# Long-Term Trends in Trawl-Caught Fishes Off Point Loma, San Diego

**Retrieving the otter trawl**

The mainland shelf off Point Loma is narrow; at roughly 140 m, it drops away into the San Diego Trough. The municipal wastewater outfall for the City of San Diego extends 4 km across the shelf and discharges approximately 256 x $10^9$ L annually (186 mgd) into 60 m of water. Shelf sediments range from sand to sandy-silt; the sand content of the sediments ranges from 37% near the outfall to 52% off Mission Bay (Word and Mearns 1979). Water temperatures are generally cool during the winter and the water column is characterized by weak thermal stratification. Water temperatures are generally warm during the summer and the water column is characterized by strong thermal stratification. Major oceanographic events like El Niño significantly affect water characteristics.

Pacific sanddab, pink surfperch, stripetail rockfish, and longspine combfish were the most abundant fishes collected off Point Loma in the early 1970s (Voglin 1975). Pacific sanddab, English sole, and Dover sole occurred at most stations. Pacific sanddab, white croaker, longfin sanddab, and calico rockfish were the most abundant species at two reference sites near San Diego in 1985 and 1990 (Thompson *et al.* 1987, 1992).

Information on long-term trends in demersal fish populations on the mainland shelf off Southern California is uncommon. Most studies last less then three years (Cross and Allen 1992). The objective of this study was to examine temporal and spatial changes in trawl-caught fishes on the 60 m isobath off Point Loma over a 10-year period. Fish catches were examined in relation to water temperatures.

## Materials and Methods

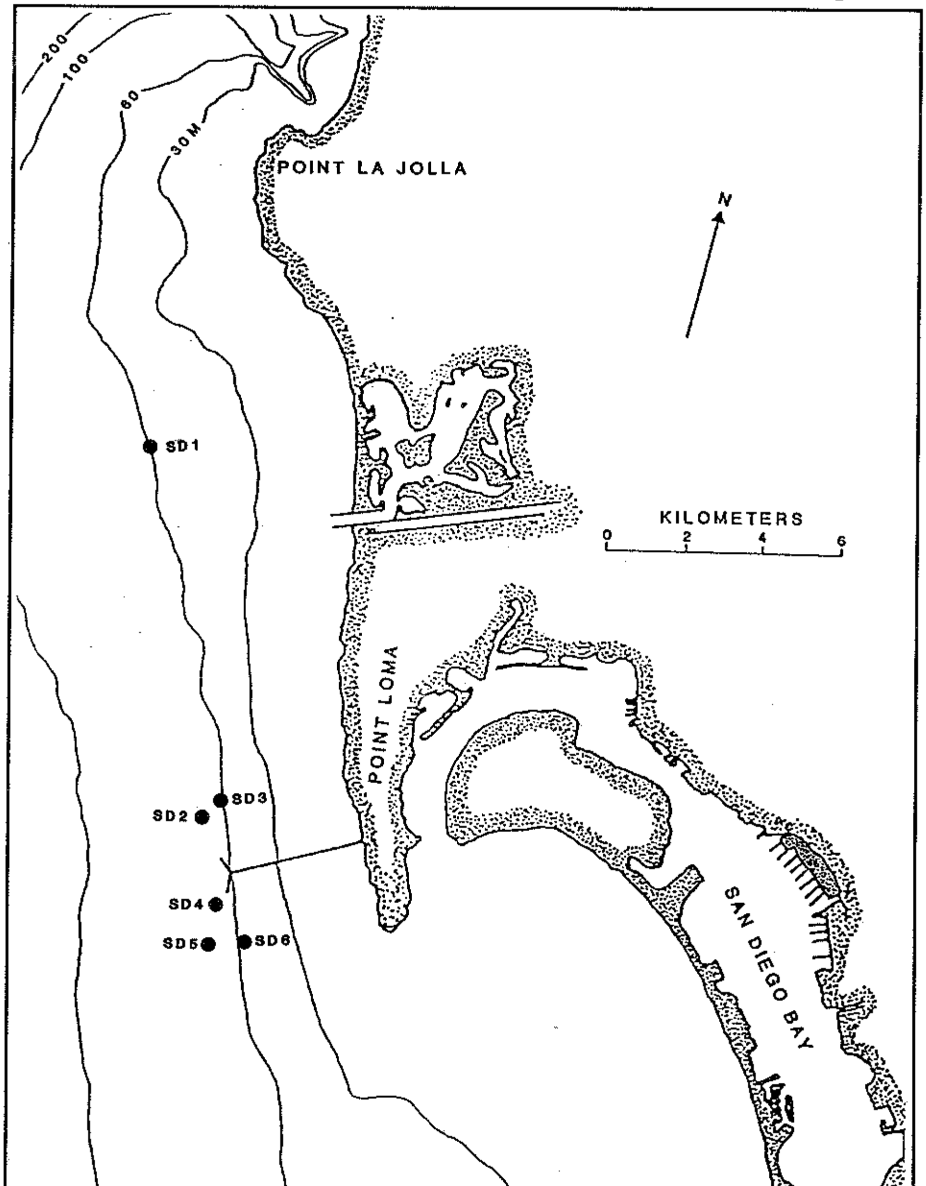
Biologists from the Point Loma Wastewater Treatment Laboratory and SCCWRP collected fishes by otter trawl at six stations off Point Loma near the municipal wastewater outfall for the city of San Diego (Figure 1). Station depths ranged from 55 to 70 m. Sampling began in the summer of 1982 and usually occurred in January (winter) and June (summer). From 1982 and 1992, 120 trawls were made.

