chapter 6

TRAWL COMMUNITIES AND ORGANISM HEALTH

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INTRODUCTION

The Orange County Sanitation District (District) Ocean Monitoring Program (OMP) samples the demersal (bottom-dwelling) fish and epibenthic macroinvertebrate (= large invertebrates that live on the bottom) organisms to assess effects of the wastewater discharge on these epibenthic communities and the health of the individual fish within the monitoring area (Figure 6-1). The District's National Pollutant Discharge Elimination System (NPDES) permit requires evaluation of these organisms to demonstrate that the biological community within the influence of the discharge is not degraded and that the outfall is not an epicenter of diseased fish (see box). The monitoring area includes populations of commercially and recreationally important species, such as California halibut (*Paralichthys californicus*), white croaker (*Genyonemus lineatus*), California scorpionfish (*Scorpaena guttata*), ridgeback rockshrimp (*Sicyonia ingentis*), sea cucumbers (*Parastichopus* spp.), and crabs (Cancridae species).

Past monitoring findings have shown that the wastewater outfall has two primary impacts to the biota of the receiving waters: reef and discharge effects (OCSD 2001, 2004). Reef effects are changes related to the habitat modification by the physical presence of the outfall structure and associated rock ballast. This structure provides a three dimensional hard substrate habitat that harbors a different suite of species than that found on the surrounding soft bottom. As a result, the area near the outfall pipe can have greater species diversity.

Compliance criteria pertaining to trawl communities and organism health contained in the District's NPDES Ocean Discharge Permit (Order No. R8-2004-0062, Permit No. CAO110604).

Criteria		Description
C.5.a	Marine Communities	Marine communities, including vertebrates, invertebrates, and algae shall not be degraded.
C.5.b	Marine Resources	The natural taste, odor, and color of fish, shellfish, or other marine resources used for human consumption shall not be altered.
C.5.c	Human Health Concerns	The concentration of organic materials in fish, shellfish, or other marine resources used for human consumption shall not bioaccumulate to levels that are harmful to human health.

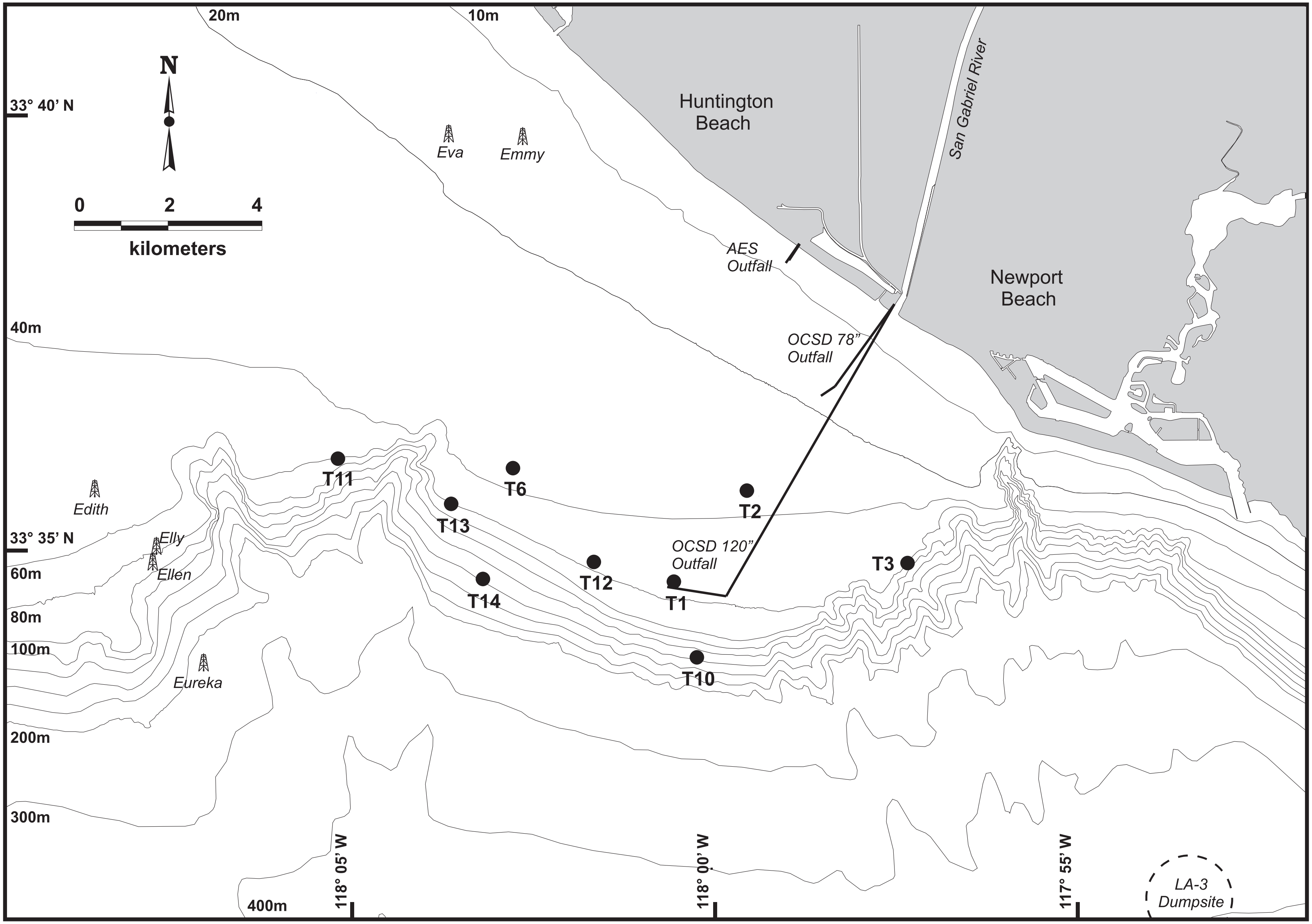

Figure 6-1. **Otter trawl stations for semi-annual surveys, 2010-11.**

Orange County Sanitation District, California.

Discharge effects are changes in water and sediment quality caused by the release of treated effluent. Organic effluent particles sink to the ocean bottom where they become available as a food resource for many invertebrate species. If these particles contain elevated contaminate loads, then the contaminants can bioaccumulate in these invertebrates. Many demersal fish (e.g., bottom dwelling) feed directly or indirectly on these invertebrates. Additionally, demersal fish live in close association with these sediments and consequently, have an increased probability of direct exposure to sediments containing discharged particles. This transfer of chemical contaminants through consumption and adsorption make demersal fish species particularly susceptible to physical abnormalities and diseases (Johnson *et al.* 1992, 1993; Moore *et al.* 1997; Myers *et al.* 1993; Stehr *et al.* 1997, 1998).

These contaminants, especially lipid-soluble (lipophilic) compounds, such as chlorinated pesticides (e.g., DDT) and polychlorinated biphenyls (PCBs) that accumulate in organisms may be transferred up the food chain to other fish, mammals, and birds at concentrations several orders of magnitude higher than in surrounding sediments or water through the process of biomagnification. Whether bioaccumulated or biomagnified, high tissue contaminant concentrations may result in greater susceptibility to disease or reproductive impairment (Arkoosh *et al.* 1998).

To assess these issues, the District uses tissue contaminant data to evaluate the following aspects of permit compliance: 1) are there temporal and/or spatial patterns in the animal communities relative to the ocean outfall; 2); are contaminant concentrations in fish muscle tissue sufficient to pose a potential human health concern and 3) are the marine organisms in the monitoring area generally healthy?

METHODS

Field Methods

Demersal fish and epibenthic macroinvertebrates (EMI) species were collected in August 2010 and January 2011 using a 7.6 meter wide, Marinovich, semi-balloon otter trawl net fitted with a 0.64 cm cod-end mesh net. The net was towed on the ocean bottom for 450 m at approximately 2 knots along a pre-determined course. Sampling was conducted at nine permit stations: inner shelf (36 m) Stations T2 and T6; middle shelf (60 m) Stations T1, T3, T11, T12, and T13; and outer shelf (137 m) Stations T10 and T14 (Figure 6-1). Two replicate hauls were conducted at the inner and outer shelf stations and three replicate hauls were conducted at the middle shelf stations during both surveys.

Trawl caught specimens were identified to the lowest possible taxon, typically to species. A minimum of 30 individuals of each fish species were measured individually to the nearest millimeter and weighed to the nearest gram. Fish in excess of 30 individuals were enumerated in 1-cm size classes and batch weighed. All fish specimens were examined for external tumors, other lesions, and parasites since gross external manifestations may indicate contaminated sediments (Murchelano 1982). The first 100 EMI were also enumerated by species and weighed to the nearest gram. Specimens with abundance greater than 100 individuals were weighed in batches and abundance calculated based on the weight/abundance ratio. Fish and EMI specimens that could not be identified in the field were retained for further identification and weighed and measured in the laboratory.

Fish from four target species were kept for tissue chemistry (bioaccumulation) analysis. These were: hornyhead turbot (*Pleuronichthys verticalis*), English sole (*Parophrys vetulus*), bigmouth sole (*Hippoglossina stomata*) and Pacific sanddab (*Citharichthys sordidus*). Pacific sanddabs were collected and analyzed as composite samples. The sampling objective was to collect 10 individuals of at least three of the four target species at both outfall (T1/T12) and farfield (T11/T13) sites. Muscle and liver contaminant concentrations from hornyhead turbot, English sole, and the whole-body tissue of Pacific sanddabs were measured at both outfall and farfield stations. Three size classes (length ranges) of Pacific sanddabs were tested: 0 (5–8 cm), 1 (9–13 cm), and 2 (14–16 cm). The analytes include mercury, total DDT (tDDT; the sum of six7 DDT isomers), total PCB (tPCB; the sum of 45 PCB congeners), and 12 other chlorinated pesticides. Organic analyte data was lipid normalized to reduce within sample variability; organics concentrate in lipid tissue and lipid tissue concentration varies considerably between fish. A complete list of analytes tested is presented in Appendix A.

Data Analyses

Fish and EMI populations were summarized in terms of total abundance and species, percent abundance, frequency of occurrence, and mean abundance per haul. In addition, mean number of species, number of individuals, biomass, and diversity indices including Shannon-Wiener (H'), Margalef's Species Richness (d), and Swartz's 75% Dominance (Dominance) were calculated for both fish and EMI. Dominance (the minimum number of species accounting for 75% of abundance) is inversely proportional to numerical dominance, such that low index values indicate high dominance (i.e., communities are dominated by a few species).
PRIMER v6 multivariate statistical software was used to examine the spatial patterns of the fish assemblages in the District's monitoring area (Clarke 1993, Warwick 1993). Analyses included hierarchical clustering with group-average linking based on Bray-Curtis similarity indices, and ordination clustering of the data using non-metric multidimensional scaling (MDS). Data were averaged by station and truncated to include only the middle shelf (60 m) stations since depth is a strong environmental factor in delineating species clusters (OCSD 2004, 2011). Clarke and Warwick (2001) warn that clustering is less useful and may be misleading where there is a strong environmental forcing, such as depth. Also, data outliers, such as species with random and/or patchy distributions that can artificially skew community assessments (i.e., halfbanded rockfish) were removed from the dataset for classification and ordination analyses. Prior to the calculation of the Bray-Curtis indices, the data were square-root transformed in order to down-weight the highly abundant species and incorporate the importance of the less common species (Clarke and Warwick 2001). The SIMPER ("similarity percentages") routine was also used to determine inter- and intra-group species differences.

Community measures from Station T1 and Station T11 were evaluated for long-term temporal and spatial patterns, and compared with regional reference values from the 1994 Southern California Bight Pilot Project (SCBPP), Bight'98, Bight'03, and Bight'08 regional monitoring programs (Allen *et al*. 1998, 2002, 2007).

Fish biointegrity was assessed using the fish response index (FRI). The Fish Response Index is a biointegrity index developed by Allen *et al.* (2001). The index was developed using the abundances of all species relative to the pollution gradient away from the Palos Verdes shelf during the 1970s. Allen *et al*. (2001) noted that the

FRI was an effective surrogate of fish community assemblages, especially in the middle shelf zone of the SCB. FRI scores less than 45 are classified as reference (normal) and those greater than 45 are non-reference (abnormal or disturbed). The FRI was calculated for all nine stations in 2010-11. For a historical perspective, FRI was calculated from 1985 to 2011 for Stations T1 and T11.

In order to evaluate human health risks from eating fish caught near the outfall, the muscle tissue concentrations of hornyhead turbot and English sole were compared to state and federal human consumption guidelines. Liver concentrations from these two species were used to evaluate the potential of various chemicals to bioaccumulate and biomagnify. The Pacific sanddab whole-fish analysis cannot be used for human health risk assessment as no whole-fish consumption standards exist. These data, except mercury, were lipid-normalized prior to the calculation of summary statistics. Non-detected analytes were treated as a zero value for summed constituents (e.g. total DDT) and as one-half the detection limit for single constituents, such as mercury. While enumerated during each survey, external parasites and other abnormalities in fish are not prevalent either regionally or in the District's monitoring area.

RESULTS AND DISCUSSION

Fish Community

<u>Abundance</u>

A total of 41,567 fish were collected in 2010-11 (Tables 6-1 and B-13). Halfbanded rockfish (*Sebastes semicinctus*), Pacific sanddabs, California lizardfish (*Synodus lucioceps*), and yellowchin sculpin (*Icelinus quadriseriatus*) were the most abundant fish collected, representing 42%, 18%, 11%, and 10% of the total catch, respectively. All other species comprised 5% or less of the total catch. Of the 22 families represented, just six families accounted for 96% of the total abundance: Scorpaenidae (scorpionfishes), Paralichthidae (sand flounders), Synodontidae (lizardfish), Cottidae (sculpins), Pleuronectidae (right-eye flounders), and Hexagrammidae (greenlings) (Table 6-2).

Synodontidae, represented by only the California lizardfish, became a dominant family in 2009-10 and remained a dominant family in 2010-11, comprising 11% (4,459 individuals) of the total fish abundance. In contrast, California lizardfish accounted for only 1% of the total fish abundance with 165 individuals in 2008-09. California lizardfish occurred frequently at both shallow and 60-m stations in 2010-11, whereas, it was predominantly found at shallow stations in 2009-10. California lizardfish abundance is highly variable through time, as evidenced in the District's long-term data, so inter-annual population changes of this magnitude are not uncommon (see Figure 6-5).

Fish abundance has historically been highly variable, although some patterns are consistent (see OCSD 2011 Figure 6-2). Generally, the shallow stations have the lowest abundances, while the deep and farfield downcoast stations have the highest. In 2010-11 winter catches at mid-shelf Stations T1 and T3 deviated from this pattern due to large catches of halfbanded rockfish (2,484 and 15,116 individuals, respectively), while abundance at deep Stations T10 and T14 were low due to smaller catches of Pacific sanddabs (Figure 6-2 and Table B-14).

