chapter 6

TRAWL COMMUNITIES AND ORGANISM HEALTH

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INTRODUCTION

The Orange County Sanitation District Ocean Monitoring Program (OMP) samples the demersal (bottom-dwelling) fish and epibenthic macroinvertebrate (EMI = large invertebrates) communities to assess affects of the wastewaster discharge on the epibenthic community and the health of the individual fish within the monitoring area. The District's 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 species (see box). Moreover, several 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 (*Cancer* spp.) are commercially and/or recreationally important.

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.

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 physical presence of the outfall structure and associated rock ballast, which provide a three dimensional hard substrate habitat that harbors a different suite of species than that found on the surrounding soft bottom. As a result, stations located near the outfall pipe can have greater species diversity and increased number of predators.

Discharge effects are changes related to the discharge of treated effluent. The effluent contains low concentrations of contaminants and organic particles. These organic particles may adhere to other particulates in the effluent and sink to the ocean bottom where they become a food resource for many invertebrate species. These, in turn, may be consumed by fish. The contaminants that accumulate in the invertebrates may then be transferred up the food chain to fish and other, higher order predators. Many demersal fish (e.g., flatfish) feed directly or indirectly on invertebrate prey that live in or on bottom sediments. Furthermore, they live in direct contact or in close association with sediments and consequently have an increased probability of direct exposure to the wastewater discharge and sediments containing discharged particles. The transfer of chemical contaminants through consumption of benthic infauna can 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).

Contaminants, especially lipid-soluble (lipophilic) compounds, such as chlorinated pesticides (e.g., DDT) and polychlorinated biphenyls (PCBs) can accumulate in organisms at concentrations several orders of magnitude higher than in sediments or water through the process of bioaccumulation. Further, certain organic compounds can increase in concentration in organisms at higher levels of the food chain via biomagnification, including humans and marine mammals. Whether bioaccumulated or biomagnified, high tissue contaminant concentrations may result in greater susceptibility to disease or reproductive impairment. Thus, the District uses tissue contaminant data to evaluate the following aspects of permit compliance: 1) are contaminant concentrations in fish muscle tissue sufficient to pose a potential human health concern; 2) are there temporal trends and spatial patterns relative to the ocean outfall; and 3) are the marine organisms in the monitoring area generally healthy, as defined in the permit? Spatial patterns in tissue contaminant data are evaluated to determine whether organisms collected near the outfall, or at other specified locations, contain elevated concentrations compared to a farfield site or other regional "background" locations within the Southern California Bight (SCB).

METHODS

Field Methods

Demersal fish and epibenthic macroinvertebrates species were collected in July 2007 and 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 for 450 m at approximately 2.0 knots along a pre-determined course. Sampling was conducted at nine permit stations: inner shelf (36 m) Stations T2 and T6; middle shelf (55 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 replicates were conducted at the middle shelf stations. Additionally, two replicate hauls were collected at T0 (18 m) in each survey to maintain a historical database, but the data are not presented in this report.

Trawl caught specimens were identified to the lowest possilble taxon (typically to species). Fish species with abundances up to 30 individuals were measured individually to the nearest millimeter (standard length) and weighed to the nearest gram. Fish species with more than 31 individuals were enumerated in 1 cm size classes and weighed in bulk. All fish specimens were examined for external tumors, other lesions, and parasites since fross external manifestations may be an indicator of contaminated sediments (Murchelano 1982). EMI were also enumerated by species and weighed to the nearest gram. Specimens with

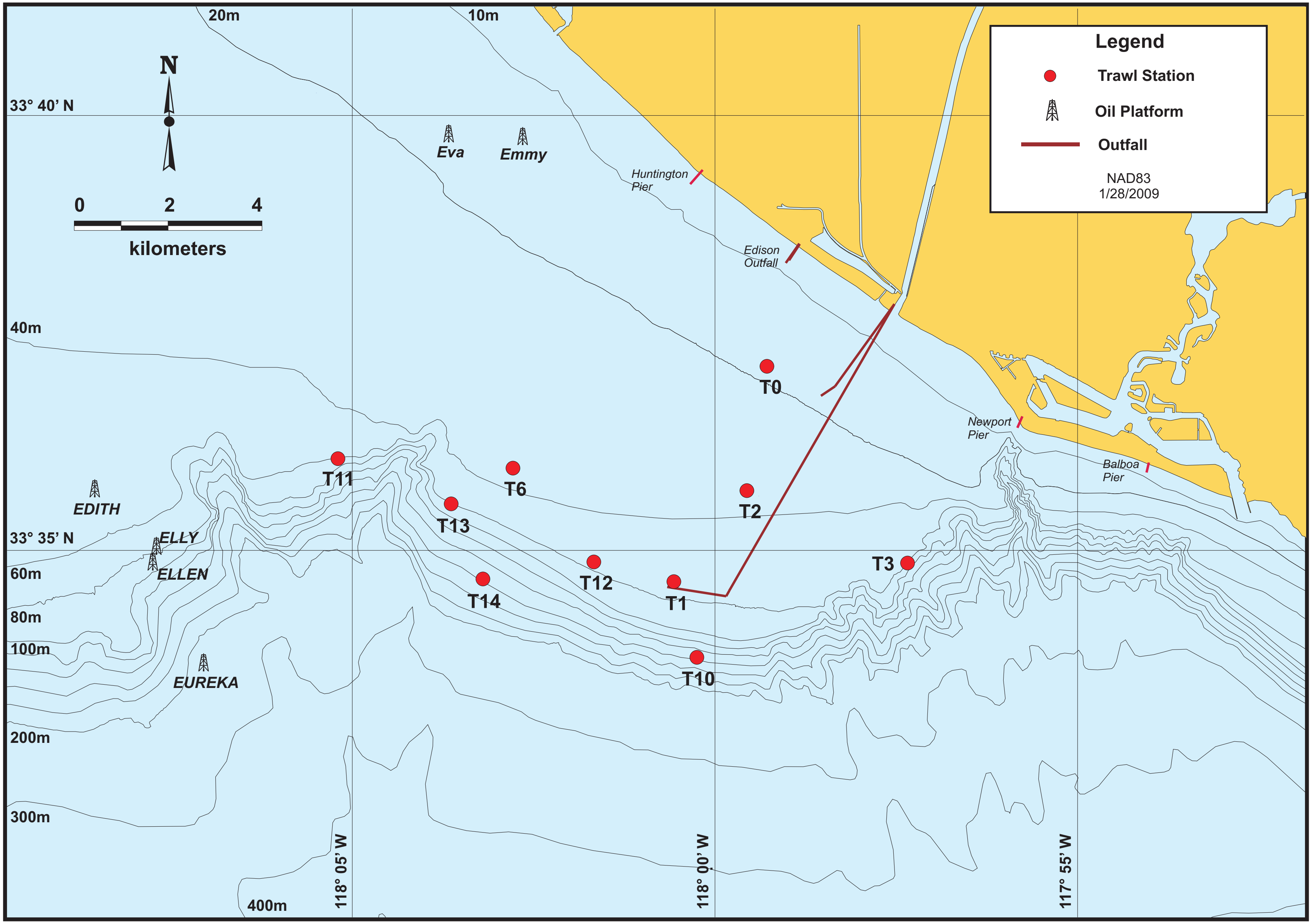

Figure 6-1. Otter trawl stations for semi-annual surveys, 2007-08.

Orange County Sanitation District, California.

abundance greater than 100 individuals were weighed in bulk batches. Some fish and EMI specimens were retained for further identification (FID) and weighed and measured in the laboratory. Fish from three target species were also collected for bioaccumulation studies: hornyhead turbot (*Pleuronichthys verticalis*), bigmouth sole (*Hippoglossina stomata*), English sole (*Parophrys vetulus*) and Pacific sanddab (*Citharichthys sordidus*). The sampling ojective was to collect 10 individuals of at least three of the four target species at both outfall (T1/T12) and farfield (T11/T13) sites. More detailed field and laboratory methods are provided in Appendix A.

Data Analyses

Fish and EMI populations were summarized in terms of percent abundance, frequency of occurrence, and mean abundance per haul. In addition, mean number of species per trawl, number of individuals per trawl, total abundance, biomass, and diversity indices including Shannon-Wiener (H'), Margalef's Species Richness (SR), Pielou's Evenness (J'), and 75% Dominance were calculated for both fish and EMI. In some analyses, stations were grouped into the following categories to assess spatial or depth-related patterns: outfall stations included T1 and T12; shallow Stations T2 and T6; deep Stations T10 and T14; farfield downcoast Station T3; and farfield upcoast Stations T11 and T13.

One-way analysis of variance (ANOVA) was calculated to test the hypothesis that there are no significant ($p \leq 0.05$) differences between the outfall and farfield stations for each community measure. Data log or rank transformations were used where appropriate to meet the assumptions of each test. Station differences were determined using the Tukey Multiple Comparison test. Community measures that were altered near the outfall, but not in the reference areas, were assumed to be affected by the wastewater discharge and/or outfall structure. Community measures from Stations T1 and T11 were also evaluated for long-term temporal and spatial patterns, and compared with regional reference conditions, such as 1994 Southern California Bight Pilot Project (SCBPP), the Bight'98, and Bight'03 regional monitoring programs.

Fish biointegrity in the District's monitoring area was assessed using the fish response index (FRI) (see Allen *et al*. 2001, 2006). The FRI is a multivariate weighted-average index produced from an ordination analysis of calibrated species abundance data. The FRI was calculated for all nine compliance stations in 2007-08. For a historical perspective, FRI was calculated from 1985 to 2008 for just outfall Station T1 and upcoast reference Station T11.

In order to evaluate human health risk, muscle and liver tissue from three target fish species were analzyed for statistical differences between outfall and farfield stations for concentrations of mercury, pesticides, and PCBs as a function of fish size and tissue lipid content. Differences among sites were tested using the T-test. All data, except mercury, were lipid-normalized prior to testing. Regression analysis was used to quantify statistical relationships between fish length, tissue lipid content, and contaminant concentrations. Station differences were determined using a one-way ANOVA ($p \leq 0.05$).

External parasites and other abnormalities in fish are not prevalent in the District's monitoring area; therefore precluding hypothesis testing. Data analysis consisted of summary statistics and qualititative comparisons only.

RESULTS AND DISCUSSION

Fish Community

<u>Number of Species</u>

A total of 45 fish species representing 22 families were collected in the District's study area in 2007-08 (Tables 6-1, 6-2, and B-15). Sixteen of the species were widely distributed and occurred at >75% of the stations. The six most frequently occurring species were the Pacific sanddab, longspine combfish, English sole, pink seaperch (*Zalembius rosaceus*), California tonguefish (*Symphurus atricaudus*), and bigmouth sole, each of which occurred at 100% of the stations. Four families, Scorpaenidae, Paralichthyidae, Pleuronectidae, and Agonidae comprised 51% of the species collected (Table 6-2). Only eight families were represented by more than one species.

During 2007-08, the mean number of species per station ranged from 12 to 20, which was similar to the previous year (Figure 6-2 and Table B-16). Differences were minimal between seasons, with slightly less mean number of species collected in winter than summer for most stations. The two shallow stations (T2 and T6) had the lowest mean species richness and 55 m Station T3 had the highest. Station T1 was statistically similar to other sites along the 55 m contour, although downcoast farfield Station T3 had significantly higher number of species than upcoast farfield Station T11 (Table 6-3).

Annual mean number of species by station group has been variable since 1985, fluctuating between four and 28 species (Figure 6-3). Overall, the fewest number of species tended to occur at the shallow station group, while the greatest number of species occurred at farfield downcoast Station T3 and the deep station group.

<u>Abundance</u>

A total of 19,855 fish were collected in 2007-08 (Tables 6-1 and B-15). Pacific sanddabs were the most abundant fish collected, representing 31% of the total catch. Yellowchin sculpins (*Icelinus quadriseriatus*), longspine combfish, and English sole each comprised 15, 11, and 10% of the total catch, respectively. All other species comprised 10% or less of the total catch. Of the 22 families represented, only six families accounted for 95% of the total abundance: Paralichthidae, Cottidae, Pleuronectidae, Hexagrammidae, Embotiotocidae, and Scorpaenidae (Table 6-2).

Variability in the abundance data was due primarily to population fluctuations of a few common species. For example, abundances of Pacific sanddabs ranged from 10 to 328 per haul, while yellowchin sculpin abundances ranged from zero to 153 per haul. On average, there were more individuals collected in winter (509 individuals/haul) than summer (328 individuals/haul). This difference was primarily due to a large catch of yellowchin sculpins, pacific sanddabs, and longspine combfish at Stations T12 and T13 in winter (Figure 6-2 and Table B-15). Most stations had a reduced mean abundance in summer compared to winter, except Station T1, which had a mean of approximately 600 individuals in both summer and winter surveys. In summer, mean abundances at T1 were statistically higher than all other 55 m stations, except T3 (Table 6-3). In winter, there were no statistical differences in abundance among the 55 m stations.

Table 6-1. Summary of demersal fish species collected during the Summer (July 2007) and Winter (January 2008) surveys. Data for each species are expressed as total abundance (Total), percent abundance (PA), frequency of occurrence (FO), and mean abundance per haul (MAH).

n = 46 hauls

Orange County Sanitation District, California.

