3.0 ENTRAINMENT AND SOURCE WATER SAMPLING

3.1 Introduction

The purpose of the Morro Bay Power Plant entrainment and source water studies was to evaluate the potential impacts of the MBPP modernized combined-cycle power plant. These studies focused on larval fishes and cancer crab megalopae whose adult populations might be affected by power plant operation. Sampling was directed at characterizing the composition and abundance of both the early life stages of fishes and cancer crabs entrained by the power plant and those at risk of being entrained from the source waters.

The studies were designed to specifically address the following questions:

- What are the species composition and abundance of larval fishes and cancer crab megalopae entrained by the MBPP?

- What are the local species composition and abundance of entrainable larval fishes and cancer crab megalopae in Morro and Estero bays?

- What are the potential impacts of entrainment losses on larval fish and megalopal cancer crab populations due to operation of the power plant's cooling water intake system (CWIS)?

A Technical Working Group (TWG) was formed by the Regional Water Quality Control Board (RWQCB); the purpose of this group was, in part, to develop a plan to direct the studies of potential effects of the modernization of the MBPP on the local larval fish and megalopal cancer crab populations. The MBPP TWG consisted of representatives of Duke Energy North America, Tenera Environmental, the RWQCB and their consultants (Drs. Raimondi and Cailliet), the California Department of Fish and Game (CDFG), and the California Energy Commission (the CEC) and their consultant (Dr. Mike Foster). Working group meetings were scheduled to coincide with the completion of written products. The TWG members reviewed and commented on several drafts of the Cooling Water Intake Study Plan. The final study plan is attached as Appendix A. Six quarterly reports describing the progress of entrainment, source water, and impingement sampling were also submitted to the TWG. These quarterly reports contained data from the entrainment, source water, and impingement surveys. The final quarterly report was submitted to the TWG on January 31, 2001.

An experimental study using molecular methods to identify and possibly quantify larval clams collected from the MBPP intakes and source water began in March 2001 (Section 3.5). The

purpose of the study is to provide information on the composition and abundance of clam larvae potentially affected by the power plant. We anticipate that the results of this study will be published in March 2002. Members of the TWG acknowledged (at the December 4, 2000 meeting) that due to the experimental nature of the proposed larval clam studies, the study's completion would not delay project certification or renewal of the facility's NPDES permit. The study plan for the clam study is presented in Appendix D.

The MBPP CWIS consists of bar racks, traveling screens, and circulating water pumps (Section 2.0). The traveling screens are constructed of 3/8-in. (1 cm) stainless steel wire mesh to exclude small debris from entering the intake conduits. Organisms small enough to pass through the screens and enter the CWIS become entrained. The weighted maximum flow rate of the cooling water withdrawn by the modernized power plant will be approximately 38 percent less than the existing power plant's water withdrawal (Table 2-2), thereby reducing existing entrainment effects. The volume of cooling water pumped by the existing power plant is compared to the modernized power plant's water withdrawals under various operating scenarios in Section 2.0 (Table 2-2).

Plankton surveys were conducted to characterize the taxonomic composition and abundance of larval fishes and cancrid crab megalopae potentially entrained in the MBPP CWIS and from the surrounding source water. Plankton samples collected from in front of the MBPP intake structures provided an estimate of the total number and types of these organisms passing through the power plant's CWIS. Data collected from source water surveys were used to estimate the abundance of fish larvae and megalopal cancer crabs at risk of entrainment. The rationale used to calculate the source water volume is presented in Appendix E. The estimates of larval abundance from entrainment and source water samples were used to calculate estimates of fractional losses that were translated into potential impacts on local fisheries (see Section 5.0— Impact Assessment).

Many marine organisms have planktonic forms that can be entrained in cooling water intake systems. The TWG decided to focus on two groups of representative target organisms; larval fishes and cancrid crab megalopae. The non-indigenous European green crab *Carcinus maenas* was labeled a species of concern by the CDFG, and they requested that we search for them in all of our plankton samples. From these groups, particular taxa were selected for further analyses by the TWG on the basis of their sampled abundance or economic or recreational value. The TWG determined that several assessment approaches would be applied to each taxon, where possible, to yield more robust and comparable impact assessments.

Cooling water system entrainment effects were evaluated using a variety of methods; all assuming 100 percent entrainment mortality (see Section 5.0 – Impact Assessment). The three

analytical techniques used were Empirical Transport Modeling (*ETM*), Fecundity Hindcasting (*FH*), and Adult Equivalent Loss (*AEL*), which are described in Section 5.0—Impact Assessment. The TWG reviewed, provided input, and approved the use of the analytical methods chosen. We assessed the potential impacts on species population demographics using the results of these analyses.

3.2 Methods

3.2.1 Entrainment Sample Collection

Weekly entrainment sampling began June 21, 1999 and continued through August 10, 1999 (Table 3-1). A species initially identified as tidewater goby *Eucyclogobius newberryi*, a federally listed endangered species, was collected during Survey 2 (June 28, 1999). This species was identified and confirmed by taxonomists in early August 1999. The U.S. Fish and Wildlife Service (USFWS) and the CDFG were immediately notified regarding the collection of tidewater goby. All plankton sampling was suspended, at their direction, because we did not possess a permit to allow for the destructive sampling of the tidewater goby. A USFWS Endangered Species Recovery Permit Application to allow for the collection of the tidewater goby was filed. We received a permit on December 2, 1999 and weekly sampling resumed December 14, 1999 and continued through December 29, 2000.

Samples were collected from in front of the MBPP intake structures (Station 2; Figure 3-1) by towing a bongo frame with 0.71 m (2.3 ft) diameter openings and equipped with two 335 μm white mesh plankton nets. Samples were collected over a continuous 24-hour period; each period was divided into six, 4-hour sampling cycles. Two tows were conducted during each cycle. Sample collection methods were similar to those developed and used by the California Cooperative Oceanic and Fisheries Investigation (CalCOFI) in their larval fish studies (Smith and Richardson 1977). The bongo nets were lowered as close to the bottom as possible. Once the nets were at the correct depth, the boat was moved forward and the nets retrieved at an oblique angle (winch cable at a 45° angle). The winch retrieval speed was constant at approximately 1 ft/sec. In contrast to CalCOFI plankton sampling protocols, the bongo net was deployed and retrieved directly aft of the vessel rather than off to one side. However, the slow speed of the vessel and the use of the winch minimized problems of vessel turbulence discussed by Smith and Richardson (1977). Each net mouth was fitted with a calibrated flowmeter to measure the water volume filtered.

The target water volume filtered by both bongo nets combined was 40 m^3 (i.e., 20 m^3/net). The sample volume (as measured by the flowmeter) was checked when the nets reached the surface. If the target volume was not collected, the nets were placed back in the water and the tow

repeated until the target volume was reached. Upon successful completion of a tow, the nets were retrieved from the water and all of the collected material was rinsed into the ends of the nets (codend). The contents of both nets were combined into a single, labeled jar (constituting one sample) immediately after collection, and were preserved in ethanol (ETOH). Preservation using ETOH allows specimen identifications to be genetically validated and allows for age and growth studies should the need arise. Each sample was given a serial number based on the location, date, time, and depth of collection. In addition, the information was logged onto a sequentially numbered data sheet. The sample serial number was used for tracking during laboratory processing, data analyses, and reporting.