Mean summer fish abundance at Station T1 was lower than other 60 m stations and significantly lower than the farfield upcoast and downcoast stations; whereas, mean winter abundance at T1 was much higher than all other 60-m stations, except T3. The small mean abundance at T1 in

Table 6-1. Summary of demersal fish species collected during the summer (August 2010) and winter (January 2011) surveys. Data for each species are expressed as total abundance (Total), percent abundance (%A), percent frequency of occurrence (%FO), and mean abundance per haul (MAH).

Orange County Sanitation District, California.

Common name	Scientific name	Total	%A	%FO	MAH
Halfbanded rockfish	*Sebastes semicinctus*	17,656	42	67	384
Pacific sanddab	*Citharichthys sordidus*	7,422	18	100	161
California lizardfish	*Synodus lucioceps*	4,459	11	100	97
Yellowchin sculpin	*Icelinus quadriseriatus*	3,951	10	89	86
Longspine combfish	*Zaniolepis latipinnis*	2,181	5	100	47
English sole	*Parophrys vetulus*	1,447	3	100	31
Slender sole	*Lyopsetta exilis*	595	1	22	13
California tonguefish	*Symphurus atricaudus*	574	1	89	12
Stripetail rockfish	*Sebastes saxicola*	554	1	67	12
Pink seaperch	*Zalembius rosaceus*	406	1	100	9
Roughback sculpin	*Chitonotus pugetensis*	326	1	89	7
Longfin sanddab	*Citharichthys xanthostigma*	314	1	78	7
Shortspine combfish	*Zaniolepis frenata*	303	1	56	7
Hornyhead turbot	*Pleuronichthys verticalis*	299	1	100	7
Dover sole	*Microstomus pacificus*	271	1	78	6
Blackbelly eelpout	*Lycodes pacificus*	162	< 1	22	4
Plainfin midshipman	*Porichthys notatus*	118	< 1	78	3
Bigmouth sole	*Hippoglossina stomata*	84	< 1	100	2
Greenstriped rockfish	*Sebastes elongatus*	83	< 1	33	2
Speckled sanddab	*Citharichthys stigmaeus*	75	< 1	22	2
Pygmy poacher	*Odontopyxis trispinosa*	56	< 1	89	1
Fantail sole	*Xystreurys liolepis*	50	< 1	44	1
California scorpionfish	*Scorpaena guttata*	45	< 1	78	1
California skate	*Raja inornata*	27	< 1	56	1
Spotted cuskeel	*Chilara taylori*	18	< 1	44	< 1
Cowcod	*Sebastes levis*	9	< 1	33	< 1
Southern spearnose poacher	*Agonopsis sterletus*	8	< 1	33	< 1
Calico rockfish	*Sebastes dallii*	8	< 1	33	< 1
Lingcod	*Ophiodon elongatus*	7	< 1	33	< 1
Vermillion rockfish	*Sebastes miniatus*	7	< 1	56	< 1
Pacific argentine	*Argentina sialis*	5	< 1	11	< 1
White croaker	*Genyonemus lineatus*	5	< 1	33	< 1
Rockfish genus (UI)*	*Sebastes* (UI)*	5	< 1	33	< 1
Pacific hake	*Merluccius productus*	4	< 1	22	< 1

Table 6-1 continues.

Table 6-1 Continued.

Common name	Scientific name	Total	%A	%FO	MAH
Curlfin sole	*Pleuronichthys decurrens*	4	<1	33	<1
Bluebarred prickleback	*Plectobranchus evides*	4	<1	11	<1
Blackeye goby	*Rhinogobiops nicholsii*	3	<1	22	<1
Ocean whitefish	*Caulolatilus princeps*	3	<1	11	<1
Hundred-fathom codling	*Physiculus rastrelliger*	3	<1	11	<1
Specklefin midshipman	*Porichthys myriaster*	2	<1	22	<1
Petrale sole	*Eopsetta jordani*	2	<1	22	<1
Diamond turbot	*Pleuronichthys guttulatus*	2	<1	11	<1
Flag rockfish	*Sebastes rubrivinctus*	2	<1	11	<1
Bearded eelpout	*Lyconema barbatum*	2	<1	11	<1
Stripedfin ronquil	*Rathbunella alleni*	1	<1	11	<1
California halibut	*Paralichthys californicus*	1	<1	11	<1
Rex sole	*Glyptocephalus zachirus*	1	<1	11	<1
Bocaccio	*Sebastes paucispinis*	1	<1	11	<1
Pink rockfish	*Sebastes eos*	1	<1	11	<1
Barcheek pipefish	*Syngnathus exilis*	1	<1	11	<1
	Total	**41,567**	**100**		
	Total no. of species	**49**			

n = 42 hauls
UI – Unidentified
* Unidentified species are not included in the total number of species calculation

Table 6-2. Summary of demersal fish species and abundance by family for the summer (August 2010) and winter (January 2011) surveys.

Orange County Sanitation District

Family	Number of Species		Family Abundance	
	Total	Percentage	Total	Percentage
Scorpaenidae (Scorpionfishes)	10	20	18,371	44
Paralichthyidae (Sand flounders)	6	12	7,946	19
Synodontidae (Lizardfish)	1	2	4,459	11
Cottidae (Sculpins)	2	4	4,277	10
Pleuronectidae (Righteye flounders)	8	16	2,621	6
Hexagrammidae (Greenlings)	3	6	2,491	6
Soleidae (Soles)	1	2	574	1
Embiotocidae (Surfperches)	1	2	406	1
Zoarcidae (Eelpouts)	2	4	164	< 1
Batrachoididae (Toadfishes)	2	4	120	< 1
Agonidae (Poachers)	2	4	64	< 1
Rajidae (Skates)	1	2	27	< 1
Ophidiidae (Cusk-eels)	1	2	18	< 1
Argentinidae (Argentines)	1	2	5	< 1
Sciaenidae (Drums)	1	2	5	< 1
Gadidae (Cods)	1	2	4	< 1
Stichaeidae (Pricklebacks)	1	2	4	< 1
Gobiidae (Gobies)	1	2	3	< 1
Malacanthidae (Tilefishes)	1	2	3	< 1
Moridae (Codlings)	1	2	3	< 1
Bathymasteridae (Ronquils)	1	2	1	< 1
Syngnathidae (Pipefish)	1	2	1	< 1
Total	49	100	41,567	100

Data for each family are ranked by number of species and abundance for all stations and surveys combined.

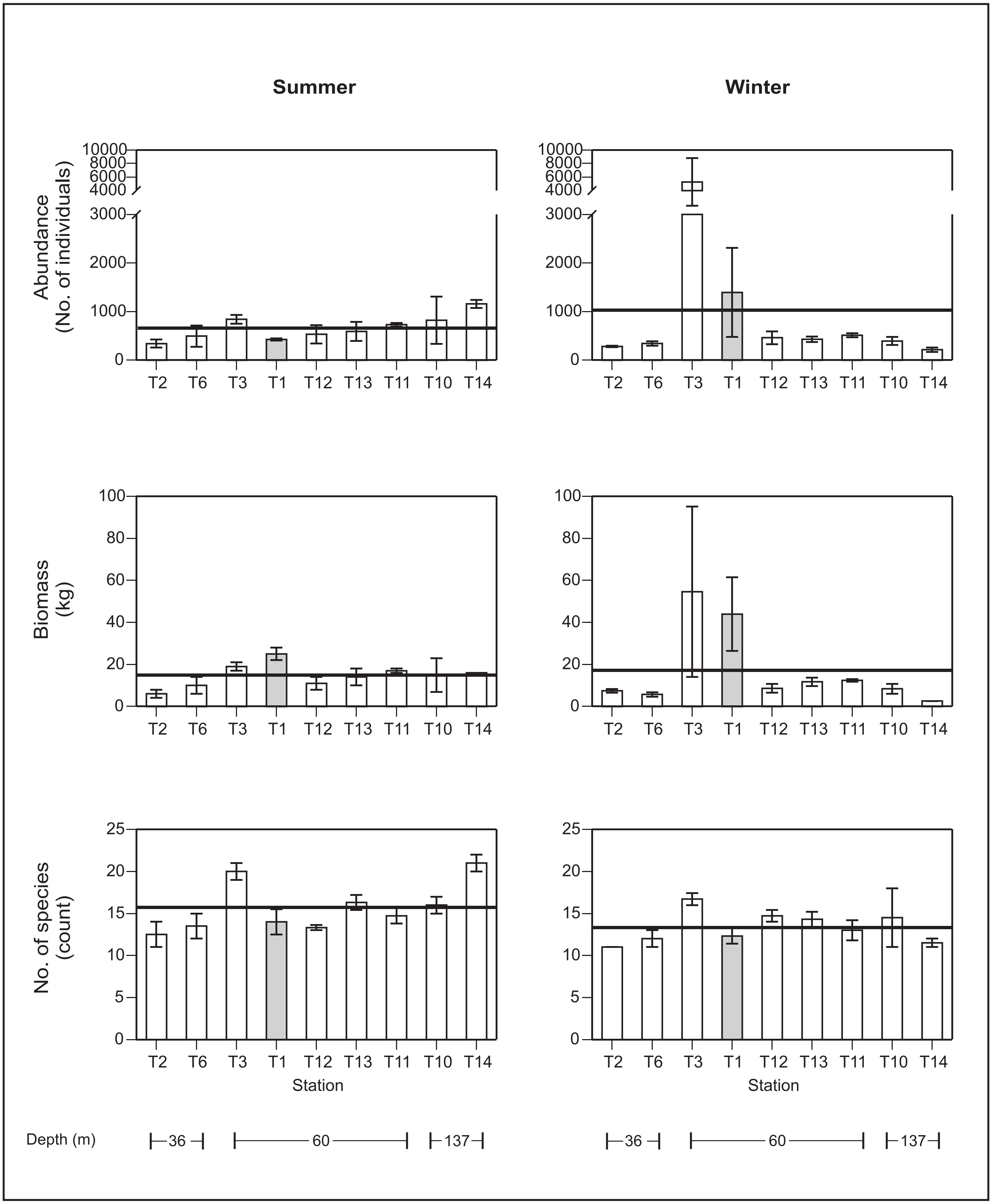

Figure 6-2. **Mean and 95% confidence interval for number of individuals (abundance), biomass, and number of species of demersal fish collected during the summer (August 2010) and winter (January 2011) surveys.**
Outfall Station T1 indicated in gray. Survey mean indicated by heavy line.

Orange County Sanitation District, California.

summer is due to a relatively small catch of two dominant species: Pacific Sanddab and English Sole. Only half the numbers of the individuals of these two species collected in winter were collected in summer at T1.

Biomass

A total of 794 kg of fish was collected in 2010-11, with four families (Paralichthyidae, Scorpaenidae, Pleuronectidae, and Synodontidae) accounting for 87% of the fish biomass. As with abundance, biomass data were highly variable (ranging from 3 to 136 kg per haul) due to population fluctuations of dominant species and variability in the size of individuals collected. Mean biomass per survey was greater in winter than summer due to large catches of halfbanded rockfish at T1 and T3, the two stations that also had the greatest biomass in both surveys (Figure 6-2 and Table B-14). These hefty catches at T1 were primarily due to an abundance of large Pacific sanddabs and English sole.

Increased fish biomass in the outfall area may be due to both a reef effect as well as a discharge effect (Diener et al 1997). Artificial reefs, such as the outfall structure, enhance habitat diversity and support higher fish biomass. The wastewater discharge contains organic particles that serve as a direct or indirect food source, thereby, enhancing fish biomass. Invertebrates feed upon the increased concentrations of organic particles in the outfall area and fish, in turn, feed upon the abundant invertebrates. Over time, biomass has followed the same patterns as for abundance described above (see OCSD 2010 Figure 6-2). Since 2005, the abundance of polychaetes near the outfall has increased, despite lessened solids discharge due to increased treatment, while other types of infauna (e.g., crustaceans) have decreased. The fish community has responded to this with an increased number of polychaetivorous (worm eating) fish. This may account for the increased fish biomass. For more information on the issue see Ordination and Classification section below. The changes in infaunal communities near the outfall are discussed in Chapters 5 and 7.

Number of Species

A total of 49 fish species representing 22 families were collected in the District's study area in 2010-11 (Tables 6-1, 6-2, and B-13). Fifteen of the species were widely distributed and occurred at >75% of the stations. The seven most frequently occurring species were the Pacific sanddab, California lizardfish, longspine combfish, English sole, pink seaperch (*Zalembius rosaceus*), hornyhead turbot, and bigmouth sole, each of which occurred at 100% of the stations. Four families, Scorpaenidae, Pleuronectidae, Paralichthyidae, and Hexagrammidae comprised 54% of the species collected. Only eight of the 22 families collected were represented by more than one species.

During 2010-11, the mean number of species per station ranged from 11 to 21 (Figure 6-2 and Table B-14). Differences between seasons were minimal. The most notable changes occurred at Station T14, which declined from a mean of 21 species in summer to 12 in winter. The two shallow stations (T2 and T6) had the lowest number of species, and mid-shelf Station T3 and deep water Station T14 had the highest. Station T1 had fewer species than the other mid-shelf stations, except T12 in summer, but not significantly fewer species than far field upcoast Station T11. Annual mean number of species by station group has been variable since 1985 and is depth-dependent (see OCSD 2010 Figure 6-3). Overall, the fewest number of species occur at the shallow station group, while the greatest numbers of species occur at the deep station group and farfield downcoast Station T3.

