AES HUNTINGTON BEACH L.L.C. GENERATING STATION ENTRAINMENT AND IMPINGEMENT STUDY

FINAL REPORT

April 2005

Prepared for:

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Huntington Beach, California

California Energy Commission
Sacramento, California

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Costa Mesa, California

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EXECUTIVE SUMMARY

This report presents data from in-plant and offshore field surveys performed for the AES Huntington Beach Generating Station (HBGS) Entrainment and Impingement Study. This study was performed to satisfy Conditions of Certification BIO-4 and BIO-6 of the AES HBGS Retool Project. Impingement sampling began in late July 2003, and entrainment and source water sampling began in September 2003. Field studies were completed in late-August 2004. This report presents all entrainment, source water, and impingement data collected as part of the study.

Thirty-two entrainment surveys and twelve combined entrainment/source water surveys were performed from September 2003 through August 2004. Fish larvae from 57 different taxonomic groups were collected during the entrainment surveys. Unidentifiable CIQ gobies were the most abundant fishes in the entrainment samples, contributing 37% to the total. This group is comprised of one or more of the following nearshore gobies that cannot be distinguished during early larval stages: arrow goby (*Clevelandia ios*), cheekspot goby (*Ilypnus gilberti*), and shadow goby (*Quietula y-cauda*). Other abundant larval fish taxa included: northern anchovy (*Engraulis mordax*; 18%), spotfin croaker (*Roncador stearnsii*; 14%), white croaker (*Genyonemus lineatus*; 7%), and queenfish (*Seriphus politus*; 5%). Seventy-nine larval fish taxa were collected during the source water surveys. Six taxa comprised 80% of the total fishes collected from the source water samples: CIQ gobies (37%), northern anchovy (18%), queenfish (10%), white croaker (9%), unidentified croakers (4%), and combtooth blennies (*Hypsoblennius* spp.; 3%).

Of the five proposed target invertebrate taxa, only two were collected in entrainment samples: sand crab (*Emerita analoga*) and rock crab (*Cancer* spp.). Sand crab larvae comprised nearly 99% of the entrained target invertebrate density. Almost all of the sand crab larvae were in the earliest stage of their larval development (Zoea Stage I). No California spiny lobster (*Panulirus interruptus*), market squid (*Loligo opalescens*), or ridgeback prawn (*Sicyonia ingentis*) larvae were collected from entrainment samples.

CIQ gobies, northern anchovy, and combtooth blennies were assessed using demographic modeling (Adult Equivalent Loss [*AEL*] and/or Fecundity Hindcasting [*FH*]) and the Empirical Transport Model (*ETM*). An additional six larval fish taxa, as well as rock crabs (*Cancer* spp.), were assessed using only the *ETM*. Impact assessment modeling could not be performed for salema (*Xenistius californiensis*) due to lack of life history parameters and the lack of sufficient larvae at both entrainment and source water stations during surveys. For fishes, *AEL* estimates were 304,125 individuals (northern anchovy) and 147,493 individuals (CIQ gobies) (Table ES-1).

FH estimates ranged from 3,233 adult females (combtooth blennies) to 101,269 adult females (CIQ gobies).

Table ES-1. Summary of entrainment modeling and impingement estimates for target taxa. The shoreline distance (km) used in the alongshore extrapolation of P_M is presented in parentheses next to the estimate.

				P_m		Impingement	
Taxon	Estimated Annual Entrainment	2·*FH*	*AEL*	Alongshore Extrapolation	Alongshore + Offshore Extrapolation	No.	Weight (kg)
CIQ gobies	113,166,834	202,538	147,493	1.0% (60.9 km)	1.0%	0	0.0
n. anchovy	54,349,017	53,490	304,125	1.2% (72.0 km)	0.7%	2,193	14.9
spotfin croaker	69,701,589	NA	NA	0.3% (16.9 km)	0.3%	49	1.8
queenfish	17,809,864	NA	NA	0.6% (84.9 km)	0.5%	35,847	648.2
white croaker	17,625,263	NA	NA	0.7% (47.8 km)	0.4%	4,903	95.4
black croaker	7,128,127	NA	NA	0.1% (19.4 km)	0.05%	65	7.0
salema	11,696,960	NA	NA	NA	NA	46	0.5
blennies	7,165,513	6,466	NA	0.8% (12.8 km)	0.3%	3	0.02
diamond turbot	5,443,118	NA	NA	0.6% (16.9 km)	0.3%	0	0.0
California halibut	5,021,168	NA	NA	0.3% (30.9 km)	0.08%	21	9.9
shiner perch						4,045	51.8
sand crab megalops	69,793	NA	NA	NA	NA		
Calif. spiny lobster	0	NA	NA	NA	NA	32	19.6
ridgeback rock shrimp	0	NA	NA	NA	NA	0	0.0
market squid	0	NA	NA	NA	NA	7	0.4
rock crab	6,411,171	NA	NA	1.1% (26.5 km)	0.8%	5,820	42.1
D. frondosus	-	NA	NA	-	-	65,150	15.0
two-spotted octopus	-	NA	NA	-	-	61	25.4
purple-striped jelly	-	NA	NA	-	-	53	21.7

NA = Not available due to insufficient life history information or low abundance in entrainment samples.
- = Not analyzed.

Two probability of mortality (P_m) estimates were calculated for each of the target taxa: one based solely on alongshore current movement, and the other on alongshore current movement and an extrapolation of densities offshore to a distance bounded by either the extrapolated densities or onshore current movement. Larval durations of target fish taxa ranged from 5 days (spotfin croaker) to 38 days (northern anchovy), while the rock crab megalops stage was vulnerable to entrainment for 12 days. The P_m estimates based on alongshore current displacement ranged from 0.1% to 1.2% (Table ES-1). The length of coastline (km) used in extrapolating the estimates of $P_m$ranged from 12.8 to 84.9 km (Table ES-1). An estimate of the area of larval production lost due to entrainment (area of production foregone) can be estimated by multiplying the P_m estimates by the alongshore source water length and the width of the source water area sampled (5 km). Estimates of the area of production foregone ranged from 0.11 to 4.47 km^2, and averaged 1.50 km^2 (Table ES-2).

Table ES-2. Summary of entrainment modeling estimates for target taxa and estimation of area of production foregone. The shoreline distance (km) used in the alongshore extrapolation of P_m is presented in parentheses next to the shoreline distance estimate.

Taxon	Estimated Annual Entrainment	P_m Alongshore Extrapolation	Shoreline Distance (km) of Production Foregone	Area of Production Foregone (km^2)
CIQ gobies	113,166,834	1.0% (60.9 km)	0.604	3.024
n. anchovy	54,349,017	1.2% (72.0 km)	0.894	4.471
spotfin croaker	69,701,589	0.3% (16.9 km)	0.050	0.248
queenfish	17,809,864	0.6% (84.9 km)	0.531	2.657
white croaker	17,625,263	0.7% (47.8 km)	0.340	1.699
black croaker	7,128,127	0.1% (19.4 km)	0.023	0.115
salema	11,696,960	NA	NA	NA
blennies	7,165,513	0.8% (12.8 km)	0.098	0.492
diamond turbot	5,443,118	0.6% (16.9 km)	0.098	0.488
California halibut	5,021,168	0.3% (30.9 km)	0.077	0.386
rock crab	6,411,171	1.1% (26.5 km)	0.284	1.418

A total of 52 normal operation impingement surveys was conducted from July 2003 to July 2004, and six heat treatment impingement surveys were conducted through July 2004. Results from the weekly normal operation surveys were extrapolated based on cooling water flow, and summed with heat treatment results to estimate total annual impingement. A total of 51,082 fishes representing 57 species and weighing 1,292 kg was impinged, with most (75%) of the losses attributable to heat treatments. Queenfish was the most abundant species impinged, accounting for 70% of total abundance. Other abundant fish species included white croaker, shiner perch (*Cymatogaster aggregata*), and northern anchovy. A total of 70,638 macroinvertebrates representing 37 species and weighing 168 kg was impinged, with most (98%) of the losses attributable to normal operations. The most abundant species were the nudibranch *Dendronotus frondosus*, yellow rock crab (*Cancer anthonyi*), slender rock crab (*Cancer gracilis*), and brown rock crab (*Cancer antennarius*).

Estimates of entrainment and impingement of fishes and macroinvertebrates at the HBGS were compared with local recreational and commercial fishery landings. Four of the larval fish and invertebrate species assessed have some commercial value: California halibut (*Paralichthys californicus*), white croaker, northern anchovy, and rock crabs. Estimated entrainment losses, based on *ETM* values, on these commercial fisheries (in 2003 and 2002 dollars) totaled $204 and $224, respectively. Estimated impingement losses on local commercial fisheries (in 2003 and 2002 dollars) totaled $1,072 and $823, respectively. If impinged queenfish were included with white croaker in landing totals, the estimated total losses for 2002 and 2003 would be $2,887 and $2,367, respectively.

Estimated entrainment losses, based on *ETM* values, on southern California recreational fisheries were calculated for queenfish, white croaker, California halibut, and spotfin croaker. Entrainment losses based on alongshore P_m values totaled 7,583 individuals, while losses based on alongshore and offshore P_m values totaled 5,757 individuals. In both cases, queenfish comprised the majority (77% or more) of these losses. Estimated impingement losses on southern California recreational fisheries were determined using two databases. Impingement losses were equivalent to 1% of southern California recreational landings using the RecFIN database, and about 10% of local landings from Huntington Beach, Newport Beach, and Long Beach, California, as reported in the NOAA Fisheries Los Angeles Times database. However, there was a large disparity between the most abundant species impinged and the most abundant species reported in landings.

A first-order analysis of cumulative entrainment and impingement impacts in southern California was performed. The cumulative entrainment analysis relied on the maximum cooling water volumes from 12 of the 13 generating stations and a source water area that extended from Pt. Conception down into Baja California and offshore to depths of 35 m and 75 m. Modeling results over a range of larval durations showed that the maximum average entrainment mortality was 1.4% for a larval duration of 40 days using a source volume out to the 75-m isobath. The maximum peak entrainment mortality of ~2.3% occurred at the geographic center of the cooling water flows from all of the power plants. Restricting the source water to the 35-m isobath increased the average estimated mortality to 4.4%. HBGS mortality rates were between 5.4 and 5.6 percent of the cumulative mortality from the 12 intake locations. This is approximately the same as the HBGS percentage of total permitted cooling water by the 12 power plants (5.4%).

Impingement results were available for 11 of 13 generating stations, though monitoring protocols varied by location. Bight-wide fish impingement was estimated at nearly 3.7 million fishes weighing over 26,400 kg in 2003, with impingement at the San Onofre Nuclear Generating Station representing 97% of impingement abundance and 83% of biomass. Bight-wide macroinvertebrate impingement was estimated at over 77,600 individuals weight 1,366 kg, with impingement at the HBGS representing 91% of the impingement abundance but only 12% of the biomass.

Cumulative impingement data were compared with 2003 landings reported in the PSMFC RecFIN database for southern California as a whole. For most species, the numbers impinged at the 11 coastal generating stations represented less than one percent of recreational landings in southern California. In total, impingement abundance in the SCB was equivalent to 8% of the recreational catch in the SCB in 2003 for those species that are fished. Impingement in the SCB was also compared with recreational landings reported in the NOAA Fisheries Recreational Sport Fisheries Database for Southern California (between Santa Barbara and Oceanside). For the ten most abundant sportfish taxa reported in 2003, Bight-wide impingement was relatively minor (4%

or less) compared to the reported catch for 2003. Overall, Impingement in the SCB was equivalent to about one-third of the reported sportfish catch.

Analysis of potential methods to reduce entrapment and impingement at the HBGS was summarized, and included both technologies (such as behavioral barriers and screens) and operational measures (such as intake relocation and flow reduction). There is a limited number of proven technologies, especially in the coastal environment, to reduce impingement and/or increase survival. Based on the feasibility, performance, and relative estimated cost of these technologies/measures examined, none are recommended for implementation at the HBGS to reduce impingement.

1.0 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 Project consisted of restoring and operating Units 3 and 4, which were retired from service in 1995. In March 2001, the CEC issued its Staff Assessment of the project, which recommended, "a license be issued for a restricted time period consistent with AES's electrical generating contract with the Department of Water Resources or until September 30, 2006" (CEC 2001). As part of this conditional license, AES was required to comply with several conditions, including Condition of Certification BIO-4:

"The project owner will prepare a monitoring/study plan and conduct one year of monitoring to determine the actual impingement and entrainment losses resulting from the operation of the cooling water system for the new Units 3 and 4 and the existing Units 1 and 2. The project owner will sample the intake and source water to determine fractional losses relative to their abundance in the source water…The methods, analysis, results, and conclusions of the monitoring study will be documented in a scientific style report and submitted to the CPM for review and approval. Other agencies, including the U.S. Fish and Wildlife Service and the California Department of Fish and Game, shall be included in the review of the draft report, if they so request. A final report shall be prepared upon completion of field sampling. The study results will be utilized during the NPDES permit renewal evaluation to be completed by the Santa Ana Regional Water Control Board in June 2005."

Furthermore, Condition of Certification BIO-6 states: "*The project owner shall conduct a study to determine if there is a feasible methodology that would greatly reduce the number of fishes trapped in the intake forebay. If the study determines that a feasible method(s) exists to reduce the number of fishes trapped in the cooling water system the project owner shall implement those methods."* The Entrainment and Impingement Study was designed and performed to satisfy Conditions of Certification BIO-4 and BIO-6.

1.1 Development of the Study Plan

In accordance with Conditions of Certification BIO-4 and BIO-6, MBC *Applied Environmental Sciences* (MBC) submitted a draft entrainment and impingement study plan to the CEC in October 2001. After reviewing the study plan, CEC staff and consultants met on 5 October 2001 to discuss specifics of the study plan. In July 2002, MBC submitted a revised draft study plan to the CEC and the Biological Resources Research Team (BRRT), which consists of interested parties representing regulatory agencies, consultants, and the applicant (AES Huntington Beach L.L.C.). Comments and recommendations to the study plan were submitted by the BRRT and discussed at a meeting on 9 October 2002. The final study plan, which incorporated further comments and recommendations, was published in July 2003.

1.2 Overview of the Study Plan

The entrainment and impingement study is designed to estimate losses of fishes and shellfish due to operation of the cooling water system of the AES Huntington Beach Generating Station (HBGS). The sampling methodologies and analysis techniques are derived from recent entrainment and impingement studies conducted for the Diablo Canyon Power Plant, Morro Bay Power Plant, and Moss Landing Power Plant (Tenera 2000a, 2000b, 2001). Similar projects were performed nation-wide in the last 25 years to comply with Section 316(b) of the Federal Clean Water Act, including the 1996–1999 study at the Diablo Canyon Power Plant. The 1999–2000 studies at Morro Bay and Moss Landing were performed as part of the California Energy Commission CEQA process for permitting power plant modernization projects.

For the Huntington Beach entrainment study, the numbers of fishes and target invertebrates 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.

Target Organisms

The BRRT selected the following organisms for analysis (target organisms) during the entrainment and impingement study at the HBGS:

Vertebrates:

- Fishes (all life stages beyond egg)

Invertebrates:

- *Cancer* spp. (rock crab megalopal life stage)
- *Loligo opalescens* (market squid larvae)
- *Panulirus interruptus* (California spiny lobster phyllosoma larvae)
- *Sicyonia ingentis* (ridgeback rock shrimp phyllosoma larvae)
- *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 rock shrimp (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 California Department of Fish and Game (CDFG) catch blocks off Huntington Beach (CDFG 2002).

The organisms analyzed in this report are 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 together comprised 90 percent of all larvae entrained and/or juveniles and adults impinged by the generating station. Concentrations of all larvae are expressed as number per 1,000 cubic meters (#/1,000 m^3).

1.3 Report Organization

Section 2 of this report characterizes the AES HBGS and the surrounding physical and biological environments. Methods used for data collection and analysis are presented in Section 3. Results of the entrainment and impingement study are presented in Section 4, including assessments for each of the target taxa in separate subsections. Included in each subsection is a summary of the organism's ecology, life history, population trends, entrainment and impingement estimates, and assessment results. An entrainment and impingement impact assessment is presented in Section 5. An evaluation of potential impingement reduction technologies/measures is presented in Section 6. A listing of literature cited in this report is presented in Section 7, and a glossary is provided in Section 8. Temperature and salinity profiles are presented in Appendix A, entrainment and source water data are presented in Appendix B, and impingement data in Appendix C. Master species lists are provided in Appendix D. A cumulative (Bight-wide) impact analysis is presented in Appendix E, and demographic and *ETM* parameterizations are provided in Appendix F.

2.0 DESCRIPTION OF THE AES HUNTINGTON BEACH GENERATING STATION AND WATERS OFFSHORE HUNTINGTON BEACH

The following section describes the HBGS and the surrounding aquatic environment. A description of the generating station and its cooling water intake system (CWIS) is presented in Section 2.1. Section 2.2 characterizes the physical environment in the vicinity of HBGS, including the nearshore shelf, Huntington State Beach, the lower Santa Ana River, and Talbert Marsh. Section 2.3 examines the invertebrate and fish communities off Huntington Beach.

2.1 Description of the Generating Station

The HBGS is located on the Orange County coast in the city of Huntington Beach (Figure 2-1). The generating station consists of four steam-powered electric generating units. Steam is supplied to each turbine generator from oil- and gas-fired boilers. Units 1 and 2 are each rated at 215 megawatts (MW) and Units 3 and 4 are each rated at 225 MW. Units 3 and 4 were operated very sparingly after 1989 and were retired from service from 1995 until completion of the retool project in 2003. Unit 5, a multiple-jet-turbine peaker unit (133 MW), was retired from service in 2002. The current total station rating is 880 MW; however, the plant operated at about 44% capacity in 2001 and only about 14% capacity in 2002, largely due to retool construction efforts (MBC 2001, 2003a).

Cooling Water Intake System Description

Ocean water for cooling purposes is supplied to the generating station via a single cooling water system. Seawater for Units 1–4 is withdrawn from an intake structure located 457 m (1,500 ft) offshore (Figure 2-2). The intake structure is located in approximately 10 m of water, and rises approximately 4 m off the bottom. The vertical riser section is 6.4-m inside-diameter (ID), and the horizontal conduit to the generating station is 4.3-m ID. The vertical riser is fitted with a velocity cap, and the vertical opening between the riser and the velocity cap is about 1.5 m (Figure 2-3). Entrance velocities at the point of withdrawal have been measured at 0.6 and 1.2 m/sec (FES et al. 1980, McGroddy et al. 1981).

Seawater is drawn into the plant by up to eight circulating water pumps, each capable of delivering 44,000 gallons per minute, or about 63.4 million gallons per day (mgd), for a station maximum of about 507 mgd (1,919,000 m^3). The flow is directed to a 4-m x 15.2-m open rectangular forebay and screening facility within the plant. The screen system is composed of

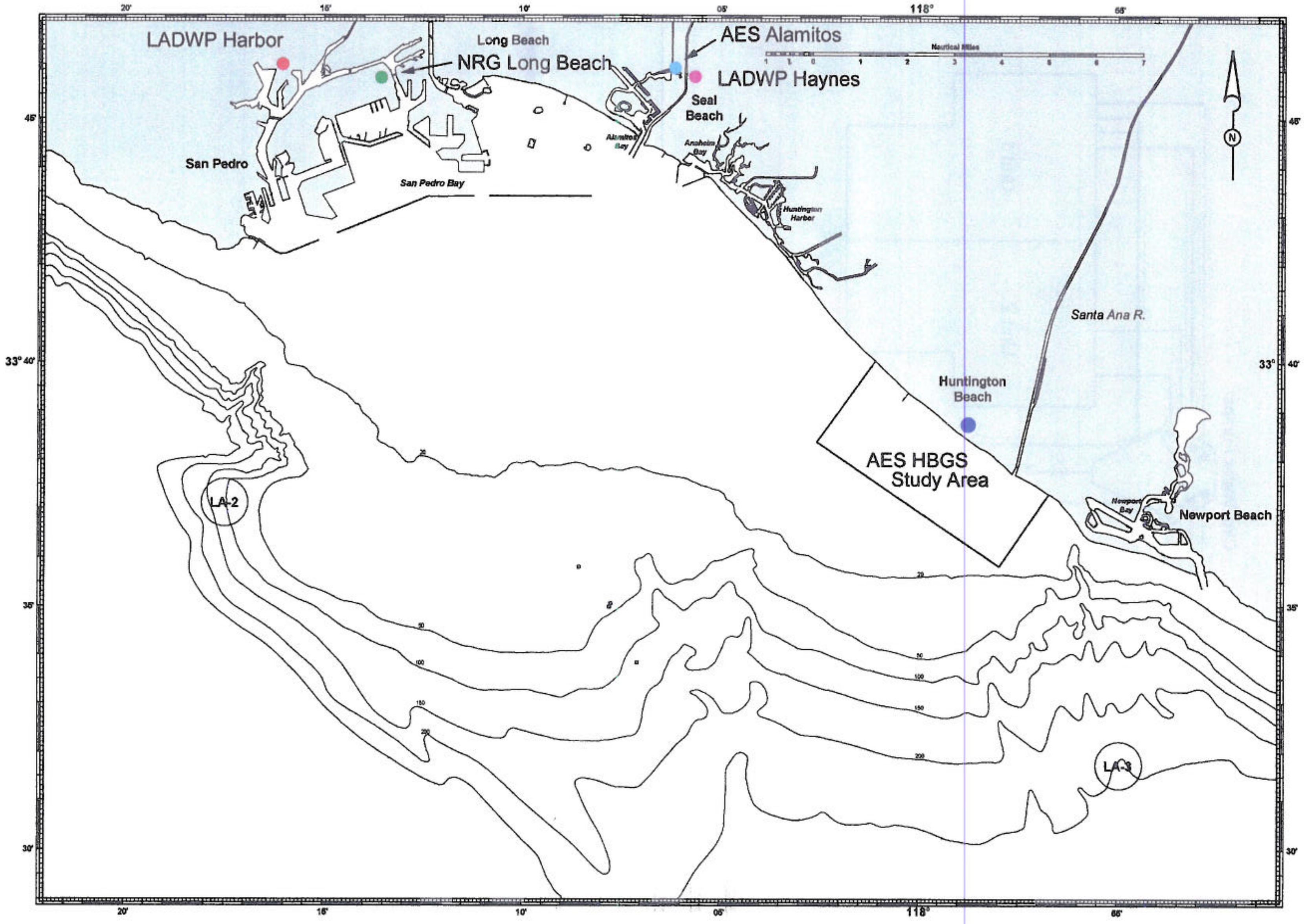

Figure 2-1. Location of the HBGS study area. (Depths in fathoms.)

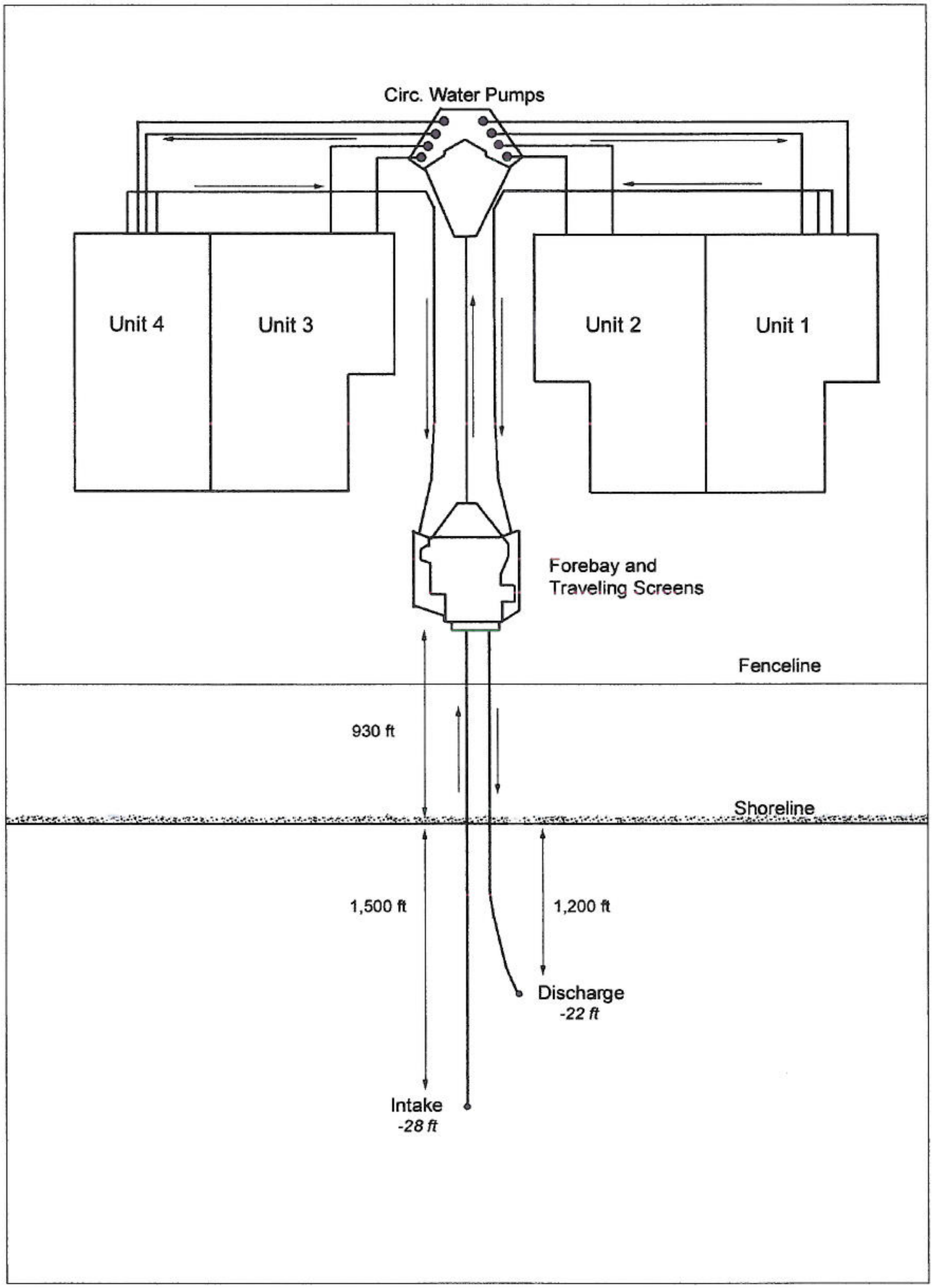

Figure 2-2. Schematic of the AES HBGS cooling water intake system.

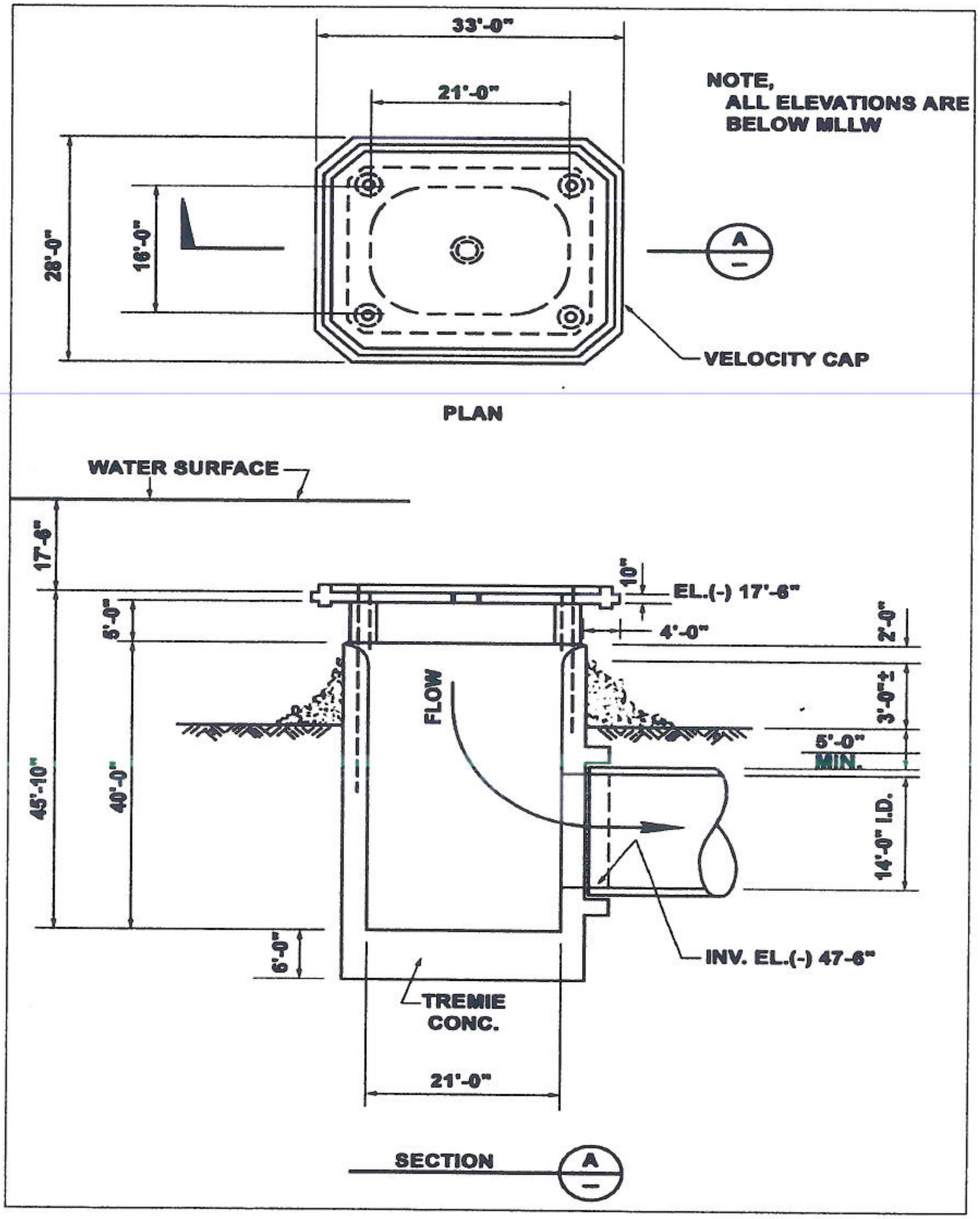

Figure 2-3. Schematic of the AES HBGS intake structure: velocity cap (top) and intake profile (bottom).

vertical bar racks spaced 76.2 mm (3") on center and vertical traveling screens with 9.5-mm (3/8") mesh designed to remove trash, algae, marine life, and other incidental debris incoming with the cooling water. After flowing through the screen system, the cooling water is pumped to two steam condensers, one per turbine generator. At full load, the temperature increase through the condensers (ΔT) is approximately 10°C (18°F). After passing through the condensers the water is directed to a single 4.3-m concrete discharge conduit, which extends approximately 366 m (1,200 ft) offshore. The discharge structure resembles the intake structure, except there is no velocity cap. Discharged waters are directed vertically to the surface to allow for dilution and atmospheric cooling.

Units 1–4 have closed cooling water systems to cool auxiliary equipment. Demineralized water is cooled by part of the main cooling stream, which is diverted to a heat exchanger and returned to the main stream. Each unit diverts about 9,750 gpm (14 mgd), and this water is subsequently elevated 4.6°C (AES and URS 2000). No modifications to the cooling water system were made as part of the Repowering Project.

Operational Procedures

To control the growth of bacteria and other micro-fouling organisms within the cooling water system, the cooling water is treated with sodium hypochlorite in accordance with the station's National Pollutant Discharge Elimination System (NPDES) permit. Biofouling within the cooling water conduits and forebay is controlled by heat treatment. During heat treatments, a portion of the heated discharge water is diverted into the forebay and intake conduits until the water temperature rises to approximately 40.5°C (105°F). Temperature of discharge waters during this procedure is about 44° to 50°C (112° to 122°F). This temperature is maintained for about one hour, during which time all mussels, barnacles, fishes, and other invertebrates within the cooling water system succumb to the high water temperature. This procedure has been used for decades at most of southern California's coastal generating stations (Graham et al. 1977), and is done in compliance with NPDES permit limitations. Divers also periodically remove accumulated debris, such as mussel and barnacle shells and sand, from the forebay and in-plant conduits.

2.2 Description of the Physical Environment Surrounding the AES Huntington Beach Generating Station

The physical and biological characteristics of the subtidal environment off Huntington Beach have been studied extensively by the Huntington Beach Generating Station operators (SCE and AES Huntington Beach L.L.C.) and by the Orange County Sanitation District (OCSD), which discharges primary- and secondary-treated wastewater from a diffuser outfall about four nautical miles offshore the generating station in about 60 m of water. Studies performed for the generating station have examined the physical and biological characteristics of the nearshore zone (depths to about 10 m), while studies performed by OCSD have been focused in deeper waters around the wastewater outfall.

The coastline of Huntington Beach runs, in general, from west-northwest to east-southeast. The continental shelf offshore the generating station is gently sloping; the 30-m isobath is nearly four miles from shore. Subtidal sediments are predominantly sand, with lesser amounts of silt and clay (OCSD 2000, 2003a). Off Huntington Beach, grain size generally decreases with depth, grain size generally increases upcoast from the OCSD wastewater outfall, and the Newport and San Gabriel Submarine Canyons (downcoast and upcoast of the generating station, respectively) are depositional areas. The nearest stand of giant kelp (*Macrocystis pyrifera*) is located inside the Newport Harbor entrance jetty 11.0 km downcoast.

Huntington State Beach

The Huntington Beach Generating Station is located just across Pacific Coast Highway (inland) from the Huntington State Beach, and the intake and discharge structures for the generating station are just offshore the state beach. The state beach is a little over two miles in length, extending north from the Santa Ana River mouth past the generating station to Beach Boulevard. At Beach Boulevard, the state beach borders the Huntington City Beach. Over 11 million people visit the beaches of Huntington Beach annually.

Santa Ana River and Talbert Marsh

The mouth of the Santa Ana River is approximately 2.4 km downcoast from the generating station. The Santa Ana River is the largest river system in southern California, with a watershed of about 2,450 mi^2. Flow volume in the river is intermittent, and is partially dependent on the amount of precipitation in the watershed. Diversion and storage of water behind dams during winter and subsequent slow release during summer result in continual flow in some stretches of the river that would be dry otherwise (MBC 2000). In addition, there is year-round input from dischargers, including wastewater treatment facilities. Talbert Marsh is a recently restored salt marsh located just west of the Santa Ana River mouth. The marsh, which was previously isolated from tidal exchange, was restored in the late 1980s, and is connected to the ocean through a 30-m wide entrance channel adjacent to the river mouth. Both the Santa Ana River and Talbert Marsh are sources of fecal indicator bacteria (fecal coliform and enterococcus) during ebb tides, and these bacteria are transported parallel to shoreline resulting in frequent beach postings in the vicinity of the generating station (Kim et al. 2004).

2.3 Description of the Biological Environment in the Vicinity of the AES Huntington Beach Generating Station

2.3.1 Invertebrate Communities

Benthic Infauna

Infaunal organisms off Huntington Beach were studied annually from 1975 through 1993 (MBC 1993). In the 19 years of sampling, an average of 43 individuals representing 17 species were collected per liter of sediment. Dominant species included the polychaetes *Apoprionospio pygmaea* and *Goniada littorea*, the amphipod *Rhepoxynius menziesi*, the cumacean *Diastylopsis tenuis*, and the gastropod *Olivella baetica*. These species are common in the sandy nearshore environments of southern California (Morris et al. 1980).

Benthic Macrofauna

Diver surveys at four to six locations offshore the generating station were conducted annually from 1975 through 2001 (MBC 2001). On average, divers observed 34 species per year during the surveys, though interannual variation was high, ranging from 22 species in 1975 to 55 species in 1984. Average density of organisms recorded by divers was 61 individuals per m^2, with values ranging from 12 individuals per m^2 (1976 and 1977) to 161 individuals per m^2 (1989). In 2001, biologist-divers recorded 25 species at an average density of 51 individuals per m^2.

Polychaete worms were numerically dominant in 2001, comprising 79% of the total abundance, followed by arthropods with 13%. A single species, the onuphid polychaete *Diopatra splendidissima*, accounted for 75% of the abundance. This species provides stability to the sediments and enhances the diversity of the bottom community by providing habitat for macrofaunal inhabitants of the shallow sandy subtidal. The density of many other macrofaunal species is intimately tied to that of *Diopatra* as it effectively acts as a biological artificial reef on an otherwise featureless sandy bottom. *Diopatra* tubes are colonized by larval organisms that require stable substrate for attachment, such as slippersnails, kelp scallops, barnacles, hydroids, bryozoans, and tube-building amphipods. Small, unidentified spider crabs (Majidae) comprised 9% of the abundance in 2001, followed by the slippersnail *Crepidula adunca* (4%), Maldanid worms (3%), barnacles in the genus *Balanus* (3%), and brittlestars (Ophiuroidea; 2%).

A total of 10 epibenthic macroinvertebrate species was collected during the 2001 trawl surveys offshore the generating station (MBC 2001). The most abundant species was the spiny sand star *Astropecten armatus*, comprising 34% of trawl-caught abundance. Other abundant trawl-caught invertebrates included the penicillate jellyfish (*Polyorchis penicillatus*; 24%), tuberculate pear crab (*Pyromaia tuberculata*; 18%), blackspotted bay shrimp (*Crangon nigromaculata*; 14%), and Pacific sand dollar (*Dendraster excentricus*; 5%).

Impinged Macroinvertebrates

A total of 30 macroinvertebrate species was collected in the 2002 fish impingement surveys at the generating station (MBC 2003a). The dominant species were the opalescent nudibranch (*Hermissenda crassicornis*), yellow rock crab (*Cancer anthonyi*), frond-aeolis (*Dendronotus frondosus*), tuberculate pear crab, and Pacific rock crab (*Cancer antennarius*). From 1994 through 2002, other abundant species impinged at the generating station were giant frond-aeolis (*Dendronotus iris*), penicillate jellyfish, red rock shrimp (*Lysmata californica*), common salp (*Thetys vagina*), California aglaja (*Navanax inermis*), and graceful rock crab (*Cancer gracilis*).

Intertidal Organisms

The intertidal community adjacent to the generating station was studied quarterly in 1971 and 1972 (EQA/MBC 1973). The major components of the intertidal community were the polychaetes *Hemipodus borealis*, *Nephtys californiensis*, and *Nerinides acuta*, the sand crab *Emerita analoga*, the Pismo clam *Tivela stultorum*, and the bean clam *Donax gouldii*. Species richness and densities of these species were lower than those recorded at similar sites in southern California. It was concluded that several factors, potentially including wave action and disturbance from beach-goers, limited the population.

2.3.2 Fish Communities

HBGS Trawl Surveys

Demersal fish surveys were conducted off the HBGS annually since 1976 (MBC 2001). Six to twelve trawls were performed at stations directly offshore the generating station, and one mile upcoast and downcoast from the generating station. At least 64 species of fishes have been collected in the trawl surveys. The catch was numerically dominated by northern anchovy (*Engraulis mordax*; 50%), white croaker (*Genyonemus lineatus*; 27%), and queenfish (*Seriphus politus*; 18%). Combined, these three species accounted for more than 95% of the trawl-caught fish abundance.

Other historically abundant species include surfperches, such as white seaperch (*Phanerodon furcatus*), walleye surfperch (*Hyperprosopon argenteum*), barred surfperch (*Amphistichus argenteus*), and shiner perch (*Cymatogaster aggregata*), and flatfishes such as California halibut (*Paralichthys californicus*) and speckled sanddab (*Citharichthys stigmaeus*). Numbers of several surfperches collected by trawl and in fish impingement surveys declined by more than 90% between 1979 and 1984, and abundances have remained relatively low since then. This coincided with a warming of ocean waters in southern California (Beck and Herbinson 2003), as well as a decrease in upwelling (Allen et al. 2003). Numbers of California halibut collected by trawl declined in 1994 when sampling effort was halved.

HBGS Impingement Sampling

In-plant fish impingement sampling has been conducted since the 1970s. From 1979 through 2002, queenfish was the dominant species in impingement samples, comprising 82% of the total abundance (MBC 2003a). Similar to trawl catches off the generating station, white croaker and northern anchovy were also abundant in impingement samples, accounting for 6% and 3% of the total abundance, respectively. Other abundant species were walleye surfperch, white seaperch, Pacific pompano (*Peprilus simillimus*), California grunion (*Leuresthes tenuis*), jacksmelt (*Atherinopsis californiensis*), shiner perch, and deepbody anchovy (*Anchoa compressa*). Similar to long-term trends observed in the trawl data, numbers of walleye surfperch, white seaperch, and Pacific pompano declined dramatically from 1979 through 1984. In 2002, the most abundant fish species impinged were queenfish (83%), white croaker (4%), shiner perch (2%), jacksmelt (2%), and deepbody anchovy (1%).

Commercial Fisheries

Two of California Department of Fish and Game's Catch Blocks are located directly offshore the HBGS: Blocks 738 and 739. Though ports of origin for most landings are reported from San Pedro, Terminal Island, and Newport Beach, some are reported from as far away as San Diego and San Francisco. From 1999 through 2001, three-year top commercial landings in Block 738 included Pacific sardine (*Sardinops sagax*; 23.9 million pounds [MP]), market squid (*Loligo opalescens*; 2.1 MP), Pacific mackerel (*Scomber japonicus*; 1.2 MP), northern anchovy (0.9 MP), California spiny lobster (*Panulirus interruptus*; 0.08 MP), and jack mackerel (*Trachurus symmetricus*; 0.06 MP) (CDFG 2002). The pelagic species (Pacific sardine, market squid, Pacific mackerel, northern anchovy, and jack mackerel) were generally caught by purse seine, drum seine, and long-line, while California spiny lobster were collected by crab/lobster trap. Landings of Pacific sardine ranked first economically ($13.3 million from 1999-2001), followed by Pacific mackerel ($1.0 million), market squid ($0.5 million), and northern anchovy ($0.39 million). From 1975 to 1981, the annual commercial catch in Catch Block 738 was fairly stable, ranging from 1.3 to 2.6 MP, and then increased to over 7 MP in 1982 due to a large increase in northern anchovy landings. From 1983 to 1986, landings in Block 738 declined to 0.07 to 0.18 MP. From 1999 through 2001, landings in Block 738 ranged from 0.82 to 15.8 MP per year.

From 1999 through 2001, top commercial landings in Block 739 included Pacific sardine (42.3 MP), Pacific mackerel (5.7 MP), market squid (2.9 MP), northern anchovy (1.2 MP), jack mackerel (0.3 MP), and California halibut (0.15 MP). Jack mackerel were caught primarily by purse seine; Pacific sardine, market squid, and northern anchovy by purse seine and drum seine; Pacific mackerel by purse seine, set gillnet and set longline; and California halibut by gillnet and trawl. Economically important landings included Pacific sardine ($1.8 million), California halibut ($0.49 million), Pacific mackerel ($0.33 million), and market squid ($0.26 million).

A setline dory fishery off Newport Beach has existed since 1891, and is one of the few traditional dory fisheries remaining on the west coast. Fisherman use dories launched from the shores of Newport Beach to fish on the continental shelf and slope with setlines at depths of about 100 to 600 m. In a yearlong study of the fishery in 1983 and 1984, most of the fishing was concentrated at slope depths of 380 to 580 m (Cross 1984). Some of the fishing areas frequented in that study were located about 10 km directly offshore the HBGS. Principal species landed in this localized fishery include sablefish (*Anoplopoma fimbria*), thornyhead (*Sebastolobus* spp.), and rockfishes (*Sebastes* spp.). While dory landings of these species pale in comparison to overall commercial landings, they represent a fishery that has changed little in over 110 years.

Fishes of the Lower Santa Ana River

In 1987, seven species of fishes were collected by a variety of methods from the tidally influenced lower Santa Ana River, which is concrete-lined (Marsh 1992). Only two species were native: California killifish (*Fundulus parvipinnis*) and striped mullet (*Mugil cephalus*). The other five species were introduced, and included common carp (*Cyprinus carpio*), fathead minnow (*Pimephales promelas*), mosquitofish (*Gambusia affinis*), green sunfish (*Lepomis cyamellus*), and Mozambique tilapia (*Tilapia mossambica*). Of these seven species, only three were impinged at the HBGS from 1979 through 2002. Mozambique tilapia occurred in 11 of the last 24 years, but not after 1998 (MBC 2003a). The highest annual impingement for this species was 105 individuals in 1983. Eleven California killifish were impinged in 1995, and three striped mullet were impinged in 1979.

Fishes of Talbert Marsh

From 1989 through 1990 eleven species of fishes were collected by beach seine from Talbert Marsh (Gorman et al. 1990). California killifish, topsmelt (*Atherinops affinis*), Pacific staghorn sculpin (*Leptocottus armatus*), and arrow goby (*Clevelandia ios*) were the most abundant species. Fishes collected in small numbers (10 individuals or less) included shiner perch, white croaker, longjaw mudsucker (*Gillichthys mirabilis*), walleye surfperch, bay goby (*Lepidogobius lepidus*), California halibut, and bay pipefish (*Syngnathus leptorhynchus*).

3.0 METHODS

The sampling plan and analysis techniques of the Entrainment and Impingement Study were developed by the Biological Resources Research Team (BRRT), which was formed by the California Energy Commission (CEC). The BRRT consists of representatives of AES Huntington Beach L.L.C., MBC *Applied Environmental Sciences*, Tenera Environmental, California Energy Commission staff and consultants, Santa Ana Regional Water Quality Control Board, U.S. Fish and Wildlife Service, NOAA Fisheries (formerly National Marine Fisheries Service), California Department of Fish and Game, and the California Coastal Commission. Members of the BRRT reviewed and commented on two drafts of the study plan, the first quarterly data report, and the Six-Month and Nine-Month Reports.

3.1 Target Organisms

Several types of organisms are susceptible to entrainment by the generating station. The intent of this study is to estimate entrainment effects on two types of organisms: fish larvae and larvae of the following invertebrate species: rock crabs (*Cancer* spp.), market squid (*Loligo opalescens*), California spiny lobster (*Panulirus interruptus*), ridgeback rock shrimp (*Sicyonia ingentis*), and sand crab (*Emerita analoga*). Assessment of entrainment effects were limited to the most abundant fish taxa that together comprised 90 percent of all larvae entrained and/or juveniles and adults impinged by the generating station.

3.2 Entrainment and Source Water Sampling

3.2.1 Introduction

The purpose of the entrainment study is to determine the extent of potential impacts from the operation of the cooling water system of the HBGS on larval fishes and selected invertebrate larvae (target species). Entrainment refers to the incorporation of aquatic organisms into the cooling water intake structure of the generating station. The entrainment study focuses on larval life stages, while the impingement study focuses on juvenile and adult forms. The entrainment sampling plan was designed to characterize the composition and abundance of those organisms both 1) entrained by the generating station, and 2) present in the source waters and potentially at risk of entrainment.

3.2.2 Methods

3.2.2.1 Entrainment Sample Collection

To determine composition and abundance of ichthyoplankton entrained by the generating station, sampling in the immediate proximity of the cooling water intake was conducted twice monthly in September and October 2003, weekly from November 2003 through July 2004, and twice during August 2004. During each sampling event, two replicate tows at the entrainment station were collected four times per 24-hr period—once every six hours. Sampling cycles were initiated at approximately 1200 hr, 1800 hr, 2400 hr, and 0600 hr. The second and fourth cycles were initiated to correspond with sunset and sunrise, respectively.

Sampling was conducted offshore (within 100 m) of the submerged intake structure (Figure 3-1) using an oblique tow that sampled the water column from approximately 13 cm off the bottom and then back to the surface. Two replicate tows were taken with a minimum target sample volume of 30 to 40 m^3 for each net on the bongo frame. The net was redeployed if the target volume was not collected during the initial tow.

The wheeled bongo frame was fitted with 60-cm diameter net rings with plankton nets constructed of 333-µm Nitex® nylon mesh, similar to the nets used by the California Cooperative Oceanic Fisheries Investigations (CalCOFI). Each net was fitted with a Dacron sleeve and a cod-end container to retain the organisms. Each net was equipped with a calibrated General Oceanics® flowmeter, allowing the calculation of the amount of water filtered. At the end of each tow, nets were retrieved and the contents of the net gently rinsed into the cod-end with seawater. Contents were washed down from the outside of the net to avoid the introduction of plankton from the wash-down water. Samples were then carefully transferred to prelabeled jars with preprinted internal labels. Samples from one of the two nets were preserved in 4 percent buffered formalin-seawater, while contents of the other net were preserved in 70 to 80 percent ethanol. Larvae preserved in ethanol can be made available for genetic and/or otolith analysis, if required. Genetic analyses have been performed in recent studies in attempts to validate the identity of certain species.

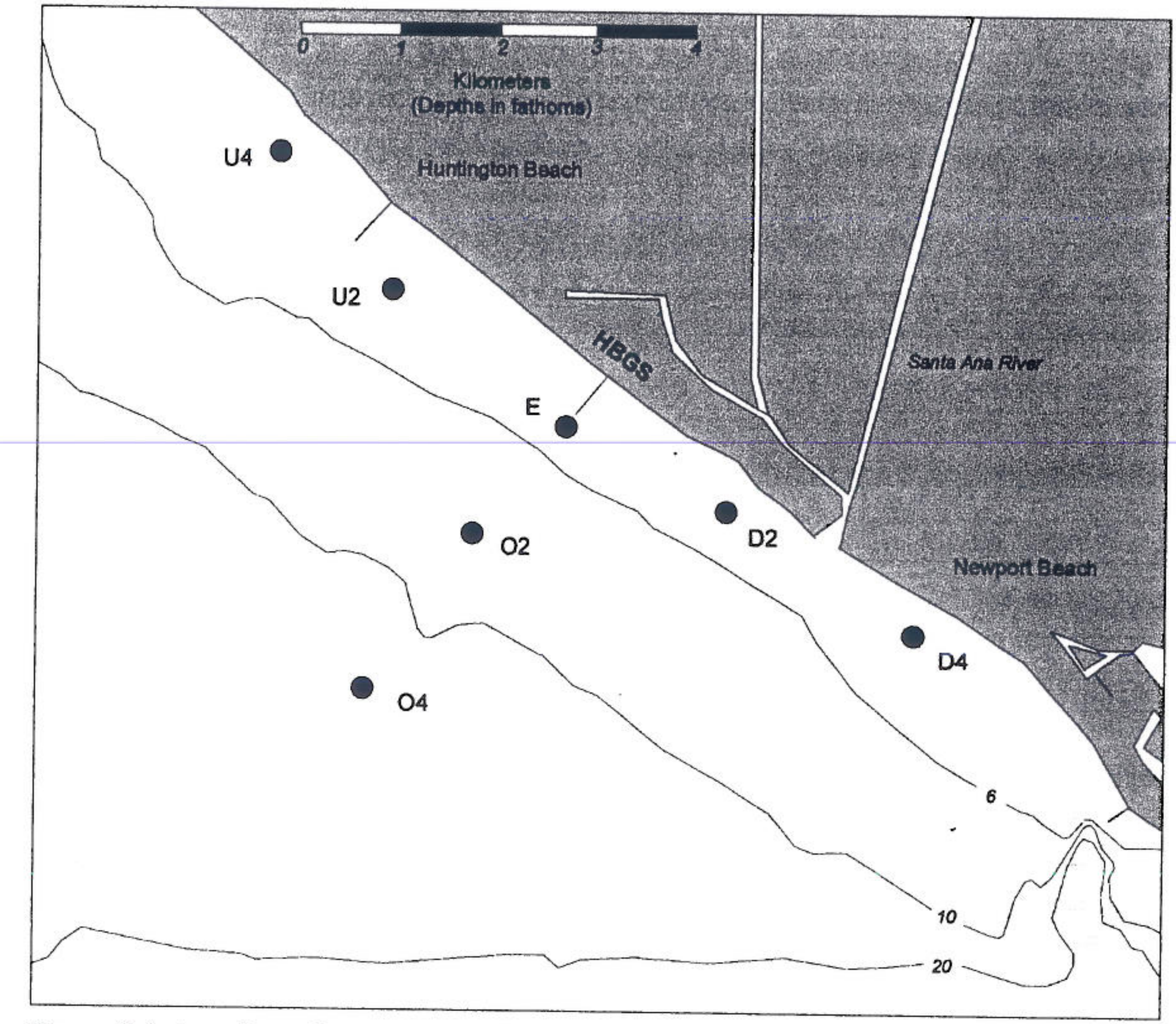

Figure 3-1. Location of entrainment (E) and source water sampling stations (U4, U2, D2, D4, O2, and O4), where U, D, and O designate stations upcoast, downcoast and offshore of the intake, respectively. Also shown are the 6-fathom (11-m), 10-fathom (18-m), and 20-fathom (36-m) isobaths.

3.2.2.2 Source Water Sample Collection

To determine composition and abundance of ichthyoplankton in the HBGS source water, sampling was conducted monthly in September and October 2003, twice per month from November 2003 through July 2004 (during the peak spawning period for fishes in late winter and spring), and once in August 2004.

Besides the entrainment station, source water sampling occurred at six additional source water stations located upcoast, downcoast, and offshore from the intake structure (Figure 3-1).

Two source water stations were located 2 km and 4 km upcoast (U2 and U4) and downcoast (D2 and D4) from the intake on the intake isobath, and two stations were located approximately 1.5 km and 3 km offshore (O2 and O4) from the intake structure. Water depth at the upcoast and downcoast stations is similar to the depth at the intake (9.5 m) while the depth at the two offshore stations is approximately 14 m and 22 m. Tows were performed in the same manner as the entrainment tows (obliquely). The sampling grid is similar in design to that used during the study of cooling water system effects at the San Onofre Nuclear Generating Station (Barnett et al. 1983).

All stations were sampled with a wheeled bongo using the same oblique tow technique described for the entrainment sampling. During each source water survey, the additional six source water stations (plus the entrainment station) were sampled four times per 24-hr period—once every six hours. Two replicates were collected at each station during each of the four sampling periods. During sampling at the seven stations (six source water plus one entrainment), the entrainment station was always bracketed by the source water station sampling.

Conductivity, temperature, and depth (CTD) profiles were collected at both entrainment and source water stations during most surveys, beginning with the second survey in September 2003 and ending August 2004. The purpose of these profiles was to determine if any oceanographic features, such as influxes of brackish or fresh water from nearby marshes, were related to the distribution of larval fishes in the study area.

3.2.2.3 Laboratory Processing

Ichthyoplankton samples were returned to the laboratory, and after approximately 72 hours the samples preserved in 4 percent buffered formalin-seawater were transferred to 70–80 percent ethanol before processing. One net from each replicate was processed from the entrainment surveys. Only the samples initially preserved in formalin from the first of the two bimonthly source water surveys (November through July) were processed, with the samples from the second monthly survey archived for potential future sorting and analysis. If analysis of entrainment results suggests relatively high concentrations of some species of interest (e.g., rockfishes), the second bimonthly source water samples were processed. Samples were examined under dissecting microscopes and fish larvae and targeted invertebrate larvae were separated from debris and other zooplankton. Larvae were identified to the lowest practical taxonomic level (species for most larvae) and enumerated. Fish eggs were not sorted or identified, as their taxonomy remains difficult and time-consuming.

Myomere counts and pigmentation patterns were used to identify the larval fishes; however this was problematic for some species. Some larval fishes could not be identified to the species level using microscopic techniques and were recorded at the lowest taxonomic classification possible (e.g., genus or family level). For example, many species of the family Gobiidae share morphologic and meristic characters during early life stages (Moser 1996) making identifications to the species level difficult. Larvae of the arrow goby (*Clevelandia ios*), cheekspot goby (*Ilypnus gilberti*), and shadow goby (*Quietula y-cauda*) are difficult to identify to species when they are newly hatched. Therefore, these three species were combined into an "unidentified goby" category referred to as the "CIQ goby complex".

Larval combtooth blennies (*Hypsoblennius* spp.) can be easily distinguished from other larval fishes (Moser et al. 1996). However, the three sympatric species that could occur in the area cannot be distinguished from each other on the basis of morphometrics or meristics at the smaller sizes common in the samples. Therefore, the combtooth blennies were grouped into an "unidentified combtooth blennies" category (e.g., *Hypsoblennius* spp.).

A number of larvae from the Family Sciaenidae (croakers) were collected during the study. The larvae in this family are recognized by their relatively large, somewhat bulbous head, compact coiled gut and relatively slender, tapering tail. Pigmentation ranges from light (e.g., white croaker) to heavy (e.g., white seabass *Atractoscion nobilis*) (Moser 1996). A great majority of yolk-sac stage larvae collected during the summer surveys belonged to the family Sciaenidae. Identification to the species level for these early developmental stages is very difficult because some of the species (e.g., queenfish and spotfin croaker *Roncador stearnsii*) have similar initial pigmentation patterns along the dorsal margin, migrating down as the larvae develop. White seabass, black croaker *Cheilotrema saturnum*, California corbina *Menticirrhus undulatus*, and yellowfin croaker *Umbrina roncador* have moderate to heavy pigmentation for this developmental stage allowing them to be separated from other species of sciaenids. The white croaker has a distinct pigmentation pattern that allows it to be separated from other sciaenids. Despite these difficulties in identifying the yolk-sac stages of this family, unidentified yolk-sac sciaenid larvae accounted for only 12 percent of the total sciaenid larvae collected from the entrainment station. Therefore, the individual species were not combined into a single group for analysis because of the difficulty in interpreting the results for a taxonomic grouping that includes both commercial and non-commercial species with varying life histories. In addition, the primary method of assessment, the Empirical Transport Model, uses an estimate of plant-induced mortality that would not be affected by small changes in the estimates from the entrainment and source water sampling as long as the proportion between the two estimates didn't change.

The lengths (notochord/standard lengths) of larvae collected from the entrainment station were measured to estimate the age of the entrained larvae. A representative number of individual larvae of each of the most abundant taxa, or species with recreational or commercial fishery importance, collected during each survey, were measured using a video capture system and Optimus™ image analysis software. The average length calculated from these measurements was used to estimate the average age of the larvae by dividing the difference between the average and minimum lengths by a larval growth rate (mm/d) obtained from the scientific literature for the species or a closely related species. The 1st percentile value was used as the minimum length to account for outliers in the measurements. The difference between the 1st and 95th percentile values was used to estimate the maximum period of time that the larvae would be exposed to entrainment.

3.3 Estimating Entrainment Effects

Estimates of daily larval entrainment for the sampling period from September 2003 through August 2004 at HBGS were calculated from data collected at the entrainment station. Assessment of entrainment effects were limited to the most abundant fish taxa (target taxa) that together comprised 90 percent of all larvae entrained and/or juveniles and adults impinged by the generating station. Estimates of entrainment loss, in conjunction with demographic data collected from the fisheries literature, were used in modeling entrainment effects on target taxa using adult equivalent loss (*AEL*) and fecundity hindcasting (*FH*) (Appendix F). Data for the same target taxa from sampling of the entrained larvae and potential source populations of larvae was used to calculate estimates of proportional entrainment (*PE*) and used to estimate the probability of mortality (P_m) due to entrainment using the Empirical Transport Model (*ETM*). In the HBGS entrainment and impingement studies each approach (e.g., *AEL*, *FH*, and *ETM*), as appropriate for each target taxon, was used to assess effects of power plant losses.

3.3.1 Demographic Approaches

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

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

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

Species-specific survivorship information (e.g., age-specific mortality) from egg or larvae to adulthood is limited for many of the taxa considered in this assessment. These rates when available are inferred from the literature along with estimates of uncertainty. Uncertainty surrounding published demographic parameters is seldom known and rarely reported, but the likelihood that it is very large needs to be considered when interpreting results from the demographic approaches for estimating entrainment effects. For some well-studied species (e.g., northern anchovy), portions of early mortality schedules and fecundity have been reported. Because the accuracy of the estimated entrainment effects from *AEL* and *FH* will depend on the accuracy of age-specific mortality and fecundity estimates, lack of demographic information may limit the utility of these approaches.

The precursor to the *AEL* and *FH* calculations is an estimate of total annual larval entrainment. Estimates of larval entrainment at HBGS were based on weekly sampling where E_T is the estimate of total entrainment for the study period and E_i is the weekly entrainment estimate. Estimates of entrainment for the study period are based on two-stage sampling designs, with days within periods and cycles (four six-hour collection periods per day) within days. The within-day sampling is based on a stratified random sampling scheme with four temporal cycles and two replicates per cycle.

There were usually no estimates of variation available for the life history information used in the models. The ratio of the mean to standard deviation (coefficient of variation) was assumed to be 50 percent for all life history parameters used in the models.

3.3.1.1 Adult Equivalent Loss *(AEL)*

The *AEL* approach uses estimates of the abundance of the entrained or impinged organisms to project the loss of equivalent numbers of adults based on mortality schedules and age-at-recruitment. The primary advantage of this approach is that it translates power plant-induced early life-stage mortality into numbers of adult fishes that are familiar units to resource managers. Adult equivalent loss does not require source water estimates of larval abundance in assessing effects. This latter advantage may be offset by the need to gather age-specific mortality rates to predict adult losses and the need for information on the adult population of interest for estimating population-level effects (i.e., fractional losses).

Starting with the number of age class *j* larvae entrained E_j, it is conceptually easy to convert these numbers to an equivalent number of adults lost *AEL* at some specified age class from the formula:

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

where

n = number of age classes from the average age at entrainment to adult recruitment;

E_j = estimated number of larvae lost in age class j; and

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

Age-specific survival rates from the average age at entrainment to recruitment into the fishery must be included in this assessment method. The average age at entrainment was estimated from lengths of a representative sample of larvae measured from the entrainment samples (Section 3.2.2.3). For some commercial species, natural survival rates are known after the fish recruit into the commercial fishery. For the earlier years of development, this information is not well known for commercial species and may not exist for some non-commercial species.

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

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

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

3.3.1.2 Fecundity Hindcasting (*FH*)

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

A potential advantage of *FH* is that survivorship need only be estimated for a relatively short period of the larval stage (e.g., egg to larval entrainment). The method requires age-specific mortality rates and fecundities to estimate entrainment effects and some knowledge of the abundance of adults to assess the fractional losses these effects represent. This method assumes that the loss of a single female's reproductive potential is equivalent to the loss of two adult fish, assuming a 50:50 male:female ratio.

In the *FH* approach, the total larval entrainment for a species, E_T, was projected backward from the average age at entrainment to estimate the number of breeding females required to provide the numbers of larvae seen in the entrainment samples. The estimated number of breeding females *FH* whose fecundity is equal to the total loss of entrained larvae was calculated as follows:

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

where

E_T = total entrainment estimate;

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

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

The two key input parameters in Equation (3) are total lifetime fecundity TLF and survival rates S_j from spawning to the average age at entrainment. The average age at entrainment was estimated from lengths of a representative sample of larvae measured from the entrainment samples (Section 3.2.2.3). Descriptions of these parameters may be limited for many species and are a possible limitation of the method. TLF is approximated using the "average" age for the females using the following formula:

$$\begin{aligned}\widehat{TLF} &= \text{Average eggs/year} \times \text{Average number of years of reproductive life} \\ &= \text{Average eggs/year} \cdot \left(\frac{\text{Longevity - Age at maturation}}{2} \right).\end{aligned}$$

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

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

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

3.3.2 Empirical Transport Model (*ETM*)

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

On any one sampling day, the conditional entrainment mortality can be expressed as

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

where

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

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

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

$$\widehat{N_i} = \sum_{k=1}^{9} V_{S_k} \cdot \widehat{\overline{\rho}_{ik}} \tag{6}$$

where V_{S_k} denotes the static volume of the source water at station k, and $\widehat{\overline{\rho}}_{ik}$ denotes an estimate of the average larval density in the source water for station k during survey i. The number of source water stations include seven sampled stations (E, D1, D2, U1, U2, O1, and O2) and two areas (I1 and I2) where the densities were interpolated using an inverse distance weighted average of the densities at the other stations (Figure 3-2). This was done to allow for a rectangular shaped source water area that could be extrapolated using alongshore current displacement, otherwise the layout of the sampling locations would have required separate source water estimates for the offshore (O1 and O2) and alongshore station areas (E, D1, D2, U1, and U2).

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

$$\widehat{P_M} = 1 - \sum_{i=1}^{N} \widehat{f}_i \left(1 - \widehat{PE_i} \bullet P_S\right)^q \tag{7}$$

where

q = number of days the larvae are exposed to entrainment,

P_S = the proportion of the sampled source water population to the total source water population vulnerable to entrainment, and

f_i = estimated fraction of total larval population present during the i th survey.

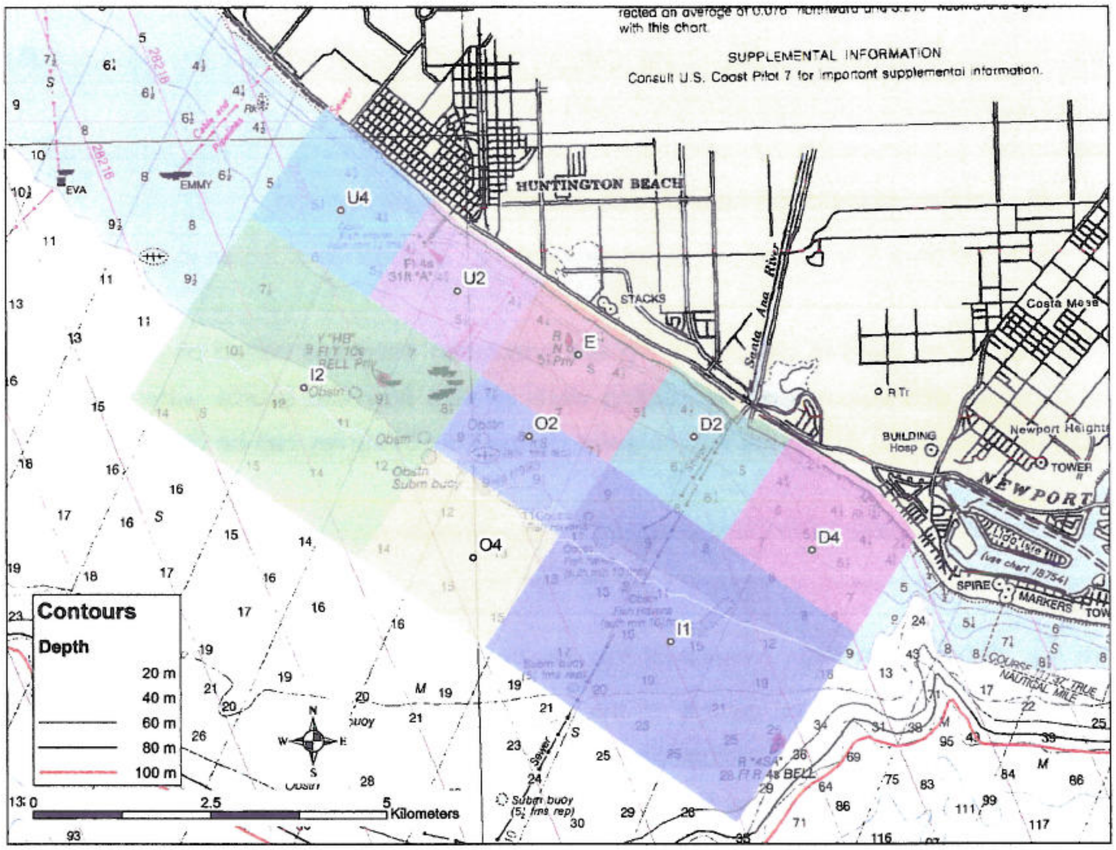

Figure 3-2. Bathymetry and areas used in calculating sampling volumes for each station used in calculating source water for *ETM* calculations. Station E is located near the plant intake where entrainment samples were collected. Source water stations U4, U2, D2, D4, O2, and O4 designate stations upcoast (U), downcoast (D) and offshore (O) of the intake, respectively. Densities in areas I1 and I2 were interpolated using an inverse distance-weighted average from the densities at the other stations.

To establish independent survey estimates, it is assumed that during each survey a new and distinct cohort of larvae is subject to entrainment. The number of days a taxon was exposed to entrainment was estimated by dividing a larval growth rate into the difference between the 1st and 95th percentile values of length measurements from the entrainment samples (Section 3.2.2.3). Each of the monthly surveys is weighted by f_i and estimated as the proportion of the total population at risk during the i th survey period. In the original study plan we proposed to use the proportion of the larvae entrained during each i th survey period as the weights for the *ETM* model. The weights were proposed to be calculated as follows:

$$f_i = \frac{E_i}{E_{Total}}, \tag{8}$$

where E_i is the estimated entrainment during the i th survey period, and E_{Total} is the estimated entrainment for the entire study period. Equation 8 conflicts with Equation 5 for *PE* that uses the population in the source water during the i th survey period to define the population at risk. If the weights are meant to represent the proportion of the population at risk during each survey then the weights should be calculated as follows:

$$f_i = \frac{N_i}{N_{Total}}, \tag{9}$$

where N_i is the estimated fraction of the source population spawned during the i th survey period, and N_{Total} is the total source population for the entire study period. The weights calculated using Equation 8 redefine the population at risk as the population entrained and represent a logical inconsistency in the model as presented in the study plan.

As shown in Equations 5 and 6 the estimates of *PE* are based on larval population estimates within specific volumes of water. While a reasonably accurate estimate of the volume of the cooling water intake flow can be obtained, estimating the volume of the source water is more difficult and will vary depending upon oceanographic conditions and taxa group. *ETM* estimates of P_M were calculated using two estimates for P_S, the proportion of the sampled source water population to the total source population. One estimate was based on alongshore and onshore current displacement while the other used only alongshore current displacement. The current displacement was calculated over the period of time that the larvae were estimated to be exposed to entrainment. This period of time was estimated using length data from a representative number of larvae (100-200) from the entrainment samples for each target taxon. The maximum age was calculated as the upper 95th percentile value of the lengths measured from the samples. The maximum age at entrainment was calculated by dividing the difference between the upper 95th percentile values of the lengths and the lower 1st percentile value of the lengths by an estimated larval growth rate.

The incorporation of P_S into the ETM model is typically defined by the ratio of the area or volume of the study grid to a larger area or volume containing the population of inference (Parker and DeMartini 1989). If an estimate of the larval (or adult) population in the larger area is available, it can also be computed using the estimate of the larval or adult population in the study grid, defined by Ricker (1975) as the proportion of the parental stock. If the distribution in the larger area is assumed to be uniform, then the value of P_S for the proportion of the population will be the same as the proportion computed using area or volume. For target taxa whose larval distribution extends to the offshore edge of the study grid, P_S will be calculated as the ratio:

$$P_S = N_G / N_P \ , \qquad (10)$$

where N_G is the number of larvae in the study grid, and N_P is the number of larvae in the population of inference. The numerator N_G is the same as the estimate, N_i (Equation 5), used in the calculation of *PE*, i.e.

$$\widehat{N_{G_i}} = \sum_{k=1}^{9} A_{G_k} \cdot \overline{D}_k \cdot \rho_{i,k} \ , \qquad (11)$$

where

A_{G_k} = area of source water sampling area station k,

$\overline{D}_k$ = average depth of the *k* th station, and

$\rho_{i,k}$ = density (per m^3) of larvae in *k*th station during survey *i*.

N_P was estimated by offshore and alongshore extrapolation of the study grid densities, using water current measurements. First, a conceptual model was formulated to extrapolate larval densities (per m^3) offshore of the grid:

$$\widehat{P_S} = \frac{\widehat{N_G}}{\widehat{N_P}} = \frac{\sum_{k=1}^{9} L_{G_k} \cdot W_k \cdot \overline{D}_k \cdot \widehat{\rho_k}}{\sum_{k=1}^{K\max} L_{Pk} \cdot W_k \cdot \overline{D}_k \cdot \widehat{\rho_k}} \ , \qquad (12)$$

where

L_{G_k} = alongshore length of source water sampling area station *k*,

W_k = average width of the *k* th station,

$\overline{D}_k$ = average depth of the *k* th station,

$\widehat{\rho_k}$ = estimated average density (per m^3) of larvae in *k* th station,

Kmax = index of offshore extent, based on current data and

L_{P_k} = alongshore length of the population based on current data,

The denominator in Equation 12 includes an extrapolation offshore that is a discrete version of a conceptually continuous function. Therefore, to ease implementation, an essentially equivalent formulation that incorporates the use of the sampling station densities for stations E, O2, and O4 during the *i* th survey and integrates a linear extrapolation of density (per m^2) calculated by multiplying the density by the station depth as a function of offshore distance:

$$\widehat{P_{S_i}} = \frac{\widehat{N_{G_i}}}{\widehat{N_{P_i}}} = \frac{\widehat{N_{G_i}}}{\sum_{k=1}^{7} \frac{L_{P_i} \cdot \widehat{N_{G_{ik}}}}{L_{G_{ik}}} + L_{P_i} \cdot \int_{W_O}^{W_{max}} \rho(w)\,dw}, \tag{13}$$

where

L_{P_i} = alongshore length of the population (P) in the *i* th study period based on current data,
$\rho(w)$ = density of larvae (per m^2) as a linear function of *w*, distance offshore, and
W_{max}, W_O = limits of integration for extrapolation outside study grid.

The limits of the integration are from the offshore margin of Station O4 to a point estimated by the onshore movement of currents, where the extrapolated density is zero, or to the edge of the shelf at a depth of 75 m (distance of 8,500 m). Note that the population number, N_P, is composed of two components that represent the alongshore extrapolation of the sampled source population and the offshore extrapolation of the sampled source population.

Parameter values needed in performing the extrapolation were obtained through a regression analysis using the data from all of the surveys. This resulted in the calculation of a common slope and intercept for all of the surveys for each of the target taxa. The differences in onshore currents changed the limit of the extrapolation used for each survey.

For a P_S using only alongshore current, displacement was calculated without using the offshore extrapolation based on onshore or offshore current movement to predict a coastwise fraction of the population of inference. The total alongshore displacement in the *i* th survey, includes both upcoast and downcoast movement calculated during a period equal to the larval duration before each survey. The P_S using only alongshore current was calculated as:

$$\widehat{P_{S_i}} = \frac{\widehat{N_{G_i}}}{\widehat{N_{P_i}}} = \frac{\widehat{N_{G_i}}}{\sum_{k=1}^{9} \frac{L_{P_i} \cdot \widehat{N_{G_{ik}}}}{L_{G_{ik}}}}. \tag{14}$$

The current data for both estimates were from data collected for the Orange County Sanitation District from June 1999 to June 2000 at station Q (33° 37.874'N, 117° 59.804'W with 14.8 m depth) directly offshore from the HBGS. The historical data was collected near the HBGS intake from June 17, 1999 to June 24, 2000. Measurements were taken at 30-min intervals, 3-hr low pass filtered, and then resampled at 1-hr intervals. North and east currents were rotated to a shore direction of 307°T. The instrument was positioned 5 m below the surface over a bottom depth of 14.8 m MLLW at 33.63129° N latitude and 117.99673° W longitude (re: NAD83). This location lies 1.47 km at 236° from the HBGS intake. The magnetic vectors were corrected to true north using a 13.35° east variation. These true vectors were then rotated to align with the coastline. Hourly excursion distances were calculated in the alongshore (positive upcoast) and cross shelf (positive onshore) directions using sums of the excursions based on the 1-hr resampled currents.

Data from the current meter deployed for this study were not used because of a failure of the internal compass during the last deployment. The failure of the system also raised concerns about the data from other deployments that were generally not characteristic of currents described from the area by Noble et al. (2003) that 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 and toward shore.

The source water volumes for the sampling areas were calculated from bathymetric data for the coastal areas around Huntington Beach (Figure 3-2, Table 3-1). These volumes were used in calculating the total number of larvae for target taxa in the sampled source water, and used with the total volume of the HBGS cooling water system (1,919,204 m^3 per day, 507 mgd) in calculating *PE* estimates used in the *ETM* calculations. The areas of the extrapolated stations are approximately four times the area of the sampled stations, while the volume for station I2 is also approximately four times the volume of the sampled stations, the volume of station I1 is substantially larger because the area includes deeper depths associated with the drop-off into Newport Canyon (Figure 3-2).

Table 3-1. Area, volume, and average depths of HBGS source water sampling locations, including the values for the two extrapolated source water areas, I1 and I2.

Station	Area (m^2)	Volume (m^3)	Average Depth (m)
D2	3,349,340	28,487,976	8.5
D4	4,164,939	34,138,031	8.1
E	3,613,797	28,360,943	7.7
O2	2,765,512	43,697,047	15.8
O4	4,234,490	99,644,641	23.7
U2	3.211.727	21.159.762	6.2
U4	3,651,953	21,696,873	5.6
I1	13,804,831	398,613,394	28.3
12	12,692,946	232,359,192	18.2

3.4 Impingement Sampling

3.4.1 Introduction

The purpose of the impingement study is to determine the extent of potential impacts from the operation of the cooling water system of the Huntington Beach Generating Station on fishes and selected invertebrates. Impingement occurs when organisms larger than the traveling screen mesh size (9.5 mm or 3/8") become trapped against the screens, either because they are too fatigued to swim against the intake flow at the screens or they are dead. The sampling plan and analysis techniques were developed by the BRRT.

There are two facets 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 treatments, when waters within the CWIS were heated and essentially all fishes and invertebrates succumbed to the high temperatures. Heat treatment procedures were carried out at approximately 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.

3.4.2 Methods

3.4.2.1 Normal Operation Impingement Sampling

MBC sampled fishes and macroinvertebrates impinged on traveling screens during normal operation of the HBGS on a weekly basis beginning in late-July 2003 and continuing through July 2004. Once per week, fish impingement samples were collected for one approximately 24-hr period in coordination with generating station operations personnel. Twenty-four hours prior to each survey, the screens were run and the accumulation dumpster emptied. The following day, traveling screens were operated for approximately 10 minutes, enough time to complete one rotation and sufficient to bring up any impinged organisms from the forebay for identification. Accumulated fishes, invertebrates, algae, and debris from the 24-hr sample were sorted, and fishes and macroinvertebrates were identified to species (whenever possible), enumerated and batch-weighed. Standard length of up to 200 individual fishes of each species was measured, and sex of up to 50 individuals of selected species was determined by external morphology or inspection of gonads. Algae and shell debris were identified and batch-weighed by species. Station operation data (number of circulator pumps operating, intake temperature, and discharge temperature) and general weather conditions were recorded during sampling.

Circulating water flow through the plant during the 24-hr sample period was determined by consulting with plant personnel. Results from each weekly 24-hr impingement sample were extrapolated to a weekly impingement total using cooling water flow for the 7-day period (Saturday through Friday). The normal operation impingement total is the sum of the weekly extrapolations based on the cooling water flow of the HBGS.

3.4.2.2 Heat Treatment Impingement Sampling

MBC sampled fishes and macroinvertebrates impinged on traveling screens during all scheduled heat treatment operations at the HBGS. The results of all six heat treatments are presented in this analysis. Heat treatments are performed periodically (usually once every six to eight weeks) to control growth of fouling organisms in the cooling water system. During these procedures, a portion of the heated discharge water is circulated through the forebay and intake conduits, raising the water temperature to approximately 41°C (106°F), and marine life succumbs to the elevated temperature.

During each survey, traveling screens were run until no more organisms were impinged on the traveling screens. Fishes, invertebrates, algae, and debris were sorted, and fishes and invertebrates were identified to species (whenever possible), enumerated and batch-weighed. Standard length of up to 200 individual fishes of each species was measured, and sex of up to 50 individuals of selected species was determined by external morphology or inspection of gonads. Algae and shell debris were identified and batch-weighed by species. Station operation data (number of circulator pumps operating, intake temperature, and discharge temperature) and general weather conditions were recorded during sampling.

3.4.3 Impingement Data Analysis

Total impingement at the generating station was calculated by summing the extrapolated normal operations estimates with the sum of the heat treatment survey data. Additional statistical analyses performed on impingement data from the HBGS as well as from additional coastal generating stations is further described in Section 5.0. Common and scientific names of fishes are from Nelson et al. (2004), and invertebrate names were derived from several sources, including Turgeon et al. (1988) and Williams et al. (1988).

4.0 RESULTS

4.1 Introduction

The following section presents results of the AES Huntington Beach Entrainment and Impingement Study, including data on entrainment and source water larval densities collected from September 2003 through August 2004, and data on impinged organisms collected from July 2003 to July 2004. Estimates of entrainment were derived from samples collected just offshore of the intake structure. Source water estimates were derived from samples collected up to four kilometers upcoast, downcoast, and offshore of the intake structure. Impingement samples were collected from within the generating station cooling water system.

4.2 Physical Oceanography

Sea surface temperatures recorded at the entrainment station displayed seasonal variation (Figure 4-1). Maximum temperatures were recorded in fall and summer, and lowest temperatures were recorded in winter. Analysis of profiles indicates that during the onset of sampling in September 2003, summer conditions prevailed and the water column was fairly stratified with a discernable thermocline (Appendix A). Beginning in the second week of October 2003, the transition to winter conditions began, and the thermocline dissipated. Winter conditions (cool water and no thermocline) were recorded from late November 2003 through early March 2004, with coolest temperatures recorded in February 2004. Warming of the water column began in March 2004 and the transition to summer conditions (warm water and establishment of a thermocline) continued through May 2004. In many cases, warmest waters were recorded during daytime cycles initiated at 1200 hr and 1800 hr.

Brackish or fresh water was detected in the study area during a few surveys. During Entrainment Survey HBS005 (first week of November 2003), light rain fell during the first cycle of sampling, and a lens of brackish water (19 to 30 practical salinity units [psu]) was present in the upper two meters of the water column. Surface salinity was also low throughout the study area during Source Water Survey HBS023 (8-9 March 2004). During that survey, lowest near-surface salinities were recorded at the offshore stations (10 psu), followed by upcoast stations (16 psu) and entrainment and downcoast stations (22 psu). Approximately two inches of rain fell in the week prior to the 8-9 March survey. Even though rain occurred during some other surveys,

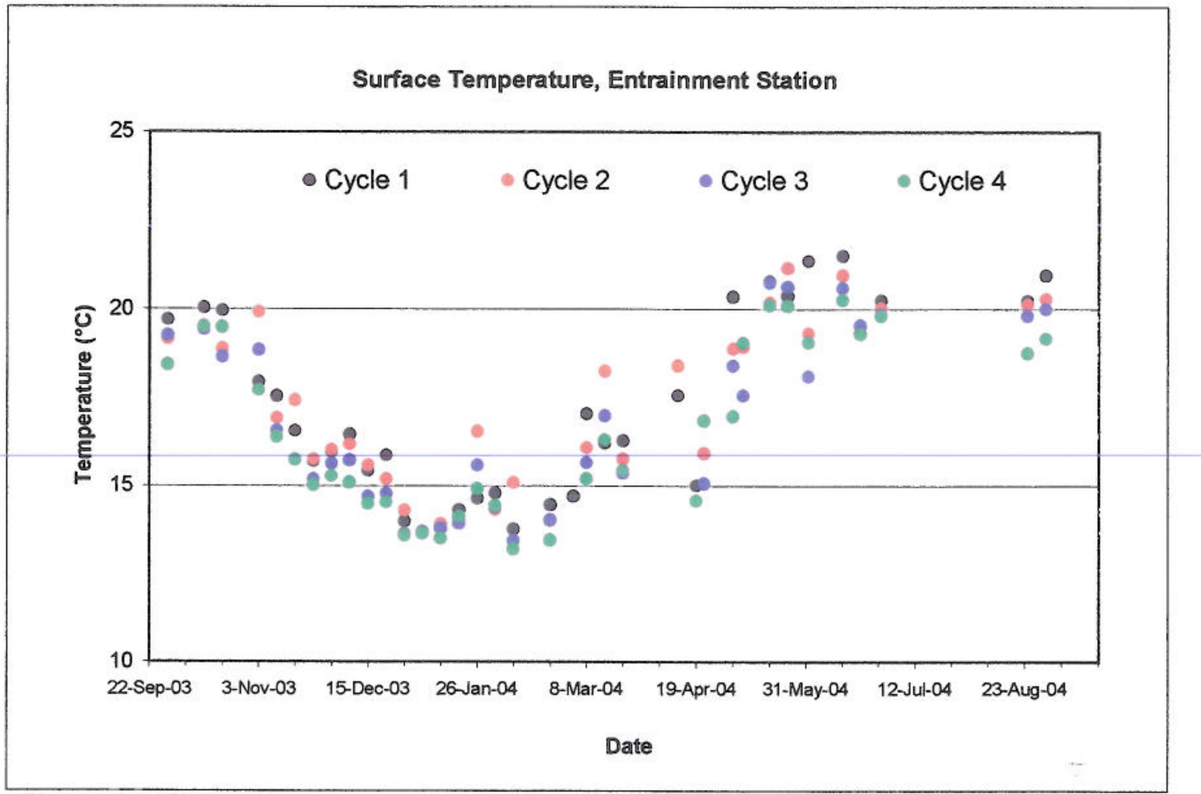

Figure 4-1. Surface temperatures at Station E during each cycle of each entrainment and source water survey.

salinity in the nearshore waters was generally >33 psu, which is considered normal for southern California nearshore waters.

Currents generally moved onshore and downcoast from June 1999 to June 2000 (Figure 4-2). Overall, during the period, there was 499 km of onshore movement and 659 km of downcoast excursion. From June through September currents moved nearly 226 km downcoast and 128 km onshore. During October through December there was onshore movement of 180 km and 145 km downcoast movement. From January through March there was similar onshore and downcoast movement of 192 km and 131 km. From April through June 24, there was no onshore movement and a 155 km downcoast excursion. Other researchers have reported similar current patterns in the area near HBGS. Noble and Xu (2003) described the currents near the HBGS and found that larger-scale coastal processes influenced local current patterns more than tides and localized wind conditions. They found that, in summer 2001, currents moved predominantly in a downcoast direction over the continental shelf with maximum velocities occurring near the surface on the outer portion of the shelf. Currents tended to decrease as a function of proximity to the shore.

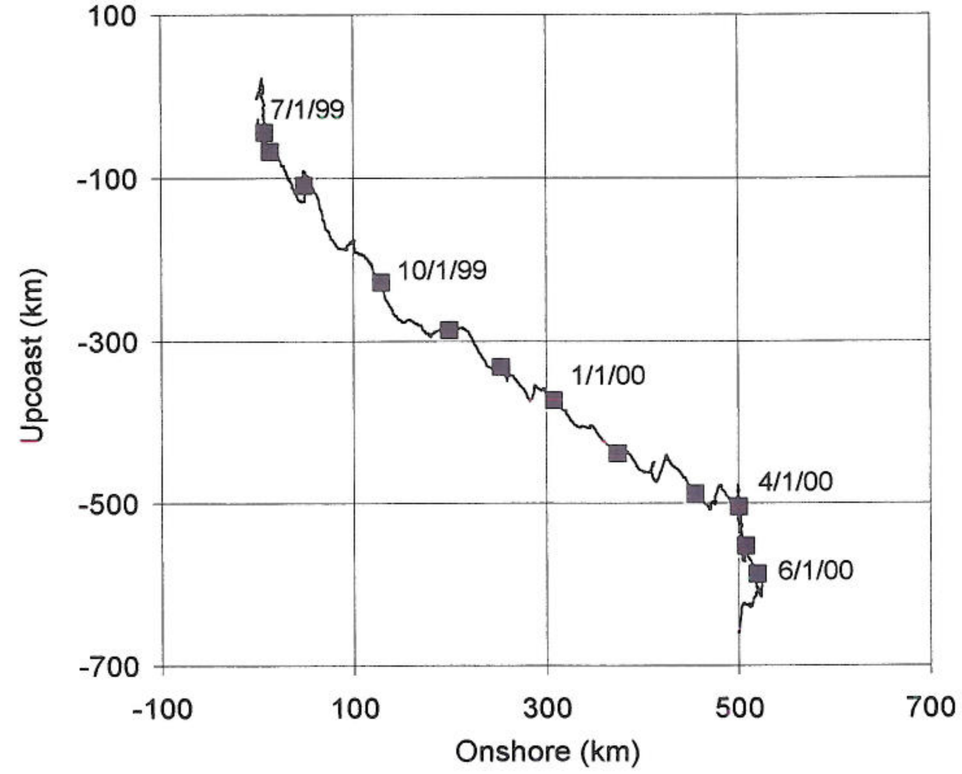

Figure 4-2. Cumulative onshore and upcoast (alongshore) current vectors from an InterOcean Systems S4 current meter moored off the HBGS from 17 June 1999 – 24 June 2000. Squares show cumulative monthly positions.

4.3 Entrainment

The U.S. EPA defines entrainment as "the incorporation of all life stages of fish and shellfish with intake water flow entering and passing through a cooling water intake structure and into a cooling water system" (USEPA 2002a). At the HBGS, organisms are entrained when they are drawn into the offshore intake structure and conveyed with the cooling water flow to the generating station. Larval fishes and invertebrates are comparatively weak swimmers, and enter the cooling water flow passively. The following sections present entrainment and source water results for larval fishes collected in 45 surveys from September 2003 through August 2004. Survey HBS026 (26-27 March 2004) was aborted due to high winds.

4.3.1 Weekly Entrainment Abundance Estimates

A total of 6,950 fish larvae in 57 different taxonomic groups was collected during the 45 entrainment surveys completed during the September 2003 through August 2004 period (Table 4-1), including 227 unidentified or damaged specimens. Ten taxa comprised 90% of the total larvae collected: unidentified gobies (mainly of the genera *Clevlandia, Ilypnus*, and *Quietula* [CIQ complex]), spotfin croaker, unidentified anchovies (>95% northern anchovy), queenfish, white croaker, salema, unidentified croakers (newly hatched larvae of several species), combtooth blennies, black croaker, and diamond turbot. The life histories and potential impacts from entrainment on the local populations of these taxa and California halibut, which is an important recreational and commercial species and ranked 11th overall, are analyzed in greater detail in this report (See Section 4.3.3–*Individual Species Results*). The target taxa are not presented in the order of abundance so that the results for the four species of Sciaenidae could be presented together. Of the five target invertebrate taxa included in the study (*Cancer* crab megalops, market squid hatchlings, mole crab (sand crab), California spiny lobster, and ridgeback rock shrimp) only mole crab and *Cancer* crabs were found in the entrainment samples (Table 4-2). Mole crab zoeae comprised almost 99% of the entrained target invertebrates. Almost all of the mole crab larvae collected were in the earliest stages of their larval development (Zoea Stage I); only two megalopal stage larvae were collected from entrainment samples and none were collected from source water samples. Sampling results are presented for *Cancer* and mole crabs, but no assessments of potential entrainment impacts were conducted for mole crab because of the low numbers collected and absence of megalops in the source water samples. Complete sampling data are presented in Appendix B.

The measured larval densities during each survey were multiplied by a total daily maximum intake flow of 1,919,204 m^3 (507 mgd) that equates to an estimated annual cooling water volume of 702,428,664 m^3. Approximately 350 million fish larvae were calculated to have been entrained during the study (Table 4-1). The number of individual taxa increased during the study with greatest numbers of taxa occurring in summer 2004, from an average of approximately 8 taxa per survey from September through February to 18 taxa per survey in summer 2004, including a survey in late July when over 30 taxa were collected (Figure 4-3). The greatest overall abundances occurred in late summer 2004 when densities were approximately five times greater than earlier months (Figure 4-4). Although gobies and anchovies were abundant throughout the sampling period, high concentrations of spotfin croaker, salema, and queenfish contributed to peak abundances in August 2004 (Appendix A). Low concentrations of larvae were measured during some surveys in early February and early March, although abundances generally increased through spring when many fishes start reproducing.

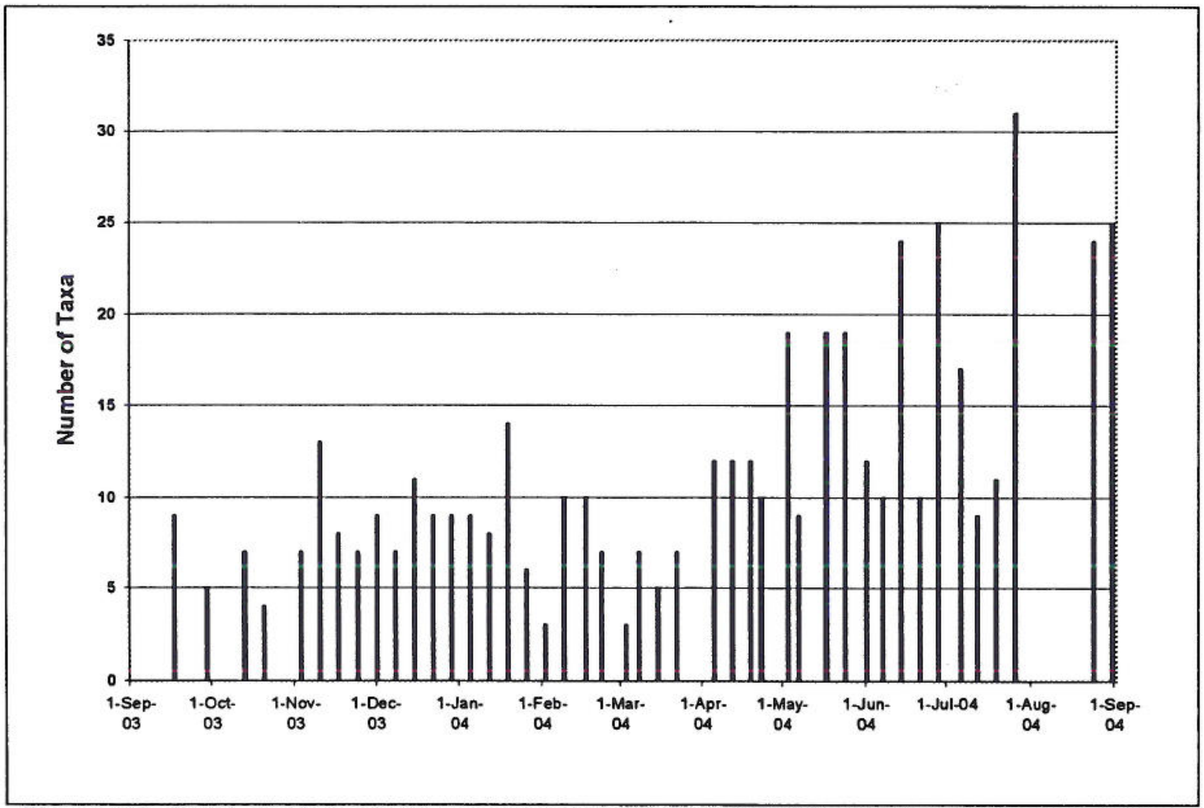

Figure 4-3. Total number of taxa per survey collected at HBGS entrainment Station E from September 2003 through August 2004.

Entrainment samples were characterized by large numbers of gobies, blennies, and several other fishes common in bay environments whose larvae were probably exported into the open ocean by tidal currents from estuarine spawning areas upcoast and downcoast of the HBGS. Some commercially and recreationally important taxa such as California halibut, white seabass, and rockfishes comprised a small percentage of the total number of taxa entrained, but others, including northern anchovy and several croaker species, comprised nearly 50% of the total fish larvae collected (Table 4-1).

Table 4-1. Larval fishes collected during 45 entrainment surveys from September 2003 through August 2004. A flow volume of 702,428,664 m^3 was used to estimate total entrainment for the sampling period.

	Taxon	Common Name	Sample Count	Percent of Total	Cumulative Percent	Mean Density (#/1000m3)	Total Estimated Entrainment	Entrainment Std. Error
1	Gobiidae (CIQ complex)	gobies	2,484	36.95	36.95	151.56	113,166,834	6,568,091
2	*Roncador stearnsi*	spotfin croaker	912	13.57	50.51	53.07	69,701,589	8,636,383
3	Engraulidae	anchovies	1,209	17.98	68.50	74.46	54,349,017	4,355,775
4	*Seriphus politus*	queenfish	306	4.55	73.05	18.17	17,809,864	2,415,487
5	*Genyonemus lineatus*	white croaker	446	6.63	79.68	28.14	17,625,263	1,491,336
6	*Xenistius califoriensis*	salema	153	2.28	81.96	7.70	11,696,960	5,186,479
7	Sciaenidae	croaker	244	3.63	85.59	14.73	10,534,802	1,004,033
8	*Hypsoblennius* spp.	blennies	166	2.47	88.06	10.28	7,165,513	580,175
9	*Cheilotrema saturnum*	black croaker	96	1.43	89.48	5.41	7,128,127	1,481,158
10	*Hypsopsetta guttulata*	diamond turbot	87	1.29	90.78	5.28	5,443,118	476,544
11	*Paralichthys californicus*	California halibut	98	1.46	92.24	6.40	5,021,168	447,516
12	Atherinopsidae	silverside	97	1.44	93.68	5.98	3,654,229	577,117
13	*Menticirrhus undulatus*	California corbina	43	0.64	94.32	2.33	2,809,417	807,329
14	*Paralabrax* spp.	sand bass	48	0.71	95.03	2.93	2,793,730	518,724
15	*Citharichthys* spp.	sanddabs	31	0.46	95.49	2.15	1,913,607	314,973
16	*Hypsypops rubicundus*	garibaldi	43	0.64	96.13	2.44	1,622,966	776,711
17	*Oxyjulis californica*	senorita	27	0.40	96.53	1.66	1,190,449	311,376
18	*Sphyraena argentea*	California barracuda	14	0.21	96.74	0.79	1,133,103	258,040
19	Pleuronectidae	flounders	17	0.25	97.00	1.02	982,419	131,877
20	*Umbrina roncador*	yellowfin croaker	24	0.36	97.35	1.63	962,905	266,187
21	*Gillichthys mirabilis*	longjaw mudsucker	20	0.30	97.65	1.29	834,682	155,798
22	*Lepidogobius lepidus*	bay goby	18	0.27	97.92	1.16	683,887	161,835
23	Syngnathidae	pipefishes	17	0.25	98.17	0.91	591,496	353,236
24	*Leptocottus armatus*	Pacific staghorn sculpin	16	0.24	98.41	0.97	584,664	115,109
25	*Pleuronichthys ritteri*	spotted turbot	12	0.18	98.59	0.75	561,958	87,434
26	*Triphoturus mexicanus*	Mexican lampfish	8	0.12	98.71	0.51	536,324	95,606
27	*Acanthogobius flavimanus*	yellowfin goby	15	0.22	98.93	0.88	522,589	176,940
28	*Diaphus theta*	California headlight fish	11	0.16	99.09	0.63	486,274	110,942
29	Myctophidae	lanternfishes	6	0.09	99.18	0.39	423,578	94,314
30	Haemulidae	grunts	5	0.07	99.26	0.28	368,219	121,028
31	*Atractoscion nobilis*	white seabass	5	0.07	99.33	0.29	347,306	114,685
32	*Gibbonsia* spp.	clinid kelpfishes	10	0.15	99.48	0.55	341,921	87,691
33	*Pleuronichthys verticalis*	hornyhead turbot	3	0.04	99.52	0.17	198,470	52,984
34	*Sardinops sagax*	Pacific sardine	4	0.06	99.58	0.25	166,724	117,891
35	*Peprilus simillimus*	Pacific butterfish	2	0.03	99.61	0.14	138,138	56,479
36	*Semicossyphus pulcher*	California sheephead	2	0.03	99.64	0.13	129,222	52,033
37	*Stenobrachius leucopsarus*	northern lampfish	3	0.04	99.69	0.21	111,109	46,395
38	Labrisomidae	labrisomid kelpfishes	3	0.04	99.73	0.18	108,964	58,784
39	*Halichoeres semicinctus*	rock wrasse	1	0.01	99.75	0.06	97,344	45,888
40	Paralichthyidae	lefteye flounders & sanddabs	2	0.03	99.78	0.12	95,195	45,031
41	*Medialuna californiensis*	halfmoon	2	0.03	99.81	0.13	77,804	58,815
42	*Scomber japonicus*	Pacific mackerel	2	0.03	99.84	0.10	61,004	32,608
43	Scorpaenidae	scorpionfishes	1	0.01	99.85	0.09	50,467	38,150
44	*Symphurus atricauda*	California tonguefish	1	0.01	99.87	0.07	42,344	32,009
45	*Strongylura exilis*	California needlefish	1	0.01	99.88	0.07	40,637	30,719
46	*Oxylebius pictus*	painted greenling	1	0.01	99.90	0.07	40,289	30,456
47	*Typhlogobius californiensis*	blind goby	1	0.01	99.91	0.06	36,976	27,951
48	*Merluccius productus*	Pacific hake	1	0.01	99.93	0.06	33,954	25,667
49	*Coryphopterus nicholsi*	blackeye goby	1	0.01	99.94	0.06	33,202	25,099
50	Agonidae	poachers	1	0.01	99.96	0.05	30,817	23,295
51	*Ruscarius creaseri*	rouchcheek sculpin	1	0.01	99.97	0.05	30,813	23,293
52	Pleuronectiformes	flatfishes	1	0.01	99.99	0.05	30,192	22,823
53	Cottidae	sculpins	1	0.01	100.00	0.05	28,990	21,914
			6,723			**406.91**	**344,570,635**	
	larvae, unidentified yolksac	unidentified yolksac larvae	136			9.23	6,100,663	1,148,559
	larval fish fragment	unidentified larval fishes	51			3.08	2,508,742	386,659
	larval/post-larval fish unid.	larval fishes	39			2.37	1,655,508	246,622
	larval fish - damaged	unidentified larval fishes	1			0.06	41,681	29,473
			227			**14.74**	**10,306,594**	

Table 4-2. Invertebrate larvae (select taxa) collected during 45 entrainment surveys from September 2003 through August 2004. A flow volume of 702,428,664 m^3 was used to estimate total entrainment for the sampling period.

Taxon	Common Name	Sample Count	Percent of Total	Cumulative Percent	Mean Density (#/1000m3)	Total Estimated Entrainment	Entrainment Std. Error
Emerita analoga (zoea)	mole crabs - larva	10,399	98.73	98.73	658.95	465,806,877	91,912,298
Cancer anthonyi (megalops)	yellow crab	77	0.73	99.46	4.68	5,207,996	1,320,180
Cancer gracilis (megalops)	slender crab	31	0.29	99.75	1.97	1,304,771	311,450
Cancer antennarius (megalops)	brown rock crab	18	0.17	99.92	1.15	973,538	202,088
Cancer productus (megalops)	red rock crab	3	0.03	99.95	0.18	164,478	53,672
Emerita analoga (megalops)	mole crabs - larva	2	0.02	99.97	0.17	69,793	54,061
Cancer spp. (megalops)	cancer crabs	2	0.02	99.99	0.11	65,159	34,834
Cancer spp.	cancer crabs	1	0.01	100.00	0.06	35,885	27,126
		10,533			**667**	**473,628,497**	

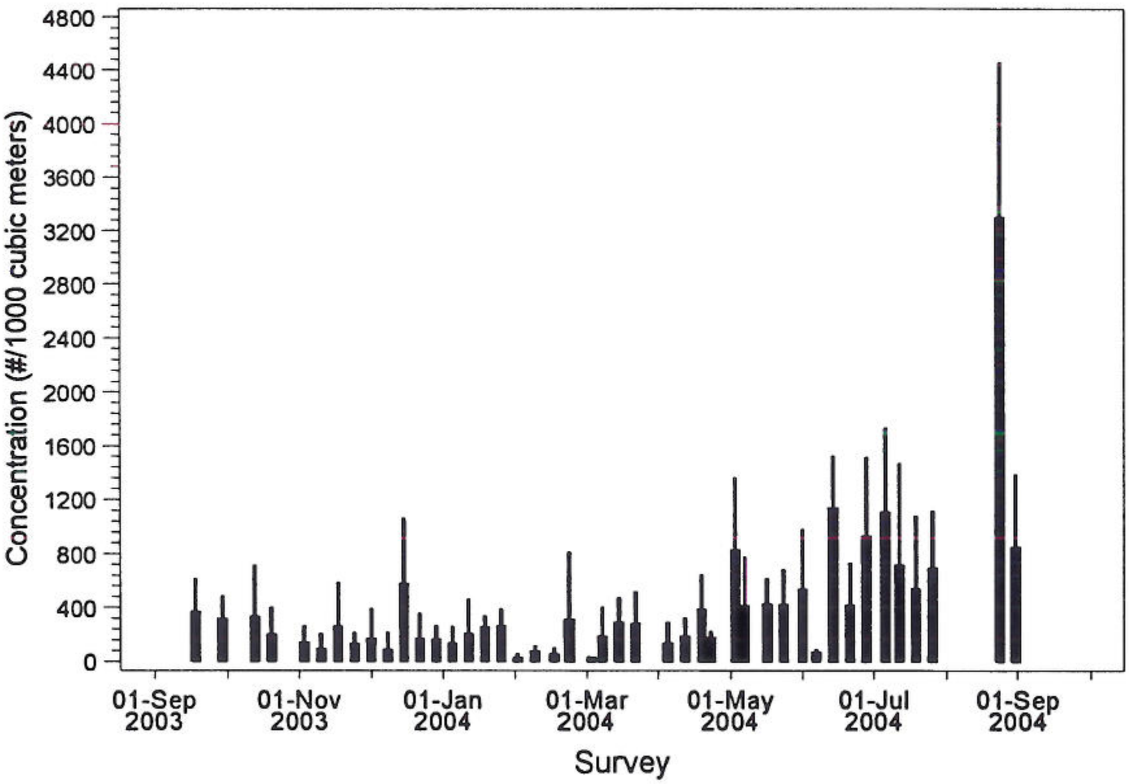

Figure 4-4. Mean concentrations (#/1000 m^3) and standard error for all larval fishes collected at HBGS entrainment Station E from September 2003 through August 2004.

4.3.2 Monthly Source Water Abundance Estimates

A total of 14,627 fish larvae in 79 different taxonomic groups was collected during the 12 source water surveys completed during the September 2003 – September 2004 period (Table 4-3), including 299 unidentified or damaged specimens. Eleven taxa comprised nearly 90% of the total larvae collected: unidentified gobies (36.8%; mainly of the genera *Clevelandia, Ilypnus*, and *Quietula* [CIQ complex]), unidentified anchovies, queenfish, white croaker, unidentified croakers (newly hatched larvae of several species), combtooth blennies, unidentified sea bass, California halibut, spotfin croaker, silversides, and Pacific sardine (Table 4-3). During the 12 source water surveys there were 23 additional taxa collected at stations other than the single entrainment Station E during 45 entrainment surveys (Table 4-4). Similar to the entrainment station densities, lowest larval densities in the source water were measured in winter and greatest in summer (Figure 4-5).

The composition of the target invertebrates collected at the source water stations was similar to the entrainment samples with mole crab larvae comprising nearly 95% of the target invertebrates (Table 4-5). Almost all of the mole crab larvae collected were in the earliest stage of larval development (Zoea Stage I); only two megalopal stage larvae were collected at the entrainment station during one of the paired entrainment-source water surveys. In addition to *Cancer* crab larvae, one California spiny lobster puerulus stage larva was collected (Table 4-5).

Concentrations of the CIQ goby complex, northern anchovy, and white croaker, three of the most abundant fish taxa, varied spatially among the seven sampling stations and temporally among months (Figures 4-6 through 4-11). The CIQ goby complex was generally more abundant at the inshore stations in all months and also tended to be more abundant at the intake (entrainment) and downcoast stations. Northern anchovy did not show a strong distributional trend among stations whereas white croaker was more abundant offshore in summer (Figure 4-11).

Table 4-3. Larval fishes collected during 12 source water surveys from September 2003 through August 2004. 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 (#/1000m3)	Density Std. Error
1	Gobiidae (CIQ complex)	gobies	5,275	36.82	36.82	169.83	46.30
2	Engraulidae	anchovies	2,525	17.62	54.44	81.41	17.20
3	*Seriphus politus*	queenfish	1,418	9.90	64.34	45.85	21.80
4	*Genyonemus lineatus*	white croaker	1,239	8.65	72.98	39.46	9.32
5	Sciaenidae	croakers	541	3.78	76.76	17.92	5.90
6	*Hypsoblennius* spp.	blennies	439	3.06	79.82	13.82	3.93
7	*Paralabrax* spp.	sand bass	408	2.85	82.67	13.61	24.05
8	*Paralichthys californicus*	California halibut	399	2.78	85.46	12.70	3.60
9	Atherinopsidae	silversides	333	2.32	87.78	10.55	4.41
10	*Sardinops sagax*	Pacific sardine	147	1.03	88.81	4.91	20.01
11	*Sphyraena argentea*	California barracuda	145	1.01	89.82	4.73	6.35
12	*Chromis punctipinnis*	blacksmith	166	1.16	90.98	4.59	20.83
13	*Citharichthys* spp.	sanddabs	141	0.98	91.96	4.53	2.21
14	*Hypsopsetta guttulata*	diamond turbot	122	0.85	92.81	3.96	1.40
15	Ophidiidae	cusk-eels	99	0.69	93.50	3.26	12.49
16	*Lepidogobius lepidus*	bay goby	86	0.60	94.10	2.73	1.65
17	*Pleuronichthys ritteri*	spotted turbot	68	0.47	94.58	2.10	0.89
18	*Pleuronichthys verticalis*	hornyhead turbot	65	0.45	95.03	2.07	1.34
19	*Cheilotrema saturnum*	black croaker	61	0.43	95.46	1.90	1.67
20	*Xenistius californiensis*	salema	50	0.35	95.81	1.75	7.07
21	*Typhlogobius californiensis*	blind goby	56	0.39	96.20	1.73	6.28
22	*Oxyjulis californica*	senorita	51	0.36	96.55	1.64	1.48
23	*Roncador stearnsi*	spotfin croaker	53	0.37	96.92	1.62	2.62
24	*Gillichthys mirabilis*	longjaw mudsucker	40	0.28	97.20	1.28	0.71
25	Pleuronectidae	flounders	41	0.29	97.49	1.25	0.77
26	*Leptocottus armatus*	Pacific staghorn sculpin	28	0.20	97.68	0.91	1.04
27	*Acanthogobius flavimanus*	yellowfin goby	23	0.16	97.84	0.78	1.36
28	*Icelinus* spp.	sculpins	25	0.17	98.02	0.75	1.70
29	*Gibbonsia* spp.	clinid kelpfishes	21	0.15	98.16	0.64	0.67
30	*Xystreurys liolepis*	fantail sole	20	0.14	98.30	0.62	1.53
31	*Triphoturus mexicanus*	Mexican lampfish	19	0.13	98.44	0.62	0.54
32	*Hypsypops rubicundus*	garibaldi	20	0.14	98.58	0.60	1.09
33	*Syngnathus* spp.	pipefishes	20	0.14	98.72	0.58	1.95
34	*Menticirrhus undulatus*	California corbina	14	0.10	98.81	0.46	1.09
35	*Atractoscion nobilis*	white seabass	14	0.10	98.91	0.43	0.92
36	*Gobiesocidae*	clingfishes	12	0.08	98.99	0.39	0.51
37	*Semicossyphus pulcher*	California sheephead	13	0.09	99.09	0.37	1.23
38	*Sebastes* spp.	rockfishes	11	0.08	99.16	0.36	1.64
39	Labrisomidae	labrisomid kelpfishes	9	0.06	99.23	0.29	0.54
40	*Stenobrachius leucopsarus*	northern lampfish	9	0.06	99.29	0.27	0.49
41	*Peprilus simillimus*	Pacific butterfish	7	0.05	99.34	0.26	2.28
42	Paralichthyidae	lefteye flounders & sanddabs	8	0.06	99.39	0.26	0.43
43	*Hippoglossina stomata*	bigmouth sole	7	0.05	99.44	0.24	0.64
44	*Umbrina roncador*	yellowfin croaker	7	0.05	99.49	0.22	0.56
45	*Ruscarius creaseri*	rouchcheek sculpin	6	0.04	99.53	0.19	0.50
46	*Symphurus atricauda*	California tonguefish	6	0.04	99.57	0.18	1.29
47	*Coryphopterus nicholsi*	blackeye goby	5	0.03	99.61	0.16	0.40
48	*Diaphus theta*	California headlight fish	5	0.03	99.64	0.16	0.45
49	Haemulidae	grunts	5	0.03	99.68	0.16	0.67
50	*Merluccius productus*	Pacific hake	5	0.03	99.71	0.15	1.04
51	Myctophidae	lanternfishes	4	0.03	99.74	0.14	0.46
52	*Halichoeres semicinctus*	rock wrasse	3	0.02	99.76	0.11	1.00
53	*Etrumeus teres*	round herring	3	0.02	99.78	0.10	0.65
54	*Medialuna californiensis*	halfmoon	3	0.02	99.80	0.09	0.63
55	Labridae	wrasses	2	0.01	99.82	0.07	0.83
56	*Lythrypnus* spp.	gobies	3	0.02	99.84	0.07	0.83
57	Cottidae	sculpins	2	0.01	99.85	0.06	0.39
58	Kyphosidae	sea chubs	2	0.01	99.87	0.06	0.77
59	*Oxylebius pictus*	painted greenling	2	0.01	99.88	0.06	0.38
60	Hexagrammidae	greenlings	2	0.01	99.90	0.06	0.37

(table continued)

Table 4-3 (continued). Larval fishes collected during 12 source water surveys from September 2003 through August 2004. 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 (#/1000m3)	Density Std. Error
61	*Artedius lateralis*	smoothhead sculpin	1	0.01	99.90	0.04	0.48
62	*Girella nigricans*	opaleye	1	0.01	99.91	0.04	0.47
63	*Anisotremus davidsonii*	sargo	1	0.01	99.92	0.04	0.44
64	*Scorpaenichthys marmoratus*	cabezon	1	0.01	99.92	0.04	0.42
65	*Parophrys vetulus*	English sole	1	0.01	99.93	0.03	0.40
66	*Aulorhynchus flavidus*	tubesnout	1	0.01	99.94	0.03	0.39
67	*Zaniolepis* spp.	combfishes	1	0.01	99.94	0.03	0.36
68	*Artedius* spp.	sculpins	1	0.01	99.95	0.03	0.34
69	Pleuronectiformes	flatfishes	1	0.01	99.96	0.03	0.33
70	Agonidae	poachers	1	0.01	99.97	0.03	0.33
71	Scorpaenidae	scorpionfishes	1	0.01	99.97	0.03	0.32
72	Chaenopsidae	tube blennies	1	0.01	99.98	0.03	0.31
73	Scombridae	mackerels & tunas	1	0.01	99.99	0.02	0.27
74	Clupeiformes	herrings and anchovies	1	0.01	99.99	0.02	0.26
75	Pomacentridae	damselfishes	1	0.01	100.00	0.02	0.22
			14,328			460.52	
	larvae, unidentified yolksac	unidentified yolksac larvae	168			5.08	3.44
	larval fish fragment	unidentified larval fishes	87			2.60	1.07
	larval/post-larval fish unid.	larval fishes	43			1.46	0.95
	larval fish - damaged	unidentified larval fishes	1			0.03	0.39
			299			9.17	

Table 4-4. Larval fishes collected at source water stations other than entrainment Station E from September 2003 through August 2004.

Taxon name	Common Name
Anisotremus davidsoni	sargo
Artedius lateralis	smoothhead sculpin
Artedius spp.	sculpins
Aulorhynchus flavidus	tubesnout
Chaenopsidae	tube blennies
Chromis punctipinnis	blacksmith
Clupeiformes	herrings and anchovies
Etrumeus teres	round herring
Girella nigricans	opaleye
Gobiesocidae	clingfishes
Hexagrammidae	greenlings
Hippoglossina stomata	bigmouth sole
Icelinus spp.	sculpins
Kyphosidae	sea chubs
Labridae	wrasses
Lythrypnus spp.	gobies
Ophidiidae	cusk-eels
Parophrys vetulus	English sole
Pomacentridae	damselfishes
Scorpaenichthys marmoratus	cabezon
Sebastes spp.	rockfishes
Xystreurys liolepis	fantail sole
Zaniolepis spp.	combfishes

Table 4-5. Larval invertebrates (target taxa) collected during 12 source water surveys from September 2003 through August 2004. 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 (#/1000m3)	Density Std. Error
Emerita analoga (zoea)	mole crabs - larva	5,476	94.54	94.54	173.26	109.94
Cancer gracilis (megalops)	slender crab	107	1.85	96.39	3.48	2.50
Cancer anthonyi (megalops)	yellow crab	106	1.83	98.22	3.41	3.72
Cancer antennarius (megalops)	brown rock crab	92	1.59	99.81	2.96	2.75
Cancer spp. (megalops)	cancer crabs	4	0.07	99.88	0.11	0.32
Cancer productus (megalops)	red rock crab	3	0.05	99.93	0.10	0.43
Cancer spp.	cancer crabs	3	0.05	99.98	0.09	0.64
Panulirus interruptus (puerulus)	California spiny lobster	1	0.02	100.00	0.03	0.34
		5,792			183.44	

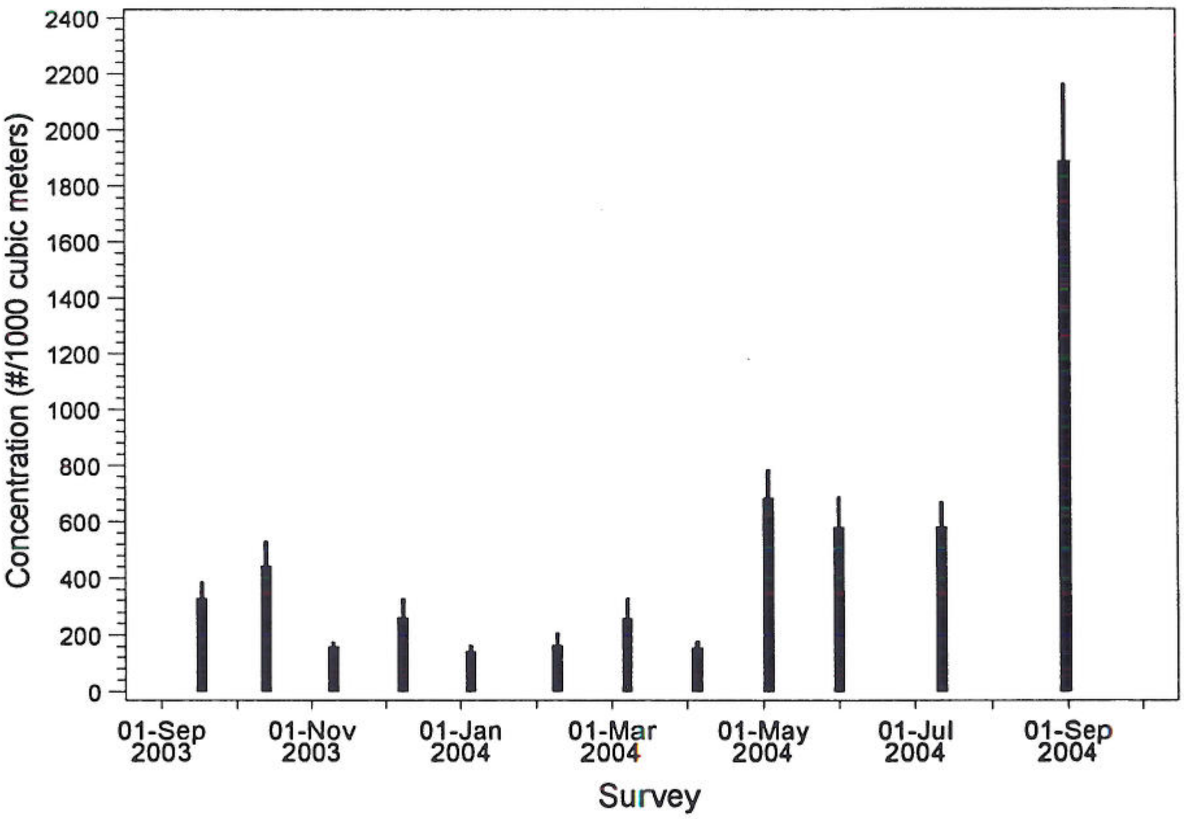

Figure 4-5. Mean concentrations (#/1000 m^3) and standard error for all larval fishes collected at seven source water stations (D2, D4, E, U2, U4, O2, O4) from September 2003 through August 2004.

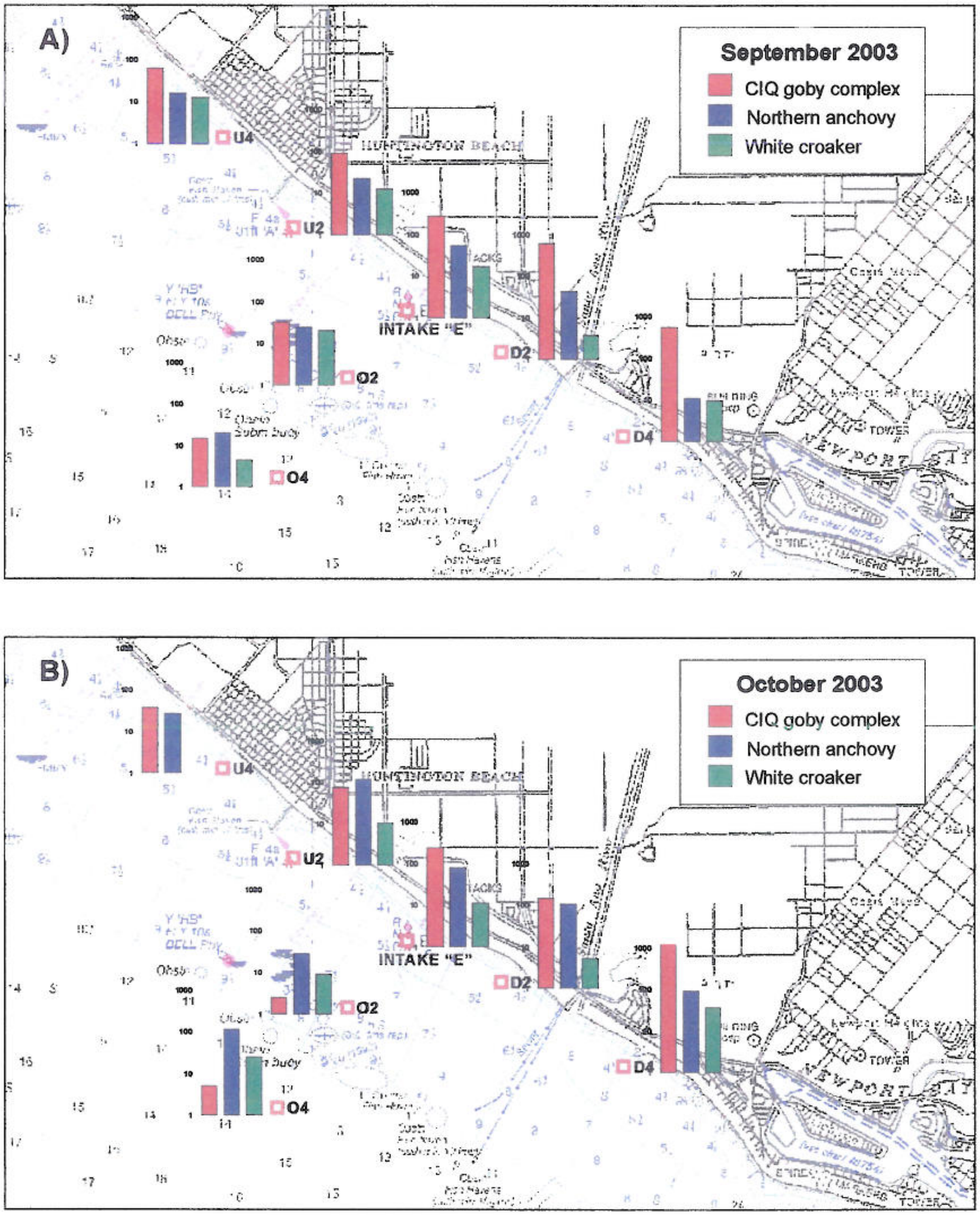

Figure 4-6. Concentrations (# per 1000 m^3) of larval CIQ gobies, northern anchovy, and white croaker at entrainment and source water stations in a) September 2003 and b) October 2003. Abundances are plotted on a logarithmic scale.

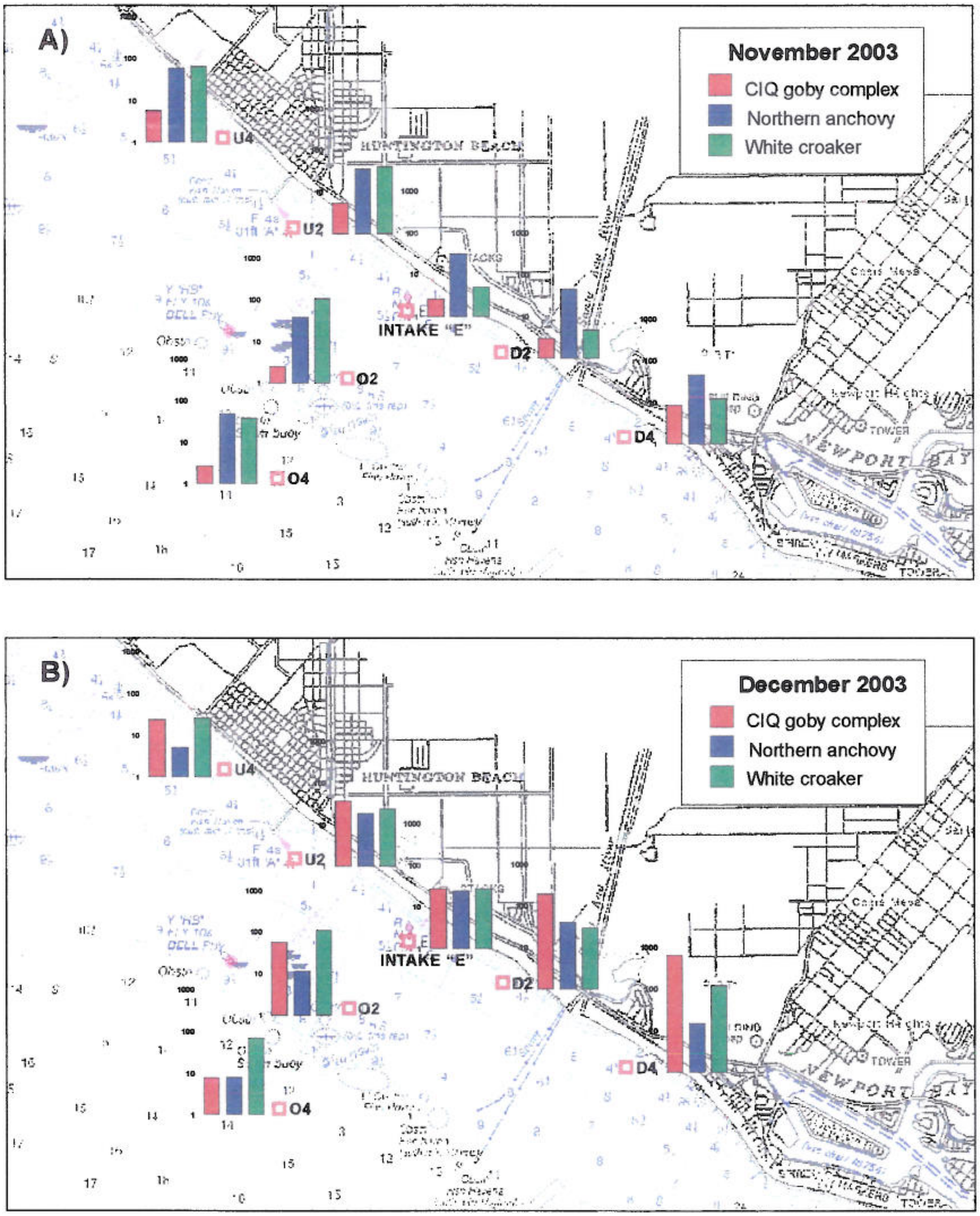

Figure 4-7. Concentrations (# per 1000 m^3) of larval CIQ gobies, northern anchovy, and white croaker at entrainment and source water stations in a) November 2003 and b) December 2003. Abundances are plotted on a logarithmic scale.

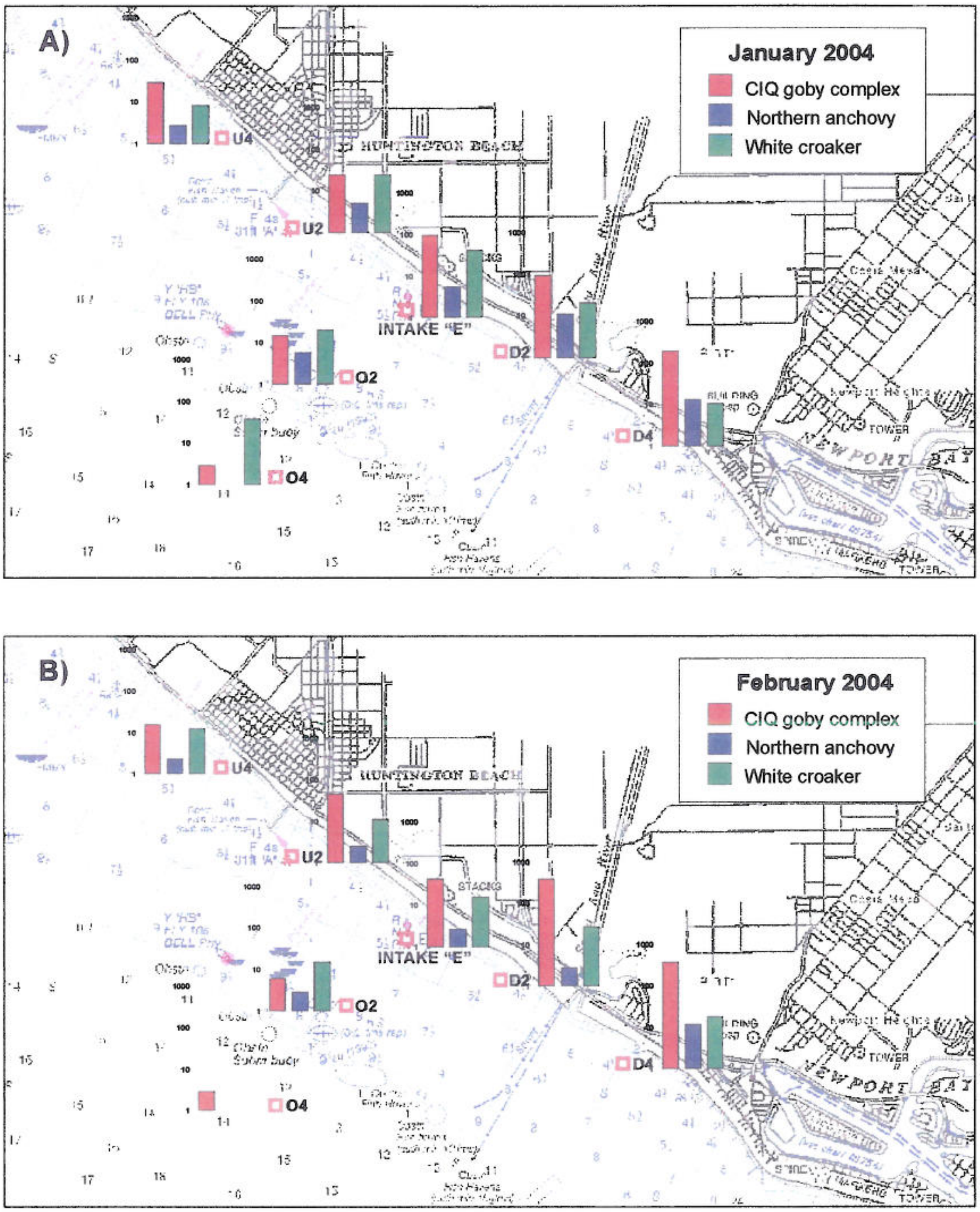

Figure 4-8. Concentrations (# per 1000 m^3) of larval CIQ gobies, northern anchovy, and white croaker at entrainment and source water stations in a) January 2004 and b) February 2004. Abundances are plotted on a logarithmic scale.

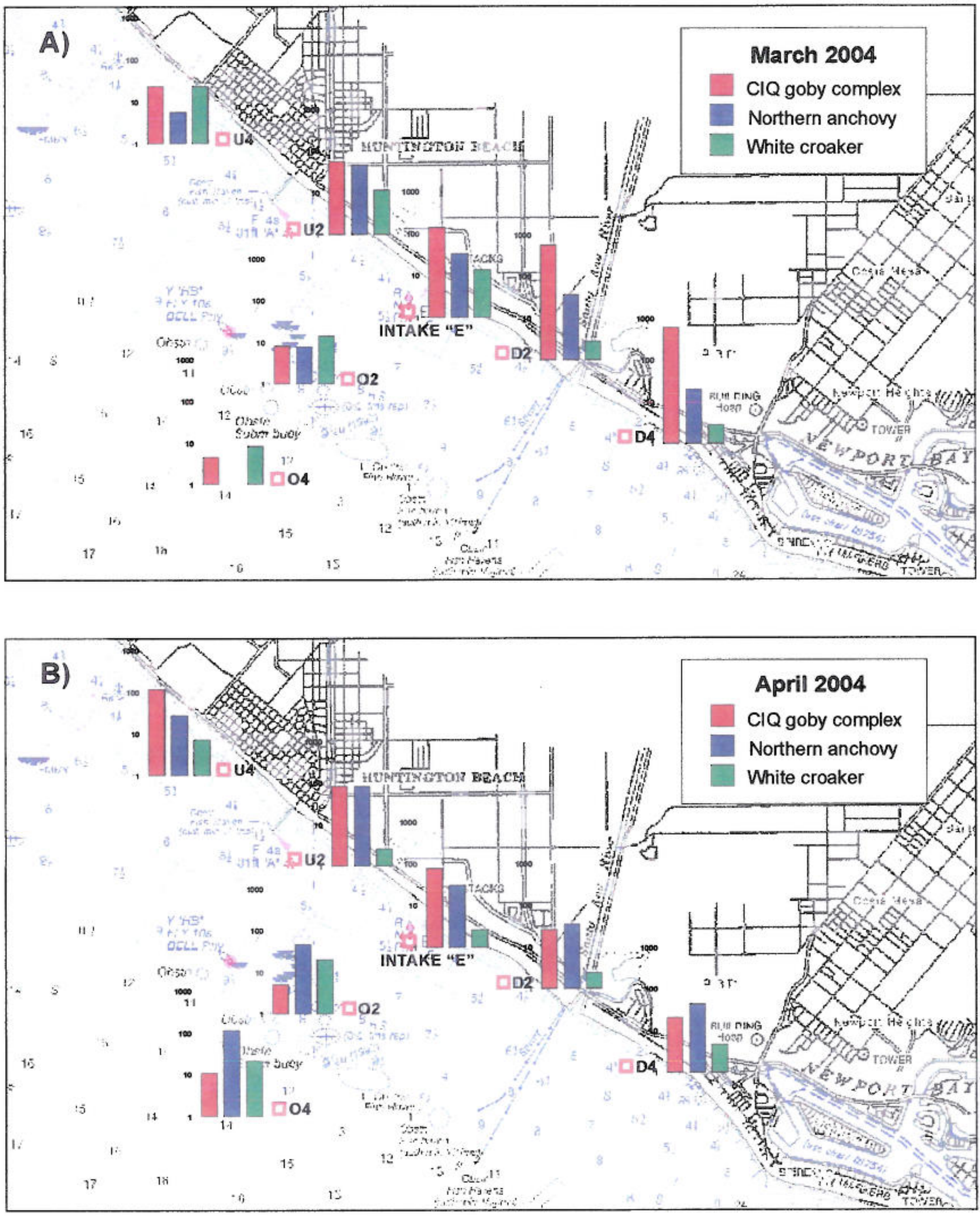

Figure 4-9. Concentrations (# per 1000 m^3) of larval CIQ gobies, northern anchovy, and white croaker at entrainment and source water stations in a) March 2004 and b) April 2004. Abundances are plotted on a logarithmic scale.

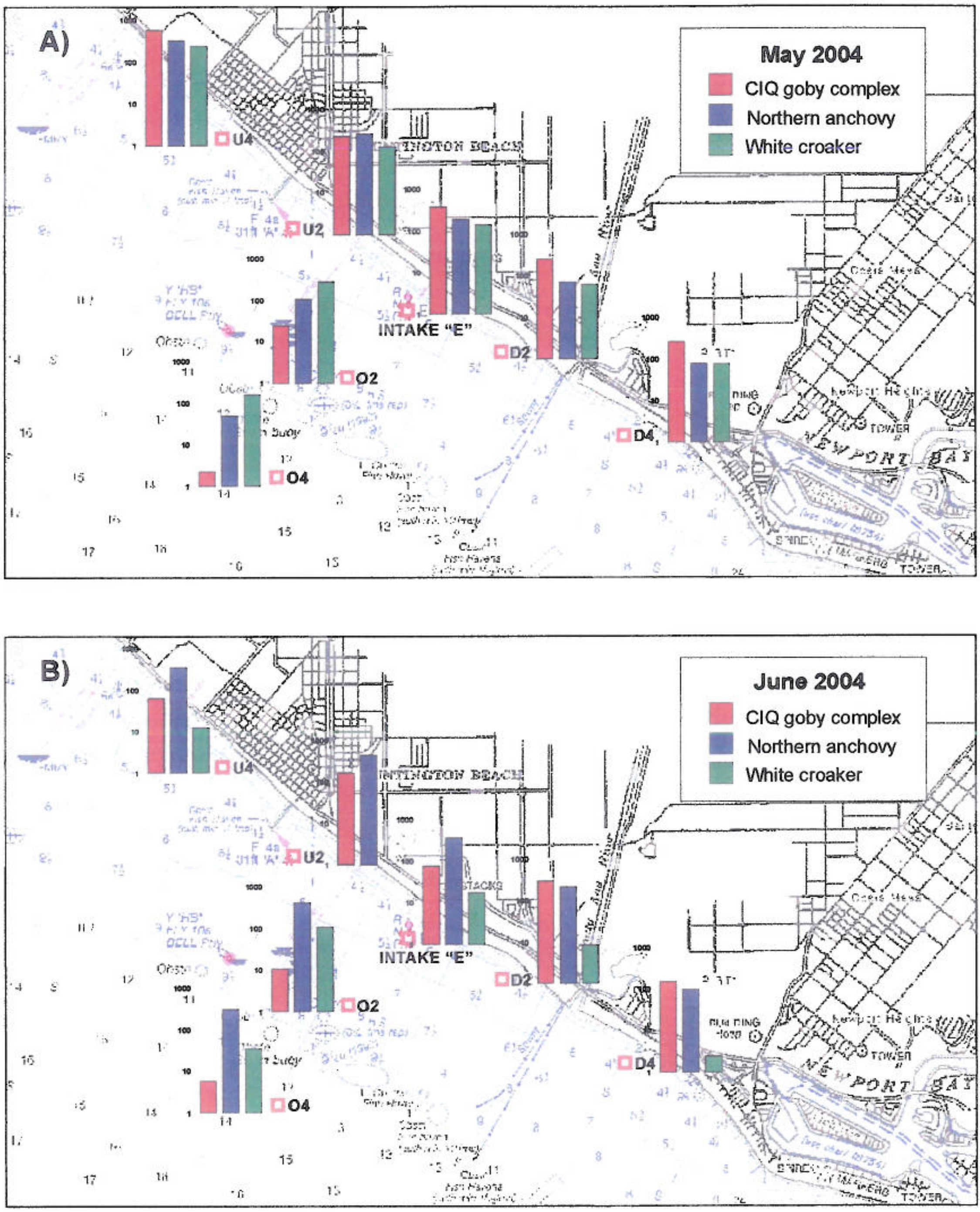

Figure 4-10. Concentrations (# per 1000 m^3) of larval CIQ gobies, northern anchovy, and white croaker at entrainment and source water stations in a) May 2004 and b) June 2004. Abundances are plotted on a logarithmic scale.

