

ATTACHMENT 5

Technical Memorandum

Assessment of the 2009 Flow Reduction of South Bay Power Plant Intake and Discharge Effects

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ABSTRACT

South Bay Power Plant (SBPP) is a four-unit, fossil-fueled, electrical generating facility owned by the Port of San Diego and operated by Dynegy South Bay, LLC. SBPP is located at the southern end of San Diego Bay from which it both withdraws and discharges the water it uses for once-through cooling of its steam condensers and a variety of smaller heat exchangers and ancillary equipment. Units 3 and 4 ceased operation and were decommissioned as of December 31, 2009. Units 1 and 2 will continue to run at least through the end of 2010 based on their Reliability-Must-Run status.

This report assesses the potential benefits in the reduction of cooling water intake and discharge flow accompanying the shutdown of Units 3 and 4. Results of detailed studies presented to the San Diego Bay Regional Water Quality Control Board on the SBPP thermal discharge and the impingement and entrainment effects of the intake (Tenera 2004a, Tenera 2004b) are used to (i) quantify reductions in impingement and entrainment effects and (ii) quantify the degree and extent of the thermal discharge plume from remaining Units 1 and 2.

As of January 1, 2010, the entrainment intake effects have been reduced by at least 63 percent and impingement effects have been reduced by 86 percent of the levels previously calculated based on assumed Plant operations at maximum generating capacity and cooling water flow rates. This reduction in maximum pumping capacity, accompanied by a 91 percent reduction in Plant capacity, qualifies the facility for an EPA 316(b) Phase II finding of “no significant entrainment” impact. Based on the results of the 2004 impingement study of each unit group, a

further 86 percent reduction in impingement is projected to have occurred as a result of the shutdown of Units 3 and 4 pumps. Impingement effects are also considered insignificant.

This report also assesses the reduction in both the size and temperature of the SBPP discharge plume based on continuous detailed receiving water temperature measurements of Plant operation when only Units 1 and 2 were running. To be conservative, periods of time when Units 1-4 were operating at maximum generating capacity and discharge volume were compared to periods when only Units 1 and 2 and their circulating water pumps were also operating at maximum capacity. Data for the comparison were obtained from the large number of thermal monitoring stations deployed during 2003 in the discharge channel and surrounding receiving water that gathered data for the SBPP 316(a) study (Tenera 2004a).

The current SBPP thermal plume that extends beyond the Plant's point of discharge at the property line is 63 percent smaller, and several degrees cooler and thinner, as a result of the shutdown of Units 3 and 4. The volume of the present thermal plume is 63 percent smaller, and the temperature is 4 to 5 degrees F cooler at the point of discharge. This lower temperature is not only significant in minimizing the potential for effects on receiving water biota but, in combination with the loss of the plume's flow and momentum, creates a thinner plume that is less likely to contact receiving water shoreline and bottom habitats. The lower temperature and smaller volume of the discharge plume from Units 1 and 2 provide increased assurance that existing discharge temperature limits are fully protective of the balanced, indigenous community (BIC) of fish, shellfish and other wildlife in the receiving waters.

1.0 INTRODUCTION

South Bay Power Plant (SBPP) is a four-unit, fossil-fueled, electrical generating facility owned by the Port of San Diego and operated by Dynegy South Bay, LLC. SBPP is located at the southern end of San Diego Bay from which it both withdraws and discharges the water it uses for once-through cooling of its steam condensers and a variety of smaller heat exchangers and ancillary equipment. Unit 1 began operations in 1960 followed by three additional units in 1962, 1964, and 1971. Under the California State Thermal Plan, the cooling water discharge from SBPP Units 1 through 4 is classified as an existing discharge. Units 3 and 4 ceased operation and were decommissioned as of December 31, 2009. It is assumed for the purposes of this assessment that Units 1 and 2 will continue to run at least through the end of 2010 based on their Reliability-Must-Run status.

The purposes of this report are to (i) summarize the conclusions of the most recent technical assessment of the thermal discharge from SBPP and the impingement and entrainment effects of the intake (Tenera 2004a, Tenera 2004b), and (ii) to quantify the reduction in impingement and entrainment effects that has occurred at the SBPP intake, as well as reductions in the potential effects of the thermal discharge both in terms of temperature and areal effects resulting from the shutdown of Units 3 and 4. Not only has there been an immediate 63 percent reduction in

impingement and entrainment effects, but a closer of examination of results from our 2004 year-long impingement study provides solid evidence of reductions in impingement effects of 86 percent and greater. This report also assesses the dynamics of the SBPP discharge plume for Units 1 and 2 by itself, particularly its extent and dispersal, based on periods of operation prior to December 31, 2009 when only these two units were running. The assessment is based our extensive receiving water temperature measurements during periods when only Units 1 and 2 were running. In so doing, we present contrasting scenarios of the thermal dynamics of the discharge plume during past operations with those anticipated for the period after December 31, 2009. To be conservative in the portrayal of the thermal plume, we have compared periods when all four units were at or near maximum generating capacity and discharge volume, with periods when only Units 1 and 2 and their circulating water pumps (CWP) were in operation and generation approached the maximum capable by those units. The time periods selected for comparison occurred during 2003 when a large number of thermal monitoring stations had been established to gather data for the SBPP 316(a) study (Tenera 2004a).

Based simply on the reduction in cooling water flow,¹ there was at least a 63 percent reduction in 2009 impingement effects with only Units 1 and 2 intake pumps operating at the time. In fact the actual reduction in SBBP impingement effects at the present time, based on our published impingement study results (see following Table 3) is at least 86 percent, an amount nearly achieving the EPA's impingement reduction standard contained in the now-vacated 316(b) Phase II Rule. This conclusion is proven in the following review of our 2004 findings.

The calculated annual intake flow for Units 3 and 4 represented 63 percent of the SBPP intake volume. Eliminating the total annual flow from these two units, as occurred in 2009, immediately reduced the estimated entrainment effects of the power plant by the same amount, 63 percent, an amount greater than that required by EPA's 316(b) Phase II Rule.

This document also provides a description of the SBPP, a description of our 2004 impingement and entrainment study methods and results, and an account of our thermal effects study monitoring stations and the methods, collection, and analysis of the 2003 receiving water temperature data.

¹The widely accepted impingement to flow relationship was relied upon to use the 63 percent reduction of intake from 2009 to 2010 to approximate a similar fractional reduction of the SBPP annualized impingement estimate reported for December 2002 to November 2003 (Tenera 2004b) for all units. More specifically, Tenera reported the estimated impingement for Units 1 and 2 separately from Units 3 and 4, making the assessment of an 86 percent reduction in impingement from 2009 to 2010 a similarly straightforward and accurate estimation.

2.0 PLANT DESCRIPTION

The South Bay Power Plant uses the waters of San Diego Bay for once-through cooling of its electric generating units. The generating capacities of the units range from 152 to 232 megawatts (MWe), making the total generating capacity of the facility 723 MWe (**Table 1**). Each unit is equipped with two circulating water pumps (CWP) that supply cooling water. CWP capacity varies between units, ranging from 148 m³/min to 259 m³/min (39,000 gallons per minute [gpm] to 68,400 gpm), based on the manufacturer's pump performance estimates. The quantity of cooling water circulated through the Plant is dependent upon the number of pumps in operation. With all eight pumps in operation, the cooling water flow through the Plant is 1,580 m³/min (417,400 gpm) (**Table 1**) or 2,275,000 m³/day (601 million gallons per day [mgd]). With the decommissioning of Units 3 and 4, the total generating capacity of the Plant has been reduced by 57 percent to 308 MWe. Total flow of the four remaining CWPs is 590 m³/min (156,000 gpm) or 849,600 m³/day (225 mgd), a reduction of 63 percent.

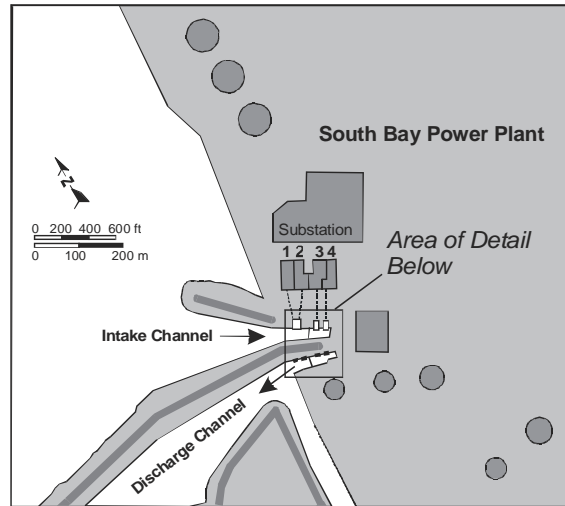
Table 1. South Bay Power Plant, generating capacity and cooling water flow by unit.

Unit	Gross Generation (MWe)	Total Flow per Unit (2 CWPs/Unit) (m ³ /min)	Total Flow per Unit (2 CWPs/Unit) (gpm)
1	152	295	78,000
2	156	295	78,000
3 (retired)	183	472	124,600 (prior to 12/31/2009)
4 (retired)	232	518	136,800 (prior to 12/31/2009)
Total Prior to 12/31/2009	723	1,580	417,400
Total as of 01/01/2010	308	590	156,000

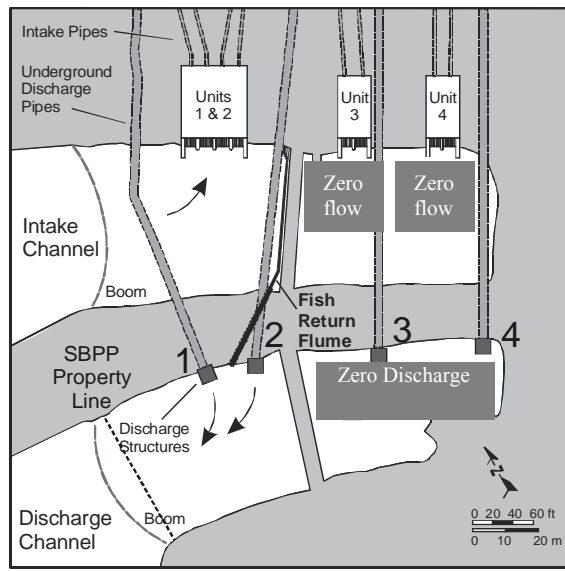
2.1 SBPP Intake

Cooling water is withdrawn from San Diego Bay via an intake channel that connects the SBPP with the southeast corner of the Bay (**Figure 1**). The intake channel is about 180 m (600 ft) in length, has a bottom width of about 60 m (200 ft) at its widest point, and tapers to 15 m (50 ft) width near the Unit 4 screenhouse. The maximum depth of the channel is approximately 5.4 m (17.7 ft) below mean lower low water (MLLW). The channel was constructed by dredging and diking operations during Plant construction in the early 1960s. Materials that were removed from the channel were used to form part of the Chula Vista Wildlife Island (CVWI), which separates the intake and discharge channels. Variations in water level due to tidal fluctuations range from a low of -0.7 m (-2.3 ft) to a high of +2.5 m (+8.2 ft) MLLW.

The cooling water intakes at the SBPP consist of three separate screenhouse structures for its four units. Units 1 and 2 share a single screenhouse structure while Unit 3 and Unit 4 each have individual screenhouses. The Unit 3 and Unit 4 screenhouses are no longer operational. As shown in **Figure 1**, water flow within the intake channel first approaches the screenhouse serving Units 1 and 2. The Unit 3 screenhouse is located an additional 40 m (131 ft) downstream, and the Unit 4 screenhouse another 28 m (92 ft) downstream, near the head of the channel.



Directly behind the screenhouses are the CWPs. Cooling water from the Units 1 and 2 CWPs exits the screenhouse via four 122 cm (48 in) diameter conduits that carry the flow approximately 61 m (200 ft) to the units' condensers. Intake conduits for Units 3 and 4 (one for each CWP and both of which are now blocked off) are 152 cm (60 in) in diameter, and 61 m long. At each of the condensers the cooling water is dispersed through several thousand thin-walled condenser tubes. Units 1 and 2, and former Unit 3, have dual-pass condensers that direct the cooling water through the condenser twice. The condenser for former Unit 4 was a single pass design.



Tubing material in the Unit 1 condenser is AL-6X, a stainless steel alloy; the other condensers are equipped with copper-nickel.

2.2 SBPP Discharge

Exhaust steam exiting the Plant's turbines passes over the exterior of the tubes in the condenser boxes where it is condensed by cool seawater water flowing through the tubes. The resulting condensate is pumped back to the Plant's boilers as part of the continuing steam cycle and the cooling water exits the condenser as heated effluent. The change in cooling water temperature (ΔT°) that occurs during passage through the condenser varies depending on a number of factors. Plant generating load and cooling water flow are the main factors affecting ΔT° . Flow can be reduced by condenser tube micro-fouling, tube blockage (caused by debris), and fluctuations in cooling water flow caused by tidal shifts or degradation of CWP performance.

Upon exiting the condensers, warmed cooling water from the two (formerly four) units is carried through discharge pipes about 137 m (450 ft) to the discharge basin located at the head of the discharge channel. The diameter of the discharge pipe for Units 1 and 2 is 183 cm (72 in) and 213 cm (84 in) for Units 3 and 4 (flow to these discharge pipes has been eliminated). The discharge channel originates on the side of the jetty, opposite the head of the intake channel. The discharge channel is defined in the SBPP NPDES Permit (CA0001368, Order 96-05, Finding 23) as “...the waters bounded by the jetty, a line extending from the southwesternmost end of the jetty to the eastern side of the mouth of the Otay River, the southern shoreline of San Diego Bay, and the shoreline of the discharge basin.” The SBPP discharge points are defined as the outlets of the cooling water discharge pipes.

2.3 Environmental Setting

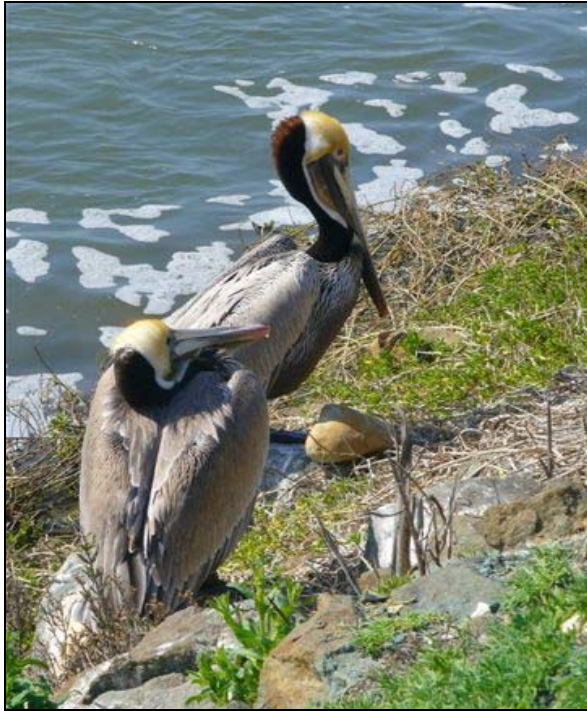
The SBPP intake and discharge channels and surrounding land is an area of south San Diego Bay rich in the abundance and diversity of wildlife. The Chula Vista Wildlife Refuge adjacent to SBPP is an artificially constructed peninsula that separates the intake and discharge areas of the power plant. The island itself was largely constructed from dredge spoils, and portions of the access causeway are armored with rock rip-rap to prevent erosion. Tidal inlets within the reserve form wetland areas, and adjacent areas provide seasonal habitat for several species of nesting shorebirds, including endangered California least terns *Sterna antillarum browni* and western snowy plovers *Charadrius alexandrinus nivosus*. Photographs of birds utilizing the area in the vicinity of the intake and discharge are provided below.

The nearby San Diego Bay National Wildlife Refuge protects a rich diversity of endangered, threatened, migratory, and native species and their habitats in the midst of the highly urbanized coastal environment near the SBPP. The Refuge manages nesting, foraging, and resting sites for a diverse assemblage of birds. It provides important habitat along the Pacific Flyway for migrating shorebirds and waterfowl to over-winter or stop to rest and feed. The refuge provides undisturbed expanses of cordgrass-dominated salt marsh that supports sustainable populations of light-footed clapper rail. Enhanced and restored wetlands provide new, high quality habitat for fish, birds, and coastal salt marsh plants, such as the endangered salt marsh bird's beak. Quiet nesting areas, away from adjacent urbanization, ensure the reproductive success of an array of ground nesting seabirds and shorebirds as well as the threatened western snowy plover and endangered California least tern.

Submerged lands in the south bay are also an important resting and feeding area for waterfowl migrating along the Pacific Flyway. Surveys by USFWS during 1993–1994 found almost 200,000 birds at a time utilizing the habitat available in the south bay (USFWS 1998). Common waterfowl include the surf scoter *Melanitta perspicillata*, scaup *Aythya* spp., black brant *Branta bernicla nigricans*, bufflehead *Bucephala albeola*, loons *Gavia* spp., and western grebe *Aechmophorus occidentalis*. Seabirds, such as gulls *Larus* spp. and cormorants *Phalacrocorax* spp., are also common in the area. Additionally, a number of listed (endangered and threatened) bird species, and species of special concern, have been observed in the south Bay. Bird species

in the area that are protected under state or federal law include the California least tern, western snowy plover, brown pelican *Pelecanus occidentalis*, peregrine falcon *Falco peregrinus*, and bald eagle *Haliaeetus leucocephalus*.

The discharge channel supports an abundance and diversity of fish species distinctly greater than found in the immediate areas of south San Diego Bay. Studies comparing fish populations living the SBPP discharge channel to other fish habitats in close proximity found a healthy fish community rich in species and with persistently high numbers of individuals (Tenera 2004a, b). It has been reasoned that many of the fish are attracted to the power plant's discharge flow and warmer temperatures during periods of cooler Bay water temperatures. The presence and abundance of fish that are prey species such as bay anchovy support local food webs and may contribute prey to the tern colonies and other wildlife in the SBPP intake and discharge.



