# 316(b) Proposal for Information Collection for AES's Redondo Beach L.L.C. Generating Station

Submitted In Compliance with
316(b) Phase II Regulatory Requirements

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## ATTACHMENTS

# List of Acronyms

| | |
|---|---|
| Board | California Regional Water Quality Control Board, Los Angeles Region |
| BTA | Best Technology Available |
| CDS | Comprehensive Demonstration Study |
| CEC | California Energy Commission |
| CWIS | Cooling Water Intake Structure |
| EPA | Environmental Protection Agency |
| HBGS | Huntington Beach Generating Station |
| RBGS | Redondo Beach Generating Station |
| IM | Impingement Mortality |
| NPDES | National Pollutant Discharge Elimination System |
| PIC | Proposal for Information Collection |
| QA/QC | Quality Assurance/Quality Control |
| RS | Representative Species |
| TIOP | Technology Installation and Operation Plan |

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# EXECUTIVE SUMMARY

This Proposal for Information Collection (PIC) is submitted in compliance with the final 316(b) Phase II Rule (the Rule) for existing electric generating stations published in the Federal Register on July 9, 2004. The PIC provides the California Regional Water Control Board, Santa Ana Region (the Board) with AES's plans for:

- providing necessary biological information,
- evaluating alternative fish protection technologies,
- evaluating the Rule's compliance alternatives and options, and
- providing information on consultations with fish and wildlife agencies.

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The Rule requires facilities that withdraw cooling water from Oceans and that have a capacity utilization that exceeds 15% to meet both the Rules impingement mortality (IM) and entrainment (E) reduction standards of 80% to 95% and 60% to 90% respectively. Redondo Beach Generating Station (RBGS) currently consists of two plants. Plant 2 consists or Units 5 & 6 which have capacity factors below 15% while Plant 3 consists of Units 7 & 8 which have capacity factors in excess of 15%. Therefore Plant 2 will only be subject to the IM performance standard while Plant 3 will be subject to both IM&E performance standards.

AES plans to conduct site-specific studies to document the effectiveness of the velocity caps and evaluate the potential benefits of collecting and returning impinged fish to the Pacific Ocean to meet the Rule's impingement mortality reduction performance standard.

AES's preferred means to comply with the Rule's entrainment performance standard is use of restoration measures. Due to some uncertainty regarding use of this alternative as a result of litigation, technologies and/or operational measures as well as site-specific standards will also be evaluated as discussed in Section 3 of this PIC. AES plans to initiate entrainment studies to establish the entrainment characterization baseline in January of 2006. This PIC also provides an updated schedule consistent with the Board's approval of the previously proposed schedule submitted in November of 2004.

# 1 INTRODUCTION

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

1. *A facility can demonstrate it has or will reduce cooling water flow commensurate with wet closed-cycle cooling to be in compliance with all applicable performance standards. A facility can also demonstrate it has or will reduce the maximum design through-screen velocity to less than 0.5 ft/s in which case it is deemed in compliance with the impingement mortality (IM) performance standard (the entrainment standard, applicable still applies).*
2. *A facility can demonstrate that it already has a combination of technologies, operational measures, and restoration measures in place to meet the applicable performance standards.*
3. *A facility can propose to install a combination of new technologies, operational measures, and restoration measures to meet applicable performance standards.*
4. *A facility can propose to install, operate and maintain an approved design and construction technology.*
5. *A facility can request a site-specific determination of best technology available (BTA) by demonstrating that the either the cost of installing technologies, operational measures, and restoration measures are either significantly greater the cost for the facility listed in Appendix A of the rule or significantly greater than the benefits of complying with the applicable performance standards.*

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

The Rule further requires that facilities using compliance alternatives 2, 3, and 5 prepare a Comprehensive Demonstration Study (CDS) as described at 125.95(b) of the Rule based on each of the seven components of the CDS (as appropriate) for the compliance alternative or alternatives selected. Facilities using compliance alternative 1 are not

[1] Performance standards are found at Federal Register, Vol. 69, 7/9/04, 125.94(b)

required to submit a CDS and those using compliance alternative 4 are only required to submit the Technology Installation and Operation Plan (TIOP) and Verification Monitoring Plan. All facilities that use compliance alternatives 2, 3 and 5 are required to prepare and submit a "Proposal for Information Collection" (PIC), the first component of the CDS. The Rule at 125.95(b)(1) requires that the PIC include:

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

The preamble to the Rule on Federal Register Page 41635 states that the PIC should provide other information, where available, to the NPDES permitting authority regarding plans for preparing the CDS such as how the facility plans to conduct a Benefits Valuation Study or gather additional data to support development of a Restoration Plan.

An important feature of the Rule is use of the calculation baseline. The calculation baseline is defined in the rule as follows:

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

This definition provides existing facilities with a variety of study options to take credit for facility features that deviate from the calculation baseline and provide the benefit of fish protection. Facilities can also simply develop the baseline by documenting current IM&E.

This PIC provides a description of RBGS including deviations from the calculation baseline and applicable performance standards in Section 2. Section 3 describes the compliance alternatives and options to be evaluated including a descriptions of alternative fish protection technologies and operational measures. Section 4 provides a brief description of existing biological information and plans for new studies. Section 5 summarizes voluntary and ongoing discussions with fish and wildlife agencies related to 316(b) and Section 6 discusses the schedule for completion of studies.

# 2 DESCRIPTION OF REDONDO BEACH GENERATING STATION

## *2.1 Location and Physical Description of Cooling Water Intake Structure and Cooling System*

RBGS is located in the city of Redondo Beach in Los Angeles County, CA, in the southern part of Santa Monica Bay (Figure 1). RBGS was designed with eight generating units. However, Plant 1 (Units 1, 2, 3, and 4) are currently retired and have not been in service since 1996. RBGS currently operates four natural gas units (Units 5, 6, 7, and 8). Plant 2 (Units 5 & 6) and Plant 3 (Units 7 & 8) utilize once-through cooling water systems with offshore intake and discharge systems. The orientation of the intakes relative to RBGS and King Harbor is shown in Figure 2. Plants 2 & 3 produce a combined output of 1,310 MW. However, over the past five years the capacity utilization of both plants has been less than 50%, with Plant 2 operating less frequently than Plant 3. The total annual energy generated is approximately 2,987,000 MWh.

Cooling water for units 5 – 8 is withdrawn through three submerged offshore intakes, two in King Harbor and one in Santa Monica Bay near the entrance to King Harbor. All of these structures are located within the near-shore zone. The two onshore screen structures for Plants 2 & 3 are located approximately 2,300 ft northeast from the offshore intakes. Trash racks are installed across the onshore intake structures to prevent large debris from entering the intake bays. Vertical traveling water screens are installed behind the trash racks to strain out smaller debris. Circulating water pumps are located downstream of the traveling water screens to convey screened flow to the condensers. Plant 2 cooling water is discharged north of King Harbor into the Santa Monica Bay. Plant 3 discharge is located in King Harbor adjacent to the intake pipe (Figure 2).

Fishes collected in the large mesh baskets conveyed from the traveling water screen sluiceway are placed in a holding tank and released back into the ocean. The benefits associated with this fish collection and release can be credited toward RBGS's compliance with the impingement mortality reduction standard. The benefits of the ongoing program will be evaluated to determine its cost-effectiveness for 316(b) compliance.

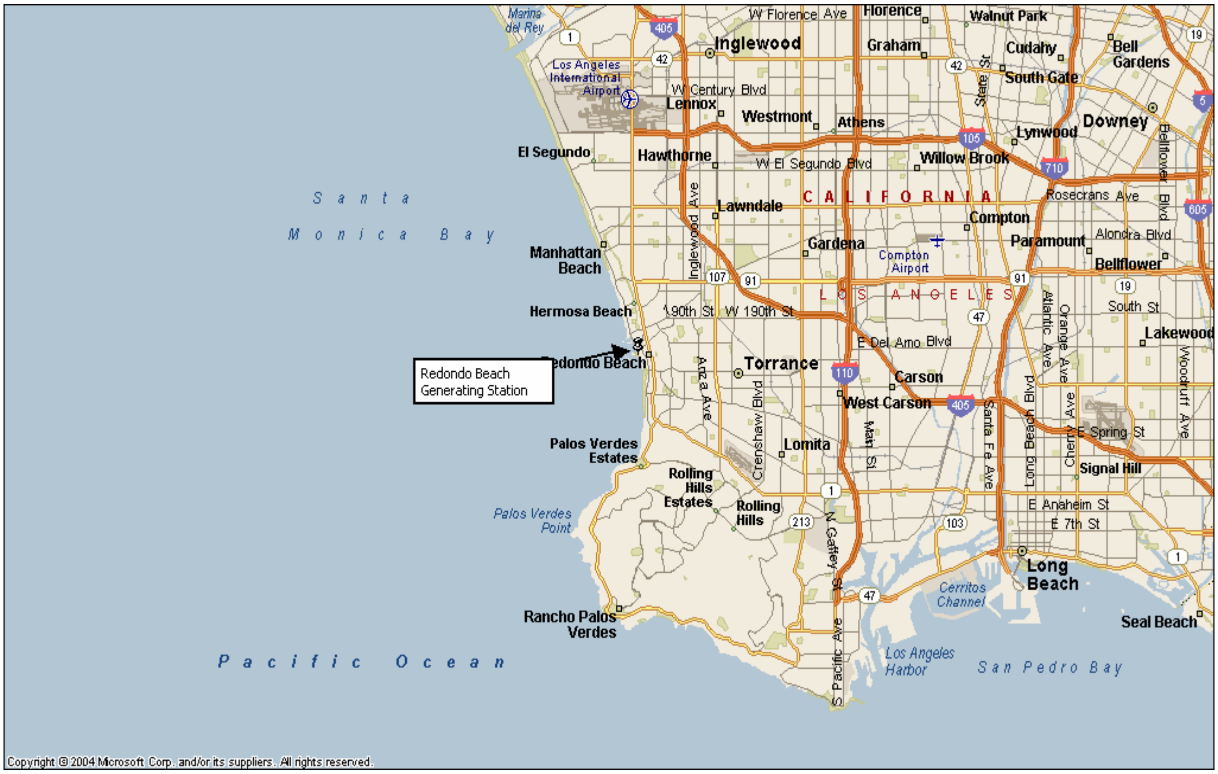


**Figure 1 Location of the RBGS**

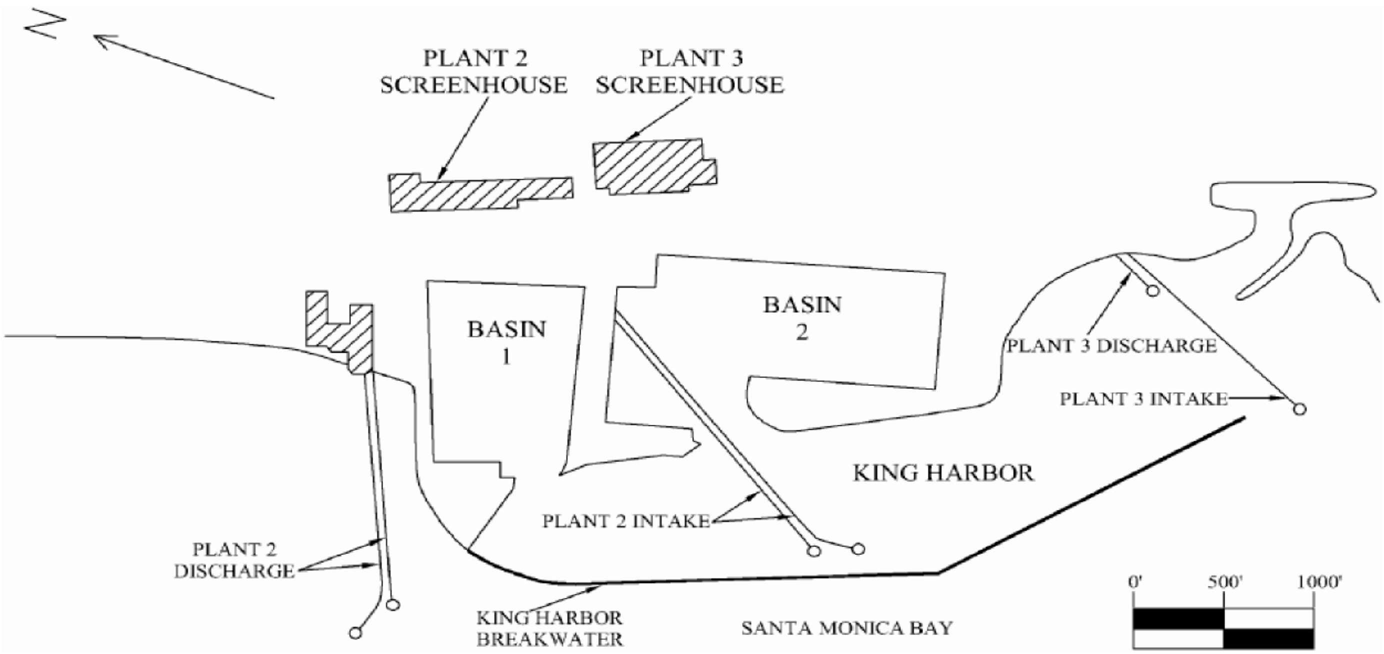


**Figure 2  Site Configuration of the Redondo Beach Generating Station**

### *2.2 Plant 2 CWIS*

Plant 2 has two offshore intake conduits running approximately 2,270 ft from King Harbor to the onshore screen structure. Both 10 ft diameter intake conduit pipes extend out from the screenhouse to two 17 ft x 11 ft 4 in. vertical risers that are 35 ft high. The top of the risers each have a 25 ft x 31 ft concrete velocity cap. The top of the caps are at El. -16.0 ft (MSL). Vertical fiberglass bars 1 ¼ in. diameter by 4 ft long with 14 in. clear spacing are installed around the perimeter of the velocity cap openings. Units 5 & 6 can withdraw water through both offshore intake structures. Figure 3 provides a cross section view of the Plant 2 velocity caps.
RBGS's onshore screenhouse structure for Plant 2 is located approximately 310 ft inland from the shoreline. Figures 4 and 5 provide a top view and side view of the CWIS. The circulating water flows in from the offshore conduit through two 8.7 ft wide, submerged inlet tunnels. These expand into a common forebay on the south side of the pumphouse. The Plant 2 screenhouse has a minimum invert at El -19.0 ft upstream of the traveling water screens. At the traveling water screens the invert is at El. -16.0 ft. Sluice gates are located at the entrance of the bay to control the routing of the cooling water. The common forebay is 50 ft wide, splitting into four 10.2 ft wide bays with trash racks installed. The trash racks prevent any large debris from reaching the circulating water pumps that may have entered through the velocity cap. The trash racks are equipped with 3/8 in. x 2 in. carbon steel bars with 4 ½ in. spacing. Debris accumulated on these racks is cleaned with an electric motor operated trash rake and disposed of in a trash car. Vertical traveling water screens are located 14 ft -11 in. upstream from the center line of the circulating water pumps. The four screens are 7 ft wide with 5/8 in. square mesh openings and extend from El. -16.0 ft to above El. 18.0 ft. Stop logs are provided upstream and downstream of the traveling water screens to allow dewatering of the bay for maintenance. The screens operate automatically when the differential pressure across the screen reaches 12 in. Each screen is designed to rotate at 10 ft/min. Screen wash water is collected in a sluiceway that conveys debris and fish into a large mesh basket. The screens are cleaned by a front and back spray wash system with a flow of 164 gpm at 70 psig. Screen wash water is supplied by two of the three pumps.

Four vertical, mixed-flow circulating water pumps (two per unit) are located downstream from the traveling screens. The two circulating water pumps for Unit 5 provide 85.3 cfs cooling water each and the operating design point of each pump for Unit 6 is 81.9 cfs. All four pumps are rated at 590 rpm at 446 hp with 42 ft TDH (i.e. the addition of Static Lift + Static Height + Friction Loss).

The total Plant 2 flow with all pumps operating is 335 cfs. The flow from all four pumps is combined into two intake pipes before reaching the condensers.

Marine fouling is controlled at RBGS by a heat treatment process. This procedure reverses the once-through circulating flow, increasing the temperature at the intake conduits. The intake conduits become temporary discharges, and vise versa. Heat treatment occurs about every 5 weeks for approximately 2 hours.

Plant 2 discharge is located approximately 1,600 ft offshore, outside of King Harbor breakwaters. The two discharge pipes return the circulating water back to Santa Monica Bay.

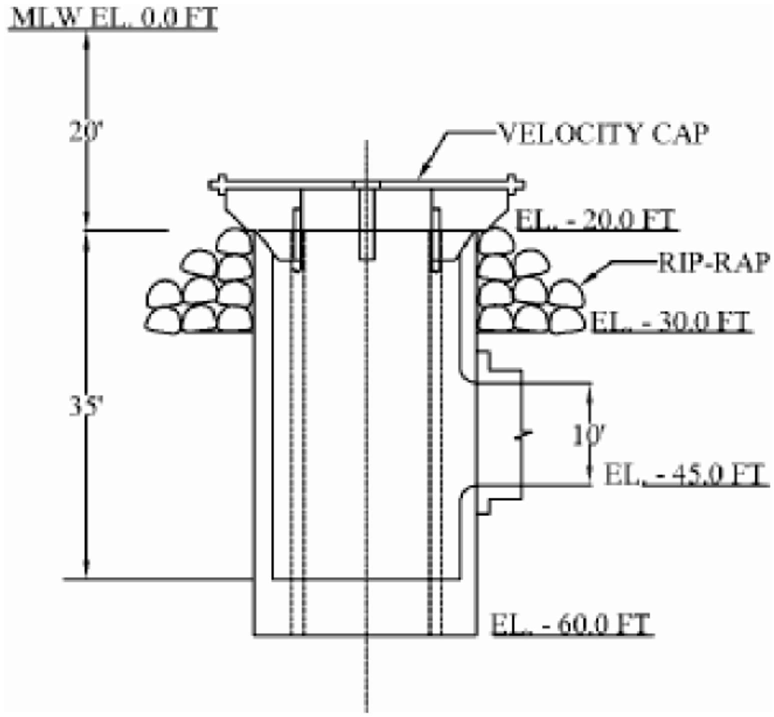


**Figure 3  Velocity Cap for Plant 2 Cross Section**

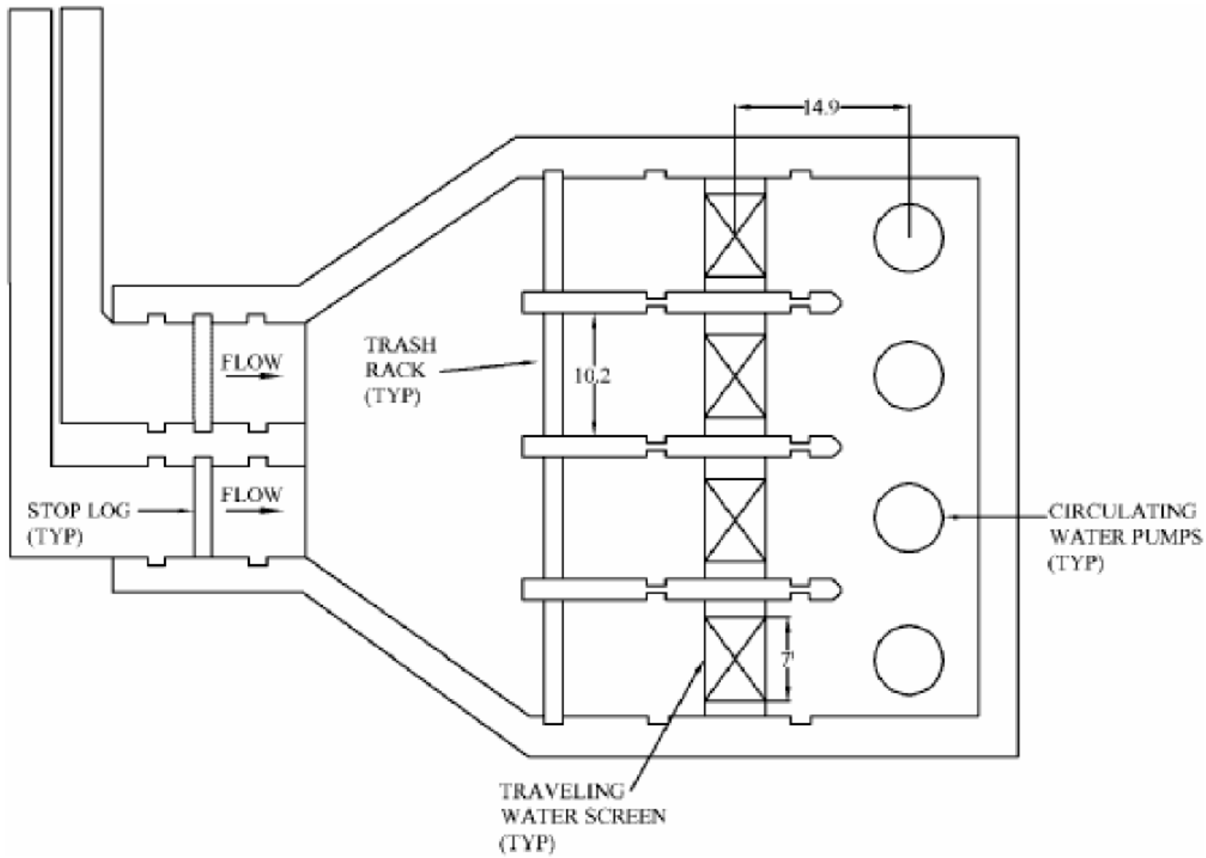


**Figure 4 Plant 3 Intake Structure– Plan View**

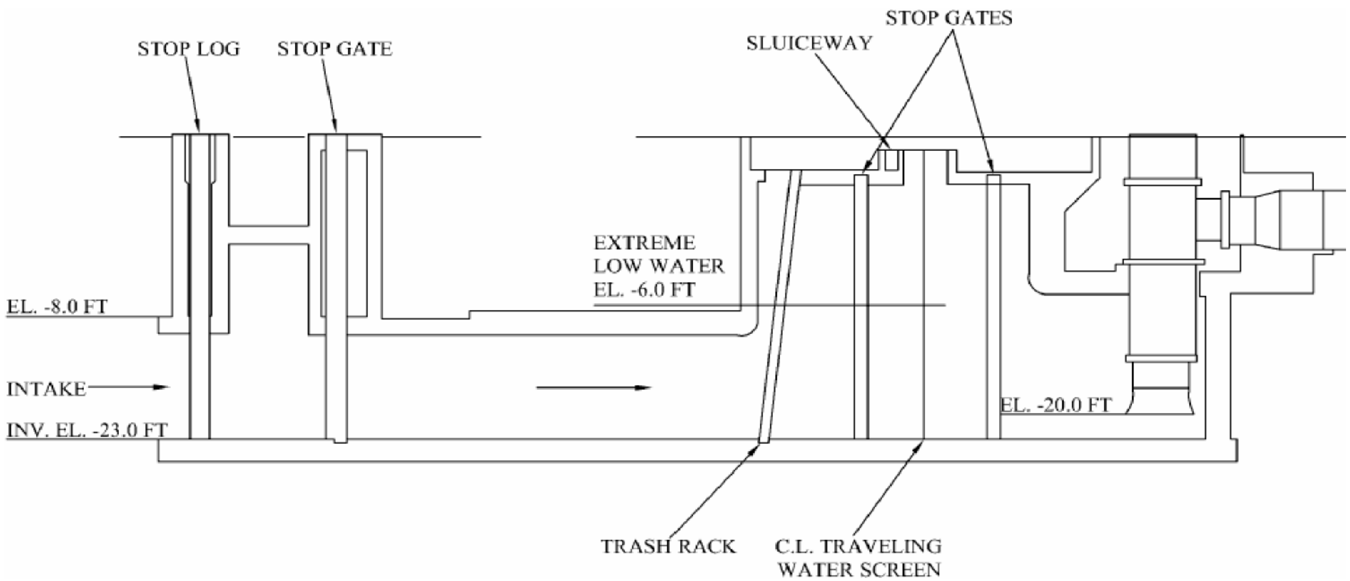


**Figure 5 Plant 3 Intake Structure– Cross Sectional View**

### *2.3 Plant 3 CWIS*

Plant 3 has an offshore intake conduit that runs approximately 3,280 ft from Santa Monica Bay (between the north and south breakwaters) to the onshore screen structure (Figure 2). The 14 ft diameter intake conduit pipe extends out from the screenhouse to a 24.5 ft x 24.5 ft vertical riser that is 29 ft high. The top of the riser has a 27 ft-2 in. x 32 ft-2 in. concrete velocity cap. The top of the cap is at El. -30.0 ft. Vertical fiberglass rods of ¾ in. diameter by 4 ft long with 14 in. clear spacing are installed around the perimeter of the velocity cap opening (Figure 6) .

