THE SEASONAL INTERTIDAL AND NEARSHORE FISH AND INVERTEBRATE COMMUNITIES OF OCEAN BEACH, SAN FRANCISCO: FINAL REPORT

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Prepared for Environmental Science Associates, Inc.
San Francisco, California

May, 1992

SUMMARY

A field study was undertaken to identify the population and determine the seasonal patterns of the local fish and invertebrate communities of the Ocean Beach area at the foot of Sloat Boulevard in San Francisco. This study was initiated in conjunction with a literature review addressing the effects of sand disposal to important local fish and invertebrate populations. This report presents the results of an October, 1991 and March, 1992 survey.

Two faunal groups and several habitats were sampled: 1) intertidal invertebrates, 2) surf zone fish, 3) subtidal benthic invertebrates, 4) subtidal bottom fish, and 5) subtidal epibenthic invertebrates. Sampling techniques varied depending on the faunal group and the habitat sampled. Six intertidal stations along an east/west transect were established and three replicate samples were taken at each station using a 1/3 meter quadrat and sieving the samples through a 1mm screen. Attempts to sample the intertidal fish in the surf were unsuccessful during both surveys. One inshore subtidal station was located approximately 1/2 to 3/4 mile offshore from the beach in nine meters of water. At this station, five replicate benthic invertebrate samples were taken using a 0.1 meter Smith McIntyre grab sampler, and two ten minute otter trawls were towed along the shore for bottom fish and epibenthic invertebrates.

Fifty three invertebrate taxa were identified from the intertidal samples, subtidal grabs and bottom trawls. Two taxonomic groups, Arthropoda and Echinodermata, were present in the highest abundances during both surveys. In addition, the crustacea (Arthropoda) comprised the greatest number of invertebrate species, a typical pattern for the high energy beach environment. *Excirolana linguifrons*, an isopod, dominated the October intertidal environment. *Emerita analoga*, the sand crab, was the most abundant intertidal organism during the March survey, as a result of late winter recruitment. Subtidal grabs were dominated by *Dendraster excentricus*, the sand dollar, and the phoxocephalidae, a group of benthic amphipods, during both surveys. During the fall survey *Crangon nigromaculata*, the blackspot shrimp; *Lissocrangon stylirostris*, a common shrimp of the surf zone and sandy bottom; and *D. excentricus* dominated the subtidal trawls. In March, *C. nigromaculata* was not found in the nearshore trawls while the other two species were present in abundance.

Two commercially important invertebrate species were present in very low abundances in the Ocean Beach invertebrate samples. *Crangon franciscorum*, the bay shrimp, and Cancer magister, the dungeness crab. *Crangon franciscorum* occurs on the open coast only in the winter, but apparently does

not come inshore. *Cancer magister* populations fluctuate widely from year to year, and the low numbers of this species in the nearshore trawls were indicative of the low 1991 recruitment.

Fifteen species of demersal fish were collected in otter trawls at the nearshore station during the two surveys. Specked sanddab was the most abundant species during both seasons, with a large population of small fish during the fall and decreased abundance of larger fish during the winter. Other abundant fish were spotfin surfperch and sand sole. These two species had a peak in abundance of small sized individuals during the fall. In the March survey, the sand sole population appeared to increase in abundance while only a few, large, spotfin surfperch were present. English sole and shiner surfperch, normally abundant offshore species, were present in low abundances during both surveys. White croaker, one of the most abundant offshore fish and a commonly caught sportfish, was not collected in the nearshore trawls in either survey.

INTRODUCTION

The construction of the Lake Merced Transport and Storage Facility, an element of San Francisco's Water Pollution Control System, began in March, 1992. Its construction will reduce the number of untreated sewage overflows at the Fort Funston Outfall and improve the water quality along Ocean Beach (GGNRA, 1991). Part of the project includes the removal of approximately 90,000 cubic yards of sand due to tunnel excavation between the Lake Merced Pump Station and Sloat Boulevard. This sand is presently being removed and stockpiled on the upper area of Ocean Beach west of the North Sloat Boulevard parking lot until it will be disposed of on the beach.

Concerns over the effects of sand disposal on the marine resources of Ocean Beach have resulted in the initiation of both a literature review and a field study. The literature review (McCormick 1991), addresses sand disposal issues and identifies the potentially impacted intertidal and subtidal invertebrate and fish populations. The focus of the field study which began in October, 1991, is: 1) to identify local fish and invertebrate populations, 2) to determine seasonal patterns of these populations and 3) to compare these patterns to other similar or local studies.

Two faunal groups from several potentially affected Ocean Beach habitats were included in the field study: 1) intertidal invertebrates, 2) fish of the surf zone, 3) subtidal benthic (bottom) invertebrates, 4) subtidal epibenthic (above the bottom) invertebrates and 5) subtidal demersal (bottom) fish. Two seasonal surveys, fall and winter, have been made for each faunal group except the surf zone fish. This report presents the results of these surveys.

SAND DISPOSAL PLAN MODIFICATION

The sand disposal plan will follow the original Sand Placement Plan (Noble 1991) for summer conditions with some modifications. The original plan specified that sand would be graded to the seaward edge of the beach berm under summer conditions. The modification specifies that under summer conditions the sand "should be graded 20 feet back from the west edge of the beach berm" (Nancy Horner, pers. comm.). The impact on the intertidal zone, fishing and beach access would be minimized by this modification. Two important potential impacts to intertidal and subtidal fauna will be reduced or eliminated by restricting the sand disposal to the upper beach area: 1) No sand will be placed directly in to the intertidal or surf zone during the important seasonal migration of striped bass or inshore migration of other commercially or ecologically important fish or sportfish, and 2) no heavy equipment will be rolling across the intertidal area destroying the habitat by scraping and compacting the sand.

DESCRIPTION OF THE ENVIRONMENT

The study area is an open coast, high energy, sandy beach environment which is pounded by wave action and subject to tidal influence. Along the exposed southern California coastline sediment motion is appreciable to 30 meters depth or more (Drake et al. 1972). In the offshore area of Ocean Beach waves have been known to break in 60 feet (approximately 20 meters) of water during winter storms (pers. comm. Orville McGoon, from McCormick 1984) causing extreme beach erosion over a few hour period and resulting in a dramatic shift in grain size and beach slope (Schlocker 1974; Seymour et al. 1981; and Hedgpeth 1957).

FIELD STUDY METHODS

The project study area lies at the foot of Sloat Boulevard, west of the Westside Pump Station (Figure 1). The area affected by sand disposal activities includes the intertidal region, the surf zone and the shallow subtidal area of Ocean Beach. Sampling techniques vary for both invertebrate and fish fauna, as well as for the habitat sampled. The sampling of fish and invertebrates in the surfzone and shallow subtidal area of a high energy beach can be difficult and dangerous. In some cases, techniques were adjusted and compromises were made to ensure both the collection of the sample and the safety of the collectors.

Intertidal Samples

Invertebrates

Six intertidal stations were sampled on November 5, 1991 and on March 15, 1992 at Ocean Beach. Stations were established by measuring the distance from a fixed object to the specific sample site, to allow for easy relocation. In this way, six stations were located perpendicular to the shore line along an east/west transect, 10-20 meters apart. Station 1 was established 30 meters from the foot of the dunes. Stations 1, 2 and 3 were ten meters apart. Station 3, 4 and 5 were 20 meters apart. Station 6 was located at the lowest possible point for the particular low tide. On November 5, station 6 was 20 meters from station 5 at a low tide of -.5 feet. On March 15, station 6 was only 10 meters below station five at a -.6 feet low tide due to the large breakers coming ashore.

Three replicates were taken at each station using a 1/3 square meter quadrat. The quadrat was placed on the sand and pushed into the substrate making an impression. The sand was then removed to a depth of approximately two inches, put into a sieve and sieved through a 1mm mesh screen in a large wash tub filled with water. The material and invertebrate organisms remaining on the screen were transferred to a container with 75% ETOH and were labeled. Most of the sand usually passed through the 1mm screen with ease. In some cases, however, the grain size of the sand exceeded the screen size. These samples were swirled in a bucket with water and poured through the screen to catch any organisms. Several swirls and pours were made until all the organisms passed onto the screen from the bucket. At each station along the transect a single sediment sample was taken for grain size analysis during November and March; and grain size, total volatile solids and total organic carbon analysis in March only.

Fish

Attempts to collect fish in the surf zone were unsuccessful in both November, 1991 and March, 1992. Problems with the net size and high surf plagued the fisheries biologists from the Bureau of Water Pollution Control (BWPC). Another attempt will be made in the summer, 1992 when both species and numerical abundance of fish is at its greatest.

Subtidal Samples

All subtidal samples were taken from the R/V *Shana Rae*, the research vessel used by the BWPC. The inshore station used in this study was added to the regular BWPC monitoring stations which are located near the diffuser for the Southwest Ocean Outfall, 4.5 miles offshore at a depth of 23-26 meters. Because of the danger associated with approaching the shore in a large vessel, the R/V *Shana Rae* was limited to nine meters of water approximately 1/2 - 3/4 miles offshore. The nearshore station, at nine meters depth, represents the outside boundry likely to be affected by sand disposal.

Benthic Samples

Five replicate samples were taken using a 0.1 square meter Smith-McIntyre bottom grab sampler at the nearshore station. Each replicate was screened through a 1.0 mm mesh sieve. The retained material was transferred to jars, preserved with 10 percent formalin and labeled. After 48 hours the formalin was decanted and replaced with 70 percent ethanol (BWPC 1990). Five sediment samples were also taken for grain size analysis, total volatile solids and total organic carbon.

Otter Trawl Samples

Two replicate bottom trawls following bathymetric contours were taken at the inshore station, using a 25 foot

Marinovich otter trawl constructed of a 1.5 inch mesh body with a 0.5 inch stretch mesh cod end. Wooden doors reinforced with metal skids were attached to the net wings. The net was weighted with galvanized chain to ensure bottom contact, and plastic floats were used to keep the mouth open during trawling. Trawls were ten minutes in duration at two knots per hour (BWPC 1990).

Both demersal (bottom) fish and large epibenthic (above the bottom) invertebrates were caught with the bottom trawl. The catch from each trawl was dumped into a plastic tub, identified, inspected for reproductive condition, counted and measured. Most fish and invertebrates from the trawls were returned to the sea. Any organism needing further identification or work was bagged, frozen and returned to the lab.

RESULTS AND DISCUSSION

Invertebrates

Major Taxonomic Groups

Fifty three invertebrate taxa were identified from the intertidal, subtidal benthic and subtidal trawl samples during the two survey periods (Table 1). Thirty eight were identified to species level. Fifteen other taxa were identified to genus or another category. Most taxa that could not be identified to species were either immature specimens or representatives of a taxonomically confusing or unworked group.

Arthropods (primarily crustacea) dominated all three habitats in terms of species richness during both surveys (Table 2; Figure 2). Arthropods were also the numerical dominants (Table 2; Figure 3) for the intertidal and subtidal grabs. Trawl samples were numerically dominated by the Echinodermata (mostly sand dollars) during both surveys.

Arthropods (primarily crustacea) comprised 100 percent of the invertebrate organisms in the intertidal habitat (Figures 2 and 3). Although the intertidal region of high energy beaches often includes representatives of other taxonomic groups (Ricketts et al. 1985; Oakden and Nybakken 1977), we did not collect them at Ocean Beach. Polychaete worms (Annelida) are usually found at the lower tidal levels and were found by Oakden and Nybakken (1977) in every sampling period in a Monterey Bay intertidal study. However, the numbers they found were small, and their study area was dominated by crustacea as well.

Subtidal grab samples, representing the nearshore benthic habitat, were dominated by crustacea (Arthropoda) both numerically (Figure 3) and by species (Figure 2). This habitat was the most diverse of the three sampled for invertebrates and included organisms from all the major taxonomic groups. Polychaeta (Annelida) were present in the nearshore benthic habitat, but the number of individuals was low (Figure 3) and represented only seven percent of the total number in October and six percent in March (Table 2). The Echinodermata, represented by one species only, contained the second highest number of individuals during both surveys.

Dominance by the crustacea in the shallow nearshore area is typical of a high energy beach and was also found in a subtidal beach study on Monterey Bay (Oliver et al. 1980). In this study, the crustacean zone ranged from six to fourteen meters in depth while the polychaeta (Annelida) species clearly dominated the deeper stations, located at 18 and 24 meters. The subtidal grab samples taken by the BWPC further offshore of Ocean Beach, at 23-26 meters in depth, are also dominated by polycheate worms (BWPC 1988, 1989, 1990). This zonation pattern appears to be a direct result of substrate movement off a high energy beach. Shallow zones, influenced by greater sediment transport are inhabited by non-tube-dwelling, mobile, deposit-feeding invertebrates. Less mobile, tube-dwelling annelids, requiring a more stable substrate, predominate in deeper water (Oliver et al. 1980).

Subtidal trawl samples, that represent the epibenthic community, contained large numbers of echinoderms during both surveys. In October, 1991, three species of echinoderms made up 80 percent of the total number of individuals collected. In March, 1992, one species of echinoderm comprised 78 percent of the total epibenthic invertebrate community. Further offshore in bottom trawls taken by the BWPC (1988, 1989, 1990), Crustaceans (Arthropoda) are the dominant epibenthic organism.

Dominant Invertebrate Species and seasonal Patterns

Intertidal Habitat

Seasonal variation in the intertidal populations is described in Figures 4a and b and on Table 3. *Excirolana linguifrons* was the most abundant organism in the November, 1991, survey and occurred most frequently at station 3 (Figure 4a). This species is an isopod of the mid-intertidal range. It may be preyed on by intertidal fish and birds and depends, to a large extent, on dead *Emerita analoga*, the sand crab, for a food source (Morris et al. 1980). In March, 1992, the numbers of *E. linguifrons* dropped to ten individuals (Figure 4b). Seasonal recruitment for this species was not yet apparent.

Emerita analoga is a filter feeder that serves as one of the most important food sources for several species of fish, invertebrate and birds. It is considered the most abundant crustacean of the middle intertidal zone on sandy beaches of the California coast (Morris et al. 1980; Ricketts et al. 1985).

In November, 1991, *E. analoga*, was the second most abundant intertidal organism and inhabited the mid to lower stations sampled (Figure 4a, Table 3). In March, 1992, *E. analoga* dominated the intertidal zone (Figures 4b and 5) and were mostly found at the upper intertidal stations. Size frequency histograms (Figures 6 and 7) indicate that most of the sand crabs present by March, 1992 were a result of recruitment (settlement of larvae from the plankton) that had occurred in the upper tidal levels (*E. analoga* from Station 1 were not measured and do not appear on the histogram). Although some small *E. analoga* were also present in November, 1991, they were not abundant. Some gravid females (females with eggs) were found in November but none in March.

Southern California populations of this species recruit in the spring with most of the gravid females occurring from February or March through September (Cox and Dudley 1968). Some gravid individuals (and presumably recruitment) can be found year round (Ricketts et al. 1985; Cox and Dudley 1968). The lack of gravid females in our spring survey indicates that reproduction probably occurs later in central and northern California populations.

Individuals of this species are known to live for two to three years but few adults were found on Ocean Beach in March, 1992 (Figure 6). This may be a result of winter mortality but is consistent with reports (from southern California) that adults tend to migrate subtidally during the winter months.

