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Relative Abundance and Size Composition of Red Sea Urchin, *Strongylocentrotus franciscanus*, Populations Along the Mendocino and Sonoma County Coasts, 1989

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ABSTRACT

Underwater surveys were conducted in the spring and summer of 1989, as part of a three year survey, to determine density and size composition of populations of the red sea urchin, *Strongylocentrotus franciscanus*, along the Mendocino and Sonoma County coasts at three different depth zones. The study was composed of two parts: i) a broad scale survey, consisting of 22 systematically chosen sites from Fort Ross to Mendocino and ii) a fine scale survey, consisting of seven sites in the vicinity of Fort Bragg. The fine scale sites were selected to represent different habitat types and levels of commercial exploitation. The sites included the Point Cabrillo Marine Reserve (PCMR) as a nonharvested control and the Caspar Closure Area, established in 1989 in an effort to assess the effects of closure upon recovery of previously harvested areas.

The mean density for all broad scale sites was 1.1 red urchins/m^2 (SD 2.4). The 15-ft. depth zone yielded only 0.5/m^2. No site in the broad scale survey had greater than 4.1 red urchins/m^2. Spring fine scale harvested sites yielded 1.5 red urchins/m^2 (SD 2.8) while the PCMR had 7.8/m^2 (SD 7.3). Summer fine scale harvested sites increased to 1.7 and the PCMR declined to 5.4/m^2. Abundance was variable; however, highest densities were generally found at the 35-ft. and 50-ft. depth zones.

Bimodality in red urchin size frequency distributions, indicative of canopy grouping (smaller urchins beneath the spines or tests of larger urchins), was apparent at PCMR, but not at harvested fine scale or broad scale sites. Broad scale sites had a similar percentage of juveniles as harvested fine scale summer and spring sites, at 7.3, 8.3 and 12.9%, respectively. Harvested sites continued to show a low level of recruitment during this second year of study.

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1 - Marine Resources Administrative Report No. 91-3
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INTRODUCTION

The commercial fishery for red sea urchins, _Strongylocentrotus franciscanus_, in northern California exhibited exponential growth prior to its recent decline. In 1985, 1.9 million pounds were landed; landings peaked at 30.4 million pounds in 1988, followed by a 12% reduction to the 26.8 million pounds landed in 1989 (Figure 1). The principal fishery area extended over 100 miles from the vicinity of Bodega Bay to north of Fort Bragg (Figure 2). This area, except for occasional stretches of sandy beach, is characterized by alternating small coves and headlands of exposed bedrock extending subtidally. Tidal areas are dominated by lush seasonal growths of large-bladed brown algae. The primary port for the fishery was Fort Bragg in Mendocino county, though the ports of Point Arena in southern Mendocino county and Bodega Bay in Sonoma county had become increasingly important.

Concern for the long-term viability of the red sea urchin fishery prompted legislation establishing a landing tax to fund investigations into the population characteristics of this important commercial echinoid. Previous sea urchin investigations along the west coast have suggested a latitudinal cline in recruitment success, with strong annual recruitment occurring in the lower latitudes (southern California and Baja California) and sporadic events in central California and British Columbia (Pearse and Hines 1987, Sloan, Lauridsen and Harbo 1987, Ebert 1983, Tegner and Dayton 1981). Recent work by Tegner and Barry (1989), Rowley (1989), and Roughgarden, Gaines, and Possingham (1988) suggests a mechanism related to current patterns and upwelling to explain the observed differential recruitment success between nearshore waters in the southern California bight and open coastal waters to the north.

Quantitative investigations of red urchin abundance on the north-coast of California prior to the California Department of Fish and Game (CDFG) 1988 surveys (Kalvass 1989, Kalvass, Taniguchi and Buttolph 1990) had been limited in scope. In 1972, the CDFG, as part of its Mendocino power plant site ecological study, extensively sampled 35 key macroinvertebrate species, including red sea urchins, at intertidal and subtidal stations in the Point Arena area. The red sea urchin was the most numerous of all invertebrates quantified (Gotshall et al. 1974).

The National Marine Fisheries Service (NMFS) has monitored the nearshore community at Albion, south of Fort Bragg, since 1981 (Hobson 1989). The NMFS study, though limited in geographic scope, is valuable in that it represents the only continuously-collected quantitative red urchin data from the Fort Bragg vicinity predating the recent rise of the commercial fishery and the last El Nino event of 1982-83. Intertidal and subtidal biotic assemblages associated with various habitats were qualitatively described in 1979 at Salt Point State Park in Sonoma county and Mendocino Headlands State Park in Mendocino county for the

California Department of Parks and Recreation (Seltenrich and DeMartini 1979). Red urchin densities were recorded along transect lines surveyed in September 1986 during a red abalone (Haliotis rufescens) abundance and size composition study conducted by the CDFG at sites off Sonoma and Mendocino counties. Red urchin densities varied by site, but high urchin abundance tended to occur at deeper depths than high abalone abundance (Parker, Haaker and Henderson 1988).

This report summarizes the second of three annual surveys designed to determine red sea urchin recruitment patterns by examining size distributions and adult-juvenile relationships, and to document relative abundance along the Mendocino and Sonoma county coasts. Comparisons with the first survey are made in this report. Following the publication of the third year survey summary in this format, a final report will compare and contrast results from each of the annual surveys.

METHODS

The study was patterned after the two-phase approach of Sloan, Lauridsen and Harbo (1987). The first phase is an annual 'broad scale' survey at systematically selected sites along the central portion of the fishery area in Mendocino and Sonoma counties. During the broad scale survey, Saunders Reef and the Salt Point urchin closure area were added as areas of special survey interest; the former area being one of the largest offshore reefs in northern California and a state-designated Area of Special Biological Significance (ASBS) (Figure 3). The second phase is a 'fine scale' survey conducted twice each year, once in spring and once in late summer. Fine scale survey sites are situated near Fort Bragg, within the Point Cabrillo Marine Reserve (PCMR), and the Caspar Point urchin closure area at the northern and more intensively harvested range of the fishery (Figure 3).

Broad Scale Survey

SCUBA divers from the CDFG and Humboldt State University (HSU) surveyed 30-meter long transects during the summer of 1989. Sea conditions were generally favorable during the entire survey, from July 31 to August 22. The DFG patrol vessels Albacore and Broadbill were utilized for surveys of all Sonoma county sites as well as most of the Mendocino county sites. Remaining sites were accessed by small boat.

One hundred transects were surveyed during the broad scale phase at 22 different sites from Fort Ross Reef, Sonoma county to Jack Peters Creek, Mendocino county (Table 1). Each site within the study area was systematically chosen at an interval of 2.7 nautical miles along the coast within four coastal zones (defined below). Sites were selected during the first survey year and an attempt was made during the second year to survey the original locations using loran and photographic landmark descriptions of the original sites. The study area was divided at Point Arena, the prominent geographical feature of the area, with each of the two resulting sections further subdivided at the Gualala River south of Point Arena, and at the Navarro River north of Point Arena (Figures 4-7). These zones were selected to represent distinct oceanographic and commercial red urchin harvest areas. There were no sites in the survey that were exempt from commercial urchin harvest.

Fine Scale Surveys

The summer fine scale survey consisted of 57 thirty-meter transects at seven sites. Sites were selected during the first survey year to represent a mix of headlands and coves with varying degrees of harvest pressure. Point Cabrillo Marine Reserve served as an unharvested control; the Caspar Point urchin closure area was selected to assess recovery in an undisturbed area. Caspar Point was closed to harvest in the spring of 1989. The fine scale survey design allowed flexibility in transect placement to compare and contrast habitats, as well as the option of using permanent transects in selected locations within sites (called subsites).

Two additional areas of special interest were included in the surveys. The Saunders Reef study area consisted of 10 transects at the shallow, intermediate and deep depth zones (defined below). Five transects were located in the Salt Point urchin closure area (300-ft. south of Gerstle Cove, a CDFG marine reserve similar to PCMR). The Salt Point closure area was closed to commercial urchin fishing in 1988 to serve a similar function as the Caspar closure zone.

The spring fine scale survey consisted of 38 transects at six sites. Due to poor diving conditions, a shift of some effort to an alternate square meter plot survey technique, and to the effort required to place three permanent subtidal transects in the Caspar closure area, fewer 30 m transects were run compared to the summer fine scale survey. The permanent transects at the Caspar closure area were marked by rebar stakes at 5 m intervals along a 30 m line at an approximate depth of 35-ft. Three permanent transects were placed in PCMR in 1988. Only two of the four permanent transects surveyed during the spring 1989 survey were resurveyed during the summer, because the others could not be relocated.

For both broad and fine scale survey sites, transect starting points were randomly selected within potential urchin habitat (essentially defined as predominantly boulder-bedrock and/or cobble). Transect lines, 30 m long x 1 m wide, were laid on a northerly compass bearing, generally along depth contours at 15, 35 and 50-feet (+/- 5-ft.). Each transect was partitioned into six 5 m long sectors. Each sector was surveyed, with the aid of a movable 1 m long pvc pipe segment, as two adjacent 0.5 m x 5 m quadrats.

Divers counted all exposed red urchins in each quadrat. Crevices and algal turf were searched for red urchins; but divers usually did not remove urchins from the substrate. Most of the divers working the 1988 surveys also worked the 1989 surveys. Urchins smaller than 5 mm were considered too small to be consistently visible to the divers and excluded from the survey. The test diameter of the first 30 red urchins encountered on the line was measured to the nearest 5mm. These urchins comprised the randomly encountered group used in analyses. Canopy-grouped red urchins within these first 30 were measured and categorized as sheltered or shelter-providing. Canopy groups were defined as red urchins exhibiting spine or test overlap, with one or more red urchins providing shelter for one or more smaller conspecific urchins (Sloan, Lauridsen and Harbo 1987). Red urchins of similar size merely aggregated or touching spines were not considered canopy groups. Following completion of the random measurement phase, each diver was directed to search for and document the first five canopy groups encountered along the remainder of the transect line.

In 1989, we sampled 1 m^2 plots near some of the regular transects and at the same depth zones in order to assess the accuracy of our transect sampling method in determining the number of juvenile cryptic urchins. A diving pair searched one or two plots for as long as 45 minutes, depending on urchin density and depth. Plots were chosen within areas of high urchin concentration on the assumption that juveniles would be in association with other urchins on generally flat substrate. All sea urchins within a plot were removed and examined on the oral surface for clinging juveniles, small rocks were removed from the substrate, and crevices searched. Plots were characterized by substrate type and by the presence of other organisms in the same manner as the regular 30 m transects.

One deep dive to 117-ft. was made off the westernmost reef in the PCMR. Five divers descended to the sandy bottom at the base of a nearly vertical rock wall. Divers ascended slowly up the wall to a depth of 25 to 40-ft. with each diver responsible for one meter of a five meter-wide band. Divers counted urchins and noted habitat and other characteristics along the band.

Additional information collected on the surveys included (i) percent of area covered by type of substrate (boulder-bedrock, cobble or sand), (ii) percent of area covered by type of algae (canopy, subcanopy, turf, or encrusting), (iii) number of red urchin competitors including exposed purple sea urchins, <u>S. purpuratus</u>, and exposed red abalones, and (iv) number of sea stars, including the sunflower star, <u>Pycnopodia</u> <u>helianthoides</u>, for which sea urchins and bivalves are preferred foods (Morris, Abbott and Haderlie 1980).

RESULTS

Broad Scale Survey

Size Composition

Mean test diameter for randomly sampled red urchins at all broad scale locations was 90 mm (SD 26 mm), with the smallest urchin in the 10-15 mm interval and the largest in the 155-160 mm interval (Figure 8). 1989 findings were very similar to 1988 for the same locations (mean diameter 92 mm, SD 30 mm).

By Coastal Zone

South of Point Arena, the mean test diameter (MTD) was 92 mm for Gualala South and 93 mm for the Gualala North zones (SD 23 and 30 mm). The Gualala North distribution appeared trimodal with modes at 20-25 mm, 75-80 mm and 105-110 mm. North of Point Arena, MTD was 90 mm and 82 mm for Navarro South and Navarro North, respectively (Figure 9). All distributions were negatively skewed, with Gualala North most notably so. As in 1988, the Navarro North zone had the lowest mean size (74 mm in 1988) and the lowest percentage of urchins over 90 mm (34%).

Size frequency distributions among coastal zones were significantly different (Table 2). The mean sizes were also significantly different between coastal zones (ANOVA, $p<0.05$). The Navarro North mean size was significantly smaller than each of the other zones ($p<0.008$) (Table 3).

By Depth Zone

The mean test diameter at the 15-ft. depth zone was 17 mm larger than at the 35 and 50-ft. depths (each at 86 mm, SD 26 mm). The distribution at the shallowest depth was distinctly negatively skewed with fewer smaller individuals (Figure 10). Frequency distributions among depths were significantly different between the 15-ft. and the other depth zones (Table 4). MTDs were significantly different between depths (ANOVA, $p<0.0000$). The 15-ft. depth had a significantly larger mean, ($p<0.0000$), as was the case in 1988 (Table 5). As in 1988, an approximate inverse relationship between depth zone and MTD was apparent for each coastal zone (Figure 11).

Recruitment

Juveniles were defined in this study as <= 50 mm test diameter (Sloan, Lauridsen and Harbo 1987) and one-year-olds as <= 30 mm. Pearse and Hines (1987) defined a one-year-old 1975 California cohort as between 20 and 40 mm, with a major mode between 26 and 30 mm. Tegner and Barry (1989) defined young-of-the-year urchins as <=35 mm on the basis of a growth study conducted at Pt Loma; however, they felt that growth was probably somewhat faster in southern California waters.