3.2.2 Source Water Sample Collection

Fifteen monthly source water surveys were conducted during the study that began in June 1999 (Table 3-1). Monthly source water surveys were collected at four sampling stations (Figure 3-1). Source water sampling initially ran from June – July 1999, but began again in December 1999 after issuance of the Recovery Permit, and then continued through mid-December 2000. Station 1 was located at the entrance to Morro Bay, two stations (stations 3 and 4) were located in the back bay, and Station 5 was located approximately 2.5 nautical miles (2.9 statute miles) downcoast (i.e., south of the harbor mouth) (Figure 3-1). Initially, source water surveys were collected twice per day during daylight hours on high and low tides. In February 2000, sample collection for source water surveys was expanded to cover a 24-hour period and was no longer directly linked to tidal cycle. Collection, preservation, and sample tracking methods for Morro Bay source water stations 1, 3, and 4 and Estero Bay Station 5 were identical to the entrainment sampling methods. However, at the Estero Bay source water Station 5 (average depth = 12 m [40 ft]), the net was lowered to within approximately 3 m (10 ft) of the bottom and then retrieved obliquely.

Table 3-1. Frequency of collections for Morro Bay Power Plant sampling stations 1 through 5, June – August[1] 1999 and December 1999 – December 2000.

Frequency of Collection	Dates	Number of Samples Collected per Survey						Total Samples per Station
Station 1 (Morro Bay Entrance)		Daytime High Tide			Daytime Low Tide			
Monthly	Jun–Jul 1999[1]	2			2			4
	Dec 1999–Jan 2000	2			2			4
	Time PST	0800	1200	1600	2000	2400	0400	
	Feb 2000–Dec 2000	2	2	2	2	2	2	12
Station 2 (MBPP Intake)		1000	1400	1800	2200	0200	0600	
Weekly	Jun–Aug 9, 1999[1]	2	2	2	2	2	2	12
	Dec 14, 1999–Dec 29, 2000	2	2	2	2	2	2	12
Station 3 (Morro Bay back bay)		Daytime High Tide			Daytime Low Tide			
Monthly	Jun–Jul 1999[1]	2			2			4
	Dec 1999–Jan 2000	2			2			4
	Time PST	0800	1200	1600	2000	2400	0400	
	Feb 2000–Dec 2000	2	2	2	2	2	2	12
Station 4 (Morro Bay back bay)		Daytime High Tide			Daytime Low Tide			
Monthly	Jun–Jul 1999[1]	2			2			4
	Dec 1999–Jan 2000	2			2			4
	Time PST	0800	1200	1600	2000	2400	0400	
	Feb 2000–Dec 2000	2	2	2	2	2	2	12
Station 5 (Estero Bay)		Daytime High Tide			Daytime Low Tide			
Monthly	Jun–Jul 1999[1]	2			2			4
	Dec 1999–Jan 2000	2			2			4
	Time PST	0800	1200	1600	2000	2400	0400	
	Mar 2000[2]–Dec 2000	2	2	2	2	2	2	12

See Figure 3-1 for station locations.

1. Sampling was suspended from August 10 through December 13, 1999 while Tenera Environmental acquired a USFWS Recovery Permit for the collection of tidewater goby. Source water stations were not sampled in August 1999.

2. Station 5 could not be sampled in February 2000 because of unsafe sea conditions.
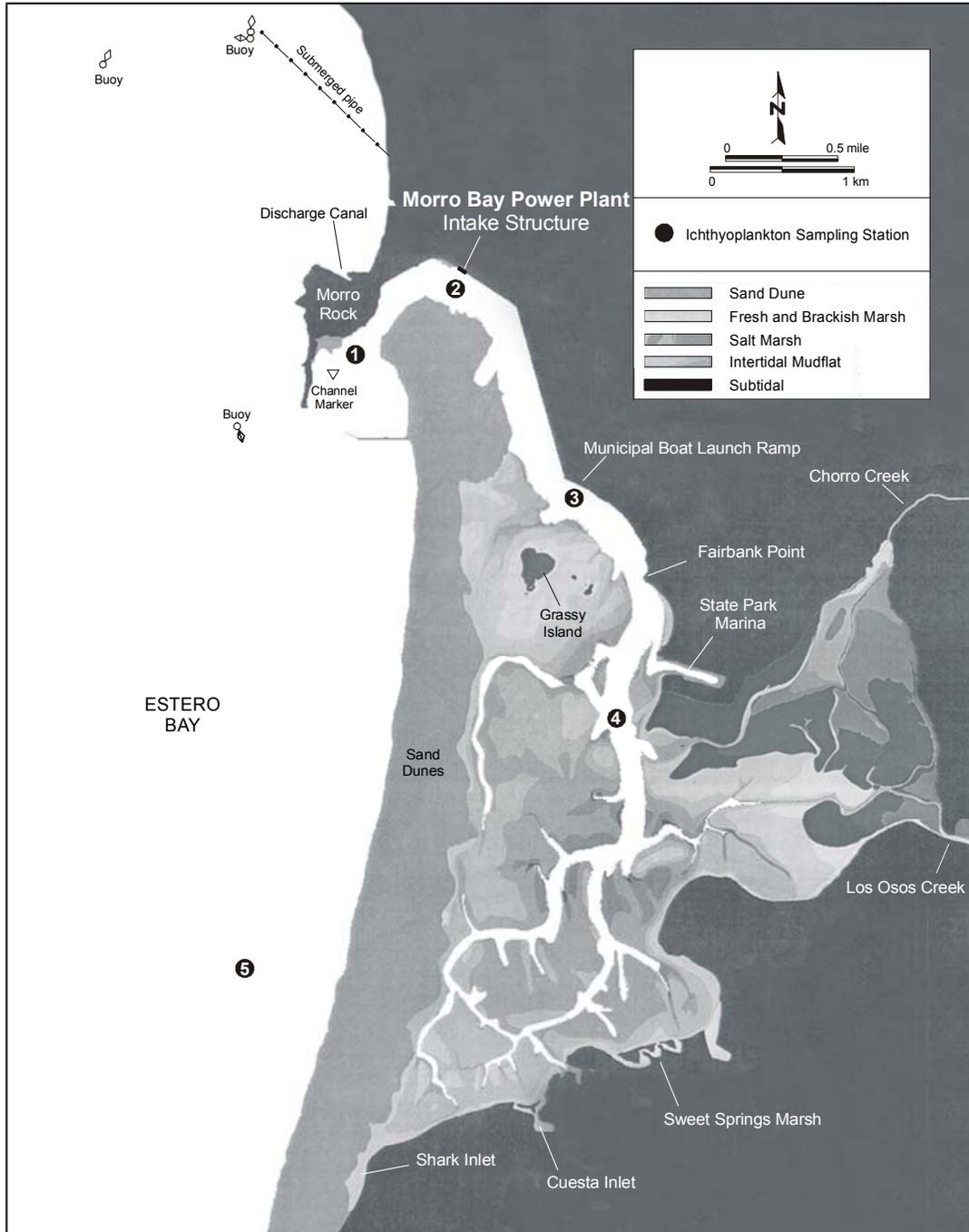
Figure 3-1. Locations of Morro Bay and Estero Bay sampling stations.

