chapter 6

TRAWL COMMUNITIES AND ORGANISM HEALTH

Chapter 6

TRAWL COMMUNITIES AND ORGANISM HEALTH

INTRODUCTION

The Orange County Sanitation District (District) Ocean Monitoring Program (OMP) conducts semi-annual trawls to collect fish and large invertebrates that live on or near the soft bottom habitat surrounding the District's ocean outfall (Figure 6-1, Table A-1). These demersal fish and epibenthic macroinvertebrates (EMI) are targeted to assess potential effects of the wastewater discharge on marine communities within the monitoring area. 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 or contaminated fish (see box below).

The NPDES permit also specifies several parameters for monitoring fish and invertebrate communities (e.g., species diversity, abundance). These community parameters are known to be highly variable over time and across sampling stations, and it can be difficult to distinguish discharge effects from those caused by natural environmental fluctuations and/or other anthropogenic impacts. Therefore, the OMP uses a multiple lines of evidence approach to assess discharge effects on marine communities. This approach includes examining the data we collect for typical depth and seasonal trends observed in healthy communities. We use spatial analyses to identify whether community parameters at outfall stations group separately from other stations in the monitoring area, provide regional and historical comparisons, measure improvement or degradation through the use of biointegrity indices, and analyze individual fish health and tissue contamination levels relative to background levels and human health consumption guidelines.

Receiving water compliance criteria pertaining to biological communities contained in section V.A.4 of the District's NPDES Ocean Discharge Permit (Order No. RS-2012-0035, Permit No. CA011 0604).

V.A.4.a. Marine communities, including vertebrates, invertebrates, and algae shall not be degraded.

V.A.4.b. The natural taste, odor, and color of fish, shellfish, or other marine resources used for human consumption shall not be altered.

V.A.4.c. 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.

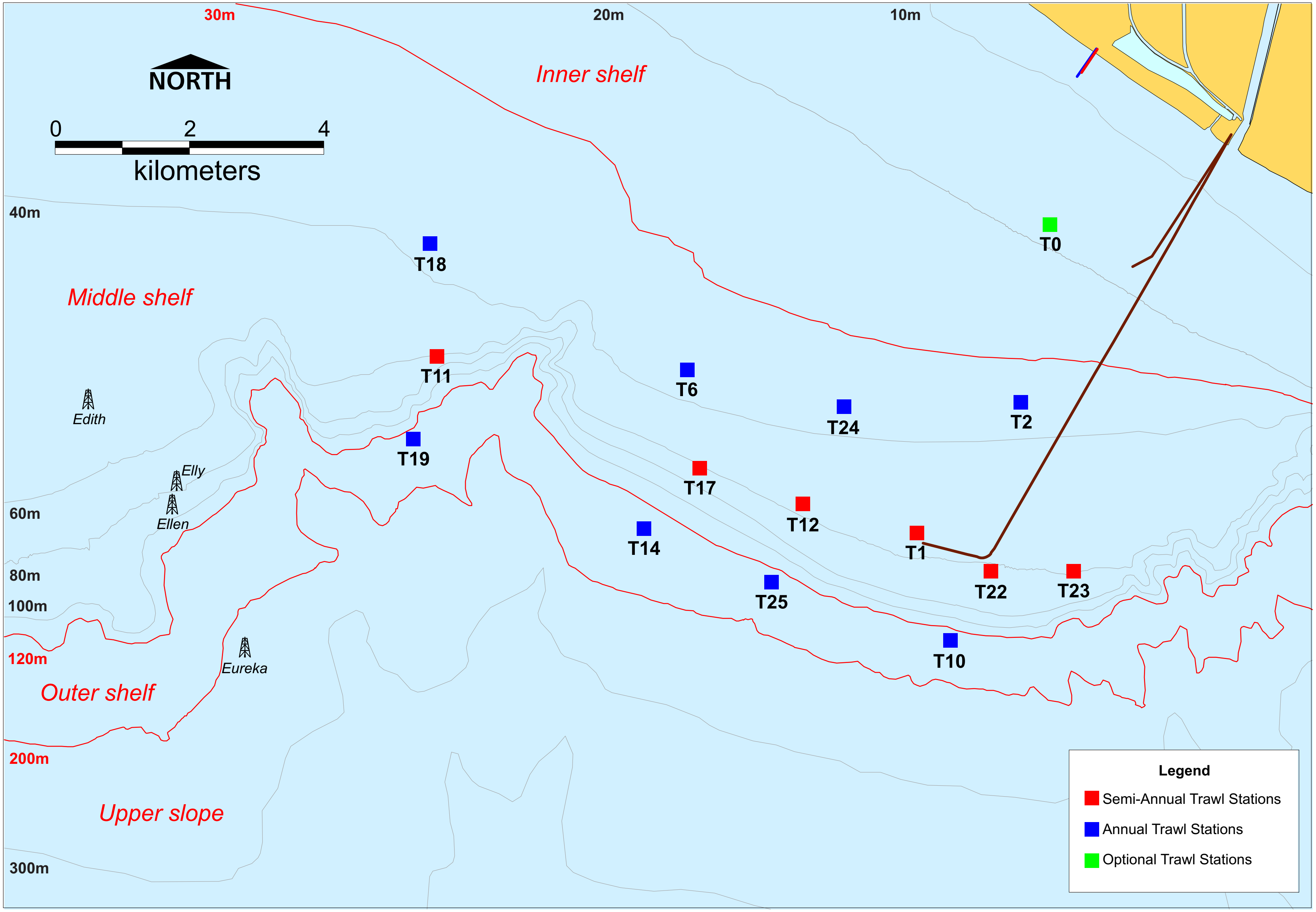

Figure 6-1. **Otter trawl stations for annual and semi-annual surveys, 2012-13.**

Orange County Sanitation District, California.

Historically, high levels of organic effluent particles resulted in poor water and sediment quality near southern California wastewater discharge sites (Schiff *et al.* 2000). This in turn resulted in high levels of fish tissue contaminants, a higher incidence of tumors and lesions on fish that were associated with the outfall, and altered fish and EMI communities (Allen 1977, 2006; Schiff *et al.* 2000). Although ecological conditions and compliance with receiving water conditions has considerably improved relative to historical conditions (Stein and Cadien 2009), the persistence of lipid-soluble (lipophilic) compounds can still pose problems to the marine environment today. Chlorinated pesticides (e.g., DDT) and polychlorinated biphenyls (PCBs) are two examples of highly persistent compounds that can bioaccumulate in tissues and biomagnify through the food chain to concentrations several orders of magnitude higher than in surrounding sediments or water. These high tissue contaminant concentrations may pose a human health risk and may result in greater susceptibility of marine organisms to disease or reproductive impairment (Arkoosh *et al.* 1998).

The 2012-13 ocean monitoring results for trawl communities and organism health are intended to address the following aspects of permit compliance: 1) are there temporal and/or spatial patterns in the demersal fish and epibenthic macroinvertebrate 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) were collected in July-August 2012 and March-April 2013 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. Single hauls were conducted at 15 stations located along four depth contours within the three shelf zones: 18 m on the Inner shelf, 36 m and 60 m on the Middle shelf, and 137 m on the Outer shelf; Figure 6-1, Table A-1. Although seven new stations were added to the NPDES permit in 2013 (T17, T18, T19, T22, T23, T24, T25), four of these were previously sampled in 2011-12 prior to the permit being finalized (T17, T18, T19, T22). Stations T0, T3, and T13 were removed from the permit (see OCSD 2013). Also as a result of the new permit, only the six middle shelf stations are sampled during winter semi-annual monitoring. Station T0 is an historical trawl station near the short 78” emergency outfall; it was sampled during the 2012 summer semi-annual monitoring to maintain the long-term record of fish and EMI abundance at this site and as a component to the J-112 outfall diversion project (see Chapter 7).

Trawl caught specimens were identified to the lowest possible taxon, typically to species. A minimum of 15 individuals of each fish species were measured individually to the nearest millimeter and weighed to the nearest gram. Species with abundance greater than 15 individuals were enumerated in 1-cm size classes and batch weighed. All fish specimens were examined for external tumors, other lesions, parasites, and skeletal deformations since gross external manifestations may indicate contaminated sediments (Murchelano 1982). We do not inspect individuals for isopods (*Elthusa* sp.), because they are easily detached from their host in trawls. The first 100 EMI of each species were enumerated and weighed to the nearest gram. Species 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 in the laboratory.

Hornyhead Turbot (*Pleuronichthys verticalis*) and English Sole (*Parophrys vetulus*) were targeted for bioaccumulation analyses during trawls at Stations T1 (nearfield) and T11 (farfield) since they are common southern California demersal fishes and have been used in other bioaccumulation studies. For human health risk assessment, rockfishes and California Scorpionfish (*Scorpaena guttata*) were targeted at the outfall (Zone 1) and a reference area (Zone 2; Table A-1) using hook-and-line fishing gear ("rig fishing"). The rockfishes and California scorpionfish are also demersal and are frequently caught and consumed by recreational anglers.

The sampling objective for both efforts was to collect 10 individuals of each target species for analysis of liver and muscle (bioaccumulation analysis) contaminant concentrations (bioaccumulation analysis) and 10 additional individuals of each target species/family for analysis of muscle contaminants only (human health risk) The analytes measured included mercury, total DDT (tDDT; the sum of seven DDT isomers), total PCB (tPCB; the sum of 44 PCB congeners), and eight other chlorinated pesticides (heptachlor, heptachlor epoxide, trans-chlordane, cis-chlordane, trans-nonachlor, cis-nonachlor, dieldrin, oxychlordane). For the 2012 permit revision, five compounds were removed from the other chlorinated compounds constituent list (aldrin, endrin, gamma-BHC, hexachlorobenzene, and mirex) and one new compound was added (oxychlordane).

The current Food and Drug Administration (FDA) action level for tDDT in edible fish tissue (i.e., muscle tissue) is 5000 µg/kg, the tolerance level for PCBs is 2000 µg/kg, the action level for methylmercury is 1 mg/kg, and the action level for other chlorinated pesticides (including dieldrin, chlordane, heptachlor, and heptachlor epoxide) is 300 µg/kg (FDA 2011).

The State of California Office of Environmental Health Hazard Assessment (OEHHA) has published advisory tissue levels (ATLs) for selected fish contaminants based on cancer or non-cancer risk using an 8-oz serving size prior to cooking (Klasing and Brodberg 2008). The no consumption ATLs for DDTs and PCBs are 2,100 and 120 µg/kg, respectively (based on non-cancer risk). The no consumption ATL for methylmercury for women aged 18-45 years and children ages 1-17 years is 0.44 mg/kg, and the no consumption ATL for methylmercury for women over 45 years and men is 1.31 mg/kg (based on non-cancer risk). No consumption ATLs for chlordane and dieldrin are 560 and 46 µg/kg (based on cancer risk), respectively.

Data Analyses

Fish and EMI populations were summarized for total abundance, total number of species, percent abundance, and frequency of occurrence (by haul). In addition, abundance per haul, abundance per occurrence, biomass, number of species, and diversity indices including Shannon-Wiener (H'), and Swartz's 75% Dominance Index (SDI) were calculated for both fish and EMI by survey and station. 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). For community measures, T1 (a historical station) and T22 (a newer station) were considered nearfield (= outfall) stations since both are within close proximity to the outfall (i.e., occurring within 250 m of the diffuser end of the outfall pipe) on the upcoast and downcoast ends, respectively. To assess potential outfall effects on community parameters we plotted the non-outfall mean relative to the outfall mean for only the middle shelf (60 m) stations since depth can influence differences in community parameters.

PRIMER v6 (2001) multivariate statistical software was used to examine the spatial patterns of the fish assemblages in the District's monitoring area (Clarke 1993, Warwick 1993). These spatial patterns are examined for the presence of a distinct assemblage driven by the presence of the outfall. Analysis consisted of hierarchical clustering with group-average linking based on Bray-Curtis similarity indices. Data were totaled by station and season and truncated to include only the middle shelf (60 m) stations since depth is a strong environmental factor in delineating station clusters (Clarke and Warwick 2001, OCSD 2004, 2011). Prior to the calculation of the Bray-Curtis indices, the data were fourth-root transformed to down-weight the highly abundant species and incorporate the importance of the less common species (Clarke and Warwick 2001). The SIMPROF ("similarity profile") test was used to test for significant clustering of groups. The SIMPER ("similarity percentages") analysis was used to identify the species contributing the most to the percent similarity and dissimilarity among and between groups.

Fish biointegrity was assessed using the fish response index (FRI; Allen *et al.* 2001). The Fish Response Index is a biointegrity index that uses 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 Southern California Bight (SCB). FRI scores less than 45 are classified as reference (normal) and those greater than 45 are non-reference (abnormal or disturbed). The mean FRI was also calculated for the six middle shelf stations sampled during summer and winter monitoring in 2012-13.

For historical perspective, we examined long-term temporal and spatial patterns from 1985-2013 in: 1) summer abundance per haul at middle shelf stations for the five most abundant fish and EMI species sampled in 2012-13, 2) community measures from one nearfield (T1) and farfield (T11) station 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, 2011), and 3) fish biointegrity indices at T1 and T11.

