

4.5.4.1.3 Sampling Results

Northern anchovy was the most abundant larval taxon collected at both Units 2 and 3, with a mean concentration of 283 larvae per 1,000 m^3, while unidentified anchovies were the second most abundant taxon at both units with a mean concentration of 149 larvae per 1,000 m^3 (Table 4.5-1). Engraulid eggs were the most abundant egg taxa at Unit 3, and second most abundant at Unit 2.

Engraulid larvae were most abundant in in-plant entrainment samples from April through June 2006, with highest densities (exceeding 6,000 larvae per 1,000 m^3 at Unit 3) in late-May 2006 (Figure 4.5-11). Engraulid eggs peaked in late-April 2006 at both units, with concentrations exceeding 61,000 eggs per 1,000 m^3 at Unit 2 and 99,000 eggs per 1,000 m^3 at Unit 3 (Figure 4.5-12). They were absent or present in only very low concentrations the remainder of the study. Larval concentrations of anchovies at the offshore entrainment stations were highest in April and June 2006, with low concentrations during all other months (Figure 4.5-13). Anchovy egg concentrations peaked in April 2006 at the offshore entrainment station, but concentrations were substantially lower than those recorded in in-plant surveys (Figure 4.5-14). Anchovy eggs were collected throughout most of the study period. The length frequency distribution of measured northern anchovy larvae ranged from 2.0 to 31.3 mm, with a mean of 13.5 mm (Figure 4.5-15).

During offshore source water sampling, anchovy larvae were concentrated near bottom, with concentrations more than 10 times higher than surface or water column concentrations (Table 4.5-9). However, engraulid egg concentrations were highest in the surface waters, with concentrations near shore about 50% higher than those offshore. While Barnett et al. (1984) found northern anchovy larvae predominantly in midwater further offshore, concentrations nearshore were highest in the epibenthos, consistent with the present study.

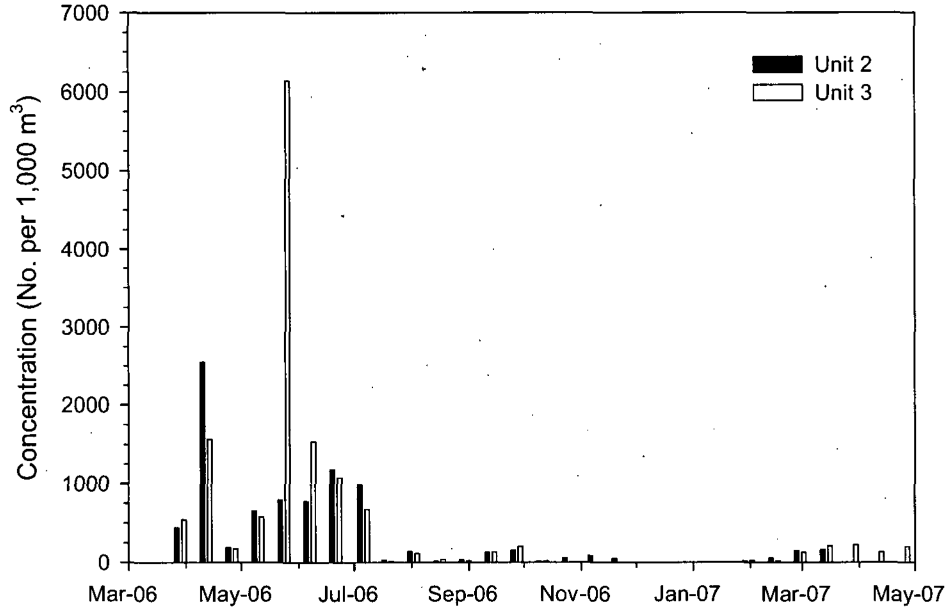


Figure 4.5-11. Mean concentration (# / 1,000 m^3 [264,172 gal]) of anchovy larvae collected at SONGS in-plant entrainment stations, March 2006 through April 2007.

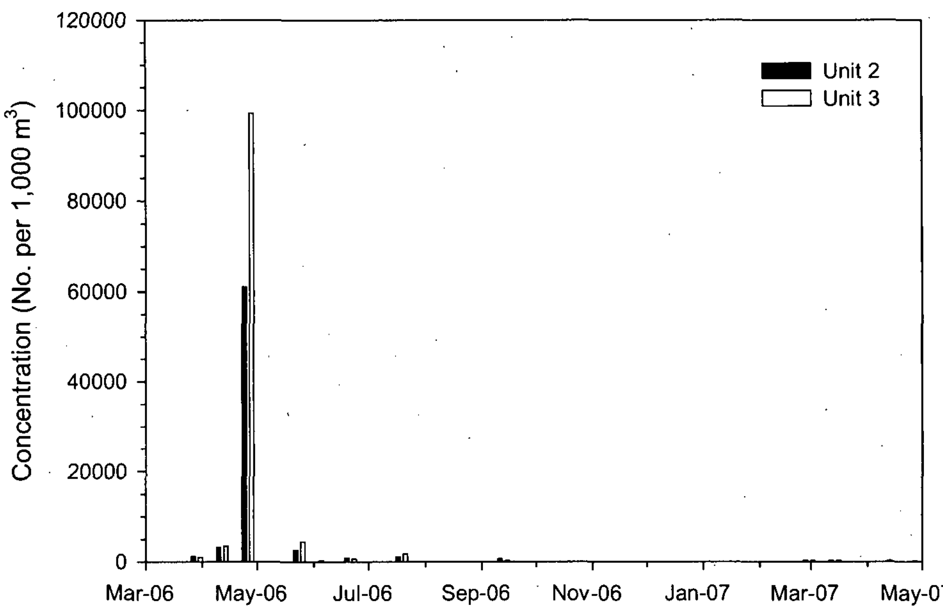


Figure 4.5-12. Mean concentration (# / 1,000 m^3 [264,172 gal]) of anchovy eggs collected at SONGS in-plant entrainment stations, March 2006 through April 2007.

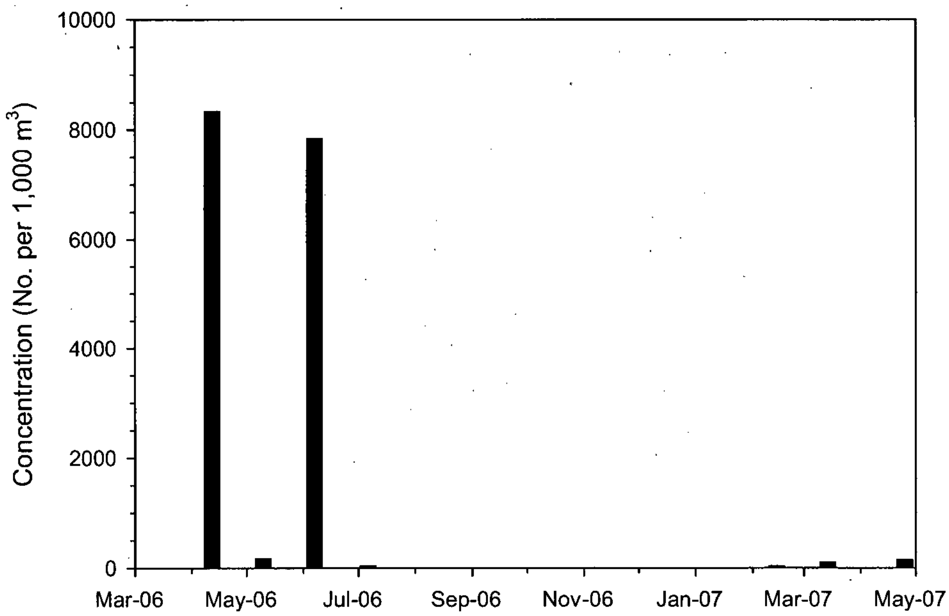


Figure 4.5-13. Mean concentration (# / 1,000 m^3 [264,172 gal]) of anchovy larvae collected at SONGS offshore entrainment stations (O1 and O2), March 2006 through April 2007.

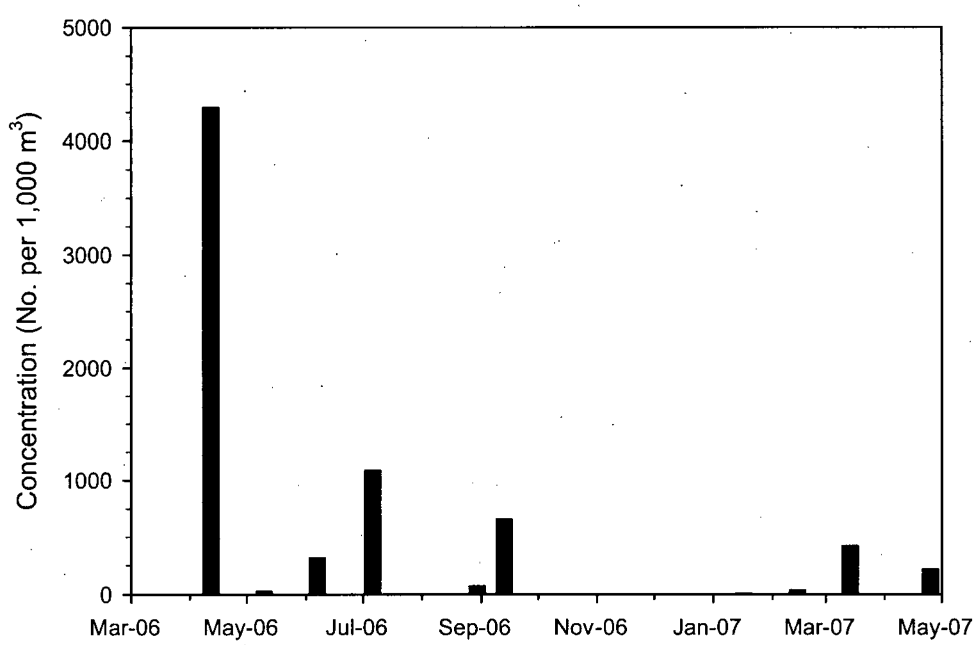


Figure 4.5-14. Mean concentration (# / 1,000 m^3 [264,172 gal]) of anchovy eggs collected at SONGS offshore entrainment stations (O1 and O2), March 2006 through April 2007.

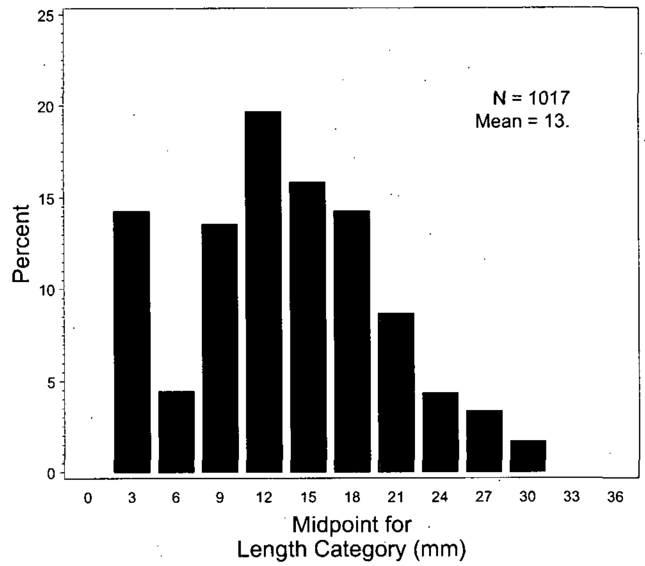
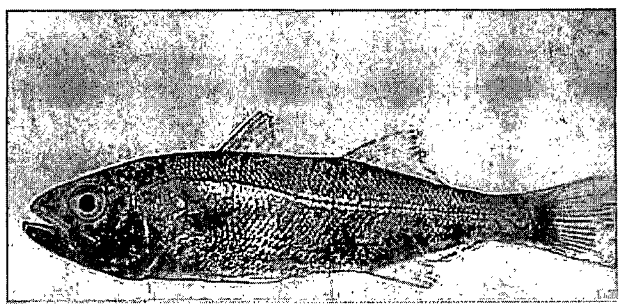


Figure 4.5-15. Length (mm) frequency distribution for larval anchovy collected at SONGS entrainment stations.

4.5.4.2 Queenfish



Milton Love

Queenfish ranges from Vancouver Island, British Columbia to southern Gulf of California (Love et al. 2005). Queenfish is common in southern California, but rare north of Monterey. It is one of eight species of croakers or 'drums' (Family Sciaenidae) found off California. The other croakers include: black croaker (*Cheilotrema saturnum*), white croaker (*Genyonemus lineatus*), California corbina (*Menticirrhus undulatus*), spotfin croaker (*Roncador stearnsii*), yellowfin croaker (*Umbrina roncador*), white seabass (*Atractoscion nobilis*), and shortfin corvina (*Cynoscion parvipinnis*).

4.5.4.2.1 Life History and Ecology

The reported depth range of queenfish is from the surface to depths of about 181 m (594 ft) (Love et al. 2005). In southern California, Allen (1982) found queenfish mainly over soft bottoms at 10–70 m (33–230 ft), with highest abundance occurring at the 10 m stratum. Queenfish form dense, somewhat inactive, schools close to shore during the day, but disperse to feed in midwater after sunset (Hobson and Chess 1976). In a study of queenfish off northern San Diego County, DeMartini et al. (1985) found that adults of both sexes made onshore and offshore migrations, but immature fish generally remained within 2.5 km of shore at night. Queenfish are active throughout the night, feeding several meters off the seafloor either in small schools or individually.

Queenfish mature at 10.5–12.7 cm TL (4.1–5.0 in) (DeMartini and Fountain 1981; Love 1996), during their first spring or second summer. Maximum reported size is 30.5 cm TL (Miller and Lea 1972). Immature individuals grow at a rate of about 2.5 mm/day, while early adults grow about 1.8 mm/day (Murdoch et al. 1989b). Mortality rate estimates are unavailable for this species.

Queenfish are summer spawners. Goldberg (1976) found queenfish enter spawning condition in April and spawn into August, while DeMartini and Fountain (1981) recorded spawning as early as March. Spawning is asynchronous among females, but there are monthly peaks in intensity during the waxing (first quarter) of the moon (DeMartini and Fountain 1981). They also state that mature queenfish spawn every 7.4 days, on average, regardless of size. Duration of the spawning season is a function of female body size, ranging from three months (April–June) in recruit spawners to six months (March–August) in repeat spawners (>13.5 cm SL). Based on the spawning frequency and number of months of spawning, these two groups of spawners can produce about 12 and 24 batches of eggs during their respective spawning seasons (DeMartini and Fountain 1981). Demartini (1991) noted the relationship between declines in fecundity, gonadal and somatic condition of queenfish in southern California, and the crash in planktonic production during the 1982–84 El Niño event.

Goldberg (1976) found no sexually mature females less than 14.8 cm SL in Santa Monica Bay. This differs from the findings of DeMartini and Fountain (1981) who found sexually mature females at 10.0–10.5 cm SL off San Onofre at slightly greater than age-1. Batch fecundities in queenfish off San Onofre ranged from 5,000 eggs in a 10.5 cm female to about 90,000 eggs in a 25 cm fish. The average-sized female (14 cm, 42 g) had a potential batch fecundity of 12,000–13,000 eggs. Murdoch et al. (1989a) estimated the average batch fecundity to be 12,700 for queenfish collected over a five-year period. Based on a female spawning frequency of 7.4 days, a 10.5-cm female that spawns for three months (April–June) can produce about 60,000 eggs per year, while a 25cm female that spawns for six months (March through August) can produce nearly 2.3 million eggs per year (DeMartini and Fountain 1981).

Queenfish feed mainly on crustaceans, including amphipods, copepods, and mysids, along with polychaetes and fishes (Quast 1968; Hobson and Chess 1976; Hobson et al. 1981; Feder et al. 1974). They are a forage species that is probably consumed by a wide variety of larger piscivorous fishes such as halibut, kelp bass, Pacific bonito (*Sarda chiliensis*), Pacific mackerel, and sharks as well as sea lions and cormorants.

4.5.4.2.2 Population Trends and Fishery

Queenfish are numerically one of the most abundant species along sandy or muddy bottom habitats in southern California. They dominate much of the surf zone along with other species such as silversides (topsmelt [*Atherinops affinis*] and jacksmelt) and northern anchovy (Allen and Pondella 2006). Large numbers of juveniles typically aggregate near drift algal beds within the surf zone (Allen and DeMartini 1983)

Queenfish are one of the most abundant species sampled in beam trawls, otter trawls, and lampara nets in southern California. They were one of the three most abundant species of soft-bottom associated fishes in southern California along with white croaker and northern anchovy during a 1982–1984 study using otter trawls (Love et al. 1986). They were more abundant in shallower water depth strata making up about 47% of the fish sampled from 6 to 12 m. Queenfish were also major constituents in beam trawl surveys and made up 50% of catches in exposed coastal sites and 72% of the catch in semi-protected coastal areas along with white croaker (Allen and Herbinson 1991).

Long term trends from coastal generating power plants indicate that queenfish was the most abundant species impinged at five southern California generating stations from 1977 to 1998, and that they accounted for over 60% of the total fishes impinged (Herbinson et al. 2001). Their abundance was stable during this period, with notable declines occurring during strong El Niño events. Abundance remained relatively high throughout the 20-year study period.

A total of 30 inner shelf and 16 bay and harbor stations were sampled during 2003 within the SCB by SCCWRP (Allen et al. 2007). Species abundance was 11.6 fish/station for queenfish at bay and harbor stations during 5-10 minute trawls. This species was scarce at inner shelf stations with a mean abundance of 0.03 fish/station.

Although queenfish is not considered a highly desired species compared to other sciaenids, it is caught in fairly substantial numbers by both recreational and commercial fisheries. No specific landings were reported in commercial landing statistics for southern California from 2000–2006 (PacFIN 2007), although they may have been grouped as 'unspecified croakers'. Recent population trends indicate a decline in shore landings by over 75% in the 1990s compared to the 1980s (Jarvis et al. 2004). Sport fishery catch estimates of queenfish in the southern California region from 2000–2006 ranged from 66,000 to 942,000 fish, with an average of 270,000 fish caught annually (Table 4.5-11).

Table 4.5-11. Annual landings for queenfish in the Southern California region based on RecFIN data.

Year	Estimated Catch
2000	83,000
2001	66,000
2002	942,000
2003	235,000
2004	213,000
2005	201,000
2006	147,000

During the MRC studies, the mean cross-shelf abundance of queenfish during the preoperational period ranged from 66 larvae per m^3 at the control site to 72 larvae per m^3 off SONGS (MEC 1987). During the operational period, densities ranged from 38 larvae per m^3 off SONGS to 55 larvae per m^3 at the control site. In the cooling water intake block sampled off SONGS (Block A), which was 0.5 to 1.1 km offshore at a depth of 6 to 9 m, preoperational densities averaged 2 larvae per m^3 in the neuston, 777 larvae per m^3 in the midwater, and 454 larvae per m^3 in the epibenthos (Kastendiek and Parker 1988). During the operational period, densities of queenfish averaged 3 larvae per m^3 in the neuston, 216 larvae per m^3 in the midwater, and 253 larvae per m^3 in the epibenthos. Data from MEC (1987) and Kastendiek and Parker (1988) are presented here for a species-specific historical comparison. The authors of this report have reason to believe that these previous species-specific estimates were calculated erroneously, and may actually represent the number of larvae per 100 m^3 or per 1,000 m^3. This contention is supported by statements in the "MRC Data Base User's Guide" (Green 1989). Queenfish larvae were most abundant inshore along the intake isobath, with the number of larvae under 100 m^2 of sea surface ranging from 274 larvae at the intake isobath to 94 larvae at depths of 45 to 75 m (Barnett et al. 1984). Queenfish larvae were most abundant in early summer through September, but occurred in winter and spring, as well (Walker et al. 1987).

4.5.4.2.3 Sampling Results

Queenfish was the third most abundant larval taxon collected at Unit 3 and the fourth most abundant at Unit 2, with a mean concentration of 43 larvae per 1,000 m^3 (Table 4.5-1). Queenfish larvae were most abundant in in-plant entrainment samples in June 2006, with highest densities exceeding 700 larvae per 1,000 m^3 at Unit 2 and 400 larvae per 1,000 m^3 at Unit 3 (Figure 4.5-16). Larval concentrations of queenfish at the offshore entrainment stations were also highest in June, and larvae were only collected during 6 of the 13 offshore surveys (Figure 4.5-17). The length frequency distribution of measured queenfish larvae ranged from 1.5 to 24.5 mm, with a mean of 5.36 mm (Figure 4.5-18). Most of the measured larvae were less than 8 mm in length, with 95% less than 10.9 mm.

During offshore source water sampling, queenfish larvae were concentrated near bottom, with concentrations of 44 larvae per 1,000 m^3 (Table 4.5-9). This corresponds to the findings of Jahn and Lavenberg (1986), who reported queenfish to be concentrated in the lower 50 cm of the water column off Seal Beach, California, as well as findings of previous investigations off SONGS (Barnett et al. 1984). Queenfish larvae were absent from surface samples, and the concentration in water column samples was less than one larva per 1,000 m^3.

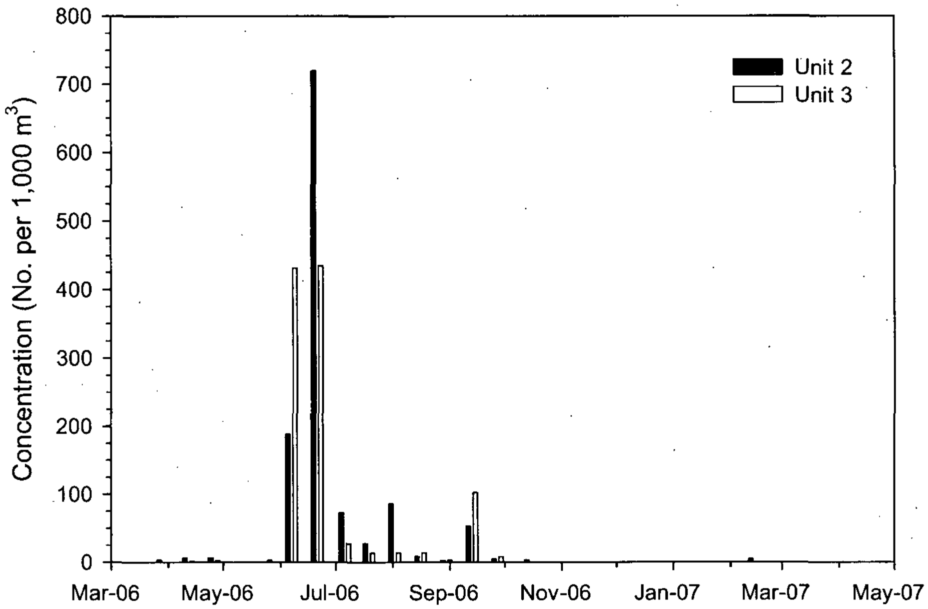


Figure 4.5-16. Mean concentration (# / 1,000 m^3 [264,172 gal]) of queenfish larvae collected at SONGS in-plant entrainment stations, March 2006 through April 2007.

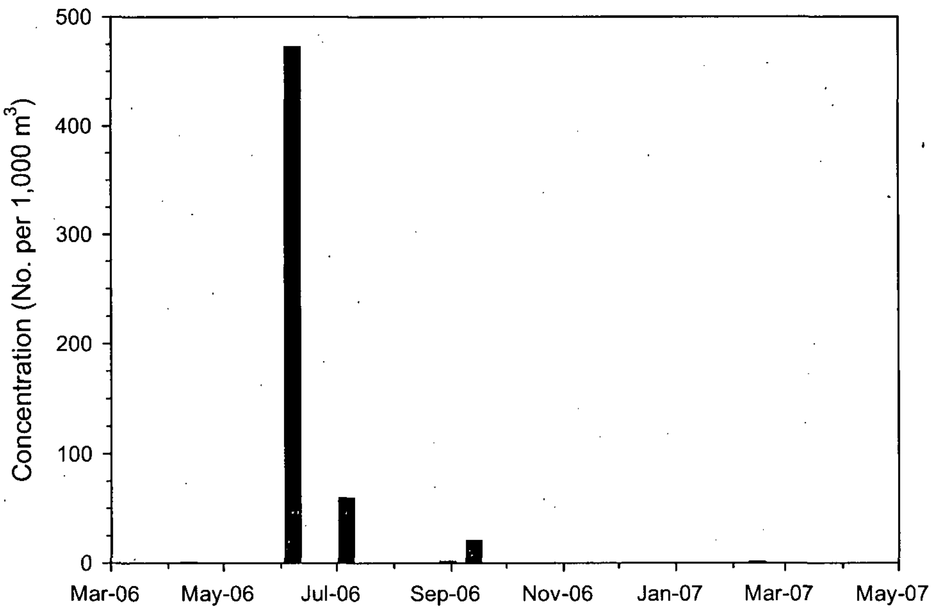


Figure 4.5-17. Mean concentration (# / 1,000 m^3 [264,172 gal]) of queenfish larvae collected at SONGS offshore entrainment stations (O1 and O2), March 2006 through April 2007.

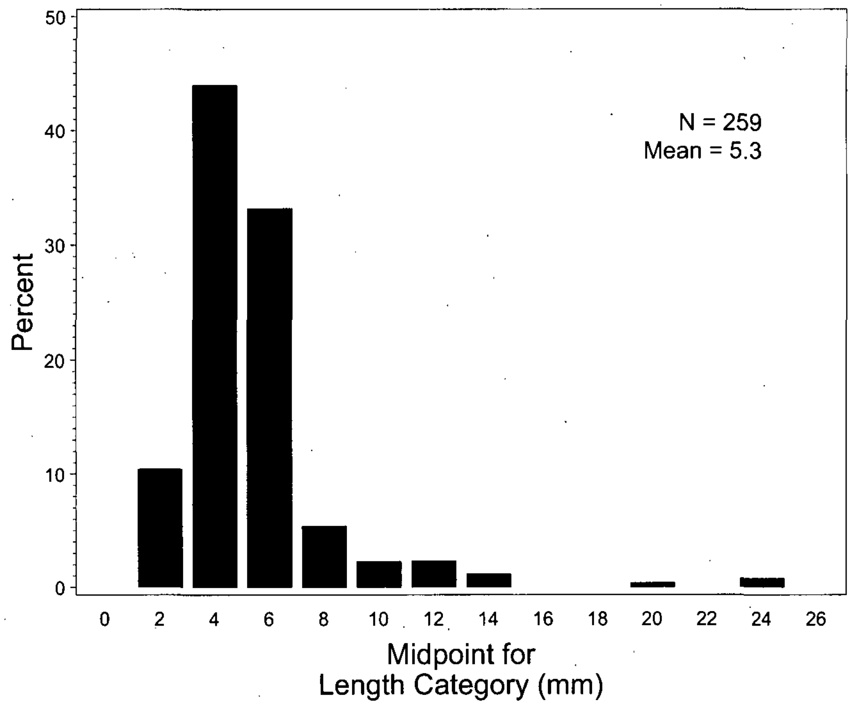


Figure 4.5-18. Length (mm) frequency distribution for queenfish collected at SONGS entrainment stations.

4.5.4.3 Pacific Sardine

The genus *Sardinops* occurs in coastal areas of warm temperature zones of nearly all ocean basins. Pacific sardine range from Kamchatka, Russia to Guaymas, Mexico, Peru, and Chile (Miller and Lea 1972; Eschmeyer et al. 1983). Similar lineages occur off Africa, Australia, and Japan. Pacific sardine is one of five species of herrings (Family Clupeidae) that could occur in the waters off the SGS.

4.5.4.3.1 Life History and Ecology

Pacific sardine is epipelagic, occurring in loosely aggregated schools (Wolf et al. 2001). Spawning occurs year-round in the upper 50 m (164 ft) of the water column, with seasonal peaks occurring from April to August between Point Conception, California and Magdalena Bay, Baja California. Adults are believed to spawn two to three times per season (Fitch and Lavenberg 1971). The primary spawning area for the principal northern subpopulation (ranging from northern Baja to Alaska) is between San Francisco and San Diego, California, and out to about 241 km (150 miles) offshore, though they are known to spawn as far offshore as 563 km (350 miles) offshore. Butler et al. (1993) estimated fecundity at 146,754 eggs to 2,156,600 eggs per two- and ten-year-old females, respectively, with longevity estimated at 13 years. Eggs and larvae occur near the sea surface, and eggs require about three days to hatch at 15°C (59°F).

Sardines are filter feeding and prey on planktonic crustaceans, fish larvae, and phytoplankton (Wolf et al. 2001). The average non-feeding swim speed of Pacific sardine is about 0.78 body lengths per second (BL/sec), while particulate feeding sardines exhibit swim speeds of 1.0 to 2.0 BL/sec; this equaled maximum speeds of 26 to 51 cm/sec (10.2 to 20.1 in/sec) (van der Lingen 1995). Pacific sardines are about 115 mm (4.5 in) after one year, 173 mm (6.8 in) after two years, 200 mm (7.9 in) after three years, and 215 mm (8.5 in) after four years (Hart 1973). They make northward migrations early in summer and return southward again in fall, with migrations becoming further with each year of life. Natural adult mortality (M) has been estimated as 0.4/year (MacCall 1979).

4.5.4.3.2 Population Trends and Fishery

Pacific sardine supported the largest fishery in the Western Hemisphere during the 1930s and 1940s. However, the fishery collapsed in the 1940s and 1950s, leading to the establishment of the CalCOFI program in 1947, originally named the Cooperative Sardine Research Program. Extreme natural variability and susceptibility to recruitment overfishing are characteristic of clupeoid stocks, including Pacific sardine (Hill et al. 2006). Regimes of high abundance of sardines (*S. sagax* and *S. pilchardus*) have alternated with regimes of high abundance of anchovy (*Engraulis* spp) in each of the five regions of the world where these taxa co-occur (Lluch-Belda et al. 1992). Both sardine and anchovy populations tend to vary over periods of roughly 60 years, although sardine have varied more than anchovy. Sardine population recoveries lasted an average of 30 years (Baumgartner et al. 1992). The Pacific sardine population began increasing at an average rate of 27% per year in the early 1980s, and recent estimates indicate the total biomass of Age-1 and older sardines is greater than one million metric tons (Hill et al. 2006; SWFSC 2007).

Sardine landed in the U.S. fishery are mostly frozen and sold overseas as bait and aquaculture feed, with smaller amounts canned or sold for human consumption and animal food (Hill et al. 2006). Commercial landings of Pacific sardine in 2006 in Santa Monica Bay catch blocks totaled 3,591,016 kg (9,134,600 lbs) at a value of $426,626 (CDFG 2007). Los Angeles area landings (between Dana Point and Santa Monica) for 2005 totaled 24,143,616 kg (53,236,674 lbs) at a value of $2,344,817 (CDFG 2006). Based on PacFIN (2007), annual commercial landings in the Los Angeles region since 2000 have varied from a high of 40 million kg (90 million lbs) in 2001, to a low of 24 million kg (52 million lbs) in 2004 (Table 4.5-12). In the five CDFG catch blocks off San Onofre, the 2006 catch totaled 24,668 kg (54,393 lbs) at an estimated value of $10,790 (CDFG 2007).

Table 4.5-12. Annual landings and revenue for Pacific sardine in the Los Angeles region based on PacFIN data.

Year	Landed Weight (kg)	Landed Weight (lbs)	Revenue
2000	39,121,935	86,263,867	$4,187,391
2001	40,755,801	89,866,542	$4,476,752
2002	39,299,341	86,655,046	$3,826,155
2003	24,422,289	53,851,147	$1,961,269
2004	23,672,717	52,198,341	$2,255,501
2005	24,143,507	53,236,434	$2,348,577
2006	26,651,664	58,766,919	$3,240,006

Larvae of Pacific sardine occurred during the MRC studies, but was not analyzed in detail due to its relatively low abundance. Seasonal occurrence of sardine larvae was similar to that of northern anchovy, with a peak in winter and spring (Walker et al. 1987). Abundance of Pacific sardine eggs and larvae in the southern California CalCOFI study area were relatively low during the MRC studies compared with densities measured since 1995 (Moser et al. 2001).

4.5.4.3.3 Sampling Results

Pacific sardine ranked 25th in larval abundance at Unit 2 and 30th at Unit 3, with a mean concentration of less than one larva per 1,000 m^3 (Table 4.5-1). Sardine eggs were also collected at both units, with a mean concentration of less than one egg per 1,000 m^3.

Sardine larvae were most abundant in in-plant entrainment samples in August and September 2006, with highest densities at both units of about 10 larvae per 1,000 m^3 (Figure 4.5-19). Sardine larvae also occurred in February and March 2007. Pacific sardine eggs were collected in entrainment samples in March 2006, and again in late-January and March 2007 (Figure 4.5-20). They were absent during the remainder of the study. Eggs and larvae of sardines were only collected at the offshore entrainment stations in March 2007, and concentrations of both were similar to those recorded in-plant (Figures 4.5-21 and 4.5-22).

During offshore source water sampling, Pacific sardine larvae were collected in highest concentrations in surface waters, with densities about twice those recorded in oblique and suprabenthic tows (Table 4.5-9). Sardine eggs were highest in offshore surface waters, although concentrations ranged narrowly between 4.6 larvae per 1,000 m^3 at offshore surface waters to 1.0 larvae per 1,000 m^3 at nearshore surface waters.

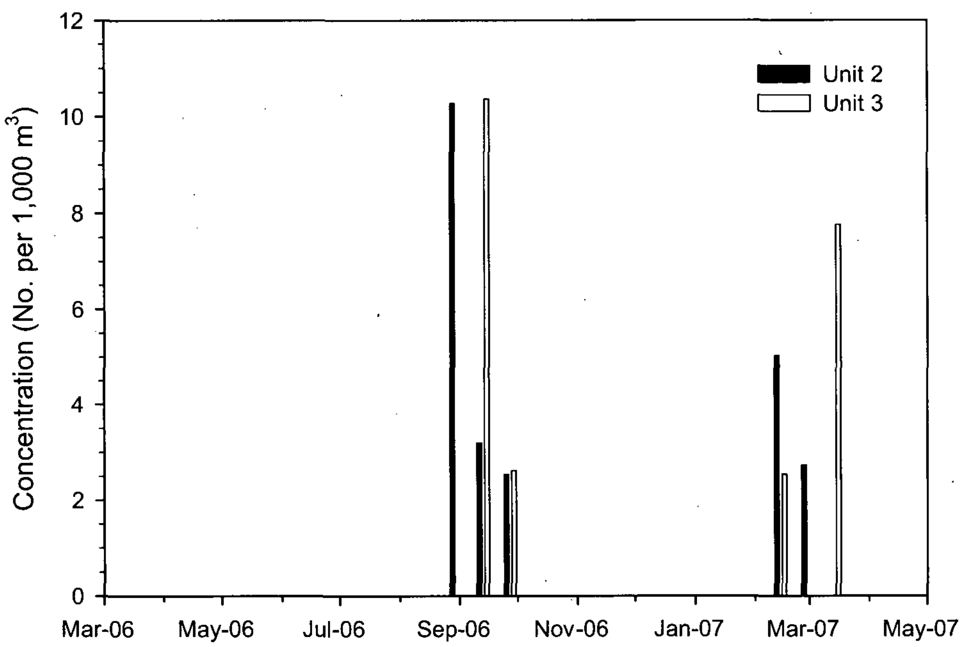


Figure 4.5-19. Mean concentration (# / 1,000 m^3 [264,172 gal]) of Pacific sardine larvae collected at SONGS in-plant entrainment stations, March 2006 through April 2007.

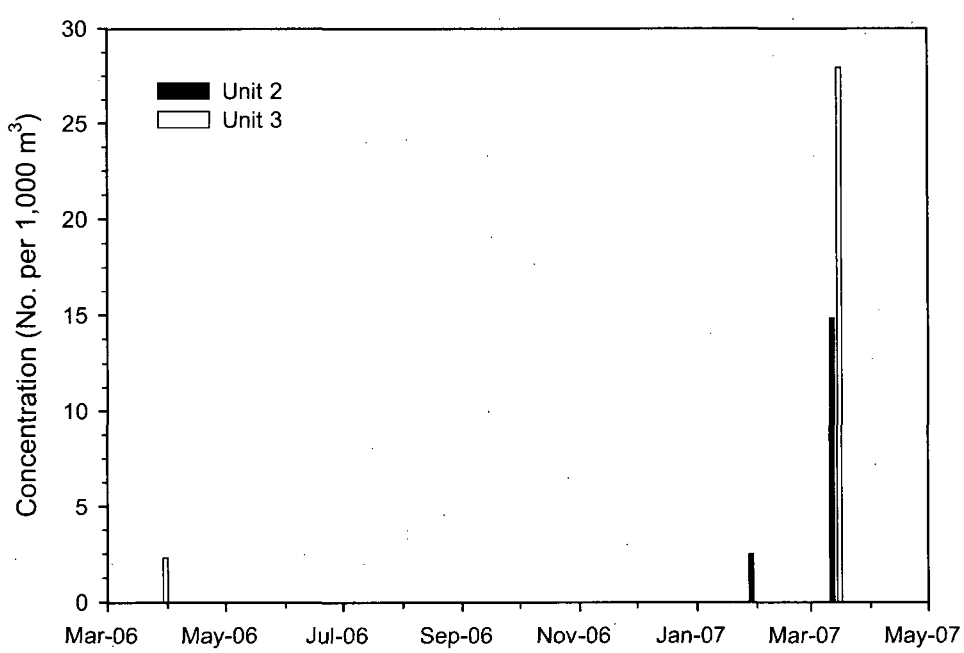


Figure 4.5-20. Mean concentration (# / 1,000 m^3 [264,172 gal]) of Pacific sardine eggs collected at SONGS in-plant entrainment stations, March 2006 through April 2007.

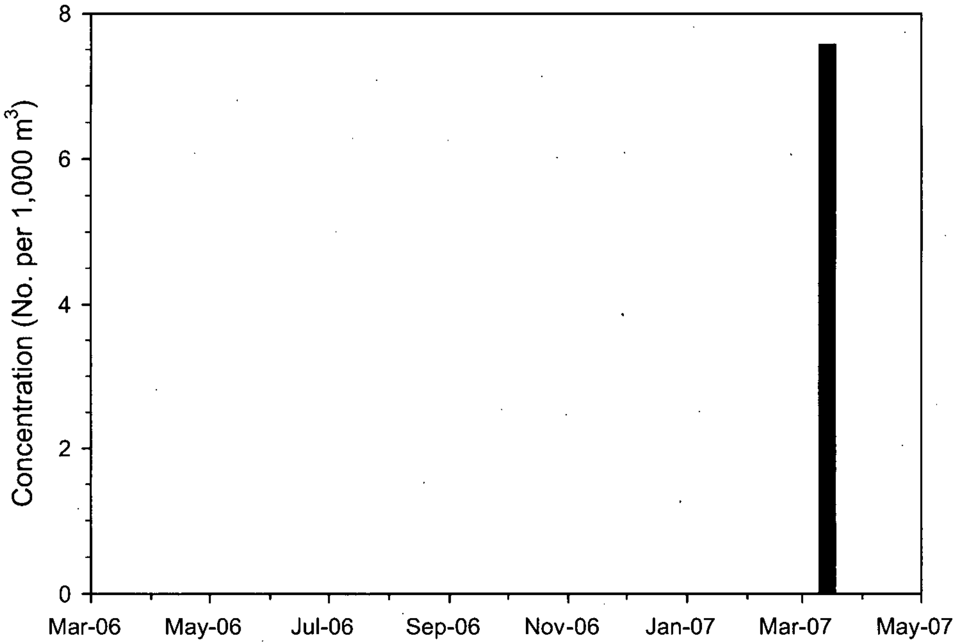


Figure 4.5-21. Mean concentration (# / 1,000 m^3 [264,172 gal]) of Pacific sardine larvae collected at SONGS offshore entrainment stations (O1 and O2), March 2006 through April 2007.

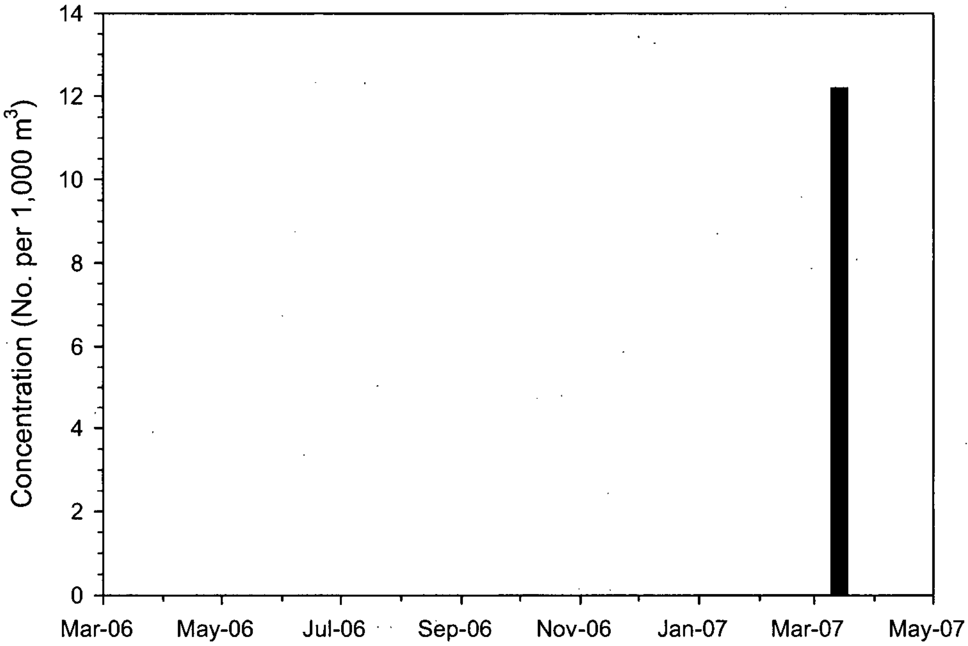
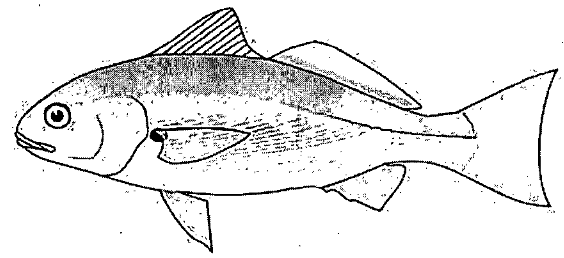


Figure 4.5-22. Mean concentration (# / 1,000 m3 [264,172 gal]) of Pacific sardine eggs collected at SONGS offshore entrainment stations (O1 and O2), March 2006 through April 2007.

4.5.4.4 White Croaker



White croaker range from Magdalena Bay, Baja California (Miller and Lea 1972), north to Barkley Sound, British Columbia (Eschmeyer et al. 1983). They are one of eight species of croakers (Family Sciaenidae) found off California. The other croaker species are listed in Section 4.5.4.2.

4.5.4.4.1 Life History and Ecology

The reported depth range of white croaker is from near the surface to depths of 238 m (781 ft) (Love et al. 2005); however, in southern California, Allen (1982) found white croaker over soft bottoms between 10 and 130 m, and it was collected most frequently at 10 m. It is nocturnally active, and is considered a benthic searcher that feeds on a wide variety of benthic invertebrate prey. Adults feed on polychaetes and crustaceans, while juveniles feed during the day in midwater on zooplankton (Allen 1982).

White croakers are oviparous broadcast spawners. They mature between 130 and 190 mm TL, from their first to fourth year; while approximately 50% spawn during their first year (Love et al. 1984). About half of males mature by 140 mm TL, and half of females by 150 mm TL, with all fish mature by 190 mm TL in their third to fourth year (Love et al. 1984). Off Long Beach, white croaker spawn primarily from November through August, with peak spawning occurring from January through March (Love et al. 1984). However, some spawning can occur year-round. Batch fecundities ranged from about 800 eggs in a 155 mm female to about 37,200 eggs in a 260 mm female, with spawning taking place as often as every five days (Love et al. 1984). In their first and second years, females spawn for three months for a total of about 18 times per season. Older fish spawn for about four months and about 24 times per season (Love et al. 1984). Some older fish may spawn for seven months. The nearshore waters from Redondo Beach (Santa Monica Bay) to Laguna Beach are considered an important spawning center for this species (Love et al. 1984). A smaller spawning center occurs off Ventura.

Newly hatched white croaker larvae are 1–2 mm SL and not well developed (Watson 1982). Larvae are principally located within 4 km from shore, and as they develop tend to move shoreward and into the epibenthos (Schlotterbeck and Connally 1982). Murdoch et al. (1989c) estimated a daily larval growth rate of 0.20 mm/day. Maximum reported size is 414 mm (Miller and Lea 1972), with a life span of 12–15 years (Frey 1971; Love et al. 1984). White croakers grow at a fairly constant rate throughout their lives, though females increase in size more rapidly than males from age 1 (Moore 2001). No mortality estimates are available for any of the life stages of this species.

White croaker are primarily nocturnal benthic feeders, though juveniles may feed in the water column during the day (Allen 1982). Important prey items include polychaetes, amphipods, shrimps, and chaetognaths (Allen 1982). In Outer Los Angeles Harbor, Ware (1979) found that important prey items included polychaetes, benthic crustaceans, free-living nematodes, and zooplankton. Younger individuals feed on holoplankonic crustaceans and polychaete larvae. White croaker may move offshore into deeper water during winter months (Allen and DeMartini 1983); however, this pattern is apparent only south of Redondo Beach (Herbinson et al. 2001).

4.5.4.4.2 Population Trends and Fishery

White croaker is an important constituent of commercial and recreational fisheries in California. Prior to 1980, most commercial catches of white croaker were taken by otter trawl, round haul net (lampara), gill net, and hook and line in southern California, but after 1980 most commercial catches were taken primarily by trawl and hook and line (Love et. al 1984). Also, since then the majority of the commercial fishery shifted to central California near Monterey mainly due to the increased demand for this species from the developing fishery by Southeast Asian refugees (Moore and Wild 2001). Most of the recreational catch still occurs in southern California from piers, breakwaters, and private and sport boats.

Before 1980, state-wide white croaker landings averaged 685,000 lbs annually, exceeding 1 million lbs for several years (Moore and Wild 2001). High landings in 1952 probably occurred due to the collapse of the Pacific sardine fishery. Since 1991, landings averaged 461,000 lbs and steadily declined to an all-time low of 142,500 lbs in 1998. Landings by recreational fishermen aboard commercial passenger fishing vessels (CPFVs) averaged about 12,000 fish per year from 1990 to 1998, with most of the catch coming from southern California.

Annual relative abundance of white croaker in impingement samples at southern California power plants showed decreases during the strong El Niño events of 1982-83, 1986-87, and 1997-98 as compared with non- El Niño years (Herbinson et al. 2001). Additionally, the relative abundance of local populations have been influenced by contamination from PCBs and other chlorinated hydrocarbons within bays and has lead to early ovulation, lower batch fecundities, and lower fertilization rates when compared to non-contaminated areas (Cross and Hose 1988).

A total of 30 inner shelf and 16 bay and harbor stations were sampled during 2003 within the SCB by SCCWRP (Allen et al. 2007). Species abundance was 0.25 fish/station for white croaker at bay and harbor stations during 5-10 minute trawls, while this species was not present in the inner shelf station samples.

Annual commercial landings in the Los Angeles region since 2000 have been variable with an average of 19686 kg (43,400 lbs) and an average net worth of $29,385 annually (Table 4.5-13). Sport fishery catch estimates of white croaker in the southern California region from 2000–2006 ranged from 64,000–253,000 fish, with an average of 189,400 fish caught annually (RecFIN 2007).

Table 4.5-13. Annual landings and revenue for white croaker in the Los Angeles region based on PacFIN data.

Year	Landed Weight (kg)	Landed Weight (lbs)	Revenue
2000	40,025	88,240	$50,688
2001	23,387	51,560	$36,086
2002	25,880	57,056	$41,816
2003	21,772	48,000	$33,837
2004	8,894	19,608	$14,653
2005	11,182	24,652	$17,531
2006	6,809	15,011	$11,079

During the MRC studies, the mean cross-shelf abundance of white croaker during the preoperational period ranged from 101 larvae per m^3 at the control site to 123 larvae per m^3 off SONGS (MEC 1987). During the operational period, densities ranged from 38 larvae per m^3 off SONGS to 71 larvae per m^3 at the control site. In the cooling water intake block sampled off SONGS (Block A), which was 0.5 to 1.1 km offshore at a depth of 6 to 9 m, preoperational densities averaged 2 larvae per m^3 in the neuston, 566 larvae per m^3 in the midwater, and 357 larvae per m^3 in the epibenthos (Kastendiek and Parker 1988). During the operational period, densities of white croaker averaged 0.09 larvae per m^3 in the neuston, 229 larvae per m^3 in the midwater, and 177 larvae per m^3 in the epibenthos. Data from MEC (1987) and Kastendiek and Parker (1988) are presented here for a species-specific historical comparison. The authors of this report have reason to believe that these previous species-specific estimates were calculated erroneously, and may actually represent the number of larvae per 100 m^3 or per 1,000 m^3. This contention is supported by statements in the "MRC Data Base User's Guide" (Green 1989). White croaker larvae were most abundant offshore the intakes, with the number of larvae under 100 m^2 of sea surface ranging from 133 larvae at the intake isobath to 567-623 larvae at depths of 12 to 45 m (Barnett et al. 1984). Larvae of white croaker were most abundant in winter and spring (December through April) (Walker et al. 1987).

4.5.4.4.3 Sampling Results

White croaker was the seventh most abundant larval taxon collected at Unit 2 and the fifth most abundant at Unit 3, with a mean concentration of 32 larvae per 1,000 m^3 (Table 4.5-1). White croaker larvae were most abundant in in-plant entrainment samples in April 2006, with highest concentrations exceeding 225 larvae per 1,000 m^3 at Unit 2 and 530 larvae per 1,000 m^3 at Unit 3 (Figure 4.5-23). Larval concentrations of white croaker at the offshore entrainment stations were also highest in April 2006, although there was a secondary peak in January and February 2007 (Figure 4.5-24). This secondary pulse was also recorded in-plant, though it was not as intense. The length frequency distribution of measured white croaker larvae ranged from 1.1 to 11.2 mm, with a mean of 3.4 mm (Figure 4.5-25).

During offshore source water sampling, white croaker larvae were concentrated near bottom, with concentrations of 202 larvae per 1,000 m^3 (Table 4.5-9). Mean water column concentration was 48 larvae per 1,000 m^3, and surface concentrations were only 9 to 19 larvae per 1,000 m^3.

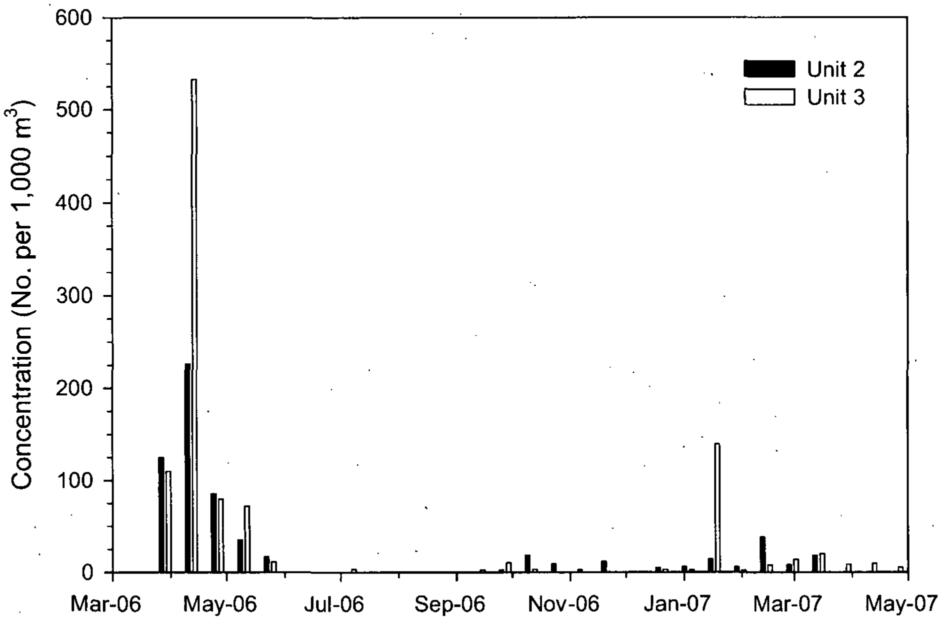


Figure 4.5-23. Mean concentration (# / 1,000 m^3 [264,172 gal]) of white croaker larvae collected at SONGS in-plant entrainment stations, March 2006 through April 2007.

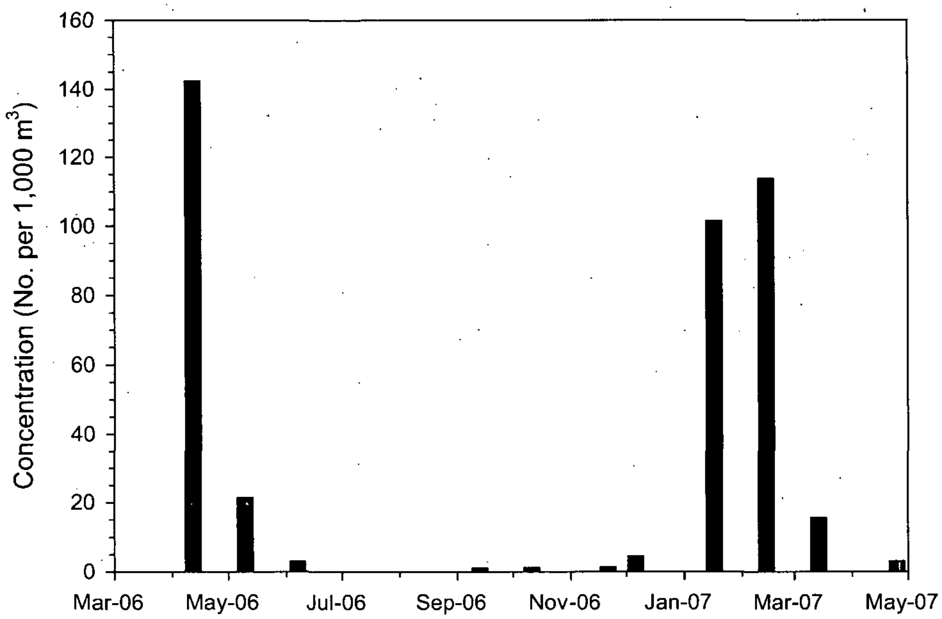


Figure 4.5-24. Mean concentration (# / 1,000 m^3 [264,172 gal]) of white croaker larvae collected at SONGS offshore entrainment stations (O1 and O2), March 2006 through April 2007.

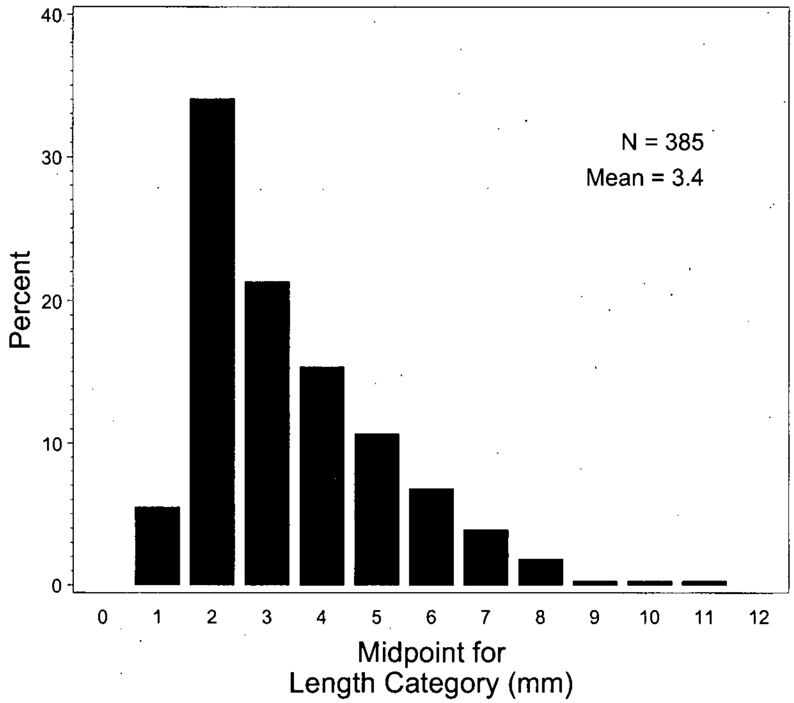
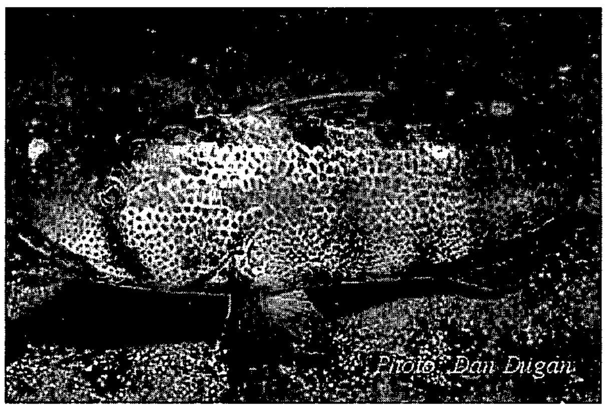


Figure 4.5-25. Length (mm) frequency distribution for white croaker collected at SONGS entrainment stations.

4.5.4.5 Sea Basses (*Paralabrax* spp)



Three species of basses, family Serranidae, genus *Paralabrax*, occur in California ocean waters: spotted sand bass (*P. maculatofasciatus*), barred sand bass, and kelp bass. Spotted sand bass are found from Monterey, California to Mazatlan, Mexico, including the Gulf of California (Robertson and Allen 2002); barred sand bass are found from Santa Cruz to Magadalena Bay; and kelp bass are found from the mouth of the Columbia River in Washington to Magdalena Bay, Baja California (Miller and Lea 1972). However, Love (1996) reports that spotted sand bass are not common north of Newport Bay in southern California and Allen and Hovey (2001a,b) state that barred and kelp bass are rare north of Point Conception.

4.5.4.5.1 Life History and Ecology

The life history of the spotted sand bass is described in Allen et al. (1995). Adults can reach 56 cm (22 in) in length and live to at least 14 years of age. Females mature within the first year and approximately half are mature when they reach 15.5 cm (6 in) long. Males are all mature at 3 yrs of age. About one-half of the males reaching maturity at 18 cm (7 in). Some individuals within populations are protogynous, changing sex from female to male as they grow. Spawning in California occurs from June through August. Love et al. (1996) analyzed life history parameters for barred sand bass and kelp bass. Adult barred sand bass can reach 65 cm (25.5 in) and live to 24 years of age. Adult kelp bass reach 72 cm (28.5 in) and live to at least 34 years of age. Kelp and barred sand bass reach sexual maturity between 18 and 27 cm (7 to 10.5 in), at about 3–5 years of age. Kelp and barred sand bass form large breeding aggregations in deeper waters and spawn from April through November, peaking in summer months. All three species are multiple spawners (Oda et al. 1993).

In a study of *Paralabrax* fecundity by DeMartini (1987), the number of eggs ranged over a factor of 15 from about 12,000 eggs in a 447 g fish to >185,000 eggs in a 2,625 g fish. The smallest fish, a 148 g sand bass, contained 16,500 eggs. Sample females contained a mean ± 1 S. E. of 760 ± 80 eggs per gram of ovary and 70 ± 12 eggs per gram of ovary-free body weight. All three species –*P. clathratus, P. maculatofasciatus,* and *P. nebulifer* – are capable of daily spawning in season (Oda et al. 1993). However, not all fish captured in the Oda et al. (1993) study demonstrated evidence of daily spawning: 32% of the *P. clathratus* females (n = 84), 20% of the *P. maculatofasciatus* females (n = 79), and 31% of the *P. nebulifer* females (n = 81) showed evidence of spawning on two consecutive days. There was no statistically significant difference in the average size of specimens that exhibited evidence of daily spawning, compared to those that had spawned the day before collection. A standard weight female (ca. 700 g OFW and 300 mm SL) was calculated to average 81,000 eggs per batch. This estimate of batch fecundity for *Paralabrax* is higher than that reported by DeMartini (1987) and may indicate the variation possible in these species of *Paralabrax*.

Kelp bass are found associated with structure, such as kelp or rocks, from the subtidal zone to depths of 61 m (200ft) (Love 1996). They are typically found in water less than 21 m (70 ft) (Allen and Hovey. 2001a). Spotted sand bass are found in back bays and lagoons, were there is extensive cover (Love 1996). They have been taken in water as deep as 61 m (200 ft), however they are usually found shallower than 6.1 m (20 ft) (Love 1996). Barred sand bass are found at the sand-rock interface, and are commonly observed at artificial reefs. Barred sand bass have been taken in water as deep as 183 m (600 ft), but are usually found in water shallower than 27 m (90 ft). Off San Onofre, important prey items of barred sand bass include brachyuran crabs, mysids, pelecypods, and epibenthic fishes (Roberts et al. 1984).

4.5.4.5.2 Population Trends and Fishery

Kelp bass and barred sand bass are two of the most important nearshore, recreational species caught within southern California waters (Allen and Hovey 2001a, b). The fishery for these species occurs throughout most of southern California from Ensenada, Baja California to Gaviota in Santa Barbara County including the Channel Islands.

A total of 30 inner shelf and 16 bay and harbor stations were sampled during 2003 within the SCB by SCCWRP (Allen et al. 2007). Species abundance was 7.4 fish per station for barred sand bass and 1.1 fish per station for spotted sand bass at bay and harbor stations during 5-10 minute trawls. These species were not as abundant at inner shelf stations as the abundance for barred sand bass was 0.03 fish per station and spotted sand bass were not taken.

These species have been an important component of both recreational and commercial catches since the early 1900s. The earliest management attempt to conserve these species occurred in 1939 when a limit of 15 fish per day was placed on sport fish catches in California. Since then a number of other regulation changes have been added including a ban on commercial fishing for these species in California waters and a size limit of 10.5 inches on the recreational fishery in 1953, a 12 inch size limit in 1959, and a limit of 10 fish in 1979 (Young 1963; Stull et al. 1987).

Records prior to 1975 did not differentiate catches of kelp bass and barred sand bass from other related species including rock bass (*Paralabrax* spp, which also includes the spotted sand bass, *P. maculatofasciatus*). Catches of both kelp and barred sand bass have fluctuated greatly since the early 1960's and are suggested to be influenced by the density of giant kelp forests which vary intra-annually (Dotson and Charter 2003). Catch rates for these species were higher during the late1980s compared to the 1970s while mean lengths were essentially unchanged between those periods (Love et al. 1996). Specific habitat requirements indicates that high adult densities of kelp bass occur within kelp/rock habitat whereas barred sand bass prefer rocky, hard-bottom or sand areas (Stull et al. 1987).

Recent population trends indicate that landings aboard Commercial Passenger Fishing Vessels (CPFVs) declined during the 1990s compared to the 1980's (Allen and Hovey 2001a, b). Specific habitat requirements and a high degree of site fidelity with limited movements (Lowe et al. 2003) suggest that these species can be subject to changes in abundance depending on the availability and amount of suitable habitat. Sport fishery catch estimates of spotted sand bass in the southern California region from 2000 to 2006 ranged from 14,000 to 74,000 fish, with an average of 44,000 fish caught annually (Table 4.5-14). Catch estimates of kelp bass in southern California ranged from 157,000 to 587,000 fish from 2000 to 2006, with an average of 351,300 fish caught annually. Barred sand bass catch estimates ranged from 139,000 to 1,130,000 fish caught annually from 2000-2006, with an average of 720,000 fish caught annually (RecFin 2007).

Table 4.5-14. Annual estimated landings for barred sand bass, kelp bass, and spotted sand bass in the Southern California region based on RecFIN data.

Year	Barred sand bass	Kelp bass	Spotted sand bass
2000	1,130,000	587,000	74,000
2001	806,000	385,000	49,000
2002	1,062,000	291,000	52,000
2003	892,000	434,000	62,000
2004	704,000	446,000	14,000
2005	307,000	157,000	38,000
2006	139,000	159,000	19,000

During the MRC studies, the mean cross-shelf abundance of sea basses during the preoperational period ranged from 41 larvae per m^3 at the control site to 51 larvae per m^3 off SONGS (MEC 1987). During the operational period, densities ranged from 30 larvae per m^3 off SONGS to 76 larvae per m^3 at the control site. Data from MEC (1987) are presented here for a species-specific historical comparison. The authors of this report have reason to believe that these previous species-specific estimates were calculated erroneously, and may actually represent the number of larvae per 100 m^3 or per 1,000 m^3. This contention is supported by statements in the "MRC Data Base User's Guide" (Green 1989). Sea bass larvae were most abundant offshore, with the number of larvae under 100 m^2 of sea surface ranging from 0.1 larvae at the intake isobath to 98 larvae at depths of 22 to 45 m (Barnett et al. 1984). Larvae of *Paralabrax* were most abundant in summer (July through October) (Walker et al. 1987).

4.5.4.5.3 Sampling Results

Sea basses ranked 21st in larval abundance at Unit 2 and 13th at Unit 3, with a mean concentration of less than 3 larvae per 1,000 m^3 (Table 4.5-1). *Paralabrax* spp eggs were also collected at both units, with a mean concentration of 5 eggs per 1,000 m^3.

Paralabrax larvae were most abundant in in-plant entrainment samples in July and August 2006, with densities of 58 larvae per 1,000 m^3 at Unit 3 and 27 larvae per 1,000 m^3 at Unit 2 (Figure 4.5-26). Sea bass larvae were only collected between June and mid-September 2006. *Paralabrax* eggs were also collected only between June and mid-September 2006, with highest densities (60 to 80 eggs per 1,000 m^3 occurring in early July 2006 (Figure 4.5-27). Eggs and larvae of sea basses were collected offshore during the same period as those collected in-plant (June – September 2006), and concentrations of both peaked in early-July 2006 at levels of about two to three times higher than concentrations measured within SONGS (Figures 4.5-28 and 4.5-29). *Paralabrax* eggs and larvae did not occur offshore during stratified sampling in spring 2007 (Table 4.5-9). The length frequency distribution of measured *Paralabrax* larvae ranged from 1.1 to 2.2 mm, with a mean of 1.4 mm (Figure 4.5-30).

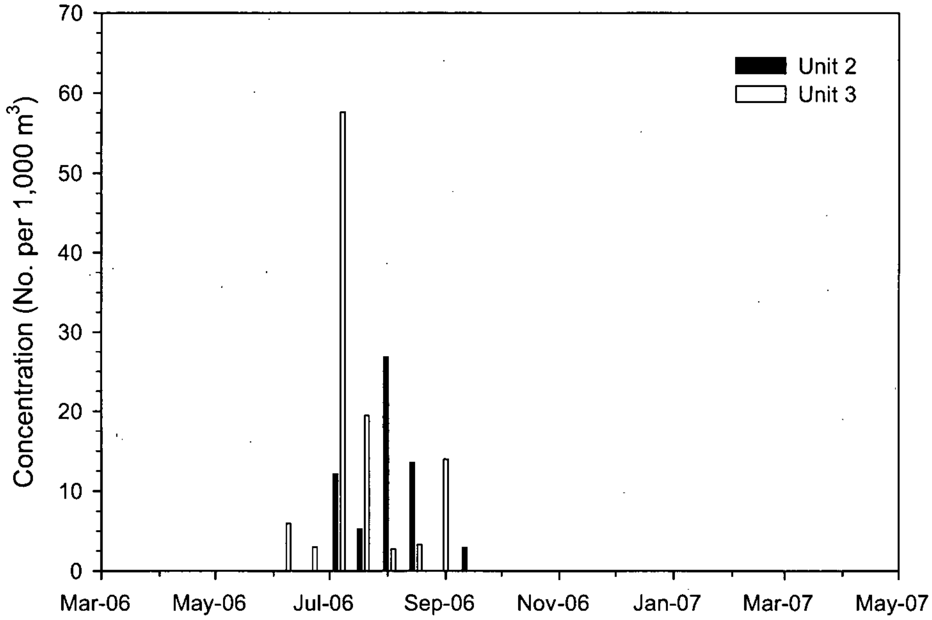


Figure 4.5-26. Mean concentration (# / 1,000 m^3 [264,172 gal]) of *Paralabrax* spp larvae collected at SONGS in-plant entrainment stations, March 2006 through April 2007.

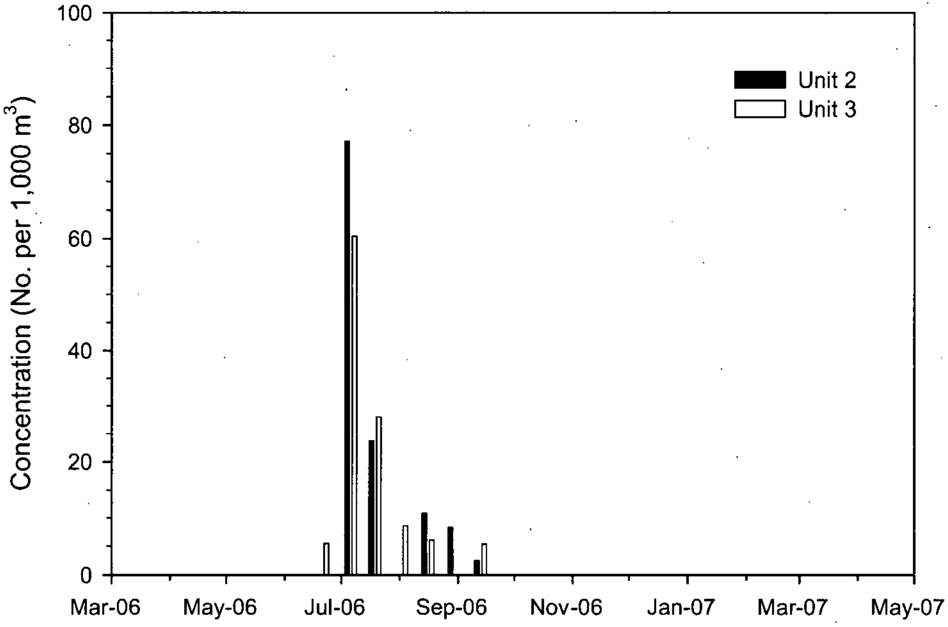


Figure 4.5-27. Mean concentration (# / 1,000 m^3 [264,172 gal]) of *Paralabrax* spp eggs collected at SONGS in-plant entrainment stations, March 2006 through April 2007.

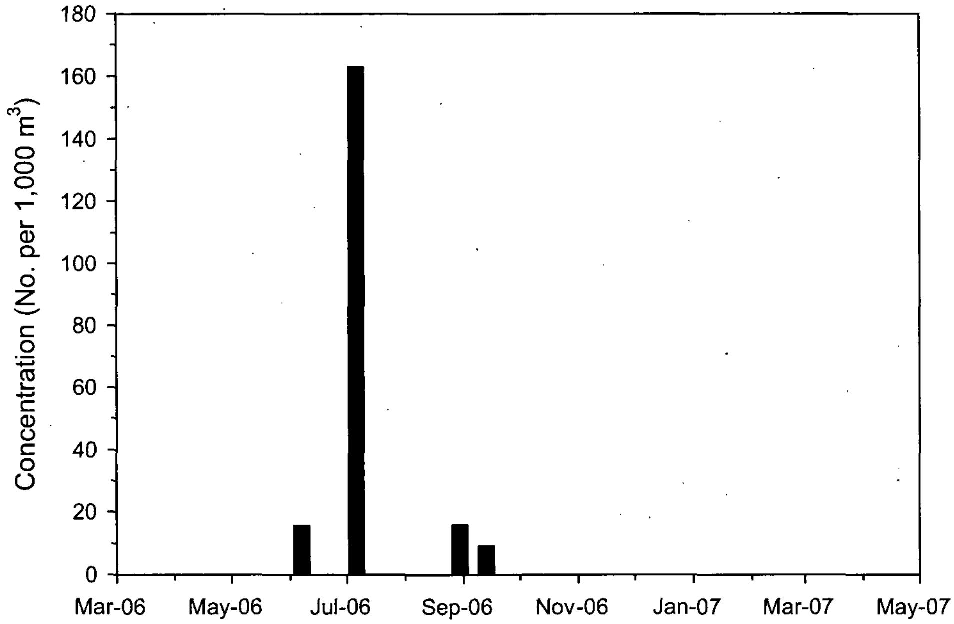


Figure 4.5-28. Mean concentration (# / 1,000 m^3 [264,172 gal]) of *Paralabrax* spp larvae collected at SONGS offshore entrainment stations (O1 and O2), March 2006 through April 2007.

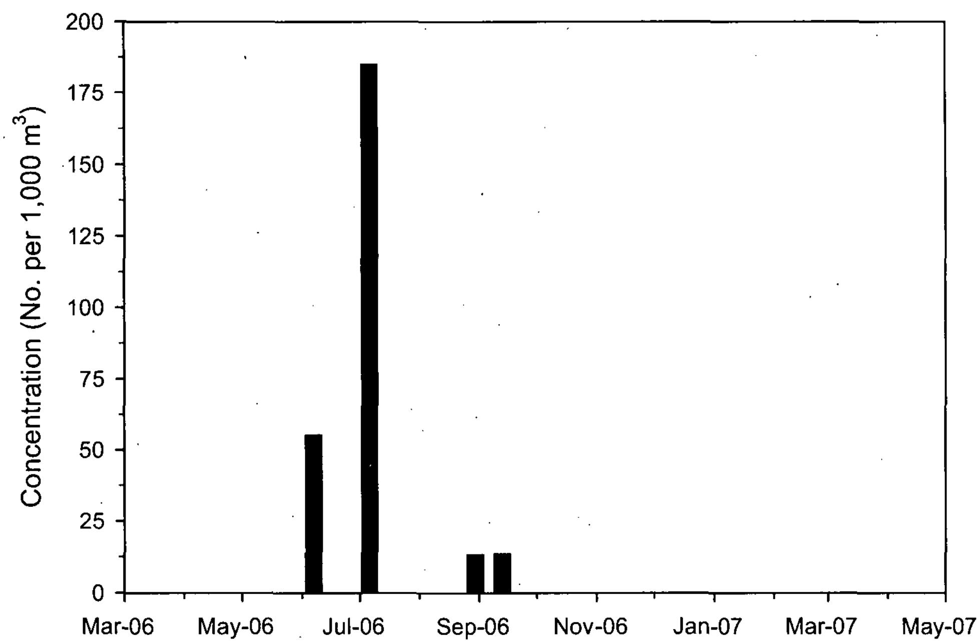


Figure 4.5-29. Mean concentration (# / 1,000 m^3 [264,172 gal]) of *Paralabrax* spp eggs collected at SONGS offshore entrainment stations (O1 and O2), March 2006 through April 2007.

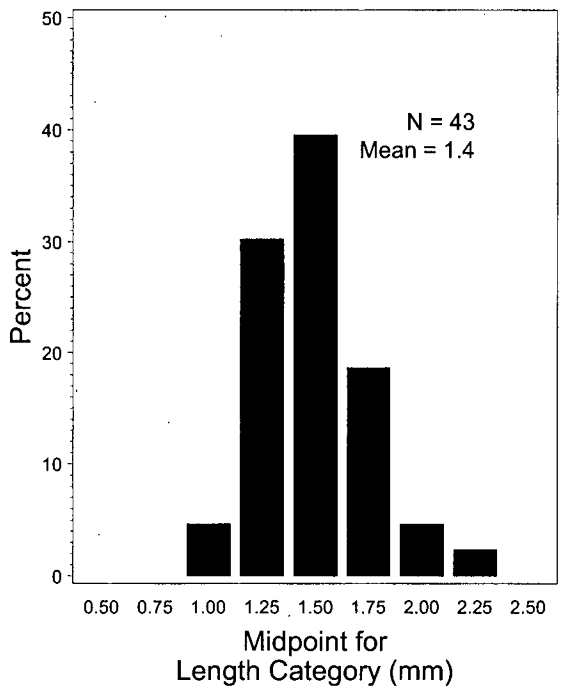
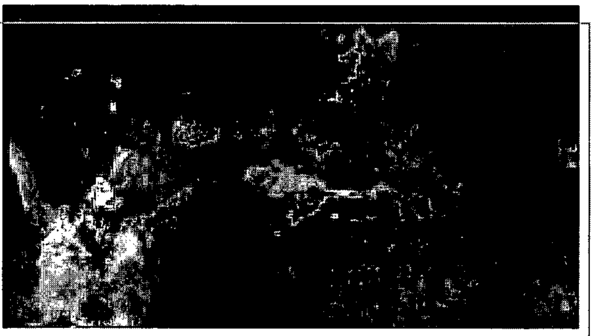


Figure 4.5-30. Length (mm) frequency distribution for *Paralabrax* spp larvae collected at SONGS entrainment stations.

4.5.4.6 Kelp Blennies (*Gibbonsia* spp)



Kelp blennies (Clinidae) of the genus *Gibbonsia* are represented in California waters by three species: crevice kelpfish (*G. montereyensis)*, striped kelpfish *(G. metzi)*, and spotted kelpfish (*G. elegans*). The first two species range from British Columbia to central Baja California while spotted kelpfish ranges from central California to southern Baja California (Love et al. 2005). All three species are similar in appearance and are differentiated mainly by fin ray counts and the presence or absence of scales on the caudal fin (Miller and Lea 1972).

4.5.4.6.1 Life History and Ecology

Kelp blennies are small, cryptic fishes generally found living in nearshore rocky reefs among kelp and seaweeds (Lamb and Edgell 1986; Moser 1996) from the intertidal zone to depths of 56 m (185 ft)

(Love et al. 1996) but is not common below about 15 m (50 ft) (Fitch and Lavenberg 1975). Kelp blennies are known to spawn year-round (Williams 1954) though exhibit a peak in their spawning between February and April (Watson 1996). Each species of *Gibbonsia* is oviparous (Nelson 1994), spawning demersal eggs which are adhesive and are attached to algal nests (Fitch and Lavenberg 1975; Moser 1996). Spotted kelpfish is reported to have a fecundity of 2,300 eggs/female (Bane and Bane 1971). Kelp blennies first spawn at 2 years of age and may spawn several times per year (Fitch and Lavenberg 1975). Larval growth was estimated by Stepien (1986) for the closely-related giant kelpfish at 0.25 mm/day ± 0.013. The larval yolk-sac stage ranges in size from 4.6-4.8 mm, preflexion from 4.6-6.4 mm, flexion from 6.6-8.0 mm, and postflexion from 8.4-20.0 mm (Watson 1996). Kelp blennies may live to about 7 years (Fitch and Lavenberg 1975). There are no catch data for these species because they are not caught commercially and only captured occasionally for aquarium display.

4.5.4.6.2 Population Trends and Fishery

There is no known fishery for kelp blennies. During the MRC studies, the mean cross-shelf abundance of *Gibbonsia* Type A larvae during the preoperational period ranged from 0.3 larvae per m^3 at the control site to 0.8 larvae per m^3 off SONGS (MEC 1987). During the operational period, densities ranged from 0.3 larvae per m^3 at the control site to 0.8 larvae per m^3 off SONGS. In the cooling water intake block sampled off SONGS (Block A), which was 0.5 to 1.1 km offshore at a depth of 6 to 9 m, preoperational densities averaged 0.1 larvae per m^3 in the neuston, 18 larvae per m^3 in the midwater, and 2 larvae per m^3 in the epibenthos (Kastendiek and Parker 1988). During the operational period, densities of *Gibbonsia* Type A averaged 0 larvae per m^3 in the neuston, 59 larvae per m^3 in the midwater, and 5 larvae per m^3 in the epibenthos. Data from MEC (1987) and Kastendiek and Parker (1988) are presented here for a species-specific historical comparison. The authors of this report have reason to believe that these previous species-specific estimates were calculated erroneously, and may actually represent the number of larvae per 100 m^3 or per 1,000 m^3. This contention is supported by statements in the "MRC Data Base User's Guide" (Green 1989). *Gibbonsia* larvae were most abundant just offshore the intakes at depths of 9 to 12 m, with the number of larvae under 100 m^2 of sea surface ranging from 0.3 larvae at depths of 22 to 45 m, to 10 larvae at depths of 9 to 12 m (Barnett et al. 1984). *Gibbonsia* larvae were most abundant in winter and spring off SONGS (MEC 1985).

4.5.4.6.3 Sampling Results

Kelp blennies (or clinid kelpfishes) were the third most abundant larval taxon collected at Unit 2 and the fourth most abundant at Unit 3, with a mean concentration of 43 larvae per 1,000 m^3 (Table 4.5-1). Kelp blenny larvae were most abundant in Unit 2 entrainment samples in February 2007, and at Unit 3 in March and May 2006 (Figure 4.5-31). *Gibbonsia* spp larvae were collected throughout the study period. Larval *Gibbonsia* concentrations at the offshore entrainment stations were highest in February 2007 and April-June 2006 (Figure 4.5-32). Concentrations recorded in-plant were substantially higher than those recorded offshore. The length frequency distribution of measured *Gibbonsia* larvae ranged from 2.8 to 20.6 mm, with a mean of 6.2 mm (Figure 4.5-33).

During offshore source water sampling, *Gibbonsia* larvae were concentrated at the surface near shore, with concentrations of 305 larvae per 1,000 m^3 (Table 4.5-9). Offshore concentrations ranged from about 6 larvae per 1,000 m^3 (in the water column) to 38 larvae per 1,000 m^3 in suprabenthic tows.

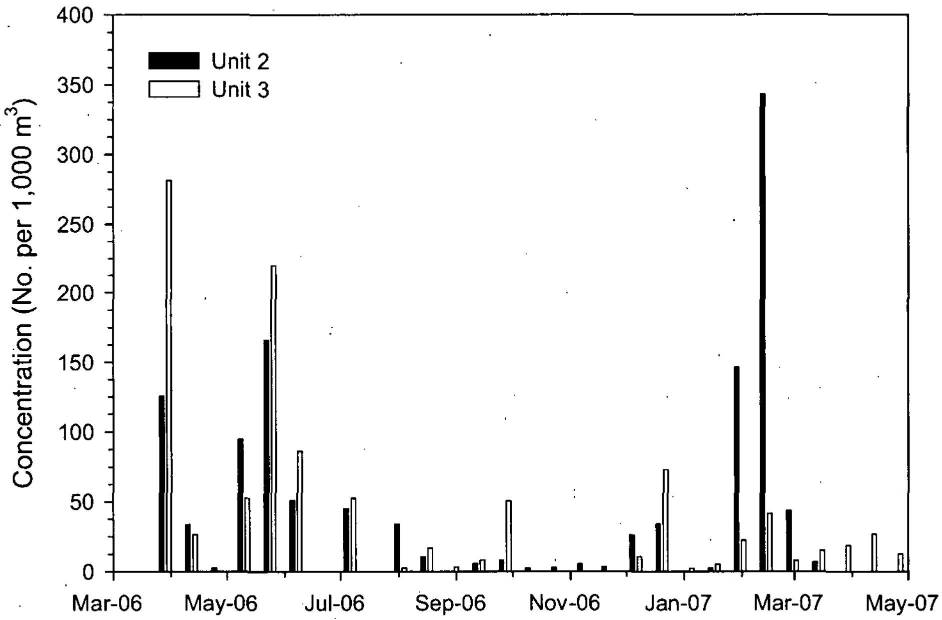


Figure 4.5-31. Mean concentration (# / 1,000 m^3 [264,172 gal]) of *Gibbonsia* spp larvae collected at SONGS in-plant entrainment stations, March 2006 through April 2007.

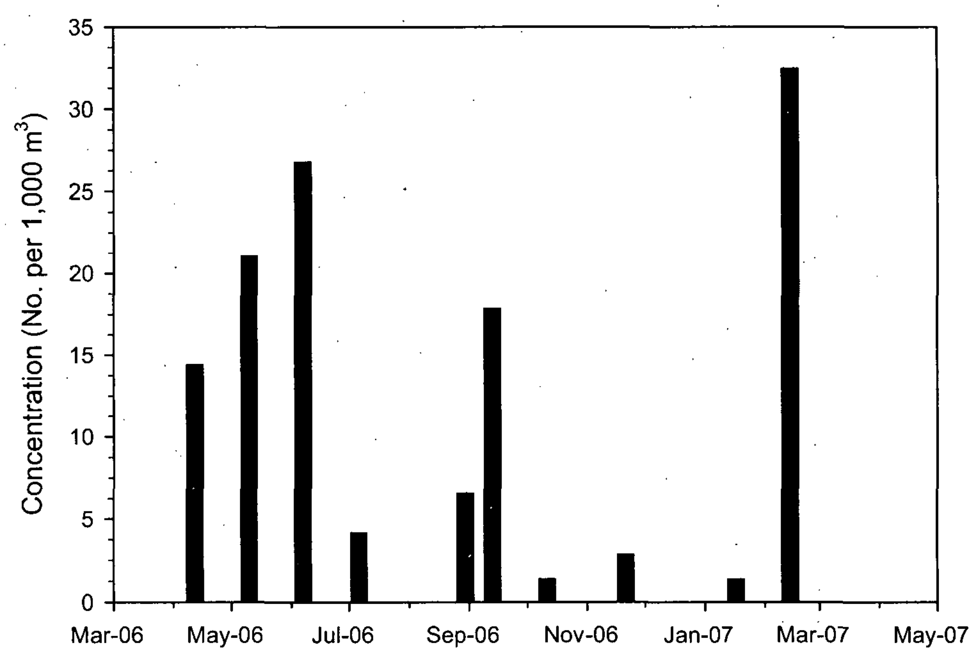


Figure 4.5-32. Mean concentration (# / 1,000 m^3 [264,172 gal]) of *Gibbonsia* spp larvae collected at SONGS offshore entrainment stations (O1 and O2), March 2006 through April 2007.

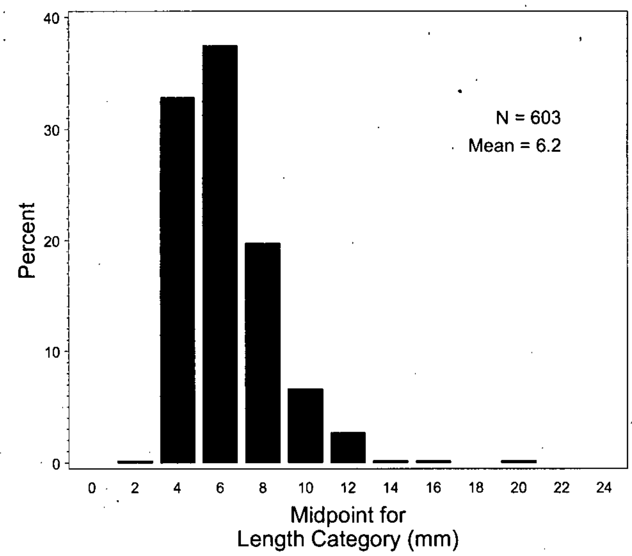
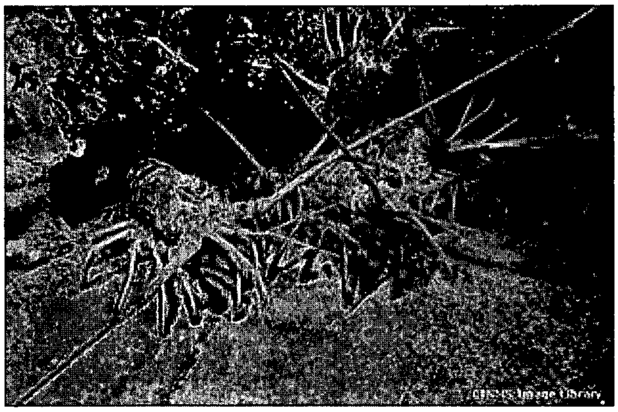


Figure 4.5-33. Length (mm) frequency distribution for *Gibbonsia* spp larvae collected at SONGS entrainment stations.

4.5.4.7 California Spiny Lobster

California spiny lobster ranges from Monterey Bay, California, to Manzanillo, Mexico, and there is also a small population along the northwestern shore of the Gulf of California (MBC 1987). They are the only representative of the spiny lobster family (Palinuridae) in southern California.



Courtesy of NOAA Central Library Photo Collection

4.5.4.7.1 Life History and Ecology

During their first two years, juveniles inhabit surfgrass beds from the lower intertidal to depths of about 5 m (16 ft). Juveniles and adults are considered benthic, though they have been observed swimming near the surface, and occur from the intertidal zone to about 80 m (262 ft). Preferred habitats include mussel beds, rocky areas, and in kelp beds (Morris et al. 1980; Barsky 2001).

California spiny lobster are oviparous, the sexes are separate, and fertilization is external. With few exceptions, adult females spawn every year. Barsky (2001) reported that mating occurs from November through May, and Wilson (1948) indicated the primary spawning season was from March to August. Mating takes place on rocky bottoms in water depths of 10–30 m (33–98 ft) (Mitchell et al. 1969).

Spawning occurs from the Channel Islands off southern California to Magdalena Bay, Baja California, including other offshore islands and banks, such as Cortez and Tanner (MBC 1987). Females move inshore to depths less than 10 m (33 ft) to extrude and fertilize the eggs. At San Clemente Island, females carried between 120,000 eggs (66 mm [2.6 in] carapace length [CL]) and 680,000 eggs (91 mm [3.6 in] CL) (Barsky 2001).

The eggs hatch from March to December. Larvae are pelagic and are found from the surface to depths of 137 m (449 ft), and within 530 km (329 mi) of shore (MBC 1987). Upon hatching, transparent larvae (phyllosoma) go through 12 molts, increasing in size with each subsequent molt. Phyllosoma are infrequently collected in the Southern California Bight (Johnson 1956, MBC 1987). After five to ten months, the phyllosoma transform into the puerulus larval stage, which resembles the adult form but is still transparent. The puerulus actively swims inshore where it settles in shallow water. At La Jolla, puerulus appeared in nearshore waters in late May and occurred there through mid-September (Serfling and Ford 1975). It is hypothesized that the puerulus stage of California spiny lobster lasts approximately two to three months (Serfling and Ford 1975).

A 6.1-mm (0.2-in) CL juvenile specimen goes through 20 molts to reach 45.7 mm (1.8 in) CL at the end of its first year (Barsky 2001). Spiny lobsters molt four times during the second year, and three times during the third year. Mitchell et al. (1969) found adult spiny lobsters (larger than 41 mm [1.6 in] CL) molt once yearly. Both sexes reach maturity at approximately 5 to 6 years at a mean size of 63.5 mm (2.5 in) CL (Barsky 2001). It takes a spiny lobster 7–11 years to reach the legal fishery size of 83 mm (3.3 in) CL. Females grow faster (4.4 mm/yr [0.2 in/yr]) than males (3.7 mm/yr [0.1 in/yr]) (Mitchell et al. 1969). Males may live up to 30 years, and reach a maximum length of 91 cm TL [35.8 in] and maximum weight of 15.8 kg (34.8 lbs). Females may live up to 17 years, and reach a maximum size of 50 cm TL [19.7 in] and 5.5 kg (12.1 lbs) (MBC 1987).

Lobsters are nocturnal, seeking crevices in which to hide during the day, and moving about the bottom at night (Wilson 1948). *Panulirus* is an omnivorous bottom forager, feeding on snails, mussels, urchins, clams, and fish (Tegner and Levin 1983; Barsky 2001). A large portion of the population makes seasonal migrations stimulated by changes in water temperature, with an offshore migration in winter and an inshore migration in late-spring and early summer (Mitchell et al. 1969; Barsky 2001). By the end of August, berried females and juveniles comprise the bulk of the shallow-water population. Warmer water temperatures shorten the development time of lobster eggs. By late September, the thermocline breaks down and lobsters move to deeper water (10–30 m) where they remain for the winter (MBC 1987).

4.5.4.7.2 Population Trends and Fishery

California spiny lobster have been fished commercially in southern California since the late 1800s (Barsky 2001). They are fished with traps, most of which are constructed of wire mesh. Most traps are fished in shallow rocky areas in waters shallower than 31 m (100 ft) deep. Commercial landings in the Los Angeles area have fluctuated, ranging between 43,084 kg and 62,585 kg (95,000 lbs and 138,000 lbs) per year since 2000 (Table 4.5-15). In 2005, commercial landings of spiny lobster in the Los

Angeles area totaled 101,324 kg (223,420 lbs) at a value of $1,771,864 (CDFG 2006). Commercial landings from catch blocks off San Onofre in 2006 totaled 40,904 kg (90,193 lbs) at an estimated value of $839,989 (CDFG 2007).

Table 4.5-15. Annual landings and revenue for California spiny lobster in the Los Angeles region based on PacFIN data.

Year	Landed Weight (kg)	Landed Weight (lbs)	Revenue
2000	47,879	105,574	$715,355
2001	49,333	108,779	$707,831
2002	43,429	95,761	$653,172
2003	54,654	120,512	$858,713
2004	62,419	137,634	$997,151
2005	55,946	123,362	$977,519
2006	52,902	116,650	$1,086,553

4.5.4.7.3 Sampling Results

California spiny lobster phyllosoma larvae were collected at both Units 2 and 3, with a mean concentration of 1.4 larvae per 1,000 m^3 (Table 4.5-3). Larvae occurred in-plant only in July and mid- to late-August 2006 (Figure 4.5-34). Spiny lobster phyllosoma occurred only at the offshore entrainment stations in July and October 2006 (Figure 4.5-35). Concentrations recorded in-plant were similar to those recorded offshore. Spiny lobster were not collected during stratified sampling offshore in spring 2007 (Table 4.5-9).

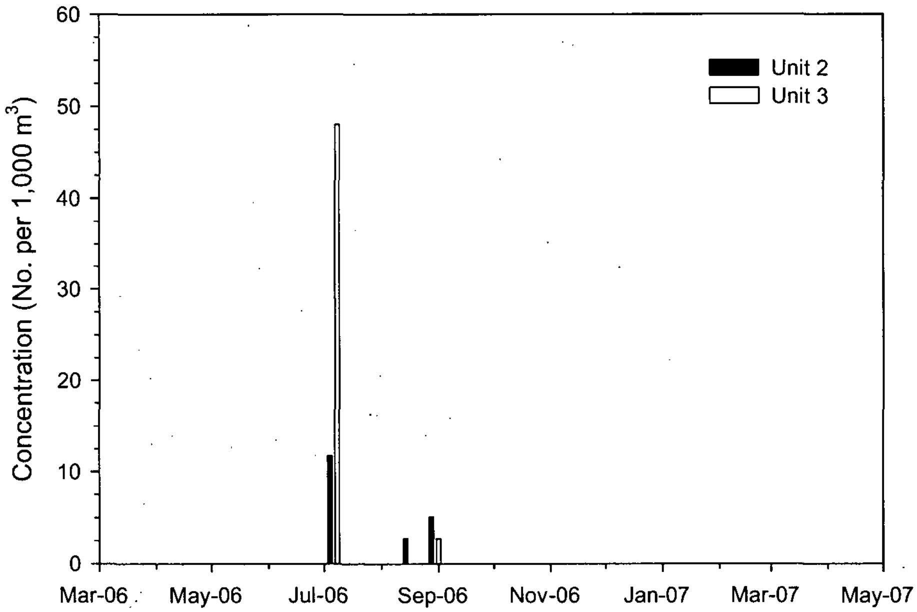


Figure 4.5-34. Mean concentration (# / 1,000 m^3 [264,172 gal]) of spiny lobster phyllosome larvae collected at SONGS in-plant entrainment stations, March 2006 through April 2007.

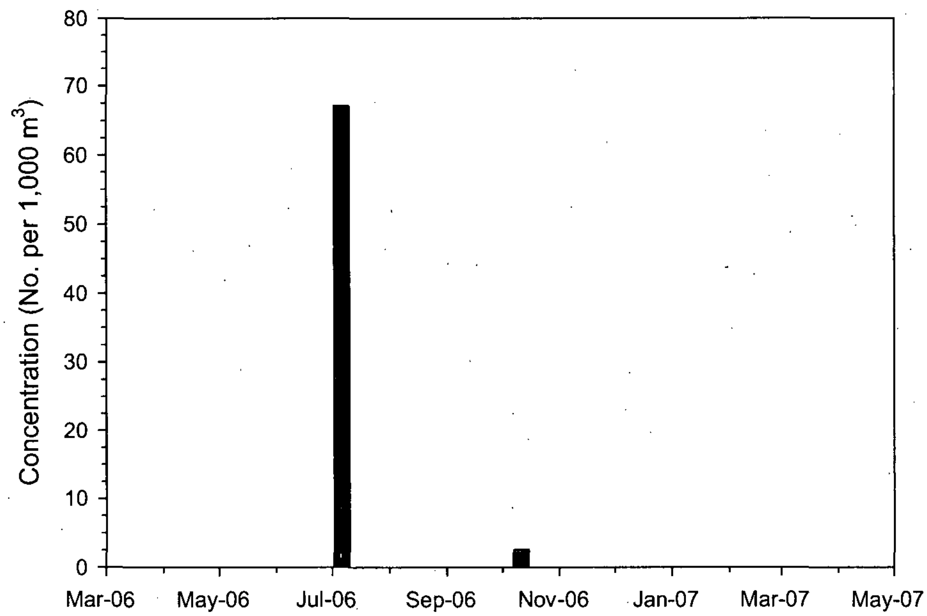


Figure 4.5-35. Mean concentration (# / 1,000 m^3 [264,172 gal]) of spiny lobster phyllosome collected at SONGS offshore entrainment stations (O1 and O2), March 2006 through April 2007.

5.0 IMPINGEMENT STUDY

5.1 INTRODUCTION

The purpose of the impingement study is to determine the extent of potential impacts from the operation of the cooling water system of SONGS on fishes and selected invertebrates. Impingement occurs when organisms larger than the traveling screen mesh size (9.5 mm or 3/8 inch) become trapped against the screens, either because they are too fatigued to swim against the intake flow at the screens, or they are injured or dead. Normal operations impingement samples were collected over a 24-hr period to determine the daily loss from operation of the cooling water intake systems. Samples were also collected during heat treatments, when waters within the cooling water system were heated and fishes and invertebrates succumbed and were subsequently impinged. Combined, data from both normal operation and heat treatment surveys were used to estimate annual impingement of juvenile and adult fishes and shellfishes at SONGS.

5.1.1 Species to Be Analyzed

Several types of organisms are susceptible to impingement by the generating station. All fishes and macroinvertebrates were processed (identified, enumerated, and where appropriate, measured) in impingement samples. However, assessment of impingement effects was limited to the fish taxa that have historically been the most abundant (or contributed most to biomass) in impingement samples at SONGS as identified in the PIC. Assessment of impingement effects on invertebrates was limited to those that were considered commercially or recreationally important, and were collected in sufficient numbers to warrant analysis.

5.2 PREVIOUSLY COLLECTED DATA

A summary of previously collected impingement data from SONGS is presented in Section 7.3 (*Discussion*).

5.3 METHODS

The following sections provide information on the impingement sample collection and data analysis methods. The impingement sampling program was designed to provide the necessary information for the impingement mortality characterization and development of the calculation baseline. The impingement sampling provided current estimates of the taxonomic composition, abundance, biomass, seasonality, and, during three surveys, diel periodicity of organisms impinged at SONGS. The sampling program also documented the size, sex, and physical condition of fish and shellfish impinged. The abundance and biomass of organisms impinged was used to calculate impingement rates (e.g., the number of organisms impinged per 10^6 m^3 [264,172,052 gallons] cooling water flowing into the CWIS).

SONGS has two screening facilities: one for Unit 2 and one for Unit 3. Each screening facility consists of traveling bars and rakes, traveling screens, the fish return (elevator) system, and the circulating water pumps. Seawater drawn into each cooling water system enters through the velocity-capped intake structure offshore, and travels into the screenwell where it is directed to the rakes and screens by a series of vanes. There the water passes through one of the six sets of screens or through the fish bypass channel into the fish removal area. Each set of screens consists of 2.5-cm (1-in) traveling bar with rakes (to remove kelp and other larger objects) followed by the 9.5-mm (3/8-in) mesh traveling screens to filter out smaller objects. Downcurrent from the fish removal area are 9.5-mm mesh traveling screens; there are no traveling bar/rakes at the fish return system. Water passing through the screens is then pumped to the condensers. All material that was impinged on the traveling bars and screens during the survey period was subsequently rotated to the top of the screens and rinsed by a high-pressure wash system into a sluiceway running to two collection baskets, one each for the bars and screens. A more complete description of the cooling water system is presented in Section 3.2.

5.3.1 Field Sampling

Field sampling for impingement surveys occurred biweekly during normal operations and during all heat treatments.

5.3.1.1 Normal Operation Impingement

Impingement sampling at SONGS was conducted over a 24-hour period one day per week every two weeks. Twenty-six impingement surveys were conducted at each unit. Three of the twenty-six surveys at each unit were modified to determine diel impingement characteristics; these surveys occurred in February, March, and April 2007. During the diel surveys, the 24-hour sampling interval was divided into two 12-hour cycles. Initiation of sample collection occurred as follows: Cycle 1 (approximately 0430-1630 hours) and Cycle 2 (approximately 1630-0430 hours).

Impingement sampling at SONGS is described in detail in SONG Environmental Procedure SO123-IX-2.7, Revision 2 (included as an appendix to this report). This procedure was used while conducting the impingement sampling, with the addition of macroinvertebrate processing. A summarized description of the procedure is described below.

Surveys were performed at SONGS when at least two circulating water pumps were operating at the beginning of each survey. Before each sampling effort, the traveling screens were rotated and washed clean of all impinged debris and organisms. The sluiceways and collection baskets were cleaned and discarded into dumpsters and hauled away or separated from any subsequent collection basket dumps for the sample period. The operating status of the circulating water pumps was recorded on an hourly basis during the study year. At the end of the 24-hour period the screens were manually triggered and run for a normal cycle of nineteen minutes. This rinse period allowed the entire screen to be rinsed of all material impinged since the last screen wash cycle. The impinged material was rinsed from the screens into two sluiceways, one associated with the bars and rakes, the other with the screens, then flowed into the collection baskets associated with each sluiceway. The collection baskets were dumped and rinsed into a bin for sample processing. On some occasions, the screen wash systems were operated (automatically or manually) prior to the end of each cycle. The material that was rinsed on these occasions was combined with the material collected at the end of each cycle. All debris and organisms rinsed from each unit was processed independently.

All fishes and macroinvertebrates collected at the end of each 24-hour cycle (12-hour cycles for the three diel surveys) were removed from other impinged debris, identified, enumerated, and weighed. Each individual was identified to the most specific taxon possible. Species that were difficult to identify or needed further literature review were brought back to the laboratory to be further analyzed. Depending on the number of individuals of a given species present in the sample, one of two specific procedures was used, as described below. Each of these procedures involves the following measurements and observations:

- The appropriate linear measurement for individual fish and lobster was determined and recorded. These measurements were recorded to the nearest 1 mm (0.04 in). The following standard linear measurements were used for the animal groups indicated:
  - Fishes - Total body length (TL) for sharks and rays and standard lengths (SL) for bony fishes.
  - Lobsters - Carapace length (CL), measured from the anterior margin of carapace between the eyes to the posterior margin of the carapace. No other shellfish were measured.
- The sex of individuals from predetermined species (Attachment 5, SONGS Environmental Procedure SO123-IX-2.7 Rev.2) were identified to female, male, or unknown (undeveloped or unidentifiable reproductive structures) using methods described below:
  - Fishes – Determination of sex was based on whether fishes had external or internal morphology allowing such determinations:
    - All species with external reproductive features were determined based on the identifiable characteristics of external genitalia.
    - Species to be sexed with no externally distinguishable features were dissected along the abdomen to expose the gonads, and identified based on color, shape, and consistency of their reproductive organs.
  - Macroinvertebrates – The sex of California spiny lobster was determined by examination of the last pair of walking legs and pleopod development.
- The wet body weight of all individuals combined was determined, shaking any loose water or debris from the individuals. All weights were recorded to the nearest 1 g (0.035 ounce).
- Shellfishes and other macroinvertebrates were identified to species and their presence and combined abundance and weight recorded.
- The amount and type of debris (e.g., *Mytilus* shell fragments, algae, etc.) and any unusual operating conditions in the screenwell system were noted by writing specific comments in the "Notes" section of the data sheet. Information on weather, temperature, swell height, and water clarity was also recorded during each collection.

The following specific procedures were used for processing fishes and shellfishes when the number of individuals per species in the sample or subsample was less than 125:

- For each individual of a given species, the linear measurement (TL, SL, or CL as indicated previously) was determined and recorded.

The following specific subsampling procedures were used for fishes and shellfishes when the number of individuals per species was greater than 125:

- The linear measurement for a subsample of 125 individuals was recorded individually on the data sheet. The individuals selected for measurement were selected after spreading out all of the individuals in a sorting container, making sure that they were well mixed and not segregated into size groups. Individuals with missing heads or other major body parts were not measured.
- For required species, the sex of up to 50 individuals from the subsample was recorded.
- The total number and total weight of all the remaining individuals combined was determined and recorded separately.

A QA/QC program was implemented to ensure that all of the organisms were removed from the debris and that the correct identification, enumeration, length and weight measurements of the organisms were recorded on the data sheets. Random surveys were chosen for QA/QC re-sorting to verify that all the collected organisms were removed from the impinged material. Quality control surveys were done on a quarterly basis during the study. The survey procedures were reviewed with all personnel prior to the start of the study and all personnel were given printed copies of the procedures.

5.3.1.2 Fish Chase/Heat Treatment Impingement

Heat treatments are a commonly used method to control growth of marine fouling organisms within a CWIS at coastal generating stations. A byproduct of the procedure is an increase in water temperature that affects all of the organisms inside the screenwells, resulting in increased impingement. To limit fatal impingement of fish and shellfish, a "fish chase" protocol was integrated into SONGS heat treatment procedures. The fish chase process involves slowly increasing the screenwell temperature to a sublethal temperature. Fish agitated by the temperature rise move into the fish removal area where they are removed using the fish return system (FRS). When most of the fish that can be removed are taken out by the fish chase procedure, the screenwell is allowed to cool down to ambient ocean temperature for thirty minutes. This allows heated water to be flushed from the discharge conduit, prior to initiation of the heat treatment. As the heat treatment tunnel reversal begins, several additional lifts of the fish elevator are conducted, the result being most of the fish removed from the system and less fish fatally impinged during the heat treatment. Results from fish chase surveys are discussed in Section 6.0

In order to account for the fish and invertebrates impinged during the 316(b) survey period, any fish or invertebrates impinged during the fish chase/heat treatment were processed using normal operations impingement procedures described in Section 5.3.1.1.

5.3.2 Data Analysis

Daily cooling water flow from each unit was obtained from SCE, based on the log for each circulator pump. Impingement rates were calculated using the circulating water flow during each of the 24-hr surveys (or cycles for diel surveys). The total time for each cycle was multiplied by the known flow rate of each of the circulating water pumps in operation during each survey or cycle.

5.3.2.1 Impingement Estimates

The estimated daily impingement rate was used to calculate biweekly and annual impingement. The study period was separated into uniform 14-day intervals, with part of each week prior to and following the impingement collection survey dates assigned to biweekly survey periods. Impingement estimates were calculated by using the flow that occurred during the sampling interval and extrapolating by the flow during the biweekly analysis period. The total calculated flow for each survey analysis period was multiplied by the taxon-specific impingement rates for both abundance and biomass. The estimated impingement rate for each survey period was summed to determine the annual normal operation impingement estimates for each taxon. These were added to impingement totals from heat treatment procedures to estimate total annual impingement.

During impingement sampling, all fishes and invertebrates that were retained on the traveling screens were rinsed from the screens, flowed along a water-filled sluiceway, and were deposited into the impingement collection baskets for processing. Data are presented for all impinged taxa, but a subset of species was selected for more detailed analysis as described in Section 5.1.1.

5.3.2.2 Impingement Impact Assessment

To put the impingement results in context, losses were compared to (1) known population estimates where available, (2) commercial fishing landings for those species harvested commercially, and (3) sport fishing landings for those species targeted by recreational anglers. Commercial landing data were derived from three potential sources: (1) the Pacific Fishery Information Network (PacFIN), which summarized all commercial landings in the Los Angeles Area for the last seven years, (2) California Department of Fish and Game landing reports originating from Los Angeles area ports from 2005, and (3) California Department of Fish and Game catch block data from Orange and San Diego County area catch blocks in 2006. The five catch blocks in this analysis included: 737, 756, 757, 801, and 802 (see Figure 4.3-2). Sport fishing landings were derived from the Recreational Fishery Information Network (RecFIN), which included all marine areas in southern California. Previous fish impingement estimates were derived from NPDES monitoring reports prepared by SCE (1983b, 1984-2006), including the most recent year of monitoring prior to the 316(b) study (2005).

5.4 DATA SUMMARY

The following sections summarize results from the 2006-2007 impingement sampling at SONGS. The study was designed to provide information necessary to characterize annual, seasonal, and diel variations in impingement mortality as required by the §316(b) Phase II regulations. Annual variation was characterized by comparison to previous impingement studies. Seasonal variation was characterized by analysis of impingement rates during the year-long study, and diel variation was characterized by analysis of daytime and nighttime impingement during three paired collections during 2007.

5.4.1 Data Summary of Collected Samples

Twenty-six concurrent normal operation impingement and fish return system surveys were completed between March 21, 2006 and May 15, 2007 at each of the two units (Table 5.4-1). Additionally, 17 fish chase and heat treatment surveys were conducted during this same period: eight at Unit 2 and nine at Unit 3 (Table 5.4-2). Twenty-six biweekly surveys were conducted at each unit to provide a 52-week (annual) analysis period. Paired Unit 2 and 3 sample collection was conducted when possible, with 26 surveys scheduled at each unit. Sample collection was blocked at Unit 2 once when a scheduled heat treatment was delayed, and subsequently re-scheduled during the 24-hour survey, and the final bi-weekly (26th) survey was delayed to provide a concurrent diel paired sample with Unit 3 in April 2007. Sample collection was blocked at Unit 3 once by maintenance on the fish return elevator, and no samples were collected during the 42-day outage in October-November 2006. The sampling plan required that the FRS be operational during all normal operation surveys. Heat treatments were conducted based on schedules set by the operational patterns of the generating station, and occurred approximately six to eight weeks apart based on estimated growth of biofouling organisms in the intake conduit.

Table 5.4-1. Summary of SONGS impingement sampling effort.

Sample Date	Unit 2	Unit 3
03/21/06	X	X
04/04/06	X	X
04/18/06	X	X
5/2/06[1]		X
05/16/06	X	X
05/30/06	X	X
6/13/06[2]	X	
06/27/06	X	X
07/11/06	X	X
07/25/06	X	X
08/08/06	X	X
08/22/06	X	X
09/05/06	X	X
09/19/06	X	X
10/03/06	X	X
10/17/06[3]	X	
10/31/06[3]	X	
11/14/06[3]	X	
11/28/06[3]	X	
12/12/06	X	X
12/27/06	X	X
01/09/07	X	X
01/23/07	X	X
02/06/07	X	X
2/20/07[4]	X	X
2/21/07[4]	X	X
3/5/07[4]	X	X
3/6/07[4]	X	X
3/20/07[5]		X
4/1/07[4]	X	X
4/2/07[4]	X	X
4/17/07[5]		X
5/1/07[5]		X
5/15/07[5]		X

1 – Unit 2 heat treatment during 24-hr survey;
2 – Unit 3 FRS maintenance;
3 – Unit 3 outage;
4 – Diel survey periods;
5 – Unit 3 only.

Table 5.4-2. Fish chase and heat treatment survey dates at SONGS.

Sample Date	Unit 2	Unit 3
5/1/06	X	
5/13/06		X
6/10/06	X	
6/24/06		X
8/1/06	X	
8/10/06		X
9/2/06	X	
9/16/06		X
10/07/06	X	
12/6/06	X	
1/4/07*		X
1/7/07*		X
1/10/07		X
1/26/07	X	
3/4/07		X
4/4/07	X	
4/25/07		X

* - Fish chase performed but heat treatment delayed

5.5 RESULTS

5.5.1 Normal Operation Impingement Summary

5.5.1.1 Fish

A total of 136,455 fishes representing 95 distinct species and weighing 5,461.650 kg (12,040.863 lbs) were collected during impingement sampling in 2006-2007. The estimated annual total impingement based on cooling water flow volumes in 2006-2007 from normal operations and heat treatments was 1,353,158 individuals weighing 13,036.521 kg (28,740.575 lbs) (Table 5.5-1). Queenfish was the most abundant species, with an estimated annual impingement of 712,937 individuals weighing 3,599.594 kg (7,935.737 lbs). The annual impingement of queenfish represented 52.7% of the total impingement abundance and 27.6% of the biomass. The next most abundant species in impingement samples were northern anchovy, Pacific sardine, deepbody anchovy, and white seaperch. Combined these taxa accounted for 91.2% of the sampled impingement abundance. Unit 2 contributed 839,487 individuals weighing 7959.729 kg (17,548.178 lbs) to the total while Unit 3 contributed 513,671 individuals and 5073.792 kg (11,192.397 lbs).

Estimated abundance from normal operations was 1,310,759 individuals (96.9% of the combined total), with 814,772 individuals taken at Unit 2 and 495,987 individuals taken at Unit 3. Estimated biomass from normal operations was 8,196.123 kg (18,069.337 lbs) (62.9% of the overall total); with 4,422.152 kg (9,749.165 lbs) taken at Unit 2 and 3,773.971 kg (8,320.172 lbs) taken at Unit 3.

Total abundance from heat treatments was 42,399 individuals (3.1% of the combined total), with 24,715 individuals taken at Unit 2 and 17,684 individuals taken at Unit 3. Biomass from heat treatments was 4,840.398 kg (10,671.238 lbs) (37.1% of the combined total); with 3,537.577 kg (7,799.013 lbs) taken at Unit 2 and 1,302.821 kg (2,872.225 lbs) taken at Unit 3.

5.5.1.2 Shellfishes

A total of 40,398 macroinvertebrates representing at least 84 distinct taxa and weighing 231.351 kg (510.041 lbs) was collected during normal operation and heat treatment impingement sampling in 2006-2007. The estimated annual total impingement based on cooling water flow volumes in 2006-2007 was 117,858 individuals weighing 1,308.667 kg (2,885.113 lbs) (Table 5.5-2). The yellow crab was the most abundant species, with 10,273 individuals collected (8.7% of the total) and an estimated annual impingement of 22,781 individuals (19.3%) weighing 76.121 kg (167.818 lbs, 5.8%). The next most abundant species in impingement samples were Xantus swimming crab (*Portunus xantusii*), blackspotted bay shrimp (*Crangon nigromaculata*), hairy rock crab (*Cancer jordani*), Pacific sand dollar (*Dendraster excentricus*), and brown rock crab. Combined these species accounted for 73% of the sampled impingement abundance and 25.4% of the biomass.

Unit 2 contributed 62,610 individuals weighing 576.197 kg (1,270.295 lbs) to the total while Unit 3 contributed 55,248 individuals and 732.470 kg (1,614.818 lbs).

Estimated invertebrate abundance from normal operations was 83,393 individuals (70.8% of the combined total), with 48,328 individuals taken at Unit 2 and 35,065 individuals taken at Unit 3. Estimated biomass from normal operations was 1,159.669 kg (2,256.629 lbs) (88.6% of the combined total); with 504.588 kg (1,112.425 lbs) taken at Unit 2 and 655.081 kg (1,444.205 lbs) taken at Unit 3.

Total invertebrate abundance from heat treatments was 34,465 individuals (29.2% of the overall total), with 14,282 individuals taken at Unit 2 and 20,183 individuals taken at Unit 3. Biomass from heat treatments was 148.998 kg (328.484 lbs, 11.4% of the overall total), with 71.609 kg (157.871 lbs) taken at Unit 2 and 77.389 kg (170.613 lbs) taken at Unit 3.

Table 5.5-1. Total estimated SONGS fish impingement during heat treatment and 26 biweekly surveys at both units from March 2006 through May 2007.

		Annual Impingement							
		Est. Normal Operation		Heat Treatment		Combined		Percent	
Taxa	Common Name	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Seriphus politus	queenfish	702,062	3,331.339	10,875	268.255	712,937	3,599.594	52.7	27.6
Engraulis mordax	northern anchovy	394,162	323.005	1,912	17.691	396,074	340.696	29.3	2.6
Sardinops sagax	Pacific sardine	107,379	1,271.014	87	3.307	107,466	1,274.321	7.9	9.8
Anchoa compressa	deepbody anchovy	21,267	168.227	2237	23.825	23,504	192.052	1.7	1.5
Phanerodon furcatus	white seaperch	18,648	63.994	76	3.347	18,724	67.341	1.4	0.5
Atherinops affinis	topsmelt	7,786	207.582	2,770	106.166	10,556	313.748	0.8	2.4
Genyonemus lineatus	white croaker	9,067	58.537	490	9.923	9,557	68.460	0.7	0.5
Umbrina roncador	yellowfin croaker	98	37.954	9,160	3,249.296	9,258	3,287.250	0.7	25.2
Anchoa delicatissima	slough anchovy	8,515	23.638	28	0.072	8,543	23.710	0.6	0.2
Xenistius californiensis	salema	2,439	20.483	5,871	161.129	8,310	181.612	0.6	1.4
Cymatogaster aggregata	shiner perch	6,552	30.954	1,089	19.146	7,641	50.100	0.6	0.4
Syngnathus californiensis	kelp pipefish	6,574	11.703	65	0.099	6,639	11.802	0.5	0.1
Peprilus simillimus	Pacific pompano	4,742	110.010	325	8.923	5,067	118.933	0.4	0.9
Atherinopsis californiensis	jacksmelt	3,220	238.735	818	61.044	4,038	299.779	0.3	2.3
Hypsoblennius gilberti	rockpool blenny	1,100	4.918	1,647	5.297	2,747	10.215	0.2	0.1
Porichthys notatus	plainfin midshipman	2,671	77.888	12	0.571	2,683	78.459	0.2	0.6
Anisotremus davidsonii	sargo	70	6.594	2,017	441.038	2,087	447.632	0.2	3.4
Sphyraena argentea	Pacific barracuda	1,862	14.154	12	0.464	1,874	14.618	0.1	0.1
Scomber japonicus	Pacific chub mackerel	1,500	148.999	247	29.888	1,747	178.887	0.1	1.4
Synodus lucioceps	California lizardfish	1,651	33.448	1	0.013	1,652	33.461	0.1	0.3
Trachurus symmetricus	jack mackerel	588	13.916	889	53.987	1,477	67.903	0.1	0.5
Porichthys myriaster	specklefin midshipman	1,332	76.619	4	1.185	1,336	77.804	0.1	0.6
Embiotoca jacksoni	black perch	972	4.119	177	14.164	1,149	18.283	0.1	0.1
Scorpaena guttata	California scorpionfish	777	33.657	179	12.925	956	46.582	0.1	0.4
Heterostichus rostratus	giant kelpfish	743	8.725	31	0.334	774	9.059	0.1	0.1
Hyperprosopon argenteum	walleye surfperch	490	5.739	185	5.275	675	11.014	0.0	0.1
Citharichthys stigmaeus	speckled sanddab	574	5.264	42	0.083	616	5.347	0.0	0.0
Pleuronichthys ritteri	spotted turbot	454	10.561	29	0.488	483	11.049	0.0	0.1
Scorp. marmoratus	cabezon	198	0.718	184	2.740	382	3.458	0.0	0.0
Syngnathus sp	pipefish unid.	364	0.420	11	0.021	375	0.441	0.0	0.0
Leuresthes tenuis	California grunion	296	5.912	14	0.160	310	6.072	0.0	0.0
Myliobatis californica	bat ray	287	134.566	2	0.590	289	135.156	0.0	1.0
Pleuronichthys verticalis	hornyhead turbot	268	16.031	1	0.021	269	16.052	0.0	0.1
Hermosilla azurea	zebraperch	-	-	218	144.400	218	144.400	0.0	1.1
Torpedo californica	Pacific electric ray	183	1,478.861	1	11.250	184	1,490.111	0.0	11.4
Rhacochilus toxotes	rubberlip seaperch	154	1.484	24	0.534	178	2.018	0.0	0.0
Paralabrax clathratus	kelp bass	98	0.420	79	3.278	177	3.698	0.0	0.0
Paralabrax nebulifer	barred sand bass	28	2.843	149	22.034	177	24.877	0.0	0.2
Gibbonsia elegans	spotted kelpfish	140	1.791	16	0.113	156	1.904	0.0	0.0
Paralichthys californicus	California halibut	126	11.452	26	2.460	152	13.912	0.0	0.1
Ophidion scrippsae	basketweave cusk-eel	126	4.409	11	0.038	137	4.447	0.0	0.0
Micrometrus minimus	dwarf perch	126	0.210	8	0.046	134	0.256	0.0	0.0
Oxyjulis californica	senorita	126	2.996	7	0.071	133	3.067	0.0	0.0
Roncador stearnsii	spotfin croaker	28	10.934	102	44.549	130	55.483	0.0	0.4
Cheilotrema saturnum	black croaker	28	1.568	98	8.485	126	10.053	0.0	0.1
Atractoscion nobilis	white seabass	84	1.946	31	3.043	115	4.989	0.0	0.0
Hypsoblennius jenkinsi	mussel blenny	103	0.477	-	-	103	0.477	0.0	0.0
Leptocottus armatus	Pacific staghorn sculpin	98	2.478	1	0.021	99	2.499	0.0	0.0
Sebastes paucispinis	bocaccio	98	0.279	-	-	98	0.279	0.0	0.0

(*table continued*)

Table 5.5-1. (Cont.). Total estimated SONGS fish impingement during heat treatment and 26 biweekly surveys at both units from March 2006 through May 2007.

		Annual Impingement							
		Est. Normal Operation		Heat Treatment		Combined		Percent	
Taxa	Common Name	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Platyrhinoidis triseriata	thornback	84	26.488	-	-	84	26.488	0.0	0.2
Gymnura marmorata	California butterfly ray	70	25.354	1	0.156	71	25.510	0.0	0.2
Syngnathus exilis	barcheek pipefish	56	0.112	2	0.003	58	0.115	0.0	0.0
Heterodontus francisci	horn shark	42	49.896	2	4.180	44	54.076	0.0	0.4
Pleuronichthys guttulatus	diamond turbot	42	7.532	-	-	42	7.532	0.0	0.1
Halichoeres semicinctus	rock wrasse	14	0.980	19	2.134	33	3.114	0.0	0.0
Ophichthus zophochir	yellow snake eel	28	2.883	-	-	28	2.883	0.0	0.0
Syngnathus leptorhynchus	bay pipefish	14	0.014	13	0.018	27	0.032	0.0	0.0
Chromis punctipinnis	blacksmith	-	-	23	1.017	23	1.017	0.0	0.0
Brachyistius frenatus	kelp perch	14	0.084	6	0.171	20	0.255	0.0	0.0
Urobatis halleri	round stingray	14	0.812	6	3.466	20	4.278	0.0	0.0
Rhinobatos productus	shovelnose guitarfish	14	0.924	4	17.470	18	18.394	0.0	0.1
Sebastes auriculatus	brown rockfish	-	-	17	1.503	17	1.503	0.0	0.0
Menticirrhus undulatus	California corbina	14	6.440	2	0.136	16	6.576	0.0	0.1
Artedius corallinus	coralline sculpin	14	0.056	1	0.005	15	0.061	0.0	0.0
Orthonopias triacis	snubnose sculpin	15	0.015	-	-	15	0.015	0.0	0.0
Pleuronichthys coenosus	C-O sole	14	0.014	1	0.003	15	0.017	0.0	0.0
Cephaloscyllium	swell shark	14	13.188	-	-	14	13.188	0.0	0.1
Mustelus californicus	grey smoothhound	14	7.938	-	-	14	7.938	0.0	0.1
Squalus acanthias	spiny dogfish	14	30.800	-	-	14	30.800	0.0	0.2
Xystreurys liolepis	fantail sole	14	1.022	-	-	14	1.022	0.0	0.0
P. maculatofasciatus	spotted sand bass	-	-	6	0.198	6	0.198	0.0	0.0
Gibbonsia metzi	striped kelpfish	-	-	5	0.082	5	0.082	0.0	0.0
Medialuna californiensis	halfmoon	-	-	5	0.654	5	0.654	0.0	0.0
Sebastes miniatus	vermilion rockfish	-	-	4	0.018	4	0.018	0.0	0.0
Sebastes rastrelliger	grass rockfish	-	-	3	0.601	3	0.601	0.0	0.0
Symphurus atricaudus	California tonguefish	-	-	3	0.004	3	0.004	0.0	0.0
Hyperprosopon anale	spotfin surfperch	-	-	2	0.044	2	0.044	0.0	0.0
Rhacochilus vacca	pile perch	-	-	2	0.316	2	0.316	0.0	0.0
Sebastes serriceps	treefish	-	-	2	0.128	2	0.128	0.0	0.0
Sebastes sp	rockfish	-	-	2	0.372	2	0.372	0.0	0.0
Amphistichus argenteus	barred surfperch	-	-	1	0.217	1	0.217	0.0	0.0
Cottidae sp	sculpin, unid.	-	-	1	0.003	1	0.003	0.0	0.0
Hypsypops rubicundus	garibaldi	-	-	1	0.009	1	0.009	0.0	0.0
Lepidogobius lepidus	bay goby	-	-	1	0.001	1	0.001	0.0	0.0
Ophididae	cusk-eel unid	-	-	1	0.096	1	0.096	0.0	0.0
Pleuronichthys decurrens	curlfin turbot	-	-	1	0.011	1	0.011	0.0	0.0
Rathbunella alleni	stripefin ronquil	-	-	1	0.007	1	0.007	0.0	0.0
Sebastes atrovirens	kelp rockfish	-	-	1	0.131	1	0.131	0.0	0.0
Semicossyphus pulcher	California sheephead	-	-	1	0.455	1	0.455	0.0	0.0
Stereolepis gigas	giant sea bass	-	-	1	65.000	1	65.000	0.0	0.5
	Totals:	**1,310,759**	**8,196.1**	**42,399**	**4,840.4**	**1,353,158**	**13,036.5**	**100.0**	**100.0**
	No. of Taxa	**67**		**80**		**90**			

Table 5.5-2. Total estimated SONGS macroinvertebrate impingement during heat treatment and 26 biweekly surveys at both units from March 2006 through May 2007.

		Annual Impingement							
		Est. Normal Operation		Heat Treatment		Combined		Percent	
Taxa	Common Name	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Cancer anthonyi	yellow crab	13,469	50.751	9,312	25.370	22,781	76.121	19.3	5.8
Portunus xantusii	Xantus swimming crab	16,353	76.654	943	3.360	17,296	80.014	14.7	6.1
Crangon nigromaculata	blackspotted bay shrimp	15,216	38.333	43	0.070	15,259	38.403	12.9	2.9
Cancer jordani	hairy rock crab	7,716	15.957	4,172	7.355	11,888	23.312	10.1	1.8
Dendraster excentricus	Pacific sand dollar	10,110	49.083	49	0.156	10,159	49.239	8.6	3.8
Cancer antennarius	brown rock crab	3,672	48.044	4,684	17.875	8,356	65.919	7.1	5.0
Cancer sp	Cancer crab, unid.	-	-	4,576	3.712	4,576	3.712	3.9	0.3
Lysmata californica	Red rock shrimp	826	0.811	3,625	3.115	4,451	3.926	3.8	0.3
Heptacarpus palpator	Intertidal coastal shrimp	853	0.699	2,167	0.983	3,020	1.682	2.6	0.1
Farfantepenaeus	Yellowleg shrimp	2,454	80.583	13	0.381	2,467	80.964	2.1	6.2
Panulirus interruptus	California spiny lobster	1,976	425.647	175	43.540	2,151	469.187	1.8	35.9
Caudina arenicola	sea cucumber	1,785	65.053	23	0.890	1,808	65.943	1.5	5.0
Pachygrapsus crassipes	striped shore crab	336	1.260	1134	2.050	1,470	3.310	1.2	0.3
Pyromaia tuberculata	tuberculate pear crab	425	0.549	747	1.201	1,172	1.750	1.0	0.1
Cancer gracilis	graceful crab	519	1.797	552	1.598	1,071	3.395	0.9	0.3
Petrolisthes cinctipes	flat porcelain crab	70	0.084	811	0.571	881	0.655	0.7	0.1
Pugettia producta	Northern kelp crab	759	3.292	122	0.824	881	4.116	0.7	0.3
O. bimaculatus/bimaculoides	Calif. two-spot octopus	577	76.676	182	19.560	759	96.236	0.6	7.4
Pisaster ochraceus	ochre star	644	22.456	67	3.868	711	26.324	0.6	2.0
Neotrypaea californiensis	bay ghost shrimp	505	1.613	10	0.010	515	1.623	0.4	0.1
Heptacarpus sp	coastal shrimp, unid.	272	0.319	232	0.201	504	0.520	0.4	0.0
Cancer productus	red rock crab	210	0.700	243	0.848	453	1.548	0.4	0.1
Cycloxanthops	ninetooth pebble crab	392	3.416	45	0.309	437	3.725	0.4	0.3
Lophopanopeus bellus	blackclaw crestleg crab	365	0.801	45	0.104	410	0.905	0.3	0.1
Polyorchis penicillatus	red jellyfish	331	0.508	-	-	331	0.508	0.3	0.0
Strongylocentrotus	purple sea urchin	238	0.560	-	-	238	0.560	0.2	0.0
Pilumnus spinohirsutus	retiring hairy crab	196	1.694	26	0.071	222	1.765	0.2	0.1
Loligo opalescens	California market squid	210	5.262	2	0.079	212	5.341	0.2	0.4
Thetys vagina	common salp	210	3.948	-	-	210	3.948	0.2	0.3
Blepharipoda occidentalis	spiny mole crab	201	3.593	-	-	201	3.593	0.2	0.3
Petrolisthes cabrilloi	Cabrillo porcelain crab	56	0.084	136	0.134	192	0.218	0.2	0.0
Hermissenda crassicornis	hermissenda	168	0.070	10	0.010	178	0.080	0.2	0.0
Petrolisthes eriomerus	flattop crab	168	0.196	-	-	168	0.196	0.1	0.0
Cancer amphioetus	bigtooth rock crab	42	0.098	109	0.129	151	0.227	0.1	0.0
Chrysaora colorata	purple-striped jellyfish	144	96.852	-	-	144	96.852	0.1	7.4
Isocheles pilosus	moon snail hermit	140	0.600	-	-	140	0.600	0.1	0.0
Neotrypaea gigas	giant ghost shrimp	119	0.343	-	-	119	0.343	0.1	0.0
Octopus rubescens	East Pacific red octopus	84	0.448	25	0.076	109	0.524	0.1	0.0
Pachycheles holosericus	sponge porcelain crab	102	0.301	1	0.001	103	0.302	0.1	0.0
Pachycheles rudis	thick claw porcelain crab	42	0.056	56	0.062	98	0.118	0.1	0.0
Strongylocentrotus	red sea urchin	84	5.502	8	0.197	92	5.699	0.1	0.4
Lepidopa californica	California mole crab	84	0.154	-	-	84	0.154	0.1	0.0
Lophopanopeus frontalis	molarless crestleg crab	84	0.210	-	-	84	0.210	0.1	0.0
Pachycheles pubescens	pubescent porcelain crab	84	0.182	-	-	84	0.182	0.1	0.0
Aplysia californica	California seahare	70	10.054	-	-	70	10.054	0.1	0.8
Loxorhynchus grandis	sheep crab	58	52.064	7	7.248	65	59.312	0.1	4.5
Pisaster giganteus	giant-spined sea star	56	7.143	5	2.795	61	9.938	0.1	0.8
Dendronotus frondosus	leafy dendronotid	56	0.014	-	-	56	0.014	0.0	0.0
Dendronotus iris	giant-frond-aeolis	56	0.112	-	-	56	0.112	0.0	0.0

(*table continued*)

Table 5.5-2. (Cont.). Total estimated SONGS macroinvertebrate impingement during heat treatment and 26 biweekly surveys at both units from March 2006 through May 2007.

		Annual Impingement							
		Est. Normal Operation		Heat Treatment		Combined		Percent	
Taxa	Common Name	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Pugettia richii	cryptic kelp crab	56	0.070	-	-	56	0.070	0.0	0.0
Paraxanthias taylori	lumpy rubble crab	43	0.206	11	0.061	54	0.267	0.0	0.0
Scyra acutifrons	sharpnose crab	49	0.259	-	-	49	0.259	0.0	0.0
Elthusa vulgaris	sea louse	42	0.042	-	-	42	0.042	0.0	0.0
Lytechinus pictus	white sea urchin	42	0.042	-	-	42	0.042	0.0	0.0
Nassarius perpinguis	fat western nassa	42	0.056	-	-	42	0.056	0.0	0.0
Pinnixa barnharti	pea crab	42	0.070	-	-	42	0.070	0.0	0.0
Renilla kollikeri	sea pansy	42	0.084	-	-	42	0.084	0.0	0.0
Tegula eiseni	banded tegula	42	0.308	-	-	42	0.308	0.0	0.0
Alpheus clamator	twistclaw pistol shrimp	14	0.014	20	0.030	34	0.044	0.0	0.0
Hemigrapsus oregonensis	yellow shore crab	14	0.014	17	0.017	31	0.031	0.0	0.0
Hemisquilla californiensis	mantis shrimp	28	0.112	-	-	28	0.112	0.0	0.0
Pinnixa sp	pea crab, unid.	28	0.056	-	-	28	0.056	0.0	0.0
Pisaster brevispinus	short-spined sea star	28	0.196	-	-	28	0.196	0.0	0.0
Synalpheus lockingtoni	littoral pistol shrimp	14	0.014	10	0.010	24	0.024	0.0	0.0
Betaeus longidactylus	visored shrimp	-	-	22	0.020	22	0.020	0.0	0.0
Navanax inermis	California aglaja	14	0.028	5	0.015	19	0.043	0.0	0.0
Asterina miniata	bat star	14	0.182	1	0.011	15	0.193	0.0	0.0
Golfingia procera	MBC peanut worm 1	14	0.084	1	0.001	15	0.085	0.0	0.0
Lophopanopeus sp	crestleg crab	14	0.014	1	0.003	15	0.017	0.0	0.0
Astropecten armatus	spiny sand star	14	0.476	-	-	14	0.476	0.0	0.0
Aurelia aurita	moon jelly	14	0.770	-	-	14	0.770	0.0	0.1
Calliostoma canaliculatum	channeled topsnail	14	0.070	-	-	14	0.070	0.0	0.0
Cnidaria sp	sea jelly, unid.	14	0.336	-	-	14	0.336	0.0	0.0
Dirona picta	spotted dirona	14	0.084	-	-	14	0.084	0.0	0.0
Lophopanopeus leucomanus	knobkneed crestleg crab	14	0.056	-	-	14	0.056	0.0	0.0
Mopalia ciliata	MBC chiton 1	14	0.014	-	-	14	0.014	0.0	0.0
Ogyrides sp	longeye shrimp unid. A	14	0.014	-	-	14	0.014	0.0	0.0
Pagurus sp	hermit crab, unid.	14	0.070	-	-	14	0.070	0.0	0.0
Pentamera sp	white sea cucumber	14	0.014	-	-	14	0.014	0.0	0.0
Pinnixa faba	mantle pea crab	14	0.014	-	-	14	0.014	0.0	0.0
Randallia ornata	globose sand crab	14	0.056	-	-	14	0.056	0.0	0.0
Roperia poulsoni	Roperia	14	0.098	-	-	14	0.098	0.0	0.0
Solenocera mutator	solenocerid shrimp 1	14	0.070	-	-	14	0.070	0.0	0.0
Taliepus nuttallii	globose kelp crab	14	0.994	-	-	14	0.994	0.0	0.1
Urechis caupo	innkeeper worm	14	0.056	-	-	14	0.056	0.0	0.0
Pugettia dalli	spined kelp crab	-	-	10	0.010	10	0.010	0.0	0.0
Pisaster sp	sea star, unid.	-	-	2	0.005	2	0.005	0.0	0.0
Betaeus sp	visored shrimp, unid.	-	-	1	0.001	1	0.001	0.0	0.0
Cystodytes lobatus	sea eraser	-	-	1	0.012	1	0.012	0.0	0.0
Gastropoda	unknown nudibranch	-	-	1	0.001	1	0.001	0.0	0.0
Loxorhynchus crispatus	moss crab	-	-	1	0.002	1	0.002	0.0	0.0
Loxorhynchus sp	unk moss/sheep crab	-	-	1	0.001	1	0.001	0.0	0.0
Petrolisthes sp	porcelain crab, unid.	-	-	1	0.002	1	0.002	0.0	0.0
Pleurobranchaea sp	sea slug unid	-	-	1	0.014	1	0.014	0.0	0.0
Protothaca staminea	Pacific littleneck	-	-	1	0.029	1	0.029	0.0	0.0
	Totals:	83,393	1,159.669	34,465	148.998	117,858	1,308.667	100.0	100.0
	No. of Taxa	83		54		95			

5.5.1.3 Seasonal Variation

Figures 5.5-1 and 5.5-2 present the fish impingement rates (based on abundance and biomass) during the 26 biweekly normal operations surveys during 2006-2007. Impingement abundance was bimodal, with a peak in early summer and one in fall/winter (June and November 2006) (Figure 5.5-1). Biomass was more variable throughout the year, corresponding with impingement of large individuals of select species (Figure 5.5-2). Invertebrate abundance was greatest from November 2006 through March 2007, with highest abundance recorded in December 2006 (Figure 5.5-3). Invertebrate biomass was more evenly distributed throughout the year, corresponding to the impingement of large individuals of select species, with a peak in April 2007 (Figure 5.5-4).

5.5.1.4 Diel Variation

In general, fish impingement abundance and biomass was greatest during nighttime (Figures 5.5-5 through 5.5-8). (Note: Disregard negative symbols with nighttime concentrations in all figures depicting diel variation). The same general trend was observed in invertebrate impingement (Figures 5.5-9 and 5.5-12).

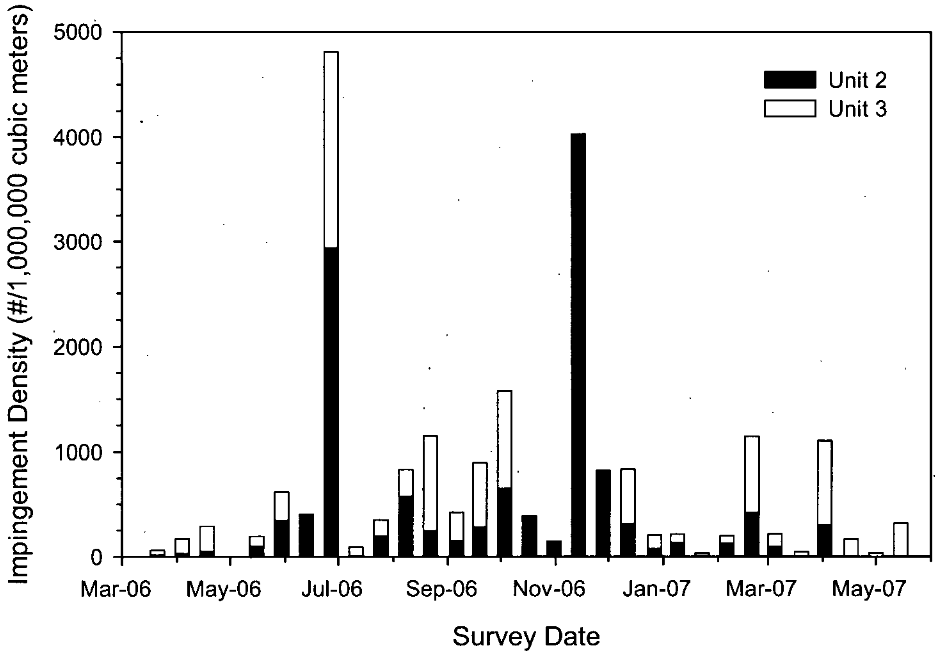


Figure 5.5-1. Mean concentration (# / 1,000,000 m^3) of fishes collected in SONGS impingement samples during 2006-2007.

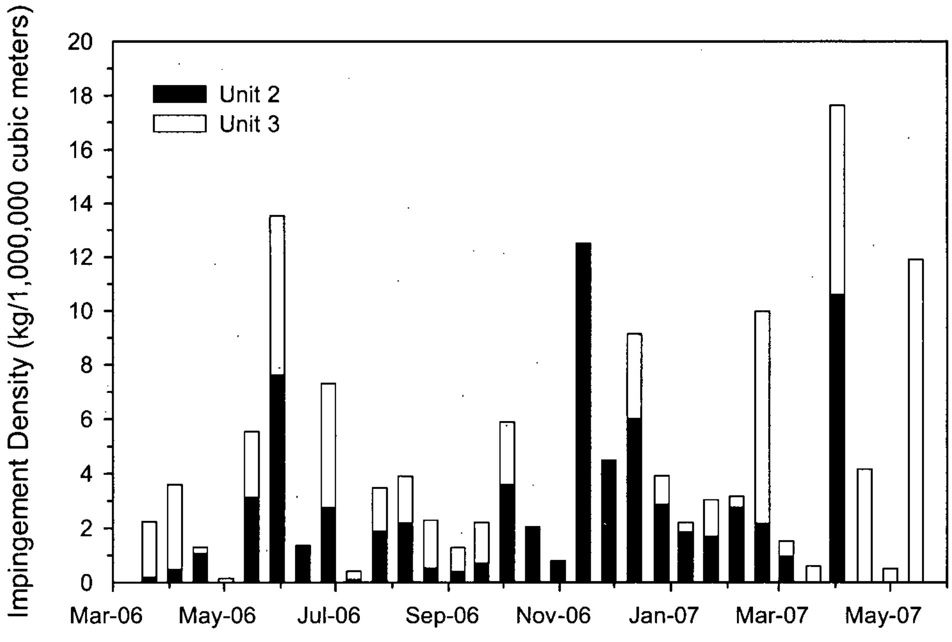


Figure 5.5-2. Mean biomass (kg / 1,000,000 m^3) of fishes collected in SONGS impingement samples during 2006-2007.

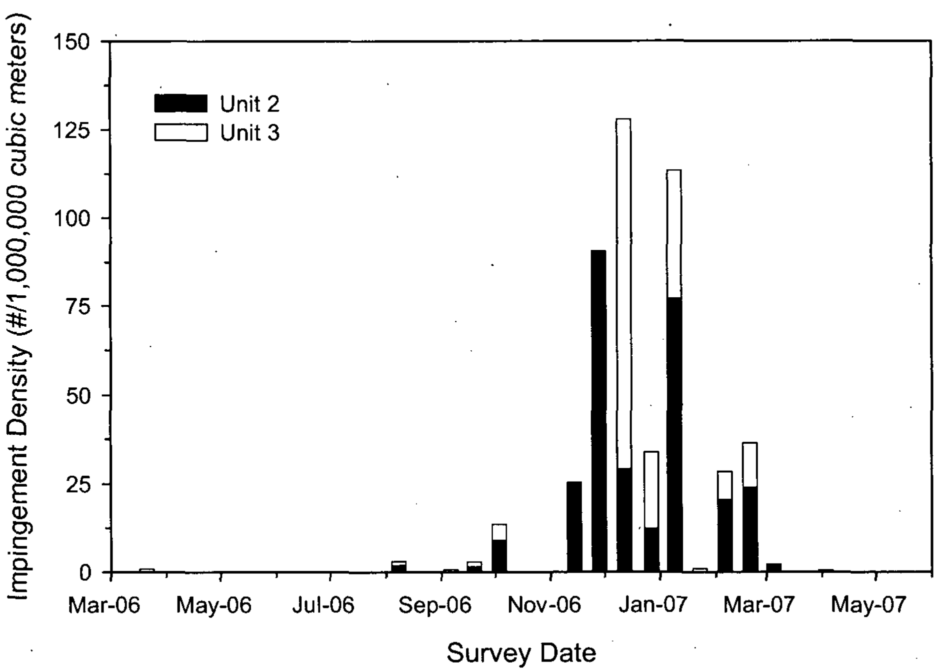


Figure 5.5-3. Mean concentration (# / 1,000,000 m^3) of invertebrates collected in SONGS impingement samples during 2006-2007.

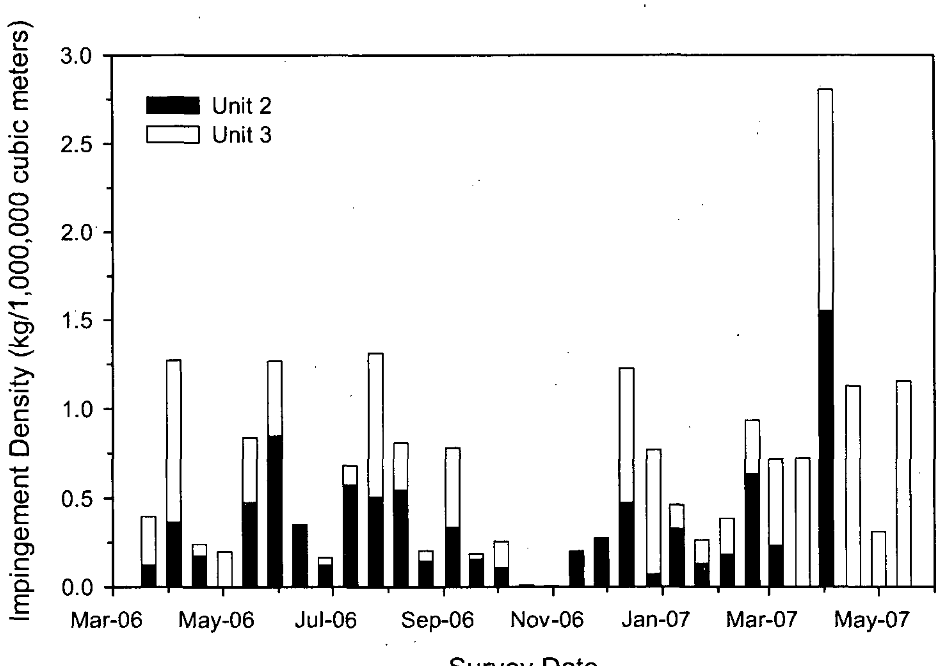


Figure 5.5-4. Mean biomass (kg / 1,000,000 m^3) of invertebrates collected in SONGS impingement samples during 2006-2007.

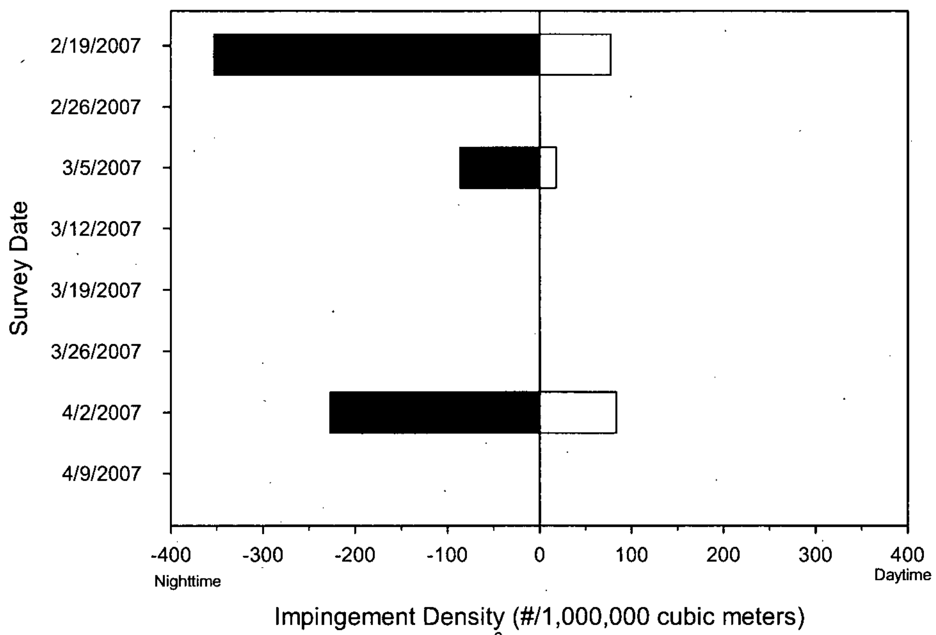


Figure 5.5-5. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of fishes collected in Unit 2 normal operation impingement samples during night and day sampling.

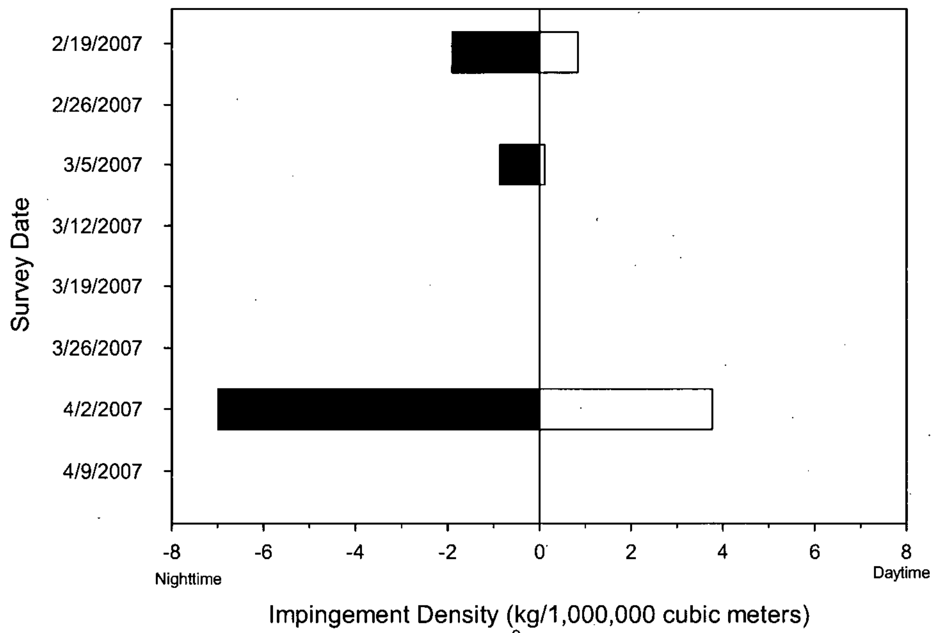


Figure 5.5-6. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of fishes collected in Unit 2 normal operation impingement samples during night and day sampling.

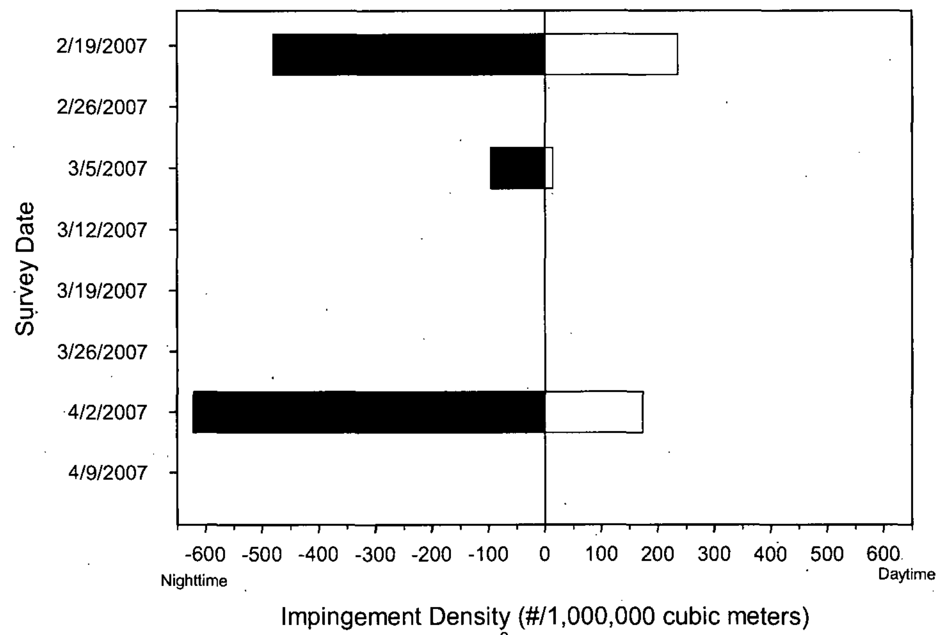


Figure 5.5-7. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of fishes collected in Unit 3 normal operation impingement samples during night and day sampling.

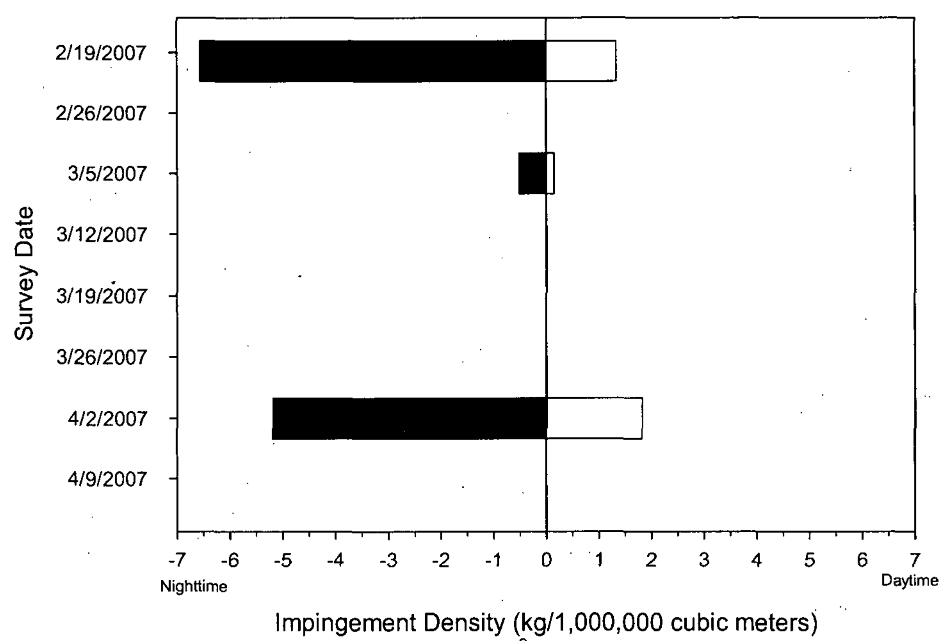


Figure 5.5-8. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of fishes collected in Unit 3 normal operation impingement samples during night and day sampling.

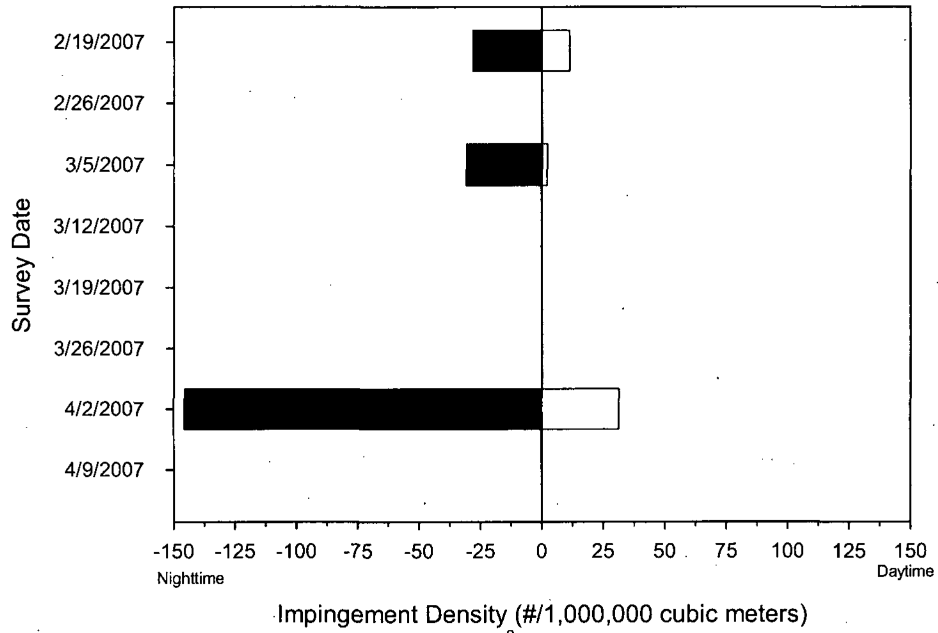


Figure 5.5-9. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of invertebrates collected in Unit 2 normal operation impingement samples during night and day sampling.

