Encina Power Station
4600 Carlsbad Boulevard
Carlsbad, CA 92008-4301

Direct: (760) 268-4000
Fax: (760) 268-4026

NRG CABRILLO POWER OPERATIONS INC.

September 2, 2004

Mr. John R. Phillips, P.E.
Senior Water Resource Control Engineer
San Diego Regional Water Quality Control Board
9174 Sky Park Court, Suite 100
San Diego, CA 92123-4340

Subject: **Cabrillo Power I LLC - Encina Power Station; Phase II 316(b) Entrainment and Impingement Sampling Plan**

Dear Mr. Phillips;

Cabrillo Power I LLC (Cabrillo) is pleased to submit a plan to conduct entrainment and impingement sampling for the Encina Power Station (EPS) to comply with the US EPA's recently published Phase II rule for compliance with Section 316(b) of the Clean Water Act. The approval of the EPS Entrainment & Impingement Sampling Plan (E&I Plan) is one of the early steps in the facility's compliance with the Phase II rule. Cabrillo requests expedited review and approval of this E&I Plan in order to optimize the sampling synergies available by virtue of the data collection efforts already underway on behalf of Poseidon Resources (Poseidon) for their proposed desalination project at EPS.

This sampling plan was prepared by Tenera Environmental (Tenera), which is the same firm that prepared the desalination sampling plan submitted to the San Diego Regional Water Quality Control Board (San Diego RWQCB) on behalf of Poseidon in July 2004. Consistent with that sampling plan, Poseidon has already collected several complete sets of entrainment and source water samples at EPS. The Poseidon study plan and collected data will produce information on the larval fish and target invertebrates contained in Poseidon's source of desalination feedwater (the power plant's cooling water discharge), as well as information on the larval fish and target invertebrates contained in the power plant's source waterbody and intake flows.

Data being collected for Poseidon on the power plant's source population of entrainable larval fish and target invertebrates is identical to the information Cabrillo will be required to collect and analyze for EPS Phase II 316(b) studies. Tenera has prepared this sampling plan to seamlessly and consistently continue the collection of the Poseidon entrainment data. In that way, Cabrillo can continue the sampling effort for compliance with the new Phase II performance standards in an efficient and cost-effective manner.

In the past five years, Tenera has completed 316(b) resource assessments for the Diablo Canyon Nuclear Power Plant, Moss Landing Power Plant, Morro Bay Power Plant and Potrero Plant. Tenera study design and assessment methods are also being employed in the ongoing 316(b) studies for the Huntington Beach Generating Station. Throughout these projects, Tenera has worked closely with State and Federal agencies in the development of their field study, impact assessment, and benefits evaluation methods. Tenera has also just recently completed a 316(b) resource assessment for the South Bay Power Plant that has been presented in final form to the San Diego RWQCB. Cabrillo's proposed E&I Plan has been developed in consideration of, and in keeping with, the 316(b) study rationales, content, sampling methodology, analysis and reporting that were used in the South Bay Power Plant 316(b) Assessment (Duke Energy South Bay, May 2004), as well as all of the power plants listed above.

This submission of the EPS E&I Plan is intended to meet part of the requirements for the Proposal for Information Collection (PIC) section of the Phase II 316(b) regulation, but not to address all of the PIC requirements at this time. All of the sampling plan requirements specified in Section 125.95(b)(1)(iv) are incorporated into the EPS E&I Plan. At a later date, Cabrillo will submit the remainder of the PIC requirements pursuant to Section 125.95(b)(1). Cabrillo requests approval of this E&I Plan specifying how new E&I data will be collected, but acknowledges that the San Diego RWQCB will be able to review the other portions of the PIC once submitted by Cabrillo.

Therefore, in order to provide continuous, efficient and cost-effective sampling at EPS, Cabrillo requests that the San Diego RWQCB expedite review and approval of this E&I Plan. Cabrillo understands that San Diego RWQCB is considering retaining an outside consultant in order to provide timely response to this request. Cabrillo is available and prepared to work with your staff and the consultant to provide any additional clarification necessary to obtain timely approval.

Please contact Tim Hemig directly at 760.268.4037 if there are any questions.

Sincerely,
Cabrillo Power I LLC
By: Its Authorized Agent,

Gregory J. Hughes

By: NRG Cabrillo Power Operations Inc.
Gregory J. Hughes
Regional Plant Manager

cc: Tim Hemig, Sheila Henika, John Steinbeck (Tenera)

Cabrillo Power I LLC, Encina Power Station

316(b) Cooling Water Intake Effects Entrainment and Impingement Sampling Plan

Submitted to the California Regional Water Quality Control Board – San Diego Region for Compliance with Section 316(b) of the Clean Water Act

September 2, 2004

Prepared by:
Tenera Environmental
971 Dewing Ave. Suite 101
Lafayette, CA 94549

225 Prado Rd. Suite D
San Luis Obispo, CA 93401

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1.0 INTRODUCTION

1.1 Development of the 316(b) Sampling Plan

This document presents a sampling plan for conducting the entrainment and impingement sampling necessary for a cooling water intake assessment required under Section 316(b) of the Federal Clean Water Act (CWA). Our sampling plan is based on a survey and compilation of available background literature, results of completed Encina Power Station (EPS) intake studies, and cooling water system studies at other power plants. The data from this study will form the basis of demonstrating compliance with the new Phase II regulations recently developed by the U.S. Environmental Protection Agency (USEPA).

1.2 Overview of the 316(b) Program

Section 316(b) of the Clean Water Act requires that "the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact" (USEPA 1977). Because no single intake design can be considered to be the best technology available at all sites, compliance with the Act requires a site-specific analysis of intake-related organism losses and a site-specific determination of the best technology available for minimizing those losses. Intake-related losses include losses resulting from entrainment (the drawing of organisms into the cooling water system) and impingement (the retention of organisms on the intake screens).

1.2.1 Target Organisms Selected for Study

The USEPA in its original 316(b) lists several criteria for selecting appropriate target organisms for assessment including the following:

1. representative, in terms of their biological requirements, of a balanced, indigenous community of fish, shellfish, and wildlife;
2. commercially or recreationally valuable (e.g., among the top ten species landed—by dollar value);
3. threatened or endangered;
4. critical to the structure and function of the ecological system (i.e., habitat formers);
5. potentially capable of becoming localized nuisance species;
6. necessary, in the food chain, for the well-being of species determined in 1–4; and
7. meeting criteria 1–6 with potential susceptibility to entrapment/impingement and/or entrainment.

In addition to these USEPA criteria there are certain practical considerations that limit the selection of target organisms such as the following:

- identifiable to the species level;
- collected in sufficient abundance to allow for impact assessment, i.e., allowing the model(s) constraints to be met and confidence intervals to be calculated; and
- having local adult and larval populations (i.e., source not sink species). For example, certain species that may be relatively abundant as entrained larvae may actually occur offshore or in deep water as adults.

These criteria, results from the previous 316(b) studies at EPS completed in 1980, results from a supplemental 316(b) study completed in 1997 (EA Engineering 1997), results from more recent studies on the ecological resources of Aqua Hedionda Lagoon (MEC Analytical Systems 1995), and data collected from studies described in this document will be used to determine the appropriate target organisms that will be evaluated in detail. The final target taxa will include the fishes that are found to be most abundant in the entrainment and impingement samples. In addition to large invertebrates that may be abundant in impingement, megalopal (final) larval stage of all species of cancer crabs (*Cancer* spp., which includes the edible species of rock crabs) and the larval stages of California spiny lobster will be identified and enumerated from all processed entrainment and source water plankton samples.

