Huntington Beach Desalination Facility

Intake Effects Assessment

Final Draft

November 17, 2004

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Executive Summary

The purpose of this report is to assess the potential impingement and entrainment effects of the proposed feedwater withdrawal of the Huntington Beach Desalination Facility (HBDF) from the cooling water intake system (CWIS) discharge of the AES Huntington Beach Generating Station (HBGS). Impingement effects occur when larger fishes and invertebrates are trapped against the intake screens and entrainment effects occur when small planktonic organisms are drawn through the intake (**Figure ES-1**). This Intake Effects Assessment study is designed to address the following specific questions:

1. **Impingement Effect** – Will HBDF operations contribute to the impingement effect (trapping of larger organisms on intake screens) of the HBGS intake?

2. **Entrainment Losses** – Will HBDF operations contribute to the entrainment effect (passage of small planktonic organisms through cooling water system) of the HBGS intake? Specifically, what are the composition and abundance of species that are entrained through the HBGS cooling water intake structure (CWIS) and what proportion of these organisms would be susceptible to further entrainment by the HBDF feedwater withdrawal?

3. **Effect on Source Populations in the Southern California Bight -** How might any additional losses of organisms due to feedwater entrainment affect the source populations of the entrained species in the Southern California Bight?

4. **Significance of Entrainment Losses** – Are these losses ecologically or economically significant?

It should be noted that the HBDF feedwater withdrawal is not subject to intake regulation under the Federal Clean Water Act (CWA) Section 316(b). The HBDF does not include a cooling water intake structure (CWIS). The CWIS is part of the HBGS existing operations and is presently regulated under Section 316(b). The HBDF's feedwater will be withdrawn from the HBGS discharge and not directly from the open ocean, and its withdrawal does not affect HBGS intake requirements. The HBDF does not require the HBGS to increase the quantity of water withdrawn nor does it increase the velocity of the water withdrawn. However, taking under consideration that the HBDF will withdraw intake seawater from the generating station discharge flow, this assessment has been conducted consistent with the intent of Section 316(b) which requires that "… the location, design, construction, and capacity of cooling water intake structures .... are based on the best technology available to minimize the adverse environmental impact associated with the use of cooling water intake structures" (USEPA 2004).

Two separate and unrelated entrainment studies are being conducted at the HBGS plant site. A long-term study, in connection with a re-powering project certified by the California Energy Commission (CEC), is underway to study entrainment effects of the HBGS's cooling water intake system (CWIS). The CEC required AES to perform a study of the power plant's CWIS as a condition of re-powering certification. The CEC entrainment study is not a 316(b) study, but was designed using the same sampling methodologies and data analyses employed in several recently completed 316(b) studies (Tenera 2000 a, b, 2001). The second, but unrelated entrainment study at the site is the Huntington Beach desalination feedwater intake study reported herein. The HBDF intake study, which is also not a 316(b) study as none is required for the HBDF intake, is designed to investigate the potential for desalination facility feedwater intake withdrawn from HBGS discharge flows to increase HBGS entrainment mortality and assess the significance of this potential entrainment effect on the source water. The study was designed to provide information for the Project's EIR submittal to the City of Huntington Beach and other interested parties. Data from both of the studies will be treated the same in mathematical models that assumed 100 percent mortality as recommended by EPA in 316(b) Phase II (see Appendix A for summary of Six-Month Data Report). In other words, Tenera's entrainment and larval mortality studies for HBDF estimate the potential for the desalination facility to increase whatever entrainment effects might be demonstrated in the CEC-required studies of the HBGS's CWIS and assess the significance of this potential entrainment effect on the source water.

The results of the HBDF Intake Effects Assessment study indicate the following:

Impingement Effect

- The HBDF will not cause any additional impingement losses to the marine organisms impinged by the HBGS – these organisms will not be exposed to further screening prior to entering the desalination facility's pretreatment system.

- The HBDF will not have a separate direct ocean water intake and screening facilities, and will only use cooling water that is already screened by HBGS's intake.

Entrainment Losses

Six taxa and a group of larvae that could not be identified were found to comprise 97 percent of all of the fish larvae present in the HBGS discharge flows from which the proposed HBDF would withdraw its feedwater supply (see **Table 4-1**). They were CIQ gobies, blennies, croakers, northern anchovy, garibaldi, unidentified fish larvae, and silversides. These were the same fishes found to be common in a parallel study of HBGS entrainment effects. Species with high commercial and recreational importance, such as California halibut and rockfishes, were shown to be very uncommon in the HBGS intake flows.

- Under HBGS minimum intake cooling water flow of 127 MGD, and assuming 100 percent through-HBGS mortality (based on USEPA 2004), the estimated larval fish entrainment loss is 0.33 percent of the total number of larvae in the generating station's intake source water.

- Based on in-plant testing, the observed mortality of HBGS is 94.1 percent and the combined estimated mortality of HBDF and HBGS at flows of 507 MGD is 95.3 percent (an increase in mortality of 1.2 percent) and 98.7 percent at HBGS flows of 127 MGD (an increase in mortality of 4.6 percent). This assessment assumes 100 percent mortality of all organisms upon withdrawal into the desalination facility (see text box below).

Projected *Source Water* Larval Fish Loss at HBGS Standby Flow (127 MGD) and 100 Percent Entrainment Mortality = 0.33 percent (de minimis)

- Estimated HBGS entrainment mortality is 94.1 percent.
- Estimated combined HBGS and HBDF entrainment mortality is 98.7 percent at HBGS 127 MGD flow an increase in mortality of 4.6 percent.
- Estimated source water larval fish loss attributed to HBDF would be 0.02 percent, an order of magnitude less than 0.33 percent, based on HBGS entrainment mortality of 94.1 percent.

Effect on Source Water Populations in the Southern California Bight

Model results for larval gobies, northern anchovy, and white croaker showed that approximately 0.33 percent of the larvae in the HBGS source water could be affected by HBGS operations at 127 MGD; this represents a de minimis fraction of the total numbers of larval fishes in the Southern California Bight. Results were modeled on encounter rates for the most abundant species entrained from the source water. The loss of marine organisms due to the HBDF entrainment has no effect on the species' ability to sustain their populations. The loss will not have a measurable effect on the source populations of the species in the Southern California

Bight and is an order of magnitude lower than the entrainment loss typically caused by HBGS operations (see **Table ES-1**).

Significance of Entrainment Losses

Calculations have shown that approximately 25,000–37,000 adult gobies and 6,000–71,000 adult northern anchovy may be lost in a 4-month period due to full HBGS operation (507 MGD) (MBC and Tenera 2004; Appendix A). Losses attributed to standby (127 MGD) operations alone would be approximately 25 percent of these amounts. To put such entrainment losses in perspective, the projected amount of the adult fishes lost at 127 MGD during this period could easily be contained within a volume equivalent to several 55-gallon drums.

- The most frequently entrained species are very abundant in the area of HBGS intake and the Southern California Bight, and therefore, the actual ecological effects due any additional entrainment from the HBDF are insignificant.

- Species of direct recreational and commercial value constitute a very small fraction of the entrained organisms in the HBGS offshore intake and therefore, the operation of the HBDF does not result in significant ecological impact in NEPA/CEQA context.

- California Department of Fish and Game (2001) in their Nearshore Fishery Management Plan provides for sustainable populations with harvests of up to 60 percent of unfished adult stocks. The maximum "harvest" effect of HBGS

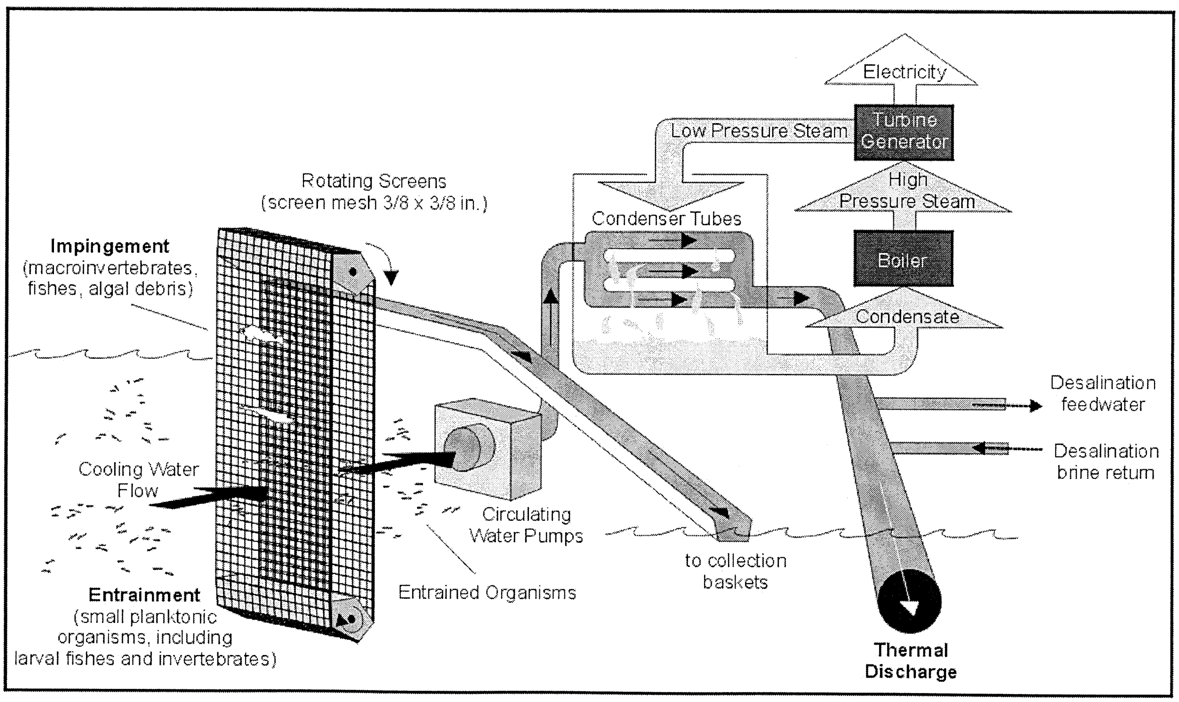


Figure ES-1. Conceptual diagram of impingement and entrainment processes and their relationship to a once-through generating station circulating water system with a desalination feedwater supply and return.

operations at 127 MGD is 0.33 percent. The maximum "harvest" effect of HBDF is 0.02 percent an order of magnitude less than 0.33 percent, based on HBGS entrainment mortality of 94.1 percent.

Study Overview

Entrainment sampling was conducted at an onshore point in the HBGS discharge line just before it is returned in conduits to an offshore discharge location. Bi-weekly samples have been collected since the beginning of March 2004 by pumping measured volumes of cooling water discharges through small-mesh nets. The preserved samples were sorted in the laboratory and the fishes and target invertebrates were identified to the lowest taxon practicable.

In general, entrainment effects are assessed using the Empirical Transport Model (*ETM*), as recommended and approved by the California Energy Commission (CEC), California Coastal Commission (CCC) and other regulatory and resources agencies. This model, used for HBGS intake studies and many other California intake effects studies, compares entrainment larval concentrations to source water larval concentrations to calculate the effects of larval removal on the standing stock of larvae in the defined source water. The *ETM* model results presented in this report are based on sampling results collected during the annual period when larval abundances are typically the highest. The source water volume used in the *ETM* calculations comprised a sub-area of the Southern California Bight and is described in Section 3.0 of this assessment. Source water volumes, cooling water volumes, larval concentrations, and larval durations were variables used in the *ETM* calculations. Conservative assumptions of HBGS volumes of 127 MGD were used for developing the estimates of potential losses due to HBDF operations. These assumptions were considered conservative since the 100 percent entrainment mortality associated with HBDF desalination flow (100 MGD) would affect nearly all of the small number of larvae surviving in HBGS lowest discharge flow of 127 MGD. The fraction of HBDF withdrawal declines along with the facility's entrainment effect as the volume of HBGS discharge increases to 507 MGD.

The HBDF feedwater intake will not increase the volume, nor the velocity of the HBGS cooling water intake nor will it increase the number of organisms entrained or impinged by the HBGS CWIS. Therefore, the impingement effects of the HBGS are not included in assessing the HBDF intake effects. This assessment focuses on the effects of HBDF's entrainment of organisms already entrained by the generating station before they would be returned to the ocean in the cooling water discharge flow.

Table ES-1. Comparison of estimated entrainment impacts at the proposed desalination facility intake and five coastal generating stations.

Site	Intake Flowrate (MGD)	Intake Location	Estimated Larval Loss (% of total source larvae)	Reference
Huntington Beach Desalination Facility (proposed) co-located with Huntington Beach Generating Station	~ 100 MGD	HBGS Discharge	0.18 – 0.33%	Section 5.3 of this report
Huntington Beach Generating Station	507 MGD	Offshore (1,840 ft) Huntington Beach	1 – 3%*	MBC and Tenera 2004
Moss Landing Power Plant	360 MGD	Shoreline, Moss Landing Harbor	13 – 28%	Tenera 2000a
Morro Bay Power Plant	370 MGD	Shoreline, Morro Bay	10 – 32%	Tenera 2001
Diablo Canyon Power Plant	1,730 MGD	Shoreline, open coast 12 miles south of Morro Bay	4 – 24%	Tenera 2000b
San Onofre Nuclear Generating Station	2,400 MGD	Offshore (6,000 to 8,000 ft) open coast south 10 miles south of San Clement	<1 – 13%	MRC 1989

*Larval loss estimates for HBGS were based on partial data sets and are currently under review.

Preliminary results from the 2004 six-month report submitted to the CEC (which is part of the ongoing HBGS intake entrainment and impingement study) indicate that the full HBGS operations may potentially reduce some source water fish populations by 1–3 percent. Sampling of the HBGS discharge water from which the HBDF feedwater would be withdrawn has shown that fewer than 6 percent of the organisms entrained by the generating station intake are alive after they pass through the generating station screening and condenser facilities. The potential increase in mortality due to entrainment, calculated for continuous full power operation, may be compensated for by increased survival of later larval and juvenile stages. The preliminary conclusion from the HBGS study (MBC and Tenera 2004) is that entrainment due to the generating station's cooling water system under full operation represents low potential risk to the target taxa populations; this was also the same as the conclusion from the previous 316(b) Demonstration (SCE 1983).

Based on similar *ETM* modeling of entrainment losses at 127 MGD, assuming 100 percent mortality through HBGS, and assuming that HBDF would cause 100 percent mortality of organisms in this flow during its operations, it was found that source water larval populations of the fishes modeled (gobies, northern anchovy and white croaker) would be reduced by no more than 0.33 percent. The *ETM* model estimates the proportion of the available larval supply in the source water that is eliminated by entrainment, but makes no assumptions as to the ultimate effects of such losses on the next generation of adult fishes.

Another approach to quantifying impacts produces an estimate of losses to adult fish populations based on the numbers of larvae lost to entrainment. The adult equivalent loss (*AEL*) model forecasts the numbers of adults that would have been produced by the quantity of entrained larvae after applying a series of mortality rates to the cohort from the time of entrainment to a mean reproductive age. The fecundity hindcasting (*FH*) modeling approach estimates the number of adult females whose reproductive output has been eliminated. Because the accuracy of estimated entrainment effects from these models depends on the accuracy of age-specific mortality and fecundity estimates; lack of these types of demographic information may limit the utility and accuracy of these approaches. The *AEL* and *FH* estimates often differ because of the variation in demographic parameters that are used, but they provide a context to evaluate absolute adult losses and, considered with the *ETM* estimates for each species, are used to evaluate potential impacts to the populations at risk.

The preliminary estimate of CIQ gobies lost due to HBGS entrainment during a 4-month time period based on a 507 MGD intake is 37,037 using the adult equivalent loss (*AEL*) modeling approach and 25,430 using the fecundity hindcasting (*FH*) modeling approach with assumed 100 percent entrainment mortality (MBC and Tenera 2004). Under a scenario in which HBGS is pumping 127 MGD, the estimate of CIQ gobies lost is between 5,100 and 7,400 adult gobies during the 4-month period modeled. The number of gobies is further reduced to approximately 305 and 444 gobies for the *FH* and *AEL* models, respectively considering the desalination facility's contribution of 1.2 percent of the total mortality (the difference between the percentage of entrained organisms alive before and after the point of HBDF feedwater withdrawal).

It should be noted that the RWQCB in issuing the present HBGS NPDES permit found the facility's cooling water intake's location, design and capacity represent best technology available (BTA). The Board's finding is based on a 316(b) assessment of the generating station's intake technology and estimated effects that demonstrated absence of potential for significant adverse impacts on source water populations of fish and shellfish. The RWQCB has upheld this finding every five years in the renewal of the generating station's NPDES permit, including the current NPDES permit.

Alternative Intake Systems

If a new 50 MGD seawater desalination facility with a separate new ocean intake was constructed next to the HBGS rather than co-located with it, the total intake of the two facilities would have been approximately 100 MGD higher than the proposed co-location approach. An additional 100 MGD of new source water would have been collected in the vicinity of the HBGS and all marine organisms in this water would have been subject to impingement and entrainment by the separate intake of the new desalination facility. Co-locating the new desalination facility with the HBGS eliminates the need for a separate desalination facility intake, and the associated additional impingement and entrainment of marine organisms. Implementing the co-location approach reduces the total amount of seawater collected from the ocean at this location.

On the other hand, beach wells, horizontal (Raney) collectors and seabed infiltration systems, which are alternative seawater intake systems, are not considered and recognized by EPA as BTA under 316(b). The large quantities of cooling water flows necessary for once-through cooled plants cannot be provided by these systems. Section 316(b) of the Clean Water Act requires that "the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." The U.S. EPA interprets Best Technology Available as "the best technology available commercially at an economically practicable cost." Determination of BTA includes the design, capacity, and location of the facility's cooling water intake, as well as cost considerations. The BTA determination is made on a case-by-case basis by assessing the relative biological value of reducing entrainment to the cost of the alternative.