Source: Dynegy, 2010.

3.0 2004 INTAKE EFFECTS STUDY

The purpose of the 2004 SBPP entrainment and impingement studies was to evaluate the potential impacts of the cooling water intake system as required under Section 316(b) of the Federal Clean Water Act (CWA). As part of this evaluation, an earlier 316(b) study conducted in 1979 (SDG&E 1980) was updated and information from the 2001 and 2003 entrainment and impingement studies was used by the San Diego Regional Water Quality Control Board in support of the NPDES permitting process for SBPP. Data on larval fishes, megalopal crabs, and larval spiny lobster collected near the SBPP intakes were used to estimate entrainment losses, while impingement losses were based on direct measurements of the abundance and biomass of fishes and selected macroinvertebrates retained on the SBPP intake screens.

3.1 Entrainment and Source Water Sampling

Entrainment and source water sampling was conducted monthly from January 2001 through January 2002 and bi-monthly from December 2002 through October 2003. This provided a complete year of data in 2001 (including January 2002) to describe seasonal differences in species abundances, and a comparison year in 2003 (including December 2002) to describe interannual variability. While the results from the second sampling were expected to confirm our initial entrainment assessment, it was recognized that the bi-monthly sampling would affect estimates for species with short larval durations that do not have extended spawning periods. The same set of entrainment and source water stations was sampled (**Figure 2; Table 2**) using the same methods during each study period. The first survey in January 2001 ended before all stations were sampled when the boat experienced mechanical problems. Data from this incomplete survey were not included in the analyses presented in this section.

3.1.1 Entrainment Sampling

Sample collection methods were similar to those developed and used by the California Cooperative Oceanic and Fisheries Investigation (CalCOFI) in their larval fish studies (Smith and Richardson 1977) but modified for sampling in the shallow areas of south San Diego Bay where depths can be less than 2 m (6.6 ft) during low tides. Entrainment samples were collected from a single station (SB1; **Figure 2**) located in the SBPP intake canal by towing a bongo frame with two 0.71 m (2.33 ft) diameter openings, each equipped with 335- μ m (0.013 in) mesh plankton nets and codends. The water volume filtered was measured by calibrated flowmeters (General Oceanics Model 2030R) mounted in the openings of the nets. Samples were collected over a 24-hour period, with each period divided into six 4-hour sampling cycles. Two replicate samples were collected at the entrainment station to improve the concentration estimate of entrained larvae. Concurrent surface water temperatures and salinity were measured at this station with a digital probe (YSI Model 30).

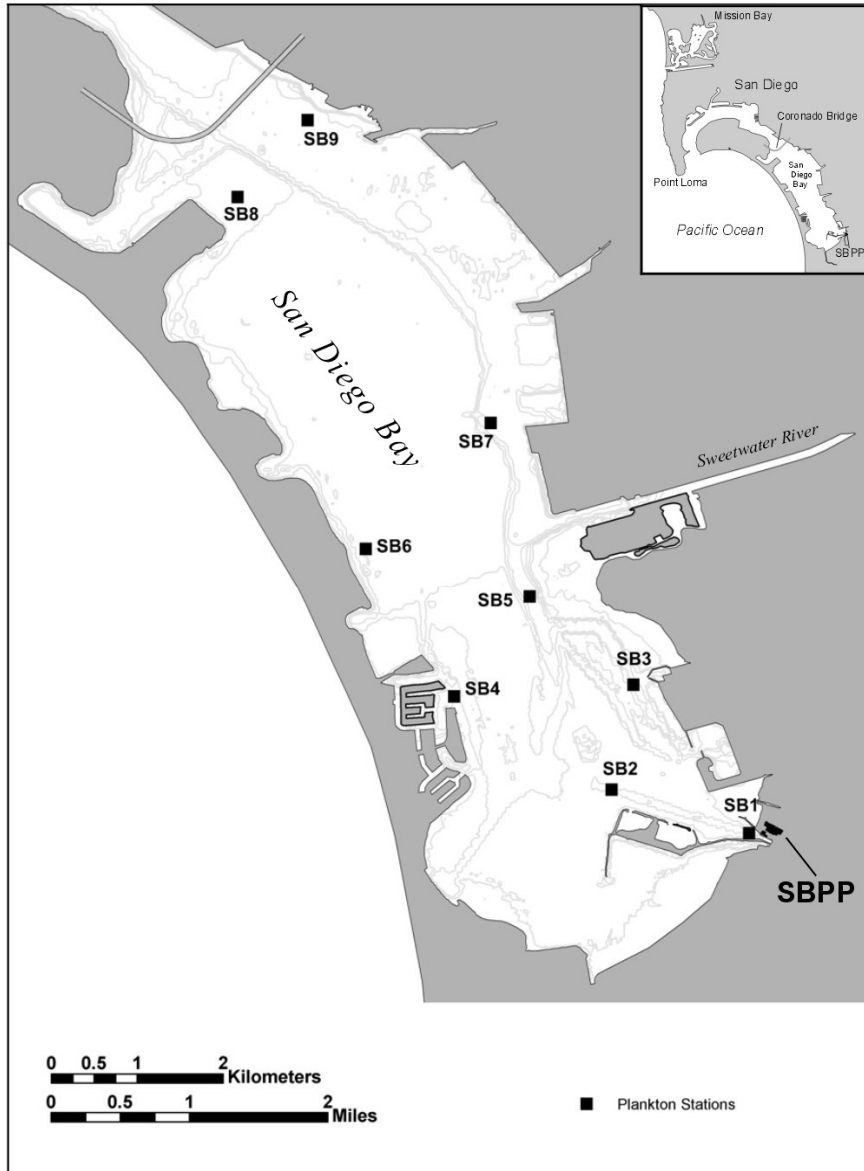


Figure 2. Location of 2001 and 2003 South Bay Power Plant entrainment (SB1) and source water plankton stations (SB2–SB9).

Source: Tenera Environmental. 2004b. Figure 3.2-1.

Table 2. Locations of entrainment (SB1) and source water (SB2–SB9) plankton stations.
*Station location also sampled in LES (1981) study.

Station	Latitude (N)	Longitude (W)	Depth below MLLW	
			meters	feet
SB1	32° 36.869'	117° 05.942'	3.0	10
SB2	32° 37.140'	117° 06.805'	3.7	12
SB3	32° 37.795'	117° 06.668'	4.9	16
SB4	32° 37.723'	117° 07.794'	4.0	13
SB5*	32° 38.347'	117° 07.320'	6.7	22
SB6	32° 38.649'	117° 08.350'	3.7	12
SB7	32° 39.437'	117° 07.565'	11.0	36
SB8*	32° 40.846'	117° 09.153'	1.5	5
SB9*	32° 41.326'	117° 08.714'	11.0	36

Source: Tenera Environmental. 2004b. Table 3.2-1.

At all stations, the bongo nets were lowered as close to the bottom as practical without contacting the substrate. Once the nets were near the bottom, the boat was moved forward and the nets retrieved at an oblique angle (winch cable at a 45° angle) to sample the widest strata of water depths possible at each station. The winch retrieval speed was maintained at approximately 0.3 m/sec (1 ft/sec). At the shallowest stations, the boat was moved forward before the nets were lowered into the water so that the codend did not contact the bottom prior to beginning the tow.

The targeted combined volume of water filtered by both nets was approximately 60 m³ (2,119 ft³). The sample volume was checked when the nets reached the surface. If the target volume was not collected, the tow was repeated until the targeted volume was reached. The nets were then retrieved from the water, and all of the collected material was rinsed into the codend. The contents of both nets were combined into one sample immediately after collection. The sample was placed into a labeled jar and was preserved in 10 percent formalin. Each sample was given a serial number based on the location, date, time, and depth of collection. In addition, the information was recorded on a sequentially numbered data sheet. The serial number was used to track the sample through laboratory processing, data analyses, and reporting.

3.1.2 Source Water Sampling

Samples were collected at eight source water stations in the south and south-central regions of San Diego Bay (**Figure 2**). The source water stations ranged in depth from approximately –2 m (–6.6 ft) MLLW at SB8 to –12 m (–39.4 ft) MLLW at SB9. The stations were stratified to

include four channel locations on the east side of the Bay and four shallower locations on the west side of the Bay. The station locations also included the three plankton tow stations sampled during the previous 316(b) studies in 1979–1980 (SDG&E 1980) (SB5 off Sweetwater River Marsh; SB8 near the U.S. Navy amphibious base; and SB9 in the navigation channel south of Coronado Bridge).

Source water sampling was conducted using the same methods and during the same time period described above for entrainment sampling with target volumes for the oblique tows of approximately 60 m³ (2-minute tow at approximately 1 knot). A single tow was completed at each of the source water stations during each of the six 4-hr cycles.

3.1.3 Data Analysis

Sample concentrations of larval fishes, *Cancer* crab megalopae, and spiny lobster larvae were computed by dividing the number of each taxon or species in each sample by the volume of water filtered. The mean survey concentrations for each taxon for the entrainment station (SB1) were calculated by averaging the two replicates during each cycle and then calculating an average concentration for the survey from the six cycles. The mean survey concentrations for the source water were calculated by averaging the data from the six cycles at each station and then averaging the concentrations from the eight source water stations (SB2–SB9).

Data were summarized for the impact assessment models using the mean survey concentrations as described above. Entrainment estimates for each survey were computed by multiplying the mean concentration of larval fishes at Station SB1 times the maximum daily cooling water intake system (CWIS) flow rate of 2,275,244 m³ (601,056,000 gal). Entrainment for each survey period was estimated by multiplying the daily entrainment estimate by the number of days in each survey period (ca. 30 days for the ‘2001’ study period and about 60 days for the ‘2003’ study period). These survey period entrainment estimates were summarized over each of the two study periods to determine the annual entrainment estimates used in the data summaries and demographic (*AEL*² and *FH*³) modeling approaches.

The estimates of total entrainment for the two study periods were used in two demographic models and one impact assessment model. The demographic models (*AEL* and *FH*) use

² The Adult Equivalent Loss (*AEL*) approach uses an estimate of the abundance of entrained or impinged organisms to forecast the loss of an equivalent number of adults. The approach requires survival estimates (had the larvae not been entrained) from entrainment to an age at recruitment to the adult population. In addition to life history information, the *AEL* model requires estimates of total entrainment for the study period and the average age of the larvae at entrainment.

³ The Fecundity Hindcast (*FH*) approach combines larval entrainment losses with adult fecundity to estimate the adult female reproductive output eliminated by entrainment, assuming no compensatory reserve of the population. *FH* requires an estimate of survival for egg and early larval stages for the time period up to entrainment. The fact that *FH* only requires survivorship for the few days that the eggs or larvae are vulnerable to entrainment is an advantage of this approach over the *AEL* model that requires survival data from the average age at entrainment (a few days) through adult recruitment (up to a few years).



information on the life history of the target organisms to calculate the numbers of female adult (through use of the *FH* model) or adult fishes (through use of the *AEL* model) represented by the entrainment losses. Both models translate larval entrainment mortality into adult fish losses, which are familiar units to resource managers. The impact assessment model (*ETM*)⁴ requires an additional level of field sampling to characterize the abundance and composition of source water larval populations. The fractional loss to the source water population represented by entrainment is provided by estimates of proportional entrainment for each survey that can then be expanded to predict regional effects on appropriate adult populations. Detailed computational descriptions of this methods and *AEL* and *FH* are found in Tenera (2004b).

3.1.4 Results

The relative species abundance of larval fish collected in the 2001 and 2003 entrainment studies are illustrated in **Figure 3**. Percent composition of entrained species varied little between the two years, but for the influx of anchovy in 2001 and their relative influence on the combined abundance of entrained larval fishes. The annual concentrations of larval fishes were remarkably similar among species. For example, similar concentrations of larval gobies (CIQ complex) in source water and entrainment samples in 2001 and 2003 are illustrated in **Figure 4**.

⁴ The empirical transport model (*ETM*) has been proposed by the U.S. Fish and Wildlife Service to estimate mortality rates resulting from cooling water withdrawals by power plants (Boreman et al. 1978, and subsequently in Boreman et al. 1981) as an alternative to the demographic models. The *ETM* model provides an estimate of incremental (a conditional estimate in absence of other mortality; Ricker 1975) mortality imposed by SBPP on local San Diego Bay larval populations by using empirical data (plankton samples) rather than relying solely on hydrodynamic and demographic calculations.

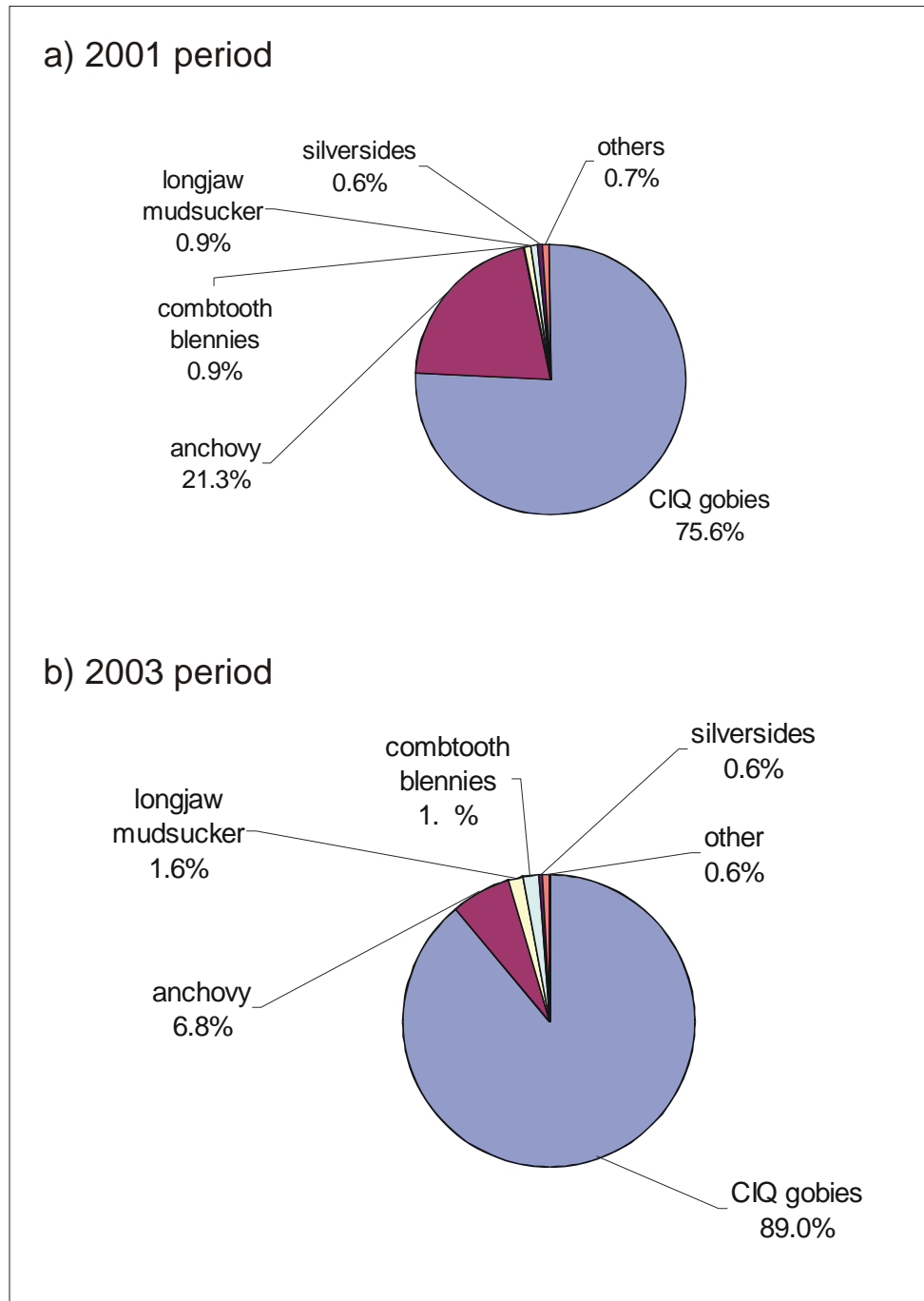


Figure 3. Percent composition of estimated total entrainment for a) 2001 period and b) 2003 period. The percentages for the taxa comprising the top 99 percent of the total estimated entrainment are listed while the remaining taxa are combined into ‘others’.

Source: Tenera Environmental 2004b, Figure 3.3-3.