1.3 Sampling Plan Organization

This sampling plan first describes the EPS environment, design, and operating characteristics. The methods for obtaining updated information on the types and concentrations of planktonic marine organisms entrained by the power plant's CWIS are then discussed. A discussion of the theoretical considerations behind the assessment methods for the entrainment and impingement data is then presented. The final 316(b) report will also include an overview of alternative intake technologies and an analysis of feasible alternatives and their cost-effectiveness to minimize adverse entrainment and impingement effects of the EPS CWIS.

2.0 DESCRIPTION OF THE ENCINA POWER STATION AND CHARACTERISTICS OF THE SOURCE WATER BODY

2.1 Background

The Encina Power Station (EPS) is situated on the southern shore of the outer segment of the Agua Hedionda Lagoon in the city of Carlsbad, California, approximately 193 km (85 miles) south of Los Angeles and 16 km (35 miles) north of San Diego. EPS is a gas- and oil-fueled generating plant with five steam turbine generators (Units 1 through 5), which all use the marine waters of Agua Hedionda Lagoon for once-through cooling, and a small gas turbine generator. EPS began withdrawing cooling water from Agua Hedionda Lagoon in 1954 with the startup of commercial operation of Unit 1. Unit 2 began operation in 1956, Unit 3 in 1958, Unit 4 in 1973, and Unit 5 in 1978. The gas turbine was installed in 1968, which does not use cooling water in its operation. The combined net generation capacity of EPS is 966 megawatts electric (Mwe) (**Table 1**).

2.1.1 Plant Cooling Water System Description and Operation

Cooling water for the five steam electric generating units are supplied by two circulating and one or two service water pumps for each unit. The quantity of cooling water circulated through the plant is dependent upon the number of units in operation. With all units in full operation, the cooling water flow through the plant is 2,253 m^3/min (595,200 gallons per minutes [gpm]) or 3,244,430 m^3/day (857 million gallons per day [mgd]) based on the manufacturer ratings for the cooling water pumps (**Table 1**).

Table 1. Encina Power Station generation capacity and cooling water flow volume.

Unit	Gross Generation (MWe)	Cooling Water Flow m^3/min (gpm)	Daily Flow m^3/day (mgd)
1	107	193 (51,000)	278,000 (73)
2	104	193 (51,000)	278,000 (73)
3	110	204 (54,000)	294,350 (78)
4	300	806 (213,000)	1,161,060 (307)
5	325	856 (226,200)	1,233,010 (326)
Gas Turbine	20		
Total	**966**	**2,252 (595,200)**	**3,244,430 (857)**

Cooling water for all five steam-generating units is supplied through a common intake structure located at the southern end of the outer segment of Aqua Hedionda Lagoon, approximately 854 m (2,800 ft) from the opening of the lagoon to the ocean (**Figure 1**). Cooling water from the system is discharged into a small discharge pond that is located to the west of the intake structure. Water from the discharge pond flows through a culvert under Carlsbad Blvd and through a discharge canal across the beach and out to the ocean.

Seawater entering the cooling water system passes through metal trash racks on the intake structure that are spaced 8.9 cm (3½ in) apart and keep any large debris from entering the system. The trash racks are cleaned periodically. Behind the trash racks the intake tapers into two 3.7 m (12 ft) wide tunnels that further splits into four 1.8 m (6 ft) wide conveyance tunnels (**Figure 2**). Conveyance tunnels 1 and 2 provide cooling water for Units 1, 2 and 3, while conveyance tunnels 3 and 4 supply cooling water to Units 4 and 5, respectively. Vertical traveling screens prevent fish and debris from entering the cooling water system and potentially clogging the condensers. There are two traveling screens for Units 1, 2 and 3, two screens for Unit 4, and three screens for Unit 5. The mesh size on the screens for Units 1 through 4 is 0.95 cm (3/8 in), while the mesh size for Unit 5 is 1.6 cm (5/8 in).

The traveling screens can be operated either manually or automatically when a specified pressure differential is detected across the screens due to the accumulation of debris. When the specified pressure is detected the screens rotate and the material on the screen is lifted out of the cooling water intake. A screen wash system (70-100 psi), located at the head of the screen, washes the debris from each panel into a trough, which empties into collection baskets where it is accumulated until disposal.

The velocity of the water as it approaches the traveling screens has a large effect on impingement and entrainment and varies depending on the number of pumps operating, tidal level, and cleanliness of the screen faces. Approach velocities at high and low tide with all pumps operating were presented in the previous 316(b) study conducted in 1979 and 1980 (**Table 2**).

Table 2. Approach velocities at traveling screens for Encina Power Station with all circulating water and service water pumps in operation.

	Estimated Mean Approach Velocity (fps)	
Unit	**High Tide**	**Low Tide**
1	0.7	1.2
2	0.7	1.2
3	0.7	1.2
4	1.0	1.6
5	0.7	1.1