Common name	Scientific name	Total	PA	FO	MAH
Pacific sanddab	*Citharichthys sordidus*	6,076	31%	100%	132
yellowchin sculpin	*Icelinus quadriseriatus*	3,063	15%	78%	67
longspine combfish	*Zaniolepis latipinnis*	2,101	11%	100%	46
English sole	*Parophrys vetulus*	1,957	10%	100%	43
pink seaperch	*Zalembius rosaceus*	1,180	6%	100%	26
longfin sanddab	*Citharichthys xanthostigma*	941	5%	78%	20
hornyhead turbot	*Pleuronichthys verticalis*	697	4%	89%	15
roughback sculpin	*Chitonotus pugetensis*	490	2%	78%	11
slender sole	*Lyopsetta exilis*	398	2%	33%	9
Dover sole	*Microstomus pacificus*	393	2%	78%	9
California tonguefish	*Symphurus atricaudus*	381	2%	100%	8
stripetail rockfish	*Sebastes saxicola*	335	2%	33%	7
bigmouth sole	*Hippoglossina stomata*	238	1%	100%	5
plainfin midshipman	*Porichthys notatus*	222	1%	89%	5
shortspine combfish	*Zaniolepis frenata*	202	1%	44%	4
California lizardfish	*Synodus lucioceps*	194	1%	89%	4
speckled sanddab	*Citharichthys stigmaeus*	184	1%	22%	4
calico rockfish	*Sebastes dallii*	139	1%	56%	3
halfbanded rockfish	*Sebastes semicinctus*	139	1%	78%	3
blackbelly eelpout	*Lycodes pacificus*	127	1%	44%	3
fantail sole	*Xystreurys liolepis*	115	1%	56%	3
California scorpionfish	*Scorpaena guttata*	111	1%	67%	2
pygmy poacher	*Odontopyxis trispinosa*	37	<1%	78%	1
shiner perch	*Cymatogaster aggregata*	24	<1%	44%	1
greenstriped rockfish	*Sebastes elongatus*	19	<1%	22%	<1
Pacific argentine	*Argentina sialis*	14	<1%	11%	<1
southern spearnose poacher	*Agonopsis sterletus*	9	<1%	44%	<1
specklefin midshipman	*Porichthys myriaster*	8	<1%	22%	<1
California skate	*Raja inornata*	8	<1%	78%	<1
greenspotted rockfish	*Sebastes chlorostictus*	8	<1%	33%	<1
spotted cuskeel	*Chilara taylori*	7	<1%	33%	<1
white croaker	*Genyonemus lineatus*	5	<1%	22%	<1
chub (Pacific) mackerel	*Scomber japonicus*	5	<1%	33%	<1
greenblotched rockfish	*Sebastes rosenblatti*	5	<1%	11%	<1
pacific hake	*Merluccius productus*	4	<1%	11%	<1
California halibut	*Paralichthys californicus*	4	<1%	11%	<1
northern (Pacific) anchovy	*Engraulis mordax*	3	<1%	11%	<1
vermillion rockfish	*Sebastes miniatus*	3	<1%	11%	<1
curlfin sole	*Pleuronichthys decurrens*	2	<1%	22%	<1
jack mackerel	*Trachiurus symmetricus*	2	<1%	11%	<1
northern spearnose poacher	*Agonopsis vulsa*	1	<1%	11%	<1
smooth stargazer	*Kathetostoma averruncus*	1	<1%	11%	<1
stripedfin (rough) ronquil	*Rathbunella alleni*	1	<1%	11%	<1
brown rockfish	*Sebastes auriculatus*	1	<1%	11%	<1
Pacific electric ray	*Torpedo californica*	1	<1%	11%	<1
	Total	19,855	100%		
	Total no. of species	45			

Table 6-2. Total number of species and abundance of demersal fish by family collected during the Summer (July 2007) and Winter (January 2008) surveys.
Data for each family are ranked by number of species and abundance for all stations and surveys combined.

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Family	Number of Species		Family Abundance	
	Total	Percentage	Total	Percentage
Paralichthyidae (Sand flounders)	6	13.33%	7,558	38.07%
Cottidae (Sculpins)	2	4.44%	3,553	17.89%
Pleuronectidae (Righteye flounders)	5	11.11%	3,447	17.36%
Hexagrammidae (Greenlings)	2	4.44%	2,303	11.60%
Embiotocidae (Surfperches)	2	4.44%	1,204	6.06%
Scorpaenidae (Scorpionfishes)	9	20.00%	760	3.83%
Soleidae (Soles)	1	2.22%	381	1.92%
Batrachoididae (Toadfishes)	2	4.44%	230	1.16%
Synodontidae (Lizardfish)	1	2.22%	194	0.98%
Zoarcidae (Eelpouts)	1	2.22%	127	0.64%
Agonidae (Poachers)	3	6.67%	47	0.24%
Argentinidae (Argentines)	1	2.22%	14	0.07%
Rajidae (Skates)	1	2.22%	8	0.04%
Ophidiidae (Cusk-eels)	1	2.22%	7	0.04%
Sciaenidae (Drums)	1	2.22%	5	0.03%
Scombridae (Mackerels)	1	2.22%	5	0.03%
Gadidae (Cods)	1	2.22%	4	0.02%
Engraulidae (Anchovies)	1	2.22%	3	0.02%
Carangidae (Jacks)	1	2.22%	2	0.01%
Bathymasteridae (ronquils)	1	2.22%	1	0.01%
Torpedinidae (Torpedo rays)	1	2.22%	1	0.01%
Uranoscopidae (Stargazers)	1	2.22%	1	0.01%
Total	45	100.00%	19,855	100.00%

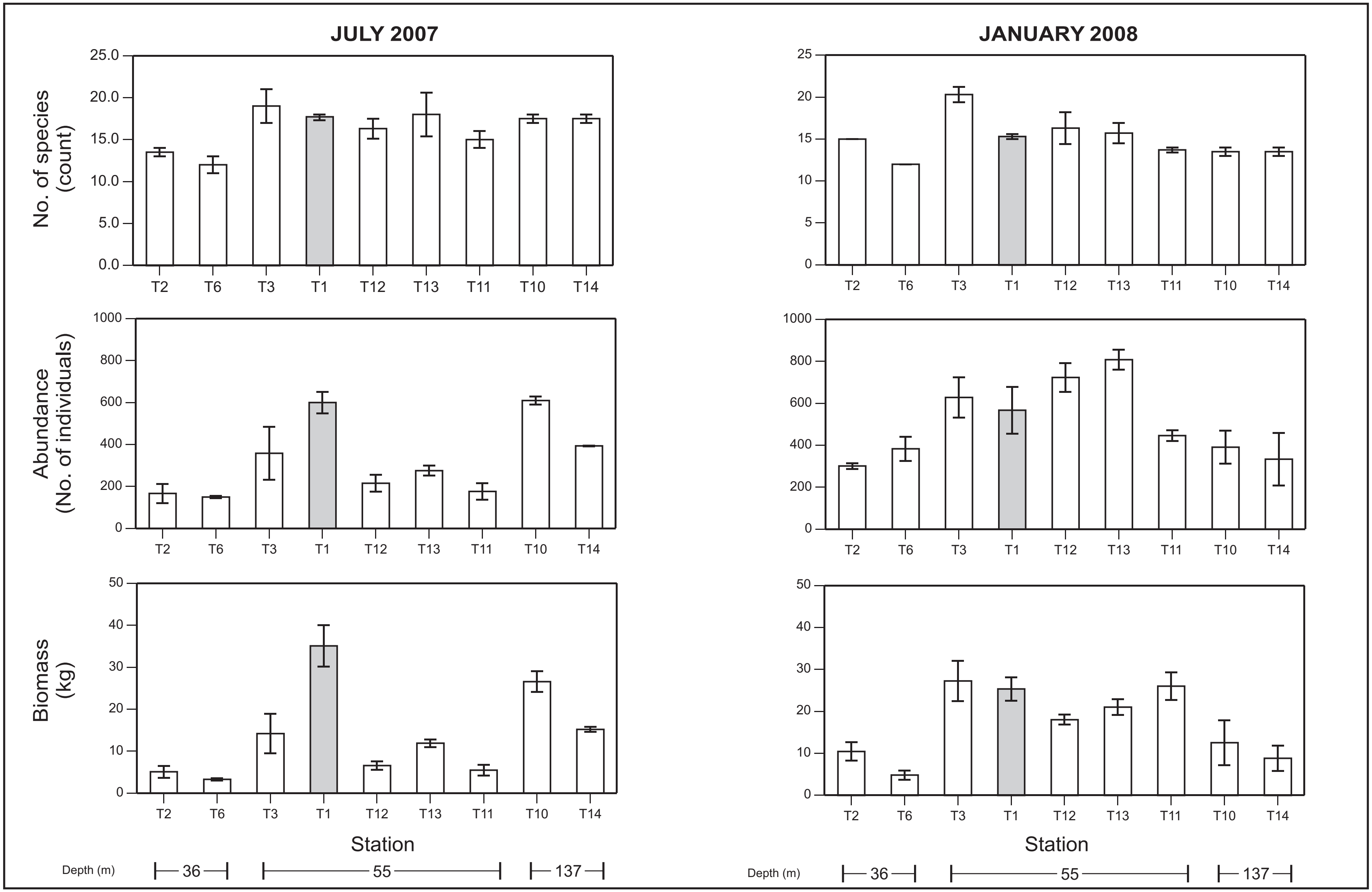

Figure 6-2. **Mean number of species, number of individuals (abundance), and biomass of demersal fish collected during the Summer (July 2007) and Winter (January 2008) surveys.**
Outfall Station T1 indicated in grey.

Table 6-3. **Results of ANOVA-Tukey analyses of demersal fish community measures for 55-m trawl stations, during Summer (July 2007) and Winter (January 2008).**

Non-transformed data are shown as "nt".

Orange County Sanitation District, California.

Parameter Tested	Transformation	ANOVA (p)	Mean Value (Untransformed) Tukey Station separation				
Summer 2007							
Number of Species (spp./trawl)	nt	0.503	19.0 T3	18.0 T13	17.7 T1	16.3 T12	15.0 T11
Total Abundance (no./trawl)	nt	0.008	600 T1	358 T3	276 T13	216 T12	177 T11
Total Biomass (kg/trawl)	nt	<0.001	35.1 T1	14.2 T3	11.9 T13	6.6 T12	5.5 T11
Shannon-Wiener Diversity (H')	nt	0.098	2.38 T12	2.33 T13	2.15 T11	2.09 T3	1.77 T1
Margalef Species Richness (SR)	nt	0.549	3.11 T3	3.02 T13	2.87 T12	2.73 T11	2.61 T1
Dominance (DOM75)	nt	0.168	7.00 T12	6.33 T13	6.00 T3	5.33 T11	4.00 T1
Evenness (J')	nt	0.039	0.85 T12	0.81 T13	0.80 T11	0.71 T3	0.62 T1
Winter 2008							
Number of Species (spp./trawl)	nt	0.016	20.3 T3	16.3 T12	15.7 T13	15.3 T1	13.7 T11
Total Abundance (no./trawl)	nt	0.056	808 T13	723 T12	628 T3	567 T1	446 T11
Total Biomass (kg/trawl)	nt	0.252	27.2 T3	26.0 T11	25.3 T1	21.0 T13	18.0 T12
Shannon-Wiener Diversity (H')	nt	0.009	2.21 T3	1.97 T12	1.87 T11	1.83 T1	1.76 T13
Margalef Species Richness (SR)	nt	0.012	3.02 T3	2.33 T12	2.28 T1	2.19 T13	2.08 T11
Dominance (DOM75)	nt	0.027	5.33 T3	4.00 T11	4.00 T12	3.67 T1	3.33 T13
Evenness (J')	nt	0.029	0.74 T3	0.72 T11	0.71 T12	0.67 T1	0.64 T13

