APPROACH FOR SOUTHERN CALIFORNIA EDISON 316(b) ENTRAINMENT STUDIES

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EXECUTIVE SUMMARY

Rationale for plankton entrainment, loss, and/or mortality studies were developed for Southern California Edison generating station 316(b) representative intake sites.

Phytoplankton entrainment has traditionally been measured by species counts or chlorophyll biomass determinations. These methods require extensive and frequent replication. Vital staining and primary production assessments of mortality are often unreliable. Source water body phytoplankton reproduction indicates populations possess compensation cabilities greatly exceeding entrainment induced mortality.

Confidence in species estimates of entrained zooplankton is reduced by the large fraction of animals less than 200 microns in diameter, for which little taxonomic information exists. Vital stains provide reliable information and are logistically superior to motility criteria; but, not all stained zooplankton species react similarly. Difficulties observed for zooplankton entrainment and mortality methodology make determination of effects on the source water body community fairly subjective. Holoplanktonic reproductive compensation capabilities are high, reducing potential effects in the source water body to a minimum.

Southern California Edison has collected extensive information on phyto- and zooplankton entrainment and receiving waters since 1970. Two independent scientific evaluations recommended that these data be standardized and reanalyzed for inclusion in the 316(b) demonstrations, and that further studies would not provide better information than the existing state-of-the-art data.

The important considerations to provide a scientifically credible 316(b) demonstration involve evaluating loss estimates and comparing those data to estimates of the standing fishery stock in the nearshore

environment. It is therefore our approach to selectively study ichthyoplankton entrainment on a monthly basis at all representative generating stations, and to compare these estimates with an evaluation of ichthyoplankton estimates within the Southern California Edison service territory and the California Bight.

Loss evaluations will be performed seasonally at sites representing velocity cap and canal intakes to develop information on mass balance and grazing by the resident biofouling communities. Should mass balance surveys detect high return of ichthyoplankters, samples will be taken to estimate survivorship.

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The objective of this document is to provide rationale for entrainment, loss, and/or mortality studies of specific planktonic assemblages at selected representative intake sites as related to Section 316(b) studies.

Coastal electric generating stations utilize large volumes of seawater as a means of dissipating waste heat from steam condensers. Members of the plankton community, which form the basis of the food chain for inshore marine organisms, are withdrawn from the water column and are entrained with the cooling waters.

Three major questions arise with respect to plankton entrainment: 1) what species are being entrained, 2) what is the transit loss resulting from entrainment (heat, mechanical damage, chemical addition, and predation); and, 3) how does entrainment loss affect the source water body plankton population? The following discussion examines the feasibility of answering these questions, and develops rationale for proposed investigations.

Phytoplankton

Entrainment. The entrainment of phytoplankton can be examined by two methods. In the first, individual species are identified and their concentrations determined by direct count. This approach defines species entrained and their concentration. However, the species composition changes continuously. Allen (1940), in a review of 20 years of phytoplankton data from southern California, indicated that no two years, months, or weeks were the same in terms of phytoplankton species composition and concentration. Both may undergo major changes in a matter of hours (Marine Biological Consultants, Inc., 1976). To develop reasonable statistical confidence in detecting the effects of phytoplankton

entrainment, studies should be continuously conducted. Because of the frequency of collection necessary to gather meaningful data (possibly daily collections), and the replication necessary to maintain data confidence (due to the contagious nature of phytoplankton distribution), the cost of such a program is prohibitive.

Biomass determination, the second method, uses chlorophyll analysis (Lorenzen, 1966). However, no information on the entrained species composition is obtained. It has been shown that cellular chlorophyll concentration is dependent on age, health, and various other environmental factors (Yentsch and Ryther, 1957; Slovacek and Bannister, 1973; Loftus and Seliger, 1975); thus, chlorphyll values may not provide exact biomass measurements.

Mortality. As entrained phytoplankton pass through the cooling system of a generating station, they are exposed to elevated temperatures and pressures, which may result in mortality depending on the species involved and ambient environmental conditions (Briand, 1975). In addition, predation by fouling organisms lining the intake and discharge conduits may add to the total entrainment mortality.

Vital stains were used with some success in distinguishing living phytoplankton cells from dead cells (Gaff and Okong'O-Ogola, 1970; Crippen and Perrier, 1974). Phaeo-pigment (degradation product of chlorophyll) analysis was also used to quantify mortality (Marine Biological Consultants, Inc., 1975a,b, 1976). However, species composition is unknown, and it is impossible to determine if changes in phaeo-pigment concentration are results of dead cells, or living cells with partially degraded chlorophyll. Some evidence suggests the latter is true (Eppley et al., 1976).

Primary production investigations may quantify phytoplankton entrainment mortality (Brooks et al., 1974a,b; Smith et al., 1974; Briand 1975; Marine Biological Consultants, Inc., 1973, 1975a,b, 1976; and Environmental Quality Analysts, Inc., and Marine Biological Consultants,

Inc., 1978). As with chlorophyll, there is no way to determine what species are affected, or if reduced production is the result of mortality or a short-term depression of production due to the entrainment process.