Juveniles totaled 7.3% by number, and one-year-olds, only 3.1% from all sites combined, compared to 13.1% and 3.3%, respectively in 1988. When partially corrected for harvesting by removing urchins greater than 90 mm from the analysis (Tegner and Dayton 1981), the values increased to 13.9% for all juveniles and 6.0% for one-year-olds, compared to 28.1% and 7.0%, respectively in 1988 (Table 6). However, the percentage of juveniles at Gualala North increased to 21.6% and one-year-olds to 15.0%.

Analysis by depth zone indicated a higher percentage of one-year-olds at the 35-ft. and 50-ft. depths than at the 15-ft. depth. In the previous year the 15-ft. depth yielded the greatest percentage. Juvenile red urchins and individuals in the 0-90mm class were also much more abundant in the deeper depth zones (Table 6).

The coefficient of variation (CV=SD/Mean x 100%) was calculated for red urchins at each site as an index of recruitment (Ebert and Russell 1988). Larger CVs indicate a distribution with a wide range of sizes relative to the mean and so could be an indication of more frequent recruitment. A mean CV was calculated for combined sites and the deviation of each site from the mean was plotted. The sites showing the greatest positive deviation from the mean, suggestive of better recruitment, are in the Gualala North zone which is bordered on the north by Point Arena. Five of the eight sites north of Point Arena show some degree of positive deviation (Figure 12).

<u>Canopy Grouping</u>

Removal of the canopy influence by deleting canopy-grouped red urchins from combined-site size distribution data changed the mean (from 90 mm to 92 mm) and the shape of the distribution only slightly. The size frequency of canopy-grouped red urchins displayed a characteristic multimodality with a mean of 63 mm (Figure 13). The mean size of canopy-providers was 95 mm compared to 30 mm for sheltered conspecifics. Survey-wide, canopy-providers and sheltered conspecifics were present in a ratio of 1.01 to 1.00 (not all sheltered red urchins are <= 50 mm) (Figure 14).

Of all randomly encountered juveniles, 45.6% were under canopy. Juveniles comprised 3.3% of all measured urchins, but canopied juveniles made up 6.3% of the total in the Gualala North and Navarro North zones (Table 7). In 1988 fewer juveniles were found under canopy (32.8%), however, they comprised a higher percentage of all urchins measured (4.3%). Depth distribution of canopied juveniles paralleled the distribution of all juveniles in that the shallowest depth zone had the lowest proportion. Gualala South and Gualala North had the lowest and highest proportions of canopied juveniles, respectively (Table 8).

Density

The mean density of red urchins for all sites combined was $1.1/m^2$ (SD 2.4). In 1988, there were 1.3 red urchins per square meter (SD 2.0). The 1988 and 1989 densities were significantly different different (ANOVA $p<0.0000$), except for the 15-ft. depth zone which had only 0.5 urchins per square meter in both years.

Red urchin densities were also significantly different between depths (ANOVA $p<0.0000$). As in 1988, the 15 ft. depth zone density was significantly different from densities in each of the deeper depths (Table 9).

Densities among all sites were also significantly different ($p<0.0000$), with site densities ranging from a low of 0.0 red urchins/m^2 at the Irish Gulch site to a high of 4.1 at the Albion Point site. Interestingly, the Albion Point site is in the vicinity of the oldest and smallest fishery on the north coast. The difference was greatest between relatively high density sites 4 and 20, and low density (<0.50 red urchins/m^2) sites 7, 9, 12, 15, 18 and 22 ($p<0.0005$) (Table 10, Figures 4-7).

The general trend was for increasing density with depth in the sites south of Point Arena in 1989 as well as in 1988. At sites north of Point Arena, the Navarro North zone 35-ft. depth yielded the highest mean density (Figure 15). Over 50% of the 600 1 x 5 m quadrats examined in all areas contained no red urchins (Figure 16). The distribution of red urchin counts is a classic negative binomial, a feature which is characteristic of contagiously distributed populations.

Habitat

Boulder-bedrock was the dominant substrate in all coastal zones (over 80% of transect surface area) regardless of depth. As in 1988, algae was most abundant at the 15-ft. depth zone. However, algal distributions were more uniform by depth and coastal zone than in 1988. Subcanopy (between approximately 0.3 m and 1.0 m off the bottom) algal estimates were generally below those of 1988.

Red urchin densities were higher than sunflower star, red abalone, and purple urchin densities in all coastal zones, with Navarro North yielding over twice as many as the next highest zone (Figure 17). Red abalone and red sea urchin mean transect counts at the 15-ft. depth zone were relatively close at 18.6 and 16.2, respectively.

Van Damme Headland (site 21) at 35-ft. had the highest count of red urchin (285) as well as the highest count of purple urchin (208). Rocky Pt (site 5) at 15-ft. had the highest red abalone count (102), while Elk Rock (site 17) at 15-ft. had the highest *Pycnopodia* count (15) (Table 11).

Fine Scale Surveys

The second annual fine scale surveys yielded size frequency and density data from 57 transects at seven sites between Laguna Pt and Van Damme Bay in the Fort Bragg area during the summer survey, and 38 transects at six sites in the same area during the spring survey (Figure 18). South Caspar Pt and Point Cabrillo Marine Reserve were intensively surveyed to assess red urchins in a variety of subhabitats including northern and southern wave and swell exposure, surge channel, protected reef pool, and depths greater than our three regular depth zones (Figures 19 and 20). Most of the sites surveyed in summer were also surveyed during the spring 1989 survey, including two permanent transects. Reference to harvested sites in both spring and summer surveys includes the Caspar closure area unless noted otherwise.

Size Composition

The mean test diameter of red urchins sampled in the 1989 summer survey at Point Cabrillo Marine Reserve and combined harvested sites was 94 mm (SD 28 mm) and 86 mm (SD 24 mm), respectively (Figure 21). The spring 1989 survey at PCMR and combined harvested sites revealed MTDs of 86 mm (SD 31) and 81 mm (SD 25), respectively (Figure 22). The smaller 25-30 mm mode evident in the summer 1988 PCMR data was not apparent in the summer 1989 data; however, it appears that this mode may represent a growing cohort evident as a 40-45 mm mode by summer 1989. Size structures from harvested areas were very similar between summer surveys in 1988 and 1989 (1988 data not shown).

Depth stratification was evident in the combined harvested sites, with a 13-15 mm mean size difference between urchins from the 15 and 50-ft. depths in both the spring and summer surveys (Tables 12 and 13). The 50-ft. depth zone yielded smaller urchins on the average.

Recruitment

Juveniles (<= 50 mm test diameter) and one-year-olds (<=30 mm) totaled 9.4% and 3.4%, respectively of all red urchins randomly sampled in the summer survey. These values are lower than the spring values of 14.8% and 5.6%, respectively. PCMR subsites had higher juvenile densities than did harvested sites in summer (11.4% versus 8.3%) and spring (17.1% versus 12.9%) surveys in 1989. The decrease in percent composition of juveniles between the spring and summer survey continues a declining trend began in spring 1988.

Conclusions regarding stratification of recruitment by depth zone are difficult to make due to limited data; but both spring and summer surveys showed fewest juveniles at the 15-ft. depth zone for harvested sites, though the picture was not as clear for PCMR data (Tables 12 and 13).

The mean size for all urchins encountered in the meter square plots during the spring survey was 75 mm (SD 34 mm, N=469). A total of 27.1% of red urchins was less than or equal to 50 mm test diameter and 14.1% were less than or equal to 30 mm. All but one of the 10 plots were in the PCMR. Nine plots were examined during the summer survey in PCMR and the Caspar closed area. The mean size was 91 mm (SD 30 mm, N=251), with 12.0% juveniles and 8.0% one-year-olds.

Canopy Grouping

Canopy-grouped red urchins within reserve and harvested sites had mean sizes of 68 mm (SD 38 mm) and 64 mm (SD 33 mm), respectively, during the summer survey. The size frequency distribution within the reserve was bimodal with modes at 30-35 mm and 95-100 mm. Harvested sites also showed bimodality for canopy-grouped red urchins with modes at 25-30 mm and 85-90 mm (Figure 23). Spring survey PCMR canopy group mean size was also 68 mm (SD 39 mm); however, modes were spread further at 21-25 mm and 106-110 mm.

Juveniles accounted for 8.3% of all measured individuals at harvested sites in the summer survey, compared to 7.3% in the broad scale survey during the same time period and 12.9% in spring. Of the juveniles at harvest sites in the summer survey, 66.2% were under canopy, compared to 45.6% in the broad scale survey and 32.8% in spring. These harvested-site canopied juveniles made up 5.5% of all randomly measured urchins in the summer survey and 4.2% in the spring (Table 14 and 15).

The square meter plots, most of which were run in PCMR, revealed that 30.5% of red urchins in the spring survey were in canopy groups, and 27.1% of all urchins were juveniles. Further, 53.5% of the juveniles were canopied juveniles. The percentage of juveniles was higher in the square meter plots than along transects, 27.1% versus 17.1% in the PCMR for the same survey period. The higher value for plots was attributed to selecting substrates with high urchin concentrations. The 53.5% for canopied juveniles in plots compares to 50.0% found during the regular spring transect survey in the PCMR.

Density

In the summer survey, the harvested sites yielded 1.7 (SD 3.0) red urchins per square meter while the PCMR site had 5.4/m^2 (SD 5.8) (Table 16). Harvested-site mean densities ranged from 0.4 urchins/m^2 at Hare Creek to 2.8 at North Caspar. Subsites within the Caspar closure area ranged from a high of 3.7 urchins/m^2 at subsite 302 to a low of 0.6 at subsite 306 (Figure 19). Subsites within the reserve ranged from 6.9 urchins/m^2 at north cove to a low of 4.3 at subsite 202. The spring fine scale survey yielded 1.5 urchins/m^2 at the combined harvested sites and 7.8 at PCMR. Two sites, and several subsites within both PCMR and the Caspar closure area, surveyed in the summer were not sampled in spring due to severe ocean conditions (Table 17).

Mean density in the 1989 summer survey was typically highest at the 35-ft. depth zone in both reserve and harvested sites. The 35 and 50-ft. depth zones in the reserve had the highest densities of urchins at 7.6 and 6.6/m^2, while the 15-ft. zone yielded only 2.9/m^2 (Figure 24). For the summer fine scale surveys, red urchin densities were significantly different by depth for 1 x 5 m quadrats within the PCMR ($p<0.0000$), and within combined harvested sites ($p<0.0000$) (Tables 18 and 19). Interestingly, red urchin densities were not significantly different by depth for these areas on spring surveys ($p>0.01$) (Tables 20 and 21).

Urchin densities were significantly different between sites sampled during the summer survey ($p<0.0000$). However, none of the harvested sites were significantly different from each other (alpha=0.05) (Table 22). The proportion of 1 x 5 m quadrats within the reserve with zero red urchin counts was 21.6%, while this percentage was 43.3 for combined harvested sites (Figure 25). For the spring fine scale survey, only 8.6% of the PCMR quadrats were empty of urchins compared to 48.7% for combined harvested sites (Figure 26).

Habitat

Boulder-bedrock substrate dominated all transects (>= 50%) at all sites except the 15-ft. depth zone at the Mitchell Pt site during the summer fine scale survey. The highest densities of purple urchins were found at the PCMR and South Caspar, where the densities of red urchins and sunflower stars were also the highest. High densities of red abalone were encountered at sites of high as well as low urchin density. Though the usual trend for red abalone abundance is inversely related to depth, at PCMR the 50ft depth zone provided the highest abalone densities during both spring and summer surveys in 1989. There did not appear to be a trend between red urchin abundance and algae type, except that in both 1989 surveys turf-type algae (algae < 0.3 m high, excluding encrusting types) was less abundant in PCMR compared to most of the other sites (Tables 23 and 24).

Field notes from the summer survey shed some interesting light on the urchin-kelp dynamic. Within the Caspar urchin closure zone, an area with reportedly high red urchin densities in the early phases of the fishery (M. Evanoff, urchin diver, pers. comm.), crustose coralline algal veneers were highly textured and overgrowing one another on rock faces in areas which had apparently been previously occupied by red urchins. Tops of rocks had turfs of Calliarthron tuberculosum and Botryoglossum farlowianum, with a new short canopy of Laminaria dentigera, Costaria costata, and Desmarestia ligulata developing. The texturing, thickening and over-growing of crustose corallines was attributed to the lack of heavy grazing by urchins.

Contrasted with the Caspar area was the benthic picture at PCMR. In the Reef Pool site at PCMR (subsite 204), purple urchins and the sea anemone Cornyactis californicus were prolific on the vertical sides of reefs. The bottom to depths of 25-ft. was dominated by red and purple urchin, with many recently recruited purple urchin under the spine canopy of congeners. The tops of reefs resembled algal assemblages present at many of the Caspar subsites, though algal turfs were not as thick and well developed.

Saunders Reef/ Salt Point

Transects at Saunders Reef, between sites 11 and 12, were surveyed at two depth zones, 35 and 50-ft., though two of the 35-ft. zone transects were actually as shallow as 25-ft. Mean densities were 2.4 urchins/m^2 (SD 3.1) and 2.0 (SD 3.2), respectively. MTDs were 91 mm and 79 mm at the two depths. Saunders Reef, as a state-designated Area of Special Biological Significance (ASBS), consists of uplifted blocks of sand and mudstone bedrock forming alternating ridges and valleys. Many red urchins were found grouped in depressions under rocky outcroppings with quite a few purple urchins found under the tests of reds. The number and variety of sponges was evidence of the high degree of water movement associated with this habitat. Sponges included the locally common orange finger sponge (Isodictyia quatsinoensis).

The Salt Point urchin closure area encompasses Gerstle Cove Marine Reserve. Our station was about 300-ft. south of the cove. At 50-ft., the substrate was characterized by emergent bedrock, large (10-15-ft. diameter) to small boulders and a relatively high volume of sand and sediment. S. franciscanus was relatively dense (2.7/m^2 along the transect), but only the shell of a flat abalone (H. walallensis) was seen. The lack of canopy kelp indicates that urchins are primary grazers here and abalone may be scarce because of the lack of drift algae. The shallower transects yielded red abalone, but canopy forming kelp remained scarce, covering only 5-10% of the area.