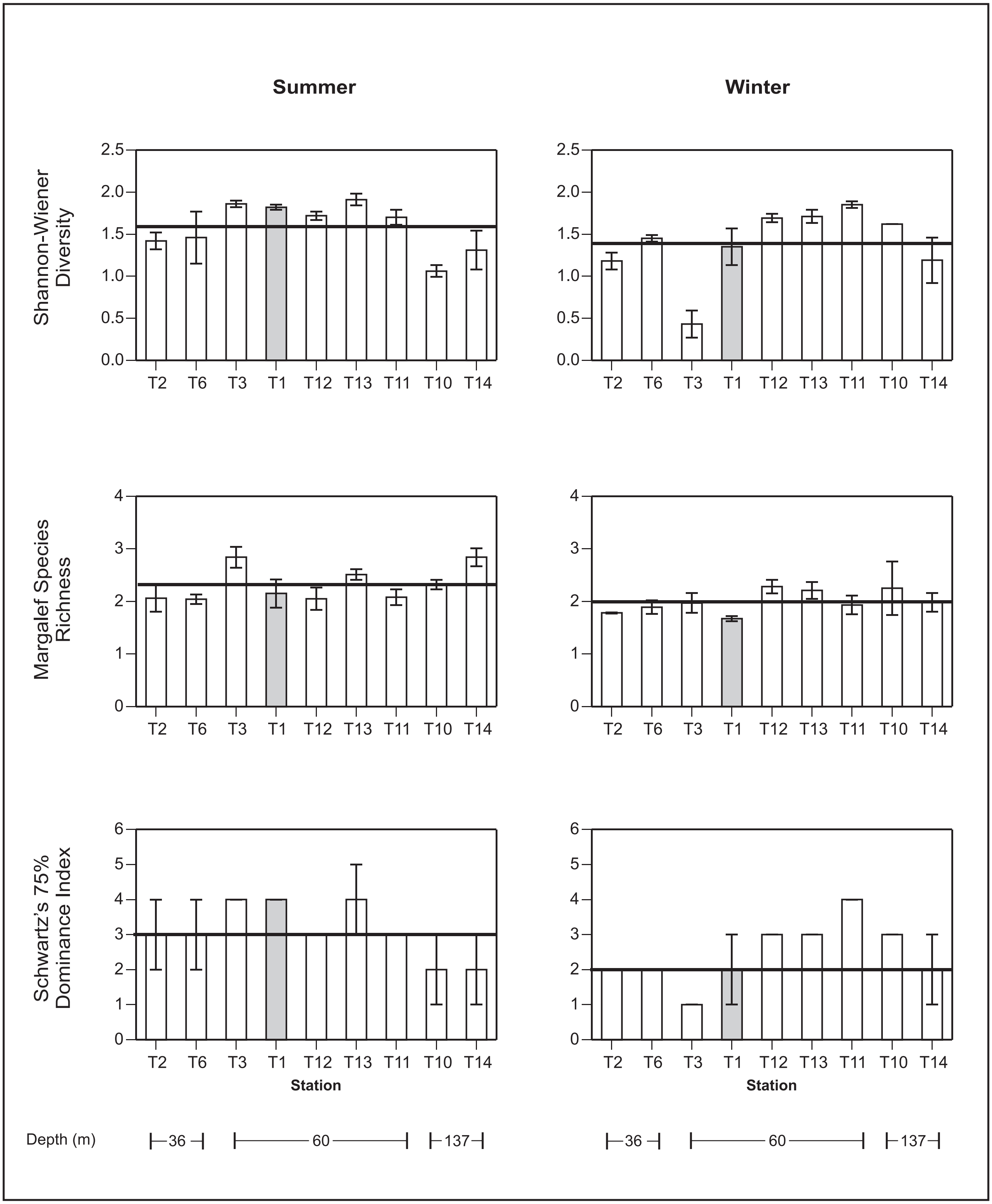

Figure 6-3. **Mean and 95% confidence interval for diversity indices — Shannon-Wiener Diversity Index (H'), Margalef Species Richness (SR), and Schwartz's 75% Dominance Index of demersal fish collected during the summer (August 2010) and winter (January 2011) surveys.** Outfall Station T1 indicated in gray. Survey mean indicated by heavy line.

Orange County Sanitation District, California.

Diversity

There was no evidence of significant impact on species diversity near the outfall (Station T1) relative to the other stations (Figure 6-3 and Table B-14). For example, mean Shannon-Wiener diversity index values at Station T1 were high in comparison to the other 60-m stations, except in winter when 2,484 halfbanded rockfish were collected in a single haul. Mean H' values at T1 were 1.82 in summer and 1.35 in winter. Overall, H' values at the 60 m stations ranged from 1.70 to 1.91 in summer and 0.43 to 1.85 in winter and were similar to the central Bight, middle shelf areas, which had a mean H' value of 1.69 (Allen *et al.* 2007). Station T3 had a very low H' value in winter due to the large number of halfbanded rockfish (15,116).

Ordination and Classification

Ordination and classification analyses of 2010-11 trawl fish data (excluding halfbanded rockfish data) at the 60 m stations resulted in four cluster groups with 70% similarity: A (Outfall T1), B (T3 in winter), C (T11 in winter, and T12 and T13), and D (T11 and T3 in summer) (Figure 6-4). The composition of each station group and the species characteristics of each assemblage are described in Table 6-3. Figure 6-5 shows the mean abundance per station and survey over time for select dominant species of each cluster group.

Cluster A, the outfall cluster, was significantly different from all other groups. The group consisted of 6 trawls from Station T1 and had a mean abundance of 496 individuals and a mean species richness of 23 species. SIMPER could not be applied to this group to determine characteristic species because there were too few samples in the group; however, the most abundant species were Pacific sanddabs, English sole, California tonguefish (*Symphurus atricaudus*) and longspine combfish (Table 6-3). Station T1 separated from the other middle shelf cluster sites (groups C and D) at the 75% resemblance level, which is likely due to large catches of Pacific sanddabs and English sole, and low abundance of yellowchin sculpin. Increases in sanddab and English sole are likely due to an increase in polychaete abundance near the outfall where the decline of yellowchin sculpin is in response to lower abundances of arthropods. California tonguefish may also be responding to increased polychaete abundances near the outfall because they have the ability to forage on arthropods or polychaetes (Telders 1981); however, 2010-11 abundances were within the range of natural variation.

Cluster Group B consisted of a single station (3 hauls) at downcoast Station T3 in winter. It consisted of 22 species with a mean abundance of 219 individuals per haul (not including halfbanded rockfish data) (Table 6-3). Again, small sample size prevented SIMPER analysis; however, the most abundant species were Pacific sanddabs and yellowchin sculpin with a mean abundance per haul of 84 and 68, respectively. This station likely formed a unique cluster in winter due to the large number of rare species. Twelve of the 22 species with mean abundance < 2 individuals per haul were found at this station.

Station T3 often differs from other middle shelf stations, possibly due to location, habitat, and difficulty in sampling. Station T3 is located in close proximity to Newport Canyon and is depositional in nature, as opposed to the rest of the middle shelf trawl stations in the study area that are erosional (Maurer et al. 1993). This station's proximity to Newport Canyon makes the bottom topography variable. For example, T3 trawls exceeded the lower limits (10%) of the nominal depth in both surveys (Figures C-2, C-4; Tables C-30, C-32).

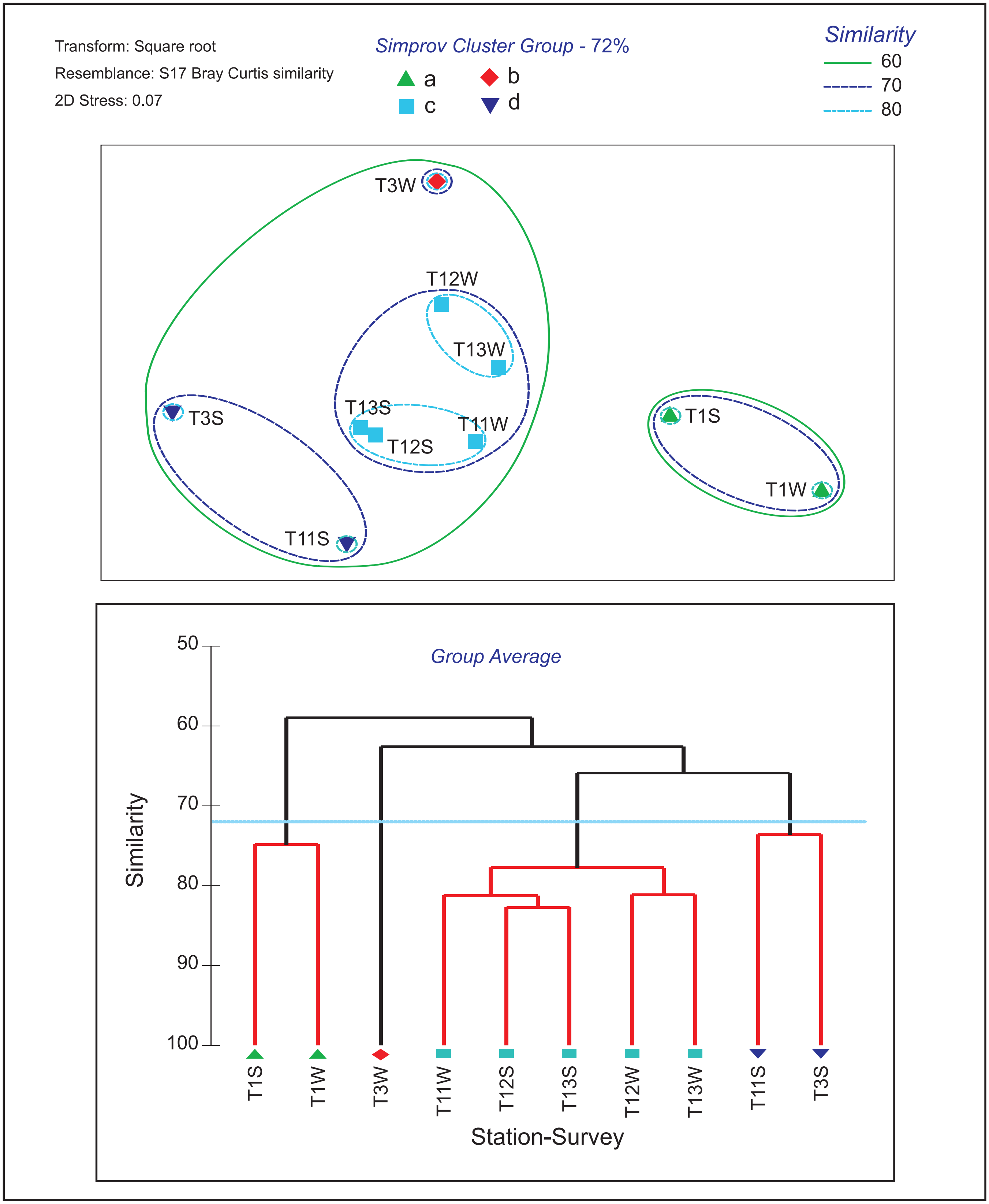

Figure 6-4. **Results of classification analysis of demersal fish assemblages collected at the five 60-m stations during the summer (August 2010) and winter (January 2011) trawl surveys. Data are presented as a non-metric multi-dimensional scaling (MDS) ordination plot and a dendrogram of major station clusters. Stations-surveys are denoted by S for summer and W for winter.**

Table 6-3. Description of cluster groups (A, B, C, and D) defined in Figure 6-4. Data include number of hauls, species richness, mean total abundance, and mean abundance of the five most abundant species for each station group. Bold values indicate species that were considered "characteristic" of that group according to SIMPER analyses (i.e. similarity/standard deviation >2.0).

Orange County Sanitation District, California.

Parameter	***Cluster Group A**	***Cluster Group B**	**Cluster Group C**	***Cluster Group D**
Number of Hauls	6	3	15	6
Species Richness	23	22	27	25
Mean Abundance/Haul	496	219	504	780
Species		**Mean Abundance**		
California lizardfish	26	10	**142**	67
California tonguefish	46	2	**12**	6
English sole	167	2	**23**	14
Longspine combfish	37	11	**99**	63
Pacific sanddab	163	84	**74**	243
Roughback sculpin	1	1	3	36
Yellowchin sculpin	13	68	**113**	254

All Halfbanded rockfish data are excluded in this table.

* Note that Simper was not applied due to too few samples in the group.

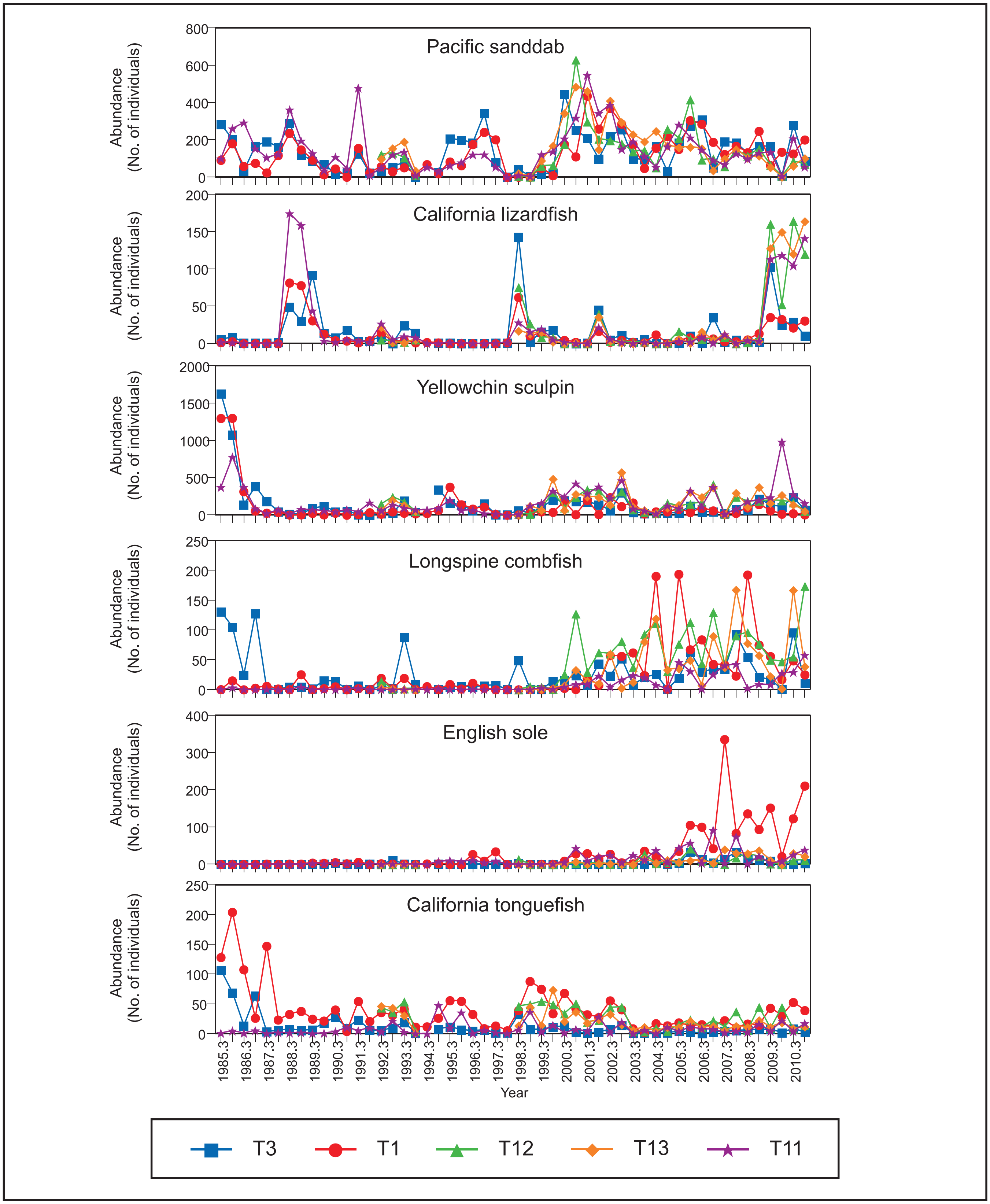

Figure 6-5. **Comparison of demersal fish mean abundance for select species at stations located along the 60 meter depth contour for 1985–2011.**

Orange County Sanitation District, California.

Cluster group C was comprised of 15 trawls from middle shelf Stations T12, T13, and T11 (winter only). Twenty-seven species with a mean abundance of 504 individuals per trawl comprised this group. California lizardfish, yellowchin sculpin, Pacific sanddabs, longspine combfish, English sole, and California tonguefish characterize this group, as determined by SIMPER. California lizardfish go through "boom and bust" years, as evidenced in the District's long-term data (Figure 6-5). This species has been a dominant in this cluster group since 2009.