Source Water Body. To determine the effect of phytoplankton entrainment on the offshore community, an investigation of the source water body is required. At generating stations with offshore discharges, little effect is documented (Marine Biological Consultants, Inc. 1976, 1977). The mixing of entrained waters with receiving waters probably masks mortality associated with station transit. Since doubling times for phytoplankton are in the range of several hours to several days (Strickland, 1970; Eppley et al., 1972; MBC, 1978), loss of phytoplankton due to entrainment mortality is naturally compensated.

At generating stations with discharge canals (e.g. Alamitos Generating Station), effects of mortality may be determined before entrained waters mix with the receiving waters. Briand (1975) observed that entrainment of phytoplankton was disruptive to the structure of the phytoplankton community, resulting in reduced species diversity. He noted that entrainment affected each species differently, generally killing diatoms in larger numbers than dinoflagellates. Briand's findings substantiate that mixing of entrained and receiving waters may mask entrainment related mortality.

Accepted techniques for entrainment and mortality studies are expensive, and must be repeated at frequent intervals. Since receiving water investigations at SONGS (Lockheed Center for Marine Research, 1975, 1976, 1977) and Ormond Beach (Marine Biological Consultants, Inc., 1975, 1976) indicated no effect of plant operation on the phytoplankton community in adjacent waters, entrainment and source water body studies do not provide a sufficient cost to benefit ratio.

Proposed Phytoplankton Studies. Previous phytoplankton studies at several Southern California Edison generating station intakes (Marine Biological Consultants, 1973, 1975a,b, 1976; Environmental Quality

Analysts and Marine Biological Consultants, Inc., 1978) indicated no offshore effect. Recent independent reviews of this and other entrainment data (Lawler, Matusky, and Skelly Engineers, 1979; Ecological Analysts, Inc, 1979) agree with our findings, and suggest all previous data be standardized and cumulatively reported for inclusion into the Southern California Edison 316(b) demonstrations, and additional studies would not increase our understanding of phytoplankton entrainment.

Zooplankton

Entrainment. Members of the inshore zooplankton community range in size from several microns to several millimeters. The community consists of macrozooplankton (less than 200 microns) and microzooplankton (35 to 200 microns). The former is composed of adult forms of most holoplanktonic species and larval forms of many intertidal and subtidal invertebrates, while the latter consists primarily of nauplii (larvae) of copepods, and many early stages of various invertebrates and protozoans. Because of the trophic and ecological importance of the two size classes of zooplankton, both must be sampled.

Major taxonomic problems are associated with entrainment studies. We must determine what species are entrained and their concentrations. Since a majority of the microzooplankton can not be identified below the family level, an important element of the entrainment data is absent and only provides narrative and subjective conclusions as to possible changes.

Mortality. To determine how transit through a generating station cooling system affects zooplankton survival, mortality investigations need to be conducted. There are two different methods for determining mortality in zooplankton. The first uses motility as a criterion for sorting live and dead zooplankton (Lauer, et al., 1974; Icanberry and Adams, 1974; Davies and Jensen, 1974a,b,c). Examination for live-dead determination must be completed at the sampling site, and may result in logistical problems. The second method is the vital stain neutral red

(Crippen and Perrier, 1974). This permits transport of samples to the laboratory before live-dead determination, and is logistically superior to motility for mortality determination. Vital stain is selective and does not work satisfactorily on all zooplankters (Crippen and Perrier, 1974; Marine Biological Consultants, unpublished data). Until such a stain is developed, only a partial solution to the problem of live-dead determination exists.

Larval members of the microzooplankton community, as well as many macrozooplankton larvae, cannot be identified below the ordinal level. These larval groups are important to the structure of the benthic and intertidal communities in adjacent nearshore areas. However our present knowledge of invertebrate larval taxonomy makes it impossible to relate the entrainment loss of planktonic larval invertebrates to local changes in the benthic and intertidal communities.

Source Water Body. Entrainment and mortality investigations do not provide sufficient information to determine the affects of zooplankton entrainment on the source water body community. Studies at the Ormond Beach Generating Station and at San Onofre (Lockheed Center for Marine Research, 1975, 1976, 1977; Marine Biological Consultants, Inc., 1975, 1976; Barnett and Sertic 1978) detected no effect of plant entrainment on the offshore zooplankton community. However, Carpenter et al. (1974) predicted that plant entrainment was responsible for a loss of from 0.1%-0.3% of the secondary production in Long Island Sound, while Naylor (1965) and Youngbluth (1976) have both observed changes in copepod speciation and diversity in bays influenced by generating station operation.

The greatest effects of zooplankton entrainment are normally manifested in receiving waters located in areas of restricted flow, such as bays; however, Heinle (1969) indicated that this is not always true. In the case of open coastal discharges, mixing of discharge with receiving waters quickly mitigates any affect of entrainment mortality. Data at San Onofre indicate no detectable change in species composition or dominance

in the holoplanktonic community between the period prior to plant operation (1968) and the present (Barnett, 1973; Lockheed, 1978).