DISCUSSION

Size Composition

Mean test diameter for all broad scale sites in the summer of 1989 was 90 mm (SD 26 mm) compared to 92 mm (SD 30 mm) in 1988. For all spring 1989 fine scale harvested sites it was 81 mm (SD 25 mm) compared to 86 mm in spring 1988. For the 1989 summer fine scale harvested sites MTD was 86 mm (SD 24 mm) compared to 85 mm (SD 31 mm) in summer 1988. Mean sizes at British Columbia broad scale sites ranged from 84 to 125 mm (Sloan, Lauridsen and Harbo 1987). The significantly higher mean size (103 mm) at the broad scale survey 15-ft. depth zone compared to other depths, and the significantly lower mean size (82 mm) at the Navarro North sites compared to the other coastal zones may be an artifact of commercial harvest patterns with a preference for deeper depths and a more intensive harvesting history in the Navarro North zone. A similar size stratification pattern was noted in 1988.

The 1989 fine scale studies revealed a size stratification by depth similar to the broad scale survey with largest mean test diameter at the 15-ft. depth for harvested sites. This is consistent with the documented concentration of fishery harvest effort at depths greater than 15-ft. (CDFG unpub. report, 1990). The Point Cabrillo subsites within either fine scale survey did not show this depth stratification. The shape of the Point Cabrillo size frequency distributions in 1988 were almost identical for the spring and summer surveys, exhibiting some degree of bimodality with a mean size of 87 mm (SD 32 and 31 mm, respectively). Bimodality was not as apparent in the 1989 surveys, however the 25-30 mm interval mode evident in summer 1988 appears as a 40-45 mm mode one year later, a 15 mm increase, possibly representing one year of growth for that cohort. The summer fine scale harvested sites size distribution is more leptokurtic than in the spring survey, and while the standard deviations are similar, means vary by 5 mm. As has been the pattern since the surveys began in 1988, the harvested areas are characterized by relatively fewer urchins in the upper and lower size categories compared to the PCMR. The upper end deficit is explainable by commercial harvesting targetted on urchins generally larger than 90 mm.

A northern California 3.5 inch (89 mm) minimum test diameter size limit went into effect in June 1990 for commercially harvested red urchins. Based upon the summer 1989 surveys, about 53% of the resource in the broad scale survey areas and about 59% in the fine scale (excluding the PCMR) was under the minimum size limit. In the 1988 broad scale survey a greater percentage of urchins were above the current legal minimum and urchin density was significantly higher (ANOVA, $p<0.0000$). The mean size of canopy providers in the broad scale survey was 95 mm (SD 22 mm), compared to an average size of 107 mm (SD 16 mm) for sampled commercially harvested red urchins in northern California in 1989 (Figure 27). The commercial fishery is removing many of the urchins from the population that currently provide canopy, with potentially negative effects upon future recruitment.

Recruitment

Juvenile red urchins in the broad scale survey constituted only 7.3% of all red urchins sampled, compared to 9.1% in the summer fine scale survey (8.3% in harvested sites) and 14.8% for the spring 1989 fine scale survey (12.9% in harvested sites). These values represent a decline from the 1988 surveys (Kalvass, Taniguchi and Buttolph 1990). Average recruitment rate at Point Loma during a three-year period for red urchins < 60 mm was 47.4% (Tegner and Dayton 1981). Since these percentages represent several age classes, the annual rate of recruitment during these years would be considerably lower.

Tegner and Barry (1989) surveyed the nearshore at San Clemente Island in 1979, taking 100 square-meter samples in an urchin barren area and an adjacent kelp forest. In the barren area with no attached macroalgae other than corallines, 7% of the animals were less than or equal to 35 mm compared to 39% in the adjacent kelp forest. At Santa Barbara Island between 1976 and 1981, the lowest proportion of recruits observed was 33%, in a clearly bimodal size distribution. Mean recruitment rates for urchins <= 50 mm in British Columbia studies ranged from 5.5 to 16.0% (Sloan, Lauridsen and Harbo 1987, Breen, Miller and Adkins 1976, Bernard and Miller 1973). Recruitment rates (based upon urchins < 50 mm) for two commercially harvested districts in Washington were 10.7% and 6.6%, respectively, in 1988 (Bradbury 1988). Based upon a 1990 survey by the Alaska Department of Fish and Game in Sitka Sound, the proportion of red urchins in the population under 50 mm was 10.8%. The annual recruitment for 1990 was estimated as 3.2% (Woodby 1991). Northern California recruitment levels appear to fall within the ranges described for Washington, British Columbia and Alaska.

Tegner and Barry (1989) developed a growth curve from a study on red urchins in the Point Loma kelp forest near San Diego. That curve, in contrast to one developed by Bernard and Miller (1973), exhibits a steeper slope initially and becomes asymptotic sooner. Visually combining both analyses produced an estimate of 3.5 to 4.0 years to reach 90 mm and recruitment to the northern California fishery.

Ebert (unpublished data, 1989) using tetracycline to tag individuals from PCMR compared individual jaw lengths from urchins tagged in situ and collected one year later (n=30, none under 80 mm TD). Jaw length was correlated to test diameter and used to develop a growth curve. Though the data set was limited, it showed that these large urchins were growing very slowly. For example, data suggested that a 99 mm animal could require 20 years to grow to 113 mm.

Tegner and Barry (1989) have shown that bimodality in red urchin populations appears to decrease with distance to the north and west within the Channel Islands as recruitment decreases and survival of mid-sized animals increases. In this respect the northwest Channel Islands might represent the southern edge of a more or less uniform recruitment pattern observed at a number of different locations from Alaska through south-central California. The more northerly Santa Rosa Island showed a pattern different from San Clemente Island to the south, with slow but steady recruitment and higher survival of mid-sized animals due to lack of predators such as spiny lobsters (Panulirus interruptus) and the California sheephead (Semicossyphus pulcher), resulting in a size structure exhibiting only transient bimodality from episodic recruitment pulses, as evidenced in their 1984 data (Tegner and Barry 1989). This is the type of size structure that may best characterize northcoast red urchin populations. Large scale seasonal oceanic transport seems to be the mechanism underlying these observed recruitment patterns (Tegner and Barry 1989).

Red urchin larval production on the northcoast, based upon gonadal index data from commercial landing samples, is greatest from February to June (CDFG, unpub. report, 1990). Settlement occurs 6-8 weeks later in the spring and late summer (Kato and Schroeter 1985). Larval production occurs during the upwelling season on the northcoast (Hobson and Chess 1988) and upwelling indices correlate positively with offshore transport of surface water (Bakun and Parrish 1980). This season is also the time of greatest phytoplankton productivity and it has been shown experimentally that spawning of green sea urchins (S. droebachiensis) may be triggered by metabolites released by phytoplankton (Starr, Himmelman and Therriault 1990). Thus, when phytoplankton densities are high, providing energy for larval growth, offshore transport of urchin larvae is also most likely. Conversely, when upwelling indices are low in late summer, phytoplankton blooms are less common.

Roughgarden, Gains and Possingham (1988) found that recruitment rates for Balanus glandula were highly negatively correlated (r=-0.96) with the upwelling index average for each of five study years. During the height of El Nino in 1983, Balanus recruitment was greatest at the study site in central California. Like urchin larvae, barnacle cypris larvae spend a number of weeks in the water column. Under this scenario, we should probably have experienced a relatively high rate of settlement and subsequent urchin recruitment in 1983. Had this been the case, then many of these urchins should have recruited to the fishery at 3.5 to 4 years of age by 1987, the year prior to the beginning of our subtidal surveys in 1988.

Canopy Grouping

There was no evidence of a bimodal size frequency distribution in the broad scale surveys, only 7.3% of red urchins were <= 50mm. Bimodality, at least in southern California, is associated with a significant amount of canopy grouping. As juveniles move out from under the spine canopy of shelter providers they become vulnerable to predation, particularly in southern California where predators are more numerous (Tegner and Barry 1989). A high percentage (46%) of juvenile red urchins in the broad scale survey were under canopy, despite the fact that bimodality was not evident. The lack of bimodality may be attributed to the low density of juveniles (3.3% of all measured urchins). Post-settlement predation does occur by the sunflower star (Pycnopodia helianthoides), wolf eel (Anarrhichthys ocellatus), cabezon (Scorpaenichthys marmoratus), senorita (Oxyjulis californica), crabs and other organisms in northern California, making some form of cryptic behavior advantageous to survival for juveniles.

Breen, Carolsfeld and Yamanaka (1985) studied juvenile red urchin social behavior in coastal British Columbia as well as in the laboratory. They concluded that juvenile red urchins are found under canopies as a result of preferential juvenile behavior, presumably to avoid predation and to benefit from the superior food capturing abilities of the adults.

While many of the urchins we encountered during the broad scale survey were aggregated, 93% were in non-canopy forming groups, due perhaps to the lack of juveniles in the populations. Canopy-providers ranged from 40-140 mm, with a mean of 95 mm, while the MTD of sheltered urchins was 30 mm. Most canopies consisted of a canopy-provider for each sheltered conspecific. When several of each occurred they were characterized as a cluster canopy. Interestingly, 49% of the canopy-providers were under 90 mm. In the harvested sites, a much higher percentage of canopy-providers were under the current minimum size limit, compared to the PCMR (79% in harvested sites vs. 65% in PCMR). The meter square survey plots showed the same trends noted in the regular surveys. Tegner and Barry (1989) found that most sheltered juveniles (95%) occurred under larger urchins (>80 mm). Therefore selective removal of larger urchins may influence juvenile behavior and survival.

Density

Overall mean density was only 1.1 (SD 2.4) red urchins/m^2 in the broad scale survey, with no individual site having greater than 4.1/m^2. This represents a small but statistically significant decline from 1988. These compare to average densities at northwest harbor Santa Catalina Island from 1977 to 1980 of 7.1 red urchins/m^2, and 6.5/m^2 from 1976 to 1982 at Johnsons Lee Santa Rosa Island (Tegner and Barry 1989). The density of first and second year red urchins at these island sites was 3.3 and 1.9, respectively. These densities are significantly higher than those obtained in any coastal zone in the broad scale survey (< 0.15 red urchins for either the 0-30 mm or 31-50 mm size classes (Figure 28). A comparison of these size groups between harvested sites and the non-harvested PCMR site for the summer fine scale survey showed less than 0.2/m^2 in each category (Figure 29). A shallow reef midway between the Straits of Juan de Fuca and the San Juan Islands which had never been legally fished was surveyed by WDF in 1990 and recorded a density of 1.9 red urchins/m^2 (Bradbury, Wash. Dept. Fish., pers. comm.). This suggests that red sea urchin density is influenced by both its distribution within its geographic range and harvest pressure.

Almost 15 million pounds of red urchins have been harvested through 1989 in the vicinity of Point Arena since that fishery began in 1987. Much of this total came from the approximately one square-mile area of Saunders Reef. This area was surveyed by CDFG divers in September 1986 as part of a larger northcoast abalone survey. Six 30 m x 2 m transects yielded an average of 7.7 red urchins/m^2. Our more intensive surveys in 1989 at similar depths yielded 2.4 and 2.0 urchins/m^2 at 35-ft. and 50-ft., respectively.

The fishery implications of reduced urchin densities are multifaceted. The most obvious and direct implication is that lowered adult densities correlate with lower catch rates. They also mean fewer refuges for young-of-the-year urchin, a factor in reducing mortality. Lowered adult densities could have serious impact on the success rate of fertilization. Pennington (1985) in both laboratory and field experiments with the green sea urchin found that egg fertilization success rates at distances greater than 20cm from spawning males were less than 15% compared to 60-95% within 20 cm. The naturally ocurring social groups of adult and juvenile urchins are therefore important for a variety of reasons, but may also make urchins more vulnerable to recruitment overfishing. Many of the remaining urchins may have little chance for successful reproduction unless they form new aggregations.

Habitat

There are approximately 85 miles of shoreline between Bodega Bay and Fort Bragg. Over 90% of the northcoast urchin harvest has originated in this region since the fishery began (CDFG, unpub. report, 1990). This region contained about 5.4 square miles of bull kelp resource at maximum biomass in late summer of 1989 (Van Wagenen 1990). The Channel Islands have about 170 shoreline miles with about 9.8 sq. miles of macrocystis beds, while the mainland shore between Point Arguello and Mexico is about 265 miles long with approximately 7.7 sq. miles of kelp (mostly macrocystis) beds. The northern California region, with only 16% of the total commercial urchin producing coastline and 24% of the canopy forming kelp resource, has yielded more urchins than the southern area in each of the last three years. This unsustainable harvest rate coupled with significantly lower settlement rates compared to the southern region suggests that harvest levels will drop significantly in the years to come.

Large scale red urchin removal in southern California may have contributed to a significant increase in purple urchins in what had traditionally been red urchin-dominated areas (K. Wilson, CDFG, pers. comm.). The purple urchin has very little commercial value at this time due to its smaller size and inconsistent gonad quality, yet is apparently just as tenacious a competitor and grazer as the red urchin. Rowley (1989) found similar settlement densities of purple urchins in kelp beds and barrens near Santa Barbara and postulates reduced post-settlement mortality of newly settled urchins in barrens to explain the difference in post-settlement densities between the two types of habitat. In our study, purple urchins were found in higher concentrations in the Navarro North coastal zone, particularly at Van Damme Headland, than in the other three zones in the broad scale survey. Interestingly, at the non-harvested PCMR site relatively high concentrations of purple and red urchins as well as red abalone are found regardless of depth.