Nearshore Habitat

The most abundant benthic invertebrate species from the subtidal grab samples, representing the nearshore benthic habitat, during both surveys, was the sand dollar, *Dendraster excentricus* (Table 4; Figure 8). The sand dollar is a deposit and filter feeder which is fed on in turn by English sole, gulls, seastars and crabs (Morris et al. 1980; Ricketts et al. 1985; and CH2M Hill 1980, 1983). Although *D. excentricus* occurs in the offshore samples taken by BWPC, they are less abundant in deeper water and are primarily juveniles (BWPC 1988, 1989, 1990). Our nearshore shallow water station contained no juveniles, only large specimens. *Dendraster excentricus* larvae probably settle in deeper water where the wave energy is less intense and migrate as adults to the shallow zones.

Other abundant species from the subtidal grabs included *Chaetozone setosa*, a polychaete worm; *Olivella pycna*, a small snail; and several species of amphipods (Table 4; Figures 8 and 9). *Chaetozone setosa* and *O. pycna* comprised a small but consistent population during both sampling periods (Figure 8). The phoxocephalid amphipods, as a group, dominated the crustaceans in both surveys (Table 4). During October, 1991, this family made up 152 individuals that included several species: *Rhepoxynius fatigans*, *Rhepoxynius lucubrans*, *Rhepoxynius tridentatus*, *Rhepoxynius* spp. juveniles and *Mandibulophoxus gelisi*. In March, 1992, only two species: *R. fatigans* and *R. lucubrans*, comprised 100 individuals. This important group of amphipod crustaceans, the phoxocephalidae, preys on other benthic invertebrates. It has been called a foundation species by some authors (Oliver et al. 1982). They are preyed on by English sole, shiner surfperch and other bottom feeding fish (CH2M Hill 1980, 1983; Oliver et al. 1982; and Oakden 1984).

The subtidal invertebrate trawls were dominated by *D. excentricus* during both surveys (Table 5; Figure 10). Interestingly, the bottom trawls taken offshore in deeper water by the BWPC did not contain sand dollars even during years such as 1987 when they were one on the most abundant organisms in grab samples from the same stations (BWPC 1988, 1989, 1990). This is probably due to the fact that the offshore *D. excentricus* are all small juveniles and are lost through the fairly large net of the otter trawl.

Two other invertebrate species were abundant in the nearshore trawls: *Lissocrangon stylirostris* and *Crangon nigromaculata* (Table 5; Figure 10). Both of these species are lumped with the group known as bay shrimp (which also includes *Crangon franciscorum* and *Crangon nigricauda*). In California, bay shrimp are trawled commercially, primarily as bait, only within San Francisco Bay (Morris et al. 1980). Within the Bay, *C. nigromaculata* and *L. stylirostris* are the two least abundant of the four species of bay shrimp. On the open coast off Ocean Beach, *C. nigromaculata* is usually the most abundant invertebrate caught in bottom trawls by the BWPC (1989, 1989, 1990). It feeds on benthic and epibenthic organisms and may be a food source for such fish as striped bass, salmon, sturgeon and staghorn sculpin. In the subtidal trawls at the nearshore station, *C. nigromaculata* occurred in October, 1991 trawls but not in March, 1992. *Lissocrangon stylirostris* is rarely caught in offshore trawls and is typical of the surf zone and shallow sandy bottoms. It was the second most abundant invertebrate in the nearshore trawls during both surveys. Despite its abundance, its biology is not well known (Morris et al. 1980).

Size frequency histograms for *L. stylirostris* show a smaller sized population in October 1991 (Figure 11), with the greatest proportion belonging to the 6 - 11 mm size classes (carapace length) indicating 1991 recruitment. In March, 1992, the majority of the population was between 12 and 15 mm long (Figure 11). In both surveys, only a small proportion of the population was gravid. The seasonal reproductive pattern cannot be determined by these two surveys, but the pattern of the size frequency histograms indicate that they probably have a specific reproductive period rather than continual recruitment.

Crangon nigromaculata size frequency histograms for October, 1991 (Figure 12) indicated that gravid individuals comprised 70 percent of the population over 10 mm carapace length at the nearshore station. These results are similar to those from the offshore samples taken by the BWPC. Large proportions of the offshore populations are gravid year-round with recruitment evident during all sampling seasons (BWPC 1988, 1989, 1990). Although *C. nigromaculata* are caught at the offshore stations during all sampling periods, no *C. nigromaculata* were caught in the March, 1992, nearshore trawls (Table 5), suggesting offshore migration during the winter months.

Important Invertebrate Populations

Six important populations of invertebrates known from local intertidal and shallow subtidal areas were identified in the literature review of fish and invertebrates of the Ocean Beach area (McCormick 1991). These were: *Cancer magister*, the dungeness crab; *Crangon franciscorum*, the bay shrimp; *C. nigromaculata*, the blackspot shrimp; *D. excentricus*, the sand dollar; *E. analoga*, the sand crab; and the phoxocephalid amphipods. These populations were selected for their importance as a commercial fishery or their utilization by other important populations as a food source. Only four of these six populations were dominant in the fall and winter surveys: *C. nigromaculata*, *D. excentricus*, *E. analoga* and the phoxocephalidae. *Crangon franciscorum and C. magister* populations were present in very low numbers, while *Lissocrangon stylirostris*, not identified by the literature review, was an abundant and apparently important population.

The absence of the bay shrimp, *C. franciscorum*, in the fall survey was thought to be a product of seasonal variability. The local population occurs most of the year within San Francisco Bay and is found on the open coast only in the winter (Hatfield 1985). It is usually abundant in the winter offshore trawls taken by the BWPC (1988, 1989, 1990). At the nearshore station, however, only one individual of *C. franciscorum* was taken in the late winter (March, 1992) survey. Apparently, this species does not come inshore, but remains at the deeper stations.

Cancer magister, the dungeness crab, is an important commercial species that has decreased greatly in central California in recent years. The low abundance of this species at the nearshore station may be attributed to the extreme fluctuations in yearly recruitment also seen at the offshore stations. Large numbers of juveniles of this species were found in the offshore trawls in 1988 (BWPC 1989), but very few in following years (BWPC 1990; Michael Kellogg, pers. comm.). The *C. magister* at our nearshore trawl station consisted of three juvenile males taken in October, 1991 and one slightly larger female caught in March, 1992. In order to confirm the use of the shallow nearshore area as a nursery for young *C. magister*, trawls would have to be taken at the nearshore station in years of higher recruitment.

Lissocrangon stylirostris was not identified in the literature review, but was the second most abundant invertebrate species collected overall during both surveys. Its abundance in the subtidal trawls suggests an important ecological role in the nearshore habitat. Although its biology is not well known, it probably serves as an important source of food for many of the same species of fish that feed on the other local crangonid species.

Fish

Dominant Species and Seasonal patterns

Fifteen species of demersal (bottom) fish were collected in otter trawls at the nearshore station (Table 6). Speckled sanddab was the dominant species found at this station during the two surveys. In October, 1991 the speckled sanddab comprised 50 percent of the total number of fish collected. In March, 1991 it was 36 percent of the total (Table 7). Kurkowski (1973, from Oliver et al. 1980) found speckled sanddab to be the only numerous fish in less than 20 meters of water in Monterey Bay. Its peak abundance is reported to occur in 14-18 meters (Ford, 1965). Offshore of Ocean Beach at depths of 23-26 meters, speckled sanddab dominates the bottom trawl samples and is consistently one of the most abundant bottom fish caught (BWPC 1988, 1989, 1990) indicating a deeper water habitat locally.

Patterns of zonation for both fish and invertebrates of the open coast are likely to reflect the relative wave energy. Oliver et al. (1980) postulated that sandy beach areas receiving larger waves, with consistently greater surge had a distinct shift in faunal zones to deeper water over areas of lower wave energy. The great abundance of speckled sanddab at depths of 23-26 meters off Ocean Beach may be a result of this faunal shift in an area of very intense wave energy.

Although not an important commercial or sportfish, the speckled sanddab is ecologically important as a food source to many large demersal fish and some birds (Ford, 1965; Hogue and Carey 1982). Juveniles settle in 15-25 meters during spring, summer and fall. The decline in numbers during the winter at these depths is attributed to mortality or offshore migration (Ford 1965). This pattern may be seen at the nearshore station. Size frequency histograms for speckled sanddab from the nearshore survey showed a fall, 1991 population ranging in size from 25-110 mm length, while the March histograms revealed a smaller population of larger sized individuals ranging from 60-100 mm length indicating offshore migration or mortality (Figure 13).

Both the sizes and seasonal pattern at the nearshore station are almost identical to offshore trawl samples during 1987, 1988, 1989 (BWPC 1988, 1989, 1990). Recruitment of speckled sanddab (ie. settlement of young) is seen in the offshore trawls in the summer although population peaks are found in both summer and fall sampling periods (BWPC, 1988, 1989, 1990). The low abundance in the winter sampling period reflects the seasonal decline (offshore migration or mortality) of this population (BWPC 1988, 1989, 1990).

The spotfin surfperch was the second most abundant fish from the nearshore otter trawls (Table 7). In the fall sampling period 62 individuals represented 27 percent of the total catch. In late winter, 11 individuals comprised 14 percent of the total. The size frequency histograms show a population dominated by small size classes during the fall, indicating 1991 recruitment (Figure 14). The late winter histograms are represented by a small number of larger fish. This species follows the same seasonal pattern as shiner surfperch: peak abundance in the fall and decreased abundance (at times falling to 0) in the winter and summer. Like the shiner surfperch, it probably gives birth to live young in the summer which are too small to catch in the summer trawl samples but are taken by trawls in the fall when they have increased in size (BWPC 1987, 1988, 1990).

Spotfin surfperch are also found consistently, although usually at lower relative abundance, at the offshore stations (BWPC 1988, 1989, 1990). During October, 1991, however, data from the offshore survey revealed a large population of recently recruited spotfin surfperch at the deeper stations (BWPC 1992, in prep.). The sizes of these small fish correspond to the peak in abundance of the small size classes seen at the nearshore station during the same period, indicating a large recruitment of these fish during the fall at both the shallow and deeper stations.

Sand sole was the third most abundant fish caught in the seasonal surveys (Table 7). In the fall 17 fish represented 7 percent of the catch, while in the late winter 24 fish comprised 32 percent of the total. This species is usually one of the twenty most abundant fish taken further offshore, but comprises only one to two percent of the total catch by number (BWPC 1987, 1988, 1990), suggesting a greater relative abundance at the nearshore station.

Size frequency measurements from the nearshore station revealed individuals ranging from 40 - 190 mm in length in the fall and 50 - 190 mm in the late winter (Figure 15). In both seasons the smaller size class predominated with 64 percent of the individuals falling between 40 and 90 mm in the fall and 83 percent between 40 and 90 mm in late winter. At the offshore stations size frequency histograms were not generated for sand sole during the late 1980's. However, data from October, 1991 indicated that the offshore sand sole population consisted mostly of individuals larger than 200 mm in length (BWPC 1992, in prep.). In addition, earlier surveys offshore (CH2M Hill 1980, 1983) found sand sole populations ranging from 40 to 450 mm length during 1978, 1979, and 1980. In most surveys more than 50 percent of the population exceeded 200 mm in length. This indicates that juveniles may be settling in shallow water and migrating to deeper water as adults.

The sand sole ranges from the Bering Sea to southern California and is found on sand and mud bottoms from 5 to about 1,100 feet (Gotshall 1989). They are almost entirely pisciverous (feeding on northern anchovy, pacific tomcod, English sole, and other sand soles) although occasionally taking large numbers of crustaceans, particularly mysids (CH2M Hill 1880, 1983).

English sole was less abundant than expected at the nearshore station during both surveys (Table 7). Fifteen individuals constituted six percent of the total catch in the fall and only two individuals and three percent of the total in March. Offshore trawls taken by the BWPC (1988, 1989, 1990) yielded high catches of the species year-round especially in summer and fall, at times constituting up to 39 percent of the total catch. Higher abundances of English sole would be expected at the nearshore station during spring and summer when recruitment occurs.

English sole is an important commercial species that is known to utilize bays and shallow inshore areas of the open coast as a nursery. The juveniles of this species usually reside in the nursery area during the spring and summer and move offshore during the fall (Forrester 1969; Krygier and Pearcy 1986; and Misitano 1970). Settlement of the young usually occurs at 16 meters or less. Biologists from the BWPC find peaks of small sized (25 - 40 mm length) English sole during the summer at 23 -26 meters offshore (BWPC 1987, 1988). This settlement in deeper water than recorded for other English sole populations may be a result of the shift in zonation mentioned above due to the intense wave energy off Ocean Beach. Although preferential use of the nearshore shallow area (ie. less than 16 meters) as a nursery by this population was not evident from these two surveys, the small size (60 - 90 mm length) of the individuals caught at the nearshore station, at nine meters depth, during the fall indicate that some settlement is occurring at this depth. During the same period an English sole population ranging in size from 60 to 245 mm length was caught in offshore trawls (BWPC 1992, in prep.).

Important Fish Populations

McCormick (1991) identified six fish populations important to the Ocean Beach surf and shallow subtidal regions: English sole, speckled sanddab, white croaker, shiner surfperch, barred surfperch and striped bass. These populations were selected from local studies, pertinent literature and other sources because of their ecological importance or their importance to the commercial or sport fishery. Representatives of only three of these populations were found in the fish samples during the two sampling periods: English sole, speckled sanddab and shiner surfperch. Only English sole and speckled sanddab were among the most abundant fish sampled. Shiner surfperch was sampled in low abundance while white croaker, barred surfperch and striped bass were missing entirely. On the other hand, two species, spotfin surfperch and sand sole, constituted a surprisingly high proportion of the catch (Table 7; Figure 16).

The lack of white croaker in the subtidal trawls during both surveys was unexpected. Although the best season for these fish in the offshore bottom trawls is winter, large numbers are usually caught in the fall as well (BWPC 1988, 1989). During October, 1991, a large population of white croaker was sampled in bottom trawls at 23 -26 meters, ranging in size from 65 to 190 mm length (BWPC 1992, in prep.) During the same period, no white croaker were caught in the nearshore trawls at nine meters. Adults of this population are known to migrate shoreward to spawn from November through May. Juveniles settle at three to six meters and migrate to deeper water as adults (Love et al. 1984). The lack of white croaker in the March, 1992 nearshore trawl samples indicates that the settlement pattern recorded for other coastal areas is not occurring at the shallow depths along Ocean Beach. It is likely that the intense wave energy along this part of the exposed coast is causing settlement to shift into deeper water (see Oliver et al. 1980). Consequently, white croaker may not be considered an important part of the shallow (less than 16 meters in depth) subtidal environment off Ocean Beach. Another possibility is that the small number of trawls at the nearshore station was not adequate to sample this population.

The low abundance of shiner surfperch from the nearshore trawls, particularly during the fall survey, was another surprise. Shiner surfperch are normally abundant in offshore trawls during the fall (BWPC 1988, 1989, 1990) and are also commonly seen in the surf zone in the summer (pers. comm., Leroy Smith). Yet our fall nearshore survey yielded few shiner surfperch. Raw data from the offshore survey during the same period (BWPC 1992, in prep.) revealed only two individuals of this species from seven offshore stations suggesting that shiner surfperch recruitment was locally very low during 1991.