Cluster group D included the summer surveys from just two middle shelf stations, T11 and T3. Both stations had significantly different assemblages in winter than summer. This group consisted of 25 species with a mean abundance of 780 individuals/haul. As with groups A and B this group had too few samples for SIMPER analysis, however, the characteristic species of this group included yellowchin sculpin, Pacific sanddab, roughback sculpin (*Chitonotus pugettensis*), and longspine combfish.

<u>Regional Comparisons</u>

FRI scores exceeded the threshold of 45 on the Palos Verdes shelf from 1970 to 1983 when sediment contamination by organics and other constituents was high (Allen 2006b). By 1990, FRI scores at Palos Verdes decreased to about 25 and remained near this value through 2002. Allen *et al.* (2007) also reported that 96% of the SCB area in 1998 was classified as reference (the remaining 4% of non-reference areas occurred on the inner shelf and in bays and harbors). Mean FRI scores at the District's core stations ranged from 15 to 26 in 2010-11, indicating reference conditions (Figure 6-6). Although all stations are well below the non-reference threshold, T1 has a considerably higher FRI score than the other 60 m stations, except T3. Historically, mean FRI scores for Stations T1 and T11 have consistently been below 45, ranging from 14 to 30. However, FRI scores for T1 and T11 have slightly increased over time, with a peak in 2005. This is same year that benthic infauna began declining near the outfall (see Chapter 5).

The summer data at Stations T1 and T11 for 2010 also followed trends in abundance and biomass similar to those described previously for the regional survey (OCSD 2008). The SCBPP, Bight'98, Bight'03, and Bight'08 regional monitoring surveys reported no degraded areas, but found enhancement of mean fish abundance and biomass at some locations near wastewater outfalls (Figure 6-7). The fish populations at the District's outfall Station T1 also showed enhanced abundance and biomass. In 2010, mean abundance at T1 was higher than the mean abundance for regional non-POTW stations (publically owned treatment works) in 2003 and 2008, but it did fall within the regional ranges. Biomass at T1 was at the high end of regional values due to a number of large individuals of Pacific sanddab and a large catch of English sole. Such patterns were observed in the regional studies and are expected at near-discharge areas (Allen et al. 2002, 2007).

The regional surveys reported slightly more species at large POTWs compared to non-POTW areas in 1994 and 1998, though the number of species was similar between the two groups in 2003. The mean number of species at T1 was equal to or lower than the Bight non-POTW areas for all surveys except 2008; T11 was less than all of the regional survey values. In 2010, the mean number of species at the District's sites were similar to regional values in 1994, 1998, and 2008, though slightly less than the 2003 regional mean. Diversity at Station T1 has been consistently high and similar to other SCB stations in the 1994, 1998, and 2003 surveys; however T1

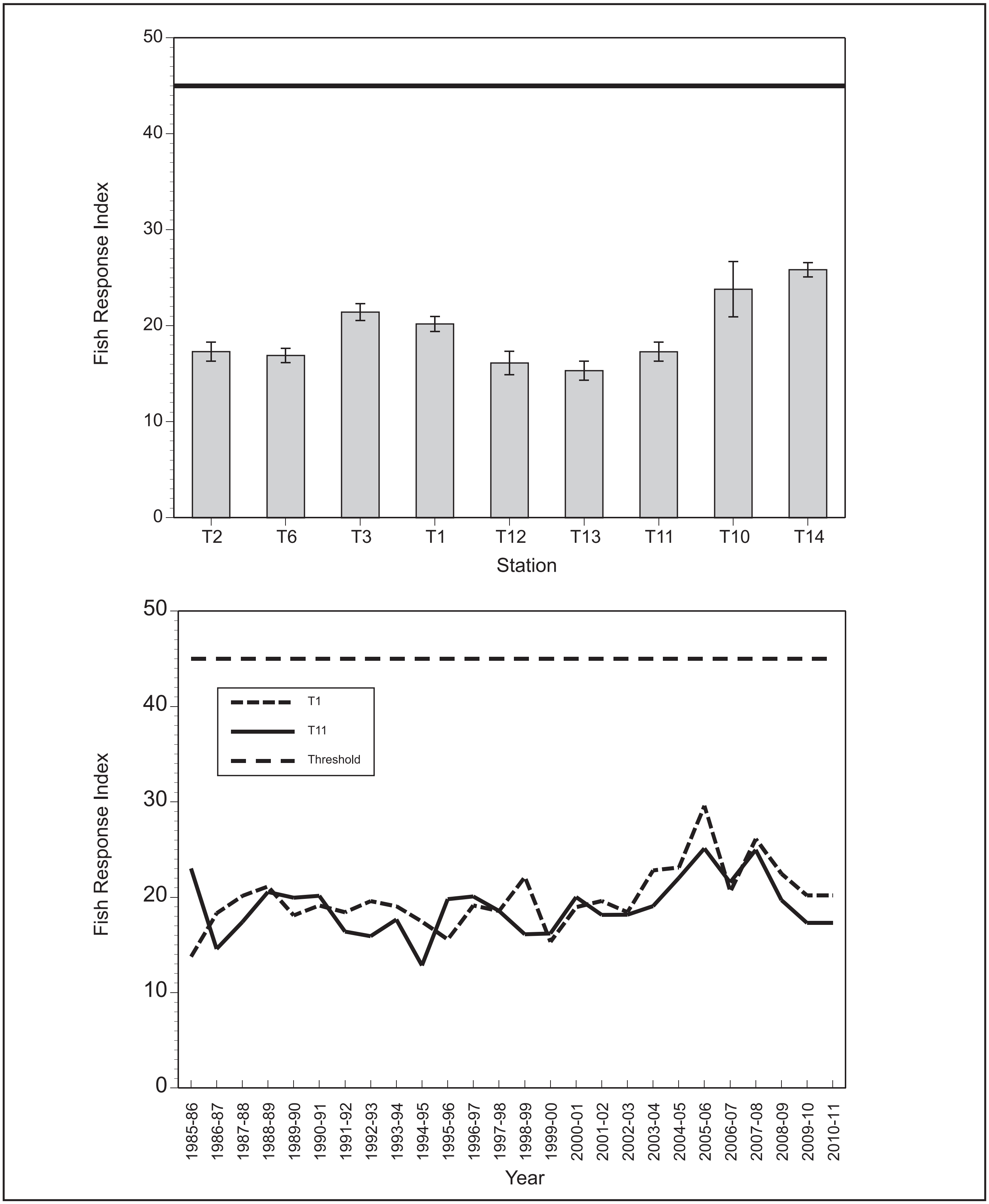

Figure 6-6. **Mean Fish Response Index (FRI) by station in 2010-11 and annual mean FRI for outfall Station T1 and farfield upcoast Station T11.**
Solid black line represents threshold value.

Orange County Sanitation District, California.

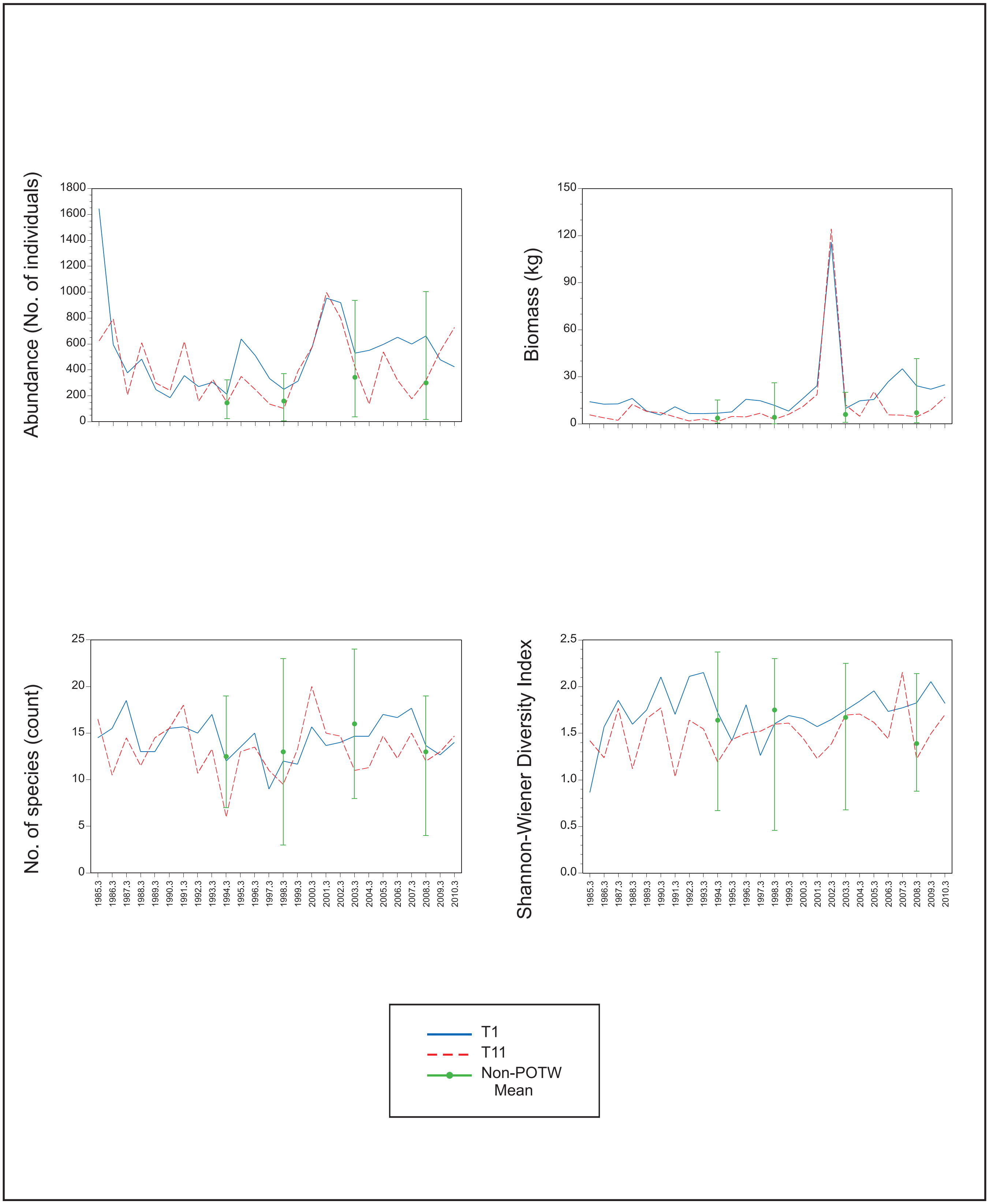

Figure 6-7. **Comparison of demersal fish parameters at OCSD stations T1 and T11 from 1985 to 2010 and regional non-POTW stations from the 1994, 1998, 2003, and 2008 regional monitoring surveys. All data for mean abundance, biomass, number of species, and Shannon-Wiener diversity (H') are for summer surveys only. Range bars represent the range of values (minimum and maximum) for the non-POTW areas per survey.**

Note: non-POTW N values: 1994=3, 1998=15, 2003=13, 2008=13 diversity was much higher than the SCB stations in 2008. Since fish community measures at outfall Station T1 approximately equaled or exceeded values characterizing the SCB at similar depths, the fish community does not appear to be degraded by the wastewater discharge.

Epibenthic Macroinvertebrate Community

Abundance

A total of 4,556 epibenthic macroinvertebrates (EMI) were collected during 2010-11 (Table B-15). The total abundance decreased by 2,149 individuals from the previous year (2009-10) due to the continuing population decline of *Acanthoptilum* sp (the trailtip sea pen). This sea pen has been occurring in large numbers at the outfall station since 2002 and peaked at an abundance of 8,265 in 2008-09. A dominant species comprising from 13 to 69% of the overall abundance for the past few years, *Acanthoptilum* sp comprised only 2% of the 2010-11 total abundance (Table 6-4). Overall, mean abundances ranged from a low of 39 in the winter to 370 in summer, with the summer survey having a slightly higher overall mean of 122 individuals compared to 95 individuals in winter (Figure 6-8 and Table B-16). The highest catches occurred at stations T14 in the summer and T6 in the winter.

In 2010-11, three species accounted for 60% of the total abundance: *Sicyonia ingentis* (the ridgeback rockshrimp) comprised 32% of the total catch (1,451 individuals), followed by the *Lytechinus pictus* (the white sea urchin) at 16% (733 individuals), and *Thesea* sp (the yellow sea twig) at 12% (553 individuals) (Table 6-4). In some instances, these species dominated a station. For example, *S. ingentis* was responsible for 90% of the summer abundance at Stations T10 and T14, while *L. pictus* contributed to over 52% of the high winter abundance at Station T6. Other generally abundant species included *Ophiura luetkenii* (the brokenspine brittlestar), *Hamatoscalpellum californicum* (the California blade barnacle), *Pleurobranchaea californica* (California sea slug), and *Astropecten verrilli* (sand star). *P. californica* increased in abundance from less than 1% of the total abundance in 2009-10 to 5% of the total abundance and the 6th most abundant species in 2010-11. The cause of this increase is unknown. Three of the 56 species occurred at all stations: *L. pictus, O. luetkenii*, and *Pleurobranchaea californica*. Another eight species, consisting of four echinoderms (*A. verrilli, Ophiothrix spiculata, Luidia foliolata, L. asthenosoma*), two mollusks (*Acanthodoris brunnea, Octopus rubescens*), one crustacean (*S. ingentis*), and a cnidarian (*Thesea* sp) were wide-ranging and occurred at over 75% of the stations. By contrast, 40 species occurred at fewer than half of the nine stations sampled.

Abundance has been highly variable over the past 23 years with mean individuals per haul ranging from 17 to 5,700 (OCSD 2010). These fluctuations typically reflect changes in several dominant species, such as the *O. luetkenii*, *Thesea* sp, *L. pictus*, *A. verrilli*, *S. ingentis*, and *Acanthoptilum* sp (Figure 6-9). Overall, there were no strong indications of potential impact at the discharge site with respect to total or individual species abundances. For example, increases in abundances of the suspension feeding sea pen *Acanthoptilum* sp at outfall Station T1 from 2002 – 2008, and the subsequent decline from 2009 through January 2011, has not been linked to an outfall effect. In addition, there has been an increase in abundances of the sand star *A. verrilli* at the discharge site in recent years 2009–2011; however populations of this species have fluctuated through time and the cause of these changes is uncertain.

Table 6-4. Summary of epibenthic macroinvertebrates species collected during the summer (August 2010) and winter (January 2011) surveys. Data for each species are expressed as total abundance (Total), percent abundance (%A), frequency of occurrence (%FO), and mean abundance per haul (MAH).

Orange County Sanitation District, California.