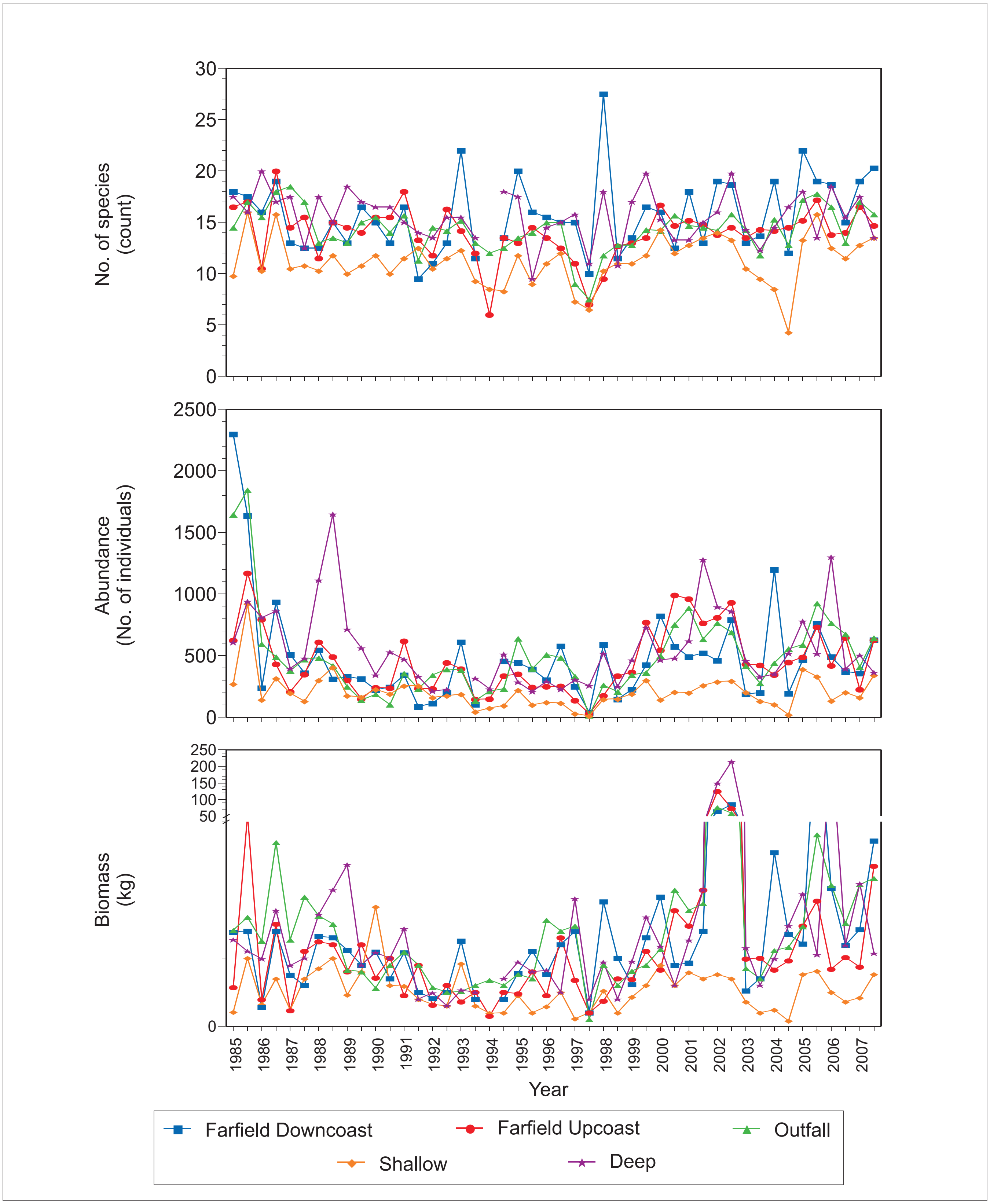

Figure 6-3. **Mean number of fish species, abundance, and biomass per station group for the period 1985–2008. Station groups are farfield downcoast (T3), farfield upcoast (T11 and T13), outfall (T1 and T12), shallow (T2 and T6), and deep (T10 and T14).**

Orange County Sanitation District, California.

The five most abundant fish species at the 55 m stations in 2007-08 were Pacific sanddab, yellowchin sculpin, English sole, longspine combfish, and pink seaperch (Table 6-1). Of these, only English sole showed significant differences in abundance (Table 6-4). Outfall Station T1 had significantly higher mean abundance of English sole than all other 55 m stations, except T13. Variability of English sole abundance was high, ranging from nine at Station T12 to 210 at outfall Station T1.

Fish abundance has been highly variable since 1985, with mean values ranging from 11 to 2,300 (Figure 6-3). Historically, the shallow stations have had the lowest abundances, while the deep and farfield downcoast stations generally have the highest abundances. Fluctuations in abundance reflect population changes of several dominant species, especially Pacific sanddab, yellowchin sculpin, longspine combfish, and English sole (Figure 6-4). For example, large catches of Pacific sanddabs were responsible for the high mean abundances in 1988-89 and 2006-07. The high mean abundance in 1985-86 was a reflection of the large catches of yellowchin sculpin and longspine combfish catches. Although less important in 2007-08, variability in the abundance trends of the half-banded rockfish (*Sebastes semicintus*) and pink seaperch have affected previously reported abundance data (e.g., OCSD 2005, 2008).

<u>Biomass</u>

A total of 746 kg of fish was collected in 2007-08, with two families (Paralichthyidae and Pleuronectidae) accounting for 75% of fish biomass. As with abundance, biomass data are highly variable (ranging from 4 to 30 kg per haul) due to population fluctuations of dominant species and variability in the size of individuals collected. For example, Pacific sanddabs collected ranged from 4 to 25 cm (Table B-15). Mean biomass per survey was greater in winter than summer, with values of 17.1 and 13.7 kg, respectively (Figure 6-2 and Table B-16). The annual mean biomass at outfall Station T1 was higher than all other 55 m stations, but only significantly higher in summer (Table 6-3). Historically, biomass has been highly variable, ranging from 1 to 215 kg (Figure 6-3). Biomass for the station groups followed a trend similar to abundance as described above.

<u>Diversity Indices</u>

The mean Shannon-Wiener diversity index values (H’) for each survey ranged from 1.32 to 2.52 in summer and 1.40 to 2.29 in winter (Figure 6-5 and Table B-16). Outfall Station T1 had lower mean diversity values of the 55 m stations, but was only statistically different from T3 in winter (Table 6-3). Diversity in the District’s monitoring area was high relative to central Bight, middle shelf area, which had a mean H’ of 1.69 (Allen *et al.* 2007). Other diversity measures (Margalef Species Richness, 75% Dominance, and Evenness) revealed similar results of no significant differences among the 55 m stations in summer, but a couple of differences in winter. Downcoast farfield Station T3 had a significantly higher SR than T1, T13, and T11 and a significantly higher 75% Dominance than T13.

<u>Regional Comparisons</u>

The Fish Response Index (FRI) 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 index was an effective fish index, especially in the middle shelf zone of the SCB. FRI values less than 45 are classified as reference (normal) and those greater than 45 are non-reference (abnormal or disturbed). For example, FRI values exceeded the threshold of 45

Table 6-4. **Results of ANOVA-Tukey analyses on mean abundance of selected demersal fish and epibenthic macroinvertebrate species for 55-m trawl stations, during Summer (July 2007) and Winter (January 2008).**

Orange County Sanitation District, California.

Parameter Tested	Transformation	ANOVA (p)	Mean Value (Untransformed) Tukey Station seperation				
DEMERSAL FISH							
Pacific sanddab (*Citharichthys sordidus*)	nt	0.066	187 T3	145 T1	125 T13	102 T12	96 T11
yellowchin sculpin (*Icelinus quadriseriatus*)	rank	0.272	153 T13	126 T12	46 T3	41 T11	17 T1
English sole (*Parophrys vetulus*)	rank	<0.001	210 T1	36 T13	38 T11	23 T3	9 T12
longspine combfish (*Zaniolepis latipinnis*)	nt	0.164	103 T13	67 T12	64 T3	42 T11	33 T1
pink seaperch (*Zalembius rosaceus*)	log_{10}	0.638	66 T1	42 T3	32 T13	26 T12	8 T11
EPIBENTHIC MACROINVERTEBRATES							
trailtip sea pen (*Acanthoptilum sp.*)	rank	<0.001	445.3 T1	14.5 T3	14.0 T12	4.7 T11	0.5 T13
brokenspine brittlestar (*Ophiura luetkenii*) *	log_{10}	0.170	187.0 T13	124.5 T3	53.7 T12	8.3 T11	2.8 T1
white sea urchin (*Lytechinus pictus*) *	log_{10}	0.159	55.5 T11	19.2 T1	12.2 T3	2.7 T12	0.2 T13
California blade barnacle (*Hamatoscalpellum californicum*)	nt	0.522	29.7 T11	20.8 T13	14.3 T12	13.3 T3	10.2 T1
yellow sea twig (*Thesea* sp.)	rank	0.751	14.7 T11	9.5 T12	8.7 T13	8.2 T3	6.8 T1

* Note: Data points with a value of zero where transformed to 1.0 prior to log_{10} transformation. Non-transformed data are shown as "nt".

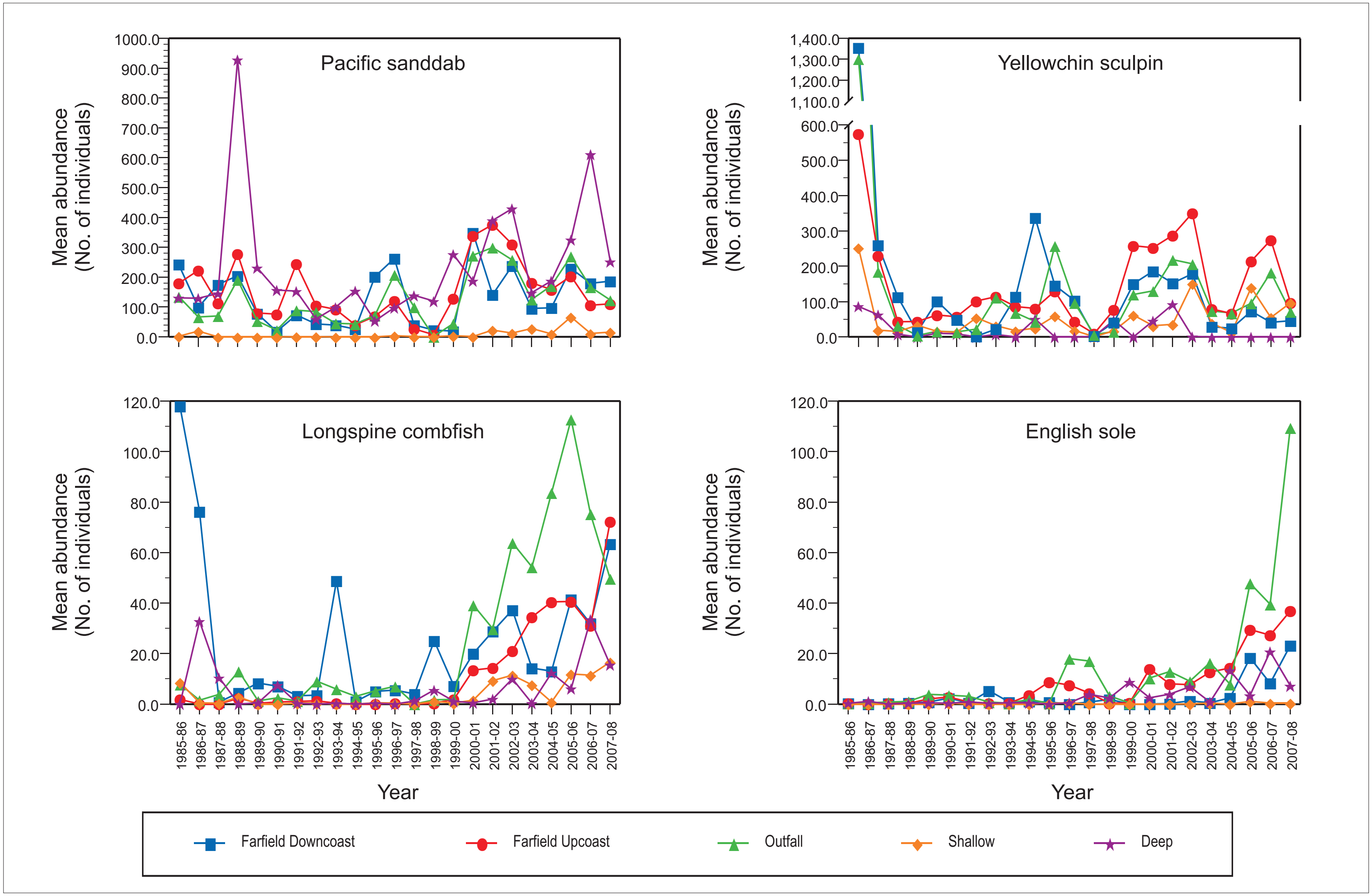

Figure 6-4. **Mean abundance from 1985 to 2008 by station group — farfield downcoast (T3), farfield upcoast (T11 and T13), outfall (T1 and T12), shallow (T2 and T6), and deep (T10 and T14), of the 2007-08 most abundant demersal fish species: Pacific sanddab (C*itharichthys sordidus)*, yellowchin sculpin (*Icelinus quadriseriatus)*, longspine combfish (*Zaniolepis latipinnis*), and English sole (*Parophrys vetulus)*.**

Data are expressed as annual means (July – June); n=4-6 replicates/station/year.