RBGS's onshore screen structure for Plant 3 is located approximately 2,130 ft from the shoreline. A top view and cross sectional view of the CWIS is provided in Figures 7 and 8. The circulating water flows from the offshore conduit into a common screenhouse for both units. The invert at the screenhouse is at El. -23.0 ft. Two stop log gates are located upstream of two 27 ft-3 in. wide forebays. Each forebay bifurcates into 11 ft-2 in. wide bays where trash racks are installed. The trash racks have 3/8 in. x 2 in. carbon steel bars with 4 ½ in. spacing. Debris is removed from the trash racks by a trash rake and emptied into a trash car. The invert of the Plant 3 screenhouse is El. -23.0 ft at the traveling water screens (i.e. the four traveling screens extend from El. -23.0 ft to El. 15.0 ft. Vertical traveling water screens are located 28 ft upstream from the centerline of the circulating water pumps. The screens are 10 ft wide with 5/8 in. square mesh openings. Stop logs are provided upstream and downstream of the traveling water screen to allow dewatering of the bay for screen maintenance. The screens operate when the differential water level exceeds 9 in. across the screen. Each screen is designed to rotate at 10 fpm. Debris collected in the stainless steel mesh baskets are washed along a sluiceway by a front spraywash system with a flow of 528 gpm at 90 psig. Plant 3 has a similar debris collection system as Plant 2. Screenwash water is supplied by two pumps located in the structure rated at 1,750 rpm at 125 hp.

Each unit has two vertical, mixed flow type circulating water pumps located downstream from the traveling screens. Each pump provides 261 cfs of cooling water to the condensers rated at 324 rpm at 900 hp with 22.8 ft TDH. The total Plant 3 flow with all pumps operating is 1,044 cfs (522 cfs per unit). Each pump is housed in separate bays and draws cooling water through a single screen.

The heat treatment process for Plant 3 returns circulating water through the overpass and discharges out into the intake. The Plant

3 discharge is located adjacent to the intake conduit and extends approximately 300 ft into King Harbor.

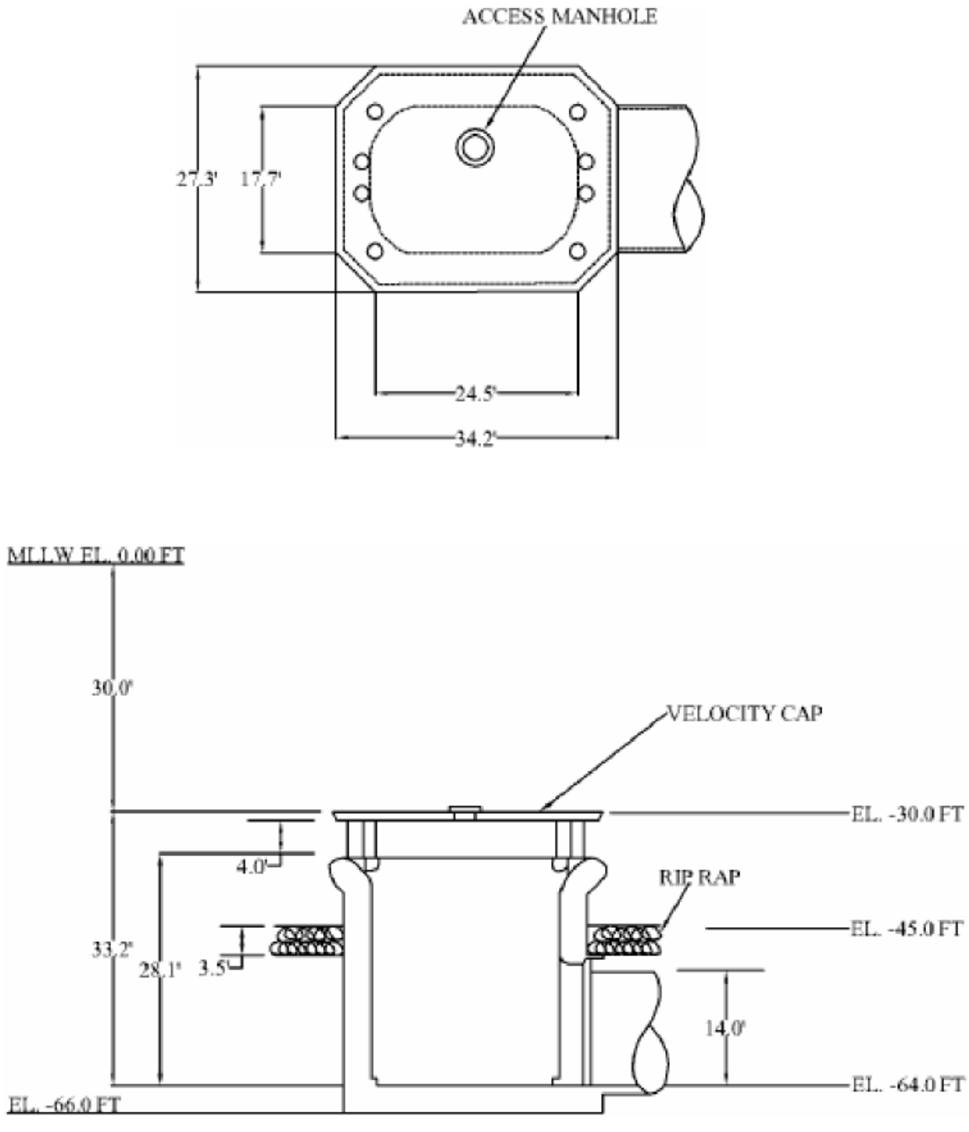


**Figure 6 Velocity Cap for Plant 3 – Plan and Section**

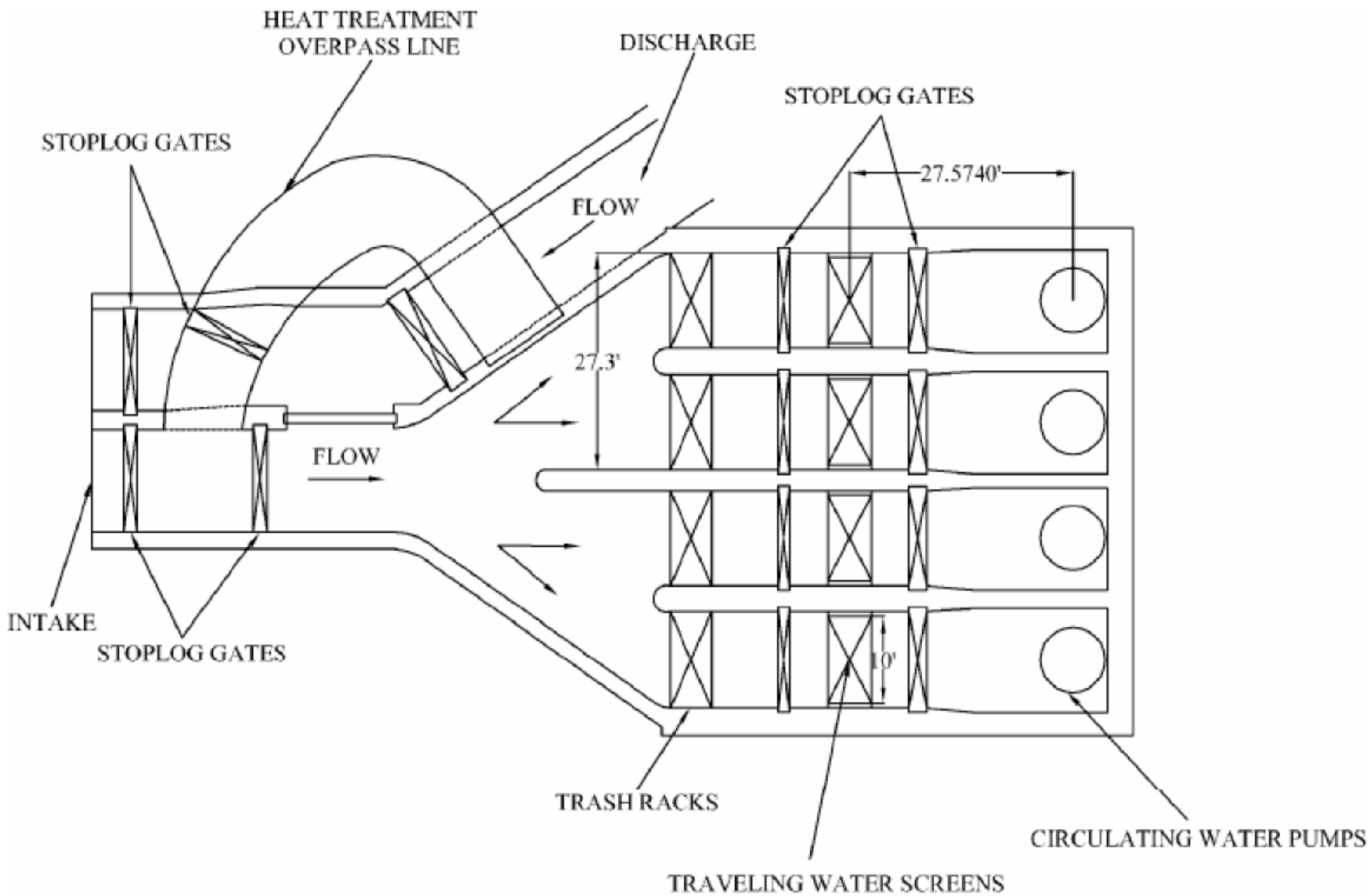


**Figure 7 Typical Plant 3 Intake Structure– Plan**

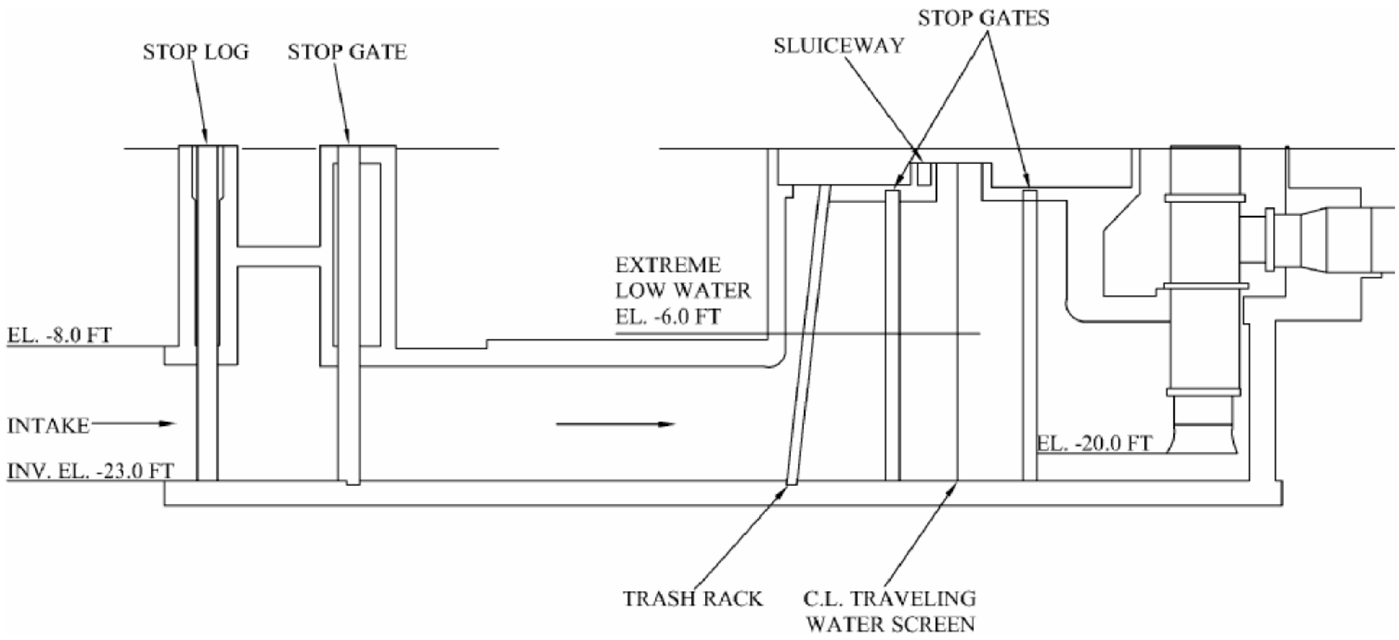


**Figure 8 Typical Plant 3 Intake Structure– Section**

## 2.4 Existing Hydraulic Conditions

King Harbor and Santa Monica Bay are on the coast of the Pacific Ocean in southern California. Normal water depth of King Harbor is 18 ft with a maximum water depth at 45 ft. Water depths in Santa Monica Bay range from 0 ft to greater than 600 ft. High water is at El. 7.0 ft and a low water at El. - 2.0 ft. Mean sea level, El. 0.0 ft, is the mean low water level, and the elevation at which all other elevations in this report are based.

Assuming that all the flow for Plant 2 goes through only one velocity cap, results in an inlet velocity of about 0.9 ft/sec and a 4.3 ft/sec velocity in the pipe. If the Plant 2 flow is through both offshore intakes, the approach velocity at the cap is 0.5 ft/sec with a pipe entrance velocity of 2.1 ft/sec. The onshore intake structure of Plant 2 has an approach velocity of 0.9 ft/sec at the trash racks and traveling water screens under full flow conditions and low water levels.

Plant 3 circulating water pump flow results in an inlet velocity of about 3.2 ft/sec through the velocity cap and a 6.8 ft/sec velocity in the pipe. The onshore intake structure of Plant 3 has an approach velocity of 0.9 ft/sec at the trash racks under full flow conditions and low water levels. The traveling water screens have an approach velocity of 1.0 ft/sec under these same conditions.

Approach velocities are approximately half the through-screen velocity and therefore the current maximum through-screen flows preclude use of Complaince Alternative 1 for both Plants under the current design.

## 2.5 Applicable Performance Standards

Because RBGS withdraws water from an ocean, it is subject to both the impingement mortality and entrainment reduction performance standards. If a facility's capacity utilization rate based on five years of operating data is 15% or less, it is only subject to the impingement mortality reduction performance standard. Importantly, the Rule's definition of capacity utilization rate it states, "In cases where a facility has more than one intake structure, and each intake structure provides cooling water exclusively to one or more generating units, the capacity utilization rate may be calculated separately for each intake structure, based on the capacity utilization of the units it services". As noted above, RBGS has two operational intake structures, one intake for Units 5&6 and a second intake for Units 7&8. Thus, the Rule allows the capacity utilization to be applied independently for RBGS. As noted in Table 1, capacity utilization for Units 5&6 over the last five years has been well below 15%. Therefore the Unit 5&6 CWIS will only be subject to the IM performance standard.

**Table 1 Capacity utilization rates for once through cooling units at RBGS**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 5 Years |
|---|---|---|---|---|---|---|
| **RB5** | 7.94% | 10.76% | 5.42% | 8.06% | 2.30% | 6.86% |
| **RB6** | 18.26% | 24.78% | 3.02% | 1.64% | 1.42% | 9.69% |
| **RB7** | 40.79% | 65.79% | 22.42% | 19.47% | 16.63% | 31.40% |
| **RB8** | 21.62% | 66.28% | 22.91% | 13.26% | 10.57% | 25.77% |
| **Total** | 26.44% | 53.33% | 17.81% | 18.10% | 10.46% | 23.21% |

However, because RBGS Units 7&8 capacity utilization exceeds 15%, this intake is subject to both the IM&E reduction performance standards.

### *2.6 Conformance with the Calculation Baseline*

The RBGS CWIS does not conform to the Rule's calculation baseline. Significant deviations include:

- The intakes are offshore rather than located at the shoreline,
- The intakes are submerged rather than at or near the surface, and
- The intake design for both Plants 2 and 3 includes use of a velocity cap.

The Rule allows facilities to take credit for deviations from the calculation baseline if it can be demonstrated that these deviations provide the benefit of fish protection to impingeable sized organisms. Opportunities to take a credit are discussed in the next section.

# 3 COMPLIANCE ALTERNATIVES TO BE EVALUATED

AES intends to evaluate the full range of compliance alternatives and options available in the final Rule for potential use in the Comprehensive Demonstration Study (CDS). However, AES also has certain preferences for compliance because some options are considered to be more feasible, cost-effective and environmentally beneficial than others. This section of the PIC provides a description of specific alternatives and options that will be evaluated for compliance. It also indicates AES's preferred compliance alternatives and options based on currently available information, as well as, some of the issues currently identified with these alternatives and options.

### *3.1 Taking Credit for Existing Use of Fish Protection Technologies and Operational Measures Under the Rule's Calculation Baseline*

The Rule specifically entitles facilities to take credit for deviations from the calculation baseline, defined in Section 1 above, that provide the benefit of fish protection. As discussed in Section 2, RBGS has a number of facility design and operational deviations from the Rule's calculation baseline that provide the benefit of fish protection. These systems include use of a submerged offshore intake with a velocity cap, operational procedures to return live impinged fishes to the Pacific Ocean source waterbody and overall low capacity utilization.

**Impingement Mortality Reduction Credits**

RBGS's submerged offshore intake fitted with a velocity cap is very similar to the system used at AES's Huntington Beach Generating Station (HBGS). Site-specific studies were conducted at HBGS in 1979 and 1980 to evaluate the effectiveness of the velocity cap in reducing impingement. A high level of fish protection performance was reported for HBGS with average effectiveness between the two years exceeding the minimum 80% impingement reduction performance standard. AES plans to conduct similar studies at RBGS to verify site-specific performance and credit towards the performance standards. A description of the proposed study is provided in Section 4 and Appendix B.

The Rule's calculation baseline also allows facilities to take credit toward meeting the performance standard for operational measures that reduce impingement mortality. EPA in the preamble states:

*Similarly, the assumptions of no impingement or entrainment controls in the definition in the proposed rule has been clarified to describe an intake where the baseline operations do not take into account* ***any procedures*** *or technologies to reduce impingement or entrainment. EPA recognizes that some facilities may have controls in place that already reduce impingement or entrainment; the final calculation baseline would allow credit for such reductions.*

AES at RBGS has engaged in the practice of collecting impinged fishes that are still alive and returning them to ocean. Quantification of the live returned fishes as a percentage of the overall impingement for use of this procedure is an additional potential source of credit towards compliance. As part of the proposed 2006 IM&E study, information will be collected to quantiy this credit and is discussed in Attachment B.

**Entrainment Reduction Credit**

In addition, the offshore submerged location of the intake may have the benefit of reducing entrainment relative to a surface, on-shore location. An evaluation of the potential for an entrainment reduction credit for this calculation baseline deviation may also be considered.

As noted in Section 2, RBSG's capacity factor over the past 5 years has been under 10% for the Plant 2 Units and less than 32% for Plant 3 Units. For facilities with lower capacity utilization such as RBGS, estimating entrainment based on actual flow is consistent with the Rule's baseline calculation reference to "the baseline practices and procedures". EPA in the Rules preamble on page 41617[2] points out that some comments on the Rule "suggested that the calculation baseline should reflect unrestricted operation at full design capacity year-round to avoid continually changing the baseline". However, EPA chose not to base the calculation baseline on this approach stating "EPA chose not to incorporate capacity into the calculation baseline, as the definition is not dependent upon intake flow volumes. EPA chose instead to adopt baseline practices and procedures under the calculation baseline or the "current level of impingement mortality and entrainment". For facilities with lower capacity utilization such as RBGS, estimating entrainment based on actual flow is consistent with the Rule. It is therefore appropriate for AES to calculate the level of IM&E by determining the current impingement mortality and entrainment based on cooling water pump operation rather than design flow. The IM&E baseline characterization using this approach will remain the baseline unless operations change. In the event cooling water pump operation increases in the future, that would constitute a change in facility operations and require further study and/or additional compliance measures. The 316(b) Rule contemplates review of 316(b) compliance during each permit cycle[3]. This ensures that if operations such as increased

[2] Federal Register, Vol 69, No.131, 7/9/04, pg. 41617, Column 2

[3] The Rule at §125.98(a)(3) states "At each permit renewal, you (referring to NPDES permitting authority) must review the application materials and monitoring data to determine whether new or revised

cooling water pump operation occur, the permit can be modified to ensure that the performance standards will continue to be achieved.

### 3.2 Use of Restoration under Compliance Alternative 3

The EPA final Phase II Rule provides that applicants may use restoration measures in addition to, or in lieu of, technology measures to meet performance standards or in establishing best technology available (BTA) on a site-specific basis. The basic philosophy of restoration is mitigation of fish losses at a CWIS by either direct supplementation (stocking) of a "species of concern" potentially impacted by the CWIS, or provision, protection and restoration of habitat that "produces" fish and thereby replaces those lost due to IM&E. AES views restoration as a preferred method for meeting the entrainment reduction performance standard. However, it is also recognized that there is some risk this option may not be available[4].

Attachment A provides a summary of the kinds of restoration measures that will be considered. Project examples are listed for the following reasons: (1) their 316(b) application history by other power companies, (2) known interest in the local area based on an internet review of state programs, and (3) because design and implementation information is readily available. The basic categories of considered projects are as follows:

- Habitat Protection or Creation Program
- Fish Stocking
- Waterbody Restoration
- Removal of Obstructions to Migratory Fishes on Tributaries

Other types of projects may be identified in discussions with appropriate state and federal agencies.

AES plans to discuss these ideas and consider other restoration alternatives that may be suggested and will also consider working with other companies with Phase II facilities located on Santa Monica Bay to develop joint projects. As part of the requirement for

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requirements for design and construction technologies, operational measures, or restoration measures should be included in the permit to meet applicable performance standards in §125.94(b) or alternative site-specific requirements established pursuant to §125.94(a)(5).

[4] AES is aware that use of restoration is currently the subject of Phase II Rule litigation. The Second Circuit ruled that restoration could not be used for compliance with the 316(b) Phase I Rule. Based on the Phase I litigation decision, EPA added significant text to the Phase II Rule to support its use in Phase II. AES plans to initially limit evaluation of this compliance option in 2005 to discussions with the Board and approapiate State and Federal fish and wildlife agencies to identify potential projects of interest and methods for scaling and verification monitoring related to projects of interest. It is AES's current understanding that the Phase II Rule litigation decision should be rendered sometime in the second quarter of 2006.

use of restoration, AES plans to fully evaluate available technologies and/or operational measures to demonstrate that restoration is more feasible, cost-effective or environmentally desirable than use of meeting performance standards through use of technologies and/or operational measures (see below in Section 3.3). The analysis of IM&E data described in Attachment B will be used in determining the amount of restoration necessary to provide a minimum benefit equivalent to an 80% impingement mortality reduction and 60% entrainment reduction as required by the Rule.