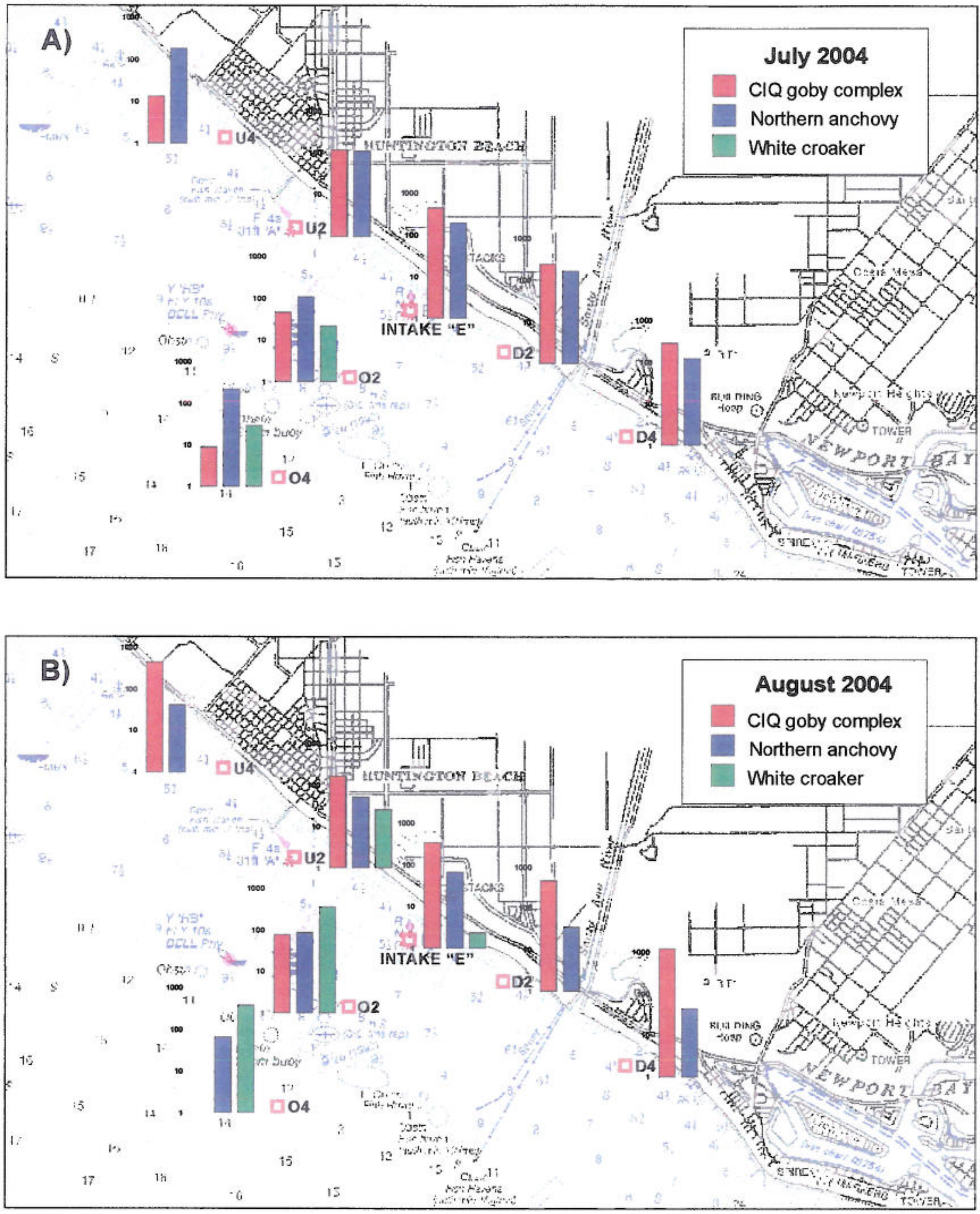

Figure 4-11. Concentrations (# per 1000 m^3) of larval CIQ gobies, northern anchovy, and white croaker at entrainment and source water stations in a) July 2004 and b) August 2004. Abundances are plotted on a logarithmic scale.

4.3.3 Individual Species Results

4.3.3.1 Unidentified Gobies: CIQ Goby Complex (*Clevelandia*, *Ilypnus*, and *Quietula*)

The family Gobiidae is the largest family of marine fishes, comprised of about 1,875 species in 212 genera (Nelson 1994, Moser 1996). In the CalCOFI study area (from northern California to southern Baja California), 21 species in 16 genera have been collected (Moser 1996). In southern California, 14 species of gobies occur in nearshore waters, and 11 are considered common (Miller and Lea 1972). Tidewater goby (*Eucyclogobius newberryi*) is listed as federally endangered, but is not known to occur in the Huntington Beach area. The nearest known populations of tidewater gobies to HBGS are in Malibu Creek (Los Angeles County) and in San Mateo Lagoon (San Diego County) (Swift, pers. comm. 2002; Gutierrez 2003). Longtail goby (*Ctenogobius sagittula*) is considered rare in southern California (Miller and Lea 1972), and prior to 1998 was not collected in California since the early 1900s. However, during the warm-water years of 1997-98, several longtail gobies were collected in southern California, including in Newport Bay and Long Beach Harbor (Lea and Rosenblatt 2000).

Larval gobiids are distinctive and unlikely to be confused with other larval fishes in the CalCOFI study area. However, positive identification of larval gobies to the species level remains difficult. Three species cannot be differentiated with certainty during early larval stages: arrow goby (*Clevelandia ios*), cheekspot goby (*Ilypnus gilberti*), and shadow goby (*Quietula y-cauda*) (Moser 1996). All three of these species are considered common in southern California (Miller and Lea 1972), and arrow goby is known to occur in Talbert Marsh (Gorman et al. 1990). These three species were combined into the CIQ goby complex for analysis. The larvae of arrow goby, cheekspot goby, shadow goby, longjaw mudsucker (*Gillichthys mirabilis*), and yellowfin goby (*Acanthogobius flavimanus*) were collected in nearby Upper Newport Bay from 1997 to 1999 (MBC 1999). Juvenile or adult arrow goby, bay goby (*Lepidogobius lepidus*), longjaw mudsucker, yellowfin goby, and cheekspot goby were also collected from Upper Newport Bay (MBC 1999). Descriptions of the life histories of arrow, cheekspot, and shadow goby were compiled by Brothers (1975) and were used to parameterize the models used in the following analysis.

Habitat Requirements

Most adult gobies are small (<10 cm) and inhabit bays, estuaries, lagoons, and nearshore open coastal waters (Allen 1985, Moser 1996). Marine gobies occupy a variety of habitats, including mudflats and reefs. Many of the soft-bottom species live in burrows. In southern California, arrow gobies use the burrows constructed by bay ghost shrimp (*Neotrypaea californiensis*) to flee predators or to escape aerial exposure at low tides (Brothers 1975). Shadow gobies construct burrows that are usually near eelgrass (*Zostera marina*) or below mats of *Ulva* or *Enteromorpha*. The cheekspot goby also constructs burrows as a refuge from predators, to escape aeration, and as a brood site for eggs guarded by the male. Bay gobies are typically found on the middle and outer shelf (Allen et al. 2002) and are also common in the Los Angeles-Long Beach Harbor complex (MBC 2002a, b).

Reproduction

Arrow gobies mature at one year, but cheekspot and shadow gobies mature at about three years (Brothers 1975). Gobies are oviparous, and the demersal eggs are elliptical, typically adhesive, and about 2–4 mm long (Moser 1996). Parental care of the nests is common, though the arrow goby does not guard its nest. Primary spawning activity of arrow goby occurs from March through June (Prasad 1958). Protracted spawning is likely in arrow, shadow, and cheekspot gobies (Brothers 1975). High abundances of arrow goby larvae in southern California were seen from March to September corresponding to the timing of settlement (Brothers 1975). Settlement of shadow and cheekspot goby occurs in late summer and early fall (Brothers 1975).

Age and Growth

The arrow goby grows faster than the cheekspot and shadow goby (Brothers 1975). After maturity, however, the growth rate in the arrow goby levels off. Shadow and cheekspot gobies settle at smaller sizes and grow more slowly, but the growth rate is relatively constant for their entire life. Shadow and cheekspot gobies live up to four years, while arrow goby rarely live longer than three years. In southern California, arrow gobies reach maximum lengths of 32 mm, shadow gobies reach 40 mm, and cheekspot 46 mm (Brothers 1975). Brothers (1975) estimated that the population mortality of arrow gobies in Mission Bay following settlement was 91% in the first year and nearly 99% thereafter. He also calculated that the annual mortality rates after settlement were 66–74% for cheekspot gobies, and 62–69% for shadow gobies.

CIQ goby larvae hatch at a size of 2–3 mm (Moser 1996). Using data available in Brothers (1975), the average growth rate of this group was estimated at 0.16 mm/day for the 60-day period from hatching until settlement. Brothers (1975) estimated that larval mortality for this period was 98.3% for arrow gobies, 98.6% for cheekspot, and 99.2% for shadow. Based on the total mortality for this period average daily survival was calculated at 0.93 for the three species. Juveniles settle to the bottom at a size of about 10–15 mm SL (Moser 1996)

Population Trends and Fishery

There is no known recreational or commercial goby fishery in southern California. No population estimates or trends are available for southern California gobies. Densities of arrow goby have been reported for two locations within 22 km of the HBGS. During the final year of a five-year monitoring project, MBC (2003) reported seasonal densities of 0.72 to 4.53

individuals/m^2 at the Golden Shore Marine Reserve. The study site was a created wetland at the mouth of the Los Angeles River. At Anaheim Bay, MacDonald (1975) reported densities of arrow goby of 4 to 5 individuals/m^2, though investigation of individual burrows resulted in much higher densities (up to 20 fishes per m^2).

Sampling Results

The CIQ goby complex larvae were the most abundant taxon collected during this study from both the entrainment and source water stations, comprising 37% of the total larvae collected (Tables 4-1 and 4-3). CIQ gobies were abundant at the entrainment station throughout the sampling period but were in highest abundance during July (Figure 4-12a). Mean abundance in the source water samples was greatest in the September survey and lowest during the November survey (Figure 4-12b). The source water stations weren't sampled during the July survey when the highest abundances occurred at the entrainment station. The number and density of larval CIQ gobies collected during each entrainment and source water survey is presented in Appendix B.

The length frequency distribution of measured CIQ gobies (Figure 4-13) illustrates that the majority of the larvae were recently hatched based on the reported hatch length of 2–3 mm (Moser 1996). The mean, maximum, and minimum sizes for the measurements were 3.8, 19.2, and 1.9 mm, respectively. A larval growth rate of 0.16 mm/day was estimated from Brothers (1975) using his reported transformation lengths for the three species and an estimated transformation age of 60 days. The difference in the lengths of the first (1.9 mm) and 95th (7.4 mm) percentiles of the measurements was used with the larval growth rate to estimate that the larvae were exposed to entrainment for a period of 34.4 days.

Impact Assessment

The following sections present the results for demographic and empirical transport modeling of the effects of the HBGS circulating water system. A comprehensive comparative study of the three goby species in the CIQ complex by Brothers (1975) provided the necessary life history information for both the *FH* and *AEL* demographic models. Total entrainment was estimated at approximately 113 million larvae for the period of September 2003 through August 2004. The estimated mean entrainment per survey was variable, ranging from zero to about 490 CIQ goby larvae per 1,000 m^3 (Figure 4-12a).

Fecundity Hindcasting (*FH*)

The entrainment estimate for CIQ gobies for the September 2003 through August 2004 study period was used to estimate the number of breeding females needed to produce the number of larvae entrained (Table 4-1). No estimates of egg survival for gobies were available, but because egg masses in gobies are demersal (Wang 1981) and parental care, usually provided by the adult male, is common in the family (Moser 1996), egg survival is probably high and was assumed to be 100 percent. Estimates of larval survival for the three species from Brothers (1975) were used to estimate an average daily survival of 0.93. Survival to the average age at entrainment (11.6 days) was then estimated as $0.93^{11.6} = 0.44$. An average batch fecundity estimate of 615 eggs was based on calculations from Brothers (1975) on size-specific fecundities for the three species. Brothers (1975) found eggs with two to three different vitellogenic stages in the ovaries. Therefore, an estimate of 2.5 spawns per year was used in calculating *FH* (615 eggs/spawn times 2.5 spawns/year = 1,538 eggs/year). Average ages of maturity and longevity of 1.0 and 3.3 years, respectively, from Brothers (1975) for the three species were used in the model.

The estimated number of adult females whose lifetime reproductive output was entrained through the HBGS circulating water system for the September 2003 – August 2004 study period was 101,269 (Table 4-6). The results show that the variation in our estimate of entrainment had much less of an effect on the range of the *FH* estimate than the life history parameters used in the model.

Table 4-6. Results of *FH* modeling for CIQ goby complex larvae entrained during the September 2003 – August 2004 sampling period. The upper and lower estimates are based on a 90% confidence interval of the mean. The upper and lower estimates for total entrainments were calculated by using the range of entrainment estimates in the *FH* calculations.

Parameter	Estimate	Std. Error	*FH* Lower Estimate	*FH* Upper Estimate	*FH* Range
FH	101,269	89,398	23,703	432,662	408,959
Total Entrainment	113,166,834	19,372,798	72,751	129,787	57,035

Adult Equivalent Loss (*AEL*)

The parameters required for calculating *AEL* include larval survival from entrainment to settlement and survival from settlement to the average age of reproduction for a mature female. Larval survival from mean age at entrainment through settlement was estimated as $0.93^{60-11.6} =$ 0.03 using the same daily survival rate used in formulating *FH*. Brothers (1975) estimated that mortality in the first year following settlement was 99 percent for arrow, 66–74 percent for cheekspot, and 62–69 percent for shadow goby. These estimates were used to calculate a daily survival of 0.995 that was used to estimate a finite survival of 0.21 for the first year following settlement. Daily survival through the average female age of 1.71 years from life table data for the three species (Brothers 1975) was estimated as 0.994 and was used to calculate a finite survival of 0.195.

The estimated number of larvae entrained through the HBGS circulating water system for the September 2003 – August 2004 study period was used to calculate an estimate of 147,493 equivalent adults (Table 4-7). The results show that the variation in our estimate of entrainment had much less of an effect on the variation of the *AEL* estimate than the life history parameters used in the model. If all of our life history parameters and assumptions regarding lifetime fecundity were accurate the *AEL* estimate should approximately equal twice the *FH* estimate. The results show that 2·*FH* is approximately 35% greater than the *AEL* estimate, but is within the range of the 90% confidence interval around the estimate.

Table 4-7. Results of *AEL* modeling for CIQ goby complex larvae entrained during the September 2003-August 2004 sampling period. The upper and lower estimates are based on a 90% confidence interval of the mean. The upper and lower estimates for total entrainments were calculated by using the range of entrainment estimates in the *AEL* calculations.

Parameter	Estimate	Std. Error	*AEL* Lower Estimate	*AEL* Upper Estimate	*AEL* Range
AEL	147,493	167,545	22,763	955,676	932,913
Total Entrainment	113,166,834	19,372,798	105,958	189,027	83,069

Empirical Transport Model (*ETM*)

The larval duration used to calculate the *ETM* estimates for CIQ gobies was based on the difference between the lengths of the 1st (1.9 mm) and 95th (7.4 mm) percentiles and a growth rate of 0.16 mm/day. These values were used to estimate that CIQ goby larvae were vulnerable to entrainment for a period of approximately 34 days.

The *PE* estimates used to calculate *ETM* estimates for CIQ gobies for the September 2003 – August 2004 ranged from 0.0003 to 0.006 (Table 4-8). The average *PE* was very close to the ratio of the entrainment volume to source water volume of 0.0021. The values of f_i show that the highest numbers of CIQ goby larvae were collected during the August 2004 survey. The values in the table were used to calculate two P_M estimates: one based on alongshore current movement, and the other based on alongshore current movement and an extrapolation of densities offshore to a distance bounded by either the extrapolated densities or onshore current movement. These two estimates of P_M were identical for CIQ gobies because the densities decreased with increasing distance offshore resulting in an extrapolated density of zero that was inside the limits of the sampling area (Table 4-9). Therefore the P_S estimate for the extrapolated offshore P_M was calculated with only alongshore current displacement; the same data used for the alongshore estimate. The estimate of P_M for the 34-day period of exposure was 0.0099 (0.99%) over an area that was estimated to extend 60.9 km alongshore.

Table 4-8. *ETM* data for CIQ goby complex larvae. *ETM* calculations based on sampling grid volume of 908,157,859 m^3, and daily circulating water volume of 1,919,204 m^3. Average *PE* estimate calculated from all surveys with *PE* > 0.

Survey Date	PE Estimate	PE Std. Error	f_I	f_I Std. Error
17-Sep-03	0.00248	0.00250	0.09340	0.06636
13-Oct-03	0.00138	0.00217	0.15955	0.10306
10-Nov-03	0.00115	0.00245	0.00218	0.00179
8-Dec-03	0.00034	0.00054	0.07560	0.07003
5-Jan-04	0.00264	0.00380	0.03845	0.02670
9-Feb-04	0.00069	0.00073	0.06557	0.05367
8-Mar-04	0.00138	0.00191	0.09670	0.08870
5-Apr-04	0.00417	0.00549	0.01810	0.01134
3-May-04	0.00381	0.00307	0.09705	0.05630
1-Jun-04	0.00156	0.00178	0.05763	0.04882
12-Jul-04	0.00608	0.00901	0.10986	0.08383
31-Aug-04	0.00185	0.00237	0.18591	0.18621
Average =	0.00229			

Table 4-9. Average P_S values and *ETM* estimates for alongshore current and offshore extrapolated models for CIQ gobies. Current displacement (km) for alongshore extrapolation included in parentheses with estimate of P_S for alongshore estimate of P_M.

Parameter	Average P_S (displacement)	*ETM* Estimate (P_M)	*ETM* Std. Err.	Upper 95% CI	Lower 95%CI
Alongshore Current	0.1714 (60.9)	0.00993	0.29534	0.30527	0
Offshore Extrapolated	0.1714	0.00993	0.29534	0.30527	0

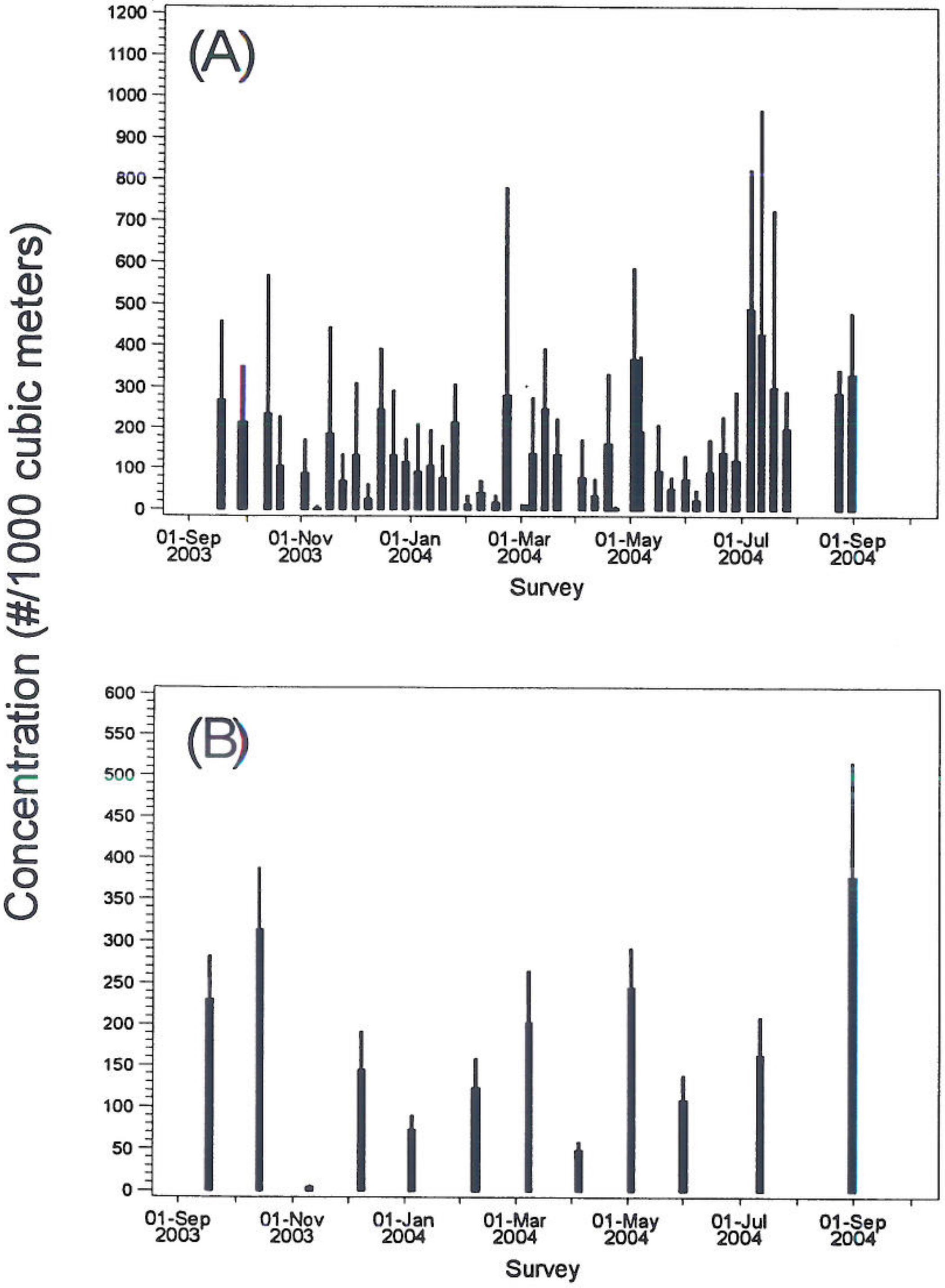

Figure 4-12. Survey mean concentration (#/1000 m^3) of CIQ goby larvae collected at the HBGS entrainment (A) and source water (B) stations with standard error indicated (+1 SE). Note that the Y-axis range is different on the two graphs.

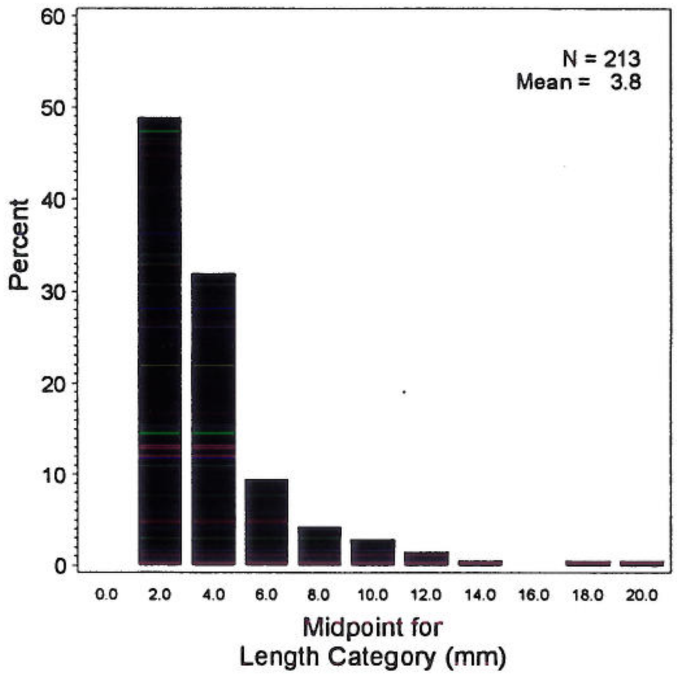

Figure 4-13. Length frequency distribution (mm) of CIQ goby larvae collected from the HBGS entrainment station from September 2003 through August 2004.

4.3.3.2 Northern Anchovy (*Engraulis mordax*)

Northern anchovy (*Engraulis mordax* Girard 1854) range from Cape San Lucas, Baja California to Queen Charlotte Island, British Columbia, and offshore to 480 km (Hart 1973). They are most common from Magdalena Bay, Baja California to San Francisco Bay and within 157 km of shore (Hart 1973, MBC 1987). Northern anchovy is one of four species of anchovies (Family Engraulidae) that occurs off California (Miller and Lea 1972). Deepbody anchovy (*Anchoa compressa*) and slough anchovy (*Anchoa delicatissima*) are found in the vicinity of the HBGS, while the anchoveta (*Cetengraulis mysticetus*) is considered rare north of Magdalena Bay, Baja California.

Three genetically distinct subpopulations are recognized for northern anchovy; (1) Northern subpopulation, from northern California to British Columbia; (2) Central subpopulation, off southern California and northern Baja California; and (3) Southern subpopulation, off southern Baja California (Emmett et al. 1991).

Habitat Requirements

The reported depth range of northern anchovy is from the surface to depths of 300 m (984 ft) (PFMC 1983). Juveniles are generally more common inshore and in estuaries. Eggs are found from the surface to 50 m, and larvae are found from the surface to 75 m in epipelagic and neritic waters (Garrison and Miller 1982). Northern anchovy larvae feed on dinoflagellates, rotifers, and copepods (MBC 1987). Juveniles and adults feed on zooplankton, including planktonic crustaceans and fish larvae (Fitch and Lavenberg 1971, Frey 1971, Hart 1973, PFMC 1983). Northern anchovy feed largely during the night, though they were previously thought to feed during the day (Allen and DeMartini 1983).

Reproduction

Northern anchovy spawn throughout the year off southern California, with peak spawning between February and May (Brewer 1978). Most spawning takes place within 100 km from shore (MBC 1987). On average, female anchovies off Los Angeles spawn every 7 to 10 days during peak spawning periods, approximately 20 times per year (Hunter and Macewicz 1980, MBC 1987). In 1979, it was determined that most spawning occurs at night (2100 to 0200 hr), with spawning complete by 0600 hr (Hunter and Macewicz 1980). Northern anchovies off southern and central California can reach sexual maturity by the end of their first year of life, with all individuals being mature by four years of age (Clark and Phillips 1952, Daugherty et al. 1955, Hart 1973). Bergen and Jacobsen (2001) stated that they are mature by two years of age, and that maturation of younger individuals is dependent on water temperature. Love (1996) reported that they release 2,700-16,000 eggs per batch, with an annual fecundity of up to 130,000 eggs per year in southern California. Parrish et al. (1986) and Butler et al. (1993) stated that the total annual fecundity for one-year old females was 20,000-30,000 eggs, while a five-year old could release up to 320,000 eggs per year.

Age and Growth

The northern anchovy egg hatches in two to four days, has a larval phase lasting approximately 70 days, and undergoes transformation into a juvenile at about 35–40 mm (Hart 1973, MBC 1987, Moser 1996). Larvae begin schooling at 11 to 12 mm SL (Hunter and Coyne 1982). Northern anchovy reach 102 mm in their first year, and 119 in their second (Sakagawa and Kimura 1976). Growth in length is most rapid during the first four months, and growth in weight is most rapid during the first year (Hunter and Macewicz 1980, PFMC 1983). They mature at 78 to 140 mm in length, in their first or second year (Frey 1971, Hunter and Macewicz 1980). Maximum size is about 230 mm and 60 g (Fitch and Lavenberg 1971, Eschmeyer et al. 1983). Maximum age is about seven years (Hart 1973), though most live less than four years (Fitch and Lavenberg 1971).

General Ecology

Northern anchovy are random planktonic feeders, filtering plankton as they swim (Fitch and Lavenberg 1971). They feed mostly on larval crustaceans, but also on fish eggs and larvae (Fitch and Lavenberg 1971). Temperatures above 25°C are avoided by juveniles and adults (Brewer 1974). Numerous fishes and marine mammals feed on northern anchovy. Elegant tern and California brown pelican production is strongly correlated with abundance of northern anchovy (Emmett et al. 1991).

Larval survival is strongly influenced by the availability and density of appropriate phytoplankton species (Emmett et al. 1991). Storms and strong upwelling reduce larval food availability, and strong upwelling may transport larvae out of the Southern California Bight (Power 1986). However, strong upwelling may benefit juveniles and adults.

Population Trends and Fishery

Northern anchovy are fished commercially for reduction (e.g., fish meal, oil, and paste) and live bait (Bergen and Jacobsen 2001). 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). Northern anchovy populations increased dramatically during the collapse of the Pacific sardine (*Sardinops sagax*) fishery, suggesting competition between these two species (Smith 1972).

Estimates of the central subpopulation averaged about 359,000 tons from 1963 through 1972, then increased to over 1.7 million tons in 1974, then declined to 359,000 tons in 1978 (Bergen and Jacobsen 2001). Anchovy biomass in 1994 was estimated at 432,000 tons. The stock is thought to be stable, and the size of the anchovy resource is largely dependent on natural influences such as ocean temperature.

In the seven commercial Catch Blocks off Huntington Beach, northern anchovy were reported in landings from five blocks from 1999 through 2001 (CDFG 2002). Maximum annual landings in Catch Block 738 by weight were in 2000 (782,707 lbs worth $32,760). During the three-year period 1999–2001, northern anchovy were among the top five species landed (by weight) in all five blocks.

Sampling Results

Engraulidae larvae (over 95% northern anchovy) were the second most abundant taxon at the entrainment station and source water stations during the September 2003 through August 2004 sampling period (Tables 4-1 and 4-3). The larvae that were identified as Engraulidae, and not northern anchovy, were either very small or damaged specimens and could not be identified beyond the family level. The estimated mean entrainment per survey was variable, ranging from zero to almost 400 larvae per 1,000 m^3 with high abundances in May, June and July (Figure 4-14a). Highest mean abundances of larvae sampled in the source water occurred in June 2004 (about 320 larvae per 1000 m^3), while abundances were low in January and February 2004 (Figure 4-12b). The number and density of larval northern anchovies collected during each entrainment and source water survey is presented in Appendix B.

The length frequency distribution of measured northern anchovy larvae show a bimodal distribution with approximately 20% being recently hatched larvae based on the reported hatch length of 2–3 mm (Moser 1996) and a large number of larger larvae ranging from 8–16 mm (Figure 4-15). The mean, maximum, and minimum sizes for the measurements were 10.6, 26.2, and 1.4 mm, respectively. A larval growth rate of 0.49 mm/day was estimated from Methot and Kramer (1979) and used with the difference in the lengths of the first (1.7 mm) and 95th (20.2 mm) percentiles of the measurements to estimate that the larvae were exposed to entrainment for a period of approximately 38 days.

Impact Assessment

The following sections present the results for demographic and empirical transport modeling of circulating water system effects on northern anchovy larvae. Total entrainment was estimated at 54.3 million larvae for the study period.

Fecundity Hindcasting (*FH*)

The entrainment estimate for northern anchovy for the September 2003 – August 2004 sampling period was used to estimate the number of breeding females needed to produce the estimated number of larvae entrained (Table 4-10). Butler et al. (1993) modeled annual fecundity and egg and larval survivorship for northern anchovy. Their "best" estimate can be derived by fitting the range of mortality estimates from field collections to the assumption of a stable and stationary population age structure. Instantaneous daily mortality estimates from Butler et al. (1993) were converted, over their average stage durations, to finite survivorship rates for each developmental stage. Egg survival for the period of 2.9 days was estimated as 0.51 using an instantaneous mortality rate of 0.23 from Butler et al. (1993). Fishes at the mean age of entrainment include yolk sac, early, and late stage larvae. Therefore, survival estimates for all three stages were combined to obtain a finite survival value up to the mean age at entrainment (18.3 days) of 0.015.

Clark and Phillips (1952) reported age at sexual maturity as 1–2 years. Similarly, Bergen and Jacobsen (2001) report that 47 to 100 percent of one-year olds may be mature in a given year while all are mature by two years. For modeling purposes we used a mid-value of 1.5 years. For longevity, Hart (1973) reports a value of seven years, but Bergen and Jacobsen (2001) state that northern anchovy in the fished population rarely exceed four years of age. A value of four years was used to represent the most likely reproductive life span. The reproductive life span was used to estimate an average annual fecundity of 147,622 over the four-year period using the data presented in Butler et al. (1993).

The estimated number of adult female northern anchovies whose lifetime reproductive output was entrained through the HBGS circulating water system for the September 2003 – August 2004 study period was 26,745 (Table 4-10). The results show that the variation in our estimate of entrainment had much less of an effect on the variation of the *FH* estimate than the life history parameters used in the model.

Table 4-10. Results of *FH* modeling for northern anchovy larvae entrained during the September 2003-August 2004 sampling period. The upper and lower estimates are based on a 90% confidence interval of the mean. The upper and lower estimates for total entrainments were calculated by using the range of entrainment estimates in the *FH* calculations.

Parameter	Estimate	Std. Error	*FH* Lower Estimate	*FH* Upper Estimate	*FH* Range
FH	26,745	24,093	6,076	117,715	111,638
Total Entrainment	54,349,017	13,485,655	15,828	37,661	21,833

Adult Equivalent Loss (*AEL*)

The larval entrainment estimate for northern anchovy was used to estimate the number of equivalent adults lost to entrainment. Stage-specific instantaneous mortality rates used to compute finite survival were estimated from the life table produced by Butler et al. (1993) in which survivorship from larvae to recruitment was apportioned into several developmental stages. *AEL* was estimated for the average age of sexually mature females (2.75 years; midpoint between 1.5 and 4 years) used in the *FH* model estimates.

The estimated number of adult northern anchovies equivalent to the number of larvae entrained through the HBGS circulating water system for the one-year study period was 304,125 (Table 4-11). The results show that the variation in our estimate of entrainment had much less of an effect on the variation of the *AEL* estimate than the life history parameters used in the model. If all of our life history parameters and assumptions regarding lifetime fecundity were accurate the *AEL* estimate should approximately equal twice the *FH* estimate. The results show that the range of *AEL* estimates greatly exceed the *FH* estimate although the large range of the estimate does encompass the *FH* estimate. The large range also indicates the high level of uncertainty associated with the life history parameters that are available and used in the model.

Table 4-11. Results of *AEL* modeling for northern anchovy larvae entrained during the September 2003 – August 2004 sampling period. The upper and lower estimates are based on a 90% confidence interval of the mean. The upper and lower estimates for total entrainments were calculated by using the range of entrainment estimates in the *AEL* calculations.

Parameter	Estimate	Std. Error	*AEL* Lower Estimate	*AEL* Upper Estimate	*AEL* Range
AEL	304,125	359,787	43,439	2,129,225	2,085,785
Total Entrainment	54,349,017	13,485,655	179,989	428,261	248,273

Empirical Transport Model (*ETM*)

The *PE* estimates used to calculate *ETM* for northern anchovies for the September 2003 – August 2004 study period ranged from 0.001 to 0.004 (Table 4-12). The average *PE* was very close to the ratio of the entrainment volume to source water volume of 0.0021. As shown in the values of f_i the largest abundance of anchovy larvae were collected during the June 2004 survey. The values in the table were used to calculate two P_M estimates: one based on alongshore current movement, and the other based on alongshore current movement and an extrapolation of densities offshore to a distance bounded by either the extrapolated densities or onshore current movement. The estimate of P_M for the 38-day period of exposure calculated using offshore extrapolated densities (0.007, 0.7%) is less than the estimate calculated using alongshore current displacement (0.012, 1.2%) because of the larger overall volume of the source area calculated due to the offshore extrapolation (Table 4-13). The P_S estimates indicate that the ratio of the sampled source water to the total population for the offshore and alongshore P_M estimates were 4.5 and 15.5 percent, respectively. The alongshore estimate of P_M was extrapolated over a shoreline distance of 72.0 km.

Table 4-12. *ETM* data for northern anchovy larvae. *ETM* calculations based on sampling grid volume of 908,157,859 m^3, and daily circulating water volume of 1,919,204 m^3. Average *PE* estimate calculated from all surveys with *PE* > 0.

Survey Date	PE Estimate	PE Std. Error	f_I	f_I Std. Error
17-Sep-03	0.00366	0.00465	0.03292	0.03400
13-Oct-03	0.00193	0.00261	0.07234	0.04127
10-Nov-03	0.00148	0.00160	0.03914	0.02047
8-Dec-03	0.00308	0.00393	0.01453	0.01320
5-Jan-04	0.00279	0.00509	0.00852	0.01003
9-Feb-04	0.00150	0.00342	0.00352	0.00391
8-Mar-04	0.00381	0.00727	0.01642	0.01736
5-Apr-04	0.00119	0.00166	0.05654	0.02337
3-May-04	0.00304	0.00348	0.12008	0.06606
1-Jun-04	0.00249	0.00347	0.34788	0.14091
12-Jul-04	0.00246	0.00250	0.23432	0.09584
31-Aug-04	0.00241	0.00335	0.05380	0.02862
Average =	0.00249			

Table 4-13. Average P_S values and *ETM* estimates for alongshore current and offshore extrapolated models for northern anchovy. Current displacement (km) for alongshore extrapolation included in parentheses with estimate of P_S for alongshore estimate of P_M.

Parameter	Average P_S (displacement)	*ETM* Estimate (P_M)	*ETM* Std. Err.	Upper 95% CI	Lower 95%CI
Alongshore Current	0.1450 (72.0)	0.01242	0.22369	0.23610	0
Offshore Extrapolated	0.0450	0.00713	0.21241	0.21954	0

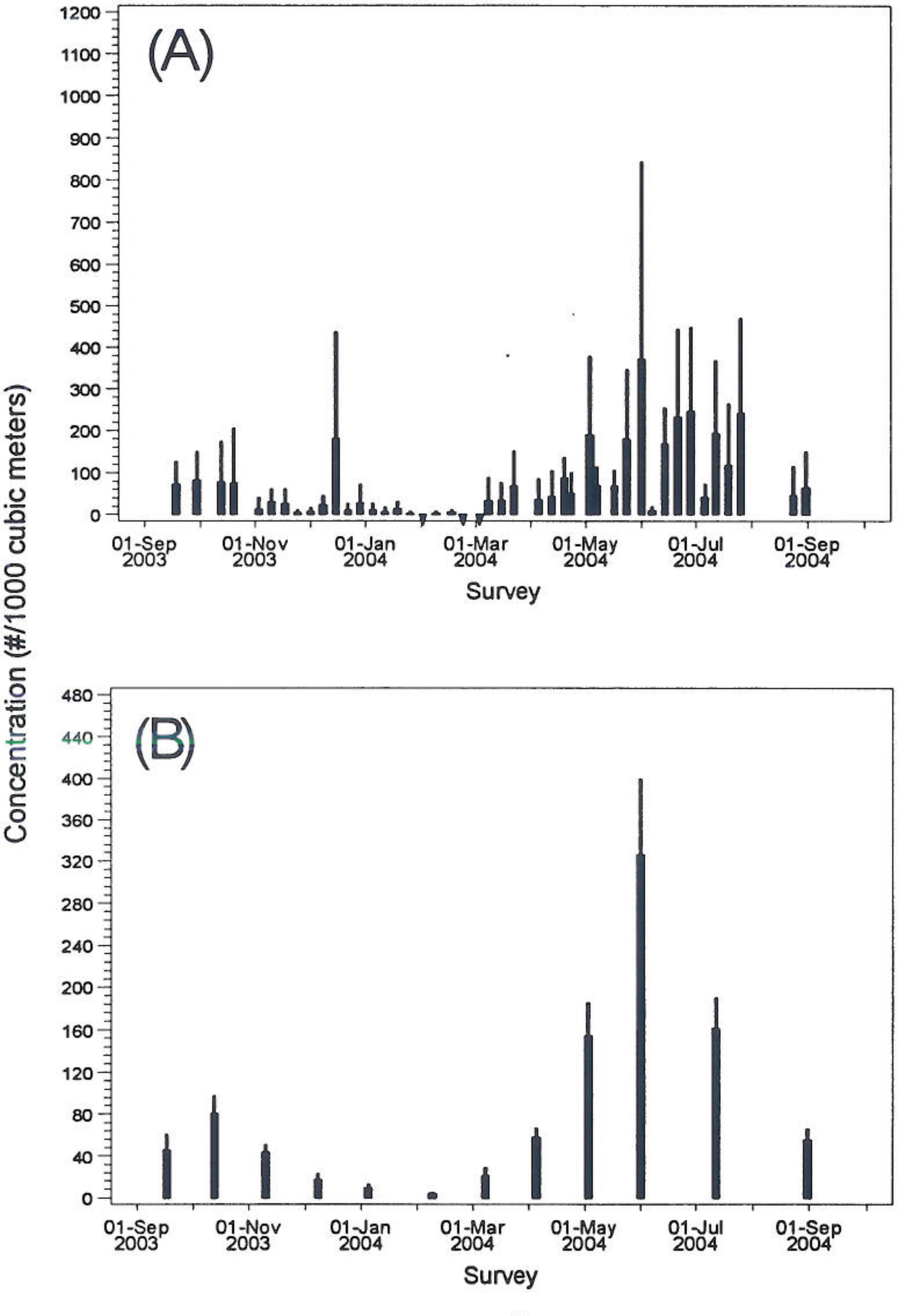

Figure 4-14. Survey mean concentration (#/1000 m^3) of northern anchovy larvae collected at the HBGS entrainment (A) and source water (B) stations with standard error indicated (+1 SE). Down arrows indicate surveys when no northern anchovy larvae were collected.

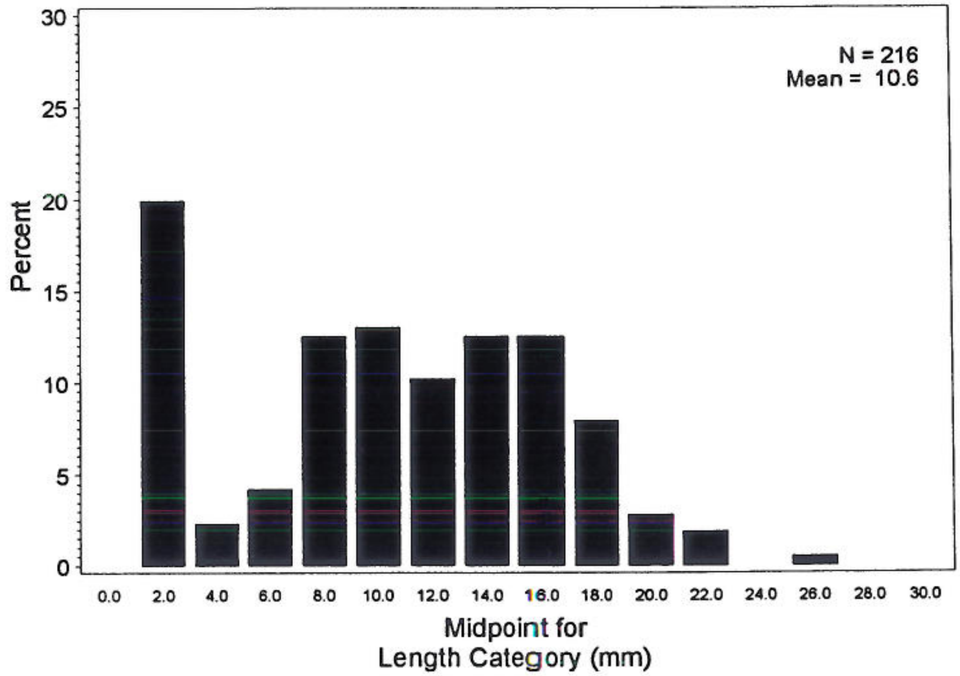

Figure 4-15. Length frequency distribution (mm) of northern anchovy larvae collected from the HBGS entrainment station from September 2003 through August 2004.

4.3.3.3 Spotfin Croaker (*Roncador stearnsii*)

Spotfin croaker (*Roncador stearnsii*) is a croaker (Family Sciaenidae) common to the San Diegan fauna, which ranges from Mazatlan, Mexico to Point Conception, California, including the Gulf of California and occurs in depths ranging from the surf zone to 17 m (Miller and Lea 1972). Seven species of croaker, in addition to spotfin croaker, are common to the Southern California Bight (SCB). These include white croaker (*Genyonemus lineatus*), queenfish (*Seriphus politus*), yellowfin croaker (*Umbrina roncador*), white seabass (*Atractoscion nobilis*), California corbina (*Menticirrhus undulatus*), black croaker (*Cheilotrema saturnum*), and shortfin corvina (*Cynoscion parvipinnis*) (Miller and Lea 1972). Two species [orangemouth corvina (*Cynoscion xanthulus*) and bairdiella (*Bairdiella icistia*)] are currently believed to be restricted to the Salton Sea, California (Nelson et al. 2004). Individuals from all species common to coastal California waters, except shortfin corvina, have been observed in impingement samples at HBGS since 1979 (MBC 2004).

Habitat Requirements

Pondella and Allen (2000) noted a predominantly coastal distribution throughout the SCB, indicated by an absence in samples from the California Channel Islands. Allen (1985) indicated spotfin croaker to be a common member of the open-coast, sandy-beach ichthyofauna, with seasonal occurrences in bays and harbors within the SCB. Love et al. (1984) observed spotfin croaker primarily on the 6.1-m (20-ft) isobath over soft-substrate, with diminishing abundances with increasing depth. Limbaugh (1955) reported sporadic occurrences of spotfin croaker in the rocky bottom/kelp bed biotope. Valle and Oliphant (2001) noted spotfin croaker prefer depressions in the sandy bottom in water depths greater than 3 m.

Reproduction

Spotfin croaker is an oviparous broadcast spawner with pelagic eggs and larvae (Moser 1996). Gonosomatic index (GSI [gonad weight expressed as percent of gonad-free body weight]) peaked for both sexes in June (Miller et al. in prep a), while peak larval abundances were observed from June to September (Moser 1996). Although usually found in small groups (< 5 individuals), observations have been made of large aggregations (> 50 individuals; Feder et al. 1974). Initially thought to migrate offshore to spawn (Valle and Oliphant 2001), recent observations within the SCB indicate an inshore spawning ground, such as Seal Beach, California, based on seasonal fluctuations in catch per unit effort and GSI (Miller et al. in prep a). Within spawning aggregations, gender ratios were significantly skewed towards males with nearly a 10:1 male to female ratio (Miller et al. in prep a). In groups not exhibiting reproductive activity (high GSI), the gender ratio is nearly 1:1 (Miller et al. in prep a). Valle and Oliphant (2001) estimated males to mature at two years old and 228.5 mm SL, while females mature, on average, in their third year and 317.4 mm SL.

Age and Growth

At hatching, spotfin croaker yolk sac larvae are 2.1 mm NL (notochord length), 5.5 mm NL at flexion, and greater than 11 mm SL (standard length) at transformation (Moser 1996). Miller and Lea (1972) indicate the maximum length for spotfin croaker at 685.8 mm SL. Joseph (1962) observed the maximum age for spotfin croaker at ten years based on scale aging. Spotfin croaker exhibit the greatest growth rate during the first and second year, with a mean increase of 100 mm SL, quickly tapering off to less than 30 mm SL per year after age five (Joseph 1962). No information on variation in growth by gender or mortality estimations is available for spotfin croaker.

General Ecology

Spotfin croaker feeds primarily on benthic invertebrates commonly found in sandy environments, such as clams and polychaetes, but also mysids (Joseph 1962). This species undergoes seasonal migrations, indicated by individuals tagged near Los Angeles, California and subsequently recaptured near Oceanside, California (Valle and Oliphant 2001). California corbina (*Menticirrhus undulatus*) is frequently encountered with spotfin croaker, due to the strong similarities in habitat affinities between the two species (Miller et al. in prep a). Within southern California, spotfin croaker populations are historically known to exhibit "runs" (Valle and Oliphant 2001) due to the formation of large aggregations, principally during spawning season (Miller et al. in prep a). Notably absent during the majority of the year near Seal Beach, California, spotfin croaker abundance rises dramatically between April and August, with peaks in abundance typically occurring in June (Miller et al. in prep a).

Population Trends and Fishery

Spotfin croaker is the least frequently impinged croaker at coastal generating stations within the SCB (Herbinson et al. 2001). Since 1977, four generating stations within the SCB between San Onofre and Redondo Beach have reported spotfin croaker in impingement samples (Herbinson et al. 2001). Based on these impingement samples, spotfin croaker populations in southern California have been low since 1983, although their abundance was less than all other croakers except white seabass (Herbinson et al. 2001). Nearshore gillnet sampling within the SCB has indicated a general rise in abundance, corresponding to a general rise in sea surface temperatures (Miller et al. in prep a).

Spotfin croaker has been reserved for recreational angling within California State waters since 1915, with a ban on the use of nets imposed in 1909 and a ban on commercial sale in 1915

(Valle and Oliphant 2001). Incidental catches were possible in the nearshore gillnet white seabass fishery, which was closed in 1992 by legislative action. Recreational angling, specifically surf-fishing, continues, as anglers enjoy greater success during periods of dense aggregation, such as spawning periods.

Sampling Results

Spotfin croaker larvae had the third highest mean density of all taxa collected in the entrainment samples for the study period with a mean density of 53.1 larvae per 1,000 m^3 (Table 4-1), but was relatively scarce in the combined source water samples with an overall mean density of only 1.6 larvae per 1000 m^3 (Table 4-3). The higher abundance in the entrainment samples resulted from very high concentrations of larvae during a single survey in August 2004 when the mean density was measured at over 1,800 larvae per 1000 m^3 (Figure 4-16a). The high, localized larval concentrations substantiate observations of nearshore spawning aggregations of spotfin croaker in summer. Spotfin croaker larvae in the source water samples were absent from September 2003 through April 2004 and were most abundant during August/September 2004 (Figure 4-16b). The number and density of larval spotfin croaker collected during each entrainment and source water survey is presented in Appendix B.

The length frequency distribution of measured spotfin croaker larvae show an extremely limited size range dominated by recently hatched larvae based on the reported hatch length of 2.1 mm (Moser 1996) (Figure 4-17). The mean, maximum, and minimum sizes for the measurements were 2.0, 2.5, and 1.3 mm, respectively. A larval growth rate of 0.20 mm/day for white croaker (Murdoch et al. 1989) was used with the difference in the lengths of the first (1.4 mm) and 95th (2.4 mm) percentiles of the measurements to estimate that the larvae were exposed to entrainment for a period of 5 days.

Impact Assessment

The following sections present the results for empirical transport modeling of entrainment effects on spotfin croaker larvae. Demographic model estimates of entrainment effects were not calculated because of the absence of life history information necessary to parameterize the models. A total of nearly 70 million spotfin croaker larvae was calculated to have been entrained through the HBGS cooling water system during the study.

Empirical Transport Model (*ETM*)

Only two *PE* estimates were calculated for spotfin croaker for the September 2003 – August 2004 study period (Table 4-14). These estimates do not necessarily reflect the actual abundance of spotfin croaker because the highest abundances occurred during surveys when only the entrainment station was sampled (Figure 4-16). In addition to the large temporal variation in abundances, during one of the paired entrainment source water surveys the larvae were collected at the source water stations but not at the entrainment station indicating that the larvae may also be patchily distributed. Even though there were only two estimates the average of the two was very close to the ratio of the entrainment volume to source water volume of 0.0021. The two P_M estimates, one based on alongshore current movement (0.003, 0.3%) and the other based on alongshore current movement and an extrapolation of densities offshore to a distance bounded by either the extrapolated densities or onshore current movement (0.003, 0.3%) (Table 4-15) are both low reflecting the short period of time (5 days) that the larvae were exposed to entrainment. The alongshore estimate of P_M was extrapolated over a shoreline distance of 16.9 km, which was much less than the values for gobies or anchovies due to the shorter period of time the spotfin croaker larvae were exposed to entrainment.

Table 4-14. *ETM* data for spotfin croaker larvae. *ETM* calculations based on sampling grid volume of 908,157,859 m^3, and daily circulating water volume of 1,919,204 m^3. Average *PE* estimate calculated from all surveys with *PE* >0.

Survey Date	PE Estimate	PE Std. Error	f_i	f_i Std. Error
17-Sep-03	0.00000	0.00000	0.00000	0.00000
13-Oct-03	0.00000	0.00000	0.00000	0.00000
10-Nov-03	0.00000	0.00000	0.00000	0.00000
8-Dec-03	0.00000	0.00000	0.00000	0.00000
5-Jan-04	0.00000	0.00000	0.00000	0.00000
9-Feb-04	0.00000	0.00000	0.00000	0.00000
8-Mar-04	0.00000	0.00000	0.00000	0.00000
5-Apr-04	0.00000	0.00000	0.00000	0.00000
3-May-04	0.00361	0.00568	0.16060	0.19528
1-Jun-04	0.00000	0.00000	0.00000	0.00000
12-Jul-04	0.00000	0.00000	0.08960	0.15792
31-Aug-04	0.00046	0.00103	0.74979	0.26538
Average =	0.00204			

Table 4-15. Average P_S values and *ETM* estimates for alongshore current and offshore extrapolated models for spotfin croaker. Current displacement (km) for alongshore extrapolation included in parentheses with estimate of P_S for alongshore estimate of P_M.

Parameter	Average P_S (displacement)	*ETM* Estimate (P_M)	*ETM* Std. Err.	Upper 95% CI	Lower 95%CI
Alongshore Current	0.6163 (16.9)	0.00294	0.36785	0.37079	0
Offshore Extrapolated	0.5981	0.00287	0.36778	0.37065	0

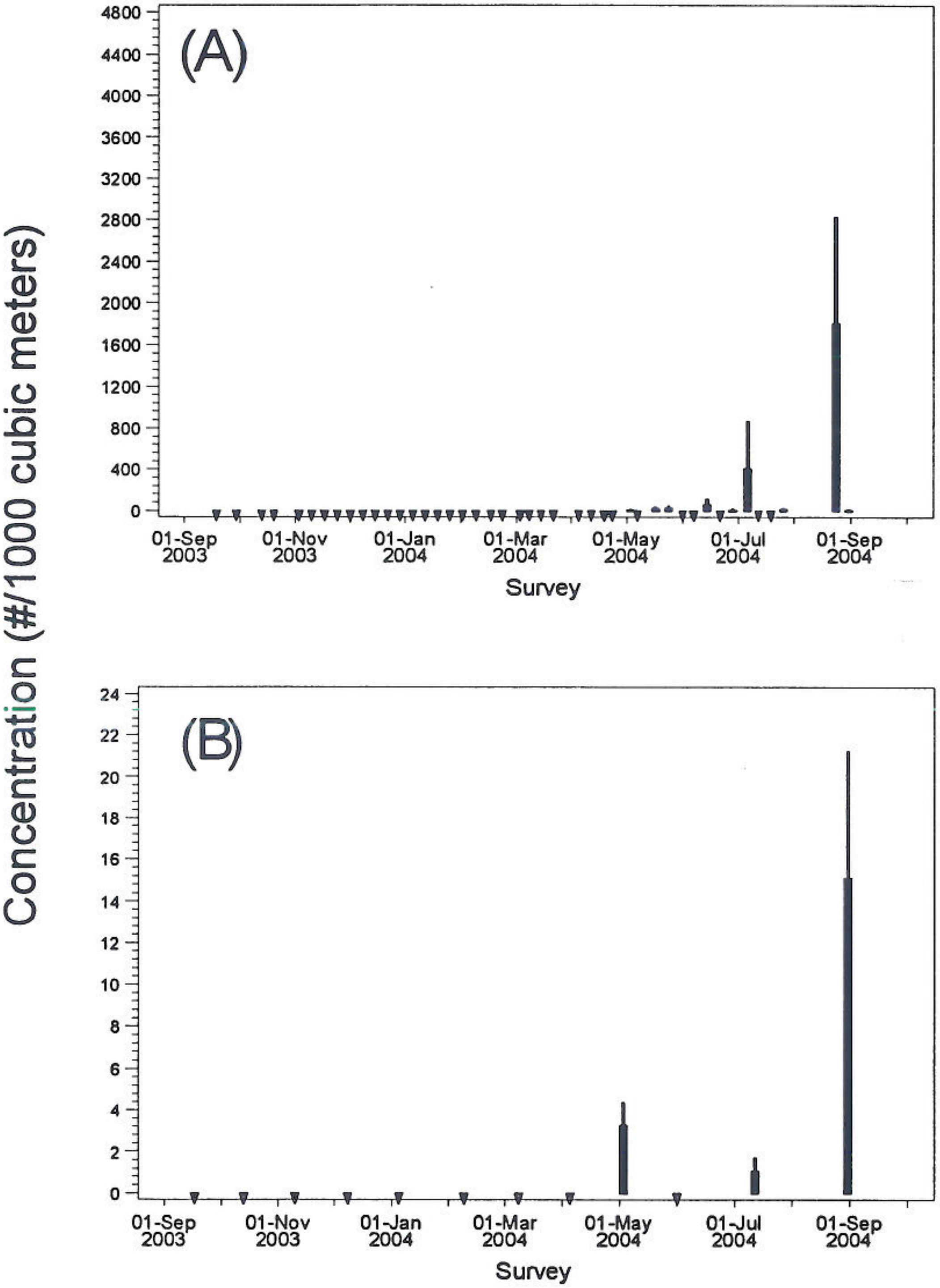

Figure 4-16. Survey mean concentration (#/1000 m^3) of spotfin croaker larvae collected at the HBGS entrainment (A) and source water (B) stations with standard error indicated (+1 SE). Down arrows indicate surveys when no spotfin croaker larvae were collected.

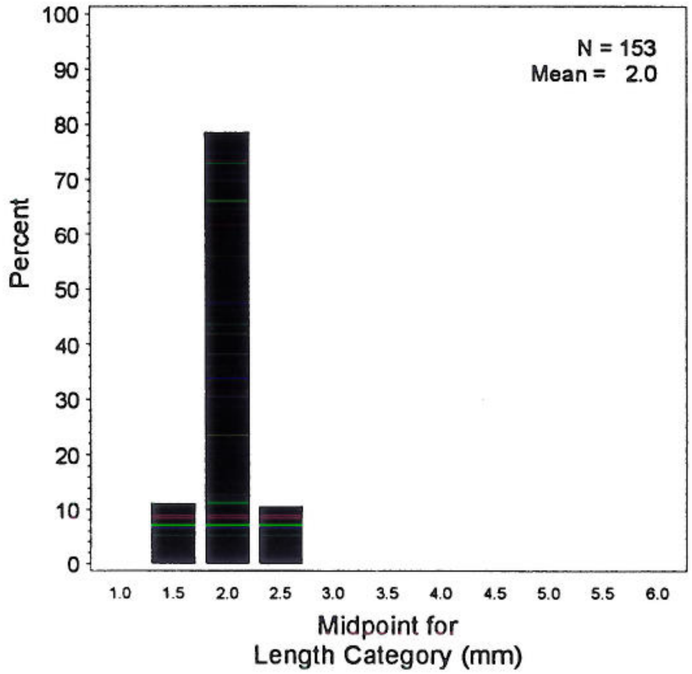

Figure 4-17. Length frequency distribution (mm) of spotfin croaker larvae collected from the HBGS entrainment station from September 2003 through August 2004.

4.3.3.4 Queenfish (*Seriphus politus*)

Queenfish (*Seriphus politus* Ayres 1860) range from west of Uncle Sam Bank, Baja California, north to Yaquina Bay, Oregon (Miller and Lea 1972). Queenfish are common in southern California, but rare north of Monterey. They are one of eight species of croaker or 'drums' (Family Sciaenidae) found off California. The other croakers include: white seabass (*Atractoscion nobilis*), black croaker (*Cheilotrema saturnum*), white croaker (*Genyonemus lineatus*), California corbina (*Menticirrhus undulatus*), spotfin croaker (*Roncador stearnsii*), yellowfin croaker (*Umbrina roncador*), and shortfin corvina (*Cynoscion parvipinnis*). All but shortfin corvina have been collected in impingement samples at the HBGS since 1979 (MBC 2004). Shortfin corvina was common off the California coast as far north as San Pedro in the late 1800s (Jordan and Evermann 1896), but has not been common off the California coast since the 1930s (Miller and Lea 1972). It presently occurs as far north as San Diego Bay (Tenera 2004).

Habitat Requirements

The reported depth range of queenfish is from the surface to depths of about 37 m (120 ft) (Miller and Lea 1972); however, in southern California, Allen (1982) found queenfish over soft bottoms between 10 and 70 m, with highest abundance occurring at 10 m. During the day, queenfish hover in dense, somewhat inactive schools close to shore, but disperse to feed in midwater after sunset (Hobson and Chess 1976). It is active throughout the night, and feeds several meters off the seafloor in small schools or as lone individuals.

Reproduction

Queenfish is a summer spawner. Goldberg (1976) found queenfish to enter spawning condition in April and spawn into August, while DeMartini and Fountain (1981) recorded spawning in queenfish between March and August. Spawning is asynchronous among females, but there are monthly peaks in intensity during the waxing (first quarter) of the moon (DeMartini and Fountain 1981). They also stated that mature queenfish spawn every 7.4 days on average, regardless of size. Duration of the spawning season is a function of female body size, ranging from three months (April–June) in recruit spawners to six months (March–August) in repeat spawners (>13.5 cm SL). Based on the spawning frequency and number of months of spawning, these two groups of spawners can produce about 12 and 24 batches of eggs during their respective spawning seasons (DeMartini and Fountain 1981).

Goldberg (1976) found no sexually mature females less than 14.8 cm SL in Santa Monica Bay. This differs from the findings of DeMartini and Fountain (1981) off San Onofre. They found females sexually mature at 10.0–10.5 cm SL at slightly greater than age-1. Batch fecundities in queenfish off San Onofre ranged from 5,000 eggs in a 10.5-cm female to about 90,000 eggs in a 25-cm fish. The average-sized female in that study (14 cm, 42 g) had a potential batch fecundity of 12,000–13,000 eggs. Murdoch (1989a) estimated the average batch fecundity to be 12,700 for queenfish collected over a five-year period. Based on a female spawning frequency of 7.4 days, a 10.5-cm female that spawns for three months (April–June) can produce about 60,000 eggs/year, while a 25-cm female that spawns for six months (March through August) can produce nearly 2.3 million eggs/year (DeMartini and Fountain 1981).

Age and Growth

Queenfish mature at 10.5 cm (DeMartini and Fountain 1981) to 12.7 cm (Love 1996), during their first spring or second summer. Maximum reported size is 30.5 cm (Miller and Lea 1972). Immature individuals grow at a rate of about 2.5 mm/day, while early adults grow about 1.8 mm/day (Murdoch et al. 1989b). Mortality estimates are unavailable for this species.

General Ecology

Queenfish feed mainly on crustaceans, including amphipods, copepods, and mysids, along with polychaetes and fishes (Quast 1968, Hobson and Chess 1976, Hobson et al. 1981, Feder et al. 1974).

Population Trends and Fishery

Queenfish was the most abundant sciaenid impinged at five generating stations (including the HBGS) from 1977 to 1998, and accounted for over 60% of the total fishes impinged (Herbinson et al. 2001). Annual abundance fluctuated from year to year, with notable declines during the strong El Niño events of 1982-83, 1986-87, and 1997-98. However, abundance remained relatively high throughout the over 20-year study period.

Sampling Results

Queenfish larvae were the fifth most abundant taxon collected from the entrainment station and the third most abundant from the source water stations during the sampling period (Tables 4-1 and 4-3). They comprised about 4.6 and 9.9 percent of the larvae collected at the entrainment and source water stations, respectively. This species was found in the entrainment samples collected from May through August, with a peak abundance of over 300 larvae per 1,000 m^3 during August 2004 (Figure 4-18a). Queenfish larvae were found at the source water stations during the same period of the year with a few individuals also being seen in October 2003 and January 2004 at the source water stations (Figure 4-18b). The number and density of larval queenfish collected during each entrainment and source water survey is presented in Appendix B.

The length frequency distribution of the measured queenfish at the entrainment station is presented in Figure 4-19. The mean, maximum and minimum measurements were 5.0, 20.4 and 1.5 mm, respectively. The majority of the larvae collected were not newly hatched, as Moser (1996) reported a hatch length of about 1.6 mm for queenfish. Only about 15% of the collected queenfish larvae were between 1 and 3 mm in total length.

Impact Assessment

The following sections present the results for empirical transport modeling of entrainment effects on queenfish larvae. Demographic model estimates of entrainment effects (*FH* and *AEL*) were not calculated because of the absence of information on life history parameters necessary for model calculations. It was estimated that approximately 17.8 million queenfish larvae are entrained annually by the HBGS cooling water system.

Empirical Transport Model (*ETM*)

The larval duration used to calculate the *ETM* estimates for queenfish was based on the difference between the lengths of the 1st (1.5 mm) and 95th (7.7 mm) percentiles and a growth rate of 0.2 mm/day. These values were used to estimate that queenfish larvae were vulnerable to entrainment for a period of 30.6 days.

Only two *PE* estimates could be calculated for queenfish for the September 2003 – August 2004 period (Table 4-16). This was due to queenfish larvae only being present in two of the paired entrainment and source water surveys (Figure 4-18). Although queenfish larvae were collected at only the source water stations in three additional surveys, over 99% of the total source population were collected during the two surveys when they were also collected at the entrainment station. These two *PE* values for these surveys were similar in value, 0.0017 and 0.0015. The average of the two estimates was less than the ratio of the entrainment volume to source water volume of 0.0021. The P_S estimates (Table 4-17) were 0.123 (12.3%) for the alongshore current and 0.089 (8.9%) for offshore-extrapolated current movement for the 30.6-day exposure period. The two estimates of mortality, P_M, were 0.006 (0.6%) using the alongshore current and 0.005 (0.5%) using the offshore extrapolation. The alongshore estimate of P_M was extrapolated over a shoreline distance of 84.9 km.

Table 4-16. *ETM* data for queenfish larvae. *ETM* calculations based on sampling grid volume of 908,157,859 m^3, and daily circulating water volume of 1,919,204 m^3. Average *PE* estimate calculated from all surveys with *PE* >0.

Survey Date	PE Estimate	PE Std. Error	f_I	f_I Std. Error
17-Sep-03	0.00000	0.00000	0.00000	0.00000
13-Oct-03	0.00000	0.00000	0.00309	0.00647
10-Nov-03	0.00000	0.00000	0.00000	0.00000
8-Dec-03	0.00000	0.00000	0.00000	0.00000
5-Jan-04	0.00000	0.00000	0.00249	0.00507
9-Feb-04	0.00000	0.00000	0.00000	0.00000
8-Mar-04	0.00000	0.00000	0.00000	0.00000
5-Apr-04	0.00000	0.00000	0.00000	0.00000
3-May-04	0.00000	0.00000	0.00122	0.00245
1-Jun-04	0.00000	0.00000	0.00305	0.00382
12-Jul-04	0.00165	0.00245	0.23174	0.19339
31-Aug-04	0.00146	0.00188	0.75841	0.19441
Average =	0.00156			

Table 4-17. Average P_S values and *ETM* estimates for alongshore current and offshore extrapolated models for queenfish. Current displacement (km) for alongshore extrapolation included in parentheses with estimate of P_S for alongshore estimate of P_M.

Parameter	Average P_S (displacement)	*ETM* Estimate (P_M)	*ETM* Std. Err.	Upper 95% CI	Lower 95%CI
Alongshore Current	0.1230 (84.9)	0.00626	0.28409	0.29036	0
Offshore Extrapolated	0.0891	0.00496	0.28222	0.28718	0

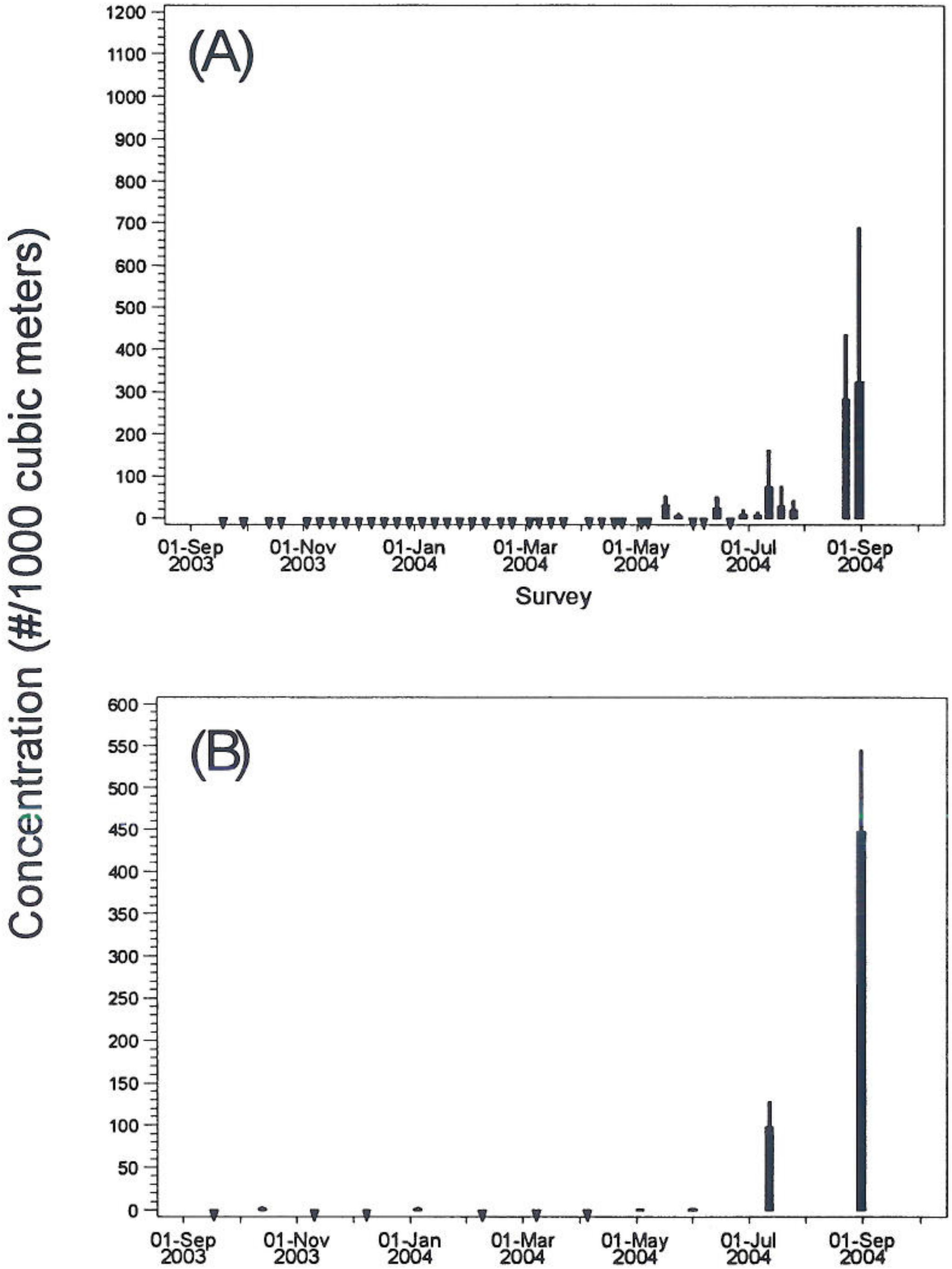

Figure 4-18. Survey mean concentration (#/1000 m^3) of queenfish larvae collected at the HBGS entrainment (A) and source water (B) stations with standard error indicated (+1 SE). Down arrows indicate surveys when no queenfish larvae were collected.

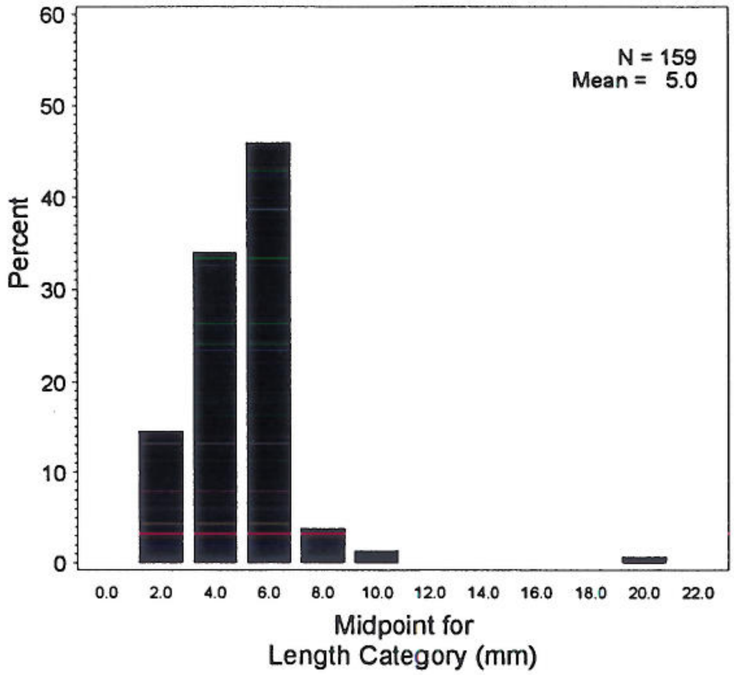

Figure 4-19. Length frequency distribution (mm) of queenfish larvae collected from the HBGS entrainment station from September 2003 through August 2004.

4.3.3.5 White Croaker (*Genyonemus lineatus*)

White croaker (*Genyonemus lineatus*) range from Magdalena Bay, Baja California, north to Vancouver Island, British Columbia (Miller and Lea 1972). They are one of eight species of croakers (Family Sciaenidae) found off California. The other croakers include: white seabass (*Atractoscion nobilis*), black croaker (*Cheilotrema saturnum*), queenfish (*Seriphus politus*), California corbina (*Menticirrhus undulatus*), spotfin croaker (*Roncador stearnsii*), yellowfin croaker (*Umbrina roncador*), and shortfin corvina (*Cynoscion parvipinnis*). All but shortfin corvina have been collected in impingement samples at the HBGS since 1979 (MBC 2004).

Habitat Requirements

The reported depth range of white croaker is from the surface to depths of 183 m (600 ft) (Miller and Lea 1972, Love et al. 1984); however, in southern California, Allen (1982) found white croaker over soft bottoms between 10 and 130 m, and it was most frequently collected at 10 m.

Reproduction

White croakers are oviparous broadcast spawners. White croaker mature between about 130 and 190 mm TL, somewhere between their first to fourth year. About one-half of males mature by 140 mm TL, and one-half of females by 150 mm TL, and all fishes are mature by 190 mm TL in their third to fourth year (Love et al. 1984). Off Long Beach, California, white croaker spawn primarily from November through August, with peak spawning from January through March (Love et al. 1984). However, some spawning can occur year-round. Batch fecundities ranged from about 800 eggs in a 155-mm female to about 37,200 eggs in a 260-mm female, with spawning taking place as often as every five days (Love et al. 1984). In their first and second years, females spawn for three months for a total of about 18 times per season. Older individuals spawn for about four months and about 24 times per season (Love et al. 1984). Some older fish may spawn for seven months. The nearshore waters from Redondo Beach (Santa Monica Bay, California) to Laguna Beach, California, are considered an important spawning center for this species (Love et al. 1984). A smaller spawning center occurs off Ventura, California (Love et al. 1984).

Age and Growth

Newly hatched white croaker larvae are 1-2 mm SL and not well developed (Watson 1982). Larvae are principally located within 4 km from shore, and as they develop tend to move shoreward and into the epibenthos (Schlotterbeck and Connally 1982). Murdoch et al. (1989) estimated a daily larval growth rate of 0.20 mm/day. Maximum reported size is 414 mm (Miller and Lea 1972), with a life span of 12–15 years (Frey 1971, Love et al. 1984). White croakers grow at a fairly constant rate throughout their lives, though females outgrow males from age 1. Growth rates of white croaker from Dana Point and Palos Verdes are described in Moore (2001). No mortality estimates are available for any of the life stages of this species.

General Ecology

White croaker are primarily nocturnal benthic feeders, though juveniles may feed in the water column during the day (Allen 1982). Important prey items include polychaetes, gammaridean amphipods, reptantian decapods, and chaetognaths (Allen 1982). In Outer Los Angeles Harbor, Ware (1979) found important prey items to include polychaetes, benthic crustaceans, free-living nematodes, and zooplankton. Younger individuals feed on holoplankonic crustaceans and polychaete larvae. White croaker may move offshore into deeper water during winter months (Allen and DeMartini 1983); however, this pattern is apparent only south of Redondo Beach, California (Herbinson et al. 2001).

Population Trends and Fishery

White croaker was the second most abundant sciaenid impinged at five generating stations (including the HBGS) from 1977 to 1998 (Herbinson et al. 2001). Annual abundance declined during that period, with marked decreases during the strong El Niño events of 1982-83, 1986-87, and 1997-98.

White croaker is an important constituent of the commercial and sport fisheries of California. Prior to 1980, most of the croaker catch was in southern California. However, since 1980, the majority of the commercial catch occurred in central California, and has been attributed to the entrance of Southeast Asian refugees into the fishery (Moore and Wild 2001). Most of the recreational catch is still in southern California from piers, breakwaters, and private boats.

Before 1980, state-wide white croaker landings averaged 685,000 lbs annually, exceeding 1,000,000 lbs in several years (Moore and Wild 2001). Highest landings in 1952 corresponded with the collapse of the Pacific sardine fishery. Since 1991, landings averaged 461,000 lbs and steadily declined to an all-time low of 142,500 lbs in 1998. State-wide landings by recreational fishermen aboard commercial passenger fishing vessels (CPFVs) averaged about 12,000 fish per year from 1990-1998, with most of the catch in southern California (Moore and Wild 2001).

From 1999 through 2001, white croaker commercial landings off Huntington Beach were far more substantial in Catch Blocks 738, 739, and 740 compared with the other five blocks (CDFG 2002). Landings ranged from 0 lbs to 86,630 lbs ($64,817) in Catch Block 740 south of

San Pedro in 1999. In Block 738, off Huntington Beach, landings ranged from 5,355 lbs ($10,710 in 2001) to 13,541 lbs ($23,532 in 2000). Most commercially caught white croaker are caught by gillnet and hook-and-line (Moore and Wild 2001).

Sampling Results

White croaker was the fourth most abundant taxon collected during the study from both the entrainment and source water stations, comprising about 7% of all of the larvae collected at the entrainment station (Tables 4-1 and 4-3). The estimated mean entrainment per survey was variable, ranging from zero to about 135 white croaker larvae per 1,000 m^3 (Figure 4-20a). Peaks in abundance occurred during April and May 2004. The May peak in abundance coincided with the peak abundance at the source water stations (Figure 4-20b), but a second peak at the source water stations in August 2004 wasn't reflected in the data from the entrainment station. The number and density of larval white croakers collected during each entrainment and source water survey is presented in Appendix B.

The length frequency distribution of measured white croaker larvae show a relatively wide size range which is dominated by recently hatched larvae based on the reported hatch length of 1-2 mm (Watson 1982) (Figure 4-21). The mean, maximum, and minimum sizes for the measurements were 3.4, 8.6, and 1.5 mm, respectively. A larval growth rate of 0.20 mm/day for white croaker (Murdoch et al. 1989c) was used with the difference in the lengths of the first (1.6 mm) and 95th (7.0 mm) percentiles of the measurements to estimate that the larvae were exposed to entrainment for a period of 27 days.

Impact Assessment

The following sections present the results for empirical transport modeling of circulating water system effects on white croaker larvae. No age-specific estimates of survival for later stages of development were available from the literature for white croaker; therefore no estimates of *FH* or *AEL* were calculated. Total entrainment through HBGS was estimated at approximately 18 million white croaker larvae for the period of September 2003 through August 2004.

Empirical Transport Model (*ETM*)

The *PE* estimates used to calculate *ETM* for white croaker for the September 2003 – August 2004 period varied considerably among surveys and ranged from nearly 0 to 0.003 (Table 4-18). The average PE was slightly less than the ratio of the entrainment volume to source water volume of 0.0021. The largest *PE* estimate was calculated for the September 2003 survey, but the largest proportions of the source population were present during the May and August 2004 surveys. The small *PE* estimate during the August survey indicates that larvae were not abundant at the entrainment station (Figures 4-20a and b). The values in the table were used to calculate two P_M estimates: one based on alongshore current movement, and the other based on alongshore current movement and an extrapolation of densities offshore to a distance bounded by either the extrapolated densities or onshore current movement. The estimate of P_M for the 27-day period of exposure calculated using offshore extrapolated densities (0.004, 0.4%) is less than the estimate calculated using alongshore current displacement (0.007, 0.7%) because the effects of entrainment are spread over a much larger source population (Table 4-19). The P_S estimates indicate that the ratio of the sampled source water to the total population for the alongshore and offshore P_M estimates were 21.8 and 7.0 percent, respectively. The alongshore estimate of P_M was extrapolated over a shoreline distance of 47.8 km.

Table 4-18. *ETM* data for white croaker larvae. *ETM* calculations based on sampling grid volume of 908,157,859 m^3, and daily circulating water volume of 1,919,204 m^3. Average *PE* estimate calculated from all surveys with *PE* >0.

Survey Date	PE Estimate	PE Std. Error	f_I	f_I Std. Error
17-Sep-03	0.00340	0.00611	0.01722	0.01426
13-Oct-03	0.00144	0.00241	0.02892	0.02256
10-Nov-03	0.00028	0.00035	0.07104	0.03526
8-Dec-03	0.00087	0.00162	0.11844	0.07330
5-Jan-04	0.00181	0.00314	0.05064	0.02916
9-Feb-04	0.00252	0.00333	0.02628	0.01944
8-Mar-04	0.00227	0.00366	0.02362	0.01357
5-Apr-04	0.00049	0.00103	0.02002	0.01315
3-May-04	0.00195	0.00170	0.28073	0.10793
1-Jun-04	0.00132	0.00216	0.06375	0.06356
12-Jul-04	0.00000	0.00000	0.02898	0.02505
31-Aug-04	0.00004	0.00008	0.27036	0.15099
Average =	0.00149			

Table 4-19. Average P_S values and *ETM* estimates for alongshore current and offshore extrapolated models for white croaker. Current displacement (km) for alongshore extrapolation included in parentheses with estimate of P_S for alongshore estimate of P_M.

Parameter	Average P_S (displacement)	*ETM* Estimate (P_M)	*ETM* Std. Err.	Upper 95% CI	Lower 95%CI
Alongshore Current	0.2183 (47.8)	0.00711	0.23364	0.24074	0
Offshore Extrapolated	0.0701	0.00359	0.22654	0.23013	0

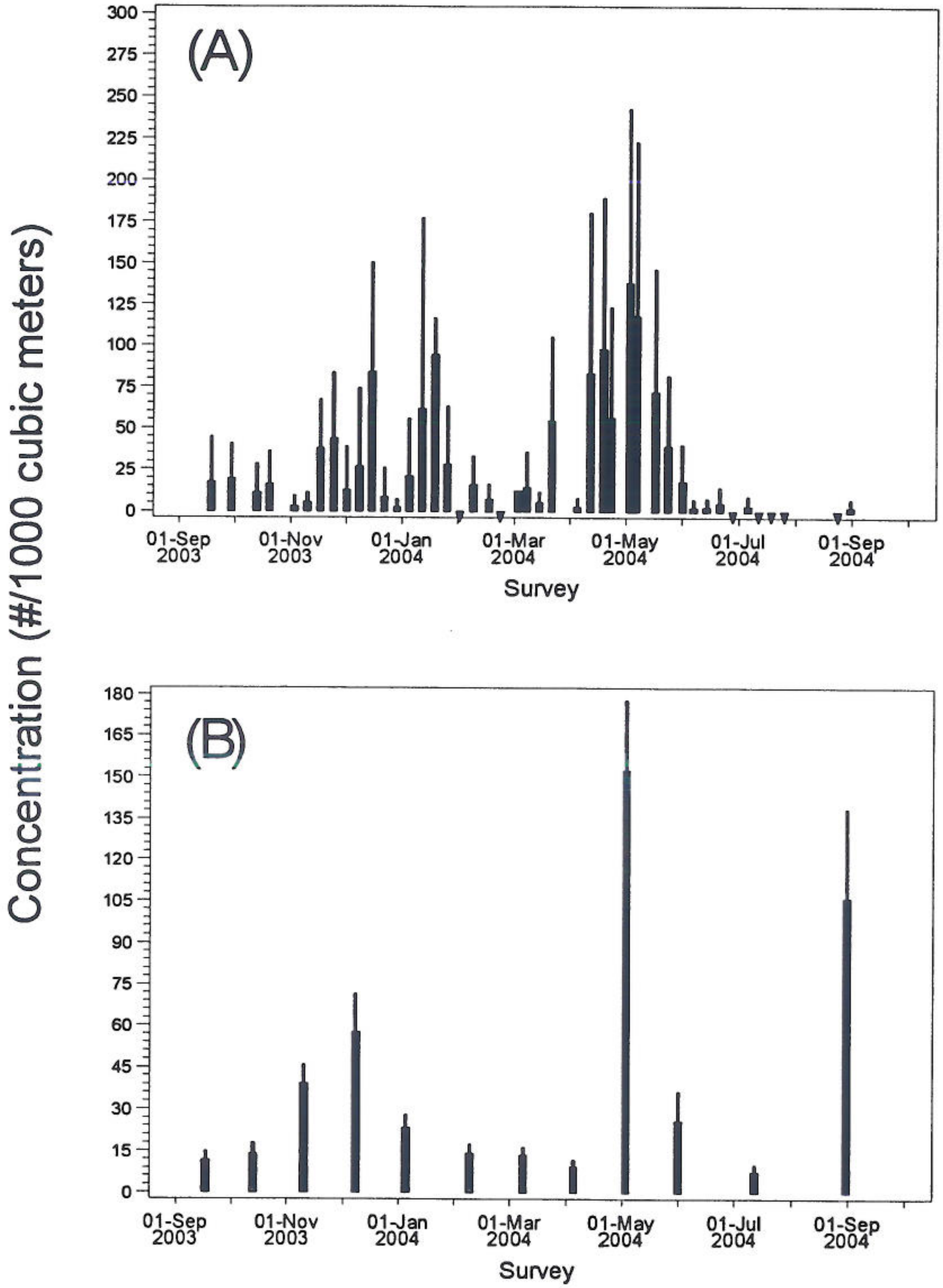

Figure 4-20. Survey mean concentration (#/1000 m^3) of white croaker larvae collected at the HBGS entrainment (A) and source water (B) stations with standard error indicated (+1 SE). Down arrows indicate surveys when no white croaker larvae were collected.

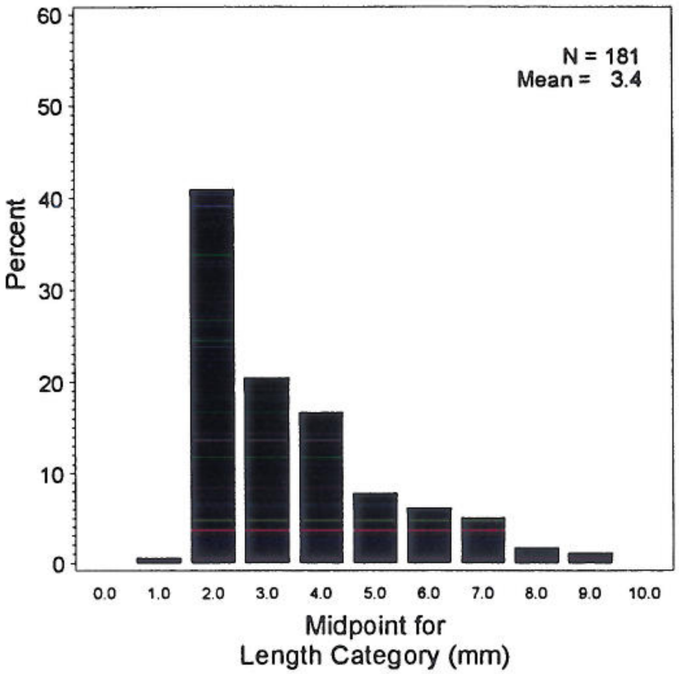

Figure 4-21. Length frequency distribution (mm) of white croaker larvae collected from the HBGS entrainment station from September 2003 through August 2004.

4.3.3.6 Black Croaker (*Cheilotrema saturnum*)

Black croaker (*Cheilotrema saturnum*) is a member of the drums and croakers family (Sciaenidae) and ranges from Point Conception, California to central Baja California (including the Gulf of California) in depths from 3–50 m (Limbaugh 1961, Miller and Lea 1972). Seven species of croaker, in addition to black croaker, are common to the Southern California Bight (SCB), including white croaker (*Genyonemus lineatus*), queenfish (*Seriphus politus*), yellowfin croaker (*Umbrina roncador*), white seabass (*Atractoscion nobilis*), California corbina (*Menticirrhus undulatus*), spotfin croaker (*Roncador stearnsii*), and shortfin corvina (*Cynoscion parvipinnis*; Miller and Lea 1972). Two other species [orangemouth corvina (*Cynoscion xanthulus*) and bairdiella (*Bairdiella icistia*)] are currently believed to be restricted to the Salton Sea, California within the SCB (Nelson et al. 2004). Individuals from all species, except shortfin corvina, are common in coastal southern California waters and have been observed in impingement samples at HBGS since 1979 (MBC 2004).

Habitat Requirements

Black croaker is common to open-coast, shallow rocky reefs and kelp beds (Limbaugh 1961, Allen 1985) with large adults occupying shelters within the reef structure and smaller individuals typically occurring above the sand substrate in and around the reef (Limbaugh 1961). Nocturnal in nature, aggregations have been observed migrating away from the reef to feed and reproduce at night, while remaining relatively sessile within the reef area during the day (Limbaugh 1961). Limbaugh (1961) observed aggregations of adults concentrated near the 7-m isobath, but as deep as 50 m. He noted that individuals were more abundant in the shallower portion of their depth distribution.

Reproduction

Black croaker is an oviparous broadcast spawner with pelagic eggs and larvae (Moser 1996). Greater than 50% of both males and females are reproductively mature by 150 mm standard length (SL) or approximately one year of age (Miller et al., in prep b). Spawning is most prevalent in the late spring to summer months, with a peak in June and July based on histological examination (Goldberg 1981) and seasonal gonosomatic index (GSI) analysis (Miller et al. in prep b). Late-stage larvae have been collected as early as July (Miller et al., in prep b), with regular collections from August through October (Limbaugh 1961, Moser 1996). Spawning populations were found to be statistically skewed towards males at a ratio of 1.22:1 (male:female), with each sex represented in all size and age classes (Miller et al., in prep b).

Age and Growth

Moser (1996) reported newly hatched black croaker larvae to be 1.5 mm NL (notochord length). Flexion occurs at approximately 5.6 mm NL and transformation occurs at standard lengths in excess of 11 mm (Moser 1996). Black croaker grows rapidly during the first six years, attaining an average length of 200 mm SL before growth rates slow (Miller et al., in prep b). Black croaker reportedly grows to 380 mm SL (Miller and Lea 1972) and 22 years old with no significant differences in the growth rates between males and females (Miller et al., in prep b). The strongest recruitment year within the last decade occurred in 1997, which corresponded to the highest sea surface temperature in the same time period (Miller et al. in prep b). The estimated annual survivorship rate for black croaker is 0.85 (0.15 mortality) (Miller et al., in prep b).

General Ecology

Gut contents of adults indicate their diet consists primarily of demersal crustaceans such as crabs, shrimp, and amphipods (Limbaugh 1961). Recent anecdotal observations of one adult black croaker gut contents included two blackeye gobies (*Rhinogobiops nicholsii*) (Miller, personal observation). Nearshore gillnet sampling from Newport Beach to Santa Barbara, California, including Santa Catalina Island, indicated the largest sustaining population to occur near the Palos Verdes Peninsula, California (Miller et al. in prep b). Pondella and Allen (2000) also noted higher population densities occurred at mainland sites compared to Santa Catalina Island sites. However, the individuals collected at the island sites were larger on average than those encountered along the mainland (Miller et al. in prep b). Black croaker is commonly found in association with sargo (*Anisotremus davidsonii*) and salema (*Xenistius californiensis*), with the juveniles of both species displaying similar body coloration to those of young black croaker (Limbaugh 1961).

Population Trends and Fishery

Historically, black croaker has been the third most abundant croaker species among impingement samples at southern California coastal generating stations since 1976, surpassed only by white croaker and queenfish (Herbinson et al. 2001). Long-term trends in impingement observations indicate an overall declining abundance, with a minor upturn in 1997. Currently, no commercial fisheries target black croaker, and only incidental catches occur in the recreational fishery.

Sampling Results

Black croaker larvae ranked 11th in mean density in entrainment samples (5.41 per 1,000 m^3; Table 4-1) and 19th in the source water samples (1.90 per 1,000 m^3;Table 4-3). They were collected from April though September 2004 with peak densities recorded in August in both the entrainment and source water samples (Figure 4-22). The highest entrainment densities occurred in late August when average concentrations exceeded 160 larvae per 1,000 m^3.

The length frequency distribution of measured black croaker larvae show an extremely limited size range dominated by recently hatched larvae based on the reported hatch length of 1.5 mm NL (Moser 1996) (Figure 4-23). The mean, maximum, and minimum sizes for the measurements were 2.1, 11.5, and 1.5 mm, respectively. A larval growth rate of 0.20 mm/day for white croaker (Murdoch et al. 1989) was used with the difference in the lengths of the first (1.5 mm) and 95th (2.9 mm) percentiles of the measurements to estimate that the larvae were exposed to entrainment for a period of 7 days.

Impact Assessment

The following sections present the results for empirical transport modeling of entrainment effects on black croaker larvae. Demographic model estimates of entrainment effects were not calculated because of the absence of information on life history necessary to parameterize the models. Total entrainment through HBGS was estimated at approximately 7.1 million black croaker larvae for the period of September 2003 through August 2004.

Empirical Transport Model (*ETM*)

Only two *PE* estimates were calculated for black croaker for the September 2003 – August 2004 period (Table 4-20). As shown in Figure 4-22 these estimates were not necessarily reflective of actual black croaker abundances because the highest abundance at the entrainment station occurred during a survey when the source water stations were not sampled. The values of f_i show that almost 60% of the black croaker larvae were collected during surveys when no entrainment occurred. In addition, the *PE*s were calculated from surveys that represent two separate spawning seasons. The two P_M estimates calculated from these estimates (Table 4-21) were both low reflecting the short period of time (7 days) that the larvae were exposed to entrainment. This was also reflected in the estimate of the shoreline distance of 19.4 km which was shorter than the value for taxa with longer larval durations.

Table 4-20. *ETM* data for black croaker larvae. *ETM* calculations based on sampling grid volume of 908,157,859 m^3, and daily circulating water volume of 1,919,204 m^3. Average *PE* estimate calculated from all surveys with *PE* >0.

Survey Date	PE Estimate	PE Std. Error	f_i	f_i Std. Error
17-Sep-03	0.00155	0.00382	0.09932	0.13513
13-Oct-03	0.00000	0.00000	0.00000	0.00000
10-Nov-03	0.00000	0.00000	0.00000	0.00000
8-Dec-03	0.00000	0.00000	0.00000	0.00000
5-Jan-04	0.00000	0.00000	0.00000	0.00000
9-Feb-04	0.00000	0.00000	0.00000	0.00000
8-Mar-04	0.00000	0.00000	0.00000	0.00000
5-Apr-04	0.00000	0.00000	0.00000	0.00000
3-May-04	0.00000	0.00000	0.11678	0.11218
1-Jun-04	0.00000	0.00000	0.11582	0.14993
12-Jul-04	0.00000	0.00000	0.36378	0.22890
31-Aug-04	0.00050	0.00107	0.30430	0.19281
Average =	0.00103			

Table 4-21. Average P_S values and *ETM* estimates for alongshore current and offshore extrapolated models for black croaker. Current displacement (km) for alongshore extrapolation included in parentheses with estimate of P_S for alongshore estimate of P_M.

Parameter	Average P_S (displacement)	*ETM* Estimate (P_M)	*ETM* Std. Err.	Upper 95% CI	Lower 95%CI
Alongshore Current	0.5375 (19.4)	0.00119	0.37910	0.38029	0
Offshore Extrapolated	0.2287	0.00050	0.37849	0.37899	0

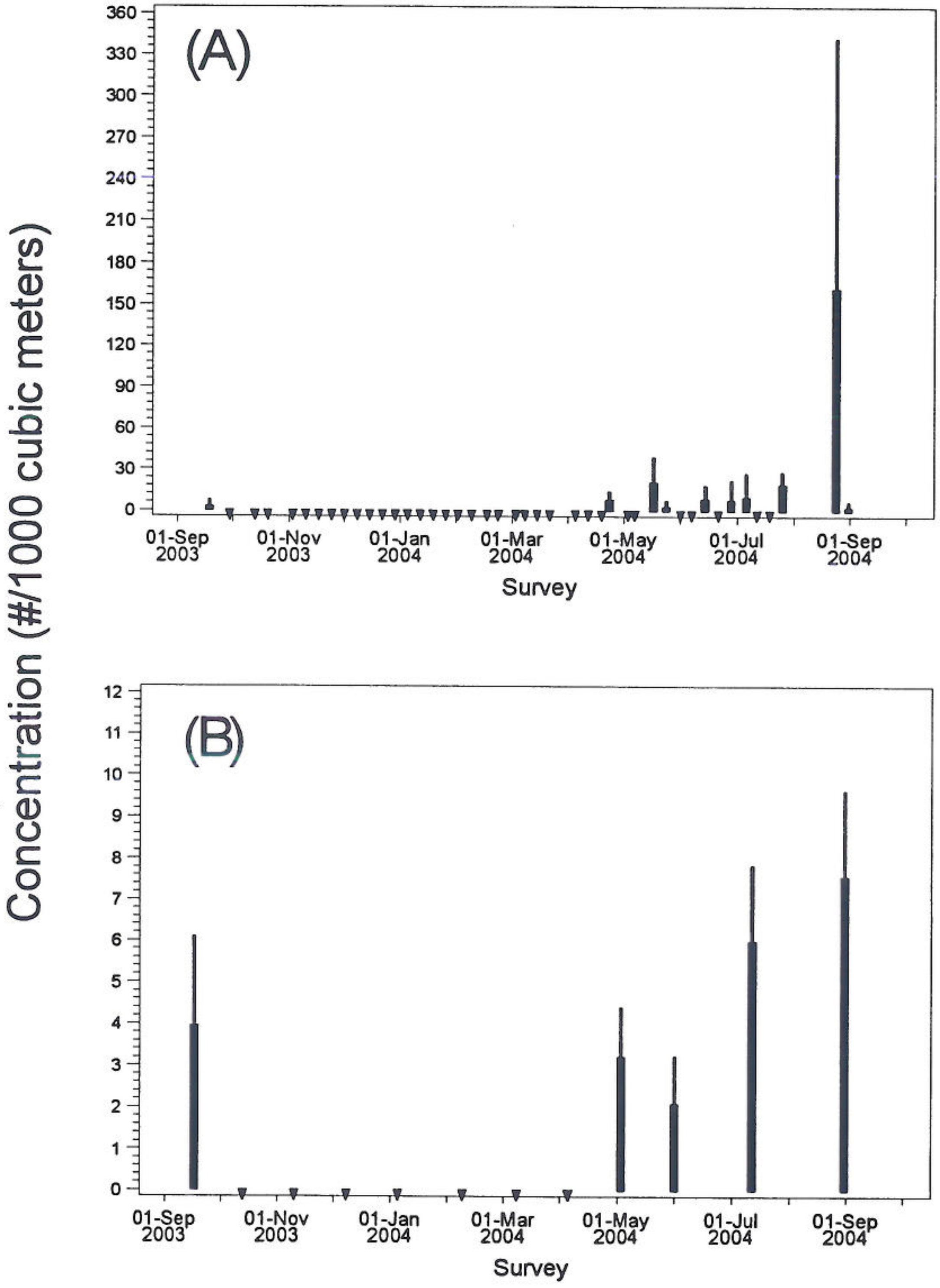

Figure 4-22. Survey mean concentration (#/1000 m^3) of black croaker larvae collected at the HBGS entrainment (A) and source water (B) stations with standard error indicated (+1 SE). Down arrows indicate surveys when no black croaker larvae were collected.

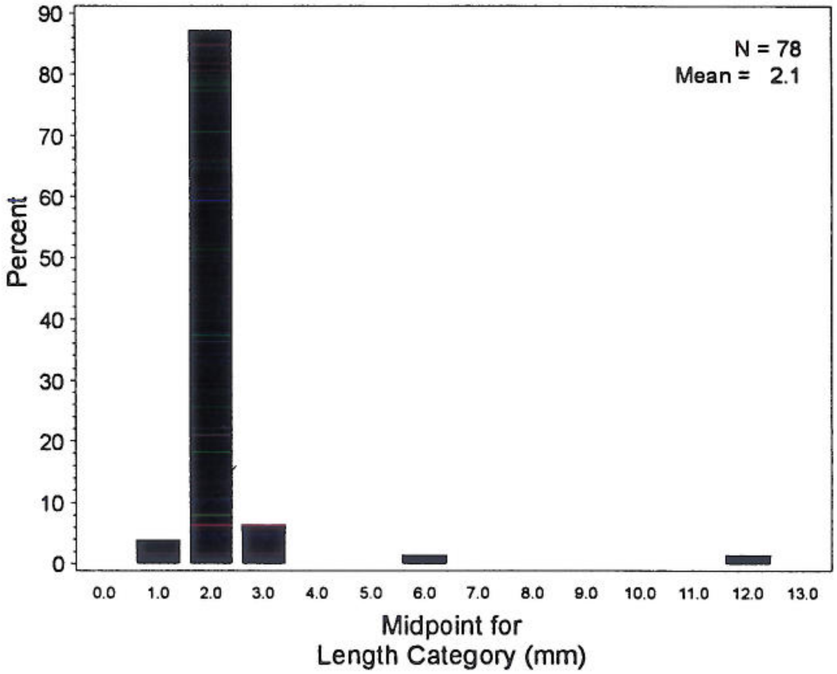

Figure 4-23. Length frequency distribution (mm) of black croaker larvae collected from the HBGS entrainment station from September 2003 through August 2004.

4.3.3.7 Salema (*Xenistius californiensis*)

Salema (*Xenistius californiensis*) is one of two grunts (Family Haemulidae) common to southern California, and ranges from Peru to Monterey Bay, California, including the Gulf of California in depths ranging from 1–12 m (Miller and Lea 1972). Sargo (*Anisotremus davidsonii*) is the other representative of the grunt family common to southern California (Miller and Lea 1972). Both are common in impingement samples from southern California coastal generating stations. Life history information for salema is scarce.

Habitat Requirements

Salema are mainly found in shallow rocky reefs and kelp bed habitats throughout the Southern California Bight (SCB), areas also frequented by black croaker (*Cheilotrema saturnum*) (Quast 1968, Allen 1985). Salema are nocturnal and can form large schools around piers and on weed-covered rocky reefs (Robertson and Allen 2002). They were found to be quite abundant during nocturnal sampling of mid-water plankton by diver operated plankton nets (Hobson and Chess 1976).

Reproduction

Moser (1996) indicated that salema are oviparous, producing planktonic eggs and larvae during the summer months. Preliminary observations of salema gonads indicate reproductive activity from June to September, with gonads being reduced to being nearly unidentifiable during April (E. Miller, MBC, personal observation). Gonosomatic index analyses indicate peak spawning in August with dramatic declines by October in both sexes (Miller unpubl. data). Gillnet sampling resulted in significantly higher percentages (Chi squared test, x^2=6.28, df=1, p=0.01) of females during peak spawning periods (Miller unpubl. data). No further information was found on salema or sargo reproduction within the primary literature.

Age and Growth

No information on the age and growth of salema is currently available. The recorded hatch length of the larvae is less than 2.2 mm (Moser 1996). Miller and Lea (1972) reported that salema have a maximum length of 25.4 cm (10 in.).

General Ecology

Adult salema generally occur in greatest abundance during nocturnal periods, and are notably absent during the day (Hobson and Chess 1976). The species is planktivorous, feeding mainly on crustaceans, including gammaridean amphipods and mysids available in the midwater in kelp beds and above rocky reefs (Quast 1968, Hobson and Chess 1976). Sikkel (1986) reported that salema were preyed upon by yellowtail (*Seriola lalandi*) and kelp bass (*Paralabrax clathratus*), at La Jolla Cove, San Diego County, California.

Population Trends and Fishery

Quast (1968) noted salema densities to be 2.57 kg/acre in kelp beds near Corona Del Mar, California. Salema have been observed in impingement samples at most coastal generating stations throughout the SCB, especially those in the vicinity of kelp beds. Impingement rates for salema at ESGS since 1978 indicate an increase in salema populations (MBC and Herbinson, unpublished data). Currently, no commercial or recreational fishery targets salema, probably due to their nocturnal activity and small size. Incidental catches may have occurred in nearshore gillnet fisheries prior to the legislative ban in 1992, which removed gillnets from state waters within three miles of shore.

Sampling Results

Although salema ranked as the sixth most abundantly entrained fish species (Table 4-1), it was only collected in substantial numbers during a single entrainment survey in late August 2004 (Figure 4-24a). The concentrations during this survey (>300 per m^3), however, were high enough to make it an important entrained taxon in the overall annual sampling. It was present in much lower abundances at the source water stations in July and August 2004 (Figure 4-24b). This indicates a strong inshore distribution and a highly seasonal reproduction period. The number and density of larval salema collected during each entrainment and source water survey are presented in Appendix B.

The length frequency distribution of measured salema larvae (Figure 4-25) shows an extremely limited size range dominated by recently hatched larvae, based on the reported hatch length of 2.2 mm NL (Moser 1996). The mean, maximum, and minimum sizes for the measurements were 2.0, 2.6, and 1.7 mm, respectively.

Impact Assessment

Total annual entrainment of salema was calculated as 11.7 million larvae. Because no salema larvae were collected in the entrainment samples and source water samples during the same survey, we did not calculate proportional losses using the *ETM* modeling approach. Salema larvae were present in the entrainment samples during the week previous to the final source water survey (Figure 4-24a, b), but the modeling methods are based on a comparison of paired larval concentrations in the entrainment and source water from the same surveys. The lack of co-occurrence further highlights the high temporal and spatial variation of these larvae.

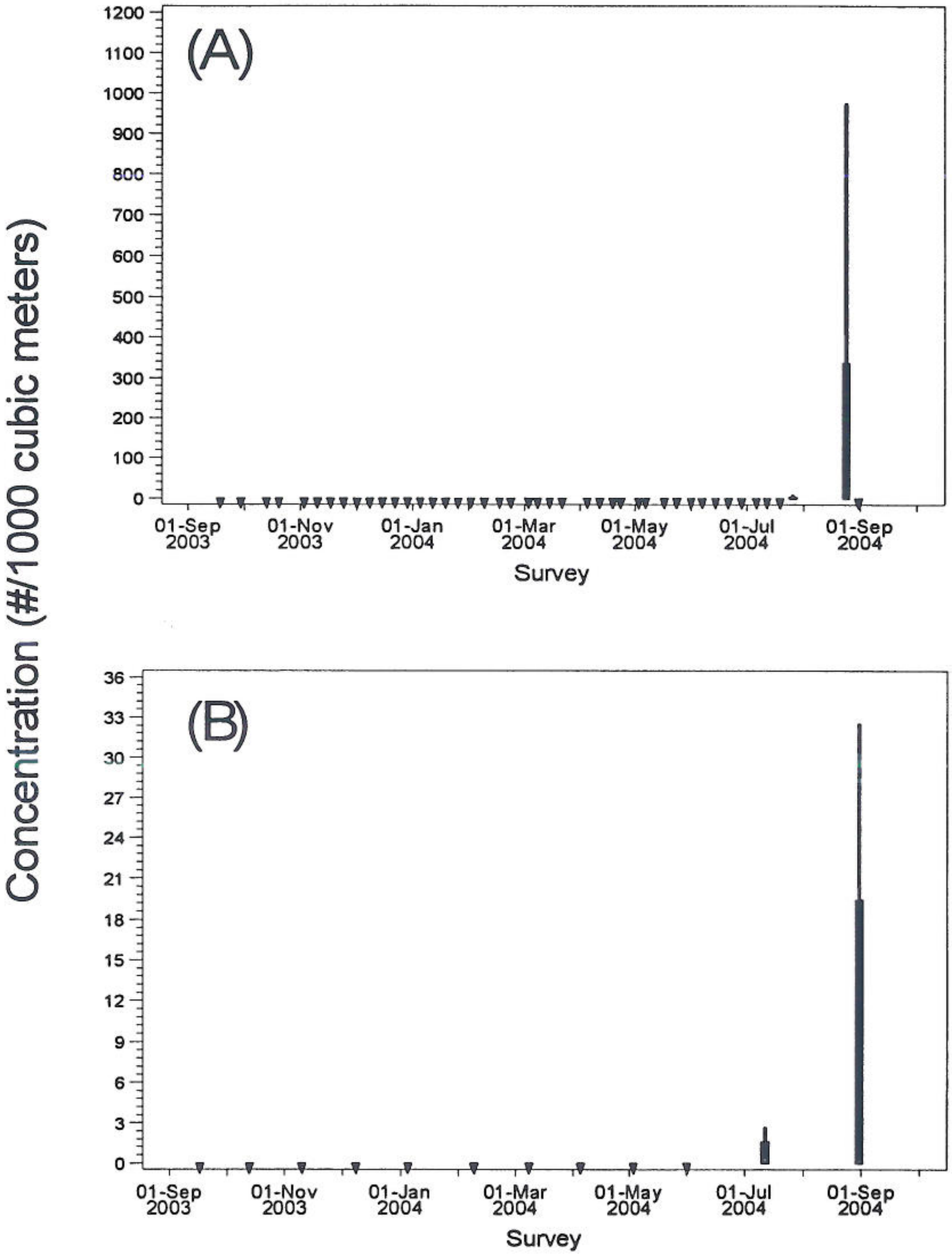

Figure 4-24. Survey mean concentration (#/1000 m^3) of salema larvae collected at the HBGS entrainment (A) and source water (B) stations with standard error indicated (+1 SE). Down arrows indicate surveys when no salema larvae were collected.

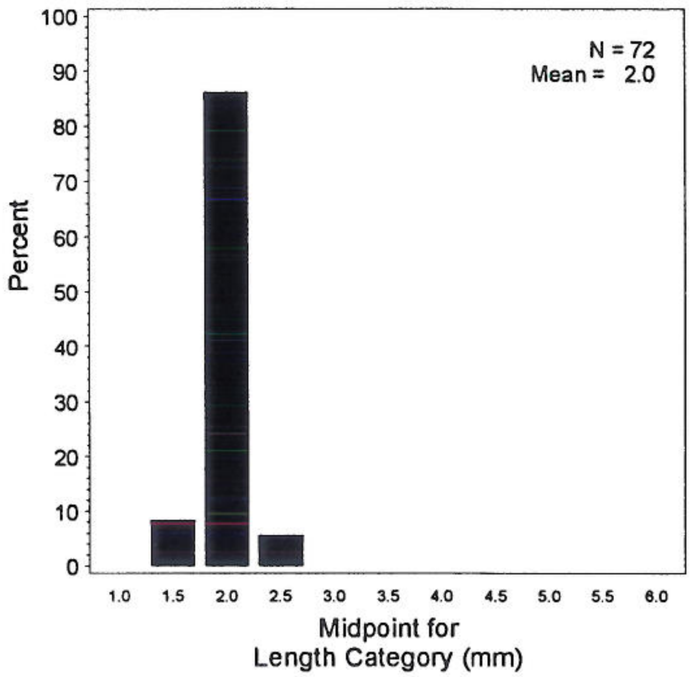

Figure 4-25. Length frequency distribution (mm) of salema larvae collected from the HBGS entrainment station from September 2003 through August 2004.

4.3.3.8 Combtooth Blennies (*Hypsoblennius spp.*)

Combtooth blennies form a prominent group among the subtropical and tropical fish fauna that inhabit inshore rocky habitats throughout much of the world. They are members of the family Blenniidae within the order Blennioidei. The family Blenniidae, the combtooth blennies, contains about 345 species in 53 genera (Nelson 1994, Moser 1996). They derive their common name from the arrangement of closely spaced teeth in their jaws.

Combtooth blennies are all relatively small fishes that typically grow to a total length of less than 200 mm (7.9 in.) (Moser 1996). Most have blunt heads that are topped with some arrangement of cirri (Moyle and Cech 1988, Moser 1996). Their bodies are generally elongate and without scales. Dorsal fins are often continuous and contain more soft rays than spines (Moyle and Cech 1988). Coloration in the group is quite variable, even among individuals of the same species (Stephens et al. 1970).

Combtooth blennies are represented along the California coast by three members of the genus *Hypsoblennius*: bay blenny (*H. gentilis*), rockpool blenny (*H. gilberti*), and mussel blenny (*H. jenkinsi*). These species co-occur throughout much of their range although they occupy different habitats. The bay blenny is found along both coasts of Baja California and up the California coast to as far north as Monterey Bay, (Miller and Lea 1972, Robertson and Allen 2002). The rockpool blenny occurs from Magdalena Bay, Baja California to Point Conception, California (Miller and Lea 1972, Stephens et al. 1970). The range of the mussel blenny extends from Morro Bay to Magdalena Bay, Baja California and in the northern Gulf of California (Tenera 2001, Robertson and Allen 2002).

The three species of *Hypsoblennius* found in California waters are morphologically similar as early larvae (Moser 1996, Ninos 1984). For this reason most *Hypsoblennius* identified in HBGS plankton tows collections were identified as *Hypsoblennius* spp. Certain morphological features (e.g., preopercular spines) develop at larger sizes and allow taxonomists to identify some larvae to the species level.

Habitat Requirements

Blennies inhabit a variety of hard substrates in the intertidal and shallow subtidal zones of tropical and subtropical marine habitats throughout the world. They may occur to depths of 24 m (80 ft) but are more frequently found in water depths of less than 5 m (15 ft) (Love 1996). Combtooth blennies are common in rocky tidepools, reefs, breakwaters, and on pier pilings. They are also frequently observed on encrusted buoys and boat hulls.

The California blennies have different habitat preferences. The mussel blenny is only found subtidally and inhabits mussel beds, the empty drill cavities of boring clams, barnacle tests, or in crevices among the vermiform snail tubes *Serpulorbis* spp. (Stephens 1969, Stephens et al. 1970). They generally remain within one meter of their chosen refuge (Stephens et al. 1970). The bay blenny is usually found subtidally but appear to have general habitat requirements and may inhabit a variety of intertidal and subtidal areas (Stephens et al. 1970). They are commonly found in mussel beds and on encrusted floats, buoys, docks, and even fouled boat hulls (Stephens 1969, Stephens et al. 1970). Bay blennies are also typically found in bays as the common name implies and are tolerant of estuarine conditions (Stephens et al. 1970). They are among the first resident fish species to colonize new or disturbed marine habitats such as new breakwaters or mooring floats after the substrate is first colonized by attached invertebrates (Stephens et al. 1970, Moyle and Cech 1988). Rockpool blennies are mainly found along shallow rocky shorelines and kelp forests along the outer coast.

Reproduction

Female blennies mature quickly and reproduce within the first year, reaching peak reproductive potential in the third year (Stephens 1969). The spawning season typically begins in spring and may extend into September (Stephens et al. 1970). Blennies are oviparous and lay demersal eggs that are attached to the nest substrate by adhesive pads or filaments (Moser 1996). Males are responsible for tending the nest and developing eggs. Females spawn 3–4 times over a period of several weeks (Stephens et al. 1970). Males guard the nest aggressively and will often chase the female away; however, several females may occasionally spawn with a single male. The number of eggs a female produces varies proportionately with size (Stephens et al. 1970). The mussel blenny spawns approximately 500 eggs in the first reproductive year and up to 1,500 eggs by the third year (Stephens et al. 1970). Total lifetime fecundity may be up to 7,700 eggs (Stephens 1969).

Age and Growth

Larvae are pelagic and hatch at a size of 2.3–2.6 mm (0.09–0.10 in) (Moser 1996). The planktonic phase for *Hypsoblennius* spp. larvae may last for 3 months (Stephens et al. 1970, Love 1996). *Hypsoblennius* larvae are visual swimmers (Ninos 1984). Captured larvae released by divers have been observed to orient to floating algae, bubbles on the surface, or the bottoms of boats or buoys. The size at settlement ranges from 12–14 mm (0.5–0.6 in.). After the first year mussel and bay blenny averaged 40 and 45 mm (1.6 and 1.8 in.) total length, respectively (Stephens et al. 1970). The bay blenny grows to a slightly larger size and lives longer than the mussel blenny, reaching a size of 15 cm (5.9 in.) and living for 6–7 years (Stephens 1969, Stephens et al. 1970, Miller and Lea 1972). Mussel blennies grow to 13 cm (5.1 in.) and have a life span of 3–6 years (Stephens et al. 1970, Miller and Lea 1972). Male and female growth rates are similar.

General Ecology

Juvenile and adult combtooth blennies are omnivores and eat both algae and a variety of invertebrates, including limpets, urchins, and bryozoa (Stephens 1969, Love 1996).

Population Trends and Fishery

There is no fishery for combtooth blennies and therefore no records on adult population trends based on landings data.

Sampling Results

Combtooth blenny was the eighth most abundant taxon collected in the entrainment samples and sixth most abundant in the source water samples (Tables 4-1 and 4-3). Combtooth blenny densities at the entrainment and source water stations peaked in summer (June–August 2004) and they were present in the study area throughout the year (Figures 3.3-20a and b). Maximum concentrations were recorded at the entrainment station in late June 2004 (105 per 1000 m^3), and source water concentrations peaked in late August 2004 (66 per 1000 m^3). Minimum entrainment and source water concentrations generally occurred from January through April. The number and density of larval combtooth blennies collected during each entrainment and source water survey is presented in Appendix B.

The length frequency distribution for a representative sample of combtooth blenny larvae is presented in Figure 4-27. The mean, maximum and minimum lengths were 2.3, 13.0, and 1.6 mm, respectively. The majority of the larvae was recently hatched based on a reported hatching size of 2.5 mm (Moser 1996).

Impact Assessment

The following sections present the results for demographic and empirical transport modeling of HBGS circulating water system effects. Species-specific life history information for combtooth blennies is scarce. Larval survival was estimated using data from Stephens (1969) and Stevens and Moser (1982). There was enough information on reproduction to parameterize the *FH* demographic model, but not to calculate the *AEL* model. Larval growth was estimated from information from Stevens and Moser (1982). The total annual entrainment estimate for the September 2003 through August 2004 sampling period was 7.17 million larvae (Table 4-1).

Fecundity Hindcasting (*FH*)

The annual entrainment estimate for combtooth blenny larvae was used to estimate the number of breeding females needed to produce the entrained larvae (Table 4-22). No estimates of egg survival for combtooth blenny were available, but because egg masses are attached and guarded by the male (Stephens et al. 1970), egg survival is probably high and was assumed to be 100 percent. The mean length for larval combtooth blenny larvae in entrainment samples was 2.3 mm. A larval growth rate of 0.20 mm/day was derived from growth rates using data in Stevens and Moser (1982). The mean length and the length at the 1st percentile (1.9 mm) were used with the growth rate to estimate that the mean age at entrainment was 3.3 days. A daily survival rate of 0.89 computed from Stephens (1969) was used to calculate survival to the average age at entrainment as $0.89^{3.8} = 0.63$. An average batch fecundity estimate of 550 eggs was based on data from Stephens (1969), and an estimate of 2.3 spawns per year based on information from Stevens and Moser (1982) were used to calculate an annual fecundity of 1,281 eggs. An average longevity for mussel blenny of 3–6 yr from Stephens (1969) and an age of maturation of 0.4 yr from Stevens and Moser (1982) were used in the model.

The estimated numbers of adult female combtooth blennies whose lifetime reproductive output was entrained through the HBGS circulating water system for the September 2003 through August 2004 period was 3,233 (Table 4-22). This was based on an annual entrainment of about 7.2 million larvae.

Table 4-22. Results of *FH* modeling for combtooth blenny larvae entrained during the September 2003 – August 2004 sampling period. The upper and lower estimates are based on a 90% confidence interval of the mean. The upper and lower estimates for total entrainments were calculated by using the range of entrainment estimates in the *FH* calculations.

Parameter	Estimate	Std. Error	*FH* Lower Estimate	*FH* Upper Estimate	*FH* Range
FH	3,233	2,907	736	14,191	13,455
Total Entrainment	7,165,513	1,735,739	1,945	4,521	2,576

Empirical Transport Model (*ETM*)

The larval duration used to calculate the *ETM* estimates for combtooth blenny was based on the lengths of entrained larvae. The difference between the lengths of the 1st (1.7 mm) and 95th (3.5 mm) percentiles was used with a growth rate of 0.20 mm/day to estimate that combtooth blenny larvae were vulnerable to entrainment for a period of about 9.3 days.

The monthly estimates of proportional entrainment (*PE*) for combtooth blennies for the September 2003 – August 2004 period varied among surveys and ranged from 0 to 0.021 (Table 4-23). The average estimate was 0.00430 which was almost twice the volumetric ratio of the entrainment to source water volumes, but the average was affected by the large *PE* estimate for February 2004 which occurred when the proportion of blennies in the source waters were low. A weighted average, similar to the calculation for P_M, would reduce the value. While the largest *PE* estimate was calculated for the February survey, the largest proportion of the source population was present during the August survey (f_i = 0.42 or 42%). The small *PE* estimate for the August survey (0.00025) indicates that larvae were not abundant at the entrainment station during this survey (Figures 4-26a and b). The results also show that there were several surveys when blenny larvae were collected at the source water stations, but not at the entrainment stations. The values in the table were used to calculate two P_M estimates: one based on alongshore current movement, and the other based on alongshore current movement and an extrapolation of densities offshore to a distance bounded by either the extrapolated densities or onshore current movement. The estimate of P_M for the 9.3-day period of exposure calculated using offshore extrapolated densities (0.0029, 0.29%) was less than the estimate calculated using alongshore current displacement (0.0077, 0.77%) because the effects of entrainment are spread over a larger source population that includes offshore areas (Table 4-24). The P_S estimates indicate that the ratio of the sampled source water to the total population for the alongshore and offshore P_M estimates were 81.4 and 41.7 percent, respectively. The alongshore estimate of P_M was extrapolated over a shoreline distance of 12.8 km.

Table 4-23. *ETM* data for combtooth blenny larvae. *ETM* calculations based on sampling grid volume of 908,157,859 m^3, and daily circulating water volume of 1,919,204 m^3. Average *PE* estimate calculated from all surveys with *PE* >0.

Survey Date	PE Estimate	PE Std. Error	f_i	f_i Std. Error
17-Sep-03	0.00000	0.00000	0.04350	0.02820
13-Oct-03	0.00000	0.00000	0.03255	0.03161
10-Nov-03	0.00423	0.00812	0.06645	0.05730
8-Dec-03	0.00167	0.00347	0.03080	0.02040
5-Jan-04	0.00133	0.00292	0.02438	0.02325
9-Feb-04	0.02108	0.07994	0.00138	0.00447
8-Mar-04	0.00000	0.00000	0.00000	0.00000
5-Apr-04	0.00000	0.00000	0.00147	0.00393
3-May-04	0.00000	0.00000	0.02012	0.01690
1-Jun-04	0.00071	0.00097	0.12027	0.06204
12-Jul-04	0.00082	0.00125	0.23727	0.17700
31-Aug-04	0.00025	0.00033	0.42181	0.16879
Average =	0.00430			

Table 4-24. Average P_S values and *ETM* estimates for alongshore current and offshore extrapolated models for combtooth blenny. Current displacement (km) for alongshore extrapolation included in parentheses with estimate of P_S for alongshore estimate of P_M.

Parameter	Average P_S (displacement)	*ETM* Estimate (P_M)	*ETM* Std. Err.	Upper 95% CI	Lower 95%CI
Alongshore Current	0.8145 (12.8)	0.00768	0.27717	0.28485	0
Offshore Extrapolated	0.4166	0.00285	0.26937	0.27222	0

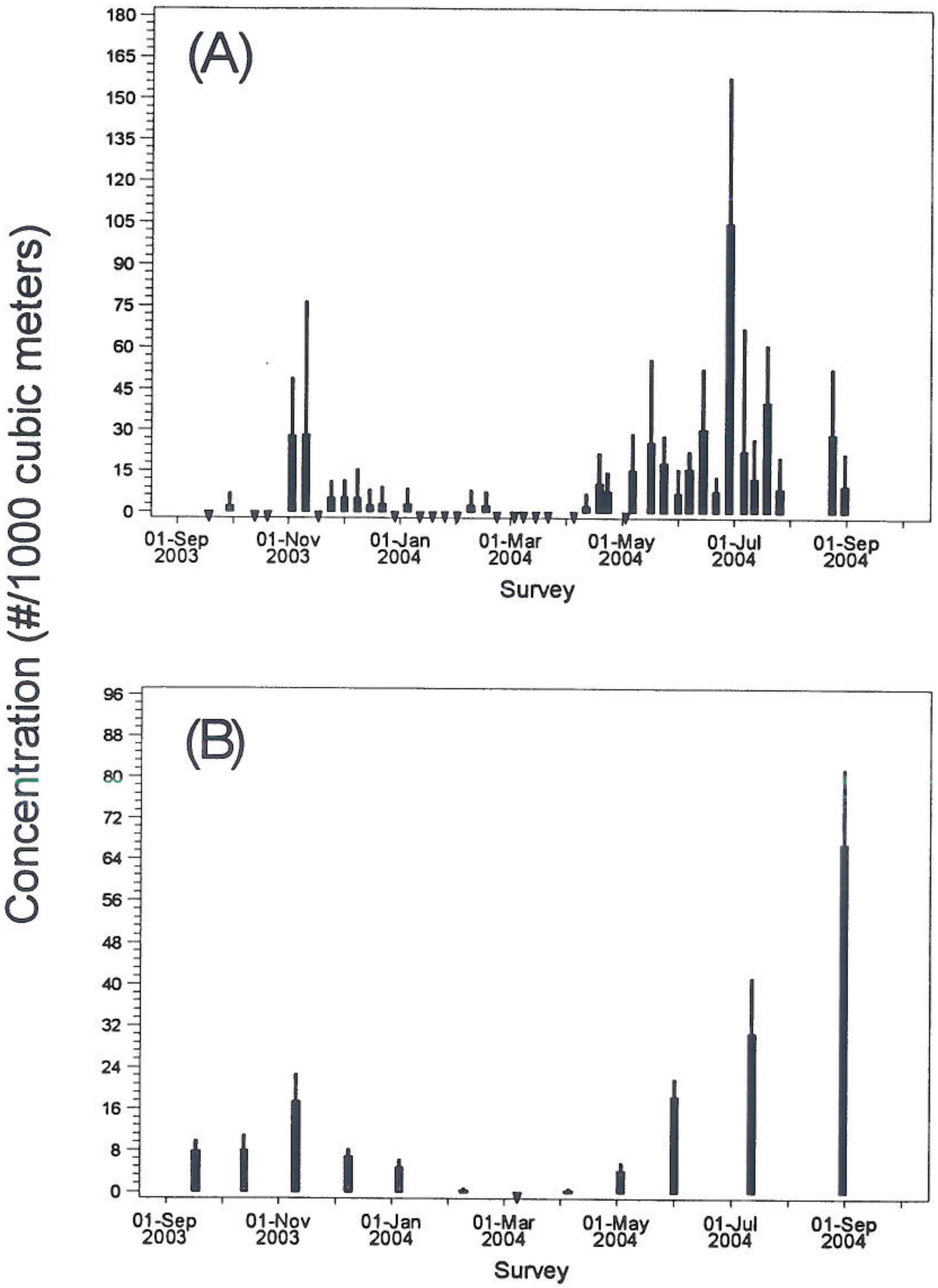

Figure 4-26. Survey mean concentration (#/1000 m^3) of combtooth blenny larvae collected at the HBGS entrainment (A) and source water (B) stations with standard error indicated (+1 SE). Down arrows indicate surveys when no combtooth blenny larvae were collected.

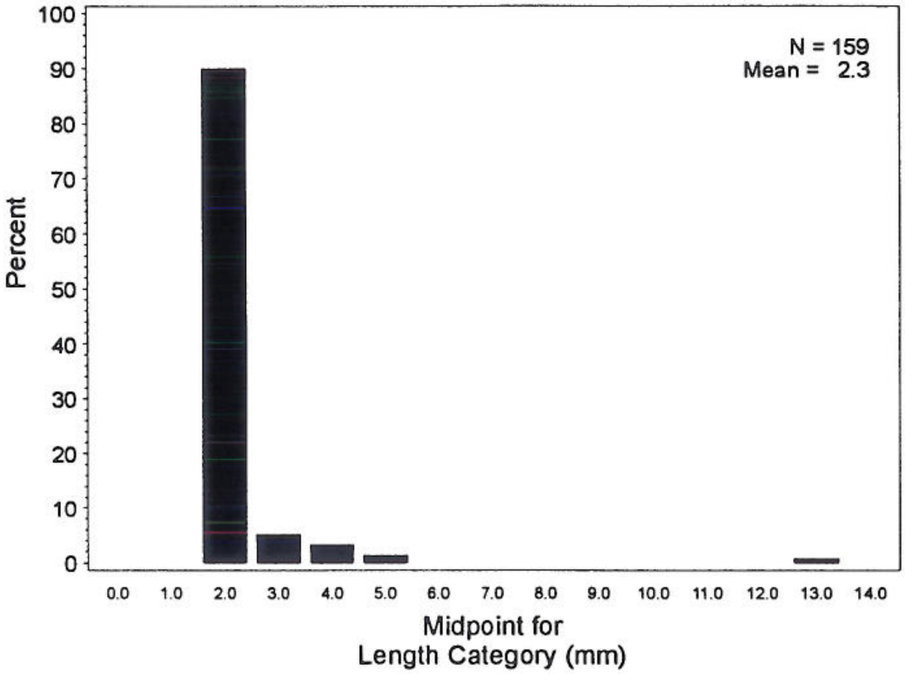

Figure 4-27. Length frequency distribution (mm) of combtooth blenny larvae collected from the HBGS entrainment station from September 2003 through August 2004.

4.3.3.9 Diamond Turbot (*Hypsopsetta guttulata*)

Diamond turbot *Hypsopsetta guttulata* is classified in the family of right-eyed flatfishes (Pleuronectidae). It is one of twenty pleuronectid species that occur off California, and ranges from Cape San Lucas, Baja California to Cape Mendocino, California (Eldridge 1975). An isolated population has also been reported from the upper Gulf of California (Miller and Lea 1972). The scientific name of this species changed from *Hypsopsetta guttulata* to *Pleuronichthys guttulatus* during the course of this study (Nelson et al. 2004). *H. guttulata* is used in this report to maintain consistency with the Six-Month and Nine-Month Reports.

Habitat Requirements

This species is found on muddy or sandy substrates in bays or along nearshore coastal areas. The diamond turbot occurs in water depths between less than 1 m and 50 m, but is most common in shallow water less than 10 m (Lane 1975).

Reproduction

Little is known of the reproductive habits of the diamond turbot. Females become sexually mature at two to three years (Fitch and Lavenberg 1975), but no equivalent information is available concerning the males. Both sexes are sexually mature at a total length of 16.5 cm (6.5 in.) (Love 1996). Spawning occurs year-round and appears to peak during the winter months (Eldridge 1975). Eggs collected in San Francisco Bay averaged 0.8 mm in diameter (Eldridge 1975).

Age and Growth

The largest diamond turbot reported in the literature was 46 cm (18 in.) in total length (Lane 1975). The maximum age for this species, based on otoliths and scales, is about eight years (Love 1996, Fitch and Lavenberg 1975). Newly hatched larvae collected in San Francisco Bay averaged 1.6 mm NL (Eldridge 1975). Larvae are planktonic and settle to the bottom in shallow water after about five to six weeks. Standard length at the time of settlement is about 1.1-1.2 cm (Eldridge 1975, Love 1996). Early growth rates appear to be similar to other flatfishes including the California halibut (*Paralichthys californicus*). Gadomski et al. (1990) calculated the growth rate to flexion of California halibut to be 0.231 mm/day. Total length of diamond turbot at one year is about 14 cm (5.5 in.) (Lane 1975).

General Ecology

Diamond turbot are found in bays and shallow coastal waters with sandy or muddy bottoms. They feed primarily on invertebrates that live on top of, or in the upper layers of the substrate. Gut contents of diamond turbot collected in Anaheim Bay, California included polychaete worms, crustaceans, and mollusks (Lane 1975). This species feeds primarily during daylight hours. Predators include angel shark, Pacific electric ray, and other piscivorous fishes.

Population Trends and Fishery

Diamond turbot makes up a minor portion of the California marine sport fishery (Leos 2001). They are taken by anglers fishing from the shore, piers, or boats in shallow bays and estuaries. This species has little commercial importance but is taken occasionally as part of the incidental catch. It is usually reported under the grouping of 'turbot' along with several other flatfish species. California Department of Fish and Game reported annual landings of 'turbot' in California of about 13,000 and 6,600 lbs for the years 2001 and 2002 respectively. The proportion of this total contributed by diamond turbot is not known.

Sampling Results

Diamond turbot was the 12th most abundant taxon collected from the entrainment station and 14th most abundant at the source water stations, comprising about 1.3% of all of the larvae collected at the entrainment station (Tables 4-1 and 4-3). The estimated mean entrainment per survey was variable, ranging from zero to about 100 diamond turbot larvae per 1,000 m^3 (Figure 4-28a). Diamond turbot larvae were present during many of the surveys with a pronounced peak during August 2004. The peak concentration at the source water stations occurred in October 2003 (Figure 4-28b). The number and density of larval diamond turbot collected during each entrainment and source water survey is presented in Appendix B.

The length frequency distribution of measured diamond turbot larvae showed that the samples were dominated by recently hatched larvae based on the reported hatch length of 1.6 mm SL (Eldridge 1975) (Figure 4-29). The mean, maximum, and minimum sizes for the measurements were 2.3, 4.7, and 1.3 mm, respectively. A larval growth rate of 0.231 mm/day calculated from data in Gadomski et al. (1990) for California halibut was used with the difference in the lengths of the first (1.3 mm) and 95th (4.3 mm) percentiles of the measurements to estimate that the larvae were exposed to entrainment for a period of 13 days.

Impact Assessment

The following sections present the results for empirical transport modeling of entrainment effects on diamond turbot larvae. Demographic model estimates of entrainment effects were not calculated because of the absence of information on life history necessary to parameterize the models. Total entrainment was estimated at approximately 5.4 million larvae for the period of September 2003 through August 2004.

Empirical Transport Model (*ETM*)

The *PE* estimates for diamond turbot ranged from 0 to 0.02 (Table 4-25). The average PE estimate was 0.00517, which is greater than the ratio of the entrainment and source water volumes of 0.00211. As shown in Table 4-25 the values of f_i indicate that diamond turbot larvae were present throughout much of the year in the source water and there were several surveys when they were present at the source water stations, but were not collected at the entrainment station. The values in the table were used to calculate two P_M estimates: one based on alongshore current movement, and the other based on alongshore current movement and an extrapolation of densities offshore to a distance bounded by either the extrapolated densities or onshore current movement. The estimate of P_M for the 13-day period of exposure calculated using offshore extrapolated densities (0.003, 0.3%) is less than the estimate calculated using alongshore current displacement (0.006, 0.6%) because the effects of entrainment are spread over a much larger population for the offshore extrapolated estimate (Table 4-26). The P_S estimates indicate that the ratio of the sampled source water to the total population for the alongshore and offshore P_M estimates were 61.7 and 28.7%, respectively, and the alongshore estimate was extrapolated over a shoreline distance of 16.9 km.

Table 4-25. *ETM* data for diamond turbot larvae. *ETM* calculations based on sampling grid volume of 908,157,859 m^3, and daily circulating water volume of 1,919,204 m^3. Average *PE* estimate calculated from all surveys with *PE* >0.

Survey Date	*PE* Estimate	*PE* Std. Error	f_I Estimate	f_I Std. Error
17-Sep-03	0.00000	0.00000	0.07266	0.07101
13-Oct-03	0.00120	0.00155	0.20314	0.10636
10-Nov-03	0.00163	0.00373	0.08881	0.09327
8-Dec-03	0.00000	0.00000	0.03104	0.04430
5-Jan-04	0.00079	0.00166	0.19283	0.11089
9-Feb-04	0.00000	0.00000	0.04220	0.05032
8-Mar-04	0.00115	0.00255	0.13051	0.11381
5-Apr-04	0.02108	0.07994	0.00564	0.01816
3-May-04	0.00000	0.00000	0.08152	0.07454
1-Jun-04	0.00000	0.00000	0.00000	0.00000
12-Jul-04	0.00000	0.00000	0.00000	0.00000
31-Aug-04	0.00000	0.00000	0.15164	0.11536
Average =	0.00517			

Table 4-26. Average P_S values and *ETM* estimates for alongshore current and offshore extrapolated models for diamond turbot. Current displacement (km) for alongshore extrapolation included in parentheses with estimate of P_S for alongshore estimate of P_M.