Conversely, spotfin surfperch, which is usually less abundant than shiner surfperch in the offshore bottom trawls (BWPC 1988, 1989) and less common in the surf zone, was the second most abundant fish overall in the nearshore bottom trawl surveys. A large population of this species was also found in offshore samples in the fall of 1991 (BWPC 1992, in prep.). Apparently, the spotfin surfperch population increased coincidental to the decrease of the shiner surfperch population in both the shallow nearshore and deeper offshore areas.

The relative abundance of sand sole at the nearshore station, particularly juveniles, was not anticipated in the literature review (McCormick 1991). The local shallow nearshore environment may play an important role in the recruitment and early development of this important population.

The inability to sample the Ocean Beach surf zone during either survey period resulted in a lack of quantitative field information on the striped bass, barred surfperch and other important fish that either live in the surf zone or come inshore during a seasonal migratory period. These populations cannot be adequately sampled in nearshore bottom trawls since they comprise a narrow band in and just outside the surf zone. It is hoped that a summer survey of the surf zone can be made, since this is the period of recruitment and inshore migration for many populations.

The striped bass migratory run peaks in July, but fish are still caught along the open coast through September (Chadwick 1967; Pers. comm., David Kohlhorst). Striped bass may be caught in the Ocean Beach surf and immediate offshore area from mid-June through September (Pers. comm., Leroy smith, surf fisherman and Jim smith, party boat captain).

Discussions with an Ocean Beach surf fisherman (Leroy Smith) indicated that the summer and early fall of 1991 were very good for barred surfperch fishing. This species is the most commonly caught surf fish on central and southern California sandy beaches (Carlisle Jr. et al. 1960). Unlike southern California, the Ocean Beach population decreases locally in the surf zone in fall and winter (pers. comm. Leroy Smith).

Sediments

Intertidal results

Particulate size analysis for the intertidal stations yielded similar grain size distribution at all stations in November, 1991. This pattern became distinctly bimodal in March, 1992 with the three upper intertidal stations having a higher percentage of smaller particles (Figure 17). In both seasons, however, most of the particles fell into the medium to fine grained size classes, and the percent silt/clay comprised 0.1 percent of the sample at all stations (Table 8).

Total volatile solids (TVS), a measure of the total amount of organic material in a sample, were less than one percent during the March survey (Table 9). These results were consistent with expectations for intertidal sediments which usually exhibit a larger grain size than offshore sediments and consequently a low percentage of TVS. The results of the total organic carbon (TOC) analysis are not complete and will be reported as an appendix to this report.

Nearshore Station

Subtidal particle size analysis for the nearshore station indicated that almost all particles fell into the three phi size class, the very-fine-sand category (Figure 17). The percent silt/clay is also quite low at this station during both surveys, in all cases 0.2 percent or less. At the offshore stations during 1987,1988, and 1989, the percent silt/clay varies greatly from station to station, ranging from 1.1 to 58.2 percent (BWPC 1988, 1989, 1990). Generally, communities of benthic organisms dominated by polychaete worms (Annelida) are associated with larger silt/clay content while crustaceans and other groups tend to dominate in zones with a low silt/clay content.

TVS are slightly higher at the nearshore station than the intertidal stations (Table 9) and range from 0.7 to 2.05 percent, reflecting the higher organic content of these sediments. At the offshore stations, TVS range from 1.3 to 9.2 percent in 1987 and 1.5 to 6.5 percent in 1988. Values greater than four percent have been assumed to indicate high organic loadings in some studies although others have reported ambient (non pollution) conditions from four to ten percent (Bascom 1978; Hendricks 1984). Values greater than six percent have been associated with changes in the benthic community (Bascom 1978).

Water

Water samples were taken in March,1992 in the surf zone and at the nearshore station in October, 1991 and March, 1992 (Table 10). These data will be used to compare to future water samples in the event that sand disposal is suspected of increasing the levels of total suspended solids (TSS) or the organic content (Total volatile suspended solids - TVSS) in the water column.

CONCLUSION

Several populations of invertebrates and fish were identified from the intertidal and nearshore areas of Ocean Beach, San Francisco during the fall, 1991 and winter, 1992 survey. The most abundant invertebrates were: the intertidal crustaceans, *Emerita analoga* and *Excirolana linguifrons;* and the subtidal invertebrates, *Dendraster excentricus*, the phoxocephalidae, *Crangon nigromaculata*, and *Lissocrangon stylirostris*. The most abundant fish populations were: speckled sanddab, spotfin surfperch, sand sole and English sole. Most of these populations had been identified previously by the Ocean Beach literature review (McCormick, 1991). The field work, however, yielded some results, among both the invertebrate and fish fauna, that were inconsistent with the earlier predictions. There are several reasons for the inconsistencies between the literature review and the field work:

1) The high intensity wave energy off Ocean Beach probably creates a zonation shift for some populations to deeper water where sediment motion is less severe. Populations observed in shallow nearshore areas (less than 16 meters) from some locations may not occur in others. This phenomenon may have been responsible for the lack of white croaker and low abundance of English sole at the nearshore stations.

2) Year-to-year variability occurs in some species and cannot be predicted. This is certainly the case for *Cancer magister*, which remains an important local species despite the low recruitment during some years. Spotfin surfperch and shiner surfperch also appear to experience population fluctuations. During the two surveys, the decline of shiner surfperch coincided with the increase in spotfin surfperch, apparently the result of a poor 1991 recruitment for the former and a strong recruitment for the latter.

3) The lack of surf zone samples during the fall and winter sampling periods ruled out local information on this habitat. Both striped bass and barred surfperch are important populations found exclusively in the surf zone

during some seasons. Local fishermen, however, caught both of these species during the summer and fall of 1991 (pers. comm. Leroy Smith), and one can only presume that they were well represented in the surf zone during this period.

4) Lack of information on some local species led to over or underestimation of their importance in the nearshore environment. The importance of *Lissocrangon stylirostris* was not anticipated in the literature review (McCormick 1991), due to the lack of local information on this species. Conversely, *Crangon franciscorum* was expected to come closer inshore during its winter migratory period than it apparently does. The abundance of this species in the offshore area during this period was misleading. Also, sand sole appears to have a more important role in the nearshore environment than previously anticipated. The relatively low abundance in the offshore samples was not indicative of the nearshore importance.

These results indicate that field work is necessary to corroborate data from the literature, particularly when local information is not available. A literature review is a good tool but does not take the place of a sampling program. Local beach and nearshore conditions vary greatly from region to region and may not be the same as those for which population reports are published. Year to year population variations, which cannot be observed without field information, may also occur.

The conclusions must also be tempered with the knowledge that the results of the intertidal and shallow nearshore survey were based on only a few samples taken during two sampling periods. A long term, in-depth sampling program would be necessary to draw a more informed conclusion about the importance of these Ocean Beach habitats and their associated fauna.

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Table 1. Scientific names of intertidal and subtidal invertebrates collected in Ocean Beach samples during October/November, 1991 and March, 1992.

Species	Inter-tidal	Subtidal Grab	Subtidal Trawl
Cnidaria			
Hydrozoa		x	
Hydroida			
Aglaophenia spp.		x	
Annelida			
Polychaeta			
Anaitides spp.		x	
Gycera tenuis		x	
Nephtys caecoides		x	
Nothria elegans		x	
Leitoscoloplos elongatus		x	
Scoloplos armiger		x	
Prionospio pygmaea		x	
Chaetozone setosa		x	
Capitella capitata		x	
Syllidae		x	
Arthropoda			
Insecta	x		
Coleoptera			
Staphylinidae	x		
Crustacea			
Ostracoda			
Euphilomedes carcharodonta		x	
Mysidacea			
Archeomysis grebnitzkii	x		
Cumacea			
Diastylopsis dawsoni		x	
Isopoda			
Bathycopea daltonae			x
Excirolana linguifrons	x		
Amphipoda			
Eohaustorius spp.	x	x	
Mandibulophoxus gilesi	x	x	
Megalorchestiodea californiana	x		
Orchestoidea benedicti	x		
Orchestoidea spp.	x		
Rhepoxynius fatigans		x	
Rhepoxynius lucubrans		x	
Rhepoxynius tridentatus		x	
Rhepoxynius spp. (juv)		x	
Synchelidium shoemakeri		x	
Gammaridea juveniles		x	
Caprella spp.		x	

Table 1 (Continued). Scientific names of intertidal and subtidal invertebrates collected in Ocean Beach samples, October/November, 1991 and March, 1992.

Species		Inter-tidal	Grab	Trawl
Amphipoda (continued)				
	Tritella laevis		x	
	Caprellidea juveniles		x	
Decapoda				
	Crangon nigromaculata			x
	Crangon nigricauda			x
	Lissocrangon stylirostris		x	x
	Cancer gracilis			x
	Cancer productus			x
	Cancer magister		x	x
	Cancer antennarius			x
	Cancer spp. (juv)		x	
	Decapod megalopa		x	
	Emerita analoga	x		
	Isocheles pilosus		x	
	Pagurus spp.		x	x
	Anomura juveniles		x	
Mollusca				
Cephalopoda				
	Loligo opalescens			x
Gastropoda				
	Olivella pycna		x	
	Nassarius ?perpinguis		x	
Bivalvia				
	Tellina bodegensis		x	
	Tellina spp. (juv.)		x	
Echinodermata				
Echinoidea				
Irregularia				
	Dendraster excentricus		x	x
Asteroidea				
Forcipulatida				
	Pisaster brevispinus			x
	Pisaster ochraceus			x

Table 2. Species abundance and richness by major taxonomic group for intertidal samples, subtidal grabs and subtidal trawls from Ocean Beach, San Francisco in October/November, 1991 and March, 1992.

October/November, 1991

Habitat	Annelida		Mollusca		Arthropoda		Echinodermata		Other		Total
	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Intertidal											
No. species	0		0		8	100	0		0		8
No. individuals					251	100					251
Subtidal Grabs											
No. species	9	32	2	7	15	54	1	4	1	4	28
No. individuals	39	7	26	5	296	53	197	35	-*	-	558
Subtidal Trawls											
No. species	0		1	0	9	69	3	23	0		13
No. individuals			4	<1	172	20	661	80	0		837

March, 1992

Habitat	Annelida		Mollusca		Arthropoda		Echinodermata		Other		Total
	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Intertidal											
No. species	0		0		4	100	0		0		4
No. individuals					112	100					112
Subtidal Grabs											
No. species	3	17	4	22	9	50	1	6	1	6	18
No. individuals	21	6	23	6	204	56	116	32	-*	-	364
Subtidal Trawls											
No. species	0		0		4	80	1	20	0		5
No. individuals			0		173	22	605	78	0		778

* Total numbers of this colonial species were not counted.

Table 3. Taxa and number of invertebrates from intertidal samples on Ocean Beach, San Francisco during November, 1991 and March, 1992. Number of individuals represents the total number of taxa from three quadrats at all tidal levels.

Taxa	Number of Individuals	
	Nov. 1991	Mar. 1992
Insect larvae (unidentified)		1
Staphylinidae	2	
Archeomysis grebnitzkii	13	2
Excirolana linguifrons	200	10
Eohaustorius spp.	1	
Mandibulophoxus gilesi	1	
Megalorchestoidea californiana	6	
Orchestoidea benedicti	4	
Orchestoidea spp. (juv.)	3	
Emerita analoga	21	199
Total	251	212

Table 4. Taxa and number of invertebrates from subtidal grab samples at the inshore Ocean Beach station during October, 1991 and March, 1992. Number of individuals represents the total number of taxa from five replicates.

Taxa	**Number of Individuals** Oct. 1991	Mar. 1992
Hydrozoa (unidentified)		+
Aglaophenia spp.	1	
Anaitides spp.	4	
Nephtys caecoides	5	3
Nothria elegans	1	
Leitoscoloplos elongatus	1	
Scoloplos armiger	9	
Prionospio pygmaea	1	
Chaetozone setosa	15	17
Capitella capitata	2	
Syllidae		1
Euphilomedes carcharodonta		3
Diastylopsis dawsoni	1	
Eohaustorius spp.	80	72
Mandibulophoxus gilesi	1	
Rhepoxynius fatigans	133	76
Rhepoxynius lucubrans	14	24
Rhepoxynius tridentatus	1	
Rhepoxynius spp. juv.	3	
Synchelidium shoemakeri	39	23
Gammaridea juveniles	2	
Caprella spp.	4	
Tritella laevis	2	
Caprellidea juveniles	5	
Lissocrangon stylirostris	2	2
Isocheles pilosus	3	
Pagurus spp.	1	
Anomura (juv.)	2	
Cancer spp. (juv.)	2	2
Decapod megalopa	1	1
Cancer magister		1
Olivella pycna	24	20
Nassarius ?perpinguis		1
Tellina bodegensis	2	1
Tellina spp. (juv.)		1
Dendraster excentricus	197	116
Total	**558**	**364**

Table 5. Taxa and number of epibenthic invertebrates from the inshore station during October, 1991 and March, 1992. Number of individuals represents the total number of taxa from two bottom trawls.

Taxa	Number of Individuals	
	Nov. 1991	Mar. 1992
Cancer gracilis	9	
Cancer productus	2	
Cancer magister	3	1
Cancer antennarius	2	
Crangon nigricauda	9	2
Crangon nigromaculata	70	
Crangon franciscorum		1
Lissocrangon stylirostris	74	169
Pagurus sp.	1	
Bathycopea daltonae	1	
Loligo opalescens	4	
Dendraster excentricus	629	605
Pisaster brevispinus	30	
Pisaster ochreceus	2	
Total	837	778

Table 6. Common and scientific names of fish collected from bottom trawls at the nearshore station off Ocean Beach, San Francisco during November, 1991 and March, 1992.

Scientific Name	**Common name**
Condrichthyes	
Squaliformes	
Triakidae	
Triakis semifasiata	Leopard shark
Osteichthyes	
Gadiformes	
Gadidae	
Microgadus proximus	Pacific tomcod
Gasterosteiformes	
Syngnathidae	
Syngnathus leptorhynchus	Bay Pipefish
Perciformes	
Embioticidae	
Amphisticus argenteus	Barred surfperch
Cymogaster aggregata	Shiner surfperch
Hyperporsopon anale	Spotfin surfperch
Hexigrammidae	
Ophiodon elongatus	Lingcod
Cottidae	
Leptocottus armatus	Staghorn sculpin
Pleuronectiformes	
Bothidae	
Citharichthys sordidus	Pacific sanddab
Citharichthys stigmaeus	Speckled sanddab
Pleuronectidae	
Parophrys vetulus	English sole
Platichtys stellatus	Starry flounder
Psettichthys melanostictus	Sand sole
Hypsopsetta guttulata	Diamond turbot
Synodontidae	
Synodotus lucioceps	California lizzardfish

Table 7. Species, number and percent of demersal fish from the inshore station during October, 1991 and March, 1992. "Number" represents the total number of species from two bottom trawls.

SPECIES	October, 1991		March, 1992	
	Number	Percent	Number	Percent
Pacific tomcod	1	<1	2	3
Spotfin surfperch	62	27	11	14
Shiner surfperch	8	3	3	4
Barred surfperch	1	<1		
Lingcod	1	<1		
Staghorn sculpin	2	1	2	3
California lizardfish	1	<1		
Pacific sanddab	7	3	3	4
Speckled sanddab	115	50	27	36
English sole	15	6	2	3
Starry flounder	1	<1		
Sand sole	17	7	24	32
Diamond turbot	1	<1		
Bay pipefish			1	1
Leopard shark			1	1
Total	232	97	76	101

Table 8. Percent sand and silt/clay for intertidal and subtidal sediments during October/November, 1991 and March, 1992.