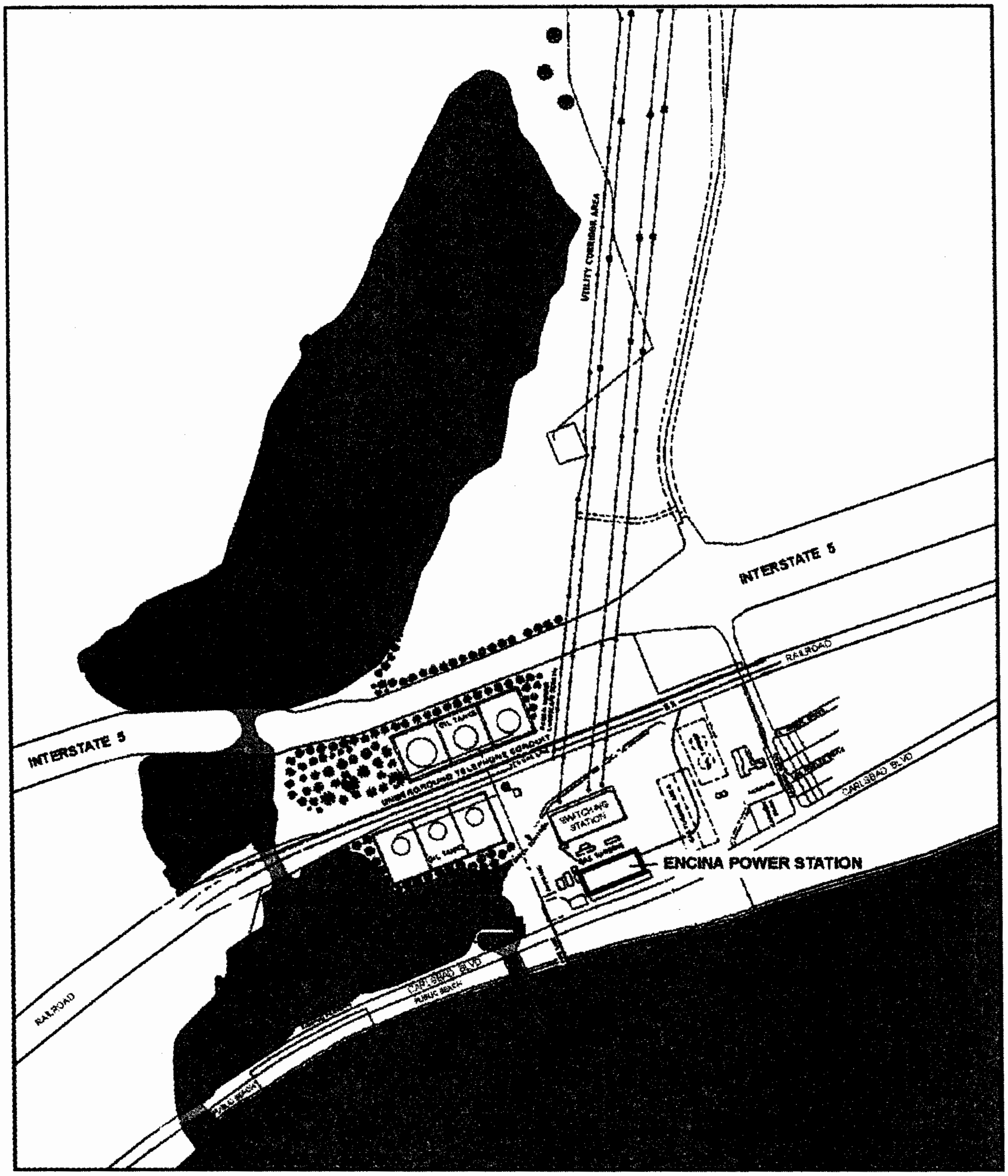

Figure 1. Location of Encina Power Station in Carlsbad, California

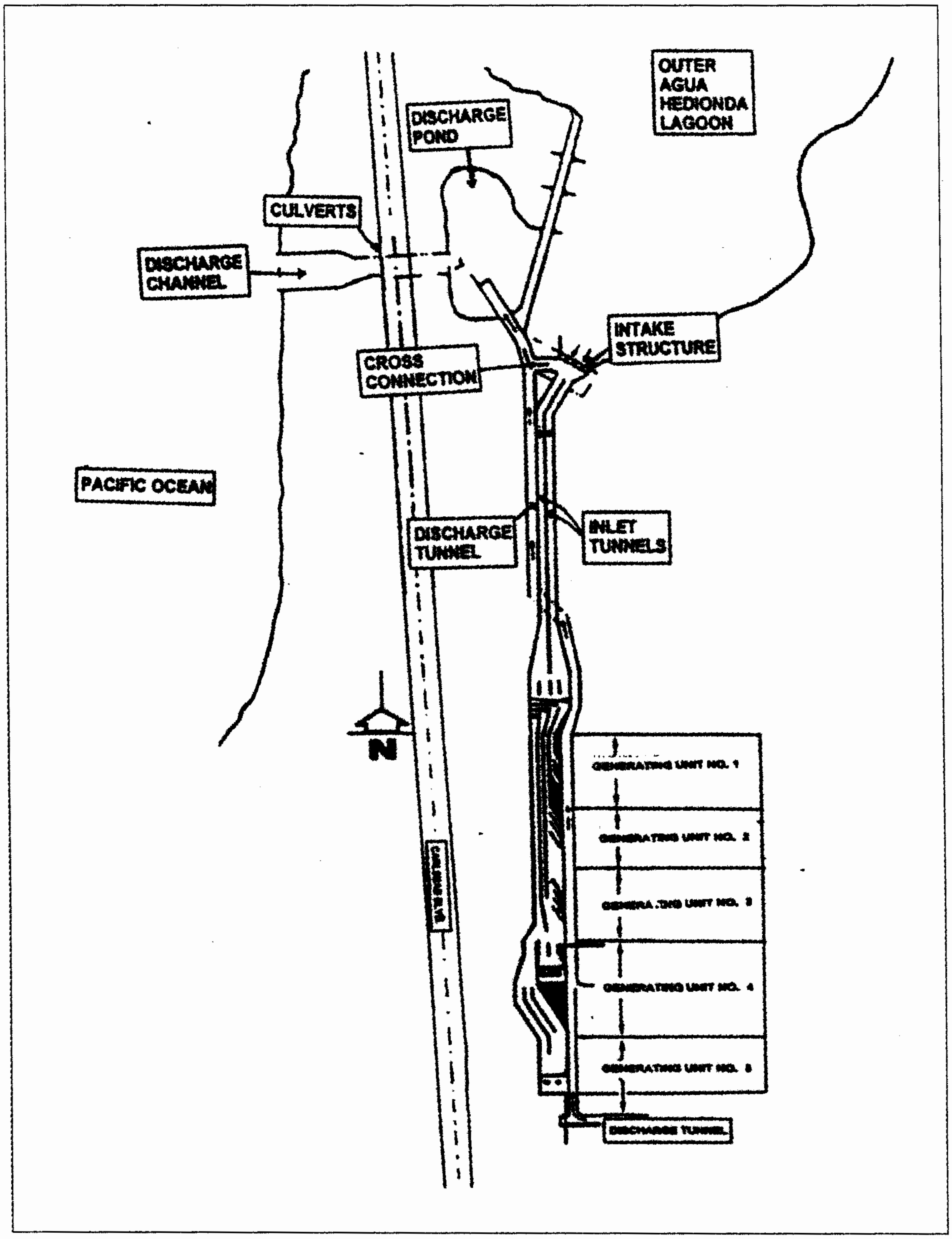

Figure 2. Schematic of Encina Power Station cooling water intake system.

2.2 Aquatic Biological Resources in the Vicinity of EPS

2.2.1 Agua Hedionda Lagoon

The Encina Power Station (EPS) is located on Agua Hedionda Lagoon, which is a man-made coastal lagoon that extends 2.7 km (1.7 miles) inland and is up to 0.8 km (0.5 mi) wide. The lagoon was constructed in 1954 to provide cooling water for the power plant. A railroad trestle and the Interstate Highway 5 bridge separate Agua Hedionda Lagoon into three interconnected segments: an Outer, Middle, and Inner lagoon. The surface areas of the Outer, Middle, and Inner lagoons are 26.7 (66 acres), 9.3 (23 acres), and 79.7 (197 acres) hectares, respectively. The lagoon is separated from the ocean by Carlsbad Boulevard and a narrow inlet 46 m [151 ft] wide and 2.7 m [9 ft] deep at the northwest end of the Outer Lagoon that passes under the highway and allows tidal exchange of water with the ocean.

Circulation and input into Aqua Hedionda Lagoon is dominated by semi-diurnal tides that bring approximately 2.0 million m^3 of seawater through the entrance to the Outer Lagoon on flood tides. Approximately half of this tidal volume flows into the Middle and Inner lagoons. On ebb tides this same tidal volume flows out through the entrance to the ocean. As a result of this tidal flushing the lagoon is largely a marine environment. Although freshwater can enter the lagoon through Buena Creek, which drains a 7,500 hectare (18,500 acres) watershed, for most of the year freshwater flow is minimal. Heavy rainfall in the winter can increase freshwater flows, reducing salinity, especially in the Inner Lagoon.

A study on the ecological resources of Agua Hedionda showed that it has good water quality and supports diverse infaunal, bird, and fish communities (MEC Analytical 1995). Eelgrass was found in all three lagoon segments, but was limited to shallower depths in the Inner Lagoon because water turbidity reduces photosynthetic light penetration in deeper areas. The eelgrass beds provide a valuable habitat for benthic organisms that are fed upon by birds and fishes. Although eelgrass beds were less well developed in areas of the Inner Lagoon, it also provides a wider range of habitats, including mud flats, salt marsh, and seasonal ponds that are not found elsewhere in Aqua Hedionda. As a result bird and fish diversity was highest in the Inner Lagoon.