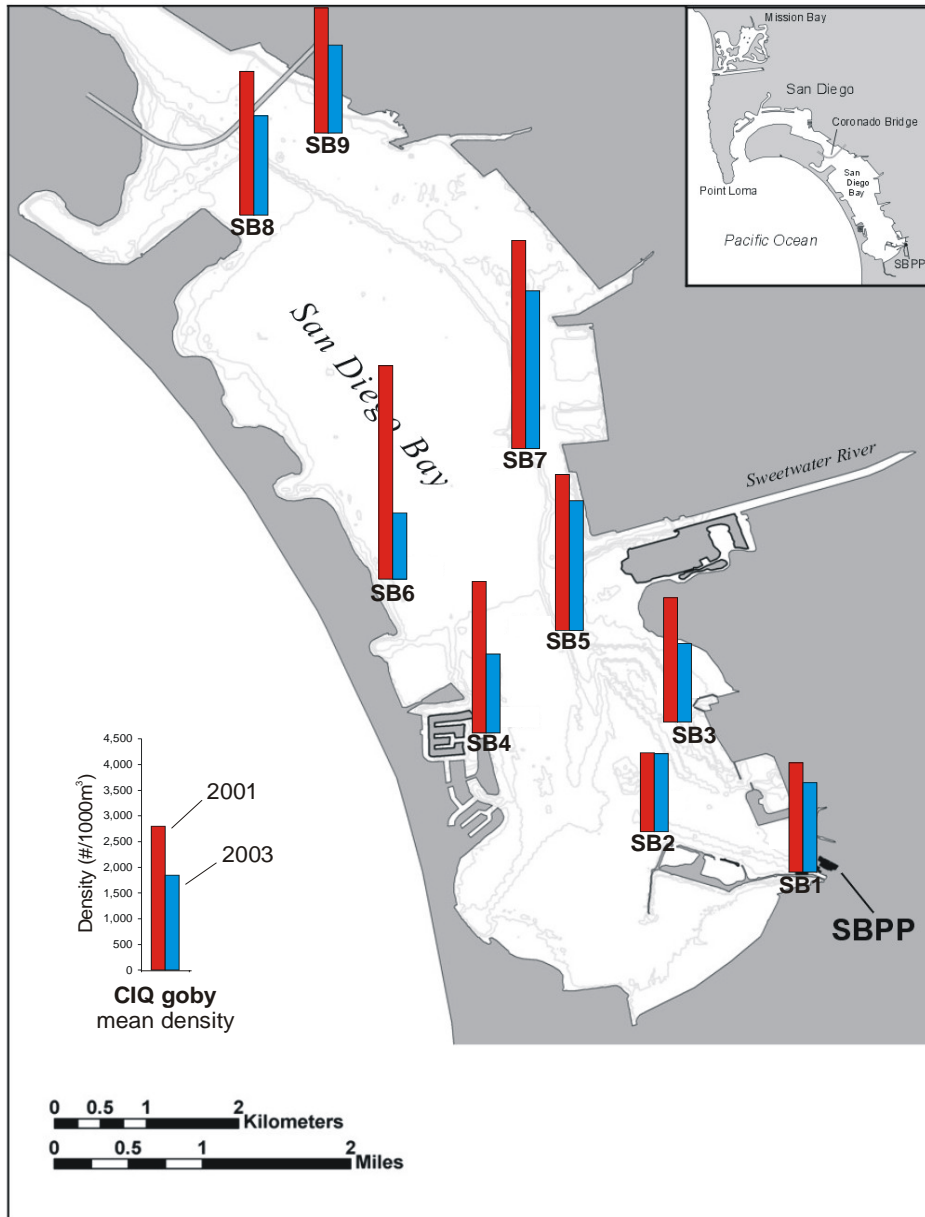


Figure 4. Annual mean concentration ($\#/1,000\text{ m}^3$) of CIQ goby complex larvae at entrainment station (SB1) and source water stations.

Source: Tenera Environmental 2004b. Figure 3.3-9.

It should also be noted that most fish populations, including bay goby, are unaffected by natural mortality as high as 90 percent in the larval stage. In other words, even if the SBPP were not withdrawing water from south San Diego Bay, up to 90 percent of the larvae would be expected to die before recruitment to the adult population. *ETM* estimates of entrainment, which assume a stable population and no compensation, represent an extremely conservative comparison to the NMFS guidelines for sustainable harvest rates that are based on recruited adult stocks after natural compensation has already occurred. Although large numbers (in absolute terms) of larvae are entrained, *ETM* estimates of entrainment mortality using extremely conservative assumptions show that the entrained larvae represent a fraction of their source water population that is well below a removal rate required to sustain their adult populations even without compensation. The life history of component species in the community must be considered when discussing potential effect to the populations. Although the study focused on species potentially affected by entrainment and impingement processes, it is important to note that several fish species in south San Diego Bay have early life stages that are not susceptible to these processes. Live-bearers, such as surfperches, some sharks, and some rays, produce young that are fully developed and too large to be affected by entrainment. Live-bearers together comprise nearly 40 percent of the fish biomass in the Bay (Allen 1999). Another common species in south San Diego Bay, striped mullet, also is not susceptible to entrainment because it spawns offshore and only the juveniles and adults subsequently utilize the Bay habitat.

3.2 Impingement Sampling

Impingement sampling at SBPP was conducted during a 24-hr period one day each week from December 5, 2002 through November 26, 2003. Each sampling period was divided into six approximately 4-hr cycles. In almost every survey throughout this study all eight circulating water pumps (two per unit) were operated during the entire 24-hr sampling period. Before each weekly sampling effort, all of the screens were rotated and rinsed clean of all impinged material. A trap door in the screen wash trough was then opened so that all impinged material would fall into a collection basket. The collection baskets used during this study were the same ones used in the earlier impingement study and were constructed from stainless steel and had ¼ inch diameter holes. During each cycle the traveling screens remained stationary for a period of approximately 3.5 hr, and were then rotated and rinsed for 30 min. This rinse period allowed the entire traveling screen to be rinsed of all material that had been impinged since the last screen wash cycle. In a few instances during impingement collections, the screen wash system started automatically due to a high differential pressure prior to the end of the cycle. The material that was rinsed from the screens during the automatic screen washes was combined with the material collected at the end of that cycle. All debris and organisms rinsed from the Units 1 and 2 traveling screens were kept separate from the material from the Units 3 and 4 traveling screens.

All fishes and selected macroinvertebrates collected at the end of each 4-hr cycle were removed from the debris and then identified and counted. Individual weights and lengths of bony fishes and sharks and rays were recorded (standard length [SL] for the bony fishes and total length [TL] for the sharks and rays). Any mutilated fishes were identified, if possible, and the total weight recorded by taxa. No length measurements were recorded for mutilated fishes. Carapace width was measured for crabs and total length was measured for shrimps and cephalopod mollusks. Weight was also recorded for these invertebrates. Other invertebrates, including hydroids, anemones, sea jellies, barnacles, worms, brittlestars, bryozoans, tunicates, gastropods, and bivalves, were not enumerated or weighed but were only recorded as present when found in the impinged material.

3.2.1 Data Analysis

The circulating water flow during each of the six cycles of the 24-hr impingement surveys was calculated by multiplying the total time each pump had operated during each cycle (generally 4 hr) by the pump's manufacturer-rated flow. Each unit has two pumps with the following flow rates: Units 1 and 2 pumps—148 m³/min /pump (39,000 gpm), Unit 3 pumps—236 m³/min/pump (62,300 gpm), and Unit 4 pumps—259 m³/min/pump (68,400 gpm). In the few instances when the traveling screen was not operational during sampling, the water flow for that pump was not added into the total for that cycle, as impinged organisms were not collected from that screen. The circulating water flow rate for each cycle (obtained from the Plant's operator pump logs showing which pumps were operating and manufacturer's rated flow for each operating pump) was then used to calculate an average daily impingement rate and associated standard error per volume of circulating water for each taxa for the two unit pairs (Units 1 and 2 or Units 3 and 4).

Although many of the impinged fishes were juveniles, for analysis purposes it was assumed that they were all adults and that none of the impinged organisms survived.

3.2.2 Results

A total of 50,970 fishes weighing a total of 74 kg (163 lb) and comprising approximately 50 taxa was impinged during the 12-month study (**Table 3**). The vast majority of the collected fishes (over 93 percent) were anchovies (*Anchoa* spp.). The next most common fishes were silversides Atherinopsidae (mainly topsmelt *Atherinops affinis*), pipefishes *Syngnathus* spp., California halfbeak *Hyporhamphus rosae*, specklefin midshipman *Porichthys myriaster*, gobies Gobiidae, and round stingray *Urolophus halleri*. The wet weight biomass was also dominated by anchovies (39.9 percent) followed by round stingray, specklefin midshipman, bat ray *Myliobatis californica*, and silversides.

The estimated total annual abundance of impinged fishes at SBPP was 385,588 based on continuous flow of all eight circulating water pumps for an entire year (**Table 3**). The estimated annual biomass of impinged fishes was 556.2 kg (1,226.4 lb). The intake screen wash system for Units 1 and 2 at SBPP is separate from that of Units 3 and 4, and impingement data were recorded separately for each of the two unit groups. About 80 percent of the total abundance and 86 percent of the total biomass of fishes was impinged at Units 3 and 4 (**Table 3**).

Table 3. Summary of SBPP Units 1-4 fish impingement from December 2002 through November 2003 for 52 24-hr surveys and extrapolated to 365-day impingement total.

Taxon	Common Name	Sampled Abundance			Extrapolated Annual Impingement			
		(#)	(kg)	(lb)	(#)	Std. Err.	(kg)	Std. Err.
<i>Anchoa</i> spp.	anchovies	47,746	29.53	65.12	359,420	105,476.2	222.01	58.62
Atherinopsidae	silversides	1,293	2.72	6.00	11,664	8,106.0	25.69	36.39
<i>Syngnathus</i> spp.	pipefishes	433	0.32	0.71	3,218	642.2	2.35	0.51
<i>Hyporhamphus rosae</i>	California halfbeak	361	0.43	0.95	2,765	722.6	3.21	1.05
<i>Porichthys myriaster</i>	specklefin midshipman	253	9.23	20.35	1,850	665.3	66.16	48.90
Gobiidae	gobies	241	0.17	0.37	1,791	420.2	1.25	0.42
<i>Urolophus halleri</i>	round stingray	203	16.46	36.29	1,532	490.6	124.57	45.56
<i>Cymatogaster aggregata</i>	shiner surfperch	77	0.28	0.62	549	216.2	2.24	1.71
<i>Strongylura exilis</i>	California needlefish	63	1.37	3.03	510	330.1	11.73	13.76
<i>Cynoscion parvipinnis</i>	shortfin corvina	60	1.57	3.46	428	178.3	10.93	9.85
<i>Hypsopsetta guttulata</i>	diamond turbot	54	0.63	1.38	382	197.8	4.52	4.20
<i>Fundulus parvipinnis</i>	California killifish	26	0.03	0.06	191	107.8	0.20	0.14
<i>Myliobatis californica</i>	bat ray	24	4.40	9.70	172	102.2	30.97	19.91
<i>Hippocampus ingens</i>	Pacific seahorse	23	0.19	0.42	165	83.1	1.27	1.41
<i>Heterostichus rostratus</i>	giant kelpfish	22	0.20	0.45	163	87.4	1.43	1.08
<i>Seriphys politus</i>	queenfish	21	0.52	1.15	152	91.0	3.66	6.10
<i>Acanthogobius flavimanus</i>	yellowfin goby	10	<0.01	0.01	73	73.2	0.03	0.03
<i>Gymnura marmorata</i>	California butterfly ray	8	1.46	3.21	56	48.8	10.37	11.07
<i>Leptocottus armatus</i>	Pacific staghorn sculpin	6	0.03	0.07	58	59.8	0.27	0.39
unidentified fish	unidentified fish	6	0.01	0.03	42	48.5	0.09	0.13
<i>Cololabis saira</i>	Pacific saury	6	0.01	0.02	42	39.1	0.05	0.06
Pleuronectidae	flounders	6	0.01	0.01	56	81.7	0.05	0.07
<i>Sardinops sagax</i>	Pacific sardine	4	0.15	0.33	28	42.0	1.05	1.86
<i>Porichthys notatus</i>	plainfin midshipman	4	0.15	0.32	28	34.3	1.03	2.50
<i>Paralabrax</i> spp.	sand basses	3	1.60	3.52	24	34.7	13.06	19.29
<i>Gillichthys mirabilis</i>	longjaw mudsucker	3	0.04	0.08	24	35.0	0.27	0.39
<i>Pleuronichthys</i> spp.	turbots	3	<0.01	0.01	21	51.7	0.02	0.05
Sciaenidae	croakers	3	<0.01	<0.01	26	35.7	0.01	0.01
<i>Mugil cephalus</i>	striped mullet	2	1.50	3.31	14	24.2	10.50	25.72
<i>Cynoscion nobilis</i>	white seabass	2	0.09	0.21	14	24.2	0.65	1.56
<i>Engraulis mordax</i>	northern anchovy	2	0.01	0.01	16	28.3	0.05	0.10
<i>Lepidogobius lepidus</i>	bay goby	2	<0.01	<0.01	14	24.2	0.01	0.01
<i>Cheilotrema saturnum</i>	black croaker	1	0.46	1.01	7	17.1	3.22	7.89
<i>Dasyatis brevis</i>	diamond stingray	1	0.42	0.93	7	17.1	2.94	7.21
<i>Paralichthys californicus</i>	California halibut	1	0.01	0.03	7	17.1	0.09	0.21
Blenniidae	combtooth blennies	1	0.01	0.03	5	11.3	0.06	0.14
<i>Tridentiger trionocephalus</i>	chameleon goby	1	0.01	0.02	9	21.7	0.09	0.23
<i>Gibbonsia</i> spp.	clinid kelpfishes	1	<0.01	0.01	9	20.0	0.03	0.07
<i>Hypsoblennius</i> spp.	combtooth blennies	1	<0.01	0.01	7	17.1	0.02	0.05
<i>Pleuronichthys ritteri</i>	spotted turbot	1	<0.01	<0.01	7	17.1	0.01	0.03
<i>Porichthys</i> spp.	midshipmans	1	<0.01	<0.01	7	17.1	0.01	0.02
<i>Albula vulpes</i>	bonefish	1	<0.01	<0.01	7	17.1	0.01	0.02
<i>Lepidopsetta bilineata</i>	rock sole	1	<0.01	<0.01	7	17.0	0.01	0.02
Stichaeidae	pricklebacks	1	<0.01	<0.01	7	17.1	<0.01	0.01
larval/post-larval fish	larval/post-larval fish	1	<0.01	<0.01	7	17.3	<0.01	0.01
<i>Pleuronectiformes</i>	flatfishes	1	<0.01	<0.01	6	14.6	<0.01	<0.01
TOTAL		50,984	74.03	163.23	385,588		556.18	
% impingement total from Units 1-2		20.3	14.4					
% impingement total from Units 3-4		79.7	85.6					

Source: Tenera Environmental 2004b. Table 4.3-1.

3.3 Conclusion

Overall, the 2004 316(b) assessment relied on a synthesis of results from modeling the effects of larvae removed from the system through entrainment and juveniles and adults removed from the system through impingement. In both cases, estimated losses were calculated using the following set of conservative assumptions that would result in the greatest projected effects on a target species:

- all entrainment and impingement loss estimates were calculated based on maximum design cooling water flows, although actual cooling water withdrawals will be reduced by at least 63 percent due to the shutdown of Units 3 and 4, and further reduced due to the reduced capacity factors that are anticipated throughout the remainder of 2010;
- entrainment modeling assumed no survival of larvae through the cooling water system, yet entrainment survival has been documented in numerous studies;
- no density-dependent compensatory effects were included in the models that would result in increased survivorship for later life-stages not subject to CWIS effects; and
- estimated economic losses of impingement fishery species were scaled up to assume that all impinged individuals represented fishes of adult size potentially lost to the fishery, without applying projected mortality rates to the impinged juveniles.

Overall, our conclusions were consistent with those from the earlier 316(b) study done in 1979–1980 (SDG&E 1980), namely that the operation of SBPP does not substantially affect populations of the most abundant or economically important fishes and invertebrates in San Diego Bay. Studies by Allen (1999) found that slough anchovy comprised over half of the fishes by number in the south-central and south ecoregions of San Diego Bay. Results from the present study show that, at historical maximum flow rate of 601 MGD, SBPP may account for a loss of approximately 8–10 percent of the larval population annually and represent an equivalent loss of approximately 1–2 percent of the adult standing stock. Another major group of fishes in the Bay affected by entrainment was the CIQ goby complex, with larval losses estimated at 21–27 percent of the source water population. Prior to 2009 and the decommissioning of Units 3 and 4, using the most conservative assumptions, the SBPP CWIS may account for losses from 1.2 to 2.2 million adult CIQ gobies per year out of an estimated standing stock of over 10 million. Subsequently without Units 3 and 4, the losses would be no more than approximately 0.450 to 0.820 million adult CIQ gobies per year, and less by the amount of cooling water flow other than 24/7 operations. For the invertebrate species investigated, there were no substantial direct effects of the CWIS on their populations. Particularly for species with commercial fishery importance, such as lobsters, crabs, and squid, the results indicate that SBPP would not affect the adult populations of these species.

Gobies, one of the most abundant groups of entrained fish larvae, are not susceptible to impingement as adults because they are bottom-dwelling species that typically not found in the water column. Even fish species that swim in the water column are generally not susceptible to

impingement effects as they mature because they are able to swim against the slow approach velocity of the cooling water inflow. For example, at the SBPP intakes it was not uncommon to see small schools of adult striped mullet swimming directly in front of the intakes and not being impinged during times when circulating water pumps were operating.

4.0 REANALYSIS OF 2003 THERMAL DISCHARGE EFFECTS STUDY RESULTS

4.1 Field Data Collection

Twenty-one subtidal and ten intertidal temperature-monitoring stations were established in the vicinity of the SBPP in 2003 (Table 4 and Figure 5). The majority of the stations were clustered around the power plant's intake and discharge channels to record the magnitude and distribution of the discharge plume. Several far-field stations were also established further to the north beyond the influence of the plume. The proximity of the stations to the power plant's discharge ranged from approximately 65 m (328 ft) to nearly 5 km (3 mi) (Table 5). These distances are estimates of the shortest flow-paths between the SBPP discharge and each monitoring station, not linear measurements between the points. Eleven of the subtidal stations (those designated A, C, D, E, F, or N) were placed at locations that were part of the ongoing NPDES receiving water monthly monitoring program for SBPP. All of the intertidal stations and the remaining ten subtidal stations (those designated R or T) were established at new locations that were concentrated around the intake and discharge channels. All of the temperature recorders were initially deployed on July 15–16, 2003.

Each of the subtidal stations was equipped with an array of three temperature recorders deployed below a buoy (Figure 6). One recorder was located just below the surface of the water, one at a depth of 1 m (about 3 ft), and one just above the sediment-water interface. The position of the upper two recorders, relative to the water's surface, remained constant regardless of tide height. The bottom recorder's position was fixed and the depth separating the recorder from the surface changed with the tides. The depth at which the bottom recorder was located also varied between stations, depending upon the position of the station within San Diego Bay. Subtidal station depth ranged from 0.4 m (1.2 ft) below MLLW (Station SR4) to 4.2 m (13.9 ft) below MLLW (Station SA3). Each of the intertidal stations was equipped with a single, fixed-position temperature recorder. The elevation of all ten intertidal recorders was approximately 0.3 m (1.0 ft) above MLLW. As such, the recorders were exposed to air during some low tide conditions. Air temperatures were deleted from the temperature database during data processing.