3.2.3 Laboratory Processing

Laboratory processing consisted of sorting, removing, identifying, and enumerating all larval fishes and megalopal stages of *Cancer* spp. and European green crabs. Sorting and identification accuracy was verified and maintained by Tenera Environmental's quality control (QC) program. All field and laboratory data were entered into a computer database, which was verified for accuracy against the original data sheets.

Many larval fishes cannot be identified to the species level; these fishes were identified to the lowest taxonomic classification possible (e.g., genus and species are lower orders of classification than order or family). Myomere and pigmentation patterns were used to identify many species, however this can be problematic for some species. For example, sympatric members of the family Gobiidae share morphologic and meristic characters during early life stages (Moser 1996) making identification to the species level difficult. We grouped those gobiids we were unable to identify to species into an "unidentified gobiid" category (i.e., unidentified Gobiidae). Larval combtooth blennies *Hypsoblennius* spp. can be easily distinguished from other larval fishes (Moser 1996). However, the three sympatric species along the central California coast cannot be distinguished from each other on the basis of morphometrics or meristics. These combtooth blennies were grouped into the "unidentified combtooth blennies" category (i.e., *Hypsoblennius* spp.). Many rockfish species are closely related, and the larvae share many morphological and meristic characteristics, making it difficult to visually identify them to species (Moser et al. 1977, Moser and Ahlstrom 1978, Baruskov 1981, Kendall and Lenarz 1987, Moreno 1993, Nishimoto in prep.). Identification of larval rockfish to the species level relies heavily on pigment patterns that change as the larvae develop (Moser 1996). Of the 59 *Sebastes* spp. known from California marine waters (Lea et al. 1999), at least five can be reliably identified to the species level as larvae (Laidig et al. 1995, Yoklavich et al. 1996): blue rockfish *Sebastes mystinus*, shortbelly rockfish *S. jordani*, cowcod *S. levis*, bocaccio *S. paucispinis*, and stripetail rockfish *S. saxicola*. Other species within this genus can only be resolved to broad sub-generic groupings based on pigment patterns; these larvae were grouped using information provided by Nishimoto (in prep.; Table 3-2).

Length measurements were taken on a representative sample of the larval fish taxa presented in the following sections. Approximately 100 fish from each taxon were measured using a video capture system and Optimus™ image analysis software. The 100 fish from each taxon were selected from the intake station (Station 2) during the 12 paired entrainment source water surveys based on the percentage frequency of occurrence of a taxon in each survey. For example, if 20 percent of the cabezon were collected from the intake station during the June paired source water survey, then approximately 20 fish were measured from that survey. The total number of fish measured for each taxon does not exactly equal 100 because at least one or two larvae were measured from surveys that had less than one or two percent of the total for that taxon.

Table 3-2. Preflexion larval rockfish pigment groups from Nishimoto (in preparation).

The code for each group is based on the following letter designations:	
V_ = long series of ventral pigmentation (starts directly at anus)	De = elongating series of dorsal pigmentation; scattered melanophores after continuous ones stop)
V = short series of ventral pigmentation (starts 3-6 myomeres after anus)	d = develops dorsal pigmentation (1-2 or scattered melanophores)
D_ = long series of dorsal pigmentation (4 or more in a continuous line) extending to above anus	P = pectoral blade pigmentation
D = short series of dorsal pigmentation (4 or more in a continuous line) not extending to anus	p = develops pectoral pigmentation (1-2 or scattered melanophores)

LETTER CODE	SPECIES	COMMON NAME
V_P	**Long ventral series, no dorsal, pectoral pigment**	
	S. chlorostictus	greenspotted
	S. ensifer	swordspine
V_D	**Long ventral series, short dorsal series, no pectoral pigment**	
	S. saxicola	stripetail
V_D_	**Long ventral series, long dorsal series, no pectoral pigment**	
	S. atrovirens	kelp
	S. chrysomelas	black and yellow
	S. maliger	quillback
	S. nebulosus	China
	S. semicinctus	halfbanded
V_De or **V_DeP** or **V_dep**	**Long ventral series, elongating dorsal series, pectoral pigment**	
	S. auriculatus	brown
	S. carnatus	gopher
	S. caurinus	copper
	S. dalli	calico
	S. rastrelliger	grass
V	**Short ventral series, no dorsal series, no pectoral pigment**	
	S. aleutianus	rougheye
	S. alutus	Pacific ocean perch
	S. brevispinis	silvergrey
	S. crameri	darkblotched
	S. diploproa	splitnose
	S. elongatus	greenstriped
	S. macdonaldi	Mexican
	S. miniatus	vermilion
	S. nigrocinctus	tiger
	S. proriger	redstripe
	S. rosaceus	rosy
	S. ruberrimus	yelloweye
	S. serriceps	treefish
	S. umbrosus	honeycomb
	S. wilsoni	pygmy
	S. zacentrus	sharpchin
VP	**Short ventral series, no dorsal series, various patterns of pectoral pigmentation**	
	S. constellatus	starry
	S. eos	pink
	S. goodei	chilipepper
	S. helvomaculatus	rosethorn
	S. levis	cowcod
	S. melanostomus	blackgill
	S. paucispinis	bocaccio
	S. rosenblatti	greenblotched
	S. rubrivinctus	flag
Vdp	**Short ventral series, develops dorsal series, develops various patterns of pectoral pigmentation** (at younger stages can be confused with V above due to lack of dorsal and pectoral pigmentation)	
	S. entomelas	widow
	S. flavidus	yellowtail
	S. melanops	black
	S. mystinus	blue
	S. rufus	bank
	S. serranoides	olive
VD	**Short dorsal series, short dorsal series**	
	S. aurora	aurora
	S. babcocki	redbanded
	S. gilli	bronzespotted
	S. hopkinsi	squarespot
	S. jordani	shortbelly
	S. ovalis	speckled
	S. pinniger	canary
	Species without descriptions or illustrations	
	S. philipsi	chameleon

3.2.4 Data Analysis

Sample concentrations of larval fishes and megalopal cancrid crabs, identified to the lowest taxonomic level practical, were computed by dividing the number of each taxon or species in each sample by the sample volume. The taxon-specific mean survey concentrations found in Appendix F (Table F-1) were calculated as simple arithmetic averages of the sample concentrations for a survey.

Data collected in entrainment and source water plankton surveys were compiled in one of two ways for the three types of analyses conducted for the impact assessment. All plankton surveys conducted at the MBPP intake structures to estimate entrainment were used to parameterize the demographic approaches to impact assessment (i.e., *FH* and *AEL*). A slightly different data set was used for the *ETM*. Concentrations of larval fishes and cancrid crab megalopae were estimated from monthly source water surveys and the concurrent entrainment survey to estimate proportional entrainment (*PE*) used in *ETM* calculations. These 'paired surveys' were collected over a continuous 12-month period from January – December 2000.