One 10-min tow using a 7.6 m (headrope length) otter trawl was made at each station at a scope ratio (towing cable length versus water depth) of 3:1 (Word and Mearns 1979). When more then one trawl was made, the first one was used in the analyses. Vessel speed was approximately 2 knots and roughly 0.7 km were trawled at each station.

All fish in the trawl were identified, counted, measured to the nearest millimeter, and weighed aboard ship. If more than 20 fish of one species were collected, all fish were measured to the nearest centimeter. Unknown fish were returned to the lab and identified to genus and species whenever possible. Fish length data were converted to 1 cm size classes for the analyses.

Temperature data were averaged from four to five Point Loma water quality stations along the 60 m contour. From January 1980 to July 1987, water temperature was measured with a Martec

**Figure 1.**
**Location of trawl stations off Point Loma and Mission Bay, San Diego.**



XMS Mark 7. From 1988 on, the water column was profiled with a Seabird CTD (conductivity, temperature, and depth).

The similarity of trawl catches among stations was examined by cluster analysis of abundances standardized to Z-scores. Species occurring in less than 10% of the collections were eliminated. The similarity measure was Euclidean distance and the clustering method was single linkage (nearest neighbor) (Wilkinson 1990). The similarity in species lists was examined with average rank correlations (Mosteller and Rourke 1973) and the relation between trawl catch parameters and temperature was examined with Spearman rank correlations (Zar 1974).

**Figure 2.**
**Mean monthly surface water temperature for 1980 to 1992, and annual deviations from the mean, along the 60 m isobath off Point Loma.**

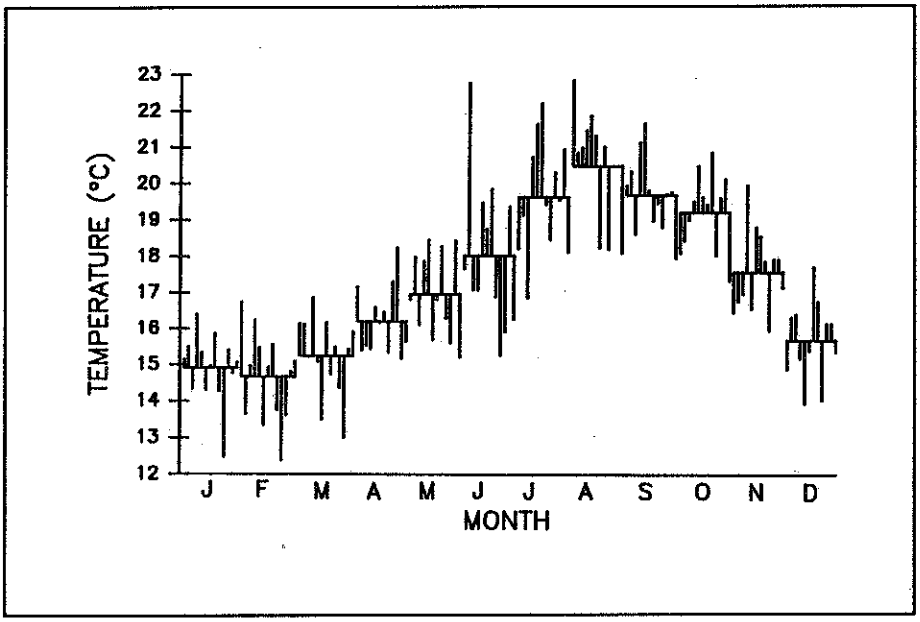
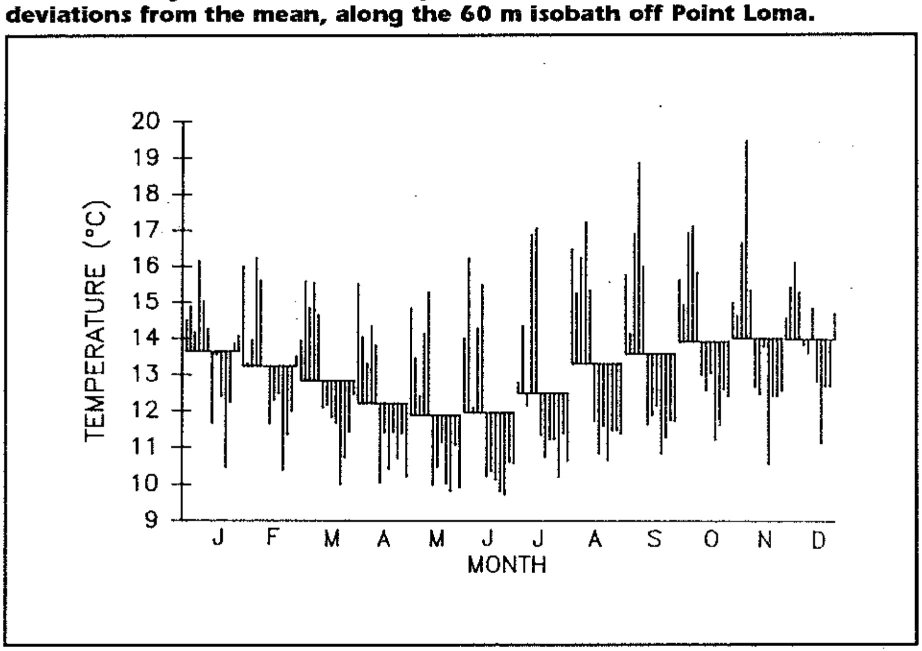



**Figure 3.**
**Mean monthly bottom water temperature for 1980 to 1992, and annual deviations from the mean, along the 60 m isobath off Point Loma.**




## Results

### Water temperature

Surface water temperatures were warm during the summer months (June to September) and cool during the winter months (December to February) (Figure 2). During some years, cool temperatures that occurred in May and June were related to upwelling. The water column was weakly stratified in the winter and strongly stratified in the summer. Average bottom temperatures declined after 1984 (Figure 3). The difference between surface and bottom temperatures increased from 1980-84 (0-6.5°C) to 1985-92 (1-11°C).