### *3.3 Use of Fish Protection Technologies and/or Operational Measures under Compliance Alternatives 3 and 4*

AES plans to evaluate a variety of technologies and operational measures for compliance. Generally the cost of technologies required for compliance with the entrainment performance standard are significantly more costly than those required for compliance with the impingement reduction performance standard. Since RBGS believes it currently meets the IM reduction performance standard (see Section 3.1 above), AES plans to focus on the evaluation of entrainment reduction technologies and operational measures. However, it should be noted that the entrainment reduction technologies and operational measures proposed for evaluation also provide the benefit of impingement mortality reduction as well. AES is using Alden Research Laboratory to assist in evaluating alternatives technologies and operational measures. In the event that use of restoration measures are not available to offset entrainment losses, the following technologies and operational measures will be evaluated:

**Narrow-Slot Cylindrical Wedgewire Screens** – A schematic of this technology is shown in Figure 9. This technology is designed to work by using a low through screen velocity relative to the ambient water current velocity. Protection of entrainable organisms is a function of the sweeping velocity of the water current past the screens relative to the through screen velocity. These screens would replace the existing velocity caps for the Plant 2 and 3 intakes. Based on RBGS's Plant 2 and 3 cooling water flow of 334.4 and 1044 cfs respectively, the appropriate number and size of cylindrical wedgewire screen modules would be selected. Wedgewire screen are typically designed to meet the entrainment standard by using 0.5 mm slots, however, RBGS entrainment data will be reviewed to determine if a larger or smaller size would be appropriate. The cost of this technology is a function of slot size, since a smaller slot size requires use of more or larger screens to provide the same volume of cooling water. In addition, the industry standard design for wedgewire screens is a maximum through slot velocity of 0.5 ft/sec which would allow use of compliance alternative in terms of the impingement performance standard.

To verify effectiveness for reducing entrainment, AES will need to evaluate current velocities in the area where the screens would be deployed to confirm there is sufficient sweeping velocity past the screen modules to prevent impingement of entrainable organisms. While these screens have been deployed at a number of freshwater facilities, they have not yet been deployed in marine environments such as the Pacific Ocean. The higher biofouling rates in an ocean environment may present feasibility issues for this technology. The technology employs use of compressed air released in a manner to cause a blast of air through the screens to control fouling and debris buildup. However, testing in ocean environments will be important to determine if the air blast system is adequate to ensure an uninterrupted supply of cooling water for facilities such as RBGS. This may include conducting pilot studies in this region of the Pacific.

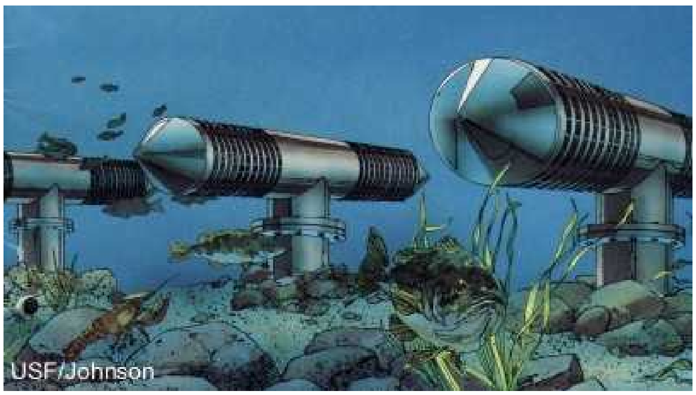


**Figure 9 Narrow Slot Wedgewire Screens**

**Fine-mesh Ristroph Traveling Water Screens -** AES also plans to evaluate replacing the existing 3/8 in. traveling water screens for Units 1 - 4 with new 0.5 mm fine-mesh Ristroph screens. This technology, while evaluated during the repowering study, will be re-evaluated as it is one of the few feasible alternatives with the potential to meet the entrainment performance standard. This fish protection technology is based on first collecting impinged and entrained organisms in a manner to maximize survival and then returning them to the source waterbody. The technology employs a combination of Ristroph fish buckets attached to the bottom of traveling screen panels (Figure 10) and replacing the 3/8 in stainless steel mesh with a fine mesh fabric (Figure 11). A low pressure screenwash spray system (~10 psi) is installed to wash entrained fish eggs and larvae gently off the screens into the Ristroph buckets. The Ristroph buckets then discharge the fishes into a fish return system to transport them back to the source waterbody in a location away from the intake to prevent re-entrainment. Fine-mesh screens are typically designed with an approach velocity of 0.5 ft/sec to help maximize survival of fish eggs and larvae. There are several issues that will need to be evaluated relative to this technology. First, the current approach velocity to the traveling screens is about double the typical design velocity for this technology. The normal design velocity for this technology is an approach velocity of 0.5 fps. Currently Plant 2 and Plant 3's approach velocities are 0.9 fps and 1.0 fps respectively. Due to the higher velocities it will be essential to perform laboratory and/or field studies to verify that the survival of entrainable organisms is higher than the existing survival through the condenser system.

If impingement survival of entrainable organisms is low at the current velocities, the screenhouse would need to be expanded to accommodate additional screens necessary to reduce the approach velocity. Such an expansion would require each unit to be shutdown for a substantial amount of time and would require considerable site work. Second, due to the location of the existing traveling screens onshore impinged and entrainable organisms collected will have to be transported a considerable distance to a safe release point. Finally, species and associated life stages tend to vary considerably in terms of their ability to tolerate the collection and handling associated with this option, again emphasizing the need for species and life stage specific testing to verify survival rates. For these reasons, and especially if expansion of the intake and installing more Ristroph screens is required this option may not be a cost-effective solution.

**Figure 10 Ristroph screen buckets attached to bottom of traveling screen panels.**

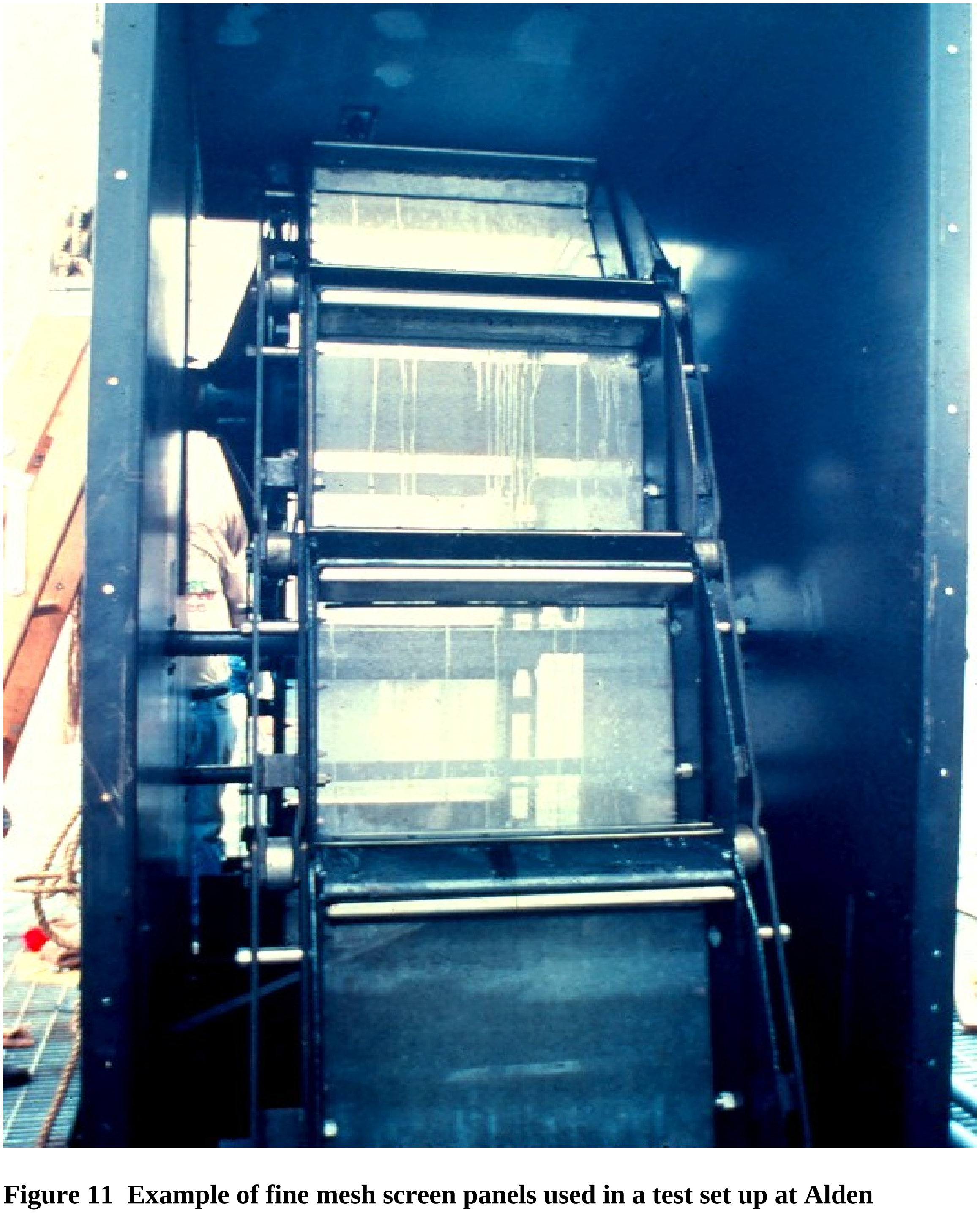

**Figure 11 Example of fine mesh screen panels used in a test set up at Alden Research Laboratory**

- **Use of an Approved Technology under Compliance Alternative 4**. Currently use of wedge wire screens in rivers that meet certain criteria is the only named EPA pre-approved technology. However the Rule provides a process that allows additional technologies to become listed pre-approved technologies. New technologies can be so designated by providing information to demonstrate that if installed in the waterbody type the technology would have little trouble meeting performance standard for which they are pre-approved.

When results of the proposed IM&E sampling are available in 2006, if use of restoration measures are not available and AES decides to comply using one or a combination of technology and/or operational measures, it may propose pilot studies in the 2006/2007 time frame to verify performance.

Now that the final 316(b) Rule is in place, a good deal of interest has been generated in developing new fish protection technologies. AES plans to monitor the development and testing of new technologies for potential use. If other technologies more effective in terms of fish protection efficacy and cost-effectiveness become available, AES will inform the Board that the new technology may be added to the PIC for evaluation at RBGS.

### *3.4 Use of Site-specific Standards under Compliance Alternative 5*

AES plans to evaluate potential use of both the cost-cost and cost-benefit tests under compliance alternative 5. Use of these alternatives are provided to allow Phase II facilities to not pay costs that would be considered significantly greater than either the costs estimated by EPA for facilities or the economic value of the site-specific environmental benefits that will be achieved. Should the evaluation of the current impingement reduction technologies and operational measures determine that the IM performance standard is not met or use of restoration for offsetting entrainment losses is not available these tests will be used in conjunction with the evaluation of technologies and operational measures discussed in the previous section of the PIC.

**Evaluation of Cost-Cost Test** - EPA, in developing the national cost of implementing the Rule, considered the cost for each Phase II facility to comply. If the actual cost estimated for a facility to meet the performance standard, based on a site-specific analysis, is determined to be significantly greater than the cost estimated by EPA for the facility to comply, the facility can apply for a site-specific standard under the cost-cost test using compliance alternative 5. The site-specific standard would be that achieved by the use of the best performing technology (i.e. achieve the highest level of protection) or operational measure that would pass the cost-cost test. RBGS is identified as facility number DNR2048. It was not initially listed in the Appendix due to the questionnaire submittal for this facility being designated as confidential business information (CBI).

AES subsequently waived that claim for the flow information and EPA as released the Appendix A cost information to AES. The estimated annualized cost for RBGS was estimated to be $61,373 for Plant 2 and $163,592 for Plant 3. These cost estimates are based on a capital cost of $365,848 for Plant 2 and $998,549 for Plant 3 and an O&M cost of $9,285/yr for Plant 2 and $21,421/yr for Plant 3.

**Evaluation of Cost-Benefit Test** - The economic value of the environmental benefit of meeting the performance standards will also be evaluated. This evaluation will include the cost of any additional impingement mortality reduction technologies needed to make up any shortfall after taking credit for the offshore submerged intake and velocity cap. It will also include evaluation of the costs of meeting the entrainment performance standard (again after any taking any credits as a result of baseline deviations that can be demonstrated to provide the benefit of fish protection) and the resulting benefit of meeting the entrainment standard. The approach for this analysis is further discussed in Attachment C of the PIC.

# 4 BIOLOGICAL STUDIES

The Rule requires that a summary of historical IM and/or physical and biological studies conducted in the vicinity of the CWIS be provided, as well as plans for any new IM studies. One year of entrainment sampling was conducted at RBGS from August 1979 through July 1980. The sampling was conducted monthly with 6 replicate samples collected over a 24 hr period. Impingement sampling has been conducted annually since 1979. Because of the long-term data available, the impingement sampling at the screens will be limited to the monthly sampling conducted annually as required by the NPDES permit. However, new impingement studies will be conducted relative to quantification of credit toward the performance standard as a result of the calculation baseline deviations discussed in Sections 2 and 3 of the PIC. Reverse flow studies conducted at the Plant 3 intake will be used as a basis to estimate credit for the submerged offshore intake and velocity cap in terms of the fish protection benefit it provides. In addition, survival studies will be carefully monitored to quantify the percent impingment mortality reduction achieved by the fish recovery and return procedures.

Due to the age of the previously collected entrainment data, a year of new entrainment monitoring is proposed to characterize entrainment of fish and shellfish. In addtion, a source waterbody study of entrainable life stages is a component of the the overall study plan for use in scaling a restoration project to offset the estimated proportional loss, since this is currently the preferred compliance alternative. Final data analysis decisions will be made as appropriate to support the compliance alternative(s) and option(s) selected. A detailed description of the existing IM&E data, biological and physical information, and plans for new biological studies and analytical approaches is provided in Appendix B.

# 5 SUMMARY OF PAST OR ONGOING CONSULTATION WITH AGENCIES

The Rule requires that "a summary of any past or ongoing consultations with appropriate Federal, State, and Tribal fish and wildlife agencies that are relevant to the CDS and a copy of written comments received as a result of such consultations be provided".

There have been no consultations with federal or state fish and wildlife agencies regarding RBGS relative to 316(b).

# 6 SCHEDULE FOR INFORMATION COLLECTION

The Rule allows facilities with NPDES permits that expire within four years of the date of publication of the Rule in the Federal Register (July 9, 2004), up to three years and six months to submit the CDS (125.95(2)(ii)). AES submitted a letter dated November 2, 2004 requesting approval of a schedule to prepare and submit the PIC, conduct necessary studies and information to prepare and submit the CDS. That schedule was approved in a letter from the Board dated December 23, 2004. The letter noted that final approval of the schedule was contingent upon submittal of the PIC and status reports.

As noted in Section 4, AES is planning to initiate new IM&E studies in 2006.
Assuming that the Board provides comments within the 60 day period suggested in the Rule, AES will make any necessary changes to modify the PIC within 30 days and provide a revised PIC to the Board by November 30, 2005. The first major task will be to complete the IM&E Characterization Study and analyze the data. Completing this analysis is critical in order for AES to make a final decision on compliance alternatives. It is anticipated this analysis will require approximately 4 months to complete (second quarter of 2007). Upon PIC approval, AES will also initiate work and discussions with appropriate State and Federal Agencies to identify potential restoration projects of interest for use under compliance alternatives 3 and/or 5. It is expected that based on the final litigation schedule that the Court will issue a decision on the on-going Phase II litigation around the end of the second quarter of 2006. This will allow AES to reassess available compliance alternatives and options based on the Court's decision. If AES's preferred use of restoration is not available for entrainment, it is anticipated a more detailed evaluation of alternative technologies including pilot studies may be initiated in the latter part of 2006. Based on completion of analysis of the biological data in 2007, if restoration is available AES should be in a position to make a final compliance decision in mid 2007 in terms of project details to be incorporated into the CDS. If restoration is not available, the CDS is anticipated to focus on use technologies and/or operational measures under compliance alternatives 3, 4 and/or 5.

Preparation of the CDS will depend on the final compliance alternative(s) selected as follows:

- Use of Technologies or Operational Measures - It is anticipated that it will require approximately 6 months to review and complete a draft and final CDS based on the technology and compliance assessment information (i.e. Design and Construction Technology Plan and Technology Installation and Operation Plan).

- Use of Restoration - If AES's preferred approach of using restoration measures is available, work will be initiated to prepare a restoration plan. It is anticipated that preparation of this plan and providing the information necessary to address the requirements necessary for this plan will also require 6 months. It is therefore likely that a final CDS based on restoration can be submitted on or before the end of 2006.
- Use of Site-specific Standards - Should use of compliance alternative 5 be a component of the CDS, it will be necessary to prepare a Comprehensive Cost Evaluation Study and if the Cost-Benefit test is used, a Benefit Valuation Study will be required. In addition, if a technology or operational measure is used as part of compliance alternative 5, the technology and compliance assessment information documents will also be required. Thus the full allowable schedule will be necessary. However, assuming an entrainment reduction technology or operational measure is not identified that would pass the site-specific standards, the final CDS would be submitted by the end of 2006.

The Rule recognizes that the CDS studies are an iterative process[5] and allows facilities to modify the PIC based on new information. AES may request Board approval of an amendment to this PIC, based on new information relative to technologies and operational measures, use of restoration measures, Phase II Rule litigation or subsequent Agency guidance. Such information may require modification of the currently proposed schedule.

[5] See Rule preamble first column pg 41235 of Federal Register/Vol. 69, No. 131/Fri 7/9/04.

# A RESTORATION MEASURES

## Restoration Measures to be Evaluated for 316(b) Compliance at AES's Redondo Beach Generating Station

The final Phase II Rule provides that applicants may use restoration measures in addition to, or in lieu of, technology measures to meet performance standards or in establishing best technology available (BTA) on a site-specific basis. Specifically, EPA's final Phase II Rule states the following requirement relative to the use of the restoration approach:

> *Facilities that propose to use restoration measures must demonstrate to the permitting authority that they evaluated the use of design and construction technologies and operational measures and determined that the use of restoration measures is appropriate because meeting the applicable performance standards or requirements through the use of other technologies is less feasible, less cost-effective, or [emphasis added] less environmentally desirable than meeting the standards in whole or in part through the use of restoration measures.*

### Types of Restoration Applicable to §316(b)

The Rule does not specify the types of restoration measures that can be used. This lack of specification provides flexibility in developing/proposing a restoration approach. Restoration measures that have been used at other power stations to meet §316(b) requirements include:

- Wetland restoration (e.g., Public Service Electric & Gas (PSEG) Delaware Bay wetland restoration program for the Salem Generating Station)(Weinstein et al. 2001).
- Fish stocking (e.g., Mirant Mid-Atlantic fish hatchery at the Chalk Point Station (Bailey et al. 2000); Exelon's (formally Commonwealth Edison) walleye hatchery at Quad Cities Station on upper Mississippi River (LaJeone and Monzingo 2000); and Southern California Edison's white sea bass hatchery.
- Submerged aquatic vegetation (SAV) restoration (e.g., Southern California Edison's kelp restoration for the San Onofre Nuclear Generating Station) (Deysher et al. 2002).
- Provision of fish passage (e.g., fish ladders or dam removal) at non-hydropower projects (e.g., PSEG fish ladders in Delaware Bay tributaries for the Salem Generating Station).
- Contribution to, or maintenance of, a restoration fund related impacts associated with the re-powering of the Moss Landing Station on Elkhorn Slough near Monterrey Bay,

California – see http://www.duke-energy.com/businesses/plants/own/us/western/morrobay/reports/

- Water quality improvements (e.g., riparian area protection or implementation of non-point source best management practices) that minimize sediment/pollutant runoff thereby resulting in fishery habitat improvements, and practices that increase dissolved oxygen content in waterbodies thereby increasing available habitat for fish spawning and survival. While this approach is plausible, there are no known existing examples of such a 316(a) or 316(b) restoration project.

## Potential Restoration Measures for AES California Facilities

AES may wish to consider the following example restoration projects[6] to attain the impingement mortality (and, if applicable, entrainment) reduction performance standard or as part of a site-specific standard developed by the permit director. These projects are listed because of their known interest to fish and wildlife agencies in California and because design and implementation information is readily available:

- Fish stocking – While forage species (e.g., gobies, anchovies, sardines) are the most common species impacted at California power plants, stocking of these species to compensate for the losses would not be of interest to any of the federal and state fish and wildlife agencies. The objective of a supplementation program would be to identify a 'species of concern', the stocking of which would compensate ('comparable to, or substantially similar to') for the production foregone as measured by a game fish's consumption (e.g., X northern anchovy are equivalent in energy or food consumption to Y white sea bass or other recreational or commercial fishes of concern). This is the approach used by Potomac Electric Power Company for estimating annual hatchery production of striped bass to compensate for bay anchovy (a forage species) losses at their Chalk Point Generating Station on the Patuxent River in Maryland.

  Fish stocking involves the direct supplementation (stocking) of a fish species of concern to aid restoration efforts for that species. Restoration stocking (as opposed to recreational gamefish stocking) is generally pursued where the species of interest has been completely extirpated or where associated habitat restoration is unlikely to contribute to stock restoration. For example, the Georgia Department of Natural Resources (GDNR), following six years of study, recently initiated a long-term effort to restore lake sturgeon to the Coosa River system in Georgia/Alabama. This species is listed as threatened throughout the U.S. and has disappeared completely from much of its original range, including the Coosa River. Through a collaborative effort

[6] Projects listed are examples – opportunities for creative restoration projects are unlimited and depend upon corporate interests and negotiations with state and federal resource agencies.

between several state and federal agencies, GDNR released 1,100 fingerlings to the Coosa River in December 2002 as the first step towards returning lake sturgeon to a healthy, self-sustained population in the river (see: http://georgiawildlife.dnr.state.ga.us/content/displaycontent.asp?txtDocument=305). A similar program may be of interest in California, particularly for the southern steelhead salmon or coastal rockfishes (*Sebastes* spp.), both of which are federal and state listed endangered and threatened species along the California coast (see: http://ecos.fws.gov/tess_public/TESSWebpageUsaLists?state=CA). CDFG and RWQCB (and USFWS/NMFS) may support AES's participation in a program to restore rare, threatened, and endangered fish to native habitat. Mirant Mid-Atlantic Inc. currently raises and stocks Atlantic sturgeon at its Chalk Point Hatchery Facility on the Patuxent River for the State of Maryland, Department of Environmental Protection. American shad restoration to the Susquehanna River basin in Maryland/Pennsylvania has been accomplished in part via stocking of juvenile shad and via provision of fish passage (St. Pierre 2003; Hendricks 1995). Restoration stocking (e.g., for southern steelhead) could also be combined with provision of fish passage (i.e., dam removal or fish ladders). This form of restoration is discussed further below.

Fish stocking program support could be via hatchery operation developed on or off plant property (e.g., SCE funds the operation of a fish hatchery in Carlsbad, CA for culturing and stocking California sea bass – see http://www.sce.com/sc3/006_about_sce/006b_generation/006b1_songs/006b1c_env_prot/006b1c3_songs_miti/default.htm). Such a hatchery would be operated and maintained under state and federal oversight. Alternatively, AES could possibly negotiate a direct annual contribution of funds to a state and federal hatchery supplementation program or a private foundation. For example, the Hubbs/Sea World Research Institute operates the SCE fish hatchery for SONGS mitigation. While hatchery or stock supplementation programs can be controversial due to concerns over protection of natural genetic integrity, California resource agencies, based on their approval and development of SCE's SONGS Mitigation Project, supported stocking as compensation for fish losses. CDFG and NMFS also have a long-term fish hatchery program to support maintenance and restoration of anadromous salmonids in California coastal rivers (CDFG/NMFS 2001). California resource agencies' experience with hatchery supplementation may mean that they could be receptive to a hatchery program established by AES as compensation for impingement and entrainment losses at AES power plants in southern California. For example, when operating at design capacity, the SCE funded hatchery is expected to exceed compensation for the total SONGS fish losses estimated by an expert panel created by the California Coastal Commission.

For approximate cost references, SCE provided \$4.7 million in funding for the white sea bass hatchery which began operation in late 1996. Similarly, the Potomac Electric Power Company (PEPCO) established an aquaculture facility at their Chalk Point Station at a capital cost (1990 dollars) of \$1 million. Annual O&M has been approximately \$175,000 to \$250,000 depending on the species and number of organisms raised and stocked in Maryland waters.