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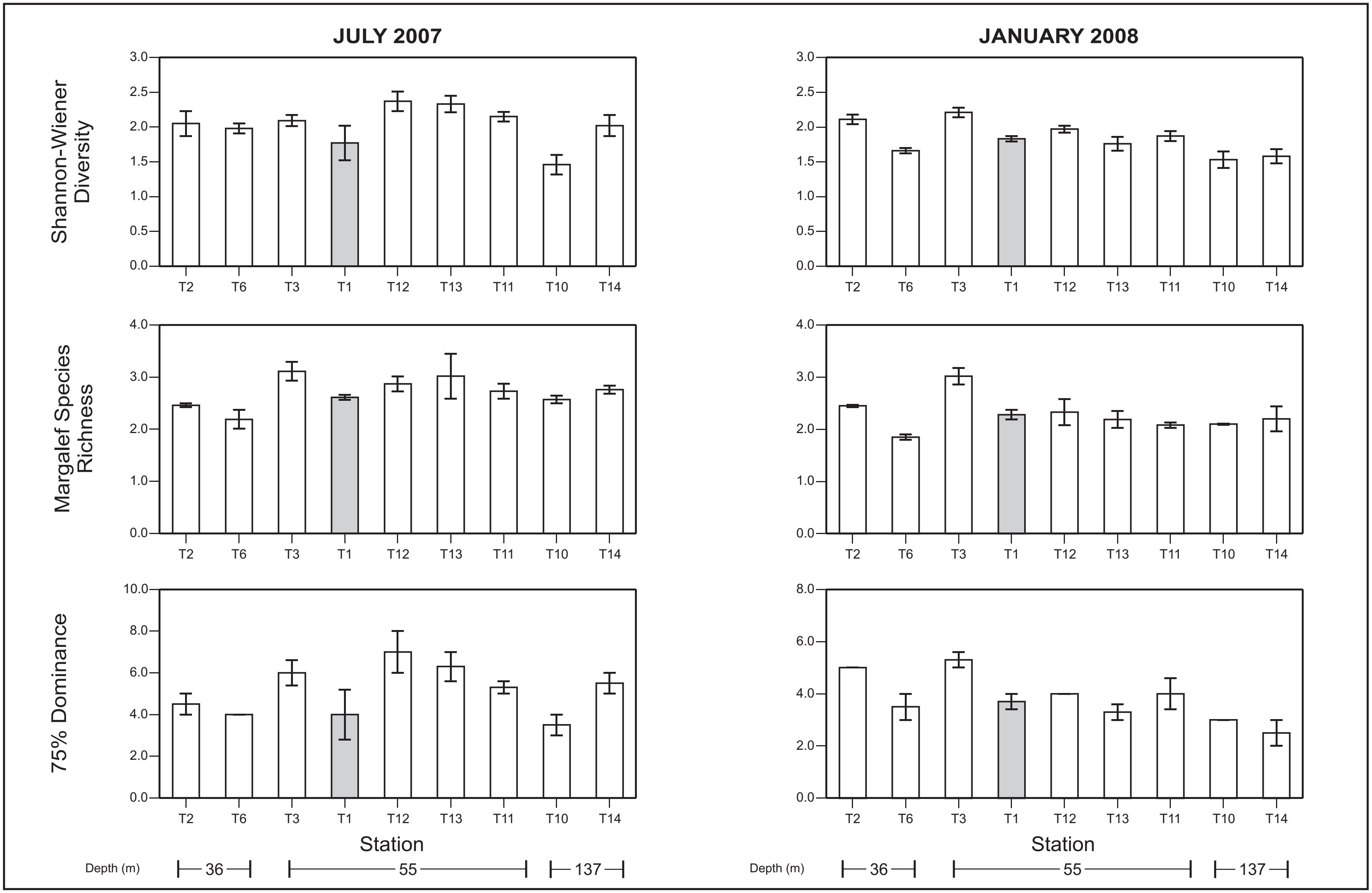

Figure 6-5. **Mean diversity indices — Shannon-Wiener (H'), Margalef Species Richness (SR), and 75% Dominance (DOM75) of demersal fish collected during the Summer (July 2007) and Winter (January 2008) surveys.**
Outfall Station T1 indicated in grey.

on the Palos Verdes shelf from 1970 to 1983 when sediment organics and contamination was high (Allen *et al.* 2006). By 1990, FRI values at Palos Verdes went down to about 25 and remained near this value through 2002. In 2007-08, mean FRI values at the District's core stations ranged from 15 to 26 and were considered reference conditions (Figure 6-6). Historically, mean FRI values for outfall Station T1 and upcoast reference Station T11 have consistently been below 45, ranging from 13 to 30 (Figure 6-6). These values are consistent with Allen *et al.* (2007), who reported that 96% of the SCB area in 1998 was classified as reference. (The remaining 4% of nonreference areas occurred on the inner shelf and in bays and harbors.)

Station T1 and T11 data from summer 2007 were compared with data from the SCBPP, Bight'98, and Bight'03 regional monitoring surveys (Figure 6-7) (Allen *et al*. 1998, Allen *et al*. 2002 and Allen *et al.* 2007). The three regional surveys reported no degraded areas, but found enhancement of demersal community measures (e.g., mean fish abundance and biomass) at some locations near wastewater outfalls. The District's summer data at outfall Station T1 and farfield upcoast Station T11 followed trends similar to those described previously for the regional survey (see OCSD 2007). Overall, the District's outfall shows enhanced abundance and biomass, especially in 2007. Abundance means are within the abundance ranges for the regional LPOTW stations. Biomass at T1 is at the high end of regional values. High mean biomass at T1 in July 2007 was high due to a number of large individuals of English Sole and a large catch of Pacific sanddabs. Diversity has been consistent over the years with a slight increase starting in 2003. Station T11 had the highest diversity in 2007, but was still within the range of values at Bight POTW and non-POTW stations. Since fish community measures at outfall Station T1 approximately equaled or exceeded values characterizing LPOTW and non-POTW areas within the central Bight at similar depths, the fish community near the discharge appears healthy and prolific.

EMI Community

<u>Number of Species</u>
A total of 57 EMI taxa were collected during 2007-08 (Tables 6-5 and B-17). Only three species occurred at every station: California blade barnacle (*Hamatoscalpellum californicum*), gray sandstar (*Luidia foliolata*) and California sand star (*Astropecten verrilli*). Another 11 species were wide ranging and occurred at over 75% of the stations. There were no seasonal differences in the mean number of species, which ranged from seven to 20 in summer and six to 19 species in winter (Figure 6-8 and Table B-18). The greatest number of species occurred at T3 in both seasons, although T6 had an equally high number of species as T3 in summer. The mean number of species at outfall Station T1 was similar to all 55 m stations, except T3, which was significantly greater than all other 55 m stations in summer and T11 and T13 in winter (Table 6-6). The mean number of EMI for the five station groups has varied over time, ranging from three to 23 species (Figure 6-9). Species richness in 2007-08 was well within the historical range.

<u>Abundance</u>
A total of 9,605 EMI were collected during 2007-08 (Tables 6-5 and B-17). Two species accounted for over 50% of the total abundance: the trailtip sea pen (*Acanthoptilum* sp.) species comprising 30% of the total catch (2,894 individuals), followed by the brokenspine brittlestar (*Ophiura luetkenii*) representing 24% (2,343 individuals) of the total catch.

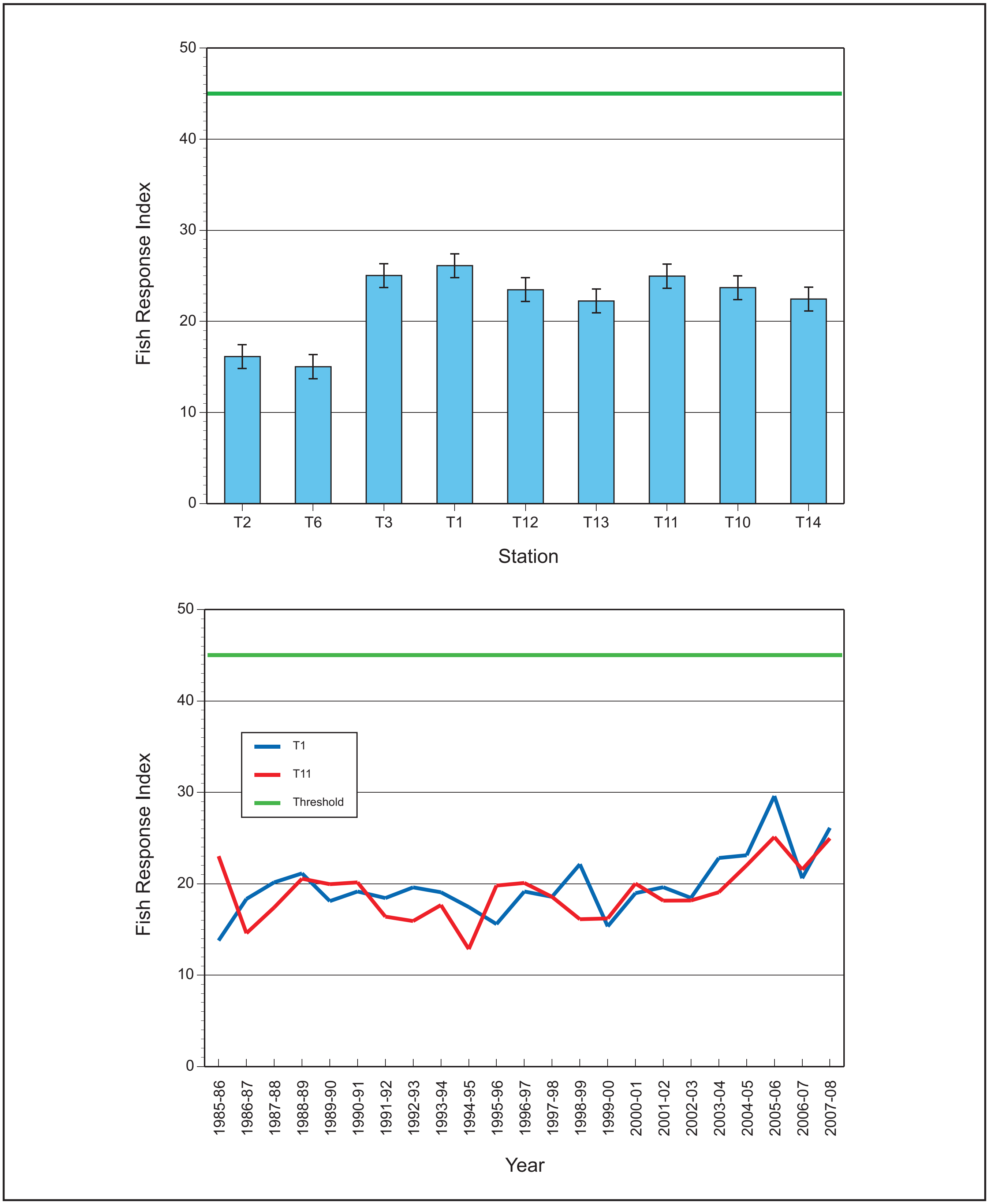

Figure 6-6. **Mean Fish Response Index (FRI) per station in 2007-08 and annual mean FRI for outfall Station T1 and farfield upcoast Station T11.**
Green line represents threshold value.

Orange County Sanitation District, California.

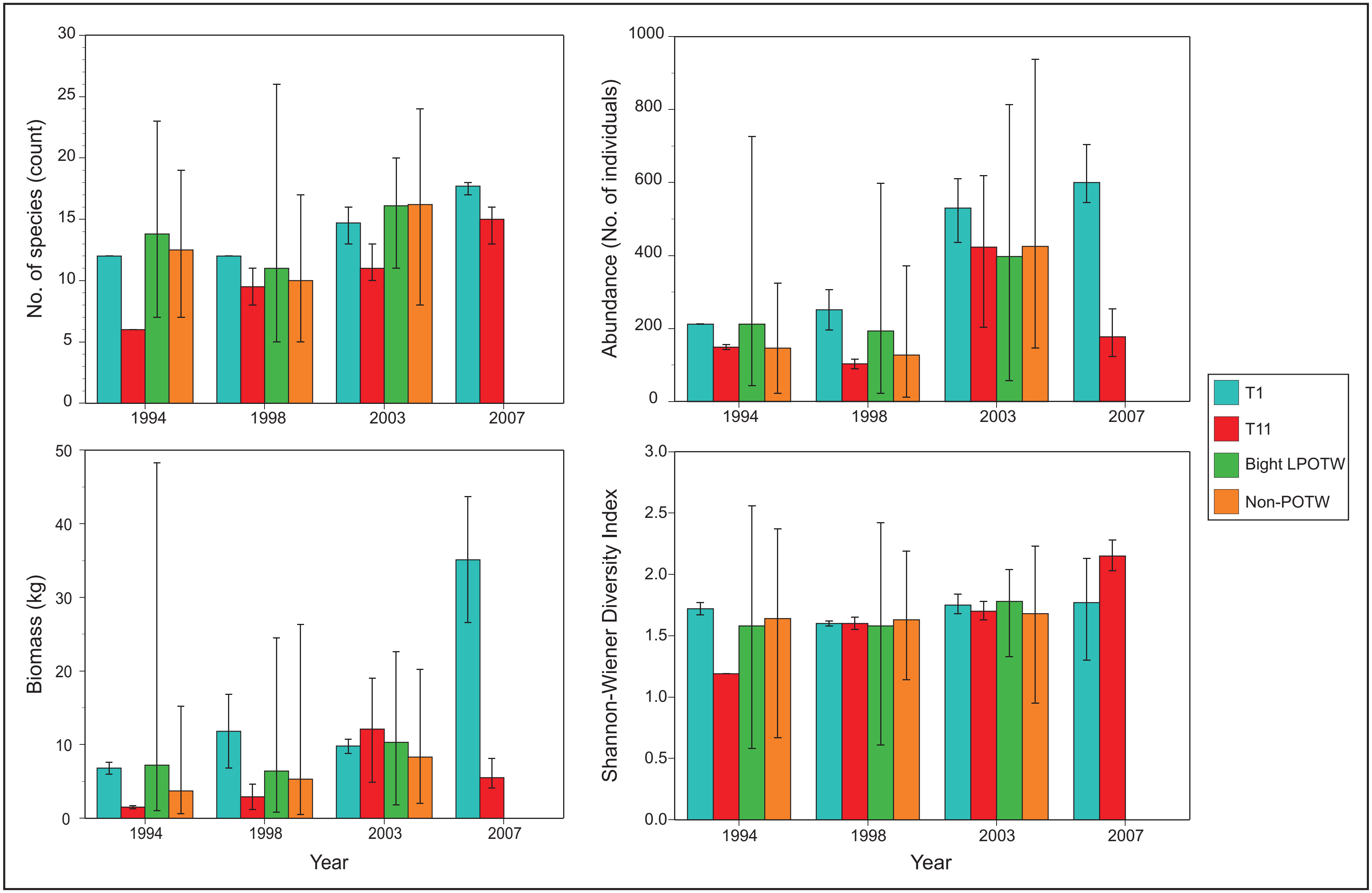

Figure 6-7. **Mean demersal fish number of species, abundance, biomass, and Shannon-Wiener diversity (H') at OCSD stations T1 and T11 in 1994, 1998, 2003, and 2007 and regional POTW and non-POTW stations from the 1994, 1998, and 2003 regional monitoring surveys. All data are for summer surveys only and error bars represent the range of values (minimum and maximum) for each station group per survey.**

Note: N values = 1994: LPOTW = 16, nonPOTW = 3; 1998: LPOTW = 25, nonPOTW = 15; 2003: LPOTW = 18, nonPOTW = 13

Orange County Sanitation District, California.