Habitat	Percent sand	Percent silt/clay
Intertidal		
November, 1991		
Station 1	99.9	0.1
Station 2	99.9	0.1
Station 3	99.9	0.1
Station 4	99.9	0.1
Station 5	99.9	0.1
Station 6	99.9	0.1
March, 1992		
Station 1	99.9	0.1
Station 2	99.9	0.1
Station 3	99.9	0.1
Station 4	99.9	0.1
Station 5	99.9	0.1
Station 6	99.9	0.1
Subtidal		
October, 1991		
Replicate 1	99.8	0.2
Replicate 2	99.9	0.1
Replicate 3	99.8	0.2
Replicate 4	99.9	0.1
Replicate 5	99.9	0.1
March, 1992		
Replicate 1	99.9	0.1
Replicate 2	99.9	0.1
Replicate 3	99.9	0.1
Replicate 4	99.9	0.1
Replicate 5	99.8	0.2

Table 9. Total volatile solids (expressed as percent TVS) for intertidal and subtidal sediments in October, 1991 and March, 1992.

Habitat	Percent TVS
Intertidal	
March, 1992	
Station 1	0.00
Station 2	0.59
Station 3	0.00
Station 4	0.63
Station 5	0.61
Station 6	0.66
Nearshore	
October, 1991	
Replicate 1	1.40
Replicate 2	1.37
Replicate 3	2.05
Replicate 4	1.39
Replicate 5	1.37
March, 1992	
Replicate 1	1.42
Replicate 2	2.04
Replicate 3	1.36
Replicate 4	0.70
Replicate 5	1.37

Table 10. Total suspended solids (TSS), total volatile suspended solids (TVSS), and turbidity for intertidal and nearshore water column samples during October, 1991 and March, 1992.

Habitat	TSS (mg/l)	TVSS (mg/l)	Turbidity
Intertidal			
March, 1992			
Station 1	71	9	5.0
Station 2	80	6	4.5
Station 3	78	8	4.5
Nearshore			
October, 1991			
Surface	9.0	3	NA*
Middle	8.0	3	NA
Bottom	13.0	3	NA
March, 1992			
Surface	6.3	NA	NA
Middle	7.1	NA	NA
Bottom	16.0	NA	NA

* No analysis was made for these parameters

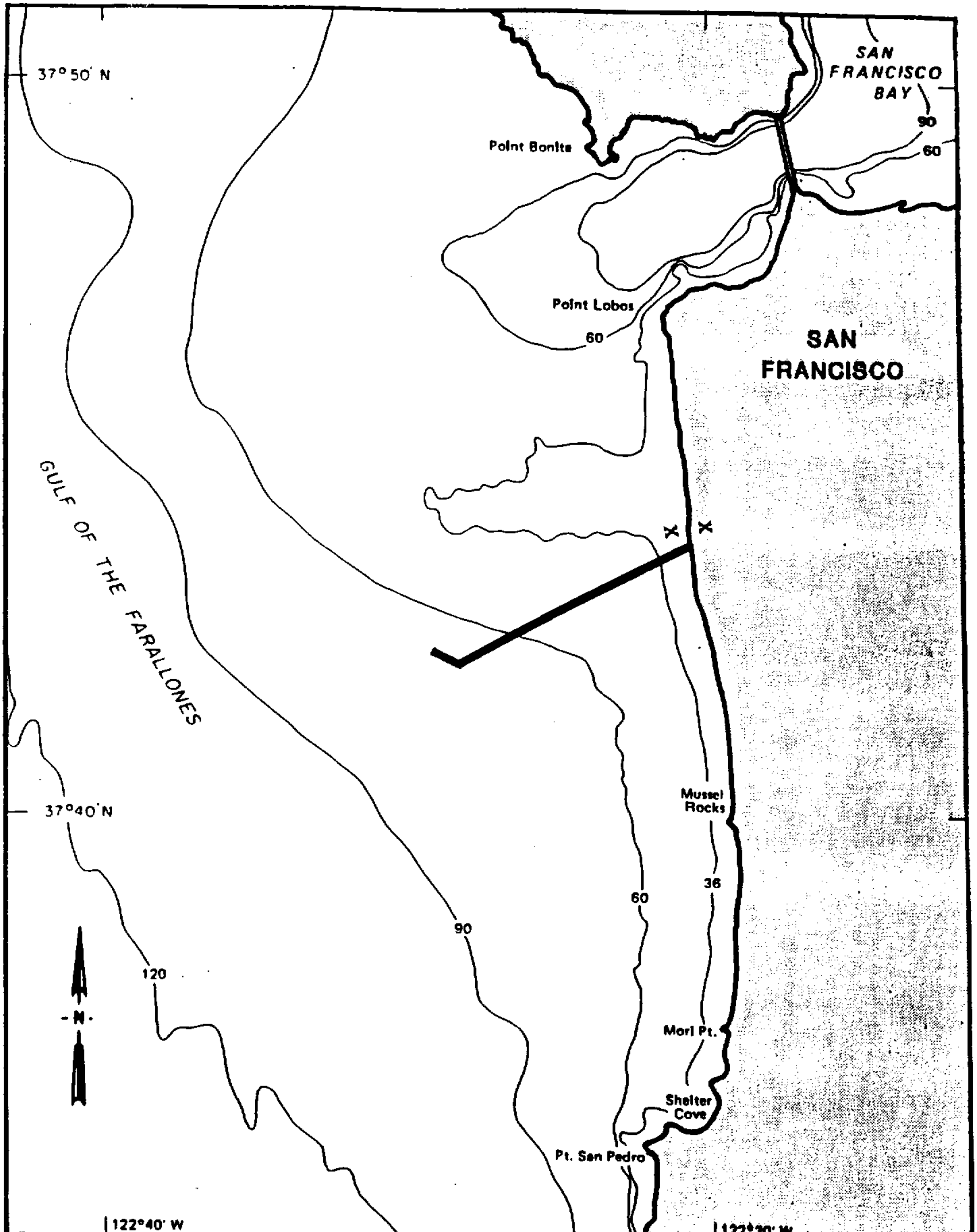


Figure 1. Sampling locations for intertidal and subtidal invertebrates and fish from Ocean Beach, San Francisco (after BWPC 1988).

0 1000 2000 3000 METERS
0 5000 10000 FEET
DEPTHS IN FEET

Figure 2. Seasonal invertebrate richness by major taxonomic group and habitat during October/November, 1991 and March, 1992 at Ocean Beach, San Francisco.

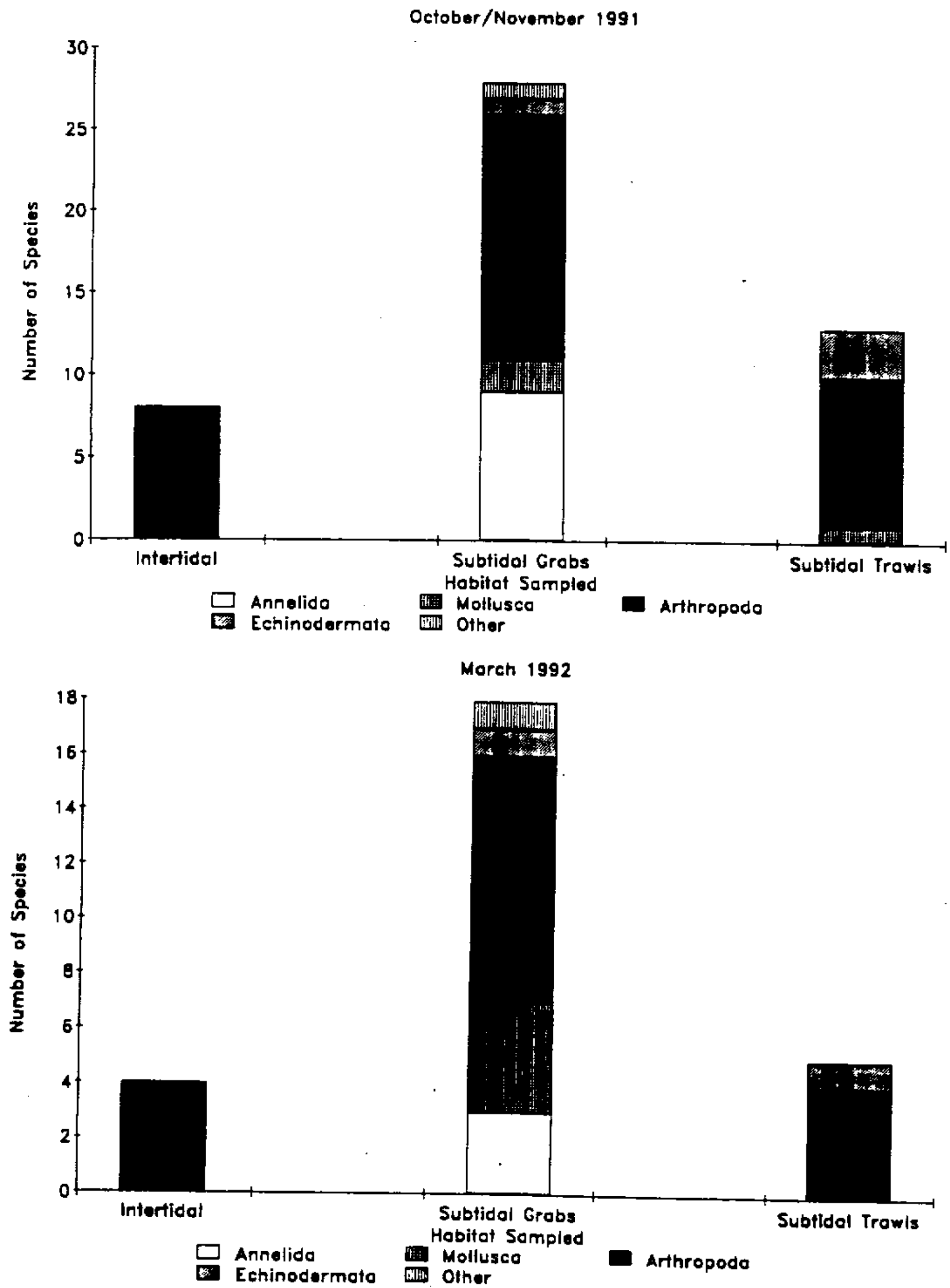


Figure 3. Seasonal invertebrate abundance by major taxonomic group and habitat during October/November, 1991 and March, 1992 at Ocean Beach, San Francisco.

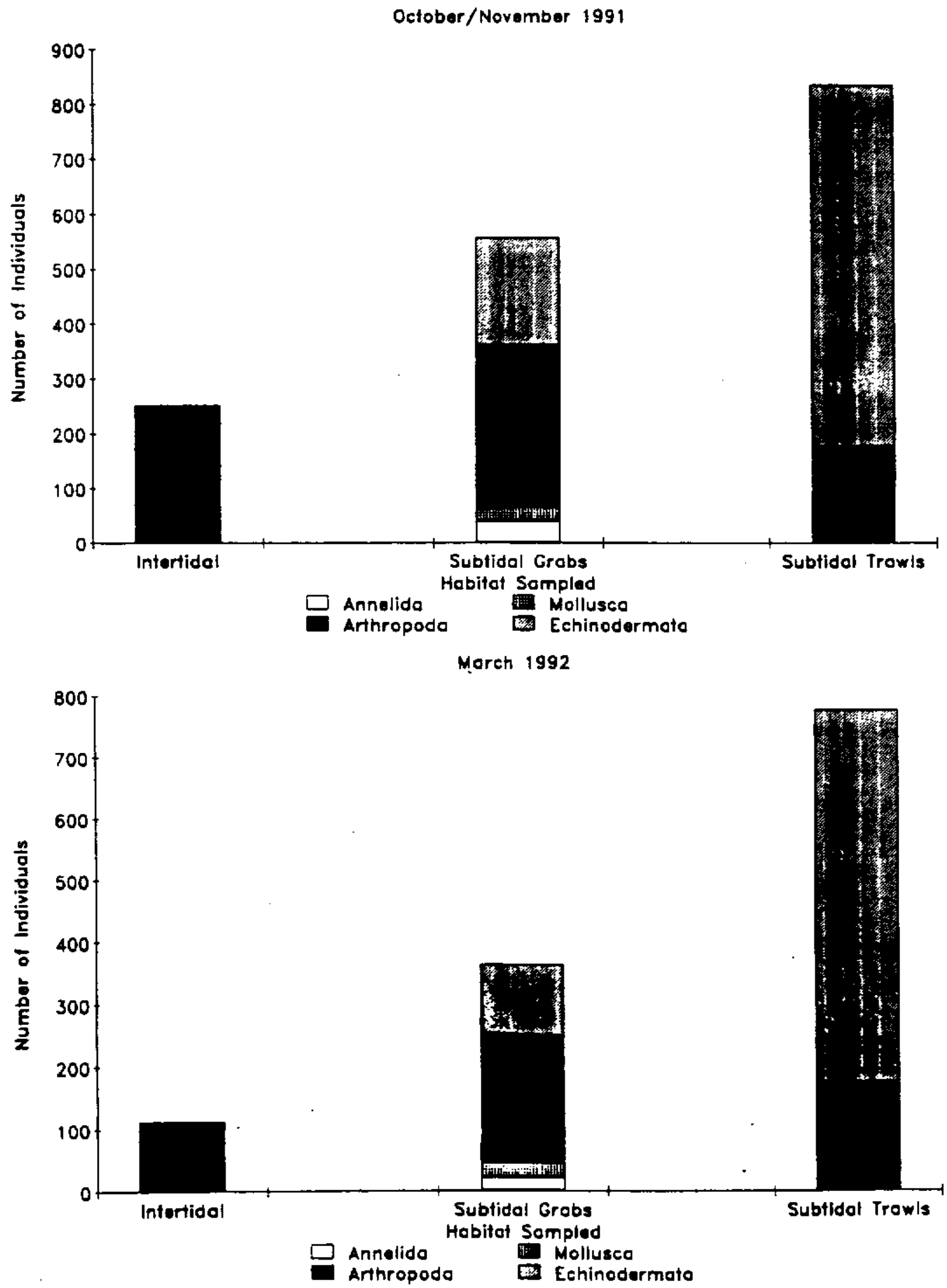


Figure 4a. Abundance of intertidal invertebrates by station and tidal level at a low tide of -0.5 feet on November 5, 1991, at Ocean Beach, San Francisco.