Fish tissue contaminants were analyzed to assess their potential to bioaccumulate in liver and muscle tissue. To evaluate human health risks from eating potentially contaminated fish, muscle tissue concentrations were compared to federal and state fish tissue action/advisory levels. Contaminant levels were also compared between nearfield (T1) and farfield (T11) stations and examined for temporal trends in recent years (2005–2012). These data, with the exception of mercury, were lipid-normalized prior to the calculation of summary statistics to reduce within sample variability; organics concentrate in lipid tissue and lipid tissue concentrations vary considerably among individuals and species. Non-detect 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 relative to the early 1970s (Allen *et al.* 2007).

RESULTS AND DISCUSSION

Fish Community

Abundance

A total of 11,822 fish were collected in 2012-13 (Tables 6-1, 6-2, and B6). Pacific Sanddab (*Citharichthys sordidus*; 46%), Longspine Combfish (*Zaniolepis latipinnis*; 14%), California Lizardfish (*Synodus lucioceps*; 12%), and Yellowchin Sculpin (*Icelinus quadriseriatus*; 6%) were the most abundant fish collected, representing 78% of the total catch. Of the 19 families represented, Paralichthyidae (sand flounders), Hexagrammidae (greenlings), Synodontidae (Lizardfish), Pleuronectidae (right-eye flounders), and Cottidae (sculpins) accounted for 41% of the species and 90% of the total abundance (Tables 6-2 and B-7). Although Scorpaenidae accounted for only 3% of the individuals, this family comprised the highest percentage of the total number of species. Fish abundance has historically been highly variable, although some patterns are consistent (see OCSD 2011 Figure 6-2); the shallower stations typically have the lowest abundances, while the deep and farfield downcoast stations have the highest abundances. Depth-related abundance patterns in 2012-13 were generally consistent with previous years, although T25 (summer semi-annual station) had lower abundance relative to the other deeper stations as a result of fewer species in the catch there (Figure 6-2). The middle shelf stations generally had higher abundance in the winter. Within the middle shelf, mean fish abundance at the outfall and non-outfall stations were more similar in the winter.

Biomass

A total of 325 kg of fish was collected in 2012-13, with Pacific Sanddab accounting for 52% of the fish biomass (Table B-7). As with abundance, biomass data were highly variable (ranging from 2 to 46 kg per haul) due to population fluctuations of dominant species and variability in the size of individuals collected at each station. Mean biomass per survey was greater in winter than summer (Figure 6-2) due to large catches of Pacific Sanddab at T1, T12, T22, and T23 and Longspine Combfish at T11 and T23. Although fish abundance at the outfall stations was generally similar to the non-outfall stations, fish biomass at the outfall stations was highest in both summer (T1) and winter (T22). This trend was due to the presence of large Pacific Sanddab at these stations during both surveys.

Higher fish biomass near the outfall 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. However, the quality of the effluent has greatly improved over time, with smaller and lighter particles being transported further away from the outfall. Thus, higher biomass near the outfall may be more indicative of reef effects rather than discharge effects.

Table 6-1. Summary of demersal fish species collected by trawl during the summer (July/August 2012) and winter (March/April 2013) surveys. Data for each species are expressed as total abundance (Total), percent abundance (%A), percent frequency of occurrence (%FO), mean abundance per haul (MAH) and mean abundance per occurrence (MAO).

Orange County Sanitation District, California.

Scientific name	Common name	Total	%A	%FO	MAH	MAO
Citharichthys sordidus	Pacific Sanddab	5,488	46	95	261	274
Zaniolepis latipinnis	Longspine Combfish	1,606	14	86	76	89
Synodus lucioceps	California Lizardfish	1,439	12	100	69	69
Icelinus quadriseriatus	Yellowchin Sculpin	674	6	67	32	48
Parophrys vetulus	English Sole	455	4	95	22	23
Citharichthys stigmaeus	Speckled Sanddab	347	3	24	17	69
Zalembius rosaceus	Pink Seaperch	219	2	52	10	20
Symphurus atricaudus	California Tonguefish	207	2	62	10	16
Sebastes saxicola	Stripetail Rockfish	185	2	24	9	37
Pleuronichthys verticalis	Hornyhead Turbot	171	1	95	8	9
Hippoglossina stomata	Bigmouth Sole	156	1	76	7	10
Porichthys notatus	Plainfin Midshipman	132	1	67	6	9
Microstomus pacificus	Dover Sole	126	1	67	6	9
Lyopsetta exilis	Slender Sole	108	1	19	5	27
Chitonotus pugetensis	Roughback Sculpin	81	1	57	4	7
Citharichthys xanthostigma	Longfin Sanddab	67	1	33	3	10
Zaniolepis frenata	Shortspine Combfish	65	1	33	3	9
Sebastes semicinctus	Halfbanded Rockfish	53	<1	33	3	8
Lycodes pacificus	Blackbelly Eelpout	52	<1	24	2	10
Odontopyxis trispinosa	Pygmy Poacher	43	<1	62	2	3
Scorpaena guttata	California Scorpionfish	24	<1	19	1	6
Sebastes sp.	rockfish genus (UI)	23	<1	19	1	6
Ophiodon elongatus	Lingcod	23	<1	33	1	3
Raja inornata	California Skate	18	<1	48	1	2
Sebastes dallii	Calico Rockfish	16	<1	29	1	3
Chilara taylori	Spotted Cusk-eel	11	<1	33	1	2
Sebastes elongatus	Greenstriped Rockfish	10	<1	14	<1	3
Sebastes serriceps	Treefish	3	<1	10	<1	2
Agonopsis sterletus	Southern Spearnose Poacher	2	<1	10	<1	1
Eopsetta jordani	Petrale Sole	2	<1	10	<1	1
Genyonemus lineatus	White Croaker	2	<1	10	<1	1
Sebastes eos	Pink Rockfish	2	<1	10	<1	1
Sebastes levis	Cowcod	2	<1	5	<1	2

Table 6-1 continues.

Table 6-1 Continued.

Scientific name	Common name	Total	%A	%FO	MAH	
Xystreurys liolepis	Fantail Sole	2	<1	5	<1	2
Argentina sialis	Pacific Argentine	1	<1	5	<1	1
Cymatogaster aggregata	Shiner Perch	1	<1	5	<1	1
Merluccius productus	Pacific Hake	1	<1	5	<1	1
Paralabrax nebulifer	Barred Sand Bass	1	<1	5	<1	1
Physiculus rastrelliger	Hundred-fathom Codling	1	<1	5	<1	1
Pleuronichthys decurrens	Curlfin Sole	1	<1	5	<1	1
Sebastes miniatus	Vermilion Rockfish	1	<1	5	<1	1
Torpedo californica	Pacific Electric Ray	1	<1	5	<1	1
	Total	11,822				
	Total no. of species	42				

n = 21 hauls
UI – Unidentified
* Unidentified species are not included in the total number of species calculation

Table 6-2. Number of species and total abundance summarized by demersal fish family for the summer (July/August 2012) and winter (March/April 2013) OCSD monitoring surveys.

Orange County Sanitation District

Family	Number of Species		Abundance	
	Total	Percentage	Total	Percentage
Paralichthyidae – sand flounders	5	12	6,060	51
Hexagrammidae – greenlings	3	7	1,694	14
Synodontidae – lizardfishes	1	2	1,439	12
Pleuronectidae – righteye flounders	6	15	863	7
Cottidae – sculpins	2	5	755	6
Scorpaenidae – scorpionfishes	10	22	319	3
Embiotocidae – surfperches	2	5	220	2
Cynoglossidae – tonguefishes	1	2	207	2
Batrachoididae – toadfishes	1	2	132	1
Zoarcidae – eelpouts	1	2	52	< 1
Agonidae – poachers	2	5	45	< 1
Rajidae – skates	1	2	18	< 1
Ophidiidae – cusk-eels	1	2	11	< 1
Sciaenidae – drums and croakers	1	2	2	< 1
Argentinidae – argentines	1	2	1	< 1
Merlucciidae – merlucciid hakes	1	2	1	< 1
Moridae – codlings	1	2	1	< 1
Serranidae – sea basses	1	2	1	< 1
Torpedinidae – torpedo electric rays	1	2	1	< 1
Total	42	100	11,822	100

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

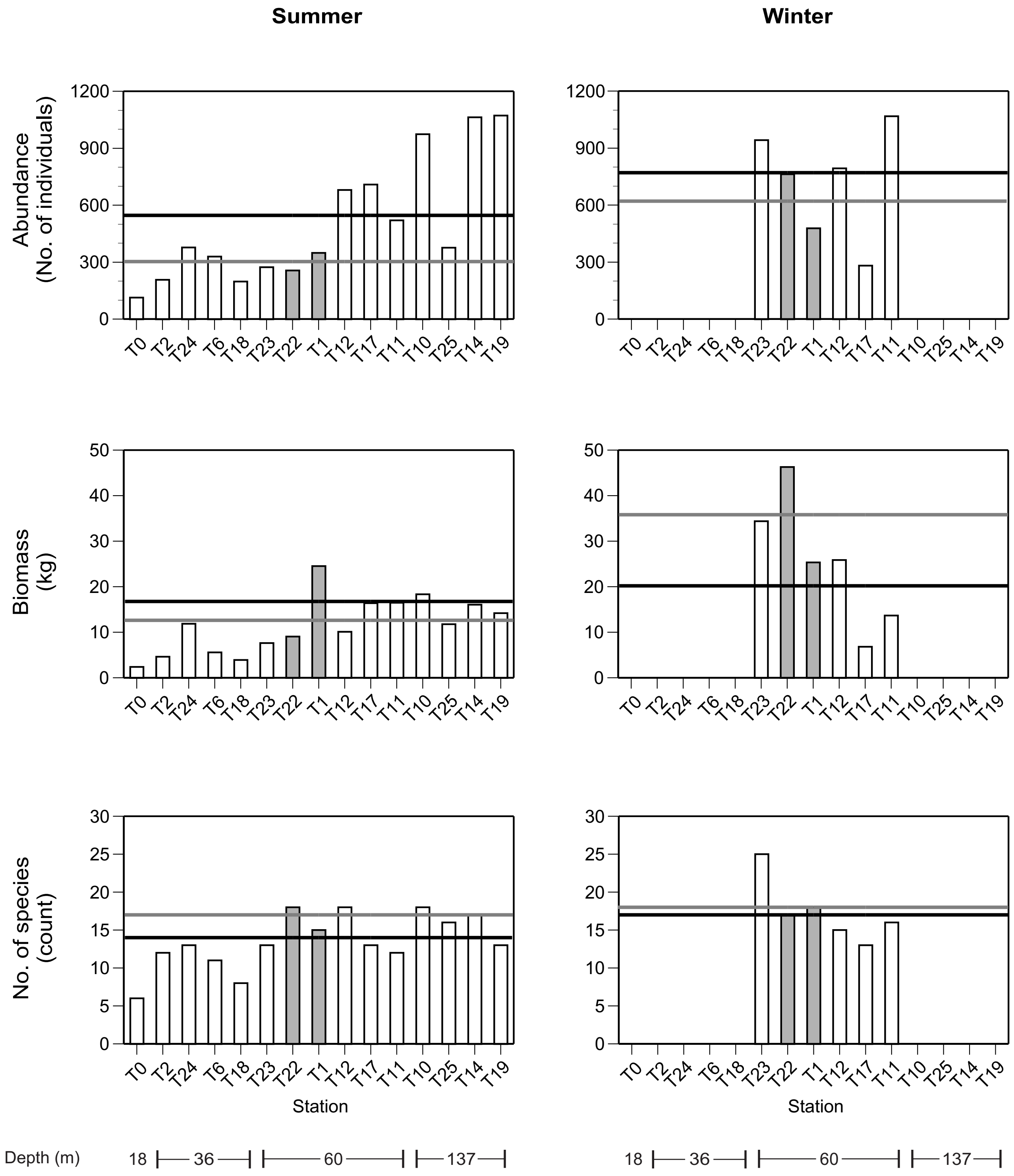

Figure 6-2. **Abundance, biomass, and number of species for demersal fishes collected by trawl during the summer (July/August 2012) and winter (March/April 2013) OCSD monitoring surveys.** Nearfield (outfall) Stations T1 and T22 indicated in gray. Survey 60 m non-outfall mean denoted by black line, 60 m outfall mean denoted by gray line.
Note: Only the 60 m stations were sampled during the winter survey.

Orange County Sanitation District, California.

Number of Species

A total of 42 fish species representing 19 families was collected in the District's study area in 2012-13 (Tables 6-1, 6-2, and B-6). California Lizardfish occurred in all of the trawls, while Pacific Sanddab, English Sole (*Parophrys vetulus*), and Hornyhead Turbot (*Pleuronichthys verticalis*) occurred in 95% of the trawls. In contrast, Speckled Sanddab (*Citharichthys stigmaeus*), the sixth most abundant species, occurred in 24% of the trawls (Table 6-1). During 2012-13, the number of species per station ranged from 6 to 25 (Figure 6-2 and Table B-6). Across depth zones, the fewest numbers of species generally occur within the shallowest station group (see OCSD 2010 Figure 6-3). The summer survey of 2012-13 followed this pattern; however, only the middle shelf stations were sampled in the winter semi-annual survey. Within this middle shelf station group, the mean number of species at the outfall had values close to the non-outfall mean in both summer and winter, suggesting no influence of the outfall on the number of species sampled in this depth zone. Differences within this station group were minimal between seasons.