### Trawl catch

Ten years of semi-annual trawling at six stations off Point Loma produced 57 species from 28 families and 26,839 individuals (Table 1). Plainfin midshipman, longspine combfish, yellowchin sculpin, California tonguefish, and longfin sanddab occurred in over 90% of the trawls and accounted for 55% of the individuals collected. The 10 most abundant species accounted for 83% of the fish captured. Two rare fishes were collected in January 1988: spotted batfish and slender snipefish (Miller and Lea 1972).

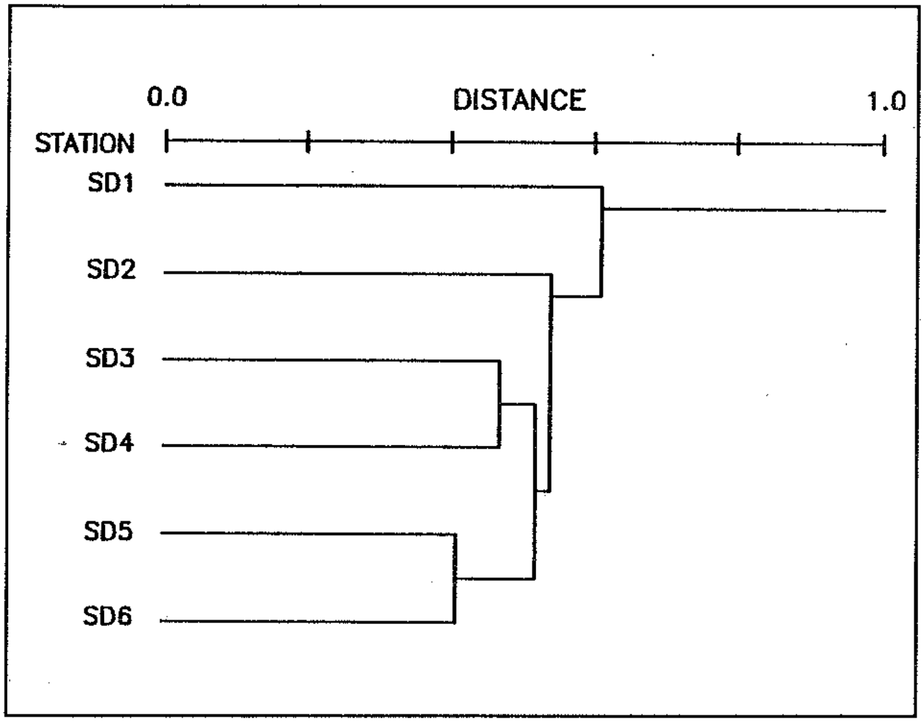
**Table 1**

**List of fish species and numbers collected and percent occurrence (PO) in 120 trawls off Point Loma, San Diego between 1982 and 1992.**