Parameter	Average P_S (displacement)	*ETM* Estimate (P_M)	*ETM* Std. Err.	Upper 95% CI	Lower 95%CI
Alongshore Current	0.6166 (16.9)	0.00578	0.28065	0.28643	0
Offshore Extrapolated	0.2866	0.00275	0.27619	0.27894	0

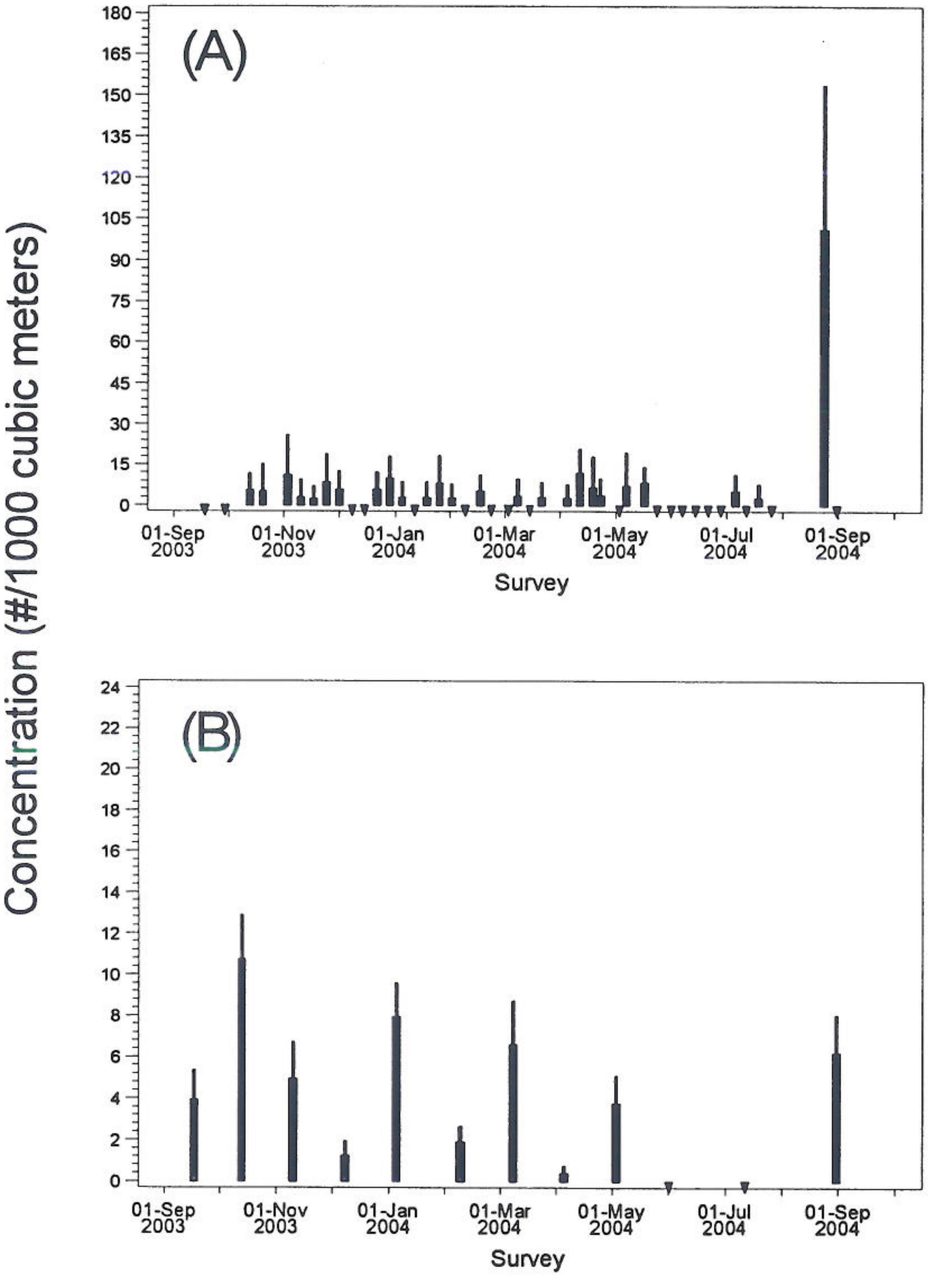

Figure 4-28. Survey mean concentration (#/1000 m^3) of diamond turbot larvae collected at the HBGS entrainment (A) and source water (B) stations with standard error indicated (+1 SE). Down arrows indicate surveys when no diamond turbot larvae were collected.

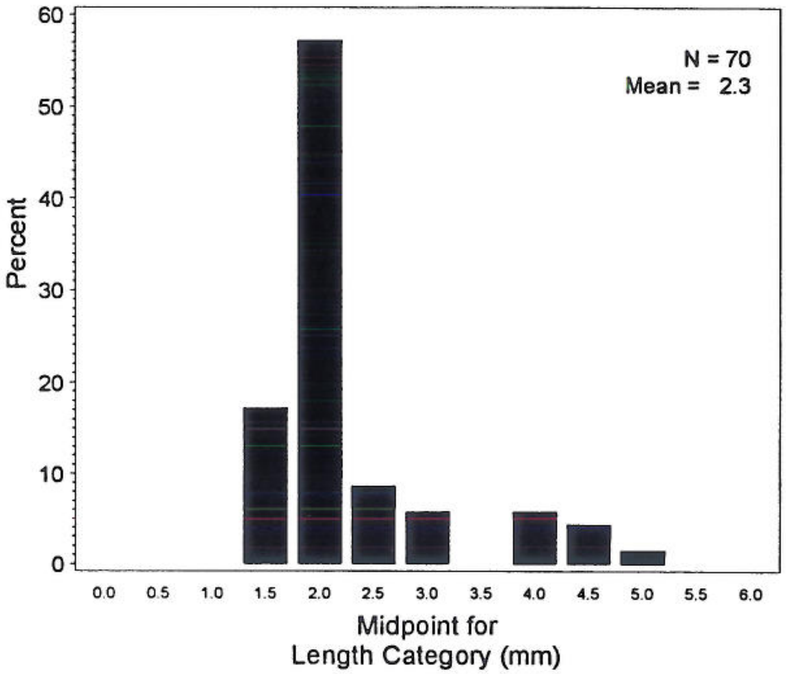

Figure 4-29. Length frequency distribution (mm) of diamond turbot larvae collected from the HBGS entrainment station from September 2003 through August 2004.

4.3.3.10 California Halibut (*Paralichthys californicus*)

California halibut is an important part of California's commercial and recreational fisheries (Starr et al. 1998, Kramer and Sunada 2001). It ranges from northern Washington to Bahia Magdalena, southern Baja California and is found from very shallow nearshore waters in bay nursery grounds to depths of at least 185 m (Miller and Lea 1972, Haaker 1975).

Habitat Requirements

Juveniles and adults typically occur on sandy sediments at depths less than 30 m but sometimes concentrate near rocks, algae, or Pacific sand dollar (*Dendraster excentricus*) beds (Feder et al. 1974). As with other flatfishes, they frequently lie buried or partially buried in the sediment. Newly settled and juvenile halibut often occur in unvegetated shallow embayments and occasionally on the outer coast, suggesting that bays are an important nursery habitat for this species (Kramer and Sunada 2001).

Reproduction

California halibut is a broadcast spawner with eggs being fertilized externally. The spawning season is generally thought to extend from February to August with most spawning occurring in May (Frey 1971), although some fall spawning may also occur. The average number of eggs per spawn is 313,000–589,000 with an average reproductive output of approximately 5.5 million eggs per spawning season (Caddell et al. 1990). During spawning season females may release eggs every 7 days and the largest individuals may produce in excess of 50 million eggs per year (Caddell et al. 1990). Captive specimens were observed to spawn at least 13 times per season (Caddell et al. 1990). Halibut eggs are 0.7–0.8 mm in diameter (Ahlstrom et al. 1984) and are most abundant in the water column at depths less than 75 m and within 6.5 km from shore (Kramer and Sunada 2001).

Age and Growth

Upon hatching, the larvae (1.6–2.1 mm NL [Moser 1996]) are pelagic (Frey 1971), and most abundant between Santa Barbara, California, and Punta Eugenia, Baja California Sur (Ahlstrom and Moser 1975) from January through April and June through August (Moser 1996). California halibut have a relatively short pelagic larval stage, from 20–29 days (Gadomski et al. 1990). Larval transformation occurs at a length of about 7.5–9.4 mm SL (Moser 1996) at which time the young fish settle to the bottom, generally in bays but also occasionally in shallow substrates along the open coast (Haugen 1990). Kramer (1991) found that 6–10 mm California halibut larvae grew <0.3 mm/day, while larger 70–120 mm halibut grew about 1.0 mm/day. In a laboratory study, California halibut held at 16°C grew to a length of 11.1 mm ± 2.61 (SD) in two months from an initial hatch length of 1.9 mm (Gadomski et al. 1990). After settling in the bays, the juveniles may remain there for about two years until they emigrate to the outer coast. Males mature at 2–3 years and 20–23 cm SL; females mature at 4–5 years and 38–43 cm SL (Fitch and Lavenberg 1971, Haaker 1975). Males emigrate out of the bays when they mature (i.e. at 20 cm) but females migrate out as subadults at a length of about 25 cm (Haugen 1990). Subadults remain nearshore at depths of 6–20 m (Clark 1930, Haaker 1975). California halibut may reach 152 cm and 33 kg (Eschmeyer et al. 1983). Individuals may live as long as 30 years (Frey 1971).

General Ecology

California halibut feed during the day and night, but show a preference for daytime feeding (Haaker 1975). The species is an ambush feeder, typically lying partially buried in the sand until prey approaches. They prey on Pacific sardine (*Sardinops sagax*), anchovies, squid, and other nektonic nearshore fish species (Kramer and Sunada 2001). Small halibut in bays eat small crustaceans and become increasingly piscivorous with size. Other similar species of flatfishes such as sand sole and bigmouth sole may compete with California halibut within their range (Haugen 1990). Because of an extensive overlap in diet, habitat, geographic and bathymetric distributions, and probable foraging behavior, the California lizardfish may be the most important potential competitor of medium-sized California halibut (Allen 1982).

Population Trends and Fishery

California halibut have a high commercial and recreational fishery value. The fishery for California halibut was reviewed by Kramer and Sunada (2001) and recent catch statistics are available through the PSMFC PacFIN (commercial) and RecFIN (recreational) databases. Historically, halibut have been commercially harvested by three principal gear types: otter trawl, set gill and trammel net, and hook and line. Presently there are numerous gear, area, and seasonal restrictions that have been imposed on the commercial halibut fishery for management purposes. Since 1980 the state-wide commercial catch has averaged approximately one million pounds per year. In southern California (San Diego, Orange and Los Angeles counties) the average annual commercial catch and ex-vessel revenue from halibut for the years 2000–2004 was approximately 56,000 lbs and $202,000 respectively. During this time the greatest catches were in 2000 (82,225 lbs) and the least were in 2003 (38,113 lbs).

It appears that the size of the California halibut population may be limited by the availability of shallow-water nursery habitat, and a long-term decline in landings corresponds to a decline in these habitats in southern California associated with dredging and filling of bays and wetlands (Kramer and Sunada 2001). A fishery-independent trawl survey for halibut conducted in the early 1990s estimated that the southern California biomass was 6.9 million pounds (3.9 million adult fish) and the central California biomass was 2.3 million pounds (0.7 million fish) (Kramer and Sunada 2001).

Sampling Results

California halibut was the ninth most abundant taxon collected from the entrainment station and eighth most abundant at the source water stations, comprising about 1.5% of all of the larvae collected at the entrainment station (Tables 4-1 and 4-3). The estimated mean entrainment per survey was variable, ranging from zero to about 130 California halibut larvae per 1,000 m^3, with most larvae occurring from April through August (Figure 4-30a). The peak concentration at the entrainment station was recorded in June but the peak source water concentrations occurred in August (Figure 4-30b). The number and density of larval California halibut collected during each entrainment and source water survey is presented in Appendix B.

The length frequency distribution of measured California halibut larvae showed a bi-modal size distribution which was dominated by recently hatched larvae based on the reported hatch length of 1.6–2.1 mm (Moser 1996) and a second peak at 7.0 mm (Figure 4-31). The mean, maximum, and minimum sizes for the measurements were 2.1, 7.4, and 1.1 mm, respectively. A larval growth rate of 0.231 mm/day calculated from data in Gadomski et al. (1990) was used with the difference in the lengths of the first (1.1 mm) and 95th (6.8 mm) percentiles of the measurements to estimate that the larvae were exposed to entrainment for a period of 25 days.

Impact Assessment

The following sections present the results for empirical transport modeling of entrainment effects on California halibut larvae. Demographic model estimates of entrainment effects were not calculated because of the absence of information on life history necessary to parameterize the models. Total entrainment was estimated at approximately 5 million larvae for the period of September 2003 through August 2004.

Empirical Transport Model (*ETM*)

The *PE* estimates for California halibut correspond to both the 2003 and 2004 spawning periods (Table 4-27). The values of f_i indicate increasing abundances of California halibut larvae in the source waters when the study was completed at the end of August 2004. This isn't necessarily problematic if the assumption that the *PE* estimates are not related to changing abundances in source water is correct. The values of f_i also indicate that although there were surveys when no larvae were collected at the entrainment station (*PE*=0), *PE* estimates were available for the surveys when the majority of the halibut larvae were found in the source water samples. The values in the table were used to calculate two P_M estimates: one based on alongshore current movement, and the other based on alongshore current movement and an extrapolation of densities offshore to a distance bounded by either the extrapolated densities or onshore current movement. The estimate of P_M for the 25-day period of exposure calculated using offshore extrapolated densities (0.0008, 0.08%) is less than the estimate calculated using alongshore current displacement (0.0025, 0.25%) because the effects of entrainment are spread over a much larger population for the offshore extrapolated estimate (Table 4-28). The P_s estimates indicate that the ratio of the sampled source water to the total population for the alongshore and offshore P_M estimates were 33.8 and 11.3 percent, respectively and the alongshore estimate was extrapolated over a shoreline distance of 30.9 km.

Table 4-27. *ETM* data for California halibut larvae. *ETM* calculations based on sampling grid volume of 908,157,859 m^3, and daily circulating water volume of 1,919,204 m^3. Average *PE* estimate calculated from all surveys with *PE* >0.

Survey Date	*PE* Estimate	*PE* Std. Error	f_i Estimate	f_i Std. Error
17-Sep-03	0.00000	0.00000	0.02009	0.01309
13-Oct-03	0.00000	0.00000	0.00987	0.01394
10-Nov-03	0.00142	0.00200	0.03617	0.03166
8-Dec-03	0.00000	0.00000	0.00000	0.00000
5-Jan-04	0.00000	0.00000	0.00616	0.01307
9-Feb-04	0.00000	0.00000	0.00158	0.00498
8-Mar-04	0.00000	0.00000	0.00873	0.01183
5-Apr-04	0.00000	0.00000	0.00599	0.00930
3-May-04	0.00137	0.00184	0.05424	0.02912
1-Jun-04	0.00043	0.00091	0.10875	0.08657
12-Jul-04	0.00089	0.00116	0.13504	0.06103
31-Aug-04	0.00010	0.00020	0.61338	0.16245
Average =	0.00084			

Table 4-28. Average P_S values and *ETM* estimates for alongshore current and offshore extrapolated models for California halibut. Current displacement (km) for alongshore extrapolation included in parentheses with estimate of P_S for alongshore estimate of P_M.

Parameter	Average P_S (displacement)	*ETM* Estimate (P_M)	*ETM* Std. Err.	Upper 95% CI	Lower 95%CI
Alongshore Current	0.3378 (30.9)	0.00250	0.20636	0.20886	0
Offshore Extrapolated	0.1125	0.00079	0.20246	0.20324	0

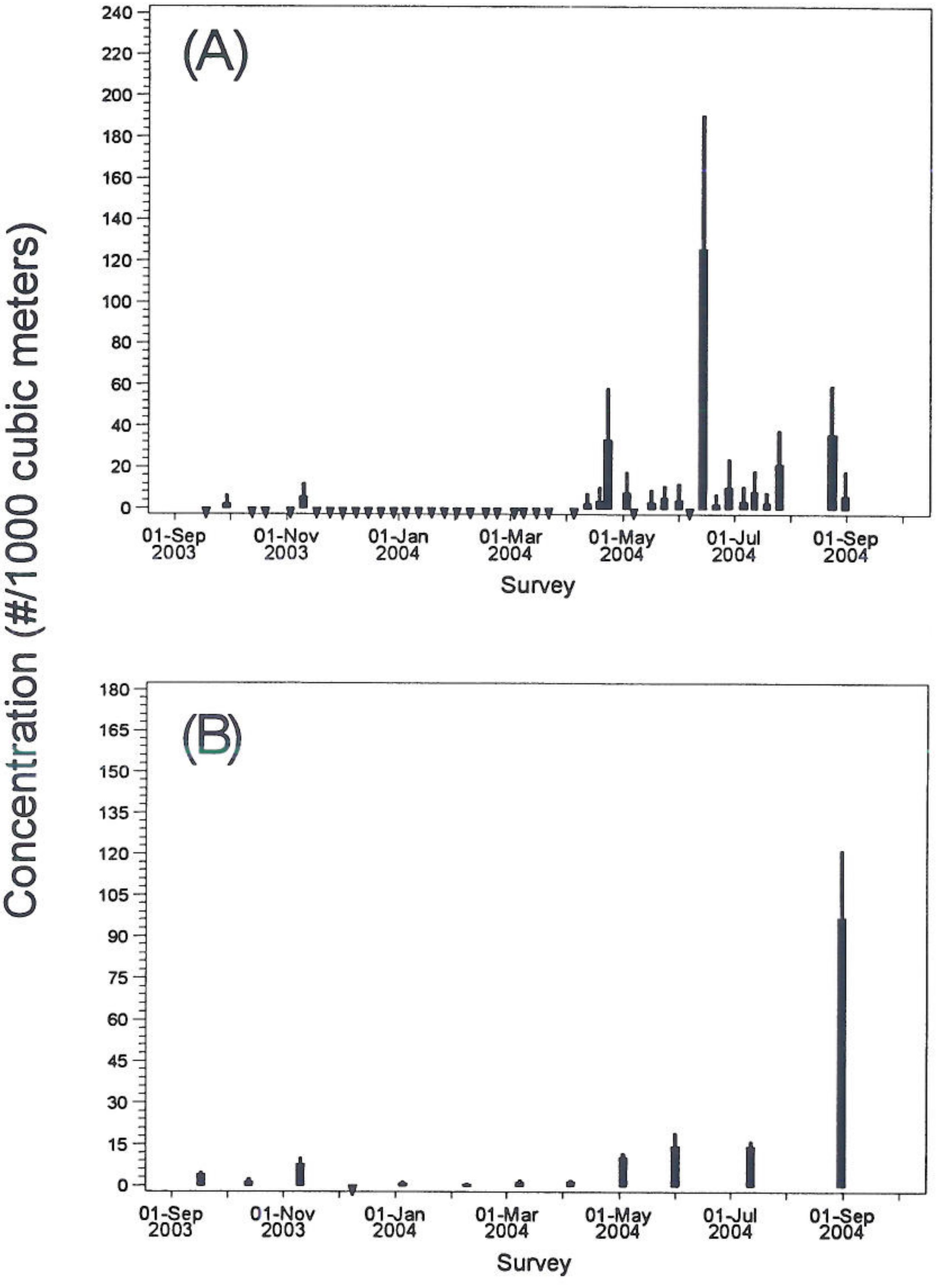

Figure 4-30. Survey mean concentration (#/1000 m^3) of California halibut larvae collected at the HBGS entrainment (A) and source water (B) stations with standard error indicated (+1 SE). Down arrows indicate surveys when no California halibut larvae were collected.

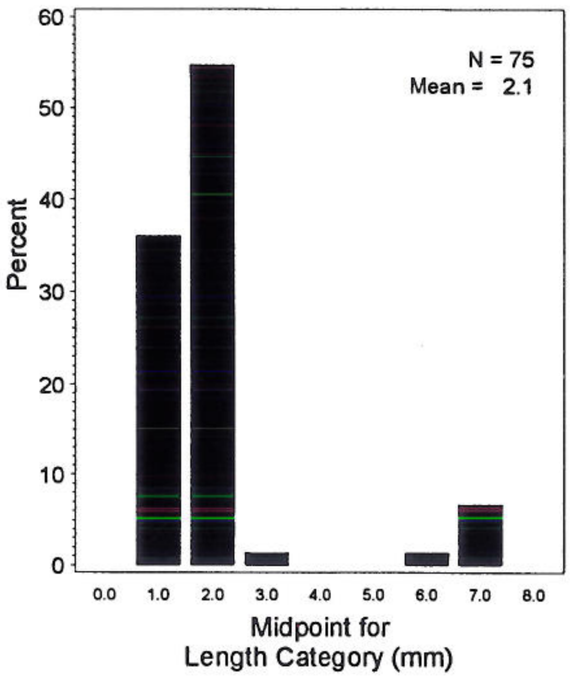

Figure 4-31. Length frequency distribution (mm) of California halibut larvae collected from the HBGS entrainment station from September 2003 through August 2004.

4.3.3.11 Sand Crab (*Emerita analoga*)

The sand crab, also known as the Pacific mole crab, is a common filter-feeding crustacean that occurs intertidally along sandy beaches of the Pacific coast of North and South America. The species ranges in the northeastern Pacific from Kodiak Island, Alaska, to Magdalena Bay, Baja California, and in the southeastern Pacific from Salavery, Peru south to False Bay, Argentina (Efford 1970). An isolated population has also been reported to occur in the northern Gulf of California (Efford 1969). A similar but larger species, the spiny mole crab (*Blepharipoda occidentalis*), occurs in the low intertidal and subtidal zone from Stinson Beach, California to Bahia Ballenas, Baja California (Morris et al. 1980).

Habitat Requirements

Juvenile and adult sand crabs inhabit sandy beaches, where they burrow in the swash zone just under the sand surface. Prime locations are on exposed beaches at, or above, the low tide line where waves and surf action are highest (Johnson 1939). Dense aggregations of up to 40,000 animals per square meter have been observed (Richards 1996). Larvae are planktonic and occur in nearshore coastal waters.

Reproduction

Mating occurs in spring and summer, with the main breeding period from March to November (Morris et al. 1980). During breeding season, females carry the eggs under the telson attached to their abdominal appendages. Several males collect near the female when she is ready to deposit her eggs, and sperm is deposited about 12 hr before eggs are laid (MacGinitie 1938). During the reproductive season females can produce one clutch per month of approximately 50–50,000 eggs with larger crabs producing more eggs per clutch. Eggs are incubated through the cleavage and embryonic stages while attached to the female and take approximately 30 days to develop fully. The larvae are released as free-swimming organisms in the first zoeal stage. Wenner et al. (1987) found that egg production varies by age class, location, and season. Females may breed repeatedly if conditions are favorable, and in the laboratory, females produced up to four consecutive egg masses (Cox and Dudley 1968). In southern California, the bulk of larvae are hatched during July and early August (Johnson and Lewis 1942). Fusaro (1980a) determined that water temperature strongly affected egg production, with seven times as many females producing eggs at 25°C than at 12°C.

Age and Growth

Sand crab larvae are planktonic zoeae, which are in the plankton for about four and one-half months. The pelagic larvae molt through five zoeal stages increasing in size from 0.53 mm carapace length (CL) in the first zoeal stage to 3.50 mm CL in the fifth zoeal stage (Johnson and Lewis 1942). Based on a laboratory rearing experiment, the first zoeal stage can last up to 34 days before molting to the second stage (Johnson and Lewis 1942). However, cultured larvae experienced difficulty in feeding, and Johnson (1939) speculated that the time required to complete each developmental stage is less under natural conditions where suitable food resources are more readily available and growth is more rapid. The longevity of subsequent stages can only be inferred from the abundances of specimens collected in the field because later stages were not successfully reared under laboratory conditions. Each of the stage 2–5 zoea probably lasts from approximately 20-30 days depending on environmental conditions. During this time, zoeae are subject to alongshore and onshore/offshore currents, and Stage 4 larvae have been found >100 miles offshore beyond the Channel Islands (Johnson 1939). Stage 5 larvae were scarce in Johnson's samples, presumably due to downward movement in preparation for assuming a benthic existence. The final larval stage is the megalops in which the body form resembles the first benthic crab stage. In one study, megalopae arrived at Scripps Beach in La Jolla, California, beginning in early August, with peak numbers arriving in early June (Efford 1970). However, in Santa Barbara, megalopae arrived on the beach in fall (Barnes and Wenner 1968). Once on the beach, megalopae molt and develop into juveniles, then into small males and females. Sand crabs reproduce in the first summer following settlement, and the females (at least) live to the second summer when they reproduce and die the following autumn.

While sand crabs range widely from Alaska to Baja, the population structure differs from beach to beach (Barnes and Wenner 1968). Crabs from southern sites tend to reproduce at smaller sizes and younger ages and attain smaller maximum sizes than crabs from northern sites (Dugan et al. 1991). Adult male sand crabs are smaller than females, and in some areas the ratio of males to females shifts with season (Morris et al. 1980). Sexually mature females range from 9–38 mm carapace length (CL), while mature males range from 6–12 mm CL (Dudley 1967, Dugan et al. 1991). Fusaro (1978) found large differences in growth rates between sand crabs at Goleta Bay and at Santa Cruz Island, which are only 42 km apart—sand crabs grew more rapidly on the mainland than at the island. He attributed this to the colder water and reduced filterable material suspended in the water at the island site. Dugan et al. (1991) also found that size at maturity and the size distribution of ovigerous crabs were inversely correlated with water temperature.

General Ecology

When moving up or down the beach, sand crabs swim until the flow of water slackens, then immediately burrow, facing toward the sea (MacGinitie 1938). Feeding is performed by screening out microorganisms such as dinoflagellates as water passes over their plumose antennae, which protrude from the surface of the shifting sands. Food items are transferred to the mouth by wiping the antennae through the mouthparts. Efficient feeding occurs with the receding wash of the breakers, and the animals tend to maintain themselves at a tidal level where the maximum wash occurs (MacGinitie 1938).

Dillery and Knapp (1970) determined that sand crabs made longshore movements corresponding to alongshore current and sediment movement. At Goleta, California, the overall mean eastward movement of 114 crabs was about 15 m (48 ft) per day. The most rapidly moving sand crab was one that was tracked 693 m (2,275 ft) in five days, a mean of 139 m (455 ft) per day. Diel movements were also reported by Fusaro (1980b), with distribution shifting seaward daily and shoreward nightly relative to the same tidal level. In southern California, a portion of the *Emerita* population tends to move offshore to subtidal waters in winter when wave motion increases, and return to beaches in spring (Morris et al. 1980). The beach population is augmented by the settlement of megalops larvae.

Population Trends and Fishery

Sand crabs are fished primarily for bait, and the recently molted soft-shelled individuals are targeted. The first commercial catch was reported in 1963, with 4,673 pounds landed statewide (Herbinson and Larson 2001). By 1967 landings totaled over 8,300 pounds worth $17,152. Since 1977, however, catch decreased greatly, averaging only 22 pounds per year. This is likely due to reduced harvest effort and replacement of sand crab with other bait species, such as ghost shrimp, clams, and mussels. There were no reported commercial landings of sand crabs within any of the CDFG catch blocks off the HBGS in 2003 (CDFG 2004) and sport catches are not reported.

Sampling Results

Sand crab larvae were the most abundant of the targeted invertebrates in entrainment (average of 659 zoea per 1,000 m^3; Table 4-2) and source water samples (average of 173 larvae per 1,000 m^3; Table 4-5). All of the zoea larvae collected were Stage 1. The entrainment estimate for the study period was 465,806,877 zoea (Table 4-1). Larval abundances in entrainment and source water surveys showed an increasing trend with the highest abundances in the August 2004 surveys (Appendix B). The greater abundances at the inshore stations (Appendix B) are consistent with the littoral distribution of the adult spawning population. Only two megalops (at a concentration of 0.17 megalopae per 1,000 m^3; Table 4-2) were collected at the entrainment station, and none were collected at the source water stations.

Impact Assessment

No impact assessment modeling of entrainment effects on sand crabs was done because megalops larvae were not collected in sufficient abundance, and did not occur in paired entrainment and source water surveys during the study.

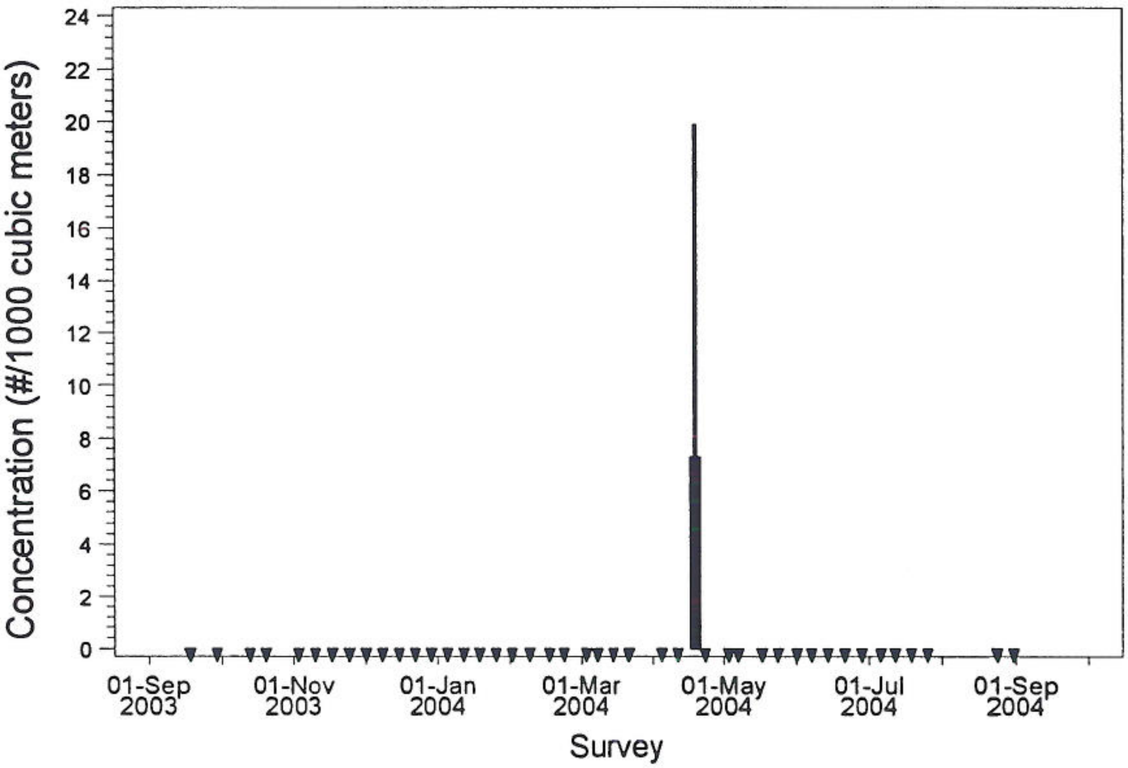

Figure 4-32. Survey mean concentration (#/1000 m^3) of sand crab megalops larvae collected at the HBGS entrainment station with standard error indicated (+1 SE). There were no sand crab megalops collected at the source water stations. Down arrows indicate surveys when no sand crab larvae were collected.

4.3.3.12 California Spiny Lobster (*Panulirus interruptus*)

California spiny lobster ranges from Monterey Bay, California, to Manzanillo, Mexico, and there is also a small population along the northwestern shore of the Gulf of California (MBC 1987). They are the only representative of the spiny lobster family (Palinuridae) in southern California.

Habitat Requirements

During the first two years, juveniles inhabit surfgrass beds from the lower intertidal to depths of about 5 m (16 ft). Juveniles and adults are considered benthic, though they have been observed swimming near the surface, and occur from the intertidal zone to about 80 m (262 ft). Preferred habitats include mussel beds, rocky areas, and in kelp beds (Morris et al. 1980, Barsky 2001).

Reproduction

California spiny lobster are oviparous, the sexes are separate, and fertilization is external. With few exceptions, adult females spawn every year. Barsky (2001) reported that mating occurs from November through May, and Wilson (1948) indicated the primary spawning season was from March to August. Mating takes place on rocky bottoms in water depths of 10–30 m (33–98 ft) (Mitchell et al. 1969). Spawning occurs from the Channel Islands off southern California to Magdalena Bay, Baja California, including other offshore islands and banks, such as Cortez and Tanner (MBC 1987). Females move inshore to depths less than 10 m (33 ft) to extrude and fertilize the eggs. At San Clemente Island, females carried between 120,000 eggs (66 mm [2.6 in] CL) and 680,000 eggs (91 mm [3.6 in] CL) (Barsky 2001).

Age and Growth

Hatching occurs from March to December. Larvae are pelagic and are found from the surface to depths of 137 m (449 ft), and within 530 km (329 mi) of shore (MBC 1987). Upon hatching, transparent larvae (phyllosoma) go through 12 molts, increasing in size in each subsequent molt. Phyllosoma larvae are infrequently collected in the Southern California Bight (Johnson 1956, MBC 1987). After five to ten months, the phyllosoma transforms into the puerulus larval stage which resembles the adult form but is still transparent. The puerulus actively swims inshore where it settles in shallow water. At La Jolla, puerulus appeared in nearshore waters in late May and occurred there through mid-September (Serfling and Ford 1975). It is hypothesized that the puerulus stage of California spiny lobster lasts approximately two to three months (Serfling and Ford 1975).

A 6.1-mm CL juvenile specimen goes through 20 molts to reach 45.7 mm CL at the end of its first year (Barsky 2001). Spiny lobsters molt four times during the second year, and three times during the third year. Mitchell et al. (1969) found adult spiny lobsters (larger than 41 mm CL) molt once yearly. Both sexes reach maturity at approximately 5–6 years at a mean size of 63.5 mm CL (Barsky 2001). It takes a spiny lobster 7–11 years to reach the legal fishery size of 83 mm CL. Females grow faster (4.4 mm/yr) than males (3.7 mm/yr) (Mitchell et al. 1969). Males may live up to 30 years, and reach a maximum length of 91 cm TL and weight of 15.8 kg (34.8 lb). Females may live up to 17 years, and reach a maximum size of 50 cm TL and 5.5 kg (12.1 lb) (MBC 1987).

General Ecology

Lobsters are nocturnal, seeking crevices in which to hide during the day, and moving about the bottom at night (Wilson 1948). *Panulirus* is an omnivorous bottom forager, feeding on snails, mussels, urchins, clams, and fishes (Tegner and Levin 1983, Barsky 2001). A large portion of the population makes seasonal migrations stimulated by changes in water temperature, with an offshore migration in winter, and an inshore migration in late-spring and early summer (Mitchell et al. 1969, Barsky 2001). By the end of August, berried females and juveniles comprise the bulk of the shallow-water population. Warmer water temperatures shorten the development time of lobster eggs. By late September, the thermocline breaks down and lobsters move to deeper water (10–30 m [33–98 ft]) where they remain for the winter (MBC 1987).

Population Trends and Fishery

California spiny lobster have been fished commercially in southern California since the late 1800s (Barsky 2001). They are fished with traps, most of which are constructed of wire mesh. Most traps are fished in shallow rocky areas in waters shallower than 31 m (100 ft) deep. Landings in Catch Block 738 off the HBGS totaled 19,776 lbs ($136,930) in 2003 and 13,095 lbs ($86,707) in 2002 (CDFG 2004). Landings were substantially smaller in the other two catch blocks off the HBGS, totaling 1,448 lbs in 2003 and 1,523 lb in 2002 in Block 739, and 2,680 lbs in 2003 and 5,909 lbs in 2002 in Block 740. Almost all landings were from crab/lobster traps, though some were reported from set longlines.

Sampling Results

Only a single spiny lobster puerulus larva was collected from the source water samples. It was collected during the first source water survey at Station U2. No spiny lobster puerulus larvae were collected from the entrainment station samples.

Impact Assessment

No impact assessment modeling of entrainment effects on spiny lobster was done because only a single lobster puerulus larva was collected in all of the samples.

4.3.3.13 Ridgeback Rock Shrimp (*Sicyonia ingentis*)

Ridgeback rock shrimp (ridgeback prawn) ranges from Monterey, California to Isla Maria Madre, Nayarit, Mexico, including the Gulf of California (MBC 1987). Major concentrations of ridgeback rock shrimp occur in the Santa Barbara Channel between Point Conception and Ventura, off Santa Monica Bay, and off Oceanside, California (Sunada 1984, MBC 1987, Sunada et al. 2001). Another sicyoniid, the target shrimp (*Sicyonia penicillata*), was one of several southern decapods collected in southern California during and after the 1997–1998 El Niño (MBC 1999, LACSD 2000). It normally occurs in the Gulf of California and off the southern half of Baja California (Word and Charwat 1976, Blake and Scott 1997).

Habitat Requirements

Sunada (1984) and Sunada et al. (2001) reported a depth range for ridgeback rock shrimp of 45 to 162 m; however, MBC (1987) listed a depth range of 5 to 307 m. Off the Palos Verdes Peninsula (Los Angeles County) from 1978 through 2000, ridgeback rock shrimp was most abundant on the 137-m isobath, less abundant on the 61-m isobath, and did not appear to be collected on the 23-m isobath (LACSD 2000). They were the most abundant invertebrate collected in 2000 on the 55-m isobath off Huntington Beach (OCSD 2000). Eggs and larvae are pelagic and neritic, while juveniles and adults are benthic (MBC 1987). They occur on substrates of sand, shell, and mud (Sunada et al. 2001).

Reproduction

Ridgeback rock shrimp are oviparous. Spawning in the Santa Barbara Channel occurs from June through October, with possible multiple spawning occurring throughout summer (Anderson et al. 1985a). The sexes are separate, and fertilization is likely external, occurring as eggs are extruded (MBC 1987). Fecundity is estimated at 47,000 to 131,000 embryos per spawn, with an average of 86,000 (Anderson 1985b).

Age and Growth

The maximum life span of ridgeback rock shrimp is about five years (Sunada et al. 2001). Females reach a maximum length of 45 mm CL, and males 37 mm CL (Sunada 1984). Ridgeback rock shrimp move deeper as they grow; hence, smaller individuals are usually found closer to shore. In one study, monthly sampling of rock shrimp revealed a narrow size range (23–

47 mm CL) at 145 m depth, while shrimp collected at 60 m were usually smaller, with a length-frequency distribution peak at about 30 mm CL (Anderson et al. 1985b). In that same study, shrimp collected at 40 m were most commonly 10–25 mm CL.

Molt frequency is high in late spring, prior to the onset of spawning (Anderson et al. 1985a). Females begin a synchronous molt cycle in June that lasts until late-October or early-November, after the spawning season. Males exhibit a similar molt synchrony, but with a shorter period and more variability.

General Ecology

Ridgeback rock shrimp feed on detritus, diatoms, sponges, snails, polychaetes, copepods, ostracods, amphipods, and euphausiids (Mearns 1982, MBC 1987).

Population Trends and Fishery

In one study of the mainland shelf of southern California, ridgeback rock shrimp was one of the most frequently occurring species; it occurred in 61% of the area surveyed, and accounted for 15% of the abundance and 9% of the biomass (Allen et al. 1998). Off the Palos Verdes Peninsula, highest catches of ridgeback rock shrimp occurred during and after El Niño events (e.g. 1982–1984, 1986–1987, and 1998–2000) (LACSD 2000).

The commercial take of ridgeback rock shrimp is exclusively by trawl, and there is a closed season between 1 October and 31 May (CDFG 1999). Ridgeback rock shrimp enter the fishery at age 1 (Anderson et al. 1985b). In 1998, 35 vessels participated in the ridgeback rock shrimp fishery, and over 98% of rock shrimp were caught in the Santa Barbara Channel. A total of 185 tons was landed in 1998, compared with 174 tons in 1997 (CDFG 1999). There were no reported landings of ridgeback rock shrimp in the catch blocks off Huntington Beach in 2002 or 2003.

Sampling Results

No ridgeback rock shrimp late-mysid stage larvae were collected in any of the entrainment or source water samples.

Impact Assessment

No impact assessment modeling of entrainment effects on ridgeback rock shrimp was done because no late-mysid stage larvae were collected.

4.3.3.14 Market Squid (*Loligo opalescens*)

Market squid range from offshore British Columbia to Bahia Asuncion, Baja California, including Guadalupe Island off Baja California (Morris et al. 1980, MBC 1987). However, they are found in highest numbers between Monterey and San Diego, California, and are found north of Puget Sound only during or following El Niño events. The distribution of this species is classified as 'Transitional Endemic' since market squid are limited to the California Current and the eastern portion of the Northeast Pacific Transition Zone. Market squid are managed under the Coastal Pelagic Species Fishery Management Plan (PFMC 1998).

Habitat Requirements

Eggs of the market squid are benthic, while juveniles and adults are considered pelagic (Fields 1965). They are actually found over the continental shelf from the surface to depths of at least 800 m (PFMC 1998). Recksiek and Kashiwada (1979) found larvae in much higher concentrations near bottom than in the water column. Mature squid form large spawning aggregations in nearshore waters, and in southern California, these usually occur from November through August (Fields 1965).

Reproduction

During copulation, a male holds the female from below, and a bundle of spermatophores is subsequently transferred from the mantle cavity of the male to a position near the female's oviduct (Hurley 1977). In southern California, squid spawn primarily in winter (November through August), though spawning has also been recorded in July (Morris et al. 1980). Fields (1965) suggested nighttime spawning in market squid; however, recent observations suggest this species spawns exclusively during daytime (Forsythe et al. 2004). Market squid are terminal spawners, spawning once then dying.

Age at first reproduction is 24–28 weeks (Yang et al. 1986). Egg capsules are usually deposited on sandy substrate, often at the edges of canyons or rocky outcroppings (McGowan 1954). Egg deposition occurs between depths of 5 and 55 m, and is most common between 20 and 35 m (PFMC 1998). Each egg capsule contains 180 to 300 eggs (Morris et al. 1980). Egg development is dependent on water temperature; eggs hatch at 19–25 days at 17°C, 27–30 days at 15°C, and 30–35 days at 14°C (Yang et al. 1986). Females produce 20–30 egg capsules, and each capsule is individually attached to the substrate (PFMC 1998). Fields (1965) reported four females depositing 17,000 eggs in 85 capsules in one evening, equivalent to about 21 capsules and 4,250 eggs per squid. Recksiek and Frey (1978) reported a fecundity of 4,000 to 9,000 eggs per female (MBC 1987). Macewicz et al. (2004) report an average fecundity of 3,844 oocytes based on an average female length of 129 mm dorsal mantle length (DML).

Age and Growth

Young squid hatch within three to five weeks after the capsule is deposited (McGowan 1954, Fields 1965). Newly hatched squid (paralarvae) resemble miniature adults and are about 2.5–3.0 mm in length. After hatching, young *Loligo* swim upward toward the light, bringing them to the sea surface (Fields 1965).

Butler et al. (1999) determined growth averages about 0.6 mm dorsal mantle length (DML) per day, and maximum ages in 1998 were 238 days for females and 243 days for males. Yang et al. (1986) recorded a maximum life span of 235 and 248 days for two laboratory-reared populations. Yang et al. (1986), Butler et al. (1999), and Jackson (1998) determined that Fields (1965) and Spratt (1979) underestimated growth and overestimated longevity—squid were initially reported to live as long as three years. Growth increases exponentially during the first two months, then slows to logarithmically thereafter (Yang et al. 1986). Schooling behavior has been observed in squid as small as 15 mm DML (Yang et al. 1986).

Squid spawned in early summer (August -May) will grow rapidly during the summer growing season when nutrients from increased upwelling cause plankton blooms. As spawning continues from June through September, newly hatched squid have less time available in the growing season, which can slow the growth rate (Spratt 1979). Adults measure up to 305 mm total length and weigh between 56 and 84 g (Vojkovich 1998), with spawning males normally being larger than females. Males reach 19 cm DML, a maximum weight of about 130 g, and have larger heads and thicker arms than females (PFMC 1998). Females reach about 17 cm DML and a maximum weight of 90 g.

General Ecology

Planktonic invertebrates are the primary food source of young squid (Spratt 1979). Squid feed mostly on crustaceans, and to a lesser degree fishes, cephalopods, gastropods, and polychaetes (Karpov and Cailliet 1979). The diet of market squid changes with water depth and location, but does not differ much among size classes or between sexes (Karpov and Cailliet 1979). Squid captured in deeper water feed more frequently on euphausiids and copepods, whereas squid captured near the surface feed predominantly on euphausiids, as well as cephalopods, fishes, mysids, and megalops larvae. In spawning schools, 75% of stomachs examined had remains of market squid (Fields 1965).

Cailliet et al. (1979) determined affinities of multiple species with market squid. In Monterey Bay, the species with the highest affinities with market squid were northern anchovy, Pacific electric ray (*Torpedo californica*), Scyphomedusae (jellies), plainfin midshipman (*Porichthys notatus*), Pacific sanddab (*Citharichthys stigmaeus*), and white croaker.

Population Trends and Fishery

Large-scale fluctuations are characteristic of the squid stock, due primarily to its short life span and from the influence of wide variations in oceanographic conditions (NMFS 1999). However, the short life history of this species allows for squid to recover after natural population declines as soon as ocean conditions improve. The best information indicates squid have a high natural mortality rate (approaching 100% per year) and that the adult population is composed almost entirely of new recruits (PFMC 1998). In 1997, California passed Assembly Bill AB 364, which not only initiated closures and established a fishery permit fee, but designated funds from the permits to be used for squid research and management.

The California fishery for market squid began in Monterey Bay in the late-1800s (Vojkovich 1998). It expanded into southern California only after the 1950s, and prior to 1987, catches in southern California rarely exceeded 20,000 metric tons. After that, landings increased four-fold until the fishery collapsed in 1998, and California squid fishers sought federal disaster assistance (Zeidberg et al. 2004). In California, most squid marketed for human consumption is frozen, but smaller amounts are canned or sold fresh (PFMC 1998). Squid are also sold live and frozen for bait.

Landings in Catch Block 738 off the HBGS totaled 34,260 lbs ($6,852) in 2003 and 4,138,223 lbs ($388,878) in 2002 (CDFG 2004). Landings in the other two catch blocks off the HBGS totaled 252,277 lbs ($42,813) in 2003 and 913,326 lb ($109,728) in 2002 in Block 739, and 133,230 lbs ($27,544) in 2003 and 76,578 lbs ($7,658) in 2002 in Block 740. The majority of the landings were from purse seine and drum seine, though some were reported from brail (dip-nets).

Sampling Results

No newly hatched market squid were collected in any of the entrainment or source water samples.

4.3.3.15 Rock Crabs (*Cancer* spp.)

Crabs of the genus *Cancer* are widely distributed in the coastal waters of the west coast of North America. They occur in intertidal and shallow subtidal habitats on both rock and sand substrate. Of the nine species known to occur in the northeast Pacific, four species contribute to economically significant fisheries. Dungeness crab (*Cancer magister*) has the highest economic value among these, and three species of rock crabs (yellow crab *C. anthonyi,* brown rock crab *C. antennarius,* and red rock crab *C. productus*) comprise the remainder of the catches. These three species of rock crab, and the smaller slender crab (*C. gracilis*) may all be found in the vicinity of HBGS.

Each species in the genus has characteristic differences in distribution, preferred habitat, growth rates, and demographic parameters. For example, brown rock crab is a relatively large species (carapace width >200 mm) that lives primarily on sand and mud substrates in estuarine and coastal shelf areas. Slender crab is a smaller species (carapace width >130 mm) associated with mixed rock-sand substrates in shallow outer coast habitats. Maximum clutch sizes in *Cancer* crabs can range from as many as 5,000,000 eggs in *C. anthonyi* to approximately 50,000 in pygmy rock crab (*C. oregonensis*), one of the smaller *Cancer* species (Hines 1991). These types of differences imply that specific information on life history parameters cannot readily be generalized among *Cancer* species.

Habitat Requirements

The brown rock crab primarily inhabits rocky shores and rocky subtidal reefs, but may bury in coarse to silty sands adjacent to preferred habitat. Ovigerous brown rock crabs have been observed buried in sand at the base of rocks in shallow water and are found more commonly in water less than 18 m (59 ft) deep in southern California.

The nearshore distribution of crab larvae depends upon developmental stage. Shanks (1985) presented evidence that early stage larvae of rock crabs (probably yellow crab in his southern California study) generally occur near the bottom, in depths up to 80 m; late stage larvae, however, were more abundant near the surface. He suggested that a combination of physical factors (primarily including wind-generated surface currents and tidally forced internal waves) caused megalopae to be transported shoreward. Late stage larvae (megalops) generally begin to recruit to the nearshore habitat in spring (Winn 1985).

During their planktonic existence, crab larvae can become widely distributed in nearshore waters. In one study in Monterey Bay, Graham (1989) found that brown rock crab Stage 1 zoea are most abundant close to shore and that subsequent zoeal stages tend to remain within a few kilometers of the coastline. The adult population primarily resides in relatively shallow rocky areas, and the nearshore retention of larvae in Graham's study (1989) was related to the formation of an oceanographic frontal zone in northern Monterey Bay that prevented substantial offshore transport during upwelling periods.

The slender crab is commonly found on mud flats and in beds of eelgrass although it is usually not found intertidally south of central California (Morris et al. 1980). It occurs from Prince William Sound, Alaska to Bahia Playa Maria, Mexico in the low intertidal to 143 m (470 ft) (Jensen 1995). Although seasonally found in bays, the slender crab does not tolerate brackish conditions.

Reproduction

All species of *Cancer* crabs share certain fundamental life history traits. Eggs are extruded from the ovaries through an oviduct and are carried in a sponge-like mass beneath the abdominal flap of the adult female. After a development period of several weeks, the eggs hatch and a pre-zoea larva emerges, beginning the planktonic life history phase. As in all crustaceans, growth progresses through a series of molts. The planktonic larvae advance through six stages of successive increases in size: five zoea (not including the brief pre-zoea stage) and one megalopal. After several weeks as planktonic larvae, the crabs metamorphose into the first crab stage (first instar) and settle out to begin their benthic life history phase. Maturity is generally attained within 1–2 years. Mature females mate while in the soft shell molt condition and extrude fertilized eggs onto the abdominal pleopods. Females generally produce one or two batches per year, typically in winter.

The main determinant of brood size and reproductive output in brachyuran crabs is body size, and the range of egg production in *Cancer* crabs generally reflects this relationship (Hines 1991). Yellow crab, the largest of the species found in the HBGS samples, produce on average 2.21 million eggs per brood. The next largest species, red rock crab, produces 877,000 eggs per brood. Brown rock crab females seem to be an exception to this relationship because they are, on average, smaller than the red rock crab, yet produce an average of 1.2 million eggs per batch. Slender crab is the smallest of the four species living near HBGS and their average egg production per brood is 454,000. Female *Cancer* crabs on average produce a single batch per year, generally in the winter; however, due to occasional multiple spawnings, the average number of batches per year may be greater than one (Carroll 1982, Hines 1991).

Age and Growth

Anderson and Ford (1976) described the growth of yellow crab under laboratory conditions. Total larval development times from hatching through the megalops stage were 33 days and 45 days at 22°C and 18°C, respectively. The total time spent in the megalops stage averaged 8 days at 22°C and 12 days at 18°C. Yellow crab can live at least 5 years and attain a carapace width of 170 mm after 16 crab instars (molts).

Brown rock crab eggs require a development time of approximately 7–8 weeks from extrusion to hatching (Carroll 1982). Larval development in the brown rock crab was described by Roesijadi (1976). Eggs hatch into pre-zoea larvae that molt to first stage zoea in less than 1 hour. Average larval development time (from hatching through completion of the fifth stage) was 36 days at 13.8°C. Although some crabs molted to the megalops stage, none molted to the first crab instar stage, so the actual duration of the megalops stage is unknown. Based on a predicted megalops duration of approximately 12 days measured for the closely related yellow crab, the estimated length of time from hatching to settling for brown rock crab is approximately 48 days. Brown rock crabs mature at an age of about 18 months post-settlement with a size of approximately 60 mm carapace width and a weight of 73 g (Carroll 1982). Faster growth rates may occur in highly productive environments such as on the supporting members of offshore oil platforms and females may become reproductive in less than 1 year post-settlement (D. Dugan, pers. comm.). Brown rock crabs can probably live to a maximum age of about 6 yr. Size at recruitment to the fishery is approximately 125 mm carapace width, at an age of 4 years for males and 4.5 years for females.

Slender crab larval development was described by Ally (1975). Eggs hatch into pre-zoea larvae, which quickly molt to first stage zoea. Average larval development time (from hatching through completion of the megalops stage) was 48.9 days at 17°C, with most zoeal stages lasting approximately one week. Ally (1975) found an average duration of the megalops stage of 14.6 days. Based on field growth studies, it was estimated that slender crabs matured at an age of about 10 months post-settlement to a size of approximately 60 mm carapace width (Orensanz and Gallucci 1988). Growth occurs through 11–12 instars, with crabs attaining an estimated maximum age of 4 years post-settlement.

There are no published estimates of rock crab larval mortality. However, data from the abundance of brown rock crab zoea and megalops in the Diablo Canyon Power Plant 316(b) demonstration (Tenera 2000a) was used to estimate mortality between stages. First stage zoea of the taxa *Cancer antennarius*, *C. anthonyi*, and *C. gracilis* (combined because of uncertainties in identification) were substantially more abundant, on average, than all other stages combined. The proportions of each species of zoea stage 1 were derived by using the proportions of each species in zoea stage 2 that could be identified to species. An instantaneous larval mortality of 0.158/day was estimated by fitting an exponential curve to the estimated numbers of entrained densities of zoea stage 1 and megalops and using 38 days as the time between stages (i.e., 5 days and 43.3 days, respectively).

General Ecology

Cancrid crabs function as both scavengers and predators in the marine environment. Prey varies as a function of age and size of the individual but benthic invertebrates such as clams, worms, and snails comprise the majority of prey species. Claw morphology of each species is adapted to the types of preferred prey. For example, the heavier crusher claws of the brown rock crab and yellow crab facilitate the breaking of gastropod shells whereas the tapered dactyls of the slender crab are used to probe in soft sediments for worms and other soft-bodied prey. Winn (1985) documented the occurrence of cannibalism among rock crabs, particularly adults on juveniles. However, since juveniles generally inhabited shallower areas than adults, effects on the younger cohorts were diminished.

During their planktonic existence, crab larvae can become widely distributed in nearshore waters. In a study in Monterey Bay, Graham (1989) found that slender crab stage 1 zoeae were very abundant close to shore (within 6 km) during March and August. Later stage larvae, including megalopae, were found further from shore during all times of the year. This offshore larval distribution, compared to the nearshore distribution of brown rock crab larvae found by Tenera (2000a), probably reflects the fact that adult slender crabs are widely distributed in coastal shelf areas, further offshore than brown rock crabs. The megalops larvae and juvenile crabs are frequently found crawling unharmed on and under the bells, and even in the stomachs, of larger jellyfishes, especially *Chrysaora colorata* (Morris et al. 1980).

Juvenile rock crabs are an important prey item for a variety of fishes and invertebrates. In southern California, this includes barred sand bass (*Paralabrax nebulifer*), shovelnose guitarfish (*Rhinobatos productus*) and the sand star (*Astropecten verrilli*) (Roberts et al. 1984, VanBlaricom 1979).

Population Trends and Fishery

Rock crabs are fished along the entire California coast with crab pots, though some landings are reported from set gill nets and trawls as well (CDFG 2004). Three species are harvested commercially: brown rock crab, red rock crab, and yellow crab. There is no commercial fishery for the slender crab. The rock crab fishery is most important in southern California (from Morro Bay south), which produces a majority of the landings, and of lesser importance in northern areas of California where a fishery for the more desirable Dungeness crab takes place. Most rock crabs are landed alive for retail sale by fresh fish markets. The commercial harvest has been difficult to assess on a species-by-species basis because the fishery statistics are combined into the general "rock crab" category. From 1991 through 1999 state-wide rock crab landings (including claws) averaged 1.2 million lb./year (Parker 2001).

Regulations currently specify a minimum harvest size of 4.25-in. carapace width. A small recreational fishery for rock crabs also exists, with a 4.00-inch minimum carapace width and a personal bag limit of 35 crabs per day. Crabs are collected by divers or shore pickers with hoop nets and crab traps.

Recent catch statistics from the PSMFC PacFIN (commercial) database were examined for the years 2000–2004 for southern California (San Diego, Orange and Los Angeles counties). The average annual commercial catch and ex-vessel revenue from rock crab for the years 2000–2004 was approximately 99,000 lbs and $120,000, respectively, with most of the landings from San Diego County. During this period the greatest catches for all counties combined were in 2000 (119,483 lbs) and the least were in 2004 (68,491 lbs).

The following commercial landings statistics were compiled from California Department of Fish and Game landings records:

Yellow rock crab. There were no reported landings for yellow rock crab in Catch Blocks 738 and 739 off the HBGS in 2002 and 2003 (CDFG 2004). There were 53 lbs ($65) reported from Catch Block 740 in 2003, but no landing from that block in 2002.

Rock crab – unspecified. Landings in Catch Block 738 off the HBGS totaled 1,340 lbs ($730) in 2003 and 5,569 lbs ($5,121) in 2002 (CDFG 2004). Landings in the other two catch blocks off the HBGS totaled 2,893 lbs ($2,949) in 2003 and 642 lb ($658) in 2002 in Block 739, and 3,729 lbs ($4,212) in 2003 and 9,771 lbs ($13,533) in 2002 in Block 740.

Crab claws – unspecified. Crab claw landings reported in Catch Block 738 off the HBGS totaled nine pounds ($0) in 2003, with no landings in 2002 (CDFG 2004). Landings in the other two catch blocks off the HBGS totaled 66 lbs ($58) in 2003 and 14 lb ($14) in 2002 in Block 739, and 187 lbs ($164) in 2003 and 717 lbs ($769) in 2002 in Block 740.

Sampling Results

Yellow crab were the most abundant rock crab megalops in the entrainment samples followed by slender crab, brown rock crab, and red rock crab (Table 4-2). In the source water samples yellow crab and slender crab megalops were collected in nearly equal concentrations, followed by brown rock crab and red rock crab (Table 4-5). A plot of entrainment sample concentrations of all species combined showed a strong seasonal occurrence in summer months with a periodicity of approximately six weeks and increasing amplitude through the August survey (Figure 4-33a). Greatest concentrations occurred in July in the source water samples (Figure 4-33b).

Impact Assessment

The total annual estimated entrainment of megalops of the three commercially fished crab species (yellow crab, brown rock crab, and red rock crab) was 6,411,171 (including *Cancer* spp. megalops). The following section presents the results for empirical transport modeling of circulating water system effects on these combined species because they are not differentiated in catch records and all three species are similar and co-occur in the study area. There was not enough information available on mortality rates to parameterize the demographic models.

Empirical Transport Model (*ETM*)

The *PE* estimates for rock crabs range from 0 to 0.01 (Table 4-29). The values of f_i indicate that rock crab larvae were most abundant in the source water during the June through August period with a peak in July. There were four surveys when larvae were collected at the source water stations, but were not collected at the entrainment station. The values of f_i indicate that these were periods when crab larvae were less abundant in the source water. The values in the table were used to calculate two P_M estimates: one based on alongshore current movement, and the other based on alongshore current movement and an extrapolation of densities offshore to a distance bounded by either the extrapolated densities or onshore current movement. A megalops larval duration of 12 days was used for the number of days at risk to entrainment based on laboratory rearing data of larvae cultured at 18°C (Anderson and Ford 1976). The estimate of P_M for the 12-day period of exposure calculated using offshore extrapolated densities (0.009, 0.9%) is less than the estimate calculated using alongshore current displacement (0.011, 1.1%) because the effects of entrainment are spread over a much larger population for the offshore extrapolated estimate (Table 4-30). The P_S estimates indicate that the ratio of the sampled source water to the total population for the alongshore and offshore P_M estimates were 39.4 and 24.5% percent, respectively and the alongshore estimate was extrapolated over a shoreline distance of 26.5 km.

Table 4-29. *ETM* data for commercially fished *Cancer* crab megalops. *ETM* calculations based on sampling grid volume of 908,157,859 m^3, and daily circulating water volume of 1,919,204 m^3. Average *PE* estimate calculated from all surveys with *PE* >0.

Survey Date	*PE* Estimate	*PE* Std. Error	f_l Estimate	f_l Std. Error
17-Sep-03	0.00000	0.00000	0.00000	0.00000
13-Oct-03	0.00000	0.00000	0.00241	0.00766
10-Nov-03	0.00000	0.00000	0.00000	0.00000
8-Dec-03	0.00000	0.00000	0.01801	0.03054
5-Jan-04	0.01356	0.02684	0.00908	0.01540
9-Feb-04	0.00000	0.00000	0.00235	0.00714
8-Mar-04	0.00000	0.00000	0.00000	0.00000
5-Apr-04	0.00000	0.00000	0.00299	0.00811
3-May-04	0.00560	0.01466	0.00899	0.01596
1-Jun-04	0.00199	0.00282	0.16365	0.14691
12-Jul-04	0.00325	0.00622	0.66245	0.23482
31-Aug-04	0.00131	0.00310	0.13007	0.15900
Average =	0.00514			

Table 4-30. Average P_S values and *ETM* estimates for alongshore current and offshore extrapolated models for *Cancer* crab megalops. Current displacement (km) for alongshore extrapolation included in parentheses with estimate of P_S for alongshore estimate of P_M.

Parameter	Average P_S (displacement)	*ETM* Estimate (P_M)	*ETM* Std. Err.	Upper 95% CI	Lower 95%CI
Alongshore Current	0.3940 (26.5)	0.01070	0.33544	0.34614	0
Offshore Extrapolated	0.2453	0.00854	0.33268	0.34122	0

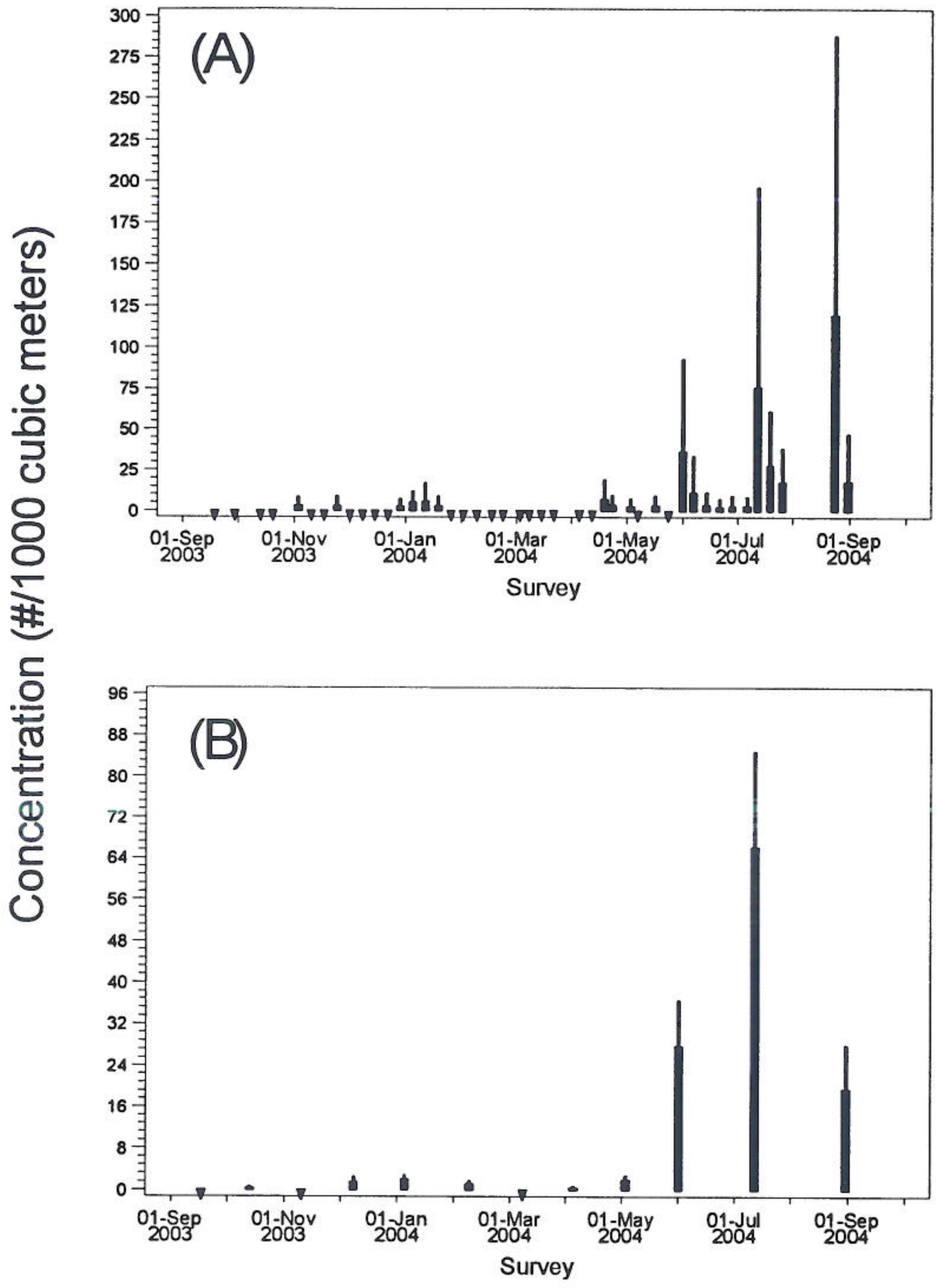

Figure 4-33. Survey mean concentration (#/1000 m^3) of *Cancer* crab megalops collected at the HBGS entrainment (A) and source water (B) stations with standard error indicated (+1 SE). Down arrows indicate surveys when no *Cancer* crab megalops were collected.

4.4 Impingement

The U.S. EPA defines entrainment as "the entrapment of all life stages of fish and shellfish on the outer part of an intake structure or against a screening device during periods of intake water withdrawal" (USEPA 2002a). At the HBGS, impingement occurs when organisms are held with the cooling water flow against the bar racks or traveling screens within the facility. Impinged organisms may be alive or dead.

4.4.1 Fish Impingement

In total, an estimated 51,082 fishes representing 57 species were impinged during 52 normal operations and six heat treatment surveys (Table 4-31). Surveys were conducted from July 2003 through July 2004. Total impingement biomass was 1,292 kg (2,848 lb). The most abundant fish species were queenfish (70%), white croaker (10%), shiner perch (8%), and northern anchovy (4%). Abundance during six heat treatment impingement surveys accounted for 75% of total impingement abundance. Data are presented by survey in Appendix C.

Normal Operations Results

An estimated 12,694 fish representing 36 species were impinged during 52 weeks of normal operations surveys (Table 4-31). Highest normal operations abundance occurred on 28 January 2004. Aside from this somewhat anomalous impingement total, there were slight seasonal peaks of abundance in Sept.-Oct. 2003 (mainly queenfish and northern anchovy) and in Apr.-May 2004 (primarily queenfish and white croaker). The most abundant species were queenfish (83%), northern anchovy (7%), white croaker (2%), and shiner perch (2%). Abundance during the 52 normal operations surveys accounted for 25% of total impingement abundance. Fish biomass for the survey year totaled 290 kg (639 lb). Biomass was dominated by larger elasmobranchs, such as Pacific electric ray (*Torpedo californica*; 45%), thornback (*Platyrhinoidis triseriata*; 6%), and bat ray (*Myliobatis californica*; 4%), as well as some of the more abundant fish species, including queenfish (20%) and specklefin midshipman (*Porichthys myriaster*; 4%).

Heat Treatment Results

An estimated 38,388 fish representing 55 species were impinged during six heat treatment surveys (Table 4-31). The most abundant species were queenfish (66%), white croaker

Table 4-31. Fish impingement totals from 52 normal operation and 6 heat treatment surveys. (Continued on following page).

Species	Common Name	Normal Operation Totals		Heat Treatment Totals		Impingement Totals		Percent of Total	
		No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt.
Seriphus politus	queenfish	10,468	58.015	25,379	590.141	35,847	648.156	70.2	50.2
Genyonemus lineatus	white croaker	274	3.374	4,629	92.047	4,903	95.421	9.6	7.4
Cymatogaster aggregata	shiner perch	215	2.014	3,830	49.813	4,045	51.827	7.9	4.0
Engraulis mordax	northern anchovy	824	5.513	1,369	9.343	2,193	14.856	4.3	1.2
Phanerodon furcatus	white seaperch	80	0.485	789	18.588	869	19.073	1.7	1.5
Peprilus simillimus	Pacific butterfish	131	2.096	470	13.826	601	15.922	1.2	1.2
Hyperprosopon argenteum	walleye surfperch	30	0.498	446	15.255	476	15.753	0.9	1.2
Atherinopsis californiensis	jacksmelt	23	2.370	309	27.298	332	29.668	0.7	2.3
Atherinops affinis	topsmelt	-	-	231	3.664	231	3.664	0.5	0.3
Leuresthes tenuis	California grunion	49	0.211	91	0.498	140	0.709	0.3	0.1
Paralabrax clathratus	kelp bass	-	-	138	46.965	138	46.965	0.3	3.6
Scorpaena guttata	California scorpionfish	35	5.528	75	21.066	110	26.594	0.2	2.1
Sardinops sagax	Pacific sardine	69	3.322	38	3.994	107	7.316	0.2	0.6
Urobatis halleri	round stingray	52	17.322	48	22.331	100	39.653	0.2	3.1
Porichthys myriaster	specklefin midshipman	99	10.249	1	0.006	100	10.255	0.2	0.8
Embiotoca jacksoni	black perch	12	1.873	54	5.288	66	7.161	0.1	0.6
Cheilotrema saturnum	black croaker	21	0.330	44	6.682	65	7.012	0.1	0.5
Paralabrax nebulifer	barred sand bass	7	0.364	55	9.301	62	9.665	0.1	0.7
Atractoscion nobilis	white seabass	11	0.135	49	4.793	60	4.928	0.1	0.4
Roncador stearnsii	spotfin croaker	-	-	49	1.766	49	1.766	0.1	0.1
Chromis punctipinnis	blacksmith	7	0.015	39	2.241	46	2.256	0.1	0.2
Xenistius californiensis	salema	11	0.101	35	0.345	46	0.446	0.1	<0.1
Pleuronichthys ritteri	spotted turbot	35	2.438	4	0.007	39	2.445	0.1	0.2
Menticirrhus undulatus	California corbina	-	-	33	3.104	33	3.104	0.1	0.2
Torpedo californica	Pacific electric ray	31	129.444	-	-	31	129.444	0.1	10.0
Heterostichus rostratus	giant kelpfish	21	1.045	9	0.708	30	1.753	0.1	0.1
Synodus lucioceps	California lizardfish	29	1.130	-	-	29	1.130	0.1	0.1
Pleuronichthys verticalis	hornyhead turbot	27	0.277	1	0.144	28	0.421	0.1	<0.1
Myliobatis californica	bat ray	19	10.659	5	7.267	24	17.926	<0.1	1.4
Citharichthys stigmaeus	speckled sanddab	14	0.043	9	0.054	23	0.097	<0.1	<0.1
Paralichthys californicus	California halibut	15	4.068	6	5.868	21	9.936	<0.1	0.8
Anchoa compressa	deepbody anchovy	6	0.032	14	0.144	20	0.176	<0.1	<0.1
Leptocottus armatus	Pacific staghorn sculpin	17	0.870	3	0.103	20	0.973	<0.1	0.1
Platyrhinoidis triseriata	thornback	18	15.812	2	1.242	20	17.054	<0.1	1.3
Girella nigricans	opaleye	7	4.274	12	8.378	19	12.652	<0.1	1.0
Rhacochilus vacca	pile perch	-	-	19	4.729	19	4.729	<0.1	0.4
Anisotremus davidsonii	sargo	-	-	17	1.434	17	1.434	<0.1	0.1
Rhacochilus toxotes	rubberlip seaperch	-	-	17	0.745	17	0.745	<0.1	0.1
Scomber japonicus	chub mackerel	-	-	17	0.336	17	0.336	<0.1	<0.1
Medialuna californiensis	halfmoon	-	-	13	3.545	13	3.545	<0.1	0.3
Porichthys notatus	plainfin midshipman	9	3.267	1	0.003	10	3.270	<0.1	0.3
Trachurus symmetricus	jack mackerel	7	0.030	2	0.253	9	0.283	<0.1	<0.1
Ophidion scrippsae	basketweave cusk-eel	7	0.378	1	0.011	8	0.389	<0.1	<0.1
Pleuronichthys guttulatus	diamond turbot	6	0.849	2	0.358	8	1.207	<0.1	0.1
Ophichthus zophochir	yellow snake eel	6	1.332	1	0.200	7	1.532	<0.1	0.1
Chilara taylori	spotted cusk eel	-	-	7	0.128	7	0.128	<0.1	<0.1
Umbrina roncador	yellowfin croaker	-	-	6	1.934	6	1.934	<0.1	0.1

Continued on next page.

Table 4-31. (Continued).

		Normal Operation Totals		Heat Treatment Totals		Impingement Totals		Percent of Total	
Species	Common Name	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt.
Halichoeres semicinctus	rock wrasse	-	-	4	1.391	4	1.391	<0.1	0.1
Hypsoblennius gilberti	rockpool blenny	-	-	3	0.016	3	0.016	<0.1	<0.1
Rhinobatos productus	shovelnose guitarfish	-	-	2	11.174	2	11.174	<0.1	0.9
Sebastes auriculatus	brown rockfish	-	-	2	1.184	2	1.184	<0.1	0.1
Triakis semifasciata	leopard shark	-	-	2	0.812	2	0.812	<0.1	0.1
Syngnathus californiensis	kelp pipefish	-	-	2	0.007	2	0.007	<0.1	<0.1
Paralabrax maculatofasciatus	spotted sand bass	-	-	1	0.900	1	0.900	<0.1	0.1
Semicossyphus pulcher	California sheephead	-	-	1	0.359	1	0.359	<0.1	<0.1
Odontopyxis trispinosa	pygmy poacher	-	-	1	0.005	1	0.005	<0.1	<0.1
Sebastes miniatus	vermillion rockfish	-	-	1	0.002	1	0.002	<0.1	<0.1
	Totals:	12,694	289.763	38,388	1,001.80	51,082	1,291.559	100.0	100.0
	No. of Species:	36		55		57			

(12%), shiner perch (10%), and northern anchovy (4%). Abundance during the six heat treatment impingement surveys accounted for 75% of total impingement abundance. Highest heat treatment abundance was recorded in May 2004 (primarily queenfish and white croaker) and in September 2003 (primarily queenfish and shiner perch).

Fish biomass during the six heat treatment surveys totaled 1,001.8 kg. Biomass was dominated by the most abundant species, such as queenfish (59%), white croaker (9%), and shiner perch (5%), and larger fish such as kelp bass (*Paralabrax clathratus*; 5%) and jacksmelt (*Atherinopsis californiensis*; 3%).

4.4.2 Fish Results by Species

Species-specific analyses are limited to the four species that together comprised 92% of total impingement abundance and 63% of impingement biomass: queenfish, white croaker, shiner perch, and northern anchovy.

4.4.2.1 Queenfish (*Seriphus politus*)

Information on the life history, ecology, population trends, and fishery of queenfish (*Seriphus politus*) is summarized in Section 4.3.3.4.

Sampling Results

Queenfish was the most abundant species collected in both normal operations and heat treatment impingement samples (Table 4-31). Total impingement for the survey period was 35,847 individuals. It occurred in 31 of 52 normal operations surveys, and all six heat treatment surveys (Appendix C). Highest normal operations abundance occurred in late January, and highest heat treatment abundance occurred in late May.

The queenfish measured in impingement surveys ranged from the 40 to 190 mm size classes (Figure 4-34). Distribution was bimodal with peaks at 60-70 mm and 120 mm. Queenfish mature at about 127 mm, during their first spring or second summer (Love 1996). Maximum reported size is 305 mm (Miller and Lea 1972). Therefore, most of the fish impinged were young-of-the-year (YOY) and Age-1 fish. Mean length of fish measured during the six heat treatments was greatest in August (mean of 132 mm SL) and lowest in February (mean of 97 mm SL). Of the 352 mature fish inspected for determination of during the study year, 253 (72%) were female, and 99 (28%) were male.

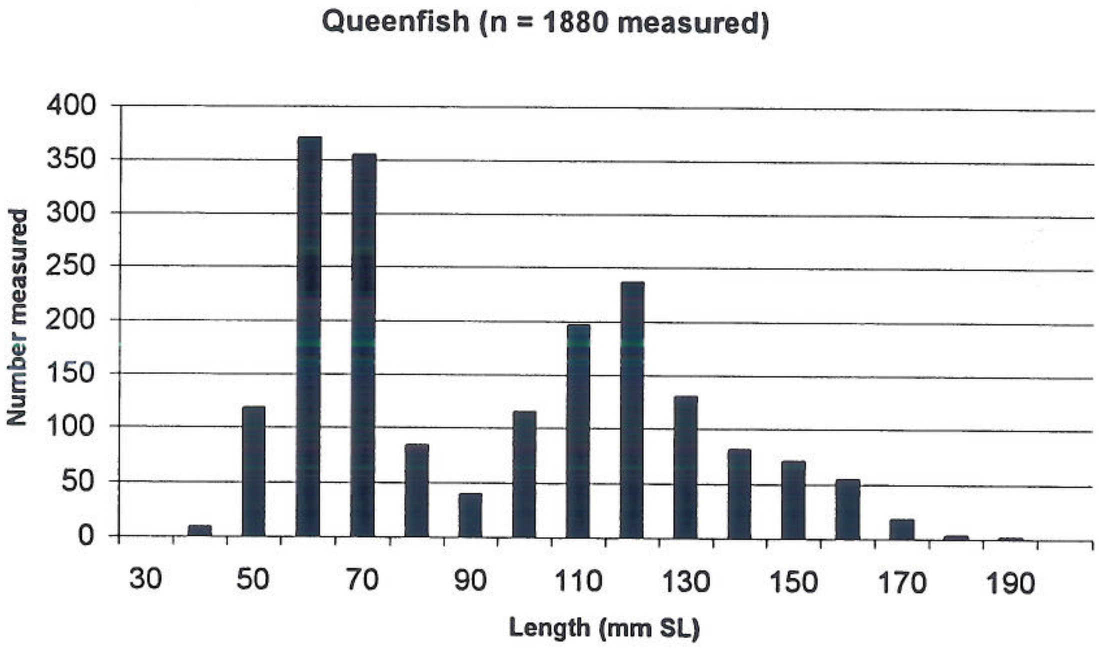

Figure 4-34. Length frequency distribution of queenfish (*Seriphus politus*) in impingement samples.

4.4.2.2 White Croaker (*Genyonemus lineatus*)

Information on the life history, ecology, population trends, and fishery of white croaker (*Genyonemus lineatus*) is summarized in Section 4.3.3.5.

Sampling Results

White croaker was the third most abundant species in normal operations impingement samples, and the second most abundant species in heat treatment samples (Table 4-31). It was collected in only 8 of 52 normal operation samples, but in all six heat treatment samples (Appendix C). Highest normal operations losses were recorded in August 2003 and April-May 2004, and highest heat treatment abundance occurred in May 2004.

The white croaker measured in impingement surveys ranged from the 50 to 200 mm size classes, with most fish in the 80-90 mm size classes (Figure 4-35). White croaker mature between about 130 and 190 mm, somewhere between their first to fourth year (Love et al. 1984, Love 1996). Therefore, most of the white croaker impinged were probably in their first year. Mean length of fish measured during the six heat treatments was greatest in February (mean of 133 mm SL) and lowest in August 2003 and May 2004 (mean of 95 mm SL). New recruits (50 to 60 mm) were most common in late winter through spring (January through May 2004). Of the 108 mature individuals inspected for determination of sex during the study year, 61 (56%) were female and 47 (44%) were male.

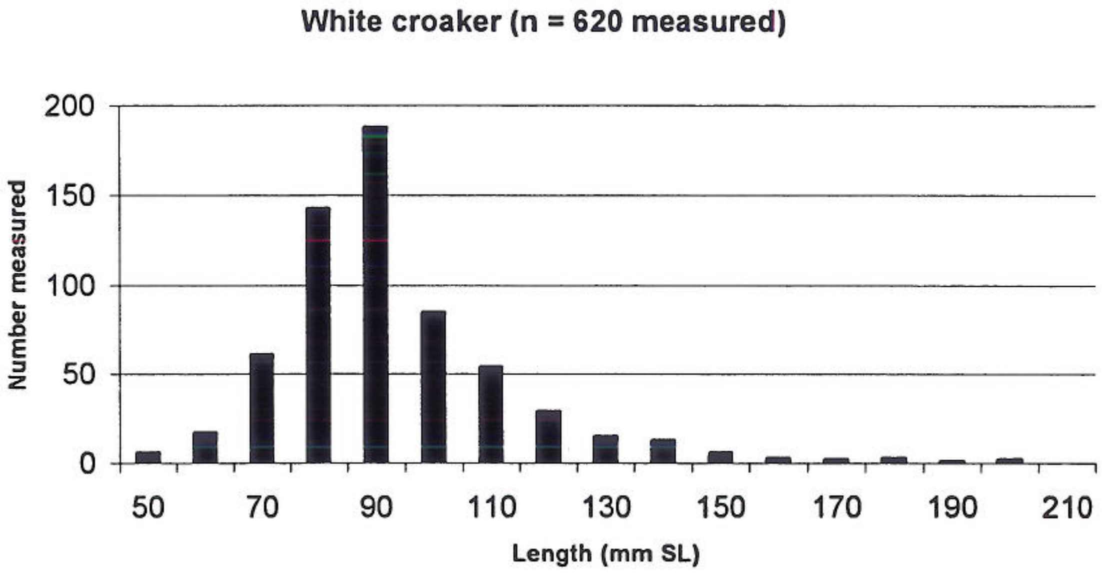

Figure 4-35. Length frequency distribution of white croaker (*Genyonemus lineatus*) in impingement samples.

4.4.2.3 Shiner Perch (*Cymatogaster aggregata*)

Shiner perch (*Cymatogaster aggregata*) ranges from San Quintin Bay, Baja California, to Port Wrangell, Alaska (Miller and Lea 1972). There are 19 species of Pacific nearshore surfperches (Family Embiotocidae) that occur off southern California (Miller and Lea 1972). Most inhabit nearshore waters, bays, and estuaries, though some are found further offshore. Of the 19 species of surfperches that occur in southern California, 10 species besides shiner perch have been collected either within or directly offshore the AES HBGS: shiner perch, walleye surfperch (*Hyperprosopon argenteum*), white seaperch (*Phanerodon furcatus*), black perch (*Embiotoca jacksoni*), kelp surfperch (*Brachyistius frenatus*), pile perch (*Rhacochilus vacca*), barred surfperch (*Amphistichus argenteus*), rubberlip surfperch (*Rhacochilus toxotes*), striped surfperch (*Embiotoca lateralis*), rainbow surfperch (*Hypsurus caryi*), and pink seaperch (*Zalembius rosaceous*) (Appendix C-5).

Habitat Requirements

Shiner perch occurs primarily in shallow-water marine, bay, and estuarine habitats (Emmett et al. 1991), and is demersal on sandy and muddy bottoms. On the southern California shelf, shiner perch are found at depths to 90 m, and Allen (1982) reported most occur at about 70 m. It has been reported to depths of 146 m (Miller and Lea 1972). Juveniles and adults occur in oligohaline to eurohaline waters, and even occasionally in fresh water. This species forms schools or aggregations during the day (Fitch and Lavenberg 1975), but solitary individuals are found on the bottom at night. Important prey items for this species off southern California include calanoid copepods and chaetognaths (Allen 1982). It is a predominantly diurnal visual plankton picker, but larger individuals may engage in nocturnal epibenthic searching (Allen 1982). Shiner perch, along with white croaker, formed Allen's (1982) "nearshore schoolers" recurrent group; the two species occur commonly off southern California even though shiner perch is considered a cold-temperate, outer-shelf species, while white croaker is a temperate, inner-shelf species.

Reproduction

Eggs of the shiner perch are fertilized internally, and females give birth to live young. Mating occurs primarily in the spring and summer in California (Bane and Robinson 1970). The reproductive capacity of this species is directly related to female size; smaller females produce as few as 5 young, while larger females can produce over 20 young (Wilson and Millemann 1969).

Age and Growth

Shiner perch have no larval stage. At birth, fully developed young are about 34 to 78 mm in length (Wilson and Millemann 1969, Hart 1973). Shiner perch live for about eight years and reach about 180 mm in length (Miller and Lea 1972, Hart 1973).

Population Trends and Fishery

This species is not commercially important, but some shiner perch are landed for bait and human consumption (Emmett et al. 1991). Shiner perch are fished recreationally, especially from piers and in bays and estuaries. Total statewide recreational landings of "surfperches" were 489,000 fish in 1999, with most of the catch in central and northern California (Fritzche and Collier 2001). Numbers of shiner perch in southern California waters declined after the mid-1970s, and this is likely related to warming ocean temperature, decreased zooplankton biomass, and reduced upwelling (Stull and Tang 1996, Beck and Herbinson 2003, Allen et al. 2003).

Sampling Results

Shiner perch ranked fourth in normal operations abundance, and third in heat treatment abundance, with 95% of the impingement occurring during heat treatments (Table 4-31). Total impingement for the study year was 4,045 individuals. This species occurred in only 6 of 41 normal operations surveys, but in all six heat treatment surveys (Appendix C). Highest abundances were recorded in September 2003.

The shiner perch measured in impingement surveys ranged from the 50 to 120 mm size classes, with most fish in the 70 mm size class (Figure 4-36). Therefore, most of the impinged fish were YOY. The smallest shiner perch (40 and 50 mm size classes) appeared in May 2004, corresponding to the known spawning season of shiner perch (Bane and Robinson 1970). Of the 170 mature fish inspected for determination of sex during the study year, 130 (76%) were female, and 40 (24%) were male.

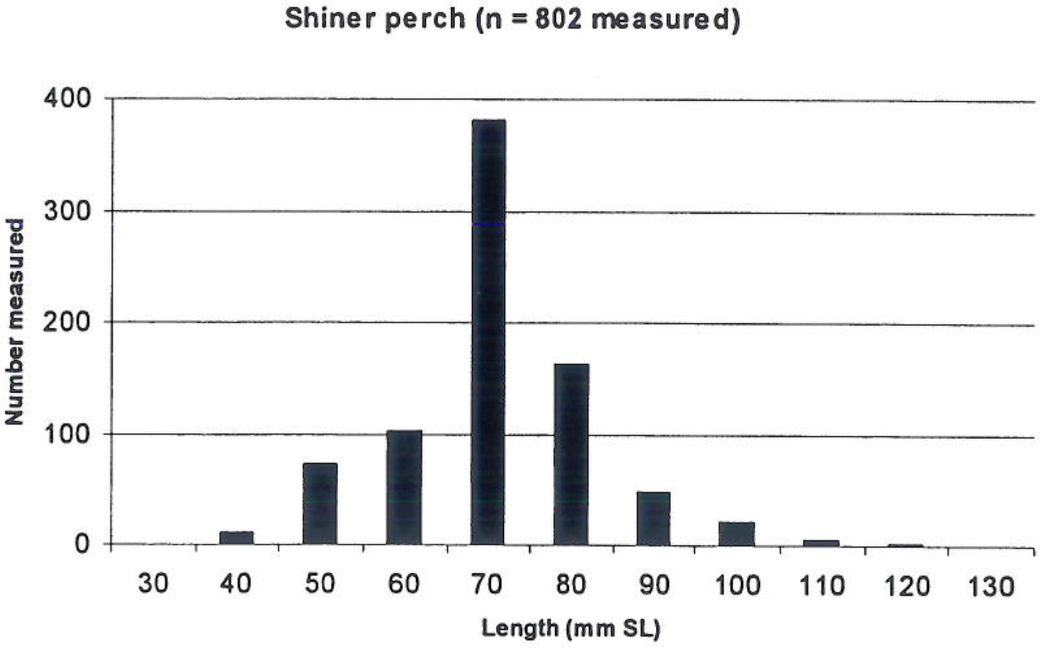

Figure 4-36. Length frequency distribution of shiner perch (*Cymatogaster aggregata*) in impingement samples.

4.4.2.4 Northern Anchovy (*Engraulis mordax*)

Information on the life history, ecology, population trends, and fishery of northern anchovy (*Engraulis mordax*) is summarized in Section 4.3.3.2.

Sampling Results

Northern anchovy were the second most abundant species in normal operations impingement samples, and the fourth most abundant species in heat treatment samples (Table 4-31). It was collected in 16 of 52 normal operation samples, and during all six heat treatment surveys (Appendix C). Highest normal operations abundance occurred in September-October, and highest heat treatment abundance was recorded in September.

The northern anchovy measured in impingement surveys ranged from the 20 to 130 mm size classes, with most fish in the 80-90 mm size classes (Figure 4-37). Northern anchovy reach 102 mm in their first year, and 119 in their second (Sakagawa and Kimura 1976). Therefore, most of the impinged fish were Age-0 and Age-1 fish. Of the 86 mature individuals inspected for determination of sex during the study year, 74 (86%) were female and 12 (14%) were male.

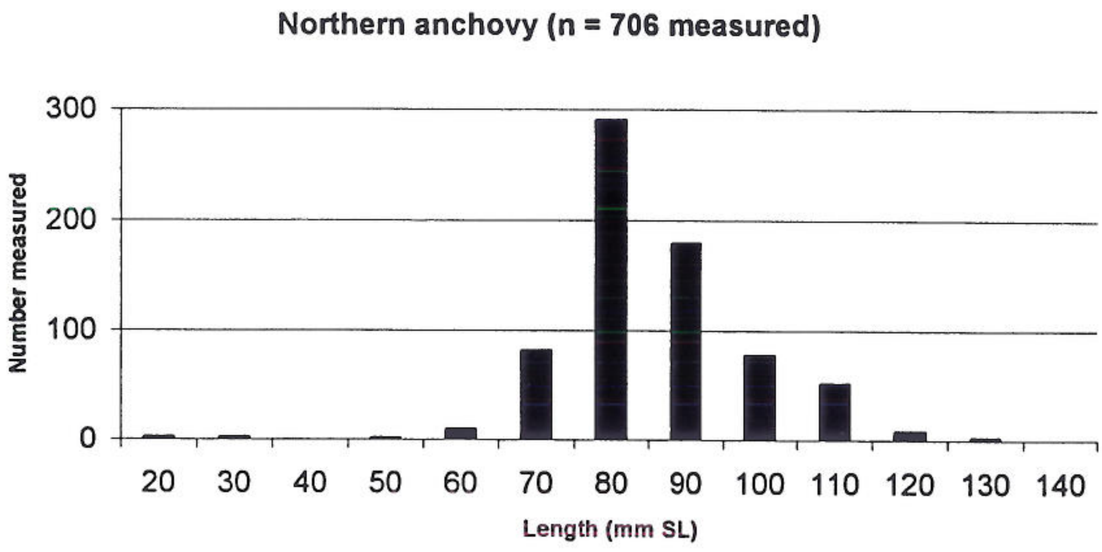

Figure 4-37. Length frequency distribution of northern anchovy (*Engraulis mordax*) in impingement samples.

4.4.3. Macroinvertebrate Impingement

In total, an estimated 70,638 invertebrates representing 37 species were impinged during the study year (Table 4-32). Total biomass was 168 kg (369 lb). The most abundant macroinvertebrate species were the nudibranch *Dendronotus frondosus* (88%), yellow rock crab (*Cancer anthonyi*; 4%), graceful rock crab (*Cancer gracilis*; 2%), and Pacific rock crab (*Cancer antennarius*; 2%). Abundance during six heat treatment impingement surveys accounted for less than 2% of total impingement abundance. Data are presented by survey in Appendix C.

Normal Operations Results

An estimated 69,432 macroinvertebrates representing 31 species were impinged during 52 normal operations surveys (Table 4-32). Impingement was highest in late-March 2004 (primarily *Dendronotus*) and early-December 2003 (mainly *Dendronotus*). The most abundant species were the nudibranch *Dendronotus frondosus* (90%), yellow rock crab (4%), and graceful rock crab (2%). Abundance during 52 normal operations surveys accounted for more than 98% of total impingement abundance. Macroinvertebrate biomass during all 52 normal operations surveys totaled 150 kg (332 lb). Biomass was dominated by two-spotted octopus (*Octopus bimaculatus/bimaculoides*; 15%), shell debris of the Pacific littleneck (*Protothaca staminea*; 15%),

Table 4-32. Macroinvertebrate impingement totals from 52 normal operation and 6 heat treatment surveys.

		Normal Operation Totals		Heat Treatment Totals		Impingement Totals		Percent of Total	
Species	**Common Name**	**No.**	**Wt. (kg)**	**No.**	**Wt. (kg)**	**No.**	**Wt. (kg)**	**No.**	**Wt.**
Dendronotus frondosus	nudibranch	62,150	14.963	-	-	62,150	14.963	88.0	8.9
Cancer anthonyi	yellow rock crab	2,706	21.754	151	1.342	2,857	23.096	4.0	13.8
Cancer gracilis	graceful rock crab	1,484	2.905	11	0.079	1,495	2.984	2.1	1.8
Cancer antennarius	Pacific rock crab	958	8.588	68	1.179	1026	9.767	1.5	5.8
Pyromaia tuberculata	tuberculate pear crab	597	0.955	386	0.382	983	1.337	1.4	0.8
Cancer productus	red rock crab	417	6.101	25	0.165	442	6.266	0.6	3.7
Crangon nigromaculata	blackspotted bay shrimp	336	0.511	2	0.004	338	0.515	0.5	0.3
Polyorchis penicillatus	jellyfish	326	4.207	-	-	326	4.207	0.5	2.5
Pachygrapsus crassipes	striped shore crab	27	0.088	149	0.401	176	0.489	0.2	0.3
Hermissenda crassicornis	nudibranch	50	0.031	111	0.114	161	0.145	0.2	0.1
Lysmata californica	red rock shrimp	20	0.026	140	0.194	160	0.220	0.2	0.1
Portunus xantusii	Xantus swimming crab	47	0.292	16	0.055	63	0.347	0.1	0.2
Octopus bimaculatus/bimaculoides	two-spotted octopus	27	22.919	34	2.474	61	25.393	0.1	15.2
Heptacarpus palpator	intertidal coastal shrimp	27	0.068	31	0.018	58	0.086	0.1	0.1
Chrysaora colorata	purple-striped jelly	53	21.674	-	-	53	21.674	0.1	12.9
Pisaster sp.	sea star (decomposed)	48	9.872	-	-	48	9.872	0.1	5.9
Ophiothrix spiculata	spiny brittlestar	26	0.082	14	0.007	40	0.089	0.1	0.1
Pugettia producta	shield-backed kelp crab	26	0.114	11	0.199	37	0.313	0.1	0.2
Panulirus interruptus	California spiny lobster	12	10.998	20	8.637	32	19.635	<0.1	11.7
Salpidae	salp, unid.	18	0.108	-	-	18	0.108	<0.1	0.1
Cerebratulus californiensis	ribbon worm	17	0.186	-	-	17	0.186	<0.1	0.1
Navanax inermis	California aglaja	-	-	15	0.038	15	0.038	<0.1	<0.1
Dendronotus subramosus	stubby dendronotus	-	-	14	0.028	14	0.028	<0.1	<0.1
Neotrypaea californiensis	bay ghost shrimp	13	0.060	-	-	13	0.060	<0.1	<0.1
Urechis caupo	innkeeper worm	6	0.577	2	0.025	8	0.602	<0.1	0.4
Flabellina iodinea	Spanish shawl	7	0.007	-	-	7	0.007	<0.1	<0.1
Loligo opalescens	market squid	7	0.442	-	-	7	0.442	<0.1	0.3
Parastichopus parvimensis	warty sea cucumber	7	0.459	-	-	7	0.459	<0.1	0.3
Loxorhynchus crispatus	masking crab	7	0.212	-	-	7	0.212	<0.1	0.1
Hemigrapsus oregonensis	yellow shore crab	6	0.006	-	-	6	0.006	<0.1	<0.1
Penaeus californiensis	yellowleg shrimp	5	0.185	-	-	5	0.185	<0.1	0.1
Pisaster ochraceous	ochre starfish	-	-	3	1.103	3	1.103	<0.1	0.7
Loxorhynchus grandis	sheep crab	-	-	1	0.657	1	0.657	<0.1	0.4
Pachycheles pubescens	pubescent porcelain crab	-	-	1	0.001	1	0.001	<0.1	<0.1
Pachycheles rudis	thick-clawed porcelain crab	-	-	1	0.001	1	0.001	<0.1	<0.1
Protothaca staminea	Pacific littleneck (debris)	-	22.012	-	-	-	22.012	<0.1	13.1
Petricola californiensis	California petricolid (debris)	-	0.058	-	-	-	0.058	<0.1	<0.1
	Totals:	69,432	150.462	1,206	17.103	70,638	167.565	100.0	100.0
	No. of Species:	31		22		37			

yellow rock crab (14%), purple-striped jelly (*Chrysaora colorata*; 14%) and the nudibranch *Dendronotus frondosus* (10%). No whole Pacific littleneck were impinged; instead, bits of shell debris were collected in 11 of 41 surveys, and in larger amounts (> five kilograms per week) during two of those nine surveys in July and September 2003. It is likely that individuals colonized the surfaces of the CWIS along with barnacles, mussels, and turf.

Heat Treatment Results

An estimated 1,206 macroinvertebrates representing 22 species were impinged during six heat treatment surveys (Table 4-32). The most abundant species were the tuberculate pear crab (32%), yellow rock crab (13%), striped shore crab (*Pachygrapsus crassipes*; 12%), and red rock shrimp (*Lysmata californica*; 12%). Abundance during the heat treatment impingement surveys accounted for only 2% of total impingement abundance. Heat treatment abundance was highest in late-May 2004, and the sample was comprised primarily of small crustaceans, including tuberculate pear crab, red rock shrimp, yellow rock crab, and striped shore crab.

4.4.4. Macroinvertebrate Results by Species

Species-specific analyses are limited to the five species that together comprised 92% of total impingement abundance and 63% of impingement biomass: the nudibranch *Dendronotus frondosus*, yellow rock crab, two-spotted octopus, purple-striped jelly, and California spiny lobster.

4.4.4.1 Nudibranch (*Dendronotus frondosus*)

The nudibranch (*Dendronotus frondosus*) is a cosmopolitan nudibranch that lives intertidally and subtidally in the northern hemisphere (Morris et al. 1980, Behrens 1991). It lives on, and feeds on, a wide variety of hydroids, including species of *Tubularia*, *Hydractinia*, *Sarsia*, *Obelia*, *Sertularia*, *Abietinaria*, *Aglaophenia*, and others (Morris et al. 1980). This species was only impinged during 5 of 41 normal operations surveys, and was absent in heat treatment surveys (Appendix C). An estimated total of 62,150 individuals were impinged during the study year, but only weighed 15.0 kg, equal to an average of over 4,150 individuals per kg (Table 4-32). It was the most abundant macroinvertebrate impinged, comprising 88% of impingement abundance. Highest impingement occurred coincident with, or immediately following, impingement of large amounts of turf (*Syncoryne eximia*, formerly *Sarsia*). It is likely individuals settled within the CWIS, and were inhabiting and grazing on the turf growing in the CWIS.

4.4.4.2 Yellow Rock Crab (*Cancer anthonyi*)

Information on the life history, ecology, population trends, and fishery of rock crabs (*Cancer* spp.) is summarized in Section 4.3.3.15. An estimated total of 2,857 individuals weighing 23.1 kg were impinged during the study year (Table 4-32). This species was impinged in 19 of 52 normal operations surveys, and only three of the six heat treatment surveys (Appendix C). Highest normal operations abundance occurred in January and May–June 2004, and highest heat treatment abundance was recorded in May 2004. Carapace lengths were not measured, so estimated size classes cannot be estimated. However, the individuals impinged at the HBGS during the study year were small, averaging 8 g per crab.

4.4.4.3 Two-Spotted Octopus (*Octopus bimaculatus/bimaculoides*)

There are two similar octopus species that occur in southern California: *Octopus bimaculatus* and *O. bimaculoides*. Both are referred to as the two-spotted octopus since they are difficult to distinguish, and for more than 60 years were thought to represent a single species (Morris et al. 1980). *O. bimaculoides* ranges from San Simeon, California, to Bahia San Quintin, Baja California, and is found in a variety of habitats to depths of 20 m (Lang and Hochberg 1997). The sibling species *O. bimaculatus* has a similar geographic distribution, occurring from Santa Barbara, California, south to Punta Eugenia, Baja California, and in some locations within the Gulf of California. It also occurs in slightly deeper depths (to 50 m) (Morris et al. 1980, Lang and Hochberg 1997). They both occur in a variety of habitats, including mudflats, intertidal zones, reefs, crevices, and kelp beds.

O. bimaculoides females lay their eggs under rocks from late winter to early summer, and brood them continuously for two to four months (Morris et al. 1980). Females lay between 200 and 800 eggs, depending on female size and condition (Lang and Hochberg 1997). The young remain on the bottom after hatching, and often move toward the intertidal. Adults feed on mollusks, crustaceans, and fishes. In the rocky intertidal zone, *O. bimaculoides* drills and feeds principally on limpets (*Collisella* and *Notoacmea*), snails (*Tegula* spp.), Pacific littleneck, and hermit crabs (*Pagurus* spp.) (Morris et al. 1980). They also feed on mussels (*Mytilus* spp.) and the Pacific calico scallop (*Argopecten ventricosus*) (Lang and Hochberg 1997).

O. bimaculatus spawns throughout most of the year, though there is a distinct seasonal peak from April through July (Lang and Hochberg 1997). Hatching takes place in a relatively short time-frame since there is an inverse relationship between development time and water temperature (Ambrose 1981). Ambrose (1981) also reported an average clutch size of about 20,000 eggs for a female weighing about 260 g. After hatching, young octopuses are planktonic for several months, then settle to the bottom (Lang and Hochberg 1997). Juvenile *O. bimaculatus* feed on small crustaceans, while adults consume a wide variety of motile benthic invertebrates.

An estimated total of 61 individuals weighing 25.4 kg were impinged during the study year (Table 4-32). This species was impinged in 4 of 52 normal operations surveys, and five of the six heat treatment surveys (Appendix C). Highest normal operations abundance occurred in

May and June 2004, and highest heat treatment abundance was recorded in August and September 2003. Mantle lengths were not measured, so estimated size classes cannot be estimated. However, the individuals impinged during normal operations (average of 0.85 kg each) were about 12 times the size of those impinged during heat treatments (average of 0.07 kg each).

4.4.4.4 Purple-Striped Jelly (*Chrysaora colorata*)

Purple-striped jelly (*Chrysaora colorata*, formerly *Pelagia colorata*) is found along the coast of California in oceanic and slope waters (Morris et al. 1980, Wrobel and Mills 1998). The purple-striped jelly feeds on ctenophores, pelagic tunicates, fish eggs and larvae, planktonic crustaceans, and other Scyphomedusae. Unlike most jellyfishes, the fertilized egg of the purple-striped jelly develops to a planula larva, which then develops directly into a free-swimming ephyra stage without intervention of a sessile, asexually reproducing polyp stage. *Chrysaora* is fed upon by ocean sunfish (*Mola mola*) and blue rockfish (*Sebastes mystinus*). An estimated 53 purple-striped jellies weighing 21.7 kg were impinged during 5 of 52 normal operations surveys, though none were impinged during heat treatments (Table 4-32). They were most abundant in June and July 2004 (Appendix C).

4.4.4.5 California Spiny Lobster (*Panulirus interruptus*)

Information on the life history, ecology, population trends, and fishery of California spiny lobster (*Panulirus interruptus*) is summarized in Section 4.3.3.12. A total of 32 spiny lobsters weighing 19.7 kg was impinged during the study year; an estimated 12 during two weeks of normal operations and 20 during four heat treatment surveys (Table 4-32). This species was most abundant in August and September 2003, which coincides with their inshore distribution during mating season. Of the 19 spiny lobsters measured, carapace lengths averaged 63 mm, ranging from 9 to 98 mm. The average length (63 mm) is the reported size at maturity and indicates an age of five to six years (Barsky 2001). Of the 14 lobsters examined, 10 (71%) were female, and 4 (29%) were male. Sex was not determined for 5 of the 19 lobsters measured.

4.4.5. Factors Affecting Impingement

Weekly flow during the one-year survey period ranged from 6,233,895 m^3 (1,647 mgd) to 12,950,150 m^3 (3,421 mgd) and averaged 9,280,820 m^3 (2,452 mgd). The highest normal operation fish impingement abundance was recorded during the 27th week (27 January 2004), where 1,346 fishes (mostly juvenile queenfish) representing 12 species were collected during a 24-hr sample period, for an extrapolated weekly impingement of 7,571 individuals weighing 95.6

kg (Figure 4-38). This represents 60% of the total annual normal operations impingement abundance. This was not the week with the highest weekly flow volume; however, all eight circulator pumps were in operation during the impingement sampling period. The highest normal operation macroinvertebrate impingement was recorded during the 30 March 2004 survey (Figure 4-39).

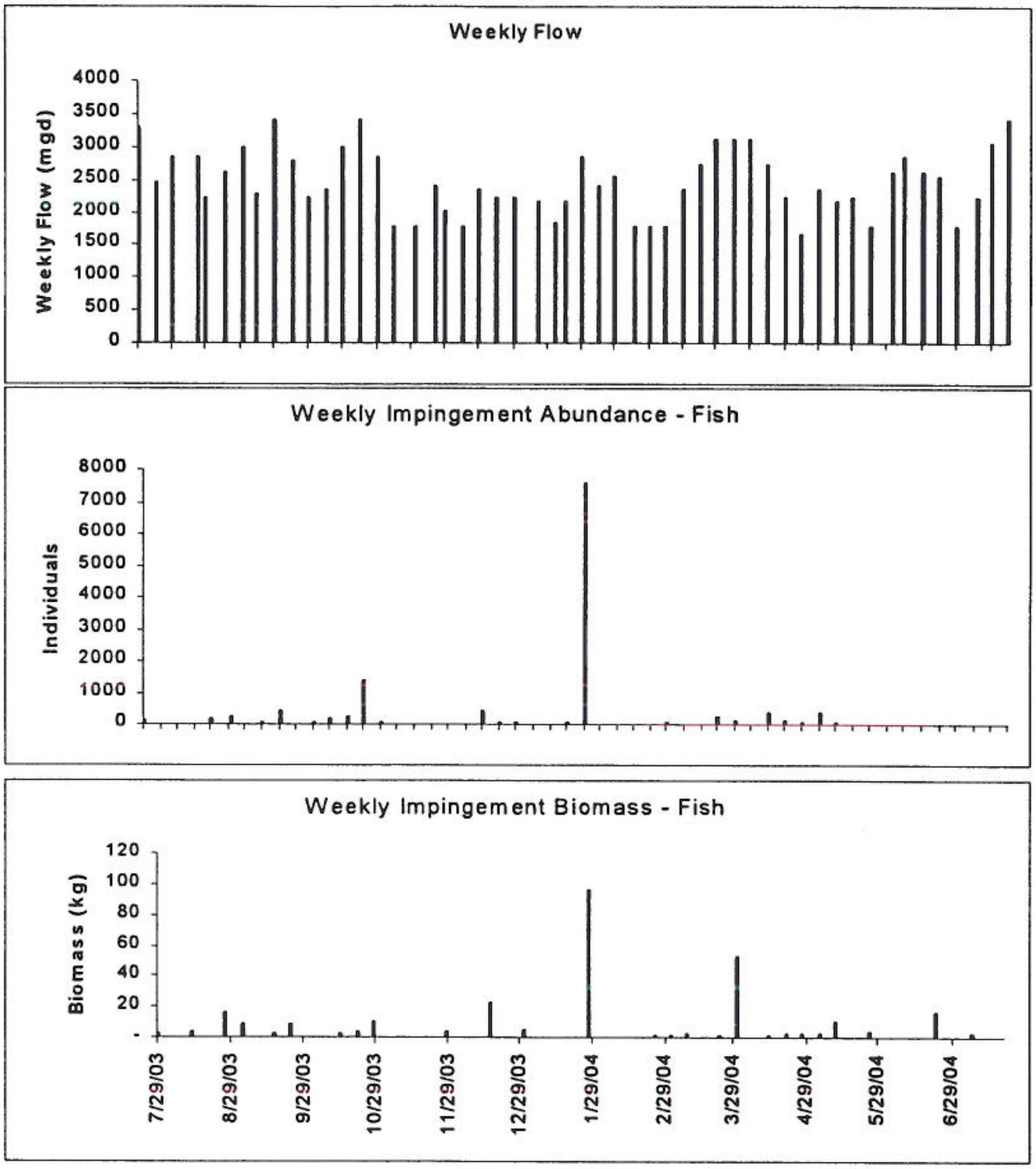

Figure 4-38. Weekly cooling water flow volume, normal operation fish impingement abundance, and normal operation fish impingement biomass, July 2003 – July 2004. Abundance and biomass were extrapolated based on survey period and weekly cooling water flow volume.

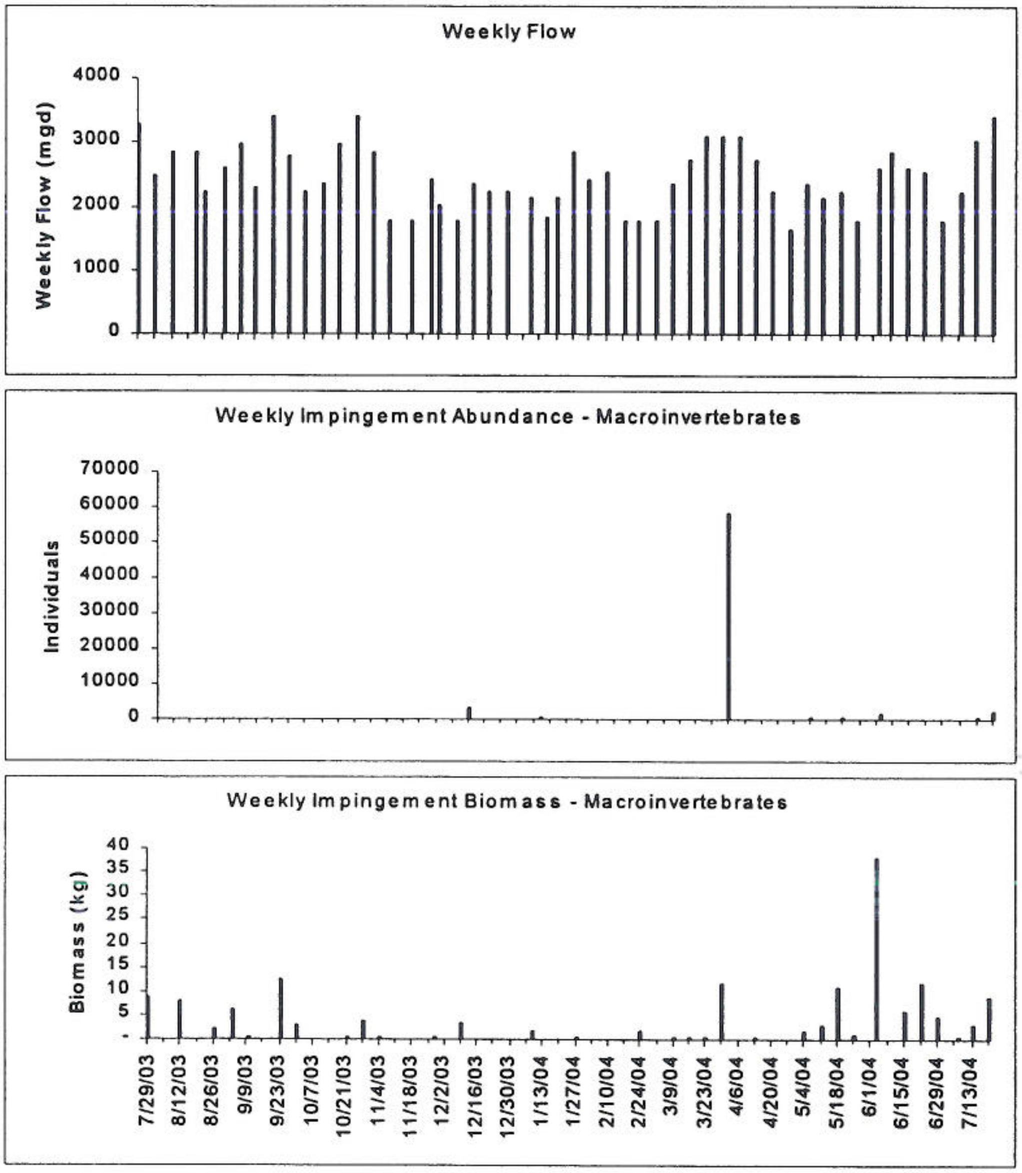

Figure 4-39. Weekly cooling water flow volume, normal operation macroinvertebrate impingement abundance, and normal operation macroinvertebrate impingement biomass, July 2003 – July 2004. Abundance and biomass were extrapolated based on survey period and weekly cooling water flow volume.

Impingement rates at coastal generating stations are dependent on intake flow and the abundance and distribution of source populations. Intake flow can vary daily, seasonally, and annually. The abundance and distribution of fish and invertebrate populations is affected by oceanographic conditions (such as water temperature and upwelling), biological processes (such as spawning, recruitment, and predation), and human influences (such as fishing and anthropogenic impacts).

The relation between intake flow volume and fish impingement has been examined before at coastal generating stations. Results of previous analyses are discussed further in Section 7.4.5. In the present study, normal operations impingement parameters for both fishes and macroinvertebrates exhibited no correlation with flow volume (Figure 4-40). Though not required for the present study, water clarity (as measured by Secchi disk) of the HBGS intake forebay was recorded during all normal operation surveys. From October 2003 – September 2004, the 2004 HBGS NPDES monitoring period, normal operation fish impingement CPUE was positively correlated with Secchi depth ($r^2 = 0.44$, $p = 0.02$). However, it should be noted that Secchi visibility may have been affected by turbulence during periods of higher flow volumes and not necessarily turbidity. The lack of strong correlations between flow and impingement rates likely results from (1) fluctuations in densities of fishes and invertebrates in the zone of influence of the intake structure, and (2) the presence of relatively low flow areas within the forebays of some generating stations that allow entrapped organisms to survive and not immediately become impinged after they are entrained.

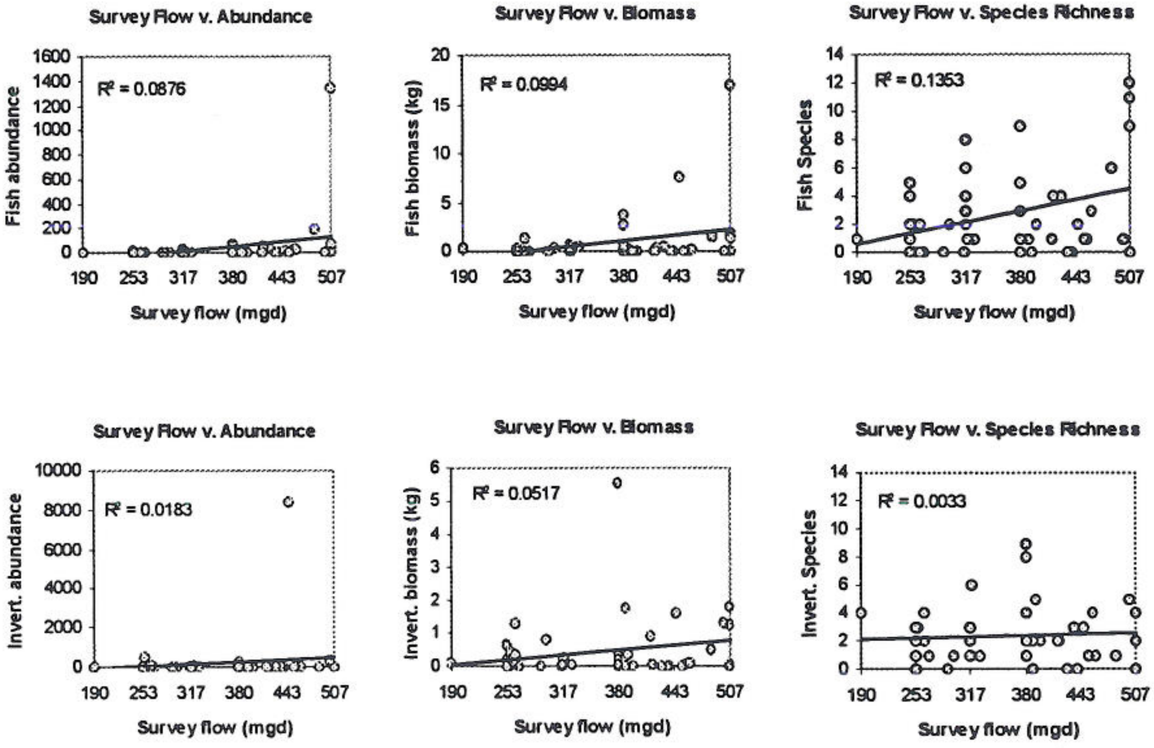

Figure 4-40. Normal operation fish (top) and macroinvertebrate (bottom) impingement parameters and their relations to survey flow volumes.

5.0 DIRECT IMPACT ASSESSMENT

The purpose of the AES HBGS Entrainment and Impingement Study is to assess the effects on populations of marine fishes and invertebrates from operation of the AES HBGS cooling water intake system. The results presented in this report were collected during a one-year entrainment study (Sept. 2003 – Aug. 2004) and a one-year impingement study (July 2003 – July 2004). Entrainment was measured by collecting samples near the HBGS intake structure, while impingement was estimated by direct measurements of fishes and macroinvertebrates impinged at the HBGS during normal operations and heat treatment surveys. Cumulative impacts due to entrainment and impingement were also analyzed for 11 coastal generating stations in southern California. The cumulative impacts assessment is presented separately in Section 7.0 of this report.

The analysis of effects due to operation of the CWIS at the HBGS was limited to the most abundant fishes and a list of target invertebrates collected during the course of the study. This approach was taken primarily because of the uncertainty associated with assessments of organisms that are in low abundance in the samples. The most abundant organisms may also have higher risk for population-level impacts, but their high entrainment levels also reflect their high overall abundance in the source water. Therefore all of the estimates need to be placed in context, either through the estimates of the source water areas affected or through independent estimates of the adult populations. At the other extreme, although no State- or Federally-listed threatened or endangered species were entrained or impinged during the study, even very low levels of impacts to these species would need to be assessed. The limits of our analyses also resulted from the uncertainty associated with assessments based on few direct observations. By focusing our analyses on the most abundant species in entrainment and impingement surveys, more accurate assessments could be made on those species. The entrainment estimates were based on a set of conservative assumptions resulting in estimates that represented 'worst-case losses' for the year. These assumptions included: (1) the estimation of entrainment losses based on maximum permitted flow at the HBGS, even though actual flow for the study year was much less, and (2) an assumed entrainment survival rate of zero.

The larval fishes entrained by the HBGS CWIS differed somewhat from the juvenile and adult fishes that were impinged. The most abundant fish larvae in entrainment samples (CIQ gobies) comprised 37% of the total fishes collected during entrainment sampling, but no gobies were collected in impingement samples. Two of the other abundant larval fish species, white croaker and northern anchovy, were well represented in impingement samples. Conversely, the most abundant fish species collected in impingement samples (queenfish) was not as abundant in the entrainment samples, comprising <5% of total entrainment. Furthermore, the various surfperch species, which were relatively abundant in impingement samples, are not subject to entrainment impacts because they bear live young that are too large to be entrained.

5.1 Entrainment Summary

Entrainment impacts were assessed using two demographic models, Adult Equivalent Loss (*AEL*) and Fecundity Hindcasting (*FH*), which translate larval entrainment estimates into adult losses. The third modeling approach, the Empirical Transport Model (*ETM*), compared the numbers of larvae entrained with the numbers of larvae at risk of entrainment in the source waters to obtain an estimate of the proportional mortality caused by entrainment. Results from these modeling estimates are presented in Table 5-1.

Table 5-1. Summary of entrainment modeling estimates on target taxa based on the three modeling techniques (*FH, AEL,* and *ETM* [P_M]). The *FH* model estimates an equivalent number of breeding adult females, therefore this estimate is multiplied by two for comparison with the AEL model that estimates an equivalent numbers of adults irrespective of sex. The comparison assumes a 50:50 ratio of males:females in the population. The shoreline distance (km) used in the alongshore extrapolation of P_M is presented in parentheses next to the estimate.

Taxon	Estimated Annual Entrainment	2·*FH*	*AEL*	P_M Alongshore Extrapolation	P_M Offshore +Alongshore Extrapolation
CIQ goby complex	113,166,834	202,538	147,493	1.0% (60.9 km)	1.0%
northern anchovy	54,349,017	53,490	304,125	1.2% (72.0 km)	0.7%
spotfin croaker	69,701,589	NA	NA	0.3% (16.9 km)	0.3%
queenfish	17,809,864	NA	NA	0.6% (84.9 km)	0.5%
white croaker	17,625,263	NA	NA	0.7% (47.8 km)	0.4%
black croaker	7,128,127	NA	NA	0.1% (19.4 km)	0.05%
salema	11,696,960	NA	NA	NA	NA
blennies	7,165,513	6,466	NA	0.8% (12.8 km)	0.3%
diamond turbot	5,443,118	NA	NA	0.6% (16.9 km)	0.3%
California halibut	5,021,168	NA	NA	0.3% (30.9 km)	0.08%
sand crab megalops	69,793	NA	NA	NA	NA
California spiny lobster	0	NA	NA	NA	NA
ridgeback rock shrimp	0	NA	NA	NA	NA
market squid	0	NA	NA	NA	NA
rock crab megalops	6,411,171	NA	NA	1.1% (26.5 km)	0.8%

NA – Estimate not available due to either insufficient life history information or low abundance in entrainment samples.

An estimated 345 million larval fishes were entrained during the one-year study period, an average of about 945,000 per day. The CIQ goby complex was the most abundant fish taxon in both the entrainment and source water samples and comprised 37% of the total larvae collected at the entrainment station (Table 4-1). The CIQ goby complex is comprised of up to three species that are common in southern California bays and estuaries (arrow, shadow, and/or cheekspot gobies) and, as early larvae, cannot be reliably identified to the species level. Northern anchovy was the second most abundant fish taxon collected in both entrainment and source water, comprising 18% of the total in both sets of samples. Four species of croakers were also included in the assessment. White croaker larvae were relatively abundant throughout the sampling period, while queenfish, spotfin croaker, and black croaker were not abundant until the latter part of the study in July and August 2004.

The fish taxa that were the focus of our analysis have different distributions and life histories. They include fishes that are primarily distributed in estuarine and enclosed bay habitats, in coastal nearshore habitats, and in coastal open ocean habitats. The CIQ goby adults are generally not found along the open coast where the HBGS intake structure is located—only 25 gobies have been impinged at the HBGS since 1979 (3 cheekspot and 22 arrow gobies), and none have been collected in annual trawls off the HBGS since 1976. Adult gobies are relatively small, bottom-dwelling fishes and may not have been adequately sampled by the mesh of the traveling screen or otter trawls. However, the coastal habitat off the generating station is not well suited for any of these three species of gobies, and it is unlikely there are large numbers of adult gobies off the coast of Huntington Beach. More likely, the adult populations are concentrated in nearby coastal embayments and harbors, such as Alamitos Bay, Anaheim Bay, and Talbert Marsh, and their larvae are dispersed in these environs and transported to coastal waters by tidal flushing and prevailing currents (Horn and Allen 1976). The arrow goby is an abundant constituent of the fish community at the Golden Shore Marine Reserve, a created wetland at the mouth of the Los Angeles River approximately 22 km (13 mi) upcoast from the HBGS (MBC 2003b). During the final year of a five-year mitigation monitoring project, densities of arrow goby ranged from 0.7 individuals/m^2 in winter to 4.5 individuals/m^2 in summer, but may have been even higher due to some escapement through the 6-mm seine mesh used for sampling. MacDonald (1975) found densities of 4 to 5 individuals/m^2 in Anaheim Bay in winter, although concentrations of up to 20 individuals/m^2 were found in some individual burrows. Combtooth blennies and diamond turbot are two other target taxa that are primarily distributed in estuarine and bay habitats (Love 1996).

The *ETM* results showed that the additional mortality to the source population resulting from entrainment was very low for gobies, blennies and diamond turbot. The estimates of the additional mortality due to entrainment (P_M) were 1.0% or less for all three taxa (Table 5-1). Demographic modeling (*AEL* and *FH*) of CIQ gobies larval entrainment estimates showed potential losses of approximately 150,000 to 200,000 adults. The *ETM* and demographic modeling results overestimate the entrainment effects on the adult populations of these taxa, which are primarily distributed in bay and estuarine areas. Adult populations of CIQ gobies, in particular, are almost entirely restricted to estuarine areas and the larvae of these species are probably capable of swimming behavior that reduces their transport into coastal waters by tidal currents (Barlow 1963, Pearcy and Myers 1973, Brothers 1975). Although the larvae that are transported into coastal waters provide for genetic exchange between estuarine areas along the coast (Dawson et al. 2002), they also experience much higher rates of mortality than larvae that are retained in estuarine areas. As a result, the survival rates from an estuarine area (Brothers 1975) used in the demographic models were probably much lower than the actual survival in the open coastal waters resulting in overestimates of the actual effects at the adult population level. Similarly, the magnitude of any effects at the adult population level would be much less than the P_M estimate of 1.0%, because this is an estimate of the mortality on the larvae population in open coastal waters and not the larvae in estuarine areas that would be contributing to adult recruitment.

Entrainment effects on fishes primarily distributed along outer coastal habitats, including California halibut, queenfish, white croaker, spotfin croaker, and black croaker were also low, with the estimated additional mortality due to HBGS entrainment of approximately 1% or less (Table 5-1). Estimated effects from the *ETM* were even less when the potential source population was increased to include offshore areas. Another open coastal taxon, salema, was not assessed using any of the models because it was only present during two surveys at the source water and entrainment stations, but not during the same surveys. Therefore, we were unable to calculate estimates of *PE* for salema for the *ETM* assessment. In addition, there is very little life history information available for salema that can be used in demographic modeling approaches. Surprisingly, critical life history information such as larval survival rates necessary for calculating the demographic models was also not available for common coastal species such as white croaker, which is found over soft-bottom habitat off the entire southern California coast, and was the second most abundant fish collected in annual trawl surveys. It also ranked second in historical impingement abundance. Despite its nearshore distribution and abundance in the areas offshore the HBGS, the estimated additional mortality from entrainment based on the *ETM* modeling was less than 1%.

Two of these species, California halibut and white croaker, are part of the local commercial fishery. The projected ex-vessel value of California halibut and white croaker lost as a result of larval entrainment was calculated for CDFG Catch Block 738 (10 km x 10 km directly off off HBGS) by multiplying the annual fishery value of reported landings for each species in that catch block by the modeled P_M alongshore extrapolations. For halibut, the fishery value from Block 738 was $18,245 in 2003 and $5,483 in 2002. The alongshore P_M estimate of 0.003 (Table 5-1) translates to values of $55 and $16 in 2003 and 2002, respectively. For white croaker, the fishery value was $9,783 in 2003 and $11,755 in 2002. The alongshore P_M estimate of 0.007 (Table 5-1) translates to values of $68 and $82 in 2003 and 2002, respectively.

Northern anchovy is a pelagic species found out to 480 km from shore, and is one of the most abundant fish species off the southern California coast. Juvenile northern anchovy, which were abundant in HBGS impingement samples, are usually found closer to shore, including in embayments and estuaries. Northern anchovy is the numerically dominant fish collected in annual trawl surveys off the HBGS, and ranks third in historical impingement abundance. Live-bait boats commonly fish the nearshore areas between the HBGS and Newport Harbor for this species. The estimated entrainment mortality based on both offshore and alongshore extrapolation of the source population is probably the most appropriate estimate to use for this wide-ranging species and this estimate from *ETM* indicates that the additional mortality resulting from entrainment is approximately 1% over a coastal distance of 72 km (Table 5-1). Although the two demographic model estimates for northern anchovy provide a wide range of estimates, the estimated numbers of adults lost due to entrainment are also low given the large adult populations of northern anchovy in the Southern California Bight. These adult losses can be compared to recent stock estimates of 388,000 MT of northern anchovy in the region from San Francisco to Punta Baja, Mexico (Jacobson et al. 1994).

Northern anchovy are fished commercially off of Huntington Beach. The projected ex-vessel value of northern anchovy lost as a result of larval entrainment was calculated for CDFG Catch Block 738 (directly off of HBGS) by multiplying the annual fishery value reported for anchovy landings in that catch block by the modeled P_M alongshore and offshore extrapolations. The fishery value was $15,094 in 2003 and $12,784 in 2002. The alongshore P_M estimate of 0.012 (Table 5-1) translates to values of $181 and $153 in 2003 and 2002, respectively.

Rock crabs (genus *Cancer*) were the only target invertebrate taxa collected in sufficient abundance to warrant analysis. Although large numbers of sand crab larvae were collected, only two of the larvae were in the later megalops stage chosen as target organisms for assessment. The other invertebrate target taxa were not collected in any of the entrainment samples. Similar to the results for the fishes, the estimated increased mortality due to entrainment for rock crab megalops larvae was low—0.8 to 1.1% (Table 5-1). The projected ex-vessel value of rock crab lost as a result of larval entrainment was calculated for Catch Block 738 (directly off of HBGS) by multiplying the annual fishery value for reported rock crab landings in that catch block by the modeled P_M alongshore extrapolations. The fishery value was $730 in 2003 and $5,121 in 2002. The alongshore P_M estimate of 0.011 (Table 5-1) translates to values of $8 and $56 in 2003 and 2002, respectively.

The estimated levels of P_M for the HBGS are less than estimated results from recent 316(b) entrainment studies at other California power plants. One of the potential reasons for the differences is the habitat where the intake structures for these power plants are located. Some of these studies were conducted in estuarine areas that have very limited source water bodies relative to the open coastal source water for the HBGS. The decreased source water bodies for these studies contribute to the higher P_M estimates relative to the HBGS. The results from the HBGS are also lower than a similar study conducted at the Diablo Canyon Power Plant (DCPP) located on the open coast in San Luis Obispo County in central California. Unlike the HBGS, the nearshore areas around the DCPP CWIS are heterogeneous with rocky reefs, kelp beds and sandy areas. In addition, the CWIS at the DCPP is protected by a rock jetty that provides additional habitat for fishes. In contrast to the DCPP and other similar CWIS intakes, the habitat around the HBGS intake is homogeneous sand flats that extend for several kilometers north, south and offshore of the intake. This homogeneous environment probably results in a more uniform distribution of larvae throughout the sampling area resulting in average estimates of *PE* that closely approximated the volumetric ratio of the cooling water to the sampled source water volume of 0.002% for several of the more abundant target taxa. As a result the P_M estimates for the HBGS are more dependent on the estimated larval durations and currents used to calculate the source water body. This result helps support the approach taken in the cumulative impact assessment that relies solely on the volumetric withdrawal of cooling water in estimating proportional entrainment for the model.

The P_M estimates based on alongshore current displacement ranged from 0.1% to 1.2% (Table 5-1). The length of coastline (km) used in extrapolating the estimates of P_M ranged from 12.8 to 84.9 km (Table 5-1). An estimate of the area of larval production lost due to entrainment (area of production foregone) can be estimated by multiplying the P_M estimates by the alongshore source water length and the width of the source water area sampled (5 km). Estimates of the area of production foregone ranged from 0.11 to 4.47 km^2, and averaged 1.50 km^2 (Table 5-2).

Table 5-2. Summary of entrainment modeling estimates for target taxa and estimation of area of production foregone. The shoreline distance (km) used in the alongshore extrapolation of P_M is presented in parentheses next to the shoreline distance estimate.

Taxon	Estimated Annual Entrainment	P_m Alongshore Extrapolation	Shoreline Distance (km) of Production Foregone	Area of Production Foregone (km^2)
CIQ gobies	113,166,834	1.0% (60.9 km)	0.604	3.024
n. anchovy	54,349,017	1.2% (72.0 km)	0.894	4.471
spotfin croaker	69,701,589	0.3% (16.9 km)	0.050	0.248
queenfish	17,809,864	0.6% (84.9 km)	0.531	2.657
white croaker	17,625,263	0.7% (47.8 km)	0.340	1.699
black croaker	7,128,127	0.1% (19.4 km)	0.023	0.115
salema	11,696,960	NA	NA	NA
blennies	7,165,513	0.8% (12.8 km)	0.098	0.492
diamond turbot	5,443,118	0.6% (16.9 km)	0.098	0.488
California halibut	5,021,168	0.3% (30.9 km)	0.077	0.386
rock crab	6,411,171	1.1% (26.5 km)	0.284	1.418

5.2 Impingement Summary

An estimated 51,082 fishes representing 57 species and weighing 1,292 kg were impinged during the one-year study period, an average daily impingement of about 140 individuals weighing 3.5 kg (7.8 lb) (Table 5-3). Heat treatments accounted for 75% of fish impingement abundance and 78% of biomass. The most abundant species were queenfish (70%), white croaker (10%), shiner perch (8%), and northern anchovy (4%), and all species impinged during the one-year study were present in previous impingement studies at the generating station. Queenfish, white croaker, and northern anchovy are the overall long-term dominants in annual HBGS impingement sampling since 1979. Shiner perch was abundant at the HBGS in 1979, but abundance declined dramatically though 1984, and remained low thereafter. The decreasing numbers of shiner perch (as well as white seaperch and walleye surfperch) were not limited to the waters off the HBGS; similar declines were noted at several locations in southern California. This decline coincided with increasing water temperatures, decreased zooplankton biomass, and reduced upwelling in the SCB (Roemmich and McGowan 1995, Allen et al. 2003). The increasing numbers of shiner perch in impingement samples the last few years could have resulted from the increased flow volume at the HBGS, increasing standing stock in the source waters, or both.

Table 5-3. Summary of annual impingement estimates for the most abundant fish species (top) and macroinvertebrate species contributing most to impingement abundance and biomass (biomass).

	Normal Operations		Heat Treatments		Annual Impingement[1]	
	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Fishes						
queenfish	10,468	58.02	25,379	590.14	35,847	648.16
white croaker	274	3.37	4,629	92.05	4,903	95.42
shiner perch	215	2.01	3,830	49.81	4,045	51.82
northern anchovy	824	5.51	1,369	9.34	2,193	14.86
Percent of total					**92%**	**63%**
Macroinvertebrates						
D. frondosus	62,150	14.96	-	-	62,150	14.96
yellow rock crab	2,706	21.75	151	1.34	2,857	23.10
graceful rock crab	1,484	2.90	11	0.08	1,495	2.98
Pacific rock crab	958	8.59	68	1.18	1,026	9.77
two-spotted octopus	27	22.92	34	2.47	61	25.39
purple-striped jelly	53	21.67	-	-	53	21.67
California spiny lobster	12	11.00	20	8.64	32	19.64
Percent of total					**96%**	**70%**

[1] Annual impingement is the sum of Normal Operations and Heat Treatments. Annual values may differ slightly from actual due to rounding.

All fish species impinged during the present study have been collected previously at the HBGS. The only species impinged in the present study that is classified as 'rare' was yellow snake eel (*Ophichthus zophochir*). The classification comes from Miller and Lea (1972), indicating 20 or less were taken prior to 1972. The scarcity of this species likely results from its burrowing behavior. Lea and Rosenblatt (2000) speculated that tropical ophichthids are transported to higher latitude waters during warm-water years, settle out, and live an expatriated existence. This species was taken in impingement samples at HBGS in seven survey years since 1979, and has also been collected at other generating stations in southern California (SCE 2000). Of the 60 white seabass impinged at the HBGS during this study, 49 were returned to MBC's laboratory and scanned for coded wire tags to determine if they were hatchery-reared or part of the natural population (Vojkovich and Crooke 2001). Of the 49 white seabass scanned, only 4 (8%) were hatchery-reared fish with tags. Coincidentally, a survey of 2–3-year-old white seabass caught by sportfishers in 2000 indicated that 7% were hatchery-reared fish with tags (Dotson and Charter 2003). All of the hatchery fish collected in impingement samples were returned to the Hubbs Sea-World Research Institute Hatchery for further analysis.

An estimated 70,638 macroinvertebrates representing 37 species and weighing 168 kg were impinged during the one-year study, an average daily impingement of about 196 macroinvertebrates weighing 0.5 kg (1.0 lb). Unlike fish impingement, most macroinvertebrates (98%) were impinged during normal operations. The most abundant species were the nudibranch *Dendronotus frondosus* (88%), yellow rock crab (4%), graceful rock crab (2%), and Pacific rock crab (2%).

The average annual macroinvertebrate impingement over the last ten years exceeded 16,000 individuals weighing about 146 kg. Abundances of the nudibranchs *Hermissenda crassicornis* and *Dendronotus frondosus* were higher in 2002 and 2003 than in any other survey year since 1994 (for which long-term macroinvertebrate data are compiled). Cause(s) for the increase in impingement of these species are unknown, but the highest abundances of these individuals coincided with surveys where large amounts of turf (*Syncoryne eximia*) were collected. It is possible that the small nudibranchs settle among the fouling invertebrates, including turf, within the CWIS. The individuals collected at the HBGS were very small (4,154 individuals per 1.0 kg for *Dendronotus*).

Comparison of impingement losses of juvenile and adult fishes and invertebrates with source water populations (as was done for larval fishes and target invertebrates) is not possible due to insufficient source water data. However, to put impingement results in context, we compared them to: (1) commercial landings from commercial Catch Block 738, located offshore the HBGS, (2) southern California recreational landings as reported by the Pacific States Marine

Fisheries Commission's (PSMFC) Recreational Fisheries Information Network database (RecFIN), and (3) recreational landings from Huntington, Newport, and Long Beach as reported by the NOAA Fisheries Los Angeles Times Sportfish Database. A discussion of cumulative impingement impacts from 11 of 13 southern California generating stations is presented in Section 7.0.

To compare impingement at the HBGS with local commercial landings, we multiplied the biomass of impinged (commercially-caught) species by the commercial value (price per pound) reported from Catch Block 738 (offshore the HBGS) in 2002 and 2003 (CDFG 2004). This analysis was limited to those fish and macroinvertebrate species that were both impinged and commercially caught offshore the HBGS during at least one of those two years. It also assumed that the fishes and macroinvertebrates impinged would otherwise be caught and sold commercially. Combined annual fish and macroinvertebrate impingement at the HBGS amounted to $823 using 2002 Catch Block values and $1,072 using 2003 Catch Block values (Table 5-4). The top-valued species were California spiny lobster, white croaker, surfperches, and California scorpionfish (*Scorpaena guttata*).

Table 5-4. Commercial value of impinged fish and macroinvertebrates at the HBGS, July 2003 – July 2004 (ranked by 2003 commercial value).

Category	2003 price per pound	2002 price per pound	Annual impingement biomass kg	lbs	2003 value	2002 value
California spiny lobster	$6.92	$6.62	19.64	43.30	$299.77	$286.66
white croaker	$1.27	$1.08	95.42	210.40	$267.40	$226.62
surfperch - unspec.	$1.00	–	99.29	218.93	$218.93	–
California scorpionfish	$1.93	$1.94	26.59	58.64	$113.30	$113.56
California halibut	$3.46	$3.30	9.94	21.91	$75.88	$72.24
rock crab - unspec.	$0.54	$0.92	42.11	92.86	$50.59	$85.38
shovelnose guitarfish	$0.66	$0.83	11.17	24.64	$16.23	$20.51
white seabass	$1.45	–	4.93	10.87	$15.76	–
rockfish - unspec.	$2.00	$2.20	1.19	2.62	$5.23	$5.74
California sheephead	$3.53	$3.75	0.36	0.79	$2.79	$2.97
jacksmelt	$0.03	–	29.67	65.42	$1.96	–
northern anchovy	$0.05	$0.03	14.86	32.76	$1.51	$1.09
leopard shark	$0.77	–	0.81	1.79	$1.37	–
Pacific sardine	$0.04	$0.04	7.32	16.13	$0.61	$0.72
sanddab - unspec.	$2.66	$2.66	0.10	0.21	$0.57	$0.57
market squid	$0.20	$0.09	0.44	0.97	$0.19	$0.09
jack mackerel	$0.10	$1.69	0.28	0.62	$0.06	$1.05
Pacific mackerel	$0.07	$0.23	0.34	0.74	$0.05	$0.17
octopus	–	$0.10	25.39	55.99	–	$5.60
				Totals:	$1,072.21	$822.97

Note: It is unknown if queenfish were included in the white croaker landing totals, since there were no reported queenfish landings. Using the price per pound of white croaker, impingement of queenfish would equal $1,815 (2003) and $1,544 (2002), raising the annual totals to $2,887 (2003) and $2,367 (2002).