A total of 35 species of fishes was found during the 1994 and 1995 sampling conducted by MEC (MEC Analytical 1995). The Middle and Inner lagoons had more species and higher abundances than the Outer Lagoon. During the 1995 survey only four species were collected in the Outer Lagoon, compared to 14 to 18 species in the Middle and Inner lagoons. The sampling did not include any surveys of the rocky revetment lining the Outer Lagoon that would increase the abundance and number of species collected. Silversides (Atherinopsidae) and gobies (Gobiidae) were the most abundant fishes collected. Silversides, including jacksmelt and topsmelt, that occur in large schools in shallow waters where water temperatures are warmest were most abundant in the shallower Middle and Inner lagoons. Gobies were most abundant in the Inner Lagoon which has large shallow mudflat areas that are their preferred habitat.

Special Status Species

The recent assessment of the ecological resources of Agua Hedionda did not collect any federally endangered tidewater goby (*Eucyclogobius newberryi*) that was once recorded from the lagoon (MEC Analytical 1995). The record of the occurrence may not be accurate or may predate the construction of the Outer Lagoon that provided a direct connection with the ocean. The current marine environment in the lagoon would not generally support tidewater gobies because they prefer brackish water habitats. No other listed fish species were collected in the study.

2.2.2 Pacific Ocean

Agua Hedionda Lagoon is tidally flushed through the small inlet in the Outer Lagoon by waters from the Pacific Ocean. The physical oceanographic processes of the southern California Bight that influence the lagoon include tides, currents, winds, swell, temperature, dissolved oxygen, salinity and nutrients through the daily tidal exchange of coastal seawater. Near the mouth of the lagoon the mean tide range is 3.7 ft (1.1 m) with a diurnal range of 5.3 ft (1.6 m). Waves breaking on the shore generally range in height from 2 to 4 ft (0.6 to 1.2 m), although larger waves (6 to 10 ft [1.8 to 3.0 m]) are not uncommon. Larger waves exceeding 15 ft (4.6 m) occur infrequently, usually associated with winter storms. Surface water in the local area ranges from a minimum of 57°F (13.9°C) to a maximum 72°F (22.2°C) with an average annual temperature between 63°F (17.2°C) and 66°F (18.9°C).

The outer coast has a diversity of marine habitats and includes zones of intertidal sandy beach, subtidal sandy bottom, rocky shore, subtidal cobblestone, subtidal mudstone and water column. Organisms typical of sandy beaches include polychaetes, sand crabs, isopods, amphipods, and clams. Grunion utilize the beaches around EPS during spawning season from March through August. Numerous infaunal species have been observed in subtidal sandy bottoms. Mollusks, polychaetes, arthropods, and echinoderms comprise the dominant invertebrate fauna. Sand dollars can reach densities of 1,200 per square meter. Typical fishes in the sandy subtidal include queenfish, white croaker, several surfperch species, speckled sanddab, and California halibut. Also, California spiny lobster and *Cancer* spp. crabs forage over the sand. Many of the typically outer coast species can occasionally occur within Agua Hedionda Lagoon, carried by incoming tidal currents.

The rocky habitat at the discharge canal and on offshore reefs supports various kelps and invertebrates including barnacles, snails, sea stars, limpets, sea urchins, sea anemones, and mussels. Giant kelp (*Macrocystis*) forests are an important habitat-forming community in the area offshore from Agua Hedionda. Kelp beds provide habitat for a wide variety of invertebrates and fishes. The water column and kelp beds are known to support many fish species, including northern anchovy, jack smelt, queenfish, white croaker, garibaldi, rockfishes, surfperches, and halibut.

Marine-associated wildlife that occur in the Pacific waters off Agua Hedionda Lagoon are numerous and include brown pelican, surf scoter, cormorants, western grebe, gulls, terns and loons. Marine mammals, including porpoise, sea lions, and migratory gray whales, also frequent the adjacent coastal area.

3.0 ENTRAINMENT STUDY AND ASSESSMENT METHODS

Entrainment studies were previously conducted in 1979 and 1980 at the EPS as part of the plant's initial Section 316(b) Demonstration requirement. The original study was conducted using pump sampling for plankton at the intake structure and net sampling of plankton at three source water stations in the Outer Lagoon (SDG&E 1980). For this study, plankton net sampling at the intake station and at an array of source water stations will be used to collect data for impact models that will be used to update the previous 316(b) Demonstration study. The following questions will be addressed by the entrainment and source water studies:

- What is the baseline entrainment mortality?
- What are the species composition and abundance of larval fishes, cancer crabs, and lobsters entrained by the EPS?
- What are the estimates of local species composition, abundance and distribution of source water stocks of entrainable larval fishes, cancer crabs, and spiny lobsters in Agua Hedionda Lagoon and the nearshore oceanic source waters?

The basis for estimation of entrainment effects is accurate knowledge of the composition and densities of planktonic organisms that are at risk of entrainment through the power plant cooling water system. Recent studies addressing 316(b) issues have focused on larval fishes and commercially important crustacean species (Tenera 2001, 2004). The basic study design involves the collection of plankton samples directly from the intake cooling water flow (entrainment sampling) and comparing the densities of various target species from plankton samples taken concurrently from the source water body (source water sampling). In the case of Encina Power Station (EPS), two areas contribute to the source water body; the lagoon sub-area and the nearshore sub-area, each having a unique contribution to the cooling water flows in terms of species composition and probability of entrainment.

3.1 Entrainment Study

Field data on the composition and abundance of potentially entrained larval fishes, *Cancer* spp. megalopae, and larval spiny lobster *Panulirus interruptus* will provide a basis to estimate the total number and types of these organisms passing through the power plant's cooling water intake system. For the purposes of modeling and calculations, through-plant mortality will be assumed to be 100 percent; unless otherwise determined through a San Diego RWQCB approved entrainment mortality study. Monthly entrainment and source water surveys started in June 2004 will be continued on a monthly basis through May 2005.

3.1.1 Entrainment Sampling Methods

This study was designed to quantify the composition and abundance of entrained larval fishes, *Cancer* spp. megalopae, and spiny lobster larvae. A map of the station locations that were sampled starting in June 2004 is shown in **Figure 3**. These stations will continued to be sampled through May 2005 on a monthly basis.

Sample collection methods are similar to those developed and used by the California Cooperative Oceanic and Fisheries Investigation (CalCOFI) in their larval fish studies (Smith and Richardson 1977) but modified for sampling in the shallow areas of Agua Hedionda Lagoon. Two replicate entrainment samples are collected from a single station (E1) located in front of the EPP intakes by towing plankton nets from a small boat. A net frame is equipped with two 0.71 m (2.33 ft) diameter openings each with a 335 µm (0.013 in) mesh plankton net and codend. The start of each tow begins close to the intake structure, proceeds in a northerly direction against the prevailing intake current, and ends approximately 100 m from the structure. It is assumed that all of the water sampled at the entrainment station would have been drawn through the EPS cooling water system.