Recent Information on Desalination Facility Siting Criteria

The State of California Desalination Task Force was established in 2003 in response to state legislation. A report of the Task Force's conclusions was delivered to the state legislature in October 2003 by the Department of Water Resources. Many papers regarding various issues were prepared based upon various public meeting and independent analysis by state agencies. Entrainment and impingement were analyzed in one of those papers[1], and certain conclusions are stated below:

> "It is important to note that in the case of co-locating a desalination plant with an existing power plant, there will be no additional entrainment and impingement impacts. A seawater reverse osmosis plant co-located with a generating station does not cause additional intake of feedwater, and therefore does not cause additional impact. It simply takes water from the return flow (heated after condenser cooling), harvests fresh water, then returns the remaining concentrate to the ocean after adequate mixing with the return cooling water flow. Co-located seawater RO plants with existing power plants would simply take advantage of an already regulated and permitted seawater intake to provide an additional water supply benefit." (Pages 11 and 12).

> "Though in the case of power plants water is used for cooling purposes, desalination feedwater intake is very similar. In fact, desalination plants require much lower water intake volumes, thus will have less significant impacts.

[1] Source: California Water Desalination Task Force: "Feedwater Intake Issue Paper Revised Draft" dated September 12, 2003.

Nevertheless, impacts from desalination intake structures should be carefully evaluated." (Page 3).

1.0 Introduction

Poseidon Resources Corporation proposes to build and operate the 50 MGD Huntington Beach Desalination Facility. The facility will be located adjacent to the AES Huntington Beach Generating Station (HBGS) on an 11-acre site currently occupied by generating station's unused fuel oil storage tanks. The proposed facility will convert a fraction of HBGS's condenser cooling seawater discharge into fresh drinking water using a reverse osmosis desalination process. Source water for this facility will be taken from the existing HBGS condenser cooling-seawater discharge pipeline system, which is permitted to circulate up to 507 MGD of seawater for cooling purposes. After the seawater passes through the HBGS's condensers, the desalination facility will intake approximately 100 MGD of HBGS's cooling water and produce 50 MGD of high-quality potable drinking water for use by residents and businesses in Orange County. The remaining 50 MGD becomes concentrated seawater, which will re-enter the HBGS condenser cooling water discharge system downstream of the desalination facility's intake point and blend with up to 407 MGD of HBGS's condenser cooling circulation system flow for dilution prior to discharge back into the Pacific Ocean.

As discussed, the desalination facility will withdraw its feedwater from the generating station's existing condenser cooling water discharge pipe system through a direct connection into the HBGS discharge lines. Since the desalination facility will reuse the generating station's cooling water discharge after its permitted use, the desalination facility will not require a new seawater intake or any additional seawater directly from the ocean. In addition, the HBGS cooling water intake system (CWIS) also protects the desalination facility's intake against impingement losses.

1.1 Regulatory Setting

Growing public awareness and concern for controlling water pollution led to enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law became commonly known as the Clean Water Act (CWA). The CWA established the basic structure for regulating discharges of pollutants into the waters of the U.S. It gave EPA the authority to implement pollution control programs such as setting wastewater standards for industry. The CWA also continued requirements to set water quality standards for all contaminants in surface waters. The CWA made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions.

When water is withdrawn from a source water body for industrial purposes, organisms within the water body may be entrained or impinged. Water intake systems can affect source water populations by uncompensated removal of larvae that are entrained in cooling water flows and removal of larger life stages that are impinged on the intake screens. The CWA addresses this area of potential effects on water bodies under the Section 316(b) rules by the regulation of large industrial facilities and power generation facilities that withdraw more than 50 MGD of water.

Section 316(b) is a technology-based regulation that requires intake systems to apply Best Technology Available (BTA) to reduce and minimize the effects of the intake and to mitigate potential entrainment and impingement impacts. Although the intent of Section 316(b) regulation is described briefly in the CWA, the implementation of Section 316(b) has been greatly expanded upon in EPA development documents and by various administrative and judicial rulings over the years. In addition, under the Section 316(b) rule, large industrial facilities and power generating facilities require a National Pollution Discharge Elimination System (NPDES) permit approved in California by the State Water Resources Control Board.

The intake designs of California's coastal- and bay-sited generating stations, summarized in **Table 1-1**, all employ vertical traveling screens fitted with 3/8-inch stainless steel mesh screens to prevent the entrainment of organisms larger than this size through the plant's seawater cooling system. This 3/8 inch size mesh is also recognized by EPA as baseline design standard, which represents BTA.

The 3/8 inch size mesh has been determined by many years of practical experience to be a size that screens out organisms large enough to survive removal and return to their source and at the same time allow the smaller organisms with a good probability of surviving entrainment to pass through the generating station without damage from impingement.

The HBGS is subject to regulations of the Clean Water Act, including the requirements of Section 316(b) because it withdraws more than 50 MGD. The HBGS circulates water withdrawn from the Pacific Ocean in a single pass through the generating station's cooling water system where freshwater steam used in power production is condensed back to recyclable boiler water. Because the quantity of cooling water withdrawn exceeds 50 MGD, the generating station cooling water system's intake design, location, and capacity require an NPDES permit approved by the Santa Ana Regional Water Quality Board under Section 316(b) of the CWA.

As found at the HBGS, the cooling water intake system employs vertical traveling screens fitted with 3/8-inch stainless steel mesh screens to prevent the entrainment of organisms larger than this size through the generating station's seawater cooling system. A 316(b) assessment of the generating station's intake technology and estimated effects on its source water resources demonstrated that the generating facility's intake design, location, and capacity had no significant effects and represented best technology available for minimizing adverse intake effects (SCE 1983). The RWQCB has upheld this finding in their renewal every five years of the generating station's NPDES permit, including its current NPDES permit.

Table 1-1. Summary of cooling water intake structure design at California coastal- and bay-sited generating stations. All screens have 3/8-inch mesh dimension.

Power Facility	Intake Location	Intake Technology
Humboldt Bay Power Plant	Shoreline, Humboldt Bay	Vertical traveling screens
Pittsburg Power Plant	Shoreline, San Francisco Bay Estuary, Suisun Bay	Vertical traveling screens
Contra Costa Power Plant	Shoreline, San Francisco Bay Estuary, San Joaquin River	Vertical traveling screens
Potrero Power Plant	Shoreline, San Francisco Bay	Vertical traveling screens
Hunter's Point Power Plant	Shoreline, San Francisco Bay	Vertical traveling screens
Moss Landing Power Plant	Shoreline, Moss Landing Harbor	Inclined traveling screens
Morro Bay Power Plant	Shoreline, Morro Bay Estuary	Vertical traveling screens
Diablo Canyon Power Plant	Shoreline, Pacific Ocean	Vertical traveling screens
Mandalay Generating Station	Shoreline, Pacific Ocean	Vertical traveling screens
Ormond Beach Generating Station	Offshore, Pacific Ocean	Velocity cap and vertical traveling screens
Scattergood Generating Station	Offshore, Pacific Ocean, Southern Bight	Velocity cap and vertical traveling screens
Redondo Beach Generating Station	Offshore, Pacific Ocean, Southern Bight	Velocity cap and vertical traveling screens
Haynes Generating Station	Shoreline, Pacific Ocean, Southern Bight	Vertical traveling screens
Alamitos Generating Station	Shoreline, Pacific Ocean, Southern Bight	Vertical traveling screens
Huntington Beach Generating Station	Offshore, Pacific Ocean, Southern Bight	Velocity cap and vertical traveling screens
San Onofre Nuclear Generating Station	Offshore, Pacific Ocean, Southern Bight	Velocity cap, vertical traveling screens, fish guidance and return system
Encina Generating Station	Shoreline, Pacific Ocean	Vertical traveling screens with bar rack
South Bay Power Plant	Shoreline, South San Diego Bay	Vertical traveling screens with bar rack

The HBGS cooling water intake is subject to the Clean Water Act Section 316(b) Phase II Rule published July 9, 2004.[2] A number of entities have filed suit against the Phase II rule (July 2004), and the U.S. Court of Appeals has decided to consolidate the various lawsuits to be heard before the Ninth Circuit possibly as early as November or December 2004. It is anticipated that RWQCB will provide AES a period of time to comply with any new rule.

Two separate and unrelated entrainment studies are being conducted at the HBGS plant site. A long-term study, in connection with a re-powering project certified by the California Energy

Commission (CEC), is underway to study entrainment effects of the HBGS's cooling water intake system (CWIS). The CEC required AES to perform a study of the power plant's CWIS as a condition of re-powering certification. The CEC entrainment study is not a 316(b) study, but was designed using the same sampling methodologies and data analyses employed in several recently completed 316(b) studies (Tenera 2000 a, b, 2001). The second, but unrelated entrainment study at the site is the Huntington Beach desalination feedwater intake study reported herein. The HBDF intake study, which is also not a 316(b) study as none is required for the HBDF intake, is designed to investigate the potential for desalination facility feedwater intake withdrawn from HBGS discharge flows to increase HBGS entrainment mortality and assess the significance of this potential entrainment effect on the source water. The study was designed to provide information for the Project's EIR submittal to the City of Huntington Beach and other interested parties. Data from both of the studies will be treated the same in mathematical models that assumed 100 percent mortality as recommended by EPA in 316(b) Phase II (see Appendix A for summary of Six-Month Data Report). In other words, Tenera's entrainment and larval mortality studies for HBDF estimate the potential for the desalination facility to increase whatever entrainment effects might be demonstrated in the CEC-required studies of the HBGS's CWIS and asses the significance of this potential entrainment effect on the source water.

1.2 Proposed Huntington Beach Desalination Facility

Feedwater for HBDF will come directly from the cooling water discharge flow of the HBGS. The proposed desalination facility's withdrawal of feedwater from the HBGS cooling water discharge is not subject to 316(b) rules since the cooling water has already served its regulated purpose and:

- HBDF does not directly withdraw seawater from the ocean (HBGS withdraws the seawater with its intake pumps);
- HBDF withdraws the water on the discharge side once the cooling water has served its regulated purpose;
- HBDF water needs do not change the HBGS seawater pumping requirements; and
- HBDF does not require the HBGS to increase the quantity of water withdrawn or the velocity of the water withdrawn

1.3 Purpose of the Study

This Intake Effect Assessment study plan is designed to address the following specific questions:

1. Will the desalination facility operations contribute to the impingement (organisms trapped on the intake screening systems) effect of the generating station intake?

2. What are the composition and abundance of species that could be entrained through the HBGS cooling water intake system and what proportion of these organisms would be susceptible to further entrainment by the HBDF feedwater intake?

3. How might any losses due to feedwater entrainment affect the source populations of the entrained species in the Southern California Bight?

4. Are these losses ecologically or economically significant?

1.4 Report Organization

This report describes the HBDF intake system and assesses the potential entrainment effects of the HBDF intake on source water resources through an assessment of the HBGS intake's entrainment effects. Section 2.0 provides a description of the project and Section 3.0 describes the environmental setting. Section 4.0 presents the results of the source water and entrainment studies and the analysis of entrainment impact follows in Section 5.0. Impingement impacts are discussed in Section 6.0 and the literature cited in the report is listed in Section 7.0. Appendix A provides a summary of six-month data report for the AES HBGS entrainment and impingement study. Appendix B provides survey counts and mean concentrations presented by lowest possible taxonomic identification.

2.0 Project Description

The Huntington Beach Desalination Facility will be a reverse osmosis seawater treatment facility, which will be located adjacent to the Huntington Beach Generating Station on an 11-acre site currently occupied by unused fuel oil storage tanks. The proposed facility will convert a fraction of HBGS's condenser cooling seawater discharge into fresh drinking water using a reverse osmosis desalination process. Source water for this facility will be taken from the existing HBGS condenser cooling-seawater discharge pipeline system, which is permitted to circulate up to 507 MGD of seawater for cooling purposes. After the seawater passes through the HBGS's condensers, the desalination facility will intake approximately 100 MGD of HBGS's cooling water and produce 50 MGD of high-quality potable drinking water for use by residents and businesses in Orange County. The remaining 50 MGD becomes concentrated seawater, which will re-enter the HBGS condenser cooling water discharge system downstream of the desalination facility's intake point and blend with up to 407 MGD of HBGS's condenser cooling circulation system flow for dilution prior to discharge back into the Pacific Ocean. In order to describe how the HBDF operates, we first provide a background on HBGS operations below.

2.1 Description of Huntington Beach Generating Station Operations

The existing HBGS consists of four generating units (Units 1-4). Each unit is equipped with two condensers. Units 1 and 2 are each rated at 215 net megawatts (MW) and Units 3 and 4 are each rated at 225 MW. HBGS has a total nominal generating capacity of 880 MW. The station uses a once-through cooling system with an offshore intake. Cooling water is supplied to the generating station from the ocean through an intake structure located 1,840 ft offshore (surveyed February 2004 by Tenera). The generating station's offshore seawater intake structure consists of a vertical riser with a horizontal velocity cap supported five feet above the opening to the cooling water conduit. The entire structure rises about 15.8 ft above the ocean floor where the total water depth is 34.1 ft. The intake collects seawater at a mean velocity of 2 feet per second and conveys the flow through a 14-ft diameter conduit to the HBGS intake structure located on the HBGS property. Cooling water flow varies between 127 MGD and 507 MGD depending on the number of pumps that are in operation. The HBGS intake structure consists of an open forebay from which the seawater flows through two trash racks, each constructed of vertical steel bars with 3-inch openings between the bars. Downstream of the trash racks, the water flows through four vertical traveling screens with 3/8-inch mesh screening. The screened seawater is then conveyed through a 14-ft x 11-ft rectangular conduit into the generating station cooling water pump well structure. The condensers are supplied with cold seawater by eight cooling water pumps (two for each generating unit). Each of the six cooling water pumps for Units 1, 2, and 4 are rated at 44,000 gpm (63.4 MGD), and the remaining two pumps (Unit 3) are each rated at 46,300 gpm (66.7 MGD). The cooling water pumps convey the screened seawater through thousands of 7/8-inch diameter tubes that make up the generating station's condensers. Steam exiting the station's turbines passes over the outer surfaces of the condenser tubes and is condensed back to a liquid state to be pumped back to the boilers. During this process heat is transferred to the seawater and its temperature is raised, on average, by 18°F (10°C). During normal operating conditions, the maximum temperature increase specified in the generating station's NPDES permit is 30°F (16.5°C).

After passing through the condensers, the warmed seawater (cooling water) is returned to the discharge well located at the HBGS intake structure via two 9-ft diameter discharge pipelines. From the discharge well, the cooling water flow is conveyed back to the ocean via a single 1,500-ft long, 14-ft diameter conduit, then through a discharge structure identical to the intake structure except for the absence of a velocity cap. Instead, the discharge vertical riser structure is capped with a 12-inch by 18-inch mesh screen constructed from a 1 inch by 3 inch flat bar.

The HBGS has been in operation since 1958. All four generating units were on-line until 1995. At that time Units 3 & 4 were taken off-line. In 2002, Unit 3 was retooled and brought back on-line and in 2003, Unit 4 was retooled and brought back on-line. The HBGS facility flow rate from the period 1979 through 2002, prior to retooling, has averaged 234 MGD, with a low flow of 127 MGD. From 2002 to July 2003, during retooling the average flow rate has increased to 265 MGD, and as before does not go below 127 MGD except for maintenance turndown. HBGS pumps have been in operation approximately 98.8 percent of the time. Like all large facilities there are scheduled outages so that maintenance needs can be performed on the system.

2.2 Interaction Between the Desalination Facility and the HBGS Operations

Source water for the desalination facility will be taken from the existing condenser cooling water discharge pipe system of the HBGS. The intake for the seawater desalination facility will only be connected to the HBGS's 108-inch cooling water discharge lines and will only collect seawater that has already been screened and pumped through the generating station. The desalination facility will not have a separate intake that would collect seawater directly from the ocean.

At any time, and under any mode of generating station operation, the desalination facility will collect approximately 100 MGD of seawater from the HBGS cooling water discharge lines. The desalination facility will be operated at 50 MGD of potable water production capacity 24 hours per day and 365 days per year. This mode is not expected to change unless a heat treatment operation is being conducted or there is an unpredicted outage.

Currently, the HBGS is permitted to operate at full capacity and to use up to 507 MGD of seawater for cooling purposes 24 hours per day and 365 days per year. The operation of the desalination facility will not result in any changes to the station's operational schedule or its maximum intake flow rate.

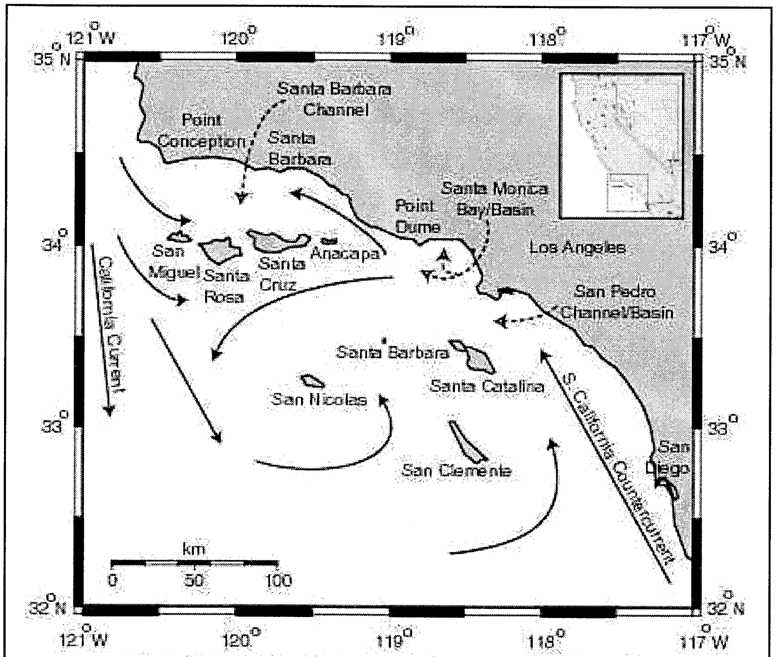
The sidestream flows of the desalination facility operations will be returned to the generating station discharge line downstream of the desalination facility's intake and include: 1) the pretreatment filter backwash water and 2) the concentrate from the desalination facility RO system. The desalination facility 50 MGD discharge stream will re-enter the HBGS condenser cooling water discharge system downstream of the desalination facility's intake point and blend with up to 407 MGD of HBGS' condenser cooling circulation system flow for dilution prior to discharge back into the Pacific Ocean.