Diversity

There was no evidence of significant impact on species diversity near the outfall (Stations T1 and T22; Figure 6-3). H' values at Stations T1 and T22 were comparable to the other 60 m stations. Station T22 in winter had a low H' due to a disproportionate catch of Pacific Sanddab (600 individuals); the next closest in abundance was Longspine Combfish with 55 individuals).

SDI followed the same pattern across stations and surveys as H' except the summer 60 m non-outfall and outfall means were not identical; the outfall mean was lower in the summer and slightly higher in the winter. Nevertheless, these trends do not represent meaningful differences and indicate similar diversity across the middle shelf station group.

Spatial analysis

In the previous year's annual report (2011-12), the fish community at outfall Station T1 clustered separately from the other middle shelf stations in the summer survey suggesting an altered fish community at the outfall (see OCSD 2013 Figure 6-4). However, cluster analysis on the 2012-13 trawl fish abundance data at the middle shelf stations resulted in a single station group with 63% similarity, indicating that all of the 60 m stations had a similar fish assemblage regardless of sampling season or other factors such as proximity to the outfall (Figure 6-4). This station group was corroborated through non-metric multidimensional scaling (MDS) using 4^{th} root transformed data and Bray-Curtis similarity as the resemblance matrix. The output stress was low (2D = 0.11; 3D = 0.05) indicating good ordination.

SIMPER characterized the 2012-13 60 m fish community by the following species assemblage (Table 6-3): Pacific Sanddab, Longspine Combfish, California Lizardfish, Yellowchin Sculpin, English Sole, Plainfin Midshipman (*Porichthys notatus*), California Tonguefish (*Symphurus atricaudus*), Hornyhead Turbot, Pink Seaperch (*Zalembius rosaceus*), and Bigmouth Sole (*Hippoglossina stomata*). Although cluster and MDS suggested some separation of the cluster group by season (64% similarity) and further structuring within season (74% similarity; Figure 6-4), this spatial structuring of sub-clusters was not deemed significant by the SIMPROF test. The high similarity among sub-clusters was evident in the relatively small number of species (15) comprising the top 10 abundance ranks across groups (Table 6-3).

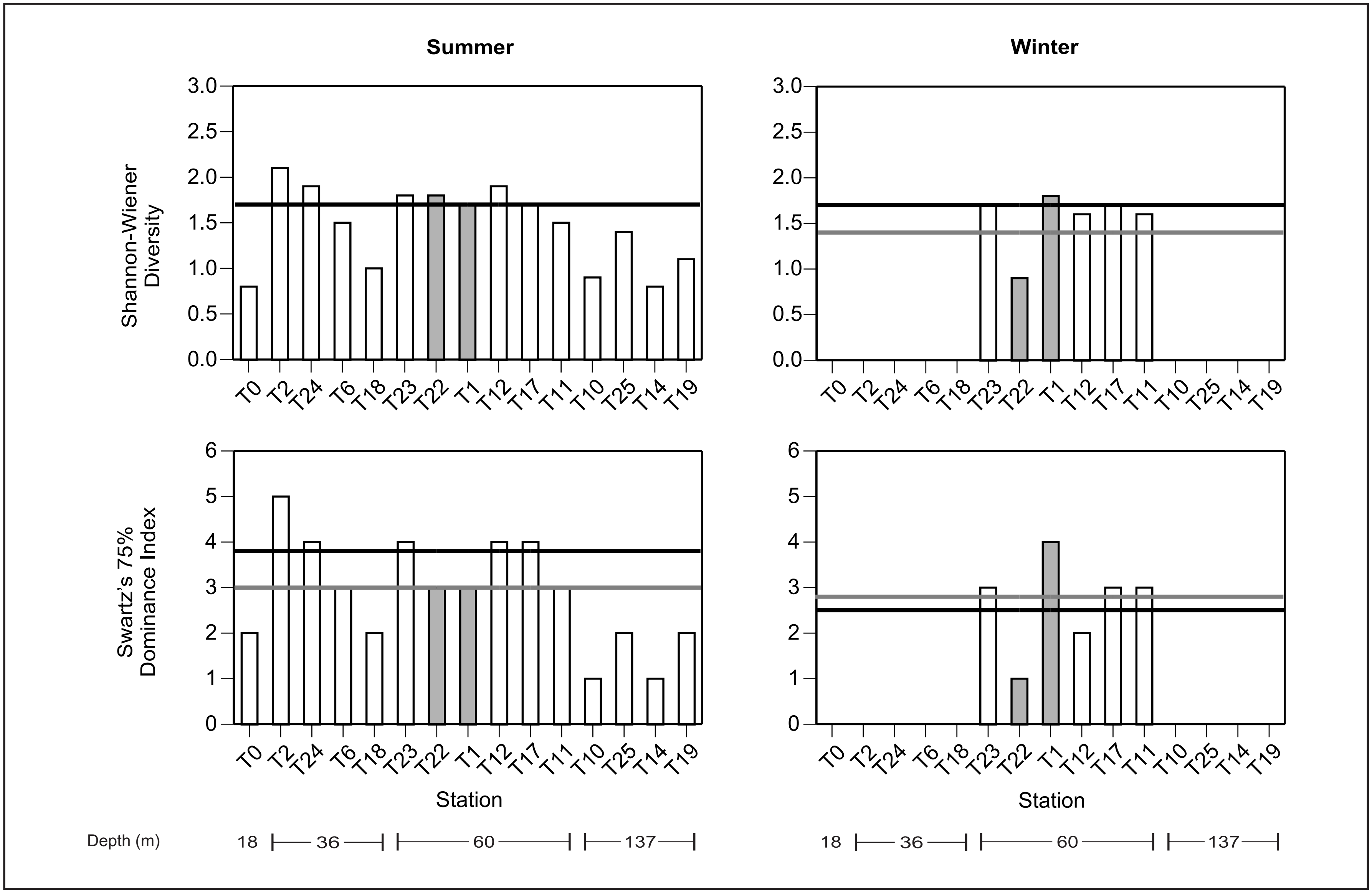

Figure 6-3. **Shannon-Wiener Diversity Index and Swartz's 75% Dominance Index of demersal fishes collected by trawl during the summer (July/August 2012) and winter (March/April 2013) OCSD monitoring surveys.**
Nearfield (outfall) Stations T1 and T22 indicated in gray. Survey 60 m non-outfall mean denoted by black line, 60 m outfall mean denoted by gray line. Means were identical where only a single line is visible. Note: Only the 60 m stations were sampled during the winter survey.

Orange County Sanitation District, California.

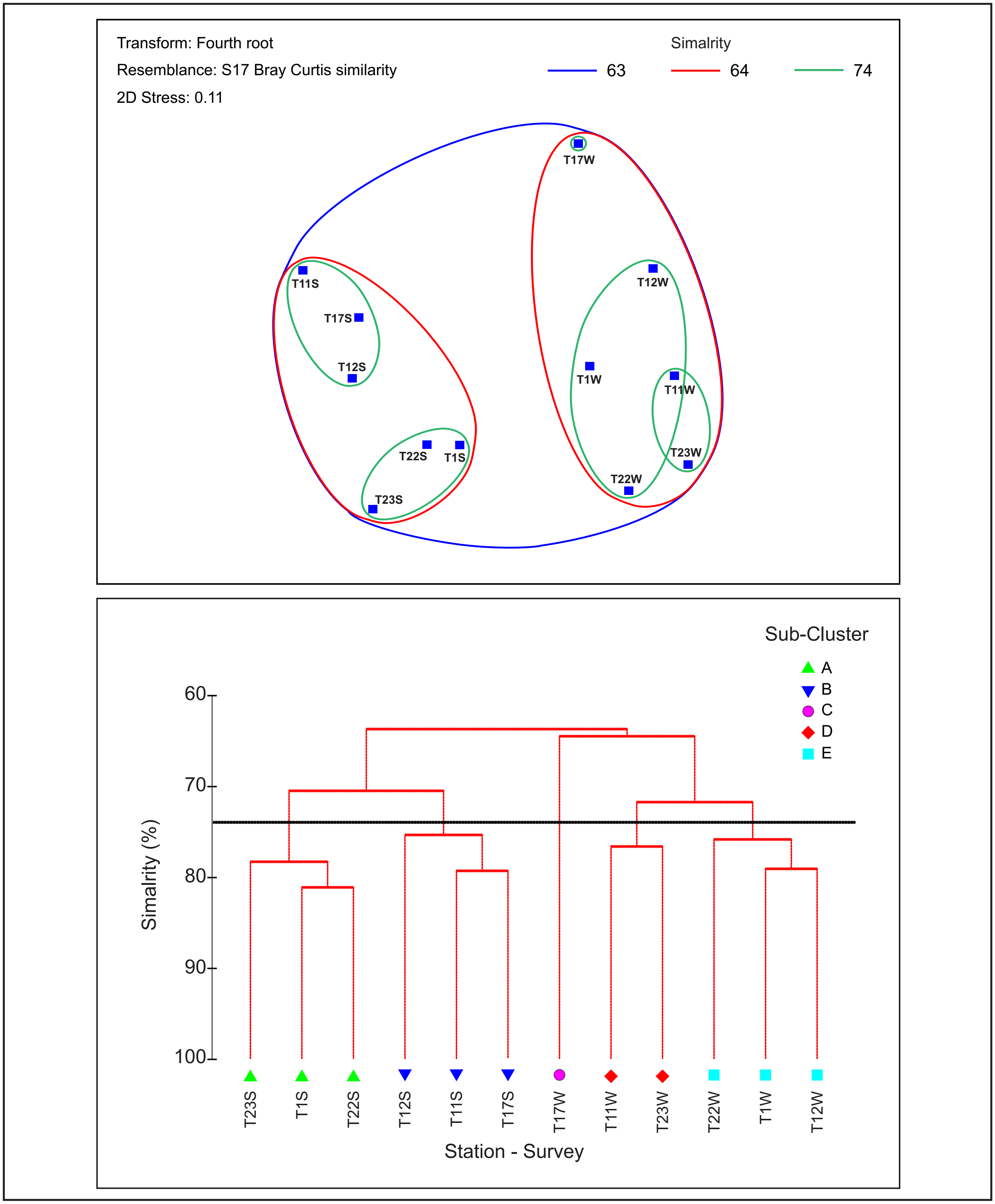

Figure 6-4. **Ordination and community classification of demersal fishes collected by trawl at the six 60 m stations during the summer (July/August 2012) and winter (March/April 2013) OCSD monitoring surveys. Data are presented as the non-metric Multi-dimensional Scaling (MDS) best 2-D configuration according to 63, 64, and 74% similarities (top panel), and a dendrogram identifying five sub-clusters within the overall 60 m station cluster (bottom panel).** Station-surveys are denoted by S for summer and W for winter. T1 and T22 are nearfield (outfall) stations.

Table 6-3. Description of trawl fish sub-cluster groups (A, B, C, D, and E) identified by cluster analysis with 74% similarity. Data include species richness and mean abundance per haul by sub-cluster, and abundance ranks for the top 10 ranking species within each sub-cluster. Bold values indicate species that were "characteristic" of the overall 60 m station Cluster Group (all sub-clusters combined) according to SIMPER analyses.

Orange County Sanitation District, California.

	Species Sub-Clusters				
	Summer		**Winter**		
Parameter	**A**	**B**	**C**	**D**	**E**
Species Richness	15	20	13	25	21
Mean Abundance/Haul	293	636	1005	397	1285
Species	**Abundance Rank**				
Bigmouth Sole	**12**	**12**	**12**	**6**	**4**
California Lizardfish	**5**	**1**	**3**	**7**	**5**
California Tonguefish	**4**	**16**	**9**	**3**	**6**
Dover Sole	14	8	--	13	13
English Sole	**2**	**4**	**4**	**16**	**8**
Halfbanded Rockfish	13	--	8	11	--
Hornyhead Turbot	**7**	**13**	**5**	**4**	**10**
Longfin Sanddab	--	20	6	--	16
Longspine Combfish	**3**	**5**	**2**	**2**	**2**
Pacific Sanddab	**1**	**3**	**1**	**1**	**1**
Pink Seaperch	**9**	**10**	--	**5**	**3**
Plainfin Midshipman	**--**	**6**	**7**	**8**	**7**
Pygmy Poacher	10	9	10	18	12
Roughback Sculpin	8	7	--	24	--
Yellowchin Sculpin	**6**	**2**	--	**14**	**9**

The primary difference noted between the summer and winter sub-clusters was an increase in abundance of Pink Seaperch in the winter; in the summer its abundance ranked 12th and in winter it ranked 2nd (Table 6-3). The Pink Seaperch breeding season occurs from March-June (Goldberg and Ticknor 1977) and Pink Seaperch may be more susceptible to trawl gear during this time of year. There were two summer sub-clusters; sub-cluster A included the outfall stations (T1 and T22) and the nearest downcoast station (Station T23), while sub-cluster B included the three upcoast stations (T12, T17, T11). Sub-cluster B showed 29% dissimilarity with sub-cluster A, primarily due to very large hauls of California Lizardfish and Yellowchin Sculpin at the upcoast stations and a lower abundance of California Tonguefish. Sub-clusters C, D, and E were winter clusters. Sub-cluster E consisted of the outfall stations (T1 and T22) and the nearest upcoast station; sub-cluster D included the downcoast station (T23) and farfield upcoast station (T11), and sub-cluster C consisted of upcoast station T17. SIMPER identified the absence of Pink Seaperch in sub-cluster C and the absence of Halfbanded Rockfish (*Sebastes semicinctus*) in sub-cluster E as the primary species driving approximately one third (~10%) of the dissimilarity among the groups. This minor degree of dissimilarity is likely an artifact of the patchy distribution of some species (e.g., schooling or aggregating species) rather than a discharge effect.