Foliose brown algae commonly occurred in the algal zone, the shallow water habitat that historically had been found down to 25-ft. or so (Seltenrich and DeMartini 1979), and included Desmarestia ligulata, Egregia menziesii, Laminaria dentigera, Costaria costata, Pterygophora californica, Alaria marginata, and Nereocystis luetkeana. Algae commonly occurring below this zone included the coralline rhodophytans Calliarthron tuberculosum and Lithothamnium sp.. The boundary of the algal zone, prior to the establishment of the urchin fishery, was approximately demarcated by the red urchin, aggregations of which often created large urchin barren grounds. PCMR had among the lowest amounts of canopy, subcanopy and turf type algaes of any site in the 1989 fine scale surveys, apparently directly attributable to its high densities of benthic algivores. Urchin grazing has been shown to be a major factor in determining the community structure in subtidal communities, partly because of the urchin's remarkable ability to detect and locate favorable forage (Himmelman and Nedelec 1990). Disease-induced mass mortalities of the green urchin on the Nova Scotian coast in the early 1990s enabled seaweeds to rapidly colonize areas formerly denuded by urchins and subsequently released from grazing pressure (Scheibling and Raymond 1990).

Boulder-bedrock substrate predominated within the survey areas, usually with pockets of cobble and sand as in 1988.
The subtidal geology of the Mendocino and Sonoma county nearshore areas consists of irregular uplifted sand and mudstone bedrock. In the Mendocino region north of Point Arena, this is principally graywacke. In the Point Arena area there is a granitic basement layer under the sedimentary rock (G. Grantham, College of the Redwoods, pers. comm.). On the Sonoma coast in the vicinity of Salt Point State Park the area is characterized by differential slumping of coastal marine terraces creating a highly variable coastline with bedrock and angular slump blocks and boulders of varying sizes (Seltenrich and DeMartini 1979).

SUMMARY

1. A total of 157 transects, covering 4710 square meters, was completed during the summer 1989 fine scale and broad scale surveys. An additional 38 transects, covering 1140 square meters, were surveyed during the spring 1989 fine scale survey.

2. Red urchin mean density for all broad scale sites was $1.1/m^2$ (SD 2.4). Summer fine scale survey density for all harvested sites was only $1.7/m^2$ (SD 3.0) compared to the Point Cabrillo Marine Reserve (PCMR) red urchin density of $5.4/m^2$ (SD 5.8). This compares to spring values of 1.5 and 7.8 at harvested sites and PCMR, respectively.

3. Relative abundance was variable within and among sites in all surveys; however, highest urchin densities were generally found at the 35-ft. and 50-ft. depth zones. The 15-ft. depth zone yielded the lowest mean (0.5 red urchins/m^2) from all broad scale depth strata. No site in the broad scale survey had more than 4.1 red urchins/m^2.

4. Based upon the summer 1989 surveys, about 53% of the resource in the broad scale areas and about 59% in the fine scale areas (excluding PCMR) was under the 3.5 inch (89 mm) minimum test diameter size limit which became effective in June 1990 for commercially harvested red urchins.

5. Though 46% of juvenile (<= 50 mm) red urchins measured in the broad scale survey were under canopy, juveniles represented only 3.3% of all measured urchins. There is little evidence of bimodal distributions in the broad scale survey size structure data. Bimodality at PCMR in the summer survey centered around the 31-35 mm and 96-100 mm modes. Juveniles accounted for 8.3% of red urchins from fine scale harvested sites in summer, compared to 12.9% in spring, and 7.3% during the broad scale survey.

6. Conclusions regarding stratification of juveniles by depth zone are difficult to make due to their low abundance, but both spring and summer surveys showed fewest juveniles at the 15ft depth zone for harvested sites. The picture was not as clear for the PCMR.

7. Though red abalone densities were usually lower than those of red urchin, mean red urchin and red abalone counts were similar at the 15-ft. depth zone in the 1988 and 1989 broad scale surveys, and in 1989 they were slightly higher for abalone ($0.62/m^2$ versus $0.54/m^2$).

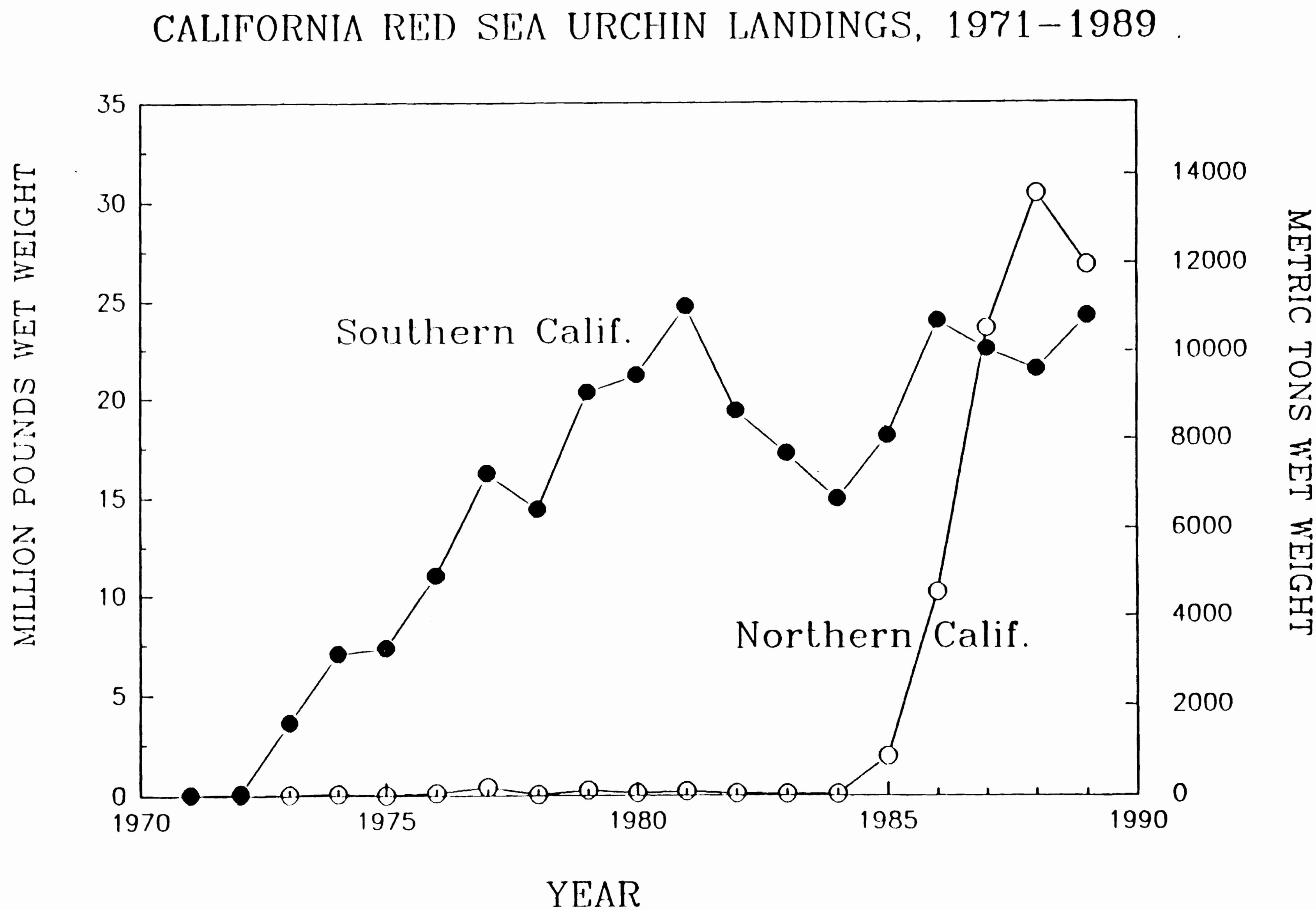

FIGURE 1. Commercial red sea urchin landings in northern and southern California from 1971 through 1989.

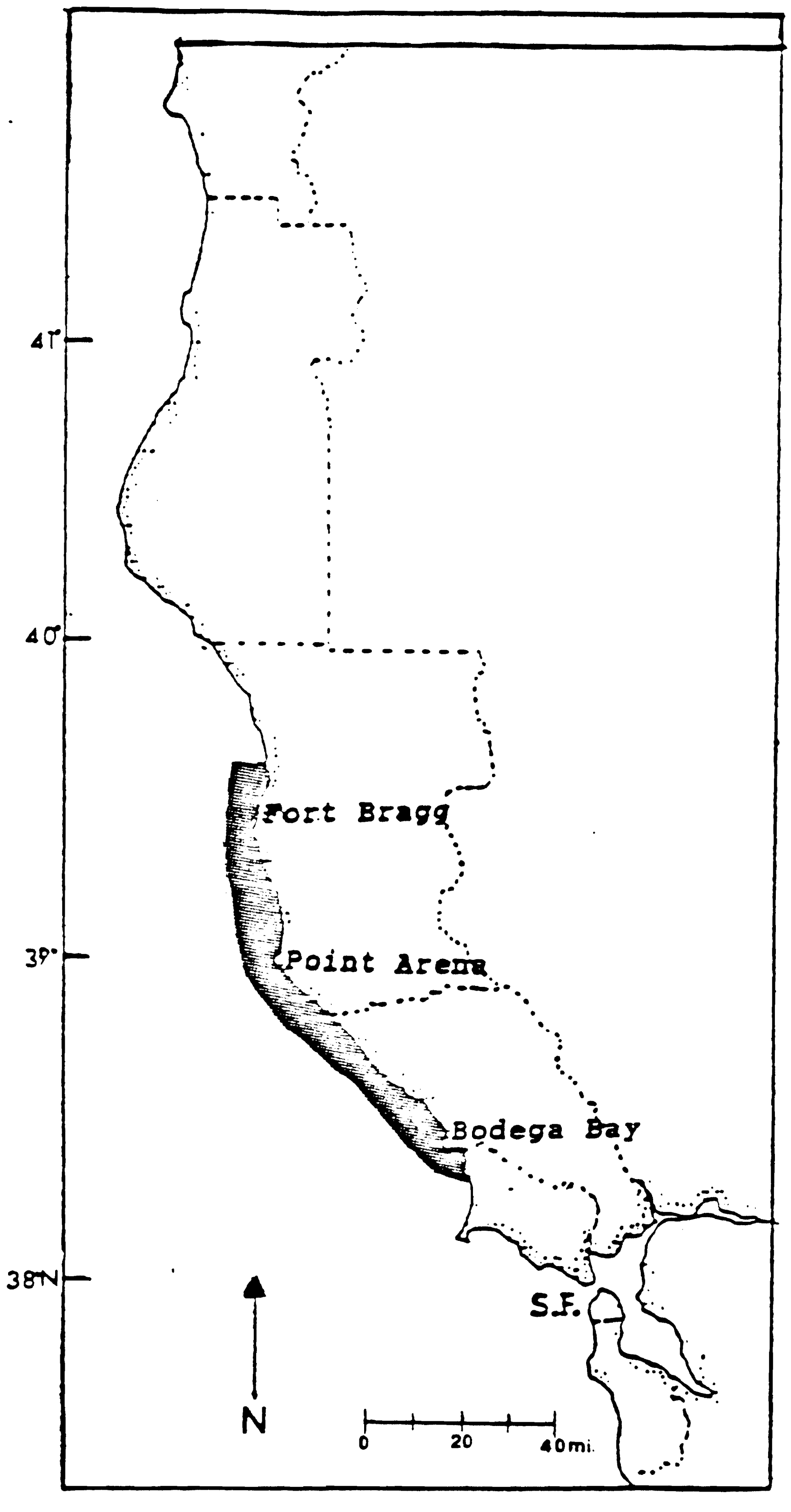

FIGURE 2. Northern California red sea urchin harvest area centered between Bodega Bay and Fort Bragg.

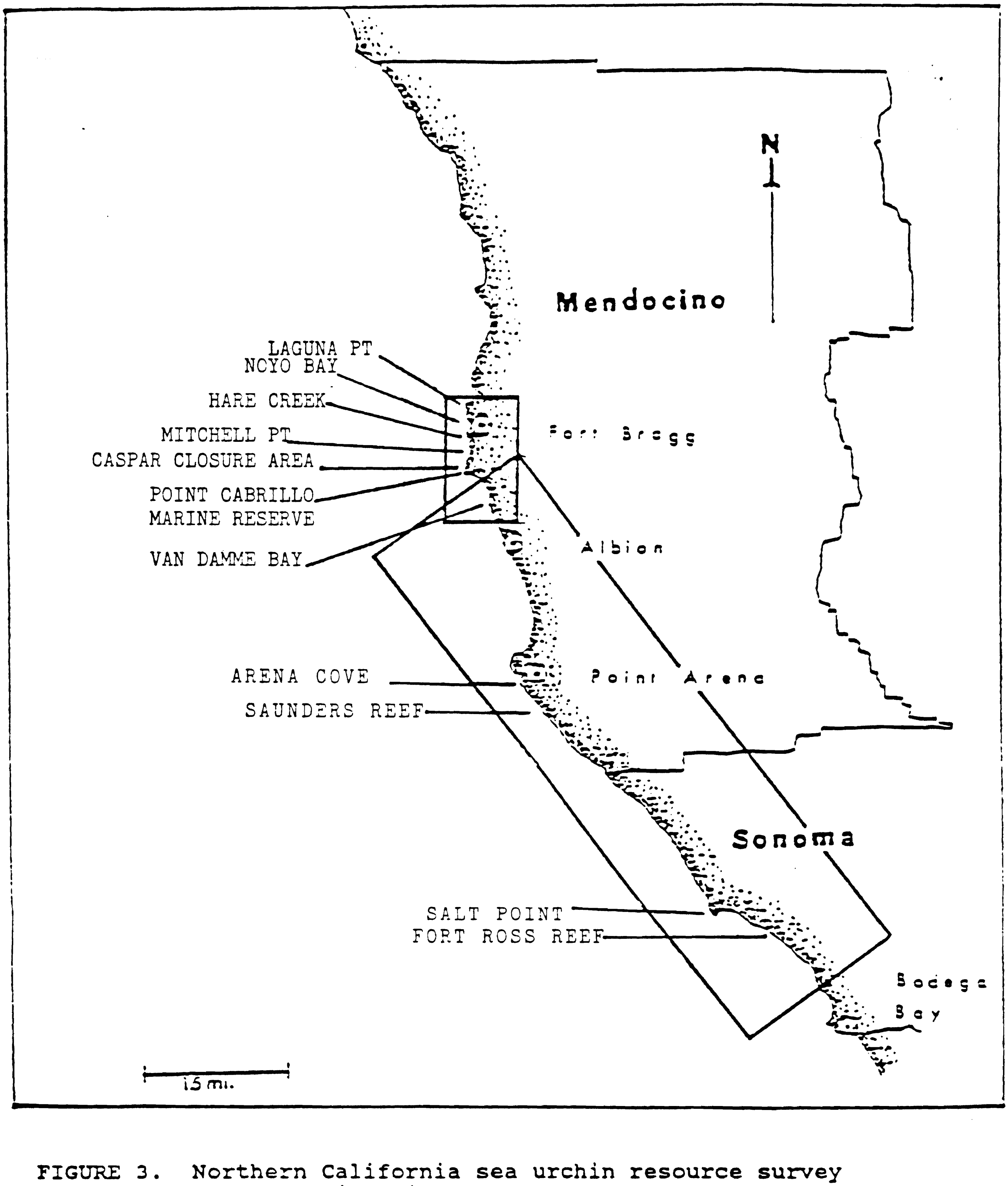

FIGURE 3. Northern California sea urchin resource survey areas showing fine scale (upper box) and broad scale areas, 1989.