3.0 Project Environmental Setting

The marine setting for Huntington Beach Desalination Facility (HBDF) is part of a larger oceanographic unit known as the Southern California Bight. The Southern California Bight comprises the offshore area reaching from Point Conception to the north and below the California/Mexican border to the south and extending outward from the shore to a distance where the ocean depth is approximately 200 fathoms (and inshore of the Santa Rosa Ridge). Although geographically identified by these boundaries, it is a region that is more accurately defined by its patterns of ocean currents, temperatures, and climatic setting. It is a dynamic oceanographic region where the area's populations of fishes and other marine organisms undoubtedly fluctuated in response to environmental alterations such as El Niño events.

3.1 Source Water Characterization

There are three dominant currents in the Southern California Bight: the California Current, the Coastal Countercurrent, and the California Undercurrent. The California Current and its Coastal Countercurrent bring cold, low salinity, highly oxygenated sub-arctic water into the Bight. Water advected from the west into the Bight warms when it mixes with the highly saline, low oxygen content of the equatorial California Undercurrent from the south. The top 200 m of the Bight's water mass is principally sub-arctic with low salinity and high oxygen, even though temperatures range between 9–18°C. The deeper water mass (below 300 m) from the California Undercurrent is consistently higher in salinity and lower in dissolved oxygen, with temperatures between 9–5°C.



After Hickey, B. M., 1992, Progress in Oceanography, V30: 37-115.

3.1.1 California Bight

The circulation of the Bight is dominated by the California Current rather than by local wind forcing. The California Current extends offshore a distance of about 400 km and to a depth of 300 m. The average current speed is approximately 0.25 m/sec and circulation occurs primarily during spring and summer. When the nearshore portion of this surface current periodically flows poleward, it becomes the Coastal Countercurrent. The Davidson Current or California Undercurrent also flows poleward and is characterized by being warmer, saltier, and having low oxygen and high phosphate. Although this northerly countercurrent exists throughout the year at depths of 200–300 m, along the continental slope it is strongest during the fall and winter months and occurs within 50 km of the coast. The appearance of this current in the late summer and fall brings warm, saline, low dissolved oxygen water to Bight nearshore habitat and beaches. Bottom contours and submarine topography also influence the movement and mixing of water masses in the Bight, resulting in a complete turnover every 1–3 months.

El Niño events produce striking changes in the Bight's oceanographic conditions. They affect both physical factors (e.g., ocean temperatures) and indices of biological productivity (e.g., zooplankton densities). The El Niño events' alteration of regional currents and upwelling interrupt the supply of nutrients and the productivity of kelp forests and zooplankton populations that in turn support populations of fishes and shellfishes.

The adults of larger fishes and other marine vertebrates are somewhat buffered from the effects of weather and other short-term physical fluctuations, and extremely long-lived organisms, such as many of the deep benthic fishes, may have populations that are nearly independent of normal short-term environmental fluctuations. Many of California's marine fishes have life history adaptations such as extended spawning seasons, multiple spawnings, migrations, and extreme longevity that reduce the harmful effects of short-term adverse environmental fluctuations and even limit the effects of El Niño events at the population level.

3.2 Source Water Fisheries Resources

The Southern California Bight and Santa Maria Basin (see map in Section 3.1) account for nearly 60 percent of California's recreational fisheries landings and about 5 percent of the total recreational landings in the continental United States (MMS 2001). As reported by California Department of Fish and Game (CDFG), the recreational fishery annual landing of rockfish from 1983–1989 averaged 2,008 metric ton (mt) (4,427,640 lb) compared to a commercial fishery average harvest of only 280 mt (617,400 lb). More recently, from 1993–1999, the average annual recreational landings declined to 806 mt (1,777,230 lb), while in the same period the commercial landings increased to an annual average of 431 mt (950,355 lb).

The majority of recreational fishing activity occurs in areas close to shore. Near-shore finfish were taken by angling or spear fishing from charter/party vessels, private/rental boats, beaches, (banks), and man-made structures such as piers and jetties. Commercial fishing activities generally occur further offshore.

California ranks among the top five seafood-producing states in the nation. The commercial landings at ports within southern and central California account for about 4 percent of the total U.S. catch. Los Angeles area ports rank among the top 10 ports in the U.S. in quantity and value of commercial catch (MMS 2001). The primary commercial fishing gears used in harvesting the 19 nearshore finfish species are hook-and-line and trap. Gill and trammel nets and trawls targeting other species occasionally take nearshore species in areas outside State waters. Landings have escalated from 23,586 to 448,149 kg (52,000 to 988,000 lb) from 1989–1995, with the number of fishers (live-fish fishers) statewide increased from 70 to nearly 700 during the same period (MMS 2001). Presently, there are 1,014 nearshore and finfish trap permittees in California, with an estimated total fleet harvest capacity of more than 2,400 tons (or roughly 24 times the current harvest allocation for 2001).

Trawlers fishing the Southern California Bight waters landed over 4 million lb of rockfish (principally bocaccio and chilipepper rockfish) in response to a developing market for live and high-quality fresh fish. Fish buyers and consumers are willing to pay high prices for live and high-quality fresh fish products; $0.50/lb in 1989 for cabezon compared to $3.80/lb in 1999. This has markedly changed the revenue potential for this fishery over the last 10 or 12 years, as shown in **Table 3-1**. These findings and fisheries values are used to assess the fisheries value of any potential HBDF entrainment losses.

Table 3-1. Commercial nearshore finfish landings and value by year for nineteen nearshore finfish species and all commercial gear types (excluding trawl).

Year	Pounds landed	Value ($)	Value/Pound
1989	6,499,439	3,925,761	0.60
1990	7,563,254	4,735,678	0.63
1991	7,504,582	5,103,869	0.68
1992	6,704,447	5,002,397	0.75
1993	5,179,340	4,626,544	0.89
1994	1,595,987	1,833,840	1.15
1995	2,890,186	4,200,306	1.45
1996	2,740,887	4,411,758	1.61
1997	2,565,162	4,263,103	1.66
1998	2,346,037	4,405,981	1.88
1999	1,341,257	3,721,838	2.77

Source: CDFG 2002.

CDFG divides the nearshore commercial finfish fishery landings among nine major ports (**Table 3-2**). The ports with the highest average value for nearshore species landed in 1989–1999 were Morro Bay and Santa Barbara, with 23 and 24 percent, respectively, of the average total value. The maximum amount in pounds landed by nearshore fishermen at each port indicates the fishing potential or harvest capacity of the fleet. As shown in **Table 3-2**, the maximum pounds landed in each port for 1989–1999, are two to three-times the average pounds landed for each respective port.

Table 3-2. Average commercial landings, pounds, and value for nearshore finfish species over years 1989–1999 for all gears except trawl.

Port area	Average pounds	Average value ($)	Maximum pounds	Maximum value ($)	Average price/pound ($)
Eureka	532,033	307,324	1,265,270	630,733	0.58
Fort Bragg	734,402	606,060	1,840,338	1,255,252	0.83
Bodega Bay	232,582	189,761	457,413	346,121	0.82
San Francisco	311,855	345,948	696,561	753,339	1.11
Monterey	326,730	306,767	818,007	761,975	0.94
Morro Bay	649,702	1,057,894	1,305,903	2,122,196	1.63
Santa Barbara	511,007	1,077,989	999,544	2,140,046	2.11
Los Angeles	202,665	393,549	582,945	1,014,974	1.94
San Diego	127,442	212,469	345,815	520,265	1.67
Totals	**3,628,421**	**$4,497,761**	**8,311,796**	**$9,544,900**	

Source: CDFG 2002.

Fish habitat in the area of Huntington Beach is primary shallow sand and silt bottom, for the most part lacking the kelp beds that harbor fishes targeted by both recreational and commercial nearshore fisheries. Giant kelp, which comprises the bulk of the kelp beds in southern California, is unable to grow and remain attached to the soft bottom substrates characteristic of the areas offshore of Huntington Beach.

4.0 Entrainment Results

4.1 Introduction

The purpose of this study was to evaluate the potential impacts of the HBDF feedwater intake system that will withdraw approximately 100 MGD from the HBGS cooling discharge flow. Although this study is not required by rule or regulation, it was undertaken in consideration of the project's co-location with the HBGS. The HBGS is required under Section 316(b) of the Federal Clean Water Act (USEPA 2004) to assess the potential entrainment and impingement effects of the generating station intake.

The HBDF feedwater entrainment study focuses on early life stages of fishes, sand crabs, *Cancer* spp. crabs, squid, ridgeback prawn, and California spiny lobster found in the HBGS cooling water discharge after they have already been entrained by the generating station intake and have passed through the 3/8-inch traveling intake screens and the 7/8-inch condenser tubes of the generating station. The scope, approach, sample collection procedures, sampling equipment, and analysis used for this study are consistent with those typically implemented for assessment of the entrainment effects of generating stations as per the 316 (b) regulations.

The entrainment study was designed to specifically address the following questions:

- What are the species composition and abundance of the larval fishes, sand crabs, *Cancer* spp. crabs, squid, ridgeback prawn, and spiny lobster in the HBGS cooling water discharge flow that could be entrained through the HBDF feedwater intake?
- How might any losses due to HBDF feedwater entrainment affect the source populations of the entrained species in the Southern California Bight?
- Are these losses significant?

4.2 Sample Collection

Ten surveys were conducted every other week from the discharge vault of the generating station from March 8–July 22, 2004. Plankton samples were collected by pumping discharge cooling water from the generating station through 4-inch diameter piping, a calibrated flow meter, and a recessed impeller pump. During the first three surveys the water was pumped into a tank containing a 335-micron mesh net. The pump was operated so that approximately 1.0 m^3 of water was filtered per minute through the plankton net. All material was rinsed from the net and preserved in a labeled jar. Beginning with Survey 4, and in all subsequent surveys, the pumped water was diverted into either a tank with a net or into a larval table that was designed to allow the collection of the larvae in a low-flow system to minimize potential damage from abrasion. The water was pumped into the larval table for approximately 15 minutes and was then diverted into the tank for the next 30 minute period. During the 30-minute period, the water in the larval table was drained and all material was removed from the table and sorted to remove larvae before preservation. All larvae that were alive in the material collected from the table were placed into numbered collection chambers in an aquarium to track their condition for a period of up to two hours after collection. All samples from both the tank and the larval table were returned to the laboratory where the organisms were identified to the lowest taxonomic level practicable. The total number of larvae collected was used to determine composition and abundance of taxa present in the samples.

It should be noted that the spring and summer months represent the period of greatest larval abundance for many fishes and therefore any annual mean abundances calculated from our spring-summer data would be overestimates. During the rest of the year, the larval abundance is expected to be significantly lower. The species composition occurring in the source water area is not expected to change substantially through the year.

4.3 Sample Results

Six taxa and a group of larvae that could not be identified were found to comprise 97 percent of all of the fish larvae present in the HBGS discharge flows from which the proposed HBDF would withdraw its feedwater supply (**Table 4-1**). They were CIQ gobies, blennies, croakers, northern anchovy, garibaldi, unidentified fish larvae, and silversides. These were the same fishes found to be common in a parallel study of HBGS entrainment effects. Species with high commercial and recreational importance, such as California halibut and rockfishes, were shown to be very uncommon in the HBGS intake flows.

Table 4-1 shows the number and mean survey concentration (number/1,000 m^3) by taxa or species of all fish larvae collected during the first 10 surveys, which were conducted from March 8 through July 22, 2004. Species composition and individual taxa abundance varied between surveys. The mean survey concentration of all fish larvae entrained from the HBGS discharge was lowest (11.4/1,000 m^3) during the May 25, 2004 survey and highest (995.6/1,000 m^3) during the July 7, 2004 survey (**Table 4-1**).

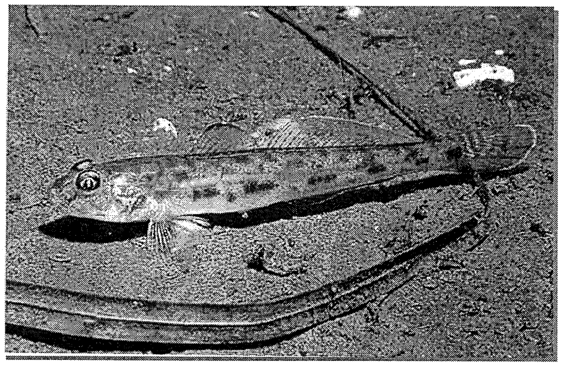
The following sections present the life history information and survey results for four target larval fish taxa: CIQ gobies, northern anchovy, silversides, and croakers. (Detailed life history information is presented for white croaker, a commercially and recreationally important croaker species.) Jacksmelt and topsmelt data were combined with the data for unidentified silversides, and all croaker data were also combined. The survey results therefore were analyzed for these fish families rather than for the individual species within each family.

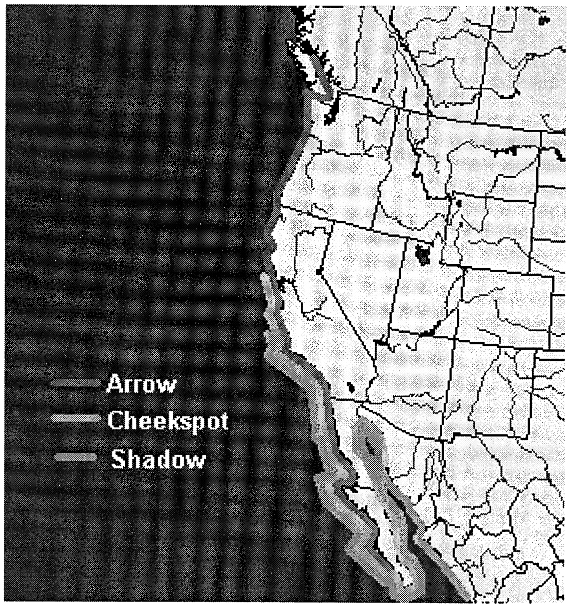
Table 4-1. Count and mean survey concentration (#/1,000 m^3) of larval fishes and target invertebrates collected from HBGS's in-plant discharge flow from March 8 through July 22, 2004.

						Survey -->	PRHBE001		PRHBS002		PRHBS003		PRHBS004		PRHBS005		PRHBS006		PRHBS007		PRHBS008		PRHBS009		PRHBS010	
						Start Date -->	03/08/04		03/22/04		04/05/04		04/27/04		05/11/04		05/25/04		06/10/04		06/22/04		07/07/04		07/22/04	
						Sample Count -->	N = 3		N = 35		N = 14		N = 18		N = 25		N = 21		N = 24		N = 17		N = 22		N = 24	
	Taxon	Common Name	Avg. Conc.	Total Count	Percent Comp.	Cum. Percent	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.
	Fishes																									
1	CIQ goby complex [a]	CIQ gobies	60.8	195	21.3%	21.3%	42	152.0	11	14.0	3	11.9	5	10.8	4	8.3	3	3.9	42	80.3	37	177.4	33	108.1	15	41.2
2	*Hypsoblennius spp.* [b]	blennies	59.5	156	17.0%	38.4%	-	-	-	-	-	-	1	3.7	-	-	-	-	39	81.3	25	106.9	63	320.8	28	82.3
3	*Sciaenidae complex* [c]	croaker complex	54.2	190	20.8%	59.1%	3	9.0	8	9.3	1	3.2	-	-	-	-	-	-	14	37.3	9	40.9	142	405.0	13	37.1
4	*Engraulis mordax*	northern anchovy	42.3	136	14.9%	74.0%	11	36.8	12	17.8	-	-	5	14.9	1	3.1	3	5.9	15	28.8	47	220.8	41	91.7	1	3.0
5	*Hypsypops rubicundus*	garibaldi	37.4	130	14.2%	88.2%	-	-	-	-	-	-	-	-	-	-	-	-	90	190.2	22	139.7	11	32.5	7	11.9
6	larval fish unid & fragments	unid larval fishes & fragments	14.3	47	5.1%	93.3%	3	10.8	1	1.2	1	7.9	1	2.5	-	-	-	-	10	24.4	9	49.9	15	22.6	7	23.7
7	Atherinopsidae complex [d]	silverside complex	9.0	34	3.7%	97.0%	7	26.4	9	9.7	14	45.1	3	7.5	-	-	1	1.6	-	-	-	-	-	-	-	-
8	*Syngnathus* spp.	pipefishes	1.8	4	0.4%	97.5%	-	-	-	-	-	-	3	10.8	-	-	-	-	-	-	1	7.4	-	-	-	-
9	Labrisomidae unid.	labrisomid kelpfishes	1.6	6	0.7%	98.1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	9.6	2	6.1
10	*Oxylebius pictus*	painted greenling	1.2	6	0.7%	98.8%	2	6.0	2	1.7	1	3.0	-	-	1	1.7	-	-	-	-	-	-	-	-	-	-
11	*Hypsopsetta guttulata*	diamond turbot	1.2	4	0.4%	99.2%	2	7.9	1	1.1	-	-	1	2.5	-	-	-	-	-	-	-	-	-	-	-	-
12	*Paralichthys californicus*	California halibut	0.5	3	0.3%	99.6%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	5.4	-	-
13	Cottidae unid.	sculpins	0.3	1	0.1%	99.7%	-	-	-	-	1	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	*Sebastes* spp.	rockfishes	0.3	1	0.1%	99.8%	-	-	1	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	*Gillichthys mirabilis*	longjaw mudsucker	0.2	1	0.1%	99.9%	-	-	-	-	1	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	Clinidae unid.	clinid kelpfishes	0.1	1	0.1%	100.0%	-	-	-	-	-	-	-	-	-	-	-	-	1	1.4	-	-	-	-	-	-
			284.7	**915**			**70**	**248.9**	**45**	**57.5**	**22**	**75.8**	**19**	**52.7**	**6**	**13.2**	**7**	**11.4**	**211**	**443.7**	**150**	**742.9**	**312**	**995.6**	**73**	**205.1**
	Target Invertebrates																									
1	*Emerita analoga*	mole crabs - zoea	535.7	180			Laboratory process of invertebrates for surveys 1–8 is not complete.																168	492.9	12	42.8
2	*Cancer anthonyi*	yellow crab - megalopae	6.4	2																			-	-	2	6.4
3	*Cancer antennarius*	brown rock crab - megalopae	1.2	1																			1	1.2	-	-
			543.3	**183**																						

[a] consists of 171 unidentified CIQ gobies, 15 arrow goby, and 9 cheekspot goby.
[b] consists of 155 *Hypsoblennius* spp. and 1 Blennioidei.
[c] consists of 98 queenfish, 43 unidentified Sciaenidae, 31 spotfin croaker, 13 white croaker, 3 California corbina, and 2 black croaker.
[d] consists of 25 unidentified Atherinopsidae, 8 jacksmelt, and 1 topsmelt.