Temporal Trends

Species Abundance

Annual trends in summer abundance per haul for the five most abundant species of the 2012-13 survey have varied considerably since 1985 (Figure 6-5). In contrast to Pacific Sanddab and Yellowchin Sculpin, which have remained relatively abundant since 1985, California Lizardfish, Longspine Combfish, and English Sole have become relatively abundant in more recent decades. This trend has also been documented across stations within the South Bay ocean outfall monitoring area off the coast of San Diego, CA (City of San Diego 2013), suggesting a regional rather than local phenomenon. Moreover, peaks in Pacific sanddab abundance at the OCSD nearfield (T1) and farfield (T11) stations have occurred during similar years, suggesting natural variability as the cause.

Peaks in mean abundance per haul for the other four species also appear to similarly occur at T1 and T11, albeit with different magnitudes and increased variability after 2002.

Fish Biointegrity

District FRI scores at Stations T1 (nearfield) and T11 (farfield) varied little from each other and continue to fall well below the threshold as in previous years (Figure 6-6). Despite a recent increase in annual FRI scores at Station T1, mean FRI values ranged from 21 to 26, indicating reference conditions and were consistent with regional assessments. The Bight ’08 regional survey indicated that none of the middle shelf areas were classified as disturbed based on the FRI index (Allen *et al.* 2011).

Regional Comparisons

Temporal trends in the District’s summer fish community data for Stations T1 (nearfield) and T11 (farfield) were plotted relative to regional means/ranges collected at non-POTWs (Publically Owned Treatment Works) during the summer 1994 SCBPP, Bight ’98, Bight ’03, and Bight ’08 surveys (Figure 6-7). These non-POTW station means were used as a proxy for reference conditions along the middle shelf of the SCB region. Historically, the District’s nearfield and farfield stations have generally followed regional variation in fish abundance,

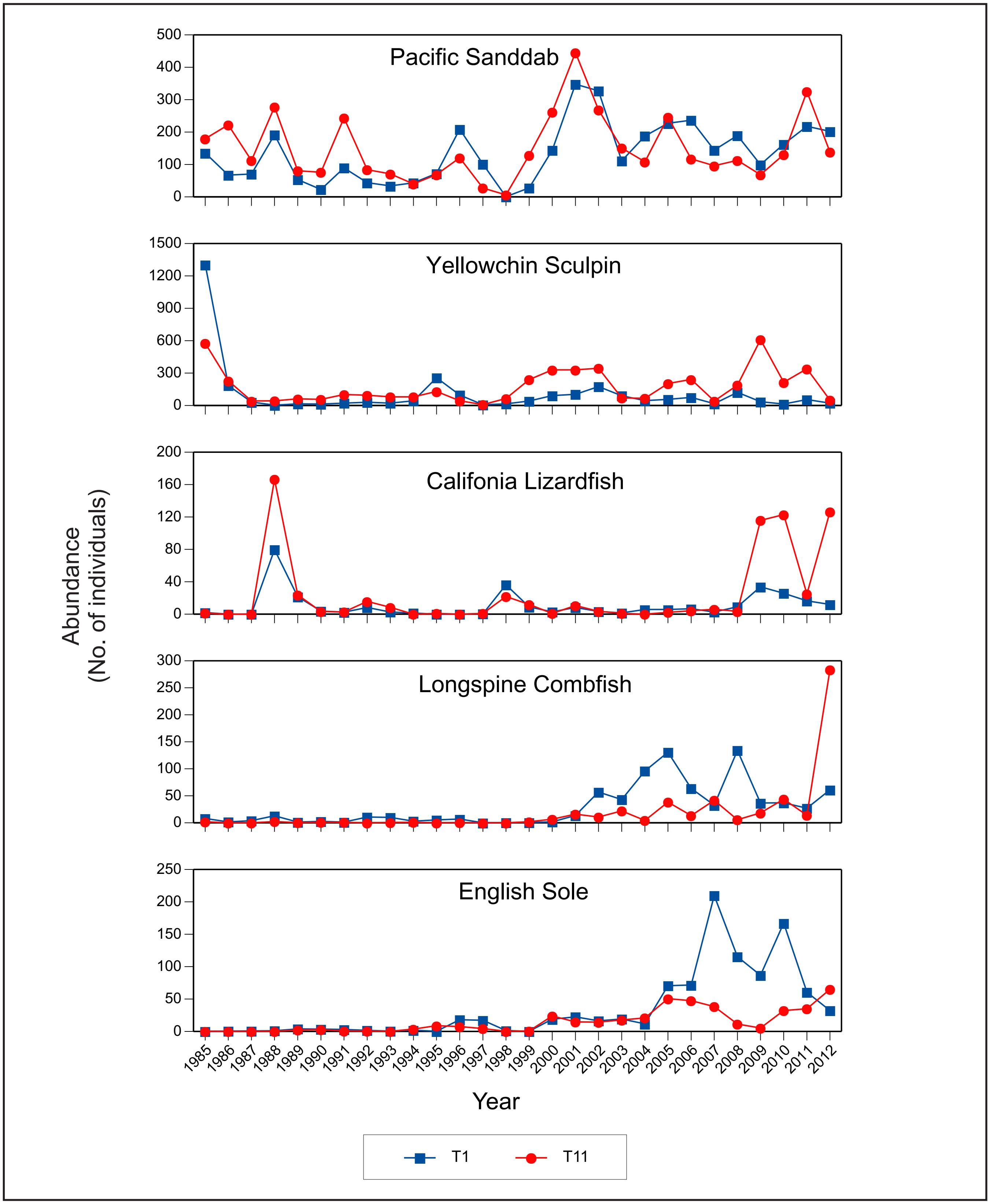

Figure 6-5. **Demersal fish mean abundance per haul at T1 (nearfield) and T11 (farfield) trawl stations from 1985-2012 for the top 5 ranking species during the OCSD summer 2012 semi-annual monitoring survey.**
Note: Haul replicates were discontinued in 2012.

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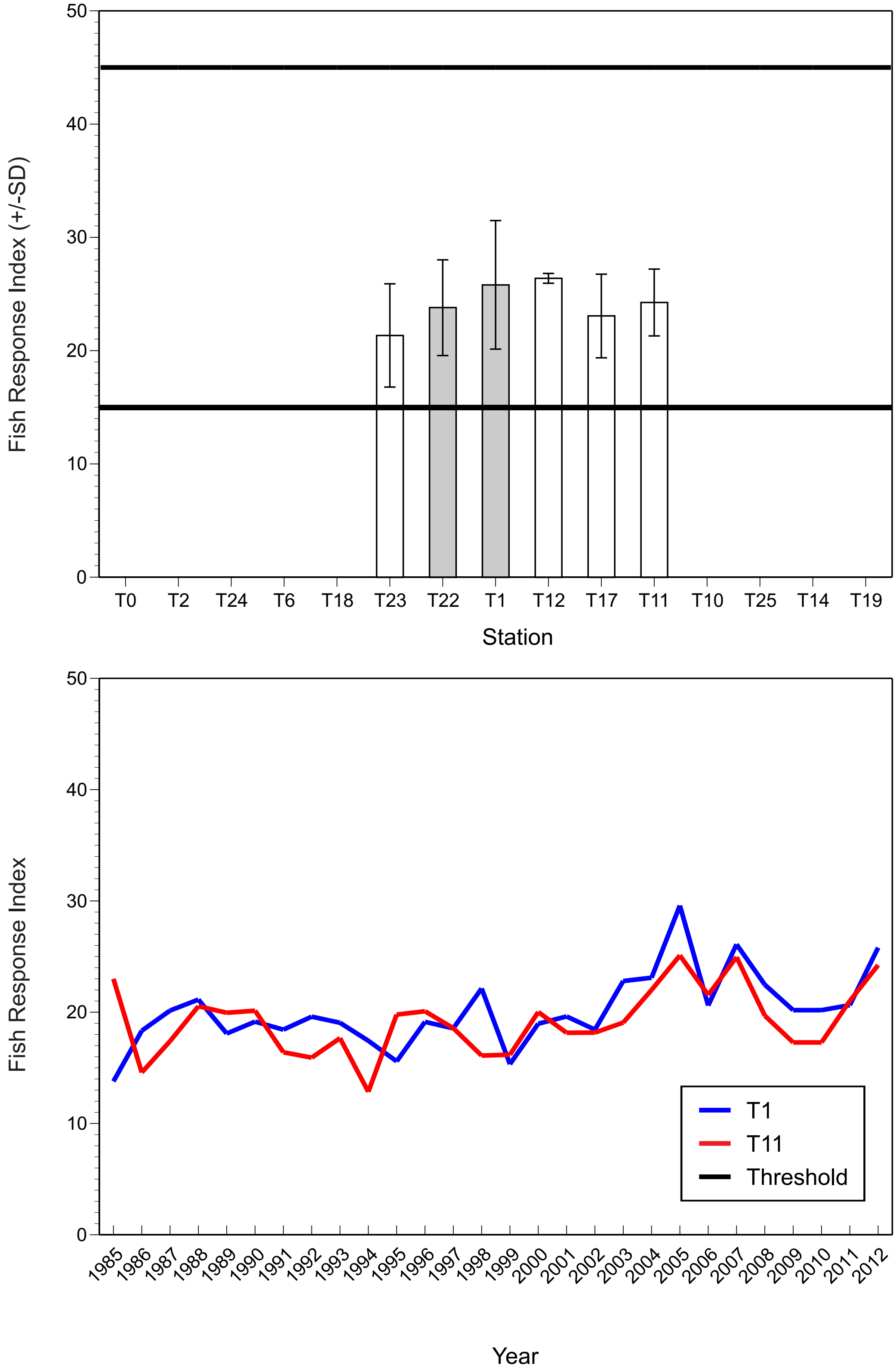

Figure 6-6. **Mean Fish Response Index (FRI) by station in 2012-13 (top panel) and annual mean FRI for nearfield Station T1 and farfield Station T11 (bottom panel).**
Nearfield (outfall) stations T1 and T22 indicated in gray (top panel). Solid black line represents the FRI threshold value (45).

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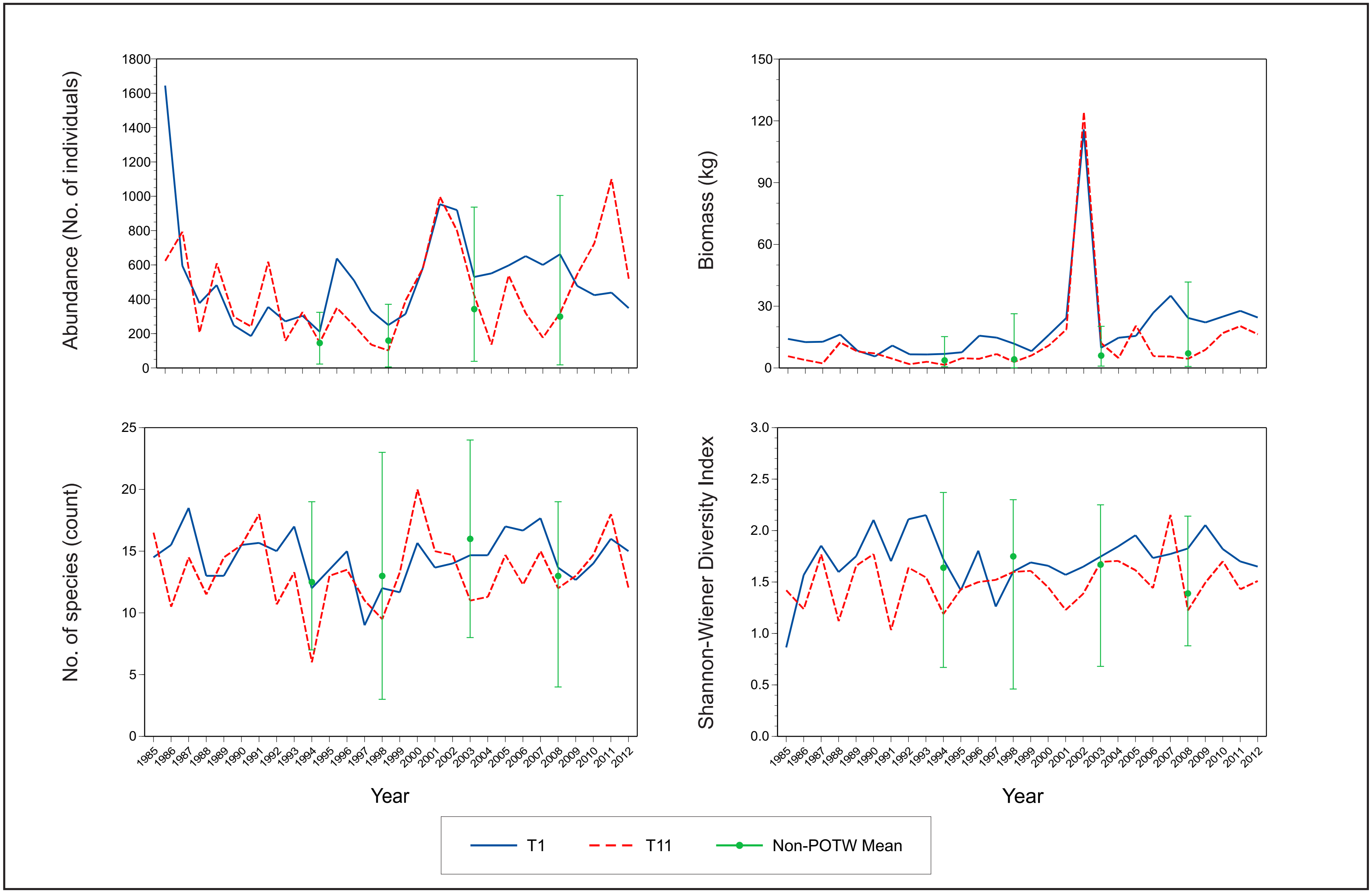