- <u>Habitat Protection Program Participation</u> – The importance of wetlands, in-stream habitat, and riparian areas as aquatic habitat for fish and invertebrates, and as habitat for wildlife is reviewed in EPRI (2003). Wetland restoration or habitat restoration in general, is becoming increasingly popular across the U.S. and there is a growing case history with use of habitat restoration as a 316(b) mitigation approach (EPRI 2003). In California, over 90% of its historic wetlands and 95% of historic streamside trees, shrubs, and ground vegetation has been lost from urbanization, agricultural conversion, logging, and flood control (USFWS 2001). Habitat restoration, therefore, should be a major interest to federal and state resource agencies and non-governmental organizations (NGOs) in California. The following identifies federal, state, and private restoration programs that provide information which AES may find of value for establishing their own restoration program or offer opportunities to collaborate on potential restoration projects.

  Example programs include:

  - *SCE's SONGS Mitigation* (see: http://www.sce.com/sc3/006_about_sce/006b_generation/006b1_songs/006b1c_env_prot/006b1c3_songs_miti/default.htm): the proximity of SONGS and its ongoing restoration program is a key starting point relative to any restoration project initiated by AES for impacts at its southern California generating stations. The California resource agencies and local non-governmental organizations will likely heavily rely on lessons learned during the negotiation and development of the SONGS Program. The San Onofre Nuclear Generating Station Marine Mitigation Program is a multi-faceted environmental enhancement program intended to mitigate unavoidable impacts to the marine environment resulting from operation of the SONGS Units 2&3 cooling water systems. The program includes:
    1. restoring 150 acres of degraded wetlands at San Dieguito Lagoon to mitigate impacts to marine fish populations caused by estimated mortality to fish eggs and larvae;
    2. improving the in-plant fish protection systems to increase survival of adult fishes which enter the cooling water systems;

3. constructing an artificial kelp reef to mitigate impacts to the San Onofre Kelp Bed;
4. co-funding a marine fish hatchery program intended as supplementary mitigation for kelp impacts; and
5. funding for Coastal Commission staff oversight and monitoring of these mitigation projects.

SCE is managing the overall mitigation program. Through its Conservation Financing Corporation (CFC) subsidiary, the two largest elements of the mitigation program, the wetlands restoration project at San Dieguito Lagoon and the artificial reef at San Clemente, are being addressed by an equity alliance with CH2MHILL, an environmental management services consulting firm. CFC finances and oversees implementation of these two mitigation projects.

SCE is the plant operator and majority owner of SONGS. SONGS is jointly owned by SCE, San Diego Gas and Electric, and the cities of Anaheim and Riverside, which are funding the mitigation work.

SONGS' owners want to keep interested parties informed about this program, which will significantly enhance the region's marine resources. Through meetings, discussions, newsletters, a Web site, and the public hearing process, SCE expects to inform and involve the largest possible number of interested parties in the development and implementation of the mitigation/enhancement plans. Detailed technical progress on implementing and monitoring the SONGS mitigation effort can be found in the Proceedings from the Second Annual Public Workshop for the SONGS Mitigation Project (Reed et al. 2002).

- *Duke Energy's Morro Bay Modernization Project Habitat Enhancement Program* (see: http://www.duke-energy.com/businesses/plants/own/us/western/morrobay/reports/) – as part of the station modernization, Duke Energy has volunteered to fund a program that would reduce sedimentation and the other major factors undermining the Bay's productivity. The concerns for Morro Bay and the target of Duke's proposal are the issues identified by the Morro Bay National Estuary Program's (MBNEP) Comprehensive Conservation Management Plan (CCMP). Those issues include sedimentation, loss of habitat, and nutrient pollution. Duke's proposal is their preferred alternative to CEC requesting dry cooling operation. The Regional Water Quality Control Board (RWQCB) staff agrees with Duke's proposal and believes that habitat enhancement would yield greater long-term benefits for the Bay. Duke Energy's proposal would fund habitat enhancement projects authorized by the RWQCB and managed through professional groups like the

MBNEP, which have plans and programs to reduce sedimentation and other factors undermining the Bay's productivity. The special value of habitat enhancement is that it not only addresses marine biology, but also protects and enhances habitat for birds and other animals and sustains important recreational resources for the community. Documents describing the program in detail can be downloaded from the noted website. Because of recent economic conditions across the U.S., Duke has canceled plans for modernizing the Morro Bay Power Station and, as a result, their habitat enhancement project has not been implemented.

- *PSEG's Delaware Bay Estuary Enhancement Program* This is the largest restoration program the U.S. implemented as compensation for impingement and entrainment losses at a power station. Established in 1995, this program was negotiated with NJDEP as a mitigative action for fish losses at the Salem Nuclear Generating Station in lieu of implementing a closed-cycle cooling system. Principally focused on the restoration of approximately 10,000 acres of former salt hay farms to natural estuarine salt marsh in the lower Delaware Estuary, the program also includes provision of fish passage in combination with some limited fish stocking to support restoration of anadromous (American shad and river herring) fish stocks. Details of the program can be found in Weinstein et al. (2001). In a following section, the method used by PSEG to scale (i.e., convert fish loss to acres of equivalent wetland habitat) the size of the requisite restoration project is demonstrated. The PSEG incurred costs to date for the ongoing restoration project, including capital, O&M, and monitoring exceed $100 million or $9,350/acre (EPRI 2003).

- *Santa Monica Bay Restoration Commission (see:* http://www.santamonicabay.org/site/aboutus/layout/index.jsp) - In recognition of the need to restore and protect the Santa Monica Bay and its resources, the State of California and the U.S. Environmental Protection Agency established the Santa Monica Bay Restoration Project (SMBRP) as a National Estuary Program in December of 1988. The Project was formed to develop a plan that would ensure the long-term health of the 266 square mile Bay and its 400 square mile watershed, located in the second most populous region in the United States. That plan, known as the Santa Monica Bay Restoration Plan, won State and Federal approval in 1995. Since then, the SMBRP's primary mission has been to facilitate and oversee the implementation of the Plan.

  On January 1st, 2003, the Santa Monica Bay Restoration Project formally became an independent state organization and is now known as the Santa Monica Bay Restoration Commission (SMBRC). The Santa Monica Bay Restoration Commission continues the mission of the Bay Restoration Project and the collaborative approach of the National Estuary Program but with a greater ability to accelerate the pace and effectiveness of Bay restoration efforts. Restoration activities are based on a comprehensive plan of action for Bay protection and management, known as the Bay Restoration Plan, that was approved by Governor Pete Wilson in December of 1994 and by USEPA Administrator Carol Browner in 1995. The Plan identifies almost 250 actions, including 74 priority actions, that address critical problems such as storm water and urban runoff pollution, habitat loss and degradation, and public health risks associated with seafood consumption and swimming near storm drain outlets. The Plan outlines specific programs to address the environmental problems facing the Bay and identifies implementers, timelines, and funding needs.

Implementation of the Plan is the focus of current efforts. Securing and leveraging funding to put solutions into action, building public-private partnerships, promoting cutting-edge research and technology, facilitating a stakeholder-driven consensus process, and raising public awareness in order to restore and preserve the Bay's many beneficial uses are key objectives of the SMBRC.

- *National Oceanic and Atmospheric Administration (NOAA) Community-based Restoration Program (CRP)(see: http://www.nmfs.noaa.gov/habitat/restoration/*: This program applies a grass-roots approach to restoration by actively engaging communities in on-the-ground restoration of fishery habitats around the nation. The CRP emphasizes partnerships and collaborative strategies built around restoring NOAA trust resources and improving the environmental quality of local communities. The program is: (1) providing seed money and technical expertise to help communities restore degraded fishery habitats, (2) developing partnerships to accomplish sound coastal restoration projects, and (3) leveraging resources through national, regional, and local partnerships. This program is one of the services of the NOAA Restoration Center. This Center's mission is to enhance living marine resources to benefit the nation's fisheries by restoring their habitat. Working with others, the Center achieves its mission by (1) restoring degraded habitats, (2) advancing the science of coastal habitat restoration, (3) transferring restoration technology to the private sector, the public, and other government agencies, and (4) fostering habitat stewardship and a conservation ethic. Recently, under the community-based program, NOAA awarded $250,000 to the Gulf of Mexico Foundation for habitat restoration in the five states bordering the Gulf of Mexico. EPA, under their Gulf of Mexico Program (see following) similarly awarded $90,000 to the Foundation. These awards launch a major new effort to reclaim essential fish habitats of the Gulf of Mexico by implementing field efforts to restore and improve marine and coastal habitats that have been degraded or lost.

- *U.S. Fish & Wildlife Service Partnership for Fish & Wildlife* (see: http://partners.fws.gov/index.htm) - This program is supported by funds from federal and state agencies, private landowners, and non-governmental organizations (e.g., Ducks Unlimited, CDFG, The Nature Conservancy). The program is a voluntary partnership program with a goal to restore wetlands and other vital habitats on private land with 70% of the current funding coming from private sources. The remaining funds, along with restoration design and technical assistance is provided by USFWS. State resource agencies, such as CDFG, work with the FWS to help establish priorities and identify focus areas. The restoration of degraded wetlands, native grasslands, streams, riparian areas, and other habitat to conditions as close as possible to natural is emphasized. The Partnership for Fish and Wildlife Program is important for restoration of critical habitats in California (USFWS 2001). AES financial support to the program and potential in-kind service could potentially be negotiated as compensation for impingement mortality and entrainment at their power plants in southern California.

- *Coastal America's Corporate Wetland's Restoration Partnership (CWRP)*(see: http://www.coastalamerica.gov/text/cwrpoperating.html) - is a program designed to foster collaboration between the federal government, state agencies, and private corporations. Private corporations that participate in this national program will donate funds for either site-specific wetland or other aquatic habitat restoration projects or provide matching funds to a national or regional effort in support of aquatic ecosystem restoration activities. Projects that will receive funds from the CWRP will all be approved Coastal America projects while federal agencies will assist in their proper execution. The Coastal America Partnership will coordinate among all of its Regional Implementation Teams to identify the appropriate private foundation or state trust fund that will receive funds from the CWRP. This organization will not likely accept support in response to regulatory requirements. However, the organization is a source of wetland restoration information and unique partnerships may be arranged.

• Dam removal or fishway construction – an integral component to USFWS and NMFS anadromous fish restoration program is the provision of fish passage at existing artificial river obstructions. Passage can be obtained via direct dam removal or via the provision of fish passage. At the federal level, the key program is the National Fish Passage Program (see: http://fisheries.fws.gov/fwsma/fishpassage/)- In 1999, the U.S. Fish and Wildlife Service initiated the National Fish Passage Program. The Program uses a voluntary, non-regulatory approach to remove and bypass barriers. The Program addresses the problem of fish barriers on a national level, working with local communities and partner agencies to restore natural flows and fish migration.

The Program is administered by National and Regional Coordinators, and delivered by Fish and Wildlife Management Assistance Offices with their 300 biologists located across the Nation. Appropriations for the Program support the Coordinators, in-the-water fish passage projects, and the Fish Passage Decision Support System (subsequently described). The Program's goal is: to restore native fishes and other aquatic species to self-sustaining levels by reconnecting habitat that has been fragmented by barriers, where such re-connection would not result in a net negative ecological effect such as providing increased habitat to exotic species. The **Fish Passage Decision Support System** (see https://ecos.fws.gov/fpdss/index.do) is a database of barriers preventing fish movement that is complemented by analytical tools (GIS software) for mapping and prioritizing fish passage projects (calculating stream mileage made available by providing fish passage at the barrier). Barrier information includes location, type, size, owner, passage capabilities, associated fish species, and local habitat information.

CDFG and NMFS are actively involved in efforts to restore anadromous salmonids in California's coastal rivers. In the area of the AES facilities, restoration of the southern steelhead is a species of particular concern. While restoration efforts to date have been largely based on hatchery supplementation, RWQCB or other state and federal resource agencies may be receptive to the development of efforts to restore access to historical spawning habitat via dam removal (e.g., see Pejchar and Warner 2001) and or fish laddering at river barriers. As mitigation for impingement mortality and entrainment impacts at AES's California power plants, AES could negotiate removal of one or more dams or provide fish passage where dam removal is not an option. Alaska Steeppass fish ladders offer an effective and moderate cost approach for fishway provision. PSEG of New Jersey has successfully installed such fishways in tributaries to the lower Delaware Bay to restore access to historical spawning habitat for American shad, alewife, and blueback herring. Dam removal, if pursued, would focus on abandoned, non-hydropower projects, such as old low-head mill dams or flow control structures (river levees). The Rindge Dam on Malibu Creek (see: http://www.irn.org/revival/decom/alerts/rindgealert.html), for example, is under strong consideration for removal. Consensus is building among local NGOs and federal and state resource agencies that this aging and silted-in dam should be removed to speed southern steelhead recovery efforts. Steelhead once spawned as far as 3 miles upstream. Removal of this structure would re-open the habitat to potential spawning by this endangered species. The major impediment to removal is a lack of funding. The California State Department of Parks and Recreation is acting as the clearinghouse for securing the state's share of the funding. Federal efforts are being led by the U.S. Army Corps of Engineers. Fish passage programs could be combined with stocking to restore specific anadromous species of concern such as the southern steelhead. As previously noted, such an approach was successful for restoring American shad to the Susquehanna River in Pennsylvania and Maryland.

- Alternative restoration measures – the above measures have been identified as the most likely restoration approaches that would be receptive to RWQCB and other federal and state resource agencies. Other potential approaches include nonpoint source pollutant runoff abatement programs and contaminated sediments restoration. While these types of efforts focus on water quality improvements, the long-term benefit is improved fish and shellfish habitat. Such efforts would have to demonstrate a clear linkage between the two as compensation for impingement mortality and entrainment losses at AES's southern California power stations. The California Coastal Commission is implementing a statewide Nonpoint Source (NPS) Program (see: http://www.coastal.ca.gov/nps/npsndx.html). Elements of the plan include management measures for reducing runoff pollution from agriculture, silviculture, urban areas, marinas and recreational boating, and via hydromodification (includes modification of stream and river channels, dams and water impoundments, and streambank/shoreline erosion). CCC, therefore, is a source of information for developing a potential nonpoint source runoff abatement program or implementing best management practices (BMPs) to meet the goals of the State's plan in the Los Angeles urban and suburban areas. RWQCB may welcome direct support by AES toward implementing some of the BMPs as compensation for the impingement (and entrainment losses) at AES power plants.

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# B DESCRIPTION OF RBGS HISTORICAL STUDIES, PHYSICAL AND BIOLOGICAL INFORMATION

See following pages.

# REDONDO BEACH GENERATING STATION

# SUMMARY OF EXISTING PHYSICAL AND BIOLOGICAL INFORMATION AND IMPINGEMENT MORTALITY AND ENTRAINMENT CHARACTERIZATION STUDY SAMPLING PLAN

**August 11, 2005**

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# 1.0 INTRODUCTION

On 9 July 2004, the U.S. Environmental Protection Agency (EPA) published Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Existing Facilities. Those §316(b) requirements went into effect in September 2004, and apply to existing generating stations with cooling water intake structures that withdraw at least 50 million gallons per day (mgd) from rivers, streams, lakes, reservoirs, oceans, estuaries, or other waters of the United States. The Redondo Beach Generating Station (RBGS) has four generating units with two separate submerged offshore intake systems equipped with velocity caps. There are two connected intake structures for Units 5&6 that withdraw a maximum of 215 million gallons per day (mgd), and one intake structure for Units 7&8 that withdraws a maximum of 674 mgd. The Units 5&6 intakes are located within King Harbor, and the Units 7&8 intake is located at the entrance to King Harbor in Santa Monica Bay. Phase II facilities as part of the Proposal for Information Collection (PIC) are required to provide:

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

This document provides this information. As part of the §316(b) Comprehensive Demonstration Study (CDS) required under the new regulations, a facility may be required to submit an Impingement Mortality and Entrainment Characterization Study depending on the chosen compliance pathway. Since RBGS's current design does not qualify for use of compliance alternative 1 and has some Units subject to the entrainment performance standard, AES plans to submit a CDS. According to the §316(b) Phase II Regulations all facilities submitting a CDS must provide an Impingement Mortality and Entrainment Characterization Study that must include the following (for all applicable components):

- Taxonomic identifications of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal Law (including threatened or endangered species) that are in the vicinity of the cooling water intake structure(s) and are susceptible to impingement and entrainment;
- A characterization of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal Law (including threatened or endangered species) identified in the taxonomic identification noted previously, including a description of the abundance and temporal and spatial characteristics in the vicinity of the cooling water intake structure(s), based on sufficient data to characterize the annual, seasonal, and diel variations in the impingement mortality and entrainment; and
- Documentation of current impingement mortality and entrainment of all life stages of fish, shellfish, and any protected species identified previously and an estimate of impingement mortality and entrainment to be used as the calculation baseline.

The Rule allows facilities to use four sources of information to developing the Impingement Mortality and Entrainment Characterization Baseline. These include:

- Use of historical studies
- Use of source waterbody biological information
- Use of data from other facilities
- Results of new studies

As discussed below, RBGS plans to use a combination of these sources of information to prepare the Impingement Mortality and Entrainment Characterization Study Report. Under the new 316(b) regulations the impingement mortality component of the IM&E studies is not required if a facility's through-screen intake velocity is less than or equal to 0.5 ft/s (15 cm/s). The through-screen velocities at both the Units 5&6 and Units 7&8 RBGS intakes exceed this value, so impingement mortality studies will be conducted at both intakes. The entrainment characterization component is not required if a facility: (a) has a capacity utilization rate of less than 15 percent; (b) withdraws cooling water from a lake or reservoir, excluding the Great Lakes; or (c) withdraws less than five percent of the mean annual flow of a freshwater river or stream. The capacity utilization rate at Units 5&6 is less than 15 percent; therefore, the entrainment component of the study applies only to Units 7&8.

## 1.1 Environmental Setting

The RBGS withdraws water from Santa Monica Bay (Figure 1-1). The cooling water intake for Units 7&8 is located just inside the breakwater at the entrance to King Harbor, while Units 5&6 withdraw cooling water from within the harbor. The coastline of Redondo Beach runs,

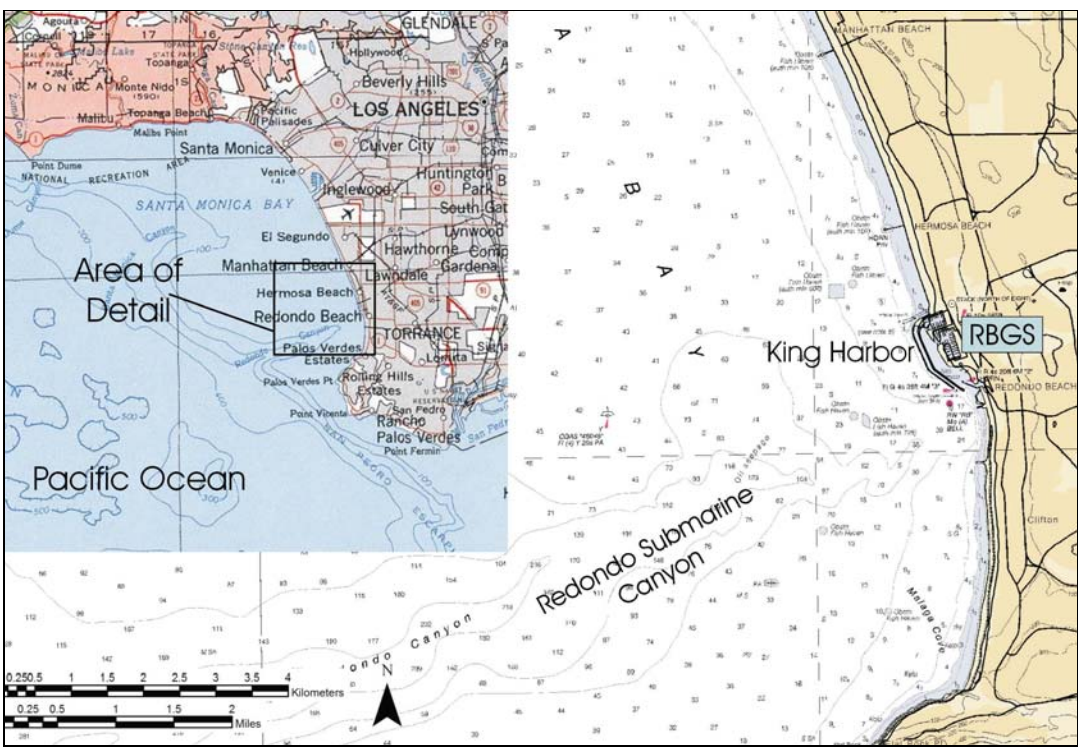


**Figure 1-1**. Location of Redondo Beach Generating Station (RBGS).

in general, from north-northwest to south-southeast. Redondo Canyon incises an otherwise gently sloping shelf. The head of Redondo Canyon is immediately offshore from the entrance to King Harbor. King Harbor is a shallow, semi-enclosed, man-made harbor. The harbor breakwaters were constructed between 1950 and 1958 (Stephens and Pondella 2002). Subtidal sediments in the harbor and in the nearshore areas are predominantly sand, with lesser amounts of silt and clay (MBC 2004). Prior to the construction of King Harbor, Redondo Canyon was likely a sediment sink. However, the King Harbor breakwater may be impounding sediments that formerly flowed into the canyon (USACE 1986).

The prevailing current direction in the shallow, nearshore areas of Santa Monica Bay is downcoast (equatorward) suggesting an eddy-type circulation pattern resulting from the upcoast (poleward) currents outside of the bay (Hendricks 1980). This description is supported by more extensive studies by Hickey (1992) that also showed downcoast currents on the shelf within the bay and prevailing upcoast (poleward) currents at the edge of the shelf at the outer boundary of Santa Monica Bay. The circulation pattern within the bay results from the presence of the Southern California Countercurrent in the outer coastal waters of the Southern California Bight.

The bottom sediments in King Harbor are primarily sand and silt, but the breakwaters and RBGS intake/discharge structures provide hard rock habitat for fishes and invertebrates. Data from subtidal dive transects showed that the harbor breakwaters were more productive (as measured by the densities of resident, juvenile surfperches) than nearby natural reefs (Pondella et al. 2002). The most common fishes observed include blacksmith (*Chromis punctipinnis*), topsmelt (*Atherinops affinis*), señorita (*Oxyjulis californica*), jacksmelt (*Atherinopsis californiensis*), sargo (*Anisotremus davidsonii*), and shiner perch (*Cymatogaster aggregata*).

# 2.0 Historical Impingement and Entrainment Studies

The following section identifies and summarizes previous entrainment and impingement studies conducted at the RBGS.

## 2.1 1978–1980 Redondo Beach Generating Station 316(b) Demonstration

From 1978 through 1980, SCE studied entrainment and impingement at both of the RBGS cooling water intake systems as part of a 316(b) Demonstration Program. The species analyzed in the report were selected in consultation with the California Regional Water Quality Control Board and the California Department of Fish and Game. Impacts of cooling water system entrainment and impingement on fishery resources were determined by comparison of losses to available fishery stocks, which were estimated from collections of ichthyoplankton in the Southern California Bight and long-term adult fish monitoring at the generating stations.

Entrainment samples were collected monthly at Redondo Beach from August 1979 through July 1980 (SCE 1983). Samples were collected by pump from both intake structures during six cycles (two day, two night, and two crepuscular cycles) each 24-hr survey period, and filtered through 333-µm mesh plankton nets. Results for only Units 7&8 are presented in Table 2-1 because the entrainment performance standard does not apply to Units 5&6. White croaker (*Genyonemus lineatus*), northern anchovy (*Engraulis mordax*), unidentifiable fish larvae, and cheekspot goby (*Ilypnus gilberti*) comprised 71% of entrainment at Units 7&8 (Table 2-1).

