Diablo Canyon License Renewal Feasibility Study
Environmental Report

Technical Data Report

IMPINGEMENT OF FISH AND SHELLFISH

Revision 0
2009

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1. Background

NRC made impacts on fish and shellfish resources resulting from impingement a Category 2 issue, because it could not assign a single significance level to the issue. Impingement impacts are small at many facilities, but might be moderate or large at other plants (NRC 1996). Information that needs to be ascertained includes (1) type of cooling system (whether once-through or cooling pond) and (2) current Clean Water Act 316(b) determination or equivalent state documentation.

Diablo Canyon Power Plant has a once-through heat dissipation system that withdraws from and discharges to the Pacific Ocean. The general design and operational parameters of the cooling system are provided in the DCPP License Renewal Application Environmental Report (Environmental Report) Section 3.1.2. This technical data report provides further detail of cooling system operations with regard to impacts on marine fish and shellfish drawn into the seawater intake system which become impinged on debris control systems.

Marine ecological resources in the vicinity of Diablo Canyon have been studied since the mid-1960s when the area was first considered as a power plant site. The early studies were conducted to provide baseline inventories of marine resources, and to evaluate potential effects of the planned thermal discharge from power plant once-through cooling systems. Predictive studies were also conducted before plant start-up to identify the environmental effects of full scale commercial operations. The majority of studies were focused on defining potential and actual thermal impacts in the discharge receiving waters. A comprehensive list of published reports from the extensive marine ecological studies is provided in Attachment 1 to the Environmental Report Section 4.4 Technical Data Report for Heat Shock (Thermal Discharge).

2. Clean Water Act (CWA) Section 401 Certification

Environmental Report Section 4.2 describes DCPP's current CWA Section 401 Certification status.

3. Description of Cooling System and Intake Design

3.1 Once-Through Cooling (OTC) System

Environmental Report Chapter 3 Subsection 3.1.2 provides the general description of the Diablo Canyon Power Plant once-through cooling system and volumes of seawater drawn through the intake structure during normal operations. The general layout and function of the intake structure for Unit 1 and Unit 2 is typical to that of most power plants using once-through cooling. Operation of the intake relies on bulk debris screening racks followed by traveling screens to filter out and remove debris large enough to occlude steam condenser tubes. However, the Diablo Canyon intake was also purposefully designed and constructed to reduce the potential for impingement of fish and other aquatic organisms during cooling system operations.

3.2 Intake Design Minimizing Impingement

The Diablo Canyon intake was designed using operational experience from Pacific Gas & Electric Company's (PG&E) former Sacramento California Delta Power Plants, and civil engineering guidance that incorporated information from "Studies on Fish Preservation at the Contra Costa Steam Plant of the Pacific Gas and Electric Company" 1953, authored by James Kerr (State of California Department of Fish and Game, Fish Bulletin No. 92). Fish impingement related operational experience, and findings of the Kerr study, were integrated into the PG&E 1960 Civil Engineering Manual for Circulation Water Systems. The manual identifies "Protection of Fish" recommendations for intake design that include engineering low intake structure approach water velocities and lateral escape routes for fish.

These engineering recommendations were incorporated into the design of the power plant intake structure. Specific impingement reduction considerations included; 1) a wide and flat face open to the environment to generate a uniform low velocity water flow from the mouth of structure up to the cooling water pump bay closure gates, 2) installation of cut-outs between closure gate forebays to provide a migration route for water and aquatic organisms, and 3) installation of passive fish return bays on each end of the structure. Operation of the cooling system has demonstrated the design to reduce fish impingement has been effective, and relatively favorable conditions are established in the source water environment immediate to the opening of the intake that facilitates the free movement and migration of fish onto and out of the structure.