Figure 6-7. **Annual trends in demersal fish community parameters at OCSD monitoring stations T1 (nearfield) and T11 (farfield) from 1985 to 2012 relative to regional values (means, min, max) reported for non-POTW stations in the 1994, 1998, 2003, and 2008 Southern California Bight regional surveys.**

Data for all community parameters are for summer surveys only.
POTW = Publicly Owned Treatment Works.
Sample sizes for non-POTW means: 1994 = 3, 1998 = 15, 2003 = 13, 2008 = 13.

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biomass, number of species, and diversity values. In 2012, community parameters at the District's nearfield and farfield stations followed similar trends and fell within the ranges reported in the Bight '08 regional survey indicating the fish community did not appear degraded by the District's wastewater discharge (Figure 6-7).

Epibenthic Macroinvertebrate Community

Abundance

A total of 8,605 EMI were collected during 2012-13 (Tables 6-4 and B-8). Two species accounted for 79% of the total abundance: the brittle star *Ophiura luetkenii* (47%) and white sea urchin *Lytechinus pictus* (32%; Table 6-4). In some instances, these species dominated a station. For example, *O. luetkenii* accounted for 86% of the summer abundance at Station T6, which had the highest abundance across both surveys (Figure 6-8). Other generally abundant species included *Thesea* sp. (yellow sea twig), *Sicyonia ingentis* (ridgeback rock shrimp), *Hamatoscalpellum californicum* (California blade barnacle), and *Pleurobranchaea californica* (California sea slug).

Five species, including *O. luetkenii, L. pictus*, *Thesea* sp., *P. californica*, and *Luidia foliata* (gray sand star) occurred in 100% of the trawls and were wide-ranging (at all stations). By contrast, 82% (40) of species occurred in fewer than half of the trawls (Table 6-4).

The number of individuals per haul ranged from 34 to 2,592 in 2012-13 (Figure 6-8 and Table B-8). Historically, abundance is highly variably from year to year. These fluctuations typically reflect changes in several dominant species, such as *O. luetkenii*, *L. pictus*, *Thesea* sp., *S. ingentis*, and *H. californicum* (Figure 6-9). There was no indication of potential impact at the discharge site with respect to total or individual species abundances. For example, the mean abundance at 60 m outfall (Stations T22 and T1) and non-outfall stations (T23, T12, T17, T11) was nearly equal during both summer and winter surveys (Figure 6-8), and the abundance patterns of dominant species at Station T1 (nearfield) and T11 (farfield) have been similar over time (Figure 6-9).

Biomass

In 2012-13, the total EMI biomass was 46.0 kg (Tables 6-4 and B-9), which is smaller than measured in previous years, and may be due to a reduction in sampling effort as specified in the new NPDES permit. Higher biomass values at stations T0 and T23 in summer were attributed to large hauls of *Muricea californica* (California golden gorgonian) and *L. foliata*, respectively (Figure 6-8). The mean biomass at 60 m outfall and non-outfall stations was nearly equal during both summer and winter surveys (Figure 6-8) suggesting no discharge effect on EMI biomass.

Number of Species

A total of 49 EMI taxa were collected during 2012-13 (Table 6-4, Table B-8). There was no apparent influence of depth on the number of species by station (Figure 6-8). The 60 m outfall mean was comparable to the 60 m non-outfall mean during both summer and winter surveys suggesting no discharge effect on the number species surveyed by station.

Diversity

H' was lower during the summer at the 60 m non-outfall stations than the outfall stations (with the exception of T12; Figure 6-10). This was driven by large catches of a single

Table 6-4. **Summary of epibenthic macroinvertebrate species collected by trawl during the summer (July/August 2012) and winter (March/April 2013) OCSD monitoring surveys. Data for each species are expressed as total abundance (Total), percent abundance (%A), percent frequency of occurrence (%FO), mean abundance per haul (MAH), mean abundance per occurrence (MAO), and biomass (kg).**

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Species	Total	%A	%FO	MAH	MAO	Biomass (kg)
Ophiura luetkenii	4,060	47	90	193	214	4.870
Lytechinus pictus	2,717	32	86	129	151	5.879
Thesea sp.	556	6	86	26	31	0.537
Sicyonia ingentis	361	4	76	17	23	5.230
Hamatoscalpellum californicum	327	4	81	16	19	0.099
Pleurobranchaea californica	138	2	95	7	7	11.917
Luidia foliolata	94	1	90	4	5	4.022
Acanthoptilum sp.	56	1	52	3	5	0.057
Acanthodoris brunnea	53	1	62	3	4	0.033
Philine auriformis	22	< 1	43	1	2	0.011
Luidia asthenosoma	21	< 1	67	1	2	0.048
Astropecten californicus	64	< 1	48	3	6	0.482
Ophiothrix spiculata	18	< 1	38	1	2	0.029
Octopus rubescens	15	< 1	33	1	2	0.421
Parastichopus californicus	12	< 1	33	1	2	4.845
Parastichopus sp. A	10	< 1	5	< 1	10	0.248
Heterocrypta occidentalis	9	< 1	14	< 1	3	0.016
Ceratostoma nuttalli	5	< 1	5	< 1	5	0.003
Neocrangon resima	5	< 1	10	< 1	3	0.003
Neosimnia sp.	5	< 1	10	< 1	3	0.006
Platymera gaudichaudii	5	< 1	19	< 1	1	0.463
Romaleon antennarius	5	< 1	5	< 1	5	0.005
Crangon nigromaculata	4	< 1	5	< 1	4	0.011
Loxorhynchus crispatus	4	< 1	14	< 1	1	0.010
Pyromaia tuberculata	4	< 1	14	< 1	1	0.004
Rossia pacifica	4	< 1	14	< 1	1	0.053
Amphichondrius granulatus	2	< 1	10	< 1	1	0.002
Amphiodia psara	2	< 1	10	< 1	1	0.002
Erileptus spinosus	2	< 1	10	< 1	1	0.002
Luidia sp.	2	< 1	5	< 1	2	0.001
Octopus californicus	2	< 1	10	< 1	1	0.902

Table 6-4 continues.

Table 6-4 continued.

Species	Total	%A	%FO	MAH	MAO	Biomass (kg)
Orthopagurus minimus	2	< 1	10	< 1	1	0.002
Ptilosarcus gurneyi	2	< 1	10	< 1	1	0.162
Strongylocentrotus fragilis	2	< 1	10	< 1	1	0.156
Antiplanes catalinae	1	< 1	5	< 1	1	0.008
Boreotrophon bentleyi	1	< 1	5	< 1	1	0.001
Calliostoma turbinum	1	< 1	5	< 1	1	0.001
Crangon alaskensis	1	< 1	5	< 1	1	0.001
Dendronotus albus	1	< 1	5	< 1	1	0.002
Dendronotus sp.	1	< 1	5	< 1	1	0.002
Euspira draconis	1	< 1	5	< 1	1	0.001
Heterocarpus brevirostris	1	< 1	5	< 1	1	0.001
Lophogorgia chilensis	1	< 1	5	< 1	1	0.060
Metacarcinus gracilis	1	< 1	5	< 1	1	0.190
Muricea californica	1	< 1	5	< 1	1	5.170
Podochela hemphillii	1	< 1	5	< 1	1	0.001
Podochela lobifrons	1	< 1	5	< 1	1	0.001
Porcellanidae	1	< 1	5	< 1	1	0.001
Stylasterias forreri	1	< 1	5	< 1	1	0.001
Total	**8,605**	**100**				**45.972**
Total no. of species	**49**					

n = 21 hauls

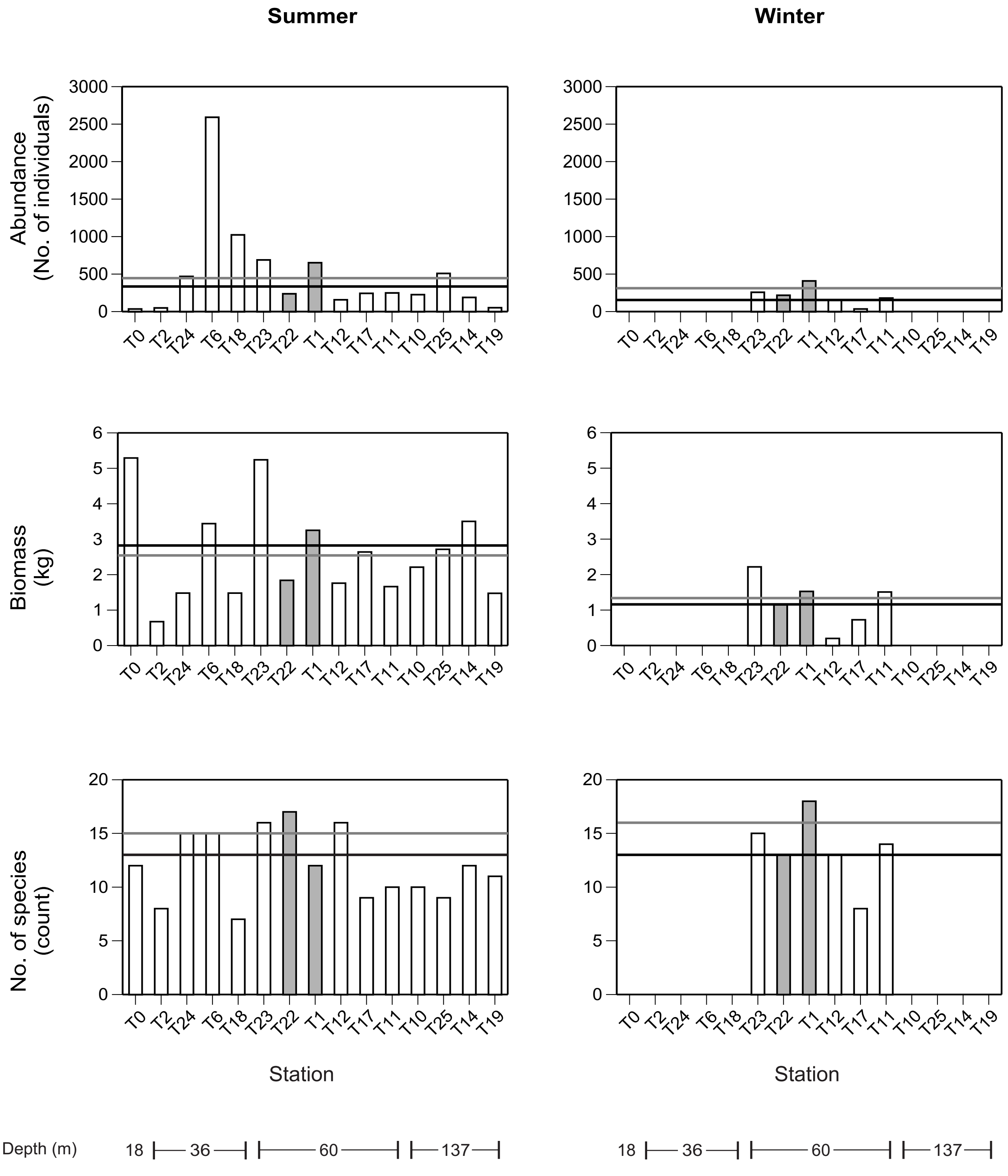

Figure 6-8. **Abundance, biomass, and number of species for epibenthic macroinvertebrates collected by trawl during the summer (July/August 2012) and winter (March/April 2013) OCSD monitoring surveys.**

Nearfield (outfall) Stations T1 and T22 indicated in gray. Survey 60 m non-outfall mean denoted by black line, 60 m outfall mean denoted by gray line. Note: Only the 60 m stations were sampled during the winter survey.