**Table 2-1.** Daily entrainment estimates at the RBGS Units 7&8 from August 1979 through July 1980.

| Fish Taxa | | Daily Entrainment at Units 7&8 | Percent of Total |
|---|---|---|---|
| white croaker | *Genyonemus lineatus* | 2,796,000 | 14.4 |
| northern anchovy | *Engraulis mordax* | 1,001,000 | 6.2 |
| miscellaneous | | 668,000 | 9.6 |
| cheekspot goby | *Ilypnus gilberti* | 465,000 | 40.3 |
| queenfish | *Seriphus politus* | 433,000 | 6.2 |
| unid. yolk sac larvae | Pisces, unid. | 317,000 | 4.6 |
| reef finspot | *Paraclinus integrippinis* | 299,000 | 4.3 |
| kelp blenny | *Gibbonsia* sp. | 279,000 | 4.0 |
| combtooth blenny | *Hypsoblennius* spp | 265,000 | 3.8 |
| blacksmith | *Chromis punctipinnis* | 214,000 | 3.1 |
| Pisces larvae | Pisces, unid. | 194,000 | 2.8 |
| kelp bass | *Paralabrax clathratus* | 5,000 | 0.1 |
| Pacific butterfish | *Peprilus simillimus* | 2,000 | <0.1 |
| barred sand bass | *Paralabrax nebulifer* | 1,000 | <0.1 |
| black croaker | *Cheilotrema saturnum* | 1,000 | <0.1 |
| sargo | *Anisotremus davidsonii* | 1,000 | <0.1 |
| **Total** | | 6,941,000 | 100.0 |

Impingement samples were collected at Redondo Beach from October 1978 through September 1980 (SCE 1983). Both 24-hr normal operation and heat treatment sampling was done at both intakes. Normal operations samples were collected once or twice per week. During normal operation surveys, traveling screens and collection baskets were initially cleared, and impinged organisms were allowed to accumulate on the screens for a 24-hr period. Estimated annual normal operations totals were calculated by multiplying the daily impingement loss by the number of operational days during each study period. The study periods were stratified by month for purposes of analysis. Heat treatment fish loss, representing the actual count and weight of organisms, was added to the estimated normal operation fish loss to determine the total fish loss on an annual basis.

Queenfish (*Seriphus politus*) and shiner perch (*Cymatogaster aggregata*) were the dominant species in the impingement study, comprising 70% of impingement abundance at Units 1–6 and 46% at Units 7&8. Daily average impingement estimates are presented in Table 2-2, and were calculated by adding the annual normal operations estimate and heat treatment totals for each cooling water system, and dividing by 365.

**Table 2-2.** Daily average impingement estimates at the RBGS from October 1978 through September 1980.

| | | Units 1-6 | | Units 7&8 | | |
|---|---|---|---|---|---|---|
| **Fish Taxa** | | **Normal Op.** | **Heat Treat** | **Normal Op.** | **Heat Treat** | **Percent of Total** |
| queenfish | *Seriphus politus* | 75.05 | 73.68 | 41.71 | 25.41 | 56.6 |
| shiner perch | *Cymatogaster aggregata* | 3.54 | 28.53 | 5.28 | 16.52 | 14.1 |
| walleye surfperch | *Hyperprosopon argenteum* | 17.26 | 11.60 | 5.57 | 3.90 | 10.0 |
| northern anchovy | *Engraulis mordax* | 19.42 | 0.02 | 9.76 | 0.05 | 7.7 |
| kelp bass | *Paralabrax clathratus* | 0.22 | 0.38 | 8.39 | 6.18 | 4.0 |
| white seaperch | *Phanerodon furcatus* | 2.08 | 5.53 | 1.32 | 2.01 | 2.9 |
| Pacific butterfish | *Peprilus simillimus* | 1.78 | 2.56 | 0.04 | <0.01 | 1.1 |
| white croaker | *Genyonemus lineatus* | 0.63 | 2.93 | 0.35 | 0.33 | 1.1 |
| black perch | *Embiotoca jacksoni* | 0.41 | 0.52 | 0.73 | 1.77 | 0.9 |
| black croaker | *Cheilotrema saturnum* | 0.28 | 0.33 | 0.45 | 1.28 | 0.6 |
| bocaccio | *Sebastes paucispinis* | 0.02 | 0.02 | 1.15 | 0.61 | 0.5 |
| barred sand bass | *Paralabrax nebulifer* | 0.04 | 0.04 | 0.47 | 0.72 | 0.3 |
| yellowfin croaker | *Umbrina roncador* | 0.18 | 0.18 | 0.14 | 0.09 | 0.2 |
| sargo | *Anisotremus davidsonii* | 0.02 | 0.02 | 0.01 | 0.03 | 0.0 |
| spotfin croaker | *Roncador stearnsii* | 0 | 0 | 0 | 0.08 | 0.0 |
| **Total** | | 120.93 | 126.34 | 75.37 | 58.98 | 100.0 |

Impact analyses were based on the proportional entrainment approach of MacCall et al. (1983), which estimates the probability of mortality due to entrainment and impingement by the cooling water intake systems at the RBGS. Mortality estimates were calculated through the first five years of the life cycle for each species analyzed using a source water population that was considered to reside in the Southern California Bight between shore and the 75-m isobath (SCE 1982). Due to the low abundance of many of the species from the study, the probability of mortality values could only be calculated for six of the target species (northern anchovy, white croaker, queenfish, kelp bass, shiner perch, and white seaperch). At the RBGS Units 1–6, probability of mortality values ranged from <0.01% (northern anchovy) to 0.95% (queenfish). At Units 7&8, probability of mortality values ranged from 0.04% (northern anchovy) to 1.40% (shiner perch). Impacts to shiner perch were restricted to impingement, since this species is viviparous. Impacts to the source water fish populations from the operation of the cooling water system at the RBGS were determined to be insignificant, indicating that the observed losses would have no effect on the long-term abundance or distribution of nearshore fish populations. Regardless, SCE examined nine alternative cooling water intake technologies and/or devices potentially applicable at Redondo Beach (LMS 1982). It was determined that the velocity-capped cooling water intakes in place at the time represented the best technology available.

## 2.2 1979-2004 NPDES Fish and Macroinvertebrate Impingement Monitoring

Composition, abundance, and biomass of juvenile and adult fishes and macroinvertebrates entrapped and impinged on traveling screens at the RBGS have been studied for many years as part of a continuing National Pollutant Discharge Elimination System (NPDES) monitoring program. Fish impingement sampling was conducted during representative periods of normal operation and during all heat treatment procedures to obtain an estimate of total impingement for a year. A normal operation survey is defined as a sample of all impingeable sized fishes and macroinvertebrates entrained by water flow into the generating station intake and subsequently impinged and removed by traveling screens during a 24-hr period. The number of operational days per year is usually less than 365 because of plant downtime for maintenance and seasonal fluctuations in power demand, which may lead to decreased cooling water flow. Normal operation abundance and biomass for a given study year were estimated by extrapolating the monitored abundance and biomass based on the percentage of the annual cooling water flow into the generating station during sampling days.

### 2.2.1 Methods

Normal operation surveys were performed monthly at each cooling water intake system (CWIS) when the systems were in operation. During normal operation surveys, the traveling screens were rotated for an approximate 10-minute rotation, and the impingement collection basket was cleared of accumulated debris. If this was not possible, a tarp was laid across the debris to separate it from the subsequent collection. Approximately 24 hr later, the screens were rotated again, and all material that accumulated from that screen wash, and any other washes that occurred in the prior 24 hr, was considered part of that normal operation sample. All fish and macroinvertebrates were separated from incidental debris, identified, and counted. Up to 200 individuals of each fish species were measured, examined for external parasites, anatomical anomalies, and other abnormalities. Aggregate weights were taken for each fish and macroinvertebrate species. Annual impingement totals (abundance and biomass) were determined by extrapolating the results from surveys to an annual total based on cooling water flow. Flow during each ~24-hr survey, as well as annual flow, was provided by plant personnel.

Heat treatment surveys were performed during all scheduled heat treatments at both CWISs. Heat treatment frequency generally varied between once per year to once per month. Heat treatments are operational procedures designed to eliminate mussels, barnacles, and other fouling organisms growing in the cooling water conduit system. During a heat treatment, heated effluent water from the discharge is redirected to the intake conduit via cross-connecting tunnels until the water temperature rises to approximately 40.5°C (105°F) in the screenwell area. This temperature is maintained for at least one hour, during which time all biofouling organisms, as well as fish and invertebrates living within the cooling water system, succumb to the heated water. During heat treatment surveys, all material impinged onto traveling screens was removed from the forebay. Fish and macroinvertebrates were separated from incidental debris, identified, and counted. Up to 200 individuals of each species were measured, examined for external parasites, anatomical anomalies, and other abnormalities. Aggregate weights were taken by species. Data were collected for each heat treatment survey and combined with the estimated normal operation data to determine estimated total impingement loss for the year. The available database for heat treatment and normal operation surveys extends back to 1991.

### 2.2.2 Results

Fish impingement monitoring results from the last six years are summarized in Tables 2-3 and 2-4. Impingement sampling at the RBGS has occurred since the 1970s, and results have been submitted to the Los Angeles Regional Water Quality Control Board (LARWQCB) annually in NPDES monitoring reports since 1990. Since 1999, the total annual fish impingement at Units 5&6 has never exceeded 54 individuals (Table 2-3). During this time period, 9 to 11 normal operation surveys and 1 to 7 heat treatment surveys were performed annually. Impingement at Units 7&8 during the same time period was substantially higher, with annual totals averaging 3,873 fish (Table 2-4). Between 4 and 12 normal operation surveys and 1 to 12 heat treatment surveys were conducted annually at Units 7&8 from 1999 to 2004.

Since 1991, the most abundant fishes in impingement samples at the RBGS were nearshore schooling/aggregating species, as well as reef-associated fishes. Species contributing most to impingement abundance at Units 5&6 and 7&8 included Pacific sardine (*Sardinops sagax*; 29%), blacksmith (*Chromis punctipinnis*; 24%), queenfish (10%), shiner perch (5%), California scorpionfish (*Scorpaena guttata*; 3%), kelp bass (*Paralabrax clathratus*; 3%), black perch (*Embiotoca jacksoni*; 3%) and salema (*Xenistius californiensis*; 3%). These eight species combined accounted for 80% of the total impingement abundance at the RBGS. The remaining 95 fish species collected in impingement samples each contributed 2% or less to the 14-year impingement total (MBC 2004).

Macroinvertebrate impingement monitoring results from the last six years are summarized in Tables 2-5 and 2-6. Since 1999, the total annual impingement at Units 5&6 has never exceeded 70 invertebrates (Table 5). Impingement at Units 7&8 during the same time period was substantially higher, with annual totals averaging 4,733 invertebrates (Table 6). Invertebrate species impinged at Units 5&6 were primarily red rock shrimp (*Lysmata californica*), California spiny lobster (*Panulirus interruptus*), and purple-striped jelly (*Chrysaora colorata*). Invertebrates common at Units 7&8 included California spiny lobster, market squid (*Loligo opalescens*), red rock shrimp, and rock crabs (*Cancer* spp.).

**Table 2-3.** Estimated annual fish impingement abundance (Oct. – Sept.), Units 5&6.

| **Survey Method** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **Average** |
|---|---|---|---|---|---|---|---|
| Normal Operations | 32 | 0 | 0 | 0 | 1 | 40 | 12 |
| Heat Treatments | 2 | 11 | 54 | 1 | 0 | 1 | 12 |
| **Total** | 34 | 11 | 54 | 1 | 1 | 41 | 24 |

**Table 2-4.** Estimated annual fish impingement abundance (Oct. – Sept.), Units 7&8.

| **Survey Method** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **Average** |
|---|---|---|---|---|---|---|---|
| Normal Operations | 950 | 2,035 | 5,610 | 4,274 | 328 | 1,034 | 2,372 |
| Heat Treatments | 1,292 | 932 | 3,592 | 1,947 | 805 | 436 | 1,501 |
| Total | 2,242 | 2,967 | 9,202 | 6,221 | 1,134* | 1,470 | 3,873 |

* Total differs slightly from sum of normal operation and heat treatment estimates due to rounding.

**Table 2-5.** Estimated annual macroinvertebrate impingement abundance (Oct. – Sept.), Units 5&6.

| Survey Method | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | Average |
|---|---|---|---|---|---|---|---|
| Normal Operations | 0 | 0 | 0 | 0 | 0 | 69 | 12 |
| Heat Treatments | 23 | 70 | 33 | 29 | 0 | 0 | 26 |
| **Total** | 23 | 70 | 33 | 29 | 0 | 69 | 38 |

**Table 2-6.** Estimated annual macroinvertebrate impingement abundance (Oct. – Sept.), Units 7&8.

| Survey Method | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | Average |
|---|---|---|---|---|---|---|---|
| Normal Operations | 1,479 | 2,859 | 2,402 | 14,331 | 1,109 | 2,077 | 4,043 |
| Heat Treatments | 234 | 1,057 | 1,287 | 1,105 | 262 | 194 | 690 |
| **Total** | 1,713 | 3,916 | 3,689 | 15,346 | 1,371 | 2,271 | 4,733 |

### **2.2.3** QA/QC Measures

**Field Sampling**

Impingement sampling was done in conformance with specifications set forth by the Los Angeles Regional Water Quality Control Board (LARWQCB) in the NPDES permits. Specimens of uncertain identity were crosschecked against taxonomic voucher collections maintained by MBC, as well as available taxonomic literature. Occasionally, outside experts were consulted to assist in the identification of species whose identification was difficult. Scales used to measure biomass (spring and electronic) were calibrated every three months.

**Data Entry/Reporting**

The following measures were employed to ensure accuracy of all data entered into computer databases and spreadsheets:

- Upon return from the field, all field data sheets were checked by the Project Manager for completeness and any obvious errors;
- Data were entered into pre-formatted spreadsheets;
- After data were entered, copies of the spreadsheets were checked against the field data sheets;
- Data were submitted annually to the LARWQCB, U.S. EPA Region IX, and the California Department of Fish and Game in NPDES reports from 1990 to the present.

## 2.3 Other Biological Studies in the Vicinity OF RBGS

### 2.3.1 1986–2004 King Harbor Video-Cine Surveys

Semiannual video-cine surveys have been conducted at three stations in King Harbor since 1986. During each survey, two 50-m transects were sampled adjacent to the Units 7&8 discharge structure, and a third station was sampled along the outer breakwater within King Harbor. Replicate videos of fishes and macroinvertebrates were recorded along each transect and to the side of each transect. Counts for each replicate at each station were summed, and results were reported as numbers of individuals per transect. To account for variations in water clarity, this total was then divided by the underwater visibility as required in the NPDES permit. Seasonal totals for the study area are presented by species in **Table 2-7**.

**Table 2-7.** Average abundance (when encountered) of the 15 most frequently occurring fish species observed in King Harbor during semiannual NPDES video-cine transects, 1986–2004.

| **Fish Taxa** | | **Winter Average No.** | **Summer Average No.** | **1986-2004 Total** | **Surveys Observed (n=27)** |
|---|---|---|---|---|---|
| blacksmith | *Chromis punctipinnis* | 1,835 | 1,273 | 41,115 | 27 |
| topsmelt | *Atherinops affinis* | 1,000 | 991 | 13,907 | 14 |
| señorita | *Oxyjulis californica* | 403 | 248 | 8,558 | 27 |
| sargo | *Anisotremus davidsonii* | 148 | 369 | 5,384 | 20 |
| black perch | *Embiotoca jacksoni* | 27 | 59 | 1,181 | 26 |
| rock wrasse | *Halichoeres semicinctus* | 58 | 37 | 1,059 | 23 |
| pile perch | *Racochilus vacca* | 28 | 32 | 779 | 26 |
| kelp bass | *Paralabrax clathratus* | 27 | 20 | 630 | 27 |
| barred sand bass | *Paralabrax nebulifer* | 11 | 37 | 630 | 24 |
| opaleye | *Girella nigricans* | 13 | 25 | 436 | 22 |
| white seaperch | *Phanerodon furcatus* | 3 | 37 | 350 | 13 |
| garibaldi | *Hypsypops rubicundus* | 11 | 8 | 217 | 23 |
| C-O sole | *Pleuronichthys coenosus* | 3 | 2 | 40 | 15 |
| spotted turbot | *Pleuronichthys ritteri* | 2 | 2 | 38 | 17 |
| orangethroat pikeblenny | *Chaenopsis alepidota* | 2 | 7 | 67 | 12 |

### 2.3.2 1974–1997 VRG Ichthyoplankton Surveys

The Vantuna Research Group (VRG) from the Moore Laboratory of Zoology at Occidental College (Los Angeles, Calfiornia) collected and analyzed quarterly ichthyoplankton samples from several stations within King Harbor between 1974 and 1997 (Stephens and Pondella 2002). The sampling program continues to the present. Samples were collected with multiple gear types at different depths; however, all nets were constructed of 333-μm mesh. Surface samples were collected at night, while mid-depth and epibenthic samples were collected diurnally.

In general, ichthyoplankton densities have declined considerably since the 1970s (Stephens and Pondella 2002). Density of larval fishes peaked in 1975 (>5 larvae/m$^3$) and then declined to less than 2 larvae/m$^3$ from 1988 to 1997. Mean larval density was highest in King Harbor near bottom (4.67 larvae/m$^3$), followed by surface (3.27 larvae/m$^3$), neuston (2.11 larvae/m$^3$), and mid-depth (1.83 larvae/m$^3$). The mean number of fish taxa per tow also decreased from a maximum of nearly 16 species in 1976 to only 3 species in 1997. The long-term mean is 10 species. On average, 34% of the collected larvae were produced by reef-dwelling species. Some of the more abundant taxa included combtooth blennies, garibaldi (*Hypsypops rubicundus*), reef finspot (*Paraclinus integripinnis*), and kelp blennies (*Gibbonsia* sp.). Results of long-term monitoring indicate that the King Harbor breakwater represents a mature artificial reef and contributes to the supply of reef fish larvae in the Southern California Bight (Stephens and Pondella 2002).

From 1974 through 1975, ichthyoplankton samples were collected approximately every two weeks (McGowen 1978). Throughout the study area, which included and extended slightly offshore from King Harbor, fish eggs were comprised mostly of unidentified taxa (80%), northern anchovy (16%), and curlfin turbot/California lizardfish (*Pleuronichthys decurrens*/*Synodus* *lucioceps*; 2%). Fish larvae were comprised primarily of cheekspot and/or shadow goby (Goby Type A; 48%), combtooth blennies (*Hypsoblennius spp.*; 33%), northern anchovy (5%), kelp blennies (Clinidae; 4%), and unidentified croakers (Sciaenidae; 6%). The relative abundance of larvae hatching from pelagic as opposed to non-pelagic eggs increased from the inner harbor to the station furthest outside the harbor. Stations furthest within the harbor were dominated by one or two taxa, whereas the larval communities at stations outside the harbor and near the Units 7&8 discharge were more diverse.

## 2.4 Studies on the Physical Environment in the Vicinity of RBGS

### 2.4.1 Physical Conditions

The physical and biological characteristics of the subtidal environment off the Redondo Beach Generating Station have been studied extensively by the owners of the Redondo Beach Generating Station (RBGS)—Southern California Edison Company (SCE) and AES Redondo Beach L.L.C.—and by the Occidental College Vantuna Research Group (VRG). Studies performed for the generating station examined the physical and biological characteristics of King Harbor and the nearshore zone of Santa Monica Bay (depths to about 15 m), while studies performed by the VRG were focused within King Harbor and downcoast to Palos Verdes Point.

The coastline of Redondo Beach runs, in general, from north-northwest to south-southeast. Redondo Canyon incises an otherwise gently sloping shelf. The head of Redondo Canyon is immediately offshore the entrance to King Harbor. Subtidal sediments in the harbor and in the nearshore areas are predominantly sand, with lesser amounts of silt and clay (MBC 2004). Prior to the construction of King Harbor, Redondo Canyon was likely a sediment sink. However, the King Harbor breakwater may be impounding sediments that formerly flowed into the canyon (USACE 1986).

### 2.4.2 Temperature and Salinity of Source Waters

The temperature and salinity of the waters in the vicinity of the Units 5&6 and Units 7&8 intake structures have been measured semiannually or annually for many years as part of the RBGS NPDES monitoring program. The monitoring program consists of 8 stations within King Harbor and 8 stations in the nearshore waters of Santa Monica Bay. From 2000 through 2004, all stations were sampled during both ebb and flood tides during four winter surveys and five summer surveys (there was no winter sampling in 2003). Results are summarized in Table 2-8.

In general, temperatures in the study area are usually several degrees warmer in summer than in winter, with bottom waters consistently colder than surface waters. On average, waters in King Harbor are about 1°C warmer than waters just outside the harbor. Volume and temperature of cooling water discharged from Units 7&8 have a strong influence on water temperature in the harbor, as waters inside King Harbor are essentially isolated from nearshore currents and wave- and surf-induced turbulence, and exchange with the open ocean is limited (EQA/MBC 1973, MBC 2004). Temperatures throughout the water column in the study area are usually warmest in the afternoon due to solar heating, and the formation of a thermocline is especially common during summer, though thermoclines may also develop in winter. Salinity in the study area is relatively uniform, ranging from 32.4 to 34.1 practical salinity units (PSU), typical for nearshore waters of southern California. Salinity is usually slightly higher near bottom than at the surface.

**Table 2-8.** Temperature and salinity of surface and bottom waters from 16 stations within King Harbor and nearshore Santa Monica Bay, 2000-2004.

| | | King Harbor | | Santa Monica Bay | |
|---|---|---|---|---|---|
| **Season** | **Parameter** | **Surface** | **Bottom** | **Surface** | **Bottom** |
| **Winter** | Minimum temperature (°C) | 14.15 | 10.97 | 12.86 | 10.59 |
| | Average temperature (°C) | 16.52 | 14.38 | 15.70 | 13.50 |
| | Maximum temperature (°C) | 19.92 | 19.46 | 18.12 | 16.06 |
| **Summer** | Minimum temperature (°C) | 17.20 | 12.77 | 17.12 | 11.17 |
| | Average temperature (°C) | 21.94 | 18.03 | 20.88 | 17.29 |
| | Maximum temperature (°C) | 26.49 | 23.04 | 24.41 | 22.91 |
| **Winter** | Minimum salinity (PSU) | 32.40 | 32.94 | 32.70 | 33.04 |
| | Average salinity (PSU) | 33.21 | 33.43 | 33.32 | 33.48 |
| | Maximum salinity (PSU) | 33.58 | 34.07 | 33.60 | 34.08 |
| **Summer** | Minimum salinity (PSU) | 32.70 | 33.04 | 33.23 | 33.20 |
| | Average salinity (PSU) | 33.32 | 33.48 | 33.44 | 33.46 |
| | Maximum salinity (PSU) | 33.60 | 34.08 | 33.63 | 33.70 |

### 2.4.3 Units 7&8 Intake Zone of Influence

Hydrodynamic studies of the RBGS Units 7&8 intake structure were performed prior to the 1978–1980 316(b) Demonstration (KLI 1979). To determine the general nature of the flow field around the intake structure, field observations were made by divers using point-source rhodamine WT dye injections at the intake structure. Qualitative observations were also made using continuous-flow line sources of dye at differing depths. Water entrained into the Units 7&8 intake was drawn from the vertical area extending from about four to five meters below the water surface all the way to the bottom. The upper surface layer was excluded from entrainment. Dye injected just above the seafloor drifted slowly along the bottom, modulated back and forth due to surge, then moved abruptly up the side of the intake riser and into the intake opening. Entrance velocities measured by electromagnetic current meter at the intake opening ranged from about 1.6 to 3.3 fps, depending on location around the intake. However, velocities dissipated quickly with distance from the intake opening. Velocities were only about 0.2 fps at a distance of 12 ft horizontally, or 6 to 12 ft vertically, from the intake opening.