The mean survey concentrations were calculated by treating each cycle as a stratum and computing a mean and variance for each cycle. These means and variances were then combined to compute estimates of the mean and variance for the survey treating the *n* for each cycle as a weight. The variance was calculated using the standard calculation for stratified sampling (Snedecor and Cochran 1967). The data used to estimate the entrainment impacts (Section 5.0) were from the continuous 12-month period from January – December 2000.

Mean concentrations for ebb and flood tidal currents were also analyzed for all the stations from the paired monthly surveys. Sampling cycles were designated as occurring during either ebb or flood tides by examining the changes in tidal height during the sampling periods. Tidal heights matching the average start time for the two plankton tows within each cycle were determined from tide charts generated by the WXTide32™ program. Changes in tidal height (computed from the tide data) of greater than 0.15 m (0.5 ft) per hour were designated as either ebb or flood tides depending on the direction of change. Changes of less than 0.15 m (0.5 ft) per hour were considered slack tides. Mean concentrations were computed for the ebb and flood tides for each station during each paired entrainment-source water survey. These concentrations do not sum to the overall mean for the survey period because cycles during slack tides were omitted and sample sizes were not equal among stations for ebb and flood tides.

To characterize species composition and abundance among the stations, data from sampling stations were compared on the basis of rank order abundance and similarity. The annual mean concentrations of the top 25 taxa at each station were computed to compare the rank order

abundance among stations. The pooled list of the top 25 taxa from each station produced a list of 40 taxa for comparison across stations. The composition and abundance among stations were analyzed using a Bray-Curtis distance computed between each pair of stations (Digby and Kempton 1987). The scale of the Bray-Curtis distance measure is from 0 to 1.0, with a value of 0 indicating zero distance between samples or 100 percent similarity and a value of 1.0 indicating a high degree of dissimilarity.

3.3 Entrainment and Source Water Results

Totals of approximately 83,600 larval fishes and nearly 11,000 megalopal *Cancer* spp. crabs were collected in plankton tows from June and August 1999 and from December 1999 – December 2000. Slightly less than half of the larval fishes were collected in weekly surveys at the MBPP intake station (Appendix F, Table F-1) while the rest were collected in monthly source water surveys (Appendix F, Table F-2). Approximately 92 percent of the *Cancer* spp. megalopae were collected in the monthly source water surveys (Appendix F, Table F-2). There were 40 species, 13 genera, 19 families, one suborder, and one order of larval fishes identified during this study. Slightly more than 1 percent of the larval fish specimens were too damaged to identify, and approximately 0.1 percent of the larval fish specimens, although undamaged, could not be identified. All *Cancer* spp. megalopae were identified to the lowest taxonomic level practical.

Unidentified gobies were the most abundant larval fish taxon collected at each of the five stations (Figure 3-2). The percent composition of the total number of larval fishes represented by unidentified gobies ranged from a low of 35 percent at Station 5 (Estero Bay) to a high of 82 percent at Station 3 (mid bay). The greatest dissimilarities occurred between Station 5, located offshore, and the mid and back bay stations (3 and 4). Stations 3 and 4 had the fewest number of species and were also the most similar to each other. Overall, the diversity of species was far greater at the Estero Bay station (Station 5) than at stations located within the bay.