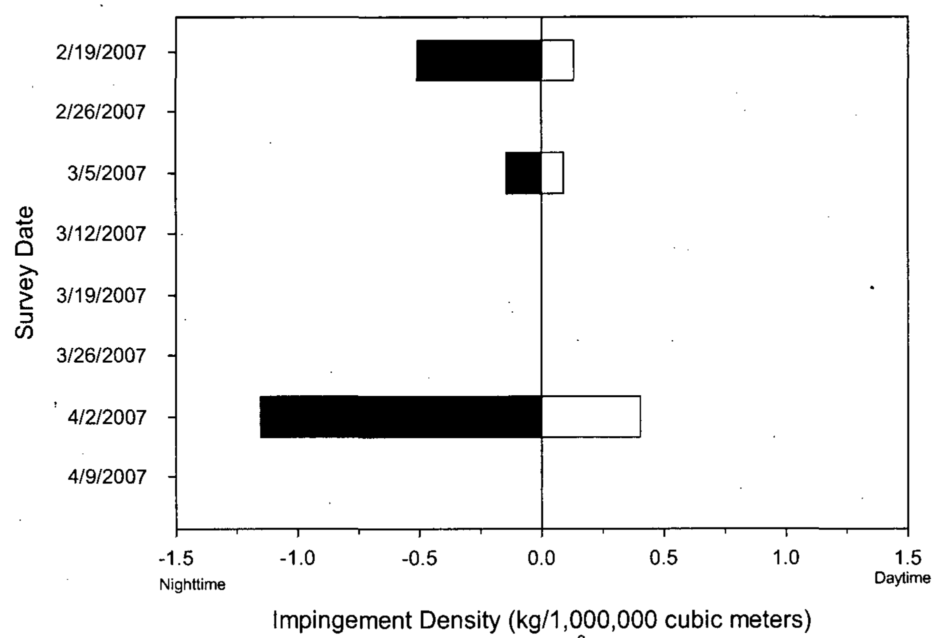


Figure 5.5-10. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of invertebrates collected in Unit 2 normal operation impingement samples during night and day sampling.

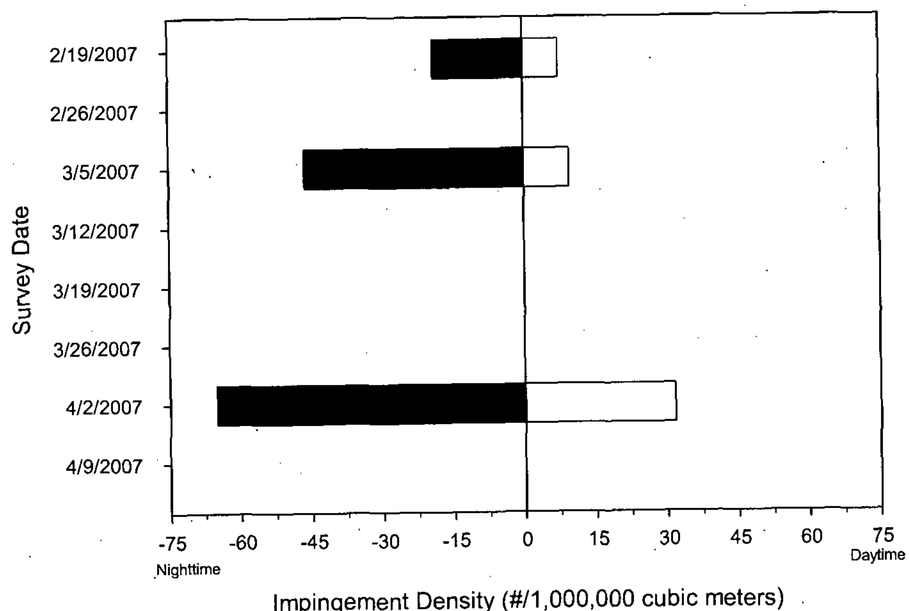


Figure 5.5-11. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of invertebrates collected in Unit 3 normal operation impingement samples during night and day sampling.

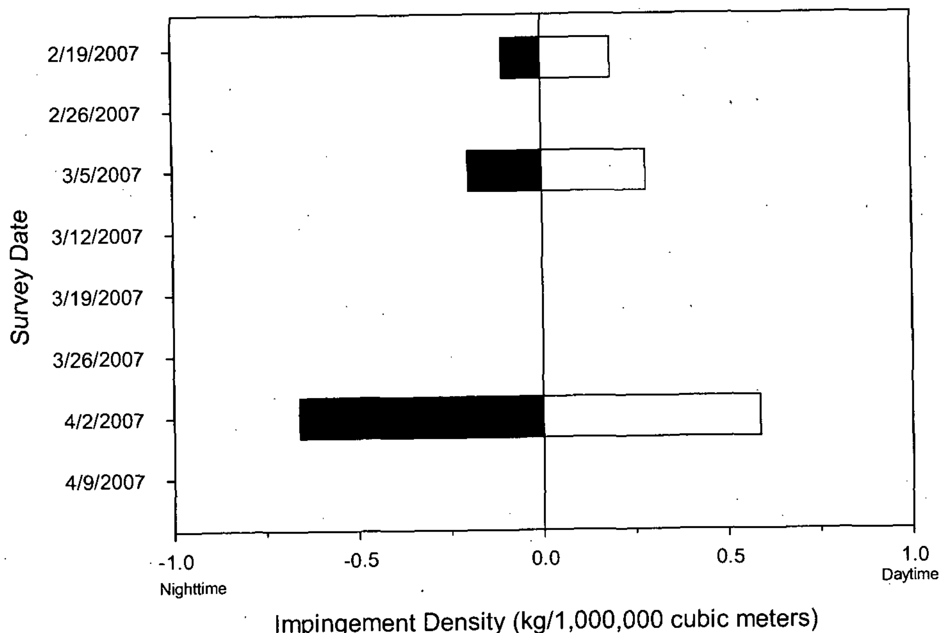


Figure 5.5-12. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of invertebrates collected in Unit 3 normal operation impingement samples during night and day sampling.

5.5.2 All Life Stages of Fishes by Species

Six fish taxa were originally proposed for analysis in the PIC; queenfish, white croaker, northern anchovy, Pacific sardine, barred sand bass, and kelp bass. Three additional taxa were included in the analysis based on their relative abundance in impingement samples: deepbody/slough anchovy (*Anchoa* spp), yellowfin croaker, and sargo (*Anisotremus davidsonii*). Combined, queenfish, northern anchovy, Pacific sardine, and deepbody and slough anchovy comprised 92.3% of the fishes in impingement samples.

5.5.2.1 Queenfish

Information on the life history, ecology, population trends, and fishery of queenfish is summarized in Section 4.5.4.2.

From 1984 through 2005, an estimated total of 17,742,270 queenfish weighing 185,084 kg (408,110 lbs) was impinged at SONGS Units 2 and 3 (SCE 1985-2006). Annual impingement has ranged from 97,474 individuals (1984) to 1,554,249 individuals (1995). Average annual impingement was 806,467 individuals weighing 8,413 kg (18,550 lbs). In 2005, a total of 1,023,218 queenfish weighing 10,566 kg (23,297 lbs) was impinged at SONGS.

5.5.2.1.1 Sampling Results

Queenfish was the most abundant fish species impinged with an estimated 712,937 individuals, or 52.7% of the annual total, weighing 3,599.594 kg (7,935.737 lbs) (Table 5.5-1). This is very similar to the annual average impingement of 806,467 queenfish. Normal operation impingement represented over 98% of the impinged individuals, with 10,875 individuals recorded during heat treatments. Highest normal operation impingement was recorded at Unit 2, which accounted for 63% of the total abundance and 53% of the biomass.

Queenfish were impinged throughout the year, and impingement density peaked in November 2006 (Figure 5.5-13). Impingement densities were low during the first six months of the study. In September occurrences were low and variable. Biomass showed a different pattern, with more uniform impingement rates throughout the year, but it also peaked in November similar to abundance (Figure 5.5-14).

Queenfish contributed to the diel periodicity observed during the three surveys conducted, comprising nearly 80% of the individuals impinged during the surveys, with about 80% of the impingement occurring at night (Figures 5.5-5 and 5.5-7). Daylight impingement reached peaks of 80 and 200 individuals per 1,000,000 m^3 at Units 2 and 3, respectively, which were less than the highest peaks observed during nighttime surveys, one of which exceeded 600 individuals per 1,000,000 m^3. A similar pattern was observed in the diel comparisons of biomass (Figures 5.5-6 and 5.5-8).

Length frequency analysis of 12,283 individuals measured during both impingement and fish return surveys indicates a mean standard length of 88 mm (3.5 inches) (Figure 5.5-15). There was a wide distribution of size, ranging from 30 to 190 mm SL size classes, with a bimodal distribution with peaks at 70 and 120 mm SL. The majority of these measured individuals were young of the year, with queenfish reaching age one at approximately 100 mm SL (3.9 inches) (MBC and VRG unpubl. data[1]). The sex was determined for 2,876 individuals, of which 56% were female, 43% male, and the sex of the remaining 1% could not be determined.

[1] MBC Applied Environmental Sciences and Vantuna Research Group. Analysis of the age and growth of juvenile and adult queenfish (*Seriphus politus*) from southern California. Project in progress.

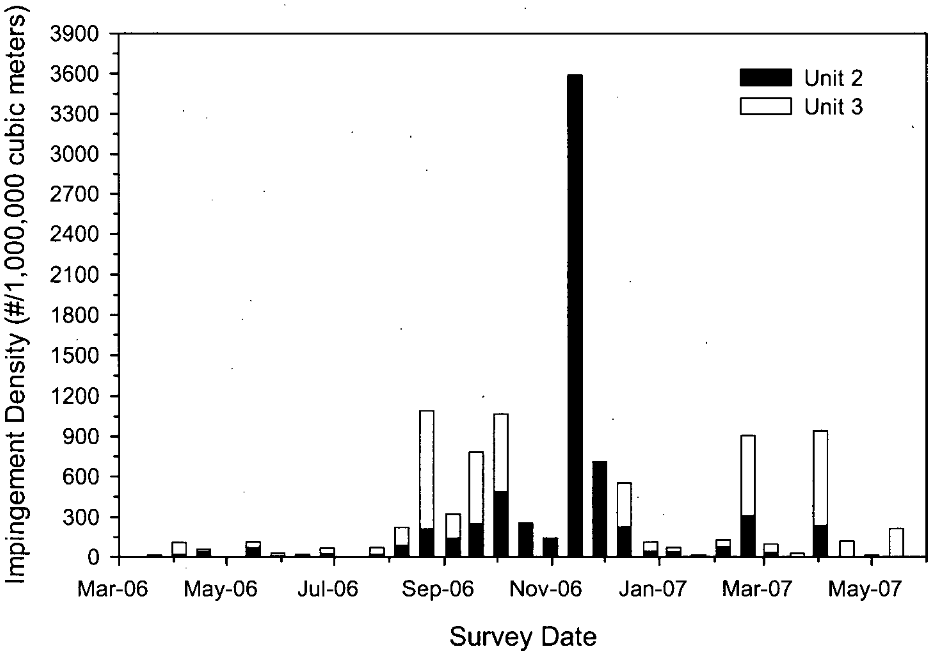


Figure 5.5-13. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of queenfish collected in SONGS normal operation impingement samples during 2006-7.

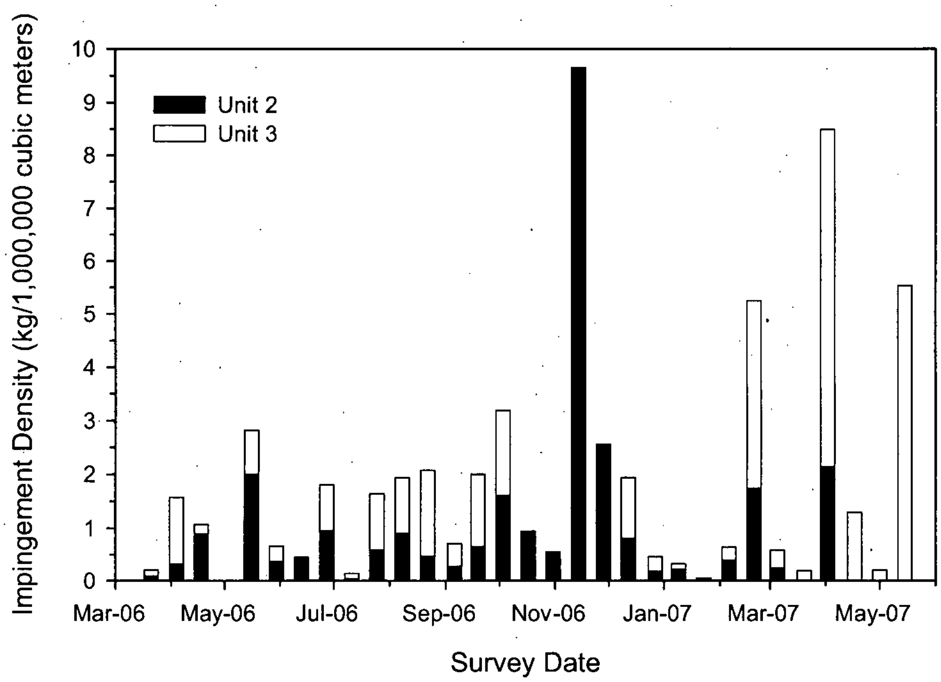


Figure 5.5-14. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of queenfish collected in SONGS normal operation impingement samples during 2006-7.

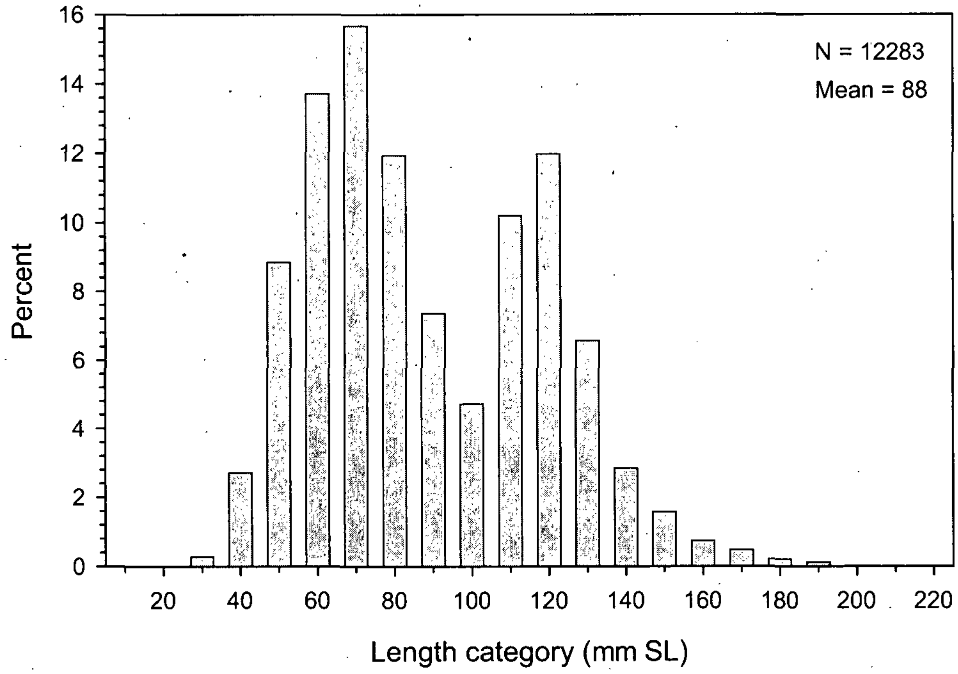


Figure 5.5-15. Length (mm) frequency distribution for queenfish collected in SONGS impingement and FRS samples.

5.5.2.2 Northern Anchovy

Information on the life history, ecology, population trends, and fishery of northern anchovy is summarized in Section 4.5.4.1.

From 1984 through 2005, an estimated total of 21,797,619 northern anchovy weighing 103,637 kg (228,520 lbs) was impinged at SONGS Units 2 and 3 (SCE 1985-2006). Annual impingement has ranged from 13,329 individuals (1998) to 3,777,680 individuals (2005). Average annual impingement was 990,801 individuals weighing 4,711 kg (10,387 lbs).

5.5.2.2.1 Sampling Results

Northern anchovy was the second most abundant fish species impinged with an estimated 396,064 individuals, or 29.3% of the annual total, weighing 340.696 kg (751.105 lbs) (Table 5.5-1). This is lower than the average annual impingement, but there has been extremely high year-to-year variability with this species. Normal operation impingement represented 99.5% of the impinged individuals, with 1,912 individuals recorded during heat treatments. Highest normal operation impingement was recorded at Unit 2, which accounted for 70% of the total abundance and 53% of the biomass.

Northern anchovy were impinged throughout the year, and impingement density peaked in June 2006 (Figure 5.5-16). Impingement densities were low during the first two months of the study, and again in early 2007. Biomass showed a similar pattern to abundance (Figure 5.5-17).

Northern anchovy contributed to the diel periodicity observed during the three surveys conducted, but only comprised about 9% of the individuals impinged during the surveys, with about 70% of the impingement occurring at night (Figures 5.5-5 and 5.5-7). A similar pattern was observed in the diel comparisons of biomass (Figures 5.5-6 and 5.5-8).

Length frequency analysis of 8,541 individuals measured during both impingement and fish return surveys indicates a mean standard length of 58 mm (2.3 inches) (Figure 5.5-18). Size ranged from 20 to 190 mm SL size classes, although most of the measured fishes were between the 30 and 70 mm SL (1.2 and 2.8 inches) size classes (Figure 5.5-18), indicating most were in their first year. The sex was determined for 755 individuals, of which 51% were females, 19% male, and sex of the remaining 30% could not be determined.

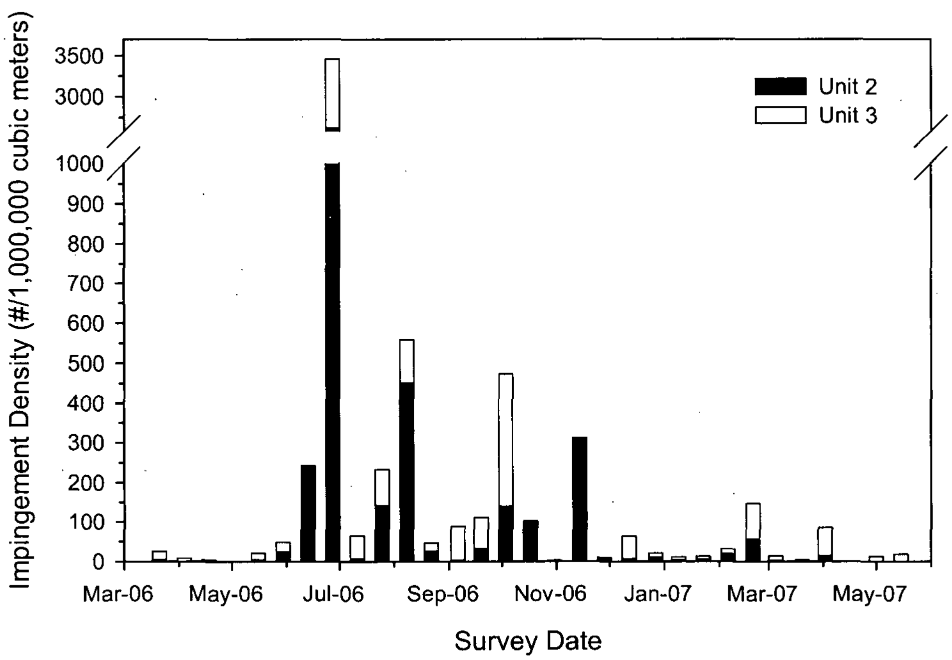


Figure 5.5-16. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of northern anchovy collected in SONGS normal operation impingement samples during 2006-7.

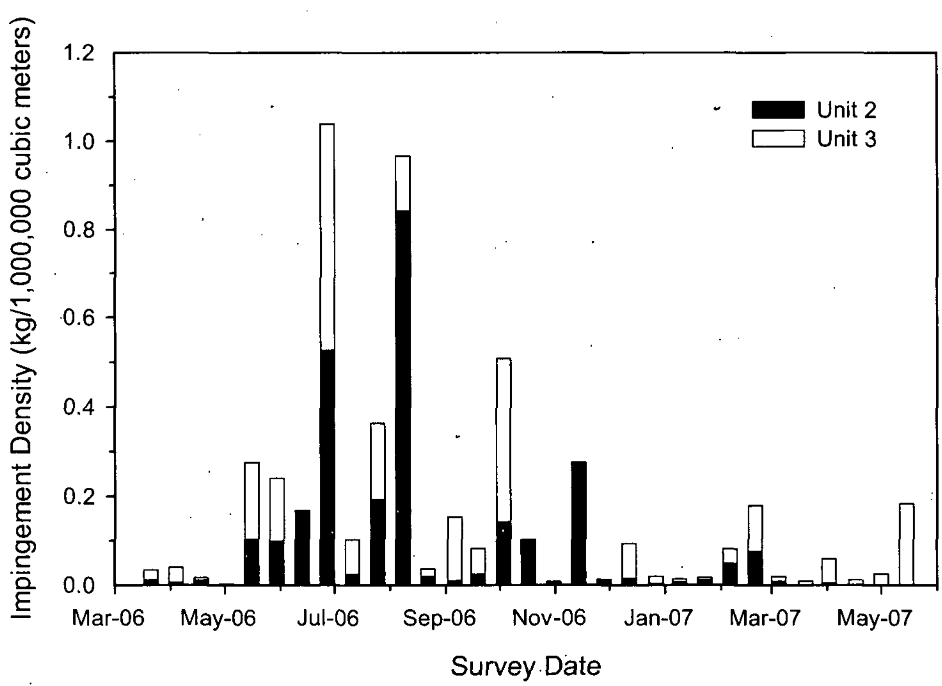


Figure 5.5-17. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of northern anchovy collected in SONGS normal operation impingement samples during 2006-7.

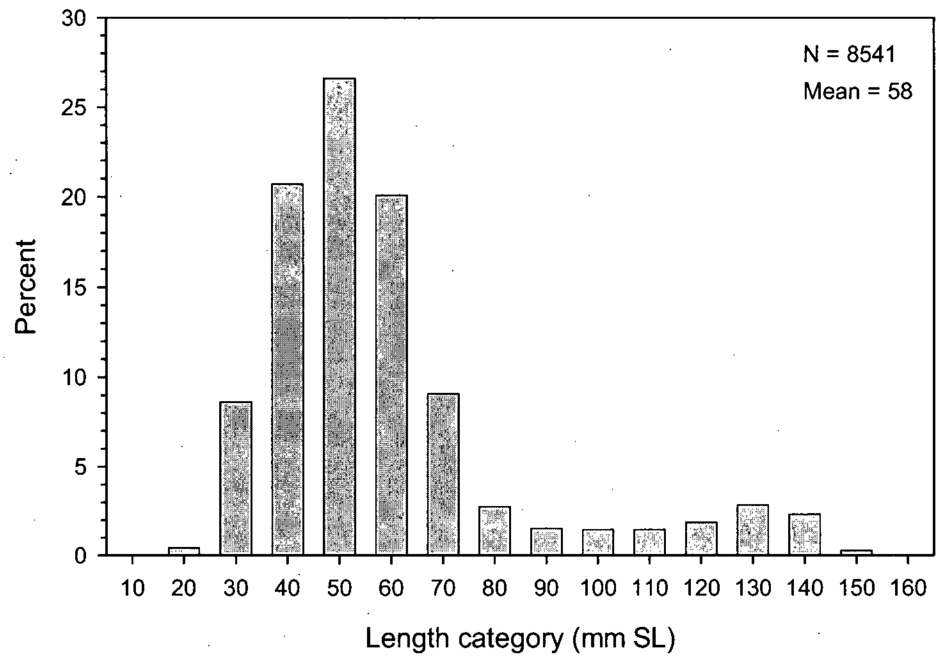


Figure 5.5-18. Length (mm) frequency distribution for northern anchovy collected in SONGS impingement and FRS samples.

5.5.2.3 Pacific Sardine

Information on the life history, ecology, population trends, and fishery of Pacific sardine is summarized in Section 4.5.4.3.

From 1984 through 2005, an estimated total of 6,433,933 Pacific sardine weighing 130,291 kg (287,292 lbs) was impinged at SONGS Units 2 and 3 (SCE 1985-2006). Annual impingement has ranged from 0 individuals (1987) to 3,144,099 individuals (2004). Average annual impingement was 292,906 individuals weighing 5,922 kg (13,059 lbs). Sardine impingement increased substantially in the 1990s, likely reflecting increased numbers of this species in southern California waters. In 2005, a total of 2,593,727 Pacific sardine weighing 59,096 kg (130,308 lbs) was impinged at SONGS.

5.5.2.3.1 Sampling Results

Pacific sardine was the third most abundant fish species impinged with an estimated 107,466 individuals, or 7.9% of the annual total, weighing 1,274.321 kg (2,809.394 lbs) (Table 5.5-1). This is lower than the average annual impingement, but there has been extremely high year-to-year variability with this species. Normal operation impingement represented 99.9% of the impinged individuals, with 87 individuals recorded during heat treatments. Highest normal operation impingement was recorded at Unit 3, which accounted for 71% of the total abundance and 54% of the biomass.

Pacific sardine were only sporadically impinged, and impingement density was highest in June and July 2006, with impingement densities low during all other occurrences (Figure 5.5-19). They were only observed during eight months of the survey period. Biomass showed a similar pattern to abundance (Figure 5.5-20).

Pacific sardine contributed slightly to the diel periodicity observed during the three surveys conducted, but comprised less than 1% of the individuals impinged during the surveys, with about 90% of their impingement occurring at night (Figures 5.5-5 and 5.5-7). A similar pattern was observed in the diel comparisons of biomass (Figures 5.5-6 and 5.5-8).

Length frequency analysis of 2,429 individuals measured during both impingement and fish return surveys indicates a mean standard length of 112 mm (4.5 inches) (Figure 5.5-21). Size ranged from 30 to 190 mm SL size classes, with a bimodal distribution with peaks at 50 and 150 mm SL; very few individuals were similar in size to the mean length. The majority of the measured individuals were greater than 120 mm SL, indicating most were in their second year. The sex was determined for 698 individuals, of which 47% were females and 53% were males.

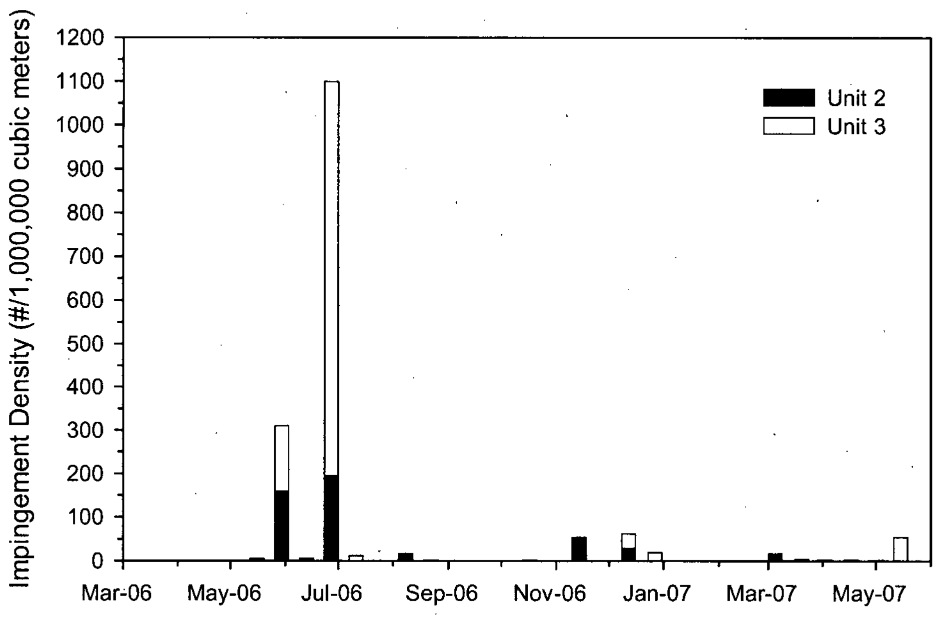


Figure 5.5-19. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of Pacific sardine collected in SONGS normal operation impingement samples during 2006-7.

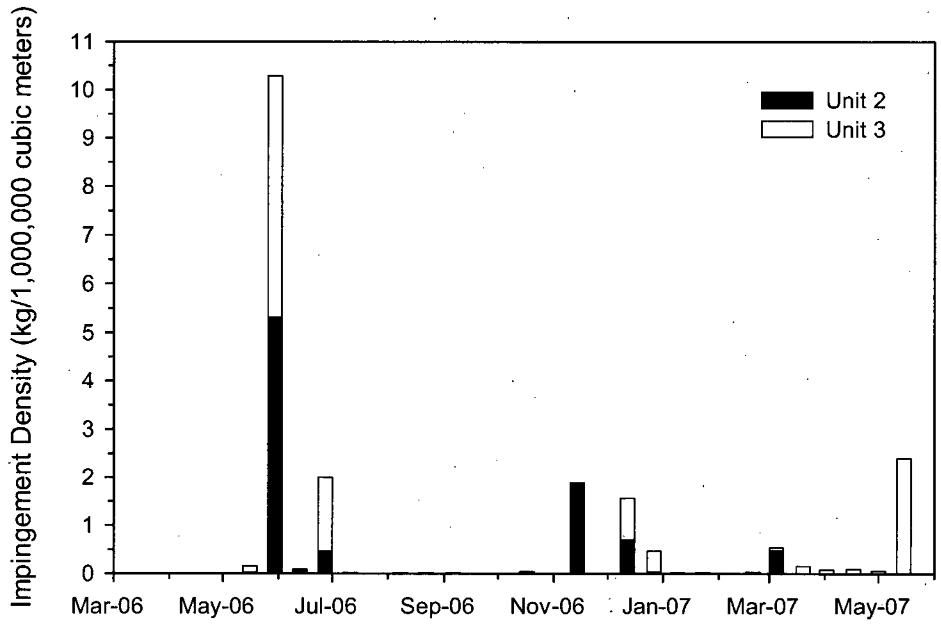


Figure 5.5-20. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of Pacific sardine collected in SONGS normal operation impingement samples during 2006-7.

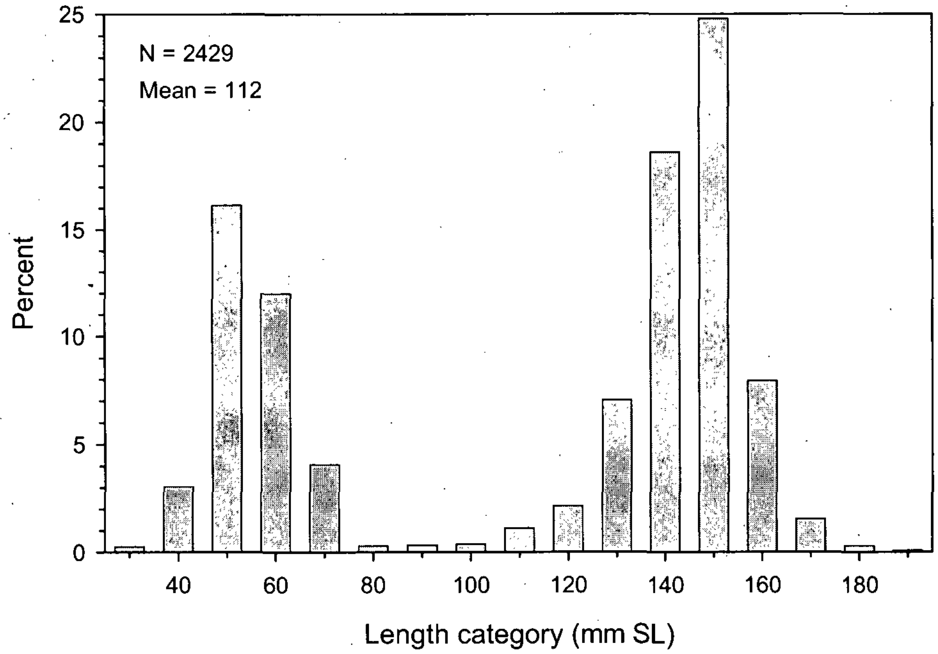
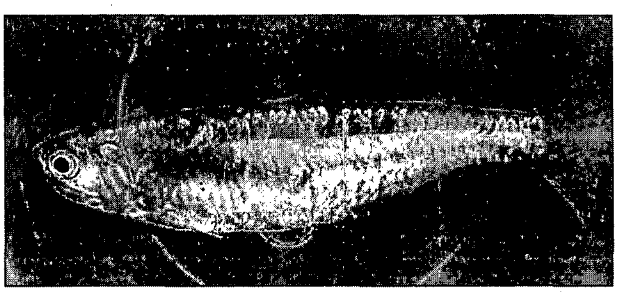


Figure 5.5-21. Length (mm) frequency distribution for Pacific sardine collected in SONGS impingement and FRS samples.

5.5.2.4 Deepbody Anchovy / Slough Anchovy



Deepbody anchovies and slough anchovies are members of the Family Engraulidae, the anchovies (Eschmeyer et al. 1983). Fish of this family tend to be silver-colored, small, compact fish and the most notable feature is a large overhanging mouth utilized in food capture. Anchovies occur in large schools in the warm waters along the shore and are an important source of food for larger organisms.

Both fish generally exhibit the silvery coloration attributed to the anchovy family with deepbody anchovies having a brownish green tint on the dorsal and slough anchovies with a green tint on the top and white on the bottom (Eschmeyer et al. 1983). Though deepbody anchovies tend to grow to a larger size than slough anchovies, the defining characteristic between these anchovies is the number of anal fin rays. An anal fin ray count of 29 or more indicates a deepbody anchovy while 23 to 26 anal fin rays are associated with slough anchovies. The range of both anchovies goes along the coast between Long Beach, California, and southern Baja California; however deepbody anchovies extend their range further to the north to central California and further south in Baja California. Estuaries and bays are a common habitat to find these anchovy schools, though they occur offshore as well.

5.5.2.4.1 Life History and Ecology

Deepbody anchovies achieve a standard length maximum of 16 cm (6.5 in) and live up to 6 years while slough anchovies grow up to 9.5 cm (3.75 in) and live as long as 3 years (Heath 1980; Eschmeyer et al. 1983; Love 1996). In general the females grew faster than the males in both species (Heath 1980). Age of sexual maturity is another similarity between the two species in that they are able to reproduce in their first year. However *A. compressa* focuses energy on growth while *A. delicatissima* focuses on reproduction as reflected in the differences of size and their mean fecundity values of about 7,000 eggs for *A. compressa* and about 15,000 eggs for *A. delicatissima.* Both species of anchovy have been recorded as broadcast spawners that spawn at night (Heath 1980; Love 1996). Spawning occurs between May and July with the peak in May (Heath 1980). Anchovies consume zooplankton (Love 1996).

5.5.2.4.2 Population Trends and Fishery

There is no reported commercial or recreational fishery. However, these small fish are caught occasionally for bait by recreational anglers with RecFIN approximating 9,000 deepbody anchovy caught in southern California between 2000 and 2006 (RecFIN 2007).

From 1984 through 2005, an estimated total of 1,004,106 anchovies (*Anchoa* spp) weighing 5,387 kg (11,878 lbs) was impinged at SONGS Units 2 and 3 (SCE 1985-2006). Annual impingement has ranged from 544 individuals (2003) to 318,619 individuals (1985). Average annual impingement was 45,315 individuals weighing 245 kg (540 lbs). In 2005, a total of 12,299 anchovies weighing 39.1 kg (86.2 lbs) was impinged. This included 4,614 slough anchovy and 7,685 deepbody anchovy.

5.5.2.4.3 Sampling Results

Deepbody anchovy was the fourth most abundant fish species impinged with an estimated 23,504 individuals, or 1.7% of the annual total, weighing 192.052 kg (423.402 lbs). Slough anchovy was the ninth most abundant species impinged with an estimated 8,543 individuals (0.6% of the total) weighing 23.710 kg (52.272 lbs) (Table 5.5-1). This is within the range measured during previous studies; the total was higher than recorded in 2005 (12,299 anchovies) but lower than in 2004 (74,412 anchovies). Both deepbody and slough anchovy were represented in greatest abundance in normal operation impingement, with 90.5 and 99.7%, respectively. Highest normal operation impingement for both was recorded at Unit 2, which accounted for 57.9% of the total abundance for deepbody anchovy and 69.9% for slough anchovy, with similar contributions to the biomass.

Both species were only impinged from late summer to winter, and impingement density peaking in December 20006; none were observed from April through July 2006 (Figure 5.5-22). Biomass showed a similar pattern to abundance (Figure 5.5-23).

Deepbody anchovy contributed slightly to the diel periodicity observed during the three surveys conducted, but only comprised about 2% of the individuals impinged during the surveys, with 69% of the impingement occurring at night (Figures 5.5-5 and 5.5-7). A similar pattern was observed in the diel comparisons of biomass (Figures 5.5-6 and 5.5-8).

Length frequency analysis of 2,205 individuals of deepbody anchovy measured during both impingement and fish return surveys indicates a mean standard length of 92 mm (3.7 inches) (Figure 5.5-24). Size ranged from 50 to 120 mm SL size classes, although most of the measured fishes were between the 80 and 100 mm SL (3.2 and 4.0 inches) size classes. The sex was determined for 145 individuals, of which 49% were female and 51% were male.

Length frequency analysis of 466 individuals of slough anchovy measured during both impingement and fish return surveys indicates a mean standard length of 63 mm (2.5 inches) (Figure 5.5-24). Size ranged from 50 to 110 mm SL size classes, although most of the measured fishes were between the 60 and 70 mm SL (2.4 and 2.8 inches) size classes.

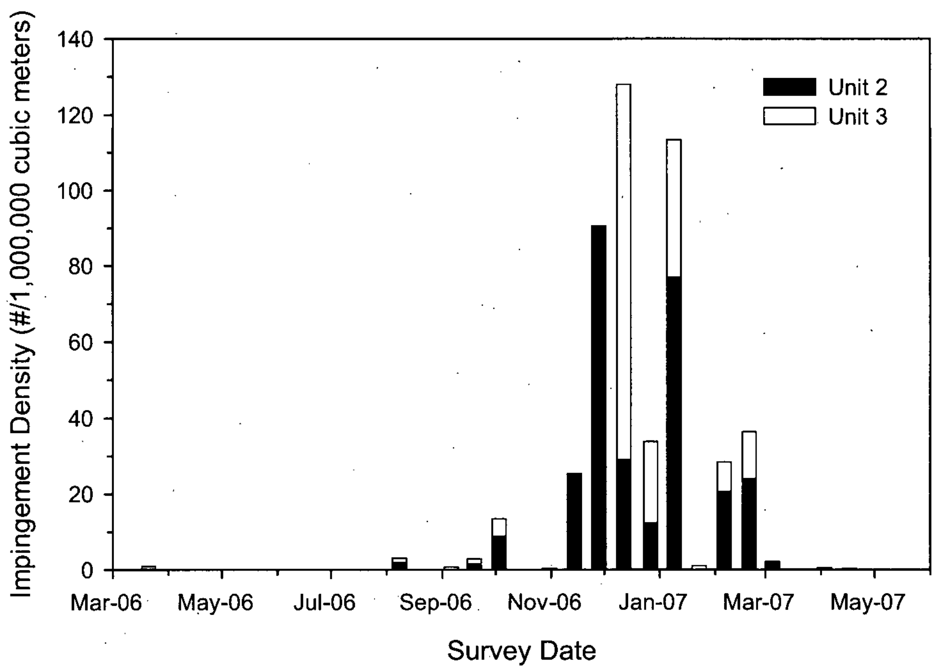


Figure 5.5-22. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of *Anchoa* spp collected in SONGS normal operation impingement samples during 2006-7.

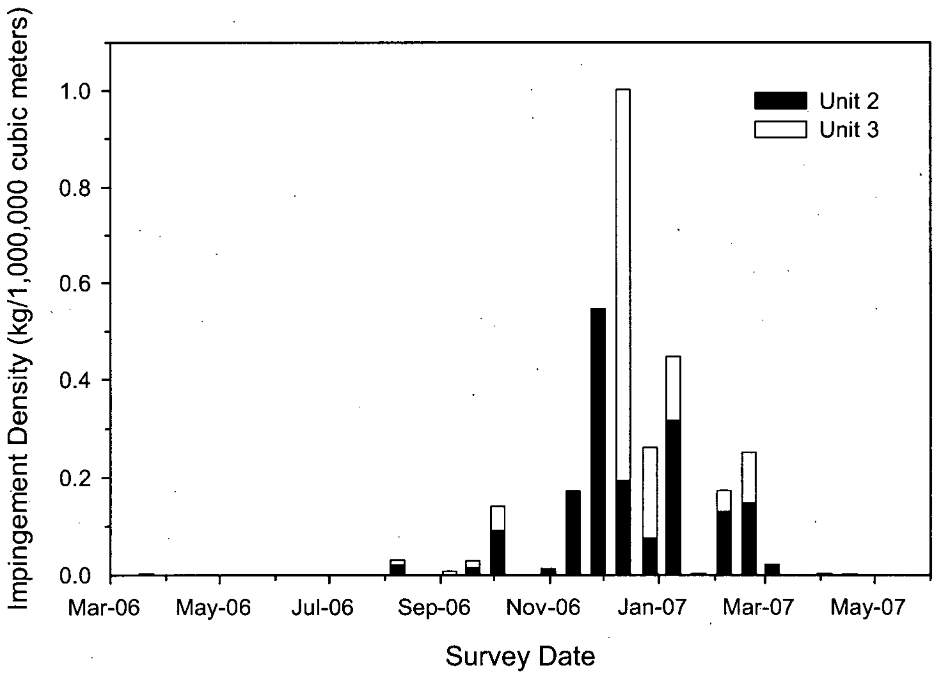


Figure 5.5-23. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of *Anchoa* spp collected in SONGS normal operation impingement samples during 2006-7.

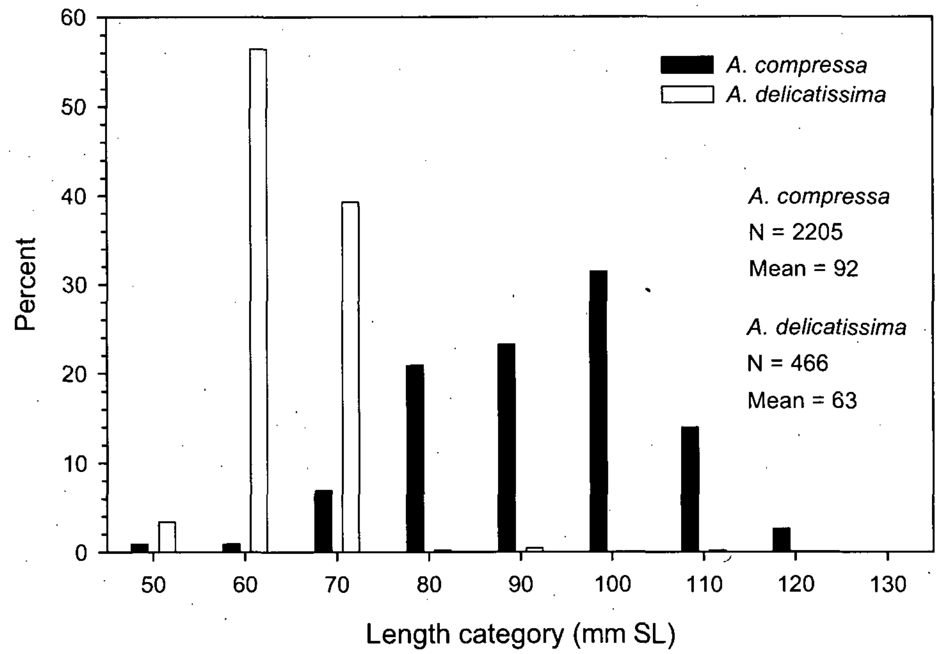


Figure 5.5-24. Length (mm) frequency distribution for deepbody anchovy (*A. compressa*) and slough anchovy (*A. delicatissima*) collected in SONGS impingement and FRS samples.

5.5.2.5 White Croaker

Information on the life history, ecology, population trends, and fishery of white croaker is summarized in Section 4.5.4.4.

From 1984 through 2005, an estimated total of 1,116,083 white croaker weighing 9,266 kg (20,432 lbs) was impinged at SONGS Units 2 and 3 (SCE 1985-2006). Annual impingement has ranged from 545 individuals (1987) to 426,831 individuals (2000). Average annual impingement was 50,731 individuals weighing 421 kg (929 lbs). In 2005, a total of 4,734 white croaker weighing 91.3 kg (201.3 lbs) was impinged.

5.5.2.5.1 Sampling Results

White croaker was the seventh most abundant fish species impinged with an estimated 9,557 individuals, less than 1% of the annual total, weighing 68.460 kg (150.928 lbs) (Table 5.5-1). This is much lower than the annual average impingement, but the highest total recorded since 2000. Normal operation impingement represented 94.9% of the impinged individuals, with 490 individuals recorded during heat treatments. Highest normal operation impingement was recorded at Unit 2, which accounted for 83.5% of the total abundance and 77% of the biomass.

White croaker were impinged throughout the year at low rates, except for June and November 2006, when impingement density showed two peaks (Figure 5.5-25). Biomass showed a similar pattern to abundance (Figure 5.5-26).

White croaker comprised less than 1% of the individuals impinged during the diel surveys, with slightly fewer occurring at night (Figures 5.5-5 and 5.5-7). A similar pattern was observed in the diel comparisons of biomass (Figures 5.5-6 and 5.5-8).

Length frequency analysis of 1,140 individuals measured during both impingement and fish return surveys indicates a mean standard length of 82 mm (3.3 inches) (Figure 5.5-27). Size ranged from 20 to 220 mm SL size classes, with a peak at 80 mm SL; the majority of the measured individuals were less than 100 mm SL, indicating most were in their first year. The sex was determined for 200 individuals, of which 58% were female, 40% male, and sex of the remaining 2% could not be determined.

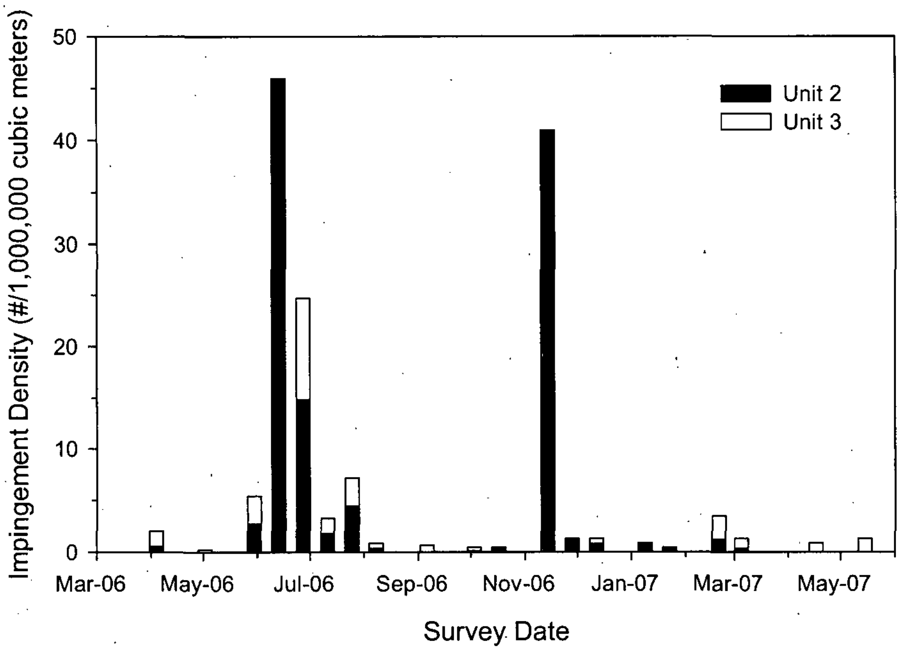


Figure 5.5-25. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of white croaker collected in SONGS normal operation impingement samples during 2006-7.

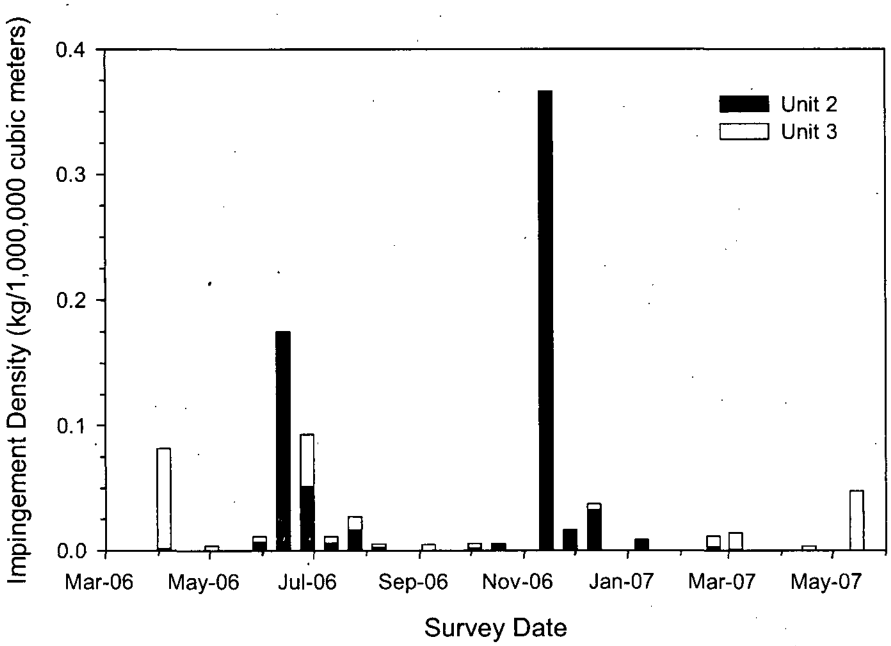


Figure 5.5-26. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of white croaker collected in SONGS normal operation impingement samples during 2006-7.

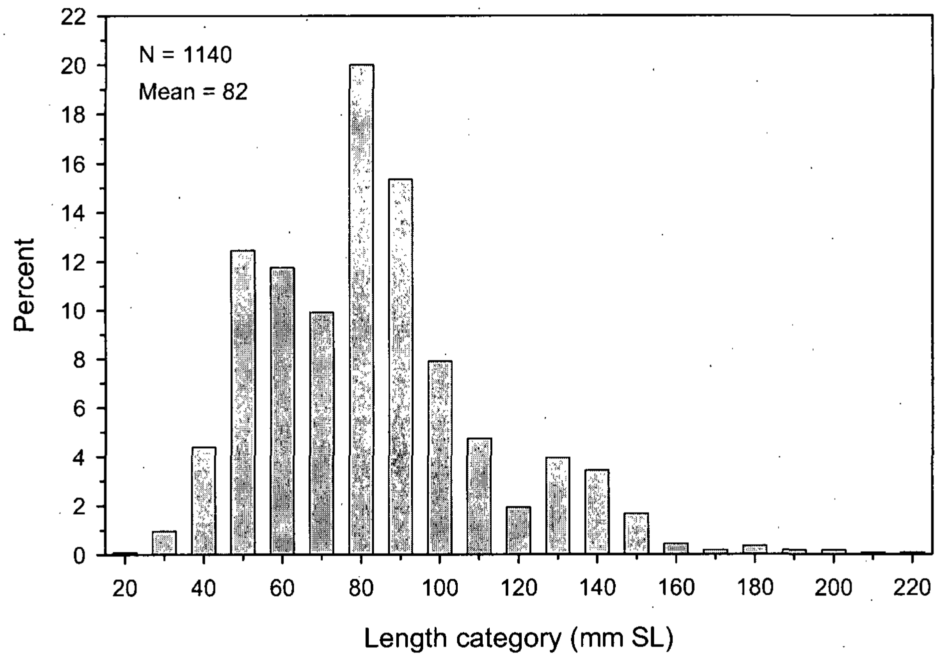


Figure 5.5-27. Length (mm) frequency distribution for white croaker collected in SONGS impingement and FRS samples.

5.5.2.6 Sea Basses

Information on the life history, ecology, population trends, and fishery of kelp bass and barred and spotted sand bass is summarized in Section 4.5.4.5.

From 1984 through 2005, an estimated total of 22,194 sea basses (*Paralabrax* spp) weighing 3,208 kg (7,073 lbs) was impinged at SONGS Units 2 and 3 (SCE 1985-2006). Annual impingement has ranged from 228 individuals (2003) to 2,179 individuals (1986). Average annual impingement was 974 individuals weighing 146 kg (322 lbs). In 2005, a total of 566 sea basses weighing 69.3 kg (152.9 lbs) were impinged.

5.5.2.6.1 Sampling Results

All three of *Paralabra*x spp (kelp bass, barred sand bass, and spotted sand bass) were observed in impingement samples, although the spotted sand bass was only observed during heat treatment monitoring. An estimated 360 individuals weighing 28.773 kg (63.445 lbs) were taken during monitoring, representing less than 0.1% of the impinged total (Table 5.5-1). This is lower than the annual average of 974 individuals, but similar to annual totals recorded since 2000.

The three species were represented in greatest abundance in heat treatment impingement, with 234 individuals (65.0% of the species abundance) weighing 25.510 kg (56.250 lbs, 88.7% of the biomass). Highest normal operation and heat treatment impingement was recorded at Unit 3, which accounted for

61.1% of the species combined abundance for *Paralabrax* spp, with similar contributions to the biomass.

All of the species were only impinged from winter to spring, and impingement density peaked in March 2007 (Figure 5.5-28) and biomass peaked in May 2007 (Figure 5.5-29). Only one of the species was observed during diel surveys. *P. clathratus* had two individuals returned during daytime and five individuals impinged at night, less than 0.1% of the total monitored abundance (Figures 5.5-5 and 5.5-8). A similar pattern was observed in the diel comparisons of biomass.

Length frequency analysis of 130 individuals of *P. nebulifer* measured during both impingement and fish return surveys indicates a mean standard length of 171 mm (6.7 inches) (Figure 5.5-30). Size ranged from 60- to 300-mm (2.4- and 11.8-inch) size classes, although most of the measured fishes were between the 160- and 200-mm (6.3 and 7.9-inch) size classes, indicating most were in their first and second years.

Length frequency analysis of 81 individuals of *P. clathratus* measured during both impingement and fish return surveys indicates a mean standard length of 87 mm (3.4 inches) (Figure 5.5-30). Size ranged from 40- to 260-mm (1.6- and 10.2-inch) size classes, although most of the measured fishes were between the 40- and 70-mm (1.6- and 2.8-inch) size classes, indicating most were in their first year.

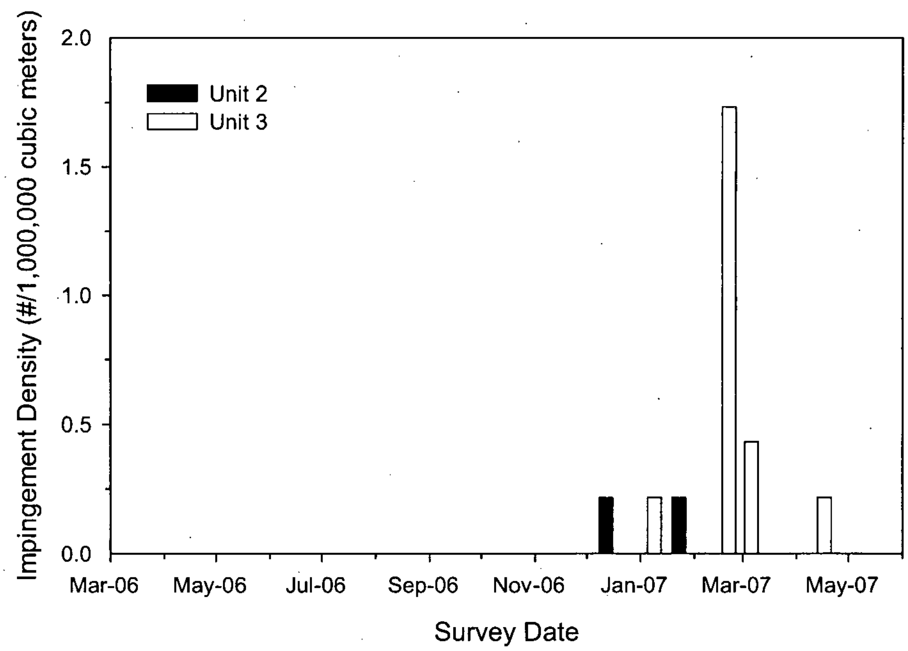


Figure 5.5-28. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of *Paralabrax* spp collected in SONGS normal operation impingement samples during 2006-7.

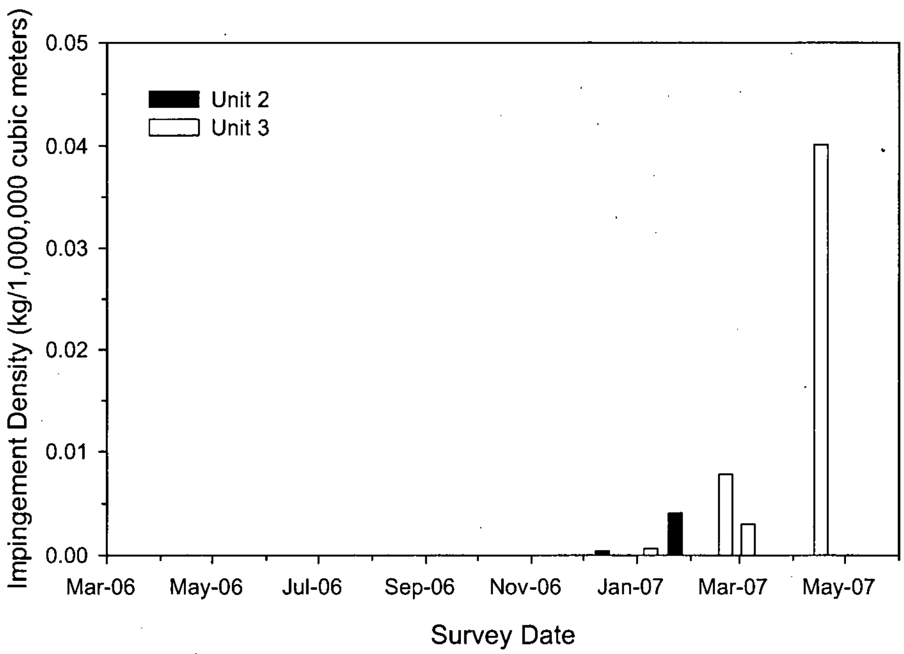


Figure 5.5-29. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of *Paralabrax* spp collected in SONGS normal operation impingement samples during 2006-7.

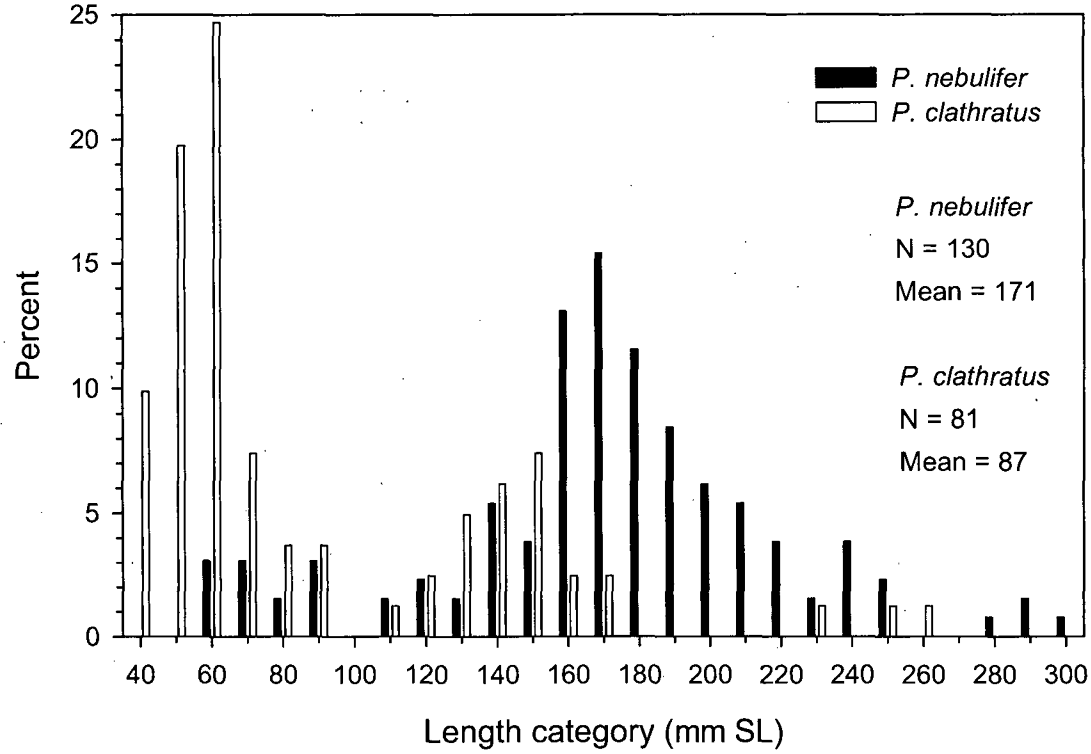
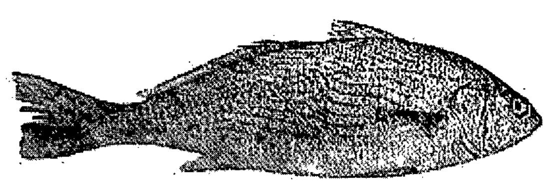


Figure 5.5-30. Length (mm) frequency distribution for barred sand bass (*P. nebulifer*) and kelp bass (*P. clathratus*) collected in SONGS impingement and FRS samples.

5.5.2.7 Yellowfin Croaker

Yellowfin croaker is a member of the family Sciaenidae, which is comprised of croakers (Eschmeyer et al. 1983). Most fish have elongate, silvery bodies and are named croakers for the croaking sound produced by a modified air bladder. They occur in both warm temperate and tropical oceans, along the coast in estuaries, with some in fresh water and at depths to 600 m (1,969 ft).



These fish are distinguishable from other local croakers by the short chin barbel, inferior jaw, and anterior to posterior dark brownish yellow oblique striations (Eschmeyer et al. 1983; Pondella et al. in review). Yellowfin croakers exhibit grey, blue or green coloration above and white below, with the distinct dark, wavy horizontal bars along the back and yellow fins (Eschmeyer et al. 1983). The northeastern Pacific range of the yellowfin croaker extends from Point Conception to the Gulf of Mexico, but they are more commonly found south of the Palos Verdes Peninsula; however, they have been recorded as far north as San Francisco. Yellowfin croaker is often associated with sandy shallow water areas, such as estuaries, surf, and bays, at depths to 7.6 m (25 ft). During spawning season, these fish tend to form schools within embayments making them susceptible to fishery pressures (Pondella et al. in review).

5.5.2.7.1 Life History and Ecology

Yellowfin croakers reach lengths of 51 cm (20 in) (Eschmeyer et al. 1983). Sexual maturity is attained early with about 50% of fish able to be visually sexed within their first year (Pondella et al. in review). At the end of the second year, all fish were reproductively viable. Yellowfin croaker spawning season seems to occur in the summer, possibly offshore, with young-of-year appearing in late fall and winter (O'Brien and Oliphant 2001; Pondella et al. in review). Pondella et al. found growth rate to be most rapid between Age-I and Age-III, especially during late summer and fall. Growth in females was found to precede males in size and weight, growing faster and larger during the early years.

The diet of yellowfin croaker is indicative of an opportunistic predator which feeds off the soft benthos (O'Brien and Oliphant 2001; Pondella et al. in review). Common prey include grunion eggs and small invertebrates; though they are known to also feed on small fish (Eschmeyer et al. 1983; O'Brien and Oliphant 2001).

5.5.2.7.2 Population Trends and Fishery

Since 1915, the only fishery concerning the yellowfin croaker has been reserved for the recreational fishery (O'Brien and Oliphant 2001). The majority of the recreational catch comes from anglers along shore areas such as beaches, piers, and harbors. Catches are numerous due to the ease of capture, requiring little effort from anglers, with most of the catch occurring between May and October. Estimated recreational catch in southern California has ranged between 37,000 and 138,000 fish annually (Table 5.5-3).

Table 5.5-3. Annual landings for yellowfin croaker in the Southern California region based on RecFIN data.

Year	Estimated Catch
2000	43,000
2001	115,000
2002	86,000
2003	37,000
2004	53,000
2005	68,000
2006	138,000

From 1984 through 2005, an estimated total of 72,629 yellowfin croaker weighing 23,095 kg (50,925 lbs) was impinged at SONGS Units 2 and 3 (SCE 1985-2006). Annual impingement has ranged from 717 individuals (1993) to 13,914 individuals (1987). Average annual impingement was 3,301 individuals weighing 1,050 kg (2,315 lbs). In 2005, a total of 2,837 yellowfin croaker weighing 698.4 kg (1,540.0 lbs) was impinged at SONGS.

5.5.2.7.3 Sampling Results

Yellowfin croaker was the eighth most abundant fish species impinged with an estimated 9,258 individuals, less than 1% of the annual total, however, it ranked second in biomass, weighing 3,827.250 kg (8,437.632 lbs) (Table 5.5-1). This is substantially higher than the average annual impingement, and the second highest annual total on record. Heat treatment impingement represented 98.9% of the impinged individuals, with 98 individuals recorded during normal operations. Highest heat treatment impingement was recorded at Unit 2, which accounted for 82.4% of the total abundance and 82.2% of the biomass. Yellowfin croaker were impinged in the summer, when impingement and biomass density peaked in August 2006.

A total of 992 individuals measured during both impingement and fish return surveys indicates a mean standard length of 261 mm (10.3 inches) (Figure 5.5-31). Size ranged from 70- to 380-mm (2.8- to 15.0-inch) SL size classes, with a peak at 280 mm SL. The sex was determined for 489 individuals, of which 40% were female and 60% male.

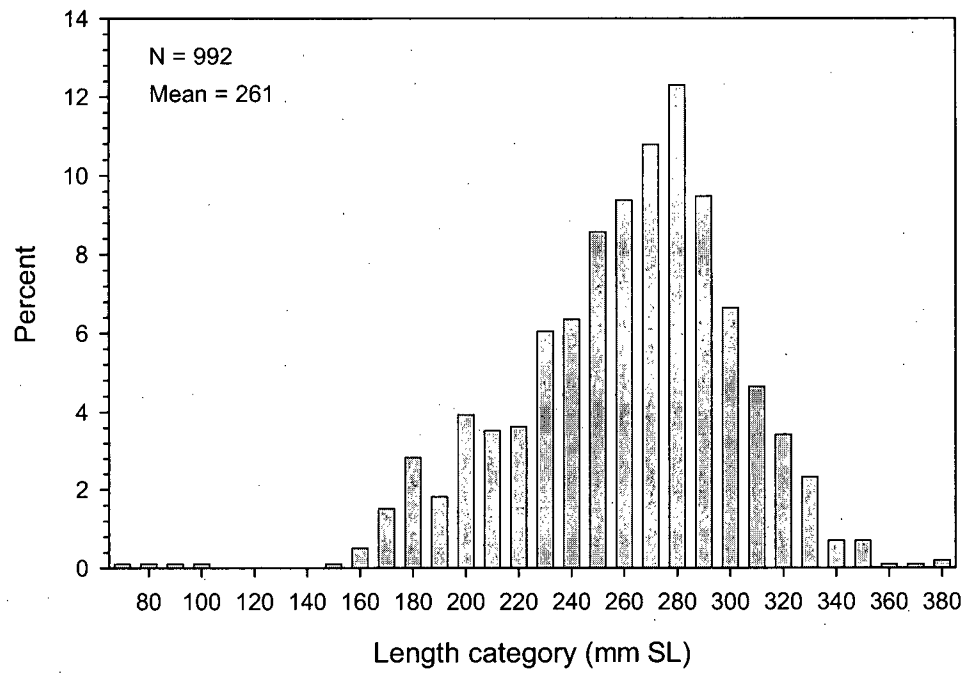
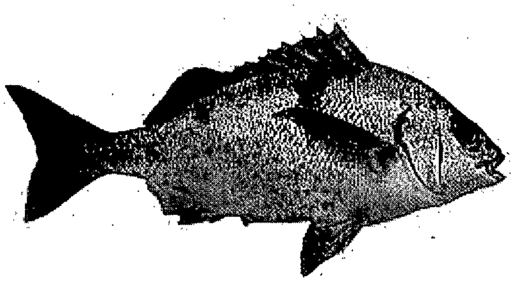


Figure 5.5-31. Length (mm) frequency distribution for yellowfin croaker collected in SONGS impingement and FRS samples.

5.5.2.8 Sargo

Sargo are a member of the Family Haemulidae, which is comprised of grunts (Eschmeyer et al. 1983). The name "grunt" comes from the distinctive grunting noises generated by the rubbing of tooth plates in the throat together. These fish tend to be large with bass-like features and generally inhabit tropical waters.



Sargo exhibit grey coloration above with a distinct dark bar on the back near the midbody and a dark area at the base of the pectoral fins (Eschmeyer et al. 1983; Thomson et al. 2000). The northeastern Pacific range of sargo extends from Santa Cruz to central Baja California, with a small population in the Gulf of California; though they are rare north of Point Conception (Eschmeyer et al. 1983; Thomson et al. 2000; Love et al. 2005). Sargo are commonly found within kelp beds and fishing piers over rocky or sandy bottoms. These grunts have been captured at depths of up to 61 m (200 ft), but more commonly occur in shallower water less than 7.6 m (25 ft).

5.5.2.8.1 Life History and Ecology

Adult sargo have been found to reach lengths of 58 cm (23 in) (Eschmeyer et al. 1983; Thomson et al. 2000). The diet of sargo is comprised of invertebrates such as crustaceans and mollusks (Eschmeyer et al. 1983). Unfortunately there is not much else known about the life history of these fish.

5.5.2.8.2 Population Trends and Fishery

There is no targeted recreational or commercial fishery for this species in California (Thomson et al. 2000). Sargo are occasionally taken by fishermen targeting reef-associated species such as kelp bass.

From 1984 through 2005, an estimated total of 54,693 sargo weighing 12,521 kg (27,608 lbs) was impinged at SONGS Units 2 and 3 (SCE 1985-2006). Annual impingement has ranged from 873 individuals (2005) to 4,366 individuals (1987). Average annual impingement was 2,399 individuals weighing 569 kg (1,255 lbs). In 2005, a total of 873 sargo weighing 31.6 kg (69.6 lbs) was impinged at SONGS.

5.5.2.8.3 Sampling Results

Sargo was the seventeenth most abundant fish species impinged in normal operations, and the sixth most abundant in heat treatments, with an estimated 2,087 individuals, less than 1% of the annual total, but was ranked fifth in biomass, weighing 447.632 kg (986.858 lbs) (Table 5.5-1). This is similar to the average annual impingement of 2,399 individuals. Heat treatment impingement represented 96.6% of the impinged individuals, with 70 individuals recorded during normal operations. Highest heat treatment impingement was recorded at Unit 3, which accounted for 51.0% of the total abundance and 59.4% of the biomass.

Sargo were impinged in the summer, when impingement and biomass density peaked in August 2006. Sargo made a minor contribution to diel composition, with two individuals impinged during daytime and one individual impinged at night, less than 0.1% of the total monitored abundance (Figures 5.5-5 and 5.5-8).

Length frequency analysis of 681 individuals measured during both impingement and fish return surveys indicates a mean standard length of 170 mm (6.7 inches) (Figure 5.5-32). Size ranged from the 40- to 300-mm SL (1.6- to 11.8-inch) size classes, with a peak at 150 mm SL. The sex was determined for 243 individuals, of which 52% were female and 48% male.

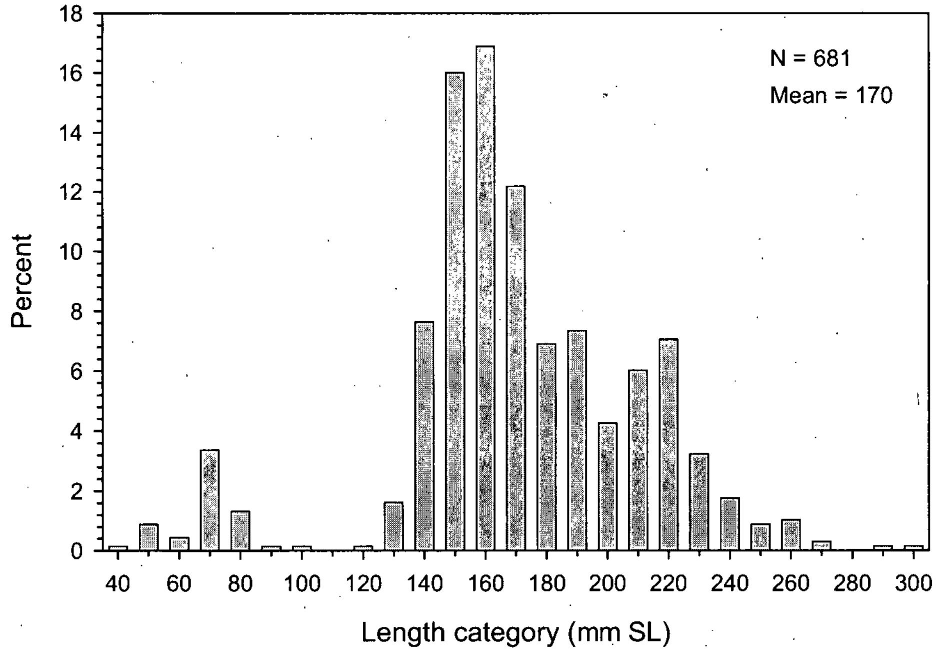
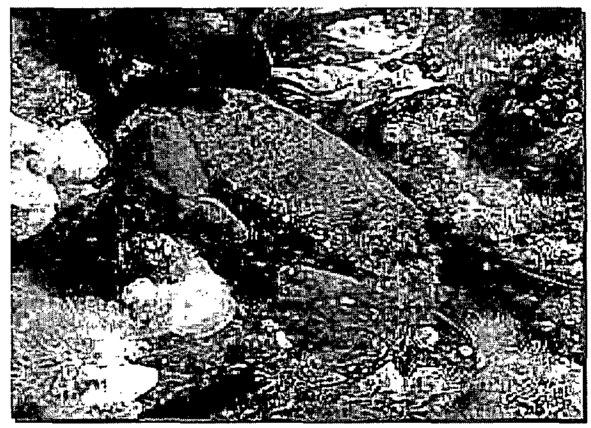


Figure 5.5-32. Length (mm) frequency distribution for sargo collected in SONGS impingement and FRS samples.

5.5.3 All Life Stages of Shellfishes by Species

One shellfish taxa was originally proposed for analysis: California spiny lobster. An additional group of shellfish (rock crabs [*Cancer* spp]) was included in the analysis based on their relative abundance and/or biomass in impingement sample. This included yellow crab (19.3% of total abundance), hairy rock crab (10.1%), brown rock crab (7.1%), unidentified rock crabs (3.9%), graceful crab (0.9%), and red rock crab (*Cancer productus*, 0.4%). Combined, rock crabs and California spiny lobster comprised nearly 44% of the macroinvertebrates in impingement samples, and 49% of the biomass.

5.5.3.1 Rock Crabs


Dan Dugan

Crabs of the genus *Cancer* are widely distributed in the coastal waters of the west coast of North America. They occur in intertidal and shallow subtidal habitats on both rock and sand substrate. Of the nine species known to occur in the northeast Pacific, four species contribute to economically significant fisheries. Dungeness crab (*Cancer magister*) has the highest economic value among these, and three species of rock crabs (yellow crab, brown [Pacific] rock crab, and red rock crab) comprise the remainder of the catches. These three species of rock crab, including hairy rock crab, the smaller slender crab, and bigtooth rock crab (*C. amphioetus*) may all be found in the vicinity of SONGS. All but Dungeness crab occurred in impingement samples at SONGS in 2006.

5.5.3.1.1 Life History and Ecology

All species of *Cancer* crabs share certain fundamental life history traits. Eggs are extruded from the ovaries through an oviduct and are carried in a sponge-like mass beneath the abdominal flap of the adult female. After a development period of several weeks, the eggs hatch and a pre-zoea larva emerges, beginning the planktonic life history phase. As in all crustaceans, growth progresses through a series of molts. The planktonic larvae advance through six stages of successive increases in size: five zoea (not including the brief pre-zoea stage) and one megalopal. After several weeks as planktonic larvae, the crabs metamorphose into the first crab stage (first instar) and settle out to begin their benthic life history phase. Maturity is generally attained within one to two years. Mature females mate while in the soft shell molt condition and extrude fertilized eggs onto the abdominal pleopods. Females generally produce one or two batches per year, typically in winter.

The main determinant of brood size and reproductive output in brachyuran crabs is body size, and the range of egg production in *Cancer* crabs generally reflects this relationship (Hines 1991). Yellow crab produce on average 2.21 million eggs per brood. The next largest species collected in impingement sampling, red rock crab, produces 877,000 eggs per brood. Brown rock crab females seem to be an exception to this relationship because they are, on average, smaller than the red rock crab, yet produce an average of 1.2 million eggs per batch. Slender crab is one of the smallest of the five species living near SONGS and their average egg production per brood is 454,000. Female *Cancer* crabs typically produce a single batch per year, generally in the winter; however, due to occasional multiple spawnings, the average number of batches per year may be greater than one (Carroll 1982; Hines 1991).

Cancrid crabs function as both scavengers and predators in the marine environment. Prey varies as a function of age and size of the individual but benthic invertebrates such as clams, worms, and snails comprise the majority of prey species. Claw morphology of each species is adapted to the types of preferred prey. For example, the heavier crusher claws of the brown rock crab and yellow crab facilitate the breaking of gastropod shells whereas the tapered dactyls of the slender crab are used to probe in soft sediments for worms and other soft-bodied prey. Winn (1985) documented the occurrence of cannibalism among rock crabs, particularly adults on juveniles. However, since juveniles generally inhabited shallower areas than adults, effects on the younger cohorts were diminished.

During their planktonic existence, crab larvae can become widely distributed in nearshore waters. In a study in Monterey Bay, Graham (1989) found that slender crab stage 1 zoeae were very abundant close to shore (within 6 km or 3.7 miles) during March and August. Later stage larvae, including megalopae, were found further from shore during all times of the year. This offshore larval distribution probably reflects the fact that adult slender crabs are widely distributed in coastal shelf areas, further offshore than brown rock crabs. The megalops larvae and juvenile crabs are frequently found crawling unharmed on and under the bells, and even in the stomachs, of larger jellyfishes, especially purple-striped jelly *Chrysaora colorata* (Morris et al. 1980).

Juvenile rock crabs are an important prey item for a variety of fishes and invertebrates. In southern California, this includes barred sand bass, shovelnose guitarfish (*Rhinobatos productus*) and the sand star (*Astropecten verrilli*) (Roberts et al. 1984; VanBlaricom 1979).

Each species in the genus has characteristic differences in distribution, preferred habitat, growth rates, and demographic parameters. For example, brown rock crab is a relatively large species (carapace width >200 mm) that lives primarily on sand and mud substrates in estuarine and coastal shelf areas. Slender crab is a smaller species (carapace width >130 mm) associated with mixed rock-sand substrates in shallow outer coast habitats. These types of differences imply that specific information on life history parameters cannot readily be generalized among *Cancer* species. The following sections describe the life history and ecology of the five most abundant rock crabs collected in impingement samples in 2006.

5.5.3.1.1.1 Yellow crab

Yellow crab ranges from Humboldt Bay, California to Bahia Magdalena, Baja California. It occurs in rocky areas of bays and estuaries, the low intertidal zone, and subtidally to depths of 132 m (291 ft), but is most commonly found in depths between 18 to 55 m (59 to 180 ft) (Morris et al. 1980; Carroll and Winn 1989; Jensen 1995). Within this range their distribution is almost exclusively associated with sand substrata (Winn 1985; Carroll and Winn 1989). The species is most abundant on the expanses of open, sandy substrata that characterize much of the SCB. It is, however, also commonly encountered near the rock-sand interface of natural and artificial reefs in the region (Morris et al. 1980; Carroll and Winn 1989). In the northern parts of their range, where rocky benthic substrata predominate, their distribution appears to be confined more to bays, sloughs, and estuaries (Jensen 1995). They are the most abundant rock crab species harvested in southern California, often composing 70 to 95% of the total crab catch in the region (Carroll and Winn 1989). During diver surveys of yellow rock crab populations in Santa Monica Bay it was noted that the species was never seen during daylight hours in the vicinity of traps, but were often abundant in the traps the next morning (R. Hardy, CDFG, pers.

comm.). These observations suggest that yellow rock crab are nocturnally active in shallow water and remain buried and inactive during daylight hours.

Anderson and Ford (1976) described the growth of yellow crab under laboratory conditions. Total larval development times from hatching through the megalops stage were 33 days and 45 days at 22°C and 18°C, respectively. The total time spent in the megalops stage averaged 8 days at 22°C and 12 days at 18°C. Yellow crab can live at least 5 years and attain a carapace width of 170 mm (6.7 inches) after 16 crab instars (molts).

5.5.3.1.1.2 Hairy rock crab

Hairy rock crab occurs primarily between Coos Bay, Oregon and Cabo Thurloe, Baja California, and is primarily found among rocks, in the low intertidal zone, and subtidally to 104 m (341 ft). Ovigerous females have been noted to occur in Monterey Bay in October and November (Morris et al. 1980). The hairy rock crab is a small *Cancer* species with males measuring up to 39.3 mm (1.5 inches) CW and females to 19.5 mm (0.7 inches) (Jensen 1995). The life span of the species and the age/size at maturity is unknown.

Information on the life history of the hairy rock crab is scarce. Reproductive behavior can be assumed to follow the pattern of other rock crabs. Ovigerous females have been found in Monterey Bay during October and November. The eggs and larvae of hairy rock crab are similar in size to those of larger rock crab species (J. Carroll, Tenera, pers. comm.). Hairy rock crab larvae have been reported to be larger than those of brown rock crab in the same stage (J. Carroll, Tenera, pers. comm.). Because of the small size of adult female hairy rock crab, and the proportionally large size of individual eggs, it has been suggested that the species is probably less prolific than larger *Cancer* species (J. Carroll, Tenera, pers. comm.). Based on these observations, the fecundity would probably be on a scale of thousands or tens of thousands of eggs instead of the hundreds of thousands or millions typical of larger cancer crab species. It is likely that the larval, juvenile, and adult hairy rock crab are preyed upon by the same assemblage of fishes and invertebrates that consume the larvae and early crab stages of other cancrid species. Because of their small size, adult hairy rock crab probably remain vulnerable to predation by fish species such as cabezon (*Scorpaenichthys marmoratus*) and rockfishes (*Sebastes* spp), and small octopi (*Octopus* spp) throughout their lives. The species is not harvested commercially or recreationally.

5.5.3.1.1.3 Brown rock crab

Brown rock crab (or Pacific rock crab) ranges between Queen Charlotte Sound, British Columbia, and Isla de Todos Santos, Baja California (Jensen 1995), although the range of peak abundance extends from San Francisco Bay to coastal areas south of the U.S.-Mexico border (Carroll and Winn 1989). They occur from the lower intertidal zone to depths exceeding 100 m (328 ft) but are typically found near the rock-sand interface in depths of less than 55 m (180 ft) (Carroll and Winn 1989). Juvenile brown rock crabs inhabiting the intertidal zone survive exposure to the air during low tide by sheltering themselves under rocks and algae (Ricketts et al. 1985). This species is a scavenger and active predator.

Mating occurs after females molt and are still soft-shelled, and ovigerous females are most common from November to January, but may be found year-round (Morris et al. 1980; Carroll 1982). Adult crabs are sexually dimorphic, with males attaining a larger size and growing larger more robust chelae (claws). Male crabs grow to a size (maximum CW) of 178 mm (7 inches) while females reach 148 mm (5.8 inches) (Jensen 1995). The life span of brown rock crab is estimated to be five to six years (Carroll 1982). The size of a female's egg mass is variable and can contain from 410,000 to 2.79 million eggs (Carroll and Winn 1989). Development of the eggs and subsequent hatching takes seven to eight weeks at temperatures of 10° to 18° C (50° to 64° F) (Anderson and Ford 1976; Carroll 1982). Size (CW) increases in the brown rock crab range from 7 to 26% per molt, while increases in body weight of 50 to 70% have been measured (Carroll 1982). The sexes undergo a molt to maturity (50% maturity value of population using Somerton [1980] method) from between 60 mm and 80 mm CW (2.4 inches and 3.1 inches) (Carroll 1982). Brown rock crabs are estimated to go through 10 to 12 molts before reaching sexual maturity (Parker 2001).

Brown rock crab eggs require a development time of approximately seven to eight weeks from extrusion to hatching (Carroll 1982). Larval development in the brown rock crab was described by Roesijadi (1976). Eggs hatch into pre-zoea larvae that molt to first stage zoea in less than 1 hour. Average larval development time (from hatching through completion of the fifth stage) was 36 days at 13.8°C. Although some crabs molted to the megalops stage, none molted to the first crab instar stage, so the actual duration of the megalops stage is unknown. Based on a predicted megalops duration of approximately 12 days measured for the closely related yellow crab, the estimated length of time from hatching to settling for brown rock crab is approximately 48 days. Brown rock crabs mature at an age of about 18 months post-settlement with a size of approximately 60 mm CW (2.4 inches) and a weight of 73 g (0.161 lbs) (Carroll 1982). Faster growth rates may occur in highly productive environments such as on the supporting members of offshore oil platforms and females may become reproductive in less than one year post-settlement (D. Dugan, pers. comm.). Brown rock crabs can probably live to a maximum age of about six years. Size at recruitment to the fishery is approximately 125 mm CW (4.9 inches), at an age of four years for males and four and one-half years for females.

5.5.3.1.1.4 Graceful (slender) crab

Graceful crab (or slender crab) ranges between Prince William Sound, Alaska, and Bahia Playa Maria, Baja California. It is found in the lower intertidal zone in bays, on mud flats, in eelgrass beds, and subtidally to 174 m (571 ft). While found in bays, this species cannot tolerate brackish conditions. It feeds primarily on animal remains and barnacles. In Elkhorn Slough (Monterey County, California), mating occurs in November, with ovigerous females appearing in July and August. Males remain with the females after mating, and are thought to protect them (Morris et al. 1980).

Females produce one batch per year, although in a laboratory setting, some females produced a small second batch. The number of eggs extruded per female can range from 143,000 to one million. Females are able to spawn for at least two, and possibly three seasons, over their lifetime (Orensanz and Gallucci 1988). Their carapace width measures up to 115 mm (4.5 inches) in males and up to 87 mm (3.4 inches) in females (Jensen 1995). It is estimated that slender crab mature at a size of about 60 mm

CW (2.4 inches) and at approximately 10 months of age (post-settlement) (Orensanz and Gallucci 1988). Slender crab molt approximately 11 to 12 times and live for about four years.

Slender crab larval development was described by Ally (1975). Eggs hatch into pre-zoea larvae, which quickly molt to first stage zoea. Average larval development time (from hatching through completion of the megalops stage) was 48.9 days at 17°C, with most zoeal stages lasting approximately one week. Ally (1975) found an average duration of the megalops stage of 14.6 days. Growth occurs through 11–12 instars, with crabs attaining an estimated maximum age of four years post-settlement.

5.5.3.1.1.5 Red rock crab

Red rock crab ranges between Kodiak Island, Alaska, and Magdalena Bay, Baja California (Schmitt 1921). The abundance of red rock crab, relative to the other rock crab species, increases with latitude within the state. Red rock crab inhabit a variety of substrata including intertidal and subtidal rocky areas, gravel, coarse sand, and mud (Carroll and Winn 1989). They are commonly found in close association with hard substratum such as rocky reefs, well-protected boulder-strewn beaches, and gravel beds (Morris et al. 1980; Carroll and Winn 1989; Jensen 1995). Red rock crab occur from the lower intertidal zone to depths of at least 91 m (299 ft) (Winn 1985; Carroll and Winn 1989). Juvenile red rock crab inhabiting the intertidal zone survive exposure to the air during low tide by sheltering themselves under rocks and algae (Ricketts 1985). Red rock crab are often collected in bays, estuaries, and sloughs, however, their distribution in these areas is affected by salinity gradients because the species lacks the ability to osmoregulate (Morris et al. 1980).

Like the brown rock crab and yellow crab, adult red rock crab are sexually dimorphic, with males attaining a larger size and growing larger, more robust chelae. Male crabs grow to a maximum size (CW) of 200 mm (7.8 inches), while females reach 158 mm (6.2 inches) (Jensen 1995). No estimates of the life span of red rock crab were cited in the literature reviewed. The size of a female's egg mass is variable and can contain from 560,000 to 1.01 million eggs (Carroll and Winn 1989). No information about the development and subsequent hatching of red rock crab eggs was available in reviewed literature. Trask (1970) found that red rock crab larvae developed to the megalopal stage in 97 days at a temperature of 11° C (52° F); however, none of his laboratory-reared larvae survived to the first crab instar.

5.5.3.1.2 Population Trends and Fishery

Rock crabs are fished along the entire California coast with crab pots, though some landings are reported from set gill nets and trawls as well (CDFG 2004). Three species are harvested commercially in southern California: brown rock crab, red rock crab, and yellow crab. There is no commercial fishery for the slender crab or hairy rock crab. The rock crab fishery is most important in southern California (from Morro Bay south), which produces a majority of the landings, and of lesser importance in northern areas of California where a fishery for the more desirable Dungeness crab takes place. Most rock crabs are landed alive for retail sale by fresh fish markets. The commercial harvest has been difficult to assess on a species-by-species basis because the fishery statistics are combined into the general "rock crab" category. From 1991 through 1999 state-wide rock crab landings (including claws) averaged 1.2 million lbs per year (Parker 2001).

Regulations currently specify a minimum harvest size of 4.25-in carapace width. A small recreational fishery for rock crabs also exists, with a 4.00-inch minimum carapace width and a personal bag limit of 35 crabs per day. Crabs are collected by divers or shore pickers with hoop nets and crab traps. Los Angeles area landings based on the PacFIN database have remained steady at an annual total of about 33,000 kg (72,765 lbs) and $110,000 (Table 5.5-13). Commercial landings of rock crabs in 2006 in San Onofre area catch blocks totaled 21,102 kg (46,530 lbs) at a value of $53,694 (CDFG 2007). In 2005, Los Angeles area landings (between Dana Point and Santa Monica) for unspecified rock crabs totaled 45,100 kg (99,446 lbs) at a value of $134,622, while landings for red rock crab totaled 325 kg (716 lbs) at a value of $1,184 (CDFG 2006).

Table 5.5-13. Annual landings and revenue for red rock crab in the Los Angeles region based on PacFIN data.

Year	Landed Weight (kg)	Landed Weight (lbs)	Revenue
2000	24,444	53,900	$79,273
2001	34,306	75,645	$115,603
2002	33,572	74,026	$113,128
2003	32,417	71,480	$109,409
2004	34,303	75,638	$109,554
2005	32,152	70,896	$105,542
2006	33,923	74,800	$112,529

5.5.3.1.3 Sampling Results

Yellow crab was the most abundant invertebrate with an estimated annual impingement of 22,781 individuals weighing 76.121 kg (167.818 lbs) (Table 5.5-2). Yellow crab were more abundant during normal operation surveys (59% of the total), and at Unit 2 (72% of normal operations abundance).

Hairy rock crab was the fourth most abundant invertebrate with an estimated annual impingement of 11,888 individuals weighing 23.312 kg (51.394 lbs) (Table 5.5-2). Hairy rock crab were more abundant during normal operation surveys (65% of the total), and at Unit 2 (59% of normal operations abundance).

Brown rock crab was the sixth most abundant invertebrate with an estimated annual impingement of 8,356 individuals weighing 65.919 kg (145.326 lbs) (Table 5.5-2). Brown rock crab were more abundant during normal operation surveys (44% of the total), and at Unit 2 (66% of normal operations abundance).

Unidentified rock crab was the seventh most abundant invertebrate with an estimated annual impingement of 4,576 individuals weighing 3.712 kg (8.184 lbs) (Table 5.5-2). Unidentified rock crab were only taken during a heat treatment survey, due to the difficulty in identification of damaged individuals (100% of the total). All of the unidentified rock crabs were from a single heat treatment at Unit 3 on March 4, 2007.

Graceful rock crab was the fifteenth most abundant invertebrate with an estimated annual impingement of 1,071 individuals weighing 3.395 kg (7.485 lbs) (Table 5.5-2). Graceful rock crab were slightly more abundant during heat treatment surveys (51% of the total), and at Unit 2 (51% of heat treatment abundance).

Red rock crab was the twenty-second most abundant invertebrate with an estimated annual impingement of 453 individuals weighing 1.548 kg (3.413 lbs) (Table 5.5-2). Red rock crab were slightly more abundant during heat treatment surveys (53.6% of the total), and were almost evenly taken at both Units (121 individuals at Unit 2 and 120 individuals at Unit 3).

Rock crabs were impinged at low levels throughout the year, with peaks in abundance occurring in July and November 2006, and April 2007 (Figure 5.5-33). Biomass followed a similar pattern (Figure 5.5-34).

Rock crabs contributed greatly to the diel periodicity observed during the three surveys conducted, comprising about 71% of the individuals impinged during the surveys, with 83% of the combined rock crab impingement occurring at night (Figures 5.5-9 and 5.5-11). Hairy rock crab contributed the most to diel abundance, with 79% of the total rock crab diel abundance, followed by red rock crab with 15% of the total. Night impingement abundance for both species had the same percent contributions to the rock crab total.

A similar pattern was observed in the diel comparisons of biomass, although rock crab species only contributed about 6% of the total biomass (Figures 5.5-10 and 5.5-12). About 61% of the total biomass for all invertebrates was impinged at night; rock crab species had 74% of their combined total biomass impinged at night. Hairy rock crab contributed 44% of the biomass, while red rock crab and yellow rock crab contributed 30 and 23%, respectively, as a result of their larger body size. Night biomass impingement for all three species had the same percent contributions to the rock crab total.

Red rock crabs were the largest individuals impinged based on average weight, at 8 grams (0.28 ounces [oz]) each. Yellow rock crab, graceful rock crab, and red rock crab all had an average weight of 3 grams each (0.11 oz), followed by hairy rock crab with 2 grams (0.07 oz) and unidentified rock crab at 1 gram (0.04 oz).

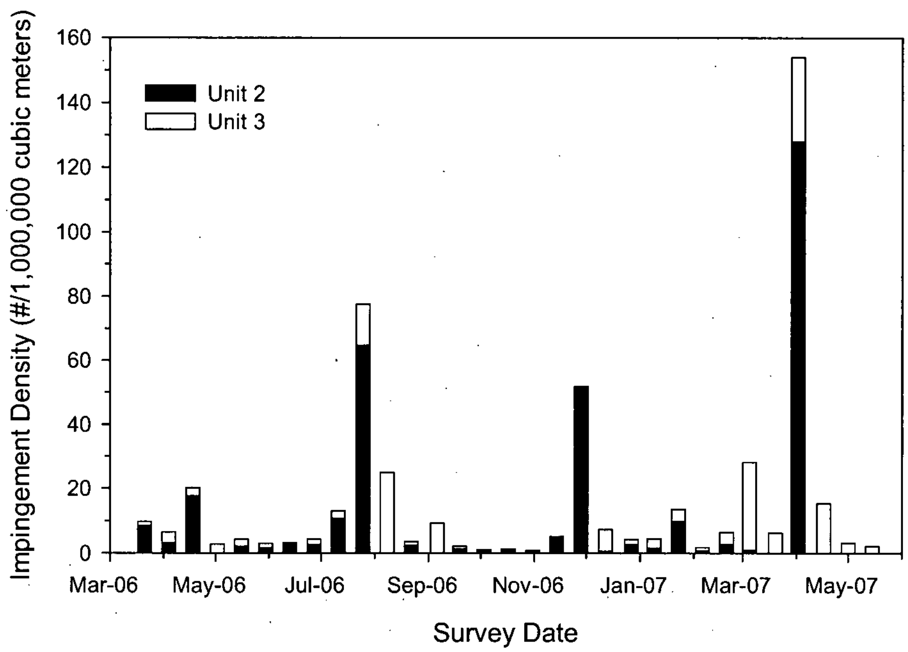


Figure 5.5-33. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of rock crabs collected in SONGS normal operation impingement samples during 2006-7.

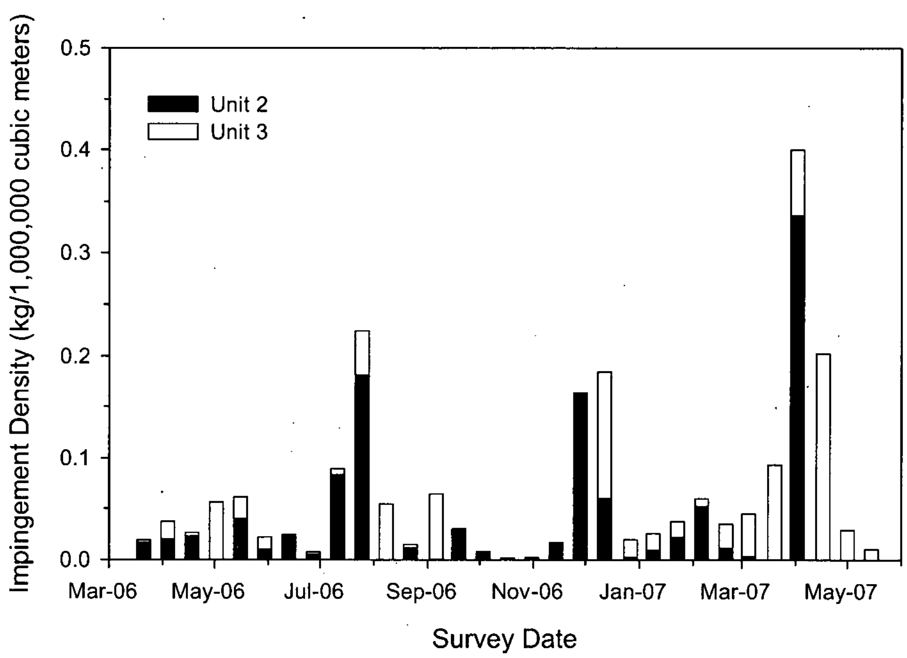


Figure 5.5-34. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of rock crabs collected in SONGS normal operation impingement samples during 2006-7.

5.5.3.2 California Spiny Lobster

Information on the life history, ecology, population trends, and fishery of spiny lobster is summarized in Section 4.5.4.7.

5.5.3.2.1 Sampling Results

California spiny lobster was the eleventh most abundant invertebrate species impinged with an estimated 2,151 individuals, or 1.8% of the annual total, weighing 469.187 kg (1,034.379 lbs) (Table 5.5-2). Impinged throughout the study period in low densities, California spiny lobster were most abundant in July 2006, with a smaller peak in abundance in April 2007 (Figure 5.5-35). Biomass followed a pattern consistent with that seen in abundance, except the April 2007 showed a larger peak value, indicating larger individuals were present (Figure 5.5-36).

California spiny lobster comprised less than 2% of the individuals impinged during the diel surveys, with slightly more occurring at night (Figures 5.5-9 and 5.5-11). A similar pattern was observed in the diel comparisons of biomass (Figures 5.5-10 and 5.5-12).

Length frequency analysis of 270 individuals measured during both impingement and fish return surveys indicates a mean carapace length of 54 mm (2.2 inches) (Figure 5.5-37). Size ranged from 10 to 100 mm CL size classes, with a peak at 70 mm CL (3.2 inches). The majority of the measured individuals were less than 100 mm CL, indicating most were younger than approximately 10 years. The sex was determined for 205 individuals, of which 44% were female, 52% male, and 4% were unsexable.

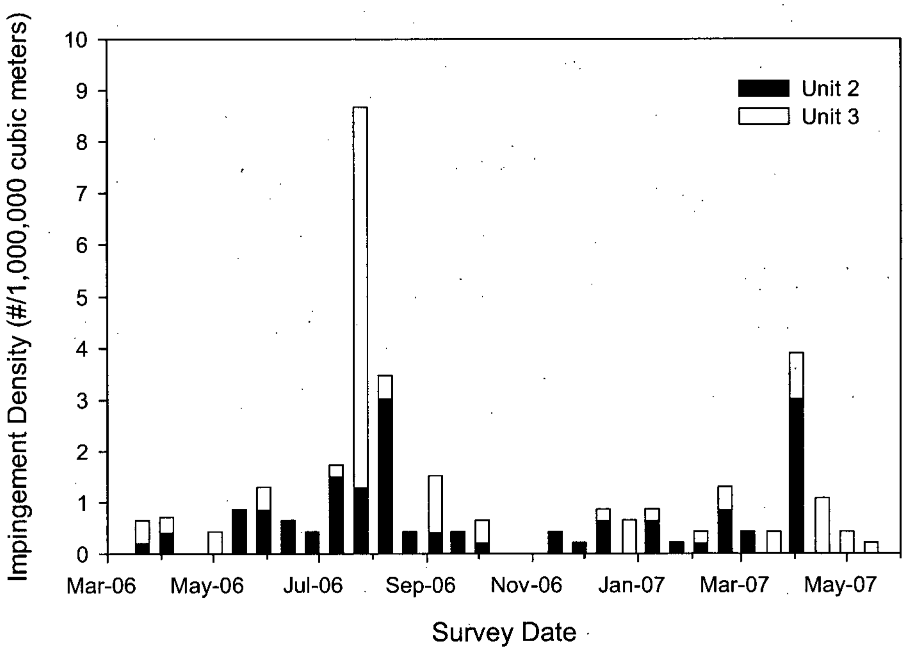


Figure 5.5-35. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of spiny lobster collected in SONGS normal operation impingement samples during 2006-7.

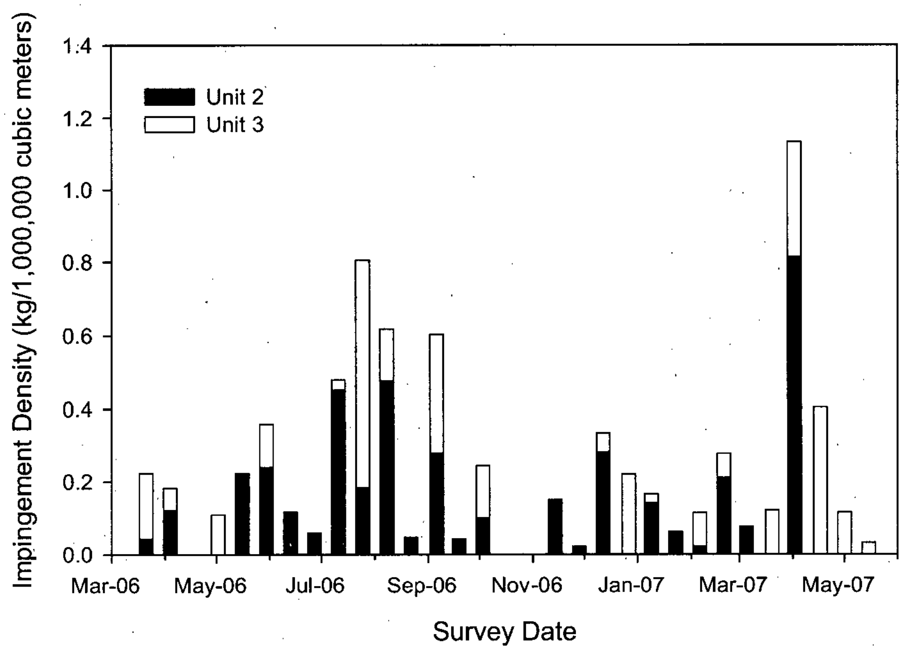


Figure 5.5-36. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of spiny lobster collected in SONGS normal operation impingement samples during 2006-7.

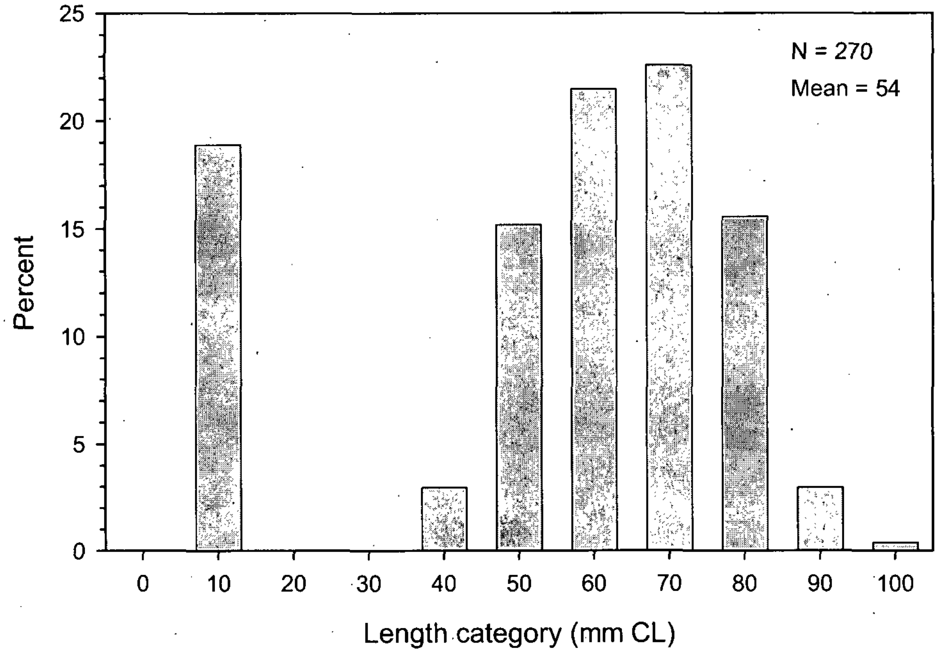


Figure 5.5-37. Carapace length (mm) frequency distribution for spiny lobster collected in SONGS impingement and FRS samples.

5.5.4 Vegetative Debris

SONGS is located adjacent to two kelp beds, and the cobble bottom substrate offshore is highly productive for small algal species. Surge and currents cause the algae to become dislodged and suspended in the water column. During some episodes, large amounts of algal debris become entrained in the flow of the CWIS and are filtered by the traveling screens. On occasion this has caused the traveling screens to operate continuously to prevent high pressure differentials across the traveling screens. If pressure differentials become too great, the drive motor is unable to start rotation of the screens, allowing debris to build up and block water flow through the screens to the circulating water pumps. In the event of this occurrence, the unit would be required to shut down. Figure 5.5-38 shows the amounts of vegetative debris entrained at each unit during the 24-hour survey periods. Amounts greater than 680 kg (1,500 lbs) per day occurred in June, October, and December 2006.

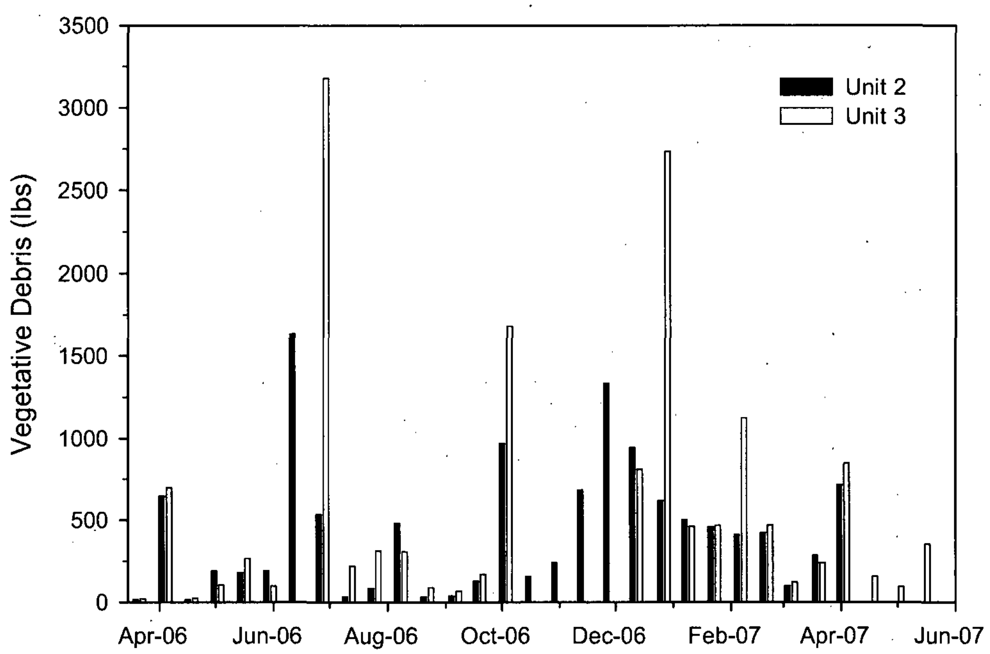


Figure 5.5-38. Biomass (lbs) of vegetative debris collected in SONGS normal operation impingement samples during 2006-2007.

6.0 CALCULATION BASELINE

6.1 INTRODUCTION

The data collected as part of the impingement and entrainment study were to be used in developing a characterization of baseline levels of IM&E for the San Onofre Nuclear Generating Station. The calculation baseline was an important feature of EPA's 2004 Phase II regulations. Calculation baseline was defined as follows:

> *"Calculation baseline means an estimate of impingement mortality and entrainment that would occur at your site assuming that: the cooling water system has been designed as a once-through system; the opening of the cooling water intake structure is located at, and the face of the standard 3/8-inch mesh traveling screen is oriented parallel to, the shoreline near the surface of the source waterbody; and the baseline practices, procedures, and structural configuration are those that your facility would maintain in the absence of any structural or operational controls, including flow or velocity reductions, implemented in whole or in part for the purposes of reducing impingement mortality and entrainment. You may also choose to use the current level of impingement mortality and entrainment as the calculation baseline. The calculation baseline may be estimated using: historical impingement mortality and entrainment data from your facility or another facility with comparable design, operational, and environmental conditions; current biological data collected in the waterbody in the vicinity of your cooling water intake structure; or current impingement mortality and entrainment data collected at your facility. You may request that the calculation baseline be modified to be based on a location of the opening of the cooling water intake structure at a depth other than at or near the surface if you can demonstrate to the Director that the other depth would correspond to a higher baseline level of impingement mortality and/or entrainment."*

As presented in the PIC, the SONGS cooling water intake structures do not match the definition of the calculation baseline. Deviations from the definition of the calculation baseline are:

- The intakes are submerged rather than at, or near, the surface;
- The intake structures are located more than 1,000 ft from the shoreline rather than at the shoreline;
- The traveling screens are not oriented parallel to the shoreline;
- The SONGS cooling water systems both employ fish return systems;
- The intake designs both include a velocity cap.

The 2004 regulations allowed facilities to take credit for deviations from the calculation baseline if it could demonstrate that these deviations provided reduced levels of IM&E. EPA did not indicate if actual cooling water flows or design (maximum) cooling water flows were to be used in determination of the calculation baseline. However, all calculations in this section were based on 52 weeks of cooling water flow at each unit at SONGS.

6.2 METHODS

The following sections describe methodologies used to estimate the calculation baseline at SONGS.

6.2.1 Entrainment Calculation Baseline

No adjustments were made in determination of the calculation baseline for entrainment.

6.2.2 Impingement Calculation Baseline

All fish and invertebrates recorded during the 2006-7 surveys were included in the calculation baseline estimate for both normal operation and heat treatment surveys. During that study, all impinged fish and macroinvertebrates were identified and analyzed during sampling. The calculation baseline for impingement mortality also included all fishes and invertebrates estimated to be returned by the FRSs, as they would have otherwise been impinged. The methods and results from FRS sampling are presented in the following sections.

6.3 REDUCING IMPINGEMENT MORTALITY

The fish return system (FRS) at SONGS is unique among the generating stations along the West Coast. Its function is to mitigate the potential loss of fish and invertebrate loss due to impingement by providing a method to isolate and return organisms entrained in the plant. This section presents the design, history, and sampling method used to determine effectiveness of the SONGS fish return systems.

The purpose of the fish return system study was to determine the extent of reduction of the potential impacts from the operation of the cooling water system of SONGS on fishes and selected invertebrates. Entrainment of adult organisms into the CWIS occurs when organisms enter the offshore intake structure and are carried by the water into the screenwell. Without the FRS, all of the juvenile/adult individuals entrained would be impinged on the traveling bars/screens. To reduce impingement, the FRS was designed to divert fish approaching the screens to the fish removal area, where the fish elevator could be used to remove them and return them back to the ocean. A more detailed description of the FRS can be found in Section 3.2. Fish return system samples were collected over a concurrent 24-hr period with normal operation impingement samples to compare the daily return of organisms to the daily losses from impingement. In addition, fish chase procedures, performed prior to heat treatments, were monitored to compare returns to heat treatment mortality. Data from these surveys were used to estimate annual return of species entrained at SONGS Units 2&3.

6.3.1 Species to Be Analyzed

Several types of organisms are susceptible to entrainment and return by the generating station. All fishes and macroinvertebrates collected were processed (identified, enumerated, and where appropriate, measured) in fish return samples. However, assessment of fish return effects was focused on the taxa included in the SONGS PIC listed in Section 4.1.1, plus the additional fish taxa listed in Section 5.5.2, and rock crabs and California spiny lobster.

6.3.2 Previously Collected Data

A summary of previously collected fish return data from SONGS is presented in Section 7.4 (*Discussion*).

6.3.3 Methods

The following sections provide study specific information on the FRS sample collection and data analysis methods. The FRS sampling program was designed to provide the necessary information for characterization and development of the calculation baseline. The FRS sampling provided current estimates of the taxonomic composition, abundance, biomass, seasonality, and, during three surveys, diel periodicity of organisms retuned to the ocean at SONGS. The sampling program also documented the size, sex, and physical condition of fish and shellfish retuned. The abundance and biomass of organisms returned was used to calculate return rates (e.g., the number of organisms returned per 10^6 m^3 [264,172,052 gallons] cooling water flowing into each CWIS).

As described in Section 3.2, water enters the screenwells and is directed via vanes to one of six sets of screens or to the fish removal area. The design of the vanes distributes water flow equally to all six sets of screens. As fish approach the louvered rake screening mechanism, water pressure differentials developed by the flow and the angle of water approach allow the fish to move along the face of the louvers to the end of the screenwell, where they move into the fish bypass channel and subsequently into the fish removal area. Water flowing into the fish removal area is diverted along the side walls, creating a low flow area behind the baffle wall where fish can swim out of the main flow. Fish accumulate in the fish removal area until the fish elevator system is activated to lift them up and pour them into the fish return sluiceway, where they are carried back to the ocean. The fish return elevator is operated sequentially until most organisms are removed, based on a visual estimation of densities present in the elevator. A more complete description of the system is presented in Section 3.2.

6.3.3.1 Field Sampling

Field sampling for the fish return surveys took place concurrent with normal operation impingement surveys, as well as during fish chase procedures conducted prior to heat treatments. Both types of surveys provide the basis for comparisons of fish return to fish impingement.

6.3.3.1.1 Normal Operation FRS Surveys

Fish return system sampling at SONGS was conducted over the same 24-hour period one day every two weeks as impingement sampling (Table 5.4-1). Twenty-six normal operation return surveys were conducted at each unit. Three surveys to determine diel characteristics were conducted, one each in February, March, and April 2007. During the diel surveys, the 24-hour sampling interval was divided into two 12-hour cycles. Initiation of sample collection occurred as follows: Cycle 1 (approximately 0430-1630 hours) and Cycle 2 (approximately 1630-0430 hours).

Before each sampling effort, the fish elevator was operated multiple times to remove all possible fish from the fish removal area. This was performed under the supervision of the attending biologist. This process reduced abundance in the fish removal area to less than approximately 5% of the abundance present at the start of the process. After the system was emptied of most organisms, an operational hold was placed on the equipment to prevent inadvertent release of any of the sample during the 24-hour survey period.

As the fish return system is designed to return live fish, two methods were used to quantify the organisms returned by the FRS. First, a non-intrusive method of estimating the abundance and biomass using visual estimates was used. When the fish elevator reached the top of its travel, it was held in place while the biologist observed the organisms present. The biologist conducting the visual observations had experience on fish identification and previous experience with the fish elevator. Estimates of fish/shellfish species and abundance were recorded on a pre-formatted datasheet. Observations were made for each subsequent operation of the elevator, with total abundance from all elevator lifts summed for a total abundance by species for each survey. Secondly, an aliquot was collected during each operation of the fish elevator as the contents were poured into the fish return sluiceway. The aliquot was collected by placing three dipnets with 9.5 mm (3/8-inch) mesh along the face of the fish return sluiceway. Each dipnet was one-tenth of the width of the fish elevator basket, providing a subsample consisting of three-tenths of the elevator basket for each lift-and-pour into the sluiceway. The edge of the sluiceway was divided into ten equal sections. Location for placement of the dipnets along the edge of the sluiceway during each lift was determined randomly prior to each survey. This prevented any bias from random fish movement as the elevator was poured into the sluiceway. After each pour, each dipnet was emptied into a single collection tub to create a composite sample for each unit. Each of the two units was sampled and processed independently. Samples were processed by the methods used for impingement samples as described in Section 5.3.1.

The visual and aliquot data sets were complimentary to each other, providing an abundance and biomass for species that may have been missed or incorrectly allotted by each method. Data from the two methods, visual observation and aliquot sub-sampling, were compared to each other after data entry processing was completed. Integration of the visual and aliquot sampling method abundance results is described below (Section 6.3.3.2).

6.3.3.1.2 Larval Fish and Shellfish

Concurrent with the adult fish and invertebrate FRS sampling, aliquot samples for the presence of larval fish and shellfish were also collected. A specially constructed dipnet consisting of 333-µm (0.01-inch) mesh was used to collect the samples. The adult organism dipnet described above was nested with the plankton dipnet, so that as the elevator sample was poured into the sluiceway, the adult fish would be retained by the 9.5 mm mesh, while larval fish and shellfish would pass through and be retained inside the plankton dipnet. All subsamples from the plankton dipnets were composited together to create a single sample for analysis. Samples were processed using the procedures for entrainment samples (Section 4.3.1). Due to extremely high debris levels in some samples, only a subset of samples were processed to provide seasonal variation of larval return via the FRS.

6.3.3.1.3 Fish Chase/Heat Treatment FRS Surveys

Prior to all heat treatments conducted at both units, fish chases were conducted (Table 5.4-2). Fish chase procedures are used to mitigate any impingement of fish or shellfish when screenwell temperatures are raised above lethal temperatures for all species. All organisms removed during the fish chase were surveyed by using only the visual estimation method described above. Due to the amount of fish returned and time constraints, it is not practical to integrate an aliquot method. All fish chase observations were performed by a biologist who had performed fish chase observations at SONGS for a minimum of ten years.

6.3.3.2 Data Analysis

The volume of water filtered with each plankton net was calculated by dividing the known volume of each FRS elevator by ten since the nets sampled one-tenth of the elevator. It was assumed that larval fishes and shellfishes did not accumulate in the return systems. For juvenile/adult fishes and shellfishes, the return rate was calculated using the same methodology used for impingement. Return rates were calculated using the circulating water flow during each of the surveys (or cycles for diel surveys) of each 24-hour survey by the same method utilized for impingement monitoring and described in Section 5.3.2. The total time for each survey or cycle was multiplied by the known flow rate of each of the circulating water pumps in operation during each survey or cycle.

6.3.3.2.1 Fish Return System Efficiency

Abundance and biomass from impingement and normal operation fish return system surveys and from fish chase and heat treatment surveys were used to calculate the total fish return system efficiency on a biweekly and annual basis, as well as for individual species.

6.3.3.2.1.1 Normal Operation Fish Return

During each lift of the FRS, the biologist made visual observations of the species present. Those species which could be distinguished clearly were listed, and abundances estimated. Observations were made for approximately five minutes to allow for fish movement in order to maximize the number of species observed and improve abundance estimates.

During the visual observation process, similar appearing species could be periodically discerned, and an estimate of the relative percent composition was made. This relative percent could then be applied to the overall abundance observed for mixed species schools to provide abundances for each species.

As the FRS was being emptied, the fish generally moved back and forth from edge to edge. On days with low abundances, and depending on the random placement of the sample nets, fish might avoid the sample nets and be underestimated, or could all be caught in the nets and overestimated. On surveys with low to medium abundance (less than approximately 1,000 individuals per FRS lift) the total estimated abundance was used if the calculated abundance was greater than 50% different from the visual estimate.

On surveys where high abundances prevented clear observations, only species easily distinguished and/or large individuals (e.g. sharks, rays, and other large species) were estimated by visual observation. Abundances of species present in high numbers, and species of similar appearance which mingled together, were estimated based on the subsample collected by the three net samples. Abundance of species not observed but caught in the sample nets were calculated based on the subsample calculation.

If large, but no small, individuals were observed, and the net sample contained only small individuals, abundances from the two methods were combined from the visual and net sample for the total abundance.

During the final data review process, the two estimates (visual and net subsample) were compared. If the fish densities were low, usually the visual estimate provided the most reasonable abundance as fish movement sometimes allowed for higher or lower catches with the nets. For small or mingled species, net samples were utilized to generate the total abundance of the species observed for that survey if a visual percentage distribution was not possible. If abundance from the visual and net aliquot were similar, the net aliquot estimate was used for the total abundance.

Average biomass of the individuals caught in the subsample was used to calculate the biomass of the total abundance, unless individuals observed in the FRS were noted to be larger than those sub-sampled. If that occurred, then a biomass was assigned to those larger individuals based on the estimated length of the observed individuals from a length-weight table that has been generated for many of the common species observed in the FRS over the past 20 years.

6.3.3.2.1.2 Fish Chase/Heat Treatment

Estimated abundance observed during each lift of the elevator during each fish chase was summed by species. Biomass was calculated from the average weight for each species as recorded during the heat treatment, or as estimated from the approximate length of large individuals and based on a length-weight table generated during impingement sampling over the past 20 years.

6.3.4 Fish Return System Summary of Results

The following sections summarize results from the 2006-2007 fish return system sampling at SONGS. The study was designed to provide information necessary to characterize annual, seasonal, and diel variations in the return of organisms, and applied to the §316(b) Phase II regulations. Annual variation was characterized by comparison to previous return studies. Seasonal variation was characterized by analysis of return rates during the year-long study, and diel variation was characterized by analysis of daytime and nighttime return during three paired collections during 2007.

6.3.4.1 Data Summary

Twenty-six concurrent normal operation impingement and fish return system surveys were completed between March 21, 2006 and May 15, 2007 at each of the two units (Table 5.4-1). Additionally, 17 fish chase and heat treatments surveys were conducted during this period: eight at Unit 2 and nine at Unit 3 (Table 5.4-2). Data are summarized separately below for fish and invertebrate species.

6.3.4.1.1 Fish

A total of 330,309 fishes representing 78 taxa and weighing 35,312.422 kg (77,850.472 lbs) were collected and visually estimated during fish return sampling in 2006-2007. The estimated annual total abundance from fish return samples based on cooling water flow volumes in 2006-2007 was 3,416,583 individuals weighing 107,882.977 kg (237,840.969 lbs) (Table 6.3-1). Northern anchovy was the most abundant species, with an estimated annual return of 2,054,337 individuals weighing 2,034.208 kg (4,484.656 lbs). The annual return of northern anchovy represented 60.1% of the total returned abundance and 1.9% of the returned biomass. The next most abundant species in returned samples were queenfish, salema, yellowfin croaker, and Pacific sardine. Combined these taxa accounted for 91.2% of the sampled return abundance.

Unit 2 contributed 2,175,149 individuals weighing 59,929.248 kg (132,121.219 lbs) to the total, while Unit 3 contributed 1,241,434 individuals and 47,953 kg (105,719.750 lbs).

Estimated abundance from normal operation fish return was 3,328,008 individuals (97.4% of the combined return total), with 2,136,540 individuals taken at Unit 2 and 1,191,461 individuals taken at Unit 3. Estimated biomass from normal operations was 78,605.909 kg (173,256.159 lbs) (72.9% of the returned total); with 47,570.054 kg (104,873.0892 lbs) taken at Unit 2 and 31,035.855 kg (68,422.267 lbs) taken at Unit 3.

Total abundance from fish chases was 88,575 individuals (2.6% of the combined total), with 38,609 individuals taken at Unit 2 and 49,966 individuals taken at Unit 3. Biomass from fish chases was 29,277.068 kg (64,544.810 lbs) (27.1% of the returned total); with 12,359.194 kg (27,247.326 lbs) taken at Unit 2 and 16,917.874 kg (37,297.483 lbs) taken at Unit 3.

6.3.4.1.2 Shellfishes

A total of 785 macroinvertebrates representing at least 19 distinct species and weighing 184.027 kg (405.710 lbs) was collected during normal operation fish return and fish chase impingement sampling in 2006-2007. The estimated annual total return based on cooling water flow volumes in 2006-2007 was 4,703 individuals weighing 865.433 kg (1,908.280 lbs) (Table 6.3-2). The California spiny lobster was the most abundant species, with an estimated annual return of 1,847 individuals (39.3%) weighing 496.159 kg (1,094.031 lbs, 57.3%). The next most abundant species in return samples were yellowleg shrimp (*Farfantepenaeus californiensis*), sheep crab (*Loxorhynchus grandis*), Pacific rock crab and yellow crab. Combined these five species accounted for 78.9% of the sampled return abundance and 96.9% of the biomass.

Unit 2 contributed 2,032 individuals (43.2% of the total) weighing 362.216 kg (798.549 lbs, 41.9% of the biomass) to the total while Unit 3 contributed 2,671 individuals (56.8%) and 503.217 kg (1,109.593 lbs, 58.1%).

Estimated invertebrate abundance from normal operation fish return was 4,174 individuals (88.8% of the combined returned total) from 19 distinct species, with 1,680 individuals taken at Unit 2 and 2,494 individuals taken at Unit 3. Estimated biomass from normal operation fish return was 725.457 kg (1,599.357 lbs) (83.8% of the combined returned total); with 261.856 kg (577.293 lbs) taken at Unit 2 and 463.601 kg (1,022.064 lbs) taken at Unit 3.

Total invertebrate abundance from fish chases was 529 individuals (11.2% of the overall returned total), with 352 individuals taken at Unit 2 and 177 individuals taken at Unit 3. Biomass from fish chases was 139.976 kg (308.507 lbs, 16.2% of the overall returned total); with 100.360 kg (221.256 lbs) taken at Unit 2 and 39.616 kg (87.353 lbs) taken at Unit 3.

Table 6.3-1. Summary of SONGS fish returned during normal operation fish return system and fish chase surveys.

		Returned							
		Normal Operation		Fish Chase		Combined		Percent of Total	
Taxa	Common Name	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Engraulis mordax	northern anchovy	2,052,425	2,016.517	1,912	17.691	2,054,337	2,034.208	60.1	1.9
Seriphus politus	queenfish	770,027	14809.410	10,875	268.255	780,902	15,077.665	22.9	14.0
Xenistius californiensis	salema	136,134	4,611.367	5871	161.129	142,005	4,772.496	4.2	4.4
Umbrina roncador	yellowfin croaker	88,564	38462.466	9160	3249.296	97,724	41,711.762	2.9	38.7
Sardinops sagax	Pacific sardine	100,618	2620.192	87	3.307	100,705	2,623.499	2.9	2.4
Anchoa compressa	deepbody anchovy	52,094	561.554	2,237	23.825	54,331	585.379	1.6	0.5
Atherinopsis californiensis	jacksmelt	27,230	2861.566	818	61.044	28,048	2,922.610	0.8	2.7
Genyonemus lineatus	white croaker	19,534	325.759	490	9.923	20,024	335.682	0.6	0.3
Peprilus simillimus	Pacific pompano	17,505	441.936	325	8.923	17,830	450.859	0.5	0.4
Phanerodon furcatus	white seaperch	14,104	294.055	76	3.347	14,180	297.402	0.4	0.3
Hyperprosopon argenteum	walleye surfperch	10,516	294.640	185	5.275	10,701	299.915	0.3	0.3
Roncador stearnsii	spotfin croaker	5,572	2287.572	102	44.549	5,674	2332.121	0.2	2.2
Hermosilla azurea	zebraperch	28	13.300	218	144.400	246	157.700	0.0	0.1
Scomber japonicus	Pacific chub mackerel	7,757	824.905	247	29.888	8,004	854.793	0.2	0.8
Atherinops affinis	topsmelt	8,015	281.203	2,770	106.166	10,785	387.369	0.3	0.4
Anisotremus davidsonii	sargo	1,036	156.996	2017	441.038	3,053	598.034	0.1	0.6
Cymatogaster aggregata	shiner perch	5,421	72.719	1,089	19.146	6,510	91.865	0.2	0.1
Trachurus symmetricus	jack mackerel	2,254	68.992	889	53.987	3,143	122.979	0.1	0.1
Embiotoca jacksoni	black perch	1,005	68.863	177	14.164	1,182	83.027	0.0	0.1
Atractoscion nobilis	white seabass	1,052	170.986	31	3.043	1,083	174.029	0.0	0.2
Scorpaena guttata	California scorpionfish	784	56.151	179	12.925	963	69.076	0.0	0.1
Menticirrhus undulates	California corbina	728	124.684	2	0.136	730	124.820	0.0	0.1
Myliobatis californica	bat ray	727	2905.493	2	0.590	729	2906.083	0.0	2.7
Paralichthys californicus	California halibut	672	591.406	26	2.460	698	593.866	0.0	0.6
Paralabrax nebulifer	barred sand bass	224	24.430	149	22.034	373	46.464	0.0	0.0
Synodus lucioceps	California lizardfish	644	20.172	1	0.013	645	20.185	0.0	0.0
Anchoa delicatissima	slough anchovy	504	1.456	28	0.072	532	1.528	0.0	0.0
Heterostichus rostratus	giant kelpfish	336	5.652	31	0.334	367	5.986	0.0	0.0
Citharichthys stigmaeus	speckled sanddab	298	1.579	42	0.083	340	1.662	0.0	0.0
Sphyraena argentea	Pacific barracuda	238	20.482	12	0.464	250	20.946	0.0	0.0
Medialuna californiensis	halfmoon	210	30.744	5	0.654	215	31.398	0.0	0.0
Cheilotrema saturnum	black croaker	85	7.413	98	8.485	183	15.898	0.0	0.0
Porichthys myriaster	specklefin midshipman	182	31.500	4	1.185	186	32.685	0.0	0.0
Paralabrax clathratus	kelp bass	140	16.282	79	3.278	219	19.560	0.0	0.0
Gymnura marmorata	California butterfly ray	154	415.142	1	0.156	155	415.298	0.0	0.4
Pleuronichthys ritteri	spotted turbot	140	16.698	29	0.488	169	17.186	0.0	0.0
Torpedo californica	Pacific electric ray	112	2310.000	1	11.250	113	2321.250	0.0	2.2
Rhinobatos productus	shovelnose guitarfish	98	320.600	4	17.470	102	338.070	0.0	0.3
Rhacochilus toxotes	rubberlip seaperch	98	4.158	24	0.534	122	4.692	0.0	0.0
Leuresthes tenuis	California grunion	84	2.044	14	0.160	98	2.204	0.0	0.0
Porichthys notatus	plainfin midshipman	70	5.502	12	0.571	82	6.073	0.0	0.0
Amphistichus argenteus	barred surfperch	56	6.552	1	0.217	57	6.769	0.0	0.0
Ophidion scrippsae	basketweave cusk-eel	56	0.182	11	0.038	67	0.220	0.0	0.0
Squalus acanthias	spiny dogfish	56	140.000	-	-	56	140.000	0.0	0.1
Syngnathus californiensis	kelp pipefish	42	0.140	65	0.099	107	0.239	0.0	0.0
Triakis semifasciata	leopard shark	42	169.400	2	0.500	44	169.900	0.0	0.2
Platyrhinoidis triseriata	thornback	42	30.940	-	-	42	30.940	0.0	0.0
Heterodontus francisci	horn shark	28	44.800	2	5.000	30	49.800	0.0	0.0
Syngnathus sp	pipefish, unid.	28	0.084	1	0.080	29	0.164	0.0	0.0

(*table continued*)

Table 6.3-1. (Cont.). Summary of SONGS fish returned during normal operation fish return system and fish chase surveys.

		Returned						Percent of Total	
		Normal Operation		Fish Chase		Combined			
Taxa	Common Name	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Porichthys sp	midshipman, unid.	28	0.574	-	-	28	0.574	0.0	0.0
Stereolepis gigas	giant sea bass	14	0.140	12	348.000	26	348.140	0.0	0.3
Hypsypops rubicundus	garibaldi	14	4.200	11	1.930	25	6.130	0.0	0.0
Chromis punctipinnis	blacksmith	14	0.980	5	0.410	19	1.390	0.0	0.0
Hypsoblennius sp	combtooth blenny	-	-	16	0.080	16	0.080	0.0	0.0
Sebastes serriceps	treefish	14	1.680	2	0.182	16	1.862	0.0	0.0
Acanthogobius flavimanus	yellowfin goby	15	0.763	-	-	15	0.763	0.0	0.0
Leptocottus armatus	Pacific staghorn sculpin	14	0.490	1	0.030	15	0.520	0.0	0.0
Rhacochilus vacca	pile perch	14	3.500	1	0.400	15	3.900	0.0	0.0
Albula sp	Cortez bonefish	14	0.014	-	-	14	0.014	0.0	0.0
Balistes polylepis	finescale triggerfish	14	35.000	-	-	14	35.000	0.0	0.0
Brachyistius frenatus	kelp perch	14	0.280	-	-	14	0.280	0.0	0.0
Hypsoblennius gentilis	bay blenny	14	0.420	-	-	14	0.420	0.0	0.0
Ophichthidae	snake eel, unid.	14	0.700	-	-	14	0.700	0.0	0.0
Ophichthus zophochir	yellow snake eel	14	1.400	-	-	14	1.400	0.0	0.0
Pleuronichthys guttulatus	diamond turbot	14	4.340	-	-	14	4.340	0.0	0.0
Pleuronichthys verticalis	hornyhead turbot	14	2.744	-	-	14	2.744	0.0	0.0
Hypsoblennius gilberti	rockpool blenny	-	-	10	0.019	10	0.019	0.0	0.0
Urobatis halleri	round stingray	-	-	9	2.650	9	2.650	0.0	0.0
Scorpaenichthys marmoratus	cabezon	-	-	6	1.000	6	1.000	0.0	0.0
Halichoeres semicinctus	rock wrasse	-	-	5	0.330	5	0.330	0.0	0.0
Sebastes auriculatus	brown rockfish	-	-	3	0.357	3	0.357	0.0	0.0
Sebastes miniatus	vermilion rockfish	-	-	2	0.014	2	0.014	0.0	0.0
Sebastes rastrelliger	grass rockfish	-	-	2	1.030	2	1.030	0.0	0.0
Gymnothorax mordax	moray eel	-	-	1	1.200	1	1.200	0.0	0.0
Mustelus californicus	grey smoothhound	-	-	1	1.500	1	1.500	0.0	0.0
Mustelus sp	smoothhound, unid.	-	-	1	0.600	1	0.600	0.0	0.0
Oxyjulis californica	senorita	-	-	1	0.100	1	0.100	0.0	0.0
Semicossyphus pulcher	California sheephead	-	-	1	0.350	1	0.350	0.0	0.0
	Totals:	**3,328,008**	**78,605.9**	**88,575**	**29,277.1**	**3,416,583**	**107,883.0**	**100.0**	**100.0**
	No. of Taxa	**65**		**60**		**78**			

Table 6.3-2. Summary of SONGS macroinvertebrates returned during normal operation fish return system and fish chase surveys.

		Returned						Percent	
		Normal Operation		Fish Chase		Combined			
Taxa	Common Name	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Panulirus interruptus	California spiny lobster	1,400	373.502	447	122.657	1,847	496.159	39.3	57.3
Farfantep. californiensis	yellowleg shrimp	1,031	29.478	7	0.290	1,038	29.768	22.1	3.4
Loxorhynchus grandis	sheep crab	360	291.594	7	9.010	367	300.604	7.8	34.7
Cancer antennarius	Pacific rock crab	238	5.264	8	0.320	246	5.584	5.2	0.6
Cancer anthonyi	yellow crab	196	6.244	16	0.080	212	6.324	4.5	0.7
Crangon nigromaculata	blackspotted bay shrimp	168	0.504	-	-	168	0.504	3.6	0.1
Loligo opalescens	California market squid	140	4.676	1	0.040	141	4.716	3.0	0.5
Strongylocentrotus	purple sea urchin	126	0.895	-	-	126	0.658	2.7	0.1
Dendraster excentricus	Pacific sand dollar	126	0.658	-	-	126	0.895	2.7	0.1
Portunus xantusii	Xantus swimming crab	91	1.162	1	0.012	92	1.174	2.0	0.1
O. bimaculatus/bimaculoides	Calif. two-spot octopus	42	4.900	26	6.105	68	11.005	1.4	1.3
Cancer sp	cancer crab unid	42	0.980	6	0.250	48	1.230	1.0	0.1
Pugettia producta	northern kelp crab	42	0.098	1	0.010	43	0.108	0.9	0.0
Octopus rubescens	East Pacific red octopus	42	0.042	-	-	42	0.042	0.9	0.0
Cancer jordani	hairy rock crab	42	0.042	-	-	42	0.042	0.9	0.0
Caudina arenicola	sweet potatoe sea	28	2.478	-	-	28	2.478	0.6	0.3
Neotrypaea gigas	giant ghost shrimp	18	0.070	-	-	18	0.070	0.4	0.0
Strongylocentrotus	red sea urchin	14	0.014	-	-	14	2.786	0.3	0.3
Pagurus sp	hermit crab unid	14	0.070	-	-	14	0.070	0.3	0.0
Hermissenda crassicornis	hermissenda	14	2.786	-	-	14	0.014	0.3	0.0
Octopus sp	octopus unid	-	-	5	0.900	5	0.900	0.1	0.1
Petrolishthes cinctipes	flat porcelain crab			2	0.001	2	0.001	0.0	0.0
Taliepus nuttallii	globose kelp crab			1	0.300	1	0.300	0.0	0.0
Pachycheles rudis	thick claw porcelain crab	-	-	1	0.001	1	0.001	0.0	0.0
	Totals:	**4,174**	**725.457**	**529**	**139.976**	**4,703**	**865.433**	**100.0**	**100.0**
	No. of Taxa	**20**		**12**		**24**			

6.3.4.1.3 Seasonal Variation

Figures 6.3-1 and 6.3-2 present the fish return rates (based on abundance and biomass) during the 26 biweekly surveys during 2006-2007. Return abundance and biomass show nearly identical patterns, with the greatest return concentrated in the early summer (July 2006), with smaller peaks in spring 2006 (May) and 2007 (April). The large summer peak coincides with the occurrence of juvenile northern anchovy entrained in the CWIS, with the smaller peaks with increased occurrences of queenfish. Invertebrate abundance showed a bimodal return, with peaks in early summer (July 2006) and spring of 2007 (March and April) (Figure 6.3-3). Invertebrate biomass was more varied, with a tri-modal pattern; peaks occurred in spring of 2006 and 2007, and summer 2006 (Figure 6.3-4).

6.3.4.1.4 Diel Variation

Fish return abundance and biomass was greatest during nighttime at both Units 2 and 3 during the three day/night surveys (Figures 6.3-5 through 6.3-8). (Note: Disregard negative symbols with nighttime concentrations in all figures depicting diel variation). During the April 2007 survey, there was a shift to greater abundance and biomass during the daytime. At Unit 2, invertebrates were returned at slightly higher rates at night, while biomass returned was greater during the daytime (Figures 6.3-9 and 6.3-10). However, at Unit 3, return rates varied between greater in nighttime to greater in daytime, and overall, rates were similar between the two periods (Figure 6.3-11). For biomass, return rates at Unit 3 were generally greater during daytime (Figures 6.3-12).

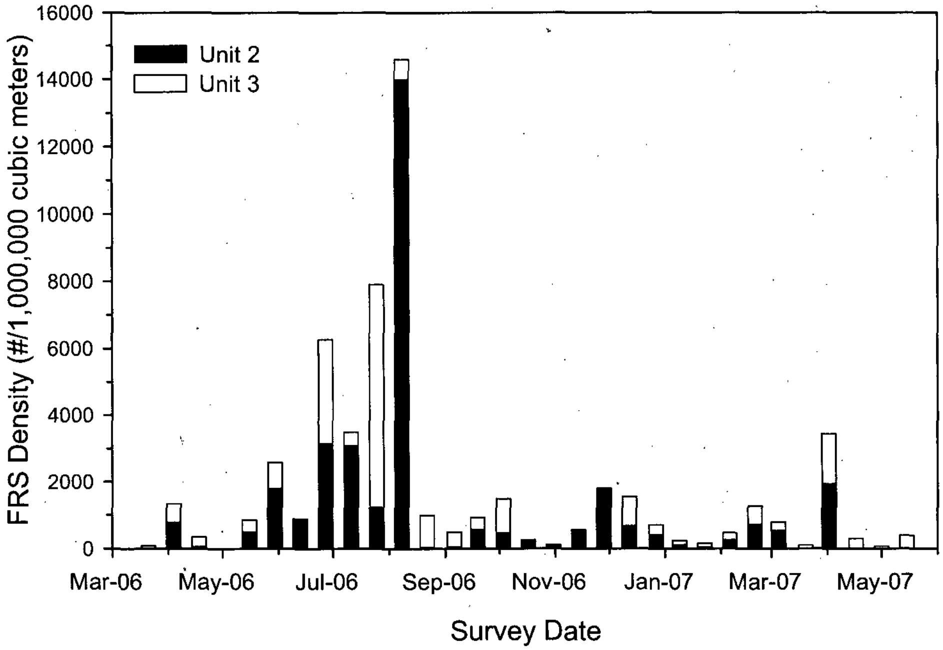


Figure 6.3-1. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of fishes returned in SONGS FRS samples during 2006-7.

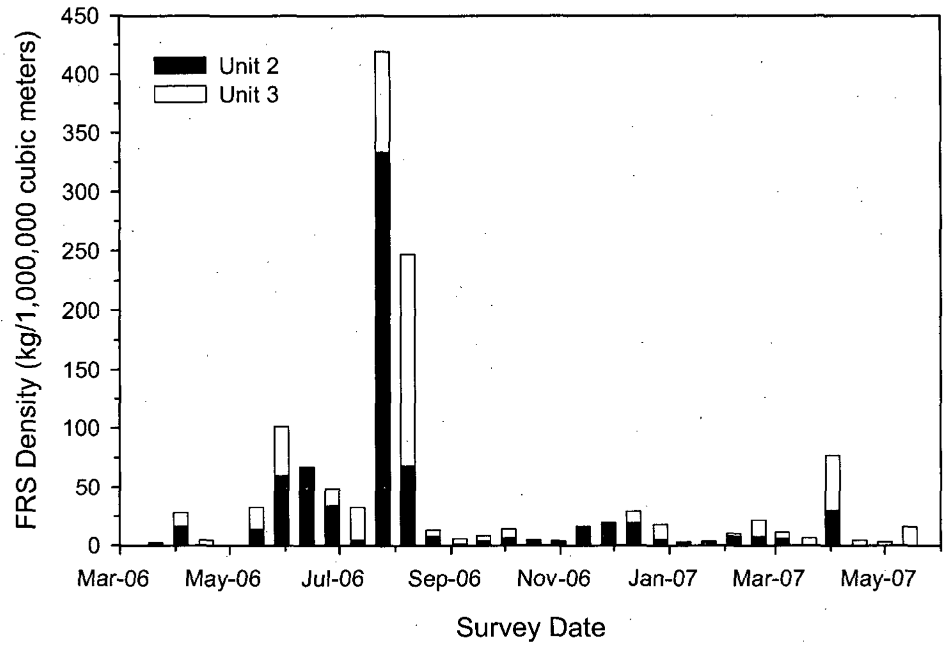


Figure 6.3-2. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of fishes returned in SONGS FRS samples during 2006-7.

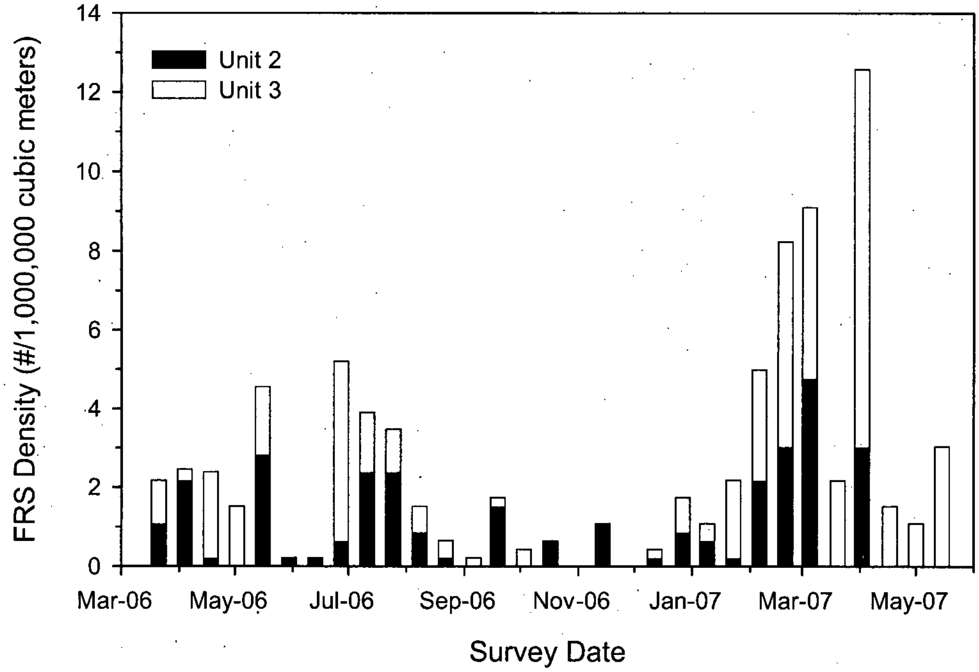


Figure 6.3-3. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of invertebrates returned in SONGS FRS samples during 2006-7.

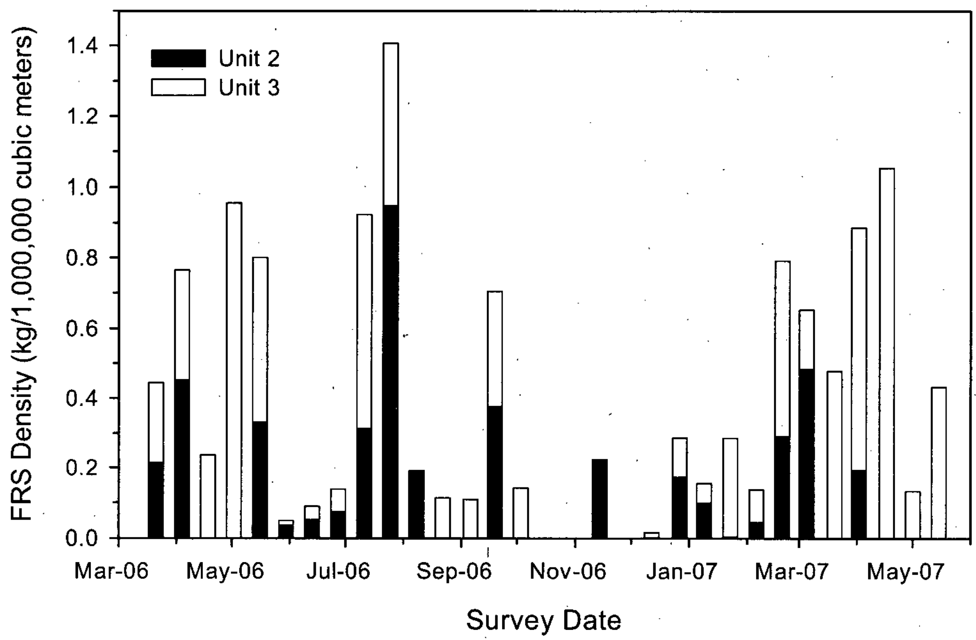


Figure 6.3-4. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of invertebrates returned in SONGS FRS samples during 2006-7.

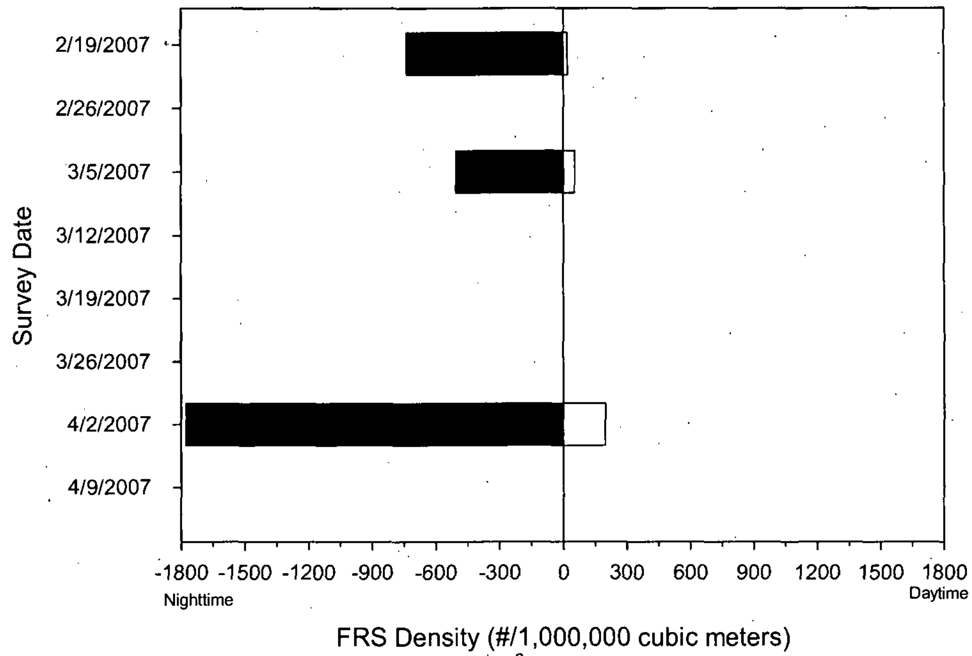


Figure 6.3-5. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of fishes collected in Unit 2 FRS samples during night and day sampling.

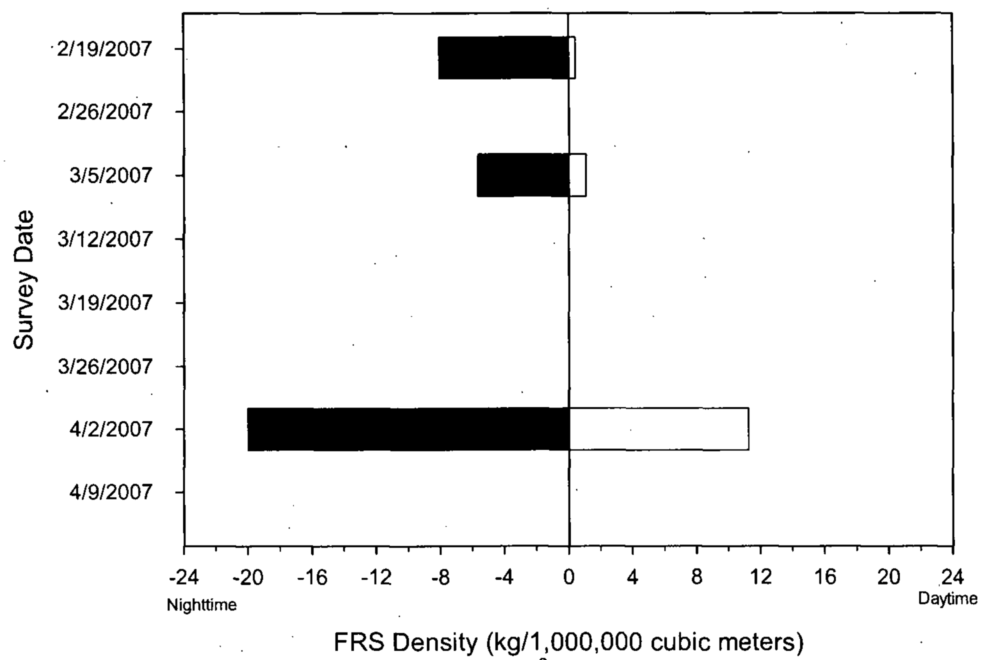


Figure 6.3-6. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of fishes collected in Unit 2 FRS samples during night and day sampling.

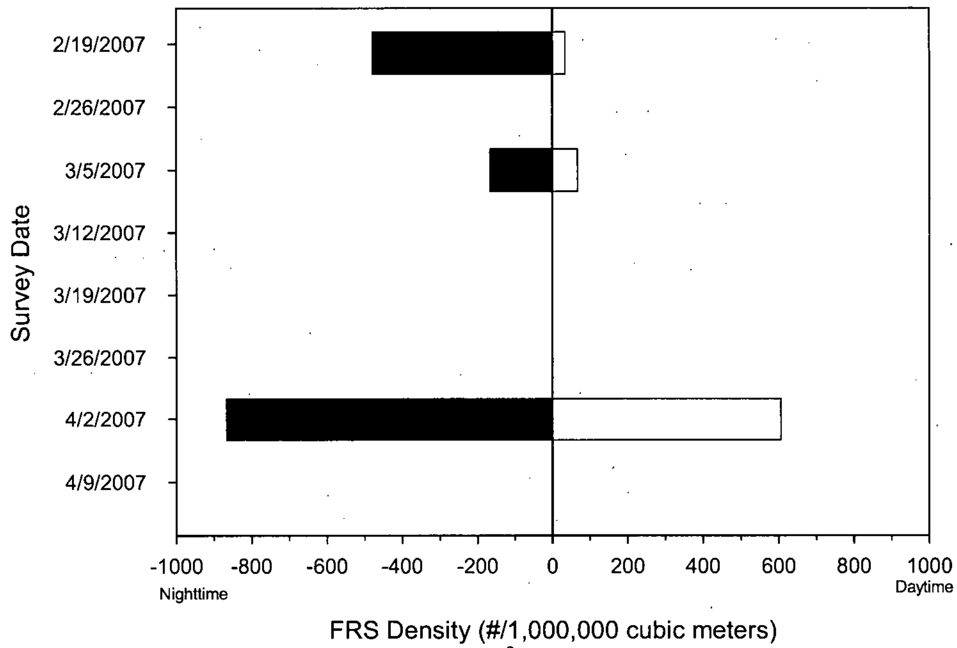


Figure 6.3-7. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of fishes collected in Unit 3 FRS samples during night and day sampling.

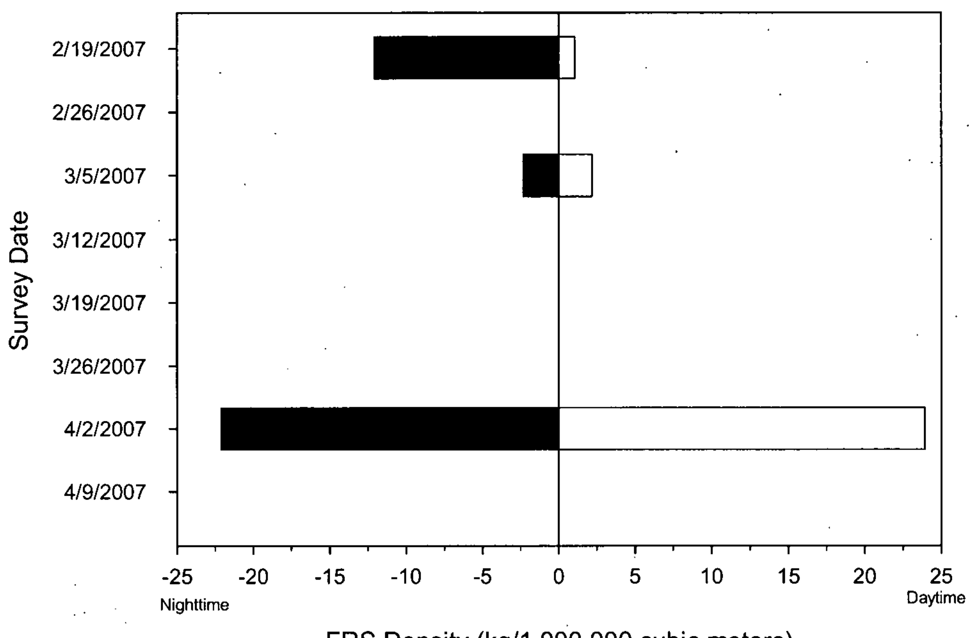


Figure 6.3-8. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of fishes collected in Unit 3 FRS samples during night and day sampling.

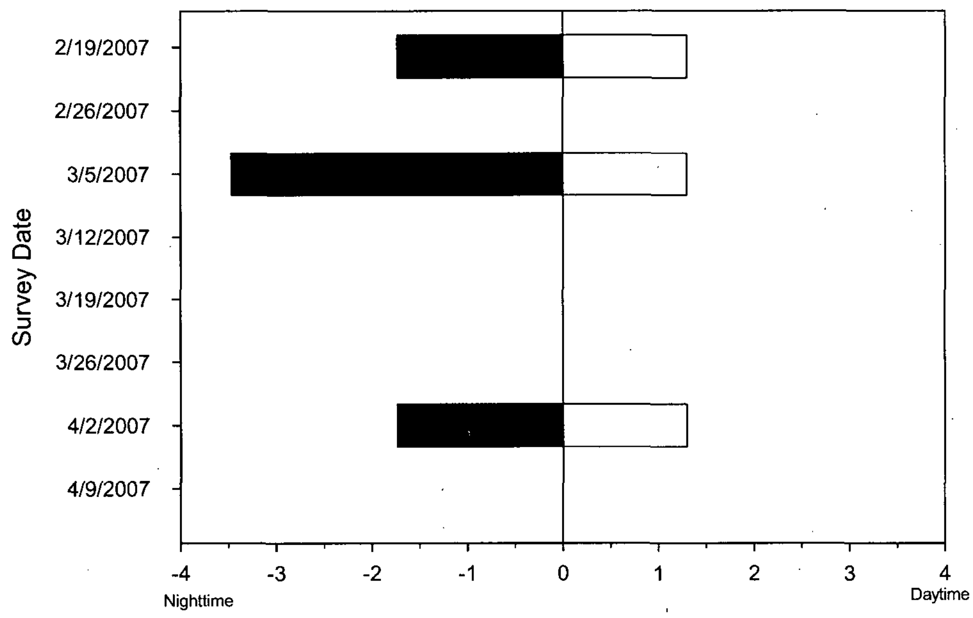


Figure 6.3-9. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of invertebrates collected in Unit 2 FRS samples during night and day sampling.