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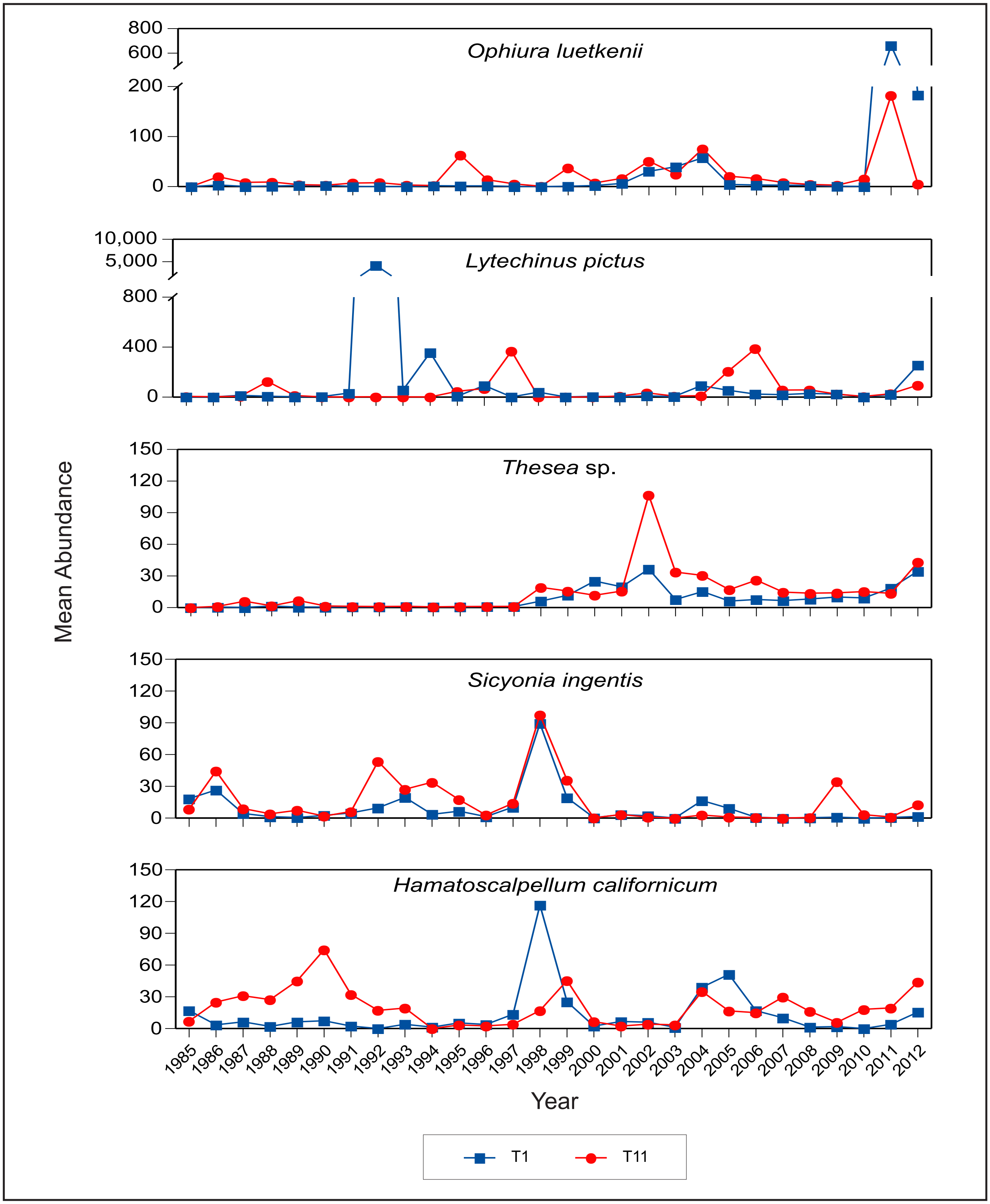

Figure 6-9. **Epibenthic macroinvertebrate mean abundance per haul at T1 (nearfield) and T11 (farfield) trawl stations from 1985-2012 for the top 5 ranking species during the summer semi-annual OCSD monitoring survey.**
Note: Haul replicates were discontinued in 2012.

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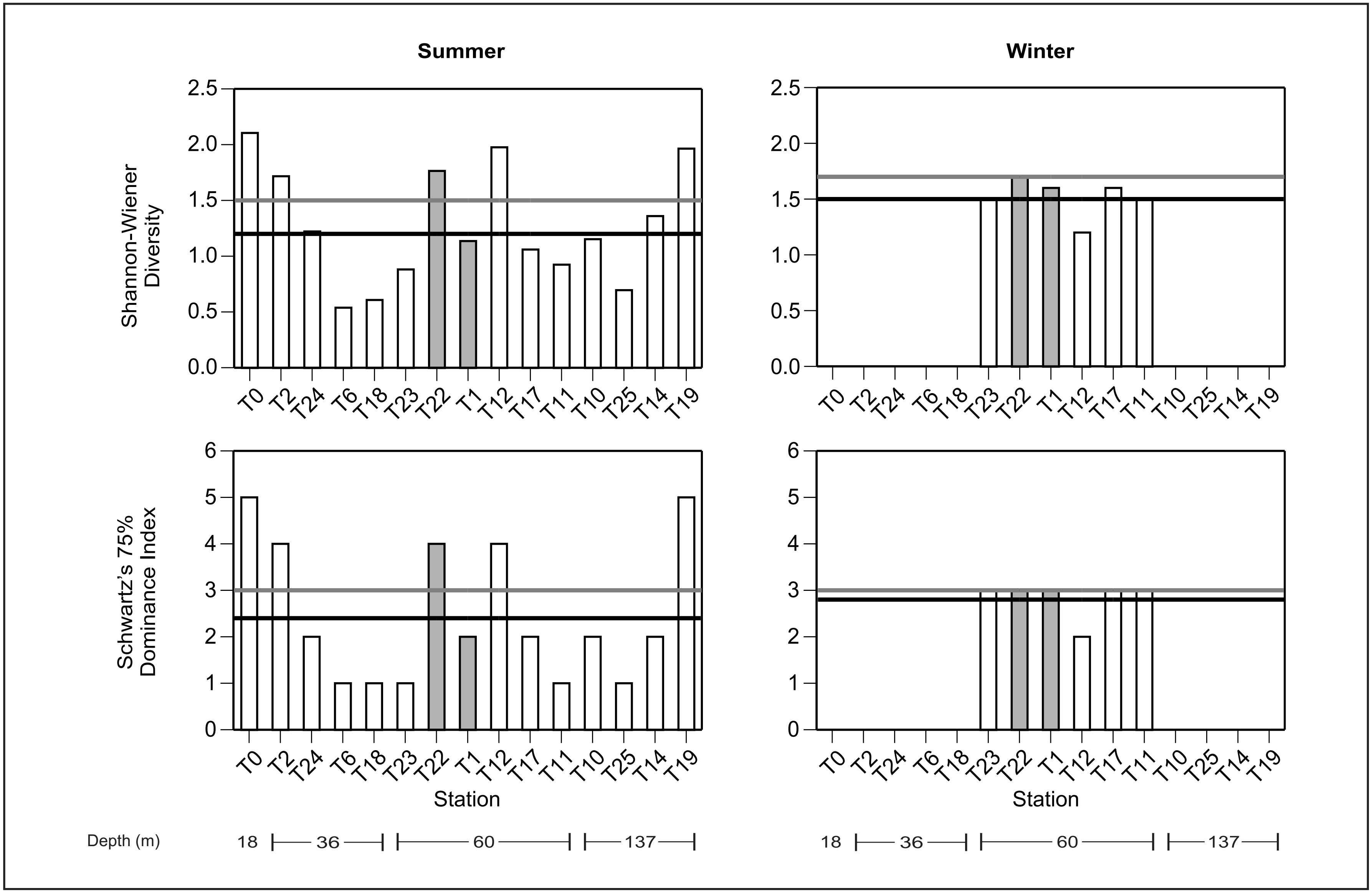

Figure 6-10. **Shannon-Wiener Diversity Index and Swartz's 75% Dominance Index of epibenthic macroinvertebrates collected by trawl during the summer (July/August 2012) and winter (March/April 2013) OCSD monitoring surveys.**
Nearfield (outfall) Stations T1 and T22 indicated in gray. Survey 60 m non-outfall mean denoted by black line, 60 m outfall mean denoted by gray line.
Note: Only the 60 m stations were sampled during the winter survey.

species at several of the non-outfall stations. Outfall Station T1 had lower species diversity in the summer than outfall Station T22 due to a low dominance value driven by large hauls of *O. luetkenii* and *L. pictus* compared to other species collected at T1. SDI and H' values in the winter were very similar between the 60 m outfall and non-outfall stations and within the ranges reported in the summer (Figure 6-10).

Regional Comparisons

Temporal trends in the District's 2012 summer EMI community data for outfall Stations T1 (nearfield) and T11 (farfield) were plotted relative to regional means/ranges collected at non-POTWs during the summer 1994 SCBPP, Bight '98, Bight '03, and Bight '08 surveys (Figure 6-11). As reported for fish, the non-POTW station means/ranges were used as a proxy for reference conditions along the middle shelf of the SCB region. Results from these regional studies have indicated that 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 fell very close to each other in 2012 with the exception of EMI abundance per haul (Figure 6-11). In 2011 and 2012, the outfall Station T1 had large hauls of *O. luetkenii*, although in 2012, abundance was lower. Over time, the District's outfall (T1) and farfield (T11) trawl stations have generally followed regional variation in biomass, number of species, and species diversity, but regional abundance values have tended to be higher (Figure 6-11). Although meaningful comparisons among the regional surveys and the District's trawl data are limited due to the high variability in the trawl invertebrate data ranges, the District's data consistently falls on the lower end of the regional ranges. The high variability in EMI population attributes is driven by changes in oceanographic conditions and fluctuations in the dominant species.

Fish Tissue Contaminants

The target sampling objective for Hornyhead Turbot and English Sole was met, but the target for rockfishes and California Scorpionfish was not met at the reference site (Zone 2). Thus, no spatial comparison for these popular sportfishes could be addressed for this survey. The sport fish tissue contaminant results from the outfall (Zone 1) can be viewed in Table B-10; tissue contaminant levels for all individuals collected (three rockfish species) were well below federal and state fish consumption action/advisory levels. Hornyhead Turbot samples for fish tissue contaminant analysis ranged in size from 120 to 177 mm standard length (SL); English Sole ranged in size from 135 to 236 mm SL.

Spatial Comparison

Muscle Tissue

Mean tDDT in Hornyhead Turbot was slightly higher at the farfield station compared to the outfall, while mean tPCB and mean mercury levels were low at both the farfield and outfall stations (Table 6-5). For English Sole, mean tDDT was over 5 times higher at the farfield station than at the outfall station. Mean values of mercury were identical at both stations, while mean values of tPCB were nearly identical. Other chlorinated pesticides were non-detectable at both stations for both species (Table 6-5). Overall, 2012-13 mean levels of mercury, tDDT, and tPCB at both outfall and farfield stations were well below federal and state fish consumption action/advisory levels.