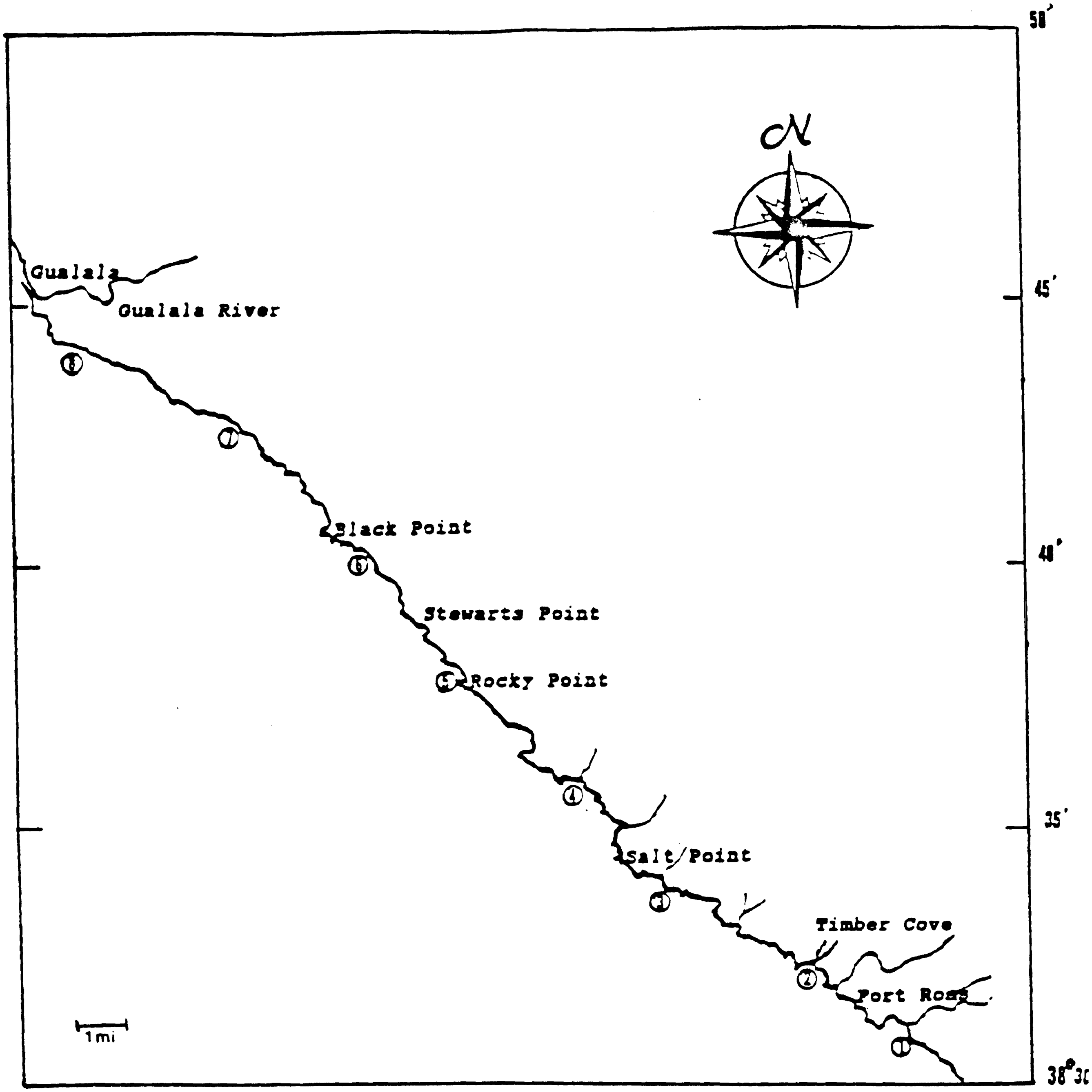

FIGURE 4. Broad scale study site locations in the Gualala South coastal zone from Fort Ross Reef to the Gualala River, summer 1989.

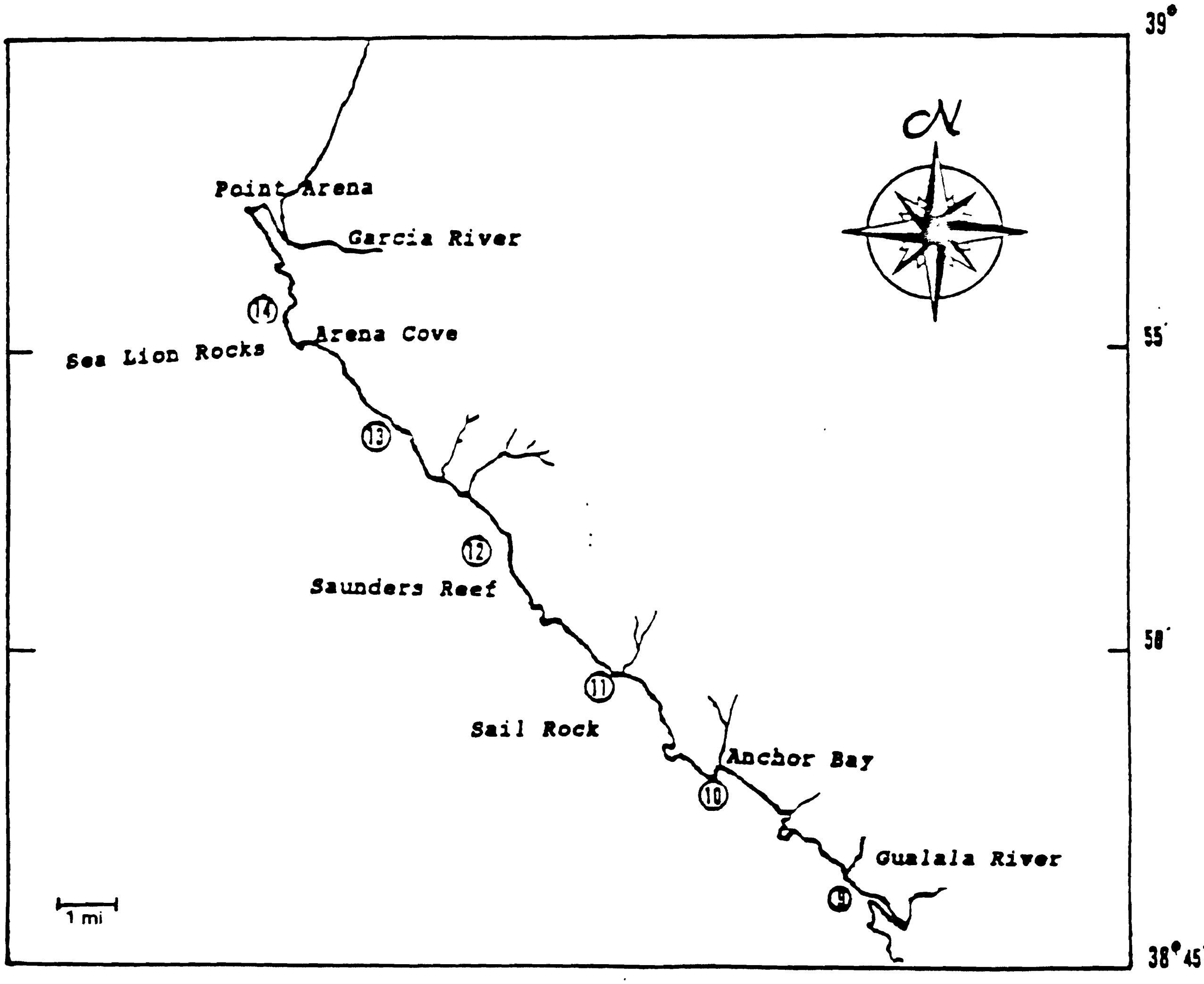

FIGURE 5. Broad scale study site locations in the Gualala North coastal zone from the Gualala River to Point Arena, summer 1989.

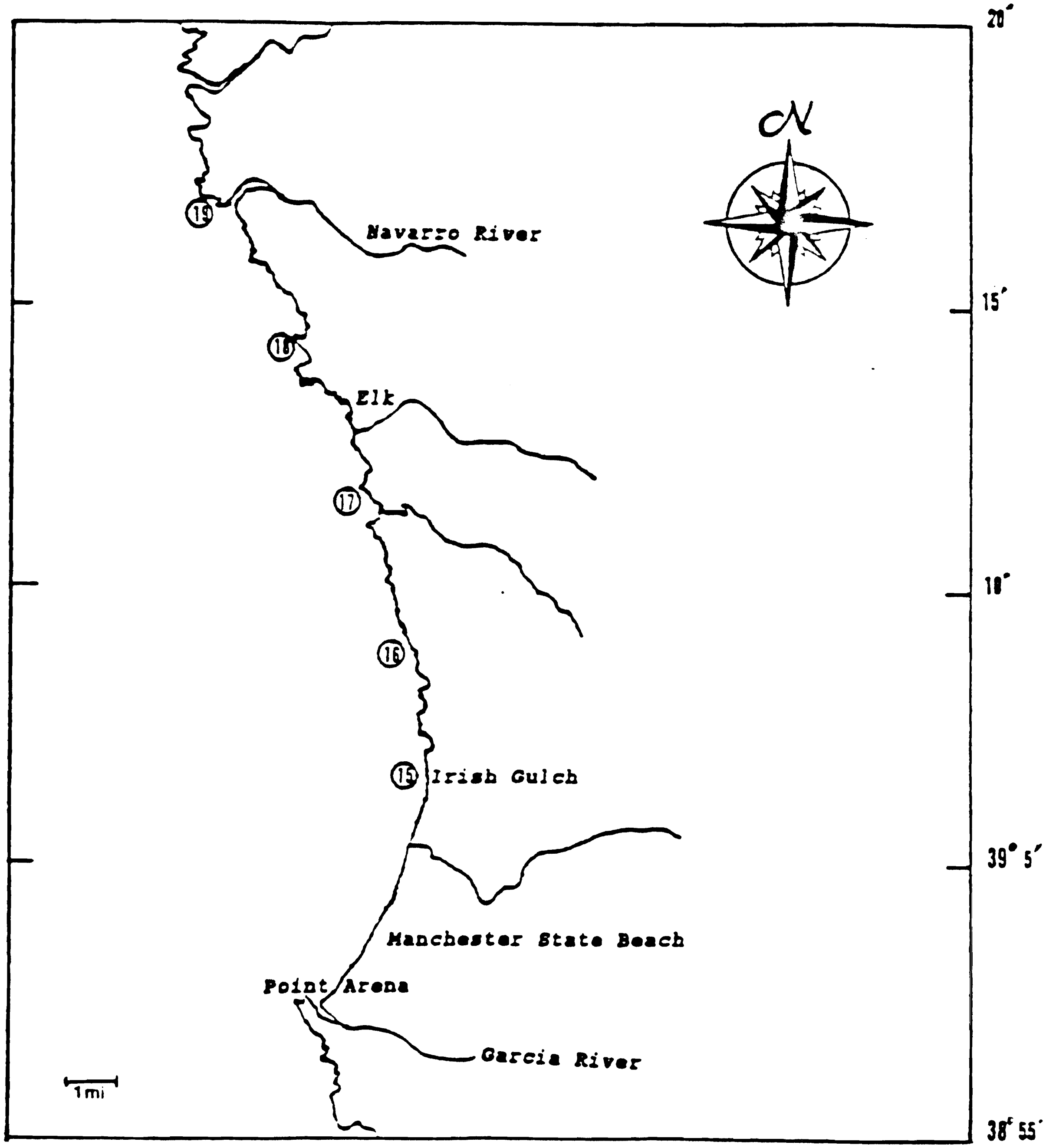

FIGURE 6. Broad scale study site locations in the Navarro South coastal zone from Point Arena to the Navarro River, summer 1989.