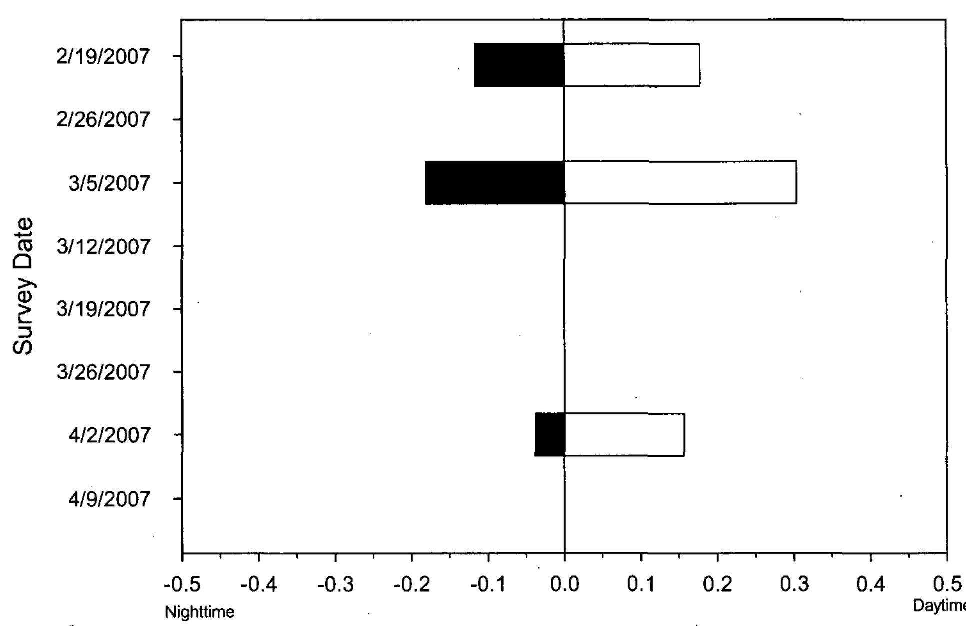


Figure 6.3-10. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of invertebrates collected in Unit 2 FRS samples during night and day sampling.

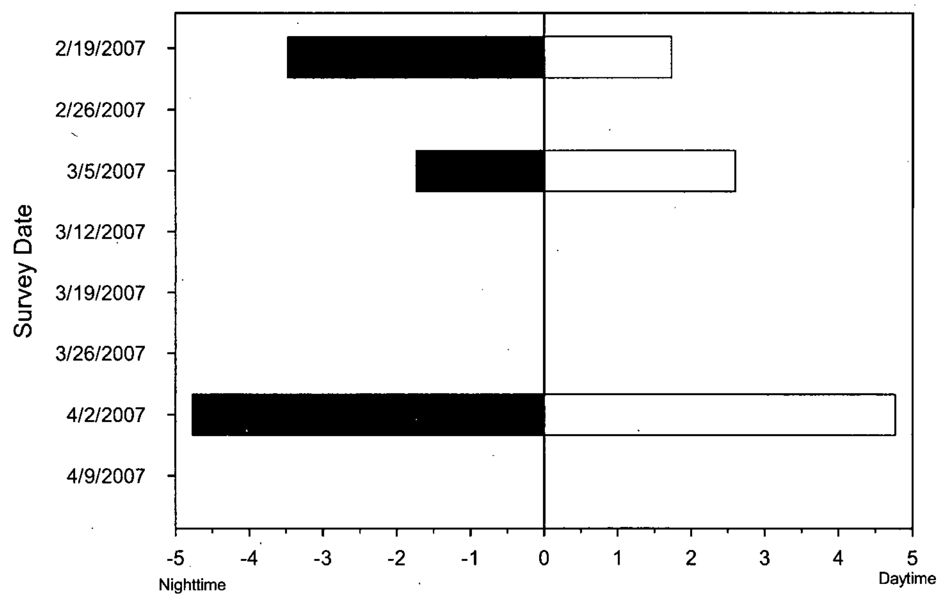


Figure 6.3-11. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of invertebrates collected in Unit 3 FRS samples during night and day sampling.

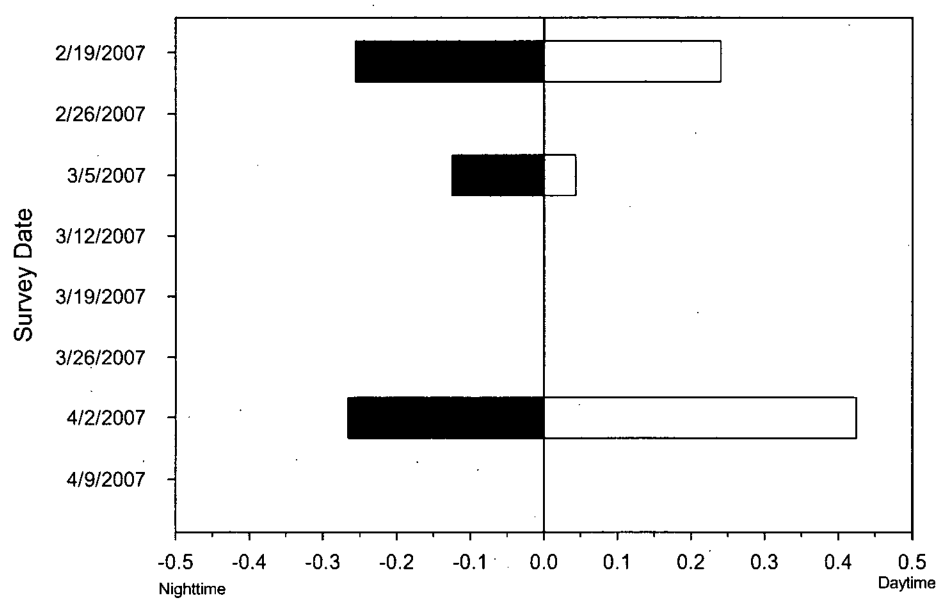


Figure 6.3-12. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of invertebrates collected in Unit 3 FRS samples during night and day sampling.

6.3.5 Fish Return System Results

The abundance and biomass of fish and target invertebrates from all survey types combined, from normal operations impingement and fish return sampling and from heat treatment and fish chase sampling, is described in the following sections.

6.3.5.1 Fish Return (All Surveys Combined)

During all survey types, an estimated 4,769,741 fish of at least 91 distinct fish species weighing an estimated 120,919.50 kg (266,581.544 lbs) was entrained by the SONGS CWIS in 2006-2007. Of these entrained fish, an estimated 1,353,158 individuals (28.4% of the total) suffered impingement mortality, and an estimated 3,416,583 individuals (71.6%) were returned via the FRS to the ocean (Table 6.3-3). The total estimated returned biomass comprised 89.2% of the entrained biomass. Northern anchovy was the most abundant species entrained, with an estimated return of 83.9% by abundance, and 85.8% return by biomass. The next four most abundant species, queenfish, Pacific sardine, salema, and yellowfin croaker had return rates by species of 52.0, 48.4, 94.4, and 93.7%, respectively. Together, these five species comprised 67.4% of the returned abundance, and 67.3% of the returned biomass.

Twenty-one species had returns of over 90% of the individuals of their respective species, but together these 21 species comprised only 5.1% of the returned abundance and 3.9% of the entrained abundance. Twenty-six species returned over 90% of their respective biomass, and together these 26 species comprised 74.8% of the returned biomass and 70.2% of the entrained biomass.

The estimated 2,175,149 fish returned at Unit 2 comprised 63.7% of the returned and 45.6% of the entrained individuals, while the estimated 1,241,434 fish returned at Unit 3 comprised 36.3% of the returned and 26.0% of the entrained individuals. The estimated returned biomass at Unit 2 (59,929.248 kg [132,121.219 lbs]) was 55.6% of the returned and 49.6 of the entrained biomass while Unit 3 (47,953. kg [105,719.750 lbs]) contributed 44.4% of the returned and 39.7% of the entrained biomass.

6.3.5.2 Shellfish Return (All Surveys Combined)

During all survey types, an estimated 122,561 macroinvertebrates representing at least 81 distinct species and weighing 2,174.10 kg (4,793.021 lbs) was entrained by the SONGS CWIS in 2006-2007. Of these entrained invertebrates, an estimated 117,858 individuals (96.2% of the total) suffered impingement mortality, and an estimated 4,703 individuals (3.8%) were returned via the FRS to the ocean (Table 6.3-4).

The California spiny lobster had an estimated 3,998 individuals weighing 965.346 kg (2,128.202 lbs) entrained, with an estimated annual return of 1,847 individuals (46.2% of the entrained total) weighing 496.159 kg (1,094.031 lbs, 51.4%). The six rock crab species had an estimated entrained abundance of 49,824 individuals with a biomass of 187.414 kg (413.173 lbs). There were 548 individuals (1.1% of the entrained total) weighing 13.180 kg (29.057 lbs) returned (7.6% of the entrained biomass).

Table 6.3-3. Summary of fish returned at SONGS during all survey types.

Taxa	Common Name	Total Impinged		Total Returned		Total Entrained		Percent Returned	
		No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Engraulis mordax	northern anchovy	396,074	340.696	2,061,541	2,059.412	2,457,615	2,400.108	83.9	85.8
Seriphus politus	queenfish	712,937	3,599.594	773,500	14,869.188	1,486,437	18,468.782	52.0	80.5
Sardinops sagax	Pacific sardine	107,466	1,274.321	100,651	2,621.709	208,117	3,896.030	48.4	67.3
Xenistius californiensis	salema	8,310	1,81.612	139,541	4,741.214	147,851	4,922.826	94.4	96.3
Umbrina roncador	yellowfin croaker	9,258	3,287.250	138,343	57,136.695	147,601	60,423.945	93.7	94.6
Anchoa compressa	deepbody anchovy	23,504	192.052	52,114	561.664	75,618	753.716	68.9	74.5
Phanerodon furcatus	white seaperch	18,724	67.341	14132	296.717	32,856	364.058	43.0	81.5
Atherinopsis californiensis	jacksmelt	4,038	299.779	27,377	2,873.286	31,415	3,173.065	87.1	90.6
Genyonemus lineatus	white croaker	9,557	68.460	19,572	327.317	29,129	395.777	67.2	82.7
Peprilus simillimus	Pacific pompano	5,067	118.933	17,532	442.654	22,599	561.587	77.6	78.8
Atherinops affinis	topsmelt	10,556	313.748	8,061	283.047	18,617	596.795	43.3	47.4
Cymatogaster aggregata	shiner perch	7,641	50.100	5422	72.749	13,063	122.849	41.5	59.2
Hyperprosopon argenteum	walleye surfperch	675	11.014	10,544	295.646	11,219	306.660	94.0	96.4
Roncador stearnsii	spotfin croaker	130	55.483	10,534	4502.093	10,664	4,557.576	98.8	98.8
Scomber japonicus	Pacific chub mackerel	1,747	178.887	8,416	909.228	10,163	1,088.115	82.8	83.6
Hermosilla azurea	zebraperch	218	144.400	9442	6248.840	9,660	6,393.240	97.7	97.7
Anchoa delicatissima	slough anchovy	8,543	23.710	504	1.456	9,047	25.166	5.6	5.8
Anisotremus davidsonii	sargo	2,087	447.632	6386	1216.051	8,473	1,663.683	75.4	73.1
Syngnathus californiensis	kelp pipefish	6,639	11.802	45	0.150	6,684	11.952	0.7	1.3
Trachurus symmetricus	jack mackerel	1,477	67.903	3,103	124.967	4,580	192.870	67.8	64.8
Hypsoblennius gilberti	rockpool blenny	2,747	10.215	10	0.019	2,757	10.234	0.4	0.2
Porichthys notatus	plainfin midshipman	2,683	78.459	71	5.587	2,754	84.046	2.6	6.6
Embiotoca jacksoni	black perch	1149	18.283	1,241	95.521	2,390	113.804	51.9	83.9
Synodus lucioceps	California lizardfish	1652	33.461	647	20.382	2299	53.843	28.1	37.9
Sphyraena argentea	Pacific barracuda	1874	14.618	239	21.232	2113	35.850	11.3	59.2
Scorpaena guttata	California scorpionfish	956	46.582	951	71.632	1907	118.214	49.9	60.6
Porichthys myriaster	specklefin midshipman	1336	77.804	189	32.834	1525	110.638	12.4	29.7
Atractoscion nobilis	white seabass	115	4.989	1,081	175.450	1196	180.439	90.4	97.2
Heterostichus rostratus	giant kelpfish	774	9.059	347	5.867	1121	14.926	31.0	39.3
Myliobatis californica	bat ray	289	135.156	729	2962.493	1018	3,097.649	71.6	95.6
Citharichthys stigmaeus	speckled sanddab	616	5.347	298	1.579	914	6.926	32.6	22.8
Paralabrax nebulifer	barred sand bass	177	24.877	657	108.506	834	133.383	78.8	81.3
Paralichthys californicus	California halibut	152	13.912	678	592.007	830	605.919	81.7	97.7
Menticirrhus undulatus	California corbina	16	6.576	748	129.764	764	136.340	97.9	95.2
Pleuronichthys ritteri	spotted turbot	483	11.049	140	16.698	623	27.747	22.5	60.2
Syngnathus sp	pipefish unid.	375	0.441	29	0.164	404	0.605	7.2	27.1
Leuresthes tenuis	California grunion	310	6.072	84	2.044	394	8.116	21.3	25.2
Scorpaenichthys marmoratus	cabezon	382	3.458	6	1.000	388	4.458	1.5	22.4
Paralabrax clathratus	kelp bass	177	3.698	187	24.377	364	28.075	51.4	86.8
Cheilotrema saturnum	black croaker	126	10.053	199	17.508	325	27.561	61.2	63.5
Torpedo californica	Pacific electric ray	184	1490.111	117	2400.000	301	3,890.111	38.9	61.7
Pleuronichthys verticalis	hornyhead turbot	269	16.052	14	2.744	283	18.796	4.9	14.6
Rhacochilus toxotes	rubberlip seaperch	178	2.018	98	4.158	276	6.176	35.5	67.3
Medialuna californiensis	halfmoon	5	0.654	220	32.488	225	33.142	97.8	98.0
Ophidion scrippsae	basketweave cusk-eel	137	4.447	56	0.182	193	4.629	29.0	3.9
Gibbonsia elegans	spotted kelpfish	156	1.904	-	-	156	1.904	0.0	0.0
Gymnura marmorata	California butterfly ray	1	0.156	155	415.892	156	416.048	99.4	100.0
Micrometrus minimus	dwarf perch	134	0.256	-	-	134	0.256	0.0	0.0
Oxyjulis californica	senorita	133	3.067	1	0.100	134	3.167	0.7	3.2
Platyrhinoidis triseriata	thornback	84	26.488	42	30.940	126	57.428	33.3	53.9
Hypsypops rubicundus	garibaldi	99	2.487	25	6.130	124	8.617	20.2	71.1

(table continued)

Table 6.3-3. (Cont.). Summary of fish returned at SONGS during all survey types.

Taxa	Common Name	Total Impinged No.	Total Impinged Wt. (kg)	Total Returned No.	Total Returned Wt. (kg)	Total Entrained No.	Total Entrained Wt. (kg)	Percent Returned No.	Percent Returned Wt. (kg)
Rhinobatos productus	shovelnose guitarfish	18	18.394	103	347.600	121	365.994	85.1	95.0
Hypsoblennius jenkinsi	mussel blenny	103	0.477	-	-	103	0.477	0.0	0.0
Sebastes paucispinis	bocaccio	98	0.279	-	-	98	0.279	0.0	0.0
Heterodontus francisci	horn shark	44	54.076	30	49.800	74	103.876	40.5	47.9
Gymnothorax mordax	moray eel	70	25.354	1	1.200	71	26.554	1.4	4.5
Squalus acanthias	spiny dogfish	14	30.800	56	140.000	70	170.800	80.0	82.0
Amphistichus argenteus	barred surfperch	1	0.217	58	6.882	59	7.099	98.3	96.9
Syngnathus exilis	barcheek pipefish	58	0.115	-	-	58	0.115	0.0	0.0
Pleuronichthys guttulatus	diamond turbot	42	7.532	14	4.340	56	11.872	25.0	36.6
Triakis semifasciata	leopard shark	-	-	44	169.900	44	169.900	100.0	100.0
Ophichthus zophochir	yellow snake eel	28	2.883	14	1.400	42	4.283	33.3	32.7
Chromis punctipinnis	blacksmith	23	1.017	19	1.390	42	2.407	45.2	57.7
Halichoeres semicinctus	rock wrasse	33	3.114	5	0.330	38	3.444	13.2	9.6
Brachyistius frenatus	kelp perch	20	0.255	14	0.280	34	0.535	41.2	52.3
Urobatis halleri	round stingray	20	4.278	9	2.650	29	6.928	31.0	38.3
Porichthys sp	midshipman, unid.	-	-	28	0.574	28	0.574	100.0	100.0
Syngnathus leptorhynchus	bay pipefish	27	0.032	-	-	27	0.032	0.0	0.0
Stereolepis gigas	giant sea bass	1	65.000	26	348.140	27	413.140	96.3	84.3
Sebastes auriculatus	brown rockfish	17	1.503	3	0.357	20	1.860	15.0	19.2
Sebastes serriceps	treefish	2	0.128	16	1.862	18	1.990	88.9	93.6
Rhacochilus vacca	pile perch	2	0.316	15	3.900	17	4.216	88.2	92.5
Leptocottus armatus	Pacific staghorn sculpin	1	0.021	15	0.520	16	0.541	93.8	96.1
Hypsoblennius sp	combtooth blenny, unid.	-	-	16	0.080	16	0.080	100.0	100.0
Artedius corallinus	coralline sculpin	15	0.061	-	-	15	0.061	0.0	0.0
Orthonopias triacis	snubnose sculpin	15	0.015	-	-	15	0.015	0.0	0.0
Pleuronichthys coenosus	C-O sole	15	0.017	-	-	15	0.017	0.0	0.0
Mustelus californicus	grey smoothhound	14	7.938	1	1.500	15	9.438	6.7	15.9
Acanthogobius flavimanus	yellowfin goby	-	-	15	0.763	15	0.763	100.0	100.0
Cephaloscyllium ventriosum	swell shark	14	13.188	-	-	14	13.188	0.0	0.0
Xystreurys liolepis	fantail sole	14	1.022	-	-	14	1.022	0.0	0.0
Albula sp	Cortez bonefish	-	-	14	0.014	14	0.014	100.0	100.0
Balistes polylepis	finescale triggerfish	-	-	14	35.000	14	35.000	100.0	100.0
Hypsoblennius gentiles	bay blenny	-	-	14	0.420	14	0.420	100.0	100.0
Ophichthidae	snake eel	-	-	14	0.700	14	0.700	100.0	100.0
Paralabrax maculatofasciatus	spotted sand bass	6	0.198	-	-	6	0.198	0.0	0.0
Sebastes miniatus	vermilion rockfish	4	0.018	2	0.014	6	0.032	33.3	43.8
Gibbonsia metzi	striped kelpfish	5	0.082	-	-	5	0.082	0.0	0.0
Sebastes rastrelliger	grass rockfish	3	0.601	2	1.030	5	1.631	40.0	63.2
Symphurus atricaudus	California tonguefish	3	0.004	-	-	3	0.004	0.0	0.0
Hyperprosopon anale	spotfin surfperch	2	0.044	-	-	2	0.044	0.0	0.0
Sebastes sp	rockfish, unid.	2	0.372	-	-	2	0.372	0.0	0.0
Semicossyphus pulcher	California sheephead	1	0.455	1	0.350	2	0.805	50.0	43.5
Cottidae sp	sculpin, unid.	1	0.003	-	-	1	0.003	0.0	0.0
Lepidogobius lepidus	bay goby	1	0.001	-	-	1	0.001	0.0	0.0
Ophididae	cusk-eel, unid.	1	0.096	-	-	1	0.096	0.0	0.0
Pleuronichthys decurrens	curlfin sole	1	0.011	-	-	1	0.011	0.0	0.0
Rathbunella alleni	stripefin ronquil	1	0.007	-	-	1	0.007	0.0	0.0
Sebastes atrovirens	kelp rockfish	1	0.131	-	-	1	0.131	0.0	0.0
Mustelus sp	smoothhound, unid.	-	-	1	0.600	1	0.600	100.0	100.0
	Totals:	**1,353,158**	**13,036.5**	**3,416,583**	**107,883.0**	**4,769,741**	**120,919.5**	**71.6**	**89.2**
	No. of Taxa	**91**		**78**		**100**			

Table 6.3-4. Summary of macroinvertebrates returned at SONGS during all survey types.

Taxa	Common Name	Total Impinged No.	Total Impinged Wt. (kg)	Total Returned No.	Total Returned Wt. (kg)	Total Entrained No.	Total Entrained Wt. (kg)	Percent Returned No.	Percent Returned Wt. (kg)
Cancer anthonyi	yellow crab	22,781	76.121	212	6.324	22,993	82.445	0.9	7.7
Cancer jordani	hairy rock crab	11,888	23.312	42	0.042	11,930	23.354	0.4	0.2
Cancer antennarius	brown rock crab	8,356	65.919	246	5.584	8,602	71.503	2.9	7.8
Cancer sp	cancer crab, unid.	4,576	3.712	48	1.230	4,624	4.942	1.0	24.9
Panulirus interruptus	California spiny lobster	2,151	469.187	1,847	496.159	3,998	965.346	46.2	51.4
Cancer gracilis	graceful crab	1,071	3.395	-	-	1,071	3.395	0.0	0.0
Cancer productus	red rock crab	453	1.548	-	-	453	1.548	0.0	0.0
Cancer amphioetus	bigtooth rock crab	151	0.227	-	-	151	0.227	0.0	0.0
	Total for 8 Taxa Analyzed	**51,427**	**643.421**	**2,395**	**509.339**	**53,822**	**1,152.760**	**4.4**	**44.2**
	No. of Taxa:	**8**		**5**		**8**			
	Total All Taxa:	**117,858**	**1,308.67**	**4,703**	**865.43**	**122,561**	**2,174.10**	**3.8**	**39.8**
	Number of Taxa:	**95**		**24**		**96**			

6.3.5.3 Normal Operation Fish Return System Summary

6.3.5.3.1 Fish

During normal operations impingement and fish return surveys, an estimated 4,638,767 fish of at least 79 distinct fish species weighing an estimated 86,802.03kg (191,311.679 lbs) was entrained by the SONGS CWIS in 2006-2007 (Table 6.3-5). Of these entrained fish, an estimated 1,310,759 individuals (28.3% of the total) suffered impingement mortality, and an estimated 3,328,008 individuals (71.7%) were returned via the FRS to the ocean (Table 6.3-4). The total estimated returned biomass comprised 90.6% of the entrained biomass. Northern anchovy was the most abundant species entrained and returned, with an estimated return of 83.9% by abundance, and 86.2% return by biomass. The next four most abundant species, returned, queenfish, Pacific sardine, salema, and yellowfin croaker had return rates by species of 52.3, 48.4, 98.2, and 99.9%, respectively. Together, these five species comprised 67.9% of the returned abundance, and 72.0% of the returned biomass.

Twenty-three species had returns of over 90% of the individuals of their respective species, but together these 23 species comprised only 7.3% of the returned abundance and 5.3% of the entrained abundance. Twenty-eight species returned over 90% of their respective biomass, and together these 28 species comprised 68.4% of the returned biomass and 61.9% of the entrained biomass.

The estimated 2,175,149 fish returned at Unit 2 comprised 63.7% of the returned and 45.6% of the entrained individuals, while the estimated 1,241,434 fish returned at Unit 3 comprised 36.3% of the returned and 26.0% of the entrained individuals. The estimated returned biomass at Unit 2 (59,929.248 kg [132,121.219 lbs]) was 55.6% of the returned and 49.6 of the entrained biomass while Unit 3 (47,953. kg [105,719.750 lbs]) contributed 44.4% of the returned and 39.7% of the entrained biomass.

6.3.5.3.2 Shellfishes

During normal operations impingement and fish return surveys, only four distinct species were observed in the return system. The entrained abundance for these species combined was 28,751 individuals (32.2% of the entrained total for these taxa), weighing 926.431 kg (2,042.780 lbs, 49.1% of the entrained total) (Table 6.3-6).

Three distinct species of rock crabs (and unidentified individuals from the FRS) returned 518 individuals (2.0% of the species total) weighing 12.530 kg (27.616 lbs, 9.8% of the species biomass). California spiny lobster returned an estimated 1,400 individuals weighing 373.502 kg (823.198 lbs, 46.7% of the species biomass.). Unit 2 contributed 41.1% (966 individuals) of the total target invertebrate return abundance and 37.5% of the biomass (189.546 kg [417.759 lbs]), while Unit 3 contributed 40.5% (952 individuals) and 38.9% (196.486 kg [433.055 lbs]), respectively.

6.3.5.4 Impingement and Return Rates

Comparing impingement and return rates of abundance at both Units 2 and 3 during individual surveys, the rates of return are much higher than impingement rates (Figures 6.3-13 and Figures 6.3-14, with both units showing very similar patterns of return. Biomass shows a similar pattern between the two units, but the return biomass rates are relatively greater than that seen for abundance (Figures 6.3-15 and Figures 6.3-16.

Table 6.3-5. Summary of fish returned at SONGS during normal operations.

Taxa	Common Name	Total Impinged		Total Returned		Total Entrained		Percent Returned	
		No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Engraulis mordax	northern anchovy	394,162	323.005	2,052,425	2016.517	2,446,587	2,339.522	83.9	86.2
Seriphus politus	queenfish	702,062	3331.339	770,027	14809.410	1,472,089	18,140.749	52.3	81.6
Sardinops sagax	Pacific sardine	107,379	1,271.014	100618	2620.192	207,997	3,891.206	48.4	67.3
Xenistius californiensis	salema	2,439	20.483	136134	4611.367	138,573	4,631.850	98.2	99.6
Umbrina roncador	yellowfin croaker	98	37.954	88564	38462.466	88,662	38,500.420	99.9	99.9
Anchoa compressa	deepbody anchovy	21,267	168.227	52,094	561.554	73,361	729.781	71.0	76.9
Phanerodon furcatus	white seaperch	18,648	63.994	14104	294.055	32,752	358.049	43.1	82.1
Atherinopsis californiensis	jacksmelt	3,220	238.735	27,230	2,861.566	30,450	3,100.301	89.4	92.3
Genyonemus lineatus	white croaker	9,067	58.537	19534	325.759	28,601	384.296	68.3	84.8
Peprilus simillimus	Pacific pompano	4,742	110.010	17,505	441.936	22,247	551.946	78.7	80.1
Atherinops affinis	topsmelt	7,786	207.582	8,015	281.203	15,801	488.785	50.7	57.5
Cymatogaster aggregata	shiner perch	6,552	30.954	5421	72.719	11,973	103.673	45.3	70.1
Hyperprosopon argenteum	walleye surfperch	490	5.739	10516	294.640	11,006	300.379	95.5	98.1
Scomber japonicus	Pacific chub mackerel	1,500	148.999	7757	824.905	9,257	973.904	83.8	84.7
Anchoa delicatissima	slough anchovy	8,515	23.638	504	1.456	9,019	25.094	5.6	5.8
Syngnathus californiensis	kelp pipefish	6,574	11.703	42	0.140	6,616	11.843	0.6	1.2
Roncador stearnsii	spotfin croaker	28	10.934	5,572	2287.572	5,600	2298.506	99.5	99.5
Trachurus symmetricus	jack mackerel	588	13.916	2254	68.992	2,842	82.908	79.3	83.2
Porichthys notatus	plainfin midshipman	2,671	77.888	70	5.502	2,741	83.390	2.6	6.6
Synodus lucioceps	California lizardfish	1,651	33.448	644	20.172	2,295	53.620	28.1	37.6
Sphyraena argentea	Pacific barracuda	1,862	14.154	238	20.482	2,100	34.636	11.3	59.1
Embiotoca jacksoni	black perch	972	4.119	1005	68.863	1,977	72.982	50.8	94.4
Scorpaena guttata	California scorpionfish	777	33.657	784	56.151	1,561	89.808	50.2	62.5
Porichthys myriaster	specklefin midshipman	1332	76.619	182	31.500	1514	108.119	12.0	29.1
Atractoscion nobilis	white seabass	84	1.946	1052	170.986	1136	172.932	92.6	98.9
Anisotremus davidsonii	sargo	70	6.594	1036	156.996	1106	163.590	93.7	96.0
Hypsoblennius gilberti	rockpool blenny	1100	4.918	-	-	1100	4.918	0.0	0.0
Heterostichus rostratus	giant kelpfish	743	8.725	336	5.652	1079	14.377	31.1	39.3
Myliobatis californica	bat ray	287	134.566	727	2905.493	1014	3040.059	71.7	95.6
Citharichthys stigmaeus	speckled sanddab	574	5.264	298	1.579	872	6.843	34.2	23.1
Paralichthys californicus	California halibut	126	11.452	672	591.406	798	602.858	84.2	98.1
Menticirrhus undulatus	California corbina	14	6.440	728	124.684	742	131.124	98.1	95.1
Pleuronichthys ritteri	spotted turbot	454	10.561	140	16.698	594	27.259	23.6	61.3
Syngnathus sp	pipefish, unid.	364	0.420	28	0.084	392	0.504	7.1	16.7
Leuresthes tenuis	California grunion	296	5.912	84	2.044	380	7.956	22.1	25.7
Torpedo californica	Pacific electric ray	183	1478.861	112	2310.000	295	3788.861	38.0	61.0
Pleuronichthys verticalis	hornyhead turbot	268	16.031	14	2.744	282	18.775	5.0	14.6
Paralabrax nebulifer	barred sand bass	28	2.843	224	24.430	252	27.273	88.9	89.6
Rhacochilus toxotes	rubberlip seaperch	154	1.484	98	4.158	252	5.642	38.9	73.7
Paralabrax clathratus	kelp bass	98	0.420	140	16.282	238	16.702	58.8	97.5
Medialuna californiensis	halfmoon	-	-	210	30.744	210	30.744	100.0	100.0
Scorpaenichthys marmoratus	cabezon	198	0.718	-	-	198	0.718	0.0	0.0
Ophidion scrippsae	basketweave cusk-eel	126	4.409	56	0.182	182	4.591	30.8	4.0
Gymnura marmorata	California butterfly ray	-	-	154	415.142	154	415.142	100.0	100.0
Gibbonsia elegans	spotted kelpfish	140	1.791	-	-	140	1.791	0.0	0.0
Micrometrus minimus	dwarf perch	126	0.210	-	-	126	0.210	0.0	0.0
Oxyjulis californica	senorita	126	2.996	-	-	126	2.996	0.0	0.0
Platyrhinoidis triseriata	thornback	84	26.488	42	30.940	126	57.428	33.3	53.9
Cheilotrema saturnum	black croaker	28	1.568	85	7.413	113	8.981	75.2	82.5
Hypsypops rubicundus	garibaldi	98	2.478	14	4.200	112	6.678	12.5	62.9
Rhinobatos productus	shovelnose guitarfish	14	0.924	98	320.600	112	321.524	87.5	99.7

(table continued)

Table 6.3-5. (Cont.). Summary of fish returned at SONGS during normal operations.

Taxa	Common Name	Total Impinged No.	Total Impinged Wt. (kg)	Total Returned No.	Total Returned Wt. (kg)	Total Entrained No.	Total Entrained Wt. (kg)	Percent Returned No.	Percent Returned Wt. (kg)
Hypsoblennius jenkinsi	mussel blenny	103	0.477	-	-	103	0.477	0.0	0.0
Sebastes paucispinis	bocaccio	98	0.279	-	-	98	0.279	0.0	0.0
Heterodontus francisci	horn shark	42	49.896	28	44.800	70	94.696	40.0	47.3
Gymnothorax mordax	moray eel	70	25.354	-	-	70	25.354	0.0	0.0
Squalus acanthias	spiny dogfish	14	30.800	56	140.000	70	170.800	80.0	82.0
Amphistichus argenteus	barred surfperch	-	-	56	6.552	56	6.552	100.0	100.0
Syngnathus exilis	barcheek pipefish	56	0.112	-	-	56	0.112	0.0	0.0
Pleuronichthys guttulatus	diamond turbot	42	7.532	14	4.340	56	11.872	25.0	36.6
Triakis semifasciata	leopard shark	-	-	42	169.400	42	169.400	100.0	100.0
Ophichthus zophochir	yellow snake eel	28	2.883	14	1.400	42	4.283	33.3	32.7
Hermosilla azurea	zebraperch	-	-	28	13.300	28	13.300	100.0	100.0
Brachyistius frenatus	kelp perch	14	0.084	14	0.280	28	0.364	50.0	76.9
Porichthys sp	midshipman, unid.	-	-	28	0.574	28	0.574	100.0	100.0
Orthonopias triacis	snubnose sculpin	15	0.015	-	-	15	0.015	0.0	0.0
Acanthogobius flavimanus	yellowfin goby	-	-	15	0.763	15	0.763	100.0	100.0
Chromis punctipinnis	blacksmith	-	-	14	0.980	14	0.980	100.0	100.0
Halichoeres semicinctus	rock wrasse	14	0.980	-	-	14	0.980	0.0	0.0
Urobatis halleri	round stingray	14	0.812	-	-	14	0.812	0.0	0.0
Syngnathus leptorhynchus	bay pipefish	14	0.014	-	-	14	0.014	0.0	0.0
Stereolepis gigas	giant sea bass	-	-	14	0.140	14	0.140	100.0	100.0
Sebastes serriceps	treefish	-	-	14	1.680	14	1.680	100.0	100.0
Rhacochilus vacca	pile perch	-	-	14	3.500	14	3.500	100.0	100.0
Leptocottus armatus	Pacific staghorn sculpin	-	-	14	0.490	14	0.490	100.0	100.0
Artedius corallinus	coralline sculpin	14	0.056	-	-	14	0.056	0.0	0.0
Pleuronichthys coenosus	C-O sole	14	0.014	-	-	14	0.014	0.0	0.0
Mustelus californicus	grey smoothhound	14	7.938	-	-	14	7.938	0.0	0.0
Cephaloscyllium ventriosum	swell shark	14	13.188	-	-	14	13.188	0.0	0.0
Xystreurys liolepis	fantail sole	14	1.022	-	-	14	1.022	0.0	0.0
Albula sp	Cortez bonefish	-	-	14	0.014	14	0.014	100.0	100.0
Balistes polylepis	finescale triggerfish	-	-	14	35.000	14	35.000	100.0	100.0
Hypsoblennius gentilis	bay blenny	-	-	14	0.420	14	0.420	100.0	100.0
Ophichthidae	snake eel	-	-	14	0.700	14	0.700	100.0	100.0
	Totals:	**1,310,75**	**8,196.1**	**3,328,00**	**78,605.9**	**4,638,76**	**86,802.0**	**71.7**	**90.6**
	No. of Taxa:	**67**		**65**		**83**			

Table 6.3-6. Summary of macroinvertebrates returned at SONGS during normal operations.

Taxa	Common Name	Total Impinged No.	Total Impinged Wt. (kg)	Total Returned No.	Total Returned Wt. (kg)	Total Entrained No.	Total Entrained Wt. (kg)	Percent Returned No.	Percent Returned Wt. (kg)
Cancer anthonyi	yellow crab	13,469	50.751	196	6.244	13,665	56.995	1.4	11.0
Cancer jordani	hairy rock crab	7,716	15.957	42	0.042	7,758	15.999	0.5	0.3
Cancer antennarius	brown rock crab	3,672	48.044	238	5.264	3,910	53.308	6.1	9.9
Panulirus interruptus	California spiny lobster	1,976	425.647	1,400	373.502	3,376	799.149	41.5	46.7
Cancer sp	cancer crab, unid.	-	-	42	0.980	42	0.980	100.0	100.0
	Total for 5 Taxa Analyzed:	**26,833**	**540.399**	**1,918**	**386.032**	**28,751**	**926.431**	**6.7**	**41.7**
	No. of Taxa:	**4**		**5**		**5**			
	Total All Taxa:	**83,393**	**1,159.67**	**4,174**	**725.457**	**87,567**	**1,885.13**	**4.8**	**38.5**

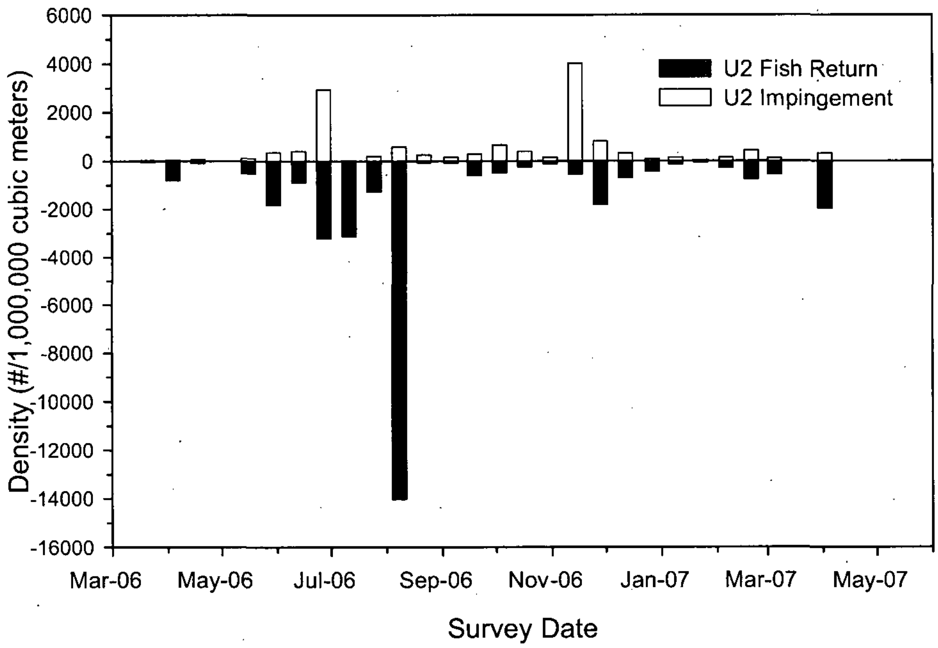


Figure 6.3-13. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of fishes in SONGS Unit 2 FRS and normal operation impingement samples, 2006-7.

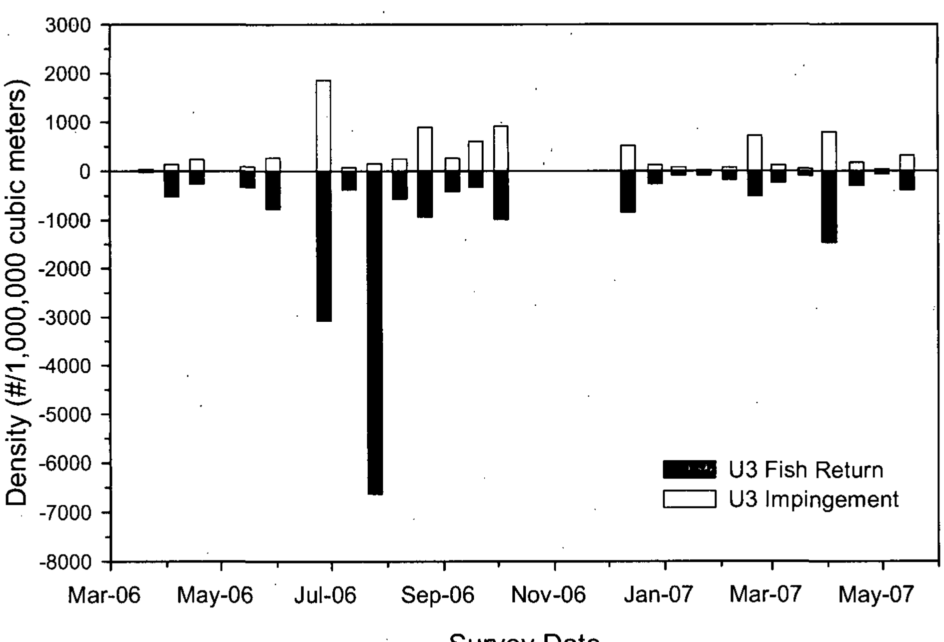


Figure 6.3-14.Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of fishes in SONGS Unit 3 FRS and normal operation impingement samples, 2006-7.

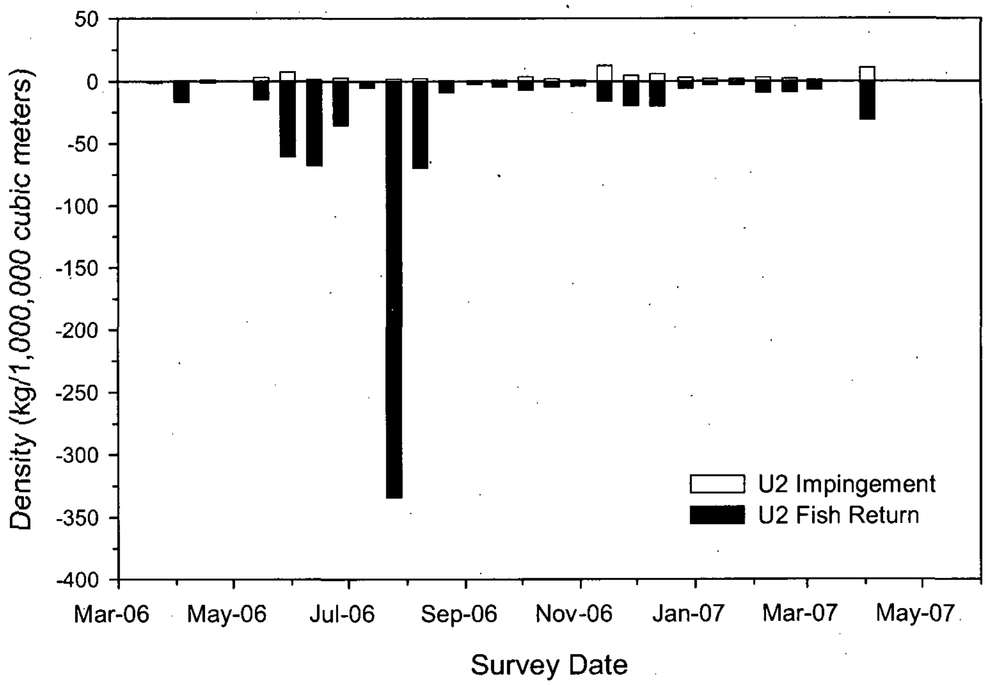


Figure 6.3-15.Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of fishes in SONGS Unit 2 FRS and normal operation impingement samples, 2006-7.

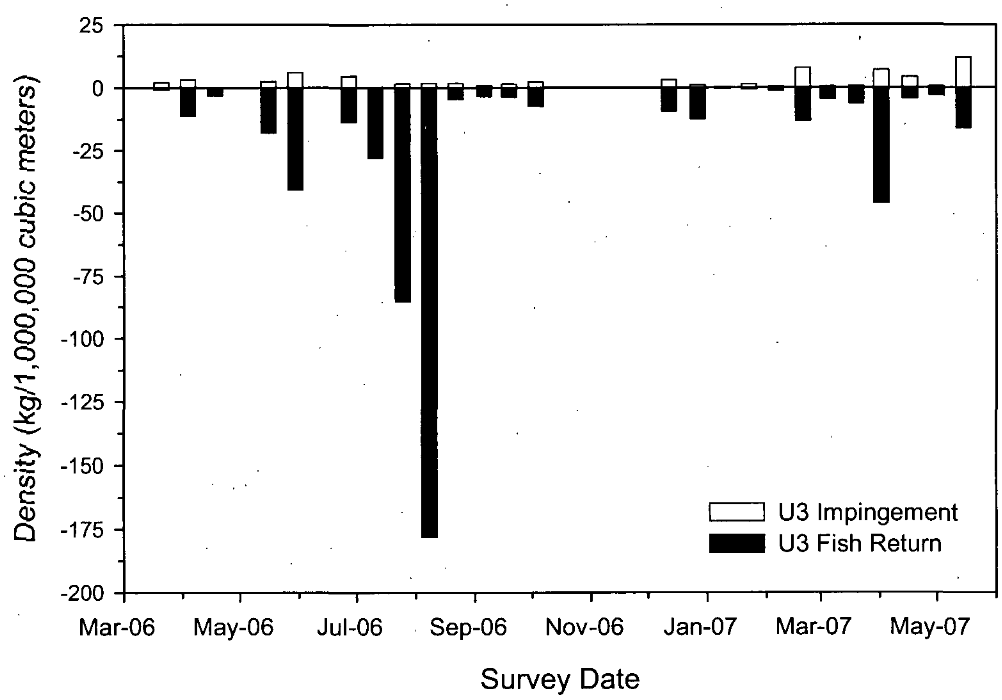


Figure 6.3-16.Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of fishes in SONGS Unit 3 FRS and normal operation impingement samples, 2006-7.

6.3.5.5 Fish Chase and Heat Treatment Return Summary

6.3.5.5.1 Fish

During heat treatment impingement and fish chase surveys, an estimated 130,974 fish of at least 77 distinct species weighing an estimated 34,117.466 kg (75,194.895 lbs) was entrained by the SONGS CWIS in 2006-2007 (Table 6.3-7). Of these entrained fish, an estimated 42,399 individuals (32.4% of the total) suffered impingement mortality, and an estimated 88,575 individuals (67.6%) were returned via the FRS to the ocean (Table 6.3-5). The total estimated returned biomass comprised 85.8% of the entrained biomass. Yellowfin croaker was the most abundant species entrained and returned, with an estimated return of 84.5% by abundance, and 85.2% return by biomass. The next four most abundant species, returned, queenfish, northern anchovy, zebraperch (*Hermosilla azurea*), and salema had return rates by species of 24.2, 82.7, 97.7, and 36.7%, respectively. Together, these five species comprised 57.4% of the returned abundance, and 73.7% of the returned biomass.

Eight distinct species had returns of over 90% of the individuals of their respective species, but together these species comprised 16.3% of the returned abundance and 11.0% of the entrained abundance. Ten distinct species returned over 90% of their respective biomass, and together these species comprised 29.1% of the returned biomass and 25.0% of the entrained biomass.

The estimated 38,609 fish returned at Unit 2 comprised 43.6% of the fish returned during the fish chases and 1.8% of the entrained individuals, while the estimated 49,966 fish returned at Unit 3 comprised 56.4% of the fish returned during the fish chases and 1.5% of the entrained individuals. The estimated returned biomass at Unit 2 (59,929.248 kg [132,121.219 lbs]) was 42.2% of the biomass returned during the fish chases and 11.5 of the estimated entrained biomass while Unit 3 (47,953. kg [105,719.750 lbs]) contributed 57.8% of the biomass returned during the fish chases and 15.7% of the estimated entrained biomass.

6.3.5.5.2 Target shellfishes

During heat treatment impingement and fish chase surveys, the only target invertebrates observed in the return system were California spiny lobster, yellow crab, Pacific rock crab, and unidentified rock crabs. The entrained heat treatment and fish chase abundance for California spiny lobster and all rock crab species combined was 24,3004 individuals (69.4% of the entrained total), weighing 223.734 kg (493.224 lbs, 79.5% of the entrained total) (Table 6.3-8).

California spiny lobster returned an estimated 447 individuals weighing 122.657 kg (270.410 lbs, 73.8% of the species biomass). Thirty rock crabs were returned (less than 0.1% of the species total) weighing 0.650 kg (1.433 lbs, 1.1% of the species biomass). Unit 2 contributed 7.1% (332 individuals) of the total target invertebrate return abundance and 11.0% of the biomass (94.960 kg [209.292 lbs]), while Unit 3 contributed 3.1% (145 individuals) and 3.3% (28.347 kg [62.494 lbs]), respectively.

Table 6.3-7. Summary of fish returned at SONGS during fish chases and heat treatments.

Taxa	Common Name	Total Impinged		Total Returned		Total Entrained		Percent Returned	
		No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Umbrina roncador	yellowfin croaker	9,160	3,249.296	49,779	18674.229	58,939	21,923.525	84.5	85.2
Seriphus politus	queenfish	10,875	268.255	3,473	59.778	14,348	328.033	24.2	18.2
Engraulis mordax	northern anchovy	1,912	17.691	9116	42.895	11,028	60.586	82.7	70.8
Hermosilla azurea	zebraperch	218	144.400	9414	6235.540	9,632	6,379.940	97.7	97.7
Xenistius californiensis	salema	5,871	161.129	3407	129.847	9,278	290.976	36.7	44.6
Anisotremus davidsonii	sargo	2,017	441.038	5,350	1059.055	7,367	1,500.093	72.6	70.6
Roncador stearnsii	spotfin croaker	102	44.549	4962	2214.521	5,064	2,259.070	98.0	98.0
Atherinops affinis	topsmelt	2,770	106.166	46	1.844	2,816	108.010	1.6	1.7
Anchoa compressa	deepbody anchovy	2,237	23.825	20	0.110	2,257	23.935	0.9	0.5
Trachurus symmetricus	jack mackerel	889	53.987	849	55.975	1,738	109.962	48.8	50.9
Hypsoblennius gilberti	rockpool blenny	1,647	5.297	10	0.019	1,657	5.316	0.6	0.4
Cymatogaster aggregata	shiner perch	1,089	19.146	1	0.030	1,090	19.176	0.1	0.2
Atherinopsis californiensis	jacksmelt	818	61.044	147	11.720	965	72.764	15.2	16.1
Scomber japonicus	Pacific chub mackerel	247	29.888	659	84.323	906	114.211	72.7	73.8
Paralabrax nebulifer	barred sand bass	149	22.034	433	84.076	582	106.110	74.4	79.2
Genyonemus lineatus	white croaker	490	9.923	38	1.558	528	11.481	7.2	13.6
Embiotoca jacksoni	black perch	177	14.164	236	26.658	413	40.822	57.1	65.3
Peprilus simillimus	Pacific pompano	325	8.923	27	0.718	352	9.641	7.7	7.4
Scorpaena guttata	California scorpionfish	179	12.925	167	15.481	346	28.406	48.3	54.5
Hyperprosopon argenteum	walleye surfperch	185	5.275	28	1.006	213	6.281	13.1	16.0
Cheilotrema saturnum	black croaker	98	8.485	114	10.095	212	18.580	53.8	54.3
Scorpaenichthys marmoratus	cabezon	184	2.740	6	1.000	190	3.740	3.2	26.7
Paralabrax clathratus	kelp bass	79	3.278	47	8.095	126	11.373	37.3	71.2
Sardinops sagax	Pacific sardine	87	3.307	33	1.517	120	4.824	27.5	31.4
Phanerodon furcatus	white seaperch	76	3.347	28	2.662	104	6.009	26.9	44.3
Syngnathus californiensis	kelp pipefish	65	0.099	3	0.010	68	0.109	4.4	9.2
Atractoscion nobilis	white seabass	31	3.043	29	4.464	60	7.507	48.3	59.5
Heterostichus rostratus	giant kelpfish	31	0.334	11	0.215	42	0.549	26.2	39.2
Citharichthys stigmaeus	speckled sanddab	42	0.083	-	-	42	0.083	0.0	0.0
Paralichthys californicus	California halibut	26	2.460	6	0.601	32	3.061	18.8	19.6
Pleuronichthys ritteri	spotted turbot	29	0.488	-	-	29	0.488	0.0	0.0
Anchoa delicatissima	slough anchovy	28	0.072	-	-	28	0.072	0.0	0.0
Chromis punctipinnis	blacksmith	23	1.017	5	0.410	28	1.427	17.9	28.7
Rhacochilus toxotes	rubberlip seaperch	24	0.534	-	-	24	0.534	0.0	0.0
Halichoeres semicinctus	rock wrasse	19	2.134	5	0.330	24	2.464	20.8	13.4
Menticirrhus undulatus	California corbina	2	0.136	20	5.080	22	5.216	90.9	97.4
Sebastes auriculatus	brown rockfish	17	1.503	3	0.357	20	1.860	15.0	19.2
Gibbonsia elegans	spotted kelpfish	16	0.113	-	-	16	0.113	0.0	0.0
Hypsoblennius sp	combtooth blenny, unid.	-	-	16	0.080	16	0.080	100.0	100.0
Medialuna californiensis	halfmoon	5	0.654	10	1.744	15	2.398	66.7	72.7
Urobatis halleri	round stingray	6	3.466	9	2.650	15	6.116	60.0	43.3
Leuresthes tenuis	California grunion	14	0.160	-	-	14	0.160	0.0	0.0
Porichthys notatus	plainfin midshipman	12	0.571	1	0.085	13	0.656	7.7	13.0
Sphyraena argentea	Pacific barracuda	12	0.464	1	0.750	13	1.214	7.7	61.8
Syngnathus leptorhynchus	bay pipefish	13	0.018	-	-	13	0.018	0.0	0.0
Stereolepis gigas	giant sea bass	1	65.000	12	348.000	13	413.000	92.3	84.3
Syngnathus sp	pipefish, unid.	11	0.021	1	0.080	12	0.101	8.3	79.2
Hypsypops rubicundus	garibaldi	1	0.009	11	1.930	12	1.939	91.7	99.5
Porichthys myriaster	specklefin midshipman	4	1.185	7	1.334	11	2.519	63.6	53.0
Ophidion scrippsae	basketweave cusk-eel	11	0.038	-	-	11	0.038	0.0	0.0
Rhinobatos productus	shovelnose guitarfish	4	17.470	5	27.000	9	44:470	55.6	60.7

(*table continued*)

Table 6.3-7 (Cont.). Summary of fish returned at SONGS during fish chases and heat treatments.

Taxa	Common Name	Total Impinged No.	Total Impinged Wt. (kg)	Total Returned No.	Total Returned Wt. (kg)	Total Entrained No.	Total Entrained Wt. (kg)	Percent Returned No.	Percent Returned Wt. (kg)
Micrometrus minimus	dwarf perch	8	0.046	-	-	8	0.046	0.0	0.0
Oxyjulis californica	senorita	7	0.071	1	0.100	8	0.171	12.5	58.5
Torpedo californica	Pacific electric ray	1	11.250	5	90.000	6	101.250	83.3	88.9
Brachyistius frenatus	kelp perch	6	0.171	-	-	6	0.171	0.0	0.0
Paralabrax maculatofasciatus	spotted sand bass	6	0.198	-	-	6	0.198	0.0	0.0
Sebastes miniatus	vermilion rockfish	4	0.018	2	0.014	6	0.032	33.3	43.8
Gibbonsia metzi	striped kelpfish	5	0.082	-	-	5	0.082	0.0	0.0
Sebastes rastrelliger	grass rockfish	3	0.601	2	1.030	5	1.631	40.0	63.2
Synodus lucioceps	California lizardfish	1	0.013	3	0.210	4	0.223	75.0	94.2
Myliobatis californica	bat ray	2	0.590	2	57.000	4	57.590	50.0	99.0
Heterodontus francisci	horn shark	2	4.180	2	5.000	4	9.180	50.0	54.5
Sebastes serriceps	treefish	2	0.128	2	0.182	4	0.310	50.0	58.7
Amphistichus argenteus	barred surfperch	1	0.217	2	0.330	3	0.547	66.7	60.3
Rhacochilus vacca	pile perch	2	0.316	1	0.400	3	0.716	33.3	55.9
Symphurus atricaudus	California tonguefish	3	0.004	-	-	3	0.004	0.0	0.0
Gymnura marmorata	California butterfly ray	1	0.156	1	0.750	2	0.906	50.0	82.8
Syngnathus exilis	barcheek pipefish	2	0.003	-	-	2	0.003	0.0	0.0
Triakis semifasciata	leopard shark	-	-	2	0.500	2	0.500	100.0	100.0
Leptocottus armatus	Pacific staghorn sculpin	1	0.021	1	0.030	2	0.051	50.0	58.8
Hyperprosopon anale	spotfin surfperch	2	0.044	-	-	2	0.044	0.0	0.0
Sebastes sp	rockfish, unid.	2	0.372	-	-	2	0.372	0.0	0.0
Semicossyphus pulcher	California sheephead	1	0.455	1	0.350	2	0.805	50.0	43.5
Pleuronichthys verticalis	hornyhead turbot	1	0.021	-	-	1	0.021	0.0	0.0
Gymnothorax mordax	moray eel	-	-	1	1.200	1	1.200	100.0	100.0
Artedius corallinus	coralline sculpin	1	0.005	-	-	1	0.005	0.0	0.0
Pleuronichthys coenosus	C-O sole	1	0.003	-	-	1	0.003	0.0	0.0
Mustelus californicus	grey smoothhound	-	-	1	1.500	1	1.500	100.0	100.0
Cottidae sp	sculpin, unid.	1	0.003	-	-	1	0.003	0.0	0.0
Lepidogobius lepidus	bay goby	1	0.001	-	-	1	0.001	0.0	0.0
Ophididae unid	cusk-eel unid	1	0.096	-	-	1	0.096	0.0	0.0
Pleuronichthys decurrens	curlfin sole	1	0.011	-	-	1	0.011	0.0	0.0
Rathbunella alleni	stripefin ronquil	1	0.007	-	-	1	0.007	0.0	0.0
Sebastes atrovirens	kelp rockfish	1	0.131	-	-	1	0.131	0.0	0.0
Mustelus sp	smoothhound, unid.	-	-	1	0.600	1	0.600	100.0	100.0
	Totals:	**42,399**	**4,840.4**	**88,575**	**29,277.1**	**130,974**	**34,117.5**	**67.6**	**85.8**
	No. of Taxa:	**67**		**65**		**83**			

Table 6.3-8. Summary of macroinvertebrates returned at SONGS during fish chases and heat treatments.

Taxa	Common Name	Total Impinged No.	Total Impinged Wt. (kg)	Total Returned No.	Total Returned Wt. (kg)	Total Entrained No.	Total Entrained Wt. (kg)	Percent Returned No.	Percent Returned Wt. (kg)
Panulirus interruptus	California spiny lobster	175	43.540	447	122.657	622	166.197	71.9	73.8
Cancer spp	rock crabs	23,648	56.887	30	0.65	23,678	57.537	0.1	1.1
	Total for 2 Taxa Analyzed:	**23,823**	**100.427**	477	123.307	24,300	223.734	2.0	55.1
	Total All Taxa:	**34,465**	**148.998**	**529**	**139.976**	**34,994**	**281.567**	**1.5**	**49.7**
	No. of Taxa:	**54**		**14**		**56**			

6.3.5.6 Return Results for Individual Fish Species

6.3.5.6.1 Northern Anchovy

Information on the life history, ecology, population trends, and fishery of northern anchovy is summarized in Section 4.5.4.1.

From 1984 through 1994, when fish return studies were conducted concurrently with normal operation impingement studies, a total of 80.8% of northern anchovies were returned through the SONGS fish return systems (SCE 1985-1995). Annual return rates ranged from 59.5% (1989) to 99.3% (1984).

6.3.5.6.1.1 Sampling Results

Northern anchovy was the most abundant fish species returned with an estimated 2,061,541 individuals weighing 2,059.413 kg (4,538.944 lbs) returned. Fish return system efficiency for northern anchovy was 83.9% of the individuals and 85.8% of the biomass returned via the FRS to the ocean (Table 6.3-5). Normal operations contributed 99.6% of the total returned fish and 97.9% of the returned biomass. Northern anchovy comprised 51.5% of the total entrained abundance and 2.0% of the total biomass.

The greatest return densities for abundance and biomass occurred in early summer (June and July 2006) coinciding with the entrainment and return of young-of-the-year individuals (Figure 6.3-17 and Figure 6.3-18). Northern anchovy were present in return samples in low abundance throughout the year, indicating they are common offshore of SONGS.

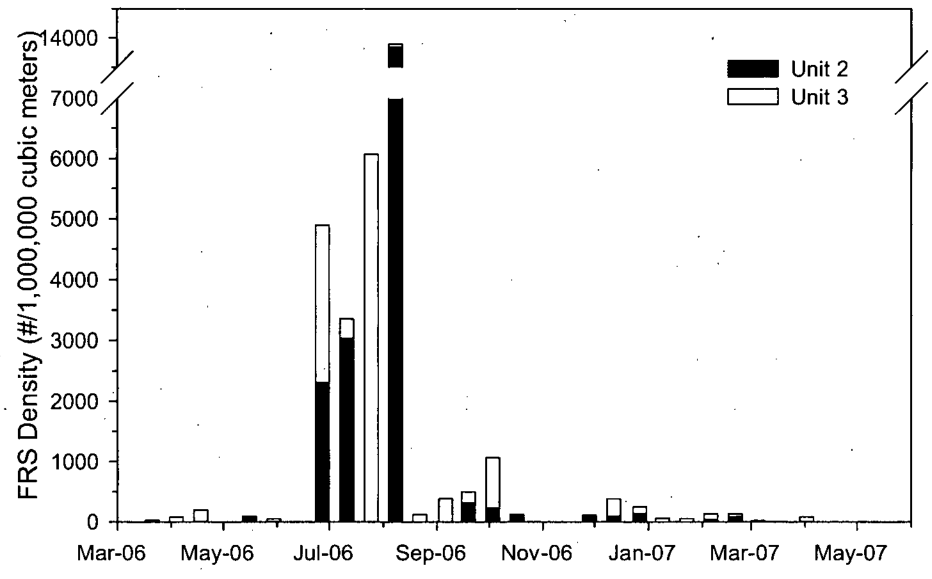


Figure 6.3-17. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of northern anchovy returned in SONGS FRS samples during 2006-7.

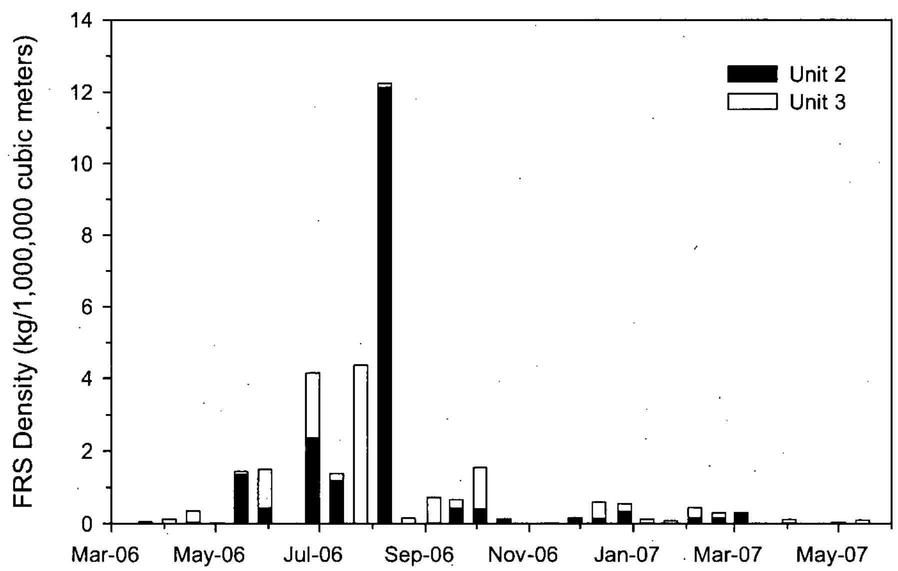


Figure 6.3-18. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of northern anchovy returned in SONGS FRS samples during 2006-7.

6.3.5.6.2 Queenfish

Information on the life history, ecology, population trends, and fishery of queenfish is summarized in Section 4.5.4.2.

From 1984 through 1994, when fish return studies were conducted concurrently with normal operation impingement studies, a total of 64.0% of queenfish were returned through the SONGS fish return systems (SCE 1985-1995). Annual return rates ranged from 36.7% (1990) to 87.9% (1984).

6.3.5.6.2.1 Sampling Results

Queenfish was the second most abundant fish species returned with an estimated 773,500 individuals weighing 14,869.188 kg (32,771.690 lbs) returned. Fish return system efficiency for queenfish was 52.0% of the individuals and 80.5% of the biomass returned via the FRS to the ocean (Table 6.3-5). Normal operations contributed 99.6% of the total returned fish and 97.9% of the returned biomass. Queenfish comprised 31.2% of the total entrained abundance and 15.3% of the total biomass.

Queenfish were present in the fish return system throughout the year. The greatest return densities for abundance occurred in spring 2007 (April) (Figure 6.3-19). The greatest return densities for biomass occurred in June and July 2006 (Figure 6.3-20). The large peak in abundance in spring 2007, with a relatively smaller peak in biomass indicates smaller individuals were present in the fish return.

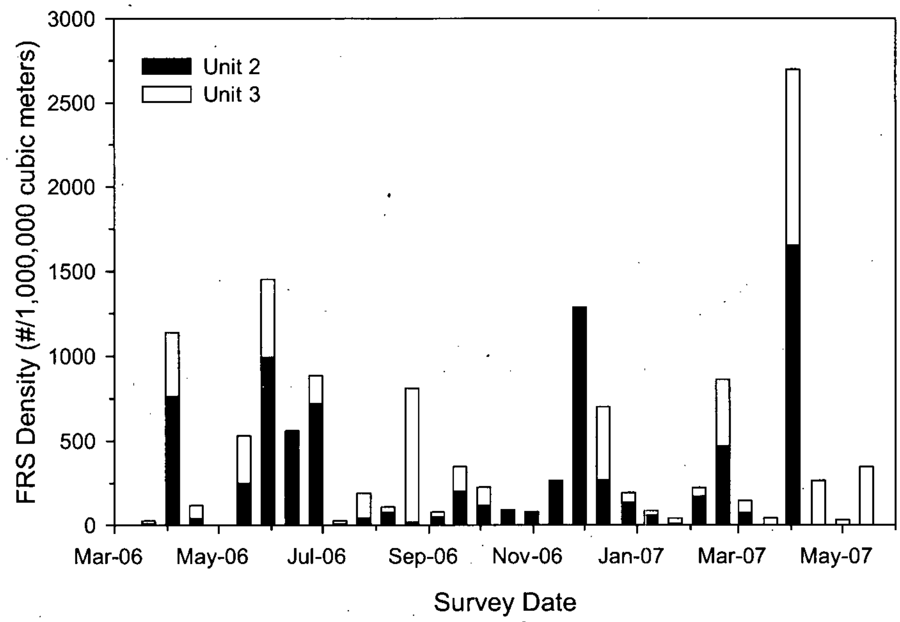


Figure 6.3-19. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of queenfish returned in SONGS FRS samples during 2006-2007.

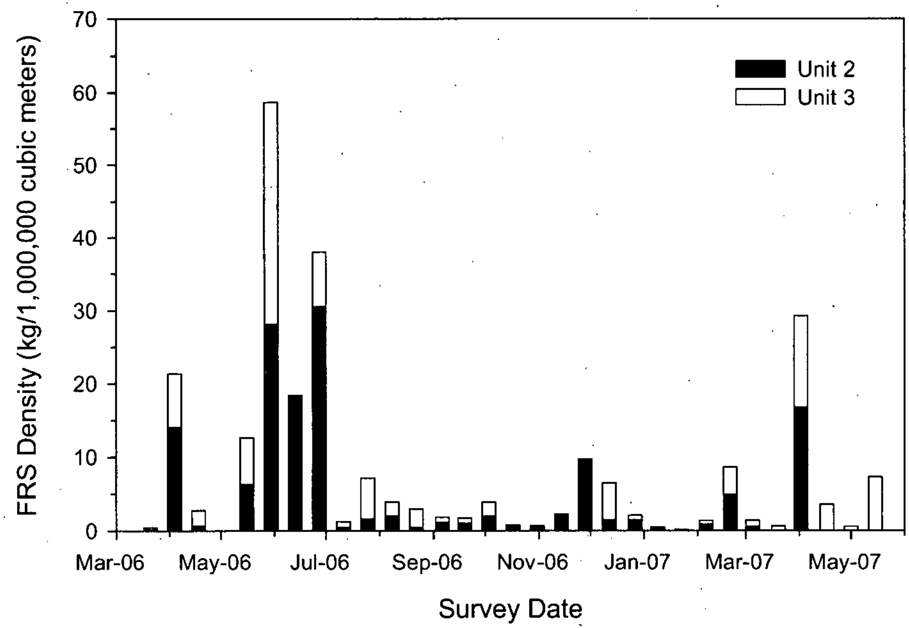


Figure 6.3-20. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of queenfish returned in SONGS FRS samples during 2006-2007.

6.3.5.6.3 Pacific Sardine

Information on the life history, ecology, population trends, and fishery of Pacific sardine is summarized in Section 4.5.4.3.

From 1984 through 1994, when fish return studies were conducted concurrently with normal operation impingement studies, a total of 35.2% of Pacific sardine were returned through the SONGS fish return systems (SCE 1985-1995). Annual return rates ranged from 0% (1985 and 1989) to 85.4% (1984).

6.3.5.6.3.1 Sampling Results

Pacific sardine was the third most abundant fish species returned with an estimated 100,651 individuals weighing 2,621.709 kg (5,778.247 lbs) returned. Fish return system efficiency for Pacific sardine was 48.4% of the individuals and 67.3% of the biomass returned via the FRS to the ocean (Table 6.3-5). Normal operations contributed 100% of the total returned fish and 99.9% of the returned biomass. Pacific sardine comprised 4.4% of the total entrained abundance and 3.2% of the total biomass.

The greatest return densities for Pacific sardine abundance and biomass occurred in spring 2006, occurring during an influx of a large school of fish (Figure 6.3-21 and Figure 6.3-22). The relatively larger biomass peak in fall indicates larger individuals were returned.

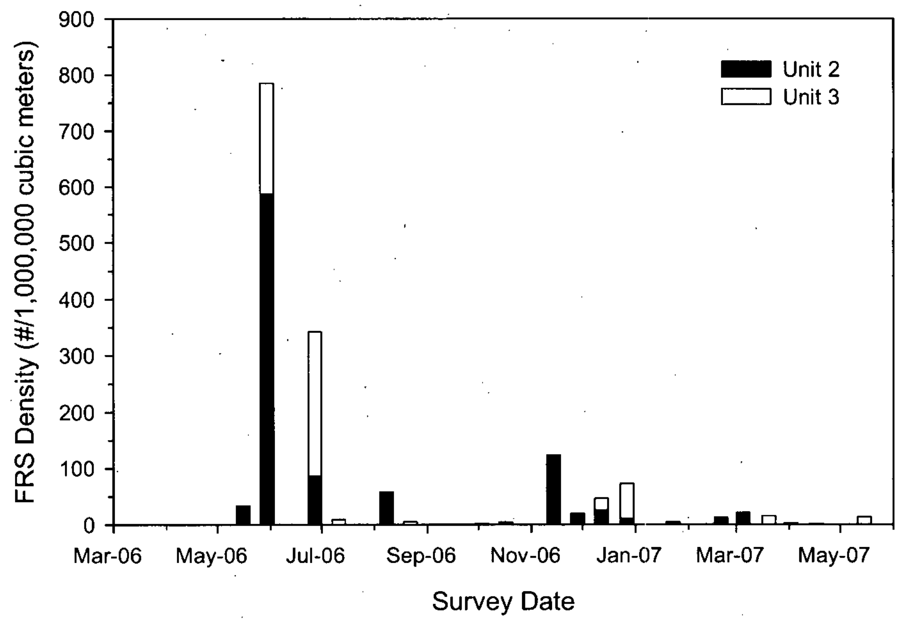


Figure 6.3-21. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of Pacific sardine returned in SONGS FRS samples during 2006-7.

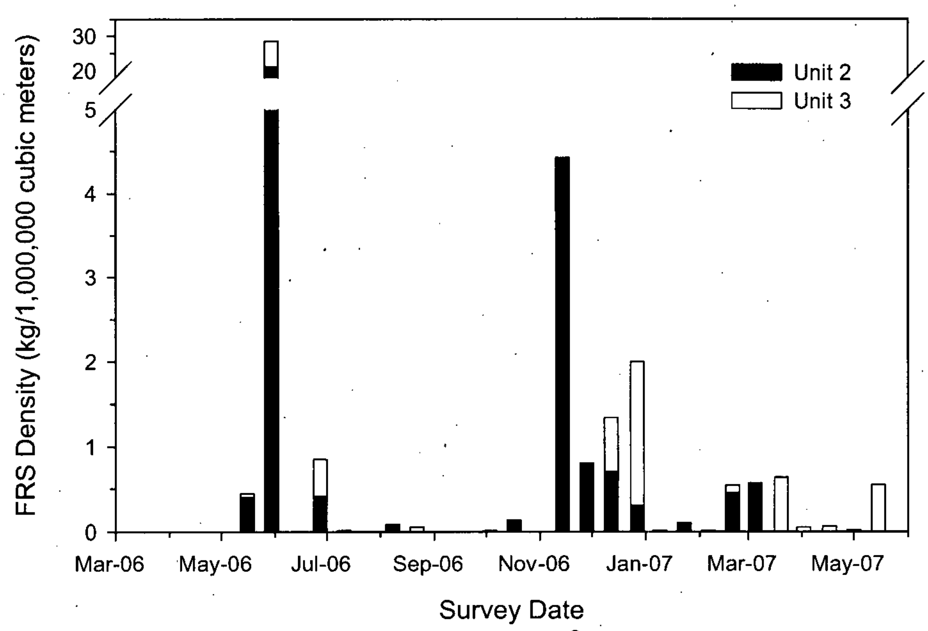


Figure 6.3-22. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of Pacific sardine returned in SONGS FRS samples during 2006-7.

6.3.5.6.4 Yellowfin Croaker

Information on the life history, ecology, population trends, and fishery of yellowfin croaker is summarized in Section 5.5.2.7.

From 1984 through 1994, when fish return studies were conducted concurrently with normal operation impingement studies, a total of 98.3% of yellowfin croaker were returned through the SONGS fish return systems (SCE 1985-1995). Annual return rates ranged from 80.2% (1990) to 100.0% (1984 and 1994).

6.3.5.6.4.1 Sampling Results

Yellowfin croaker was the fifth most abundant fish species returned during normal operations, but the most abundant during fish chases, with an estimated 138,343 individuals weighing 57,136.695 kg (125,929.276 lbs) returned. Fish return system efficiency for yellowfin croaker was 93.7% of the individuals and 94.6% of the biomass returned via the FRS to the ocean (Table 6.3-5). Sixty-four percent of the abundance and 67.3% of the biomass was returned during normal operations. The greatest mortality occurred during a single heat treatment at Unit 2 in August 2006. Yellowfin croaker comprised 3.1% of the total entrained abundance and 50.0% of the total biomass. The greatest return densities for abundance and biomass occurred in July and August 2006 (Figure 6.3-23 and Figure 6.3-24).

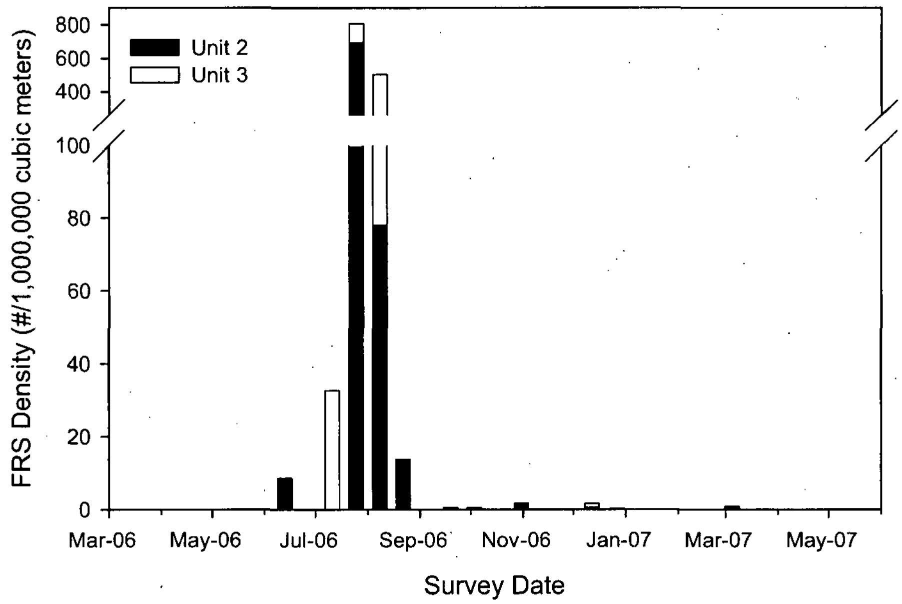


Figure 6.3-23. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of yellowfin croaker returned in SONGS FRS samples during 2006-7.

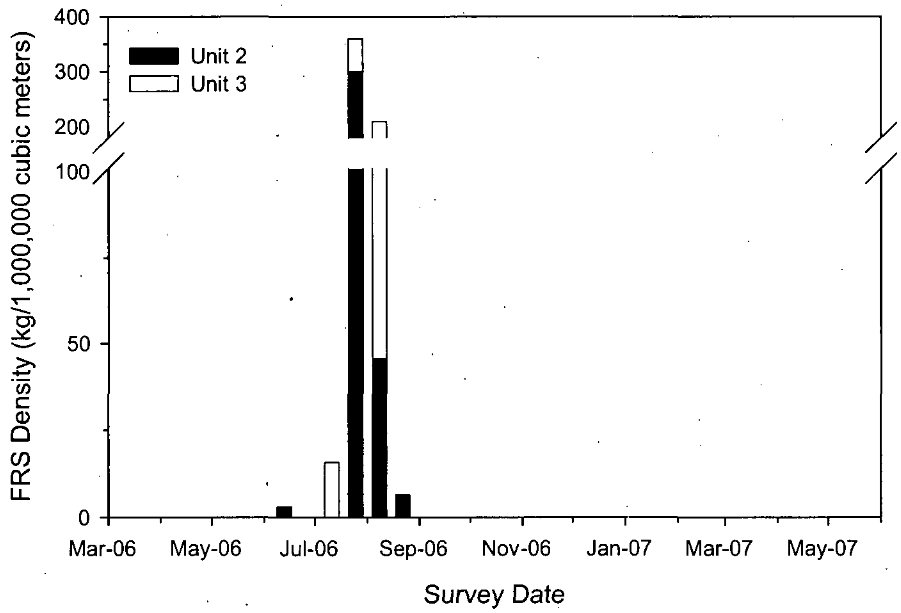


Figure 6.3-24. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of yellowfin croaker returned in SONGS FRS samples during 2006-7.

6.3.5.6.5 Deepbody Anchovy / Slough Anchovy

Information on the life history, ecology, population trends, and fishery of deepbody anchovy and slough anchovy is summarized in Section 5.5.2.4.

From 1984 through 1994, when fish return studies were conducted concurrently with normal operation impingement studies, a total of 31.9% of anchovies (*Anchoa* spp) were returned through the SONGS fish return systems (SCE 1985-1995). Annual return rates ranged from 9.9% (1985) to 82.2% (1984).

6.3.5.6.5.1 Sampling Results

Anchoa species (deepbody and slough anchovy) were the sixth and fifteenth most abundant fish species returned, respectively, with a combined estimated 52,618 individuals weighing 563.120 kg (1,241.116 lbs) returned. Fish return system efficiency for both species combined was 62.1% of the individuals and 72.3% of the biomass returned via the FRS to the ocean (Table 6.3-5). Normal operations accounted 100% of the total returned fish abundance and biomass. *Anchoa* spp comprised 1.8% of the total entrained abundance and less than 1% of the total biomass.

The greatest return densities for *Anchoa* abundance and biomass occurred in winter 2006 (Figure 6.3-25 and Figure 6.3-26). The pattern of abundance and biomass indicate that the *Anchoa* spp are seasonal visitors to the SONGS area.

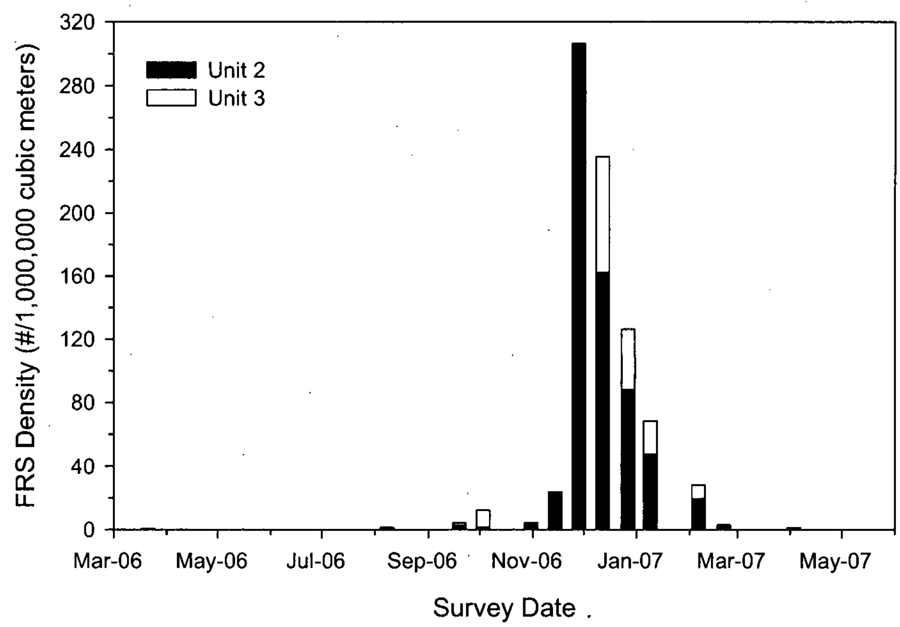


Figure 6.3-25. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of *Anchoa* spp returned in SONGS FRS samples during 2006-7.

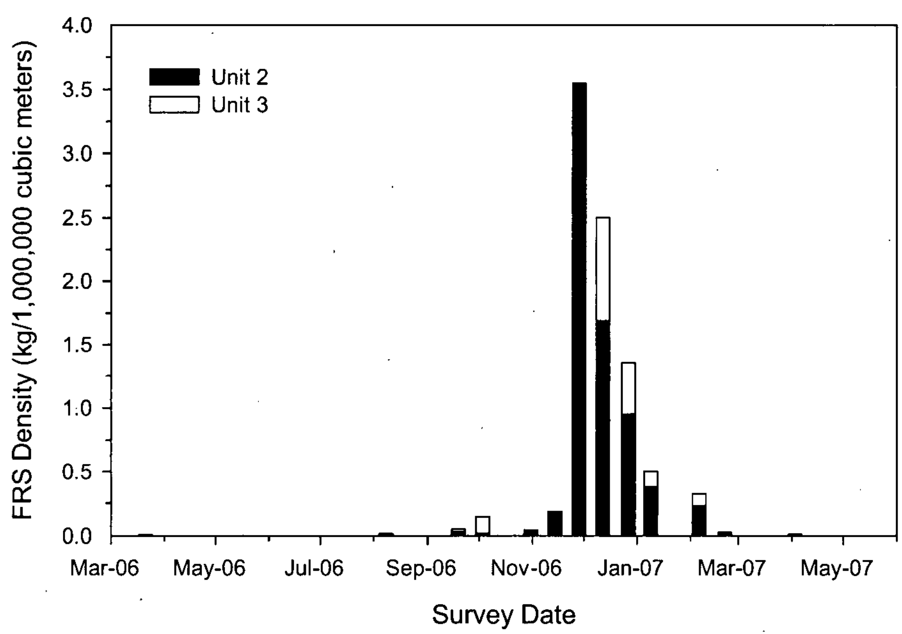


Figure 6.3-26. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of *Anchoa* spp returned in SONGS FRS samples during 2006-7.

6.3.5.6.6 White Croaker

Information on the life history, ecology, population trends, and fishery of white croaker is summarized in Section 4.5.4.4.

From 1984 through 1994, when fish return studies were conducted concurrently with normal operation impingement studies, a total of 62.1% of white croaker were returned through the SONGS fish return systems (SCE 1985-1995). Annual return rates ranged from 29.2% (1989) to 93.2% (1984).

6.3.5.6.6.1 Sampling Results

White croaker was the ninth most abundant fish species returned with an estimated 19,572 individuals weighing 327.317 kg (721.407 lbs) returned. Fish return system efficiency for white croaker was 67.2% of the individuals and 82.7% of the biomass returned via the FRS to the ocean (Table 6.3-5). Normal operations contributed 99.8% of the total returned fish abundance and 99.5% of the biomass. White croaker comprised less than 1% of the total returned abundance and biomass.

The greatest return densities for abundance and biomass occurred in two periods, early summer and early winter of 2006 (Figure 6.3-27 and Figure 6.3-28). The relative biomass amount indicates that the spring peak was composed of larger individuals.

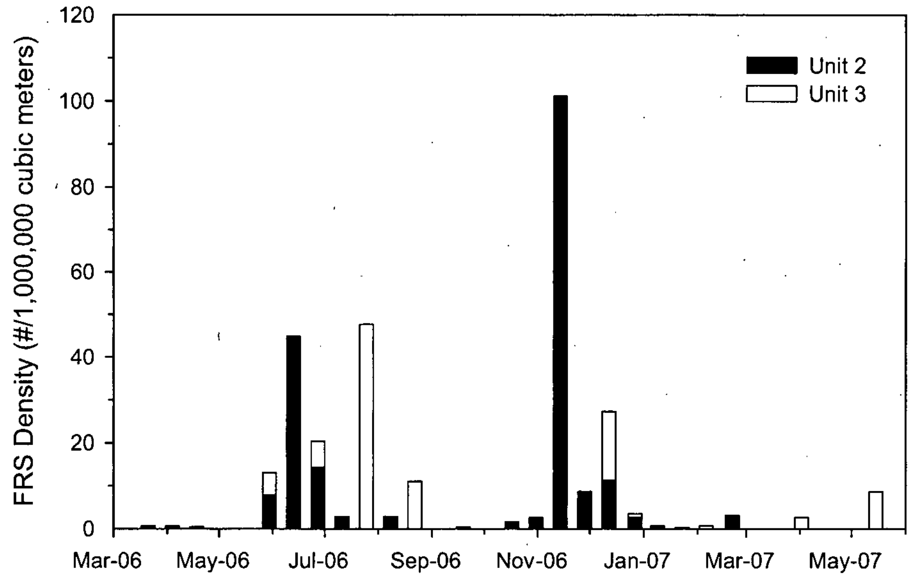


Figure 6.3-27. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of white croaker returned in SONGS FRS samples during 2006-7.

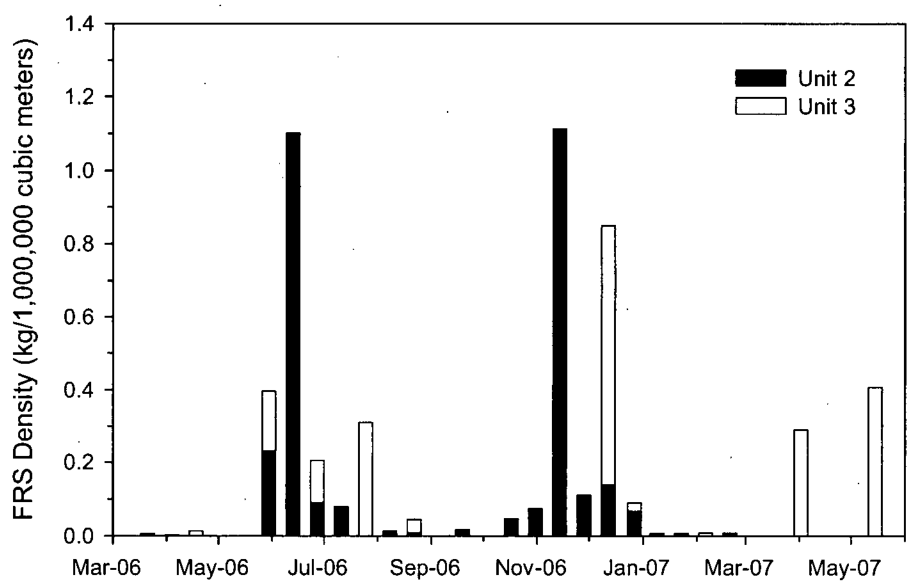


Figure 6.3-28. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of white croaker returned in SONGS FRS samples during 2006-7.

6.3.5.6.7 Sargo

Information on the life history, ecology, population trends, and fishery of sargo is summarized in Section 5.5.2.8.

From 1984 through 1994, when fish return studies were conducted concurrently with normal operation impingement studies, a total of 92.9% of sargo were returned through the SONGS fish return systems (SCE 1985-1995). Annual return rates ranged from 57.2% (1988) to 100.0% (1990).

6.3.5.6.7.1 Sampling Results

Sargo was the eighteenth most abundant fish species returned during normal operations, but the sixth most abundant during fish chases, with an estimated 6,386 individuals weighing 1,216.051 kg (2,680.176 lbs) returned. Fish return system efficiency for sargo was 75.4% of the individuals and 73.1% of the biomass returned via the FRS to the ocean (Table 6.3-5). Heat treatment fish chases contributed 83.8% of the total returned fish abundance and 87.1% of the biomass. Sargo comprised less than 1% of the total returned abundance and 1.4% of the total biomass.

The greatest return densities for abundance and biomass occurred in summer, indicating sargo are seasonal in the SONGS area (Figure 6.3-29 and Figure 6.3-30). Abundance and biomass were both greater at Unit 3.

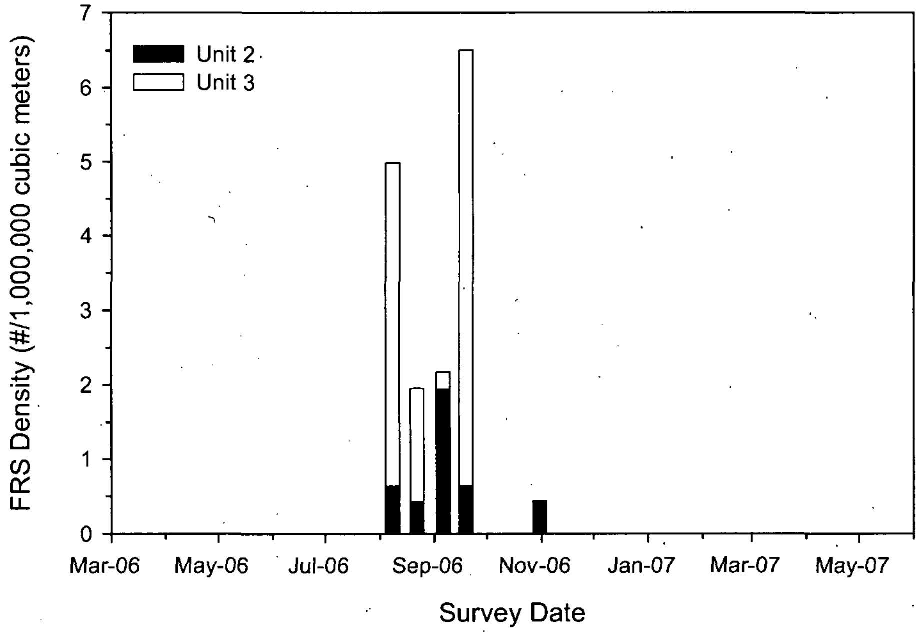


Figure 6.3-29. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of sargo returned in SONGS FRS samples during 2006-7.

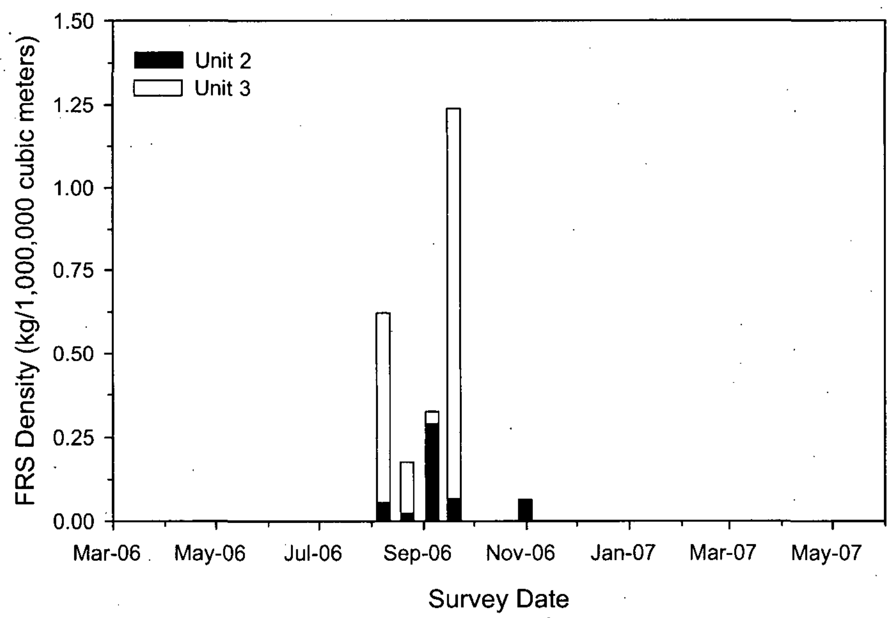


Figure 6.3-30. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of sargo returned in SONGS FRS samples during 2006-7.

6.3.5.6.8 Sea Basses

Information on the life history, ecology, population trends, and fishery of *Paralabrax* spp is summarized in Section 4.5.4.5.

From 1984 through 1994, when fish return studies were conducted concurrently with normal operation impingement studies, a total of 82.4% of sea basses (*Paralabrax* spp) were returned through the SONGS fish return systems (SCE 1985-1995). Annual return rates ranged from 60.9% (1986) to 98.7% (1984).

6.3.5.6.8.1 Sampling Results

Paralabrax species (kelp bass and barred sand bass) were both present in relatively low abundance, with a combined estimated 52,618 individuals weighing 563.120 kg (1,241.116 lbs) returned. Spotted sand bass was not observed in the fish return samples. Fish return system efficiency for both species combined was 62.1% of the individuals and 72.3% of the biomass returned via the FRS to the ocean (Table 6.3-5). Normal operations contributed 100% of the total returned fish abundance and biomass. *Paralabrax* spp comprised less than 1% of the total returned abundance and biomass. No spotted sand bass were observed in return sampling, with only six individuals taken during heat treatments.

The return densities for *Paralabrax* spp abundance were similar throughout the year, with a peak in winter (Figure 6.3-31). Biomass showed a similar pattern, but the relative biomass return in October indicates the presence of larger individuals (Figure 6.3-31). The pattern of abundance and biomass indicate that *Paralabrax* spp commonly occur in the SONGS area. They were more abundant in the return samples from Unit 2.

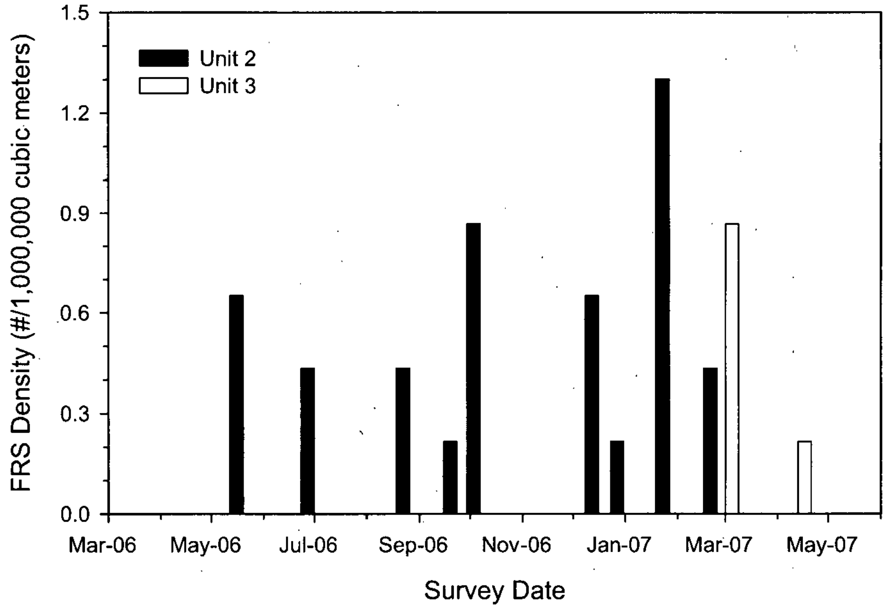


Figure 6.7-31. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of *Paralabrax* spp returned in SONGS FRS samples during 2006-7.

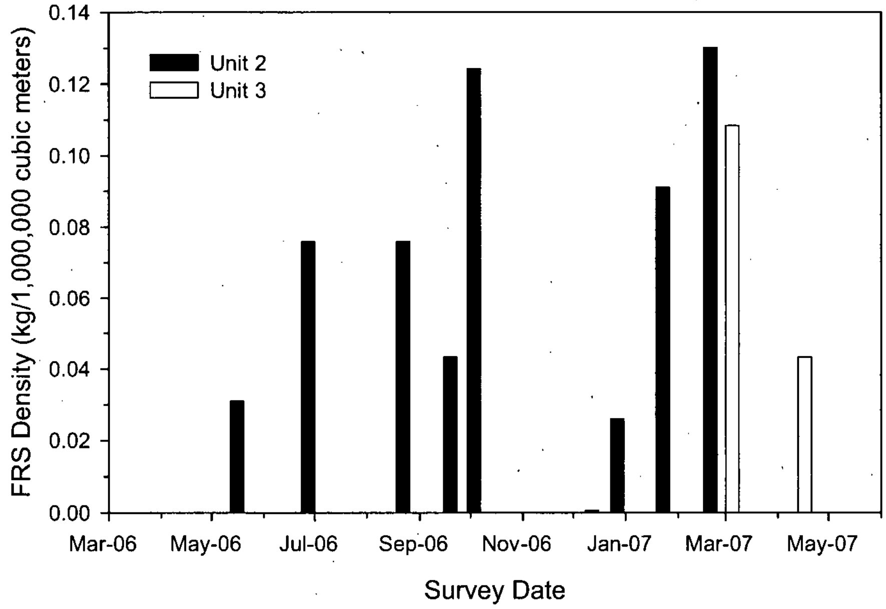


Figure 6.7-32. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of *Paralabrax* spp returned in SONGS FRS samples during 2006-7.

6.3.6 Return Results for Target Invertebrates by Species

6.3.6.1.1 California Spiny Lobster

Information on the life history, ecology, population trends, and fishery of California spiny lobster is summarized in Section 4.5.4.7.

6.3.6.1.1.1 Sampling Results

An estimated 1,847 California spiny lobster weighing 496.159 kg (1,094.031 lbs) were returned during the study. Fish return system efficiency for California spiny lobster was 46.2% of the individuals and 51.4% of the biomass returned via the FRS to the ocean (Table 6.3-6). Normal operation fish return contributed 75.8% of the total returned abundance and 75.3% of the biomass. California spiny lobster comprised 3.3% of the total entrained abundance and 44.2% of the total entrained biomass.

The return densities for abundance and biomass was bimodal with similar size peaks in summer and spring, with regular monthly returns, indicating California spiny lobster are common year round in the SONGS area (Figure 6.3-33 and Figure 6.3-34). Abundance and biomass were both slightly greater at Unit 2. Relative size of the peaks indicates similar size individuals present throughout the year.

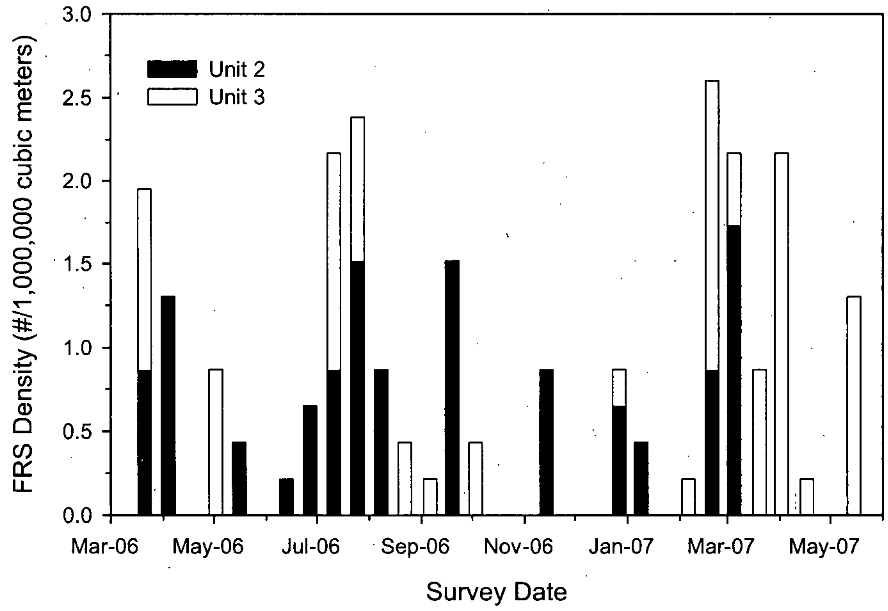


Figure 6.3-33. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of spiny lobster returned in SONGS FRS samples during 2006-7.

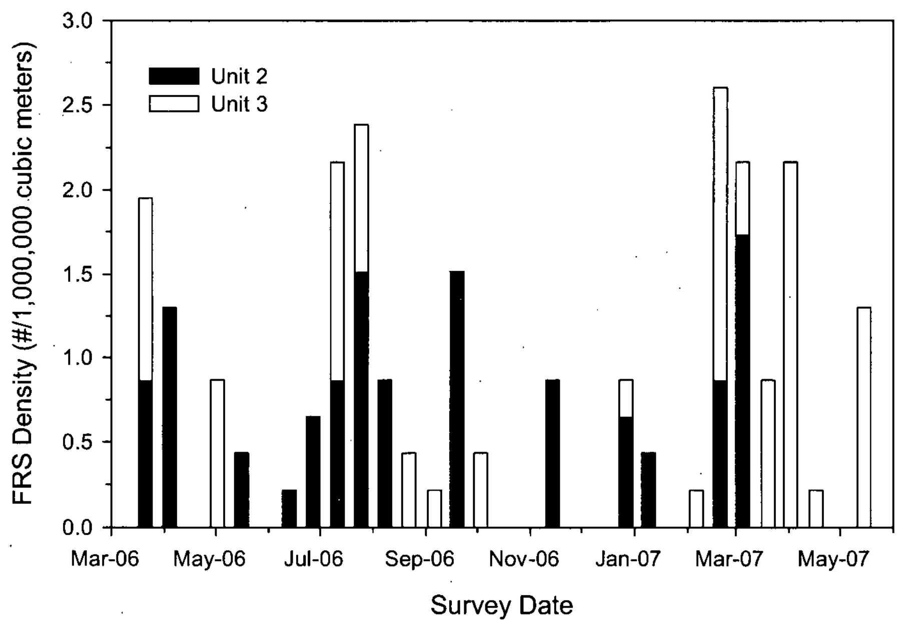


Figure 6.3-34. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of spiny lobster returned in SONGS FRS samples during 2006-7.

6.3.6.1.2 Rock Crabs

Information on the life history, ecology, population trends, and fishery of rock crabs is summarized in Section 5.5.3.1.

An estimated 548 individual rock crabs (all taxa combined) weighing 13.180 kg (29.057 lbs) were returned. Fish return system efficiency for rock crabs was 1.1% of the individuals and 7.0% of the biomass returned via the FRS to the ocean (Table 6.3-6). Normal operation fish return contributed over 98% of the total returned abundance and biomass. Rock crabs comprised 40.7% of the total entrained abundance and 8.6% of the total biomass.

The greatest return densities for abundance were similar throughout the year with a peak in July, indicating rock crabs are common year round in the SONGS area (Figure 6.3-35). However, biomass was less uniform, with very little returned over the year, but with a large peak in spring 2007 (Figure 6.3-36). Most of the individuals for all species observed were small, contributing little to the returned biomass. Larger individuals were present in spring 2007, creating the large biomass return observed. Abundance was similar between the units, but the greatest portion of the biomass was taken at Unit 2.

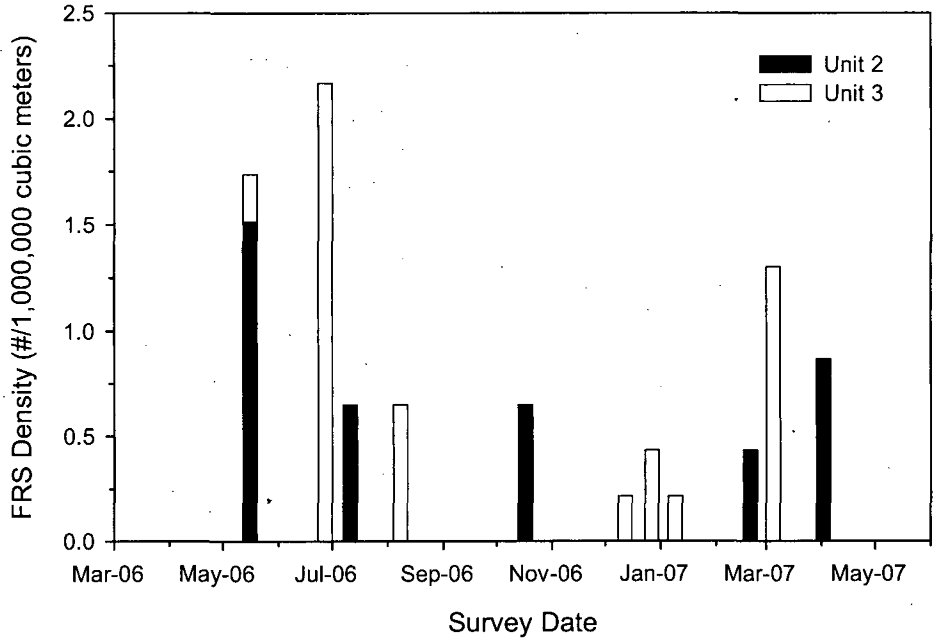


Figure 6.3-35. Mean concentration (# / 1,000,000 m^3 [264,172,052 gal]) of rock crabs returned in SONGS FRS samples during 2006-2007.

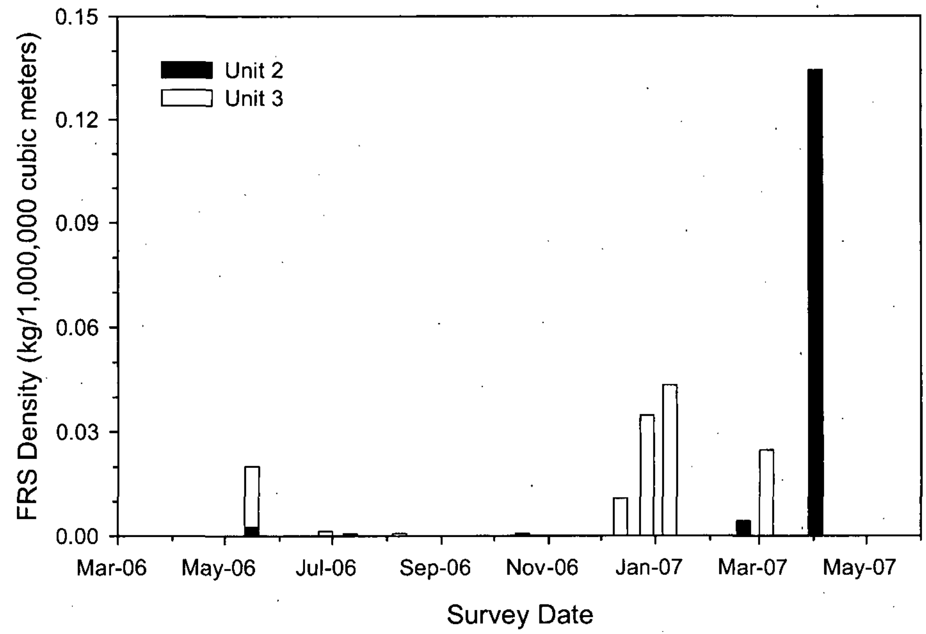


Figure 6.3-36. Mean concentration (kg / 1,000,000 m^3 [264,172,052 gal]) of rock crabs returned in SONGS / FRS samples during 2006-7.

6.3.6.2 Return Results for Larval Fish and Shellfish

6.3.6.2.1 Fish Eggs and Larvae

The most abundant larval fish taxa collected in fish return plankton samples at Unit 2 were northern anchovy, unidentified anchovies, queenfish, and white croaker (Table 6.3-9). At Unit 3, the four most abundant larval fish taxa were northern anchovy, white croaker, mussel blenny, fish fragments, and Engraulid eggs. The most abundant fish egg taxa collected in fish return plankton was unidentified fish eggs at both units, followed by Sciaenidae / Paralichthyidae / Labridae (eggs) complex and jacksmelt eggs at Unit 2 and unidentified Paralichthyidae (eggs) and *Pleuronichthys* spp (eggs) at Unit 3. Also collected in the nets were larger non-larval fish stages of northern anchovy, sanddabs (*Citharichthys* spp), and English sole (*Parophrys vetulus*). These were enveloped in the debris (fish scales, sand, shell hash, and algae) that passed through the adult fish nets and was retained by the plankton nets. They occurred in low abundance, and densities were not extrapolated by flow to determine total larval return during the study period due to the low volume of water returned compared to the total volume of cooling water entrained at SONGS.

Table 6.3-9. Average concentration (No. per 1,000 m^3) of larval fishes and fish eggs collected from the SONGS Fish Return Systems.

Taxon	Common Name	Unit 2 FRS	Unit 3 FRS
Fishes			
Engraulis mordax	northern anchovy	2,850.62	4,439.74
Genyonemus lineatus	white croaker	532.86	532.86
Hypsoblennius jenkinsi	mussel blenny	0.00	355.11
larval fish fragment	unid. larval fishes	177.62	295.99
Engraulidae unid.	Anchovies	674.72	236.74
Hypsoblennius spp	combtooth blennies	251.54	177.56
Gobiidae unid.	Gobies	467.57	142.05
Gobiesocidae unid.	Clingfishes	0.00	118.37
Hypsoblennius gilberti	rockpool blenny	0.00	118.37
Seriphus politus	Queenfish	662.88	0.00
Cheilotrema saturnum	black croaker	177.56	0.00
	Total Fishes:	**5,795.36**	**6,416.79**
Fish Eggs			
fish eggs unid.	unid. fish eggs	1,931,010.33	138,293.09
Sciaen. / Paralichthy. / Labr. (eggs)	Fish eggs	9,055.40	0.00
Atherinopsis californiensis (eggs)	jacksmelt eggs	5,208.33	88.78
Paralichthyidae unid. (eggs)	sand flounder eggs	3,255.21	4,290.96
Engraulidae unid. (eggs)	anchovy eggs	1,598.01	0.00
Pleuronichthys spp (eggs)	turbot eggs	606.66	615.53
Sciaenidae unid. (eggs)	croaker eggs	88.78	88.78
	Total Fish Eggs:	**1,950,822.72**	**143,377.13**
Non-Entrainable Fishes			
Citharichthys spp	sanddabs	177.62	177.62
Parophrys vetulus	English sole	177.62	177.62
Engraulis mordax	northern anchovy	0.00	2,225.38
	Total Non-Entrainable Fishes:	**355.24**	**2,580.62**

Larval concentrations had peaks in April 2006 at both Units and again in August 2006 at Unit 3. Concentrations were generally low except during peak periods seen in offshore and in-plant samples. Egg concentrations followed a similar pattern but delayed slightly, peaking in June and again in July 2006.

6.3.6.2.2 Target Shellfishes

The most abundant target shellfish larvae collected in fish return plankton samples at Unit 2 were slender crab megalops, California spiny lobster phyllosoma, and brown rock crab megalops (Table 6.3-10). The only taxa at Unit 3, in rank order, were California spiny lobster phyllosoma, slender crab megalops, and red rock crab megalops.

Table 6.3-10. Average concentration (No. per 1,000 m^3) of target invertebrate larvae collected from the SONGS Fish Return Systems.

Taxon	Common Name	Unit 2 FRS	Unit 3 FRS
Cancer gracilis (megalops)	slender crab megalops	1,503.31	236.74
Panulirus interruptus (phyllosome)	California spiny lobster	710.23	946.97
Cancer productus (megalops)	red rock crab megalops	266.35	118.37
Cancer antennarius (megalops)	brown rock crab megalops	177.56	0.00
Cancer anthonyi (megalops)	yellow crab megalops	118.37	0.00
	Total	**2,775.82**	**1,302.08**

6.4 CREDITS TOWARD PERFORMANCE STANDARDS

As indicated in Section 6.1, the SONGS cooling water intakes do not conform to EPA's definition of calculation baseline. In the preamble to the Phase II regulations, EPA indicated: "*In many cases, existing technologies at the site show some reduction in impingement and entrainment when compared to the baseline. In such cases, impingement mortality and entrainment reductions (relative to the calculated baseline) achieved by these existing technologies should be counted toward the performance standards. In addition, operational measures such as operation of traveling screens, employment of more efficient return systems, and even locational choices should be credited for any corresponding reduction in impingement mortality and entrainment.*" EPA chose not incorporate operating capacity into the calculation baseline, as the definition is not dependent upon intake flow volumes.

Determination of the entrainment calculation baseline did not assume any credits. However, determination of the calculation baseline took into account (1) performance of the velocity cap, and (2) efficiency of the fish return systems in diverting fish and invertebrates that would have otherwise been impinged. The full credit for operation of the fish return systems was also calculated using published survival rates of fishes upon return to the nearshore waters off SONGS.

6.4.1 Results

6.4.1.1 Entrainment

There is evidence to suggest that calculation baseline adjustments to entrainment losses could be justified at SONGS for the following reasons: (1) The intakes at SONGS are submerged and draw water from mid-depths while densities of larvae and eggs off SONGS are highest in the neuston and epibenthos. However, it is unclear from existing studies whether the withdrawal zone of the intakes is confined to the middle portions of the water column; and (2) Densities of larvae and eggs off SONGS were 10.1 and 3.6 times higher in the nearshore surface waters than in the water column near the intakes. (Densities of target invertebrate larvae, however, were 50% higher near the intakes than in nearshore surface waters.). This spatial difference in larval and egg densities could justify calculation baseline credit for the SONGS intake location. However, observations were limited (three surveys), and the relatively low abundance measured during these surveys, compared to during the rest of the year, leave unanswered the question of whether these conditions exist year-round. Because the data supporting these issues are inconclusive at this time, no adjustments to entrainment estimates are proposed for determination of the entrainment calculation baseline. Therefore, the entrainment estimates presented in Tables 4.5-2 and 4.5-4 (based on in-plant sample collection) and Tables 4.5-6 and 4.5-8 (based on offshore sample collection) are considered the estimates of the calculation baseline for entrainment. Annual estimates based on collections both in-plant and offshore are presented so that results from any future compliance monitoring could be compared at either location.

6.4.1.2 Impingement

The calculation baseline for impingement at SONGS involves the following assumptions:

- There are no velocity caps on the cooling water intake structures;

- Fishes are not guided to the fish return systems and returned to the ocean;
- The fish chase procedure is not performed.

Since it has not been confirmed that the withdrawal zone of the intakes is confined to the middle portions of the water column, or that the offshore locations provide the benefit of fish protection compared to a shoreline intake, no adjustments to the impingement calculation baseline were made for intake location.

The determination of calculation baseline for fish impingement mortality assumed a credit for the velocity cap. Velocity caps work on the premise that fish will avoid rapid changes in horizontal flow but are less able to detect and avoid vertical velocity vectors. Velocity caps are installed at many offshore intakes nationwide, and have been documented to reduce impingement by more than 90% (EPA 2004). The 316(b) Phase II regulations allow the use of data from representative studies that have been conducted at a similar facility's cooling water intake structures located in the same waterbody type with similar biological characteristics. Since no field studies on velocity cap performance have been conducted at SONGS due to the configuration of the intake system, results from representative studies were summarized to provide an estimate of velocity cap performance at SONGS Units 2&3.

6.4.1.2.1 Previous Velocity Cap Performance Studies

In the design phase of the generating station, extensive studies were made to optimize the water flow characteristics to increase the ability to reduce entrainment and remove fish from the intake structure (Downs and Meddock 1974; Schuler and Larson 1975). To reduce entrainment of adults, these studies observed fish behavior and entrainment rates with several offshore intake structure designs and water approach velocities. Early studies indicated that entrainment of adult fish was reduced by as much as 90% by changing the flow from vertical to horizontal using a velocity cap (Weight 1958). The SCE laboratory studies observed fish behavior patterns at a variety of flow velocities and louver angles to determine the best combination at SONGS that would allow the greatest number of individuals to move through the bypass into the fish removal area, rather than be impinged on the screens.

Several studies have been performed in southern California to determine the effectiveness of velocity caps in reducing impingement. Since it is these studies that form the basis for determination of velocity cap effectiveness at SONGS, these studies are summarized in the following sections.

6.4.1.2.1.1 El Segundo Velocity Cap Effectiveness

Weight (1958) evaluated the effectiveness of the velocity cap at Units 1&2 at El Segundo Generating Station (ESGS), located adjacent to Santa Monica Bay in El Segundo, California. ESGS Units 1&2 became operational in May 1955, and at the time, there was no velocity cap on the intake structure. The velocity cap was installed in June 1957. The impingement periods analyzed by Weight (1958) were July 1956 to June 1957 (pre-velocity cap installation) and July 1957 to June 1958 (velocity cap in place). Specific methods to measure impingement were not specified, but the paper indicated that fish biomass removed during intake was recorded after heat treatments, and the dead fish were sold for fertilizer. No data on fish abundance, or species-specific data, were reported. However, the author noted: "*Though a large variety and kinds of fish were found in the structure, about 90% of them were either sardines or anchovies from six to eight inches long*". These are assumed to be Pacific sardine and northern anchovy.

In 1956, Southern California Edison (SCE), who owned and operated the ESGS, was designing the Huntington Beach Generating Station (HBGS) and was performing model testing for its cooling water system. They analyzed flow patterns with and without a velocity cap on the model structure, and inserted "small fish" in the laboratory setting to observe their behavior. The fishes were entrained rapidly in the structure without the velocity cap, but oriented to the horizontal flow., and avoided entrainment altogether, with the velocity-capped structure (Weight 1958). Following this success in the lab setting, a full-scale prototype velocity cap was constructed for Units 1&2 weighing 39 metric tons (43 tons). Fish impingement biomass during the one-year period without the velocity cap was 246,940 kg (544,409 lbs), and during the one-year period following installation of the velocity cap was 13,563 kg (29,901 lbs), equivalent to a reduction in impingement of 94.5%. The author noted that in July 1957, the first month after installation of the velocity cap, impingement was very low (less than 2,000 pounds) and this could have been due to an outage on one unit, which reduced cooling water flow. However, both units were operational again in August 1957.

6.4.1.2.1.2 Scattergood Velocity Cap Effectiveness

A velocity cap was installed on the intake riser at the Scattergood Generating Station (SGS), located adjacent to Santa Monica Bay, California, in 1958 (not as part of the original design of the cooling water intake system, but as a modification to the intake structure). The SGS is approximately one kilometer upcoast from the ESGS. The intake terminus at SGS differs from that at ESGS Units 1&2 primarily in that (1) it is slightly closer to shore (488 m [1,600 ft] compared with 796 m [2,611 ft]), (2) it is circular as opposed to rectangular, and (3) maximum flow rate is more than twice that at ESGS Units 1&2 (495 mgd compared with 207 mgd). However, depth of withdrawal is essentially the same.

The velocity cap suffered damage during large storms, and in June 1970, LADWP decided to remove the damaged structure and replace it. Until the velocity cap was removed on August 5, 1970, the SGS operated in reverse configuration (i.e., withdrawing cooling water from the normal discharge conduit, and discharging through the normal intake). While operating in this configuration, impingement mortality was particularly high. The California Department of Fish and Game requested that LADWP not replace the velocity cap immediately, but try to estimate its effectiveness as a fish protection device by comparing impingement before and after its replacement (Pender 1975).

The new velocity cap that was installed in October 1974 was designed slightly different than the previous velocity cap. The design changes took into account (1) the susceptibility of the prior design to storm damage, (2) the operational requirements of a new unit at SGS (Unit 3), and (3) studies performed by Southern California Edison to determine optimum flow requirement for reducing impingement. The intake riser was fitted with a "riser lip" so the outer circumference of the velocity cap was the same as that of the riser. This design minimizes vertical flow components in the intake zone of influence.

Comparisons between periods were confounded by variations in plant operations and cooling water flows due to power demand and outages. That is, the SGS operated under different conditions during the various periods. Based on all of the data recorded by Pender (1975), the effectiveness of the velocity caps at the SGS based on fish impingement biomass (standardized to cooling water flow between heat treatment procedures) was about 83%.

A new study to estimate the effectiveness of the velocity cap in reducing impingement at the SGS was carried out in 2006-7. The study involved sampling impingement with the plant operating in normal flow (with the velocity cap) and in reverse flow (without the velocity cap). Before switching flow directions, heat treatments were performed to ensure all fish entrapped during each flow regime were impinged and included in the analyses. Hydroacoustic sampling was also carried out to determine potential differences in fish densities between the intake and discharge structures. The study began in early October 2006, and on December 15, 2006, the Los Angeles Regional Water Quality Control Board issued a letter to LADWP directing them to cease the reverse flow study immediately due to the extremely high numbers of fish impinged without the velocity cap. Preliminary estimates of the effectiveness of the SGS velocity cap based on impingement rate exceeded 95% based on both abundance and biomass (MBC and Tenera unpubl. data).

6.4.1.2.1.3 SCE Velocity Cap Laboratory Studies

In the 1950s, Southern California Edison Company recognized the need to minimize fish impingement (Downs and Meddock 1974). Following the success of the prototypical velocity cap at El Segundo (see previous section), SCE examined the characteristics of the velocity caps at Redondo Marine Laboratory (located at the Redondo Beach Generating Station, Los Angeles County, California). They utilized this laboratory for a variety of purposes, including the analysis of cooling water systems and ways of reducing entrainment and entrapment (Weight 1958). In the design phase of SONGS, extensive studies were made to optimize the water flow characteristics to increase the ability to reduce entrainment and remove fish from intake structures (Schuler 1973, 1974; Downs and Meddock 1974). To reduce entrainment of adults, these studies observed fish behavior and entrainment rates in the laboratory with several intake structure designs and water approach velocities. The results from El Segundo indicated that entrainment of adult fish was reduced by as much as 90% by changing the flow from vertical to horizontal using a velocity cap (Weight 1958).

In 1972 and 1973, laboratory studies were directed at evaluating and enhancing the fish protection aspects of offshore intake structures fitted with velocity cap (Schuler 1974). Since the initial observations on the effectiveness of velocity caps at El Segundo in the mid-1950s, all of SCE's coastal generating stations with offshore intake structures were fitted with velocity caps of similar design. All laboratory tests were performed in a cylindrical, redwood tank at the Redondo Marine Laboratory, which was 2.4 m (8 ft) deep and 4.9 m (16 ft) in diameter, and integrated with a 15.2-m (50-ft flume). A 94.6 m^3/min (25,000 gpm) circulating water pump provided sea water for the tests. Various intake structure and velocity cap arrangements were modeled in the tank, and multi-species test groups of >4,000 fishes were introduced to experimental conditions.

The fish species selected for analysis were those that were most common in impingement collections at SCE's coastal power plants: northern anchovy, queenfish, white croaker, walleye surfperch, and shiner perch. Specimens were collected by an independent contractor knowledgeable in the capture and handling of fishes, and specimens were used only once.

Capped vs. Uncapped. The first relevant experiment evaluated the entrainment of fish into a capped structure relative to an uncapped structure. Two identical structures, each 91.4 cm (36 in) high and 76.2 cm (30 in) square were modeled after a prototype and installed in the cylindrical tank. Water withdrawal through each structure was controlled independently. A removable velocity cap was used so that experimental (with the cap) and control (without the cap) conditions could be reversed to eliminate potential bias from positioning with the tank. The horizontal intake velocity was set at 0.8 mps (2.5 fps), standard for all SCE intakes. Each group of fishes introduced into the tank contained approximately 4,000 northern anchovy, and between 20 and 30 surfperches and croakers, except queenfish. Specimens were divided evenly between two test chambers, each containing an intake structure.

White croaker and surfperches remained near bottom at each structure, with none entrained in the flow. The anchovy formed schools and swam throughout the test chambers. Anchovies in the uncapped (control) section repeatedly swam over the open structure, and each time they passed those closest to the vertical opening were entrained. Schuler (1974) noted they were usually drawn while in a horizontal position, and they demonstrated little effort to escape. Attrition continued for the duration of each test period (15 min). In the chamber with the velocity cap, anchovies also swam throughout the chamber, but were not exposed to the vertical currents. As the school passed the horizontal opening, the individuals closest to the structure oriented tail-first to the intake flow, and in most cases resisted entrainment and rejoined the school. Entrainment only occurred during the first few minutes of the test period, after which the survivors avoided the structure. The author noted that between 85 and 90% more anchovy were lost to the uncapped structure compared with the structure fitted with a velocity cap.

Intake Velocity. Schuler (1974) also examined the effect of varying intake velocity. Four tests were run with a velocity-capped structure at intake velocities between 0.2- and 0.6-mps (0.5- and 2.0-fps) intervals. The percent reduction (from the 0.8 mps control) for northern anchovy was 28 to 35% at 0.6 mps, 47 to 65% at 0.5 mps, 81 to 88% at 0.3 mps, and 86 to 99% at 0.2 mps. By decreasing intake velocity, entrainment of white croaker was decreased 29 to 80%, and entrainment of surfperches was decreased by 37 to 78%. No queenfish resisted intake flows for more than 30 minutes, and effect of reduced velocity could not be established. This was attributed to their poor physical condition. During the course of these tests, measurements recorded across each structure revealed that the velocity at the bottom of the opening was 1.5 times the mean across the structure, and it was in this area of highest velocity where most specimens were entrained. It was hypothesized that more uniform velocity at the intake entrance might minimize entrapment.

Uniform vs. Non-uniform Intake Velocity. Schuler (1974) constructed an experimental intake structure which resembled the conventional structure being modeled, but with a velocity cap and "riser lip" that extended horizontally from vertical 1.5 times the depth of the opening, and was referred to as the "T" configuration. Entrance velocities of 0.2, 0.45, 0.55, and 0.72 mps were tested. This modification reduced entrainment of anchovies by 73 to 98% at 0.2 mps, 45 to 89% at 0.3 mps, 58 to 81% at 0.45 mps, 46 to 71% at 0.55 mps, and 23 to 58% at 0.6 mps. Entrainment of surfperches was reduced 60 to 95% with the "T" structure, and white croaker by 55 to 94%.

Accelerating vs. Non-accelerating Entrance Flows. The next series of experiments performed by Schuler (1974) examined the effectiveness of a circular intake structure and velocity cap. With a circular structure, flow velocity increases (accelerates) as water moves toward the midpoint of the structure. To determine the effect of accelerating flow, the author constructed two structurally similar structures: one induced a constant velocity of 0.52 mps (1.7 fps), the other accelerated from 0.52 to 0.88 mps (1.7 to 2.9 fps) upon entrance into the riser. In short, acceleration of intake flow did not result in increased entrainment of fishes tested. Schuler also examined varying the base velocity between 0.2 and 0.6 mps (0.5 and 2.0 fps), compared with the control of 0.76 mps (2.5 fps). Between 5 and 11 replicates were performed with northern anchovy at each base level, and at least two replicates of other species at each level. The entrainment of fishes increased with base velocity, with the mean intake of northern anchovy at 0.2 mps (0.5 fps) equivalent to 5% of that at 0.76 mps (2.5 fps), and at 0.6 mps (2.0 fps) equivalent to 62% of that at 0.76 mps (2.5 fps). The intake of other species ranged from 0 to 54% of base levels.

Circular Structure / Accelerating Flow vs. Conventional Rectangular Structure. Schuler (1974) compared entrainment using the circular structure with the conventional rectangular structure at consistent mean intake velocities. He noted that the range about the mean with the circular structure was ±0, but with the conventional structure it was 0.15 to 0.21 mps (0.5 to 0.7 fps) greater than the means of 0.55, 0.5, and 0.3 mps (1.8, 1.5, and 1.0 fps). The mean percent intake of northern anchovy to the circular structure relative to the conventional structure was 28% at all velocity levels, and the intake of other species ranged from 25 to 36%.

Summary. In short, SCE was able to optimize the design of the velocity cap for use at San Onofre. The relationship between conventional and circular velocity caps at multiple intake velocities is presented in Figure 6.4-1. Schuler and Larson (1975) determined that lowering intake velocity from 0.76 mps (2.5 fps) to 0.5 mps (1.5 fps) using a conventional velocity cap reduced impingement of anchovies by about 45% and all other taxa by about 50%. Impingement was further reduced by using the circular velocity cap and intake structure currently in use at SONGS Units 2&3. Using the circular cap with an intake velocity of 0.5 mps (1.5 fps) reduced impingement by about 90% compared with the conventional cap at an intake velocity of 0.76 mps (2.5 fps). Comparison of fish intake at 0.5 mps (1.5 fps) indicates that the circular cap reduces impingement by 78% to 80% over a conventional cap (Figure 6.4-1).

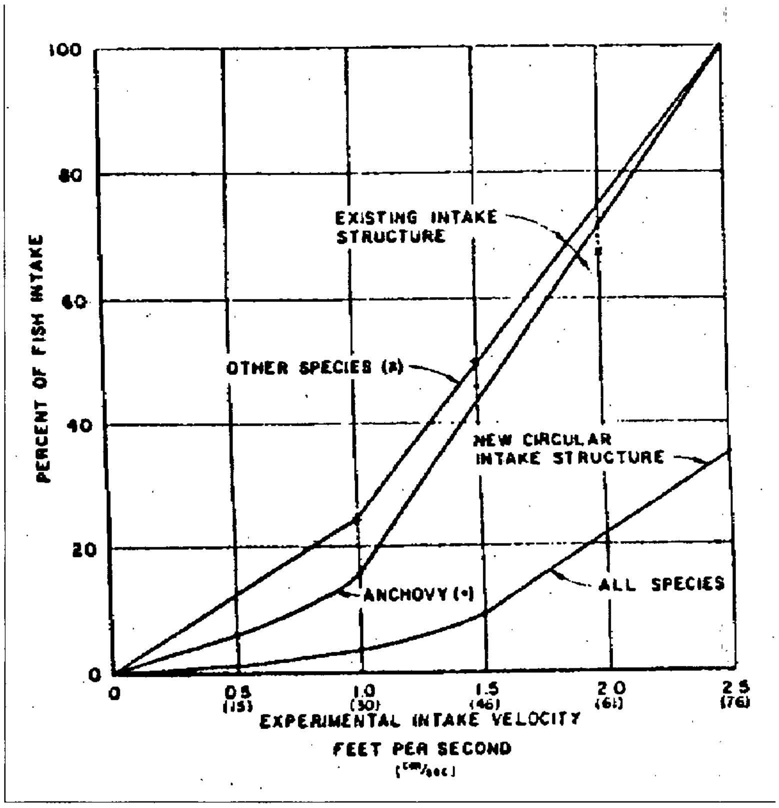


Figure 6.4-1. Percentage of fish intake for various flow velocities below 2.5 fps. Top line is all taxa except northern anchovy using standard SCE velocity cap, middle line is northern anchovy using standard SCE velocity cap, and bottom line is all taxa using circular velocity cap. Source: Schuler and Larson (1975).

6.4.1.2.1.4 Huntington Beach Velocity Cap Effectiveness

The Huntington Beach Generating Station (HBGS) Velocity Cap Effectiveness Study was carried out by a team of researchers from the University of Washington College of Fisheries. The HBGS is located on the coast of Orange County, California. This study may be the most comprehensive evaluation of velocity cap effectiveness ever conducted. This study collected impingement and source water data on individual species and the results were reported in several University of Washington technical reports. The results were also published in an IEEE journal (Thomas and Johnson 1980). The hydroacoustic methods used as one of the approaches for sampling the source water fish populations were presented at a Scientific Committee on Oceanic Research (SCOR) meeting in 1980 (Thorne 1980).

The study consisted of a series of field trials at four different power plants over one year, with the majority of the trials at HBGS. The seven trials at HBGS resulted in 123 hourly estimates of impingement and source water fish abundances with 70 observations at full flow with the velocity cap in place. This was the control condition and was used to compare impingement and source water abundances under several other plant operating conditions. Source water abundances of fishes were estimated using hydroacoustic sampling that was supplemented with net sampling to verify the composition of the acoustic targets. Gill nets were also positioned at different depths in the water column to determine the vertical distribution of the different species. Data were collected with the plant under full operation in reverse flow (without velocity cap).

The study had several unique features that improved the ability to measure the effectiveness of the velocity cap. First, unlike the 1950s study at the ESGS, test conditions were evaluated for a few hours or days and then changed to evaluate another set of test conditions. This insured that fish composition and source water abundances didn't change dramatically between tests. Secondly, the intake tunnels were cleared of fishes between observations by injecting chlorine at the upstream end of the screenwell in concentrations that forced the fishes towards the traveling screens. This insured a complete count of fish entrapment during each trial. In addition, several trials of each test condition were conducted over the course of the study to ensure that seasonal differences in ocean conditions and fish composition were taken into account. Finally, the entrapment data were combined with estimates of source water fish populations in the vicinity of the intakes to calculate estimates of entrapment vulnerability. The source water population estimates were made using net and hydroacoustic sampling. This enabled the effects of the velocity cap to be evaluated independently of offshore population abundances. The statistical technique for adjusting the entrapment rates was to calculate the ratio of entrapment to fish densities in the source water in the vicinity of the intake (*E/B*). This ratio was used to estimate the relative vulnerability of fishes to entrapment by the intake.

The use of the vulnerability ratio (*E/B*) in assessing differences among treatments had additional benefits that increased the statistical power to determine if there was a significant decrease in the vulnerability of fishes to impingement in the control condition with the velocity cap. The ratio of vulnerability resulted in a measure that adjusted the impingement data for the abundances of fishes in the source water during each observation to insure that any differences in impingement were the results of the presence or absence of the velocity cap and not source water abundances. This decreased the variation among observations within a treatment, which contributed to the ability to detect differences among treatments. The use of the *E/B* ratio and the large number of replicates of each treatment increased the statistical power of the study to detect any differences due to the velocity cap.

The final report presents results both for total impingement of all fish species combined (Table 6.4-1) and three individual fishes: queenfish, white croaker, and northern anchovy. There were also large numbers of silversides collected, but they were mostly collected in the source water sampling, and were only collected from impingement sampling during reverse operations in the absence of the velocity cap. Although not analyzed in the report due to the absence of normal operations data for comparison, the results for silversides are a good example of the effectiveness of the velocity cap. Results showed that silversides were primarily distributed in the surface layers where they were less likely to be pulled into the system during normal operations with the velocity cap. In the absence of the velocity cap the intake draws water vertically from surface layers resulting in greater impingement of silversides.

Table 6.4-1. Entrapment Densities for Total Fishes at the HBGS.

Year	Velocity Cap Present	Time	Entrapment Density (kg/hr)	Effectiveness
1979	No	Day/Night 18-hr	20.45	
1979	Yes	Day/Night 18-hr	1.97	90%
1979	No	Night	32.93	
1979	Yes	Night	15.53	53%
			Average:	**72%**
1980	No	Day	47.2	
1980	Yes	Day	0.65	99%
1980	No	Night	52.99	
1980	Yes	Night	6.78	87%
			Average:	**93%**
			Overall:	**82%**

*Data from 1979 and 1980 Velocity Cap Studies (from Thomas et al. 1980, Table 3, p. 18).

The vulnerability ratios from the study present a more accurate measure of the true effectiveness of the velocity cap. The difference in vulnerability for Treatment 2 (full flow without the velocity cap) and Treatment 3 (full flow without the velocity cap) was highly significant which was verified by analyzing the data with a one-tailed Mann-Whitney U-Test ($p < 0.0001$). At the HBGS, entrapment vulnerability during periods of operation with the velocity cap in use ranged from 0.0030 to 0.0095. Without the velocity cap, vulnerabilities were 0.0296 and 0.0638, or nearly one order of magnitude higher than velocity cap vulnerability. The reduction in the average vulnerabilities presented in Thomas et al. (1980) through use of the velocity cap was 87%. Although these results clearly demonstrate the effectiveness of the velocity cap, the estimated efficiency is conservative since data from silversides were not included in the analysis. Silversides are usually found in the upper water column, and are more susceptible to an intake without a velocity cap than one with a velocity cap.

6.4.1.2.1.5 Ormond Beach Velocity Cap Effectiveness

The Ormond Beach Generating Station (OBGS) Velocity Cap Effectiveness Study was carried out concurrently with the HBGS study by a team of researchers from the University of Washington College of Fisheries (Thomas et al. 1980). The OBGS is located on the coast in Oxnard, California. The study consisted of 35 hourly estimates of entrapment (compared with 123 at HBGS), comprised of 24 estimates of control and 11 estimates with no velocity cap in place. Entrapment vulnerability indices corroborated those from HBGS, with the difference in vulnerability between velocity cap and no velocity cap determined to be statistically significant (one-tailed Mann Whitney U-Test, $p=0.0083$). Overall, reductions in fish entrapment rates due to the velocity cap were 61% (nighttime) and 87% (daytime). Data were treated "differently in data reduction because of an unusually high relative abundance of mackerel schools (*Scomber japonicus* and *Trachurus symmetricus*) in the study area", which could have obscured species-specific trends of "key" fishes in lower abundance, which were the focus of the study. Offshore data from these mackerel schools were removed from the analysis when determining velocity cap effectiveness, similar to the approach used for silversides at HBGS. Therefore, velocity cap effectiveness at the OBGS is likely much higher than that presented by Thomas et al. (1980).

6.4.2 SONGS IM Calculation Baseline Estimate

Due to the configuration of the SONGS diffuser discharges, reverse flow studies to determine velocity cap effectiveness (similar to those performed at Huntington Beach, Ormond Beach, and Scattergood) cannot be performed. Characteristics of the cooling water systems and velocity caps discussed in Section 6.4 are presented in Table 6.4-2. Data on design cooling water flow volumes and intake velocities are reported in McGroddy et al. (1981), URS et al. (2005), and SCE and EPRI Solutions (2006).

Table 6.4-2. Characteristics of cooling water systems and velocity caps previously studied.

Station	Units	Velocity Cap Design	Design Cooling Water Flow (mgd)	Design Intake Velocity (fps)	Estimated Entrapment Reduction*
ESGS	1&2	Conventional	207	2.4	95%
HBGS	1-4	Conventional	507	2.0	82-87%
OBGS	1&2	Conventional	689	2.7	>74%
SGS	1-3	Circular	495	1.5	83% - >95%
SONGS	2 or 3	Circular	1,195	1.7	

* Results from Weight (1958), Thomas et al. (1980), Pender (1975), and MBC and Tenera (unpubl. data).

The laboratory results from Schuler and Larson (1975) indicated the circular intakes and velocity caps in use at SONGS reduce fish entrapment by an additional 78 to 80% over the protection afforded by conventional velocity caps at the same intake velocity, such as those in use at the ESGS, HBGS, and OBGS. The laboratory study was limited in the number of species analyzed, however, so it is unknown how the results translate to other taxa outside of the laboratory. While an analysis of the intake designs and capacities may be useful in the determination of the effectiveness of the SONGS velocity caps, this comparison cannot take into account site-specific biological conditions. The habitat offshore SONGS (coarse sediments, reefs, and kelp beds) is different from that offshore the other facilities (relatively featureless sandy bottom) included in this analysis. Other differences in nearshore current patterns or water clarity may also contribute to site-specific differences in velocity cap effectiveness. Still, the composition in fish entrapment and impingement is relatively similar among all facilities. The studies examining velocity caps in southern California have calculated impingement reductions between >74 and 95% (Figure 6.4-2).

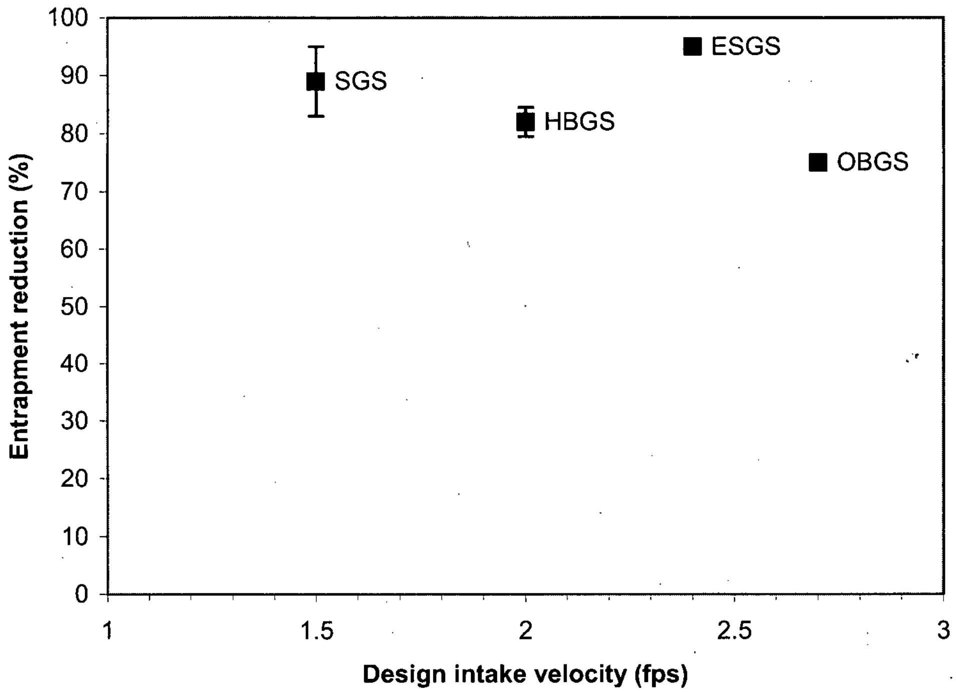


Figure 6.4-2. Relationship between design intake velocity (fps) and reported impingement reductions at four southern California generating stations.

Using impingement reduction values from ESGS (95%), HBGS (82%), OBGS (75%), and SGS (average of 89%) and the reported design intake velocities, the relationship between intake velocity and impingement reduction can be described as:

$$\textit{Effectiveness} = -6.358(v) + 98.92$$

Where v = design intake velocity (fps)

Using this equation, the estimated effectiveness of the SONGS velocity caps (with the design intake flow velocity of 1.7 fps) was calculated as 88.17%. This estimate is considered conservative based on the recent study at Scattergood, which utilizes a velocity cap of similar design to those in use at SONGS.

To account for the reduction in impingement due to the velocity caps and fish return systems, the percent reduction from the use of the velocity caps (88.17%) was applied to the annual combined fish impingement and fish return abundance and biomass. The combined impingement reduction afforded by the velocity caps and FRSs at SONGS was calculated as:

$$1-(1-X)(1-Y)$$

Where:

X = Velocity cap impingement mortality reduction

Y = FRS impingement mortality reduction

The return estimates derived from the 2006-7 were adjusted to account for fish survival through the FRSs. Survival estimates were modified from those reported from prior studies performed for the MRC (DeMartini et al. 1989), and were based on the weights of fish returned. Survival estimates were 68% for small fish (<30 g each), 82.5% for medium fish (30-199 g each), and 100% for large fish (>199 g each). The survival for medium-sized fishes reported in the MRC report (77%) was increased to 82.5% based on the statement that "*77% was probably an underestimate of survivorship for medium species; survivorship could be as high as 95%.*" Survival based on size class was preferred over species-specific survival (Love et al. 1989) since only a few taxa were analyzed in the species-specific analysis. To account for survival through the fish return system, the total estimated return (both abundance and biomass) was parsed into the three size classes discussed above. The respective survival estimates were applied to each size class, and the results summed to determine total survival through the FRS. Of the total number of fishes drawn into the SONGS cooling water intakes, it was estimated that 51.2% are subsequently returned to the ocean and survive transit (Table 6.4-2). When considering fish biomass, the survival estimate increased substantially to 80.1%.

Using the equation defined above, the combined impingement reduction afforded by the velocity caps and FRSs (taking into account return survival) at SONGS was 94.22% based on abundance and 97.65% based on biomass. These estimates were slightly lower than those calculated assuming all returned fishes survived transit (96.64% based on abundance and 98.72% based on biomass).

Estimates of calculation baseline for impingement are presented in Tables 6.4-3 and 6.4-4. The estimates for fishes assumed the number of juvenile/adult fishes entrained (estimated by summing the impingement and return totals) represented 11.83% (calculated as 100 – 88.17) of the total that would have been entrained without the use of the velocity caps. No adjustments were made for shellfish impingement based on the use of the velocity cap, since velocity caps have not been demonstrated to effectively exclude invertebrates.

Table 6.4-2. Summary of fish impingement, return, and return survival estimates for fishes at SONGS.

Common Name	Total Impinged and Returned		Total Returned		Estimated Surviving Return		% Entrained Surviving Return	
	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
northern anchovy	2,457,615	2,400.11	2,061,541	2,059.41	1,410,478	1,409.02	57.4	58.7
queenfish	1,486,437	18,468.78	773,500	14,869.19	554,497	10,659.24	37.3	57.7
Pacific sardine	208,117	3,896.03	100,651	2,621.71	76,804	2,000.57	36.9	51.3
salema	147,851	4,922.83	139,541	4,741.21	105,759	3,593.42	71.5	73.0
yellowfin croaker	147,601	60,423.95	138,343	57,136.70	131,241	54,203.68	88.9	89.7
deepbody anchovy	75,618	753.72	52,114	561.66	35,438	381.93	46.9	50.7
white seaperch	32,856	364.06	14,132	296.72	11,645	244.50	35.4	67.2
jacksmelt	31,415	3,173.07	27,377	2,873.29	24,134	2,532.91	76.8	79.8
white croaker	29,129	395.78	19,572	327.32	14,760	246.84	50.7	62.4
Pacific pompano	22,599	561.59	17,532	442.65	13,184	332.88	58.3	59.3
topsmelt	18,617	596.80	8,061	283.05	6,507	228.54	35.0	38.3
shiner perch	13,063	122.85	5,422	72.75	3,921	52.61	30.0	42.8
walleye surfperch	11,219	306.66	10,544	295.65	8,080	226.54	72.0	73.9
spotfin croaker	10,664	4,557.58	10,534	4,502.09	10,363	4,429.09	97.2	97.2
Pacific chub mackerel	10,163	1,088.12	8,416	909.23	7,336	792.54	72.2	72.8
zebraperch	9,660	6,393.24	9,442	6,248.84	9,442	6,248.84	97.7	97.7
slough anchovy	9,047	25.17	504	1.46	343	0.99	3.8	3.9
sargo	8,473	1,663.68	6,386	1,216.05	5,747	1,094.45	67.8	65.8
kelp pipefish	6,684	11.95	45	0.15	31	0.10	0.5	0.9
jack mackerel	4,580	192.87	3,103	124.97	2,509	101.04	54.8	52.4
rockpool blenny	2,757	10.23	10	0.02	7	0.01	0.3	0.1
plainfin midshipman	2,754	84.05	71	5.59	64	5.00	2.3	5.9
black perch	2,390	113.80	1,241	95.52	1,042	80.29	43.6	70.6
California lizardfish	2,299	53.84	647	20.38	490	15.43	21.3	28.7
Pacific barracuda	2,113	35.85	239	21.23	204	18.09	9.7	50.5
California scorpionfish	1,907	118.21	951	71.63	819	61.72	42.9	52.2
specklefin midshipman	1,525	110.64	189	32.83	178	31.00	11.7	28.0
white seabass	1,196	180.44	1,081	175.45	978	158.78	81.8	88.0
giant kelpfish	1,121	14.93	347	5.87	257	4.34	22.9	29.1
bat ray	1,018	3,097.65	729	2,962.49	725	2,944.46	71.2	95.1
speckled sanddab	914	6.93	298	1.58	203	1.07	22.2	15.5
barred sand bass	834	133.38	657	108.51	603	99.58	72.3	74.7
California halibut	830	605.92	678	592.01	603	526.39	72.7	86.9
California corbina	764	136.34	748	129.76	690	119.67	90.3	87.8
spotted turbot	623	27.75	140	16.70	120	14.28	19.3	51.5
pipefish, unid.	404	0.61	29	0.16	23	0.13	5.7	21.0
California grunion	394	8.12	84	2.04	57	1.39	14.5	17.1
cabezon	388	4.46	6	1.00	6	0.88	1.5	19.7
kelp bass	364	28.08	187	24.38	167	21.86	45.9	77.9
black croaker	325	27.56	199	17.51	167	14.73	51.4	53.4
Pacific electric ray	301	3,890.11	117	2,400.00	117	2,400.00	38.9	61.7
hornyhead turbot	283	18.80	14	2.74	12	2.36	4.2	12.6
rubberlip seaperch	276	6.18	98	4.16	84	3.54	30.4	57.2
halfmoon	225	33.14	220	32.49	202	29.89	89.8	90.2
basketweave cusk-eel	193	4.63	56	0.18	38	0.12	19.7	2.7
California butterfly ray	156	416.05	155	415.89	155	415.89	99.4	100.0
spotted kelpfish	156	1.90	-	-	-	-	0.0	0.0
senorita	134	3.17	1	0.10	1	0.09	0.7	2.7
dwarf perch	134	0.26	-	-	-	-	0.0	0.0
thornback	126	57.43	42	30.94	35	25.99	27.8	45.3
garibaldi	124	8.62	25	6.13	24	5.99	19.4	69.5

(table continued)

Table 6.4-2. (Cont.). Summary of fish impingement, return, and return survival estimates for fishes.

	Total Impinged and Returned		Total Returned		Estimated Surviving Return		% Entrained Surviving Return	
Common Name	**No.**	**Wt. (kg)**	**No.**	**Wt. (kg)**	**No.**	**Wt. (kg)**	**No.**	**Wt. (kg)**
shovelnose guitarfish	121	365.99	103	347.60	103	347.60	85.1	95.0
mussel blenny	103	0.48	-	-	-	-	0.0	0.0
bocaccio	98	0.28	-	-	-	-	0.0	0.0
horn shark	74	103.88	30	49.80	30	49.80	40.5	47.9
moray eel	71	26.55	1	1.20	1	1.20	1.4	4.5
spiny dogfish	70	170.80	56	140.00	56	140.00	80.0	82.0
barred surfperch	59	7.10	58	6.88	50	5.92	84.7	83.4
barcheek pipefish	58	0.12	-	-	-	-	0.0	0.0
diamond turbot	56	11.87	14	4.34	14	4.34	25.0	36.6
leopard shark	44	169.90	44	169.90	44	169.90	100.0	100.0
yellow snake eel	42	4.28	14	1.40	12	1.20	28.6	28.1
blacksmith	42	2.41	19	1.39	16	1.20	38.1	49.6
rock wrasse	38	3.44	5	0.33	4	0.28	10.5	8.2
kelp perch	34	0.54	14	0.28	10	0.19	29.4	35.5
round stingray	29	6.93	9	2.65	9	2.65	31.0	38.3
midshipman, unid.	28	0.57	28	0.57	19	0.39	67.9	67.9
giant sea bass	27	413.14	26	348.14	25	334.22	92.6	80.9
bay pipefish	27	0.03	-	-	-	-	0.0	0.0
brown rockfish	20	1.86	3	0.36	3	0.32	15.0	17.2
treefish	18	1.99	16	1.86	14	1.60	77.8	80.5
pile perch	17	4.22	15	3.90	15	3.63	88.2	86.0
Pacific staghorn sculpin	16	0.54	15	0.52	13	0.45	81.3	82.6
combtooth blenny, unid.	16	0.08	16	0.08	11	0.05	68.8	67.5
grey smoothhound	15	9.44	1	1.50	1	1.50	6.7	15.9
yellowfin goby	15	0.76	15	0.76	13	0.66	86.7	86.0
coralline sculpin	15	0.06	-	-	-	-	0.0	0.0
C-O sole	15	0.02	-	-	-	-	0.0	0.0
snubnose sculpin	15	0.02	-	-	-	-	0.0	0.0
finescale triggerfish	14	35.00	14	35.00	14	35.00	100.0	100.0
swell shark	14	13.19	-	-	-	-	0.0	0.0
fantail sole	14	1.02	-	-	-	-	0.0	0.0
snake eel, unid.	14	0.70	14	0.70	12	0.60	85.7	86.0
bay blenny	14	0.42	14	0.42	12	0.36	85.7	86.0
Cortez bonefish	14	0.01	-	-	-	-	0.0	0.0
spotted sand bass	6	0.20	-	-	-	-	0.0	0.0
vermilion rockfish	6	0.03	2	0.01	1	0.01	16.7	31.3
grass rockfish	5	1.63	2	1.03	2	1.03	40.0	63.2
striped kelpfish	5	0.08	-	-	-	-	0.0	0.0
California tonguefish	3	0.00	-	-	-	-	0.0	0.0
California sheephead	2	0.81	1	0.35	1	0.35	50.0	43.5
rockfish, unid.	2	0.37	-	-	-	-	0.0	0.0
spotfin surfperch	2	0.04	-	-	-	-	0.0	0.0
smoothhound, unid.	1	0.60	1	0.60	1	0.60	100.0	100.0
kelp rockfish	1	0.13	-	-	-	-	0.0	0.0
cusk-eel, unid.	1	0.10	-	-	-	-	0.0	0.0
curlfin sole	1	0.01	-	-	-	-	0.0	0.0
stripefin ronquil	1	0.01	-	-	-	-	0.0	0.0
sculpin, unid.	1	0.00	-	-	-	-	0.0	0.0
bay goby	1	0.00	-	-	-	-	0.0	0.0
Totals:	**4,769,741**	**120,919.50**	**3,416,569**	**107,882.96**	**2,440,796**	**96,887.71**	**51.17**	**80.13**

Table 6.4-3. Calculation Baseline estimates for fishes at SONGS.

Taxa	Common Name	Total Impinged and Returned No.	Total Impinged and Returned Wt. (kg)	Calculation Baseline Estimate No.	Calculation Baseline Estimate Wt. (kg)
Engraulis mordax	northern anchovy	2,457,615	2400.108	20,769,338	20,283.346
Seriphus politus	queenfish	1,486,437	18468.782	12,561,899	156,079.930
Sardinops sagax	Pacific sardine	208,117	3896.030	1,758,800	32,925.403
Xenistius californiensis	salema	147,851	4922.826	1,249,491	41,602.870
Umbrina roncador	yellowfin croaker	147,601	60423.945	1,247,378	510,643.587
Anchoa compressa	deepbody anchovy	75,618	753.716	639,049	6,369.664
Phanerodon furcatus	white seaperch	32,856	364.058	277,667	3,076.659
Atherinopsis californiensis	jacksmelt	31,415	3173.065	265,489	26,815.616
Genyonemus lineatus	white croaker	29,129	395.777	246,170	3,344.717
Peprilus simillimus	Pacific pompano	22,599	561.587	190,984	4,745.979
Atherinops affinis	topsmelt	18,617	596.795	157,333	5,043.523
Cymatogaster aggregata	shiner perch	13,063	122.849	110,396	1,038.199
Hyperprosopon argenteum	walleye surfperch	11,219	306.660	94,812	2,591.588
Roncador stearnsii	spotfin croaker	10,664	4557.576	90,122	38,516.137
Scomber japonicus	Pacific chub mackerel	10,163	1088.115	85,888	9,195.675
Hermosilla azurea	zebraperch	9,660	6393.240	81,637	54,029.359
Anchoa delicatissima	slough anchovy	9,047	25.166	76,456	212.678
Anisotremus davidsonii	sargo	8,473	1663.683	71,605	14,059.808
Syngnathus californiensis	kelp pipefish	6,684	11.952	56,487	101.007
Trachurus symmetricus	jack mackerel	4,580	192.870	38,706	1,629.947
Hypsoblennius gilberti	rockpool blenny	2,757	10.234	23,299	86.488
Porichthys notatus	plainfin midshipman	2,754	84.046	23,274	710.274
Embiotoca jacksoni	black perch	2,390	113.804	20,198	961.759
Synodus lucioceps	California lizardfish	2,299	53.843	19,429	455.028
Sphyraena argentea	Pacific barracuda	2,113	35.850	17,857	302.969
Scorpaena guttata	California scorpionfish	1,907	118.214	16,116	999.028
Porichthys myriaster	specklefin midshipman	1,525	110.638	12,888	935.003
Atractoscion nobilis	white seabass	1,196	180.439	10,107	1,524.892
Heterostichus rostratus	giant kelpfish	1,121	14.926	9,474	126.140
Myliobatis californica	bat ray	1,018	3097.649	8,603	26,178.274
Citharichthys stigmaeus	speckled sanddab	914	6.926	7,724	58.532
Paralabrax nebulifer	barred sand bass	834	133.383	7,048	1,127.222
Paralichthys californicus	California halibut	830	605.919	7,014	5,120.630
Menticirrhus undulatus	California corbina	764	136.340	6,457	1,152.211
Pleuronichthys ritteri	spotted turbot	623	27.747	5,265	234.490
Syngnathus sp	pipefish, unid.	404	0.605	3,414	5.113
Leuresthes tenuis	California grunion	394	8.116	3,330	68.588
Scorpaenichthys marmoratus	cabezon	388	4.458	3,279	37.675
Paralabrax clathratus	kelp bass	364	28.075	3,076	237.262
Cheilotrema saturnum	black croaker	325	27.561	2,747	232.918
Torpedo californica	Pacific electric ray	301	3890.111	2,544	32,875.381
Pleuronichthys verticalis	hornyhead turbot	283	18.796	2,392	158.845
Rhacochilus toxotes	rubberlip seaperch	276	6.176	2,332	52.193
Medialuna californiensis	halfmoon	225	33.142	1,901	280.083
Ophidion scrippsae	basketweave cusk-eel	193	4.629	1,631	39.120
Gymnura marmorata	California butterfly ray	156	416.048	1,318	3,516.027
Gibbonsia elegans	spotted kelpfish	156	1.904	1,318	16.091
Oxyjulis californica	senorita	134	3.167	1,132	26.764
Micrometrus minimus	dwarf perch	134	0.256	1,132	2.163
Platyrhinoidis triseriata	thornback	126	57.428	1,065	485.325
Hypsypops rubicundus	garibaldi	124	8.617	1,048	72.822
Rhinobatos productus	shovelnose guitarfish	121	365.994	1,023	3,093.020

(*table continued*)

Table 6.4-3. (Cont.). Calculation Baseline estimates for fishes at SONGS.