| Family | Common Name | Scientific Name | Number | PO |
|---|---|---|---|---|
| Myxinidae | Pacific hagfish | *Eptatretus stoutii* | 1 | < 1 |
| Squalidae | spiny dogfish | *Squalus acanthias* | 6 | 3 |
| Torpedinidae | Pacific electric ray | *Torpedo californica* | 2 | 2 |
| Rajidae | big skate | *Raja binoculata* | 2 | 2 |
| | California skate | *Raja inornata* | 23 | 17 |
| | longnose skate | *Raja rhina* | 3 | < 1 |
| | unidentified skate | *Raja* spp. | 1 | < 1 |
| Myliobatididae | bat ray | *Myliobatus californica* | 1 | < 1 |
| Chimaeridae | ratfish | *Hydrolagus colliei* | 15 | 7 |
| Engraulididae | northern anchovy | *Engraulis mordox* | 4 | 3 |
| Argentinidae | Pacific argentine | *Argentina sialis* | 647 | 34 |
| Synodontidae | California lizardfish | *Synodus lucioceps* | 1,012 | 68 |
| Batrachoididae | specklefin midshipman | *Porichthys myriaster* | 6 | 2 |
| | plainfin midshipman | *Porichthys notatus* | 3,962 | 92 |
| Ophidiidae | spotted cuskeel | *Chilara taylori* | 44 | 14 |
| Merlucciidae | Pacific hake (whiting) | *Merluccius productus* | 1 | < 1 |
| Ogcocephalidae | spotted batfish | *Zalieutes elater* | 1 | < 1 |
| Centriscidae | slender snipefish | *Macrorhamphosus gracilis* | 1 | < 1 |
| Syngnathidae | kelp pipefish | *Sygnathus californiensis* | 1 | < 1 |
| Scorpaenidae | scorpionfish | *Scorpaena guttata* | 274 | 48 |
| | bocaccio | *Sebastes paucispinis* | 1 | < 1 |
| | calico rockfish | *Sebastes dallii* | 1,118 | 63 |
| | cowcod | *Sebastes levis* | 1 | < 1 |
| | greenblotched rockfish | *Sebastes rosenblatti* | 10 | 6 |
| | greenspotted rockfish | *Sebastes chlorostictus* | 1 | < 1 |
| | halfbanded rockfish | *Sebastes semicinctus* | 42 | 8 |
| | unidentified rockfish | *Sebastes* spp. | 40 | 17 |
| | splitnose rockfish | *Sebastes diploproa* | 1 | < 1 |
| | stripetail rockfish | *Sebastes saxicola* | 1,444 | 48 |
| | vermilion rockfish | *Sebastes miniatus* | 24 | 13 |
| Zaniolepididae | longspine combfish | *Zaniolepis latipinnis* | 2,701 | 93 |
| | shortspine combfish | *Zaniolepis frenata* | 1 | < 1 |
| Hexagrammidae | lingcod | *Ophiodon elongatus* | 1 | < 1 |
| Cottidae | roughback sculpin | *Chitonotus pugetensis* | 106 | 31 |
| | yellowchin sculpin | *Icelinus quadriseriatus* | 2,829 | 93 |
| Agonidae | pigmy poacher | *Odontopyxis trispinosa* | 48 | 15 |
| Sciaenidae | queenfish | *Seriphus politus* | 62 | 5 |
| | white croaker | *Genyonemus lineatus* | 803 | 33 |
| Embiotocidae | pile surfperch | *Damalichthys vacca* | 1 | < 1 |
| | pink surfperch | *Zalembius rosaceus* | 2,267 | 74 |
| | shiner surfperch | *Cymatogaster aggregata* | 4 | 3 |
| Uranoscopidae | smooth stargazer | *Kathetostoma averruncus* | 8 | 6 |
| Gobiidae | bay goby | *Lepidogobius lepidus* | 354 | 51 |
| | blackeye goby | *Coryphopterus nicholsii* | 1 | < 1 |
| | unidentified goby | Gobiidae spp. | 1 | < 1 |
| Stromateidae | Pacific butterfish | *Peprilus simillimus* | 2 | 2 |
| Cynoglossidae | California tonguefish | *Symphyrus atricauda* | 1,670 | 93 |
| Bothidae | bigmouth sole | *Hippoglossina stomata* | 341 | 76 |
| | fantail sole | *Xystreurys liolepis* | 54 | 26 |
| | gulf sanddab | *Citharichthys fragilis* | 63 | 14 |
| | longfin sanddab | *Citharichthys xanthostigma* | 3,687 | 97 |
| | Pacific sanddab | *Citharichthys sordidus* | 1,489 | 64 |
| | unidentified sanddab | *Citharichthys* spp. | 341 | 8 |
| Pleuronectidae | Dover sole | *Microstomus pacificus* | 845 | 71 |
| | English sole | *Pleuronectes (=Parophrys) vetulus* | 149 | 43 |
| | hornyhead turbot | *Pleuronichthys verticalis* | 313 | 78 |
| | slender sole | *Eopsetta (=Lyopsetta) exilis* | 9 | 4 |
| | | | 26,839 | |

**Figure 4.**

**Tree diagram of relations among trawl stations off Point Loma (SD1 to SD6) based on the composition and abundance of fishes in trawl catches between 1982 and 1992. Distance is a relative measure of dissimilarity.**




The composition and rank order of abundance of trawl-caught fishes were similar among the six stations (Table 2). The average rank correlation among the species in Table 2 was 0.64 ($p<0.01$) indicating that the conditions that resulted in their dominance were similar among the stations. The control station (SD1) was the most dissimilar of all the stations, while the downcoast stations (SD5 and SD6) were the most similar (Figure 4). Eliminating SD1 from the calculations only raised the average rank correlation to 0.69.

Trawl catches were the smallest at SD1 (Figure 5). The mean number of species per trawl was 12% lower, the mean number of individuals was 39% lower, and the mean biomass was 60% lower at SD1 compared to the mean for the five remaining stations. The abundance of yellowchin sculpin,

**Table 2.**

**Rank order of the 10 most abundant species caught in trawls (20 per station) off Point Loma (stations SD1 to SD6) from 1982 to 1992, and the most abundant species for the periods 1982-84 (30 trawls) and 1985-92 (90 trawls).**

| | 1982-92 | | | | | | All Stations | |
|---|---|---|---|---|---|---|---|---|
| | SD1 | SD2 | SD3 | SD4 | SD5 | SD6 | 82-84 | 85-92 |
| Longfin sanddab | 1 | 2 | 2 | 7 | 1 | 3 | 6 | 2 |
| Pink surfperch | 2 | 3 | 6 | 5 | 6 | 5 | 9 | 5 |
| Pacific sanddab | 3 | 13 | 11 | 6 | 4 | 8 | 11 | 6 |
| Longspine combfish | 4 | 5 | 3 | 4 | 5 | 2 | 4 | 4 |
| California tonguefish | 5 | 8 | 7 | 8 | 8 | 4 | 1 | 9 |
| Plainfin midshipman | 6 | 1 | 1 | 1 | 2 | 6 | 3 | 1 |
| Yellowchin sculpin | 7 | 4 | 4 | 3 | 3 | 1 | 5 | 3 |
| California lizardfish | 8 | 9 | 10 | 11 | 10 | 12 | 7 | 10 |
| Bigmouth sole | 9 | 17 | 16 | 18 | 17 | 13 | 16 | 15 |
| Stripetail rockfish | 10 | 11 | 12 | 2 | 7 | 9 | 10 | 7 |
| Dover sole | 11 | 10 | 9 | 10 | 14 | 11 | 8 | 11 |
| White croaker | 12 | 12 | 5 | 12 | 15 | 10 | 2 | 16 |
| Calico rockfish | 13 | 7 | 8 | 9 | 9 | 7 | 12 | 8 |
| Pacific argentine | 15 | 6 | 13 | 15 | 12 | 16 | 30 | 12 |

plainfin midshipman, and calico rockfish were three to five times lower at SD1 compared to the remaining stations.