The brown rock crab *Cancer antennarius* was the most abundant megalopal cancer crab species collected at each of the five stations (Figure 3-3). The percent composition of the total number of cancer crabs represented by brown rock crab ranged from a low of 49 percent at Station 1 to 95 percent at Station 5. Although the species composition was fairly similar among the stations, the abundance of species at each sampling station was most similar between the stations located within the bay. Station 5 (located outside the bay) had a proportionally greater abundance of brown rock crab larvae than stations within the bay.
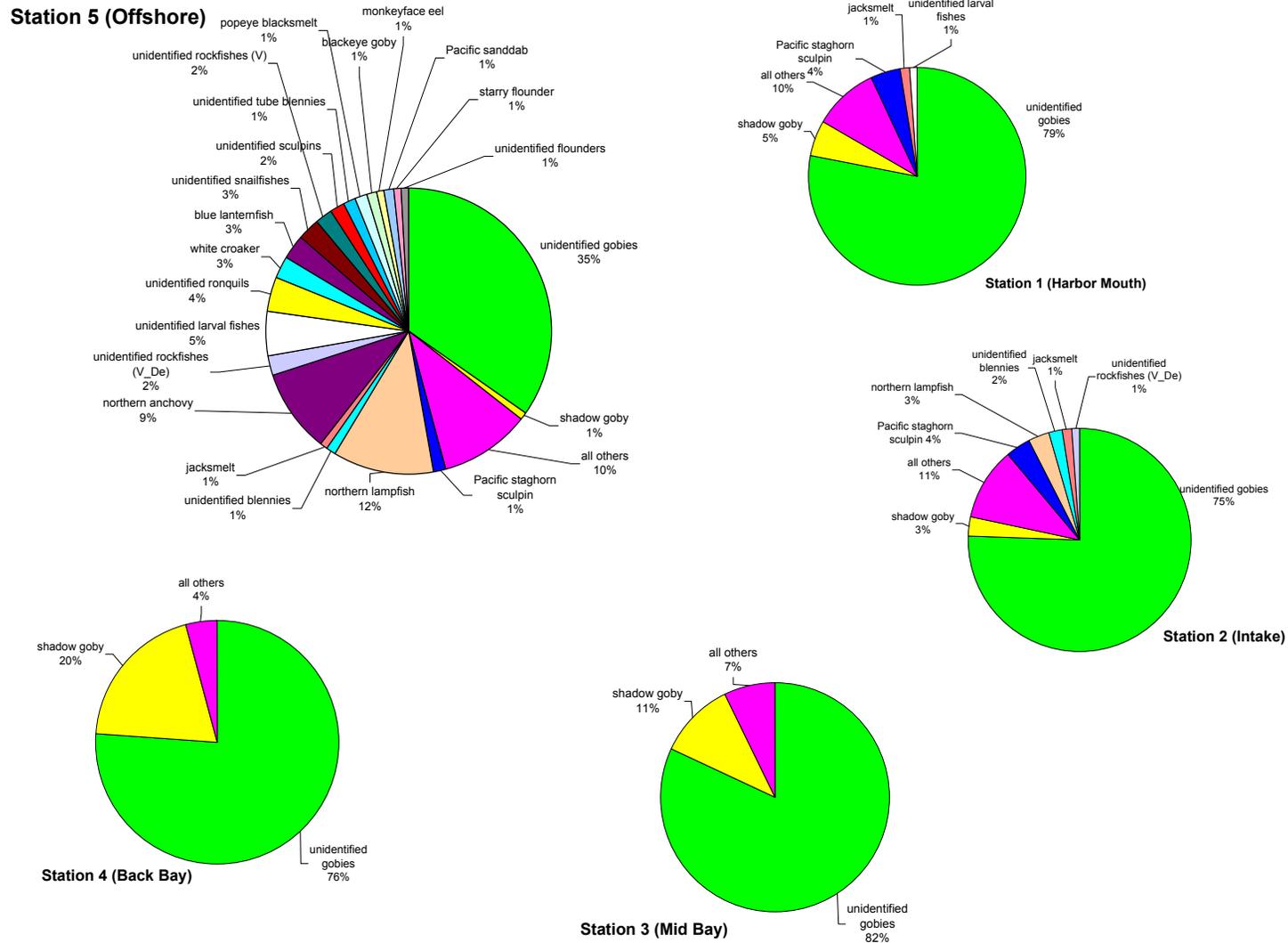
Figure 3-2. Percent composition of the total number of larval fishes collected by station in the vicinity of the Morro Bay Power Plant: January – December 2000.
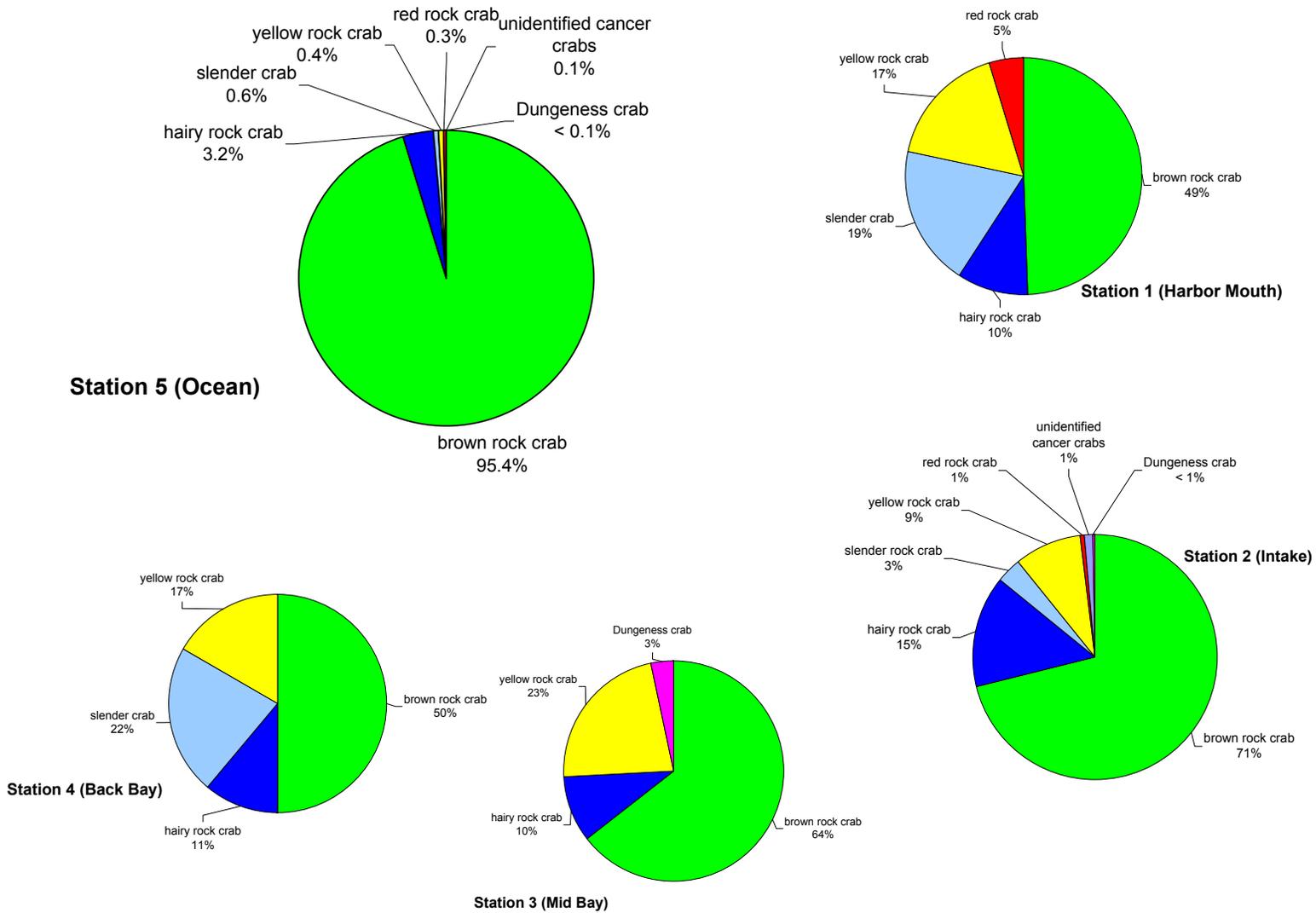
Figure 3-3. Percent composition of the total number of cancer crab megalopae collected by station in the vicinity of the Morro Bay Power Plant: January – December 2000.

In 1998, adults of the introduced European green crab were collected from Morro Bay
(T. Grosholz, UCD, pers. comm. 1999). Therefore, an attempt was made to identify and
enumerate megalopae of this crab from MBPP entrainment and source water plankton samples.
Early life stage descriptions of this crab are from European specimens and may not describe the
morphologic characters of the local populations in sufficient detail to separate European green
crab larvae from other locally co-occurring crabs (D. Innis, Tenera Environmental, pers. comm.
2000). In cooperation with Dr. Grosholz, we were unable to either definitively identify
megalopal European green crabs in the MBPP 316(b) plankton samples or duplicate Grosholz'
observations of adult green crabs in Morro Bay. Megalopal crabs that had been tentatively
identified as European green crab are thought to closely resemble the native pebble crabs
Lophopanopeus spp. European green crab megalopae were not found in our plankton surveys
from Morro and Estero bays.

Our initial larval fish identifications, based on existing morphometric and meristic descriptions,
(Wang 1986, Matarese et al. 1989, Moser 1996) classified a number of gobiid larvae as the
endangered tidewater goby *Eucyclogobius newberryi*. The USFWS and taxonomic experts
recommended DNA testing to confirm the tidewater goby identification. A total of 53 larval fish
were sent to Dr. David Jacobs (at the University of California Los Angeles) for DNA testing.
DNA sequencing results were obtained for 52 of the 53 larval fishes; one fish could not be
sequenced. Five of the 53 larval fishes were not morphometrically identified as tidewater goby
but were sent with the other gobies to verify the DNA sequencing procedure; Dr. Jacobs did not
know the specimen numbers of these fishes. These five specimens were from the unidentified
gobiid category (Gobiidae) and their taxonomic characters did not match tidewater goby. These
five specimens were genetically identified as arrow goby *Clevelandia ios*. The DNA analyses
performed on the 48 other larvae did not match their morphometric identifications as tidewater
goby. None of these specimens were tidewater goby based on the DNA test results. Most
(96 percent) of the tidewater goby-like specimens sent to Dr. Jacobs were genetically identified
as shadow goby *Quietula y-cauda*. Two of the 48 tidewater-goby-like specimens were from
unknown gobies whose DNA did not match any of the sequencing information in the
laboratory's data banks; these "unknown gobies" also did not match sequencing information for
tidewater goby. In this report, we have presented numbers, concentrations, and percent
composition information about specimens that were originally identified as tidewater goby and
are now referred to as shadow goby[*]. Dr. Jacobs' report, and a response by Dr. Giacomo
Bernardi (U.C. Santa Cruz) are attached to this document as Appendix G.

---

[*]Ninety-six percent of the larval fishes displaying the same taxonomic characteristics as tidewater goby were genetically
identified as shadow goby. These were therefore classified as shadow goby. No tidewater goby were identified in the DNA
analyses.