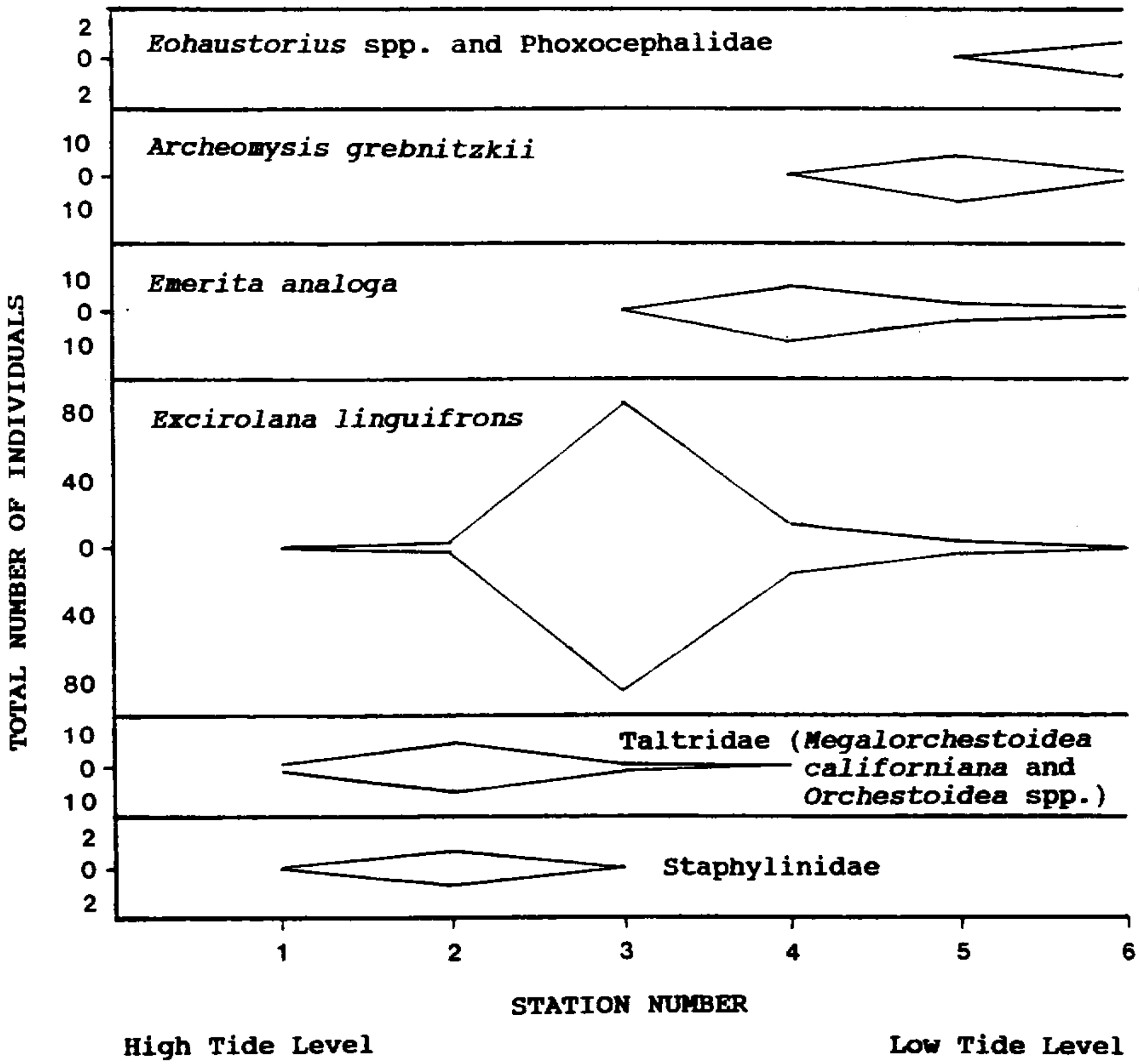


Figure 4b. Abundance of intertidal invertebrates by station and tidal level at a low tide of -0.6 feet on March, 15, 1992, at Ocean Beach, San Francisco.

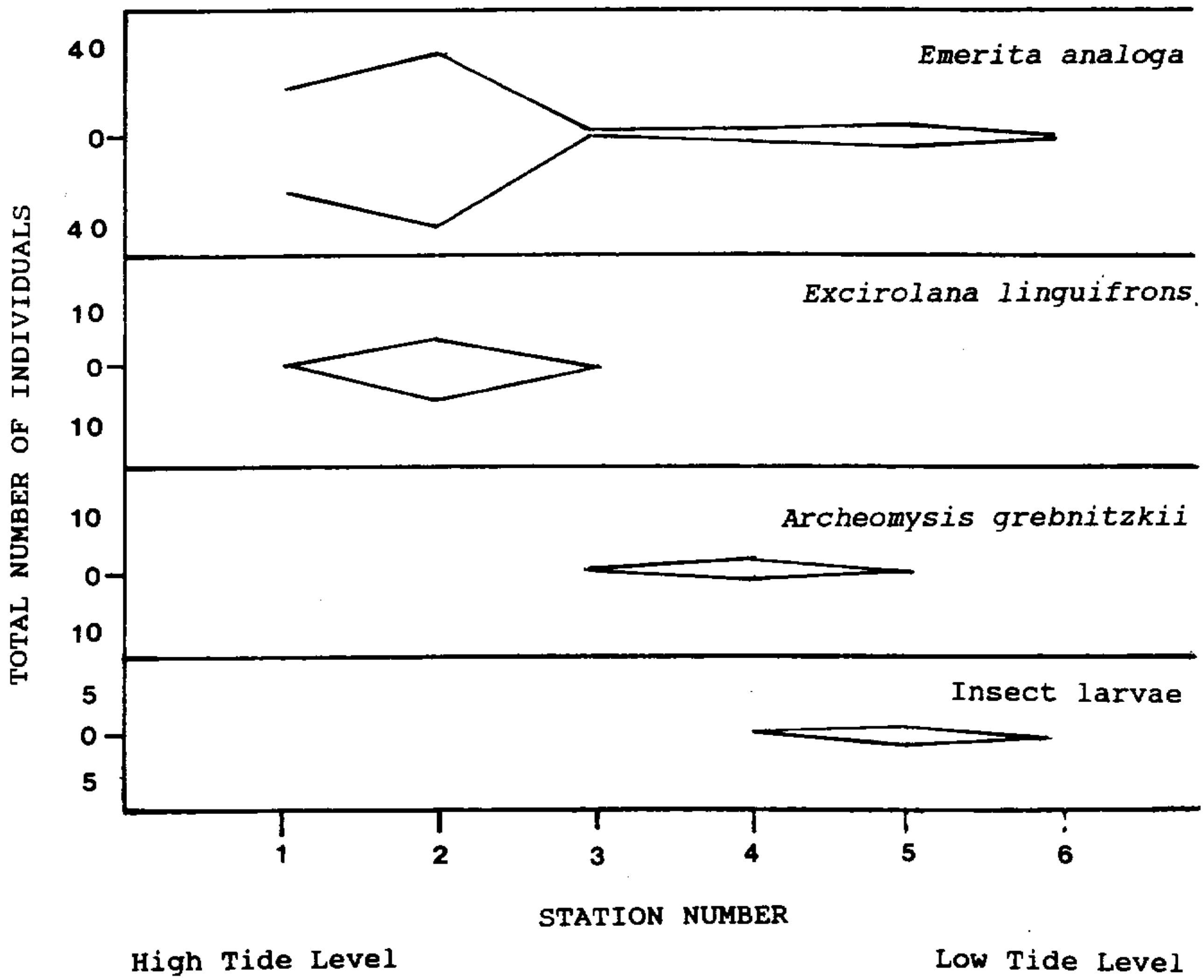


Figure 5. Abundance of *Emerita analoga* by station during November, 1991 and March, 1992 at Ocean Beach, San Francisco.

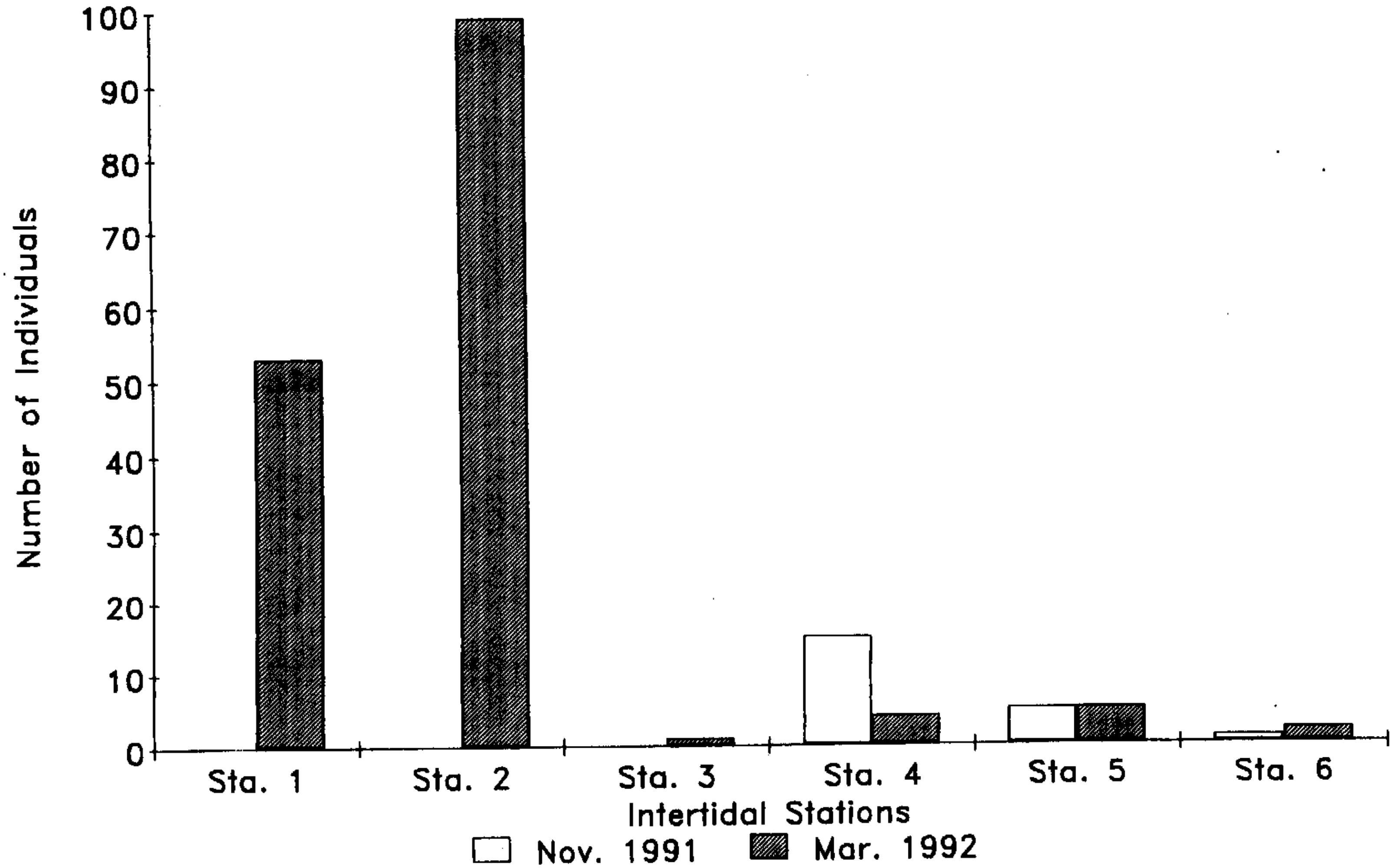
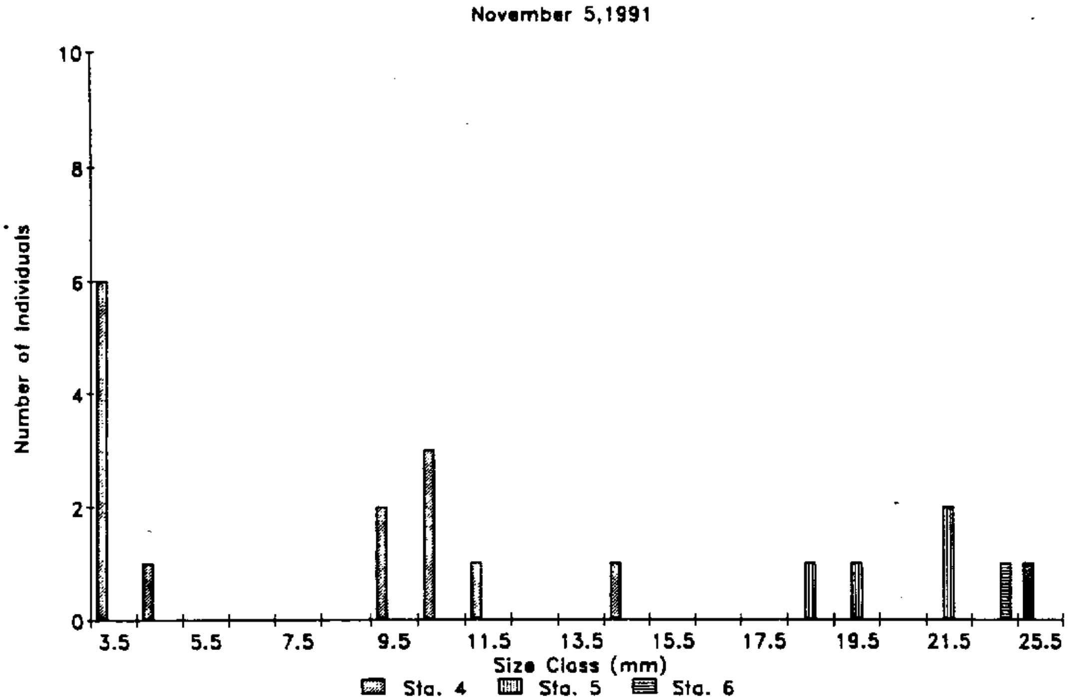


Figure 6. Size frequency of Emerita analoga at intertidal stations during November, 1991 and March, 1992 at Ocean Beach, San Francisco.