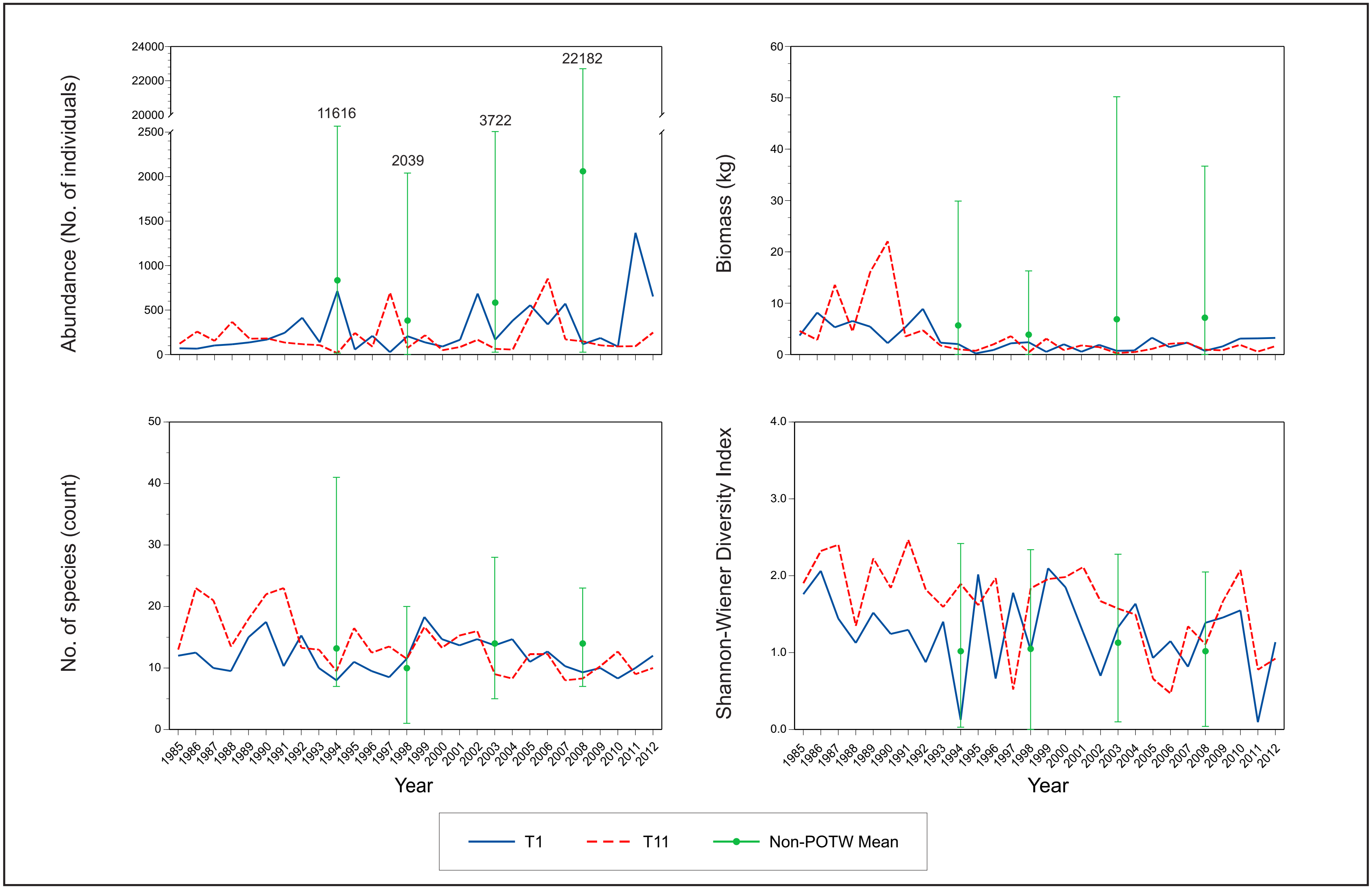

Figure 6-11. **Annual trends in epibenthic macroinvertebrate community parameters at OCSD monitoring stations T1 (nearfield) and T11 (farfield) from 1985 to 2012 relative to regional values (means, min, max) reported for non-POTW stations in the 1994, 1998, 2003, and 2008 Southern California Bight regional surveys.**
Data for all community parameters are for summer surveys only.
POTW = Publicly Owned Treatment Works.
Sample sizes for non-POTW means: 1994 = 3, 1998 = 15, 2003 = 13, 2008 = 13.

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

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Species	Tissue	Station Group	n	Mean Standard Length (mm)	Mean Percent Lipid	Mean Mercury* (mg/kg)	Mean Total DDT (µg/kg)	Mean Total PCB (µg/kg)	Mean Total Other Chlorinated Pesticides (µg/kg)
Hornyhead Turbot	Muscle	Outfall	10	142	0.21	0.09 (0.03–0.17)	8.27 (0–27.5)	1.85 (0–13.3)	ND
		Farfield	10	160	0.26	0.06 (0.02–0.18)	14.7 (0–43.8)	0.49 (0–3.8)	ND
	Liver	Outfall	10	142	9.64	0.24 (0.09–0.36)	67.5 (43.2–122)	8.33 (1.50–18.7)	ND
		Farfield	10	160	7.95	0.17 (0.08–0.30)	119 (17.1–355)	8.32 (0–26.1)	ND
English Sole	Muscle	Outfall	10	169	0.98	0.07 (0.03–0.11)	102.2 (1.15–389)	22.06 (0–141)	ND
		Farfield	10	179	0.33	0.07 (0.03–0.12)	543 (14.6–1635)	22.51 (0–103)	ND
	Liver	Outfall	10	169	4.61	0.07 (0.03–0.16)	191 (27.0–423)	32.9 (0–105)	ND
		Farfield	10	179	10.62	0.09 (0.03–0.19)	290 (12.8–1104)	33.7 (2.42–79.2)	ND
California No Consumption Advisory Tissue Level (ATL)						0.44*	2100	120	560/46***
FDA Action Level for edible tissue						1.0*	5000	2000**	300***

Data for total DDT, total PCB, and total other chlorinated pesticides are lipid-normalized; ND = not detected

* Methyl mercury can be measured as total mercury; CA ATL is level of methylmercury for women (18-45 yrs. of age) and children (1-17 yrs. of age); FDA action level is for methylmercury

** FDA PCBs level is listed as a tolerance level

***The two CA ATL values for other chlorinated pesticides are for chlordane and dieldrin, respectively; FDA other chlorinated pesticides action level is for dieldrin, chlordane, heptachlor and heptachlor epoxide.

Liver Tissue

Mean tDDT in Hornyhead Turbot was higher at the farfield station compared to the outfall, while mean tPCB and mercury levels were low at both the farfield and outfall stations (Table 6-5). For English Sole, mean tDDT was higher at the farfield station than at the outfall station. Mean values of mercury and tPCB were nearly identical at both stations. Other chlorinated pesticides were non-detectable at both stations for both species (Table 6-5). Overall, the 2012-13 mean levels of mercury, tDDT, and tPCB at both outfall and farfield stations lend support to the historical data which demonstrate that the outfall is not an epicenter of disease due to the bioaccumulation of these contaminants in liver tissue (Table 6-5).

Temporal Trends

Fish tissue contaminant data has been collected annually for Hornyhead Turbot and English Sole since July 2005. Although contaminant concentrations for all analytes have remained low (i.e., below action/advisory levels) during this timeframe, there is considerable inter-annual and interspecific variability, especially for tDDT and tPCB. Elevated mean concentrations are typically due to high concentrations in one or two individuals of the sample (OCSD 2010). For both tDDT and tPCB, the highest muscle tissue concentrations for Hornyhead Turbot and English Sole occurred during the 2008-09 monitoring year (Figures 6-12 and 6-13). Overall, mercury levels have shown less interannual variability than the organic contaminants (Figure 6-15). Results for total chlorinated pesticides have been non-detectable in muscle tissue for the majority of annual surveys, including the present survey (Figure 6-14).

Organic Contaminants (tDDT, tPCB, other chlorinated pesticides)

Since 2005, mean tissue levels of all organic contaminants have been well below state and federal levels for both species (despite occasional elevated concentrations; Figures 6-12 to 6-14). Annual trends in mean fish tissue levels of tDDT and tPCB have followed a similar pattern (Figures 6-12 and 6-13). For tDDT, there has been no pattern of higher concentrations in fishes collected at the outfall compared to the farfield site (Figure 6-12). Mean tPCB levels in Hornyhead Turbot have been consistently higher at the outfall than at farfield sites, with the exception of the 2011-12 monitoring year for muscle tissue. This pattern was not evident in English Sole (Figure 6-13). Overall, there has been no outfall-related trend of increasing tDDT, tPCBs, or other chlorinated pesticide levels in fish muscle or liver tissue (Figures 6-12 to 6-14).

Mercury

Since 2005, mean mercury tissue levels have been well below state and federal levels for both species and concentrations have been relatively stable from year to year (Figure 6-15). Similar to the previous two surveys, the mean mercury level in Hornyhead Turbot and English Sole muscle was higher at the outfall than the farfield location. Overall, there has been no outfall-related trend of increasing mercury levels in fish muscle or liver tissue (Figure 6-15).

Parasites and Abnormalities

External parasites and abnormalities (e.g., skeletal deformities, tumors, lesions, and ambicolorism) occurred in less than 1% of all fishes collected in 2012-13. The most

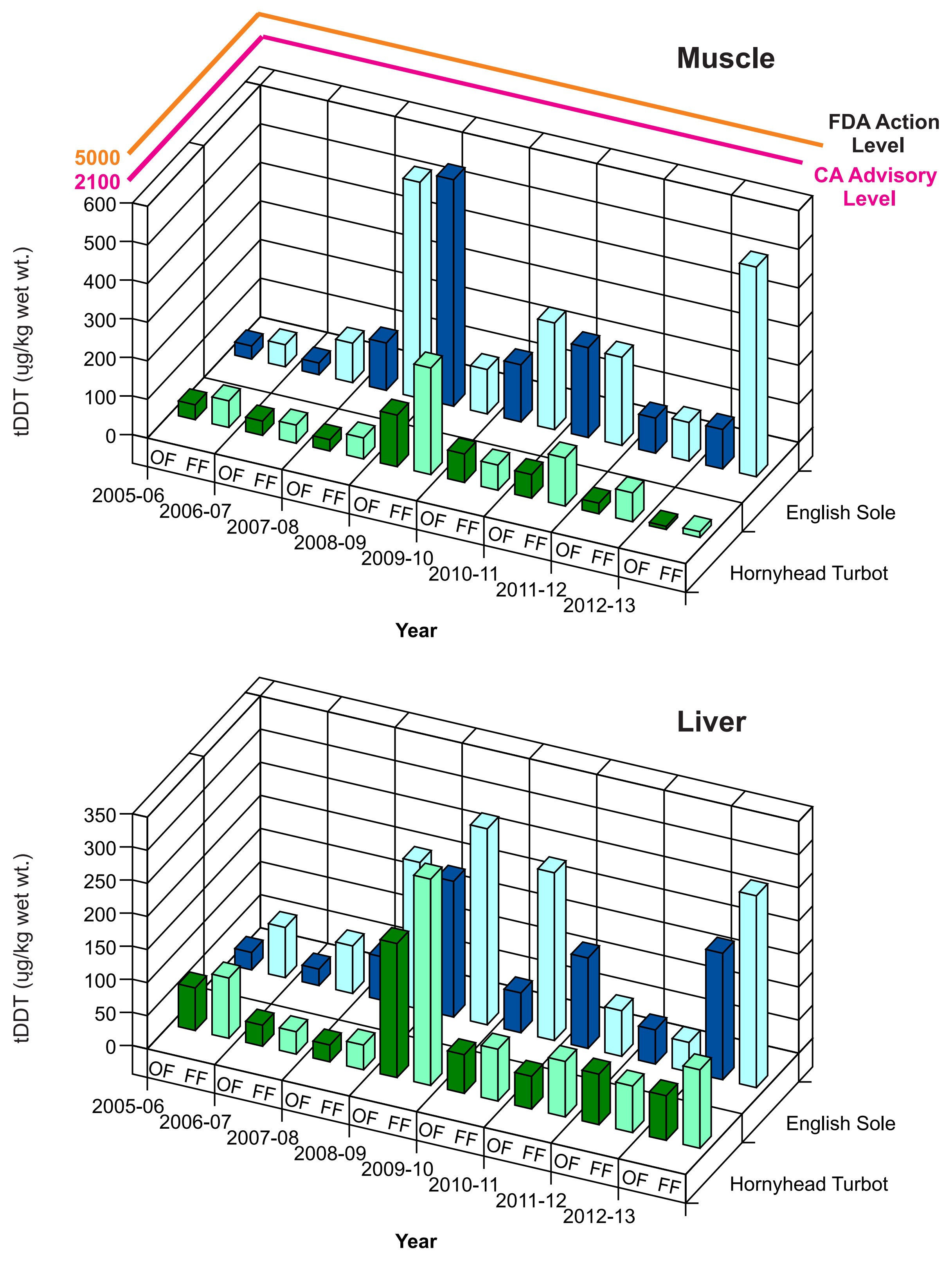

Figure 6-12. **Mean concentrations of total DDT (ųg/kg wet weight) in Hornyhead Turbot (*Pleuronichthys verticalis*) and English Sole (*Parophrys vetulus*) muscle and liver tissue in March 2013 at outfall Station T1 (OF) versus upcoast farfield Station T11 (FF).**
Data normalized to % lipids.