# 3.0 PROPOSED NEW BIOLOGICAL STUDIES

The proposed impingement mortality and entrainment (IM&E) studies will examine losses at RBGS resulting from impingement of juvenile and adult fish and shellfishes on traveling screens at both the Units 5&6 and Units 7&8 intakes during normal operations and during heat treatment operations and from entrainment of larval fishes and invertebrates into the Units 7&8 cooling water intake system. Proposed sampling methodologies and analysis techniques are designed to collect the data necessary for compliance with the §316(b) Phase II Final Rule and are similar to recent impingement and entrainment studies conducted for the AES Huntington Beach Generating Station (MBC and Tenera 2005), the Duke Energy South Bay Power Plant (Tenera 2004), and the Cabrillo Power I LLC, Encina Power Station. The studies at Huntington Beach were performed as part of the California Energy Commission CEQA process for permitting power plant modernization projects, while the South Bay and Encina projects were for §316(b) compliance.

Under the new 316(b) regulations the impingement mortality component of the IM&E studies is not required if a facility's through-screen intake velocity is less than or equal to 0.5 ft/s (15 cm/s). The through-screen velocities at both the Units 5&6 and Units 7&8 RBGS intakes exceed this value, so RGBS is proposing to continue impingement monitoring at both intakes (i.e. continuation of the existing NPDES-required monitoring). The goal of the proposed impingement study is to characterize the fishes and shellfishes affected by impingement by the Units 5&6 and Units 7&8 cooling water intake structures (CWIS). The §316(b) Final Regulations allow "historical data that are representative of the current operation of your facility and of biological conditions at the site." Impingement data at RBGS has been collected regularly since the early 1970s during normal plant operations and also during all heat treatment procedures. The long time series of existing impingement data provides an adequate data set for estimating baseline impingement levels. Therefore this plan proposes continuing impingement sampling during all heat treatments and at the current monthly sampling interval during normal operations at both intakes. Impingement sampling frequency and methodologies will be similar to those described in the summary of NPDES impingement sampling, 1979-2004. Normal operation sampling will be divided into four 6-hr cycles instead of one 24-hr survey, and more information on the size of shellfishes will be collected. AES will also examine the results of the Velocity Cap Effectiveness Study for potential application at the RBGS.

The entrainment characterization component is not required if a facility: (a) has a capacity utilization rate of less than 15 percent; (b) withdraws cooling water from a lake or reservoir, excluding the Great Lakes; or (c) withdraws less than five percent of the mean annual flow of a freshwater river or stream. The capacity utilization rate at Units 5&6 is less than 15 percent and is therefore exempt from the entrainment component of the study. Therefore, RGBS is proposing to conduct a yearlong study to characterize larval entrainment at the Units 7&8 intake. The goal of the proposed entrainment study is to characterize the larval fishes and invertebrates entrained by the Units 7&8 cooling water intake structure (CWIS). Concurrent with entrainment sampling, the study plan also proposes sampling of the source water to characterize the larval populations potentially affected by entrainment. The source water sampling would be used to help evaluate population level impacts to entrained species and to assist in designing appropriate restoration projects that might be used to help offset estimated entrainment losses due to the RBGS CWIS.

The proposed 316(b) entrainment study plan incorporates design elements that reflect the present uncertainties surrounding the use of restoration for compliance with the new rule. The use of restoration in offsetting IM&E losses under the new 316(b) rules is currently being challenged in the courts. If the use of restoration is not allowed as a result of the court decision, only an estimate of entrainment losses would be required to calculate the commercial and recreational values of adult fish losses in a cost benefit analysis of various technology and operational alternatives to comply with required reductions in entrainment mortality. Larval fish and invertebrate abundances can vary greatly through the year and therefore biweekly sampling is proposed for characterizing entrainment. If the restoration option was upheld in the court decision, models of the conditional mortality due to entrainment would be used in designing appropriate restoration projects for offsetting entrainment losses. These models are based on proportional comparisons of entrainment and source water abundances and are theoretically insensitive to seasonal or annual changes in the abundance of entrained species. Therefore, source water sampling is being proposed monthly which is consistent with the sampling frequency for recently completed studies in southern California. The frequency of the entrainment sampling and the continuation of source water sampling may change depending on the outcome of the court decision.

The sampling efforts conducted for this study may be coordinated with similar studies at the NRG El Segundo Generating Station (ESGS) and the Los Angeles Department of Water and Power Scattergood Generating Station (SGS). The intakes for the ESGS and SGS are located approximately 5 mi (8 km) upcoast from the RBGS intakes. Coordinating the entrainment and source water sampling will allow for a more comprehensive characterization of the source water and the organisms potentially affected by the CWISs at the three facilities. Although the same data may be shared for the IM&E studies conducted at all three facilities, the data may not necessarily be used or presented in the same way.

## 3.1 Impingement Study

Impingement sampling at the RBGS has been ongoing since 1978 when the first impingement study was conducted. The existing NPDES permit for the plant requires regular sampling during periods of normal operation and during all heat treatment procedures. Since 1999, impingement sampling during normal operations has occurred monthly. The results from the two types of surveys are combined to obtain an estimate of the total impingement for the year. A normal operation survey is defined as a sample of all fish and shellfishes entrained by water flow into the generating station intake and subsequently impinged and removed by the traveling screens during a 24-hr period. Fish and shellfishes are separated from incidental debris, identified, and counted. Up to 200 individuals of each species are measured, and examined for external parasites, and any anatomical or other abnormalities. Aggregate weights are taken by species. The plant usually does not operate 365 days per year due to plant maintenance and seasonal fluctuations in power demand, resulting in decreased cooling water flow during these periods. Therefore, normal operation abundance and biomass for each sampling period were estimated by extrapolating the impingement rates measured during the survey using the total flow for the period between surveys.

Heat treatments are operational procedures designed to eliminate mussels, barnacles, and other fouling organisms growing in the cooling water conduit system. During a heat treatment, heated effluent water from the discharge is redirected to the intake conduit via cross-connecting tunnels until the water temperature rises to approximately 105°F (40.5°C) in the screenwell area. This temperature is maintained for at least one hour, during which time all biofouling organisms, as well as fish and invertebrates living within the cooling water system, succumb to the heated water. During heat treatment surveys, all material impinged onto the traveling screens is removed from the forebay, identified, counted, and measured using the same procedures used for normal operations surveys.

The estimates from the normal operations and heat treatment surveys are combined to estimate total annual impingement. Data for heat treatment surveys date back to 1979, while normal operation data are available from weekly surveys done from October 1978 to September 1980, and from monthly surveys done from 1999 to the present. The data from the July 2000 through March 2005 surveys for Units 7&8 were analyzed to determine if the existing long-term data were adequate for calculating baseline impingement for the RBGS.

A comparison of total annual estimated impingement for Units 7&8 shows low levels of impingement during both normal operations and heat treatment surveys (**Table 3-1**). The monthly normal operations data for the same period were used to determine the effects of more frequent sampling on the estimate of impingement rates. The analysis was done by resampling the 2000-2005 data with replacement to generate 1,000 estimates of annual impingement based on monthly (n=12), biweekly (n=24) and weekly (n=52) sampling frequencies. The mean impingement rates (# per $10^6$ gal) from the 1,000 sets of samples were used to calculate a 95% confidence interval for the mean for each sampling frequency. The resampling approach was taken because the large numbers of zero values in the data did not allow the use of standard statistical probability distributions in calculating confidence intervals. As expected, the average impingement rates for the different sampling frequencies are approximately equal since the samples were drawn from the same set of data (**Table 3-2**). The decrease in sampling frequency from weekly to biweekly to monthly resulted in increases in the confidence interval around the mean of 32 and 93 percent, respectively. These potential differences in the precision of the estimate of average normal operations impingement do not justify increasing the sampling frequency during the study since the levels of impingement during normal operations are so low. Increased sampling frequency also isn't justified because the same resampling techniques used in this analysis could be used with the long-term data set and data collected during the characterization study to provide estimates of impingement that are representative of current and long-term conditions. The estimates from these data will be superior to estimates obtained from a one-year study with more frequent sampling because they represent impingement under a range of environmental and operational conditions.

**Table 3-1:** Comparison of total annual estimated numbers of fishes impinged at Units 7&8 during normal operations and heat treatments from 2000 through 2004 NPDES reporting periods.

| Year | Normal Operations Estimate | Heat Treatment Estimate | Number of Heat Treatments | Total Annual Impingement | Normal Operations Percentage of Total |
|---|---|---|---|---|---|
| 2000 | 2,035 | 932 | 2 | 2,967 | 68.59% |
| 2001 | 5,610 | 3,592 | 12 | 9,202 | 60.97% |
| 2002 | 4,274 | 1,947 | 7 | 6,221 | 68.70% |
| 2003 | 328 | 805 | 2 | 1,133 | 28.95% |
| 2004 | 1,034 | 436 | 2 | 1,470 | 70.34% |
| Totals | 13,281 | 7,712 | 25 | 20,993 | 63.26% |

**Table 3-2**. Comparison of monthly, biweekly, and weekly sampling frequency on confidence intervals for the mean impingement rate (# fishes per $10^6$ gallons) based on 1000 estimates of annual impingement drawn randomly with replacement from monthly normal operations impingement data for Units 7&8 for the July 2000 through March 2004 sampling period.

| Sampling Frequency | Mean Rate per $10^6$ gal | Low Value for 95% Interval | High Value for 95% Interval | % Increase in Confidence Interval from Weekly Sampling |
|---|---|---|---|---|
| Weekly | 0.0125 | 0.0301 | 0.0176 | |
| Bi-Weekly | 0.0097 | 0.0354 | 0.0257 | 31.8% |
| Monthly | 0.0064 | 0.0402 | 0.0338 | 92.6% |

### 3.1.1 Impingement Sampling

The purpose of the proposed 316(b) impingement study will be to characterize the juvenile and adult fishes and shellfishes (e.g., crabs, shrimp, lobsters, octopus, and squid) impinged by the power plant's CWIS (see Section 4.1 for selection of target taxa). The sampling program is designed to provide current estimates of the abundance, biomass, taxonomic composition, diel periodicity, and seasonality of organisms impinged at RBGS. In particular, the study will estimate the rates (i.e., number and biomass of organisms per water volume flowing per time into the plant) at which various species of fishes and shellfishes 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.

In accordance with procedures employed in similar studies, impingement sampling will occur over a 24-hour period one day per month unless the facility is in a cold shutdown or otherwise unable to generate electricity. Before each sampling effort, the traveling screens will be rotated and washed clean of all impinged debris and organisms. The sluiceways and collection baskets will 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 four 6-hour cycles. The traveling screens will remain stationary for a period of 5.5 hours then they will be rotated and washed for 30 minutes. The impinged material from the traveling screens will be rinsed into the collection baskets associated with each set of screens. If during the 24-hour sampling an extreme event occurs resulting in the impingement of a large number of fishes, sampling may continue an additional day or two to obtain a more representative estimate of the impingement rate for the sampling period.

If the traveling screens are operating in the continuous mode, then sampling will be coordinated with generating station personnel 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. Other parameters recorded during impingement surveys will include intake and discharge temperatures and meteorological conditions.

Impingement sampling will also be conducted during heat treatment 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 dead fishes or shellfishes are collected on the screens. Processing of the samples will occur using the same procedures used for normal impingement sampling. Six to eight heat treatments may occur during the one-year study period.

Depending on the number of individuals of a 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 shellfishes is determined and recorded. These measurements are recorded to the nearest 1 mm. The following linear measurements are used for the animal groups indicated:

   - Fishes - Total body length for sharks and rays and standard lengths (or 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.

- Octopus - Maximum “tentacle” spread, measured from the tip of one tentacle to the tip of the opposite tentacle.
- Squid – Dorsal mantle length, measured from the edge of the mantle 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 0.035 ounce (1 g).

3. The qualitative body condition of individual fishes and shellfishes is determined and recorded, using codes for decomposition and physical damage.

4. Shellfishes and other 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 also 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. Information on weather, tide and sea conditions will also be recorded during each collection.

The following specific procedures are used for processing fishes and shellfishes when the number of individuals per species in the sample or subsample is < 30:

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

The following specific subsampling procedures are used for fishes and shellfishes when the number of individuals per species is >30:

- The linear measurement, individual weight, and body condition codes for a subsample of 30 individuals are recorded individually on the data sheet. The individuals selected for measurement are selected after spreading out all of the individuals in a sorting container, making sure that they are well mixed and not segregated into size groups. Individuals with missing heads or other major body parts are eliminated from consideration, since their linear measurements are not representative.
- The linear measurements of up to 200 individuals of each taxa are recorded.
- The total number and total weight of all the remaining individuals combined are determined and recorded separately.

### 3.1.2 Proposed study on the effects of the velocity cap on fish impingement at RBGS Units 7&8, with the use of a fish kill event

The effectiveness of the velocity caps of the Huntington Beach Generating Station (HBGS) and Ormond Beach Generating Station (OBGS) cooling water intake structures, which are similar in design to the intake structures at the RBGS, was studied in July 1979 and July 1980 (Thomas et al. 1980). The study examined entrapment (the entry of fishes into the cooling water intake system) during periods of normal flow (with the velocity cap) and reverse flow (without the velocity cap). Researchers also examined differences between entrapment rates during daytime and nighttime. Results are summarized in **Table 3-3**.

**Table 3-3.** Entrapment densities at the HBGS and OBGS during the 1979 and 1980 velocity cap studies (Thomas et al. 1980).

| Year | Station | Velocity Cap? | Species (time) | Entrapment Density | Velocity Cap Effectiveness |
|---|---|---|---|---|---|
| 1980 | HBGS | No | All (daytime) | 47.2 kg/hr | |
| 1980 | HBGS | Yes | All (daytime) | 0.65 kg/hr | 99% |
| 1980 | HBGS | No | All (nighttime) | 52.99 kg/hr | |
| 1980 | HBGS | Yes | All (nighttime) | 6.78 kg/hr | 87% |
| | | | | **Average:** | **93%** |
| 1979 | HBGS | No | All (day/night 18-hr) | 20.45 kg/hr | |
| 1979 | HBGS | Yes | All (day/night 18-hr) | 1.97 kg/hr | 90% |
| 1979 | HBGS | No | All (nighttime) | 32.93 kg/hr | |
| 1979 | HBGS | Yes | All (nighttime) | 15.53 kg/hr | 53% |
| | | | | **Average:** | **72%** |
| 1980 | OBGS | No | All (daytime) | 0.95 kg/hr | |
| 1980 | OBGS | Yes | All (daytime) | 0.12 kg/hr | 87% |
| 1980 | OBGS | No | All (nighttime) | 4.99 kg/hr | |
| 1980 | OBGS | Yes | All (nighttime) | 1.97 kg/hr | 61% |
| | | | | **Average:** | **74%** |

During both study periods, entrapment rates were substantially lower when the velocity cap was in use. Entrapment was also higher at nighttime than during daytime. On average, the velocity cap resulted in an 82% reduction in entrapment at the HBGS, and 74% at the OBGS.

Based on the high level of effectiveness demonstrated at HBGS, a similar site specific study will be conducted at RBGS Units 7&8. Surveys will be conducted in succession, initially a 24-hr normal flow sample, followed by a 24-hr reverse flow sample. Each survey would require the removal of all fish species from within the forebay prior to the survey. This may be achieved by raising the water temperature in the forebay to 85-90°F for approximately twenty minutes. Previous preliminary studies of the thermal tolerances of coastal California marine fishes indicate a critical maximum temperature of 84-87°F for most species, such as queenfish. Some species common to King Harbor, such as shiner perch, have shown higher thermal tolerances, which would necessitate the 85-90°F range.

The aforementioned temperature spike to remove all fishes from the forebay would precede the initial 24-hr normal operation survey. Impinged fish abundance would be monitored to determine when the forebay has been cleared of fish. At this time the 24-hr sample would commence. At the end of the 24-hr period, another temperature spike would occur, with all fish counted, weighed and measured by MBC and Tenera personnel. All organisms that may have been impinged in the interim would be included in the overall sample. Once impingement abundance has subsided to near zero, the flow configuration would be reversed. During the period immediately following flow reversal, intake flows may entrain an abnormal number of fish in the vicinity of the discharge structure. It may be necessary to operate in a reverse configuration for an extended period to obviate the any such start-up effect from a comparison of impingement rates with and without a velocity cap. The traveling screens would be operated to clear any debris dislodged by the flow reversal. Reverse configuration would be maintained for 24 hours. At the end of the 24-hr cycle, the temperature spike procedure would occur followed by the enumeration of the entrapped/impinged fish. Once all fish were removed from the forebay, the flow would be returned to normal configuration.

MBC proposes to conduct four complete surveys (normal flow-reverse flow-normal flow) occurring every other week over a seven-week period from 21 August 2006 to 2 October 2006. This time frame represents the period with the highest mean monthly normal operation impingement per 100 million gallons water circulated for 2000 to 2004, and coincides with expected periods of peak operations at Units 7&8. Scheduling of surveys would be coordinated with the generating station personnel to coincide with normal operations in the most advantageous way for both parties, such as conducting temperature spikes at periods of normal seasonal reduction in power generation.

### 3.1.3 Quality Control Program

A quality control (QC) program will be implemented to ensure that all of the organisms are removed from the debris and that the correct identification, enumeration, length and weight measurements of the organisms are 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. Quality control surveys will be done on a quarterly or more frequent basis if necessary during the study. If the count of any of individual taxon made during the QC survey varies by more than 5 percent (or one if the total number of individuals is less than 20) from the count recorded by the observer then the next three sampling cycles for that observer will be checked. The survey procedures will be reviewed with all personnel prior to the start of the study and all personnel will be given printed copies of the procedures that will also be included with the final IM&E study report.

## 3.2 Entrainment Study

The proposed entrainment study plan incorporates two design elements 1) cooling water intake system sampling and 2) source water sampling, which reflect the present uncertainties surrounding the use of restoration for compliance with the new rule. If restoration is not upheld by the court as an alternative to comply with entrainment mortality reduction requirements, then the number of larval fish collected in the entrainment sampling would be used with various demographic modeling techniques to estimate the theoretical loss of adult fish. In this case, the commercial and recreational values of adult fish losses would be calculated and compared in a cost benefit analysis to the cost of various technology and operational alternatives to comply with required reductions in entrainment mortality. The source water populations of entrained fish larvae are sampled to estimate the proportional entrainment losses, using a conditional mortality model that could be used to determine appropriate restoration projects for offsetting entrainment.

The study plan also incorporates a sampling frequency strategy that recognizes the basic difference in the statistical uncertainty of the two design elements. Abundances of larval fishes and invertebrates in entrainment vary throughout the year due to changes in composition and the oceanographic environment. The models used to estimate adult equivalents from larval entrainment vary directly with these natural changes in abundance. Estimates of conditional mortality, using the *ETM* or other proportional loss models, are theoretically insensitive to seasonal or annual changes in the abundance of entrained species. Therefore, entrainment sampling has been proposed to occur biweekly, while source water sampling can be conducted less frequently on a monthly basis. The monthly sampling frequency is consistent with other recently completed entrainment studies conducted for the AES Huntington Beach Generating Station (MBC and Tenera 2005), the Duke Energy South Bay Power Plant (Tenera 2004), and the Cabrillo Power I LLC, Encina Power Station.

The continuation of the proposed source water sampling and the frequency of the entrainment sampling will depend on the court decision regarding the use of restoration for compliance with the new rule. If restoration is not upheld by the court as an alternative to comply with entrainment mortality reduction requirements, then a decision may be made to discontinue the source water sampling since it would be primarily used in scaling restoration projects. If the use of restoration is upheld, the frequency of entrainment sampling may be reduced so that only the surveys that occur concurrently with source water sampling are continued.

### 3.2.1 Cooling-Water Intake System Entrainment Sampling

The 14 ft (4.3 m) diameter intake conduit pipe for Units 7&8 at the RBGS extends out approximately 2,300 ft (700 m) from the shoreline and terminates between the north and south breakwaters that form the entrance into King Harbor. The intake structure is a 25 ft x 25 ft (7.6 m x 7.6 m) vertical riser that is located where the water depth is approximately 45 ft (13.7 m) Mean Lower Low Water (MLLW). The top of the riser has a 27 ft x 32 ft (8.2 m x 9.7 m) concrete velocity cap approximately 30 ft (9.1 m) MLLW below the water surface. Cooling water is directed horizontally through the opening between the top of the intake riser and the velocity cap (a distance of approximately 4 ft [1.2 m] at approximately 3.2 ft/s (0.7 m/s). Maximum flow rate for Units 7&8 is 468,000 gallons per minute (gpm), or 674 million gallons per day (mgd).

To determine composition and abundance of larval fishes and invertebrates entrained by the generating station, sampling in the immediate proximity of the cooling water intake is proposed to be conducted every two weeks (biweekly) from January through December 2006 (**Figure 3-1**). The RBGS intake structure is located in the lower third of the water column, and

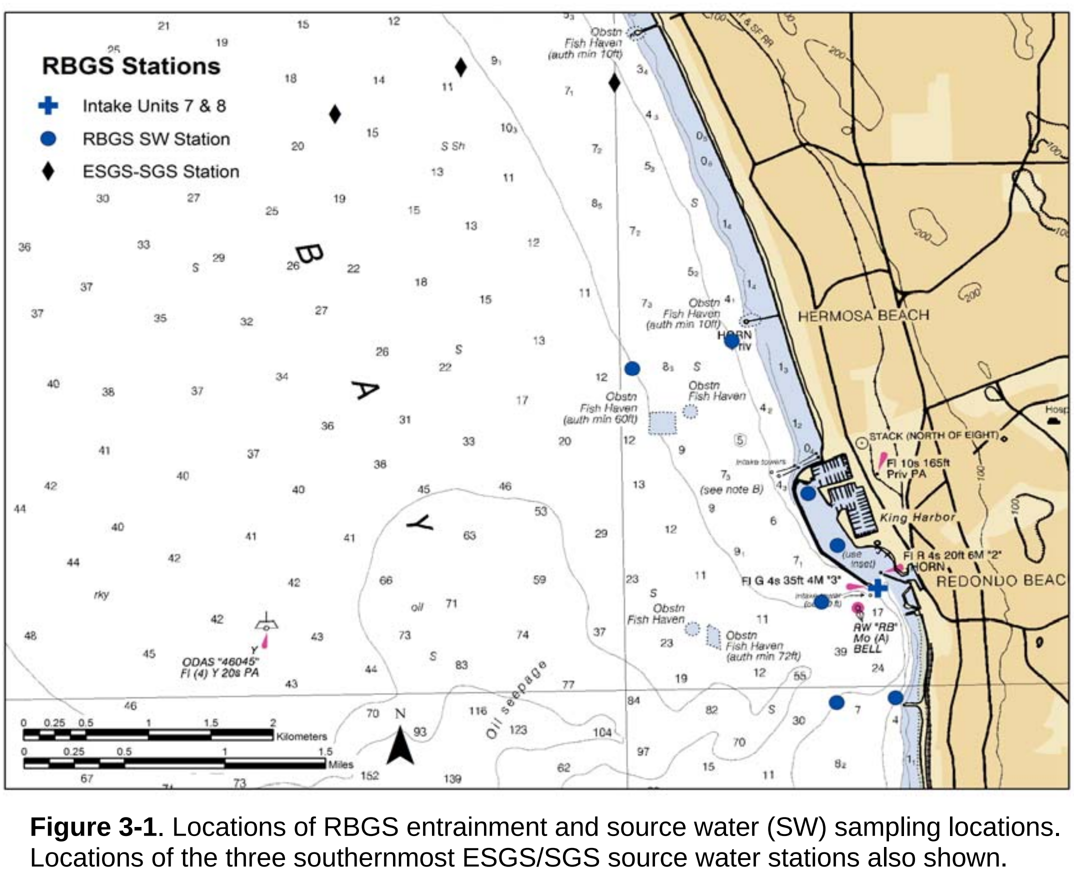


**Figure 3-1**. Locations of RBGS entrainment and source water (SW) sampling locations. Locations of the three southernmost ESGS/SGS source water stations also shown.

studies have shown that water is drawn into the intake structure from the lower 2/3 of the water column (KLI 1979), but there is also significant mixing in the vicinity of the intake due to tides and currents and therefore we propose to sample within 82-246 ft (25-75 m) of the intake structure using an oblique tow that will sample the water column from the surface down to approximately 6 inches (13 cm) off the bottom, and back to the surface. Two replicate tows will be taken at the intake with a target sample volume of 7,900 to 10,570 gal (30 to 40 $m^3$) for each net on the bongo frame. The net will be redeployed if the target volume is not collected during the initial tow. Sampling will be conducted four times per 24-hr period--once every six hours.