Impingement at the HBGS was also compared with local recreational landings. This analysis was limited to those fish and macroinvertebrate species that were both impinged in the current study and caught recreationally in southern California in 2003 and reported in at least one of the sportfishing databases: PSMFC's RecFIN database (PSMFC 2004) and/or the NOAA Fisheries Southern California Recreational Sport Fisheries Database (NOAA Fisheries 2004). The two databases were compiled using different methods. The RecFIN database relied heavily on phone surveys, while the NOAA Fisheries database was compiled using sportfish landing data from daily reports published in the Los Angeles Times. Data from the PSMFC RecFIN database were analyzed for southern California as a whole (analysis on a finer scale was not possible). For most species, the numbers impinged at the HBGS represented less than one percent of recreational landings in southern California (Table 5-5). Exceptions to this included giant kelpfish (2%), white croaker (3%), queenfish (4%), white seaperch (14%), and shiner perch (16%). There are no known recreational fisheries for queenfish or giant kelpfish in southern California. White seaperch and shiner perch are likely targeted by fishermen from piers and breakwaters.

Table 5-5. Annual fish impingement abundance and projected annual losses from larval entrainment at the HBGS compared to 2003 recreational fishing landings in southern California as reported in the RecFIN database (ranked by RecFIN landings, top 29 species) (PSFMC 2004).

Common Name	2003 Southern California Recreational Landings	HBGS Impingement	Proportion of Impingement to Recreational Capture	P_M Alongshore	P_M Offshore + Alongshore	Estimated Losses using P_M Alongshore	Estimated Losses using P_M Offshore + Alongshore
queenfish	974,312	35,847	3.7%	0.006	0.005	5,846	4,872
pacific mackerel	828,490	17	<0.1%	NA	NA	NA	NA
barred sand bass	802,096	62	<0.1%	NA	NA	NA	NA
kelp bass	595,291	138	<0.1%	NA	NA	NA	NA
white croaker	180,002	4,903	2.7%	0.007	0.004	1,260	720
vermillion rockfish	160,170	1	<0.1%	NA	NA	NA	NA
walleye surfperch	143,524	476	0.3%	0	0	0	0
California halibut	142,075	21	<0.1%	0.003	0.0008	426	114
California scorpionfish	130,126	110	0.1%	NA	NA	NA	NA
jacksmelt	118,464	332	0.3%	NA	NA	NA	NA
halfmoon	110,425	13	<0.1%	NA	NA	NA	NA
topsmelt	93,605	231	0.2%	NA	NA	NA	NA
yellowfin croaker	71,932	6	<0.1%	NA	NA	NA	NA
California sheephead	69,843	1	<0.1%	NA	NA	NA	NA
blacksmith	66,822	46	0.1%	NA	NA	NA	NA
opaleye	51,956	19	<0.1%	NA	NA	NA	NA
white seabass	50,521	60	0.1%	NA	NA	NA	NA
black perch	42,120	66	0.2%	0	0	0	0
brown rockfish	36,193	2	<0.1%	NA	NA	NA	NA
shiner perch	25,114	4,045	16.1%	0	0	0	0
California corbina	19,680	33	0.2%	NA	NA	NA	NA
sargo	17,159	17	0.1%	NA	NA	NA	NA
spotfin croaker	16,977	49	0.3%	0.003	0.003	51	51
pile perch	8,926	19	0.2%	0	0	0	0
rock wrasse	6,728	4	0.1%	NA	NA	NA	NA
rubberlip seaperch	6,520	17	0.3%	0	0	0	0
white seaperch	6,110	869	14.2%	0	0	0	0
spotted sand bass	3,538	1	<0.1%	NA	NA	NA	NA
giant kelpfish	1,281	30	2.3%	NA	NA	NA	NA
	4,780,002	47,435	1.0%				

White croaker are targeted primarily by fishermen from piers, breakwaters, and private boats (Moore and Wild 2001).

Impingement at the HBGS was also compared with recreational landings reported in the NOAA Fisheries Recreational Sport Fisheries Database for Southern California (NOAA Fisheries 2004). This database was originally compiled for NOAA Fisheries by MBC, and includes sportfish catch by landing as reported daily in the Los Angeles Times from 1959 through 2003 (Mitchell 1999). Our analysis of the NOAA database was limited to recreational landings from Long Beach, Huntington Beach, and Newport Beach (Table 5-6).

Table 5-6. Comparison of fish impingement abundance at the HBGS from 2003–2004 and recreational fishing landings from Huntington, Newport, and Long Beach as reported in the NOAA Fisheries Los Angeles Times Sportfish Database (NOAA Fisheries 2004).

Common Name	HBGS Annual Impingement	2003 Landings	1999-2003 Average Annual Landings	1959-2003 Average Annual Landings
California barracuda	0	50,094	95,620	90,694
"sea bass"		21	14	57,440
white seabass	60	3,404	3,407	1,022
brown rockfish	2	0	19	7
bocaccio	0	0	1,495	219
black croaker	65	77	37	24
white croaker	4,903	296	645	1,756
queenfish	35,847	0	0	1,020
spotfin croaker	49	0	1	18
yellowfin croaker	6	1,120	573	111
California corbina	33	0	0	1
"croakers"		54	27	9
black surfperch	66	30	13	10
rubberlip perch	17	2	1	1
"perch"	5,492	21,793	14,110	5,296
blacksmith	46	2,732	1,901	375
kelp bass	138	77,004	66,783	79,203
barred sand bass	62	219,721	242,771	86,648
halfmoon	13	110	66	202
California sheephead	1	7,490	10,061	3,193
California halibut	21	2,350	2,726	8,561
jack mackerel	9	415	1,268	658
chub mackerel	17	3,974	15,338	98,519
jacksmelt	332	2	2	502
leopard shark	2	14	8	2
olive rockfish	0	0	43	136
opaleye	19	374	428	133
"sanddab"	23	32,680	43,680	7,220
sargo	17	1,020	728	210
California scorpionfish	110	32,390	35,981	12,559
round stingray	100	0	0	1
"turbot"	75	0	0	1
Totals:	**47,479**	**457,167**	**537,746**	**455,751**

Catches of species generally fluctuate over time because species not only vary in their availability and abundance, but also in their desirability to anglers. Table 5-6 presents total catch numbers, and does not take into account variability in fishing effort over time. Catch from three different time periods (2003, 1999-2003, and 1959-2003) are presented to show trends through time. The annual number of sport anglers in southern California has varied little over the last 40 years, remaining at about 620,000 angler trips per year, though the total number of fish landed has steadily decreased (Dotson and Charter 2003). Between San Pedro and San Clemente, the total catch per angler peaked in 1980, then steadily decreased by about 50% to 1999. The authors noted that fishing regulations, including size limits, take limits, and closures, have affected catch rates in southern California (Dotson and Charter 2003).

There are no known stock estimates of fishes or macroinvertebrates in southern California for species other than those managed by NOAA fisheries (e.g., Pacific groundfish and coastal pelagics), and those stock estimates are generally for population units in areas much larger than solely in the SCB. The Bight '98 Study, performed in 1998, is the latest of the regional monitoring efforts for which fish and invertebrate data are available (Allen et al. 2002). The purposes of the Bight '98 study were to describe patterns in fish and invertebrate population attributes in the SCB, to describe fish and invertebrate assemblages, and to assess the condition and extent of anthropogenic impact on fish and invertebrate populations based on the extent and distribution of tissue contamination in flatfishes, anomalies and sublethal effects, the status of population attributes in affected areas compared with reference areas, assemblage biointegrity and organization, and debris. The Regional Monitoring Surveys coordinated by the Southern California Coastal Water Research Project (SCCWRP), which were performed in 1994, 1998, and 2003 are useful in describing the fish and invertebrate communities of the SCB, but these surveys did not determine stock estimates.

The Bight '98 study included sampling in bays and harbors, and extended the sampling area inshore of the 20-m isobath (the inshore limit of the 1994 Pilot Project) to the 5-m isobath. White croaker, queenfish, northern anchovy, and shiner perch accounted for 28%, 6%, 5%, and 1% of survey fish abundance, respectively, with white croaker being the most abundant species in the Bight. The authors compared fish population attributes (such as abundance, biomass, and diversity) in the SCB from three different time periods: 1957-1975, 1994, and 1998. Though there were slight differences among the time periods, Allen et al. (2002) note "*Fish population attribute mean values for the SCB were very similar between the three time periods: fish abundance was 156-173 individuals/haul; biomass was 4.9-7.1 kg/haul; species richness was 10.1-11.7 species/haul; and diversity was 1.28-1.59 bits/individual/haul*". Herbinson et al. (2001) reported a long-term decline in white croaker abundance in the SCB from 1976 through 1998. In spite of this, white croaker still appear (as of 1998) to be the most abundant fish species on the southern California shelf.

The macroinvertebrate species most affected by the generating station were not well-represented in the 1998 trawl survey. Tuberculate pear crab comprised 1% of the survey abundance, with all other commonly impinged invertebrates comprising <0.2% of survey abundance or less in trawl samples (Allen et al. 2002). Ridgeback prawn (one of the entrainment target species in the present study) was the second most abundant invertebrate in the Bight-wide trawl survey, comprising 16% of total abundance. Unlike fish population attributes (such as abundance, biomass, and diversity), Allen et al. (2002) noted that invertebrate population attributes in 1998 were generally lower than in 1994 or 1957-1975, with highest abundance and biomass per haul occurring in 1994, and highest species richness in 1957-1975. Diversity was not measured in 1957-1975, but dropped from 1.09 to 0.99 per haul between 1994 and 1998.

We summarized results of annual trawl surveys offshore the HBGS from 1976-2004 for the most abundant species in impingement samples (Figure 5-1). The trawl surveys were conducted annually each August off the HBGS between the Santa Ana River mouth and the Huntington Beach Pier. From 1976-1993, a total of twelve trawls was performed, including six performed perpendicular to shore. Beginning in 1994, sampling effort was reduced to six trawls per year, with all performed parallel to shore on the discharge isobath.

Fish abundance offshore the generating station in summer declined after 1994, when the trawl program was halved (Figure 5-1). This could be due to reduced numbers of fishes in the study area, reduced sampling effort, and/or the elimination of trawls that extended further offshore. The trawl locations were limited to the discharge isobath, and cannot account for cross-shelf shifts in fish populations. However, when the relationship between fish abundance and flow rate is considered, it is likely there has been a decrease in fish abundance offshore Huntington Beach through time (Figure 5-2).

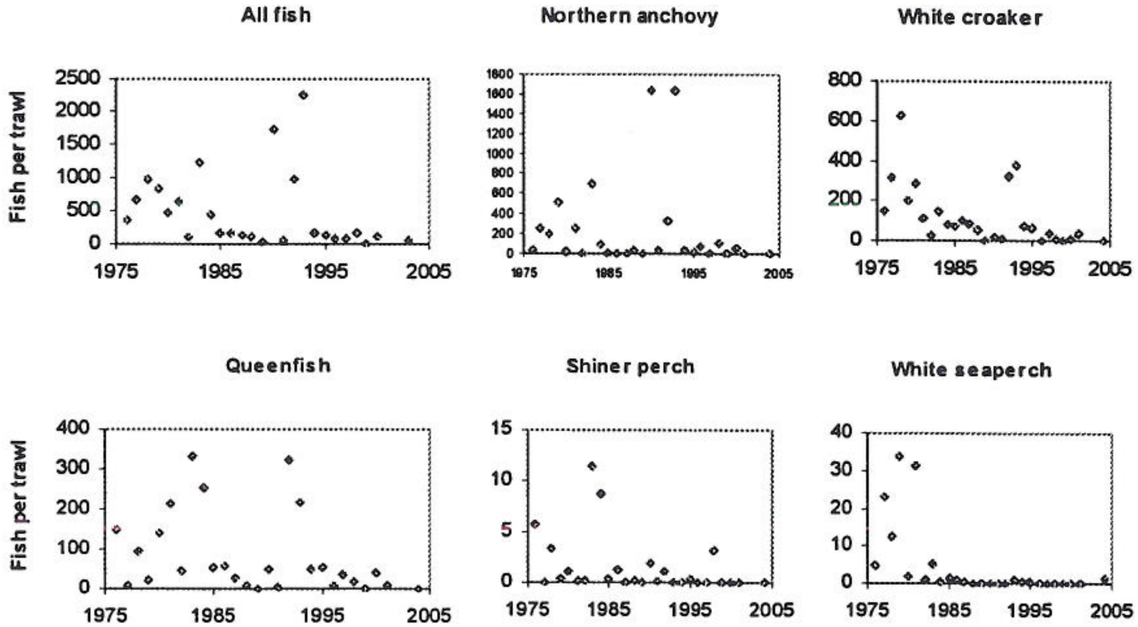

Figure 5-1. Trawl abundance (catch-per-unit-effort [CPUE]) for select fish species offshore the HBGS, 1976–2004. Surveys performed in August of each year, except 2002–2003 (no surveys). Trawl effort was halved in 1994. Note: Y-axis values are different for each graph.

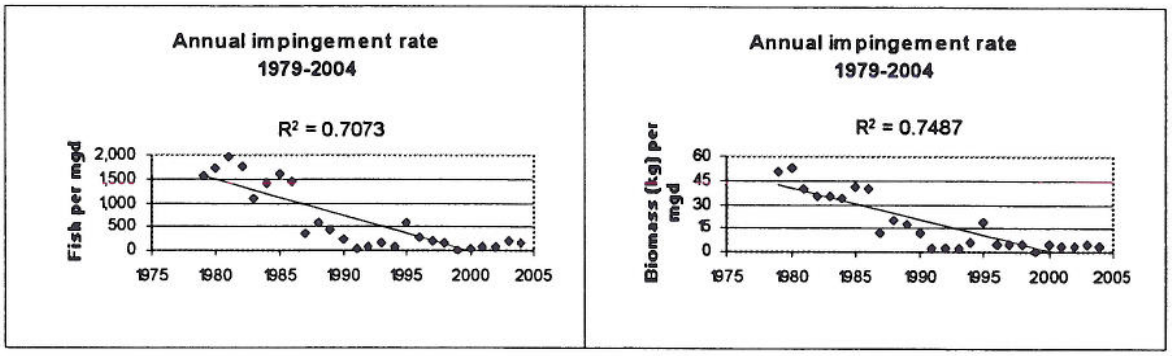

Figure 5-2. Fish impingement (CPUE) from 1976 to the present at the HBGS. CPUE expressed as individuals (left) and biomass (right) per 1,000,000 gallons per day of cooling water flow.

The long-term dataset for impinged macroinvertebrates is not as complete as that for fishes; annual macroinvertebrate impingement totals are available only from 1994 to present. During that time period, the impingement rate has increased slightly with respect to abundance, but biomass has remained stable (Figure 5-3).

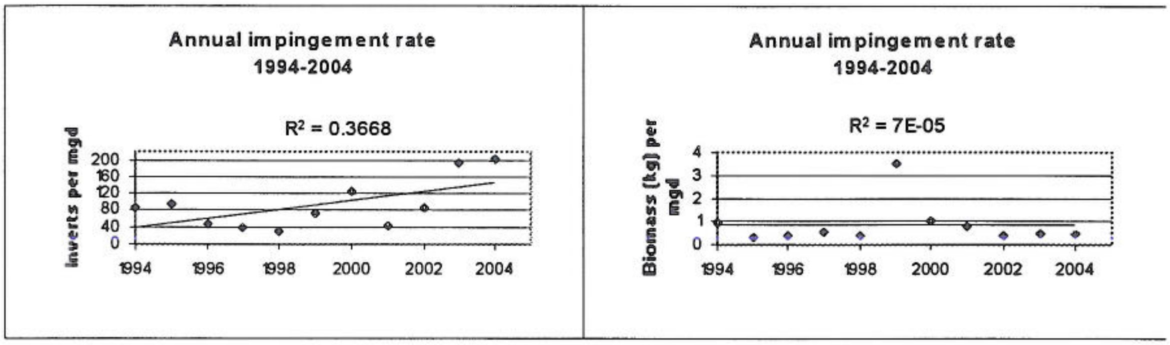

Figure 5-3. Macroinvertebrate impingement (CPUE) from 1994 to the present at the HBGS. CPUE expressed as individuals (left) and biomass (right) per 1,000,000 gallons per day of cooling water flow.

Trend analysis may provide insight to population trends; however, it would be extremely difficult to determine the reasons for the annual variations and patterns. Numerous factors, such as regional oceanographic conditions, availability of food resources, and anthropogenic impacts (including I&E), probably affect the composition and abundance of nearshore fishes and invertebrates. Most of our the long-term impingement data set was collected under a warm oceanic regime in the SCB, and further influenced by a series of El Niño/Southern Oscillation events within this time period (Moser et al. 2001) (Figure 5-4). These included El Niño events in 1982–1983, 1993, and 1997–1998, and La Niña events in 1988–1989 and 1999.

In addition to periodic El Niño and La Niña events, the lower frequency Pacific Decadal Oscillation (PDO) describes multidecadal cycles of warm and cold oceanic regimes off California. The PDO affects ocean climate (water temperature, upwelling, productivity, precipitation, and runoff) along the Pacific Coast. When the Aleutian Low atmospheric pressure cell is strong, there is a warm temperature regime off California. During this time, the California Current is weak, upwelling is reduced, and productivity is low. However, precipitation and runoff are high. When the Aleutian Low is weak, the California Current is strong, upwelling is greater, and precipitation and runoff are low. These regime shifts have caused shifts in fish populations in the Pacific Ocean (Allen et al. 2004).

From 1951 through the mid-1990s, macrozooplankton biomass in waters off southern California decreased by 80%, coinciding with a temperature increase in the oceanic surface layer (Roemmich and McGowan 1995). All of the fish species examined (Figure 5-1) feed on zooplankton with the decrease possibly affecting overall fish abundance. Holbrook et al. (1997) estimated a 69% decrease in populations of 75 fish species at King Harbor and off Palos Verdes, California, between 1975 and 1993. Brooks et al. (2002) examined impingement data from four coastal generating stations, including the HBGS, and determined that the abundance of 37 fish species declined an average of 41% from 1978 to 1992. The authors attributed this to a regional decline in productivity.

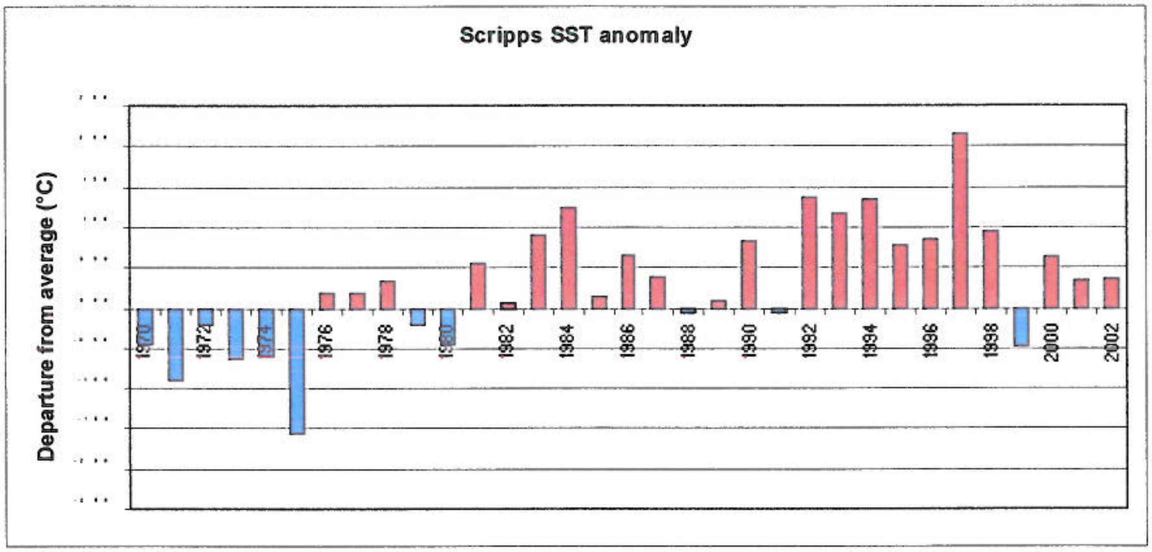

Figure 5-4. Annual sea surface temperature anomaly (departure from 82-year average) from 1970-2002 at Scripps Pier, La Jolla, CA.

5.3 Direct Impact Summary

CEQA does not provide a clear definition of significant impact with respect to biological resources, only that it equates to a "substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project..." (CEQA Guidelines §15382). The operation of the cooling water intake system at present results in an annual estimated impingement of 51,082 fishes weighing 1,292 kg (2,848 lb.), and an estimated 70,368 macroinvertebrates weighing 168 kg (369 lb.). These estimates are equal to approximately 140 fish weighing 3.5 kg (8 lb.) per day, and 194 macroinvertebrates weighing 0.5 kg (1 l.b) per day. There are no source population estimates for impinged species with which to determine if the losses are "substantial" on a population level.

Impacts to SCB fish and invertebrate populations caused by the entrainment of planktonic larvae through the HBGS CWIS can only be assessed indirectly through modeling (Section 5.1). These impacts are additive with the direct impingement losses. The definition of "effects" or "impacts" in CEQA is not limited to direct impacts, such as impingement losses, but may also include "...indirect or secondary effects which are caused by the project and are later in time or farther removed in distance, but are still reasonably foreseeable..." (CEQA Guidelines

§15358). Of the ten abundant fish species entrained at HBGS, seven have some commercial or recreational fishery value. The *ETM* procedure estimates the annual probability of mortality due to entrainment (P_M). It puts the entrainment estimate into context by comparing it with a known source population at risk of entrainment. The P_M estimates for all of the target taxa were approximately one percent or less (Table 5-1). The alongshore estimates indicate that these impacts occur over an estimated 13 to 85 km of coastline. The distance of shoreline potentially affected is directly proportional to the estimate of time that the larvae are exposed to entrainment. Nearly half of the 53 different fish taxa entrained belonged to species with some direct fishery value (e.g., sand basses, white seabass, California barracuda) even though most of those were very infrequent in the samples. Because of their low abundance in the samples, most of these taxa were not modeled for potential impacts. The single invertebrate taxon modeled for entrainment impacts, *Cancer* crabs, had projected impacts of 1.1% of a source water population extrapolated along a shoreline distance of 27 km. Even in a heavily exploited commercial species these levels of additional mortality would be considered very low, especially when the populations of these species extend over a much larger geographic range than the extrapolated source water bodies.

There were a few fishes where the combined effects of entrainment and impingement could be assessed. This was done using the RecFIN data presented in Table 5-4. Estimates of entrainment effects based on P_M estimates when added to impingement resulted in losses to the recreational catch for southern California totaling 4.2% for queenfish, 3.4% for white croaker, 0.3% for California halibut, and 0.6% for spotfin croaker. The entrainment estimates were determined by multiplying the P_m estimates by the total southern California landing estimates.

Key findings of the entrainment study are as follows:

- No State- or Federally-listed threatened or endangered species were entrained in the year-long study;
- Annual entrainment losses of equivalent adults could only be projected for CIQ gobies (101,269 using *FH* and 147,493 using *AEL*) and northern anchovy (26,745 using *FH* and 304,125 using *AEL*);
- Fish entrainment losses were equivalent to 0.1% to 1.2% of the source water populations of those species modeled. Approximately one-half of the taxa entrained through HBGS had some direct value to sport or commercial fishers, although most were entrained in very low abundance.

- The five most abundantly entrained fish species (CIQ gobies, anchovies, spotfin croaker, white croaker and queenfish) represented fishes from a variety of habitats including bay/wetland (gobies), benthic nearshore (croakers), and pelagic nearshore/offshore (anchovies). Of these species spotfin croaker is probably the least abundant in the SCB. The most abundantly impinged macroinvertebrate larvae (sand or mole crabs) are widely distributed along shorelines in the SCB.

- Cost estimates for entrainment losses based on using the P_M estimate as a proportion of the dollar value of the catch landed from Catch Block 738 totaled \$307 and \$312 based on 2002 and 2003 data, respectively. These estimates underestimate the potential value of the losses because they are based on P_M estimates for only four of the target taxa, and the size of the block is much smaller than the potential source water for the species analyzed.

The following is a summary of impingement impacts:

- No State- or Federally-listed threatened or endangered species were impinged in the year-long study;

- Impingement losses (fishes and macroinvertebrates) were equivalent to \$823–\$2,367 using 2002 commercial catch data, and \$1,072–\$2,887 using 2003 data;

- Fish impingement losses were equivalent to 1% of southern California recreational landings as reported by PSFMC (2004), and about 10% of recreational landings from Huntington, Newport, and Long Beach as reported by NOAA Fisheries (2004). However, many of the species most commonly impinged are those which are not highly prized by sport fishers;

- The four most abundantly impinged fish species are fairly abundant in the SCB, together comprising 40% of fish abundance from the 1998 Regional Monitoring Study in the SCB. The most abundantly impinged macroinvertebrates were not nearly as abundant in the Bight-wide study, however.

Based on results of long-term impingement and trawl studies at the HBGS, numbers of fishes at intake depth off the HBGS have declined since the 1970s and 1980s. It is unclear whether this resulted from coastwise or cross-shelf population shifts, or a reduction in stocks through time, and what led to these changes (e.g., oceanographic conditions, anthropogenic impacts, etc.).

6.0 IMPINGEMENT REDUCTION EVALUATION

6.1 Introduction

EPA defines entrainment as "the incorporation of all life stages of fish and shellfish with intake flow entering and passing through a cooling water intake structure and into a cooling water system" (EPA 2002). Impingement refers to the entrapment of fishes and shellfishes on screening structures during cooling water withdrawals. At the HBGS, juvenile and adult fishes that are entrained in the cooling water intake structure are drawn downstream to the generating station screening structure where they are susceptible to impingement on the traveling screens. However, upcurrent from the traveling screens, the intake conduit directs the cooling water flow to an open-air forebay (Figure 6-1).

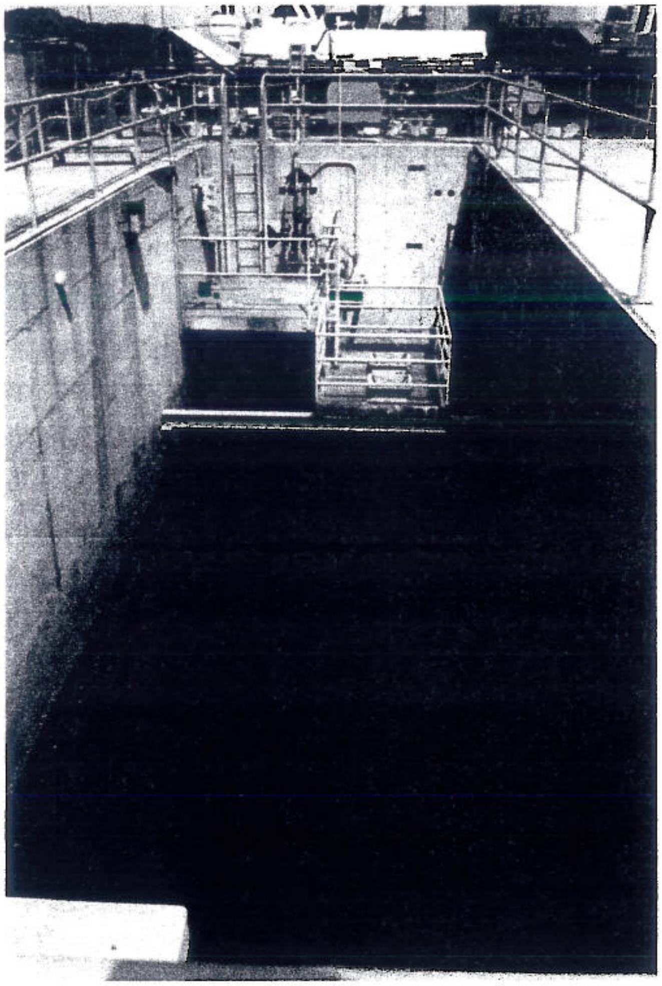

Figure 6-1. AES HBGS forebay.

This forebay is larger and deeper in dimension than the intake conduit and, as a result, there are portions of the forebay with lower water velocities than those found in the intake conduit. Some fishes are impinged and removed during normal plant operations. However, many of the fishes that are drawn into the generating station's cooling water intake system (CWIS) remain within the forebay until the plant conducts a heat treatment, at which time all of the fishes and macroinvertebrates in the forebay succumb to the heated water and are subsequently impinged on the traveling screens and removed from the system.

During the AFC proceedings for the Retool Project it was hypothesized by some individuals that netting entrapped fishes out of the intake forebay may be feasible to reduce impingement losses. Subsequently, the CEC imposed Condition of Certification BIO-6 upon AES Huntington Beach L.L.C., which specifies the following:

The project owner shall conduct a study to determine if there is a feasible methodology that would greatly reduce the number of fishes trapped in the intake forebay. If the study determines that a feasible method(s) exists to reduce the number of fishes trapped in the cooling water system the project owner shall implement those methods.

6.2 Methods

The purpose of this study is to examine a variety of ways to reduce impingement at the HBGS, and to evaluate the feasibility of each method. Here we examine different methodologies for reducing fish entrapment at HBGS, discuss their principles of effectiveness, performance, and cost, and determine their feasibility for use at the HBGS. Section 6.3 summarizes the history of entrapment studies and attempts at reducing entrapment at other power stations in California. Section 6.4 examines a variety of potential methods for reducing fish entrapment, including behavioral barriers, fish collection and return systems, and alternative intake locations. Section 6.5 discusses the results of our analysis and prioritizes the available technologies/methods based on feasibility.

6.3 History of Entrapment Studies

There are six coastal generating stations in southern California with offshore, velocity-capped intake structures, including the HBGS. In total, there are nine such intake structures in southern California coastal waters; all others are shoreline-type intake structures or intake canals that withdraw cooling water from bays, harbors, or lagoons. Entrapment at generating stations with offshore intake structures occurs when organisms are drawn into the intake structure and transported, along with the cooling water flow, to the generating station. Impingement occurs when entrapped organisms are trapped on traveling screens designed to remove organisms and debris from the cooling water. This occurs when the fishes die, or their swimming ability is no longer capable of countering intake flow.

Fish entrapment is largely a function of cooling water intake flow, fish distribution, and fish density. At the HBGS, fish entrapment is dominated by only a few species, including queenfish (*Seriphus politus*), shiner perch (*Cymatogaster aggregata*), northern anchovy (*Engraulis mordax*), and white croaker (*Genyonemus lineatus*) (MBC 2004). Helvey (1985) considered queenfish, northern anchovy, and white croaker to be "transient" in that they are rarely observed at intakes during the day, and their nocturnal interactions with intake structures are largely incidental. Shiner perch were considered by Helvey (1985) to be "intake-associated" in that they remain associated with reefs for most of their lives.

The previous owners of the HBGS studied ways to reduce entrapment at the generating station (and other similar coastal generating stations), and also implemented methods to reduce entrapment. This section summarizes both actual demonstrations and studies to reduce entrapment at some of southern California's coastal generating stations, including the HBGS.

6.3.1 Previous Attempts to Reduce Entrapment at HBGS

Velocity Caps

Southern California Edison (SCE), the former operator of the HBGS, began studying ways to reduce impingement in the 1950s, including behavioral barriers such as light and sound. The velocity cap, in use at HBGS today, was considered a feasible method to greatly reduce entrapment and impingement not only at HBGS, but at all generating stations with offshore intakes. The velocity cap is a concrete cap that is supported above the vertical intake riser, and it acts to direct intake flows horizontally rather than vertically (many fishes are more sensitive to horizontal flows than vertical flows) (Downs and Meddock 1974). There are different shapes (e.g., circular and rectangular) and configurations of velocity caps (Figure 6-2). The velocity cap at the HBGS intake and at the two intakes at the El Segundo Generating Station (ESGS) are similar in design and referred to as "overhang cap" since the cap extends horizontally beyond the riser (Schlotterbeck et al. 1979). Others are "flush" if the cap and riser are the same shape and diameter, and "overhang cap and riser lip" if both the cap and riser are extended horizontally. Studies at the ESGS and Scattergood Generating Stations, which draw cooling water from Santa

Monica Bay, indicated velocity caps reduced entrapment and subsequent impingement by up to 90% (Weight 1958; SCE 1975).

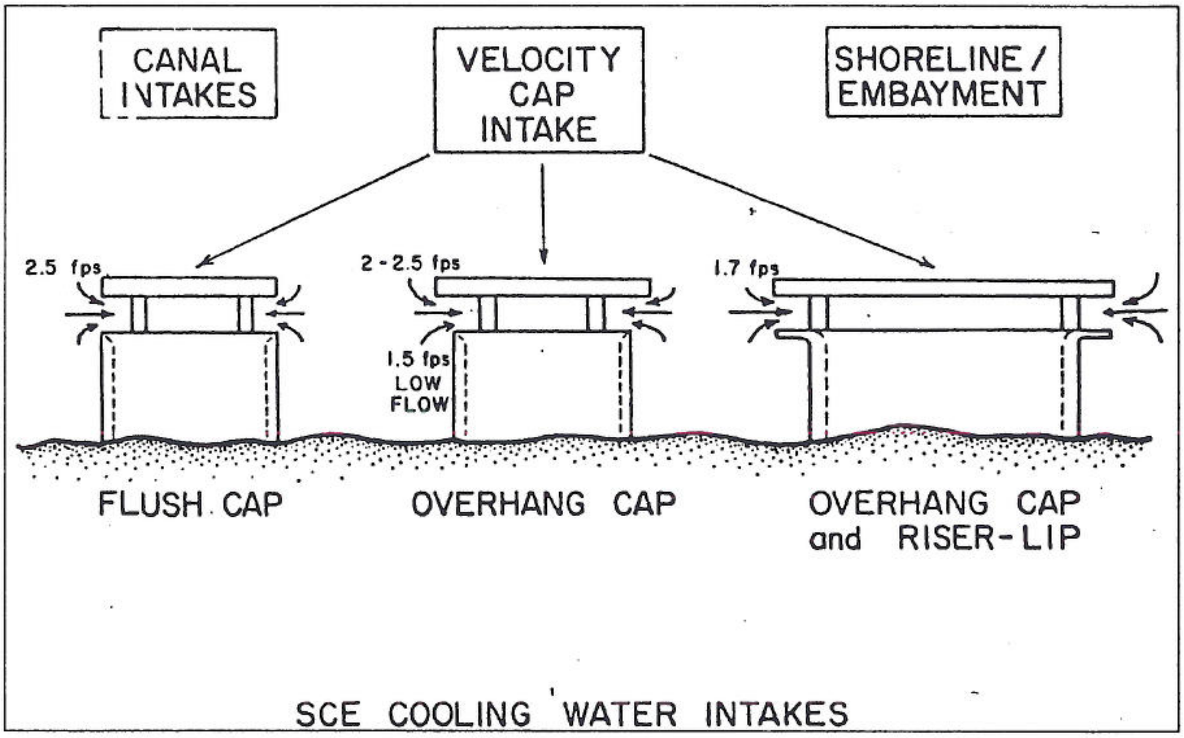

Figure 6-2. Examples of velocity cap types at southern California coastal generating stations. (From Schlotterbeck et al. 1979).

Fish Pumps and Return Systems

SCE studied fish return (via pump) as early as 1956, and by 1968 a pump system for fish removal was installed at the HBGS (SCE 1975, Stipanov 1979). The pump used at HBGS was an eight-inch diameter food-handling pump. A similar pump was also used at Pacific Gas & Electric's Contra Costa Power Plant in Antioch, California (Bechtel 1971). At the HBGS, fishes were pumped out of the forebay and into the discharge conduit. The concrete platform constructed for this operation is still in place in the HBGS forebay. The number of fishes removed was estimated by a photoelectric cell counter within the pump pipe. The system was designed to transfer fish up to 30-cm (12-in.) in length (SCE 1975, Stipanov 1979).

The system was operated during the nighttime, and a light was suspended in the forebay to attract fishes into the vicinity of the pump. The effect of different periods of light on fish attraction was studied (e.g., constant light versus a variety of intervals of alternating light and dark). Removal rates were relatively similar during all of the light regimes. Fish removal rates gradually decreased to almost zero after about two hours of pump operation, and after consecutive days of two-hour operation, the removal rate continued to decrease. It was hypothesized that this resulted not from a decrease in fish abundance, but from fish acclimatization to the light operation and their avoidance of the area.

SCE estimated the pump removal effectiveness to be as high as 55%; however, given the high variability in observed removal rates, and the lack of data on survivability, this estimate was probably not reliable. There were also times when stunned or deceased fish were found on the adjacent state beach, probably after they had been discharged from the generating station (C.T. Mitchell, MBC, pers. comm. 2003).

Fish Netting

In 1995, MBC took part in a study that examined responses of several fish species to sonic stimuli at Redondo Marine Laboratory (see Section 6.4.1). The four target species were northern anchovy, white croaker, queenfish, and Pacific sardine, which were collected using a variety of methods, including netting from the HBGS forebay. Prior to a heat treatment on 26 April 1995, MBC personnel used a modified net to collect approximately 400 queenfish and white croaker from the HBGS forebay. These fishes were placed in a specially designed holding tank filled with ambient intake water from the generating station and equipped with aeration. The test organisms were then driven to the Redondo Marine Laboratory in Redondo Beach, approximately 30 miles upcoast from Huntington Beach. Field notes from the transfer indicate that survival of white croaker was approximately 75%, while only "few queenfish lived." It is MBC's experience in working with trawl-caught or impinged queenfish that they do not tolerate handling well in comparison with similar-sized individuals of many other species, including other sciaenids (croakers) found off southern California.

MBC biologists removed Pacific electric rays (*Torpedo californica*) from the HBGS forebay for many years, and continue to do so. When entrapped in the forebay, these fishes often cruise slowly at the water surface and are visible to plant personnel. Removal was accomplished through the use of a custom net fitted with four long bridles that enabled biologists to lower and retrieve the net from the concrete platform surrounding the forebay. One side of the net was weighted so the net could be positioned under the swimming electric ray. Once captured, it would be brought to the surface, placed in an aerated holding tank, and transported to the nearest appropriate release site. Most often, the rays were released at the public dock near the entrance to Newport Harbor (Newport Beach, CA), approximately six miles from the generating station.

6.3.2 Previous Entrapment Reduction Studies

Huntington Beach Generating Station

Fish Encounter Studies (FES) et al. (1980) examined trends in fish entrapment in southern California to determine if they were associated with differences in intake structure design, capacity, siting, and environmental parameters. In-plant entrapment and offshore abundance data were collected simultaneously for queenfish, white croaker, and northern anchovy at the HBGS. The authors calculated "vulnerability indices" as follows:

Vulnerability = E/B

Where: E = Entrapment biomass
B = Density of fishes surrounding the intake structure

Entrapment biomass was determined by incapacitating all fishes within the cooling water intake system so they could be impinged, removed by the traveling screens, and processed. This was accomplished by two methods: abbreviated heat treatment and sodium hypochlorite treatment. The density of fishes surrounding the intake structure was calculated by hydroacoustics. As the hydroacoustic surveys were underway, a simultaneous lampara and gill net sampling program was initiated to determine the species composition of a subsample of the acoustic targets. The following is a summary of the results.

Diel Variation. At HBGS, the mean rate of hourly fish entrapment was highest at night compared with crepuscular (dawn/dusk) and diurnal (daylight) periods (Friedman's $p>0.05$) (FES et al. 1980). Further diel entrapment studies indicated that entrapment rates were 7.9 times higher between midnight and dawn than during the remaining hours of the day. One possible explanation for this disparity was the vertical migration of queenfish and white croaker at night, leading to an increased frequency of encounter with the intake system.

Water Clarity. Water clarity measurements were recorded at the HBGS forebay during daylight hours (FES et al. 1980). Measurements were made by observing the number of rungs visible on a submerged grid in the forebay, and comparing them with Vulnerability indices during days of full flow and "normal" operating conditions. For some species, there was a significant negative correlation between vulnerability and water clarity. Spearman rank correlation coefficients were -0.790 for queenfish, -0.804 for white croaker, and -0.793 for all species combined, and were statistically significant ($p<0.01$). Northern anchovy entrapment was not significantly affected by water clarity (-0.274, $p>0.05$).

Intake Velocity. FES et al. (1980) deployed an electromagnetic current sensor on the velocity cap to measure intake currents at a distance of about 1.2 m from the riser bowl at the HBGS intake structure. Comparison of Vulnerability Indices and entrance velocities yielded no significant relationships. Intake velocities of up to 1.2 m/s were recorded at that location.

Intake Volume. FES et al. (1980) compared nocturnal fish entrapment during half-flow (four cooling water pumps) and full flow (eight cooling water pumps) conditions. Vulnerability Indices were then compared to determine if entrapment rates were more closely related to changes in flow than with changes in offshore population densities. Mean hourly entrapment rates for queenfish, white croaker, northern anchovy, and all species combined were 75% or lower on nights with reduced flows than on nights with full flows. However, there were large fluctuations in offshore densities, and the variability in the data suggested that the differences were not statistically significant. In conclusion, it was noted: "For queenfish...there was some evidence supporting the conclusion that reduced flow, and not changes in abundance, was the factor responsible for the observed decreases in entrapment. This latter observation is encouraging in that queenfish comprise a very large percentage of SCE's fish entrapment."

Redondo Beach Generating Station

Johnson et al. (1976) studied factors affecting entrapment at the Redondo Beach Generating Station (Redondo Beach, California) from 1974 to 1976. The Redondo Beach Generating Station Units 7&8 intake is similar in design to the one off the HBGS, and withdraws cooling water from the mouth of King Harbor. The authors of this study concluded the following:

- The highest fish impingement was associated with storms producing winds greater than 15 kn. Twenty-one percent of total impingement during the two-year study occurred during two storms with high wind speeds.
- Higher water temperatures (18°-23°C) were associated with increased entrapment. This, however, coincided with the seasonal presence of small schooling fishes in the intake area and was most likely a spurious correlation.

- Relative swimming ability was not an apparent factor in impingement relative to cooling water intake flow; however, surge during storm events may have led to increased impingement.

- Females, particularly those in an advanced reproductive state, were more frequently impinged than males. The reproductive state of females has been shown to affect swimming ability.

6.4 Potential Impingement Reduction Systems and Methods

The following section examines potential means of reducing fish impingement at HBGS. Some systems are in use at generating stations, while others are considered experimental. The different options considered are classified as behavioral barriers/technologies, screening and return technologies, fish elevators, intake relocation, and flow modifications.

6.4.1 Behavioral Barriers and Technologies

Behavioral barriers/technologies include light stimuli, sonic stimuli, and bubble curtains (EPA 2004). Some of these technologies have been considered for generating stations with CWIS designs similar to that of the HBGS. In 1991, the California Coastal Commission required the operators of the San Onofre Nuclear Generating Station (SONGS; San Clemente, California) to "install and maintain behavioral barriers including but not limited to mercury lights and sonic devices at SONGS Units 2 and 3 to reduce midwater fish impingement losses." Studies determined mercury lights were not effective in reducing impingement, and acoustic technology was deemed infeasible due to logistical difficulties and high costs (CCC 2000). Though these technologies are not in use at SONGS, the operators utilize a "fish chase" procedure which reduces fish impingement by optimizing the effectiveness of the fish return system. The following is a discussion of behavioral barriers/technologies considered for the HBGS.

Sonic Stimuli

Sonic stimuli, or sound barriers, rely on mechanical or electronic equipment that generates sound patterns to elicit avoidance responses in fishes. Sound has been shown to effectively deter certain species of fishes. Very low frequency (VLF) sound has been demonstrated to reduce the numbers of chinook salmon (*Oncorhynchus tshawytscha*) yearlings and sockeye salmon (*O. nerka*) from entering an irrigation canal intake in Chelan County, Washington (Hays et al. 1995). Crude tests were conducted to evaluate the effectiveness of acoustic barriers in southern California in the 1970s (Schuler 1974). EPA (2004) notes that most studies performed to document the performance of such technologies "have been inconclusive or have shown no significant reduction in impingement or entrainment. As a result, the full-scale application of behavioral devices has been limited. Where data are available, performance appears to be highly dependent on the types and sizes of species and environmental conditions. One exception might be the use of sound systems to divert alewife." Alewife (*Alosa pseudoharengus*) is a common, anadromous clupeid on the Atlantic coast. In general, sonic systems are implemented to reduce impingement of one, or a few, target species.

In 1972, Virginia Electric and Power Company conducted preliminary tests on the use of sound (primarily rock music) from underwater speakers to repel fishes from the vicinity (Schuler 1974). Test results suggested sound could be used to effectively deter fishes from specific areas. Subsequently, studies were performed at SCE's Long Beach Generating Station (Long Beach, California). The studies used various sounds (rock music, a "killer whale tape," and a range of frequencies from 20 to 15,000 cycles per second) aimed at eliciting startle responses in various fish species, including black perch, shiner perch, kelp perch, northern anchovy, and queenfish. No startle response in these fishes was observed by divers. The striking of a mallet on partially submerged wooden planks did elicit a startle response, suggesting the absence of a shock wave in the taped sounds may have reduced their effectiveness.

In that same study at the Long Beach Generating Station, an underwater pneumatic device (referred to as a "popper") was tested (Schuler 1974). Fishes demonstrated a startle response within 60 ft of the popper, especially when it was cycled continuously. The same device was tested at two offshore intake structures off the Redondo Beach Generating Station. The popper was placed at each intake structure in the intake opening between the top of the riser and the velocity cap. Upon activation, all observable fishes (surfperches, kelp bass, and spotted sand bass) within approximately 12 ft of the intake left the immediate vicinity. Fishes on the other three sides of the intake structure showed no reaction. After approximately three hours, with the device operating continuously at 6 to 12 cycles per minute, a few individual surfperches were observed approximately five to eight feet from the popper, but below and away from the intake opening. No fishes were ever observed in the intake opening while the popper operated. Currently, there are no such systems available that have proven effectiveness at deterring fishes (Popper pers. comm. 2005).

Sonalysts Study

Introduction. The potential use of sonic stimuli to reduce fish impingement and improve fish-return performance at SCE's San Onofre Nuclear Generating Station (SONGS) was studied in 1995 (Sonalysts and MBC 1995a). It was hypothesized that sonic devices could be installed in the forebay of SONGS to direct fishes to the fish return system (FRS), and/or that sonic devices could be installed at the offshore intake structure(s) to deter fishes from the area. The experiment was designed to evaluate the response of selected species to acoustic stimuli. The target species selected for analysis were northern anchovy, white croaker, queenfish, and Pacific sardine. Combined these four species represented 91.3% of impingement abundance and 73.6% of impingement biomass at HBGS between 1979 and 2002. Walleye surfperch (*Hyperprosopon argenteum*) was also analyzed since it was incidentally collected with the other test organisms. From 1979 through 2002, this species comprised 2.3% of impingement abundance and 2.4% of impingement biomass at HBGS.

Methods. Fishes were collected and placed in a large, redwood-walled holding tank supplied with running seawater at SCE's Redondo Marine Laboratory. The tank was large enough that fishes were presumed to be free-swimming and capable of making preferential selections of the acoustical environments. The tank was 25 ft in diameter with a concrete bottom and lower sides. A 12-ft diameter circular "island" was installed in the center of the tank to form a circular water path that was approximately 6 ft wide, and water depth in this raceway was maintained at approximately 6 ft. Seawater flow in the raceway was unidirectional so as to produce circular water flow that the fishes were able to orient to. Within the tank, two identical tunnels (test flues) were installed, and each tunnel was fabricated with access ports for transducers, underwater lights, and video equipment for recording observations. The tunnels were located about mid-depth in the water column, and a concrete barrier between the two tunnels prevented acoustic contamination between them. To minimize turbulence, a ramp composed of cinder blocks was placed at the entrance and exit of each tunnel. Overall, the setup was designed to provide fishes with identical paths, provide acoustic isolation, and minimize background noise. Transducers were installed under the test flues and video recorders were installed above them to record fish movements. Recordings were made during periods of normal (no acoustic stimuli) behavior and all periods of fish behavior when test signals were broadcast.

Results. Very Low Frequency (VLF) signals always elicited avoidance responses from the test subjects. The most dramatic results were recorded when circulating (swimming) fishes were exposed to recorded signals of other swimming fishes. It was hypothesized that large-magnitude VLF sound fields are interpreted by fishes as either an attacking predator or large obstacle that must be avoided. With sonic stimuli enacted, white croaker approached the flues every few minutes, yet they turned around and swam away every time. Interestingly, with good visibility and no threat visible, avoidance continued.

Medium Frequency (MF) signals elicited weak startle responses from northern anchovy and Pacific sardine, but not from white croaker and walleye surfperch. It was concluded that MF signals were not effective in altering the behavior of the target species. Very High Frequency (VHF) signals elicited no response from any of the test species.

Discussion. Overall, the project demonstrated that "biologically significant sound can be artificially generated and that it elicited a consistent, repeatable avoidance response from four species of fishes" (Sonalysts and MBC 1995a). Subsequently, the feasibility of installing an acoustic behavioral barrier at SONGS was analyzed (Sonalysts and MBC 1995b). The feasibility study analyzed the installation of both 1) a system within the forebay/screenwell that increased the number of fishes entering the FRS, and 2) a system at one of the offshore intake structures to deter fishes from the intake area. While this study was specific to SONGS, the similarity in impingement catches between SONGS and HBGS, as well as the similarity in cooling water systems, results from SONGS could potentially be applicable to HBGS.

Installation of an acoustic barrier at one of the SONGS offshore intake structures was analyzed. In theory, such a barrier would have to continuously deter fishes from entering the cooling water intake system, while allowing local fishes to reside in the area. Transducer mounting was considered 1) at a point midway between the velocity cap and lower flange and directed outward, and 2) in a similar configuration as (1), but at a reduced radius from the center of the intake structure. A cost estimate associated with the first option included 40 transducers ($480,000), 14 amplifiers ($20,000), a PC-based digital acquisition system ($10,000), and submersible cable ($20,000 to $40,000). Additional costs would be associated with the design and implementation of an appropriate system to ensure cable integrity, the design and fabrication of custom transducer mounts, and labor and travel expenses required for design, preparation, installation, and periodic monitoring of the acoustic deterrence system. In the end, it was determined that the system was not feasible at SONGS due to the potential for impacts to fishes and marine mammals, and the technological limitations of such a system.

Currently, EPA does not consider some of the fairly basic sonic systems (pneumatic air gun, pulser, and hammer) to be reliable, while the more sophisticated systems, such as the one evaluated for SONGS, require relatively expensive systems (EPA 2004). However, since no system has been permanently installed at a facility, there is no reliable cost information.

Light Stimuli

Light barriers consist of the controlled application of strobes or mercury vapor lights to lure fishes away from a CWIS or to deflect natural migration patterns (EPA 2004). As with sonic stimuli, EPA notes that full-scale application of this technology has been limited due to inconclusive or poor results from pilot studies.

SCE studied the effect of various combinations of artificial lighting on the success of the FRS at SONGS in the late-1990s. Incandescent lights were installed in 1998, and a three-phased experiment investigating the effects of these lights in reducing fish losses was conducted between February and December 1999. The first phase studied the effectiveness of the lights in diverting fishes to the fish return system (FRS). Results of this first phase showed "no evidence that lights worked as an effective behavioral barrier device" (CCC 2000).

The second phase of the light study used a lower light intensity because it was hypothesized that there was too much light reaching the waters directly upcurrent of the traveling screens. Results of this phase of the experiment, which lasted two months, indicated "no significant effects of the treatment; however, there was a trend for the lights-off condition to reduce impingement and increase fish return via the FRS." The third phase of the study controlled ambient light entering the screenwell. The two-month study showed that "impingement was increased in the dark condition (compared to ambient light) and there was no difference in fish return under the two conditions." SCE studies also indicated that strobe lights "showed inconsistent results for northern anchovy and apparent attraction for Pacific sardines. Strobe lights were therefore eliminated from consideration due to the probability that they would increase fish impingement at SONGS" (CCC 2000).

Bubble Curtains

Bubble curtains consist of an air header with jets arranged to provide a continuous curtain of air bubbles over a cross-sectional area (EPA 2004). The bubbles, in theory, would repel fishes that might otherwise approach a CWIS. These systems have been tested primarily in estuarine and freshwater systems, and results are highly variable (LMS 1982). In summary, most tests and application of air bubblers for fish protection "have produced negative results." Results of these studies also indicated better effectiveness during the day than at night. There is no available information on expected biological performance or cost to implement such a system at the HBGS.

6.4.2 Screening Technologies

Screening technologies include barrier nets and traveling screens. Barrier nets would reduce entrapment by preventing juvenile/adult fishes from entering the CWIS. Conventional traveling screens are currently used at the HBGS and other coastal generating stations in southern California. However, there are modifications or changes to these screens, and other screening technologies that, when coupled with an effective return system, could reduce impingement at the HBGS. These are discussed in the following section.

Fish Barrier Net

Fish barrier nets are designed specifically to reduce fish impingement by excluding them from areas where they would be susceptible to entrainment/impingement. They consist of netting and a support system. Design considerations include the size of fishes to be excluded, near-field hydraulic conditions (velocity), and debris loading (EPA 2004). Such systems have been used successfully, but there are no known open coastal applications; barrier nets are usually used to exclude fishes from intake canals. EPA notes that these systems "lend themselves to intakes where the seasonal migration of fish and other organisms require fish diversion facilities for only specific times of the year."

SCE evaluated a barrier net system in the 1970s, and a prototype net was developed for installation at El Segundo Generating Station (El Segundo, California), which has two offshore intakes similar to the one at HBGS (SCE 1975). The net was constructed of heavy polyethylene line and designed to minimize the probability of trapping fishes by the gills. The mesh size used for this prototype net was not documented, but based on its description, seems to have been designed primarily to prevent entrainment of juvenile and adult fishes, not larvae. The prototype was installed at El Segundo in 1972, but the anchoring system was inadequate and the net was removed after only four days.

Aquatic Filter Barrier

Aquatic microfiltration barriers are exclusionary systems designed for deployment near cooling water intake structures. The filter fabric of the system allows for passage of water into a cooling water system while excluding aquatic organisms. The extent of exclusion is largely dependent on the mesh size of the barrier. Gunderboom, Inc. has designed and patented a full-water-depth curtain made up of polyethylene or polypropylene fabric that is suspended by flotation billets at the surface of the water and anchored to the substrate below (EPA 2001, 2004). The curtain is fabricated with unwoven fibers with small pores (0.4 to 2.0 mm) in the fabric that can be sized to satisfy the specific requirements of each installation. The system is also equipped with an air-burst system that periodically agitates the filter material and passes air bubbles through the system to prevent the buildup of debris on the curtain.

The Gunderboom Aquatic Filter Barrier (AFB) has been used at some facilities on the east coast of the U.S., but as of 2001 the EPA designated the technology as still "experimental in nature" (EPA 2001). The Lovett Generating Station on the Hudson River in New York, (Orange & Rockland Utilities, Inc.) has been using a Gunderboom AFB since the mid-1990s to reduce ichthyoplankton entrainment. Reductions of up to 82% for eggs and larvae were recorded from 1999 through 2001, though there have been some operational difficulties to overcome. Tearing, overtopping, and plugging/clogging have been addressed through design modifications, though EPA notes that these same problems "could be significantly greater concern [sic] at marine sites with higher wave action and debris flows" (EPA 2001). The Gunderboom system has been considered for use at Contra Costa Power Plant along the San Joaquin River, and also at Morro Bay Power Plant in central California. A feasibility study for its use at a coastal generating station (NRG El Segundo Generating Station, El Segundo, California) with wave exposure and bathymetry similar to HBGS, is proposed for the near future.

Use of an aquatic filter barrier at the HBGS would be experimental. Current uses of the Gunderboom are primarily at river sites with unidirectional flow. Due to the configuration and location of the intake structure, the barrier would have to either 1) surround the intake structure, or 2) cover the intake structure, like a dome.

At the present time, no AFB systems have been installed at any coastal facility similar to HBGS. Any such installation would require a detailed feasibility study. Gunderboom is presently conducting a pilot study at the Arthur Kill Power Station (Staten Island, NY) at an estimated cost of $750,000. Vendor costs provided by EPA (2004) are for a floating boom system anchored onshore, with the fabric suspended by the boom and weighted at the bottom. The system would also include an air backwash system to prevent sediment/debris buildup entrained in the filter fabric. This design would probably not work at the HBGS; instead, a fixed-support system would most likely be necessary. Nonetheless, capital costs at a facility with a cooling water flow volume of 352,000 gallons per minute (gpm) would cost between $7,310,000 and $9,092,000 (costs based on EPA [2004] estimates). Annual operational and maintenance costs are estimated at $779,000.

Traveling Screen and Fish Return System Options

One potential method to reduce fish entrapped in the HBGS forebay includes the removal of impinged fishes by traveling screens and returning them to the nearshore waters off the HBGS. This would involve either retrofitting or replacing the vertical traveling screens currently in use at the HBGS, and installing a fish return system whereby live fishes are discharged back to the nearshore waters. There are currently four sets of conventional vertical traveling screens at the HBGS. Each set of traveling screens is 10 ft wide, extends approximately 35 ft below the concrete pad upon which it sits, and has a screen mesh size of 9.5 mm (3/8 in.). These screens were designed for debris removal and to prevent fishes from passing through the CWIS and entering the facility's steam condenser. There are, however, new screen types and technologies that could aid in reducing fish entrapment by facilitating their live removal from the intake system. These systems include: (1) adding fine mesh overlay panels to the existing vertical traveling screens and installing a fish return sluiceway; (2) replacing the traveling screens with double-entry/single-exit (dual-flow) or single-entry/double-exit (centerflow) traveling screens and installing a fish return sluiceway; and (3) replacing the traveling screens with modified vertical traveling screens with fish-handling capabilities and installing a fish return sluiceway.

Modified Vertical Traveling Screens with Fish Return System

Modified vertical traveling screens are conventional traveling screens with the addition of a collection bucket beneath each of the screen panels. When the screens are operated, the collection bucket retains water along with any impinged fish while moving upward, thereby enhancing their survival (EPA 2004). At the uppermost point of travel during screen operation, water drains from the collection bucket while the impinged organisms and debris are retained in the screen panel by a deflector plate. Two material removal (spray) systems are often provided instead of a single, high-pressure system common to many vertical traveling screens. The first is a low-pressure spray that gently washes fish from the collection bucket into a recovery trough. The second is a typical high-pressure spray that rinses the remaining debris into a second trough.

The effectiveness of a screening system such as this is enhanced by continuous operation, keeping impingement times to a minimum.

Screening systems with fish collection and return capabilities have been tested, or are in use, at 10 generating stations across the United States, with the majority of the systems located on the east coast. The EPA (2004) states that these screening systems "have good potential for alleviating impingement mortality." However, they also note that latent mortality can be high, especially with fragile species. At the Dominion Power Surry Station (Virginia) installation of modified traveling screens and a fish return system resulted in a 94% impingement survival rate (EPA 2004). The Arthur Kill Power Station has both conventional vertical traveling screens and modified traveling screens with collection troughs and a fish return system. Average 24-hr survival rate for the conventional screens is 15%, while the modified screens with troughs have 79-92% survival rates (EPA 2004). EPA notes that continuous operation of such screening systems can result in undesirable maintenance problems.

Such a system at the HBGS would require installation of new screen units with collection buckets, spray pumps, and a fish return system to return impinged fishes and macroinvertebrates to the ocean. Equipment costs for removal of the existing screens and replacing the panels with fish handling screens (1/8-in. by ½- in. smooth top) is estimated at approximately $1.4 million for all four screen units at the HBGS (EPA 2004). Costs for downtime, labor, and power and water requirements are unknown. Capital costs for a 2,400-ft above-ground fish return flume (12-inch fiberglass pipe supported by wood pilings) and spray pump would cost an additional $560,000. However, a fish return structure at the HBGS would also need to be directed underground beneath the Pacific Coast Highway and Huntington State Beach, which would require excavation, trenching, and permitting. The pump required for oceanic discharge would need to be considerably more powerful than a conventional sluiceway pump to counter the increased head pressures associated with the system. The costs of these added requirements are unknown.

Fine Mesh Screens with Fish Return System

The vertical traveling screens currently in use at the HBGS could be retrofitted with fine mesh panels to potentially enhance fish survival. Depending on the mesh size, these screens are also effective at removing entrained fish eggs, larvae, and juvenile fish. However, while reducing entrainment, fine mesh screening systems inherently increase impingement. Regardless of the target organisms to be removed, the overall effectiveness of these systems is contingent on the application of satisfactory handling and recovery facilities to allow the safe return of impinged organisms to the aquatic environment.

The EPA (2004) specifies that "biological effectiveness of the whole cycle, from impingement to survival in the source water body, should be investigated thoroughly prior to implementation of this option." Design considerations include low through-screen velocities to prevent larval damage or mortality, low-pressure wash sprays, smooth return sluiceway flows to prevent turbulence, and screen mesh material. Due to the smaller mesh size, these screens will clog much faster than conventional screens, and they will require frequent maintenance.

Fine mesh screening systems have been used at the Big Bend Power Plant (Tampa Bay, Florida) and at the Brunswick Power Plant (North Carolina). At Big Bend, the 0.5-mm mesh Ristroph screens were 95% efficient in screening fish eggs, and 86% efficient in screening larvae (EPA 2004). However, latent survival was 80% for drum eggs, 93% for bay anchovy eggs, 65% for drum larvae, and 66% for bay anchovy larvae. At Brunswick, entrainment has been reduced by 84% with similar screens.

At HBGS additional fish handling capabilities could be added to the existing conventional traveling screens and combined with construction and operation of a fish return system. This would involve replacing the 3/8" screens with finer panel overlays (<0.5-mm) and adding additional spray water pumps and a fish return flume. Capital costs for screen retrofit are \$2,400,000, with Operation & Maintenance (O&M) costs estimated at about \$255,000 (EPA 2004). Additional modifications to the intake forebay would be required to increase the surface area of the screens to provide lower through-screen flow velocities. Through-screen velocities during a 1978 study averaged 0.2 to 0.3 m/sec (0.8 to 1.0 fps), and individual measurements ranged from 0.1 to 0.8 m/sec (0.2 to 2.7 fps) (SCE 1983). Capital costs for a 2,400-ft above-ground fish return flume (12-inch fiberglass pipe supported by wood pilings) and spray pump would cost an additional \$560,000. However, a fish return structure at the HBGS would also need to be directed underground beneath the Pacific Coast Highway and Huntington State Beach, which would require excavation, trenching, and permitting. The pump required for oceanic discharge would need to be considerably more powerful than a conventional sluiceway pump to counter the increased head pressures associated with the system. The costs of these added requirements are unknown.

Dual Flow and Centerflow Traveling Screens with Fish Return System

Dual flow traveling screens, also referred to as double-entry/single-exit screens, are designed to filter water continuously using both upward and downward moving screens (EPA 2004). The screens are oriented so that the screen face is parallel to the flow direction. Centerflow traveling screens operate on a similar concept, except water passes through the center (single-entry) and exits on both sides (double-exit) of the vertical screen conveyer. Both systems allow finer mesh sizes to be used without increasing through-screen velocity, and they also require a fish return system.

Coupled with an appropriate return system, centerflow screens have demonstrated relatively high survival of impinged organisms. Therefore, use at the HBGS would rely on the construction of an appropriate fish return system. Actual biological benefits from installation of such a system are unknown. Capitol costs for dual-flow screens are estimated at $1.8 million (EPA 2004). This does not include labor, operation and maintenance, and station downtime.

Capital costs for a 2,400-ft above-ground fish return flume (12-inch fiberglass pipe supported by wood pilings) and spray pump would cost an additional $560,000. However, a fish return structure at the HBGS would also need to be directed underground beneath the Pacific Coast Highway and Huntington State Beach, which would require excavation, trenching, and permitting. The pump required for oceanic discharge would need to be considerably more powerful than a conventional sluiceway pump to counter the increased head pressures associated with the system. The costs of these added requirements are unknown.

6.4.3 Fish Elevator

The fish elevator is a form of fish return system that does not use actual traveling screens to convey fishes to a sluiceway. Instead, a lifting bucket that retains water is hoisted vertically and 'dumped' into the sluiceway. The San Onofre Nuclear Generating Station (San Clemente, California) is the only coastal generating station on the west coast of the United States that operates an elevator fish return system (FRS). Fish elevators have been used for decades at hydroelectric facilities for transporting migratory fishes, primarily salmonids, around dams (LMS 1982). There are two FRSs at SONGS, one each at Units 2 and 3. Each FRS is comprised of a network of guiding vanes, louvers, a fish return elevator, and a fish return sluiceway (Love et al. 1989). At each unit, the intake conduit opens into a forebay, where fishes within the cooling water flow encounter concrete vanes and angled plastic louvers in front of the angled traveling screens. The vanes and louvers are angled toward a bypass area away from the traveling screens. The fishes sense the pressure differential created by the vanes and louvers and are directed toward the fish elevator, a relatively quiet-water basin measuring approximately 4.9 x 4 m. A watertight elevator basket, open at the top, is capable of ascending and collecting fishes within this basin. Once at its maximum height, the elevator tips slightly, and the fishes spill into the fish return sluiceway. Unidirectional flow within the sluiceway is maintained and the fishes are discharged into a pipe that terminates approximately 400 m from shore in about 6 m of water.

Each FRS is operated by equipment operators at least twice daily at SONGS (SCE 2001). At each unit, a "fish chase" is performed prior to each heat treatment (conducted at about six-week intervals at each unit). During the fish chase, a portion of the discharge water is routed to the intake waters, such that the temperature in the screenwell is raised approximately 0.5°F per minute. Manipulation of intake cross-over gates also creates eddy currents that dislodge fish congregating in areas of low flow. The elevated temperatures and changes in flow patterns agitate fishes in the screenwell, and many seek new habitat and find their way to the FRS and are subsequently released. Before the screenwell water temperature reaches a lethal limit, the fish chase is terminated and the temperature slowly returns to ambient. During each elevator lift, a biologist estimates the abundance of each species visible in the elevator prior to their release. After completion of the fish chase, the heat treatment then proceeds. MBC biologists have recorded fish return and heat treatment data at SONGS since the 1980s.

Both the efficiency and survivorship of the FRSs at SONGS have been studied (Love et al. 1989). Efficiency was measured by dividing the estimated number of fish returned by the total number of fish entrained by each unit (number returned + number impinged). Survivorship was measured by collecting returned fishes in a holding net moored at the fish return conduit terminus and assessing returned fishes by biologist-divers for 96 hours. In 1984 and 1985, fishes were diverted and returned by the FRSs at SONGS with high frequency (Love et al. 1989). Overall efficiencies were 96% in 1984 and 75% in 1985. The two most abundant species during each year, northern anchovy and queenfish, were diverted with higher efficiencies in 1984 (99% and 88%, respectively) than in 1985 (94% and 74%, respectively). Stronger swimmers were generally returned at higher rates than weaker swimmers. Most fishes also survived transit through the FRS, though there were size-specific trends. Northern anchovy (94% and 98% at Units 2 and 3, respectively) and salema (*Xenistius californiensis*) (100%) had higher survival than queenfish (32% and 54%), white croaker (50% and 25%), and slough anchovy (*Anchoa delicatissima*) (0% at Unit 2).

Fish return efficiency is evaluated each year by comparing the number of fishes returned during fish chase operations and the total number of fishes entrained by each unit (number returned plus the number impinged). In 2000, total return efficiencies for Units 2 and 3 combined were 30% by abundance and 65% by biomass (SCE 2001). Returns were particularly low for some of the most abundant species, including queenfish (21% abundance and 12% biomass), northern anchovy (13% abundance and 31% biomass), and white croaker (14% abundance and 17% biomass). Annual normal operation return efficiencies from 1984 through 1994 and 1999 were variable at each unit. At Unit 2, return efficiency ranged from 42% in 1989 to 97% in 1984, averaging 74%. At Unit 3, return efficiency ranged from 37% in 1990 to 95% in 1984, averaging 67%.

For potential use at HBGS, a FRS similar to the ones used at SONGS would entail the following: 1) construction of guiding vanes and louvers within the intake forebay, 2) construction of a fish elevator system, 3) construction of a fish return sluiceway to the ocean. The configuration of the intake forebay at HBGS is currently not well-suited for such a system. However, modifications to the intake system, or modifications to a FRS design could be considered. At SONGS, the linear distance from where the intake conduit joins the forebay to the FRS is approximately 46 m. The guiding vanes are located such that fishes entering the system with the cooling water flow can be directed away from traveling screens and toward the FRS. At HBGS, the forebay is much smaller, and the linear distance between the intake conduit terminus and the trash racks is only about 4.3 m. Therefore, the forebay would need to be redesigned to accommodate an effective guiding system. Costs for such a system are unknown.

Modified Fish Return System

A variant of the FRS design currently in use at SONGS could potentially be used at HBGS. The system would need to be adapted to the HBGS cooling water system configuration, but still be designed to maintain high removal and return efficiencies. The components of such a system would include (insert):

1. A crowding system, designed to "herd" fish in the forebay toward the elevator,
2. A fish elevator, similar to the ones used at SONGS. The elevator would be comprised of a watertight fish basket and a conveyance system to raise and lower it out of the forebay,
3. A sluiceway to convey the fishes from the elevator to the discharge conduit.

The crowding system would be composed of a wire mesh panel that would be moved across the forebay, 90° to the flow (lengthwise). This would concentrate the fishes in the forebay to the side of the forebay where the elevator would be located. The crowding screen would presumably be composed of 3/8" wire mesh, similar to that used on the traveling screens. If the screen were designed to fit within the forebay, extending up to the high water line and down to within a few feet from the forebay bed (to allow for accumulation of sediment), it would be able to divert fishes throughout most of the vertical cross-section of the forebay. The screen could travel on a rail system and be powered by motors.

The elevator system would be similar to the ones currently in use at SONGS. The elevator would consist of a stainless steel, watertight fish basket, sufficiently deep to allow for the estimated number of fishes to be removed. The basket is powered by motor, and is driven by chain-sprockets. The elevator would be able to be lifted out of the water, brought to the forebay deck, held so biologists could ascertain species composition and abundance, and then dumped into/onto the interface. The elevator would need to be lifted well above the forebay deck surface. The concrete pads currently installed in the forebay would need to be removed.

The conveyance system between the elevator and the discharge conduit would be an angled, stainless steel flume, whereby the fishes would be dumped into the flume and they would slide into the conduit. The conveyance system could be outfitted with rinse-water (such as a bubbling system) to facilitate the transfer of fish to the conduit.

The biological performance of this option would be largely dependent on the survival of fishes 1) in transfer from the elevator to the conduit, and 2) in transit to the discharge point. If the conveyance flume transferred fishes from an elevator at the southern end of the forebay to the discharge vault, the fishes would be "discharged" into the discharge vault, which could result in some mortality due to the vertical drop into the cooling water flow. Additional mortality could result from stress associated with exposure to higher water temperatures. At full operating capacity, the temperature differential across the condensers is about 10°C (18°F). Removal procedures during periods of low thermal input would increase chances of survival. However, the current operating configuration of the generating station does not allow the station to "shed load" to decrease the temperature differential. The cost associated with this option would include construction and installation of the crowding system, elevator, and conveyance system, and operation/maintenance costs, which are presently unknown.

6.4.4 Intake Relocation

The offshore intake structure at HBGS could potentially be "relocated," either by shortening the intake conduit and installing a shallow-water or shoreline intake, or by extending the intake conduit so the intake terminus would be in deeper water. Subsequent reductions in fish entrapment would rely on decreased densities of fishes in the relocation areas. If offshore relocation resulted in substantially cooler source water, it is possible that less water would be required by the generating station to achieve the same degree of cooling. Since the present study did not collect juvenile/adult fishes at offshore locations, available historic data would need to be analyzed.

Shallow Relocation

Relocation of the intake structure to a point inshore, either submerged with a velocity cap or on the shoreline, is likely not feasible due to the safety hazard it would impose on the public using the nearshore waters of Huntington State Beach. In addition, no studies have been conducted on the larval, juvenile, or adult fish communities inshore of the existing intake, and densities may be greater than those found at the current location.

Offshore Relocation

Unlike relocation of the intake structure to an inshore location, extending the intake conduit offshore would not impose the same public safety issues. A decrease in impingement could potentially occur if 1) fewer fishes in the deeper source water were susceptible to entrainment, and/or 2) deeper, cooler intake water provided an equivalent cooling capacity at a lower volume. In 1999 it was hypothesized that the HBGS intake interacted with the wastewater effluent discharged by the Orange County Sanitation District (OCSD) nearly five miles offshore (Grant et al. 2000). In 1999-2000, the OCSD discharged an average of 236 mgd, though peak flows during storm periods can exceed 550 mgd (OCSD 2000). To date, there has been no evidence that the plume contacts the shoreline off the HBGS, nor is there any evidence that effluent is drawn into the generating station's intake system. However, plume tracking and monitoring studies tracked the wastewater plume inshore to depths ranging from 10 to 20 m directly offshore the generating station (Boehm et al. 2002). An extension of the intake structure, and potentially the discharge structure, could affect the distribution of the wastewater plume by 1) entrainment with incoming cooling water and subsequent discharge, and/or 2) entrainment of the wastewater within the cooling water discharge plume and transport toward the sea surface. The OCSD is reconfiguring their wastewater facilities to provide full secondary treatment to all wastewaters discharged offshore. The potential sanitary effects of the relocation of the HBGS intake structure would still need critical study.

The demersal fishes in the vicinity of the OCSD discharge have been examined for many years. In 2000, the dominant species in the OCSD study area were yellowchin sculpin (*Icelinus quadriseriatus*), Pacific sanddab (*Citharichthys sordidus*), longfin sanddab (*Citharichthys xanthostigma*), California tonguefish (*Symphurus atricauda*), and California lizardfish (*Synodus lucioceps*). Most of these fishes comprise the "Middle Shelf Assemblage" described by Allen et al. (1998) during a 1994 assessment of Southern California Bight fish populations; this group occurred between depths of 42 to 89 m. These are some of the species that might be more susceptible to entrainment/entrapment if the intake were extended beyond the 40-m isobath. Cost of extending the intake is unknown, but would likely be extremely high. Estimated cost of relocating the existing intake to the 22-m isobath was estimated at $73.5 million in 1983 (SCE 1983).

6.4.5 Flow Modifications

The flow velocities that fishes are exposed to at the offshore intake structure are determined by the flow rate of the cooling water pumps operating, the size and shape of the intake opening and velocity cap, and the ambient currents in the source waters. Here we discuss the possibility of (1) reducing cooling water flow volume of the generating station, and (2) increasing the size of the offshore intake structure to reduce intake flow velocities.

Flow Volume Reduction / Larger Intake Opening

Expanding the offshore intake opening would increase the cross-sectional area of the intake, thereby decreasing the velocity of the incoming water. In theory, this could lead to a decrease in juvenile/adult fishes entrained and entrapped in the HBGS CWIS. A similar effect could potentially occur with a decrease in actual flow volume, although this would lead to a proportional decrease in entrainment. However, the current operational status of the generating station does not allow for a reduction in cooling water flow.

The swimming performance of many of the species most commonly impinged has not been studied. Dorn et al. (1979) studied the swimming performance of nine fish species, including some common in HBGS impingement samples (shiner perch, walleye surfperch, white seaperch, and white croaker). The authors of this report documented both the continuous swimming speed of a given size class for each species, as well as the burst swimming speed. In summary, they concluded: "*The results of our experiments in conjunction with impingement data demonstrate that the intake velocity should not be a major consideration in evaluating the causative factors of fish entrainment. Swimming performance tests would not appear to be useful for such future analytical endeavors.*" A combination of additional factors, including wave surge, light level, schooling, and feeding behavior, where thought to influence the degree of impingement.

Downs and Meddock (1974) studied the velocity-capped intake structure at the RBGS and determined "the lower the approach velocity, the more effective the structure. However, below 1.5 fps, the advantage of the lower velocity decreased. Accordingly, a 1.5 fps approach velocity was considered optimum. Above 1.5 fps, the fish intake was directly proportional to the increase in velocity." At the Scattergood Generating Station, impingement was higher during periods of low and medium flow than during periods of high flow, but only at night (IRC 1981). Daytime impingement conditions were unrelated to flow conditions. The reason for the lower impingement at higher flow rates could potentially be attributed to fewer fishes in the source water, or the fishes may have better sensed the intake currents at higher velocities and avoided the area (IRC 1981).

Herbinson (1981) analyzed impingement differences between the two intakes at the El Segundo Generating Station, which are approximately 150 m apart. The two intakes are different in size and cycle different volumes of water, but under maximum flow conditions, intake entrance velocities are identical (2.4 fps). However, high impingement rates were as likely to occur during periods of reduced flow as during full flow. The same trend was observed at Alamitos Generating Station, where three intakes all draw water from Alamitos Bay. In conclusion, it was determined that impingement rates were driven by the densities of fishes in the immediate vicinity of the intake structures as opposed to flow rates. In summary, there is little evidence that a predictable biological benefit would result from decreased flow velocities resulting from an expanded intake opening. There are no cost estimates available for expanding the intake opening.

6.5 Conclusions

This evaluation considered technologies and measures under five categories: behavioral barriers, screening technologies, fish elevators, intake relocation, and flow modifications. A summary of the screening considerations is presented in Table 6.1.

Behavioral Barriers

There are no known applications of behavioral barriers/devices (sonic stimuli, lights, and bubble curtains) in an offshore, marine environment. A crude sonic device, the "popper", showed promise in deterring fishes from the Redondo Beach Generating Station intake structures, which are similar to the intake for the HBGS, but are located in King Harbor. However, there are currently no known offshore applications of this technology. Use of such a technology would also require an analysis of potential effects to protected species, including marine mammals and sea turtles. Previous studies indicated potential harmful effects to hearing systems of marine mammals, and the potential to attract mammals or sea turtles. Therefore, behavioral barriers are not considered feasible to reduce impingement at the HBGS.

Screening Technologies

There are no known applications of barrier nets or aquatic filter barriers (such as the Gunderboom AFB) in an offshore, marine environment. The exposed coastal location of the HBGS renders these options infeasible at present. The three screening options (modified vertical traveling screens with fish handling, fine mesh traveling screens with fish handling, and dual flow or centerflow screens with fish handling) would all require a dedicated fish return system. The cost of such a return system to return fishes to the nearshore waters, which would entail tunneling under Pacific Coast Highway and Huntington State Beach, is unknown.

Table 6-1. Summary of technologies/measures considered for impingement reduction at the HBGS.

Technology / Measure	In Use at a Coastal Facility?	Impingement Benefit	Comments
Behavior Barriers / Devices			
Sonic stimuli	No known application	Unknown	
Popper	Testing only	Unknown	Effects to mammals would need study.
Lights	No known application	Unknown	
Bubble Curtain	No known application	Unknown	
Screening Technologies			
Barrier net	No known application	Based on mesh	
Aquatic filter barrier	No known application	Based on mesh	
Modified vertical traveling screens	Yes	Up to 94% survival	Cost of FRS prohibitive.
Fine mesh screens	Unknown	Unknown	Cost of FRS prohibitive.
Dual flow / centerflow screens	Unknown	Unknown	Cost of FRS prohibitive.
Return Systems			
Fish elevator	Yes		Cost of FRS prohibitive.
Modified fish elevator	No known application	Unknown	Cost of FRS prohibitive.
Intake Relocation			
Shallow relocation	Not applicable	Unknown	Cost prohibitive.
Offshore relocation	Not applicable	Unknown	Cost prohibitive.
Flow Reduction			
Flow reduction	Not applicable	Unknown	Not possible.
Larger intake opening	Not applicable	Unknown	Cost prohibitive.

Survivorship of queenfish (which comprised 70% of impingement abundance during the current study) during 96-hr return studies at the San Onofre Nuclear Generating Station (SONGS) was calculated to be 32% at Unit 2 and 54% at Unit 3, an average of 43% (Love et al. 1989). Survivorship of white croaker (10% of impingement abundance at the HBGS) was 50% at Unit 2 and 25% at Unit 3, an average of 38%. Assuming all queenfish and white croaker could be returned at the HBGS, it is estimated impingement mortality might decrease from 40,750 individuals (normal operations and heat treatments combined) of the two most abundant species to 23,473, a reduction of approximately 42% for those two species. While the cost of a return system at the HBGS is not estimated, it is likely prohibitive based on the relative biological benefit.

Fish Elevators

Construction of a fish elevator similar to the one in use at SONGS would entail modifications to the intake forebay and construction of a return system. Construction of a modified elevator, without extensive modifications to the forebay, would also require construction of a fish return. While the cost of a return system at the HBGS is not estimated, it is likely prohibitive based on the relative biological benefit.

Intake Relocation

Relocation of the intake to deeper depths is likely not feasible due to potential interactions with the OCSD wastewater plume. This could also lead to a potential increase in effects on protected groundfish, such as rockfishes. Relocating the intake to shallower waters would require construction of a shoreline intake at Huntington State Beach. The anticipated biological benefits of either option are unknown. The estimated cost of relocating the intake structure to the 22-m isobath was $73.5 million in 1983, and is likely much higher at present.

Flow Modifications

Lacking a strong correlation between impingement rate and flow velocity (or flow volume), the expected biological benefit, if any, from enlarging the intake structure or reducing intake flow cannot be calculated. The average flow rate for the study year (350 mgd) was nearly 50% higher than the 25-year average (236 mgd), while fish impingement abundance during the present study (51,082 individuals) was 21% lower than the 25-year average (64,294 individuals). Costs to enlarge the existing intake opening are unknown, but would likely far outweigh any benefit achieved by such a modification. The current operating configuration of the HBGS does not allow for voluntary flow reductions. Therefore, reduced cooling water flow is considered infeasible for the reduction of impingement at the HBGS.

In short, the value of impinged fishes and macroinvertebrates at the HBGS is likely much higher than the equivalent commercial value of less than $2,000. Even so, impingement at the HBGS is not significant to warrant the substantial modifications to the intake system that would be required to definitively reduce impingement rates.

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8.0 GLOSSARY

AEL	Adult Equivalent Loss. Forecast the number of adults that would have resulted from the number of entrained larvae, assuming the larvae survived entrainment. Calculated using available estimates of natural mortality rates applied to various life stages.
benthic	Occurring on or in the seafloor.
BRRT	Biological Resources Research Team. The working group overseeing the development, implementation, and analysis of the Entrainment and Impingement Study.
CalCOFI	California Cooperative Oceanic Fisheries Investigations. Large-scale physical and biological monitoring program sponsored by the California Department of Fish and Game, the National Marine Fisheries Service, and the Scripps Institute of Oceanography.
Catch Block	10-km x 10-km areas fishery management areas offshore California. Overseen by the California Department of Fish and Game.
CCC	California Coastal Commission.
CDFG	California Department of Fish and Game.
CEC	California Energy Commission.
CIQ Goby Complex	A group of three goby species (*Clevelandia ios*, *Ilypnus gilberti*, and *Quietula y-cauda*) that cannot be distinguished during their earliest larval stages.
CPFV	Commercial Passenger Fishing Vessel.
CTD	An instrument used to collect conductivity, temperature, and depth measurements as a function of depth.
CWIS	Cooling Water Intake System. The entire cooling water system of the HBGS, including the offshore intake structure, conduits, forebay, condensers, and discharge structure.
demersal	Living close to the seafloor (just above bottom).
entrainment	Passage of planktonic organisms through the HBGS cooling water system.
entrapment	The occurrence of organisms within a cooling water intake system that have been entrained but not impinged on traveling screens, and cannot escape the cooling water intake flow.
EPA	U.S. Environmental Protection Agency.
ETM	Empirical Transport Model. A mathematical model that estimates the total annual probability of mortality (P_m) due to entrainment using *PE* estimates.

FH	Fecundity Hindcasting. The number of larvae entrained are hindcast to estimate the number of eggs by applying mortality estimates; the number of eggs is then used to estimate the number of adult females that would have produced that quantity of eggs.
forebay	The exposed area of the cooling water intake system at the HBGS directly upcurrent from the trash racks and traveling screens (see Figure 6-1).
FRS	Fish Return System. A mechanical system designed to collect juvenile and adult fish (and invertebrates) entrained in a cooling water intake system and return them alive to the source waters.
HBGS	The AES Huntington Beach L.L.C. Generating Station, formerly the Huntington Beach Generating Station.
heat treatment	Operational procedure to eliminate the growth of marine organisms, primarily mussels and barnacles, within a cooling water intake system. During this procedure, heated discharge waters are circulated through the cooling water intake system to raise the water temperature for a sufficient time period to eliminate fouling marine organisms that occlude cooling water flow.
impingement	The entrapment of macroscopic fish and invertebrates on traveling screens.
MBC	MBC Applied Environmental Sciences, formerly Marine Biological Consultants.
megalops	Advanced larval stage of crabs following zoea.
mgd	Million gallons per day.
molt	Periodic shedding of the cuticle (outer skeletal structure) in arthropods (crabs, shrimps, and lobster).
NMFS	National Marine Fisheries Service, now referred to as NOAA Fisheries.
normal operations	Referring to the normal operation of the cooling water intake system of a generating station. Distinguished from heat treatment operations.
NPDES	National Pollutant Discharge Elimination System. Permitting system of Section 401 of the Clean Water Act to enforce effluent limitations.
oblique	At a slanted angle; neither perpendicular nor parallel to a given surface.
OCSD	The Orange County Sanitation District.
PE	Proportional Entrainment. A mathematical value comparing the number of larvae entrained to the number of larvae available in the source water body.
pelagic	Occurring in the open water, between the water surface and the seafloor.
PFMC	Pacific Fishery Management Council.

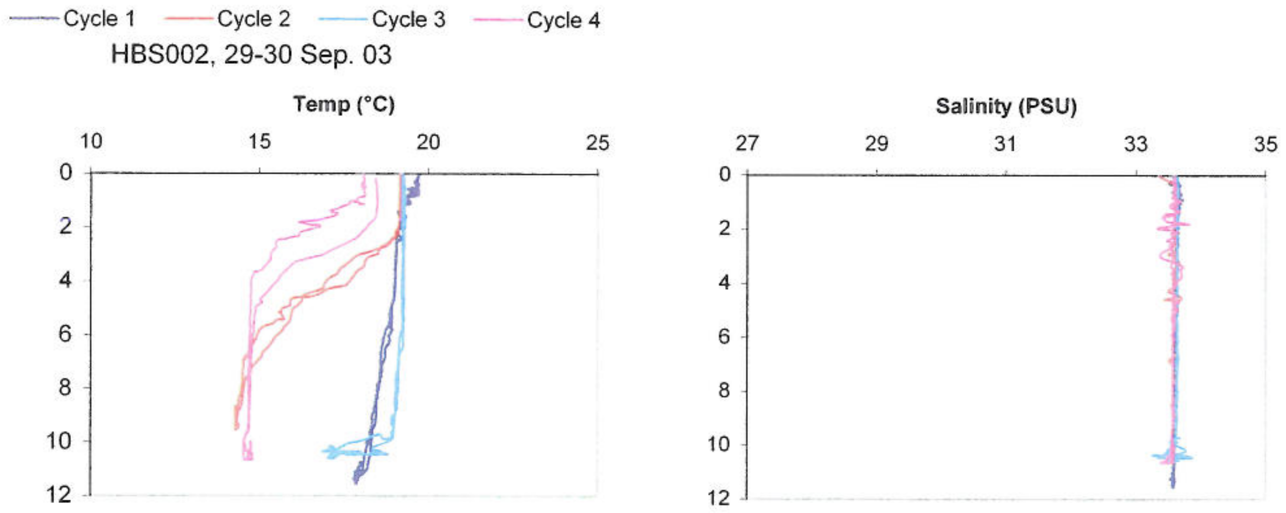
phyllosoma	Early larval (zoea) stage of California spiny lobster.
P_m	Annual probability of mortality due to entrainment.
P_s	The proportion of the population of inference represented by the number of larvae in the source water (study grid).
PSMFC	Pacific States Marine Fisheries Commission.
puerulus	Final larval stage of California spiny lobster, resembling the adult, transparent, and free-swimming.
recruitment	Measure of the number of fish that enter a class during a specified time period, such as the spawning class. Usually refers to the first year class settling from larvae.
RWQCB	Regional Water Quality Control Board. There are three RWQCBs in southern California: the Los Angeles RWQCB, the Santa Ana RWQCB, and the San Diego RWQCB.
SONGS	San Onofre Nuclear Generating Station (San Clemente, California).
subpopulations	A group of individuals of a species which interbreeds but is reproductively isolated from other such groups of the same species.
traveling screens	Mechanical system designed to prevent debris and marine organisms larger than the screen mesh size (usually 3/8-in. or 5/8-in.) from passing through the condensers and through the cooling water system. Usually rotated at periodic intervals.
upwelling	Offshore transport of surface waters usually resulting from steady northwest/west winds, causing deep, colder, nutrient-rich water to rise to the surface.
velocity cap	Concrete pad mounted above offshore cooling water intake structures. Designed to direct cooling water flow horizontally rather than vertically (see Figure 2-3).
Z	Instantaneous mortality rate.
zoea	Early larval stage in crustaceans.

Appendix A

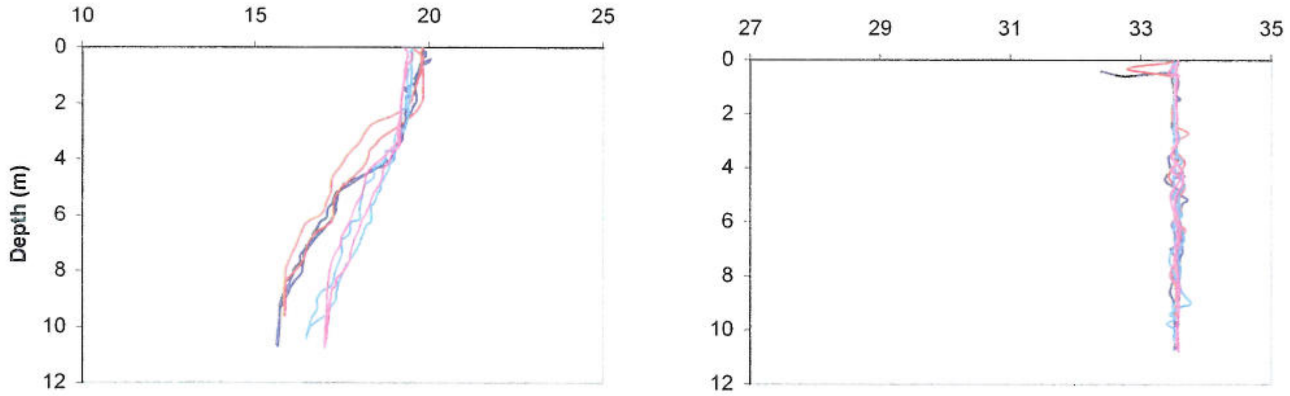
Temperature and Salinity Profiles

Appendix A-1. Temperature and salinity profiles at the entrainment station, Sept. 2003 to Sept. 2004.

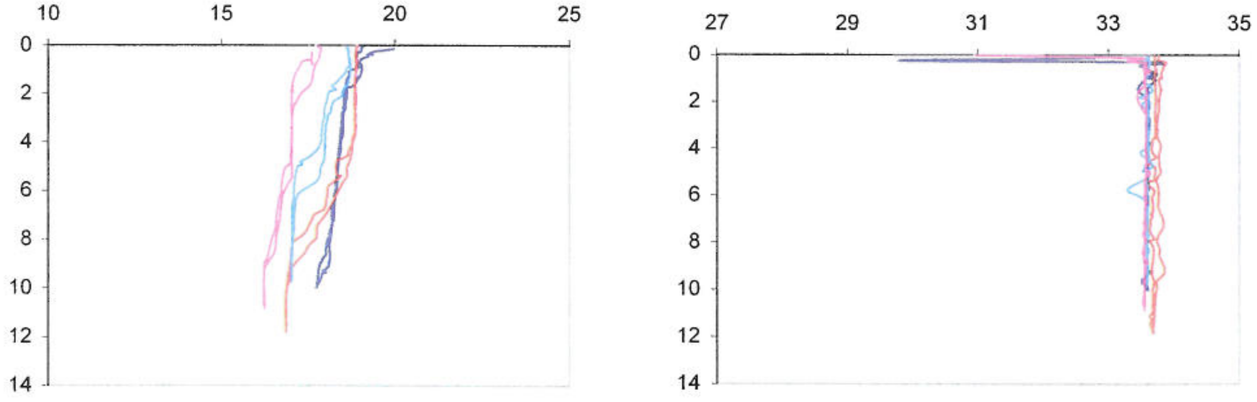
HBS002, 29-30 Sep. 03



HBS003, 13-14 Oct. 03



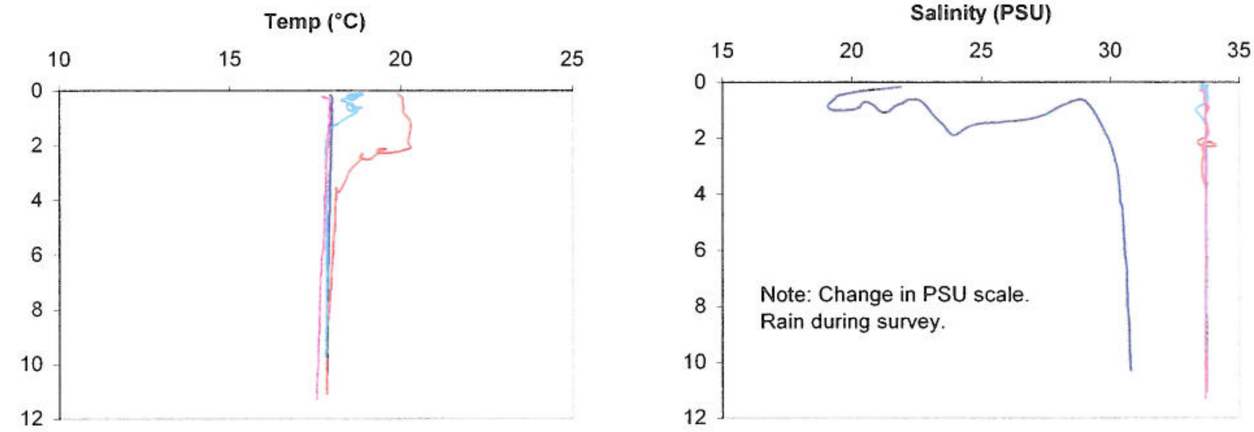
HBS004, 20-21 Oct. 03



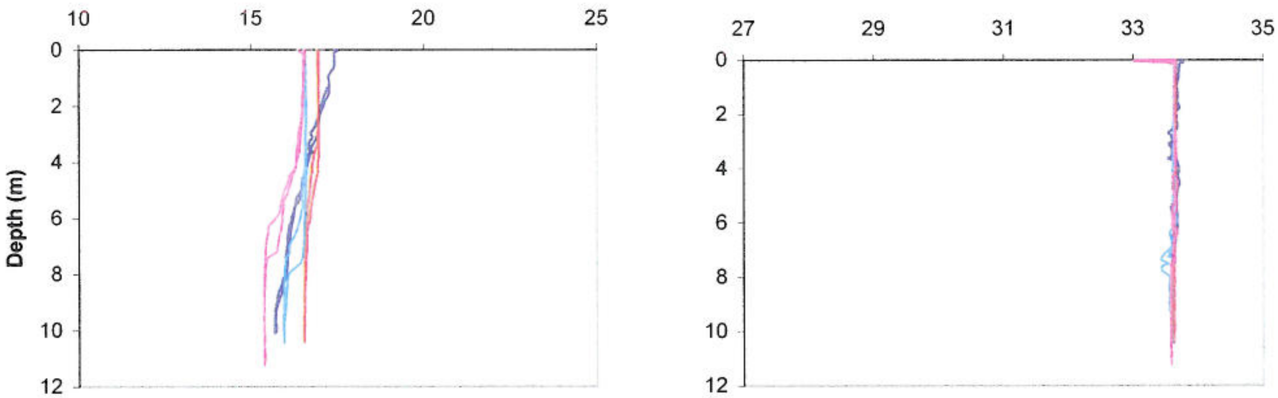
Appendix A-1. (Cont.)

—— Cycle 1 —— Cycle 2 —— Cycle 3 —— Cycle 4

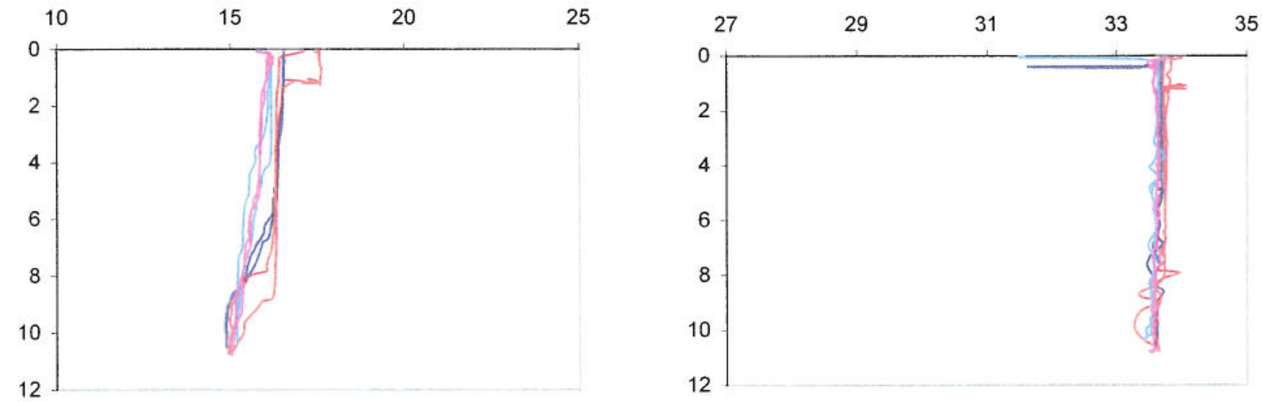
HBS005, 3-4 Nov. 03



HBS006, 10-11 Nov. 03



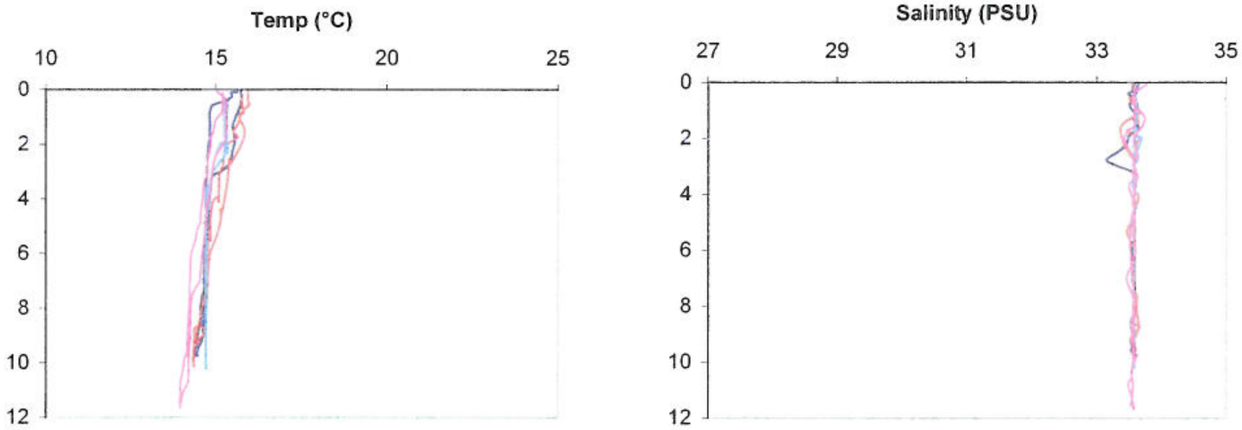
HBS007, 17-18 Nov. 03



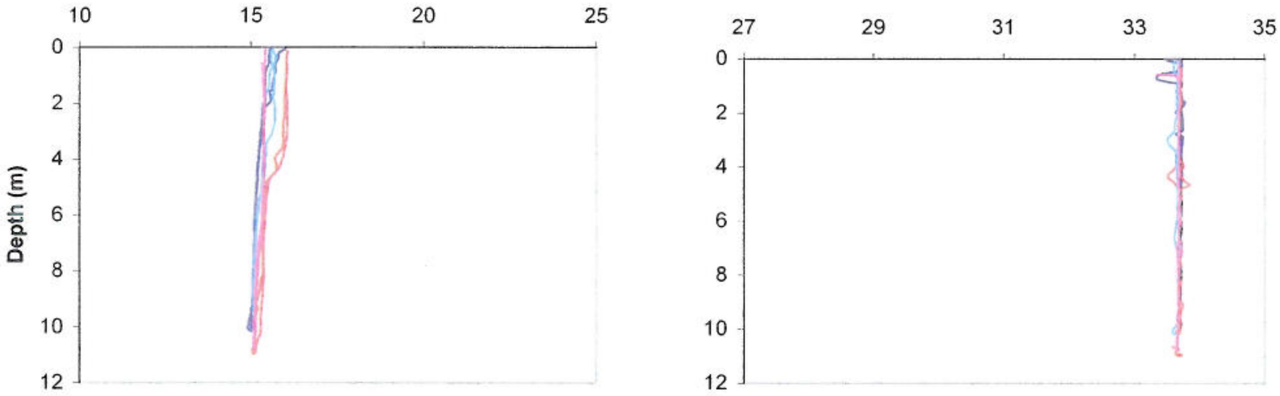
Appendix A-1. (Cont.)

Cycle 1 Cycle 2 Cycle 3 Cycle 4

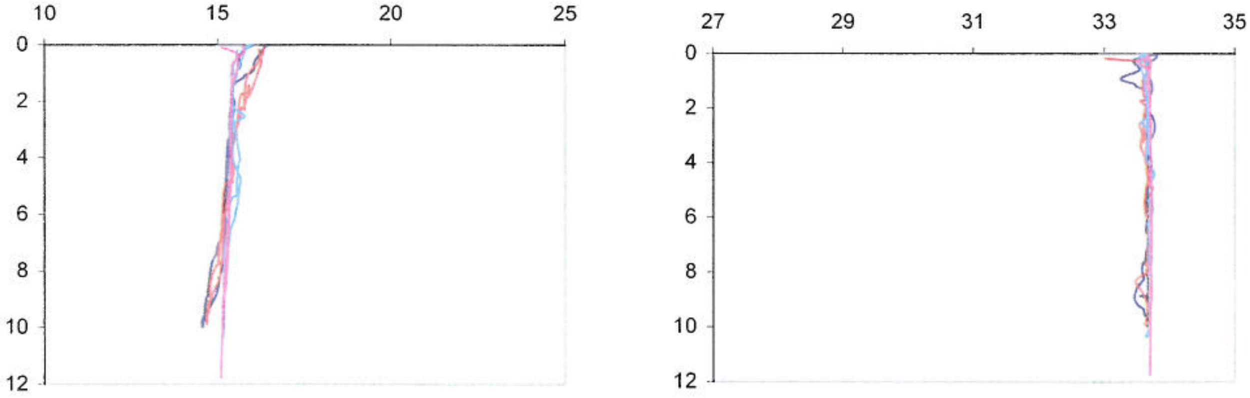
HBS008, 24-25 Nov. 03



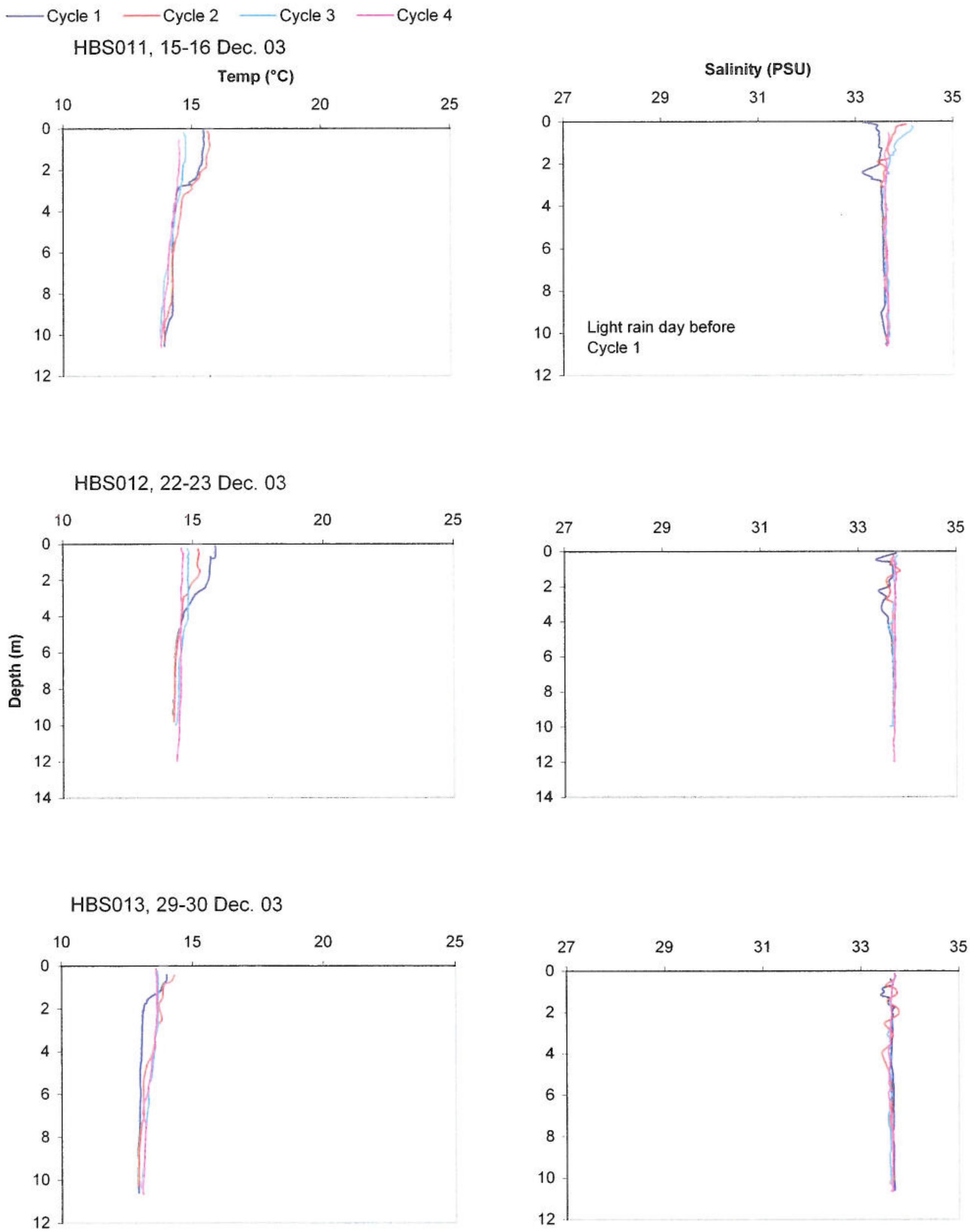
HBS009, 1-2 Dec. 03



HBS010, 8-9 Dec. 03

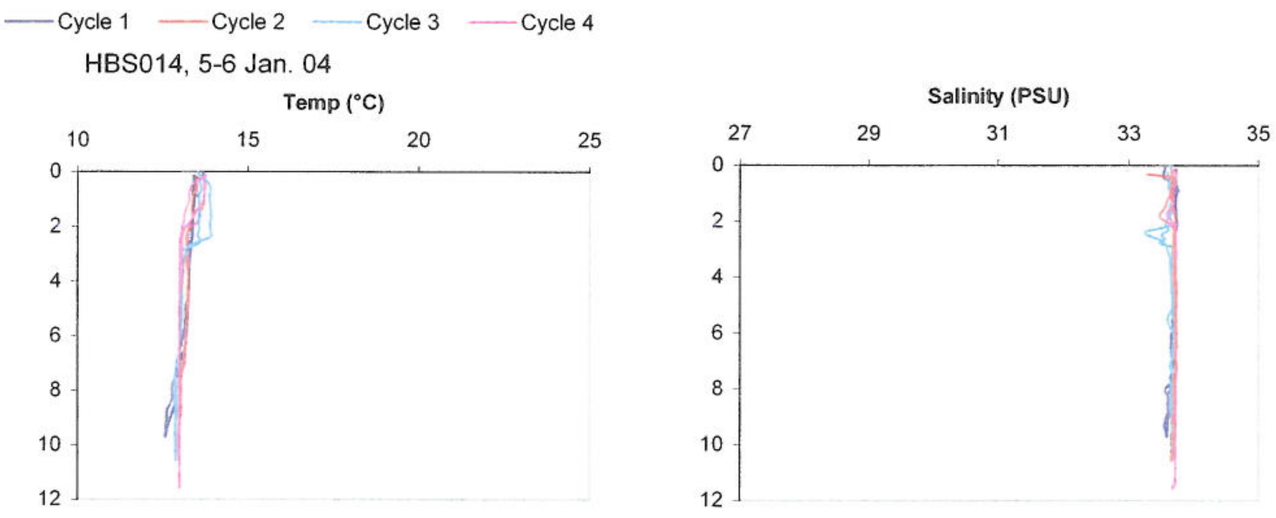


Appendix A-1. (Cont.)

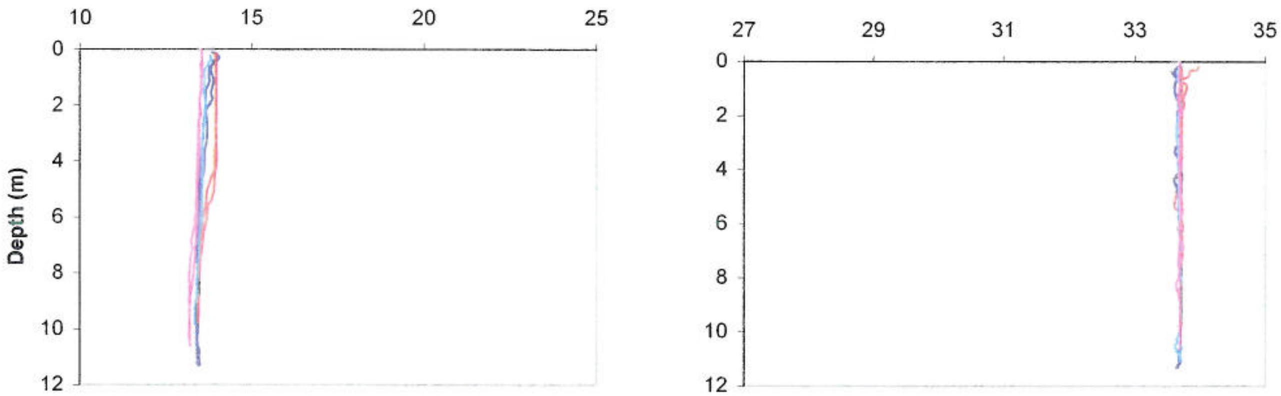


Appendix A-1. (Cont.)

HBS014, 5-6 Jan. 04

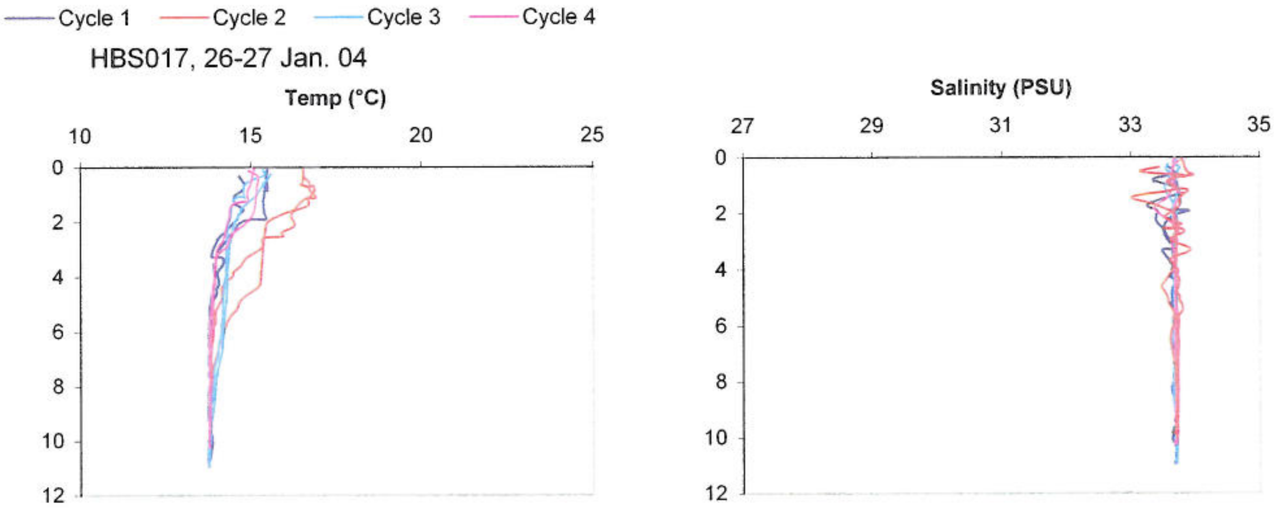


HBS015, 12-13 Jan. 04



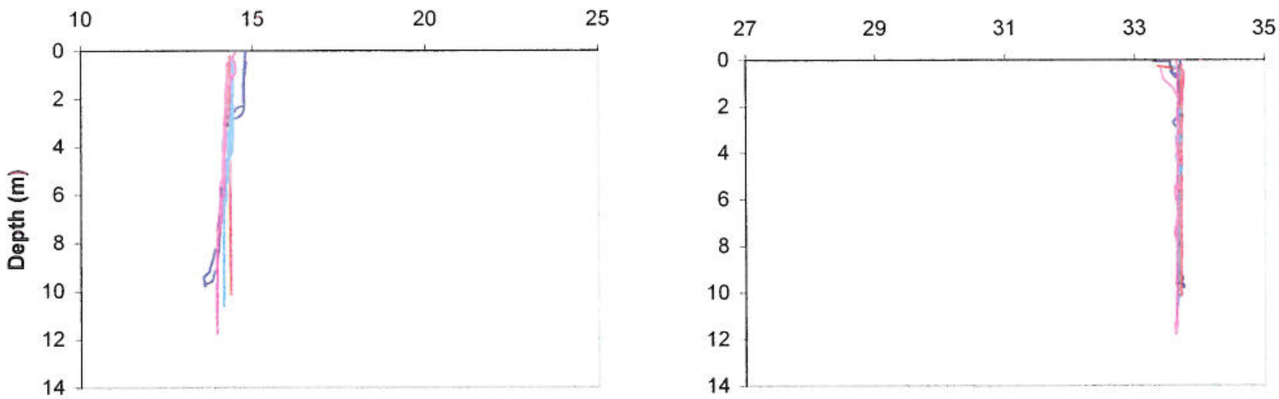
HBS016, 19-20 Jan. 04

Appendix A-1. (Cont.)

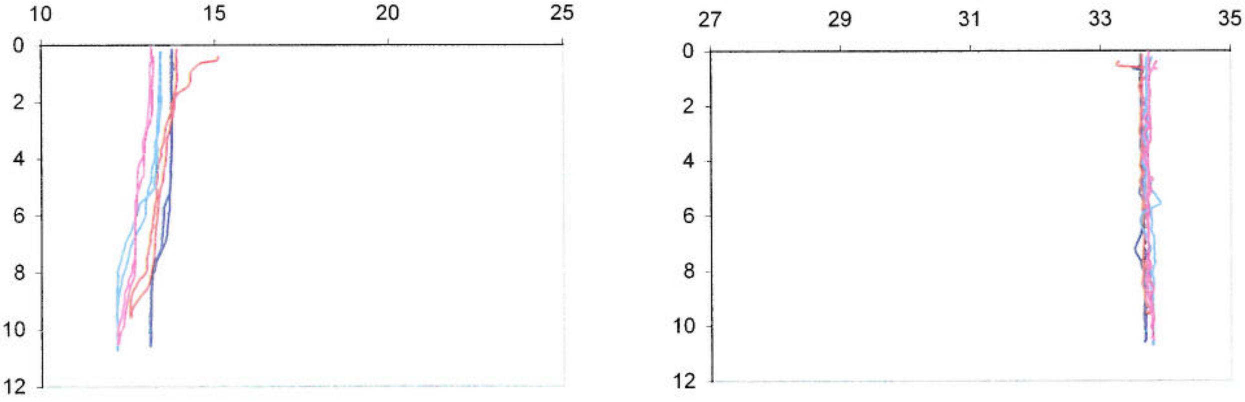


HBS017, 26-27 Jan. 04

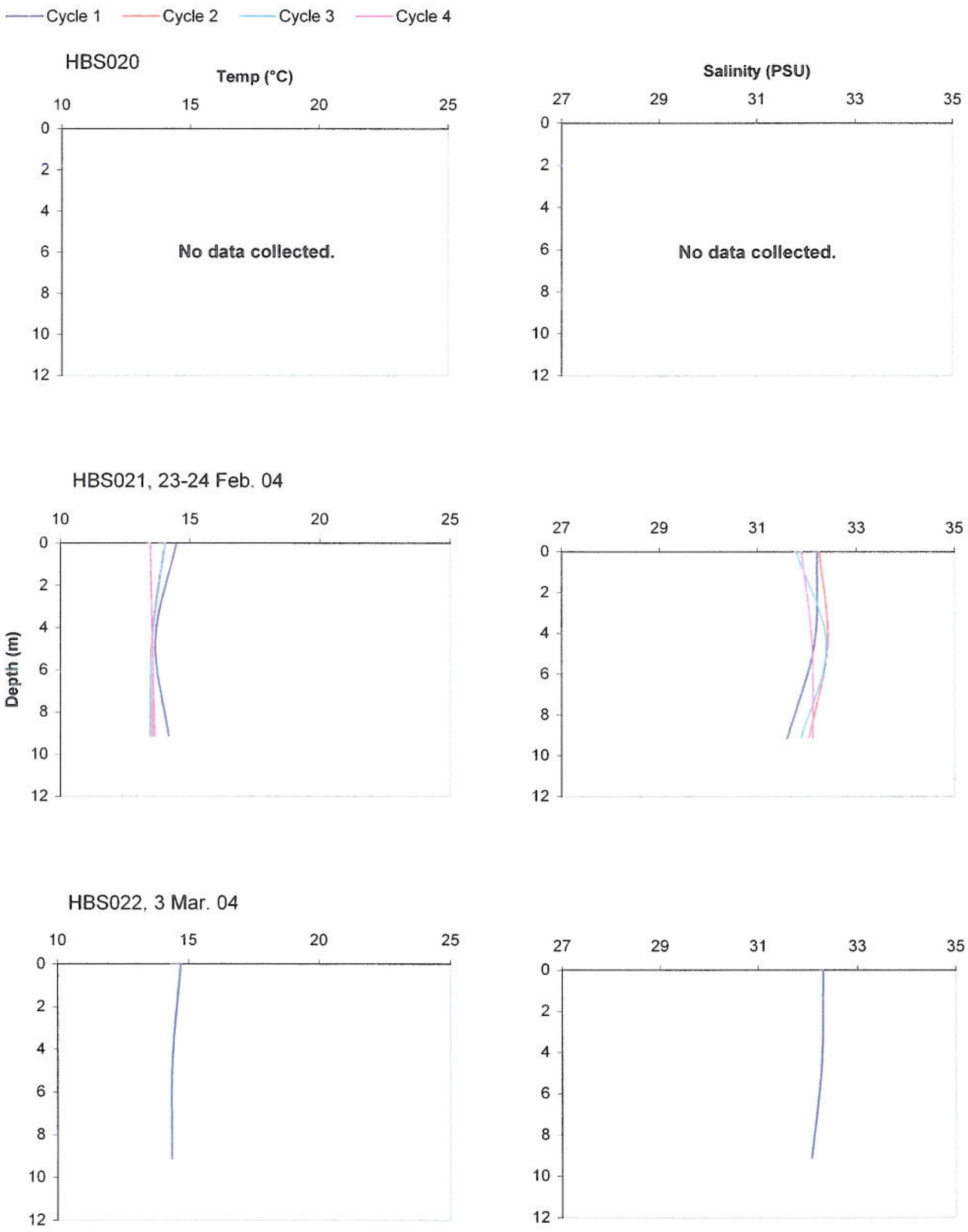
HBS018, 2-3 Feb. 04



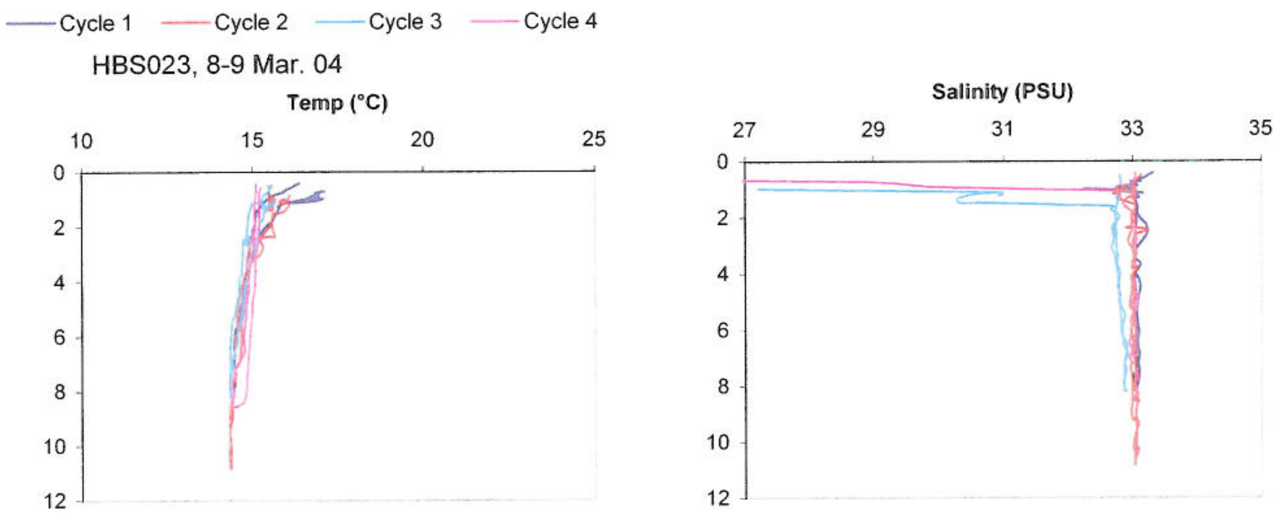
HBS019, 9-10 Feb. 04



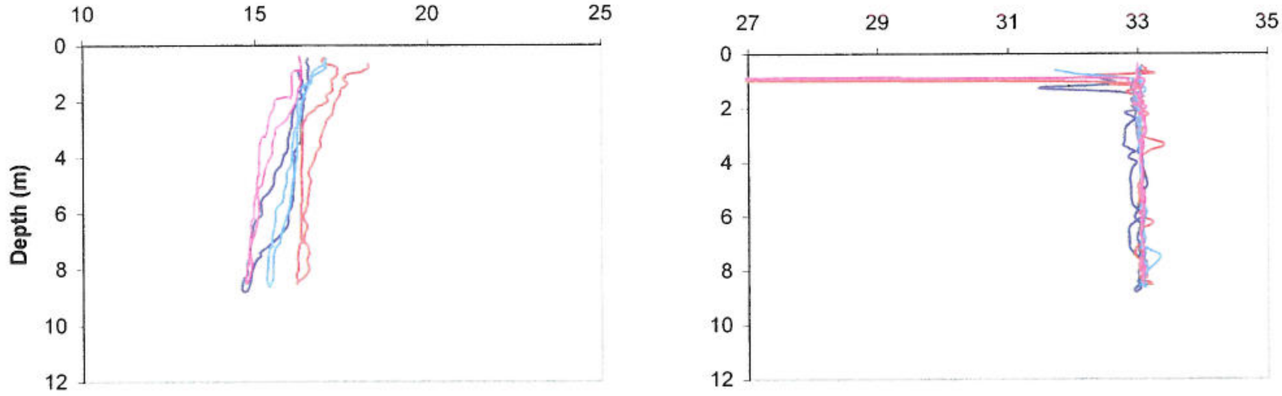
Appendix A-1. (Cont.)



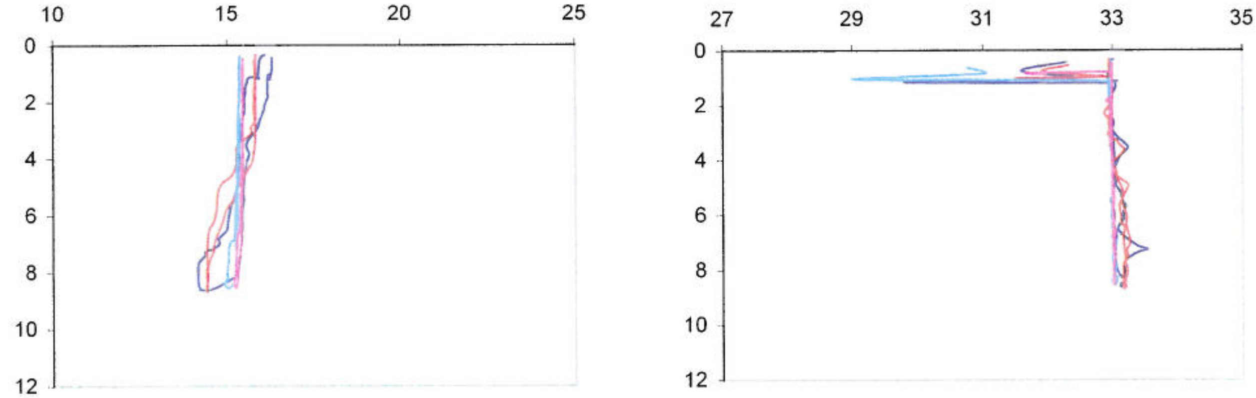
Appendix A-1. (Cont.)


HBS023, 8-9 Mar. 04

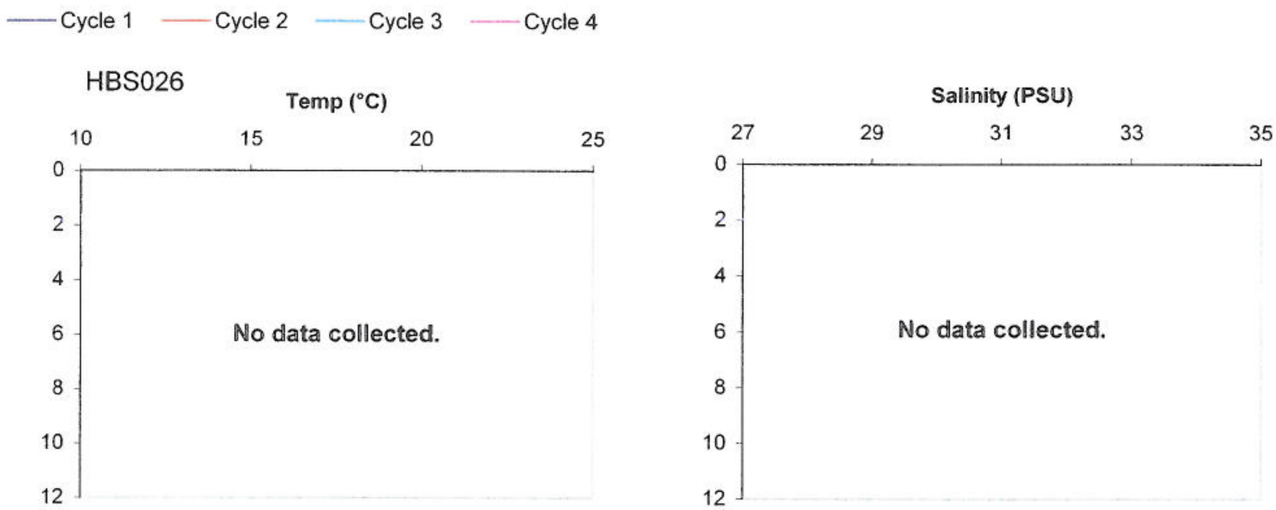
HBS024, 15-16 Mar. 04



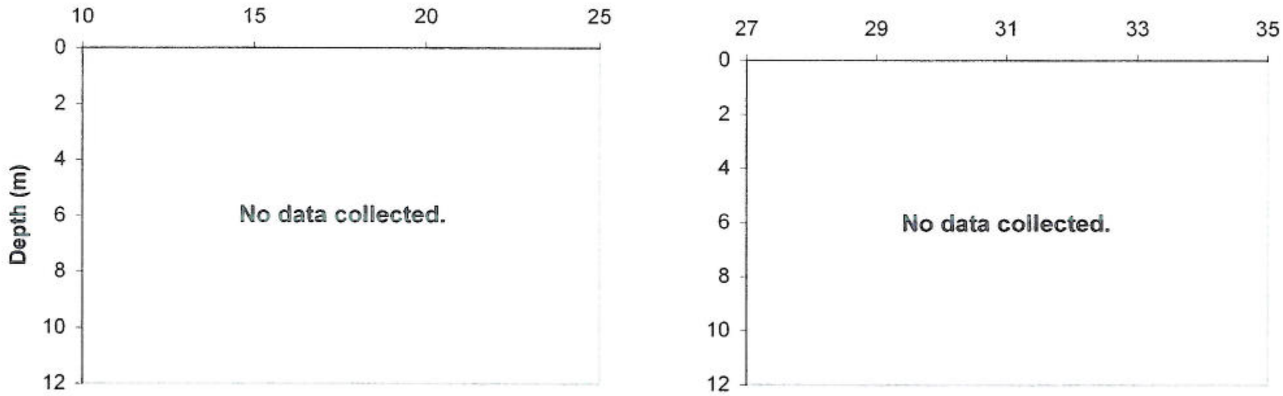
HBS025, 22-23 Mar. 04



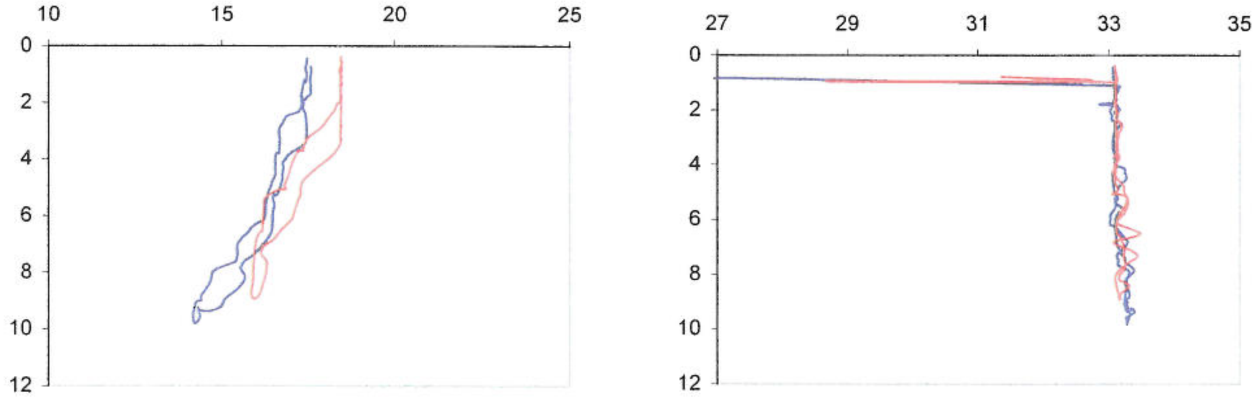
Appendix A-1. (Cont.)



HBS027



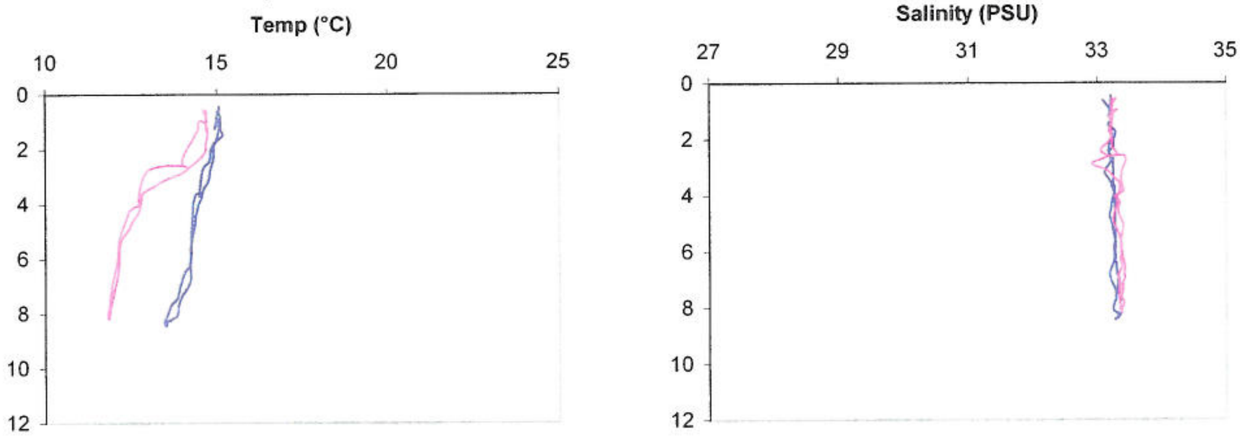
HBS028, 12-13 Apr. 04



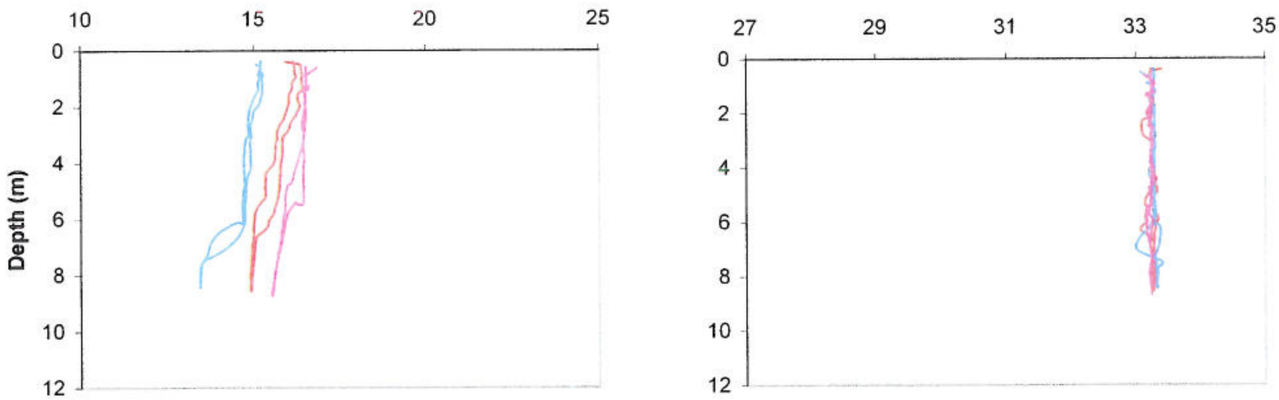
Appendix A-1. (Cont.)

— Cycle 1 — Cycle 2 — Cycle 3 — Cycle 4

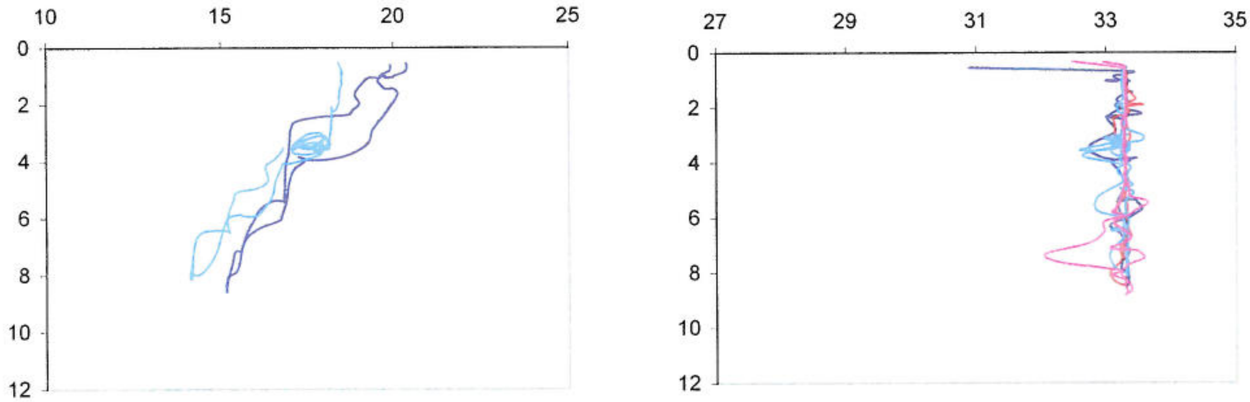
HBS029, 19-20 Apr. 04



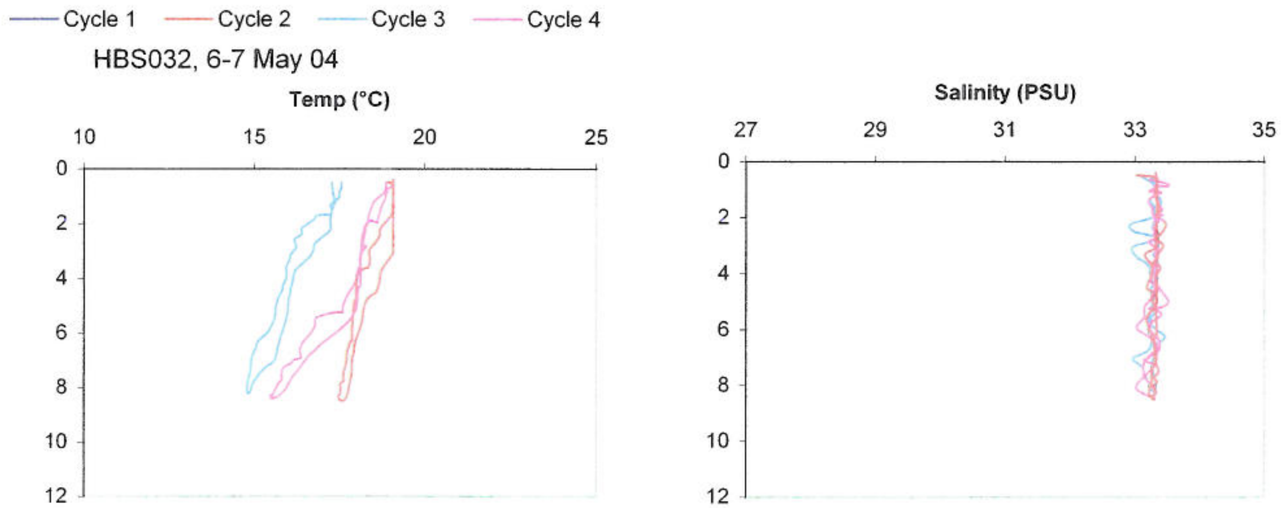
HBS030, 23 Apr. 04



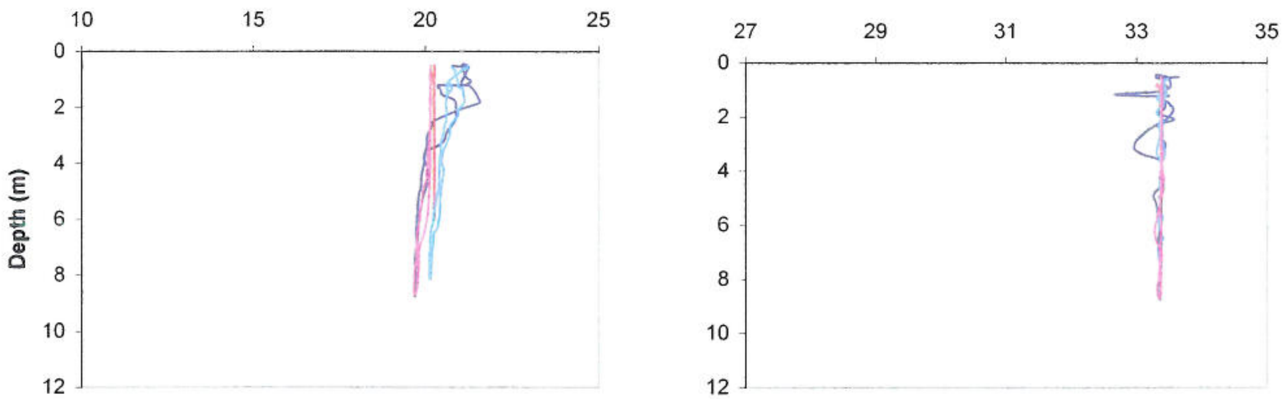
HBS031, 3-4 May 04



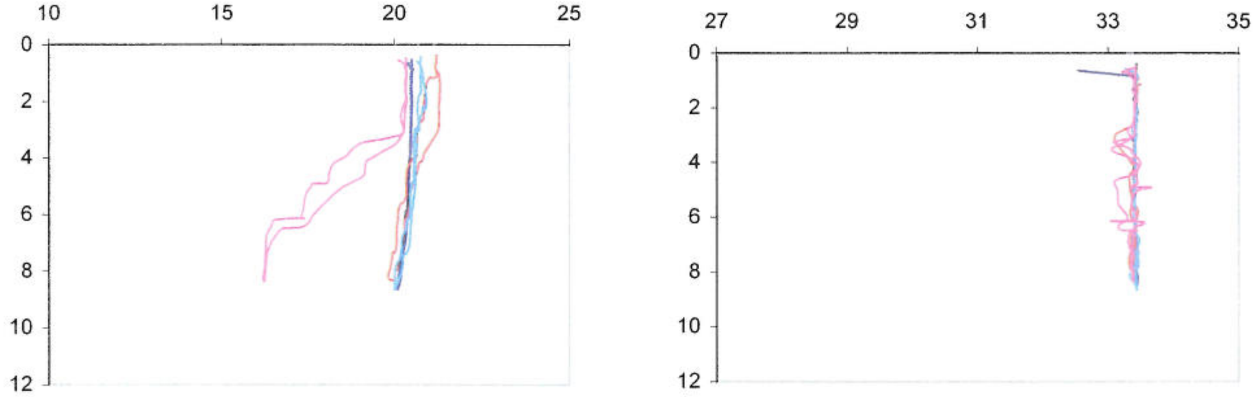
Appendix A-1. (Cont.)