Taxa	Common Name	Total Impinged and Returned No.	Total Impinged and Returned Wt. (kg)	Calculation Baseline Estimate No.	Calculation Baseline Estimate Wt. (kg)
Hypsoblennius jenkinsi	mussel blenny	103	0.477	870	4.031
Sebastes paucispinis	bocaccio	98	0.279	828	2.358
Heterodontus francisci	horn shark	74	103.876	625	877.857
Gymnothorax mordax	moray eel	71	26.554	600	224.408
Squalus acanthias	spiny dogfish	70	170.800	592	1,443.433
Amphistichus argenteus	barred surfperch	59	7.099	499	59.994
Syngnathus exilis	barcheek pipefish	58	0.115	490	0.972
Pleuronichthys guttulatus	diamond turbot	56	11.872	473	100.330
Triakis semifasciata	leopard shark	44	169.900	372	1,435.827
Ophichthus zophochir	yellow snake eel	42	4.283	355	36.196
Chromis punctipinnis	blacksmith	42	2.407	355	20.342
Halichoeres semicinctus	rock wrasse	38	3.444	321	29.105
Brachyistius frenatus	kelp perch	34	0.535	287	4.521
Urobatis halleri	round stingray	29	6.928	245	58.549
Porichthys sp	midshipman, unid.	28	0.574	237	4.851
Stereolepis gigas	giant sea bass	27	413.140	228	3,491.452
Syngnathus leptorhynchus	bay pipefish	27	0.032	228	0.270
Sebastes auriculatus	brown rockfish	20	1.860	169	15.719
Sebastes serriceps	treefish	18	1.990	152	16.818
Rhacochilus vacca	pile perch	17	4.216	144	35.629
Leptocottus armatus	Pacific staghorn sculpin	16	0.541	135	4.572
Hypsoblennius sp	combtooth blenny, unid.	16	0.080	135	0.676
Mustelus californicus	grey smoothhound	15	9.438	127	79.761
Acanthogobius flavimanus	yellowfin goby	15	0.763	127	6.448
Artedius corallinus	coralline sculpin	15	0.061	127	0.516
Pleuronichthys coenosus	C-O sole	15	0.017	127	0.144
Orthonopias triacis	snubnose sculpin	15	0.015	127	0.127
Balistes polylepis	finescale triggerfish	14	35.000	118	295.785
Cephaloscyllium ventriosum	swell shark	14	13.188	118	111.452
Xystreurys liolepis	fantail sole	14	1.022	118	8.637
Ophichthidae	snake eel, unid.	14	0.700	118	5.916
Hypsoblennius gentilis	bay blenny	14	0.420	118	3.549
Albula sp	Cortez bonefish	14	0.014	118	0.118
Paralabrax maculatofasciatus	spotted sand bass	6	0.198	51	1.673
Sebastes miniatus	vermilion rockfish	6	0.032	51	0.270
Sebastes rastrelliger	grass rockfish	5	1.631	42	13.784
Gibbonsia metzi	striped kelpfish	5	0.082	42	0.693
Symphurus atricaudus	California tonguefish	3	0.004	25	0.034
Semicossyphus pulcher	California sheephead	2	0.805	17	6.803
Sebastes sp	rockfish, unid.	2	0.372	17	3.144
Hyperprosopon anale	spotfin surfperch	2	0.044	17	0.372
Mustelus sp	smoothhound, unid.	1	0.600	8	5.071
Sebastes atrovirens	kelp rockfish	1	0.131	8	1.107
Ophidiidae	cusk-eel, unid.	1	0.096	8	0.811
Pleuronichthys decurrens	curlfin sole	1	0.011	8	0.093
Rathbunella alleni	stripefin ronquil	1	0.007	8	0.059
Cottidae sp	sculpin, unid.	1	0.003	8	0.025
Lepidogobius lepidus	bay goby	1	0.001	8	0.008
	Totals:	**4,769,741**	**120919.498**	**40,309,147**	**1,021,892.334**

Table 6.4-4. Calculation Baseline estimates for macroinvertebrates at SONGS.

Taxa	Common Name	Total Impinged and Returned No.	Total Impinged and Returned Wt. (kg)	Calculation Baseline Estimate No.	Calculation Baseline Estimate Wt. (kg)
Cancer anthonyi	yellow crab	22,993	82.445	22,993	82.445
Portunus xantusii	Xantus swimming crab	17,388	81.188	17,388	81.188
Crangon nigromaculata	blackspotted bay shrimp	15,427	38.907	15,427	38.907
Cancer jordani	hairy rock crab	11,930	23.354	11,930	23.354
Dendraster excentricus	Pacific sand dollar	10,285	50.134	10,285	50.134
Cancer antennarius	Pacific rock crab	8,602	71.503	8,602	71.503
Cancer sp	cancer crab, unid.	4,624	4.942	4,624	4.942
Lysmata californica	red rock shrimp	4,451	3.926	4,451	3.926
Panulirus interruptus	California spiny lobster	3,998	965.346	3,998	965.346
Farfantepenaeus californiensis	yellowleg shrimp	3,505	110.732	3,505	110.732
Heptacarpus palpator	intertidal coastal shrimp	3,020	1.682	3,020	1.682
Caudina arenicola	sweet potatoe sea cucumber	1,836	68.421	1,836	68.421
Pachygrapsus crassipes	striped shore crab	1,470	3.310	1,470	3.310
Pyromaia tuberculata	tuberculate pear crab	1,172	1.750	1,172	1.750
Cancer gracilis	graceful crab	1,071	3.395	1,071	3.395
Pugettia producta	northern kelp crab	924	4.224	924	4.224
Petrolisthes cinctipes	flat porcelain crab	883	0.656	883	0.656
Octopus bimac./bimac.	California two-spot octopus	827	107.241	827	107.241
Pisaster ochraceus	ochre star	711	26.324	711	26.324
Neotrypaea californiensis	bay ghost shrimp	515	1.623	515	1.623
Heptacarpus sp	coastal shrimp, unid.	504	0.520	504	0.520
Cancer productus	red rock crab	453	1.548	453	1.548
Cycloxanthops novemdentatus	ninetooth pebble crab	437	3.725	437	3.725
Loxorhynchus grandis	sheep crab	432	359.916	432	359.916
Lophopanopeus bellus	blackclaw crestleg crab	410	0.905	410	0.905
Strongylocentrotus purpuratus	purple sea urchin	364	1.218	364	1.218
Loligo opalescens	California market squid	353	10.057	353	10.057
Polyorchis penicillatus	red jellyfish	331	0.508	331	0.508
Pilumnus spinohirsutus	retiring hairy crab	222	1.765	222	1.765
Thetys vagina	common salp	210	3.948	210	3.948
Blepharipoda occidentalis	spiny mole crab	201	3.593	201	3.593
Petrolisthes cabrilloi	Cabrillo porcelain crab	192	0.218	192	0.218
Hermissenda crassicornis	hermissenda	192	0.094	192	0.094
Petrolisthes eriomerus	flattop crab	168	0.196	168	0.196
Octopus rubescens	East Pacific red octopus	151	0.566	151	0.566
Cancer amphioetus	bigtooth rock crab	151	0.227	151	0.227
Chrysaora colorata	purple-striped jellyfish	144	96.852	144	96.852
Isocheles pilosus	moon snail hermit	140	0.600	140	0.600
Neotrypaea gigas	giant ghost shrimp	137	0.413	137	0.413
Strongylocentrotus franciscanus	red sea urchin	106	8.485	106	8.485
Pachycheles holosericus	sponge porcelain crab	103	0.302	103	0.302
Pachycheles rudis	thick claw porcelain crab	99	0.119	99	0.119
Lophopanopeus frontalis	molarless crestleg crab	84	0.210	84	0.210
Pachycheles pubescens	pubescent porcelain crab	84	0.182	84	0.182
Lepidopa californica	California mole crab	84	0.154	84	0.154
Aplysia californica	California seahare	70	10.054	70	10.054
Pisaster giganteus	giant-spined sea star	61	9.938	61	9.938
Dendronotus iris	giant-frond-aeolis	56	0.112	56	0.112
Pugettia richii	cryptic kelp crab	56	0.070	56	0.070
Dendronotus frondosus	leafy dendronotid	56	0.014	56	0.014
Paraxanthias taylori	lumpy rubble crab	54	0.267	54	0.267
Scyra acutifrons	sharpnose crab	49	0.259	49	0.259

(*table continued*)

Table 6.4-4. (Cont.). Calculation Baseline estimates for macroinvertebrates at SONGS.

Taxa	Common Name	Total Impinged and Returned No.	Total Impinged and Returned Wt. (kg)	Calculation Baseline Estimate No.	Calculation Baseline Estimate Wt. (kg)
Tegula eiseni	banded tegula	42	0.308	42	0.308
Renilla kollikeri	sea pansy	42	0.084	42	0.084
Pinnixa barnharti	pea crab no common name	42	0.070	42	0.070
Nassarius perpinguis	fat western nassa	42	0.056	42	0.056
Elthusa vulgaris	sea louse	42	0.042	42	0.042
Lytechinus pictus	white sea urchin	42	0.042	42	0.042
Alpheus clamator	twistclaw pistol shrimp	34	0.044	34	0.044
Hemigrapsus oregonensis	yellow shore crab	31	0.031	31	0.031
Pisaster brevispinus	short-spined sea star	28	0.196	28	0.196
Pagurus sp	hermit crab, unid.	28	0.140	28	0.140
Hemisquilla californiensis	mantis shrimp	28	0.112	28	0.112
Pinnixa sp	pea crab, unid.	28	0.056	28	0.056
Synalpheus lockingtoni	littoral pistol shrimp	24	0.024	24	0.024
Betaeus longidactylus	visored shrimp	22	0.020	22	0.020
Navanax inermis	California aglaja	19	0.043	19	0.043
Taliepus nuttallii	globose kelp crab	15	1.294	15	1.294
Asterina miniata	bat star	15	0.193	15	0.193
Golfingia procera	MBC peanut worm 1	15	0.085	15	0.085
Lophopanopeus sp	crestleg crab	15	0.017	15	0.017
Aurelia aurita	moon jelly	14	0.770	14	0.770
Astropecten armatus	spiny sand star	14	0.476	14	0.476
Cnidaria	sea jelly, unid.	14	0.336	14	0.336
Roperia poulsoni	mollusk	14	0.098	14	0.098
Dirona picta	spotted dirona	14	0.084	14	0.084
Calliostoma canaliculatum	channeled topsnail	14	0.070	14	0.070
Solenocera mutator	solenocerid shrimp 1	14	0.070	14	0.070
Lophopanopeus leucomanus	knobkneed crestleg crab	14	0.056	14	0.056
Randallia ornata	globose sand crab	14	0.056	14	0.056
Urechis caupo	innkeeper worm	14	0.056	14	0.056
Mopalia ciliata	MBC chiton 1	14	0.014	14	0.014
Ogyrides sp	longeye shrimp unid. A	14	0.014	14	0.014
Pentamera sp	white sea cucumber, unid.	14	0.014	14	0.014
Pinnixa faba	mantle pea crab	14	0.014	14	0.014
Pugettia dalli	spined kelp crab	10	0.010	10	0.010
Octopus sp	octopus, unid.	5	0.900	5	0.900
Pisaster sp	sea star, unid.	2	0.005	2	0.005
Protothaca staminea	Pacific littleneck	1	0.029	1	0.029
Pleurobranchaea sp	sea slug , unid.	1	0.014	1	0.014
Cystodytes lobatus	sea eraser	1	0.012	1	0.012
Loxorhynchus crispatus	moss crab	1	0.002	1	0.002
Petrolisthes sp	porcelain crab, unid.	1	0.002	1	0.002
Betaeus sp	visored shrimp, unid.	1	0.001	1	0.001
Gastropoda	nudibranch, unid.	1	0.001	1	0.001
Loxorhynchus sp	moss/sheep crab	1	0.001	1	0.001
	Totals:	**122,561**	**2,174.100**	**122,561**	**2,174.100**

7.0 DISCUSSION

7.1 OVERVIEW

The analysis of effects due to operation of the cooling water systems at SONGS was focused on fishes/invertebrates that were/are abundant in the waters off San Onofre, either as measured in previous studies or the present investigation. This approach was taken primarily because of the uncertainty associated with assessments of organisms that are in low abundance in the samples. The most abundant organisms may also have higher risk for population-level impacts, but their high entrainment levels also reflect their high overall abundance in the source water. At the other extreme, although no protected species were entrained or impinged during the study, even very low levels of impacts to these species would need to be assessed. The focus of our analyses also resulted from the uncertainty associated with assessments based on few direct observations. By focusing our analyses on the most abundant species in entrainment and impingement surveys, more accurate assessments could be made on those species. The entrainment estimates were based on two conservative assumptions: (1) operation of the SONGS cooling water systems during 52 weeks per year, and (2) an assumed entrainment survival rate of zero.

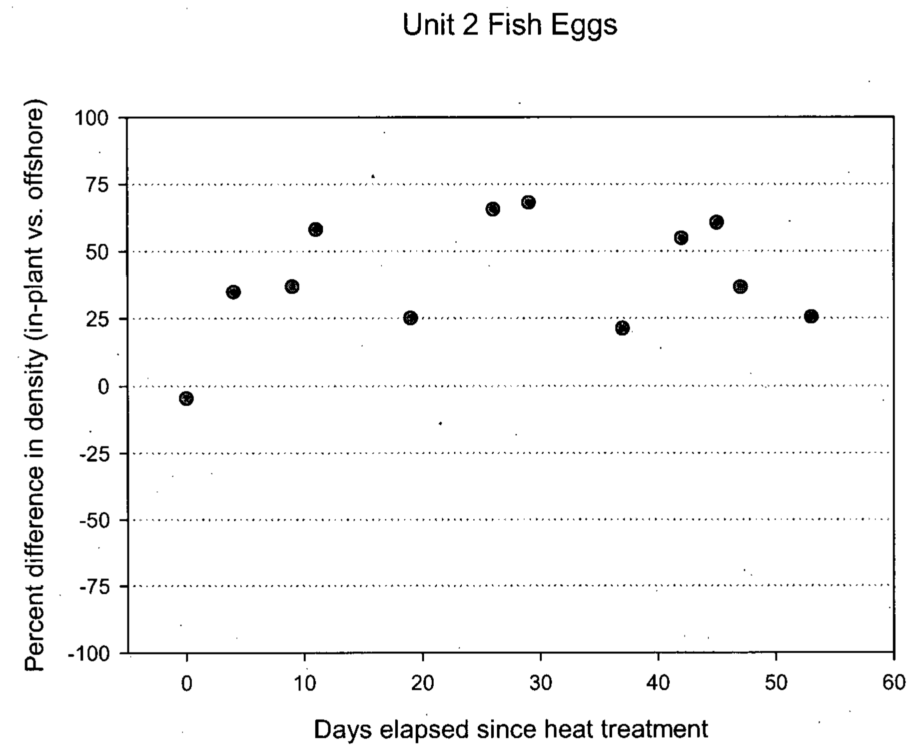
The larval fishes entrained by the SONGS cooling water systems differed somewhat from the juvenile and adult fishes that were impinged. The most abundant fish larvae in entrainment samples (anchovies) comprised nearly 70% of the larval concentrations measured during entrainment sampling. Anchovies were also abundant in impingement samples, comprising 29% of impingement abundance. The same was true of queenfish, which were the second most abundant and comprised 7% of larval concentrations and the majority (53%) of fish impinged. Conversely, other species relatively abundant in impingement samples (such as Pacific sardine) were not as abundant in the entrainment samples, comprising about 0.1% of entrainment density. Furthermore, the various surfperch species, which were relatively abundant in impingement samples, are not subject to larval entrainment impacts because they bear live young that are susceptible only to impingement.

7.2 SUMMARY OF ENTRAINMENT RESULTS

The most abundant larval taxa affected by entrainment in 2006-7 included northern anchovy, queenfish, clinid kelpfishes, combtooth blennies, gobies, and white croaker. The most abundant fish eggs in entrainment samples could not be identified to the family level due to the limitations in fish egg taxonomic knowledge in southern California. Total annual entrainment based on in-plant collections were approximately 1.1 to 1.4 billion larvae per unit, and 13 to 14 billion fish eggs per unit. Egg and larval concentrations peaked in spring, and were relatively low throughout the remainder of the year. There was no clear diel pattern of entrainment with fish eggs, although larvae were generally entrained in higher numbers at nighttime.

Greater concentrations of larvae were measured at the offshore entrainment station than the in-plant entrainment stations, particularly for anchovies. Estimated annual entrainment based on offshore samples was approximately three times higher than the estimates from in-plant samples for larvae, but only about 40% higher than the in-plant estimates for fish eggs. This could be due to several factors, including differences in sampling methodology, sampling frequency, etc. Concentrations of fish larvae were higher in-plant than offshore during 5 of the 13 paired surveys at both units, and fish egg concentrations were higher in-plant during 11 of the 13 paired surveys (Figures 7.2-1 and 7.2-2; positive numbers indicate higher concentrations in-plant compared with offshore). Analysis of differences in egg/larval concentrations and days elapsed since heat treatments indicates that cropping of eggs/larvae within the intake system was not a major factor in the differences. Studies at the Scattergood Generating Station (adjacent to Santa Monica Bay, California) determined that the numbers of eggs and larvae can be substantially reduced by both the fouling community and fish within the forebay of a cooling water intake system, and that with increasing duration since heat treatment, both communities grow and the level of cropping can increase (IRC 1981). The high concentrations of larvae offshore in April 2006 (>8,000 larvae per 1,000 m^3) and June 2006 (>11,000 larvae per 1,000 m^3) resulted in relatively higher entrainment estimates; 34% of annual entrainment was estimated to occur in April, with another 46% in June.

While the absolute numbers of eggs and larvae may seem relatively large, it is important to put these losses in context. For example, a single female queenfish can produce more than 2,000,000 eggs per year. Batch fecundity of white croaker can reach 37,200 eggs, with spawning occurring up to 24 times per season. It was previously estimated that queenfish produce between 5 trillion and 900 trillion eggs per kilometer of coastline per year, and of these, 500 billion to 99 trillion were expected to die from natural mortality within the first week (MBC 1988). Similarly, it was estimated that for northern anchovy 250 billion larvae per day die during the first eight days due to natural mortality. Other taxa, such as gobies, are primarily distributed in estuarine and enclosed bay habitats, and are not normally found along the open coast in habitat such as that surrounding SONGS. The coastal habitat off the generating station is not well suited for gobies, and it is unlikely there are large numbers of adult gobies off San Clemente. More likely, adult populations are concentrated in nearby coastal embayments and their larvae are dispersed in these environs and transported to coastal waters by tidal flushing and prevailing currents.



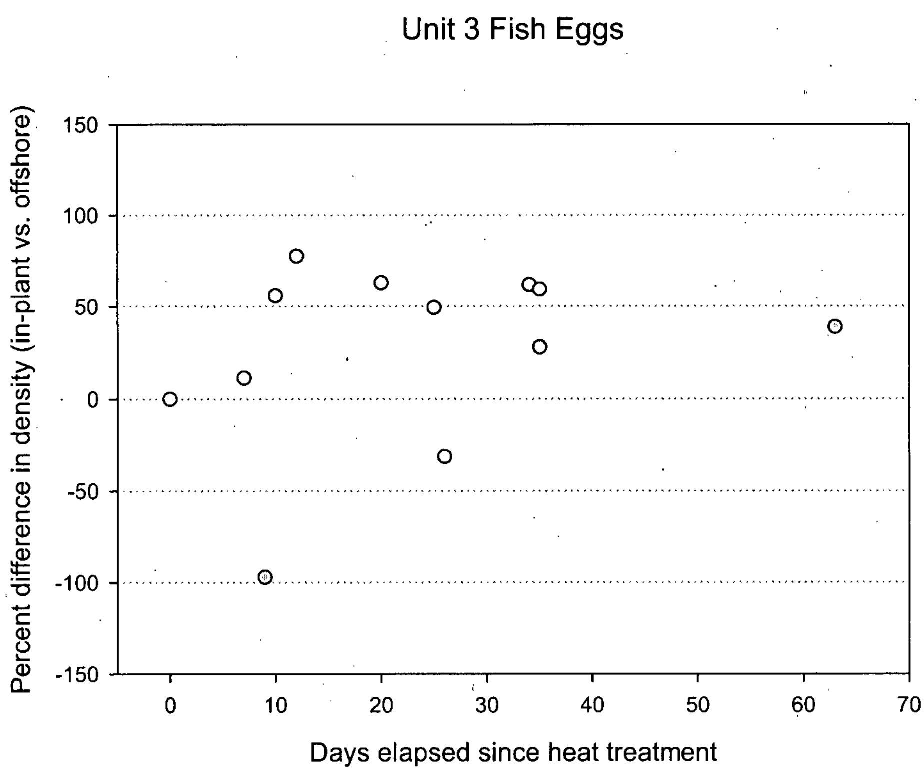
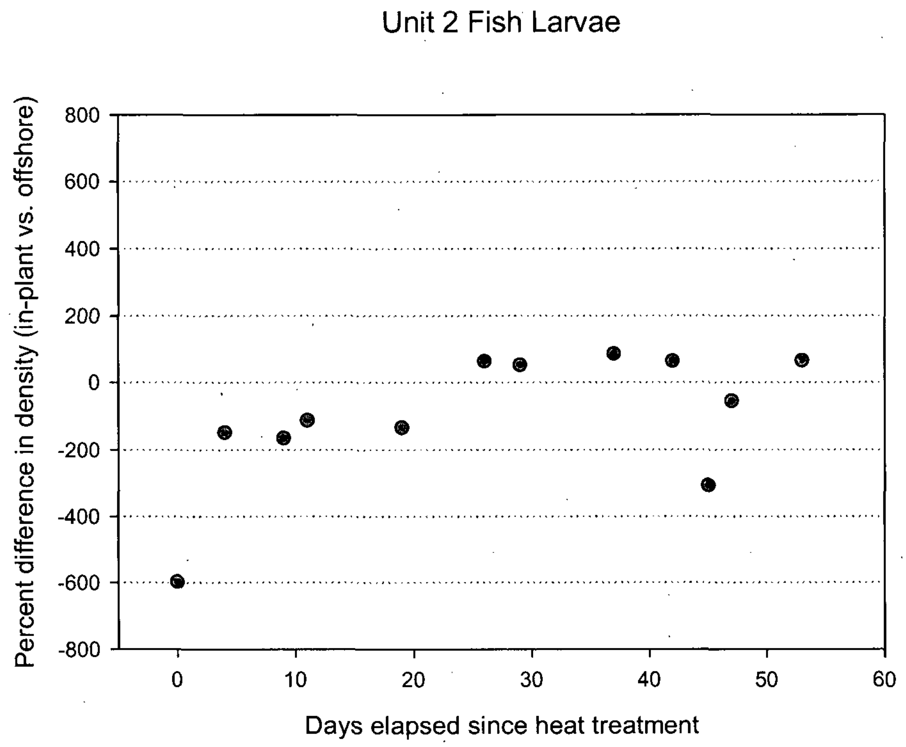


Figure 7.2-1. Percent difference in fish egg concentrations between in-plant and offshore samples plotted against days elapsed since the last heat treatment at Units 2 and 3 during 2006-7.



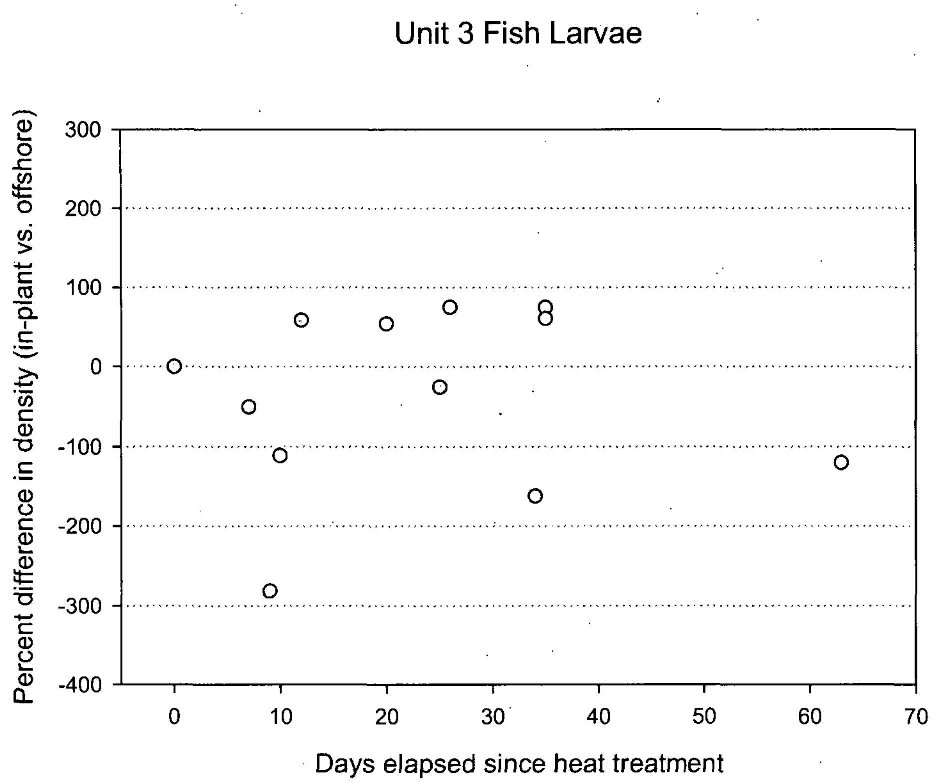


Figure 7.2-2. Percent difference in larval fish concentrations between in-plant and offshore samples plotted against days elapsed since the last heat treatment at Units 2 and 3 during 2006-7.

7.2.1 Summary of Previously Collected Entrainment Data

The environmental effects of SONGS Units 2 and 3 were studied extensively in the 1970s and 1980s, and include one of the most comprehensive entrainment studies conducted in California. The pre- and post-operation environmental studies were required by California Coastal Commission (CCC), and overseen by the Marine Review Committee (MRC). The MRC study/review process began in 1975 and concluded in 1989, and investigated potential effects from the operation of SONGS to plankton, juvenile/adult fish, kelp, benthos, and water quality. Fish larvae were sampled with a Before-After/Control-Impact Paired (BACIP) sampling design

Preoperational surveys were conducted between July 1979 and November 1981, and operational monitoring began in May 1984. Ichthyoplankton was collected along two transect lines: an 'impact' line 1.0 km downcoast of SONGS and a 'control' line 18.5 km downcoast of SONGS. Each transect consisted of five contiguous 'blocks' extending from inshore to offshore within 7.2 km of shore (between the 6-m and 75-m isobaths). Within each of the blocks, a depth contour for sampling the surface (neuston), midwater, and near-bottom (epibenthos) layers of the water column was randomly selected. Neuston was sampled with an 88-cm wide Manta net, the midwater was sampled with an opening-closing 71-cm bongo net in a stepped-oblique tow, and a 2-m wide Auriga net was used to sample the epibenthos. All sampling gear was fitted with 333-µm mesh Nitex nets and calibrated flowmeters, with a target sample volume of 400 m^3. All sampling was conducted at nighttime.

Table 7.2-1 summarizes larval fish concentrations off SONGS and the control area during preoperational and operational periods (from MEC 1985). The results presented in Table 7.2-1 illustrate differences in densities at both affected and unaffected areas. Some species, such as white croaker, showed marked declines in both areas between preoperational and operational periods. Others, such as sea basses (*Paralabrax* spp) increased between the two periods at both sites.

Barnett et al. (1984) examined the spatial distribution and vertical stratification of ichthyoplankton off SONGS. As depicted in Table 7.2-2, the number of larvae under 100 m^2 of sea surface off SONGS increases substantially with distance offshore, which is expected given the increase in volume with increasing depth. Fifteen of the nineteen most abundant taxa showed statistically significant abundance patterns, with five taxa principally in the nearshore epibenthic layer (white croaker, queenfish, *Gibbonsia*, *Gobiesox*, and Goby Type A), one in the nearshore neuston (Atherinidae), two taxa in the neuston/midwater within 5 km from shore (diamond turbot [*Pleuronichthys guttulatus*] and *Hypsoblennius* spp), two in the midwater 2-5 km from shore (northern anchovy and California halibut), and four in the midwater offshore from 3.5 km (hornyhead turbot [*Pleuronichthys verticalis*], *Citharichthys* spp, *Sebastes* spp, and *Stenobrachius leucopsarus*). Northern anchovy increased with increasing depth from inshore to well offshore (75 m depth). White croaker increased from near shore to 12-45 m depth, and then decreased to 75 m. Rockfish (*Sebastes* spp) were virtually absent from the nearshore zone (6-12 m) then increased with distance offshore. Silversides (Atherinidae) and Goby Type A were two examples of taxa concentrated in shallower waters compared with deeper waters.

Seasonality of larval fishes off San Onofre was described by Walker et al. (1987), who found two major larval assemblages: a winter/spring (December-May) assemblage, and a summer/fall (June-November) assemblage. The winter/spring assemblage was comprised primarily of northern anchovy, white croaker, scorpionfishes (*Sebastes* spp), and California halibut, while the most abundant members of the summer/fall assemblage included queenfish, sea basses (*Paralabrax* spp), and combtooth blennies (*Hypsoblennius* spp), although northern anchovy was still the dominant taxa.

Table 7.2-1. Relative abundance of ichthyoplankton (No. per 1,000 m^3) at SONGS and control sites during preoperational and operational surveys (MEC [1985]; S/F = Summer/Fall; W/S = Winter/Spring).

	Preoperational Period				**Operational Period**			
	SONGS		**Control**		**SONGS**		**Control**	
Taxon	**S/F**	**W/S**	**S/F**	**W/S**	**S/F**	**W/S**	**S/F**	**W/S**
Engraulis mordax	324.8	4,087.5	381.3	2,822.5	360.1	301.7	557.9	201.0
Seriphus politus	139.9	285.0	162.9	171.9	29.4	301.7	34.8	275.0
Paralabrax spp	95.0	0.0	74.9	0.0	108.3	0.0	110.1	1.6
Hypsoblennius spp	60.8	26.9	51.5	23.2	6.1	34.0	9.4	27.5
Paralichthys californicus	44.7	133.6	48.6	88.5	27.8	21.0	33.8	8.4
Pleuronichthys ritteri	12.6	3.9	7.2	1.1	0.7	3.4	6.9	0.0
Pleuronichthys verticalis	8.2	12.1	12.8	16.4	13.5	10.5	2.9	0.5
Genyonemus lineatus	4.2	1,044.0	11.7	811.8	0.1	27.5	0.7	10.4
Gobiidae Type A	2.6	5.8	11.7	3.2	10.1	20.2	46.8	36.1
Citharichthys spp	2.4	1.9	2.3	2.1	23.6	0.2	8.4	0.0
Chromis punctipinnis	1.4	0.0	4.9	0.0	6.8	0.0	0.0	0.0
Gobiesox rhessodon	1.2	2.2	0.1	0.8	3.9	0.8	0.0	0.1
Sebastes spp	1.1	2.7	0.7	4.6	0.0	4.0	0.0	5.1
Atherinidae	1.0	17.9	1.4	22.4	0.0	8.0	0.0	9.9
Hypsopsetta guttulata	0.9	4.8	0.4	2.3	0.0	0.3	0.4	0.1
Gibbonsia Type A	0.8	3.5	0.3	1.1	0.5	1.5	0.0	0.2
Stenobrachius leucopsarus	0.4	10.1	0.5	6.5	0.0	3.1	0.0	0.0
Parophrys vetulus	0.1	0.6	1.0	0.0	0.0	0.0	0.0	0.0
Peprilus simillimus	0.0	7.1	0.0	7.5	0.0	0.0	0.6	0.0

Table 7.2-2. Number of fish larvae under 100 m^2 of sea surface off SONGS during 57 surveys (From Barnett et al. [1984]).

Offshore limit (km):	**0.5 - 1.1**	**1.1 - 1.9**	**1.9 - 3.7**	**3.7 - 5.4**	**5.4 - 7.2**
Depth range (m):	**6 - 9**	**9 - 12**	**12 - 22**	**22 - 45**	**45 - 75**
Taxon					
Engraulis mordax	970	1,833.4	6,454.4	9,250.2	10,263.5
Genyonemus lineatus	132.7	312.4	623.3	566.5	221.1
Sebastes spp	<0.1	<0.1	18.2	77.7	518.6
Seriphus politus	273.9	3.9	217.9	118.9	93.7
Paralichthys californicus	4.3	11.4	90	103.2	42.4
Paralabrax spp	0.1	0.8	34.3	97.8	84.1
Hypsoblennius spp	27.5	26.9	48.1	63	36.9
Stenobrachius leucopsarus	0.1	0.4	4.4	29.1	106.1
Atherinidae	35.7	28.1	11.7	8.9	4.9
Citharichthys spp	2.9	3.5	9.9	17.9	31
Pleuronichthys verticalis	0.4	2.3	13.4	36.4	11.7
Pleuronichthys ritteri	<0.1	0.2	5.6	30.9	13.9
Chromis punctipinnis	0	0	0.8	6.6	53.3
Gobiidae Type A	24.5	17.5	3.5	2.9	1.1
Parophrys vetulus	0.5	0.3	0.1	7.3	33.6
Peprilus simillimus	2	4.1	3.6	10	17.4
Gobiesox rhessodon	4.6	12.1	5.3	1.1	3
Gibbonsia Type A	6.4	10.3	1.5	0.3	1.1
Hypsopsetta guttulata	3.1	3.2	3.9	0.6	0.7
	1,489	**2,271**	**7,550**	**10,429**	**11,538**

The average annual entrainment estimates for SONGS was estimated by averaging the density of plankton in the water column at or near intake depth over eight years (1978-1986) and then multiplying that number by the volume of water withdrawn at SONGS under specific operating conditions. Annual entrainment estimates ranged from 4.2 billion to 6.2 billion larvae annually depending on flow volume (Barnett et al. 1987; Kastendiek and Parker 1988) (Table 7.2-3). Approximately 41% to 65% of the larvae drawn into the plant were northern anchovy, with another 3% comprised of species with sport/commercial fishing importance. Egg entrainment ranged from 13.7 to 19.0 billion fish eggs, with approximately 13% comprised of anchovy eggs.

Table 7.2-3. Annual number of fish larvae/eggs estimated to be entrained at SONGS (From MEC [1987] and Kastendiek and Parker [1988]).

	75% Flow		100% Flow	
	Midwater Only	Water Column	Midwater Only	Water Column
All fish larvae	4,261,500,000	4,645,600,000	5,682,000,000	6,194,100,000
Engraulis larvae	2,888,800,000	1893,300,000	3,851,800,000	3,758,700,000
21 other taxonomic groups	132,600,000	122,600,000	176,800,000	163,400,000
All fish eggs	14,255,200,000	13,763,700,000	19,006,900,000	18,351,500,000
Engraulis mordax eggs	1,824,600,000	1,819,300,000	2,432,800,000	2,425,700,000

The MRC studies also estimated that 1,350 tons (dry weight) of zooplankton were taken into the Units 2&3 intakes each year (Murdoch et al. 1989c). Contrary to expectations, the plant appeared to have increased the local abundance of meroplankton, and to have had no distinguishable effect on holoplankton. The abundance of meroplankton (including barnacle nauplii, bryozoan larvae, and unidentified meroplankton) increased at SONGS relative to the control site by about 60% on average. Lastly, the MRC examined losses to phytoplankton and determined "SONGS has not reduced the local abundance of phytoplankton: no statistically significant change was detected, and ignoring statistical considerations, there was an increase in relative concentration near SONGS."

The entrainment of white croaker was analyzed further in a special study that took place in spring 1991 (Jahn 1991). The objective of the study was to test the overall proportional withdrawal assumption (that withdrawal in the SONGS cooling water intake structures affects 100% of the organisms within the affected source waters) by comparing field densities of postflexion stage white croaker to their densities in the SONGS Units 2&3 cooling water streams. This was accomplished by sampling offshore in the epibenthic layer and water column with Auriga and bongo nets fitted with 500 μm mesh nets. Samples were collected at nighttime immediately downcoast of the Unit 3 intake along the 9-m depth contour. In-plant samples were collected from the Units 2&3 intake wells with 0.5-m conical plankton nets with 500 μm mesh. Epibenthic densities of postflexion white croaker larvae at nighttime averaged 3,646 larvae per 1,000 m^3, compared with 14 per 1,000 m^3 in midwater and 46 per 1,000 m^3 measured in the generating station (Jahn 1991). The study confirmed that epibenthic stages of white croaker (and presumably other larval taxa with strongly epibenthic stages) are withdrawn less than midwater counterparts. This may suggest that earlier MRC studies overestimated white croaker entrainment.

7.2.2 QA/QC Procedures and Data Validation

The MRC operated under a stringent internal and external review process, and all scientific reports were distributed for review by the MRC and outside scientists. The MRC hired a statistical analyst to evaluate all analyses performed by scientific contractors and to make recommendations for improving the studies and analyses. A data analyst was also employed by the MRC to ensure the integrity of the MRC data. External consultants and reviewers were engaged throughout the study periods as needed or when a particularly difficult problem of study design arose. The technical reports submitted by contractors were subject to standard internal and external review. During the MRC process, 99 non-

MRC scientists either reviewed reports or consulted on various aspects of the program, and between 1982 and 1989, at least 573 written reviews were submitted (Murdoch et al. 1989c).

7.2.3 Comparison of 2006-7 Results with Previously Collected Entrainment Data

The dominance of northern anchovy in entrainment and offshore samples is consistent with results from the previous ichthyoplankton investigations at SONGS (Barnett et al. 1984; MEC 1985). The winter/spring peak in larval abundance measured during the current study is also similar to the pattern noted during the previous plankton studies (Walker et al. 1987). Direct comparison of densities of various species between the current study and previous studies is confounded by differences in sampling methodologies. The vertical distribution of larval taxa offshore was consistent with that recorded in previous studies off SONGS (Barnett et al. 1984), as expected. One noticeable difference was the high concentrations of clinid kelpfishes in the neuston in 2007, which were many times higher than concentrations measured in the water column and epibenthos along the intake isobath. During the MRC studies, clinid kelpfishes were most abundant in the midwater and epibenthic layers.

The midwater concentrations of fish larvae measured in the present study appeared to be substantially lower than those measured during the MRC studies. Concentrations of northern anchovy larvae, for instance, appeared to be two times higher or more during the MRC studies than at present. Many of the reported species-specific concentrations reported in MEC (1987) and Kastendiek and Parker (1988) appear to be erroneous, and inconsistent with total annual entrainment estimates calculated during that time period. For instance, based on maximum cooling water flow, the annual entrainment of 5.7 to 6.2 billion fish larvae annually equates to a mean density of 1.6 to 1.8 larvae per m^3, well below the mean species-specific densities reported by MEC (1987) and Kastendiek and Parker (1988), and more consistent with densities reported in other previous studies of the area (SCE 1980; Jahn 1991). The mean concentration of larval fishes during present study was 0.7 fish per m^3 as measured in-plant, and 2.0 fish per m^3 as measured offshore.

From 1951 through the mid-1990s, macrozooplankton biomass in waters off southern California decreased by 80%, coinciding with a temperature increase in the oceanic surface layer (Roemmich and McGowan 1995). Most of the fish species analyzed feed on zooplankton with the decrease possibly affecting overall fish abundance. The Pacific Decadal Oscillation (PDO) describes multidecadal cycles of warm and cold oceanic regimes off California. The PDO affects climate (water temperature, upwelling, productivity, precipitation, and runoff) along the Pacific Coast. When the Aleutian Low atmospheric pressure cell is strong, there is a warm temperature regime off California. During this time, the California Current is weak, upwelling is reduced, and productivity is low. However, precipitation and runoff are high. When the Aleutian Low is weak, the California Current is strong, upwelling is greater, and precipitation and runoff are low. Regime shifts between the two have caused shifts in fish populations in the Pacific Ocean (Allen et al. 2004).

Hsieh et al. (2005) examined long-term larval abundance off southern California and its relationship with several factors. When abundances between the cold period (1951-1976) and the warm period (1977-1998) were compared, larval densities of Pacific sardine and Pacific chub mackerel increased significantly, while densities of northern anchovy larvae decreased slightly. *Paralabrax* larvae increased significantly, and were positively correlated with shifts in the PDO. Allen et al. (2004) found a significant positive correlation in the abundance of several species, including spotted kelpfish, and shifts in the PDO. Other fish species, including combtooth blennies, northern anchovy, and deepbody anchovy, correlated negatively with the PDO.

The CalCOFI program has sampled fish eggs and larvae throughout the SCB since 1951, and the abundance of both has varied substantially (Moser et al. 2001). As mentioned previously, production in the California Current region decreased substantially following the regime shift of 1977. Along with El Niño and La Niña events, the regime shift resulted in major changes in the distributions of larval fishes as the boundaries between subarctic and equatorial water masses shifted latitudinally. From 1977 to 1998, annual density of fish larvae in the Bight ranged between about 350 and 1,200 larvae per 10 m^2, with annual fluctuations exceeding 200%. (The CalCOFI program standardizes egg and larvae concentrations to area of sea surface as opposed to the volume of sea water.) Concentrations of fish eggs ranged between about 500 and 1,400 eggs per 10 m^2, with annual variability between the high and low values.

In King Harbor (Redondo Beach, California), larval fish densities decreased substantially during the period 1974-1997 (Stephens and Pondella 2002). The authors noted that the decrease was probably attributable to changing oceanic conditions, although zooplankton volume lagged by about 10 years. Habitat alteration was listed as another potential reason for the decrease in larval abundance.

In summary, there is high year-to-year variability in the densities of fish eggs and larvae in southern California. The relatively high concentrations of fish eggs and larvae measured off SONGS in April 2006 were not measured in April 2007; however, this may just be due to timing of spawning events in 2007. The potential decrease in density of fish eggs and larvae between the MRC studies and the present study is a region-wide occurrence that has been documented in other studies throughout the Bight.

7.3 SUMMARY OF IMPINGEMENT RESULTS

The most abundant fish taxa in impingement samples in 2006-7 included queenfish, northern anchovy, Pacific sardine, and deepbody anchovy. The most abundant macroinvertebrates in impingement samples included rock crabs, Xantus swimming crab, blackspotted bay shrimp, and Pacific sand dollar. Total annual impingement was approximately 1,353,000 fishes weighing 13,037 kg (28,747 lbs), and 117,858 macroinvertebrates weighing 1,309 kg (2,886 lbs). Fish impingement peaked in summer and winter (June and December), while invertebrate abundance was highest from November through March. Impingement was generally higher at nighttime than daytime.

7.3.1 Summary of Previously Collected Impingement Data

Impingement sampling has been conducted at Unit 2 since 1982 and at Unit 3 since 1983 as required by the SONGS NPDES permit (SCE 2006). These data are summarized to provide information on historical impingement at SONGS. An estimated total of 51,522,167 fish weighing 638,495 kg (1,407,639 lbs) were impinged during the impingement sampling program at SONGS since monitoring began with initiation of operations at Unit 2 in 1982 (Table 7.3-1). The estimated average annual impingement from 1982 to 2005 based on extrapolations of impingement rates was 2,146,757 fish weighing 26,604 kg (58,652 lbs). Number of fish taxa collected between unit start-up and 2005 averaged 67 species at Unit 2 and 66 species at Unit 3, with the lowest number of species collected at both units found during unit start-up years, 1982 and 1983, respectively. Impingement abundance and biomass by year are depicted in Figures 7.3-1 and 7.3-2. The mean daily cooling water flow rate at Units 2 and 3 combined during between 1982 and 2005 varied from 2,749,485 to 9,224,181 m^3/day (726.34 to 2,436.77 mgd), with an average annual flow of approximately 2,767,405,000 m^3 (731.07 billion gallons).

Table 7.3-1. Annual fish impingement abundance and biomass (kg) at SONGS by unit.

	Unit 2		Unit 3	
Year	**No. Fish**	**Biomass (kg)**	**No. Fish**	**Biomass (kg)**
1982	48,234	641	-	-
1983	118,906	2,698	41,684	1,037
1984	71,954	2,014	106,806	1,658
1985	189,303	2,982	609,718	5,244
1986	1,170,974	11,293	1,626,241	11,799
1987	289,879	5,139	435,005	9,989
1988	704,725	7,627	949,511	34,084
1989	644,012	12,652	696,342	12,344
1990	767,130	18,426	573,515	6,058
1991	1,147,817	9,929	2,164,072	20,804
1992	535,470	5,054	1,588,002	12,279
1993	908,752	8,294	1,329,765	15,211
1994	317,071	4,426	602,860	9,153
1995	712,063	7,073	2,012,729	35,539
1996	1,317,175	15,146	2,074,864	24,276
1997	251,407	4,065	366,527	10,158
1998	278,439	8,193	707,247	15,986
1999	1,387,839	15,451	1,630,173	14,528
2000	675,102	10,033	1,665,183	18,618
2001	1,944,408	5,810	1,616,585	11,560
2002	775,180	6,583	711,736	8,391
2003	995,398	5,644	2,569,039	16,279
2004	1,950,486	21,920	2,494,533	32,324
2005	2,425,567	37,783	5,322,739	82,300
Total:	**19,627,291**	**228,875**	**31,894,876**	**409,620**
Mean:	**817,804**	**9,536**	**1,328,953**	**17,068**

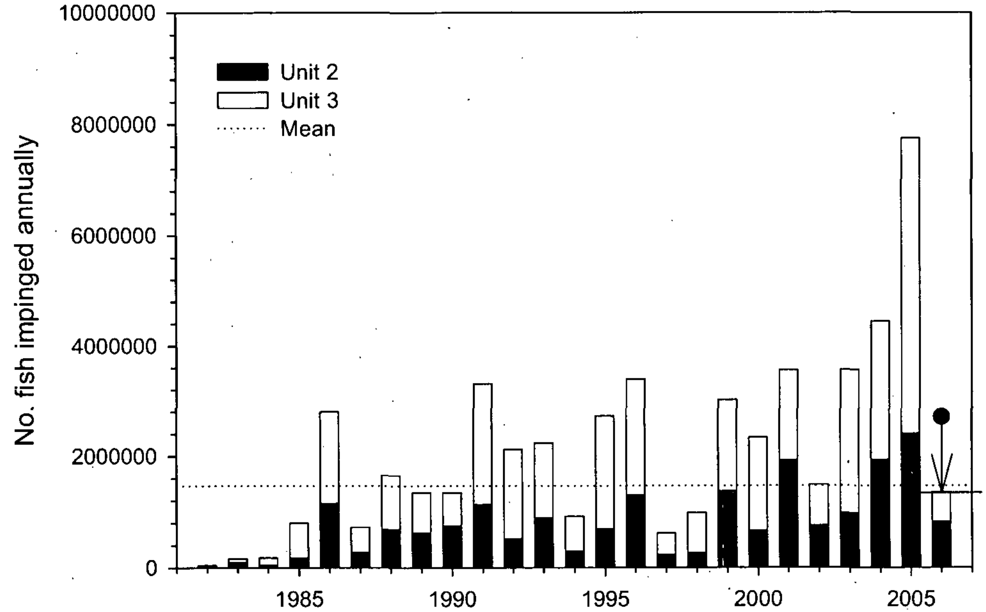


Figure 7.3-1. Estimated number of fish impinged annually by unit at SONGS, 1982-2005 (NPDES) and present 316(b) study (indicated by arrow).

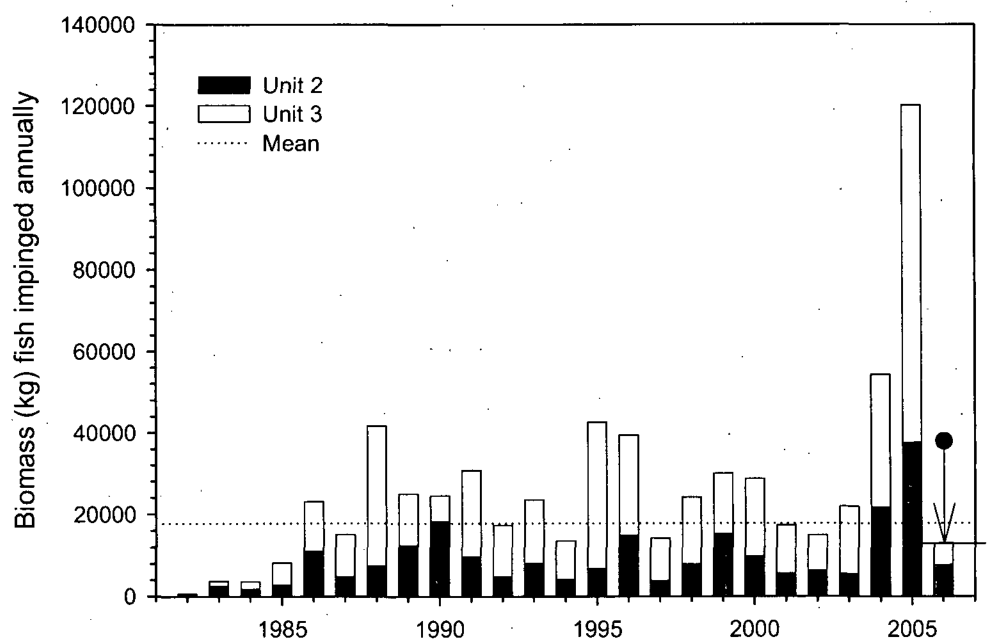


Figure 7.3-2. Estimated biomass (kg) of fish impinged annually by unit at SONGS, 1982-2005 (NPDES) and present 316(b) study (indicated by arrow).

Impingement abundance and biomass at SONGS typically peaked in summer (July). During the most recent year of impingement monitoring at SONGS (2005), a total of four normal operation impingement surveys was performed at each unit. In addition, 9 heat treatment surveys occurred at Unit 2 and 10 heat treatments were performed at Unit 3. During these surveys, an estimated total of 7,748,306 fish weighing 120,083 kg (264,737 lbs) was impinged. The most abundant fish species impinged were Pacific sardine and northern anchovy, which combined accounted for 82% of the total estimated impingement abundance and 79% of estimated biomass impinged.

7.3.2 QA/QC Procedures

During the NPDES impingement surveys (1983–2005), sampling was done in accordance with technical specifications developed as part of the Environmental Technical Specifications (ETS) set forth by the Nuclear Regulatory Commission (NRC; previously called the Atomic Energy Commission) and the SDRWQCB in the NPDES permit for the plant. The data from 1982 through 1990 were inputted into the Environmental Monitoring Database Access System (EMDAS) and rechecked for errors by reentering data from original data sheets by two separate operators and using computer comparisons to detect any entry errors. From 1991 through 2005 data sheets were checked for errors by the supervising field biologist, the data were then verified by the Project Manager. Additional data checks are listed below.

Specimens of uncertain identity were crosschecked against taxonomic voucher collections maintained by MBC, as well as available taxonomic literature. Occasionally, outside experts were consulted to assist in the identification of species whose identification was difficult. Scales used to measure biomass (spring and electronic) were calibrated every three months.

The following measures were employed to ensure accuracy of all data entered into computer databases and spreadsheets:

- Upon returning from the field, all field data sheets were checked by the Project Manager for completeness and any obvious errors;
- Data were entered into pre-formatted spreadsheets;
- After data were entered, copies of the spreadsheets were checked against the field data sheets;

Data were submitted annually to the SDRWQCB, NRC, U.S. EPA Region IX, and the California Department of Fish and Game.

7.3.3 Comparison with Previously Collected Impingement Data

Impingement sampling has been conducted since initiation of operations at each unit as required by the SONGS NPDES permit (SCE 2006). As a result, impingement data is available from Unit 2 since 1982 and from Unit 3 since 1983. In yearly monitoring reports from these years to the present, impingement results have been reported only for the present reporting year. Historical summaries of annual impingement have been reported as part of the NPDES monitoring program. However, in this report, these data are analyzed to provide species-specific information on previously collected impingement samples at SONGS Units 2 and 3, with the most recent NPDES data available for 2005. Abundance and biomass values utilized represent total estimated impingement for each year, determined as an extrapolated daily impingement rate based on normal operation 24-hour impingement sampling results and flow rates, plus total impingement take during heat treatments.

The annual fish impingement abundance estimate for 2006-7 is similar to the long-term averages (Figure 7.3-1), but annual biomass was well below the long-term average (Figure 7.3-2). Impingement at SONGS has shown much variability since 1984, with abundances increasing in cycles of four to five years, and then dropping suddenly. Much of this variability is likely due to the shift in distribution of the several schooling fishes that predominate in the impingement samples based on oceanographic conditions. The high impingement in 2004 and 2005 resulted primarily from high impingement of Pacific sardine in normal operation impingement samples. As noted in Section 4.5.4.3, the biomass of Pacific sardine in southern California is increasing (see SCE 2007), and increased impingement of this species at coastal power plants is not limited to SONGS. The peaks in impingement in Figure 7.3-1 occurred during years when sea surface temperature was both warmer than average (such as 1986), and cooler than average (1991, 1996, and 2003-5).

Impingement abundance at SONGS is usually tied closely to the impingement of the three most abundant species: northern anchovy, Pacific sardine, and queenfish. In some years, impingement of one species is relatively high, such as in 2004 (Pacific sardine), 2003 (northern anchovy), 2001 (northern anchovy), and 2000 (queenfish). In other years, two or more species are impinged in relatively high numbers, leading to increased impingement, such as in 2005 (northern anchovy and Pacific sardine), and 1999 and 1986 (northern anchovy and queenfish). Regardless of the absolute impingement at SONGS, the same species continue to comprise the same core group of fish taxa impinged at SONGS.

As with fish larvae, declines of numerous juvenile/adult fish stocks have been documented in southern California since the MRC studies. Holbrook et al. (1997) estimated a 69% decrease in populations of 75 fish species at King Harbor and off Palos Verdes, California, between 1975 and 1993. Brooks et al. (2002) examined impingement data from four coastal generating stations, including SONGS, and determined the abundance of 37 fish species declined an average of 41% from 1978 to 1992. The authors attributed this to a regional decline in productivity (see Roemmich and McGowan 1995).

When compared with fishery losses, impingement totals in 2006-7 were minimal. For species that are commercially fished, impingement losses represented only a fraction of recently reported landings for those species, including northern anchovy (0.04%), Pacific sardine (0.005%), and California spiny lobster (0.9%). White croaker impingement represented a slightly higher fraction of the commercial catch (1.0%); however, this species is not a popular commercial target in southern California, with only 6,809 kg landed in 2006. The number of sea basses impinged (360) represented 0.1% of the recreational catch in southern California in 2006, and the number of yellowfin croaker impinged (9,258) represented about 6.7% of the southern California recreational catch of 2006.

7.4 SUMMARY OF FISH RETURN RESULTS

The most abundant fish taxa in FRS samples in 2006-7 included northern anchovy, queenfish, Pacific sardine, and salema. California spiny lobster was also highly abundant in FRS samples. Total annual return estimates for fishes were 72% based on abundance and 89% based on biomass. For invertebrates, return rates were approximately 4% based on abundance and 40% based on biomass. Fish and invertebrate return rates were highest in spring and early summer. Return was generally higher at nighttime than daytime for fishes, while there was no consistent pattern with respect to invertebrates. Concentrations of fish eggs in the FRS samples were very high, as were the larvae of northern anchovy and white croaker.

7.4.1 Summary of Previously Collected Fish Return Data

During the eleven-year period of FRS sampling from 1984 to 1994, an estimated 108,105,288 fish were entrapped into the Units 2 and 3 cooling water systems. Of this number, a reported 74,862,388 were estimated to have been returned to the ocean through the FRS, for a long-term return rate of more than 69%. Return rates were somewhat variable by unit and by year. At Unit 2, return percentages varied from 39% in 1989 to 87% of the fish drawn into the unit returned to the ocean in 1985 and 1997, with a long-term average return of 68% and an overall return rate of nearly 73% for the eleven-year period (Figure 7.4-1). At Unit 3, return percentages varied from 38% in 1990 to 80% in 1993 (Figure 7.4-2). Long-term, the average yearly return rate was 61%, but with all years for the study period combined the FRS at Unit 3 released about 67% of the fish entrapped back to the ocean.

The MRC studies were designed to allow estimation of species-specific FRS efficiencies. In 1989, the MRC reviewed fish entrapment at SONGS utilizing results for a 41-month period from 1983 to 1986. In the study, the MRC reported that in general medium and large fish were more likely to be diverted to the FRS and returned to the ocean than small species and that for most species, individuals diverted were larger than individuals that were impinged (Swarbrick and Ambrose 1989). For small species such as northern anchovy and queenfish, 68% of the number and 76% of the biomass were diverted to the FRS. Similarly, diversion rates for medium species were reported at 68% of the number of individuals and 66% of the biomass, while for large species, 74% of the number and 67% of the biomass were diverted. Species-specific return rates from the FRS monitoring program show that different species are differentially returned by the system. Return rates ranged from 41% for Pacific sardine to 97% for yellowfin croaker, a relatively large species (Figure 7.4-3). Northern anchovy and queenfish, the most abundantly entrapped fish at SONGS, had return rates of 83% and 65%, respectively

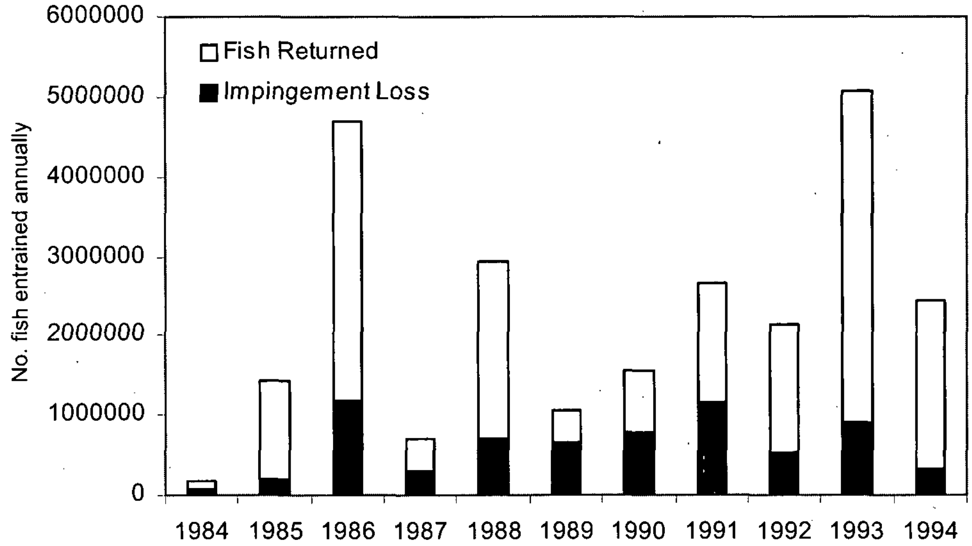


Figure 7.4-1. Estimated annual impingement and fish return abundance at SONGS Unit 2, 1984-1994.

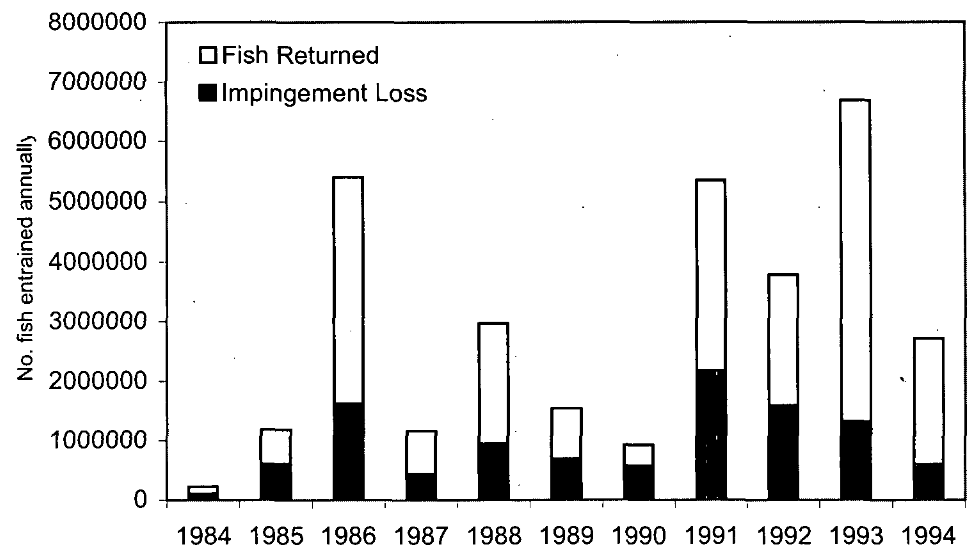


Figure 7.4-2. Estimated annual impingement and fish return abundance at SONGS Unit 3, 1984-1994.

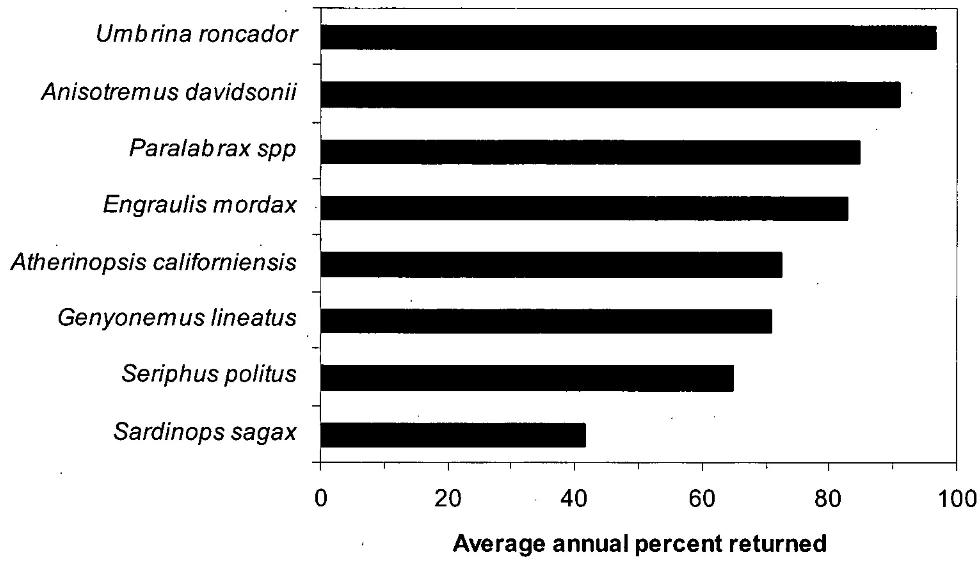


Figure 7.4-3. Average annual return rates (based on abundance) for select species at SONGS Units 2&3 combined from 1984-1994 based on data in Swarbrick and Ambrose (1989).

Survival of fishes through the Fish Return Systems was analyzed in 1984-5 (Love et al. 1989). Twice-weekly fish elevator and fish impingement samples were collected at Units 2 and 3, resulting in 55 samples at Unit 2 and 65 samples at Unit 3. Fish return samples were collected using two 15-in diameter dipnets to subsample the fish elevator as it was dumped – similar to methodology from the present study. Impingement was sampled by running the traveling screens during 22 to 26 hour intervals – also similar to current methodology. Fish return survival was evaluated *in situ* by collecting the fish at the FRS terminus in a 3.5 m^2 net. Survivorship was assessed for 96-hour periods after operation of the return system.

Fish return efficiency and survival results are presented for Unit 2 in Table 7.4-1, and for Unit 3 in Table 7.4-2. Analysis of survival was limited to taxa with >40 observations offshore. For instance, survival of deepbody anchovy at Unit 2 was reported as 50%, but was based on two individuals.

Table 7.4-1. SONGS Unit 2 Fish return diversion efficiency and survival (from Love et al. [1989]).

Taxon	No. Entrained	No. Returned	% Returned	% Survival[1]	Total % Return/Survival[1]
Northern anchovy	135,688	134,676	99.25	94.3	93.6
Queenfish	50,566	44,369	87.74	31.6	27.7
White croaker	644	601	93.32	49.5	46.2
Kelp bass	270	269	99.63		
Barred sand bass	89	86	96.63		
Sargo	211	210	99.53		
Yellowfin croaker	258	258	100.00	100.0	100.0
Pacific sardine	75	61	81.33		
Deepbody anchovy	889	708	79.64		
Slough anchovy	3,693	3,058	82.81		
All species	**196,978**	**188,583**	**95.74**		

1 – Only taxa with >40 individuals per unit observed offshore included.

Table 7.4-2. SONGS Unit 3 Fish return diversion efficiency and survival (from Love et al. [1989]).

Taxon	No. Entrained	No. Returned	% Returned	% Survival[1]	Total % Return/Survival[1]
northern anchovy	210,108	198,157	94.31	97.9	92.3
Queenfish	104,394	76,963	73.72	54.1	39.9
white croaker	52,938	20,390	38.52	25.0	9.6
kelp bass	165	161	97.58		
barred sand bass	50	47	94.00		
Sargo	284	282	99.30		
yellowfin croaker	2,026	2,021	99.75	97.0	96.8
Pacific sardine	0	0	-		
deepbody anchovy	3,809	1,883	49.44		
slough anchovy	27514	1230	4.47		
All species	**407,755**	**306,200**	**75.09**		

1 – Only taxa with >40 individuals per unit observed offshore included.

Survivorship was assessed based on fish size, with small fish (<30 g) averaging 68%, medium-sized fish (30-199 g each) averaging 77%, and large fish (>199 g) near 100% (DeMartini et al. 1989), with all fish in the nets measured at the completion of each test.

Utilizing these survivorship rates from the MRC report and the return rates presented above for the long-term data (1984-1994) it is possible to determine FRS efficiency estimates of 80% for northern anchovy and 44% for queenfish entrapped in SONGS that survive passage through the water intake and fish return systems. These estimates are similar, if slightly lower, than the efficiency estimates of 87% for northern anchovy and 48% for queenfish presented in the MRC report (Swarbrick and Ambrose 1989).

7.4.2 QA/QC Procedures

See sections 7.2 and 7.3 for discussion of QA/QC procedures during MRC and NPDES sampling periods.

7.4.3 Comparison with Previously Collected Fish Return Data

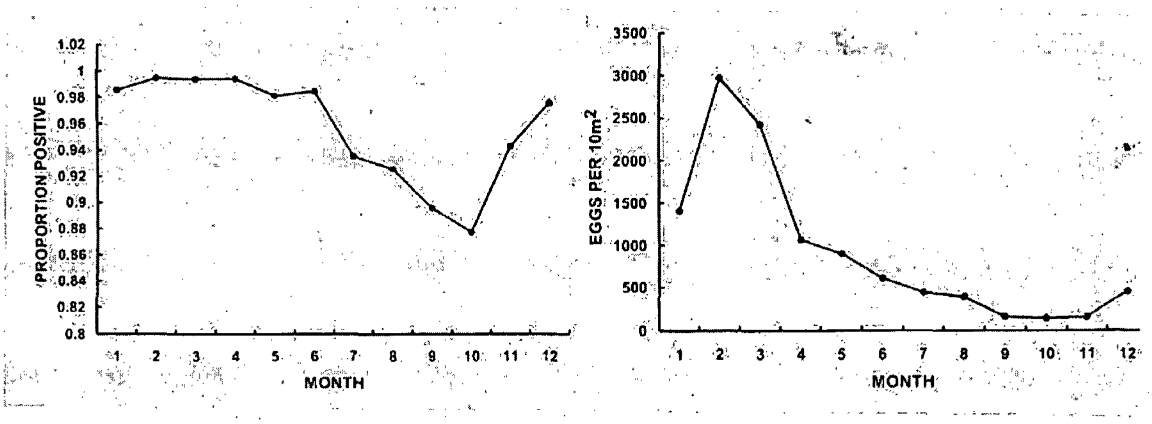
The overall effectiveness of the SONGS fish return systems (72% of abundance and 89% of biomass returned) remains relatively high compared with previous studies. With some exceptions, species-specific return rates are very similar to those reported in earlier studies. Larger fish with better swimming ability are generally diverted at higher rates than smaller fish that are more susceptible to impingement. Almost all of the fish taxa returned in highest abundance had slightly higher return efficiencies based on biomass, indicating that in general larger individuals are returned with greater efficiency than smaller individuals. This was particularly true with queenfish, Pacific sardine, white seaperch, and white croaker (Table 6.5-1). Previous FRS studies did not analyze effectiveness with respect to macroinvertebrates.

7.5 SEASONAL DISTRIBUTION OF FISHES

There is an obvious seasonal component to the abundance of both larval and juvenile/adult fishes and invertebrates off San Onofre, and this has been documented through time both within the SCB and specifically off San Onofre.

The CalCOFI program has monitored fish egg and larvae distributions in the SCB, and from 1951 through 1998 over 11,000 net tows were conducted (Moser et al. 2001). In the SCB, highest densities of fish eggs and larvae are usually found between January and April, while lowest densities generally occur in fall (September through November) (Figure 7.5-1). Within this general pattern of egg/larval density, however, timing of spawning varies by species, and as a result the densities of their eggs and larvae vary by season.

Fish eggs



Fish larvae

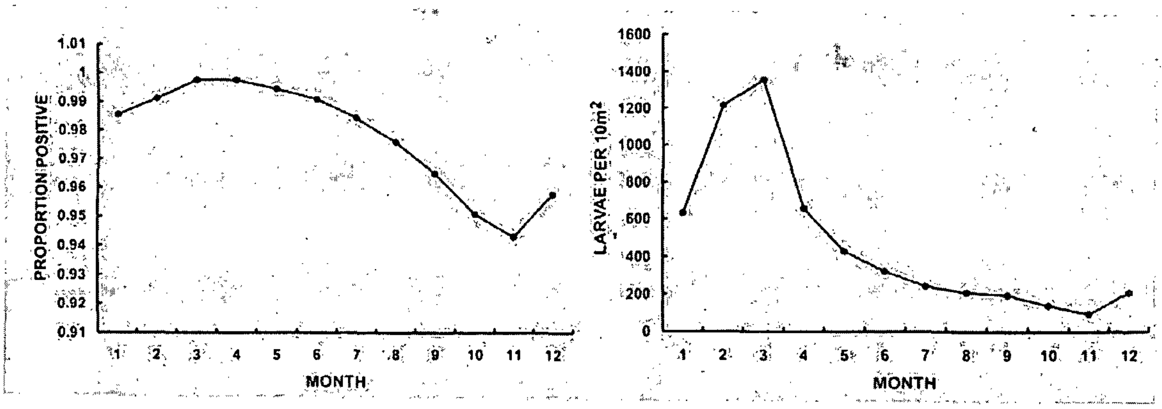
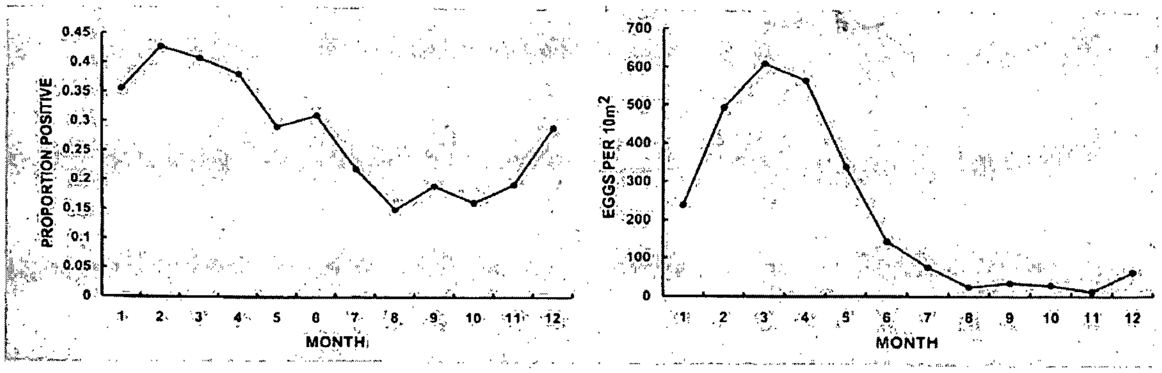


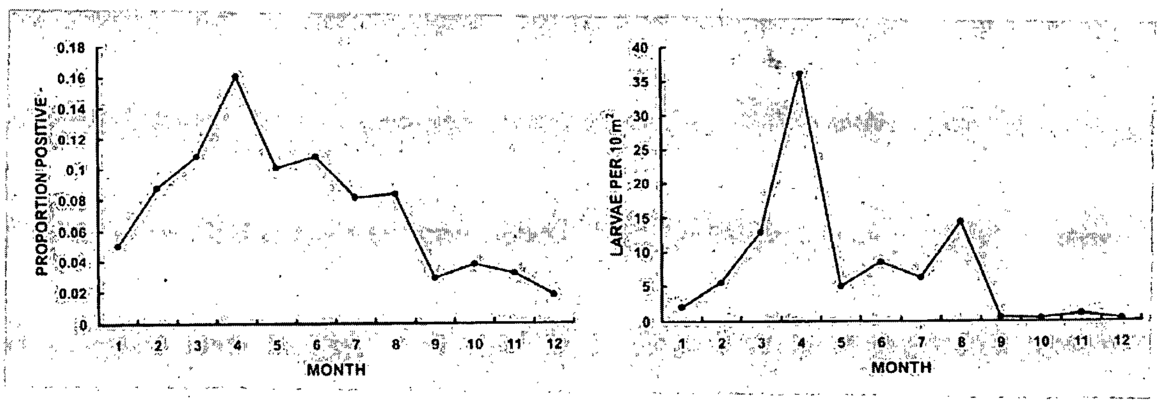
Figure 7.5-1. Seasonal abundance of fish eggs (top) and fish larvae (bottom) in the California Current system. Left graph is the proportion of plankton tows with positive collections. Right graph is concentration (#/$10m^2$). Source: Moser et al. (2001).

Northern anchovy, for example, spawns throughout the year off southern California, with peak spawning between February and May (Brewer 1978). This is illustrated in Figure 7.5-2, with northern anchovy eggs present year-round but found in highest densities during the first five months of the year. A similar pattern was observed in previous studies off San Onofre, with larvae most abundant in winter and spring, but present year-round (Walker et al. 1987). Highest numbers of anchovy eggs and larvae in the present study were collected from April through June (Figures 4.5-11 through 4.5-14).

Northern anchovy eggs



Pacific sardine larvae



Sea bass (*Paralabrax* spp.) larvae

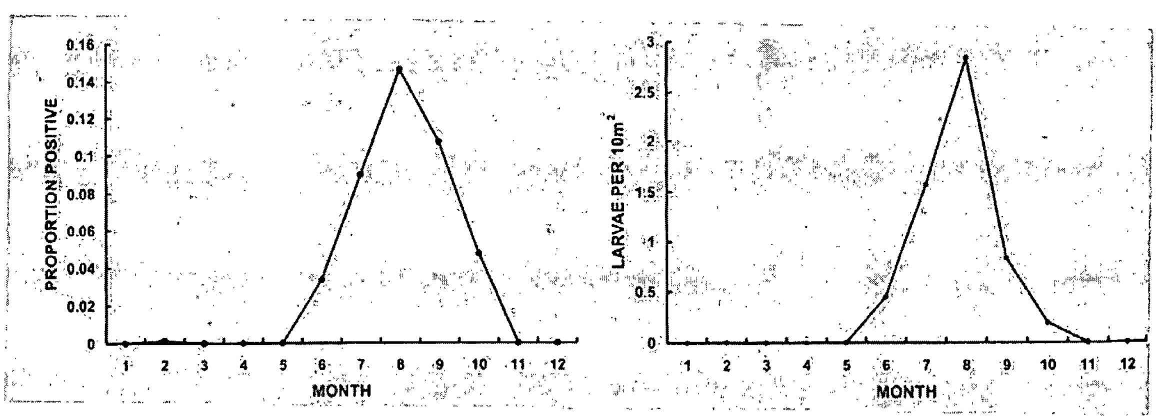


Figure 7.5-2. Seasonal abundance of northern anchovy eggs (top), Pacific sardine larvae (middle), and sea bass larvae (bottom) in the California Current system. Left graph is the proportion of plankton tows with positive collections. Right graph is concentration (#/10m^2). Source: Moser et al. (2001).

Pacific sardine is another species that spawns year-round, with adults spawning two or three times per season (Fitch and Lavenberg 1971). The occurrence of sardine larvae in the CalCOFI study area shows distinct peaks in April and August, with intermediate densities between those months (Figure 7.5-2). A similar pattern was observed in previous studies off San Onofre, with larvae most abundant in winter and spring (Walker et al. 1987). Highest numbers of Pacific sardine eggs and larvae in the present study also displayed two distinct seasonal peaks: February-March and August-September (Figures 4.5-19 through 4.5-22).

Sea basses (*Paralabrax* spp.), unlike northern anchovy and sardine, have a single spawning season during each year centered on summer months, with larvae absent from the SCB during the remainder of the year (Figure 7.5-2). This was also documented during the MRC studies (Walker et al. 1987) and the present 316(b) study (Figures 4.5-26 through 4.5-29).

Walker et al. (1987) determined there were two major larval assemblages off San Onofre: a winter-spring (December-May) assemblage, and a summer-fall (June-November) assemblage. The winter-spring assemblage was most abundant from January to May, and was composed primarily of northern anchovy, white croaker, rockfishes (*Sebastes* spp.), and California halibut. The summer-fall assemblage was most abundant from July to September, and was the most abundant taxa included queenfish, sea basses, combtooth blennies (*Hypsoblennius* spp.), and northern anchovy. The authors surmised that the year-round spawning of many demersal-spawning species may be the result from a combination of broad temperature tolerance and low batch fecundity, which may necessitate periodic spawning over long time spans to ensure reproductive success. Water temperature is an important determinant in the seasonal pattern of larval occurrence off San Onofre. Larvae found in cooler months (winter-spring) are generally species whose adults have northern ranges that extend to Canada, whereas larvae found in warmer months (summer-fall) are generally species whose northern ranges extend to Point Conception or northern California.

Large-scale climatic events, such as El Niño, can obviously affect fish populations, although the level and structure of responses can vary by species. Small-scale features (occurring on 1s to 10s of kilometers), such as localized upwelling, internal waves, and tides, may also contribute to spatial and temporal variation in larval delivery (Carr and Syms 2006).

As with eggs and larvae, juvenile and adult fish and invertebrates exhibit temporal variability on multiple scales. Off San Onofre, Allen and DeMartini (1983) documented the seasonality of pelagic fishes during a 19-month study using lampara nets. Three pelagic species—Pacific bonito (*Sarda chiliensis*), Pacific mackerel (*Scomber japonicus*), and jack mackerel (*Trachurus symmetricus*)—comprised a group of pelagic carnivores that occurred offshore (18-27 m, or 59 to 89 ft) during spring-summer, while four other species—California barracuda (*Sphyraena argentea*), deepbody anchovy, salema, and yellowfin croaker—were more abundant inshore (5-11 m, or 16 to 36 ft) during fall-winter. The authors noted that deepbody anchovy and yellowfin croaker occur primarily in bay/estuarine habitats during summer months, and their presence off San Onofre in fall-winter suggested a seasonal migration out of embayments in response to cooler temperatures. In the present study, deepbody anchovy occurred primarily in November-December (Figures 5.5-22 and 6.5-13) and yellowfin croaker occurred primarily in July-August (Figure 6.5-11).

Seasonal patterns of abundance can be discerned from quarterly trawl surveys off San Onofre (SCE 2007). In 2006, white croaker was found in highest numbers in May, while queenfish and northern anchovy were most abundant in August, especially directly off the generating station. Deepbody anchovy was most abundant in November.

Impingement of croakers (Sciaenidae) at five coastal generating stations in the southern California, including SONGS, indicated seasonal patterns of abundance that varied by species (Herbinson et al. 2001). For example, abundances of queenfish, white croaker, and California corbina (*Menticirrhus undulatus*) were higher in spring. Impingement of black croaker and white seabass, however, peaked in June, while yellowfin croaker and spotfin croaker (*Roncador stearnsii*) were collected in highest numbers in September. Both Herbinson et al. (2001) and Allen and DeMartini (1983) found that white croaker may migrate offshore into deeper waters during winter months.

Spiny lobsters move inshore to spawn from March through August, and it is during this time that they may be more susceptible to impingement. Peak impingement during the present study occurred in late July 2006, and early April 2007 (Figure 5.5-35).

7.6 ESSENTIAL FISH HABITAT

No Federal/State threatened or endangered fish/shellfish species were identified in entrainment and impingement samples collected from SONGS (see Sections 4.0 through 6.0). This is consistent with past entrainment and impingement sampling conducted at SONGS. National Marine Fisheries Service (NMFS) has requested that fish/invertebrates that have designated Essential Fish Habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) be assessed in the environmental documents. Therefore, the following was intended to provide NMFS with a summary of entrainment and impingement information on species managed under the Magnuson-Stevens Act.

Off southern California, the species with EFH designations are listed in the Coastal Pelagics Fishery Management Plan (FMP) and the Pacific Groundfish FMP. The goals of the management plans include, but are not limited to: the promotion of an efficient and profitable fishery, achievement of optimal yield, provision of adequate forage for dependent species, prevention of overfishing, and development of long-term research plans (PFMC 1998, 2006). There are four fish and one invertebrate species covered under the Coastal Pelagics Fishery Management Plan FMP: northern anchovy, Pacific sardine, jack mackerel, Pacific (chub) mackerel, and market squid. There are 89 fish species covered under the Pacific Groundfish FMP, including ratfish (*Hydrolagus colliei*), finescale codling (*Antimora microlepis*), Pacific rattail (*Coryphaenoides acrolepis*), three species of sharks, three skates, six species of roundfish, 62 species of scorpionfishes and thornyheads, and 12 species of flatfishes. For both the Coastal Pelagics and Pacific Groundfish, EFH includes all waters off southern California offshore to the Exclusive Economic Zone. A list of species covered under the two FMPs that occurred in entrainment, impingement and/or FRS samples at SONGS is provided in Table 7.5-1. More information on these species is presented in Sections 4.0 through 6.0.

Table 7.5-1. Annual entrainment, impingement, and fish return estimates at SONGS for species covered under the Coastal Pelagics and Pacific Groundfish FMPs.

Taxa	Common Name	No. Entrained Annually	No. Impinged Annually	No. Returned Annually
Coastal Pelagics				
Engraulis mordax	northern anchovy	913,349,918 larvae	396,074	2,061,541
Engraulidae	unid. anchovy	11,157,637,827 eggs		
Engraulidae	unid. anchovy	498,098,097 larvae		
Sardinops sagax	Pacific sardine	3,074,004 eggs	107,466	100,651
Sardinops sagax	Pacific sardine	3,037,838 larvae		
Trachurus symmetricus	jack mackerel	-	1,477	3,103
Scomber japonicus	Pacific chub mackerel	-	1,747	8,416
Loligo opalescens	market squid	-	212	141
Pacific Groundfish				
Parophrys vetulus	English sole	395,229 larvae	-	-
Citharichthys sordidus	Pacific sanddab	385,855 larvae	-	-
Sebastes spp	rockfish, unid.	170,491 larvae	2	-
Scorpaenichthys marmoratus	cabezon	146,596 larvae	382	6
Scorpaena guttata	California scorpionfish	-	956	951
Sebastes paucispinis	bocaccio	-	98	-
Sebastes auriculatus	brown rockfish	-	17	3
Squalus acanthias	spiny dogfish	-	14	56
Sebastes miniatus	vermilion rockfish	-	4	2
Sebastes rastrelliger	grass rockfish	-	3	2
Sebastes serriceps	treefish	-	2	16
Pleuronichthys decurrens	curlfin sole	-	1	-
Sebastes atrovirens	kelp rockfish	-	1	-
Triakis semifasciata	leopard shark	-	-	44

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FINAL REPORT

SAN ONOFRE NUCLEAR GENERATING STATION

CLEAN WATER ACT
SECTION 316(b) IMPINGEMENT MORTALITY AND ENTRAINMENT CHARACTERIZATION STUDY

APPENDICES A TO F

Prepared by

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December 11, 2007

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APPENDIX TABLE OF CONTENTS

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San Onofre Nuclear Generating Station

Appendix A

Field Sampling and Sample Processing Procedures

A1. Entrainment Inplant Field Sampling

A2. Entrainment Offshore Field Sampling

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A4. Entrainment Sample Identification

A5. Impingement Field Sampling (SO123-IX-2.7)

A6. Quality Assurance / Quality Control (QA/QC) Procedures

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APPENDIX A1: PROCEDURE FOR COLLECTING PLANKTON SAMPLES FOR ENTRAINMENT STUDIES

1.0 PURPOSE

The purpose of this document is to define the steps and equipment necessary to accurately collect plankton samples using a 0.6 m plankton net frame in the circulating water intake system (CWIS) inside the San Onofre Nuclear Generating Station (SONGS).

2.0 RESPONSIBILITIES

2.1 Task/Field leader:

- Notify the station of the proposed sampling dates.
- Schedule and coordinate sampling surveys and notifying the respective Control Rooms and 51 Desk prior to sampling.
- Verify that all investigating biologists conducting the sampling have read and understand these procedures.
- Verify that procedures have been followed during sample collection and that the sampling has been conducted safely.
- Verify that information on data sheets have been reviewed and properly recorded.

2.2 Investigating biologist:

- Conduct sampling using the following procedures.

3.0 SONGS CONTACT INFORMATION

Name	Outside Line	E-mail Information
Robert Heckler	949-368-6816	robert.heckler@sce.com
Unit 2 Control	949-368-6301	
Unit 3 Control	949-368-6401	
51 Desk	949-368-6501	

4.0 PROCEDURES

4.1 Mobilization

a. Notify plant personnel of the dates of field sampling prior to the sampling day.

b. Ensure there are enough jars, labels, and preservative (formalin) for the sample collection. Print the required number of blank field data sheets.

c. Inspect the plankton nets and codends for any damage. If damaged, repairs must be made before sampling begins. Ensure that the flowmeters have been calibrated within the past 90 days and that they are operational. Attach a flowmeter in approximately the center of the frame mouth.

d. Ensure that all additional equipment (Table A1-1) is in good operating condition. Make repairs if necessary.

4.2 Sample Collection

a. Samples will be collected every six hours in a 24-hr period (four cycles) according to the schedule developed by the Task Leader. A survey team consists of at least two investigating biologists to conduct the sampling.

b. Verify with 51 Desk there are no changes in circulating pump status scheduled during sampling activities.

c. Verify air quality on the catwalk using the confined space monitor prior to entry. Complete Confined Space Entry Evaluation Checklist prior to entry.

d. Lower all necessary equipment onto the catwalk (two nets with attached codends, data sheets, calculator, and flashlight).

e. Inspect cables and winches to ensure they are in operable condition. Ensure that the weight (65 lb salmon ball) is securely attached to the downrigger cable at the start of sampling at each Unit. Ensure that the nets, codends, and flowmeter are securely attached together, and the net is secured to the net deployment cable. The nets should be 333-µm mesh.

f. Record the flowmeter's serial number on the field data sheet (Attachment A1-1). Record the number from the flowmeter counter spins on the field data sheet prior to lowering the frame into the water. Record the start time (local time) on the field data sheet.

g. Lower the weight and nets rapidly until the net is fully submerged. Monitor the net postion to ensure it remains submerged in the flow, and that the codend does not come in contact with the traveling rakes. Collect sample for approximately 2-1/2 minutes. After the correct collection time, rapidly retrieve the net and weight to minimize the surface transition time. When the frame reaches the catwalk, carefully pull it over the railing. Verify that the net and flowmeter have not been fouled by drift algae. If there is any fouling of the net or flowmeter, discard the sample by replacing with a clean net and codend. Repeat the sample collection at that station.

h. Check that the number of spins on the flowmeter counter to verify that the target volume of 35 m^3 has been collected (number of spins should be about 4,500). If the target volume has not been met with one tow, sample for additional time at the station until the target volume has been collected.

i. If the correct volume has been collected record the end number of spins from each flowmeter on the field data sheet. Subtract the initial number of spins from the end number and record the total on the field data sheet. Record the end time (local time) on the field data sheet.

j. Collect the replicate tow by removing Replicate A Net, replacing with Replicate B Net, and following the above procedure.

k. Beginning at the top of the net, rinse the collected material down into the codend. Since the wash water is not filtered and may contain plankton, rinse the net from the outside ensuring that unfiltered water does not contaminate the sample. Inspect the net to ensure that it has been thoroughly rinsed. Samples will then be carefully transferred to prelabeled jars with preprinted internal labels. The sample from each net will be placed in separate labeled jars.

l. Detach the codend from Replicate A Net and rinse the sample from the codend into a labeled sample jar using a squirt bottle containing filtered seawater. Then, using a graduated cylinder add enough formalin to make a 10 %-formalin seawater solution. Rinse and inspect the codend before reattaching to the net. Follow the same procedure for Replicate B Net. Sample preservation should be completed soon after collection.

m. If the collected material will fill over ¾ of the sample jar, split the sample into at least two labeled jars so that there is enough formalin for proper preservation.

n. Ensure that the sample jar contains both an inner label and an exterior label.

o. The following is an explanation of the coding for the field data sheet survey and station numbers and jar labels:

1. Each survey number on the data sheet consists of a series of 4 letters followed by 2 numbers (SOEA##). The first two letters are "SO" refers to San Onofre, and the "EA" refers to entrainment abundance. The two numbers refer to the survey number with the first survey being 01. The survey number increases by one for each new 24-hour sampling effort.

2. The station designation consists of a letter-number-letter-number combination. The first letter refers to the station, Entrainment Station. The first number refers to the Unit Number that links to the station letter. The numbers for each of the stations listed above are as follows:

Station Letter	Station Number
Entrainment	Unit 2
Entrainment	Unit 3

3. The second letter designates the replicate, either "A" or "B". The second number designates the net number, "1" For example, E3A1 means that the sample was collected from Station E3, Replicate A, and Net 1.

4. The date of sampling will correspond to the actual start date of each sample. At the start of a new day (midnight), use a new field data sheet.

p. Deliver the samples to the laboratory at the completion of the sampling effort.

4.3. Sample Voiding in the Field

a. Samples should be voided if any of the following occurs: 1) possible flowmeter obstruction due to kelp or other debris on the propeller, 2) obviously malfunctioning or damaged flowmeter; 3) damaged (torn) net found after a sample is collected; 4) large quantities of sediment in the net; 5) gear failure which prevents completion of any tow; 6) an incident or situation which may prevent reliable data collection; 7) an incident or situation which may jeopardize the safety of sampling personnel.

b. If a hole or tear is found in the net mesh, mark the damaged area and either repair or replace the net. Discard both samples and repeat the sample collection. Record this on the data sheet.

Table A1-1. Equipment List.

1. Net frame, attached 333/335 micron mesh nets, codends, and calibrated flowmeters (include at least 1 back up net and flowmeter)
2. Winches and cable for net deployment and retrieval
3. Salmon Ball
4. Stock solution of formalin
5. Squeeze bottles
6. Labeled jars for sample storage
7. Data sheets, black pens, permanent markers, and labels
8. Wash-down pump
9. Watch

San Onofre Generating Station (SONGS) Entrainment Abundance Field Data Sheet

Sheet #: ______ Date: ______ Mesh: 0.335 mm Flowmeter 1: ______ Conversion 1: ______

Survey #: S O E A ___ Crew: ______ Net Dia.: 0.6 m Flowmeter 2: ______ Conversion 2: ______

Station (A#A#)	Flowmeter Start	Flowmeter End	Total Flow	Volume (cu. m)	Sample Number	Cycle (1-4)	Station Depth (ft)	Start Time (PST)	End Time (PST)	Total (min)
E 1										
E 1										
E 1										
E 1										
E 1										
E 1										
E 1										
E 1										
E 1										
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E 1										
E 1										
E 1										
E 1										
E 1										

Survey: SOEA## (San Onofre Entrainment Abundance)
Date: DD/MM/YY
Station: A#A1
A#: (Station Designation - Entrainment In Plant 2-3 or Offshore 1) Ex. E2A1/E2B1
A (Replicate A or B - Only Entrainment samples have two replicates)
1 (Net 1 - only single net used for entrainment sampling at SONGS)

NOTES:

Reviewed By / Date: ______ Entered By / Date: ______ Copied By / Date: ______

Attachment A1-1. Example field data sheet for SONGS inplant sampling.

APPENDIX A2: PROCEDURE FOR COLLECTING PLANKTON SAMPLES FOR ENTRAINMENT STUDIES

1.0 PURPOSE

The purpose of this document is to define the steps and equipment necessary to accurately collect plankton samples using a 0.6 m plankton net bongo frame near the San Onofre Nuclear Generating Station (SONGS).

2.0 RESPONSIBILITIES

2.1 Task/Field leader:

- Notify the station of the proposed sampling dates.
- Schedule and coordinate sampling surveys and notifying the U.S. Coast Guard prior to sampling.
- Verify that all investigating biologists conducting the sampling have read and understand these procedures.
- Verify that procedures have been followed during sample collection and that the sampling has been conducted safely.
- Verify that information on data sheets have been reviewed and properly recorded.

2.3 Investigating biologist:

- Conduct sampling using the following procedures.

3.0 SONGS CONTACT INFORMATION

Name	Outside Line	E-mail Information
Robert Heckler	949-368-6816	robert.heckler@sce.com
Unit 2 Control	949-368-6301	
Unit 3 Control	949-368-6401	

4.0 PROCEDURES

4.1. Mobilization

a. Notify plant personnel of the dates of field sampling prior to the sampling day.

b. Ensure there are enough jars, labels, and preservative (formalin) for the sample collection. Print the required number of blank field data sheets on waterproof paper.

c. Inspect the wheeled bongo frame, manta frame, nets, and codends for any damage. If damaged, repairs must be made before sampling begins. Ensure that the flowmeters have been calibrated within the past 90 days and that they are operational. Attach a flowmeter in approximately the center of each frame mouth.

d. Ensure that all additional equipment (Table A2-1) is in good operating condition. Make repairs if necessary.

4.2. Sample Collection

a. Samples will be collected every six hours in a 24-hr period (four cycles) according to the schedule developed by the Task Leader. A survey team consists of at least a boat driver and two investigating biologists to conduct the sampling.

b. Locate the station using the latitude/longitude coordinates. Determine the water depth with the fathometer and record the water depth on the field data sheet.

c. Ensure that the winch line and a weight (50 lb salmon ball) are securely attached to the center of the bongo frame. Ensure that the nets, codends, and flowmeters are securely attached. The nets should be 333-μm mesh.

d. Record each flowmeter's serial number on the field data sheet (Attachment A2-1 and A2-2). Record the number from the flowmeter counter spins on the field data sheet prior to lowering the frame into the water. Record the start time (local time) on the field data sheet.

e. For oblique tows, using the measured marks on the winch line, lower the frame and nets through the water column until the near bottom. When the appropriate depth is reached, the boat is motored forward and the line is retrieved trying to maintain a 45-degree tow angle. Collect sample for approximately 3 minutes. For bottom tows, lower the frame and nets through the water column until the wheels on the sides of the frame are on thebottom. When the winch line starts to slack, the boat is motored forward and additional line is let out to maintain a 45-degree angle during the tow to ensure the frame remains on the bottom. Collect sample for approximately 4 minutes. At the end of the tow, retrieve the line. When the frame reaches the surface, carefully pull it into the boat. Verify that the nets have not picked up any sediment from the bottom. If there is any sediment in the nets or codends, discard both samples by detaching the codends and rinsing the nets of collected material and then reattach the codends. Repeat the sample collection at that station. For manta tows, deploy the frame with the salmon ball attached to the brides off the side of the boat and tow in undisturbed water. Collect sample for approximately 5 minutes. At the end of the tow, retrieve the line. Verify the the net and flowmeter were not fouled by drift algae. If there is any algae fouling the net or flowmeter, discard thesample by following the above procedure.

f. Check that the number of spins on each flowmeter counter to verify that the target volume of 35 m^3 has been collected (number of spins should be about 4,500 when using the bongo frame and about 9,900 when using the manta frame). If the target volume has not been met with one tow, subsequent tows will be performed at the station until the target volume has been collected.

g. If the correct volume has been collected record the end number of spins from each flowmeter on the field data sheet. Subtract the initial number of spins from the end number and record the total on the field data sheet. If the integrity of either or both flowmeter readings is questionable (e.g., algae wrapped around the propellers), discard both samples by detaching the codends and rinsing the nets of collected material and then reattach the codends. Repeat the sample collection at that station.

h. Record the end time (local time) on the field data sheet.

i. Beginning at the top of the net, rinse the collected material down into the codend. Since the wash water is not filtered and may contain plankton, rinse the net from the outside ensuring that unfiltered water does not contaminate the sample. Inspect the net to ensure that it has been thoroughly rinsed. Samples will then be carefully transferred to prelabeled jars with preprinted internal labels. The sample from each net will be placed in separate labeled jars.

j. Detach the codend from net #1 and rinse the sample from the codend into a labeled sample jar using a squirt bottle containing filtered seawater. Then, using a graduated cylinder add enough formalin to make a 10%-formalin seawater solution. Rinse and inspect the codend of net #1 before reattaching to the net. Follow the same procedure for net #2. Sample preservation should be completed soon after collection.

k. If the collected material will fill over ¾ of the sample jar, split the sample into at least two labeled jars so that there is enough formalin for proper preservation.

l. Ensure that the sample jar contains both an inner label and an exterior label.

m. The following is an explanation of the coding for the field data sheet survey and station numbers and jar labels:

1. Each survey number on the data sheet consists of a series of 4 letters followed by 2 numbers (SOEA##). The first two letters are "SO" refers to San Onofre, and the "EA" refers to entrainment abundance. The two numbers refer to the survey number with the first survey being 01. The survey number increases by one for each new 24-hour sampling effort.

2. The station designation consists of either a letter-number-letter-number combination for entrainment sampling (Attachment A2-1) or a letter-number-letter-letter-number combination for source water sampling (Attachment A2-2). The first letter refers to the station, Offshore or Shore Station (see map in Attachment A2-3). The first number refers to the number of the station that links to the station letter. The numbers for each of the stations listed above are as follows:

Station Letter	Station Number
Offshore - SONGS	1
Offshore - SONGS (modified)	2
Offshore - Don Light	3
Shore - SONGS	2
Shore - Don Light	3

3. When the letter-number-letter-letter-number designation is being used, the second letter refers to type of tow being conducted: Oblique, Bottom, or Manta.

4. The second set of letter-number designates the replicate, either "A" or "B" and net number, either "1" or "2." For example, O3A1 means that the sample was collected from Station O3, Replicate A, and Net 1.

5. The date of sampling will correspond to the actual start date of each sample. At the start of a new day (midnight), use a new field data sheet.

n. Deliver the samples to the laboratory at the completion of the sampling effort.

4.3. Sample Voiding in the Field

a. Samples should be voided if any of the following occurs: 1) possible flowmeter obstruction due to kelp or other debris on the propeller, 2) obviously malfunctioning or damaged flowmeters; 3) damaged (torn) nets found after a sample is collected; 4) large quantities of sediment in the net that were collected when the wheeled bongo frame was on the bottom; 5) gear failure which prevents completion of any tows; 6) an incident or situation which may prevent reliable data collection; 7) an incident or situation which may jeopardize the safety of sampling personnel.

b. If a hole or tear is found in the net mesh, mark the damaged area and either repair or replace the net. Discard both samples and repeat the sample collection. Record this on the data sheet.

c. The number of flowmeter spins from the paired bongo nets needs to be checked in the field to confirm that the measured volumes were within 15 % of each other.

Table A2-1. Equipment List.

1. Net frames, attached 333/335 micron mesh nets, codends, and calibrated flowmeters (include at least 1 back up net and flowmeter)
2. Winch (davits) and line for net deployment and retrieval
3. Salmon Ball
4. Stock solution of formalin
5. Squeeze bottles
6. Labeled jars for sample storage
7. Data sheets, pencils, permanent markers, and labels
8. Wash-down pump
9. Watch
10. Fathometer
11. GPS

San Onofre Generating Station (SONGS) Entrainment Abundance Field Data Sheet

Sheet #: ______ Date: ______ Mesh: 0.335 mm Flowmeter 1: ______ Conversion 1: ______

Survey #: S O E A ______ Crew: ______ Net Dia.: 0.6 m Flowmeter 2: ______ Conversion 2: ______

Station (A#A#)	Flowmeter Start	Flowmeter End	Total Flow	Volume (cu. m)	Sample Number	Cycle (1-4)	Station Depth (ft)	Start Time (PST)	End Time (PST)	Total (min)
1										
2										
1										
2										
1										
2										
1										
2										
1										
2										
1										
2										
1										
2										
1										
2										

Survey: SOEA## (San Onofre Entrainment Abundance)
Date: DD/MM/YY
Station: A#A1
A#: (Station Designation - Offshore 1-2)
A (Replicate A or B)
(Net 1 or 2)

NOTES:

Reviewed By / Date: ______ Entered By / Date: ______ Copied By / Date: ______

Attachment A2-1. Example field data sheet for SONGS offshore entrainment sampling.

San Onofre Generating Station (SONGS) Entrainment Abundance Field Data Sheet

Sheet #: ______ Date: ______ Mesh: 0.335 mm Flowmeter 1: ______ Conversion 1: ______

Survey #: S O E A Crew: ______ Net Dia.: 0.6 m Flowmeter 2: ______ Conversion 2: ______

Manta Net: 0.335 mm Flowmeter 3: ______ Conversion 3: ______

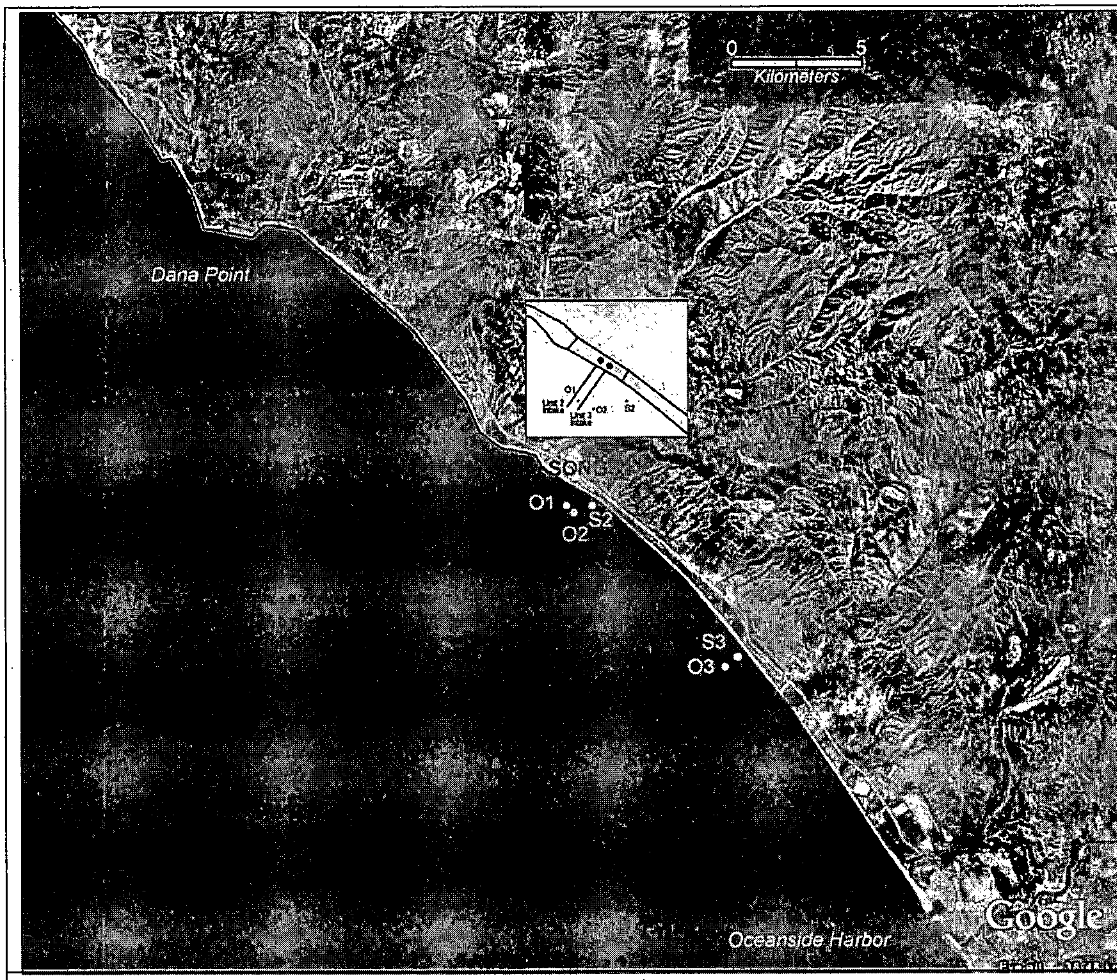
Station (A##A#)	Flowmeter Start	Flowmeter End	Total Flow	Volume (cu. m)	Sample Number	Cycle (1-4)	Station Depth (ft)	Start Time (PST)	End Time (PST)	Total (min)

Survey: SOEA## (San Onofre Entrainment Abundance)
Date: DD/MM/YY
Station: A##A1
A##: (Station Designation - Offshore 2-3 or Shore 2-3 & Type of Tow - Bottom, Oblique, Manta)
A (Replicate A or B - Only Oblique and Manta tows have two replicates)
\# (Net 1 or 2 - Manta tows use only 1 net)

NOTES:

Reviewed By / Date: ______ Entered By / Date: ______ Copied By / Date: ______

Attachment A2-2. Example field data sheet for SONGS offshore source water sampling.



Attachment A2-3. Location of SONGS offshore plankton sampling stations.

APPENDIX A3: PROCEDURE FOR SORTING PLANKTON SAMPLES IN THE LABORATORY

1.0 PURPOSE

The purpose of this procedure is to define the steps for sorting target organisms from plankton samples collected at San Onofre Nuclear Generating Station, and to describe the Quality Control Program (QC) used to monitor the sorting accuracy of individual sorters.

2.0 RESPONSIBILITIES

- Laboratory Supervisor is responsible for assuring that plankton sample sorting is in accordance with written procedures.
- The Quality Control Supervisor is responsible for implementing the Quality Control Program, which monitors sorting accuracy in accordance with written procedures.
- Investigating biologists are responsible for sorting samples in accordance with written procedures.

3.0 INSTRUCTIONS

3.1 Sorting Procedures

3.1.1 Sample Processing

a. Ensure that the proper equipment necessary for sample processing is available (Table A3-1).

b. Samples that were originally fixed in 10 %-formalin seawater solution after collection must be transferred to 70% ethanol before laboratory processing. This is done outside to lessen the exposure to formalin fumes. Only qualified personnel who have read and signed the information about the hazards of working with formalin may transfer samples.

1. A plankton screen with the appropriate mesh size is used to transfer samples. The mesh must not be larger than that used during sample collection.
2. Pour the sample carefully into the plankton screen. The sample jar and lid are rinsed with water, directing the water and organisms into the plankton screen. Rinse the sample with water to flush the formalin from the sample.
3. Rinse the sample into the labeled jar with 70% ethanol from a squeeze bottle. Additional ethanol is added to the sample jar to cover the sample.
4. The waste formalin and rinse water is then discarded into the appropriate hazardous waste container.

c. Consult the sorting schedule posted in the processing laboratory to determine sorting priorities.

d. Sign out the sample in the Laboratory Tracking MS Excel file and the Laboratory Sample Tracking Sheet (Attachment A3-1) by writing your initials under the 'sorter' column. Transcribe information from the sample label into the Sorter's Log Book (Attachment A3-2) and into the sorter's notebook (each sorter has separate log sheets and a notebook for this purpose).

e. Take two clean funnels with attached mesh netting, one labeled 'sorted' and the other labeled 'unsorted'. The mesh size should be no larger than that used to collect the samples.

f. Place the 'unsorted' funnel over the 'used alcohol' bottle, which is located in a dish so samples can be retrieved if a spill occurs. Pour the sample into the funnel. The funnel will contain the material to be sorted, while the ethanol will drain into the 'used alcohol' bottle.

g. Using 70% ethanol or 70% used alcohol in a squeeze bottle, rinse any remaining sample from the sample jar, the jar lid and inner sample label into the funnel containing the unsorted sample.

h. Place the 'unsorted' funnel containing the sample and the empty 'sorted' funnel into individual glass bowls in a tray. Make sure the sample is covered with water so it will not dehydrate during processing.

i. Using forceps, transfer a small amount of the sample from the 'unsorted' funnel to the sorting tray. Add enough water to cover the sample. Distribute the sample in the sorting tray.

j. Place the sorting tray on the base of the dissecting microscope. Adjust the magnification so that the field of view is slightly larger than the width of an individual marked grid.

k. Arrange the light source to provide adequate illumination.

l. Carefully scan the entire sorting tray using the grids for orientation. Remove the target organism with forceps and place them either into a shell vial containing 70% ethanol or into a small dish containing water. Count the organisms as they are removed. A list of what target organisms and when to pull them is posted in the lab.

m. Log the number of organisms removed from the sample in the sorter notebook.

n. Scan the tray a second time. If target organisms are found on the second pass, repeat a third time. Continue this process until a scan does not produce any additional target organisms.

o. Once sorted, pour the sorted sample into the 'sorted' funnel and rinse with a small amount of water. Take a second aliquot from the 'unsorted' funnel as described above. Repeat the above steps until the entire sample has been sorted.

p. If the sorter thinks there will be more than 500 fish eggs in a sample then the sample may be "sub-sampled" for eggs. When sub-sampling the sample should be processed first for fish larvae and selected invertebrate larvae. When ready to sub-sample put the sorted sample back in the original sample jar and fill the jar with 70% ethanol up to the lip of the jar. Jar size varies, but they will typically be 500 ml (if sizes varies there will be a posting in the lab). A sub-sample should be 10 percent of the sample volume so the sorter will use the aliquot transfer pipette with the 10 ml attachment and take 5 aliquots. The sample should be stirred up in order to get a fair amount of sample in the aliquot. Once the aliquot is processed for fish eggs it may be returned to the original sample jar with the rest of the sorted sample. Make sure it is noted in the logbook and record the total volume of the sample and the volume of the sub-sample. There will be an extra data sheet in the laboratory tracking sheets and a column in the MS Excel tracking sheets to record the sub-sample information. On top of the sample jar put a white dot with survey number, sample number, sorters initials, sub-sample date, and "SS".

q. When the sorting has been completed, the sorted organisms should be placed into a shell vial containing 70% ethanol. Fill the shell vial completely with clean 70% ethanol then place cotton into the top end of thevial to keep the organisms inside. Place the vial into a labeled snap cap containing 70% ethanol. Make sure the shell vial and cotton are completely covered with 70% ethanol.

r. Label each jar lid with the appropriate colored dot label. Prepare a waterproof inner label for the jar containing the shell vial. Both labels should contain the following information:

1. Survey number
2. Collection date
3. Station, cycle and sample number
4. Collection start time
5. Jar number (if more than one jar)
6. Sorter's initials

7. Number of organisms in shell vial

s. The total number of sorted organisms and the total time required to process the sample is recorded in the sorter's notebook.

t. Put the sorted sample back into the original sample jar. Used alcohol may be used to fill sample jar to at least ¾ full. Rinse any remaining sample from the funnel into the jar using a squirt bottle containing ethanol. Make sure the inner waterproof label is in the sample jar. Thoroughly clean the funnels of all remaining sample.

u. If a sample must be stored before completion:

1. Put the sorted portion of the sample back into the original sample jar. Rinse any remaining material from the funnel into the jar using a squirt bottle containing ethanol. Make sure that the sample is adequately covered with ethanol.

2. Put the unsorted sample into a second jar. Rinse any sample from the 'unsorted' funnel into the jar using a squirt bottle containing ethanol. Using a dot label, label the jar lid with the sample identification information, sorter's initials, and the word "unsorted". Make an additional inner label with the sample identification information and marked unsorted. Place the label inside the jar with the unsorted sample. Make certain that the 'unsorted' sample is adequately covered with ethanol.

3. The sorted and unsorted portion of the sample should be stored until sorting can continue.

3.1.2 Once the sample is completed, place an appropriately colored dot label on the jar top with the sorter's initials and date of sorting. Return the jar to the box from which it was originally removed.

a. Transcribe the information recorded in the sorter's notebook to the computer on the Laboratory Tracking Sheets and the Quality Control log and on the Laboratory Sample Tracking Sheet, and to the Sorter's Log.

3.2 Sorting Quality Control Program

3.2.1 Quality Control Sorting Criteria

a. The first ten samples that are sorted by an individual are completely resorted by a designated quality control (QC) sorter. A sorter is allowed to miss one target organism when the original sorted count is 1–19. For original counts above 20 a sorter must maintain a sorting accuracy of 90%.

b. After the sorter has passed 10 consecutive sorts, the program is switched to a '1 sample in 10' QC program for that sorter. After the sorter has completed another 10 samples, one sample is randomly selected by the designated QC sorter for a QC resort.

c. If the sorter maintains the 90% accuracy sorting rate for this sample, then the sorter continues in the '1 sample in 10' QC mode.

d. If a sample does not meet the 90% accuracy rate their subsequent samples will be resorted until 10 consecutive samples meet the criteria.

3.2.2 Quality Control Resorting

a. Sorting procedures used during the QC resort are the same as the sorting procedures described in Section 3.1.

b. All fish and selected invertebrate larvae that were missed by the sorter are removed during the QC resort.

c. For the QC process, a larval fish is defined as having a head plus at least 50% of the body. Any parts without a head and/or less than 50% of the body will be considered fragments and will not be counted against the original sorter as a missed fish. However, it is important for each sorter to remove all fish and fragments from each sample that is sorted and correctly record them as # fish / # fragments in the sorter's notebook and on the tracking sheet.

d. Any vials of fish larvae or selected invertebrate larvae generated from the resort are labeled with an orange dot label, and labeled as described in the sorting procedures with the addition of "QC" added to the label.

e. An orange dot label should also be placed on the top of the jar of the sample that was resorted and labeled with the QC person's initials, survey number, sample number, and date the resort was completed.

f. The vials are stored in the appropriate location.

3.3 Waste Disposal

3.3.1 No formaldehyde or water contaminated with formaldehyde should be disposed of into the sewage system. Dispose of any water contaminated with this chemical in the designated waste water container to be disposed of at a local hazardous materials waste depository.

4.0 RECORDS

4.1 All data sheets are later reviewed by the Lab Manager or designated staff.

4.2 Original data sheets are permanently stored.

Table A3-1. Equipment List

1. Tray or dish
2. Bowls
3. Sample jars
4. Two funnels with attached plankton mesh netting, labeled with mesh size, and labeled 'sorted' and 'unsorted'
5. Squeeze bottle containing 70 % ethanol (denatured)
6. Squeeze bottle containing fresh water
7. Sorting tray or petri dish marked with a sorting grid
8. Dissecting microscope with light source
9. Glass shell vials and cotton
10. Jar/vials with lids
11. Forceps
12. Waterproof labels
13. Dot labels
14. Sorter's notebook
15. Plankton splitter

SONGS - Lab Tracking Sheet

Survey: ____________________

Sample Information							Sort Information							QC Information			
Project #	Sample Date	Station	Cycle	Sample	Start	# Jars	Sorter	Sort Date	Time (hrs)	# Fish	# Eggs	# Meg.	# Lobster / Squid	QC'd By	QC Date	QC Fish	QC Other*

* Specify species in QC other column (S for Squid, M for Megalops, or L for Lobster)

Attachment A3-1. Lab Tracking Sheet

San Onofre Nuclear Generating Station-Sorter's log
(SONGS)

Name: ____________________

Sample Information					Sort Information						Quality Control							
Survey Number	Station	Cycle	Sample	Collection Time	Date Sorted	Sort Time	# of Fish	# of Fish Eggs*	# of Cancer Megs	# of Lobster/ Squid	QC'ed By	QC'ed Date	QC Fish	Fish P/F	QC Can	Can P/F	QC Other*	Other P/F

*specify which (fish eggs(E), lobster(L), or squid(S))

Attachment A3-2. Sorter's Log Sheet

APPENDIX A4: PROCEDURES FOR THE IDENTIFICATION OF LARVAL FISHES and TARGET INVERTEBRATES

1.0 PURPOSE

The purpose of these procedures is to define the steps for identifying planktonic organisms, and to describe the Quality Control (QC) Program used to monitor the accuracy of each individual's identification performance.

2.0 RESPONSIBILITIES

The Lead Taxonomist is responsible for assuring that plankton identifications are performed in accordance with written procedures and for implementing the Quality Control Program.

Investigating biologists are responsible for plankton identifications and for monitoring accuracy in accordance with written procedures.

3.0 INSTRUCTIONS

3.1 Identification procedures for larval fishes, *Cancer* spp crabs and *Panulirus* lobsters.

a. Ensure that the proper equipment necessary for the identification of target organisms is available (Table A4-1).

b. The fish and target invertebrates from each sample are kept in separate containers and processed following this procedure in essentially the same manner.

c. The container of target organisms to be identified is carefully emptied into a dish. The dish is placed on the microscope stage and the lighting adjusted to provide adequate illumination.

d. Each target organism is identified to the lowest taxonomic classification possible. The total number of each taxon is recorded on the Entrainment /Source Water Plankton Tow Lab Data Sheet (Attachment A4-1).

e. All individuals of each identified taxon of larvae from a sample should be put into a shell vial containing 100% ethanol. Each vial should contain a label with the taxon name and sample number. Cotton should be pushed into the upper end of the vial to keep the label and organisms enclosed.

f. Mutilated larvae (partial organisms that are missing body parts and are unable to be identified) are placed in a separate labeled vial. Whole larvae that are unidentified, are also placed in a separate labeled vial.

g. All vials containing target organisms from an individual sample should be put into a labeled jar containing enough ethanol to cover the vials. The jar should contain both an inside label and a label attached to the outside of the lid denoting the sample number, date and time collected, and identifier's initials. Tighten the jar lid to prevent evaporation of the preservative. Samples with many different fish taxa may require more than one labeled jar.

h. On the Laboratory Sample Tracking Sheet, record the identifier's initials and date sample was logged in. The identifier's log will contain the total number of larvae identified and the date identified. If more than one day was needed to complete the identification, record the date the sample identification was completed.

i. Place the jar into the appropriate box containing identified samples.

j. Dispose of any liquids containing ethanol into the appropriate waste container.

3.2 Identification Quality Control (QC) Program

3.2.1 Fishes

a. The first ten samples of larval fishes that are identified by an individual identifying biologist will be completely re-identified by a designated identification QC biologist. A total of at least 50 individuals from at least 5 taxa (50/5 criteria) must be present in these first ten samples. If the first 10 consecutive samples do not pass the 50/5 criteria, additional samples must be re-identified until this criteria is met.

b. The identifying biologist must maintain a 95% identification accuracy level in these first 10 samples. For all samples, if a sample contains between 1–19 larvae, one larvae can be misidentified and the sample will not fail the QC check.

c. If the identifying biologist identifies a larval fish to a certain family or genus and subsequently the identification QC biologist is able to refine the identification to a lower taxonomic level, this will not be considered a misidentification pertaining to the 95% identification accuracy level. A misidentification will be one in which the identifying biologist identifies the fish as belonging to a certain family, genus or species, and then the identification QC biologist determines that the initial identification was incorrect and changes the identification to a different family, genus or species or changes it to a higher taxonomic group.

d. After the identifying biologist has passed 10 consecutive samples, the program is switched to a "1 sample in 10" QC program. After the identifying biologist has completed another 10 samples, one sample is randomly selected by the designated identification QC biologist for a QC review.

e. If this sample maintains the 95% accuracy level as determined by the identification QC biologist, then the identifying biologist continues in the "1 sample in 10" QC mode. If a sample does not meet the 95% accuracy level, their subsequent samples will be re-identified until 10 consecutive samples meet this level of accuracy.

f. Any misidentified fish found by the identification QC biologist, will be placed into the appropriate labeled vial for that sample. This information will be recorded on the Fish Identification Data Sheet.

3.2.2 Invertebrate larvae

a. The first ten samples identified by an individual identifying biologist will be completely re-identified by a designated identification QC biologist.

b. The identifying biologist must maintain a 95% accuracy level in these first 10 samples. For all samples, if a sample contains between 1-19 larvae, one larvae can be misidentified and the sample will not fail the QC check.

c. After the identifying biologist has passed 10 consecutive samples, the program is switched to a "1 sample in 10" QC program. After the identifying biologist has completed another 10 samples, one sample is randomly selected by the designated identification QC biologist for a QC review.

d. If this sample maintains the 95% accuracy level as determined by the identification QC biologist, then the identifying biologist continues in the "1 sample in 10" QC mode.

e. If an identifier's sample does not meet the 95% accuracy level, their subsequent samples will be re-identified until 10 consecutive samples meet this level.

f. Any misidentified larva found by the identification QC biologist, will be placed into the appropriate labeled vial for that sample and recorded on the appropriate laboratory identification data sheet.

3.3 Larval Fish Measuring

3.3.1 Larval Fish Measuring Procedure

a. Turn on the computer, camera, and light source at the measuring station.

b. Consult the measuring schedule near the measuring station to determine measuring priorities and retrieve the binder containing the appropriate data sheets.

c. Locate the box containing the fish to be measured and place it in a easily accessible area close to the measuring station.

d. Open the Optimas Image Analysis or ImageJ software by clicking with the mouse on the appropriate software icon.

e. Open the Larval Fish Measuring macro in Optimas, or the FishMeasure2 macro in ImageJ and follow the macros' directions.

f. Select the jar of fish to be measured and consult the jar label. Compare data on the jar label with the inner label and the data sheet for this sample. Consult an identifier regarding discrepancies between labels.

g. Enter the data queried for by the macro including the last five digits of the serial number, the measurer's initials, the data sheet sequence number and the species code.

h. Open the jar and remove the vials for the target taxa to be measured as per the posted list. Place the vials in a rack designed to allow the vials to maintain an upright posture as to reduce spillage.

i. Select the first vial to be measured. Remove the cotton and the label. Compare the label with the data sheet for confirmation.

j. Empty the vial into a shallow dish. Remove any fish that have adhered to the vial, cotton, label, or any tools used in the transferring process and place the fish in the dish. Add alcohol to the dish if necessary to prevent desiccation.

k. If the number of larval fish in the vial exceeds what can be reasonably measured on a single image capture, transfer some of the fish to another glass dish and immerse them in alcohol.

l. Place the dish on the stage of the microscope. Arrange the fish so that all fish appear on the screen. Adjust the zoom, focus, and lighting for the best possible image. If this is the first group of larval fish being measured, or if the magnification has been changed, it is necessary to re-calibrate. Place the micrometer on the stage of the microscope and re-calibrate by drawing a line from one of the micrometers millimeter marks to another, noting the distance between the two marks, and entering that value when queried. Replace the dish containing the larval fish to be measured.

m. Measure larval fish by drawing a line from the pre-maxillary to the end of the notochord, being careful to follow the contours of the fish. If the fish is too damaged to find either the pre-maxillary or to estimate the path taken by the notochord, do not measure, and proceed to the next larval fish. If the line does not adequately approximate the larval fish's length it must be re-measured.

n. Note the program's display of the measurement, check that it seems reasonable. If it does not seem reasonable, it may be necessary to re-calibrate and re-measure. If the problem persists, contact an identifier. Make note of any problems in measuring and post near the measuring station.

o. The macro will store the measurement in separate data files along with the necessary sample information.

p. Repeat the above steps for all fish in the dish.

q. When all larval fish in the dish have been measured, fill the vial that originally contained the fish with alcohol and transfer the measured fish to the vial.

r. If the larval fish from this vial have been segregated into two or more groups, place another group into the dish, being careful to submerse them in alcohol, and measure as above. Do not measure more than fifty larval fish of any one taxon from each survey.

4.0 RECORDS

4.1 All data sheets are later reviewed by the Lab Manager or designated staff.

4.2 Original data sheets are permanently stored.

Table A4-1. Equipment List

1. Dissecting microscope, with camera attachment connected to computer equipped with Optimas 6.2 or ImageJ if measuring larvae
2. Light source
3. Micrometer
4. Sorting tray or petri dish
5. Squeeze bottle containing 70% ethanol (denatured)
6. Glass shell vials
7. Holder for shell vials
8. Jar containing target organisms to be identified
9. Cotton
10. Forceps
11. Waterproof labels
12. Dot labels
13. Data sheets
14. Identifier's log sheet
15. Taxonomic references

SONGS - Lab Data Sheet Sheet: ____

Survey: ________ Date: ________ Start Time: ______ Cycle: ______ Station: ________

Species Code	Taxon	Count	QC Resort Additional Count	Total Count	Stage	Entrain-able	Comments

NOTES: Total: ____

	ID'cd By / Date	ID QC By / Date	QC Resort By / Date	Entered By / Date
Fish				
Eggs				
Inverts				

Attachment A4-1. Entrainment /Source Water Plankton Tow Lab Data Sheet

NUCLEAR ORGANIZATION
UNITS 1, 2 AND 3
EFFECTIVE DATE October 8, 2003

ENVIRONMENTAL PROCEDURE SO123-IX-2.7
REVISION 2
TCN 2-2
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FISH IMPINGEMENT MONITORING

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INFORMATION USE

NOT QA PROGRAM AFFECTING
50.59 DNA/72.48 DNA

FISH IMPINGEMENT MONITORING

1.0 OBJECTIVES

1.1 To delineate the procedure used by the Environmental Protection Group (EPG) for performing fish impingement monitoring during heat treatments and normal operations to determine the efficiency of the Fish Handling System at Unit 2 and Unit 3 per References 2.4.2 and 2.4.3 requirements.

2.0 REFERENCES

2.1 NRC Commitments

2.1.1 Unit 2 and Unit 3 Technical Specifications, Appendix B, Environmental Protection Plan

2.2 Orders

2.2.1 SO123-EN-1, Environmental Protection

2.3 Procedures

2.3.1 SO23-2-6, Fish Handling System and Entrainment of Marine Mammals and Reptiles

2.3.2 SO23-2-7, Operation of Traveling Rakes and Screens

2.3.3 SO23-5-1.1, Heat Treating the Circulating Water System

2.3.4 SO123-XV-1, Calibration and Control of Measure and Test Equipment

2.3.5 SO123-XV-2.1, NPDES Monitoring

2.3.6 SO123-XV-3.3, NRC Reporting Requirements

2.4 Other

2.4.1 Code of Federal Regulations, Title 40, Protection of Environment

2.4.2 California Regional Water Quality Control Board NPDES Permit No. CA0108073, San Diego Region Order R9-2005-0005 (SONGS Unit 2)

2.4.3 California Regional Water Quality Control Board NPDES Permit No. CA0108181, San Diego Region Order R9-2005-0006 (SONGS Unit 3)

2.4.4 Guide to the Coastal Marine Fishes of California, California Fish Bulletin Number 157

2.4.5 Peterson Field Guides, Pacific Coast Fishes

2.4.6 California Fish and Game Code

2.4.7 Memo, A. Kneisel to J. Bellomy, dated November 5, 1985; Subject: Proposed TCNs to SO23-2-6, SO23-2-7

2.4.8 Memo, G. Gibson to H. Morgan, dated August 31, 1983; Subject: Interpretation - Tech. Spec. Appendix B, Section 4.1, Unusual Fish Loss

2.4.9 Memo, P. J. Knapp to H. W. Newton, dated December 2, 1994; Subject: Release of Fish for Use as Teaching Aids

2.4.10 Letter, J. E. Fitch, Research Director California Department of Fish and Game, to R. Strachan, Southern California Edison, dated December 4, 1974; Species Considered to be Resident Offshore San Onofre

3.0 PREREQUISITES

3.1 Before using this document, verify the revision and any issued TCNs and/or ECs (Editorial Corrections) are current by using one of the following methods:

3.1.1 Access the Nuclear Document Management System (NDMS) (preferred method).

3.1.2 Check it against a Corporate Documentation Management-SONGS (CDM-SONGS) controlled copy and any issued TCNs/ECs.

3.1.3 Contact CDM-SONGS by telephone or through counter inquiry.

3.1.4 Obtain a user-controlled copy of this procedure from CDM-SONGS or NDMS.

3.2 Verify level of use requirements on the first page of the document.

4.0 PRECAUTIONS

4.1 Caution should be exercised when handling fish that may be potentially dangerous (e.g., poisonous).

5.0 CHECKLISTS

5.1 None

6.0 PROCEDURE

6.1 Responsibilities

6.1.1 The Manager, EPG or designee, shall:

.1 Designate an EPG Lead for each survey performed.

.2 Verify survey data.

.3 Prepare annual reports required per References 2.4.2 and 2.4.3.

6.1.2 The EPG Lead shall be responsible for recording data and making decisions relative to the survey, unless otherwise stated in this procedure.

6.1.3 The Corporate Environmental Health and Safety Division shall:

.1 Provide technical review of field work and reports.

.2 Provide an expert in marine biology to support fish impingement operations when necessary as delineated in this procedure.

6.1.4 ***For Information Only*** - The Operations organization shall operate equipment in support of fish impingement activities in accordance with References 2.3.2 and 2.3.3.

6.2 Survey Types/Frequencies

6.2.1 Normal Survey

.1 The normal survey consists of recording required data for fish impinged upon the traveling screens during a continuous isolation period, lasting approximately 24 hours (± three hours).

.2 EPG shall perform the normal survey quarterly.

.3 If the 24-hour isolation period is disrupted, the NPDES Engineer or designee shall be contacted immediately for resolution.

6.2.2 Heat Treatment (HT) Survey

.1 HT frequency is dependent upon the rate of biological growth and is usually conducted at approximately six-week intervals per Reference 2.3.3.

.2 *For Information Only* - Operations shall notify EPG of an impending HT as soon as possible per SO23-5-1.1.

.3 Where practical, EPG shall notify the San Diego Regional Water Quality Control Board (SDRWQCB) and the California Department of Fish and Game 48 hours in advance of the HT date, time, and the Unit involved.

.3.1 Notifications shall be logged by the National Pollutant Discharge Elimination System (NPDES) Engineer/designee.

.3.2 If the notification is made less than 48 hours before the start of the heat treat, state the reason on the applicable fax notification pages in the EPG Heat Treat notification logbook.

.4 EPG shall interface with Operations in conducting the fish chase and shall perform survey responsibilities during the fish chase and immediately following the HT.

.5 The EPG Heat Treat Cognizant Engineer should complete the Heat Treat Checklist form (Attachment 6) to ensure all actions that should be performed before the commencement of the heat treat are completed.

6.2.3 The type of survey being performed and the survey date shall be recorded on Attachment 1.

6.3 <u>Sample Types and Requirements</u>

6.3.1 Samples for normal surveys shall be taken from two sample points:

- The Unit 2 trash basket
- The Unit 3 trash basket

.1 Data shall be recorded per Section 6.6 for each sample point, independently.

6.3.2 Following completion of a Heat Treat, a sample is taken from the trash basket of the involved Unit. A Heat Treat survey is considered complete after at least one full cycle run of the screens and rakes is completed after the Heat Treat target temperature is achieved.

6.3.3 When possible, animals such as sharks, rays, large fish, and lobsters caught during the sampling process should be returned to the ocean as soon as possible when survival is judged possible.

NOTE: Animals returned to the ocean are counted as "killed," as their survival cannot be established.

.1 Dead fish shall not be discharged to the outfall, unless incidental to discharging live fish.

.2 In the event a mammal or reptile is detected during sampling activities, notify Operations for handling per Reference 2.3.1.

6.3.4 Provided plant operating and effluent release parameters are verified to be normal, marine life involved in sampling operations may be released for use as a teaching aid or research. (Reference 2.4.9)

.1 The removal of any marine life for personal consumption or any other use is <u>prohibited</u>. (References 2.4.6 and 2.4.7)

6.3.5 Quality control should be exercised by having at least two individuals involved in each sampling activity.

.1 These individuals should cross-check each other's accuracy and compliance with the procedural provisions contained herein to ensure the highest level of sampling data accuracy.

6.3.6 All scales used for fish measurement shall be calibrated in accordance with the SONGS MT&E program (Reference SO123-XV-1).

6.4 <u>Environmental Conditions</u>

NOTE: Weather condition and wind velocity/swell height data aids in determining if a relationship exists between sampling results and the environmental conditions at the time of sampling.

6.4.1 Record the following data on Attachment 1 directly before conducting surveys:

.1 Choose the selection that best describes the overall weather conditions.

.2 Estimate the wind velocity and swell height.

6.5 Normal Survey

NOTE: Refer to Section 6.2.1.

6.5.1 Applicability

.1 Activities defined in Sections 6.5.2 through 6.5.4 apply to fish impingement monitoring conducted at Units 2 and 3.

.2 For Unit 1, fish impingement monitoring is not required.

6.5.2 Pre-sample Setup

.1 Approximately 24 hours (± three hours) prior to the intended sample time, request Operations to operate the rakes and screens.

.1.1 Traveling rakes and screens are operated per Reference 2.3.2 to dislodge fish into trash basket.

.1.2 The trash basket is emptied into a dumpster and covered with plastic or otherwise designated to provide distinction between the initial load and the sample load.

.2 Record the following on Attachment 1:

.2.1 Date/time of initial screen/rake operation for each Unit.

.2.2 Number of circulating pumps in operation.

.2.3 Initial load estimate (i.e., light, medium, or heavy).

.2.4 Bin number of the dumpster.

6.5.3 Trash Basket Samples

.1 Following the 24-hour isolation period (see step 6.2.1.1), request Operations to run the traveling rakes and screens through a complete cycle to purge the sample to the trash basket (Reference 2.3.2).

.1.1 Record the final time for each Unit on Attachment 1.

.2 Determine, based on time and sample size considerations, if the entire sample shall be considered or a representative sample (aliquot) is required.

.3 Indicate sample type and aliquot percentage, if applicable, on Attachment 3.

.4 If an aliquot is necessary, follow the guidelines provided in Attachment 2.

6.5.3.5 Operations shall empty the basket into the dumpster.

NOTE: Sample is distinguished from initial load per Step 6.5.1.1.

.6 Segregate fish from other sample elements (e.g., invertebrates, algae, debris, etc.).

.6.1 If Unit 1 monitoring is being conducted (refer to Section 6.5.1), macroinvertibrates shall be segregated for analysis per Section 6.5.4.

6.5.4 Fish Analysis

.1 Segregate fish by species.

.2 Record each species on Attachment 3.

NOTE: Refer to References 2.4.4 and 2.4.5 or other similar publications for identification assistance.

.2.1 When identification is questionable or not possible, the specimen shall be delivered to the NPDES Engineer or equivalent for species determination.

.3 Measure and record the standard length of a representative sample of each species on Attachment 4.

.3.1 Use the form that is most appropriate based on the number present for the species.

.3.2 If up to 125 individuals of a species are removed, the *representative sample* shall consist of all the individuals removed.

.3.3 Where more than 125 individuals of a species are removed, the *representative sample* shall consist of not less than 125 individuals.

.4 Record the total weight of the measured fish of each species.

.4.1 If number exceeds 125, record the number and total weight of the unmeasured fish.

.4.2 Use calibrated equipment per Reference 2.3.4.

.4.3 Record the last and next calibration dates of the scale on Attachment 1.

6.5.4.5 Up to 50 of those species considered to be commercial and/or having sport fishing value as determined by the California Department of Fish and Game (see Attachment 5 for length guidelines) shall be sexed if possible. This helps determine the relative population dynamics of the fish impinged.

.5.1 Record the sex by indicating "F" for Female or "M" for male in the block were the measurement was recorded on Attachment 4.

.6 If any White Sea Bass are obtained in a sample, they should also be scanned to determine if an identifying tag is present.

NOTE: The tags identify bass which are part of a repopulation effort by Hubbs Sea World.

.6.1 Notify Hubbs Sea World and the SCE Marine Biologist upon tag detection.

NOTE: *TOTAL* includes measured and unmeasured fish.

.7 Transfer the *TOTAL* count and weight of each species (from Attachment 4) to Attachment 3.

.8 For aliquotted samples:

.8.1 Divide the number of each species counted by the aliquot percentage and record the total on Attachment 3.

.8.2 Divide the total weight for each species by the aliquot percentage and record the total on Attachment 3.

.9 Complete Attachment 3 by totaling the columns for:

- Fish species
- Number of fish
- Fish weight

6.6 Heat Treatment (HT) Survey

NOTE: Refer to Section 6.2.2.

6.6.1 Prior to fish chase:

.1 Request Operations run the elevator several times to flush out fish present before beginning temperature increase.

6.6.2 Interface with Operations on temperature control to minimize fish kill due to thermal shock.

NOTES:
1) Target temperature is normally 85°F.
2) Temperature rise should not exceed 90°F.
3) Target temperature is reached by increasing temperature at a rate of 1°F per two minutes.
4) The time of year, seawater temperature, and fish species present should be taken into consideration when deciding target temperature.

.1 Do not prolong fish chase.

.1.1 When a temperature above 80° is reached resulting in heavy diversion, hold the temperature until a decrease is seen.

.1.2 Temperature rise may then continue, up to the 85°F target temperature.

.1.3 If fish have stopped coming out by 83°F, there are probably no fish remaining in the forebay.

6.6.3 Continue to flush fish until forebay is sufficiently empty.

.1 Temperature should not be raised as long as fish are still being heavily diverted.

6.6.4 Inform Operations of fish chase completion.

.1 ***For Information Only*** - Operations shall perform HT operations per Reference 2.3.3.

.2 The maximum temperature reached during the HT process shall be recorded on Attachment 1.

NOTE: To minimize the amount of fish killed, HT should begin within one hour after fish chase completion (Reference 2.3.3).

6.6.5 Following HT completion:

.1 Request Operations to operate the rakes and screens to dislodge fish into the trash basket.

.2 Obtain, process, and document trash basket samples per Sections 6.5.2 and 6.5.3.

NOTES:

1) HT fish kill limit is 4,500 lbs. at Units 2/3.

2) Compliance reports fish kills in excess of 4,500 pounds to the NRC within 24 hours per Reference 2.3.6.

6.6.6 If greater than 4,500 pounds of fish are killed during a HT, EPG shall notify Compliance immediately. (References 2.1.1 and 2.4.8)

6.7 Equipment Failure

6.7.1 In the event of equipment failure, the survey should be conducted using the available sample if possible.

6.7.2 The Manager, EPG or designee shall be notified of the nature of the failure, and shall provide any special instructions necessary regarding survey adjustments.

6.8 Training

6.8.1 Individuals participating in species identification and other methodologies involved in HT and normal surveys shall be adequately trained.

7.0 RECORDS

7.1 The Manager, EPG or designee shall review data recorded on Attachments 1, 3, and 4 for verification and signing/dating the verification block on Attachment 1.

7.2 ***For Information Only*** - The NPDES Engineer or designee should provide the total combined (all sample points) fish weight figure for HT surveys to Operations.

7.3 Survey records (Attachments 1, 3, and 4) should be sent to CDM-SONGS for retention for a period of no less than five years.

SAMPLE BREAKDOWN

UNIT ______________

PREPARED BY: ______________________________ DATE: ______________

Aliquot % ______ (if applicable)

Scientific Name (a)	# Fish Counted (b)	Fish Weight (c)	# Fish ÷ Aliquot % (d)	Weight ÷ Aliquot % (e)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				
26.				
27.				
28.				
29.				
30.				
31.				
32.				
33.				
34.				
35.				
TOTAL SPECIES: TOTALS:				

EXAMPLE PAGE____ OF____

ALIQUOT GUIDELINES - TRASH BASKET SAMPLES

1. Determine if aliquot is required. The EPG lead person present determines if the sample is too large to analyze in a reasonable time period, which would make using the entire sample impractical from a cost-effective standpoint.

2. Remove low abundance species. Sort through the sample to remove low abundance species. This is to ensure all species are adequately represented in the sampling data.

3. Subdivide the sample into a manageable size. The larger the aliquot percentage, the more accurate the data is considered; therefore, the largest percentage possible should be used taking all factors into consideration. The EPG lead person present decides what percentage of the sample to use and how to divide the sample.

4. Sort the fish by species. Count and weigh each species present using the same process defined in Sections 6.6.2 and 6.6.3 of this procedure. Ensure appropriate data is recorded.

5. Obtain supplemental length data. Sift through the unused portion of the original sample for any species for which there were less than 125 present in the aliquot. If possible, obtain up to the 125 quantity.

SURVEY DATA SUMMARY SHEET

SURVEY TYPE: ☐ Normal ☐ HT, UNIT ________

SURVEY DATE:

SCREEN/RAKE OPERATION
(Normal Survey only)

U2: Initial: ________ Date ________ Time
Final: ________ Date ________ Time

U3: Initial: ________ Date ________ Time
Final: ________ Date ________ Time

ENVIRONMENTAL CONDITIONS

WEATHER (circle one):

1. Clear, fair
2. Variable high clouds
3. Partly cloudy
4. Overcast
5. Fog
6. Rain
7. Haze
8. Cloudy
9. Stormy
10. Other

WIND (circle one):

0. No wind
1. 1 to 5 knots
2. 6 to 10 knots
3. 11 to 15 knots
4. 16 to 20 knots
5. 21 to 30 knots
6. 31 + knots

SWELL HEIGHT:
______ m

LOAD ESTIMATE:

U2: Heavy, Med, Light,

Bin (dumpster) # ________

U3: Heavy, Med, Light,

Bin (dumpster) # ________

PLANT CONDITIONS:

INTAKE FLOW DIRECTION:

Normal Reverse

NUMBER OF CIRCULATING PUMPS IN OPERATION:

U2: ___ of 4

U3: ___ of 4

SCREENWELL (intake) TEMP:

U2 _____ °F U3 _____ °F

MAX TEMP (HT only): ___ °F

PERSONNEL PRESENT:

EPG Lead: ________________________________
____
____
____

VERIFIED BY:

________________________________ ________________
Supervisor, EPG/designee Date

SCALE USED:

No. ________ No. ________ No. ________ No. ________

EXAMPLE

PAGE ____ of ____

KEYPOINTS - SAMPLE BREAKDOWN (Continued)

(a) List every species present in the sample by scientific name.

(b) Enter the total number counted (measured and unmeasured) for each species from the *Fish Species Data* sheet(s), Attachment 4.

(c) Enter the total weight (measured and unmeasured) for each species from the *Fish Species Data* sheet(s), Attachment 4.

(d) If the sample was aliquotted, divide the number from column (b) by the aliquot percentage to determine the approximate total number of each species present in the entire sample. Express percentage as a decimal (e.g., 50% = 0.5).

(e) If sample was aliquotted, divide the weight from column (c) by the aliquot percentage to determine the approximate total weight of each species for the entire sample. Express percentage as a decimal (e.g., 50% = 0.5).

FISH SPECIES DATA UNIT: ________

PREPARED BY: ________________ DATE: ________

SPECIES:										#	Kg
										Measured Fish	
										Unmeasured Fish	
										Total	

SPECIES:										#	Kg
										Measured Fish	
										Unmeasured Fish	
										Total	

EXAMPLE

PAGE____OF____

FISH SPECIES DATA (Continued) UNIT: ________

PREPARED BY: ______________________ DATE: ________

SPECIES:										TOTAL	
										#	Kg

SPECIES:										TOTAL	
										#	Kg

SPECIES:										TOTAL	
										#	Kg

SPECIES:										TOTAL	
										#	Kg

SPECIES:										TOTAL	
										#	Kg

SPECIES;										TOTAL	
										#	Kg

SPECIES:										TOTAL	
										#	Kg

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SPECIES TO BE SEXED AND LENGTH GUIDELINES

SPECIES	GUIDELINE, SEXABLE SIZE (mm)
Barracuda	> 640
Barred Sand Bass	> 150
Bat Ray	All, External
Black Croaker	> 120
Black Surfperch	> 100, External
Bocaccio	N/A
Brown Smoothhound	All, External
Butterfly Ray	All, External
California Halibut	> 150
Gray Smoothhound	All, External
Horn Shark	All, External
Kelp Bass	> 150
Kelp Surfperch	External
Leopard Shark	All, External
Northern Anchovy	> 95
Pacific Butterfish	> 90
Pacific Electric Ray	All, External
Pacific Sardine	> 120
Rainbow Surfperch	External
Round Stingray	All, External
Rubberlip Surfperch	External
Queenfish	> 95
Sardines	> 140
Sargo	> 100
Shiner Surfperch	All, External
Shovelnose Guitarfish	All, External
Spiny Dogfish	All, External
Spotfin Croaker	> 100
Spotted Sand Bass	> 150
Thornback Ray	All, External
Walleye Surfperch	> 90, External
White Croaker	> 90
White Sea Bass	> 640
White Surfperch	> 100, External
Yellowfin Croaker	> 100

HEAT TREAT CHECKLIST

The following items should be completed by the Heat Treat Cognizant Engineer or designee:

Action	Performed By Heat Treat Cog (Initials)	Date
Heat Treat Team Assembled		
Offsite Emergency Planning (OEP) Notified State Parks if discharge to the beach (949) 720-7001		
MBC Biologist Notified (714) 850-4830		
Security escort paperwork completed		
Dumpster change out scheduled		
The following item must be completed at least 48 hours before the start of a heat treat if practicable:		
Heat Treat FAX sent to San Diego Regional Board (858) 571-6972		
Heat Treat FAX sent to San Diego California Dept. of Fish & Game office (858) 467-4299		

NOTES: ______________________________

EXAMPLE

1.0 ENTRAINMENT MONITORING

Due to the Clean Water Act 316(b) new rule for existing facilities, San Onofre needs to conduct a comprehensive demonstration study (CDS) to demonstrate compliance with the new rule. This includes entrainment monitoring and fish return system efficiency monitoring. Entrainment monitoring was conducted at the San Onofre Nuclear Generating Station during 1979 and 1980 at Unit 1 (prior to construction of Units 2 and 3). Additional studies, focusing on Units 2 and 3, ran from August 1979 through September 1986. These studies included pre- and post-operational periods so that a Before-After-Control-Impact (BACI) analysis could be utilized to estimate entrainment losses. This monitoring provides useful, but dated entrainment information for SONGS, as the data was collected over 19 years ago.. The proposed entrainment monitoring will supplement the previous studies and will document the current entrainment rates and species and life stage composition in entrainment samples. The following sections describe the sampling design, equipment and methodology.. One full year of entrainment monitoring will be conducted.

1.1 ENTRAINMENT AND SOURCE WATER SAMPLING DESIGN

Entrainment monitoring will be done biweekly for one year. This sampling frequency has been widely used as the standard for entrainment sampling at other facilities, including recent studies in California, and considered adequate to describe seasonal patterns in entrainment, as requested in the Phase II rule (EPRI 2005).

Sampling will occur over a full 24-hour period for each sampling event. Sampling will be scheduled to begin on the same day of the week (e.g., Tuesday). One sample will be taken every 6 hours according to the following time intervals: 0-0600, 0600-1200, 1200-1800 and 1800-2400 hours. Exact sampling dates may fluctuate depending on required nuclear maintenance outages and heat treatment schedules.

1.1.1 Entrainment Sampling Gear and Deployment

Samples will be collected within the CWIS intake screenwell in front of the traveling bar racks. Samples will be collected by use of standard plankton nets. Final sampling protocol will be selected in consultation with the CRWQCB, considering representativesness of actual entrainment, temporal coverage of sampling, sampling accuracy and precision, and constraints imposed by operational and safety requirements at SONGS. As part of an overall evaluation of the best practicable sampling location and gear for entrainment monitoring at SONGS, a pilot study will be conducted to compare ichthyoplankton densities collected in standard plankton tows at the SONGS intake (Source Water samples) with densities obtained using plankton nets within the station's cooling water system.

A series of at least ten concurrent samples will be collected during the same time period at the beginning of the sampling program.

In-plant entrainment samples will be collected from the well mixed area at the cooling water intake screenwell within the station site (Figures 5A and 5B). Sampling will be performed using a bongo frame fitted with 60-cm diameter net rings with plankton nets constructed of 333-μm Nitex© nylon mesh. Each net will be equipped with a calibrated flowmeter, allowing the calculation of total flow volume. Each sample will sample a minimum of 30 m^3 of water. Larger samples will be obtained if feasible. Clogging of the plankton nets Netting will be of sufficient size and surface area to reduce the likelihood of net extrusion of smaller eggs and larvae and net overflow. The sampler will be equipped with an inline electronic flowmeter to measure the volume of water pumped.

1.1.2 Source Water Sampling Gear and Deployment

Samples will be collected as close as practicable to the intake. These samples are designed to characterize the larvae of target species occurring in the vicinity of the intake and provide a comparison to historical data. Samples will be collected by use of standard plankton nets.

The offshore net samples will be collected with equipment similar or equal to that used in-plant, a bongo frame fitted with 60-cm diameter net rings with plankton nets constructed of 333-μm Nitex© nylon mesh. Each net will be equipped with a calibrated flowmeter, allowing the calculation of total flow volume.

Each sample will process a minimum of 30 m^3 of water. Larger samples will be obtained if feasible. Clogging of the plankton nets may limit sample volume because of the proximity of the SONGS intake to adjacent kelp forests.

1.1.3 Sample Processing

At the conclusion of the samples, the nets will be washed down to concentrate captured organisms and detritus in the collection cup attached to the net. The concentrated sample will be preserved in a 4-percent buffered formalin-seawater solution, then, after approximately 72-hours, will be transferred to 70% ethanol solution. Further processing of the sample will occur in the laboratory.

In the laboratory, fish larvae, juveniles and targeted invertebrate larvae will be sorted and removed from the sample. If the sample contains a large number of specimens or a large amount of detritus, subsampling will be performed using a Folsom splitter or other appropriate sample volume splitting device.

If subsampling becomes necessary, subsamples will be processed until a minimum of 200 identifiable specimens are found, but counts for individual subsamples will be maintained. Fish eggs will not be sorted or identified because a full assessment of their abundance would require different sampling techniques and they cannot be identified to the same taxonomic levels as fish larvae.

Technicians trained in taxonomy will identify the specimens to life stage and the lowest practicable taxon. Counts will be made be species (taxon) and life stage. Up to 30 specimens per species and life stage will be measured to the nearest 0.1 mm.

1.2 FISH RETURN SYSTEM STUDIES

The fish return system (FRS) monitoring program is proposed for one year (12 months) at both Units 2 and 3. The monitoring program shall be conducted monthly in conjunction with the impingement studies discussed in Section 4.2, with the objective to quantify the diversion efficiency of the FRS for small fish (,50 mm), including larvae and early juveniles, that may otherwise be entrained at an intake without this fish protection technology.

In conjunction with impingement and entrainment sampling, 24-hour fish elevator samples will be collected once per month. All four circulating water pumps should be operated for the unit to be sampled. For each interval, the contents of the elevator basket will be sub-sampled using two 15-inch wide "double" nets equipped with both large (approximately 5 mm) mesh to catch larger fish and debris followed by a second net of approximately 1-2 mm mesh, sufficient to collect larger larvae and early juveniles. Based on initial testing, the process will be adjusted to sample a portion of the elevator volume sufficient to yield at least 200 fish per sample (number of organisms). This process is repeated until fish are no longer present in the elevator basket.

If the number of specimens in the sample for a particular species is large, the count and condition may be taken on a subsample.

In the laboratory, all fish larvae and juveniles will be sorted and removed from the sample. If the sample contains a large number of specimens, subsampling will be performed using a Folsom splitter or other appropriate sample volume splitting device. If subsampling becomes necessary, subsamples will be processed until a minimum of 200 identifiable specimens are found, but counts for individual subsamples will be maintained. Technicians trained in taxonomy will identify the specimens to life stage and the lowest practicable taxon. Counts will be made by species (taxon) and life stage. Up to 30 specimens are species and life stage will be measured to the nearest 0.1 mm.

1.3 RELEVANT ANCILLARY INFORMATION

There is ancillary information that must be recorded relevant to environmental conditions at the time of entrainment monitoring, as well as plant operation data needed to estimate total entrainment. Environmental data relevant to each sample will be recorded on an accompanying field data sheet at the start of each 6-hour entrainment sampling period or 24-hour impingement and FRS sampling period. In addition to date and sample start/end time recordings, these data will include operation parameters for the intake (identify pumps operating); tidal stage; and water temperature, and water clarity, all recorded at the beginning of each collection. A unique sample identification number will be assigned to each sample. Other relevant observations will be recorded, such as air temperature, wind speed, cloud cover, and precipitation.

Plant operation records will be obtained to determine the operation regime during the sampled and unsampled days in each month. Data required include hourly pumping rates (or volumes) for each unit, generation output (MWh) and discharge water temperature.

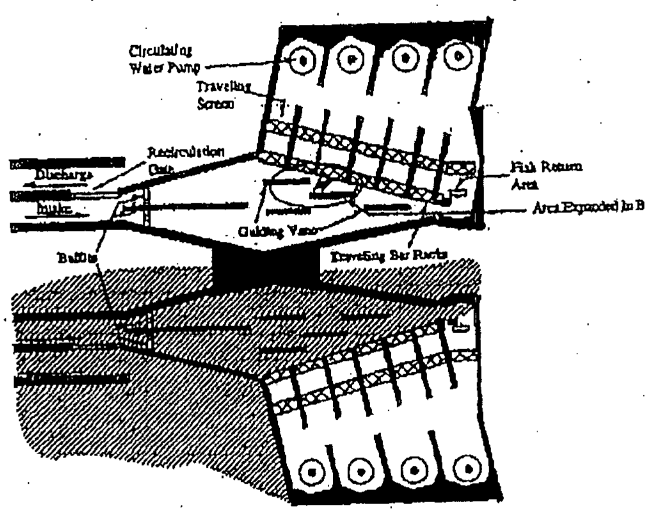

FIGURE 5A.

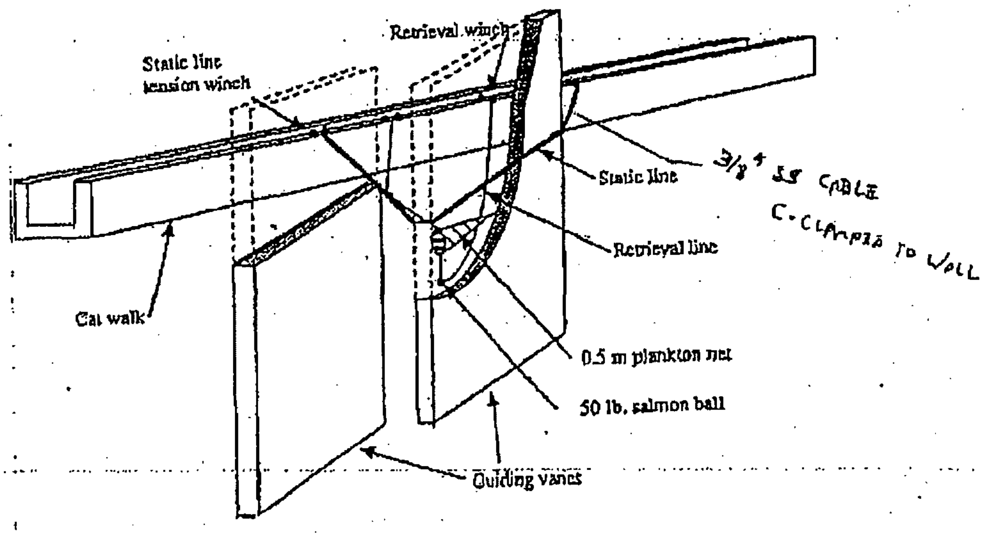
Retrieval winch
Static line tension winch
3/8" SS CABLE
C-CLAMPED TO WALL
Static line
Retrieval line
Cat walk
0.5 m plankton net
50 lb. salmon ball
Guiding vanes

FIGURE 5B.

SONGS 316(b) ENTRAINMENT MORTALITY AND IMPINGEMENT CHARACTERIZATION STUDY SAMPLING AND QUALITY ASSURANCE AND QUALITY CONTROL PROGRAMS

Impingement

- Field leaders are experienced with impingement of southern California fishes and shellfishes;
- All impingement personnel review written procedures prior to field sampling;
- All impingement personnel review specialized field taxonomic guides of the species most commonly impinged. The guides highlights the distinguishing characteristics of the commonly impinged species;
- All field data are verified after completion of each survey;
- Voucher or unknown specimens are returned to the laboratory for confirmation of identity;
- All field data are double-entered into an MS Access database. The two sets of entered data are checked against one another for data entry errors;
- Errors are corrected and data re-checked as required.