The tows are done by first lowering the nets as close to the bottom as practical without contacting the substrate. Once the nets are near the bottom, the boat is moved forward and the nets retrieved at an oblique angle (winch cable at approximately 45° angle) to sample the widest strata of water depths possible. Total time of each tow is approximately two minutes at a speed of 1 kt during which a combined volume of at least $60m^3$ ($2{,}119\ ft^3$) of water is filtered through both nets. In similar studies conducted by Tenera, this volume has been shown to typically provide a reasonable number and diversity of larvae for data modeling. The water volume filtered is measured by calibrated flowmeters (General Oceanics Model 2030R) mounted in the openings of the nets. Accuracy of individual instruments differed by less than 5% between calibrations. The sample volume is checked when the nets reach the surface. If the target volume is not collected, the tow was repeated until the targeted volume is reached. The nets are then retrieved from the water, and all of the collected material rinsed into the codend. The contents of both nets are combined into one sample immediately after collection. The sample is placed into a labeled jar and preserved in 10 percent formalin. Each sample is given a serial number based on the location, date, time, and depth of collection. In addition, the information is logged onto a sequentially numbered data sheet. The sample's serial number is used to track it through laboratory processing, data analyses, and reporting.

Entrainment samples are collected over a 24-hour period, with each period divided into four 6-hour sampling cycles. Larval fishes show day-night differences in abundances related to their vertical migratory behavior and spawning periodicity, and the 24-hr sampling regime allows these differences to be averaged for assessing entrainment abundances. Concurrent surface water temperatures and salinities are measured with a digital probe (YSI Model 30).

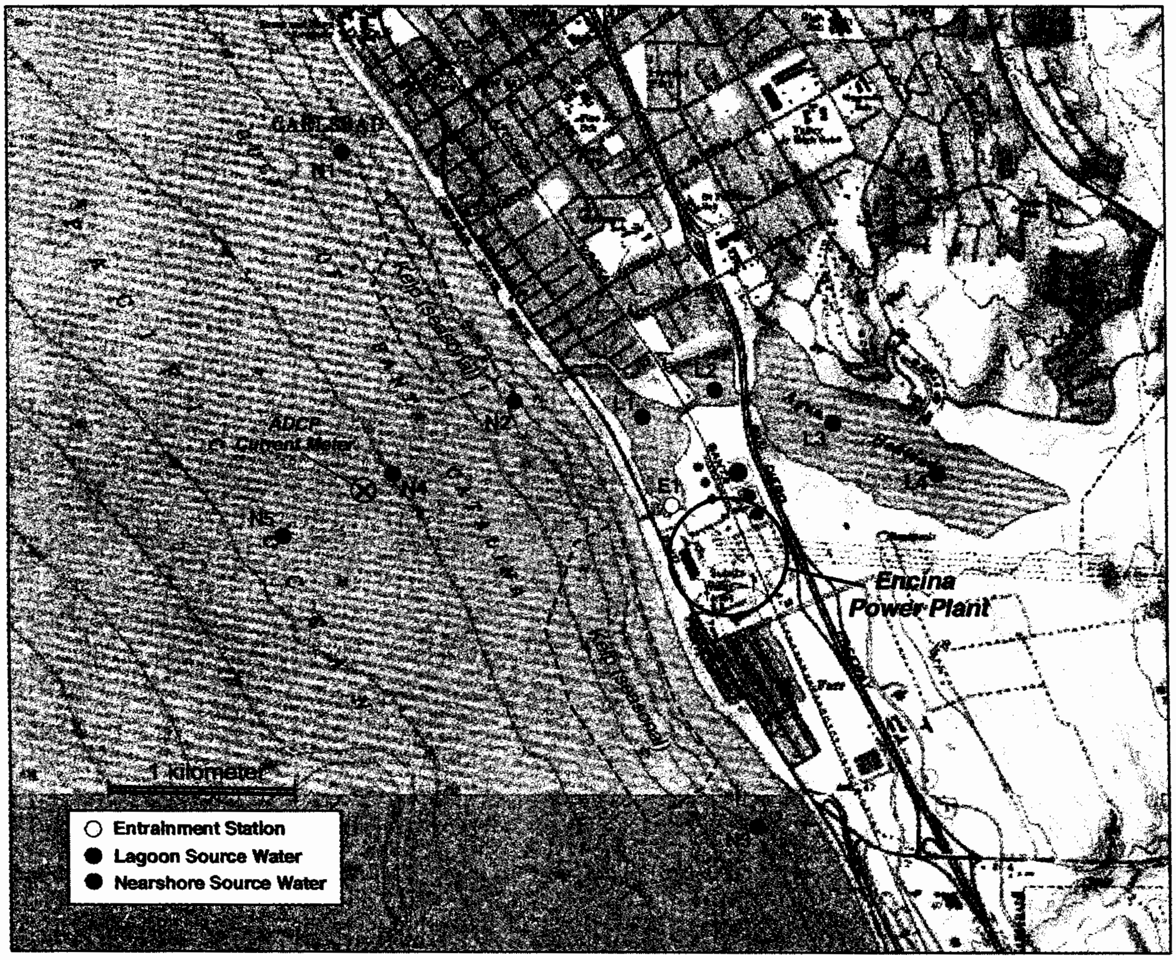

Figure 3. Location of Encina Power Station entrainment (E1) and source water stations (L1 through L4, and N1 through N5).

3.2 Source Water Study

This study was designed to quantify the local source water composition and abundance of larval fishes, *Cancer* spp. megalopae, and larval *Panulirus interruptus* in Agua Hedionda Lagoon and the nearshore source waters. The source water is partitioned into lagoon and nearshore sub-areas for modeling cooling water withdrawal effects (**Figure 3**). Collection methods are identical to the entrainment sample collection, with the exception that a single paired-net sample is collected at each station and the nearshore samples are be collected from a larger vessel capable of navigating open coastal waters in all weather conditions, day or night. The shallow waters in the Middle and Inner lagoons required a different sampling protocol than the oblique tows used at the Outer Lagoon and nearshore stations. The Inner Lagoon is sampled using a single frame plankton net mounted on the bow of a small boat which pushes the net through the water thereby eliminating any obstructions in front of the net during sampling. The net is raised and lowered during sampling to sample the range of depths available in the shallow Inner Lagoon.

The stations are stratified to include four lagoon stations within the inner (2), middle (1), and outer lagoons (1), and five nearshore stations that cover a depth range of 5–30 m (16–98 ft). The array of locations and depths was chosen to assure that all potential source water community types are represented. For example, stations in the inner lagoon will have a greater proportion of larvae from species with demersal eggs, such as gobies, that spawn in quiet water environments, while nearshore stations will have more larvae of species that spawn in open water such as California halibut and white seabass. The study will allow comparison to earlier larval fish studies done for the original EPS 316(b) in 1979-80 (SDG&E 1980).

A current meter is placed in the nearshore between Stations N4 and N5. The data from the meter will be used to characterize currents in the nearshore area that would directly affect the dispersal of planktonic organisms that could be entrained by the power plant. The data will be used to define the size of the nearshore component of the source water by using the current speed and the estimated larval durations of the entrained organisms.

The number of source water stations will be evaluated as data become available to determine if fewer stations can be sampled. For example, a reduction in the number of stations may be recommended if analysis indicates that only one station is necessary to characterize the Inner Lagoon, or the Middle Lagoon is sufficiently similar to the Inner Lagoon that it does not need to be sampled separately. Analysis of current meter data may also indicate that Station N5 does not need to be sampled because the current is predominantly alongshore and can be adequately characterized using the other stations closer to shore.