HBS032, 6-7 May 04

HBS033, 17-18 May 04

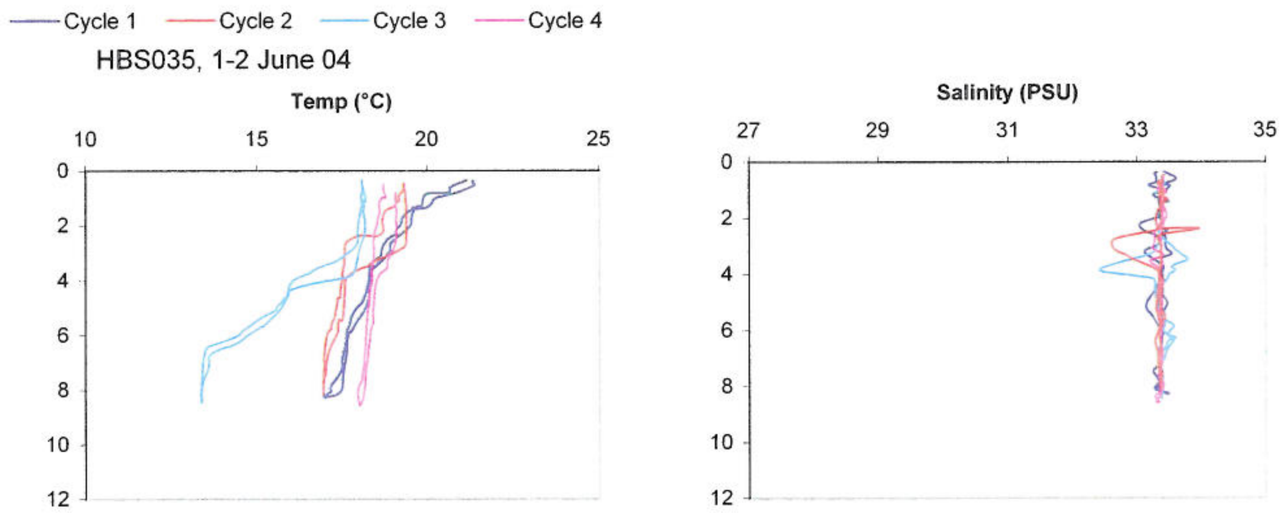


HBS034, 24-25 May 04

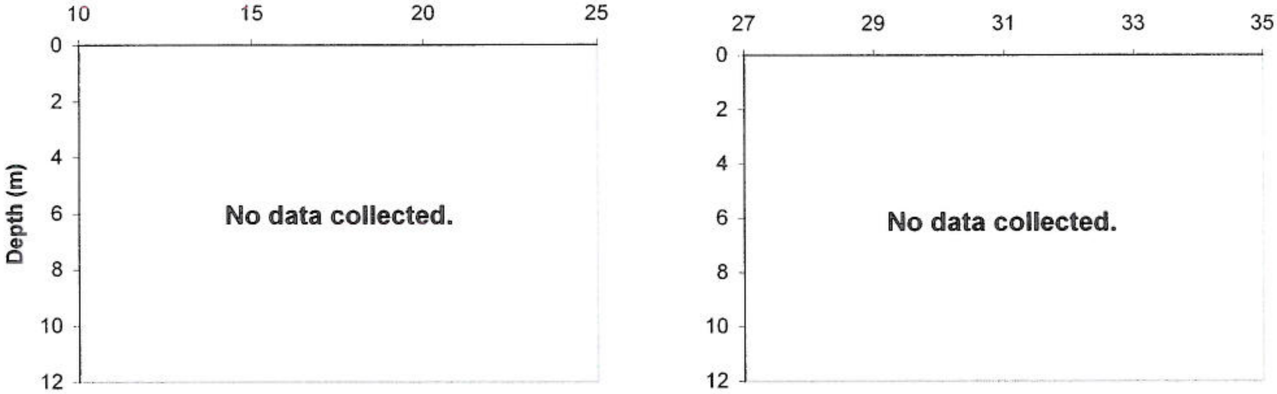


Appendix A-1. (Cont.)

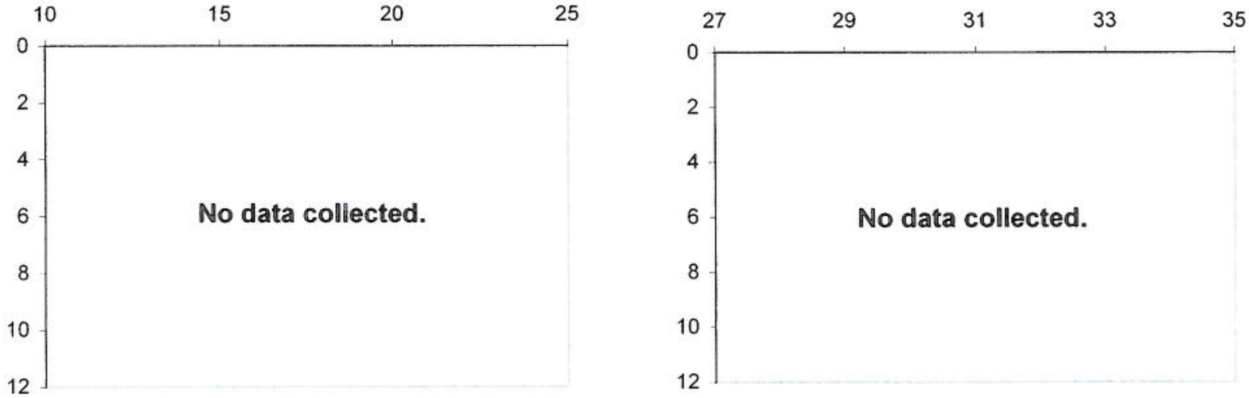
HBS035, 1-2 June 04



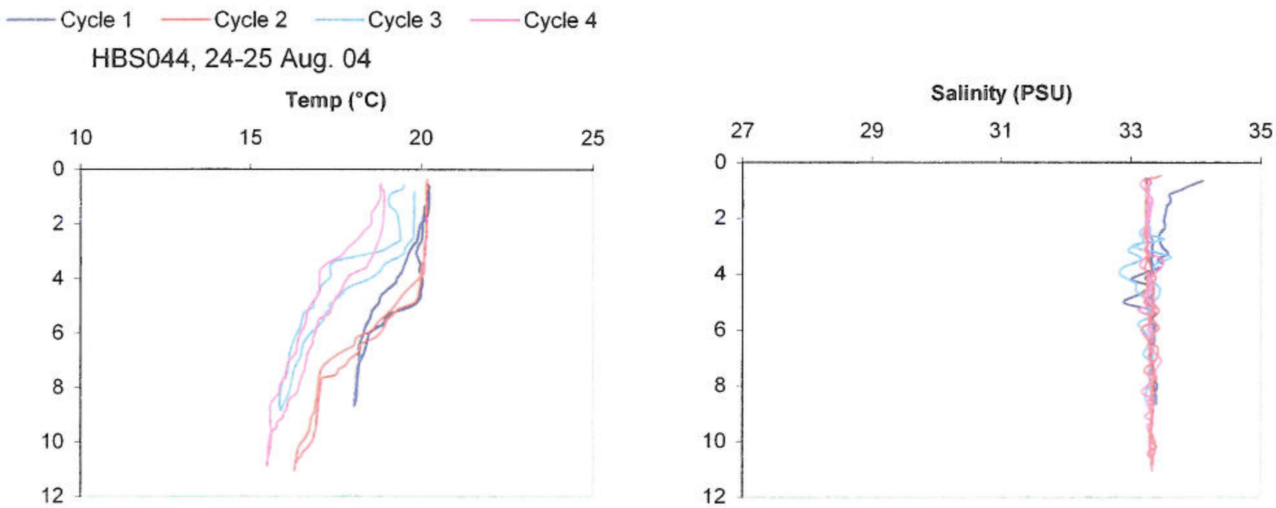
HBS036

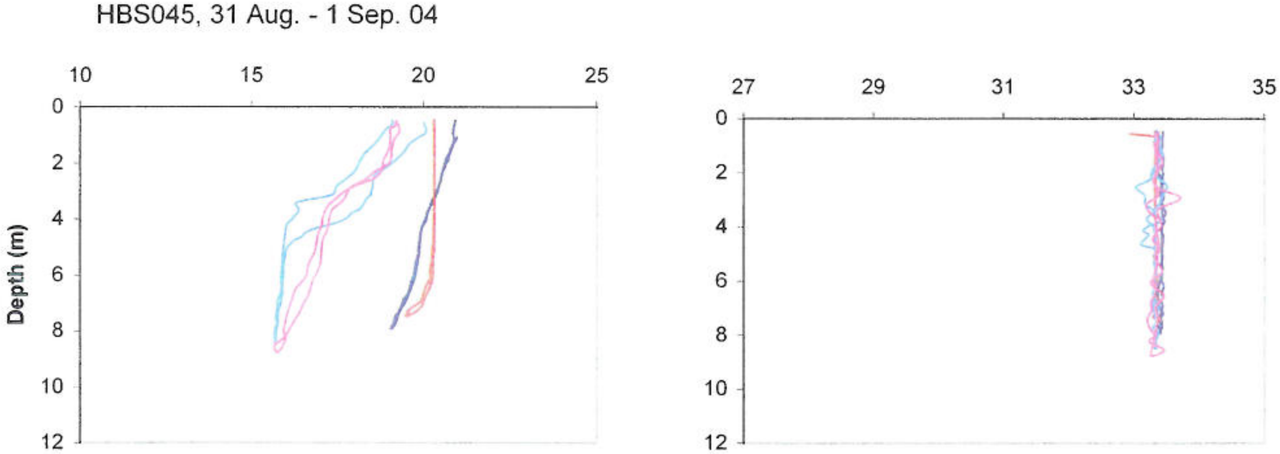


HBS037



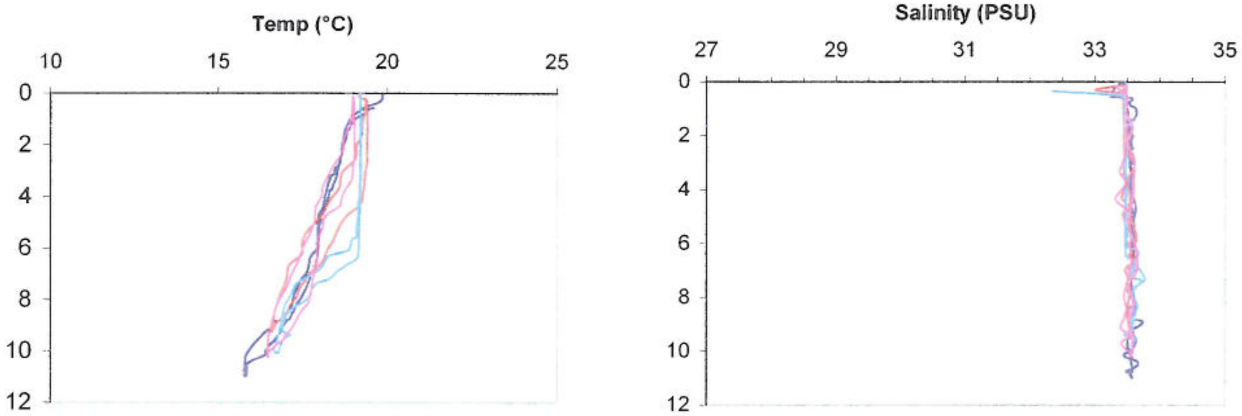
Appendix A-1. (Cont.)



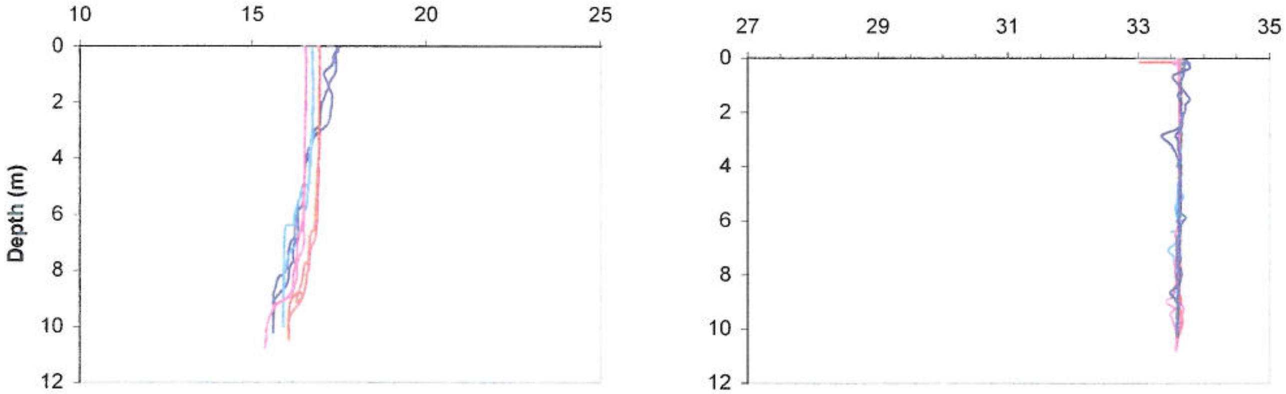


Appendix A-2. Temperature and salinity profiles at Station U2, Sept. 2003 to Sept. 2004.

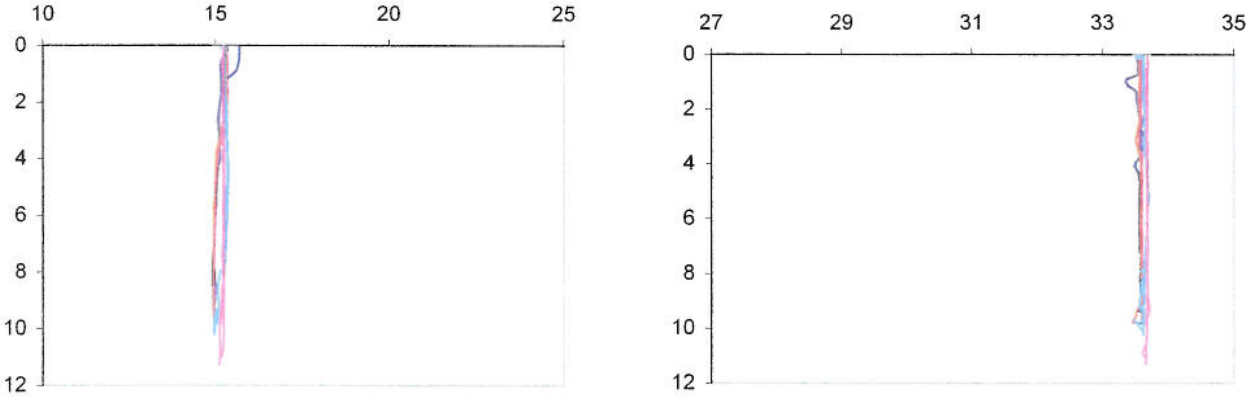
HBS003, 13-14 Oct. 03



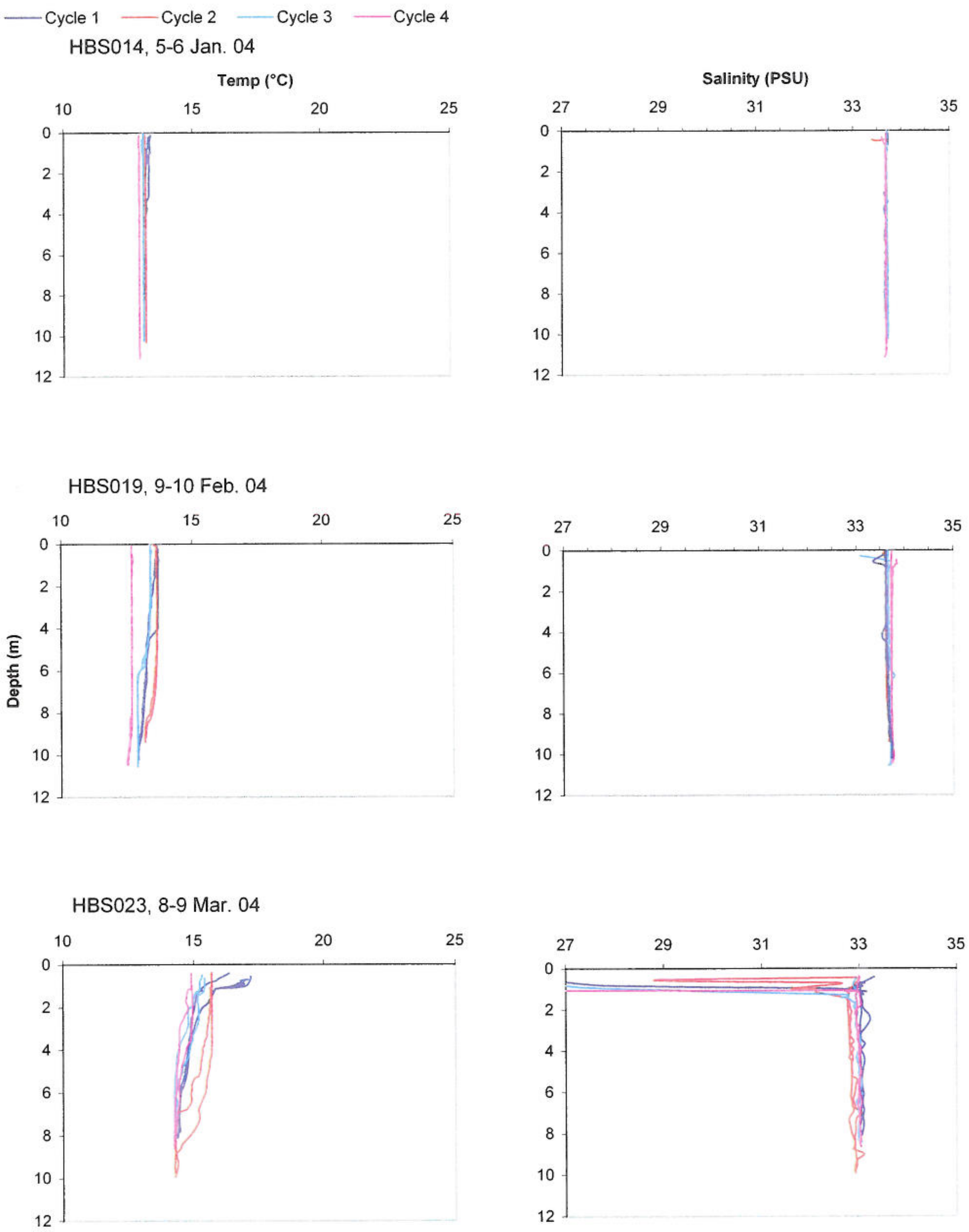
HBS006, 10-11 Nov. 03



HBS010, 8-9 Dec. 03



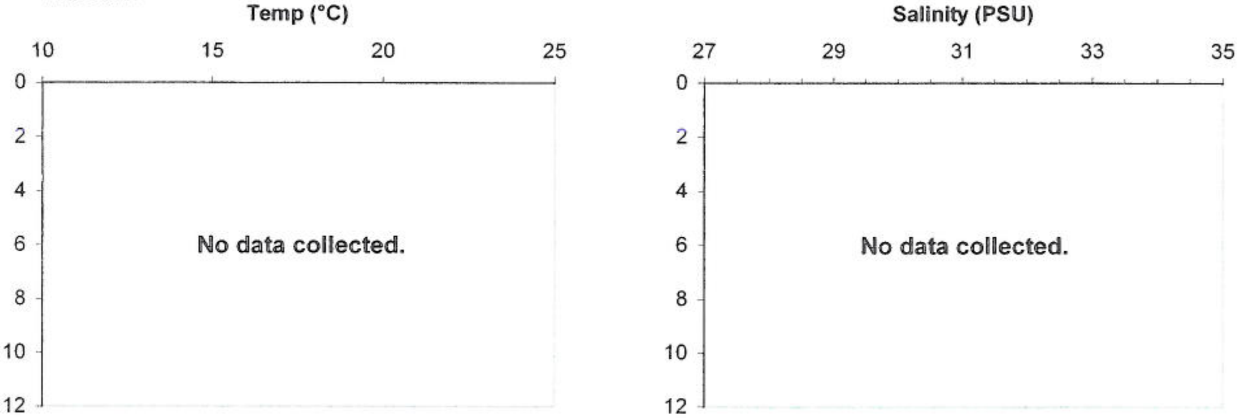
Appendix A-2. (Cont.)



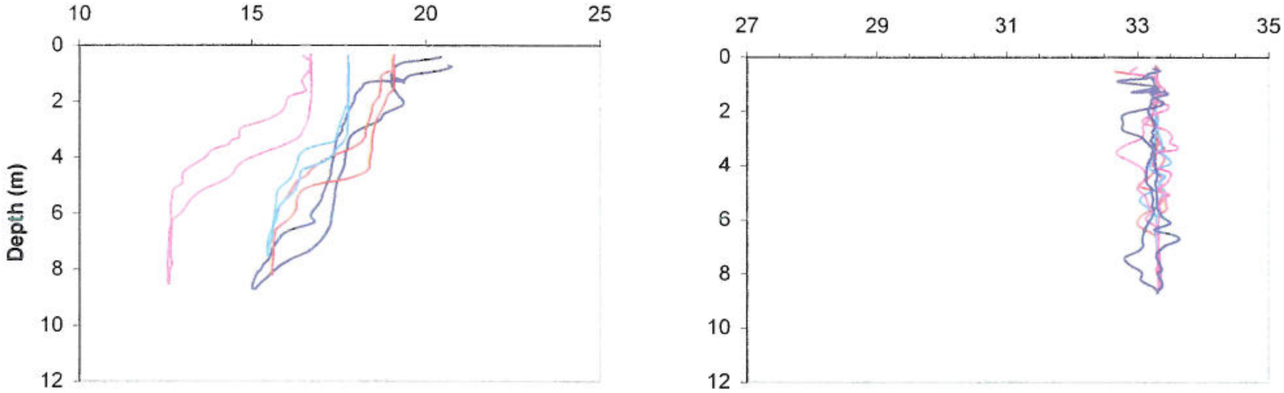
Appendix A-2. (Cont.)

Cycle 1 Cycle 2 Cycle 3 Cycle 4

HBS027

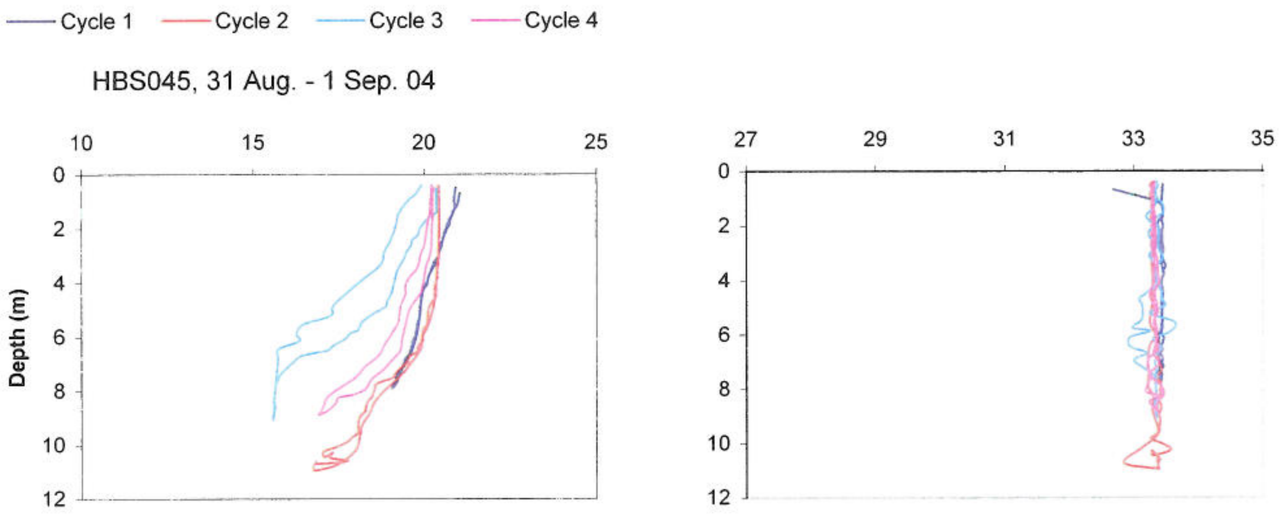


HBS031, 3-4 May 04

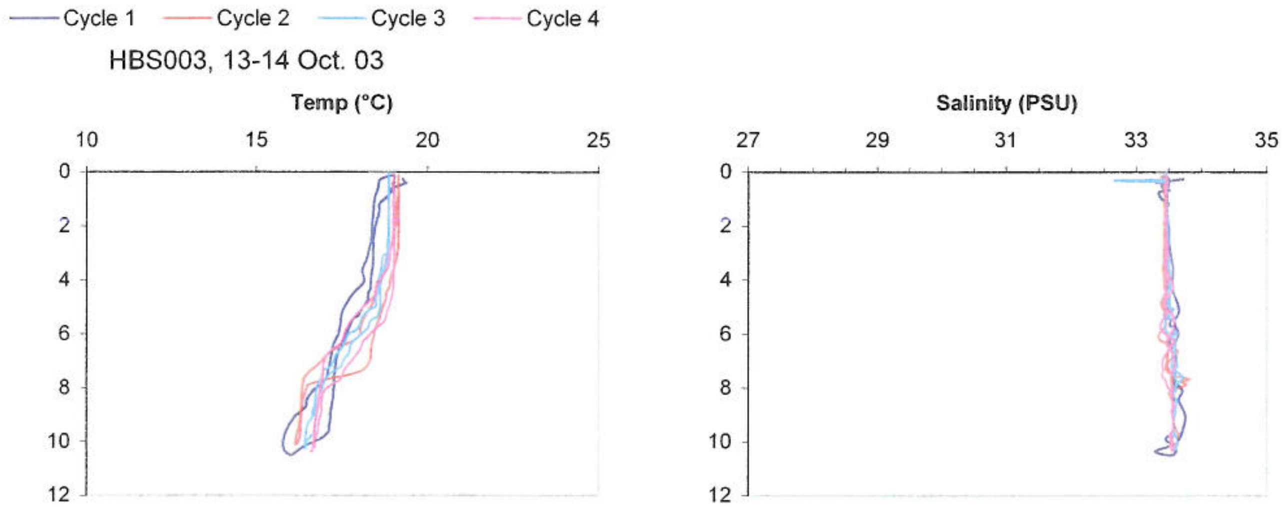


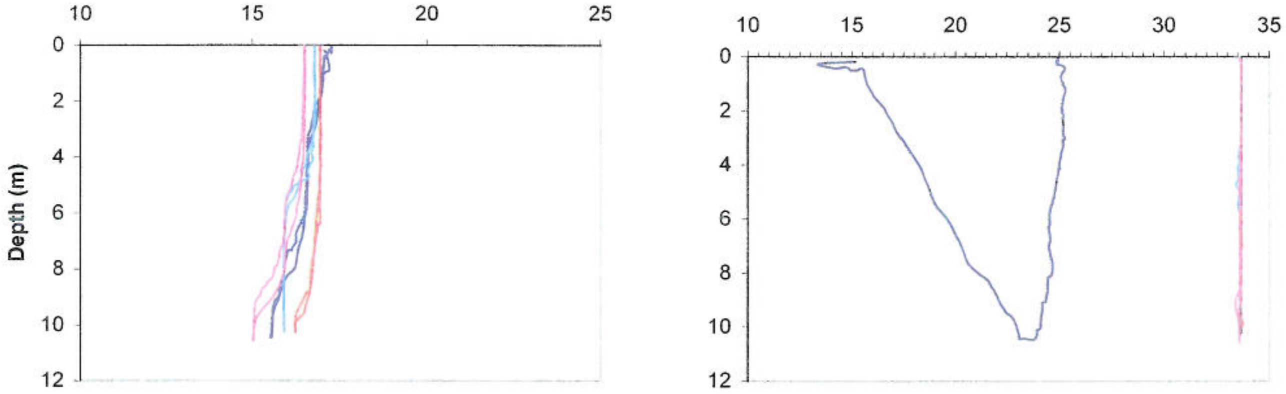
HBS035, 1-2 June 04

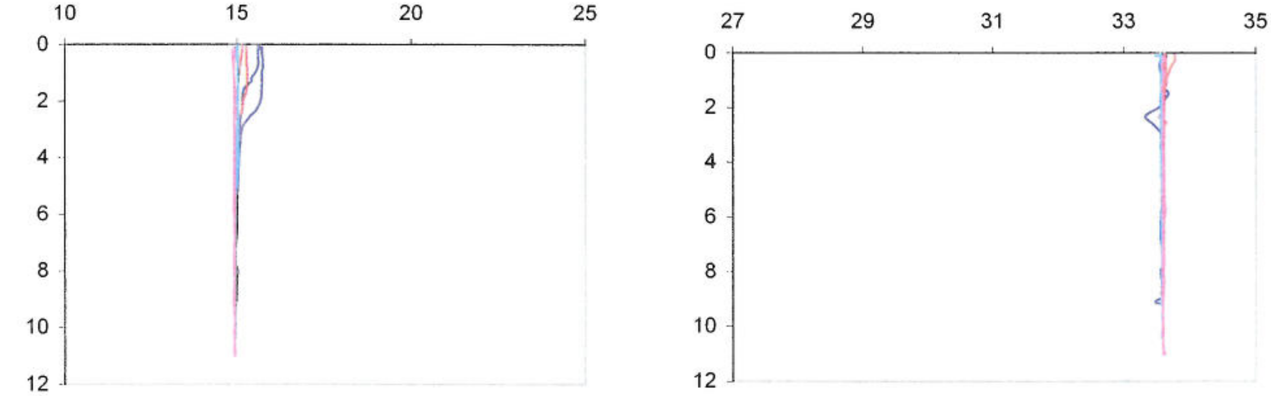
Appendix A-2. (Cont.)



Appendix A-3. Temperature and salinity profiles at Station U4, Sept. 2003 to Sept. 2004.

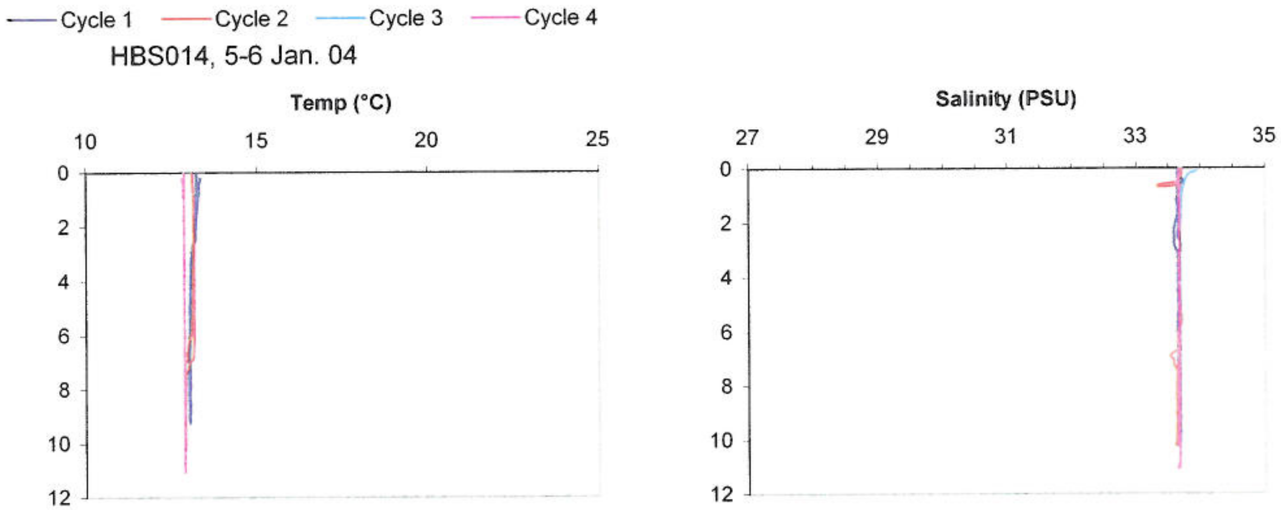

HBS003, 13-14 Oct. 03


HBS006, 10-11 Nov. 03

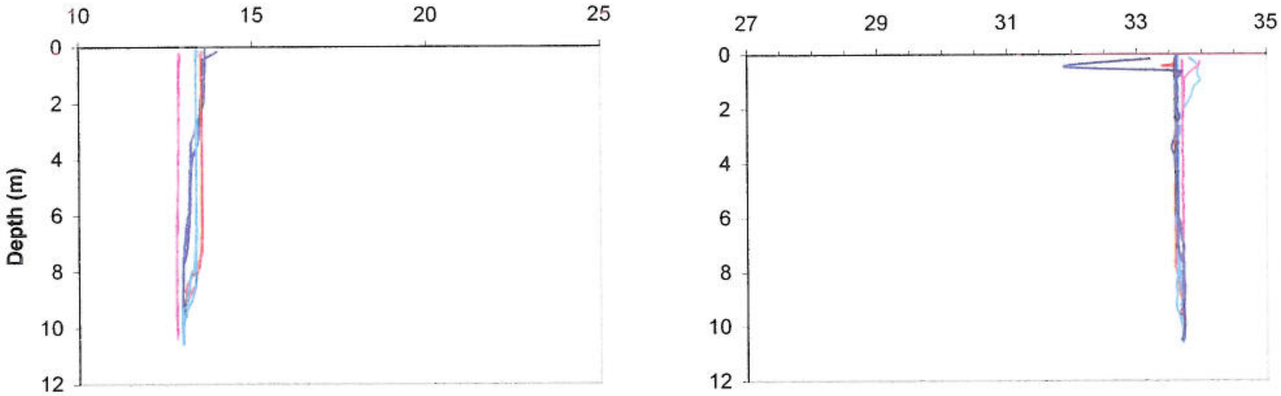

HBS010, 8-9 Dec. 03

Appendix A-3. (Cont.)

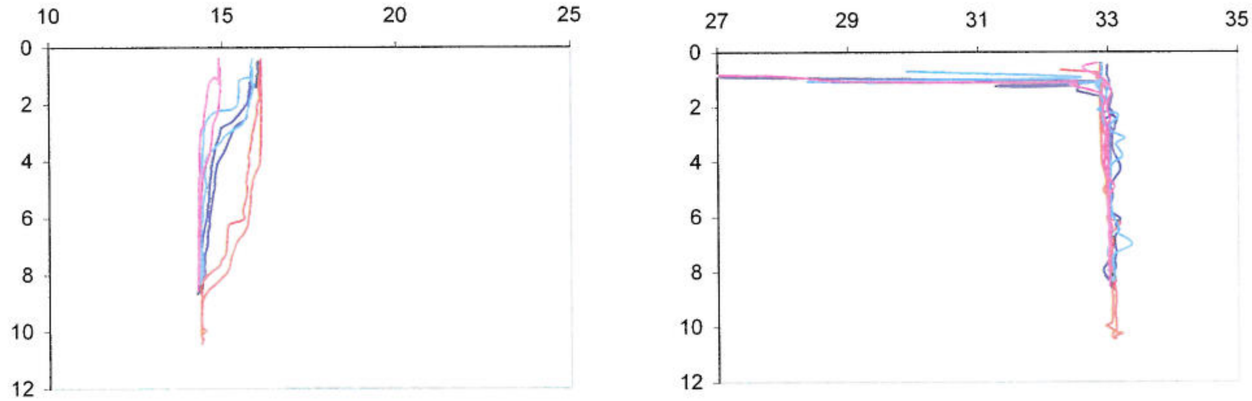
HBS014, 5-6 Jan. 04



HBS019, 9-10 Feb. 04



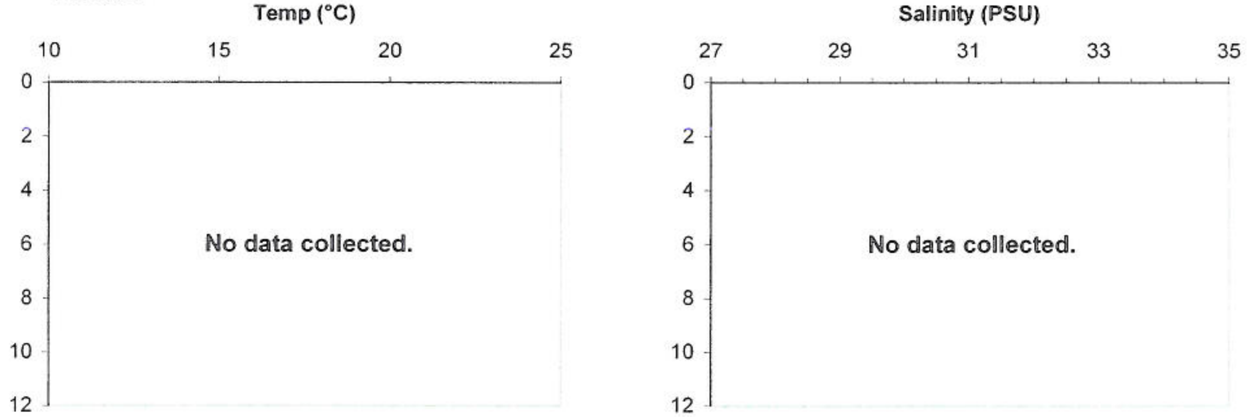
HBS023, 8-9 Mar. 04



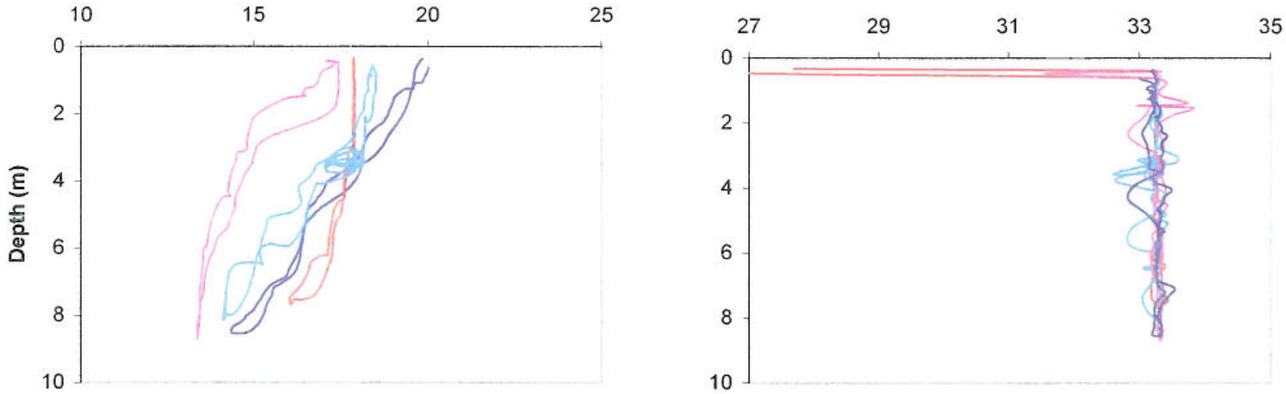
Appendix A-3. (Cont.)

— Cycle 1 — Cycle 2 — Cycle 3 — Cycle 4

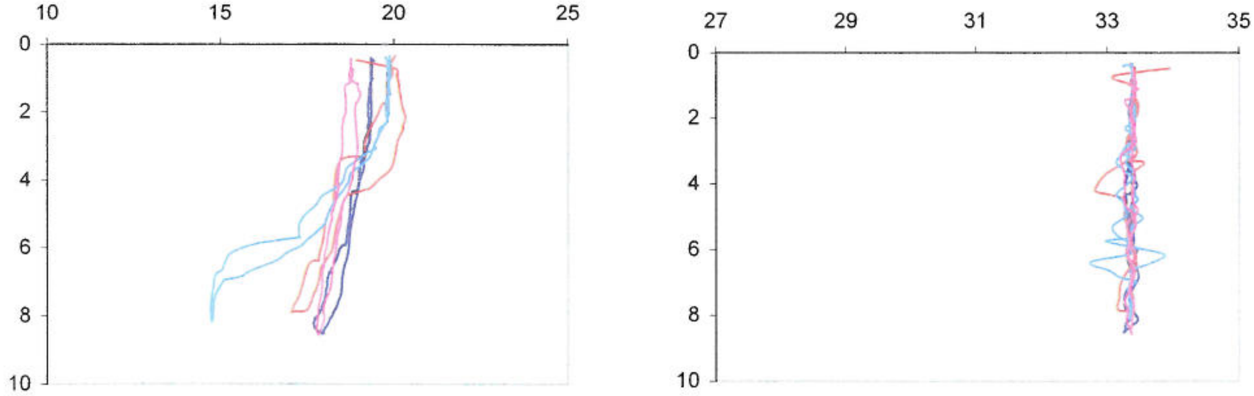
HBS027



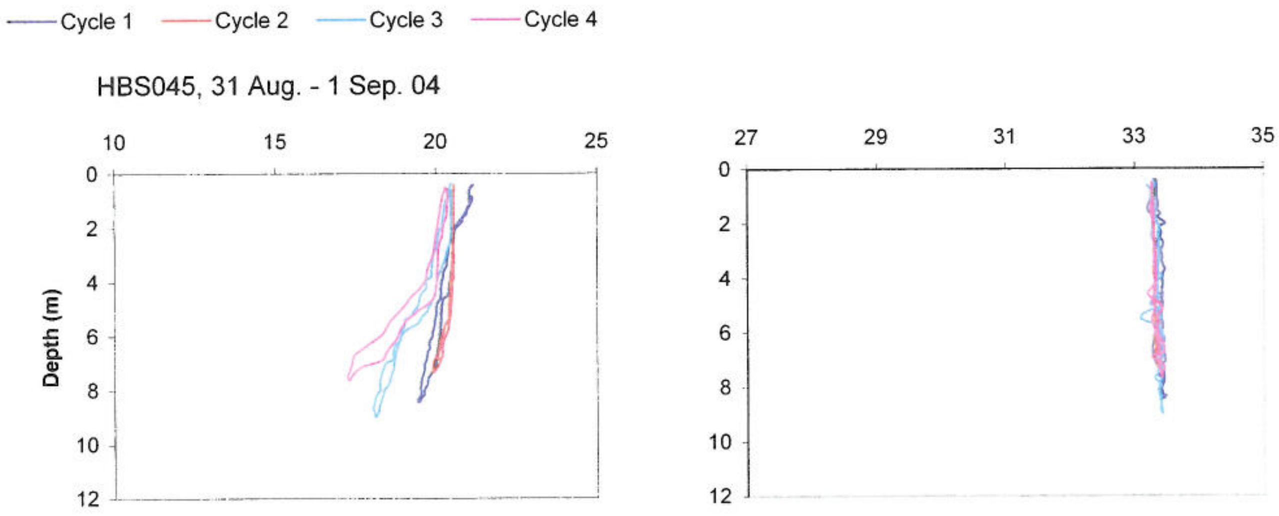
HBS031, 3-4 May 04



HBS035, 1-2 June 04

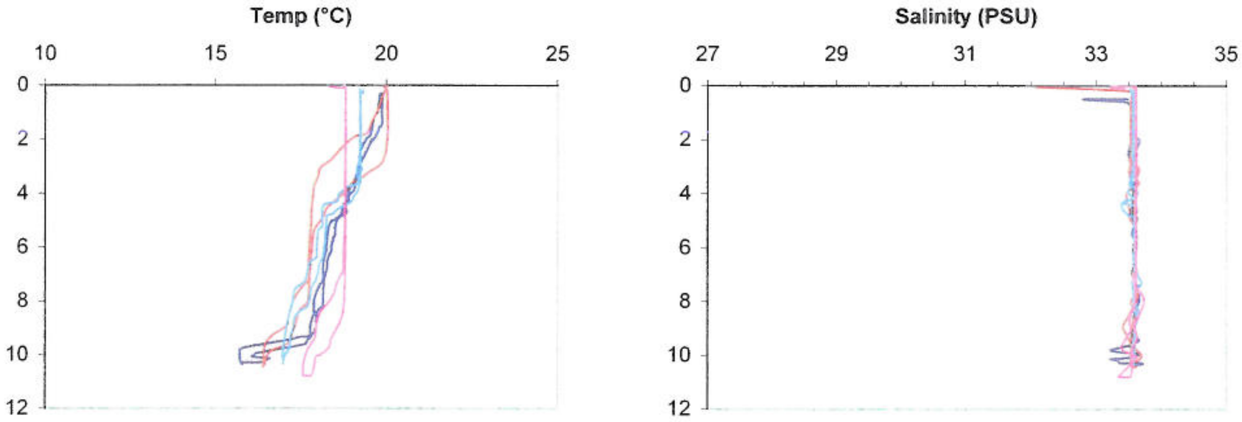


Appendix A-3. (Cont.)

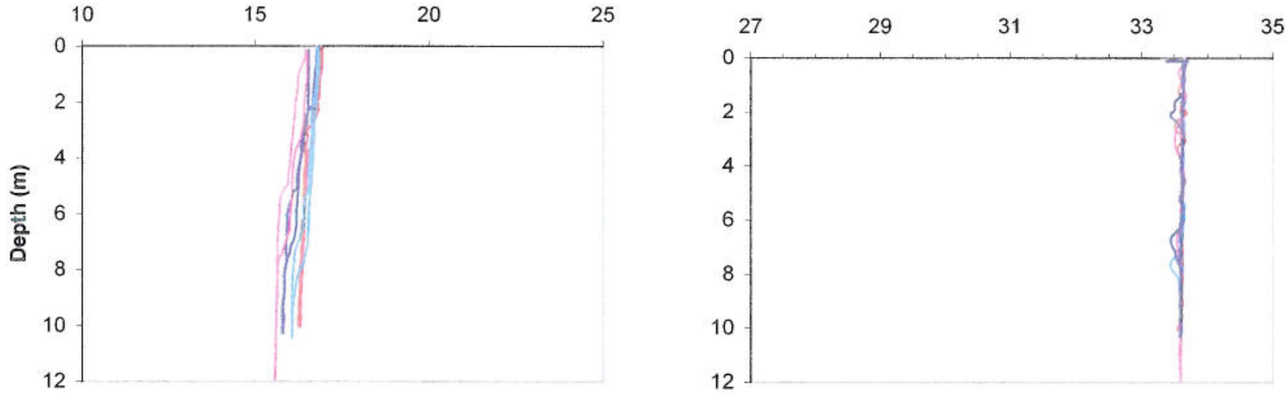


Appendix A-4. Temperature and salinity profiles at Station D2, Sept. 2003 to Sept. 2004.

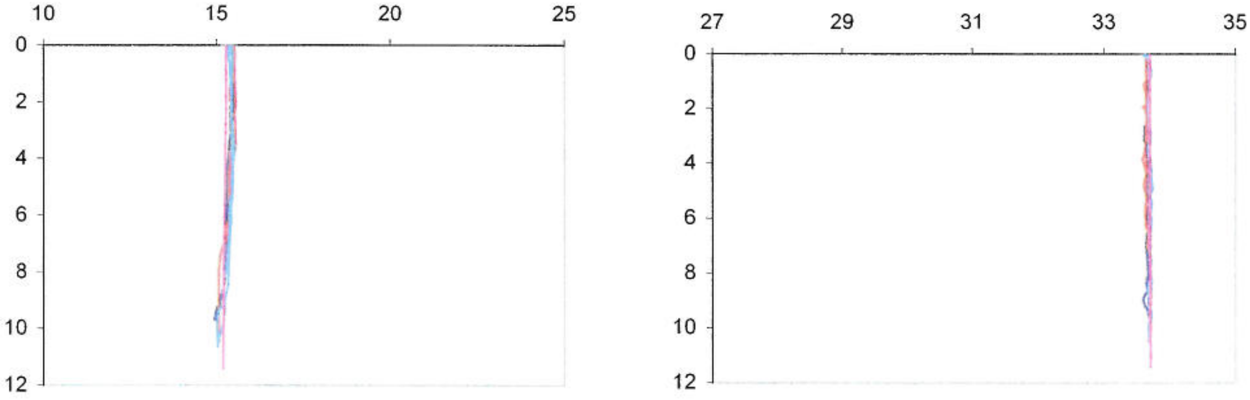
HBS003, 13-14 Oct. 03



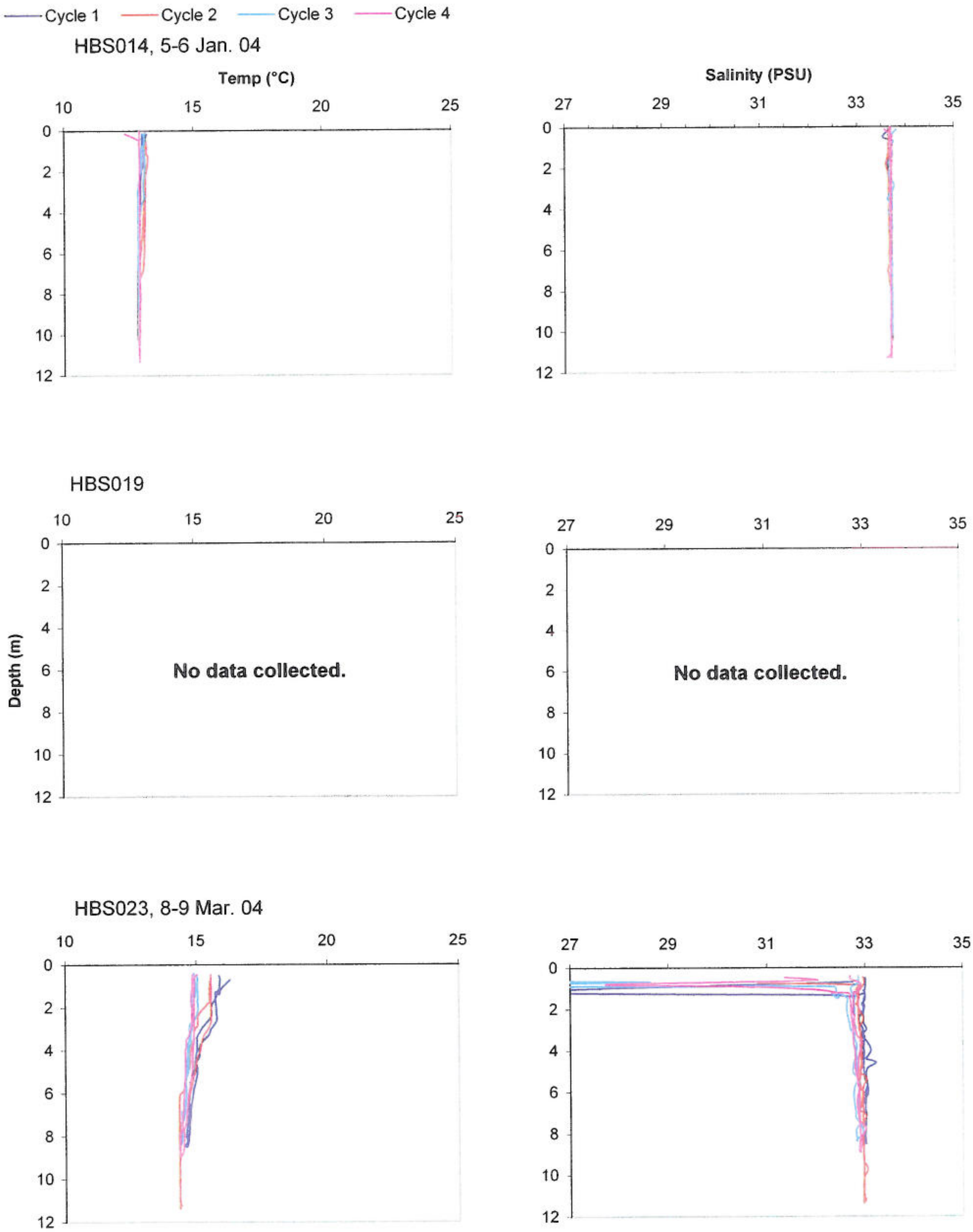
HBS006, 10-11 Nov. 03



HBS010, 8-9 Dec. 03

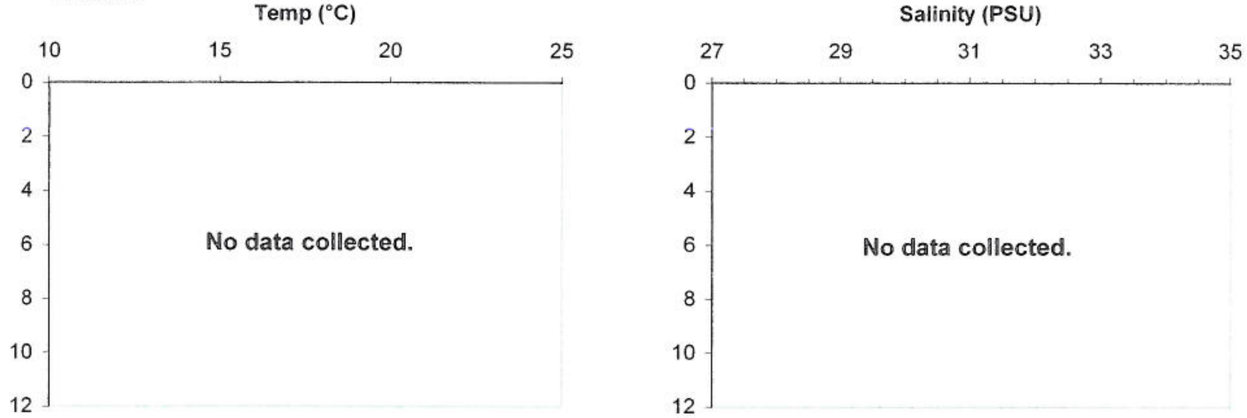


Appendix A-4. (Cont.)

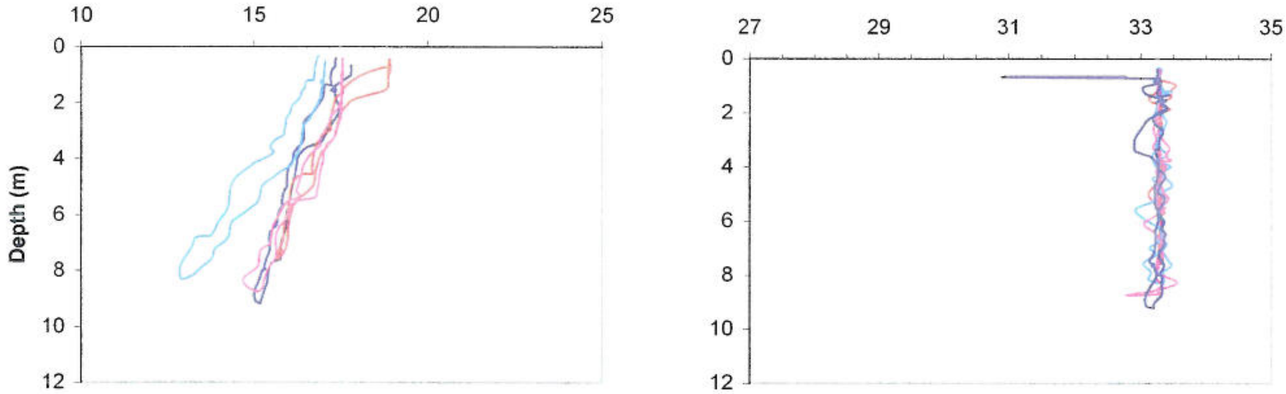


Appendix A-4. (Cont.)

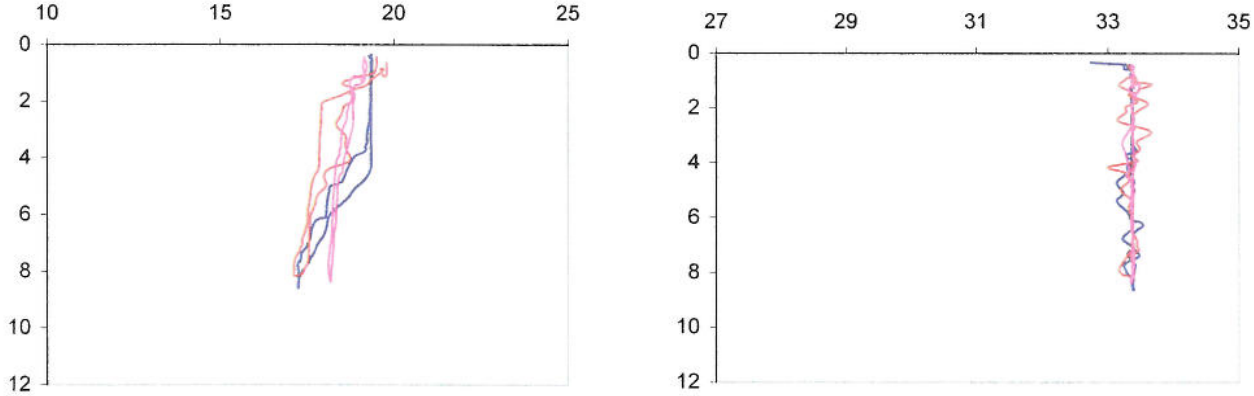
HBS027



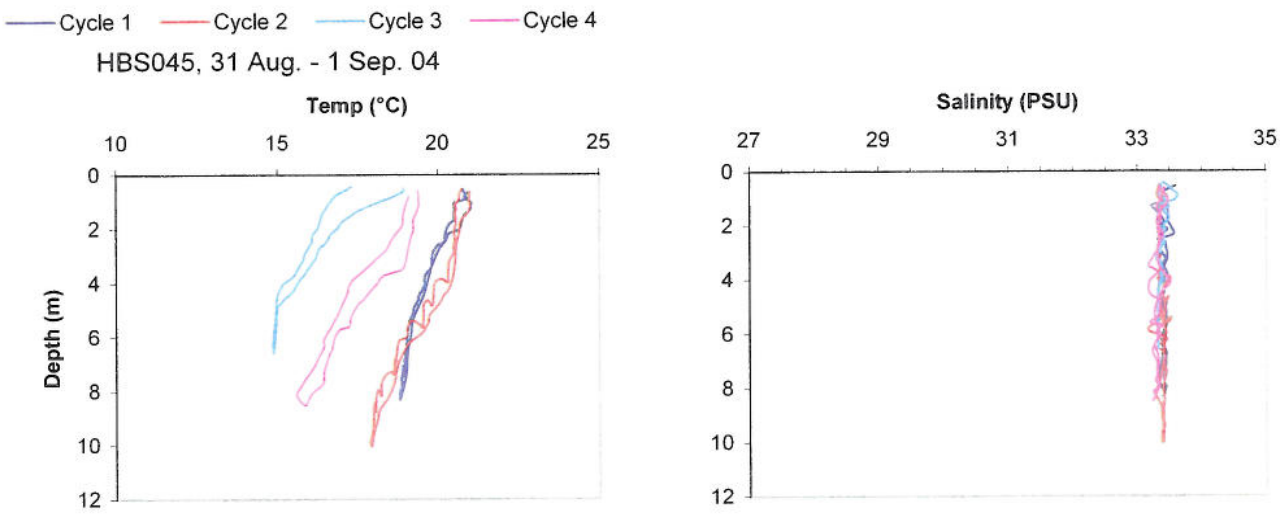
HBS031, 3-4 May 04



HBS035, 1-2 June 04

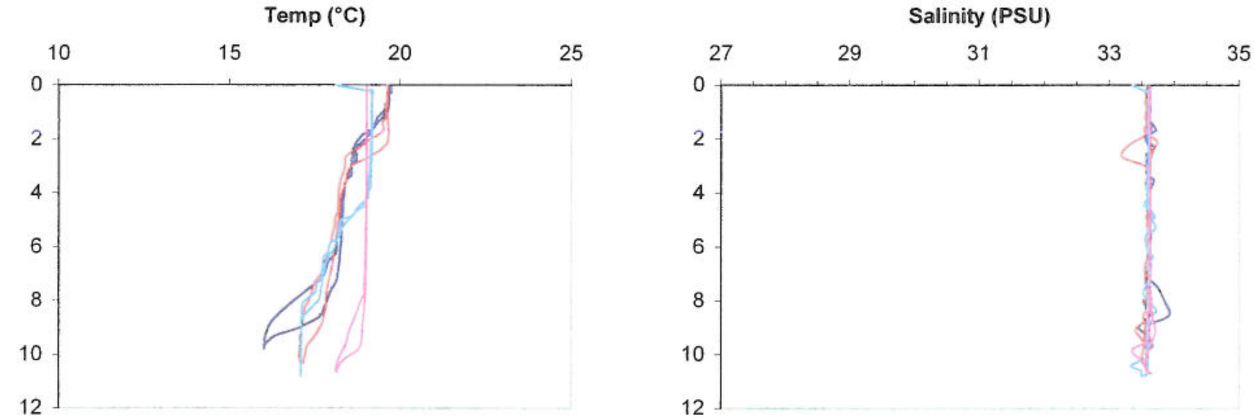


Appendix A-4. (Cont.)

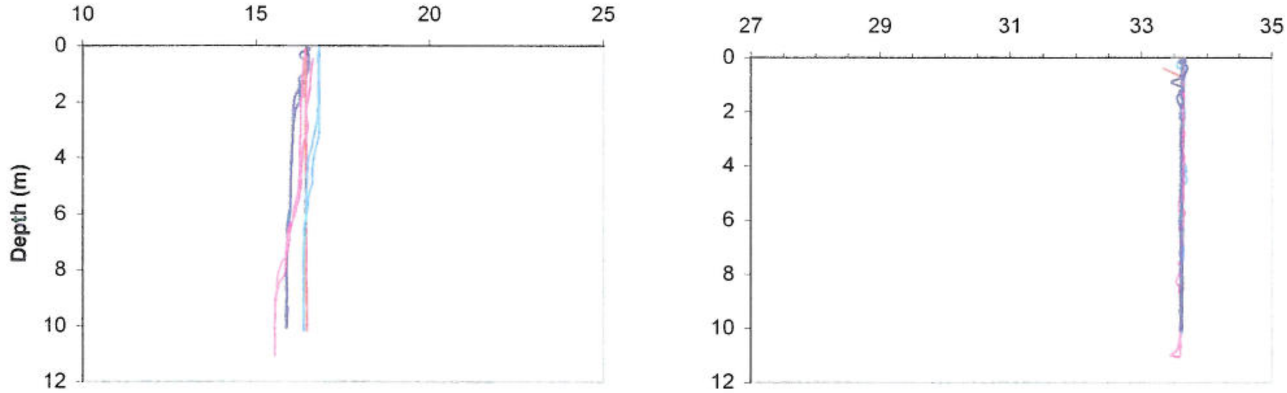


Appendix A-5. Temperature and salinity profiles at Station D4, Sept. 2003 to Sept. 2004.

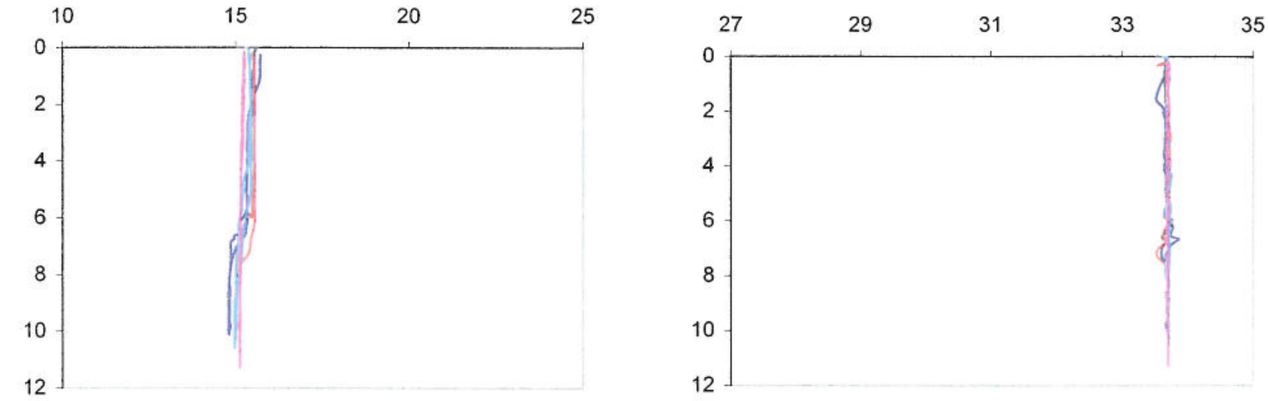
HBS003, 13-14 Oct. 03



HBS006, 10-11 Nov. 03



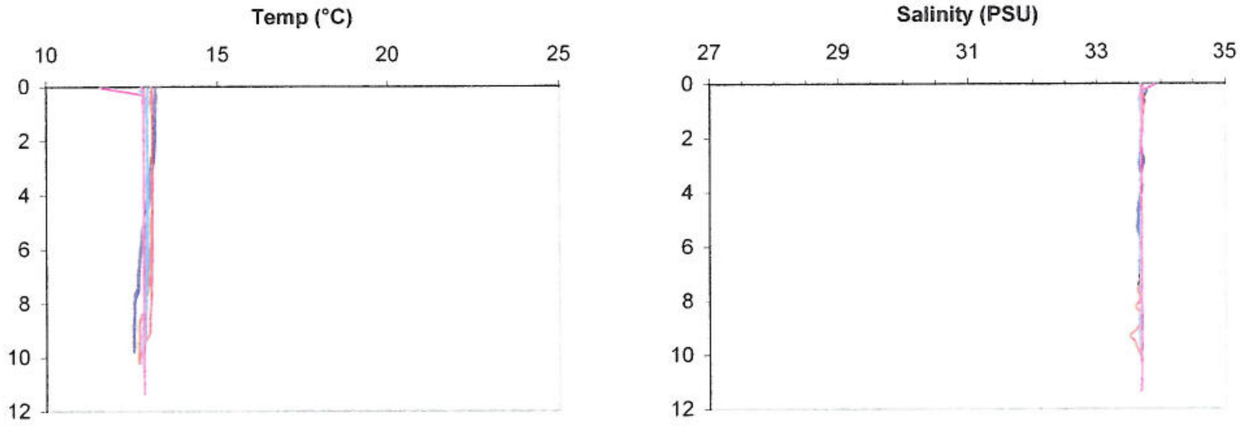
HBS010, 8-9 Dec. 03



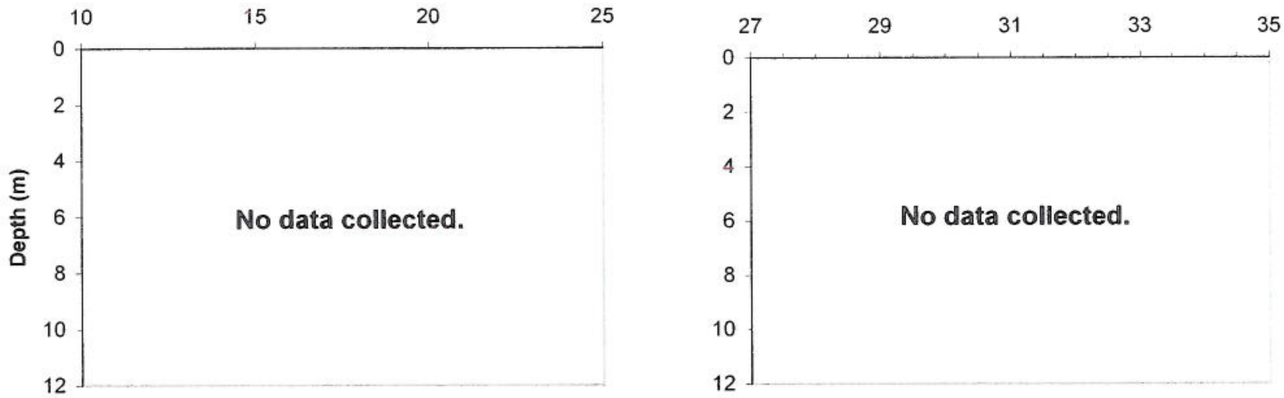
Appendix A-5. (Cont.)

— Cycle 1 — Cycle 2 — Cycle 3 — Cycle 4

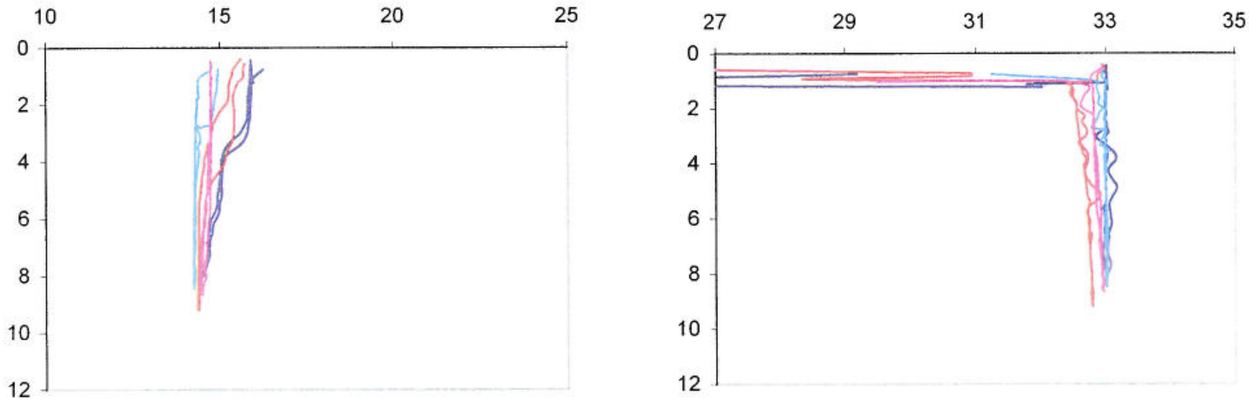
HBS014, 5-6 Jan. 04



HBS019

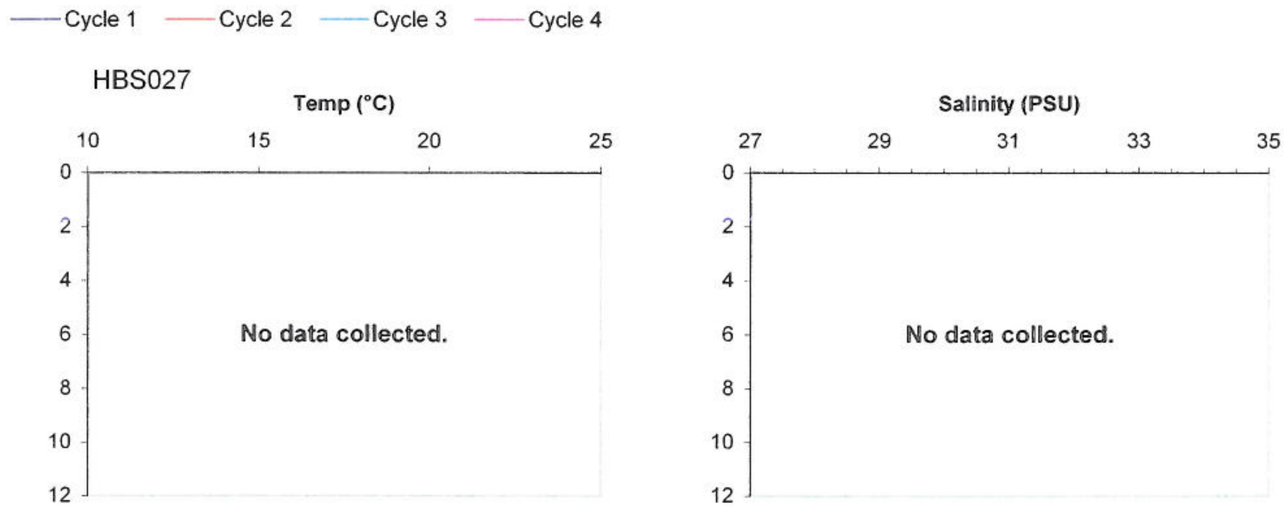


HBS023, 8-9 Mar. 04

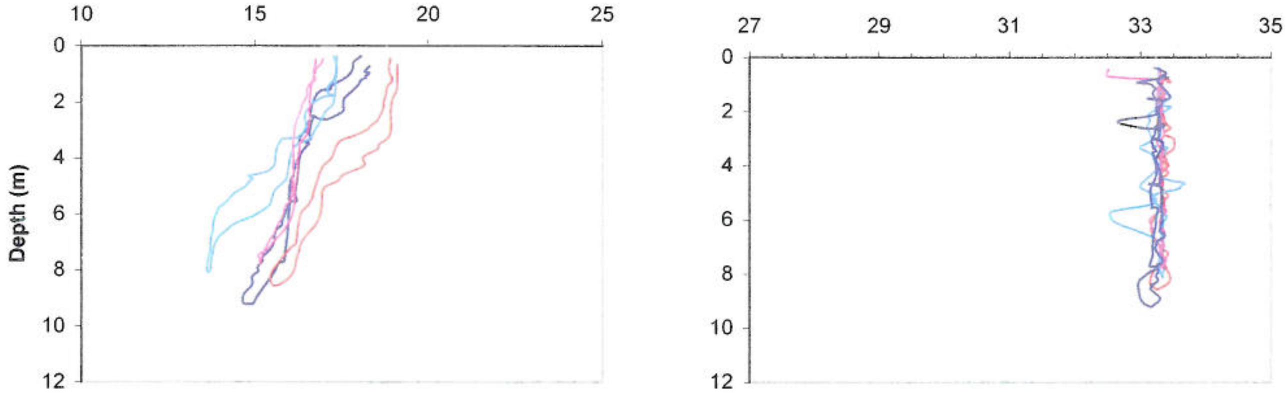


Appendix A-5. (Cont.)

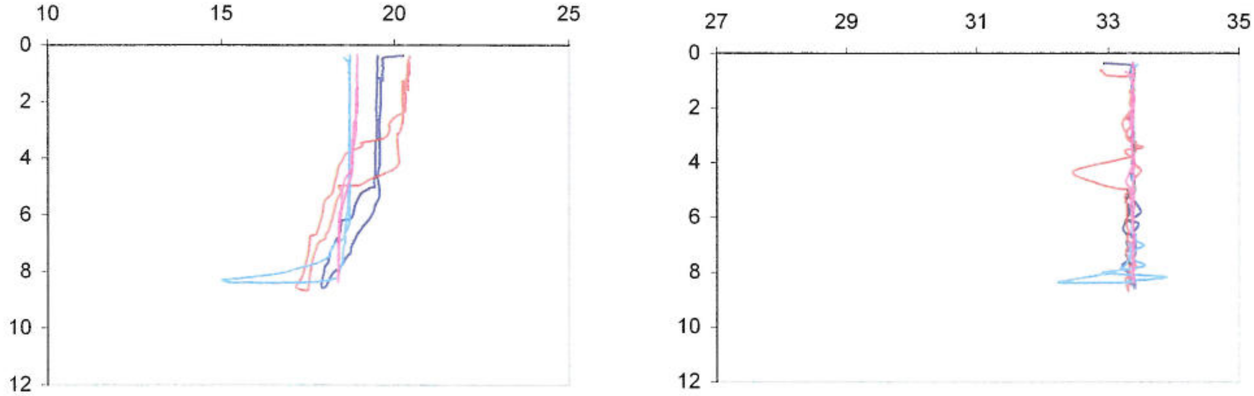
HBS027



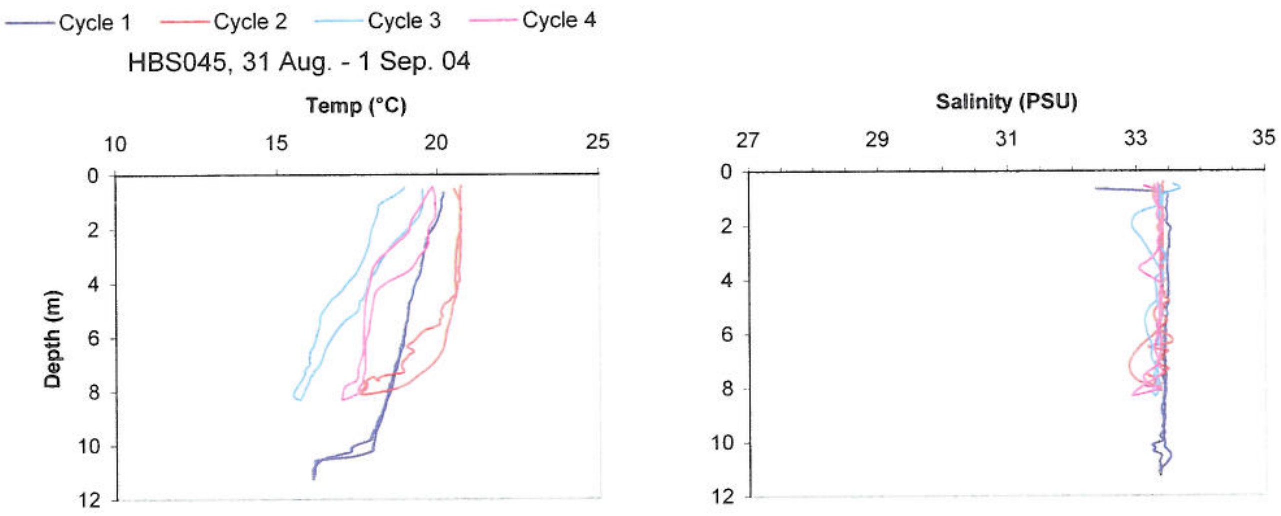
HBS031, 3-4 May 04



HBS035, 1-2 June 04

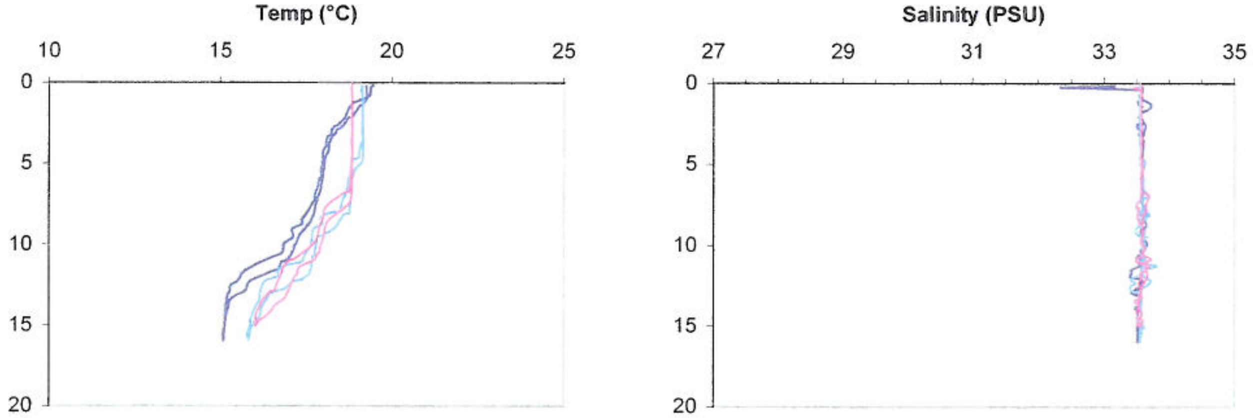


Appendix A-5. (Cont.)

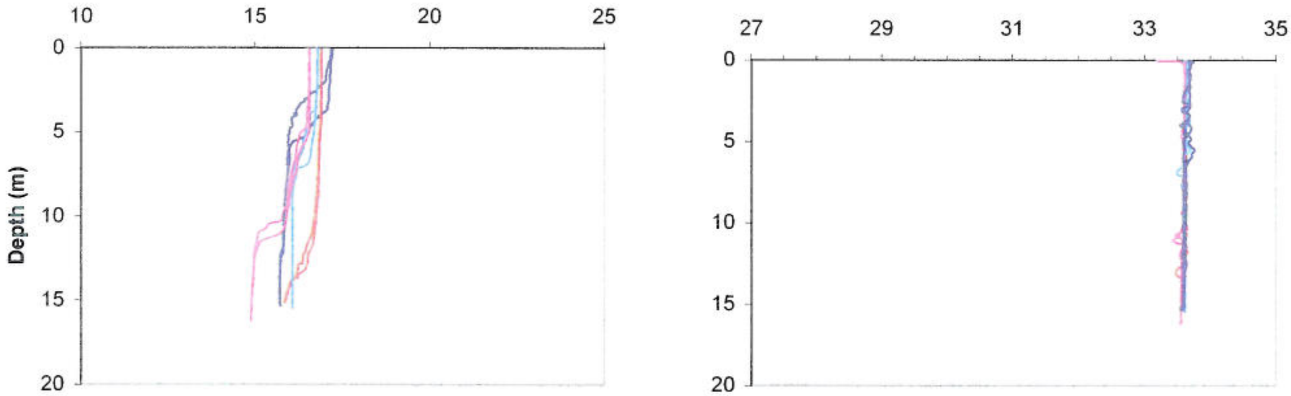


Appendix A-6. Temperature and salinity profiles at Station O2, Sept. 2003 to Sept. 2004.

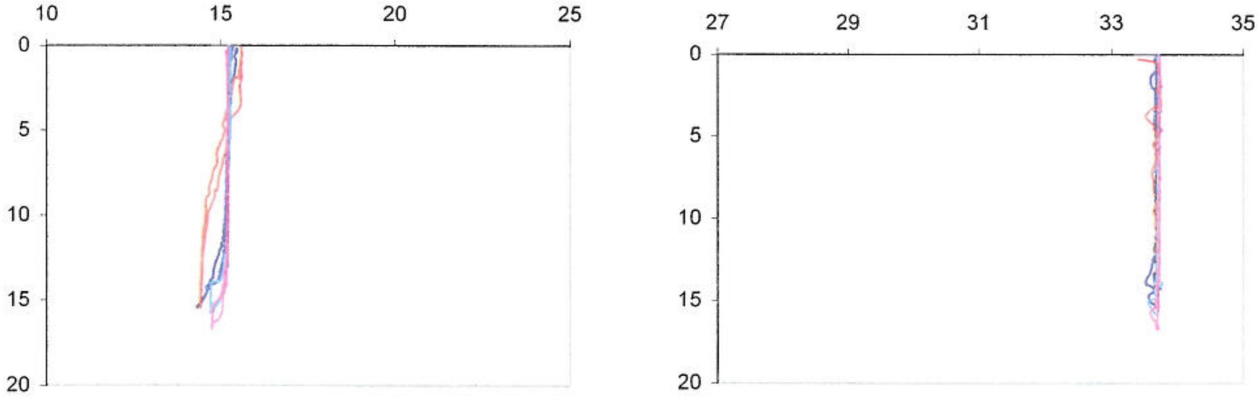
HBS003, 13-14 Oct. 03



HBS006, 10-11 Nov. 03

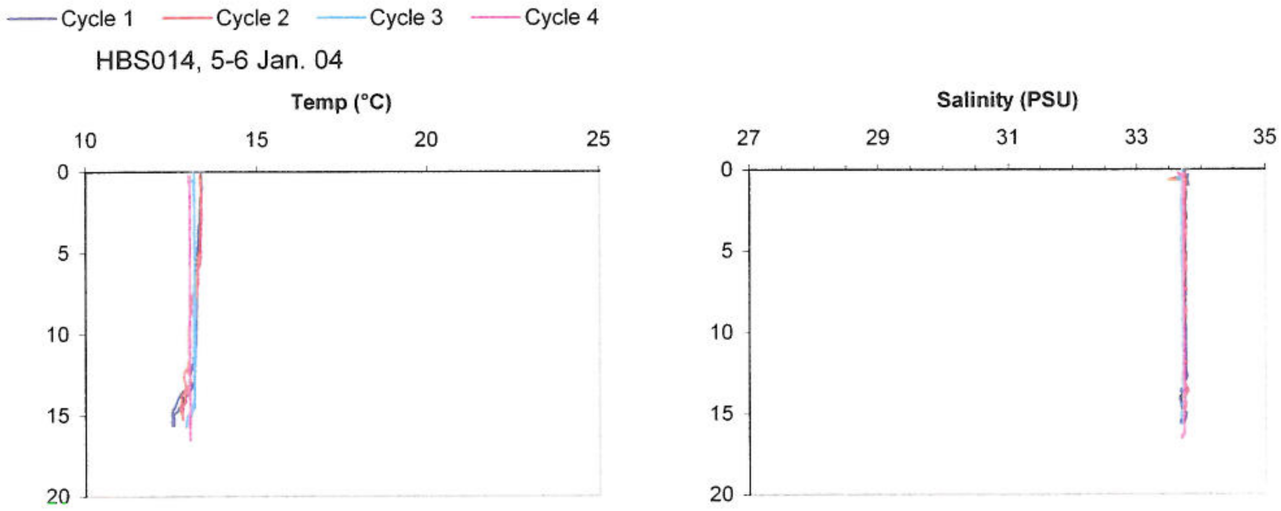


HBS010, 8-9 Dec. 03

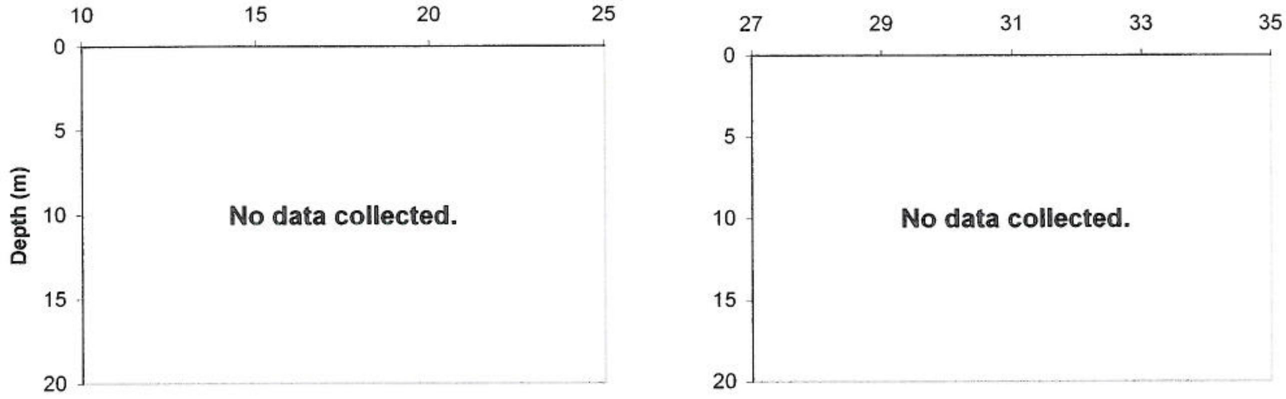


Appendix A-6. (Cont.)

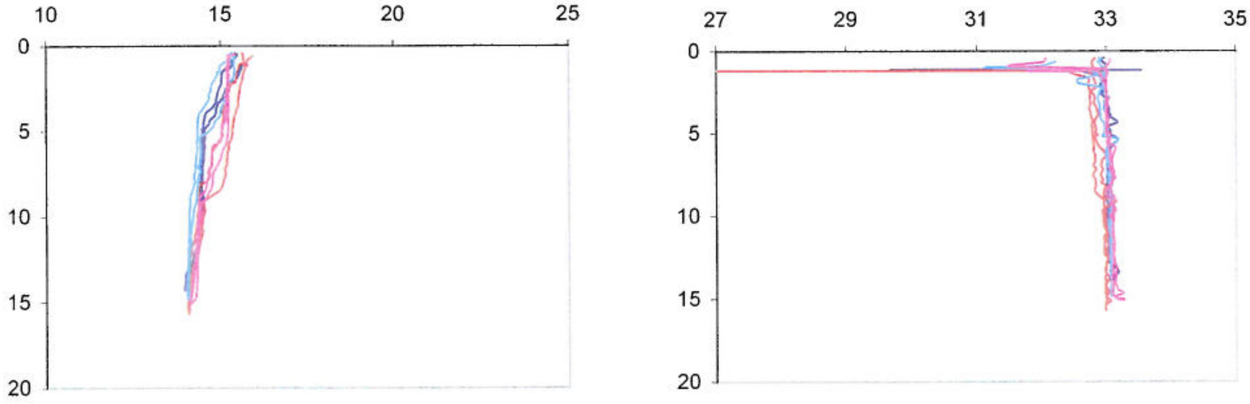
HBS014, 5-6 Jan. 04



HBS019



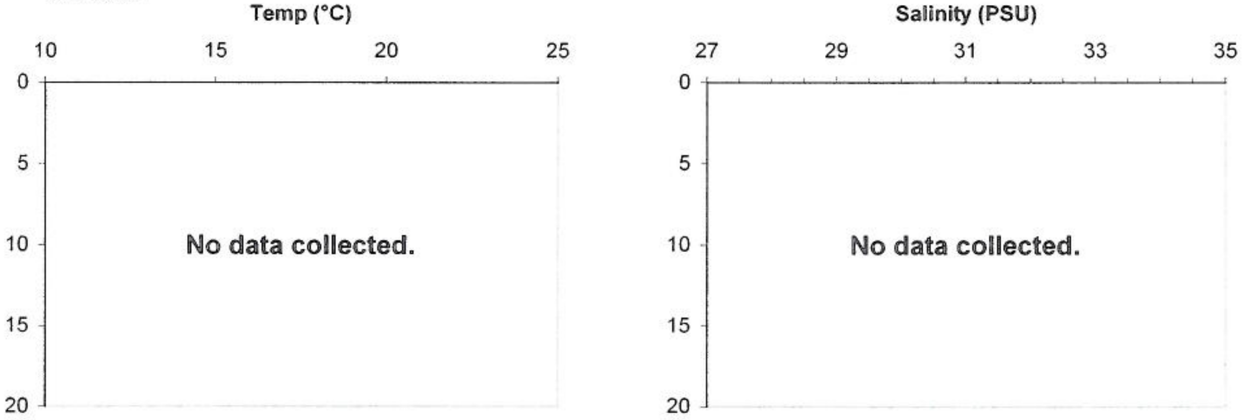
HBS023, 8-9 Mar. 04



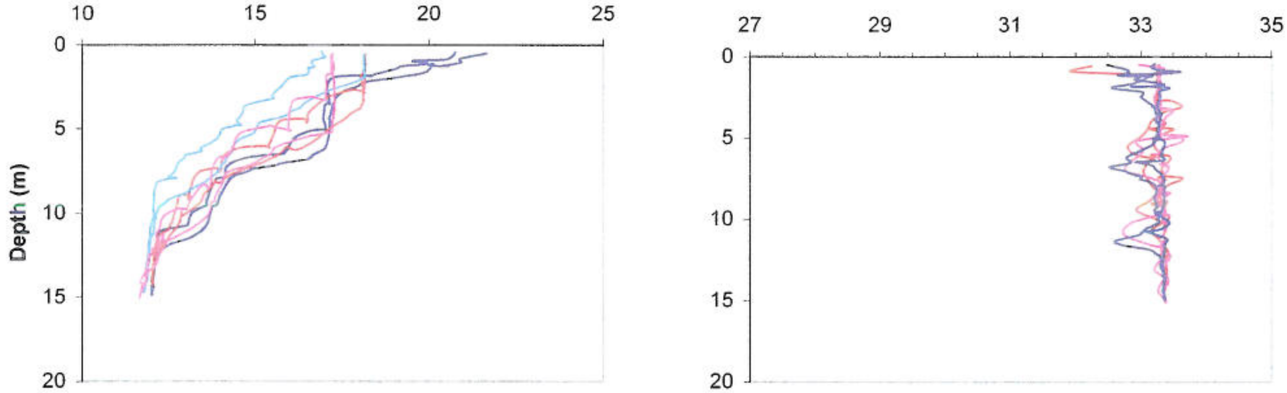
Appendix A-6. (Cont.)

Cycle 1 Cycle 2 Cycle 3 Cycle 4

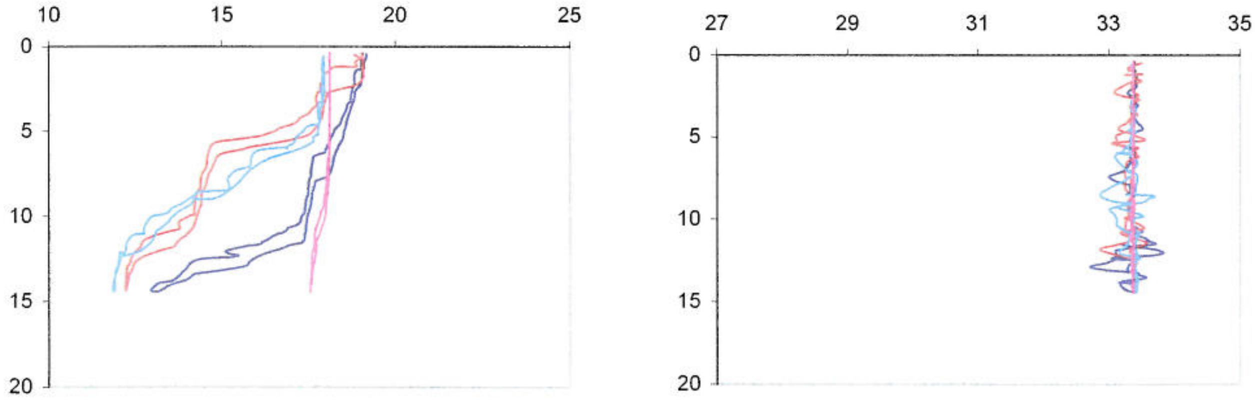
HBS027



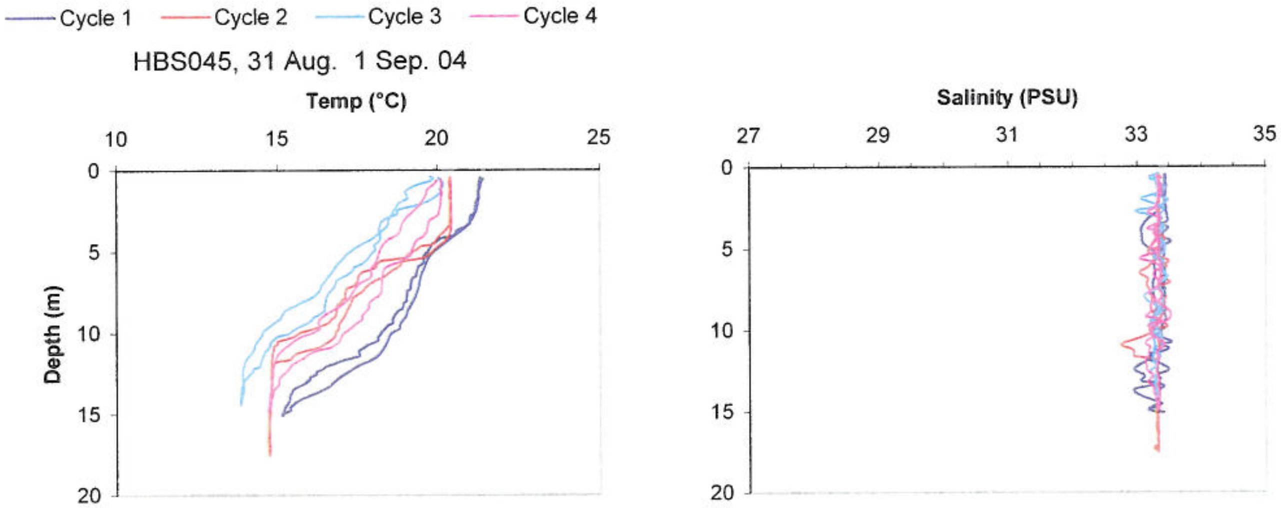
HBS031, 3-4 May 04



HBS035, 1-2 June 04

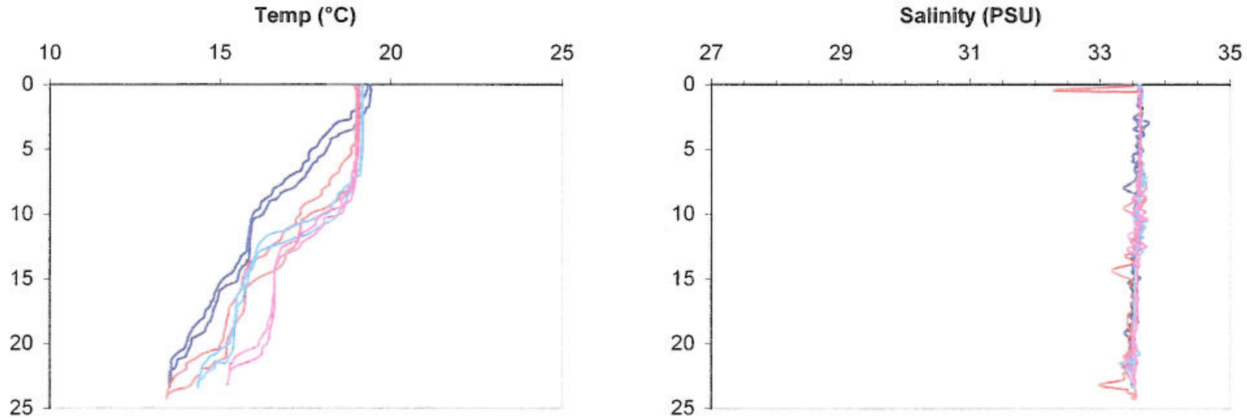


Appendix A-6. (Cont.)

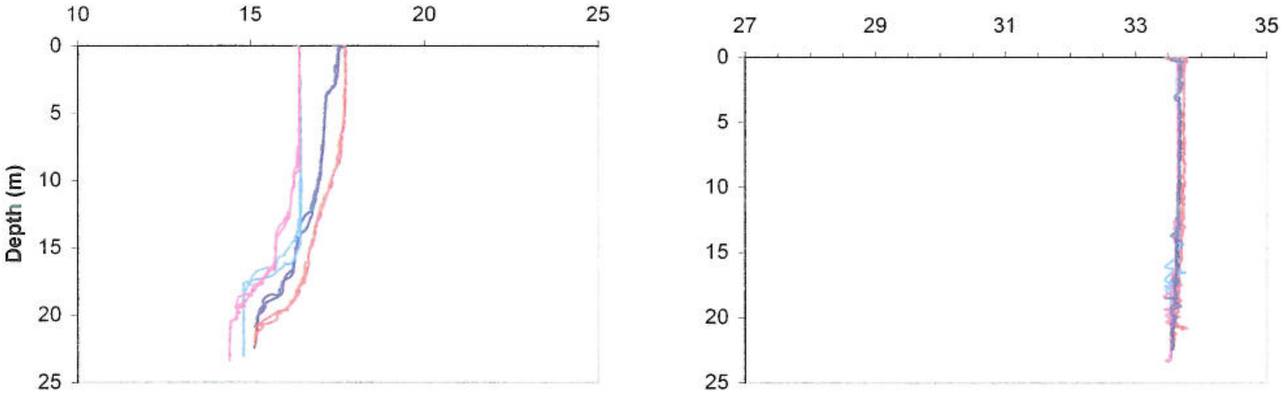


Appendix A-7. Temperature and salinity profiles at Station O4, Sept. 2003 to Sept. 2004.

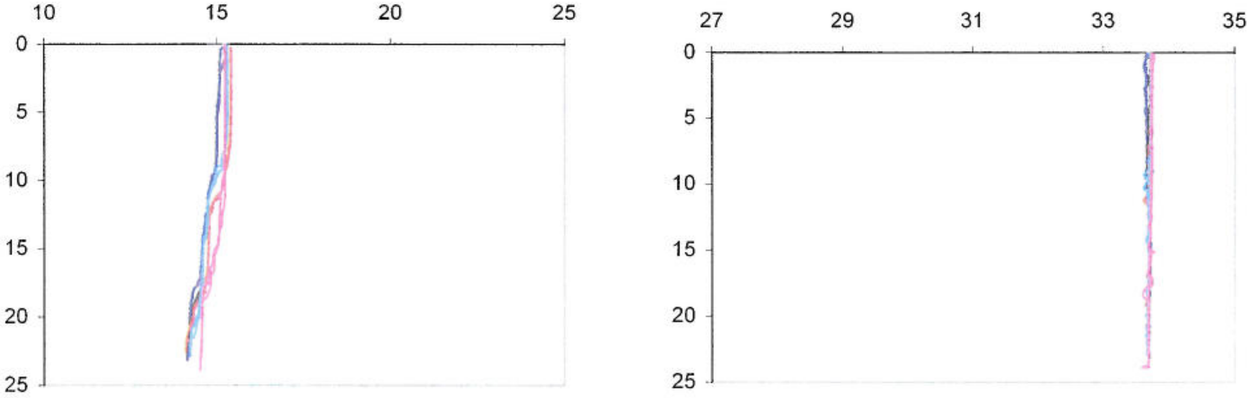
HBS003, 13-14 Oct. 03



HBS006, 10-11 Nov. 03



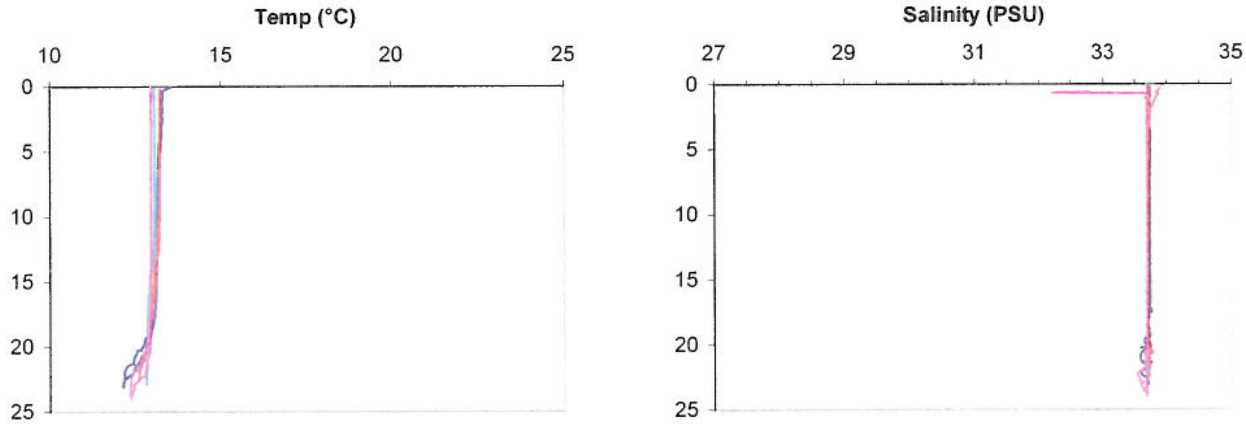
HBS010, 8-9 Dec. 03



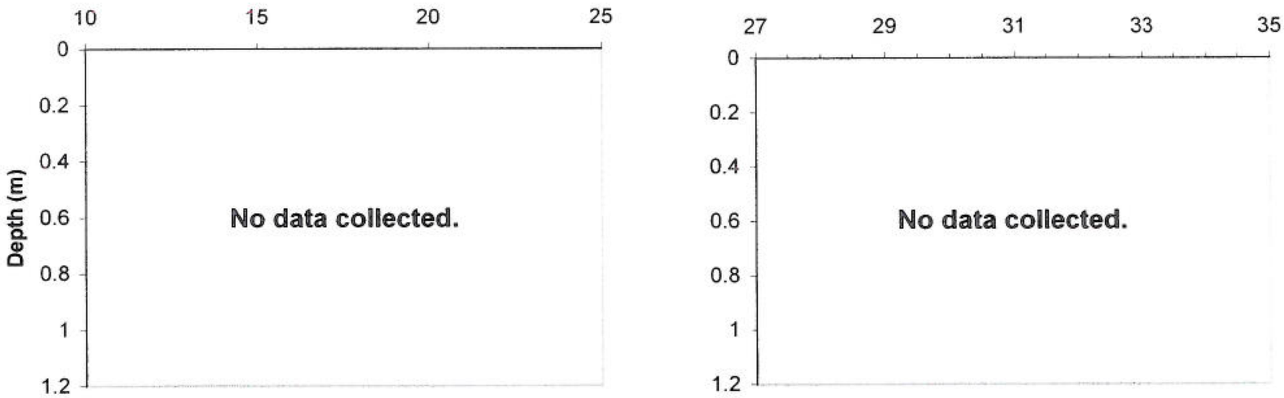
Appendix A-7. (Cont.)

— Cycle 1 — Cycle 2 — Cycle 3 — Cycle 4

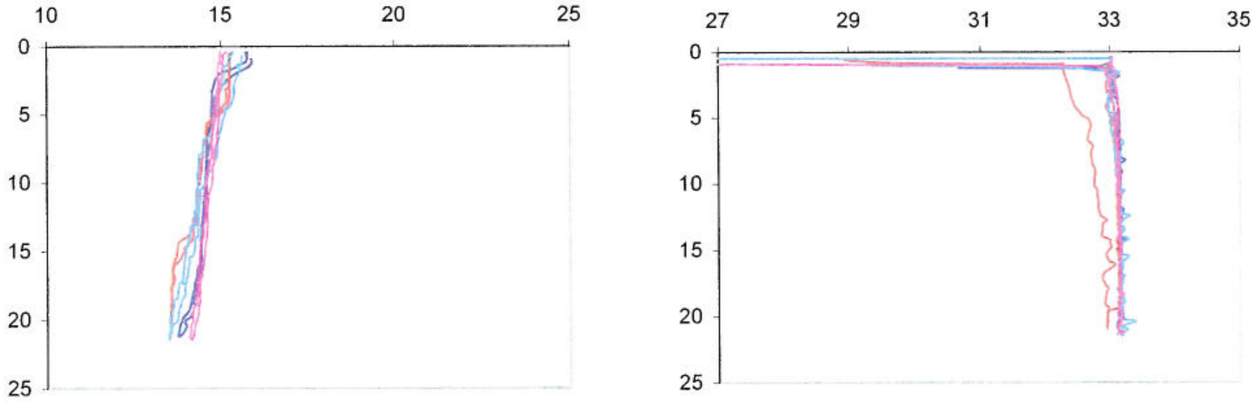
HBS014, 5-6 Jan. 04



HBS019



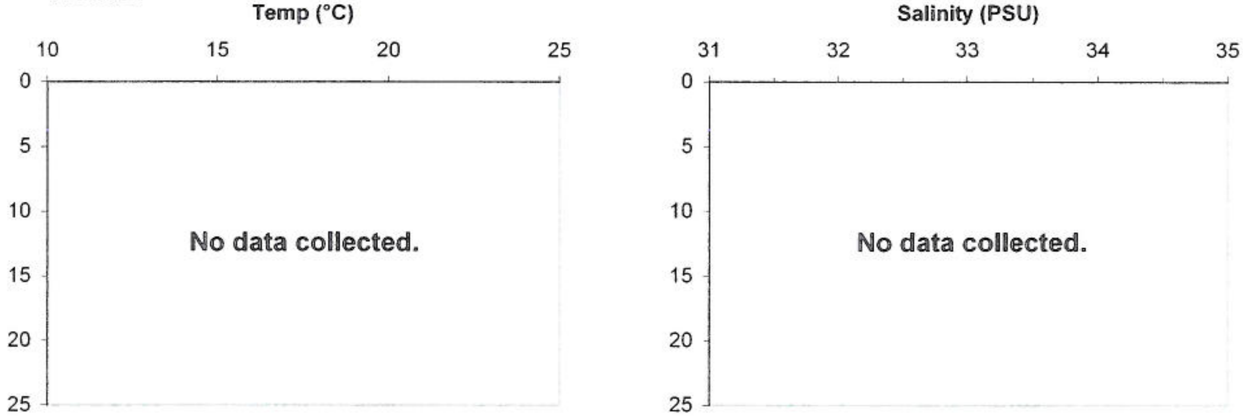
HBS023, 8-9 Mar. 04



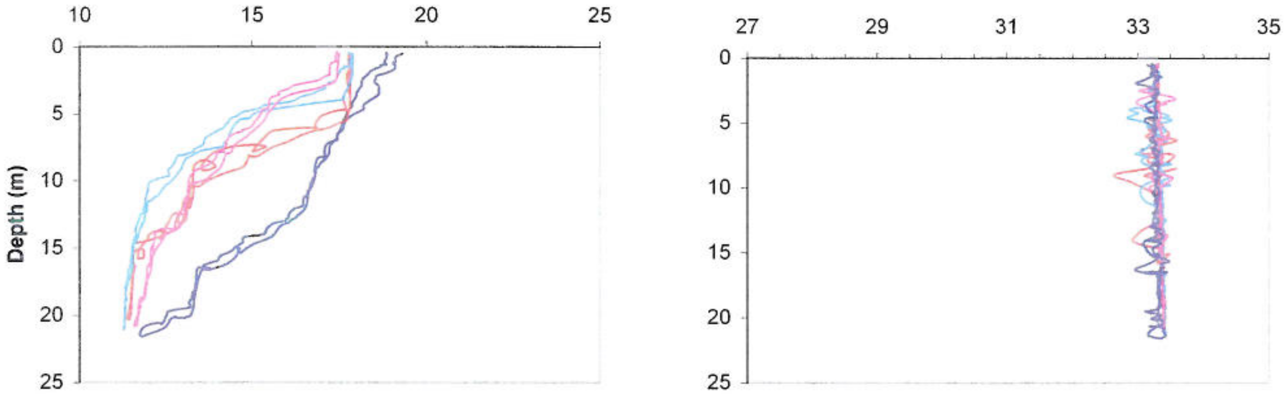
Appendix A-7. (Cont.)

Cycle 1 Cycle 2 Cycle 3 Cycle 4

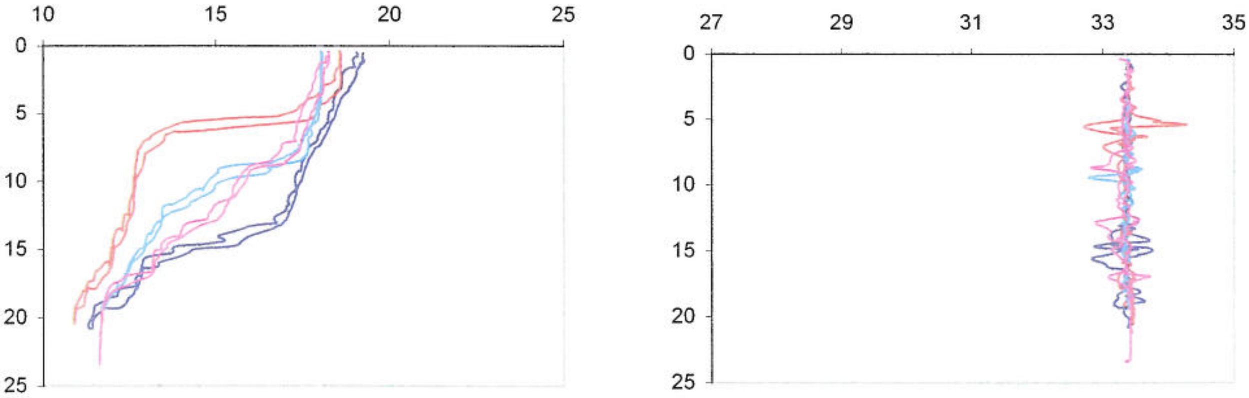
HBS027



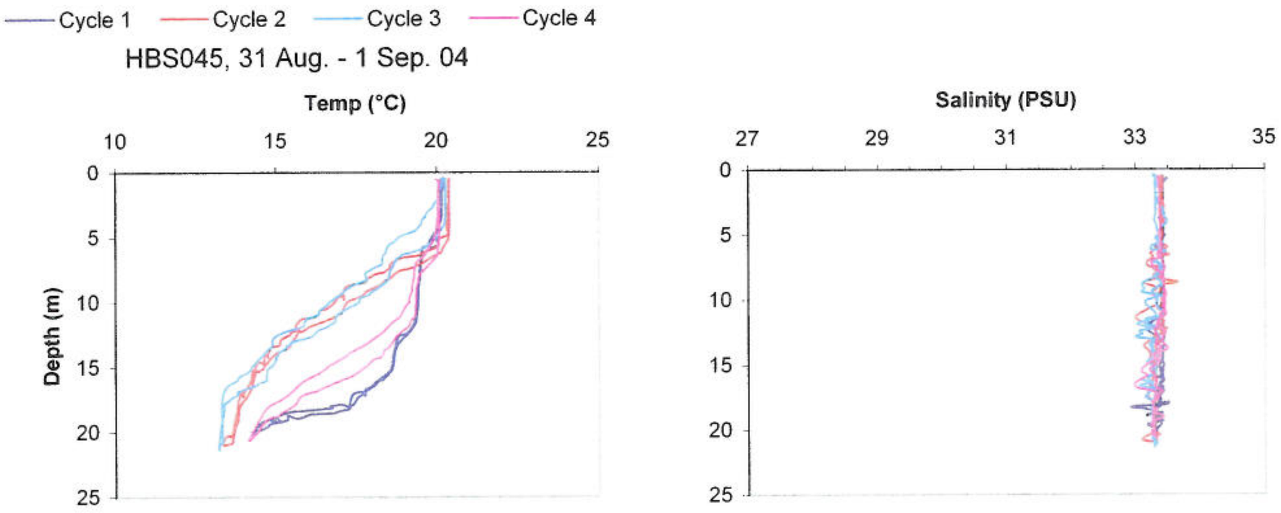
HBS031, 3-4 May 04



HBS035, 1-2 June 04



Appendix A-7. (Cont.)



Appendix B

Entrainment and Source Water Data

Appendix B-1. Larval fish and target invertebrate counts and mean concentrations (#/1000m^3) for entrainment surveys.

		Survey	1		2		3		4		5	
		Date	09/17/03		09/29/03		10/13/03		10/20/03		11/03/03	
		Sample Count	8		8		8		8		8	
Taxon	Common Name	Total	Count	Mean Conc.	Count	Mean Conc.	Count	Mean Conc.	Count	Mean Conc.	Count	Mean Conc.
Gobiidae unid.	gobies	2,458	96	265.4	84	214.6	81	229.0	40	106.4	30	88.0
Engraulis mordax	northern anchovy	1,152	20	53.6	30	82.6	32	77.6	30	76.1	4	10.4
Roncador stearnsi	spotfin croaker	912	-	-	-	-	-	-	-	-	-	-
Genyonemus lineatus	white croaker	446	7	17.0	7	19.4	4	11.2	6	16.0	1	3.0
Seriphus politus	queenfish	306	-	-	-	-	-	-	-	-	-	-
Sciaenidae unid.	croakers	244	1	3.2	-	-	-	-	-	-	-	-
Hypsoblennius spp.	blennies	161	-	-	1	2.2	-	-	-	-	9	27.6
Xenistius califoriensis	salema	153	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	unidentified yolksac larvae	136	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	98	-	-	1	2.0	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	96	1	2.4	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	87	-	-	-	-	2	5.4	2	5.0	3	11.0
Atherinopsis californiensis	jacksmelt	59	-	-	-	-	-	-	-	-	-	-
Engraulidae	anchovies	57	6	18.8	-	-	-	-	-	-	1	2.8
larval fish fragment	unidentified larval fishes	51	-	-	-	-	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	43	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	43	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	39	-	-	-	-	-	-	-	-	-	-
Paralabrax spp.	sand bass	36	-	-	-	-	-	-	-	-	-	-
Citharichthys stigmaeus	speckled sanddab	30	1	3.2	-	-	-	-	-	-	-	-
Oxyjulis californica	senorita	27	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silversides	25	-	-	-	-	-	-	-	-	-	-
Ilypnus gilberti	cheekspot goby	24	1	2.4	-	-	2	5.9	-	-	-	-
Umbrina roncador	yellowfin croaker	24	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	20	-	-	-	-	2	5.1	-	-	-	-
Lepidogobius lepidus	bay goby	18	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	16	-	-	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	15	-	-	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	15	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	14	-	-	-	-	-	-	-	-	-	-
Leuresthes tenuis	California grunion	13	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	12	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	12	-	-	-	-	-	-	-	-	-	-
Pleuronichthys spp.	turbots	12	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	11	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	10	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	8	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	6	1	3.2	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	5	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	5	-	-	-	-	-	-	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	5	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	5	-	-	-	-	-	-	-	-	1	3.0
Sardinops sagax	Pacific sardine	4	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	3	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	3	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	3	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	2	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	2	-	-	-	-	-	-	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	2	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders &	2	-	-	-	-	1	2.9	-	-	-	-
Peprilus simillimus	Pacific butterfish	2	-	-	-	-	-	-	-	-	-	-
Scomber japonicus	Pacific mackerel	2	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	2	-	-	-	-	-	-	-	-	-	-
Agonidae unid.	poachers	1	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	1	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	1	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	1	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	1	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	1	-	-	-	-	-	-	-	-	-	-
larval fish - damaged	unidentified larval fishes	1	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	1	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	1	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	1	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	1	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_De	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V̅D	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Strongylura exilis	California needlefish	1	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	1	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	1	-	-	-	-	-	-	-	-	-	-
Invertebrates												
Emerita analoga (zoea)	mole crab	10,399	9	30.0	3	7.9	10	29.0	3	7.7	-	-
Cancer anthonyi (meg.)	yellow crab	77	-	-	-	-	-	-	-	-	-	-
Cancer gracilis (meg.)	slender crab	31	-	-	-	-	-	-	-	-	1	2.8
Cancer antennarius (meg.)	brown rock crab	18	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	3	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	3	-	-	-	-	-	-	-	-	-	-
Emerita analoga (meg.)	mole crab	2	-	-	-	-	-	-	-	-	-	-
	Total:	17,489	143		126		134		81		50	

(continued)

Appendix B-1. (Continued).

		Survey	6		7		8		9		10	
		Date	11/10/03		11/17/03		11/24/03		12/01/03		12/08/03	
		Station Count	8		8		8		8		8	
Taxon	Common Name	Total	Count	Mean Conc.	Count	Mean Conc.	Count	Mean Conc.	Count	Mean Conc.	Count	Mean Conc.
Gobiidae unid.	gobies	2,458	1	2.6	81	186.6	28	66.8	41	121.0	10	26.8
Engraulis mordax	northern anchovy	1,152	11	31.1	11	25.7	2	5.1	3	7.8	9	24.0
Roncador stearnsi	spotfin croaker	912	-	-	-	-	-	-	-	-	-	-
Genyonemus lineatus	white croaker	446	2	5.2	16	37.7	17	43.4	4	12.9	10	26.8
Seriphus politus	queenfish	306	-	-	-	-	-	-	-	-	-	-
Sciaenidae unid.	croakers	244	-	-	-	-	-	-	-	-	-	-
Hypsoblennius spp.	blennies	161	10	28.1	-	-	2	5.0	2	5.3	2	5.1
Xenistius califoriensis	salema	153	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	unidentified yolksac larvae	136	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	98	2	5.5	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	96	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	87	1	3.1	1	2.3	3	8.5	2	5.7	-	-
Atherinopsis californiensis	jacksmelt	59	-	-	-	-	-	-	1	3.2	-	-
Engraulidae	anchovies	57	-	-	-	-	-	-	-	-	-	-
larval fish fragment	unidentified larval fishes	51	1	2.6	1	2.2	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	43	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	43	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	39	-	-	-	-	-	-	1	2.6	-	-
Paralabrax spp.	sand bass	36	-	-	-	-	-	-	-	-	-	-
Citharichthys stigmaeus	speckled sanddab	30	-	-	-	-	-	-	-	-	-	-
Oxyjulis californica	senorita	27	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silversides	25	-	-	-	-	-	-	-	-	1	2.9
Ilypnus gilberti	cheekspot goby	24	-	-	-	-	1	2.9	4	11.5	-	-
Umbrina roncador	yellowfin croaker	24	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	20	-	-	1	2.3	-	-	1	3.2	1	2.7
Lepidogobius lepidus	bay goby	18	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	16	-	-	-	-	1	2.4	-	-	2	5.1
Acanthogobius flavimanus	yellowfin goby	15	-	-	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	15	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	14	-	-	-	-	-	-	-	-	-	-
Leuresthes tenuis	California grunion	13	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	12	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	12	-	-	-	-	-	-	-	-	-	-
Pleuronichthys spp.	turbots	12	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	11	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	10	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	8	1	2.9	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	6	-	-	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	5	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	5	-	-	-	-	-	-	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	5	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	5	1	2.9	1	2.3	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	4	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	3	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	3	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	3	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	2	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	2	-	-	-	-	-	-	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	2	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders &	2	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	2	-	-	-	-	-	-	-	-	-	-
Scomber japonicus	Pacific mackerel	2	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	2	-	-	-	-	-	-	-	-	-	-
Agonidae unid.	poachers	1	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	1	1	2.6	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	1	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	1	-	-	1	2.2	-	-	-	-	-	-
Gobiesox spp.	clingfishes	1	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	1	-	-	-	-	-	-	-	-	-	-
larval fish - damaged	unidentified larval fishes	1	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	1	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	1	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	1	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	1	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	1	1	2.6	-	-	-	-	-	-	-	-
Sebastes spp. V_De	rockfishes	1	1	2.9	-	-	-	-	-	-	-	-
Sebastes spp. V̄D	rockfishes	1	1	2.9	-	-	-	-	-	-	-	-
Strongylura exilis	California needlefish	1	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	1	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	1	-	-	-	-	-	-	-	-	-	-
Invertebrates												
Emerita analoga (zoea)	mole crab	10,399	6	15.8	1	2.4	6	18.5	2	6.2	5	13.0
Cancer anthonyi (meg.)	yellow crab	77	-	-	-	-	-	-	-	-	-	-
Cancer gracilis (meg.)	slender crab	31	-	-	-	-	1	2.9	-	-	-	-
Cancer antennarius (meg.)	brown rock crab	18	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	3	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	3	-	-	-	-	-	-	-	-	-	-
Emerita analoga (meg.)	mole crab	2	-	-	-	-	-	-	-	-	-	-
	Total:	17,489	40		114		61		61		40	

(continued)

Appendix B-1. (Continued).

		Survey	11		12		13		14		15	
		Date	12/15/03		12/22/03		12/29/03		01/05/04		01/12/04	
		Station Count	8		16		16		16		16	
Taxon	Common Name	Total	Count	Mean Conc.	Count	Mean Conc.	Count	Mean Conc.	Count	Mean Conc.	Count	Mean Conc.
Gobiidae unid.	gobies	2,458	89	243.2	48	65.3	46	58.2	29	41.9	37	53.6
Engraulis mordax	northern anchovy	1,152	63	180.0	4	5.7	11	14.2	4	5.6	2	2.8
Roncador stearnsi	spotfin croaker	912	-	-	-	-	-	-	-	-	-	-
Genyonemus lineatus	white croaker	446	30	83.6	3	4.3	1	1.2	8	10.5	22	30.9
Seriphus politus	queenfish	306	-	-	-	-	-	-	-	-	-	-
Sciaenidae unid.	croakers	244	-	-	-	-	1	1.2	1	1.5	4	5.6
Hypsoblennius spp.	blennies	161	1	2.7	1	1.5	-	-	1	1.4	-	-
Xenistius californiensis	salema	153	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	unidentified yolksac larvae	136	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	98	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	96	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	87	-	-	2	2.8	4	4.9	1	1.4	-	-
Atherinopsis californiensis	jacksmelt	59	-	-	-	-	-	-	1	1.5	1	1.4
Engraulidae	anchovies	57	-	-	-	-	-	-	-	-	-	-
larval fish fragment	unidentified larval fishes	51	2	6.4	2	2.8	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	43	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	43	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	39	-	-	-	-	-	-	-	-	-	-
Paralabrax spp.	sand bass	36	-	-	-	-	-	-	-	-	-	-
Citharichthys stigmaeus	speckled sanddab	30	-	-	-	-	-	-	-	-	-	-
Oxyjulis californica	senorita	27	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silversides	25	1	2.7	1	1.4	1	1.3	-	-	-	-
Ilypnus gilberti	cheekspot goby	24	1	2.7	1	1.4	1	1.1	3	4.2	-	-
Umbrina roncador	yellowfin croaker	24	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	20	3	8.9	1	1.4	-	-	-	-	-	-
Lepidogobius lepidus	bay goby	18	7	19.9	-	-	-	-	1	1.5	2	2.8
Leptocottus armatus	Pacific staghorn sculpin	16	2	5.7	-	-	1	1.2	-	-	4	5.7
Acanthogobius flavimanus	yellowfin goby	15	8	22.0	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	15	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	14	-	-	-	-	-	-	-	-	-	-
Leuresthes tenuis	California grunion	13	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	12	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	12	-	-	-	-	-	-	-	-	-	-
Pleuronichthys spp.	turbots	12	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	11	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	10	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	8	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	6	-	-	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	5	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	5	-	-	-	-	-	-	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	5	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	5	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	4	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	3	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	3	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	3	-	-	-	-	1	1.2	-	-	-	-
Clevelandia ios	arrow goby	2	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	2	-	-	-	-	-	-	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	2	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders &	2	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	2	-	-	-	-	-	-	-	-	-	-
Scomber japonicus	Pacific mackerel	2	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	2	-	-	-	-	-	-	-	-	-	-
Agonidae unid.	poachers	1	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	1	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	1	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	1	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	1	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	1	-	-	-	-	-	-	-	-	-	-
larval fish - damaged	unidentified larval fishes	1	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	1	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	1	-	-	-	-	-	-	-	-	1	1.5
Pleuronectiformes unid.	flatfishes	1	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	1	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_De	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V$\overline{D}$	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Strongylura exilis	California needlefish	1	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	1	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	1	-	-	-	-	-	-	-	-	-	-
Invertebrates												
Emerita analoga (zoea)	mole crab	10,399	2	5.1	14	19.7	5	6.5	14	20.1	9	12.8
Cancer anthonyi (meg.)	yellow crab	77	-	-	-	-	-	-	-	-	2	2.8
Cancer gracilis (meg.)	slender crab	31	-	-	-	-	-	-	-	-	-	-
Cancer antennarius (meg.)	brown rock crab	18	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	3	-	-	-	-	-	-	2	2.7	-	-
Cancer spp. (meg.)	cancer crabs	3	-	-	-	-	1	1.2	-	-	-	-
Emerita analoga (meg.)	mole crab	2	-	-	-	-	-	-	-	-	-	-
		Total: 17,489	209		77		73		65		84	

(continued)

Appendix B-1. (Continued).

		Survey	16		17		18		19		20	
		Date	01/19/04		01/26/04		02/02/04		02/09/04		02/17/04	
		Station Count	8		8		8		8		8	
Taxon	Common Name	Total	Count	Mean Conc.	Count	Mean Conc.	Count	Mean Conc.	Count	Mean Conc.	Count	Mean Conc.
Gobiidae unid.	gobies	2,458	29	78.5	80	215.1	5	13.6	16	41.9	7	18.6
Engraulis mordax	northern anchovy	1,152	5	13.9	1	2.5	-	-	1	2.6	2	5.4
Roncador stearnsi	spotfin croaker	912	-	-	-	-	-	-	-	-	-	-
Genyonemus lineatus	white croaker	446	34	94.4	11	28.3	-	-	6	15.6	3	7.2
Seriphus politus	queenfish	306	-	-	-	-	-	-	-	-	-	-
Sciaenidae unid.	croakers	244	-	-	-	-	-	-	-	-	-	-
Hypsoblennius spp.	blennies	161	-	-	-	-	-	-	1	2.6	1	2.4
Xenistius califoriensis	salema	153	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	unidentified yolksac larvae	136	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	98	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	96	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	87	1	2.8	3	8.1	1	2.6	-	-	2	5.1
Atherinopsis californiensis	jacksmelt	59	8	22.7	1	2.2	5	13.6	1	2.5	3	8.4
Engraulidae	anchovies	57	-	-	-	-	-	-	-	-	-	-
larval fish fragment	unidentified larval fishes	51	3	8.8	-	-	-	-	1	2.5	-	-
Hypsypops rubicundus	garibaldi	43	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	43	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	39	1	2.8	-	-	-	-	-	-	-	-
Paralabrax spp.	sand bass	36	-	-	-	-	-	-	-	-	-	-
Citharichthys stigmaeus	speckled sanddab	30	4	11.6	-	-	-	-	-	-	-	-
Oxyjulis californica	senorita	27	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silversides	25	1	2.7	-	-	-	-	-	-	-	-
Ilypnus gilberti	cheekspot goby	24	-	-	-	-	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	24	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	20	1	2.8	-	-	-	-	1	2.6	1	2.7
Lepidogobius lepidus	bay goby	18	2	5.9	-	-	-	-	1	2.9	2	5.3
Leptocottus armatus	Pacific staghorn sculpin	16	2	6.1	-	-	-	-	1	2.6	1	2.4
Acanthogobius flavimanus	yellowfin goby	15	-	-	5	12.4	-	-	-	-	1	2.3
Syngnathidae unid.	pipefishes	15	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	14	-	-	-	-	-	-	-	-	-	-
Leuresthes tenuis	California grunion	13	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	12	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	12	1	3.1	-	-	-	-	-	-	-	-
Pleuronichthys spp.	turbots	12	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	11	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	10	1	2.8	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	8	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	6	-	-	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	5	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	5	-	-	-	-	-	-	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	5	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	5	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	4	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	3	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	3	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	3	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	2	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	2	-	-	-	-	-	-	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	2	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders &	2	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	2	-	-	-	-	-	-	-	-	-	-
Scomber japonicus	Pacific mackerel	2	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	2	-	-	-	-	-	-	-	-	-	-
Agonidae unid.	poachers	1	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	1	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	1	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	1	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	1	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	1	-	-	-	-	-	-	-	-	-	-
larval fish - damaged	unidentified larval fishes	1	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	1	-	-	-	-	-	-	1	2.5	-	-
Oxylebius pictus	painted greenling	1	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	1	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	1	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_De	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V̄D	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Strongylura exilis	California needlefish	1	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	1	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	1	-	-	-	-	-	-	-	-	-	-
Invertebrates												
Emerita analoga (zoea)	mole crab	10,399	3	8.5	5	13.7	6	17.2	1	2.4	2	5.0
Cancer anthonyi (meg.)	yellow crab	77	-	-	-	-	-	-	-	-	-	-
Cancer gracilis (meg.)	slender crab	31	1	2.9	-	-	-	-	-	-	-	-
Cancer antennarius (meg.)	brown rock crab	18	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	3	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	3	-	-	-	-	-	-	-	-	-	-
Emerita analoga (meg.)	mole crab	2	-	-	-	-	-	-	-	-	-	-
	Total:	17,489	97		106		17		31		25	

(continued)

Appendix B-1. (Continued).

		Survey	21		22		23		24		25	
		Date	02/23/04		03/03/04		03/08/04		03/15/04		03/22/04	
		Station Count	8		2		8		8		8	
Taxon	**Common Name**	**Total**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**
Gobiidae unid.	gobies	2,458	122	282.2	1	12.0	46	134.1	89	242.6	48	131.0
Engraulis mordax	northern anchovy	1,152	-	-	-	-	12	33.6	13	35.0	24	68.9
Roncador stearnsi	spotfin croaker	912	-	-	-	-	-	-	-	-	-	-
Genyonemus lineatus	white croaker	446	-	-	1	12.0	5	14.0	2	5.3	20	54.0
Seriphus politus	queenfish	306	-	-	-	-	-	-	-	-	-	-
Sciaenidae unid.	croakers	244	-	-	-	-	-	-	-	-	-	-
Hypsoblennius spp.	blennies	161	-	-	-	-	-	-	-	-	-	-
Xenistius califoriensis	salema	153	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	unidentified yolksac larvae	136	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	98	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	96	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	87	-	-	-	-	1	3.2	-	-	1	2.7
Atherinopsis californiensis	jacksmelt	59	4	9.6	-	-	-	-	-	-	7	19.8
Engraulidae	anchovies	57	-	-	-	-	-	-	-	-	-	-
larval fish fragment	unidentified larval fishes	51	-	-	-	-	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	43	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	43	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	39	1	2.5	-	-	-	-	-	-	-	-
Paralabrax spp.	sand bass	36	-	-	-	-	-	-	-	-	-	-
Citharichthys stigmaeus	speckled sanddab	30	-	-	1	12.0	-	-	-	-	-	-
Oxyjulis californica	senorita	27	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silversides	25	-	-	-	-	1	3.0	3	9.1	-	-
Ilypnus gilberti	cheekspot goby	24	-	-	-	-	1	3.0	2	4.8	1	3.3
Umbrina roncador	yellowfin croaker	24	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	20	1	2.8	-	-	1	3.0	-	-	1	3.3
Lepidogobius lepidus	bay goby	18	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	16	2	4.5	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	15	1	2.0	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	15	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	14	-	-	-	-	-	-	-	-	-	-
Leuresthes tenuis	California grunion	13	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	12	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	12	-	-	-	-	-	-	-	-	-	-
Pleuronichthys spp.	turbots	12	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	11	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	10	4	8.7	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	8	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	6	-	-	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	5	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	5	-	-	-	-	-	-	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	5	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	5	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	4	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	3	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	3	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	3	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	2	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	2	-	-	-	-	-	-	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	2	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders &	2	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	2	-	-	-	-	-	-	-	-	-	-
Scomber japonicus	Pacific mackerel	2	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	2	-	-	-	-	-	-	-	-	-	-
Agonidae unid.	poachers	1	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	1	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	1	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	1	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	1	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	1	-	-	-	-	-	-	-	-	-	-
larval fish - damaged	unidentified larval fishes	1	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	1	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	1	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	1	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	1	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_De	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Strongylura exilis	California needlefish	1	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	1	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	1	-	-	-	-	-	-	-	-	-	-
Invertebrates												
Emerita analoga (zoea)	mole crab	10,399	3	7.0	-	-	-	-	9	24.7	33	92.5
Cancer anthonyi (meg.)	yellow crab	77	-	-	-	-	-	-	-	-	-	-
Cancer gracilis (meg.)	slender crab	31	-	-	-	-	-	-	-	-	-	-
Cancer antennarius (meg.)	brown rock crab	18	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	3	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	3	-	-	-	-	-	-	-	-	-	-
Emerita analoga (meg.)	mole crab	2	-	-	-	-	-	-	-	-	-	-
	Total:	17,489	138		3		67		118		135	

(continued)

Appendix B-1. (Continued).

		Survey	26		27		28		29		30	
		Date	03/26/04		04/05/04		04/12/04		04/19/04		04/23/04	
		Station Count	0		8		8		6		6	
Taxon	**Common Name**	**Total**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**
Gobiidae unid.	gobies	2,458			32	75.1	13	31.7	48	158.3	1	3.0
Engraulis mordax	northern anchovy	1,152			13	31.6	18	44.4	26	87.8	15	51.7
Roncador stearnsi	spotfin croaker	912			-	-	-	-	-	-	-	-
Genyonemus lineatus	white croaker	446			1	2.6	35	83.1	29	97.6	17	56.0
Seriphus politus	queenfish	306			-	-	-	-	-	-	-	-
Sciaenidae unid.	croakers	244			-	-	2	4.5	1	3.2	2	8.1
Hypsoblennius spp.	blennies	161			-	-	1	2.2	3	10.4	2	7.5
Xenistius califoriensis	salema	153			-	-	-	-	-	-	-	-
larvae, unidentified yolksac	unidentified yolksac larvae	136			2	4.5	-	-	-	-	2	7.0
Paralichthys californicus	California halibut	98			-	-	1	2.3	1	3.7	9	33.1
Cheilotrema saturnum	black croaker	96			-	-	-	-	-	-	2	7.1
Hypsopsetta guttulata	diamond turbot	87			1	2.5	5	11.8	2	6.5	1	3.5
Atherinopsis californiensis	jacksmelt	59			1	2.5	1	2.4	-	-	-	-
Engraulidae	anchovies	57			2	4.5	-	-	-	-	-	-
larval fish fragment	unidentified larval fishes	51			-	-	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	43			-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	43			-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	39			1	2.7	-	-	1	3.2	-	-
Paralabrax spp.	sand bass	36			-	-	-	-	-	-	-	-
Citharichthys stigmaeus	speckled sanddab	30			2	4.2	-	-	-	-	2	7.0
Oxyjulis californica	senorita	27			1	2.4	-	-	-	-	-	-
Atherinopsidae	silversides	25			-	-	-	-	3	10.5	-	-
Ilypnus gilberti	cheekspot goby	24			1	2.7	1	2.6	1	3.6	-	-
Umbrina roncador	yellowfin croaker	24			-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	20			1	2.5	-	-	1	3.1	-	-
Lepidogobius lepidus	bay goby	18			-	-	1	2.3	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	16			-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	15			-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	15			-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	14			-	-	-	-	-	-	-	-
Leuresthes tenuis	California grunion	13			-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	12			-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	12			-	-	-	-	-	-	-	-
Pleuronichthys spp.	turbots	12			-	-	1	2.3	-	-	-	-
Diaphus theta	California headlight fish	11			-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	10			-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	8			-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	6			-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	5			-	-	-	-	-	-	-	-
Haemulidae	grunts	5			-	-	-	-	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	5			-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	5			-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	4			-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	3			-	-	-	-	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	3			-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	3			-	-	-	-	1	3.1	-	-
Clevelandia ios	arrow goby	2			-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	2			-	-	-	-	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	2			-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders &	2			-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	2			-	-	-	-	-	-	-	-
Scomber japonicus	Pacific mackerel	2			-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	2			-	-	-	-	-	-	-	-
Agonidae unid.	poachers	1			-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	1			-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	1			-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	1			-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	1			-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	1			-	-	-	-	-	-	-	-
larval fish - damaged	unidentified larval fishes	1			-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	1			-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	1			-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	1			-	-	1	2.2	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	1			-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	1			-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	1			-	-	-	-	-	-	-	-
Sebastes spp. V_De	rockfishes	1			-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	1			-	-	-	-	-	-	-	-
Strongylura exilis	California needlefish	1			-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	1			-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	1			-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	1			-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	1			-	-	-	-	-	-	-	-
Invertebrates												
Emerita analoga (zoea)	mole crab	10,399			114	295.0	416	1,053.7	54	187.0	77	275.6
Cancer anthonyi (meg.)	yellow crab	77			-	-	-	-	1	3.2	1	3.5
Cancer gracilis (meg.)	slender crab	31			-	-	-	-	1	3.6	-	-
Cancer antennarius (meg.)	brown rock crab	18			-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	3			-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	3			-	-	-	-	-	-	-	-
Emerita analoga (meg.)	mole crab	2			-	-	-	-	2	7.3	-	-
	Total:	17,489			172		496		175		131	

(continued)

Appendix B-1. (Continued).