Table 6-5. Summary of epibenthic macroinvertebrates species collected during the Summer (July 2007) and Winter (January 2008) surveys. Data for each species are expressed as total abundance (Total), percent abundance (PA), frequency of occurrence (FO), and mean abundance per haul (MAH).

n = 46 hauls

Orange County Sanitation District, California.

Species	Total	PA	FO	MAH
Acanthoptilum sp.	2,894	30%	78%	63
Ophiura luetkenii	2,343	24%	89%	51
Sicyonia ingentis	1,332	14%	78%	29
Hamatoscalpellum californicum	868	9%	100%	19
Thesea sp.	658	7%	89%	14
Lytechinus pictus	585	6%	89%	13
Luidia foliolata	231	2%	100%	5
Dendronotus frondosus	170	2%	22%	4
Astropecten verrilli	122	1%	100%	3
Parastichopus californicus	67	1%	78%	1
Ophiothrix spiculata	33	<1	78%	1
Luidia asthenosoma	30	<1	67%	1
Pleurobranchaea californica	25	<1	78%	1
Amphichondrius granulatus	24	<1	44%	1
Spatangus californicus	24	<1	11%	1
Virgularia californica	23	<1	44%	1
Stylatula elongata	20	<1	22%	<1
Acanthodoris brunnea	20	<1	67%	<1
Heterogorgia sp.	20	<1	78%	<1
Octopus rubescens	13	<1	67%	<1
Neocrangon zacae	12	<1	33%	<1
Orthopagurus minimus	11	<1	22%	<1
Tunicate	9	<1	33%	<1
Strongylocentrotus fragilis	7	<1	11%	<1
Rossia pacifica	6	<1	33%	<1
Loxorhynchus grandis	5	<1	11%	<1
Porifera - Unidentified	5	<1	44%	<1
Styela clava	5	<1	11%	<1
Calliostoma turbinum	4	<1	44%	<1
Philine auriformis	4	<1	44%	<1
Armina californica	3	<1	22%	<1
Virgularia sp.	3	<1	22%	<1
Amphipholis squamata	2	<1	11%	<1
Podochela lobifrons	2	<1	22%	<1
Tritonia diomedea	2	<1	11%	<1
Virgularia agassizi	2	<1	22%	<1
Loxorhynchus crispatus	1	<1	11%	<1
Pyromaia tuberculata	1	<1	11%	<1
Amphioda psara	1	<1	11%	<1
Amphiodia sp.	1	<1	11%	<1
Anisodoris nobilis	1	<1	11%	<1
Austrotrophon catalinensis	1	<1	11%	<1
Brisaster townsendi	1	<1	11%	<1
Cancellaria cooperii	1	<1	11%	<1
Cancellaria crawfordiana	1	<1	11%	<1

Table 6-5 continues.

Table 6-5 continued.

Species	Total	PA	FO	MAH
Cancer anthonyi	1	<1	11%	<1
Crangon alaskensis	1	<1	11%	<1
Euspira draconis	1	<1	11%	<1
Fusinus barbarensis	1	<1	11%	<1
Heptacarpus stimpsoni	1	<1	11%	<1
Heptacarpus tenuissimus	1	<1	11%	<1
Hippolytidae	1	<1	11%	<1
Metacrangon spinosissima	1	<1	11%	<1
Octopus californicus	1	<1	11%	<1
Paguristes bakeri	1	<1	11%	<1
Platymera gaudichaudii	1	<1	11%	<1
Sicyonia penicillata	1	<1	11%	<1
Total	9,605	100%		
Total no. of species	57			

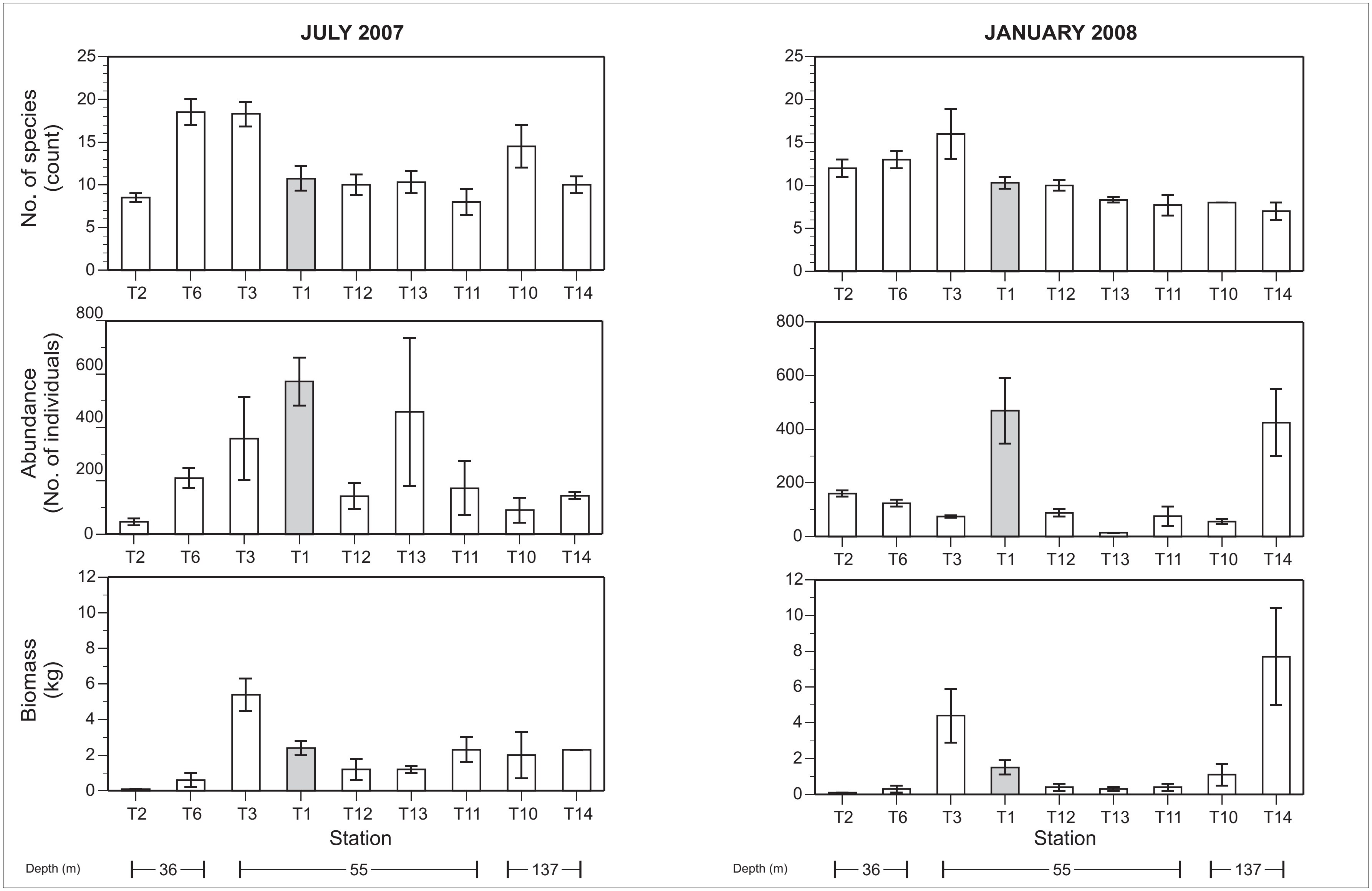

Figure 6-8. **Mean number of species, number of individuals (abundance), and biomass of epibenthic macroinvertebrates collected during the Summer (July 2007) and Winter (January 2008) surveys.**
Outfall Station T1indicated in grey.

Table 6-6. **Results of ANOVA-Tukey analyses of epibenthic macroinvertebrate community measures for 55-m trawl stations, Summer (July) 2007 and Winter (January 2008).**

Non-transformed data are shown as “nt”.

Orange County Sanitation District, California.

Parameter Tested	Transformation	ANOVA (p)	Mean Value (Untransformed) Tukey Station separation				
Summer 2007							
Number of Species (spp./trawl)	nt	0.003	18.3 T3	10.7 T1	10.3 T13	10.0 T12	8.0 T11
Total Abundance (no./trawl)	nt	0.302	572 T1	458 T13	358 T3	172 T11	142 T12
Total Biomass (kg/trawl)	nt	0.004	5.4 T3	2.4 T1	2.3 T11	1.2 T12	1.2 T13
Shannon-Wiener Diversity (H’)	nt	0.395	1.56 T3	1.51 T12	1.34 T11	1.03 T13	0.82 T1
Margalef Species Richness (SR)	nt	0.006	3.07 T3	1.89 T12	1.67 T13	1.54 T1	1.52 T11
Dominance (DOM75)	nt	0.321	3.67 T3	2.67 T12	2.33 T11	2.00 T13	1.33 T1
Evenness (J’)	nt	0.347	0.67 T12	0.54 T3	0.68 T11	0.44 T13	0.34 T1
Winter 2008							
Number of Species (spp./trawl)	nt	0.017	16.0 T3	10.3 T1	10.0 T12	8.3 T13	7.7 T11
Total Abundance (no./trawl)	nt	0.006	469 T1	88 T12	76 T11	74 T3	14 T13
Total Biomass (kg/trawl)	nt	0.034	4.4 T3	1.5 T1	0.4 T12	0.4 T11	0.3 T13
Shannon-Wiener Diversity (H’)	nt	<0.001	2.17 T3	1.93 T13	1.48 T12	1.35 T11	0.55 T1
Margalef Species Richness (SR)	nt	0.007	3.48 T3	2.81 T13	2.02 T12	1.74 T11	1.53 T1
Dominance (DOM75)	nt	<0.001	5.67 T3	5.00 T13	3.00 T12	2.33 T11	1.00 T1
Evenness (J’)	nt	<0.001	0.91 T13	0.79 T3	0.68 T11	0.65 T12	0.24 T1

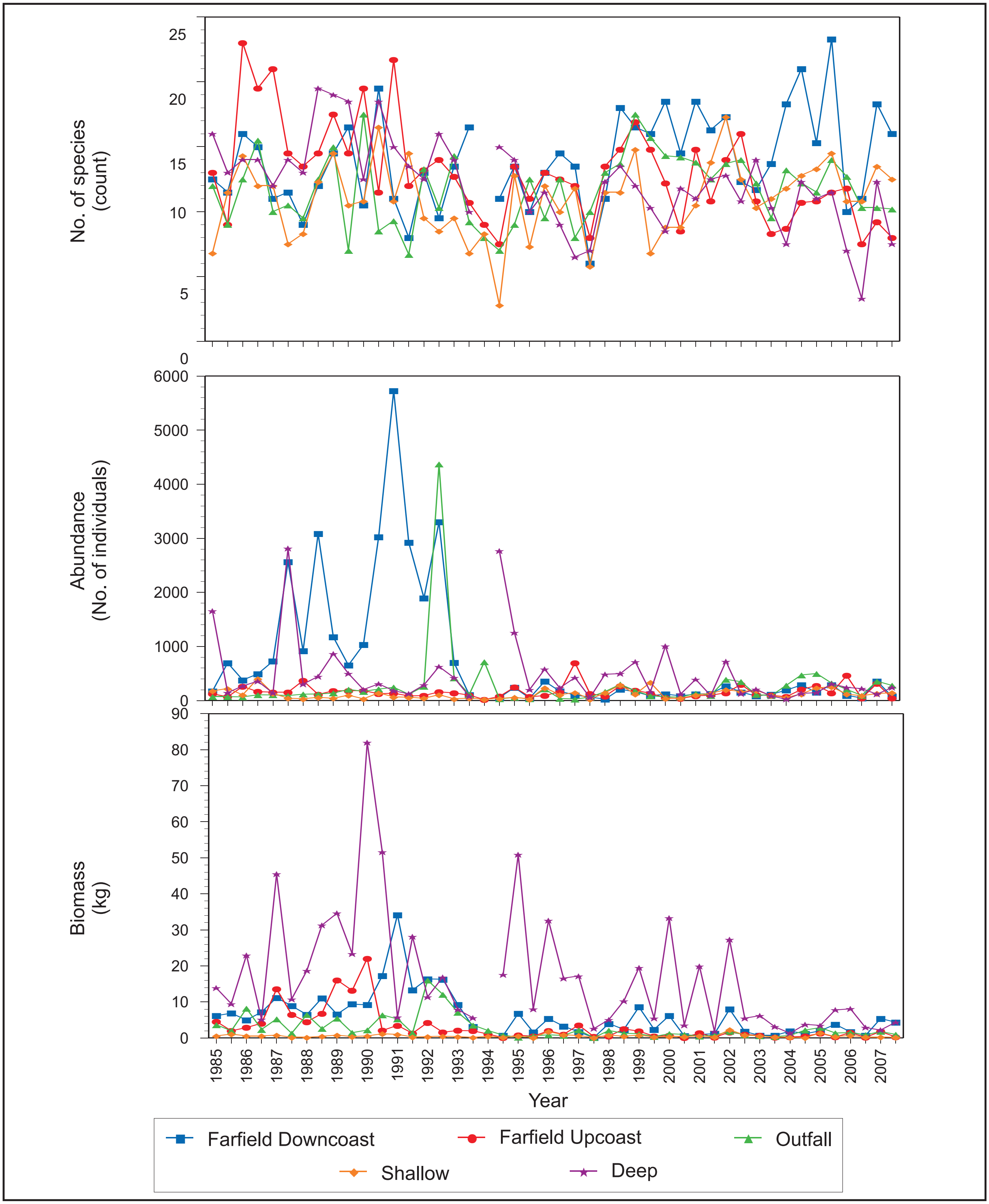

Figure 6-9. **Mean number of epibenthic macroinvertebrate species, abundance, and biomass per station group for the period 1985-2008. Station groups are farfield downcoast (T3), farfield upcoast (T11 and T13), outfall (T1 and T12), shallow (T2 and T6), and deep (T10 and T14).**

Orange County Sanitation District, California.