3.2.1 Source Water Sampling Methods

Sampling is conducted using the same methods and during the same time period described earlier for the entrainment collections (Section 3.1.1) with target volumes for the oblique tows of approximately 60 m^3 (2–3 minute tow at approximately 1 knot).

3.3 Laboratory Processing and Data Management

Laboratory processing will remove all larval fishes, megalopal stages of *Cancer* spp., and larvae of spiny lobster from the samples. Fish eggs will not be sorted from the samples. Although many marine fish eggs are described in the scientific literature, most identifications are difficult and very time consuming, and impact models can be adequately parameterized without egg density data. Larval fishes and all species of cancer crab megalopae will be identified to the lowest taxonomic level possible by Tenera's taxonomists. In addition, the developmental stage of fish larvae (yolk-sac, preflexion, flexion, postflexion, transformation) will be recorded on the data sheet. A laboratory quality control (QC) program for all levels of laboratory sorting and taxonomic identification will be applied to all samples. The QC program will also incorporate the use of outside taxonomic experts to provide taxonomic QC and resolve identification uncertainties.

Many larval fish cannot be identified to the species level; these fish will be identified to the lowest taxonomic classification possible (e.g., genus and species are lower orders of classification than order or family). Myomere and pigmentation patterns are used to identify many species; however, this can be problematic for some species. For example, sympatric members of the family Gobiidae share similar characteristics during early life stages (Moser 1996), making identifications to the species level uncertain. Those gobiids that we are unable to identify to species will be grouped into an "unidentified goby" category.

Laboratory data sheets will be coded with species or taxon codes. These codes will be verified with species/taxon lists and signed off by the data manager. The data will be entered into a computer database for analysis.

Length measurements will be taken on a representative sample of the target larval fish taxa. Approximately 100 fish from each taxon will be measured using a video capture system and Optimus™ image analysis software. The 100 fish from each taxon will be selected from the entrainment station based on the percentage frequency of occurrence of a taxon in each survey. For example, if 20 percent of the California halibut larvae for the entire year-long study were collected from during the June survey then 20 fish will be measured from that survey.

3.4 Assessment Methods

Potential cooling water intake system (CWIS) entrainment effects will be evaluated using a suite of methods, with no single method being superior to any others. The potential entrainment effects of the EPS CWIS, assuming 100 percent through-plant mortality, will be estimated using the site-specific field data collected in this proposed study. The potential for any such CWIS effects to cause long-term population level impacts will be evaluated through the use of three analytical techniques: proportional entrainment (*PE*), adult equivalent loss (*AEL*), and fecundity hindcasting (*FH*). The results of these analytical steps will support assessments with respect to species population demographics (e.g., standing stock, age structure stability, fishery trends, and sustainable harvest management plans).

3.4.1 Demographic Approaches (FH and AEL)

The fecundity hindcasting or *FH* analysis approach (Horst 1975) compares larval entrainment losses with adult fecundity to estimate the amount of adult female reproductive output eliminated by entrainment. It thereby hindcasts the numbers of adult females effectively removed from the reproductively active population. The accuracy of these estimates of effects is dependent upon such factors as accurate estimates of age-specific mortality from the egg and early larval stages to entrainment, and also on age-specific estimates of adult fecundity, spawning periodicity, and reproductive lifespan. If it is assumed that the adult population has been stable at some current level of exploitation and that the male:female ratio is known and constant, then fecundity and mortality are integrated into an estimate of loss by converting entrained larvae back into females (i.e., hindcasting). In making this conversion, the number of eggs, derived from the number of larvae adjusted for egg to larvae mortality, are divided by the average number of eggs produced by each age class (size) of reproductive females in the stable population's ideal age structure. However this degree of information is rarely available for a population. In most cases, a simple range of eggs per females is reported without age-specificity.

An advantage of *FH* is that survivorship need only be estimated for a relatively short period of the larval stage (i.e., egg to larva). This method does not require source water sampling in addition to estimates of larval entrainment concentrations. This method assumes that the loss of a single female's reproductive potential is equivalent to the loss of adults. For the purpose of the resource assessment, if EPS-induced entrainment losses are to be equated to population level units in terms of fractional losses, it is still necessary to estimate the size of the population of interest. To this end, our assessment will employ any available, scientifically acceptable sources of information on fisheries stock or population estimates of unexploited species entrained by the EPS.

The adult equivalent loss or *AEL* approach (Goodyear 1978) uses age-specific estimates of the abundance of entrained or impinged organisms to project the loss of equivalent numbers of adults based on mortality schedules and age at recruitment. The primary advantage of this approach is that it translates power plant-induced, early life-stage mortality into equivalent numbers of adult fishes, the units used by resource managers. Adult equivalent loss does not necessarily require source water estimates of larval abundance in addition to entrainment estimates, as required in *PE*. This latter advantage may be offset by the need to gather age-specific mortality rates to predict adult losses and the need for information on the adult population of interest for estimating population-level effects (i.e., fractional losses). However, the need for age-specific mortality estimates can be reduced by various approximations as shown by Saila et al. (1987), who used six years of entrainment and two years of impingement data for winter flounder *Pleuronectes americanus*, red hake *Urophycis chuss*, and pollock *Pollachius virens* at the Seabrook Station in New Hampshire. Their model assumed an adult population at equilibrium, a stable age distribution, a constant male:female ratio, and an absence of density-dependent (i.e., compensatory) mortality between entrainment and recruitment to the adult or fished stocks. Input data to their model parameters were gathered in field surveys of spawning populations, egg and larval production, and local hydrology.

Declining populations can be accounted for in both the *AEL* and *FH* approaches by using age-specific adult mortality estimates from fishery catch data and by assuming no compensatory mortality. However, we know that this is not an assumption that fits the reality of population dynamics. The removal (mortality) of any life stage will have an effect if it exceeds the number of reproductive adults required to produce that number of larvae. That is, the adult population will decline one for one with every larva lost. This is clearly not the case, nor does every larva survive to become an adult. Although we have essentially no way of estimating the degree to which a population can sustain losses and remain stable, it is an important issue when estimating long-range effects. The effect, known as density-dependence (sometimes called compensation), can affect the vital rates of impacted organisms. Density-dependence is not confined to acting through mortality; growth and fecundity may also be density-dependent. In fisheries management models, which we will take as our working models in forecasting long-term population trends, the level of compensation possible in species can be examined empirically by the response of its population to harvest rates.

Some entrainment studies have assumed that compensation is not acting between entrainment and the time when adult recruitment would have taken place, and further, that this specific assumption resulted in conservative estimates of projected adult losses (Saila et al. 1987). Others, such as Parker and DeMartini (1989), did not include compensatory mortality in estimates of equivalent adult losses because of a lack of consensus on how to include it in the models and, more importantly, uncertainty about how compensation would operate on the populations under study. The uncertainty arises because the effect of compensation on the ultimate number of adults is directly related to which of the vital processes (fecundity, somatic growth, mortality) and which life stages are being affected. In particular, Nisbet et al. (1996) showed that neglecting compensation does not always lead to conservative long-term estimates of equivalent adult losses.