There were occasional large catches of schooling and non-schooling fishes. Among the schooling species, pink surfperch occurred in 70% of the trawls at SD3, but one trawl in the winter of 1990 yielded 62% of the total catch at that station. White croaker occurred in 40% of trawls at SD6, but one trawl in the winter of 1983 and one trawl in the winter of 1990 accounted for 77% of the total catch. Among the non-schooling species, yellowchin sculpin occurred in 80% of the trawls at SD1, but one trawl in the summer of 1982 and one trawl in the winter of 1992 produced 57% of the total catch. Bigmouth sole occurred in 75% of the trawls at SD1, but one trawl in the summer of 1987 yielded 68% of the total catch.

Seasonal differences were apparent in the trawl catches. White croaker, longfin sanddab, California lizardfish, and hornyhead turbot were more abundant in the winter. Queenfish were only caught in the winter trawls. Dover sole, stripetail rockfish, Pacific sanddab, calico rockfish, and juvenile rockfish (*Sebastes* spp.) were more abundant in the summer. Longspine combfish, plainfin midshipman, yellowchin sculpin, pink surfperch, and gulf sanddab were more abundant in the summer before 1985 and in the winter after 1985 (Table 2).

Long-term differences were also apparent in the trawl catches. Pacific argentine and halfbanded rockfish were not collected until after 1984. Most of the white croaker, queenfish, and pigmy

**Figure 5.**
**Mean and one standard deviation for the number of species and individuals, and amount of biomass in trawl catches at stations off Point Loma (n=20 trawls/station) between 1982 and 1992, and in trawl catches in the 1990 Reference Survey (n=7 trawls; Thompson et al. 1990).**