4.3.1 CIQ Goby Complex (*Clevelandia ios, Ilypnus gilberti, Quietula y-cauda*)





Distribution map for CIQ gobies.

Range: Vancouver Island, British Columbia to Gulf of California;

Life History: Size up to 50 mm (2 in);
Age at maturity from 0.7–1.5 yr;
Life span ranges from <3 yr (arrow goby) to 5 yr (shadow goby);
Spawns year-round in bays and estuaries; demersal, adhesive eggs with fecundity from 225–1,400 eggs per female with multiple spawning 2–5 per yr;
Juveniles from 14.0–29.0 mm are less than 1 yr old;

Habitat: Mud and sand substrates of bays and estuaries; commensally in burrows of shrimps and other invertebrates.

Fishery: None.

4.3.1.1 Life History

Gobies belong to a speciose family (Gobiidae) of small, demersal fishes that are found worldwide in shallow tropical and subtropical environments. The family contains approximately 1,875 species in 212 genera (Nelson 1994, Moser et al. 1996). Twenty-one goby species from 16 genera occur from the northern California border to south of Baja California (Moser et al. 1996) and six species were found in San Diego Bay during a five-year study (Allen 1999).

Members of the goby family share a variety of distinguishing characteristics. Their body shape is elongate and can be either somewhat compressed or depressed (Moser et al. 1996). Most members of the family lack both a lateral line and swim bladder (Moyle and Cech 1988). Gobies generally have two dorsal fins, the first consisting of 2–8 flexible spines and the second containing a spine and several segmented rays. Their caudal fin is rounded and their pelvic fins are typically joined to form a cup-like disc (Moser et al. 1996). The eyes of most gobies are relatively large and are a dominant feature of their blunt heads. Goby species are extremely variable in coloration. They range from the drab, cryptically colored species that inhabit mudflats to the striking, brightly colored species of tropical and subtropical reefs (Moser et al. 1996).

One of the most important characteristics of the goby family is their small size (1 to 3 inches). Due to their size and evolved tolerances for a variety of environmental conditions, gobies have been able to colonize habitats that are inaccessible to most other fishes. These include cracks and crevices in coral reefs, invertebrate burrows, mudflats, mangrove swamps, freshwater streams on oceanic islands, and inland seas and estuaries (Moyle and Cech 1988).

Three species of goby make up the CIQ complex: arrow goby *Clevelandia ios,* cheekspot goby *Ilypnus gilberti,* and shadow goby *Quietula y-cauda* (for *Clevelandia*, *Ilypnus* and *Quietula*). Arrow goby occupy the most northerly range of the three species, occurring from Vancouver Island, British Columbia to Baja California (Eschmeyer et al. 1983). The reported northern range limits of both shadow goby and cheekspot goby are in central California with sub-tropical southern ranges that extend well into the Gulf of California (Robertson and Allen 2002). Their physiological tolerances reflect their geographic distributions with arrow goby being less able to withstand warmer temperatures compared to cheekspot goby. When exposed to temperatures of 32.1°C for three days in a laboratory experiment, no arrow goby survived but 95 percent of cheekspot goby survived (Brothers 1975). Gobies exposed to warm temperatures on mudflats can seek refuge in their burrows where temperatures can be several degrees cooler than surface temperatures.

All three species have overlapping ranges in the HBGS area and occupy similar habitats. Arrow goby is generally the most abundant of the three species in San Diego Bay (juveniles and adults), followed by cheekspot and shadow gobies (Allen 1999). The life history of the arrow goby was reviewed by Emmett et al. (1991) and the comparative ecology and behavior of all three species were studied by Brothers (1975) in Mission Bay, approximately 6 km (3.7 mi) north of San Diego Bay. Arrow goby is the most abundant of the three species in bays and estuaries from Tomales Bay to San Diego Bay, including Elkhorn Slough (Calliet et al. 1977), Anaheim Bay (MacDonald 1975) and Newport Bay (Allen 1982). The species inhabits burrows of ghost shrimps *Neotrypnea* spp. and other burrowing invertebrates. In a 5-year study of fishes in San Diego Bay, approximately 75 percent of the estimated 4.5 million (standing stock) gobies were juveniles (Allen et al. 2002).

Myomere counts, gut proportions, and pigmentation characteristics can be used to identify most fish larvae to the species level. However, the arrow, cheekspot, and shadow gobies cannot be differentiated with complete confidence at most larval stages (Moser et al. 1996). Therefore, larval gobies collected during this sampling that could not be identified to the species level were grouped into the 'CIQ' goby complex or the family level 'Gobiidae' if specimens were damaged but could still be recognized as gobiids. Some larger larval specimens with well-preserved pigmentation patterns could be identified to the species level (W. Watson, Southwest Fisheries Science Center, pers. comm.) but those that were speciated in this study were subsequently combined into the CIQ complex for analysis.

The reproductive biology is similar among the three species in the CIQ complex. Arrow goby typically mature sooner than the other two species, attaining 50 percent maturity in the population after approximately 8 months as compared to 16–18 months for cheekspot and shadow gobies. Mature females for all three of these species are oviparous and produce demersal eggs that are elliptical in shape, typically adhesive, and attached to a nest substratum at one end (Matarese et al. 1989, Moser et al. 1996). Hatched larvae are planktonic and the duration of the planktonic stage was estimated at 60 days for populations in Mission Bay (Brothers 1975). Arrow goby mature more quickly and spawn a greater number of eggs at a younger age than either the cheekspot or shadow gobies. Fecundity is dependent on age and size of the female. For the Mission Bay populations of gobies Brothers (1975) measured fecundity ranged from 225–750 eggs per batch for arrow gobies (depending on adult size), 225–1,030 eggs for cheekspot, and 340–1,400 for shadow, for a mean value of 615 per batch for the CIQ complex. Mature females for the CIQ complex deposit 2–5 batches of eggs per year.

CIQ complex larvae hatch at a size of 2–3 mm (Moser et al. 1996). Data from Brothers (1975) were used to estimate an average growth rate of 0.16 mm/day for the approximately 60 day period from hatching to settlement. Brothers (1975) estimated a 60-day larval mortality of 98.3 percent for arrow goby larvae, 98.6 percent for cheekspot, and 99.2 percent for shadow. These values were used to estimate average daily survival at 0.93 for the three species. Once the larvae transform at a size of approximately 10–15 mm SL, depending on the species (Moser et al. 1996), the juveniles settle into the benthic environment. For the Mission Bay populations mortality following settlement was 99 percent per year for arrow goby, 66–74 percent for cheekspot goby, and 62–69 percent for shadow goby. Few arrow gobies in the Mission Bay study exceeded 3 years of age based on otolith records, whereas cheekspot and shadow gobies commonly lived for 4 years (Brothers 1975).

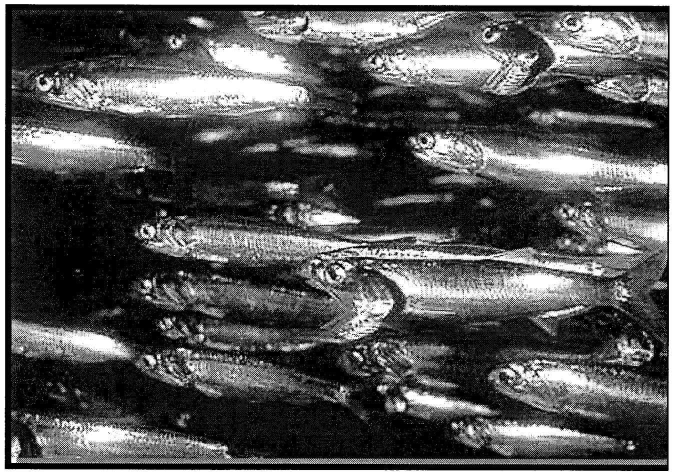
4.3.1.2 Commercial and Recreational Fishery Information

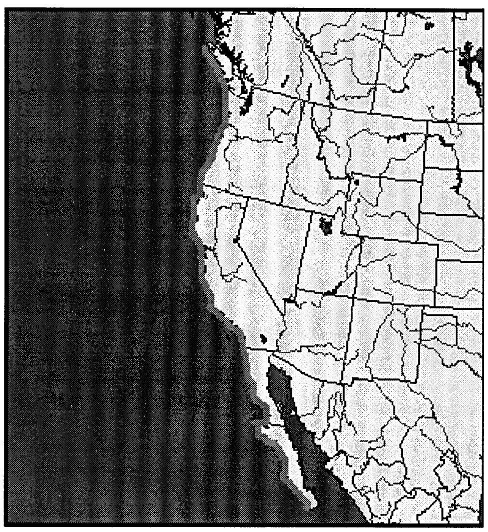
CIQ gobies are not part of a recreational or commercial fishery.

4.3.1.3 Sampling Results

CIQ goby larvae were found during all surveys (**Table 4-1**). The lowest mean survey concentration (3.9/1,000 m^3) occurred on May 25, 2004, and the highest concentration (177.4/1,000 m^3) occurred on June 22, 2004 (**Table 4-1**).

4.3.2 Northern Anchovy *Engraulis mordax*





Distribution map for northern anchovy

Range: From British Columbia to southern Baja.

Life History: Size: to 229 mm (9 in.); Size at maturity: 152 mm (6 in.); Fecundity: spawn 2 to 3 times a year, releasing from 2,700 to 16,000 eggs per batch; Life span: to 7 years.

Habitat: Pelagic; found in surface waters down to depths of 300 m (1,000 ft).

Fishery: Commercial fishery for reduction, human consumption, live and dead bait.

4.3.2.1 Life History

The northern anchovy is one of the approximately 139 species in the family Engraulidae (the anchovies) that occur in the CalCOFI study area (Moser 1996). The CalCOFI study area covers more than one million square kilometers between the Oregon-California border and the tip of Baja California extending from around 3–400 nautical miles offshore (Moser 1996). Other representatives of this family that occur in central California waters are the deepbody anchovy *Anchoa compressa*, slough anchovy *Anchoa delicatissima*, and the anchoveta *Centengraulis mysticetus* (Miller and Lea 1972, Eschmeyer et al. 1983, Love et al. 1996).

Three sub-populations of northern anchovy are recognized and managed separately along the Pacific coast of the U.S. (Lo 1985, PFMC 1990, 1998, Love 1996). The northern sub-population occurs from the northern limit of their range in British Columbia south to San Francisco, the central sub-population occurs from San Francisco to northern Baja California with the bulk of these animals found in the Southern California Bight, and the southern sub-population is found along the southern coast of Baja, the southern limit for this species. They range from the surface to depths of over 300 m (1,000 ft; Love 1996). Northern anchovy eggs and larvae have been collected 480 km (298 mi) from shore (Hart 1973) and the adults can exhibit extensive movements within their range (Love 1996). They tend to occur closer to the shoreline in the summer and fall and move offshore during the winter (Hart 1973).

Reproductive activity of northern anchovy varies within their range. Off southern and central California they can reach sexual maturity by the end of their first year at 110–130 mm (4.3–5.12 in.) TL, with all individuals maturing by four years of age and 152 mm (6 in.) total length (TL) (Hubbs 1925, Pike 1951, Clark and Phillips 1952, Daugherty et al. 1955, Hart 1973); off Oregon and Washington they do not mature until their third year (Love 1996). Leet et al. (2001) state that all northern anchovy are mature by two and that the proportion of mature one-year-olds is temperature dependent and has been observed to range between 47–100 percent. In southern California, anchovy spawn year-round with peaks during late winter to spring (Love 1996, Moser 1996). In Oregon and Washington, spawning can occur from mid-June to mid-August (Love 1996). Northern anchovy are multiple spawners and females spawn batches of eggs at intervals as short as 6–10 days (Schlotterbeck and Connally 1982, Love 1996, Leet et al. 2001). Spawning normally occurs at night in the upper layers of the water column (Hart 1973). An early estimate of northern anchovy fecundity (Baxter 1967) indicates an annual range of 20,000–30,000 eggs per female. More recent data from Love (1996) indicate that females can release from 2,700–16,000 eggs per batch, with annual fecundity as high as 130,000 eggs in southern California and around 35,000 eggs per year in northern populations. Parrish et al. (1986) and Butler et al. (1993) indicate that total annual fecundity varies with the age of the female from 20,000–30,000 eggs for a one-year old female to more than 320,000 for a five-year old. The eggs hatch within 2–4 days, depending on the water temperature, and release 2.5–3.0 mm (0.10–0.12 in.) long relatively undeveloped larvae (Hart 1973, Moser 1996) that begin schooling at 11–12 mm (0.4–0.5 in.) and transform into juveniles at 35–40 mm (1.4–1.6 in.) in approximately 70 days (Hart 1973).

Northern anchovy in the central sub-population are harvested commercially in Mexico and California for human consumption, live bait, dead bait, and other commercial uses (PFMC 1998). Landings of northern anchovy in California between 1916–1997 varied from a low of 72 metric tons (MT) in 1926 to a high of 143,799 MT in 1975 (PFMC 1998). The non-reduction live-bait fishery is primarily centered in southern California and principally serves the sport fishing market. Northern anchovy have historically comprised the majority of the live-bait catch, but now Pacific sardine are landed in greater numbers; between 1996–1999 Pacific sardine comprised 72 percent of the live-bait catch (Leet et al. 2001). Although northern anchovy are fished throughout the state, commercial landings are usually made in San Francisco, Monterey, and Los Angeles.

4.3.2.2 Commercial and Recreational Fishery Information

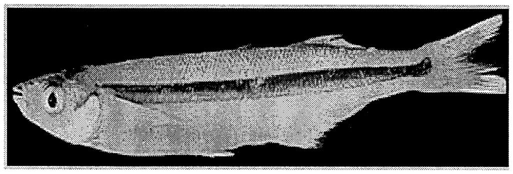
This species is collected for both live bait and also for reduction (to make fish meal, oil and paste). This species is the most important bait fish in southern California, and is also used in Oregon and Washington as bait for sturgeon (*Acipenser* spp.), salmonids (*Oncorhynchus* spp.), and other species (Emmett et al. 1991).

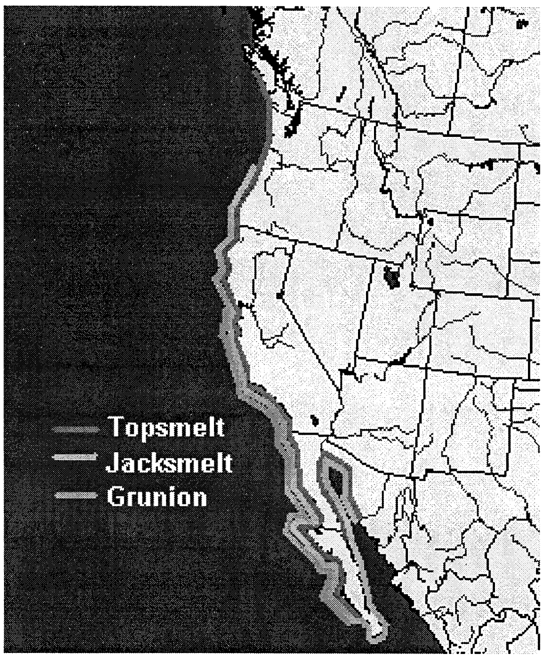
The landing of anchovies in Los Angeles and Orange Counties from 1999 through 2003 has varied from 206 to 3,658 metric tons, with a value of $30,645 to $332,547 (Pacific Fisheries Management Council web site). As of 2001 (CDFG 2002) this fishery is not actively managed due to a low demand for this fish and a high stock size.

4.3.2.3 Sampling Results

Anchovy larvae were found during all surveys except Survey 3, which was conducted on April 5, 2004 (**Table 4-1**). The highest concentration (220.8/1,000 m^3) occurred on June 22, 2004.

4.3.3 Atherinopsidae Complex (silversides, topsmelt, jacksmelt, and grunion)





Distribution map for Atherinopsidae complex.

Range: Topsmelt—Vancouver Island, British Columbia, to southern Baja California and the upper Gulf of California;
Jacksmelt—Yaquina Bay, Oregon through Gulf of California;
Grunion—San Francisco to southern Baja California.

Life History: Size: topsmelt to 37 cm (14.5 in), jacksmelt to 44 cm (17 in), grunion to 19 cm (7.5 in);
Age at maturity: all species 2–3 yr;
Life span: topsmelt 8 yr, jacksmelt 9–10 yr, grunion 4 yr;
Annual fecundity: topsmelt 1,000 eggs, jacksmelt >2,000 eggs, grunion 1,000–3,000 eggs.

Habitat: Bays, estuaries, nearshore surface waters to depths of 29 m (95 ft).

Fishery: Incidental commercial and limited recreational take on hook and line or with nets.

4.3.3.1 Life History

Three species of silversides (family Atherinopsidae) occur in California ocean waters: topsmelt *Atherinops affinis*, jacksmelt *Atherinopsis californiensis*, and the California grunion *Leuresthes tenuis*. Topsmelt are found from Vancouver Island British Columbia, to the Gulf of California, (Miller and Lea 1972), with a disjunct distribution in the northern gulf (Robertson and Allen 2002). These schooling fishes are very common in estuaries, kelp beds, and along sandy beaches. Topsmelt have a wide salinity tolerance and can survive in a range conditions from 0–90 ppt (Love 1996). Adults mature within 2–3 years to an approximate length of 10–15 cm (4–6 in), can reach a length of 37 cm (14.5 in), and have a life expectancy of up to eight years (Love 1996). Both topsmelt and jacksmelt are caught by sportfishers from piers and along shores.