The larval fish concentration (all taxa) at the MBPP intake station was highest during the winter and spring months (Figure 3-4). This is consistent with spawning periods of most coastal California fishes (Moser 1996). These fishes typically release their larvae in the water column prior to the spring upwelling season, possibly to reduce the risk of being transported away from shore to areas of lower potential food sources (Parrish et al. 1981).

Larval fish abundance at all five stations were compared for the paired intake and source water plankton surveys (Figure 3-5). Results from these monthly surveys revealed that mid and back bay stations 3 and 4 consistently had some of the highest larval fish concentrations. In contrast, larval fish concentration was consistently lower at the Estero Bay station (Station 5) than at the other stations.

These same data were also compared among the five stations for ebb and flood tidal current conditions (Figure 3-6). While some of the differences may be due to the absence of flood tide currents during a survey, it appears that larval fish concentrations were consistently greater during ebb tidal currents. Ebb tides are drawing water out of the interior portions of Morro Bay, which are breeding areas for many of the fishes collected in our samples. This is most apparent at stations 3 and 4 in the interior areas of Morro Bay where concentrations of larval fishes were greatest (Figure 3-5). The concentrations of larvae at these stations may be increased during ebb tide currents that draw water out of the shallower areas of the back bay where eelgrass *Zostera marina* and other important habitat for fishes are located. The differences were less for stations 1 and 2 in the outer areas of the bay.

Mean concentrations of the top 25 taxa (40 pooled across all five stations) were compared among the five sampling locations (Figure 3-7). The top 25 taxa were those in highest abundance at each station and co-occurring at all five of the stations. Unidentified gobies were the most abundant larval fish taxon at all five stations. Concentrations of the more abundant taxa were similar among stations within Morro Bay (i.e., Stations 1–4). Overall, larval concentrations in Estero Bay (Station 5) were lower and more evenly distributed among the 25 taxa. Station 4 (back bay) and Station 5 (offshore of the sand spit in Estero Bay) had the fewest taxa in common.

The annual mean concentrations of the pooled list of 40 taxa were also analyzed using a Bray-Curtis distance computed between each pair of stations (Table 3-3). Stations 1 and 2 at the harbor entrance and intake, respectively, had the lowest Bray-Curtis value and were the most similar. Stations 3 and 4 in the mid and back bay also had a low Bray-Curtis value. The greatest dissimilarities occurred between Station 5, located offshore, and the two back bay stations (3 and 4). Dissimilarity also increased between Station 1 at the harbor entrance and stations further back in the bay. Even though Station 1 was located at the harbor entrance it was more

dissimilar to the station located in Estero Bay (5) than it was to Station 4 located furthest inside Morro Bay. The similarities between adjacent stations in Morro Bay as compared with Estero Bay may indicate that tidal influences within Morro Bay had the greatest influence on species distribution and abundance throughout the bay and input from offshore sources was less important in determining larval abundance and composition within Morro Bay.

The concentrations (#/m^3) of larval fishes and cancrid crab megalopae collected at the MBPP intake station were analyzed to determine the proportional contribution of each taxon to the total abundance over the period January 1, 2000 through December 29, 2000 (Appendix F, Table F-1).
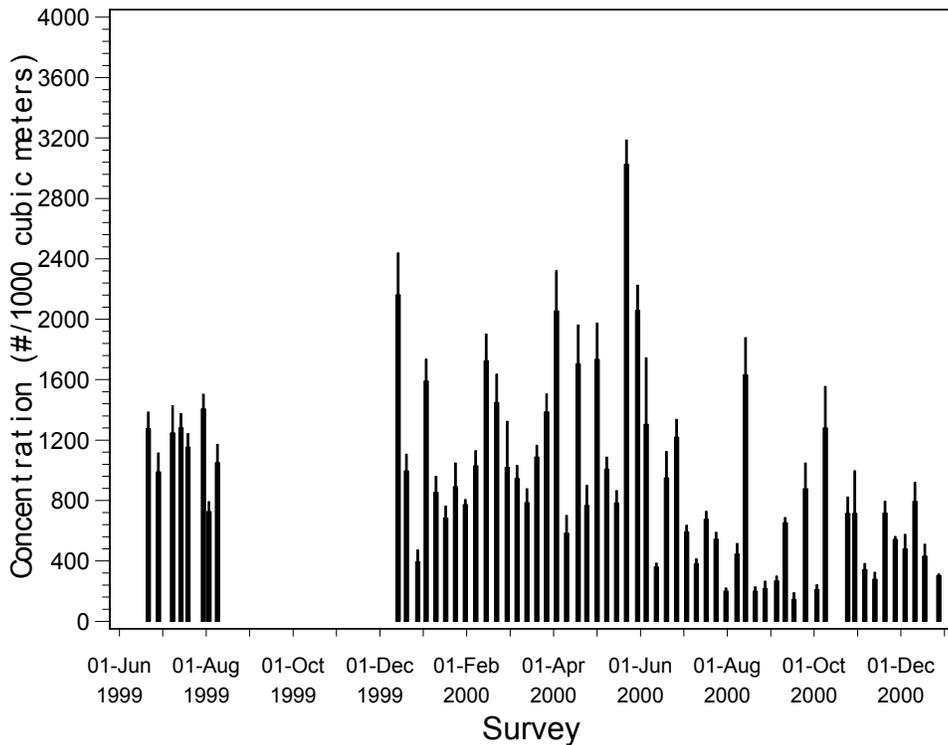
Figure 3-4. Weekly survey mean larval fish concentrations at the MBPP intake station for all taxa combined with standard error indicated (+1 SE). Weekly surveys were collected from June 21 through August 10, 1999 and from December 14, 1999 through December 29, 2000.