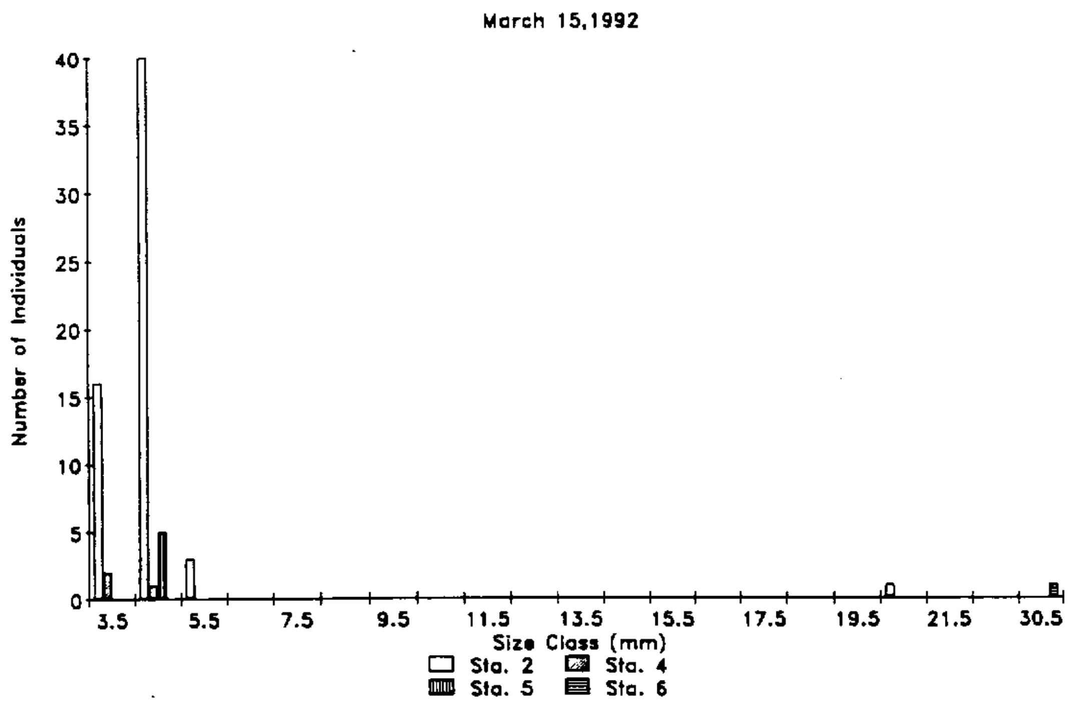
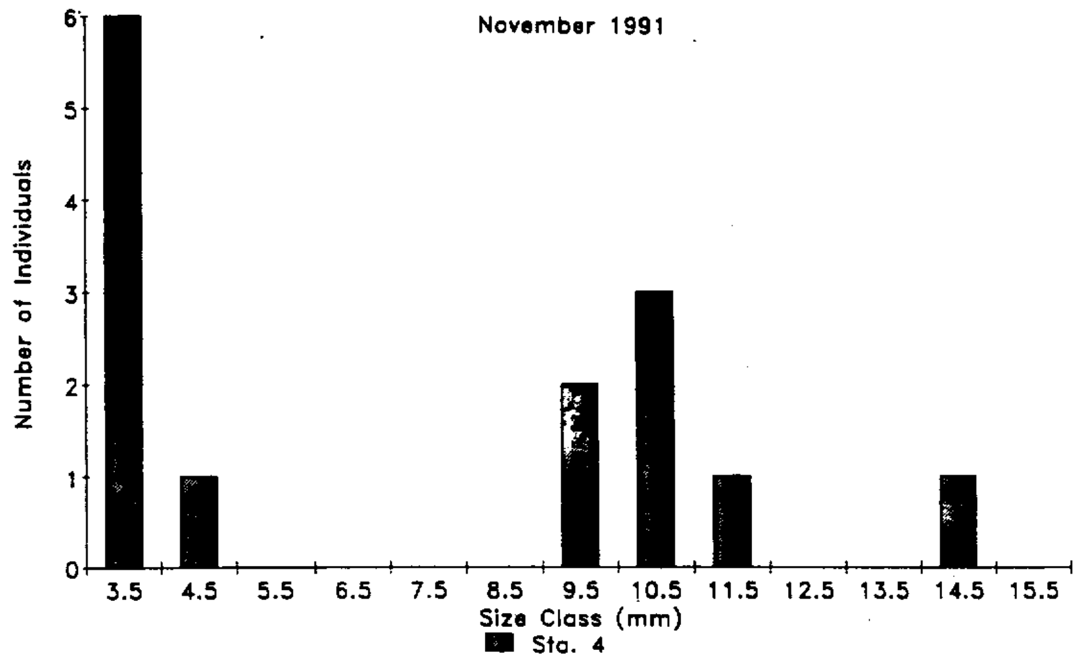


Figure 7. Size frequency of small *Emerita analoga* at intertidal stations during November, 1991 and March, 1992 at Ocean Beach, San Francisco.



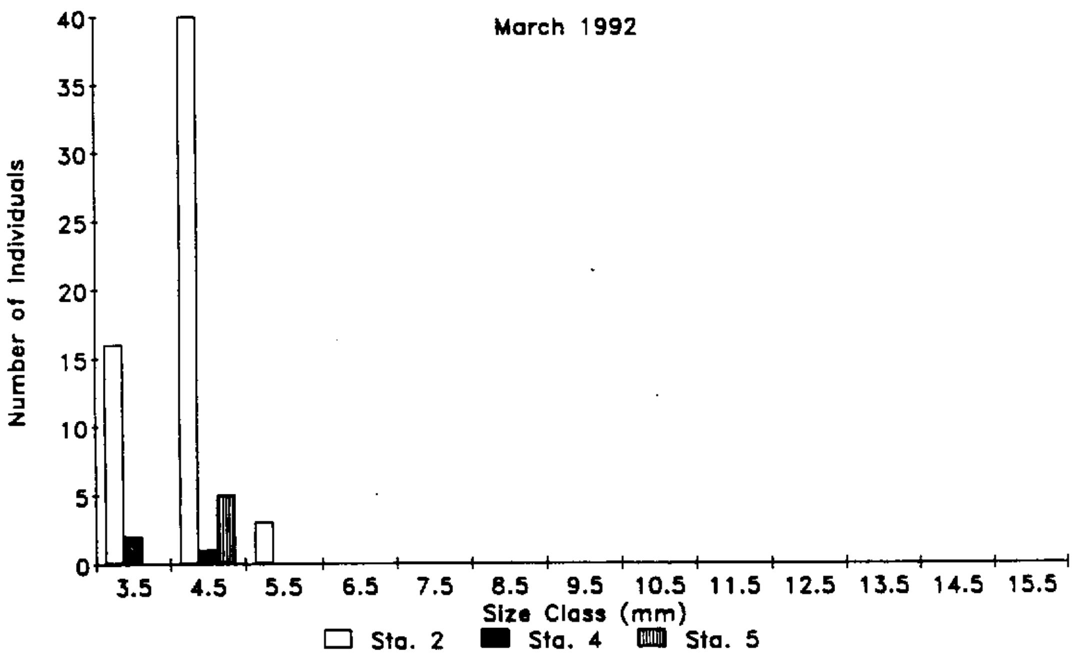


Figure 8. Abundance of selected invertbrates from subtidal grabs at the nearshore station during October, 1991 and March, 1992 off Ocean Beach, San Francisco.

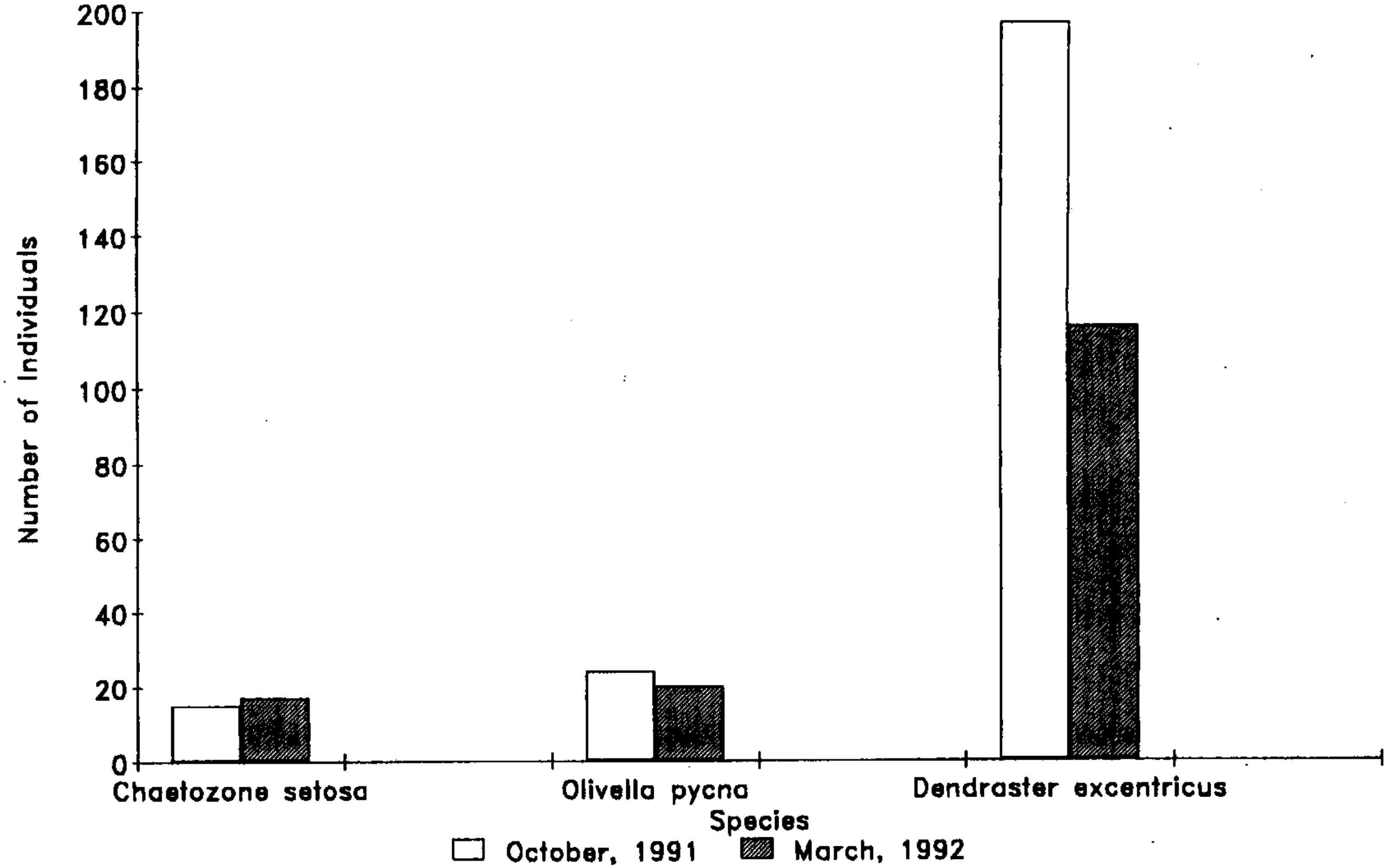


Figure 9. Abundance of selected crustacean species from subtidal grabs the nearshore station during October, 1991 and March, 1992 off Ocean Beach, San Francisco.

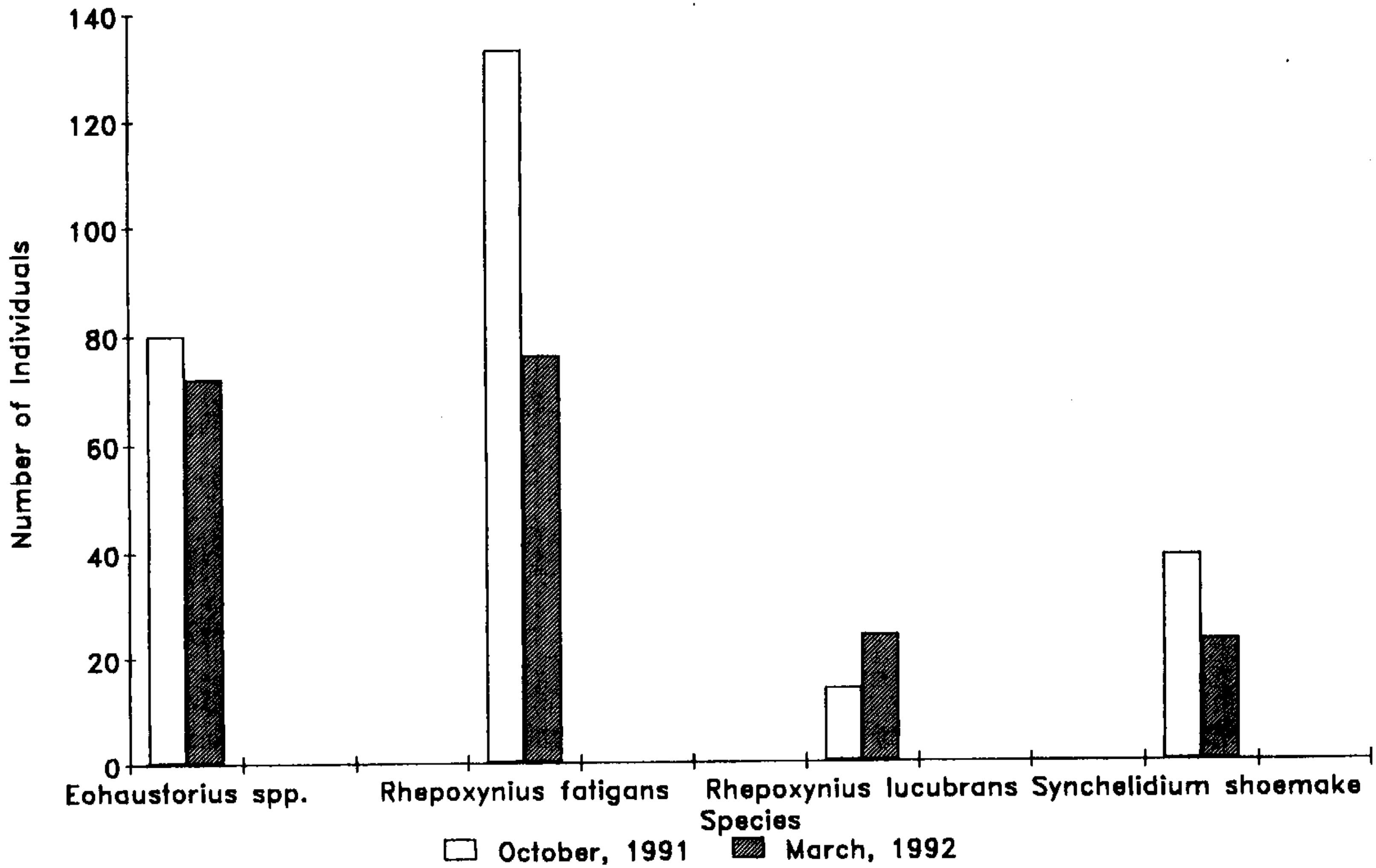


Figure 10. Abundance of selected invertebrates from subtidal trawls at the nearshore station during October, 1991 and March, 1992 off Ocean Beach, San Francisco.