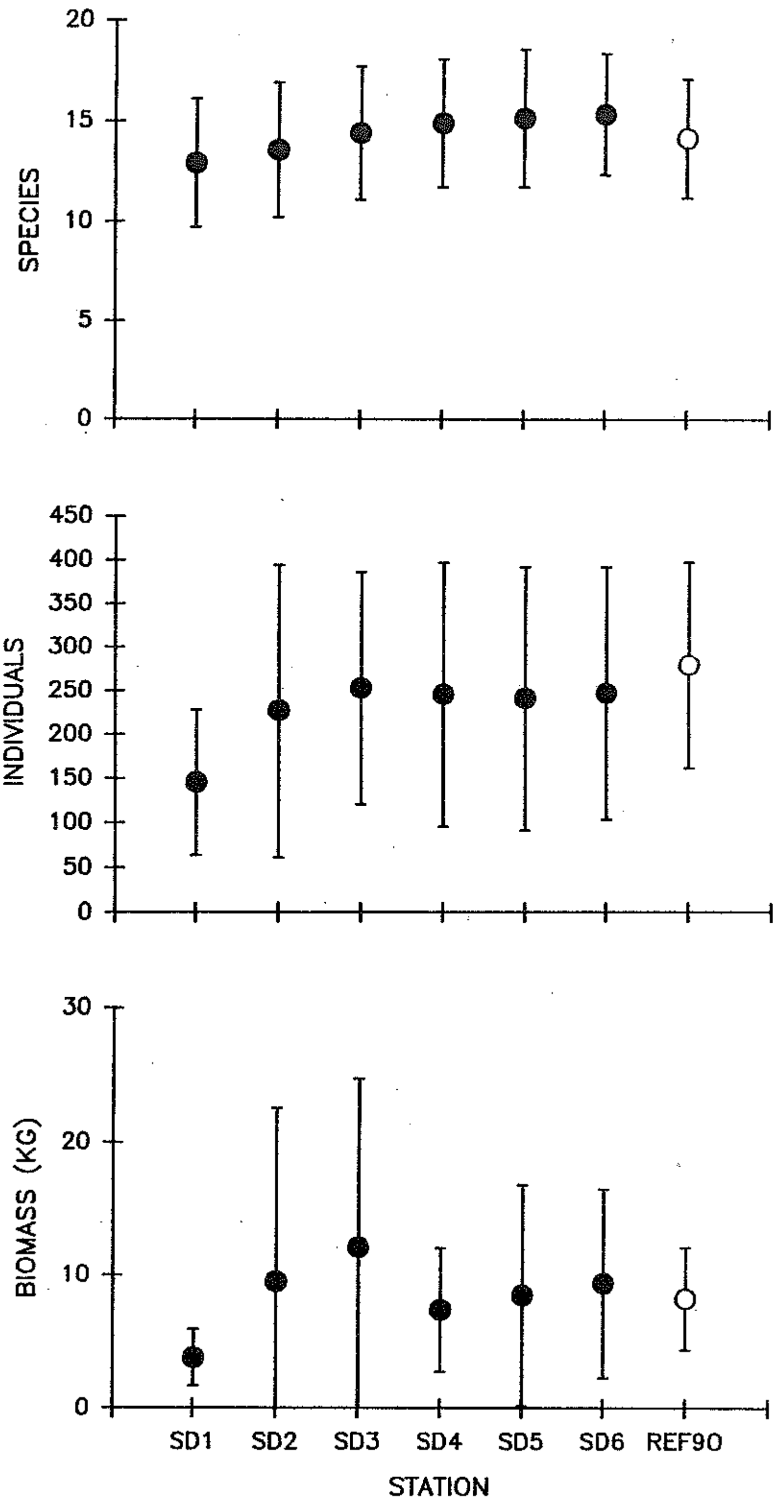
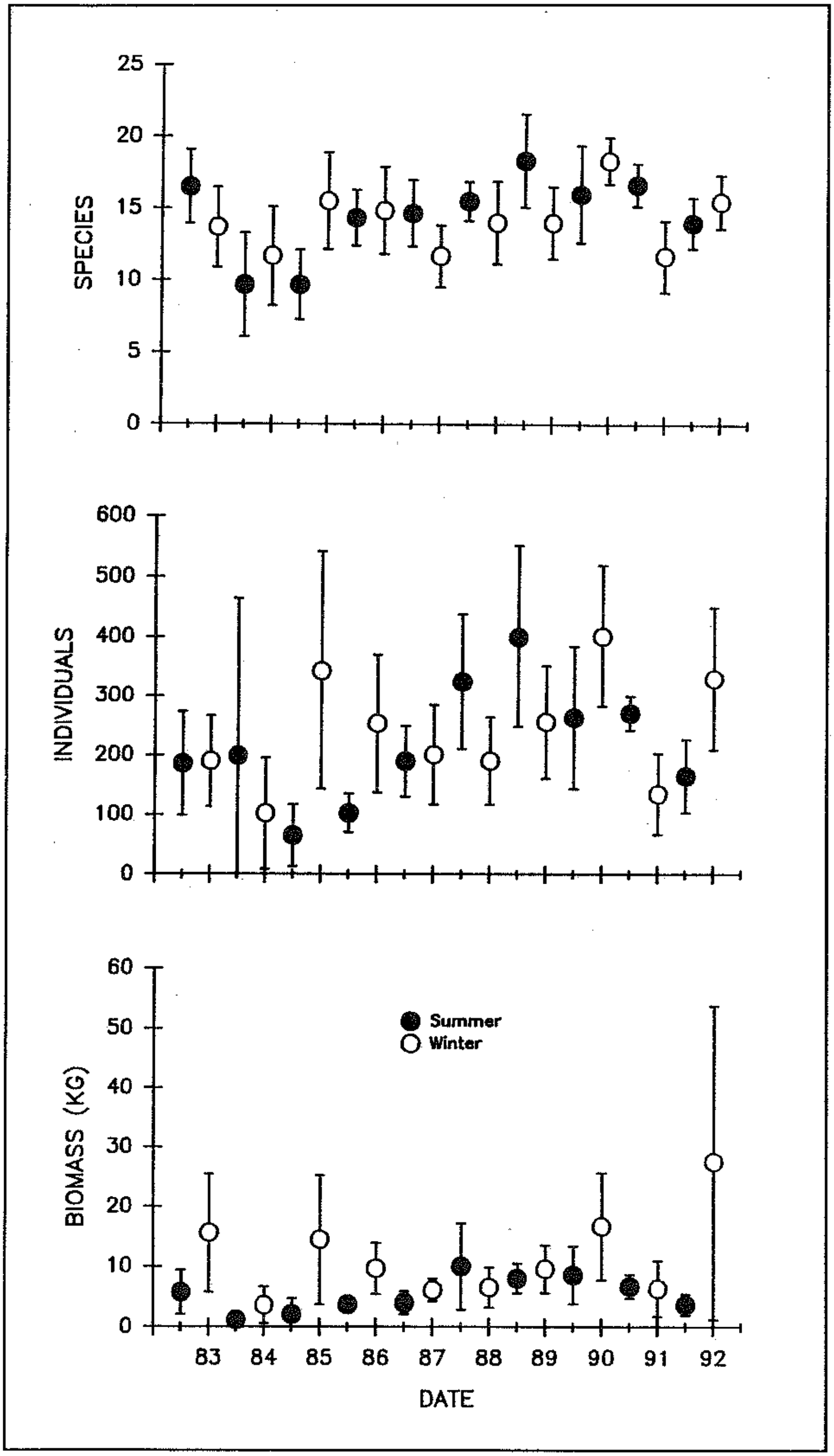


**Figure 6**
**Mean and one standard deviation for the number of species and individuals, and amount of biomass in trawl catches at stations off Point Loma (n=6 trawls/ date).**




poacher were caught before 1985, while most of the Pacific sanddab and scorpionfish were caught after 1985. From 1982 through 1984, catches of longfin sanddab averaged 9 fish/trawl (SD=10, N=30) for the six stations; from 1985 through 1992, catches averaged 38 fish/trawl (SD=27, N=90).

The number of species, individuals, and biomass declined in 1983-84 following the 1982-83 El Niño (Figure 6). For the 10 years beginning in 1982, the fewest species were collected during the summers of 1983 and 1984. The fewest individuals were collected in the summer of 1984 and the lowest biomass was collected in the summer of 1983. By 1985, trawl catch parameters had returned to levels comparable to the early 1980s. Trawl parameters decreased again in 1991.

The number of fish species collected during each sampling period was negatively correlated with bottom water temperature (Figure 7); the number of individuals was not correlated with temperature (Figure 8). The number of species per trawl was positively correlated with number of fishes per trawl ($r_s$= 0.703, $p<0.01$).

## Discussion

The most abundant species collected off Point Loma between 1982 and 1992 were also among the most abundant species collected by Voglin (1975) and by the 1985 and 1990 Reference Surveys (Thompson *et al.* 1987, 1992). The major differences among the four surveys are: 1) longfin sanddab were not collected in 1975; 2) California lizardfish were rare in 1975 and in the 1985 Reference Survey, but common thereafter; 3) English sole, which were abundant in 1975, were rare in both Reference Surveys and the present study; and 4) Pacific argentine were not collected before 1985.