		Survey	31		32		33		34		35	
		Date	05/03/04		05/07/04		05/17/04		05/24/04		06/01/04	
		Station Count	8		6		8		8		8	
Taxon	**Common Name**	**Total**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**
Gobiidae unid.	gobies	2,458	145	356.0	58	191.6	32	93.5	20	50.6	29	74.1
Engraulis mordax	northern anchovy	1,152	75	186.6	17	55.2	23	66.3	68	160.5	128	365.8
Roncador stearnsi	spotfin croaker	912	2	4.8	-	-	7	18.3	11	26.7	-	-
Genyonemus lineatus	white croaker	446	56	137.9	35	117.6	25	71.7	16	39.2	6	17.5
Seriphus politus	queenfish	306	-	-	-	-	11	31.1	2	4.5	-	-
Sciaenidae unid.	croakers	244	4	10.0	-	-	17	46.7	26	64.1	1	2.0
Hypsoblennius spp.	blennies	161	-	-	4	15.2	9	25.5	7	17.9	3	6.8
Xenistius califoriensis	salema	153	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	unidentified yolksac larvae	136	3	8.6	-	-	2	6.1	3	9.2	-	-
Paralichthys californicus	California halibut	98	3	7.6	-	-	1	3.0	2	5.0	2	4.0
Cheilotrema saturnum	black croaker	96	-	-	-	-	7	20.2	1	2.3	-	-
Hypsopsetta guttulata	diamond turbot	87	-	-	2	7.1	3	8.4	-	-	-	-
Atherinopsis californiensis	jacksmelt	59	23	57.4	2	6.9	-	-	-	-	-	-
Engraulidae	anchovies	57	1	2.6	4	14.7	1	3.0	7	18.8	3	5.9
larval fish fragment	unidentified larval fishes	51	1	2.5	-	-	3	8.9	2	4.7	-	-
Hypsypops rubicundus	garibaldi	43	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	43	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	39	-	-	-	-	1	2.3	-	-	3	6.9
Paralabrax spp.	sand bass	36	-	-	-	-	2	5.6	-	-	-	-
Citharichthys stigmaeus	speckled sanddab	30	1	3.0	-	-	3	9.0	1	2.6	-	-
Oxyjulis californica	senorita	27	-	-	-	-	2	4.9	1	2.3	-	-
Atherinopsidae	silversides	25	7	17.5	-	-	-	-	1	2.3	5	12.8
Ilypnus gilberti	cheekspot goby	24	3	7.5	-	-	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	24	-	-	-	-	-	-	1	2.6	-	-
Gillichthys mirabilis	longjaw mudsucker	20	2	5.0	-	-	-	-	-	-	-	-
Lepidogobius lepidus	bay goby	18	1	2.6	1	3.5	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	16	-	-	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	15	-	-	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	15	-	-	-	-	-	-	-	-	15	34.4
Sphyraena argentea	California barracuda	14	-	-	-	-	-	-	-	-	-	-
Leuresthes tenuis	California grunion	13	-	-	-	-	-	-	1	2.8	2	6.0
Paralabrax clathratus	kelp bass	12	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	12	-	-	-	-	1	3.0	-	-	-	-
Pleuronichthys spp.	turbots	12	2	4.9	-	-	-	-	3	8.2	-	-
Diaphus theta	California headlight fish	11	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	10	4	10.4	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	8	-	-	-	-	1	3.0	-	-	-	-
Myctophidae unid.	lanternfishes	6	-	-	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	5	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	5	-	-	-	-	-	-	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	5	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	5	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	4	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	3	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	3	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	3	-	-	1	3.5	-	-	-	-	-	-
Clevelandia ios	arrow goby	2	2	4.5	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	2	-	-	-	-	-	-	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	2	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders &	2	1	2.5	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	2	-	-	-	-	-	-	-	-	-	-
Scomber japonicus	Pacific mackerel	2	-	-	-	-	-	-	1	2.3	-	-
Semicossyphus pulcher	California sheephead	2	-	-	-	-	-	-	-	-	-	-
Agonidae unid.	poachers	1	-	-	-	-	-	-	-	-	1	2.3
Citharichthys spp.	sanddabs	1	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	1	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	1	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	1	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	1	-	-	-	-	-	-	-	-	-	-
larval fish - damaged	unidentified larval fishes	1	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	1	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	1	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	1	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	1	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_De	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD̄	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Strongylura exilis	California needlefish	1	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	1	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	1	-	-	-	-	-	-	-	-	-	-
Invertebrates												
Emerita analoga (zoea)	mole crab	10,399	78	175.1	292	1,020.9	119	346.1	216	573.1	16	41.1
Cancer anthonyi (meg.)	yellow crab	77	-	-	-	-	1	3.0	-	-	2	4.6
Cancer gracilis (meg.)	slender crab	31	-	-	-	-	-	-	-	-	8	23.3
Cancer antennarius (meg.)	brown rock crab	18	-	-	-	-	-	-	-	-	3	8.6
Cancer productus (meg.)	red rock crab	3	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	3	1	2.5	-	-	-	-	-	-	-	-
Emerita analoga (meg.)	mole crab	2	-	-	-	-	-	-	-	-	-	-
	Total:	17,489	415		416		271		390		227	

(continued)

Appendix B-1. (Continued).

		Survey	36		37		38		39		40	
		Date	06/07/04		06/14/04		06/21/04		06/28/04		07/06/04	
		Station Count	8		8		8		8		8	
Taxon	**Common Name**	**Total**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**
Gobiidae unid.	gobies	2,458	9	23.7	28	92.1	54	139.9	43	120.9	185	490.1
Engraulis mordax	northern anchovy	1,152	4	10.7	45	134.4	91	226.3	82	217.3	16	42.4
Roncador stearnsi	spotfin croaker	912	-	-	18	59.1	-	-	2	4.5	152	406.7
Genyonemus lineatus	white croaker	446	1	2.3	1	2.5	2	4.6	-	-	1	2.9
Seriphus politus	queenfish	306	-	-	7	24.4	-	-	3	8.1	2	5.8
Sciaenidae unid.	croakers	244	-	-	69	205.0	3	7.4	27	67.7	30	74.9
Hypsoblennius spp.	blennies	161	6	15.8	8	25.2	3	7.7	41	104.7	8	22.3
Xenistius califoriensis	salema	153	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	unidentified yolksac larvae	136	2	5.1	68	224.3	-	-	38	102.2	-	-
Paralichthys californicus	California halibut	98	-	-	41	125.8	1	2.2	4	10.1	1	3.5
Cheilotrema saturnum	black croaker	96	-	-	3	8.1	-	-	3	7.2	3	9.0
Hypsopsetta guttulata	diamond turbot	87	-	-	-	-	-	-	-	-	2	5.1
Atherinopsis californiensis	jacksmelt	59	-	-	-	-	-	-	-	-	-	-
Engraulidae	anchovies	57	-	-	10	33.5	2	5.5	10	28.6	-	-
larval fish fragment	unidentified larval fishes	51	-	-	6	20.6	-	-	4	12.6	-	-
Hypsypops rubicundus	garibaldi	43	-	-	5	15.7	-	-	35	82.9	-	-
Menticirrhus undulatus	California corbina	43	-	-	2	5.0	-	-	10	27.4	1	2.2
larval/post-larval fish unid.	larval fishes	39	-	-	11	29.2	9	25.6	6	15.2	-	-
Paralabrax spp.	sand bass	36	-	-	9	31.2	-	-	10	24.2	1	2.1
Citharichthys stigmaeus	speckled sanddab	30	-	-	-	-	-	-	4	10.1	1	2.6
Oxyjulis californica	senorita	27	-	-	-	-	-	-	20	55.3	-	-
Atherinopsidae	silversides	25	-	-	-	-	-	-	-	-	-	-
Ilypnus gilberti	cheekspot goby	24	-	-	-	-	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	24	-	-	21	64.5	1	2.2	1	2.3	-	-
Gillichthys mirabilis	longjaw mudsucker	20	-	-	-	-	-	-	-	-	-	-
Lepidogobius lepidus	bay goby	18	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	16	-	-	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	15	-	-	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	15	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	14	-	-	-	-	-	-	1	3.2	-	-
Leuresthes tenuis	California grunion	13	-	-	-	-	1	2.2	3	9.0	3	8.5
Paralabrax clathratus	kelp bass	12	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	12	-	-	6	17.5	-	-	-	-	-	-
Pleuronichthys spp.	turbots	12	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	11	-	-	-	-	-	-	-	-	9	22.5
Gibbonsia spp.	clinid kelpfishes	10	-	-	-	-	-	-	1	2.3	-	-
Triphoturus mexicanus	Mexican lampfish	8	-	-	-	-	-	-	-	-	2	5.6
Myctophidae unid.	lanternfishes	6	-	-	-	-	-	-	-	-	2	5.8
Atractoscion nobilis	white seabass	5	-	-	2	4.8	-	-	-	-	-	-
Haemulidae	grunts	5	-	-	-	-	-	-	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	5	-	-	2	5.0	-	-	-	-	-	-
Pleuronectidae unid.	flounders	5	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	4	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	3	-	-	-	-	-	-	2	5.0	-	-
Pleuronichthys verticalis	hornyhead turbot	3	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	3	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	2	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	2	-	-	-	-	-	-	2	5.8	-	-
Ophidion scrippsae	basketweave cusk-eel	2	1	3.3	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders &	2	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	2	-	-	1	3.9	-	-	-	-	-	-
Scomber japonicus	Pacific mackerel	2	-	-	-	-	-	-	1	2.3	-	-
Semicossyphus pulcher	California sheephead	2	-	-	-	-	-	-	1	3.2	-	-
Agonidae unid.	poachers	1	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	1	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	1	1	2.5	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	1	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	1	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	1	-	-	-	-	-	-	-	-	-	-
larval fish - damaged	unidentified larval fishes	1	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	1	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	1	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	1	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	1	1	2.3	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	1	-	-	1	3.8	-	-	-	-	-	-
Sebastes spp. V	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_De	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD̄	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Strongylura exilis	California needlefish	1	1	3.0	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	1	-	-	1	3.2	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	1	1	2.8	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	1	-	-	1	2.8	-	-	-	-	-	-
Invertebrates												
Emerita analoga (zoea)	mole crab	10,399	515	1,357.4	1,142	3,633.1	773	2,004.8	1,674	4,775.0	2,349	6,305.5
Cancer anthonyi (meg.)	yellow crab	77	-	-	-	-	-	-	-	-	1	2.8
Cancer gracilis (meg.)	slender crab	31	4	11.2	1	3.8	1	2.4	1	3.0	-	-
Cancer antennarius (meg.)	brown rock crab	18	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	3	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	3	-	-	-	-	-	-	-	-	-	-
Emerita analoga (meg.)	mole crab	2	-	-	-	-	-	-	-	-	-	-
	Total:	17,489	546		1,509		941		2,029		2,769	

(continued)

Appendix B-1. (Continued).

		Survey	41		42		43		44		45	
		Date	07/12/04		07/19/04		07/26/04		08/24/04		08/31/04	
		Station Count	8		8		8		8		8	
Taxon	**Common Name**	**Total**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**
Gobiidae unid.	gobies	2,458	160	428.6	112	298.9	70	197.9	118	287.0	117	330.9
Engraulis mordax	northern anchovy	1,152	72	187.5	45	119.4	78	219.8	18	46.7	24	64.9
Roncador stearnsi	spotfin croaker	912	-	-	-	-	3	8.2	716	1,803.9	1	2.7
Genyonemus lineatus	white croaker	446	-	-	-	-	-	-	-	-	1	2.4
Seriphus politus	queenfish	306	28	74.1	10	28.9	7	18.7	111	281.3	125	322.4
Sciaenidae unid.	croakers	244	-	-	13	34.6	6	16.4	24	56.2	12	27.5
Hypsoblennius spp.	blennies	161	5	12.2	15	40.2	3	8.6	9	23.1	3	7.8
Xenistius californiensis	salema	153	-	-	-	-	1	2.5	152	336.1	-	-
larvae, unidentified yolksac	unidentified yolksac larvae	136	2	5.2	-	-	3	7.8	8	19.4	3	6.7
Paralichthys californicus	California halibut	98	3	8.0	1	2.5	8	21.4	14	35.9	3	6.0
Cheilotrema saturnum	black croaker	96	-	-	-	-	7	18.5	68	161.3	1	2.0
Hypsopsetta guttulata	diamond turbot	87	-	-	1	2.5	-	-	40	101.1	-	-
Atherinopsis californiensis	jacksmelt	59	-	-	-	-	-	-	-	-	-	-
Engraulidae	anchovies	57	2	4.8	-	-	8	21.2	-	-	-	-
larval fish fragment	unidentified larval fishes	51	1	2.4	3	8.4	2	5.2	11	24.1	8	18.0
Hypsypops rubicundus	garibaldi	43	-	-	-	-	3	8.6	-	-	-	-
Menticirrhus undulatus	California corbina	43	-	-	-	-	-	-	30	67.9	-	-
larval/post-larval fish unid.	larval fishes	39	-	-	-	-	4	11.1	-	-	-	-
Paralabrax spp.	sand bass	36	-	-	-	-	7	19.1	4	9.7	3	7.8
Citharichthys stigmaeus	speckled sanddab	30	-	-	-	-	9	23.4	-	-	1	3.1
Oxyjulis californica	senorita	27	-	-	-	-	3	8.1	-	-	-	-
Atherinopsidae	silversides	25	-	-	-	-	-	-	-	-	-	-
Ilypnus gilberti	cheekspot goby	24	-	-	-	-	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	24	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	20	-	-	-	-	-	-	-	-	1	3.9
Lepidogobius lepidus	bay goby	18	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	16	-	-	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	15	-	-	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	15	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	14	-	-	-	-	6	15.6	7	15.9	-	-
Leuresthes tenuis	California grunion	13	-	-	1	3.2	-	-	-	-	2	5.7
Paralabrax clathratus	kelp bass	12	-	-	-	-	7	18.8	-	-	5	10.7
Pleuronichthys ritteri	spotted turbot	12	-	-	1	2.9	1	2.6	1	2.2	1	2.0
Pleuronichthys spp.	turbots	12	-	-	1	2.5	2	5.7	3	8.2	-	-
Diaphus theta	California headlight fish	11	-	-	-	-	2	5.3	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	10	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	8	-	-	-	-	3	8.0	1	2.7	-	-
Myctophidae unid.	lanternfishes	6	-	-	-	-	1	2.7	1	2.7	1	2.7
Atractoscion nobilis	white seabass	5	-	-	-	-	2	6.0	1	2.2	-	-
Haemulidae	grunts	5	-	-	-	-	1	2.8	3	6.6	1	2.7
Hypsoblennius jenkinsi	mussel blenny	5	-	-	-	-	-	-	2	5.3	1	2.0
Pleuronectidae unid.	flounders	5	-	-	-	-	1	2.8	-	-	1	2.0
Sardinops sagax	Pacific sardine	4	-	-	-	-	-	-	-	-	4	10.9
Labrisomidae unid.	labrisomid kelpfishes	3	-	-	-	-	-	-	-	-	1	2.7
Pleuronichthys verticalis	hornyhead turbot	3	-	-	-	-	-	-	2	4.4	1	3.1
Stenobrachius leucopsarus	northern lampfish	3	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	2	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	2	-	-	-	-	-	-	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	2	-	-	-	-	1	2.5	-	-	-	-
Paralichthyidae unid.	lefteye flounders &	2	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	2	-	-	-	-	1	2.5	-	-	-	-
Scomber japonicus	Pacific mackerel	2	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	2	-	-	-	-	1	2.5	-	-	-	-
Agonidae unid.	poachers	1	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	1	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	1	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	1	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	1	1	2.7	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	1	-	-	-	-	1	2.8	-	-	-	-
larval fish - damaged	unidentified larval fishes	1	-	-	-	-	-	-	-	-	1	2.7
Merluccius productus	Pacific hake	1	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	1	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	1	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	1	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_De	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V̄D	rockfishes	1	-	-	-	-	-	-	-	-	-	-
Strongylura exilis	California needlefish	1	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	1	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	1	-	-	-	-	-	-	1	2.6	-	-
Syngnathus spp.	pipefishes	1	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	1	-	-	-	-	-	-	-	-	-	-
Invertebrates												
Emerita analoga (zoea)	mole crab	10,399	1,072	2,954.4	60	161.6	236	683.7	1,042	2,718.1	3	8.6
Cancer anthonyi (meg.)	yellow crab	77	22	59.8	3	7.7	3	9.0	41	106.7	-	-
Cancer gracilis (meg.)	slender crab	31	3	8.0	3	7.7	2	5.3	-	-	4	9.9
Cancer antennarius (meg.)	brown rock crab	18	3	8.2	4	12.2	1	3.2	4	10.1	3	8.1
Cancer productus (meg.)	red rock crab	3	-	-	-	-	-	-	1	2.6	-	-
Cancer spp. (meg.)	cancer crabs	3	1	2.7	-	-	-	-	-	-	-	-
Emerita analoga (meg.)	mole crab	2	-	-	-	-	-	-	-	-	-	-
	Total:	17,489	1,375		273		494		2,433		332	

Appendix B-2. Larval fish and target invertebrate counts and mean concentrations (#/1000m^3) for source water surveys.

Survey: 1		Stations	D2		D4		O2		O4		U2		U4	
Start Date: 09/17/03		Sample Count	8		8		8		8		8		8	
Taxon	Common Name	Survey Count	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc
Gobiidae unid.	gobies	534	246	549.5	205	543.6	16	32.4	6	15.0	36	89.4	25	60.9
Engraulis mordax	northern anchovy	49	13	30.9	4	10.7	10	24.3	7	17.6	9	22.4	6	15.8
Seriphus politus	queenfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Genyonemus lineatus	white croaker	27	2	3.8	4	9.6	9	20.1	2	4.5	5	12.2	5	13.0
Sciaenidae unid.	croaker	7	3	7.8	1	2.8	-	-	2	5.2	-	-	1	2.8
Paralichthys californicus	California halibut	11	1	1.9	-	-	2	6.5	6	14.5	1	2.4	1	2.6
Hypsoblennius spp.	blennies	20	-	-	2	6.2	5	15.4	11	25.4	1	2.3	1	2.8
Paralabrax spp.	sand bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsis californiensis	jacksmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Chromis punctipinnis	blacksmith	-	-	-	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	larvae	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	12	1	2.7	1	2.8	3	4.6	1	2.1	4	9.8	2	5.4
Citharichthys stigmaeus	speckled sanddab	1	1	2.1	-	-	-	-	-	-	-	-	-	-
Engraulidae	anchovies	42	41	110.0	-	-	-	-	1	2.8	-	-	-	-
Lepidogobius lepidus	bay goby	5	-	-	-	-	4	8.6	1	2.5	-	-	-	-
larval fish fragment	unidentified larval fishes	6	-	-	1	2.4	-	-	2	3.9	2	4.9	1	2.8
Leuresthes tenuis	California grunion	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	1	-	-	-	-	-	-	1	3.1	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	8	-	-	-	-	2	6.8	6	11.8	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	10	-	-	-	-	1	2.5	1	2.6	1	2.9	7	17.2
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxyjulis californica	senorita	-	-	-	-	-	-	-	-	-	-	-	-	-
Roncador stearnsi	spotfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Xenistius califoriensis	salema	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silverside	-	-	-	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	3	1	3.2	-	-	1	3.1	1	3.1	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	1	-	-	-	-	-	-	1	2.2	-	-	-	-
Ilypnus gilberti	cheekspot goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophidiidae unid.	cusk-eels	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	1	-	-	-	-	1	1.5	-	-	-	-	-	-
Pleuronichthys spp.	turbots	-	-	-	-	-	-	-	-	-	-	-	-	-
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	-	-	-	-	-	-	-	-	-	-	-	-	-
Xystreurys liolepis	fantail sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	1	1	2.7	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	1	1	1.9	-	-	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	2	-	-	-	-	-	-	-	-	-	-	2	5.1
Menticirrhus undulatus	California corbina	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippoglossina stomata	bigmouth sole	1	-	-	-	-	-	-	1	2.6	-	-	-	-
Peprilus simillimus	Pacific butterfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	4	-	-	-	-	-	-	4	7.7	-	-	-	-
Umbrina roncador	yellowfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	sanddabs	3	-	-	1	2.4	1	3.1	-	-	1	2.5	-	-
Ruscarius creaseri	rouchcheek sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	-	-	-	-	-	-	-	-	-	-	-	-	-

(continued)

Appendix B-2. (Continued).

Survey: 1 (continued)		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 09/17/03		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
Taxon	**Common Name**	**Survey Count**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**
Atherinidae unid.	silversides	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-
Etrumeus teres	round herring	-	-	-	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	-	-	-	-	-	-	-	-	-	-	-	-	-
Lythrypnus spp.	gobies	3	-	-	-	-	-	-	3	5.8	-	-	-	-
Medialuna californiensis	halfmoon	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox rhessodon	California clingfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-
Kyphosidae	sea chubs	-	-	-	-	-	-	-	-	-	-	-	-	-
Labridae	wrasses	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	1	-	-	-	-	-	-	-	-	1	2.9	-	-
Oxylebius pictus	painted greenling	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Anisotremus davidsonii	sargo	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	1	-	-	-	-	-	-	1	2.2	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Girella nigricans	opaleye	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesocidae unid.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus / Clinocottus	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomacentridae	damselfishes	1	-	-	-	-	1	1.6	-	-	-	-	-	-
Scombridae unid.	mackerels & tunas	1	1	1.9	-	-	-	-	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	1	-	-	-	-	-	-	-	-	-	-	1	2.2
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Invertebrates														
Emerita analoga (zoea)	mole crab	73	2	5.4	4	10.9	13	30.6	-	-	53	109.3	1	2.2
Cancer gracilis (meg.)	slender crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer antennarius (meg.)	brown rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer anthonyi (meg.)	yellow crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer oregonsis (zoea V)	pygmy rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Panulirus interruptus	California spiny lobster	1	-	-	-	-	-	-	-	-	1	2.3	-	-
	Total:	832	314		223		69		58		115		53	

Appendix B-2. (Continued).

Survey: 3		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 10/13/2003		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
Taxon	**Common Name**	**Survey Count**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**
Gobiidae unid.	gobies	697	51	146.3	602	1,695.1	1	2.5	2	5.0	28	74.9	13	37.5
Engraulis mordax	northern anchovy	178	42	107.5	32	91.1	11	28.3	41	117.8	42	116.3	10	26.6
Seriphus politus	queenfish	4	-	-	4	11.8	-	-	-	-	-	-	-	-
Genyonemus lineatus	white croaker	30	2	5.4	13	36.5	3	9.0	8	24.5	4	10.6	-	-
Sciaenidae unid.	croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	3	-	-	-	-	-	-	3	10.1	-	-	-	-
Hypsoblennius spp.	blennies	20	-	-	-	-	11	29.1	-	-	2	6.6	7	20.7
Paralabrax spp.	sand bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsis californiensis	jacksmelt	1	1	2.3	-	-	-	-	-	-	-	-	-	-
Chromis punctipinnis	blacksmith	-	-	-	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	larvae	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	23	4	11.6	3	8.4	2	5.9	1	3.3	5	16.1	8	24.6
Citharichthys stigmaeus	speckled sanddab	3	-	-	-	-	-	-	2	4.9	-	-	1	2.5
Engraulidae	anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepidogobius lepidus	bay goby	2	-	-	1	2.3	-	-	1	2.5	-	-	-	-
larval fish fragment	unidentified larval fishes	1	-	-	1	2.3	-	-	-	-	-	-	-	-
Leuresthes tenuis	California grunion	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	2	-	-	-	-	-	-	2	5.1	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	3	-	-	-	-	-	-	1	2.6	1	3.2	1	3.6
Ophidion scrippsae	basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxyjulis californica	senorita	-	-	-	-	-	-	-	-	-	-	-	-	-
Roncador stearnsi	spotfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Xenistius califoriensis	salema	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silverside	-	-	-	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	2	-	-	-	-	1	2.4	1	3.6	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilypnus gilberti	cheekspot goby	1	-	-	1	2.9	-	-	-	-	-	-	-	-
Ophidiidae unid.	cusk-eels	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	2	-	-	1	2.9	1	3.0	-	-	-	-	-	-
Pleuronichthys spp.	turbots	3	-	-	1	2.6	-	-	1	3.3	1	3.1	-	-
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	-	-	-	-	-	-	-	-	-	-	-	-	-
Xystreurys liolepis	fantail sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	1	-	-	-	-	-	-	1	3.6	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	1	-	-	-	-	-	-	-	-	-	-	1	2.5
Atractoscion nobilis	white seabass	-	-	-	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	1	-	-	-	-	-	-	-	-	1	2.5	-	-
Gobiesox spp.	clingfishes	1	-	-	1	3.0	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippoglossina stomata	bigmouth sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	-	-	-	-	-	-	-	-	-	-	-	-	-

(continued)

Appendix B-2. (Continued).

Survey: 3 (continued)		Stations	D2		D4		O2		O4		U2		U4	
Start Date: 10/13/2003		Sample Count	8		8		8		8		8		8	
Taxon	Common Name	Survey Count	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc
Atherinidae unid.	silversides	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-
Etrumeus teres	round herring	-	-	-	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	-	-	-	-	-	-	-	-	-	-	-	-	-
Lythrypnus spp.	gobies	-	-	-	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	1	-	-	1	3.2	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox rhessodon	California clingfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-
Kyphosidae	sea chubs	-	-	-	-	-	-	-	-	-	-	-	-	-
Labridae	wrasses	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Anisotremus davidsonii	sargo	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Girella nigricans	opaleye	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesocidae unid.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus / Clinocottus	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomacentridae	damselfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Scombridae unid.	mackerels & tunas	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Invertebrates														
Emerita analoga (zoea)	mole crab	116	15	40.7	19	58.8	2	5.5	3	9.5	9	24.9	68	228.1
Cancer gracilis (meg.)	slender crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer antennarius (meg.)	brown rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer anthonyi (meg.)	yellow crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	1	1	2.0	-	-	-	-	-	-	-	-	-	-
Cancer oregonsis (zoea V)	pygmy rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Panulirus interruptus	California spiny lobster	-	-	-	-	-	-	-	-	-	-	-	-	-
		Total: 1,097	116		680		32		67		93		109	

Appendix B-2. (Continued).

Survey: 6		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 11/10/2003		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
		Survey		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**
Taxon	**Common Name**	**Count**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**
Gobiidae unid.	gobies	10	1	3.0	3	8.4	1	2.5	1	2.7	2	5.4	2	5.7
Engraulis mordax	northern anchovy	99	17	46.8	15	43.3	15	38.1	18	47.0	13	35.5	21	58.7
Seriphus politus	queenfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Genyonemus lineatus	white croaker	97	3	7.8	4	12.1	39	104.9	14	38.1	14	40.4	23	65.5
Sciaenidae unid.	croaker	6	-	-	-	-	3	7.3	1	2.4	1	2.8	1	2.7
Paralichthys californicus	California halibut	18	1	2.6	-	-	5	12.5	6	15.6	3	8.5	3	8.8
Hypsoblennius spp.	blennies	35	4	9.6	2	5.7	7	18.2	-	-	7	19.0	15	41.1
Paralabrax spp.	sand bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsis californiensis	jacksmelt	6	-	-	1	2.5	-	-	-	-	2	5.5	3	7.7
Chromis punctipinnis	blacksmith	-	-	-	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	larvae	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	11	1	2.6	-	-	3	8.7	-	-	1	2.7	6	17.4
Citharichthys stigmaeus	speckled sanddab	35	2	5.5	-	-	13	33.5	13	33.4	-	-	7	18.8
Engraulidae	anchovies	2	-	-	1	2.9	-	-	1	2.4	-	-	-	-
Lepidogobius lepidus	bay goby	1	-	-	-	-	-	-	1	2.4	-	-	-	-
larval fish fragment	unidentified larval fishes	3	-	-	-	-	-	-	-	-	-	-	3	7.7
Leuresthes tenuis	California grunion	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	3	-	-	-	-	2	4.8	-	-	1	2.6	-	-
Pleuronichthys verticalis	hornyhead turbot	2	-	-	-	-	1	2.8	1	3.1	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxyjulis californica	senorita	-	-	-	-	-	-	-	-	-	-	-	-	-
Roncador stearnsi	spotfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Xenistius califoriensis	salema	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silverside	-	-	-	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	11	3	8.3	-	-	2	5.6	1	2.7	3	8.3	2	5.4
Hypsoblennius jenkinsi	mussel blenny	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilypnus gilberti	cheekspot goby	1	-	-	1	2.5	-	-	-	-	-	-	-	-
Ophidiidae unid.	cusk-eels	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys spp.	turbots	1	-	-	-	-	-	-	-	-	-	-	1	2.8
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	-	-	-	-	-	-	-	-	-	-	-	-	-
Xystreurys liolepis	fantail sole	1	-	-	-	-	-	-	-	-	1	3.1	-	-
Triphoturus mexicanus	Mexican lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	-	-	-	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	9	-	-	1	3.0	3	8.2	4	11.5	1	2.6	-	-
Semicossyphus pulcher	California sheephead	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	2	-	-	-	-	-	-	1	2.3	1	2.8	-	-
Citharichthys spp.	sanddabs	7	-	-	-	-	1	2.5	3	9.0	2	5.9	1	2.4
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippoglossina stomata	bigmouth sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	2	-	-	-	-	-	-	-	-	1	2.6	1	3.1
Umbrina roncador	yellowfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	sanddabs	1	-	-	-	-	-	-	-	-	1	2.7	-	-
Ruscarius creaseri	rouchcheek sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	-	-	-	-	-	-	-	-	-	-	-	-	-

(continued)

Appendix B-2. (Continued).

Survey: 6 (continued)		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 11/10/2003		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
Taxon	**Common Name**	**Survey Count**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**
Atherinidae unid.	silversides	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-
Etrumeus teres	round herring	-	-	-	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	-	-	-	-	-	-	-	-	-	-	-	-	-
Lythrypnus spp.	gobies	-	-	-	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	3	-	-	-	-	-	-	1	2.7	2	5.6	-	-
Syngnathus spp.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox rhessodon	California clingfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-
Kyphosidae	sea chubs	-	-	-	-	-	-	-	-	-	-	-	-	-
Labridae	wrasses	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	2	-	-	-	-	2	5.4	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	2	-	-	-	-	-	-	1	2.5	1	2.6	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Anisotremus davidsonii	sargo	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Girella nigricans	opaleye	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesocidae unid.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus / Clinocottus	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomacentridae	damselfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Scombridae unid.	mackerels & tunas	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	1	-	-	-	-	1	2.9	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	1	-	-	-	-	-	-	1	3.1	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Invertebrates														
Emerita analoga (zoea)	mole crab	11	2	5.2	-	-	-	-	3	7.6	1	2.7	5	14.4
Cancer gracilis (meg.)	slender crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer antennarius (meg.)	brown rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer anthonyi (meg.)	yellow crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer oregonsis (zoea V)	pygmy rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Panulirus interruptus	California spiny lobster	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	383	34		28		98		71		58		94	

Appendix B-2. (Continued).

Survey: 10			D2		D4		O2		O4		U2		U4	
Start Date: 12/8/2003	Sample Count		8		8		8		8		8		8	
Taxon	Common Name	Survey Count	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc
Gobiidae unid.	gobies	361	72	192.7	246	634.4	20	56.1	3	7.9	14	38.0	6	15.6
Engraulis mordax	northern anchovy	37	15	39.9	6	14.7	4	11.5	3	8.0	7	18.9	2	5.1
Seriphus politus	queenfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Genyonemus lineatus	white croaker	142	12	29.8	46	119.5	39	107.8	26	68.9	9	24.4	10	26.1
Sciaenidae unid.	croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsoblennius spp.	blennies	16	1	2.8	4	9.9	3	8.2	1	2.8	3	8.4	4	10.5
Paralabrax spp.	sand bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsis californiensis	jacksmelt	13	2	5.1	9	22.2	1	2.8	-	-	-	-	1	2.8
Chromis punctipinnis	blacksmith	-	-	-	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	larvae	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	3	-	-	-	-	1	3.0	1	2.8	1	2.8	-	-
Citharichthys stigmaeus	speckled sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-
Engraulidae	anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepidogobius lepidus	bay goby	20	-	-	1	2.7	15	44.9	4	10.7	-	-	-	-
larval fish fragment	unidentified larval fishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Leuresthes tenuis	California grunion	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	1	-	-	-	-	-	-	-	-	1	2.7	-	-
Pleuronichthys verticalis	hornyhead turbot	1	-	-	-	-	-	-	1	2.8	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxyjulis californica	senorita	-	-	-	-	-	-	-	-	-	-	-	-	-
Roncador stearnsi	spotfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Xenistius californiensis	salema	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silverside	-	-	-	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	1	-	-	-	-	1	2.5	-	-	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilypnus gilberti	cheekspot goby	17	2	4.8	11	28.2	-	-	1	2.6	-	-	3	8.1
Ophidiidae unid.	cusk-eels	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	6	2	4.9	4	10.3	-	-	-	-	-	-	-	-
Pleuronichthys spp.	turbots	1	1	2.2	-	-	-	-	-	-	-	-	-	-
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	17	5	13.4	6	16.4	2	6.0	-	-	3	8.2	1	2.5
Acanthogobius flavimanus	yellowfin goby	11	-	-	1	2.5	10	30.0	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	-	-	-	-	-	-	-	-	-	-	-	-	-
Xystreurys liolepis	fantail sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	-	-	-	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	2	-	-	-	-	-	-	2	5.1	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippoglossina stomata	bigmouth sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	sanddabs	1	1	2.8	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	1	-	-	-	-	-	-	1	2.9	-	-	-	-
Symphurus atricauda	California tonguefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	-	-	-	-	-	-	-	-	-	-	-	-	-

(continued)

Appendix B-2. (Continued).

Survey: 10 (continued)			D2		D4		O2		O4		U2		U4	
Start Date: 12/8/2003	Sample Count		8		8		8		8		8		8	
Taxon	Common Name	Survey Count	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc
Atherinidae unid.	silversides	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-
Etrumeus teres	round herring	-	-	-	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	-	-	-	-	-	-	-	-	-	-	-	-	-
Lythrypnus spp.	gobies	-	-	-	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox rhessodon	California clingfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-
Kyphosidae	sea chubs	-	-	-	-	-	-	-	-	-	-	-	-	-
Labridae	wrasses	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	1	1	2.6	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Anisotremus davidsonii	sargo	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Girella nigricans	opaleye	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesocidae unid.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus / Clinocottus	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomacentridae	damselfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Scombridae unid.	mackerels & tunas	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Invertebrates														
Emerita analoga (zoea)	mole crab	54	17	39.2	1	2.7	6	16.4	4	10.8	16	42.5	10	28.2
Cancer gracilis (meg.)	slender crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer antennarius (meg.)	brown rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer anthonyi (meg.)	yellow crab	4	1	2.6	2	5.2	-	-	1	2.8	-	-	-	-
Cancer spp. (meg.)	cancer crabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer oregonsis (zoea V)	pygmy rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Panulirus interruptus	California spiny lobster	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	710	132		337		102		48		54		37	

Appendix B-2. (Continued).

Survey: 14		Stations	D2		D4		O2		O4		U2		U4	
Start Date: 01/05/04		**Sample Count**	**16**		**16**		**16**		**16**		**16**		**16**	
Taxon	**Common Name**	**Survey Count**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**	**Count**	**Mean Conc.**
Gobiidae unid.	gobies	152	58	81.0	69	94.4	5	7.3	1	1.4	9	12.4	10	13.4
Engraulis mordax	northern anchovy	19	9	12.5	5	6.6	2	2.8	-	-	2	2.5	1	1.4
Seriphus politus	queenfish	3	-	-	1	1.4	2	3.1	-	-	-	-	-	-
Genyonemus lineatus	white croaker	51	15	20.3	4	5.3	7	10.0	13	18.6	9	12.4	3	4.1
Sciaenidae unid.	croaker	12	7	9.5	4	5.5	1	1.6	-	-	-	-	-	-
Paralichthys californicus	California halibut	2	-	-	-	-	-	-	2	2.6	-	-	-	-
Hypsoblennius spp.	blennies	11	4	5.5	2	2.6	1	1.4	1	1.2	1	1.4	2	2.8
Paralabrax spp.	sand bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsis californiensis	jacksmelt	7	1	1.5	2	2.7	1	1.4	-	-	1	1.3	2	2.8
Chromis punctipinnis	blacksmith	-	-	-	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	larvae	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	19	-	-	2	2.9	-	-	3	4.4	14	19.2	-	-
Citharichthys stigmaeus	speckled sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-
Engraulidae	anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepidogobius lepidus	bay goby	7	-	-	-	-	3	4.5	4	5.9	-	-	-	-
larval fish fragment	unidentified larval fishes	1	1	1.4	-	-	-	-	-	-	-	-	-	-
Leuresthes tenuis	California grunion	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxyjulis californica	senorita	-	-	-	-	-	-	-	-	-	-	-	-	-
Roncador stearnsi	spotfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Xenistius califoriensis	salema	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silverside	8	3	4.6	1	1.2	2	2.9	1	1.4	-	-	1	1.4
larval/post-larval fish unid.	larval fishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilypnus gilberti	cheekspot goby	3	-	-	2	2.5	-	-	-	-	-	-	1	1.4
Ophidiidae unid.	cusk-eels	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys spp.	turbots	-	-	-	-	-	-	-	-	-	-	-	-	-
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	2	1	1.4	-	-	-	-	1	1.6	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	1	-	-	-	-	-	-	1	1.6	-	-	-	-
Hypsypops rubicundus	garibaldi	-	-	-	-	-	-	-	-	-	-	-	-	-
Xystreurys liolepis	fantail sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	1	-	-	1	1.4	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	-	-	-	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	1	-	-	1	1.2	-	-	-	-	-	-	-	-
Hippoglossina stomata	bigmouth sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	1	1	1.4	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	1	-	-	-	-	1	1.6	-	-	-	-	-	-
Diaphus theta	California headlight fish	-	-	-	-	-	-	-	-	-	-	-	-	-

(continued)

Appendix B-2. (Continued).

Survey: 14 (continued)		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 01/05/04		**Sample Count**	**16**		**16**		**16**		**16**		**16**		**16**	
		Survey		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**
Taxon	**Common Name**	**Count**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**
Atherinidae unid.	silversides	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-
Etrumeus teres	round herring	-	-	-	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	-	-	-	-	-	-	-	-	-	-	-	-	-
Lythrypnus spp.	gobies	-	-	-	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox rhessodon	California clingfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-
Kyphosidae	sea chubs	-	-	-	-	-	-	-	-	-	-	-	-	-
Labridae	wrasses	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	1	-	-	1	1.3	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Anisotremus davidsonil	sargo	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Girella nigricans	opaleye	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesocidae unid.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus / Clinocottus	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomacentridae	damselfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Scombridae unid.	mackerels & tunas	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Invertebrates														
Emerita analoga (zoea)	mole crab	10	6	8.0	1	1.5	-	-	-	-	1	1.5	2	2.6
Cancer gracilis (meg.)	slender crab	2	-	-	-	-	1	1.4	-	-	-	-	1	1.4
Cancer antennarius (meg.)	brown rock crab	1	-	-	-	-	-	-	-	-	1	1.4	-	-
Cancer anthonyi (meg.)	yellow crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer oregonsis (zoea V)	pygmy rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Panulirus interruptus	California spiny lobster	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	316	106		96		26		27		38		23	

Appendix B-2. (Continued).

Survey: 19		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 02/09/04		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
Taxon	**Common Name**	**Survey Count**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**
Gobiidae unid.	gobies	314	156	388.0	131	366.4	2	5.8	1	2.8	18	44.8	6	15.6
Engraulis mordax	northern anchovy	8	1	2.7	4	11.6	1	2.8	-	-	1	2.4	1	2.3
Seriphus politus	queenfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Genyonemus lineatus	white croaker	33	11	26.6	7	18.6	6	15.0	-	-	4	10.8	5	12.4
Sciaenidae unid.	croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	1	1	2.4	-	-	-	-	-	-	-	-	-	-
Hypsoblennius spp.	blennies	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralabrax spp.	sand bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsis californiensis	jacksmelt	20	2	4.6	14	39.2	1	2.8	2	5.6	-	-	1	2.3
Chromis punctipinnis	blacksmith	-	-	-	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	larvae	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	5	2	4.8	1	2.8	-	-	-	-	-	-	2	5.7
Citharichthys stigmaeus	speckled sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-
Engraulidae	anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepidogobius lepidus	bay goby	6	3	7.5	1	2.8	-	-	-	-	2	4.9	-	-
larval fish fragment	unidentified larval fishes	1	-	-	-	-	1	2.4	-	-	-	-	-	-
Leuresthes tenuis	California grunion	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxyjulis californica	senorita	-	-	-	-	-	-	-	-	-	-	-	-	-
Roncador stearnsi	spotfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Xenistius califoriensis	salema	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silverside	-	-	-	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	1	-	-	-	-	1	2.9	-	-	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilypnus gilberti	cheekspot goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophidiidae unid.	cusk-eels	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	3	2	4.8	-	-	-	-	-	-	1	2.5	-	-
Pleuronichthys spp.	turbots	-	-	-	-	-	-	-	-	-	-	-	-	-
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	5	1	2.5	3	8.2	-	-	-	-	-	-	1	2.7
Acanthogobius flavimanus	yellowfin goby	4	1	2.5	3	8.4	-	-	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	-	-	-	-	-	-	-	-	-	-	-	-	-
Xystreurys liolepis	fantail sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	-	-	-	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	1	-	-	-	-	-	-	-	-	-	-	1	2.3
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	1	1	2.5	-	-	-	-	-	-	-	-	-	-
Hippoglossina stomata	bigmouth sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	-	-	-	-	-	-	-	-	-	-	-	-	-

(continued)

Appendix B-2. (Continued).

Survey: 19 (continued)		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 02/09/04		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
Taxon	**Common Name**	**Survey Count**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**
Atherinidae unid.	silversides	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	4	2	4.8	2	4.9	-	-	-	-	-	-	-	-
Etrumeus teres	round herring	-	-	-	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	-	-	-	-	-	-	-	-	-	-	-	-	-
Lythrypnus spp.	gobies	-	-	-	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox rhessodon	California clingfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	1	-	-	-	-	-	-	1	2.4	-	-	-	-
Kyphosidae	sea chubs	-	-	-	-	-	-	-	-	-	-	-	-	-
Labridae	wrasses	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Anisotremus davidsonii	sargo	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	1	1	2.4	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Girella nigricans	opaleye	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesocidae unid.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus / Clinocottus	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomacentridae	damselfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Scombridae unid.	mackerels & tunas	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Invertebrates														
Emerita analoga (zoea)	mole crab	8	-	-	3	8.1	-	-	1	2.8	4	10.5	-	-
Cancer gracilis (meg.)	slender crab	2	-	-	-	-	-	-	2	5.7	-	-	-	-
Cancer antennarius (meg.)	brown rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer anthonyi (meg.)	yellow crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	1	-	-	-	-	-	-	-	-	-	-	1	2.3
Cancer oregonsis (zoea V)	pygmy rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Panulirus interruptus	California spiny lobster	-	-	-	-	-	-	-	-	-	-	-	-	-
		Total: 420	184		169		12		7		30		18	

Appendix B-2. (Continued).

Survey: 23		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 03/08/04		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
Taxon	**Common Name**	**Survey Count**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**
Gobiidae unid.	gobies	461	205	565.5	224	619.4	3	8.0	2	4.5	19	55.9	8	23.0
Engraulis mordax	northern anchovy	42	13	35.8	8	20.4	3	7.9	-	-	16	46.3	2	5.7
Seriphus politus	queenfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Genyonemus lineatus	white croaker	30	1	2.8	8	20.3	5	13.7	3	8.4	4	11.6	9	23.5
Sciaenidae unid.	croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	3	-	-	-	-	-	-	3	8.6	-	-	-	-
Hypsoblennius spp.	blennies	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralabrax spp.	sand bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsis californiensis	jacksmelt	4	1	3.2	1	2.3	-	-	-	-	2	4.8	-	-
Chromis punctipinnis	blacksmith	-	-	-	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	larvae	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphyraena argentea	California barracuda	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	16	8	22.6	1	2.2	-	-	1	2.4	1	2.7	5	12.9
Citharichthys stigmaeus	speckled sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-
Engraulidae	anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepidogobius lepidus	bay goby	3	-	-	2	5.0	-	-	-	-	-	-	1	2.9
larval fish fragment	unidentified larval fishes	2	-	-	-	-	-	-	-	-	2	6.2	-	-
Leuresthes tenuis	California grunion	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxyjulis californica	senorita	-	-	-	-	-	-	-	-	-	-	-	-	-
Roncador stearnsi	spotfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Xenistius califoriensis	salema	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silverside	1	-	-	1	2.5	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsoblennius jenkinsi	mussel blenny	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilypnus gilberti	cheekspot goby	2	2	5.5	-	-	-	-	-	-	-	-	-	-
Ophidiidae unid.	cusk-eels	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	8	3	8.2	4	10.9	-	-	-	-	1	3.1	-	-
Pleuronichthys spp.	turbots	1	-	-	1	3.0	-	-	-	-	-	-	-	-
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	1	-	-	1	2.8	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	5	3	8.4	2	5.3	-	-	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	-	-	-	-	-	-	-	-	-	-	-	-	-
Xystreurys liolepis	fantail sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	-	-	-	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippoglossina stomata	bigmouth sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	2	1	2.8	-	-	1	2.7	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	1	-	-	-	-	-	-	1	2.2	-	-	-	-
Diaphus theta	California headlight fish	-	-	-	-	-	-	-	-	-	-	-	-	-

(continued)

Appendix B-2. (Continued).

Survey: 23 (continued)		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 03/08/04		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
		Survey		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**
Taxon	**Common Name**	**Count**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**
Atherinidae unid.	silversides	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-
Etrumeus teres	round herring	-	-	-	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	-	-	-	-	-	-	-	-	-	-	-	-	-
Lythrypnus spp.	gobies	-	-	-	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox rhessodon	California clingfish	2	-	-	2	5.7	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-
Kyphosidae	sea chubs	-	-	-	-	-	-	-	-	-	-	-	-	-
Labridae	wrasses	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Anisotremus davidsonii	sargo	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Girella nigricans	opaleye	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesocidae unid.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus / Clinocottus	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomacentridae	damselfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Scombridae unid.	mackerels & tunas	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Invertebrates														
Emerita analoga (zoea)	mole crab	15	8	21.5	3	7.3	1	3.2	1	2.2	1	2.1	1	2.7
Cancer gracilis (meg.)	slender crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer antennarius (meg.)	brown rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer anthonyi (meg.)	yellow crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer oregonsis (zoea V)	pygmy rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Panulirus interruptus	California spiny lobster	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	599	245		258		13		11		46		26	

Appendix B-2. (Continued).

Survey: 27 Start Date: 04/05/04	Sample Count		D2 8		D4 8		O2 8		O4 8		U2 8		U4 8	
Taxon	Common Name	Survey Count	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc
Gobiidae unid.	gobies	104	11	25.4	8	21.2	2	5.0	4	11.0	34	86.5	45	116.7
Engraulis mordax	northern anchovy	139	11	27.1	19	48.0	23	50.7	43	111.9	32	84.1	11	28.3
Seriphus politus	queenfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Genyonemus lineatus	white croaker	25	1	2.4	3	7.2	8	19.6	8	21.5	2	5.2	3	7.2
Sciaenidae unid.	croaker	3	1	2.4	1	2.2	1	2.1	-	-	-	-	-	-
Paralichthys californicus	California halibut	4	1	2.7	-	-	3	6.6	-	-	-	-	-	-
Hypsoblennius spp.	blennies	1	-	-	-	-	1	2.1	-	-	-	-	-	-
Paralabrax spp.	sand bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsis californiensis	jacksmelt	10	2	4.9	2	5.0	-	-	-	-	-	-	6	15.3
Chromis punctipinnis	blacksmith	-	-	-	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	larvae	5	4	9.6	-	-	-	-	1	2.5	-	-	-	-
Sphyraena argentea	California barracuda	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys stigmaeus	speckled sanddab	3	-	-	-	-	-	-	3	8.2	-	-	-	-
Engraulidae	anchovies	9	6	15.2	1	2.3	-	-	-	-	1	2.4	1	2.6
Lepidogobius lepidus	bay goby	1	-	-	-	-	-	-	1	2.8	-	-	-	-
larval fish fragment	unidentified larval fishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Leuresthes tenuis	California grunion	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	2	-	-	-	-	-	-	2	5.5	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	49	-	-	-	-	-	-	-	-	1	2.9	48	124.6
Oxyjulis californica	senorita	-	-	-	-	-	-	-	-	-	-	-	-	-
Roncador stearnsi	spotfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Xenistius califoriensis	salema	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silverside	1	-	-	-	-	1	2.4	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	2	-	-	1	2.5	-	-	-	-	1	2.8	-	-
Hypsoblennius jenkinsi	mussel blenny	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilypnus gilberti	cheekspot goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophidiidae unid.	cusk-eels	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	1	-	-	-	-	-	-	-	-	1	2.6	-	-
Pleuronichthys spp.	turbots	1	-	-	-	-	1	2.2	-	-	-	-	-	-
Icelinus spp.	sculpins	1	-	-	-	-	-	-	-	-	1	2.7	-	-
Leptocottus armatus	Pacific staghorn sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	1	-	-	-	-	-	-	-	-	-	-	1	2.3
Hypsypops rubicundus	garibaldi	-	-	-	-	-	-	-	-	-	-	-	-	-
Xystreurys liolepis	fantail sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	1	-	-	-	-	-	-	-	-	-	-	1	2.5
Atractoscion nobilis	white seabass	-	-	-	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippoglossina stomata	bigmouth sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	sanddabs	1	-	-	-	-	-	-	1	2.5	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	2	2	4.5	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	-	-	-	-	-	-	-	-	-	-	-	-	-

(continued)

Appendix B-2. (Continued).

Survey: 27 (continued)			D2		D4		O2		O4		U2		U4	
Start Date: 04/05/04		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
Taxon	**Common Name**	**Survey Count**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**
Atherinidae unid.	silversides	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-
Etrumeus teres	round herring	-	-	-	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	-	-	-	-	-	-	-	-	-	-	-	-	-
Lythrypnus spp.	gobies	-	-	-	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	1	-	-	-	-	-	-	1	2.7	-	-	-	-
Clevelandia ios	arrow goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox rhessodon	California clingfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-
Kyphosidae	sea chubs	-	-	-	-	-	-	-	-	-	-	-	-	-
Labridae	wrasses	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Anisotremus davidsonii	sargo	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Girella nigricans	opaleye	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesocidae unid.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus / Clinocottus	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	1	-	-	1	2.3	-	-	-	-	-	-	-	-
Pomacentridae	damselfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Scombridae unid.	mackerels & tunas	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	1	-	-	-	-	-	-	1	2.5	-	-	-	-
Invertebrates														
Emerita analoga (zoea)	mole crab	1,059	32	78.9	98	218.1	42	92.7	48	132.0	66	175.6	773	2,008.4
Cancer gracilis (meg.)	slender crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer antennarius (meg.)	brown rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer anthonyi (meg.)	yellow crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	1	-	-	-	-	1	2.1	-	-	-	-	-	-
Cancer oregonsis (zoea V)	pygmy rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Panulirus interruptus	California spiny lobster	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	1,429	71		134		83		113		139		889	

Appendix B-2. (Continued).

Survey: 31		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 05/03/04		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
		Survey		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**
Taxon	**Common Name**	**Count**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**
Gobiidae unid.	gobies	491	90	250.1	92	245.4	10	24.0	1	2.2	86	209.6	212	578.1
Engraulis mordax	northern anchovy	337	28	71.1	30	76.7	40	102.2	19	48.5	99	253.9	121	328.9
Seriphus politus	queenfish	2	-	-	1	2.3	1	2.4	-	-	-	-	-	-
Genyonemus lineatus	white croaker	361	24	62.6	28	74.6	110	265.0	59	157.2	53	126.6	87	242.2
Sciaenidae unid.	croaker	59	12	30.7	3	7.6	11	28.3	12	29.7	12	31.5	9	25.4
Paralichthys californicus	California halibut	25	2	5.3	4	10.2	4	9.3	9	24.1	2	4.9	4	10.6
Hypsoblennius spp.	blennies	11	2	4.8	-	-	-	-	3	7.9	2	4.7	4	11.3
Paralabrax spp.	sand bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsis californiensis	jacksmelt	75	9	24.5	5	11.8	4	10.0	3	8.2	45	106.6	9	24.1
Chromis punctipinnis	blacksmith	-	-	-	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	larvae	23	2	4.9	-	-	6	14.5	6	16.0	4	10.7	5	12.6
Sphyraena argentea	California barracuda	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	10	4	10.7	-	-	1	2.2	1	2.6	4	10.8	-	-
Citharichthys stigmaeus	speckled sanddab	5	-	-	1	2.7	2	4.7	1	2.9	1	2.2	-	-
Engraulidae	anchovies	4	1	2.4	1	2.7	-	-	2	5.2	-	-	-	-
Lepidogobius lepidus	bay goby	14	3	7.3	1	2.2	5	12.5	1	2.8	2	4.7	2	5.2
larval fish fragment	unidentified larval fishes	10	2	5.5	-	-	-	-	4	10.8	2	4.7	2	5.7
Leuresthes tenuis	California grunion	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	2	-	-	1	2.4	1	2.6	-	-	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	1	-	-	-	-	-	-	1	2.8	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	9	2	5.0	-	-	1	2.3	2	5.4	3	7.5	1	2.2
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxyjulis californica	senorita	2	-	-	-	-	1	2.2	1	2.5	-	-	-	-
Roncador stearnsi	spotfin croaker	7	2	4.8	1	2.5	1	2.7	-	-	2	5.0	1	3.0
Xenistius californiensis	salema	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silverside	14	5	13.9	-	-	3	8.0	-	-	2	4.9	4	10.2
larval/post-larval fish unid.	larval fishes	1	-	-	-	-	-	-	-	-	1	2.5	-	-
Hypsoblennius jenkinsi	mussel blenny	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilypnus gilberti	cheekspot goby	13	2	4.8	5	11.7	-	-	-	-	4	10.3	2	5.4
Ophidiidae unid.	cusk-eels	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	7	4	11.8	1	2.7	1	2.1	-	-	1	2.6	-	-
Pleuronichthys spp.	turbots	3	1	2.2	-	-	1	2.1	-	-	1	2.8	-	-
Icelinus spp.	sculpins	5	-	-	-	-	-	-	5	11.8	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	1	1	2.7	-	-	-	-	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	-	-	-	-	-	-	-	-	-	-	-	-	-
Xystreurys liolepis	fantail sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	13	2	5.5	4	10.1	1	2.1	1	2.5	2	4.9	3	9.0
Atractoscion nobilis	white seabass	-	-	-	-	-	-	-	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	4	-	-	1	3.1	1	2.6	-	-	-	-	2	4.8
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	1	1	2.5	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippoglossina stomata	bigmouth sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	1	-	-	-	-	-	-	1	2.9	-	-	-	-

(continued)

Appendix B-2. (Continued).

Survey: 31 (continued)		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 05/03/04		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
Taxon	**Common Name**	**Survey Count**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**
Atherinidae unid.	silversides	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-
Etrumeus teres	round herring	-	-	-	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	-	-	-	-	-	-	-	-	-	-	-	-	-
Lythrypnus spp.	gobies	-	-	-	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	2	-	-	1	3.1	-	-	-	-	1	2.7	-	-
Gobiesox rhessodon	California clingfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	1	-	-	-	-	-	-	1	2.7	-	-	-	-
Kyphosidae	sea chubs	-	-	-	-	-	-	-	-	-	-	-	-	-
Labridae	wrasses	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Anisotremus davidsonii	sargo	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	1	1	3.4	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Girella nigricans	opaleye	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesocidae unid.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus / Clinocottus	sculpins	1	-	-	-	-	-	-	1	2.7	-	-	-	-
Parophrys vetulus	English sole	1	-	-	-	-	-	-	1	2.8	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomacentridae	damselfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Scombridae unid.	mackerels & tunas	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Invertebrates														
Emerita analoga (zoea)	mole crab	388	9	25.1	49	122.4	24	64.1	12	31.3	213	547.9	81	242.2
Cancer gracilis (meg.)	slender crab	2	-	-	-	-	-	-	1	2.9	1	2.7	-	-
Cancer antennarius (meg.)	brown rock crab	2	-	-	-	-	1	2.6	-	-	1	2.7	-	-
Cancer anthonyi (meg.)	yellow crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer spp. (meg.)	cancer crabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer oregonsis (zoea V)	pygmy rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Panulirus interruptus	California spiny lobster	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	1,909	209		229		230		148		544		549	

Appendix B-2. (Continued).

Survey: 35		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 06/01/04		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
		Survey		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**
Taxon	**Common Name**	**Count**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**
Gobiidae unid.	gobies	245	100	297.0	56	149.0	4	10.6	2	5.8	59	161.4	24	64.2
Engraulis mordax	northern anchovy	643	75	216.0	37	97.0	149	409.4	104	301.2	146	435.5	132	350.9
Seriphus politus	queenfish	3	-	-	-	-	-	-	2	6.0	-	-	1	2.4
Genyonemus lineatus	white croaker	59	3	8.6	1	2.5	37	104.6	13	34.5	-	-	5	12.6
Sciaenidae unid.	croaker	13	2	5.7	2	5.4	-	-	1	2.4	7	19.1	1	2.7
Paralichthys californicus	California halibut	34	2	6.0	1	2.4	9	23.9	21	61.8	-	-	1	2.5
Hypsoblennius spp.	blennies	45	2	5.8	6	14.8	-	-	16	44.0	9	26.0	12	32.2
Paralabrax spp.	sand bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsis californiensis	jacksmelt	32	2	6.3	6	16.3	-	-	-	-	22	60.4	2	5.7
Chromis punctipinnis	blacksmith	-	-	-	-	-	-	-	-	-	-	-	-	-
larvae, unidentified yolksac	larvae	3	1	2.5	1	2.4	-	-	-	-	1	2.8	-	-
Sphyraena argentea	California barracuda	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys stigmaeus	speckled sanddab	7	-	-	-	-	-	-	7	22.4	-	-	-	-
Engraulidae	anchovies	38	1	2.5	8	20.7	5	12.8	18	49.3	1	3.4	5	13.1
Lepidogobius lepidus	bay goby	4	-	-	-	-	1	2.9	3	7.2	-	-	-	-
larval fish fragment	unidentified larval fishes	2	1	2.5	-	-	-	-	1	2.4	-	-	-	-
Leuresthes tenuis	California grunion	66	49	141.0	1	2.7	-	-	-	-	3	9.1	13	34.2
Pleuronichthys ritteri	spotted turbot	4	-	-	-	-	2	5.5	2	5.0	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	3	-	-	-	-	1	2.9	2	5.0	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	5	2	5.3	1	2.4	-	-	2	7.0	-	-	-	-
Typhlogobius californiensis	blind goby	6	-	-	-	-	1	2.5	1	2.6	-	-	4	10.3
Oxyjulis californica	senorita	1	-	-	-	-	-	-	1	2.5	-	-	-	-
Roncador stearnsi	spotfin croaker	-	-	-	-	-	-	-	-	-	-	-	-	-
Xenistius californiensis	salema	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsidae	silverside	16	3	8.2	5	13.4	-	-	-	-	2	5.8	6	16.0
larval/post-larval fish unid.	larval fishes	6	3	8.3	2	5.1	-	-	-	-	1	2.5	-	-
Hypsoblennius jenkinsi	mussel blenny	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilypnus gilberti	cheekspot goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophidiidae unid.	cusk-eels	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	1	-	-	-	-	1	2.9	-	-	-	-	-	-
Pleuronichthys spp.	turbots	5	-	-	1	2.7	-	-	3	7.5	-	-	1	2.5
Icelinus spp.	sculpins	2	-	-	-	-	-	-	2	5.0	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	5	2	5.1	2	5.3	-	-	-	-	-	-	1	2.7
Xystreurys liolepis	fantail sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	2	-	-	-	-	1	2.9	-	-	-	-	1	2.7
Menticirrhus undulatus	California corbina	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	1	-	-	-	-	-	-	1	2.4	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippoglossina stomata	bigmouth sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	1	1	2.5	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinops affinis	topsmelt	5	-	-	-	-	-	-	-	-	-	-	5	14.2
Rhinogobiops nicholsi	blackeye goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	1	-	-	-	-	-	-	1	2.5	-	-	-	-

(continued)

Appendix B-2. (Continued).

Survey: 35 (continued)		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 06/01/04		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
Taxon	**Common Name**	**Survey Count**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**	**Count**	**Mean Conc**
Atherinidae unid.	silversides	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-
Etrumeus teres	round herring	-	-	-	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	-	-	-	-	-	-	-	-	-	-	-	-	-
Lythrypnus spp.	gobies	-	-	-	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	1	-	-	-	-	1	2.6	-	-	-	-	-	-
Clevelandia ios	arrow goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox rhessodon	California clingfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-
Kyphosidae	sea chubs	-	-	-	-	-	-	-	-	-	-	-	-	-
Labridae	wrasses	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	2	1	3.3	-	-	1	2.9	-	-	-	-	-	-
Anisotremus davidsonii	sargo	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Girella nigricans	opaleye	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesocidae unid.	clingfishes	1	-	-	-	-	-	-	-	-	1	3.0	-	-
Oligocottus / Clinocottus	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomacentridae	damselfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Scombridae unid.	mackerels & tunas	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Invertebrates														
Emerita analoga (zoea)	mole crab	1,747	10	26.7	112	289.4	22	61.2	112	303.6	285	909.6	1,206	3,113.4
Cancer gracilis (meg.)	slender crab	28	1	2.8	9	23.1	12	32.0	1	2.5	1	3.4	4	11.2
Cancer antennarius (meg.)	brown rock crab	24	4	11.6	4	10.8	10	27.1	4	11.1	1	2.5	1	2.7
Cancer anthonyi (meg.)	yellow crab	6	-	-	-	-	2	5.5	-	-	3	9.5	1	2.5
Cancer spp. (meg.)	cancer crabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer oregonsis (zoea V)	pygmy rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Panulirus interruptus	California spiny lobster	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	3,067	265		255		259		320		542		1,426	

Appendix B-2. (Continued).

Survey: 41		Stations	D2		D4		O2		O4		U2		U4	
Start Date: 07/12/04		Sample Count	8		8		8		8		8		8	
Taxon	Common Name	Survey Count	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc
Gobiidae unid.	gobies	269	87	239.2	111	287.8	19	45.9	3	8.9	44	114.8	5	13.2
Engraulis mordax	northern anchovy	332	58	162.5	47	120.0	40	105.6	78	214.4	40	106.8	69	184.8
Seriphus politus	queenfish	230	57	155.0	87	232.2	3	7.8	5	13.1	39	103.5	39	100.9
Genyonemus lineatus	white croaker	19	-	-	-	-	8	21.7	11	29.2	-	-	-	-
Sciaenidae unid.	croaker	20	-	-	1	2.6	2	5.4	13	35.2	1	3.2	3	9.2
Paralichthys californicus	California halibut	34	1	2.9	2	5.6	3	7.9	22	60.3	6	15.7	-	-
Hypsoblennius spp.	blennies	75	16	40.7	5	12.6	27	74.2	8	21.8	12	30.2	7	18.4
Paralabrax spp.	sand bass	15	1	2.9	-	-	2	5.9	9	24.4	-	-	3	8.8
Paralabrax clathratus	kelp bass	22	-	-	-	-	3	8.1	19	51.5	-	-	-	-
Atherinopsis californiensis	jacksmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Chromis punctipinnis	blacksmith	4	-	-	-	-	2	5.0	1	2.5	-	-	1	2.5
larvae, unidentified yolksac	larvae	21	1	3.0	-	-	3	8.8	10	25.5	1	2.2	6	16.7
Sphyraena argentea	California barracuda	3	2	5.6	1	2.9	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	diamond turbot	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys stigmaeus	speckled sanddab	13	-	-	-	-	1	2.7	12	30.0	-	-	-	-
Engraulidae	anchovies	15	2	5.8	-	-	2	5.5	9	24.5	-	-	2	5.8
Lepidogobius lepidus	bay goby	20	-	-	-	-	8	21.0	12	32.0	-	-	-	-
larval fish fragment	unidentified larval fishes	8	1	2.9	3	7.9	-	-	-	-	2	5.3	2	5.0
Leuresthes tenuis	California grunion	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	spotted turbot	8	1	2.8	-	-	3	7.4	4	10.4	-	-	-	-
Pleuronichthys verticalis	hornyhead turbot	13	-	-	-	-	6	16.3	6	16.0	1	2.2	-	-
Ophidion scrippsae	basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheilotrema saturnum	black croaker	16	5	12.2	3	7.9	-	-	4	11.1	-	-	4	10.8
Typhlogobius californiensis	blind goby	1	-	-	-	-	1	2.8	-	-	-	-	-	-
Oxyjulis californica	senorita	18	-	-	1	2.7	2	5.5	11	30.9	-	-	4	12.2
Roncador stearnsi	spotfin croaker	3	1	2.4	1	2.2	-	-	-	-	-	-	1	2.9
Xenistius califoriensis	salema	4	-	-	-	-	-	-	4	11.0	-	-	-	-
Atherinopsidae	silverside	2	-	-	1	2.6	-	-	-	-	1	2.9	-	-
larval/post-larval fish unid.	larval fishes	1	-	-	-	-	-	-	-	-	-	-	1	2.5
Hypsoblennius jenkinsi	mussel blenny	2	-	-	1	2.8	-	-	1	2.6	-	-	-	-
Ilypnus gilberti	cheekspot goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophidiidae unid.	cusk-eels	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	2	1	3.0	1	2.7	-	-	-	-	-	-	-	-
Pleuronichthys spp.	turbots	3	-	-	-	-	-	-	3	7.6	-	-	-	-
Icelinus spp.	sculpins	17	-	-	-	-	1	2.5	16	41.1	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	14	3	7.1	4	10.4	2	5.5	-	-	4	9.0	1	2.9
Xystreurys liolepis	fantail sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Triphoturus mexicanus	Mexican lampfish	12	-	-	1	2.8	3	8.2	7	18.7	-	-	1	2.8
Gibbonsia spp.	clinid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	9	2	5.1	-	-	-	-	7	18.3	-	-	-	-
Menticirrhus undulatus	California corbina	7	-	-	-	-	3	8.3	2	5.2	-	-	2	5.3
Citharichthys sordidus	Pacific sanddab	1	-	-	-	-	-	-	1	2.5	-	-	-	-
Semicossyphus pulcher	California sheephead	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	6	-	-	-	-	1	2.5	-	-	1	2.8	4	10.5
Labrisomidae unid.	labrisomid kelpfishes	4	-	-	-	-	-	-	-	-	4	11.0	-	-
Hippoglossina stomata	bigmouth sole	1	-	-	-	-	1	2.7	-	-	-	-	-	-
Peprilus simillimus	Pacific butterfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	1	-	-	-	-	-	-	1	2.6	-	-	-	-
Umbrina roncador	yellowfin croaker	2	-	-	-	-	1	2.7	1	2.7	-	-	-	-
Paralichthyidae unid.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	1	-	-	-	-	1	2.6	-	-	-	-	-	-
Diaphus theta	California headlight fish	3	-	-	-	-	1	2.7	2	5.3	-	-	-	-

(continued)

Appendix B-2. (Continued).

Survey: 41 (continued)		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 07/12/04		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
		Survey		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**
Taxon	**Common Name**	**Count**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**
Atherinidae unid.	silversides	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae	grunts	3	-	-	-	-	-	-	1	3.2	2	5.1	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-
Etrumeus teres	round herring	-	-	-	-	-	-	-	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	-	-	-	-	-	-	-	-	-	-	-	-	-
Lythrypnus spp.	gobies	-	-	-	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox rhessodon	California clingfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-
Kyphosidae	sea chubs	-	-	-	-	-	-	-	-	-	-	-	-	-
Labridae	wrasses	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	1	-	-	-	-	1	2.6	-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Anisotremus davidsonii	sargo	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	1	-	-	-	-	1	2.7	-	-	-	-	-	-
Girella nigricans	opaleye	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesocidae unid.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus / Clinocottus	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomacentridae	damselfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Scombridae unid.	mackerels & tunas	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Invertebrates														
Emerita analoga (zoea)	mole crab	428	237	619.7	78	168.3	-	-	2	4.9	89	244.9	22	58.8
Cancer gracilis (meg.)	slender crab	47	2	5.8	4	10.8	11	29.2	7	19.2	15	42.0	8	23.2
Cancer antennarius (meg.)	brown rock crab	33	2	5.8	5	13.4	9	23.9	5	13.3	5	14.3	7	19.8
Cancer anthonyi (meg.)	yellow crab	60	13	36.7	8	21.3	9	23.9	7	18.8	17	46.6	6	16.8
Cancer spp. (meg.)	cancer crabs	2	-	-	1	2.6	-	-	1	2.5	-	-	-	-
Cancer oregonsis (zoea V)	pygmy rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (meg.)	red rock crab	1	-	-	-	-	-	-	1	2.8	-	-	-	-
Panulirus interruptus	California spiny lobster	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	1,827	493		366		180		306		284		198	

Appendix B-2. (Continued).

Survey: 45		Stations	D2		D4		O2		O4		U2		U4	
Start Date: 08/31/04		Sample Count	8		8		8		8		8		8	
Taxon	Common Name	Survey Count	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc	Count	Mean Conc
Gobiidae unid.	gobies	823	162	462.9	412	1,177.3	26	75.5	-	-	64	157.6	159	443.0
Engraulis mordax	northern anchovy	114	13	35.3	15	42.7	29	83.1	24	63.2	19	49.9	14	40.7
Seriphus politus	queenfish	1,023	133	351.2	408	1,151.7	100	289.0	104	274.9	73	180.8	205	560.8
Genyonemus lineatus	white croaker	259	-	-	-	-	118	345.8	132	367.9	9	25.3	-	-
Sciaenidae unid.	croaker	402	25	68.3	6	18.3	108	304.7	133	379.9	44	105.7	86	261.2
Paralichthys californicus	California halibut	251	7	21.8	3	8.8	50	137.2	147	408.1	27	50.9	17	43.5
Hypsoblennius spp.	blennies	142	7	21.2	2	6.2	28	67.5	66	180.3	13	23.4	26	77.4
Paralabrax spp.	sand bass	212	10	27.9	2	6.6	50	149.0	118	315.2	14	28.6	18	53.2
Paralabrax clathratus	kelp bass	151	4	14.8	1	3.0	33	99.3	95	277.6	11	26.5	7	21.7
Atherinopsis californiensis	jacksmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Chromis punctipinnis	blacksmith	162	-	-	-	-	5	11.2	156	361.3	-	-	1	3.0
larvae, unidentified yolksac	larvae	106	3	8.4	2	5.7	42	101.8	22	60.2	12	18.8	25	72.2
Sphyraena argentea	California barracuda	142	4	15.1	-	-	32	95.2	98	258.0	4	10.6	4	9.8
Sardinops sagax	Pacific sardine	143	-	-	-	-	33	94.4	86	241.9	11	29.4	13	36.2
Hypsopsetta guttulata	diamond turbot	17	4	11.3	2	5.3	3	7.6	2	6.2	2	3.5	4	9.8
Citharichthys stigmaeus	speckled sanddab	47	-	-	-	-	4	9.8	40	112.6	1	3.5	2	4.4
Engraulidae	anchovies	3	1	2.5	1	3.6	-	-	1	2.8	-	-	-	-
Lepidogobius lepidus	bay goby	-	-	-	-	-	-	-	-	-	-	-	-	-
larval fish fragment	unidentified larval fishes	41	2	5.0	2	5.1	9	23.9	16	45.4	12	22.6	-	-
Leuresthes tenuis	California grunion	4	1	2.5	-	-	1	3.2	-	-	2	5.4	-	-
Pleuronichthys ritteri	spotted turbot	46	2	6.9	-	-	11	27.7	25	66.6	3	5.2	5	13.8
Pleuronichthys verticalis	hornyhead turbot	31	-	-	-	-	6	17.2	22	59.4	1	2.1	2	5.0
Ophidion scrippsae	basketweave cusk-eel	63	-	-	-	-	7	21.4	55	145.7	1	1.4	-	-
Cheilotrema saturnum	black croaker	19	1	2.8	3	8.7	5	13.7	4	11.9	3	5.2	3	8.6
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxyjulis californica	senorita	29	1	2.8	2	5.2	4	12.7	17	43.3	2	4.7	3	8.3
Roncador stearnsi	spotfin croaker	40	6	19.9	3	8.5	1	1.8	1	2.9	13	30.1	16	39.8
Xenistius califoriensis	salema	46	-	-	-	-	24	72.6	19	55.3	2	5.1	1	3.0
Atherinopsidae	silverside	-	-	-	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	larval fishes	11	2	5.0	-	-	-	-	8	24.5	-	-	1	3.2
Hypsoblennius jenkinsi	mussel blenny	34	1	2.5	-	-	6	15.3	23	55.9	2	5.0	2	5.0
Ilypnus gilberti	cheekspot goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophidiidae unid.	cusk-eels	36	3	8.1	-	-	10	28.2	19	58.1	1	2.1	3	8.7
Gillichthys mirabilis	longjaw mudsucker	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys spp.	turbots	12	-	-	-	-	2	3.6	6	16.3	3	9.2	1	3.1
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	yellowfin goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsypops rubicundus	garibaldi	1	-	-	-	-	-	-	-	-	-	-	1	2.5
Xystreurys liolepis	fantail sole	19	-	-	-	-	7	16.3	7	19.3	2	5.7	3	7.6
Triphoturus mexicanus	Mexican lampfish	4	-	-	2	5.3	-	-	2	5.1	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Atractoscion nobilis	white seabass	1	-	-	-	-	1	1.8	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	7	-	-	1	2.9	-	-	-	-	-	-	6	17.0
Citharichthys sordidus	Pacific sanddab	3	-	-	-	-	-	-	3	7.3	-	-	-	-
Semicossyphus pulcher	California sheephead	12	-	-	-	-	5	13.0	7	15.6	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	2	-	-	1	2.9	-	-	1	2.8	-	-	-	-
Hippoglossina stomata	bigmouth sole	5	-	-	-	-	2	6.0	3	8.6	-	-	-	-
Peprilus simillimus	Pacific butterfish	7	-	-	-	-	1	3.0	6	19.1	-	-	-	-
Pleuronectidae unid.	flounders	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	4	-	-	1	2.9	1	2.9	1	2.3	-	-	1	2.8
Paralichthyidae unid.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Symphurus atricauda	California tonguefish	6	-	-	-	-	-	-	6	15.3	-	-	-	-
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	blackeye goby	2	-	-	-	-	-	-	2	5.7	-	-	-	-
Diaphus theta	California headlight fish	-	-	-	-	-	-	-	-	-	-	-	-	-

(continued)

Appendix B-2. (Continued).

Survey: 45 (continued)		**Stations**	**D2**		**D4**		**O2**		**O4**		**U2**		**U4**	
Start Date: 08/31/04		**Sample Count**	**8**		**8**		**8**		**8**		**8**		**8**	
		Survey		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**		**Mean**
Taxon	**Common Name**	**Count**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**	**Count**	**Conc**
Atherinidae unid.	silversides	4	-	-	1	2.9	-	-	3	8.8	-	-	-	-
Haemulidae	grunts	1	-	-	-	-	-	-	-	-	1	2.1	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-
Etrumeus teres	round herring	3	-	-	-	-	1	3.2	2	5.5	-	-	-	-
Halichoeres semicinctus	rock wrasse	3	-	-	-	-	1	3.2	2	6.2	-	-	-	-
Lythrypnus spp.	gobies	-	-	-	-	-	-	-	-	-	-	-	-	-
Medialuna californiensis	halfmoon	3	-	-	-	-	1	2.9	1	2.1	-	-	1	2.5
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Clevelandia ios	arrow goby	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox rhessodon	California clingfish	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-
Kyphosidae	sea chubs	2	-	-	-	-	-	-	2	5.4	-	-	-	-
Labridae	wrasses	2	-	-	-	-	2	5.8	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-
Anisotremus davidsonii	sargo	1	-	-	-	-	-	-	-	-	-	-	1	3.1
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	1	-	-	-	-	1	2.7	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	1	-	-	-	-	1	1.8	-	-	-	-	-	-
Cottidae unid.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Girella nigricans	opaleye	1	-	-	-	-	1	3.3	-	-	-	-	-	-
Gobiesocidae unid.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus / Clinocottus	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomacentridae	damselfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Scombridae unid.	mackerels & tunas	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpaenidae	scorpionfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-
Invertebrates														
Emerita analoga (zoea)	mole crab	239	3	10.6	-	-	91	261.6	9	22.3	135	330.1	1	2.5
Cancer gracilis (meg.)	slender crab	11	1	3.0	1	2.9	2	5.8	3	8.6	4	9.1	-	-
Cancer antennarius (meg.)	brown rock crab	23	1	2.4	1	2.9	3	9.0	3	7.7	13	32.4	2	5.1
Cancer anthonyi (meg.)	yellow crab	12	-	-	-	-	2	5.8	2	5.7	7	15.4	1	2.5
Cancer spp. (meg.)	cancer crabs	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer oregonsis (zoea V)	pygmy rock crab	2	-	-	-	-	-	-	-	-	2	5.7	-	-
Cancer productus (meg.)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-
Panulirus interruptus	California spiny lobster	-	-	-	-	-	-	-	-	-	-	-	-	-
		Total: 4,791	397		872		870		1,504		513		635	

Appendix B-3. Estimated entrainment of HBGS entrainment target species by survey.

			CIQ gobies		northern anchovy		spotfin croaker	
Survey	Date	Days in Period	Period Entrainment	Entrainment Std. Error	Period Entrainment	Entrainment Std. Error	Period Entrainment	Entrainment Std. Error
HBS001	9/18/2003	19	9,763,905	6,961,871	2,637,926	1,939,235	0	0
HBS002	9/29/2003	12	4,942,612	3,115,340	1,902,173	1,522,446	0	0
HBS003	10/13/2003	11	4,959,000	7,039,118	1,637,744	2,018,418	0	0
HBS004	10/20/2003	10	2,042,279	2,349,529	1,459,738	2,490,356	0	0
HBS005	11/3/2003	11	1,858,154	1,753,450	279,946	559,892	0	0
HBS006	11/10/2003	7	34,621	69,243	417,603	404,931	0	0
HBS007	11/17/2003	7	2,506,595	3,467,022	345,362	471,093	0	0
HBS008	11/24/2003	7	937,064	866,153	68,105	80,295	0	0
HBS009	12/1/2003	7	1,780,282	2,377,385	105,454	125,473	0	0
HBS010	12/8/2003	7	359,485	457,961	322,292	295,833	0	0
HBS011	12/15/2003	7	3,303,348	1,963,821	2,417,927	3,434,637	0	0
HBS012	12/22/2003	7	1,783,140	2,128,965	152,890	205,972	0	0
HBS013	12/29/2003	7	1,559,717	763,133	379,870	581,588	0	0
HBS014	1/5/2004	7	1,232,451	1,579,086	149,928	210,800	0	0
HBS015	1/12/2004	7	1,436,569	1,177,765	75,086	150,172	0	0
HBS016	1/19/2004	7	1,054,365	1,047,181	186,833	230,674	0	0
HBS017	1/26/2004	7	2,889,116	1,226,888	33,218	66,435	0	0
HBS018	2/2/2004	7	182,559	267,950	0	0	0	0
HBS019	2/9/2004	7	562,313	382,491	34,337	68,674	0	0
HBS020	2/17/2004	7	249,875	217,546	72,535	84,274	0	0
HBS021	2/23/2004	8	4,333,117	7,624,209	0	0	0	0
HBS022	3/3/2004	7	161,125	0	0	0	0	.
HBS023	3/8/2004	6	1,578,937	1,577,955	386,427	616,148	0	0
HBS024	3/15/2004	7	3,323,459	1,942,136	470,690	551,490	0	0
HBS025	3/22/2004	10	2,577,297	1,716,506	1,322,354	1,568,970	0	0
HBS027	4/5/2004	11	1,641,550	1,962,205	761,976	1,028,047	0	0
HBS028	4/12/2004	7	461,735	537,881	596,744	801,731	0	0
HBS029	4/19/2004	5	1,554,008	1,621,313	842,925	451,615	0	0
HBS030	4/23/2004	7	40,499	70,146	695,085	650,715	0	0
HBS031	5/3/2004	7	4,943,840	2,929,025	2,541,328	2,527,280	64,409	74,431
HBS032	5/7/2004	7	2,574,053	2,453,940	938,986	595,791	0	0
HBS033	5/17/2004	9	1,614,503	1,976,404	1,197,871	624,159	315,526	215,633
HBS034	5/24/2004	7	680,326	366,737	2,409,481	2,238,136	359,224	171,155
HBS035	6/1/2004	7	996,027	767,680	4,993,619	6,324,286	0	0
HBS036	6/7/2004	7	318,403	313,129	143,152	118,181	0	0
HBS037	6/14/2004	7	1,236,673	1,060,869	2,256,271	1,149,322	794,500	726,474
HBS038	6/21/2004	7	1,879,662	1,193,451	3,114,339	2,827,049	0	0
HBS039	6/28/2004	7	1,623,829	2,261,321	3,303,799	2,689,029	60,830	121,660
HBS040	7/6/2004	7	6,583,673	4,467,024	570,105	399,564	5,464,332	6,178,803
HBS041	7/12/2004	7	5,758,655	7,215,916	2,583,753	2,359,182	0	0
HBS042	7/19/2004	7	4,016,186	5,722,304	1,603,501	1,939,648	0	0
HBS043	7/26/2004	18	6,835,518	3,163,680	8,326,402	7,846,825	282,947	370,068
HBS044	8/24/2004	18	9,915,429	1,879,568	1,614,609	2,343,448	62,317,931	35,251,477
HBS045	8/31/2004	8	5,080,879	2,284,615	996,637	1,290,573	41,890	83,780
			113,166,833		54,349,021		69,701,589	

Appendix B-3. (Continued).

			queenfish		white croaker		black croaker	
Survey	Date	Days in Period	Period Entrainment	Entrainment Std. Error	Period Entrainment	Entrainment Std. Error	Period Entrainment	Entrainment Std. Error
HBS001	9/18/2003	19	0	0	621,719	1,001,194	87,422	174,845
HBS002	9/29/2003	12	0	0	446,570	488,034	0	0
HBS003	10/13/2003	11	0	0	236,706	354,742	0	0
HBS004	10/20/2003	10	0	0	306,897	379,484	0	0
HBS005	11/3/2003	11	0	0	63,669	127,338	0	0
HBS006	11/10/2003	7	0	0	69,941	80,769	0	0
HBS007	11/17/2003	7	0	0	506,437	394,563	0	0
HBS008	11/24/2003	7	0	0	582,951	539,511	0	0
HBS009	12/1/2003	7	0	0	173,834	347,668	0	0
HBS010	12/8/2003	7	0	0	360,166	630,777	0	0
HBS011	12/15/2003	7	0	0	1,123,540	893,076	0	0
HBS012	12/22/2003	7	0	0	114,657	229,314	0	0
HBS013	12/29/2003	7	0	0	32,042	64,085	0	0
HBS014	1/5/2004	7	0	0	280,532	462,330	0	0
HBS015	1/12/2004	7	0	0	827,911	1,552,401	0	0
HBS016	1/19/2004	7	0	0	1,268,216	295,474	0	0
HBS017	1/26/2004	7	0	0	379,601	466,112	0	0
HBS018	2/2/2004	7	0	0	0	0	0	0
HBS019	2/9/2004	7	0	0	208,937	233,414	0	0
HBS020	2/17/2004	7	0	0	96,196	118,796	0	0
HBS021	2/23/2004	8	0	0	0	0	0	0
HBS022	3/3/2004	7	0	0	161,125	0	0	
HBS023	3/8/2004	6	0	0	160,882	244,948	0	0
HBS024	3/15/2004	7	0	0	70,552	81,619	0	0
HBS025	3/22/2004	10	0	0	1,036,912	974,438	0	0
HBS027	4/5/2004	11	0	0	54,242	108,484	0	0
HBS028	4/12/2004	7	0	0	1,116,812	1,304,875	0	0
HBS029	4/19/2004	5	0	0	936,570	876,949	0	0
HBS030	4/23/2004	7	0	0	752,025	900,105	95,558	82,768
HBS031	5/3/2004	7	0	0	1,852,787	1,406,469	0	0
HBS032	5/7/2004	7	0	0	1,580,468	1,410,789	0	0
HBS033	5/17/2004	9	536,753	369,006	1,239,186	1,286,931	348,260	316,953
HBS034	5/24/2004	7	61,100	70,552	526,170	571,779	30,510	61,020
HBS035	6/1/2004	7	0	0	235,136	299,384	0	0
HBS036	6/7/2004	7	0	0	30,937	61,873	0	0
HBS037	6/14/2004	7	327,588	335,536	33,479	66,958	108,195	130,697
HBS038	6/21/2004	7	0	0	61,956	123,912	0	0
HBS039	6/28/2004	7	108,219	146,983	0	0	97,189	194,379
HBS040	7/6/2004	7	78,202	90,391	39,027	78,054	121,023	242,045
HBS041	7/12/2004	7	995,105	1,178,519	0	0	0	0
HBS042	7/19/2004	7	388,690	609,623	0	0	0	0
HBS043	7/26/2004	18	647,366	788,438	0	0	638,447	311,889
HBS044	8/24/2004	18	9,716,995	5,305,198	0	0	5,571,043	6,231,731
HBS045	8/31/2004	8	4,949,845	5,620,490	36,473	72,946	30,480	60,961
			17,809,863		17,625,261		7,128,127	

Appendix B-3. (Continued).

			salema		combtooth blennies		diamond turbot	
Survey	Date	Days in Period	Period Entrainment	Entrainment Std. Error	Period Entrainment	Entrainment Std. Error	Period Entrainment	Entrainment Std. Error
HBS001	9/18/2003	19	0	0	0	0	0	0
HBS002	9/29/2003	12	0	0	51,247	102,494	0	0
HBS003	10/13/2003	11	0	0	0	0	113,051	132,009
HBS004	10/20/2003	10	0	0	0	0	95,824	191,647
HBS005	11/3/2003	11	0	0	583,665	447,948	231,263	317,251
HBS006	11/10/2003	7	0	0	376,866	648,490	41,219	82,437
HBS007	11/17/2003	7	0	0	0	0	30,721	61,443
HBS008	11/24/2003	7	0	0	67,602	79,898	114,442	138,476
HBS009	12/1/2003	7	0	0	70,715	83,050	76,696	88,567
HBS010	12/8/2003	7	0	0	68,837	137,674	0	0
HBS011	12/15/2003	7	0	0	35,768	71,536	0	0
HBS012	12/22/2003	7	0	0	41,052	82,105	74,541	86,104
HBS013	12/29/2003	7	0	0	0	0	132,535	107,157
HBS014	1/5/2004	7	0	0	38,047	76,093	38,138	76,277
HBS015	1/12/2004	7	0	0	0	0	0	0
HBS016	1/19/2004	7	0	0	0	0	38,197	76,394
HBS017	1/26/2004	7	0	0	0	0	108,261	136,499
HBS018	2/2/2004	7	0	0	0	0	34,546	69,092
HBS019	2/9/2004	7	0	0	35,303	70,606	0	0
HBS020	2/17/2004	7	0	0	32,435	64,870	68,528	79,354
HBS021	2/23/2004	8	0	0	0	0	0	0
HBS022	3/3/2004	7	0	.	0	.	0	.
HBS023	3/8/2004	6	0	0	0	0	36,655	73,310
HBS024	3/15/2004	7	0	0	0	0	0	0
HBS025	3/22/2004	10	0	0	0	0	52,640	105,281
HBS027	4/5/2004	11	0	0	0	0	53,246	106,491
HBS028	4/12/2004	7	0	0	29,420	58,841	158,273	120,180
HBS029	4/19/2004	5	0	0	99,789	105,033	62,176	107,692
HBS030	4/23/2004	7	0	0	100,926	92,375	47,301	81,927
HBS031	5/3/2004	7	0	0	0	0	0	0
HBS032	5/7/2004	7	0	0	204,519	179,587	95,083	164,689
HBS033	5/17/2004	9	0	0	440,064	523,694	144,449	99,099
HBS034	5/24/2004	7	0	0	240,389	131,691	0	0
HBS035	6/1/2004	7	0	0	91,995	118,095	0	0
HBS036	6/7/2004	7	0	0	212,576	84,337	0	0
HBS037	6/14/2004	7	0	0	404,869	297,390	0	0
HBS038	6/21/2004	7	0	0	102,892	69,495	0	0
HBS039	6/28/2004	7	0	0	1,406,634	710,572	0	0
HBS040	7/6/2004	7	0	0	299,867	599,735	68,685	80,773
HBS041	7/12/2004	7	0	0	163,288	196,416	0	0
HBS042	7/19/2004	7	0	0	539,435	277,308	34,014	68,027
HBS043	7/26/2004	18	86,333	172,666	295,574	392,788	0	0
HBS044	8/24/2004	18	11,610,627	22,003,691	982,007	833,364	3,492,636	1,818,773
HBS045	8/31/2004	8	0	0	149,729	178,757	0	0
			11,696,960		7,165,510		5,443,120	

Appendix B-3. (Continued).

			California halibut	
Survey	Date	Days in Period	Period Entrainment	Entrainment Std. Error
HBS001	9/18/2003	19	0	0
HBS002	9/29/2003	12	46,158	92,317
HBS003	10/13/2003	11	0	0
HBS004	10/20/2003	10	0	0
HBS005	11/3/2003	11	0	0
HBS006	11/10/2003	7	73,624	85,153
HBS007	11/17/2003	7	0	0
HBS008	11/24/2003	7	0	0
HBS009	12/1/2003	7	0	0
HBS010	12/8/2003	7	0	0
HBS011	12/15/2003	7	0	0
HBS012	12/22/2003	7	0	0
HBS013	12/29/2003	7	0	0
HBS014	1/5/2004	7	0	0
HBS015	1/12/2004	7	0	0
HBS016	1/19/2004	7	0	0
HBS017	1/26/2004	7	0	0
HBS018	2/2/2004	7	0	0
HBS019	2/9/2004	7	0	0
HBS020	2/17/2004	7	0	0
HBS021	2/23/2004	8	0	0
HBS022	3/3/2004	7	0	
HBS023	3/8/2004	6	0	0
HBS024	3/15/2004	7	0	0
HBS025	3/22/2004	10	0	0
HBS027	4/5/2004	11	0	0
HBS028	4/12/2004	7	31,110	62,221
HBS029	4/19/2004	5	35,728	61,883
HBS030	4/23/2004	7	445,098	333,817
HBS031	5/3/2004	7	102,680	132,680
HBS032	5/7/2004	7	0	0
HBS033	5/17/2004	9	51,305	102,609
HBS034	5/24/2004	7	66,638	78,421
HBS035	6/1/2004	7	53,075	106,150
HBS036	6/7/2004	7	0	0
HBS037	6/14/2004	7	1,690,567	866,751
HBS038	6/21/2004	7	29,508	59,016
HBS039	6/28/2004	7	136,144	180,466
HBS040	7/6/2004	7	46,767	93,535
HBS041	7/12/2004	7	107,760	137,465
HBS042	7/19/2004	7	34,014	68,027
HBS043	7/26/2004	18	739,401	568,589
HBS044	8/24/2004	18	1,240,150	803,738
HBS045	8/31/2004	8	91,441	182,882
			5,021,168	

Appendix C

Impingement Data

Appendix C-1. Extrapolated normal operations and heat treatment fish impingement losses by survey.

	Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
	Survey No.:	1	2	3	4	5	6
	Date:	29-Jul-03	5-Aug-03	12-Aug-03	22-Aug-03	26-Aug-03	3-Sep-03
Seriphus politus	queenfish	32	6	-	-	23	31
Genyonemus lineatus	white croaker	13	-	-	-	82	5
Engraulis mordax	northern anchovy	25	-	-	-	6	51
Phanerodon furcatus	white seaperch	32	-	-	-	-	5
Cymatogaster aggregata	shiner perch	13	-	10	-	29	82
Hyperprosopon argenteum	walleye surfperch	6	12	-	-	-	-
Paralichthys californicus	California halibut	-	-	10	-	-	5
Myliobatis californica	bat ray	-	-	-	-	12	-
Porichthys myriaster	specklefin midshipman	-	-	-	-	6	-
Sardinops sagax	Pacific sardine	-	-	-	-	29	5
Peprilus simillimus	Pacific butterfish	-	-	-	-	12	31
Pleuronichthys verticalis	hornyhead turbot	-	-	-	-	6	-
Cheilotrema saturnum	black croaker	-	-	-	-	-	-
Halichoeres semicinctus	rock wrasse	-	-	-	-	-	-
Menticirrhus undulatus	California corbina	-	-	-	-	-	-
Scorpaena guttata	California scorpionfish	-	-	-	-	-	-
Medialuna californiensis	halfmoon	-	-	-	-	-	-
Girella nigricans	opaleye	-	-	-	-	-	-
Anisotremus davidsonii	sargo	-	-	-	-	-	-
Heterostichus rostratus	giant kelpfish	-	-	-	-	-	-
Embiotoca jacksoni	black perch	-	-	-	-	-	-
Chromis punctipinnis	blacksmith	-	-	-	-	-	-
Rhacochilus vacca	pile perch	-	-	-	-	-	-
Umbrina roncador	yellowfin croaker	-	-	-	-	-	-
Sebastes auriculatus	brown rockfish	-	-	-	-	-	-
Paralabrax nebulifer	barred sand bass	-	-	-	-	-	-
Paralabrax clathratus	kelp bass	-	-	-	-	-	-
Rhinobatos productus	shovelnose guitarfish	-	-	-	-	-	-
Atherinopsis californiensis	jacksmelt	-	-	-	-	-	-
Leuresthes tenuis	California grunion	-	-	-	-	-	-
Platyrhinoidis triseriata	thornback	-	-	-	-	-	5
Leptocottus armatus	Pacific staghorn sculpin	-	-	-	-	-	10
Synodus lucioceps	California lizardfish	-	-	-	-	-	5
Pleuronichthys ritteri	spotted turbot	-	-	-	-	-	-
Paralabrax maculatofasciatus	spotted sand bass	-	-	-	-	-	-
Trachurus symmetricus	jack mackerel	-	-	-	-	-	-
Atherinops affinis	topsmelt	-	-	-	-	-	-
Hypsoblennius gilberti	rockpool blenny	-	-	-	-	-	-
Citharichthys stigmaeus	speckled sanddab	-	-	-	-	-	-
Atractoscion nobilis	white seabass	-	-	-	-	-	-
Scomber japonicus	chub mackerel	-	-	-	-	-	-
Xenistius californiensis	salema	-	-	-	-	-	-
Rhacochilus toxotes	rubberlip seaperch	-	-	-	-	-	-
Urobatis halleri	round stingray	-	-	-	-	-	-
Torpedo californica	Pacific electric ray	-	-	-	-	-	-
Ophichthus zophochir	yellow snake eel	-	-	-	-	-	-
Roncador stearnsii	spotfin croaker	-	-	-	-	-	-
Pleuronichthys guttulatus	diamond turbot	-	-	-	-	-	-
Anchoa compressa	deepbody anchovy	-	-	-	-	-	-
Semicossyphus pulcher	California sheephead	-	-	-	-	-	-
Triakis semifasciata	leopard shark	-	-	-	-	-	-
Chilara taylori	spotted cusk eel	-	-	-	-	-	-
Syngnathus californiensis	kelp pipefish	-	-	-	-	-	-
Sebastes miniatus	vermillion rockfish	-	-	-	-	-	-
Ophidion scrippsae	basketweave cusk-eel	-	-	-	-	-	-
Odontopyxis trispinosa	pygmy poacher	-	-	-	-	-	-
Porichthys notatus	plainfin midshipman	-	-	-	-	-	-
	Total:	121	19	19	-	204	236
	No. of Species:	6	2	2	-	9	11

Appendix C-1. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	7	8	9	10	11	12	13	14	15	16
Date:	10-Sep-03	16-Sep-03	23-Sep-03	30-Sep-03	7-Oct-03	14-Oct-03	21-Oct-03	28-Oct-03	4-Nov-03	11-Nov-03
queenfish	-	-	47	-	28	52	208	1190	50	-
white croaker	-	-	-	-	-	-	-	-	-	-
northern anchovy	-	29	250	-	-	59	28	106	-	-
white seaperch	-	-	-	-	-	-	-	-	-	-
shiner perch	-	-	68	-	-	-	-	-	-	-
walleye surfperch	-	-	-	-	-	-	-	-	-	-
California halibut	-	-	-	-	-	-	-	-	-	-
bat ray	-	-	-	-	-	-	7	-	-	-
specklefin midshipman	-	-	7	-	-	7	-	-	-	-
Pacific sardine	-	-	-	-	7	-	-	-	-	-
Pacific butterfish	-	-	27	-	-	-	-	-	-	-
hornyhead turbot	-	-	7	-	7	-	-	7	-	-
black croaker	-	-	-	-	-	-	-	14	-	-
rock wrasse	-	-	-	-	-	-	-	-	-	-
California corbina	-	-	-	-	-	-	-	-	-	-
California scorpionfish	-	14	14	-	-	-	7	-	-	-
halfmoon	-	-	-	-	-	-	-	-	-	-
opaleye	-	-	-	-	-	-	-	-	-	-
sargo	-	-	-	-	-	-	-	-	-	-
giant kelpfish	-	-	-	-	7	7	-	-	-	-
black perch	-	-	-	-	-	-	-	-	-	-
blacksmith	-	-	-	-	-	7	-	-	-	-
pile perch	-	-	-	-	-	-	-	-	-	-
yellowfin croaker	-	-	-	-	-	-	-	-	-	-
brown rockfish	-	-	-	-	-	-	-	-	-	-
barred sand bass	-	-	-	-	-	-	-	-	-	-
kelp bass	-	-	-	-	-	-	-	-	-	-
shovelnose guitarfish	-	-	-	-	-	-	-	-	-	-
jacksmelt	-	-	-	-	-	-	-	-	-	-
California grunion	-	-	-	-	-	-	-	42	-	-
thornback	-	-	-	-	-	-	-	7	-	-
Pacific staghorn sculpin	-	-	-	-	-	-	-	-	-	-
California lizardfish	-	-	7	-	-	-	-	-	-	-
spotted turbot	-	-	14	-	-	15	-	-	-	-
spotted sand bass	-	-	-	-	-	-	-	-	-	-
jack mackerel	-	-	-	-	-	7	-	-	-	-
topsmelt	-	-	-	-	-	-	-	-	-	-
rockpool blenny	-	-	-	-	-	-	-	-	-	-
speckled sanddab	-	-	-	-	-	7	-	-	-	-
white seabass	-	-	-	-	-	-	-	-	-	-
chub mackerel	-	-	-	-	-	-	-	-	-	-
salema	-	-	-	-	-	-	-	-	-	-
rubberlip seaperch	-	-	-	-	-	-	-	-	-	-
round stingray	-	-	-	-	-	-	-	-	-	-
Pacific electric ray	-	-	-	-	-	-	-	-	-	-
yellow snake eel	-	-	-	-	-	-	-	-	-	-
spotfin croaker	-	-	-	-	-	-	-	-	-	-
diamond turbot	-	-	-	-	-	-	-	-	-	-
deepbody anchovy	-	-	-	-	-	-	-	-	-	-
California sheephead	-	-	-	-	-	-	-	-	-	-
leopard shark	-	-	-	-	-	-	-	-	-	-
spotted cusk eel	-	-	-	-	-	-	-	-	-	-
kelp pipefish	-	-	-	-	-	-	-	-	-	-
vermillion rockfish	-	-	-	-	-	-	-	-	-	-
basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-
pygmy poacher	-	-	-	-	-	-	-	-	-	-
plainfin midshipman	-	-	-	-	-	-	-	-	-	-
Total:	-	43	439	-	49	163	250	1366	50	-
No. of Species:	-	2	9	-	4	8	4	6	1	-

Appendix C-1. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	17	18	19	20	21	22	23	24	25	26
Date:	20-Nov-03	28-Nov-03	2-Dec-03	9-Dec-03	16-Dec-03	23-Dec-03	30-Dec-03	9-Jan-04	16-Jan-04	20-Jan-04
queenfish	-	-	-	-	370	21	21	7	-	14
white croaker	-	-	-	-	-	-	-	-	-	-
northern anchovy	7	-	-	-	6	7	7	-	-	21
white seaperch	-	-	-	-	-	-	-	-	-	-
shiner perch	-	-	-	-	-	-	-	-	-	-
walleye surfperch	-	-	-	-	-	-	-	-	-	-
California halibut	-	-	-	-	-	-	-	-	-	-
bat ray	-	-	-	-	-	-	-	-	-	-
specklefin midshipman	-	-	-	-	37	-	14	-	-	-
Pacific sardine	-	-	-	-	-	-	-	-	-	-
Pacific butterfish	-	-	-	-	-	-	-	-	-	-
hornyhead turbot	-	-	-	-	-	-	-	-	-	-
black croaker	-	-	-	-	-	7	-	-	-	-
rock wrasse	-	-	-	-	-	-	-	-	-	-
California corbina	-	-	-	-	-	-	-	-	-	-
California scorpionfish	-	-	-	-	-	-	-	-	-	-
halfmoon	-	-	-	-	-	-	-	-	-	-
opaleye	-	7	-	-	-	-	-	-	-	-
sargo	-	-	-	-	-	-	-	-	-	-
giant kelpfish	-	-	-	-	-	-	-	-	-	-
black perch	-	-	-	-	-	-	-	-	-	-
blacksmith	-	-	-	-	-	-	-	-	-	-
pile perch	-	-	-	-	-	-	-	-	-	-
yellowfin croaker	-	-	-	-	-	-	-	-	-	-
brown rockfish	-	-	-	-	-	-	-	-	-	-
barred sand bass	-	-	-	-	-	-	-	-	-	-
kelp bass	-	-	-	-	-	-	-	-	-	-
shovelnose guitarfish	-	-	-	-	-	-	-	-	-	-
jacksmelt	-	-	-	-	-	-	-	-	-	-
California grunion	-	-	-	-	-	-	-	-	-	-
thornback	-	-	-	-	-	-	-	-	-	-
Pacific staghorn sculpin	-	-	-	-	-	-	7	-	-	-
California lizardfish	-	-	-	-	-	-	-	-	-	-
spotted turbot	-	-	-	-	-	-	7	-	-	-
spotted sand bass	-	-	-	-	-	-	-	-	-	-
jack mackerel	-	-	-	-	-	-	-	-	-	-
topsmelt	-	-	-	-	-	-	-	-	-	-
rockpool blenny	-	-	-	-	-	-	-	-	-	-
speckled sanddab	-	-	-	-	-	-	7	-	-	-
white seabass	-	-	-	-	-	-	-	-	-	-
chub mackerel	-	-	-	-	-	-	-	-	-	-
salema	-	-	-	-	-	-	-	-	-	-
rubberlip seaperch	-	-	-	-	-	-	-	-	-	-
round stingray	-	-	-	-	-	-	-	-	-	-
Pacific electric ray	-	-	-	-	6	-	-	-	-	-
yellow snake eel	-	-	-	-	6	-	-	-	-	-
spotfin croaker	-	-	-	-	-	-	-	-	-	-
diamond turbot	-	-	-	-	-	-	-	-	-	-
deepbody anchovy	-	-	-	-	-	-	-	-	-	-
California sheephead	-	-	-	-	-	-	-	-	-	-
leopard shark	-	-	-	-	-	-	-	-	-	-
spotted cusk eel	-	-	-	-	-	-	-	-	-	-
kelp pipefish	-	-	-	-	-	-	-	-	-	-
vermillion rockfish	-	-	-	-	-	-	-	-	-	-
basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-
pygmy poacher	-	-	-	-	-	-	-	-	-	-
plainfin midshipman	-	-	-	-	-	-	-	-	-	-
Total:	7	7	-	-	426	35	63	7	-	35
No. of Species:	1	1	-	-	5	3	6	1	-	2

Appendix C-1. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	27	28	29	30	31	32	33	34	35	36
Date:	27-Jan-04	3-Feb-04	10-Feb-04	18-Feb-04	24-Feb-04	2-Mar-04	9-Mar-04	16-Mar-04	23-Mar-04	30-Mar-04
queenfish	7335	15	26	7	21	35	7	14	94	97
white croaker	17	-	-	-	-	-	-	-	-	-
northern anchovy	101	-	-	-	-	-	-	-	114	-
white seaperch	-	-	-	-	-	-	-	-	-	-
shiner perch	-	-	-	-	-	-	-	-	-	-
walleye surfperch	11	-	-	-	-	-	-	-	-	-
California halibut	-	-	-	-	-	-	-	-	-	-
bat ray	-	-	-	-	-	-	-	-	-	-
specklefin midshipman	-	-	-	-	-	28	-	-	-	-
Pacific sardine	-	8	-	-	-	-	-	7	-	-
Pacific butterfish	34	-	-	-	-	7	7	7	7	-
hornyhead turbot	-	-	-	-	-	-	-	-	-	-
black croaker	-	-	-	-	-	-	-	-	-	-
rock wrasse	-	-	-	-	-	-	-	-	-	-
California corbina	-	-	-	-	-	-	-	-	-	-
California scorpionfish	-	-	-	-	-	-	-	-	-	-
halfmoon	-	-	-	-	-	-	-	-	-	-
opaleye	-	-	-	-	-	-	-	-	-	-
sargo	-	-	-	-	-	-	-	-	-	-
giant kelpfish	-	-	-	-	-	7	-	-	-	-
black perch	-	-	-	-	-	-	-	-	-	-
blacksmith	-	-	-	-	-	-	-	-	-	-
pile perch	-	-	-	-	-	-	-	-	-	-
yellowfin croaker	-	-	-	-	-	-	-	-	-	-
brown rockfish	-	-	-	-	-	-	-	-	-	-
barred sand bass	-	-	-	-	-	7	-	-	-	-
kelp bass	-	-	-	-	-	-	-	-	-	-
shovelnose guitarfish	-	-	-	-	-	-	-	-	-	-
jacksmelt	17	-	-	-	-	-	-	-	-	-
California grunion	-	-	-	7	-	-	-	-	-	-
thornback	6	-	-	-	-	-	-	-	-	-
Pacific staghorn sculpin	-	-	-	-	-	-	-	-	-	-
California lizardfish	11	-	-	-	-	-	-	-	-	-
spotted turbot	-	-	-	-	-	-	-	-	-	-
spotted sand bass	-	-	-	-	-	-	-	-	-	-
jack mackerel	-	-	-	-	-	-	-	-	-	-
topsmelt	-	-	-	-	-	-	-	-	-	-
rockpool blenny	-	-	-	-	-	-	-	-	-	-
speckled sanddab	-	-	-	-	-	-	-	-	-	-
white seabass	11	-	-	-	-	-	-	-	-	-
chub mackerel	-	-	-	-	-	-	-	-	-	-
salema	11	-	-	-	-	-	-	-	-	-
rubberlip seaperch	-	-	-	-	-	-	-	-	-	-
round stingray	-	-	-	-	-	-	7	-	-	-
Pacific electric ray	11	-	-	-	-	-	-	-	-	7
yellow snake eel	-	-	-	-	-	-	-	-	-	-
spotfin croaker	-	-	-	-	-	-	-	-	-	-
diamond turbot	6	-	-	-	-	-	-	-	-	-
deepbody anchovy	-	-	-	-	-	-	-	-	-	-
California sheephead	-	-	-	-	-	-	-	-	-	-
leopard shark	-	-	-	-	-	-	-	-	-	-
spotted cusk eel	-	-	-	-	-	-	-	-	-	-
kelp pipefish	-	-	-	-	-	-	-	-	-	-
vermillion rockfish	-	-	-	-	-	-	-	-	-	-
basketweave cusk-eel	-	-	-	-	7	-	-	-	-	-
pygmy poacher	-	-	-	-	-	-	-	-	-	-
plainfin midshipman	-	-	-	-	-	-	-	-	-	-
Total:	7571	23	26	14	28	84	22	29	215	104
No. of Species:	12	2	1	2	2	5	3	3	3	2

Appendix C-1. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	37	38	39	40	41	42	43	44	45	46
Date:	6-Apr-04	13-Apr-04	20-Apr-04	27-Apr-04	4-May-04	11-May-04	18-May-04	25-May-04	3-Jun-04	8-Jun-04
queenfish	7	305	123	26	247	8	-	-	-	-
white croaker	-	65	12	13	68	-	-	-	-	-
northern anchovy	-	-	-	7	-	-	-	-	-	-
white seaperch	-	-	-	-	43	-	-	-	-	-
shiner perch	-	-	-	-	-	-	-	-	-	-
walleye surfperch	-	-	-	-	-	-	-	-	-	-
California halibut	-	-	-	-	-	-	-	-	-	-
bat ray	-	-	-	-	-	-	-	-	-	-
specklefin midshipman	-	-	-	-	-	-	-	-	-	-
Pacific sardine	-	6	-	-	-	-	-	-	-	-
Pacific butterfish	-	-	-	-	-	-	-	-	-	-
hornyhead turbot	-	-	-	-	-	-	-	-	-	-
black croaker	-	-	-	-	-	-	-	-	-	-
rock wrasse	-	-	-	-	-	-	-	-	-	-
California corbina	-	-	-	-	-	-	-	-	-	-
California scorpionfish	-	-	-	-	-	-	-	-	-	-
halfmoon	-	-	-	-	-	-	-	-	-	-
opaleye	-	-	-	-	-	-	-	-	-	-
sargo	-	-	-	-	-	-	-	-	-	-
giant kelpfish	-	-	-	-	-	-	-	-	-	-
black perch	-	-	12	-	-	-	-	-	-	-
blacksmith	-	-	-	-	-	-	-	-	-	-
pile perch	-	-	-	-	-	-	-	-	-	-
yellowfin croaker	-	-	-	-	-	-	-	-	-	-
brown rockfish	-	-	-	-	-	-	-	-	-	-
barred sand bass	-	-	-	-	-	-	-	-	-	-
kelp bass	-	-	-	-	-	-	-	-	-	-
shovelnose guitarfish	-	-	-	-	-	-	-	-	-	-
jacksmelt	-	-	-	-	6	-	-	-	-	-
California grunion	-	-	-	-	-	-	-	-	-	-
thornback	-	-	-	-	-	-	-	-	-	-
Pacific staghorn sculpin	-	-	-	-	-	-	-	-	-	-
California lizardfish	-	-	-	-	6	-	-	-	-	-
spotted turbot	-	-	-	-	-	-	-	-	-	-
spotted sand bass	-	-	-	-	-	-	-	-	-	-
jack mackerel	-	-	-	-	-	-	-	-	-	-
topsmelt	-	-	-	-	-	-	-	-	-	-
rockpool blenny	-	-	-	-	-	-	-	-	-	-
speckled sanddab	-	-	-	-	-	-	-	-	-	-
white seabass	-	-	-	-	-	-	-	-	-	-
chub mackerel	-	-	-	-	-	-	-	-	-	-
salema	-	-	-	-	-	-	-	-	-	-
rubberlip seaperch	-	-	-	-	-	-	-	-	-	-
round stingray	-	-	-	7	-	33	-	-	-	-
Pacific electric ray	-	-	-	-	-	-	-	-	-	-
yellow snake eel	-	-	-	-	-	-	-	-	-	-
spotfin croaker	-	-	-	-	-	-	-	-	-	-
diamond turbot	-	-	-	-	-	-	-	-	-	-
deepbody anchovy	-	6	-	-	-	-	-	-	-	-
California sheephead	-	-	-	-	-	-	-	-	-	-
leopard shark	-	-	-	-	-	-	-	-	-	-
spotted cusk eel	-	-	-	-	-	-	-	-	-	-
kelp pipefish	-	-	-	-	-	-	-	-	-	-
vermillion rockfish	-	-	-	-	-	-	-	-	-	-
basketweave cusk-eel	-	-	-	-	-	-	-	-	-	-
pygmy poacher	-	-	-	-	-	-	-	-	-	-
plainfin midshipman	-	-	-	-	-	-	-	9	-	-
Total:	7	383	146	52	370	41	-	9	-	-
No. of Species:	1	4	3	4	5	2	-	1	-	-

Appendix C-1. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	47	48	49	50	51	52
Date:	15-Jun-04	22-Jun-04	29-Jun-04	7-Jul-04	13-Jul-04	20-Jul-04
queenfish	-	-	-	-	-	-
white croaker	-	-	-	-	-	-
northern anchovy	-	-	-	-	-	-
white seaperch	-	-	-	-	-	-
shiner perch	-	-	-	-	-	14
walleye surfperch	-	-	-	-	-	-
California halibut	-	-	-	-	-	-
bat ray	-	-	-	-	-	-
specklefin midshipman	-	-	-	-	-	-
Pacific sardine	6	-	-	-	-	-
Pacific butterfish	-	-	-	-	-	-
hornyhead turbot	-	-	-	-	-	-
black croaker	-	-	-	-	-	-
rock wrasse	-	-	-	-	-	-
California corbina	-	-	-	-	-	-
California scorpionfish	-	-	-	-	-	-
halfmoon	-	-	-	-	-	-
opaleye	-	-	-	-	-	-
sargo	-	-	-	-	-	-
giant kelpfish	-	-	-	-	-	-
black perch	-	-	-	-	-	-
blacksmith	-	-	-	-	-	-
pile perch	-	-	-	-	-	-
yellowfin croaker	-	-	-	-	-	-
brown rockfish	-	-	-	-	-	-
barred sand bass	-	-	-	-	-	-
kelp bass	-	-	-	-	-	-
shovelnose guitarfish	-	-	-	-	-	-
jacksmelt	-	-	-	-	-	-
California grunion	-	-	-	-	-	-
thornback	-	-	-	-	-	-
Pacific staghorn sculpin	-	-	-	-	-	-
California lizardfish	-	-	-	-	-	-
spotted turbot	-	-	-	-	-	-
spotted sand bass	-	-	-	-	-	-
jack mackerel	-	-	-	-	-	-
topsmelt	-	-	-	-	-	-
rockpool blenny	-	-	-	-	-	-
speckled sanddab	-	-	-	-	-	-
white seabass	-	-	-	-	-	-
chub mackerel	-	-	-	-	-	-
salema	-	-	-	-	-	-
rubberlip seaperch	-	-	-	-	-	-
round stingray	-	-	-	6	-	-
Pacific electric ray	-	7	-	-	-	-
yellow snake eel	-	-	-	-	-	-
spotfin croaker	-	-	-	-	-	-
diamond turbot	-	-	-	-	-	-
deepbody anchovy	-	-	-	-	-	-
California sheephead	-	-	-	-	-	-
leopard shark	-	-	-	-	-	-
spotted cusk eel	-	-	-	-	-	-
kelp pipefish	-	-	-	-	-	-
vermillion rockfish	-	-	-	-	-	-
basketweave cusk-eel	-	-	-	-	-	-
pygmy poacher	-	-	-	-	-	-
plainfin midshipman	-	-	-	-	-	-
Total:	6	7	-	6	-	14
No. of Species:	1	1	-	1	-	1

Appendix C-1. (Cont.)

Survey Type:	Heat Treat	Heat Treat	Heat Treat	Heat Treat	Heat Treat	Heat Treat
Survey No.:	1	2	3	4	5	6
Date:	16-Aug-03	26-Sep-03	7-Nov-03	6-Jan-04	22-Feb-04	30-May-04
queenfish	3200	3548	4272	4529	4204	5626
white croaker	1192	497	17	44	10	2869
northern anchovy	70	643	167	482	4	3
white seaperch	386	102	86	64	61	90
shiner perch	665	2428	570	46	1	120
walleye surfperch	47	15	100	106	55	123
California halibut	2	1	2	-	-	1
bat ray	2	-	1	1	-	1
specklefin midshipman	-	-	-	1	-	-
Pacific sardine	2	17	4	-	14	1
Pacific butterfish	4	134	41	26	146	119
hornyhead turbot	-	-	-	1	-	-
black croaker	9	3	17	11	1	3
rock wrasse	1	2	1	-	-	-
California corbina	3	2	1	11	14	2
California scorpionfish	11	13	16	5	2	28
halfmoon	7	5	1	-	-	-
opaleye	4	2	-	-	1	5
sargo	5	-	8	4	-	-
giant kelpfish	1	1	1	6	-	-
black perch	1	5	9	3	2	34
blacksmith	1	13	12	8	-	5
pile perch	3	2	1	9	2	2
yellowfin croaker	1	5	-	-	-	-
brown rockfish	1	-	-	1	-	-
barred sand bass	12	20	20	3	-	-
kelp bass	45	28	46	4	1	14
shovelnose guitarfish	1	1	-	-	-	-
jacksmelt	20	5	18	22	48	196
California grunion	47	12	32	-	-	-
thornback	-	-	-	2	-	-
Pacific staghorn sculpin	-	-	-	3	-	-
California lizardfish	-	-	-	-	-	-
spotted turbot	-	-	-	4	-	-
spotted sand bass	-	1	-	-	-	-
jack mackerel	-	1	-	-	-	1
topsmelt	-	122	57	52	-	-
rockpool blenny	-	1	-	1	-	1
speckled sanddab	-	-	-	2	7	-
white seabass	-	-	8	21	8	12
chub mackerel	-	-	17	-	-	-
salema	-	-	3	17	14	1
rubberlip seaperch	-	-	1	-	-	16
round stingray	-	-	2	6	2	38
Pacific electric ray	-	-	-	-	-	-
yellow snake eel	-	-	-	-	1	-
spotfin croaker	-	-	-	28	-	21
diamond turbot	-	-	-	1	-	1
deepbody anchovy	-	-	-	2	6	6
California sheephead	-	-	-	1	-	-
leopard shark	-	-	-	2	-	-
spotted cusk eel	-	-	-	-	7	-
kelp pipefish	-	-	-	-	2	-
vermillion rockfish	-	-	-	-	1	-
basketweave cusk-eel	-	-	-	-	-	1
pygmy poacher	-	-	-	-	1	-
plainfin midshipman	-	-	1	-	-	-
Total:	5743	7629	5532	5529	4615	9340
No. of Species:	28	29	31	36	26	29

Appendix C-1. (Cont.)

Survey Type:	Normal Operations		Heat Treatments		
Survey No.:	Total	Occurrence	Total	Occurrence	Total
Date:	Abundance	(n=52)	Abundance	(n=6)	Impingement
queenfish	10468	31	25379	6	35847
white croaker	274	8	4629	6	4903
northern anchovy	824	16	1369	6	2193
white seaperch	80	3	789	6	869
shiner perch	215	6	3830	6	4045
walleye surfperch	30	3	446	6	476
California halibut	15	2	6	4	21
bat ray	19	2	5	4	24
specklefin midshipman	99	6	1	1	100
Pacific sardine	69	7	38	5	107
Pacific butterfish	131	8	470	6	601
hornyhead turbot	27	4	1	1	28
black croaker	21	2	44	6	65
rock wrasse	-	-	4	3	4
California corbina	-	-	33	6	33
California scorpionfish	35	3	75	6	110
halfmoon	-	-	13	3	13
opaleye	7	1	12	4	19
sargo	-	-	17	3	17
giant kelpfish	21	3	9	4	30
black perch	12	1	54	6	66
blacksmith	7	1	39	5	46
pile perch	-	-	19	6	19
yellowfin croaker	-	-	6	2	6
brown rockfish	-	-	2	2	2
barred sand bass	7	1	55	4	62
kelp bass	-	-	138	6	138
shovelnose guitarfish	-	-	2	2	2
jacksmelt	23	2	309	6	332
California grunion	49	2	91	3	140
thornback	18	3	2	1	20
Pacific staghorn sculpin	17	2	3	1	20
California lizardfish	29	4	-	-	29
spotted turbot	35	3	4	1	39
spotted sand bass	-	-	1	1	1
jack mackerel	7	1	2	2	9
topsmelt	-	-	231	3	231
rockpool blenny	-	-	3	3	3
speckled sanddab	14	2	9	2	23
white seabass	11	1	49	4	60
chub mackerel	-	-	17	1	17
salema	11	1	35	4	46
rubberlip seaperch	-	-	17	2	17
round stingray	52	4	48	4	100
Pacific electric ray	31	4	-	-	31
yellow snake eel	6	1	1	1	7
spotfin croaker	-	-	49	2	49
diamond turbot	6	1	2	2	8
deepbody anchovy	6	1	14	3	20
California sheephead	-	-	1	1	1
leopard shark	-	-	2	1	2
spotted cusk eel	-	-	7	1	7
kelp pipefish	-	-	2	1	2
vermillion rockfish	-	-	1	1	1
basketweave cusk-eel	7	1	1	1	8
pygmy poacher	-	-	1	1	1
plainfin midshipman	9	1	1	1	10
Total:	12694		38388		51082
No. of Species:	36		55		57

Appendix C-2. Extrapolated normal operation and heat treatment fish impingement biomass (kg) by survey.

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	1	2	3	4	5	6
Date:	29-Jul-03	5-Aug-03	12-Aug-03	22-Aug-03	26-Aug-03	3-Sep-03
queenfish	0.907	0.099	-	-	0.449	0.805
white croaker	0.444	-	-	-	1.120	0.056
northern anchovy	0.305	-	-	-	0.064	0.261
white seaperch	0.286	-	-	-	-	0.082
shiner perch	0.089	-	0.095	-	0.333	0.774
walleye surfperch	0.057	0.143	-	-	-	-
California halibut	-	-	3.827	-	-	0.241
bat ray	-	-	-	-	9.269	-
specklefin midshipman	-	-	-	-	1.989	-
Pacific sardine	-	-	-	-	2.444	0.318
Pacific butterfish	-	-	-	-	0.111	0.405
hornyhead turbot	-	-	-	-	0.023	-
black croaker	-	-	-	-	-	-
rock wrasse	-	-	-	-	-	-
California corbina	-	-	-	-	-	-
California scorpionfish	-	-	-	-	-	-
halfmoon	-	-	-	-	-	-
opaleye	-	-	-	-	-	-
sargo	-	-	-	-	-	-
giant kelpfish	-	-	-	-	-	-
black perch	-	-	-	-	-	-
blacksmith	-	-	-	-	-	-
pile perch	-	-	-	-	-	-
yellowfin croaker	-	-	-	-	-	-
brown rockfish	-	-	-	-	-	-
barred sand bass	-	-	-	-	-	-
kelp bass	-	-	-	-	-	-
shovelnose guitarfish	-	-	-	-	-	-
jacksmelt	-	-	-	-	-	-
California grunion	-	-	-	-	-	-
thornback	-	-	-	-	-	6.150
Pacific staghorn sculpin	-	-	-	-	-	0.149
California lizardfish	-	-	-	-	-	0.103
spotted turbot	-	-	-	-	-	-
spotted sand bass	-	-	-	-	-	-
jack mackerel	-	-	-	-	-	-
topsmelt	-	-	-	-	-	-
rockpool blenny	-	-	-	-	-	-
speckled sanddab	-	-	-	-	-	-
white seabass	-	-	-	-	-	-
chub mackerel	-	-	-	-	-	-
salema	-	-	-	-	-	-
rubberlip seaperch	-	-	-	-	-	-
round stingray	-	-	-	-	-	-
Pacific electric ray	-	-	-	-	-	-
yellow snake eel	-	-	-	-	-	-
spotfin croaker	-	-	-	-	-	-
diamond turbot	-	-	-	-	-	-
deepbody anchovy	-	-	-	-	-	-
California sheephead	-	-	-	-	-	-
leopard shark	-	-	-	-	-	-
spotted cusk eel	-	-	-	-	-	-
kelp pipefish	-	-	-	-	-	-
vermillion rockfish	-	-	-	-	-	-
basketweave cusk-eel	-	-	-	-	-	-
pygmy poacher	-	-	-	-	-	-
plainfin midshipman	-	-	-	-	-	-
Total:	2.088	0.242	3.922	-	15.803	9.343
No. of Species:	6	2	2	-	9	11

Appendix C-2. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	7	8	9	10	11	12	13	14
Date:	10-Sep-03	16-Sep-03	23-Sep-03	30-Sep-03	7-Oct-03	14-Oct-03	21-Oct-03	28-Oct-03
queenfish	-	-	0.891	-	0.147	1.177	0.688	3.712
white croaker	-	-	-	-	-	-	-	-
northern anchovy	-	0.216	2.315	-	-	0.348	0.104	0.556
white seaperch	-	-	-	-	-	-	-	-
shiner perch	-	-	0.628	-	-	-	-	-
walleye surfperch	-	-	-	-	-	-	-	-
California halibut	-	-	-	-	-	-	-	-
bat ray	-	-	-	-	-	-	1.390	-
specklefin midshipman	-	-	0.007	-	-	0.030	-	-
Pacific sardine	-	-	-	-	0.084	-	-	-
Pacific butterfish	-	-	0.331	-	-	-	-	-
hornyhead turbot	-	-	0.155	-	0.070	-	-	0.028
black croaker	-	-	-	-	-	-	-	0.092
rock wrasse	-	-	-	-	-	-	-	-
California corbina	-	-	-	-	-	-	-	-
California scorpionfish	-	2.549	1.937	-	-	-	1.042	-
halfmoon	-	-	-	-	-	-	-	-
opaleye	-	-	-	-	-	-	-	-
sargo	-	-	-	-	-	-	-	-
giant kelpfish	-	-	-	-	0.119	0.807	-	-
black perch	-	-	-	-	-	-	-	-
blacksmith	-	-	-	-	-	0.015	-	-
pile perch	-	-	-	-	-	-	-	-
yellowfin croaker	-	-	-	-	-	-	-	-
brown rockfish	-	-	-	-	-	-	-	-
barred sand bass	-	-	-	-	-	-	-	-
kelp bass	-	-	-	-	-	-	-	-
shovelnose guitarfish	-	-	-	-	-	-	-	-
jacksmelt	-	-	-	-	-	-	-	-
California grunion	-	-	-	-	-	-	-	0.169
thornback	-	-	-	-	-	-	-	5.747
Pacific staghorn sculpin	-	-	-	-	-	-	-	-
California lizardfish	-	-	0.776	-	-	-	-	-
spotted turbot	-	-	1.789	-	-	0.614	-	-
spotted sand bass	-	-	-	-	-	-	-	-
jack mackerel	-	-	-	-	-	0.030	-	-
topsmelt	-	-	-	-	-	-	-	-
rockpool blenny	-	-	-	-	-	-	-	-
speckled sanddab	-	-	-	-	-	0.022	-	-
white seabass	-	-	-	-	-	-	-	-
chub mackerel	-	-	-	-	-	-	-	-
salema	-	-	-	-	-	-	-	-
rubberlip seaperch	-	-	-	-	-	-	-	-
round stingray	-	-	-	-	-	-	-	-
Pacific electric ray	-	-	-	-	-	-	-	-
yellow snake eel	-	-	-	-	-	-	-	-
spotfin croaker	-	-	-	-	-	-	-	-
diamond turbot	-	-	-	-	-	-	-	-
deepbody anchovy	-	-	-	-	-	-	-	-
California sheephead	-	-	-	-	-	-	-	-
leopard shark	-	-	-	-	-	-	-	-
spotted cusk eel	-	-	-	-	-	-	-	-
kelp pipefish	-	-	-	-	-	-	-	-
vermillion rockfish	-	-	-	-	-	-	-	-
basketweave cusk-eel	-	-	-	-	-	-	-	-
pygmy poacher	-	-	-	-	-	-	-	-
plainfin midshipman	-	-	-	-	-	-	-	-
Total:	-	2.765	8.829	-	0.420	3.041	3.224	10.305
No. of Species:	-	2	9	-	4	8	4	6

Appendix C-2. (Cont.)

Survey Type: Survey No.: Date:	Normal Op 15 4-Nov-03	Normal Op 16 11-Nov-03	Normal Op 17 20-Nov-03	Normal Op 18 28-Nov-03	Normal Op 19 2-Dec-03	Normal Op 20 9-Dec-03	Normal Op 21 16-Dec-03	Normal Op 22 23-Dec-03
queenfish	0.162	-	-	-	-	-	1.289	0.238
white croaker	-	-	-	-	-	-	-	-
northern anchovy	-	-	0.028	-	-	-	0.019	0.035
white seaperch	-	-	-	-	-	-	-	-
shiner perch	-	-	-	-	-	-	-	-
walleye surfperch	-	-	-	-	-	-	-	-
California halibut	-	-	-	-	-	-	-	-
bat ray	-	-	-	-	-	-	-	-
specklefin midshipman	-	-	-	-	-	-	4.674	-
Pacific sardine	-	-	-	-	-	-	-	-
Pacific butterfish	-	-	-	-	-	-	-	-
hornyhead turbot	-	-	-	-	-	-	-	-
black croaker	-	-	-	-	-	-	-	0.238
rock wrasse	-	-	-	-	-	-	-	-
California corbina	-	-	-	-	-	-	-	-
California scorpionfish	-	-	-	-	-	-	-	-
halfmoon	-	-	-	-	-	-	-	-
opaleye	-	-	-	4.274	-	-	-	-
sargo	-	-	-	-	-	-	-	-
giant kelpfish	-	-	-	-	-	-	-	-
black perch	-	-	-	-	-	-	-	-
blacksmith	-	-	-	-	-	-	-	-
pile perch	-	-	-	-	-	-	-	-
yellowfin croaker	-	-	-	-	-	-	-	-
brown rockfish	-	-	-	-	-	-	-	-
barred sand bass	-	-	-	-	-	-	-	-
kelp bass	-	-	-	-	-	-	-	-
shovelnose guitarfish	-	-	-	-	-	-	-	-
jacksmelt	-	-	-	-	-	-	-	-
California grunion	-	-	-	-	-	-	-	-
thornback	-	-	-	-	-	-	-	-
Pacific staghorn sculpin	-	-	-	-	-	-	-	-
California lizardfish	-	-	-	-	-	-	-	-
spotted turbot	-	-	-	-	-	-	-	-
spotted sand bass	-	-	-	-	-	-	-	-
jack mackerel	-	-	-	-	-	-	-	-
topsmelt	-	-	-	-	-	-	-	-
rockpool blenny	-	-	-	-	-	-	-	-
speckled sanddab	-	-	-	-	-	-	-	-
white seabass	-	-	-	-	-	-	-	-
chub mackerel	-	-	-	-	-	-	-	-
salema	-	-	-	-	-	-	-	-
rubberlip seaperch	-	-	-	-	-	-	-	-
round stingray	-	-	-	-	-	-	-	-
Pacific electric ray	-	-	-	-	-	-	15.417	-
yellow snake eel	-	-	-	-	-	-	1.332	-
spotfin croaker	-	-	-	-	-	-	-	-
diamond turbot	-	-	-	-	-	-	-	-
deepbody anchovy	-	-	-	-	-	-	-	-
California sheephead	-	-	-	-	-	-	-	-
leopard shark	-	-	-	-	-	-	-	-
spotted cusk eel	-	-	-	-	-	-	-	-
kelp pipefish	-	-	-	-	-	-	-	-
vermillion rockfish	-	-	-	-	-	-	-	-
basketweave cusk-eel	-	-	-	-	-	-	-	-
pygmy poacher	-	-	-	-	-	-	-	-
plainfin midshipman	-	-	-	-	-	-	-	-
Total:	0.162	-	0.028	4.274	-	-	22.730	0.511
No. of Species:	1	-	1	1	-	-	5	3

Appendix C-2. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	23	24	25	26	27	28	29
Date:	30-Dec-03	9-Jan-04	16-Jan-04	20-Jan-04	27-Jan-04	3-Feb-04	10-Feb-04
queenfish	0.350	0.142	-	0.055	40.793	0.099	0.118
white croaker	-	-	-	-	0.951	-	-
northern anchovy	0.028	-	-	0.083	0.506	-	-
white seaperch	-	-	-	-	-	-	-
shiner perch	-	-	-	-	-	-	-
walleye surfperch	-	-	-	-	0.298	-	-
California halibut	-	-	-	-	-	-	-
bat ray	-	-	-	-	-	-	-
specklefin midshipman	3.353	-	-	-	-	-	-
Pacific sardine	-	-	-	-	-	0.106	-
Pacific butterfish	-	-	-	-	0.653	-	-
hornyhead turbot	-	-	-	-	-	-	-
black croaker	-	-	-	-	-	-	-
rock wrasse	-	-	-	-	-	-	-
California corbina	-	-	-	-	-	-	-
California scorpionfish	-	-	-	-	-	-	-
halfmoon	-	-	-	-	-	-	-
opaleye	-	-	-	-	-	-	-
sargo	-	-	-	-	-	-	-
giant kelpfish	-	-	-	-	-	-	-
black perch	-	-	-	-	-	-	-
blacksmith	-	-	-	-	-	-	-
pile perch	-	-	-	-	-	-	-
yellowfin croaker	-	-	-	-	-	-	-
brown rockfish	-	-	-	-	-	-	-
barred sand bass	-	-	-	-	-	-	-
kelp bass	-	-	-	-	-	-	-
shovelnose guitarfish	-	-	-	-	-	-	-
jacksmelt	-	-	-	-	1.643	-	-
California grunion	-	-	-	-	-	-	-
thornback	-	-	-	-	3.915	-	-
Pacific staghorn sculpin	0.721	-	-	-	-	-	-
California lizardfish	-	-	-	-	0.141	-	-
spotted turbot	0.035	-	-	-	-	-	-
spotted sand bass	-	-	-	-	-	-	-
jack mackerel	-	-	-	-	-	-	-
topsmelt	-	-	-	-	-	-	-
rockpool blenny	-	-	-	-	-	-	-
speckled sanddab	0.021	-	-	-	-	-	-
white seabass	-	-	-	-	0.135	-	-
chub mackerel	-	-	-	-	-	-	-
salema	-	-	-	-	0.101	-	-
rubberlip seaperch	-	-	-	-	-	-	-
round stingray	-	-	-	-	-	-	-
Pacific electric ray	-	-	-	-	45.563	-	-
yellow snake eel	-	-	-	-	-	-	-
spotfin croaker	-	-	-	-	-	-	-
diamond turbot	-	-	-	-	0.849	-	-
deepbody anchovy	-	-	-	-	-	-	-
California sheephead	-	-	-	-	-	-	-
leopard shark	-	-	-	-	-	-	-
spotted cusk eel	-	-	-	-	-	-	-
kelp pipefish	-	-	-	-	-	-	-
vermillion rockfish	-	-	-	-	-	-	-
basketweave cusk-eel	-	-	-	-	-	-	-
pygmy poacher	-	-	-	-	-	-	-
plainfin midshipman	-	-	-	-	-	-	-
Total:	4.508	0.142	-	0.139	95.546	0.205	0.118
No. of Species:	6	1	-	2	12	2	1

Appendix C-2. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	30	31	32	33	34	35	36	37
Date:	18-Feb-04	24-Feb-04	2-Mar-04	9-Mar-04	16-Mar-04	23-Mar-04	30-Mar-04	6-Apr-04
queenfish	0.042	0.413	0.553	0.052	0.079	0.343	0.584	0.027
white croaker	-	-	-	-	-	-	-	-
northern anchovy	-	-	-	-	-	0.618	-	-
white seaperch	-	-	-	-	-	-	-	-
shiner perch	-	-	-	-	-	-	-	-
walleye surfperch	-	-	-	-	-	-	-	-
California halibut	-	-	-	-	-	-	-	-
bat ray	-	-	-	-	-	-	-	-
specklefin midshipman	-	-	0.196	-	-	-	-	-
Pacific sardine	-	-	-	-	0.136	-	-	-
Pacific butterfish	-	-	0.119	0.318	0.086	0.074	-	-
hornyhead turbot	-	-	-	-	-	-	-	-
black croaker	-	-	-	-	-	-	-	-
rock wrasse	-	-	-	-	-	-	-	-
California corbina	-	-	-	-	-	-	-	-
California scorpionfish	-	-	-	-	-	-	-	-
halfmoon	-	-	-	-	-	-	-	-
opaleye	-	-	-	-	-	-	-	-
sargo	-	-	-	-	-	-	-	-
giant kelpfish	-	-	0.119	-	-	-	-	-
black perch	-	-	-	-	-	-	-	-
blacksmith	-	-	-	-	-	-	-	-
pile perch	-	-	-	-	-	-	-	-
yellowfin croaker	-	-	-	-	-	-	-	-
brown rockfish	-	-	-	-	-	-	-	-
barred sand bass	-	-	0.364	-	-	-	-	-
kelp bass	-	-	-	-	-	-	-	-
shovelnose guitarfish	-	-	-	-	-	-	-	-
jacksmelt	-	-	-	-	-	-	-	-
California grunion	0.042	-	-	-	-	-	-	-
thornback	-	-	-	-	-	-	-	-
Pacific staghorn sculpin	-	-	-	-	-	-	-	-
California lizardfish	-	-	-	-	-	-	-	-
spotted turbot	-	-	-	-	-	-	-	-
spotted sand bass	-	-	-	-	-	-	-	-
jack mackerel	-	-	-	-	-	-	-	-
topsmelt	-	-	-	-	-	-	-	-
rockpool blenny	-	-	-	-	-	-	-	-
speckled sanddab	-	-	-	-	-	-	-	-
white seabass	-	-	-	-	-	-	-	-
chub mackerel	-	-	-	-	-	-	-	-
salema	-	-	-	-	-	-	-	-
rubberlip seaperch	-	-	-	-	-	-	-	-
round stingray	-	-	-	1.954	-	-	-	-
Pacific electric ray	-	-	-	-	-	-	52.138	-
yellow snake eel	-	-	-	-	-	-	-	-
spotfin croaker	-	-	-	-	-	-	-	-
diamond turbot	-	-	-	-	-	-	-	-
deepbody anchovy	-	-	-	-	-	-	-	-
California sheephead	-	-	-	-	-	-	-	-
leopard shark	-	-	-	-	-	-	-	-
spotted cusk eel	-	-	-	-	-	-	-	-
kelp pipefish	-	-	-	-	-	-	-	-
vermillion rockfish	-	-	-	-	-	-	-	-
basketweave cusk-eel	-	0.378	-	-	-	-	-	-
pygmy poacher	-	-	-	-	-	-	-	-
plainfin midshipman	-	-	-	-	-	-	-	-
Total:	0.084	0.791	1.351	2.324	0.301	1.035	52.722	0.027
No. of Species:	2	2	5	3	3	3	2	1

Appendix C-2. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	38	39	40	41	42	43	44
Date:	13-Apr-04	20-Apr-04	27-Apr-04	4-May-04	11-May-04	18-May-04	25-May-04
queenfish	1.475	0.583	0.111	1.610	0.024	-	-
white croaker	0.273	0.070	0.065	0.395	-	-	-
northern anchovy	-	-	0.026	-	-	-	-
white seaperch	-	-	-	0.117	-	-	-
shiner perch	-	-	-	-	-	-	-
walleye surfperch	-	-	-	-	-	-	-
California halibut	-	-	-	-	-	-	-
bat ray	-	-	-	-	-	-	-
specklefin midshipman	-	-	-	-	-	-	-
Pacific sardine	0.071	-	-	-	-	-	-
Pacific butterfish	-	-	-	-	-	-	-
hornyhead turbot	-	-	-	-	-	-	-
black croaker	-	-	-	-	-	-	-
rock wrasse	-	-	-	-	-	-	-
California corbina	-	-	-	-	-	-	-
California scorpionfish	-	-	-	-	-	-	-
halfmoon	-	-	-	-	-	-	-
opaleye	-	-	-	-	-	-	-
sargo	-	-	-	-	-	-	-
giant kelpfish	-	-	-	-	-	-	-
black perch	-	1.873	-	-	-	-	-
blacksmith	-	-	-	-	-	-	-
pile perch	-	-	-	-	-	-	-
yellowfin croaker	-	-	-	-	-	-	-
brown rockfish	-	-	-	-	-	-	-
barred sand bass	-	-	-	-	-	-	-
kelp bass	-	-	-	-	-	-	-
shovelnose guitarfish	-	-	-	-	-	-	-
jacksmelt	-	-	-	0.728	-	-	-
California grunion	-	-	-	-	-	-	-
thornback	-	-	-	-	-	-	-
Pacific staghorn sculpin	-	-	-	-	-	-	-
California lizardfish	-	-	-	0.111	-	-	-
spotted turbot	-	-	-	-	-	-	-
spotted sand bass	-	-	-	-	-	-	-
jack mackerel	-	-	-	-	-	-	-
topsmelt	-	-	-	-	-	-	-
rockpool blenny	-	-	-	-	-	-	-
speckled sanddab	-	-	-	-	-	-	-
white seabass	-	-	-	-	-	-	-
chub mackerel	-	-	-	-	-	-	-
salema	-	-	-	-	-	-	-
rubberlip seaperch	-	-	-	-	-	-	-
round stingray	-	-	1.937	-	10.608	-	-
Pacific electric ray	-	-	-	-	-	-	-
yellow snake eel	-	-	-	-	-	-	-
spotfin croaker	-	-	-	-	-	-	-
diamond turbot	-	-	-	-	-	-	-
deepbody anchovy	0.032	-	-	-	-	-	-
California sheephead	-	-	-	-	-	-	-
leopard shark	-	-	-	-	-	-	-
spotted cusk eel	-	-	-	-	-	-	-
kelp pipefish	-	-	-	-	-	-	-
vermillion rockfish	-	-	-	-	-	-	-
basketweave cusk-eel	-	-	-	-	-	-	-
pygmy poacher	-	-	-	-	-	-	-
plainfin midshipman	-	-	-	-	-	-	3.267
Total:	1.852	2.526	2.139	2.960	10.632	-	3.267
No. of Species:	4	3	4	5	2	-	1

Appendix C-2. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	45	46	47	48	49	50	51	52
Date:	3-Jun-04	8-Jun-04	15-Jun-04	22-Jun-04	29-Jun-04	7-Jul-04	13-Jul-04	20-Jul-04
queenfish	-	-	-	-	-	-	-	-
white croaker	-	-	-	-	-	-	-	-
northern anchovy	-	-	-	-	-	-	-	-
white seaperch	-	-	-	-	-	-	-	-
shiner perch	-	-	-	-	-	-	-	0.096
walleye surfperch	-	-	-	-	-	-	-	-
California halibut	-	-	-	-	-	-	-	-
bat ray	-	-	-	-	-	-	-	-
specklefin midshipman	-	-	-	-	-	-	-	-
Pacific sardine	-	-	0.162	-	-	-	-	-
Pacific butterfish	-	-	-	-	-	-	-	-
hornyhead turbot	-	-	-	-	-	-	-	-
black croaker	-	-	-	-	-	-	-	-
rock wrasse	-	-	-	-	-	-	-	-
California corbina	-	-	-	-	-	-	-	-
California scorpionfish	-	-	-	-	-	-	-	-
halfmoon	-	-	-	-	-	-	-	-
opaleye	-	-	-	-	-	-	-	-
sargo	-	-	-	-	-	-	-	-
giant kelpfish	-	-	-	-	-	-	-	-
black perch	-	-	-	-	-	-	-	-
blacksmith	-	-	-	-	-	-	-	-
pile perch	-	-	-	-	-	-	-	-
yellowfin croaker	-	-	-	-	-	-	-	-
brown rockfish	-	-	-	-	-	-	-	-
barred sand bass	-	-	-	-	-	-	-	-
kelp bass	-	-	-	-	-	-	-	-
shovelnose guitarfish	-	-	-	-	-	-	-	-
jacksmelt	-	-	-	-	-	-	-	-
California grunion	-	-	-	-	-	-	-	-
thornback	-	-	-	-	-	-	-	-
Pacific staghorn sculpin	-	-	-	-	-	-	-	-
California lizardfish	-	-	-	-	-	-	-	-
spotted turbot	-	-	-	-	-	-	-	-
spotted sand bass	-	-	-	-	-	-	-	-
jack mackerel	-	-	-	-	-	-	-	-
topsmelt	-	-	-	-	-	-	-	-
rockpool blenny	-	-	-	-	-	-	-	-
speckled sanddab	-	-	-	-	-	-	-	-
white seabass	-	-	-	-	-	-	-	-
chub mackerel	-	-	-	-	-	-	-	-
salema	-	-	-	-	-	-	-	-
rubberlip seaperch	-	-	-	-	-	-	-	-
round stingray	-	-	-	-	-	2.823	-	-
Pacific electric ray	-	-	-	16.327	-	-	-	-
yellow snake eel	-	-	-	-	-	-	-	-
spotfin croaker	-	-	-	-	-	-	-	-
diamond turbot	-	-	-	-	-	-	-	-
deepbody anchovy	-	-	-	-	-	-	-	-
California sheephead	-	-	-	-	-	-	-	-
leopard shark	-	-	-	-	-	-	-	-
spotted cusk eel	-	-	-	-	-	-	-	-
kelp pipefish	-	-	-	-	-	-	-	-
vermillion rockfish	-	-	-	-	-	-	-	-
basketweave cusk-eel	-	-	-	-	-	-	-	-
pygmy poacher	-	-	-	-	-	-	-	-
plainfin midshipman	-	-	-	-	-	-	-	-
Total:	-	-	0.162	16.327	-	2.823	-	0.096
No. of Species:	-	-	1	1	-	1	-	1

Appendix C-2. (Cont.)