All of the monitoring stations were equipped with Stowaway Tidbit[®] temperature recorders manufactured by the Onset Computer Corporation. The units had a recording range from -5–37°C (24–99°F), were accurate to $\pm 0.2^\circ\text{C}$ ($\pm 0.4^\circ\text{F}$), and were programmed to synchronously record temperatures at 10-minute intervals. The recorders closest to the discharge were replaced in early September 2003 with similar instruments that had a range of -20–50°C (-4–122°F) and were accurate to $\pm 0.4^\circ\text{C}$ ($\pm 0.8^\circ\text{F}$). All recorders were calibrated and each was checked to verify its operability and accuracy after it was retrieved and the data were downloaded.

Table 4. Locations of subtidal (S series) and intertidal (I series) temperature stations. Subtidal stations consisted of a surface, 1-m (3.3 ft) subsurface, and bottom temperature recorder (see **Figure 5a**). *Intertidal stations were at a fixed elevation of 0.3 m (1.0 ft) above MLLW (see **Figure 5b**).

Station	Latitude (N)	Longitude (W)	Depth below MLLW*	
			meters	feet
SUBTIDAL				
SA3	32° 37.780'	117° 07.136'	4.2	13.8
SC3	32° 37.211'	117° 07.149'	2.3	7.5
SD4	32° 37.109'	117° 06.884'	1.4	4.6
SE3	32° 36.863'	117° 07.143'	1.1	3.6
SE4	32° 36.866'	117° 06.858'	1.3	4.3
SE5	32° 36.785'	117° 06.603'	1.7	5.6
SE7	32° 36.801'	117° 05.930'	1.7	5.6
SF2	32° 36.566'	117° 07.482'	0.4	1.3
SF3	32° 36.621'	117° 06.971'	1.4	4.6
SF4	32° 36.552'	117° 06.852'	1.8	5.9
SN2	32° 38.201'	117° 07.704'	2.0	6.6
SR1	32° 36.988'	117° 06.392'	3.1	10.2
SR2	32° 37.013'	117° 06.480'	2.2	7.2
SR3	32° 37.070'	117° 06.650'	2.6	8.5
SR4	32° 37.143'	117° 06.364'	0.9	3.0
SR5	32° 37.238'	117° 06.401'	0.4	1.3
ST1	32° 36.792'	117° 06.005'	2.0	6.6
ST2	32° 36.777'	117° 06.141'	2.0	6.6
ST3	32° 36.772'	117° 06.254'	1.6	5.2
ST4	32° 36.723'	117° 06.430'	1.9	6.2
ST5	32° 36.825'	117° 06.788'	2.0	6.6
INTERTIDAL				
IR1	32° 36.955'	117° 06.438'	+0.3	+1.0
IR2	32° 36.984'	117° 06.547'	+0.3	+1.0
IR3	32° 37.018'	117° 06.683'	+0.3	+1.0
IR4	32° 37.131'	117° 06.217'	+0.3	+1.0
IR5	32° 37.223'	117° 06.257'	+0.3	+1.0
IT1	32° 36.816'	117° 06.006'	+0.3	+1.0
IT2	32° 36.799'	117° 06.144'	+0.3	+1.0
IT3	32° 36.777'	117° 06.288'	+0.3	+1.0
IT4	32° 36.741'	117° 06.403'	+0.3	+1.0
IT5	32° 36.853'	117° 06.804'	+0.3	+1.0

Source: Tena Environmental 2004a. Table 2.

Table 5. Distance of subtidal (S series) and intertidal (I series) temperature stations from the SBPP discharge boom (property line). Distances are the shortest drift path to the station from the Plant discharge. Order of stations reflects increasing distance.

Station	Drifter distance from discharge boom	
	meters	feet
SUBTIDAL		
SE7	65	213
ST1	181	594
ST2	396	1,299
ST3	572	1,877
ST4	857	2,812
SE5	1,150	3,773
ST5	1,445	4,741
SF4	1,591	5,220
SF3	1,817	5,961
SE3	2,294	7,526
SE4	2,305	7,562
SF2	2,624	8,609
SD4	2,728	8,950
SR3	2,805	9,203
SC3	2,938	9,639
SR2	3,089	10,135
SR1	3,234	10,610
SR4	3,272	10,735
SR5	3,301	10,830
SA3	4,017	13,179
SN2	4,917	16,132
INTERTIDAL		
IT1	182	597
IT2	362	1,188
IT3	621	2,037
IT4	833	2,733
IT5	1,475	4,839
IR3	3,345	10,974
IR2	3,570	11,713
IR1	3,742	12,277
IR5	3,999	13,120
IR4	4,038	13,248

Source: Tenera Environmental 2004a. Table 3.

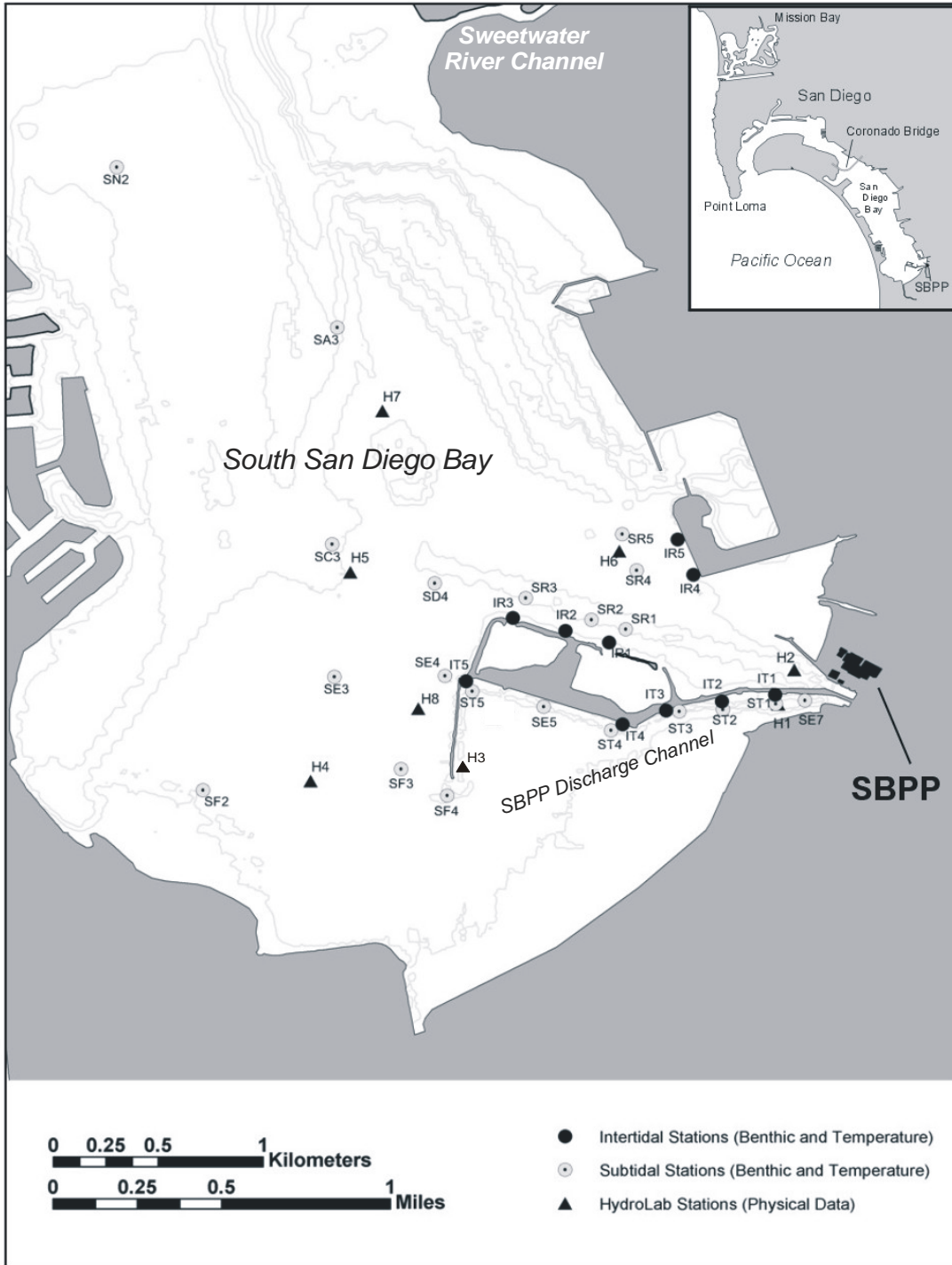


Figure 5a. Station location map of intertidal and subtidal thermal monitoring stations.

Source: Tena Environmental 2004a.

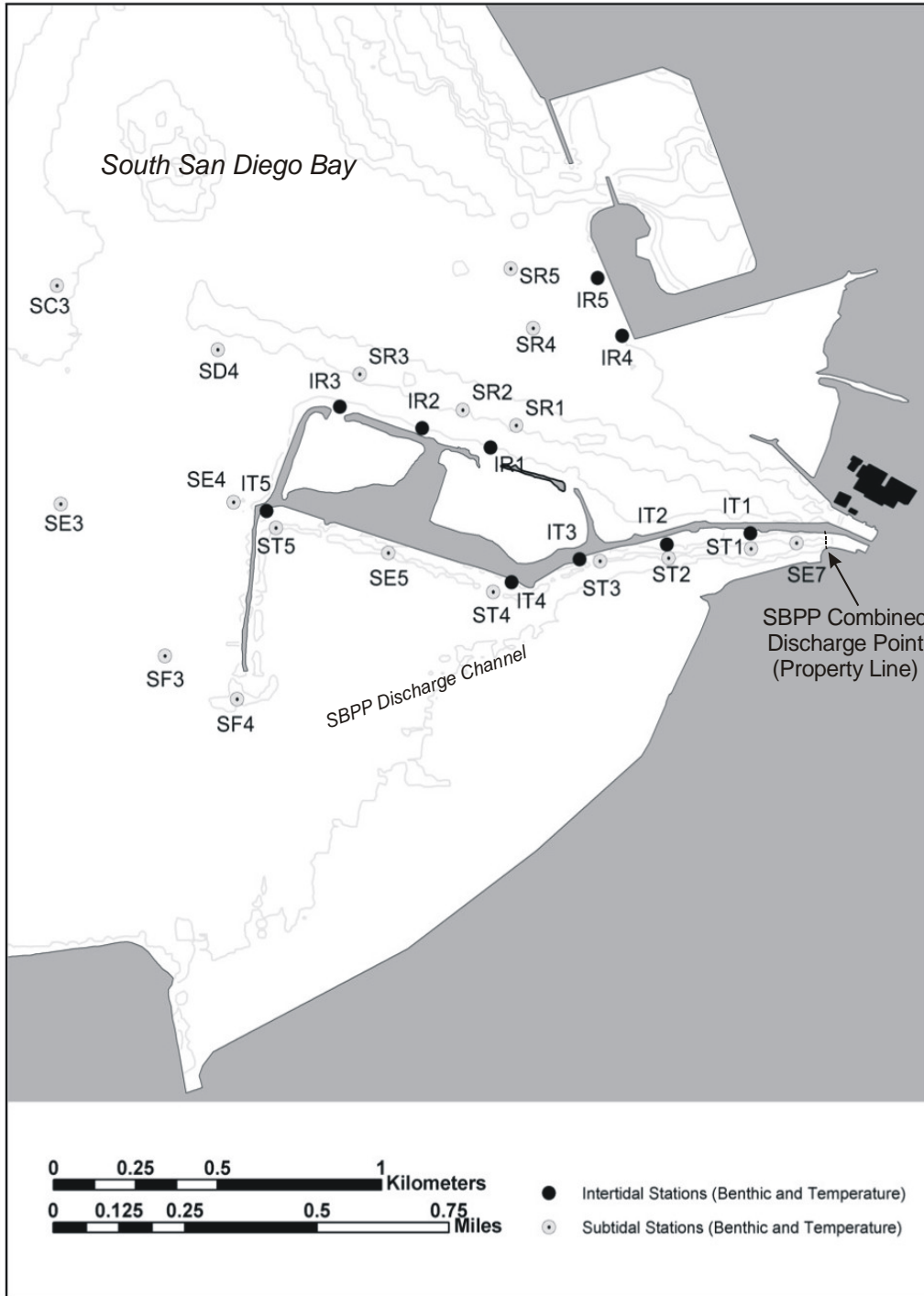


Figure 5b. Station location map of intertidal and subtidal thermal monitoring stations.

Source: Tenera Environmental 2004a.

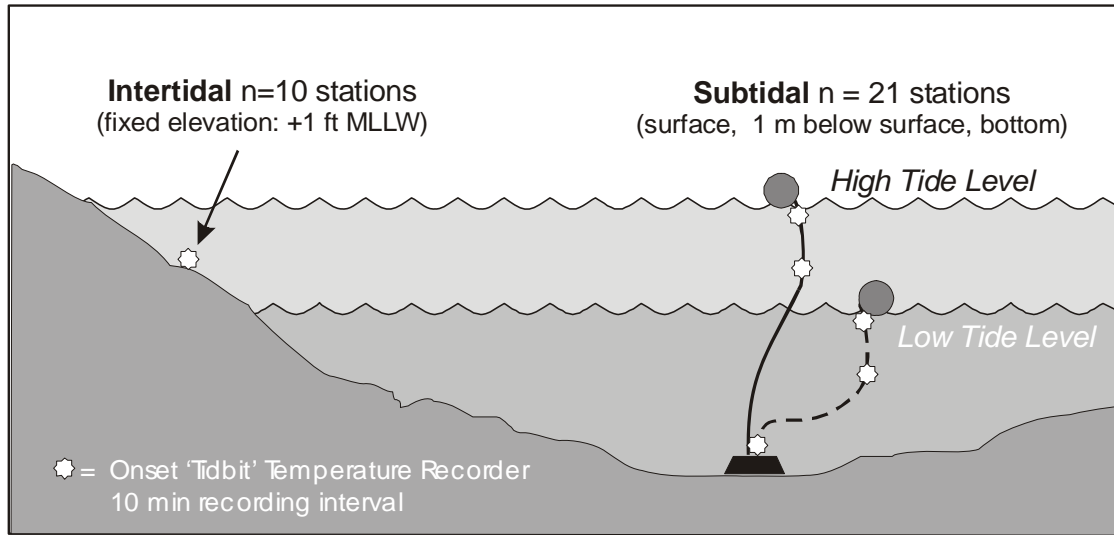


Figure 6. Diagram of intertidal and subtidal temperature arrays in relation to tidal elevation and channel morphology.

Source: Tenera Environmental 2004a.

4.2 Data Analysis

For the purpose of this comparison eight days were selected from the July–November 2003 thermal monitoring period that fell into three different Plant operation categories. The three operating categories were:

- A) Four unit operation with high Plant generation output and high discharge volume (conditions approaching the four unit maximum of 723 MWe and 25.0 mgh);
- B) Two unit operation (Units 1 and 2) with high Plant generation output and high discharge volume (conditions approaching the two unit maximum of 308 MWe and 9.4 mgh);
- C) Two unit operation (Units 1 and 2) with Plant generation output at about 2/3 of maximum with full discharge volume (about 200 MWe and 9.4 mgh).

Categories A and B are representative of the maximum operating conditions prior to and after December 31, 2009. The days falling into these categories that were selected for this document were July 16, 2003, September 5, 2003, October 21, 2003, and October 28, 2003 (Category A), and October 10, 2003, October 14, 2003, and November 5, 2003 (Category B) (**Figure 7**). Category C conditions are representative of a regularly occurring operating condition for which the data collected on September 29, 2003 were selected (**Figure 7**).

Data analysis was limited to those time periods when the Plant was operating at, or near, the conditions described above. Only those data collected while the delta T calculated at the SBPP property equaled or exceeded 4.5 degrees C at the surface monitoring level were included (**Table 6**).

Table 6. Data analysis periods (property line delta T ≥ 4.5° C) on the dates selected for comparison.

Start of Data Analysis Period	End of Data Analysis Period
July 16, 2003 10:40	July 17, 2003 00:20
September 5, 2003 07:20	September 5, 2003 22:30
September 29, 2003 09:00	September 29, 2003 20:00
October 10, 2003 09:30	October 10, 2003 23:50
October 14, 2003 05:20	October 14, 2003 23:50
October 21, 2003 08:30	October 21, 2003 22:00
October 28, 2003 00:00	October 28, 2003 23:50
November 5, 2003 08:30	November 5, 2003 23:50

Data source: Tena Environmental 2004a.

Statistical analysis for comparing the eight periods (**Table 6**) and the units' conditions followed that used in the previous SBPP 316(a) study. The difference in temperature, or delta T°, between the reference stations and discharge stations was calculated for each of the synoptic 10 min readings. For intertidal stations, the mean reference temperature was calculated from the readings taken at Stations IR1, IR2, and IR3, and was subtracted from the readings taken at the same time at each of the intertidal stations. For subtidal stations, temperature readings from Stations SR1, SR2, and SR3 were used as reference. The mean of the three stations was calculated for each of the monitoring depths (surface, -1 meter, and bottom), for each 10-min reading. In the 316(a) study a paired t-test of the daily mean reference and SBPP intake temperatures found no significant difference between the two.

Linear regressions were fit to delta T° at each 10 min. Temperature as a function of distance *x* from the discharge were fit to stations within 2,800 m (9,186 ft) from the discharge boom (about the distance to the first reference station). The synoptic mean temperatures at the reference stations (T_{SR}) used in calculating station delta T° (*i.e.*, SR1, SR2, and SR3) were not included in regressions,

$$\text{Model : } \left(T - \frac{\sum_{i=1}^3 T_{SRi}}{3} \right) = a + b x + \dots$$

The mean and standard deviation of the regressions' a and b parameters were calculated for the eight periods. These means and standard deviations were used to test the hypothesis that the plume differed between conditions A, B and C. For example, a significantly smaller intercept in the B condition with similar slope would indicate a significantly reduced thermal plume when only Units 1 and 2 are operating.