Changes in dominance among trawl-caught fishes are not uncommon in the Southern California Bight. Stripetail rockfish dominated rockfish catches on the mainland shelf throughout the SCB from 1971 to 1975. Significant recruitment occurred in 1971, 1973, and 1975 when average annual water temperatures were 16°C or less. Significant recruitment of calico rockfish occurred in 1975 and 1977 when average annual water temperatures were 17°C or higher. Calico rockfish dominated rockfish catches from 1975 to 1978 (Mearns *et al.* 1980). The ranges of both species extend south to central Baja California, but calico rockfish are rare north of Santa Barbara and sripetail rockfish occur as far north as Alaska (Eschmeyer *et al.* 1983). The switch in dominance from stripetail rockfish to calico rockfish spanned 100 km of coast south of Point Dume and was linked to changing oceanographic conditions.

Bottom water temperatures off San Diego were above the 12 year mean (13.1°C) from 1980 to the end of 1984. The greatest deviations occurred in summer of 1983 coincident with the 1982-1983 El Niño. Trawl catches declined during the El Niño. The mean number of species per trawl declined 16-32% and the mean number of individuals and mean catch weight declined 57-65% over the periods immediately before and after the El Niño (Cross and Allen 1992). Immediately following the El Niño, catches of longfin sanddab, yellowchin sculpin, Dover sole, California lizardfish, and plainfin midshipman increased by 50-75%, while catches of longspine combfish, pink surfperch, calico rockfish, and stripetail rockfish increased by 80-99%. More species of fish were collected when bottom water temperatures were lower. Mearns (1978),

**Figure 7**

**Relation between the mean number of species caught by trawl at all stations on one sampling date (n=6 trawls/date) and bottom water temperature. $r_s$ is Spearman rank correlation.**

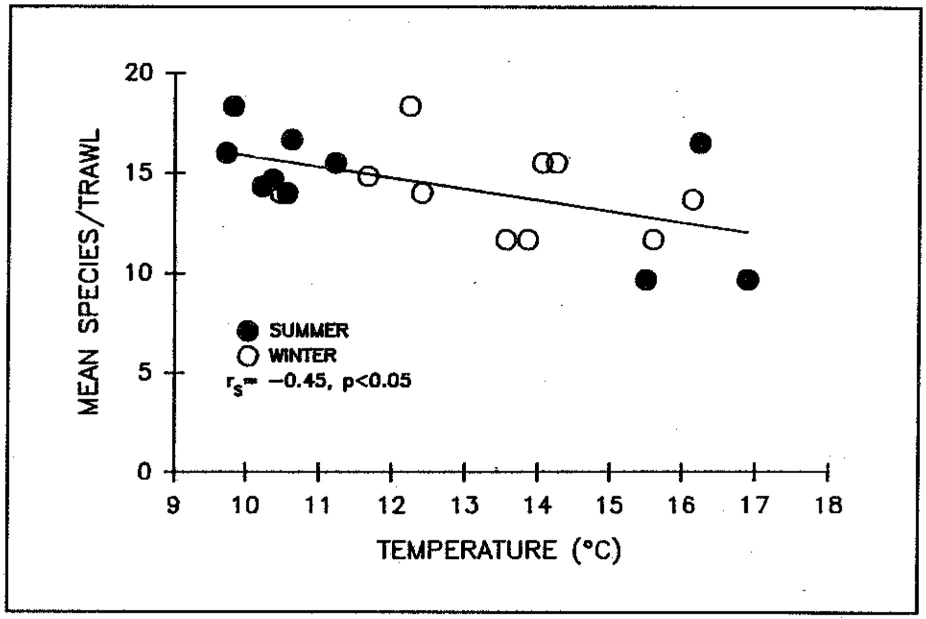
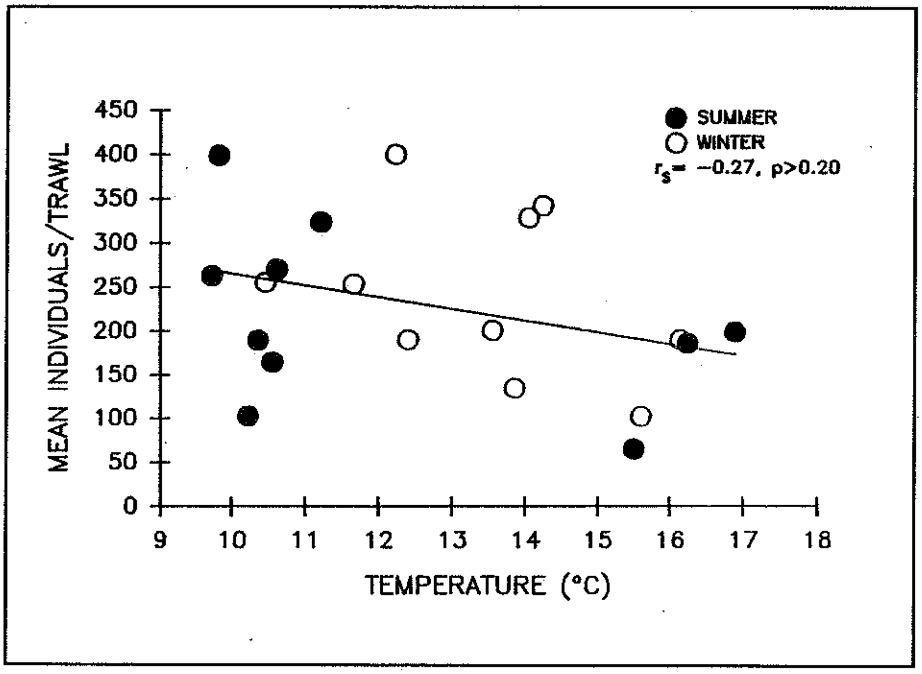
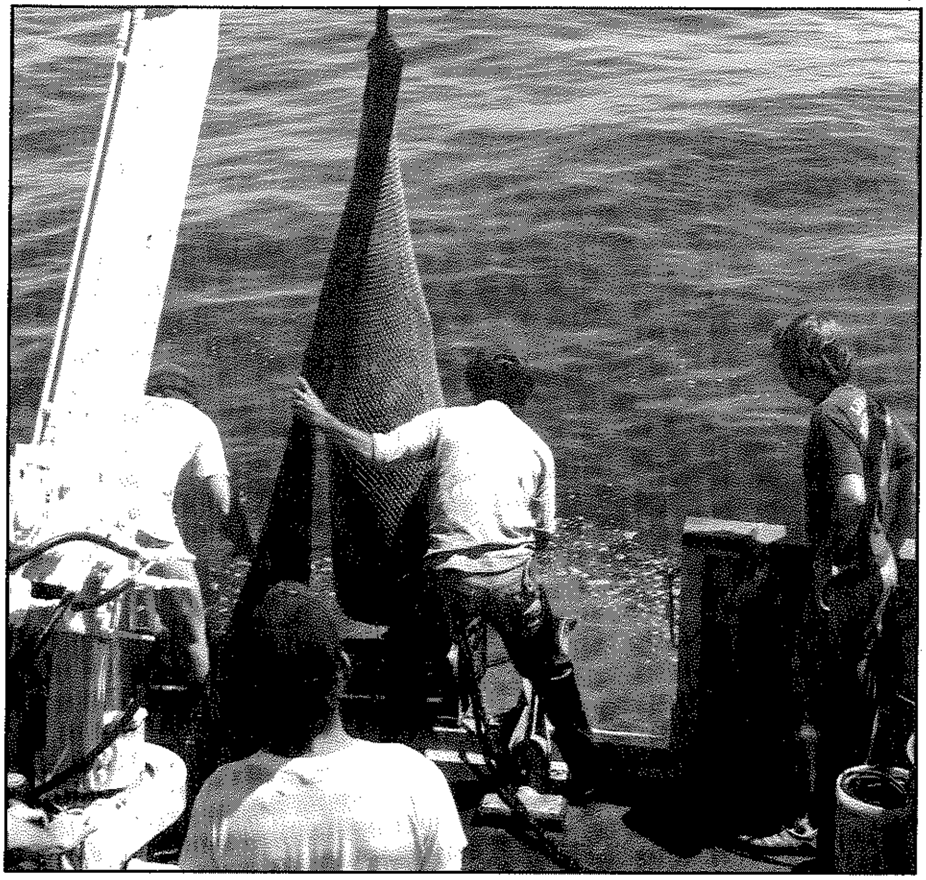