Operational assessments have shown that approach water velocities into the mouth of the structure (between the curtain wall and basement concrete floor) are relatively uniform at approximately 0.8 feet per second (fps) leading up to the debris screening bar racks. Water velocities then increase to approximately 1.1 fps past the bar racks as the flow is channeled between concrete support partitions leading up to pump bay isolation gates that are installed in front of (seaward side) of each vertical traveling screen unit. The concrete partitions become slightly wider moving into the interior of the structure accounting for the minor increase in flow velocity. The velocity of water immediately in front of the main circulating water pump traveling screens increases, approaching 1.8 to 2.3 fps at the seaward face of the screen mesh. Initial traveling screen equipment design and installation produced velocities primarily toward the lower part of the range. Improvement to the framework of the screening equipment in the 1990's resulted in increase of velocities toward the higher end of the range. Localized differences due to equipment condition and levels of debris loading produce variances in through screen velocities at any given time within the range. For the auxiliary salt water bays, the through screen velocity is much lower, averaging only 0.5 fps. Though the through screen velocities of the main circulating pumps are appreciable, the uniform lower flow leading up to the immediate screen faces, and fact there are no abrupt directional changes in flow throughout the system, allow fish to move away from and ultimately escape impingement on the screens.

Large 5 foot by 27.9 foot (139.5 square-foot) cut-outs were placed in the concrete forebay partitions to provide a route for water and fish to freely migrate across the structure behind the debris exclusion bar racks. The design also maintains a generally uniform moderate velocity flow throughout the continuous space created within the interior of the structure. Subsequently, a relatively uniform water velocity is generated at the entrance of each of the concrete partitioned channels leading into individual main circulating pump traveling screen bays. Overall, the design facilitates reduction of abrupt changes in flow velocity or direction throughout the structure which produces a more predictable and accommodating environment for the free movement of fish.

An additional forebay was constructed at each end of the intake structure with a 9 foot wide debris exclusion racked opening leading back to the aquatic environment. Large cut-outs also exist in the inward wall of these forebays. Together, the cut-outs and extra forebays provide a lateral escape route designed into the structure. Fish are provided a location to migrate out of the low to moderate velocity intake flow and move out of or into the structure in relatively calm conditions with low induced currents.

The intake structure is also situated within an engineered cove protected by breakwaters. The design was primarily intended to protect the structure itself, exposed upper deck equipment, and traveling debris screens which are directly exposed to the marine environment from damage due to the impact of severe ocean swell activity. The size and shape of the cove created a confined area that restricts the movement of large numbers of fish in the immediate vicinity of the intake structure. This effectively reduces the occurrence of schooling fish common in the open ocean, reducing susceptibility to impingement.

Impingement losses experienced during power plant operations have been very low due to the purposeful placement of the intake in a perpendicular to shoreline configuration within a small source water cove, and internal design characteristics. The impingement performance assessment of the intake has determined that " Water flow in all areas of the intake structure between the bar racks and through the traveling screens is below the burst swimming speed of most species and appears to be slow enough to allow healthy fish to swim freely away from the traveling screens" (Tenera, 2000). Design criteria to limit loss of marine organisms due to impingement trapping and subsequent mortality has been successful.

4. Evaluation of Plant Intake Impingement and Impacts

4.1 Intake Impingement Studies

An analysis of impingement resulting from intake operations was conducted from April 1985 (just prior to the beginning of commercial operation of Unit-1 in May of 1985) through March of 1986. The study comprised a full year of impingement sampling, and impingement survivability evaluations conducted in accordance with the power plants initial 316(b) Demonstration Assessment (Tenera 1988). The study methodology used and summary of data obtained is provided in Section 4.0 of the 1988 study report.

The study was designed to provide quantitative information necessary to characterize impingement of fish and invertebrates resulting from source water flow drawn through the bar racks and traveling screens due to operation of the circulating water pumps. Multiple issues were investigated including species composition of impinged organisms, seasonal impingement distribution and diel patterns, the number and size of fish and selected invertebrates susceptible to impingement, and an examination the relationship between impingement and cooling water system operational parameters such as frequency of traveling debris screen rotation and washing cycles.

4.2 Fish and Shellfish Resources Susceptible to Impingement

During the year long study, a total of only 79 cartilaginous skates and rays (Chondrichtheys) and 323 bony fish (Osteichthyes) representing 66 separate taxonomic categories were collected and identified during the impingement sampling periods. The three most abundant fish species included yellow/olive rockfish (representing 20% of fish collected), thornback rays (14%), and plainfin midshipmen (5%). The entire list of species observed during the study is provided in the 316(b) Demonstration Reports for Diablo Canyon (Tenera 1988 & Tenera 2000). The summary of organisms found impinged in the highest abundance is provided in Table 1.