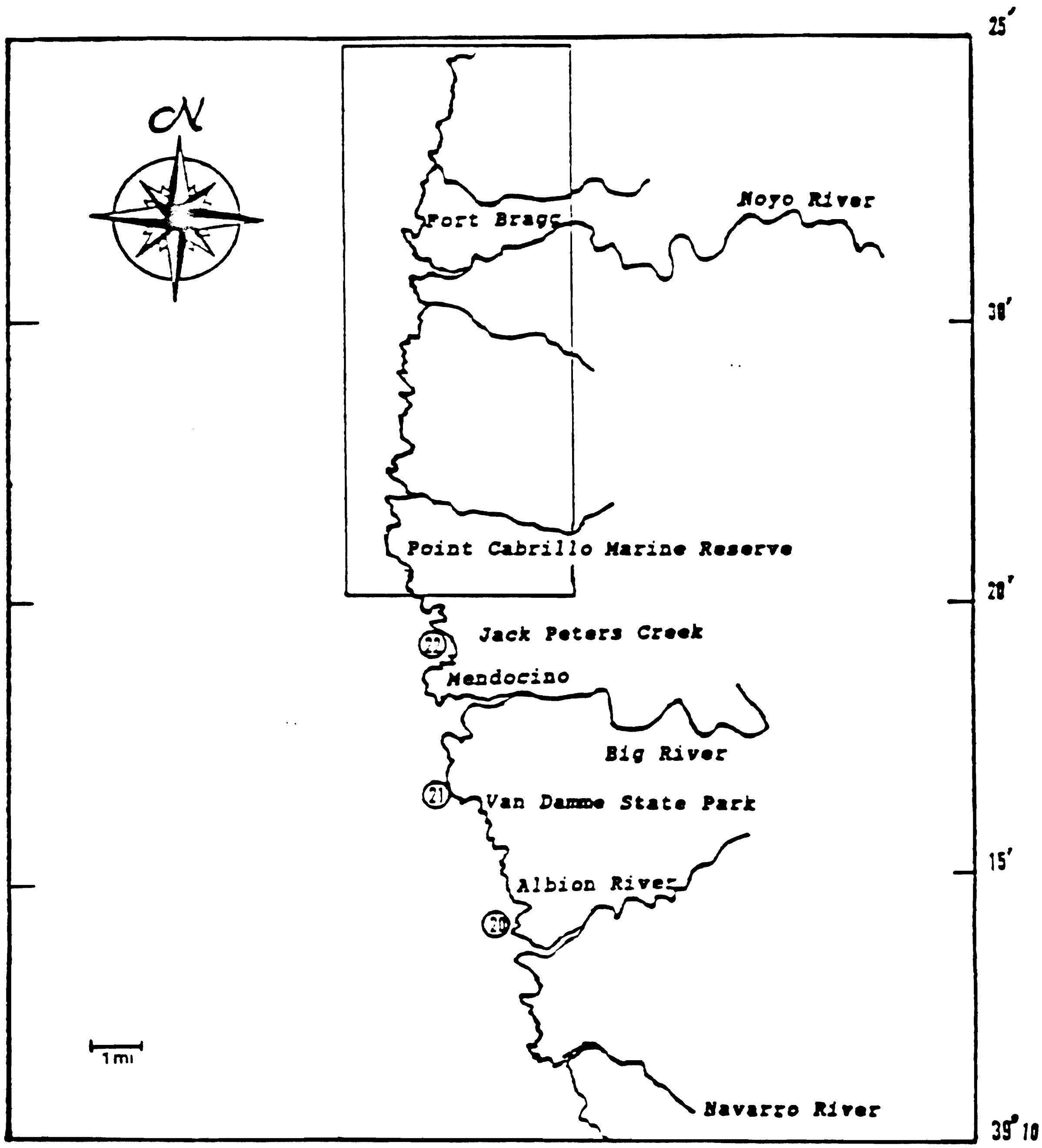

FIGURE 7. Broad scale study site locations in the Navarro North coastal zone from the Navarro River to Mendocino, and fine scale study area (in box, except Van Damme), summer 1989.

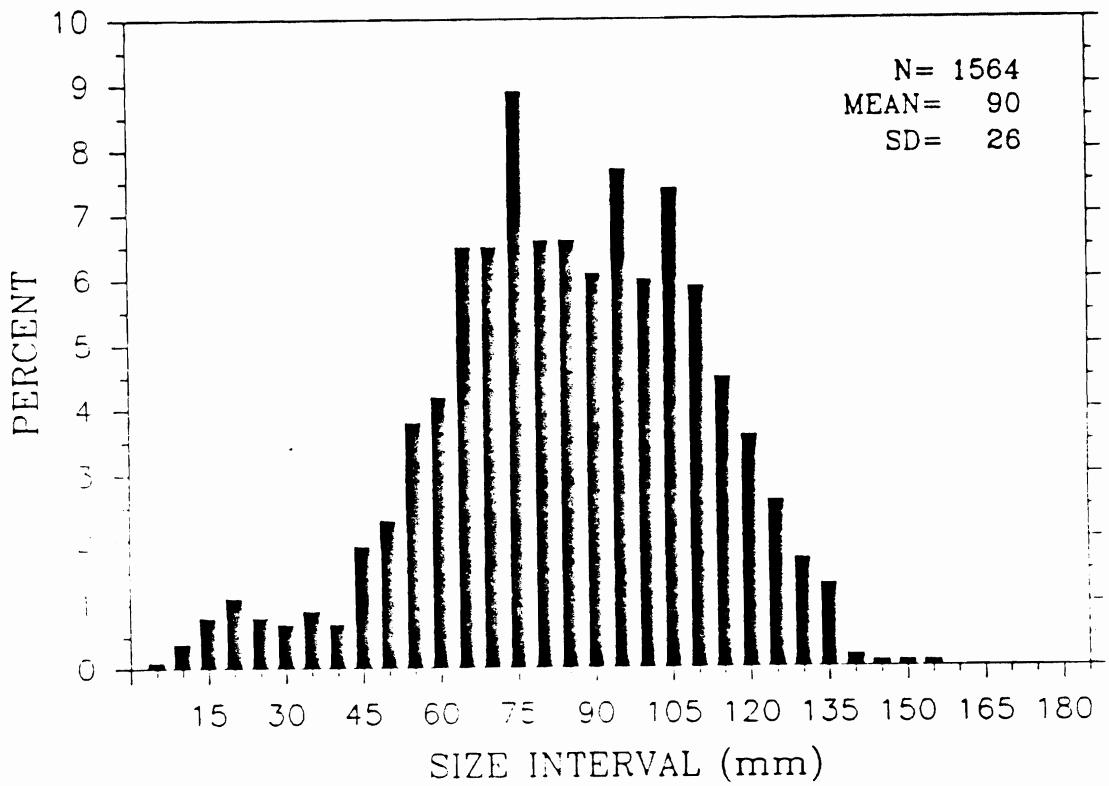

FIGURE 8. Frequency distribution of red sea urchin test diameters from all broad scale survey sites, summer 1989.

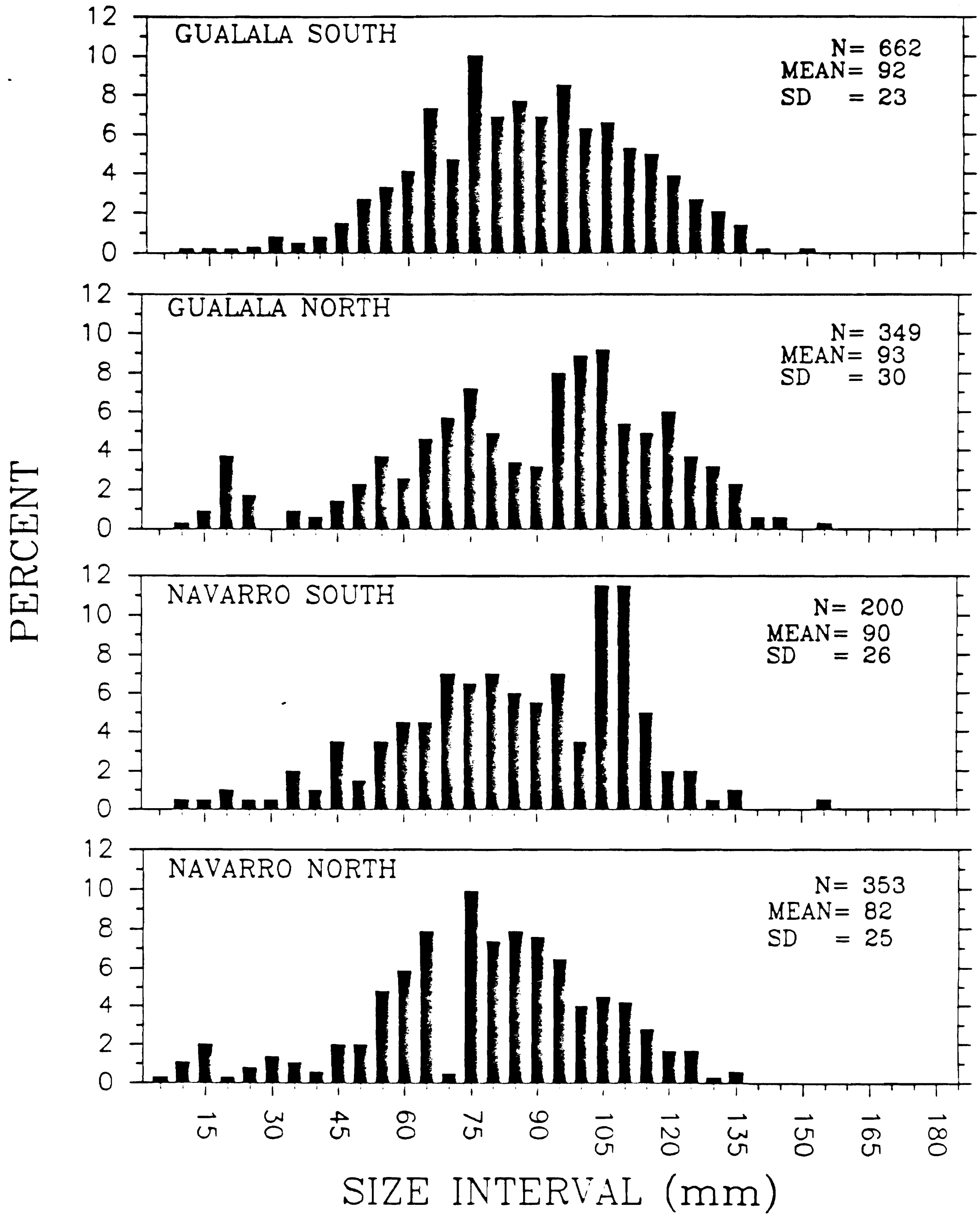

FIGURE 9. Frequency distribution of red sea urchin test diameters by coastal zone from the 1989 broad scale survey.

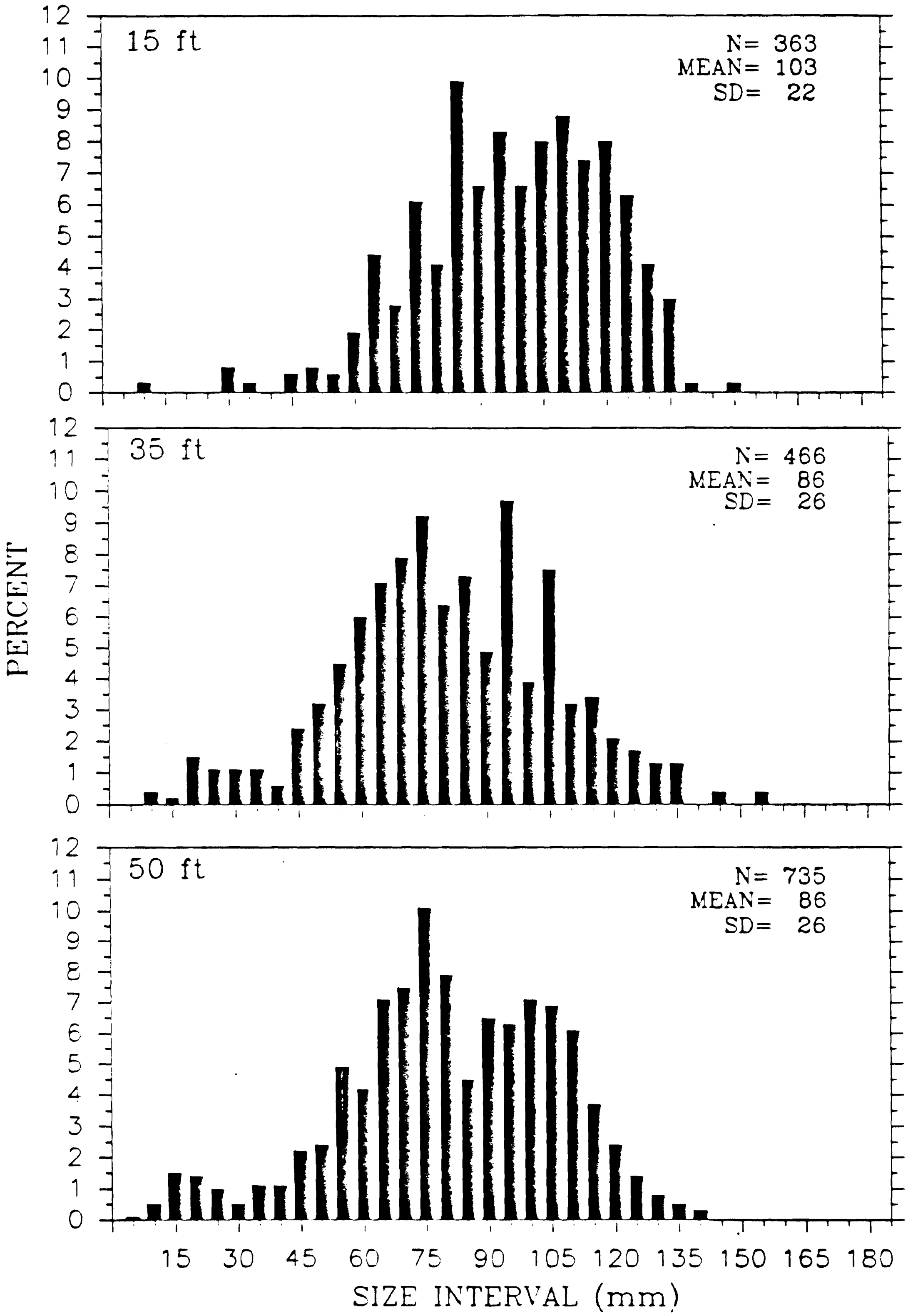

FIGURE 10. Frequency distribution of red sea urchin test diameters by depth zone from all broad scale sites.