Note: The October 16, 2000 survey was cancelled due to the unavailability of a boat.
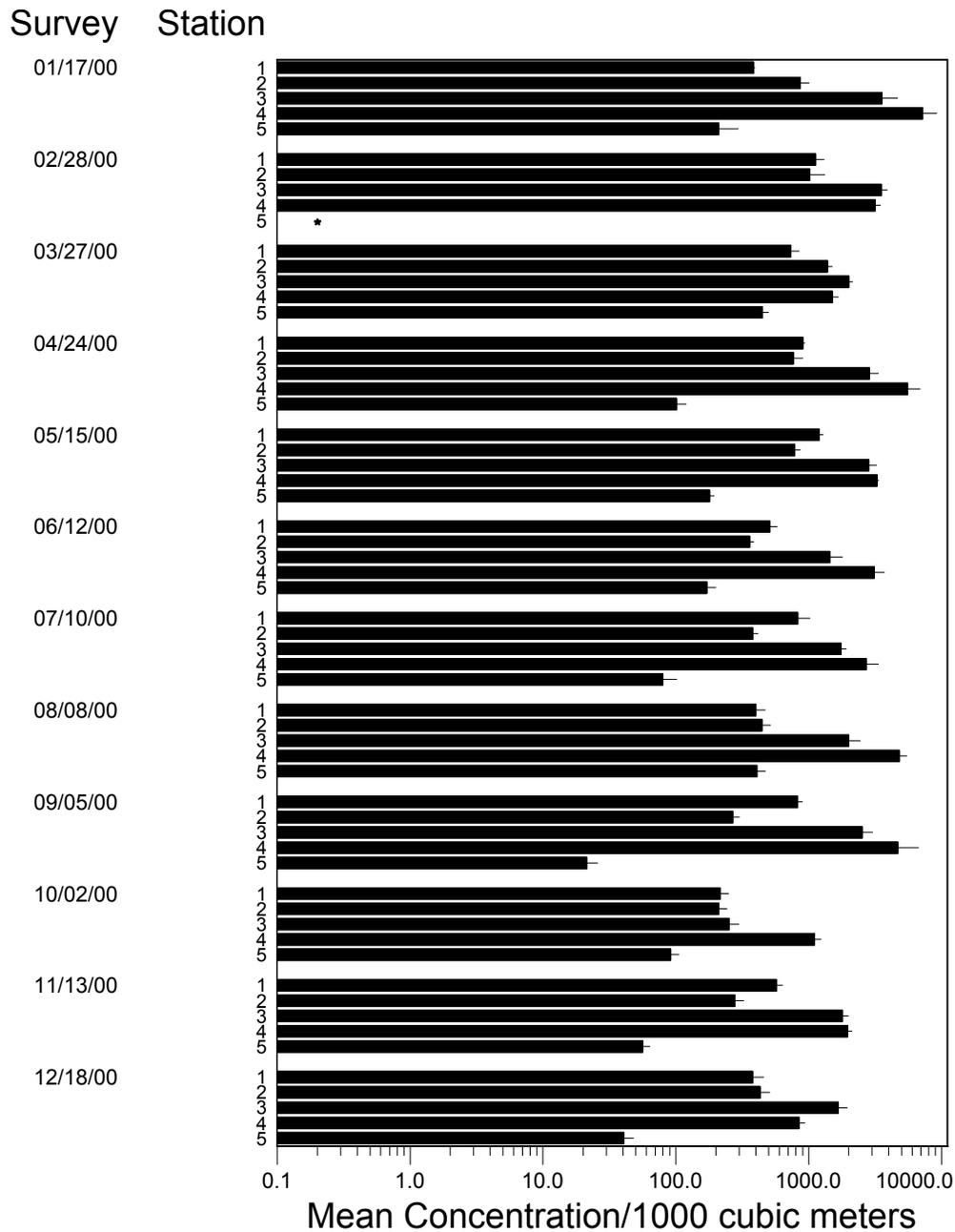
Figure 3-5. Mean larval fish (all taxa combined) concentration in monthly paired surveys at the MBPP intakes (Station 2), Morro Bay source water (Stations 1, 3, and 4), and Estero Bay (Station 5) from January – December 2000 with standard error indicated (+1 SE).

Note: During the January 17, 2000 survey, source water stations 1, 3, 4, and 5 were sampled only in daylight hours. Beginning in February 2000 the sampling frequency was increased to cover a 24-hour period.

* Estero Bay Station 5 could not be sampled in February 2000 due to unsafe sea conditions.
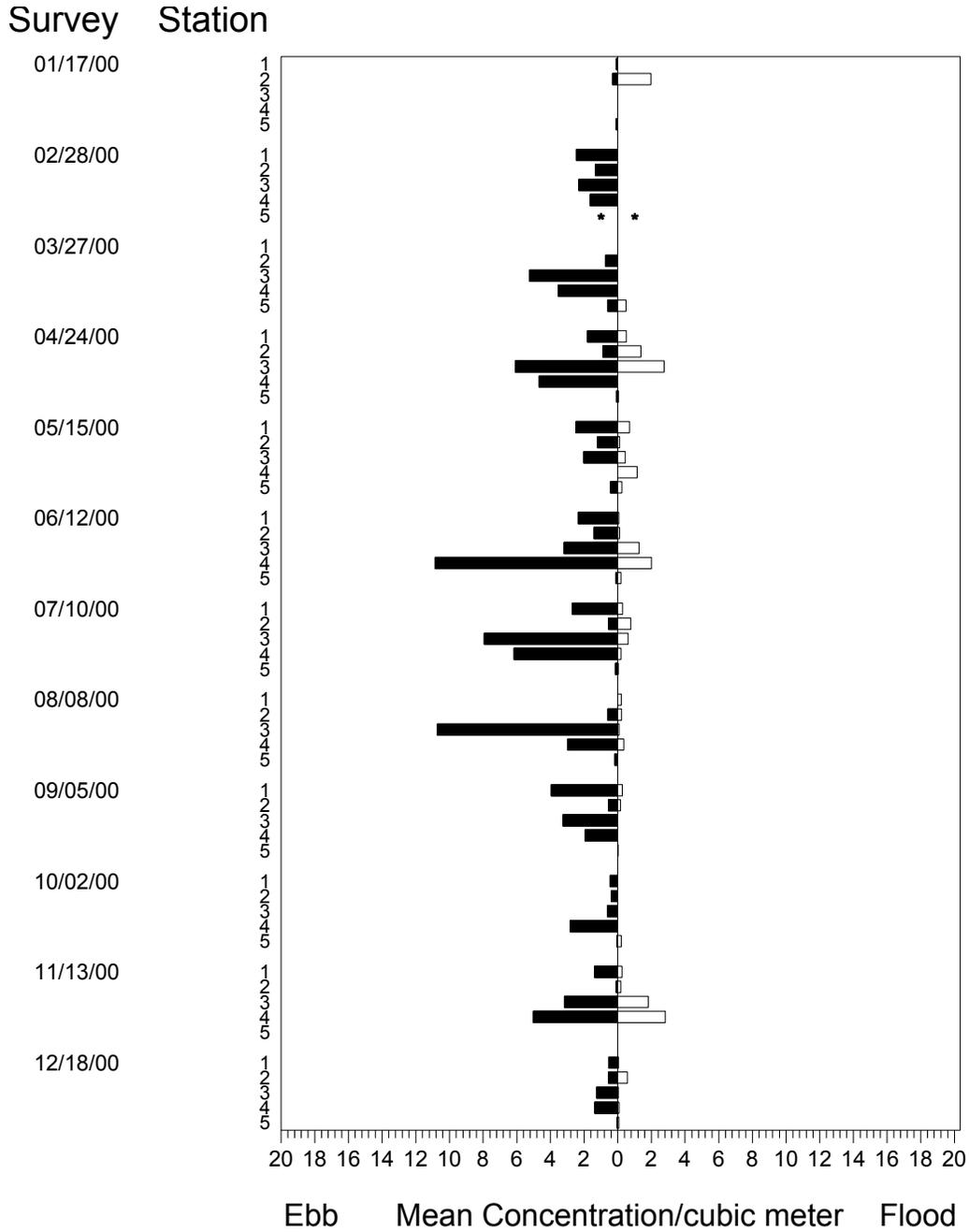
Figure 3-6. Mean concentration of all larval fish taxa from monthly paired surveys by tidal current (ebb – solid bars; flood – clear bars) and sampling station (Morro Bay stations 1–4 and Estero Bay Station 5) from January – December 2000.