TABLE 1

Species Susceptible to Impingement
Moss Abundant Organisms - DCPP Impingement Demonstration Study

Fish (Vertebrate and Cartilaginous)	Shellfish (Invertebrate)
1. **Rockfish** (*Sebastes*) 2. **Thornback Ray** (*Platyrhinoidia triseriata*) 3. **Surfperch**(*Embiotocidae*) 4. **Sculpins** (*Cottidae*)	1. **Brown Rock Crab** (*Cancer antennarius*) 2. **Sharpnose Crab** (*Scyra acutifrons*). 3. **Kelp Crab** (*Pugettia producta*) 4. **Spider Crab** (*Pugettia richii*)

Rockfish, a group important to the regional commercial fishery, and also the largest percentage of boney fish found impinged during the intake assessment, were primarily smaller juveniles. In general, only a low percentage of juveniles naturally survive to reproductive adult life stages for most fish species. The predominance of juveniles in impingement samples is an indication that fish which have reached reproductive maturity are not highly susceptible to impingement in the DCPP intake. This is most likely attributable to the intake design which provides a uniform flow across the structure facilitating fish migration and escape.

For invertebrate shellfish, the most abundant species impinged included rock crabs (*Cancer antennarius*), and sharpnose crab (Scyra acutifrons). Total numbers collected for the year long study were only 1,294 and 1,143 respectively. Both species are abundant in the rocky tidal and subtidal zones along the central coast near the power plant, and proliferate within the plant intake cove, breakwater structures, and associated kelp habitat that occurs on native rocks and the concrete breakwater components. Cancer crabs are commercially harvested on the west coast, sharpnose crab are not of commercial importance. Susceptibility to impingement for some species including spider crabs (*Pugettia richii*) and kelp crabs (*Pugettia producta*) was tied to the quantity of ocean debris impinged on intake screens. Impingement numbers for these species were highest during the same period of time (October-December) when quantities of algal debris can be transported into the intake at the end of the algal growth season that is simultaneous with the beginning of significant West Coast Pacific storm activity.

Initial survival of invertebrates was found to be high (60-95%) however for fish much less so averaging only 27%. Of note during the study, quantities of bony fish (Osteichthyes) impinged was so low, that long term survival studies of recovered fish could not be completed as the results would have been invalid due to the very small sample sizes.

During the study, fish were observed (and have continued to be observed in informal surveys conducted throughout commercial plant operations) actively inhabiting and foraging in the intake structure. The design of the intake, and environmental conditions during operations, effectively creates habitat found favorable by many indigenous fish and shellfish species.

In addition to the very low impingement demonstrated by the year long assessment, operation of the cooling system during the initial license period has not resulted in any known or recorded acute mass impingement events for fish or shellfish.

The current design and operation of the intake directs screen wash water and entrained material through sluices into a debris grinding system. Debris grinding is necessary to adequately manage heavy ocean debris loading events by reducing the occurrence of pump clogging, allowing screen wash system operability to be maintained. All material impinged and washed off the traveling screens is subjected to reduction in the grinding system, and is subsequently pumped to discharge with the wash water. Survivability of impingement for all organisms is therefore assumed to be zero

4.3 Assessment of Impingement Losses

Extrapolation of the sampling results from the 1985-1986 study to include those periods not sampled concluded that full power operations results in the impingement of approximately 2.3 pounds of fish biomass per day. Of this total, approximately 0.7 pounds are boney fish, and 1.6 pound represents cartilaginous fish (skates and rays). Unit-2 impingement is higher for cartilaginous fish than Unit-1, however boney fish are impinged at similar rates for both Units 1 & 2. Invertebrate shellfish impingement biomass losses attributable to the most abundant as well as commercially important organism, cancer crabs, averaged approximately 0.5 pounds per day for both Units.

Loss estimates are based on the once-through cooling system operating at maximum flow (four main circulating water pumps and two auxiliary system pumps in operation)on a continues basis. Scheduled outages, forced outages, and periodic curtailment for maintenance reduce actual unit operations. Therefore, actual biomass impingement for all fish and commercially important shellfish is estimated at approximately 2.5 pounds per day on average. The total for all aquatic organisms observed impinged results in a biomass loss estimate of approximately 900-1200 pounds per year.