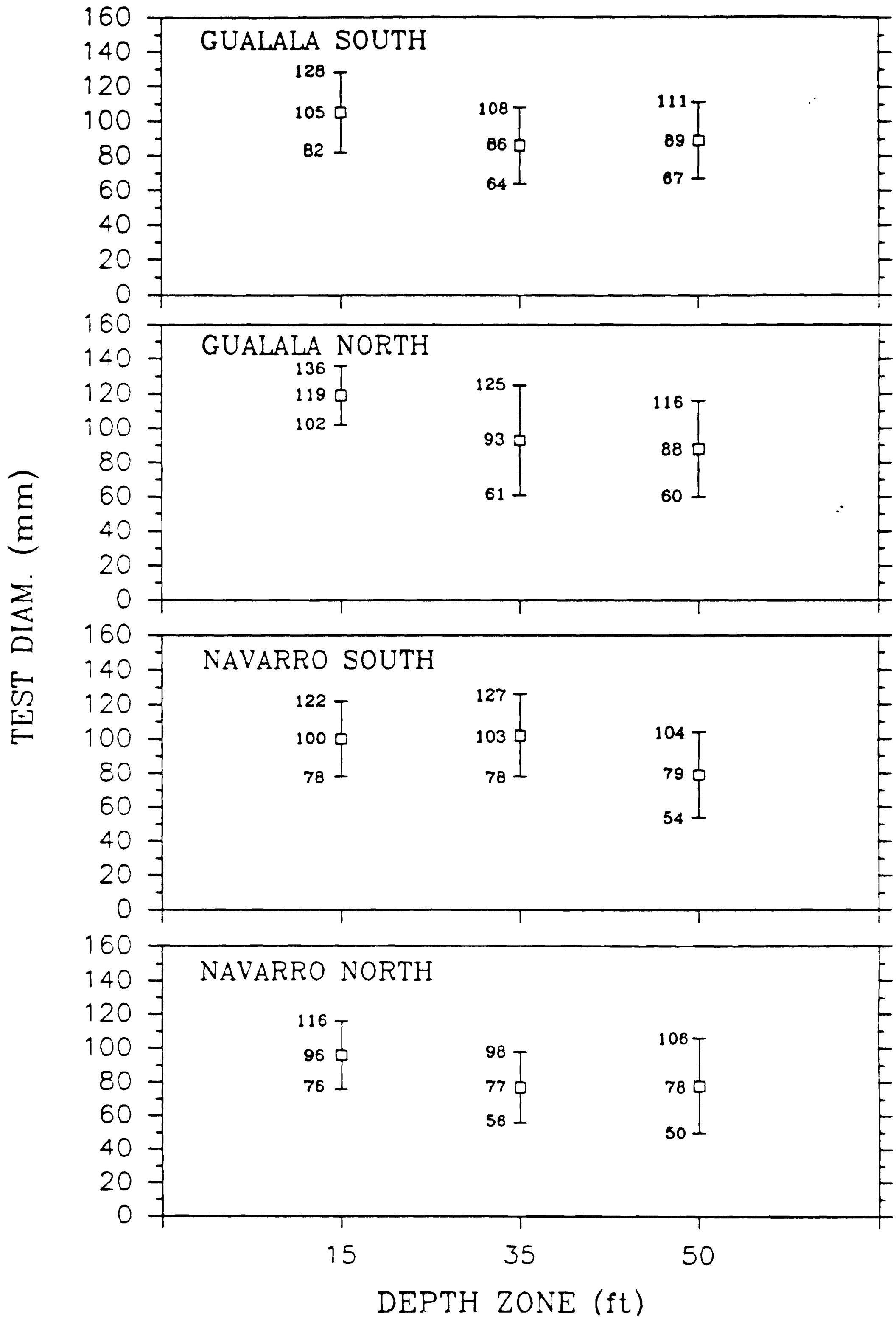

FIGURE 11. Mean and SD of red sea urchin test diameters by depth zone and coastal zone from the 1989 broad scale survey.

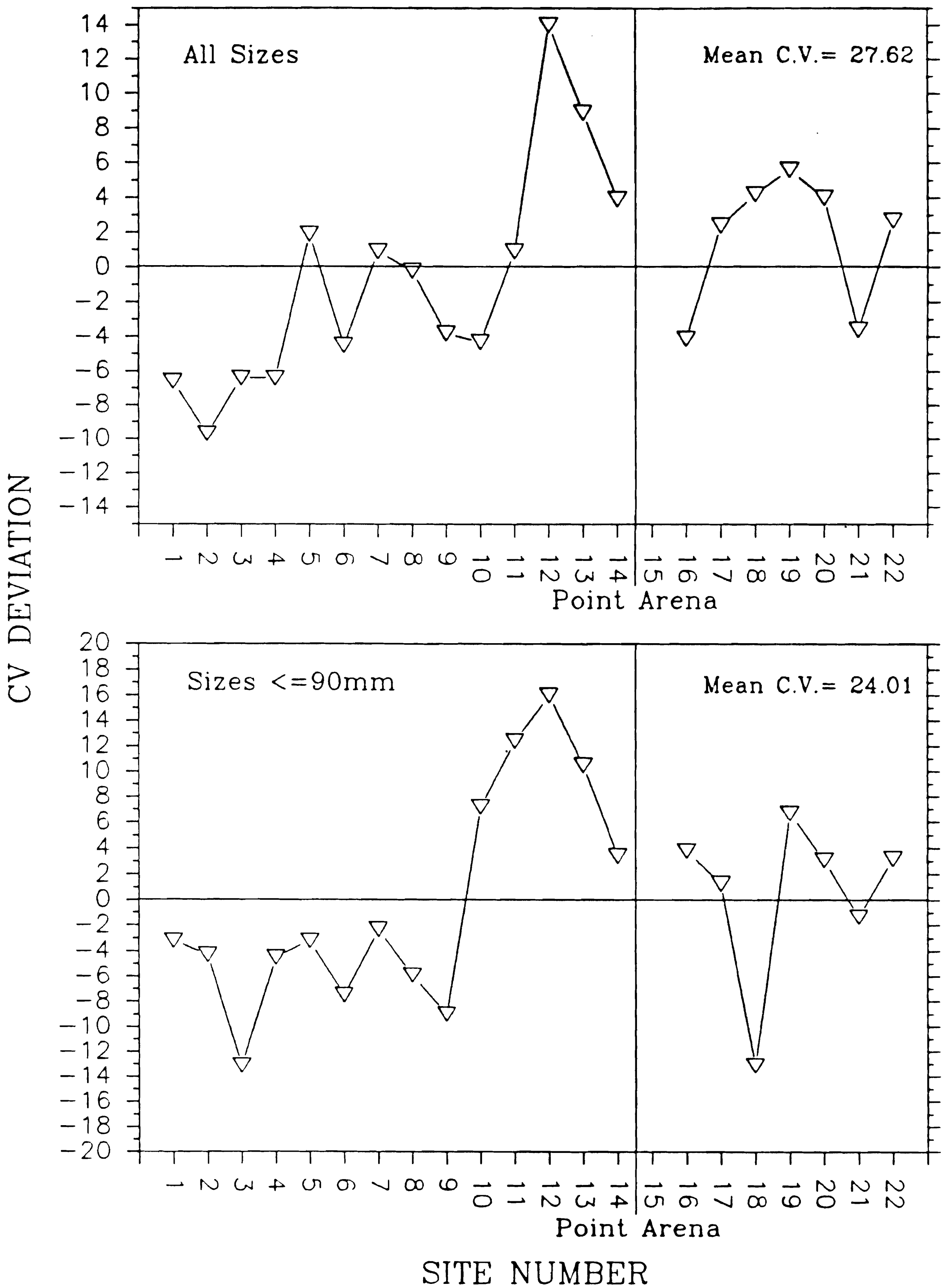

FIGURE 12. Deviations from the mean coefficient of variation (CV) for red sea urchin test diameters by site for all sizes and for urchins less than 90mm, broad scale survey.

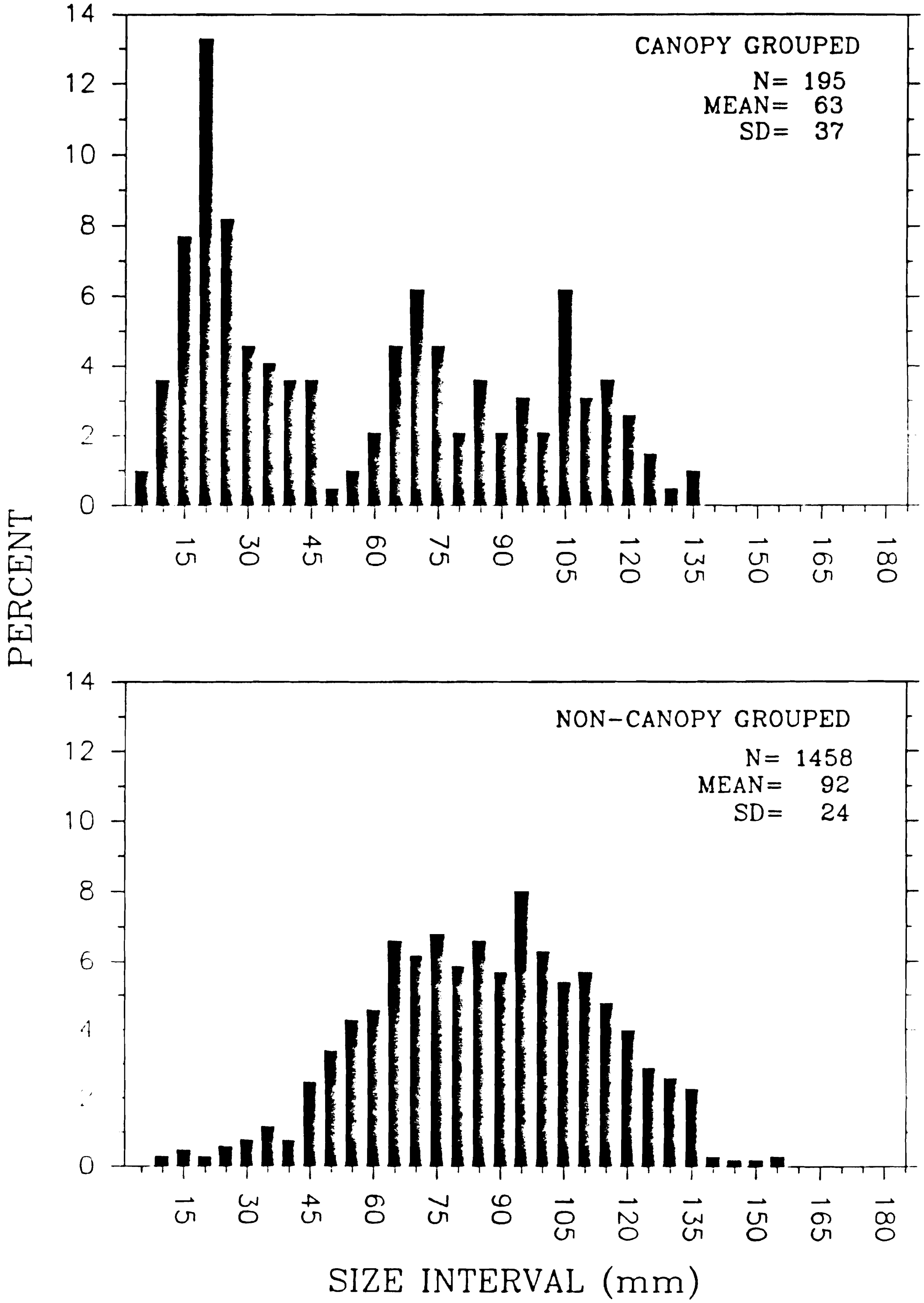

FIGURE 13. Frequency distribution of red sea urchin test diameters for canopy grouped and non-canopy grouped urchin from all broad scale sites.