Development of zooplankton entrainment and source water body studies are not cost effective. Several problems must be resolved before these studies will provide the data necessary to examine entrainment effects. Taxonomic problems need be solved before the fate of many invertebrate larval forms can be determined. Techniques for live-dead determination must be further developed. Once these and other problems are alleviated, entrainment and mortality studies directed towards the fate of larval forms may provide sufficient information to develop a valuable data base.

Proposed Zooplankton Studies. Previous zooplankton studies at Ormond Beach and San Onofre (Marine Biological Consultants, Inc., 1975, 1976) demonstrated no change in the temporal or spatial qualities of the sampled populations. All zooplankton data has been recently reviewed by Lawler, Matusky, and Skelly Engineers (1979) and Ecological Analysts, Inc., (1979). Conclusions and recommendations of these independent evaluations indicate no detectable affects on zooplankton as a result of entrainment, and additional studies would not provide better information than the existing state-of-the-art data. All previous data will be standardized and reported cumulatively, directed toward the objectives of the SCE 316(b) demonstrations.

Because little information exists on entrainment at our canal intakes, we will use data obtained by the Los Angeles Department of Water and Power (LADWP) in Anaheim Bay for the Haynes (LADWP) and Alamitos (SCE) Generating Stations 316(b) demonstrations.

Ichthyoplankton Studies

The taxonomy of ichthyoplankton, unlike most other meroplanktonic forms, is relatively well known in southern California nearshore waters, particularly those species that are economically important as either

sport or commercial resources. Because their concentrations are normally considerably less than either zooplankton or phytoplankton species, and the adult reproductive potential is also considerably lower, the possibility arises that ichthyoplankton entrainment related losses may have a detrimental effect on the adult standing stock.

Entrainment. Ichthyoplankton entrainment studies do not produce a sufficient data base to evaluate the effects in the source water body of larval fish transit through a cooling system. These studies provide species concentration information. Some estimate of entrainment mortality must be developed together with data on the available resource in the source water body, and an estimate of adult populations present in the offshore area. We will assume that entrainment mortality is 100%. The need for mortality studies is eliminated together with considerable cost savings.

Mortality. There are two approaches to determine the significance of loss. The estimated number of ichthyoplankters entrained can be considered lost to the system and compared to estimates of the available fishery stock of either ichthyoplankters or adult stock potential. The second approach would be to determine the number of organisms exiting the cooling water system and develop a ratio of organisms entrained to those returned to receiving waters. Survivorship could provide information on the effects of the system components on entrained organisms (conduit grazing, chlorine, heat, etc.). However, the present state of the art dictates that component analysis (with the exception of grazing) is not realistic.

A "larval table" (McGroddy and Wyman, 1977) has been proposed for the collection of ichthyoplankton to determine mortality. The device has been used only at generating stations with discharge canals. Because there is a strong possibility that cropping of zooplankton and ichthyoplankton by the fouling community lining the intake and discharge conduits occurs at generating stations with offshore intakes and discharges (Marine Biological Consultants, Inc., 1975a; Barnett and Sertic, 1978),

the device must sample at the offshore discharge. Sampling at this site may require substantial modification of the larval table and has been demonstrated unfeasible under almost all conditions (personal communication, John Schumann, Los Angeles Department of Water and Power).

Source Water Body. To examine what fraction of the available ichthyoplankton resource is lost to entrainment mortality, an investigation of the ichthyoplankton community present in the source water body is required. The investigation should be designed to sample that fraction of the available resource that is consistently exposed to entrainment.

Concurrently with ichthyoplankton studies, an investigation of adult fish populations, whose larvae are consistently entrained, is needed. Without these data, the effects of entrainment mortality cannot be determined.

Ichthyoplankton is the only plankton community with a suitable data base for the southern California coastal waters. Approximately two years of monthly intake and offshore collections were conducted by Marine Biological Consultants, Inc. (1979), and Barnett and Sertic (1978, 1979) at San Onofre Nuclear Generating Station. Four years of monthly sampling adjacent to the Redondo Beach Generating Station were conducted by McGowen, and approximately 12 months of ichthyoplankton data were collected from the Southern California Bight by Brewer and McGowen (Brewer et al., 1979).

Proposed Ichthyoplankton Studies. We believe that the important considerations to providing a scientifically credible 316(b) demonstration involve evaluating loss estimates and comparing those data to estimates of the standing fishery stock in the nearshore environment. It is therefore our approach to selectively study ichthyoplankton entrainment on a monthly basis at all representative generating stations and to compare these estimates with an evaluation of ichthyoplankton estimates within the Southern California Edison service territory and the California Bight.

Evaluations will be performed seasonally at sites representing velocity cap and canal intakes to develop information on through plant loss grazing by the resident biofouling communities. Should through plant loss surveys detect high return of ichthyoplankters, samples will be taken to estimate survivorship.

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