In comparison to biomass impingement recorded at other west coast power generation facilities, Diablo Canyon's annual impingement losses have been exceeded in a single day at other plants with lower net once-though cooling withdrawal volumes. Total annualized losses at other power plants can also be significant in relation to Diablo Canyon. "For comparison, the Huntington Beach Power Plant, with flow volumes one fourth the flow volumes of DCPP, and with an offshore intake structure, impinges up to 21 tons of fish per year. The El Segundo Power Plant, also with flow values about one fourth DCPP flows and using an offshore intake, impinges about 15 tons of fish per year" (CCRWQCB 2003).

The majority of observed impinged fish are small, primarily young-of-year juveniles such as rockfish in the 60-80 mm length range. Reproductive capable fish are rarely found impinged at the power plant intake. Juveniles of most species have low percentage survivorship to adult stages in the marine environment. Loss of juvenile fish is therefore generally considered less impactful to the ecological system than loss of mature reproductive adults

In terms of impingement rates, losses for fish during the study averaged approximately 2 fish per 1 million cubic meters of source water withdrawn from the intake cove. 1 million cubic meters of water is equivalent to 264 million gallons of water. During full power operations (4 main circulators and 2 auxiliary circulators in operation), Diablo Canyon Units 1 & 2 have the potential to circulate 2.53 billion gallons of water per day through the seawater cooling system when maximum pump capacity ratings are used. This is equivalent to 9.6 million cubic meters of seawater. In this context, only 19 individual fish per day are lost due to plant operations. Assuming continuous full power operations (not accounting for outages or curtailments), approximately 7,000 individual organisms, the majority small non-reproductive juveniles, represents the total estimated loss of fish due to intake impingement on an annual basis.

The low total biomass lost, low impingement rate and associated low absolute number of organisms impacted, and fact that losses for fish are primarily non-reproductive juveniles, supports a determination that impingement impacts are insignificant for the power plant.

4.4 Ecological Impacts due to Impingement Losses

Losses from impingement due to plant operations are so low that ecological or cumulative effects are not quantifiable. Available evidence supports the conclusion that adverse ecological impacts due to impingement losses from operation of the Diablo Canyon Power Plant are most likely non-existent.

Because impingement losses are insignificant, they are not considered a factor in assessing potential cumulative impacts from operation of the once-through cooling system. Larval fish and shellfish entrainment losses are appreciable in the context of absolute numbers (Reference Environmental Report Section 4.2) however, degradation of the marine ecological system attributable to those entrainment losses have also not been observed or quantified. Based on the information available from the extensive marine ecological studies conducted at the plant site, as well as independent assessments of fisheries health in the immediate coastal region, a relatively stable and productive marine ecological system continues to exist. As such, apportionment of observable ecological impacts attributable to plant impingement losses are not possible.

4.5 Mitigation Measures to Reduce Impingement Losses

During the initial license period, no specific measures have been implemented to reduce impingement losses. This is primarily due to the fact impingement losses are insignificant, and no adverse ecological impacts from the losses can be quantified. Additionally, the cost of any technology installation to further reduce the levels of impingement would be substantial in comparison to any potential benefit. "The minor impingement losses at DCPP are so insignificant that they do not justify implementation of alternatives to the cooling water intake structure to further reduce the losses (the losses are already minimized)" (CCRWQCB 2003).

In order to reduce the through screen approach velocities of the intake to 0.5 fps or less construction of an intake structure two to three times the size of the current structure would be required (0.5 fps criteria was incorporated in the initial USEPA Phase II Rule for existing intakes). Installation of modified screening systems with a fish return system would require extensive modification of the existing intake. The cost of such modifications would be very significant in relation to any environmental benefit that could be realized. In addition, for advanced screening technologies, operability in the open ocean environment at the power plant location would not be assured. The survivability of fish or invertebrates would likewise be speculative for any given capture and return system.

In summary, there is no strategy beyond current design and operational practices that would provide a significant reduction in the already very low impingement performance of the power plant, and no quantifiable ecological level environmental benefit would be realized from any such effort.

5. Monitoring of Aquatic Resources Potentially Impacted by Power Plant Operations

An extensive marine ecological monitoring program has been conducted at Diablo Canyon. The program is ongoing, with studies conducted both prior to operation of the facility, as well as continuously since start of commercial operations. Reference Environmental Report Section 4.4, Heat Shock (Thermal Discharge), for more detailed information on the monitoring of aquatic resources potentially impacted by power plant operations.