The wheeled bongo frame proposed for sampling has 2 ft (60 cm) diameter net rings with plankton nets constructed of 333-μm Nitex® nylon mesh, similar to the nets used by the California Cooperative Oceanic Fisheries Investigations (CalCOFI). Each net will be fitted with a Dacron sleeve and a plastic cod-end container to retain the organisms. Each net will be equipped with a calibrated General Oceanics flowmeter, allowing the calculation of the amount of water filtered. If the target volume (7,900 to 10,570 gal [30 to 40 $m^3$] per net) is not met with one oblique tow, subsequent tows will be performed at the station until the target volume is collected. Coordinates of each sampling station will be determined using a differential Global Positioning System (DGPS). At the end of each tow, nets will be retrieved and the contents of the net gently rinsed into the cod-end with seawater. Contents will be washed down from the outside of the net to avoid the introduction of plankton from the wash-down water. Samples will then be carefully transferred to prelabeled jars with preprinted internal labels. Samples from one of the two nets will be preserved in 4 to 10 percent buffered formalin-seawater, while contents of the other net will be preserved in 70 to 80 percent ethanol. Larvae preserved in ethanol can be made available for genetic and/or otolith analysis, if required. Genetic analyses have been performed in recent studies in attempts to validate the identity of certain species. Normally the data from the two subsamples will be combined for analysis, but if the quantity of material in the two samples is very large only one of the two subsamples will be processed and analyzed.

### 3.2.2 Source Water Sampling

The source water study area is designed to 1) characterize the larvae of species potentially entrained by the RBGS cooling water intakes, and 2) represent a variety of nearshore habitats. To determine composition and abundance of ichthyoplankton in the source water, sampling will be done monthly at the same time that the entrainment station is sampled. The source water sampling design is being proposed because of the need to extrapolate densities offshore and into King Harbor to determine the appropriate source water area during each survey. Besides the entrainment stations, we propose that source water sampling occur at two stations inside King Harbor and at five additional source water stations upcoast, downcoast, and offshore from the RBGS Units 7&8 intake structure (**Figure 3-1**). Stations at the 33 ft (10 m) and 66 ft (20 m) isobaths will be located midway (~1.5 mi [2.4 km] upcoast) between the RBGS intake and the closest source water station (~2.9 mi [4.7 km]) being proposed for the ESGS and SGS sampling. Another station is proposed to be located directly offshore from the RBGS intake at a depth of 66 ft (20 m). Two other stations are proposed 0.6 mi (1 km) downcoast along the 33 ft (10 m) and 66 ft (20 m) isobaths, which are closer together due to the drop into the Redondo Submarine Canyon.

The proposed source water stations provide consistency with the source water sampling being proposed for the ESGS and SGS facilities and benefit all three studies by providing a more complete characterization of the source water in the southern portion of Santa Monica Bay. The spacing of the stations upcoast for ESGS and SGS was based on a review of water current data available from the area. Data from Hickey (1992) showed that nearshore alongshelf water currents in Santa Monica Bay averaged 0.15 ft/sec (4.5 cm/sec) with a monthly maximum average speed of 0.29 ft/sec (8.8 cm/sec). Based on these water current speeds, the distances that larvae could be transported alongshore during one day ranged from 2.4 to 4.7 miles (3.9 to

7.6 km). The average value was used to determine the alongshore extent of the source water sampling locations upcoast and downcoast from the two facilities since the proportional entrainment estimate used in the Empirical Transport Model is an estimate of the daily entrainment mortality on the available source water population. The combined source water stations for RBGS and ESGS/SGS provide data that ensure that an adequate source water area is sampled even during periods with higher water current speeds. The water current data for Santa Monica Bay indicate that the Redondo Submarine Canyon acts to direct surface currents offshore, while entraining deeper water from the canyon onshore (Kolpack 1980). Therefore only two stations were located downcoast from the plant where alongshore currents are affected by the submarine canyon and the rocky headlands along the Palos Verde Peninsula (**Figure 3-1**).

Data from long-term studies on ichthyoplankton have been conducted in King Harbor by the Vantuna Research Group (VRG) of Occidental College (Los Angeles, CA) (Pondella et al. 2002, Stephens and Pondella 2002). These data have been collected monthly or quarterly since 1974 at several stations and provide a detailed characterization of ichthyoplankton composition and abundance in King Harbor. We have only proposed collecting samples from two source water stations in King Harbor since these data and on-going data collection by VRG will be used to provide a more thorough characterization of the King Harbor component of the source water.

All stations will be sampled using a wheeled bongo plankton net using the same oblique tows described for the entrainment sampling (See Section 4.1). During each source water survey, the additional seven source water stations (plus the entrainment stations) will be sampled four times per 24-hr period--once every six hours. This allows adequate time to conduct all source water and entrainment sampling. During each sample cycle the order that the stations are sampled will be varied to avoid introducing a systematic bias into the data.

### 3.2.3 Laboratory Processing

Ichthyoplankton samples will be returned to the laboratory; after approximately 72 hours the samples preserved in 4 to 10 percent buffered formalin-seawater will be transferred to 70–80 percent ethanol. All entrainment and source water samples will be processed. Samples will be examined under dissecting microscopes and all fish, *Cancer* crab, lobster and squid larvae (target organism groups) will be removed from the debris and other plankton and placed in labeled vials. Larvae will be identified to the lowest practical taxonomic level (species for most larvae) and enumerated. Fish eggs will not be sorted or identified because a full assessment of their abundance would require different sampling techniques and they cannot be identified to the same taxonomic levels as fish larvae. In addition, recent studies have shown that entrainment at coastal plants located near harbor areas such as the RBGS is largely comprised of species that do not have a planktonic egg stage. The assessment of the results for the fishes with planktonic eggs is discussed in Section 4.3.2.

If *Cancer* crab, lobster, or squid larvae are in very high abundances in the samples we will process only one of the paired nets from the bongo frame for invertebrates after thorough analysis is performed to determine the effect of this reduction in sample volume on the estimates.

A maximum of 200 representative fish larvae from each of the taxa that will be analyzed will be measured using a dissecting microscope and image analysis system. Larvae will be measured to the nearest 0.02 inch (0.5 mm).

### 3.2.4 Quality Control Program

A quality control (QC) program will be implemented for the field and laboratory components of the study. Quality control surveys will be done on a quarterly or more frequent basis to ensure that the field sampling is properly conducted. The field survey procedures will be reviewed with all personnel prior to the start of the study and all personnel will be given printed copies of the procedures that will be included with the final IM&E study report.

A more detailed QC program will be applied to all laboratory processing. The first ten samples sorted by an individual will be resorted by a designated quality control (QC) sorter. A sorter is allowed to miss one fish, *Cancer* crab, lobster or squid larva when the total number of target organisms in the sample is less than 20. For samples with 20 or greater target organisms the sorter must maintain a sorting accuracy of 90 percent. After a sorter has ten consecutive samples with greater than 90 percent accuracy, the sorter will have one of their next ten samples randomly selected for a QC check. If the sorter fails to achieve an accuracy level of 90 percent, their next ten samples will be resorted by the QC sorter until they meet the required level of accuracy. If the sorter maintains the required level of accuracy one of their next ten samples will be resorted by QC personnel.

A similar QC program will be conducted for the taxonomists identifying the samples. The first ten samples of fish or invertebrates identified by an individual taxonomist will be completely re-identified by a designated QC taxonomist. A total of at least 50 individual fish larvae from at least five taxa must be present in these first ten samples; if not, additional samples will be reidentified until this criterion is met. Taxonomists are required to maintain a 95 percent identification accuracy level in these first ten samples. After the taxonomist has identified ten consecutive samples with greater than 95 percent accuracy, they will have one of their next ten samples checked by a QC taxonomist. If the taxonomist maintains an accuracy level of 95 percent then they will continue to have one of each ten samples checked by a QC taxonomist. If they fall below this level then ten consecutive samples they have identified will be checked for accuracy. Samples will be re-identified until ten consecutive samples meet the 95 percent criterion. Identifications will be cross-checked against taxonomic voucher collections maintained by MBC and Tenera Environmental.

### 3.2.5 Data Management

Field and laboratory data will be recorded on preprinted data sheets formatted for entry into a computer database for analysis and archiving. On a monthly basis these data will be transmitted to Tenera Environmental for entry into the project database and eventual analysis. Density of ichthyoplankton by taxon will be reported as number per 1,000 cubic meters (#/1,000 $m^3$). Entered data will be cross-checked with field and laboratory data sheets for transcription errors.

# 4.0 Analytical Methods

Power plant intake effects occur due to impingement of larger organisms onto the intake screens and entrainment of organisms into the CWIS that are smaller than the screen mesh on the intake screens. Consistent with the Phase II regulations, we assume for purposes of the entrainment characterization that all entrainable organisms do not survive. Considerable effort among regulatory agencies and the scientific community has been expended on the evaluation of power plant intake effects over the past three decades. The variety of approaches developed reflects the many differences in power plant locations and resource settings. MacCall et al. (1983), in their review of the various approaches, divided them into those that offer a judgment on the presence or absence of impact and those that describe the sensitivity of populations to varying operational conditions. These efforts have helped to establish the context for the modeling approaches that may be used to estimate impingement and entrainment effects at the RBGS. Impact assessment approaches that will be considered in the final evaluation in the CDS include:

Methods used in estimating the calculation baseline:

- Annual estimates of total individuals impinged and entrained
- Annual estimates of total biomass impinged

Methods for evaluating impacts for calculation baseline and cost benefit analysis:

- Adult-equivalent loss (*AEL*) (Horst 1975; Goodyear 1978)
- Fecundity hindcasting (*FH*) proposed by Alec MacCall, NOAA/NMFS, which is related to the adult-equivalent loss approach
- Production Foregone (*PF*) (Rago 1984)

Methods for evaluating population-level impacts and estimating appropriate restoration efforts:

- Empirical transport model (*ETM*), which is similar to the approach described by MacCall et al. (1983), and used by Parker and DeMartini (1989).

The Rule provides flexibility in terms of demonstrating compliance and therefore the need for and nature of additional analysis that may be conducted will be based on the compliance alternative and options selected by AES. Consistent with the regulatory requirements, impingement mortality and entrainment estimates for all fish and shellfish species for each life stage will be generated based on cooling water volumes representative of operations during the past five years.

The assessment approach used in the final report that will be submitted as part of the Comprehensive Demonstration Study (CDS) for the RBGS will also depend upon the facility's baseline calculations and its method(s) of compliance with the new §316(b) rule's performance standards for reductions in impingement mortality and entrainment. Compliance at RBGS may be achieved singly, or in combination, by technological or operational changes to the CWIS (TIOP), restoration methods, and site-specific BTA standards. In order to demonstrate compliance through the TIOP it is only necessary to analyze entrainment data to determine baseline entrainment levels and assess those levels against the improvements achieved through the implementation of the TIOP. In the case where restoration is limited to only commercially or recreationally important species, entrainment data may also be adequate to assess the levels of restoration necessary to offset entrainment and impingement losses, assuming that scientifically valid population models exist for the species providing the lost benefits. In assessing compliance with the performance standard in whole or in part through restoration of habitat to include non-use species in addition to the losses of recreational and commercial species it is necessary to assess the entrainment and impingement losses from the source water using a combination of assessment methods to determine the commensurate level of restoration. The same source water and entrainment data, and assessment methods would also be used to determine a site-specific BTA standard based on cost-benefit analysis of both use and non-use entrainment losses. Source water data would not be necessary for cost-benefit analysis based simply on the value of commercial and recreational species losses.

## 4.1 Target Organisms and Selection of Taxa for Assessment

The proposed impingement mortality and entrainment (IM&E) studies are designed to optimally sample particular groups of organisms that have historically been the focus of 316(b) assessments and have been used in recent IM&E studies in southern California, including the AES Huntington Beach Generating Station (MBC and Tenera 2005), the Duke Energy South Bay Power Plant (Tenera 2004), and the Cabrillo Power I LLC, Encina Power Station. The groups of organisms were selected because of their ecological roles or commercial and/or recreational fisheries importance. They can also be sampled effectively using one method. This is especially critical for the entrainment and source water sampling where sampling other invertebrate larvae may require the use of smaller mesh nets, which would add significant labor and costs to the study.

Consistent with the regulatory requirements, impingement mortality and entrainment estimates for all fish and shellfish species for each life stage will be generated based on cooling water volumes representative of operations during the past five years.

The specific taxa (species or group of species) that will be analyzed in the assessment will be limited to the taxa that are sufficiently abundant to provide reasonable assessment of impacts. For the purposes of this study plan, the taxa analyzed in the assessment will be limited to the most abundant taxa that together comprise 90-95 percent of all larvae entrained and/or juveniles and adults impinged by the generating station. The most abundant taxa are used in the assessment because they provide the most robust and reliable estimates for the purpose of scaling restoration projects or quantification of the ecological benefits under the cost-benefit test. Since the most abundant organisms may not necessarily be the organisms that experience the greatest effects on the population level, the data will be examined carefully before the final selection of taxa to determine if additional taxa should be included in the assessment. This may include commercially or recreationally important taxa, and taxa with limited habitats.

### 4.1.1 Impingement

All fishes and shellfishes will be collected from impingement samples and identified, but the following groups of marine organisms, that include the most important commercial and recreational species, will be enumerated, weighed, and measured:

<u>Vertebrates</u>

- fishes

<u>Invertebrates</u>

- crabs
- shrimp
- octopus
- squid
- California spiny lobster

These same target groups have been used in other recent impingement studies in southern California. Estimates of annual impingement will be calculated for all the target organisms, but a detailed assessment will only be conducted on the most abundant organisms in the samples. The assessment may also include other commercially or recreationally important taxa from the samples.

### 4.1.2 Entrainment

The following groups of marine organisms will be sorted, identified and enumerated from entrainment intake and source water plankton samples:

<u>Vertebrates</u>

- fishes (all life stages beyond egg)

<u>Invertebrates</u>

- rock crab megalopal larvae
- market squid hatchlings [larvae]
- California spiny lobster phyllosoma larvae

These same groups of organisms were also analyzed in most of the recent entrainment studies in southern California and are being proposed in the study plans for SGS and ESGS. Fishes and rock crab larvae were selected because of their respective ecological roles or commercial and/or recreational fisheries importance. Market squid and California spiny lobster were selected because of their commercial and/or recreational importance in the area. All the target organism groups (fishes, rock crabs, squid, and lobster) will be counted and identified to the lowest taxonomic level possible.

The power plant also entrains numerous other planktonic and larval life forms that will not be specifically included in the study. These other groups, potentially including the larvae of other shellfish (shrimp, clams, etc.), are not included because they are smaller than the larvae from the target organism groups and would require separate sampling efforts and equipment to collect. In addition, the identification of many of these other larvae to the species level is problematic and would likely lead to uncertainty in the estimates of their abundance. The *ETM* model provides a means of examining the potential effects on these other organisms by assuming that they are uniformly distributed in the source water area and are withdrawn at a rate equal to the volumetric ratio of the cooling water flow to the source water volume. The effect of entrainment on these organisms also depends on their larval duration or the time period they are exposed to entrainment.

Fish eggs will not be sorted or identified because a full assessment of their abundance would also require different sampling techniques and they also cannot be identified to the same taxonomic levels as fish larvae. In addition, recent studies at other coastal power plants near estuarine or harbor areas similar to the RBGS have shown that entrainment is largely dominated by fishes that do not have an entrainable planktonic egg stage. Even though egg life stages will not be quantified from the entrainment and source water samples, entrainment effects on fishes with planktonic egg stages will be accounted for in the assessment models. For organisms with available life history information, estimates of larval and egg survival can be used to estimate the number of eggs that would have been entrained from abundances of larvae in the samples. Egg mortality can be accounted for in the *ETM* model by adding the time period that eggs are planktonic to the estimate of the time period that larvae of that species are at risk of entrainment. This approach assumes that the proportional mortality estimate used in the modeling of larval entrainment also applies to egg mortality and that mortality on passage through the cooling system is 100% for both egg and larval stages.

## 4.2 Impingement Assessment

The impingement mortality study will estimate the rates (i.e., number and biomass of organisms per water volume flowing per time into the plant) at which various species of fishes and shellfishes are impinged. Annual impingement estimates will be calculated by extrapolating the impingement rates measured during normal operations over the monthly survey periods. To calculate an estimate of impingement mortality, fishes and shellfishes that survive (for one week) during the impingement survival study and are released will be subtracted from the impingement mortality estimate. The number and biomass of individual fishes that survive for one-week post-impingement and are released will be subtracted from the total mortality estimate. The impingement mortality estimates for each period will be added to provide annual estimates of impingement for each species. These estimates would be added to the heat treatment totals to provide estimates of the total annual impingement mortality.

The estimates of total annual impingement can be combined with estimates of equivalent adults from entrainment to provide total impact assessment for a taxon. The demographic models used to calculate these estimates (described below) are limited to taxa that have sufficient life history information available.

Additionally, the overall reduction in impingement provided by the velocity cap, as calculated by the proposed velocity cap effectiveness study, will be applied to the impingement total. The overall average percent reduction in impingement due to the velocity cap will be used as a reduction in impingement mortality from the performance standard.

## 4.3 Entrainment Assessment

Estimates of daily and annual larval entrainment at the RBGS Units 7&8 intake will be calculated from data collected at the entrainment station. Estimates of entrainment loss, in conjunction with available demographic data collected from the fisheries literature, will permit modeling of adult equivalent loss (*AEL*) and fecundity hindcasting (*FH*). Data from sampling of the potential source populations of larvae will be used to calculate estimates of proportional entrainment (*PE*) that are used to estimate the probability of mortality due to entrainment using the Empirical Transport Model (*ETM*). In the RBGS entrainment and impingement studies we will use each approach (i.e., *AEL*, *FH*, and *ETM*) as appropriate to assess power plant losses.

The various modeling approaches that will be considered for the assessment at RBGS can be placed under the umbrella of two general approaches: demographic models that rely on species life history information such as the equivalent adult model (*EAM*; Horst 1975; Goodyear 1978) which includes adult equivalent loss (*AEL*) and fecundity-hindcasting (*FH*); and models that estimate the conditional mortality on a population resulting from power plant CWIS operations such as the empirical transport model (*ETM*; Boreman et al. 1978).

The application of several models to estimate power plant effects is not unique (Murdoch et al. 1989; PSE&G 1993; Tenera 2000a; Tenera 2000b). Equivalent adult modeling (*AEL* and *FH*) is an accepted method that will be used at RBGS and has been applied in other 316(b) demonstrations (PSE&G 1993; Tenera 2000a; Tenera 2000b). The advantage of these demographic modeling approaches, which includes production foregone (*PF*), is that they translate losses into adult fishes that are familiar units to resource managers, but they require life history data that are not available for many species. These estimates can be also combined with estimated losses to adult and juvenile organisms due to impingement to provide combined estimates of cooling water system effects.

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 at power plants (Boreman et al. 1978, 1981). Variations of this model have been discussed in MacCall et al. (1983) and used to assess impacts at the San Onofre Nuclear Generating Station (Parker and DeMartini 1989). The *ETM* has also been used to assess impacts at the Diablo Canyon Power Plant and Huntington Beach Generating Station in California (Tenera 2000a, MBC and Tenera 2005), and 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 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 *ETM* provides an estimate of power plant effects that may be less subject to inter-annual variation than demographic model estimates. It also provides an estimate of population-level effects not provided by demographic approaches.

The results of the *ETM* modeling provide the best and most direct estimates of the effects of entrainment on source water populations since the effects are estimated on the larval populations being affected. The *ETM* estimates can be used to appropriately scale restoration projects that might be used to help offset entrainment losses. The estimates can also be used to provide a context for demographic model estimates that are based solely on entrainment estimates. For example, especially in estuarine systems, entrainment estimates may show large losses of fish larvae that are sometimes difficult to interpret and put in context without estimates of the adult or larval source water populations. The *ETM* provides a context for these estimates that can account for some of the uncertainty associated with determining an appropriate level of entrainment reduction.

### 4.3.1 Demographic Approaches

Adult equivalent loss models evolved from impact assessments that compared power plant losses to commercial fisheries harvests and/or estimates of the abundance of adults. In the case of adult fishes impinged by intake screens, the comparison was relatively straightforward. To compare the numbers of impinged sub-adults and juveniles and entrained larval fishes to adults, it was necessary to convert all these losses to adult equivalents. Horst (1975) provided an early example of the equivalent adult model (*EAM*) to convert numbers of entrained early life stages of fishes to their hypothetical adult equivalency. Goodyear (1978) extended the method to include the extrapolation of impinged juvenile losses to equivalent adults.

Demographic approaches, exemplified by the *EAM*, produce an absolute measure of loss beginning with simple numerical inventories of entrained or impinged individuals and increasing in complexity when the inventory results are extrapolated to estimate numbers of adult fishes or biomass. We will use two different but related demographic approaches in assessing entrainment effects at RBGS: *AEL*, which expresses effects as absolute losses of numbers of adults, and *FH*, which estimates the number of adult females whose reproductive output has been effectively eliminated by entrainment of larvae. Both estimates require an estimate of the age at entrainment. These estimates will be obtained by measuring a random sample of up to 200 larvae of each of the taxa identified for assessment from the entrainment samples and using published larval growth rates to estimate the age at entrainment. The age at entrainment will be calculated by dividing the difference between the size at hatching and the average size of the larvae from entrainment by a growth rate obtained from the literature.

Age-specific survival and fecundity rates are required for *AEL* and *FH*. Adult-equivalent loss estimates require survivorship estimates from the age at entrainment to adult recruitment; *FH* requires egg and larval survivorship until entrainment. Furthermore, to make estimation practical, the affected population is assumed to be stable and stationary, and age-specific survival and fecundity rates are assumed to be constant over time. Each of these approaches provides estimates of adult fish loss, which will still need to be placed into context regarding standing stocks of adult fishes.

Species-specific survivorship information (e.g., age-specific mortality) from egg or larvae to adulthood is limited for many of the taxa likely to be considered in this assessment. Thus, in many cases, these rates must be inferred from the literature along with their measures of uncertainty. Uncertainty surrounding published demographic parameters is seldom known and rarely reported, but the likelihood that it is very large should be considered when interpreting results from the demographic approaches for estimating entrainment effects. For some well-studied species (e.g., northern anchovy, *Engraulis mordax*), portions of early mortality schedules and fecundity have been reported (e.g., Zweifel and Smith 1981; Hewitt 1982; Hewitt and Methot 1982; Hewitt and Brewer 1983; Lo 1983, 1985, and 1986; McGurk 1986). Because the accuracy of the estimated entrainment effects from *AEL* and *FH* will depend on the accuracy of age-specific mortality and fecundity estimates, lack of demographic information may limit the utility of these approaches.

The precursor to the *AEL* and *FH* calculations is an estimate of total annual larval entrainment. Estimates of larval entrainment at RBGS will be based on the monthly sampling where $\widehat{E}_T$ is the estimate of total entrainment and $\widehat{E}_i$ is the monthly entrainment estimate. Estimates of total entrainment are based on two-stage sampling designs, with days within each sampling period and cycles within days. The within-day sampling is based on a stratified random sampling scheme with four temporal cycles and two replicates per cycle.

## Adult Equivalent Loss *(AEL)*

The *AEL* approach uses estimates of the abundance of the 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 numbers of adult fishes that are familiar units to resource managers. Adult equivalent loss does not require source water estimates of larval abundance in assessing effects. 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).

Starting with the number of age class $j$ larvae entrained, $\widehat{E}_j$, it is conceptually easy to convert these numbers to an equivalent number of adults lost $\widehat{AEL}$ at some specified age class from the formula:

$$\widehat{AEL} = \sum_{j=1}^{n} \widehat{E}_j S_j \qquad (1)$$

where

$n$ = number of age classes;

$\widehat{E}_j$ = estimated number of larvae lost in age class $j$; and

$S_j$ = survival probability for the $j$ th class to adulthood (Goodyear 1978).