The spawning activity of topsmelt corresponds to changes in water temperature (Middaugh et al. 1990). In Newport Bay, topsmelt spawn from February through June peaking in May and June (Love 1996). Females deposit the eggs on marine plants and other floating objects where fertilization occurs (Love 1996). Fecundity is a function of female body size with individuals in the 110–120 mm range spawning approximately 200 eggs per season, and fish 160 mm or greater spawning 1,000 eggs per season (Fronk 1969). Topsmelt eggs maintained in the laboratory hatched 10–14 d after fertilization (Middaugh et al. 1990). Moser et al. (1996) reported that topsmelt hatch at lengths of 4.3–5.4 mm and transformation to the juvenile form occurs at 14–21 mm. Middaugh et al. (1990) reported a hatch length of 5.4 mm and growth to an average length of 9.7 mm after 8 days. These values were used to estimate a larval growth rate of 0.53 mm/d.

Jacksmelt is a pelagic species found in estuaries and coastal marine environments from Yaquina Bay, Oregon to the Gulf of California (Eschmeyer et al. 1983, Robertson and Allen 2002). Jacksmelt is the largest member of the three species of the silverside that occur in California with adults reaching a maximum length of 44 cm (17 in) (Miller and Lea 1972). The fish reach maturity after two years at a size range of 18–20 cm (7.0–7.8 in) SL, and may live to a maximum age of nine or ten years (Clark 1929).

The spawning season for jacksmelt is from October through March (Clark 1929), with peak activity from January through March (Allen et al. 1983). Individuals may spawn multiple times during the reproductive season and reproductive females have eggs of various sizes and maturities present in the ovary (Clark 1929). Fecundity has not been well documented but is possibly over 2,000 eggs per female (Emmett et al. 1991). Females lay eggs on marine plants and other floating objects where fertilization by males occurs (Love 1996). Jacksmelt larvae hatch at an average length of 8.3 mm and reach a length of 11 mm after 8 d (Middaugh et al. 1990). These laboratory data were used to estimate a larval growth rate of 0.34 mm/d. Although there are no data specific to HBGS pertaining to the annual peak in Atherinopsid larvae abundance, the greatest concentrations of in south San Diego Bay were found from April through June (McGowen 1981).

California grunion are found from San Francisco to Magdalena Bay, Baja California (Miller and Lea 1972) but are most abundant from Point Conception southward (Love 1996). These are pelagic, schooling fish, usually seen from just behind the surf line to depths of about 18 m (60 ft). Grunion reach 19 cm (7.5 in) in length, with a life span of up to four years. They mature at one year old at a length of approximately 12–13 cm (5 in).

Spawning occurs only three or four nights following each full or new moon, and then only for 1–3 hours immediately after the high tide, from late February to early September (peaking late

March to early June) (Love 1996). The female swims onto the beach and digs into the wet sand, burying herself up to her pectoral fins or above. The male or males curve around her with vents touching her body, and when the female lays her eggs beneath the sand, males emit sperm, which flows down her body and fertilizes the eggs (Love 1996). Females spawn four to eight times per season at about 15-day intervals, producing 1,000–3,000 eggs. Eggs hatch at temperatures between 13.9–28.3°C (57–83°F). The eggs remain in the sand until they are liberated by the next tide high enough to reach them (approximately 10 days). Larvae hatch at approximately 6.5–7.0 mm transforming into juveniles at 15–20 mm (Moser et al. 1996).

4.3.3.2 Commercial and Recreational Fishery Information

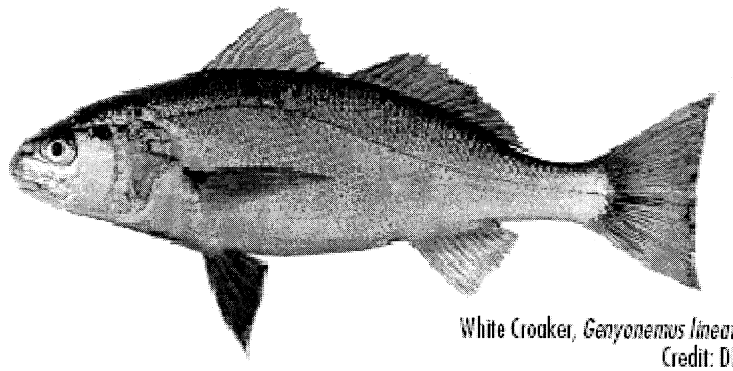
There is a limited fishery for silversides that are marketed fresh for human consumption or for bait (Leet et al. 2001). The commercial fishery for silversides has been conducted with a variety of gear. Historically, set-lines have been used in San Francisco Bay for jacksmelt, and during the 1920s beach nets, pulled ashore by horses, were used at Newport Beach (Leet et al. 2001). Commercial catches of jacksmelt have varied sharply over the past 80 years fluctuating from more than two million pounds in 1945 to 2,530 pounds in 1998 and 1999 (Leet et al. 2001). This is an incidental fishery and the large fluctuations in the catch records reflect demand, not actual abundances (Leet et al. 2001).

The commercial use of grunion is limited as this species forms a minor portion of the commercial “smelt” catch (Leet et al. 2001). Grunion are taken incidentally in bait nets and other round haul nets, and limited quantities are used as live bait, though no commercial landings have been reported (Leet et al. 2001). In the 1920s, the recreational fishery was showing signs of depletion, and a regulation was passed in 1927 establishing a closed season of three months, April through June. The fishery improved, and in 1947, the closure was shortened to April through May. Grunion may be taken by sport fishermen, using their hands only, and no holes may be dug in the beach to entrap them (Leet et al. 2001)

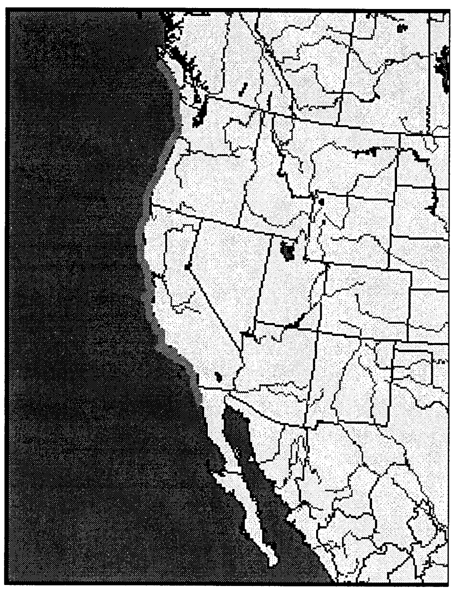
4.3.3.3 Sampling Results

The majority of this group have not been able to be identified past the family level. For this analysis, we have combined three taxa: unidentified Atherinopsidae, jacksmelt, and topsmelt. No grunion have yet been identified from the samples collected from the HBGS discharge water. Atherinopsidae larvae were found only in the first four surveys and in Survey 6 (**Table 4-1**). The highest concentration (45.1/1,000 m^3) occurred on April 5, 2004 (**Table 4-1**).

4.3.4 White Croaker *Genyonemus lineatus*



White Croaker, *Genyonemus lineatus*
Credit: DFG



Distribution map for adult white croaker.

Adult Range: From Todos Santos Bay, Baja California north to Barkley Sound, Vancouver Island, British Columbia.

Life History: Size: up to 380 mm (15 in.) and 0.5 kg (1 lb); Age at maturity: one to four years; Fecundity: spawns 18 to 24 times a season, annual fecundity–105,000 eggs; Life_span: twelve years.

Adult Habitat: Near shore areas less than 30 m (98 ft) deep just outside the surf zone; offshore waters to 100 m (328 ft) in depth.

Adult Fishery: Recreational, small commercial market.

4.3.4.1 Life History

White croaker is one of eight species of drums, from the family Sciaenidae, recorded off of California. They are often sold in fish markets under the name kingfish, and are also called tomcod, tommy, roncador, or ronkie by sport fishermen. They are typically silvery to brassy colored, with a small but prominent black spot at the base of each pectoral fin and a cluster of minute barbells on the membranes underneath the lower jaw.

The white croaker is an abundant nearshore species in California, usually found over soft, sandy-mud substrata. They range from Vancouver Island, British Columbia to Magdalena Bay, Baja California, but are not abundant north of Point Reyes, California. They usually swim in schools and are found from the surf zone to depths as great as 237.7 meters (780 feet) and in shallow bays, sloughs, and lagoons. Most of the time, they occupy nearshore areas at depths of 3–30 m (10–100 ft), but sometimes are fairly abundant to a depth of 91 m (300 ft). The maximum recorded length for white croaker is 5.0 m (16.3 in.); however, fish larger than about 30.5 cm (12 in.) are rare. Fish up to 1.8 kg (4 lb) have been reported, but those weighing over 0.9 kg (2 lb) are rare.

White croaker live to about 15 years and over 50 percent of both sexes are sexually mature by one year (at about 14.0 cm (5 1/2 in.) for males, 15.2 cm (6 in.) for females). By three or four years and 19.1 cm (7.5 in.), all white croaker are mature. In southern California white croaker spawn mainly from November–April, with peak months being January–March. Adults spawn in both near-shore shallow waters and the open waters of bays and estuaries. A large spawning center is located north and south of the Palos Verdes Peninsula, from Redondo Beach to Laguna Beach, and a smaller center is found north of Ventura (Love et al. 1984).

Females lay from 800–37,000 eggs, and are able to spawn 18–24 times a season (Love et al. 1984). The fertilized eggs are pelagic and most drift into the shallow sand and gravel bottom regions of the bays and estuaries. The spherical eggs hatch in about one week, with the newly hatched larvae averaging about 1.6 mm (0.06 in.) (Watson 1982). The young larvae are pelagic, flexion takes place at about 5.9 mm, and post-flexion larvae settle out to the sand and gravel bottom substrate as they develop (Love et al. 1984). The shallows of bays and estuaries are used as nursery grounds for the white croaker, but larvae are found in open water as well (Wang 1986). While a few larvae have been taken as far as 241.4 km (150 miles) offshore, most larvae reside within 32.2 km (20 miles) of the coast (Love 1996). Murdoch et al. (1989) estimates a daily larval growth rate of 0.20 mm/day (0.008 in./day).

White croaker inhabit depths ranging from about 7.6–36.6 meters (25–120 ft). The larvae initially are pelagic and most abundant in ocean depth ranges from about 15.2–22.9 meters (50–75 feet). As the larvae grow, they descend toward the bottom and migrate towards shore. Juveniles occur near the bottom where ocean depth is about 3.0–6.1 meters (10–20 ft). As they mature, they migrate to somewhat deeper water. White croaker are omnivores, their diet including a variety of worms, shrimps, crabs, squid, octopuses, clams, small fishes, and other items, living or dead. They feed primarily at night and on the bottom, although some midwater feeding occurs during the day. They are preyed upon by seals, sea lions, halibut, giant sea bass, bluefin tuna, and other fishes.

White croaker that live near marine waste discharges may concentrate toxic materials such as pesticides (DDT, DDE, etc.), polychlorinated biphenyls (PCB's), metals (zinc, selenium, mercury, etc.), and petroleum products in their bodies at levels that are considered hazardous for human consumption. Some white croaker in these areas are diseased, malformed or some show reproductive impairment. Current health guidelines advise against human consumption of white croakers from southern California waters in Santa Monica Bay, off the Palos Verdes Peninsula, and the Los Angeles-Long Beach Harbor area.

4.3.4.2 Commercial and Recreational Fishery Information

Although not a highly prized species, the white croaker has been an important constituent of commercial and sport fisheries in California. Before 1980 most of the catch was in southern California. However, since 1980 the majority of the catch has been in central California. The changes since 1980 in fishing methodology and area of greatest landings are due primarily to the entrance of Southeast Asian refugees (mainly Vietnamese) into this fishery. Many of these refugees who settled in California's coastal areas were gillnet fishermen in their homelands and sought to earn their living here by that method of fishing. The underutilized white croaker resource (especially in central California) and moderate start-up costs required for gillnetting (small to medium size boats and moderate gear costs) offered many of them an opportunity to enter the commercial fishing business. In contrast, most of the sport catch of white croaker is in southern California. Anglers fishing from piers, breakwaters, and private boats account for about 90 percent of the catch.

Prior to 1980, white croaker landings averaged 298,464 kg (658,000 lb) annually and exceeded 453,592 kg (1 million lb) in several years (**Figure 4-1**). Peak landings in 1952 (88 percent in southern California) were probably in response to the total collapse of the sardine fishery that year. From 1980–1991, total landings have averaged 1.1 million lb and were above one million lb in all but four years. Since 1991, landings have averaged 461,000 lb and have steadily declined to an all time low of 64,636 kg (142,500 lb) in 1998. Before 1980, the commercial catch of white croaker was primarily by round haul net (mainly lampara), although some were taken by trawl, gillnet, and hook-and-line. After 1980, most white croaker have been taken by gillnet and hook-and-line. Most of the commercial catch is sold in the fresh fish market, although a small amount is used for live bait. Also, small quantities of another croaker, the queenfish, are included in the commercial landing records, mostly for southern California.

Landings of white croaker by recreational anglers aboard commercial passenger fishing vessels were highest in the late 1940s and early 1950s, averaging about 70,000 fish per year. Since 1954, however, they have averaged well below 30,000 fish per year, with one exceptional peak in 1988 of about 120,000 fish. Landings from 1990–1998 have averaged about 12,000 fish per year, with approximately 96 percent of the landings from southern California.

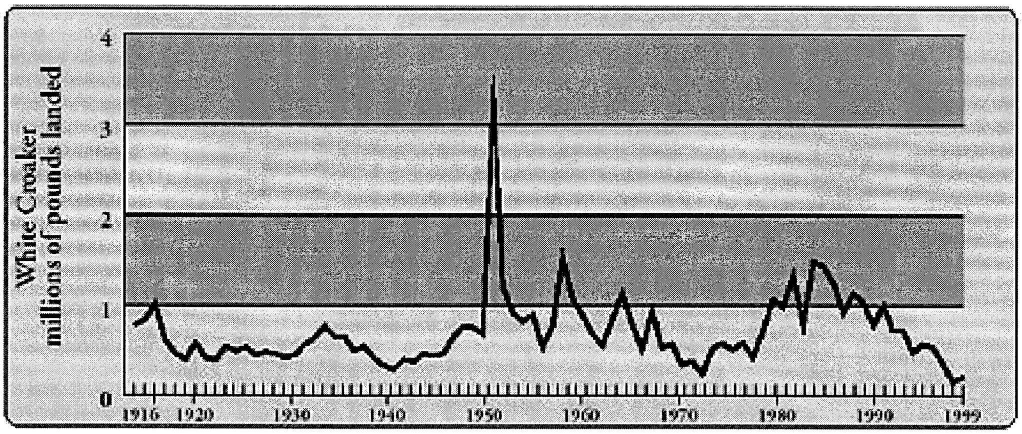


Figure 4-1. Commercial landings of white croaker 1916–1999. Source: CDFG Catch Bulletins and Commercial Landing Receipts.

4.3.4.3 Sampling Results

Croaker larvae were the third most abundant larvae collected in the HBGS discharge (**Table 4-1**). A total of 190 croaker larvae were collected from the first ten surveys: 98 queenfish, 43 unidentified croakers, 31 spotfin croaker, 13 white croaker, 3 corbina, and 2 black croaker. Croakers were not found during surveys collected on April 27, May 11, and May 25, 2004 (**Table 4-1**). The highest concentration of this taxon (405.0/1,000 m^3) occurred on July 7, 2004 (**Table 4-1**).

4.3.5 Larval Survival Study Results

Seven surveys have been conducted in the HBGS discharge flow using the larval table to assess the survival of larval fishes. These surveys have been conducted during afternoon and evening hours from April 27 through July 22, 2004 (**Table 4-2**). Fish larvae that were alive when collected were placed in separate labeled containers and observed for at least two hours after collection. The total number of larvae collected and the number surviving varied between surveys (**Table 4-2**). Of the 13 larval fishes that were alive after being removed from the larval table, seven survived for at least two hours after collection. Two died within 15 minutes of collection. The larvae that survived at least two hours included unidentified gobies, pipefish, black croaker, and combtooth blennies. The average larval fish survival immediately after collection was 5.9 percent.

Table 4-2. Summary of larval fish survival in HBGS's in-plant discharge flow from April through July 2004.

Parameter	PRHBS04 04/27/04	PRHBS05 05/11/04	PRHBS06 05/25/04	PRHBS07 06/10/04	PRHBS08 06/22/04	PRHBS09 07/07/04	PRHBS10 07/22/04
Number of Samples	9	13	10	12	8	11	12
Volume Filtered (m^3)	159	239	195	174	89	110	151
Total # Larvae Collected	**8**	**3**	**2**	**68**	**43**	**82**	**13**
Avg. Larval Conc. (# per 1,000 m^3)	50.31	12.55	10.25	402.30	483.15	745.45	86.09
Total # Alive	0	1	0	1	6	3	2
% Alive	**0%**	**33.3%**	**0%**	**1.5%**	**14.0%**	**3.7%**	**15.4%**

5.0 Entrainment Impact Assessment

The potential entrainment effects of the proposed Huntington Beach Desalination Project were estimated in two steps: first estimating the potential entrainment effects of the HBGS's cooling water intake, and then assessing the potential for any additional entrainment effects resulting from HBDF's withdrawal of a portion of HBGS cooling water before it is discharged to the ocean. The entrainment effects of the HBGS were estimated using an assessment method developed by the U.S. Fish and Wildlife Service that Tenera has recently adapted and used for similar entrainment impact assessments at a number of California ocean- and bay-sited generating stations. These case studies include, in chronological order beginning in 1995, Diablo Canyon Power Plant, Moss Landing Power Plant, Morro Bay Power Plant, San Francisco Bay's Potrero Power Plant, and San Diego's South Bay Power Plant. The California Energy Commission has selected Tenera's assessment method and model in their studies of the HBGS intake effects. It should be noted that the calendar period, spring–summer, represents the period of greatest abundance for these young organisms and therefore is a conservative approach to estimating overall annual entrainment effects.