**Figure 8**

**Relation between the mean number of individuals caught by trawl at all stations on one sampling date (n=6 trawls/date) and bottom water temperature. $r_s$ is Spearman rank correlation.**





**Cod end of otter trawl containing the catch**

using surface water temperature, found a similar correlation between trawl catches and water temperature. Many demersal species had poor recruitment during the warm-water years of 1957 to 1959 (Carlisle 1969) and 1974 to 1975 (Allen and Voglin 1976).

Cluster analysis separated the control station (SD1) from the remaining stations based on the composition and abundance of the trawl catches. The control station had the lowest catches of the six stations and lower catches than the 60 m stations in the 1990 Reference Survey (Figure 5). The organic content of sediments off Mission Bay (0.45% total organic carbon) is lower than the organic content of sediments close to the Point Loma outfall (0.54-0.65%) (see *Total Organic Carbon and Total Nitrogen in Marine Sediments, Sediment Trap Particles, Municipal Effluents, and Surface Runoff* in this report). The organic content of sediments close to the outfall was similar to the organic content of sediments collected at 60 m in the 1990 Reference Survey (0.57%; Thompson *et al.* 1992).

Changes in the composition of fish assemblages around some outfalls may be the result of alterations in the sediments caused by the discharge of wastewater solids. Changes in sediment properties, particularly increases in organic content, lead to alteration in benthic invertebrate assemblages. As the infauna changes, so does the assemblage of demersal fishes that prey on them (Cross *et al.* 1985).

## Conclusions

The abundance and composition of the trawl catches, as well as the sediment organic content, at stations close to the Point Loma outfall were similar to the values obtained for the 60 m stations in the 1990 Reference Survey (Thompson *et al.* 1992). The control station (SD1) had the lowest trawl catches and sediment organic content. Either the control station is located in an area that is not typical of mainland shelf conditions, or the shelf off San Diego is similar to SD1 and there are not enough data to verify it. The similarity of trawl fish abundance and composition among the six stations, and the similarity in abundance and composition between this study and the 1990 Reference Survey, suggest that the effects of wastewater discharge on the fish assemblage off Point Loma are minimal.

It is not surprising that the fish assemblage off Point Loma responds to oceanographic events such as El Niño. The coupling of environmental changes and biological responses underscores the importance of long-term data collection (Wolfe *et al.* 1987). The data generated by monitoring programs should be adequate to differentiate between the natural variability of the biota and anthropogenic impacts on the biota (e.g., Stull *et al.* 1987). ■

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