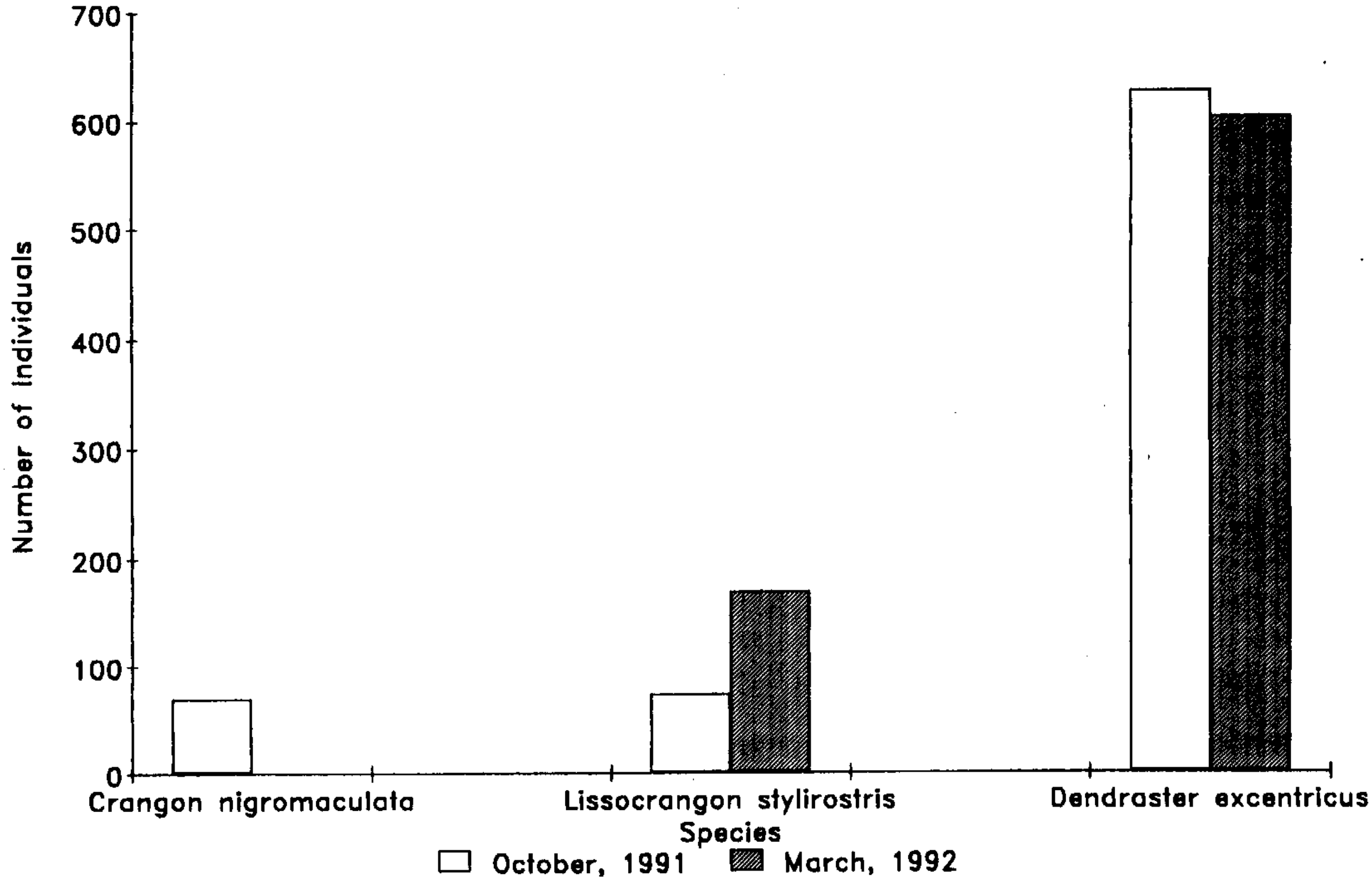


Figure 11. Size frequency of *Lissocrangon stylirostris* from subtidal trawls at the nearshore station during October, 1991 and March, 1992 off Ocean Beach, San Francisco.

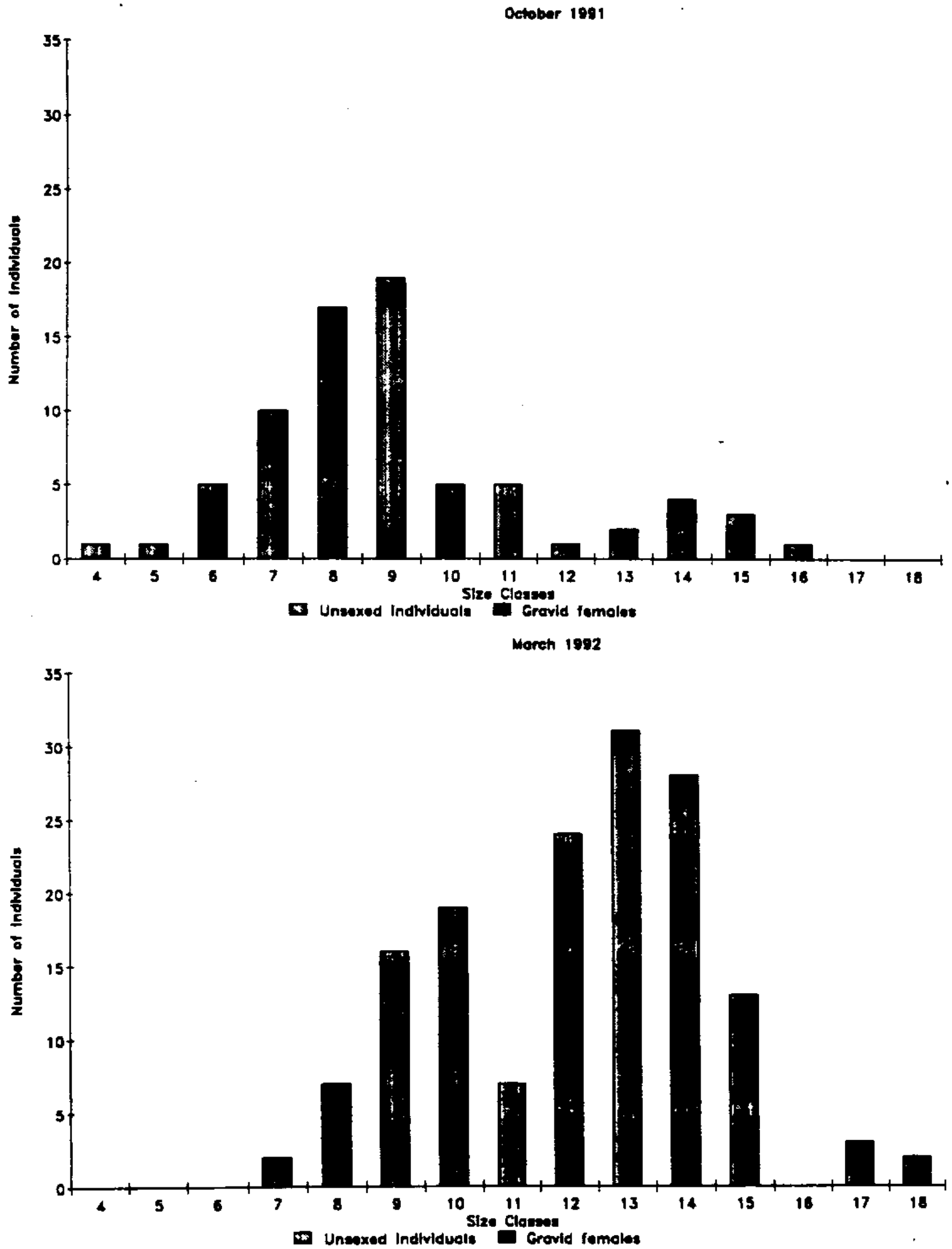


Figure 12. Size frequency of *Crangon nigromaculata* from subtidal trawls at the nearshore station during October, 1991 and March, 1992 off Ocean Beach, San Francisco.

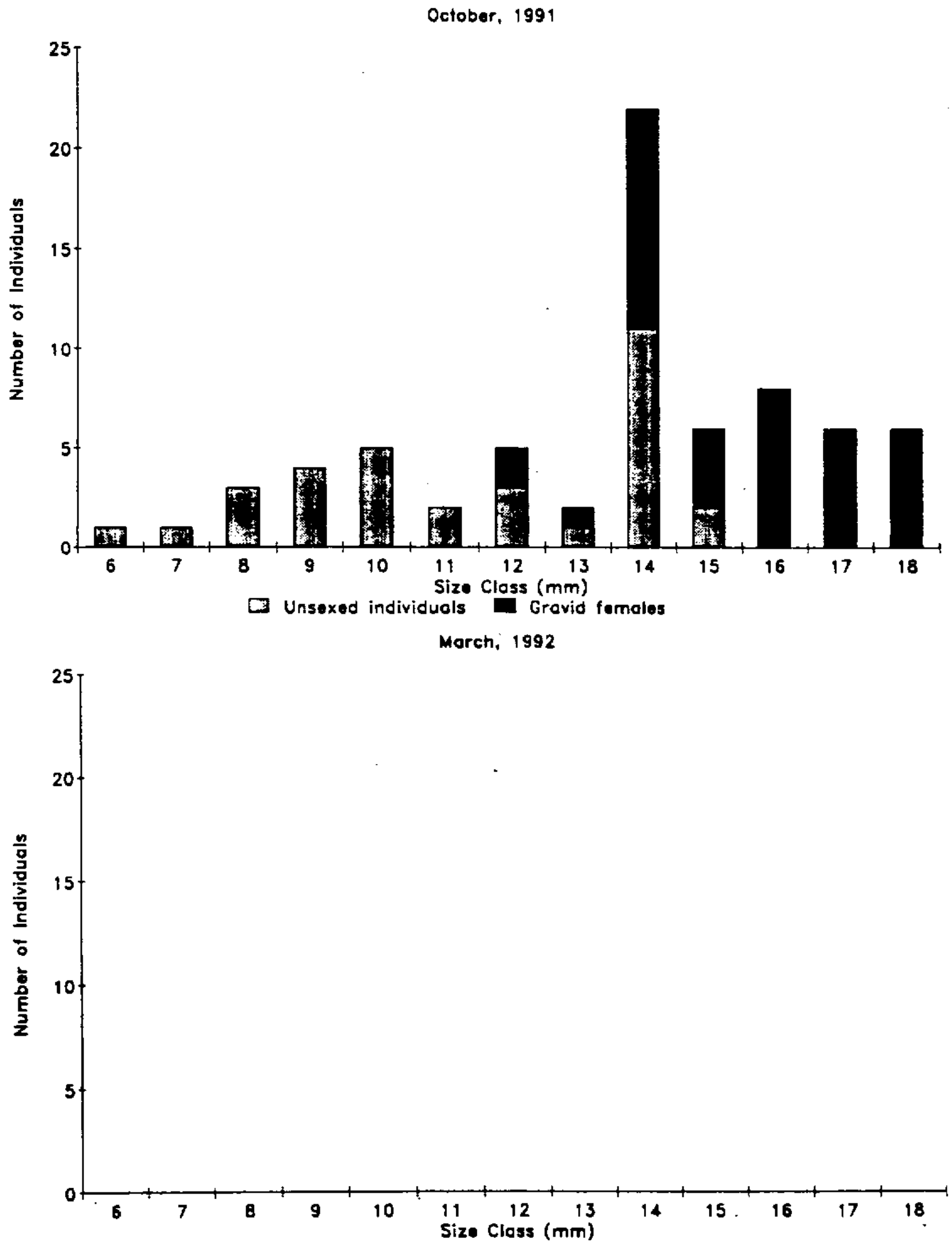


Figure 13. Size frequency of speckled sanddab from subtidal trawls at the nearshore station during October, 1991 and March, 1992 off Ocean Beach, San Francisco.

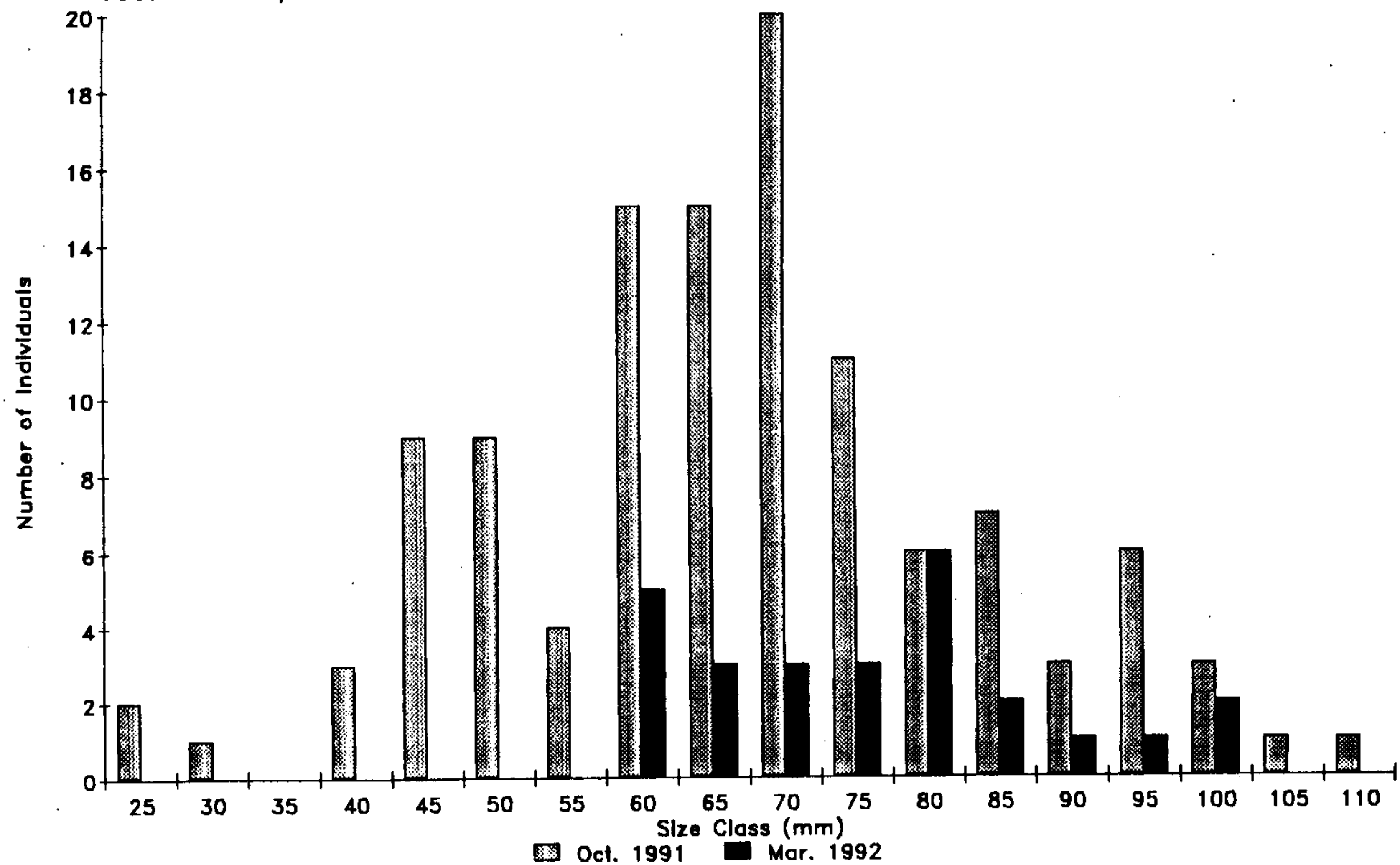


Figure 14. Size frequency of spotfin surfperch from subtidal trawls at the nearshore station during October, 1991 and March, 1992 off Ocean Beach, San Francisco.