In addition, in order to assess any potential effects of the HBDF feedwater intake on local fishery resources, for this report Tenera selected to use the white croaker (*Genyonemus lineatus*), CIQ gobies, and northern anchovy (*Engraulis mordax*) larvae in the Empirical Transport Model (*ETM*) model. The white croaker is a commonly entrained commercially important species in the HBGS source water, as was the case in studies of the San Onofre Generating Station's (SONGS) cooling water intake effects (Murdoch et al. 1989). Its abundance in entrainment samples at SONGS and its commercial value made it the choice of the NOAA fisheries scientists assessing the generating station's potential to affect local fisheries resources. Of the other two taxa, CIQ gobies are a forage fish, and the northern anchovy is caught in both the commercial and recreational fishery.

The following sections describe the model, source water volume used in the model, life history data relevant to the model for these three taxa, and the *ETM* model results. Section 5.3 discusses any potential for HBGS entrainment effects to be increased by the HBDF feedwater withdrawals of a portion of HBGS cooling water discharge. The HBDF feedwater intake cannot increase the volume of the HBGS cooling water intake nor increase the number of organisms entrained or impinged by the HBGS CWIS. Therefore the impingement effects of the HBGS are not included in assessing the HBDF intake. The assessment focuses on the effects of HBDF entraining HBGS-entrained organisms before they would be returned to the ocean in the cooling water discharge flow.

5.1 Entrainment Effects Model

The *ETM* model provides an estimate of incremental mortality (a conditional estimate in absence of other mortality [Ricker 1975]) imposed on local larval populations by using an empirical measure of proportional entrainment (*PE*) rather than relying solely on demographic calculations. Proportional entrainment (*PE*) (an estimate of the daily mortality) to the source water population from entrainment is expanded to predict regional effects on appropriate adult populations using the *ETM*, as described below.

Variations of this model have been discussed in MacCall et al. (1983) and have been used to assess impacts at a southern California generating station (Parker and DeMartini 1989). The *ETM* has also been used to assess impacts at the Salem Nuclear Generating Station in Delaware Bay, New Jersey (PSE&G 1993) as well as other generating 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 generating station withdrawals. The modeling approach described below uses a *PE* approach that is similar to the method described by MacCall et al. (1983) and used by Parker and DeMartini (1989) in their final report to the California Coastal Commission (Murdoch et al. 1989) for the San Onofre Nuclear Generating Station (SONGS). This estimate can then be summarized over appropriate blocks of time in a manner similar to that of the *ETM*.

The general equation to estimate *PE* for a day on which entrainment was sampled is:

$$\hat{PE} = \frac{\hat{N}_{Ei}}{\hat{N}_{Si}}$$

where:

$\hat{N}_{Ei}$ = estimated number of larvae entrained during the day in survey i, calculated as (estimated density of larvae in the water entrained that day) × (design specified daily cooling water intake volume),

$\hat{N}_{Si}$ = estimated number of larvae in the source water that day in survey i (estimated density of larvae in the souce water that day) × (source water volume).

A source water volume is used because: 1) cooling water flow is measured in volume per time, and 2) biological sampling measures larval concentration in terms of numbers per sample volume (#/1,000 m^3) – see Section 4.0. Entrained numbers of larvae are estimated using the volume of water withdrawn. A source population is similarly estimated using the source water volume. If one assumes that larval concentrations at the point of entrainment are the same as larval concentrations in the source population volume then it follows that:

$$\hat{P}E = \frac{\hat{V}_{Ei}}{\hat{V}_{Si}},$$

where:

$\hat{V}_{Ei}$ = design specified daily cooling water intake volume,

$\hat{V}_{Si}$ = estimated source water volume.

The ratio of daily entrainment volume to source volume can thus serve as an estimate of daily mortality. The *PE* value is estimated for each larval duration period over the course of a year by using a source water estimate from an advection model described below.

If larval entrainment mortality is constant throughout the period and a larva is susceptible to entrainment over a larval duration of *d* days, then the proportion of larvae that escape entrainment in period *i* is:

$$(1 - \hat{P}E_i)^{\hat{d}}.$$

A larval duration of 23 days from hatching to entrainment was calculated from growth rates using the length representing the upper 99th percentile of the length measurements from white croaker larvae collected from entrainment samples during 316(b) studies (Tenera 2000a, Tenera 2001). The value for *d* was computed by dividing an estimate of growth rate into the change in length based on this 95th percentile estimate. The minimum size used for computing the larval duration was determined after removing the smallest 1 percent of the values.

It is possible that aging was biased, even though standard lengths of larval fish (i.e., measurements of minimum, mean, and maximum), and larval growth rates were applied to estimate the ages of the entrained larvae. It was assumed that larvae shorter than the minimum length were just hatched and therefore, aged at zero days. Subsequent ages were estimated using this length. Other reported data for various species suggest that hatching length can be either smaller or larger than the size estimated from the samples, and indicate that the smallest observed larvae represent either natural variation in hatch lengths within the population or shrinkage following preservation (Theilacker 1980). The possibility remains that all larvae from the observed minimum length to the greatest reported hatching length (or to some other size) could have just hatched, leading to overestimation of ages for all larvae.

Sixteen larval duration periods over the course of a year were used to estimate larval mortality (P_M) due to entrainment using the following equation

$$\hat{P}_M = \frac{1}{16}\sum_{i=1}^{16} 1 - (1 - \hat{P}E_i)^{\hat{d}}$$

where

$\hat{P}E_i$ = estimate of proportional entrainment for the *i*th period and

$\hat{d}$ = the estimated number of days of larval life.

The estimate of the population-wide probability of entrainment ($\hat{P}E_i$) is the central feature of the *ETM* approach (Boreman et al. 1981, MacCall et al. 1983). If a population is stable and stationary, then $\hat{P}_M$ estimates the effects on the fully-recruited adult age classes when uncompensated natural mortality from larva to adult is assumed.

Assumptions associated with the estimation of P_M include the following:

1) Lengths and applied growth rate of larvae accurately estimate larval duration.
2) A source population of larvae is defined by the region from which entrainment is possible.
3) Source water volume adequately describes the population.
4) The currents used to calculate the source water volume are representative of other years.

The ratio of daily entrainment volume to source volume will serve as an estimate of daily mortality. The *ETM* method estimates the source population using an estimate of the source volume of water from which larvae could possibly be entrained. Boreman et al. (1981) point out that if some members of the target group lie outside the sampling area, the *ETM* will overestimate the population mortality.

Recent work by Largier (2003) showed the value of advection and diffusion modeling in the study of larval dispersal, which is central to the *ETM* method. Ideally, three components could be considered in estimating entrainable populations: advection, diffusion, and biological behavior. An ad-hoc approach, developed by the Technical Working Group during the Diablo Canyon Nuclear Power Plant 316(b) study (Tenera 2000a), modeled the three components using a single offshore current meter. The maximum and minimum of alongshore excursions during the larval period defined the alongshore extent of a potentially entrainable area, while the maximum of the cross-shelf excursion defined the offshore extent of the area. Although this simplistic approach does not explicitly account for advection, diffusion and larval behavior in an advection-diffusion equation (Gaines et al. 2003), it is used below in the study area near the

HBGS to account for the advective-diffusive spread of larvae over time. In addition, this approach is conservative when compared with drifter excursions reported by Hickey (1992).

5.2 Source Water Volume

The HBGS lies adjacent to the San Pedro basin and the Pacific Ocean. The San Pedro basin has an area of about 300 sq. mi. Hickey (1992) describes the large-scale oceanography of the San Pedro basin as dominated by the California Current system, "The California Current flows equatorward year-round offshore of the California Bight, bringing colder, fresher subarctic water southward. South of Point Conception, the California Current turns southeastward and then shoreward and poleward in a large eddy known as the Southern California Countercurrent or the Southern California Eddy." Besides a surface poleward current, at depths of 100–300 m a subsurface undercurrent moves equatorial water northwest. In summer to early fall and winter, the maximum poleward flow occurs while minimum poleward flow occurs in summer. Nearshore, less than about 10 km offshore in the Santa Monica basin, Hickey (1992) showed that flow was equatorward in fall and early winter. Therefore, it is expected that the flow is often equatorward in shallow water less than 50 m.

Recent current measurements done in the Huntington Beach region have been collected for the Orange County Sanitation District (OCSD) waste treatment effluent that discharges offshore. For example, in a study on transport mechanisms near HBGS, Boehm et al. (2002) showed the potential for internal tides to transport water onshore. They reported that cold water is regularly advected cross-shelf, into and out of the nearshore, at both semi-diurnal and diurnal frequencies.

Noble et al. (2003) described the current patterns near the HBGS and found that, after tides and sea breeze were removed, larger scale coastal processes cause currents. They described, for summer 2001, a downcoast average current over the shelf with a maximum near the surface on the outer shelf, decreasing in magnitude and depth toward shore. Mean surface currents of 10–12 cm/s (were reported). At depths below about 70 m they found predominantly upcoast flow, rising occasionally to shallower depths for a few days. Maximum currents exceeded 60 and 30 cm/s on the outer and inner shelf, respectively. Close to shore, alongshelf current fluctuations were closely related to alongshore winds with potential to be in the opposite direction to flows over the middle and outer shelf. They noted that at depths deeper than about 30–55 m dispersal is primarily along the isobaths rather than across the shelf. They found the maximum subtidal cross-shelf excursion was on the order of 2–3 km over a period of two days and that currents were not a major factor in the movement of cold water towards shore from those deeper depths.

Boehm et al. (2002) analyzed long-term current and temperature measurements from June 1999 to June 2000, at six locations. One of these stations (33° 37.874'N, 117° 59.804'W) at 14.8 m depth, was directly offshore the HBGS and equipped with current meters at 5-m (S4, Interocean Systems, Inc., San Diego, CA) and 10-m depths (2-D acoustic current meter, Falmouth Scientific, Cataumet, MA).

Source volume was estimated using cross-shelf and alongshore currents from this station over a larval duration period of 23 days and the offshore bathymetric cross section offshore of HBGS (Based on Noble et al. (2003) findings of cross-shelf transport, source volume calculations are limited to a 40 m depth). The shoreline at the HBGS intake faces southwest, laying about 307°T, and the offshore cross section points 217°T. The extent of the cross section was developed using the cross shelf component of currents. Water current data at the station near the HBGS intake were downloaded from the OCSD ftp website,

> *ftp://ftp.ocsd.com/OCSD%20Offshore%20&%20Shoreline%20Data/OCSD%20Historical%20Data/1999-2000%20Currents/Orange_nodc/.*

The data were collected at 30-min intervals and then 3-hr low pass filtered and resampled at 1-hr intervals. North and east currents were rotated to the shore direction of 307°T.

A bathymetry transect was estimated directly offshore HBGS to a depth of 10 m (**Figure 5-1**) using ArcView GIS and two sets of contours (10-m and 50-ft) from CDFG. The bathymetry transect shows a gradual shelf to approximately 7 km offshore where the shelf ends at 40 m depth. While the transect dropoff at about 40 m depth is typical of the area's bathymetry, the San Pedro Bay shelf is widest seaward from Los Angeles Harbor where it extends 21 km offshore (**Figure 5-2**). The volume of San Pedro Bay above 40 m depth was estimated as 7.2 km^3.

The alongshore and cross shelf excursions at the 5-m and-10 m depths are shown in **Figure 5-3**. The entrainment flow used in the estimation of *PE* was 480,695 m^3 (127 MGD) which represents the minimum flow conditions at HBGS. This operating condition would conservatively estimate the maximum source water effects from HBDF, assuming 100 percent through-plant mortality. These assumptions were considered conservative since the 100 percent entrainment mortality associated with HBDF desalination flow (100 MGD) would affect nearly all of the small number of larvae surviving in HBGS lowest discharge flow of 127 MGD. The fraction of HBDF withdrawal declines along with the facility's entrainment effect as the volume of HBGS discharge increases to 507 MGD. Source water volume was estimated over each larval duration period as the product of the alongshore current movement and a cross section area determined by the cross shelf current. The alongshore current excursion was calculated by sum of the maximum and minimum alongshore excursion. The cross shelf excursion was estimated by the maximum of the onshore or offshore movement. If the cross shelf excursion exceeded 7 km then the cross sectional area to 40 m depth was used.

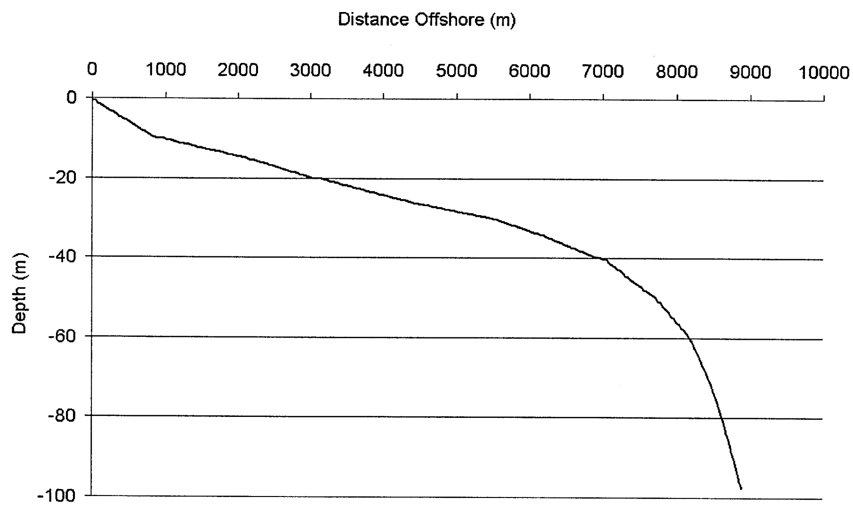


Figure 5-1. Bathymetry directly offshore the Huntington Beach Generating Station.

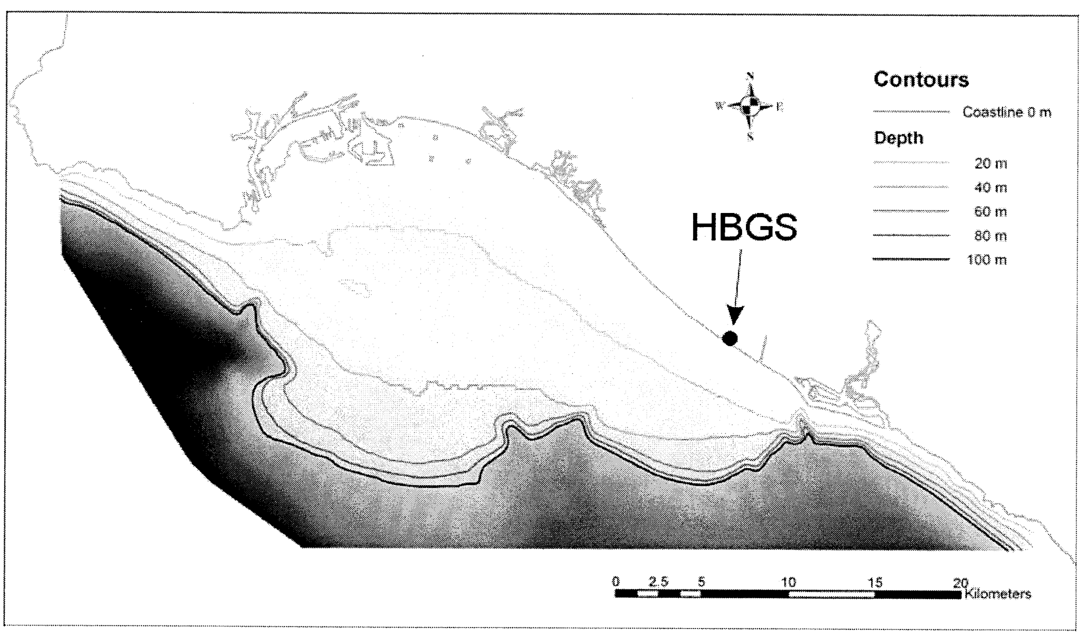


Figure 5-2. Bathymetry in San Pedro Bay, from Point Vincente to Laguna Beach. The Huntington Beach Generating Station is indicated.

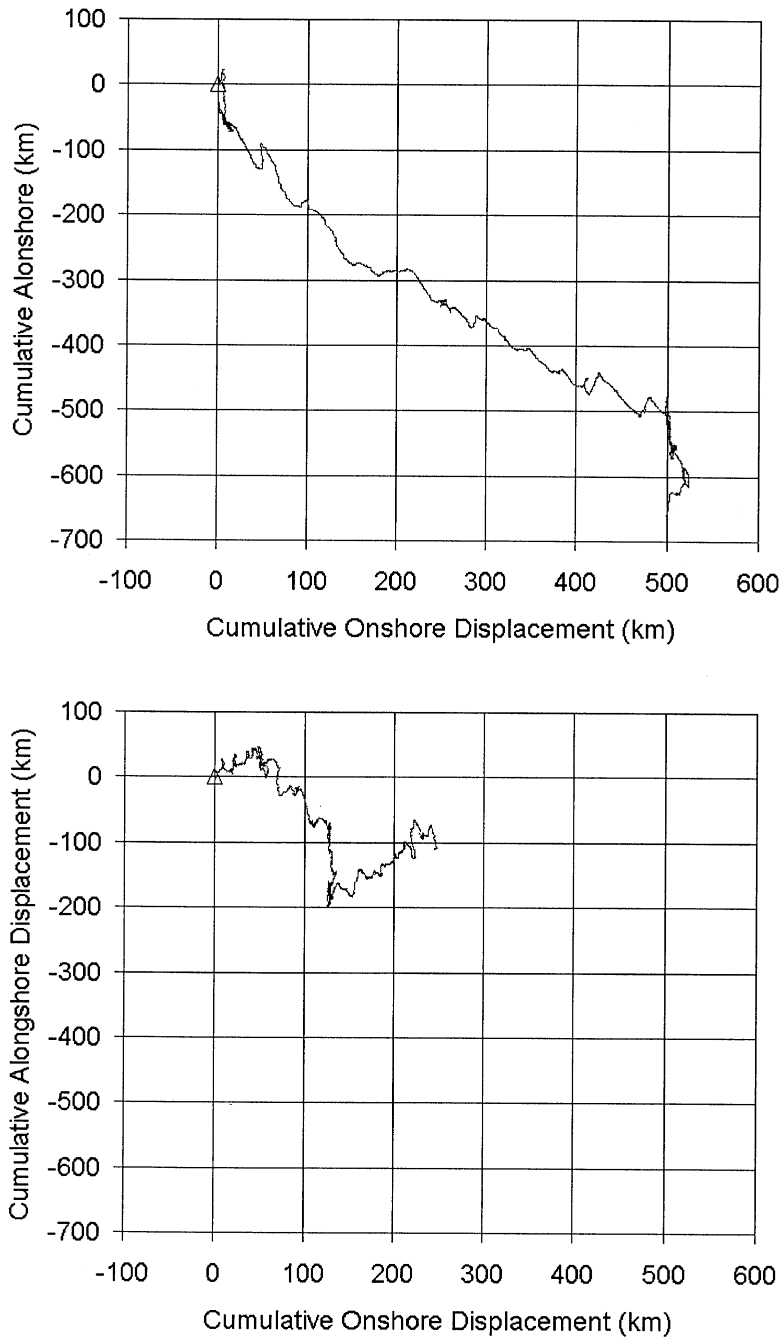


Figure 5-3. Cumulative currents at Station Q near the HBGS intake, June 1999–June 2000, at 5-m (above) and 10-m (below). Positive values are upcoast and onshore.