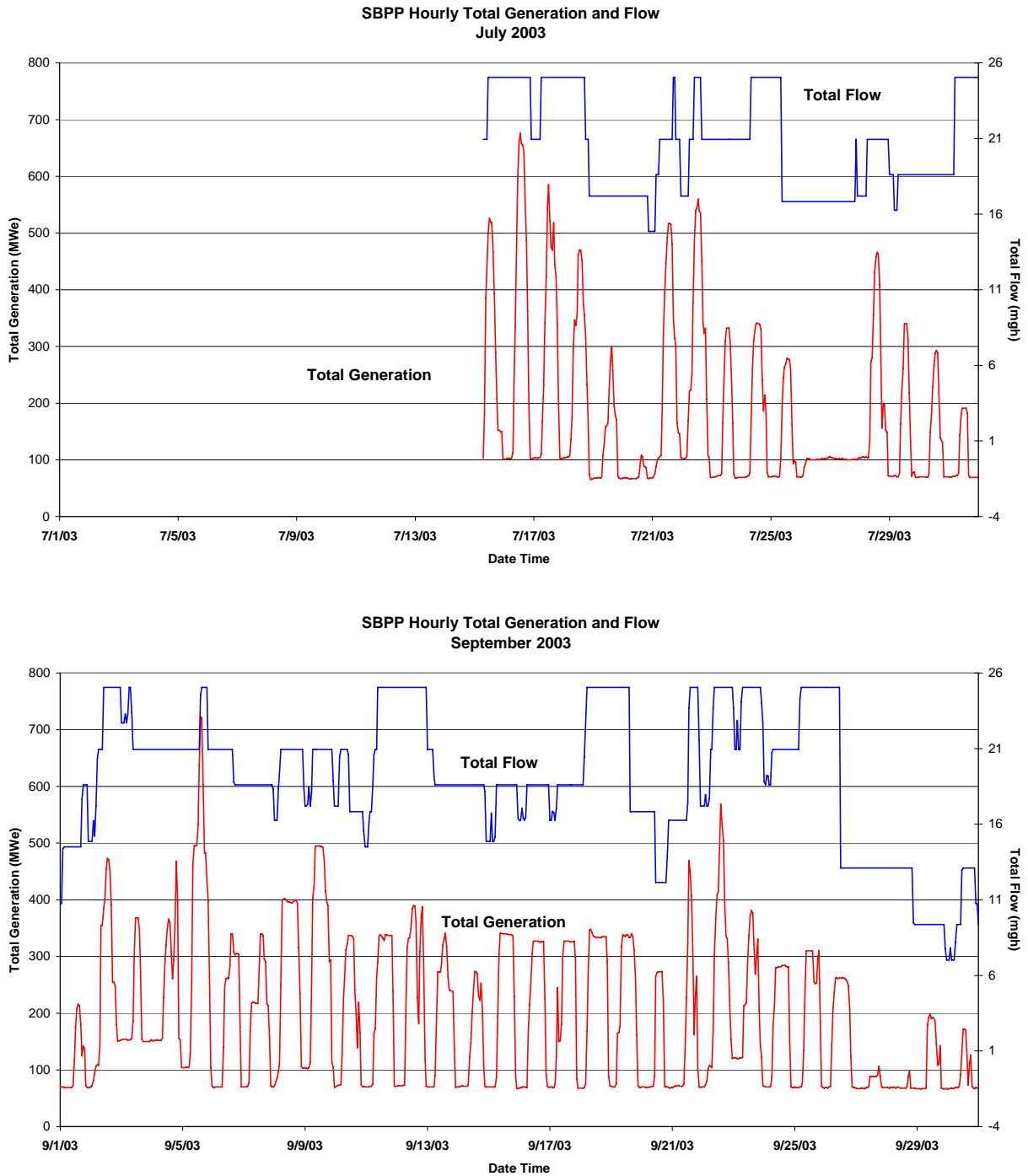


Figure 7a. Averaged total Plant output (MWe) and Plant discharge volume (mgd) calculated hourly for July 15-31, 2003 and September 2003. Thermal Monitoring stations were established on July 15&16, 2003.

Source: Tena Environmental 2004a. Figure 4a.

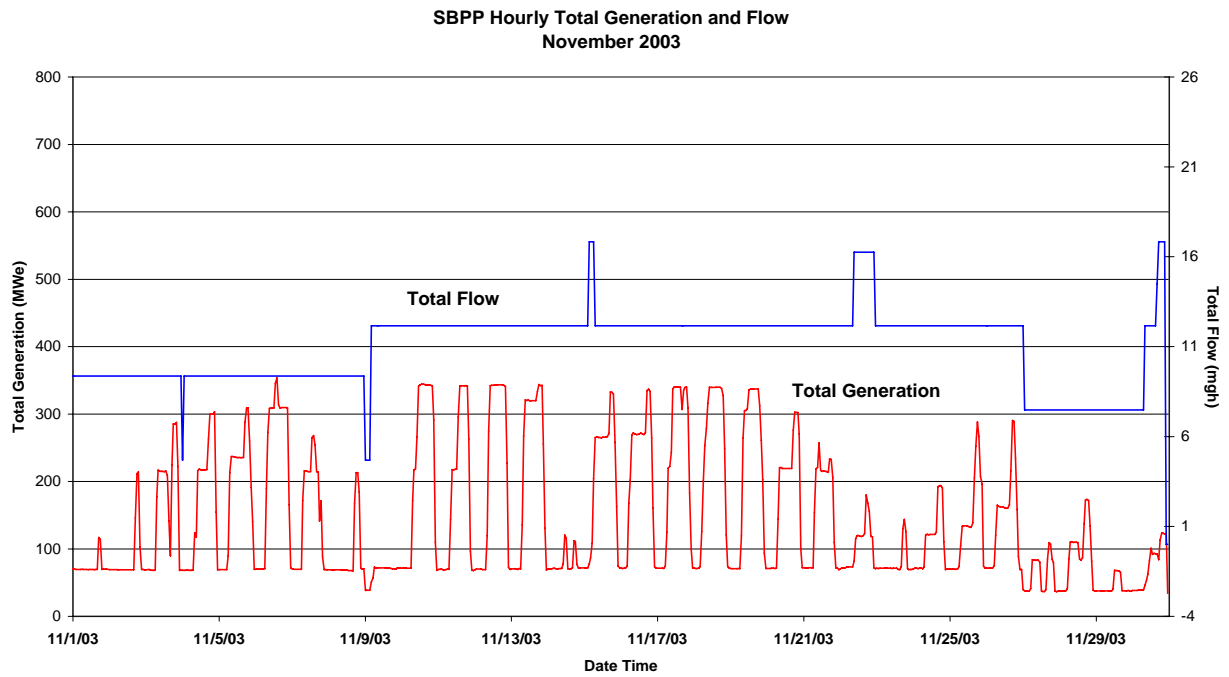
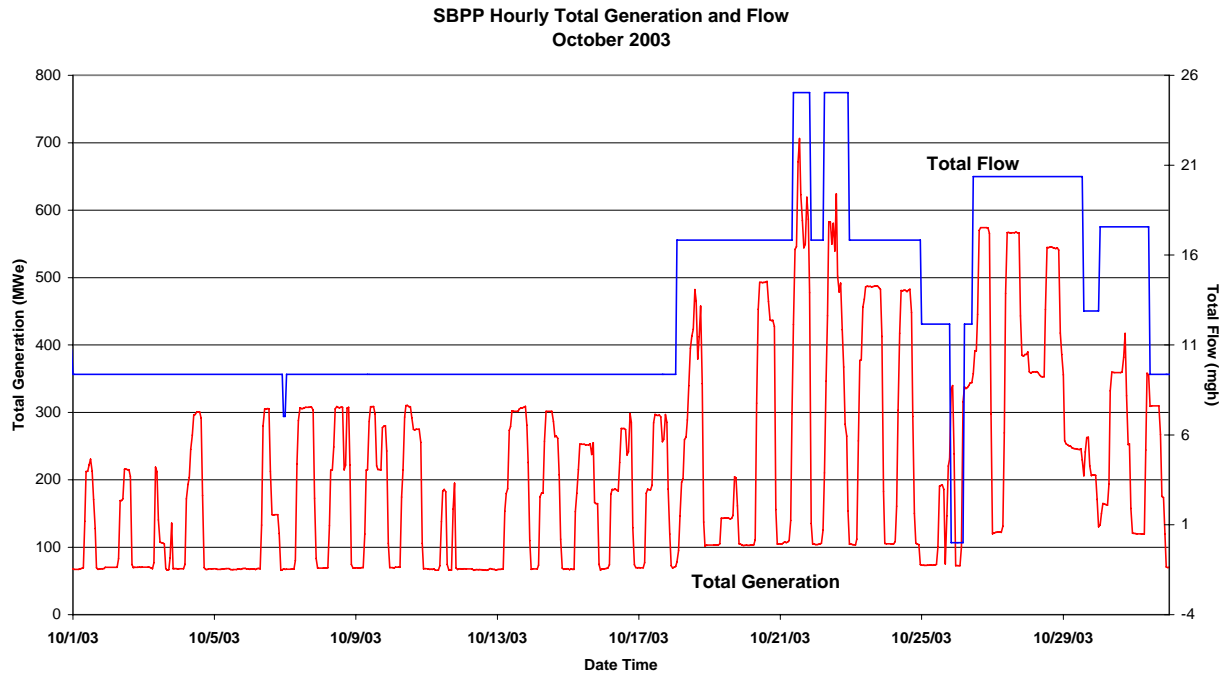


Figure 7b. Averaged total Plant output (MWe) and Plant discharge volume (mgh) calculated hourly for October and November 2003.

Source: Tena Environmental 2004a. Figure 4b.

4.3 Results

Figure 8 shows a three dimensional view of one of the 10-minute readings made about one hour after peak output for the four periods when all units were operating. **Figure 9** shows similar views for the four periods when only Units 1 and 2 were operating. **Figure 10** shows enlarged views when only Units 1 and 2 were operating (November 5, 2003) and when Units 1, 2, 3 and 4 were operating (September 5, 2003). Operating conditions for the eight analysis periods are summarized in **Table 7**.

Table 7. Mean, minimum and maximum power generation and pump flow in periods for data analysis (property line surface model $\Delta T \geq 4.5^\circ\text{C}$) of temperature plume assessment.

Analysis Period (start, end)	Mean MWe	Max MWe	Min MWe	Mean Flow (mgh)	Max Flow (mgh)	Min Flow (mgh)
7/16/2003 10:40 7/17/2003 00:20	437.0	678.9	101.2	24.5	25.0	20.9
9/5/2003 07:20 9/5/2003 22:30	488.8	726.0	104.1	22.5	25.0	20.9
10/21/2003 08:30 10/21/2003 22:00	525.5	706.2	104.5	24.0	25.0	16.8
10/28/2003 00:00 10/28/2003 23:50	436.4	545.5	352.8	20.4	20.4	20.4
10/10/2003 09:30 10/10/2003 23:50	244.7	310.5	67.8	9.4	9.4	9.4
10/14/2003 05:20 10/14/2003 23:50	209.5	301.7	67.3	9.4	9.4	9.4
11/5/2003 08:30 11/5/2003 23:50	230.5	309.3	69.7	9.4	9.4	9.4
9/29/2003 09:00 9/29/2003 20:00	156.1	200.4	67.2	9.4	9.4	9.4

Data source: Tenera Environmental 2004a.

Delta T° calculations made for each of the readings taken at 10-minute intervals during each period were used for estimating linear regression parameters *a* (intercept) and *b* (slope) for each 10-minute interval. The regression slope intercept *a* estimates a discharge delta T near the property line and the slope *b* is a measure of the rate of temperature decrease with increasing distance from the SBPP discharge.

Tables 8 to 11 summarize the regression parameters corresponding to three operating conditions in periods when the model property line delta T was greater than 4.5°C. **Figures 11 to 14** depict the regressions for all conditions and plume levels. At the surface, the mean intercepts (model property line delta T) over the selected periods were 8.61°C (n=401, condition A: all units operating), 7.76°C (n=292, condition B: Units 1 and 2 operating) and 5.82°C (n=67, condition C: Units 1 and 2 operating at 2/3 capacity). Means slopes from the surface model were -3.23°C/km (condition A), -2.99°C/km (condition B) and -2.22°C/km (condition C). One meter below the

surface, the mean intercepts were less than on the surface: 7.70°C (condition A), 6.50°C (n=292, condition B) and 4.80°C (condition C). Means slopes from the subsurface model were also reduced: -3.10°C/km (condition A), -2.57°C/km (condition B) and -1.87°C/km (condition C). On the bottom, the mean intercepts were less than the subsurface: 5.48°C (condition A), 3.79°C (n=292, condition B) and 2.39°C (condition C). Means slopes from the bottom model were also reduced: -2.12°C/km (condition A), -1.33°C/km (condition B) and -0.69°C/km (condition C).

In the intertidal region, the mean intercepts (model property line ΔT) over the selected periods were 7.73°C (n=393, condition A: all units operating), 6.62°C (n=275, condition B: Units 1 and 2 operating) and 4.42°C (n=43, condition C: Units 1 and 2 operating at 2/3 capacity). Means slopes from the intertidal model were -3.50°C/km (condition A), -3.14°C/km (condition B) and -2.64°C/km (condition C).

The probability that the regression models' means of parameters differed was tested using an analysis of variance (ANOVA). **Table 12** presents the ANOVA test results. In addition to testing if differences occurred in the total grouping (conditions A, B, and C), *a priori* comparisons were made in A versus B and B versus C. The results showed differences in the surface plume property line intercept, including a 0.066 probability of rejecting the hypothesis that the conditions with all units running is the same than with Units 1 and 2 running a full capacity. Slopes were not rejected as being similar ($Pr > F = .2754$). This can be interpreted as the surface plume is reduced by about 1° C. The difference is even greater when comparing all units to 2/3 capacity on Units 1 and 2. All comparisons of parameters in the subsurface layer showed probabilities less than 0.05. At that probability level one cannot say that the plume is similar at all conditions examined. The subsurface plume at the property line is smaller when Units 1 and 2 are operating and even smaller with reduced capacity. The rate of change becomes steeper with all units operating and indicates that convergence between conditions occurs at lower ΔT temperatures in the farfield. On the bottom there was no difference detected between the two conditions if Unit 1 and 2 operations, however the similarity to all units running is rejected. The plume is thinner by almost 2° C near the property line and converges in the farfield. The hypothesis that the intertidal plume was different between conditions cannot be rejected at the 0.05 probability level. However, the mean intercepts become smaller with Units 1 and 2 operations. As in the subsurface and bottom plumes, the mean change in temperature is diminished with Units 1 and 2 operations.

Table 8. Mean regression parameters of data analysis periods (property line surface delta T $\geq 4.5^\circ\text{C}$) on the dates selected for comparison of temperature plume on surface.

Analysis Period (start, end)	Condition	N	($^\circ\text{C}$)	stdev a ($^\circ\text{C}$)	($^\circ\text{C}/\text{m}$)	stdev b ($^\circ\text{C}/\text{m}$)
7/16/2003 10:40 7/17/2003 00:20	A-All Units	83	8.44	1.51	-0.003321	0.000783
9/5/2003 07:20 9/5/2003 22:30	A-All Units	92	9.38	1.84	-0.003690	0.001110
10/21/2003 08:30 10/21/2003 22:00	A-All Units	82	9.04	1.98	-0.003350	0.000896
10/28/2003 00:00 10/28/2003 23:50	A-All Units	144	7.96	1.09	-0.002808	0.000456
10/10/2003 09:30 10/10/2003 23:50	B-Units 1&2	87	7.67	1.94	-0.003057	0.000896
10/14/2003 05:20 10/14/2003 23:50	B-Units 1&2	112	7.86	1.81	-0.002953	0.000708
11/5/2003 08:30 11/5/2003 23:50	B-Units 1&2	93	7.74	1.17	-0.002983	0.000681
9/29/2003 09:00 9/29/2003 20:00	C-Units 1&2 ~2/3 output	67	5.82	0.72	-0.002225	0.000542

Data source: Tena Environmental 2004a.

Table 9. Mean regression parameters of data analysis periods (property line delta T $\geq 4.5^\circ\text{C}$) on the dates selected for comparison of temperature plume one meter subsurface.

Analysis Period (start, end)	Condition	N	($^\circ\text{C}$)	stdev a ($^\circ\text{C}$)	($^\circ\text{C}/\text{m}$)	stdev b ($^\circ\text{C}/\text{m}$)
7/16/2003 10:40 7/17/2003 00:20	A-All Units	83	7.47	1.60	-0.003149	0.000729
9/5/2003 07:20 9/5/2003 22:30	A-All Units	92	8.29	1.93	-0.003465	0.001081
10/21/2003 08:30 10/21/2003 22:00	A-All Units	82	8.11	1.97	-0.003277	0.000952
10/28/2003 00:00 10/28/2003 23:50	A-All Units	144	7.22	1.41	-0.002746	0.000404
10/10/2003 09:30 10/10/2003 23:50	B-Units 1&2	87	6.45	2.17	-0.002645	0.000981
10/14/2003 05:20 10/14/2003 23:50	B-Units 1&2	112	6.71	1.97	-0.002569	0.000779
11/5/2003 08:30 11/5/2003 23:50	B-Units 1&2	93	6.29	1.60	-0.002506	0.000765
9/29/2003 09:00 9/29/2003 20:00	C-Units 1&2 ~2/3 output	67	4.80	0.45	-0.001870	0.000297

Data source: Tena Environmental 2004a.

Table 10. Mean regression parameters of data analysis periods (property line delta T $\geq 4.5^{\circ}$ C) on the dates selected for comparison of temperature plume on the bottom.