Other abundant species included the ridgeback rockshrimp, California blade barnacle, yellow sea twig (*Thesea* sp.), and white sea urchin (*Lytechinus pictus*). Seasonal differences were present with more EMI collected in summer than winter. Mean abundances ranged from 33 to 734 in summer and 13 to 592 in winter (Figure 6-8 and Table B-18). Mean abundance for both surveys was highest at T1, but was only significantly different from Station T13 in winter (Table 6-6). High abundance at T1 for both seasons was primarily due to the large catches of the trailtip sea pen, which have been occurring there in large numbers since 2002 (Figure 6-10). The success of the trailtip sea pen at T1 did not come at the expense of other species: Shannon-Wiener Diversity at T1 was the second highest (after T3) of the 55 m stations when sea pen data were excluded from the 2007-08 data.

The five most abundant EMI at the 55 m stations were the trailtip sea pen (*Acanthoptilum* sp.), brokenspine brittlestar (*Ophiura luetkenii*), white sea urchin (*Lytechinus pictus*), California blade barnacle (*Hamatoscalpellum californicum*), and yellow sea twig (*Thesea* sp.) (Table B-17). Trailtip sea pen mean abundance was significantly greater at T1 than at any other 55 m station (Table 6-4). No statistical differences were detected among the 55 m stations for mean abundance of the other four dominant species.

Abundance for the five station groups has been highly variable over the past 22 years with ranges from 17 to 5,700 individuals (Figure 6-9). These fluctuations typically reflect changes in several dominant species, such as the trailtrip seapen, brokenspine brittlestar, ridgeback rockshrimp, California blade barnacle, yellow sea twig, and white sea urchin (Figure 6-10).

<u>Biomass</u>

In 2007-08, 86.7 kg of EMI were collected in the District's monitoring area. The California sea cucumber (*Parastichopus californicus*) comprised 40 kg (46%) of this biomass and the ridgeback rockshrimp made up 16 kg (19%). The highest biomass values occurrred at stations T3 (summer) due to the large catch of California sea cucumbers, and T14 (winter) due to a large catch of ridgeback rockshrimp (Figure 6-8). Outfall Station T1 biomass values were similar to the other 55 m stations, except T3 in summer (Table 6-6). Of the 55 m stations, T3 also had a significantly higher biomass than T11, T12, and T13 in summer and T13 in winter. Historically, biomass has been highest at the outer shelf stations and lowest at the inner shelf stations; however, biomass values at the deep stations have declined in recent years (Figure 6-9).

<u>Diversity Indices</u>

Diversity, as represented by H', SR, and Dominance, was generally highest at farfield downcoast Station T3 and inner shelf Stations T2 and T6 (Figure 6-11 and Table B-18). Deep Station T10 also had a high diversity comparable to that at T3 in summer. Mean diversity at outfall Station T1 was relatively low and statistically different from all four of the other 55 m stations in winter for H' and 75% Dominance (Table 6-6). Station T1 also had significanlty lower SR than Station T3 in both seasons. Low diversity values at T1 were due to the extremely high abundances of the trailtip sea pen. Shannon-Wiener diversity is affected by both the number of species and their evenness, hence a large abundance of a single species at one location will substantially lower the H' value. When H' was recalculated on the 55 m station data excluding the sea pen, T1 mean diversity was 1.66 in

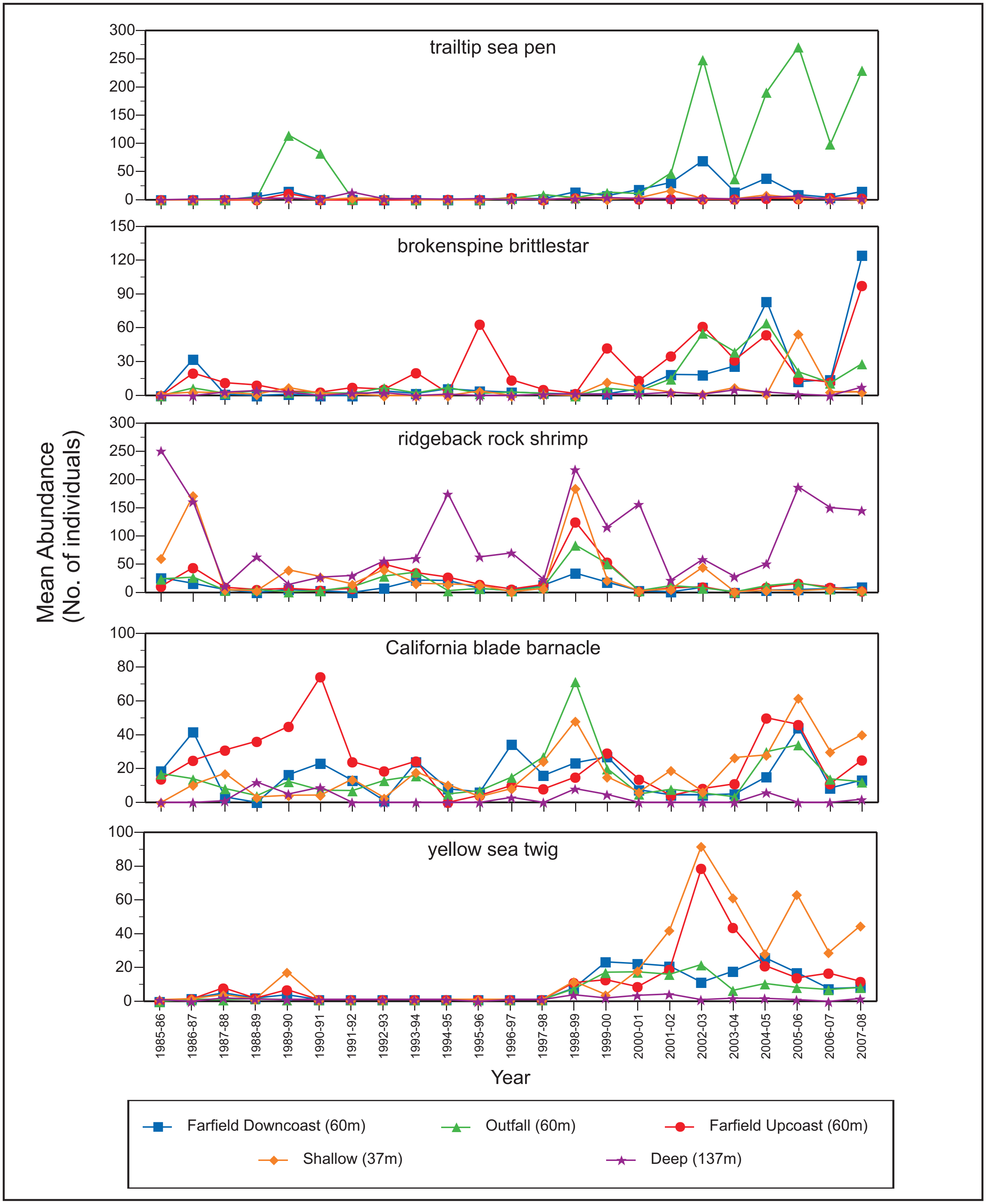

Figure 6-10. **Mean abundance from 1985 to 2008 by station group — farfield downcoast (T3), farfield upcoast (T11 and T13), outfall (T1 and T12), shallow (T2 and T6), and deep (T10 and T14)] of the 2007-08 most abundant epibenthic macroinvertebrates: trailtip sea pen (*Acanthoptilum* sp.), brokenspine brittlestar (*Ophiura luetkenii*), ridgeback rock shrimp (*Sicyonia ingentis*), California blade barnacle (*Hamatoscalpellum californicum*), and yellow sea twig (*Thesea* sp.).** **Data are expressed as annual means (July – June); n=4–6 replicates/station/year.**

Orange County Sanitation District, California.

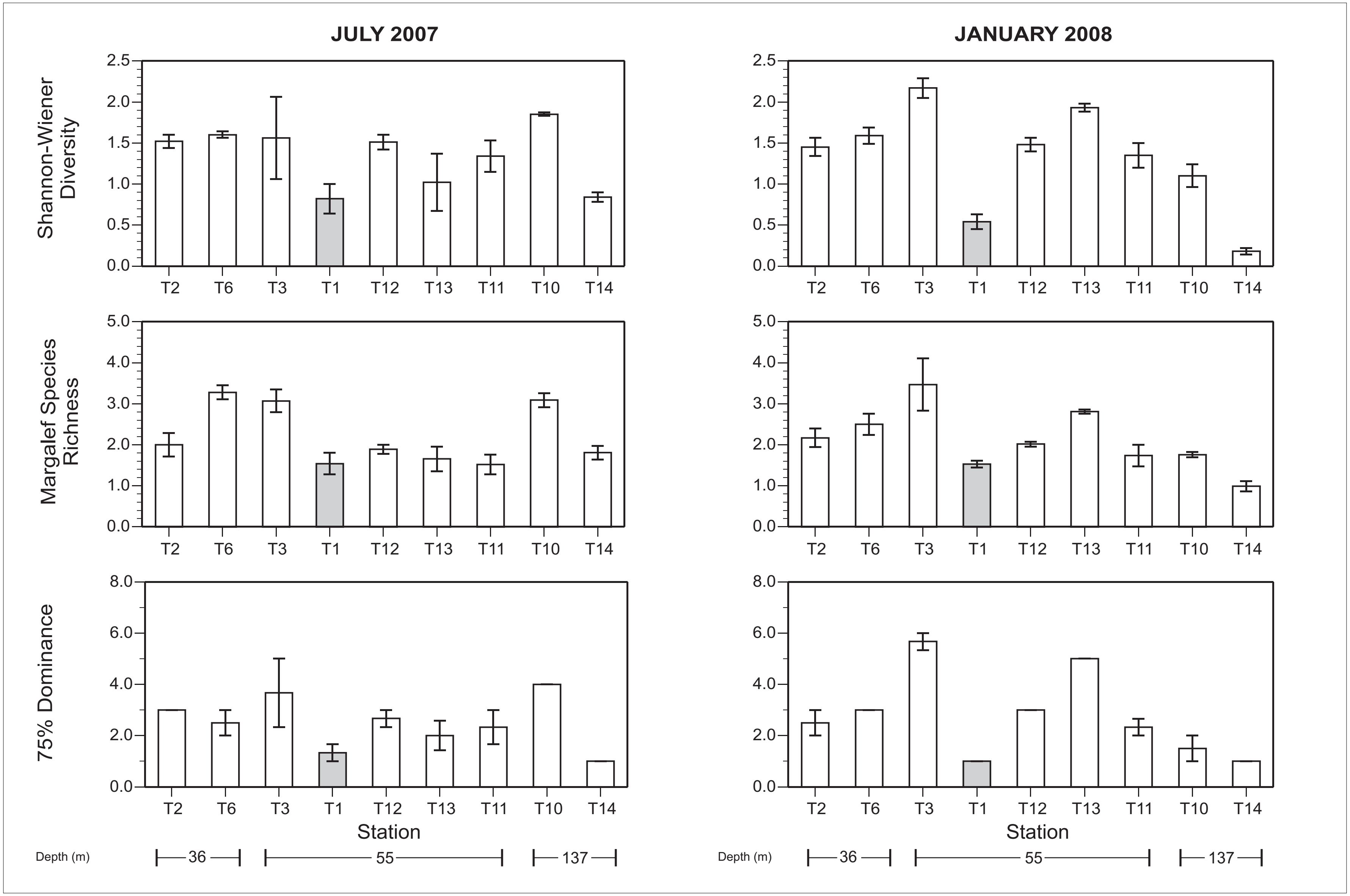

Figure 6-11. Mean diversity indices — Shannon-Wiener (H'), Margalef Species Richness (SR), and 75% Dominance (DOM75) of epibenthic macroinvertebrates collected during the Summer (July 2007) and Winter (January 2008) surveys.
Outfall Station T1 indicated in grey.

in summer and 1.53 in winter and not statistically different from any other 55 m stations in either season.