5.3 ETM Modeling Results

The mortalities of one species group (CIQ gobies) and two species (northern anchovy and white croaker) that could potentially be caused by the operation of the proposed HBDF were assessed using the *ETM* methodology described above. The following results show estimates of mortalities imposed by the approximately 100 MGD feedwater requirements of HBDF in relation to source water volumes derived from current meter measurements.

5.3.1 CIQ Goby Complex

The larval duration used to calculate the *ETM* estimates for gobies was based on the lengths of larvae collected in San Diego Bay (Tenera 2004). Due to the low number of individuals from samples processed to date, it was decided to use the length of entrained larval gobies from a recent study in San Diego Bay. For the final report, lengths of larvae collected from the HBGS discharge conduit will be used for the analysis. The difference between the lengths of the 1st (2.2 mm) and 99th (5.8 mm) percentiles was used with a growth rate of 0.16 mm/day to estimate that larvae were vulnerable to entrainment for a period of 23 days.

ETM estimates of proportional mortality (P_m) for gobies reflected the difference in the two levels of currents (5-m and 10-m depths) (**Table 5-1**). The average source water volumes used in the *ETM* estimates of larval mortality were 7.8 km^3 and 4.8 km^3 using 5-m and 10-m currents, respectively. The estimates of larval mortality were 0.18 and 0.33 percent using the 5-m and 10-m currents respectively. Assuming 100 percent mortality through HBGS during standby (127 MGD) operation, these results indicate that the potential effect on gobies caused by the HBGS is less than 0.33 percent of the source water population of gobies using the 10-m current level. This loss is insignificant to the adult population of gobies.

In comparison, larval mortality attributed to HBGS at full operation of 507 MGD was calculated as 0.7 and 1.3 percent using the 5-m and 10-m currents, respectively. California Department of Fish and Game (2001) in their Nearshore Fishery Management Plan provides for sustainable populations with harvests of up to 60 percent of unfished adult stocks. Under full HBGS operation, where only a small fraction of larval fish are alive (average estimated mortality upon collection was 94.1 percent) at the point of HBDF feedwater withdrawal from the HBGS discharge flow, the effects on source populations due to HBDF alone would be an order of magnitude lower than the 0.33 percent estimate.

Proportional entrainment *(PE)* estimates ranged from 0.00003 to 0.00015 using 5-m currents (**Table 5-1**). Using 10-m currents, *PE* estimates ranged from 0.00005 to 0.00051 (**Table 5-1**). Increased estimates of *PE* between the 5-m and 10-m current bases are related to decreased source volume. That is, average source volume estimates decreased from 7.8 km^3 to 4.8 km^3 and resulted in increased mortality estimates. By way of comparison, the volume of water from Pt. Vincente to Laguna Beach to 40 m depth is estimated as 7.5 km^3. There appeared to be no seasonal trend in mortality using 5-m currents. On the other hand, using 10-m currents the highest mortality occurred in January, midway through the 16 estimates.

5.3.2 Northern Anchovy

Due to the low number of individuals collected in the samples processed to date, the larval duration used to calculate the *ETM* estimates for northern anchovy was based on the lengths of larvae collected off the central California coast near Diablo Canyon Nuclear Power Plant (Tenera 2000a). The difference between the lengths of the 1st (2.1 mm) and 99th (24.9 mm) percentiles was used with a growth rate of 0.445 mm/day to estimate that larvae were vulnerable to entrainment for a period of 51 days.

ETM estimates of P_m for northern anchovy reflected the difference in the two levels of currents (5-m and 10-m depths) (**Table 5-2**). The average source water volumes used in the *ETM* estimates of larval mortality were 14.9 km^3 and 9.5 km^3 using 5-m and 10-m currents. The estimates of larval mortality were 0.18 and 0.24 percent using the 5-m and 10-m currents respectively (**Table 5-2**). Assuming 100 percent mortality through HBGS during (127 MGD) operation, these results indicate that the potential effect on northern anchovy caused by the HBGS is less than 0.24 percent of the source water population of northern anchovy. This loss is insignificant to the adult population of anchovy.

In comparison, larval mortality attributed to HBGS at full operation of 507 MGD was calculated as 0.71 and 1.15 percent using the 5-m and 10-m currents, respectively. Under full HBGS operation, where only a small fraction of larval fish are alive (average estimated mortality of 94.1 percent immediately after collection) at the point of HBDF feedwater withdrawal from the HBGS discharge flow, the effects on source populations due to HBDF would be an order of magnitude lower than the 0.24 percent estimate.

PE estimates ranged from 0.00002 to 0.00005 using 5-m currents (**Table 5-2**). Using 10-m currents, *PE* estimates ranged from 0.00003 to 0.00008 (**Table 5-2**). Increased estimates of *PE* between the 5-m and 10-m current bases are related to decreased source volume. That is, average source volume estimates decreased from 14.9 km^3 to 9.5 km^3 and resulted in increased mortality estimates. The average source volume using 5-m currents is twice the volume of water from Pt. Vincente to Laguna Beach to 40 m depth (7.5 km^3).

Mortality was highest in January using both 5-m and 10-m currents (0.26 and 0.43 percent respectively) (**Table 5-2**). Lowest mortality, using 5-m currents, occurred in September and

November (0.12–0.13 percent) (**Table 5-2**). Using 10-m current data, the lowest mortality occurred in November (0.17 percent) (**Table 5-2**).

5.3.3 White Croaker

The larval duration used to calculate the *ETM* estimates for white croaker was based on the lengths of larvae at two sites: the central California coast near Diablo Canyon Nuclear Power Plant (Tenera 2000a) and Morro Bay Power Plant (Tenera 2001), two recently completed studies. The difference between the lengths measured at Diablo Canyon and Morro Bay of the 1st (1.1–1.4 mm) and 99th (5.5–6.11 mm) percentiles and at Moss Landing of hatching (1.65 mm) and flexion (5.95 mm) were used with a growth rate of 0.2 mm/day to estimate that larvae were vulnerable to entrainment for a period of 23 days. This estimate corresponds closely to a larval duration of 23 days estimated from biological measures of hatching (1.65 mm) and flexion (5.95 mm) and used in a study at the Moss Landing Power Plant in Monterey Bay (Tenera 2000b).

ETM estimates of P_m for white croaker were the same as gobies because the larval duration was similar, i.e. 23 days. Estimates of P_m reflected the difference in the two levels of currents (5-m and 10-m depths) (**Table 5-1**). The average source water volumes used in the *ETM* estimates of larval mortality were 7.8 km^3 and 4.8 km^3 using 5-m and 10-m currents. The estimates of larval mortality were 0.18 and 0.33 percent using the 5-m and 10-m currents respectively. Assuming 100 percent mortality through HBGS operation (127 MGD), these results indicate that the potential effect on white croaker caused by the HBDF is less than 0.33 percent of the source water population of white croaker. This loss is insignificant to the adult population of white croaker.

In comparison, larval mortality attributed to HBGS at full operation of 507 MGD were calculated as 0.72 and 1.31 percent using the 5-m and 10-m currents respectively. California Department of Fish and Game (2001) in their Nearshore Fishery Management Plan provides for sustainable populations with harvests of up to 60 percent of adult stocks. Under full HBGS operation, where only a small fraction of larval fish are alive (average estimated mortality of 94.1 percent immediately after collection) at the point of HBDF feedwater withdrawal from the HBGS discharge flow, the effects on source populations due to HBDF would be an order of magnitude lower than the 0.33 percent estimate.

Proportional entrainment *(PE)* estimates ranged from 0.00003 to 0.00015 using 5-m currents (**Table 5-1**). Using 10-m currents, *PE* estimates ranged from 0.00005 to 0.00051 (**Table 5-1**). Increased estimates of *PE* between the 5-m and 10-m current bases are related to decreased source volume. That is, average source volume estimates decreased from 7.8 km^3 to 4.8 km^3 and resulted in increased mortality estimates. By way of comparison, the volume of water from Pt. Vincente to Laguna Beach to 40 m depth is estimated as 7.5 km^3. There appeared to be no seasonal trend in mortality using 5-m currents. On the other hand, using 10-m currents the highest mortality occurred in January, midway through the 16 estimates.

5.4 Assessment Discussion

Based on *ETM* modeling of entrainment losses at 127 MGD, which are the minimum flows produced by HBGS, it was found that source water populations of the fishes modeled (gobies, northern anchovy, and white croaker) would be reduced by no more than 0.33 percent. The estimated source water larval fish loss attributed to HBDF would be 0.02 percent, an order of magnitude less than 0.33 percent, based on HBGS entrainment mortality of 94.1 percent.

The *ETM* model estimates the proportion of the available larval supply in the source water that is eliminated by entrainment, but makes no assumptions as to the ultimate effects of such losses on the next generation of adult fishes. Another approach to quantifying impacts produces an estimate of losses to adult fish populations based on the numbers of larvae lost to entrainment. The adult equivalent loss (*AEL*) model forecasts the number of adults that would have been produced by the quantity of entrained larvae after applying a series of mortality rates to the cohort from the time of entrainment to a mean reproductive age. The fecundity hindcasting (*FH*) modeling approach estimates the number of adult females whose reproductive output has been eliminated. Because the accuracy of estimated entrainment effects from these models depends on the accuracy of age-specific mortality and fecundity estimates, lack of demographic information may limit the utility and accuracy of these approaches. The *AEL* and *FH* estimates often differ because of the variation in demographic parameters that are used, but they provide a context to evaluate absolute losses and, considered with the *ETM* estimates for each species, are used to evaluate potential impacts to the populations at risk.

From the 6-month report (MBC and Tenera 2004), the preliminary estimate of CIQ gobies lost due to HBGS entrainment based on a 507 MGD intake was 37,037 using the adult equivalent loss (*AEL*) modeling approach and 25,430 using the fecundity hindcasting (*FH*) modeling approach with assumed 100 percent entrainment mortality (**Appendix A, Table A-3**). Under a scenario in which HBGS is pumping 127 MGD, the estimate of CIQ gobies lost is between 5,100 and 7,400 adults during the 4-month period modeled. The number of gobies is further reduced to approximately 305 and 444 gobies for the *FH* and *AEL* models, respectively considering the desalination facility's contribution of 1.2 percent of the total mortality (the difference between the percentage of entrained organisms alive before and after the point of HBDF feedwater withdrawal).

Table 5-1. *ETM* data for gobies and white croaker larvae. *ETM* calculations based on larval period source water volumes over 23 days, and daily water volume = 480,695 m^3 (127 MGD).

Period End Date	Cross shelf Area (km^2)	Alongshore Excursion (km)	Source Volume (km^3)	PE_i	P_m
5-m currents					
10-Jul-99	0.15	84.4	12.67	0.00004	0.00087
2-Aug-99	0.15	23.2	3.48	0.00014	0.00318
25-Aug-99	0.15	60.2	9.03	0.00005	0.00122
17-Sep-99	0.15	97.7	14.65	0.00003	0.00075
10-Oct-99	0.15	102.2	15.33	0.00003	0.00072
2-Nov-99	0.15	21.4	3.20	0.00015	0.00345
25-Nov-99	0.15	58.0	8.70	0.00006	0.00127
18-Dec-99	0.15	29.0	4.35	0.00011	0.00254
10-Jan-00	0.15	51.7	7.75	0.00006	0.00143
2-Feb-00	0.15	36.7	5.50	0.00009	0.00201
25-Feb-00	0.15	38.2	5.74	0.00008	0.00193
19-Mar-00	0.15	54.9	8.24	0.00006	0.00134
11-Apr-00	0.10	73.2	7.08	0.00007	0.00156
4-May-00	0.14	24.9	3.39	0.00014	0.00326
27-May-00	0.15	59.4	8.91	0.00005	0.00124
19-Jun-00	0.15	42.3	6.35	0.00008	0.00174
Mean 5-m Flow P_m = 0.00178 *S.D.* = 0.00089					
10-m currents					
10-Jul-99	0.15	36.5	5.47	0.00009	0.00202
2-Aug-99	0.15	24.0	3.60	0.00013	0.00307
25-Aug-99	0.15	32.6	4.89	0.00010	0.00226
17-Sep-99	0.15	46.9	7.03	0.00007	0.00157
10-Oct-99	0.15	57.1	8.57	0.00006	0.00129
2-Nov-99	0.15	14.8	2.22	0.00022	0.00497
25-Nov-99	0.15	59.6	8.94	0.00005	0.00124
18-Dec-99	0.15	25.0	3.75	0.00013	0.00294
10-Jan-00	0.03	36.1	0.94	0.00051	0.01172
2-Feb-00	0.06	33.1	2.03	0.00024	0.00544
25-Feb-00	0.06	36.7	2.37	0.00020	0.00465
19-Mar-00	0.10	32.9	3.42	0.00014	0.00323
11-Apr-00	0.15	43.0	6.45	0.00007	0.00171
4-May-00	0.15	36.3	5.45	0.00009	0.00203
27-May-00	0.15	46.3	6.94	0.00007	0.00159
19-Jun-00	0.15	29.8	4.47	0.00011	0.00247

Mean 10-m Flow P_m = 0.00326 *S.D.* = 0.00261

Table 5-2. *ETM* data for northern anchovy larvae. *ETM* calculations based on larval period source water volumes over 51 day periods, and daily water volume = 480,695 m^3 (127 MGD).

Period End Date	Cross shelf Area (km^2)	Alongshore Excursion (km)	Source Volume (km^3)	PE_i	*Pm*
5-m currents					
7-Aug-99	0.15	95.0	14.25	0.00003	0.00172
27-Sep-99	0.15	142.6	21.39	0.00002	0.00115
17-Nov-99	0.15	129.1	19.37	0.00002	0.00126
7-Jan-00	0.15	62.6	9.39	0.00005	0.00261
27-Feb-00	0.15	81.6	12.24	0.00004	0.00200
18-Apr-00	0.15	107.8	16.16	0.00003	0.00152
8-Jun-00	0.15	76.4	11.46	0.00004	0.00214
Mean 5-m Flow P_m = 0.00177 *S.D.* = 0.00052					
10-m currents					
7-Aug-99	0.15	46.6	6.98	0.00007	0.00350
27-Sep-99	0.15	46.9	7.04	0.00007	0.00348
17-Nov-99	0.15	98.1	14.71	0.00003	0.00167
7-Jan-00	0.15	38.1	5.71	0.00008	0.00429
27-Feb-00	0.15	79.5	11.92	0.00004	0.00205
18-Apr-00	0.15	57.9	8.68	0.00006	0.00282
8-Jun-00	0.15	75.9	11.38	0.00004	0.00215
Mean 10-m Flow P_m = 0.00238 *S.D.* = 0.00079					

6.0 Impingement Impact Assessment

Organisms can be affected by intake facilities through impingement and entrainment. Impingement occurs when organisms too large to pass through the intake screens are retained on the screens, and entrainment occurs when organisms too small to be retained by the screens enter the cooling water system (CWS). The HBGS's traveling screens (equipped with 3/8-in. mesh openings) prevent juvenile and adult fishes and other large invertebrates from entering the plant's CWS (**Table 6-1**). These same traveling screens also prevent these organisms from reaching HBDF's seawater intake located on the discharge side of the HBGS's CWS. Therefore, there are no impingement concerns associated with the HBDF intake. However, organisms that pass through HBGS's 3/8-inch traveling screens openings, (entrained organisms), may also be present in the HBGS discharge cooling water at the location in the area of the HBDF intake, since it is located inside the HBGS cooling water discharge conduit. The HBDF intake flow must pass through the plant pretreatment system, which would consist of either sand filters (20 to 50-micron filtration media pore openings) or of microfiltration membranes (filtration media pore openings of 0.1 microns in diameter). Because the larvae size, which usually is 50 microns and larger, is larger than the filtration media pore openings, practically all of the larvae will be retained in the filter media and removed from the filters with the filter backwash water. Since the spent filter backwash is proposed to be conveyed the ocean, the biomass of source water larvae would ultimately be returned to the ocean with the filter backwash.

Table 6-1. Comparison of HBGS and HBDF intake systems.

	HBGS	HBDF
Type of intake	ocean intake	interconnects at HBGS discharge line
Intake velocity	2.0 fps*	0.25 – 0.5 fps
Trash rack (screens adult fishes)	3-inch (7.6 cm)	N/A
Fine screens (screens juvenile fishes)	3/8-inch (0.9 mm)	Sand or membrane filtration (screens larvae and plankton)

* Mean intake velocity—measured at inlet to conduit at Mean Lower Low Water (HBGS NPDES permit).