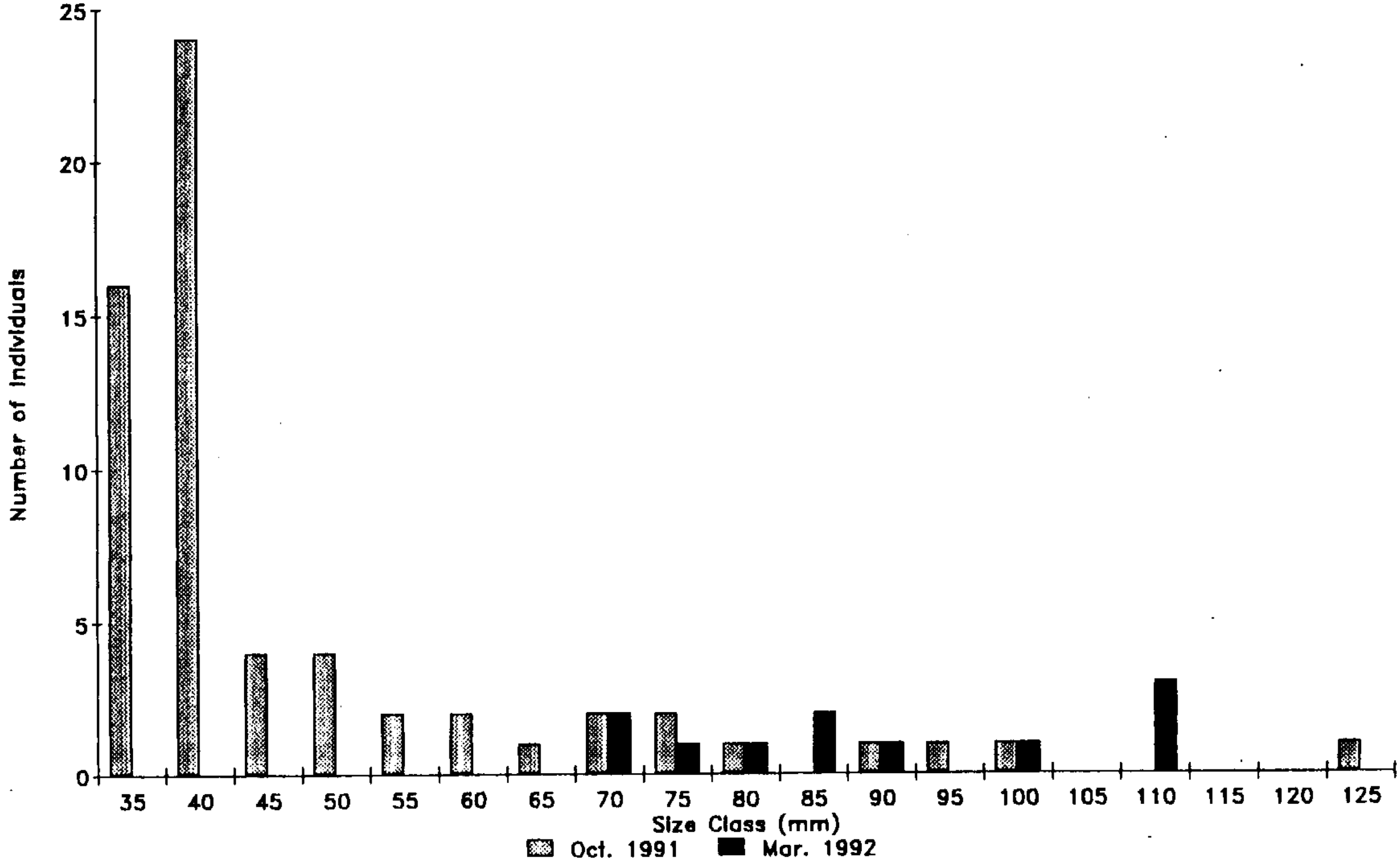


Figure 15. Size frequency of sand sole from subtidal trawls at the nearshore station during October, 1991 and March, 1992 off Ocean Beach, San Francisco.

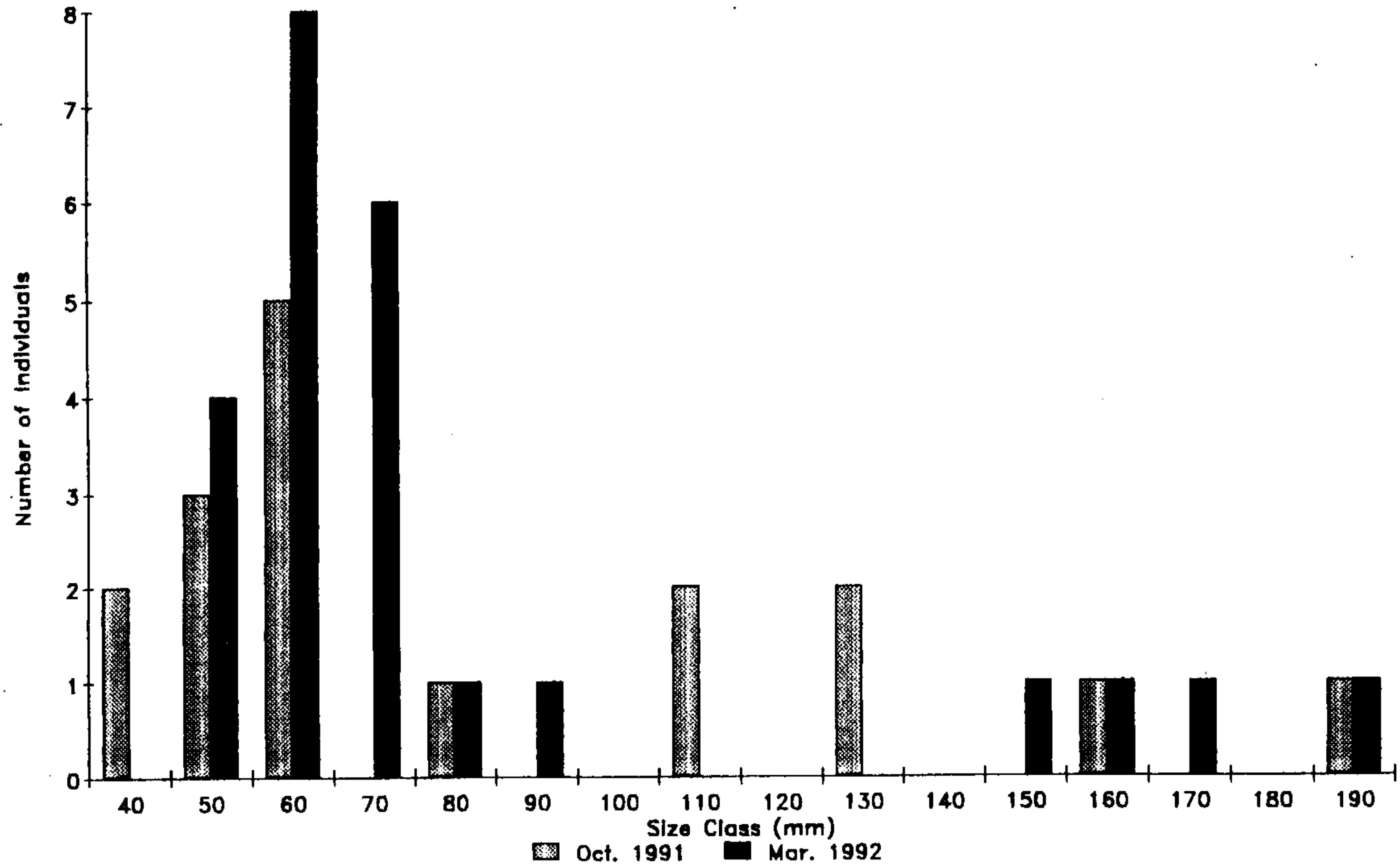


Figure 16. Seasonal abundance of selected fish from the subtidal trawls at the nearshore station during October, 1991 and March, 1992 off Ocean Beach, San Francisco.

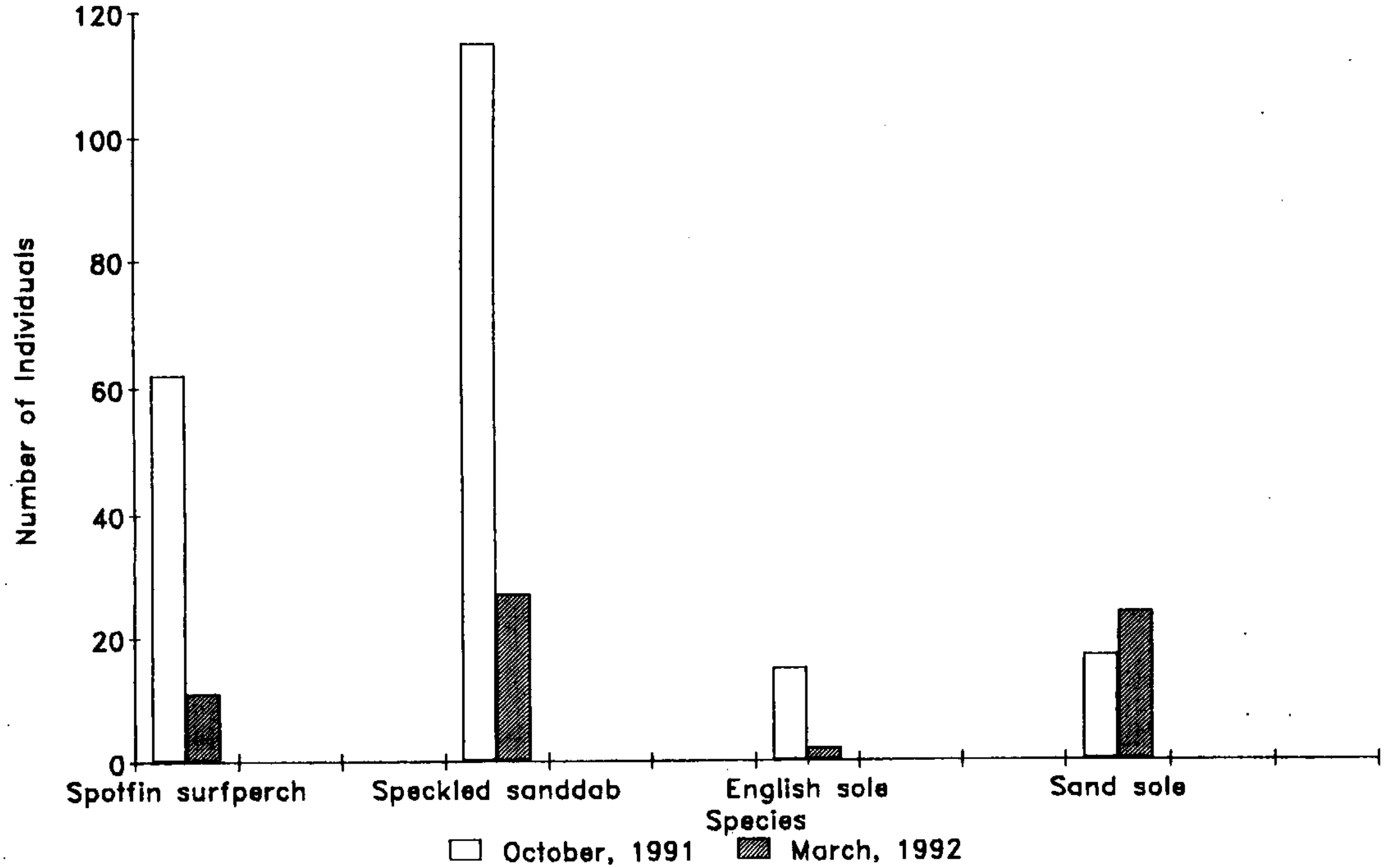
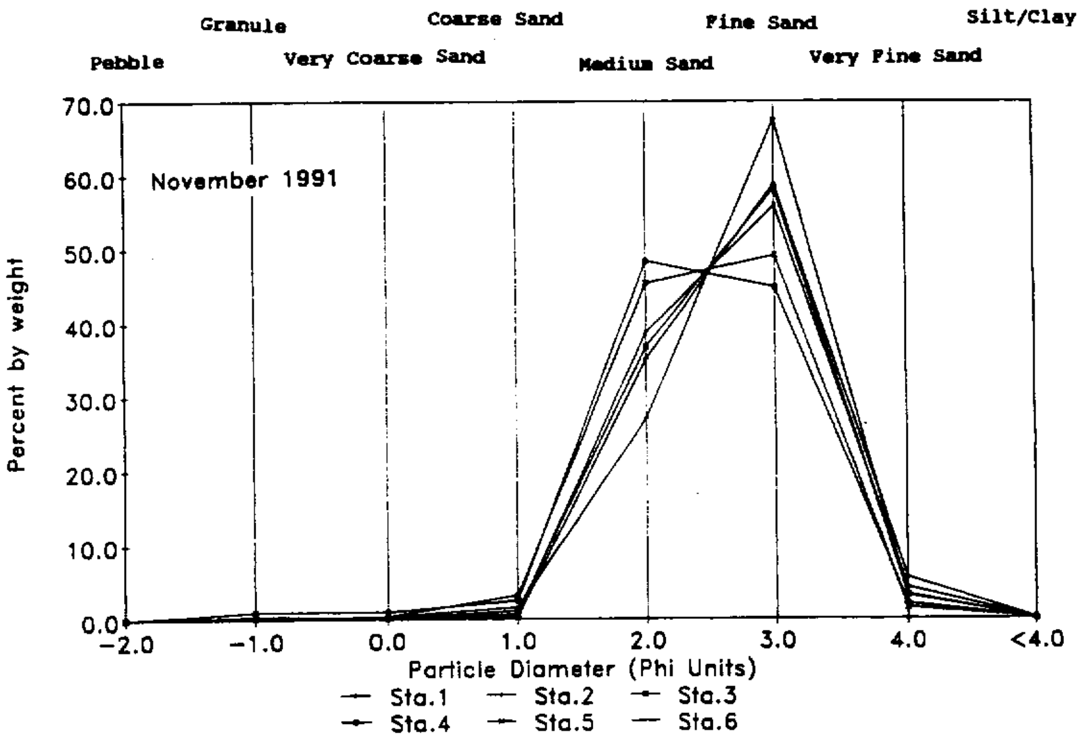


Figure 17. Sediment particle size distribution at the intertidal stations during November, 1991 and March, 1992 on Ocean Beach, San Francisco.



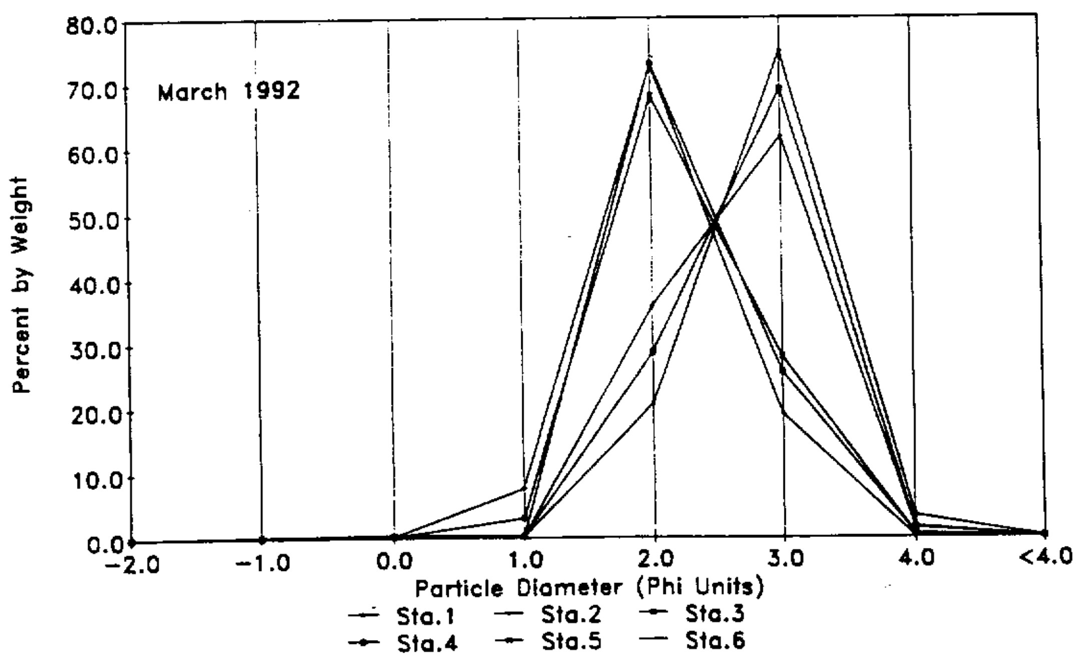


Figure 18. Sediment particle size distribution at the nearshore station during November, 1991 and March, 1992 off Ocean Beach, San Francisco.