Entrainment

- All entrainment personnel review written procedures prior to field sampling;
- At each entrainment/source water station, samples are voided and recollected if any of the following occur: (1) potential flowmeter malfunction, (2) damaged/torn nets, (3) large amounts of sediment in the codends, (4) any other gear failure, (5) any situation that prevents reliable collection of data, or (6) any situation that jeopardizes the safety of sampling personnel;
- Flowmeters are calibrated quarterly;
- Flowmeter readings are checked in the field to ensure both bongo nets are filtering similar volumes of water;
- Nets are inspected and repaired as necessary prior to each survey;
- Samples are transferred to containers with both internal and external labels.

Source Water

- All entrainment personnel review written procedures prior to field sampling;
- At the source water station, samples are voided and recollected if any of the following occur: (1) potential flowmeter malfunction, (2) damaged/torn nets, (3) large amounts of sediment in the codends, (4) any other gear failure, (5) any situation that prevents reliable collection of data, or (6) any situation that jeopardizes the safety of sampling personnel;
- Flowmeters are calibrated quarterly;
- Flowmeter readings are checked in the field to ensure both bongo nets are filtering similar volumes of water;

- Nets are inspected and repaired as necessary prior to each survey;
- Samples are transferred to containers with both internal and external labels.

QA/QC OVERVIEW

Field sampling

Impingement

On a quarterly basis, the QA/QC scientist will verify all individuals are removed from the impinged material. Re-sorting of the fish and invertebrate species, and verification of the identification of the sorted species will be conducted. If the count of any individual taxon made during the QA/QC survey varies by more than 5% (or one individual if the total number of individuals is less than 20) from the count of the observer then the next three sampling cycles for that observer will be checked in a followup survey. If the identification is incorrect, the observer will have additional training in identification procedures.

Entrainment and source water

On a quarterly basis, the QA/QC scientist will verify that field personnel set up all sampling equipment correctly, that correct sampling procedures are followed, nets are thoroughly washed, sample containers are properly labeled inside and outside, sample transfer and preservation is completed correctly, and all data are recorded accurately.

Laboratory sorting and identification

A more detailed QA/QC program will be applied to all laboratory processing. The first ten samples sorted by an individual will be resorted by a designated quality control (QC) sorter. A sorter is allowed to miss one organism when the total number of organisms in the sample is less than 20. For samples with 20 or greater organisms the sorter must maintain a sorting accuracy of 90 percent. After a sorter has ten consecutive samples with greater than 90 percent accuracy, the sorter will have one of their next ten samples randomly selected for a QA/QC check. If the sorter fails to achieve an accuracy level of 90 percent their next ten samples will be resorted by the QC sorter until they meet the required level of accuracy. If the sorter maintains the required level of accuracy one of their next ten samples will be resorted by QC personnel.

A similar QA/QC program will be conducted for the taxonomists identifying the samples. The first ten samples of fish or shellfish identified by an individual taxonomist will be completely re-identified by a designated QC taxonomist. A total of at least 50 individual fish larvae from at least five taxa must be present in these first ten samples; if not, additional samples will be re-identified until this criterion is met. Taxonomists are required to maintain a 95 percent identification accuracy level in these first ten samples. After the taxonomist has identified ten consecutive samples with greater than 95 percent accuracy, they will have one of their next ten samples checked by a QC taxonomist. If the taxonomist maintains an accuracy level of 95 percent then they will continue to have one of each ten samples checked by a QC taxonomist. If they fall below this level then ten consecutive samples they have identified will be checked for accuracy. Samples will be re-identified until ten consecutive samples meet the 95 percent criterion. Identifications will be cross-checked against taxonomic voucher collections maintained by MBC and Tenera Environmental.

Field and laboratory data will be recorded on preprinted data sheets formatted for entry into a computer database for analysis and archiving. On a monthly basis the entrainment and source water data will be transmitted to Tenera Environmental for entry into the project database and eventual analysis. Printed spreadsheets will be checked for accuracy against original field and laboratory data sheets. Density of larval fish and shellfish by species will be reported as number per 1,000 cubic meters (#/1,000 m^3).

San Onofre Nuclear Generating Station

Appendix B

Entrainment and Source Water Data

B1. Inplant Data by Survey and Station

B2. Offshore Data by Survey and Station

B3. Source Water Data by Survey and Station

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SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA01
Start Date: March 29, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	139	394.55
Gobiidae unid.	gobies	58	171.87
Genyonemus lineatus	white croaker	44	125.19
Gibbonsia spp.	clinid kelpfishes	40	125.36
Engraulidae unid.	anchovies	15	45.93
Gobiesocidae unid.	clingfishes	5	17.00
Typhlogobius californiensis	blind goby	4	12.03
Rimicola spp.	kelp clingfishes	3	8.25
Chaenopsidae unid.	tube blennies	2	4.97
larval/post-larval fish unid.	larval fishes	2	6.34
Paralichthys californicus	California halibut	2	5.61
Pleuronichthys guttulatus	diamond turbot	2	5.52
Clinidae unid.	kelp blennies	1	3.42
larval fish - damaged	unidentified larval fishes	1	3.13
larval fish fragment	unidentified larval fishes	1	3.66
Parophrys vetulus	English sole	1	3.66
Rimicola eigenmanni	slender clingfish	1	2.33
Sciaenidae unid.	croakers	1	3.19
Seriphus politus	queenfish	1	3.13
	Total Entrainable Larval Fishes:	**323**	
Eggs			
fish eggs unid.	unidentified fish eggs	2,392	5,835.08
Engraulidae unid. (eggs)	anchovy eggs	386	1,181.25
Paralichthyidae unid. (eggs)	sand flounder eggs	169	459.87
Citharichthys spp. (eggs)	sanddab eggs	145	394.75
Pleuronichthys spp. (eggs)	turbot eggs	31	96.93
Sciaenidae unid. (eggs)	croaker eggs	14	40.10
	Total Eggs:	**3,137**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	2.48
	Total Invertebrates:	**1**	
	Total Station Count:	**3,461**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA01
Start Date: March 29, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	184	528.69
Gobiidae unid.	gobies	110	324.82
Gibbonsia spp.	clinid kelpfishes	93	281.33
Genyonemus lineatus	white croaker	41	110.01
Engraulidae unid.	anchovies	4	11.48
Leuresthes tenuis	California grunion	4	10.91
Sciaenidae unid.	croakers	4	12.17
Atherinopsis californiensis	jacksmelt	3	9.13
Gobiesox spp.	clingfishes	3	10.94
larvae, unidentified yolksac	unidentified yolksac larvae	3	6.97
Typhlogobius californiensis	blind goby	3	10.94
Heterostichus rostratus	giant kelpfish	2	7.70
larval fish - damaged	unidentified larval fishes	2	6.48
larval/post-larval fish unid.	larval fishes	2	5.77
Paralichthys californicus	California halibut	2	5.39
Pleuronichthys guttulatus	diamond turbot	2	5.36
Atherinopsidae unid.	silversides	1	2.07
Gobiesocidae unid.	clingfishes	1	2.73
Rimicola spp.	kelp clingfishes	1	2.07
	Total Entrainable Larval Fishes:	**465**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	15	48.60
	Total Non-Entrainable Fishes:	**15**	
Eggs			
fish eggs unid.	unidentified fish eggs	668	1,703.41
Engraulidae unid. (eggs)	anchovy eggs	328	946.73
Paralichthyidae unid. (eggs)	sand flounder eggs	120	297.43
Citharichthys spp. (eggs)	sanddab eggs	101	250.42
Pleuronichthys spp. (eggs)	turbot eggs	50	137.35
Sciaenidae unid. (eggs)	croaker eggs	20	44.55
Sardinops sagax (eggs)	Pacific sardine eggs	1	2.32
	Total Eggs:	**1,288**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	2.73
	Total Invertebrates:	**1**	
	Total Station Count:	**1,769**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA02
Start Date: April 12, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	1,608	2,553.76
Genyonemus lineatus	white croaker	145	226.34
Typhlogobius californiensis	blind goby	81	126.71
Gobiidae unid.	gobies	47	74.20
Gibbonsia spp.	clinid kelpfishes	22	33.82
Gobiesox spp.	clingfishes	11	16.59
larval fish fragment	unidentified larval fishes	5	7.80
Atherinopsis californiensis	jacksmelt	4	5.99
Paralichthys californicus	California halibut	4	6.58
Sciaenidae unid.	croakers	4	6.16
Seriphus politus	queenfish	4	6.24
Pleuronichthys guttulatus	diamond turbot	3	4.83
Hypsoblennius spp.	combtooth blennies	1	1.61
larval/post-larval fish unid.	larval fishes	1	1.68
	Total Entrainable Larval Fishes:	**1,940**	
Eggs			
Engraulidae unid. (eggs)	anchovy eggs	2,072	3,255.86
fish eggs unid.	unidentified fish eggs	1,339	2,104.18
Sciaen./Paralich./Labridae (eggs)	fish eggs	60	95.92
Pleuronichthys spp. (eggs)	turbot eggs	53	85.54
Paralichthyidae unid. (eggs)	sand flounder eggs	46	69.16
Sciaenidae unid. (eggs)	croaker eggs	27	42.56
Citharichthys spp. (eggs)	sanddab eggs	10	14.86
	Total Eggs:	**3,607**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	1.59
Cancer productus (megalops)	red rock crab megalops	1	1.56
	Total Invertebrates:	**2**	
	Total Station Count:	**5,549**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA02
Start Date: April 12, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	1,012	1,546.70
Genyonemus lineatus	white croaker	352	532.74
Typhlogobius californiensis	blind goby	25	37.96
Gobiidae unid.	gobies	19	31.62
Paralichthys californicus	California halibut	18	26.03
Engraulidae unid.	anchovies	16	21.45
Gibbonsia spp.	clinid kelpfishes	16	26.47
Gobiesox spp.	clingfishes	7	11.27
larval fish fragment	unidentified larval fishes	3	4.69
Pleuronichthys guttulatus	diamond turbot	3	4.74
Pleuronichthys spp.	turbots	3	4.29
larval fish - damaged	unidentified larval fishes	2	3.12
Sciaenidae unid.	croakers	2	3.40
Atherinopsis californiensis	jacksmelt	1	1.81
Hypsoblennius spp.	combtooth blennies	1	1.40
Pleuronichthys ritteri	spotted turbot	1	1.39
Seriphus politus	queenfish	1	1.40
Stenobrachius leucopsarus	northern lampfish	1	1.58
	Total Entrainable Larval Fishes:	**1,483**	
Eggs			
Engraulidae unid. (eggs)	anchovy eggs	2,243	3,513.26
fish eggs unid.	unidentified fish eggs	1,028	1,622.95
Pleuronichthys spp. (eggs)	turbot eggs	101	154.55
Paralichthyidae unid. (eggs)	sand flounder eggs	40	62.76
Sciaenidae unid. (eggs)	croaker eggs	39	57.27
Sciaen./Paralich./Labridae (eggs)	fish eggs	32	54.97
Citharichthys spp. (eggs)	sanddab eggs	22	33.74
Atherinops affinis (eggs)	topsmelt eggs	2	3.08
	Total Eggs:	**3,507**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**4,990**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA03
Start Date: April 26, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Engraulidae unid.	anchovies	57	173.56
Typhlogobius californiensis	blind goby	38	100.03
Genyonemus lineatus	white croaker	30	85.50
Engraulis mordax	northern anchovy	6	16.74
Gobiidae unid.	gobies	3	8.27
Seriphus politus	queenfish	2	6.67
Stenobrachius leucopsarus	northern lampfish	2	5.42
Atherinopsidae unid.	silversides	1	2.30
Gibbonsia spp.	clinid kelpfishes	1	2.58
Gillichthys mirabilis	longjaw mudsucker	1	3.07
Gobiesox spp.	clingfishes	1	2.58
Hypsoblennius spp.	combtooth blennies	1	3.11
Paralichthys californicus	California halibut	1	3.07
	Total Entrainable Larval Fishes:	**144**	
Eggs			
Engraulidae unid. (eggs)	anchovy eggs	1,439	61,073.69
fish eggs unid.	unidentified fish eggs	51	2,047.85
Pleuronichthys spp. (eggs)	turbot eggs	5	147.35
	Total Eggs:	**1,495**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	3.11
	Total Invertebrates:	**1**	
	Total Station Count:	**1,640**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA03
Start Date: April 26, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Typhlogobius californiensis	blind goby	75	174.42
Engraulidae unid.	anchovies	60	170.48
Genyonemus lineatus	white croaker	30	79.51
Hypsoblennius spp.	combtooth blennies	4	9.18
Gobiidae unid.	gobies	3	7.38
Engraulis mordax	northern anchovy	2	5.36
Atherinopsidae unid.	silversides	1	2.23
Atherinopsis californiensis	jacksmelt	1	2.27
Heterostichus rostratus	giant kelpfish	1	2.43
Pleuronichthys ritteri	spotted turbot	1	2.92
Sciaenidae unid.	croakers	1	3.22
Seriphus politus	queenfish	1	2.43
Stenobrachius leucopsarus	northern lampfish	1	1.91
Syngnathus spp.	pipefishes	1	2.23
	Total Entrainable Larval Fishes:	**182**	
Eggs			
Engraulidae unid. (eggs)	anchovy eggs	2,479	99,329.23
fish eggs unid.	unidentified fish eggs	26	990.75
Pleuronichthys spp. (eggs)	turbot eggs	2	55.21
	Total Eggs:	**2,507**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**2,689**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA04
Start Date: May 10, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	214	594.82
Leuresthes tenuis	California grunion	95	258.03
Gobiidae unid.	gobies	48	133.54
Gibbonsia spp.	clinid kelpfishes	35	94.69
Hypsoblennius spp.	combtooth blennies	24	69.13
Typhlogobius californiensis	blind goby	24	69.63
Engraulidae unid.	anchovies	21	58.31
Genyonemus lineatus	white croaker	12	34.95
Atherinopsidae unid.	silversides	4	10.96
Heterostichus rostratus	giant kelpfish	4	10.34
Gobiesox spp.	clingfishes	2	5.17
Acanthogobius flavimanus	yellowfin goby	1	2.91
larvae, unidentified yolksac	unidentified yolksac larvae	1	3.09
larval/post-larval fish unid.	larval fishes	1	2.83
Parophrys vetulus	English sole	1	2.46
	Total Entrainable Larval Fishes:	**487**	
Non-Entrainable Fishes			
Syngnathus exilis	barcheek pipefish	1	3.09
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	601	1,671.96
Paralichthyidae unid. (eggs)	sand flounder eggs	83	232.44
Citharichthys spp. (eggs)	sanddab eggs	54	157.72
Engraulidae unid. (eggs)	anchovy eggs	18	49.04
Sciaenidae unid. (eggs)	croaker eggs	10	28.26
Pleuronichthys spp. (eggs)	turbot eggs	6	16.39
Atherinopsidae unid. (eggs)	silverside eggs	5	12.30
Atherinopsis californiensis (eggs)	jacksmelt eggs	4	11.39
Blenniidae (eggs)	blenny eggs	2	6.18
	Total Eggs:	**783**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	1	2.91
	Total Invertebrates:	**1**	
	Total Station Count:	**1,272**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA04
Start Date: May 10, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	221	550.70
Leuresthes tenuis	California grunion	118	269.75
Genyonemus lineatus	white croaker	28	71.68
Typhlogobius californiensis	blind goby	25	62.81
Gibbonsia spp.	clinid kelpfishes	21	52.66
Gobiidae unid.	gobies	20	48.41
Hypsoblennius spp.	combtooth blennies	13	33.30
Engraulidae unid.	anchovies	11	27.87
Gobiesox spp.	clingfishes	1	2.22
Heterostichus rostratus	giant kelpfish	1	2.19
larval fish fragment	unidentified larval fishes	1	2.22
	Total Entrainable Larval Fishes:	**460**	
Eggs			
fish eggs unid.	unidentified fish eggs	591	1,444.61
Paralichthyidae unid. (eggs)	sand flounder eggs	135	345.80
Citharichthys spp. (eggs)	sanddab eggs	74	193.95
Engraulidae unid. (eggs)	anchovy eggs	32	78.77
Sciaenidae unid. (eggs)	croaker eggs	9	22.99
Atherinopsis californiensis (eggs)	jacksmelt eggs	8	20.31
Pleuronichthys spp. (eggs)	turbot eggs	6	14.89
Atherinopsidae unid. (eggs)	silverside eggs	1	2.89
	Total Eggs:	**856**	
Invertebrates			
Cancer antennarius (megalops)	brown rock crab megalops	1	2.19
	Total Invertebrates:	**1**	
	Total Station Count:	**1,317**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA05
Start Date: May 24, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulidae unid.	anchovies	253	755.33
Gibbonsia spp.	clinid kelpfishes	59	166.15
Hypsoblennius spp.	combtooth blennies	36	104.59
Gobiidae unid.	gobies	21	60.53
Typhlogobius californiensis	blind goby	17	48.66
Gobiesox spp.	clingfishes	14	41.34
Engraulis mordax	northern anchovy	13	37.20
Genyonemus lineatus	white croaker	6	16.81
Leuresthes tenuis	California grunion	4	11.45
Sciaenidae unid.	croakers	2	5.86
Anchoa spp.	anchovy	1	2.85
Heterostichus rostratus	giant kelpfish	1	3.17
larvae, unidentified yolksac	unidentified yolksac larvae	1	2.95
larval fish fragment	unidentified larval fishes	1	2.76
Oxyjulis californica	senorita	1	2.76
Paralichthyidae unid.	sand flounders	1	2.63
	Total Entrainable Larval Fishes:	**431**	
Eggs			
fish eggs unid.	unidentified fish eggs	2,075	5,944.14
Sciaen./Paralich./Labridae (eggs)	fish eggs	987	2,805.10
Engraulidae unid. (eggs)	anchovy eggs	902	2,586.88
Paralichthyidae unid. (eggs)	sand flounder eggs	129	371.05
Pleuronichthys spp. (eggs)	turbot eggs	71	202.40
Citharichthys spp. (eggs)	sanddab eggs	19	53.57
Sciaenidae unid. (eggs)	croaker eggs	16	46.14
Pleuronichthys guttulatus (eggs)	diamond turbot eggs	5	14.38
Merlucci./Sphyraenidae (eggs)	hake / barracuda eggs	3	8.69
	Total Eggs:	**4,207**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	2.85
	Total Invertebrates:	**1**	
	Total Station Count:	**4,639**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA05
Start Date: May 24, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulidae unid.	anchovies	2,429	6,069.66
Gibbonsia spp.	clinid kelpfishes	82	219.55
Hypsoblennius spp.	combtooth blennies	43	117.24
Sciaenidae unid.	croakers	27	67.93
Engraulis mordax	northern anchovy	26	70.27
Gobiidae unid.	gobies	12	32.33
Typhlogobius californiensis	blind goby	7	19.52
Gobiesox spp.	clingfishes	6	16.89
Genyonemus lineatus	white croaker	4	11.11
Leuresthes tenuis	California grunion	4	12.52
Cheilotrema saturnum	black croaker	2	5.00
Peprilus simillimus	Pacific butterfish	2	5.00
Semicossyphus pulcher	California sheephead	2	4.83
Atherinopsidae unid.	silversides	1	2.65
larvae, unidentified yolksac	unidentified yolksac larvae	1	2.42
larval fish - damaged	unidentified larval fishes	1	2.58
Paralichthys californicus	California halibut	1	2.42
Seriphus politus	queenfish	1	2.58
	Total Entrainable Larval Fishes:	**2,651**	
Eggs			
fish eggs unid.	unidentified fish eggs	2,335	7,461.46
Sciaen./Paralich./Labridae (eggs)	fish eggs	1,572	5,107.08
Engraulidae unid. (eggs)	anchovy eggs	1,501	4,476.90
Pleuronichthys spp. (eggs)	turbot eggs	72	264.27
Citharichthys spp. (eggs)	sanddab eggs	46	154.16
Blenniidae (eggs)	blenny eggs	6	18.12
Pleuronichthys guttulatus (eggs)	diamond turbot eggs	5	15.70
Merlucci./Sphyraenidae (eggs)	hake / barracuda eggs	4	12.44
Pleuronectidae unid. (eggs)	righteye flounder eggs	4	10.84
	Total Eggs:	**5,545**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	2.78
	Total Invertebrates:	**1**	
	Total Station Count:	**8,197**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA06
Start Date: June 07, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	249	709.02
Hypsoblennius spp.	combtooth blennies	86	242.95
Seriphus politus	queenfish	67	188.54
Typhlogobius californiensis	blind goby	43	118.22
Engraulidae unid.	anchovies	23	63.67
larval fish fragment	unidentified larval fishes	21	58.64
Gibbonsia spp.	clinid kelpfishes	19	50.93
Sphyraena argentea	Pacific barracuda	11	31.23
Gobiesocidae unid.	clingfishes	8	21.66
Labrisomidae unid.	labrisomid blennies	8	22.02
Gobiidae unid.	gobies	6	16.89
larval/post-larval fish unid.	larval fishes	6	16.56
Gobiesox spp.	clingfishes	5	14.30
Leuresthes tenuis	California grunion	5	14.02
Heterostichus rostratus	giant kelpfish	4	11.34
Sciaenidae unid.	croakers	2	5.35
Cheilotrema saturnum	black croaker	1	3.12
Paralichthys californicus	California halibut	1	2.78
Rimicola spp.	kelp clingfishes	1	2.67
Roncador stearnsi	spotfin croaker	1	2.77
	Total Entrainable Larval Fishes:	**567**	
Eggs			
Sciaen./Paralich./Labridae (eggs)	fish eggs	433	11,801.68
fish eggs unid.	unidentified fish eggs	411	11,467.90
Engraulidae unid. (eggs)	anchovy eggs	9	235.47
Paralichthyidae unid. (eggs)	sand flounder eggs	7	197.04
Sphyraena argentea (eggs)	Pacific barracuda eggs	3	78.79
Atractoscion nobilis (eggs)	white seabass	1	31.23
Citharichthys spp. (eggs)	sanddab eggs	1	27.85
Pleuronichthys spp. (eggs)	turbot eggs	1	27.85
	Total Eggs:	**866**	
Invertebrates			
Cancer antennarius (megalops)	brown rock crab megalops	9	24.92
Cancer anthonyi (megalops)	yellow crab megalops	5	14.00
	Total Invertebrates:	**14**	
	Total Station Count:	**1,447**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA06
Start Date: June 07, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	488	1,450.56
Seriphus politus	queenfish	141	431.29
Hypsoblennius spp.	combtooth blennies	116	338.72
Engraulidae unid.	anchovies	29	83.55
Gibbonsia spp.	clinid kelpfishes	29	86.47
Typhlogobius californiensis	blind goby	28	80.81
Rimicola spp.	kelp clingfishes	26	79.73
larval/post-larval fish unid.	larval fishes	17	51.42
Roncador stearnsi	spotfin croaker	12	38.61
Sphyraena argentea	Pacific barracuda	12	35.27
larval fish fragment	unidentified larval fishes	8	23.70
larvae, unidentified yolksac	unidentified yolksac larvae	6	17.07
Gobiesox spp.	clingfishes	5	15.99
Leuresthes tenuis	California grunion	5	14.37
Labrisomidae unid.	labrisomid blennies	3	9.66
Gobiesocidae unid.	clingfishes	2	5.93
Gobiidae unid.	gobies	2	5.98
Heterostichus rostratus	giant kelpfish	2	6.00
Paralabrax spp.	sand bass	2	5.98
Atherinops affinis	topsmelt	1	2.66
Citharichthys spp.	sanddabs	1	3.15
Menticirrhus undulatus	California corbina	1	2.96
Oxyjulis californica	senorita	1	2.96
Paralichthys californicus	California halibut	1	2.85
	Total Entrainable Larval Fishes:	**938**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	2	6.64
	Total Non-Entrainable Fishes:	**2**	
Eggs			
fish eggs unid.	unidentified fish eggs	2,972	22,854.57
Sciaen./Paralich./Labridae (eggs)	fish eggs	2,271	16,060.00
Paralichthyidae unid. (eggs)	sand flounder eggs	23	735.28
Engraulidae unid. (eggs)	anchovy eggs	15	74.54
Sphyraena argentea (eggs)	Pacific barracuda eggs	3	8.52
Atractoscion nobilis (eggs)	white seabass	1	28.51
Citharichthys spp. (eggs)	sanddab eggs	1	33.21
Pleuronichthys spp. (eggs)	turbot eggs	1	28.51
	Total Eggs:	**5,287**	
Invertebrates			
Cancer antennarius (megalops)	brown rock crab megalops	3	8.34
	Total Invertebrates:	**3**	
	Total Station Count:	**6,230**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA07
Start Date: June 21, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	387	1,104.30
Seriphus politus	queenfish	257	719.89
Gobiidae unid.	gobies	68	195.91
Hypsoblennius spp.	combtooth blennies	34	98.29
Engraulidae unid.	anchovies	25	72.30
Roncador stearnsi	spotfin croaker	8	23.62
larval/post-larval fish unid.	larval fishes	7	20.05
Typhlogobius californiensis	blind goby	6	16.37
Gobiesox spp.	clingfishes	1	2.85
larval fish - damaged	unidentified larval fishes	1	2.98
Leuresthes tenuis	California grunion	1	2.85
	Total Entrainable Larval Fishes:	**795**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	40	120.58
Syngnathus spp.	pipefishes	1	2.70
	Total Non-Entrainable Fishes:	**41**	
Eggs			
fish eggs unid.	unidentified fish eggs	1,036	11,297.63
Sciaen./Paralich./Labridae (eggs)	fish eggs	706	9,157.76
Engraulidae unid. (eggs)	anchovy eggs	90	854.97
Citharichthys spp. (eggs)	sanddab eggs	5	120.98
Paralichthyidae unid. (eggs)	sand flounder eggs	3	90.87
Pleuronichthys spp. (eggs)	turbot eggs	3	8.24
Sphyraena argentea (eggs)	Pacific barracuda eggs	1	2.83
	Total Eggs:	**1,844**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	2.70
	Total Invertebrates:	**1**	
	Total Station Count:	**2,681**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA07
Start Date: June 21, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	365	1,055.70
Seriphus politus	queenfish	151	434.75
Gobiidae unid.	gobies	24	70.16
Hypsoblennius spp.	combtooth blennies	11	30.68
Engraulidae unid.	anchovies	6	16.69
larval fish - damaged	unidentified larval fishes	1	2.65
larval/post-larval fish unid.	larval fishes	1	3.08
Paralabrax spp.	sand bass	1	3.02
Peprilus simillimus	Pacific butterfish	1	3.02
Syngnathus spp.	pipefishes	1	3.06
	Total Entrainable Larval Fishes:	**562**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	4	11.82
	Total Non-Entrainable Fishes:	**4**	
Eggs			
Sciaen./Paralich./Labridae (eggs)	fish eggs	832	3,545.64
fish eggs unid.	unidentified fish eggs	693	4,700.55
Engraulidae unid. (eggs)	anchovy eggs	129	600.21
Paralichthyidae unid. (eggs)	sand flounder eggs	16	463.15
Pleuronichthys spp. (eggs)	turbot eggs	3	8.47
Citharichthys spp. (eggs)	sanddab eggs	2	6.11
Paralabrax spp. (eggs)	sand bass eggs	2	5.45
	Total Eggs:	**1,677**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	3	8.03
	Total Invertebrates:	**3**	
	Total Station Count:	**2,246**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA08
Start Date: July 06, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	339	985.01
Seriphus politus	queenfish	26	72.52
Sciaenidae unid.	croakers	24	70.74
larvae, unidentified yolksac	unidentified yolksac larvae	20	59.25
Gibbonsia spp.	clinid kelpfishes	16	45.22
Gobiesox spp.	clingfishes	15	41.18
Gobiidae unid.	gobies	13	37.59
Typhlogobius californiensis	blind goby	11	31.93
Hypsoblennius spp.	combtooth blennies	8	22.63
Labrisomidae unid.	labrisomid blennies	7	19.91
Paralichthys californicus	California halibut	5	14.00
Paralabrax spp.	sand bass	4	12.16
Perciformes unid.	perch-like fishes	4	12.40
Roncador stearnsi	spotfin croaker	4	10.75
Diaphus theta	California headlight fish	2	5.24
larval fish - damaged	unidentified larval fishes	2	5.76
larval fish fragment	unidentified larval fishes	2	6.18
Engraulidae unid.	anchovies	1	2.86
Oxyjulis californica	senorita	1	2.90
Sphyraena argentea	Pacific barracuda	1	3.08
Triphoturus mexicanus	Mexican lampfish	1	2.62
	Total Entrainable Larval Fishes:	**506**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	1	3.08
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	663	18,969.13
Sciaen./Paralich./Labridae (eggs)	fish eggs	165	1,907.05
Paralichthyidae unid. (eggs)	sand flounder eggs	21	588.21
Engraulidae unid. (eggs)	anchovy eggs	8	158.07
Paralabrax spp. (eggs)	sand bass eggs	7	77.12
Sphyraena argentea (eggs)	Pacific barracuda eggs	4	86.32
Labridae unid. (eggs)	wrasse eggs	2	55.17
Pleuronichthys spp. (eggs)	turbot eggs	2	56.07
Citharichthys spp. (eggs)	sanddab eggs	1	3.10
	Total Eggs:	**873**	
Invertebrates			
Panulirus interruptus (phyllo.)	California spiny lobster (larval)	4	11.73
Cancer antennarius (megalops)	brown rock crab megalops	1	3.08
Cancer anthonyi (megalops)	yellow crab megalops	1	3.08
Cancer gracilis (megalops)	slender crab megalops	1	3.08
	Total Invertebrates:	**7**	
	Total Station Count:	**1,387**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA08
Start Date: July 06, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	229	672.67
Sciaenidae unid.	croakers	68	198.35
larvae, unidentified yolksac	unidentified yolksac larvae	65	183.30
Hypsoblennius spp.	combtooth blennies	22	63.48
Perciformes unid.	perch-like fishes	21	60.21
Paralabrax spp.	sand bass	20	57.59
Gibbonsia spp.	clinid kelpfishes	18	52.53
Labrisomidae unid.	labrisomid blennies	16	46.26
Paralichthys californicus	California halibut	11	32.81
Gobiesox spp.	clingfishes	10	29.64
Gobiidae unid.	gobies	10	29.87
Typhlogobius californiensis	blind goby	10	30.53
larval fish fragment	unidentified larval fishes	9	25.17
Roncador stearnsi	spotfin croaker	9	28.24
Seriphus politus	queenfish	9	27.37
Haemulidae unid.	grunts	8	22.13
Cheilotrema saturnum	black croaker	5	15.27
Diaphus theta	California headlight fish	4	11.40
Pleuronichthys spp.	turbots	4	12.11
larval fish - damaged	unidentified larval fishes	3	9.13
Sphyraena argentea	Pacific barracuda	3	8.75
Paralichthyidae unid.	sand flounders	2	5.33
Xystreurys liolepis	fantail sole	2	6.05
Citharichthys stigmaeus	speckled sanddab	1	3.09
Genyonemus lineatus	white croaker	1	3.20
Pleuronectiformes unid.	flatfishes	1	2.85
Pleuronichthys verticalis	hornyhead turbot	1	2.85
	Total Entrainable Larval Fishes:	**562**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	4	11.97
	Total Non-Entrainable Fishes:	**4**	
Eggs			
fish eggs unid.	unidentified fish eggs	307	8,951.37
Sciaen./Paralich./Labridae (eggs)	fish eggs	159	4,476.70
Paralichthyidae unid. (eggs)	sand flounder eggs	13	384.12
Pleuronichthys spp. (eggs)	turbot eggs	4	120.84
Sphyraena argentea (eggs)	Pacific barracuda eggs	3	87.80
Citharichthys spp. (eggs)	sanddab eggs	2	62.87
Engraulidae unid. (eggs)	anchovy eggs	2	57.97
Paralabrax spp. (eggs)	sand bass eggs	2	60.45
	Total Eggs:	**492**	
Invertebrates			
Panulirus interruptus (phyllo.)	California spiny lobster (larval)	16	48.04
Cancer anthonyi (megalops)	yellow crab megalops	3	9.26
Cancer antennarius (megalops)	brown rock crab megalops	2	6.18
Cancer gracilis (megalops)	slender crab megalops	2	5.42
	Total Invertebrates:	**23**	
	Total Station Count:	**1,081**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA09
Start Date: July 19, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Hypsoblennius spp.	combtooth blennies	13	36.64
Engraulis mordax	northern anchovy	11	28.42
Seriphus politus	queenfish	11	27.77
larvae, unidentified yolksac	unidentified yolksac larvae	10	26.18
larval fish fragment	unidentified larval fishes	3	7.92
Typhlogobius californiensis	blind goby	3	8.47
Paralabrax spp.	sand bass	2	5.28
Gobiidae unid.	gobies	1	2.40
Halichoeres semicinctus	rock wrasse	1	2.63
Paralichthys californicus	California halibut	1	2.40
	Total Entrainable Larval Fishes:	**56**	
Eggs			
Sciaen./Paralich./Labridae (eggs)	fish eggs	308	1,141.29
fish eggs unid.	unidentified fish eggs	229	4,967.87
Engraulidae unid. (eggs)	anchovy eggs	43	1,092.33
Paralabrax spp. (eggs)	sand bass eggs	9	23.67
Paralichthyidae unid. (eggs)	sand flounder eggs	7	196.63
Pleuronichthys spp. (eggs)	turbot eggs	2	50.34
Citharichthys spp. (eggs)	sanddab eggs	1	24.03
Labridae/Serranidae (eggs)	wrasse eggs	1	27.97
	Total Eggs:	**600**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	1	2.40
Cancer gracilis (megalops)	slender crab megalops	1	2.45
	Total Invertebrates:	**2**	
	Total Station Count:	**658**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA09
Start Date: July 19, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Hypsoblennius spp.	combtooth blennies	11	30.76
larvae, unidentified yolksac	unidentified yolksac larvae	11	30.76
larval fish fragment	unidentified larval fishes	11	31.61
Paralabrax spp.	sand bass	7	19.45
Seriphus politus	queenfish	5	13.64
Engraulis mordax	northern anchovy	4	10.58
Haemulidae unid.	grunts	2	5.46
Sphyraena argentea	Pacific barracuda	2	4.61
Diaphus theta	California headlight fish	1	2.74
Engraulidae unid.	anchovies	1	2.93
larval fish - damaged	unidentified larval fishes	1	2.93
Perciformes unid.	perch-like fishes	1	2.74
Sciaenidae unid.	croakers	1	2.82
Syngnathus spp.	pipefishes	1	2.82
	Total Entrainable Larval Fishes:	**59**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	2	4.61
	Total Non-Entrainable Fishes:		**2**
Eggs			
fish eggs unid.	unidentified fish eggs	246	6,860.86
Engraulidae unid. (eggs)	anchovy eggs	63	1,726.69
Sciaen./Paralich./Labridae (eggs)	fish eggs	55	1,559.26
Paralichthyidae unid. (eggs)	sand flounder eggs	14	376.69
Labridae unid. (eggs)	wrasse eggs	3	80.64
Pleuronichthys spp. (eggs)	turbot eggs	2	56.41
Citharichthys spp. (eggs)	sanddab eggs	1	28.20
Paralabrax spp. (eggs)	sand bass eggs	1	27.96
	Total Eggs:	**385**	
Invertebrates			
Cancer antennarius (megalops)	brown rock crab megalops	5	12.43
Cancer anthonyi (megalops)	yellow crab megalops	2	5.48
	Total Invertebrates:	**7**	
	Total Station Count:	**453**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA10
Start Date: August 02, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Hypsoblennius spp.	combtooth blennies	76	202.19
Engraulis mordax	northern anchovy	52	135.17
Labrisomidae unid.	labrisomid blennies	33	87.19
Seriphus politus	queenfish	33	86.00
Roncador stearnsi	spotfin croaker	23	61.87
Menticirrhus undulatus	California corbina	16	42.57
Gobiesox spp.	clingfishes	14	36.63
Gibbonsia spp.	clinid kelpfishes	13	34.16
Gobiidae unid.	gobies	12	31.10
Paralichthys californicus	California halibut	11	28.47
Sphyraena argentea	Pacific barracuda	11	29.17
Paralabrax spp.	sand bass	10	26.83
Sciaenidae unid.	croakers	8	20.88
Cheilotrema saturnum	black croaker	6	16.01
larvae, unidentified yolksac	unidentified yolksac larvae	6	15.80
larval fish - damaged	unidentified larval fishes	3	8.28
larval fish fragment	unidentified larval fishes	3	7.82
Ophidiidae unid.	cusk-eels	3	8.25
Peprilus simillimus	Pacific butterfish	3	8.03
Engraulidae unid.	anchovies	2	5.11
Haemulidae unid.	grunts	1	2.71
Pleuronichthys guttulatus	diamond turbot	1	2.71
Syngnathus spp.	pipefishes	1	2.71
Typhlogobius californiensis	blind goby	1	2.57
	Total Entrainable Larval Fishes:	**342**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	1	2.56
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	1,761	11,816.25
Paralichthyidae unid. (eggs)	sand flounder eggs	62	213.52
Labridae unid. (eggs)	wrasse eggs	42	114.03
Pleuronichthys spp. (eggs)	turbot eggs	22	56.56
Engraulidae unid. (eggs)	anchovy eggs	16	64.05
Citharichthys spp. (eggs)	sanddab eggs	14	60.89
Sciaenidae unid. (eggs)	croaker eggs	8	21.54
Sphyraena argentea (eggs)	Pacific barracuda eggs	7	17.85
Hippoglossina stomata (eggs)	bigmouth sole eggs	1	2.53
	Total Eggs:	**1,933**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**2,276**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA10
Start Date: August 02, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	42	115.09
Hypsoblennius spp.	combtooth blennies	13	35.86
Sciaenidae unid.	croakers	13	34.94
Gobiesox spp.	clingfishes	7	19.07
Roncador stearnsi	spotfin croaker	7	19.56
Menticirrhus undulatus	California corbina	5	14.12
Seriphus politus	queenfish	5	13.90
Gobiidae unid.	gobies	3	9.33
Citharichthys sordidus	Pacific sanddab	1	2.67
Gibbonsia spp.	clinid kelpfishes	1	2.67
Gobiesocidae unid.	clingfishes	1	2.70
Labrisomidae unid.	labrisomid blennies	1	2.70
Paralabrax spp.	sand bass	1	2.74
	Total Entrainable Larval Fishes:	**100**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	27	74.66
Seriphus politus	queenfish	1	2.60
Syngnathus spp.	pipefishes	1	2.60
	Total Non-Entrainable Fishes:	**29**	
Eggs			
fish eggs unid.	unidentified fish eggs	911	2,489.45
Paralichthyidae unid. (eggs)	sand flounder eggs	34	92.77
Labridae unid. (eggs)	wrasse eggs	26	72.55
Pleuronichthys spp. (eggs)	turbot eggs	20	55.52
Citharichthys spp. (eggs)	sanddab eggs	9	25.43
Sphyraena argentea (eggs)	Pacific barracuda eggs	9	24.93
Sciaenidae unid. (eggs)	croaker eggs	4	11.03
Paralabrax spp. (eggs)	sand bass eggs	3	8.56
Engraulidae unid. (eggs)	anchovy eggs	1	2.80
	Total Eggs:	**1,017**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
Non-Targeted Invertebrates			
Cancer spp. (juv.)	cancer crabs	1	2.60
	Total Non-Targeted	**1**	
	Total Station Count:	**1,147**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA11
Start Date: August 16, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Gobiesox spp.	clingfishes	37	98.24
Gobiidae unid.	gobies	20	54.96
Hypsoblennius spp.	combtooth blennies	9	25.39
Engraulis mordax	northern anchovy	6	15.42
larvae, unidentified yolksac	unidentified yolksac larvae	6	16.80
Paralabrax spp.	sand bass	5	13.57
Gibbonsia spp.	clinid kelpfishes	4	10.47
Heterostichus rostratus	giant kelpfish	3	8.40
Seriphus politus	queenfish	3	8.62
Peprilus simillimus	Pacific butterfish	2	5.24
larval fish fragment	unidentified larval fishes	1	2.82
Ophidiidae unid.	cusk-eels	1	2.70
Paralabrax clathratus	kelp bass	1	2.47
Paralichthys californicus	California halibut	1	3.04
Sphyraena argentea	Pacific barracuda	1	2.77
	Total Entrainable Larval Fishes:	**100**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	8	20.95
	Total Non-Entrainable Fishes:	**8**	
Eggs			
fish eggs unid.	unidentified fish eggs	343	1,058.94
Sciaen./Paralich./Labridae (eggs)	fish eggs	86	230.50
Pleuronichthys spp. (eggs)	turbot eggs	46	126.00
Engraulidae unid. (eggs)	anchovy eggs	18	49.25
Paralichthyidae unid. (eggs)	sand flounder eggs	13	38.00
Labridae unid. (eggs)	wrasse eggs	9	99.07
Citharichthys spp. (eggs)	sanddab eggs	5	14.85
Paralabrax spp. (eggs)	sand bass eggs	4	10.82
Sphyraena argentea (eggs)	Pacific barracuda eggs	2	5.62
	Total Eggs:	**526**	
Invertebrates			
Cancer antennarius (megalops)	brown rock crab megalops	2	4.94
Cancer anthonyi (megalops)	yellow crab megalops	2	5.17
Panulirus interruptus (phyllo.)	California spiny lobster (larval)	1	2.76
	Total Invertebrates:	**5**	
	Total Station Count:	**639**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA11
Start Date: August 16, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Hypsoblennius spp.	combtooth blennies	39	108.70
Gobiesox spp.	clingfishes	32	82.36
Gobiidae unid.	gobies	13	36.99
Ophidiidae unid.	cusk-eels	12	30.86
Engraulis mordax	northern anchovy	10	26.74
Gibbonsia spp.	clinid kelpfishes	6	16.92
Seriphus politus	queenfish	5	13.86
Engraulidae unid.	anchovies	4	11.33
Labrisomidae unid.	labrisomid blennies	3	9.39
larvae, unidentified yolksac	unidentified yolksac larvae	3	7.91
Paralichthys californicus	California halibut	3	8.36
Haemulidae unid.	grunts	2	5.27
Heterostichus rostratus	giant kelpfish	2	5.16
Oxyjulis californica	senorita	2	5.39
Sciaenidae unid.	croakers	2	5.49
Gillichthys mirabilis	longjaw mudsucker	1	2.52
Hypsypops rubicundus	garibaldi	1	3.09
Paralabrax spp.	sand bass	1	3.32
Pleuronichthys guttulatus	diamond turbot	1	2.64
Umbrina roncador	yellowfin croaker	1	2.71
	Total Entrainable Larval Fishes:	**143**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	2	5.16
	Total Non-Entrainable Fishes:		**2**
Eggs			
fish eggs unid.	unidentified fish eggs	409	1,856.47
Sciaen./Paralich./Labridae (eggs)	fish eggs	137	530.10
Pleuronichthys spp. (eggs)	turbot eggs	34	164.98
Engraulidae unid. (eggs)	anchovy eggs	19	120.92
Labridae unid. (eggs)	wrasse eggs	3	8.13
Paralichthyidae unid. (eggs)	sand flounder eggs	3	8.13
Paralabrax spp. (eggs)	sand bass eggs	2	6.03
	Total Eggs:	**607**	
Invertebrates			
Cancer antennarius (megalops)	brown rock crab megalops	2	5.16
	Total Invertebrates:	**2**	
	Total Station Count:	**754**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA12
Start Date: August 30, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	12	30.68
Hypsoblennius spp.	combtooth blennies	7	18.64
Sardinops sagax	Pacific sardine	4	10.27
Sciaenidae unid.	croakers	2	5.43
Engraulidae unid.	anchovies	1	2.57
Gobiesocidae unid.	clingfishes	1	2.65
Gobiidae unid.	gobies	1	2.53
larval fish fragment	unidentified larval fishes	1	2.50
larval/post-larval fish unid.	larval fishes	1	2.57
Seriphus politus	queenfish	1	2.50
Typhlogobius californiensis	blind goby	1	2.50
	Total Entrainable Larval Fishes:	**32**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	4	10.02
	Total Non-Entrainable Fishes:	**4**	
Eggs			
fish eggs unid.	unidentified fish eggs	310	806.32
Paralichthyidae unid. (eggs)	sand flounder eggs	63	163.68
Citharichthys spp. (eggs)	sanddab eggs	15	40.11
Pleuronichthys spp. (eggs)	turbot eggs	14	36.86
Labridae unid. (eggs)	wrasse eggs	12	32.48
Engraulidae unid. (eggs)	anchovy eggs	11	28.17
Paralabrax spp. (eggs)	sand bass eggs	3	8.23
Sphyraena argentea (eggs)	Pacific barracuda eggs	2	5.75
Sciaenidae unid. (eggs)	croaker eggs	1	2.88
	Total Eggs:	**431**	
Invertebrates			
Panulirus interruptus (phyllo.)	California spiny lobster (larval)	2	5.10
	Total Invertebrates:	**2**	
	Total Station Count:	**469**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA12
Start Date: August 30, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Hypsoblennius spp.	combtooth blennies	8	22.56
Engraulis mordax	northern anchovy	7	19.02
Paralabrax spp.	sand bass	5	13.96
Gibbonsia spp.	clinid kelpfishes	1	3.09
Gobiesox spp.	clingfishes	1	2.77
Gobiidae unid.	gobies	1	2.87
larvae, unidentified yolksac	unidentified yolksac larvae	1	2.71
Menticirrhus undulatus	California corbina	1	2.93
Paralichthys californicus	California halibut	1	2.93
Pleuronichthys ritteri	spotted turbot	1	2.87
Seriphus politus	queenfish	1	2.87
	Total Entrainable Larval Fishes:	**28**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	1	2.87
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	370	1,040.24
Paralichthyidae unid. (eggs)	sand flounder eggs	35	100.77
Engraulidae unid. (eggs)	anchovy eggs	28	77.96
Pleuronichthys spp. (eggs)	turbot eggs	14	38.91
Citharichthys spp. (eggs)	sanddab eggs	7	20.70
Labridae unid. (eggs)	wrasse eggs	7	19.90
Blenniidae (eggs)	blenny eggs	1	2.71
Sciaenidae unid. (eggs)	croaker eggs	1	2.93
	Total Eggs:	**463**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	1	2.62
Cancer gracilis (megalops)	slender crab megalops	1	2.62
Panulirus interruptus (phyllo.)	California spiny lobster (larval)	1	2.71
	Total Invertebrates:	**3**	
	Total Station Count:	**495**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA13
Start Date: September 13, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	43	122.83
Seriphus politus	queenfish	19	52.94
Gobiidae unid.	gobies	9	25.23
Heterostichus rostratus	giant kelpfish	3	8.40
Hypsoblennius spp.	combtooth blennies	3	8.73
Gibbonsia spp.	clinid kelpfishes	2	5.84
Gobiesox spp.	clingfishes	2	5.60
Labrisomidae unid.	labrisomid blennies	2	4.96
Engraulidae unid.	anchovies	1	3.13
larvae, unidentified yolksac	unidentified yolksac larvae	1	3.20
Paralabrax spp.	sand bass	1	2.93
Rimicola spp.	kelp clingfishes	1	3.20
Roncador stearnsi	spotfin croaker	1	2.48
Sardinops sagax	Pacific sardine	1	3.20
	Total Entrainable Larval Fishes:	**89**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	1	2.90
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	216	629.53
Engraulidae unid. (eggs)	anchovy eggs	199	588.55
Labridae unid. (eggs)	wrasse eggs	24	67.29
Paralichthyidae unid. (eggs)	sand flounder eggs	14	41.39
Sciaenidae unid. (eggs)	croaker eggs	8	22.91
Pleuronichthys spp. (eggs)	turbot eggs	6	17.65
Citharichthys spp. (eggs)	sanddab eggs	3	9.29
Paralabrax spp. (eggs)	sand bass eggs	1	2.48
	Total Eggs:	**471**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**561**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA13
Start Date: September 13, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Seriphus politus	queenfish	36	102.38
Engraulis mordax	northern anchovy	35	93.22
Engraulidae unid.	anchovies	13	38.35
Gobiidae unid.	gobies	10	27.89
Labrisomidae unid.	labrisomid blennies	5	12.99
Sardinops sagax	Pacific sardine	4	10.36
Gibbonsia spp.	clinid kelpfishes	3	8.15
Atherinopsidae unid.	silversides	2	5.94
Anisotremus davidsonii	sargo	1	2.70
Genyonemus lineatus	white croaker	1	2.50
Hypsoblennius spp.	combtooth blennies	1	2.87
Pleuronichthys verticalis	hornyhead turbot	1	2.76
Rimicola spp.	kelp clingfishes	1	2.84
	Total Entrainable Larval Fishes:	**113**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	164	469.91
Engraulidae unid.	anchovies	3	7.49
Seriphus politus	queenfish	1	2.41
	Total Non-Entrainable Fishes:	**168**	
Eggs			
fish eggs unid.	unidentified fish eggs	314	858.53
Engraulidae unid. (eggs)	anchovy eggs	70	201.37
Pleuronichthys spp. (eggs)	turbot eggs	20	56.86
Paralichthyidae unid. (eggs)	sand flounder eggs	19	50.06
Labridae unid. (eggs)	wrasse eggs	18	47.78
Citharichthys spp. (eggs)	sanddab eggs	6	16.68
Sciaenidae unid. (eggs)	croaker eggs	6	15.83
Paralabrax spp. (eggs)	sand bass eggs	2	5.39
	Total Eggs:	**455**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	1	2.41
	Total Invertebrates:	**1**	
	Total Station Count:	**737**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA14
Start Date: September 27, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	51	126.82
Engraulidae unid.	anchovies	11	27.06
Gibbonsia spp.	clinid kelpfishes	3	8.13
Gobiidae unid.	gobies	3	7.40
Heterostichus rostratus	giant kelpfish	2	4.97
Hypsoblennius spp.	combtooth blennies	2	6.55
Seriphus politus	queenfish	2	4.92
Diaphus theta	California headlight fish	1	2.68
Genyonemus lineatus	white croaker	1	2.68
Sardinops sagax	Pacific sardine	1	2.54
Triphoturus mexicanus	Mexican lampfish	1	2.48
	Total Entrainable Larval Fishes:	**78**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	7	18.11
Seriphus politus	queenfish	2	4.97
	Total Non-Entrainable Fishes:	**9**	
Eggs			
fish eggs unid.	unidentified fish eggs	66	169.18
Engraulidae unid. (eggs)	anchovy eggs	7	20.22
Pleuronichthys spp. (eggs)	turbot eggs	4	10.58
Paralichthyidae unid. (eggs)	sand flounder eggs	3	7.54
Labridae unid. (eggs)	wrasse eggs	1	2.49
Sciaen./Paralich./Labridae (eggs)	fish eggs	1	2.45
	Total Eggs:	**82**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	2	4.96
	Total Invertebrates:	**2**	
	Total Station Count:	**171**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA14
Start Date: September 27, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	69	183.65
Gibbonsia spp.	clinid kelpfishes	19	50.55
Gobiidae unid.	gobies	10	26.91
Hypsoblennius spp.	combtooth blennies	10	32.18
Rimicola spp.	kelp clingfishes	8	20.73
Engraulidae unid.	anchovies	7	18.99
Triphoturus mexicanus	Mexican lampfish	7	17.75
Genyonemus lineatus	white croaker	4	10.03
Heterostichus rostratus	giant kelpfish	3	7.92
Seriphus politus	queenfish	3	8.13
Labrisomidae unid.	labrisomid blennies	2	5.11
Gobiesox spp.	clingfishes	1	2.46
Paralichthyidae unid.	sand flounders	1	2.46
Sardinops sagax	Pacific sardine	1	2.62
Sphyraena argentea	Pacific barracuda	1	3.09
	Total Entrainable Larval Fishes:	**146**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	6	17.56
Seriphus politus	queenfish	1	2.76
	Total Non-Entrainable Fishes:	**7**	
Eggs			
fish eggs unid.	unidentified fish eggs	192	501.95
Paralichthyidae unid. (eggs)	sand flounder eggs	10	26.46
Pleuronichthys spp. (eggs)	turbot eggs	6	17.38
Engraulidae unid. (eggs)	anchovy eggs	5	14.96
Sciaenidae unid. (eggs)	croaker eggs	1	2.46
	Total Eggs:	**214**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	3	7.86
	Total Invertebrates:	**3**	
	Total Station Count:	**370**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA15
Start Date: October 11, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Genyonemus lineatus	white croaker	7	18.53
Hypsoblennius spp.	combtooth blennies	7	18.77
larvae, unidentified yolksac	unidentified yolksac larvae	4	11.23
larval fish fragment	unidentified larval fishes	4	12.69
Paralichthys californicus	California halibut	4	11.11
Engraulis mordax	northern anchovy	3	8.12
Engraulidae unid.	anchovies	2	5.75
Citharichthys stigmaeus	speckled sanddab	1	2.65
Gibbonsia spp.	clinid kelpfishes	1	2.65
	Total Entrainable Larval Fishes:	**33**	
Eggs			
fish eggs unid.	unidentified fish eggs	200	585.98
Pleuronichthys spp. (eggs)	turbot eggs	38	109.70
Paralichthyidae unid. (eggs)	sand flounder eggs	36	103.23
Sciaen./Paralich./Labridae (eggs)	fish eggs	30	85.25
Citharichthys spp. (eggs)	sanddab eggs	17	50.81
Sciaenidae unid. (eggs)	croaker eggs	15	43.64
Engraulidae unid. (eggs)	anchovy eggs	2	5.75
Labridae unid. (eggs)	wrasse eggs	1	2.82
	Total Eggs:	**339**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**372**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA15
Start Date: October 11, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	5	15.70
Gobiidae unid.	gobies	4	12.70
Hypsoblennius spp.	combtooth blennies	4	12.06
Genyonemus lineatus	white croaker	1	2.98
Seriphus politus	queenfish	1	2.98
	Total Entrainable Larval Fishes:	**15**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	1	2.85
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	143	447.67
Pleuronichthys spp. (eggs)	turbot eggs	38	119.12
Paralichthyidae unid. (eggs)	sand flounder eggs	24	76.10
Sciaenidae unid. (eggs)	croaker eggs	17	54.57
Sciaen./Paralich./Labridae (eggs)	fish eggs	12	35.29
Citharichthys spp. (eggs)	sanddab eggs	8	25.95
Engraulidae unid. (eggs)	anchovy eggs	3	8.97
	Total Eggs:	**245**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**261**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA16
Start Date: October 25, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Engraulidae unid.	anchovies	11	33.32
Engraulis mordax	northern anchovy	8	26.68
Gobiidae unid.	gobies	7	19.84
larvae, unidentified yolksac	unidentified yolksac larvae	5	18.29
Atherinopsidae unid.	silversides	2	6.00
Genyonemus lineatus	white croaker	2	8.86
Atherinopsis californiensis	jacksmelt	1	2.91
Gibbonsia spp.	clinid kelpfishes	1	2.91
Labrisomidae unid.	labrisomid blennies	1	3.19
larval fish fragment	unidentified larval fishes	1	2.20
Paralichthys californicus	California halibut	1	2.85
Pleuronichthys guttulatus	diamond turbot	1	3.19
	Total Entrainable Larval Fishes:	**41**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	1	3.00
	Total Non-Entrainable Fishes:	**1**	
Eggs			
Sciaen./Paralich./Labridae (eggs)	fish eggs	292	844.00
fish eggs unid.	unidentified fish eggs	131	386.94
Engraulidae unid. (eggs)	anchovy eggs	39	112.21
Pleuronichthys spp. (eggs)	turbot eggs	9	30.73
Citharichthys spp. (eggs)	sanddab eggs	7	24.10
Paralichthyidae unid. (eggs)	sand flounder eggs	3	17.13
Blenniidae (eggs)	blenny eggs	1	3.15
	Total Eggs:	**482**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**524**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA17
Start Date: November 08, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	29	73.35
Gobiidae unid.	gobies	7	18.71
Engraulidae unid.	anchovies	4	12.03
larvae, unidentified yolksac	unidentified yolksac larvae	3	7.66
Gibbonsia spp.	clinid kelpfishes	2	5.48
Atherinopsis californiensis	jacksmelt	1	2.21
Genyonemus lineatus	white croaker	1	2.58
Gobiesox spp.	clingfishes	1	3.27
Heterostichus rostratus	giant kelpfish	1	2.82
larval fish fragment	unidentified larval fishes	1	3.27
	Total Entrainable Larval Fishes:	**50**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	5	16.78
	Total Non-Entrainable Fishes:	**5**	
Eggs			
fish eggs unid.	unidentified fish eggs	125	313.10
Sciaenidae unid. (eggs)	croaker eggs	56	156.56
Paralichthyidae unid. (eggs)	sand flounder eggs	29	79.76
Citharichthys spp. (eggs)	sanddab eggs	25	60.16
Sciaen./Paralich./Labridae (eggs)	fish eggs	24	60.02
Pleuronichthys spp. (eggs)	turbot eggs	21	55.71
Engraulidae unid. (eggs)	anchovy eggs	17	53.74
	Total Eggs:	**297**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**352**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA18
Start Date: November 21, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	19	55.51
Gobiidae unid.	gobies	14	40.34
Genyonemus lineatus	white croaker	4	11.52
Atherinopsidae unid.	silversides	1	3.33
Gibbonsia spp.	clinid kelpfishes	1	3.33
Hypsoblennius spp.	combtooth blennies	1	2.53
Pleuronichthys guttulatus	diamond turbot	1	2.61
	Total Entrainable Larval Fishes:	**41**	
Eggs			
Paralichthyidae unid. (eggs)	sand flounder eggs	44	127.99
fish eggs unid.	unidentified fish eggs	35	99.60
Pleuronichthys spp. (eggs)	turbot eggs	14	40.05
Citharichthys spp. (eggs)	sanddab eggs	4	11.82
Engraulidae unid. (eggs)	anchovy eggs	1	2.87
	Total Eggs:	**98**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**139**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA19
Start Date: December 06, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Gibbonsia spp.	clinid kelpfishes	10	26.16
Heterostichus rostratus	giant kelpfish	5	12.88
Atherinopsidae unid.	silversides	4	10.08
Engraulis mordax	northern anchovy	3	7.74
Gobiidae unid.	gobies	3	7.39
Typhlogobius californiensis	blind goby	3	7.82
Labrisomidae unid.	labrisomid blennies	2	5.21
Hypsoblennius spp.	combtooth blennies	1	2.61
	Total Entrainable Larval Fishes:	**31**	
Non-Entrainable Fishes			
Atherinops affinis	topsmelt	2	5.01
	Total Non-Entrainable Fishes:	**2**	
Eggs			
fish eggs unid.	unidentified fish eggs	141	361.32
Paralichthyidae unid. (eggs)	sand flounder eggs	23	60.71
Citharichthys spp. (eggs)	sanddab eggs	11	26.62
Pleuronichthys spp. (eggs)	turbot eggs	10	24.76
Sciaenidae unid. (eggs)	croaker eggs	5	11.30
Sciaen./Paralich./Labridae (eggs)	fish eggs	4	10.02
	Total Eggs:	**194**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**227**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA19
Start Date: December 06, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Gibbonsia spp.	clinid kelpfishes	4	10.72
Hypsoblennius spp.	combtooth blennies	4	10.72
Heterostichus rostratus	giant kelpfish	2	5.38
Engraulis mordax	northern anchovy	1	2.97
Gobiidae unid.	gobies	1	2.97
larvae, unidentified yolksac	unidentified yolksac larvae	1	2.84
Pleuronichthys verticalis	hornyhead turbot	1	2.61
Syngnathus spp.	pipefishes	1	2.73
Typhlogobius californiensis	blind goby	1	2.78
	Total Entrainable Larval Fishes:	**16**	
Eggs			
fish eggs unid.	unidentified fish eggs	254	689.05
Paralichthyidae unid. (eggs)	sand flounder eggs	32	88.02
Sciaenidae unid. (eggs)	croaker eggs	23	61.24
Citharichthys spp. (eggs)	sanddab eggs	19	52.21
Pleuronichthys spp. (eggs)	turbot eggs	15	42.45
	Total Eggs:	**343**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**359**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA20
Start Date: December 20, 2006
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Gibbonsia spp.	clinid kelpfishes	12	34.12
Gobiidae unid.	gobies	6	15.06
Atherinopsis californiensis	jacksmelt	4	10.20
Labrisomidae unid.	labrisomid blennies	4	12.15
Atherinopsidae unid.	silversides	2	4.54
Genyonemus lineatus	white croaker	2	4.61
Clinidae unid.	kelp blennies	1	3.04
Engraulis mordax	northern anchovy	1	3.13
Hypsoblennius spp.	combtooth blennies	1	2.34
larvae, unidentified yolksac	unidentified yolksac larvae	1	2.83
Scorpaenichthys marmoratus	cabezon	1	2.27
Typhlogobius californiensis	blind goby	1	3.13
	Total Entrainable Larval Fishes:	**36**	
Eggs			
Sciaen./Paralich./Labridae (eggs)	fish eggs	283	786.05
fish eggs unid.	unidentified fish eggs	49	125.41
Engraulidae unid. (eggs)	anchovy eggs	4	11.36
	Total Eggs:	**336**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**372**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA20
Start Date: December 20, 2006
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Gibbonsia spp.	clinid kelpfishes	27	73.10
Heterostichus rostratus	giant kelpfish	5	13.38
Hypsoblennius spp.	combtooth blennies	4	10.41
Engraulis mordax	northern anchovy	2	5.35
Gobiidae unid.	gobies	2	5.17
Atherinopsidae unid.	silversides	1	2.47
Atherinopsis californiensis	jacksmelt	1	2.69
Genyonemus lineatus	white croaker	1	2.71
Pleuronichthys guttulatus	diamond turbot	1	2.47
Typhlogobius californiensis	blind goby	1	2.69
	Total Entrainable Larval Fishes:	**45**	
Eggs			
Sciaen./Paralich./Labridae (eggs)	fish eggs	80	212.63
fish eggs unid.	unidentified fish eggs	56	147.68
Pleuronichthys spp. (eggs)	turbot eggs	6	17.55
Paralichthyidae unid. (eggs)	sand flounder eggs	5	15.42
Sciaenidae unid. (eggs)	croaker eggs	4	10.70
Engraulidae unid. (eggs)	anchovy eggs	1	2.68
	Total Eggs:	**152**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	1	2.47
Cancer gracilis (megalops)	slender crab megalops	1	2.69
Cancer productus (megalops)	red rock crab megalops	1	2.57
	Total Invertebrates:	**3**	
	Total Station Count:	**200**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA21
Start Date: January 03, 2007
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Genyonemus lineatus	white croaker	2	5.50
Clinidae unid.	kelp blennies	1	2.79
Gobiidae unid.	gobies	1	2.75
larvae, unidentified yolksac	unidentified yolksac larvae	1	2.81
larval fish fragment	unidentified larval fishes	1	2.75
	Total Entrainable Larval Fishes:	**6**	
Non-Entrainable Fishes			
Synodus lucioceps	California lizardfish	1	2.52
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	124	341.24
Sciaen./Paralich./Labridae (eggs)	fish eggs	91	257.60
Paralichthyidae unid. (eggs)	sand flounder eggs	15	37.70
Pleuronichthys spp. (eggs)	turbot eggs	14	38.13
Sciaenidae unid. (eggs)	croaker eggs	4	10.09
Citharichthys spp. (eggs)	sanddab eggs	2	5.60
	Total Eggs:	**250**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	2.40
	Total Invertebrates:	**1**	
	Total Station Count:	**258**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA21
Start Date: January 03, 2007
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
larvae, unidentified yolksac	unidentified yolksac larvae	3	6.97
Heterostichus rostratus	giant kelpfish	2	4.39
Paralichthys californicus	California halibut	2	5.10
Genyonemus lineatus	white croaker	1	2.20
Gibbonsia spp.	clinid kelpfishes	1	2.20
Hypsoblennius spp.	combtooth blennies	1	2.33
Typhlogobius californiensis	blind goby	1	2.58
Xenistius californiensis	salema	1	2.33
	Total Entrainable Larval Fishes:	**12**	
Eggs			
fish eggs unid.	unidentified fish eggs	238	575.74
Sciaen./Paralich./Labridae (eggs)	fish eggs	25	60.88
Paralichthyidae unid. (eggs)	sand flounder eggs	15	36.64
Pleuronichthys spp. (eggs)	turbot eggs	14	33.96
Citharichthys spp. (eggs)	sanddab eggs	8	19.08
Engraulidae unid. (eggs)	anchovy eggs	1	2.47
	Total Eggs:	**301**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**313**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA22
Start Date: January 17, 2007
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Genyonemus lineatus	white croaker	5	13.72
Gobiidae unid.	gobies	3	7.72
Gobiesox spp.	clingfishes	2	5.56
Paralichthys californicus	California halibut	2	4.92
Atherinopsidae unid.	silversides	1	2.56
Engraulis mordax	northern anchovy	1	2.99
Gibbonsia spp.	clinid kelpfishes	1	2.56
Hypsoblennius spp.	combtooth blennies	1	2.50
larval fish fragment	unidentified larval fishes	1	2.50
Oligocottus / Clinocottus	sculpins	1	2.99
Sciaenidae unid.	croakers	1	2.46
	Total Entrainable Larval Fishes:	**19**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	3	7.68
	Total Non-Entrainable Fishes:	**3**	
Eggs			
fish eggs unid.	unidentified fish eggs	159	413.05
Sciaenidae unid. (eggs)	croaker eggs	16	40.34
Paralichthyidae unid. (eggs)	sand flounder eggs	15	39.49
Pleuronichthys spp. (eggs)	turbot eggs	7	18.15
Citharichthys spp. (eggs)	sanddab eggs	5	12.87
Engraulidae unid. (eggs)	anchovy eggs	1	2.50
	Total Eggs:	**203**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**225**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA22
Start Date: January 17, 2007
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Genyonemus lineatus	white croaker	50	139.26
Gobiidae unid.	gobies	13	31.67
Atherinopsidae unid.	silversides	2	4.77
Engraulis mordax	northern anchovy	2	5.50
Gibbonsia spp.	clinid kelpfishes	2	5.18
Citharichthys stigmaeus	speckled sanddab	1	2.38
larval fish fragment	unidentified larval fishes	1	2.80
Lepidogobius lepidus	bay goby	1	3.12
Ophidiidae unid.	cusk-eels	1	3.12
Paralichthys californicus	California halibut	1	3.12
Sciaenidae unid.	croakers	1	2.38
Sebastes spp.	rockfishes	1	2.64
Typhlogobius californiensis	blind goby	1	2.23
	Total Entrainable Larval Fishes:	**77**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	1	2.38
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	293	746.86
Sciaenidae unid. (eggs)	croaker eggs	74	185.58
Paralichthyidae unid. (eggs)	sand flounder eggs	20	49.80
Citharichthys spp. (eggs)	sanddab eggs	9	21.98
Pleuronichthys spp. (eggs)	turbot eggs	9	24.80
Engraulidae unid. (eggs)	anchovy eggs	1	3.12
	Total Eggs:	**406**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	2.39
	Total Invertebrates:	**1**	
	Total Station Count:	**485**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA23
Start Date: January 31, 2007
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Gibbonsia spp.	clinid kelpfishes	52	146.39
Atherinopsis californiensis	jacksmelt	34	88.05
Heterostichus rostratus	giant kelpfish	22	61.83
Atherinopsidae unid.	silversides	13	29.89
Gobiidae unid.	gobies	7	19.70
Engraulis mordax	northern anchovy	6	16.25
Genyonemus lineatus	white croaker	2	5.30
Clinidae unid.	kelp blennies	1	2.82
Gobiesox spp.	clingfishes	1	2.82
Hypsoblennius spp.	combtooth blennies	1	2.27
Paralichthys californicus	California halibut	1	2.81
Typhlogobius californiensis	blind goby	1	2.82
	Total Entrainable Larval Fishes:	**141**	
Eggs			
fish eggs unid.	unidentified fish eggs	851	2,112.72
Paralichthyidae unid. (eggs)	sand flounder eggs	281	688.18
Citharichthys spp. (eggs)	sanddab eggs	158	399.38
Sciaenidae unid. (eggs)	croaker eggs	106	275.10
Pleuronichthys spp. (eggs)	turbot eggs	20	49.14
Engraulidae unid. (eggs)	anchovy eggs	3	8.16
Pleuronectidae unid. (eggs)	righteye flounder eggs	1	2.85
Sardinops sagax (eggs)	Pacific sardine eggs	1	2.49
	Total Eggs:	**1,421**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**1,562**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA23
Start Date: January 31, 2007
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Atherinopsis californiensis	jacksmelt	23	52.77
Engraulis mordax	northern anchovy	9	24.54
Gibbonsia spp.	clinid kelpfishes	8	22.29
Gobiidae unid.	gobies	5	12.95
Heterostichus rostratus	giant kelpfish	5	14.12
Clinidae unid.	kelp blennies	2	5.46
Atherinopsidae unid.	silversides	1	2.48
Citharichthys stigmaeus	speckled sanddab	1	2.73
Genyonemus lineatus	white croaker	1	2.00
Paralichthyidae unid.	sand flounders	1	2.48
Paralichthys californicus	California halibut	1	2.63
Pleuronectidae unid.	righteye flounders	1	2.73
Pleuronichthys guttulatus	diamond turbot	1	2.19
Typhlogobius californiensis	blind goby	1	2.73
	Total Entrainable Larval Fishes:	**60**	
Eggs			
fish eggs unid.	unidentified fish eggs	372	864.17
Paralichthyidae unid. (eggs)	sand flounder eggs	178	407.10
Citharichthys spp. (eggs)	sanddab eggs	112	249.43
Sciaenidae unid. (eggs)	croaker eggs	69	169.09
Pleuronichthys spp. (eggs)	turbot eggs	9	19.78
	Total Eggs:	**740**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**800**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA24
Start Date: February 14, 2007
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Gibbonsia spp.	clinid kelpfishes	143	343.04
Engraulis mordax	northern anchovy	24	57.49
Genyonemus lineatus	white croaker	12	37.55
Gobiidae unid.	gobies	10	24.11
Heterostichus rostratus	giant kelpfish	5	11.54
Atherinopsis californiensis	jacksmelt	4	9.97
Clinidae unid.	kelp blennies	4	9.65
larvae, unidentified yolksac	unidentified yolksac larvae	2	4.92
Sardinops sagax	Pacific sardine	2	5.02
Seriphus politus	queenfish	2	4.92
Chaenopsidae unid.	tube blennies	1	2.58
Hypsoblennius spp.	combtooth blennies	1	2.22
larval fish fragment	unidentified larval fishes	1	2.44
Pleuronichthys guttulatus	diamond turbot	1	3.13
Ruscarius creaseri	roughcheek sculpin	1	2.22
	Total Entrainable Larval Fishes:	**213**	
Eggs			
fish eggs unid.	unidentified fish eggs	1,155	3,011.19
Sciaenidae unid. (eggs)	croaker eggs	802	2,151.79
Paralichthyidae unid. (eggs)	sand flounder eggs	42	109.43
Citharichthys spp. (eggs)	sanddab eggs	13	33.59
Pleuronichthys spp. (eggs)	turbot eggs	13	36.78
Engraulidae unid. (eggs)	anchovy eggs	4	10.04
	Total Eggs:	**2,029**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**2,242**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA24
Start Date: February 14, 2007
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Gibbonsia spp.	clinid kelpfishes	18	41.39
Engraulis mordax	northern anchovy	8	19.38
Genyonemus lineatus	white croaker	3	7.65
Gobiidae unid.	gobies	3	7.90
Atherinopsidae unid.	silversides	2	4.71
Atherinopsis californiensis	jacksmelt	1	2.54
Engraulidae unid.	anchovies	1	2.54
Sardinops sagax	Pacific sardine	1	2.54
	Total Entrainable Larval Fishes:	**37**	
Eggs			
fish eggs unid.	unidentified fish eggs	616	1,564.34
Sciaenidae unid. (eggs)	croaker eggs	462	1,177.23
Pleuronichthys spp. (eggs)	turbot eggs	34	88.28
Paralichthyidae unid. (eggs)	sand flounder eggs	29	73.82
Citharichthys spp. (eggs)	sanddab eggs	1	2.30
	Total Eggs:	**1,142**	
Invertebrates			
Cancer productus (megalops)	red rock crab megalops	1	2.35
	Total Invertebrates:	**1**	
	Total Station Count:	**1,180**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA25
Start Date: February 28, 2007
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	57	148.82
Gibbonsia spp.	clinid kelpfishes	15	43.58
Stenobrachius leucopsarus	northern lampfish	6	15.37
Genyonemus lineatus	white croaker	3	7.90
Gobiidae unid.	gobies	3	8.10
Heterostichus rostratus	giant kelpfish	3	8.60
Ruscarius creaseri	roughcheek sculpin	3	6.62
Atherinopsis californiensis	jacksmelt	2	5.55
Hypsoblennius spp.	combtooth blennies	2	4.96
Artedius lateralis	smoothhead sculpin	1	2.21
Sardinops sagax	Pacific sardine	1	2.73
Typhlogobius californiensis	blind goby	1	2.73
	Total Entrainable Larval Fishes:	**97**	
Eggs			
fish eggs unid.	unidentified fish eggs	381	1,024.93
Engraulidae unid. (eggs)	anchovy eggs	112	297.79
Pleuronichthys spp. (eggs)	turbot eggs	33	85.35
Sciaenidae unid. (eggs)	croaker eggs	8	20.25
Bathylagidae (eggs)	blacksmelt eggs	3	8.26
Citharichthys spp. (eggs)	sanddab eggs	3	7.86
Paralichthyidae unid. (eggs)	sand flounder eggs	1	2.73
	Total Eggs:	**541**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**638**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA25
Start Date: February 28, 2007
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	48	127.74
Stenobrachius leucopsarus	northern lampfish	7	16.79
Genyonemus lineatus	white croaker	5	13.82
Atherinopsis californiensis	jacksmelt	3	6.77
Gibbonsia spp.	clinid kelpfishes	3	7.85
Oxylebius pictus	painted greenling	3	8.48
Engraulidae unid.	anchovies	1	2.17
Gobiidae unid.	gobies	1	2.76
Heterostichus rostratus	giant kelpfish	1	2.94
Hypsoblennius spp.	combtooth blennies	1	2.72
larvae, unidentified yolksac	unidentified yolksac larvae	1	2.72
larval fish fragment	unidentified larval fishes	1	2.94
Ruscarius creaseri	roughcheek sculpin	1	2.72
	Total Entrainable Larval Fishes:	**76**	
Eggs			
fish eggs unid.	unidentified fish eggs	480	1,232.42
Engraulidae unid. (eggs)	anchovy eggs	99	266.67
Pleuronichthys spp. (eggs)	turbot eggs	23	61.07
Sciaenidae unid. (eggs)	croaker eggs	9	25.35
Paralichthyidae unid. (eggs)	sand flounder eggs	6	16.70
Bathylagidae (eggs)	blacksmelt eggs	1	2.81
	Total Eggs:	**618**	
Invertebrates			
Cancer antennarius (megalops)	brown rock crab megalops	1	2.44
	Total Invertebrates:	**1**	
	Total Station Count:	**695**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA26
Start Date: March 14, 2007
Station: E2

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	58	162.46
Typhlogobius californiensis	blind goby	9	22.92
Gobiidae unid.	gobies	7	19.38
Genyonemus lineatus	white croaker	6	18.18
Hypsoblennius spp.	combtooth blennies	3	7.00
Gibbonsia spp.	clinid kelpfishes	2	6.77
Atherinopsidae unid.	silversides	1	2.72
Gobiesox spp.	clingfishes	1	2.33
Pleuronichthys verticalis	hornyhead turbot	1	2.97
Sciaenidae unid.	croakers	1	2.50
	Total Entrainable Larval Fishes:	**89**	
Eggs			
Atherinopsis californiensis (eggs)	jacksmelt eggs	450	1,222.44
fish eggs unid.	unidentified fish eggs	233	644.73
Paralichthyidae unid. (eggs)	sand flounder eggs	107	285.46
Engraulidae unid. (eggs)	anchovy eggs	97	260.60
Citharichthys spp. (eggs)	sanddab eggs	95	242.50
Sciaenidae unid. (eggs)	croaker eggs	49	126.69
Pleuronichthys spp. (eggs)	turbot eggs	22	55.77
Sardinops sagax (eggs)	Pacific sardine eggs	6	14.84
	Total Eggs:	**1,059**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**1,148**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA26
Start Date: March 14, 2007
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	74	208.59
Gobiidae unid.	gobies	14	39.06
Hypsoblennius spp.	combtooth blennies	9	22.08
Genyonemus lineatus	white croaker	7	19.75
Gibbonsia spp.	clinid kelpfishes	5	15.18
Sardinops sagax	Pacific sardine	3	7.76
Typhlogobius californiensis	blind goby	3	8.95
Atherinopsidae unid.	silversides	1	2.62
larvae, unidentified yolksac	unidentified yolksac larvae	1	2.62
larval fish - damaged	unidentified larval fishes	1	3.53
Paralichthys californicus	California halibut	1	2.62
Pleuronichthys guttulatus	diamond turbot	1	2.35
Pleuronichthys ritteri	spotted turbot	1	2.62
	Total Entrainable Larval Fishes:	**121**	
Eggs			
fish eggs unid.	unidentified fish eggs	267	763.22
Paralichthyidae unid. (eggs)	sand flounder eggs	122	332.46
Sciaenidae unid. (eggs)	croaker eggs	97	267.07
Citharichthys spp. (eggs)	sanddab eggs	96	256.14
Engraulidae unid. (eggs)	anchovy eggs	94	266.24
Pleuronichthys spp. (eggs)	turbot eggs	26	71.17
Sardinops sagax (eggs)	Pacific sardine eggs	11	27.95
	Total Eggs:	**713**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**834**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA27
Start Date: March 28, 2007
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	86	222.20
Typhlogobius californiensis	blind goby	28	79.90
Stenobrachius leucopsarus	northern lampfish	21	53.74
Gibbonsia spp.	clinid kelpfishes	7	18.66
Gobiidae unid.	gobies	7	17.51
Genyonemus lineatus	white croaker	3	8.20
Atherinopsis californiensis	jacksmelt	1	2.88
Gobiesox spp.	clingfishes	1	2.81
Hypsoblennius spp.	combtooth blennies	1	2.70
Ruscarius creaseri	roughcheek sculpin	1	2.70
	Total Entrainable Larval Fishes:	**156**	
Eggs			
fish eggs unid.	unidentified fish eggs	158	420.73
Engraulidae unid. (eggs)	anchovy eggs	37	97.93
Paralichthyidae unid. (eggs)	sand flounder eggs	2	4.78
Atherinopsis californiensis (eggs)	jacksmelt eggs	1	2.08
Blenniidae (eggs)	blenny eggs	1	2.08
Sciaenidae unid. (eggs)	croaker eggs	1	2.70
	Total Eggs:	**200**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	2.81
	Total Invertebrates:	**1**	
	Total Station Count:	**357**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA28
Start Date: April 11, 2007
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	46	132.37
Atherinopsidae unid.	silversides	14	43.08
Gobiesox spp.	clingfishes	13	36.03
Atherinopsis californiensis	jacksmelt	10	25.19
Gibbonsia spp.	clinid kelpfishes	10	26.64
Heterostichus rostratus	giant kelpfish	10	26.81
Gobiidae unid.	gobies	9	25.66
Typhlogobius californiensis	blind goby	4	10.07
Genyonemus lineatus	white croaker	3	9.22
Hypsoblennius spp.	combtooth blennies	3	9.59
Pleuronichthys guttulatus	diamond turbot	2	5.95
Clinidae unid.	kelp blennies	1	2.52
Leuresthes tenuis	California grunion	1	3.04
	Total Entrainable Larval Fishes:	**126**	
Eggs			
Atherinopsis californiensis (eggs)	jacksmelt eggs	225	659.18
fish eggs unid.	unidentified fish eggs	180	535.57
Engraulidae unid. (eggs)	anchovy eggs	89	268.59
Paralichthyidae unid. (eggs)	sand flounder eggs	38	110.85
Sciaenidae unid. (eggs)	croaker eggs	30	92.00
Citharichthys spp. (eggs)	sanddab eggs	12	35.27
Pleuronichthys spp. (eggs)	turbot eggs	8	22.79
Leuresthes tenuis (eggs)	California grunion eggs	5	14.80
Atherinopsidae unid. (eggs)	silverside eggs	1	3.13
Blenniidae (eggs)	blenny eggs	1	2.41
	Total Eggs:	**589**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
Non-Targeted Invertebrates			
Cancer jordani (juv.)	hairy rock crab	1	3.13
	Total Non-Targeted Invertebrates:	**1**	
	Total Station Count:	**716**	

SONGS Entrainment Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA29
Start Date: April 25, 2007
Station: E3

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	79	200.36
Hypsoblennius spp.	combtooth blennies	21	55.08
Typhlogobius californiensis	blind goby	7	19.05
Gibbonsia spp.	clinid kelpfishes	5	12.67
Gobiidae unid.	gobies	3	7.55
Genyonemus lineatus	white croaker	2	5.12
Paralichthys californicus	California halibut	2	5.06
Atherinopsidae unid.	silversides	1	2.90
Atractoscion nobilis	white seabass	1	2.51
larvae, unidentified yolksac	unidentified yolksac larvae	1	2.51
Leuresthes tenuis	California grunion	1	2.51
Peprilus simillimus	Pacific butterfish	1	2.68
Pleuronichthys spp.	turbots	1	2.21
	Total Entrainable Larval Fishes:	**125**	
Non-Entrainable Fishes			
Engraulis mordax	northern anchovy	2	5.19
	Total Non-Entrainable Fishes:	**2**	
Eggs			
fish eggs unid.	unidentified fish eggs	624	1,607.44
Paralichthyidae unid. (eggs)	sand flounder eggs	115	295.06
Engraulidae unid. (eggs)	anchovy eggs	82	210.93
Pleuronichthys spp. (eggs)	turbot eggs	59	150.57
Sciaenidae unid. (eggs)	croaker eggs	59	149.50
Citharichthys spp. (eggs)	sanddab eggs	43	109.90
Sciaen./Paralich./Labridae (eggs)	fish eggs	24	64.43
Blenniidae (eggs)	blenny eggs	1	2.51
Carangidae (eggs)	jack eggs	1	2.53
	Total Eggs:	**1,008**	
Invertebrates			
Cancer antennarius (megalops)	brown rock crab megalops	2	5.41
Cancer anthonyi (megalops)	yellow crab megalops	2	5.41
	Total Invertebrates:	**4**	
	Total Station Count:	**1,139**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA02
Start Date: April 12, 2006
Station: O1

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	6,353	6,546.61
Engraulidae unid.	anchovies	1,924	1,789.29
Typhlogobius californiensis	blind goby	145	134.81
Genyonemus lineatus	white croaker	144	142.35
larval fish fragment	unidentified larval fishes	130	139.44
Paralichthys californicus	California halibut	20	19.76
Gibbonsia spp.	clinid kelpfishes	14	14.42
Pleuronichthys guttulatus	diamond turbot	12	12.23
Gobiidae unid.	gobies	9	8.13
Atherinopsis californiensis	jacksmelt	5	4.88
Hypsoblennius spp.	combtooth blennies	5	4.81
larval fish - damaged	unidentified larval fishes	5	5.07
Sciaenidae unid.	croakers	5	4.60
Pleuronichthys verticalis	hornyhead turbot	4	4.13
larvae, unidentified yolksac	unidentified yolksac larvae	3	3.10
Pleuronichthys spp.	turbots	3	2.93
Citharichthys sordidus	Pacific sanddab	2	1.97
Gobiesox spp.	clingfishes	2	1.89
Labrisomidae unid.	labrisomid blennies	2	1.81
Ophidiidae unid.	cusk-eels	2	2.23
Paralichthyidae unid.	sand flounders	2	2.31
Stenobrachius leucopsarus	northern lampfish	2	1.79
Atherinopsidae unid.	silversides	1	1.07
Citharichthys stigmaeus	speckled sanddab	1	1.07
Clinidae unid.	kelp blennies	1	0.79
Gillichthys mirabilis	longjaw mudsucker	1	1.01
Heterostichus rostratus	giant kelpfish	1	0.79
Lepidogobius lepidus	bay goby	1	0.79
Merluccius productus	Pacific hake	1	0.92
Pleuronectiformes unid.	flatfishes	1	1.15
Pleuronichthys ritteri	spotted turbot	1	1.11
Seriphus politus	queenfish	1	1.00
	Total Entrainable Larval Fishes:	**8,803**	
Eggs			
Engraulidae unid. (eggs)	anchovy eggs	4,341	4,293.85
fish eggs unid.	unidentified fish eggs	2,816	2,743.55
Paralichthyidae unid. (eggs)	sand flounder eggs	235	240.59
Citharichthys spp. (eggs)	sanddab eggs	124	120.11
Sciaenidae unid. (eggs)	croaker eggs	120	118.65
Pleuronichthys spp. (eggs)	turbot eggs	93	91.53
	Total Eggs:	**7,729**	
Invertebrates			
Cancer productus (megalops)	red rock crab megalops	1	0.79
	Total Invertebrates:	**1**	
	Total Station Count:	**16,533**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA04
Start Date: May 10, 2006
Station: O1

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulidae unid.	anchovies	61	88.23
Engraulis mordax	northern anchovy	52	82.07
Leuresthes tenuis	California grunion	52	82.62
Hypsoblennius spp.	combtooth blennies	45	67.82
Typhlogobius californiensis	blind goby	36	57.84
Gobiidae unid.	gobies	15	22.63
Genyonemus lineatus	white croaker	14	21.38
Gibbonsia spp.	clinid kelpfishes	14	21.06
Atherinopsidae unid.	silversides	13	19.66
larval fish fragment	unidentified larval fishes	13	20.44
larvae, unidentified yolksac	unidentified yolksac larvae	11	16.55
larval fish - damaged	unidentified larval fishes	3	4.85
Paralichthys californicus	California halibut	2	2.86
Citharichthys stigmaeus	speckled sanddab	1	1.42
Heterostichus rostratus	giant kelpfish	1	1.62
	Total Entrainable Larval Fishes:	**333**	
Eggs			
fish eggs unid.	unidentified fish eggs	100	2,952.39
Paralichthyidae unid. (eggs)	sand flounder eggs	12	340.52
Citharichthys spp. (eggs)	sanddab eggs	5	141.59
Engraulidae unid. (eggs)	anchovy eggs	1	27.05
	Total Eggs:	**118**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	2	3.23
	Total Invertebrates:	**2**	
	Total Station Count:	**453**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA06
Start Date: June 07, 2006
Station: O1

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	3,553	5,144.11
Engraulidae unid.	anchovies	1,912	2,700.48
Hypsoblennius spp.	combtooth blennies	698	991.78
larval fish fragment	unidentified larval fishes	434	625.88
larval/post-larval fish unid.	larval fishes	346	503.27
Seriphus politus	queenfish	323	472.85
Sphyraena argentea	Pacific barracuda	186	266.00
Roncador stearnsi	spotfin croaker	90	130.54
Typhlogobius californiensis	blind goby	68	96.69
Sciaenidae unid.	croakers	48	68.94
Gibbonsia spp.	clinid kelpfishes	18	26.80
Paralichthys californicus	California halibut	14	20.42
Leuresthes tenuis	California grunion	12	15.87
Paralabrax spp.	sand bass	11	15.73
Labrisomidae unid.	labrisomid blennies	9	13.32
Atherinopsidae unid.	silversides	7	9.51
Menticirrhus undulatus	California corbina	6	9.24
Symphurus atricauda	California tonguefish	5	7.30
Citharichthys spp.	sanddabs	4	5.87
Gobiidae unid.	gobies	3	4.01
Genyonemus lineatus	white croaker	2	3.02
Gillichthys mirabilis	longjaw mudsucker	2	3.24
Gobiesox spp.	clingfishes	2	2.86
Rhinogobiops nicholsi	blackeye goby	2	2.89
Sarda chiliensis	Pacific bonito	2	3.12
Cottidae unid.	sculpins	1	1.30
Girella nigricans	opaleye	1	1.65
Oxyjulis californica	senorita	1	1.47
Triphoturus mexicanus	Mexican lampfish	1	1.59
	Total Entrainable Larval Fishes:	**7,761**	
Eggs			
fish eggs unid.	unidentified fish eggs	619	16,426.34
Sciaen./Paralich./Labridae (eggs)	fish eggs	468	12,992.53
Paralichthyidae unid. (eggs)	sand flounder eggs	12	330.61
Engraulidae unid. (eggs)	anchovy eggs	11	316.16
Citharichthys spp. (eggs)	sanddab eggs	5	152.10
Paralabrax spp. (eggs)	sand bass eggs	2	55.40
Pleuronichthys spp. (eggs)	turbot eggs	1	24.96
	Total Eggs:	**1,118**	
Invertebrates			
Cancer antennarius (megalops)	brown rock crab megalops	18	23.91
Cancer gracilis (megalops)	slender crab megalops	13	19.57
Cancer anthonyi (megalops)	yellow crab megalops	4	5.77
	Total Invertebrates:	**35**	
	Total Station Count:	**8,914**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA08
Start Date: July 06, 2006
Station: O1

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
larvae, unidentified yolksac	unidentified yolksac larvae	1,015	1,425.43
Sciaenidae unid.	croakers	592	843.16
Perciformes unid.	perch-like fishes	246	347.08
Haemulidae unid.	grunts	205	278.28
larval fish fragment	unidentified larval fishes	197	272.09
Hypsoblennius spp.	combtooth blennies	176	247.36
Paralabrax spp.	sand bass	117	163.05
Paralichthys californicus	California halibut	54	79.39
Seriphus politus	queenfish	42	59.64
Engraulis mordax	northern anchovy	26	36.78
Labrisomidae unid.	labrisomid blennies	23	32.30
Typhlogobius californiensis	blind goby	14	21.07
Sphyraena argentea	Pacific barracuda	12	17.38
Oxyjulis californica	senorita	11	15.87
larval fish - damaged	unidentified larval fishes	10	14.19
Pleuronichthys spp.	turbots	9	13.03
Paralichthyidae unid.	sand flounders	5	7.64
Diaphus theta	California headlight fish	4	6.21
Gobiidae unid.	gobies	4	5.71
Semicossyphus pulcher	California sheephead	4	5.96
Xystreurys liolepis	fantail sole	4	6.06
Engraulidae unid.	anchovies	3	4.68
Gibbonsia spp.	clinid kelpfishes	3	4.17
Menticirrhus undulatus	California corbina	3	4.09
Pleuronichthys verticalis	hornyhead turbot	3	4.61
Atractoscion nobilis	white seabass	2	2.73
Cheilotrema saturnum	black croaker	2	2.78
larval/post-larval fish unid.	larval fishes	2	2.86
Pleuronectiformes unid.	flatfishes	2	2.71
Gobiesox spp.	clingfishes	1	1.34
Labridae unid.	wrasses	1	1.36
Myctophidae unid.	lanternfishes	1	1.36
Ophidiidae unid.	cusk-eels	1	1.39
Pleuronichthys ritteri	spotted turbot	1	1.39
Stenobrachius leucopsarus	northern lampfish	1	1.39
	Total Entrainable Larval Fishes:	**2,796**	
Eggs			
fish eggs unid.	unidentified fish eggs	1,731	50,130.21
Sciaen./Paralich./Labridae (eggs)	fish eggs	387	11,099.97
Engraulidae unid. (eggs)	anchovy eggs	37	1,090.25
Labridae unid. (eggs)	wrasse eggs	20	572.30
Pleuronichthys spp. (eggs)	turbot eggs	8	238.34
Paralabrax spp. (eggs)	sand bass eggs	6	185.03
Citharichthys spp. (eggs)	sanddab eggs	3	83.83
Sphyraena argentea (eggs)	Pacific barracuda eggs	3	95.88
	Total Eggs:	**2,195**	

(continued)

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3) continued

Survey: SOEA08
Start Date: July 06, 2006
Station: O1

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Invertebrates			
Panulirus interruptus (phyllo.)	California spiny lobster (larval)	48	67.14
	Total Invertebrates:	**48**	
	Total Station Count:	**5,039**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA12
Start Date: August 30, 2006
Station: O1

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Hypsoblennius spp.	combtooth blennies	45	73.38
larvae, unidentified yolksac	unidentified yolksac larvae	10	15.95
Paralabrax spp.	sand bass	10	15.85
Sciaenidae unid.	croakers	5	8.03
Gibbonsia spp.	clinid kelpfishes	4	6.59
Semicossyphus pulcher	California sheephead	4	6.34
Labrisomidae unid.	labrisomid blennies	3	4.95
Paralichthys californicus	California halibut	3	4.81
Typhlogobius californiensis	blind goby	3	4.91
Engraulis mordax	northern anchovy	2	3.36
Labridae unid.	wrasses	2	3.27
larval fish - damaged	unidentified larval fishes	2	3.16
larval fish fragment	unidentified larval fishes	2	2.95
Sphyraena argentea	Pacific barracuda	2	3.27
Anisotremus davidsonii	sargo	1	1.72
Gillichthys mirabilis	longjaw mudsucker	1	1.65
Haemulidae unid.	grunts	1	1.72
Halichoeres semicinctus	rock wrasse	1	1.72
Hypsoblennius jenkinsi	mussel blenny	1	1.64
Menticirrhus undulatus	California corbina	1	1.55
Oxyjulis californica	senorita	1	1.53
Seriphus politus	queenfish	1	1.53
Symphurus atricauda	California tonguefish	1	1.55
	Total Entrainable Larval Fishes:	**106**	
Non-Entrainable Fishes			
Leuresthes tenuis	California grunion	1	1.64
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	722	2,219.51
Paralichthyidae unid. (eggs)	sand flounder eggs	259	804.69
Citharichthys spp. (eggs)	sanddab eggs	73	222.43
Labridae unid. (eggs)	wrasse eggs	42	121.74
Engraulidae unid. (eggs)	anchovy eggs	23	72.87
Pleuronichthys spp. (eggs)	turbot eggs	17	48.69
Paralabrax spp. (eggs)	sand bass eggs	5	13.32
Sciaenidae unid. (eggs)	croaker eggs	3	9.29
Sphyraena argentea (eggs)	Pacific barracuda eggs	1	3.25
	Total Eggs:	**1,145**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	2	3.29
Cancer antennarius (megalops)	brown rock crab megalops	1	1.65
	Total Invertebrates:	**3**	
	Total Station Count:	**1,255**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA13
Start Date: September 13, 2006
Station: O1

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Seriphus politus	queenfish	16	20.63
Gibbonsia spp.	clinid kelpfishes	14	17.87
Labrisomidae unid.	labrisomid blennies	11	13.65
Hypsoblennius spp.	combtooth blennies	10	14.12
larvae, unidentified yolksac	unidentified yolksac larvae	10	13.64
Engraulidae unid.	anchovies	7	9.73
Paralabrax spp.	sand bass	7	9.25
Gobiesox spp.	clingfishes	2	2.63
Heterostichus rostratus	giant kelpfish	2	2.52
Oxyjulis californica	senorita	2	2.65
Triphoturus mexicanus	Mexican lampfish	2	2.65
Blennioidei unid.	blennies	1	1.26
Diaphus theta	California headlight fish	1	1.30
Engraulis mordax	northern anchovy	1	1.13
Genyonemus lineatus	white croaker	1	1.13
Gobiidae unid.	gobies	1	1.39
larval fish - damaged	unidentified larval fishes	1	1.26
Rimicola spp.	kelp clingfishes	1	1.26
Umbrina roncador	yellowfin croaker	1	1.33
	Total Entrainable Larval Fishes:	**91**	
Non-Entrainable Fishes			
Seriphus politus	queenfish	1	1.26
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	521	2,158.48
Engraulidae unid. (eggs)	anchovy eggs	75	659.76
Paralichthyidae unid. (eggs)	sand flounder eggs	48	223.50
Labridae unid. (eggs)	wrasse eggs	47	125.66
Citharichthys spp. (eggs)	sanddab eggs	19	46.03
Sciaenidae unid. (eggs)	croaker eggs	15	41.95
Pleuronichthys spp. (eggs)	turbot eggs	6	15.42
Paralabrax spp. (eggs)	sand bass eggs	5	13.62
	Total Eggs:	**736**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	12	15.46
	Total Invertebrates:	**12**	
	Total Station Count:	**840**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA15
Start Date: October 11, 2006
Station: O1

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Paralichthys californicus	California halibut	7	10.18
Hypsoblennius spp.	combtooth blennies	5	7.22
Pleuronichthys guttulatus	diamond turbot	3	4.33
Citharichthys stigmaeus	speckled sanddab	2	2.95
larvae, unidentified yolksac	unidentified yolksac larvae	2	2.61
Triphoturus mexicanus	Mexican lampfish	2	2.81
Engraulidae unid.	anchovies	1	1.39
Genyonemus lineatus	white croaker	1	1.22
Gibbonsia spp.	clinid kelpfishes	1	1.39
larval/post-larval fish unid.	larval fishes	1	1.32
Pleuronichthys ritteri	spotted turbot	1	1.56
	Total Entrainable Larval Fishes:	**26**	
Non-Entrainable Fishes			
Engraulidae unid.	anchovies	1	1.32
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	276	818.75
Sciaen./Paralich./Labridae (eggs)	fish eggs	70	202.02
Paralichthyidae unid. (eggs)	sand flounder eggs	49	153.09
Pleuronichthys spp. (eggs)	turbot eggs	38	110.51
Sciaenidae unid. (eggs)	croaker eggs	38	122.93
Citharichthys spp. (eggs)	sanddab eggs	33	103.01
Engraulidae unid. (eggs)	anchovy eggs	2	5.88
	Total Eggs:	**506**	
Invertebrates			
Panulirus interruptus (phyllo.)	California spiny lobster (larval)	2	2.55
	Total Invertebrates:	**2**	
	Total Station Count:	**535**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA18
Start Date: November 21, 2006
Station: O1

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	7	10.14
Pleuronichthys guttulatus	diamond turbot	3	4.17
Atherinopsidae unid.	silversides	2	3.12
Gibbonsia spp.	clinid kelpfishes	2	2.84
Atherinopsis californiensis	jacksmelt	1	1.41
Genyonemus lineatus	white croaker	1	1.45
larvae, unidentified yolksac	unidentified yolksac larvae	1	1.42
Paralichthys californicus	California halibut	1	1.56
Pleuronichthys ritteri	spotted turbot	1	1.56
Pleuronichthys spp.	turbots	1	1.56
	Total Entrainable Larval Fishes:	**20**	
Eggs			
fish eggs unid.	unidentified fish eggs	120	340.40
Paralichthyidae unid. (eggs)	sand flounder eggs	60	174.21
Sciaen./Paralich./Labridae (eggs)	fish eggs	28	81.96
Citharichthys spp. (eggs)	sanddab eggs	20	56.64
Pleuronichthys spp. (eggs)	turbot eggs	13	37.94
Sciaenidae unid. (eggs)	croaker eggs	1	2.80
	Total Eggs:	**242**	
Invertebrates			
Cancer antennarius (megalops)	brown rock crab megalops	1	1.44
	Total Invertebrates:	**1**	
	Total Station Count:	**263**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA19
Start Date: December 06, 2006
Station: O1

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Genyonemus lineatus	white croaker	3	4.51
Engraulis mordax	northern anchovy	2	2.75
Hypsoblennius spp.	combtooth blennies	1	1.50
larvae, unidentified yolksac	unidentified yolksac larvae	1	1.42
larval fish fragment	unidentified larval fishes	1	1.28
	Total Entrainable Larval Fishes:	**8**	
Eggs			
fish eggs unid.	unidentified fish eggs	136	342.62
Paralichthyidae unid. (eggs)	sand flounder eggs	31	81.37
Citharichthys spp. (eggs)	sanddab eggs	8	20.24
Pleuronichthys spp. (eggs)	turbot eggs	7	17.49
Sciaenidae unid. (eggs)	croaker eggs	5	11.61
	Total Eggs:	**187**	
Invertebrates			
No invertebrates			
	Total Invertebrates:	**0**	
	Total Station Count:	**195**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA22
Start Date: January 17, 2007
Station: O1

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Genyonemus lineatus	white croaker	75	101.51
larval fish fragment	unidentified larval fishes	6	7.78
Paralichthys californicus	California halibut	5	7.91
larvae, unidentified yolksac	unidentified yolksac larvae	3	4.03
Pleuronichthys guttulatus	diamond turbot	3	4.08
Sciaenidae unid.	croakers	2	2.82
Atherinopsidae unid.	silversides	1	1.51
Citharichthys sordidus	Pacific sanddab	1	1.46
Cottidae unid.	sculpins	1	1.46
Engraulis mordax	northern anchovy	1	1.51
Gibbonsia spp.	clinid kelpfishes	1	1.38
Gobiidae unid.	gobies	1	1.63
Pleuronectiformes unid.	flatfishes	1	1.26
	Total Entrainable Larval Fishes:	**101**	
Eggs			
fish eggs unid.	unidentified fish eggs	282	801.24
Sciaenidae unid. (eggs)	croaker eggs	84	243.74
Paralichthyidae unid. (eggs)	sand flounder eggs	18	50.78
Citharichthys spp. (eggs)	sanddab eggs	12	34.67
Pleuronichthys spp. (eggs)	turbot eggs	8	23.80
Engraulidae unid. (eggs)	anchovy eggs	3	9.02
	Total Eggs:	**407**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	1.26
	Total Invertebrates:	**1**	
	Total Station Count:	**509**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA24
Start Date: February 14, 2007
Station: O2
Tow Type: B

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Gobiidae unid.	gobies	169	350.60
Engraulis mordax	northern anchovy	160	319.29
Seriphus politus	queenfish	130	263.10
Gibbonsia spp.	clinid kelpfishes	87	180.96
Heterostichus rostratus	giant kelpfish	33	66.34
Genyonemus lineatus	white croaker	23	59.45
larval fish fragment	unidentified larval fishes	11	21.91
Lepidogobius lepidus	bay goby	5	12.93
Gobiesox spp.	clingfishes	5	10.17
Clinidae unid.	kelp blennies	4	8.61
Sardinops sagax	Pacific sardine	2	4.02
larval fish - damaged	unidentified larval fishes	1	2.16
Clupeidae unid.	herrings	1	2.15
Bathylagus ochotensis	popeye blacksmelt	1	1.84
Stenobrachius leucopsarus	northern lampfish	1	1.84
	Total Entrainable Larval Fishes:	**633**	
Non-Entrainable Fishes			
Seriphus politus	queenfish	1	2.16
Sebastes spp.	rockfishes	1	1.84
Syngnathus spp.	pipefishes	1	1.84
	Total Non-Entrainable Fishes:	**3**	
Eggs			
fish eggs unid.	unidentified fish eggs	143	636.69
Sciaenidae unid. (eggs)	croaker eggs	103	498.07
Sciaenidae/Paralichthyidae (eggs)	fish eggs	27	101.20
Paralichthyidae unid. (eggs)	sand flounder eggs	10	51.09
Pleuronichthys spp. (eggs)	turbot eggs	6	27.65
Citharichthys spp. (eggs)	sanddab eggs	3	14.40
Atherinopsis californiensis (eggs)	jacksmelt eggs	3	12.93
Engraulidae unid. (eggs)	anchovy eggs	2	10.62
	Total Eggs:	**297**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	1	2.99
Cancer antennarius (megalops)	brown rock crab megalops	1	1.84
Cancer gracilis (megalops)	slender crab megalops	1	1.84
	Total Invertebrates:	**3**	
	Total Station Count:	**936**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA24
Start Date: February 14, 2007
Station: O2
Tow Type: O

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Genyonemus lineatus	white croaker	79	115.16
Engraulis mordax	northern anchovy	25	32.68
Gibbonsia spp.	clinid kelpfishes	25	32.45
Heterostichus rostratus	giant kelpfish	7	9.12
Paralichthys californicus	California halibut	4	5.83
Pleuronichthys guttulatus	diamond turbot	4	5.53
Gobiidae unid.	gobies	3	3.76
Citharichthys sordidus	Pacific sanddab	2	2.75
Sciaenidae unid.	croakers	2	2.73
Typhlogobius californiensis	blind goby	2	2.57
Pleuronichthys spp.	turbots	2	2.44
Pleuronichthys verticalis	hornyhead turbot	1	1.61
Pleuronichthys ritteri	spotted turbot	1	1.53
larval fish - damaged	unidentified larval fishes	1	1.44
Lepidogobius lepidus	bay goby	1	1.40
larvae, unidentified yolksac	unidentified yolksac larvae	1	1.39
Stenobrachius leucopsarus	northern lampfish	1	1.39
Seriphus politus	queenfish	1	1.19
	Total Entrainable Larval Fishes:	**162**	
Eggs			
fish eggs unid.	unidentified fish eggs	678	3,724.70
Sciaenidae unid. (eggs)	croaker eggs	230	2,562.89
Sciaenidae/Paralichthyidae (eggs)	fish eggs	172	470.36
Pleuronichthys spp. (eggs)	turbot eggs	16	213.09
Paralichthyidae unid. (eggs)	sand flounder eggs	26	121.00
Engraulidae unid. (eggs)	anchovy eggs	4	35.98
Citharichthys spp. (eggs)	sanddab eggs	7	18.36
	Total Eggs:	**1,133**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	1.40
Cancer productus (megalops)	red rock crab megalops	1	1.40
	Total Invertebrates:	**2**	
	Total Station Count:	**1,297**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA24
Start Date: February 14, 2007
Station: O2
Tow Type: M

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Atherinopsis californiensis	jacksmelt	103	349.83
Atherinopsidae unid.	silversides	74	224.60
Gibbonsia spp.	clinid kelpfishes	24	71.95
Scorpaenichthys marmoratus	cabezon	16	52.37
Genyonemus lineatus	white croaker	11	35.32
Clinidae unid.	kelp blennies	8	25.32
Paralichthys californicus	California halibut	7	21.33
Citharichthys stigmaeus	speckled sanddab	2	6.35
Atherinops affinis	topsmelt	2	6.26
Sardinops sagax	Pacific sardine	2	5.98
larval fish - damaged	unidentified larval fishes	2	5.80
larval fish fragment	unidentified larval fishes	1	3.45
Pleuronichthys spp.	turbots	1	3.45
Citharichthys sordidus	Pacific sanddab	1	3.06
Engraulis mordax	northern anchovy	1	3.06
larvae, unidentified yolksac	unidentified yolksac larvae	1	3.06
Paralichthyidae unid.	sand flounders	1	3.06
	Total Entrainable Larval Fishes:	**257**	
Non-Entrainable Fishes			
Syngnathus spp.	pipefishes	1	3.40
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	2,891	9,871.82
Sciaenidae unid. (eggs)	croaker eggs	1,996	8,450.63
Paralichthyidae unid. (eggs)	sand flounder eggs	98	564.97
Pleuronichthys spp. (eggs)	turbot eggs	101	390.43
Citharichthys spp. (eggs)	sanddab eggs	23	73.72
Engraulidae unid. (eggs)	anchovy eggs	5	15.02
	Total Eggs:	**5,114**	
	Total Station Count:	**5,372**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA24
Start Date: February 14, 2007
Station: O3
Tow Type: B

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Lepidogobius lepidus	bay goby	236	542.22
Engraulis mordax	northern anchovy	196	443.91
Genyonemus lineatus	white croaker	107	240.56
Gobiidae unid.	gobies	89	205.36
Gibbonsia spp.	clinid kelpfishes	12	26.79
larval fish fragment	unidentified larval fishes	5	11.62
Heterostichus rostratus	giant kelpfish	5	11.04
Labrisomidae unid.	labrisomid blennies	2	4.64
Sardinops sagax	Pacific sardine	1	2.31
Paralichthys californicus	California halibut	1	2.30
Atherinopsidae unid.	silversides	1	1.91
Engraulidae unid.	anchovies	1	1.91
Leptocottus armatus	Pacific staghorn sculpin	1	1.91
larvae, unidentified yolksac	unidentified yolksac larvae	1	1.83
	Total Entrainable Larval Fishes:	**658**	
Eggs			
Sciaenidae unid. (eggs)	croaker eggs	110	499.84
fish eggs unid.	unidentified fish eggs	110	489.99
Pleuronichthys spp. (eggs)	turbot eggs	2	9.27
Citharichthys spp. (eggs)	sanddab eggs	1	4.68
Paralichthyidae unid. (eggs)	sand flounder eggs	1	4.62
	Total Eggs:	**224**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	6	13.64
Cancer antennarius (megalops)	brown rock crab megalops	3	6.94
Cancer productus (megalops)	red rock crab megalops	2	4.60
	Total Invertebrates:	**11**	
	Total Station Count:	**893**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA24
Start Date: February 14, 2007
Station: O3
Tow Type: O

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Genyonemus lineatus	white croaker	95	133.07
Engraulis mordax	northern anchovy	13	18.09
Pleuronichthys guttulatus	diamond turbot	7	9.89
Lepidogobius lepidus	bay goby	7	9.65
Paralichthys californicus	California halibut	5	6.81
larvae, unidentified yolksac	unidentified yolksac larvae	4	5.88
Sciaenidae unid.	croakers	3	4.08
Ruscarius creaseri	roughcheek sculpin	1	1.53
Atherinopsis californiensis	jacksmelt	1	1.50
Engraulidae unid.	anchovies	1	1.48
Pleuronichthys ritteri	spotted turbot	1	1.33
Gibbonsia spp.	clinid kelpfishes	1	1.19
Stenobrachius leucopsarus	northern lampfish	1	1.18
	Total Entrainable Larval Fishes:	**140**	
Eggs			
fish eggs unid.	unidentified fish eggs	351	4,095.09
Sciaenidae unid. (eggs)	croaker eggs	316	3,315.67
Pleuronichthys spp. (eggs)	turbot eggs	5	63.04
Paralichthyidae unid. (eggs)	sand flounder eggs	18	46.93
Citharichthys spp. (eggs)	sanddab eggs	3	29.61
Engraulidae unid. (eggs)	anchovy eggs	1	2.88
	Total Eggs:	**694**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	4	5.40
Cancer productus (megalops)	red rock crab megalops	1	1.19
	Total Invertebrates:	**5**	
	Total Station Count:	**839**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA24
Start Date: February 14, 2007
Station: O3
Tow Type: M

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Atherinopsis californiensis	jacksmelt	35	100.56
Atherinopsidae unid.	silversides	24	68.91
Genyonemus lineatus	white croaker	19	52.35
Atherinops affinis	topsmelt	18	50.62
Gibbonsia spp.	clinid kelpfishes	16	46.34
larvae, unidentified yolksac	unidentified yolksac larvae	8	23.32
Paralichthys californicus	California halibut	5	14.09
Engraulis mordax	northern anchovy	5	14.06
Sardinops sagax	Pacific sardine	4	11.39
Engraulidae unid.	anchovies	3	8.59
larval fish fragment	unidentified larval fishes	2	5.92
Clinidae unid.	kelp blennies	2	5.76
Lepidogobius lepidus	bay goby	2	5.46
Citharichthys stigmaeus	speckled sanddab	1	2.90
larval fish - damaged	unidentified larval fishes	1	2.90
Citharichthys sordidus	Pacific sanddab	1	2.90
Gobiidae unid.	gobies	1	2.80
Pleuronichthys guttulatus	diamond turbot	1	2.80
	Total Entrainable Larval Fishes:	**148**	
Non-Entrainable Fishes			
Atherinopsis californiensis	jacksmelt	3	8.69
Atherinops affinis	topsmelt	2	5.69
Syngnathus spp.	pipefishes	1	2.90
Leuresthes tenuis	California grunion	1	2.90
	Total Non-Entrainable Fishes:	**7**	
Eggs			
fish eggs unid.	unidentified fish eggs	807	6,761.68
Sciaenidae unid. (eggs)	croaker eggs	730	4,746.76
Pleuronichthys spp. (eggs)	turbot eggs	16	225.04
Paralichthyidae unid. (eggs)	sand flounder eggs	43	176.44
Citharichthys spp. (eggs)	sanddab eggs	15	42.98
Engraulidae unid. (eggs)	anchovy eggs	3	8.52
	Total Eggs:	**1,614**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	2	5.46
	Total Invertebrates:	**2**	
	Total Station Count:	**1,771**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA24
Start Date: February 14, 2007
Station: S2
Tow Type: M

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Atherinopsis californiensis	jacksmelt	138	715.66
Gibbonsia spp.	clinid kelpfishes	51	299.73
Atherinopsidae unid.	silversides	46	281.48
larval fish - damaged	unidentified larval fishes	4	23.42
Genyonemus lineatus	white croaker	4	20.43
Clinidae unid.	kelp blennies	2	11.71
Sciaenidae unid.	croakers	2	11.17
Paralichthys californicus	California halibut	2	10.54
Pleuronichthys guttulatus	diamond turbot	2	10.54
Sardinops sagax	Pacific sardine	1	5.86
Engraulidae unid.	anchovies	1	4.95
	Total Entrainable Larval Fishes:	**253**	
Eggs			
Sciaenidae unid. (eggs)	croaker eggs	1,799	9,409.60
fish eggs unid.	unidentified fish eggs	1,308	7,426.09
Paralichthyidae unid. (eggs)	sand flounder eggs	90	486.84
Pleuronichthys spp. (eggs)	turbot eggs	55	288.76
Citharichthys spp. (eggs)	sanddab eggs	19	101.66
Engraulidae unid. (eggs)	anchovy eggs	9	47.73
	Total Eggs:	**3,280**	
	Total Station Count:	**3,533**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA24
Start Date: February 14, 2007
Station: S3
Tow Type: M

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Gibbonsia spp.	clinid kelpfishes	260	1,510.57
Atherinopsidae unid.	silversides	85	544.54
Atherinopsis californiensis	jacksmelt	80	427.95
Atherinops affinis	topsmelt	17	85.72
Gibbonsia spp.	clinid kelpfishes	5	32.65
larval fish fragment	unidentified larval fishes	5	32.54
Sardinops sagax	Pacific sardine	4	19.79
Clinidae unid.	kelp blennies	3	19.59
larvae, unidentified yolksac	unidentified yolksac larvae	2	9.78
larval fish - damaged	unidentified larval fishes	1	6.43
Citharichthys stigmaeus	speckled sanddab	1	4.42
	Total Entrainable Larval Fishes:	**463**	
Non-Entrainable Fishes			
Atherinopsis californiensis	jacksmelt	6	28.63
Atherinops affinis	topsmelt	3	15.14
Atherinopsidae unid.	silversides	1	6.53
	Total Non-Entrainable Fishes:	**10**	
Eggs			
fish eggs unid.	unidentified fish eggs	206	1,222.46
Sciaenidae unid. (eggs)	croaker eggs	143	761.35
Paralichthyidae unid. (eggs)	sand flounder eggs	13	66.27
Pleuronichthys spp. (eggs)	turbot eggs	3	16.20
Engraulidae unid. (eggs)	anchovy eggs	2	12.95
Citharichthys spp. (eggs)	sanddab eggs	1	5.36
	Total Eggs:	**368**	
	Total Station Count:	**841**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA26
Start Date: March 14, 2007
Station: O2
Tow Type: B

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	168	469.58
Genyonemus lineatus	white croaker	86	244.68
Gobiidae unid.	gobies	28	70.68
Gibbonsia spp.	clinid kelpfishes	4	11.09
larval fish - damaged	unidentified larval fishes	3	8.35
Sardinops sagax	Pacific sardine	1	3.24
Atherinopsidae unid.	silversides	1	2.40
Pleuronichthys spp.	turbots	1	2.40
Pleuronichthys guttulatus	diamond turbot	1	2.26
	Total Entrainable Larval Fishes:	**293**	
Eggs			
fish eggs unid.	unidentified fish eggs	99	465.58
Paralichthyidae unid. (eggs)	sand flounder eggs	89	348.68
Sciaenidae unid. (eggs)	croaker eggs	45	205.44
Engraulidae unid. (eggs)	anchovy eggs	40	182.52
Citharichthys spp. (eggs)	sanddab eggs	46	176.10
Pleuronichthys spp. (eggs)	turbot eggs	11	51.74
Sardinops sagax (eggs)	Pacific sardine eggs	4	14.85
Atherinopsidae unid. (eggs)	silverside eggs	1	4.80
	Total Eggs:	**335**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	4	11.95
Cancer anthonyi (megalops)	yellow crab megalops	2	5.09
	Total Invertebrates:	**6**	
	Total Station Count:	**634**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA26
Start Date: March 14, 2007
Station: O2
Tow Type: O

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	72	104.88
Genyonemus lineatus	white croaker	11	15.63
Sardinops sagax	Pacific sardine	5	7.58
Paralichthys californicus	California halibut	5	7.18
Pleuronichthys guttulatus	diamond turbot	5	7.16
larvae, unidentified yolksac	unidentified yolksac larvae	4	5.74
Pleuronichthys verticalis	hornyhead turbot	1	1.62
Atherinopsis californiensis	jacksmelt	1	1.58
Sciaenidae unid.	croakers	1	1.52
Typhlogobius californiensis	blind goby	1	1.52
Gobiidae unid.	gobies	1	1.42
Engraulidae unid.	anchovies	1	1.42
Atherinopsidae unid.	silversides	1	1.38
Stenobrachius leucopsarus	northern lampfish	1	1.35
	Total Entrainable Larval Fishes:	**110**	
Eggs			
fish eggs unid.	unidentified fish eggs	798	2,256.28
Paralichthyidae unid. (eggs)	sand flounder eggs	336	958.35
Citharichthys spp. (eggs)	sanddab eggs	155	434.31
Engraulidae unid. (eggs)	anchovy eggs	150	421.43
Sciaenidae unid. (eggs)	croaker eggs	135	385.04
Pleuronichthys spp. (eggs)	turbot eggs	13	38.15
Sardinops sagax (eggs)	Pacific sardine eggs	4	12.19
	Total Eggs:	**1,591**	
	Total Station Count:	**1,701**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA26
Start Date: March 14, 2007
Station: O2
Tow Type: M

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Leuresthes tenuis	California grunion	140	395.52
Atherinopsis californiensis	jacksmelt	52	151.45
Atherinopsidae unid.	silversides	48	135.35
Engraulis mordax	northern anchovy	20	60.07
Atherinops affinis	topsmelt	8	23.05
Paralichthys californicus	California halibut	6	18.44
Genyonemus lineatus	white croaker	4	11.95
Engraulidae unid.	anchovies	1	2.81
Sardinops sagax	Pacific sardine	1	2.81
Pleuronichthys guttulatus	diamond turbot	1	2.80
Citharichthys stigmaeus	speckled sanddab	1	2.75
larvae, unidentified yolksac	unidentified yolksac larvae	1	2.75
Pleuronichthys ritteri	spotted turbot	1	2.75
Sciaenidae unid.	croakers	1	2.75
	Total Entrainable Larval Fishes:	**285**	
Eggs			
fish eggs unid.	unidentified fish eggs	2,344	9,041.51
Paralichthyidae unid. (eggs)	sand flounder eggs	665	2,924.56
Engraulidae unid. (eggs)	anchovy eggs	305	1,630.07
Sciaenidae unid. (eggs)	croaker eggs	170	1,184.59
Citharichthys spp. (eggs)	sanddab eggs	187	903.85
Pleuronichthys spp. (eggs)	turbot eggs	58	262.54
Sardinops sagax (eggs)	Pacific sardine eggs	4	11.52
	Total Eggs:	**3,733**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	2.98
	Total Invertebrates:	**1**	
	Total Station Count:	**4,019**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA26
Start Date: March 14, 2007
Station: O3
Tow Type: B

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	737	2,036.05
Genyonemus lineatus	white croaker	217	600.20
Gobiidae unid.	gobies	172	479.69
Gibbonsia spp.	clinid kelpfishes	3	9.24
Pleuronichthys guttulatus	diamond turbot	4	7.76
Atherinopsidae unid.	silversides	2	4.90
larvae, unidentified yolksac	unidentified yolksac larvae	1	3.11
Leuresthes tenuis	California grunion	1	3.11
Heterostichus rostratus	giant kelpfish	1	3.07
Engraulidae unid.	anchovies	1	2.18
Pleuronichthys ritteri	spotted turbot	1	1.85
Sardinops sagax	Pacific sardine	1	1.83
	Total Entrainable Larval Fishes:	**1,141**	
Eggs			
fish eggs unid.	unidentified fish eggs	335	1,621.81
Engraulidae unid. (eggs)	anchovy eggs	75	360.57
Paralichthyidae unid. (eggs)	sand flounder eggs	28	149.71
Citharichthys spp. (eggs)	sanddab eggs	26	132.17
Pleuronichthys spp. (eggs)	turbot eggs	14	62.30
Sciaenidae unid. (eggs)	croaker eggs	6	26.73
Sardinops sagax (eggs)	Pacific sardine eggs	1	3.70
	Total Eggs:	**485**	
	Total Station Count:	**1,626**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA26
Start Date: March 14, 2007
Station: O3
Tow Type: O

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	62	95.58
Genyonemus lineatus	white croaker	12	17.23
Pleuronichthys guttulatus	diamond turbot	11	16.03
larvae, unidentified yolksac	unidentified yolksac larvae	4	5.62
Paralichthys californicus	California halibut	3	4.40
Sardinops sagax	Pacific sardine	3	4.38
Citharichthys stigmaeus	speckled sanddab	2	3.15
Engraulidae unid.	anchovies	2	2.90
Pleuronichthys spp.	turbots	1	1.59
Leuresthes tenuis	California grunion	1	1.55
Typhlogobius californiensis	blind goby	1	1.49
larval fish fragment	unidentified larval fishes	1	1.48
Pleuronichthys verticalis	hornyhead turbot	1	1.38
Atherinopsidae unid.	silversides	1	1.37
Clupeidae unid.	herrings	1	1.33
	Total Entrainable Larval Fishes:	**106**	
Eggs			
fish eggs unid.	unidentified fish eggs	807	2,286.44
Engraulidae unid. (eggs)	anchovy eggs	139	388.35
Paralichthyidae unid. (eggs)	sand flounder eggs	132	373.40
Citharichthys spp. (eggs)	sanddab eggs	110	311.40
Sciaenidae unid. (eggs)	croaker eggs	36	99.60
Pleuronichthys spp. (eggs)	turbot eggs	19	52.42
Sardinops sagax (eggs)	Pacific sardine eggs	1	2.70
	Total Eggs:	**1,244**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	1	1.59
Cancer productus (megalops)	red rock crab megalops	1	1.48
Cancer anthonyi (megalops)	yellow crab megalops	1	1.33
	Total Invertebrates:	**3**	
	Total Station Count:	**1,353**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA26
Start Date: March 14, 2007
Station: O3
Tow Type: M

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	80	232.14
Leuresthes tenuis	California grunion	47	137.06
Atherinopsidae unid.	silversides	29	84.04
Atherinopsis californiensis	jacksmelt	18	51.00
larvae, unidentified yolksac	unidentified yolksac larvae	5	14.18
Gobiidae unid.	gobies	3	8.39
Paralichthys californicus	California halibut	2	6.06
Genyonemus lineatus	white croaker	2	5.58
Pleuronichthys guttulatus	diamond turbot	2	5.58
Citharichthys stigmaeus	speckled sanddab	1	2.78
	Total Entrainable Larval Fishes:	**189**	
Non-Entrainable Fishes			
Syngnathus spp.	pipefishes	1	2.72
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	2,316	10,361.89
Engraulidae unid. (eggs)	anchovy eggs	291	1,530.05
Paralichthyidae unid. (eggs)	sand flounder eggs	285	961.50
Citharichthys spp. (eggs)	sanddab eggs	165	747.25
Pleuronichthys spp. (eggs)	turbot eggs	72	481.29
Sciaenidae unid. (eggs)	croaker eggs	95	400.39
Sciaen./Paralich./Labridae (eggs)	fish eggs	8	244.68
	Total Eggs:	**3,232**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	2	5.60
Cancer gracilis (megalops)	slender crab megalops	1	2.80
	Total Invertebrates:	**3**	
	Total Station Count:	**3,425**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m³)

Survey: SOEA26
Start Date: March 14, 2007
Station: S2
Tow Type: M

Taxon	Common Name	Count	Mean Concentration (#/1000m³)
Entrainable Larval Fishes			
Atherinopsis californiensis	jacksmelt	68	379.17
Atherinopsidae unid.	silversides	29	163.93
Engraulis mordax	northern anchovy	12	65.35
Leuresthes tenuis	California grunion	10	53.22
Genyonemus lineatus	white croaker	4	21.63
larval fish fragment	unidentified larval fishes	1	5.75
Pleuronectidae unid.	righteye flounders	1	5.75
Atherinops affinis	topsmelt	1	5.30
	Total Entrainable Larval Fishes:	**126**	
Non-Entrainable Fishes			
Atherinops affinis	topsmelt	2	10.59
	Total Non-Entrainable Fishes:	**2**	
Eggs			
fish eggs unid.	unidentified fish eggs	695	5,345.72
Paralichthyidae unid. (eggs)	sand flounder eggs	403	3,127.76
Engraulidae unid. (eggs)	anchovy eggs	193	1,181.56
Sciaenidae unid. (eggs)	croaker eggs	97	751.56
Citharichthys spp. (eggs)	sanddab eggs	86	478.95
Pleuronichthys spp. (eggs)	turbot eggs	5	28.61
Sardinops sagax (eggs)	Pacific sardine eggs	1	5.72
	Total Eggs:	**1,480**	
Invertebrates			
Cancer productus (megalops)	red rock crab megalops	1	5.72
	Total Invertebrates:	**1**	
	Total Station Count:	**1,609**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA26
Start Date: March 14, 2007
Station: S3
Tow Type: M

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Atherinopsis californiensis	jacksmelt	84	484.64
Engraulis mordax	northern anchovy	36	186.80
Atherinopsidae unid.	silversides	23	129.81
Leuresthes tenuis	California grunion	12	63.44
Atherinops affinis	topsmelt	4	22.58
Engraulidae unid.	anchovies	1	6.09
Genyonemus lineatus	white croaker	1	5.05
	Total Entrainable Larval Fishes:	**161**	
Non-Entrainable Fishes			
Atherinops affinis	topsmelt	1	5.05
	Total Non-Entrainable Fishes:	**1**	
Eggs			
fish eggs unid.	unidentified fish eggs	613	5,790.76
Engraulidae unid. (eggs)	anchovy eggs	483	4,574.32
Paralichthyidae unid. (eggs)	sand flounder eggs	183	1,507.37
Citharichthys spp. (eggs)	sanddab eggs	92	762.41
Sciaenidae unid. (eggs)	croaker eggs	65	485.69
Pleuronichthys spp. (eggs)	turbot eggs	7	88.07
	Total Eggs:	**1,443**	
	Total Station Count:	**1,605**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA29
Start Date: April 25, 2007
Station: O2
Tow Type: B

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulis mordax	northern anchovy	230	559.13
Engraulidae unid.	anchovies	47	147.41
Gobiidae unid.	gobies	7	20.94
Genyonemus lineatus	white croaker	7	18.35
Heterostichus rostratus	giant kelpfish	3	8.90
larval fish fragment	unidentified larval fishes	2	6.25
Paralichthys californicus	California halibut	2	5.59
Hypsoblennius spp.	combtooth blennies	2	5.34
larval fish - damaged	unidentified larval fishes	2	5.21
Peprilus simillimus	Pacific butterfish	1	2.34
Syngnathus spp.	pipefishes	1	2.28
Pleuronichthys guttulatus	diamond turbot	1	2.22
Typhlogobius californiensis	blind goby	1	2.22
	Total Entrainable Larval Fishes:	**306**	
Eggs			
fish eggs unid.	unidentified fish eggs	147	866.99
Paralichthyidae unid. (eggs)	sand flounder eggs	31	164.64
Engraulidae unid. (eggs)	anchovy eggs	28	159.03
Citharichthys spp. (eggs)	sanddab eggs	16	89.94
Pleuronichthys spp. (eggs)	turbot eggs	15	83.62
Sciaenidae unid. (eggs)	croaker eggs	13	72.65
	Total Eggs:	**250**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	3	8.58
Cancer antennarius (megalops)	brown rock crab megalops	2	5.18
Cancer gracilis (megalops)	slender crab megalops	1	3.00
Cancer spp. (megalops)	cancer crabs megalops	1	2.22
	Total Invertebrates:	**7**	
	Total Station Count:	**563**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA29
Start Date: April 25, 2007
Station: O2
Tow Type: O

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulidae unid.	anchovies	90	145.34
Paralichthys californicus	California halibut	9	13.84
Peprilus simillimus	Pacific butterfish	5	7.79
Hypsoblennius spp.	combtooth blennies	4	6.10
larvae, unidentified yolksac	unidentified yolksac larvae	3	5.29
Engraulis mordax	northern anchovy	2	3.28
Genyonemus lineatus	white croaker	2	3.19
Leuresthes tenuis	California grunion	2	3.08
Pleuronichthys guttulatus	diamond turbot	1	1.71
Typhlogobius californiensis	blind goby	1	1.71
Cottidae unid.	sculpins	1	1.55
larval fish fragment	unidentified larval fishes	1	1.51
Citharichthys sordidus	Pacific sanddab	1	1.48
Orthonopias triacis	snubnose sculpin	1	1.48
Citharichthys stigmaeus	speckled sanddab	1	1.46
Atherinopsidae unid.	silversides	1	1.44
	Total Entrainable Larval Fishes:	**125**	
Eggs			
fish eggs unid.	unidentified fish eggs	901	1,900.14
Paralichthyidae unid. (eggs)	sand flounder eggs	182	364.02
Engraulidae unid. (eggs)	anchovy eggs	106	259.75
Citharichthys spp. (eggs)	sanddab eggs	86	176.28
Sciaenidae unid. (eggs)	croaker eggs	69	135.75
Pleuronichthys spp. (eggs)	turbot eggs	41	85.21
	Total Eggs:	**1,385**	
Invertebrates			
Cancer antennarius (megalops)	brown rock crab megalops	1	1.46
	Total Invertebrates:	**1**	
	Total Station Count:	**1,511**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA29
Start Date: April 25, 2007
Station: O2
Tow Type: M

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Leuresthes tenuis	California grunion	158	515.98
Engraulidae unid.	anchovies	40	128.39
Atherinopsis californiensis	jacksmelt	27	86.93
Atherinopsidae unid.	silversides	19	61.20
Paralichthys californicus	California halibut	4	12.77
larvae, unidentified yolksac	unidentified yolksac larvae	2	6.74
Genyonemus lineatus	white croaker	2	6.51
Atherinops affinis	topsmelt	1	3.38
Gobiidae unid.	gobies	1	3.38
Pleuronectiformes unid.	flatfishes	1	3.38
Typhlogobius californiensis	blind goby	1	3.38
Hypsoblennius spp.	combtooth blennies	1	3.32
	Total Entrainable Larval Fishes:	**257**	
Eggs			
fish eggs unid.	unidentified fish eggs	2,019	22,757.72
Pleuronichthys spp. (eggs)	turbot eggs	247	6,236.99
Engraulidae unid. (eggs)	anchovy eggs	327	1,443.86
Paralichthyidae unid. (eggs)	sand flounder eggs	320	1,342.46
Sciaenidae unid. (eggs)	croaker eggs	90	778.79
Citharichthys spp. (eggs)	sanddab eggs	71	256.79
Sardinops sagax (eggs)	Pacific sardine eggs	2	6.24
Labridae unid. (eggs)	wrasse eggs	1	3.32
	Total Eggs:	**3,077**	
Invertebrates			
Cancer gracilis (megalops)	slender crab megalops	2	6.75
Cancer anthonyi (megalops)	yellow crab megalops	1	3.13
	Total Invertebrates:	**3**	
	Total Station Count:	**3,337**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA29
Start Date: April 25, 2007
Station: O3
Tow Type: B

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Gobiidae unid.	gobies	101	261.35
Engraulis mordax	northern anchovy	67	173.82
Genyonemus lineatus	white croaker	25	64.38
Engraulidae unid.	anchovies	23	57.41
Stenobrachius leucopsarus	northern lampfish	2	4.89
Paralichthyidae unid.	sand flounders	1	2.63
Pleuronectidae unid.	righteye flounders	1	2.63
Gillichthys mirabilis	longjaw mudsucker	1	2.27
Hypsoblennius spp.	combtooth blennies	1	2.27
Typhlogobius californiensis	blind goby	1	2.27
Gobiesox spp.	clingfishes	1	2.26
Paralichthys californicus	California halibut	1	2.25
Pleuronichthys guttulatus	diamond turbot	1	2.25
Pleuronichthys verticalis	hornyhead turbot	1	2.25
	Total Entrainable Larval Fishes:	**227**	
Eggs			
fish eggs unid.	unidentified fish eggs	238	1,096.46
Paralichthyidae unid. (eggs)	sand flounder eggs	27	128.85
Pleuronichthys spp. (eggs)	turbot eggs	18	87.30
Engraulidae unid. (eggs)	anchovy eggs	12	59.11
Citharichthys spp. (eggs)	sanddab eggs	11	50.56
Sciaenidae unid. (eggs)	croaker eggs	7	36.57
	Total Eggs:	**313**	
Invertebrates			
Cancer antennarius (megalops)	brown rock crab megalops	1	2.63
Cancer anthonyi (megalops)	yellow crab megalops	1	2.59
	Total Invertebrates:	**2**	
	Total Station Count:	**542**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA29
Start Date: April 25, 2007
Station: O3
Tow Type: O

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Engraulidae unid.	anchovies	37	49.98
Genyonemus lineatus	white croaker	7	9.36
Engraulis mordax	northern anchovy	5	6.96
Gobiidae unid.	gobies	4	5.28
larvae, unidentified yolksac	unidentified yolksac larvae	3	4.40
Paralichthys californicus	California halibut	3	3.86
Pleuronichthys verticalis	hornyhead turbot	2	2.84
Atherinopsidae unid.	silversides	2	2.75
Paralichthyidae unid.	sand flounders	1	1.41
Hypsoblennius spp.	combtooth blennies	1	1.37
Lyopsetta exilis	slender sole	1	1.37
larval fish - damaged	unidentified larval fishes	1	1.30
Atherinopsis californiensis	jacksmelt	1	1.27
Gibbonsia spp.	clinid kelpfishes	1	1.21
Peprilus simillimus	Pacific butterfish	1	1.16
	Total Entrainable Larval Fishes:	**70**	
Eggs			
fish eggs unid.	unidentified fish eggs	1,014	1,742.01
Paralichthyidae unid. (eggs)	sand flounder eggs	422	712.54
Engraulidae unid. (eggs)	anchovy eggs	163	279.08
Citharichthys spp. (eggs)	sanddab eggs	116	207.44
Sciaenidae unid. (eggs)	croaker eggs	85	146.60
Pleuronichthys spp. (eggs)	turbot eggs	62	108.02
Carangidae (eggs)	jack eggs	1	1.90
	Total Eggs:	**1,863**	
Invertebrates			
Cancer anthonyi (megalops)	yellow crab megalops	1	1.15
	Total Invertebrates:	**1**	
	Total Station Count:	**1,934**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA29
Start Date: April 25, 2007
Station: O3
Tow Type: M

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Leuresthes tenuis	California grunion	83	259.02
Atherinopsidae unid.	silversides	65	198.61
Atherinopsis californiensis	jacksmelt	34	106.53
Engraulidae unid.	anchovies	14	45.08
Engraulis mordax	northern anchovy	5	17.30
Gobiidae unid.	gobies	4	13.73
larvae, unidentified yolksac	unidentified yolksac larvae	2	6.65
Gibbonsia spp.	clinid kelpfishes	2	5.93
Paralichthyidae unid.	sand flounders	2	5.48
Genyonemus lineatus	white croaker	1	3.56
larval fish - damaged	unidentified larval fishes	1	3.08
larval fish fragment	unidentified larval fishes	1	3.08
Paralichthys californicus	California halibut	1	3.08
Citharichthys stigmaeus	speckled sanddab	1	3.05
	Total Entrainable Larval Fishes:	**216**	
Non-Entrainable Fishes			
Atherinopsis californiensis	jacksmelt	5	16.27
	Total Non-Entrainable Fishes:	**5**	
Eggs			
fish eggs unid.	unidentified fish eggs	1,576	13,462.39
Engraulidae unid. (eggs)	anchovy eggs	897	3,381.78
Paralichthyidae unid. (eggs)	sand flounder eggs	633	2,662.99
Citharichthys spp. (eggs)	sanddab eggs	107	490.46
Sciaenidae unid. (eggs)	croaker eggs	90	443.17
Pleuronichthys spp. (eggs)	turbot eggs	61	374.31
Labridae unid. (eggs)	wrasse eggs	5	15.08
Sardinops sagax (eggs)	Pacific sardine eggs	3	9.70
	Total Eggs:	**3,372**	
Invertebrates			
Cancer antennarius (megalops)	brown rock crab megalops	3	9.66
	Total Invertebrates:	**3**	
	Total Station Count:	**3,596**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA29
Start Date: April 25, 2007
Station: S2
Tow Type: M

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Leuresthes tenuis	California grunion	218	1,378.32
Atherinopsidae unid.	silversides	147	890.48
Atherinopsis californiensis	jacksmelt	53	330.36
Engraulidae unid.	anchovies	6	38.98
Atherinops affinis	topsmelt	6	36.32
Gibbonsia spp.	clinid kelpfishes	2	12.99
Stenobrachius leucopsarus	northern lampfish	1	6.70
Genyonemus lineatus	white croaker	1	6.05
larval fish - damaged	unidentified larval fishes	1	6.05
Typhlogobius californiensis	blind goby	1	6.05
	Total Entrainable Larval Fishes:	**436**	
Eggs			
fish eggs unid.	unidentified fish eggs	778	26,979.07
Pleuronichthys spp. (eggs)	turbot eggs	118	6,249.82
Engraulidae unid. (eggs)	anchovy eggs	188	1,376.04
Paralichthyidae unid. (eggs)	sand flounder eggs	92	1,080.11
Sciaenidae unid. (eggs)	croaker eggs	24	395.79
Citharichthys spp. (eggs)	sanddab eggs	21	196.09
	Total Eggs:	**1,221**	
	Total Station Count:	**1,657**	

SONGS Source Water Abundance Count and Mean Concentration (#/1000m^3)

Survey: SOEA29
Start Date: April 25, 2007
Station: S3
Tow Type: M

Taxon	Common Name	Count	Mean Concentration (#/1000m^3)
Entrainable Larval Fishes			
Leuresthes tenuis	California grunion	372	2,458.78
Atherinopsidae unid.	silversides	102	684.92
Atherinopsis californiensis	jacksmelt	57	378.29
Pleuronectiformes unid.	flatfishes	2	14.27
Gibbonsia spp.	clinid kelpfishes	1	7.14
Engraulidae unid.	anchovies	1	6.10
	Total Entrainable Larval Fishes:	**535**	
Eggs			
fish eggs unid.	unidentified fish eggs	1,108	14,020.15
Engraulidae unid. (eggs)	anchovy eggs	319	5,209.36
Paralichthyidae unid. (eggs)	sand flounder eggs	321	3,555.48
Sciaenidae unid. (eggs)	croaker eggs	60	811.12
Citharichthys spp. (eggs)	sanddab eggs	46	602.41
Pleuronichthys spp. (eggs)	turbot eggs	22	372.97
Labridae unid. (eggs)	wrasse eggs	5	35.68
	Total Eggs:	**1,881**	
Invertebrates			
Cancer productus (megalops)	red rock crab megalops	1	6.10
	Total Invertebrates:	**1**	
	Total Station Count:	**2,417**	

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San Onofre Nuclear Generating Station

Appendix C

Impingement and Fish Return Data

C1. Normal Operation Fish and Invertebrate Data

C2. Fish Return System Fish and Invertebrate Data

C3. Heat Treatment Fish and Invertebrate Data

C4. Fish Chase Fish and Invertebrate Data

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Survey Type: Normal Operations
Survey: SONGSNO01
Date: March 21, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	2	0.006
		Citharichthys stigmaeus	speckled sanddab	3	0.053
		Engraulis mordax	northern anchovy	32	0.063
		Hypsoblennius gilberti	rockpool blenny	2	0.015
		Ophidion scrippsae	basketweave cusk-eel	1	0.035
		Peprilus simillimus	Pacific pompano	6	0.104
		Phanerodon furcatus	white seaperch	3	0.141
		Scorpaenichthys marmoratus	cabezon	2	0.003
		Seriphus politus	queenfish	50	0.495
		Syngnathus californiensis	kelp pipefish	13	0.016
		Synodus lucioceps	California lizardfish	8	0.077
		Xenistius californiensis	Salema	2	0.031
				124	1.039
2	Fish eggs	Atherinopsidae	Atherinopsid eggs		0.001
					0.001
2	Invertebrate	*Blepharipoda occidentalis*	Spiny mole crab	1	0.002
		Cancer anthonyi	Yellow crab	39	0.073
		Cancer productus	red rock crab	2	0.008
		Caudina arenicola	Sweet potatoe sea cucumber	1	0.066
		Cnidaria sp	sea jelly unid	1	0.024
		Crangon nigromaculata	Blackspotted bay shrimp	23	0.078
		Farfantepenaeus californiensis	Yellowleg shrimp	2	0.054
		Heptacarpus sp	Coastal shrimp unk	3	0.003
		Loligo opalescens	California market squid	1	0.014
		Lysmata californica	red rock shrimp	3	0.003
		Pachygrapsus crassipes	Striped shore crab	1	0.002
		Panulirus interruptus	California spiny lobster	1	0.214
		Portunus xantusii	Xantus swimming crab	27	0.052
				105	0.593

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Survey Type: Normal Operations
Survey: SONGSNO01 (continued)
Date: March 21, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	2	0.010
		Citharichthys stigmaeus	speckled sanddab	1	0.011
		Embiotoca jacksoni	black perch	1	0.004
		Engraulis mordax	northern anchovy	82	0.092
		Hypsoblennius jenkinsi	mussel blenny	2	0.017
		Myliobatis californica	bat ray	1	0.411
		Peprilus simillimus	Pacific pompano	6	0.099
		Pleuronichthys verticalis	hornyhead turbot	1	0.077
		Scorpaena guttata	California scorpionfish	2	0.093
		Seriphus politus	queenfish	18	0.442
		Syngnathus californiensis	kelp pipefish	8	0.011
		Synodus lucioceps	California lizardfish	30	0.273
		Torpedo californica	Pacific electric ray	1	7.700
		Xenistius californiensis	salema	2	0.038
				157	9.278
3	Invertebrate	*Blepharipoda occidentalis*	spiny mole crab	1	0.002
		Cancer anthonyi	yellow crab	4	0.006
		Caudina arenicola	sweet potatoe sea cucumber	2	0.238
		Crangon nigromaculata	blackspotted bay shrimp	11	0.038
		Farfantepenaeus californiensis	yellowleg shrimp	2	0.040
		Heptacarpus sp	coastal shrimp unk	1	0.001
		Loligo opalescens	California market squid	1	0.017
		Lophopanopeus frontalis	molarless crestleg crab	1	0.003
		Lophopanopeus leucomanus	knobkneed crestleg crab	1	0.004
		Neotrypaea gigas	giant ghost shrimp	1	0.007
		Panulirus interruptus	California spiny lobster	2	0.816
		Petrolisthes cabrilloi	Cabrillo porcelain crab	1	0.003
		Pilumnus spinohirsutus	retiring hairy crab	2	0.005
		Portunus xantusii	Xantus swimming crab	24	0.060
				54	1.240

Survey Type: Normal Operations
Survey: SONGSNO02
Date: April 4, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinopsis californiensis*	jacksmelt	5	0.210
		Embiotoca jacksoni	black perch	7	0.028
		Engraulis mordax	northern anchovy	8	0.039
		Genyonemus lineatus	white croaker	3	0.011
		Hypsoblennius gilberti	rockpool blenny	1	0.012
		Myliobatis californica	bat ray	1	0.198
		Peprilus simillimus	Pacific pompano	2	0.044
		Pleuronichthys ritteri	spotted turbot	2	0.013
		Seriphus politus	queenfish	120	1.565
		Syngnathus sp	pipefish unid.	16	0.022
		Synodus lucioceps	California lizardfish	17	0.185
				182	2.327
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	12	0.074
		Cancer anthonyi	yellow crab	3	0.011
		Cancer gracilis	graceful crab	1	0.009
		Chrysaora colorata	purple-striped jellyfish	1	0.484
		Crangon nigromaculata	blackspotted bay shrimp	18	0.073
		Dendraster excentricus	Pacific sand dollar	11	0.052
		Loligo opalescens	California market squid	1	0.021
		Panulirus interruptus	California spiny lobster	2	0.572
		Portunus xantusii	Xantus swimming crab	75	0.410
		Pugettia producta	northern kelp crab	1	0.005
				125	1.711

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Survey Type: Normal Operations
Survey: SONGSNO02 (continued)
Date: April 4, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinops affinis*	topsmelt	1	0.025
		Atherinopsis californiensis	jacksmelt	46	2.794
		Embiotoca jacksoni	black perch	3	0.010
		Engraulis mordax	northern anchovy	22	0.110
		Genyonemus lineatus	white croaker	5	0.281
		Heterostichus rostratus	giant kelpfish	1	0.016
		Hypsoblennius gilberti	rockpool blenny	3	0.014
		Leuresthes tenuis	California grunion	1	0.017
		Myliobatis californica	bat ray	4	1.333
		Peprilus simillimus	Pacific pompano	43	0.828
		Pleuronichthys ritteri	spotted turbot	1	0.003
		Pleuronichthys verticalis	hornyhead turbot	1	0.046
		Porichthys myriaster	specklefin midshipman	1	0.488
		Porichthys notatus	plainfin midshipman	1	0.021
		Scomber japonicus	Pacific chub mackerel	1	0.069
		Scorpaena guttata	California scorpionfish	2	0.211
		Scorpaenichthys marmoratus	Cabezon	1	0.003
		Seriphus politus	queenfish	292	4.366
		Syngnathus californiensis	kelp pipefish	19	0.024
		Synodus lucioceps	California lizardfish	22	0.295
				470	10.954
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	5	0.015
		Cancer anthonyi	yellow crab	6	0.044
		Caudina arenicola	sweet potatoe sea cucumber	1	0.054
		Chrysaora colorata	purple-striped jellyfish	2	1.396
		Crangon nigromaculata	blackspotted bay shrimp	18	0.077
		Dendraster excentricus	Pacific sand dollar	1	0.010
		Heptacarpus sp	coastal shrimp unk	1	0.002
		Loxorhynchus grandis	sheep crab	1	1.069
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.246
		Panulirus interruptus	California spiny lobster	1	0.209
		Portunus xantusii	Xantus swimming crab	20	0.068
		Pugettia producta	northern kelp crab	1	0.007
				58	3.197

Survey Type: Normal Operations
Survey: SONGSNO03
Date: April 18, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Cymatogaster aggregata*	shiner perch	1	0.029
		Embiotoca jacksoni	black perch	4	0.015
		Engraulis mordax	northern anchovy	12	0.062
		Hypsoblennius gilberti	rockpool blenny	4	0.023
		Peprilus simillimus	Pacific pompano	15	0.313
		Phanerodon furcatus	white seaperch	3	0.118
		Pleuronichthys verticalis	hornyhead turbot	1	0.036
		Porichthys notatus	plainfin midshipman	2	0.145
		Seriphus politus	queenfish	224	4.211
		Synodus lucioceps	California lizardfish	10	0.081
				276	5.033
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	78	0.062
		Cancer anthonyi	yellow crab	4	0.046
		Cancer productus	red rock crab	1	0.001
		Caudina arenicola	sweet potatoe sea cucumber	1	0.005
		Crangon nigromaculata	blackspotted bay shrimp	293	0.505
		Heptacarpus palpator	intertidal coastal shrimp	9	0.012
		Hermissenda crassicornis	hermissenda	6	0.002
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.002
		Lysmata californica	red rock shrimp	2	0.002
		Neotrypaea gigas	giant ghost shrimp	1	0.001
		Portunus xantusii	Xantus swimming crab	27	0.187
		Pyromaia tuberculata	tuberculate pear crab	2	0.002
		Thetys vagina	common salp	1	0.001
				426	0.828
3	Fish	*Engraulis mordax*	northern anchovy	2	0.006
		Hypsoblennius jenkinsi	mussel blenny	1	0.003
		Pleuronichthys ritteri	spotted turbot	1	0.029
		Scorpaena guttata	California scorpionfish	1	0.048
		Seriphus politus	queenfish	18	0.361
		Syngnathus californiensis	kelp pipefish	3	0.022
				526	0.469
3	Fish eggs	Atherinopsidae	atherinopsid eggs	500	0.030
					0.030
3	Invertebrate	*Blepharipoda occidentalis*	spiny mole crab	1	0.008
		Cancer antennarius	Pacific rock crab	5	0.006
		Caudina arenicola	sweet potatoe sea cucumber	1	0.006
		Crangon nigromaculata	blackspotted bay shrimp	25	0.071
		Heptacarpus sp	coastal shrimp unk	1	0.002
		Neotrypaea gigas	giant ghost shrimp	2	0.006
		Pachycheles holosericus	sponge porcelain crab	1	0.002
		Portunus xantusii	Xantus swimming crab	8	0.026
		Scyra acutifrons	sharpnose crab	2	0.014
				46	0.141

Survey Type: Normal Operations
Survey: SONGSNO04
Date: May 2, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinopsis californiensis*	jacksmelt	2	0.154
		Embiotoca jacksoni	black perch	1	0.007
		Engraulis mordax	northern anchovy	2	0.012
		Genyonemus lineatus	white croaker	1	0.018
		Myliobatis californica	bat ray	1	0.304
		Phanerodon furcatus	white seaperch	1	0.003
		Porichthys notatus	plainfin midshipman	4	0.150
		Seriphus politus	queenfish	2	0.017
				14	0.665
3	Fish eggs	Atherinopsidae	atherinopsid eggs		0.022
					0.022
3	Invertebrate	*Blepharipoda occidentalis*	spiny mole crab	1	0.034
		Cancer antennarius	Pacific rock crab	13	0.260
		Caudina arenicola	sweet potatoe sea cucumber	1	0.011
		Crangon nigromaculata	blackspotted bay shrimp	4	0.016
		Heptacarpus palpator	intertidal coastal shrimp	1	0.001
		Heptacarpus sp	coastal shrimp unk	1	0.001
		Lysmata californica	red rock shrimp	1	0.001
		Pachygrapsus crassipes	striped shore crab	2	0.019
		Panulirus interruptus	California spiny lobster	2	0.503
		Pinnixa sp	pea crab unid	1	0.001
		Portunus xantusii	Xantus swimming crab	3	0.033
		Pugettia producta	northern kelp crab	2	0.037
				32	0.917

Survey Type: Normal Operations
Survey: SONGSNO05
Date: May 16, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	10	0.315
		Atherinopsis californiensis	jacksmelt	2	0.187
		Cymatogaster aggregata	shiner perch	2	0.007
		Embiotoca jacksoni	black perch	16	0.081
		Engraulis mordax	northern anchovy	32	0.486
		Gymnura marmorata	California butterfly ray	1	1.008
		Hyperprosopon argenteum	walleye surfperch	1	0.004
		Hypsoblennius gilberti	rockpool blenny	1	0.020
		Myliobatis californica	bat ray	3	1.205
		Peprilus simillimus	Pacific pompano	21	0.523
		Phanerodon furcatus	white seaperch	8	0.019
		Porichthys myriaster	specklefin midshipman	1	0.006
		Porichthys notatus	plainfin midshipman	30	0.724
		Sardinops sagax	Pacific sardine	7	0.226
		Scomber japonicus	Pacific chub mackerel	4	0.319
		Seriphus politus	queenfish	350	9.339
		Syngnathus californiensis	kelp pipefish	4	0.010
		Synodus lucioceps	California lizardfish	2	0.022
		Xenistius californiensis	salema	2	0.058
				497	14.559
2	Fish Eggs	Atherinopsidae	atherinopsid eggs		0.395
					0.395
2	Invertebrate	*Cancer anthonyi*	yellow crab	1	0.016
		Cancer gracilis	graceful crab	1	0.001
		Cancer jordani	hairy rock crab	9	0.171
		Caudina arenicola	sweet potatoe sea cucumber	6	0.092
		Chrysaora colorata	purple-striped jellyfish	1	0.434
		Crangon nigromaculata	blackspotted bay shrimp	9	0.045
		Farfantepenaeus californiensis	yellowleg shrimp	9	0.300
		Panulirus interruptus	California spiny lobster	4	1.030
		Portunus xantusii	Xantus swimming crab	17	0.126
				57	2.215

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Survey Type: Normal Operations
Survey: SONGSNO05 (continued)
Date: May 16, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinops affinis*	topsmelt	35	1.205
		Atherinopsis californiensis	jacksmelt	4	0.456
		Cymatogaster aggregata	shiner perch	1	0.003
		Embiotoca jacksoni	black perch	2	0.009
		Engraulis mordax	northern anchovy	60	0.784
		Heterostichus rostratus	giant kelpfish	1	0.005
		Hypsoblennius gilberti	rockpool blenny	1	0.009
		Myliobatis californica	bat ray	1	0.246
		Ophidion scrippsae	basketweave cusk-eel	1	0.013
		Peprilus simillimus	Pacific pompano	12	0.489
		Phanerodon furcatus	white seaperch	17	0.391
		Pleuronichthys ritteri	spotted turbot	1	0.011
		Pleuronichthys verticalis	hornyhead turbot	3	0.140
		Porichthys myriaster	specklefin midshipman	3	1.076
		Porichthys notatus	plainfin midshipman	35	1.109
		Sardinops sagax	Pacific sardine	14	0.501
		Scomber japonicus	Pacific chub mackerel	6	0.504
		Scorpaena guttata	California scorpionfish	1	0.034
		Seriphus politus	queenfish	177	3.704
		Syngnathus californiensis	kelp pipefish	3	0.003
		Synodus lucioceps	California lizardfish	7	0.098
		Trachurus symmetricus	jack mackerel	1	0.057
		Xenistius californiensis	salema	1	0.064
		Xystreurys liolepis	fantail sole	1	0.073
				388	10.984
3	Invertebrate	*Aplysia californica*	California seahare	1	0.045
		Blepharipoda occidentalis	spiny mole crab	1	0.002
		Cancer anthonyi	yellow crab	1	0.087
		Cancer gracilis	graceful crab	1	0.001
		Cancer jordani	hairy rock crab	7	0.007
		Caudina arenicola	sweet potatoe sea cucumber	10	0.187
		Crangon nigromaculata	blackspotted bay shrimp	34	0.094
		Dirona picta	spotted dirona	1	0.006
		Farfantepenaeus californiensis	yellowleg shrimp	13	0.334
		Loligo opalescens	California market squid	1	0.017
		Lophopanopeus bellus	blackclaw crestleg crab	2	0.008
		Loxorhynchus grandis	sheep crab	1	0.736
		Octopus rubescens	East Pacific red octopus	1	0.001
		Pachycheles holosericus	sponge porcelain crab	1	0.004
		Pilumnus spinohirsutus	retiring hairy crab	1	0.018
		Polyorchis penicillatus	red jellyfish	1	0.003
		Portunus xantusii	Xantus swimming crab	19	0.094
				96	1.644

Survey Type: Normal Operations
Survey: SONGSNO06
Date: May 30, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	11	0.354
		Atherinopsis californiensis	jacksmelt	1	0.076
		Citharichthys stigmaeus	speckled sanddab	4	0.014
		Cymatogaster aggregata	shiner perch	62	0.293
		Embiotoca jacksoni	black perch	7	0.034
		Engraulis mordax	northern anchovy	118	0.468
		Genyonemus lineatus	white croaker	13	0.035
		Gymnura marmorata	California butterfly ray	1	0.183
		Heterodontus francisci	horn shark	1	1.024
		Hyperprosopon argenteum	walleye surfperch	1	0.002
		Hypsoblennius gilberti	rockpool blenny	4	0.020
		Ophidion scrippsae	basketweave cusk-eel	1	0.022
		Peprilus simillimus	Pacific pompano	121	2.666
		Phanerodon furcatus	white seaperch	439	1.128
		Porichthys myriaster	specklefin midshipman	6	0.115
		Porichthys notatus	plainfin midshipman	3	0.077
		Rhacochilus toxotes	rubberlip seaperch	2	0.021
		Sardinops sagax	Pacific sardine	744	24.617
		Scorpaena guttata	California scorpionfish	3	0.106
		Seriphus politus	queenfish	76	1.786
		Squalus acanthias	spiny dogfish	1	2.200
		Syngnathus californiensis	kelp pipefish	6	0.023
				1,625	35.264
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	9	0.050
		Caudina arenicola	sweet potatoe sea cucumber	20	0.195
		Chrysaora colorata	purple-striped jellyfish	2	1.063
		Crangon nigromaculata	blackspotted bay shrimp	97	0.387
		Dendraster excentricus	Pacific sand dollar	111	0.362
		Dendronotus iris	giant-frond-aeolis	3	0.006
		Elthusa vulgaris	sea louse	1	0.001
		Farfantepenaeus californiensis	yellowleg shrimp	1	0.030
		Heptacarpus sp	coastal shrimp unk	4	0.004
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.006
		Lysmata californica	red rock shrimp	2	0.002
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.036
		Octopus rubescens	East Pacific red octopus	1	0.004
		Ogyrides spa	longeye shrimp unid A	1	0.001
		Pachygrapsus crassipes	striped shore crab	2	0.006
		Panulirus interruptus	California spiny lobster	4	1.119
		Pilumnus spinohirsutus	retiring hairy crab	1	0.016
		Pinnixa sp	pea crab unid	1	0.003
		Portunus xantusii	Xantus swimming crab	52	0.555
		Pyromaia tuberculata	tuberculate pear crab	1	0.005
		Taliepus nuttallii	globose kelp crab	1	0.071
				316	3.922