Species	Total	%A	%FO	MAH
Sicyonia ingentis (A)	1,451	31.8	88.9	31.8
Lytechinus pictus (E)	733	16.1	100.0	16.1
Thesea sp (C)	553	12.1	88.9	12.1
Ophiura luetkenii (E)	393	8.6	100.0	8.6
Hamatoscalpellum californicum (A)	268	5.9	66.7	5.9
Pleurobranchaea californica (M)	221	4.9	100.0	4.9
Astropecten verrilli (E)	207	4.5	88.9	4.5
Ophiothrix spiculata (E)	151	3.3	77.8	3.3
Luidia foliolata (E)	126	2.8	88.9	2.8
Acanthoptilum sp (C)	80	1.8	55.6	1.8
Parastichopus californicus (E)	66	1.4	66.7	1.4
Acanthodoris brunnea (M)	50	1.1	77.8	1.1
Neocrangon zacae (A)	42	0.9	33.3	0.9
Luidia asthenosoma (E)	41	0.9	88.9	0.9
Octopus rubescens (M)	38	0.8	77.8	0.8
Heterogorgia sp (C)	13	0.3	55.6	0.3
Tritonia diomedea (M)	10	0.2	22.2	0.2
Amphichondrius granulatus (E)	9	0.2	33.3	0.2
Megasurcula carpenteriana (M)	9	0.2	44.4	0.2
Cancellaria crawfordiana (M)	8	0.2	33.3	0.2
Loxorhynchus crispatus (A)	7	0.2	55.6	0.2
Sicyonia penicillata (A)	7	0.2	33.3	0.2
Calliostoma turbinum (M)	5	0.1	44.4	0.1
Neocrangon resima (A)	5	0.1	22.2	0.1
Podochela hemphillii (A)	5	0.1	22.2	0.1
Rossia pacifica (M)	5	0.1	22.2	0.1
Tunicate (Ch)	5	0.1	33.3	0.1
Baptodoris mimetica (M)	4	0.1	33.3	0.1
Philine auriformis (M)	4	0.1	44.4	0.1
Stylatula elongata (C)	4	0.1	11.1	0.1
Crangon alaskensis (A)	3	0.1	11.1	0.1
Heterocrypta occidentalis (A)	2	<0.1	11.1	<0.1
Metacarcinus anthonyi (A)	2	<0.1	22.2	<0.1
Peltodoris nobilis (M)	2	<0.1	22.2	<0.1
Pisaster brevispinus (E)	2	<0.1	22.2	<0.1
Platymera gaudichaudii (A)	2	<0.1	22.2	<0.1
Podochela lobifrons (A)	2	<0.1	22.2	<0.1

Table 6-4 continues.

Table 6-4 continued.

Species	Total	PA	FO	MAH
Silicea	2	<0.1	11.1	<0.1
Spatangus californicus (E)	2	<0.1	11.1	<0.1
Amphioda psara (E)	1	<0.1	11.1	<0.1
Antiplanes catalinae (M)	1	<0.1	11.1	<0.1
Aphrodita japonica (P)	1	<0.1	11.1	<0.1
Barbarofusus barbarensis (M)	1	<0.1	11.1	<0.1
Boreotrophon bentleyi (M)	1	<0.1	11.1	<0.1
Crossata californica (M)	1	<0.1	11.1	<0.1
Diaulula sandiegensis (M)	1	<0.1	11.1	<0.1
Doryteuthis opalescens (M)	1	<0.1	11.1	<0.1
Loxorhynchus grandis (A)	1	<0.1	11.1	<0.1
Octopus californicus (M)	1	<0.1	11.1	<0.1
Paguristes turgidus (A)	1	<0.1	11.1	<0.1
Pagurus spilocarpus (A)	1	<0.1	11.1	<0.1
Pandalus platyceros (A)	1	<0.1	11.1	<0.1
Pinnixa sp (A)	1	<0.1	11.1	<0.1
Pteropurpura macroptera (M)	1	<0.1	11.1	<0.1
Strongylocentrotus sp (E)	1	<0.1	11.1	<0.1
Triopha catalinae (M)	1	<0.1	11.1	<0.1
Total	**4,556**	**100**		
Total no. of species	**56**			

A = Arthropoda; C = Cnidaria; Ch = Chordata (Asicidacea); E = Echinodermata; M = Mollusca; P = Polychaeta.
n = 46 hauls

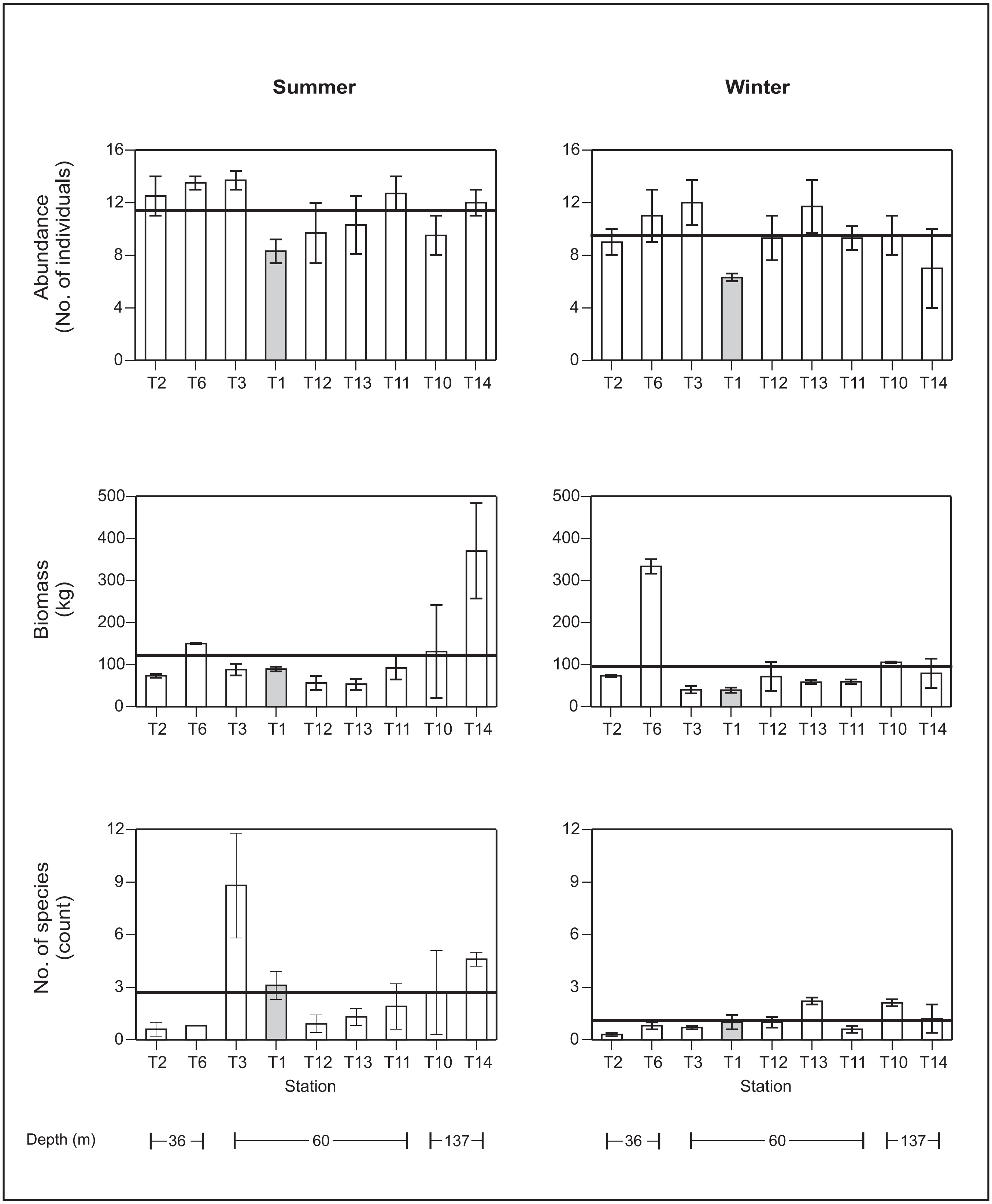

Figure 6-8. **Mean and 95% confidence interval for number of individuals (abundance), biomass, and number of species of epibenthic macroinvertebrates collected during the summer (August 2010) and winter (January 2011) surveys.**
Outfall Station T1indicated in gray. Survey mean indicated by heavy line.

Orange County Sanitation District, California.

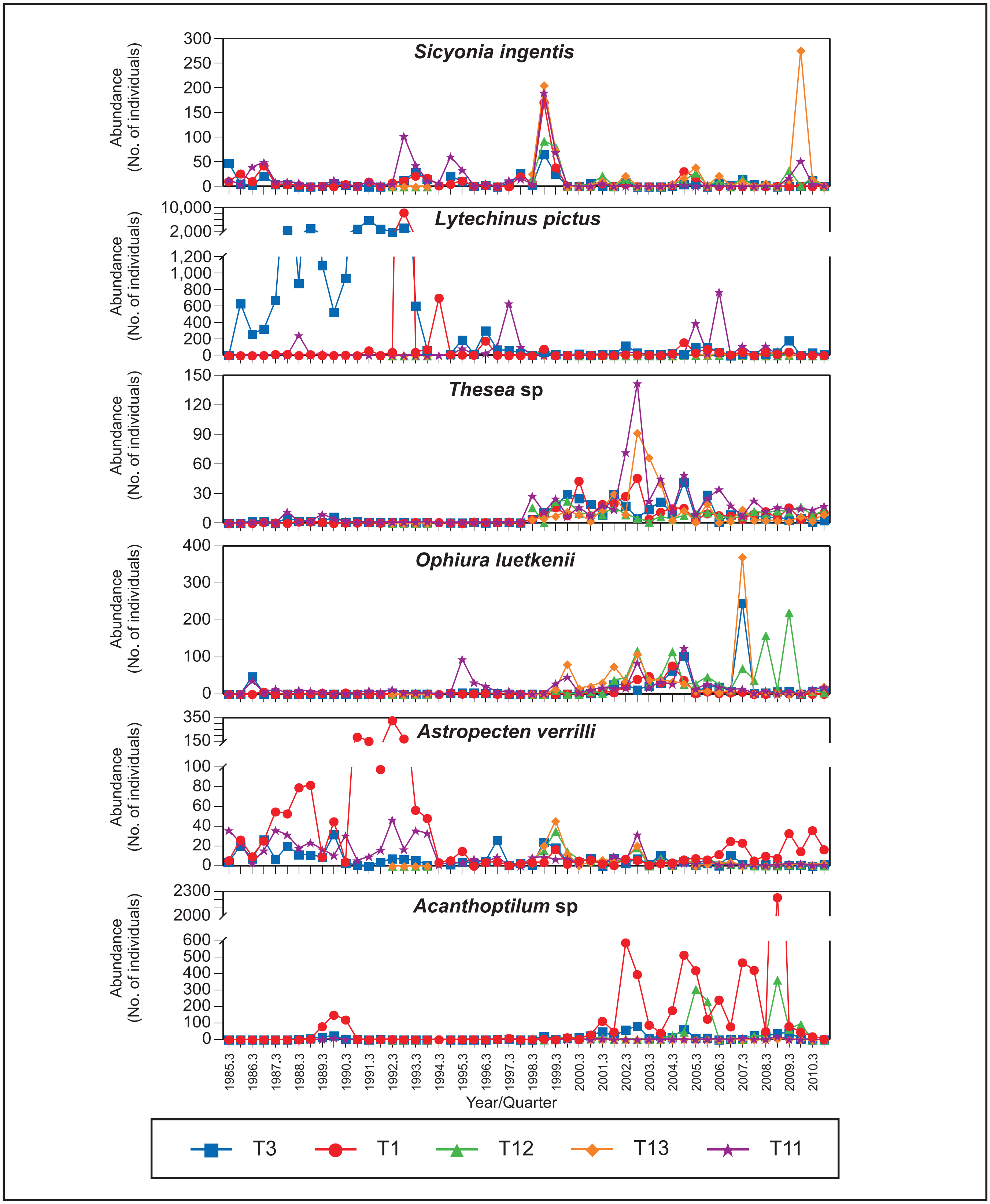

Figure 6-9. Comparison of epibenthic macroinvertebrate mean abundance for select species at stations located along the 60 meter depth contour for 1985–2011.

Orange County Sanitation District, California.

Biomass

In 2010-11, the total EMI biomass was 90.7 kg, which was nearly twice that of the 52.4 kg of the previous year (Table B- 17). Most of the difference between years was due to the higher summer biomass values at Stations T1, T3, T10, and T14 (Figure 6-8). *Parastichopus californicus* (the California sea cucumber) and the *S. ingentis* made up 41% (37 kg) and 18% (16 kg) of the biomass, respectively. *P. californicus* made up 58% and 82% of the high summer biomass values Stations T1 and T3, respectively, while *S. ingentis* contributed 86% of the high summer biomass at Station T14. Overall, the biomass at Station T1 was similar to the other middle shelf stations and there were no indications of change that could be attributed to the outfall.

Number of Species

A total of 56 EMI taxa were collected during 2010-11 (Table B-15). Species richness was slightly higher during the summer survey and greatest at Stations T3 and T6 in summer and Stations T3 and T13 in winter (Figure 6-8 and Table B-16). There was a relatively low number of species present near the outfall in both surveys. In summer, outfall Station T1 averaged only eight species, less than the survey mean of 11 and farfield Station T11 mean of 13. Station T1 averaged only six species during the winter survey, which was again lower than the mean of all other 60-m stations and well below the survey mean (10.5 and 9, respectively).

Diversity

Overall survey means of Shannon-Wiener (H'), Margalef Species Richness (d), and Swartz's 75% Dominance Index (Dominance) were similar in summer and winter, although some individual stations varied significantly between surveys (Figure 6-10). Mean diversity and d values at outfall Station T1 were less than other 60-m stations in both seasons, and were significantly less than farfield Station T11. Dominance at T1 was lower than other 60-m stations in summer and was low, but similar to them in winter. The lower diversity indices at Station T1 suggest that the wastewater discharge may be impacting the epibenthic macroinvertebrate assemblages near the outfall.

Regional Comparisons

The District's summer 2010 EMI data for Stations T1 and T11 were compared to regional data collected during the 1994 SCBPP, Bight'98, Bight'03, and Bight'08 surveys (Figure 6-11). These regional studies have established several general conclusions: that invertebrate population attributes at large POTW areas and non-POTW sites were generally similar (Allen *et al.* 2007); in contrast to fish, mean EMI abundance was highest in 1994 (warm regime), but biomass was highest in 2003 (cold regime) (Allen, *et al.* 2007); and differences in the EMI assemblages between surveys were likely due to the prevailing oceanographic regime associated with the Pacific Decadal Oscillation (Francis *et al*. 1998).