Analysis Period (start, end)	Condition	N	($^{\circ}$ C)	stdev <i>a</i> ($^{\circ}$ C)	($^{\circ}$ C/m)	stdev <i>b</i> ($^{\circ}$ C/m)
7/16/2003 10:40 7/17/2003 00:20	A-All Units	83	5.39	1.70	-0.002308	0.000660
9/5/2003 07:20 9/5/2003 22:30	A-All Units	92	5.40	1.41	-0.002169	0.000703
10/21/2003 08:30 10/21/2003 22:00	A-All Units	82	5.77	2.02	-0.002318	0.000965
10/28/2003 00:00 10/28/2003 23:50	A-All Units	144	5.42	2.86	-0.001858	0.000972
10/10/2003 09:30 10/10/2003 23:50	B-Units 1&2	87	3.56	1.85	-0.001298	0.000812
10/14/2003 05:20 10/14/2003 23:50	B-Units 1&2	112	3.59	0.95	-0.001181	0.000385
11/5/2003 08:30 11/5/2003 23:50	B-Units 1&2	93	4.26	1.66	-0.001527	0.000762
9/29/2003 09:00 9/29/2003 20:00	C-Units 1&2 ~2/3 output	67	2.39	1.57	-0.000692	0.000513

Source: Tenera Environmental 2004a.

Table 11. Mean regression parameters of data analysis periods (property line delta T $\geq 4.5^{\circ}$ C) on the dates selected for comparison of temperature plume on intertidal locations.

Analysis Period (start, end)	Condition	N	($^{\circ}$ C)	stdev <i>a</i> ($^{\circ}$ C)	($^{\circ}$ C/m)	stdev <i>b</i> ($^{\circ}$ C/m)
7/16/2003 10:40 7/17/2003 00:20	A-All Units	83	7.99	3.20	-0.004132	0.003215
9/5/2003 07:20 9/5/2003 22:30	A-All Units	84	9.10	1.55	-0.004801	0.001317
10/21/2003 08:30 10/21/2003 22:00	A-All Units	82	8.26	1.86	-0.004003	0.001365
10/28/2003 00:00 10/28/2003 23:50	A-All Units	144	6.47	2.34	-0.002100	0.002606
10/10/2003 09:30 10/10/2003 23:50	B-Units 1&2	70	5.98	2.38	-0.003382	0.001677
10/14/2003 05:20 10/14/2003 23:50	B-Units 1&2	112	6.67	2.74	-0.002616	0.002127
11/5/2003 08:30 11/5/2003 23:50	B-Units 1&2	93	7.05	0.83	-0.003596	0.000789
9/29/2003 09:00 9/29/2003 20:00	C-Units 1&2 ~2/3 output	43	4.42	1.41	-0.002640	0.001117

Data source: Tenera Environmental 2004a.

Table 12. Significant levels ($Pr>F$) from ANOVA tests of mean a (modeled property line delta T) and b (rate of temperature change) parameters for temperature plume comparisons in three condition groups. Groups were condition A: all units operating, condition B: Units 1 and 2 operating, and condition C: Units 1 and 2 operating at 2/3 capacity. Significant levels less than 0.05 are highlighted (reject hypothesis that means are same at that level).

Plume Level	Means in A	Means in B	Means in C	Pr>F ABC	Pr>F AB	Pr>F BC	SNK Groups
Surface a (°C)	8.61	7.76	5.82	0.0192	0.0664	0.0045	ABvsC
b (°C/km)	-3.22	-2.99	-2.22	0.1084	0.2754	0.0083	ABC
Subsurface a	7.70	6.50	4.80	0.0059	0.0122	0.0288	ABvsC
b	-3.10	-2.57	-1.87	0.0222	0.0345	0.0158	ABvsBC
Bottom a	5.48	3.79	2.39	0.0004	0.0005	0.1136	AvsBvsC
b	-2.12	-1.33	-0.69	0.0037	0.0041	0.1142	AvsBC
Intertidal a	7.73	6.62	4.42	0.1109	0.1321	0.1129	ABC
b	-3.50	-3.14	-2.64	0.7041	0.5291	0.5813	ABC

Data source: TENERA Environmental 2004a.

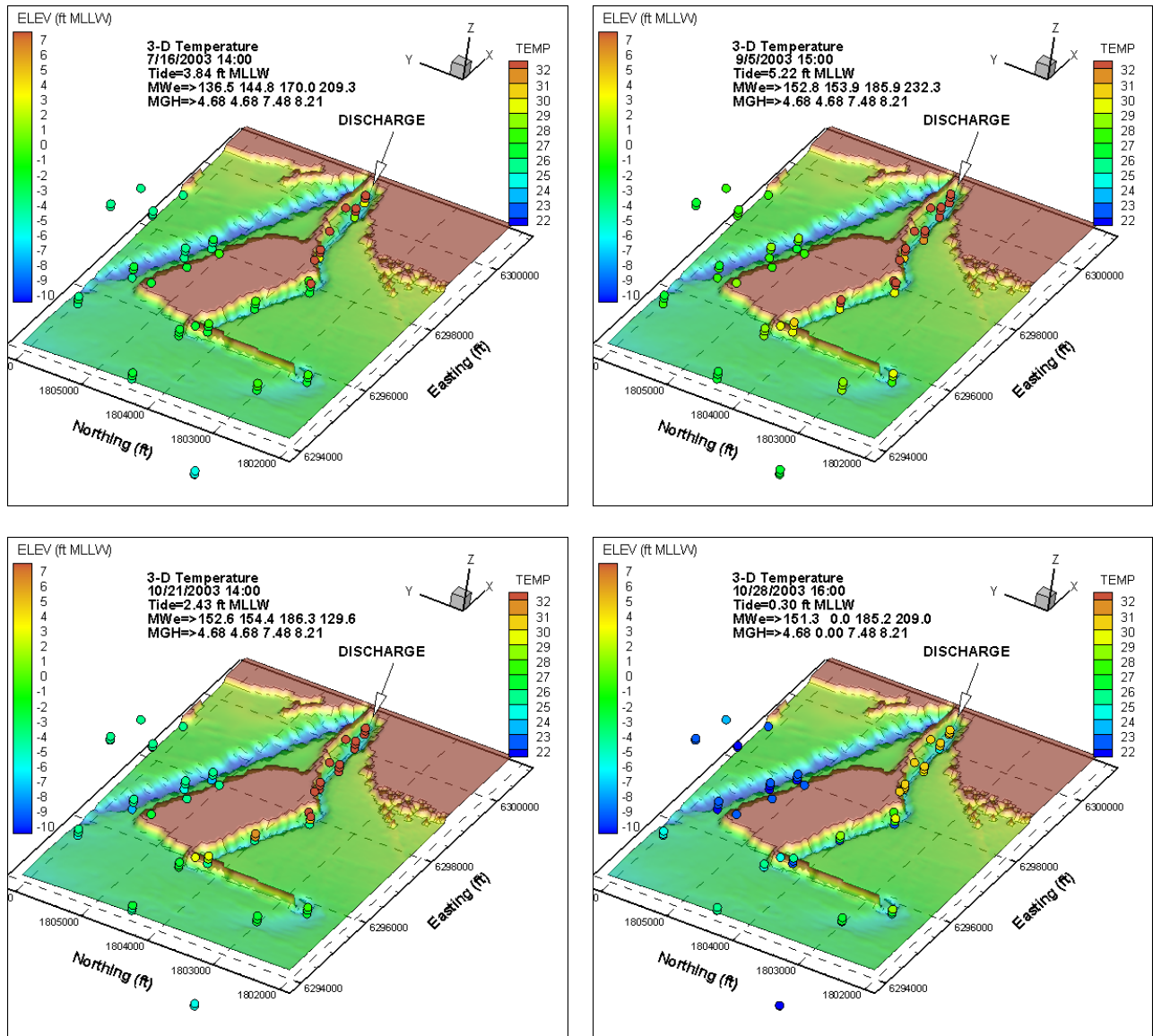


Figure 8. Three-dimensional view of temperatures near SBPP discharge for selected times when all units were operating (Condition A: July 16, September 5, October 21, and October 28, 2003). Time captured is one to two hours post the day's maximum generation. Bathymetry, tide, SBPP pump flow and output per unit are also shown.

Data source: Tintera Environmental 2004a.

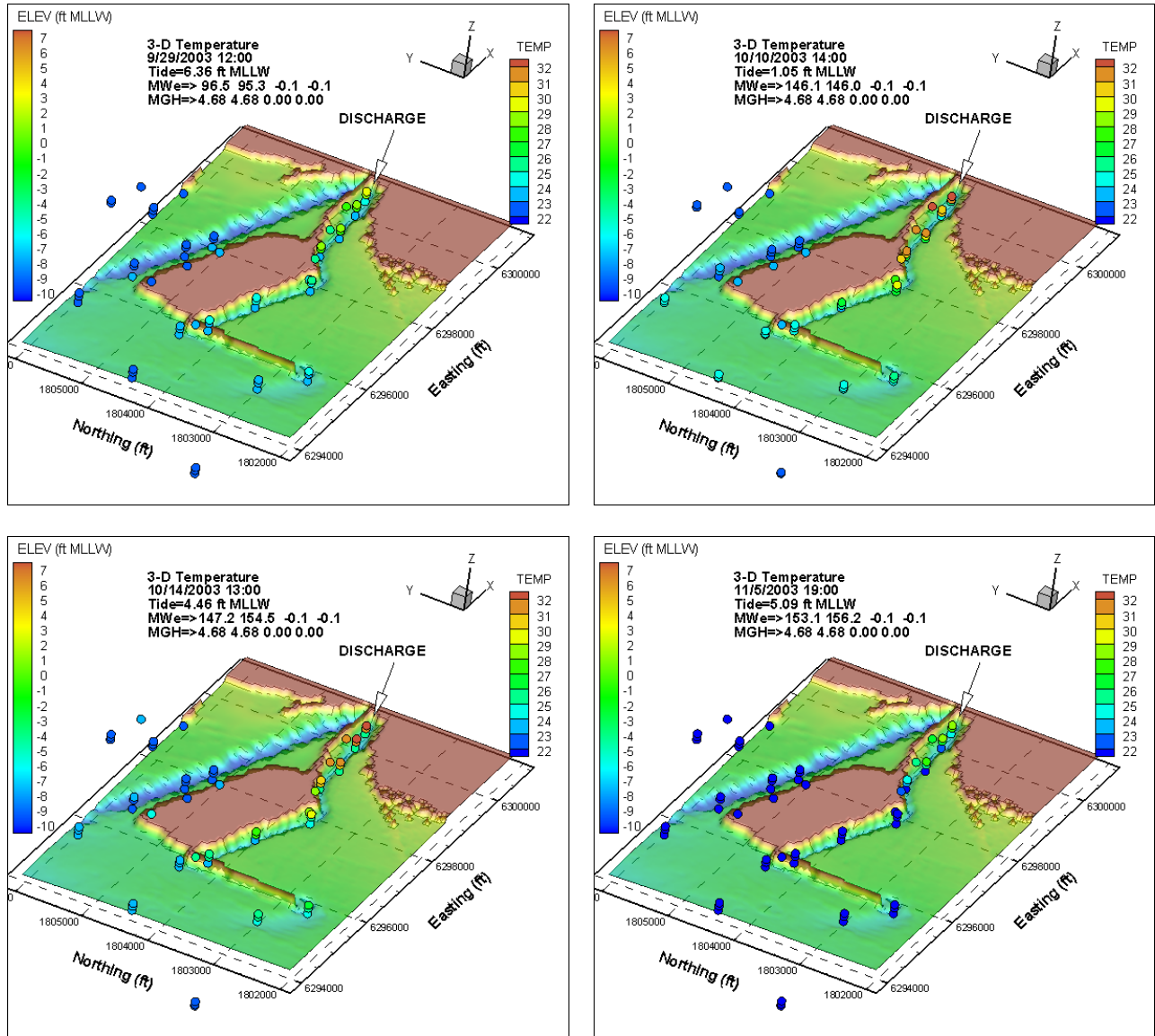


Figure 9. Three-dimensional view of temperatures near SBPP discharge for selected times when Units 1 and 2 only were operating (Condition B: October 10, October 14, and November 5, 2003; Condition C: September 29, 2003). Time captured is one to two hours post the day’s maximum generation. Bathymetry, tide, SBPP pump flow and output per unit are also shown.

Data source: Tena Environmental 2004a.

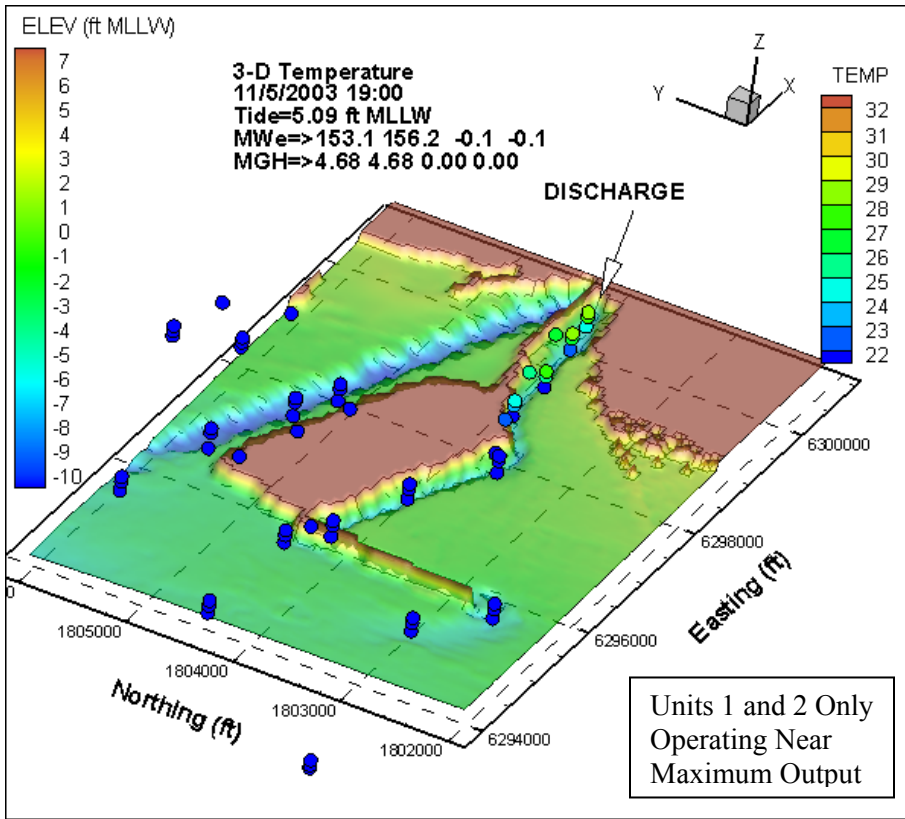
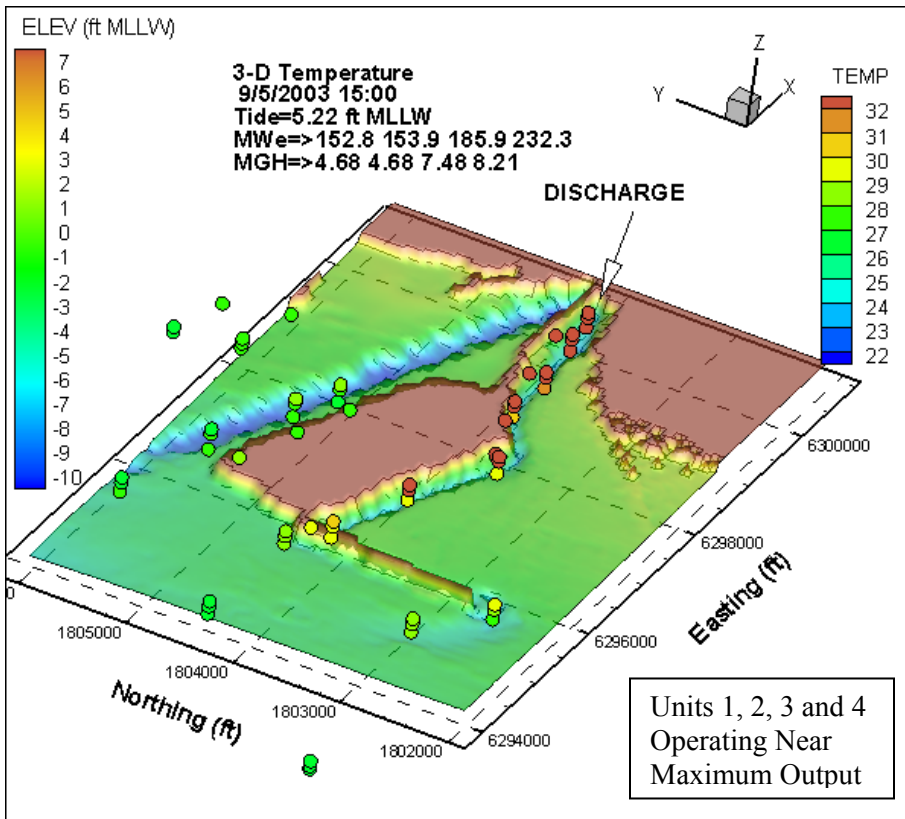


Figure 10. Enlarged three-dimensional view of temperatures near SBPP discharge for selected times from previous Figures 8 and 9 when Units 1 and 2 only were operating (November 5, 2003) and Units 1, 2, 3 and 4 were operating (September 5, 2003). Time captured is one to two hours post the day's maximum generation. Bathymetry, tide, SBPP pump flow and output per unit are also shown.