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Survey Type: Normal Operations
Survey: SONGSNO06 (continued)
Date: May 30, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinops affinis*	topsmelt	2	0.032
		Citharichthys stigmaeus	speckled sanddab	5	0.014
		Cymatogaster aggregata	shiner perch	35	0.072
		Embiotoca jacksoni	black perch	7	0.032
		Engraulis mordax	northern anchovy	104	0.641
		Genyonemus lineatus	white croaker	12	0.016
		Hyperprosopon argenteum	walleye surfperch	2	0.007
		Hypsoblennius gilberti	rockpool blenny	3	0.018
		Leuresthes tenuis	California grunion	1	0.015
		Myliobatis californica	bat ray	1	0.316
		Paralichthys californicus	California halibut	1	0.250
		Peprilus simillimus	Pacific pompano	12	0.224
		Phanerodon furcatus	white seaperch	271	0.771
		Platyrhinoidis triseriata	thornback	1	0.023
		Pleuronichthys ritteri	spotted turbot	2	0.016
		Porichthys myriaster	specklefin midshipman	19	0.346
		Porichthys notatus	plainfin midshipman	1	0.023
		Sardinops sagax	Pacific sardine	685	22.845
		Scomber japonicus	Pacific chub mackerel	2	0.144
		Seriphus politus	queenfish	55	1.283
		Syngnathus californiensis	kelp pipefish	3	0.009
		Synodus lucioceps	California lizardfish	1	0.016
				1,225	27.113
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	5	0.051
		Crangon nigromaculata	blackspotted bay shrimp	80	0.282
		Dendraster excentricus	Pacific sand dollar	70	0.220
		Dendronotus iris	giant-frond-aeolis	1	0.002
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.003
		Panulirus interruptus	California spiny lobster	2	0.535
		Pinnixa barnharti	pea crab no common name	1	0.003
		Portunus xantusii	Xantus swimming crab	74	0.834
		Synalpheus lockingtoni	littoral pistol shrimp	1	0.001
				235	1.931

Survey Type: Normal Operations
Survey: SONGSNO07
Date: June 13, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	12	0.300
		Cymatogaster aggregata	shiner perch	91	0.364
		Embiotoca jacksoni	black perch	1	0.002
		Engraulis mordax	northern anchovy	1,121	0.777
		Genyonemus lineatus	white croaker	212	0.809
		Gymnura marmorata	California butterfly ray	1	0.167
		Hyperprosopon argenteum	walleye surfperch	9	0.048
		Micrometrus minimus	dwarf perch	9	0.015
		Oxyjulis californica	senorita	3	0.148
		Peprilus simillimus	Pacific pompano	3	0.055
		Phanerodon furcatus	white seaperch	267	0.422
		Pleuronichthys ritteri	spotted turbot	3	0.070
		Pleuronichthys verticalis	hornyhead turbot	9	0.521
		Porichthys myriaster	specklefin midshipman	2	0.033
		Porichthys notatus	plainfin midshipman	2	0.052
		Sardinops sagax	Pacific sardine	24	0.422
		Seriphus politus	queenfish	94	2.076
		Syngnathus californiensis	kelp pipefish	3	0.009
				1,866	6.290
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	3	0.106
		Cancer anthonyi	yellow crab	9	0.003
		Cancer gracilis	graceful crab	3	0.003
		Crangon nigromaculata	blackspotted bay shrimp	55	0.170
		Dendraster excentricus	Pacific sand dollar	30	0.088
		Farfantepenaeus californiensis	yellowleg shrimp	6	0.252
		Octopus bimaculatus/bimaculoides	California two-spot octopus	3	0.291
		Panulirus interruptus	California spiny lobster	3	0.539
		Portunus xantusii	Xantus swimming crab	24	0.170
		Pyromaia tuberculata	tuberculate pear crab	3	0.003
				139	1.625

Survey Type: Normal Operations
Survey: SONGSNO08
Date: June 27, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	67	1.101
		Cymatogaster aggregata	shiner perch	66	0.285
		Embiotoca jacksoni	black perch	5	0.008
		Engraulis mordax	northern anchovy	12,152	2.440
		Genyonemus lineatus	white croaker	69	0.241
		Heterostichus rostratus	giant kelpfish	1	0.003
		Leptocottus armatus	Pacific staghorn sculpin	1	0.012
		Ophichthus zophochir	yellow snake eel	1	0.185
		Phanerodon furcatus	white seaperch	111	0.366
		Platyrhinoidis triseriata	thornback	1	0.400
		Pleuronichthys ritteri	spotted turbot	1	0.027
		Porichthys myriaster	specklefin midshipman	13	0.776
		Porichthys notatus	plainfin midshipman	1	0.023
		Sardinops sagax	Pacific sardine	912	2.232
		Scorpaena guttata	California scorpionfish	1	0.029
		Seriphus politus	queenfish	153	4.499
		Sphyraena argentea	Pacific barracuda	20	0.016
		Trachurus symmetricus	jack mackerel	10	0.124
		Xenistius californiensis	salema	1	0.072
				13,586	12.839
2	Invertebrate	*Blepharipoda occidentalis*	spiny mole crab	1	0.023
		Cancer anthonyi	yellow crab	14	0.028
		Crangon nigromaculata	blackspotted bay shrimp	25	0.082
		Dendraster excentricus	Pacific sand dollar	13	0.028
		Lysmata californica	red rock shrimp	1	0.001
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.074
		Panulirus interruptus	California spiny lobster	2	0.276
		Portunus xantusii	Xantus swimming crab	5	0.067
		Pugettia producta	northern kelp crab	2	0.001
		Pyromaia tuberculata	tuberculate pear crab	2	0.001
				66	0.581

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Survey Type: Normal Operations
Survey: SONGSNO08 (continued)
Date: June 27, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinops affinis*	topsmelt	100	2.618
		Cymatogaster aggregata	shiner perch	108	0.483
		Embiotoca jacksoni	black perch	3	0.013
		Engraulis mordax	northern anchovy	3,800	2.350
		Genyonemus lineatus	white croaker	45	0.188
		Myliobatis californica	bat ray	3	1.265
		Peprilus simillimus	Pacific pompano	3	0.113
		Phanerodon furcatus	white seaperch	180	0.610
		Porichthys myriaster	specklefin midshipman	3	1.338
		Rhacochilus toxotes	rubberlip seaperch	8	0.075
		Sardinops sagax	Pacific sardine	4,160	7.000
		Scomber japonicus	Pacific chub mackerel	3	0.228
		Scorpaena guttata	California scorpionfish	3	0.233
		Seriphus politus	queenfish	150	3.825
		Sphyraena argentea	Pacific barracuda	5	0.005
		Syngnathus californiensis	kelp pipefish	13	0.025
		Synodus lucioceps	California lizardfish	3	0.183
		Trachurus symmetricus	jack mackerel	18	0.315
				8,608	20.867
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	3	0.003
		Cancer anthonyi	yellow crab	3	0.003
		Caudina arenicola	sweet potatoe sea cucumber	3	0.118
		Crangon nigromaculata	blackspotted bay shrimp	3	0.008
		Dendraster excentricus	Pacific sand dollar	8	0.040
				20	0.172

Survey Type: Normal Operations
Survey: SONGSNO09
Date: July 11, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	3	0.106
		Cymatogaster aggregata	shiner perch	6	0.019
		Engraulis mordax	northern anchovy	44	0.126
		Genyonemus lineatus	white croaker	9	0.031
		Phanerodon furcatus	white seaperch	3	0.007
		Rhacochilus toxotes	rubberlip seaperch	1	0.010
		Seriphus politus	queenfish	7	0.266
		Sphyraena argentea	Pacific barracuda	1	0.003
				74	0.568
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	10	0.209
		Cancer anthonyi	yellow crab	41	0.181
		Caudina arenicola	sweet potatoe sea cucumber	1	0.015
		Crangon nigromaculata	blackspotted bay shrimp	3	0.004
		Dendraster excentricus	Pacific sand dollar	32	0.128
		Lysmata californica	red rock shrimp	1	0.001
		Panulirus interruptus	California spiny lobster	7	2.091
		Portunus xantusii	Xantus swimming crab	3	0.042
		Pugettia producta	northern kelp crab	1	0.003
		Roperia poulsoni	no common name	1	0.007
				100	2.681

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Survey Type: Normal Operations
Survey: SONGSNO09 (continued)
Date: July 11, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinops affinis*	topsmelt	1	0.023
		Cymatogaster aggregata	shiner perch	6	0.038
		Engraulis mordax	northern anchovy	254	0.347
		Genyonemus lineatus	white croaker	6	0.020
		Hyperprosopon argenteum	walleye surfperch	1	0.006
		Hypsoblennius gilberti	rockpool blenny	2	0.008
		Porichthys myriaster	specklefin midshipman	1	0.061
		Sardinops sagax	Pacific sardine	55	0.109
		Seriphus politus	queenfish	11	0.374
		Sphyraena argentea	Pacific barracuda	1	0.002
		Umbrina roncador	yellowfin croaker	1	0.294
				339	1.282
3	Invertebrate	*Blepharipoda occidentalis*	spiny mole crab	1	0.003
		Cancer antennarius	Pacific rock crab	2	0.004
		Cancer anthonyi	yellow crab	7	0.019
		Caudina arenicola	sweet potatoe sea cucumber	2	0.105
		Crangon nigromaculata	blackspotted bay shrimp	1	0.002
		Cycloxanthops novemdentatus	ninetooth pebble crab	2	0.033
		Dendraster excentricus	Pacific sand dollar	25	0.083
		Pachygrapsus crassipes	striped shore crab	1	0.001
		Panulirus interruptus	California spiny lobster	1	0.113
		Pilumnus spinohirsutus	retiring hairy crab	1	0.010
		Portunus xantusii	Xantus swimming crab	1	0.005
		Pugettia producta	northern kelp crab	2	0.009
		Pyromaia tuberculata	tuberculate pear crab	1	0.001
		Strongylocentrotus purpuratus	purple sea urchin	1	0.001
		Thetys vagina	common salp	4	0.083
				52	0.472

Survey Type: Normal Operations
Survey: SONGSNO10
Date: July 25, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	89	3.048
		Citharichthys stigmaeus	speckled sanddab	1	0.198
		Cymatogaster aggregata	shiner perch	12	0.054
		Engraulis mordax	northern anchovy	666	0.902
		Genyonemus lineatus	white croaker	21	0.079
		Gibbonsia elegans	spotted kelpfish	1	0.009
		Halichoeres semicinctus	rock wrasse	1	0.070
		Hypsoblennius gilberti	rockpool blenny	1	0.002
		Phanerodon furcatus	white seaperch	3	0.011
		Porichthys myriaster	specklefin midshipman	2	0.123
		Sardinops sagax	Pacific sardine	1	0.003
		Seriphus politus	queenfish	128	2.804
		Trachurus symmetricus	jack mackerel	2	0.045
		Umbrina roncador	yellowfin croaker	4	1.467
		Xenistius californiensis	salema	1	0.031
				933	8.846
2	Invertebrate	*Cancer amphioetus*	bigtooth rock crab	1	0.003
		Cancer antennarius	Pacific rock crab	32	0.089
		Cancer anthonyi	yellow crab	254	0.695
		Cancer gracilis	graceful crab	8	0.023
		Cancer productus	red rock crab	5	0.029
		Caudina arenicola	sweet potatoe sea cucumber	2	0.016
		Crangon nigromaculata	blackspotted bay shrimp	1	0.001
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.003
		Dendraster excentricus	Pacific sand dollar	8	0.038
		Heptacarpus palpator	intertidal coastal shrimp	4	0.002
		Lysmata californica	red rock shrimp	19	0.011
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.082
		Pachycheles rudis	thick claw porcelain crab	1	0.002
		Pachygrapsus crassipes	striped shore crab	1	0.011
		Panulirus interruptus	California spiny lobster	6	0.860
		Portunus xantusii	Xantus swimming crab	4	0.037
		Pugettia producta	northern kelp crab	2	0.043
		Pyromaia tuberculata	tuberculate pear crab	2	0.002
		Strongylocentrotus franciscanus	red sea urchin	2	0.377
		Strongylocentrotus purpuratus	purple sea urchin	8	0.028
		Tegula eiseni	banded tegula	1	0.008
		Urechis caupo	innkeeper worm	1	0.004
				364	2.364

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Survey Type: Normal Operations
Survey: SONGSNO10 (continued)
Date: July 25, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinopsis californiensis*	jacksmelt	8	0.433
		Cheilotrema saturnum	black croaker	1	0.108
		Cymatogaster aggregata	shiner perch	24	0.146
		Embiotoca jacksoni	black perch	1	0.003
		Engraulis mordax	northern anchovy	411	0.776
		Genyonemus lineatus	white croaker	12	0.046
		Hyperprosopon argenteum	walleye surfperch	1	0.016
		Hypsoblennius gilberti	rockpool blenny	1	0.011
		Menticirrhus undulatus	California corbina	1	0.460
		Oxyjulis californica	senorita	1	0.052
		Peprilus simillimus	Pacific pompano	1	0.023
		Phanerodon furcatus	white seaperch	12	0.285
		Porichthys myriaster	specklefin midshipman	1	0.020
		Seriphus politus	queenfish	195	4.765
		Sphyraena argentea	Pacific barracuda	1	0.001
		Syngnathus californiensis	kelp pipefish	1	0.005
		Xenistius californiensis	salema	1	0.032
				673	7.182
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	10	0.040
		Cancer anthonyi	yellow crab	48	0.157
		Caudina arenicola	sweet potatoe sea cucumber	2	0.010
		Crangon nigromaculata	blackspotted bay shrimp	2	0.001
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.003
		Dendraster excentricus	Pacific sand dollar	18	0.076
		Farfantepenaeus californiensis	yellowleg shrimp	5	0.282
		Lysmata californica	red rock shrimp	2	0.001
		Nassarius perpinguis	fat western nassa	1	0.001
		Octopus bimaculatus/bimaculoides	California two-spot octopus	2	0.215
		Pachygrapsus crassipes	striped shore crab	1	0.002
		Panulirus interruptus	California spiny lobster	34	2.855
		Portunus xantusii	Xantus swimming crab	6	0.041
		Pugettia producta	northern kelp crab	2	0.008
		Strongylocentrotus franciscanus	red sea urchin	1	0.003
				135	3.695

Survey Type: Normal Operations
Survey: SONGSNO11
Date: August 8, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	10	0.106
		Atherinops affinis	topsmelt	4	0.102
		Atherinopsis californiensis	jacksmelt	1	0.180
		Atractoscion nobilis	white seabass	4	0.079
		Cymatogaster aggregata	shiner perch	19	0.089
		Engraulis mordax	northern anchovy	2,092	3.900
		Genyonemus lineatus	white croaker	2	0.016
		Gymnura marmorata	California butterfly ray	1	0.097
		Heterostichus rostratus	giant kelpfish	1	0.001
		Ophidion scrippsae	basketweave cusk-eel	1	0.055
		Paralichthys californicus	California halibut	2	0.147
		Peprilus simillimus	Pacific pompano	8	0.289
		Phanerodon furcatus	white seaperch	3	0.092
		Pleuronichthys ritteri	spotted turbot	1	0.056
		Pleuronichthys verticalis	hornyhead turbot	2	0.178
		Porichthys myriaster	specklefin midshipman	1	0.303
		Sardinops sagax	Pacific sardine	69	0.094
		Seriphus politus	queenfish	435	4.219
		Sphyraena argentea	Pacific barracuda	40	0.216
		Syngnathus californiensis	kelp pipefish	1	0.001
				2,697	10.220
2	Invertebrate	*Dendraster excentricus*	Pacific sand dollar	7	0.038
		Farfantepenaeus californiensis	yellowleg shrimp	5	0.285
		Panulirus interruptus	California spiny lobster	14	2.203
		Portunus xantusii	Xantus swimming crab	2	0.017
				28	2.543

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Survey Type: Normal Operations
Survey: SONGSNO11 (continued)
Date: August 8, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	4	0.037
		Atherinops affinis	topsmelt	11	0.328
		Atractoscion nobilis	white seabass	1	0.024
		Citharichthys stigmaeus	speckled sanddab	1	0.001
		Cymatogaster aggregata	shiner perch	5	0.033
		Engraulis mordax	northern anchovy	486	0.560
		Genyonemus lineatus	white croaker	2	0.008
		Gymnura marmorata	California butterfly ray	1	0.356
		Hyperprosopon argenteum	walleye surfperch	6	0.085
		Paralichthys californicus	California halibut	3	0.271
		Peprilus simillimus	Pacific pompano	3	0.073
		Sardinops sagax	Pacific sardine	7	0.009
		Seriphus politus	queenfish	592	4.703
		Sphyraena argentea	Pacific barracuda	7	0.060
		Syngnathus californiensis	kelp pipefish	1	0.001
		Synodus lucioceps	California lizardfish	1	0.142
		Umbrina roncador	yellowfin croaker	2	0.950
		Xenistius californiensis	salema	6	0.137
				1,139	7.778
3	Invertebrate	*Cancer amphioetus*	bigtooth rock crab	1	0.002
		Cancer antennarius	Pacific rock crab	8	0.021
		Cancer anthonyi	yellow crab	93	0.211
		Cancer jordani	hairy rock crab	13	0.016
		Caudina arenicola	sweet potatoe sea cucumber	1	0.056
		Farfantepenaeus californiensis	yellowleg shrimp	4	0.227
		Heptacarpus palpator	intertidal coastal shrimp	1	0.001
		Lysmata californica	red rock shrimp	1	0.001
		Panulirus interruptus	California spiny lobster	2	0.647
		Pugettia producta	northern kelp crab	2	0.007
		Pyromaia tuberculata	tuberculate pear crab	1	0.001
		Scyra acutifrons	sharpnose crab	1	0.001
				128	1.191

Survey Type: Normal Operations
Survey: SONGSNO12
Date: August 22, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	4	0.090
		Cymatogaster aggregata	shiner perch	2	0.007
		Engraulis mordax	northern anchovy	132	0.100
		Hyperprosopon argenteum	walleye surfperch	4	0.057
		Sardinops sagax	Pacific sardine	4	0.026
		Seriphus politus	queenfish	1,009	2.232
		Sphyraena argentea	Pacific barracuda	24	0.084
				1,179	2.596
2	Invertebrate	*Cancer anthonyi*	yellow crab	12	0.055
		Cancer jordani	hairy rock crab	1	0.001
		Caudina arenicola	sweet potatoe sea cucumber	7	0.106
		Crangon nigromaculata	blackspotted bay shrimp	3	0.002
		Dendraster excentricus	Pacific sand dollar	22	0.102
		Farfantepenaeus californiensis	yellowleg shrimp	1	0.023
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.002
		Panulirus interruptus	California spiny lobster	2	0.222
		Portunus xantusii	Xantus swimming crab	2	0.018
		Thetys vagina	common salp	8	0.163
				59	0.694
3	Fish	*Atherinops affinis*	topsmelt	1	0.029
		Cymatogaster aggregata	shiner perch	3	0.005
		Engraulis mordax	northern anchovy	82	0.066
		Pleuronichthys coenosus	C-O sole	1	0.001
		Porichthys myriaster	specklefin midshipman	1	0.360
		Rhinobatos productus	shovelnose guitarfish	1	0.066
		Sardinops sagax	Pacific sardine	5	0.076
		Seriphus politus	queenfish	4,028	7.340
		Sphyraena argentea	Pacific barracuda	6	0.023
				4,128	7.966
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	2	0.009
		Cancer anthonyi	yellow crab	2	0.003
		Caudina arenicola	sweet potatoe sea cucumber	1	0.026
		Dendraster excentricus	Pacific sand dollar	27	0.148
		Lysmata californica	red rock shrimp	1	0.001
		Neotrypaea gigas	giant ghost shrimp	4	0.009
		Portunus xantusii	Xantus swimming crab	4	0.017
		Thetys vagina	common salp	1	0.030
				42	0.243

Survey Type: Normal Operations
Survey: SONGSNO13
Date: September 6, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anisotremus davidsonii*	sargo	1	0.120
		Atherinops affinis	topsmelt	11	0.315
		Cymatogaster aggregata	shiner perch	1	0.005
		Engraulis mordax	northern anchovy	29	0.057
		Heterostichus rostratus	giant kelpfish	1	0.010
		Hypsoblennius gilberti	rockpool blenny	1	0.004
		Sardinops sagax	Pacific sardine	2	0.080
		Seriphus politus	queenfish	684	1.353
		Sphyraena argentea	Pacific barracuda	10	0.048
				740	1.992
2	Invertebrate	*Aplysia californica*	California seahare	1	0.179
		Cancer antennarius	Pacific rock crab	1	0.003
		Cancer anthonyi	yellow crab	1	0.002
		Caudina arenicola	sweet potatoe sea cucumber	2	0.012
		Crangon nigromaculata	blackspotted bay shrimp	1	0.001
		Dendraster excentricus	Pacific sand dollar	10	0.055
		Pachygrapsus crassipes	striped shore crab	1	0.003
		Panulirus interruptus	California spiny lobster	2	1.300
		Portunus xantusii	Xantus swimming crab	1	0.012
				20	1.567

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Survey Type: Normal Operations
Survey: SONGSNO13 (continued)
Date: September 6, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	3	0.038
		Atherinops affinis	topsmelt	1	0.049
		Cymatogaster aggregata	shiner perch	1	0.005
		Engraulis mordax	northern anchovy	379	0.653
		Genyonemus lineatus	white croaker	3	0.022
		Hyperprosopon argenteum	walleye surfperch	1	0.017
		Hypsoblennius gilberti	rockpool blenny	1	0.001
		Peprilus simillimus	Pacific pompano	1	0.008
		Roncador stearnsii	spotfin croaker	1	0.690
		Scomber japonicus	Pacific chub mackerel	1	0.123
		Scorpaena guttata	California scorpionfish	1	0.193
		Seriphus politus	queenfish	800	1.929
		Sphyraena argentea	Pacific barracuda	5	0.031
		Syngnathus californiensis	kelp pipefish	1	0.001
		Synodus lucioceps	California lizardfish	1	0.123
		Trachurus symmetricus	jack mackerel	2	0.007
		Xenistius californiensis	salema	3	0.027
				1,205	3.917
3	Invertebrate	*Blepharipoda occidentalis*	spiny mole crab	2	0.056
		Cancer antennarius	Pacific rock crab	4	0.038
		Cancer anthonyi	yellow crab	35	0.246
		Cancer jordani	hairy rock crab	2	0.007
		Crangon nigromaculata	blackspotted bay shrimp	1	0.002
		Cycloxanthops novemdentatus	ninetooth pebble crab	2	0.016
		Dendraster excentricus	Pacific sand dollar	18	0.070
		Farfantepenaeus californiensis	yellowleg shrimp	1	0.031
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.002
		Loxorhynchus grandis	sheep crab	1	0.030
		Lysmata californica	red rock shrimp	1	0.003
		Panulirus interruptus	California spiny lobster	5	1.483
		Pisaster brevispinus	short-spined sea star	1	0.008
		Pisaster giganteus	giant-spined sea star	2	0.017
		Portunus xantusii	Xantus swimming crab	5	0.018
		Thetys vagina	common salp	1	0.005
				82	2.032

Survey Type: Normal Operations
Survey: SONGSNO14
Date: September 19, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	8	0.081
		Cymatogaster aggregata	shiner perch	2	0.015
		Engraulis mordax	northern anchovy	157	0.121
		Hypsoblennius gilberti	rockpool blenny	1	0.003
		Pleuronichthys verticalis	hornyhead turbot	1	0.118
		Seriphus politus	queenfish	1,176	3.117
				1,345	3.455
2	Invertebrate	*Aplysia californica*	California seahare	1	0.325
		Cancer antennarius	Pacific rock crab	1	0.123
		Cancer anthonyi	yellow crab	3	0.005
		Cancer gracilis	graceful crab	1	0.001
		Cancer jordani	hairy rock crab	3	0.006
		Crangon nigromaculata	blackspotted bay shrimp	24	0.022
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.004
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.024
		Pachycheles holosericus	sponge porcelain crab	4	0.014
		Panulirus interruptus	California spiny lobster	2	0.202
		Pilumnus spinohirsutus	retiring hairy crab	1	0.006
		Portunus xantusii	Xantus swimming crab	2	0.002
				44	0.734
3	Fish	*Anchoa compressa*	deepbody anchovy	5	0.056
		Anisotremus davidsonii	sargo	1	0.096
		Atherinops affinis	topsmelt	2	0.088
		Cymatogaster aggregata	shiner perch	1	0.005
		Engraulis mordax	northern anchovy	354	0.257
		Hypsoblennius gilberti	rockpool blenny	2	0.009
		Sardinops sagax	Pacific sardine	2	0.073
		Seriphus politus	queenfish	2,431	6.121
		Trachurus symmetricus	jack mackerel	1	0.003
				2,799	6.708
3	Invertebrate	*Cancer anthonyi*	yellow crab	1	0.002
		Cancer jordani	hairy rock crab	1	0.001
		Crangon nigromaculata	blackspotted bay shrimp	13	0.013
		Cycloxanthops novemdentatus	ninetooth pebble crab	3	0.019
		Dendraster excentricus	Pacific sand dollar	15	0.069
		Pilumnus spinohirsutus	retiring hairy crab	1	0.005
		Pisaster brevispinus	short-spined sea star	1	0.006
		Portunus xantusii	Xantus swimming crab	2	0.003
				37	0.118

Survey Type: Normal Operations
Survey: SONGSNO15
Date: October 3, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	42	0.430
		Atherinops affinis	topsmelt	2	0.062
		Engraulis mordax	northern anchovy	657	0.667
		Genyonemus lineatus	white croaker	1	0.012
		Heterodontus francisci	horn shark	2	2.540
		Hyperprosopon argenteum	walleye surfperch	6	0.108
		Paralichthys californicus	California halibut	1	0.094
		Peprilus simillimus	Pacific pompano	16	0.388
		Phanerodon furcatus	white seaperch	1	0.014
		Scomber japonicus	Pacific chub mackerel	40	4.758
		Seriphus politus	queenfish	2,278	7.484
		Sphyraena argentea	Pacific barracuda	2	0.075
		Synodus lucioceps	California lizardfish	1	0.132
				3,049	16.764
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	1	0.022
		Cancer anthonyi	yellow crab	3	0.012
		Dendraster excentricus	Pacific sand dollar	2	0.002
		Panulirus interruptus	California spiny lobster	1	0.476
		Portunus xantusii	Xantus swimming crab	3	0.002
				10	0.514
3	Fish	*Anchoa compressa*	deepbody anchovy	20	0.218
		Atherinopsis californiensis	jacksmelt	1	0.078
		Atractoscion nobilis	white seabass	1	0.036
		Cymatogaster aggregata	shiner perch	2	0.014
		Engraulis mordax	northern anchovy	1,528	1.676
		Genyonemus lineatus	white croaker	1	0.013
		Heterostichus rostratus	giant kelpfish	2	0.004
		Peprilus simillimus	Pacific pompano	12	0.296
		Sardinops sagax	Pacific sardine	1	0.003
		Scomber japonicus	Pacific chub mackerel	6	0.672
		Seriphus politus	queenfish	2,645	7.226
		Sphyraena argentea	Pacific barracuda	6	0.178
		Syngnathus californiensis	kelp pipefish	1	0.002
				4,226	10.416
3	Invertebrate	*Cancer anthonyi*	yellow crab	1	0.001
		Crangon nigromaculata	blackspotted bay shrimp	1	0.001
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.007
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.001
		Panulirus interruptus	California spiny lobster	2	0.652
		Portunus xantusii	Xantus swimming crab	5	0.005
				11	0.667

Survey Type: Normal Operations
Survey: SONGSNO16
Date: October 17, 2006

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	136	3.528
		Engraulis mordax	northern anchovy	471	0.470
		Genyonemus lineatus	white croaker	2	0.025
		Hypsoblennius gilberti	rockpool blenny	2	0.009
		Peprilus simillimus	Pacific pompano	1	0.009
		Sardinops sagax	Pacific sardine	10	0.178
		Scomber japonicus	Pacific chub mackerel	8	0.812
		Seriphus politus	queenfish	1,169	4.355
		Sphyraena argentea	Pacific barracuda	1	0.040
		Syngnathus californiensis	kelp pipefish	1	0.001
		Trachurus symmetricus	jack mackerel	1	0.008
				1,802	9.435
2	Invertebrate	*Cancer anthonyi*	yellow crab	3	0.003
		Cancer gracilis	graceful crab	1	0.002
		Cancer jordani	hairy rock crab	2	0.002
		Crangon nigromaculata	blackspotted bay shrimp	2	0.001
		Dendraster excentricus	Pacific sand dollar	5	0.018
		Mopalia ciliata	MBC chiton 1	1	0.001
		Pachycheles pubescens	pubescent porcelain crab	1	0.005
		Portunus xantusii	Xantus swimming crab	14	0.022
				29	0.054

Survey Type: Normal Operations
Survey: SONGSNO17
Date: October 31, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	1	0.060
		Engraulis mordax	northern anchovy	13	0.036
		Phanerodon furcatus	white seaperch	1	0.075
		Platyrhinoidis triseriata	thornback	1	0.854
		Scomber japonicus	Pacific chub mackerel	1	0.080
		Seriphus politus	queenfish	655	2.573
		Xenistius californiensis	salema	2	0.008
				674	3.686
2	Invertebrate	*Cancer anthonyi*	yellow crab	3	0.009
		Cancer jordani	hairy rock crab	1	0.001
		Portunus xantusii	Xantus swimming crab	14	0.022
				18	0.032

Survey Type: Normal Operations
Survey: SONGSNO18
Date: November 14, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	113	0.781
		Anchoa delicatissima	slough anchovy	4	0.012
		Atherinops affinis	topsmelt	3	0.090
		Cymatogaster aggregata	shiner perch	2	0.021
		Engraulis mordax	northern anchovy	1,440	1.270
		Genyonemus lineatus	white croaker	189	1.690
		Heterostichus rostratus	giant kelpfish	2	0.008
		Hypsoblennius gilberti	rockpool blenny	2	0.012
		Peprilus simillimus	Pacific pompano	3	0.037
		Phanerodon furcatus	white seaperch	2	0.064
		Porichthys myriaster	specklefin midshipman	11	0.118
		Sardinops sagax	Pacific sardine	248	8.689
		Scomber japonicus	Pacific chub mackerel	1	0.106
		Seriphus politus	queenfish	16,550	44.510
		Sphyraena argentea	Pacific barracuda	1	0.055
		Syngnathus californiensis	kelp pipefish	1	0.002
		Synodus lucioceps	California lizardfish	2	0.148
		Xenistius californiensis	salema	16	0.053
				18,590	57.666
2	Invertebrate	*Asterina miniata*	bat star	1	0.013
		Cancer antennarius	Pacific rock crab	4	0.020
		Cancer anthonyi	yellow crab	10	0.044
		Cancer gracilis	graceful crab	1	0.001
		Cancer jordani	hairy rock crab	9	0.011
		Crangon nigromaculata	blackspotted bay shrimp	2	0.002
		Dendraster excentricus	Pacific sand dollar	2	0.002
		Elthusa vulgaris	sea louse	1	0.001
		Heptacarpus palpator	intertidal coastal shrimp	2	0.001
		Lepidopa californica	California mole crab	2	0.003
		Neotrypaea californiensis	bay ghost shrimp	1	0.004
		Panulirus interruptus	California spiny lobster	2	0.690
		Portunus xantusii	Xantus swimming crab	60	0.137
		Pyromaia tuberculata	tuberculate pear crab	1	0.001
		Strongylocentrotus purpuratus	purple sea urchin	1	0.001
				99	0.931

Survey Type: Normal Operations
Survey: SONGSNO19
Date: November 28, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	334	2.280
		Anchoa delicatissima	slough anchovy	84	0.239
		Atherinops affinis	topsmelt	6	0.194
		Engraulis mordax	northern anchovy	42	0.057
		Genyonemus lineatus	white croaker	6	0.076
		Heterostichus rostratus	giant kelpfish	3	0.024
		Hyperprosopon argenteum	walleye surfperch	1	0.027
		Hypsoblennius gilberti	rockpool blenny	6	0.011
		Leuresthes tenuis	California grunion	1	0.019
		Peprilus simillimus	Pacific pompano	3	0.019
		Pleuronichthys ritteri	spotted turbot	2	0.009
		Porichthys myriaster	specklefin midshipman	1	0.056
		Scomber japonicus	Pacific chub mackerel	4	0.438
		Scorpaena guttata	California scorpionfish	2	0.054
		Seriphus politus	queenfish	3,280	11.826
		Syngnathus californiensis	kelp pipefish	5	0.018
		Synodus lucioceps	California lizardfish	1	0.258
		Torpedo californica	Pacific electric ray	1	5.000
		Xenistius californiensis	salema	4	0.076
				3,786	20.681
2	Invertebrate	*Cancer amphioetus*	bigtooth rock crab	1	0.002
		Cancer antennarius	Pacific rock crab	6	0.132
		Cancer anthonyi	yellow crab	207	0.574
		Cancer gracilis	graceful crab	2	0.002
		Cancer jordani	hairy rock crab	23	0.044
		Caudina arenicola	sweet potatoe sea cucumber	1	0.011
		Crangon nigromaculata	blackspotted bay shrimp	20	0.028
		Cycloxanthops novemdentatus	ninetooth pebble crab	5	0.030
		Dendraster excentricus	Pacific sand dollar	8	0.048
		Farfantepenaeus californiensis	yellowleg shrimp	2	0.092
		Golfingia procera	MBC peanut worm 1	1	0.006
		Heptacarpus palpator	intertidal coastal shrimp	9	0.007
		Lepidopa californica	California mole crab	2	0.002
		Lophopanopeus bellus	blackclaw crestleg crab	10	0.016
		Lysmata californica	red rock shrimp	1	0.001
		Navanax inermis	California aglaja	1	0.002
		Octopus bimaculatus/bimaculoides	California two-spot octopus	3	0.032
		Panulirus interruptus	California spiny lobster	1	0.104
		Petrolisthes cinctipes	flat porcelain crab	1	0.001
		Pilumnus spinohirsutus	retiring hairy crab	2	0.011
		Portunus xantusii	Xantus swimming crab	41	0.116
		Pyromaia tuberculata	tuberculate pear crab	2	0.005
				349	1.266

Survey Type: Normal Operations
Survey: SONGSNO20
Date: December 12, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	108	0.826
		Anchoa delicatissima	slough anchovy	27	0.076
		Atherinops affinis	topsmelt	25	0.490
		Atherinopsis californiensis	jacksmelt	2	0.124
		Cheilotrema saturnum	black croaker	1	0.004
		Citharichthys stigmaeus	speckled sanddab	11	0.035
		Cymatogaster aggregata	shiner perch	1	0.023
		Engraulis mordax	northern anchovy	44	0.078
		Genyonemus lineatus	white croaker	4	0.153
		Heterostichus rostratus	giant kelpfish	3	0.017
		Myliobatis californica	bat ray	2	3.250
		Ophidion scrippsae	basketweave cusk-eel	1	0.088
		Paralabrax clathratus	kelp bass	1	0.002
		Platyrhinoidis triseriata	thornback	1	0.014
		Pleuronichthys ritteri	spotted turbot	1	0.112
		Pleuronichthys verticalis	hornyhead turbot	1	0.023
		Porichthys myriaster	specklefin midshipman	12	0.058
		Sardinops sagax	Pacific sardine	144	3.336
		Scorpaena guttata	California scorpionfish	1	0.001
		Seriphus politus	queenfish	1,065	3.820
		Syngnathus californiensis	kelp pipefish	2	0.010
		Synodus lucioceps	California lizardfish	3	0.300
		Torpedo californica	Pacific electric ray	1	15.000
		Urobatis halleri	round stingray	1	0.058
				1,462	27.898
2	Invertebrate	*Cancer anthonyi*	yellow crab	1	0.277
		Cancer jordani	hairy rock crab	3	0.002
		Caudina arenicola	sweet potatoe sea cucumber	5	0.084
		Crangon nigromaculata	blackspotted bay shrimp	23	0.027
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.016
		Elthusa vulgaris	sea louse	1	0.001
		Farfantepenaeus californiensis	yellowleg shrimp	4	0.130
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.280
		Panulirus interruptus	California spiny lobster	3	1.313
		Petrolisthes eriomerus	flattop crab	1	0.001
		Pinnixa faba	mantle pea crab	1	0.001
		Portunus xantusii	Xantus swimming crab	22	0.065
		Pugettia producta	northern kelp crab	5	0.010
				71	2.207

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Survey Type: Normal Operations
Survey: SONGSNO20 (continued)
Date: December 12, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	415	3.610
		Anchoa delicatissima	slough anchovy	40	0.110
		Atherinops affinis	topsmelt	5	0.046
		Brachyistius frenatus	kelp perch	1	0.006
		Citharichthys stigmaeus	speckled sanddab	4	0.015
		Cymatogaster aggregata	shiner perch	1	0.010
		Engraulis mordax	northern anchovy	250	0.350
		Genyonemus lineatus	white croaker	2	0.019
		Heterostichus rostratus	giant kelpfish	4	0.026
		Hyperprosopon argenteum	walleye surfperch	1	0.022
		Hypsoblennius gilberti	rockpool blenny	7	0.030
		Leptocottus armatus	Pacific staghorn sculpin	1	0.035
		Myliobatis californica	bat ray	1	0.366
		Platyrhinoidis triseriata	thornback	1	0.270
		Pleuronichthys ritteri	spotted turbot	2	0.086
		Porichthys myriaster	specklefin midshipman	11	0.075
		Sardinops sagax	Pacific sardine	143	3.876
		Scomber japonicus	Pacific chub mackerel	2	0.095
		Scorpaena guttata	California scorpionfish	3	0.003
		Seriphus politus	queenfish	1,480	5.130
		Sphyraena argentea	Pacific barracuda	1	0.006
		Syngnathus californiensis	kelp pipefish	4	0.005
		Trachurus symmetricus	jack mackerel	1	0.024
		Xenistius californiensis	salema	5	0.022
				2,385	14.237

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Survey Type: Normal Operations
Survey: SONGSNO20 (continued)
Date: December 12, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Invertebrate	*Blepharipoda occidentalis*	spiny mole crab	1	0.035
		Cancer antennarius	Pacific rock crab	7	0.453
		Cancer anthonyi	yellow crab	17	0.111
		Cancer gracilis	graceful crab	2	0.002
		Cancer jordani	hairy rock crab	4	0.005
		Caudina arenicola	sweet potatoe sea cucumber	16	0.333
		Crangon nigromaculata	blackspotted bay shrimp	26	0.011
		Cycloxanthops novemdentatus	ninetooth pebble crab	3	0.044
		Dendraster excentricus	Pacific sand dollar	1	0.005
		Farfantepenaeus californiensis	yellowleg shrimp	5	0.286
		Hemigrapsus oregonensis	yellow shore crab	1	0.001
		Hemisquilla californiensis	mantis shrimp	2	0.008
		Heptacarpus palpator	intertidal coastal shrimp	4	0.001
		Lophopanopeus bellus	blackclaw crestleg crab	2	0.005
		Lysmata californica	red rock shrimp	3	0.003
		Octopus bimaculatus/bimaculoides	California two-spot octopus	4	0.861
		Pachycheles rudis	thick claw porcelain crab	1	0.001
		Panulirus interruptus	California spiny lobster	1	0.227
		Petrolisthes eriomerus	flattop crab	11	0.013
		Pisaster ochraceus	ochre star	38	0.971
		Portunus xantusii	Xantus swimming crab	23	0.059
		Pugettia producta	northern kelp crab	5	0.011
		Pyromaia tuberculata	tuberculate pear crab	2	0.002
				179	3.448

Survey Type: Normal Operations
Survey: SONGSNO21
Date: December 27, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	42	0.312
		Anchoa delicatissima	slough anchovy	16	0.044
		Anisotremus davidsonii	sargo	2	0.004
		Engraulis mordax	northern anchovy	56	0.024
		Gibbonsia elegans	spotted kelpfish	2	0.046
		Heterostichus rostratus	giant kelpfish	2	0.002
		Ophidion scrippsae	basketweave cusk-eel	1	0.075
		Paralichthys californicus	California halibut	2	0.056
		Peprilus simillimus	Pacific pompano	2	0.016
		Pleuronichthys ritteri	spotted turbot	6	0.070
		Sardinops sagax	Pacific sardine	10	0.270
		Seriphus politus	queenfish	222	0.922
		Syngnathus sp	pipefish unid.	10	0.008
		Torpedo californica	Pacific electric ray	2	11.500
		Xenistius californiensis	salema	10	0.032
				385	13.381
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	2	0.004
		Cancer anthonyi	yellow crab	2	0.004
		Cancer jordani	hairy rock crab	8	0.006
		Cancer productus	red rock crab	2	0.002
		Crangon nigromaculata	blackspotted bay shrimp	12	0.012
		Dendraster excentricus	Pacific sand dollar	6	0.022
		Petrolisthes cinctipes	flat porcelain crab	2	0.004
		Portunus xantusii	Xantus swimming crab	112	0.266
		Pugettia producta	northern kelp crab	8	0.022
		Strongylocentrotus purpuratus	purple sea urchin	2	0.002
				156	0.344

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Survey Type: Normal Operations
Survey: SONGSNO21 (continued)
Date: December 27, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	93	0.838
		Anchoa delicatissima	slough anchovy	5	0.015
		Engraulis mordax	northern anchovy	38	0.065
		Heterostichus rostratus	giant kelpfish	3	0.026
		Peprilus simillimus	Pacific pompano	3	0.020
		Pleuronichthys guttulatus	diamond turbot	3	0.538
		Pleuronichthys ritteri	spotted turbot	5	0.033
		Sardinops sagax	Pacific sardine	78	1.893
		Seriphus politus	queenfish	303	1.210
		Syngnathus californiensis	kelp pipefish	3	0.003
		Xenistius californiensis	salema	13	0.048
				547	4.689
3	Invertebrate	*Cancer anthonyi*	yellow crab	3	0.018
		Cancer gracilis	graceful crab	3	0.055
		Caudina arenicola	sweet potatoe sea cucumber	5	0.590
		Crangon nigromaculata	blackspotted bay shrimp	8	0.003
		Dendraster excentricus	Pacific sand dollar	5	0.008
		Farfantepenaeus californiensis	yellowleg shrimp	3	0.150
		Octopus bimaculatus/bimaculoides	California two-spot octopus	8	1.250
		Panulirus interruptus	California spiny lobster	3	1.018
		Portunus xantusii	Xantus swimming crab	55	0.113
				93	3.205

Survey Type: Normal Operations
Survey: SONGSNO22
Date: January 9, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	127	0.814
		Anchoa delicatissima	slough anchovy	229	0.654
		Anisotremus davidsonii	sargo	1	0.251
		Atherinops affinis	topsmelt	1	0.010
		Atherinopsis californiensis	jacksmelt	3	0.301
		Citharichthys stigmaeus	speckled sanddab	4	0.015
		Engraulis mordax	northern anchovy	31	0.044
		Genyonemus lineatus	white croaker	4	0.039
		Gibbonsia elegans	spotted kelpfish	5	0.056
		Hypsoblennius gilberti	rockpool blenny	2	0.010
		Leptocottus armatus	Pacific staghorn sculpin	2	0.056
		Peprilus simillimus	Pacific pompano	5	0.050
		Platyrhinoidis triseriata	thornback	1	0.331
		Sardinops sagax	Pacific sardine	2	0.040
		Scorpaena guttata	California scorpionfish	4	0.112
		Seriphus politus	queenfish	210	1.069
		Syngnathus californiensis	kelp pipefish	15	0.039
		Torpedo californica	Pacific electric ray	1	4.750
		Xenistius californiensis	salema	6	0.030
				653	8.671
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	2	0.006
		Cancer anthonyi	yellow crab	5	0.035
		Cancer gracilis	graceful crab	1	0.003
		Cancer jordani	hairy rock crab	1	0.001
		Crangon nigromaculata	blackspotted bay shrimp	8	0.013
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.025
		Dendraster excentricus	Pacific sand dollar	34	0.155
		Farfantepenaeus californiensis	yellowleg shrimp	2	0.064
		Heptacarpus sp	coastal shrimp unk	3	0.001
		Lysmata californica	red rock shrimp	1	0.001
		Neotrypaea californiensis	bay ghost shrimp	4	0.012
		Octopus bimaculatus/bimaculoides	California two-spot octopus	3	0.532
		Pachygrapsus crassipes	striped shore crab	1	0.008
		Panulirus interruptus	California spiny lobster	3	0.658
		Portunus xantusii	Xantus swimming crab	9	0.020
		Pugettia producta	northern kelp crab	2	0.007
		Pugettia richii	cryptic kelp crab	1	0.001
		Renilla kollikeri	sea pansy	1	0.003
				82	1.545

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Survey Type: Normal Operations
Survey: SONGSNO22 (continued)
Date: January 9, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	51	0.305
		Anchoa delicatissima	slough anchovy	116	0.290
		Atherinops affinis	topsmelt	9	0.073
		Atherinopsis californiensis	jacksmelt	1	0.080
		Engraulis mordax	northern anchovy	20	0.019
		Heterostichus rostratus	giant kelpfish	2	0.045
		Hypsoblennius gilberti	rockpool blenny	2	0.003
		Leptocottus armatus	Pacific staghorn sculpin	1	0.051
		Paralabrax clathratus	kelp bass	1	0.003
		Peprilus simillimus	Pacific pompano	2	0.019
		Pleuronichthys ritteri	spotted turbot	1	0.005
		Sardinops sagax	Pacific sardine	2	0.048
		Scorpaena guttata	California scorpionfish	1	0.075
		Seriphus politus	queenfish	108	0.443
		Syngnathus californiensis	kelp pipefish	9	0.021
		Xenistius californiensis	salema	4	0.016
				330	1.496
3	Fish eggs	Atherinopsidae	atherinopsid eggs		0.052
					0.052
3	Invertebrate	*Alpheus clamator*	twistclaw pistol shrimp	1	0.001
		Cancer antennarius	Pacific rock crab	2	0.038
		Cancer anthonyi	yellow crab	5	0.029
		Cancer jordani	hairy rock crab	5	0.005
		Caudina arenicola	sweet potatoe sea cucumber	1	0.034
		Crangon nigromaculata	blackspotted bay shrimp	6	0.006
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.001
		Dendraster excentricus	Pacific sand dollar	34	0.205
		Heptacarpus palpator	intertidal coastal shrimp	2	0.001
		Hermissenda crassicornis	hermissenda	1	0.001
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.003
		Lysmata californica	red rock shrimp	10	0.011
		Lytechinus pictus	white sea urchin	1	0.001
		Nassarius perpinguis	fat western nassa	1	0.002
		Neotrypaea californiensis	bay ghost shrimp	1	0.003
		Pachygrapsus crassipes	striped shore crab	2	0.001
		Panulirus interruptus	California spiny lobster	1	0.107
		Petrolisthes cinctipes	flat porcelain crab	2	0.001
		Pilumnus spinohirsutus	retiring hairy crab	1	0.001
		Pisaster ochraceus	ochre star	3	0.090
		Portunus xantusii	Xantus swimming crab	17	0.042
		Pugettia richii	cryptic kelp crab	1	0.001
		Pyromaia tuberculata	tuberculate pear crab	2	0.003
		Strongylocentrotus purpuratus	purple sea urchin	1	0.002
				102	0.589

Survey Type: Normal Operations
Survey: SONGSNO23
Date: January 23, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	1	0.003
		Citharichthys stigmaeus	speckled sanddab	4	0.001
		Engraulis mordax	northern anchovy	44	0.065
		Genyonemus lineatus	white croaker	2	0.002
		Gibbonsia elegans	spotted kelpfish	1	0.007
		Hypsoblennius gilberti	rockpool blenny	1	0.001
		Paralabrax nebulifer	barred sand bass	1	0.019
		Porichthys myriaster	specklefin midshipman	1	0.004
		Sardinops sagax	Pacific sardine	5	0.114
		Scorpaena guttata	California scorpionfish	3	0.005
		Seriphus politus	queenfish	39	0.159
		Syngnathus californiensis	kelp pipefish	9	0.010
		Torpedo californica	Pacific electric ray	1	7.550
		Xenistius californiensis	salema	5	0.022
				117	7.962
2	Invertebrate	*Aplysia californica*	California seahare	1	0.001
		Cancer antennarius	Pacific rock crab	4	0.038
		Cancer anthonyi	yellow crab	25	0.049
		Cancer jordani	hairy rock crab	17	0.017
		Cancer productus	red rock crab	1	0.001
		Caudina arenicola	sweet potatoe sea cucumber	1	0.026
		Crangon nigromaculata	blackspotted bay shrimp	14	0.020
		Dendraster excentricus	Pacific sand dollar	23	0.056
		Farfantepenaeus californiensis	yellowleg shrimp	1	0.020
		Heptacarpus palpator	intertidal coastal shrimp	15	0.010
		Hermissenda crassicornis	hermissenda	2	0.001
		Lophopanopeus frontalis.	molarless crestleg crab	1	0.001
		Lysmata californica	red rock shrimp	1	0.001
		Nassarius perpinguis	fat western nassa	1	0.001
		Neotrypaea californiensis	bay ghost shrimp	3	0.008
		Pachygrapsus crassipes	striped shore crab	2	0.002
		Panulirus interruptus	California spiny lobster	1	0.288
		Pentamera sp	white sea cucumber unid	1	0.001
		Polyorchis penicillatus	red jellyfish	11	0.013
		Portunus xantusii	Xantus swimming crab	15	0.066
		Pugettia producta	northern kelp crab	1	0.001
		Pugettia richii	cryptic kelp crab	2	0.003
		Pyromaia tuberculata	tuberculate pear crab	1	0.001
				144	0.625

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Survey Type: Normal Operations
Survey: SONGSNO23 (continued)
Date: January 23, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	1	0.003
		Anchoa delicatissima	slough anchovy	2	0.005
		Engraulis mordax	northern anchovy	11	0.011
		Hypsoblennius gilberti	rockpool blenny	2	0.007
		Hypsoblennius jenkinsi	mussel blenny	1	0.003
		Orthonopias triacis	snubnose sculpin	1	0.001
		Seriphus politus	queenfish	21	0.066
		Syngnathus californiensis	kelp pipefish	5	0.005
		Torpedo californica	Pacific electric ray	1	5.250
		Xenistius californiensis	salema	2	0.015
				47	5.366
3	Fish eggs	*Atherinopsidae*	atherinopsid eggs		0.277
					0.277
3	Invertebrate	*Blepharipoda occidentalis*	spiny mole crab	1	0.018
		Cancer antennarius	Pacific rock crab	4	0.044
		Cancer anthonyi	yellow crab	4	0.006
		Cancer gracilis	graceful crab	1	0.004
		Cancer jordani	hairy rock crab	5	0.005
		Caudina arenicola	sweet potatoe sea cucumber	1	0.034
		Crangon nigromaculata	blackspotted bay shrimp	4	0.006
		Dendraster excentricus	Pacific sand dollar	2	0.014
		Farfantepenaeus californiensis	yellowleg shrimp	3	0.061
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.002
		Neotrypaea californiensis	bay ghost shrimp	1	0.003
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.228
		Paraxanthias taylori	lumpy rubble crab	1	0.008
		Polyorchis penicillatus	red jellyfish	7	0.014
		Portunus xantusii	Xantus swimming crab	19	0.070
		Pugettia producta	northern kelp crab	1	0.003
		Pyromaia tuberculata	tuberculate pear crab	4	0.002
				60	0.522

Survey Type: Normal Operations
Survey: SONGSNO24
Date: February 6, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	54	0.500
		Anchoa delicatissima	slough anchovy	42	0.106
		Atherinopsis californiensis	jacksmelt	1	0.057
		Engraulis mordax	northern anchovy	98	0.232
		Oxyjulis californica	senorita	2	0.002
		Sardinops sagax	Pacific sardine	2	0.012
		Seriphus politus	queenfish	380	1.904
		Syngnathus californiensis	kelp pipefish	18	0.018
		Torpedo californica	Pacific electric ray	1	10.000
		Xenistius californiensis	salema	8	0.040
				606	12.871
2	Fish eggs	Atherinopsidae	atherinopsid eggs		6.100
					6.100
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	1	0.236
		Cancer anthonyi	yellow crab	2	0.004
		Cancer jordani	hairy rock crab	2	0.004
		Crangon nigromaculata	blackspotted bay shrimp	6	0.016
		Dendraster excentricus	Pacific sand dollar	14	0.102
		Farfantepenaeus californiensis	yellowleg shrimp	8	0.170
		Heptacarpus sp	coastal shrimp unk	2	0.006
		Pachygrapsus crassipes	striped shore crab	2	0.010
		Panulirus interruptus	California spiny lobster	1	0.116
		Portunus xantusii	Xantus swimming crab	26	0.168
		Pugettia producta	northern kelp crab	4	0.010
		Tegula eiseni	banded tegula	2	0.014
				70	0.856

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Survey Type: Normal Operations
Survey: SONGSNO24 (continued)
Date: February 6, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	18	0.153
		Anchoa delicatissima	slough anchovy	17	0.038
		Engraulis mordax	northern anchovy	45	0.145
		Leuresthes tenuis	California grunion	1	0.005
		Myliobatis californica	bat ray	1	0.281
		Oxyjulis californica	senorita	1	0.002
		Seriphus politus	queenfish	217	1.051
		Syngnathus californiensis	kelp pipefish	10	0.027
		Xenistius californiensis	salema	1	0.002
				311	1.704
3	Fish eggs	Atherinopsidae	atherinopsid eggs		34.600
3	Invertebrate	*Cancer anthonyi*	yellow crab	2	0.030
		Cancer jordani	hairy rock crab	1	0.001
		Caudina arenicola	sweet potatoe sea cucumber	2	0.205
		Crangon nigromaculata	blackspotted bay shrimp	1	0.003
		Dendraster excentricus	Pacific sand dollar	1	0.001
		Farfantepenaeus californiensis	yellowleg shrimp	6	0.112
		Heptacarpus palpator	intertidal coastal shrimp	1	0.001
		Lytechinus pictus	white sea urchin	1	0.001
		Panulirus interruptus	California spiny lobster	1	0.410
		Polyorchis penicillatus	red jellyfish	1	0.001
		Portunus xantusii	Xantus swimming crab	39	0.144
		Pugettia producta	northern kelp crab	3	0.006
		Pyromaia tuberculata	tuberculate pear crab	1	0.001
				60	0.9168
3	Invertebrate eggs	*Loligo opalescens* eggs	California market squid eggs		0.012
					0.012

Survey Type: Normal Operations
Survey: SONGSNO25 [Diel 12 hours]
Date: February 20, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	9	0.070
		Anchoa delicatissima	slough anchovy	1	0.003
		Engraulis mordax	northern anchovy	47	0.053
		Scorpaenichthys marmoratus	cabezon	1	0.001
		Seriphus politus	queenfish	105	0.531
		Syngnathus californiensis	kelp pipefish	16	0.023
				179	0.681
2	Fish eggs	Atherinopsidae	atherinopsid eggs		1.250
					1.250
2	Invertebrate	*Cancer anthonyi*	yellow crab	3	0.003
		Caudina arenicola	sweet potatoe sea cucumber	1	0.055
		Crangon nigromaculata	blackspotted bay shrimp	4	0.011
		Dendraster excentricus	Pacific sand dollar	2	0.017
		Neotrypaea californiensis	bay ghost shrimp	2	0.002
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.148
		Portunus xantusii	Xantus swimming crab	9	0.056
		Pugettia producta	northern kelp crab	1	0.001
		Pyromaia tuberculata	tuberculate pear crab	1	0.001
		Strongylocentrotus franciscanus	red sea urchin	2	0.009
				26	0.303
3	Fish	*Anchoa compressa*	deepbody anchovy	13	0.115
		Anchoa delicatissima	slough anchovy	3	0.010
		Engraulis mordax	northern anchovy	82	0.103
		Genyonemus lineatus	white croaker	3	0.012
		Hypsoblennius jenkinsi	mussel blenny	1	0.005
		Sardinops sagax	Pacific sardine	1	0.041
		Seriphus politus	queenfish	434	2.572
		Syngnathus californiensis	kelp pipefish	3	0.010
		Syngnathus leptorhynchus	bay pipefish	1	0.001
		Xenistius californiensis	salema	2	0.014
				543	2.883
3	Fish eggs	Atherinopsidae	atherinopsid eggs		0.208
					0.208
3	Invertebrate	*Cancer anthonyi*	yellow crab	2	0.022
		Caudina arenicola	sweet potatoe sea cucumber	3	0.170
		Crangon nigromaculata	blackspotted bay shrimp	1	0.001
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.015
		Dendraster excentricus	Pacific sand dollar	2	0.018
		Farfantepenaeus californiensis	yellowleg shrimp	1	0.020
		Panulirus interruptus	California spiny lobster	1	0.148
		Pisaster ochraceus	ochre star	1	0.025
		Portunus xantusii	Xantus swimming crab	4	0.013
		Strongylocentrotus franciscanus	red sea urchin	1	0.004
				17	0.436

Survey Type: Normal Operations
Survey: SONGSNO26 [Diel 24 hours]
Date: February 21, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	27	0.219
		Anchoa delicatissima	slough anchovy	19	0.053
		Atherinopsis californiensis	jacksmelt	1	0.077
		Engraulis mordax	northern anchovy	88	0.125
		Genyonemus lineatus	white croaker	3	0.008
		Heterostichus rostratus	giant kelpfish	6	0.048
		Hypsoblennius gilberti	rockpool blenny	1	0.004
		Sardinops sagax	Pacific sardine	2	0.043
		Scomber japonicus	Pacific chub mackerel	1	0.108
		Scorpaena guttata	California scorpionfish	1	0.078
		Scorpaenichthys marmoratus	cabezon	1	0.002
		Sebastes paucispinis	bocaccio	1	0.004
		Seriphus politus	queenfish	624	3.508
		Syngnathus californiensis	kelp pipefish	32	0.078
		Synodus lucioceps	California lizardfish	1	0.001
		Xenistius californiensis	salema	6	0.038
				814	4.394
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	4	0.025
		Caudina arenicola	sweet potatoe sea cucumber	5	0.219
		Crangon nigromaculata	blackspotted bay shrimp	10	0.026
		Dendraster excentricus	Pacific sand dollar	5	0.045
		Heptacarpus palpator	intertidal coastal shrimp	1	0.001
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.135
		Pagurus sp	hermit crab unid	1	0.005
		Panulirus interruptus	California spiny lobster	2	0.493
		Pinnixa barnharti	pea crab no common name	1	0.001
		Portunus xantusii	Xantus swimming crab	33	0.218
		Renilla kollikeri	sea pansy	1	0.002
		Solenocera mutator	solenocerid shrimp 1	1	0.005
				65	1.175

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Survey Type: Normal Operations
Survey: SONGSNO26 [Diel 24 hours] (continued)
Date: February 21, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	12	0.112
		Atherinopsis californiensis	jacksmelt	4	0.374
		Engraulis mordax	northern anchovy	122	0.132
		Genyonemus lineatus	white croaker	2	0.006
		Heterostichus rostratus	giant kelpfish	2	0.012
		Oxyjulis californica	senorita	2	0.010
		Paralabrax clathratus	kelp bass	4	0.018
		Scorpaena guttata	California scorpionfish	2	0.072
		Scorpaenichthys marmoratus	cabezon	2	0.004
		Seriphus politus	queenfish	924	5.482
		Syngnathus californiensis	kelp pipefish	24	0.030
		Torpedo californica	Pacific electric ray	1	8.750
		Xenistius californiensis	salema	6	0.060
				1,107	15.062
3	Fish eggs	Atherinopsidae	atherinopsid eggs		0.080
					0.080
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	2	0.016
		Cancer anthonyi	yellow crab	2	0.008
		Cancer jordani	hairy rock crab	2	0.006
		Crangon nigromaculata	blackspotted bay shrimp	6	0.012
		Dendraster excentricus	Pacific sand dollar	4	0.016
		Heptacarpus palpator	intertidal coastal shrimp	2	0.002
		Loligo opalescens	California market squid	2	0.074
		Portunus xantusii	Xantus swimming crab	24	0.108
				44	0.242

Survey Type: Normal Operations
Survey: SONGSNO27 [Diel 12 hours]
Date: March 5, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	2	0.018
		Engraulis mordax	northern anchovy	3	0.014
		Seriphus politus	queenfish	23	0.176
		Syngnathus californiensis	kelp pipefish	10	0.029
		Xenistius californiensis	salema	3	0.020
				41	0.257
2	Invertebrate	*Cancer anthonyi*	yellow crab	1	0.004
		Dendraster excentricus	Pacific sand dollar	2	0.021
		Pachygrapsus crassipes	striped shore crab	1	0.009
		Panulirus interruptus	California spiny lobster	1	0.176
				5	0.210
3	Fish	*Atherinops affinis*	topsmelt	1	0.027
		Engraulis mordax	northern anchovy	1	0.001
		Genyonemus lineatus	white croaker	1	0.015
		Hypsoblennius gilberti	rockpool blenny	2	0.005
		Hypsoblennius jenkinsi	mussel blenny	2	0.005
		Sardinops sagax	Pacific sardine	1	0.040
		Scorpaena guttata	California scorpionfish	1	0.121
		Seriphus politus	queenfish	15	0.099
		Syngnathus californiensis	kelp pipefish	5	0.006
		Xenistius californiensis	salema	3	0.025
				32	0.344
3	Invertebrate	*Blepharipoda occidentalis*	spiny mole crab	1	0.027
		Cancer antennarius	Pacific rock crab	1	0.029
		Cancer anthonyi	yellow crab	1	0.010
		Caudina arenicola	sweet potatoe sea cucumber	1	0.105
		Crangon nigromaculata	blackspotted bay shrimp	4	0.014
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.011
		Dendraster excentricus	Pacific sand dollar	7	0.088
		Loligo opalescens	California market squid	2	0.069
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.202
		Pachycheles pubescens	pubescent porcelain crab	1	0.001
		Pachygrapsus crassipes	striped shore crab	1	0.001
		Pisaster ochraceus	ochre star	1	0.090
				22	0.647

Survey Type: Normal Operations
Survey: SONGSNO28 [Diel 24 hours]
Date: March 6, 2007

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
2	Fish	*Anchoa delicatissima*	slough anchovy	3	0.033
		Citharichthys stigmaeus	speckled sanddab	1	0.001
		Cymatogaster aggregata	shiner perch	1	0.014
		Engraulis mordax	northern anchovy	10	0.011
		Genyonemus lineatus	white croaker	1	0.004
		Sardinops sagax	Pacific sardine	35	1.184
		Seriphus politus	queenfish	70	0.421
		Syngnathus californiensis	kelp pipefish	42	0.063
		Xenistius californiensis	salema	37	0.273
				200	2.004
2	Invertebrate	*Blepharipoda occidentalis*	spiny mole crab	1	0.012
		Cancer antennarius	Pacific rock crab	1	0.003
		Cancer anthonyi	yellow crab	1	0.002
		Crangon nigromaculata	blackspotted bay shrimp	27	0.073
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.005
		Dendraster excentricus	Pacific sand dollar	12	0.036
		Farfantepenaeus californiensis	yellowleg shrimp	1	0.029
		Loligo opalescens	California market squid	3	0.063
		Neotrypaea californiensis	bay ghost shrimp	13	0.044
		Portunus xantusii	Xantus swimming crab	9	0.063
		Pugettia producta	northern kelp crab	1	0.002
		Pyromaia tuberculata	tuberculate pear crab	1	0.001
				71	0.333

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Survey Type: Normal Operations
Survey: SONGSNO28 [Diel 24 hours] (continued)
Date: March 6, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Citharichthys stigmaeus*	speckled sanddab	1	0.013
		Engraulis mordax	northern anchovy	18	0.018
		Genyonemus lineatus	white croaker	1	0.013
		Hypsoblennius gilberti	rockpool blenny	5	0.020
		Paralabrax clathratus	kelp bass	1	0.007
		Sardinops sagax	Pacific sardine	1	0.022
		Seriphus politus	queenfish	115	0.668
		Syngnathus californiensis	kelp pipefish	70	0.113
		Synodus lucioceps	California lizardfish	4	0.004
		Xenistius californiensis	salema	5	0.033
				221	0.911
3	Fish eggs	Atherinopsidae	atherinopsid eggs		0.271
					0.271
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	2	0.022
		Cancer anthonyi	yellow crab	4	0.007
		Cancer jordani	hairy rock crab	54	0.026
		Caudina arenicola	sweet potatoe sea cucumber	2	0.065
		Crangon nigromaculata	blackspotted bay shrimp	8	0.007
		Dendraster excentricus	Pacific sand dollar	16	0.187
		Farfantepenaeus californiensis	yellowleg shrimp	1	0.016
		Lepidopa californica	California mole crab	1	0.003
		Loligo opalescens	California market squid	3	0.075
		Neotrypaea californiensis	bay ghost shrimp	6	0.020
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.020
		Pachygrapsus crassipes	striped shore crab	3	0.005
		Portunus xantusii	Xantus swimming crab	6	0.009
				107	0.462

Survey Type: Normal Operations
Survey: SONGSNO29
Date: March 20, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	None			
2	Invertebrate	None			
3	Fish	*Artedius corallinus*	coralline sculpin	1	0.004
		Atherinops affinis	topsmelt	1	0.062
		Atherinopsidae	atherinopsid eggs		0.745
		Engraulis mordax	northern anchovy	18	0.040
		Heterostichus rostratus	giant kelpfish	1	0.013
		Hypsoblennius gilberti	rockpool blenny	2	0.006
		Phanerodon furcatus	white seaperch	1	0.037
		Porichthys myriaster	specklefin midshipman	2	0.021
		Porichthys notatus	plainfin midshipman	8	0.250
		Roncador stearnsii	spotfin croaker	1	0.091
		Sardinops sagax	Pacific sardine	18	0.708
		Scomber japonicus	Pacific chub mackerel	6	0.404
		Scorpaena guttata	California scorpionfish	3	0.005
		Seriphus politus	queenfish	124	0.889
		Sphyraena argentea	Pacific barracuda	2	0.168
		Syngnathus californiensis	kelp pipefish	27	0.055
		Xenistius californiensis	salema	3	0.025
				218	3.523
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	5	0.365
		Cancer anthonyi	yellow crab	5	0.034
		Cancer jordani	hairy rock crab	19	0.032
		Caudina arenicola	sweet potatoe sea cucumber	1	0.150
		Crangon nigromaculata	blackspotted bay shrimp	6	0.026
		Dendraster excentricus	Pacific sand dollar	2	0.004
		Farfantepenaeus californiensis	yellowleg shrimp	10	0.240
		Heptacarpus sp	coastal shrimp unk	3	0.002
		Isocheles pilosus	moon snail hermit	1	0.006
		Lophopanopeus bellus	blackclaw crestleg crab	2	0.004
		Loxorhynchus grandis	sheep crab	1	1.742
		Octopus bimaculatus/bimaculoides	California two-spot octopus	2	0.071
		Pachycheles holosericus	sponge porcelain crab	1	0.001
		Pachygrapsus crassipes	striped shore crab	1	0.001
		Panulirus interruptus	California spiny lobster	2	0.560
		Polyorchis penicillatus	red jellyfish	1	0.001
		Portunus xantusii	Xantus swimming crab	39	0.086
		Pugettia producta	northern kelp crab	1	0.002
		Strongylocentrotus purpuratus	purple sea urchin	2	0.004
				104	3.331

Survey Type: Normal Operations
Survey: SONGSNO30 [Diel 12 hours]]
Date: April 2, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	1	0.046
		Atherinopsis californiensis	jacksmelt	92	7.406
		Engraulis mordax	northern anchovy	12	0.003
		Sardinops sagax	Pacific sardine	1	0.032
		Scorpaena guttata	California scorpionfish	1	0.115
		Seriphus politus	queenfish	83	0.785
		Syngnathus californiensis	kelp pipefish	1	0.001
		Syngnathus exilis	barcheek pipefish	2	0.001
				193	8.389
2	Fish eggs	Atherinopsidae	atherinopsid eggs		0.295
					0.295
2	Invertebrate	*Cancer anthonyi*	yellow crab	5	0.031
		Cancer jordani	hairy rock crab	40	0.098
		Cancer productus	red rock crab	2	0.006
		Crangon nigromaculata	blackspotted bay shrimp	6	0.013
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.005
		Dendraster excentricus	Pacific sand dollar	3	0.019
		Farfantepenaeus californiensis	yellowleg shrimp	3	0.098
		Pachygrapsus crassipes	striped shore crab	1	0.008
		Panulirus interruptus	California spiny lobster	2	0.605
		Portunus xantusii	Xantus swimming crab	7	0.042
		Pugettia producta	northern kelp crab	1	0.005
		Strongylocentrotus purpuratus	purple sea urchin	1	0.001
				72	0.931

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Survey Type: Normal Operations
Survey: SONGSNO30 [Diel 12 hours] (continued)
Date: April 2, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinopsis californiensis*	jacksmelt	3	0.142
		Cymatogaster aggregata	shiner perch	1	0.021
		Engraulis mordax	northern anchovy	11	0.028
		Hypsoblennius gilberti	rockpool blenny	1	0.003
		Ophidion scrippsae	basketweave cusk-eel	1	0.010
		Pleuronichthys ritteri	spotted turbot	1	0.139
		Sardinops sagax	Pacific sardine	2	0.044
		Sebastes paucispinis	bocaccio	1	0.001
		Seriphus politus	queenfish	372	3.810
		Syngnathus californiensis	kelp pipefish	7	0.008
				400	4.206
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	2	0.018
		Cancer anthonyi	yellow crab	4	0.008
		Cancer jordani	hairy rock crab	11	0.027
		Caudina arenicola	sweet potatoe sea cucumber	1	0.031
		Crangon nigromaculata	blackspotted bay shrimp	10	0.026
		Dendraster excentricus	Pacific sand dollar	6	0.068
		Farfantepenaeus californiensis	yellowleg shrimp	18	0.411
		Heptacarpus palpator	intertidal coastal shrimp	1	0.001
		Pachycheles pubescens	pubescent porcelain crab	1	0.004
		Panulirus interruptus	California spiny lobster	1	0.359
		Pisaster giganteus	giant-spined sea star	1	0.333
		Portunus xantusii	Xantus swimming crab	17	0.068
				73	1.354

Survey Type: Normal Operations
Survey: SONGSNO31 [Diel 24 hours]
Date: April 3, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	1	0.068
		Cephaloscyllium ventriosum	swell shark	1	0.942
		Cymatogaster aggregata	shiner perch	1	0.012
		Embiotoca jacksoni	black perch	1	0.004
		Engraulis mordax	northern anchovy	26	0.011
		Heterostichus rostratus	giant kelpfish	1	0.017
		Hypsoblennius gilberti	rockpool blenny	1	0.009
		Sardinops sagax	Pacific sardine	1	0.019
		Scorpaena guttata	California scorpionfish	1	0.087
		Sebastes paucispinis	bocaccio	1	0.003
		Seriphus politus	queenfish	476	4.201
		Syngnathus californiensis	kelp pipefish	8	0.009
		Torpedo californica	Pacific electric ray	1	10.700
		Xenistius californiensis	salema	3	0.018
				523	16.100
2	Fish eggs	Atherinopsidae	atherinopsid eggs		0.032
					0.032
2	Invertebrate	*Aurelia aurita*	moon jelly	1	0.055
		Cancer antennarius	Pacific rock crab	1	0.009
		Cancer anthonyi	yellow crab	39	0.181
		Cancer jordani	hairy rock crab	208	0.452
		Cancer productus	red rock crab	1	0.001
		Caudina arenicola	sweet potatoe sea cucumber	4	0.228
		Crangon nigromaculata	blackspotted bay shrimp	23	0.064
		Dendraster excentricus	Pacific sand dollar	2	0.009
		Dendronotus frondosus	leafy dendronotid	4	0.001
		Farfantepenaeus californiensis	yellowleg shrimp	10	0.268
		Heptacarpus palpator	intertidal coastal shrimp	1	0.001
		Hermissenda crassicornis	hermissenda	3	0.001
		Lophopanopeus frontalis	molarless crestleg crab	1	0.003
		Lysmata californica	red rock shrimp	1	0.001
		Lytechinus pictus	white sea urchin	1	0.001
		Neotrypaea californiensis	bay ghost shrimp	1	0.001
		Panulirus interruptus	California spiny lobster	5	1.279
		Portunus xantusii	Xantus swimming crab	26	0.090
		Pugettia producta	northern kelp crab	2	0.007
		Pyromaia tuberculata	tuberculate pear crab	2	0.006
				336	2.658

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Survey Type: Normal Operations
Survey: SONGSNO31 [Diel 24 hours] (continued)
Date: April 3, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	1	0.006
		Atherinopsis californiensis	jacksmelt	7	0.414
		Citharichthys stigmaeus	speckled sanddab	1	0.005
		Cymatogaster aggregata	shiner perch	2	0.033
		Engraulis mordax	northern anchovy	147	0.094
		Heterostichus rostratus	giant kelpfish	2	0.060
		Hypsoblennius gilberti	rockpool blenny	2	0.007
		Porichthys notatus	plainfin midshipman	5	0.195
		Sardinops sagax	Pacific sardine	2	0.088
		Scorpaena guttata	California scorpionfish	4	0.061
		Scorpaenichthys marmoratus	cabezon	1	0.003
		Seriphus politus	queenfish	1,241	10.786
		Syngnathus californiensis	kelp pipefish	14	0.020
		Trachurus symmetricus	jack mackerel	1	0.124
		Xenistius californiensis	salema	4	0.032
				1,434	11.928
3	Fish eggs	Atherinopsidae	atherinopsid eggs		0.045
3	Invertebrate	*Blepharipoda occidentalis*	spiny mole crab	1	0.031
		Cancer antennarius	Pacific rock crab	1	0.020
		Cancer anthonyi	yellow crab	7	0.018
		Cancer gracilis	graceful crab	4	0.008
		Cancer jordani	hairy rock crab	29	0.043
		Cancer productus	red rock crab	1	0.002
		Caudina arenicola	sweet potatoe sea cucumber	5	0.480
		Crangon nigromaculata	blackspotted bay shrimp	36	0.122
		Dendraster excentricus	Pacific sand dollar	12	0.098
		Farfantepenaeus californiensis	yellowleg shrimp	9	0.228
		Isocheles pilosus	moon snail hermit	2	0.009
		Pachycheles rudis	thick claw porcelain crab	1	0.001
		Panulirus interruptus	California spiny lobster	1	0.370
		Paraxanthias taylori	lumpy rubble crab	1	0.005
		Portunus xantusii	Xantus swimming crab	40	0.088
				150	1.523

Survey Type: Normal Operations
Survey: SONGSNO32
Date: April 17, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	1	0.009
		Atherinopsis californiensis	jacksmelt	10	0.842
		Embiotoca jacksoni	black perch	6	0.025
		Engraulis mordax	northern anchovy	6	0.053
		Genyonemus lineatus	white croaker	4	0.016
		Gibbonsia elegans	spotted kelpfish	1	0.010
		Heterostichus rostratus	giant kelpfish	10	0.182
		Hyperprosopon argenteum	walleye surfperch	1	0.011
		Hypsoblennius gilberti	rockpool blenny	11	0.040
		Ophichthus zophochir	yellow snake eel	1	0.021
		Ophidion scrippsae	basketweave cusk-eel	2	0.017
		Paralabrax nebulifer	barred sand bass	1	0.185
		Pleuronichthys ritteri	spotted turbot	2	0.068
		Porichthys myriaster	specklefin midshipman	1	0.006
		Porichthys notatus	plainfin midshipman	77	2.255
		Sardinops sagax	Pacific sardine	11	0.450
		Scomber japonicus	Pacific chub mackerel	5	0.468
		Scorpaena guttata	California scorpionfish	10	0.592
		Scorpaenichthys marmoratus	cabezon	6	0.035
		Sebastes paucispinis	bocaccio	4	0.012
		Seriphus politus	queenfish	549	5.976
		Syngnathus californiensis	kelp pipefish	34	0.042
		Torpedo californica	Pacific electric ray	1	7.800
		Xenistius californiensis	salema	6	0.060
				760	19.175

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Survey Type: Normal Operations
Survey: SONGSNO32 (continued)
Date: April 17, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Invertebrate	*Calliostoma canaliculatum*	channeled topsnail	1	0.005
		Aplysia californica	California seahare	1	0.169
		Cancer antennarius	Pacific rock crab	4	0.734
		Cancer anthonyi	yellow crab	10	0.075
		Cancer gracilis	graceful crab	1	0.002
		Cancer jordani	hairy rock crab	56	0.123
		Caudina arenicola	sweet potatoe sea cucumber	4	0.215
		Chrysaora colorata	purple-striped jellyfish	1	0.437
		Crangon nigromaculata	blackspotted bay shrimp	27	0.095
		Dendraster excentricus	Pacific sand dollar	42	0.345
		Farfantepenaeus californiensis	yellowleg shrimp	4	0.115
		Heptacarpus palpator	intertidal coastal shrimp	8	0.008
		Isocheles pilosus	moon snail hermit	6	0.023
		Loligo opalescens	California market squid	1	0.026
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.002
		Lophopanopeus frontalis	molarless crestleg crab	1	0.003
		Lysmata californica	red rock shrimp	7	0.012
		Neotrypaea californiensis	bay ghost shrimp	3	0.015
		Octopus bimaculatus/bimaculoides	California two-spot octopus	3	0.452
		Pachycheles pubescens	pubescent porcelain crab	3	0.003
		Panulirus interruptus	California spiny lobster	5	1.865
		Petrolisthes cabrilloi	Cabrillo porcelain crab	1	0.002
		Pisaster giganteus	giant-spined sea star	1	0.161
		Portunus xantusii	Xantus swimming crab	50	0.300
		Pugettia producta	northern kelp crab	2	0.018
				243	5.205

Survey Type: Normal Operations
Survey: SONGSNO33
Date: May 1, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinopsis californiensis*	jacksmelt	1	0.041
		Embiotoca jacksoni	black perch	2	0.010
		Engraulis mordax	northern anchovy	57	0.118
		Porichthys myriaster	specklefin midshipman	2	0.025
		Porichthys notatus	plainfin midshipman	7	0.180
		Sardinops sagax	Pacific sardine	9	0.246
		Scomber japonicus	Pacific chub mackerel	8	0.666
		Seriphus politus	queenfish	63	0.939
		Syngnathus californiensis	kelp pipefish	6	0.013
		Syngnathus exilis	barcheek pipefish	2	0.007
		Trachurus symmetricus	jack mackerel	2	0.095
		Xenistius californiensis	salema	1	0.010
				160	2.350
3	Fish eggs	Atherinopsidae	atherinopsid eggs		0.642
					0.642
3	Invertebrate	*Cancer anthonyi*	yellow crab	2	0.114
		Cancer gracilis	graceful crab	6	0.011
		Cancer jordani	hairy rock crab	7	0.008
		Caudina arenicola	sweet potatoe sea cucumber	2	0.212
		Crangon nigromaculata	blackspotted bay shrimp	6	0.022
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.006
		Dendraster excentricus	Pacific sand dollar	16	0.117
		Farfantepenaeus californiensis	yellowleg shrimp	1	0.023
		Isocheles pilosus	moon snail hermit	1	0.005
		Lepidopa californica	California mole crab	1	0.003
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.001
		Lophopanopeus frontalis	molarless crestleg crab	1	0.002
		Lophopanopeus sp	crestleg crab	1	0.001
		Panulirus interruptus	California spiny lobster	2	0.532
		Paraxanthias taylori	lumpy rubble crab	1	0.001
		Petrolisthes cabrilloi	Cabrillo porcelain crab	2	0.001
		Pilumnus spinohirsutus	retiring hairy crab	4	0.049
		Pisaster ochraceus	ochre star	2	0.263
		Polyorchis penicillatus	red jellyfish	1	0.001
		Portunus xantusii	Xantus swimming crab	6	0.054
		Pyromaia tuberculata	tuberculate pear crab	1	0.001
		Randallia ornata	globose sand crab	1	0.004
		Renilla kollikeri	sea pansy	1	0.001
		Strongylocentrotus purpuratus	purple sea urchin	1	0.001
				68	1.433

Survey Type: Normal Operations
Survey: SONGSNO34
Date: May 15, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinopsis californiensis*	jacksmelt	29	2.260
		Cymatogaster aggregata	shiner perch	9	0.106
		Embiotoca jacksoni	black perch	2	0.008
		Engraulis mordax	northern anchovy	81	0.847
		Genyonemus lineatus	white croaker	6	0.220
		Heterostichus rostratus	giant kelpfish	5	0.103
		Hypsoblennius gilberti	rockpool blenny	1	0.003
		Leptocottus armatus	Pacific staghorn sculpin	2	0.023
		Leuresthes tenuis	California grunion	17	0.364
		Mustelus californicus	grey smoothhound	1	0.567
		Myliobatis californica	bat ray	1	0.260
		Peprilus simillimus	Pacific pompano	29	1.043
		Phanerodon furcatus	white seaperch	6	0.017
		Porichthys notatus	plainfin midshipman	15	0.368
		Sardinops sagax	Pacific sardine	250	11.100
		Scomber japonicus	Pacific chub mackerel	8	0.642
		Scorpaena guttata	California scorpionfish	4	0.039
		Seriphus politus	queenfish	990	25.524
		Syngnathus californiensis	kelp pipefish	5	0.006
		Synodus lucioceps	California lizardfish	1	0.012
		Torpedo californica	Pacific electric ray	1	11.200
		Trachurus symmetricus	jack mackerel	3	0.192
				1,467	54.904
3	Fish eggs	Atherinopsidae	atherinopsid eggs		0.800
					0.800

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Survey Type: Normal Operations
Survey: SONGSNO34 (continued)
Date: May 15, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Invertebrate	*Astropecten armatus*	spiny sand star	1	0.034
		Cancer antennarius	Pacific rock crab	1	0.031
		Cancer anthonyi	yellow crab	1	0.003
		Cancer jordani	hairy rock crab	8	0.012
		Caudina arenicola	sweet potatoe sea cucumber	2	0.071
		Chrysaora colorata	purple-striped jellyfish	3	2.921
		Crangon nigromaculata	blackspotted bay shrimp	27	0.075
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.001
		Dendraster excentricus	Pacific sand dollar	26	0.172
		Farfantepenaeus californiensis	yellowleg shrimp	34	1.360
		Lophopanopeus frontalis	molarless crestleg crab	1	0.003
		Lysmata californica	red rock shrimp	1	0.001
		Neotrypaea californiensis	bay ghost shrimp	1	0.003
		Octopus bimaculatus/bimaculoides	California two-spot octopus	2	0.247
		Octopus rubescens	East Pacific red octopus	4	0.027
		Pachygrapsus crassipes	striped shore crab	1	0.001
		Panulirus interruptus	California spiny lobster	1	0.150
		Pinnixa barnharti	pea crab no common name	1	0.001
		Pisaster ochraceus	ochre star	1	0.165
		Polyorchis penicillatus	red jellyfish	1	0.002
		Portunus xantusii	Xantus swimming crab	11	0.049
		Pugettia producta	northern kelp crab	2	0.009
				131	5.338

Survey Type: Normal Operations
Survey: SONGSFRS01
Date: March 21, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	3	0.030
		Atherinopsis californiensis	jacksmelt	5	0.320
		Cymatogaster aggregata	shiner perch	33	0.997
		Embiotoca jacksoni	black perch	2	0.140
		Engraulis mordax	northern anchovy	43	0.107
		Genyonemus lineatus	white croaker	3	0.027
		Menticirrhus undulatus	California corbina	1	0.220
		Myliobatis californica	bat ray	4	1.450
		Peprilus simillimus	Pacific pompano	20	0.417
		Phanerodon furcatus	white seaperch	3	0.093
		Scorpaena guttata	California scorpionfish	3	0.140
		Seriphus politus	queenfish	87	1.320
		Synodus lucioceps	California lizardfish	8	0.770
		Xenistius californiensis	salema	17	0.457
				232	6.488
2	Invertebrate	*Loligo opalescens*	California market squid	1	0.080
		Panulirus interruptus	California spiny lobster	4	0.920
				5	1.000
3	Fish	*Atherinopsis californiensis*	jacksmelt	6	0.384
		Citharichthys stigmaeus	speckled sanddab	1	0.011
		Engraulis mordax	northern anchovy	73	0.130
		Heterostichus rostratus	giant kelpfish	1	0.080
		Myliobatis californica	bat ray	5	1.810
		Peprilus simillimus	Pacific pompano	3	0.062
		Seriphus politus	queenfish	34	0.833
		Sphyraena argentea	Pacific barracuda	1	0.500
		Synodus lucioceps	California lizardfish	4	0.038
		Xenistius californiensis	salema	4	0.110
				132	3.958
3	Invertebrate	*Panulirus interruptus*	California spiny lobster	5	1.050
				5	1.050

Survey Type: Normal Operations
Survey: SONGSFRS02
Date: April 4, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinopsis californiensis*	jacksmelt	130	10.333
		Atractoscion nobilis	white seabass	3	0.290
		Cymatogaster aggregata	shiner perch	7	0.190
		Embiotoca jacksoni	black perch	3	0.013
		Genyonemus lineatus	white croaker	3	0.013
		Hyperprosopon argenteum	walleye surfperch	3	0.133
		Peprilus simillimus	Pacific pompano	20	0.450
		Phanerodon furcatus	white seaperch	3	0.137
		Scorpaena guttata	California scorpionfish	8	0.584
		Seriphus politus	queenfish	3,553	65.707
		Synodus lucioceps	California lizardfish	7	0.010
		Xenistius californiensis	salema	17	0.520
				3,757	78.380
2	Invertebrate	*Crangon nigromaculata*	blackspotted bay shrimp	3	0.013
		Loxorhynchus grandis	sheep crab	1	1.000
		Panulirus interruptus	California spiny lobster	6	1.080
				10	2.093
3	Fish	*Atherinops affinis*	topsmelt	3	0.197
		Atherinopsis californiensis	jacksmelt	163	11.667
		Atractoscion nobilis	white seabass	1	0.100
		Cymatogaster aggregata	shiner perch	3	0.117
		Engraulis mordax	northern anchovy	270	0.423
		Myliobatis californica	bat ray	3	1.050
		Peprilus simillimus	Pacific pompano	87	0.733
		Phanerodon furcatus	white seaperch	3	0.150
		Seriphus politus	queenfish	1,313	25.147
		Synodus lucioceps	California lizardfish	4	0.040
				1,850	39.624
3	Invertebrate	*Loxorhynchus grandis*	sheep crab	1	1.100
				1	1.100

Survey Type: Normal Operations
Survey: SONGSFRS03
Date: April 18, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Brachyistius frenatus*	kelp perch	1	0.020
		Cymatogaster aggregata	shiner perch	2	0.050
		Embiotoca jacksoni	black perch	5	0.400
		Engraulis mordax	northern anchovy	130	0.314
		Heterostichus rostratus	giant kelpfish	1	0.050
		Myliobatis californica	bat ray	1	0.250
		Phanerodon furcatus	white seaperch	1	0.100
		Seriphus politus	queenfish	214	3.638
		Synodus lucioceps	California lizardfish	3	0.027
		Xenistius californiensis	salema	38	1.040
				396	5.889
2	Invertebrate	*Crangon nigromaculata*	blackspotted bay shrimp	1	0.005
				1	0.005
3	Fish	*Atherinopsis californiensis*	jacksmelt	17	1.243
		Citharichthys stigmaeus	speckled sanddab	9	0.023
		Cymatogaster aggregata	shiner perch	7	0.173
		Embiotoca jacksoni	black perch	3	0.023
		Engraulis mordax	northern anchovy	393	0.657
		Genyonemus lineatus	white croaker	1	0.030
		Myliobatis californica	bat ray	2	0.510
		Peprilus simillimus	Pacific pompano	3	0.090
		Seriphus politus	queenfish	165	4.591
		Synodus lucioceps	California lizardfish	6	0.090
				606	7.430
3	Invertebrate	*Loxorhynchus grandis*	sheep crab	2	0.500
		Neotrypaea gigas	giant ghost shrimp	1	0.004
		Portunus xantusii	Xantus swimming crab	2	0.040
				5	0.544

Survey Type: Normal Operations
Survey: SONGSFRS04
Date: May 2, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinopsis californiensis*	jacksmelt	2	0.400
		Engraulis mordax	northern anchovy	31	0.100
		Porichthys sp	midshipman unidentified	1	0.021
		Seriphus politus	queenfish	2	0.038
				36	0.559
3	Invertebrate	*Loxorhynchus grandis*	sheep crab	2	2.400
		Panulirus interruptus	California spiny lobster	4	2.000
		Portunus xantusii	Xantus swimming crab	1	0.007
				7	4.407

Survey Type: Normal Operations
Survey: SONGSFRS05
Date: May 16, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	30	1.056
		Atherinopsis californiensis	jacksmelt	10	1.067
		Embiotoca jacksoni	black perch	3	0.047
		Engraulis mordax	northern anchovy	380	6.436
		Hyperprosopon argenteum	walleye surfperch	10	0.617
		Medialuna californiensis	halfmoon	3	0.263
		Myliobatis californica	bat ray	1	0.449
		Paralabrax clathratus	kelp bass	3	0.143
		Peprilus simillimus	Pacific pompano	47	1.290
		Phanerodon furcatus	white seaperch	3	0.233
		Pleuronichthys ritteri	spotted turbot	3	0.653
		Pleuronichthys verticalis	hornyhead turbot	1	0.196
		Porichthys notatus	plainfin midshipman	3	0.093
		Rhinobatos productus	shovelnose guitarfish	1	0.400
		Sardinops sagax	Pacific sardine	150	1.875
		Scomber japonicus	Pacific chub mackerel	48	4.512
		Seriphus politus	queenfish	1,177	29.427
		Synodus lucioceps	California lizardfish	2	0.065
		Trachurus symmetricus	jack mackerel	7	0.480
		Xenistius californiensis	salema	533	19.533
				2,415	68.835
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	7	0.013
		Loxorhynchus grandis	sheep crab	1	1.000
		Panulirus interruptus	California spiny lobster	2	0.500
		Strongylocentrotus purpuratus	purple sea urchin	3	0.027
				13	1.540

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Survey Type: Normal Operations
Survey: SONGSFRS05 (continued)
Date: May 16, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinops affinis*	topsmelt	4	0.155
		Atherinopsis californiensis	jacksmelt	12	1.572
		Cymatogaster aggregata	shiner perch	3	0.013
		Engraulis mordax	northern anchovy	31	0.235
		Hyperprosopon argenteum	walleye surfperch	2	0.120
		Menticirrhus undulatus	California corbina	1	0.100
		Myliobatis californica	bat ray	6	3.300
		Ophichthus zophochir	yellow snake eel	1	0.100
		Paralichthys californicus	California halibut	1	0.200
		Peprilus simillimus	Pacific pompano	50	1.230
		Phanerodon furcatus	white seaperch	10	0.247
		Porichthys notatus	plainfin midshipman	1	0.100
		Roncador stearnsii	spotfin croaker	1	0.200
		Sardinops sagax	Pacific sardine	3	0.167
		Scomber japonicus	Pacific chub mackerel	21	1.883
		Scorpaena guttata	California scorpionfish	1	0.092
		Seriphus politus	queenfish	1,265	29.120
		Synodus lucioceps	California lizardfish	3	0.073
		Torpedo californica	Pacific electric ray	1	40.000
		Trachurus symmetricus	jack mackerel	7	0.330
		Xenistius californiensis	salema	100	3.328
				1,524	82.565
3	Invertebrate	*Cancer anthonyi*	yellow crab	1	0.080
		Crangon nigromaculata	blackspotted bay shrimp	3	0.010
		Farfantepenaeus californiensis	yellowleg shrimp	1	0.030
		Loligo opalescens	California market squid	1	0.030
		Loxorhynchus grandis	sheep crab	2	2.000
				8	2.150

Survey Type: Normal Operations
Survey: SONGSFRS06
Date: May 30, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	37	1.440
		Atherinopsis californiensis	jacksmelt	5	1.250
		Citharichthys stigmaeus	speckled sanddab	3	0.027
		Cymatogaster aggregata	shiner perch	43	0.783
		Embiotoca jacksoni	black perch	3	0.017
		Engraulis mordax	northern anchovy	110	2.120
		Genyonemus lineatus	white croaker	37	1.080
		Hyperprosopon argenteum	walleye surfperch	7	0.210
		Menticirrhus undulatus	California corbina	3	0.857
		Paralichthys californicus	California halibut	2	25.000
		Peprilus simillimus	Pacific pompano	583	15.403
		Phanerodon furcatus	white seaperch	253	0.847
		Rhacochilus toxotes	rubberlip seaperch	3	0.030
		Sardinops sagax	Pacific sardine	2,717	99.010
		Scorpaena guttata	California scorpionfish	3	0.043
		Seriphus politus	queenfish	4,613	130.083
		Trachurus symmetricus	jack mackerel	3	0.227
		Xenistius californiensis	salema	20	1.010
				8,445	279.437
2	Invertebrate	*Caudina arenicola*	sweet potatoe sea cucumber	1	0.177
				1	0.177
3	Fish	*Citharichthys stigmaeus*	speckled sanddab	3	0.003
		Cymatogaster aggregata	shiner perch	10	0.140
		Embiotoca jacksoni	black perch	7	0.057
		Engraulis mordax	northern anchovy	117	4.787
		Genyonemus lineatus	white croaker	23	0.750
		Hyperprosopon argenteum	walleye surfperch	3	0.027
		Peprilus simillimus	Pacific pompano	227	5.627
		Phanerodon furcatus	white seaperch	60	0.540
		Porichthys myriaster	specklefin midshipman	8	0.770
		Sardinops sagax	Pacific sardine	903	32.183
		Scomber japonicus	Pacific chub mackerel	7	0.683
		Seriphus politus	queenfish	2,087	140.567
		Trachurus symmetricus	jack mackerel	7	0.050
		Xenistius californiensis	salema	57	1.947
				3,519	188.131
3	Invertebrate	None			

Survey Type: Normal Operations
Survey: SONGSFRS07
Date: June 13, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	7	0.257
		Atherinopsis californiensis	jacksmelt	263	32.270
		Atractoscion nobilis	white seabass	30	6.367
		Cymatogaster aggregata	shiner perch	110	0.927
		Embiotoca jacksoni	black perch	3	0.020
		Genyonemus lineatus	white croaker	207	5.077
		Gymnura marmorata	California butterfly ray	3	0.753
		Hyperprosopon argenteum	walleye surfperch	10	0.520
		Menticirrhus undulatus	California corbina	10	2.253
		Myliobatis californica	bat ray	4	85.000
		Paralichthys californicus	California halibut	2	10.400
		Phanerodon furcatus	white seaperch	357	1.927
		Rhinobatos productus	shovelnose guitarfish	1	1.500
		Roncador stearnsii	spotfin croaker	133	43.070
		Seriphus politus	queenfish	2,583	84.860
		Umbrina roncador	yellowfin croaker	40	14.367
		Xenistius californiensis	salema	340	21.917
				4,103	311.485
2	Invertebrate	*Panulirus interruptus*	California spiny lobster	1	0.250
				1	0.250

Survey Type: Normal Operations
Survey: SONGSFRS08
Date: June 27, 2006

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	15	0.391
		Atherinopsis californiensis	jacksmelt	3	0.403
		Chromis punctipinnis	blacksmith	1	0.070
		Cymatogaster aggregata	shiner perch	37	0.190
		Embiotoca jacksoni	black perch	10	0.347
		Engraulis mordax	northern anchovy	10,723	10.986
		Genyonemus lineatus	white croaker	67	0.430
		Paralabrax clathratus	kelp bass	2	0.350
		Peprilus simillimus	Pacific pompano	20	1.167
		Phanerodon furcatus	white seaperch	40	0.893
		Pleuronichthys ritteri	spotted turbot	1	0.100
		Porichthys myriaster	specklefin midshipman	1	0.300
		Rhacochilus toxotes	rubberlip seaperch	1	0.120
		Roncador stearnsii	spotfin croaker	7	2.100
		Sardinops sagax	Pacific sardine	408	1.959
		Scorpaena guttata	California scorpionfish	7	0.340
		Seriphus politus	queenfish	3,356	141.380
		Synodus lucioceps	California lizardfish	1	0.070
		Trachurus symmetricus	jack mackerel	40	0.697
		Xenistius californiensis	salema	7	0.500
				14,747	162.793
2	Invertebrate	*Panulirus interruptus*	California spiny lobster	3	0.350
				3	0.350

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Survey Type: Normal Operations
Survey: SONGSFRS08 (continued)
Date: June 27, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Amphistichus argenteus*	barred surfperch	3	0.360
		Atherinops affinis	topsmelt	53	1.700
		Atherinopsis californiensis	jacksmelt	14	1.690
		Citharichthys stigmaeus	speckled sanddab	3	0.043
		Cymatogaster aggregata	shiner perch	67	0.500
		Embiotoca jacksoni	black perch	3	0.013
		Engraulis mordax	northern anchovy	11,849	8.144
		Genyonemus lineatus	white croaker	27	0.517
		Heterostichus rostratus	giant kelpfish	3	0.007
		Hyperprosopon argenteum	walleye surfperch	7	0.433
		Myliobatis californica	bat ray	2	0.250
		Peprilus simillimus	Pacific pompano	40	1.820
		Phanerodon furcatus	white seaperch	90	0.663
		Sardinops sagax	Pacific sardine	1,170	1.970
		Seriphus politus	queenfish	733	34.000
		Squalus acanthias	spiny dogfish	2	6.000
		Trachurus symmetricus	jack mackerel	70	1.513
		Xenistius californiensis	salema	50	2.800
				14,186	62.423
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	7	0.003
		Cancer anthonyi	yellow crab	3	0.003
		Loxorhynchus grandis	sheep crab	2	0.250
		Octopus rubescens	East Pacific red octopus	3	0.003
		Pugettia producta	northern kelp crab	3	0.007
		Strongylocentrotus purpuratus	purple sea urchin	3	0.017
				21	0.283

Survey Type: Normal Operations
Survey: SONGSFRS09
Date: July 11, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	13	0.657
		Atherinopsis californiensis	jacksmelt	14	2.212
		Atractoscion nobilis	white seabass	4	0.900
		Engraulis mordax	northern anchovy	14,070	5.613
		Genyonemus lineatus	white croaker	13	0.367
		Hyperprosopon argenteum	walleye surfperch	7	0.440
		Menticirrhus undulatus	California corbina	5	0.500
		Phanerodon furcatus	white seaperch	9	0.720
		Rhacochilus vacca	pile perch	1	0.250
		Sardinops sagax	Pacific sardine	10	0.003
		Scomber japonicus	Pacific chub mackerel	1	0.140
		Seriphus politus	queenfish	70	2.777
		Trachurus symmetricus	jack mackerel	4	0.240
		Umbrina roncador	yellowfin croaker	1	0.475
		Xenistius californiensis	salema	165	8.270
				14,387	23.564
2	Invertebrate	*Cancer anthonyi*	yellow crab	3	0.003
		Loxorhynchus grandis	sheep crab	1	0.450
		Panulirus interruptus	California spiny lobster	4	1.000
		Strongylocentrotus purpuratus	purple sea urchin	3	0.003
				11	1.456
3	Fish	*Atherinopsis californiensis*	jacksmelt	4	0.800
		Atractoscion nobilis	white seabass	1	0.198
		Cheilotrema saturnum	black croaker	1	0.095
		Engraulis mordax	northern anchovy	1,400	0.777
		Hermosilla azurea	zebraperch	1	0.400
		Hyperprosopon argenteum	walleye surfperch	17	0.160
		Myliobatis californica	bat ray	2	40.000
		Phanerodon furcatus	white seaperch	3	0.253
		Roncador stearnsii	spotfin croaker	10	6.490
		Sardinops sagax	Pacific sardine	33	0.067
		Seriphus politus	queenfish	50	3.030
		Umbrina roncador	yellowfin croaker	150	72.330
		Xenistius californiensis	salema	60	3.550
				1,732	128.150
3	Invertebrate	*Loxorhynchus grandis*	sheep crab	1	1.000
		Panulirus interruptus	California spiny lobster	6	1.800
				7	2.800

Survey Type: Normal Operations
Survey: SONGSFRS10
Date: July 25, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	160	5.847
		Atherinopsis californiensis	jacksmelt	7	1.697
		Atractoscion nobilis	white seabass	2	0.500
		Menticirrhus undulatus	California corbina	3	0.450
		Myliobatis californica	bat ray	1	0.300
		Porichthys notatus	plainfin midshipman	1	0.200
		Roncador stearnsii	spotfin croaker	8	3.120
		Seriphus politus	queenfish	223	8.057
		Sphyraena argentea	Pacific barracuda	2	0.160
		Umbrina roncador	yellowfin croaker	3,224	1,394.091
		Xenistius californiensis	salema	2,243	126.326
				5,874	1,540.748
2	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	1	0.067
		Loxorhynchus grandis	sheep crab	2	1.200
		Panulirus interruptus	California spiny lobster	7	2.920
		Strongylocentrotus franciscanus	red sea urchin	1	0.199
				11	4.386
3	Fish	*Atherinopsis californiensis*	jacksmelt	82	8.200
		Atractoscion nobilis	white seabass	3	1.047
		Cymatogaster aggregata	shiner perch	3	0.020
		Engraulis mordax	northern anchovy	28,000	20.160
		Genyonemus lineatus	white croaker	220	1.430
		Menticirrhus undulatus	California corbina	7	1.386
		Myliobatis californica	bat ray	2	0.600
		Phanerodon furcatus	white seaperch	3	0.293
		Roncador stearnsii	spotfin croaker	44	17.220
		Sardinops sagax	Pacific sardine	3	0.003
		Seriphus politus	queenfish	653	24.960
		Umbrina roncador	yellowfin croaker	500	265.430
		Xenistius californiensis	salema	1,050	52.970
				30,570	393.719
3	Invertebrate	*Loxorhynchus grandis*	sheep crab	1	0.500
		Panulirus interruptus	California spiny lobster	4	1.600
				5	2.100

Survey Type: Normal Operations
Survey: SONGSFRS11
Date: August 8, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	7	0.083
		Anisotremus davidsonii	sargo	3	0.267
		Atherinops affinis	topsmelt	7	0.167
		Atherinopsis californiensis	jacksmelt	1	0.180
		Atractoscion nobilis	white seabass	4	0.275
		Cymatogaster aggregata	shiner perch	20	0.227
		Embiotoca jacksoni	black perch	1	0.200
		Engraulis mordax	northern anchovy	63,335	56.115
		Genyonemus lineatus	white croaker	13	0.060
		Gymnura marmorata	California butterfly ray	2	1.500
		Hyperprosopon argenteum	walleye surfperch	18	0.288
		Menticirrhus undulatus	California corbina	2	0.220
		Paralichthys californicus	California halibut	4	0.462
		Peprilus simillimus	Pacific pompano	7	0.273
		Phanerodon furcatus	white seaperch	13	1.140
		Rhinobatos productus	shovelnose guitarfish	2	5.000
		Roncador stearnsii	spotfin croaker	36	14.803
		Sardinops sagax	Pacific sardine	270	0.383
		Scorpaena guttata	California scorpionfish	1	0.050
		Seriphus politus	queenfish	377	10.097
		Squalus acanthias	spiny dogfish	2	4.000
		Triakis semifasciata	leopard shark	2	2.100
		Umbrina roncador	yellowfin croaker	361	211.990
		Xenistius californiensis	salema	230	10.063
				64,718	319.943
2	Invertebrate	*Panulirus interruptus*	California spiny lobster	4	0.880
				4	0.880

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Survey Type: Normal Operations
Survey: SONGSFRS11 (continued)
Date: August 8, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anisotremus davidsonii*	sargo	20	2.607
		Atherinopsis californiensis	jacksmelt	2	0.500
		Atractoscion nobilis	white seabass	1	0.300
		Engraulis mordax	northern anchovy	245	0.367
		Gymnura marmorata	California butterfly ray	1	10.000
		Hermosilla azurea	zebraperch	1	0.550
		Hyperprosopon argenteum	walleye surfperch	20	1.097
		Medialuna californiensis	halfmoon	3	0.813
		Menticirrhus undulatus	California corbina	3	0.780
		Myliobatis californica	bat ray	1	1.000
		Paralichthys californicus	California halibut	2	2.600
		Phanerodon furcatus	white seaperch	7	0.433
		Porichthys myriaster	specklefin midshipman	1	0.600
		Roncador stearnsii	spotfin croaker	63	30.043
		Seriphus politus	queenfish	117	8.007
		Umbrina roncador	yellowfin croaker	1,963	755.520
		Xenistius californiensis	salema	113	5.523
				2,563	820.740
3	Invertebrate	*Cancer anthonyi*	yellow crab	3	0.003
				3	0.003

Survey Type: Normal Operations
Survey: SONGSFRS12
Date: August 22, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anisotremus davidsonii*	sargo	2	0.120
		Atherinopsis californiensis	jacksmelt	12	1.440
		Cymatogaster aggregata	shiner perch	3	0.063
		Embiotoca jacksoni	black perch	5	0.500
		Engraulis mordax	northern anchovy	56	0.056
		Genyonemus lineatus	white croaker	1	0.050
		Hyperprosopon argenteum	walleye surfperch	13	0.300
		Paralabrax clathratus	kelp bass	1	0.150
		Paralabrax nebulifer	barred sand bass	1	0.200
		Phanerodon furcatus	white seaperch	2	0.164
		Roncador stearnsii	spotfin croaker	6	3.600
		Sardinops sagax	Pacific sardine	3	0.003
		Seriphus politus	queenfish	104	2.857
		Umbrina roncador	yellowfin croaker	64	30.000
		Xenistius californiensis	salema	18	0.834
				291	40.337
2	Invertebrate	*Caudina arenicola*	sweet potatoe sea cucumber	1	
				1	
3	Fish	*Anisotremus davidsonii*	sargo	7	0.700
		Atherinopsis californiensis	jacksmelt	3	0.360
		Balistes polylepis	finescale triggerfish	1	2.500
		Cymatogaster aggregata	shiner perch	7	0.020
		Engraulis mordax	northern anchovy	496	0.650
		Genyonemus lineatus	white croaker	50	0.157
		Gymnura marmorata	California butterfly ray	1	1.000
		Hyperprosopon argenteum	walleye surfperch	12	0.280
		Paralichthys californicus	California halibut	2	0.200
		Phanerodon furcatus	white seaperch	23	1.893
		Roncador stearnsii	spotfin croaker	2	1.400
		Sardinops sagax	Pacific sardine	21	0.250
		Seriphus politus	queenfish	3,637	10.893
		Xenistius californiensis	salema	15	0.720
				4,277	21.023
3	Invertebrate	*Panulirus interruptus*	California spiny lobster	2	0.520
				2	0.520

Survey Type: Normal Operations
Survey: SONGSFRS13
Date: September 6, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anisotremus davidsonii*	sargo	9	1.350
		Atherinops affinis	topsmelt	20	0.640
		Atherinopsis californiensis	jacksmelt	3	0.580
		Atractoscion nobilis	white seabass	2	0.400
		Engraulis mordax	northern anchovy	79	0.220
		Hyperprosopon argenteum	walleye surfperch	10	0.240
		Scomber japonicus	Pacific chub mackerel	12	1.668
		Seriphus politus	queenfish	253	5.680
				388	10.778
2	Invertebrate	None			
3	Fish	*Anisotremus davidsonii*	sargo	1	0.150
		Engraulis mordax	northern anchovy	1,703	3.145
		Hyperprosopon argenteum	walleye surfperch	1	0.020
		Medialuna californiensis	halfmoon	1	0.200
		Paralichthys californicus	California halibut	4	0.400
		Phanerodon furcatus	white seaperch	1	0.150
		Porichthys myriaster	specklefin midshipman	1	0.200
		Roncador stearnsii	spotfin croaker	9	4.630
		Scomber japonicus	Pacific chub mackerel	2	0.280
		Seriphus politus	queenfish	101	2.930
		Sphyraena argentea	Pacific barracuda	3	0.043
		Xenistius californiensis	salema	77	3.820
				1,904	15.968
3	Invertebrate	*Panulirus interruptus*	California spiny lobster	1	0.500
				1	0.500

Survey Type: Normal Operations
Survey: SONGSFRS14
Date: September 19, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	17	0.200
		Anisotremus davidsonii	sargo	3	0.320
		Atractoscion nobilis	white seabass	1	0.200
		Embiotoca jacksoni	black perch	1	0.080
		Engraulis mordax	northern anchovy	1,530	2.117
		Genyonemus lineatus	white croaker	2	0.080
		Heterodontus francisci	horn shark	2	3.200
		Hyperprosopon argenteum	walleye surfperch	2	0.038
		Menticirrhus undulatus	California corbina	1	0.200
		Paralabrax nebulifer	barred sand bass	1	0.200
		Paralichthys californicus	California halibut	2	0.250
		Phanerodon furcatus	white seaperch	11	0.790
		Rhacochilus toxotes	rubberlip seaperch	3	0.147
		Seriphus politus	queenfish	954	5.137
		Trachurus symmetricus	jack mackerel	3	0.063
		Xenistius californiensis	salema	225	8.560
				2,758	21.582
2	Invertebrate	*Panulirus interruptus*	California spiny lobster	7	1.750
				7	1.750
3	Fish	*Anchoa compressa*	deepbody anchovy	3	0.040
		Anisotremus davidsonii	sargo	27	5.400
		Atherinops affinis	topsmelt	10	0.440
		Embiotoca jacksoni	black perch	1	0.180
		Engraulis mordax	northern anchovy	764	0.960
		Hyperprosopon argenteum	walleye surfperch	3	0.045
		Medialuna californiensis	halfmoon	1	0.200
		Paralichthys californicus	California halibut	1	0.250
		Peprilus simillimus	Pacific pompano	2	0.060
		Roncador stearnsii	spotfin croaker	6	4.610
		Scomber japonicus	Pacific chub mackerel	2	0.280
		Seriphus politus	queenfish	643	2.810
		Umbrina roncador	yellowfin croaker	2	0.440
		Xenistius californiensis	salema	40	1.600
				1,505	17.315
3	Invertebrate	*Loxorhynchus grandis*	sheep crab	1	1.500
				1	1.500

Survey Type: Normal Operations
Survey: SONGSFRS15
Date: October 3, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	10	0.123
		Atherinops affinis	topsmelt	1	0.035
		Atractoscion nobilis	white seabass	3	0.157
		Engraulis mordax	northern anchovy	1,130	2.000
		Hyperprosopon argenteum	walleye surfperch	10	0.217
		Paralabrax clathratus	kelp bass	1	0.150
		Paralabrax nebulifer	barred sand bass	3	0.423
		Paralichthys californicus	California halibut	2	0.200
		Peprilus simillimus	Pacific pompano	33	1.077
		Phanerodon furcatus	white seaperch	4	0.400
		Porichthys myriaster	specklefin midshipman	1	0.300
		Scomber japonicus	Pacific chub mackerel	50	6.883
		Scorpaena guttata	California scorpionfish	4	0.400
		Seriphus politus	queenfish	563	9.583
		Sphyraena argentea	Pacific barracuda	1	0.035
		Umbrina roncador	yellowfin croaker	1	0.200
		Xenistius californiensis	salema	495	10.100
				2,312	32.283
2	Invertebrate	None			
3	Fish	*Anchoa compressa*	deepbody anchovy	47	0.557
		Atherinopsis californiensis	jacksmelt	1	0.150
		Atractoscion nobilis	white seabass	1	0.100
		Cymatogaster aggregata	shiner perch	3	0.033
		Embiotoca jacksoni	black perch	1	0.120
		Engraulis mordax	northern anchovy	3,770	5.150
		Heterostichus rostratus	giant kelpfish	1	0.002
		Hyperprosopon argenteum	walleye surfperch	1	0.030
		Paralichthys californicus	California halibut	11	1.100
		Peprilus simillimus	Pacific pompano	20	0.640
		Roncador stearnsii	spotfin croaker	12	6.240
		Sardinops sagax	Pacific sardine	10	0.057
		Scomber japonicus	Pacific chub mackerel	25	3.450
		Seriphus politus	queenfish	474	8.413
		Sphyraena argentea	Pacific barracuda	1	0.080
		Synodus lucioceps	California lizardfish	1	0.120
		Umbrina roncador	yellowfin croaker	1	0.200
		Xenistius californiensis	salema	150	6.750
				4,530	33.192
3	Invertebrate	*Panulirus interruptus*	California spiny lobster	2	0.650
				2	0.650

Survey Type: Normal Operations
Survey: SONGSFRS16
Date: October 17, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinopsis californiensis*	jacksmelt	2	0.240
		Embiotoca jacksoni	black perch	1	0.200
		Engraulis mordax	northern anchovy	559	0.604
		Genyonemus lineatus	white croaker	7	0.217
		Hyperprosopon argenteum	walleye surfperch	8	0.168
		Sardinops sagax	Pacific sardine	19	0.619
		Scomber japonicus	Pacific chub mackerel	130	14.370
		Seriphus politus	queenfish	420	3.703
		Sphyraena argentea	Pacific barracuda	2	0.045
		Trachurus symmetricus	jack mackerel	3	0.210
		Xenistius californiensis	salema	15	0.570
				1,166	20.946
2	Invertebrate	*Cancer jordani*	hairy rock crab	3	0.003
				3	0.003
3	Fish	None			
3	Invertebrate	None			

Survey Type: Normal Operations
Survey: SONGSFRS17
Date: October 31, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	20	0.213
		Anisotremus davidsonii	sargo	2	0.300
		Atherinops affinis	topsmelt	37	1.273
		Atherinopsis californiensis	jacksmelt	11	3.256
		Atractoscion nobilis	white seabass	3	0.103
		Embiotoca jacksoni	black perch	3	0.330
		Engraulis mordax	northern anchovy	3	0.003
		Genyonemus lineatus	white croaker	12	0.343
		Hyperprosopon argenteum	walleye surfperch	11	0.282
		Menticirrhus undulatus	California corbina	1	0.150
		Paralichthys californicus	California halibut	2	0.100
		Phanerodon furcatus	white seaperch	10	0.260
		Platyrhinoidis triseriata	thornback	1	0.010
		Roncador stearnsii	spotfin croaker	3	1.500
		Scomber japonicus	Pacific chub mackerel	40	5.350
		Seriphus politus	queenfish	367	3.033
		Umbrina roncador	yellowfin croaker	8	0.960
		Xenistius californiensis	salema	10	0.280
				544	17.746

2	Invertebrate	None

Survey Type: Normal Operations
Survey: SONGSFRS18
Date: November 14, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	110	0.870
		Atherinops affinis	topsmelt	50	2.260
		Atherinopsis californiensis	jacksmelt	5	0.580
		Atractoscion nobilis	white seabass	5	0.250
		Embiotoca jacksoni	black perch	1	0.122
		Engraulis mordax	northern anchovy	60	0.100
		Genyonemus lineatus	white croaker	467	5.133
		Heterostichus rostratus	giant kelpfish	1	0.011
		Hyperprosopon argenteum	walleye surfperch	2	0.060
		Leuresthes tenuis	California grunion	3	0.076
		Myliobatis californica	bat ray	1	30.000
		Paralichthys californicus	California halibut	1	0.100
		Peprilus simillimus	Pacific pompano	17	0.330
		Phanerodon furcatus	white seaperch	3	0.057
		Roncador stearnsii	spotfin croaker	1	0.300
		Sardinops sagax	Pacific sardine	570	20.413
		Scomber japonicus	Pacific chub mackerel	18	2.080
		Seriphus politus	queenfish	1,226	10.407
		Sphyraena argentea	Pacific barracuda	5	0.400
		Synodus lucioceps	California lizardfish	4	0.090
		Trachurus symmetricus	jack mackerel	3	0.450
		Xenistius californiensis	salema	27	0.090
				2,580	74.179
2	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	1	0.030
		Panulirus interruptus	California spiny lobster	4	1.000
				5	1.030

Survey Type: Normal Operations
Survey: SONGSFRS19
Date: November 28, 2006

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
2	Fish	*Amphistichus argenteus*	barred surfperch	1	0.108
		Anchoa compressa	deepbody anchovy	1,407	16.343
		Anchoa delicatissima	slough anchovy	7	0.020
		Atherinops affinis	topsmelt	53	1.977
		Atherinopsis californiensis	jacksmelt	27	5.120
		Atractoscion nobilis	white seabass	3	0.117
		Cheilotrema saturnum	black croaker	3	0.370
		Embiotoca jacksoni	black perch	1	0.100
		Engraulis mordax	northern anchovy	500	0.783
		Genyonemus lineatus	white croaker	40	0.510
		Hyperprosopon argenteum	walleye surfperch	60	2.087
		Phanerodon furcatus	white seaperch	7	0.300
		Roncador stearnsii	spotfin croaker	5	2.330
		Sardinops sagax	Pacific sardine	93	3.703
		Scomber japonicus	Pacific chub mackerel	81	8.156
		Scorpaena guttata	California scorpionfish	6	0.476
		Seriphus politus	queenfish	5,940	44.810
		Xenistius californiensis	salema	93	3.173
				8,327	90.483
2	Invertebrate	None			

Survey Type: Normal Operations
Survey: SONGSFRS20
Date: December 12, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	753	7.833
		Atherinops affinis	topsmelt	23	0.393
		Atherinopsis californiensis	jacksmelt	38	8.740
		Atractoscion nobilis	white seabass	3	0.332
		Cymatogaster aggregata	shiner perch	10	0.300
		Engraulis mordax	northern anchovy	517	0.803
		Genyonemus lineatus	white croaker	53	0.650
		Heterostichus rostratus	giant kelpfish	1	0.010
		Hyperprosopon argenteum	walleye surfperch	240	6.653
		Leptocottus armatus	Pacific staghorn sculpin	1	0.035
		Medialuna californiensis	halfmoon	5	0.500
		Menticirrhus undulatus	California corbina	2	0.250
		Myliobatis californica	bat ray	5	32.369
		Ophidion scrippsae	basketweave cusk-eel	3	0.003
		Paralabrax nebulifer	barred sand bass	3	0.003
		Paralichthys californicus	California halibut	4	0.400
		Peprilus simillimus	Pacific pompano	3	0.027
		Phanerodon furcatus	white seaperch	60	5.903
		Platyrhinoidis triseriata	thornback	2	2.200
		Pleuronichthys guttulatus	diamond turbot	1	0.310
		Porichthys myriaster	specklefin midshipman	1	0.080
		Roncador stearnsii	spotfin croaker	23	11.160
		Sardinops sagax	Pacific sardine	127	3.283
		Scomber japonicus	Pacific chub mackerel	25	1.250
		Seriphus politus	queenfish	1,267	7.370
		Sphyraena argentea	Pacific barracuda	1	0.100
		Synodus lucioceps	California lizardfish	1	0.020
		Umbrina roncador	yellowfin croaker	4	0.510
		Xenistius californiensis	salema	77	0.793
				3,253	92.280
2	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	1	0.024
				1	0.024

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Survey Type: Normal Operations
Survey: SONGSFRS20 (continued)
Date: December 12, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	333	3.713
		Atherinops affinis	topsmelt	2	0.053
		Atherinopsis californiensis	jacksmelt	7	1.645
		Atractoscion nobilis	white seabass	4	0.484
		Embiotoca jacksoni	black perch	1	0.100
		Engraulis mordax	northern anchovy	1,243	1.953
		Genyonemus lineatus	white croaker	73	3.267
		Heterostichus rostratus	giant kelpfish	1	0.010
		Hyperprosopon argenteum	walleye surfperch	85	1.280
		Medialuna californiensis	halfmoon	1	0.120
		Menticirrhus undulatus	California corbina	2	0.120
		Myliobatis californica	bat ray	1	0.250
		Phanerodon furcatus	white seaperch	2	0.182
		Roncador stearnsii	spotfin croaker	12	3.456
		Sardinops sagax	Pacific sardine	90	2.897
		Scomber japonicus	Pacific chub mackerel	3	0.120
		Scorpaena guttata	California scorpionfish	2	0.120
		Seriphus politus	queenfish	1,967	22.523
		Umbrina roncador	yellowfin croaker	4	0.516
		Xenistius californiensis	salema	27	0.263
				3,860	43.072
3	Invertebrate	*Cancer* sp	cancer crab unid	1	0.050
				1	0.050

Survey Type: Normal Operations
Survey: SONGSFRS21
Date: December 27, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	407	4.413
		Anchoa delicatissima	slough anchovy	3	0.013
		Atherinops affinis	topsmelt	7	0.060
		Atherinopsis californiensis	jacksmelt	4	0.520
		Cymatogaster aggregata	shiner perch	3	0.037
		Embiotoca jacksoni	black perch	2	0.240
		Engraulis mordax	northern anchovy	687	1.657
		Genyonemus lineatus	white croaker	13	0.320
		Hyperprosopon argenteum	walleye surfperch	23	0.603
		Menticirrhus undulatus	California corbina	2	0.300
		Myliobatis californica	bat ray	2	0.700
		Paralabrax clathratus	kelp bass	1	0.120
		Paralichthys californicus	California halibut	1	0.046
		Peprilus simillimus	Pacific pompano	23	0.347
		Phanerodon furcatus	white seaperch	7	0.603
		Pleuronichthys ritteri	spotted turbot	1	0.010
		Rhinobatos productus	shovelnose guitarfish	1	6.000
		Roncador stearnsii	spotfin croaker	1	0.022
		Sardinops sagax	Pacific sardine	55	1.450
		Seriphus politus	queenfish	650	7.440
		Stereolepis gigas	giant sea bass	1	0.010
		Syngnathus californiensis	kelp pipefish	3	0.010
		Syngnathus sp	pipefish unid.	2	0.006
		Xenistius californiensis	salema	147	0.943
				2,046	25.870
2	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	1	0.060
		Panulirus interruptus	California spiny lobster	3	0.750
				4	0.810

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Survey Type: Normal Operations
Survey: SONGSFRS21 (continued)
Date: December 27, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	173	1.827
		Atherinopsis californiensis	jacksmelt	7	0.983
		Atractoscion nobilis	white seabass	1	0.080
		Cheilotrema saturnum	black croaker	1	0.010
		Engraulis mordax	northern anchovy	445	0.900
		Genyonemus lineatus	white croaker	3	0.093
		Gymnura marmorata	California butterfly ray	1	0.200
		Hyperprosopon argenteum	walleye surfperch	3	0.067
		Myliobatis californica	bat ray	3	1.053
		Paralichthys californicus	California halibut	2	0.200
		Peprilus simillimus	Pacific pompano	30	0.330
		Phanerodon furcatus	white seaperch	1	0.150
		Pleuronichthys ritteri	spotted turbot	1	0.100
		Rhinobatos productus	shovelnose guitarfish	2	10.000
		Roncador stearnsii	spotfin croaker	1	0.800
		Sardinops sagax	Pacific sardine	281	7.760
		Seriphus politus	queenfish	243	2.390
		Torpedo californica	Pacific electric ray	1	30.000
		Umbrina roncador	yellowfin croaker	1	0.080
		Xenistius californiensis	salema	13	0.093
				1,213	57.116
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	2	0.160
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.100
		Panulirus interruptus	California spiny lobster	1	0.250
				4	0.510

Survey Type: Normal Operations
Survey: SONGSFRS22
Date: January 9, 2007

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	213	1.760
		Anchoa delicatissima	slough anchovy	10	0.027
		Atherinops affinis	topsmelt	10	0.233
		Atherinopsis californiensis	jacksmelt	40	6.590
		Embiotoca jacksoni	black perch	4	0.550
		Engraulis mordax	northern anchovy	73	0.200
		Genyonemus lineatus	white croaker	3	0.030
		Hyperprosopon argenteum	walleye surfperch	6	0.240
		Hypsypops rubicundus	garibaldi	1	0.300
		Phanerodon furcatus	white seaperch	2	0.160
		Sardinops sagax	Pacific sardine	3	0.060
		Scorpaena guttata	California scorpionfish	1	0.050
		Seriphus politus	queenfish	294	1.882
		Xenistius californiensis	salema	7	0.039
				667	12.121
2	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	1	0.060
		Panulirus interruptus	California spiny lobster	2	0.400
				3	0.460
3	Fish	*Anchoa compressa*	deepbody anchovy	80	0.507
		Anchoa delicatissima	slough anchovy	13	0.037
		Atherinops affinis	topsmelt	13	0.190
		Engraulis mordax	northern anchovy	180	0.353
		Paralichthys californicus	California halibut	1	0.100
		Seriphus politus	queenfish	103	0.500
		Xenistius californiensis	salema	17	0.120
				407	1.807
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	1	0.200
		Farfantepenaeus californiensis	yellowleg shrimp	1	0.050
				2	0.250

Survey Type: Normal Operations
Survey: SONGSFRS23
Date: January 23, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	1	0.019
		Atherinops affinis	topsmelt	1	0.020
		Atherinopsis californiensis	jacksmelt	48	9.620
		Engraulis mordax	northern anchovy	47	0.170
		Genyonemus lineatus	white croaker	1	0.030
		Hyperprosopon argenteum	walleye surfperch	14	0.140
		Menticirrhus undulatus	California corbina	1	0.080
		Paralabrax nebulifer	barred sand bass	6	0.420
		Paralichthys californicus	California halibut	1	0.100
		Phanerodon furcatus	white seaperch	1	0.050
		Sardinops sagax	Pacific sardine	20	0.456
		Scomber japonicus	Pacific chub mackerel	1	0.065
		Scorpaena guttata	California scorpionfish	6	0.867
		Seriphus politus	queenfish	69	0.360
		Xenistius californiensis	salema	92	0.610
				309	13.007
2	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	1	0.030
				1	0.030
3	Fish	*Acanthogobius flavimanus*	yellowfin goby	1	0.050
		Atherinops affinis	topsmelt	1	0.020
		Atherinopsis californiensis	jacksmelt	24	1.880
		Cheilotrema saturnum	black croaker	1	0.050
		Engraulis mordax	northern anchovy	171	0.170
		Hyperprosopon argenteum	walleye surfperch	13	0.130
		Scomber japonicus	Pacific chub mackerel	1	0.066
		Seriphus politus	queenfish	106	0.390
		Xenistius californiensis	salema	50	0.250
				368	3.006
3	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	7	0.140
		Loxorhynchus grandis	sheep crab	1	1.000
				8	1.140

Survey Type: Normal Operations
Survey: SONGSFRS24
Date: February 6, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	90	1.080
		Anchoa delicatissima	slough anchovy	3	0.007
		Atherinops affinis	topsmelt	7	0.220
		Atherinopsis californiensis	jacksmelt	11	2.365
		Cymatogaster aggregata	shiner perch	3	0.070
		Embiotoca jacksoni	black perch	2	0.200
		Engraulis mordax	northern anchovy	244	0.911
		Hyperprosopon argenteum	walleye surfperch	27	0.860
		Phanerodon furcatus	white seaperch	3	0.213
		Scomber japonicus	Pacific chub mackerel	1	0.100
		Seriphus politus	queenfish	813	4.733
		Torpedo californica	Pacific electric ray	1	30.000
		Xenistius californiensis	salema	100	0.777
				1,305	41.536
2	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	10	0.213
				10	0.213
3	Fish	*Anchoa compressa*	deepbody anchovy	37	0.410
		Atherinopsis californiensis	jacksmelt	7	0.510
		Embiotoca jacksoni	black perch	1	0.100
		Engraulis mordax	northern anchovy	382	1.133
		Genyonemus lineatus	white croaker	3	0.037
		Heterostichus rostratus	giant kelpfish	1	0.030
		Hyperprosopon argenteum	walleye surfperch	11	0.260
		Menticirrhus undulatus	California corbina	1	0.100
		Phanerodon furcatus	white seaperch	1	0.080
		Pleuronichthys ritteri	spotted turbot	1	0.100
		Sardinops sagax	Pacific sardine	2	0.060
		Scomber japonicus	Pacific chub mackerel	2	0.200
		Seriphus politus	queenfish	217	1.543
		Xenistius californiensis	salema	165	0.990
				831	5.553
3	Fish eggs	Atherinopsidae	atherinopsid eggs		0.070
					0.070
3	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	11	0.204
		Panulirus interruptus	California spiny lobster	1	0.200
		Portunus xantusii	Xantus swimming crab	1	0.010
				13	0.414

Survey Type: Normal Operations
Survey: SONGSFRS25 [Diel 12 hours]
Date: February 20, 2007

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
2	Fish	*Atherinopsis californiensis*	jacksmelt	1	0.080
		Engraulis mordax	northern anchovy	10	0.015
		Heterostichus rostratus	giant kelpfish	6	0.054
		Seriphus politus	queenfish	26	0.780
		Xenistius californiensis	salema	5	0.045
				48	0.974
2	Invertebrate	*Octopus bimaculatus/bimaculoides*	California two-spot octopus	1	0.150
		Panulirus interruptus	California spiny lobster	1	0.250
		Portunus xantusii	Xantus swimming crab	1	0.010
				3	0.410
3	Fish	*Atherinopsis californiensis*	jacksmelt	17	1.360
		Engraulis mordax	northern anchovy	4	0.010
		Heterostichus rostratus	giant kelpfish	2	0.020
		Hyperprosopon argenteum	walleye surfperch	3	0.120
		Menticirrhus undulatus	California corbina	2	0.210
		Peprilus simillimus	Pacific pompano	1	0.010
		Scorpaena guttata	California scorpionfish	1	0.080
		Seriphus politus	queenfish	10	0.300
		Xenistius californiensis	salema	39	0.350
				79	2.460
3	Invertebrate	*Pagurus* sp	hermit crab unid	1	0.005
		Panulirus interruptus	California spiny lobster	3	0.550
				4	0.555

Survey Type: Normal Operations
Survey: SONGSFRS26 [Diel 24 hours]
Date: February 21, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	7	0.063
		Atherinopsis californiensis	jacksmelt	10	0.650
		Engraulis mordax	northern anchovy	227	0.397
		Genyonemus lineatus	white croaker	7	0.017
		Gymnura marmorata	California butterfly ray	1	0.500
		Heterostichus rostratus	giant kelpfish	2	0.020
		Hyperprosopon argenteum	walleye surfperch	21	0.830
		Paralabrax nebulifer	barred sand bass	1	0.300
		Pleuronichthys ritteri	spotted turbot	1	0.100
		Sardinops sagax	Pacific sardine	24	1.070
		Scomber japonicus	Pacific chub mackerel	9	0.800
		Scorpaena guttata	California scorpionfish	1	0.080
		Seriphus politus	queenfish	1,066	10.840
		Trachurus symmetricus	jack mackerel	1	0.080
		Xenistius californiensis	salema	320	2.873
				1,698	18.620
2	Invertebrate	*Cancer* sp	cancer crab unid	1	0.010
		Crangon nigromaculata	blackspotted bay shrimp	1	0.003
		Panulirus interruptus	California spiny lobster	1	0.250
		Portunus xantusii	Xantus swimming crab	1	0.006
				4	0.269
3	Fish	*Atherinopsis californiensis*	jacksmelt	24	1.560
		Engraulis mordax	northern anchovy	59	0.260
		Hyperprosopon argenteum	walleye surfperch	27	0.860
		Sardinops sagax	Pacific sardine	4	0.180
		Scomber japonicus	Pacific chub mackerel	14	1.040
		Seriphus politus	queenfish	885	7.970
		Torpedo californica	Pacific electric ray	1	15.000
		Xenistius californiensis	salema	90	0.990
				1,104	27.860
3	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	6	0.300
		Loligo opalescens	California market squid	1	0.040
		Panulirus interruptus	California spiny lobster	1	0.250
				8	0.590

Survey Type: Normal Operations
Survey: SONGSFRS27 [Diel 12 hours]
Date: March 5, 2007

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
2	Fish	*Atherinopsis californiensis*	jacksmelt	1	0.110
		Engraulis mordax	northern anchovy	3	0.020
		Hypsoblennius gentilis	bay blenny	1	0.030
		Scorpaena guttata	California scorpionfish	2	0.080
		Seriphus politus	queenfish	6	0.050
		Umbrina roncador	yellowfin croaker	2	0.210
		Xenistius californiensis	salema	110	1.980
				125	2.480
2	Invertebrate	*Panulirus interruptus*	California spiny lobster	3	0.700
				3	0.700
3	Fish	*Atherinopsis californiensis*	jacksmelt	27	2.970
		Engraulis mordax	northern anchovy	1	0.010
		Paralabrax clathratus	kelp bass	2	0.250
		Seriphus politus	queenfish	43	0.340
		Xenistius californiensis	salema	82	1.480
				155	5.050
3	Invertebrate	*Cancer anthonyi*	yellow crab	3	0.057
		Dendraster excentricus	Pacific sand dollar	3	0.043
				6	0.100

Survey Type: Normal Operations
Survey: SONGSFRS28 [Diel 24 hours]
Date: March 6, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	4	0.180
		Atherinopsis californiensis	jacksmelt	3	0.450
		Cymatogaster aggregata	shiner perch	3	0.043
		Embiotoca jacksoni	black perch	2	0.684
		Engraulis mordax	northern anchovy	31	0.627
		Hyperprosopon argenteum	walleye surfperch	1	0.026
		Medialuna californiensis	halfmoon	1	0.100
		Sardinops sagax	Pacific sardine	49	1.310
		Scorpaena guttata	California scorpionfish	1	0.050
		Seriphus politus	queenfish	180	1.573
		Xenistius californiensis	salema	887	8.003
				1,162	13.046
2	Invertebrate	*Crangon nigromaculata*	blackspotted bay shrimp	1	0.002
		Farfantepenaeus californiensis	yellowleg shrimp	2	0.030
		Loligo opalescens	California market squid	3	0.087
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.100
		Panulirus interruptus	California spiny lobster	1	0.200
				8	0.419
3	Fish	*Atherinops affinis*	topsmelt	3	0.157
		Atherinopsis californiensis	jacksmelt	11	1.490
		Cymatogaster aggregata	shiner perch	3	0.053
		Engraulis mordax	northern anchovy	10	0.020
		Hyperprosopon argenteum	walleye surfperch	2	0.050
		Seriphus politus	queenfish	105	1.280
		Xenistius californiensis	salema	250	2.310
				384	5.360
3	Invertebrate	*Loligo opalescens*	California market squid	3	0.087
		Panulirus interruptus	California spiny lobster	1	0.200
				4	0.287

Survey Type: Normal Operations
Survey: SONGSFRS29
Date: March 20, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Biomass (kg)
3	Fish	*Atherinopsis californiensis*	jacksmelt	57	3.720
		Embiotoca jacksoni	black perch	1	0.120
		Gymnura marmorata	California butterfly ray	1	15.000
		Heterostichus rostratus	giant kelpfish	2	0.020
		Phanerodon furcatus	white seaperch	8	0.720
		Roncador stearnsii	spotfin croaker	1	0.200
		Sardinops sagax	Pacific sardine	70	2.930
		Scomber japonicus	Pacific chub mackerel	28	2.390
		Scorpaena guttata	California scorpionfish	1	0.040
		Seriphus politus	queenfish	196	2.830
		Trachurus symmetricus	jack mackerel	2	0.080
		Xenistius californiensis	salema	80	0.740
				447	28.790
3	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	4	0.200
		Loxorhynchus grandis	sheep crab	2	1.000
		Panulirus interruptus	California spiny lobster	4	1.000
				10	2.200

Survey Type: Normal Operations
Survey: SONGSFRS30 [Diel 12 hours]
Date: April 2, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinopsis californiensis*	jacksmelt	3	0.240
		Engraulis mordax	northern anchovy	41	0.087
		Hyperprosopon argenteum	walleye surfperch	2	0.020
		Myliobatis californica	bat ray	1	0.327
		Scorpaena guttata	California scorpionfish	1	0.120
		Seriphus politus	queenfish	360	4.950
		Torpedo californica	Pacific electric ray	1	20.000
		Xenistius californiensis	salema	50	0.150
				459	25.894
2	Invertebrate	*Cancer anthonyi*	yellow crab	1	0.300
		Farfantepenaeus californiensis	yellowleg shrimp	1	0.060
		Hermissenda crassicornis	hermissenda	1	0.001
				3	0.361
3	Fish	*Atherinopsis californiensis*	jacksmelt	368	29.440
		Engraulis mordax	northern anchovy	133	0.132
		Genyonemus lineatus	white croaker	6	0.670
		Hyperprosopon argenteum	walleye surfperch	15	0.150
		Menticirrhus undulatus	California corbina	1	0.250
		Porichthys sp	midshipman unidentified	1	0.020
		Scomber japonicus	Pacific chub mackerel	11	1.350
		Scorpaena guttata	California scorpionfish	2	0.080
		Seriphus politus	queenfish	845	12.960
		Triakis semifasciata	leopard shark	1	10.000
		Xenistius californiensis	salema	15	0.140
				1,398	55.192
3	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	8	0.200
		Panulirus interruptus	California spiny lobster	3	0.780
				11	0.980

Survey Type: Normal Operations
Survey: SONGSFRS31 [Diel 24 hours]
Date: April 3, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	3	0.027
		Atherinops affinis	topsmelt	1	0.040
		Atherinopsis californiensis	jacksmelt	5	0.240
		Engraulis mordax	northern anchovy	10	0.030
		Hyperprosopon argenteum	walleye surfperch	2	0.130
		Myliobatis californica	bat ray	1	5.400
		Pleuronichthys ritteri	spotted turbot	1	0.080
		Sardinops sagax	Pacific sardine	1	0.020
		Scomber japonicus	Pacific chub mackerel	2	0.060
		Scorpaena guttata	California scorpionfish	2	0.080
		Seriphus politus	queenfish	3,460	33.950
		Xenistius californiensis	salema	610	6.080
				4,098	46.137
2	Invertebrate	*Cancer* sp	cancer crab unid	1	0.010
		Farfantepenaeus californiensis	yellowleg shrimp	3	0.078
				4	0.088
3	Fish	*Atherinopsis californiensis*	jacksmelt	270	23.220
		Engraulis mordax	northern anchovy	5	0.015
		Hyperprosopon argenteum	walleye surfperch	4	0.140
		Menticirrhus undulatus	California corbina	1	0.150
		Ophichthidae unid	snake eel	1	0.050
		Sardinops sagax	Pacific sardine	5	0.100
		Seriphus politus	queenfish	1,560	15.640
		Sphyraena argentea	Pacific barracuda	1	0.100
		Torpedo californica	Pacific electric ray	1	10.000
		Xenistius californiensis	salema	150	1.530
				1,998	50.945
3	Invertebrate	*Crangon nigromaculata*	blackspotted bay shrimp	3	0.003
		Farfantepenaeus californiensis	yellowleg shrimp	5	0.100
		Loligo opalescens	California market squid	1	0.010
		Panulirus interruptus	California spiny lobster	2	0.500
				11	0.613

Survey Type: Normal Operations
Survey: SONGSFRS32
Date: April 17, 2007

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
3	Fish	*Atherinopsis californiensis*	jacksmelt	11	1.063
		Cymatogaster aggregata	shiner perch	3	0.123
		Engraulis mordax	northern anchovy	5	0.043
		Heterostichus rostratus	giant kelpfish	1	0.050
		Paralabrax nebulifer	barred sand bass	1	0.200
		Paralichthys californicus	California halibut	3	0.136
		Pleuronichthys ritteri	spotted turbot	1	0.050
		Sardinops sagax	Pacific sardine	7	0.286
		Scomber japonicus	Pacific chub mackerel	3	0.225
		Scorpaena guttata	California scorpionfish	3	0.240
		Seriphus politus	queenfish	1,220	16.543
		Xenistius californiensis	salema	125	1.428
				1,383	20.387
3	Invertebrate	*Dendraster excentricus*	Pacific sand dollar	3	0.018
		Loxorhynchus grandis	sheep crab	3	4.590
		Panulirus interruptus	California spiny lobster	1	0.250
				7	4.858

Survey Type: Normal Operations
Survey: SONGSFRS33
Date: May 1, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinopsis californiensis*	jacksmelt	60	9.350
		Embiotoca jacksoni	black perch	1	0.010
		Engraulis mordax	northern anchovy	56	0.176
		Hyperprosopon argenteum	walleye surfperch	14	0.663
		Ophidion scrippsae	basketweave cusk-eel	1	0.010
		Sardinops sagax	Pacific sardine	3	0.097
		Scomber japonicus	Pacific chub mackerel	17	1.516
		Seriphus politus	queenfish	143	2.746
		Trachurus symmetricus	jack mackerel	7	0.343
		Xenistius californiensis	salema	3	0.030
				305	14.941
3	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	4	0.108
		Loxorhynchus grandis	sheep crab	1	0.500
				5	0.608

Survey Type: Normal Operations
Survey: SONGSFRS34
Date: May 15, 2007

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
3	Fish	*Atherinopsis californiensis*	jacksmelt	59	5.664
		Cymatogaster aggregata	shiner perch	2	0.067
		Engraulis mordax	northern anchovy	18	0.450
		Genyonemus lineatus	white croaker	40	1.876
		Gymnura marmorata	California butterfly ray	1	0.700
		Heterostichus rostratus	giant kelpfish	1	0.040
		Leuresthes tenuis	California grunion	3	0.070
		Menticirrhus undulatus	California corbina	3	0.330
		Myliobatis californica	bat ray	3	1.200
		Peprilus simillimus	Pacific pompano	2	0.064
		Phanerodon furcatus	white seaperch	3	0.240
		Roncador stearnsii	spotfin croaker	14	6.104
		Sardinops sagax	Pacific sardine	63	2.534
		Sebastes serriceps	treefish	1	0.120
		Seriphus politus	queenfish	1,595	33.597
		Torpedo californica	Pacific electric ray	2	20.000
		Trachurus symmetricus	jack mackerel	4	0.165
				1,814	73.221
3	Invertebrate	*Dendraster excentricus*	Pacific sand dollar	3	0.003
		Farfantepenaeus californiensis	yellowleg shrimp	4	0.109
		Loxorhynchus grandis	sheep crab	1	0.500
		Panulirus interruptus	California spiny lobster	6	1.380
				14	1.992

Survey Type: Heat Treatment
Survey: SONGSHT01
Date: May 1, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinops affinis*	topsmelt	1	0.035
		Atherinopsis californiensis	jacksmelt	27	1.715
		Cheilotrema saturnum	black croaker	2	0.167
		Citharichthys stigmaeus	speckled sanddab	21	0.040
		Cymatogaster aggregata	shiner perch	90	3.100
		Embiotoca jacksoni	black perch	13	0.400
		Engraulis mordax	northern anchovy	6	0.047
		Hyperprosopon argenteum	walleye surfperch	2	0.126
		Hypsoblennius gilberti	rockpool blenny	33	0.208
		Ophididae unid	cusk-eel unid	1	0.096
		Ophidion scrippsae	basketweave cusk-eel	3	0.019
		Paralabrax clathratus	kelp bass	1	0.056
		Paralabrax nebulifer	barred sand bass	9	1.215
		Paralichthys californicus	California halibut	1	0.131
		Peprilus simillimus	Pacific pompano	106	2.697
		Phanerodon furcatus	white seaperch	14	0.495
		Pleuronichthys ritteri	spotted turbot	10	0.151
		Porichthys notatus	plainfin midshipman	4	0.204
		Scorpaena guttata	California scorpionfish	35	2.146
		Scorpaenichthys marmoratus	cabezon	33	0.250
		Sebastes atrovirens	kelp rockfish	1	0.131
		Sebastes auriculatus	brown rockfish	4	0.147
		Sebastes miniatus	vermillion rockfish	1	0.003
		Sebastes serriceps	treefish	1	0.032
		Seriphus politus	queenfish	154	8.655
		Syngnathus californiensis	kelp pipefish	3	0.005
		Synodus lucioceps	California lizardfish	1	0.013
		Urobatis halleri	round stingray	2	1.376
		Xenistius californiensis	salema	86	2.692
				665	26.352

(continued on next page)

Survey Type: Heat Treatment
Survey: SONGSHT01 (continued)
Date: May 1, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	444	2.204
		Cancer anthonyi	yellow crab	100	0.684
		Cancer gracilis	graceful crab	5	0.050
		Cancer productus	red rock crab	19	0.246
		Crangon nigromaculata	blackspotted bay shrimp	3	0.011
		Dendraster excentricus	Pacific sand dollar	4	0.022
		Heptacarpus sp	coastal shrimp unk	84	0.092
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.001
		Loxorhynchus grandis	sheep crab	2	1.700
		Lysmata californica	red rock shrimp	132	0.188
		Octopus bimaculatus/bimaculoides	California two-spot octopus	5	0.100
		Pachygrapsus crassipes	striped shore crab	2	0.018
		Panulirus interruptus	California spiny lobster	21	7.300
		Pilumnus spinohirsutus	retiring hairy crab	1	0.011
		Portunus xantusii	Xantus swimming crab	2	0.019
		Pugettia producta	northern kelp crab	2	0.032
		Pyromaia tuberculata	tuberculate pear crab	2	0.001
				829	12.679

Survey Type: Heat Treatment
Survey: SONGSHT02
Date: May 13, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Amphistichus argenteus*	barred surfperch	1	0.217
		Atherinops affinis	topsmelt	11	0.439
		Atherinopsis californiensis	jacksmelt	331	24.570
		Atractoscion nobilis	white seabass	1	0.123
		Brachyistius frenatus	kelp perch	5	0.163
		Cheilotrema saturnum	black croaker	1	0.150
		Citharichthys stigmaeus	speckled sanddab	13	0.033
		Cymatogaster aggregata	shiner perch	70	2.635
		Embiotoca jacksoni	black perch	11	0.257
		Engraulis mordax	northern anchovy	297	6.834
		Genyonemus lineatus	white croaker	7	0.166
		Heterostichus rostratus	giant kelpfish	1	0.018
		Hyperprosopon argenteum	walleye surfperch	5	0.168
		Hypsoblennius gilberti	rockpool blenny	19	0.185
		Paralabrax clathratus	kelp bass	2	0.091
		Paralabrax nebulifer	barred sand bass	6	0.837
		Peprilus simillimus	Pacific pompano	106	3.156
		Pleuronichthys ritteri	spotted turbot	5	0.099
		Porichthys notatus	plainfin midshipman	1	0.056
		Scorpaena guttata	California scorpionfish	19	1.864
		Scorpaenichthys marmoratus	cabezon	44	0.611
		Sebastes auriculatus	brown rockfish	1	0.023
		Semicossyphus pulcher	California sheephead	1	0.455
		Seriphus politus	queenfish	2,128	47.182
		Trachurus symmetricus	jack mackerel	3	0.156
		Umbrina roncador	yellowfin croaker	1	0.132
		Xenistius californiensis	salema	133	5.068
				3,223	95.688
3	Invertebrate	*Betaeus* sp	visored shrimp unid	1	0.001
		Cancer antennarius	Pacific rock crab	7	0.632
		Cancer anthonyi	yellow crab	80	0.631
		Cancer gracilis	graceful crab	8	0.076
		Dendraster excentricus	Pacific sand dollar	1	0.007
		Heptacarpus palpator	intertidal coastal shrimp	11	0.013
		Loxorhynchus grandis	sheep crab	1	1.181
		Lysmata californica	red rock shrimp	16	0.035
		Octopus bimaculatus/bimaculoides	California two-spot octopus	18	1.229
		Pachygrapsus crassipes	striped shore crab	1	0.003
		Panulirus interruptus	California spiny lobster	10	2.890
		Portunus xantusii	Xantus swimming crab	55	0.338
		Pugettia producta	northern kelp crab	2	0.024
		Pyromaia tuberculata	tuberculate pear crab	3	0.010
				214	7.070

Survey Type: Heat Treatment
Survey: SONGSHT03
Date: June 10, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anisotremus davidsonii*	sargo	10	1.650
		Atherinops affinis	topsmelt	402	13.910
		Atherinopsis californiensis	jacksmelt	17	1.634
		Brachyistius frenatus	kelp perch	1	0.008
		Cheilotrema saturnum	black croaker	35	3.600
		Chromis punctipinnis	blacksmith	2	0.306
		Citharichthys stigmaeus	speckled sanddab	1	0.002
		Cymatogaster aggregata	shiner perch	97	1.997
		Embiotoca jacksoni	black perch	50	1.862
		Engraulis mordax	northern anchovy	72	1.879
		Genyonemus lineatus	white croaker	32	1.420
		Halichoeres semicinctus	rock wrasse	1	0.138
		Heterostichus rostratus	giant kelpfish	1	0.012
		Hyperprosopon argenteum	walleye surfperch	3	0.022
		Hypsoblennius gilberti	rockpool blenny	2	0.044
		Leuresthes tenuis	California grunion	1	0.022
		Micrometrus minimus	dwarf perch	5	0.004
		Paralabrax clathratus	kelp bass	2	0.130
		Paralabrax nebulifer	barred sand bass	5	1.427
		Paralichthys californicus	California halibut	1	0.107
		Peprilus simillimus	Pacific pompano	19	0.493
		Phanerodon furcatus	white seaperch	3	0.239
		Pleuronichthys coenosus	C-O sole	1	0.003
		Pleuronichthys ritteri	spotted turbot	3	0.067
		Porichthys myriaster	specklefin midshipman	1	0.339
		Porichthys notatus	plainfin midshipman	1	0.030
		Rhacochilus toxotes	rubberlip seaperch	3	0.043
		Rhinobatos productus	shovelnose guitarfish	2	9.130
		Roncador stearnsii	spotfin croaker	6	2.236
		Sardinops sagax	Pacific sardine	16	0.708
		Scomber japonicus	Pacific chub mackerel	35	4.090
		Scorpaena guttata	California scorpionfish	7	0.417
		Scorpaenichthys marmoratus	cabezon	8	0.191
		Sebastes rastrelliger	grass rockfish	2	0.345
		Seriphus politus	queenfish	735	20.520
		Syngnathus californiensis	kelp pipefish	1	0.012
		Trachurus symmetricus	jack mackerel	179	12.730
		Umbrina roncador	yellowfin croaker	9	1.644
		Urobatis halleri	round stingray	2	0.792
		Xenistius californiensis	salema	115	4.950
				1,888	89.153

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Survey Type: Heat Treatment
Survey: SONGSHT03 (continued)
Date: June 10, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	1,180	1.788
		Cancer anthonyi	yellow crab	132	0.756
		Cancer gracilis	graceful crab	188	0.408
		Cancer productus	red rock crab	10	0.040
		Heptacarpus sp	coastal shrimp unk	72	0.048
		Lysmata californica	red rock shrimp	72	0.112
		Octopus bimaculatus/bimaculoides	California two-spot octopus	10	0.716
		Pachycheles rudis	thick claw porcelain crab	2	0.006
		Pachygrapsus crassipes	striped shore crab	10	0.026
		Panulirus interruptus	California spiny lobster	3	0.702
		Portunus xantusii	Xantus swimming crab	24	0.228
		Pugettia producta	northern kelp crab	4	0.006
		Pyromaia tuberculata	tuberculate pear crab	16	0.024
				1,723	4.860

Survey Type: Heat Treatment
Survey: SONGSHT04
Date: June 24, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anisotremus davidsonii*	sargo	78	16.697
		Atherinops affinis	topsmelt	134	4.014
		Atherinopsis californiensis	jacksmelt	19	1.084
		Cheilotrema saturnum	black croaker	4	0.433
		Chromis punctipinnis	blacksmith	2	0.100
		Cymatogaster aggregata	shiner perch	213	4.380
		Embiotoca jacksoni	black perch	24	0.881
		Engraulis mordax	northern anchovy	112	3.427
		Genyonemus lineatus	white croaker	58	1.240
		Halichoeres semicinctus	rock wrasse	1	0.086
		Heterostichus rostratus	giant kelpfish	3	0.024
		Hyperprosopon anale	spotfin surfperch	1	0.031
		Hyperprosopon argenteum	walleye surfperch	11	0.239
		Hypsoblennius gilberti	rockpool blenny	17	0.243
		Leptocottus armatus	Pacific staghorn sculpin	1	0.021
		Leuresthes tenuis	California grunion	1	0.013
		Micrometrus minimus	dwarf perch	2	0.004
		Paralabrax clathratus	kelp bass	3	0.646
		Paralabrax maculatofasciatus	spotted sand bass	1	0.159
		Paralabrax nebulifer	barred sand bass	7	1.262
		Paralichthys californicus	California halibut	1	0.181
		Peprilus simillimus	Pacific pompano	26	0.793
		Phanerodon furcatus	white seaperch	4	0.440
		Porichthys myriaster	specklefin midshipman	2	0.837
		Rhacochilus toxotes	rubberlip seaperch	6	0.099
		Sardinops sagax	Pacific sardine	5	0.285
		Scomber japonicus	Pacific chub mackerel	28	4.054
		Scorpaena guttata	California scorpionfish	7	0.802
		Scorpaenichthys marmoratus	cabezon	15	0.286
		Seriphus politus	queenfish	1,376	49.320
		Syngnathus californiensis	kelp pipefish	1	0.001
		Trachurus symmetricus	jack mackerel	314	23.107
		Umbrina roncador	yellowfin croaker	144	36.196
		Xenistius californiensis	salema	176	7.926
				2,797	159.311

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Survey Type: Heat Treatment
Survey: SONGSHT04 (continued)
Date: June 24, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Biomass (kg)
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	8	0.675
		Cancer anthonyi	yellow crab	1,218	4.383
		Cancer gracilis	graceful crab	180	0.370
		Cancer productus	red rock crab	40	0.070
		Heptacarpus palpator	intertidal coastal shrimp	1,433	0.561
		Loxorhynchus crispatus	moss crab	1	0.002
		Loxorhynchus grandis	sheep crab	1	1.349
		Lysmata californica	red rock shrimp	70	0.088
		Octopus bimaculatus/bimaculoides	California two-spot octopus	12	1.381
		Pachygrapsus crassipes	striped shore crab	10	0.020
		Panulirus interruptus	California spiny lobster	9	1.950
		Pilumnus spinohirsutus	retiring hairy crab	1	0.013
		Pleurobranchaea sp	sea slug unid	1	0.014
		Portunus xantusii	Xantus swimming crab	10	0.310
		Pugettia producta	northern kelp crab	4	0.048
				2,998	11.234

Survey Type: Heat Treatment
Survey: SONGSHT05
Date: August 1, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	5	0.053
		Anisotremus davidsonii	sargo	415	74.100
		Atherinops affinis	topsmelt	305	12.810
		Atherinopsis californiensis	jacksmelt	3	0.241
		Atractoscion nobilis	white seabass	1	0.018
		Cheilotrema saturnum	black croaker	2	0.189
		Chromis punctipinnis	blacksmith	4	0.163
		Cymatogaster aggregata	shiner perch	236	2.047
		Embiotoca jacksoni	black perch	13	1.222
		Engraulis mordax	northern anchovy	45	0.606
		Genyonemus lineatus	white croaker	73	1.056
		Halichoeres semicinctus	rock wrasse	1	0.148
		Hermosilla azurea	zebraperch	218	144.400
		Heterostichus rostratus	giant kelpfish	1	0.014
		Hyperprosopon argenteum	walleye surfperch	24	0.633
		Hypsoblennius gilberti	rockpool blenny	9	0.024
		Myliobatis californica	bat ray	1	0.257
		Paralabrax clathratus	kelp bass	4	0.185
		Paralabrax nebulifer	barred sand bass	2	0.598
		Peprilus simillimus	Pacific pompano	1	0.033
		Phanerodon furcatus	white seaperch	18	0.530
		Pleuronichthys verticalis	hornyhead turbot	1	0.021
		Rhacochilus toxotes	rubberlip seaperch	6	0.181
		Roncador stearnsii	spotfin croaker	52	25.700
		Scomber japonicus	Pacific chub mackerel	6	0.761
		Scorpaena guttata	California scorpionfish	1	0.219
		Scorpaenichthys marmoratus	cabezon	1	0.018
		Sebastes sp	rockfish unid	2	0.372
		Seriphus politus	queenfish	1,214	35.561
		Trachurus symmetricus	jack mackerel	166	7.513
		Umbrina roncador	yellowfin croaker	6,661	2,326.404
		Xenistius californiensis	salema	197	10.270
				9,688	2,646.347

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Survey Type: Heat Treatment
Survey: SONGSHT05 (continued)
Date: August 1, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Biomass (kg)
2	Invertebrate	*Cancer amphioetus*	bigtooth rock crab	45	0.089
		Cancer antennarius	Pacific rock crab	8	0.269
		Cancer anthonyi	yellow crab	3,783	6.261
		Cancer gracilis	graceful crab	55	0.186
		Cancer productus	red rock crab	22	0.067
		Caudina arenicola	sweet potatoe sea cucumber	15	0.287
		Farfantepenaeus californiensis	yellowleg shrimp	1	0.083
		Heptacarpus palpator	intertidal coastal shrimp	92	0.047
		Lysmata californica	red rock shrimp	363	0.364
		Octopus bimaculatus/bimaculoides	California two-spot octopus	14	0.845
		Panulirus interruptus	California spiny lobster	5	1.699
		Pugettia producta	northern kelp crab	23	0.069
		Pyromaia tuberculata	tuberculate pear crab	68	0.068
				4,494	10.334