Mean community measures at stations T1 and T11 in 2010 fell within the range of values for the regional Bight stations, but with slight differences (Figure 6-11). For example, the District's outfall (T1) and farfield T11) trawl sights have generally followed regional variation in species richness and diversity values, but tended to have lower abundance and biomass values than the regional average. Meaningful comparisons among the regional surveys and the District's trawl data are limited, however, due to the high variability, in particular, the wide ranges observed for trawl invertebrate data. For example, non-POTW abundance and biomass in 2008 were extraordinarily high due to a large catch of *L. pictus, the* white sea urchin, at just two stations. Overall, the EMI population attributes at the District's outfall

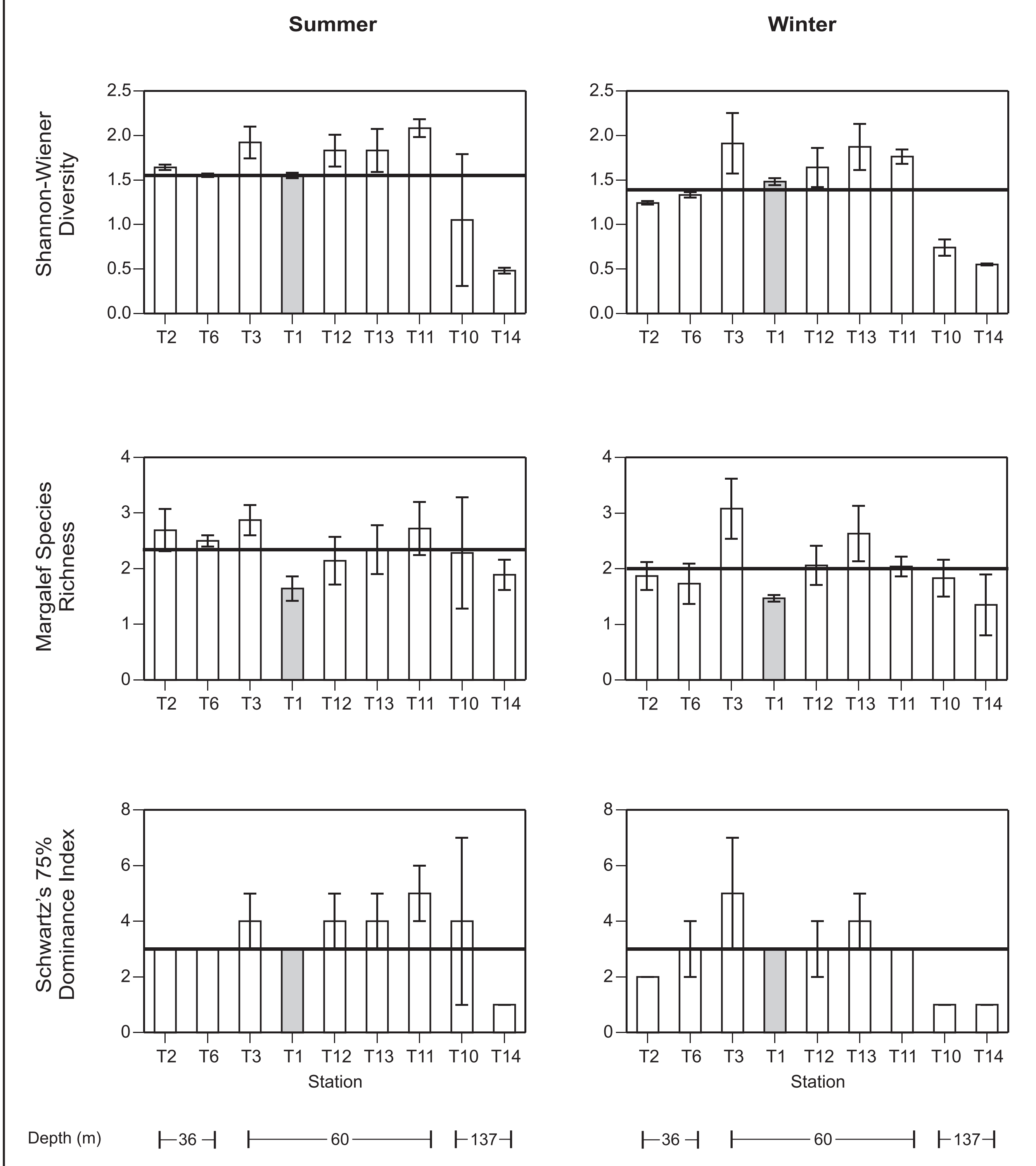

Figure 6-10. **Mean and 95% confidence interval for diversity indices — Shannon-Wiener Diversity Index (H'), Margalef Species Richness (SR), and Schwartz's 75% Dominance Index of epibenthic macroinvertebrates collected during the summer (August 2010) and winter (January 2011) surveys.**

Orange County Sanitation District, California.

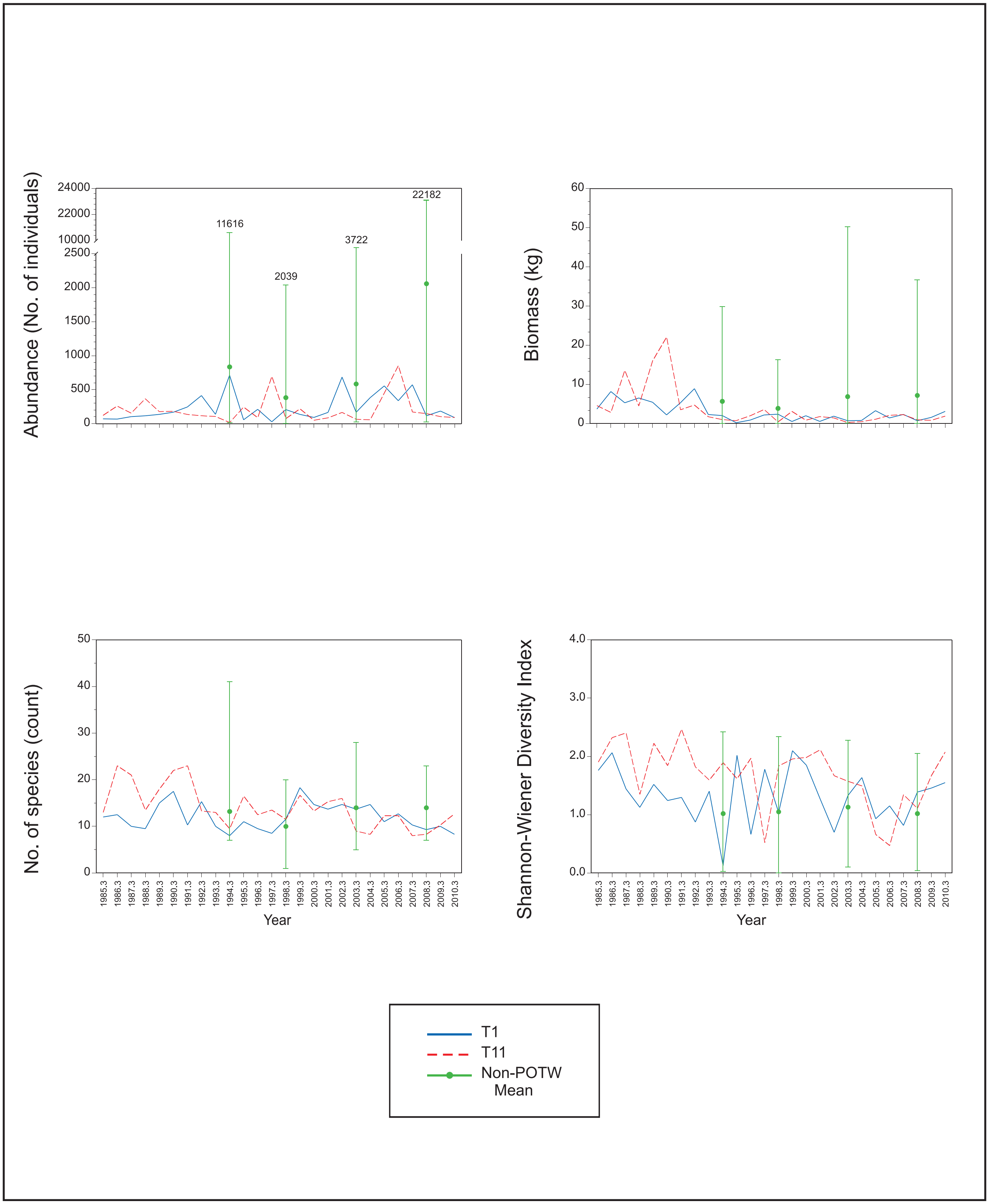

Figure 6-11. **Comparison of epibenthic macroinvertebrate parameters at OCSD stations T1 and T11 from 1985 to 2010 and regional non-POTW stations from the 1994, 1998, 2003, and 2008 regional monitoring surveys. All data for mean abundance, biomass, number of species, and Shannon-Wiener diversity (H') are for summer surveys only. Range bars represent the range of values (minimum and maximum) for the non-POTW areas per survey.**

Note: non-POTW N values: 1994=3, 1998=15, 2003=13, 2008=13 and within the SCB area were highly variable, mostly due to changes in oceanographic conditions, but also due to fluctuations in the dominant species.

Fish Tissue Contaminants

Outfall vs. Farfield Stations Comparisons

Hornyhead turbot

Hornyhead turbots collected at the outfall stations were about 10% bigger than at farfield stations. The mean standard length and biomass between the two stations differed by 17 mm and 37 g, respectively. Size matters because contaminant concentrations can relate to the age/size of the fish. For example, Phillips *et al.* (1997) found that tissue concentrations of mercury in barred sandbass (*Paralabrax nebulifer*) were highest in larger, older fish and that size/age was more important to the contaminate level than location of capture.

Overall contaminants in Hornyhead turbot muscle tissues were low in 2010-11 (Table 6-5; Figures 6-12 through 6-15). Lipids were not detected in muscle tissue at outfall Station T1, but averaged 0.024% at farfield Station T11. Muscle tissue tDDT levels were three times higher at the farfield (20.0 ug/kg) compared to outfall (6.12 ug/kg) station. Concentrations of tPCB were not detected in outfall-collected fish and were 0.04 ug/kg in the farfield fish. Mean muscle mercury concentrations have increased slightly since 2007-08 and this year mercury levels in hornyhead turbot were almost two times higher at the outfall site than the farfield (0.068 and 0.037, respectively). However, these values are much less than the state and federal health advisory action level concentrations. Other pesticides concentrations were non-detectable at both stations.

Overall, contaminant concentrations in non-regulated liver tissue were low (Table 6-5, Figure 6-16). Mean lipid concentrations in fish collected near the outfall were 13% as compared to 9% in farfield fish. Liver tissue mercury was comparable at outfall and farfield stations. Total PCB levels were approximately two times higher at the outfall versus farfield sites (7 and 3 ug/kg, respectively), while tDDT was about two times higher at farfield over outfall stations (84 and 49 ug/kg, respectively). The higher levels of tPCB in outfall collected fish is consistent with sediment tPCB concentrations (see Chapter 4). Pesticides were non-detected at farfield stations and 1.34 ug/kg at the outfall.

English sole

The mean standard length of English sole collected at the outfall and those from the farfield stations were identical this year, and there was only a 0.1% difference in muscle lipid concentrations (Table 6-5). In contrast, muscle tissue concentrations of tDDT, tPCB, and mercury were over twice as high at the outfall over farfield site (Figures 6-12 through 6-15). No fish at either site had measurable muscle pesticide concentrations. Despite the higher contaminate concentrations near the outfall all parameters measured were well below any federal or state action or advisory levels.

In contrast to muscle tissue concentrations, liver lipid, mercury, and tPCB concentrations were comparable in outfall and farfield fish (Table 6-5). Total DDT, however, was two times higher in outfall liver tissues (137 ug/kg) relative to the farfield (69 ug/kg). Chlorinated pesticides were not detected in any of the fish collected (Figure 6-16).

Pacific sanddab

Pacific sanddab whole-fish contaminant concentrations generally showed the expected pattern of higher tissue concentrations with increased size class for all analytes at both outfall and farfield stations. Values for most parameters were

Table 6-5. Results of tissue contaminant analysis of trawl fish collected at outfall and farfield station groups.

Orange County Sanitation District, California.

Species	Tissue	Station Group	n	Range	Standard Length / Size Class (mm)	Percent Lipid	Mercury (mg/kg)	Total DDT (ug/kg)	Total PCB (ug/kg)	Other Pest (ug/kg)
Hornyhead Turbot	Muscle	Outfall	10	Mean	166	ND	0.068	6.12	ND	ND
				Min.	135	ND	0.020	3.20	ND	ND
				Max	190	ND	0.124	9.38	ND	ND
		Farfield	10	Mean	149	0.024	0.037	20.0	0.36	ND
				Min.	135	0.024	0.014	4.19	ND	ND
				Max	162	0.024	0.091	85.0	3.60	ND
	Liver	Outfall	10	Mean	166	12.6	0.200	49.3	7.2	1.34
				Min.	135	5.60	0.051	18.3	ND	ND
				Max	190	26.4	0.589	77.8	27	10.5
		Farfield	10	Mean	149	8.71	0.104	83.5	2.96	ND
				Min.	135	0.90	0.047	20.5	ND	ND
				Max	162	27.9	0.215	216	15.5	ND
English Sole	Muscle	Outfall	10	Mean	156	0.583	0.077	232	18.7	ND
				Min.	130	0.30	0.014	28.4	ND	ND
				Max	190	0.97	0.229	691	42.1	ND
		Farfield	10	Mean	156	0.48	0.032	104	6.53	ND
				Min.	131	ND	0.016	23.2	ND	ND
				Max	182	3.11	0.063	365	52.0	ND
	Liver	Outfall	10	Mean	156	12.5	0.053	137	11.6	ND
				Min.	130	5.04	0.023	51.7	ND	ND
				Max	190	23.3	0.127	436	38.8	ND
		Farfield	10	Mean	156	10.9	0.050	68.9	8.55	ND
				Min.	131	3.12	0.028	18.9	0.760	ND
				Max	182	23.1	0.104	130	63.1	ND
Pacific Sanddab	Whole Fish	Outfall	3	Mean	0 (5–8 cm)	0.48	0.009	36.74	ND	ND
				Min.		0.47	0.008	36.60	ND	ND
				Max		0.48	0.0085	36.88	ND	ND
		Farfield	3	Mean		0.50	0.008	37.69	0.93	ND
				Min.		0.47	0.008	34.07	0	ND
				Max		0.54	0.008	36.88	1.85	ND
		Outfall	3	Mean	1 (9–13 cm)	0.40	0.016	52.9	5.39	ND
				Min.		0.28	0.016	41.15	3.77	ND
				Max		0.52	0.016	64.68	7.0	ND
		Farfield	3	Mean		0.68	0.011	48.24	5.79	ND
				Min.		0.58	0.011	47.93	0	ND
				Max		0.78	0.011	48.55	11.59	ND
		Outfall	3	Mean	2 (14–16 cm)	0.79	0.0315	43.61	5.3	ND
				Min.		0.65	0.031	39.98	0	ND
				Max		0.93	0.032	47.23	10.60	ND
		Farfield	3	Mean		0.80	0.035	44.04	4.82	ND
				Min.		0.75	0.027	40.67	2.93	ND
				Max		0.85	0.042	47.41	6.71	ND

Data for total DDT, total PCB, and total other pesticides are lipid-normalized; mercury is not lipid-normalized.
ND = not detected, NS = no sample.