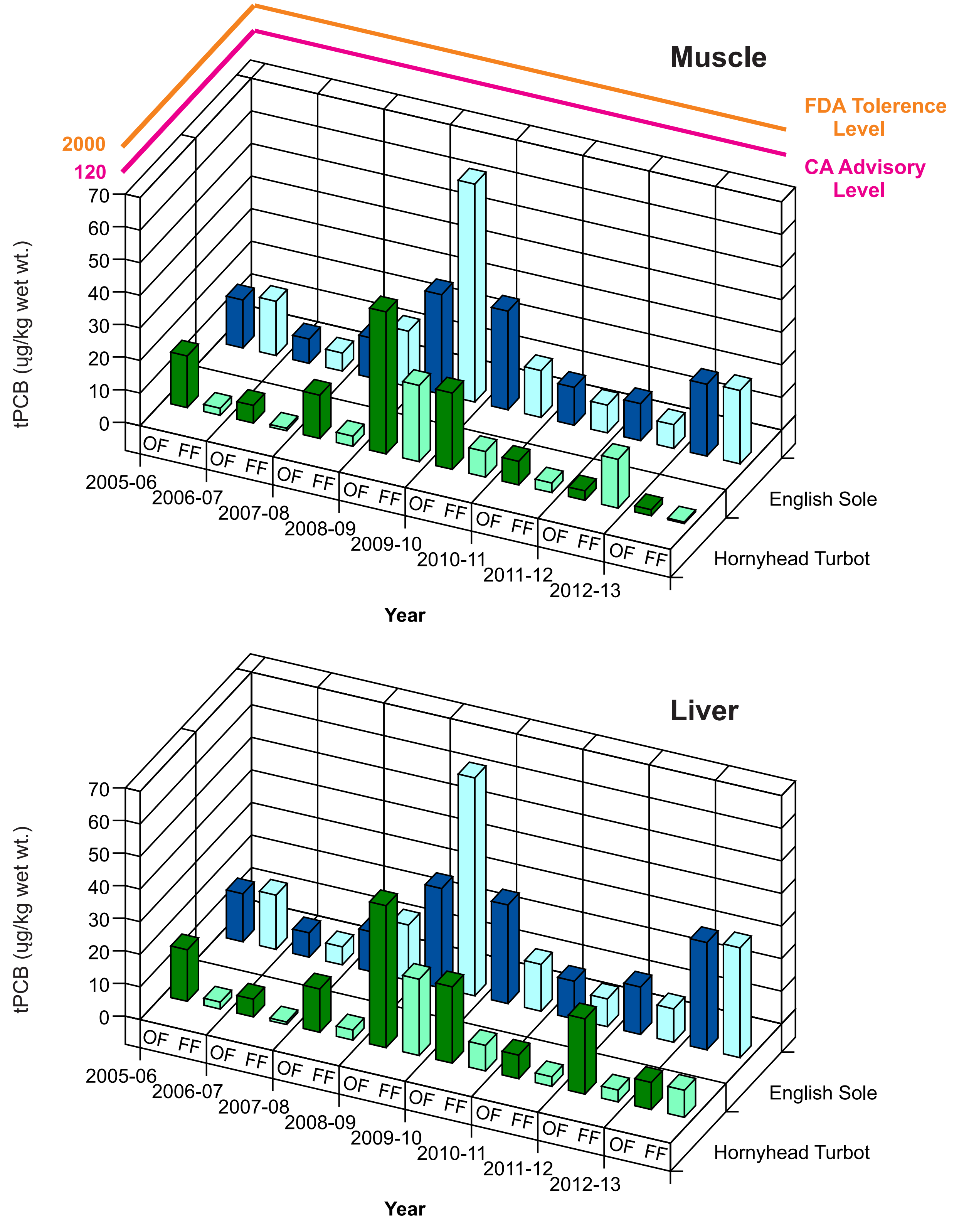

Figure 6-13. **Mean concentrations of total PCB (ųg/kg wet weight) in Hornyhead Turbot (*Pleuronichthys verticalis*) and English Sole (*Parophrys vetulus*) muscle and liver tissue in March 2013 at outfall Station T1 (OF) versus upcoast farfield Station T11 (FF).**
Data normalized to % lipids.

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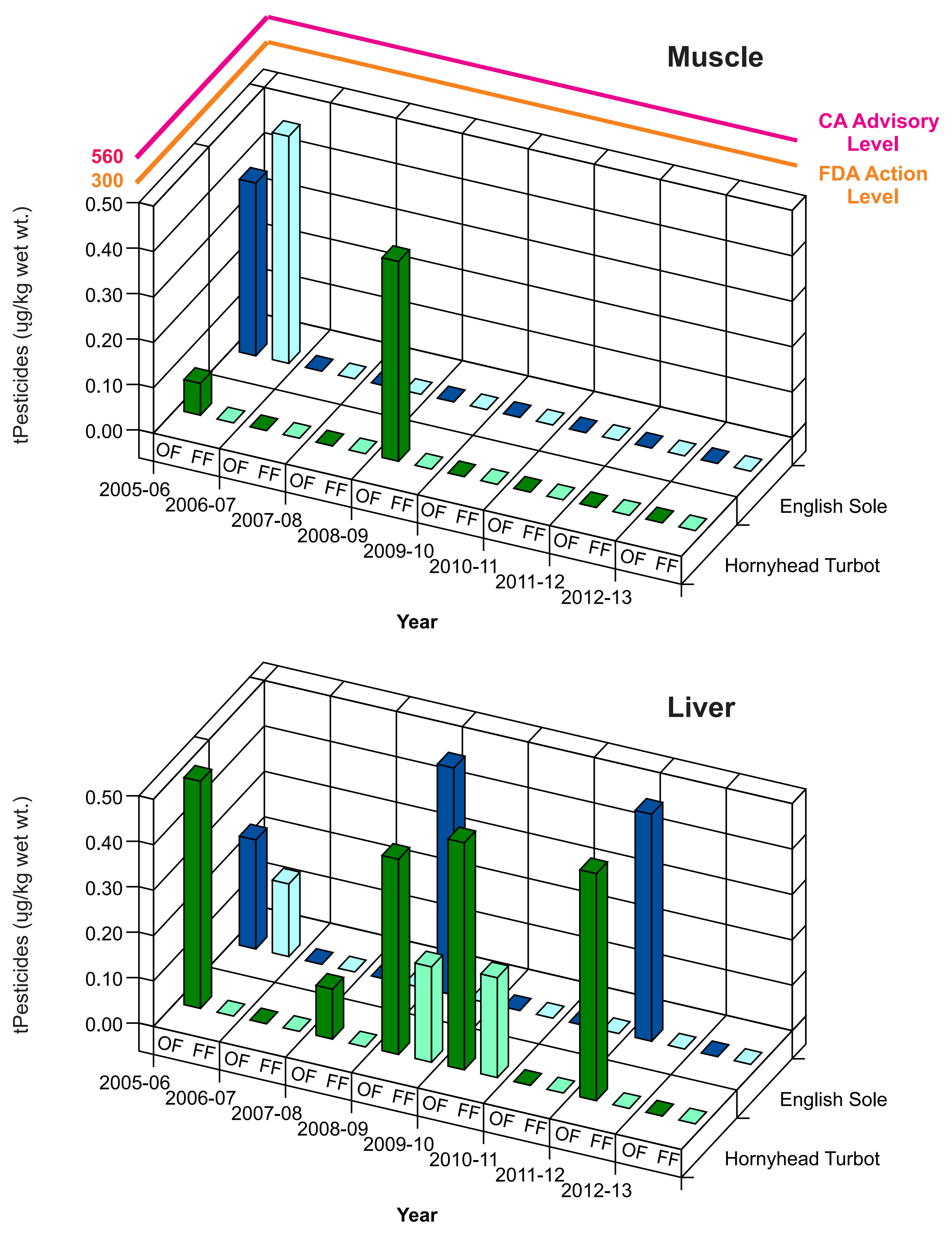

Figure 6-14. **Mean concentrations of total other chlorinated pesticides (ųg/kg wet weight) in Hornyhead Turbot (*Pleuronichthys verticalis*) and English Sole (*Parophrys vetulus*) muscle and liver tissue in March 2013 at outfall Station T1 (OF) versus upcoast farfield Station T11 (FF).**
Data normalized to % lipids.
FDA Action Level for dieldrin, heptachlor, and heptachlorepoxide; CA Advisory Level for chlordane.

Orange County Sanitation District, California.

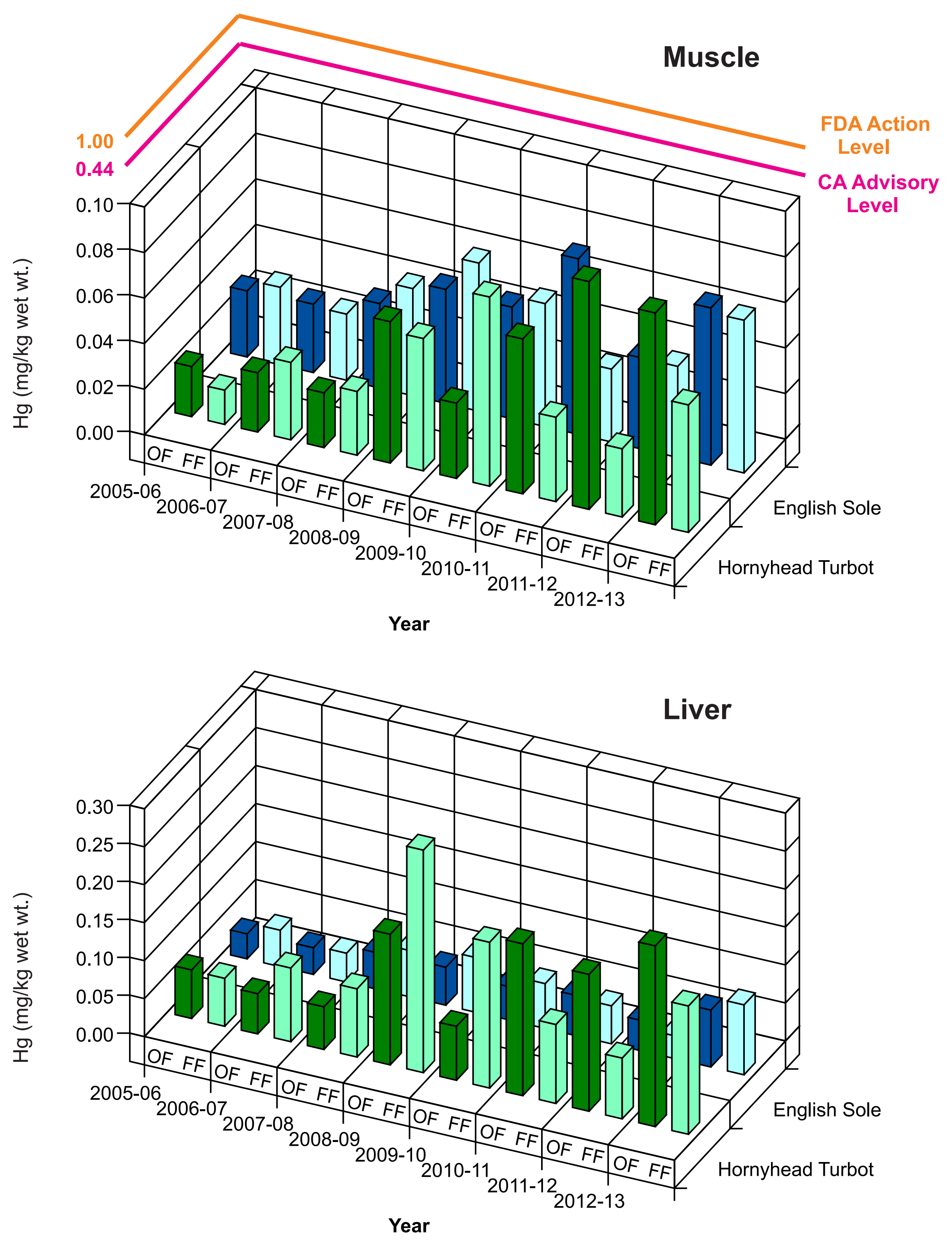

Figure 6-15. **Mean concentrations of mercury (mg/kg wet weight) in Hornyhead Turbot (*Pleuronichthys verticalis*) and English Sole (*Parophrys vetulus*) muscle and liver tissue in March 2013 at outfall Station T1 (OF) versus farfield Station T11 (FF).**

common occurrence was the presence of the parasitic copepod, *Phrixocephalus cincinnatus*. This parasite occurred on the eyes of 0.25% (29 occurrences) of Pacific Sanddab, a notably lower incidence than in 2011-12 (1.1%; 89 occurrences). *P. cincinnatus* is found throughout the SCB, most often occurring on Pacific Sanddab. Perkins and Gartman (1997) found that *P. cincinnatus* occurred on 1.4% of the Pacific Sanddab 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). Thus, the overall incidence rate for 2012-13 is well below the range found regionally in the SCB. *P. cincinnatus* was recorded at all of the middle shelf stations (T1, T11, T12, T17, T22, and T23), two inner shelf stations (T6 and T24), and two outer shelf stations (T14 and T25). No outfall trend was evident (there was only a single occurrence of *P. cincinnatus* at T1).

In addition to *P. cincinnatus*, there were four other abnormalities reported for 2012-13. One English sole (T1) and one Hornyhead Turbot (T17) were infected with an unidentified external parasite. Ambicolorism (i.e., deviation from normal skin/scale coloration) occurred in one English Sole (T17). Lastly, one Pink Rockfish (*Sebastes eos*) caught by hook-and-line had a tumor.

CONCLUSIONS

The results from the 2012-13 trawl monitoring surveys indicate: 1) healthy fish and epibenthic macroinvertebrate (EMI) communities are present within the District's monitoring area, 2) the outfall is not an epicenter of disease, and 3) NPDES permit compliance criteria V.A.4.a, V.A.4.b., and V.A.4.c were met. Community measures of the fish and EMI populations were similar between the 60 m outfall and non-outfall stations, within historical ranges, and comparable to regional non-POTW values. The cluster analysis also indicated a normal fish community as the outfall stations did not cluster separately from the other 60 m stations in either of the semiannual surveys. This was an improvement from the 2011 summer survey that suggested the fish community sampled at the outfall was altered relative to the other 60 m stations (OCSD 2013).

Other positive results included a low incidence of fish abnormalities and low fish tissue contaminant concentrations in English Sole and Hornyhead Turbot at the nearfield and farfield stations. Although contaminant levels in these species were below both state and federal human health advisory levels at both stations, we could not conduct a similar assessment for sport-caught fishes because we did not meet our rig fishing sampling goal. In addition, 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 2006). 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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