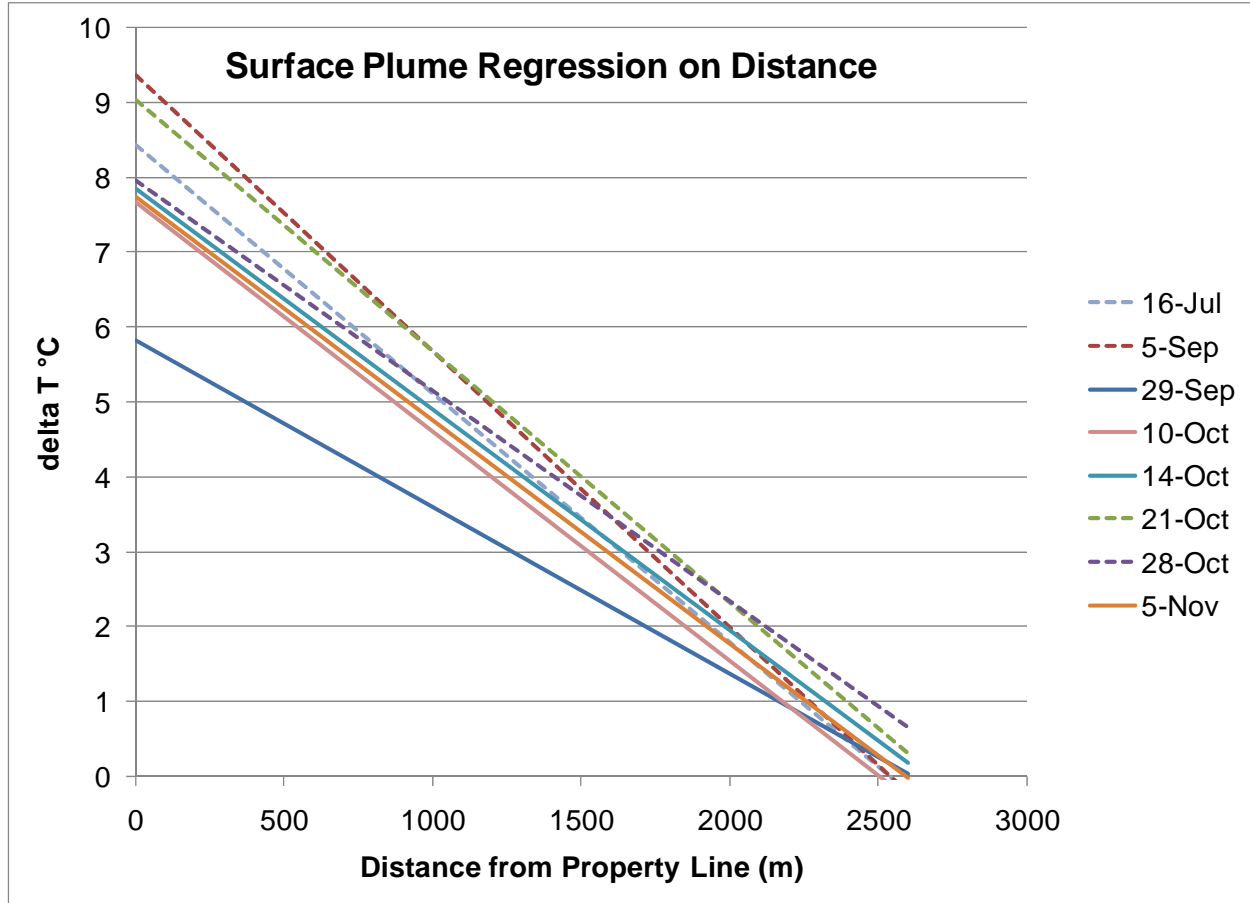


Figure 11. Lines representing average intercepts and slopes for linear regressions of year 2003 SBPP surface plume delta T* as a function of distance from the property line point of discharge across the area of observed benthic effects. Dotted lines are shown when all units were running. Solid lines are shown when Units 1 and 2 only were running. Power output of the Units 1 and 2 on September 29, 2003 was reduced to ~2/3 of maximum. *Delta T is the difference between ambient water temperature and receiving water temperatures recorded every 20 minutes. The slope shows the decay of delta T from the property line point of discharge at its intercept on the left hand vertical axis to ambient temperature on the horizontal axis showing distance from the discharge.

Data source: Tenera Environmental 2004a.

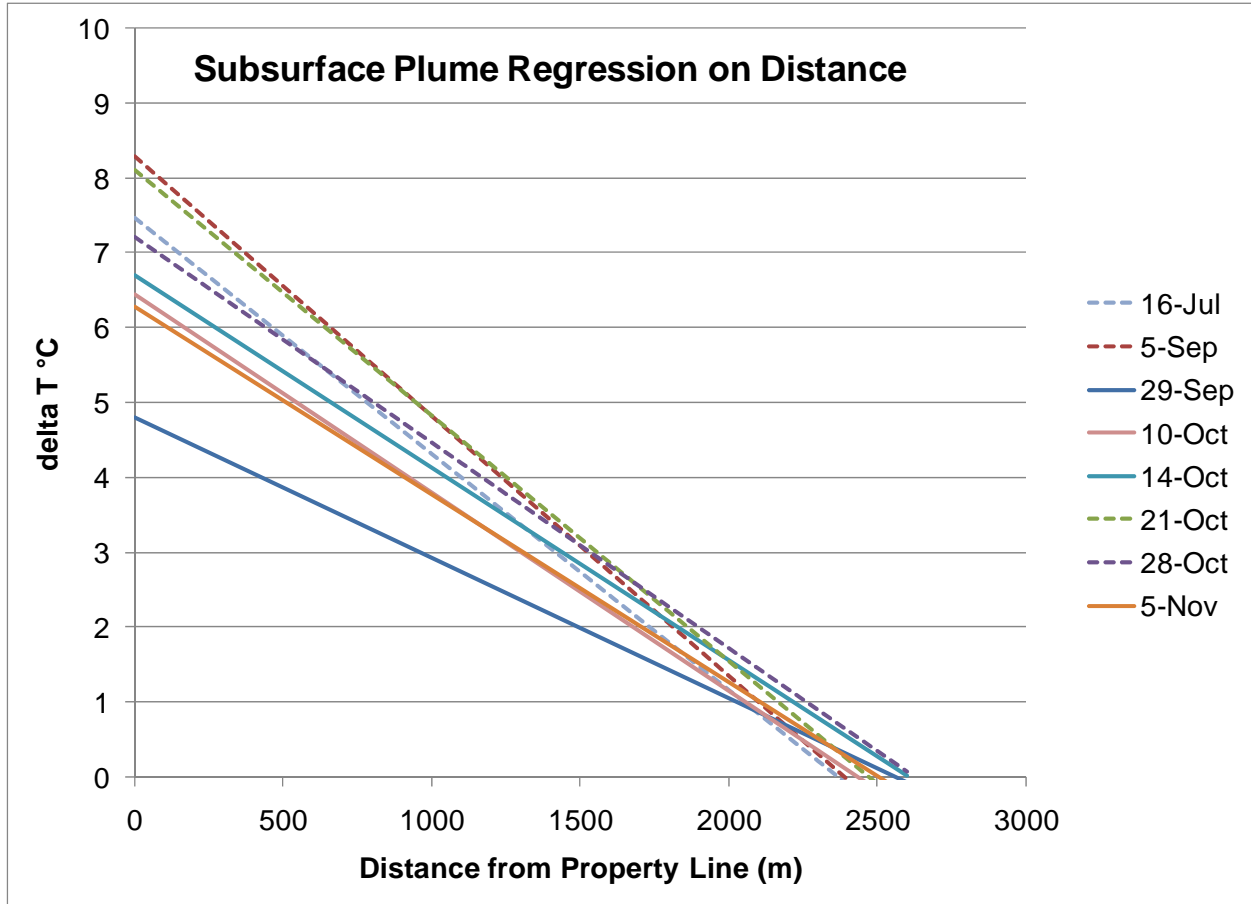


Figure 12. Lines representing average intercepts and slopes for linear regressions of year 2003 SBPP one meter subsurface plume delta T* as a function of distance from the property line point of discharge across the area of observed benthic effects. Dotted lines are shown when all units were running. Solid lines are shown when Units 1 and 2 only were running. Power output of the Units 1 and 2 on September 29, 2003 was reduced to ~2/3 of maximum. *Delta T is the difference between ambient water temperature and receiving water temperatures recorded every 20 minutes. The slope shows the decay of delta T from the property line point of discharge at its intercept on the left hand vertical axis to ambient temperature on the horizontal axis showing distance from the discharge.

Data source: Tena Environmental 2004a..

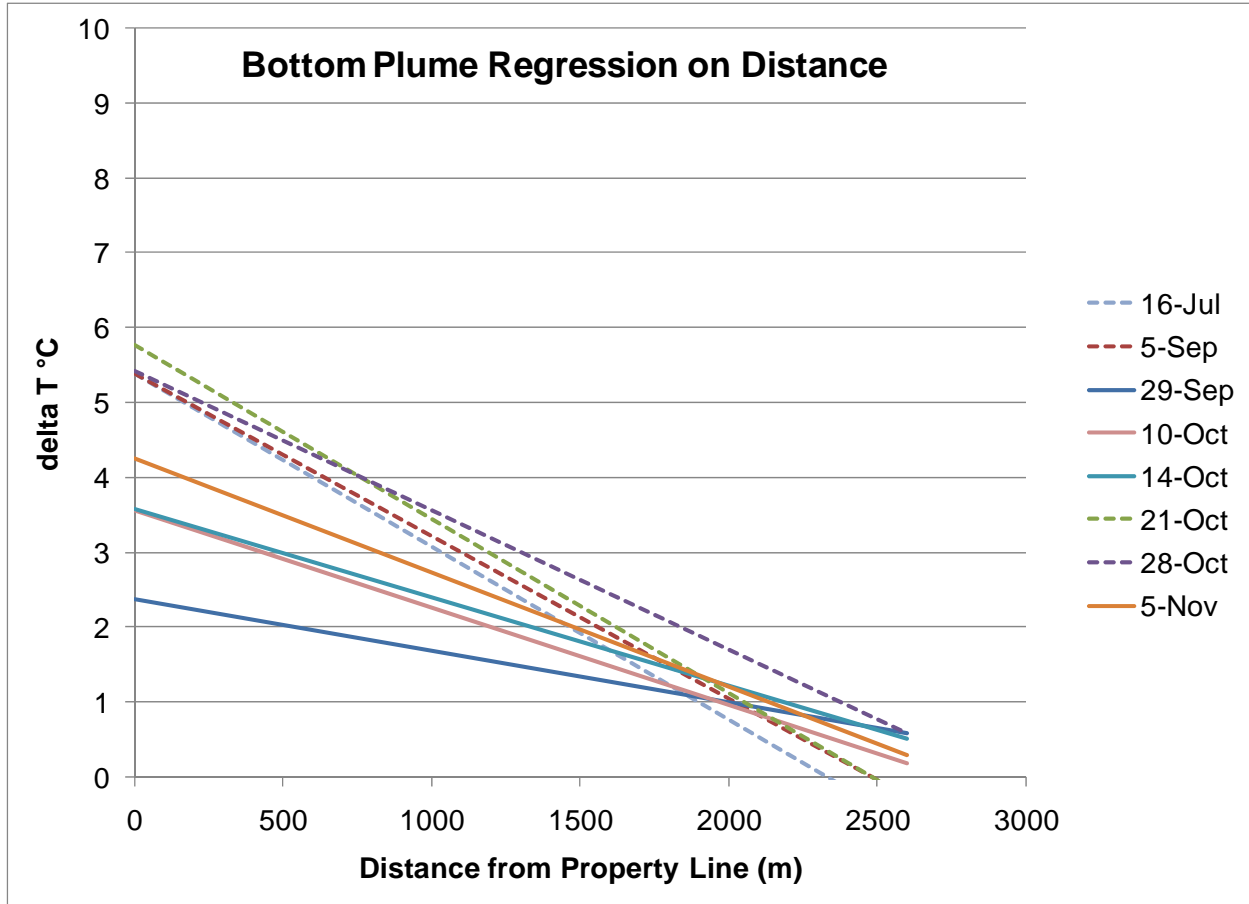


Figure 13. Lines representing average intercepts and slopes for linear regressions of year 2003 SBPP bottom plume delta T* as a function of distance from the property line point of discharge across the area of observed benthic effects. Dotted lines are shown when all units were running. Solid lines are shown when Units 1 and 2 only were running. Power output of the Units 1 and 2 on September 29, 2003 was reduced to ~2/3 of maximum. *Delta T is the difference between ambient water temperature and receiving water temperatures recorded every 20 minutes. The slope shows the decay of delta T from the property line point of discharge at its intercept on the left hand vertical axis to ambient temperature on the horizontal axis showing distance from the discharge.

Source: Tenera Environmental 2004a. Figure 9.

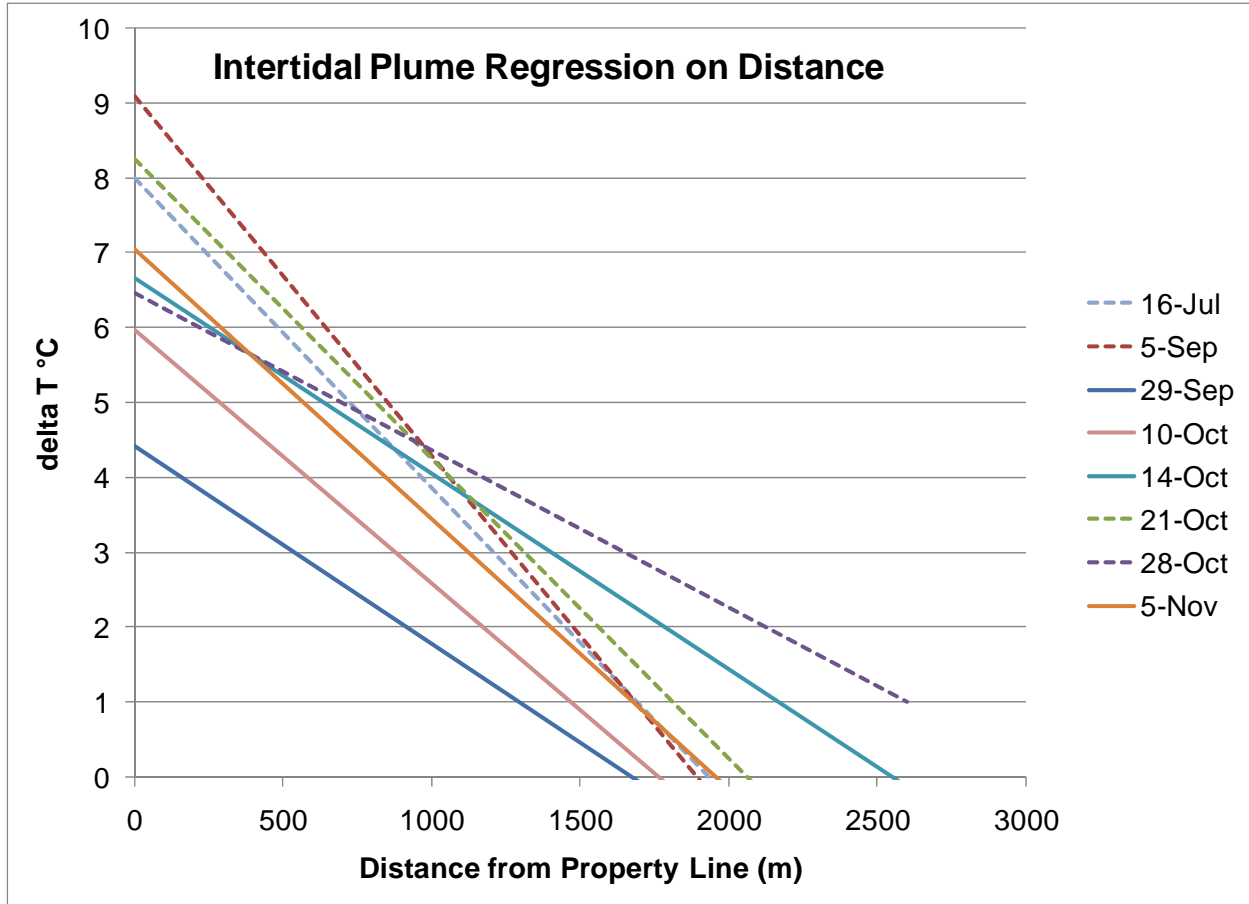


Figure 14. Lines representing average intercepts and slopes for linear regressions of year 2003 SBPP plume delta T in the intertidal zone as a function of distance from the property line point of discharge across the area of observed benthic effects. Dotted lines are shown when all units were running. Solid lines are shown when Units 1 and 2 only were running. Power output of the Units 1 and 2 on September 29, 2003 was reduced to $\sim 2/3$ of maximum. *Delta T is the difference between ambient water temperature and receiving water temperatures recorded every 20 minutes. The slope shows the decay of delta T from the property line point of discharge at its intercept on the left hand vertical axis to ambient temperature on the horizontal axis showing distance from the discharge.

Source: Tenera Environmental 2004a. Figure 9.

5.0 DISCUSSION OF SBPP INTAKE AND DISCHARGE EFFECTS

5.1 Impingement and Entrainment Effects

The purpose of the SBPP 2001 and 2003 entrainment and impingement studies was to evaluate the potential impacts of the cooling water intake system as required under Section 316(b) of the Federal Clean Water Act (CWA). As part of this evaluation, an earlier 316(b) study conducted in 1979 (SDG&E 1980) was updated and information from the 2001 and 2003 entrainment and impingement studies was used by the San Diego Regional Water Quality Control Board in support of the NPDES permitting process for SBPP. Data on larval fishes, megalopal crabs, and larval spiny lobster collected near the SBPP intakes were used to estimate entrainment losses, while impingement losses were based on direct measurements of the abundance and biomass of fishes and selected macroinvertebrates retained on the SBPP intake screens.