Survey Type: Heat Treatment
Survey: SONGSHT06
Date: August 10, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	29	0.392
		Anisotremus davidsonii	sargo	690	150.580
		Atherinops affinis	topsmelt	116	4.562
		Atractoscion nobilis	white seabass	4	0.427
		Cymatogaster aggregata	shiner perch	81	0.804
		Embiotoca jacksoni	black perch	10	0.850
		Engraulis mordax	northern anchovy	130	1.311
		Genyonemus lineatus	white croaker	13	0.274
		Gibbonsia metzi	striped kelpfish	1	0.031
		Halichoeres semicinctus	rock wrasse	2	0.238
		Heterodontus francisci	horn shark	1	3.480
		Heterostichus rostratus	giant kelpfish	3	0.022
		Hyperprosopon argenteum	walleye surfperch	5	0.122
		Hypsoblennius gilberti	rockpool blenny	30	0.620
		Menticirrhus undulatus	California corbina	1	0.074
		Oxyjulis californica	senorita	1	0.053
		Paralabrax clathratus	kelp bass	10	1.520
		Paralabrax nebulifer	barred sand bass	18	2.876
		Paralichthys californicus	California halibut	1	0.102
		Peprilus simillimus	Pacific pompano	6	0.196
		Phanerodon furcatus	white seaperch	14	0.556
		Rhacochilus toxotes	rubberlip seaperch	6	0.142
		Roncador stearnsii	spotfin croaker	14	2.684
		Sardinops sagax	Pacific sardine	2	0.002
		Seriphus politus	queenfish	1,372	44.990
		Sphyraena argentea	Pacific barracuda	1	0.024
		Trachurus symmetricus	jack mackerel	193	7.780
		Umbrina roncador	yellowfin croaker	1,280	496.480
		Xenistius californiensis	salema	1,374	77.040
				5,408	798.232
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	539	1.585
		Cancer anthonyi	yellow crab	109	0.696
		Cancer gracilis	graceful crab	55	0.208
		Cancer productus	red rock crab	7	0.020
		Heptacarpus palpator	intertidal coastal shrimp	55	0.021
		Lysmata californica	red rock shrimp	224	0.218
		Octopus bimaculatus/bimaculoides	California two-spot octopus	39	2.517
		Pachygrapsus crassipes	striped shore crab	3	0.133
		Panulirus interruptus	California spiny lobster	30	7.459
		Pyromaia tuberculata	tuberculate pear crab	22	0.027
		Strongylocentrotus purpuratus	purple sea urchin	3	0.037
				1,086	12.921

Survey Type: Heat Treatment
Survey: SONGSHT07
Date: September 2, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	111	1.698
		Anisotremus davidsonii	sargo	371	78.890
		Atherinops affinis	topsmelt	58	2.004
		Atherinopsis californiensis	jacksmelt	3	0.265
		Atractoscion nobilis	white seabass	5	0.428
		Cheilotrema saturnum	black croaker	10	0.850
		Cymatogaster aggregata	shiner perch	87	0.894
		Embiotoca jacksoni	black perch	29	4.960
		Engraulis mordax	northern anchovy	338	0.940
		Genyonemus lineatus	white croaker	7	0.064
		Gibbonsia elegans	spotted kelpfish	2	0.003
		Gymnura marmorata	California butterfly ray	1	0.156
		Halichoeres semicinctus	rock wrasse	3	0.324
		Hyperprosopon argenteum	walleye surfperch	37	1.123
		Hypsoblennius gilberti	rockpool blenny	163	0.172
		Medialuna californiensis	halfmoon	2	0.220
		Paralabrax nebulifer	barred sand bass	9	1.550
		Paralichthys californicus	California halibut	2	0.247
		Peprilus simillimus	Pacific pompano	6	0.221
		Phanerodon furcatus	white seaperch	4	0.274
		Rhinobatos productus	shovelnose guitarfish	2	8.340
		Roncador stearnsii	spotfin croaker	8	2.860
		Scorpaena guttata	California scorpionfish	4	0.448
		Seriphus politus	queenfish	424	11.590
		Trachurus symmetricus	jack mackerel	4	0.108
		Umbrina roncador	yellowfin croaker	857	341.420
		Xenistius californiensis	salema	195	8.240
				2,742	468.289
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	400	1.150
		Cancer anthonyi	yellow crab	1,920	1.780
		Cancer gracilis	graceful crab	10	0.030
		Cancer jordani	hairy rock crab	190	0.140
		Cancer productus	red rock crab	40	0.070
		Heptacarpus palpator	intertidal coastal shrimp	10	0.010
		Lophopanopeus bellus	blackclaw crestleg crab	10	0.010
		Lysmata californica	red rock shrimp	250	0.180
		Navanax inermis	California aglaja	1	0.002
		Octopus bimaculatus/bimaculoides	California two-spot octopus	3	0.730
		Pachygrapsus crassipes	striped shore crab	30	0.090
		Panulirus interruptus	California spiny lobster	21	3.353
		Portunus xantusii	Xantus swimming crab	90	0.130
		Pugettia producta	northern kelp crab	10	0.040
				2,985	7.715

Survey Type: Heat Treatment
Survey: SONGSHT08
Date: September 16, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	209	2.520
		Anisotremus davidsonii	sargo	255	94.690
		Atherinops affinis	topsmelt	212	6.377
		Atherinopsis californiensis	jacksmelt	4	0.142
		Atractoscion nobilis	white seabass	14	1.533
		Chromis punctipinnis	blacksmith	4	0.264
		Cymatogaster aggregata	shiner perch	90	0.924
		Embiotoca jacksoni	black perch	8	1.348
		Engraulis mordax	northern anchovy	405	0.956
		Genyonemus lineatus	white croaker	4	0.046
		Halichoeres semicinctus	rock wrasse	10	1.150
		Heterostichus rostratus	giant kelpfish	2	0.006
		Hyperprosopon argenteum	walleye surfperch	24	0.476
		Hypsoblennius gilberti	rockpool blenny	146	0.156
		Leuresthes tenuis	California grunion	2	0.036
		Medialuna californiensis	halfmoon	2	0.336
		Paralabrax clathratus	kelp bass	6	0.228
		Paralabrax nebulifer	barred sand bass	28	4.190
		Paralichthys californicus	California halibut	4	0.100
		Peprilus simillimus	Pacific pompano	20	0.550
		Pleuronichthys decurrens	curlfin sole	1	0.011
		Rhacochilus toxotes	rubberlip seaperch	2	0.016
		Rhacochilus vacca	pile perch	2	0.316
		Roncador stearnsii	spotfin croaker	21	10.961
		Scorpaena guttata	California scorpionfish	3	0.058
		Seriphus politus	queenfish	344	8.257
		Sphyraena argentea	Pacific barracuda	3	0.161
		Trachurus symmetricus	jack mackerel	4	0.036
		Umbrina roncador	yellowfin croaker	186	43.600
		Xenistius californiensis	salema	96	4.128
				2,111	183.572

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Survey Type: Heat Treatment
Survey: SONGSHT08 (continued)
Date: September 16, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Invertebrate	*Cancer amphioetus*	bigtooth rock crab	64	0.040
		Cancer antennarius	Pacific rock crab	1,588	1.432
		Cancer anthonyi	yellow crab	160	0.484
		Cancer jordani	hairy rock crab	68	0.676
		Cancer productus	red rock crab	12	0.008
		Crangon nigromaculata	blackspotted bay shrimp	4	0.004
		Cystodytes lobatus	sea eraser	1	0.012
		Dendraster excentricus	Pacific sand dollar	1	0.001
		Gastropoda unid	unknown nudibranch	1	0.001
		Heptacarpus palpator	intertidal coastal shrimp	28	0.008
		Lophopanopeus bellus	blackclaw crestleg crab	16	0.020
		Lysmata californica	red rock shrimp	600	0.224
		Octopus bimaculatus/bimaculoides	California two-spot octopus	5	0.252
		Pachygrapsus crassipes	striped shore crab	12	0.016
		Panulirus interruptus	California spiny lobster	11	2.100
		Pisaster sp	sea star unid	2	0.005
		Portunus xantusii	Xantus swimming crab	172	0.188
		Pyromaia tuberculata	tuberculate pear crab	12	0.008
				2,757	5.479

Survey Type: Heat Treatment
Survey: SONGSHT09
Date: October 7, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	386	4.734
		Anisotremus davidsonii	sargo	109	14.672
		Atherinops affinis	topsmelt	145	5.906
		Atherinopsis californiensis	jacksmelt	1	0.124
		Atractoscion nobilis	white seabass	4	0.316
		Cheilotrema saturnum	black croaker	5	0.238
		Cottidae sp	sculpin unid	1	0.003
		Cymatogaster aggregata	shiner perch	41	0.460
		Embiotoca jacksoni	black perch	7	0.850
		Engraulis mordax	northern anchovy	284	1.006
		Genyonemus lineatus	white croaker	5	0.118
		Gibbonsia elegans	spotted kelpfish	1	0.006
		Heterostichus rostratus	giant kelpfish	6	0.027
		Hyperprosopon argenteum	walleye surfperch	6	0.146
		Hypsoblennius gilberti	rockpool blenny	49	0.068
		Leuresthes tenuis	California grunion	1	0.003
		Paralabrax clathratus	kelp bass	8	0.141
		Paralabrax nebulifer	barred sand bass	7	0.814
		Paralichthys californicus	California halibut	2	0.342
		Peprilus simillimus	Pacific pompano	10	0.240
		Sardinops sagax	Pacific sardine	2	0.058
		Scomber japonicus	Pacific chub mackerel	7	1.056
		Scorpaena guttata	California scorpionfish	11	0.766
		Seriphus politus	queenfish	392	10.590
		Sphyraena argentea	Pacific barracuda	3	0.070
		Syngnathus californiensis	kelp pipefish	1	0.002
		Trachurus symmetricus	jack mackerel	1	0.013
		Umbrina roncador	yellowfin croaker	3	0.810
		Xenistius californiensis	salema	33	1.260
				1,531	44.839

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Survey Type: Heat Treatment
Survey: SONGSHT09 (continued)
Date: October 7, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	206	0.289
		Cancer anthonyi	yellow crab	26	0.061
		Cancer gracilis	graceful crab	2	0.002
		Cancer jordani	hairy rock crab	30	0.057
		Cancer productus	red rock crab	1	0.001
		Caudina arenicola	sweet potatoe sea cucumber	1	0.022
		Crangon nigromaculata	blackspotted bay shrimp	2	0.001
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.003
		Dendraster excentricus	Pacific sand dollar	1	0.001
		Heptacarpus palpator	intertidal coastal shrimp	9	0.008
		Lophopanopeus sp	crestleg crab	1	0.003
		Lysmata californica	red rock shrimp	56	0.054
		Octopus bimaculatus/bimaculoides	California two-spot octopus	4	0.489
		Pachycheles holosericus	sponge porcelain crab	1	0.001
		Pachygrapsus crassipes	striped shore crab	18	0.048
		Panulirus interruptus	California spiny lobster	9	1.950
		Petrolisthes cinctipes	flat porcelain crab	1	0.001
		Pilumnus spinohirsutus	retiring hairy crab	1	0.001
		Portunus xantusii	Xantus swimming crab	54	0.124
		Protothaca staminea	Pacific littleneck	1	0.029
		Pyromaia tuberculata	tuberculate pear crab	5	0.004
				430	3.149

Survey Type: Heat Treatment
Survey: SONGSHT10
Date: December 6, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	1,344	13.120
		Anisotremus davidsonii	sargo	78	9.580
		Atherinops affinis	topsmelt	1,290	53.150
		Atherinopsis californiensis	jacksmelt	11	1.020
		Atractoscion nobilis	white seabass	1	0.130
		Cheilotrema saturnum	black croaker	25	1.494
		Cymatogaster aggregata	shiner perch	34	0.530
		Embiotoca jacksoni	black perch	2	0.300
		Genyonemus lineatus	white croaker	224	4.400
		Heterodontus francisci	horn shark	1	0.700
		Heterostichus rostratus	giant kelpfish	6	0.047
		Hyperprosopon argenteum	walleye surfperch	39	1.256
		Hypsoblennius gilberti	rockpool blenny	481	0.908
		Leuresthes tenuis	California grunion	8	0.068
		Paralabrax clathratus	kelp bass	36	0.224
		Paralabrax maculatofasciatus	spotted sand bass	5	0.039
		Paralabrax nebulifer	barred sand bass	8	0.936
		Paralichthys californicus	California halibut	7	0.450
		Peprilus simillimus	Pacific pompano	9	0.256
		Phanerodon furcatus	white seaperch	14	0.624
		Pleuronichthys ritteri	spotted turbot	4	0.043
		Rathbunella alleni	stripefin ronquil	1	0.007
		Roncador stearnsii	spotfin croaker	1	0.108
		Sardinops sagax	Pacific sardine	42	1.470
		Scomber japonicus	Pacific chub mackerel	137	17.150
		Scorpaena guttata	California scorpionfish	8	1.230
		Seriphus politus	queenfish	1,023	13.500
		Sphyraena argentea	Pacific barracuda	4	0.204
		Syngnathus californiensis	kelp pipefish	2	0.005
		Trachurus symmetricus	jack mackerel	19	2.300
		Umbrina roncador	yellowfin croaker	11	1.500
		Urobatis halleri	round stingray	1	0.558
		Xenistius californiensis	salema	517	10.420
				5,393	137.727

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Survey Type: Heat Treatment
Survey: SONGSHT10 (continued)
Date: December 6, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Invertebrate	*Betaeus longidactylus*	visored shrimp	2	0.001
		Cancer antennarius	Pacific rock crab	8	0.083
		Cancer anthonyi	yellow crab	339	1.290
		Cancer jordani	hairy rock crab	12	0.025
		Cancer productus	red rock crab	1	0.002
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.001
		Hemigrapsus oregonensis	yellow shore crab	9	0.008
		Heptacarpus palpator	intertidal coastal shrimp	237	0.128
		Heptacarpus sp	coastal shrimp unk	14	0.008
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.001
		Loxorhynchus sp	unk moss/sheep crab	1	0.001
		Lysmata californica	red rock shrimp	25	0.028
		Navanax inermis	California aglaja	2	0.004
		Octopus bimaculatus/bimaculoides	California two-spot octopus	22	3.354
		Panulirus interruptus	California spiny lobster	25	5.542
		Petrolisthes cabrilloi	Cabrillo porcelain crab	1	0.001
		Pilumnus spinohirsutus	retiring hairy crab	1	0.001
		Portunus xantusii	Xantus swimming crab	19	0.072
		Pugettia producta	northern kelp crab	1	0.002
		Pyromaia tuberculata	tuberculate pear crab	24	0.024
		Strongylocentrotus purpuratus	purple sea urchin	1	0.130
				746	10.706

Survey Type: Heat Treatment
Survey: SONGSHT11
Date: January 4, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	21	0.208
		Anisotremus davidsonii	sargo	2	0.018
		Atherinops affinis	topsmelt	1	0.037
		Atherinopsis californiensis	jacksmelt	18	0.498
		Cheilotrema saturnum	black croaker	1	0.014
		Chromis punctipinnis	blacksmith	5	0.018
		Embiotoca jacksoni	black perch	1	0.025
		Engraulis mordax	northern anchovy	4	0.024
		Genyonemus lineatus	white croaker	4	0.045
		Gibbonsia elegans	spotted kelpfish	12	0.093
		Hyperprosopon argenteum	walleye surfperch	8	0.206
		Hypsoblennius gilberti	rockpool blenny	12	0.033
		Lepidogobius lepidus	bay goby	1	0.001
		Oxyjulis californica	senorita	6	0.018
		Paralabrax clathratus	kelp bass	5	0.035
		Paralabrax nebulifer	barred sand bass	6	0.150
		Pleuronichthys ritteri	spotted turbot	3	0.071
		Rhacochilus toxotes	rubberlip seaperch	1	0.053
		Scorpaena guttata	California scorpionfish	27	2.041
		Sebastes auriculatus	brown rockfish	1	0.036
		Seriphus politus	queenfish	73	1.404
		Trachurus symmetricus	jack mackerel	1	0.013
		Xenistius californiensis	salema	121	0.821
				334	5.862

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Survey Type: Heat Treatment
Survey: SONGSHT11 (continued)
Date: January 4, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Invertebrate	*Betaeus longidactylus*	visored shrimp	1	0.001
		Cancer antennarius	Pacific rock crab	1	0.029
		Cancer anthonyi	yellow crab	41	0.334
		Cancer gracilis	graceful crab	7	0.078
		Cancer jordani	hairy rock crab	4	0.015
		Cancer productus	red rock crab	1	0.009
		Caudina arenicola	sweet potatoe sea cucumber	1	0.017
		Dendraster excentricus	Pacific sand dollar	1	0.005
		Heptacarpus sp	coastal shrimp unk	62	0.053
		Lophopanopeus bellus	blackclaw crestleg crab	2	0.035
		Lysmata californica	red rock shrimp	54	0.070
		Navanax inermis	California aglaja	1	0.005
		Octopus bimaculatus/bimaculoides	California two-spot octopus	5	0.806
		Pachycheles rudis	thick claw porcelain crab	4	0.003
		Pachygrapsus crassipes	striped shore crab	6	0.012
		Panulirus interruptus	California spiny lobster	2	0.322
		Petrolisthes sp	porcelain crab unid	1	0.002
		Pilumnus spinohirsutus	retiring hairy crab	1	0.017
		Portunus xantusii	Xantus swimming crab	11	0.041
		Strongylocentrotus purpuratus	purple sea urchin	2	0.022
				208	1.876

Survey Type: Heat Treatment
Survey: SONGSHT12
Date: January 7, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	76	0.795
		Anchoa delicatissima	slough anchovy	28	0.072
		Atherinops affinis	topsmelt	14	0.295
		Atherinopsis californiensis	jacksmelt	7	0.293
		Atractoscion nobilis	white seabass	1	0.068
		Branchiostoma californiense	California lancelet	1	0.001
		Citharichthys stigmaeus	speckled sanddab	1	0.001
		Cymatogaster aggregata	shiner perch	2	0.022
		Engraulis mordax	northern anchovy	88	0.123
		Genyonemus lineatus	white croaker	28	0.495
		Gibbonsia elegans	spotted kelpfish	1	0.011
		Heterostichus rostratus	giant kelpfish	1	0.005
		Hypsoblennius gilberti	rockpool blenny	6	0.018
		Paralabrax clathratus	kelp bass	1	0.008
		Paralabrax nebulifer	barred sand bass	1	0.344
		Paralichthys californicus	California halibut	3	0.169
		Peprilus simillimus	Pacific pompano	15	0.263
		Pleuronichthys ritteri	spotted turbot	2	0.025
		Sardinops sagax	Pacific sardine	5	0.089
		Scorpaena guttata	California scorpionfish	5	0.186
		Sebastes auriculatus	brown rockfish	1	0.045
		Seriphus politus	queenfish	177	1.276
		Sphyraena argentea	Pacific barracuda	1	0.005
		Syngnathus californiensis	kelp pipefish	5	0.005
		Umbrina roncador	yellowfin croaker	2	0.292
		Xenistius californiensis	salema	23	0.134
				495	5.040

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Survey Type: Heat Treatment
Survey: SONGSHT12 (continued)
Date: January 7, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Invertebrate	*Betaeus longidactylus*	visored shrimp	2	0.001
		Cancer antennarius	Pacific rock crab	4	0.034
		Cancer anthonyi	yellow crab	15	0.084
		Cancer gracilis	graceful crab	1	0.001
		Cancer jordani	hairy rock crab	1	0.001
		Caudina arenicola	sweet potatoe sea cucumber	1	0.087
		Crangon nigromaculata	blackspotted bay shrimp	8	0.014
		Cycloxanthops novemdentatus	ninetooth pebble crab	1	0.011
		Golfingia procera	MBC peanut worm 1	1	0.001
		Heptacarpus palpator	intertidal coastal shrimp	12	0.009
		Loligo opalescens	California market squid	1	0.040
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.001
		Lysmata californica	red rock shrimp	32	0.046
		Octopus bimaculatus/bimaculoides	California two-spot octopus	4	0.490
		Panulirus interruptus	California spiny lobster	1	0.242
		Paraxanthias taylori	lumpy rubble crab	1	0.001
		Petrolisthes cabrilloi	Cabrillo porcelain crab	7	0.005
		Pilumnus spinohirsutus	retiring hairy crab	1	0.001
		Pisaster giganteus	giant-spined sea star	2	0.043
		Portunus xantusii	Xantus swimming crab	5	0.014
				101	1.126

Survey Type: Heat Treatment
Survey: SONGSHT13
Date: January 11, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	47	0.260
		Anisotremus davidsonii	sargo	2	0.085
		Atherinops affinis	topsmelt	17	0.391
		Atherinopsis californiensis	jacksmelt	2	0.120
		Branchiostoma californiense	California lancelet	10	0.010
		Cheilotrema saturnum	black croaker	1	0.032
		Chromis punctipinnis	blacksmith	1	0.054
		Embiotoca jacksoni	black perch	1	0.044
		Engraulis mordax	northern anchovy	57	0.067
		Hypsoblennius gilberti	rockpool blenny	109	0.207
		Paralabrax nebulifer	barred sand bass	24	3.126
		Paralichthys californicus	California halibut	1	0.015
		Scorpaena guttata	California scorpionfish	10	0.372
		Seriphus politus	queenfish	134	0.559
		Syngnathus sp	pipefish unid.	5	0.004
		Xenistius californiensis	salema	33	0.192
				454	5.538
3	Invertebrate	*Alpheus clamator*	twistclaw pistol shrimp	20	0.030
		Cancer antennarius	Pacific rock crab	110	4.470
		Cancer anthonyi	yellow crab	340	1.700
		Cancer jordani	hairy rock crab	40	0.040
		Cancer productus	red rock crab	10	0.010
		Crangon nigromaculata	blackspotted bay shrimp	10	0.020
		Cycloxanthops novemdentatus	ninetooth pebble crab	40	0.280
		Farfantepenaeus californiensis	yellowleg shrimp	1	0.022
		Heptacarpus palpator	intertidal coastal shrimp	50	0.040
		Lophopanopeus bellus	blackclaw crestleg crab	10	0.020
		Lysmata californica	red rock shrimp	920	0.980
		Octopus bimaculatus/bimaculoides	California two-spot octopus	9	3.319
		Pachycheles rudis	thick claw porcelain crab	10	0.010
		Pachygrapsus crassipes	striped shore crab	400	0.550
		Paraxanthias taylori	lumpy rubble crab	10	0.060
		Petrolisthes cinctipes	flat porcelain crab	810	0.570
		Pisaster giganteus	giant-spined sea star	1	0.864
		Pisaster ochraceus	ochre star	56	2.776
		Portunus xantusii	Xantus swimming crab	130	0.390
		Puggetia dalli	spined kelp crab	10	0.010
		Pyromaia tuberculata	tuberculate pear crab	30	0.030
				3,017	16.191

Survey Type: Heat Treatment
Survey: SONGSHT14
Date: January 27, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anchoa compressa*	deepbody anchovy	7	0.021
		Anisotremus davidsonii	sargo	6	0.067
		Atherinops affinis	topsmelt	6	0.132
		Atherinopsis californiensis	jacksmelt	8	1.023
		Cheilotrema saturnum	black croaker	2	0.354
		Chromis punctipinnis	blacksmith	5	0.112
		Cymatogaster aggregata	shiner perch	2	0.029
		Embiotoca jacksoni	black perch	3	0.300
		Engraulis mordax	northern anchovy	18	0.073
		Genyonemus lineatus	white croaker	9	0.140
		Gibbonsia metzi	striped kelpfish	4	0.051
		Halichoeres semicinctus	rock wrasse	1	0.050
		Heterostichus rostratus	giant kelpfish	1	0.004
		Hyperprosopon anale	spotfin surfperch	1	0.013
		Hyperprosopon argenteum	walleye surfperch	2	0.065
		Hypsoblennius gilberti	rockpool blenny	63	0.239
		Medialuna californiensis	halfmoon	1	0.098
		Paralabrax nebulifer	barred sand bass	13	2.195
		Paralichthys californicus	California halibut	1	0.102
		Porichthys myriaster	specklefin midshipman	1	0.009
		Sardinops sagax	Pacific sardine	4	0.168
		Scorpaena guttata	California scorpionfish	20	0.949
		Scorpaenichthys marmoratus	cabezon	2	0.716
		Sebastes auriculatus	brown rockfish	3	0.249
		Sebastes serriceps	treefish	1	0.096
		Seriphus politus	queenfish	35	0.409
		Syngnathus sp	pipefish unid.	6	0.017
		Torpedo californica	Pacific electric ray	1	11.250
		Umbrina roncador	yellowfin croaker	2	0.240
		Xenistius californiensis	salema	77	0.468
				305	19.639

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Survey Type: Heat Treatment
Survey: SONGSHT14 (continued)
Date: January 27, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Invertebrate	*Asterina miniata*	bat star	1	0.011
		Cancer antennarius	Pacific rock crab	31	0.130
		Cancer anthonyi	yellow crab	51	0.158
		Cancer jordani	hairy rock crab	10	0.041
		Cancer productus	red rock crab	9	0.018
		Caudina arenicola	sweet potatoe sea cucumber	1	0.153
		Crangon nigromaculata	blackspotted bay shrimp	1	0.001
		Farfantepenaeus californiensis	yellowleg shrimp	2	0.037
		Hemigrapsus oregonensis	yellow shore crab	8	0.009
		Heptacarpus palpator	intertidal coastal shrimp	7	0.008
		Lophopanopeus bellus	blackclaw crestleg crab	3	0.015
		Lysmata californica	red rock shrimp	42	0.072
		Octopus bimaculatus/bimaculoides	California two-spot octopus	8	1.506
		Pachycheles rudis	thick claw porcelain crab	8	0.011
		Pachygrapsus crassipes	striped shore crab	16	0.085
		Panulirus interruptus	California spiny lobster	13	4.050
		Portunus xantusii	Xantus swimming crab	24	0.145
		Pugettia producta	northern kelp crab	1	0.001
		Pyromaia tuberculata	tuberculate pear crab	1	0.002
				237	6.453

Survey Type: Heat Treatment
Survey: SONGSHT15
Date: March 4, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	2	0.024
		Artedius corallinus	coralline sculpin	1	0.005
		Atherinops affinis	topsmelt	57	2.056
		Atherinopsidae	atherinopsid eggs		0.132
		Atherinopsis californiensis	jacksmelt	94	6.608
		Cheilotrema saturnum	black croaker	3	0.248
		Citharichthys stigmaeus	speckled sanddab	4	0.005
		Cymatogaster aggregata	shiner perch	3	0.073
		Engraulis mordax	northern anchovy	15	0.119
		Genyonemus lineatus	white croaker	9	0.272
		Heterostichus rostratus	giant kelpfish	1	0.006
		Hyperprosopon argenteum	walleye surfperch	7	0.215
		Hypsoblennius gilberti	rockpool blenny	295	1.091
		Hypsypops rubicundus	garibaldi	1	0.009
		Myliobatis californica	bat ray	1	0.333
		Paralabrax clathratus	kelp bass	1	0.014
		Paralabrax nebulifer	barred sand bass	1	0.011
		Pleuronichthys ritteri	spotted turbot	1	0.014
		Sardinops sagax	Pacific sardine	3	0.134
		Scomber japonicus	Pacific chub mackerel	7	0.648
		Scorpaena guttata	California scorpionfish	3	0.095
		Scorpaenichthys marmoratus	cabezon	11	0.042
		Sebastes auriculatus	brown rockfish	1	0.053
		Seriphus politus	queenfish	604	4.932
		Symphurus atricaudus	California tonguefish	2	0.003
		Syngnathus californiensis	kelp pipefish	49	0.066
		Umbrina roncador	yellowfin croaker	1	0.011
		Xenistius californiensis	salema	639	4.910
				1,816	22.129

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Survey Type: Heat Treatment
Survey: SONGSHT15 (continued)
Date: March 4, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	45	0.854
		Cancer anthonyi	yellow crab	5	0.027
		Cancer gracilis	graceful crab	2	0.014
		Cancer jordani	hairy rock crab	45	0.058
		Cancer productus	red rock crab	2	0.001
		Cancer sp	cancer crab unid	4,576	3.712
		Caudina arenicola	sweet potatoe sea cucumber	1	0.073
		Crangon nigromaculata	blackspotted bay shrimp	5	0.009
		Cycloxanthops novemdentatus	ninetooth pebble crab	2	0.014
		Dendraster excentricus	Pacific sand dollar	37	0.116
		Farfantepenaeus californiensis	yellowleg shrimp	3	0.056
		Heptacarpus palpator	intertidal coastal shrimp	40	0.024
		Loligo opalescens	California market squid	1	0.039
		Loxorhynchus grandis	sheep crab	1	0.908
		Lysmata californica	red rock shrimp	163	0.098
		Navanax inermis	California aglaja	1	0.004
		Octopus bimaculatus/bimaculoides	California two-spot octopus	9	0.666
		Pachygrapsus crassipes	striped shore crab	416	0.560
		Panulirus interruptus	California spiny lobster	2	0.611
		Petrolisthes cabrilloi	Cabrillo porcelain crab	64	0.064
		Pilumnus spinohirsutus	retiring hairy crab	1	0.007
		Pisaster ochraceus	ochre star	10	0.990
		Portunus xantusii	Xantus swimming crab	193	0.483
		Pugettia producta	northern kelp crab	3	0.006
		Pyromaia tuberculata	tuberculate pear crab	194	0.252
		Strongylocentrotus purpuratus	purple sea urchin	1	0.004
				5,822	9.650

Survey Type: Heat Treatment
Survey: SONGSHT16
Date: April 4, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinopsis californiensis*	jacksmelt	113	8.086
		Branchiostoma californiense	California lancelet	40	0.010
		Cheilotrema saturnum	black croaker	6	0.600
		Cymatogaster aggregata	shiner perch	36	1.044
		Embiotoca jacksoni	black perch	3	0.538
		Engraulis mordax	northern anchovy	24	0.246
		Genyonemus lineatus	white croaker	4	0.158
		Heterostichus rostratus	giant kelpfish	2	0.034
		Hyperprosopon argenteum	walleye surfperch	8	0.316
		Hypsoblennius gilberti	rockpool blenny	119	0.625
		Menticirrhus undulatus	California corbina	1	0.062
		Micrometrus minimus	dwarf perch	1	0.038
		Ophidion scrippsae	basketweave cusk-eel	4	0.008
		Paralabrax nebulifer	barred sand bass	3	0.330
		Phanerodon furcatus	white seaperch	4	0.170
		Pleuronichthys ritteri	spotted turbot	1	0.018
		Porichthys notatus	plainfin midshipman	5	0.200
		Sardinops sagax	Pacific sardine	1	0.056
		Scomber japonicus	Pacific chub mackerel	16	1.231
		Scorpaena guttata	California scorpionfish	9	0.623
		Scorpaenichthys marmoratus	cabezon	32	0.237
		Sebastes auriculatus	brown rockfish	1	0.270
		Sebastes miniatus	vermillion rockfish	1	0.005
		Sebastes rastrelliger	grass rockfish	1	0.256
		Seriphus politus	queenfish	506	6.540
		Stereolepis gigas	giant sea bass	1	65.000
		Symphurus atricaudus	California tonguefish	1	0.001
		Syngnathus californiensis	kelp pipefish	3	0.003
		Trachurus symmetricus	jack mackerel	5	0.231
		Umbrina roncador	yellowfin croaker	2	0.275
		Urobatis halleri	round stingray	1	0.740
		Xenistius californiensis	salema	1,589	17.290
				2,543	105.241

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Survey Type: Heat Treatment
Survey: SONGSHT16 (continued)
Date: April 4, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	100	2.140
		Cancer anthonyi	yellow crab	600	4.980
		Cancer gracilis	graceful crab	20	0.140
		Cancer jordani	hairy rock crab	1,470	4.060
		Cancer productus	red rock crab	20	0.090
		Crangon nigromaculata	blackspotted bay shrimp	10	0.010
		Farfantepenaeus californiensis	yellowleg shrimp	6	0.183
		Heptacarpus palpator	intertidal coastal shrimp	100	0.060
		Hermissenda crassicornis	hermissenda	10	0.010
		Lysmata californica	red rock shrimp	150	0.130
		Neotrypaea californiensis	bay ghost shrimp	10	0.010
		Octopus bimaculatus/bimaculoides	California two-spot octopus	4	0.150
		Pachygrapsus crassipes	striped shore crab	30	0.020
		Panulirus interruptus	California spiny lobster	8	2.150
		Portunus xantusii	Xantus swimming crab	140	0.850
		Pugettia producta	northern kelp crab	40	0.420
		Pyromaia tuberculata	tuberculate pear crab	110	0.300
		Synalpheus lockingtoni	littoral pistol shrimp	10	0.010
				2,838	15.713

Survey Type: Heat Treatment
Survey: SONGSHT17
Date: April 25, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anisotremus davidsonii*	sargo	1	0.009
		Atherinops affinis	topsmelt	1	0.048
		Atherinopsis californiensis	jacksmelt	160	13.621
		Cheilotrema saturnum	black croaker	1	0.116
		Citharichthys stigmaeus	speckled sanddab	2	0.002
		Cymatogaster aggregata	shiner perch	7	0.207
		Embiotoca jacksoni	black perch	2	0.327
		Engraulis mordax	northern anchovy	17	0.033
		Genyonemus lineatus	white croaker	13	0.029
		Heterostichus rostratus	giant kelpfish	3	0.115
		Hyperprosopon argenteum	walleye surfperch	4	0.162
		Hypsoblennius gilberti	rockpool blenny	94	0.456
		Leuresthes tenuis	California grunion	1	0.018
		Ophidion scrippsae	basketweave cusk-eel	4	0.011
		Paralabrax nebulifer	barred sand bass	2	0.173
		Paralichthys californicus	California halibut	2	0.514
		Peprilus simillimus	Pacific pompano	1	0.025
		Phanerodon furcatus	white seaperch	1	0.019
		Porichthys notatus	plainfin midshipman	1	0.081
		Sardinops sagax	Pacific sardine	7	0.337
		Scomber japonicus	Pacific chub mackerel	11	0.898
		Scorpaena guttata	California scorpionfish	10	0.709
		Scorpaenichthys marmoratus	cabezon	38	0.389
		Sebastes auriculatus	brown rockfish	5	0.680
		Sebastes miniatus	vermillion rockfish	2	0.010
		Seriphus politus	queenfish	184	2.970
		Syngnathus exilis	barcheek pipefish	2	0.003
		Syngnathus leptorhynchus	bay pipefish	13	0.018
		Umbrina roncador	yellowfin croaker	1	0.292
		Xenistius californiensis	salema	467	5.320
				1,057	27.592

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Survey Type: Heat Treatment
Survey: SONGSHT17 (continued)
Date: April 25, 2007

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
3	Invertebrate	*Betaeus longidactylus*	visored shrimp	17	0.017
		Cancer antennarius	Pacific rock crab	5	0.111
		Cancer anthonyi	yellow crab	393	1.061
		Cancer gracilis	graceful crab	19	0.035
		Cancer jordani	hairy rock crab	2,302	2.242
		Cancer productus	red rock crab	49	0.196
		Caudina arenicola	sweet potatoe sea cucumber	3	0.251
		Dendraster excentricus	Pacific sand dollar	4	0.004
		Heptacarpus palpator	intertidal coastal shrimp	83	0.046
		Lophopanopeus bellus	blackclaw crestleg crab	1	0.001
		Loxorhynchus grandis	sheep crab	2	2.110
		Lysmata californica	red rock shrimp	456	0.228
		Octopus bimaculatus/bimaculoides	California two-spot octopus	11	1.010
		Octopus rubescens	East Pacific red octopus	25	0.076
		Pachycheles rudis	thick claw porcelain crab	32	0.032
		Pachygrapsus crassipes	striped shore crab	180	0.469
		Panulirus interruptus	California spiny lobster	5	1.220
		Petrolisthes cabrilloi	Cabrillo porcelain crab	64	0.064
		Pilumnus spinohirsutus	retiring hairy crab	19	0.020
		Pisaster giganteus	giant-spined sea star	2	1.888
		Pisaster ochraceus	ochre star	1	0.102
		Portunus xantusii	Xantus swimming crab	14	0.028
		Pugettia producta	northern kelp crab	32	0.176
		Pyromaia tuberculata	tuberculate pear crab	260	0.451
		Strongylocentrotus purpuratus	purple sea urchin	1	0.004
				3,980	11.842

Survey Type: Heat Treatment
Survey: SONGSHT18
Date: May 18, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anisotremus davidsonii*	sargo	1	0.086
		Atherinopsis californiensis	jacksmelt	62	5.626
		Chilara taylori	spotted cusk-eel	1	0.048
		Chromis punctipinnis	blacksmith	4	0.139
		Citharichthys stigmaeus	speckled sanddab	6	0.021
		Cymatogaster aggregata	shiner perch	181	5.138
		Embiotoca jacksoni	black perch	10	0.121
		Engraulis mordax	northern anchovy	11	0.143
		Genyonemus lineatus	white croaker	28	1.304
		Gibbonsia elegans	spotted kelpfish	4	0.037
		Halichoeres semicinctus	rock wrasse	1	0.006
		Heterostichus rostratus	giant kelpfish	3	0.038
		Hyperprosopon argenteum	walleye surfperch	5	0.216
		Hypsoblennius gilberti	rockpool blenny	71	0.396
		Hypsypops rubicundus	garibaldi	1	0.125
		Leuresthes tenuis	California grunion	17	0.440
		Myliobatis californica	bat ray	1	0.251
		Ophidion scrippsae	basketweave cusk-eel	2	0.010
		Oxyjulis californica	senorita	1	0.002
		Paralabrax clathratus	kelp bass	2	0.447
		Paralabrax nebulifer	barred sand bass	12	2.773
		Paralichthys californicus	California halibut	3	0.235
		Peprilus simillimus	Pacific pompano	4	0.138
		Phanerodon furcatus	white seaperch	24	1.553
		Porichthys notatus	plainfin midshipman	15	0.331
		Roncador stearnsii	spotfin croaker	9	4.700
		Sardinops sagax	Pacific sardine	22	1.038
		Scomber japonicus	Pacific chub mackerel	178	18.250
		Scorpaena guttata	California scorpionfish	47	2.418
		Scorpaenichthys marmoratus	cabezon	22	0.201
		Sebastes auriculatus	brown rockfish	6	0.555
		Sebastes miniatus	vermillion rockfish	2	0.006
		Sebastes rastrelliger	grass rockfish	1	0.280
		Seriphus politus	queenfish	326	8.286
		Syngnathus californiensis	kelp pipefish	3	0.012
		Trachurus symmetricus	jack mackerel	242	14.161
		Umbrina roncador	yellowfin croaker	6	0.705
		Xenistius californiensis	salema	356	6.417
				1,690	76.653

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Survey Type: Heat Treatment
Survey: SONGSHT18 (continued)
Date: May 18, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Invertebrate	*Betaeus* sp	visored shrimp unid	1	0.001
		Cancer antennarius	Pacific rock crab	7	0.700
		Cancer anthonyi	yellow crab	69	0.279
		Cancer gracilis	graceful crab	7	0.020
		Cancer jordani	hairy rock crab	842	1.196
		Cancer productus	red rock crab	21	0.084
		Caudina arenicola	sweet potatoe sea cucumber	4	0.244
		Crangon nigromaculata	blackspotted bay shrimp	73	0.098
		Cycloxanthops novemdentatus	ninetooth pebble crab	2	0.007
		Dendraster excentricus	Pacific sand dollar	4	0.047
		Farfantepenaeus californiensis	yellowleg shrimp	2	0.062
		Heptacarpus palpator	intertidal coastal shrimp	13	0.012
		Hermissenda crassicornis	hermissenda	1	0.001
		Loligo opalescens	California market squid	1	0.016
		Lophopanopeus frontalis	molarless crestleg crab	1	0.006
		Lysmata californica	red rock shrimp	221	0.171
		Octopus bimaculatus/bimaculoides	California two-spot octopus	28	0.386
		Octopus rubescens	East Pacific red octopus	75	0.280
		Pachycheles rudis	thick claw porcelain crab	41	0.041
		Pachygrapsus crassipes	striped shore crab	140	0.560
		Panulirus interruptus	California spiny lobster	3	0.846
		Pelia tumida	dwarf teardrop crab	20	0.040
		Petrolisthes cabrilloi	Cabrillo porcelain crab	2	0.002
		Pisaster giganteus	giant-spined sea star	1	0.382
		Portunus xantusii	Xantus swimming crab	29	0.102
		Pugettia producta	northern kelp crab	5	0.042
		Pyromaia tuberculata	tuberculate pear crab	33	0.045
		Renilla kollikeri	sea pansy	1	0.007
				1,647	5.677

Survey Type: Heat Treatment
Survey: SONGSHT19
Date: June 2, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinops affinis*	topsmelt	10	0.370
		Atherinopsis californiensis	jacksmelt	119	6.937
		Chromis punctipinnis	blacksmith	1	0.055
		Cymatogaster aggregata	shiner perch	77	2.055
		Embiotoca jacksoni	black perch	9	0.356
		Engraulis mordax	northern anchovy	8	0.101
		Genyonemus lineatus	white croaker	15	0.820
		Halichoeres semicinctus	rock wrasse	1	0.206
		Heterostichus rostratus	giant kelpfish	1	0.047
		Hyperprosopon argenteum	walleye surfperch	5	0.273
		Hypsoblennius gilberti	rockpool blenny	40	0.130
		Leptocottus armatus	Pacific staghorn sculpin	1	0.014
		Leuresthes tenuis	California grunion	42	0.894
		Ophidion scrippsae	basketweave cusk-eel	2	0.017
		Paralabrax clathratus	kelp bass	1	0.157
		Peprilus simillimus	Pacific pompano	2	0.083
		Phanerodon furcatus	white seaperch	1	0.054
		Porichthys myriaster	specklefin midshipman	1	0.698
		Roncador stearnsii	spotfin croaker	1	0.562
		Sardinops sagax	Pacific sardine	2	0.095
		Scomber japonicus	Pacific chub mackerel	44	4.473
		Scorpaena guttata	California scorpionfish	14	0.061
		Scorpaenichthys marmoratus	cabezon	23	0.260
		Sebastes auriculatus	brown rockfish	1	0.219
		Seriphus politus	queenfish	656	13.739
		Syngnathus californiensis	kelp pipefish	2	0.004
		Trachurus symmetricus	jack mackerel	136	8.192
		Xenistius californiensis	salema	21	0.682
				1,236	41.554

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Survey Type: Heat Treatment
Survey: SONGSHT19 (continued)
Date: June 2, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Invertebrate	*Betaeus* sp	visored shrimp unid	5	0.005
		Cancer antennarius	Pacific rock crab	6	0.154
		Cancer anthonyi	yellow crab	53	0.152
		Cancer gracilis	graceful crab	35	0.074
		Cancer jordani	hairy rock crab	61	0.127
		Farfantepenaeus californiensis	yellowleg shrimp	2	0.054
		Heptacarpus palpator	intertidal coastal shrimp	3	0.003
		Lophopanopeus frontalis	molarless crestleg crab	1	0.007
		Lysmata californica	red rock shrimp	14	0.010
		Octopus bimaculatus/bimaculoides	California two-spot octopus	37	0.542
		Pachygrapsus crassipes	striped shore crab	17	0.072
		Petrolisthes cabrilloi	Cabrillo porcelain crab	7	0.007
		Pilumnus spinohirsutus	retiring hairy crab	6	0.023
		Pisaster ochraceus	ochre star	2	0.340
		Portunus xantusii	Xantus swimming crab	6	0.071
		Pugettia producta	northern kelp crab	2	0.037
		Pyromaia tuberculata	tuberculate pear crab	4	0.006
				261	1.684

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC01
Date: May 1, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anisotremus davidsonii*	sargo	1	0.200
		Atherinopsis californiensis	jacksmelt	2	0.127
		Cheilotrema saturnum	black croaker	1	0.084
		Chromis punctipinnis	blacksmith	1	0.060
		Embiotoca jacksoni	black perch	5	0.154
		Genyonemus lineatus	white croaker	4	0.225
		Heterostichus rostratus	giant kelpfish	2	0.030
		Paralabrax nebulifer	barred sand bass	25	3.375
		Phanerodon furcatus	white seaperch	1	0.035
		Porichthys myriaster	specklefin midshipman	4	0.204
		Scorpaena guttata	California scorpionfish	13	0.797
		Sebastes serriceps	treefish	1	0.032
		Seriphus politus	queenfish	1	0.056
				61	5.379
2	Invertebrate	*Loxorhynchus grandis*	sheep crab	1	1.500
		Panulirus interruptus	California spiny lobster	5	1.800
				6	3.300

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC02
Date: May 13, 2006

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
3	Fish	*Amphistichus argenteus*	barred surfperch	1	0.150
		Anisotremus davidsonii	sargo	1	0.100
		Atherinops affinis	topsmelt	24	0.960
		Atherinopsis californiensis	jacksmelt	20	1.480
		Cheilotrema saturnum	black croaker	1	0.150
		Embiotoca jacksoni	black perch	2	0.300
		Engraulis mordax	northern anchovy	18	0.410
		Hypsoblennius sp	combtooth blenny	2	0.030
		Hypsypops rubicundus	garibaldi	1	0.220
		Paralabrax clathratus	kelp bass	3	0.300
		Paralabrax nebulifer	barred sand bass	17	2.370
		Paralichthys californicus	California halibut	2	0.200
		Peprilus simillimus	Pacific pompano	19	0.570
		Phanerodon furcatus	white seaperch	2	0.200
		Roncador stearnsii	spotfin croaker	3	1.100
		Scomber japonicus	Pacific chub mackerel	1	0.200
		Scorpaena guttata	California scorpionfish	13	1.270
		Sebastes serriceps	treefish	1	0.150
		Semicossyphus pulcher	California sheephead	1	0.350
		Stereolepis gigas	giant sea bass	1	50.000
		Syngnathus sp	pipefish unid.	1	0.080
		Synodus lucioceps	California lizardfish	1	0.050
		Triakis semifasciata	leopard shark	1	0.300
		Umbrina roncador	yellowfin croaker	6	0.780
				142	61.720
3	Invertebrate	*Cancer* sp	cancer crab unid	1	0.150
		Loxorhynchus grandis	sheep crab	3	3.600
		Panulirus interruptus	California spiny lobster	5	1.500
		Portunus xantusii	Xantus swimming crab	1	0.012
				10	5.262

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC03
Date: June 10, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anisotremus davidsonii*	sargo	36	12.560
		Atherinops affinis	topsmelt	5	0.170
		Atherinopsis californiensis	jacksmelt	17	1.634
		Atractoscion nobilis	white seabass	2	1.250
		Cheilotrema saturnum	black croaker	33	3.490
		Chromis punctipinnis	blacksmith	1	0.150
		Embiotoca jacksoni	black perch	3	0.750
		Engraulis mordax	northern anchovy	1,500	20.000
		Heterodontus francisci	horn shark	1	3.500
		Menticirrhus undulatus	California corbina	8	2.250
		Mustelus californicus	grey smoothhound	1	1.500
		Paralabrax clathratus	kelp bass	2	0.750
		Paralabrax nebulifer	barred sand bass	44	12.500
		Phanerodon furcatus	white seaperch	3	0.239
		Rhacochilus toxotes	rubberlip seaperch	1	0.400
		Rhinobatos productus	shovelnose guitarfish	2	11.000
		Roncador stearnsii	spotfin croaker	62	23.100
		Scomber japonicus	Pacific chub mackerel	110	12.850
		Scorpaena guttata	California scorpionfish	19	4.500
		Sebastes rastrelliger	grass rockfish	1	0.600
		Seriphus politus	queenfish	12	0.340
		Sphyraena argentea	Pacific barracuda	1	0.750
		Stereolepis gigas	giant sea bass	1	33.000
		Trachurus symmetricus	jack mackerel	619	44.020
		Umbrina roncador	yellowfin croaker	40	12.000
		Xenistius californiensis	salema	208	8.950
				2,732	212.253
2	Invertebrate	*Panulirus interruptus*	California spiny lobster	16	5.250
				16	5.250

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC04
Date: June 24, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Amphistichus argenteus*	barred surfperch	1	0.180
		Anisotremus davidsonii	sargo	219	46.880
		Atherinops affinis	topsmelt	10	0.300
		Atherinopsis californiensis	jacksmelt	12	0.680
		Atractoscion nobilis	white seabass	5	1.050
		Cheilotrema saturnum	black croaker	9	0.970
		Chromis punctipinnis	blacksmith	1	0.080
		Cymatogaster aggregata	shiner perch	1	0.030
		Embiotoca jacksoni	black perch	2	0.400
		Engraulis mordax	northern anchovy	350	1.740
		Hermosilla azurea	zebraperch	3	1.990
		Hyperprosopon argenteum	walleye surfperch	1	0.090
		Menticirrhus undulatus	California corbina	8	1.600
		Paralabrax clathratus	kelp bass	16	3.450
		Paralabrax nebulifer	barred sand bass	58	11.780
		Porichthys myriaster	specklefin midshipman	1	0.500
		Roncador stearnsii	spotfin croaker	608	243.200
		Scomber japonicus	Pacific chub mackerel	2	0.400
		Scorpaena guttata	California scorpionfish	6	0.680
		Seriphus politus	queenfish	1	0.030
		Stereolepis gigas	giant sea bass	2	60.000
		Trachurus symmetricus	jack mackerel	59	4.340
		Umbrina roncador	yellowfin croaker	432	108.430
		Urobatis halleri	round stingray	2	0.700
		Xenistius californiensis	salema	132	0.750
				1,941	490.250
3	Invertebrate	*Panulirus interruptus*	California spiny lobster	3	0.750
				3	0.750

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC05
Date: July 31, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anisotremus davidsonii*	sargo	487	86.880
		Atherinopsis californiensis	jacksmelt	3	0.240
		Atractoscion nobilis	white seabass	2	0.300
		Cheilotrema saturnum	black croaker	5	0.470
		Chromis punctipinnis	blacksmith	1	0.080
		Embiotoca jacksoni	black perch	156	14.660
		Hermosilla azurea	zebraperch	9,410	6,233.050
		Medialuna californiensis	halfmoon	1	0.250
		Myliobatis californica	bat ray	1	55.000
		Paralabrax clathratus	kelp bass	2	0.370
		Paralabrax nebulifer	barred sand bass	20	5.980
		Phanerodon furcatus	white seaperch	1	0.100
		Roncador stearnsii	spotfin croaker	419	207.080
		Scomber japonicus	Pacific chub mackerel	4	0.510
		Scorpaena guttata	California scorpionfish	2	0.300
		Seriphus politus	queenfish	178	5.210
		Stereolepis gigas	giant sea bass	1	35.000
		Trachurus symmetricus	jack mackerel	165	7.470
		Umbrina roncador	yellowfin croaker	12,764	4,457.920
		Xenistius californiensis	salema	1,645	85.760
				25,267	11,196.630
2	Invertebrate	*Octopus bimaculatus/bimaculoides*	California two-spot octopus	5	1.200
		Panulirus interruptus	California spiny lobster	96	31.060
				101	32.260

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC06
Date: August 10, 2006

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
3	Fish	*Anisotremus davidsonii*	sargo	1,941	423.590
		Atherinopsis californiensis	jacksmelt	2	0.200
		Atractoscion nobilis	white seabass	2	0.250
		Hermosilla azurea	zebraperch	1	0.500
		Mustelus sp	smoothhound unid	1	0.600
		Paralabrax clathratus	kelp bass	6	1.108
		Paralabrax nebulifer	barred sand bass	14	5.530
		Phanerodon furcatus	white seaperch	7	0.980
		Porichthys myriaster	specklefin midshipman	1	0.600
		Roncador stearnsii	spotfin croaker	787	236.100
		Seriphus politus	queenfish	5	0.160
		Stereolepis gigas	giant sea bass	4	80.000
		Synodus lucioceps	California lizardfish	2	0.160
		Umbrina roncador	yellowfin croaker	35,417	13,737.370
		Xenistius californiensis	salema	77	8.520
				38,267	14,495.668
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	1	0.200
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	
		Panulirus interruptus	California spiny lobster	42	6.000
		Taliepus nuttallii	globose kelp crab	1	0.300
				45	6.500

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC07
Date: September 2, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Biomass (kg)
2	Fish	*Anisotremus davidsonii*	sargo	962	204.560
		Atherinopsis californiensis	jacksmelt	29	2.560
		Atractoscion nobilis	white seabass	9	0.770
		Cheilotrema saturnum	black croaker	20	1.700
		Embiotoca jacksoni	black perch	34	5.820
		Engraulis mordax	northern anchovy	1,915	5.330
		Gymnura marmorata	California butterfly ray	1	0.750
		Hyperprosopon argenteum	walleye surfperch	2	0.080
		Medialuna californiensis	halfmoon	1	0.110
		Menticirrhus undulatus	California corbina	1	0.750
		Paralabrax clathratus	kelp bass	3	1.100
		Paralabrax nebulifer	barred sand bass	38	6.540
		Phanerodon furcatus	white seaperch	4	0.108
		Rhinobatos productus	shovelnose guitarfish	3	16.000
		Roncador stearnsii	spotfin croaker	338	120.830
		Scorpaena guttata	California scorpionfish	12	1.340
		Seriphus politus	queenfish	76	2.080
		Trachurus symmetricus	jack mackerel	5	0.135
		Umbrina roncador	yellowfin croaker	616	245.410
		Xenistius californiensis	salema	71	3.000
				4,140	618.973
2	Invertebrate	*Cancer antennarius*	Pacific rock crab	2	0.150
		Octopus bimaculatus/bimaculoides	California two-spot octopus	2	0.750
		Panulirus interruptus	California spiny lobster	98	23.450
				102	24.350

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC08
Date: September 16, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anisotremus davidsonii*	sargo	1,020	195.269
		Atractoscion nobilis	white seabass	2	0.219
		Cheilotrema saturnum	black croaker	7	0.700
		Embiotoca jacksoni	black perch	9	1.517
		Engraulis mordax	northern anchovy	3,729	8.802
		Heterostichus rostratus	giant kelpfish	1	0.080
		Medialuna californiensis	halfmoon	3	0.504
		Paralabrax clathratus	kelp bass	6	0.612
		Paralabrax nebulifer	barred sand bass	12	1.796
		Peprilus simillimus	Pacific pompano	1	0.028
		Roncador stearnsii	spotfin croaker	2,421	1,263.647
		Scomber japonicus	Pacific chub mackerel	3	1.566
		Scorpaena guttata	California scorpionfish	2	0.045
		Seriphus politus	queenfish	366	8.788
		Stereolepis gigas	giant sea bass	2	55.000
		Umbrina roncador	yellowfin croaker	272	63.759
		Xenistius californiensis	salema	223	9.589
				8,079	1,611.921
3	Invertebrate	*Loxorhynchus grandis*	sheep crab	1	3.000
		Octopus sp	octopus unid	1	0.250
		Panulirus interruptus	California spiny lobster	33	10.433
				35	13.683

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC09
Date: October 7, 2006

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anisotremus davidsonii*	sargo	492	66.226
		Atherinops affinis	topsmelt	1	0.041
		Atherinopsis californiensis	jacksmelt	3	0.372
		Atractoscion nobilis	white seabass	5	0.395
		Cheilotrema saturnum	black croaker	2	0.095
		Chromis punctipinnis	blacksmith	1	0.040
		Embiotoca jacksoni	black perch	19	2.307
		Engraulis mordax	northern anchovy	1,217	4.311
		Medialuna californiensis	halfmoon	1	0.110
		Paralabrax clathratus	kelp bass	6	0.105
		Paralabrax nebulifer	barred sand bass	24	6.480
		Paralichthys californicus	California halibut	1	0.171
		Rhacochilus vacca	pile perch	1	0.121
		Roncador stearnsii	spotfin croaker	4	1.080
		Scomber japonicus	Pacific chub mackerel	245	36.960
		Scorpaena guttata	California scorpionfish	9	1.166
		Scorpaenichthys marmoratus	cabezon	2	0.200
		Seriphus politus	queenfish	685	18.505
		Umbrina roncador	yellowfin croaker	57	15.390
		Xenistius californiensis	salema	3	0.115
				2,778	154.190
2	Invertebrate	*Octopus bimaculatus/bimaculoides*	California two-spot octopus	3	1.000
		Panulirus interruptus	California spiny lobster	46	13.840
				49	14.840

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC10
Date: December 6, 2006

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
2	Fish	*Anisotremus davidsonii*	sargo	179	21.980
		Atherinops affinis	topsmelt	3	0.120
		Atherinopsis californiensis	jacksmelt	2	0.190
		Atractoscion nobilis	white seabass	1	0.130
		Cheilotrema saturnum	black croaker	29	1.730
		Embiotoca jacksoni	black perch	4	0.600
		Hyperprosopon argenteum	walleye surfperch	10	0.320
		Medialuna californiensis	halfmoon	2	0.320
		Paralabrax clathratus	kelp bass	1	0.200
		Paralabrax nebulifer	barred sand bass	51	5.970
		Phanerodon furcatus	white seaperch	4	0.400
		Roncador stearnsii	spotfin croaker	33	5.564
		Sardinops sagax	Pacific sardine	1	0.035
		Scomber japonicus	Pacific chub mackerel	180	22.530
		Scorpaena guttata	California scorpionfish	3	0.620
		Scorpaenichthys marmoratus	cabezon	1	0.100
		Seriphus politus	queenfish	54	0.710
		Umbrina roncador	yellowfin croaker	62	8.450
		Xenistius californiensis	salema	275	5.540
				895	75.509
2	Invertebrate	*Panulirus interruptus*	California spiny lobster	11	2.750
				11	2.750

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC11
Date: January 4, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Biomass (kg)
3	Fish	*Anisotremus davidsonii*	sargo	9	0.720
		Cheilotrema saturnum	black croaker	1	0.010
		Engraulis mordax	northern anchovy	18	0.108
		Genyonemus lineatus	white croaker	2	0.035
		Halichoeres semicinctus	rock wrasse	1	0.100
		Heterodontus francisci	horn shark	1	1.500
		Hypsypops rubicundus	garibaldi	3	0.210
		Oxyjulis californica	senorita	1	0.100
		Paralabrax clathratus	kelp bass	2	0.100
		Paralabrax nebulifer	barred sand bass	43	6.450
		Roncador stearnsii	spotfin croaker	31	25.000
		Scorpaena guttata	California scorpionfish	19	1.440
		Scorpaenichthys marmoratus	cabezon	1	0.050
		Sebastes auriculatus	brown rockfish	1	0.100
		Sebastes miniatus	vermillion rockfish	1	0.004
		Seriphus politus	queenfish	10	0.190
		Trachurus symmetricus	jack mackerel	1	0.010
		Umbrina roncador	yellowfin croaker	38	5.550
		Urobatis halleri	round stingray	2	0.430
				185	42.107
3	Invertebrate	*Octopus* spp.	octopus unidentified	4	0.650
		Panulirus interruptus	California spiny lobster	10	1.610
				14	2.260

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC12
Date: January 7, 2007

				Survey Totals	
Unit	Group	Species	Common Name	Abundance	Biomass (kg)
3	Fish	*Atherinops affinis*	topsmelt	1	0.210
		Engraulis mordax	northern anchovy	29	0.410
		Halichoeres semicinctus	rock wrasse	1	0.080
		Hyperprosopon argenteum	walleye surfperch	5	0.130
		Hypsypops rubicundus	garibaldi	1	0.300
		Leptocottus armatus	Pacific staghorn sculpin	1	0.030
		Medialuna californiensis	halfmoon	1	0.250
		Menticirrhus undulatus	California corbina	1	0.080
		Paralabrax nebulifer	barred sand bass	11	2.700
		Peprilus simillimus	Pacific pompano	7	0.120
		Roncador stearnsii	spotfin croaker	10	2.200
		Sardinops sagax	Pacific sardine	1	0.020
		Scorpaena guttata	California scorpionfish	6	0.220
		Seriphus politus	queenfish	165	1.190
		Umbrina roncador	yellowfin croaker	16	2.340
		Urobatis halleri	round stingray	1	0.300
				257	10.580
3	Invertebrate	*Farfantepenaeus californiensis*	yellowleg shrimp	4	0.200
		Octopus bimaculatus/bimaculoides	California two-spot octopus	2	0.245
		Panulirus interruptus	California spiny lobster	5	1.210
				11	1.655

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC13
Date: January 10, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Anchoa compressa*	deepbody anchovy	20	0.110
		Atherinops affinis	topsmelt	1	0.023
		Cheilotrema saturnum	black croaker	1	0.030
		Engraulis mordax	northern anchovy	22	0.020
		Genyonemus lineatus	white croaker	1	0.018
		Heterostichus rostratus	giant kelpfish	1	0.005
		Hyperprosopon argenteum	walleye surfperch	1	0.026
		Hypsoblennius gilberti	rockpool blenny	10	0.019
		Paralabrax nebulifer	barred sand bass	2	0.260
		Paralichthys californicus	California halibut	1	0.030
		Sardinops sagax	Pacific sardine	1	0.018
		Scorpaena guttata	California scorpionfish	11	0.410
		Seriphus politus	queenfish	243	1.010
		Torpedo californica	Pacific electric ray	1	25.000
		Xenistius californiensis	salema	148	0.860
				464	27.839
3	Invertebrate	*Cancer antennarius*	Pacific rock crab	8	0.320
		Cancer anthonyi	yellow crab	16	0.080
		Octopus bimaculatus/bimaculoides	California two-spot octopus	5	1.840
		Pachycheles rudis	thick claw porcelain crab	1	0.001
		Panulirus interruptus	California spiny lobster	5	1.250
		Petrolisthes cinctipes	flat porcelain crab	2	0.001
				37	3.492

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC14
Date: January 26, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Anisotremus davidsonii*	sargo	3	0.090
		Atherinops affinis	topsmelt	1	0.020
		Cheilotrema saturnum	black croaker	2	0.350
		Engraulis mordax	northern anchovy	236	0.960
		Genyonemus lineatus	white croaker	1	0.090
		Gymnothorax mordax	moray eel	1	1.200
		Halichoeres semicinctus	rock wrasse	3	0.150
		Hypsypops rubicundus	garibaldi	6	1.200
		Menticirrhus undulatus	California corbina	1	0.200
		Paralabrax nebulifer	barred sand bass	48	8.100
		Paralichthys californicus	California halibut	1	0.150
		Scorpaena guttata	California scorpionfish	23	1.090
		Scorpaenichthys marmoratus	cabezon	1	0.200
		Seriphus politus	queenfish	11	0.130
		Torpedo californica	Pacific electric ray	3	45.000
		Urobatis halleri	round stingray	3	1.000
				344	59.930
2	Invertebrate	*Octopus bimaculatus/bimaculoides*	California two-spot octopus	4	0.750
		Panulirus interruptus	California spiny lobster	45	14.020
				49	14.770

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC15
Date: March 4, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinopsis californiensis*	jacksmelt	21	1.480
		Atractoscion nobilis	white seabass	1	0.100
		Embiotoca jacksoni	black perch	2	0.150
		Engraulis mordax	northern anchovy	8	0.060
		Heterostichus rostratus	giant kelpfish	4	0.040
		Hypsoblennius sp	combtooth blenny	11	0.040
		Paralabrax nebulifer	barred sand bass	2	0.320
		Scorpaena guttata	California scorpionfish	11	0.330
		Sebastes rastrelliger	grass rockfish	1	0.430
		Seriphus politus	queenfish	38	0.310
		Syngnathus californiensis	kelp pipefish	3	0.010
		Torpedo californica	Pacific electric ray	1	20.000
		Umbrina roncador	yellowfin croaker	2	0.300
		Xenistius californiensis	salema	12	0.090
				117	23.660
3	Invertebrate	*Loligo opalescens*	California market squid	1	0.040
		Loxorhynchus grandis	sheep crab	2	0.910
		Octopus bimaculatus/bimaculoides	California two-spot octopus	3	0.220
		Panulirus interruptus	California spiny lobster	16	4.800
				22	5.970

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC16
Date: April 4, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
2	Fish	*Atherinopsis californiensis*	jacksmelt	23	1.650
		Cheilotrema saturnum	black croaker	2	0.200
		Engraulis mordax	northern anchovy	72	0.740
		Genyonemus lineatus	white croaker	30	1.190
		Hyperprosopon argenteum	walleye surfperch	9	0.360
		Hypsoblennius sp	combtooth blenny	3	0.010
		Medialuna californiensis	halfmoon	1	0.200
		Menticirrhus undulatus	California corbina	1	0.200
		Myliobatis californica	bat ray	1	2.000
		Paralabrax nebulifer	barred sand bass	6	0.660
		Paralichthys californicus	California halibut	1	0.050
		Phanerodon furcatus	white seaperch	3	0.300
		Porichthys myriaster	specklefin midshipman	1	0.030
		Roncador stearnsii	spotfin croaker	2	0.220
		Scorpaena guttata	California scorpionfish	4	0.280
		Scorpaenichthys marmoratus	cabezon	1	0.450
		Seriphus politus	queenfish	1,620	20.940
		Triakis semifasciata	leopard shark	1	0.200
		Xenistius californiensis	salema	611	6.650
				2,392	36.330
2	Invertebrate	*Cancer* sp	cancer crab unid	5	0.100
		Farfantepenaeus californiensis	yellowleg shrimp	3	0.090
		Octopus bimaculatus/bimaculoides	California two-spot octopus	1	0.100
		Panulirus interruptus	California spiny lobster	10	2.690
		Pugettia producta	northern kelp crab	1	0.010
				20	2.990

Survey Type: Heat Treatment - Fish Chase
Survey: SONGSFC17
Date: April 25, 2007

Unit	Group	Species	Common Name	Survey Totals Abundance	Survey Totals Biomass (kg)
3	Fish	*Atherinopsis californiensis*	jacksmelt	13	1.107
		Cheilotrema saturnum	black croaker	1	0.116
		Engraulis mordax	northern anchovy	2	0.004
		Heterostichus rostratus	giant kelpfish	3	0.060
		Paralabrax nebulifer	barred sand bass	18	3.265
		Phanerodon furcatus	white seaperch	3	0.300
		Porichthys notatus	plainfin midshipman	1	0.085
		Roncador stearnsii	spotfin croaker	244	85.400
		Sardinops sagax	Pacific sardine	30	1.444
		Scomber japonicus	Pacific chub mackerel	114	9.307
		Scorpaena guttata	California scorpionfish	14	0.993
		Sebastes auriculatus	brown rockfish	1	0.136
		Sebastes miniatus	vermillion rockfish	1	0.010
		Seriphus politus	queenfish	8	0.129
		Stereolepis gigas	giant sea bass	1	35.000
		Umbrina roncador	yellowfin croaker	57	16.530
		Urobatis halleri	round stingray	1	0.220
		Xenistius californiensis	salema	2	0.023
				514	154.129

Unit	Group	Species	Common Name	Abundance	Biomass (kg)
3	Invertebrate	*Panulirus interruptus*	California spiny lobster	1	0.244
				1	0.244

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San Onofre Nuclear Generating Station

Appendix D

Quality Assurance Quality Control Survey Data

D1. Entrainment Inplant Surveys

D2. Entrainment Offshore Surveys

D3. Impingement Surveys

D4. Fish Return System Surveys

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Entrainment QA/QC Quarterly Survey - Cycle 3
13 April 2006
Biologists – W. Dossett and A. Morris

Sampling Setup

Task	Unit 2	Unit 3
Nets and codends inspected for damage	√	√
Flowmeters calibrated	√*	√*
Interior/exterior sample container labels match, labels have correct information	√	√

Sampling

Task	Unit 2	Unit 3
Flowmeter information recorded properly	√	√
Net deployed properly	√	√
Sample times recorded accurately	√	√

Sample Processing

Task	Unit 2	Unit 3
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√	√
Sample transferred to proper container	√	√
Sample preserved properly	√	√
Sample stored securely on-site prior to departure	√	√

Note: Unit 2 had four circulator pumps running, and Unit 3 had two pumps running.

* After the survey it was discovered the incorrect conversion number was used for volume calculations . The flowmeter ID number occurred two times on the calibration sheet. Flow volumes were recalculated; re-calculations increased volumes above target sample volumes. The duplicate conversion values were removed from the calibration sheet to prevent a recurrence.

Robert Moore
Project Scientist

Entrainment QA/QC Quarterly Survey
6 July 2006
Biologists -- R. Moore and T. Ross

Sampling Setup

Task	Unit 2	Unit 3
Nets and codends inspected for damage	√	√
Flowmeters calibrated	√	√
Interior/exterior sample container labels match, labels have correct information	√	√

Sampling

Task	Unit 2	Unit 3
Flowmeter information recorded properly	√	√
Net deployed properly	√	√
Sample times recorded accurately	√	√

Sample Processing

Task	Unit 2	Unit 3
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√*	√
Sample transferred to proper container	√	√
Sample preserved properly	√	√
Sample stored securely on-site prior to departure	√	√

* At Unit 2, the replicate that was collected first was rinsed second. To minimize the chance of larval dessication, samples should be rinsed in the order collected.

Shane Beck
Senior Scientist

Entrainment QA/QC Quarterly Survey
25 October 2006
Biologists – W. Dossett and B. Kay

Unit 3 off line for refueling outage

Sampling Setup

Task	Unit 2
Nets and codends inspected for damage	√
Flowmeters calibrated	√
Interior/exterior sample container labels match, labels have correct information	√

Sampling

Task	Unit 2
Flowmeter information recorded properly	√
Net deployed properly	√
Sample times recorded accurately	√

Sample Processing

Task	Unit 2
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√
Sample transferred to proper container	√
Sample preserved properly	√
Sample stored securely on-site prior to departure	√

Net A was less than 35 m^3 on first deployment, and was re-deployed to increase sample volume.

Robert Moore
Project Scientist

Entrainment QA/QC (Cycle 1) Quarterly Survey
3 January 2007
Biologists – A. Macleod, W. Dossett

Sampling Setup

Task	Unit 2	Unit 3
Nets and codends inspected for damage	X	X
Flowmeters calibrated	X	X
Interior/exterior sample container labels match, labels have correct information	X	X

Sampling

Task	Unit 2	Unit 3
Flowmeter information recorded properly	X	X
Net deployed properly	X	X
Sample times recorded accurately	X	X

Sample Processing

Task	Unit 2	Unit 3
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	X	X
Sample transferred to proper container	X	X
Sample preserved properly	X	X
Sample stored securely on-site prior to departure	X	X

Also made sure dilution water was filtered with 202-micron mesh, and that nets were washed in the order the replicates were sampled. I spoke with biologists about making sure transferred samples were not left sitting in public spaces, but instead should be kept in the locker during cleanup.

(Continued)

Entrainment QA/QC (Cycle 3) Quarterly Survey
4 January 2007
Biologists – J. May, B. Kay

Sampling Setup

Task	Unit 2	Unit 3
Nets and codends inspected for damage	X	X
Flowmeters calibrated	X	X
Interior/exterior sample container labels match, labels have correct information	X	X

Sampling

Task	Unit 2	Unit 3
Flowmeter information recorded properly	X	X
Net deployed properly	X	X
Sample times recorded accurately	X	X

Sample Processing

Task	Unit 2	Unit 3
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	X	X
Sample transferred to proper container	X	X
Sample preserved properly	X	X
Sample stored securely on-site prior to departure	X	X

Also made sure dilution water was filtered with 202-micron mesh, and that nets were washed in the order the replicates were sampled.

Shane Beck
Senior Scientist

Entrainment QA/QC Quarterly Survey
14 March 2007
Biologists – W. Dossett and A. Macleod

Sampling Setup

Task	Unit 2	Unit 3
Nets and codends inspected for damage	√	√
Flowmeters calibrated	√	√
Interior/exterior sample container labels match, labels have correct information	√	√

Sampling

Task	Unit 2	Unit 3
Flowmeter information recorded properly	√	√
Net deployed properly	√	√
Sample times recorded accurately	√	√

Sample Processing

Task	Unit 2	Unit 3
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√	√
Sample transferred to proper container	√	√
Sample preserved properly	√	√
Sample stored securely on-site prior to departure	√	√

(Continued)

Entrainment QA/QC Quarterly Survey
15 March 2007
Biologists – B. Kay and J.May

Sampling Setup

Task	Unit 2	Unit 3
Nets and codends inspected for damage	√	√
Flowmeters calibrated	√	√
Interior/exterior sample container labels match, labels have correct information	√	√

Sampling

Task	Unit 2	Unit 3
Flowmeter information recorded properly	√	√
Net deployed properly	√	√
Sample times recorded accurately	√	√

Sample Processing

Task	Unit 2	Unit 3
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√	√
Sample transferred to proper container	√	√
Sample preserved properly	√	√
Sample stored securely on-site prior to departure	√	√

Robert Moore
Project Scientist

Offshore Entrainment QA/QC (Cycle 1) Quarterly Survey
7 June 2006
Biologists – T. Duvall, J. May

Sampling Setup

Task	Cycle 1
Nets and codends inspected for damage	√
Flowmeters calibrated	√
Interior/exterior sample container labels match, labels have correct information	√

Sampling

Task	Cycle 1
Flowmeter information recorded properly	√
Net deployed properly	√
Sample times recorded accurately	√
Sufficient water volume sampled	√

Sample Processing

Task	Cycle 1
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√
Sample transferred to proper container	√
Sample preserved properly	√
Sample stored securely	√

Comments: None

Observer: Robert H. Moore
Title: Project Scientist

San Onofre Nuclear Generating Station
316(b) Impingement Mortality and Entrainment Characterization Study

Offshore Entrainment QA/QC (Cycle 2) Quarterly Survey
30 August 2006
Biologists – T. Duvall, F. Petry

Sampling Setup

Task	Cycle 2
Nets and codends inspected for damage	√
Flowmeters calibrated	√
Interior/exterior sample container labels match, labels have correct information	√

Sampling

Task	Cycle 2
Flowmeter information recorded properly	√
Net deployed properly	√
Sample times recorded accurately	√
Sufficient water volume sampled	√

Sample Processing

Task	Cycle 2
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√
Sample transferred to proper container	√
Dilution water filtered	√
Sample preserved properly	√
Sample stored securely	√

Comments: None

Observer: Robert H. Moore
Title: Project Scientist

Offshore Entrainment QA/QC (Cycle 3) Quarterly Survey
30 August 2006
Biologists – D. Cronce, J. May

Sampling Setup

Task	Cycle 3
Nets and codends inspected for damage	√
Flowmeters calibrated	√
Interior/exterior sample container labels match, labels have correct information	√

Sampling

Task	Cycle 3
Flowmeter information recorded properly	√
Net deployed properly	√
Sample times recorded accurately	√
Sufficient water volume sampled	√

Sample Processing

Task	Cycle 3
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√
Sample transferred to proper container	√
Dilution water filtered	√
Sample preserved properly	√
Sample stored securely on-site prior to departure	√

Comments: Replicate B tow had greater than 15% difference between flowmeter readings; the samples were discarded and the station re-sampled.

Observer: Robert H. Moore
Title: Project Scientist

Offshore Entrainment QA/QC (Cycle 1) Quarterly Survey
12 October 2006
Biologists –J. May, F. Petry

Sampling Setup

Task	Cycle 4
Nets and codends inspected for damage	√
Flowmeters calibrated	√
Interior/exterior sample container labels match, labels have correct information	√

Sampling

Task	Cycle 4
Station location occupied properly	√
Flowmeter information recorded properly	√
Net deployed properly	√
Sample times recorded accurately	√
Sufficient water volume sampled	√

Sample Processing

Task	Cycle 4
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√
Sample transferred to proper container	√
Sample preserved properly	√
Sample stored securely	√

Comments: None

Observer: Robert H. Moore
Title: Project Scientist

Offshore Entrainment QA/QC (Cycle 1) Quarterly Survey
17 January 2007
Biologists – T. Duvall, J. Kuratomi

Sampling Setup

Task	Cycle 1
Nets and codends inspected for damage	√
Flowmeters calibrated	√
Interior/exterior sample container labels match, labels have correct information	√

Sampling

Task	Cycle 1
Flowmeter information recorded properly	√
Net deployed properly	√
Sample times recorded accurately	√
Sufficient water volume sampled	√

Sample Processing

Task	Cycle 1
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√
Sample transferred to proper container	√
Dilution water filtered	√
Sample preserved properly	√
Sample stored securely	√

Comments: None

Observer: Shane Beck
Title: Senior Scientist

Offshore Entrainment QA/QC (Cycle 4) Quarterly Survey
18 January 2007
Biologists – F. Petry, J. Nunez

Sampling Setup

Task	Cycle 4
Nets and codends inspected for damage	√
Flowmeters calibrated	√
Interior/exterior sample container labels match, labels have correct information	√

Sampling

Task	Cycle 4
Flowmeter information recorded properly	√
Net deployed properly	√
Sample times recorded accurately	√
Sufficient water volume sampled	√

Sample Processing

Task	Cycle 4
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√
Sample transferred to proper container	√
Dilution water filtered	√
Sample preserved properly	√
Sample stored securely on-site prior to departure	√

Comments: None

Observer: Robert H. Moore
Title: Project Scientist

Offshore Entrainment QA/QC (Cycle 2) Quarterly Survey
14 February 2007
Biologists – T. Duvall, J. Nunez

Sampling Setup

Task	Cycle 2
Nets and codends inspected for damage	√
Flowmeters calibrated	√
Interior/exterior sample container labels match, labels have correct information	√

Sampling

Task	Cycle 2
Flowmeter information recorded properly	√
Net deployed properly	√
Sample times recorded accurately	√
Sufficient water volume sampled	√

Sample Processing

Task	Cycle 2
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√
Sample transferred to proper container	√
Dilution water filtered	√
Sample preserved properly	√
Sample stored securely	√

Comments: New locations for stratified sampling: epibenthic and manta added.

Observer: Robert Moore
Title: Project Scientist

San Onofre Nuclear Generating Station
316(b) Impingement Mortality and Entrainment Characterization Study

Offshore Entrainment QA/QC (Cycle 2) Quarterly Survey
15 March 2007
Biologists – N. Johnson, F. Petry

Sampling Setup

Task	Cycle 3
Nets and codends inspected for damage	√
Flowmeters calibrated	√
Interior/exterior sample container labels match, labels have correct information	√

Sampling

Task	Cycle 3
Flowmeter information recorded properly	√
Net deployed properly	√
Sample times recorded accurately	√
Sufficient water volume sampled	√

Sample Processing

Task	Cycle 3
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√
Sample transferred to proper container	√
Dilution water filtered	√
Sample preserved properly	√
Sample stored securely	√

Comments: percent difference of O2 OA1&2 >15%, 2nd attempt >15%, changed flowmeter

Observer: Robert Moore
Title: Project Scientist

Fish Return / Impingement Mortality QA/QC Quarterly Survey
30 May 2006
Biologists -- W. Dossett, C. Monson, K. Musson, T. Ross

Fish Return System Sampling

Sampling Setup

Task	Unit 2	Unit 3
Nets and codends inspected for damage	√	√
Interior/exterior sample container labels match, labels have correct information	√	√

Sampling

Task	Unit 2	Unit 3
Net deployed properly	√	√
Net contents transferred to sample containers / holding bins properly	√	√
Sample times recorded accurately	√	√

Sample Processing

Task	Unit 2	Unit 3
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√	√
Sample transferred to proper container	√	√
Sample preserved properly	√	√
Sample stored securely on-site prior to departure	√	√

Normal Operation Impingement System Sampling

Sampling

Task	Unit 2	Unit 3
Sampling performed properly	√	√
Sample information transferred to data sheets properly	√	√
Sample times recorded accurately	√	√

Sample Processing

Task	Unit 2	Unit 3
Organisms identified properly	√	√
Lengths recorded properly	√	√
Abundance / biomass recorded properly	√	√

Several shrimp and crabs were returned to MBC for identifications.

Impingement Sampling and Measurement Audit

During the impingement sampling, the QA/QC biologist re-measured and re-weighed a subset of impinged fishes. A summary of the difference between the two sets of measurements is presented in Table 1. A list of organisms not removed from each of the impingement samples by the biologists is presented in Tables 2 and 3.

Table 1. Measurement Audit comparing counts and measurements between biologists (BIO) and QA/QC biologist (QA). Lengths in mm.

	Queenfish (U2 NO)	White seaperch (U2 FRS)	White croaker (U2 NO)	Topsmelt (U2 NO)	Specklefin midshipman (U3 NO)
Abundance (BIO)	76	76	13	11	19
Abundance (QA)	76	76	13	11	19
Weight (kg - BIO)	1.786	0.254	0.035	0.354	0.346
Weight (kg - QA)	1.790	0.252	0.037	0.357	0.348
Sex (BIO)	34 M, 15 F, 1 U	-	-	-	-
Sex (QA)	34 M, 15 F, 1 U	-	-	-	-
Min. Length (BIO)	43	49	40	98	100
Min. Length (QA)	45	48	40	100	98
Max. Length (BIO)	169	65	71	169	180
Max. Length (QA)	168	66	71	169	182
Avg. Length (BIO)	114.9	53.7	51.3	154.3	120.6
Avg. Length (QA)	114.8	54.7	51.5	144.8	121.1
Avg. Length % Difference	0.1%	1.8%	0.3%	0.3%	0.4%

Table 2. Organisms not removed from collection dumpster at Unit 2 during impingement survey.

	Missed	Counted	Survey Total	Percent Missed of Counted	Percent Missed of Survey
Northern anchovy	3	118	118	2.5%	2.5%
White seaperch	1	439	439	0.2%	0.2%
All fishes	**4**	**1,621**	**1,625**	**0.2%**	**0.2%**
Blackspotted bay shrimp	1	97	97	1%	1%
All invertebrates	**1**	**316**	**316**	**0.3%**	**0.3%**

Table 3. Organisms not removed from collection dumpster at Unit 3 during impingement survey.

	Missed	Counted	Survey Total	Percent Missed of Counted	Percent Missed of Survey
Northern anchovy	2	271	271	1%	0.3%
All fishes	**2**	**1,223**	**1,225**	**0.2%**	**0.2%**

Submitted 2 June 2006

Robert Moore
Project Scientist

Fish Return / Impingement Mortality QA/QC Quarterly Survey
8 August 2006
Biologists -- R. Moore, T. Ross, W. Dossett, A. Macleod, B. Kay

Fish Return System Sampling

Sampling Setup

Task	Unit 2	Unit 3
Nets and codends inspected for damage	√	√
Interior/exterior sample container labels match, labels have correct information	√	√

Sampling

Task	Unit 2	Unit 3
Net deployed properly	*	√
Net contents transferred to sample containers / holding bins properly	√	√
Sample times recorded accurately	√	√

* At Unit 2, one of the Fish Return plankton sampling nets was accidentally released and lost in the Fish Return sluiceway.

Sample Processing

Task	Unit 2	Unit 3
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√*	√*
Sample transferred to proper container	√	√
Sample preserved properly	√	√
Sample stored securely on-site prior to departure	√	√

* There was a high abundance of small northern anchovy in the plankton nets. The plankton codends were not rinsed after each elevator lift; instead the contents were rinsed after all six lifts. To minimize the chance of larval dessication and damage, samples could be transferred more often, and any samples that aren't transferred immediately should be placed in a bucket of sea water to prevent dessication.

Normal Operation Impingement System Sampling

Sampling

Task	Unit 2	Unit 3
Subsample performed properly	√	√
Subsample information transferred to data sheets properly	√	√
Sample times recorded accurately	√	√

* At Unit 2, one of the Fish Return plankton sampling nets was accidentally released and lost in the Fish Return sluiceway.

Sample Processing

Task	Unit 2	Unit 3
Organisms identified properly	√	√
Lengths recorded properly	√	√
Abundance / biomass recorded properly	√	√

Organisms of uncertain identity (small Cancer crabs) were preserved and returned to the laboratory for confirmation.

Impingement Sampling and Measurement Audit

During the impingement sampling, the QA/QC biologist remeasured and reweighed a subset of impinged fishes and macroinvertebrates. A summary of the difference between the two sets of measurements is presented in Table 1. A list of organisms not removed from each of the impingement samples (or subsamples) by the biologists is presented in Table 2.

Table 1. Measurement Audit comparing counts and measurements between biologists (BIO) and QA/QC biologist (QA). Lengths in mm.

	Pacific sardine (U2 FRS)	Salema (U2 FRS Dipnet)	Yellowfin croaker (U3 TB)	California lizardfish (U3 TB)	California spiny lobster (U3 TB)
Abundance (BIO)	31	48	2	1	2
Abundance (QA)	31	48	2	1	2
Weight (kg - BIO)	0.036	2.100	0.950	0.142	0.647
Weight (kg - QA)	0.036	2.087	0.953	0.142	0.642
Sex (BIO)	-	-	1F, 1M	-	1F, 1M
Sex (QA)	-	-	1F, 1M	-	1F, 1M
Min. Length (BIO)	41	110	254	265	58
Min. Length (QA)	42	110	259	260	58
Max. Length (BIO)	58	165	346	265	75
Max. Length (QA)	58	166	358	260	74
Avg. Length (BIO)	46.3	121.8	300.0	265.0	66.5
Avg. Length (QA)	46.8	120.1	308.5	260.0	66.0
Avg. Length % Difference	1.1%	1.4%	2.8%	1.9%	0.8%

Table 3. Organisms not removed from collection dumpster at Unit 2 during impingement survey.

				Percent Missed of:	
	Missed	Counted	Survey Total	Counted	Survey
Pacific sardine	2	16	69	13%	3%
Queenfish	7	222	435	3%	2%
white seaperch	1	3	3	33%	33%
All fishes	**10**	**433**	**2697**	**2%**	**0.4%**
California spiny lobster	1	14	14	7%	7%

Fish Return System Identification and Enumeration Audit

During the Fish Return System sampling, the QA/QC biologist made simultaneous estimates of fish/lobster species composition and abundance in each fish return lift. Data comparison is presented in a separate appendix.

Submitted 1 September 2006

Shane Beck
Senior Scientist

Impingement Sampling Re-audit
6 September 2006
Biologists -- T. Ross, B. Kay

Impingement Mortality QA/QC Followup Survey

Missed organisms

U2 TB	Abund.	Bio. (kg)	Lengths (mm)
Seriphus politus	8	0.010	46 43 41 46 41 45 41 +1 damaged

U3 TB	Abund.	Bio. (kg)	Lengths (mm)
Seriphus politus	13	0.018	38 39 53 52 43 59 57 39 43 50 52 33 +1 damaged
Engraulis mordax	2	0.001	54 +1 damaged

Fish collected from U2 TB

				Percent Missed of Counted	
	Missed	Counted	Survey Total	Counted	Survey
Seriphus politus	8	665	673	1%	1%
Total	8	732	740	1%	1%

Fish collected from U3 TB

				Percent Missed of Counted	
	Missed	Counted	Survey Total	Counted	Survey
Seriphus politus	13	787	800	2%	2%
Engraulis mordax	2	665	667	0%	0%
Total all fishes	2	1190	1192	0.2%	0.2%

Invertebrates collected from U3 TB

Cancer sp	2	39	41	5%	5%
Total all inverts	2	80	82	3%	2%

The resort of impingement sampling by biologists in the Unit 2 dumpster on 8 August exceeded 5% for several species, thus followup audit surveys were conducted after review of sorting procedures with the impingement crew.

This is followup survey number 1 of 3.
Submitted by:

Shane Beck
Senior Scientist

Impingement Sampling Re-audit
19 September 2006
Biologists -- B. Kay, A. Macleod

Impingement Mortality QA/QC Followup Survey

Missed organisms

U2 TB	Abund.	Bio. (kg)	Lengths (mm)									
Seriphus politus	11	0.018	38	39	53	52	43	59	57	39	43	33
			+1 damaged									
Engraulis mordax	2	0.001	54	44								

Fish collected from U2 TB

	Missed	Counted	Survey Total	Percent Missed of Counted	
				Counted	Survey
Seriphus politus	11	575	586	2%	2%
Engraulis mordax	2	77	79	3%	3%
Total all fishes	13	1345	1358	1%	1%

Invertebrates collected from U2 TB

None

The resort of impingement sampling by biologists in the Unit 2 dumpster on 8 August exceeded 5% for several species, thus followup audit surveys were conducted after review of sorting procedures with the impingement crew.

This is followup survey number 2 of 3.
Submitted by:

Mike Curtis
Senior Scientist

Impingement Sampling Re-audit
3 October 2006
Biologists -- B. Kay, A. Macleod

Impingement Mortality QA/QC Followup Survey

Missed organisms

U2 TB	Abund.	Bio. (kg)	Lengths (mm)									
Seriphus politus	14	0.036	48	49	48	45	54	56	51	54	50	54
			63	57	48	58						
Engraulis mordax	5	0.005	35	42	48	37	46					

Fish collected from U2 TB

				Percent Missed of Counted	
	Missed	Counted	Survey Total	Counted	Survey
Seriphus politus	14	519	533	3%	3%
Engraulis mordax	5	126	131	4%	4%
Total all fishes	13	753	766	2%	2%

Invertebrates collected from U2 TB

None

The resort of impingement sampling by biologists in the Unit 2 dumpster on 8 August exceeded 5% for several species, thus followup audit surveys were conducted after review of sorting procedures with the impingement crew.

This is followup survey number 3 of 3.
Submitted by:

Mike Curtis
Senior Scientist

Fish Return / Impingement Mortality QA/QC Quarterly Survey
14 November 2006
Biologists -- W. Dossett, B. Kay, A. Macleod, J. May

Note: Unit 3 undergoing a refueling outage

Fish Return System Sampling

Sampling Setup

Task	Unit 2	Unit 3
Nets and codends inspected for damage	√	No survey
Interior/exterior sample container labels match, labels have correct information	√	

Sampling

Task	Unit 2	Unit 3
Net deployed properly	√	No survey
Net contents transferred to sample containers / holding bins properly	√	
Sample times recorded accurately	√	

Sample Processing

Task	Unit 2	Unit 3
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√	No survey
Sample transferred to proper container	√	
Sample preserved properly	√	
Sample stored securely on-site prior to departure	√	

Normal Operation Impingement System Sampling

Sampling

Task	Unit 2	Unit 3
Sampling performed properly	√	No survey
Sample information transferred to data sheets properly	√	
Sample times recorded accurately	√	

Sample Processing

Task	Unit 2	Unit 3
Organisms identified properly	√	No survey
Lengths recorded properly	√	
Abundance / biomass recorded properly	√	

Ghost shrimp returned to MBC for identifications.

Impingement Sampling and Measurement Audit

During the impingement sampling, the QA/QC biologist re-measured and re-weighed a subset of impinged fishes and macroinvertebrates. A summary of the difference between the two sets of measurements is presented in Table 1. A list of organisms not removed from each of the impingement samples by the biologists is presented in Table 2.

Table 1. Measurement Audit comparing counts and measurements between biologists (BIO) and QA/QC biologist (QA). Lengths in mm.

	Pacific sardine (U2 FRS)	Northern anchovy (U2 FRS)	Deepbody anchovy (U2 FRS)	Specklefin midshipman (U2 TB)	Deepbody anchovy (U2 TB)
Abundance (BIO)	13	18	33	11	106
Abundance (QA)	13	17	34	11	105
Weight (kg – BIO)	1.500	0.030	0.261	0.118	0.740
Weight (kg – QA)	1.495	0.032	0.267	0.115	0.734
Sex (BIO)	-	-	-	-	
Sex (QA)	-	-	-	-	
Min. Length (BIO)	180	48	66	50	63
Min. Length (QA)	179	46	72	48	59
Max. Length (BIO)	254	72	99	191	113
Max. Length (QA)	244	68	101	188	112
Avg. Length (BIO)	215.4	63.4	84.1	87.7	84.1
Avg. Length (QA)	211.4	61.2	87.7	84.7	83.7
Avg. Length % Difference	1.9%	3.5%	4.1%	3.5%	0.5%

Table 2. Organisms not removed from collection dumpster at Unit 2 during impingement survey.

				Percent missed of:	
	Missed	Counted	Survey Total	Counted	Survey
Northern anchovy	4	144	1,430	2.8%	0.3%
Queenfish	29	1,528	16,550	1.9%	0.2%
All fishes	**33**	**1,625**	**18,590**	**1.4%**	**0.2%**
Xantus swimming crab	3	60	60	5%	5%
All invertebrates	**3**	**99**	**99**	**3%**	**3%**

Fish Return System Identification and Enumeration Audit

During the Fish Return System sampling, the QA/QC biologist made simultaneous estimates of fish/lobster species composition and abundance in each fish return lift. Data comparison is presented in a separate appendix.

4 December 2006

Robert Moore
Project Scientist

Fish Return / Impingement Mortality QA/QC Quarterly Survey
23 January 2007
Biologists -- W. Dossett, B. Kay, A. Macleod, J. May

Fish Return System Sampling

Sampling Setup

Task	Unit 2	Unit 3
Nets and codends inspected for damage	√	√
Interior/exterior sample container labels match, labels have correct information	√	√

Sampling

Task	Unit 2	Unit 3
Net deployed properly	√	√
Net contents transferred to sample containers / holding bins properly	√	√
Sample times recorded accurately	√	√

Sample Processing

Task	Unit 2	Unit 3
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	√	√
Sample transferred to proper container	√	√
Sample preserved properly	√	√
Sample stored securely on-site prior to departure	√	√

Normal Operation Impingement System Sampling

Sampling

Task	Unit 2	Unit 3
Sampling performed properly	√	√
Sample information transferred to data sheets properly	√	√
Sample times recorded accurately	√	√

Sample Processing

Task	Unit 2	Unit 3
Organisms identified properly	√	√
Lengths recorded properly	√	√
Abundance / biomass recorded properly	√	√

Four invertebrates (snails and shrimp) returned to MBC for identifications.

Impingement Sampling and Measurement Audit

During the impingement sampling, the QA/QC biologist re-measured and re-weighed a subset of impinged fishes and macroinvertebrates. A summary of the difference between the two sets of measurements is presented in Table 1. A list of organisms not removed from each of the impingement samples by the biologists is presented in Tables 2 and 3.

Table 1. Measurement Audit comparing counts and measurements between biologists (BIO) and QA/QC biologist (QA). Lengths in mm.

	Queenfish (U2 NO)	Salema (U2 NO)	Kelp pipefish (U3 NO)
Abundance (BIO)	38	5	5
Abundance (QA)	38	5	5
Weight (kg – BIO)	0.159	0.022	0.005
Weight (kg – QA)	0.156	0.022	0.005
Sex (BIO)	1F	-	
Sex (QA)	1F	-	
Min. Length (BIO)	50	50	139
Min. Length (QA)	50	49	138
Max. Length (BIO)	123	74	208
Max. Length (QA)	124	75	208
Avg. Length (BIO)	62.2	61.4	166.4
Avg. Length (QA)	62.3	61.6	165.8
Avg. Length % Difference	0.1%	0.3%	0.6%

Table 2. Organisms not removed from collection dumpster at Unit 2 during impingement survey.

	Missed	Counted	Survey Total	Percent Missed of: Counted	Survey
Northern anchovy	3	41	44	7.3%	6.8%
California scorpionfish	1	2	3	50%	33.3%
Kelp pipefish	2	7	9	28.6%	22.2%
All fishes	**6**	**111**	**117**	**5.4%**	**5.1%**
Hairy rock crab	2	15	17	13%	12%
Yellow crab	1	24	25	4%	4%
Intertidal coastal shrimp	1	14	15	7%	7%
Blackspotted bay shrimp	2	12	14	17%	14%
Xantus swimming crab	2	60	62	5%	5%
All invertebrates	**8**	**136**	**144**	**5.9%**	**5.6%**

Table 3. Organisms not removed from collection dumpster at Unit 3 during impingement survey.

	Missed	Counted	Survey Total	Percent Missed of: Counted	Survey
Slough anchovy	1	1	2	100%	50%
Rockpool blenny	1	1	2	100%	50%
Queenfish	1	20	21	5.0%	4.8%
All fishes	**3**	**44**	**47**	**6.8%**	**6.4%**
Hairy rock crab	1	4	5	25%	20%
Blackspotted bay shrimp	2	2	4	100%	50%
Xantus swimming crab	1	18	19	6%	5%
All invertebrates	**4**	**56**	**60**	**7.1%**	**6.7%**

Fish Return System Identification and Enumeration Audit

During the Fish Return System sampling, the QA/QC biologist made simultaneous estimates of fish/lobster species composition and abundance in each fish return lift. Data comparison is presented in a separate appendix.

Submitted 31 January 2007

Robert Moore
Project Scientist

Impingement Sampling Re-audit
Date: 6 February 2007
Biologists: B. Kay, A. Macleod

Impingement Mortality QA/QC Followup Survey

Missed organisms U2 TB

Fish	Abund.	Bio. (kg)	Lengths (mm)							
Engraulis mordax	2	0.005	47	45						
Seriphus politus	8	0.038	58	63	60	56	61	66	66	61
Anchoa delicatissima	1	0.003	56							

Invertebrates
None

Fish collected from U2 TB

	Missed	Counted	Survey Total	Percent Missed of Counted	
				Counted	Survey
Engraulis mordax	2	47	49	4%	4%
Seriphus politus	8	181	189	4%	4%
Anchoa delicatissima	1	20	21	5%	5%
Total all fishes	11	293	304	4%	4%

Missed organisms U3 TB

Fish	Abund.	Bio. (kg)	Lengths (mm)				
Engraulis mordax	2	0.006	49	58			
Seriphus politus	5	0.007	67	64	64	59	69

Invertebrates
None

Fish collected from U3 TB

	Missed	Counted	Survey Total	Percent Missed of Counted	
				Counted	Survey
Engraulis mordax	2	43	45	5%	4%
Seriphus politus	5	212	217	2%	2%
Total all fishes	7	304	311	2%	2%

The resort of impingement sampling by biologists in the Unit 2 and 3 dumpsters on 23 January exceeded 5% for several species, thus followup audit surveys were conducted after review of sorting procedures with the impingement crew.

This is followup survey number 1 of 3.
Submitted by:

Robert Moore
Project Scientist

Impingement Sampling Re-audit
Date: 20 February 2007
Biologists: B. Kay, J. May, A. Macleod, J. Nunez

Impingement Mortality QA/QC Followup Survey

Missed organisms U2 TB

Fish	Abund.	Bio. (kg)	Lengths (mm)	
Engraulis mordax	2	0.001	47	45
Seriphus politus	2	0.009	58	63

Invertebrates
None

Fish collected from U2 TB

	Missed	Counted	Survey Total	Percent Missed of Counted: Counted	Percent Missed of Counted: Survey
Engraulis mordax	2	45	47	4%	4%
Seriphus politus	2	103	105	2%	2%
Total all fishes	4	175	179	2%	2%

Missed organisms U3 TB

Fish	Abund.	Bio. (kg)	Lengths (mm)					
Engraulis mordax	3	0.004	43	51	49			
Seriphus politus	6	0.045	65	63	58	69	65	62

Invertebrates
None

Fish collected from U3 TB

	Missed	Counted	Survey Total	Percent Missed of Counted: Counted	Percent Missed of Counted: Survey
Engraulis mordax	3	79	82	4%	4%
Seriphus politus	6	428	434	1%	1%
Total all fishes	9	534	543	2%	2%

The resort of impingement sampling by biologists in the Unit 2 and 3 dumpsters on 23 January exceeded 5% for several species, thus followup audit surveys were conducted after review of sorting procedures with the impingement crew.

This is followup survey number 2 of 3.
Submitted by:

Mike Curtis
Senior Scientist

Impingement Sampling Re-audit
Date: 6 March 2007
Biologists: B. Kay, E. Miller

Impingement Mortality QA/QC Followup Survey

Missed organisms U2 TB

Fish	Abund.	Bio. (kg)	Lengths (mm)									
Syngnathus californiensis	12	0.008	131	170	145	145	136	153	158	152	148	165
			134	157								
Engraulis mordax	5	0.003	36	46	46	42	35					
Xenistius californiensis	1	0.007	71									
Seriphus politus	1	0.007	76									

Invertebrates		
Neotrypaea californiensis	2	0.005
Crangon nigromaculata	4	0.014
Pyromaia tuberculata	1	0.001
Portunus xantusii	2	0.004
Cancer anthonyi	1	0.002
Blepharipoda occidentalis	1	0.012

Fish collected from U2 TB				Percent Missed of Counted	
	Missed	Counted	Survey Total	Counted	Survey
Syngnathus californiensis	12	29	41	41%	29%
Engraulis mordax	5	5	10	100%	50%
Xenistius californiensis	1	36	37	3%	3%
Seriphus politus	1	69	70	1%	1%
Total all fishes	19	181	200	10%	10%

				Percent Missed of Counted	
Invertebrates	Missed	Counted	Survey Total	Counted	Survey
Neotrypaea californiensis	2	11	13	18%	15%
Crangon nigromaculata	4	23	27	17%	15%
Pyromaia tuberculata	1	0	1	100%	100%
Portunus xantusii	2	7	9	29%	22%
Cancer sp.	1	1	2	100%	50%
Blepharipoda occidentalis	1	0	1	100%	100%
Total all invertebrates	11	71	82	15%	13%

Missed organisms U3 TB

Fish	Abund.	Bio. (kg)	Lengths (mm)									
Engraulis mordax	5	0.007	45	54	53	49	55					
Syngnathus californiensis	15	0.020	150	152	162	177	131	178	191	231	148	165
			150	191	150	175	163					
Seriphus politus	3	0.017	71	71	67							

Missed organisms U3 TB, cont'd.

	Abund.	Bio. (kg)
Invertebrates		
Crangon nigromaculata	1	0.002
Portunus xantusii	3	0.003
Cancer antennarius	1	0.017
Cancer anthonyi	1	0.001

Fish collected from U3 TB				Percent Missed of Counted	
	Missed	Counted	Survey Total	Counted	Survey
Engraulis mordax	5	13	18	38%	28%
Syngnathus californiensis	15	55	70	27%	21%
Seriphus politus	3	111	114	3%	3%
Total all fishes	23	198	221	12%	10%

Invertebrates	Missed	Counted	Survey Total	Counted	Survey
Crangon nigromaculata	1	7	8	14%	13%
Portunus xantusii	3	3	6	100%	50%
Cancer sp.	2	58	60	3%	3%
Total all invertebrates	6	107	113	6%	5%

The resort of impingement sampling by biologists in the Unit 2 and 3 dumpsters on 23 January exceeded 5% for several species, thus followup audit surveys were conducted after review of sorting procedures with the impingement crew. QA/QC criteria were not met, and three additional surveys will be conducted following this survey

Submitted by:

Robert Moore
Project Scientist

Impingement Sampling Re-audit
Date: 20 March 2007
Biologists: B. Kay, J. May

Impingement Mortality QA/QC Followup Survey
Date: March 20, 2007

Missed organisms U3 TB

Fish	Abund.	Bio. (kg)	Lengths (mm)						
Syngnathus californiensis	2	0.002	175	158					
Engraulis mordax	7	0.001	25	34	31	34	27	32	30
Hypsoblennius gilberti	1	0.002	49						
Seriphus politus	2	0.010	75	70					
Invertebrates									
Pugettia producta	1	0.002							
Portunus xantusii	4	0.005							

Fish collected from U3 TB

	Missed	Counted	Survey Total	Percent Missed of Counted	
				Counted	Survey
Syngnathus californiensis	2	25	27	8%	7%
Engraulis mordax	7	9	16	78%	44%
Hypsoblennius gilberti	1	1	2	100%	50%
Seriphus politus	2	122	124	2%	2%
Total all fishes	12	206	218	5%	5%

				Percent Missed of Counted	
Invertebrates	Missed	Counted	Survey Total	Counted	Survey
Pugettia producta	1	0	1	0%	100%
Portunus xantusii	4	35	39	11%	10%
Total all invertebrates	5	92	97	5%	5%

The resort of impingement sampling by biologists in the Unit 2 and 3 dumpsters on 6 March exceeded 5% for several species, thus followup audit surveys were conducted after review of sorting procedures with the impingement crew.

This is followup survey number 1 of 3.
Submitted by:

Alex Macleod
Technician

Impingement Sampling Re-audit
Date: 2 April 2007
Biologists: B. Kay, J. Nunez

Impingement Mortality QA/QC Followup Survey

Missed organisms U2 TB

Fish	Abund.	Bio. (kg)	Lengths (mm)	
Seriphus politus	2	0.004	63	74

Invertebrates
None

Fish collected from U2 TB

				Percent Missed of Counted	
	Missed	Counted	Survey Total	Counted	Survey
Seriphus politus	2	81	83	2%	2%
Total all fishes	2	191	193	1%	1%

The resort of impingement sampling by biologists in the Unit 2 and 3 dumpsters on 20 March exceeded 5% for several species, thus followup audit surveys were conducted after review of sorting procedures with the impingement crew.

This is followup survey number 1 of 3.
Submitted by:

Robert Moore
Project Scientist

Impingement Sampling Re-audit
Date: 17 April 2007
Biologists: W. Dossett, T. Duvall, B. Kay, F. Petry

Impingement Mortality QA/QC Followup Survey

Missed organisms U3 TB

Fish	Abund.	Bio. (kg)	Lengths (mm)
Seriphus politus	3	0.008	65 71 77
Porichthys notatus	1	0.002	70
Invertebrates			
Pugettia producta	1	0.007	
Portunus xantusii	3	0.005	

Fish collected from U3 TB				Percent Missed of Counted	
	Missed	Counted	Survey Total	Counted	Survey
Porichthys notatus	1	76	77	1%	1%
Seriphus politus	3	546	549	1%	1%
Total all fishes	4	756	760	1%	1%

				Percent Missed of Counted	
Invertebrates	Missed	Counted	Survey Total	Counted	Survey
Pugettia producta	1	1	2	0%	50%
Portunus xantusii	3	47	50	6%	6%
Total all invertebrates	4	243	247	2%	2%

The resort of impingement sampling by biologists in the Unit 2 and 3 dumpsters on 20 March exceeded 5% for several species, thus followup audit surveys were conducted after review of sorting procedures with the impingement crew.

This is followup survey number 2 of 3.
Submitted by:

Robert Moore
Project Scientist

Impingement Sampling Re-audit
Date: 1 May 2007
Biologists: B. Kay, A. Macleod, J. May

Impingement Mortality QA/QC Followup Survey

Missed organisms U3 TB

Fish	Abund.	Bio. (kg)	Lengths (mm)
None			

Invertebrates
None

The resort of impingement sampling by biologists in the Unit 2 and 3 dumpsters on 20 March exceeded 5% for several species, thus followup audit surveys were conducted after review of sorting procedures with the impingement crew.

This is followup survey number 3 of 3.
Submitted by:

Robert Moore
Project Scientist

Fish Return / Impingement Mortality QA/QC Quarterly Survey
15 May 2007
Biologists – B. Kay, W. Dossett, A. Macleod, J. May

Fish Return System Sampling

Sampling Setup

Task	Unit 2	Unit 3
Nets and codends inspected for damage	No survey	√
Interior/exterior sample container labels match, labels have correct information		√

Sampling

Task	Unit 2	Unit 3
Net deployed properly	No survey	√
Net contents transferred to sample containers / holding bins properly		√
Sample times recorded accurately		√

Sample Processing

Task	Unit 2	Unit 3
Net washed thoroughly, codend inspected to ensure all organisms transferred to sample containers	No survey	√
Sample transferred to proper container		√
Sample preserved properly		√
Sample stored securely on-site prior to departure		√

Fish Return System Identification and Enumeration Audit

During the Fish Return System sampling, the QA/QC biologist made simultaneous estimates of fish/lobster species composition and abundance in each fish return lift. Data comparison is presented in a separate appendix.

Submitted 16 May 2007

Shane Beck
Senior Scientist

Survey Number: SONGSFRS11 Biologist (BIO)
Survey Date: August 8, 2006 QA Biologist (QA)

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	18	13
Observed no. of species (QA)	20	16
Percent Difference	10.0%	18.8%
No. of species caught and observed	24	17
Percent Difference (BIO)	25%	24%
Percent Difference (QA)	17%	6%
Visual Estimate Fish Abundance (BIO)	16,952	2,480
Visual Estimate Fish Abundance (QA)	26,069	2,266
Percent Difference	35.0%	9.4%
Fish Abundance (Net Sampling)	67,256	915
Percent Difference (BIO)	75%	171%
Percent Difference (QA)	61%	148%

Survey Number: SONGSFRS13
Survey Date: September 6, 2006

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	9	12
Observed no. of species (QA)	8	11
Percent Difference	12.5%	9.1%
No. of species caught and observed	9	13
Percent Difference (BIO)	0%	8%
Percent Difference (QA)	11%	15%
Visual Estimate Fish Abundance (BIO)	388	1,901
Visual Estimate Fish Abundance (QA)	255	1,947
Percent Difference	52.2%	2.4%
Fish Abundance (Net Sampling)	240	1297
Percent Difference (BIO)	62%	47%
Percent Difference (QA)	6%	50%

Survey Number: SONGSFRS14 Biologist (BIO)
Survey Date: September 19, 2006 QA Biologist (QA)

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	14	15
Observed no. of species (QA)	14	14
Percent Difference	0.0%	7.1%
No. of species caught and observed	19	17
Percent Difference (BIO)	26%	12%
Percent Difference (QA)	26%	18%
Visual Estimate Fish Abundance (BIO)	2,631	1,729
Visual Estimate Fish Abundance (QA)	2,814	1,526
Percent Difference	6.5%	13.3%
Fish Abundance (Net Sampling)	2,857	930
Percent Difference (BIO)	8%	86%
Percent Difference (QA)	2%	64%

Survey Number: SONGSFRS15
Survey Date: October 3, 2006

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	16	
Observed no. of species (QA)	15	
Percent Difference	6.7%	
No. of species caught and observed	20	
Percent Difference (BIO)	20%	
Percent Difference (QA)	25%	
Visual Estimate Fish Abundance (BIO)	1,767	
Visual Estimate Fish Abundance (QA)	1,874	
Percent Difference	5.7%	
Fish Abundance (Net Sampling)	1,967	
Percent Difference (BIO)	10%	
Percent Difference (QA)	5%	

Survey Number: SONGSFRS17 — Biologist (BIO)
Survey Date: October 31, 2006 — QA Biologist (QA)

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	15	
Observed no. of species (QA)	16	not sampled
Percent Difference	6.3%	
No. of species caught and observed	18	
Percent Difference (BIO)	17%	
Percent Difference (QA)	11%	
Visual Estimate Fish Abundance (BIO)	532	
Visual Estimate Fish Abundance (QA)	443	
Percent Difference	20.1%	
Fish Abundance (Net Sampling)	560	
Percent Difference (BIO)	5%	
Percent Difference (QA)	21%	

Survey Number: SONGSFRS18
Survey Date: November 14, 2006

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	15	
Observed no. of species (QA)	14	not sampled
Percent Difference	7.1%	
No. of species caught and observed	23	
Percent Difference (BIO)	35%	
Percent Difference (QA)	39%	
Visual Estimate Fish Abundance (BIO)	1,887	
Visual Estimate Fish Abundance (QA)	1,928	
Percent Difference	2.1%	
Fish Abundance (Net Sampling)	2,577	
Percent Difference (BIO)	27%	
Percent Difference (QA)	25%	

Survey Number: SONGSFRS19 Biologist (BIO)
Survey Date: November 28, 2006 QA Biologist (QA)

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	14	
Observed no. of species (QA)	17	*not sampled*
Percent Difference	17.6%	
No. of species caught and observed	19	
Percent Difference (BIO)	26%	
Percent Difference (QA)	11%	
Visual Estimate Fish Abundance (BIO)	4,732	
Visual Estimate Fish Abundance (QA)	5,598	
Percent Difference	15.5%	
Fish Abundance (Net Sampling)	8,370	
Percent Difference (BIO)	43%	
Percent Difference (QA)	33%	

Survey Number: SONGSFRS20
Survey Date: December 12, 2006

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	22	19
Observed no. of species (QA)	27	18
Percent Difference	18.5%	5.6%
No. of species caught and observed	19	20
Percent Difference (BIO)	16%	5%
Percent Difference (QA)	42%	10%
Visual Estimate Fish Abundance (BIO)	2,566	1,220
Visual Estimate Fish Abundance (QA)	3,102	2,179
Percent Difference	17.3%	44.0%
Fish Abundance (Net Sampling)	3,200	3997
Percent Difference (BIO)	20%	69%
Percent Difference (QA)	3%	45%

Survey Number: SONGSFRS22 Biologist (BIO)
Survey Date: January 9, 2007 QA Biologist (QA)

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	10	6
Observed no. of species (QA)	9	6
Percent Difference	11.1%	0.0%
No. of species caught and observed	14	7
Percent Difference (BIO)	29%	14%
Percent Difference (QA)	36%	14%
Visual Estimate Fish Abundance (BIO)	595	326
Visual Estimate Fish Abundance (QA)	452	353
Percent Difference	31.6%	7.6%
Fish Abundance (Net Sampling)	550	417
Percent Difference (BIO)	8%	22%
Percent Difference (QA)	18%	15%

Survey Number: SONGSFRS23
Survey Date: January 23, 2007

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	15	9
Observed no. of species (QA)	12	8
Percent Difference	25.0%	12.5%
No. of species caught and observed	15	9
Percent Difference (BIO)	0%	0%
Percent Difference (QA)	20%	11%
Visual Estimate Fish Abundance (BIO)	309	368
Visual Estimate Fish Abundance (QA)	384	531
Percent Difference	19.5%	30.7%
Fish Abundance (Net Sampling)	110	253
Percent Difference (BIO)	181%	45%
Percent Difference (QA)	249%	110%

Survey Number: SONGSFRS24 Biologist (BIO)
Survey Date: February 6, 2007 QA Biologist (QA)

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	10	NA*
Observed no. of species (QA)	9	12
Percent Difference	11.1%	
No. of species caught and observed	13	7
Percent Difference (BIO)	23%	
Percent Difference (QA)	31%	71%
Visual Estimate Fish Abundance (BIO)	1,302	NA*
Visual Estimate Fish Abundance (QA)	1,297	780
Percent Difference	0.4%	
Fish Abundance (Net Sampling)	1,237	243
Percent Difference (BIO)	5%	
Percent Difference (QA)	5%	221%

* Biologist was not present during U3 FRS operation due to access requirements (Drug Screen)

Survey Number: SONGSFRS26
Survey Date: February 21, 2007

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	13	8
Observed no. of species (QA)	14	8
Percent Difference	7.1%	0.0%
No. of species caught and observed	15	8
Percent Difference (BIO)	13%	0%
Percent Difference (QA)	7%	0%
Visual Estimate Fish Abundance (BIO)	1,895	1,104
Visual Estimate Fish Abundance (QA)	1,571	1,188
Percent Difference	20.6%	7.1%
Fish Abundance (Net Sampling)	1,257	317
Percent Difference (BIO)	51%	248%
Percent Difference (QA)	25%	275%

Survey Number: SONGSFRS28 Biologist (BIO)
Survey Date: March 6, 2007 QA Biologist (QA)

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	12	5
Observed no. of species (QA)	11	5
Percent Difference	9.1%	0.0%
No. of species caught and observed	12	7
Percent Difference (BIO)	0%	29%
Percent Difference (QA)	8%	29%
Visual Estimate Fish Abundance (BIO)	1,549	333
Visual Estimate Fish Abundance (QA)	1,159	378
Percent Difference	33.6%	11.9%
Fish Abundance (Net Sampling)	1,103	103
Percent Difference (BIO)	40%	223%
Percent Difference (QA)	5%	267%

Survey Number: SONGSFRS29
Survey Date: March 20, 2007

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)		13
Observed no. of species (QA)	not sampled	12
Percent Difference		8.3%
No. of species caught and observed		13
Percent Difference (BIO)		0%
Percent Difference (QA)		8%
Visual Estimate Fish Abundance (BIO)		447
Visual Estimate Fish Abundance (QA)		516
Percent Difference		13.4%
Fish Abundance (Net Sampling)		287
Percent Difference (BIO)		56%
Percent Difference (QA)		80%

Survey Number:	SONGSFRS31	Biologist (BIO)
Survey Date:	April 3, 2007	QA Biologist (QA)

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)	11	10
Observed no. of species (QA)	10	10
Percent Difference	10.0%	0.0%
No. of species caught and observed	12	10
Percent Difference (BIO)	8%	0%
Percent Difference (QA)	17%	0%
Visual Estimate Fish Abundance (BIO)	4,095	1,998
Visual Estimate Fish Abundance (QA)	6,927	3,844
Percent Difference	40.9%	48.0%
Fish Abundance (Net Sampling)	2,023	2100
Percent Difference (BIO)	102%	5%
Percent Difference (QA)	242%	83%

Survey Number:	SONGSFRS32
Survey Date:	April 17, 2007

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)		10
Observed no. of species (QA)	not sampled	8
Percent Difference		25.0%
No. of species caught and observed		12
Percent Difference (BIO)		17%
Percent Difference (QA)		33%
Visual Estimate Fish Abundance (BIO)		1,302
Visual Estimate Fish Abundance (QA)		1,266
Percent Difference		2.8%
Fish Abundance (Net Sampling)		1273
Percent Difference (BIO)		2%
Percent Difference (QA)		1%

Survey Number: SONGSFRS33 Biologist (BIO)
Survey Date: May 1, 2007 QA Biologist (QA)

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)		10
Observed no. of species (QA)	not sampled	10
Percent Difference		0.0%
No. of species caught and observed		10
Percent Difference (BIO)		0%
Percent Difference (QA)		0%
Visual Estimate Fish Abundance (BIO)		316
Visual Estimate Fish Abundance (QA)		270
Percent Difference		17.0%
Fish Abundance (Net Sampling)		273
Percent Difference (BIO)		16%
Percent Difference (QA)		1%

Survey Number: SONGSFRS34
Survey Date: May 15, 2007

	U2 Fish Return System	U3 Fish Return System
Observed no. of species (BIO)		16
Observed no. of species (QA)	not sampled	12
Percent Difference		33.3%
No. of species caught and observed		17
Percent Difference (BIO)		6%
Percent Difference (QA)		29%
Visual Estimate Fish Abundance (BIO)		1,779
Visual Estimate Fish Abundance (QA)		3,186
Percent Difference		44.2%
Fish Abundance (Net Sampling)		503
Percent Difference (BIO)		254%
Percent Difference (QA)		533%

San Onofre Nuclear Generating Station

Appendix E

Cooling Water Flow Data

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Date	Julian Day	Unit 2 Flow (mgd)	Unit 2 Flow (m^3)	Unit 3 Flow (mgd)	Unit 3 Flow (m^3)
1/1/06	1	1218.586	4612850.1	1218.586	4612850.1
1/2/06	2	1218.586	4612850.1	1218.586	4612850.1
1/3/06	3	1218.586	4612850.1	1218.586	4612850.1
1/4/06	4	1218.586	4612850.1	1218.586	4612850.1
1/5/06	5	365.580	1383870.9	1218.586	4612850.1
1/6/06	6	69.120	261647.7	1218.586	4612850.1
1/7/06	7	0.000	0.0	1218.586	4612850.1
1/8/06	8	0.000	0.0	1218.586	4612850.1
1/9/06	9	0.000	0.0	1218.586	4612850.1
1/10/06	10	0.000	0.0	1218.586	4612850.1
1/11/06	11	0.000	0.0	1218.586	4612850.1
1/12/06	12	0.000	0.0	1218.586	4612850.1
1/13/06	13	0.000	0.0	1218.586	4612850.1
1/14/06	14	0.000	0.0	1218.586	4612850.1
1/15/06	15	0.000	0.0	1218.586	4612850.1
1/16/06	16	0.000	0.0	1218.586	4612850.1
1/17/06	17	0.000	0.0	1218.586	4612850.1
1/18/06	18	0.000	0.0	1218.586	4612850.1
1/19/06	19	0.000	0.0	1218.586	4612850.1
1/20/06	20	0.000	0.0	1218.586	4612850.1
1/21/06	21	0.000	0.0	1218.586	4612850.1
1/22/06	22	0.000	0.0	1218.586	4612850.1
1/23/06	23	0.000	0.0	1218.586	4612850.1
1/24/06	24	0.000	0.0	1218.586	4612850.1
1/25/06	25	0.000	0.0	1218.586	4612850.1
1/26/06	26	0.000	0.0	1218.586	4612850.1
1/27/06	27	0.000	0.0	1218.586	4612850.1
1/28/06	28	0.000	0.0	1218.586	4612850.1
1/29/06	29	0.000	0.0	1218.586	4612850.1
1/30/06	30	0.000	0.0	1218.586	4612850.1
1/31/06	31	0.000	0.0	1218.586	4612850.1
2/1/06	32	0.000	0.0	1218.586	4612850.1
2/2/06	33	0.000	0.0	1218.586	4612850.1
2/3/06	34	0.000	0.0	1218.586	4612850.1
2/4/06	35	0.000	0.0	1218.586	4612850.1
2/5/06	36	0.000	0.0	1218.586	4612850.1
2/6/06	37	0.000	0.0	1218.586	4612850.1
2/7/06	38	0.000	0.0	1218.586	4612850.1
2/8/06	39	0.000	0.0	1218.586	4612850.1
2/9/06	40	0.000	0.0	1218.586	4612850.1
2/10/06	41	23.040	87215.9	1218.586	4612850.1
2/11/06	42	69.120	261647.7	1218.586	4612850.1
2/12/06	43	69.120	261647.7	1218.586	4612850.1
2/13/06	44	69.120	261647.7	1218.586	4612850.1
2/14/06	45	78.024	295353.0	1218.586	4612850.1

Date	Julian Day	Unit 2 Flow (mgd)	Unit 2 Flow (m^3)	Unit 3 Flow (mgd)	Unit 3 Flow (m^3)
2/15/06	46	69.120	261647.7	1218.586	4612850.1
2/16/06	47	69.120	261647.7	1218.586	4612850.1
2/17/06	48	113.640	430174.2	1218.586	4612850.1
2/18/06	49	100.92	382023.8	1218.586	4612850.1
2/19/06	50	374.4	1417258.3	1218.586	4612850.1
2/20/06	51	374.4	1417258.3	1218.586	4612850.1
2/21/06	52	374.4	1417258.3	1218.586	4612850.1
2/22/06	53	374.4	1417258.3	1218.586	4612850.1
2/23/06	54	537.64	2035188.9	1218.586	4612850.1
2/24/06	55	609.29	2306413.7	1218.586	4612850.1
2/25/06	56	609.29	2306413.7	1218.586	4612850.1
2/26/06	57	609.29	2306413.7	1218.586	4612850.1
2/27/06	58	609.29	2306413.7	1218.586	4612850.1
2/28/06	59	609.29	2306413.7	1218.586	4612850.1
3/1/06	60	1167.706	4420248.3	1218.586	4612850.1
3/2/06	61	913.94	3459639.4	1218.586	4612850.1
3/3/06	62	913.94	3459639.4	1218.586	4612850.1
3/4/06	63	1002.98	3796692.5	1218.586	4612850.1
3/5/06	64	1009.34	3820767.7	1218.586	4612850.1
3/6/06	65	1218.586	4612850.1	1218.586	4612850.1
3/7/06	66	913.94	3459639.4	1218.586	4612850.1
3/8/06	67	913.94	3459639.4	1218.586	4612850.1
3/9/06	68	913.94	3459639.4	1218.586	4612850.1
3/10/06	69	913.94	3459639.4	1218.586	4612850.1
3/11/06	70	913.94	3459639.4	1218.586	4612850.1
3/12/06	71	913.94	3459639.4	1218.586	4612850.1
3/13/06	72	1218.586	4612850.1	1218.586	4612850.1
3/14/06	73	1218.586	4612850.1	1218.586	4612850.1
3/15/06	74	1218.586	4612850.1	1218.586	4612850.1
3/16/06	75	1218.586	4612850.1	1218.586	4612850.1
3/17/06	76	1218.586	4612850.1	1218.586	4612850.1
3/18/06	77	1218.586	4612850.1	1218.586	4612850.1
3/19/06	78	1218.586	4612850.1	1218.586	4612850.1
3/20/06	79	1218.586	4612850.1	1218.586	4612850.1
3/21/06	80	1218.586	4612850.1	1218.586	4612850.1
3/22/06	81	1218.586	4612850.1	1218.586	4612850.1
3/23/06	82	1218.586	4612850.1	1218.586	4612850.1
3/24/06	83	1218.586	4612850.1	1218.586	4612850.1
3/25/06	84	1218.586	4612850.1	1218.586	4612850.1
3/26/06	85	1218.586	4612850.1	1218.586	4612850.1
3/27/06	86	1218.586	4612850.1	1218.586	4612850.1
3/28/06	87	1218.586	4612850.1	1218.586	4612850.1
3/29/06	88	1218.586	4612850.1	1218.586	4612850.1
3/30/06	89	1218.586	4612850.1	1218.586	4612850.1
3/31/06	90	1218.586	4612850.1	1218.586	4612850.1

Date	Julian Day	Unit 2 Flow (mgd)	Unit 2 Flow (m^3)	Unit 3 Flow (mgd)	Unit 3 Flow (m^3)
4/1/06	91	1218.586	4612850.1	1218.586	4612850.1
4/2/06	92	1218.586	4612850.1	1218.586	4612850.1
4/3/06	93	1218.586	4612850.1	1218.586	4612850.1
4/4/06	94	1218.586	4612850.1	936.1533	3543726.0
4/5/06	95	1218.586	4612850.1	913.9395	3459637.6
4/6/06	96	1218.586	4612850.1	913.9395	3459637.6
4/7/06	97	1218.586	4612850.1	913.9395	3459637.6
4/8/06	98	1218.586	4612850.1	913.9395	3459637.6
4/9/06	99	1218.586	4612850.1	913.9395	3459637.6
4/10/06	100	1218.586	4612850.1	913.9395	3459637.6
4/11/06	101	1218.586	4612850.1	1113.864	4216433.3
4/12/06	102	1218.586	4612850.1	672.761	2546677.6
4/13/06	103	1218.586	4612850.1	609.293	2306425.0
4/14/06	104	1218.586	4612850.1	609.293	2306425.0
4/15/06	105	1218.586	4612850.1	609.293	2306425.0
4/16/06	106	1218.586	4612850.1	609.293	2306425.0
4/17/06	107	1218.586	4612850.1	796.5237	3015170.2
4/18/06	108	1218.586	4612850.1	609.293	2306425.0
4/19/06	109	1218.586	4612850.1	609.293	2306425.0
4/20/06	110	1218.586	4612850.1	609.293	2306425.0
4/21/06	111	1218.586	4612850.1	609.293	2306425.0
4/22/06	112	1218.586	4612850.1	698.1482	2642778.7
4/23/06	113	1218.586	4612850.1	1190.025	4504736.4
4/24/06	114	1218.586	4612850.1	1218.586	4612850.1
4/25/06	115	1218.586	4612850.1	1218.586	4612850.1
4/26/06	116	1218.586	4612850.1	1218.586	4612850.1
4/27/06	117	1218.586	4612850.1	1218.586	4612850.1
4/28/06	118	1218.586	4612850.1	1218.586	4612850.1
4/29/06	119	1218.586	4612850.1	1218.586	4612850.1
4/30/06	120	1218.586	4612850.1	1218.586	4612850.1
5/1/06	121	1218.586	4612850.1	1218.586	4612850.1
5/2/06	122	1218.586	4612850.1	1218.586	4612850.1
5/3/06	123	1218.586	4612850.1	1218.586	4612850.1
5/4/06	124	1218.586	4612850.1	1218.586	4612850.1
5/5/06	125	1218.586	4612850.1	1218.586	4612850.1
5/6/06	126	1218.586	4612850.1	1218.586	4612850.1
5/7/06	127	1218.586	4612850.1	1218.586	4612850.1
5/8/06	128	1218.586	4612850.1	1218.586	4612850.1
5/9/06	129	1218.586	4612850.1	1218.586	4612850.1
5/10/06	130	1218.586	4612850.1	1218.586	4612850.1
5/11/06	131	1218.586	4612850.1	1218.586	4612850.1
5/12/06	132	1218.586	4612850.1	1218.586	4612850.1
5/13/06	133	1218.586	4612850.1	1218.586	4612850.1
5/14/06	134	1218.586	4612850.1	1218.586	4612850.1
5/15/06	135	1218.586	4612850.1	1218.586	4612850.1

	Julian	Unit 2		Unit 3	
Date	Day	Flow (mgd)	Flow (m^3)	Flow (mgd)	Flow (m^3)
5/16/06	136	1218.586	4612850.1	1218.586	4612850.1
5/17/06	137	1218.586	4612850.1	1218.586	4612850.1
5/18/06	138	1218.586	4612850.1	1218.586	4612850.1
5/19/06	139	1218.586	4612850.1	1218.586	4612850.1
5/20/06	140	1218.586	4612850.1	1218.586	4612850.1
5/21/06	141	1218.586	4612850.1	1218.586	4612850.1
5/22/06	142	1218.586	4612850.1	1218.586	4612850.1
5/23/06	143	1218.586	4612850.1	1218.586	4612850.1
5/24/06	144	1218.586	4612850.1	1218.586	4612850.1
5/25/06	145	1218.586	4612850.1	1218.586	4612850.1
5/26/06	146	1218.586	4612850.1	1218.586	4612850.1
5/27/06	147	1218.586	4612850.1	1218.586	4612850.1
5/28/06	148	1218.586	4612850.1	1218.586	4612850.1
5/29/06	149	1218.586	4612850.1	1218.586	4612850.1
5/30/06	150	1218.586	4612850.1	1218.586	4612850.1
5/31/06	151	1218.586	4612850.1	1218.586	4612850.1
6/1/06	152	1218.586	4612850.1	1218.586	4612850.1
6/2/06	153	1218.586	4612850.1	1218.586	4612850.1
6/3/06	154	1218.586	4612850.1	1218.586	4612850.1
6/4/06	155	1218.586	4612850.1	1218.586	4612850.1
6/5/06	156	1218.586	4612850.1	1218.586	4612850.1
6/6/06	157	1218.586	4612850.1	1218.586	4612850.1
6/7/06	158	1218.586	4612850.1	1218.586	4612850.1
6/8/06	159	1218.586	4612850.1	1218.586	4612850.1
6/9/06	160	1218.586	4612850.1	1218.586	4612850.1
6/10/06	161	1218.586	4612850.1	1218.586	4612850.1
6/11/06	162	1218.586	4612850.1	1218.586	4612850.1
6/12/06	163	1218.586	4612850.1	1218.586	4612850.1
6/13/06	164	1218.586	4612850.1	1218.586	4612850.1
6/14/06	165	1218.586	4612850.1	1218.586	4612850.1
6/15/06	166	1218.586	4612850.1	1218.586	4612850.1
6/16/06	167	1218.586	4612850.1	1218.586	4612850.1
6/17/06	168	1218.586	4612850.1	1218.586	4612850.1
6/18/06	169	1218.586	4612850.1	1218.586	4612850.1
6/19/06	170	1218.586	4612850.1	1218.586	4612850.1
6/20/06	171	1218.586	4612850.1	1218.586	4612850.1
6/21/06	172	1218.586	4612850.1	1218.586	4612850.1
6/22/06	173	1218.586	4612850.1	1218.586	4612850.1
6/23/06	174	1218.586	4612850.1	1218.586	4612850.1
6/24/06	175	1218.586	4612850.1	1218.586	4612850.1
6/25/06	176	1218.586	4612850.1	1218.586	4612850.1
6/26/06	177	1218.586	4612850.1	1218.586	4612850.1
6/27/06	178	1218.586	4612850.1	1218.586	4612850.1
6/28/06	179	1218.586	4612850.1	1218.586	4612850.1
6/29/06	180	1218.586	4612850.1	1218.586	4612850.1

Date	Julian Day	Unit 2 Flow (mgd)	Unit 2 Flow (m^3)	Unit 3 Flow (mgd)	Unit 3 Flow (m^3)
6/30/06	181	1218.586	4612850.1	1218.586	4612850.1
7/1/06	182	1218.586	4612850.1	1218.586	4612850.1
7/2/06	183	1218.586	4612850.1	1218.586	4612850.1
7/3/06	184	1218.586	4612850.1	1218.586	4612850.1
7/4/06	185	1218.586	4612850.1	1218.586	4612850.1
7/5/06	186	1218.586	4612850.1	1218.586	4612850.1
7/6/06	187	1218.586	4612850.1	1218.586	4612850.1
7/7/06	188	1218.586	4612850.1	1218.586	4612850.1
7/8/06	189	1218.586	4612850.1	1218.586	4612850.1
7/9/06	190	1218.586	4612850.1	1218.586	4612850.1
7/10/06	191	1218.586	4612850.1	1218.586	4612850.1
7/11/06	192	1218.586	4612850.1	1218.586	4612850.1
7/12/06	193	1218.586	4612850.1	1218.586	4612850.1
7/13/06	194	1218.586	4612850.1	1218.586	4612850.1
7/14/06	195	1218.586	4612850.1	1218.586	4612850.1
7/15/06	196	1218.586	4612850.1	1218.586	4612850.1
7/16/06	197	1218.586	4612850.1	1218.586	4612850.1
7/17/06	198	1218.586	4612850.1	1218.586	4612850.1
7/18/06	199	1218.586	4612850.1	1218.586	4612850.1
7/19/06	200	1218.586	4612850.1	1218.586	4612850.1
7/20/06	201	1218.586	4612850.1	1218.586	4612850.1
7/21/06	202	1218.586	4612850.1	1218.586	4612850.1
7/22/06	203	1218.586	4612850.1	1218.586	4612850.1
7/23/06	204	1218.586	4612850.1	1218.586	4612850.1
7/24/06	205	1218.586	4612850.1	1218.586	4612850.1
7/25/06	206	1218.586	4612850.1	1218.586	4612850.1
7/26/06	207	1218.586	4612850.1	1218.586	4612850.1
7/27/06	208	1218.586	4612850.1	1218.586	4612850.1
7/28/06	209	1218.586	4612850.1	1218.586	4612850.1
7/29/06	210	1218.586	4612850.1	1218.586	4612850.1
7/30/06	211	1218.586	4612850.1	1218.586	4612850.1
7/31/06	212	1218.586	4612850.1	1218.586	4612850.1
8/1/06	213	1218.586	4612850.1	1218.586	4612850.1
8/2/06	214	1218.586	4612850.1	1218.586	4612850.1
8/3/06	215	1218.586	4612850.1	1218.586	4612850.1
8/4/06	216	1218.586	4612850.1	1218.586	4612850.1
8/5/06	217	1218.586	4612850.1	1218.586	4612850.1
8/6/06	218	1218.586	4612850.1	1218.586	4612850.1
8/7/06	219	1218.586	4612850.1	1218.586	4612850.1
8/8/06	220	1218.586	4612850.1	1218.586	4612850.1
8/9/06	221	1218.586	4612850.1	1218.586	4612850.1
8/10/06	222	1218.586	4612850.1	1218.586	4612850.1
8/11/06	223	1218.586	4612850.1	1218.586	4612850.1
8/12/06	224	1218.586	4612850.1	1218.586	4612850.1
8/13/06	225	1218.586	4612850.1	1218.586	4612850.1

Date	Julian Day	Unit 2 Flow (mgd)	Unit 2 Flow (m^3)	Unit 3 Flow (mgd)	Unit 3 Flow (m^3)
8/14/06	226	1218.586	4612850.1	1218.586	4612850.1
8/15/06	227	1218.586	4612850.1	1218.586	4612850.1
8/16/06	228	1218.586	4612850.1	1218.586	4612850.1
8/17/06	229	1218.586	4612850.1	1218.586	4612850.1
8/18/06	230	1218.586	4612850.1	1218.586	4612850.1
8/19/06	231	1218.586	4612850.1	1218.586	4612850.1
8/20/06	232	1218.586	4612850.1	1218.586	4612850.1
8/21/06	233	1218.586	4612850.1	1218.586	4612850.1
8/22/06	234	1218.586	4612850.1	1218.586	4612850.1
8/23/06	235	1218.586	4612850.1	1218.586	4612850.1
8/24/06	236	1218.586	4612850.1	1218.586	4612850.1
8/25/06	237	1218.586	4612850.1	1218.586	4612850.1
8/26/06	238	1218.586	4612850.1	1218.586	4612850.1
8/27/06	239	1218.586	4612850.1	1218.586	4612850.1
8/28/06	240	1218.586	4612850.1	1218.586	4612850.1
8/29/06	241	1218.586	4612850.1	1218.586	4612850.1
8/30/06	242	1218.586	4612850.1	1218.586	4612850.1
8/31/06	243	1218.586	4612850.1	1218.586	4612850.1
9/1/06	244	1218.586	4612850.1	1218.586	4612850.1
9/2/06	245	1218.586	4612850.1	1218.586	4612850.1
9/3/06	246	1218.586	4612850.1	1218.586	4612850.1
9/4/06	247	1218.586	4612850.1	1218.586	4612850.1
9/5/06	248	1218.586	4612850.1	1218.586	4612850.1
9/6/06	249	1218.586	4612850.1	1218.586	4612850.1
9/7/06	250	1218.586	4612850.1	1218.586	4612850.1
9/8/06	251	1218.586	4612850.1	1218.586	4612850.1
9/9/06	252	1218.586	4612850.1	1218.586	4612850.1
9/10/06	253	1218.586	4612850.1	1218.586	4612850.1
9/11/06	254	1218.586	4612850.1	1218.586	4612850.1
9/12/06	255	1218.586	4612850.1	1218.586	4612850.1
9/13/06	256	1218.586	4612850.1	1218.586	4612850.1
9/14/06	257	1218.586	4612850.1	1218.586	4612850.1
9/15/06	258	1218.586	4612850.1	1218.586	4612850.1
9/16/06	259	1218.586	4612850.1	1218.586	4612850.1
9/17/06	260	1218.586	4612850.1	1218.586	4612850.1
9/18/06	261	1218.586	4612850.1	1218.586	4612850.1
9/19/06	262	1218.586	4612850.1	1218.586	4612850.1
9/20/06	263	1218.586	4612850.1	1218.586	4612850.1
9/21/06	264	1218.586	4612850.1	1218.586	4612850.1
9/22/06	265	1218.586	4612850.1	1218.586	4612850.1
9/23/06	266	1218.586	4612850.1	1218.586	4612850.1
9/24/06	267	1218.586	4612850.1	1218.586	4612850.1
9/25/06	268	1218.586	4612850.1	1218.586	4612850.1
9/26/06	269	1218.586	4612850.1	1218.586	4612850.1
9/27/06	270	1218.586	4612850.1	1218.586	4612850.1

Date	Julian Day	Unit 2 Flow (mgd)	Unit 2 Flow (m^3)	Unit 3 Flow (mgd)	Unit 3 Flow (m^3)
9/28/06	271	1218.586	4612850.1	1218.586	4612850.1
9/29/06	272	1218.586	4612850.1	1218.586	4612850.1
9/30/06	273	1218.586	4612850.1	1218.586	4612850.1
10/1/06	274	1218.586	4612850.1	1218.586	4612850.1
10/2/06	275	1218.586	4612850.1	1218.586	4612850.1
10/3/06	276	1218.586	4612850.1	1218.586	4612850.1
10/4/06	277	1218.586	4612850.1	1218.586	4612850.1
10/5/06	278	1218.586	4612850.1	1218.586	4612850.1
10/6/06	279	1218.586	4612850.1	1218.586	4612850.1
10/7/06	280	1218.586	4612850.1	1218.586	4612850.1
10/8/06	281	1218.586	4612850.1	1218.586	4612850.1
10/9/06	282	1218.586	4612850.1	1218.586	4612850.1
10/10/06	283	1218.586	4612850.1	1218.586	4612850.1
10/11/06	284	1218.586	4612850.1	1218.586	4612850.1
10/12/06	285	1218.586	4612850.1	1218.586	4612850.1
10/13/06	286	1218.586	4612850.1	1218.586	4612850.1
10/14/06	287	1218.586	4612850.1	1218.586	4612850.1
10/15/06	288	1218.586	4612850.1	1218.586	4612850.1
10/16/06	289	1218.586	4612850.1	1218.586	4612850.1
10/17/06	290	1218.586	4612850.1	853.01	3228994.3
10/18/06	291	1218.586	4612850.1	69.12	261647.7
10/19/06	292	1218.586	4612850.1	0	0.0
10/20/06	293	1218.586	4612850.1	0	0.0
10/21/06	294	1218.586	4612850.1	0	0.0
10/22/06	295	1218.586	4612850.1	0	0.0
10/23/06	296	1218.586	4612850.1	0	0.0
10/24/06	297	1218.586	4612850.1	0	0.0
10/25/06	298	1218.586	4612850.1	0	0.0
10/26/06	299	1218.586	4612850.1	0	0.0
10/27/06	300	1218.586	4612850.1	0	0.0
10/28/06	301	1218.586	4612850.1	0	0.0
10/29/06	302	1218.586	4612850.1	0	0.0
10/30/06	303	1218.586	4612850.1	0	0.0
10/31/06	304	1218.586	4612850.1	0	0.0
11/1/06	305	1218.586	4612850.1	0	0.0
11/2/06	306	1218.586	4612850.1	0	0.0
11/3/06	307	1218.586	4612850.1	0	0.0
11/4/06	308	1218.586	4612850.1	0	0.0
11/5/06	309	1218.586	4612850.1	0	0.0
11/6/06	310	1218.586	4612850.1	0	0.0
11/7/06	311	1218.586	4612850.1	0	0.0
11/8/06	312	1218.586	4612850.1	0	0.0
11/9/06	313	1218.586	4612850.1	34.56	130823.8
11/10/06	314	1218.586	4612850.1	34.56	130823.8
11/11/06	315	1218.586	4612850.1	34.56	130823.8

Date	Julian Day	Unit 2 Flow (mgd)	Unit 2 Flow (m^3)	Unit 3 Flow (mgd)	Unit 3 Flow (m^3)
11/12/06	316	1218.586	4612850.1	34.56	130823.8
11/13/06	317	1218.586	4612850.1	34.56	130823.8
11/14/06	318	1218.586	4612850.1	229.96	870493.3
11/15/06	319	1218.586	4612850.1	457.92	1733415.9
11/16/06	320	1218.586	4612850.1	629.29	2382121.9
11/17/06	321	1218.586	4612850.1	629.29	2382121.9
11/18/06	322	1218.586	4612850.1	629.29	2382121.9
11/19/06	323	1218.586	4612850.1	629.29	2382121.9
11/20/06	324	1218.586	4612850.1	629.29	2382121.9
11/21/06	325	1218.586	4612850.1	629.29	2382121.9
11/22/06	326	1218.586	4612850.1	629.29	2382121.9
11/23/06	327	1218.586	4612850.1	629.29	2382121.9
11/24/06	328	1218.586	4612850.1	629.29	2382121.9
11/25/06	329	1218.586	4612850.1	731.05	2767325.4
11/26/06	330	1218.586	4612850.1	913.93	3459601.6
11/27/06	331	1218.586	4612850.1	1143.89	4330094.9
11/28/06	332	1218.586	4612850.1	1218.586	4612850.1
11/29/06	333	1218.586	4612850.1	1218.586	4612850.1
11/30/06	334	1218.586	4612850.1	1218.586	4612850.1
12/1/06	335	1218.586	4612850.1	1218.586	4612850.1
12/2/06	336	1218.586	4612850.1	1218.586	4612850.1
12/3/06	337	1218.586	4612850.1	1218.586	4612850.1
12/4/06	338	1218.586	4612850.1	1218.586	4612850.1
12/5/06	339	1218.586	4612850.1	1218.586	4612850.1
12/6/06	340	1218.586	4612850.1	1218.586	4612850.1
12/7/06	341	1218.586	4612850.1	1218.586	4612850.1
12/8/06	342	1218.586	4612850.1	1218.586	4612850.1
12/9/06	343	1218.586	4612850.1	1218.586	4612850.1
12/10/06	344	1218.586	4612850.1	1218.586	4612850.1
12/11/06	345	1218.586	4612850.1	1218.586	4612850.1
12/12/06	346	1218.586	4612850.1	1218.586	4612850.1
12/13/06	347	1218.586	4612850.1	1218.586	4612850.1
12/14/06	348	1218.586	4612850.1	1218.586	4612850.1
12/15/06	349	1218.586	4612850.1	1218.586	4612850.1
12/16/06	350	1218.586	4612850.1	1218.586	4612850.1
12/17/06	351	1218.586	4612850.1	1218.586	4612850.1
12/18/06	352	1218.586	4612850.1	1218.586	4612850.1
12/19/06	353	1218.586	4612850.1	1218.586	4612850.1
12/20/06	354	1218.586	4612850.1	1218.586	4612850.1
12/21/06	355	1218.586	4612850.1	1218.586	4612850.1
12/22/06	356	1218.586	4612850.1	1218.586	4612850.1
12/23/06	357	1218.586	4612850.1	1218.586	4612850.1
12/24/06	358	1218.586	4612850.1	1218.586	4612850.1
12/25/06	359	1218.586	4612850.1	1218.586	4612850.1
12/26/06	360	1218.586	4612850.1	1218.586	4612850.1

Date	Julian Day	Unit 2 Flow (mgd)	Unit 2 Flow (m^3)	Unit 3 Flow (mgd)	Unit 3 Flow (m^3)
12/27/06	361	1218.586	4612850.1	1218.586	4612850.1
12/28/06	362	1218.586	4612850.1	1218.586	4612850.1
12/29/06	363	1218.586	4612850.1	1218.586	4612850.1
12/30/06	364	1218.586	4612850.1	1218.586	4612850.1
12/31/06	365	1218.586	4612850.1	1218.586	4612850.1
1/1/07	1	1218.586	4612850.1	1218.586	4612850.1
1/2/07	2	1218.586	4612850.1	1218.586	4612850.1
1/3/07	3	1218.586	4612850.1	1218.586	4612850.1
1/4/07	4	1218.586	4612850.1	1218.586	4612850.1
1/5/07	5	1218.586	4612850.1	1218.586	4612850.1
1/6/07	6	1218.586	4612850.1	1218.586	4612850.1
1/7/07	7	1218.586	4612850.1	1218.586	4612850.1
1/8/07	8	1218.586	4612850.1	1218.586	4612850.1
1/9/07	9	1218.586	4612850.1	1218.586	4612850.1
1/10/07	10	1218.586	4612850.1	1218.586	4612850.1
1/11/07	11	1218.586	4612850.1	1218.586	4612850.1
1/12/07	12	1218.586	4612850.1	1218.586	4612850.1
1/13/07	13	1218.586	4612850.1	1218.586	4612850.1
1/14/07	14	1218.586	4612850.1	1218.586	4612850.1
1/15/07	15	1218.586	4612850.1	1218.586	4612850.1
1/16/07	16	1218.586	4612850.1	1218.586	4612850.1
1/17/07	17	1218.586	4612850.1	1218.586	4612850.1
1/18/07	18	1218.586	4612850.1	1218.586	4612850.1
1/19/07	19	1218.586	4612850.1	1218.586	4612850.1
1/20/07	20	1218.586	4612850.1	1218.586	4612850.1
1/21/07	21	1218.586	4612850.1	1066.263	4036243.8
1/22/07	22	1218.586	4612850.1	913.94	3459639.4
1/23/07	23	1218.586	4612850.1	1078.956	4084294.3
1/24/07	24	1218.586	4612850.1	1218.586	4612850.1
1/25/07	25	1218.586	4612850.1	1218.586	4612850.1
1/26/07	26	1218.586	4612850.1	1218.586	4612850.1
1/27/07	27	1218.586	4612850.1	1218.586	4612850.1
1/28/07	28	1218.586	4612850.1	1218.586	4612850.1
1/29/07	29	1218.586	4612850.1	1218.586	4612850.1
1/30/07	30	1218.586	4612850.1	1218.586	4612850.1
1/31/07	31	1218.586	4612850.1	1218.586	4612850.1
2/1/07	32	1218.586	4612850.1	1218.586	4612850.1
2/2/07	33	1218.586	4612850.1	1218.586	4612850.1
2/3/07	34	1218.586	4612850.1	1218.586	4612850.1
2/4/07	35	1218.586	4612850.1	1218.586	4612850.1
2/5/07	36	1218.586	4612850.1	1218.586	4612850.1
2/6/07	37	1218.586	4612850.1	1218.586	4612850.1
2/7/07	38	1218.586	4612850.1	1218.586	4612850.1
2/8/07	39	1218.586	4612850.1	1218.586	4612850.1
2/9/07	40	1218.586	4612850.1	1218.586	4612850.1

Date	Julian Day	Unit 2 Flow (mgd)	Unit 2 Flow (m^3)	Unit 3 Flow (mgd)	Unit 3 Flow (m^3)
2/10/07	41	1218.586	4612850.1	1218.586	4612850.1
2/11/07	42	1218.586	4612850.1	1218.586	4612850.1
2/12/07	43	1218.586	4612850.1	1218.586	4612850.1
2/13/07	44	1218.586	4612850.1	1218.586	4612850.1
2/14/07	45	1218.586	4612850.1	1218.586	4612850.1
2/15/07	46	1218.586	4612850.1	1218.586	4612850.1
2/16/07	47	1218.586	4612850.1	1218.586	4612850.1
2/17/07	48	1218.586	4612850.1	1218.586	4612850.1
2/18/07	49	1218.586	4612850.1	1218.586	4612850.1
2/19/07	50	1218.586	4612850.1	1218.586	4612850.1
2/20/07	51	1218.586	4612850.1	1218.586	4612850.1
2/21/07	52	1218.586	4612850.1	1218.586	4612850.1
2/22/07	53	1218.586	4612850.1	1218.586	4612850.1
2/23/07	54	1218.586	4612850.1	1218.586	4612850.1
2/24/07	55	1218.586	4612850.1	1218.586	4612850.1
2/25/07	56	1218.586	4612850.1	1218.586	4612850.1
2/26/07	57	1218.586	4612850.1	1218.586	4612850.1
2/27/07	58	1218.586	4612850.1	1218.586	4612850.1
2/28/07	59	1218.586	4612850.1	1218.586	4612850.1
3/1/07	60	1218.586	4612850.1	1218.586	4612850.1
3/2/07	61	1218.586	4612850.1	1218.586	4612850.1
3/3/07	62	1218.586	4612850.1	1218.586	4612850.1
3/4/07	63	1218.586	4612850.1	1218.586	4612850.1
3/5/07	64	1218.586	4612850.1	1218.586	4612850.1
3/6/07	65	1218.586	4612850.1	1218.586	4612850.1
3/7/07	66	1218.586	4612850.1	1218.586	4612850.1
3/8/07	67	1218.586	4612850.1	1218.586	4612850.1
3/9/07	68	1218.586	4612850.1	1218.586	4612850.1
3/10/07	69	1218.586	4612850.1	1218.586	4612850.1
3/11/07	70	1218.586	4612850.1	1218.586	4612850.1
3/12/07	71	1218.586	4612850.1	1218.586	4612850.1
3/13/07	72	1218.586	4612850.1	1218.586	4612850.1
3/14/07	73	1218.586	4612850.1	1218.586	4612850.1
3/15/07	74	1218.586	4612850.1	1218.586	4612850.1
3/16/07	75	1218.586	4612850.1	1218.586	4612850.1
3/17/07	76	1218.586	4612850.1	1218.586	4612850.1
3/18/07	77	1218.586	4612850.1	1218.586	4612850.1
3/19/07	78	1218.586	4612850.1	1218.586	4612850.1
3/20/07	79	1218.586	4612850.1	1218.586	4612850.1
3/21/07	80	1218.586	4612850.1	1218.586	4612850.1
3/22/07	81	1218.586	4612850.1	1218.586	4612850.1
3/23/07	82	1218.586	4612850.1	1218.586	4612850.1
3/24/07	83	1218.586	4612850.1	1218.586	4612850.1
3/25/07	84	1218.586	4612850.1	1218.586	4612850.1
3/26/07	85	1218.586	4612850.1	1218.586	4612850.1

Date	Julian Day	Unit 2 Flow (mgd)	Unit 2 Flow (m^3)	Unit 3 Flow (mgd)	Unit 3 Flow (m^3)
3/27/07	86	1218.586	4612850.1	1218.586	4612850.1
3/28/07	87	1218.586	4612850.1	1218.586	4612850.1
3/29/07	88	1218.586	4612850.1	1218.586	4612850.1
3/30/07	89	1218.586	4612850.1	1218.586	4612850.1
3/31/07	90	1218.586	4612850.1	1218.586	4612850.1
4/1/07	91	1218.586	4612850.1	1218.586	4612850.1
4/2/07	92	1218.586	4612850.1	1218.586	4612850.1
4/3/07	93	1218.586	4612850.1	1218.586	4612850.1
4/4/07	94	1218.586	4612850.1	1218.586	4612850.1
4/5/07	95	1218.586	4612850.1	1218.586	4612850.1
4/6/07	96	1218.586	4612850.1	1218.586	4612850.1
4/7/07	97	1218.586	4612850.1	1218.586	4612850.1
4/8/07	98	1218.586	4612850.1	1218.586	4612850.1
4/9/07	99	1218.586	4612850.1	1218.586	4612850.1
4/10/07	100	1218.586	4612850.1	1218.586	4612850.1
4/11/07	101	1218.586	4612850.1	1132.904	4288509.0
4/12/07	102	1218.586	4612850.1	1218.586	4612850.1
4/13/07	103	1218.586	4612850.1	1218.586	4612850.1
4/14/07	104	1218.586	4612850.1	1218.586	4612850.1
4/15/07	105	1218.586	4612850.1	1218.586	4612850.1
4/16/07	106	1218.586	4612850.1	1218.586	4612850.1
4/17/07	107	1218.586	4612850.1	1218.586	4612850.1
4/18/07	108	1218.586	4612850.1	1218.586	4612850.1
4/19/07	109	1218.586	4612850.1	1218.586	4612850.1
4/20/07	110	1218.586	4612850.1	1218.586	4612850.1
4/21/07	111	1218.586	4612850.1	1218.586	4612850.1
4/22/07	112	1218.586	4612850.1	1218.586	4612850.1
4/23/07	113	1218.586	4612850.1	1218.586	4612850.1
4/24/07	114	1218.586	4612850.1	1218.586	4612850.1
4/25/07	115	1218.586	4612850.1	1218.586	4612850.1
4/26/07	116	1218.586	4612850.1	1218.586	4612850.1
4/27/07	117	1218.586	4612850.1	1218.586	4612850.1
4/28/07	118	1218.586	4612850.1	1218.586	4612850.1
4/29/07	119	1218.586	4612850.1	1218.586	4612850.1
4/30/07	120	1218.586	4612850.1	1218.586	4612850.1
5/1/07	121	1218.586	4612850.1	1218.586	4612850.1
5/2/07	122	1218.586	4612850.1	1218.586	4612850.1
5/3/07	123	1218.586	4612850.1	1218.586	4612850.1
5/4/07	124	1218.586	4612850.1	1218.586	4612850.1
5/5/07	125	1218.586	4612850.1	1218.586	4612850.1
5/6/07	126	1218.586	4612850.1	1218.586	4612850.1
5/7/07	127	1218.586	4612850.1	1218.586	4612850.1
5/8/07	128	1218.586	4612850.1	1218.586	4612850.1
5/9/07	129	1218.586	4612850.1	1218.586	4612850.1
5/10/07	130	1218.586	4612850.1	1218.586	4612850.1

Date	Julian Day	Unit 2 Flow (mgd)	Unit 2 Flow (m^3)	Unit 3 Flow (mgd)	Unit 3 Flow (m^3)
5/11/07	131	1218.586	4612850.1	1218.586	4612850.1
5/12/07	132	1218.586	4612850.1	1218.586	4612850.1
5/13/07	133	1218.586	4612850.1	1218.586	4612850.1
5/14/07	134	1218.586	4612850.1	1218.586	4612850.1
5/15/07	135	1218.586	4612850.1	1218.586	4612850.1
5/16/07	136	1218.586	4612850.1	1218.586	4612850.1
5/17/07	137	1218.586	4612850.1	1218.586	4612850.1
5/18/07	138	1218.586	4612850.1	1218.586	4612850.1
5/19/07	139	1218.586	4612850.1	1218.586	4612850.1
5/20/07	140	1218.586	4612850.1	1218.586	4612850.1
5/21/07	141	1218.586	4612850.1	1218.586	4612850.1
5/22/07	142	1218.586	4612850.1	1218.586	4612850.1
5/23/07	143	1218.586	4612850.1	1218.586	4612850.1
5/24/07	144	1218.586	4612850.1	1218.586	4612850.1
5/25/07	145	1218.586	4612850.1	1218.586	4612850.1
5/26/07	146	1218.586	4612850.1	1218.586	4612850.1
5/27/07	147	1218.586	4612850.1	1218.586	4612850.1
5/28/07	148	1218.586	4612850.1	1218.586	4612850.1
5/29/07	149	1218.586	4612850.1	1218.586	4612850.1
5/30/07	150	1218.586	4612850.1	1218.586	4612850.1
5/31/07	151	1218.586	4612850.1	1218.586	4612850.1

San Onofre Nuclear Generating Station

Appendix F

SCE Responses to Calculation Baseline Advisory Team Comments

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Calculation Baseline Advisory Team
Summary Document
Summary of Comments and Associated Responses

Patrick Tennant
Southern California Edison
December 7, 2007

Introduction

Southern California Edison (SCE) operates the San Onofre Nuclear Generating Station (SONGS), a two-unit nuclear power generation facility south of San Clemente, CA. SONGS is subject to regulations under section 316(b) of the federal Clean Water Act. A new 316(b) rule was issued by the Environmental Protection Agency (EPA) in 2004. The rule required all Phase II facilities (existing facilities that utilize once through cooling systems and use greater than 50 mgd of water) to prepare a Comprehensive Demonstration Study (CDS) to evaluate the potential impacts of the facility on the biological community on the waterbody from which it withdraws water. A detailed analysis of potential engineering or operational options to minimize the impacts is required in the document. In order to evaluate these options, a facility that does not comply with baseline conditions of the rule must establish a theoretical baseline of impingement and entrainment. Since SONGS deviates from the standard baseline due to intake modifications, engineered fish protection devices, and operational procedures to minimize impacts, SCE must develop a calculation baseline.