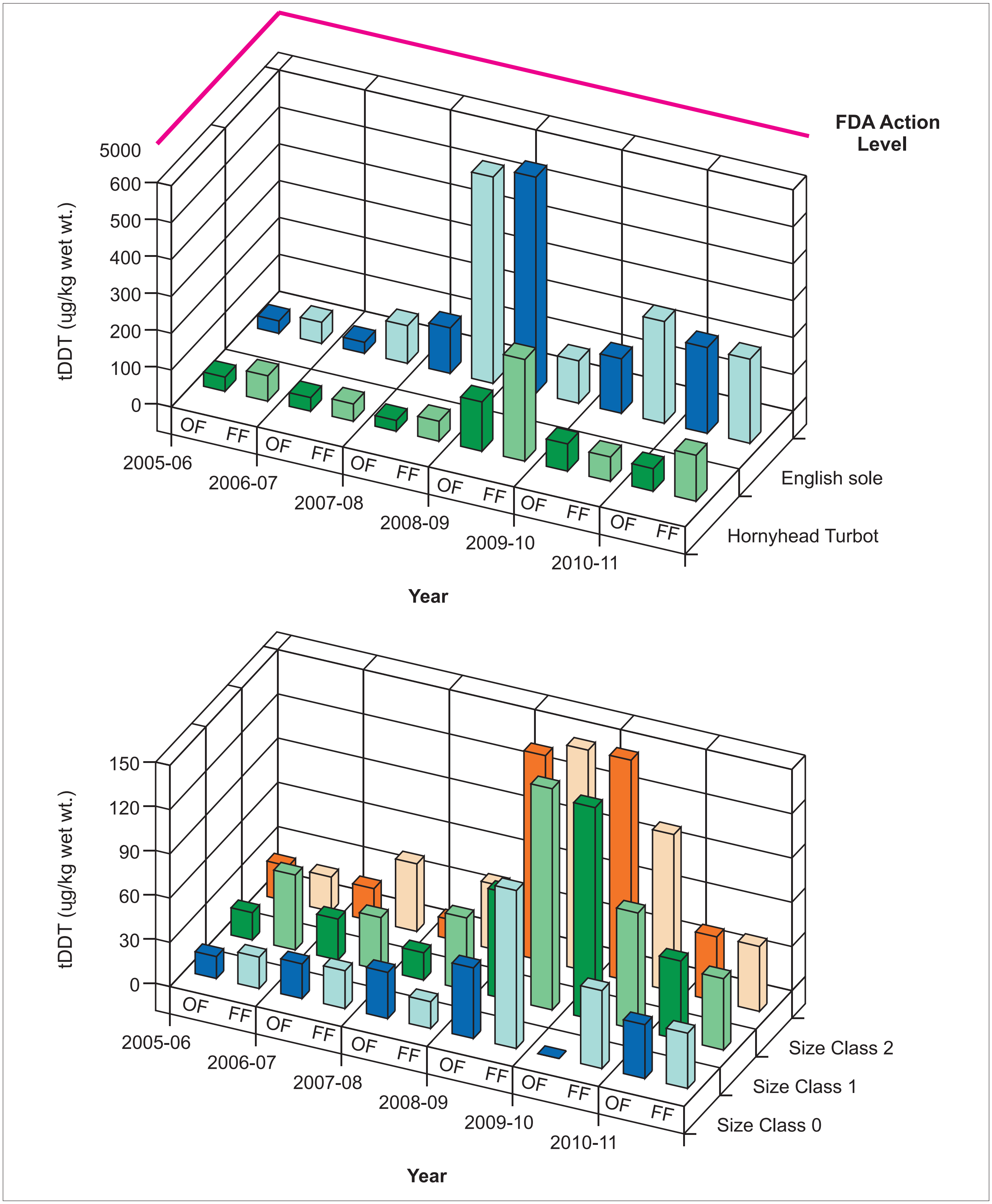

Figure 6-12. **Mean concentrations of total DDT (ug/kg wet weight) in hornyhead turbot (*Pleuronichthys verticalis*) muscle tissue, English sole (*Parophrys vetulus*) muscle tissue, and Pacific sanddab (*Citharichthys sordidus*) whole body tissue for size classes 0 (5–8 cm), 1 (9–13 cm), and 2 (14–16 cm) in January 2011 at outfall (OF) versus farfield (FF) sites.**
Data normalized to % lipids.

Orange County Sanitation District, California.

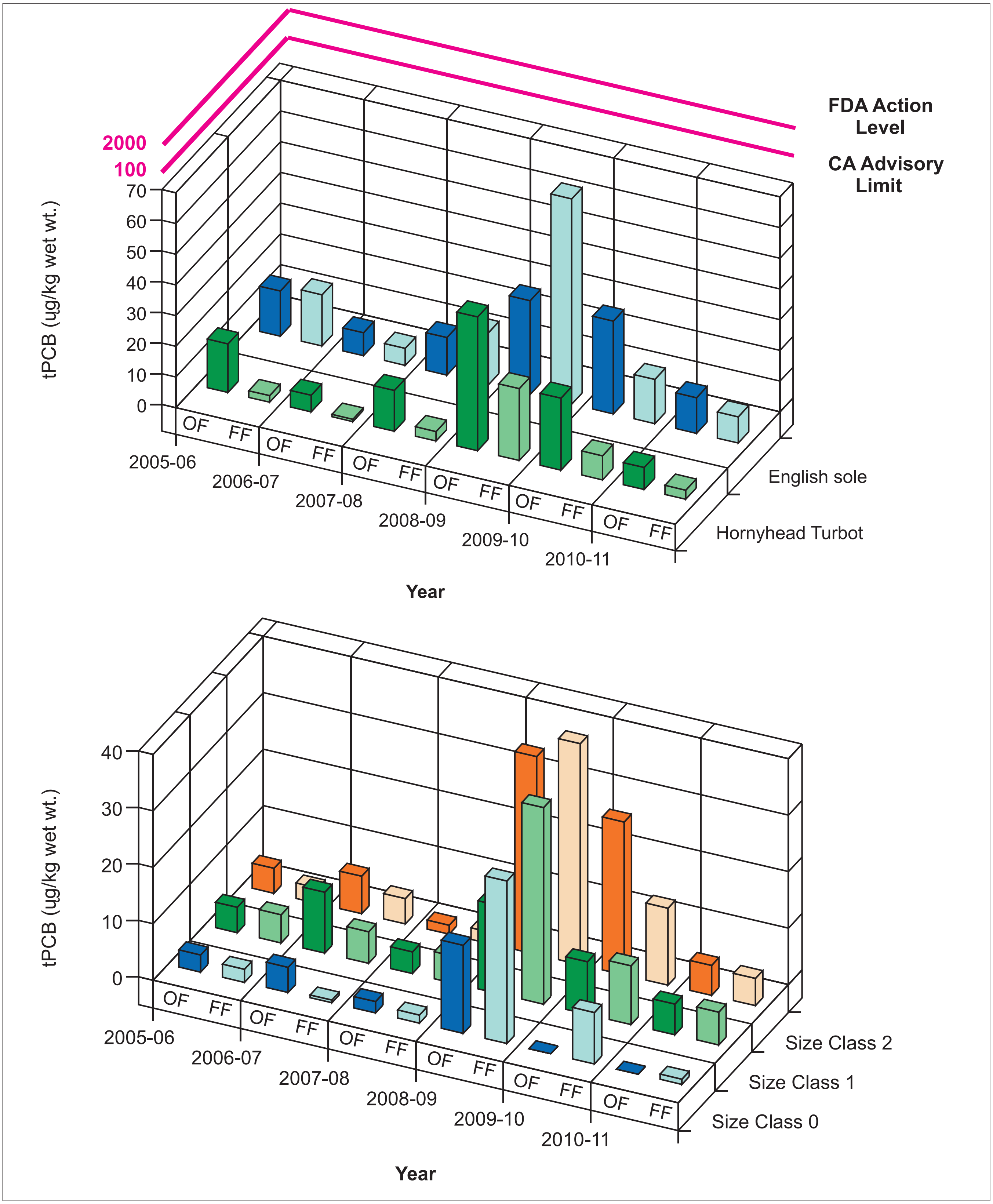

Figure 6-13. **Mean concentrations of total PCB (ųg/kg wet weight) in hornyhead turbot (*Pleuronichthys verticalis*) muscle tissue, English sole (*Parophrys vetulus*) muscle tissue, and Pacific sanddab (*Citharichthys sordidus*) whole body tissue for size classes 0 (5–8 cm), 1 (9–13 cm), and 2 (14–16 cm) in January 2011 at outfall (OF) versus farfield (FF) sites.**
Data normalized to % lipids.

Orange County Sanitation District, California.

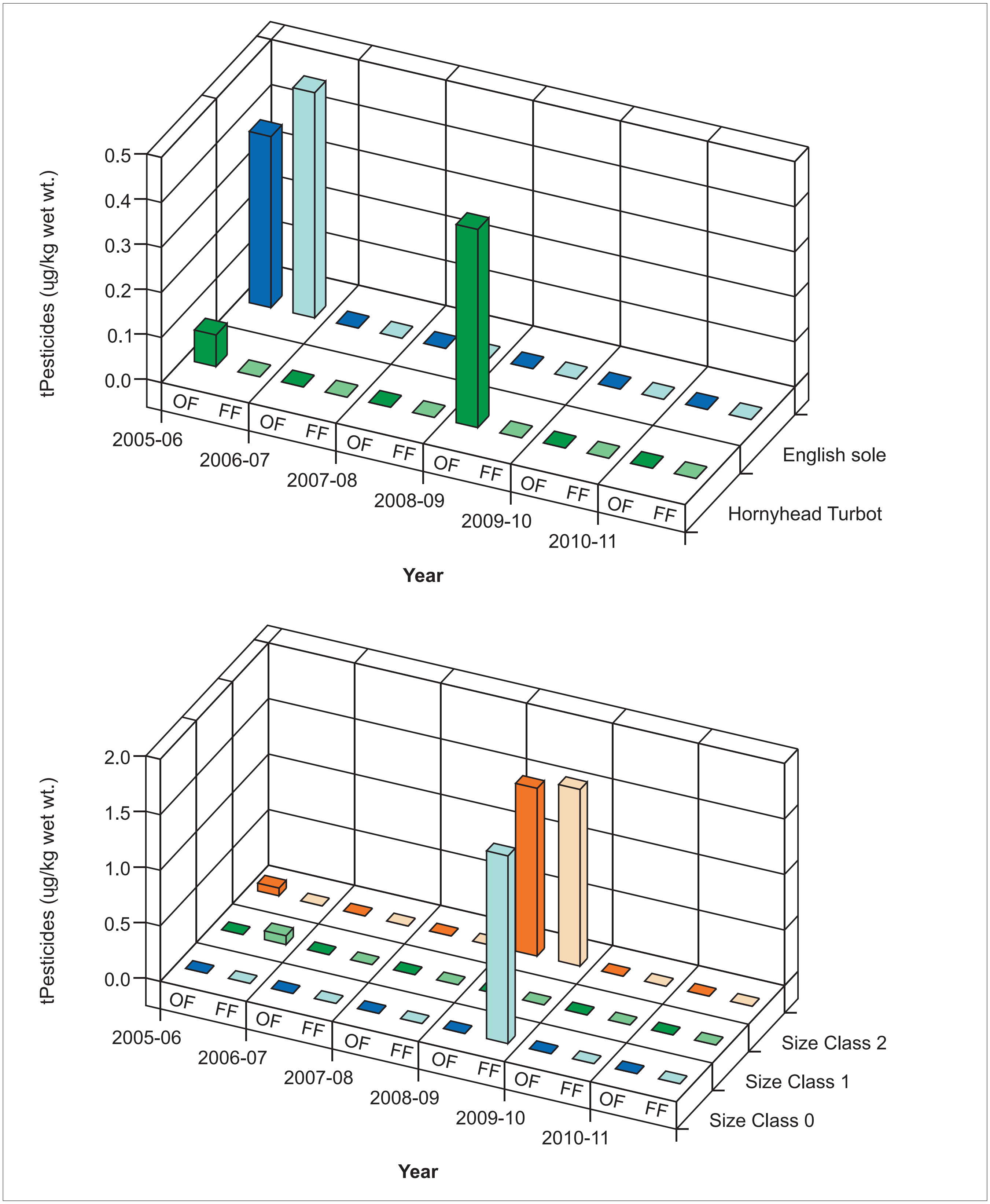

Figure 6-14. **Mean concentrations of total chlorinated pesticides (ųg/kg wet weight) in hornyhead turbot (*Pleuronichthys verticalis*) muscle tissue, English sole (*Parophrys vetulus*) muscle tissue, and Pacific sanddab (*Citharichthys sordidus*) whole body tissue for size classes 0 (5–8 cm), 1 (9–13 cm), and 2 (14–16 cm) in January 2011 at outfall (OF) versus farfield (FF) sites.**
Data normalized to % lipids.

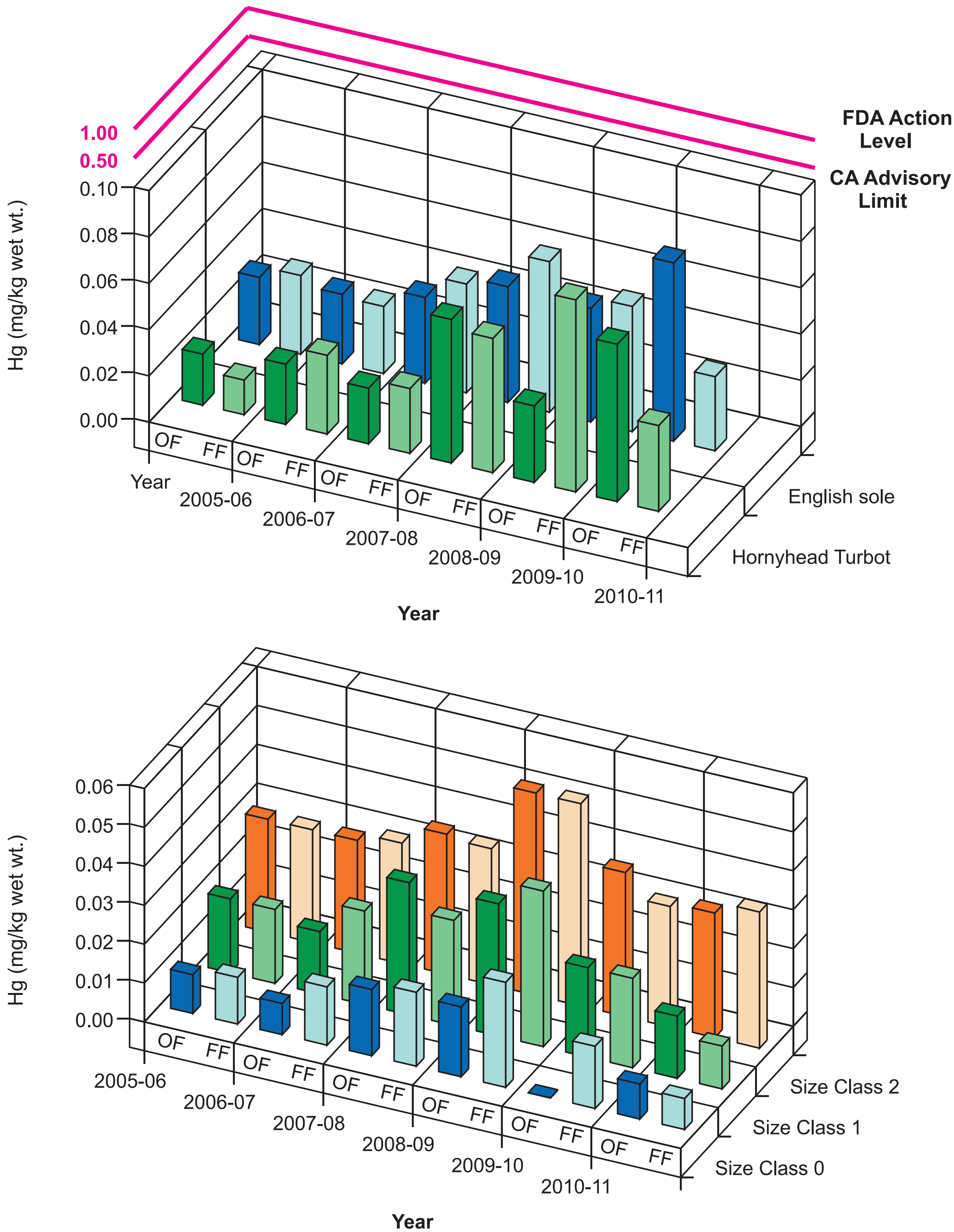

Figure 6-15. **Mean concentrations of mercury (mg/kg wet weight) in hornyhead turbot (*Pleuronichthys verticalis*) muscle tissue, English sole (*Parophrys vetulus*) muscle tissue, and Pacific sanddab (*Citharichthys sordidus*) whole body tissue for size classes 0 (5-8 cm), 1 (9-13 cm), and 2 (14-16 cm) in January 2011 at outfall (OF) versus farfield (FF) sites.**
Data normalized to % lipids.