Our ability to evaluate CWIS effects was limited to the fishes and invertebrates that were in high abundances in entrainment or impingement samples. The abundances of the majority of the entrained and impinged species were low and would not result in any risk of population-level effects. However, by focusing on the most abundant species, we were able to estimate the magnitude of effects on the component species in the biological community. After evaluating the sampling results only two groups of fishes—anchovies and silversides—were found to be abundant enough to be affected by both entrainment and impingement. Based on the data collected in our studies, it was determined that the collective entrainment and impingement losses with all SBPP units running at 100 percent 24/7 would have some small but undetectable effect on biological community functioning. However, the slight potential of these losses to cause harm (see impact assessment in Tenera 2004b) has been essentially eliminated by the 63 percent reduction in entrainment and the 86 percent reduction in impingement resulting from the shutdown of Units 3 and 4.

The maximum number of larval fishes that could be entrained in 2010 will be at least 63 percent fewer than the maximum number that could have entrained in 2002 and 2003. While the number of individual larvae that were entrained by SBPP in 2003 and 2004 was a large number in absolute terms (e.g., in excess of two billion for the goby species complex), this loss of larval-aged fish, which does not translate directly into loss of adult-aged fish, did not pose a risk to fish populations in San Diego Bay then and even less so with the present day 63 percent reduction in entrainment losses. Even the highest estimates of *ETM* for the South Bay species (e.g., the overall 17 percent average from sampling years 2001 and 2003, or the species-specific range of approximately 17 to 50 percent, which in 2010 is now reduced to 8 to 25 percent, for the longjaw mudsucker) are within the range of sustainable harvest considered acceptable by the NMFS. Other considerations further reduce the apparent biological significance of these larval losses, namely, that many of the most frequently entrained species are not fished commercially or recreationally, and that the compensatory reserve of these species is disregarded altogether in this analysis. Compensatory reserve (or compensation) refers to known biological mechanisms that

act to increase growth rates, survival, and reproduction by the surviving members of a population in the face of biological or ecological pressure on the population. Indeed, from a fisheries standpoint, biomass production in a stock is maximized when it is subject to harvest at maximum sustainable yield. NMFS believes that, given the compensatory reserve inherent in most fish stocks, up to 60 to 70 percent of a virgin stock's reproductive potential may be removed without compromising the species long-term sustainability of the stock. Under the NMFS guidelines, 60 to 70 percent of the virgin stock's reproductive potential may be removed and still afford the fishery manager a substantial margin of safety against the occurrence of a decline. The CDFG acknowledges similar sustainable harvest levels in its Nearshore Fishery Management Plan. This resource management practice is supported by the scientific literature and provides broad-based evidence of the robustness of fish populations to thrive in the face of a wide range of exploitation rates, based on their compensatory reserve.

In addition, we have assumed for purposes of this study that 100 percent of the larvae that are entrained by the power plant are killed despite documentation through intensive through-plant entrainment survival studies at power plants across the U.S. that survival of larval fish and invertebrates can be very high (EPRI 2000). Mean survival rates for most taxonomic groups have exceeded 50 percent, the only major exceptions being the relatively fragile herrings (Clupeidae) and anchovies (Engraulidae), which have mean survival rates around 25 percent. Survival rates of 65 percent or higher (up to 100 percent) have been common. For example, total survival rates of 88 and 98 percent were reported for naked goby *Gobiosoma bosc* in entrainment survival studies at the Calvert Cliffs Power Plant in southern Maryland. Gobies make up nearly 76 percent in 2001 and 89 percent in 2003 of the larval fish entrained at SBPP.

It should also be noted that most fish populations, including bay goby, are unaffected by natural mortality as high as 90 percent in the larval stage. In other words, even if the SBPP were not withdrawing water from south San Diego Bay, up to 90 percent of the larvae would be expected to die before recruitment to the adult population. *ETM* estimates of entrainment, which assume a stable population and no compensation, represent an extremely conservative comparison to the NMFS guidelines for sustainable harvest rates that is based on recruited adult stocks after natural compensation has already occurred. Although large numbers of larvae are entrained, *ETM* estimates of entrainment mortality using extremely conservative assumptions show that the entrained larvae represent a fraction of their source water population that is well below a removal rate required to sustain their adult populations even without compensation. The life history of component species in the community must be considered when discussing potential effect to the populations. Although the study focused on species potentially affected by entrainment and impingement processes, it is important to note that several fish species in south San Diego Bay have early life stages that are not susceptible to these processes. Live-bearers, such as surfperches, some sharks, and some rays, produce young that are fully developed and too large to be affected by entrainment. Live-bearers together comprise nearly 40 percent of the fish biomass in the Bay (Allen 1999). Another common species in south San Diego Bay, striped mullet, also is not susceptible to entrainment because it spawns offshore and only the juveniles and adults subsequently utilize the Bay habitat. From the standpoint of impingement effects, one of the

most abundant groups of species in the Bay, gobiid fishes, are generally not susceptible to impingement after transformation to the juvenile life stage because they are bottom-dwelling species that typically do not move up into the water column. Even fish species that swim in the water column are generally not susceptible to impingement effects as they mature because they are able to swim against the slow approach velocity of the cooling water inflow. For example, at the SBPP intakes it was not uncommon to see small schools of adult striped mullet swimming directly in front of the intakes and not being impinged during times when circulating water pumps were operating.

5.2 Thermal Effects

General conclusions from earlier studies (Ogden 1994) concerning the importance of temperature in defining assemblages were substantiated in this study, although several of the specific conclusions regarding temperature responses of individual taxa differed between the two studies. Based on regression analysis, Ogden (1994) found a significant positive relationship between temperature and infaunal density (i.e., taxa increased in abundance as temperatures increased) for the following taxa: Armandia, Capitella, Marphysa, Neanthes, Streblospio, Oligochaeta, and Paracereis. From this list, Capitella, Streblospio and Oligochaeta showed a significant positive relationship with temperature in the Tenera (2004a) study and Paracereis had a negative relationship. The other taxa were not abundant enough to draw any conclusions about their relationship to temperature. The earlier study identified significant negative relationships between temperature and infaunal density (i.e., taxa decreased in abundance as temperatures increased) for the following taxa: Leitoscoloplos, Mayerella, Acteocina (Cyllichnella), Solen, Tagelus, and Phoronida. Of these taxa, the Tenera (2004a) analysis confirmed that only Leitoscoloplos followed this relationship between temperature and abundance, with Tagelus, Acteocina (Cyllichnella), and Phoronida showing a statistically significant opposite response. The distributions of Solen and Mayerella had no significant relationship to temperature. The Tenera (2004a) study also identified other positive and negative relationships between temperature and faunal abundances that were not seen in the earlier studies. The differences between the results in the two studies were probably due to the lack of spatial resolution within the discharge zone in the earlier study which was unable to measure infaunal densities where the greatest temperature changes occurred. The weighting of the station array in far-field and reference areas in the Ogden (1994) analysis masked the relationship between temperature and faunal distributions, or in some cases, yielded contradictory results. By increasing the number of stations from 11 to 21, we could delineate temperature-faunal relationships for some taxa more accurately than in the previous study design (Tenera Environmental 2004a).

5.3 Conclusion

The South Bay Power Plant has operated its cooling water intake and discharge for nearly five decades in south San Diego Bay. Although a frequent target over the years of claims that the Plant has had a devastating effect on San Diego Bay, the scientific study confirms that the Plant has operated without significant effect on either its source water or receiving water populations

of fish. This fact has been repeatedly demonstrated in the findings of studies of both the impingement and entrainment in the Plant’s cooling water intake flow and the absence of any effect on their source water populations, and in surveys of fish distribution in the Plant’s discharge plume.

5.3.1 Intake Effects

The potential effects of the SBPP intake on source water populations of fish and shellfish—as slight as they were even assuming the pumps for all four units (Units 1-4) would be running 24/7 for a year (i.e. at a capacity factor of 100%)—are now dramatically reduced with the decommissioning and shutdown of the Units 3 and 4 pumps.

An annual capacity factor is determined by dividing the actual unit gross generation by the maximum potential generation during the year. The capacity factor gives an indication of the amount of generation units produce versus the maximum generation units can produce. The annual capacity factors of SBPP Units 1-4 from 2000–2009 are provided in **Figure 15**. Capacity factors have declined over the past nine years from a high of over 35 percent in 2000 to a low of only 9 percent in 2009 (**Figure 15**). The EPA Phase II Rule standard for entrainment specified that a facility must reduce entrainment by 60 percent to 90 percent if capacity factors were greater than 15 percent. The SBPP met the EPA standard for no significant entrainment impacts (<15 percent capacity rate) in 2006, 2007 and 2009.

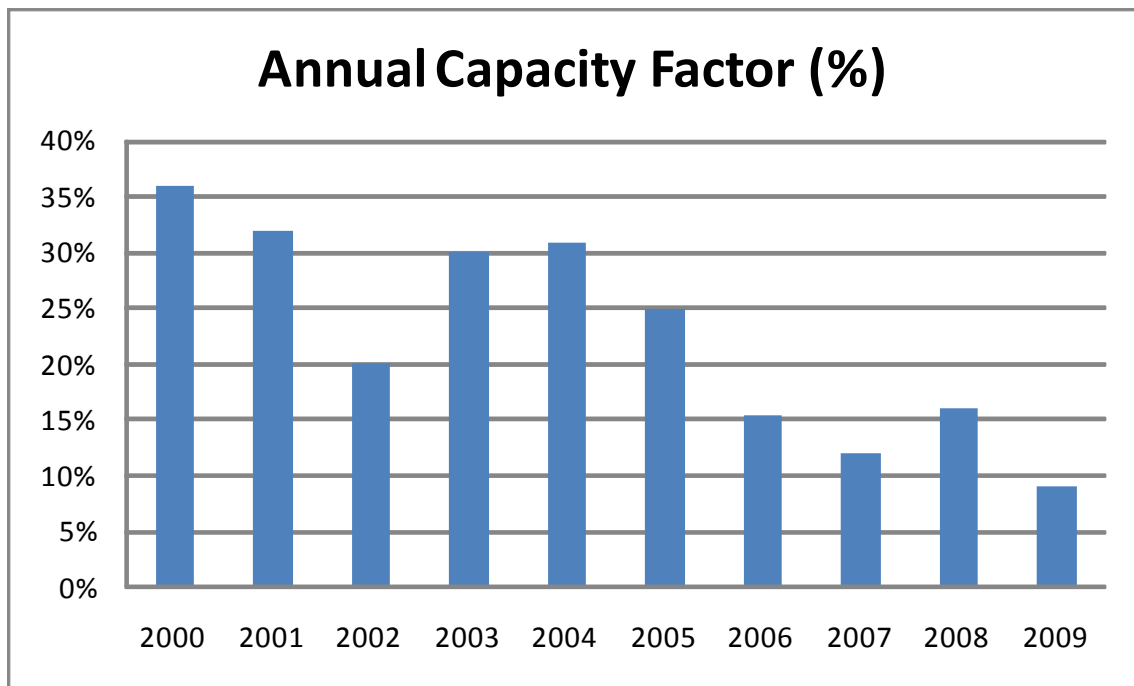


Figure 15. Annual capacity factors for South Bay Power Plant Units 1-4 from 2000 through 2009.

The reductions in intake losses took effect immediately in 2010:

- Entrainment—with the decommissioning of SBPP Units 3 and 4, the total number of organisms entrained by SBPP is immediately reduced by at least 63 percent and more to the extent actual operation of Units 1 and 2 pumps is less than 24/7.
- Impingement—with the decommissioning of SBPP Units 3 and 4, the total number of organisms impinged by the power plant intake screens has been reduced by approximately 80 percent, and the total biomass impinged has been reduced by 86 percent.

These reductions of 63 percent of entrainment losses and 86 percent impingement losses exceed the EPA Phase II Rule standard of 60 percent entrainment reduction and closely approach the Phase II Rule standard of 95 percent for impingement. Given the permanent retirement of Units 3 and 4, these reductions will continue to be realized over time.

The estimated SBPP intake losses for both the 2004 and the present 2010 assessment of intake impacts were calculated using the following set of conservative assumptions that would result in the greatest projected effects on a target species:

- all entrainment and impingement loss estimates were calculated based on maximum design cooling water flows, although actual cooling water withdrawals were only a small fraction of the maximum due to variable demand for power generation throughout the year;
- entrainment modeling assumed no survival of larvae through the cooling water system;
- no density-dependent compensatory effects were included in the models that would result in increased survivorship for later life-stages not subject to CWIS effects; and
- estimated economic losses of impingement fishery species were scaled up to assume that all impinged individuals represented fishes of adult size potentially lost to the fishery, without applying projected mortality rates to the impinged juveniles.

Overall, our conclusions in 2004 were consistent with those from the earlier 316(b) study done in 1979–1980 (SDG&E 1980) that the operation of SBPP does not substantially affect populations of the most abundant or economically important fishes and invertebrates in San Diego Bay. Studies by Allen (1999) found that slough anchovy comprised over half of the fishes by number in the south-central and south ecoregions of San Diego Bay. Results from the 2003 study show that SBPP may account for a loss of approximately 8–10 percent of the larval population annually and represent an equivalent loss of approximately 1–2 percent of the adult standing stock. A major group the Bay's non-commercial/recreational fishes entrained in SBPP intake flow were the CIQ goby complex, with larval losses estimated in 2004 at 21–27 percent, but now in 2010 reduced to 14 to 18 percent of the source water population. Under the most conservative assumptions (24/7 operations), the SBPP CWIS (which in 2004 might have accounted for losses from 1.2 to 2.2 million adult CIQ gobies per year out of an estimated standing stock of over 10 million), in 2010 and going forward, would account for an estimated 0.8 to 1.5 million out of the same source water population of over 10 million. For the invertebrate species investigated,

there were no substantial direct effects of the CWIS on their populations. Particularly for species with commercial fishery importance, such as lobsters, crabs, and squid, the results indicate that SBPP would not affect the adult populations of these species.

Impingement generally varies with intake flow. Lower intake flow brings fewer organisms into the area of intake screens and reduces the likelihood of their impingement on the screens by lower approach and through-screen velocities. If this widely accepted direct relationship of impingement to flow is relied upon to adjust the SBPP annualized impingement estimate reported for December 2002 to November 2003 for all units, there is no uncertainty that there would have been at least a 63 percent reduction in impingement based simply on the reduced volume resulting from only Units 1 and 2 intake pumps operating at the time. In fact the actual SBPP impingement effects reduction at the present time, based on our published impingement study results, is at least 86 percent, an amount nearly achieving the EPA's impingement reduction standard in the 316(b) Phase II Rule.

5.3.2 Discharge Effects

The results of our analysis demonstrate that the SBPP cooling water discharge plume will be smaller, cooler, and thinner. To the degree and extent that the temperature of the cooling water discharge prior to the 2009 shutdown of Units 3 and 4 was affecting receiving water populations, any such effect has now been reduced by at least 63 percent due simply to the reduction in discharge volume. As we discussed in our analysis of the Units 1 and 2 thermal discharge plume, a smaller discharge volume also has less horizontal momentum, allowing the buoyancy of the plume to separate from the bottom sooner and avoid contact with the receiving water's benthic community of clams and worms. The smaller volume and momentum of the thermal discharge also reduced the linear distance of shoreline contact as shown in our graphic analysis of projected temperature at the discharge channel's intertidal stations.

6.0 LITERATURE CITED

- Allen, L. G. 1999. Fisheries Inventory and Utilization of San Diego Bay, San Diego, California. Final Report: Sampling Period July 1994 to April 1999. Prepared for U.S. Navy and the San Diego Unified Port District.
- Boreman, J., C.P. Goodyear, and S.W. Christensen. 1978. An Empirical Transport Model for Evaluating Entrainment of Aquatic Organism by Power Plants. United States Fish and Wildlife Service. FWS/OBS-78/90, Ann Arbor, MI.
- Boreman, J., C.P. Goodyear, and S.W. Christensen. 1981. An Empirical Methodology for Estimating Entrainment Losses at Power Plants Sited on Estuaries. Transactions of the American Fishery Society. 110:253-260.
- Electric Power Research Institute (EPRI). 2000. Review of entrainment survival studies: 1970 – 2000. Final Report December 2000. Document Number 1000757. Electric Power Research Institute. Palo Alto, California. 54 pp + Appendix.
- Lockheed Environmental Sciences (LES). 1981. South Bay Power Plant Receiving Water Monitoring Program – A Four-year Cumulative Analysis Report (1977-1980).
- Ogden Environmental and Energy Services Co., Inc. (Ogden). 1994. Review of the long-term receiving water monitoring done for the South Bay San Diego Power Plant. Prepared for San Diego Gas & Electric. 29 pp. + App.
- Ricker, W.E. Computation and Interpretation of Biological Statistics of Fish Populations. Fishery Research Board of Canada Bulletin 91. 382 pp. 1975.
- Tenera Environmental. 2004a. SBPP Cooling Water System Effects on San Diego Bay. Volume I Compliance with Section 316(a) of the Clean Water Act A.2 for the South Bay Power Plant. Submitted to: San Diego Regional Water Quality Control Board. Submitted by: Duke Energy South Bay, LLC. Prepared by: Tenera Environmental Lafayette, CA.
- Tenera Environmental. 2004b. Duke Energy South Bay Power Plant, SBPP Cooling Water System Effects on San Diego Bay. Volume II: Compliance with Section 316(b) of the Clean Water Act A.2 for the South Bay Power Plant. Submitted to: San Diego Regional Water Quality Control Board. Submitted by: Duke Energy South Bay, LLC. Prepared by: Tenera Environmental Lafayette, CA.
- San Diego Gas and Electric Company (SDG&E). 1980. South Bay Power Plant Cooling Water Intake System Demonstration Summary. Prepared for: California Regional Water Quality Control Board San Diego Region, San Diego, CA.

Smith, P. E. and S. L. Richardson. 1977. Standard Techniques for Pelagic Fish Egg and Larva Surveys. FAO Fisheries Technical Paper 175:1-100.

U. S. Fish and Wildlife Service. 1998. Proposed South San Diego Bay Unit, National Wildlife Refuge. Draft Environmental and Land Protection Plan. U.S. Fish Wild. Serv. 89 pp.