Survey Type:	Heat Treat	Heat Treat	Heat Treat	Heat Treat	Heat Treat	Heat Treat
Survey No.:	1	2	3	4	5	6
Date:	16-Aug-03	26-Sep-03	7-Nov-03	6-Jan-04	22-Feb-04	30-May-04
queenfish	116.908	104.300	106.810	88.728	52.445	120.950
white croaker	21.196	8.570	0.846	1.643	0.252	59.540
northern anchovy	1.806	3.317	1.100	3.084	0.021	0.015
white seaperch	4.645	2.530	2.452	2.526	2.215	4.220
shiner perch	6.748	31.570	9.092	1.207	0.035	1.161
walleye surfperch	0.780	0.400	3.208	1.977	2.790	6.100
California halibut	2.210	1.050	0.688	-	-	1.920
bat ray	4.261	-	1.478	0.323	-	1.205
specklefin midshipman	-	-	-	0.006	-	-
Pacific sardine	0.086	1.400	0.298	-	2.195	0.015
Pacific butterfish	0.135	2.900	1.578	0.653	3.530	5.030
hornyhead turbot	-	-	-	0.144	-	-
black croaker	3.128	0.800	1.111	0.714	0.365	0.564
rock wrasse	0.366	0.550	0.475	-	-	-
California corbina	0.672	0.379	0.170	1.009	0.576	0.298
California scorpionfish	2.583	4.220	5.201	1.707	0.515	6.840
halfmoon	2.005	1.150	0.390	-	-	-
opaleye	2.400	1.200	-	-	0.593	4.185
sargo	1.207	-	0.174	0.053	-	-
giant kelpfish	0.125	0.140	0.050	0.393	-	-
black perch	0.135	1.500	2.544	0.140	0.236	0.733
blacksmith	0.031	1.000	0.446	0.303	-	0.461
pile perch	1.173	0.850	0.804	1.250	0.241	0.411
yellowfin croaker	0.184	1.750	-	-	-	-
brown rockfish	0.733	-	-	0.451	-	-
barred sand bass	2.930	3.670	2.533	0.168	-	-
kelp bass	22.677	9.870	2.700	0.919	0.240	10.559
shovelnose guitarfish	3.674	7.500	-	-	-	-
jacksmelt	1.365	0.226	1.026	1.826	4.485	18.370
California grunion	0.189	0.097	0.212	-	-	-
thornback	-	-	-	1.242	-	-
Pacific staghorn sculpin	-	-	-	0.103	-	-
California lizardfish	-	-	-	-	-	-
spotted turbot	-	-	-	0.007	-	-
spotted sand bass	-	0.900	-	-	-	-
jack mackerel	-	0.082	-	-	-	0.171
topsmelt	-	1.200	0.644	1.820	-	-
rockpool blenny	-	0.003	-	0.007	-	0.006
speckled sanddab	-	-	-	0.004	0.050	-
white seabass	-	-	1.000	1.667	0.160	1.966
chub mackerel	-	-	0.336	-	-	-
salema	-	-	0.120	0.111	0.111	0.003
rubberlip seaperch	-	-	0.620	-	-	0.125
round stingray	-	-	1.236	2.485	1.220	17.390
Pacific electric ray	-	-	-	-	-	-
yellow snake eel	-	-	-	-	0.200	-
spotfin croaker	-	-	-	0.616	-	1.150
diamond turbot	-	-	-	0.220	-	0.138
deepbody anchovy	-	-	-	0.011	0.063	0.070
California sheephead	-	-	-	0.359	-	-
leopard shark	-	-	-	0.812	-	-
spotted cusk eel	-	-	-	-	0.128	-
kelp pipefish	-	-	-	-	0.007	-
vermillion rockfish	-	-	-	-	0.002	-
basketweave cusk-eel	-	-	-	-	-	0.011
pygmy poacher	-	-	-	-	0.005	-
plainfin midshipman	-	-	0.003	-	-	-
Total:	204.352	193.124	149.345	118.688	72.680	263.607
No. of Species:	28	29	31	36	26	29

Appendix C-2. (Cont.)

Survey Type:	Normal Operations		Heat Treatments		
Survey No.:	Total	Occurrence	Total	Occurrence	Total
Date:	Abundance	(n=52)	Abundance	(n=6)	Impingement
queenfish	58.015	31	590.141	6	648.156
white croaker	3.374	8	92.047	6	95.421
northern anchovy	5.513	16	9.343	6	14.856
white seaperch	0.485	3	18.588	6	19.073
shiner perch	2.014	6	49.813	6	51.827
walleye surfperch	0.498	3	15.255	6	15.753
California halibut	4.068	2	5.868	4	9.936
bat ray	10.659	2	7.267	4	17.926
specklefin midshipman	10.249	6	0.006	1	10.255
Pacific sardine	3.322	7	3.994	5	7.316
Pacific butterfish	2.096	8	13.826	6	15.922
hornyhead turbot	0.277	4	0.144	1	0.421
black croaker	0.330	2	6.682	6	7.012
rock wrasse	-	-	1.391	3	1.391
California corbina	-	-	3.104	6	3.104
California scorpionfish	5.528	3	21.066	6	26.594
halfmoon	-	-	3.545	3	3.545
opaleye	4.274	1	8.378	4	12.652
sargo	-	-	1.434	3	1.434
giant kelpfish	1.045	3	0.708	4	1.753
black perch	1.873	1	5.288	6	7.161
blacksmith	0.015	1	2.241	5	2.256
pile perch	-	-	4.729	6	4.729
yellowfin croaker	-	-	1.934	2	1.934
brown rockfish	-	-	1.184	2	1.184
barred sand bass	0.364	1	9.301	4	9.665
kelp bass	-	-	46.965	6	46.965
shovelnose guitarfish	-	-	11.174	2	11.174
jacksmelt	2.370	2	27.298	6	29.668
California grunion	0.211	2	0.498	3	0.709
thornback	15.812	3	1.242	1	17.054
Pacific staghorn sculpin	0.870	2	0.103	1	0.973
California lizardfish	1.130	4	-	-	1.130
spotted turbot	2.438	3	0.007	1	2.445
spotted sand bass	-	-	0.900	1	0.900
jack mackerel	0.030	1	0.253	2	0.283
topsmelt	-	-	3.664	3	3.664
rockpool blenny	-	-	0.016	3	0.016
speckled sanddab	0.043	2	0.054	2	0.097
white seabass	0.135	1	4.793	4	4.928
chub mackerel	-	-	0.336	1	0.336
salema	0.101	1	0.345	4	0.446
rubberlip seaperch	-	-	0.745	2	0.745
round stingray	17.322	4	22.331	4	39.653
Pacific electric ray	129.444	4	-	-	129.444
yellow snake eel	1.332	1	0.200	1	1.532
spotfin croaker	-	-	1.766	2	1.766
diamond turbot	0.849	1	0.358	2	1.207
deepbody anchovy	0.032	1	0.144	3	0.176
California sheephead	-	-	0.359	1	0.359
leopard shark	-	-	0.812	1	0.812
spotted cusk eel	-	-	0.128	1	0.128
kelp pipefish	-	-	0.007	1	0.007
vermillion rockfish	-	-	0.002	1	0.002
basketweave cusk-eel	0.378	1	0.011	1	0.389
pygmy poacher	-	-	0.005	1	0.005
plainfin midshipman	3.267	1	0.003	1	3.270
Total:	289.763		1001.796		1291.559
No. of Species:	36		55		57

Appendix C-3. Extrapolated normal operations and heat treatment macroinvertebrate losses by survey.

	Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
	Survey No.:	1	2	3	4	5	6
	Date:	29-Jul-03	5-Aug-03	12-Aug-03	22-Aug-03	26-Aug-03	3-Sep-03
Urechis caupo	innkeeper worm	6	-	-	-	-	-
Neotrypaea californiensis	bay ghost shrimp	6	-	-	-	-	-
Polyorchis penicillatus	jellyfish	-	6	-	-	-	-
Lysmata californica	red rock shrimp	-	6	-	-	-	-
Chrysaora colorata	purple-striped jelly	-	-	10	-	-	-
Salpidae	salp, unid.	-	-	-	18	-	-
Cancer antennarius	Pacific rock crab	-	-	-	-	-	-
Cancer anthonyi	yellow rock crab	-	-	-	-	-	-
Hemigrapsus oregonensis	yellow shore crab	-	-	-	-	-	-
Pachygrapsus crassipes	striped shore crab	-	-	-	-	-	-
Panulirus interruptus	California spiny lobster	-	-	-	-	-	5
Pisaster ochraceous	ochre starfish	-	-	-	-	-	-
Penaeus californiensis	yellowleg shrimp	-	-	-	-	-	5
Pyromaia tuberculata	tuberculate pear crab	-	-	-	-	-	-
Portunus xantusii	Xantus swimming crab	-	-	-	-	-	-
Heptacarpus palpator	intertidal coastal shrimp	-	-	-	-	-	-
Navanax inermis	California aglaja	-	-	-	-	-	-
Dendronotus frondosus	nudibranch	-	-	-	-	-	-
Hermissenda crassicornis	nudibranch	-	-	-	-	-	-
Pugettia producta	shield-backed kelp crab	-	-	-	-	-	-
Loligo opalescens	market squid	-	-	-	-	-	-
Ophiothrix spiculata	spiny brittlestar	-	-	-	-	-	-
Crangon nigromaculata	blackspotted bay shrimp	-	-	-	-	-	-
Cancer gracilis	graceful rock crab	-	-	-	-	-	-
Cancer productus	red rock crab	-	-	-	-	-	-
Pachycheles pubescens	pubescent porcelain crab	-	-	-	-	-	-
Cerebratulus californiensis	ribbon worm	-	-	-	-	-	-
Dendronotus subramosus	stubby dendronotus	-	-	-	-	-	-
Pisaster sp.	sea star (decomposed)	-	-	-	-	-	-
Flabellina iodinea	Spanish shawl	-	-	-	-	-	-
Parastichopus parvimensis	warty sea cucumber	-	-	-	-	-	-
Octopus bimaculoides	Two-spotted octopus	-	-	-	-	6	-
Protothaca staminea	Pacific littleneck (shell debris)	-	-	-	-	-	-
Loxorhynchus crispatus	masking crab	-	-	-	-	-	-
Loxorhynchus grandis	sheep crab	-	-	-	-	-	-
Pachycheles rudis	thick-clawed porcelain crab	-	-	-	-	-	-
Petricola californiensis	California petricolid (shell debris)	-	-	-	-	-	-
	Total:	13	12	10	18	6	10
	No. of Species:	2	2	1	1	1	2

Appendix C-3. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	7	8	9	10	11	12	13
Date:	10-Sep-03	16-Sep-03	23-Sep-03	30-Sep-03	7-Oct-03	14-Oct-03	21-Oct-03
innkeeper worm	-	-	-	-	-	-	-
bay ghost shrimp	-	-	-	-	-	-	-
jellyfish	-	7	14	6	7	37	-
red rock shrimp	-	-	7	-	-	-	-
purple-striped jelly	-	-	-	-	-	-	-
salp, unid.	-	-	-	-	-	-	-
Pacific rock crab	-	-	-	-	7	-	-
yellow rock crab	-	-	-	6	-	-	-
yellow shore crab	-	-	-	6	-	-	-
striped shore crab	-	-	-	-	-	-	-
California spiny lobster	-	-	7	-	-	-	-
ochre starfish	-	-	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-	-
tuberculate pear crab	-	7	-	-	-	-	-
Xantus swimming crab	-	-	7	-	-	-	-
intertidal coastal shrimp	-	-	-	-	-	-	-
California aglaja	-	-	-	-	-	-	-
nudibranch	-	-	-	-	-	-	-
nudibranch	-	-	-	-	-	-	-
shield-backed kelp crab	-	-	-	-	-	-	-
market squid	-	-	-	-	-	-	-
spiny brittlestar	-	-	-	-	-	-	-
blackspotted bay shrimp	-	-	-	-	-	-	-
graceful rock crab	-	-	-	-	-	-	-
red rock crab	-	-	-	-	-	-	-
pubescent porcelain crab	-	-	-	-	-	-	-
ribbon worm	-	-	-	-	-	-	-
stubby dendronotus	-	-	-	-	-	-	-
sea star (decomposed)	-	-	-	-	-	-	-
Spanish shawl	-	-	-	-	-	-	-
warty sea cucumber	-	-	-	-	-	-	-
Two-spotted octopus	-	-	-	-	-	-	-
Pacific littleneck (shell debris)	-	-	-	-	-	-	-
masking crab	-	-	-	-	-	-	-
sheep crab	-	-	-	-	-	-	-
thick-clawed porcelain crab	-	-	-	-	-	-	-
California petricolid (shell debris)	-	-	-	-	-	-	-
Total:	-	14	34	19	14	37	-
No. of Species:	-	2	4	3	2	1	-

Appendix C-3. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	14	15	16	17	18	19	20
Date:	28-Oct-03	4-Nov-03	11-Nov-03	20-Nov-03	28-Nov-03	2-Dec-03	9-Dec-03
innkeeper worm	-	-	-	-	-	-	-
bay ghost shrimp	7	-	-	-	-	-	-
jellyfish	-	-	-	-	-	-	7
red rock shrimp	-	-	-	-	-	-	-
purple-striped jelly	-	-	-	-	-	-	-
salp, unid.	-	-	-	-	-	-	-
Pacific rock crab	-	-	-	7	-	-	-
yellow rock crab	-	12	-	-	-	-	-
yellow shore crab	-	-	-	-	-	-	-
striped shore crab	-	-	-	-	-	-	-
California spiny lobster	-	-	-	-	-	-	-
ochre starfish	-	-	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-	-
tuberculate pear crab	-	-	-	-	-	-	-
Xantus swimming crab	-	-	7	-	-	-	-
intertidal coastal shrimp	-	-	-	-	-	-	-
California aglaja	-	-	-	-	-	-	-
nudibranch	-	50	-	-	-	-	3464
nudibranch	-	50	-	-	-	-	-
shield-backed kelp crab	-	6	-	-	-	-	7
market squid	-	-	-	-	7	-	-
spiny brittlestar	-	-	-	-	-	-	-
blackspotted bay shrimp	-	-	-	-	-	-	-
graceful rock crab	-	-	-	-	-	-	-
red rock crab	-	-	-	-	-	-	-
pubescent porcelain crab	-	-	-	-	-	-	-
ribbon worm	-	-	-	-	-	-	-
stubby dendronotus	-	-	-	-	-	-	-
sea star (decomposed)	-	-	-	-	-	-	-
Spanish shawl	-	-	-	-	-	-	-
warty sea cucumber	-	-	-	-	-	-	-
Two-spotted octopus	-	-	-	-	-	-	-
Pacific littleneck (shell debris)	-	-	-	-	-	-	-
masking crab	-	-	-	-	-	-	-
sheep crab	-	-	-	-	-	-	-
thick-clawed porcelain crab	-	-	-	-	-	-	-
California petricolid (shell debris)	-	-	-	-	-	-	-
Total:	7	118	7	7	7	-	3478
No. of Species:	1	4	1	1	1	-	3

Appendix C-3. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	21	22	23	24	25	26	27
Date:	16-Dec-03	23-Dec-03	30-Dec-03	9-Jan-04	16-Jan-04	20-Jan-04	27-Jan-04
innkeeper worm	-	-	-	-	-	-	-
bay ghost shrimp	-	-	-	-	-	-	-
jellyfish	31	21	-	115	-	-	6
red rock shrimp	-	-	-	7	-	-	-
purple-striped jelly	-	-	-	-	-	-	-
salp, unid.	-	-	-	-	-	-	-
Pacific rock crab	12	-	-	7	-	-	6
yellow rock crab	-	-	7	615	-	7	-
yellow shore crab	-	-	-	-	-	-	-
striped shore crab	-	-	-	-	-	-	-
California spiny lobster	-	-	-	-	-	-	-
ochre starfish	-	-	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-	-
tuberculate pear crab	-	-	-	-	-	-	-
Xantus swimming crab	-	-	-	-	-	7	-
intertidal coastal shrimp	-	-	14	-	-	-	-
California aglaja	-	-	-	-	-	-	-
nudibranch	31	-	-	-	-	-	-
nudibranch	-	-	-	-	-	-	-
shield-backed kelp crab	6	-	-	-	-	-	-
market squid	-	-	-	-	-	-	-
spiny brittlestar	-	7	-	-	-	-	-
blackspotted bay shrimp	-	-	-	7	-	14	-
graceful rock crab	-	-	-	7	-	-	6
red rock crab	-	-	-	-	-	-	-
pubescent porcelain crab	-	-	-	-	-	-	-
ribbon worm	-	-	-	-	-	-	17
stubby dendronotus	-	-	-	-	-	-	-
sea star (decomposed)	-	-	-	-	-	-	-
Spanish shawl	-	-	-	-	-	-	-
warty sea cucumber	-	-	-	-	-	-	-
Two-spotted octopus	-	-	-	-	-	-	-
Pacific littleneck (shell debris)	-	-	-	-	-	-	-
masking crab	-	-	-	-	-	-	-
sheep crab	-	-	-	-	-	-	-
thick-clawed porcelain crab	-	-	-	-	-	-	-
California petricolid (shell debris)	-	-	-	-	-	-	-
Total:	80	28	21	756	-	28	34
No. of Species:	4	2	2	6	-	3	4

Appendix C-3. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	28	29	30	31	32	33	34
Date:	3-Feb-04	10-Feb-04	18-Feb-04	24-Feb-04	2-Mar-04	9-Mar-04	16-Mar-04
innkeeper worm	-	-	-	-	-	-	-
bay ghost shrimp	-	-	-	-	-	-	-
jellyfish	-	-	-	-	-	22	-
red rock shrimp	-	-	-	-	-	-	-
purple-striped jelly	-	-	-	-	-	-	-
salp, unid.	-	-	-	-	-	-	-
Pacific rock crab	-	-	-	14	-	7	7
yellow rock crab	23	-	-	-	-	-	-
yellow shore crab	-	-	-	-	-	-	-
striped shore crab	-	-	-	7	-	-	-
California spiny lobster	-	-	-	-	-	-	-
ochre starfish	-	-	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-	-
tuberculate pear crab	-	-	-	-	-	-	-
Xantus swimming crab	-	-	-	-	7	-	-
intertidal coastal shrimp	-	-	-	-	-	-	-
California aglaja	-	-	-	-	-	-	-
nudibranch	-	-	210	-	-	-	-
nudibranch	-	-	-	-	-	-	-
shield-backed kelp crab	-	-	-	-	-	-	-
market squid	-	-	-	-	-	-	-
spiny brittlestar	-	-	-	-	-	-	-
blackspotted bay shrimp	-	-	49	-	14	-	-
graceful rock crab	-	-	-	-	-	-	-
red rock crab	-	-	-	-	-	-	-
pubescent porcelain crab	-	-	-	-	-	-	-
ribbon worm	-	-	-	-	-	-	-
stubby dendronotus	-	-	-	-	-	-	-
sea star (decomposed)	-	-	-	7	-	-	-
Spanish shawl	-	-	-	-	-	7	-
warty sea cucumber	-	-	-	-	-	-	7
Two-spotted octopus	-	-	-	-	-	-	-
Pacific littleneck (shell debris)	-	-	-	-	-	-	-
masking crab	-	-	-	-	-	-	-
sheep crab	-	-	-	-	-	-	-
thick-clawed porcelain crab	-	-	-	-	-	-	-
California petricolid (shell debris)	-	-	-	-	-	-	-
Total:	23	-	259	28	21	37	14
No. of Species:	1	-	2	3	2	3	2

Appendix C-3. (Cont.)

Survey Type:	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
Survey No.:	35	36	37	38	39	40	41	42
Date:	23-Mar-04	30-Mar-04	6-Apr-04	13-Apr-04	20-Apr-04	27-Apr-04	4-May-04	11-May-04
innkeeper worm	-	-	-	-	-	-	-	-
bay ghost shrimp	-	-	-	-	-	-	-	-
jellyfish	-	-	-	6	-	-	19	-
red rock shrimp	-	-	-	-	-	-	-	-
purple-striped jelly	-	-	-	-	-	-	-	8
salp, unid.	-	-	-	-	-	-	-	-
Pacific rock crab	-	-	-	-	23	-	31	-
yellow rock crab	13	-	34	84	35	26	321	122
yellow shore crab	-	-	-	-	-	-	-	-
striped shore crab	-	-	-	-	-	7	-	-
California spiny lobster	-	-	-	-	-	-	-	-
ochre starfish	-	-	-	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-	-	-
tuberculate pear crab	-	-	-	-	-	-	6	-
Xantus swimming crab	-	7	-	-	-	-	12	-
intertidal coastal shrimp	-	-	-	-	-	-	6	-
California aglaja	-	-	-	-	-	-	-	-
nudibranch	-	58394	-	-	-	-	-	-
nudibranch	-	-	-	-	-	-	-	-
shield-backed kelp crab	-	-	-	-	-	-	-	-
market squid	-	-	-	-	-	-	-	-
spiny brittlestar	-	-	-	-	-	-	-	-
blackspotted bay shrimp	-	-	-	-	-	-	253	-
graceful rock crab	-	14	-	-	-	-	-	-
red rock crab	-	-	-	-	-	-	19	-
pubescent porcelain crab	-	-	-	-	-	-	-	-
ribbon worm	-	-	-	-	-	-	-	-
stubby dendronotus	-	-	-	-	-	-	-	-
sea star (decomposed)	-	-	-	-	-	-	-	-
Spanish shawl	-	-	-	-	-	-	-	-
warty sea cucumber	-	-	-	-	-	-	-	-
Two-spotted octopus	-	-	-	-	-	-	-	-
Pacific littleneck (shell debris)	-	-	-	-	-	-	-	-
masking crab	-	-	-	-	-	-	-	-
sheep crab	-	-	-	-	-	-	-	-
thick-clawed porcelain crab	-	-	-	-	-	-	-	-
California petricolid (shell debris)	-	-	-	-	-	-	-	-
Total:	13	58415	34	91	58	33	666	131
No. of Species:	1	3	1	2	2	2	8	2

Appendix C-3. (Cont.)

Survey Type: Survey No.: Date:	Normal Op 43 18-May-04	Normal Op 44 25-May-04	Normal Op 45 3-Jun-04	Normal Op 46 8-Jun-04	Normal Op 47 15-Jun-04	Normal Op 48 22-Jun-04	Normal Op 49 29-Jun-04	Normal Op 50 7-Jul-04
innkeeper worm	-	-	-	-	-	-	-	-
bay ghost shrimp	-	-	-	-	-	-	-	-
jellyfish	-	-	-	-	-	-	-	-
red rock shrimp	-	-	-	-	-	-	-	-
purple-striped jelly	-	-	-	-	-	13	7	-
salp, unid.	-	-	-	-	-	-	-	-
Pacific rock crab	-	-	191	-	-	-	-	-
yellow rock crab	344	9	888	-	25	-	-	23
yellow shore crab	-	-	-	-	-	-	-	-
striped shore crab	-	-	14	-	-	-	-	-
California spiny lobster	-	-	-	-	-	-	-	-
ochre starfish	-	-	-	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-	-	-
tuberculate pear crab	25	112	-	-	-	-	-	12
Xantus swimming crab	-	-	-	-	-	-	-	-
intertidal coastal shrimp	-	-	7	-	-	-	-	-
California aglaja	-	-	-	-	-	-	-	-
nudibranch	-	-	-	-	-	-	-	-
nudibranch	-	-	-	-	-	-	-	-
shield-backed kelp crab	-	-	7	-	-	-	-	-
market squid	-	-	-	-	-	-	-	-
spiny brittlestar	-	19	-	-	-	-	-	-
blackspotted bay shrimp	-	-	-	-	-	-	-	-
graceful rock crab	-	-	116	-	-	-	7	-
red rock crab	34	9	355	-	-	-	-	-
pubescent porcelain crab	-	-	-	-	-	-	-	-
ribbon worm	-	-	-	-	-	-	-	-
stubby dendronotus	-	-	-	-	-	-	-	-
sea star (decomposed)	-	-	41	-	-	-	-	-
Spanish shawl	-	-	-	-	-	-	-	-
warty sea cucumber	-	-	-	-	-	-	-	-
Two-spotted octopus	8	-	-	-	6	7	-	-
Pacific littleneck (shell debris)	-	-	-	-	-	-	-	-
masking crab	-	-	7	-	-	-	-	-
sheep crab	-	-	-	-	-	-	-	-
thick-clawed porcelain crab	-	-	-	-	-	-	-	-
California petricolid (shell debris)	-	-	-	-	-	-	-	-
Total:	412	149	1626	-	31	20	14	35
No. of Species:	4	4	9	-	2	2	2	2

Appendix C-3. (Cont.)

Survey Type:	Normal Op	Normal Op	Heat Treat	Heat Treat	Heat Treat	Heat Treat	Heat Treat	Heat Treat
Survey No.:	51	52	1	2	3	4	5	6
Date:	13-Jul-04	20-Jul-04	16-Aug-03	26-Sep-03	7-Nov-03	6-Jan-04	22-Feb-04	30-May-04
innkeeper worm	-	-	2	-	-	-	-	-
bay ghost shrimp	-	-	-	-	-	-	-	-
jellyfish	16	7	-	-	-	-	-	-
red rock shrimp	-	-	3	4	-	-	-	133
purple-striped jelly	16	-	-	-	-	-	-	-
salp, unid.	-	-	-	-	-	-	-	-
Pacific rock crab	16	630	1	13	2	-	-	52
yellow rock crab	-	110	-	-	-	21	20	110
yellow shore crab	-	-	-	-	-	-	-	-
striped shore crab	-	-	17	7	2	11	24	88
California spiny lobster	-	-	11	6	1	-	-	2
ochre starfish	-	-	3	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-	-	-
tuberculate pear crab	31	404	-	9	1	27	-	349
Xantus swimming crab	-	-	-	-	-	11	4	1
intertidal coastal shrimp	-	-	-	2	-	14	4	11
California aglaja	-	-	-	3	-	4	8	-
nudibranch	-	-	-	-	-	-	-	-
nudibranch	-	-	-	-	2	-	85	24
shield-backed kelp crab	-	-	-	-	-	1	1	9
market squid	-	-	-	-	-	-	-	-
spiny brittlestar	-	-	-	-	-	-	-	14
blackspotted bay shrimp	-	-	-	-	-	-	2	-
graceful rock crab	233	1102	-	-	-	-	-	11
red rock crab	-	-	-	-	-	2	-	23
pubescent porcelain crab	-	-	-	-	-	1	-	-
ribbon worm	-	-	-	-	-	-	-	-
stubby dendronotus	-	-	-	-	-	-	14	-
sea star (decomposed)	-	-	-	-	-	-	-	-
Spanish shawl	-	-	-	-	-	-	-	-
warty sea cucumber	-	-	-	-	-	-	-	-
Two-spotted octopus	-	-	12	14	2	-	1	5
Pacific littleneck (shell debris)	-	-	-	-	-	-	-	-
masking crab	-	-	-	-	-	-	-	-
sheep crab	-	-	-	-	-	-	-	1
thick-clawed porcelain crab	-	-	-	-	-	-	-	1
California petricolid (shell debris)	-	-	-	-	-	-	-	-
Total:	310	2252	49	58	10	92	163	834
No. of Species:	5	5	7	8	6	9	10	15

Appendix C-3. (Cont.)

Survey Type:	Normal Ops		Heat Treat		
Survey No.: Date:	Total Abundance	Occurrence (n=52)	Total Abundance	Occurrence (n=6)	Total Impingement
innkeeper worm	6	1	2	1	8
bay ghost shrimp	13	2	-	-	13
jellyfish	326	16	-	-	326
red rock shrimp	20	3	140	3	160
purple-striped jelly	53	5	-	-	53
salp, unid.	18	1	-	-	18
Pacific rock crab	958	13	68	4	1026
yellow rock crab	2706	19	151	3	2857
yellow shore crab	6	1	-	-	6
striped shore crab	27	3	149	6	176
California spiny lobster	12	2	20	4	32
ochre starfish	-	-	3	1	3
yellowleg shrimp	5	1	-	-	5
tuberculate pear crab	597	7	386	4	983
Xantus swimming crab	47	6	16	3	63
intertidal coastal shrimp	27	3	31	4	58
California aglaja	-	-	15	3	15
nudibranch	62150	5	-	-	62150
nudibranch	50	1	111	3	161
shield-backed kelp crab	26	4	11	3	37
market squid	7	1	-	-	7
spiny brittlestar	26	2	14	1	40
blackspotted bay shrimp	336	5	2	1	338
graceful rock crab	1484	7	11	1	1495
red rock crab	417	4	25	2	442
pubescent porcelain crab	-	-	1	1	1
ribbon worm	17	1	-	-	17
stubby dendronotus	-	-	14	1	14
sea star (decomposed)	48	2	-	-	48
Spanish shawl	7	1	-	-	7
warty sea cucumber	7	1	-	-	7
Two-spotted octopus	27	4	34	5	61
Pacific littleneck (shell debris)	-	-	-	-	-
masking crab	7	1	-	-	7
sheep crab	-	-	1	1	1
thick-clawed porcelain crab	-	-	1	1	1
California petricolid (shell debris)	-	-	-	-	-
Total:	69432		1206		70638
No. of Species:	29		21		35

Appendix C-4. Extrapolated normal operations and heat treatment macroinvertebrate biomass (kg) by survey.

		Normal Op 1 29-Jul-03	Normal Op 2 5-Aug-03	Normal Op 3 12-Aug-03	Normal Op 4 22-Aug-03	Normal Op 5 26-Aug-03	Normal Op 6 3-Sep-03
Urechis caupo	innkeeper worm	0.577	-	-	-	-	-
Neotrypaea californiensis	bay ghost shrimp	0.032	-	-	-	-	-
Polyorchis penicillatus	jellyfish	-	0.012	-	-	-	-
Lysmata californica	red rock shrimp	-	0.012	-	-	-	-
Chrysaora colorata	purple-striped jelly	-	-	7.797	-	-	-
Salpidae	salp, unid.	-	-	-	0.108	-	-
Cancer antennarius	Pacific rock crab	-	-	-	-	-	-
Cancer anthonyi	yellow rock crab	-	-	-	-	-	-
Hemigrapsus oregonensis	yellow shore crab	-	-	-	-	-	-
Pachygrapsus crassipes	striped shore crab	-	-	-	-	-	-
Panulirus interruptus	California spiny lobster	-	-	-	-	-	5.125
Pisaster ochraceous	ochre starfish	-	-	-	-	-	-
Penaeus californiensis	yellowleg shrimp	-	-	-	-	-	0.185
Pyromaia tuberculata	tuberculate pear crab	-	-	-	-	-	-
Portunus xantusii	Xantus swimming crab	-	-	-	-	-	-
Heptacarpus palpator	intertidal coastal shrimp	-	-	-	-	-	-
Navanax inermis	California aglaja	-	-	-	-	-	-
Dendronotus frondosus	nudibranch	-	-	-	-	-	-
Hermissenda crassicornis	nudibranch	-	-	-	-	-	-
Pugettia producta	shield-backed kelp crab	-	-	-	-	-	-
Loligo opalescens	market squid	-	-	-	-	-	-
Ophiothrix spiculata	spiny brittlestar	-	-	-	-	-	-
Crangon nigromaculata	blackspotted bay shrimp	-	-	-	-	-	-
Cancer gracilis	graceful rock crab	-	-	-	-	-	-
Cancer productus	red rock crab	-	-	-	-	-	-
Pachycheles pubescens	pubescent porcelain crab	-	-	-	-	-	-
Cerebratulus californiensis	ribbon worm	-	-	-	-	-	-
Dendronotus subramosus	stubby dendronotus	-	-	-	-	-	-
Pisaster sp.	sea star (decomposed)	-	-	-	-	-	-
Flabellina iodinea	Spanish shawl	-	-	-	-	-	-
Parastichopus parvimensis	warty sea cucumber	-	-	-	-	-	-
Octopus bimaculoides	two-spotted octopus	-	-	-	-	1.108	-
Protothaca staminea	Pacific littleneck (shell debris)	7.869	-	-	-	0.875	1.025
Loxorhynchus crispatus	masking crab	-	-	-	-	-	-
Loxorhynchus grandis	sheep crab	-	-	-	-	-	-
Pachycheles rudis	thick-clawed porcelain crab	-	-	-	-	-	-
Petricola californiensis	California petricolid (shell debris)	-	-	-	-	0.058	-
		8.478	0.025	7.797	0.108	2.042	6.335
		3	2	1	1	3	3

Appendix C-4. (Cont.)

	Normal Op 7 10-Sep-03	Normal Op 8 16-Sep-03	Normal Op 9 23-Sep-03	Normal Op 10 30-Sep-03	Normal Op 11 7-Oct-03	Normal Op 12 14-Oct-03	Normal Op 13 21-Oct-03
innkeeper worm	-	-	-	-	-	-	-
bay ghost shrimp	-	-	-	-	-	-	-
jellyfish	-	0.079	0.216	0.115	0.098	0.155	-
red rock shrimp	-	-	0.007	-	-	-	-
purple-striped jelly	-	-	-	-	-	-	-
salp, unid.	-	-	-	-	-	-	-
Pacific rock crab	-	-	-	-	0.035	-	-
yellow rock crab	-	-	-	0.013	-	-	-
yellow shore crab	-	-	-	0.006	-	-	-
striped shore crab	-	-	-	-	-	-	-
California spiny lobster	-	-	5.873	-	-	-	-
ochre starfish	-	-	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-	-
tuberculate pear crab	-	0.007	-	-	-	-	-
Xantus swimming crab	-	-	0.034	-	-	-	-
intertidal coastal shrimp	-	-	-	-	-	-	-
California aglaja	-	-	-	-	-	-	-
nudibranch	-	-	-	-	-	-	-
nudibranch	-	-	-	-	-	-	-
shield-backed kelp crab	-	-	-	-	-	-	-
market squid	-	-	-	-	-	-	-
spiny brittlestar	-	-	-	-	-	-	-
blackspotted bay shrimp	-	-	-	-	-	-	-
graceful rock crab	-	-	-	-	-	-	-
red rock crab	-	-	-	-	-	-	-
pubescent porcelain crab	-	-	-	-	-	-	-
ribbon worm	-	-	-	-	-	-	-
stubby dendronotus	-	-	-	-	-	-	-
sea star (decomposed)	-	-	-	-	-	-	-
Spanish shawl	-	-	-	-	-	-	-
warty sea cucumber	-	-	-	-	-	-	-
two-spotted octopus	-	-	-	-	-	-	-
Pacific littleneck (shell debris)	0.339	-	6.075	-	-	-	0.347
masking crab	-	-	-	-	-	-	-
sheep crab	-	-	-	-	-	-	-
thick-clawed porcelain crab	-	-	-	-	-	-	-
California petricolid (shell debris)	-	-	-	-	-	-	-
	0.339	0.086	12.204	0.134	0.133	0.155	0.347
	1	2	5	3	2	1	1

Appendix C-4. (Cont.)

	Normal Op 14 28-Oct-03	Normal Op 15 4-Nov-03	Normal Op 16 11-Nov-03	Normal Op 17 20-Nov-03	Normal Op 18 28-Nov-03	Normal Op 19 2-Dec-03	Normal Op 20 9-Dec-03
innkeeper worm	-	-	-	-	-	-	-
bay ghost shrimp	0.028	-	-	-	-	-	-
jellyfish	-	-	-	-	-	-	0.014
red rock shrimp	-	-	-	-	-	-	-
purple-striped jelly	-	-	-	-	-	-	-
salp, unid.	-	-	-	-	-	-	-
Pacific rock crab	-	-	-	0.007	-	-	-
yellow rock crab	-	0.019	-	-	-	-	-
yellow shore crab	-	-	-	-	-	-	-
striped shore crab	-	-	-	-	-	-	-
California spiny lobster	-	-	-	-	-	-	-
ochre starfish	-	-	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-	-
tuberculate pear crab	-	-	-	-	-	-	-
Xantus swimming crab	-	-	0.013	-	-	-	-
intertidal coastal shrimp	-	-	-	-	-	-	-
California aglaja	-	-	-	-	-	-	-
nudibranch	-	0.037	-	-	-	-	3.118
nudibranch	-	0.031	-	-	-	-	-
shield-backed kelp crab	-	0.012	-	-	-	-	0.007
market squid	-	-	-	-	0.442	-	-
spiny brittlestar	-	-	-	-	-	-	-
blackspotted bay shrimp	-	-	-	-	-	-	-
graceful rock crab	-	-	-	-	-	-	-
red rock crab	-	-	-	-	-	-	-
pubescent porcelain crab	-	-	-	-	-	-	-
ribbon worm	-	-	-	-	-	-	-
stubby dendronotus	-	-	-	-	-	-	-
sea star (decomposed)	-	-	-	-	-	-	-
Spanish shawl	-	-	-	-	-	-	-
warty sea cucumber	-	-	-	-	-	-	-
two-spotted octopus	-	-	-	-	-	-	-
Pacific littleneck (shell debris)	3.522	0.156	-	-	-	-	-
masking crab	-	-	-	-	-	-	-
sheep crab	-	-	-	-	-	-	-
thick-clawed porcelain crab	-	-	-	-	-	-	-
California petricolid (shell debris)	-	-	-	-	-	-	-
	3.550	0.255	0.013	0.007	0.442	-	3.139
	2	5	1	1	1	0	3

Appendix C-4. (Cont.)

	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
	21	22	23	24	25	26	27
	16-Dec-03	23-Dec-03	30-Dec-03	9-Jan-04	16-Jan-04	20-Jan-04	27-Jan-04
innkeeper worm	-	-	-	-	-	-	-
bay ghost shrimp	-	-	-	-	-	-	-
jellyfish	0.062	0.042	-	0.804	-	-	0.011
red rock shrimp	-	-	-	0.007	-	-	-
purple-striped jelly	-	-	-	-	-	-	-
salp, unid.	-	-	-	-	-	-	-
Pacific rock crab	0.012	-	-	0.027	-	-	0.039
yellow rock crab	-	-	0.014	0.702	-	0.007	-
yellow shore crab	-	-	-	-	-	-	-
striped shore crab	-	-	-	-	-	-	-
California spiny lobster	-	-	-	-	-	-	-
ochre starfish	-	-	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-	-
tuberculate pear crab	-	-	-	-	-	-	-
Xantus swimming crab	-	-	-	-	-	0.007	-
intertidal coastal shrimp	-	-	0.028	-	-	-	-
California aglaja	-	-	-	-	-	-	-
nudibranch	0.031	-	-	-	-	-	-
nudibranch	-	-	-	-	-	-	-
shield-backed kelp crab	0.006	-	-	-	-	-	-
market squid	-	-	-	-	-	-	-
spiny brittlestar	-	0.007	-	-	-	-	-
blackspotted bay shrimp	-	-	-	0.014	-	0.021	-
graceful rock crab	-	-	-	0.020	-	-	0.068
red rock crab	-	-	-	-	-	-	-
pubescent porcelain crab	-	-	-	-	-	-	-
ribbon worm	-	-	-	-	-	-	0.186
stubby dendronotus	-	-	-	-	-	-	-
sea star (decomposed)	-	-	-	-	-	-	-
Spanish shawl	-	-	-	-	-	-	-
warty sea cucumber	-	-	-	-	-	-	-
two-spotted octopus	-	-	-	-	-	-	-
Pacific littleneck (shell debris)	-	-	-	-	-	-	-
masking crab	-	-	-	-	-	-	-
sheep crab	-	-	-	-	-	-	-
thick-clawed porcelain crab	-	-	-	-	-	-	-
California petricolid (shell debris)	-	-	-	-	-	-	-
	0.111	0.049	0.042	1.573	-	0.035	0.304
	4	2	2	6	0	3	4

Appendix C-4. (Cont.)

	Normal Op 28 3-Feb-04	Normal Op 29 10-Feb-04	Normal Op 30 18-Feb-04	Normal Op 31 24-Feb-04	Normal Op 32 2-Mar-04	Normal Op 33 9-Mar-04
innkeeper worm	-	-	-	-	-	-
bay ghost shrimp	-	-	-	-	-	-
jellyfish	-	-	-	-	-	0.155
red rock shrimp	-	-	-	-	-	-
purple-striped jelly	-	-	-	-	-	-
salp, unid.	-	-	-	-	-	-
Pacific rock crab	-	-	-	0.196	-	0.141
yellow rock crab	0.030	-	-	-	-	-
yellow shore crab	-	-	-	-	-	-
striped shore crab	-	-	-	0.028	-	-
California spiny lobster	-	-	-	-	-	-
ochre starfish	-	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-
tuberculate pear crab	-	-	-	-	-	-
Xantus swimming crab	-	-	-	-	0.112	-
intertidal coastal shrimp	-	-	-	-	-	-
California aglaja	-	-	-	-	-	-
nudibranch	-	-	0.098	-	-	-
nudibranch	-	-	-	-	-	-
shield-backed kelp crab	-	-	-	-	-	-
market squid	-	-	-	-	-	-
spiny brittlestar	-	-	-	-	-	-
blackspotted bay shrimp	-	-	0.046	-	0.049	-
graceful rock crab	-	-	-	-	-	-
red rock crab	-	-	-	-	-	-
pubescent porcelain crab	-	-	-	-	-	-
ribbon worm	-	-	-	-	-	-
stubby dendronotus	-	-	-	-	-	-
sea star (decomposed)	-	-	-	1.050	-	-
Spanish shawl	-	-	-	-	-	0.007
warty sea cucumber	-	-	-	-	-	-
two-spotted octopus	-	-	-	-	-	-
Pacific littleneck (shell debris)	-	-	-	-	-	-
masking crab	-	-	-	-	-	-
sheep crab	-	-	-	-	-	-
thick-clawed porcelain crab	-	-	-	-	-	-
California petricolid (shell debris)	-	-	-	-	-	-
	0.030	-	0.144	1.274	0.161	0.303
	1	0	2	3	2	3

Appendix C-4. (Cont.)

	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
	34	35	36	37	38	39	40
	16-Mar-04	23-Mar-04	30-Mar-04	6-Apr-04	13-Apr-04	20-Apr-04	27-Apr-04
innkeeper worm	-	-	-	-	-	-	-
bay ghost shrimp	-	-	-	-	-	-	-
jellyfish	-	-	-	-	0.019	-	-
red rock shrimp	-	-	-	-	-	-	-
purple-striped jelly	-	-	-	-	-	-	-
salp, unid.	-	-	-	-	-	-	-
Pacific rock crab	0.014	-	-	-	-	0.047	-
yellow rock crab	-	0.034	-	0.096	0.260	0.076	0.065
yellow shore crab	-	-	-	-	-	-	-
striped shore crab	-	-	-	-	-	-	0.026
California spiny lobster	-	-	-	-	-	-	-
ochre starfish	-	-	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-	-
tuberculate pear crab	-	-	-	-	-	-	-
Xantus swimming crab	-	-	0.028	-	-	-	-
intertidal coastal shrimp	-	-	-	-	-	-	-
California aglaja	-	-	-	-	-	-	-
nudibranch	-	-	11.679	-	-	-	-
nudibranch	-	-	-	-	-	-	-
shield-backed kelp crab	-	-	-	-	-	-	-
market squid	-	-	-	-	-	-	-
spiny brittlestar	-	-	-	-	-	-	-
blackspotted bay shrimp	-	-	-	-	-	-	-
graceful rock crab	-	-	0.042	-	-	-	-
red rock crab	-	-	-	-	-	-	-
pubescent porcelain crab	-	-	-	-	-	-	-
ribbon worm	-	-	-	-	-	-	-
stubby dendronotus	-	-	-	-	-	-	-
sea star (decomposed)	-	-	-	-	-	-	-
Spanish shawl	-	-	-	-	-	-	-
warty sea cucumber	0.459	-	-	-	-	-	-
two-spotted octopus	-	-	-	-	-	-	-
Pacific littleneck (shell debris)	-	0.558	-	-	-	-	-
masking crab	-	-	-	-	-	-	-
sheep crab	-	-	-	-	-	-	-
thick-clawed porcelain crab	-	-	-	-	-	-	-
California petricolid (shell debris)	-	-	-	-	-	-	-
	0.473	0.591	11.748	0.096	0.279	0.123	0.091
	2	2	3	1	2	2	2

Appendix C-4. (Cont.)

	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
	41	42	43	44	45	46	47
	4-May-04	11-May-04	18-May-04	25-May-04	3-Jun-04	8-Jun-04	15-Jun-04
innkeeper worm	-	-	-	-	-	-	-
bay ghost shrimp	-	-	-	-	-	-	-
jellyfish	0.062	-	-	-	-	-	-
red rock shrimp	-	-	-	-	-	-	-
purple-striped jelly	-	2.611	-	-	-	-	-
salp, unid.	-	-	-	-	-	-	-
Pacific rock crab	0.222	-	-	-	4.947	-	-
yellow rock crab	0.543	0.188	0.773	0.233	16.721	-	0.025
yellow shore crab	-	-	-	-	-	-	-
striped shore crab	-	-	-	-	0.034	-	-
California spiny lobster	-	-	-	-	-	-	-
ochre starfish	-	-	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-	-
tuberculate pear crab	0.006	-	0.050	0.364	-	-	-
Xantus swimming crab	0.099	-	-	-	-	-	-
intertidal coastal shrimp	0.006	-	-	-	0.034	-	-
California aglaja	-	-	-	-	-	-	-
nudibranch	-	-	-	-	-	-	-
nudibranch	-	-	-	-	-	-	-
shield-backed kelp crab	-	-	-	-	0.089	-	-
market squid	-	-	-	-	-	-	-
spiny brittlestar	-	-	-	0.075	-	-	-
blackspotted bay shrimp	0.382	-	-	-	-	-	-
graceful rock crab	-	-	-	-	1.155	-	-
red rock crab	0.025	-	0.067	0.187	5.822	-	-
pubescent porcelain crab	-	-	-	-	-	-	-
ribbon worm	-	-	-	-	-	-	-
stubby dendronotus	-	-	-	-	-	-	-
sea star (decomposed)	-	-	-	-	8.822	-	-
Spanish shawl	-	-	-	-	-	-	-
warty sea cucumber	-	-	-	-	-	-	-
two-spotted octopus	-	-	9.887	-	-	-	5.589
Pacific littleneck (shell debris)	-	-	-	-	-	-	-
masking crab	-	-	-	-	0.212	-	-
sheep crab	-	-	-	-	-	-	-
thick-clawed porcelain crab	-	-	-	-	-	-	-
California petricolid (shell debris)	-	-	-	-	-	-	-
	1.344	2.799	10.777	0.859	37.836	-	5.614
	8	2	4	4	9	0	2

Appendix C-4. (Cont.)

	Normal Op	Normal Op	Normal Op	Normal Op	Normal Op
	48	49	50	51	52
	22-Jun-04	29-Jun-04	7-Jul-04	13-Jul-04	20-Jul-04
innkeeper worm	-	-	-	-	-
bay ghost shrimp	-	-	-	-	-
jellyfish	-	-	-	0.062	2.300
red rock shrimp	-	-	-	-	-
purple-striped jelly	5.081	4.711	-	1.474	-
salp, unid.	-	-	-	-	-
Pacific rock crab	-	-	-	0.217	2.683
yellow rock crab	-	-	0.012	-	1.944
yellow shore crab	-	-	-	-	-
striped shore crab	-	-	-	-	-
California spiny lobster	-	-	-	-	-
ochre starfish	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-
tuberculate pear crab	-	-	0.018	0.031	0.479
Xantus swimming crab	-	-	-	-	-
intertidal coastal shrimp	-	-	-	-	-
California aglaja	-	-	-	-	-
nudibranch	-	-	-	-	-
nudibranch	-	-	-	-	-
shield-backed kelp crab	-	-	-	-	-
market squid	-	-	-	-	-
spiny brittlestar	-	-	-	-	-
blackspotted bay shrimp	-	-	-	-	-
graceful rock crab	-	0.007	-	0.279	1.335
red rock crab	-	-	-	-	-
pubescent porcelain crab	-	-	-	-	-
ribbon worm	-	-	-	-	-
stubby dendronotus	-	-	-	-	-
sea star (decomposed)	-	-	-	-	-
Spanish shawl	-	-	-	-	-
warty sea cucumber	-	-	-	-	-
two-spotted octopus	6.335	-	-	-	-
Pacific littleneck (shell debris)	-	-	0.408	0.838	-
masking crab	-	-	-	-	-
sheep crab	-	-	-	-	-
thick-clawed porcelain crab	-	-	-	-	-
California petricolid (shell debris)	-	-	-	-	-
	11.416	4.718	0.438	2.901	8.741
	2	2	3	6	5

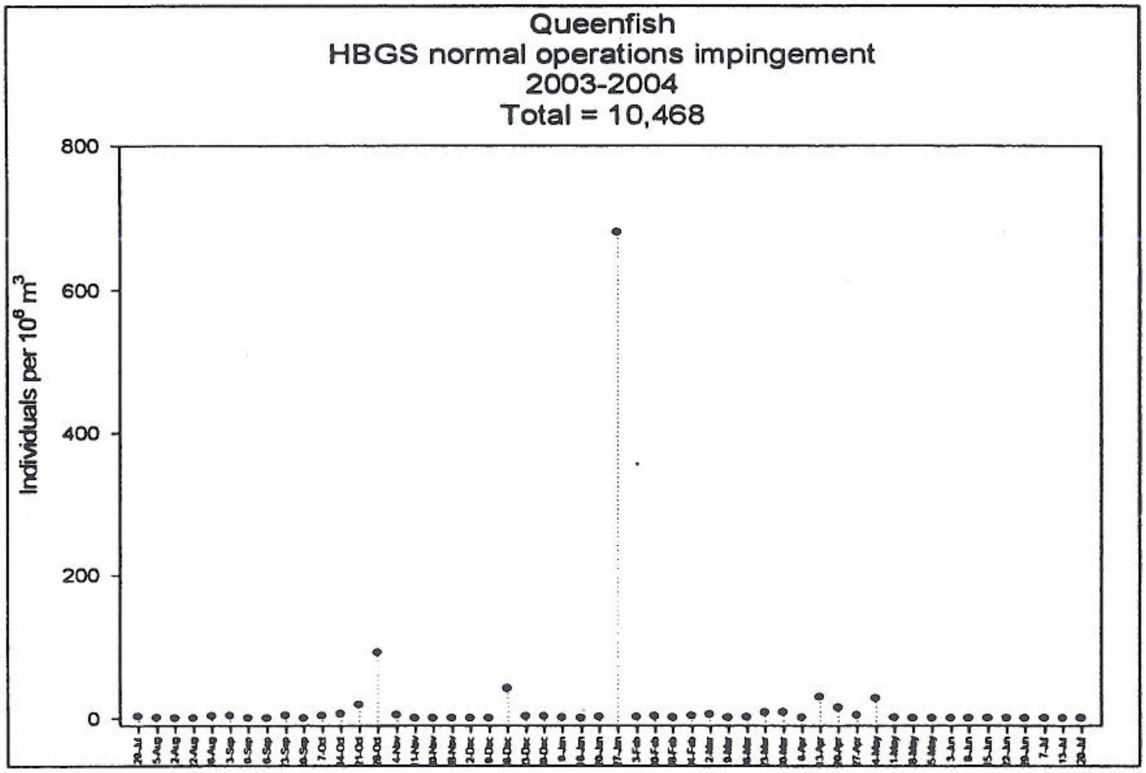
Appendix C-4. (Cont.)

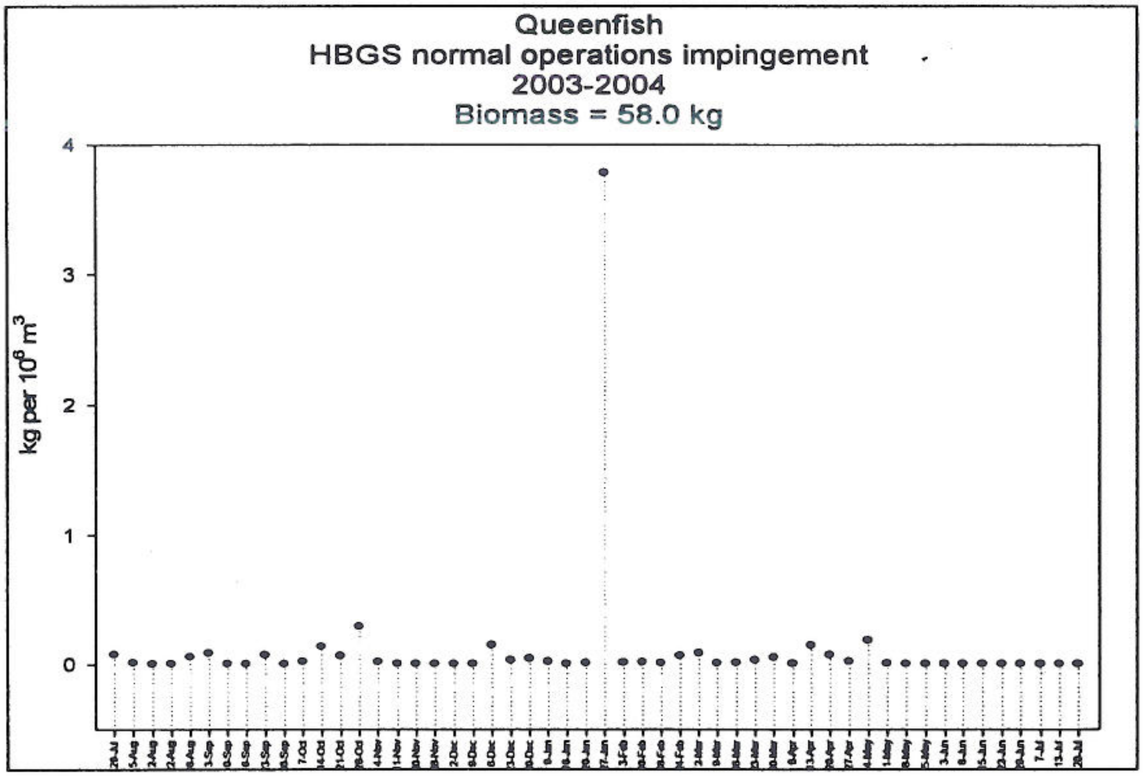
	Heat Treat 1 16-Aug-03	Heat Treat 2 26-Sep-03	Heat Treat 3 7-Nov-03	Heat Treat 4 6-Jan-04	Heat Treat 5 22-Feb-04	Heat Treat 6 30-May-04
innkeeper worm	0.025	-	-	-	-	-
bay ghost shrimp	-	-	-	-	-	-
jellyfish	-	-	-	-	-	-
red rock shrimp	0.008	0.006	-	-	-	0.180
purple-striped jelly	-	-	-	-	-	-
salp, unid.	-	-	-	-	-	-
Pacific rock crab	0.056	0.008	0.010	-	-	1.105
yellow rock crab	-	-	-	0.037	0.035	1.270
yellow shore crab	-	-	-	-	-	-
striped shore crab	0.028	0.030	0.042	0.046	0.052	0.203
California spiny lobster	5.000	2.750	0.604	-	-	0.283
ochre starfish	1.103	-	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-
tuberculate pear crab	-	0.006	0.002	0.028	-	0.346
Xantus swimming crab	-	-	-	0.019	0.020	0.016
intertidal coastal shrimp	-	0.001	-	0.005	0.004	0.008
California aglaja	-	0.005	-	0.015	0.018	-
nudibranch	-	-	-	-	-	-
nudibranch	-	-	0.004	-	0.095	0.015
shield-backed kelp crab	-	-	-	0.054	0.015	0.130
market squid	-	-	-	-	-	-
spiny brittlestar	-	-	-	-	-	0.007
blackspotted bay shrimp	-	-	-	-	0.004	-
graceful rock crab	-	-	-	-	-	0.079
red rock crab	-	-	-	0.018	-	0.147
pubescent porcelain crab	-	-	-	0.001	-	-
ribbon worm	-	-	-	-	-	-
stubby dendronotus	-	-	-	-	0.028	-
sea star (decomposed)	-	-	-	-	-	-
Spanish shawl	-	-	-	-	-	-
warty sea cucumber	-	-	-	-	-	-
two-spotted octopus	0.047	0.041	0.030	-	1.556	0.800
Pacific littleneck (shell debris)	-	-	-	-	-	-
masking crab	-	-	-	-	-	-
sheep crab	-	-	-	-	-	0.657
thick-clawed porcelain crab	-	-	-	-	-	0.001
California petricolid (shell debris)	-	-	-	-	-	-
	6.267	2.847	0.692	0.223	1.827	5.247
	7	8	6	9	10	16

Appendix C-4. (Cont.)

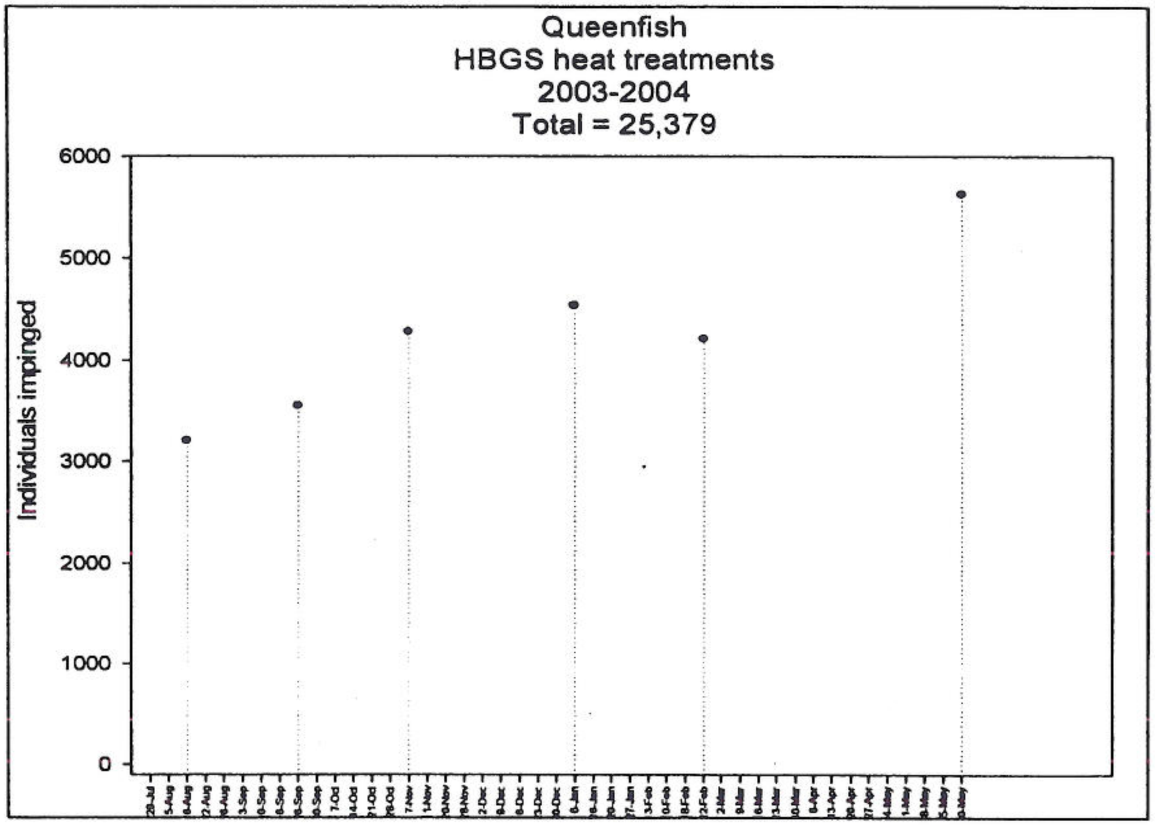
	Normal Ops		Heat Treat		
	Total Biomass	Occurrence (n=52)	Total Biomass	Occurrence (n=6)	Total Impingement
innkeeper worm	0.577	1	0.025	1	0.602
bay ghost shrimp	0.060	2	-	-	0.060
jellyfish	4.207	16	-	-	4.207
red rock shrimp	0.026	3	0.194	3	0.220
purple-striped jelly	21.674	5	-	-	21.674
salp, unid.	0.108	1	-	-	0.108
Pacific rock crab	8.588	13	1.179	4	9.767
yellow rock crab	21.754	19	1.342	3	23.096
yellow shore crab	0.006	1	-	-	0.006
striped shore crab	0.088	3	0.401	6	0.489
California spiny lobster	10.998	2	8.637	4	19.635
ochre starfish	-	-	1.103	1	1.103
yellowleg shrimp	0.185	1	-	-	0.185
tuberculate pear crab	0.955	7	0.382	4	1.337
Xantus swimming crab	0.292	6	0.055	3	0.347
intertidal coastal shrimp	0.068	3	0.018	4	0.086
California aglaja	-	-	0.038	3	0.038
nudibranch	14.963	5	-	-	14.963
nudibranch	0.031	1	0.114	3	0.145
shield-backed kelp crab	0.114	4	0.199	3	0.313
market squid	0.442	1	-	-	0.442
spiny brittlestar	0.082	2	0.007	1	0.089
blackspotted bay shrimp	0.511	5	0.004	1	0.515
graceful rock crab	2.905	7	0.079	1	2.984
red rock crab	6.101	4	0.165	2	6.266
pubescent porcelain crab	-	-	0.001	1	0.001
ribbon worm	0.186	1	-	-	0.186
stubby dendronotus	-	-	0.028	1	0.028
sea star (decomposed)	9.872	2	-	-	9.872
Spanish shawl	0.007	1	-	-	0.007
warty sea cucumber	0.459	1	-	-	0.459
two-spotted octopus	22.919	4	2.474	5	25.393
Pacific littleneck (shell debris)	22.012	11	-	-	22.012
masking crab	0.212	1	-	-	0.212
sheep crab	-	-	0.657	1	0.657
thick-clawed porcelain crab	-	-	0.001	1	0.001
California petricolid (shell debris)	0.058	1	-	-	0.058
	150.462		17.103		167.565
	31		22		37

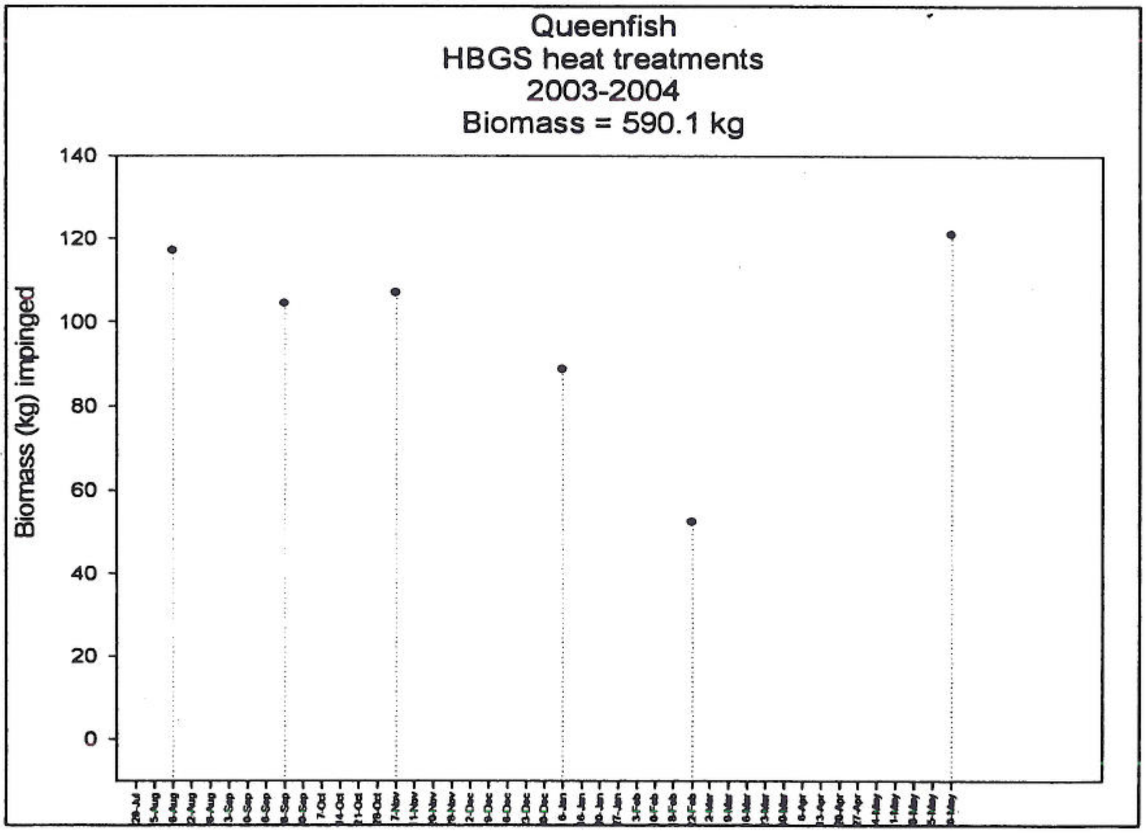
Appendix C-5. Temporal normal operation and heat treatment impingement patterns by species, HBGS 2003-2004.


Queenfish
HBGS normal operations impingement
2003-2004
Total = 10,468

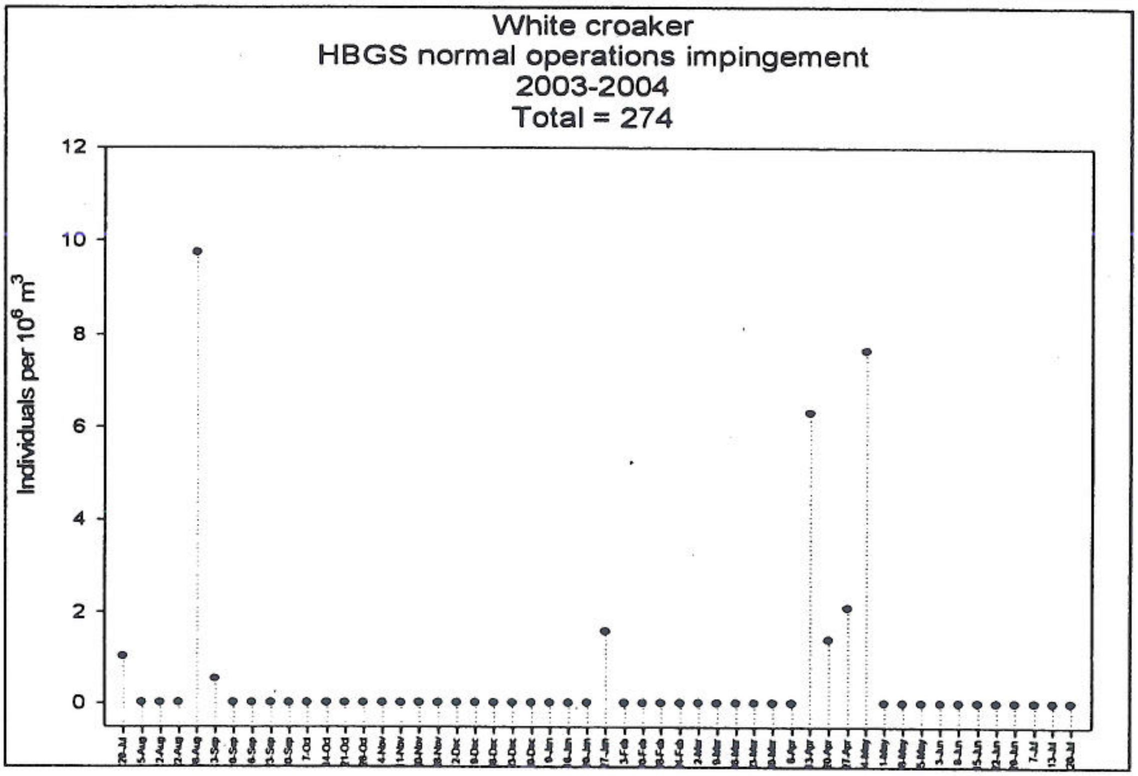

Queenfish
HBGS normal operations impingement
2003-2004
Biomass = 58.0 kg

Appendix C-5. (Cont.)

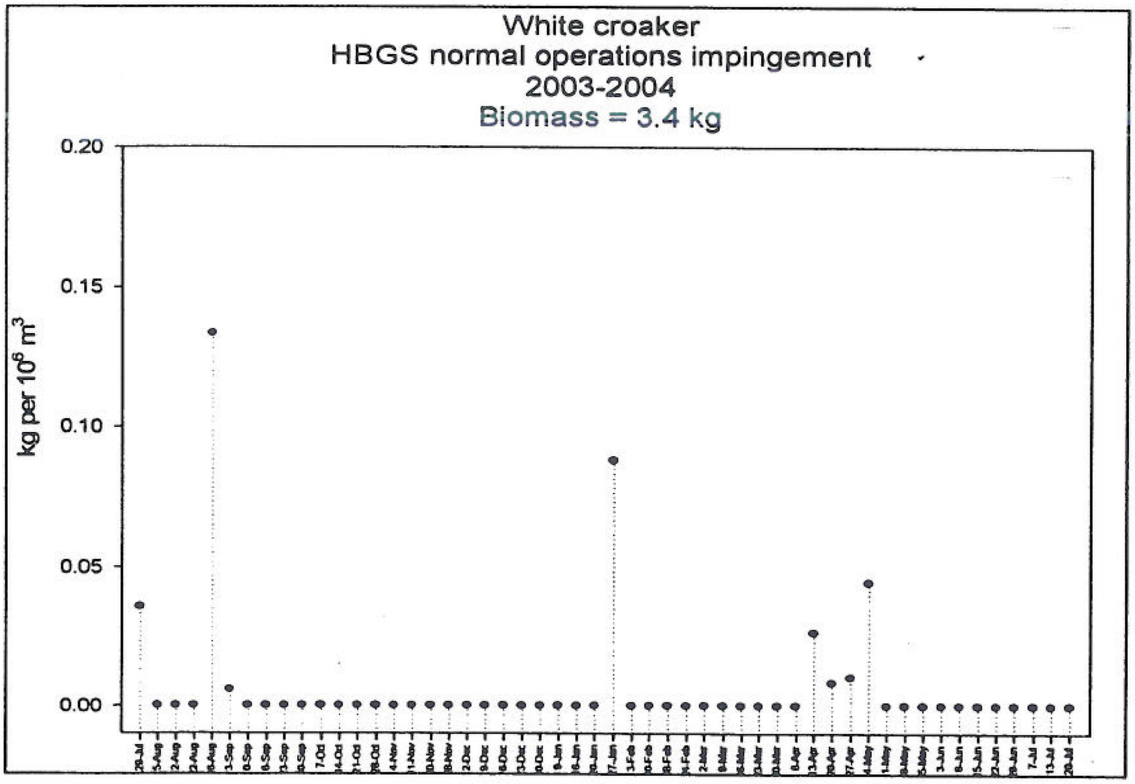




Appendix C-5. (Cont.)

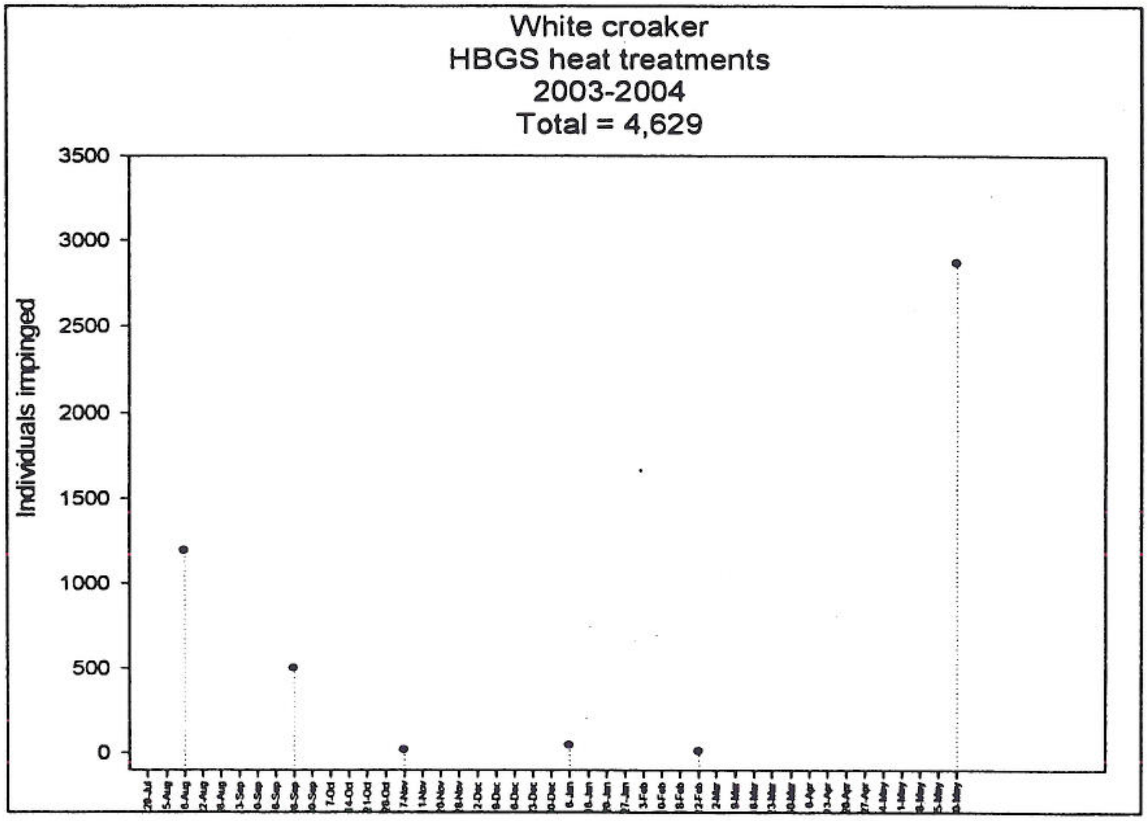


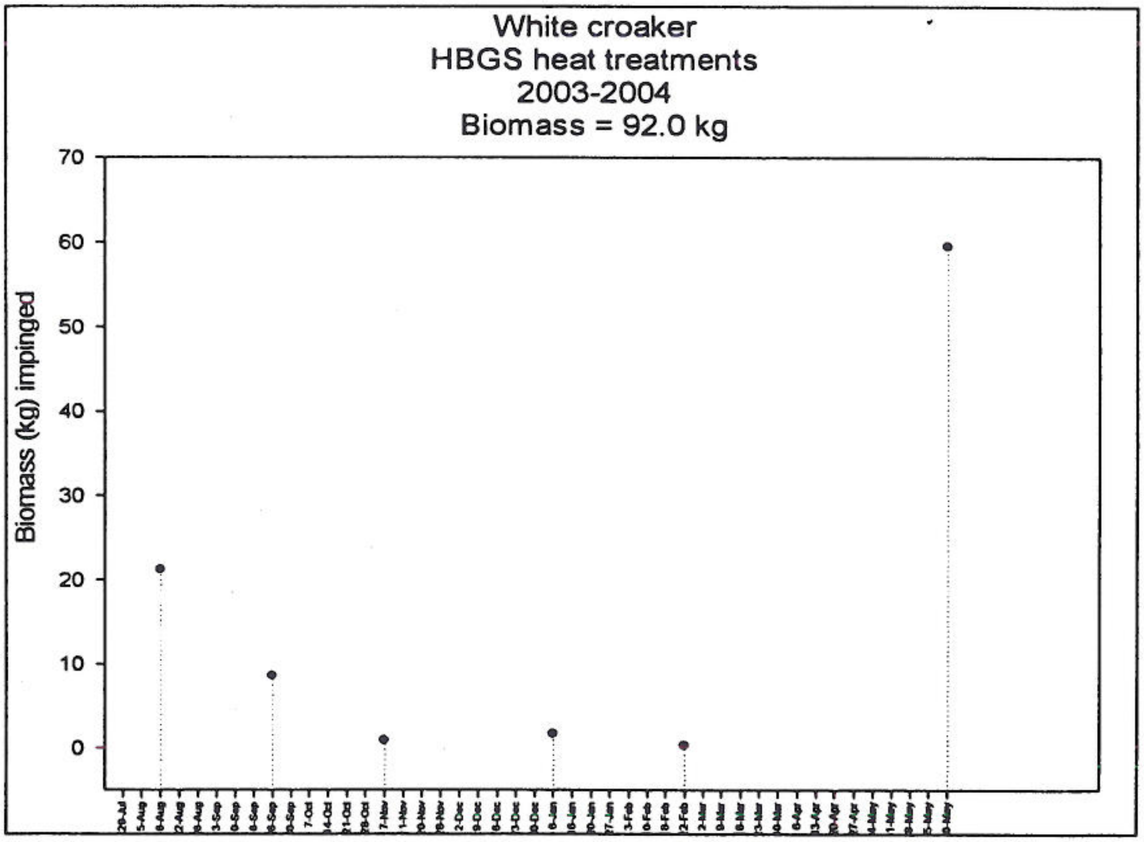
White croaker
HBGS normal operations impingement
2003-2004
Total = 274



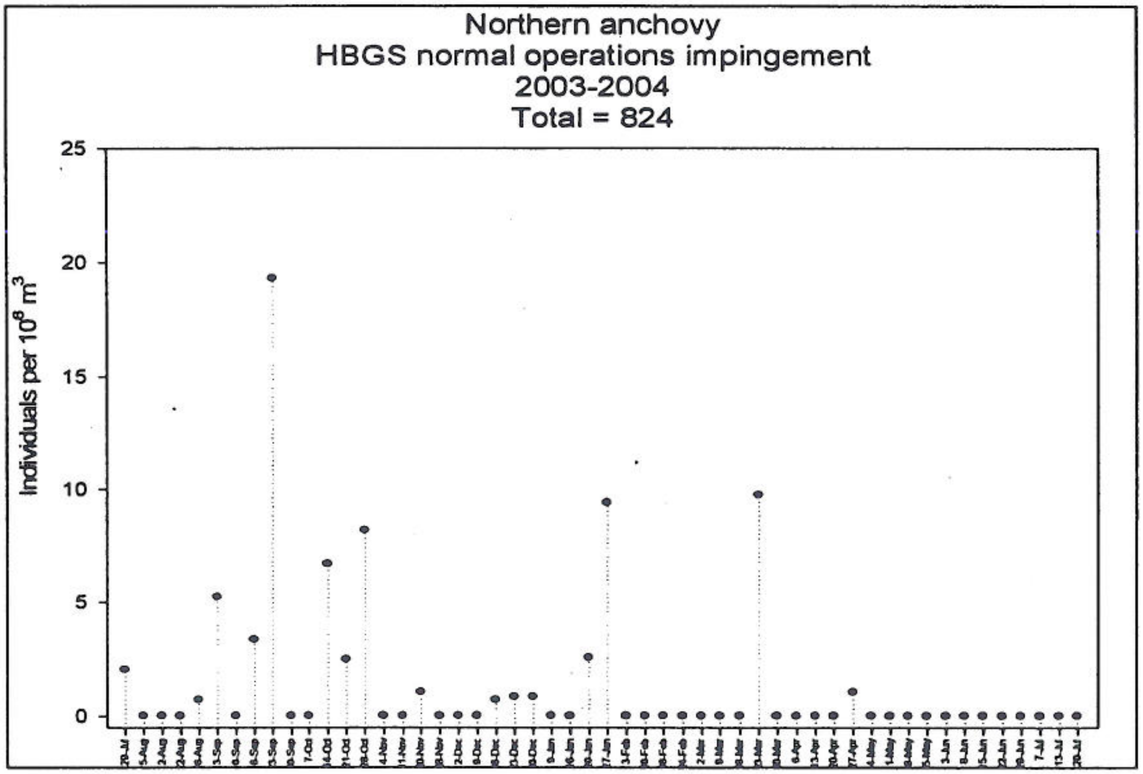
White croaker
HBGS normal operations impingement
2003-2004
Biomass = 3.4 kg

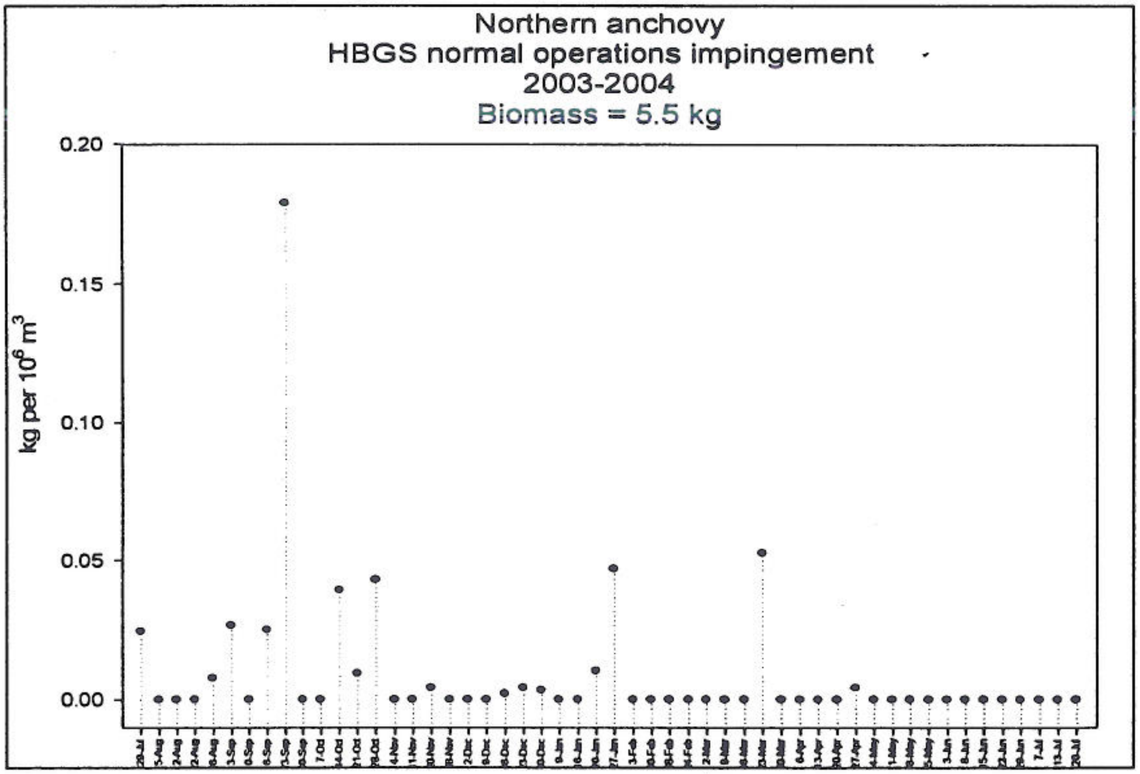
Appendix C-5. (Cont.)



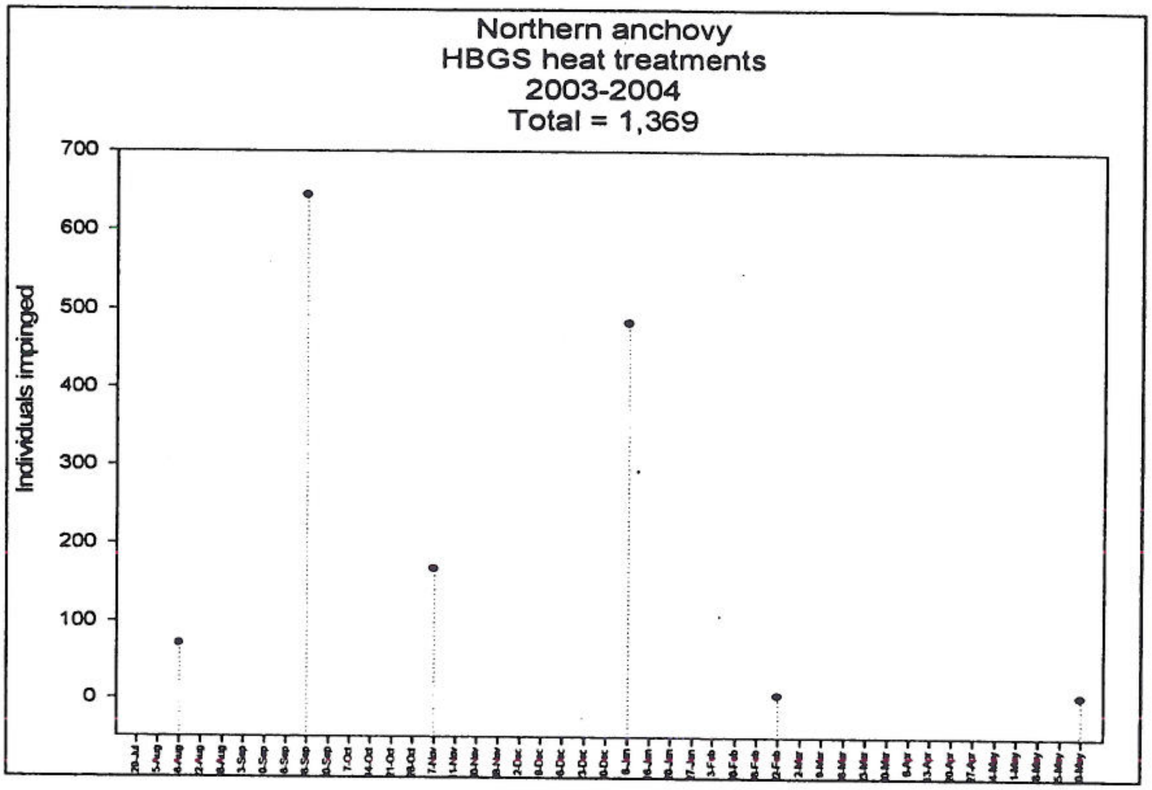


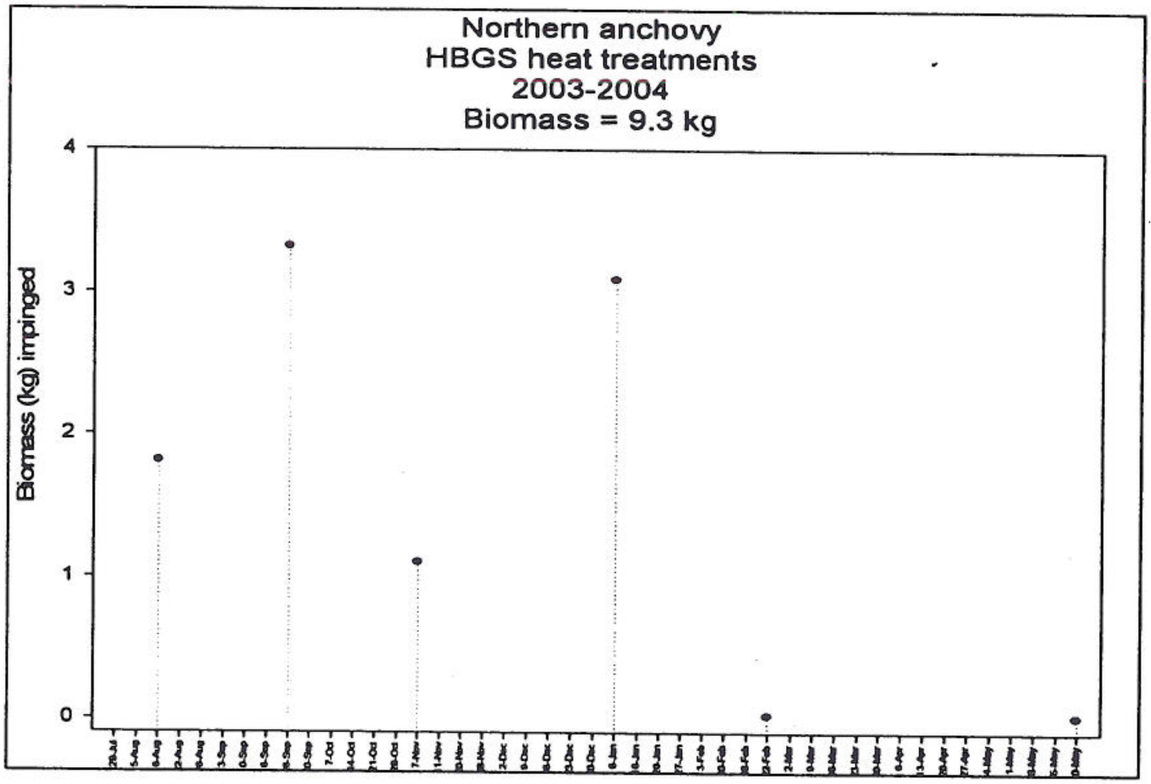
Appendix C-5. (Cont.)



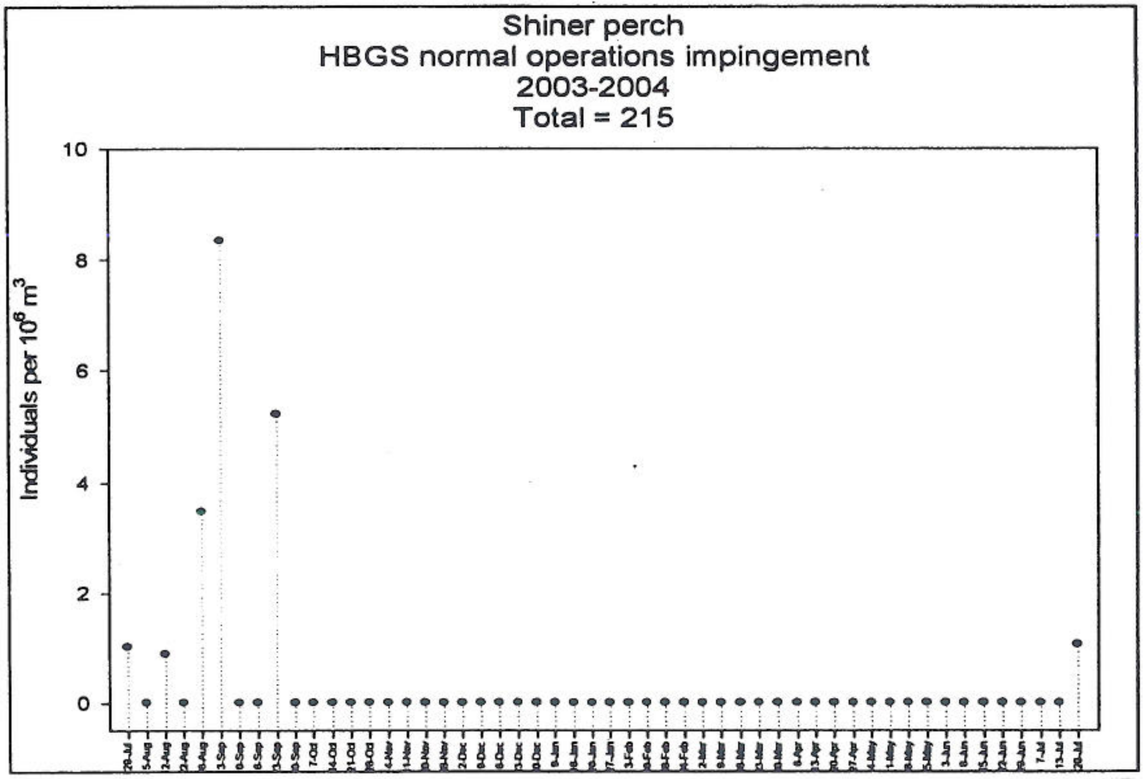


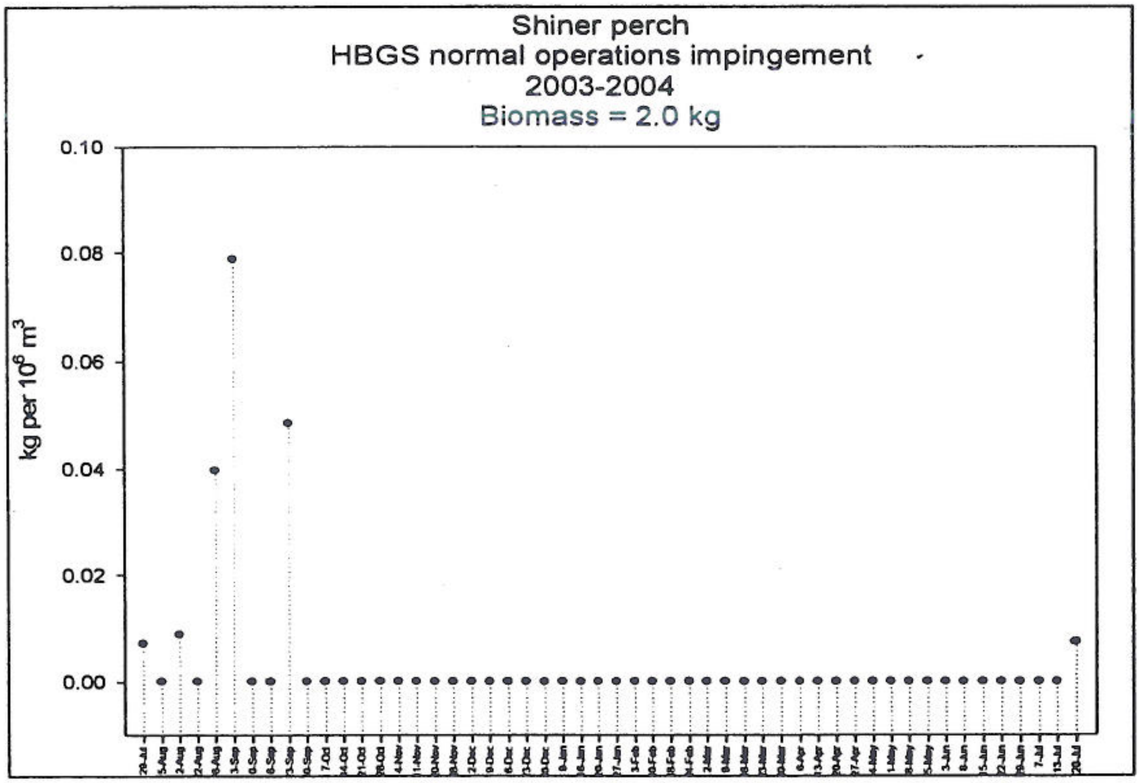
Appendix C-5. (Cont.)



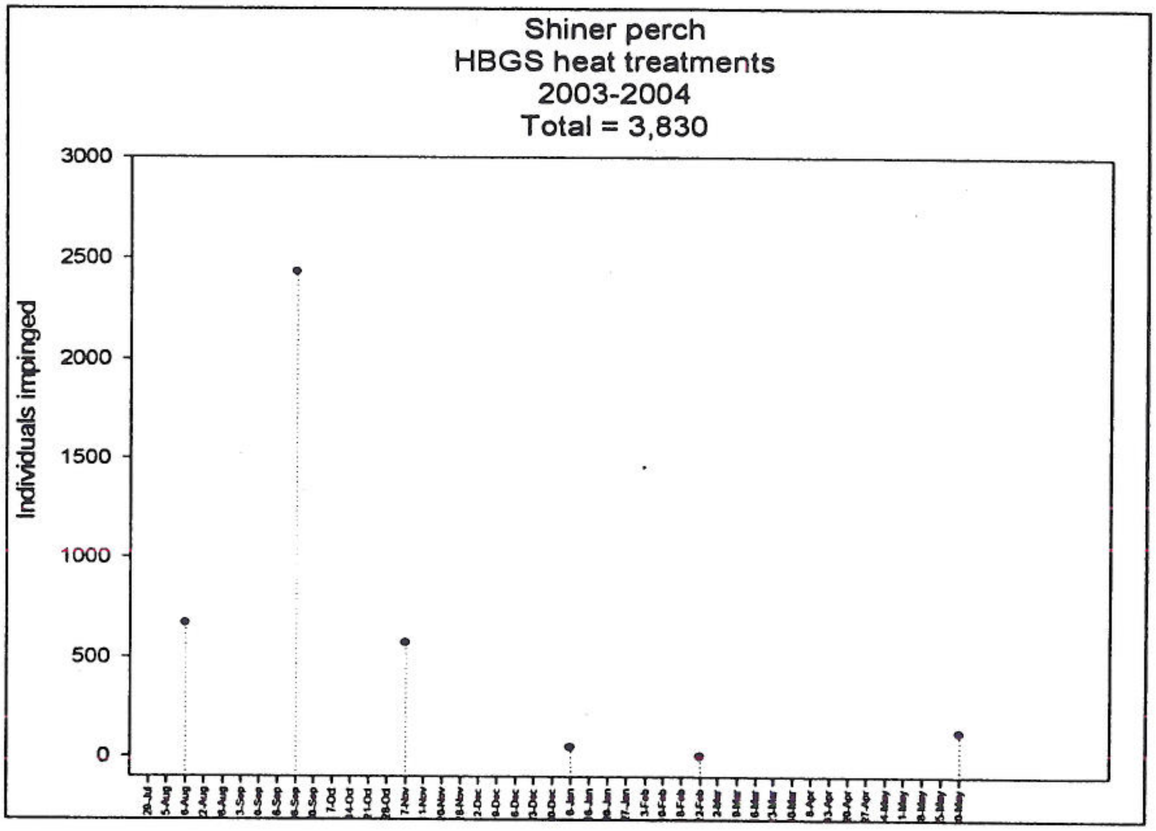


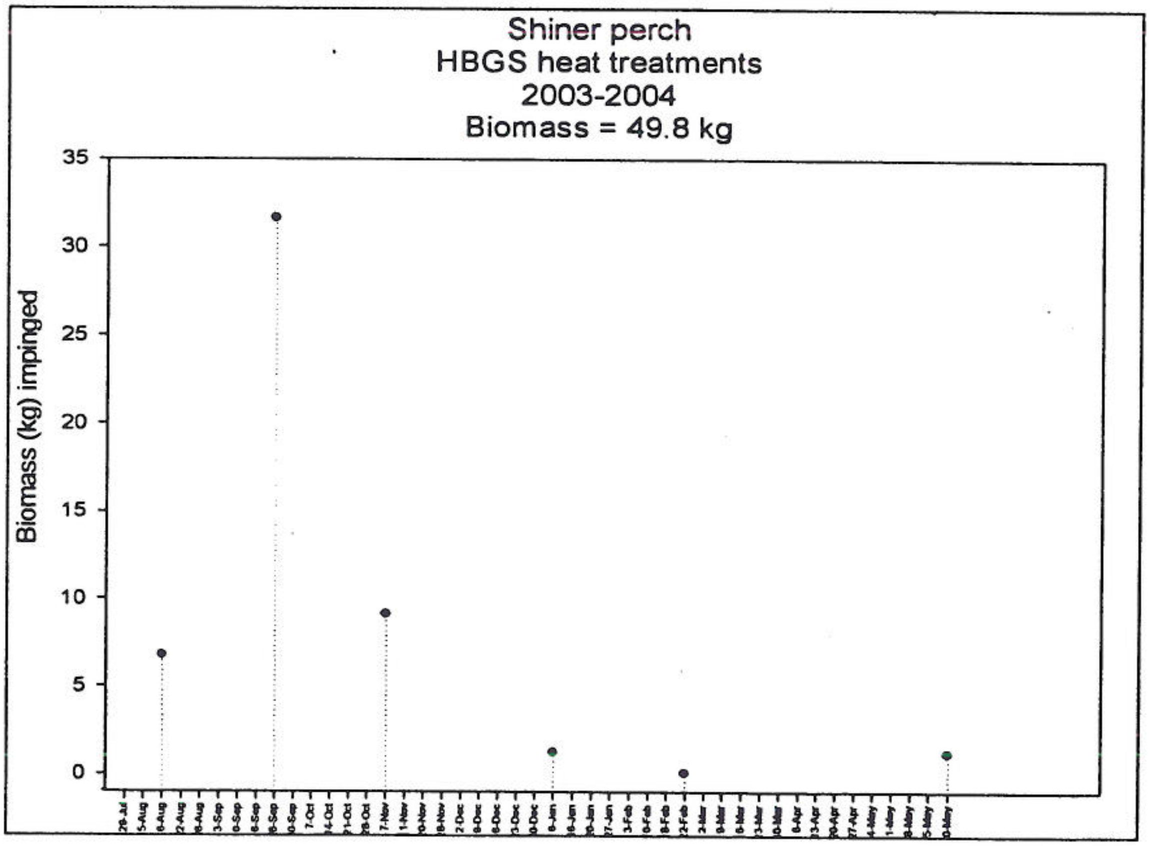
Appendix C-5. (Cont.)


Shiner perch
HBGS normal operations impingement
2003-2004
Total = 215

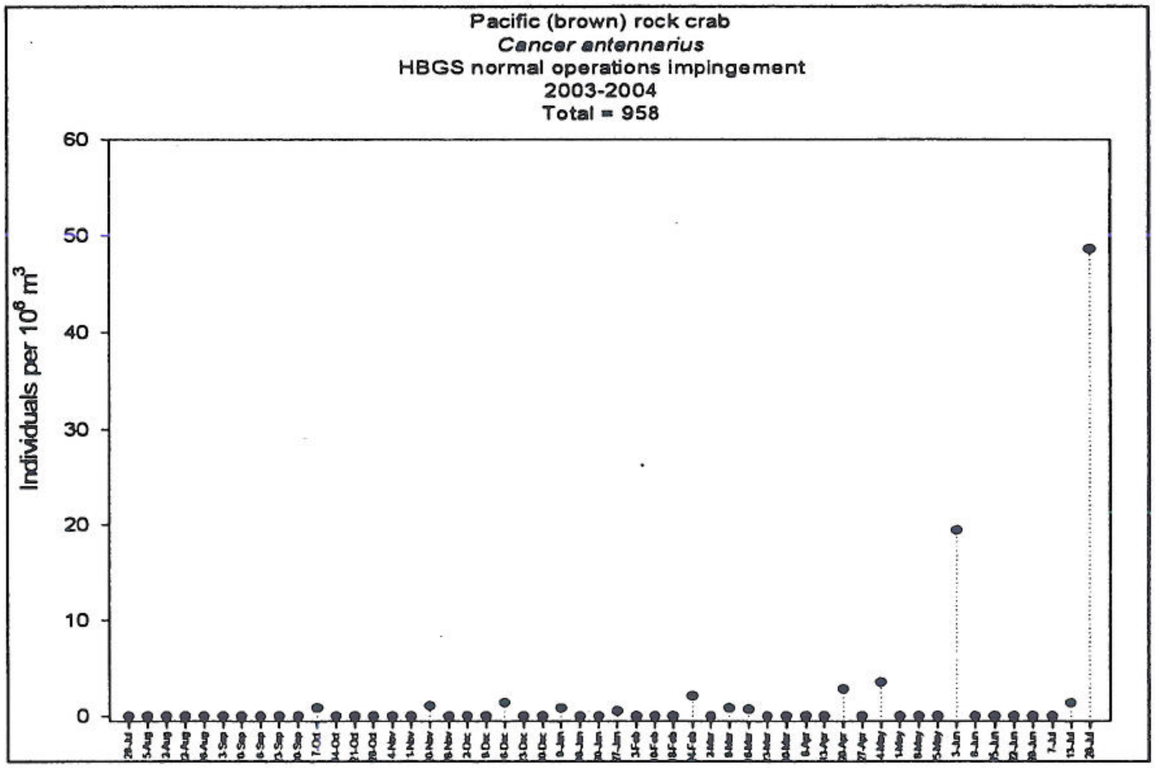

Shiner perch
HBGS normal operations impingement
2003-2004
Biomass = 2.0 kg

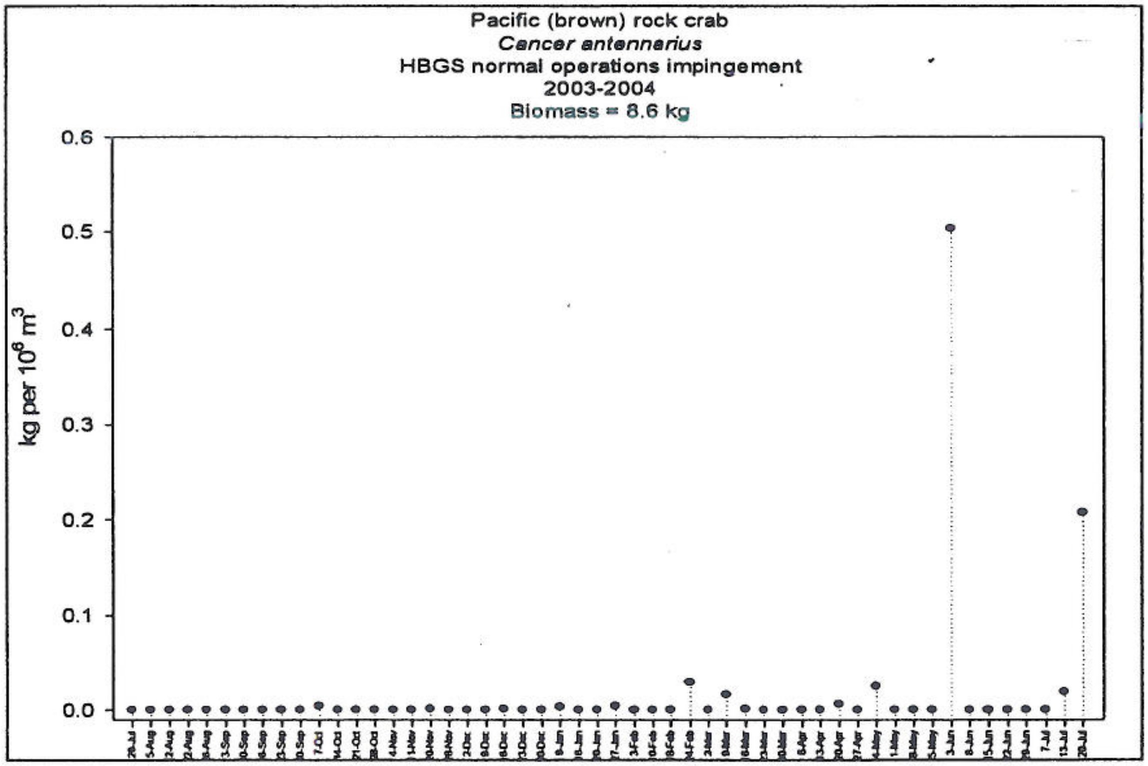
Appendix C-5. (Cont.)



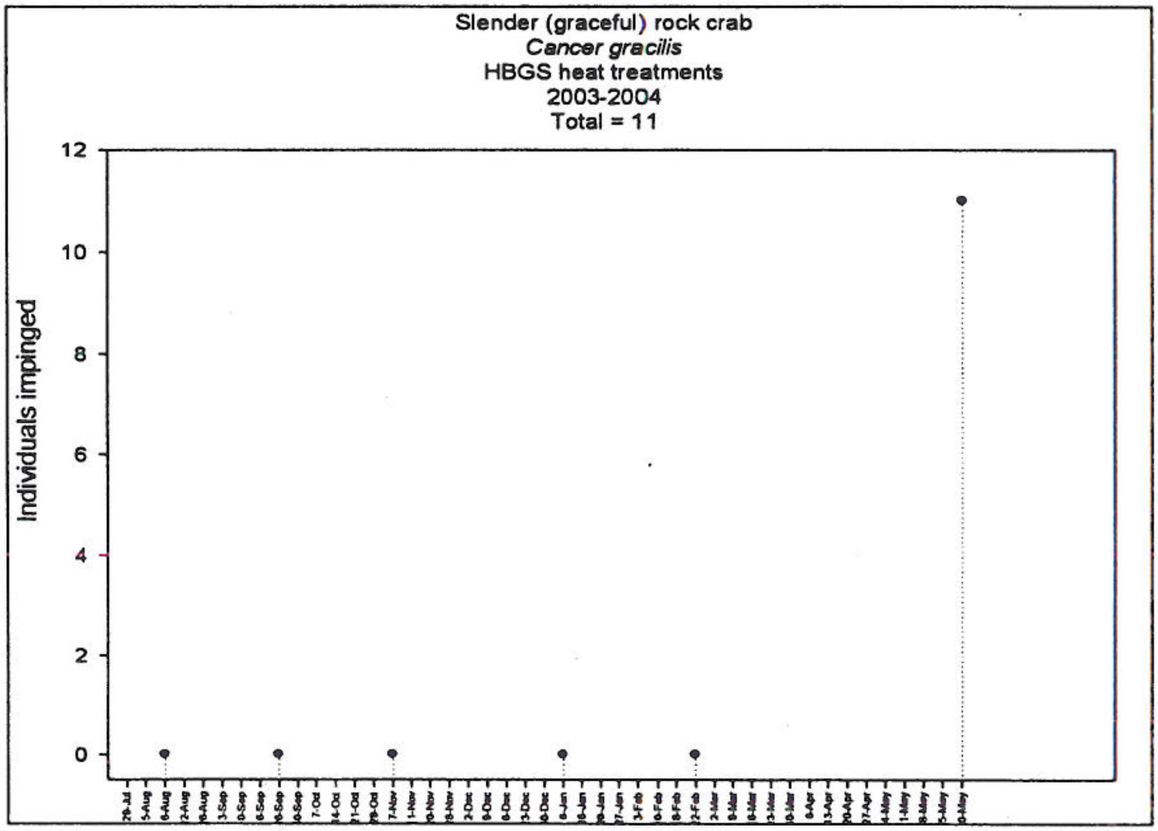


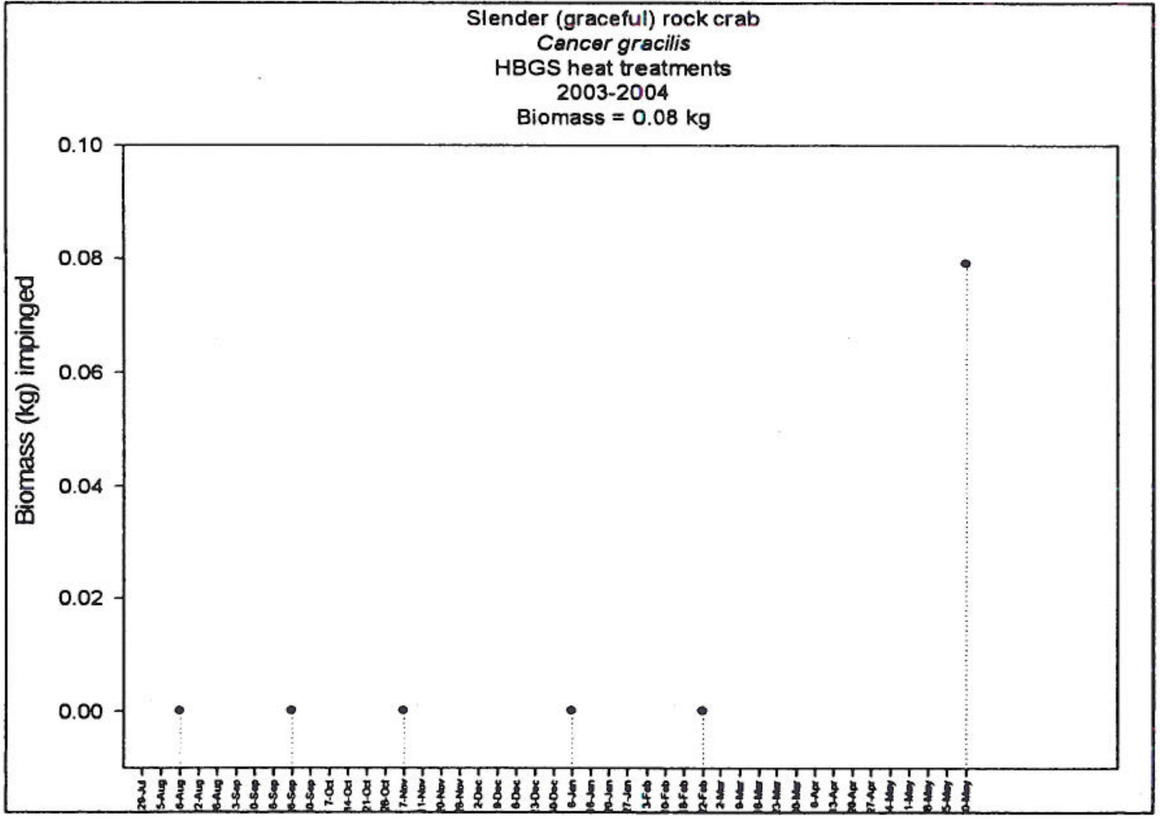
Appendix C-5. (Cont.)


Pacific (brown) rock crab
Cancer antennarius
HBGS normal operations impingement
2003-2004
Total = 958

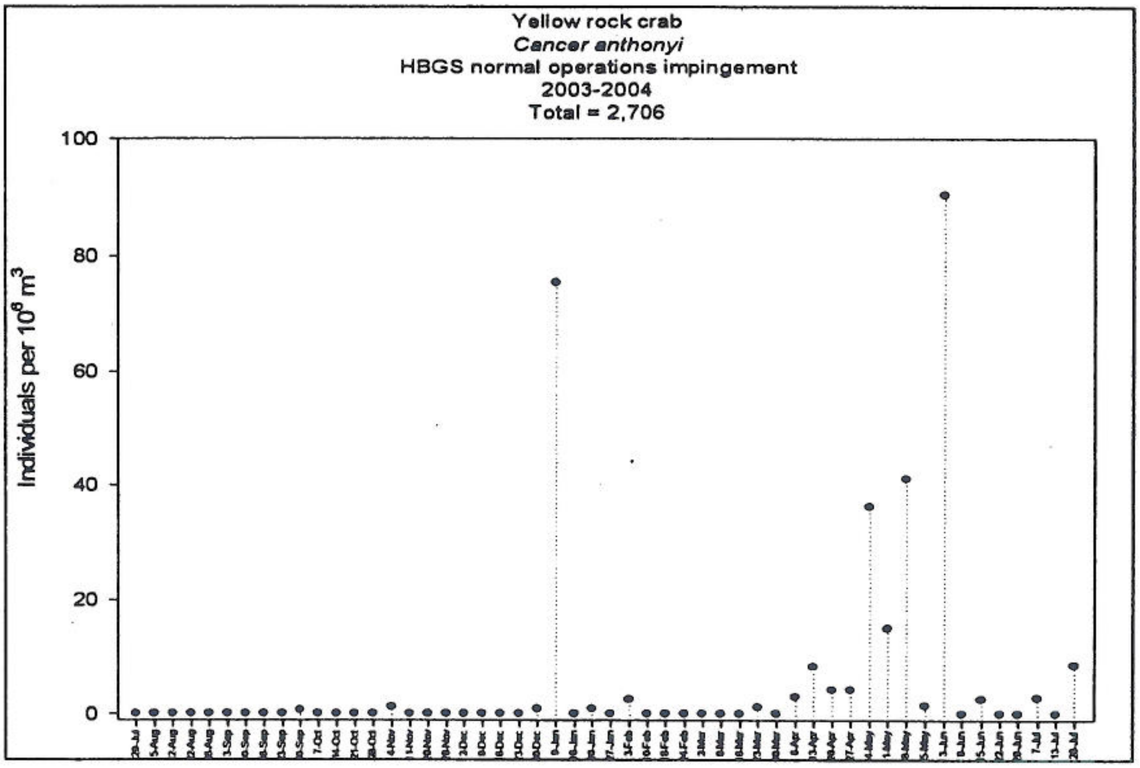

Pacific (brown) rock crab
Cancer antennarius
HBGS normal operations impingement
2003-2004
Biomass = 8.6 kg

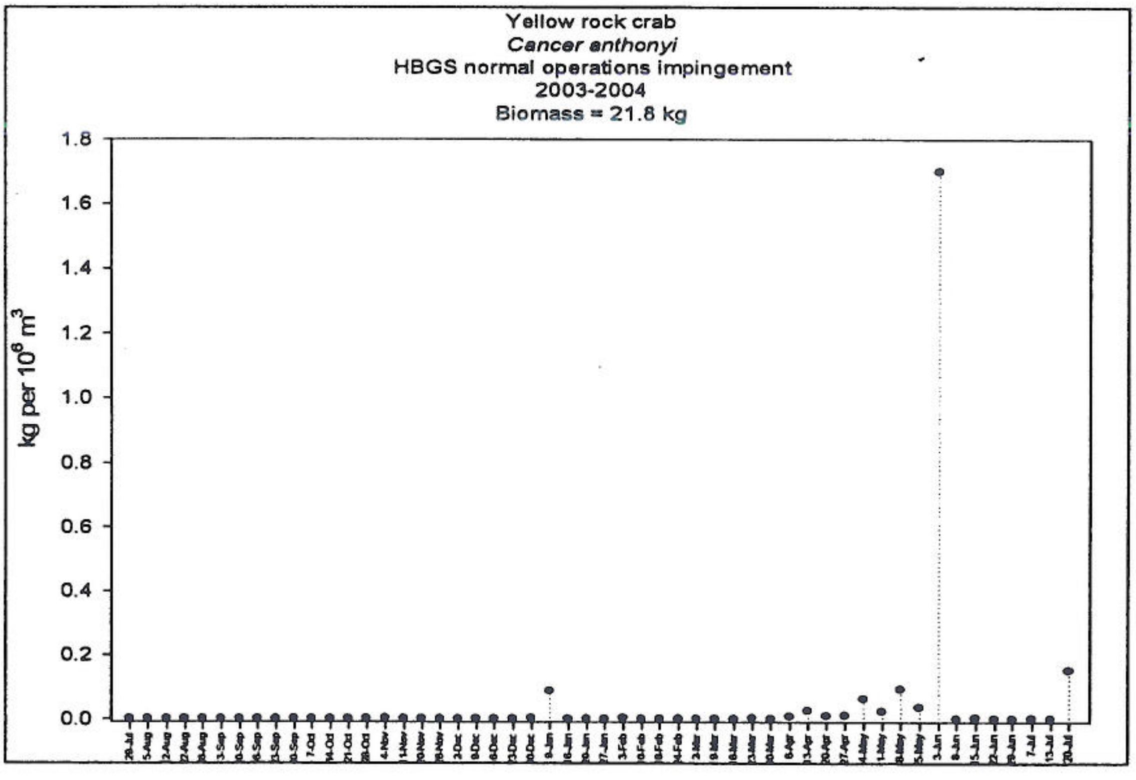
Appendix C-5. (Cont.)



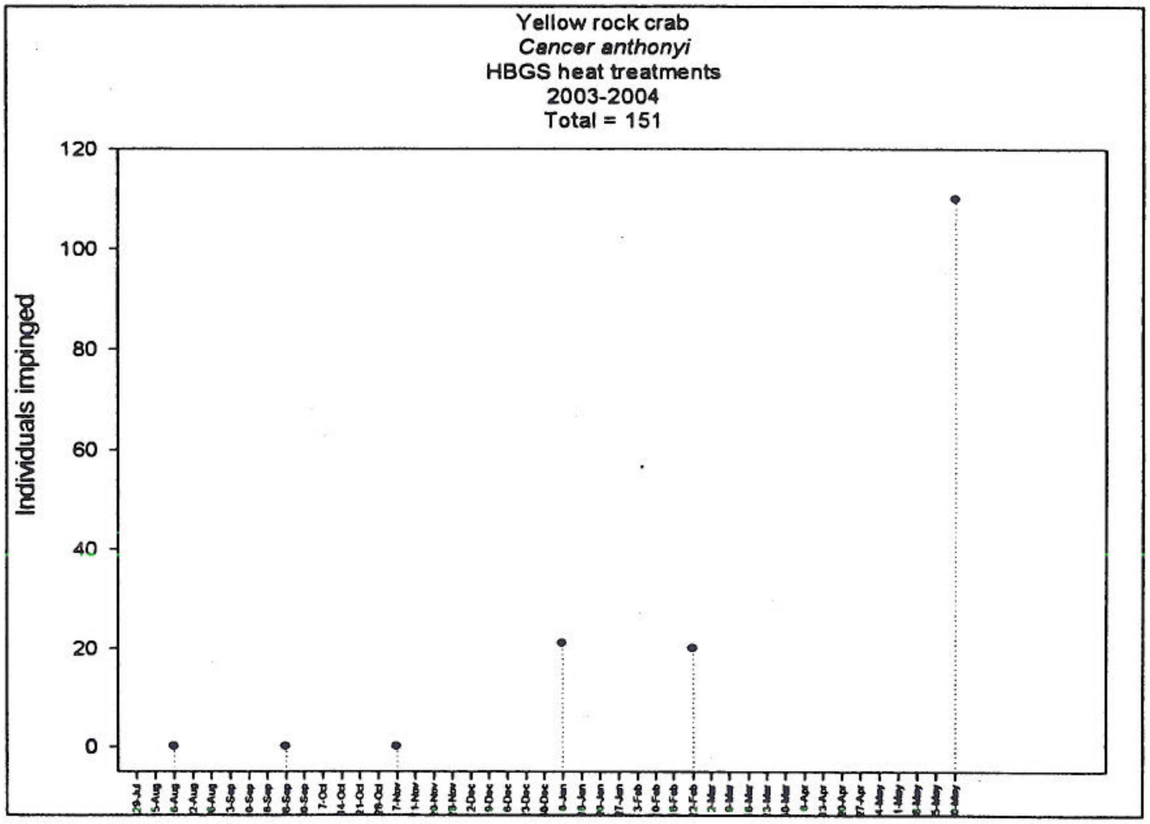


Appendix C-5. (Cont.)

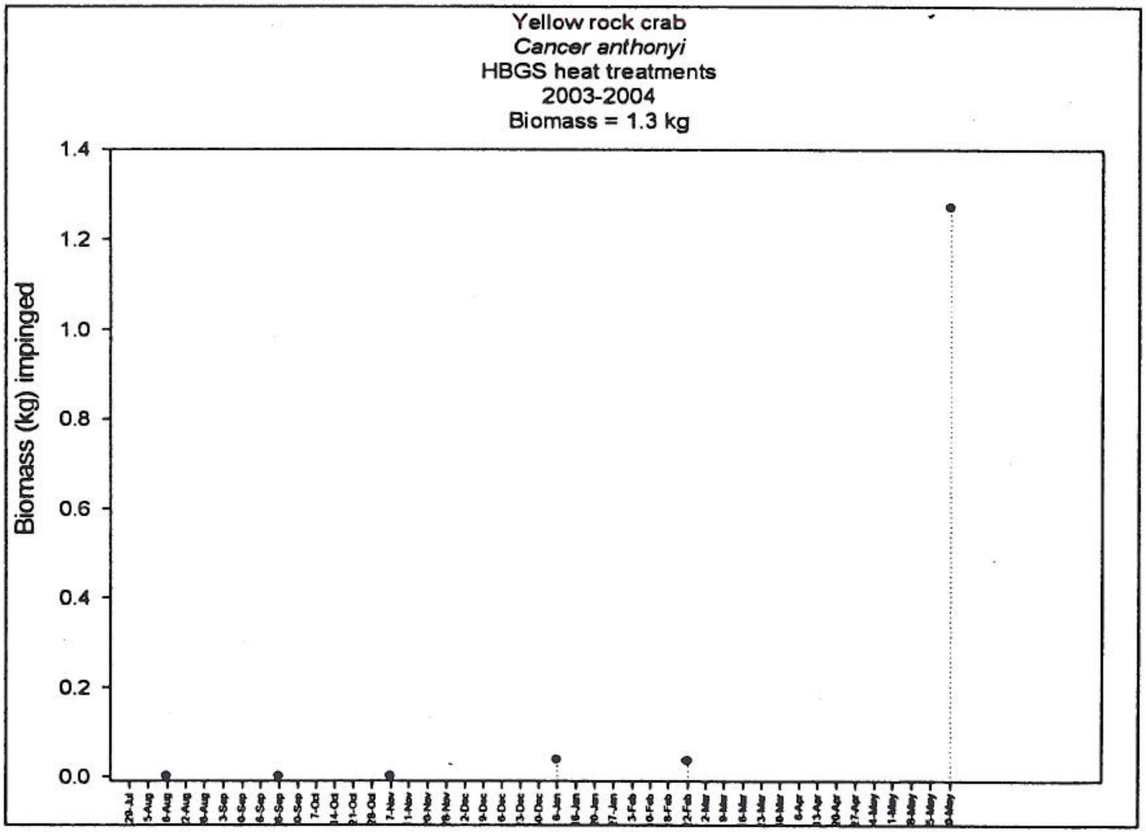




Appendix C-5. (Cont.)

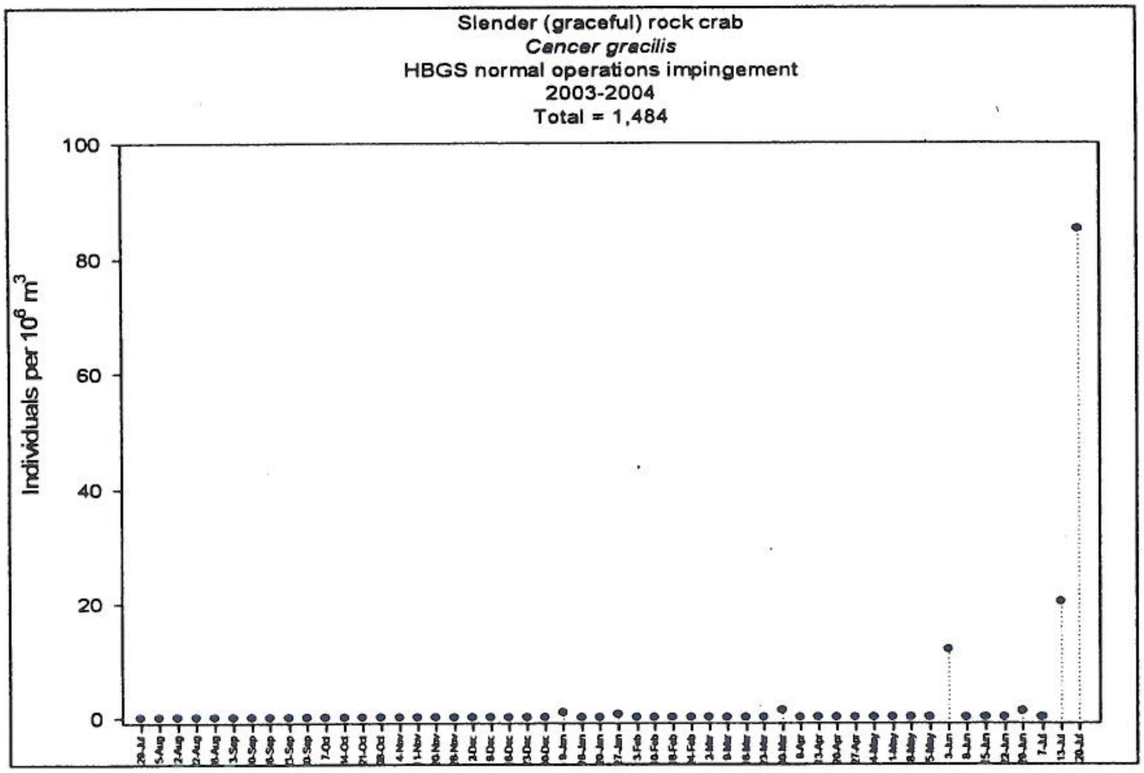


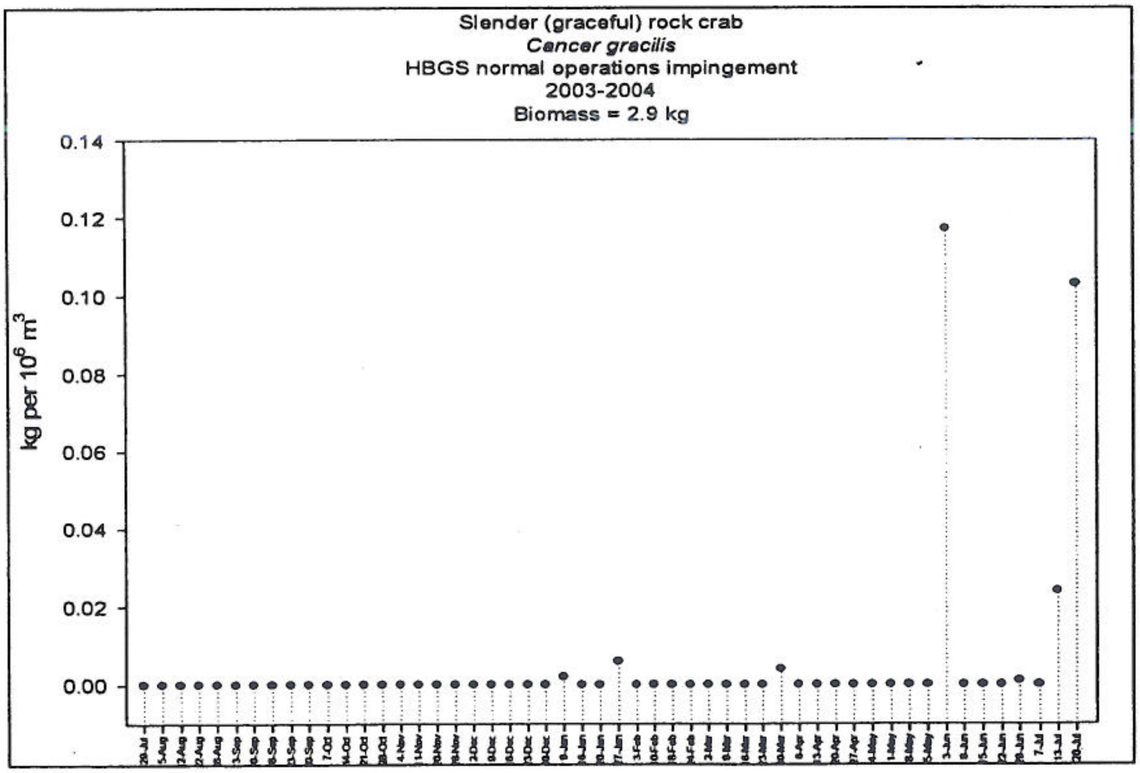
Yellow rock crab
Cancer anthonyi
HBGS heat treatments
2003-2004
Total = 151



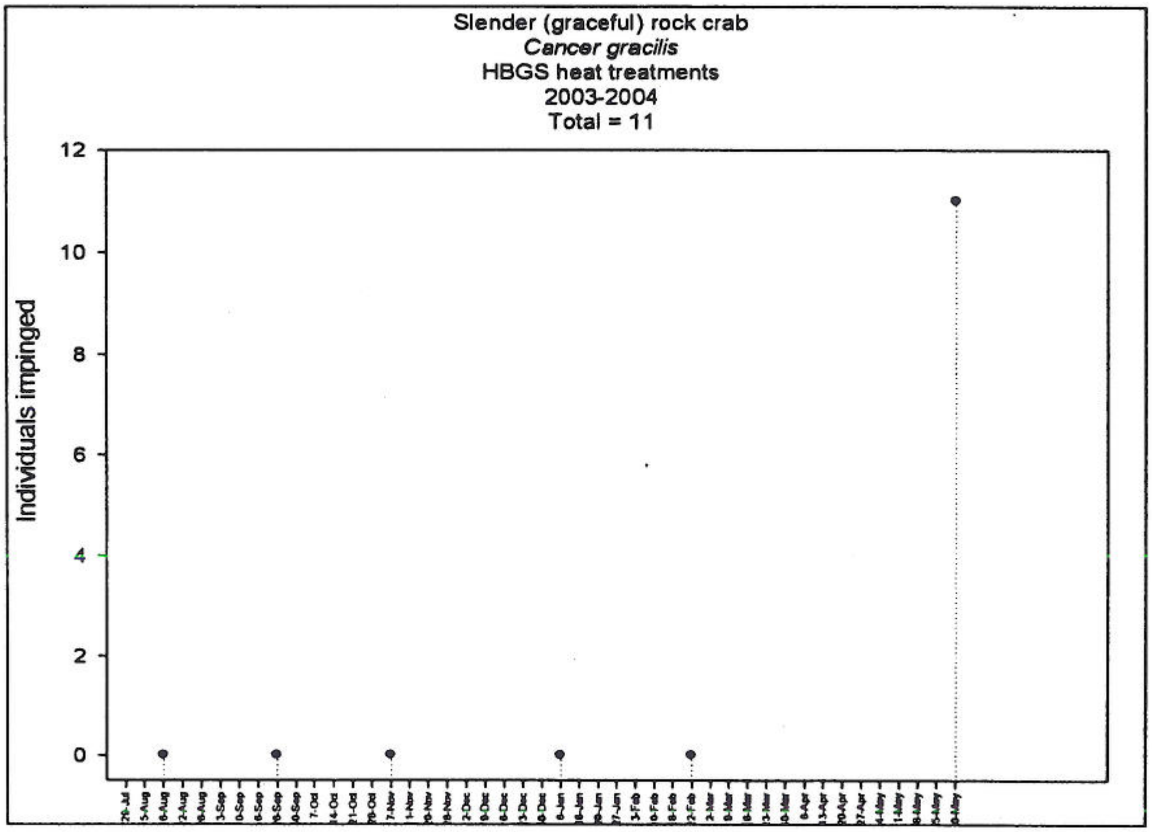
Yellow rock crab
Cancer anthonyi
HBGS heat treatments
2003-2004
Biomass = 1.3 kg

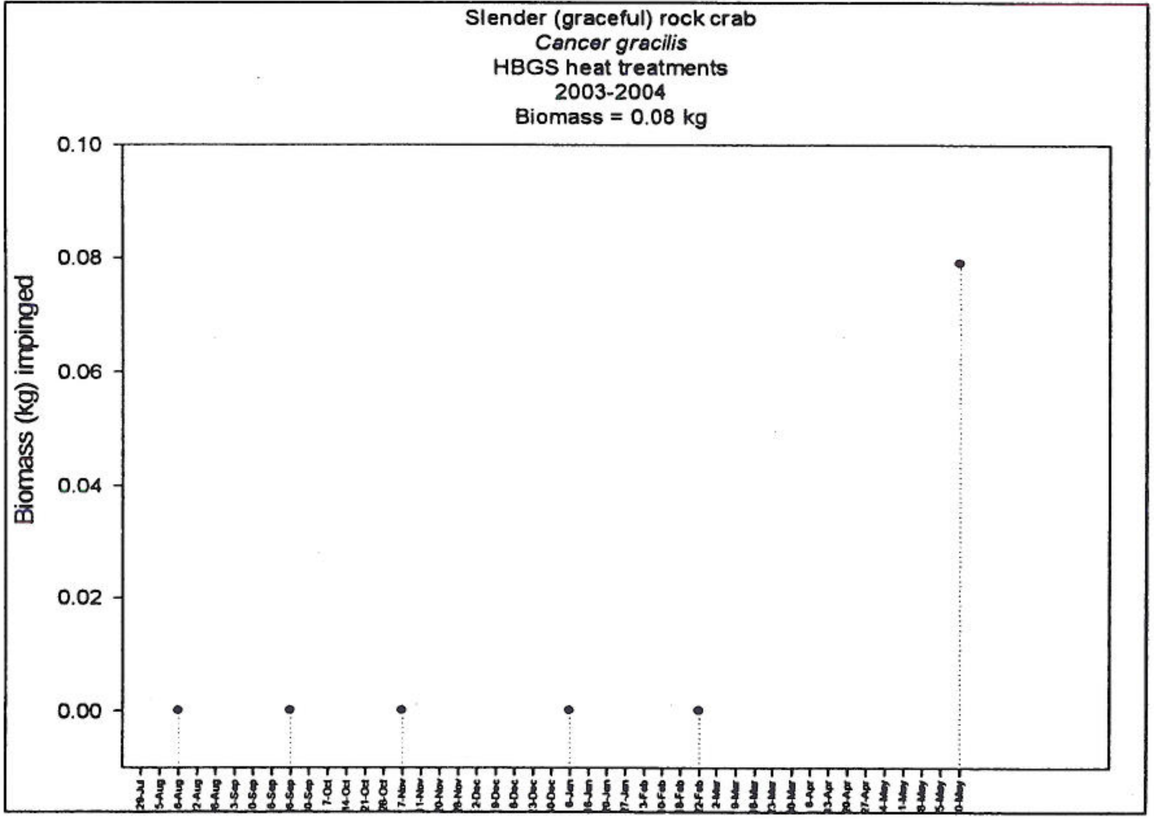
Appendix C-5. (Cont.)