6. Consultations with Regulatory Agencies

6.1 Regulatory Assessment of Impingement Impacts

The regulatory agency directly responsible for Diablo Canyon NPDES permitting provided oversight for an independent Technical Working Group that assessed the significance of plant impingement. The agency staff report dated July 10, 2003 (CCRWQCB 2003) provides a summary of the assessment. "Regarding impingement of adult fish in the intake structure, the number of fish lost per year is so minor (a few hundred fish per year) that intake structure modifications or operational changes are not necessary. These losses are already minimized pursuant to Clean Water Act Section 316(b)".

During development of the 316(b) Demonstration Study conducted in the 1990's for the Diablo Canyon once-through cooling system, an evaluation of impingement was not required. The Technical Working Group coordinated by the regulatory agency providing design and implementation oversight for the study determined that impingement was so low at the power plant, that a second evaluation was unnecessary (Tenera 2000), and results of the 1985-1986 assessment were sufficient to support the conclusion that impingement losses were already minimized, and that no technology improvements to the intake structure or mitigation for losses was necessary.

6.2 USEPA Phase II Regulation Impingement Standard

In 2004, USEPA promulgated the Phase II Rule for Implementation of CWA Section 316(b) for existing power generation facilities with once-through cooling systems that withdraw in excess of 50 million gallons per day (mgd) of source water. For existing intakes with approach velocities at or below 0.5 fps, facilities were to be considered in compliance with 316(b) for impingement performance regardless of site specific impingement losses. For those facilities with intake approach velocities 0.5-fps, a technology reduction standard of 85-95% of baseline impingement losses was to be achieved in order to meet the impingement performance requirement. However, in the initial Phase II Rule, if the cost of technology implementation to meet the performance based standard was found to be significantly in excess to potential benefits, the facility could be subject to a site-specific determination of compliance. In January of 2007, the

US Federal 2nd Circuit Court ruled (Riverkeeper Decision), that site specific cost benefit evaluation was not an appropriate component in the determination of compliance with requirements of Section 316(b) of the CWA. The Phase II Rule was remanded to the US Environmental Protection Agency (USEPA), and implementation of the Phase II Rule subsequently suspended by the Federal Agency. The cost benefit ruling of the 2nd Circuit Court was appealed to the US Supreme Court. The high court ruling on the issue was released on April 01, 2009 allowing consideration of cost verse benefits by USEPA in the development of rulemaking and rule compliance strategies. The Supreme Court ruling may result in the development of a final rule that will be supportive of the conclusion that any attempt to reduce impingement at the DCPP would be significantly disproportionate to any potential ecological benefits.

Uncertainty remains regarding final regulations for assessing impingement impacts and the subsequent compliance strategies which will be available to meet intake performance standards related to Section 316(b) of the CWA. However, regardless of final federal rule requirements, impingement losses of fish and shellfish from the operation of the Diablo Canyon Power Plant intake will remain insignificant in absolute numbers related to cooling water withdrawal volume, not result in quantifiable adverse impacts to populations of those organisms impinged, and not result in ecological level impacts.

7. Conclusion – Impacts on Fish and Shellfish Resources Due to Impingement During a Period of Extended Operation

Impingement of fish and shellfish has not been significant during the initial license period. In accordance with the assessment completed during operation of the power plant intake, and testimony of regulatory agency staff (CCRWQCB 2003), there are no reasonable structural or operational changes that can be implemented to further reduce impingement losses at the facility. Additionally, losses are so minor that mitigation is not necessary.

Therefore, use of once-through cooling at the Diablo Canyon Power Plant does not result in significant impingement losses, or demonstrable adverse impacts to fish and shellfish resources in the vicinity of the facility. Impingement impacts from cooling system operations during a license renewal period, based on determinations of impingement significance and ecological impacts during the current operating license period, are projected to be SMALL.

8. References

Diablo Canyon Power Plant Cooling Water Intake Structure 316(b) Demonstration. Tenera Inc. 1988.

Diablo Canyon Power Plant Cooling 316(b) Demonstration Report. Tenera Inc. 2000.

Staff Testimony for Regular Meeting of July 10, 2003 Pacific Gas and Electric Company's (PG&E's) Diablo Canyon Power Plant Renewal of NPDES Permit. Central Coast Regional Water Quality Control Board [CCRWQCB], 2003.