3.4.2 Empirical Transport Model (ETM)

The *PE* approach (Boreman et al. 1978, Boreman et al. 1981) will provide an estimate of incremental (conditional, Ricker 1975) mortality imposed by EPS on local source water larval populations by using empirical data (plankton samples) rather than relying solely on hydrodynamic and demographic calculations. Consequently, *PE* requires an additional level of field sampling to characterize abundance and composition of larvae using results from the larval fish surveys defined in this document (Section 3.2.1). These estimates of species-specific fractional losses (entrainment losses relative to source water abundance) can then be expanded to predict regional effects on appropriate adult populations using an empirical transport model (*ETM*), as described below. Required parameters for the *PE* approach include the rate of cooling water withdrawal, estimates of entrained larval fish concentrations, and estimates of the larval fish concentrations in the source waters.

The use of *PE* as an input to the empirical transport model (*ETM*) has been proposed by the U.S. Fish and Wildlife Service to estimate mortality rates resulting from cooling water withdrawals by power plants (Boreman et al. 1978, and subsequently in Boreman et al. 1981). Variations of this model have been discussed in MacCall et al. (1983) and have been used to assess impacts at a southern California power plant (Parker and DeMartini 1989). The *ETM* has also been used to assess impacts at the Salem Nuclear Generating Station in Delaware Bay, New Jersey (PSE&G 1993) as well as other power stations along the East Coast. Empirical transport modeling permits the estimation of annual conditional mortality due to entrainment while accounting for the spatial and temporal variability in distribution and vulnerability of each life stage to power plant withdrawals. The generalized form of the *ETM* incorporates many time-, space-, and age-specific estimates of mortality as well as information regarding spawning periodicity and duration, many of which are limited or unknown for the marine taxa being investigated at EPS. The applicability of the *ETM* to the present study at EPS will be limited by a lack of either empirically derived or reported demographic parameters needed as input to the model. However, the concept of summarizing *PE* over time that originated with the *ETM* can be used to estimate entrainment effects over appropriate temporal scales either through modeling or by making assumptions about species-specific life histories. We will employ a *PE* approach that is similar to the method described by MacCall et al. (1983) and used by Parker and DeMartini (1989) in their final report to the California Coastal Commission (Murdoch et al. 1989), as an example for the San Onofre Nuclear Generating Station (SONGS). This estimate can then be summarized over appropriate blocks of time in a manner similar to that of the *ETM*.

4.0 IMPINGEMENT EFFECTS

The two primary ways cooling water withdrawal can affect aquatic organisms are through impingement and entrainment. Larger organisms are subjected to impingement on the screening system on the power plant's cooling water intake system (CWIS) that excludes debris from the circulating water pumps. EPS presently has seven sets of vertical traveling screens in three separate areas. Approach velocities vary from approximately 0.7 fps at high tide to 1.6 fps at low tide. Impingement occurs when an organism larger than the traveling screen mesh size is trapped against the screens. These impinged organisms are assumed to undergo 100 percent mortality for the purposes of this study. The following questions will be addressed by the impingement study:

- What is the baseline impingement mortality?
- What are the species composition and abundance of fishes and macroinvertebrates impinged by EPS?

4.1 Review of 1980 Impingement Study

In earlier impingement studies at EPS, fish samples were collected from screen washes during high and low impingement periods for one year (SDG&E 1980). Samples were collected over two-12 hour periods during each day to represent daytime and nighttime impingement. Since samples were collected every day the study provides a direct measure of EPS impingement. During the one-year period during normal plant operations 76 species of fishes and 45 species of macro-invertebrates totaling 85,943 individuals and weighing 1,548 kg (3,414 lb) were impinged. During the seven heat treatments conducted during the sampling period 108,102 fishes weighing 2422 kg (5,341 lb) were collected. The most abundant fishes collected in impingement samples were actively swimming, open-water schooling species such as deepbody and northern anchovy, topsmelt, and California grunion. Other abundant species included queenfish and shiner surfperch. During heat treatments larger fishes were collected that were less common during normal impingement. These larger fishes probably live in the CWIS and are able to avoid impingement during normal plant operation, but succumb to the warmer temperatures during heat treatment. Marine plants, largely eelgrass and giant kelp, made up the largest component of material in impingement samples.

Impingement losses at EPS were much less when compared with impingement at other coastal plant in southern California. Impingement was much greater at the Redondo Beach Generating Station and San Onofre Nuclear Generating Station Unit 1, even though the cooling water flows at those two facilities are less than the flow at EPS (673 and 500 MGD, respectively compared with 828 mgd at EPS). The intake approach velocities at the screenwells at EPS are lower than the velocities at these other facilities allowing most fishes to avoid impingement by continuous or burst swimming. The SDG&E report (SDG&E 1980) and a later evaluation (EA 1997) both concluded that the biological impact of EPS was insignificant in terms of impingement losses.

4.2 Impingement Study Methods

The purpose of the proposed 316(b) impingement study will be to characterize the juvenile and adult fishes and selected macroinvertebrates (e.g., shrimps, crabs, lobsters, squid, and octopus) impinged by the power plant's CWIS. The sampling program is designed to provide current estimates of the abundance, taxonomic composition, diel periodicity, and seasonality of organisms impinged at EPS. In particular, the study will focus on the rates (i.e., number or biomass of organisms per m^3 water flowing per time into the plant) at which various species of fishes and macroinvertebrates are impinged. The impingement rate is subject to tidal and seasonal influences that vary on several temporal scales (e.g., hourly, daily, and monthly) while the rate of cooling water flow varies with power plant operations and can change at any time. A review of the previous impingement study at EPS will provide context for interpreting changes in the magnitude and characteristics of the present day impingement effects. Studies of the Agua Hedionda fish assemblages independent of EPS (e.g., MEC Analytical 1995) will also provide information regarding the marine environment in southern and central Agua Hedionda Lagoon.

In accordance with procedures employed in similar studies, impingement sampling will occur over a 24-hour period one day per week. Before each sampling effort, the trash racks will be cleaned and the traveling screens will be rotated and washed clean of all impinged debris and organisms. The sluiceways and collection baskets will also be cleaned before the start of each sampling effort. The operating status of the circulating water pumps on an hourly basis will be recorded during the collection period. Each 24-hour sampling period at the traveling screens will be divided into six 4-hour cycles. The traveling screens will remain stationary for a period of 3.5 hours then they will be rotated and washed for 30 minutes. The trash racks will be cleaned once every 24 hours. The impinged material from the traveling screens will be rinsed into the collection baskets associated with each set of screens and the impinged material from the trash racks will be collected in the bin on the rake apparatus. The debris and organisms rinsed from each set of traveling screens and the trash racks will be kept separate and processed according to the procedures presented in the following section.

If the traveling screens are operating in the continuous mode, then sampling will be coordinated with the intake crew so samples can be collected safely. A log containing hourly observations of the operating status (on or off) of the circulating water pumps for the entire study period will be obtained from the power plant operation staff. This will provide a record of the amount of cooling water pumped by the plant, which will then be used to calculate impingement rates. The same procedure will be used to coordinate additional sampling efforts at the trash racks in case they need to be cleaned more frequently than once every 24 hours. The sampling at each of the three sets of traveling screens will be offset by one hour to allow screen wash and collection to occur at each set of screens separately.