Age-specific survival rates from larval stage to recruitment into the fishery must be included in this assessment method. For some commercial species, natural survival rates are known after the fish recruit into the commercial fishery. For the earlier years of development, this information is not well known and may not exist for non-commercial species.

An alternative expression of adult-equivalent loss would be to standardize $\widehat{AEL}$ by the size of the adult population of interest to estimate the relative magnitude of the equivalent adult loss such that,

$$\widehat{RAEL} = \frac{\widehat{AEL}}{\widehat{P}}, \tag{2}$$

where $\widehat{P}$ = estimated size of the adult population of interest. Information on adult source populations will be limited for many species and thereby limit the utility of Equation (2), although the same approach will be used to place the estimated losses into context for taxa with published commercial or recreational fishery catch data.

## Fecundity Hindcasting (*FH*)

The *FH* approach compares larval entrainment losses with adult fecundity to estimate the amount of adult female reproductive output eliminated by entrainment, hindcasting the numbers of adult females effectively removed from the reproductively active population. The accuracy of *FH* estimates is dependent upon accurate estimates of age-specific mortality from the egg and early larval stages to entrainment and accurate estimates of the total lifetime female fecundity. If it can be assumed that the adult population has been stable at some current level of exploitation and that the male:female ratio is constant and 50:50, then fecundity and mortality are integrated into an estimate of loss by converting entrained larvae back into females (i.e., hindcasting).

A potential advantage of *FH* is that survivorship need only be estimated for a relatively short period of the larval stage (i.e., egg to larval entrainment). The method requires age-specific mortality rates and fecundities to estimate entrainment effects and some knowledge of the abundance of adults to assess the fractional losses these effects represent. This method assumes that the loss of a single female's reproductive potential is equivalent to the loss of an adult fish.

In the *FH* approach, the total of larval entrainment for a species $\widehat{E}_T$ will be projected backward to estimate the number of breeding females required to provide the numbers of larvae seen in the entrainment samples. The estimated number of breeding females $\widehat{FH}$ whose fecundity is equal to the total loss of entrained larvae would be calculated as follows:

$$\widehat{FH} = \frac{\widehat{E_T}}{\widehat{TLF} \bullet \prod_{j=1}^{n} S_j} \tag{3}$$

where

$\widehat{E}_T$ = total entrainment estimate;

$S_j$ = survival rate from eggs to entrained larvae of the $j$ th stage ;

$\widehat{TLF}$ = average total lifetime fecundity for females, equivalent to the average number of eggs spawned per female over their reproductive years.

The two key input parameters in Equation (3) are total lifetime fecundity $\widehat{TLF}$ and very early survival rates $S_j$ from spawning to entrainment. Descriptions of these parameters may be limited for many species and are a possible limitation of the method.

An alternative interpretation of *FH* is possible by expressing the estimate in terms of the relative size of the adult fish stock in the source populations where

$$\widehat{RFH} = \frac{\widehat{FH}}{\widehat{P}} \tag{4}$$

where $\widehat{P}$ = estimated size of the adult population of interest. Information on adult source populations will be limited for many species and thereby limit the utility of Equation (4), although the same approach can be used to place the estimated losses into context for taxa with published commercial or recreational fishery catch data where $\widehat{RFH}$ is the proportion of the breeding females whose fecundity was lost due to entrainment by the RBGS.

### 4.3.2 Empirical Transport Model (*ETM*)

The ETM calculations provide an estimate of the probability of mortality due to power plant entrainment. The calculations require not only the abundance of larvae entrained but also the abundance of the larval populations at risk of entrainment. Sampling at the cooling water intake is used to estimate the total number of larvae entrainment for a given time period, while sampling in the coastal waters around the RBGS intake is used to estimate the source population for the same period.

On any one sampling day, the conditional entrainment mortality (*PE*) can be expressed as

$$PE_i = \frac{\widehat{E_i}}{\widehat{R_i}} \tag{5}$$

where

$E_i$ = total numbers of larvae entrained during the *i* th survey; and

$R_i$ = numbers of larvae at risk of entrainment, i.e., abundance of larvae in source water.

The values used in calculating *PE* are population estimates based on the respective densities and volumes of the cooling water system flow and source water areas. The abundance of larvae at risk in the source water during the *i* th survey can be directly expressed as

$$\widehat{R_i} = V_S \cdot \widehat{\bar{\rho}_{S_i}} \tag{6}$$

where $V_S$ denotes the static volume of the source water ($S_i$), and $\widehat{\bar{\rho}}$ denotes an estimate of the average density in the source water.

Regardless of whether the species has a single spawning period per year or multiple overlapping spawnings the estimate of total larval entrainment mortality can be expressed by

$$\widehat{P_M} = 1 - \sum_{i=1}^{N} \widehat{f_i} \left(1 - \widehat{PE_i}\right)^q \qquad (7)$$

where

$q$ = number of days that the eggs and larvae are susceptible to entrainment, and

$\hat{f}_i$ = estimated annual fraction of total larvae hatched during the $i$ th survey period.

To establish independent survey estimates, it is assumed that during each survey a new and distinct cohort of larvae is subject to entrainment. Each of the monthly surveys is weighted by $\hat{f}_i$ and estimated as the proportion of the total source population present during the $i$ th survey period.

As shown in Equations 5 and 6 the estimates of *PE* are based on population estimates of specific volumes of water. While a reasonably accurate estimate of the volume of the cooling water intake flow can be obtained, estimating the volume of the source water is more difficult and will vary depending upon oceanographic conditions and the organism being assessed. Source water volumes will be estimated separately for each taxon during each survey. Onshore and alongshore current vectors measured during each survey period will be used to determine the maximum distance a larvae could travel based on the estimated maximum larval duration for each taxon. The maximum age at entrainment will be calculated using the lengths of a random sample of up to 200 larvae from the entrainment samples for each taxon being assessed. The maximum age will be calculated based on the upper 95th percentile value of the lengths measured from the samples. The maximum age at entrainment will be calculated by dividing the difference between the upper 95th percentile value of the lengths measured from the samples minus the hatch length by the growth rate.

Alongshore and onshore current velocities will be measured using current meter(s) positioned offshore from the RBGS Units 7&8 intake. The final position and depth of the current meters will be chosen to ensure that they are outside the influence of the intake flow. The direction in degrees true from north and speed in cm per second will be estimated for each hour of the source water survey periods. The hourly current meter data will be analyzed by rotating the current vectors so that they are orthogonal to the coast and then tracking the movement of water during each survey period. A total alongshore length or displacement in kilometers will be calculated from these data using the range of both upcoast and downcoast movement over the larval duration period prior to each survey period. The maximum upcoast and downcoast displacement measured prior to each survey period will be added together to obtain an estimate of total alongshore movement. Onshore movement, excluding periods of offshore movement, will be similarly calculated for the egg and larval durations for each species.

Data from the source water sampling will be used to extrapolate densities onshore and offshore using the following approaches:

1. For species where the regression of density versus offshore distance has a negative slope, the offshore distance predicted where density is zero (i.e., integral of zero) will be calculated. The alongshore distance will be calculated from the cumulative current data vectors for the duration based on the maximum larval length.

2. For species where the regression of density versus offshore distance has a slope of $\geq 0$, either the offshore distance from the water current data or an average distance based on literature values on the depth distribution of the adults offshore will be used. Literature

values (e.g., CalCOFI) will be used to place a ceiling on both the distance and density values used in the offshore extrapolation.

3. The offshore distance of the source water study area will be used when the onshore water current displacement is less than the width of the study area unless the limits of the regression or the depth distribution for the taxa is less than the distance offshore.

These three approaches will use the same regression coefficients to extrapolate source water densities to the shoreline. Survey specific regression coefficients will be calculated by fitting either a linear, quadratic, or other model to the density data. For example, a linear model would be fit as follows:

$$\rho_{ij} = \alpha + \beta w_i + \varepsilon_{ij}$$

where

$\rho_{ij} =$ larval density for the $j$ th observation in the $i$ th survey,
$w_i =$ distance for the $i$ th survey, and
$\alpha, \beta =$ regression coefficients.

The regression analysis will treat the four six-hour cycles during each source water survey as sampling strata according to Cochran (1977). The data collected during the surveys will be converted to counts per $m^3$ using the sample volumes from the flow meters in the bongo nets. Depths at each station will be recorded and used to convert, by multiplication, these data on larval concentration to densities per $m^2$. The larval densities ($\rho_{ij}$) will be analyzed using a model to define density as a function of distance from shore ($\rho_{ij} = f(w_i)$). This function will then be used to extrapolate density as a function of distance from shore by integrating from the offshore margin of the sampling area to a point estimated by the maximum current vector, or where the extrapolated larval density is zero or biologically limited. This point may occur beyond the offshore extent of the study area. A similar integration of the function will occur from the inshore edge of the study area towards the shoreline. This integration will result in units of counts per $m^2$. When multiplied by the alongshore distance from the cumulative current vectors we obtain our final estimate for the source water ($R_i$). This is used in Equation 5 to obtain an estimate of *PE* for the survey. Alternatively, the sampling locations within the source water study area could be treated as spatial strata and an estimate of counts per $m^2$ obtained.

# 5.0 REPORTING

Tenera Environmental and MBC Applied Environmental Sciences will produce a final report on the findings from the entrainment and impingement studies. The report will be submitted as part of the Comprehensive Demonstration Study for the RBGS.

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# C PROPOSED METHOD FOR EVALUATION OF ENVIRONMENTAL BENEFITS

See following pages.

**Proposal for Information Collection (PIC): Deriving Economic Benefits of Reduced Impingement and Entrainment at AES's Redondo Beach L.L.C. Generating Station**

***Background***

For use of the Cost-Benefit test under the site-specific standards, AES is required to have a Benefits Valuation Study prepared. The final 316(b) Phase II Final Rule (herein after referred to as the Rule) requires use of a comprehensive methodology to value fully the impacts of impingement and entrainment mortality at the Redondo Beach L.L.C. Generating Station. Other requirements for use of the test include:

- A description of the methodology(ies) used to value commercial, recreational, and ecological benefits (including non-use benefits, if applicable);
- Documentation of the basis for any assumptions and quantitative estimates. If the valuation includes use of an entrainment survival rate other than zero, a determination of entrainment survival at the facility based on a study approved by the NPDES permitting authority must be submitted;
- An analysis of the effects of significant sources of uncertainty on the results of the study;
- If requested by the NPDES permitting authority, a peer review of the items you submit in the Benefits Valuation Study. You must choose the peer reviewers in consultation with the Director who may consult with EPA and Federal, State, and Tribal fish and wildlife management agencies with responsibility for fish and wildlife potentially affected by your cooling water intake structure. Peer reviewers must have appropriate qualifications depending upon the materials to be reviewed.
- A narrative description of any non-monetized benefits that would be realized at your site if you were to meet the applicable performance standards and a qualitative assessment of their magnitude and significance.

All benefits, whether expressed qualitatively or quantitatively, should be addressed in the Benefits Valuation Study and considered by the NPDES permitting authority and in determining whether compliance costs significantly exceed benefits.

The benefits assessment begins with an impingement and entrainment (IM&E) mortality study that quantifies both the baseline mortality as well as the expected change from rule compliance. Based on the information generated by the IM&E mortality studies, the benefits assessment includes a qualitative and/or quantitative description of the benefits that would be produced by compliance with the applicable performance standards at the facility site. To the extent feasible, dollar estimates of all significant benefits categories would be made using well-established and generally accepted valuation methodologies.

In order to have the appropriate information if the benefit/cost option is chosen, we propose a strategy for the collection and analysis of economic information. The strategy is based on information obtained from previous impingement and entrainment studies conducted at the Redondo Beach facility and a brief review of economic studies of fishing in the southern California region. It should be noted that one particular benefit category, benefits accruing to individuals even if they have no plans ever to use resources associated with the Redondo Beach Generating Station (non-use benefits), are to be estimated only

> "In cases where the impingement or entrainment study identifies **substantial harm** to a threatened or endangered species, to the sustainability of populations of important species of fish, shellfish or wildlife, or to the maintenance of community structure and function in a facility's water body or watershed ." (Final Rule, Federal Register page 41648).

"Substantial harm" is a stringent requirement to necessitate estimation of non-use values and thus non-use values usually would not be included in the final analysis. However, because the Final Rule does raise the potential for estimation of non-use values, we do provide some contingency for their estimation.

***Description of Methodologies to Determine Benefits***

The 316(b) rule defines a performance standard that the EPA has established for all existing power plant facilities to meet. The Redondo Beach Generating Station is located in King Harbor on Santa Monica Bay on the Pacific Ocean. Therefore, it is subject to the impingement mortality (IM) performance standard (requiring a reduction in IM of 80% to 95%) and the entrainment (E) reduction performance standard (requiring a reduction in E of 60% to 90%). However, the Final Rule states that facilities do not have to meet the IM and E performance standard if it can be shown that the costs of achieving the performance standard are significantly greater than the benefits. Therefore we are providing a plan to collect information in case it is necessary to determine whether the benefits of the identified technology are significantly less than costs.

Impingement studies have been conducted at Redondo Beach during 1979-1980 and more recently from 1991 through 1999. Based on that information, we believe that the potentially representative commercial and recreational species (RS) with impingement and entrainment mortality might be white croaker, Pacific sardine, yellowfin croaker, northern anchovy, and queenfish. If additional impingement and entrainment studies are done and these species continue to the RS, then there may be both commercial and recreational fisheries that benefit from reduced mortalities. It is also possible that non-use values will need to be addressed.

The EPA examined a technology (closed-cycle cooling) to achieve a national standard for entrainment and impingement mortality. In determining benefits at a national level, EPA used certain economic concepts of benefits associated with using the assets that cooling water adversely effects and methodologies to estimate the benefits (U.S. EPA, 2004a; U.S. EPA 2004b; U.S. EPA 2004c). In order to make the benefits comparable to costs, they presented benefits in a monetary unit, dollars. Their benefit estimates reflected the willingness to pay of individuals to go from the current environmental status to one associated with an identified technology. All of the methods proposed in this PIC were also used in EPA's national analysis.

More specifically, this benefit analysis will seek to provide a unit value per fish caught ($/fish) for recreational and commercial species affected by the new technology. With this information, total recreational and commercial benefits can be determined by multiplying the unit value times the expected increase in recreational and commercial catch arising from the identified technology. In addition, some information will be provided with respect to non-use values.

***Recreational Angling***

For the recreational anglers, there are two potential ways to proceed:

1.) Benefit Transfer- the application of benefit estimates provided in other studies to the Redondo Beach situation;
2.) Primary research- collection and/or assemblage of data on recreational fishing on the Southern California area and using the data to derive an estimate of the value per fish for the important species.

While the two approaches initially will be discussed independently, there is a sound reason to consider them in concert with one another. That is, the benefit transfer information provides a reality check for any values derived in the primary research. Any primary research effort should contain a thorough literature review, a component that would have information very similar in nature to the benefits transfer analysis. Also, the benefit transfer approach may provide a fallback position if the primary research is unsuccessful in providing benefit estimates. After both have been discussed independently, a strategy that integrates them will be offered.

***A Benefit Transfer Approach***

The use of benefit transfers requires finding a previous economic study (or studies) that considers a comparable situation to fishing near the Redondo Beach Generating Station and contains dollar values per unit fish caught or a value function for dollar values per unit fish caught. Particularly important would be having species similar to the effected species and a fishing population similar to the Redondo Beach Generating Station situation. Although there are numerous other aspects of the fishing situation that might be important, these two are the most critical.

In order to identify an appropriate study or studies, it would be essential to visit the site to examine first-hand the type of recreational fishing that is occurring. At the same time, contact with key people in the area will be made to determine if any relevant studies or data do exist (see references for some articles). We would consider it essential that the following sources be contacted or examined:

1. State or Federal Hearings on previous Redondo Beach L.L.C. station's license renewal.
2. State or Federal Hearings on previous power plant facilities in the general southern California area.
3. Authors of EPA "in-house" studies associated with the Final Rule. In particular, EPA's RUM analysis of the California region (U. S. EPA. 2004d) should be considered.
4. Personnel from California Fish and Game.
5. Key Informants at universities or other research facilities
    a. University of California, San Diego
    Dr. Richard Carson (Department of Economics) is an expert in contingent valuation and non-use valuation.
    b. University of California, Berkeley
    Dr. Michael Hanneman (Department of Agricultural and Resource Economics) is an expert in economic valuation and has studied sportfishing in southern California
    c. University of California, Los Angeles
    Dr. Trudy Cameron is an expert in econometrics and has studied sportfishing in California.
    d. Southwest Fisheries Science Center, National Marine Fisheries Service
    Drs. Dale Squires, Cynthia Thompson and Sam Herrick are experts in fisheries economics and management.
    e. Local Consulting firms. Jones and Stokes Inc. (particularly Thomas Wegge) of Sacramento completed numerous sportfishing studies in California.
6. Existing bibliography sources available by internet
    a. National Marine Fisheries Service, Southeast Fisheries Center
    b. Sportfishing Values Database
    c. Environmental Valuation Reference Inventory (EVRI): Canadian based.
    d. Beneficial Use Values Database (BUVD)
    e. Regulatory Economic Analysis Inventory, (REAI) maintained by the U.S. EPA
    f. ENVALUE, an environmental value database maintained in Australia.
7. *Investigation and Valuation of Fish Kills* (American Fisheries Society, 1992) Excerpt: "Chapter 4 ("Monetary and Economic Valuation of Fish Kills") dates back to the Pollution Committee's *Monetary Values of Fish* booklets of 1970 and 1975, which dealt with southern U.S. species. In 1978, the AFS North Central Division's Monetary Values of Fish Committee published *Reimbursement Values for Fish*, addressing species in 12 northern states and 2 Canadian provinces. To integrate these and other regional values, a special AFS Monetary Values of Freshwater Fish Committee collected values from 135 federal, state, provincial, and private agencies and hatcheries. These data were published in 1982 as Part I of AFS Special Publication 13. For the present book, the Socioeconomics Section has repeated the earlier survey to update replacement costs for killed fish and summarized procedures for estimating the broader economic losses resulting from a fish kill."

These potential sources will be used to obtain "off-the-shelf" values that could possibly be relevant to the effected species at the Redondo Beach Generating Station. In addition, some of these contacts may be useful as researchers, data sources, and/or witnesses for any hearings that evolve. They may also be useful as peer reviewers or as sources to identify peer reviewers.

***Primary Research***

There are several other methodologies that could be used to estimate economic values for the species considered, but they will require some level of primary research.

Data and programs could be obtained from the U.S. EPA and examined to see if the results reported in USEPA (2004d) are defensible. If they are not, a new RUM model could be estimated with the data. The major changes introduced in the research would be to consider:

1.) correcting (if necessary) problems associated with the original analysis;
2.) the RS species rather than in a grouping[1];
3.) the Huntington Beach, Redondo Beach and Alimitos sites would be delineated rather that using aggregate sites used in the USEPA study (Southern California counties were used as sites).

The analysis would also update the angling activity and possible generalized the RUM model in ways that current research is including.

***Strategy to Obtain Recreational Unit Values per Fish Caught***

The initial portion of the study would be to complete a benefits transfer analysis and determine whether or not the values obtained were reasonable for the purposes of the decisions to be made. That is, if the mitigation strategy returned recreational benefits of that were approximately equal to the costs, it may be unwise and inefficient to move onto primary research because in all likelihood the estimate of costs would not be "significantly larger" than the benefits. If however, the benefit transfer method suggested that the benefits were to be small relative to costs, it may or may not be useful to do one of the primary research plans suggested in the previous section. The quality of existing studies would also be a determinant.

Discussions with key informants in the benefit transfer work would determine the availability and reliability of data from the previous studies of recreational fishing. In addition, some notion of the potential improvement in estimates from using new data and a new model would be obtained.

[1] For example, California halibut is considered in the category "flatfish" in previous studies. If there were sufficient anglers targeting California halibut, then a category California halibut could be designated.

With this information and a better understanding on the costs of doing the primary research studies, decisions regarding what combination of benefit transfer and primary research would be most advantageous. The primary research would in all likelihood provide better estimates of value but may be more costly. Given the present information, it is likely that the analysis performed by the U.S. EPA in 2004 could be used although it would be necessary to obtain the data and programs to refine the benefit estimates to the location to the Redondo Beach area. Additional effort would be devoted to determining whether the aggregation of sites and species could cause the estimated values to be biased.

***Commercial Fishing***

The first determination would be whether commercial fishing is affected by reduced mortality to effected species. California Fish and Game and the National Marine Fisheries Service would be consulted regarding species that the impingement and entrainment studies identified. Both producers and consumers could gain from increases in commercial catch, but the assessment would likely only estimate the gains to direct producers, i.e. commercial fishermen. This is based on the expectation that relatively small changes in commercial landings result from reduced IM&E mortalities. This is the approach that EPA took in the 2004 study.

The approach that EPA uses for assessing commercial benefits to producers bases the unit value on the ex-vessel price (sometimes referred to as dockside price) of the species under consideration. The logic of the approach begins with an assumption that harvest increases do not induce effort (inputs used in harvesting) to increase following reductions of entrained and/or impinged organisms. If this were entirely true, then the ex-vessel price times the increase in quantity harvested would represent producers surplus. However, EPA appreciates that this would not likely be true and that effort and costs would undoubtedly increase in the long run in response to increased commercial profits (i.e. producer surplus). In the absence of property rights to the harvest, one would expect the producer surplus to be eliminated. Recognizing this and allowing for uncertainty in effort response, the EPA proposes using a range of 0-40% of the ex-vessel price times the increase in harvest as a measure of the increase in producers' surplus.

In the unlikely event that the change in landings would be relatively large and cause a change in commercial fisheries prices, we would need to collect information on commercial harvests and prices. There is not a good way to use benefit transfer methods for the consumers' surplus although EPA is exploring one proposed by Bishop and Holt (2003). This approach at present does not look that promising. At present, it does not appear that the change in commercial landings will be sufficiently large to cause prices changes.

However, if additional information suggests price changes, existing data from California Fish and Game and the National Marine Fisheries Service could be sufficient to estimate an inverse, general equilibrium demand curve (see Just, et al. for a description) for the species in question. With these estimates, the benefits to consumers could be calculated.

### *Non-use Valuation*

Based on current knowledge, it does not appear necessary to estimate non-use values. That is, the criteria EPA proposed in the final ruling for their estimation does not appear to be met.

But, in the unlikely event that non-use values will have to be estimated, we would look to using a benefit transfer approach or doing primary research for Redondo Beach. Based on the draft impingement and entrainment studies, we do not believe that the magnitude of the non-use values would justify undertaking a primary research study for non-use values associated with the Redondo Beach station.

Thus, if non-use values were needed, we would suggest using a benefit transfer method in all likelihood. There have not been any studies of non-use values associated with power plant activities *per se.* People have had to rely on studies associated with other types of activities. For example, EPA used a benefit transfers approach in their Proposal for the 316(b) regulations and in the NODA. EPA (Tudor et al., 2003) reviewed numerous studies of use and nonuse values that were associated with surface water improvements (their Appendix A). Of those shown, only three address both changes in fish populations and non-use values associated with them (Huang, et al. 1997; Whitehead and Groothuis, 1992; Olsen, et al. 1991).

We propose considering these three studies in addition to doing a review of the recent literature. The recent literature may be important because EPA has placed some emphasis on this ecological valuation recently. For example, there is a meeting entitled “Improving the Valuation of Ecological Benefits, a STAR Progress Review Workshop” that was held in Washington in October, 2004. The papers presented at that workshop are now available on the internet. One of them is directly related to California.

The results of this activity would likely be the development of a relationship (specifically a ratio) between use values and non-use values. For years, EPA used the 50% rule, a practice that implied that nonuse values were 50% of use values. Our approach, just like some of their 316(b) efforts (Tudor 2003), would be to refine this ratio for situations more akin to the changes associated with power plant operations.

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