SCE submitted a Proposal for Information Collection (PIC) in October 2005. This PIC was distributed to resource agencies for review and comments. Several agencies commented that a committee should be created to review the development of the calculation baseline. A revised PIC was issued in November 2006, which incorporated many of the comments, and also stated that a committee would be formed.

The Calculation Baseline Advisory Team (CBAT) was created to provide a forum to present technical, scientific, and policy developments of the calculation baseline to a team of stakeholder agencies. The calculation baseline was based on biological data collected during the year-long Impingement Mortality and Entrainment (IM&E) Study and existing, relevant historical data. The team was updated on study results and then presented with a draft IM&E study for review and comments. This document serves to summarize and address the comments of the team.

It should be noted that the EPA has since suspended the rule due to recent litigation. Although the EPA is currently working on a revised rule, and expects to have a draft prepared by the end of 2008, language in SONGS National Pollutant Discharge Elimination System (NPDES) permits still requires the development of the CDS. Although many of the key elements of the rule were remanded to the EPA during the litigation, neither the IM&E Study nor the calculation baseline was contested.

CBAT Members

CBAT members were selected by SCE staff and were chosen based on the need for their respective agency comments and their experience on the subject. Members represented resource agencies, contract scientists and engineers, and subject matter experts. A list of the members and their affiliation is provided below. Peter Raimondi* was asked to review the final document but was not part of the team meetings.

<u>San Diego – Regional Water Quality Control Board</u>
John Odermat – Senior Engineering Geologist
Charles Cheng – Engineering Geologist

<u>California Department of Fish and Game</u>
William Paznokas – Staff Environmental Scientist – Marine Region

<u>National Marine Fisheries Service</u>
Bryant Chesney – Southern California Habitat Coordinator

<u>California State Parks</u>
Dave Pryor – Resource Ecologist

<u>MBC Applied Environmental Sciences (IM&E Study Consultant)</u>
Shane Beck – Vice President

<u>EPRI (CDS – Consultant)</u>
Dave Bailey – Senior Project Manager

<u>Tenera (IM&E Study Consultant)</u>
John Steinbeck

<u>ACT Environmental (SCE Marine Biology/316(b) Support)</u>
Kevin Herbinson – Senior Marine Biologist

<u>Subject Matter Experts</u>

Andy Jahn, PhD – Environmental and Statistical Consulting

*Peter Raimondi, PhD – Associate Professor, University of California, Santa Cruz, Department of Ecology and Evolutionary Biology, Long Marine Laboratory. Member of the California Coastal Commission's Scientific Advisory Panel for SONGS.

CBAT Process

CBAT members met regularly at SONGS and by phone between May 1 and August 20, 2007. Meetings occurred on May 1, May 29, July 10, and August 20, 2007. At each meeting, updates of study results and project development were presented and strategies discussed. On August 14, 2007, the draft copy of the IM&E Study was distributed. The document was discussed at the August 20, 2007 meeting, and a deadline of September 5, 2007 was given for any comments. Upon receiving comments, they were either incorporated into the final version of the IM&E report or are discussed below in more detail.

Summary of Comments

Comments have been presented below in a summary format to address multiple comments with similar concerns. This means the comments have been paraphrased or summarized when possible. Comments that were grammatical in nature were not included in the summary below. These comments were incorporated into the final IM&E report. The actual comments of team members have been included in the appendices of this document. Comments from SCE staff and team members responsible for the development of the document were not included, but were incorporated into the document where warranted. Comments were not received from State Parks or the Regional Water Quality Control Board. The board was willing to accept the agency comments as the most technically informed individuals.

Issue 1: Seasonal Affects

Data shows an obvious seasonal component. Fish species occur in pulses and averaging data over a year could underestimate. There should be a discussion of the weakness of an annual average approach. Finally, the relative efficacy of velocity caps and the fish return system (FRS) during peak events should be addressed.

SCE Response:
Seasonal data was collected and summarized for all impingement and entrainment samples. Annual entrainment and impingement estimates were not calculated using an annual average. Instead, mean concentrations measured during biweekly surveys were multiplied by the cooling water intake flow for the associated biweekly interval. An additional section (Section 7.5) was added in the discussion chapter to address the response in detail. However, the annual average is an effective means of measuring the impacts of the facility and for comparing inter-annual differences. Due to the natural fluctuations in offshore fish populations, fish numbers will go up and down, therefore estimates will be either above or below an unknowable true value. Since the true value is not known, it is not possible to know if an estimate is too high or too low. However, the more frequently a population is sampled, the higher the precision and the likelihood of missing an unusual event such as a pulse of fish would be decreased. In the case of this study, the annual average was based on short term intervals throughout the year that would take into account any seasonal effects.

Issue # 2: Analysis of Source Water

Resource agencies commented that SCE was not opting to analyze source water and the proportional mortality was needed to properly quantify entrainment impacts.

SCE Response:
A proportional mortality component was not added to this study, nor was it proposed in the PIC. The rationale is that the 316(b) rule did not focus on this type of impact. The goal of the IM&E Study in respect to the CDS is to develop a numerical level of impacts due to impingement and entrainment. Then, this level would have to be reduced by a certain percentage dictated by the rule. Although the analysis of proportional mortality is beneficial for assessing regional impacts and has even been proposed by the State Water Resources Control Board in their draft policy, it is not necessary to develop the required elements of the 316(b) rule and was not part of the scope of this study. Difficulties

arise with this type of study because very little data exists on the life histories of many of the species in the southern California Bight. The only species that such an entrainment study could be performed on include northern anchovies, white croaker (or queenfish), and Pacific sardines. It should be noted that these types of analyses were performed during the Marine Review Committee studies discussed in the IM&E report.

Issue # 3 Velocity Cap Estimate Needed Refinement

Several team members noted that the velocity cap analysis needed to be refined to more accurately assess the benefits of the velocity cap. Comments noted the need for more details on past studies and for E/B ratios for all species discussed. Another commenter noted that evaluating the past studies on larval fish in the water column may actually give a higher reduction level. Another commenter indicated that past studies were conducted at other facilities with much different environmental and operational differences.

SCE Response:
The velocity cap analysis was revised and additional information from the past studies (where possible) was included in the IM&E Report (See Section 6.4.1.2). However, some comments were not addressed in this section so they will be clarified here. The species-specific entrapment biomass measured near the intake in relation to the biomass measured in-plant or E/B ratios are not available and could not be provided. With regards to the analysis of the past postflexion larvae work to further quantify the benefits of the velocity cap, SCE chose not to perform these additional analyses at this time. The analysis of the ability of postflexion larvae to avoid entrainment would be beneficial to the assessment of entrainment benefits of the velocity cap. However, there are several issues that made this study problematic. The first is that there are limited studies on postflexion larvae, except for white croaker. It may be difficult to argue that other species behave the same way. But the critical need for this type of study is a detailed analysis of the flow dynamics of the velocity cap in the environment. Although it was studied in detail in the laboratory, it has never been measured in the field. A detailed study is proposed in 2009, but without this key data, the analyses could not be done.

Regarding the differences in environmental conditions between SONGS and the facilities conducting velocity cap studies, SCE acknowledges that there are physical differences. However, several similarities existed at all the facilities and in the laboratory. The basic flow characteristics of the caps are the same. During the surveys the operations at the studied plants were more similar to SONGS operation than during current times. Finally, laboratory studies evaluated several different scenarios including variations in flows and velocity cap shape and size. All of these factors were used in the development of SONGS velocity cap. The SONGS velocity cap was engineered to exceed the benefits of the other velocity caps, so SCE considers the results from those studies to be conservative compared to SONGS. Details of each study are included in the IM&E Report and SCE feels they justify the use of other velocity cap surveys.

Issue # 4– Field Sampling Descriptions

Two commenters requested additional information on the field sampling methods.

SCE Response:
The methodology section in both the impingement and entrainment Methods Sections were expanded to incorporate additional details of sampling methods. One specific concern was for a shift in the sampling sites. This is explained in detail on Page 4-5 of the report.

Issue # 5 – Vertically Stratified Sampling

Two commenters questioned the rationale for the three months of vertical stratified sampling and what was achieved from this study.

SCE Response:
Past studies have suggested that offshore, midwater intakes reduce the amount of fish eggs and larvae entrained into the facility. To test these hypotheses, SCE conducted a short-term trial investigation. The study involved tiered sampling in the water column and inshore/offshore sampling. SCE was well underway with the study when comments from the RWQCB prompted the sampling, so this component was an addition to the original study plan. The study timed the sampling to occur in the months when larval and egg densities were the highest. The goal was to determine if there were any detectable trends in the ichthyoplankton concentrations in relation to their position in the water column and/or their distance from shore. Although the study was too short to make any definitive statements, the study suggested that the original hypotheses were correct. In short, ichthyoplankton surveys suggested that there were fewer eggs and larvae in the mid-water column and fewer eggs offshore than inshore. Since there were relatively few samples, nothing could be said that was statistically justified, but these two trends were evident. Although SCE did not attempt to claim entrainment credits for the intake design, this study suggests that reduction in entrainment is likely and could be further studied to quantify the level.

Issue # 6 – Larval Density

Several commenters noted that larval densities were much higher in the MRC study than in the present study. Historic larvae concentrations from the MRC study were 1,000 times higher than at present. It was suggested in the document that changes in larval density were due to shifting oceanographic conditions, however CalCOFI suggest that larval levels are back to MRC levels. This implies that there was incompatible sampling which would preclude temporal comparisons, inshore larval concentrations are different from offshore, and larvae of entrained species have decreased dramatically.

SCE Response:

The numbers presented in the IM&E Report for the historical data were quoted directly from the MEC Final Report[1] from the MRC Study. The values were presented in units of cubic meters (m^3). All of the results presented in the current study are presented in 1,000 m^3. Based on documents from the MRC database, and evaluation of other data available for that time period, SCE feels that the MEC sample volume data was erroneously reported in m^3 and that the actual units were 100 m^3. This is demonstrated from the following statement from the MRC's database user's guide[2]:

> *The units associated with the abundance with the values are reported in error in the Data Standards Document. They are given as per cubic meter or per square meter; however, the units actually are per 100 cubic meters (AAB,ABUND) or 100 square meters (AB2).*

The differences in data values were discussed in detail Section 7.2.3 of the IM&E Report.

Issue # 7 – Standard Errors

Two commenters questioned how the standard errors in the document were calculated and why standard errors were not included

[1] Marine Ecological Consultants, 1987. MEC Biological Project, San Onofre Nuclear Generating Station, Monitoring Studies in Ichthyoplankton and Zooplankton Final Report, Vol. 1 and 2.
[2] Green, Karen. 1989. MRC Data Base User's Guide: I. Ichthyoplankton, Zooplankton and Phytoplankton, Mysids, and Soft-Bottom Benthos.

SCE Response:

Some standard errors listed in the draft were not actually standard errors and were recalculated. In some cases, standard errors were not included in the tables because of lack of space. A description of how standard errors were calculated was included in the entrainment methods section.

Issue # 8 – Difference Between In-plant and Offshore Entrainment Data

Two commenters noted differences between the in-plant and offshore sampling. One commenter suggested that differences in day and night samples would be because of sampler avoidance. Another commenter felt that differences could be associated with cropping effects in the pipeline.

SCE Response:
There are several reasons for differences in day and night sampling efforts. Some larvae may avoid the sampling devices, but others have vertical migrations or are patchy in distribution in space and time. It is simply the nature of field sampling to have such natural variations.

One commenter noted the problem with sampling in-plant. Cropping of entrained larvae by filter-feeding fouling organisms on the inside of the pipeline could reduce the amount of larvae measured in plant. SCE does not agree that cropping has a significant effect on the numbers. Several heat treatments that kill the fouling organisms in the intake were conducted during the study. If there was a substantial effect from the fouling organisms, then one would expect to see greater entrainment values immediately after a heat teat. This was not seen in these studies. This suggests that any differences in offshore sampling and in-plant we more related to avoidance of the intake system, rather than cropping effects. SCE postulated that sampling in-plant was a much better measure of what is being entrained into the plant due to the inherent field sampling variation discussed above. Offshore samples were conducted to remain consistent with other studies in the area as well as with historic MRC data.

Issue # 9 – General Flaws with Entrainment Study

One commenter suggested several flaws with the entrainment sampling portion of the study. Some of these were already discussed and included sampling in the screenwell, shifting in sampling locations, and differences between offshore and in-plant data. It was suggested that the study was severely flawed because there was no attempt to estimate adult loss associated with entrainment. The Empirical Transport Model was suggested.

SCE Response:
The study plan did not include modeling the impacts of entrainment on adult populations because it was not a requirement of the 316(b) rule to do such analyses. The 316(b) rule simply stated that the level of fish and shellfish entrained into the plant should be enumerated. Once a number was determined, the value would have to be reduced by 60-90% by some technological or operational measure. The value of estimating loss to adult populations would be in situations where regional impacts were being assessed or when mitigation or restoration was being designed. Such analyses were conducted during the MRC study for the species most likely to be entrained.

Issue # 10 – Target Species Selection

One commenter noted that only dominant, harvested, and recreationally important species were selected which is a relic of the idea that these are the only important species.

SCE Response:
The species discussed in detail in the SONGS IM&E report included the most common species impinged and entrained at SONGS. The PIC outlined several species that were considered target species. These species were based on the most common species detected at SONGS. The study also addressed any species that occurred in larger numbers than expected. There are two main reasons for using the target species for detailed analyses. Mathematically it makes sense to use the most

abundant species since the statistical analyses of less frequent species is problematic and generally weak. The most abundant species make up over 95% of the impingement and entrainment, and are much better representatives of the facility's potential for impact. The second advantage is that these species have the most life history data. Generally, commercially and recreationally important species have had the most effort of study to determine crucial life stage information. SCE notes that rare or listed species are important. When the PIC was distributed for review, no other species were suggested by the agencies involved.

Issue # 11 – Survivorship Values

One commenter noted that that survivorship rates between the two units did not coincide with one another.

SCE Response:

The site-specific FRS survivorship study performed offshore SONGS determined different survivorship between the two units. In the present analysis, survivorship was assessed as it was during the MRC study (i.e., by fish size).

Issue # 12 – Entrainment Comparisons to Fecundity Insignificant

One commenter noted that comparisons of entrainment levels to the fecundity of species were insignificant. This may be true but need a full demographic estimate of entrainment equivalency to make this point.

SCE Response:
Statements mentioning the fact that egg and larval concentrations may appear to be very large but when compared to the amount of eggs and subsequent larvae that are produced by reproductively active fish and shellfish are appropriate. Although this argument could be strengthened by additional sampling and better quantification of existing egg and larvae concentrations, this is beyond the scope of the study. The purpose for making these statements was to put the numbers into perspective and a simple comparison of numbers.

Issue # 13 – Fish Return System Effectiveness Higher than in Past

One commenter noted that the FRS effectiveness was higher than in the past and suggested this may be an artifact of sampling differences.

SCE Response:
There has been no change in sampling methodology. In the 2006-2007 study period, several heat treat events occurred in warm water periods. These heat treats were characterized by high abundance of yellowfin croakers. Due to the large numbers, additional hold points were added during the fish chase, and the overall fish return was increased. This resulted in most of the yellowfin croakers being returned. The ability to do this is subject to the biologist's recommendations. Another reason, and probably the most notable, is the addition of normal operations FRS data. Normally, this is not included in the annual FRS efficiency estimates presented to the CCC. Prior to this study, the last time data were collected on the FRS was 1999.

A3 ATTACHMENT

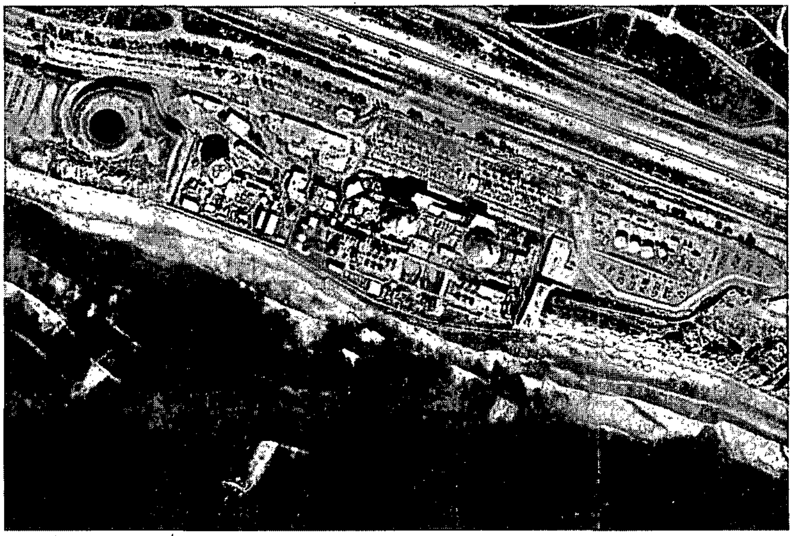
Technology and Compliance Assessment Information

ALDEN Solving flow problems since 1894

ATTACHMENT 3

TECHNOLOGY AND COMPLIANCE ASSESSMENT INFORMATION

SAN ONOFRE NUCLEAR GENERATING STATION



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1.0 INTRODUCTION

Southern California Edison (SCE) is required to submit a Comprehensive Demonstration Study (CDS) for the San Onofre Nuclear Generating Station (SONGS). SCE believes the existing Cooling Water Intake Structure (CWIS) is BTA as it results in a 94.2% reduction in impingement mortality. Consequently, SCE is pursuing Compliance Alternative 2 and this Technology and Compliance Assessment is provided in support of the CDS. This report addresses existing technology, operations, and proposed, verification monitoring measures to meet the Rule.

Section 2.0 provides a description of all existing technology and operations (Design and Technology Plan) and an assessment of the biological efficacy of the existing design and operations to meet EPA's impingement mortality and entrainment reduction performance standards.

Section 3.0 is the Technology Installation and Operation Plan.

Section 4.0 provides the proposed Verification Monitoring Plan.

2.0 DESIGN AND CONSTRUCTION TECHNOLOGY PLAN

2.1 Intake Technology Description

The existing intakes for SONGS Units 2 and 3 are identical in design. They are located 3150 ft offshore and 650 ft apart at an approximate water depth of 30.0 ft. Each intake has a velocity cap installed. The caps are supported 7 ft above the intake riser by columns. The tops of the caps are 12.0 ft below mean low low water (MLLW). A plan and elevation of the intake is shown on Figure 1. The caps are 49 ft in diameter with 7 ft openings. The velocity at the entrance is 1.7 ft/sec which is significantly higher than the surrounding ambient currents which range from 0.1 to 0.7 ft/sec.

The circulating water flow of 1,849 cfs per unit is conveyed to the onshore intake structures through 18 ft diameter concrete pipes at a velocity of 7.3 ft/sec. The onshore intake system incorporates fish protection measures described below.

There are 12 traveling bar racks (TBR) (6 per unit) angled at about 20° to the incoming flow. The bars are 0.25 in. wide with 1 in. clear spacing. The TBR acts as a louver system to guide fish to a fish collection area. Located east of the TBR's there are 12 traveling water screens (TWS) (6 per unit) and one TWS per unit isolating the flow into the fish return system from the circulating water pumps. The TWS have 3/8 in. square mesh. The velocity approaching the screens TWS is 1.3 ft/sec with an estimated through-screen velocity of 3.0 ft/sec. The TBR and TWS operate whenever the differential pressure system indicates cleaning is needed.

The fish collection area (downstream of the TBR) is a 16 ft by 14 ft concrete basin which includes a watertight bucket elevator. A traveling water screen isolates the basin from the circulating water pumps. A schematic of the fish elevator is shown on Figure 2. The elevator is manually operated and is raised at least once per shift. At deck level, the bucket is tipped into a water-filled sluice. The basket is then lowered, and the process repeated until the majority of fish in the collection area are removed. A plan view of the onshore intake is provided on Figure 3. The Unit 2 and 3 onshore intake structures are identical. The structures are symmetrical about the center line. Additional water is added to the fish sluice which discharges into a common 4 ft diameter conduit. Fish are transported within the common conduit and discharged 1900 ft offshore in 19.5 ft of water. A plan and section of the discharge is provided on Figure 4. The system is normally operated at least twice daily by operators. These components comprise the "fish return system" (FRS).

2.2 Operational Procedures

Heat treatment is used to control biofouling. The heat treatment raises the water temperature to 105° F to control biofouling in the intake structure and condenser. This treatment is conducted on an as-needed basis based upon a biofouling model developed for SONGS.

Fish can accumulate in the cooling water system, residing in habitat provided by gate slots, guide vanes and other structures within the system. Consequently, this heat treatment process includes a "Fish Chase" procedure to minimize mortality. The temperature and eddy currents are manipulated by operating crossover gates in the screen well. Heated discharge water is slowly added to the screen well. The elevated water temperature and changing eddy currents in the screen well agitate the fish enough for them to seek new habitat. This procedure chases the fish to the elevator for collection and release.

This procedure is closely monitored by biologists, operators, and engineers to maximize process efficiency and to minimize stress to the organisms.

2.3 Operation and Maintenance

The fish elevator is operated at least once per shift depending on the number of fish present. The traveling bar racks, traveling water screens and fish elevator are also inspected each shift. Heat treatment and the fish chase are conducted as needed for plant operations at an approximate 6 week interval. All operations are recorded on daily status sheets. All equipment is serviced and maintained based on the SONGS Preventative Maintenance Program.

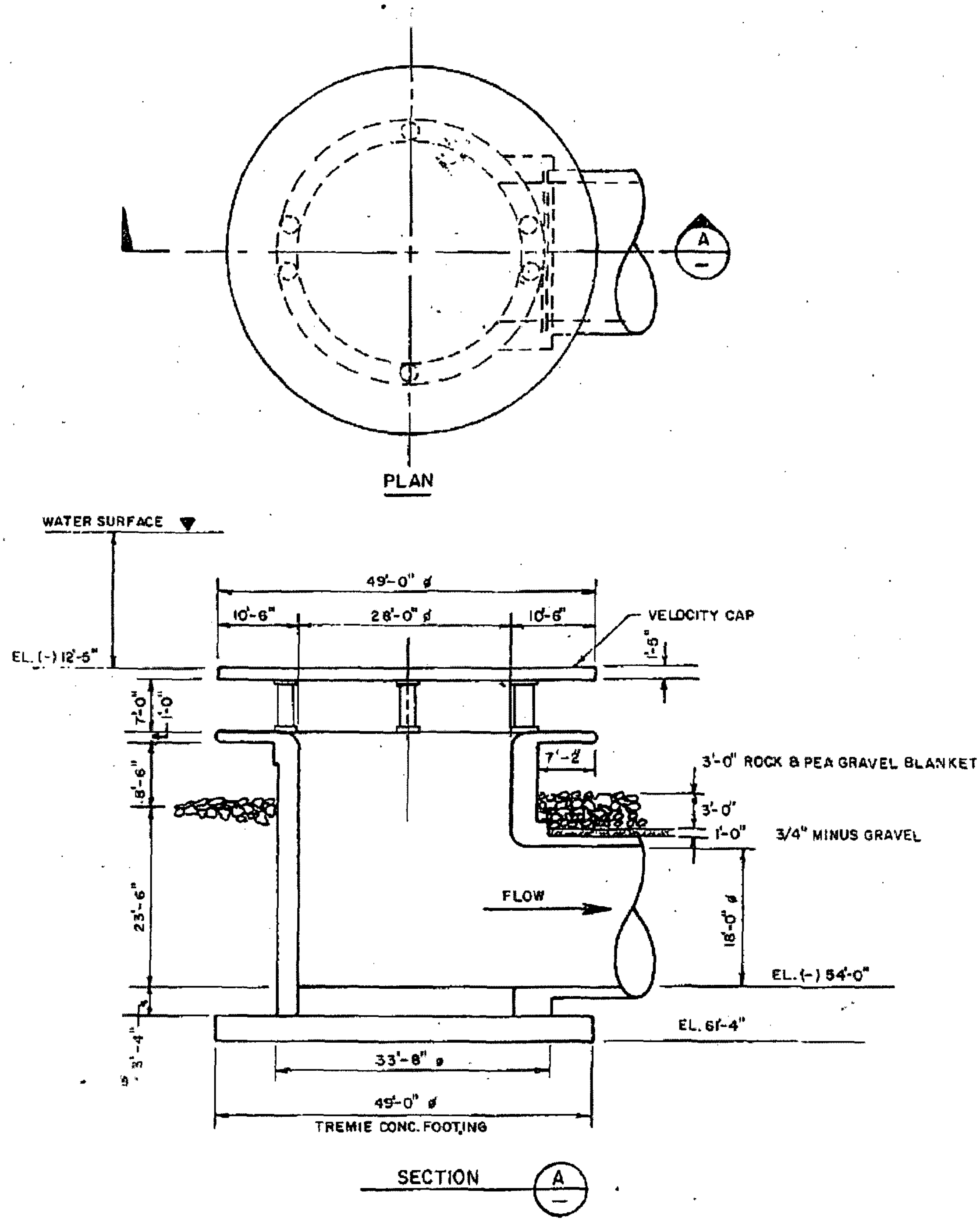

Figure 1 – SONGS Velocity Cap – Plan & Section

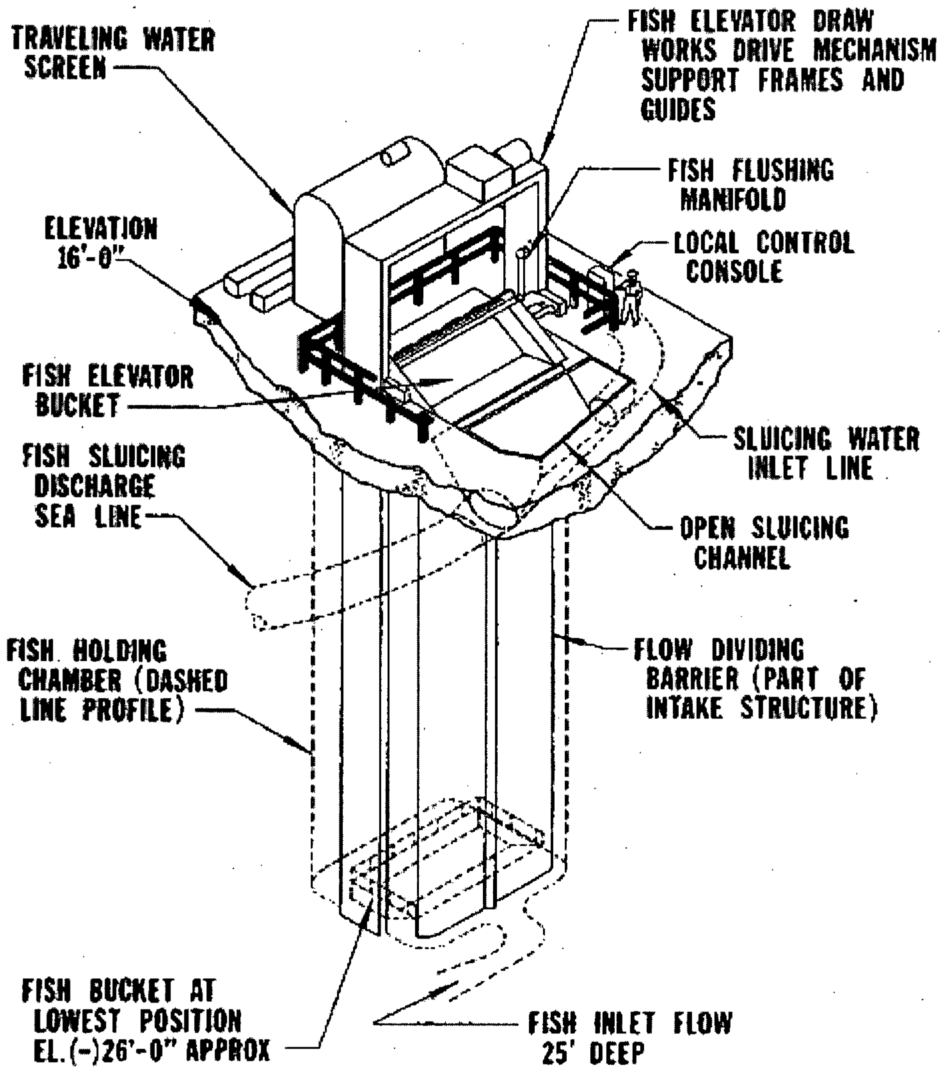

Figure 2 – SONGS Fish Collection Elevator

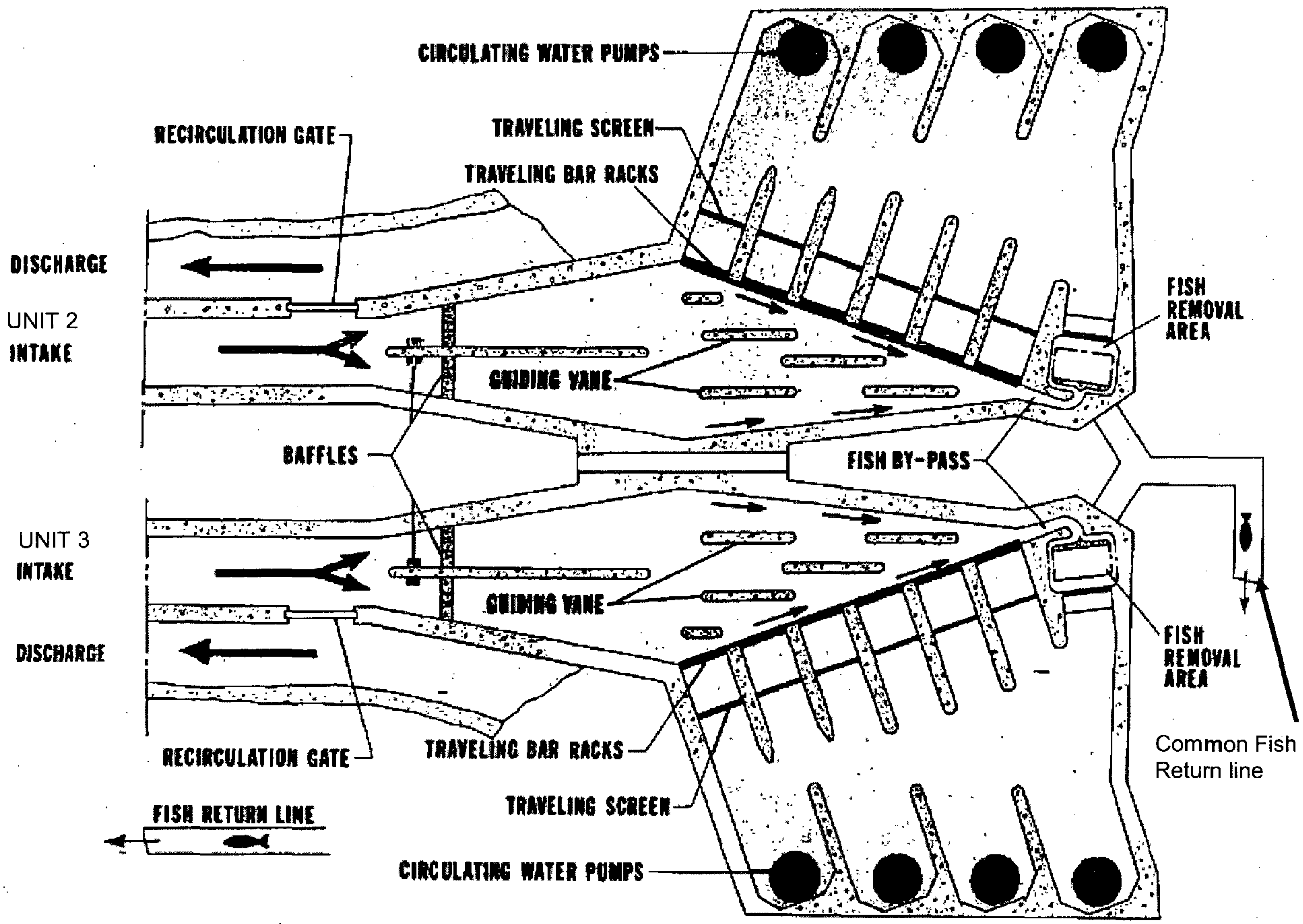

Figure 3 – SONGS Intake Structure - Plan

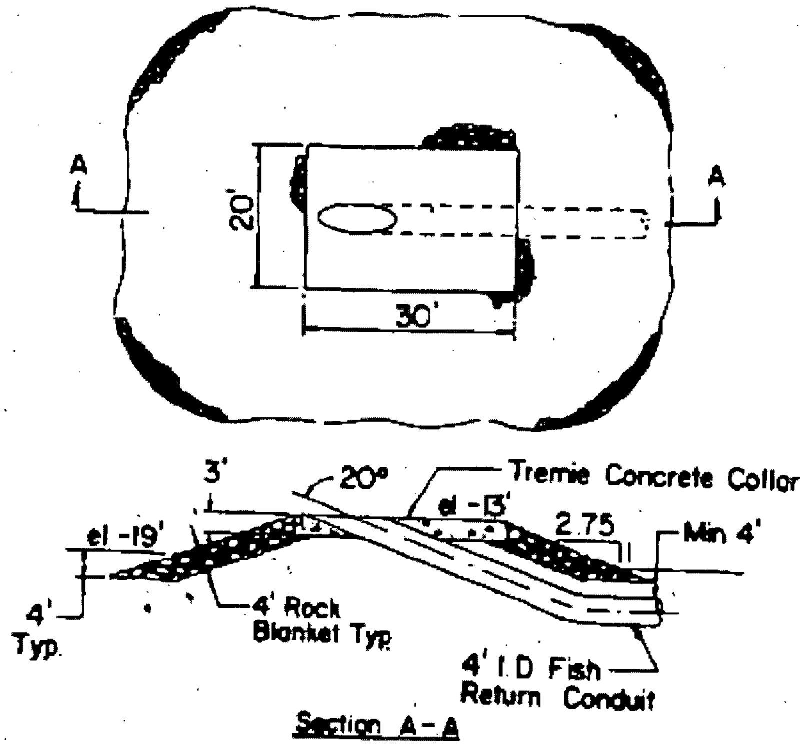

Figure 4 – SONGS Fish Return Pipe Discharge – Plan & Section

2.4 Biological Efficacy of Technology and Operations

SCE believes that the existing operation and configuration of the CWIS meets the IM reduction standard. There are several components to the existing system that reduce the impingement mortality over what would be expected with a shoreline intake: the velocity cap, the offshore location of the intake, and the FRS which includes the guide vanes, TBS, fish elevator, offshore return line, and fish chase procedure.

Based on previous evaluations of velocity caps in southern California, the velocity cap at SONGS is estimated to reduce impingement by 88.2% based on fish numbers. Detailed discussions of previous velocity cap studies are presented in the Impingement Mortality and Entrainment (IM&E) Characterization Study (Attachment 2)

Efficiency studies indicated that about 84% of the fish that enter the intake are diverted by the fish return system (MRC 1990). Survival of the fish into the return sluice was fairly high, ranging from 68–100% for most species.

Southern California Edison (SCE) has conducted several studies to quantify the benefits associated with the louvers and fish return system. Survival of fishes through the FRS was analyzed in 1984-5 (Love et al. 1989 – as cited in MBC 2007). Twice weekly fish elevator and fish impingement samples were collected at Units 2 and 3, resulting in 55 samples at Unit 2 and 65 samples at Unit 3. Fish return survival was evaluated for 96-hour periods after operation of the return system.

Fish return efficiency and survival results are presented in Table 1. Survival was calculated for only those species where 40 or more individuals were sampled. Survival was assessed based on fish size, with small fish (<30 g) averaging 68%, medium-sized fish (30-199 g each) averaging 77%, and large fish (>199 g) near 100% (DeMartini et al. 1989 – as cited in MBC 2007).

The result is that the FRS contributes an additional 6 % to reduction in impingement mortality for an overall station value of 94.2% reduction in impingement mortality at SONGS.

Table 1 - SONGS Unit 2 and 3 Fish Return Diversion Efficiency and Survival (Love et al. 1989)

Taxon	Unit	No. Entrained	No. Returned	Returned (%)	Survival[1] (%)	Total Returned/ Survival[1] (%)
barred sand bass	2	89	86	96.63		
barred sand bass	3	50	47	94.00		
deepbody anchovy	2	889	708	79.64		
deepbody anchovy	3	3,809	1,883	49.44		
kelp bass	2	270	269	99.63		
kelp bass	3	165	161	97.58		
northern anchovy	2	135,688	134,676	99.25	94.3	93.6
northern anchovy	3	210,108	198,157	94.31	97.9	92.3
pacific sardine	2	75	61	81.33		
pacific sardine	3	0	0	-		
queenfish	2	50,566	44,369	87.74	31.6	27.7
queenfish	3	104,394	76,963	73.72	54.1	39.9
sargo	2	211	210	99.53		
sargo	3	284	282	99.30		
slough anchovy	2	3,693	3,058	82.81		
slough anchovy	3	27514	1230	4.47		
white croaker	2	644	601	93.32	49.5	46.2
white croaker	3	52,938	20,390	38.52	25.0	9.6
yellowfin croaker	2	258	258	100.00	100.0	100.0
yellowfin croaker	3	2,026	2,021	99.75	97.0	96.8
All species	2	196,978	188,583	95.74		
All species	3	407,755	306,200	75.09		

3.0 TECHNOLOGY INSTALLATION AND OPERATION PLAN

The technologies for impingement mortality reduction are already installed and operational at SONGS. The Technology Installation and Operations Plan will consist of continued adherence to the existing operation and maintenance program(s).

In addition to following SONGS Preventative Maintenance Program on all CWIS components, the following procedures will be followed:

- The fish elevator is operated at least once per shift depending on the number of fish present.
- The TBR, TWS and fish elevator will be inspected each shift
- Records will be maintained on the daily status sheets.
- Heat treatment and the fish chase are conducted as needed for plant operations.
- In addition, the fish chase procedure will continue to be closely monitored by biologists, operators, and engineers to maximize its efficiency and to minimize stress to the organisms.
- All pump flows will be monitored to ensure that they are operating within the design parameters.
- Daily records of pump operation with flow rates will be maintained.

4.0 VERIFICATION MONITORING PLAN

Field sampling for impingement surveys is proposed to occur biweekly during normal operations and during all heat treatments.

4.1 Normal Operation Impingement

Impingement sampling at SONGS is proposed to be conducted over a 24-hour period one day per week every two weeks. Impingement sampling at SONGS is described in detail in SONGS Environmental Procedure SO123-IX-2.7, Revision 2. A summarized description of the procedure is described below.

Surveys will be performed at SONGS when at least two circulating water pumps are operating at the beginning of each survey (at each unit). Before each sampling effort, the traveling screens will be rotated and washed clean of all impinged debris and organisms. The sluiceways and collection baskets will be cleaned and discarded into dumpsters and hauled away or separated from any subsequent collection basket dumps for the sample period. The operating status of the circulating water pumps will be recorded on an hourly basis during the study. At the end of the 24-hour period the screens will be manually triggered and run for a normal cycle of nineteen minutes. This rinse period will allow the entire screen to be rinsed of all material impinged since the last screen wash cycle. The impinged material will be rinsed from the screens into two sluiceways, one associated with the bars and rakes, the other with the screens, and then flow into the collection baskets associated with each sluiceway. The collection baskets will be dumped and rinsed into a bin for sample processing. On some occasions, the screen wash systems may operate (automatically or manually) prior to the end of each cycle. The material that is rinsed on these occasions will be combined with the material collected at the end of each cycle. All debris and organisms rinsed from each unit will be processed independently.

All fishes and macroinvertebrates collected at the end of each 24-hour cycle will be removed from other impinged debris, identified, enumerated, and weighed. Each individual will be identified to the most specific taxon possible. Depending on the number of individuals of a given species present in the sample, one of two specific procedures may be used, as described below. Each of these procedures involves the following measurements and observations:

- The appropriate linear measurement for individual fish and lobster will be determined and recorded. These measurements will be recorded to the nearest 1 mm (0.04 in). The following standard linear measurements will be used for the animal groups indicated:
    - Fishes - Total body length (TL) for sharks and rays and standard lengths (SL) for bony fishes.
    - Lobsters - Carapace length (CL), measured from the anterior margin of carapace between the eyes to the posterior margin of the carapace. No other shellfish will be measured.

- The sex of individuals from predetermined species (Attachment 5, SONGS Environmental Procedure SO123-IX-2.7 Rev.2) will be identified to female, male, or unknown (undeveloped or unidentifiable reproductive structures) using methods described below:
    - Fishes – Determination of sex will be based on whether fishes had external or internal morphology allowing such determinations:
        - All species with external reproductive features will be determined based on the identifiable characteristics of external genitalia.
        - Species to be sexed with no externally distinguishable features will be dissected along the abdomen to expose the gonads, and identified based on color, shape, and consistency of their reproductive organs.
    - Macroinvertebrates – The sex of California spiny lobster will be determined by examination of the last pair of walking legs and pleopod development.
        - The wet body weight of all individuals combined will be determined, shaking any loose water or debris from the individuals. All weights will be recorded to the nearest 1 g (0.035 ounce).
        - Shellfishes and other macroinvertebrates will be identified to species and their presence and combined abundance and weight recorded.
        - The amount and type of debris (e.g., *Mytilus* shell fragments, algae, etc.) and any unusual operating conditions in the screenwell system will be noted by writing specific comments in the "Notes" section of the data sheet. Information on weather, temperature, swell height, and water clarity will also recorded during each collection.

The following specific procedures may be used for processing fishes and shellfishes when the number of individuals per species in the sample or subsample is less than 125:

- For each individual of a given species, the linear measurement will be determined and recorded.

The following specific subsampling procedures will be used for fishes and shellfishes when the number of individuals per species is greater than 125:

- The linear measurement for a subsample of 125 individuals will be recorded individually on the data sheet. The individuals selected for measurement are selected after spreading out all of the individuals in a sorting container, making sure that they are well mixed and not segregated into size groups. Individuals with missing heads or other major body parts will not be measured.
- For required species, the sex of up to 50 individuals from the subsample will be recorded.
- The total number and total weight of all the remaining individuals combined will be determined and recorded separately.

4.2 Fish Chase/Heat Treatment Impingement

Heat treatments are a commonly used method to control growth of marine fouling organisms within a CWIS at coastal generating stations. A byproduct of the procedure is an increase in water temperature that affects all of the organisms inside the screenwells, resulting in increased impingement. To limit fatal impingement of fish and shellfish, a "fish chase" protocol was integrated into SONGS heat treatment procedures. The fish chase process involves slowly increasing the screenwell temperature to a sub-lethal temperature. Fish agitated by the temperature rise move into the fish removal area where they are removed using the fish return system (FRS). When most of the fish that can be removed are taken out by the fish chase procedure, the screenwell is allowed to cool down to ambient ocean temperature for thirty minutes. This allows heated water to be flushed from the discharge conduit, prior to initiation of the heat treatment. As the heat treatment tunnel reversal begins, several additional lifts of the fish elevator are conducted, the result being most of the fish removed from the system and less fish fatally impinged during the heat treatment. In order to account for the fish and invertebrates impinged during the study period, any fish or invertebrates impinged during the fish chase/heat treatment will be processed using normal operations impingement procedures described above.

4.3 Data Analysis

Daily cooling water flow from each unit will be obtained from SCE, based on the log for each circulator pump. Impingement rates will be calculated using the circulating water flow during each of the 24-hr surveys. The total time for each cycle will be multiplied by the known flow rate of each of the circulating water pumps in operation during each survey.

4.4 Impingement Estimates

The estimated daily impingement rate will be used to calculate biweekly and annual impingement. The study period will be separated into uniform 14-day intervals, with part of each week prior to and following the impingement collection survey dates assigned to biweekly survey periods. Impingement estimates will be calculated by using the flow that occurred during the sampling interval and extrapolating by the flow during the analysis period. The total calculated flow for each survey analysis period will be multiplied by the taxon-specific impingement rates for both abundance and biomass. The estimated impingement rate for each survey period will be summed to determine the annual normal operation impingement estimates for each taxon. These will be added to impingement totals from heat treatment procedures to estimate total annual impingement.

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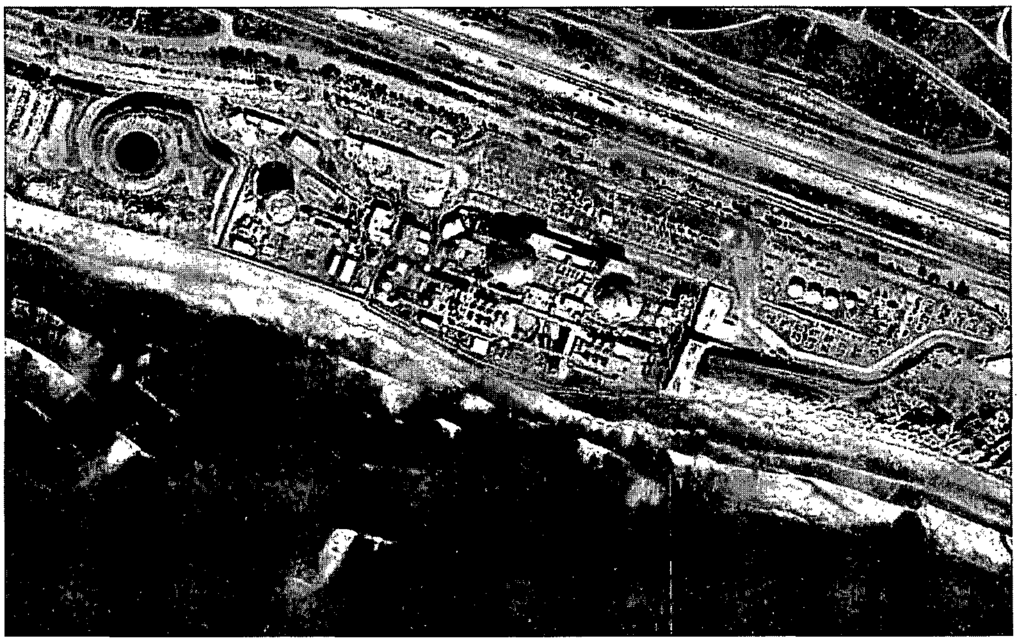
A4 ATTACHMENT

Site-specific Determination of BTA

ALDEN

Solving flow problems since 1894

ATTACHMENT 4
COMPREHENSIVE COST EVALUATION
SAN ONOFRE NUCLEAR GENERATING STATION



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Appendices

1.0 INTRODUCTION

SONGS is located on the Pacific Ocean and is required to meet both the IM&E performance standards. SCE believes the existing technology installed at SONGS is the Best Technology Available (BTA) for meeting the impingement mortality reduction performance standards. Based on a detailed assessment of entrainment reduction technologies and operational changes, no cost-effective alternative is available for SONGS. This Comprehensive Cost Evaluation is provided in support of SCE's request for a Site-specific Determination for entrainment reduction under Compliance Alternative 5.

This report addresses costs and biological efficacy associated with implementing any new technology or operational changes to meet the Rule compared to EPA's estimated cost (cost-cost test); provides the Site-specific Technology Plan; and, the Verification Monitoring Plan.

2.0 ASSESSMENT OF ALTERNATIVES

In 2005, Alden Research Laboratory, Inc. (Alden) provided an appraisal-level assessment of alternative technologies and operational measures that were likely to meet the performance standards, their estimated effectiveness, and the monetary impact associated with both implementation and operation at SONGS (Alden 2005) (Appendix A).

The technologies selected in 2005 are summarized below and have been updated to reflect current IM&E data, the current state-of-knowledge, and present-day costs. Subsequent to the 2005 assessment, additional considerations were requested. These included reconsideration of an extension of the cooling water intake to deeper water and use of flow reduction to reduce cooling water withdrawal. These options are discussed in detail below.

The options considered to reduce entrainment are:

- Offshore narrow-slot (0.5 mm) cylindrical wedgewire screens
- Aquatic Filter Barrier (AFB)
- Fine-mesh (0.5 mm) modified traveling screens
- Relocation of the intake further offshore
- Reduced circulating pump flow using variable frequency drives
- Closed-cycle cooling

Estimates of biological efficacy have been assigned to each technology or operational option based on the species and lifestages of the organisms entrained at SONGS (Table 1).

These estimates are designed to provide the basis for determining the benefits associated with each option. When determining benefits, the effects of entrainment reducing technologies on impingeable-size organisms have also been determined. A detailed discussion of the methodology used to determine exclusion and survival of aquatic organisms is included in Appendix B.

2.1 Fine-mesh (0.5 mm) Modified Traveling Screens

Fine-mesh screens at SONGS would decrease the entrainment of larval fish through the circulating water system (CWS). The effectiveness of a fine-mesh screening system is measured in two ways: exclusion/retention and survival. However, the number is dependent upon the size of the organisms exposed to the system and the mesh size considered.

Fine-mesh screens are often designed to meet a 0.5 ft/sec approach velocity. To meet a 0.5 ft/sec screen approach velocity, 32 screens would be needed and a new, larger intake would have to be built. However, expanding the intake to meet a 0.5 ft/sec velocity is a costly option and SONGS should first conduct a pilot study to determine if replacing the existing screens with fine-mesh screens without intake expansion would provide acceptable survival. Fish and debris removed from the screens would have to be transported back to the ocean. This would be accomplished by combining the new troughs into the existing return pipe for release offshore.

Replacing the existing screens with fine-mesh Ristroph screens would cost $11,089,000 and could be completed during a scheduled outage. Construction of a new expanded screenhouse for the 32 new screens is estimated to exceed $60,000,000 and would require the plant to be shut-down for a minimum of 1 year to connect the new structure. Due to space limitations on site, a new intake would need to be built into the ocean. Detailed costs for replacing the existing screens are provided in the following section.

The finer mesh of the fine-mesh screens may result in an increased rate of biofouling of the screen mesh. This increase should not be an issue if SONGS utilizes continuous screen rotation and high and low-pressure screen spraywashes.

Conclusion

Fine-mesh traveling screens are technically an "exclusion technology". However, unlike narrow-slot wedgewire screens that depend on an air-burst cleaning system coupled with ambient currents to "carry" impinged fish and debris away from the CWIS, this technology uses a "collection/transfer" concept. As discussed in Appendix B, organisms previously entrained will now be impinged. Although the system is designed to minimize stress to aquatic organisms, the process of collection and transfer will impart a stress to the organism that would not be experienced if they were not impinged. This is especially true for the earliest lifestages (e.g. yolk-sac larvae). Generally, as fish grow survival will increase. For those fish that do come in contact with the screen, collecting them on a fine-mesh screen and returning them to the ocean rather than allowing them to be entrained should result in some reduction in losses.

Expanding the intake is not considered feasible based on preliminary engineering. A large screen structure would need to be built on the shoreline extending out into the ocean requiring the plant to be shut down for at least 1 year. Due to the impacts to the shoreline, loss of aquatic habitat, and cost associated with replacement power, expanding the intake should only be evaluated further if the results from the pilot study indicate it is worthwhile.

2.2 Aquatic Filter Barrier (AFB, a.k.a. Marine Life Exclusion System (MLES) or

Gunderboom)

An AFB has the potential to exclude all fish from the intake flow if the system could be designed to withstand the hydraulic forces and debris loading conditions that exist at SONGS. This option was dismissed in the 2005 assessment because of the large area and support structure required. In addition, it was expected that there would be difficulty in maintaining the barrier and the size of the structure would have significant visual impacts. An AFB has not been successfully deployed in a marine environment and is considered an experimental technology for open ocean conditions. To be thorough, Alden has re-evaluated this option with a new design.

The water depth in the area of the intakes is 30 ft. At this depth, 2,820 ft of AFB material would be required to maintain a design flow rate of 10 gpm/ft^2 which provides a through-fabric velocity of about 0.02 ft/sec. An AFB would be deployed in the shape of a square with 725 ft on each side and would surround both intakes. Substantial intermediate support structures would be required to hold the AFB fabric in place. The installation would also require a storm-proof shelter to house the air burst system required to dislodge impinged debris from the fabric. An AFB installation of this size would encompass 12 acres of ocean bottom habitat.

If the AFB could be successfully deployed, it would also require substantial operation and maintenance efforts to maintain in a clean condition. An AFB has two layers of material, with an air purge system installed between the layers to permit automatic cleaning of accumulated silt and debris. Approximately, 3 to 4 diving crews may be required year-round to maintain, repair, replace, and clean the AFB fabric and components.

Conclusion

An AFB could prevent the entrainment of early life stages of fish if the system could be maintained in a marine environment. The cleaning system can also free impinged fish larvae and other non-motile life stages. This technology has a very low through-material velocity and therefore an extremely large surface area is required and would enclose a very large area of the bottom. The size of the enclosure would also affect navigation near the intake. Securing and maintaining an AFB deployment in the open ocean will be extremely difficult, if even possible. An AFB deployment would have a very high installation, operation and maintenance cost. Due to the level of uncertainty in this option, Alden does not believe that an AFB would be a viable option for SONGS and it has been dropped from further consideration.

2.3 Narrow-slot (0.5 mm) Cylindrical Wedgewire Screens

In the original assessment, Alden estimated that 49 high-flow, stainless steel T-84 (7 ft. diameter) screens with a 0.5 mm slot opening would be required to screen the total facility flow. Alden has re-evaluated this option with a new design and a detailed discussion is provided in the following section.

The new design uses 68, T-120 (10 ft. diameter) screens with 0.5 mm slot openings. One additional screen per intake is added to allow one screen to be out of service for cleaning without increasing the velocity over manufacturer's design velocity (0.5 ft/sec through-slot). To reduce the effects of bio-fouling a 70-30 copper-nickel alloy would be used. These screens have a lower flow capability therefore requiring an increase in the number of screens from the previous assessment. The screens would be mounted to six, 14-ft diameter intake pipes located beneath a large offshore work platform. The platform would provide: housing for compressors for the air backwash system; a mechanical cleaning system; and, a work deck from which to remove and maintain the screens. Each of the intakes includes an emergency bypass to allow uninterrupted water flow to SONGS during extreme fouling events. These gates will also allow continued use of the existing heat treatments to prevent biofouling in the intake pipes. A plan is shown on Figure 1.

Since there are no biological efficacy data with wedgewire screens for the species entrained at SONGS, head capsule depth data, as discussed in detail in Appendix B, can be used to estimate the physical exclusion that could be achieved. Several species entrained at SONGS are relatively small; therefore, the estimated exclusion is low for some species.

Observations of fish eggs and larvae in the laboratory indicate that those organisms that are not entrained are carried away by the ambient currents and do not typically impinge. Therefore, these screens are not "handling" the organisms in the same way that fine-mesh traveling screens do and thus there is no post-impingement survival component to estimating the efficacy. Additionally, hydraulic conditions near the wedgewire screens may stimulate rheotactic responses in the larvae, causing them to swim away from the screens.

Conclusion

The installation of narrow-slot wedgewire screens is feasible from an engineering stand point; however, it would require extensive civil structure, disturbance to the sea bottom in the area of the CWIS, and down-time for construction. In addition, there is considerably more operation and maintenance cost associated with them compared to the existing O&M. Narrow-slot wedgewire screens should be effective at excluding some lifestages of ichthyoplankton at SONGS. The ultimate efficacy is dictated by species-specific lifestages and abundance of those lifestages in the entrained population. In all likelihood, the screens would not meet the entrainment reduction standards.

2.4 Relocation of the Intake

The Marine Review Committee (MRC) conducted several evaluations on the impacts of moving the cooling water intakes. Moving the intakes an additional 3,000 ft offshore to a depth of 60 ft would disrupt 192,000 ft^2 of habitat. Moving the intakes would have an effect on the composition of species entrained. MRC (1989) estimated that moving the intake would reduce the entrainment of forage fish, but an increase the entrainment of sport and commercial species.

Moving the intakes to a different location along the coast revealed no consistent differences in species composition and total abundances were not significantly different between the sites evaluated. MRC concluded that moving the intakes would not reduce entrainment of fish at SONGS.

Conclusion

Moving the intakes at SONGS would disturb a significant area of habitat for the excavation and installation of new intake pipes. Species composition would be changed by moving the intakes offshore; however, species of greater economic value (sport and commercial species) would be adversely impacted. Moving the intakes up or down the coast would have no positive effect due to similar species and density composition. Therefore, relocating the intake will not be evaluated further.

2.5 Reduced Circulating Pump Flow Using Variable Frequency Drives

Flow reduction would reduce the number of organisms entrained by reducing the volume of water through the plant. The potential use of this option is contingent upon the diel and seasonal densities of entrainable lifestages, which would dictate when operation of cooling water pumps could be effective in entrainment reduction. The results of the seasonal variations for entrained organisms from previous studies demonstrate an increase in entrainment numbers from February through May. There was no clear diel pattern of entrainment with fish eggs, but larvae were generally entrained in higher numbers at night (MBC 2007).

The pumps would need to be retrofitted with new motors and variable frequency drives (VFD). The VFD's would allow much finer control of flow reductions while ensuring adequate flow to meet the heat rate and generation needs. Earlier evaluations indicated that it may be possible to reduced flow by 33% and would maintain the thermal standard of <4° F at 100 ft from the diffusers except during the warmer summer months. Currently, during the summer, SONGS reduces generation to meet the thermal requirements of their discharge which is also the period of highest entrainment. However, SONGS is a base-loaded facility. Reducing the plant output during high demand periods incurs a significant cost in lost generation. In addition, replacement power provided from other sources, including fossil-fuel generating stations, is less desirable due to emission issues. However, a waiver would be required for a temperature increase across the condenser. The complexities of the nuclear-fueled steam generating system and the inherent safety precautions that govern its operation will generally prevent the plant from increasing its thermal load.

Operation of the plant at 67% capacity for February though May and full-flow the remainder of the year is estimated to reduce larval fish losses by 26%.

Conclusion

Flow reduction could be used to reduce entrainment at SONGS. In addition to significant power replacement cost, air pollution concerns associated with getting the replacement power from fossil fuel plants raises air quality issues. Flow reduction would increase the discharge temperature and generation would need to be reduced. General trends in load demand must be clearly understood to predict periods where running at reduced loads would not affect reliability of the plant. Currently during periods of high demand and high water temperatures SONGS already needs to reduce its generation to maintain thermal discharge limits. Due to the issues discussed above and uncertainties in the ability to achieve even minimal entrainment reductions, flow reduction at SONGS is not considered for further evaluation.

2.6 Closed-cycle Cooling

Retrofitting SONGS with closed-cycle cooling would automatically meet the performance standards of the Federal Rule and comply with the NPDES permit. This option has been investigated for SONGS as part of a study to determine the costs of retrofitting all of California's once-through cooling facilities with closed-cycle cooling. That report has been submitted to the State Water Resources Control Board and the cost estimate for SONGS from that document is provided in Appendix C. In addition to providing cost estimates this study took a qualitative look at adverse environmental and social impacts associated with closed-cycle cooling. Appendix C provides site-specific retrofit costs for SONGS. These issues would include:

- Human health impacts from fine-particulate emissions
- Salt drift effects on nearby residences and nearby salt marshes being restored
- Fogging
- Noise
- Visual impacts to community and nearby parks

The cost estimates for wet cooling provided in the next section are based on the costs for a difficult installation in the Appendix C. The discussion in Appendix C does not include an estimate of the O&M costs associated with operating the cooling towers, therefore Alden assumed the O&M cost was 3% of the construction cost. This assumption is based on the costing methodology provided in an earlier EPRI cooling tower report (EPRI 2002)

Conclusion

Closed-cycle cooling could be used to meet both the impingement mortality and entrainment reduction performance standards at SONGS. However, as discussed in the next Section this option has the highest cost and the most significant adverse environmental and social impacts to the local area. These issues would have to be addressed in order to obtain the necessary permits for implementation of this option.

2.7 Estimated Costs

Based on the screening of intake technologies, three alternatives for entrainment reduction were selected for consideration at SONGS:

Alternative 1– Fine-mesh (0.5 mm) modified traveling screens

Alternative 2– Narrow-slot (0.5 mm) cylindrical wedgewire screens

Alternative 3– Closed-cycle cooling

Alden prepared detailed conceptual designs for each of these alternatives as a basis for evaluation and cost estimates. Estimated construction costs and operating and maintenance costs, including replacement power, are presented below.

The costs were estimated using quantities developed from the conceptual design for each of the alternatives and cost data from other projects that were adjusted for identifiable differences in project sizes and operations. These costs allow a valid comparison of the cost difference among alternatives.

The estimated costs are based on the following:

- Present-day prices and fully contracted labor rates as of September 2007.
- Forty-hour work-week with single-shift operation for construction activities that do not impact plant operations and fifty-hour workweek with double-shift operation for construction activities that impact plant operations.
- Direct costs for material and labor required for construction of all project features. The direct costs also include distributable costs for site non-manual supervision, temporary facilities, equipment rental, and support services incurred during construction. These costs have been taken as 85% of the labor portion of the direct costs for each alternative.
- Indirect costs for labor and related expenses for engineering services to prepare drawings, specifications, and design documents. The indirect costs have been taken as 10% of the direct costs for each alternative.
- Allowance for indeterminates to cover uncertainties in design and construction at this preliminary stage of study. An allowance for indeterminates is a judgment factor that is added to estimated figures to complete the final cost estimate, while still allowing for other uncertainties in the data used in developing these estimates. The allowance for indeterminates has been taken as 10% of the direct, distributable, and indirect costs of each alternative.
- Contingency factor to account for possible additional costs that might develop but cannot be predetermined (e.g., labor difficulties, delivery delays, weather). The contingency factor has been taken as 15% of the direct, distributable, indirect, and allowance for indeterminate costs of each concept.

The project costs do not include the following items that should be included to obtain total capital cost estimates:

- Costs to perform additional laboratory or field studies that may be required, such as hydraulic model studies, biological evaluations of prototype fish protection systems, soil sampling, and wetlands delineation and mitigation.
- Costs to dispose of any hazardous or non-hazardous materials that may be encountered during excavation and dredging activities.
- SCE costs for administration of project contracts and for engineering and construction management.
- Price escalation
- Permitting costs
- Replacement power costs

The estimated project costs for the selected options are presented in Table 2 through Table 4. Capital costs, including lost generation during construction, range from $11,090,000 for replacing screens with fine-mesh screens to $676,384,000 for closed-cycle cooling. The annualized costs associated with each of the technologies are presented in Table 5. To annualize the costs, several assumptions were made:

- The capital costs were annualized over 10 years.
- A 7% discount rate was used.
- The cost per MWh is $50.00.

Alden included an estimate of existing annual O&M costs to allow incremental costs to be calculated. The exiting O&M costs were estimated using the same assumptions as used in calculating the O&M costs for the selected technologies. Incremental costs provide a better estimate of the additional cost that each technology will cost the facility.

3.0 COST-COST TEST

Detailed engineering cost estimates of the technologies that would reduce entrainment and do not have any major engineering uncertainties were presented in the previous section. Costs were then compared to the cost USEPA selected for the facility to determine if the site-specific costs are "significantly greater than" USEPA's costs. It is important to note that USEPA has not defined "significantly greater than," so it is not possible at this time to determine conclusively if a facility will satisfy the requirements of the Cost-Cost test.

The costs that USEPA assigned to SONGS for the purpose of estimating the national costs for implementing the Rule are $0. This indicates that the USEPA believes that SONGS is already in compliance with the Federal Rule.

This evaluation provides conceptual designs and a site-specific assessment of relative costs and biological efficacy for each option. However, due to nuclear safety issues, additional study would be recommended to fully evaluate the engineering considerations and potential biological effectiveness of each option prior to full-scale installation at SONGS.

Fine-mesh traveling water screens with fish removal features could be used to reduce impingement mortality and entrainment. Replacement of the existing screens would cost about $11 million. This option is significantly less because it has been assumed that the screen replacement can be completed during a scheduled outage. An expanded intake with through-screen velocity under 0.5 ft/sec is estimated to cost in excess of $60 million and require the plant to be shut down for at least 1 year.

Wedgewire screens with a 0.5 mm slot width would reduce entrainment and the low through-slot velocity would eliminate impingement. This option would cost about $59 million and require SONGS to be shut down for about 6 months during construction.

Closed-cycle cooling would greatly reduce the flow through the plant with a corresponding reduction of organisms entrained. Area constraints, condenser ability to handle the resultant increased pressures, permitting, and reduction in the available output are significant issues that still need to be addressed. The estimated cost would be about $676 million. No construction-related shutdowns were assumed with this option as the plant would only need to be taken offline during the final tie-in. In actuality, SONGS may need to be shut down during the construction of the cooling towers, however there is no information available to estimate the amount of time required.

A summary of capital costs for the alternatives evaluated including estimates for replacement power during construction when applicable are provided in Table 5.

The costs associated with each alternative are "significantly greater than" the USEPA cost and do not pass the cost-cost test. Therefore, the existing CWIS at SONGS is BTA for entrainment reduction.

4.0 SITE-SPECIFIC TECHNOLOGY PLAN

4.1 Intake Technology Description

The existing intakes at SONGS for Units 2 and 3 are identical in design. They are located 3150 ft offshore, 650 ft apart at a bottom depth of 30.0 ft. Each intake has a velocity cap installed. The caps are supported 7 ft above the intake riser by columns. The tops of the caps are 12.0 ft below mean lower low water (MLLW). The caps are 49 ft in diameter with 7 ft openings. The velocity at the entrance is 1.7 ft/sec which is significantly higher than the surrounding ambient currents which range from 0.1 to 0.7 ft/sec.

The circulating water flow of 1848.5 cfs per unit is conveyed to the onshore intake structures through 18 ft diameter concrete pipes at a velocity of 7.3 ft/sec. The onshore intake system incorporates fish protection measures described below.

There are traveling bar racks (TBR) angled at about 20° to the incoming flow. The bars are 0.25 in. wide with 1 in. clear spacing. The TBR acts as a louver system to guide fish to a fish collection area. Downstream of the TBR are 14 traveling water screens (TWS) 7 per unit. The screens have 3/8 in. square mesh. The approach velocity at the screens is 1.3 ft/sec with an estimated through-screen velocity of 3.0 ft/sec. The TBR and TWS operate whenever the differential pressure system indicates cleaning is needed.

The fish collection area (downstream of the TBR) is a 16 ft by 14 ft concrete basin which includes a watertight bucket elevator. A traveling water screen isolates the basin from the circulating water pumps. The elevator is manually operated and is raised at least once per shift. At deck level, the bucket is tipped into a water-filled sluice. The basket is then lowered, and the process repeated until the majority of fish in the collection area are removed. The Unit 2 and 3 onshore intake structures are the same. The structures are symmetrical about the center line. Additional water is added to the fish sluice which discharges into a common 4 ft diameter conduit. Fish are transported within the conduit and discharged 1900 ft offshore in 19.5 ft of water. The system is normally operated at least twice daily by operators. These components comprise the "fish return system" (FRS).

4.2 Operational Procedures

Heat treatment is used to control biofouling. The heat treatment raises the water temperature to 105° F to control biofouling in the intake structure and condenser. This treatment is conducted on an as-needed basis based upon a biofouling model developed for SONGS.

Fish can accumulate in the cooling water system, residing in habitat provided by gate slots, guide vanes and other structures within the system. Consequently, this heat treatment process includes a "Fish Chase" procedure to minimize mortality. The temperature and eddy currents are manipulated by operating crossover gates in the screen well. Heated discharge water is slowly added to the screen well. The elevated water temperature and changing eddy currents in the screen well agitate the fish enough for them to seek new habitat. This procedure chases the fish to the elevator for collection and release.

This procedure is closely monitored by biologists, operators, and engineers to maximize process efficiency and to minimize stress to the organisms.

4.3 Operation and Maintenance

The fish elevator is operated at least once per shift depending on the number of fish present. The traveling bar racks, traveling water screens and fish elevator are also inspected each shift. Heat treatment and the fish chase are conducted as needed for plant operations. All operations are recorded on daily status sheets. All equipment is serviced and maintained based on the SONGS Preventative Maintenance Program.

5.0 VERIFICATION MONITORING PLAN

Field sampling for impingement surveys is proposed to occur biweekly during normal operations and during all heat treatments.

5.1 Normal Operation Impingement

Impingement sampling at SONGS is proposed to be conducted over a 24-hour period one day per week every two weeks. Impingement sampling at SONGS is described in detail in SONG Environmental Procedure SO123-IX-2.7, Revision 2. A summarized description of the procedure is described below.

Surveys will be performed at SONGS when at least two circulating water pumps are operating at the beginning of each survey (at each unit). Before each sampling effort, the traveling screens will be rotated and washed clean of all impinged debris and organisms. The sluiceways and collection baskets will be cleaned and discarded into dumpsters and hauled away or separated from any subsequent collection basket dumps for the sample period. The operating status of the circulating water pumps will be recorded on an hourly basis during the study. At the end of the 24-hour period the screens will be manually triggered and run for a normal cycle of nineteen minutes. This rinse period will allow the entire screen to be rinsed of all material impinged since the last screen wash cycle. The impinged material will be rinsed from the screens into two sluiceways, one associated with the bars and rakes, the other with the screens, and then flow into the collection baskets associated with each sluiceway. The collection baskets will be dumped and rinsed into a bin for sample processing. On some occasions, the screen wash systems may operate (automatically or manually) prior to the end of each cycle. The material that is rinsed on these occasions will be combined with the material collected at the end of each cycle. All debris and organisms rinsed from each unit will be processed independently.

All fishes and macroinvertebrates collected at the end of each 24-hour cycle will be removed from other impinged debris, identified, enumerated, and weighed. Each individual will be identified to the most specific taxon possible. Depending on the number of individuals of a given species present in the sample, one of two specific procedures may be used, as described below. Each of these procedures involves the following measurements and observations:

- The appropriate linear measurement for individual fish and lobster will be determined and recorded. These measurements will be recorded to the nearest 1 mm (0.04 in). The following standard linear measurements will be used for the animal groups indicated:
    - Fishes - Total body length (TL) for sharks and rays and standard lengths (SL) for bony fishes.
    - Lobsters - Carapace length (CL), measured from the anterior margin of carapace between the eyes to the posterior margin of the carapace. No other shellfish will be measured.
- The sex of individuals from predetermined species (Attachment 5, SONGS Environmental Procedure SO123-IX-2.7 Rev.2) will be identified to female, male, or unknown (undeveloped or unidentifiable reproductive structures) using methods described below:
    - Fishes – Determination of sex will be based on whether fishes had external or internal morphology allowing such determinations:
        - All species with external reproductive features will be determined based on the identifiable characteristics of external genitalia.
        - Species to be sexed with no externally distinguishable features will be dissected along the abdomen to expose the gonads, and identified based on color, shape, and consistency of their reproductive organs.
    - Macroinvertebrates – The sex of California spiny lobster will be determined by examination of the last pair of walking legs and pleopod development.
- The wet body weight of all individuals combined will be determined, shaking any loose water or debris from the individuals. All weights will be recorded to the nearest 1 g (0.035 ounce).
- Shellfishes and other macroinvertebrates will be identified to species and their presence and combined abundance and weight recorded.

- The amount and type of debris (e.g., *Mytilus* shell fragments, algae, etc.) and any unusual operating conditions in the screenwell system will be noted by writing specific comments in the "Notes" section of the data sheet. Information on weather, temperature, swell height, and water clarity will also recorded during each collection.

The following specific procedures may be used for processing fishes and shellfishes when the number of individuals per species in the sample or subsample is less than 125:

- For each individual of a given species, the linear measurement will be determined and recorded.

The following specific subsampling procedures will be used for fishes and shellfishes when the number of individuals per species is greater than 125:

- The linear measurement for a subsample of 125 individuals will be recorded individually on the data sheet. The individuals selected for measurement are selected after spreading out all of the individuals in a sorting container, making sure that they are well mixed and not segregated into size groups. Individuals with missing heads or other major body parts will not be measured.
- For required species, the sex of up to 50 individuals from the subsample will be recorded.
- The total number and total weight of all the remaining individuals combined will be determined and recorded separately.

5.2 Fish Chase/Heat Treatment Impingement

Heat treatments are a commonly used method to control growth of marine fouling organisms within a CWIS at coastal generating stations. A byproduct of the procedure is an increase in water temperature that affects all of the organisms inside the screenwells, resulting in increased impingement. To limit fatal impingement of fish and shellfish, a "fish chase" protocol was integrated into SONGS heat treatment procedures. The fish chase process involves slowly increasing the screenwell temperature to a sub-lethal temperature. Fish agitated by the temperature rise move into the fish removal area where they are removed using the fish return system (FRS). When most of the fish that can be removed are taken out by the fish chase procedure, the screenwell is allowed to cool down to ambient ocean temperature for thirty minutes. This allows heated water to be flushed from the discharge conduit, prior to initiation of the heat treatment. As the heat treatment tunnel reversal begins, several additional lifts of the fish elevator are conducted, the result being most of the fish removed from the system and less fish fatally impinged during the heat treatment. In order to account for the fish and invertebrates impinged during the study period, any fish or invertebrates impinged during the fish chase/heat treatment will be processed using normal operations impingement procedures described above.

5.3 Data Analysis

Daily cooling water flow from each unit will be obtained from SCE, based on the log for each circulator pump. Impingement rates will be calculated using the circulating water flow during each of the 24-hr surveys. The total time for each cycle will be multiplied by the known flow rate of each of the circulating water pumps in operation during each survey.

5.4 Impingement Estimates

The estimated daily impingement rate will be used to calculate biweekly and annual impingement. The study period will be separated into uniform 14-day intervals, with part of each week prior to and following the impingement collection survey dates assigned to biweekly survey periods. Impingement estimates will be calculated by using the flow that occurred during the sampling interval and extrapolating by the flow during the analysis period. The total calculated flow for each survey analysis period will be multiplied by the taxon-specific impingement rates for both abundance and biomass. The estimated impingement rate for each survey period will be summed to determine the annual normal operation impingement estimates for each taxon. These will be added to impingement totals from heat treatment procedures to estimate total annual impingement.

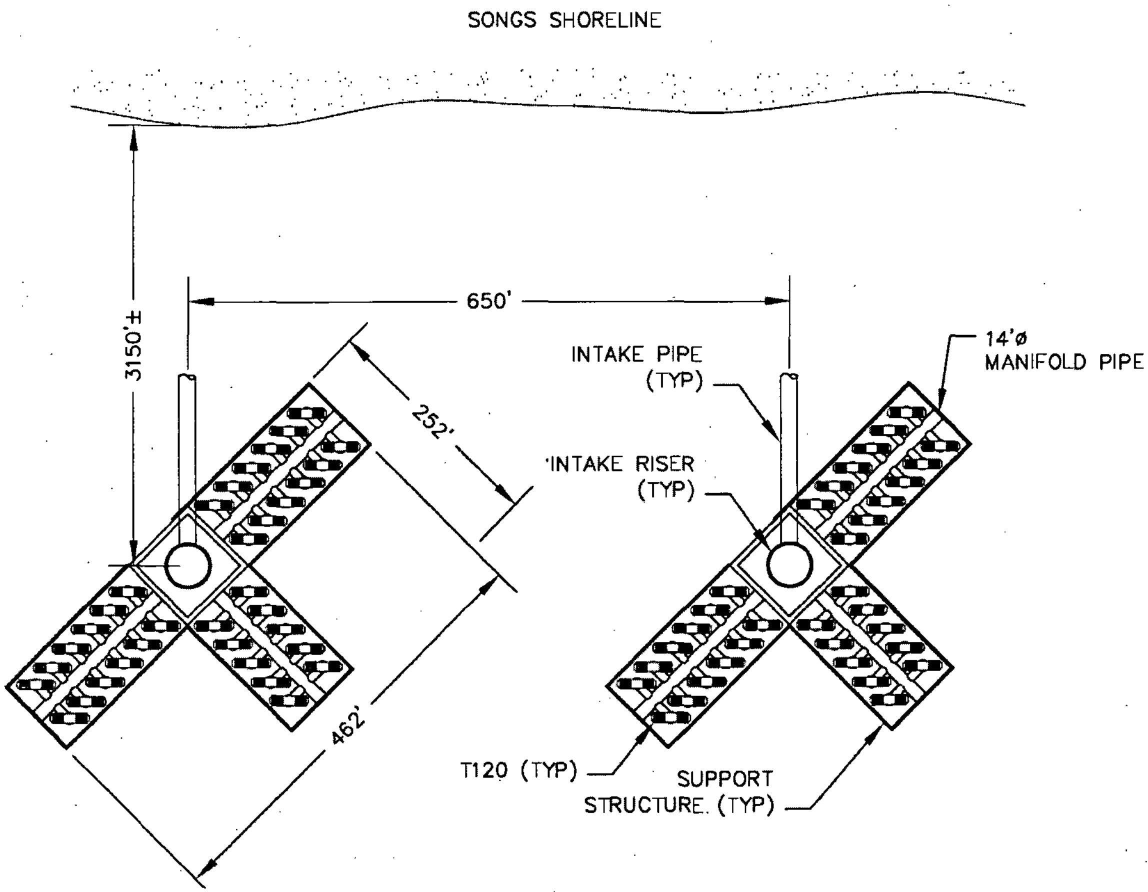

Figure 1 Narrow-slot Wedgewire – Plan

Table 1 Estimated Maximum Reduction in Larval Entrainment with the Technological and Operational Alternatives Being Considered for Application at SONGS.

	Fine-mesh screens			Narrow-slot Wedgewire	Variable Frequency Drives	Closed-cycle Cooling
Species	**Retention[1]**	**Survival[2]**	**Percent Reduction in Entrainment**	**Percent Reduction in Entrainment[1]**	**Percent Reduction in Entrainment**	**Percent Reduction in Entrainment**
northern anchovy	81.3	12.2	9.9	81.3	26.0	95.0
queenfish	89.8	18.6	16.7	89.8	26.0	95.0
white croaker	60.7	18.0	10.9	60.7	26.0	95.0
Paralabrax spp.	0.0	95.5	0.0	0.0	26.0	95.0
Gibbonsia spp.	81.7	95.5	78.0	81.7	26.0	95.0
Hypsoblennius spp.	21.8	95.5	20.8	21.8	26.0	95.0
gobies	64.1	0.0	0.0	64.1	26.0	95.0
California grunion	78.4	59.0	46.3	78.4	26.0	95.0

1 Size distributions of *Hypsoblennius* spp. and gobies is unknown at SONGS; used size distribution from another west-coast power plant. Size distribution of California grunion is unknown; used the highest retention value to be conservative.

2 Survival unknown for *Paralabrax* spp. and *Hypsoblennius* spp.; to be conservative used highest value (0.955)

Table 2 – Replace Existing Screens with Fine-mesh Modified Traveling Screens

Item	Estimated Cost ($ x 10³)
Direct Costs	-
Mobilization and Demobilization	733
Through-flow Fine-mesh Screen (0.5 mm)	6,068
Spraywash System	452
Fish Troughs and Return Piping	812
-	
Direct Costs (September 2007 $)	$8,065
Indirect Costs	807
Subtotal	$8,872
Allowance for Indeterminates/Contingencies	2,218
Total Estimated Project Cost (September 2007 $)	$11,090

Annual Operation and Maintenance Requirements	
Item	**Impact**
Incremental Annual Operation and Maintenance	
Labor, (hrs)	300
Component Replacement	$630,800
Energy (kwh)	275,940
Peak Power (kw)	2,575,440

Table 3 – Narrow-slot Cylindrical Wedgewire Screens (0.5 mm slot width)

Item	Estimated Cost ($ x 10^3)
Direct Costs	-
Mobilization and Demobilization	3,901
Maintenance Deck	22,308
Air Burst Cleaning System	4,165
Wedgewire Screens	6,452
Slide gate operator	494
Hoist	190
Barges, Cranes, Divers and Equipment	5,398
-	
Direct Costs (September 2007 $)	$42,908
Indirect Costs	4,291
Subtotal	$47,199
Allowance for Indeterminates/Contingencies	11,800
Total Estimated Project Costs (September 2007 $)	$59,000

Annual Operation and Maintenance Requirements	
Item	**Impact**
Incremental Annual Operation and Maintenance	
Labor, (hrs)	6,240
Component Replacement	$1,090,800
Energy (kwh)	1,380,000
Peak Power (kw)	1,380,000

Table 4 – Retrofit to Closed-cycle Cooling

Item	Estimated Cost
Direct Costs	
Total Cost $	$676,384,000
O & M (3% of total)	$20,291,500
Capacity Limits (7.5%) MWh	1,224,627

Table 5 – Cost Summary of Evaluated Alternatives

Alternative	Capital Costs		
	Total Project Construction Costs (2007 $)	Replacement Power during Construction (MWh)	Total Capital Costs (2007 $)
Replace existing Screens with Fine-mesh Traveling Water Screens	$11,090,000	0	$11,090,000
Narrow-slot Wedgewire Screens	$59,000,000	4,368,729	$277,436,000
Closed-cycle Cooling[1]	$676,384,000	0	$676,384,000

1. Based on EPRI cooling tower costs for SONGS (EPRI 2007)

Table 5 (Continued)

Alternative	Annualized O&M				Annualized Costs		
	Annual Energy (MWh)	Energy (2007 $)[1]	Labor (2007 $)	Component Replacement (2007 $)	Total Annual O&M	Annualized Capital Costs	Total Annualized Costs
Replace existing Screens with Fine-mesh Traveling Water Screens	276	$13,800	$18,000	$630,800	$663,000	$1,579,000	$2,242,000
Narrow-slot Wedgewire Screens	1,380	$69,000	$374,400	$1,090,800	$1,534,000	$39,501,000	$41,035,000
Closed-cycle Cooling	1,224,627	$61,231,300	$20,291,500		$81,523,000	$96,302,000	$177,825,000

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APPRAISAL LEVEL ASSESSMENT EPA §316(b) PERMIT REQUIREMENTS SAN ONOFRE NUCLEAR GENERATING STATION

for Southern California Edison

Prepared by: Alden Research Laboratory, Inc.

Report #: 157-05/E113F May 2005

INTRODUCTION

Alden Research Laboratory, Inc. (Alden) has conducted a preliminary technology assessment for San Onofre Nuclear Generating Station (SONGS) relative to §316(b) of the Environment Protection Agency's (EPA) Clean Water Act for existing Phase II facilities (EPA 2004a). Our assessment identifies alternative fish protection technologies that have potential to meet the impingement mortality and entrainment (IM&E) reduction standards required by the EPA's Rule.

COOLING WATER INTAKE STRUCTURE (CWIS) DESCRIPTION

The CWIS for Units 2 & 3 at SONGS was previously characterized in Appendix A of the "Technical Report to the California Coastal Commission" (MRC 1990). SONGS is a baseloaded facility. In 2003, the average capacity factor for the entire facility was 96.9%. Unit 2 generated 9,712,482 MWh and Unit 3 produced 8,596,268 MWh (DOE 2005). SONGS Unit 1 was decommissioned in 1992.

EXISTING HYDRAULIC CONDITIONS

Velocities at different locations throughout the CWIS are presented in the table below. Alden calculated velocities at full flow conditions (1,850.5 cfs) for Units 2 & 3 at mean low water levels (El. 0.0 ft).

Location	Alden Calculated
Velocity Cap	1.8 ft/sec
Intake Pipe	9.0 ft/sec
Approaching Trash Rack and Traveling Screens	1.2 ft/sec

BASELINE CONSIDERATIONS

SONGS is a Phase II facility because the design flow is greater than 50 MGD, at least 25% of the flow is used for cooling water, and the facility generates electricity for transmission or sale. SONGS withdraws from the Pacific Ocean and is required to meet the IM&E standards. The information provided to Alden indicates that the design and operation of the Units 2 & 3 CWIS should meet the impingement mortality (IM) standard via their velocity cap and fish return system, but may not currently meet the entrainment reduction standard.

This appraisal level assessment of fish protection alternatives includes all technologies that could reduce entrainment by 60–90% as compared to the calculation baseline. The calculation baseline is an estimate of IM&E that would occur at a facility assuming once-through cooling, a shoreline intake, 3/8 in. mesh screens, and the facility operating at design flow rate.

The existing CWISs at SONGS differ substantially from EPA's baseline. Both of the intakes have offshore velocity caps and a fish diversion and return system. Velocity caps may reduce the entrapment of juvenile and adult fish by acting as a behavioral barrier. Fish are better able to detect changes in velocity in the horizontal direction than in the vertical direction. However, fish are unable to detect and avoid velocities that are substantively similar to the ambient velocities in the waterbody. The entrance velocity for the Units 2 & 3 caps is 1.8 ft/sec. Since this velocity is higher than the ambient currents, a behavioral response can be expected. In addition to the behavioral component, the location of the velocity caps in areas that are less biologically productive may reduce the entrainment of eggs and larvae as compared to what would be entrained if the intakes were located on the shoreline.

The fish diversion and return system consists of a louver system made of vertical bars angled at about 20° to the incoming flow. These bars are 0.25 in. wide with 1.25 in. clear spacing. As a fish enters the intake bay, the louvers act to guide them to a collection area. Once in the collection area, a mechanized bucket lifts the fish and places them into a return sluice. This sluice returns the fish to the ocean. Efficiency studies indicated that about 84% of the fish that enter the intake are diverted by the fish return system (MRC 1990). Survival of the fish into the return sluice was fairly high, ranging from 68–100% for most species. No studies have been conducted to determine if the fish return system affects entrainment rates.

Southern California Edison (SCE) has conducted several studies to quantify the benefits associated with the louvers and fish return system. These historical studies show that the features described above act to reduce impingement rates (and subsequent mortality) to a level that would meet the impingement mortality reduction standard. These studies should meet the CDS data requirements demonstrating the current CWIS configuration and operation meets the IM reduction standard.

SCREENING PROCESS

Alternatives that would reduce impingement only were not considered for further evaluation at SONGS since the existing fish return system and intake location should meet the impingement mortality reduction performance standard. Therefore, this discussion addresses technologies and flow reduction options that might meet the entrainment reduction standard.

Narrow-slot wedgewire screens and fine-mesh Ristroph screens are the only practicable intake technologies that could reduce entrainment for SONGS. Wedgewire screens would also meet the IM standard (see discussion below). Fine-mesh Ristroph screens would reduce entrainment, but the velocities approaching the existing screens in the screenhouse may be high enough to cause substantial mortality to organisms retained by the fine-mesh screens. Assuming that California Environmental Protection Agency (CalEPA) is concerned with the survival of early lifestages, installing fine-mesh Ristroph screens under the existing velocities may not achieve an acceptable organism survival rate. Despite the uncertainty regarding the biological efficacy of fine-mesh Ristroph screens at SONGS, Alden included them in this evaluation as a lower cost alternative with potential to provide some reduction in entrainment losses. To increase the survival potential, the screenhouse could be expanded to reduce screen approach velocities. Unfortunately, the layout of the existing screenhouse and plant configuration would not permit such an expansion. A new screenhouse could be constructed at another location, but this option would require extensive civil works which would not be as cost-effective as wedgewire screens.

Aquatic Filter Barriers (AFB) (typically referred to as the Gunderboom) could be used to reduce entrainment, but it would require a large surface area and would require a support structure located at the water surface. Due to the location of the intakes in the open ocean, an AFB would be difficult if not impossible to maintain and would be very costly. An AFB deployment would also have significant visual impacts. Therefore, the AFB was eliminated from further consideration for application at SONGS.

Cooling towers would substantially reduce flow and therefore could reduce both IM&E at SONGS. This option would be very expensive and has only been included to define the most expensive technological or operational option for meeting the performance standards. Other modified facility operations were not considered viable since SONGS is a baseloaded facility. Any modification to facility operations would result in a loss of generating capacity and higher replacement power costs. In MRC 1990 (Chapter 6), SCE indicates that the replacement power fuel differential would be $1.1 million per effective full power day. If SONGS were to shut down for all of March and April, the cost to SCE would be about $30-40 million annually (MRC 1990).

A more detailed assessment of the wedgewire screen, fine-mesh screen, and cooling alternatives is presented below.

ASSESSMENT OF INTAKE ALTERNATIVES

Narrow-Slot Wedgewire Screens

Narrow-slot cylindrical wedgewire screens could be installed to reduce both IM&E. These screens would replace the existing velocity caps. Cooling water for each unit would be conveyed through 49, 84-in. diameter, submerged, cylindrical wedgewire screens mounted on intake pipes connected to the existing intakes. Alden typically designs entrainment-reducing wedgewire screens with 0.5 mm slots. Depending upon the size of entrained organisms (determined from the results of the IM&E study or from historical entrainment sampling), larger slots may be as effective in reducing entrainment at a substantially lower cost (that is, fewer screens and attendant equipment would be required). In addition, the industry standard design for wedgewire screens is a maximum slot velocity of 0.5 ft/sec which meets the IM standard.

The orientation of the screens relative to the existing pipes will depend on the currents in the area. The screens should be positioned parallel to the predominant current to lessen the affects of debris buildup and to facilitate cleaning. The spacing between screens and the length of the new pipe will depend on the screen orientation.

An air backwash system, complete with necessary air compressors and controls, would be installed to clean the screens. The air backwash system could be an effective method for maintaining the screens in a clean condition. Local tidal and coastal currents should be of sufficient magnitude to transport debris and organisms away from the screens. Periodic manual cleaning for removal of biofouling would likely be necessary. However, the required effort could be reduced by using an anti-fouling material or coating.

Ambient current velocities at the wedgewire screens would be tidally driven. The maximum through-slot velocity would not exceed 0.5 ft/sec. Head losses through the screens should not exceed 1 ft (assuming biofouling would not be a significant problem). Except for the slightly lower water level in the screenhouse, flow characteristics in the intake pipe leading to the screenbay would not differ than the existing intake. Flow patterns to the pumps would not change from the existing conditions.

Wedgewire screens will not prevent biofouling agents from entering the intake system and attaching to the intake pipes. With wedgewire screens in place, the existing thermal backflushing system would not be effective. As a result, a new method of removing the biofouling would be necessary.

The existing traveling screens would need to remain operational to collect biofouling organisms that slough off the intake pipes between the velocity cap and the screenhouse. The fish return system would also no longer be required.

To meet NRC safety requirements, an intake bypass pipe may be needed. This pipe would allow water to enter the intake without passing through the wedgewire screens. If a bypass pipe was required, the existing traveling screens would need to be left in place to screen water entering through the bypass pipe.

Because of the low through-screen velocity, wedgewire would automatically meet the IM standard via Compliance Alternative 1 (0.5 ft/sec through-screen design velocity criterion). Recent laboratory evaluations of wedgewire screens indicate that 0.5 mm screens can be effective in reducing entrainment and impingement of larval fish and eggs (EPRI 2003). With the exception of rainbow smelt, when ambient currents were 0.5 ft/sec or greater, 0.5 mm wedgewire screens configured for slot velocities of 0.5 ft/sec resulted in entrainment of 10% or less for all species tested (alewife, common carp, winter flounder, white sucker, bluegill, striped bass, and yellow perch) (EPRI 2003). Rainbow smelt larval entrainment with a slot opening of 0.5 mm and slot velocity of 0.5 ft/sec was 75%, 67%, and 25% at channel velocities of 0.3, 0.5, and 1.0 ft/sec, respectively. During the laboratory study, eggs and larvae were released directly in front of the screens. Therefore, the entrainment rates observed in the laboratory are potentially higher than what Alden would expect in the field. The screens, as designed, have the potential to decrease the entrainment of fish eggs and larvae, but the degree of protection will vary by species and life stage.

Install Fine-mesh Ristroph Traveling Water Screens

SCE could replace the existing 3/8 in. traveling water screens for both units with new 0.5 mm fine-mesh Ristroph screens. Fine-mesh screens are often designed with an approach velocity of 0.5 ft/sec to maximize the survival of fish eggs and larvae. This velocity is about one-third of the velocity approaching the existing traveling water screens. If CalEPA were concerned about the survival of previously entrained organisms, SCE would need to perform a pilot study to verify that the survival of entrainable organisms off of the fine-mesh would meet the entrainment reduction standard.

Impinged organism would be removed from the fine-mesh screens via a low-pressure spray wash (~10 psi) and washed into a fish return trough. This fish return trough could be tied into the existing fish return system.

Fine-mesh screens at SONGS would decrease the entrainment of larval fish and eggs through the circulating water system. Any fish protection technology that substantially reduces the entrainment of the most abundantly entrained organisms (e.g., northern anchovy (*Engraulis mordax*)) should provide sufficient protection to meet the proposed national standard.

Northern anchovy eggs are broadcast throughout the water column and are typically found floating near the surface. Therefore, it is not expected that large numbers are currently entrained into the velocity cap. However, for those that are entrained, the eggs should be large enough to be physically prevented from passage through fine-mesh screens. Larval length of northern anchovy at hatching is between 2.5 and 3.0 mm with a head capsule depth of 0.25 mm; therefore, no all of larvae would be prevented from being entrained. While some larvae may not be physically excluded, near field hydraulic conditions may prevent some entrainment.

A second factor to consider with fine-mesh screens is that such screens result in the impingement of fish that were previously entrained. Use of fine mesh screens is a tradeoff. Some species and life stages benefit, but others might experience greater mortality than under existing conditions. These screens are beneficial from an organism protection viewpoint only if impingement survival for abundant species is relatively high and exceeds entrainment survival levels. The Rule is silent on the fate of entrainable organisms that would be impinged on fine-mesh screens. If, CalEPA were to apply a stricter standard or interpret the Rule to require a reduction in entrainment *survival*, fine-mesh screens may no longer be a viable option for meeting the national performance standard given the large percentage of northern anchovy ichthyoplankton.

Past studies show that anchovy have relatively low survival following impingement on fine-mesh screens. Immediate survival of anchovy larvae was reported to be 31 to 66% when adjusted for control survival (depending upon velocity and duration of impingement) (Edwards et al. 1981). Post-impingement survival of bay anchovy (*Anchoa mitchilli*), which is in the same family as northern anchovy, has ranged from 0 to 37% (Brueggemeyer 1988; LMS 1987).

If impingement survival of entrainable organisms from fine-mesh screens in the existing screen location was low, the screenhouse would need to be expanded to accommodate nine additional screens necessary and thereby reduce the approach velocity to a more acceptable level. Such an expansion would require each unit to be shut down for a substantial amount of time and would require considerable site work. For these reasons, expanding the intake and installing more Ristroph screens is not considered to be a cost-effective solution.

Retrofit Intake with Closed-Cycle Cooling

Retrofitting the once-through cooling water system with a closed-cycle cooling system would reduce water use for plant cooling systems. The average amount of make-up water required for cooling towers would be about 56 cfs (i.e., about 3% of the once-through cooling water requirement) per unit, with an approximately equal reduction in organism entrainment.

Mechanical or natural draft cooling towers could be retrofitted to meet the cooling requirements of the facility. For the purpose of this evaluation, Alden has assumed that a mechanical draft tower would be installed at the site. Siting cooling towers at SONGS may be difficult because of the limited space. Mist eliminators and plume abatement measures would be necessary to reduce the effects of cooling tower drift on Interstate 5. For these reasons, along with the fact that SONGS is nuclear fueled, Alden classified the site as very difficult relative to EPRI's cooling tower cost methodology (EPRI 2002).

Most of the existing condenser and cooling system components would remain intact and would use approximately the same condenser flows. Cooling water that is currently discharged into the discharge channel would be redirected into a wet pit pump structure, where booster pumps would convey cooling water to the cooling tower spray deck and back to the existing intake. Cooling water would be conveyed through the condensers similar to the existing once-through system. A new, smaller pump would be installed in the screenhouse to supply makeup water from the ocean the closed-cycle cooling system.

Annual maintenance would be necessary on the mechanical and electrical components of a mechanical draft tower and the other pumping components for a closed-loop cooling water system. Pumps, fans, motors, controls, fill sections, support structures, and the tower basin and hardware all require periodic inspections and maintenance. The EPRI study indicates that the operating and maintenance costs for a cooling tower retrofit would be 2% of the total construction costs.

APPRAISAL LEVEL COST SUMMARY

The costs for wedgewire screens were estimated using Alden's cost database of alternatives for over 35 plants. These costs were adjusted for identifiable differences in project sizes and operations. The cooling tower cost is based on values provided in EPRI 2002. Costs below are given on a per unit basis. However, since both Units 2 & 3 are identical, costs for both units combined would be double.

The costs presented in the following table do not account for additional labor, time, and permits that would be required to satisfy design, safety, and security concerns resulting from SONGS being nuclear-fueled. EPA assigned a cost multiplier of 1.8 to adjust costs for nuclear facilities (EPA 2004b). EPA only considers increases in security costs resulting from the design and operation of a more robust security system. Since this cost does not take into consideration additional permit requirements, Alden expects that the actual cost multiplier would be closer to 2.0. Applying either of these costs multipliers to the costs in the following table may provide a more realistic estimate of the cost to apply one of the selected technologies at SONGS.

Due to their generalized nature, this appraisal level cost estimate are intended to provide a rough estimate of what the technology might cost. More detailed cost estimates based on detailed quantity takeoffs would be required if SCE plans to apply either of these alternative technologies at SONGS or to support the Cost-Cost or Cost-Benefit test (Compliance Alternative 5).

The appraisal level estimate of the capital and associated annual operation and maintenance (O&M) costs per unit are show in the table below. Capital costs take into account unit shutdowns during construction. Alden estimates that construction of wedgewire screens would require each unit to be shut down for 3 months and cooling towers would require each unit to be shut down for about 6 months. The Ristroph screens could be replaced one at a time allowing each unit to operate normally during construction.

O&M cost estimates do not include the existing O&M associated with each unit. Annualized costs are included for comparison to EPA's costs in Appendix A of the Rule. These annualized costs also provide a more realistic estimate of what a technology will actually cost the facility. The O&M costs also do not consider costs associated with increased wages and safety concerns at nuclear facilities.

	Total Capital Costs	Annual Operation and Maintenance Costs	Total Annualized Costs
Narrow-slot Submerged Cylindrical Wedgewire Screens	$101,090,000	$217,000	$14,610,000
Fine-mesh Ristroph Traveling Water Screens in the Existing Screenhouse	$2,940,000	$449,000	$868,000
Closed-cycle Cooling	$429,000,000	$12,857,000	$73,937,000

Chapter 5 of MRC provided costs for different types of cooling towers at SONGS. The costs ranged from $370,000,000 for mechanical draft cooling towers up to $500,000,000 for dry cooling towers. These installation costs are consistent with the one calculated for this evaluation.

EPA COSTS

In Appendix A of the Rule, EPA had a zero cost for SONGS (Facility ID – AUT-0573), indicating that EPA believes that the facility already meets the performance standard or the flow information provided by SCE to EPA was designated confidential business information.

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Appendix B

Fine-mesh Screen Efficacy and Headloss Calculations

San Onofre Nuclear Generating Station

There have been few empirical studies to determine the effects of organism length on entrainment through fine-mesh screen panels. The majority of studies has looked at extrusion through towed, ichthyoplankton nets and may not be representative of the efficiency of fine-mesh traveling water screens to exclude specific sizes of organisms.

Given the limited data, the predicted retention (or exclusion) that can be achieved with a given mesh-size can be estimated using the body depth of an organism. Estimates of the retention of organisms by a given mesh size can be developed from the physical dimensions of the organism. Since larval fish are soft bodied and can be compressed, the deepest non-compressible portion of the body (head capsule) can be used to predict exclusion. Exclusion is species-specific because there is substantial variation in the morphometric characteristics of the head capsule among species. Therefore, species-specific estimates were generated for several of the commonly entrained species at SONGS. To estimate retention, relationships between head capsule depth and fish length were developed for each species. Smith et al. (1968) found that the maximum cross-sectional diameter of the organism must be greater than the mesh diagonal if it is to be fully retained. Therefore, for a given cross-sectional diameter and associated standard deviation, the percentage retained and excluded is calculated by integration under a normal curve.

Head capsule depths were estimated by developing regressions of body length to head capsule depth based on measurements gleaned from scale-drawings of specimens. These regressions were then used to interpolate head capsule depths for fish of given lengths. In some cases, substitutions were used to estimate morphometric characteristics. White croaker (*Genyonemus lineatus*) morphometric data were used to represent queenfish (*Seriphus politus*). Morphometric data for diamond turbot (*Pleuronichthys guttulatus*) were supplemented with other closely related species: C-O turbot (*P. coenosus*), curlfin turbot (*P. decurrens*), hornyhead turbot (*P. verticalis*), and spotted turbot (*P. ritteri*). For these flat fishes, head capsule width after transformation was used in the calculations. Data from barnaclebill blenny (*Hypsoblennius brevipinnis*), bay blenny (*H. gentilis*), rockpool blenny (*H. gilberti*), mussel blenny (*H. jenkinsi*), and Socorro blenny (*H. proteus*) were used to represent combtooth blennies. Data from kelp bass (*Paralabrax clathratus*), spotted sand bass (*P. maculatofasciatus*), and barred sand bass (*Paralabrax nebulifer*) were used to estimate the retention of sea basses. Spotted kelpfish (*Gibbonsia elegans*) was the only member of the genus for which morphological measurements were available. The estimated retention of several important taxa at SONGS is presented in Figure 1. The probability of entrainment is displayed graphically in Figure 2.

The size distribution of entrained organisms (based on histograms presented in the IM&E Characterization Study - MBC 2007) were used to determine the total estimated reduction in entrainment by species for those species that length distributions were available (Table 1). With the exception of sea basses (*Paralabrax* spp.) the exclusion of ichthyoplankton at SONGS is predicted to range from 61-90%. The sea bass entrained were less than 3 mm in length and have head capsule depths which allow them to be entrained. Therefore the exclusion is expected to be 0% for these species.

The second measurement of effectiveness is the survival of the eggs, larvae, and early juveniles retained on fine-mesh screens that would previously have been entrained. The survival of impinged organisms is dependent upon their biology (life stage, relative hardiness, etc.) and the screen operating characteristics (rotation speed, spraywash pressure, etc.).

Survival estimates were derived from other sites with data from modified traveling screens or from other evaluations (e.g., laboratory and pilot-scale studies). Data on the efficacy of fine-mesh screens with fish eggs and larvae are limited and estimates are often based on only a few data points. In such cases, data were expanded to include other members of the same genus. The underlying assumption is that fish in the same genus have similar morphology and hardiness. There were several cases where no other data within the same genus were available. In such cases, the database was further expanded to include members of the same family. Estimates of egg and larval survival are presented in Figure 1.

Species-specific post-impingement survival estimates for the juvenile and adult life stages of several fish species commonly impinged at SONGS were developed for modified traveling water screens. Biological estimates were derived from other sites with data from modified traveling screens or from other evaluations (e.g., laboratory and pilot-scale studies) . Data were also obtained from published papers in peer-reviewed journals and corporate-sponsored efficacy reports (gray literature). Data were limited to juvenile or adult fish. The data were further limited to studies that: 1) were conducted at facilities with modified Ristroph or other screen designs with fish-friendly modifications, 2) were conducted at facilities with the more sophisticated bucket designs developed in the 1980s, and 3) held organisms for at least 24 hours post-impingement to assess latent survival rate.

Post-impingement survival of juvenile and adult fish from fine-mesh screens is assumed to be similar to what has been observed at other locations with other modified screen designs (regardless of mesh-size). That is, survival of a 45 mm juvenile from a fine-mesh screen should not be different than survival from a coarse-mesh screen. Estimates of juvenile and adult post-impingement survival are presented in Table 2.

There is limited data on post-impingement larval survival (and to a lesser extent juvenile and adult fish) for the species of fishes typically entrained at SONGS. Since these estimates are generated from facilities with a wide range of operating conditions, there is substantial uncertainty on the performance that could be achieved at SONGS with fine-mesh screens. This lack of certainty about the efficacy of fine-mesh screens at SONGS emphasizes the need for species and life stage specific testing to verify performance in situ before embarking on full-scale deployment.

<table>
<tr><td colspan="2">Sciaenidae</td><td colspan="50">Length (mm)</td></tr>
<tr><td></td><td>Eggs</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td><td>32</td><td>33</td><td>34</td><td>35</td><td>36</td><td>37</td><td>38</td><td>39</td><td>40</td><td>41</td><td>42</td><td>43</td><td>44</td><td>45</td><td>46</td><td>47</td><td>48</td><td>49</td><td>50</td></tr>
<tr><td>Survival</td><td>74</td><td colspan="23">18</td><td colspan="11">96</td><td colspan="16">See Juvenile Adult Table</td></tr>
<tr><td>Exclusion</td><td>56</td><td>0</td><td>2</td><td>98</td><td colspan="47">100</td></tr>
</table>

<table>
<tr><td colspan="2">Gibbonsia spp.
(kelp blennies)</td><td colspan="50">Length (mm)</td></tr>
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<tr><td>Survival</td><td>74</td><td colspan="12">No Data Avaiable</td><td colspan="12">15</td><td colspan="26">No Data Available</td></tr>
<tr><td>Exclusion</td><td>unk</td><td colspan="2">0</td><td>1</td><td>45</td><td>94</td><td colspan="45">100</td></tr>
</table>

<table>
<tr><td colspan="2">Hypsoblennius spp.
(combtooth blennies)</td><td colspan="50">Length (mm)</td></tr>
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<tr><td>Survival</td><td>74</td><td colspan="29">No Data Available</td><td colspan="21">See Juvenile and Adult Table</td></tr>
<tr><td>Exclusion</td><td>31</td><td>0</td><td>13</td><td>95</td><td colspan="47">100</td></tr>
</table>

<table>
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<tr><td></td><td>Eggs</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td><td>32</td><td>33</td><td>34</td><td>35</td><td>36</td><td>37</td><td>38</td><td>39</td><td>40</td><td>41</td><td>42</td><td>43</td><td>44</td><td>45</td><td>46</td><td>47</td><td>48</td><td>49</td><td>50</td></tr>
<tr><td>Survival</td><td>26</td><td colspan="19">10</td><td colspan="14">22</td><td colspan="17">See Juvenile and Adult Table</td></tr>
<tr><td>Exclusion</td><td>47</td><td colspan="5">0</td><td>11</td><td>47</td><td>82</td><td>96</td><td>99</td><td colspan="40">100</td></tr>
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<table>
<tr><td colspan="2">Gobiidae (gobies)</td><td colspan="50">Length (mm)</td></tr>
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<tr><td>Survival</td><td>74</td><td colspan="29">0</td><td colspan="21">See Juvenile and Adult Table</td></tr>
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<tr><td colspan="2">Paralabrax spp.
(sea basses)</td><td colspan="50">Length (mm)</td></tr>
<tr><td></td><td>Eggs</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td><td>32</td><td>33</td><td>34</td><td>35</td><td>36</td><td>37</td><td>38</td><td>39</td><td>40</td><td>41</td><td>42</td><td>43</td><td>44</td><td>45</td><td>46</td><td>47</td><td>48</td><td>49</td><td>50</td></tr>
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</table>

<table>
<tr><td colspan="2">California grunion</td><td colspan="50">Length (mm)</td></tr>
<tr><td></td><td>Eggs</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td><td>32</td><td>33</td><td>34</td><td>35</td><td>36</td><td>37</td><td>38</td><td>39</td><td>40</td><td>41</td><td>42</td><td>43</td><td>44</td><td>45</td><td>46</td><td>47</td><td>48</td><td>49</td><td>50</td></tr>
<tr><td>Survival</td><td>26</td><td colspan="12">No Data Available</td><td colspan="12">59</td><td colspan="26">See Juvenile and Adult Table</td></tr>
<tr><td>Exclusion</td><td>100</td><td colspan="5">0</td><td>10</td><td>82</td><td>99</td><td colspan="42">100</td></tr>
</table>

Figure 1 Estimated exclusion (reduction in entrainment) and survival by taxon and length – SONGS.

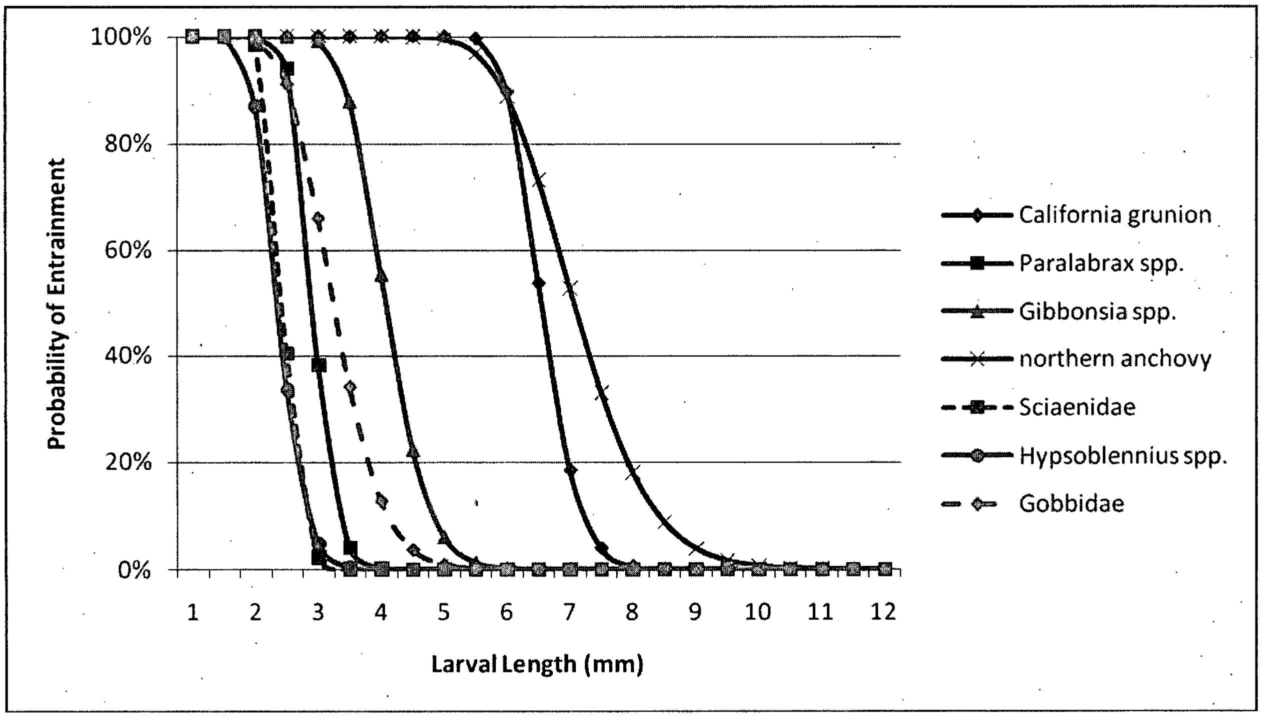


Figure 2 Predicted entrainment of key taxa at SONGS using 0.5 mm screens.

Table 1 Estimated overall reduction in entrainment associated with the use of 0.5 mm fine-mesh screens at SONGS with species for which length distributions in entrainment samples were available.

Taxon	Percent Reduction in Entrainment
northern anchovy	81.3
Gibbonsia spp. (kelp blennies)	81.7
queenfish	89.9
Paralabrax spp. (sea basses)	0.0
white croaker	60.7

Table 2 Estimated Post-Impingement Survival (Weighted Mean), Number of Organisms Used to Estimate (N), the Range in Reported Post Impingement Survival, and the 95% Confidence Interval Surrounding the Weighted Mean

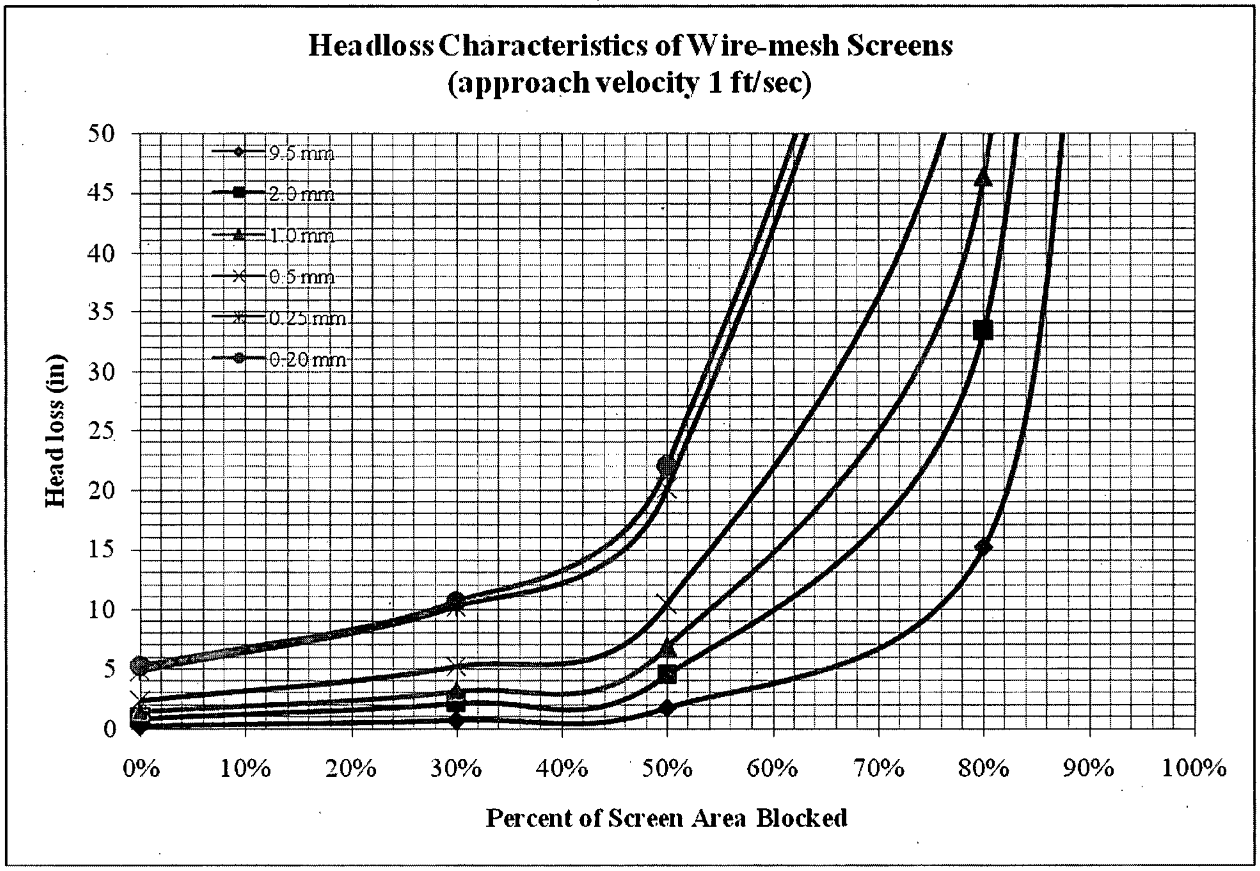
Common Name	Surrogate	*N*	Range	Weighted Mean	95% CI Lower	95% CI Upper
California grunnion	Atherinopsidae	965	97.8 - 100.0	98.2	97.4	99.1
combtooth blennies	*Hypsoblennius spp.*	1	100.0	100.0	50.0	150.0
deepbodied anchovy	Engraulidae	10,844	0.0 - 77.7	23.2	22.4	24.0
gobies	Gobiidae	44	0.0 - 100.0	93.2	84.6	101.8
Gibbonsia spp.	Clinidae	106	0.0 - 54.0	15.1	7.8	22.4
northern anchovy	Engraulidae	10,844	0.0 - 77.7	23.2	22.4	24.0
Pacific sardine	Clupeidae	62,525	0.0 - 100.0	13.6	13.4	13.9
queenfish	Sciaenidae[1]	22,176	0.0 - 100.0	56.0	55.4	56.7
sea basses	Serranidae	30	92.3 - 94.1	93.3	82.7	103.9
topsmelt	Atherinopsidae	965	97.8 - 100.0	98.2	97.4	99.1
white croaker	Sciaenidae[1]	22,176	0.0 - 100.0	56.0	55.4	56.7
white sea perch	Sciaenidae[1]	22,176	0.0 - 100.0	56.0	55.4	56.7

1 Sciaenidae were limited to marine and estuarine species (i.e., freshwater drum excluded from the analysis)

SCREEN MESH HEADLOSS

The screen mesh/headloss assessment was prepared by Alden with data provided by Johnson Screens and Siemens Screens.

Wire-mesh screen headloss characteristics



Assumptions for head loss calculations:

Screen approach velocity at 1 feet/sec
Through-flow screen (two screen mesh baskets in flow path)
Head loss coefficients from M. Papworth 1972

Screen characteristics:

Screen Mesh	Wire spacing (in)	Wire dia. (in)	Wire dia. (mm)	opening (mm)	Open area	Back-up screen (1" mesh)	combined open area with 1" back-up screen
3/8" mesh	0.444	0.08	2.0	9.3	67%	no	67%
10 mesh	0.100	0.025	0.64	1.9	56%	yes	45%
18 mesh	0.056	0.017	0.43	1.0	48%	yes	39%
30 mesh	0.033	0.012	0.30	0.5	41%	yes	33%
50 mesh	0.020	0.009	0.23	0.3	30%	yes	24%
70 mesh	0.014	0.0065	0.17	0.2	30%	yes	24%

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Appendix C
EPRI Cooling Tower Evaluation of SONGS

B.15 San Onofre Nuclear Power Station Southern California Edison

Location

5000 Pacific Coast Highway
San Clemente, California 92672
33° 22' 12.95" N; 117° 33' 17.11" W
Contact: Patrick Tennant, 626-302-3066

Figure Error! No text of specified style in document.**-1**
San Onofre Nuclear Power Station Boundaries and Neighborhood

Figure Error! No text of specified style in document.**-2**
San Onofre Nuclear Power Station Site View

Plant/Site Information

Unit 2: 1127 MW
Unit 3: 1127 MW

Table Error! No text of specified style in document.**-1**
San Onofre Cooling System Operating Conditions

Unit	MW	Cooling Water flow		Steam flow	Heat duty	Tin	Tex	Range	Tcond	TTD	Backpressure
		gpm	cfs	lb/hr	Btu/hr	F	F	F	F	F	in Hga
2	**1127**	795,600	1770	8.368E+06	7.950E+09	64.0	83.0	19.0	103.0	20.0	2.10
3	**1127**	795,600	1770	8.368E+06	7.950E+09	64.0	83.0	19.0	103.0	20.0	2.10

Table Error! No text of specified style in document.**-2**
San Onofre Capacity Factors

Unit	MW (net)	Capacity Factor (%)						
		2001	2002	2003	2004	2005	2006	Average
2	**1127**	96.1%	86.1%	98.4%	81.6%	90.5%	68.4%	**85%**
3	**1127**	57.2%	96.7%	87.1%	70.7%	95.9%	69.0%	**84%**

SAN CLEMENTE **CA** WMO No. 722925

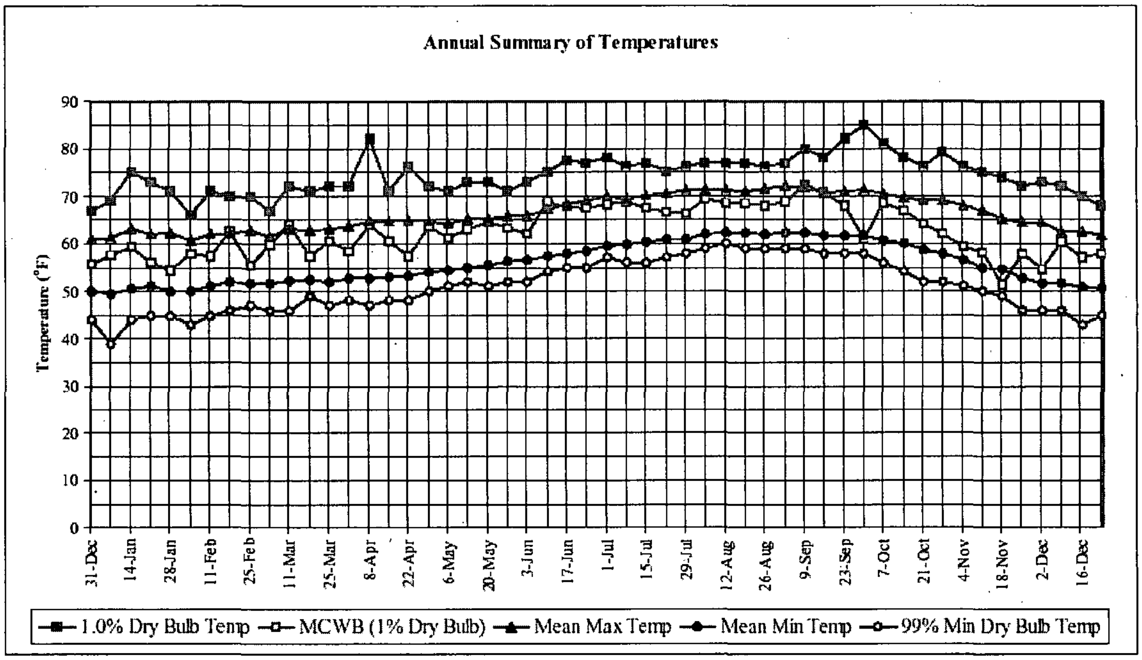

Figure Error! No text of specified style in document.**-3**
San Onofre Meteorological Data

Table Error! No text of specified style in document.**-3**
San Onofre Meteorological Data

Temperature	Max.	Average	Min.
San Onofre inlet temp., °F	68	62	57
Atmos. wet bulb, °F	67	57	40
Atmos. dry bulb, °F	87	73	41

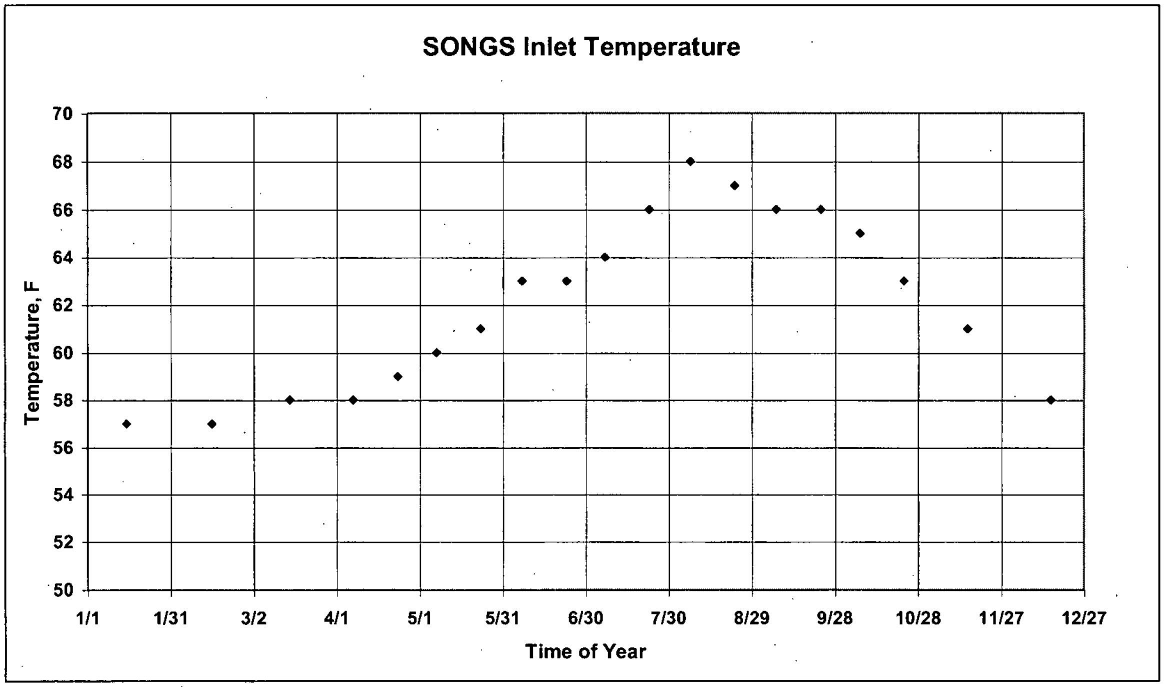

Figure Error! No text of specified style in document.**-4**
San Onofre Ocean Temperature

Plant Operating Data

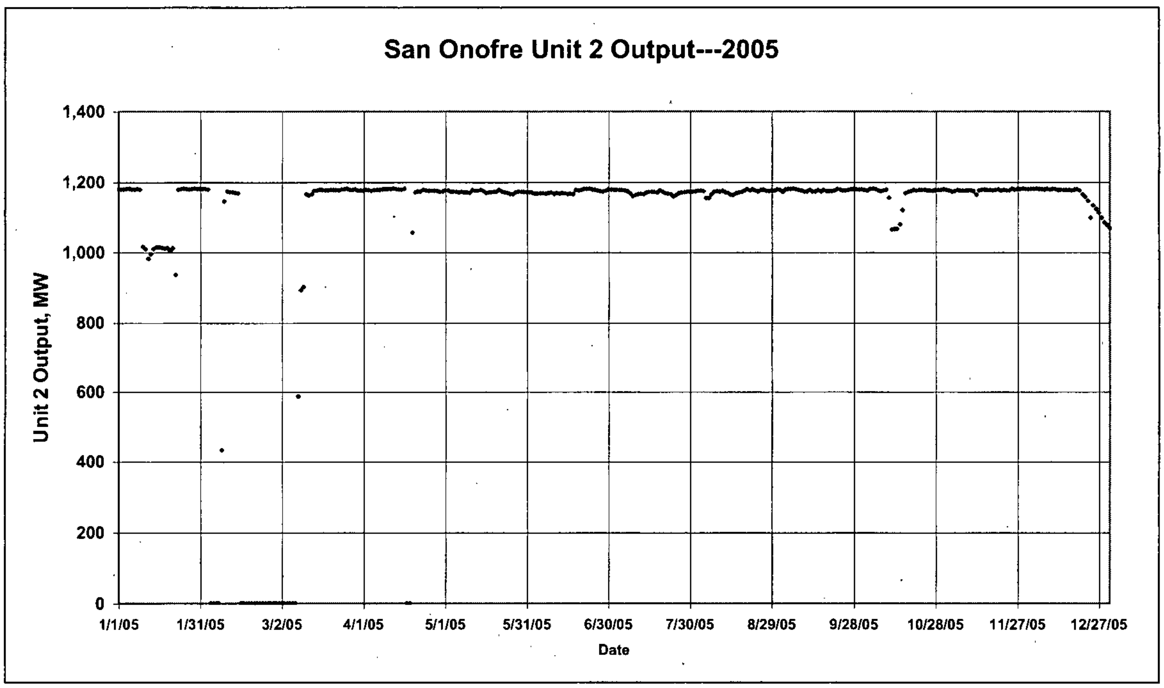

Figure Error! No text of specified style in document.**-5**
San Onofre Unit 2 Output—2005

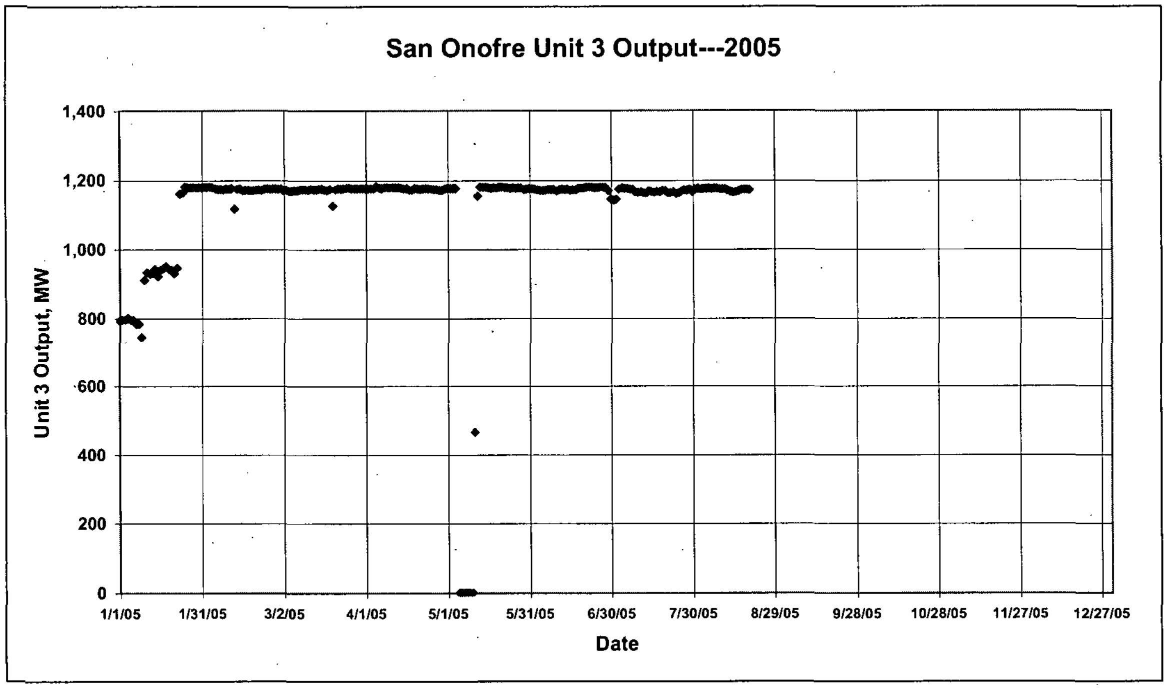

Figure Error! No text of specified style in document.-**6**
San Onofre Unit 3 Output—2005

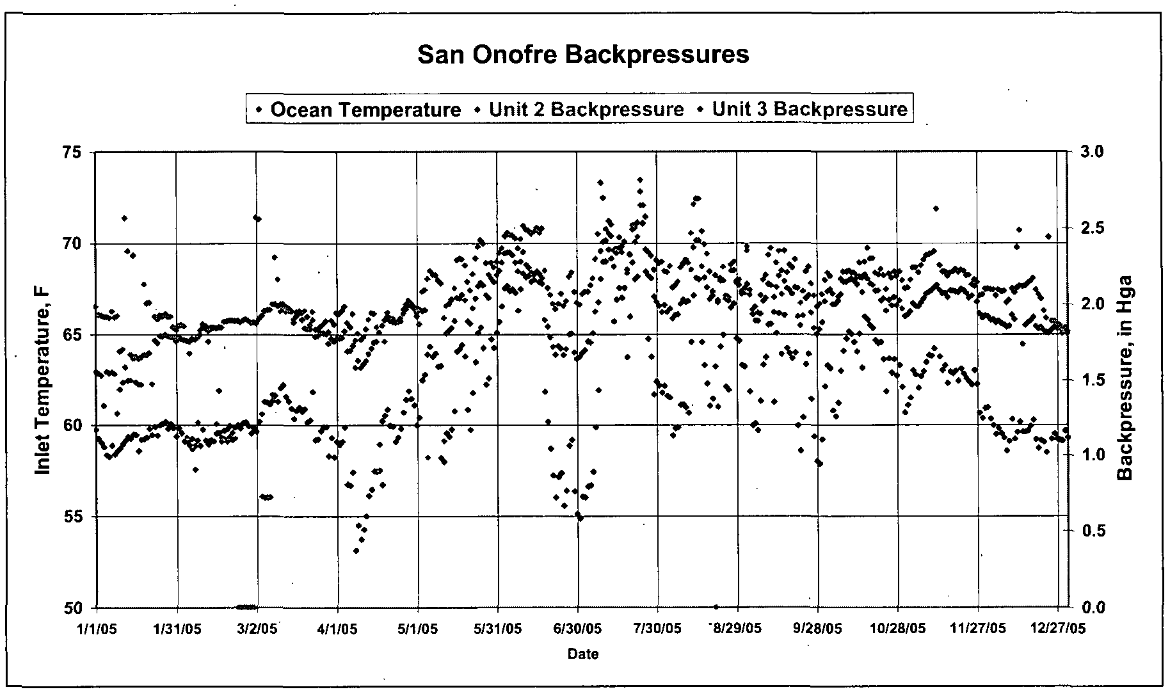

Figure Error! No text of specified style in document.-**7**
San Onofre Backpressure (Once-Through Cooling)

Cooling Tower Assumptions/Design

- Tower type: mechanical draft, counterflow, FRP construction
- Make-up water source: Sea water; 35,000 ppm salinity
- Operating cycles of concentration: n = 1.5
- Evaporation rate: Units 2 and 3---~ 17,000 gpm each
- Make-up rate (@ n = 1.5): Units 2 and 3---~ 51,000 gpm each
- Blowdown (@ n = 1.5): Units 2 and 3---~ 34,000 gpm each

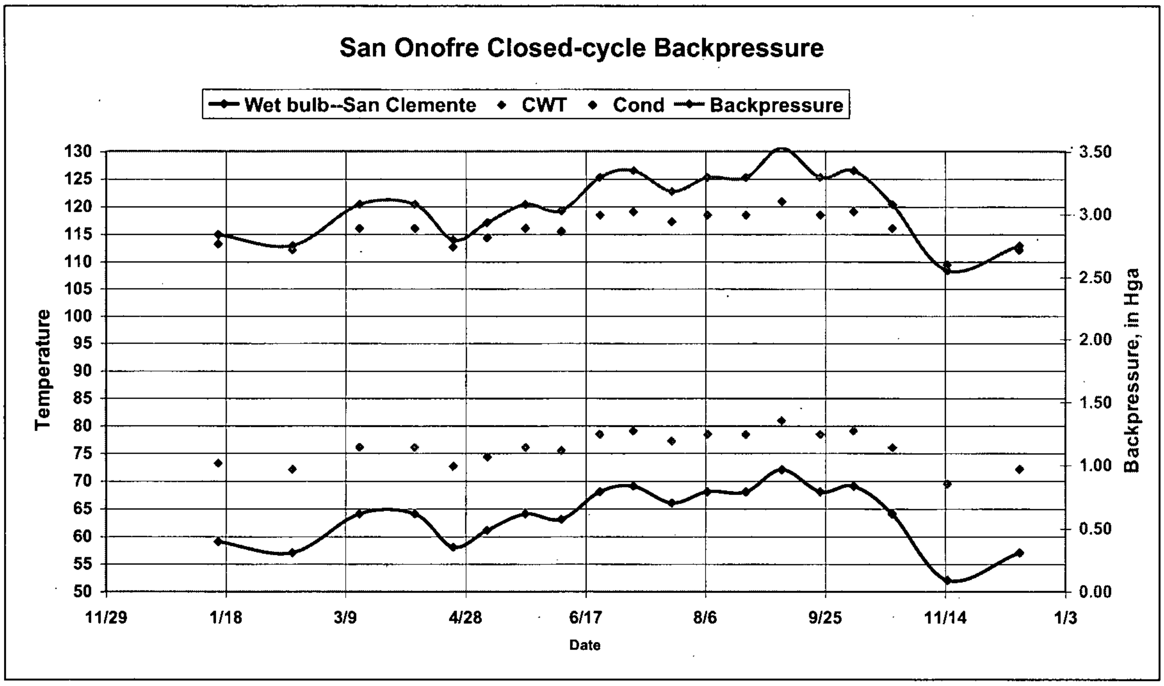

Figure Error! No text of specified style in document.**-8**
Backpressure Comparisons-Full Load for Year

Wet Retro Fit Costs

Table Error! No text of specified style in document.**-4**
S&W Cost Estimates

S&W Costs---escalated to 2007; x 1.07 for seawater					
Unit	Labor	Material	Equipment	Indirect	Total
2	$43,551,000	$16,496,000	$34,280,000	$54,709,000	$149,036,000
3	$43,551,000	$16,496,000	$34,280,000	$54,709,000	$149,036,000
Plant Total	$87,102,000	$32,992,000	$68,560,000	$109,418,000	$298,072,000

Table Error! No text of specified style in document.-**5**
Maulbetsch Consulting Survey Estimates

Maulbetsch Consulting Survey; escalated to 2007 $; x 1.07 for salinity			
Unit	Easy	Average	Difficult
2	$131,298,000	$218,830,000	$338,192,000
3	$131,298,000	$218,830,000	$338,192,000
Plant Total	$262,596,000	$437,660,000	$676,384,000

This site is the one instance where the agreement between the S&W estimate and the "average" estimate from the survey is poor. The S&W estimate for this case is much closer to the "easy" category. While there is no provable explanation for this difference, it must stem from the fact that the large nuclear station that S&W used for the reference case, from which the San Onofre estimate was scaled, was a relatively easy situation for retrofit.

Independent Case Study

An independent estimate of the wet cooling retrofit cost is available from a study performed by PLG, Inc. (formerly Pickard, Lowe and Garrick) for Southern California Edison in August, 1990. The capital cost of the wet system for Units 2 and 3 was estimated at $172 million in 1990$. Escalating this to 2007$ at 3% per year, yields an estimate of $284 million in current dollars. If "Indirects" are added in the same proportion as was used in the S&W study, the comparable estimated project cost is approximately $450 million which is in reasonable agreement with the "average" difficulty estimate from the survey.

There are some differences in the operating parameters for the towers in PLG analysis than are generally used in this study. For example, the evaporation rate seems much lower than would be expected and the chosen approach of 8 °F seems low for the site meteorology. However, with the exception of the approach temperature, all the major variables affecting the cost are reasonably consistent.

Dry Cooling

Dry cooling estimates will not be made for a nuclear plant. There have never been any nuclear plants equipped with direct dry cooling (using an air-cooled condenser) in the U.S. It has not been determined whether such a configuration could be permitted if proposed. While an indirect dry cooling system could likely be permitted, the additional temperature rise associated with the condenser range in addition to the ITD of an air-cooled heat exchanger would raise the achievable backpressure well above reasonable operating limits.

For an ambient design dry bulb temperature of 90°F, an ITD of 20°F and the existing range plus TTD of 40°F, the condensing temperature would be approximately 150°F corresponding to a backpressure of 7.5 in Hga. Furthermore, even if elaborate turbine modifications were made to accommodate the dry cooled system, it would be of a type and size for which no reasonable cost estimates can be made at this time.

At the present time, there are some proposed nuclear plants in the Eastern U.S. which are considering the use of hybrid (wet/dry) cooling systems, consisting of a fin-fan air-cooled heat exchanger in series with a wet or wet/dry tower. At least one plant with a system of this type operates in Germany. However, any estimate of the cost or performance of such a system would be highly speculative since there is no experience or even literature information to assist in bracketing the costs of air-cooled exchangers (not air-cooled condensers) of this size and type of service and it is not addressed further in this report.

Effect on Plant Performance

A retrofitted cooling system of either the wet or dry type would have a deleterious effect on the plant net heat rate. This arises from two effects:

1. Considering only the wet system, the power requirements will be higher than the current pumping power requirements for the once-through system. This power is used for the additional circulating pumps and for the cooling tower fans and represents power that must be generated but cannot be sold.
2. The plant will operate at a higher backpressure and therefore a higher heat rate with closed cycle cooling. This effect will be much more pronounced for a dry system than for a wet system.

The additional power requirements are estimated as follows:

Pumping power: The circulating water flow rate must be pumped through an additional head rise. At the locations where the tower must be placed, there is significant elevation relative to the location of the plant buildings. Plant estimates suggest that a total head rise of 100 feet will be required to account for this grade elevation in addition to the 40 feet to account for the lift out of the sump, the rise to the hot water distribution deck on the top of the tower and the head loss through the circulating water lines. A combined pump/motor efficiency of 75% is assumed. Each of these factors would be refined in a detailed analysis, but these are considered adequate to give a reasonable estimate of the effect of additional operating power on the plant. For the two units at San Onofre:

Table Error! No text of specified style in document.**-6**
San Onofre Units: Retrofit Additional Pumping Power

Unit	Flow	Head	Eff	Power	Motor
	gpm	ft		kW	MW
2	811,000	100	0.75	15271.8	20.36
3	811,000	100	0.75	15271.8	20.36

Fan power: Similarly cooling tower fan power can be roughly estimated. It is assumed for retrofits on older, lower capacity factor units, the tower would be sized to "low first cost" design since the number of operating hours is low and power penalties are less severe. This is consistent with the assumptions made in the retrofit capital cost estimates. The number of cells will be estimated as one cell per 10,000 gpm of circulating water flow, the fan horsepower at 200 HP and a motor efficiency of 90%. For the San Onofre units, this results in:

Table Error! No text of specified style in document.**-7**
San Onofre Units: Retrofit Fan Power

Unit	Flow	Cells	Eff	Power	Motor
	gpm	n		hp	kW
2	811,000	81	0.9	16,220	13,445
3	811,000	81	0.9	16,220	13,445

Note that the PLG analysis estimated 96 cells. This results from the lower approach temperature and the higher recirculation allowance, which gives a higher inlet, wet bulb temperature.

This represents a combined, full-load operating power requirement of approximately 67.5. MW or approximately 3 % of the plant power rating of 2,254 MW. The actual annual cost will obviously depend on the capacity factor, the number of hours on-line, and whether some fans are turned off when operating at part load. Also, the cooling system was sized for full load at acceptable backpressures at so-called "1%" ambient conditions; it would be well oversized for nearly the entire year. Therefore, the effect of requiring additional operating power for the pumps and fans coupled with operation at higher heat rate would be an increase in the fuel burned rather than a reduction in plant output.

Heat rate penalty: As can be seen by comparing the annual variation in backpressure plotted for both once-through cooling and for closed-cycle wet cooling in earlier plots, the condensing pressure with closed-cycle wet cooling will run typically 0.5 to 1.0 in Hga higher than it would with once-through ocean cooling and increases to about 3.5 in Hga on the hottest days. The effect is less at part load. The annual average effect if evaluated at the average wet bulb temperature of 57°F is approximately 0.25 in Hga. This is consistent with the conclusion reached in the PLG study. Based on turbine heat rate curves available to them at the time, the resulted in an average output reduction of about 1% (~ 12 MW per unit).

Capacity Limits

The increased backpressure will result in a higher output restriction on the hottest day. If the effect of an increased backpressure of ~ 1 in Hga is extrapolated from the information above, a shortfall of about 4% is expected, corresponding to approximately 100 MW for the plant. This, when added to the additional operating fan and pump power of 67.5 MW results in a total peak day shortfall of 168. MW or nearly 7.5 %.

Maintenance Costs

Commonly used factors for maintenance (labor, materials, chemicals, etc.) for wet cooling systems range from 2. to 3. % of the system capital costs.

For wet systems, the important costs are for water treatment, biofouling control and keeping the basin clean. Using salt water and having salt drift around the plant would require rust control, extra painting, etc. Using the high end of typical factors, assume 3. to 3.5% of the capital cost of the tower. It is unclear how SONGS would allocate these costs between operation and maintenance, but an estimate of 3% of the "average" capital costs for all units of $250 to 300 million could amount to approximately $8,000,000 per year.

Additional Cost Considerations

Although there is reasonable agreement between the estimated costs escalated from the PLG study and the "average" cost from the Maulbetsch Consulting survey, it is unclear that either of these estimates has captured all of the site-specific issues, which might lead to a higher cost. Some these considerations include:

- Difficulty in locating the tower
- Unusual site preparation costs
- Significant interferences to the cost of installation of the circulating water lines
- The need for cooling tower plume abatement
- Stringent noise control
- The use of an alternate make-up water

Location of Tower/Unusual Site Preparation Costs/Interferences:

It does not appear, from examining the aerial photos at the beginning of this write-up and some site plans made available for the study, that there is anyplace to site these large (~ 40 cell) cooling towers other than at the far ends of the property. As indicated in the figure below, all open land on the existing site is either protected area, state park land, is used for storage of materials, which cannot be stored elsewhere, or needed for traffic control to maintain compliance with safety requirements. Relocation of the parking area would require shuttling of employees and contractors to a distant location across the highway.

Locating the towers at the far ends of the property would require the installation of 4,000 feet of large (~ 20 foot diameter) for each tower. At a nominal cost of $11/foot length/inch diameter, the cost is at least $20 million assuming no interferences. This is significantly higher than the escalated cost for this item from the PLG report suggesting that shorter runs were assumed or lower (real dollar) costs for installation. In any case, there was clearly no allowance for the presence of interferences in the vicinity of the plant.

There is no information available to assess the possibility of unfavorable soil conditions, which could require extraordinary measures to stabilize the foundations for the towers. However, on "near coastal" cliffs this is a possibility, which would need to be considered in advance of committing to any tower location.

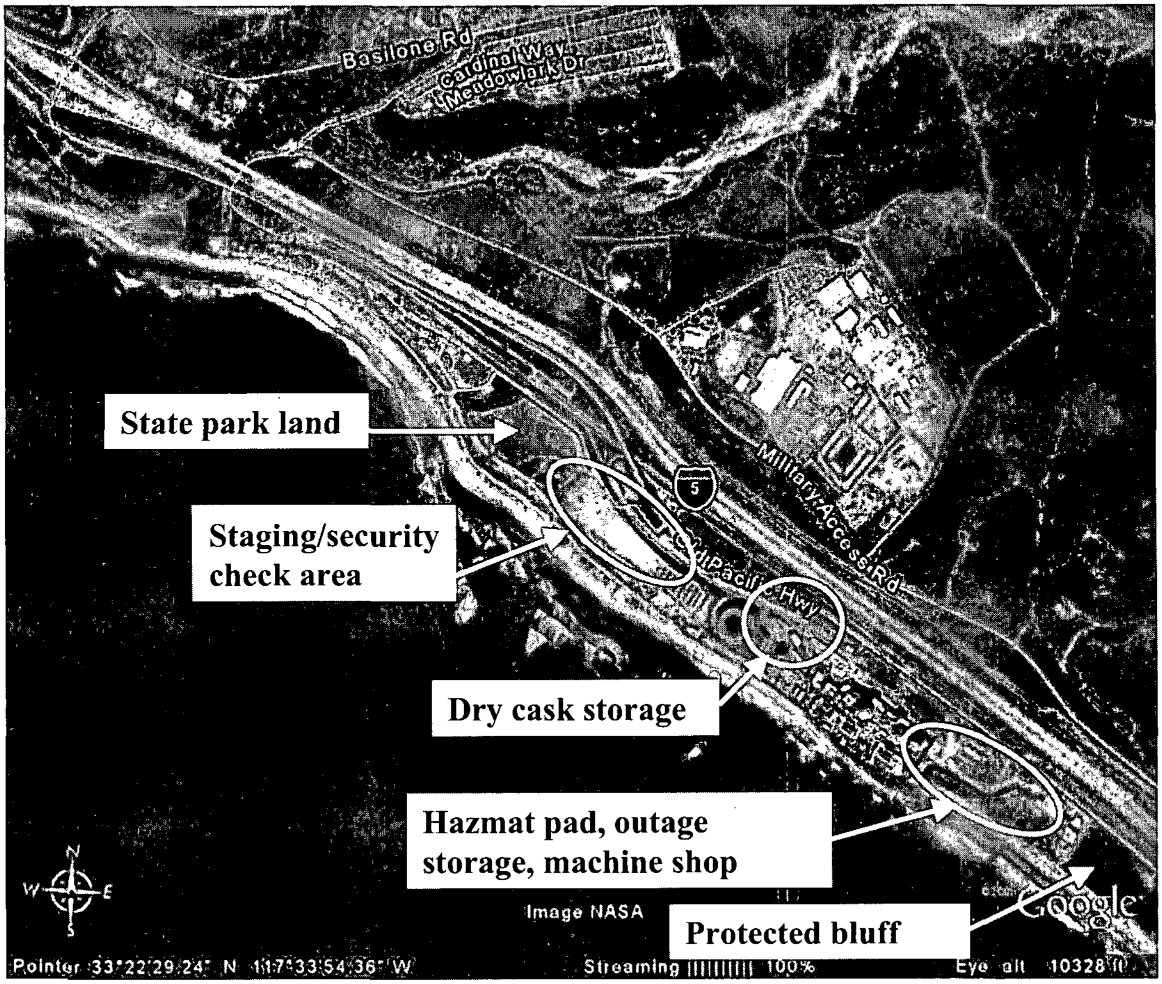

Figure Error! No text of specified style in document.**-9**
Conflicting Area Uses

Other Installation Constraints

The location and configuration of the intake area severely restricts the ability to locate an intermediate sump and the new circulating water pumps and motors.

Plume Abatement

Based on the view in the aerial photo of the neighboring area, it appears that a visible plume could be a serious issue at this site. This stems from safety concerns on I-5, which runs within 0.15 miles of the plant along the eastern boundary; from the possible effects on Marine air operations to the south, and from aesthetic sensitivity of the beach area.

It is reasonable to assume that a plume abatement tower would be required. Plume abatement towers have an air-cooled section on top of the wet tower. The hot water is pumped to the top of the tower, passes down through the dry section and then discharged onto the hot water distribution deck of the wet section. The air passing across the finned tubes of the dry section mixes with the wet plume coming off the wet section and keeps it from becoming saturated and condensing in the cold atmosphere. The need for a plume abatement tower would increase both the capital cost of the tower itself by a factor of perhaps 2. To 2.5 and the additional pumping power by an additional 30 to 50% due to the greater height to which the hot water must be pumped.

Aesthetics

In addition to any issues with a visual plume, the simple appearance of a cooling tower is sometimes considered an aesthetic affront. In this instance, the concern would be primarily the appearance of the towers from the beach and possibly from the residential areas (one to the east of I-5 located 1 to 1.5 miles to the north-northwest of the plant, another 2.5 to 3 miles to the north.). Considering the number, size and bulk of the plant buildings already present, this may not present a major problem. However, given the prevailing attitudes with regard to scenic issues on the coast and from recreational areas, it should be expected to be a contentious, time-consuming and costly issue.

Noise Control

Noise from wet cooling towers comes both from the fans and from the water cascading through the fill. Fan design or the reduction in air velocity, which sometime requires the use of bigger, or more, cells, can diminish fan noise. The water noise is more difficult to reduce and usually requires the construction of sound barriers around the cooling tower. It appears that cooling tower noise would not be a serious constraint based on the distance to residential areas. It may be that noise on the beach would be considered undesirable. An additional consideration is that the cliffs running west of the plant above the beach are a nesting habitat for the California coastal gnatcatcher, an endangered avian species. It might be argued that the noise would disrupt their nesting and breeding habits. On the other hand, the fact that highway noise from I-5 already exists may be a mitigating factor.

There is no information or experience available to this study to evaluate this issue, but it should be explored if a retrofit were undertaken. If noise abatement were required, the capital cost of the tower itself cost might increase from 20 to 40%.

Alternate Sources of Make-Up Water

The use of seawater make-up can introduce intractable problems regarding drift and related maintenance considerations. (See later discussion of drift and PM10.) An alternative can be to purchase reclaimed water from nearby municipal water treatment facilities.

In this instance, however, possibility of using reclaimed water for wet cooling tower makeup was considered and rejected due to the distance of sources from the plant, the expected very high cost of installing delivery and return pipelines to the remote sources and the expected extended time required to obtain permits even if the approach were deemed feasible.

Shutdown Period

There is often concern over the period of lost plant availability during the retrofit construction period. In this instance, it appears that the major part of the construction could be done while the plant is on-line, with shutdown required only for the final tie-in of the circulating water lines to the existing water circuit. There is no information available to estimate how long this might be.

Service Water System

The existing salt water "service water" system may require special attention since it represents an additional water intake (although not a cooing water intake under the normal 316 (b) definition and purview).

Other Environmental Issues

Retrofit to a closed-cycle cooling system introduces some environmental issues, which a once-through cooling system does not. These are increased air emissions from the stack and drift from the cooling tower.

Stack Emissions

It was estimated earlier that a capacity shortfall averaging 25 MW for the year and as much as 100 MW on the hottest days is to be expected. Therefore, the delivery of the same amount of electric power to the grid will require the burning of additional fuel at some location to make up that lost at San Onofre. Furthermore, in the discussion of this issue in Chapter 7, it was pointed out that the effect of making up this shortfall was highly variable depending on how and where the replacement power was generated. However, the capacity would almost surely be replaced with fossil generation since existing nuclear plants are already operating at high capacity factors and now ones cannot be rapidly installed. Therefore, the replacement power will come from units with air emissions that nuclear units do not have. No attempt is made to assess the effect in quantitative terms beyond pointing out that reliable estimates of the shortfall to be expected from full load operation can be made.

Drift

It is assumed that any cooling tower would be equipped with state-of-the-art drift eliminators rated at about 0.0005% of circulating water flow. The following table estimates the amount of drift to be expected from such designs. In addition, as discussed earlier, Federal EPA and State regulations characterize all solids carried off in cooling tower drift as PM10. The cost of offsetting this amount, should it be necessary will vary considerably form site to site as will the severity of the regulatory constraints.

Figure Error! No text of specified style in document.**-10**
San Onofre Drift Estimates

Unit	Flow	Drift[1]	Drift	PM10	PM10	Cap. Factor	PM10
	gpm	gpm	lb/hr	lb/hr	tons/year[2]	%	tons/year[3]
2	**811,000**	4.06	2027	101.33	443.8	**68.4**	**303.6**
3	**811,000**	4.06	2027	101.33	443.8	**69.0**	**306.3**

1. At drift eliminator efficiency of 0.0005%
2. Assumes full load all year
3. At 2006 capacity factor

Permitting Issues

As noted earlier, the site is bounded by state parks, environmentally sensitive areas and is within the coastal zone requiring approvals from several agencies. Since San Onofre is a nuclear plant, the NRC has jurisdiction over all aspects of any plant redesign and operational modification. Clearly, the permitting process will be more than normally complex, lengthy and costly with the many different agencies involved.

Changes in discharge from once-through cooling to closed cycle blowdown may require modifications to both NPDES and NRC discharge permits. Treated sewage discharge is not combined with cooing water discharge. Any chemical addition for befouling control of the intake and discharge tunnels or the tower fill would need to be considered in permits.

Special Considerations

Re-Optimization

It should be noted that all of the discussion so far has been based on the generic assumption made for this study that the existing circulating water system would be left in its existing operating state; that is, the condenser, the existing circulating water flowrate and the existing circulating water pumps themselves would be unchanged. The additional pumping power required to lift the water to the top of the towers and to pump them through the new circulating water lines would be supplied with a new set of pumps and the connection between the two circuits would be accomplished through existing intake and discharge bays or with a newly installed sump from which water to the towers is drawn. These assumptions are reasonable and appropriate for smaller, older plants with lower capacity factors and limited remaining life. They are likely not appropriate for San Onofre with a high capacity factor and a long expected remaining life.

In such circumstances, it would be economically preferred to re-optimize the cooling system to a configuration appropriate for closed-cycle wet cooling. Specifically, it is well known that closed-cycle systems optimize at lower circulating flowrates and higher condenser ranges than do once-through cooling systems.

Such a system will require somewhat larger towers but will operate at lower auxiliary power and provide better cooling and result in significantly lower total evaluated costs over the remaining life the plant. Such a conversion would involve a redesign and replacement of the condensers to operate at the lower flow rates (likely a change from single to two-pass configuration) with the likely requirement for extensive rearrangement of the massive piping into and out of the waterboxes and the opening up of the building structure around the condensers to accommodate the modifications.

If condenser modifications are required, the location of the condensers at 23 feet below grade would require extensive demolition and excavation to gain access. This would not only add to the cost but would greatly extend any required outage period for the retrofit to 6 to 12 months based on plant staff estimates. This is in comparison to a normal refueling outage of 30 to 40 days.

Even a cursory estimate of the cost of such massive modifications is well beyond the scope of this study. However, some guidance may be gained from the several studies conducted for Diablo Canyon as discussed in Section 6 of this report. It is noted that the S&W estimate was again well below the "average" survey result. However, two separate site studies were both well above the "difficult" survey result. The second of those studies, which attempted to account for the re-optimization, exceeded the "average" cost by nearly a factor of x3. It is noted that the PLG study did not capture these costs of re-optimization but rather estimated costs for an off-optimum system, as is the usual assumption in cooling system retrofit studies.

Security

If the cooling towers must be located on land outside of the existing security perimeter, as appears likely from the prior discussion of tower location, the additional area would have to be protected with additional fencing, guard towers an security staff. This would incur additional capital and operating costs in excess of average retrofit situations.

General Conclusion

It is difficult to capture the range of possible issues for a cooling system retrofit at San Onofre. If the existing circulating system is retained and the price of off-optimum cooling system performance is accepted, then the project cost would appear to be in the "average" to "difficult" range of perhaps $500 to $600 million. If the choice were made to re-optimize the system, it would likely exceed the "difficult" estimate of $675 million and perhaps significantly so.