Impingement sampling will also be conducted during heat treatment "tunnel shock" operations. Procedures for heat treatment will involve clearing and rinsing the traveling screens prior to the start of the heat treatment procedure. At the end of the heat treatment procedure normal pump operation is resumed and the traveling screens rinsed until no more fish are collected on the screens. Processing of the samples will occur using the same procedures used for normal impingement sampling. We anticipate that up to eight heat treatments will occur during the one-year study period.

A quality control (QC) program will be implemented to ensure the correct identification, enumeration, length and weight measurements of the organisms recorded on the data sheet. Random cycles will be chosen for QC re-sorting to verify that all the collected organisms were removed from the impinged material.

Depending on the number of individuals of a given target species present in the sample, one of two specific procedures is used, as described below. Each of these procedures involves the following measurements and observations:

1. The appropriate linear measurement for individual fishes and motile invertebrates is determined and recorded. These measurements are made in millimeters to the nearest 1 mm. The following standard linear measurements are used for the animal groups indicated:

Fishes	Total body length for sharks and rays and standard lengths (fork length) for bony fishes.
Crabs	Maximum carapace width.
Shrimps & Lobsters	Carapace length, measured from the anterior margin of carapace between the eyes to the posterior margin of the carapace.
Gastropod & Pelecypod Molluscs	Maximum shell length or maximum body length.
Octopus	Maximum "arm" spread, measured from the tip of one tentacle to the tip of the opposite tentacle.
Squid	Maximum body length, measured from the tip of one tentacle to the posterior end of the body.

2. The wet body weight of individual animals is determined after shaking loose water from the body. Total weight of all individuals combined is determined in the same manner. All weights are recorded to the nearest 1 g.

3. The qualitative body condition of individual fishes and macroinvertebrates is determined and recorded, using codes for decomposition and physical damage. These codes are shown on the attached form.

4. Other non-target, sessile macroinvertebrates are identified to species and their presence recorded, but they are not measured or weighed. Rare occurrences of other impinged animals, such as dead marine birds, are recorded and their individual weights determined and recorded.

5. The amount and type of debris (e.g., *Mytilus* shell fragments, wood fragments, etc.) and any unusual operating conditions in the screen well system are noted by writing specific comments in the "Notes" section of the data sheet.

The following specific procedures are used for processing fishes and motile invertebrates when the number of individuals per species in the sample or subsample is ≤ 29 :

1. For each individual of a given species the linear measurement, weight, and body condition codes are determined and recorded on separate lines.

The following specific subsampling procedures are used for fishes and motile invertebrates when the number of individuals per species is > 29:

1. The linear measurement, individual weight, and body condition codes for a subsample of 30 individuals are recorded on individual lines of the data sheet. The individuals selected for measurement should 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 are eliminated from consideration, since linear measurements of them are not representative.

2. The total number and total weight of all the remaining individuals combined are determined and recorded on a separate line.

4.2.1 Sampling Frequency

Results from the previous impingement study indicated that the impingement is much greater during the heat treatment "tunnel shock" events. Almost 60 percent of the total impinged fishes (over 60 percent by weight) were collected during the seven tunnel shock events. Impingement rates during normal operations were much less. Although we have proposed to sample normal impingement weekly, we will evaluate the potential to reduce the sampling frequency to once every two weeks. The analysis will be done using the weekly data collected at EPS during this study and data from other southern California power plants with shoreline intake structures. The reduced sampling frequency may provide an adequate estimate of impingement especially since we will continue to sample impingement during each of the tunnel shock events when impingement is highest.

5.0 COOLING WATER SYSTEM IMPACT ASSESSMENT

The entrainment and impingement effects of the cooling water intake system for the EPS project will be assessed on the basis of historical studies and 12 months of recent plankton and 12 months of impingement survey information. The assessment will consider the effects of entraining larval fishes, crabs and lobsters, and impinging larger fishes and invertebrates in the CWIS. The three methods for assessing CWIS effects are fecundity hindcasting (*FH*), adult equivalent loss (*AEL*) and empirical transport modeling (*ETM*). These methods were explained in Section 3.5—Assessment Methods. The report will contain estimates of *AEL* and *FH* where data are available to parameterize these demographic approaches.

The impacts of impingement and entrainment on source water populations can be evaluated by estimating the fractional losses to the population attributable to the CWIS. Impingement rates and biomass estimates from the study will provide estimates of impingement losses that can then be translated directly to estimate potential impingement effects on local fisheries. Estimated entrainment losses are extrapolated to fishery losses using *FH* and *AEL* estimates. One constraint in the modeling approach is that life history data are available for only a portion of the entrained taxa and commercial fishery statistics will also only be available for a few of the entrained species (e.g., California halibut, northern anchovy, white croaker). Many of the fishes that have historically been entrained in highest numbers are small fishes that are not the focus of any recreational or commercial fishery.

Present-day findings on the EPS CWIS entrainment effects will be reviewed and assessed for the most abundant larval fish taxa, megalopal cancer crabs, and larval spiny lobster. By comparing the number of larvae and megalopae withdrawn by the power plant to the number available (i.e., at risk to entrainment), an estimate of the conditional mortality due to entrainment (*PE*) can be generated for each taxon or species. These estimates of conditional mortality will be combined in the *ETM* model to provide an estimate of the annual probability of mortality due to entrainment (P_m) that can be used for determining CWIS effects and the potential for long-term population declines. Fishery management practices and other forms of stock assessments will provide the context required to interpret P_m. In the case of a harvested species, P_m must be considered in addition to these harvest losses when assessing impacts and any potential for population decline.

5.1 Entrainment Effects Assessment

The assessment will focus on entrainment effects to the most abundant and to commercially or recreationally important fish taxa, cancer crab megalops and lobster larvae. Larval fishes analyzed will tentatively be the Goby complex, three Engraulid species, three Atherinopsid species, California halibut, white croaker, black croaker, spotted sand bass, and barred sand bass. These taxa likely comprise over 90 percent of all the entrained larval fishes based on earlier studies. Other species, which may occur in lower abundances, may also be included in the assessment because they represent species of commercial or recreational importance

5.2 Summary of Entrainment Effects

The length of time that a larval fish is in the plankton and subject to entrainment is a key parameter in *ETM* calculations. Length measurements taken from representative samples of the larval fish taxa presented in Section 4.0 will be used to estimate the number of days that larvae (for a specific taxon) are at risk to entrainment. Reports on larval duration from the scientific literature are likely to overestimate the period of time that larvae are exposed to entrainment. This is because ontogenetic changes during larval development result in increased swimming ability or behavioral changes, such as association with the bottom or other pre-settlement microhabitats. Possible outliers are eliminated by basing the minimum and maximum lengths on the central 98 percent of the length distribution for a taxon and excluding the lengths of the top and bottom percentiles. Estimates of larval growth rates (mm/day) are then used on this range to estimate the number of days the larvae are exposed to entrainment. The estimates of growth rates and their source from the literature will be presented in the impact assessment section for the different taxa. The average duration of entrainment risk for a taxon is calculated from the bottom percentile value to the mean value, while the maximum duration is calculated from the bottom percentile value to the 99 percentile value. Our estimates of the period of entrainment risk for cancer crabs and spiny lobster will be derived from literature values on the average age of the stages for each crustacean species.

5.3 Summary of Impingement Effects

Impingement effects in relation to source water fishery resources and potential ecological effects will be summarized based on data summarized from the earlier impingement study (SDG&E 1980), data on fish populations in Agua Hedionda Lagoon (MEC 1995), and CDF&G catch records for sport and commercial fishery resources.

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