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APPENDIX A

Summary of Six-Month Data Report for the AES Huntington Beach Generating Station Entrainment and Impingement Study Submitted to the California Energy Commission on March 30, 2004

(MBC Applied Environmental Sciences and Tenera Environmental, 2004)

Introduction

In December 2000, AES Huntington Beach L.L.C. submitted its Application for Certification to the California Energy Commission (CEC) for the AES Huntington Beach L.L.C. generating station Retool Project (AES and URS 2000). The Entrainment and Impingement Study was designed and performed to satisfy Conditions of Certification BIO-4 and BIO-6 by estimating losses of fish and shellfish due to operation of the cooling water system of the Huntington Beach Generating Station (HBGS). The sampling methodologies and analysis techniques are derived from recent entrainment and impingement studies that have been done nationwide in the last 25 years to comply with Section 316(b) of the Federal Clean Water Act and more recently as part of the California Energy Commission CEQA process for permitting generating station modernization projects.

For the Huntington Beach entrainment study, the numbers of fish and shellfish entrained by the generating station are estimated from plankton samples collected just offshore of the intake structure. Samples collected at the entrainment station and at six other stations extending 4 km upcoast, downcoast, and offshore the intake structure, are used to estimate the source water populations at risk of entrainment. For the impingement study, impingement samples are collected from the screening facility within the generating station.

The target organisms for the study include fishes (all life stages beyond egg), and five invertebrate species: *Cancer* spp. (rock crab megalopal life stage), *Loligo opalescens* (market squid larvae), *Panulirus interruptus* (California spiny lobster phyllosoma larvae), *Sicyonia ingentis* (ridgeback prawn larvae), and *Emerita analoga* (sand crab larvae). Fishes, rock crabs, and sand crabs were chosen because of their respective ecological roles and because some of them are commercially or recreationally important. Market squid, California spiny lobster, and ridgeback prawn were selected because of their commercial and/or recreational importance in the area; these three species had the highest combined invertebrate biomass from 1999 through 2001 in the two CDFG catch blocks off Huntington Beach.

The organisms analyzed in the report were limited to those that were sufficiently abundant to provide reasonable assessment of impacts. For the purposes of this study, assessments were limited to the most abundant fish taxa that comprised 90 percent of all larvae entrained and/or juveniles and adults impinged by HBGS.

Study Methods Overview

Plankton sampling in the immediate proximity of the cooling water intake was conducted twice monthly in September and October 2003, and weekly from November 2003 through December 2003 (the last month of data presented in the interim report). During each sampling event, two replicate tows at the entrainment station were collected four times per 24-hr period--once every six hours. Sampling was conducted offshore (within 100 m) of the submerged intake structure using an oblique tow that sampled the water column from the surface down to approximately 13 cm off the bottom and then back to the surface. Two replicate tows were taken with a target sample volume of 30 to 40 m^3 for each net on the bongo frame. Larvae were sorted, identified, and enumerated in the laboratory.

Source water sampling was conducted monthly in September and October 2003, and twice per month thereafter during the peak spawning period for fishes in late winter and spring. Besides the entrainment station, source water sampling occurred at six additional source water stations located upcoast, downcoast, and offshore the intake structure (Figure A-1). Tows were performed in the same manner and with the same equipment as the entrainment tows.

The purpose of the impingement study was to determine the extent of potential impacts from the operation of the HBGS cooling water system on fishes and selected invertebrates that become drawn into the cooling water flow and trapped against the intake screens. There were two parts to the impingement study: normal operation sampling and heat treatment sampling. Samples collected during normal operations were used to characterize fish loss from the day-to-day operation of the generating station. Normal operations samples were collected over a 24-hr period to determine the daily loss from operation of the CWIS. Samples were also collected during heat treatment biofouling control operations, when waters within the CWIS were heated and essentially all fish and invertebrates succumbed to the high temperatures. Heat treatment procedures were carried out at approximately six- to eight-week intervals to control biofouling within the CWIS. Combined, normal operation and heat treatment samples were used to estimate the annual loss of juvenile and adult fishes and selected macroinvertebrates due to operation of the CWIS.

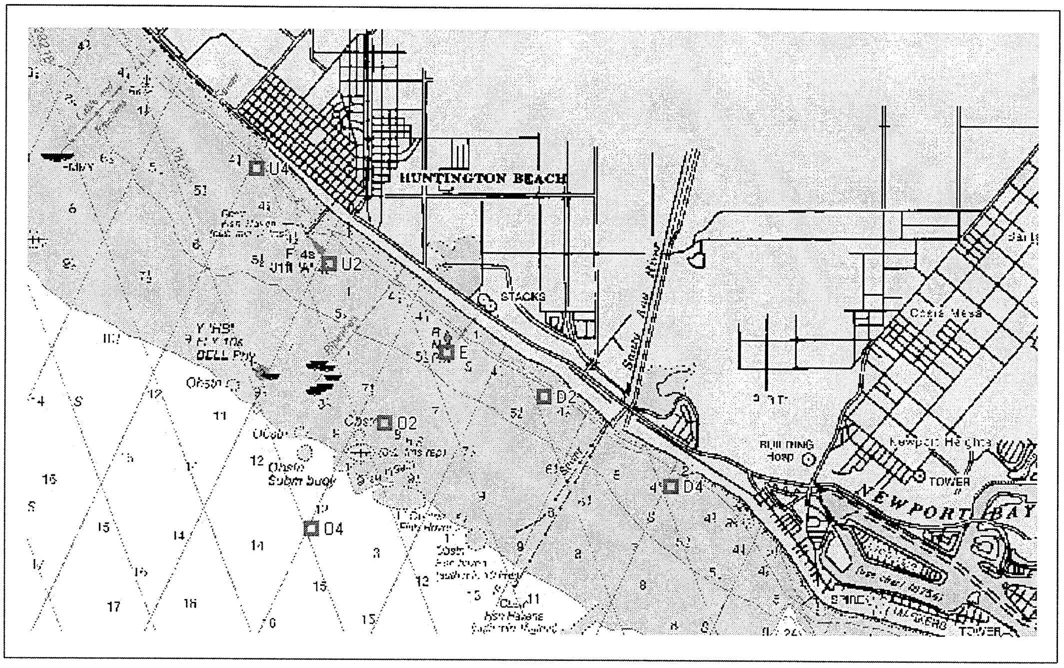

Figure A- 1. Location of HBGS plankton collection stations.

Results

Weekly Entrainment Abundance Estimates

A total of 957 fish larvae in 19 different taxonomic groups was collected during the 13 entrainment surveys completed during the September-December 2003 period (**Table A-1**). Three taxa comprised greater than 90 percent of the total larvae collected: CIQ gobies, northern anchovy, and white croaker.

The densities during each survey were used with an estimated total daily flow of 1,919,204 m^3 (507 MGD) to estimate a total entrainment for the period of over 51 million larvae (**Table A-1**). The largest concentrations of larvae were collected during one of the December surveys. There was also a noticeable drop in average concentration following the September and early October surveys. Larval fishes are generally at their lowest abundances during the fall months in the California coastal areas. Important commercial fishes such as California halibut and rockfishes were collected in very low numbers. Sand crabs were the only target invertebrate larvae entrained in any abundance, and these were in low concentrations overall.

Table A-1. Summary of larval fish taxa collected during 13 entrainment surveys from September through December 2003. A total flow of 234,142,888 m^3 for the period was used in estimating total entrainment.

Taxon	Common Name	Sample Count	Percent of Total	Cumulative Percent	Total Estimated Entrainment
Gobiidae unid.	CIQ gobies	588	61.4%	61.4%	33,724,385
Engraulis mordax	northern anchovy	197	20.6%	82.0%	9,765,747
Genyonemus lineatus	white croaker	89	9.3%	91.3%	3,948,839
Hypsoblennius spp.	blennies	24	2.5%	93.8%	1,093,130
Hypsopsetta guttulata	diamond turbot	15	1.6%	95.4%	679,022
14 other taxa		44	4.6%	100.0%	1,983,456
	Totals	**957**			**51,194,579**

Monthly and Semimonthly Source Water Abundance Estimates

A total of 2,622 fish larvae in 38 different taxonomic groups was collected during the 4 source water surveys completed during the September-December 2003 period (**Table A-2**). Although there were only four source water surveys completed, there were over twice as many taxonomic groups (38) collected in comparison to the 13 entrainment surveys. The pattern of abundances during the four surveys appears to show the same pattern seen in the entrainment results with lower concentrations of larvae in the late fall. Concentrations of the three most abundant fish taxa varied spatially among the seven sampling stations and temporally among months. The CIQ goby complex was generally more abundant at the inshore stations than the offshore stations in all months and also tended to be more abundant at the intake and downcoast stations.

Table A-2. Summary of larval fish taxa collected during four source water surveys from September through December 2003. Sample totals and mean densities were calculated from all seven stations, which includes entrainment Station E.

Taxon	Common Name	Sample Count	Percent of Total	Cumulative Percent	Mean Density (#/1,000m^3)
Gobiidae unid.	CIQ gobies	1,704	65.0%	65.0%	162.25
Engraulis mordax	northern anchovy	340	13.0%	78.0%	32.01
Genyonemus lineatus	white croaker	238	9.1%	87.0%	22.66
Hypsoblennius spp.	blennies	84	3.2%	90.2%	8.15
Hypsopsetta guttulata	diamond turbot	42	1.6%	91.8%	4.24
33 other taxa		524	8.2%	100.0%	
	Totals	**2,622**			

Impingement Sampling

A total of 24 normal operation impingement surveys were conducted from July 2003 to early January 2004, and five heat treatment impingement surveys were conducted through February 2004. Results from the weekly normal operation surveys were extrapolated based on cooling water flow, and summed with heat treatment results to estimate total impingement to date. A total of 32,550 fish representing 56 species and weighing nearly 831 kg were impinged, with most (89 percent) of the losses attributable to heat treatment operations. Queenfish (*Seriphus politus*) was the most abundant species impinged, accounting for 67 percent of total abundance. Other abundant fish species included shiner perch (*Cymatogaster aggregata*), northern anchovy, and white croaker. A total of 5,069 macroinvertebrates representing 28 species and weighing nearly 40 kg were impinged, with most (93 percent) of the losses occurring during to normal operations. The most abundant species were the nudibranch *Dendronotus frondosus*, yellow rock crab (*Cancer anthonyi*), and the sea jelly *Polyorchis penicillatus*.

Impact Assessment

CIQ gobies, northern anchovy, and white croaker were assessed using demographic modeling (Adult Equivalent Losses (*AEL*) and/or Fecundity Hindcasting (*FH*)) and the Empirical Transport Model (*ETM*). For the September-December period mean *AEL* estimates ranged from 37,037 individuals for CIQ gobies to 71,346 individuals for northern anchovy; no estimates were computed for white croaker because inadequate information was available on age-specific survival for later stages of development (**Table A-3**). Mean *FH* estimates ranged from 387 adult females white croaker to 22,541 adult females CIQ gobies for the four-month period.

Proportional mortality (P_m) caused by larval entrainment were estimated for a range of source water volumes, from the volume of water in the immediate vicinity of the seven source water sampling stations to 100 times that volume. Based on the larval duration of the target taxa, which ranged from 31 days (CIQ gobies) to about 42 days (northern anchovy), the source volume was likely considerably larger than ten times that of the sampling grid. P_m estimates based simply on the sampling grid volume ranged from 20 percent (white croaker) to 44 percent (northern anchovy). At 10 times the sampling grid volume, P_m estimates decreased to 2–6 percent, and at 20 times the sampling grid volume, P_m estimates were only 1–3 percent.

Table A-3. Summary of estimates for three measures of HBGS entrainment effects from September through December 2003 using modeled data. *ETM* calculations were based on a sampling grid volume of = 277,185,273 m^3, and daily circulating water volume = 1,919,204 m^3.

	AEL	*FH*	*ETM* lower	*ETM* upper
CIQ Gobies	37,037	25,430	0	0.0100
Northern Anchovy	71,346	6,325	0.00808	0.0168
White Croaker	–	318	0	0.0117

Discussion

The results presented in the report were collected during the first four months of a twelve-month entrainment study, and during the first six months of a twelve-month impingement study, and were therefore preliminary. The majority of larvae collected were spawned by species common in bays and estuaries nearby HBGS. The highest densities were generally recorded from the stations downcoast from the power station, which may indicate that the Talbert Marsh is the primary source for these larvae. While northern anchovy is a pelagic species, its larvae are found close to shore with peak densities from March through May. Preliminary findings were that the HBGS was not significantly impacting local populations of the fish larvae that were studied.

Since 1979, impingement from HBGS has been dominated by queenfish, and this was also the case in the present study. However, overall impingement abundances in the present study were higher than the annual impingement abundances since 1986. This was likely due to the higher flow volumes during the study (average 357 MGD) compared with previous years (average 236 MGD), but potentially related to the increased sampling frequency. All fish species impinged had been collected in previous years. Apart from a small species of dendronotid nudibranch, macroinvertebrate impingement was relatively low. Tuberculate pear crab and yellow rock crab were two of the more common invertebrates historically impinged at HBGS, and tend to peak in abundance in late spring and summer. The impinged individuals were largely juveniles with a collective impinged weight of less that 1 kg (2.2 lb) over the period.

APPENDIX B

Table B-1. Count and mean survey concentration (#/1,000 m^3) of larval fishes collected from HBGS's in-plant discharge flow from March 8 through July 22, 2004.[1]

			Survey -->	PRHBE001		PRHBS002		PRHBS003		PRHBS004		PRHBS005		PRHBS006		PRHBS007		PRHBS008		PRHBS009		PRHBS010	
			Start Date -->	03/08/04		03/22/04		04/05/04		04/27/04		05/11/04		05/25/04		06/10/04		06/22/04		07/07/04		07/22/04	
			Sample Count -->	N = 3		N = 35		N = 14		N = 18		N = 25		N = 21		N = 24		N = 17		N = 22		N = 24	
	Taxon	Common Name	Total Count	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.	Ct	Mean Conc.
1	CIQ goby complex	CIQ gobies	171	42	152.0	11	14.0	3	11.9	5	10.8	4	8.3	-	-	22	41.9	37	177.4	33	108.1	14	38.7
2	*Hypsoblennius* spp.	blennies	155	-	-	-	-	-	-	1	3.7	-	-	-	-	39	81.3	25	106.9	62	315.7	28	82.3
3	*Engraulis mordax*	northern anchovy	131	11	36.8	12	17.8	-	-	2	4.4	1	3.1	3	5.9	13	24.3	47	220.8	41	91.7	1	3.0
4	*Hypsypops rubicundus*	garibaldi	130	-	-	-	-	-	-	-	-	-	-	-	-	90	190.2	22	139.7	11	32.5	7	11.9
5	*Seriphus politus*	queenfish	98	-	-	-	-	-	-	-	-	-	-	-	-	2	3.2	5	27.8	87	238.5	4	10.9
6	Sciaenidae unid.	croaker complex	43	-	-	-	-	-	-	-	-	-	-	-	-	10	29.4	3	9.8	23	59.4	7	19.7
7	larval fish fragment	unidentified larval fishes	35	3	10.8	1	1.2	1	7.9	1	2.5	-	-	-	-	7	15.4	8	42.5	10	15.1	4	12.3
8	*Roncador stearnsi*	spotfin croaker	31	-	-	-	-	-	-	-	-	-	-	-	-	1	3.2	-	-	30	97.5	-	-
9	Atherinopsidae	silverside complex	25	-	-	9	9.7	14	45.1	2	4.4	-	-	-	-	-	-	-	-	-	-	-	-
10	*Clevelandia ios*	arrow goby	15	-	-	-	-	-	-	-	-	-	-	-	-	14	26.2	-	-	-	-	1	2.5
11	*Genyonemus lineatus*	white croaker	13	3	9.0	8	9.3	1	3.2	-	-	-	-	-	-	1	1.5	-	-	-	-	-	-
12	larval/post-larval fish unid.	larval fishes	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	7.4	5	7.5	3	11.4
13	*Ilypnus gilberti*	cheekspot goby	9	-	-	-	-	-	-	-	-	-	-	3	3.9	6	12.2	-	-	-	-	-	-
14	*Atherinopsis californiensis*	jacksmelt	8	7	26.4	-	-	-	-	1	3.1	-	-	-	-	-	-	-	-	-	-	-	-
15	Labrisomidae unid.	labrisomid kelpfishes	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	9.6	2	6.1
16	*Oxylebius pictus*	painted greenling	6	2	6.0	2	1.7	1	3.0	-	-	1	1.7	-	-	-	-	-	-	-	-	-	-
17	Engraulidae	anchovies	5	-	-	-	-	-	-	3	10.5	-	-	-	-	2	4.5	-	-	-	-	-	-
18	*Syngnathus* spp.	pipefishes	4	-	-	-	-	-	-	3	10.8	-	-	-	-	-	-	1	7.4	-	-	-	-
19	*Hypsopsetta guttulata*	diamond turbot	4	2	7.9	1	1.1	-	-	1	2.5	-	-	-	-	-	-	-	-	-	-	-	-
20	*Menticirrhus undulatus*	California corbina	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3.3	1	4.5	1	3.0
21	larvae, unidentified yolksac	unidentified yolksac larvae	3	-	-	-	-	-	-	-	-	-	-	-	-	3	9.0	-	-	-	-	-	-
22	*Paralichthys californicus*	California halibut	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	5.4	-	-
23	*Cheilotrema saturnum*	black croaker	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5.1	1	3.5
24	Blennioidei	blennies	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5.1	-	-
25	Cottidae unid.	sculpins	1	-	-	-	-	1	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	Sebastes spp.	rockfishes	1	-	-	1	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	*Gillichthys mirabilis*	longjaw mudsucker	1	-	-	-	-	1	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	*Atherinops affinis*	topsmelt	1	-	-	-	-	-	-	-	-	-	-	1	1.6	-	-	-	-	-	-	-	-
29	Clinidae unid.	clinid kelpfishes	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1.4	-	-	-	-	-	-
			915	**70**	**248.9**	**45**	**57.5**	**22**	**75.8**	**19**	**52.7**	**6**	**13.2**	**7**	**11.4**	**211**	**443.7**	**150**	**742.9**	**312**	**995.6**	**73**	**205.1**

[1] Individual species were kept separate when possible (e.g., cheekspot goby that could be positively identified were not listed under the CIQ goby category but were recorded in their own category).