Regional Comparisons

The District's summer 2007 EMI data for outfall Station T1 and upcoast reference Station T11 were compared to regional data collected during the 1994 SCBPP, Bight'98, and Bight'03 surveys (Figure 6-12). The regional studies found that invertebrate population attributes at LPOTW areas and non-POTW were generally similar (Allen *et al.* 2007). (A more detailed summary of the Bight results can be found in OCSD 2007.) Differences in the EMI assemblages among the three surveys were likely due to the prevailing oceanographic regime associated with the Pacific Decadal Oscillation (PDO, Francis et al 1998). The Bight'03 report concluded that, in contrast to fish, mean EMI abundance was highest in 1994 (warm regime), but biomass was highest in 2003 (cold regime).

Station T1 and T11 data from 2007 were comparable to the Bight data, with means falling within the range of values for the Bight stations. Overall, the EMI population attributes at the District's outfall and within the Central Bight area were highly variable, mostly due to changes in oceanographic conditions, but also due to fluctuations in the dominant species. The EMI populations do not seem to show significant trends of increasing or decreasing values, based on the four years considered for this evaluation (Figure 6-12).

Fish Tissue Contaminants

Muscle and liver contaminant concentrations were measured for hornyhead turbot, English sole and the whole-body tissue of Pacific sanddabs. Three size classes (lengths) of Pacific Sanddabs were tested: zero (5-8 cm), one (9-13 cm), and two (14-16 cm). The analytes include mercury, total DDT (tDDT; the sum of six DDT isomers), total PCB (tPCB; the sum of 45 PCB congeners), and 20 other chlorinated pesticides. The mean tissue concentrations of the analytes are presented in Table B-19. DDT was the only pesticide measured above the detection limit and is the only one reported. A complete list of analytes tested is presented in Appendix A. Muscle and liver tissue contaminant mean concentrations for the three target species are presented graphically in Figure 6-13 (hornyhead turbot), Figure 6-14 (English sole), and Figure 6-15 (Pacific sanddab).

The mean standard lengths of hornyhead turbots was significantly greater at the outfall (157 mm) than the farfield station (128 mm) (P=0.003) (Table B-19). This is important 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 than location of capture. In July 2007, no significant differences were found between stations in hornyhead turbot muscle tissue contaminants. Muscle tissue concentrations of tDDT and tPCB were sometimes greater than the liver tissue, which is atypical. This anomaly resulted from the very low tissue lipid concentrations in the liver samples. This lessened the normally higher difference between liver and muscle lipid-normalized tissue concentrations. This pattern was also seen in English sole (see below).

Percent liver lipid and tPCB concentrations were significantly greater at the outfall than at the farfield station ($p<0.001$). In contrast, liver mercury concentrations were significantly

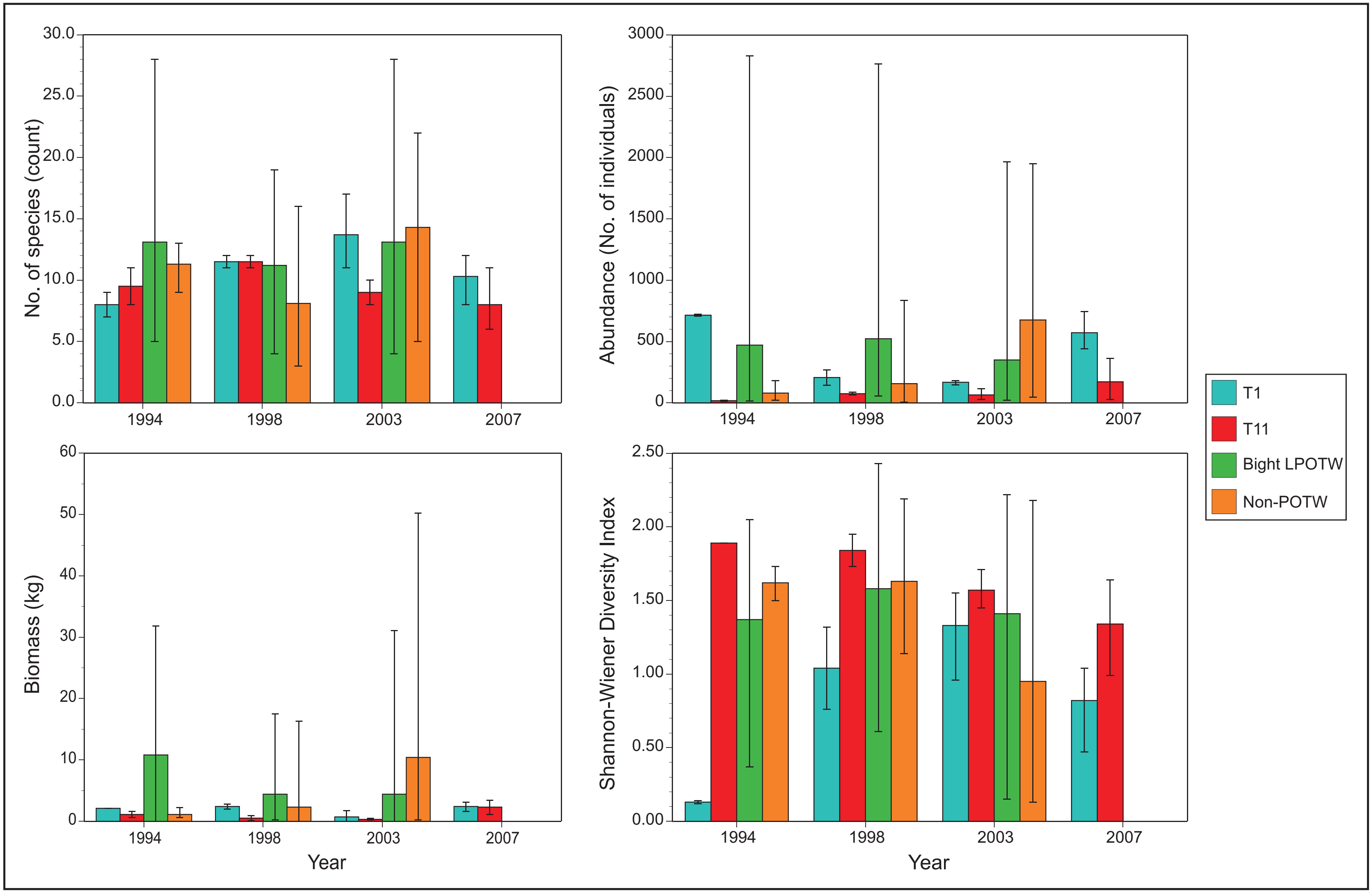

Figure 6-12. **Mean epibenthic macroinvertebrate number of species, abundance, biomass, and Shannon-Wiener diversity (H') at OCSD Stations T1 and T11 in 1994, 1998, 2003, and 2007 and regional POTW and non-POTW stations from the 1994, 1998, and 2003 regional monitoring surveys. All data are for summer surveys only and error bars represent the range of values (minimum and maximum) for each station group per survey.**

Note: N values = 1994: LPOTW = 16, nonPOTW = 3; 1998: LPOTW = 25, nonPOTW = 15; 2003: LPOTW = 18, nonPOTW = 13

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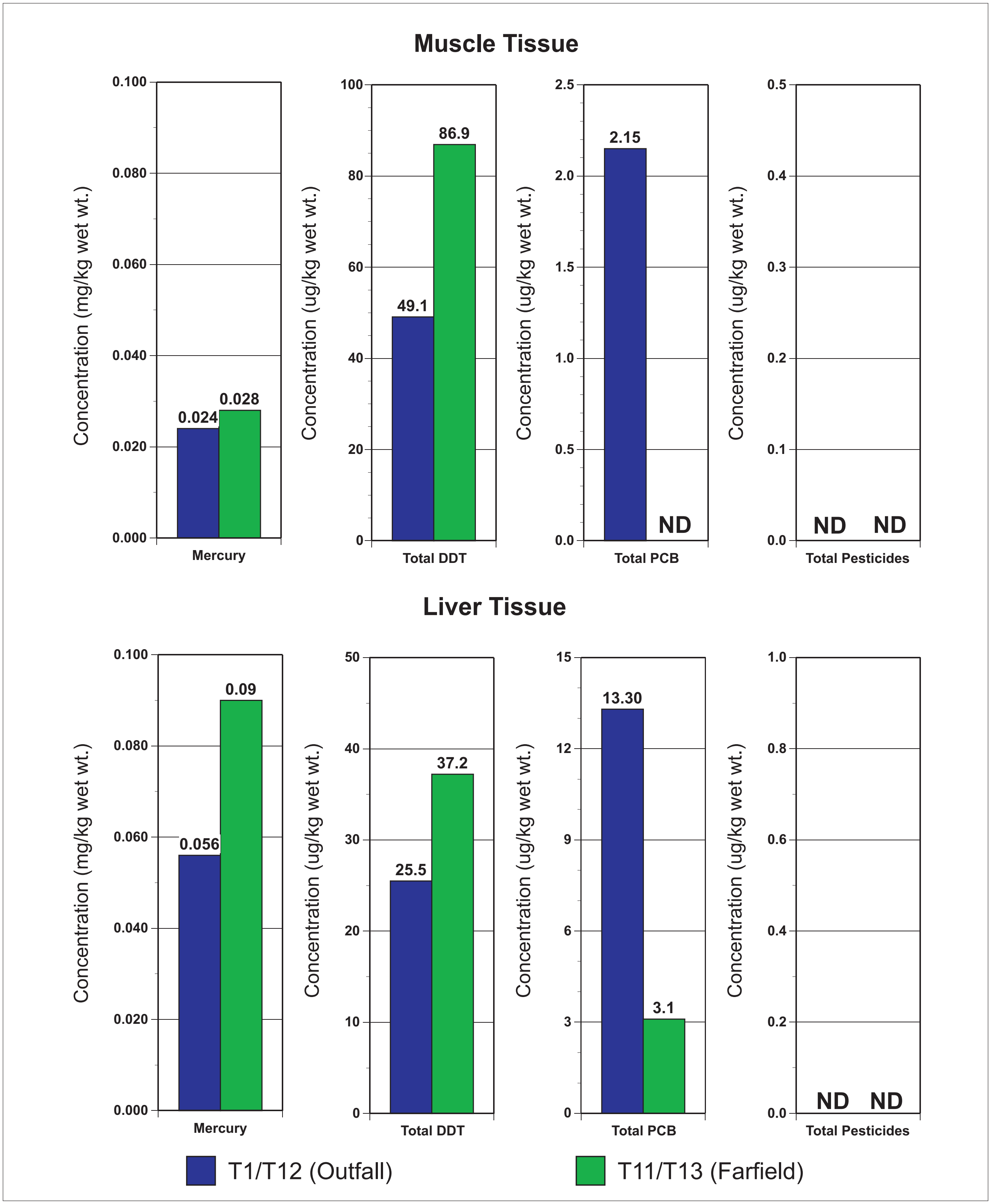

Figure 6-13. **Mean concentrations of mercury, total DDT, total PCB, and total other pesticides (ug/kg wet weight) in Hornyhead Turbot (*Pleuronichthys verticalis*) muscle and liver tissues in July 2007.**
Data normalized to % lipids. ND signifies data not detected.