Orange County Sanitation District, California.

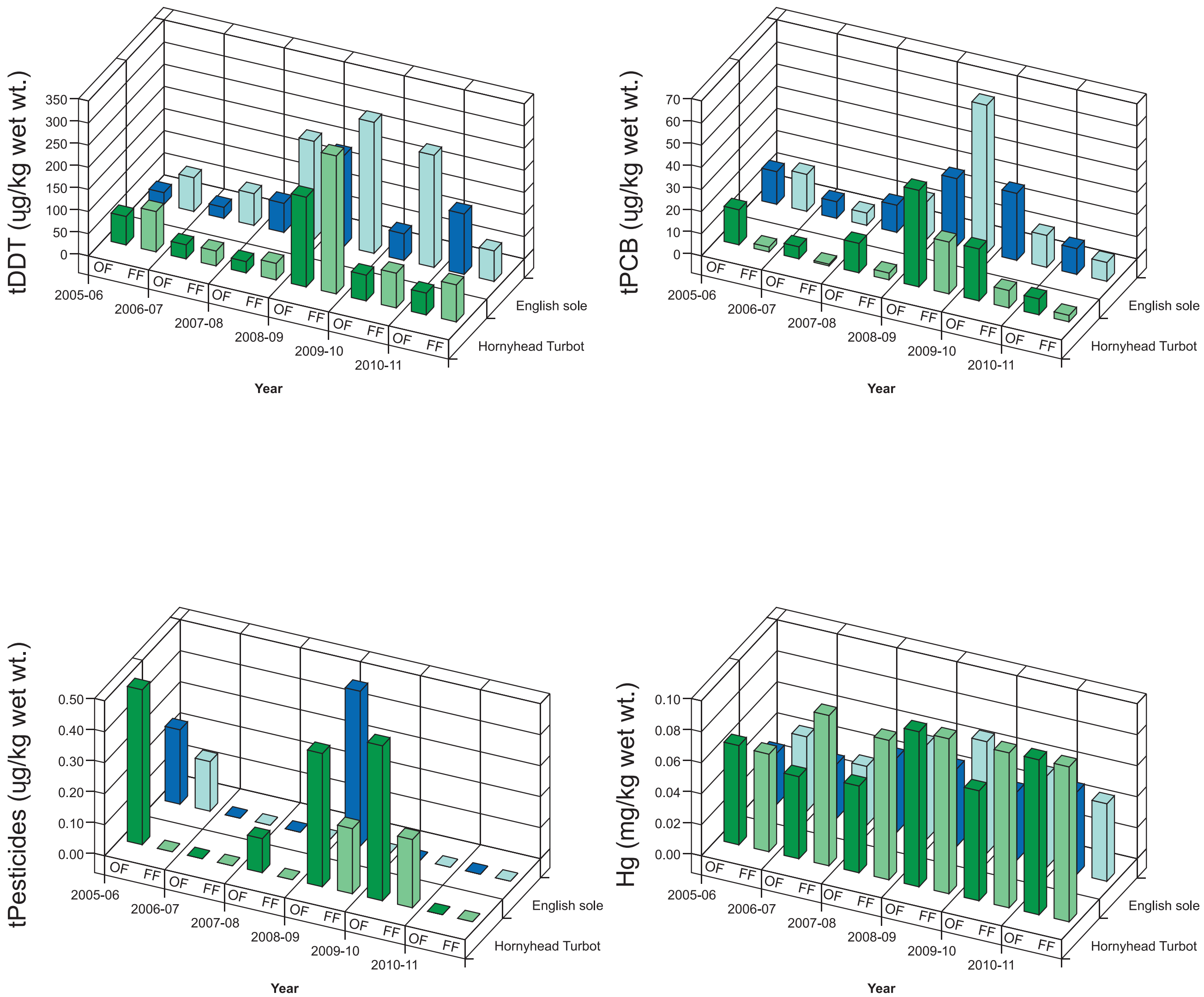

Figure 6-16. Mean concentrations of total DDT (ųg/kg wet weight), total PCBs (ųg/kg wet weight), total chlorinated pesticides (ųg/kg wet weight), and mercury (mg/kg wet weight) in hornyhead turbot (*Pleuronichthys verticalis*) and English sole (*Parophrys vetulus*) liver tissue in January 2011 at outfall (OF) versus farfield (FF) sites.
DDT, PCB, and chlorinated pesticides data normalized to % lipids.

Orange County Sanitation District, California.

lower than last year (Table 6-5; Figures 6-12 through 6-15

Long-term Trends

Muscle tissue contaminant data has been consistently collected and analyzed for hornyhead turbot since July 2004 and English sole and Pacific sanddabs since July 2005. Contaminant concentrations have been generally well below any action limits for all analytes, but certain contaminants have shown high interannual and interspecies variability.

Total DDT

Muscle tissue tDDT concentrations have been well below action limits in all three species with occasional periods of increased concentrations (e.g., in 2008-09; Figure 6-12). There has been no consistent pattern of higher concentrations of tDDT in fish collected at the outfall compared to the farfield site nor is there any relationship to age. Elevated station concentrations are usually due to high concentrations in one or two individuals with the majority of fish having low tissue levels. The highest tissue concentrations for hornyhead turbot and Pacific sanddab occurred in the 2008-09 monitoring year, while the highest tissue concentration in English sole occurred at the farfield site in 2007-08. There were no apparent reasons for the high values since there were no concomitant increases in sediment tDDT concentrations.

Total PCB

Tissue concentrations of tPCB showed a similar interannual pattern as tDDT for all three species (Figure 6-13). The highest concentrations in hornyhead turbot, English sole and pacific sanddab occurred in the 2008-9 monitoring year. Like tDDT, long-term trends were unrelated to sediment tPCB concentrations, though tPCB tissue and sediment levels are consistently higher at the outfall than at farfield sites.

Chlorinated Pesticides

Fish tissue samples were analyzed for 12 chlorinated pesticides other than DDT. Detection of these compounds in fish tissue is sporadic with more than half the annual surveys yielding results below the detection limit for all three species (Figure 6-14).

Mercury

Mercury tissue concentrations were comparable to previous years. Overall, mercury contamination has been fairly consistent since 2004-05 (Figure 6-15). Mercury concentrations in fish from outfall and farfield sites are generally comparable. The largest difference occurred in 2009-10 when the farfield hornyhead turbots had a mean concentration (0.083 mg/kg) almost three times that of outfall fish (0.033 mg/kg; Table 6-5).

Health Advisory Assessments

Mercury concentrations in hornyhead turbot and English sole muscle tissue samples were well below the Federal Food and Drug Administration (FDA) Action Level of 1.0 mg/kg and the California State Department of Health Services (CDHS) advisory limit of 0.5 mg/kg. All concentrations of tDDT and tPCB in muscle tissue samples were below the FDA Action Levels of 5,000 and 2,000 µg/kg, respectively, and state advisory limit for PCB of 100 µg/kg.

The State of California Office of Environmental Health Hazard Assessment (OEHHA) has published safe eating guidelines on several sport fish species from Ventura to San Mateo Point in south Orange County (OEHHA 2009). Mercury is the most common contaminant in southern California sport fish. Mercury has several sources into the environment including aerial deposition from coal-burning power plants and point sources, including wastewater discharge. DDT was also very common in fish tissues, but in relatively low concentrations except in white croaker on the Palos Verdes Shelf near Los Angeles.

PCBs are found in higher concentrations than DDT and are considered more of a regional human health concern due to fish consumption. DDT and PCBs are legacy contaminants that are still found in sediments from previous, now discontinued, discharges due to their long degradation times. In the region encompassing the District's outfall, Seal Beach Pier to San Mateo Point, 19 fish species have consumption advisories. However, no advisories exist based specifically on the District's wastewater discharge.

No human consumption advisory levels exist for whole-fish tissue, so human health risk could not be assessed for Pacific sanddab.

Regional Comparisons

The sanddab guild was used for tissue contaminant assessment in the Bight'98 survey and subsequently by the District for making a regional comparisons of the District's Pacific sanddab whole-fish tDDT, tPCB, and mercury data. Unfortunately, doing tissue chemistry on the sanddab guild has not continued in subsequent regional surveys.

In the Bight'98 regional study, 99% of all sanddab composites analyzed from SCB mainland shelf stations had detectable levels of tDDT, including 100% of both large POTW and non-POTW stations. Total DDT concentrations ranged from ND to 10,462 μg/kg at large POTW sites and 4.2 μg/kg to 1,061 μg/kg at non-POTW locations (Allen *et al.* 2002). In 2010-11, tDDT was detected in all Pacific sanddab composites tested with concentrations ranging from 36.74 μg/kg (outfall size class 0) to 62.90 μg/kg (outfall size class 1). In 2010-11, all Pacific sanddab composites collected by the District tested fell within the range of mainland shelf non-POTW tissue concentrations.

In the Bight'98 study, 46% of the sanddab guild samples from the mainland shelf stations had detectable tissue concentrations of tPCB (range = ND–710 μg/kg), while 72% of the large POTW stations and 40% of the non-POTW stations had detectable tissue concentrations of tPCB (range = ND–710 μg/kg and ND–105 μg/kg, respectively) (Allen *et al.* 2002). In the present survey, all Pacific sanddab composite samples were well below 6.9 ug/kg, and well within the range of mainland shelf non-POTW tissue concentrations.

The Outfall as an Epicenter for Fish Tissue Contamination

The mercury, tDDT, and tPCB values for all fish composites and the station means of composite samples (Table 6-5) are within the ranges of non-POTW strata within the SCB and do not show patterns of measured concentrations near the outfall. Consequently, the outfall does not seem to be causing degradation due to the bioaccumulation of contaminants in fish.

Parasites and Abnormalities

External Parasites and Abnormalities

External parasites and abnormalities, such as skeletal deformities, tumors, lesions, and abnormal coloring occurred in less than 1% of the fish collected. The most common occurrence was the presence of the parasitic eye copepod *Phrixocephalus cincinnatus*, which occurred in 1.1% (82 occurrences) of Pacific sanddabs and in less than 1% (1 occurrence) of slender sole (*Lyopsetta exilis*). This parasite was found at all of the 60 m and 137 m stations in both surveys, with the exception of T13 in summer. At the 40 m stations (T6 and T2) there was only one occurrence at Station T2 in summer. No outfall trend was evident. Only 15 of the 82 *P. cincinnatus* were found at T1 and the 1.5% incidence rate is within the range found regionally in the SCB (Perkins and Gartman 1997; Allen *et al.* 1998, 2002). *P. cincinnatus* is found throughout the SCB, most often occurring on Pacific sanddabs. Perkins and Gartman (1997) found that *P. cincinnatus* occurred in 1.4% of the Pacific sanddabs collected near SCB wastewater outfalls, while the SCB regional monitoring surveys found occurrences of 1.1% in 1994 and 3.5% in 1998 (Allen *et al*. 1998, 2002).

In addition to the parasitic eye copepod, five other abnormalities were found in 2010-11. One Dover sole collected at deep Station T14 was affected with a tumor. One other Dover sole collected at T10 had a lesion. Ambicolorism occurred in one Pacific sanddab collected at Station T3. One English sole at Station T13 had a deformity and one unidentified parasite was found in a single California skate collected at Station T2.

CONCLUSIONS

Community measures of the fish and EMI populations remained within historical ranges and concentrations of contaminants in fish were comparable to regional non-POTW values and below both state and federal human health advisory levels. However, the fish and EMI assemblages near the discharge site have changed, likely as a response to the same influences driving changes in the infaunal community (see Chapter 5). The outfall Station T1 fish community clustered separately from the other middle shelf stations due to low abundance of yellowchin sculpin and high abundances of Pacific sanddabs and English sole. Polychaete abundance has increased near the outfall and polychaete-eating fish, such as English sole and Pacific sanddab, have also increased in abundance at the outfall. Similarly, decreases in gammarid amphipods near the outfall are impacting fish that forage on them, like the yellowchin sculpin. Further, there is some evidence of a gradient effect, as T12 shows similar trends, although to a lesser extent than T1. Finally, diversity measures for the epibenthic macroinvertebrate communities near the outfall were lower than the other middle shelf stations in 2010-11.

While the fish abundance and cluster results indicate some impacts from the wastewater discharge, other assessments do not. For example, fish diversity, fish tissue, epibenthic macroinvertebrate abundance, and regional comparison results suggest that the outfall was not an epicenter of disease. Further, the species assemblages present near the outfall were representative of those found elsewhere on the southern San Pedro shelf.

Comparisons of tissue chemistry burdens between outfall and reference sites are complicated by evidence suggesting that there are no areas of the SCB sufficiently free of contamination to be considered a reference site (Brown et al. 1986). For example, Schiff and Allen (1997) concluded that 100% of certain flatfish species in the SCB are contaminated with DDT and PCB. Similarly, Mearns *et al.* (1991) found that there are no regional patterns in fish tissue mercury concentrations within the SCB.

Comparison between sites is further complicated by the transitory nature of fishes. In making these comparisons we assume that the location of capture is also the location of exposure. Generally, concentrations of contaminants in fish tissues are highest in fish residing near the source of the contaminant (Mearns *et al.* 1991). However, demersal fish with large ranges may transport contaminants away from the source or be captured away from the primary location of exposure (Allen 2006b). Little is known about the migratory patterns of the fish species used in the District's ocean monitoring program. Immigration of fish into the monitoring area may account for the occasional high tissue concentrations of some contaminants (e.g., DDT and PCB).

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