Note: During the January 17, 2000 survey, source water stations 1, 3, 4, and 5 were sampled only in daylight hours. Beginning in February 2000 the sampling frequency was increased to cover a 24-hour period.

* Estero Bay Station 5 could not be sampled in February 2000 due to unsafe sea conditions.

Table 3-3. Bray-Curtis dissimilarities in diversity among Morro Bay (stations 1, 3, and 4) and Estero Bay (Station 5) and the MBPP Intake (Station 2) based on mean survey concentrations from twelve surveys collected from January – December 2000.

Station	1	2	3	4
1	0			
2	0.082	0		
3	0.567	0.596	0	
4	0.700	0.716	0.218	0
5	0.756	0.740	0.924	0.951

Nearly 81 percent of the larval fishes collected at the intake station during the year analyzed were gobies: Gobiidae unidentified (75 percent), shadow goby *Quietula y-cauda* (approximately 3 percent), blackeye goby *Coryphopterus nicholsi*, longjaw mudsucker *Gillichthys mirabilis*, bay goby *Lepidogobius lepidus*, and blind goby *Typhlogobius californiensis*; each of the latter four comprised less than 1 percent of the total. The majority of fish taxa collected at the intake station are found in estuaries at some point in their life cycle (e.g., Pacific staghorn sculpin *Leptocottus armatus*, jacksmelt *Atherinopsis californiensis*, Pacific herring *Clupea pallasii*, Pacific sandlance *Ammodytes hexapterus*, and others). Rockfish larvae *Sebastes* spp. were notable for their low abundance during the year; kelp/gopher/black-and-yellow (KGB) complex rockfish larvae comprised approximately 1 percent of the total and the remaining *Sebastes* spp. comprised less than 1 percent overall. Brown rock crab *Cancer antennarius*, hairy rock crab *C. jordani*, and yellow crab *C. anthonyi* (comprising 95 percent of the cancrid crab megalopae collected at the MBPP intake station) are all coastal crabs often found in bays and estuaries.

Seven larval fish taxa and three *Cancer* spp. megalopae comprised approximately 90 percent of the larval fishes and cancrid crab megalopae concentrations from samples collected at the intake station for the one year period from January 1, 2000 – December 29, 2000 (Figures 3-2 and 3-3, respectively). The top 85 percent of larval fishes collected at the MBPP intake station were dominated by demersal and pelagic estuarine taxa (i.e., unidentified gobies [75 percent], Pacific staghorn sculpin [4 percent], shadow goby [3 percent], and northern lampfish *Stenobrachius leucopsarus* [3 percent]) (Figure 3-2). Megalopal cancrid crab abundance was dominated by brown rock crab (71 percent), followed by hairy rock crab (15 percent), and yellow crab (9 percent) (Figure 3-3). Results for the seven fish taxa comprising 89 percent of all larval fishes are presented in the following sections. In addition, results for three commercially important taxa (white croaker *Genyonemus lineatus*, Pacific herring *Clupea pallasii*, and cabezon *Scorpaenichthys marmoratus*) that were collected in lower abundances are also presented along with the results for all cancrid crab megalopae.
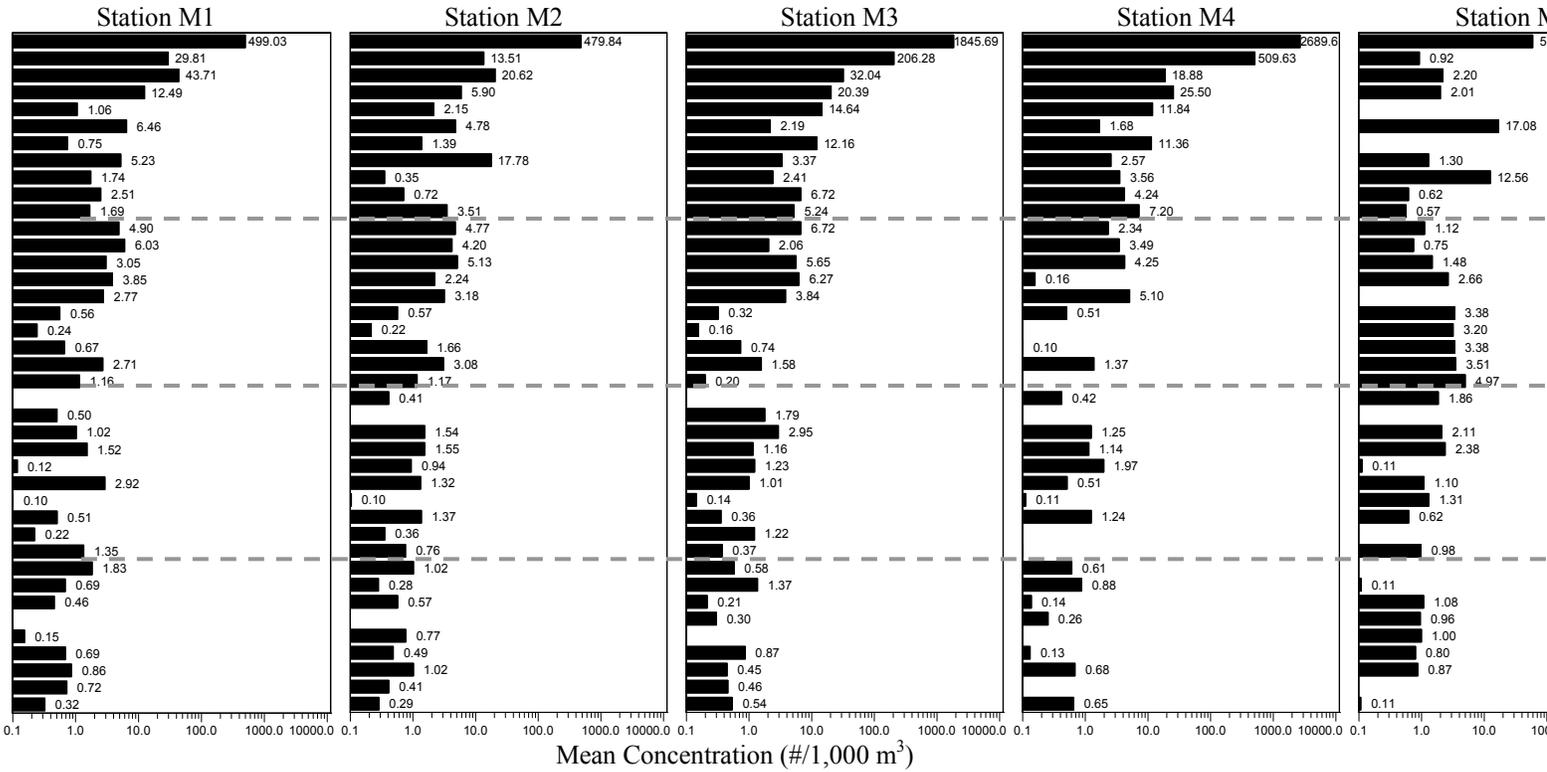
Figure 3-7. Comparison of the mean concentration (#/1,000 m^3) of the 25 most abundant fishes (39 taxa pooled) from the intake station (2) and source water stations (1, 3, 4 and 5) from January – December 2000.