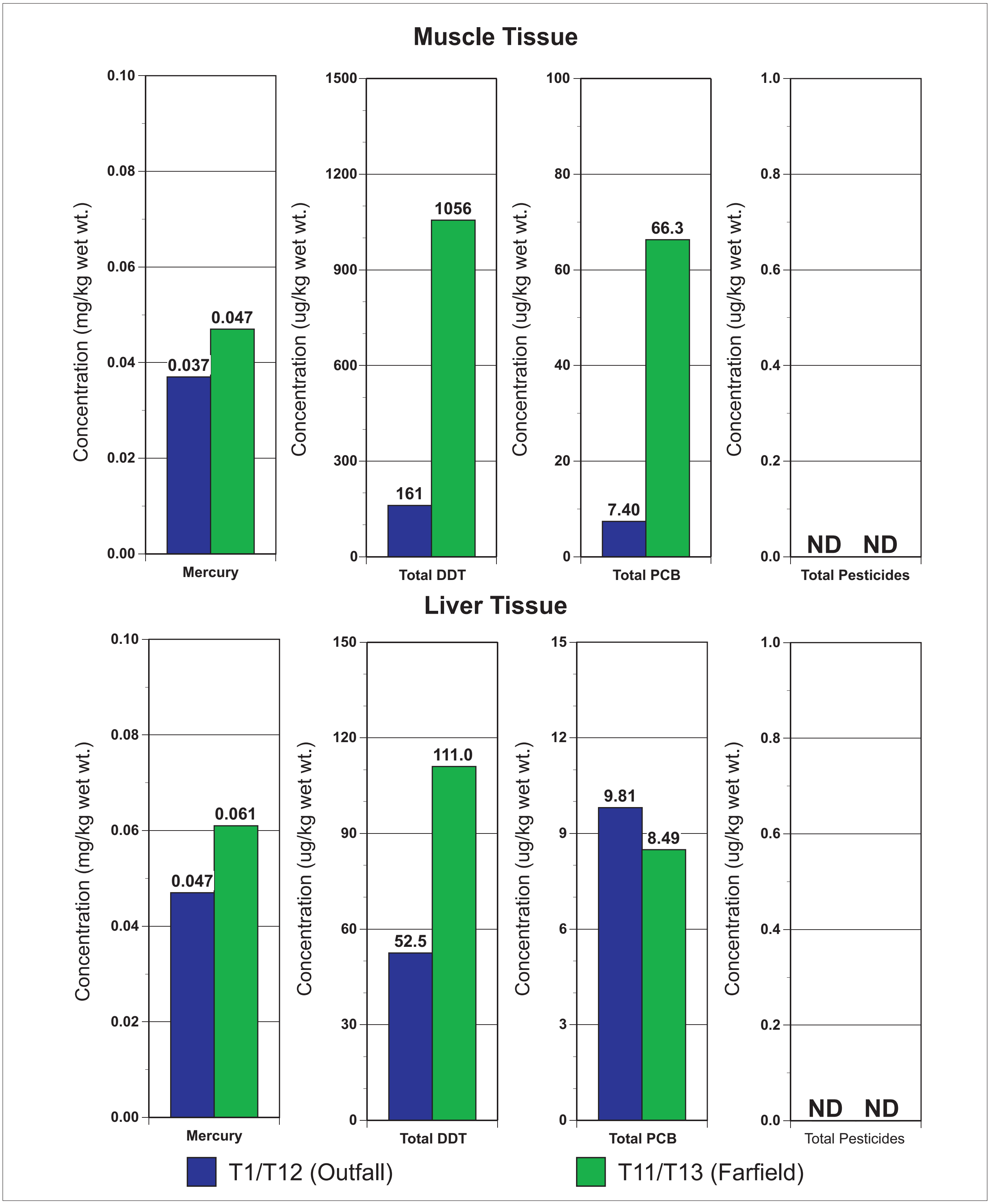

Figure 6-14. **Mean concentrations of mercury, total DDT, total PCB, and total other pesticides (ug/kg wet weight) in English sole (*Parophrys vetulus*) muscle and liver tissues in July 2007.**
Data normalized to % lipids. ND signifies data not detected.

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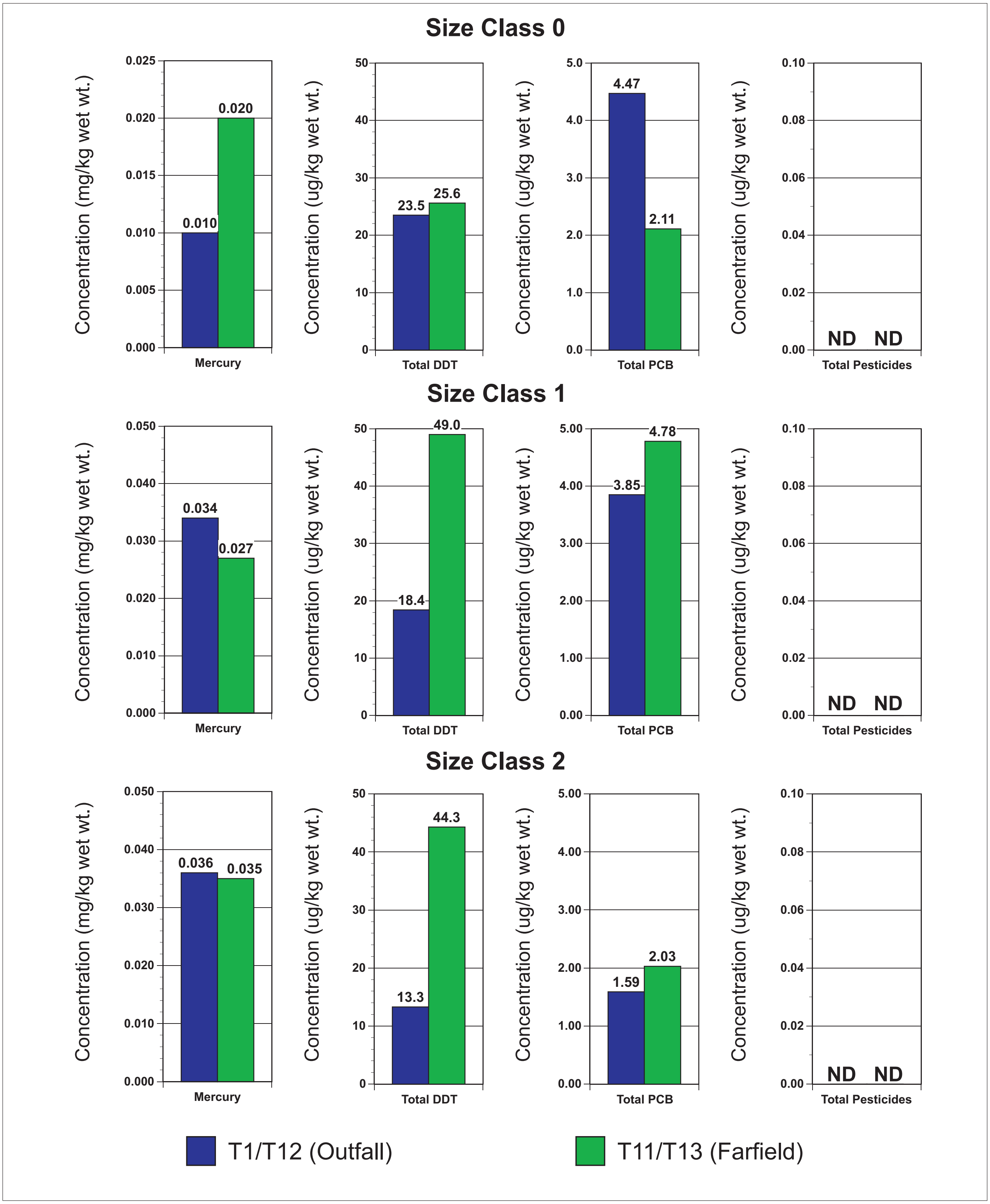

Figure 6-15. **Mean concentrations of mercury, total DDT, total PCB, and total other pesticides (ug/kg wet weight) in Pacific sanddab (*Citharichthys sordidus*) whole body tissue for size class 0 [5-8 cm], size class 1 [9-13 cm], and size class 2 [14-16 cm] in July 2007.**
Data normalized to % lipids. ND signifies data not detected.

Orange County Sanitation District, California.

higher in farfield than in outfall fish (P=0.01), though both concentrations were low. There was no difference in tDDT concentrations among stations.

Sediment concentrations of tPCB were elevated at outfall stations compared to other 60-m stations, which may potentially effect fish liver tissue concentrations. Another factor may be that larger, and presumably older, fish have accumulated higher liver tPCB concentrations. The fish collected at the outfall were significantly larger, and therefore older (Cooper 1997), than those collected at the farfield stations (p = 0.01). Consequently, it is not clear whether the high tPCB concentrations in fish collected at the outfall stations was due to outfall exposure, the greater length/age of those fish, or a combination of the two. Since the movement of hornyhead turbot during their life history is not well understood, it is not known if the outfall is the location of exposure to these contaminants.

The mean standard length of English sole used in this analysis was significantly greater at the farfield station (189 mm) than at the outfall (169 mm) (P=0.03). There were no significant differences among stations in either muscle or liver tissue for any analyte.

No significant differences were detected in Pacific sanddab whole-fish tissue for any analyte in any of the three size classes tested.

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 (see Table B-19). 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. No muscle tissue samples exceeded the CDHS advisory limit of 100 µg/kg for tPCB. Pacific sanddab whole-fish tissue concentrations of mercury, tDDT, and tPCB were all below state and federal action levels for muscle tissue; no human consumption advisory levels exist for whole-fish.

Regional Comparisons

The sanddab guild was used for tissue contaminant assessment in the Bight'98 survey and subsequently by the District for making a Bight-wide comparison of the District's Pacific sanddab whole-fish tDDT, tPCB, and mercury data.

In the Bight'98 regional study, 99% of all mainland shelf stations tested in the SCB had detectable levels of tDDT, including 100% of both the 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 2007-08, tDDT was detected in all Pacific sanddab composites tested with concentrations ranging from 16 µg/kg (Outfall; Size Class 2) to 122 µg/kg (Farfield; Size Class 1). In the present survey, all Pacific sanddab composites tested fell within the range of mainland shelf non-POTW tissue concentrations.

In the Bight'98 study, 46% of the sanddab guild samples tested from the mainland shelf stations had detectable tissue concentrations of tPCB (range = nd–710 µg/kg), while 72% of the large POTW stations (range = nd–710 µg/kg) and 40% of the non-POTW stations (range = nd–105 µg/kg) had detectable tissue concentrations of tPCB (Allen *et al.* 2002). Total PCB concentrations ranged from not detected (Outfall; Size Classes 0 and 2) to 12.2

μg/kg (Farfield; Size Class 1). In the present survey, all Pacific sanddab composites tested fell within the range of mainland shelf non-POTW tissue concentrations.

The mercury, tDDT, and tPCB values for all fish composites and the station means of composite samples (Table B-19) were within the ranges of both POTW and non-POTW strata within the SCB, indicating that the outfall is not causing degradation due to the bioaccumulation of contaminants in fish.

The Outfall as an Epicenter for Fish Tissue Contamination
Total PCB was higher in fish collected at the outfall for hornyhead turbot muscle and liver, English sole liver, and in Pacific sanddab size class 0. This suggests an outfall effect for tPCB, though all concentrations were below human health advisory levels. Tissue lipid concentrations are generally higher in outfall fish for all tissues, though none of those differences were statistically significant. For mercury, all mean tissue concentrations are either greater at the farfield station or are equivalent values for both stations. Similarly, most tissue concentrations of tDDT are higher at the farfield station, though none were significantly different.

Comparisons 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) concluded that there are no regional patterns in fish tissue mercury concentrations within the SCB.

Parasites, Abnormalities and Liver Pathologies

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 1.6% (97 occurrences) of Pacific sanddabs. This parasite was found at all the 55 m and 137 m station in both surveys, except for T11 in summer, but not at either of the two shallow Stations T2 and T6. No outfall trend was evident, as only eight of the 97 P*. cincinnatus* were found at T1, and the 1.6% 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, 23 other abnormalities were found in 2007-08. There was one occurrence of abnormal coloring (ambicolorism) and one of albinism that occurred in two different horneyhead turbot. Two lesions occurred, one each on a California scorpionfish and a California tonguefish, and three tumors were found on Dover Sole. In addition, 16 other parasites were found in nine horneyhead turbot, four in English sole, and one each in Pacific sanddab, California scorpionfish, bigmouth sole, and fantail sole (*Xystreurys liolepis*).

Liver Pathologies

Fish liver histopathology analysis is conducted once per permit cycle on at least 80 individual fish representing each target species. In July 2005, 602 fish liver samples were collected and subsequently examined for pathologies from the following target species: hornyhead turbot (n=272), bigmouth sole (n=103), white croaker (n=43), and English sole (n=184) (Table B-20). Of the 602 fish, only two hornyhead turbot individuals had serious lesions: one sample from Station T13 had two putatively preneoplastic foci of cellular alteration (FCA) and the other from station T3 had a neoplasm (NEO), specifically, a trabecular liver cell adenoma.

Some non-toxicopathic liver lesions were also found in 14 (2%) of the samples collected. These lesions may have multiple causes, including exposure to environmental contaminants, normal aging, bacterial infections, and parasitic invasion. Of the fish livers collected at the outfall group (Stations T1 and T12), five had these lesion types, while nine from the farfield stations had such lesions. A complete listing of these pathologies is presented in Table B-20.

These results are consistent with those of previous monitoring years (e.g., OCSD 2004) in demonstrating that fish collected near the outfall do not have a higher prevalence of liver pathologies or parasitism compared to those collected from farfield sites. Further, a recent study of liver lesions in demersal fish over a 15-year period (1988—2003) found that severe lesions occurred in just 6.2% of the 7,694 fish examined (Basmadijian *et al*. 2007). Hydropic vacuolation (HYDVAC) was the most common (4.1%) toxicopathic lesion type, followed by FCA (1.4%) and NEO (0.7%). HYDVAC lesions only occurred in white croaker and prevalence increased with age and size, but there was no relationship between lesoin rate and location effect or size/age of onset. In 2005-06, no HYDVAC lesions were found, but few white croaker were collected (43 individuals). The paucity of serious lesions and non-toxicopathic lesions in 2005-06, compared to the historical data, suggest that conditions are good and possibly improving in the District’s monitoring area.

CONCLUSIONS

In summary, there was no indication that the wastewater discharge caused adverse effects on fish and epibenthic macroinvertebrates residing near the outfall. 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. These results support the conclusion that the outfall area was not degraded by the wastewater discharge, that the outfall was not an epicenter of disease, and that the species assemblages present near the outfall were representative of those found elsewhere on the southern San Pedro shelf.

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