Slender (graceful) rock crab
Cancer gracilis
HBGS normal operations impingement
2003-2004
Total = 1,484

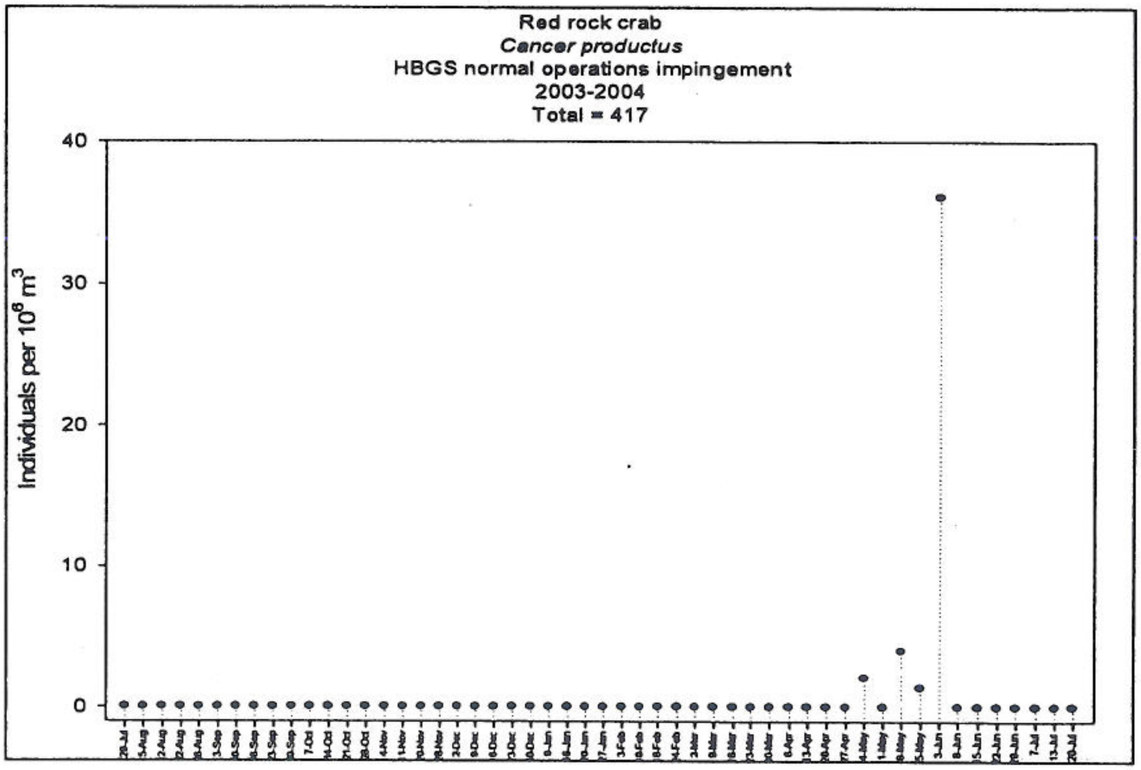

Slender (graceful) rock crab
Cancer gracilis
HBGS normal operations impingement
2003-2004
Biomass = 2.9 kg

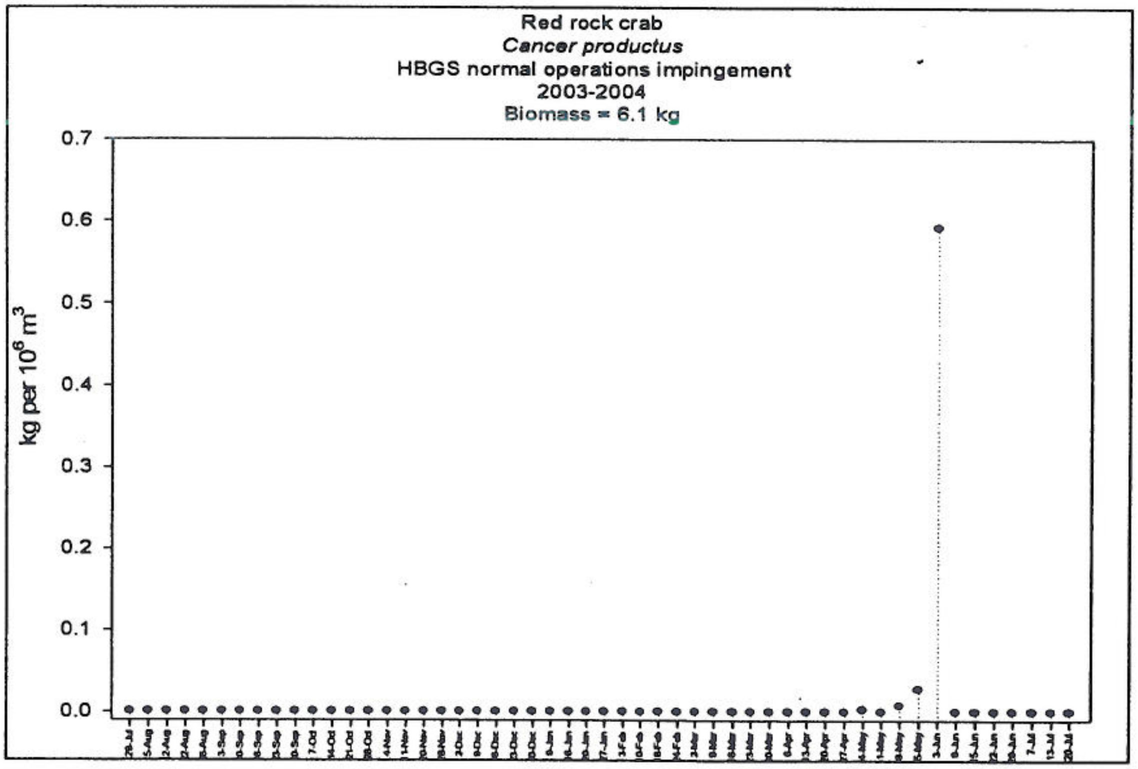
Appendix C-5. (Cont.)


Slender (graceful) rock crab
Cancer gracilis
HBGS heat treatments
2003-2004
Total = 11


Slender (graceful) rock crab
Cancer gracilis
HBGS heat treatments
2003-2004
Biomass = 0.08 kg

Appendix C-5. (Cont.)





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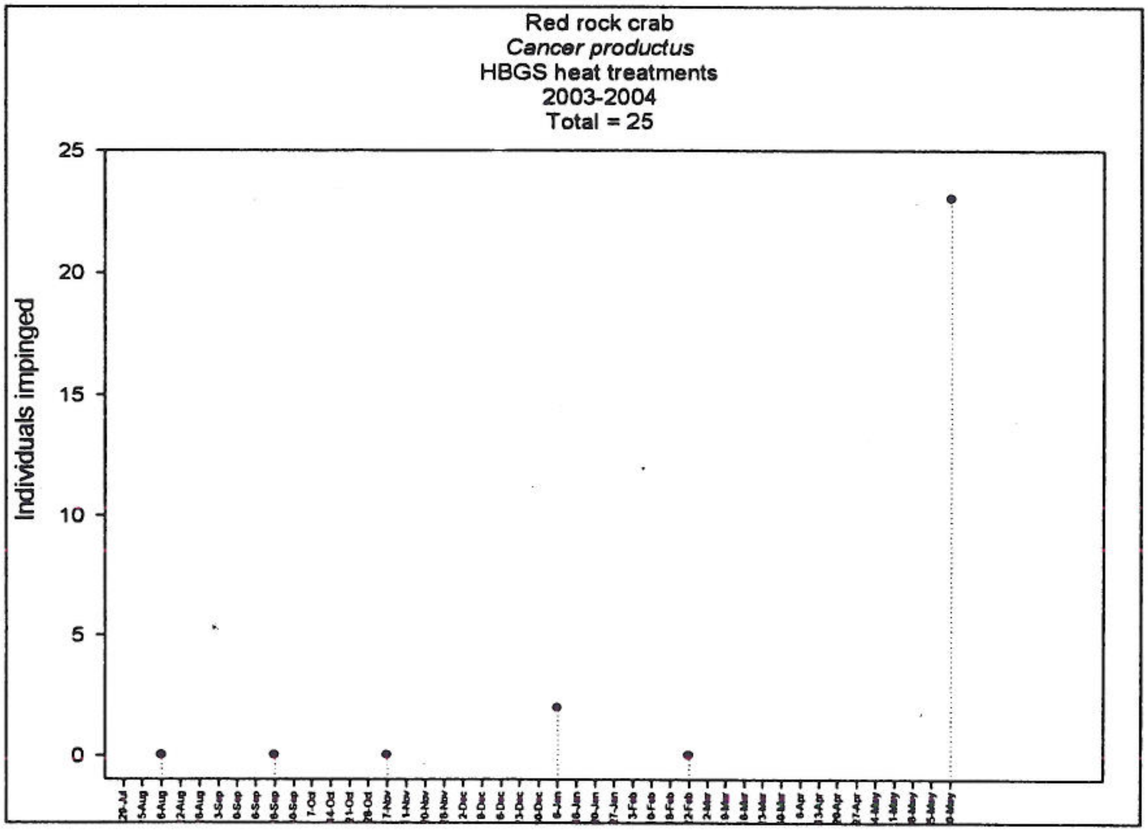
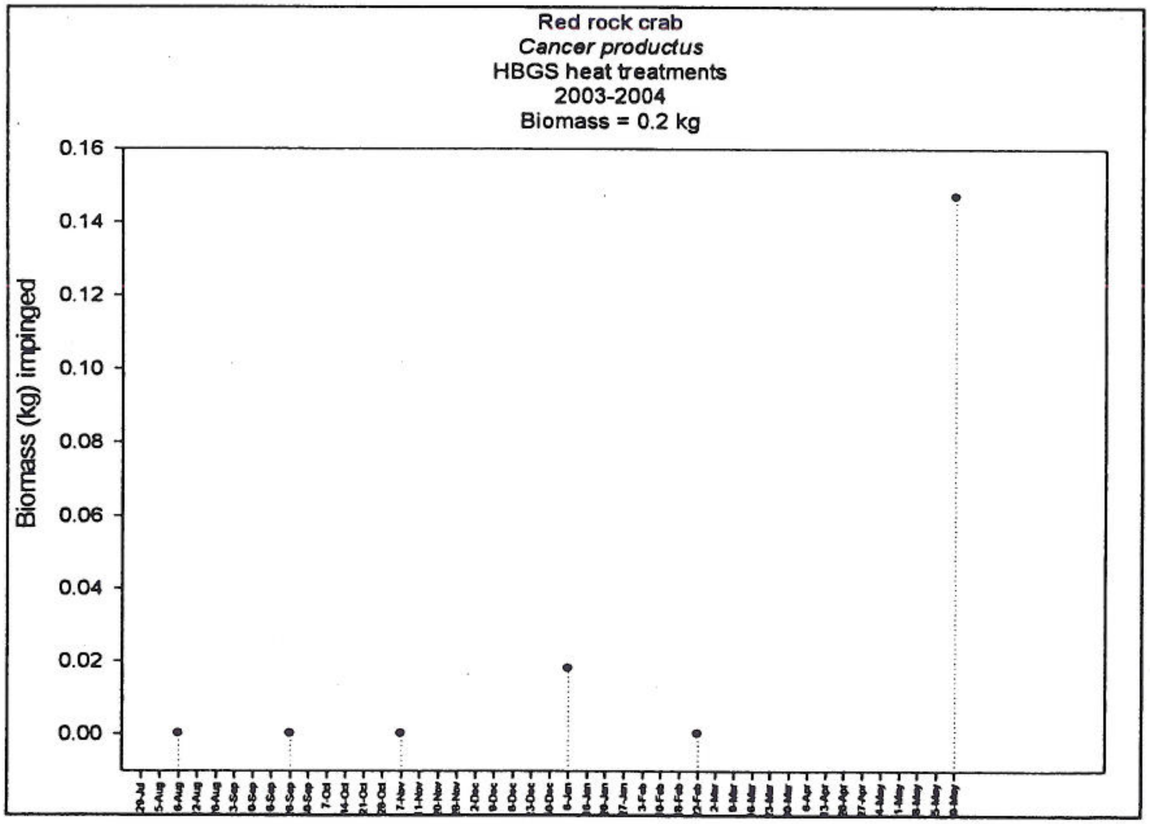
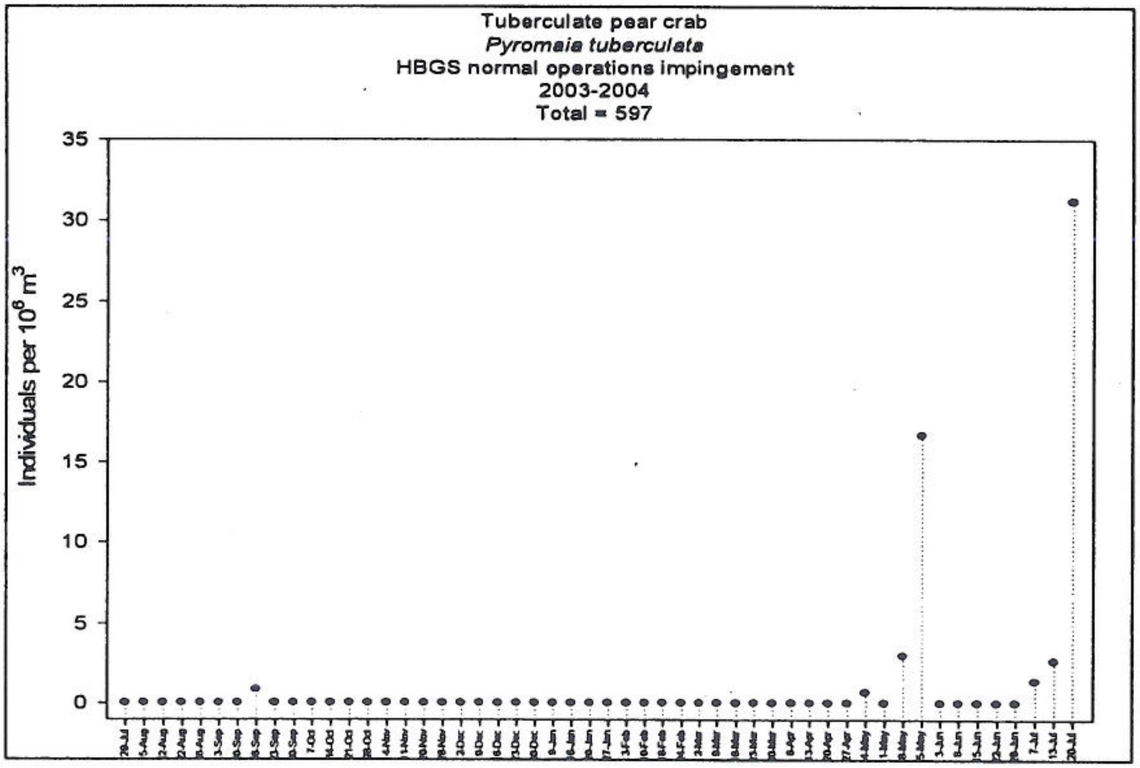
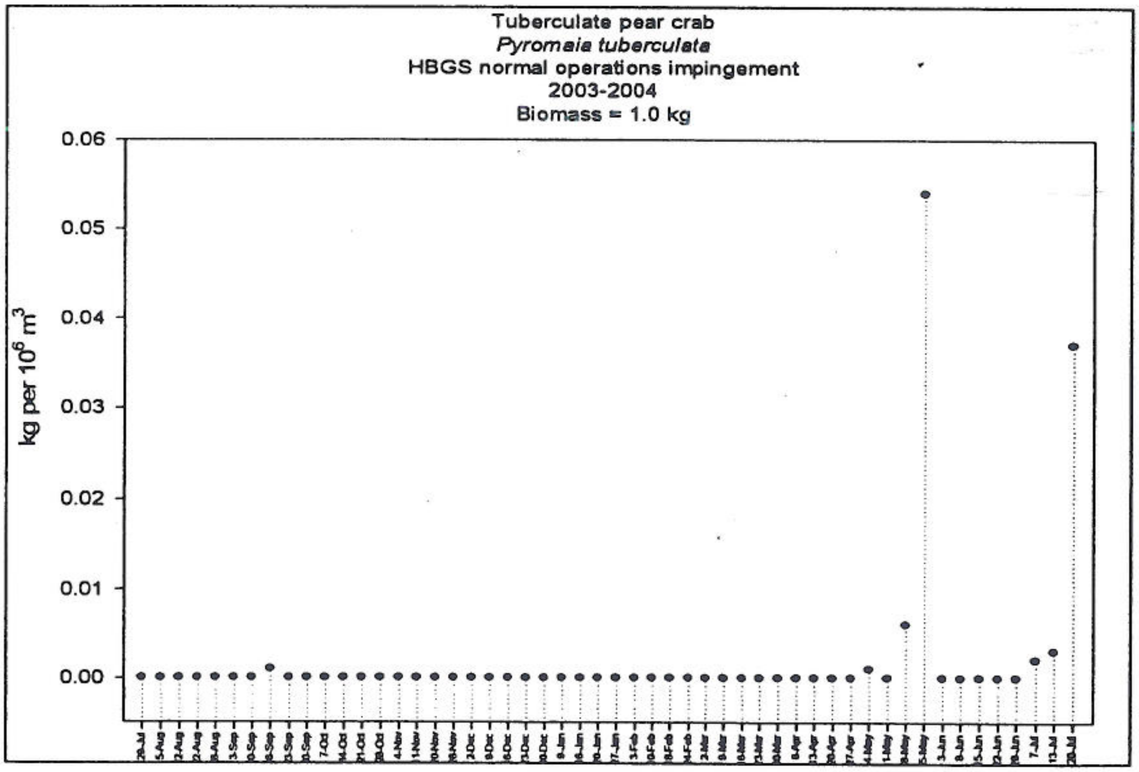
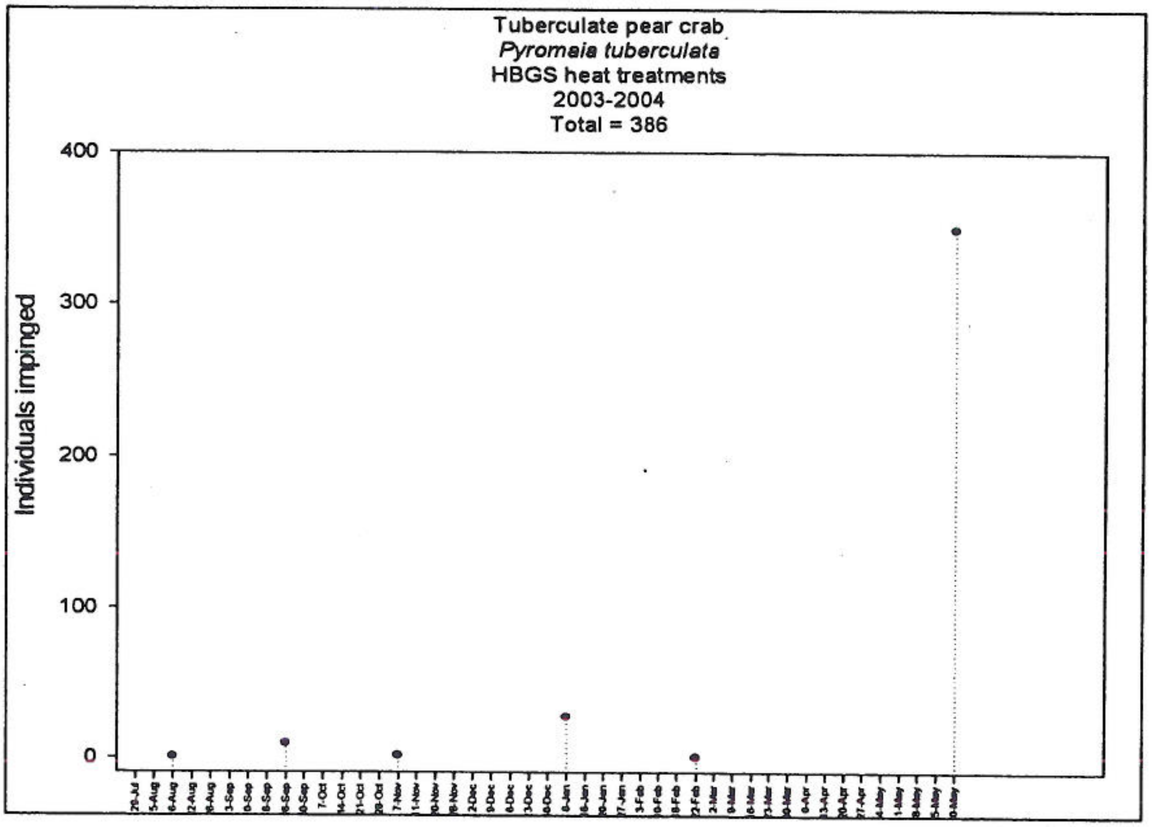


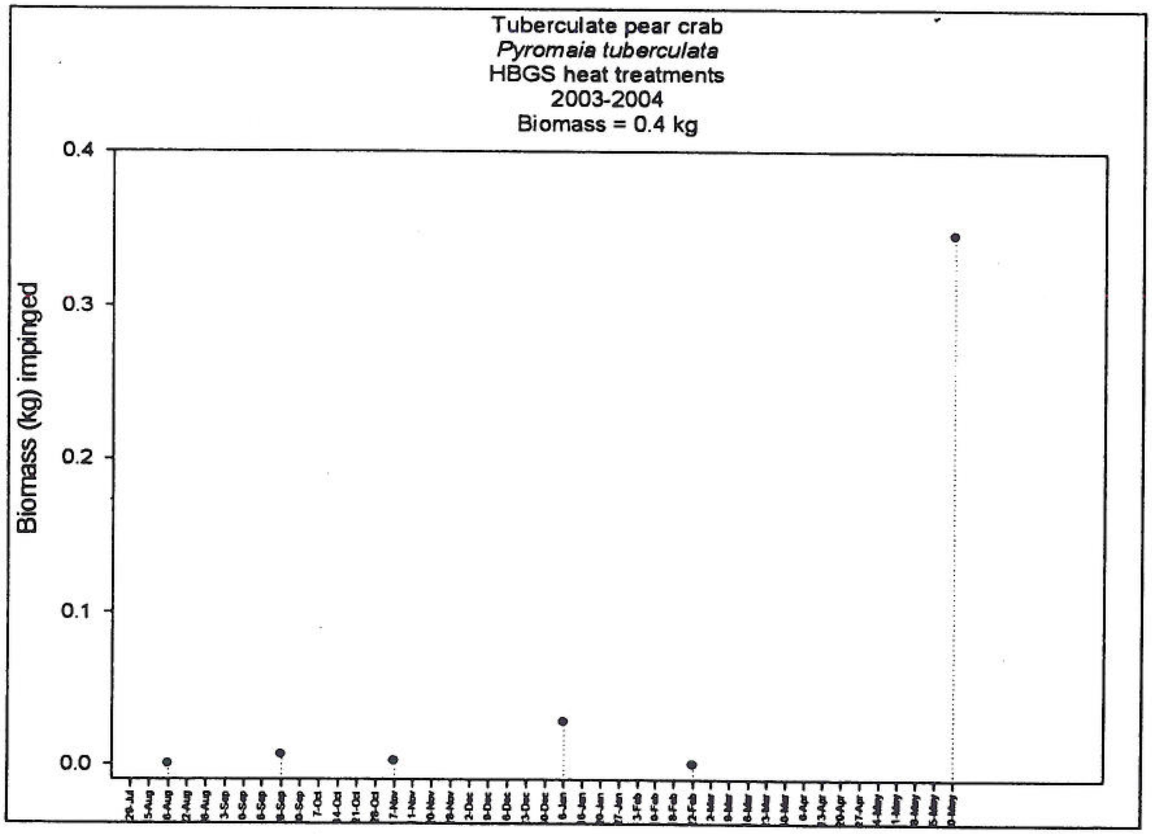



Tuberculate pear crab
Pyromaia tuberculata
HBGS normal operations impingement
2003-2004
Total = 597
Individuals per 10^6 m^3
35
30
25
20
15
10
5
0
29-Jul
5-Aug
7-Oct
4-Nov
2-Dec
9-Dec
9-Jan
3-Feb
10-Feb
2-Mar
9-Mar
6-Apr
13-Apr
20-Apr
27-Apr
4-May
11-May
3-Jun
8-Jun
15-Jun
7-Jul
13-Jul
20-Jul


Tuberculate pear crab
Pyromaia tuberculata
HBGS normal operations impingement
2003-2004
Biomass = 1.0 kg
kg per 10^6 m^3
0.06
0.05
0.04
0.03
0.02
0.01
0.00
29-Jul
5-Aug
7-Oct
4-Nov
2-Dec
9-Dec
9-Jan
3-Feb
10-Feb
2-Mar
9-Mar
6-Apr
13-Apr
20-Apr
27-Apr
4-May
11-May
3-Jun
8-Jun
15-Jun
7-Jul
13-Jul
20-Jul

Appendix C-5. (Cont.)





Appendix D

Master Species Lists

Appendix D-1. Master species list of fishes entrained and/or impinged at the AES HBGS, July 2003 - August 2004.

PHYLUM Class Family Species	Common Name
VERTEBRATA	
Elasmobranchiomorphi	
Carcharhinidae	
Triakis semifasicata	leopard shark
Torpedinidae	
Torpedo californica	Pacific electric ray
Platyrhinidae	
Platyrhinoidis triseriata	thornback
Rhinobatidae	
Rhinobatos productus	shovelnose guitarfish
Urolophidae	
Urolophus halleri = *Urolobatis halleri*	round stingray
Myliobatidae	
Myliobatis californica	bat ray
Osteichthys	
Ophichthidae	
Ophichthus zophochir	yellow snake eel
Clupeidae	
Etrumeus teres	round herring
Sardinops sagax	Pacific sardine
Engraulidae	
Anchoa compressa	deepbody anchovy
Engraulis mordax	northern anchovy
Synodontidae	
Synodus lucioceps	California lizardfish
Myctophidae	
Diaphus theta	California headlightfish
Stenobrachius leucopsarus	northern lampfish
Triphotorus mexicanus	Mexican lampfish
Merlucciidae	
Merluccius productus	Pacific hake

Appendix D-1. (Cont.)

PHYLUM Class Family Species	Common Name
Ophidiidae	
Chilara taylori	spotted cusk-eel
Ophidion scrippsae	basketweave cusk-eel
Batrachoididae	
Porichthys myriaster	specklefin midshipman
Porichthys notatus	plainfin midshipman
Gobiesocidae	
Gobiesox rhessodon	California clingfish
Atherinopsidae	
Atherinops affinis	topsmelt
Atherinopsis californiensis	jacksmelt
Leuresthes tenuis	California grunion
Belonidae	
Strongylura exilis	California needlefish
Aulorhynchidae	
Aulorhynchus flavidus	tubesnout
Syngnathidae	
Syngnathus californiensis	kelp pipefish
Syngnathus leptorhynchus	bay pipefish
Scorpaenidae	
Scorpaena guttata	California scorpionfish
Sebastes auriculatus	brown rockfish
Sebastes miniatus	vermillion rockfish
Sebastes spp. V	16 potential rockfish
Sebastes spp. V_De	KGB Rockfish Cmplx.
Sebastes spp. VD	
Hexagrammidae	
Oxylebius pictus	painted greenling
Zaniolepis spp.	combfishes
Cottidae	
Artedius lateralis	smoothhead sculpin
Leptocottus armatus	Pacific staghorn sculpin
Ruscarius creaseri	roughcheek sculpin
Scorpaenichthys marmoratus	cabezon

Appendix D-1. (Cont.)

PHYLUM Class Family Species	Common Name
Agonidae	
Odontopyxis trispinosa	pygmy poacher
Serranidae	
Paralabrax clathratus	kelp bass
Paralabrax maculatofasciatus	spotted sand bass
Paralabrax nebulifer	barred sand bass
Carangidae	
Trachurus symmetricus	jack mackerel
Haemulidae	
Anisotremus davidsonii	sargo
Xenistius californiensis	salema
Sciaenidae	
Atractoscion nobilis	white seabass
Cheilotrema saturnum	black croaker
Genyonemus lineatus	white croaker
Menticirrhus undulatus	California corbina
Seriphus politus	queenfish
Roncador stearnsii	spotfin croaker
Umbrina roncador	yellowfin croaker
Kyphosidae	
Girella nigricans	opaleye
Medialuna californiensis	halfmoon
Embiotocidae	
Cymatogaster aggregata	shiner perch
Embiotoca jacksoni	black perch
Hyperprosopon argenteum	walleye surfperch
Phanerodon furcatus	white seaperch
Rhacochilus toxotes	rubberlip seaperch
Rhacochilus vacca	pile perch
Pomacentridae	
Chromis punctipinnis	blacksmith
Hypsypops rubicundus	garibaldi

Appendix D-1. (Cont.)

PHYLUM Class Family Species	Common Name
Labridae	
Halichoeres semicinctus	rock wrasse
Oxyjulis californica	senorita
Semicossyphus pulcher	California sheephead
Labrisomidae	labrisomid blennies
Clinidae	
Gibbonsia spp.	kelp blennies
Heterostichus rostratus	giant kelpfish
Chaenopsidae	tube blennies
Blenniidae	
Hypsoblennius gilberti	rockpool blenny
Hypsoblennius jenkinsi	mussel blenny
Gobiidae	
Acanthogobius flavimanus	yellowfin goby
Clevlandia ios	arrow goby
Coryphopterus nicholsi = *Rhinogobiops nicholsi*	blackeye goby
Gillichthys mirabilis	longjaw mudsucker
Ilypnus gilberti	cheekspot goby
Lepidogobius lepidus	bay goby
Quietula y-cauda	shadow goby
Typhlogobius californiensis	blind goby
Sphyraenidae	
Sphyraena argentea	Pacific barracuda
Scombridae	
Scomber japonicus	Pacific (chub) mackerel
Stromateidae	
Peprilus simillimus	Pacific butterfish
Paralichthyidae	
Citharichthys sordidus	Pacific sanddab
Citharichthys stigmaeus	speckled sanddab
Hippoglossina stomata	bigmouth sole
Paralichthys californicus	California halibut
Xystreurys liolepis	fantail sole

Appendix D-1. (Cont.)

PHYLUM Class Family Species	Common Name
Pleuronectidae	
Hypsopsetta guttulata = *Pleuronichthys guttulatus*	diamond turbot
Parophrys vetulus	English sole
Pleuronichthys ritteri	spotted turbot
Pleuronichthys verticalis	hornyhead turbot
Cynoglossidae	
Symphurus atricauda = *Symphurus atricaudus*	California tonguefish

Appendix D-2. Master species list of macroinvertebrates impinged during normal operation and/or heat treatment surveys at the HBGS, July 2003 - July 2004.

PHYLUM Class Family Species	Common Name
CNIDARIA	
Hydrozoa	
Polyorchidae	
Polyorchis penicillatus	jellyfish
Pelagiidae	
Chrysaora colorata	purple-striped jelly
NEMERTEA	
Anopla	
Lineidae	
Cerebratulus californiensis	ribbon worm
MOLLUSCA	
Gastropods	
Aglajidae	
Navanax inermis	California aglaja
Dendronotidae	
Dendronotus frondosus	nudibranch
Dendronotus subramosus	stubby dendronotus
Flabellinidae	
Flabellina iodinea	Spanish shawl
Facelinidae	
Hermissenda crassicornis	nudibranch also hermissenda
Bivalvia	
Veneridae	
Protothaca staminea	Pacific littleneck
Petricolidae	
Petricola californiensis	California petricola
Cephalopoda	
Loliginidae	
Loligo opalescens	market squid
Octopididae	
Octopus bimaculatus / bimaculoides	two-spotted octopus

PHYLUM Class Family Species	Common Name
ECHIURA	
Echiuridea	
Urechidae	
Urechis caupo	innkeeper worm
ARTHROPODA	
Malacostraca	
Penaeidae	
Penaeus californiensis	yellowleg shrimp
Hippolytidae	
Heptacarpus palpator	intertidal coastal shrimp
Lysmata californica	red rock shrimp
Crangonidae	
Crangon nigromaculata	blackspotted bay shrimp
Callianassidae	
Neotrypaea californiensis	bay ghost shrimp
Palinuridae	
Panulirus interruptus	California spiny lobster
Porcellanidae	
Pachycheles pubescens	pubescent porcealain crab
Pachycheles rudis	thick-clawed porcelain crab
Majidae	
Loxorhynchus crispatus	masking crab also moss crab
Loxorhynchus grandis	sheep crab
Pugettia producta	shield-backed kelp crab also northern kelp crab
Pyromaia tuberculata	tuberculate pear crab
Cancridae	
Cancer antennarius	Pacific rock crab also brown rock crab
Cancer anthonyi	yellow rock crab
Cancer gracilis	graceful rock crab also slender crab
Cancer productus	red rock crab

Appendix D-2. (Cont.)

PHYLUM Class Family Species	Common Name
Portunidae	
Portunus xantusii	Xantus swimming crab
Grapsidae	
Hemigrapsus oregonensis	yellow shore crab
Pachygrapsus crassipes	striped shore crab
ECHINODERMATA	
Asteroidea	
Asteriidae	
Pisaster sp	sea star
Pisaster ochraceus	ochre starfish
Ophiuroidea	
Ophiotricidae	
Ophiothrix spiculata	spiny brittlestar
Holothuroidea	
Stichopodidae	
Parastichophus parvimensis	warty sea cucumber
CHORDATA	
Thaliacea	
Salpidae	salp, unid.

Appendix E

Cumulative Impacts Analysis

CUMULATIVE IMPACTS ANALYSIS

1.0 Introduction

The Commission Decision requires the AES Huntington Beach Entrainment and Impingement Study to "*consider the cumulative effect of all southern California coastal power plants on nearshore fish populations.*" There are 13 coastal power plants in southern California (between Pt. Conception and the U.S./Baja California border) that utilize once-through cooling (Figure 6-1). Such a cumulative impacts analysis is not only unprecedented for the region, few such analyses have been performed in the United States. Realizing this, the BRRT convened a workshop on 5 October 2004 to determine potential methods of performing a cumulative impacts analysis in southern California. The methods identified during this workshop were used in the analysis, and are detailed in Section 6.2.

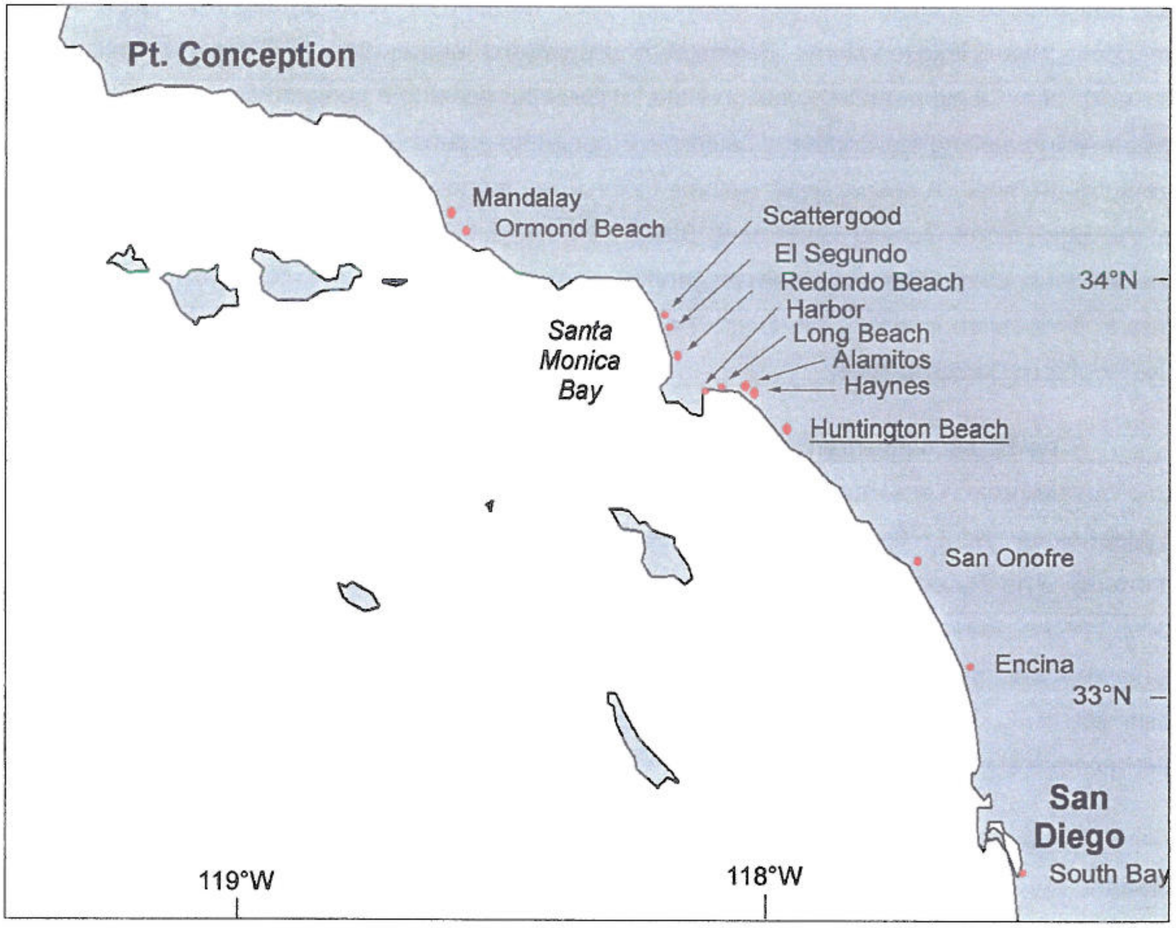


Figure 1. Location of the 13 coastal generating stations in southern California.

Cumulative Impacts of Southern California Coastal Generating Stations Workshop

The Cumulative Impacts Workshop convened at the Moss Landing Marine Laboratories on October 5, 2004. Attending were:

- California Energy Commission – Dick Anderson, Rick York, Noel Davis, Mike Foster (Moss Landing Marine Labs), and Pete Raimondi (U.C. Santa Cruz).
- AES Huntington Beach L.L.C. – Rick Tripp and Paul Hurt.
- MBC Applied Environmental Sciences – Chuck Mitchell and Shane Beck
- Tenera Environmental – David Mayer, John Steinbeck, and John Hedgepeth
- U.C. Davis, Bodega Marine Lab – John Largier
- NOAA Fisheries, Santa Cruz – Alec MacCall

CEC Staff and MBC presented introductory information, including California coastal facility overviews and a summary of EPA's Tampa Bay cumulative impact analysis. The discussion ten focused on appropriate methods for describing cumulative effects of entrainment at coastal generating stations given the limited recent data available. An initial depiction of cumulative impact would be to estimate entrainment mortality for each coastal power plant based on cooling water intake volume. Estimates of proportional entrainment (*PE*) would be calculated for each plant using permitted cooling water intake volumes and a common source volume, such as the volume along the Southern California Bight out to a depth of 35 or 75 m, approximating the depth of the shelf. A source water volume to the 75-m isobath was used in an entrainment study at the San Onofre Nuclear Generating Station (Parker and DeMartini 1989). The analysis would include all southern California coastal generating stations except Duke's South Bay Power Plant due to its location in south San Diego Bay, which limits its effects on the open coastal areas of the Southern California Bight.

The *PE* estimates from the individual plants would be used as estimates of daily mortality to calculate proportional mortality (P_m) over a range of larval durations. Both the individual *PE* and P_m estimates would be plotted to describe the geographical pattern of power plant induced mortality. The P_m estimates would be converted to survival to estimate the cumulative effects because the product of the survival estimates would account for potential overlapping effects of multiple power plants. This product of the survival estimates would be converted to a cumulative estimate of P_m. The initial analysis would assume that the effects of the plants are overlapping producing a single cumulative effect.

This initial approach can be expanded using current data to identify discrete areas affected by individual power plants. Where these areas overlap survival estimates can be accumulated to estimate the cumulative mortality. The overlapping levels of mortality can be plotted to show variation along the coast in contrast to the uniform estimate from the initial analysis.

Impingement data (fishes and macroinvertebrates impinged during the 2003 study year) were presented for 12 of 13 coastal generating stations. Data for Encina Generating Station were not currently available, and macroinvertebrate impingement data are not collected at San Onofre Nuclear Generating Station. Sampling types and frequency vary among generating stations, but annual estimates would be made based on extrapolated normal operations and heat treatment surveys where available. MBC would compile 2003 annual fish and macroinvertebrate loss estimates for all 12 generating stations for the cumulative impact analysis.

Facility Overview

Huntington Beach Generating Station is one of 13 coastal generating stations along the coast of the Southern California Bight (SCB) that utilizes once-through cooling (Figure 1). Six generating stations have nearshore, velocity-capped intakes, four have shoreline intakes, and three have canals (Table 1). There are also three desalination facilities not included in this analysis: two that utilize subsurface wells (Pebbly Beach on Santa Catalina Island and the U.S. Navy facility on San Nicholas Island), and one facility (Chevron Gaviota in Santa Barbara County) that has relatively low flow volume (<0.5 mgd). The intake flows from these three desalination facilities combined comprise less than one percent of the permitted flow volume in southern California.

Table 1. Overview of cooling water intake systems of southern California coastal generating stations.

Facility	Location	Immediate Source Water	Intakes	Max. Flow (mgd)
Reliant Mandalay	Oxnard	Channel I. Harbor	1 canal	255
Reliant Ormond Beach	Oxnard	Nearshore	1 velocity-capped	689
LADWP Scattergood	Los Angeles	Santa Monica Bay	1 velocity-capped	496
NRG El Segundo	Los Angeles	Santa Monica Bay	2 velocity-capped	607
AES Redondo Beach	Los Angeles	Santa Monica Bay/King Harbor	2 velocity-capped	889
LADWP Harbor	Los Angeles	Los Angeles Harbor	1 shoreline	108
NRG Long Beach	Long Beach	Long Beach Harbor	1 shoreline	265
AES Alamitos	Long Beach	Alamitos Bay	2 canals	1,283
LADWP Haynes	Long Beach	Alamitos Bay	1 canal	1,014
AES Huntington Beach	Huntington Beach	Nearshore	1 velocity-capped	507
SCE San Onofre	San Clemente	Nearshore	2 velocity-capped	2,390
NRG Encina	Carlsbad	Agua Hedionda	1 shoreline	860
Duke South Bay	San Diego	San Diego Bay	1 shoreline	601
		Totals:	17 intakes	9,964

Overview of Cumulative Impact Analyses

Cumulative impact analyses are required as part of the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA). However, the extent and depth of such analyses vary considerably. As a component of every Environmental Impact Statement, Environmental Impact Report, and Environmental Assessment, the project proponent is required to assess the potential cumulative impacts of the proposed project. The analysis of a project's potential cumulative impact generally focuses on the areas of transportation, socioeconomics, air quality, and land-based natural resources. Cumulative impact analyses focusing on marine resources are often limited in scope. In most cases, this reflects the shortcoming of contemporary marine and fishery science to provide meaningful, integrated cause-and-effect analyses in open-ocean settings of more than one or two stressors acting on populations. Fortunately, our ability to make environmental decisions is not normally constrained by the demands of the analysis, but is advanced by a process of narrowing the focus of the analysis.

There are a few recent examples of cumulative impact analyses with respect to impingement and entrainment (I&E) at coastal generating stations. The U.S. EPA recently published examples used in equating benefits associated with reductions in I&E at Tampa Bay (Florida) and the Delaware Estuary Transition Zone (Delaware and New Jersey) (EPA 2002). Analysis methods at the two locations were similar; losses of fishes due to entrainment and impingement were all converted to Age-1 equivalents to standardize the calculation of foregone fishery yield and production foregone. Economic losses were calculated using available recreational and commercial fishery statistics. Effects of improved fishing opportunities resulting from cessation of I&E were assessed using a Random Utility Model (EPA 2002). This model is based on the premise that anglers would get greater satisfaction, and thus greater economic value, from sites where the catch rate is higher, all else being equal. Analyses such as these are useful because they equate biological losses with economic values. However, many of the fishes and invertebrates most affected by I&E in the SCB are not targeted by commercial or recreational fishermen, so the conversion of I&E losses to dollars based on utilitarian approaches may be of little use.

Another example of a recent cumulative impacts analysis is a project initiated by the Atlantic States Marine Fisheries Commission (ASMFC) that was requested by its member States to investigate the cumulative impacts on commercial fishery stocks, particularly overutilized stocks, attributable to cooling water intakes located in coastal regions of the Atlantic. Specifically, the ASMFC study intended to evaluate the potential cumulative impacts of multiple cooling water intakes on Atlantic menhaden (*Brevoortia tyrannus*), which ranges along most of the U.S. Atlantic coast, with a focus on revising existing fishery management models so that they accurately consider and account for losses of fishes from multiple cooling water intakes. Typically, assessments of power plant mortality have focused on individual power plant impacts with little information being provided on the cumulative effects on migratory species. Additionally, mortality estimates have often been expressed in terms of numbers of fish killed, which is difficult to relate to the mortality estimates provided by stock assessments, usually expressed as a fishing mortality rate or spawning stock biomass. The panel working on the issue has found that the biggest obstacle to developing cumulative assessments was lack of data on impingement and entrainment from power plants on the East Coast (L. Barnthouse pers. comm. 2004). There are only a handful of plants for which entrainment and impingement losses were routinely monitored. At the other plants, the only I&E data available consisted of one-time studies done to support 316(b) demonstrations, and many of these were performed in the 1970s.

2.0 Methods

The collection of I&E data at all southern California facilities was outside the scope of the current project at the HBGS. Impingement data are collected at most generating stations as part of NPDES monitoring, though the types (normal operations and/or heat treatments) and frequency (e.g. weekly, monthly, etc.) of monitoring vary by location. Unlike impingement, entrainment is not a usual monitoring component for any of southern California's generating stations. Major factors in determining methods for analysis of cumulative impacts with respect to entrainment included (1) the availability of recent entrainment data, and (2) the availability of recent oceanographic current data.

Entrainment

Although some eggs and larvae of fishes and invertebrates survive passage through power plant cooling water systems, impact modeling assumes that all organisms die during entrainment, representing mortality due to power plant operations in addition to natural mortality. Because more than one power plant may entrain eggs and larvae there can be cumulative (additive) mortality upon a single population. This entrainment analysis focuses on 12 of the 13 generating stations listed in Table 1. Duke Energy's South Bay Power Plant is relatively isolated from the coastal oceanic flow and is not considered in the analysis of cumulative entrainment impacts.

The larval source population in the SCB is assumed to be shoreward of the 75-m depth limit, a distance that varies from more than 20 km off of San Pedro Bay to less than 1 km off of La

Jolla submarine canyon (Figure 2). Although some species live outside or are more restricted inside this limit, the definition follows Lavenberg et al. (1986) who used ichthyoplankton transects shoreward of the 75-m isobath to be representative of the coastal zone. Five of six species they studied occurred predominantly shoreward of the 36-m isobath. Other species, such as those belonging to the genera *Engraulis*, *Paralabrax*, *Stenobrachius* and *Sebastes*, occurred further offshore (McGowen 1993, Lavenberg et al. 1986). McGowen (1993) found that while the density of many species peaked at the 36-m isobath, others were found primarily at the offshore stations (36 and 75 m). The analysis of cumulative impacts will use the 75-m limit as an initial limit and also a range from 30 to 75 m for comparison. That is, effects on mortality of changing this offshore limit will be examined by varying the depth limit from 75 m to as shallow as 30 m.

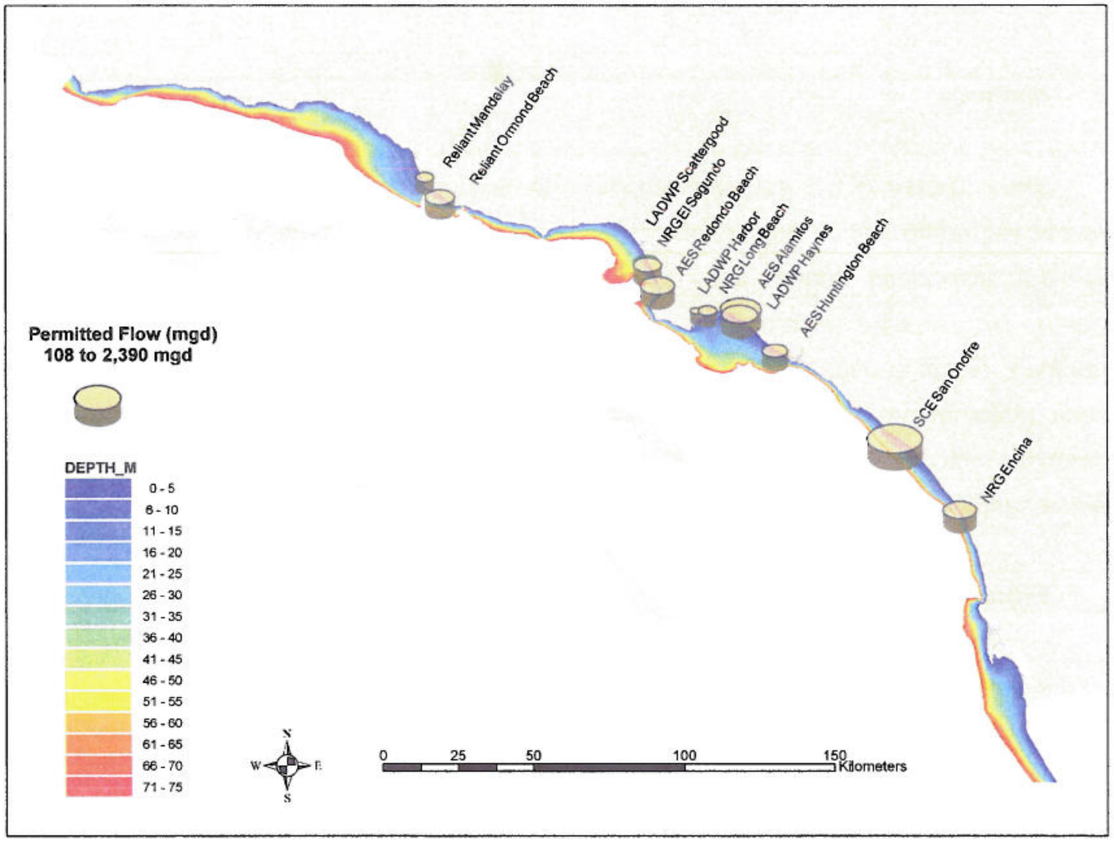


Figure 2. Bathymetry of the coastal zone of the Southern California Bight from Pt. Conception to 28 km south of the US-Mexico border, and permitted cooling water flow at twelve generating stations.

The SCB has been defined extending southward from Pt. Conception as "the region of the North American west coast where the coastline bends almost 90 degrees toward the east, indenting the relatively straight coastline to the north and south for about 300 km" (Hickey et al. 2003). Although the SCB extends south of Ensenada, Baja California to Cabo Colnett, a boundary 28 km south of the border was chosen because it is approximately the same distance from the southernmost plant as the northernmost power plant is from Point Conception. The bathymetry of this area is shown in Figure 2. Also depicted in Figure 2 are power plant locations and the relative permitted cooling volumes. Volumes of water along the coast from Pt. Conception to 28 km south of the US-Mexico border (the northern and southern boundaries of the SCB) from the 30-m to the 75-m isobath were calculated using ESRI ArcView GIS (Table 2). In a historical perspective, a study of adult equivalent loss at the San Onofre Nuclear Generating Station used the 75-m limit (7 km offshore at San Onofre) in extrapolation of intake losses to the coastal zone of the SCB from Pt. Conception to Cabo Colnett, Mexico (Parker and DeMartini 1989). The San Onofre study used a coastline length of 500 km and a volume of 10^{11} m^3 (26,417,205 Mgal). We found a similar length and volume of 548 km and 26,904,345 Mgal even though Cabo Colnett is about 100 km south of the US-Mexico border.

Table 2. Coastal zone volume as a function of the offshore boundary.

Offshore Depth (m)	Volume (10^6 gallon) (Pt. Conception to 28 km S of	Cumulative fraction US-Mexico Border)
30	6,700,271	0.249
35	8,409,239	0.313
40	10,259,441	0.381
45	12,374,840	0.460
50	14,510,720	0.539
55	16,766,557	0.623
60	19,121,614	0.711
65	21,545,822	0.801
70	24,146,959	0.898
75	26,904,345	1.000

In the following analysis of cumulative effects, the terms "mortality" and "survival" refer to values associated only with cooling water system effects from coastal generating stations. Larval fish and invertebrate survival *S* over *t* days is calculated following MacCall et al. (1983) and applied similarly in Parker and DeMartini (1989) as:

$$S = e^{-PE\,t}$$

$$\text{where } PE = \frac{\text{Cooling Water Volume per day}}{\text{Coastal Volume}} \tag{1}$$

The term *PE*, or proportional entrainment, estimates the relative effects of entrainment by using the ratio of entrainment volume and larval source population volume. The survival calculation assumes that larval densities are constant throughout the coastal volume and that the coastal volume adequately describes the source population.

We modeled a range of larval durations from 5 to 40 days based on estimated larval durations of target species presented in Section 4.3.3. Table 3 presents the estimates of larval durations of 10 of the species entrained at HBGS. Although some of these species may not be entrained at all of the 13 coastal power plants, we believe that the range of durations is typical. The larval durations were based on the difference between the lengths of the 1st and 95th percentiles and a growth rate found in the literature. The range of values of the period that larvae were vulnerable to entrainment was used in the above equation to estimate larval survival.

Table 3. Larval durations of target study species entrained at HBGS.

Taxon	Common Name	Larval Duration (days)
Gobiidae (CIQ complex)	gobies	34
Roncador stearnsi	spotfin croaker	5
Engraulidae	anchovies	38
Seriphus politus	queenfish	31
Genyonemus lineatus	white croaker	27
Hypsoblennius spp.	blennies	9
Cheilotrema saturnum	black croaker	7
Hypsopsetta guttulatus	diamond turbot	13
Paralichthys californicus	California halibut	25
Cancer spp.	rock crab	12

Impingement

Impingement sampling at coastal generating stations is comprised of normal operations monitoring and/or heat treatment monitoring. Methods at all the generating stations generally conform to those described in Section 3.4.2 of this report. At the 5 October 2004 workshop, participants agreed to exclude 2 of the 13 generating stations from the impingement analysis: NRG Encina Power Plant in Carlsbad and Duke South Bay Power Plant in San Diego Bay. NRG Encina was excluded due to the lack of recent impingement data (although an impingement study is currently underway) and Duke South Bay Power Plant was excluded because of its unique source water. The majority of organisms impinged at Duke South Bay are primarily residents of South San Diego Bay (Tenera 2004).

We compiled available, recent, annual fish and macroinvertebrate impingement data from the remaining 11 coastal generating stations. Macroinvertebrates excluded fouling organisms, algae, and seagrasses. The time period analyzed varied by location. Data from the current impingement study at HBGS (2003-2004) were used, data from January 2002 through December 2003 were used for SONGS, and data from October 2002 through September 2003 were used for the remaining nine generating stations. All data were derived from published 2003 NPDES monitoring reports. For generating stations with more than one intake or screening facility, all data were combined to produce totals for each generating station.

Of the 11 generating stations analyzed, all but Scattergood conducted at least one normal operation impingement sample during the period analyzed. Of these 10 generating stations, results from the normal operations surveys at all but three of the plants were extrapolated to annual totals based on generating station flow, the same method employed in the HBGS analysis. Heat treatment surveys were conducted at all generating stations except Harbor Generating Station, which does not perform heat treatments. Lastly, of the 11 generating stations, all except SONGS monitor macroinvertebrate impingement as well as fish impingement. A summary of survey parameters and results is presented in Table 4.

Table 4. Fish and invertebrate impingement: Cumulative impact analysis survey and data summary by generating station.

	MGS	OBGS	SGS	ESGS	RBGS	HGS	LBGS	AGS	HnGS	HBGS	SONGS	EPP	Total
2003 Surveys													
Normal Ops (N.O.)	4	12	0	20	16	3	11	7	1	52	8	NA	134
N.O. Extrapolated?	Yes	Yes		Yes	Yes	No	Yes	No	No	Yes	Yes	NA	
Heat Treatments	2	4	4	4	3	0	1	2	10	6	16	NA	52
Fish													
No. of Species	11	53	62	45	35	7	1	16	12	57	70	NA	100
Abundance	7,724	11,332	29,711	1,756	1,134	52	153	498	96	51,082	3,564,419	NA	3,667,655
Biomass (kg)	186.8	771.3	1,512.1	671.4	85.7	8.3	0.5	4.8	1.4	1,291.6	21,918.4	NA	26,452.3
Macroinvertebrates													
No. of Species	4	20	17	20	9	3	6	11	10	35	NA	NA	56
Abundance	20	1,196	2,019	2,232	1,371	3	14	73	104	70,636	NA	NA	77,676
Biomass (kg)	4.5	373.9	119.3	473.1	222.5	0.8	1.3	0.9	1	167.6	NA	NA	1,366.0
Cooling Water Systems													
Number of Intakes	1	1	1	2	2	1	1	2	1	1	2	1	16
Intake Type	Canal	VC	VC	VC	VC	Shoreline	Shoreline	Canal	Canal	VC	VC	Shoreline	
Max. Flow (mgd)	255	689	496	607	889	108	265	1,283	1,014	507	2,390	860	9,363

Key: MGS (Mandalay), OBGS (Ormond Beach), SGS (Scattergood), ESGS (El Segundo), RBGS (Redondo Beach), HGS (Harbor), LBGS (Long Beach), AGS (Alamitos), HnGS (Haynes), HBGS (Huntington Beach), SONGS (San Onofre Nuclear), and EPP (Encina).
HBGS data from the present CEC study (July 2003 – July 2004).
SONGS data from January 2003 through December 2003 (SCE 2004).
All other data from October 2002 through September 2003 (Compiled from NPDES Monitoring Reports).
NA = Not available.
VC = Velocity capped.
South Bay Power Plant excluded from analysis.

3.0 Results

Bight-Wide Entrainment

The mortalities (*1-S*) due to each power plant are shown in Figure 3 for durations (*t*) of 5, 10, 20, 20 and 40 days, and assuming the total source volume of the SCB inshore of the 75-m isobath. This assumption is discussed below as it has a profound impact on the mortality estimates. The cumulative cooling water volume (sum of all plants' permitted flow) is 9,363 mgd. If one assumes a homogeneous impact of power plant cooling then the overall survival and mortality rates are shown in Table 5 for two source water volumes, inshore of 35 m and 75 m. By way of comparison, HBGS mortality rates were between 5.4 and 5.6 percent of the cumulative mortality from the 12 intake locations. This is approximately the same as HBGS percentage of total permitted cooling water by the 12 power plants, 5.4%.

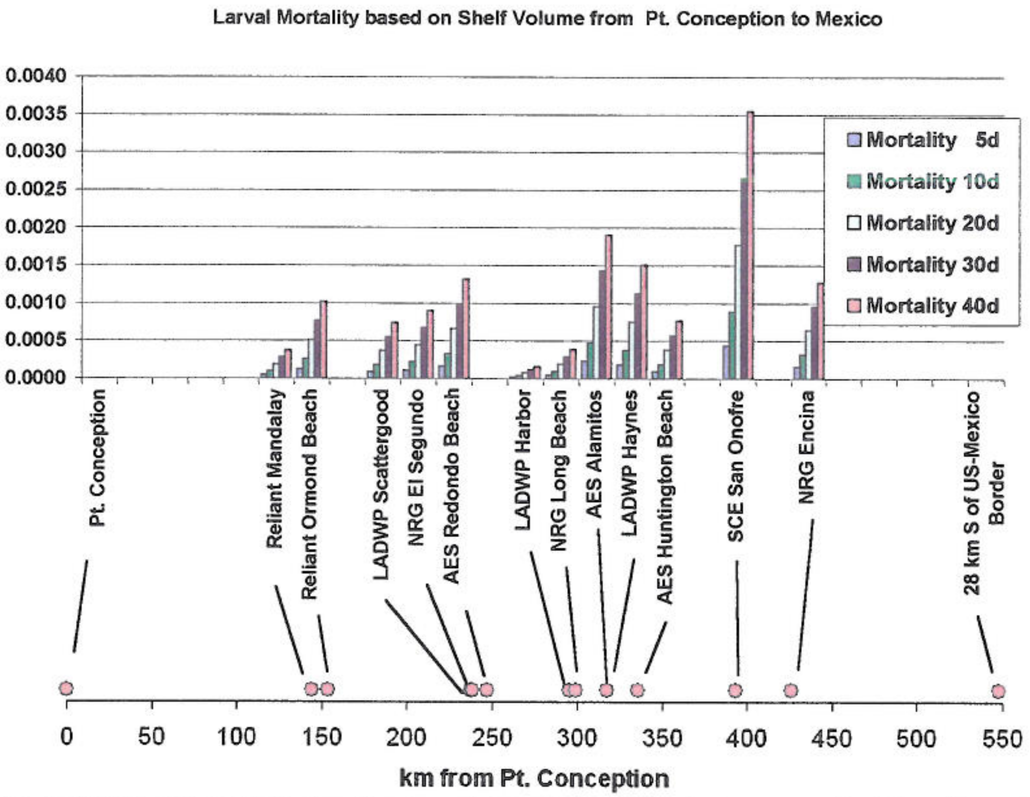


Figure 3. Larval mortality for five larval durations at twelve power plant locations in the Southern California Bight.

Table 5. Overall survival and mortality for several larval durations of susceptibility based on cumulative cooling flow of twelve power plants and the coastal zone volume shoreward of 35 m and 75 m, extending from Pt. Conception to 28 km south of the US-Mexico border.

	Shelf Limit (m)	Duration of Susceptibility (days)				
Survival		5	10	20	30	40
	35	0.9944	0.9889	0.9780	0.9671	0.9564
	75	0.9983	0.9965	0.9931	0.9896	0.9862
Mortality						
	35	0.0056	0.0111	0.0220	0.0329	0.0436
	75	0.0017	0.0035	0.0069	0.0104	0.0138

Percentage of Cumulative Mortality		Huntington Beach Generation Station				
		5	10	20	30	40
	35	5.429%	5.443%	5.472%	5.501%	5.530%
	75	5.419%	5.424%	5.433%	5.442%	5.451%

Figure 4 shows the relation between different source water volumes and the resulting mortality estimates. Mortality estimates increase exponentially as source water volumes become smaller.

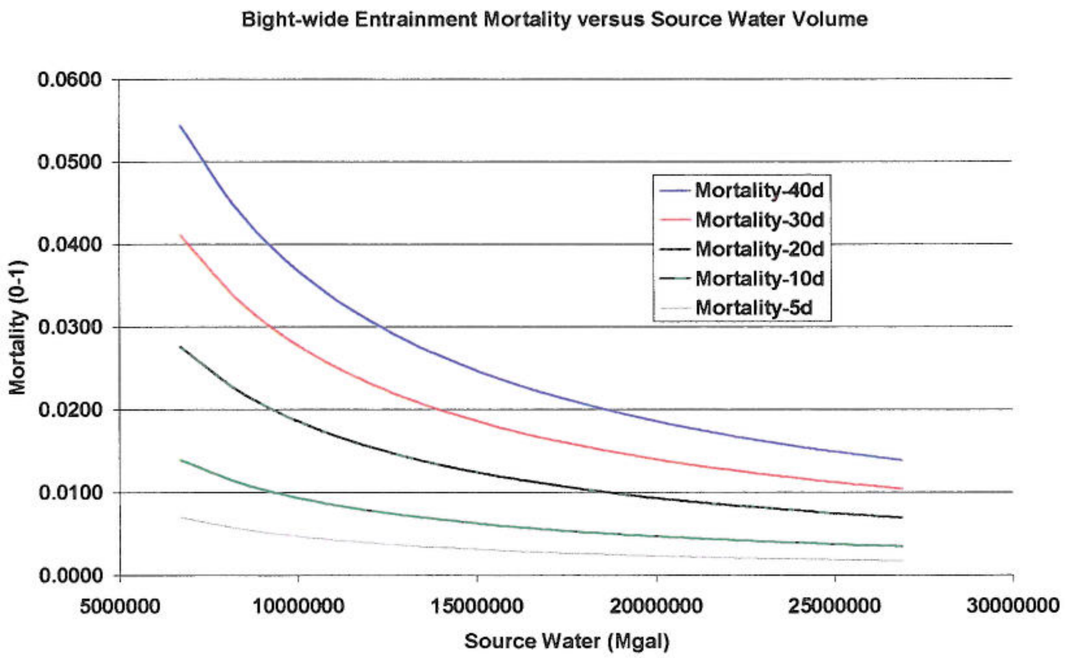


Figure 4. Cumulative larval mortality from twelve power plant locations in the Southern California Bight and for five larval durations as a function of the source water volume. The range of source water volume corresponds to the offshore depth limit of the Bight's shelf, from 30 m to 75 m.

Overall survival rates from Table 5 are useful for normalizing the following simulation of mortality where survival increases linearly with distance from each power plant location. The simulation assumes that survival is 1 at each end of the coastal zone strip, i.e. at Pt. Conception and at 28 km S of the US-Mexico border. The survival at each power plant location is adjusted so that values along the coast are linear and that they integrate over distance to the same value as the spatially homogenous survival. In this simulation, overall survival is the product of the power plant contributions. Cumulative mortality impact, i.e. one minus the overall survival, is unimodal, centered at 320 km from Pt. Conception for all larval durations (Figure 5). As expected, the greatest mortality is found with the longest larval duration.

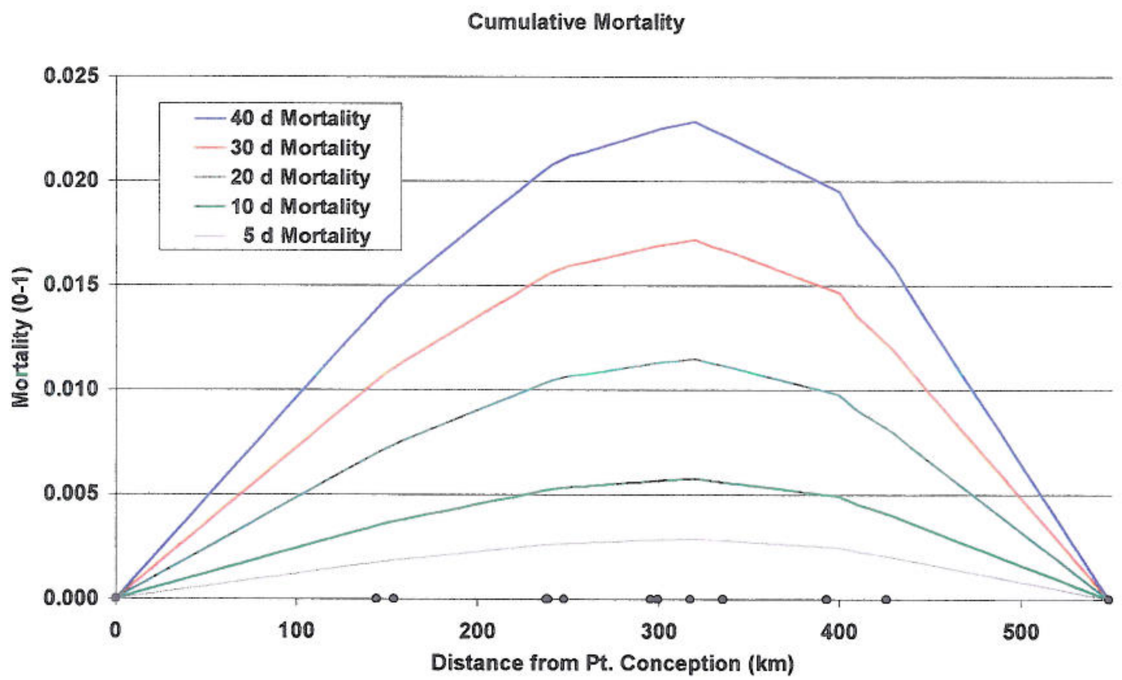


Figure 5. Cumulative larval mortality simulation from twelve power plant locations in the Southern California Bight and for five larval durations based on a common source volume. Survival is 1 at the ends of the graph. Small circles (100-500 km) show power plant locations.

A second simulation models cumulative mortality where mortality diminishes linearly with distance from each power plant (as in the first) but the distance of impact is a function of larval duration. This dependence on larval duration could result from currents, for example. The excursion distance can extend beyond Pt. Conception or 28 km south of the Mexican border. The simulation assumes that the 40-day survival is 1 at a distance of one-half the 548-km coastal zone extent distance from each generating station location. The 30-day simulation assumes that the effective distance is ¾ of the coastal zone extent, and so on for 20-, 10- and 5-day durations. Survival at each power plant location is adjusted so that the survival (or alternatively mortality) values along the coast are linear and that they integrate over distance to the same value as the case of spatially homogenous survival. The survival rates between plants are multiplied along the coast. The sum of the products, shown in Figure 6, is normalized so that the area under the mortality curves is the same as shown in Figure 5.

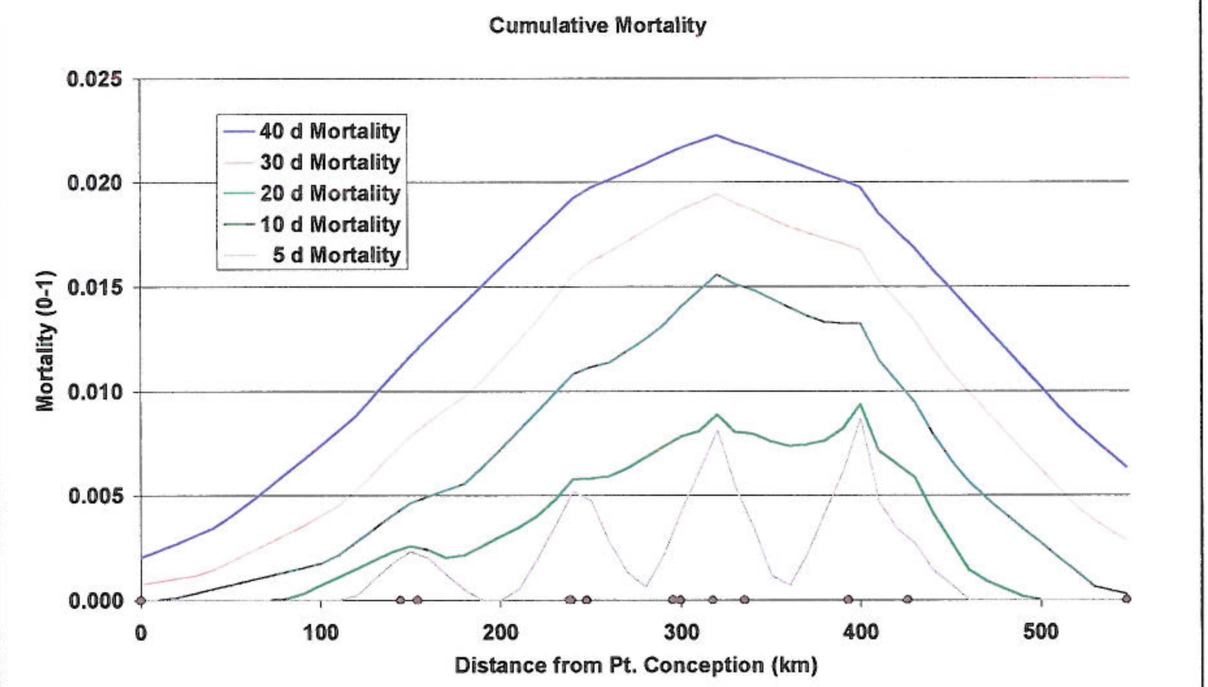


Figure 6. Cumulative larval mortality simulation from twelve power plant locations in the Southern California Bight and for five larval durations based on a common source volume and differential zones of influence. The distance from each plant where survival is 1 is a function of larval duration. Small circles (100-500 km) show power plant locations.

As durations lessen, the apparent mortality lessens but the effects of individual power plants (or groups of power plants) can be seen in multiple modes of cumulative mortality due to the zone of influence being a function of larval duration. In addition to distance from each generating station, a second factor that contributes to the volume of the affected larval source population is the extent of the offshore boundary. When this boundary is brought inshore from 75 m to 30 m, perhaps reflecting such factors as species behavior, prevalence, larval duration and oceanic currents, the shape of the curves does not change. The magnitude of mortality, however, does change. As the source water volume lessens cumulative mortality increases exponentially similar to the change shown in Figure 4.

A third simulation allows the source volume to be a linear function of larval duration. This simulation applies the zone of influence based on larval duration as well as setting the source volume equal to d/40 times the bight's source volume shoreward of the 75-m depth limit, where d is the number of days of larval duration of susceptibility to entrainment. The results rely on the assumption that a 40-day larval duration of susceptibility is associated with the total Bight source volume.

Analysis shows that the mortalities at individual power plants are the same regardless of duration as a result of the modified source volume. Survival *S* is modified to form a survival *S'* which is independent of duration of susceptibility *t*:

$$\begin{aligned} S &= e^{-PEt} = e^{-\frac{V_E}{V_{S\max}}t} \\ S' &= e^{-\left(\frac{V_E}{\frac{t}{t_{\max}}V_{S\max}}\right)t} = e^{-\frac{V_E}{V_{S\max}}t_{\max}} \end{aligned} \tag{2}$$

where t_{max} = 40 days, V_E = Entrainment Volume, and V_{max} = Bight Volume.

Table 6 shows the source volumes and coastal lengths associated with average cumulative mortality estimates. Figure 7 shows the resulting cumulative mortalities using a 75 m depth limit of the source volume. Average cumulative mortalities are equivalently estimated using Equation 1, the sum of the permitted maximum intake flows (9,363 Mgal d^{-1}), the source volumes in Table 6 and larval durations of susceptibility. Figure 7 is similar to Figure 6 due to similar cumulative source water volumes.

Although estimated mortality at a particular power plant is the same for all durations of larval susceptibility, the volumes and zones of influence are different for different durations. In addition, the zones of influence and source volumes accumulate due to the spread of locations. Though simulation was restricted to the Southern California Bight, if allowed, the zone of influence (based on an assumption that the 40-day coastal zone of influence was 548 km centered at each plant) would have extended beyond Pt. Conception and 28 km south of the US Mexico border for durations of 30 and 40 d.

Table 6. Source volume and coastal zones of influence based on simulation and a shelf depth limit of 75 m. Individual intake source volumes are a linear function of larval susceptibility where the maximum was equal to the volume of the Southern California Bight to the 75-m depth limit, 26,904,345 million gallons. Cumulative source volume is proportional to coastal length affected.

Larval Susceptibility (d)	Source Volume per Plant (Mgal)	Cumulative Source Volume (Mgal)	Coastal Length (km)	Cumulative Mortality
5	3,363,043	16,201,522	330	0.00289
10	6,726,086	20,620,118	420	0.00453
20	13,452,173	26,413,390	538	0.00707
30	20,178,259	26,904,345	548	0.01040
40	26,904,345	26,904,345	548	0.01382

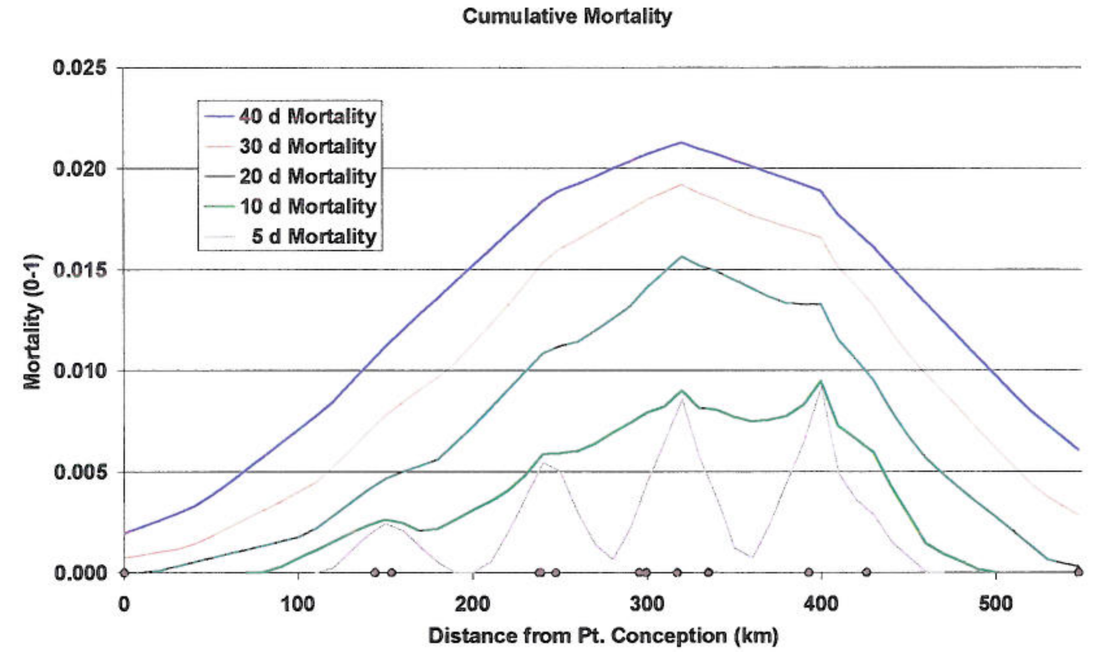


Figure 7. Cumulative larval mortality simulation from twelve power plant locations in the Southern California Bight and for five larval durations based on differential source volumes. The distance from each plant where survival is 1 and the source volume are a function of larval duration. Small circles (100-500 km) show power plant locations.

Cumulative mortality estimates were dependent on the definition of source water population that is susceptible to entrainment. By way of comparison, if the source water were restricted to the 35-m depth limit, cumulative mortalities would be over three times higher due to the restricted source volumes. However, the affected coastal zones (not volumes) would remain the same as shown in Table 6.

Cumulative mortality applies to coastal volumes and lengths that are not only a function of duration but also the spread of power plant locations. Such features as coastal currents, eddies and biological factors play an important role in determining the actual extent of mortality power plants have on a source population. So far, we have assumed a source covering the Southern California Bight as well as providing more realistic estimates of mortality by allowing the source water volume to be a function of the duration larvae are susceptible to entrainment. Although actual results based on estimates of larval excursions at each power generation facility may be similar to Figure 7, it is expected that source volumes and coastal zones will not be the same as portrayed in the figure or in Table 6. Estimates based on refined studies of local conditions will provide a more realistic portrayal of power plants' cumulative effect on larval mortality.

One result of the coastal spread of locations of power plant intakes is an extension of vulnerable source water volume and coastal zone of influence (Figure 7 and Table 6). A hypothetical example shows that the extension is not only a function of larval durations but also of the relative locations, using the same assumptions as the final simulation for a 5-day larval duration of susceptibility and a 75 m depth as the outer shelf limit. If all the power plants were sited at the same location, then the coastal zone of influence would be limited to 5/40 of the Bight's 548 km coastal length or 68 km corresponding to a source volume of 3,363,043 Mgal and resulting in a mortality of 0.01382. In simulation, due to the actual plant locations, the coastal zone of influence was 330 km and 16,201,522 Mgal with cumulative mortality of 0.00289.

Bight-Wide Impingement

Fish impingement data were collected during 134 normal operations and 52 heat treatment surveys at the 11 coastal generating stations. An estimated total of 3,667,655 fish representing at least 98 species and weighing 26,452 kg (58,327 lb.) was impinged at the 11 generating stations over a 12-month period that varied by location (Table 7). Impingement at SONGS Units 2 and 3 combined represented 97% of fish abundance and 83% of fish biomass (Table 4). Bight-wide impingement abundance was dominated by northern anchovy (87%), queenfish (9%), and Pacific sardine (2%). Impingement biomass was also dominated by northern anchovy (51%), queenfish (20%), and Pacific sardine (9%) (Table 7).

Table 7. 2003 fish impingement totals (top 10 speceis) from 11 coastal generating stations in the SCB.

	Bight-wide Impingement		Cumulative Total		HBGS contribution to:	
Species	**No.**	**Wt. (kg)**	**% No.**	**% Wt.**	**No.**	**Wt.**
northern anchovy	3,173,100	13,411	86.5%	50.7%	0.1%	0.1%
queenfish	330,773	5,165	95.5%	70.2%	10.8%	12.5%
Pacific sardine	64,876	2,436	97.3%	79.4%	0.2%	0.3%
Pacific pompano	27,554	591	98.1%	81.7%	2.2%	2.7%
jacksmelt	12,979	847	98.4%	84.9%	2.6%	3.5%
shiner perch	9,643	96	98.7%	85.2%	41.9%	53.9%
white croaker	9,159	277	98.9%	86.3%	53.5%	34.4%
California grunion	7,737	186	99.1%	87.0%	1.8%	0.4%
walleye surfperch	5,511	143	99.3%	87.5%	8.6%	11.0%
white seaperch	5,162	62	99.4%	87.8%	16.8%	30.6%
Total (100 taxa)	3,667,655	26,452	100.0%	100.0%	1.4%	4.9%

Fish impingement abundance was highest at SONGS (97%), and was followed by the HBGS (1%) and LADWP's SGS (0.8%); fish impingement abundance at all other generating stations contributed 0.3% or less to the Bight-wide total (Figure 8). Fish biomass was also highest at SONGS (83%), and was followed by LADWP's SGS (6%), the HBGS (5%), and the OBGS (3%); fish biomass at all other generating stations each contributed less than 3% to the Bight-wide biomass total (Figure 9).

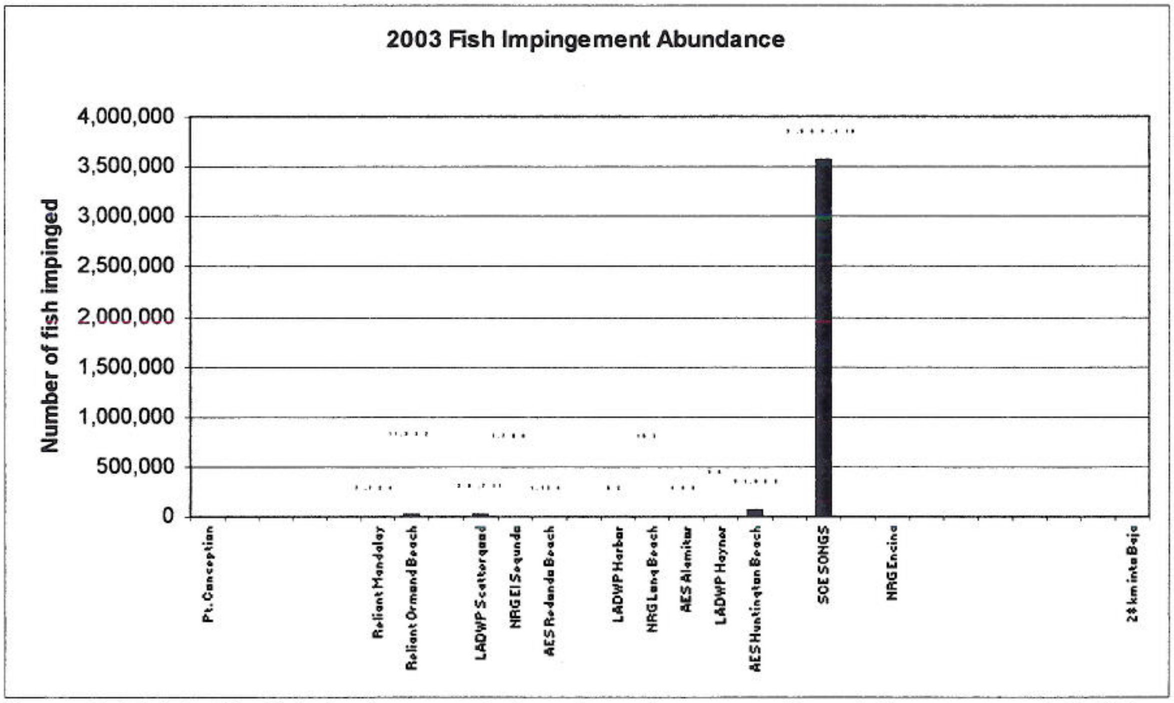


Figure 8. Bight-wide fish impingement abundance by generating station, upcoast (left) to downcoast (right).

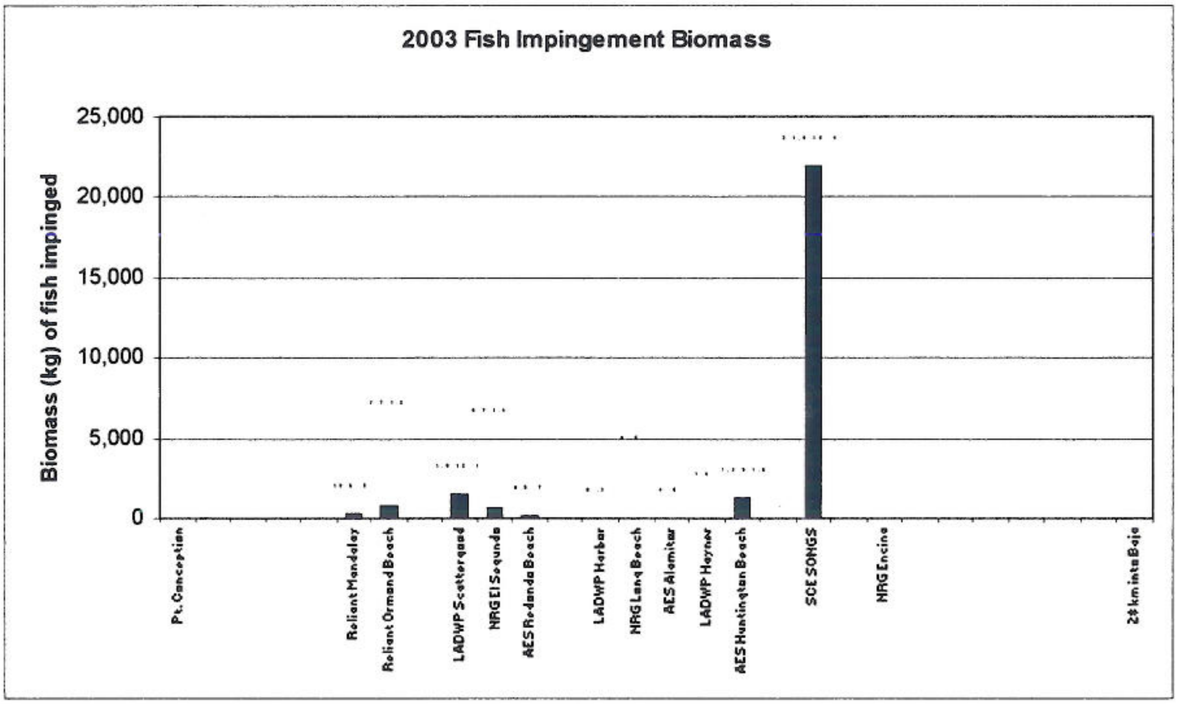


Figure 9. Bight-wide fish impingement abundance by generating station, upcoast (left) to downcoast (right).

An estimated total of 77,676 macroinvertebrates representing at least 56 species and weighing 1,366.0 kg (3,012.0 lb) was impinged at the 11 generating stations (Table 8). Impingement abundance was highest at the HBGS (91% of the Bight-wide total) (Figure 10), while impingement biomass was highest at the ESGS (35%) (Figure 11). Bight-wide impingement abundance was dominated by the nudibranch *Dendronotus frondosus* (80%), yellow rock crab (5%), and Pacific rock crab (4%). Impingement biomass was dominated by the purple-striped jelly *Chrysaora colorata* (49%), California spiny lobster (21%), and Pacific rock crab (10%) (Table 8).

Table 8. 2003 macroinvertebrate impingement totals (top 10 species) from 11 coastal generating stations in the SCB.

	Bight-wide Impingement		Cumulative Total		HBGS contribution to:	
Species	**No.**	**Wt. (kg)**	**% No.**	**% Wt.**	**No.**	**Wt.**
D. frondosus	62,150	15	80.0%	1.1%	100.0%	100.0%
yellow rock crab	4,119	36	85.3%	3.8%	69.4%	63.5%
Pacific rock crab	3,082	138	89.3%	13.9%	33.3%	7.1%
graceful rock crab	1,772	6	91.6%	14.3%	84.4%	48.3%
tuberculate pear crab	1,034	1	92.9%	14.4%	95.1%	94.6%
purple-striped jelly	683	670	93.8%	63.5%	7.8%	3.2%
California spiny lobster	664	282	94.6%	84.2%	4.8%	7.0%
red rock shrimp	653	1	95.5%	84.2%	24.5%	22.5%
striped shore crab	499	3	96.1%	84.4%	35.3%	18.0%
red rock crab	478	6	96.7%	84.9%	92.5%	96.6%
Total (56 taxa)	77,676	1,366	100.0%	100.0%	90.9%	12.3%

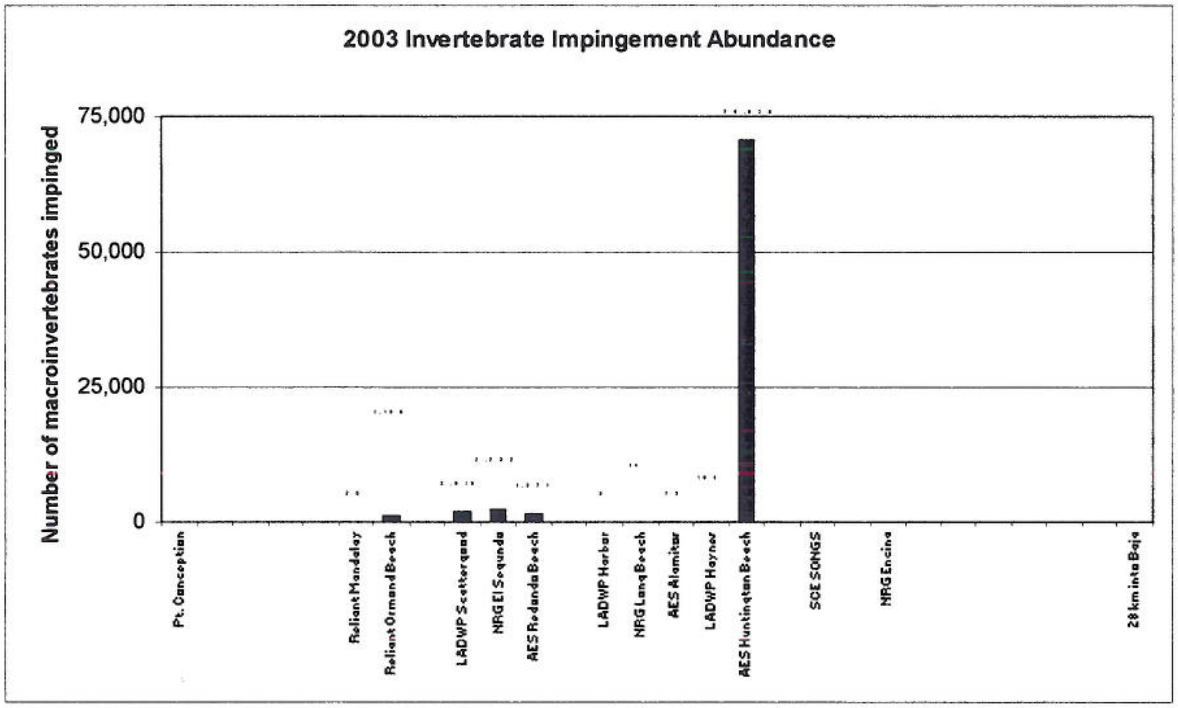


Figure 10. Bight-wide macroinvertebrate impingement abundance by generating station, upcoast (left) to downcoast (right).

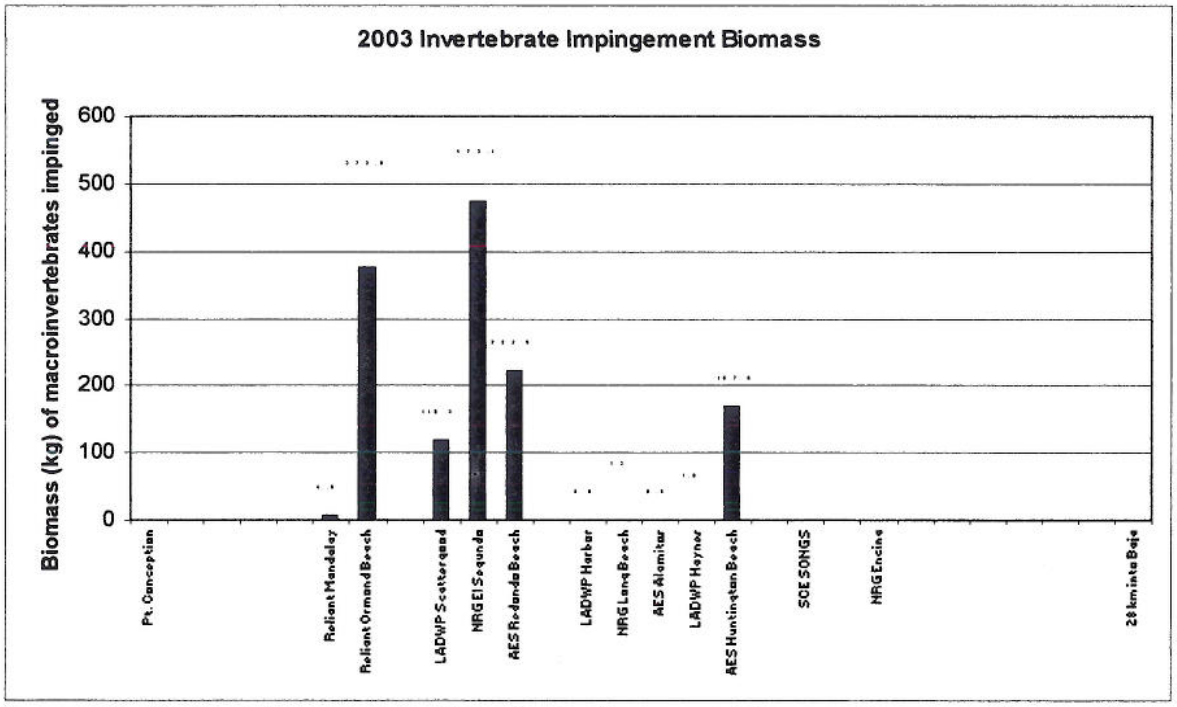


Figure 11. Bight-wide macroinvertebrate impingement biomass by generating station, upcoast (left) to downcoast (right).

A large portion of the California spiny lobsters impinged at coastal generating stations is returned to the ocean each year since they can survive impingement much better than other invertebrate species. Only those lobsters that do not appear thermally stressed or injured are returned, and even those that are returned are included in impingement totals because their ultimate survival cannot be determined. In 2003 for example, 18 of 78 (23%) were returned at ESGS Units 3&4, 69 of 161 (43%) were returned at SGS, and at least 80 of 84 (95%) were returned from two heat treatments at RBGS Units 7&8. The proximity of these facilities to their source waters (King Harbor and Santa Monica Bay) facilitates the prompt return of the lobsters, increasing their chances of survival.

Macroinvertebrate impingement abundance was highest at the HBGS (91%), and was followed by the ESGS (1%) and LADWP's SGS (0.8%); impingement abundance at all other generating stations contributed 0.3% or less to the Bight-wide total (Figure 10). Macroinvertebrate biomass was highest at the ESGS (35%), followed by OBGS (27%), RBGS (16%), and the HBGS (12%); macroinvertebrate biomass at all other generating stations each contributed less than 9% to the Bight-wide biomass total (Figure 11). Although macroinvertebrate abundance was highest at the HBGS, biomass was only fourth highest due to the abundance of small nudibranchs (*Dendronotus frondosus*). At the two generating stations where macroinvertebrate biomass was highest (ESGS and OBGS), impingement biomass was dominated by purple-striped jelly (*Chrysaora colorata*). At the RBGS, where macroinvertebrate abundance and biomass ranked third, impingement biomass was dominated by California spiny lobster (*Panulirus interruptus*). As noted previously, a large portion of these are returned to the ocean but still included in impingement totals nonetheless.

6.4 Discussion

CEQA Guidelines (§15064-15065) identify potentially significant cumulative impacts as those effects that... "*are individually limited but cumulatively considerable*". Furthermore, the guidelines state... "*The mere existence of significant cumulative impacts caused by other projects alone shall not constitute substantial evidence that the proposed project's incremental effects are cumulatively considerable.*" The guidelines define 'cumulatively considerable' as the incremental effects of an individual project that are considerable when viewed in connection with the effects of past projects, other current projects, and probable future projects. There are no plans that we are aware of for construction of new coastal generating stations in southern California. However, there are repowering efforts proposed at the NRG ESGS and the LADWP Haynes Generating Station (HnGS).

Entrainment

The cumulative entrainment analysis presented here was essentially a first-order analysis designed to give some indication of potential mortalities from entrainment at coastal generating stations. It is important to note that this was based on mathematical calculations using maximum flow volumes, assumed source water volumes, and hypothetical larval durations, and did not involve the collection of biological data. The analysis also did not take into account other potential sources of mortality on source populations. However, the analysis showed that cumulative mortality was very dependent on the volume of the source water larval population, i.e. that body that is potentially susceptible to entrainment. As source water volume lessened (for a given larval duration of susceptibility), larval mortality exponentially increased. This suggests that in the presence of limiting factors, such as circulation that would restrict larval populations, larval mortality would be much higher than indicated using a volume of water of the shelf of the Southern California Bight.

A key determinant of the entrainment effects of individual and multiple intakes is the dispersal distance (or, preferably, two or more length parameters describing dispersal of eggs and larvae – e.g., advection and diffusion coefficients) (Largier 2003). As Dr. Largier (pers. comm.) described: "*If these length scales are short, then the impact of entrainment on mortality is large but localized. If the length scales are shorter than the spacing of the intakes, then cumulative impacts (in the sense addressed here) are negligible. On the other hand, if dispersal length scales are long, then the entrainment impact on mortality is small but more widespread. If the length scales are longer than the spacing of the intakes, then cumulative impacts are important and mortality may be significant between intakes.*" The selection of source water volume has a profound effect on the calculation of *PE* and ultimately mortality. Estimates of dispersal lengths are needed in developing entrainment models. Although first order estimates of dispersal lengths can be calculated, it is not practical to do so within this report. The numbers in the report are useful as an illustration and show that cumulative effects can be important, but they are not intended as a basis for management or policy decisions. Further analyses could take into account multiple source boundaries based on known distributions or preferences of different species.

Impingement

There are several points worthy of comment with respect to cumulative impingement impacts in the SCB. A large proportion of fish impingement occurs at SONGS (97% abundance and 83% biomass) compared to all other generating stations. Flow volume is fairly high at

SONGS compared to all other coastal generating stations in the SCB, and the SONGS Unit 2 and 3 intakes are sited near areas of hard bottom substrate and kelp beds. Total impingement at SONGS in 2003 (nearly 3.6 million fish weighing 22,000 kg) was within the range of variability from 2000–2002 (approximately 1.5 million to 3.6 million fish weighing 15,000 to 28,000 kg). In the absence of macroinvertebrate impingement data from SONGS, impingement abundance was highest at the HBGS compared to the other generating stations, but impingement biomass contributed only 12% to the SCB total, primarily due to the low weight of *Dendronotus frondosus*.

Also worthy of note is the history of the SONGS mitigation projects, which are in various stages of implementation and completion. The history is too complex to list here, but will be briefly summarized. Studies to determine the environmental effects from the operation of the CWIS at SONGS began in 1974 and continued for 15 years. In 1991, the California Coastal Commission ordered the operators of SONGS to implement a comprehensive mitigation package to address impacts to marine resources (CCC 2000). Mitigation included (1) 150 acres of wetland restoration, (2) 300 acres of kelp reef construction, (3) reduction of impingement through installation and maintenance of fish behavioral modification devices, (4) reduction of impingement through the fish elevator and fish chase procedure, and (5) funding for the Hubbs-Sea World Research Institute white seabass hatchery. Additionally, SCE and its partners have funded the independent monitoring and technical oversight committees of all mitigation projects. The performance of behavioral devices (light and sonic stimuli) have been demonstrated to be ineffective in substantially reducing impingement (see Section 7.0).

Cumulative impingement data were compared with 2003 landings reported in the PSMFC RecFIN database for southern California as a whole (PSFMC 2004). For most species, the numbers impinged at the 11 coastal generating stations represented less than one percent of recreational landings in southern California (Table 8). For some species, however, impingement losses were larger compared to the total recreational take: white seaperch (85%), giant kelpfish (56%), shiner perch (38%), queenfish (33%), jacksmelt (11%), sargo (7%), white croaker (5%), walleye surfperch (4%), rubberlip seaperch (3%), black perch (3%), topsmelt (2%), and yellowfin croaker (1%). Many of these species, especially the perches, are caught primarily by recreational fishers from piers. In total, impingement abundance in the SCB was equivalent to 8% of the recreational catch in the SCB in 2003 for those species that are fished.

Table 8. Comparison of 2003 fish impingement abundance in the SCB and 2003 recreational fishing landings in southern California as reported in the RecFIN database (ranked by RecFIN landings, top 29 species) (PSFMC 2004).

Common Name	2003 Southern California Recreational Landings	2003 SCB Cumulative Impingement	Proportion of Impingement to Recreational Capture
queenfish	974,312	330,773	33.9%
pacific mackerel	828,490	80	<0.1%
barred sand bass	802,096	538	0.1%
kelp bass	595,291	352	0.1%
white croaker	180,002	9,159	5.1%
vermillion rockfish	160,170	17	<0.1%
walleye surfperch	143,524	5,511	3.8%
California halibut	142,075	107	0.1%
California scorpionfish	130,126	490	0.4%
jacksmelt	118,464	12,979	11.0%
halfmoon	110,425	28	<0.1%
topsmelt	93,605	2,112	2.3%
yellowfin croaker	71,932	972	1.4%
California sheephead	69,843	2	<0.1%
blacksmith	66,822	365	0.5%
opaleye	51,956	28	0.1%
white seabass	50,521	265	0.5%
black perch	42,120	1,050	2.5%
brown rockfish	36,193	188	0.5%
shiner perch	25,114	9,643	38.4%
California corbina	19,680	87	0.4%
sargo	17,159	1,243	7.2%
spotfin croaker	16,977	65	0.4%
pile perch	8,926	83	0.9%
rock wrasse	6,728	34	0.5%
rubberlip seaperch	6,520	217	3.3%
white seaperch	6,110	5,162	84.5%
spotted sand bass	3,538	1	<0.1%
giant kelpfish	1,281	718	56.1%
Totals:	4,780,002	382,269	8.0%

Impingement in the SCB was also compared with recreational landings reported in the NOAA Fisheries Recreational Sport Fisheries Database for Southern California (NOAA Fisheries 2004). This database was originally compiled for NOAA Fisheries by Mitchell (1999), and includes sportfish catch by landing as reported daily in the Los Angeles Times from 1959 through 2003. Our analysis of the NOAA database was limited to recreational landings from Santa Barbara south to Oceanside (Table 9).

Table 9. Comparison of 2003 fish impingement abundance from 11 coastal generating stations in the SCB and recreational fishing landings between Santa Barbara and Oceanside (20 ports) as reported in the NOAA Fisheries Los Angeles Times Sportfish Database (NOAA Fisheries 2004).

Common Name	2003 SCB Impingement	2003 SCB Landings	1999-2003 Average Annual SCB Landings	1959-2003 Average Annual SCB Landings
barred sand bass	538	469,588	547,480	254,573
kelp bass	352	233,997	203,475	373,796
"sanddab"	607	172,591	161,419	22,073
California barracuda	5	103,713	224,275	230,362
California scorpionfish	490	89,303	114,740	47,003
blue rockfish	0	46,706	51,483	56,971
chub mackerel	80	19,021	36,097	355,551
white seabass	265	9,710	11,615	4,414
blacksmith	365	9,131	3,701	655
California halibut	107	6,542	9,732	30,037
opaleye	28	4,899	2,521	506
sargo	1,243	4,134	2,003	675
jack mackerel	1,334	3,117	2,411	1,909
yellowfin croaker	972	2,047	1,098	256
white croaker	9,159	615	969	5,038
cabezon	693	275	1,252	573
giant seabass	0	169	332	178
halfmoon	28	132	158	1,489
black croaker	193	77	38	66
leopard shark	5	45	21	7
black surfperch	1,050	30	61	17
rubberlip seaperch	217	26	6	1
jacksmelt	12,979	5	16	1,660
kelp greenling	12	3	1	3
bocaccio	2,468	0	3,717	1,521
olive rockfish	38	0	267	335
brown rockfish	188	0	22	69
queenfish	330,773	0	13	1,688
grass rockfish	5	0	8	5,811
barred surfperch	2	0	2	10
California lizardfish	217	0	2	3
spotted sand bass	1	0	2	2
spotfin croaker	65	0	0	26
horn shark	8	0	0	0
turbot	550	0	0	2
California corbina	87	0	0	9
walleye surfperch	5,511	0	0	0
Totals:	370,700	1,175,876	1,378,939	1,397,316

SCB Ports included: Santa Barbara, Goleta, Ventura, Oxnard, Port Hueneme, Paradise Cove, Malibu, Santa Monica, Marina del Rey, Hermosa Beach, Redondo Beach, San Pedro, Wilmington, Long Beach, Seal Beach, Huntington Beach, Newport Beach, Dana Point, San Clemente, and Oceanside.

Catches of species fluctuate over time because species not only vary in their availability and abundance, but also in their desirability to anglers. Table 9 presents total catch numbers but does not take into account variability in fishing effort over time. Catch from three different time periods (2003, 1999-2003, and 1959-2003) are presented to show trends through time. The annual number of sport anglers in southern California has varied little over the last 40 years, remaining at about 620,000 angler trips per year, though the total number of fish landed has steadily decreased (Dotson and Charter 2003). Between San Pedro and San Clemente, the total catch per angler peaked in 1980, then steadily decreased by about 50% to 1999. A similar trend was observed between Wilmington and Goleta. The authors noted that fishing regulations, including size limits, take limits, and closures, have affected catch rates in southern California (Dotson and Charter 2003).

For the ten most abundant sportfish taxa reported in 2003, Bight-wide impingement was relatively minor (4% or less) compared to the reported catch for 2003. The percentages were higher, however, for species such as sargo, jack mackerel, and yellowfin croaker. These three species are not historically important targets of sportfishers, but their increasing importance is apparent by the increasing catch through time (Table 9). Impingement in the SCB was equivalent to about one-third of the reported sportfish catch. However, queenfish accounted for 89% of the impinged species included in the sportfish comparison, and jacksmelt comprised another 4%. These two species are not usually common sportfishing targets. Jacksmelt are caught by pier and shore anglers, and are especially important in central and northern California (Gregory 2001). Queenfish are likely caught by anglers from piers and shore.

Appendix F

Model Parameterization

Appendix F1
Estimating Total Entrainment

The following sections describe calculations used for assessing entrainment effects at the Huntington Beach Generating Station (HBGS). The equations are presented in a general form that is applicable to sample designs that may have differing numbers of stations, sampling periods, or replicates. The present design for the HBGS entrainment study will sample one station with two replicates four times per sample day. As described below, there will be one sampling day per monthly sampling period. While summation signs over stations are presented in the equations they will be summing over an *n* of one in the actual calculations and therefore will drop out of the formulas.

A general form can be written for summing entrainment over stations at an intake or entrainment site using cycles within a day and days within time periods. Let

$i =$ period $\left(i = 1, \ldots, N\right)$;

$j =$ day within period $\left(j = 1, \ldots, N_i\right)$;

$k =$ cycle within day $\left(k = 1, \ldots, N_{ij}\right)$;

$l =$ station $\left(l = 1, \ldots, N_{ijk}\right)$;

$m =$ volume at station within cycle $\left(m = 1, \ldots, N_{ijkl}\right)$.

The total larval entrainment at an intake source can be expressed as

$$E_T = \sum_{i=1}^{N} \sum_{j=1}^{N_i} \sum_{k=1}^{N_{ij}} \sum_{l=1}^{N_{ijk}} \rho_{ijkl} V_{ijkl} \tag{A1}$$

where

ρ_{ijkl} = density of larvae at the *l*th station within the *k*th cycle on the *j*th day in the *i*th time period;

V_{ijkl} = volume of water passing the at the *l*th station within the *k*th cycle on the *j*th day in the *i*th time period.

This summation assumes that stations represent the total intake volume of the power plant. It also assumes that the larval density in the volume of water passing a station is constant over time and space over any cycle. An estimate of the total larval entrainment can be made by taking n_{ijkl} samples of the N_{ijkl} volumes passing a station as

$$\hat{E}_T = \sum_{i=1}^{N}\sum_{j=1}^{N_i}\sum_{k=1}^{N_{ij}}\sum_{l=1}^{N_{ijk}} \frac{V_{ijkl}}{n_{ijkl}} \sum_{m=1}^{n_{ijkl}} \rho_{ijklm} \tag{A2}$$

If we also assume that entrainment volume is constant and the same at all stations then

$$\hat{E}_T = \sum_{i=1}^{N} V_{ijkl} \sum_{j=1}^{N_i}\sum_{k=1}^{N_{ij}}\sum_{l=1}^{N_{ijk}} \frac{1}{n_{ijkl}} \sum_{m=1}^{n_{ijkl}} \rho_{ijklm} \tag{A3}$$

Strata will be defined as the stations and cycles with constant N_{ij} and N_{ijk}. In addition, we sample n_i days of the N_i possible during a period so that

$$\begin{aligned} \hat{E}_T &= \sum_{i=1}^{N} N_i N_{ij} N_{ijk} V_{ijkl} \frac{1}{n_i} \sum_{j=1}^{n_i}\sum_{k=1}^{N_{ij}}\sum_{l=1}^{N_{ijk}} \left(\frac{1}{N_{ij} N_{ijk} n_{ijkl}} \right) \sum_{m=1}^{n_{ijkl}} \rho_{ijklm} \\ &= \sum_{i=1}^{N} V_i \frac{1}{n_i} \sum_{j=1}^{n_i}\sum_{k=1}^{N_{ij}}\sum_{l=1}^{N_{ijk}} \left(\frac{1}{N_{ij} N_{ijk} n_{ijkl}} \right) \sum_{m=1}^{n_{ijkl}} \rho_{ijklm} \end{aligned} \tag{A4}$$

where

$$V_i = \sum_{j=1}^{N_i}\sum_{l=1}^{N_{ij}}\sum_{k=1}^{N_{ijk}} V_{ijkl} \text{ or } N_i N_{ij} N_{ijk} V_{ijkl} \text{ since } V_{ijkl} \text{ is constant.}$$

If only one day per period is sampled Equation A4 can be expressed as

$$\begin{aligned} \hat{E}_T &= \sum_{i=1}^{N} V_i \sum_{k=1}^{N_{ij}}\sum_{l=1}^{N_{ijk}} \left(\frac{1}{N_{ij} N_{ijk} n_{ijkl}} \right) \sum_{m=1}^{n_{ijkl}} \rho_{ijklm} \\ &= \sum_{i=1}^{N} V_i \sum_{k=1}^{N_{ij}}\sum_{l=1}^{N_{ijk}} \left(\frac{1}{N_{ij} N_{ijk}} \right) \widehat{\rho}_{ijkl} \end{aligned} \tag{A5}$$

with estimated variance

$$\widehat{Var}\left(\hat{E}_T\right)=\sum_{i=1}^{N}V_i^2\sum_{k=1}^{N_{ij}}\sum_{l=1}^{N_{ijk}}\left(\frac{1}{N_{ij}N_{ijk}}\right)^2\left(1-\frac{n_{ijkl}}{N_{ijkl}}\right)\frac{\widehat{Var}\left(\rho_{ijkl}\right)}{n_{ijkl}} \tag{A6}$$

where

$$\widehat{Var}\left(\rho_{ijkl}\right)=\frac{\sum_{m=1}^{n_{ijkl}}\left(\rho_{ijklm}-\hat{\bar{\rho}}_{ijkl}\right)^2}{\left(n_{ijkl}-1\right)};$$

$$\hat{\bar{\rho}}_{ijkl}=\frac{\sum_{m=1}^{n_{ijkl}}\rho_{ijklm}}{n_{ijkl}}.$$

Estimates of E_T based on Equation A5 will be used in *FH* and *AEL* calculations to estimate annual effects of entrainment on fishes and invertebrates. Equation A6 will underestimate the true variance because it does not include within-period variance. In practice, we ignore the finite population correction, $\left(1-\frac{n_{ijkl}}{N_{ijkl}}\right)$ because N_{ijkl} is large. Estimators similar to Equation A5 and Equation A6 are used for calculating survey period estimates of intake and source populations for use in ETM calculations.

Appendix F2
Estimating Proportional Entrainment and the *ETM* Calculations

The empirical transport model (*ETM*) is used to estimate the total mortality probability for larvae from power plant entrainment. The estimate is based on periodic estimates of the probability of entrainment mortality based on daily samples. In the following calculations we assume all larvae entrained die. Generally, sampling takes place over the course of a year so that larval mortality of various species is estimated.

The daily probability of entrainment can be defined as

$$PE_i = \frac{\text{abundance of entrained larvae}_i}{\text{abundance of larvae in source population}_i}$$

$$= \text{probability of entrainment in } i\text{th time period } \left(i = 1, \ldots, N\right).$$

In turn, the daily probability can be estimated and expressed as

$$PE_i = \frac{\widehat{E_i}}{\widehat{R_i}} \qquad \text{(B1)}$$

where

$\widehat{E_i}$ = estimated abundance of larvae entrained in the ith time period $\left(i = 1, \ldots, N\right)$;

$\widehat{R_i}$ = estimated abundance of larvae at risk of entrainment from the source population in the ith time period $\left(i = 1, \ldots, N\right)$.

Estimating Daily Entrainment

The estimate of total Huntington Beach Generating Station (HBGS) entrainment on day j in period *i* can be expressed from equation (A4) as

$$\widehat{E_{ij}} = \sum_{k=1}^{4}\sum_{l=1}^{1} V_{ijkl}\frac{1}{2}\sum_{m=1}^{2}\rho_{ijklm} \tag{B2}$$

$$= V_{ij}\sum_{k=1}^{4}\sum_{l=1}^{1}\left(\frac{1}{8}\right)\sum_{m=1}^{2}\rho_{ijklm}$$

with associated variance

$$Var\left(\widehat{E_{ij}}\middle|E_{ij}\right) = V_{ij}^{2}\sum_{k=1}^{4}\sum_{l=1}^{1}\left(\frac{1}{2}\right)^{2}\left(1-\frac{2}{N_{ijkl}}\right)S^{2}_{\rho_{ijkl}} \tag{B3}$$

which can be estimated by

$$\widehat{Var}\left(\widehat{E_{ij}}\right) = V_{ij}^{2}\sum_{k=1}^{4}\sum_{l=1}^{1}\left(\frac{1}{8}\right)^{2}\left(1-\frac{2}{N_{ijkl}}\right)s^{2}_{\rho_{ijkl}}\ . \tag{B4}$$

The finite population correction [i.e., $\left(1-\frac{2}{N_{ijk}}\right)$] can be ignored because N_{ijkl} is exceedingly large. Only one day is sampled per period. The period estimated entrainment and variance are

$$\widehat{E_{i}} = V_{i}\sum_{k=1}^{4}\sum_{l=1}^{1}\left(\frac{1}{8}\right)\sum_{m=1}^{2}\rho_{ijklm} \tag{B5}$$

$$\widehat{Var}\left(\widehat{E_{i}}\right) = V_{i}^{2}\sum_{k=1}^{4}\sum_{l=1}^{1}\left(\frac{1}{8}\right)^{2} s^{2}_{\rho_{ijkl}}\ . \tag{B6}$$

Estimating Numbers of Larvae at Risk

With the defined and agreed-upon sources for Huntington Beach (S) larvae, the daily abundance of larvae at risk can be estimated by

$$\widehat{R_{ij}} = V_{S}\cdot\widehat{\overline{\rho}_{S_{ij}}} \tag{B7}$$

where V_S denotes the agreed upon volume of the Huntington Beach source water (S), and $\widehat{\overline{\rho}}$ denotes an estimate of average density in the source water body. The variance of Expression B7 can be written as

$$Var\left(\widehat{R_{ij}}\mid R_{ij}\right) = V_{S}^{2}\cdot Var\left(\widehat{\overline{\rho}_{S_{ij}}}\mid\overline{\rho}_{S_{ij}}\right) \tag{B8}$$

The individual variances within Formula B8 describe temporal-spatial variance in density within the source population during the day of sampling. Seven source water locations are sampled in the Huntington Beach source water body (including the entrainment station). Ideally, tow samples would be collected randomly through time and space during a sampling day over a potential source population. However, the large sampling area required the use of a sampling design with fixed time and locations. Our source water estimates of population and variance are made for each period using only one day, i.e. $\widehat{R_i} = \widehat{R_{ij}}$ and $\widehat{Var}\left(\widehat{R_i}\right) = Var\left(\widehat{R_{ij}} \mid R_{ij}\right)$.

Period Entrainment and ETM Calculations

By dividing estimated period entrainment (B5) by the corresponding source population (B7) an estimate of entrainment mortality can be written as

$$\widehat{PE_i} = \frac{\widehat{E_i}}{\widehat{R_i}} \tag{B9}$$

Variance for the Estimate of PE_i

The variance for the period estimate of $\widehat{PE_i}$ can be expressed as

$$Var\left(\widehat{PE_i}\middle|PE_i\right) = Var\left(\frac{\widehat{E_i}}{\widehat{R_{ij}}}\middle|E_i, R_i\right).$$

Assuming zero covariance between the entrainment and source and using a Taylor series approximation, the Delta method (Seber 1982), the variance of an estimator formed from a quotient (like $\widehat{PE_i}$) can be effectively approximated by

$$Var\left(\frac{A}{B}\right) \approx Var(A)\left(\frac{\partial\left[\frac{A}{B}\right]}{\partial A}\right)^2 + Var(B)\left(\frac{\partial\left[\frac{A}{B}\right]}{\partial B}\right)^2.$$

The delta method approximation of $Var(\widehat{PE_i})$ is shown as

$$Var\left(\widehat{PE_i}\right) = Var\left(\frac{\widehat{E_i}}{V_S \cdot \widehat{\bar{\rho}_{S_i}}}\right)$$

which by the Delta method can be approximated by

$$\widehat{Var}\left(\widehat{PE_i}\right) \approx \widehat{Var}\left(\widehat{E_i}\right)\left(\frac{1}{V_S \cdot \widehat{\bar{\rho}_{S_i}}}\right)^2 + \widehat{Var}\left(V_S \cdot \bar{\rho}_{S_i}\right)\left(\frac{-\widehat{E_i}}{V_S \cdot \left(\widehat{\bar{\rho}_{S_i}}\right)^2}\right)^2 \tag{B10}$$

and is equivalent to

$$= PE_i^2\left[CV\left(\widehat{E_i}\right)^2 + CV\left(V_S \cdot \widehat{\bar{\rho}_{S_i}}\right)^2\right]$$

where

$$\widehat{R_i} = V_S \cdot \widehat{\bar{\rho}_{S_{ij}}} \text{ and}$$

$$CV\left(\hat{\theta}\middle|\theta\right) = \frac{\widehat{Var}\left(\hat{\theta}\middle|\theta\right)}{\widehat{\theta^2}}.$$

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

$$\widehat{P_M} = 1 - \sum_{i=1}^{N} \widehat{f_i}\left(1 - \widehat{PE_i}\right)^q \tag{B11}$$

where

q = number of days of larval life, and

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

Formula (B11) is based on the total probability law where $P(A \mid B_i) = (1 - \widehat{PE_i})^q$, the conditional survival and

$$P(A) = \sum_{i=1}^{N} P\left(A \middle| B_i\right) \cdot P\left(B_i\right).$$

In the above example, the event A is larval survival and event B is hatching with $P(B)$ estimated by $\widehat{f_i}$ where

$$\widehat{f}_i = \frac{\widehat{E_i}}{\widehat{E_T}},$$

where $\widehat{E_i}$ = estimated entrainment for the *i*th survey period. Then based on the Delta method

$$\begin{aligned}
\widehat{Var}(\widehat{f}_i) &= \widehat{Var}\left[\frac{\widehat{E_i}}{\widehat{E_T}}\right] \\
&= \widehat{Var}\left[\frac{\widehat{E_i}}{\widehat{E_i} + \sum_{j \neq i}^{N} \widehat{E_j}}\right] \\
&= \widehat{f}_i^{\,2} (1 - \widehat{f}_i)^2 \left[\frac{\widehat{Var}(\widehat{E_i})}{\widehat{E_i}^{\,2}} + \frac{\widehat{Var}(\widehat{E_T})}{\widehat{E_T}^{\,2}}\right].
\end{aligned}$$

The estimates of PE_i and f_i and their respective variance estimates can be combined in an estimate of the variance for $\widehat{P_M}$ following the Delta method for variance and covariance as follows:

$$\begin{aligned}
\widehat{Var}(\widehat{P_M}) &= \widehat{Var}\left(1 - \sum_{i=1}^{N} \widehat{f}_i (1 - \widehat{PE_i})^q\right) \\
&= \widehat{Var}\left(\sum_{i=1}^{N} \widehat{f}_i (1 - \widehat{PE_i})^q\right) \\
&= \sum_{i=1}^{N} \left[Var(\widehat{f}_i)(1 - \widehat{PE_i})^{2q}\right] \\
&\quad + \sum_{i=1}^{N} \left[Var(\widehat{PE_i})(\widehat{f}_i q (1 - \widehat{PE_i})^{q-1})^2\right] \\
&\quad + 2 \sum_{i=1}^{N} \sum_{j>i}^{N} \operatorname{cov}\left(\widehat{f}_i, \widehat{f}_j\right)(1 - \widehat{PE_j})^q (1 - \widehat{PE_i})^q \qquad \text{where}
\end{aligned}$$

$$\operatorname{cov}\left(\widehat{f}_i, \widehat{f}_j\right) = \left(\frac{1}{\widehat{E_T}}\right)^2 \left[\widehat{f}_i \widehat{f}_j Var\left(\sum_{g \neq i,j}^{N} \widehat{E_g}\right) + \widehat{f}_i \left(1 - \widehat{f}_j\right) \widehat{E_i} + \widehat{f}_j \left(1 - \widehat{f}_i\right) \widehat{E_j}\right].$$

Appendix F3
Demographic Model Calculations

Fecundity Hindcasting (FH)

The estimated total larval entrainment for a species ($\widehat{E_T}$) was used to estimate the number of breeding females needed to produce the number of larvae entrained. The estimated number of breeding females ($\widehat{FH}$) whose fecundity was equal to the estimated total loss of entrained larvae is calculated as follows:

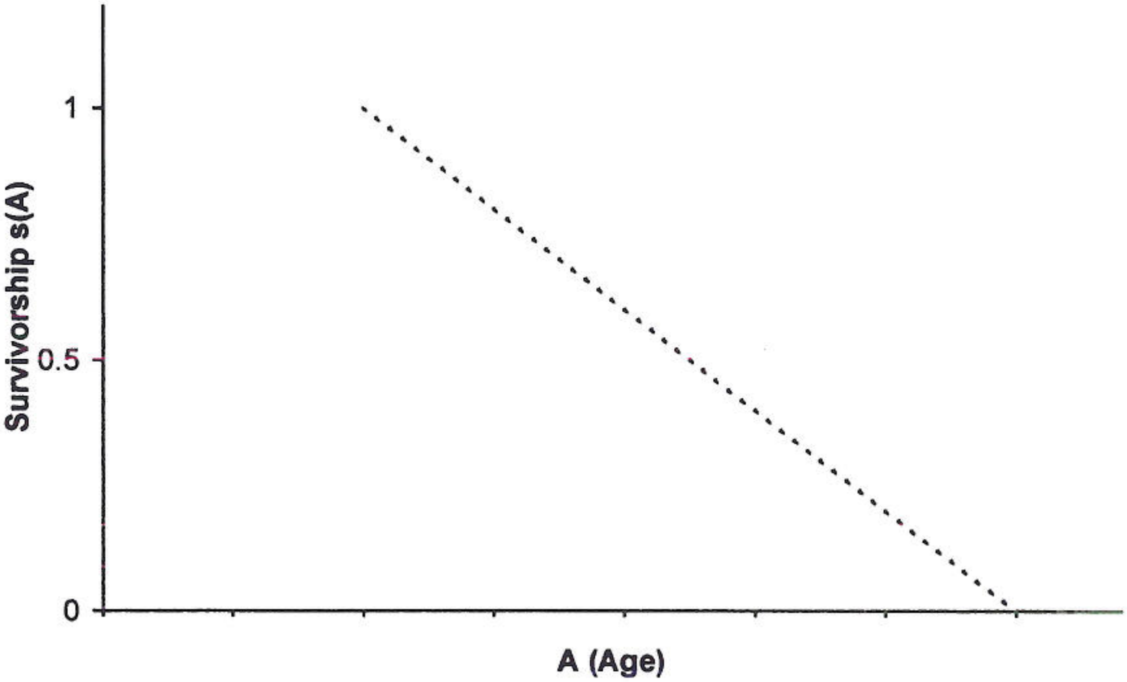
$$\widehat{FH} = \frac{\widehat{E_T}}{\widehat{TLF} \bullet \prod_{i=1}^{n} S_i} \qquad \text{(C1)}$$

where

$n =$ number of larval stages vulnerable to entrainment,
$\widehat{E_T} =$ estimated total entrainment,
$S_i =$ survival rate from eggs to larvae of the ith stage, and
$\widehat{TLF} =$ estimated total life time fecundity for females, equivalent to the average number of eggs spawned per female over their reproductive years.

Equation C1 is based on the simplified case of a single synchronized spawning by a species. For species with overlapping or continuous spawning, larval abundance would have to be specified by week and age class (i.e., $\widehat{E_{ij}}$). However, we used the mean size of all larvae entrained to estimate a representative age of larvae, and then estimated a survival rate to this representative age. Two input parameters in Equation C1 that may not be available for many species, and thus may limit the method, are lifetime fecundity (TLF) and survival rates (S_i) from spawning to entrainment.

In practice, survival was estimated by either one or several age classes, depending on the data source, to the estimated age at entrainment. The expected total lifetime fecundity $E(TLF)$ was approximated by modeling a linear survivorship for a female once she reached the age of maturity, and using a constant number of eggs produced per year.



The number of eggs produced per year was approximated as the average number of eggs per year. Thus

$$\widehat{TLF} = \int_{A_M}^{A_L} F(A)s(A)dA$$
$$= \overline{F} \int_{A_M}^{A_L} \frac{A_L - A}{A_L - A_M} dA$$
$$= \overline{F}\left(\frac{A_L - A_M}{2}\right)$$

where

$s(A)$ = survivorship of a female;

$F(A)$ = eggs produced;

A_M = age of maturity; and

A_L = age at death.

In other words,

$$\begin{aligned}\widehat{TLF} &= \text{Estimated Total Lifetime Fecundity} \\ &= \text{Average eggs/year} \cdot \text{Average number of years of reproductive life} \\ &= \text{Average eggs/year} \cdot \left(\frac{\text{Longevity - Age at maturation}}{2} \right). \end{aligned} \tag{C2}$$

The expected length of reproductive life was approximated as the midpoint between the times of maturation and longevity. The approximation of linear survivorship between these events implies uniform survival. For exploited species such as northern anchovy and sardine, the expected number of years of reproductive life may be much less than predicted using this assumption.

Simulation, comparing exponential survival, shows that the calculation of $\widehat{TLF}$ will be negatively biased for species with short reproductive lifespans, and positively biased for those with longer durations.

The variance of $\widehat{FH}$ was approximated by the Delta method (Appendix B2) (Seber 1982):

$$\widehat{Var}(\widehat{FH}) = (\widehat{FH})^2 \left[CV^2(\hat{E}_T) + \sum_{j=1}^{n} CV^2(\widehat{S}_j) + CV^2(\hat{\widehat{F}}) + \left(\frac{\widehat{Var}(A_L) + \widehat{Var}(A_M)}{(A_L - A_m)^2} \right) \right]$$

where

$\text{CV}(\hat{E}_T)$ = CV of estimated entrainment (estimated by $\text{CV}(\hat{\hat{\text{I}}})$ when available),
$\text{CV}(\widehat{S}_j)$ = CV of estimated survival of eggs and larvae up to entrainment,
$\text{CV}(\hat{\widehat{F}})$ = CV of estimated average annual fecundity,
A_M = age at maturation, and
A_L = age at maturity.

The behavior of the estimator for *FH* appears log-linear, suggesting that an approximate confidence interval can be based on the assumptions that $\ln(\widehat{FH})$ is normally distributed and uses the pivotal quantity

$$Z = \frac{\ln \widehat{FH} - \ln FH}{\sqrt{\dfrac{\widehat{Var}(\widehat{FH})}{\widehat{FH}^2}}}.$$

A 90% confidence interval for *FH* was estimated by solving for *FH* and setting Z equal to

+/-1.645, i.e.

$$\widehat{FH}\cdot e^{-1.645\sqrt{\frac{\widehat{Var}(\widehat{FH})}{\widehat{FH}^2}}} \text{ to } \widehat{FH}\cdot e^{+1.645\sqrt{\frac{\widehat{Var}(\widehat{FH})}{\widehat{FH}^2}}}.$$

Adult Equivalent Loss (AEL)

The *AEL* approach uses estimates of the abundance of entrained or impinged organisms to forecast the loss of equivalent numbers of adults. Starting with the number of age class *j* larvae entrained ($\widehat{E}_j$), it is conceptually easy to convert these numbers to an equivalent number of adults lost ($\widehat{AEL}$) at some specified age class from the formula:

$$\widehat{AEL} = \sum_{j=1}^{n} \widehat{E}_j \widehat{S}_j \tag{C3}$$

where

n = number of age classes,
$\widehat{E}_j$ = estimated number of larvae lost in age class j, and
$\widehat{S}_j$ = survival rate for the jth age class to adulthood (Goodyear 1978).

Age-specific survival rates from larval stage to recruitment into the fishery (through juvenile and early adult stages) must be included in this assessment method. For some commercial species, survival rates are known for adults in the fishery; but for most species, age-specific larval survivorship has not been well described.

When age-specific survival rates from larval stage to recruitment into the fishery were available, *AEL* was calculated using survival from a representative age of the entrained larvae. This age was calculated by dividing the average larval length at entrainment (minus hatch length) by a literature-based growth rate. Age-specific survivorship for any interval of time (t) was then calculated following the formula (Ricker 1975)

$$\frac{N_t}{N_0} = e^{-Zt}$$

where

$N_t =$ number of animals in the population at time t,
$N_0 =$ number of animals in the population at time $t = 0$,
$\frac{N_t}{N_0} = S$ (finite survivorship to time t),
$e = 2.71828...$(base of the natural log), and
$Z =$ instantaneous mortality rate.

Survivorship to recruitment, to an adult age, was apportioned into several age stages, and *AEL* was calculated using the total entrainment as

$$\widehat{AEL} = \hat{E}_T \prod_{j=1}^{n} \widehat{S}_j \tag{C4}$$

where

$n =$ number of age classes from entrainment to recruitment and
$\widehat{S}_j =$ survival rate from the beginning to end of the jth age class.

The variance of $\widehat{AEL}$ can be estimated using the Delta method as

$$\widehat{Var}(\widehat{AEL}) = \widehat{AEL}^2 \left(CV^2(\hat{E}_T) + \sum_{j=1}^{n} CV^2(\widehat{S}_j) \right). \tag{C5}$$

An alternative analysis would be to compare $\widehat{AEL}$ with the size of the adult population of interest or with fishery harvest data. This method converts numbers of adult losses into fractional loss of the population of interest (e.g., stock assessment). However, information describing adult stocks is limited for many species, and independent field estimates of survival from time of entrainment to adulthood are not available for some species. For some species where such information is unavailable, we can estimate this parameter by assuming a stationary population where an adult female must produce two adults (i.e., one male and one female). Overall survival (S_T) can then be estimated from total lifetime fecundity (TLF) by the quantity

$$\widehat{S}_T = \frac{2}{\widehat{TLF}} = \hat{S}_{egg} \cdot \hat{S}_{larvae} \cdot \hat{S}_{adult},$$

which leads to

$$\hat{S}_{adult} = \frac{2}{\widehat{TLF} \cdot \hat{S}_{egg} \cdot \hat{S}_{larvae}}. \tag{C6}$$

Substituting Equation 11 into the overall form of the *AEL* equation where

$$\widehat{AEL} = \hat{E}_T \cdot \hat{S}_{adult} \tag{C7}$$

yields

$$\widehat{AEL} = \frac{2(\hat{E}_T)}{\hat{S}_{egg} \cdot \hat{S}_{larva} \cdot \widehat{TLF}}$$

where

$$\widehat{AEL} \equiv 2\widehat{FH}\ . \tag{C8}$$

Without independent adult survival rates and assuming a 50:50 sex ratio, $\widehat{AEL}$ and $\widehat{FH}$ are deterministically related according to Equation C8, with an associated standard error of $\widehat{SE}(\widehat{AEL}) = 2\widehat{SE}(\widehat{FH})$. Equation C8 should be aligned so that the average female age is also the age of recruitment used in computing $\widehat{AEL}$. This alignment is accomplished by solving the simple exponential survival equation (Ricker 1975)

$$N_t = N_0 \cdot e^{-Z(t-t_0)}$$

by substituting numbers of either equivalent adults or hindcast females, their associated ages, and mortality rates into the equation where,

N_t = number of adults at time t,
N_0 = number of adults at time t_0,
Z = instantaneous rate of natural mortality, and
t = age of hindcast animals (FH) or extrapolated age of animals (AEL).

This allows for the alignment of ages in either direction such that $2FH \equiv AEL$ since they are either hindcast or extrapolated to the same age.

The estimates of mortality calculated from the *AEL* and *FH* approaches can be compared for the same time periods for taxa where independent estimates are available for (1) survival from entrainment to recruitment into the fishery and (2) entrainment back to hatching. These comparisons serve as a method of cross-validation for the demographic approaches to impact assessment.