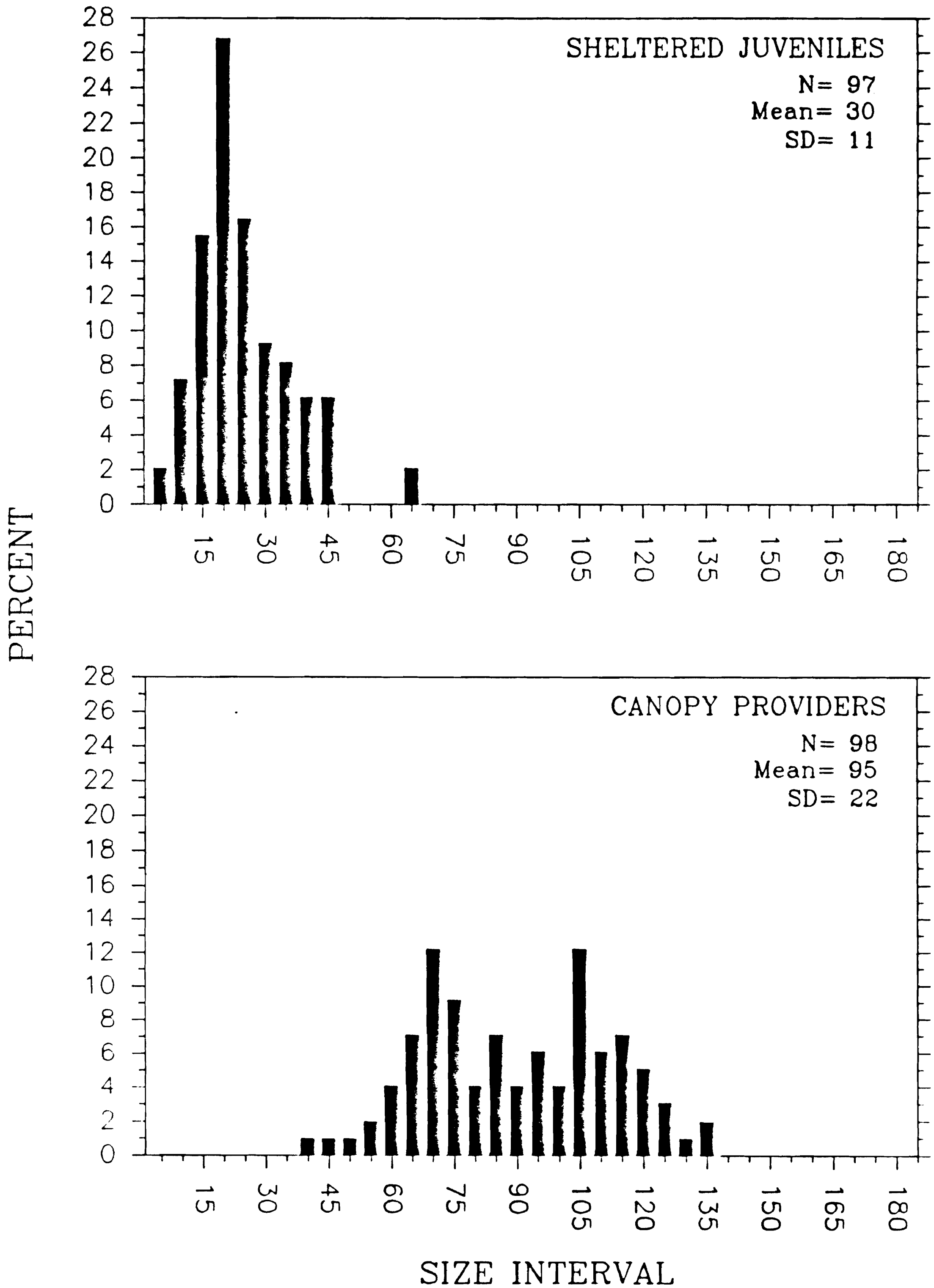

FIGURE 14. Frequency distribution of red sea urchin test diameters for sheltered juveniles and canopy providers from all broad scale sites.

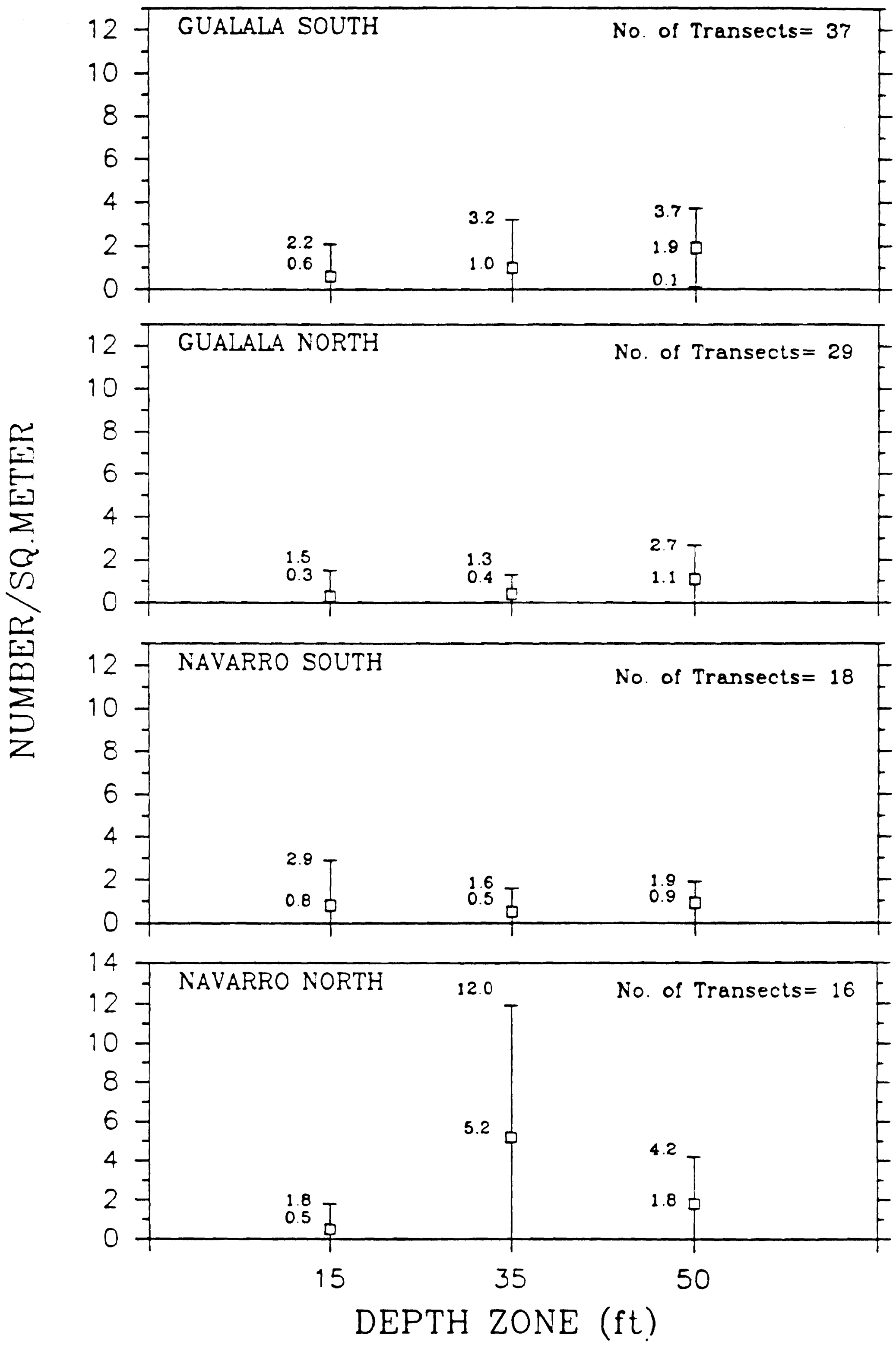

FIGURE 15. Mean and SD of red sea urchin densities (number per sq. meter) by depth zone and coastal zone from the 1989 broad scale survey.

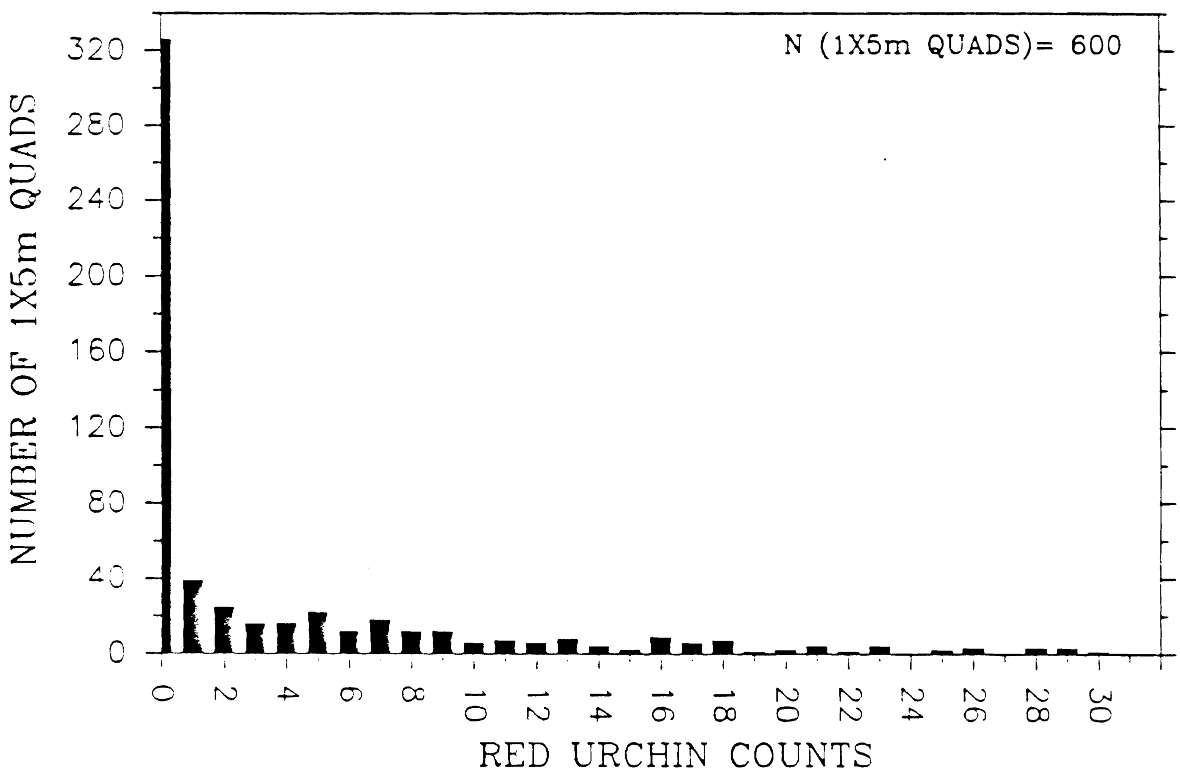

FIGURE 16. Frequency distribution of red sea urchin counts by transect quadrat for all broad scale survey sites.

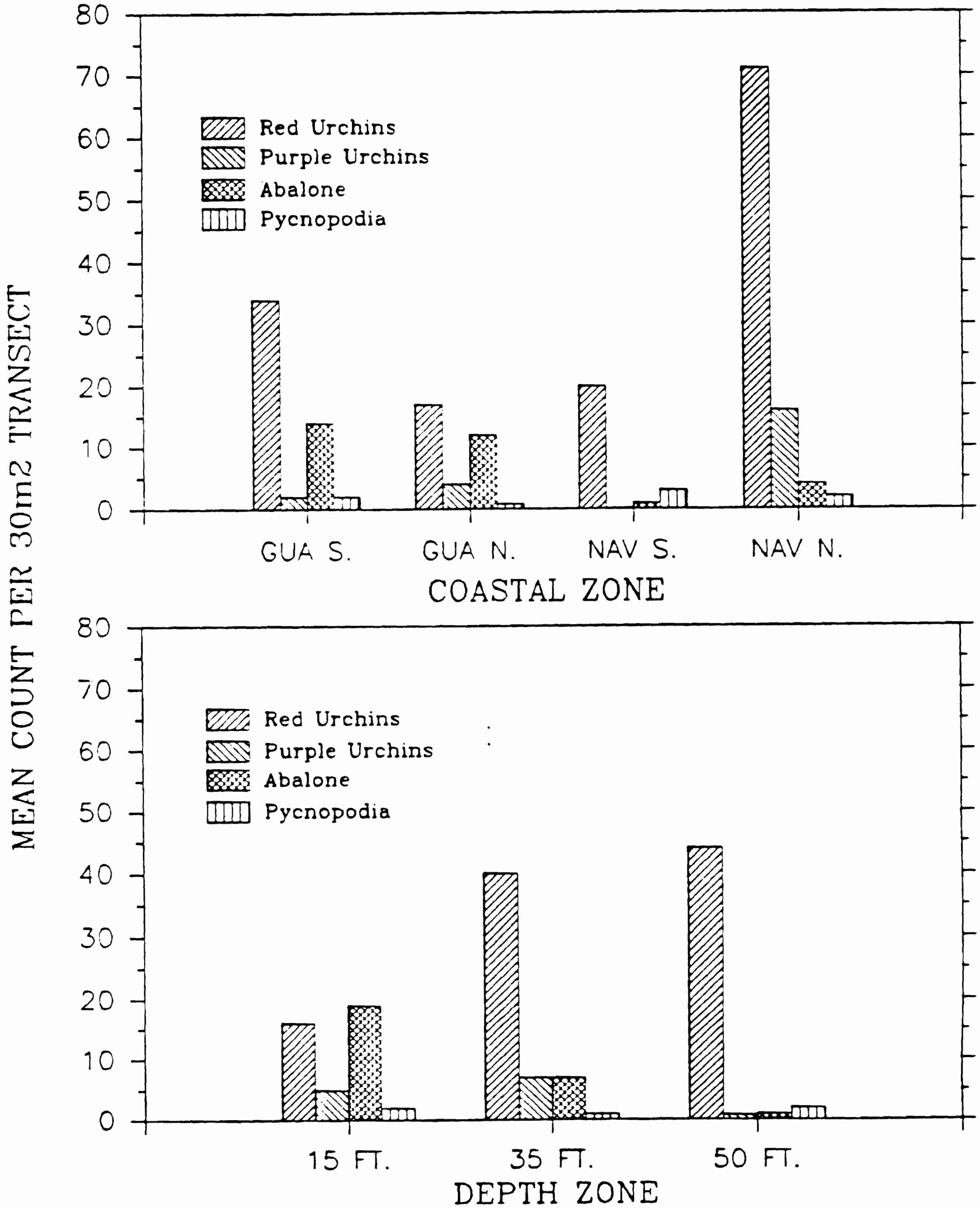

FIGURE 17. Comparison of invertebrate densities by coastal zone and depth zone from the 1989 broad scale survey.

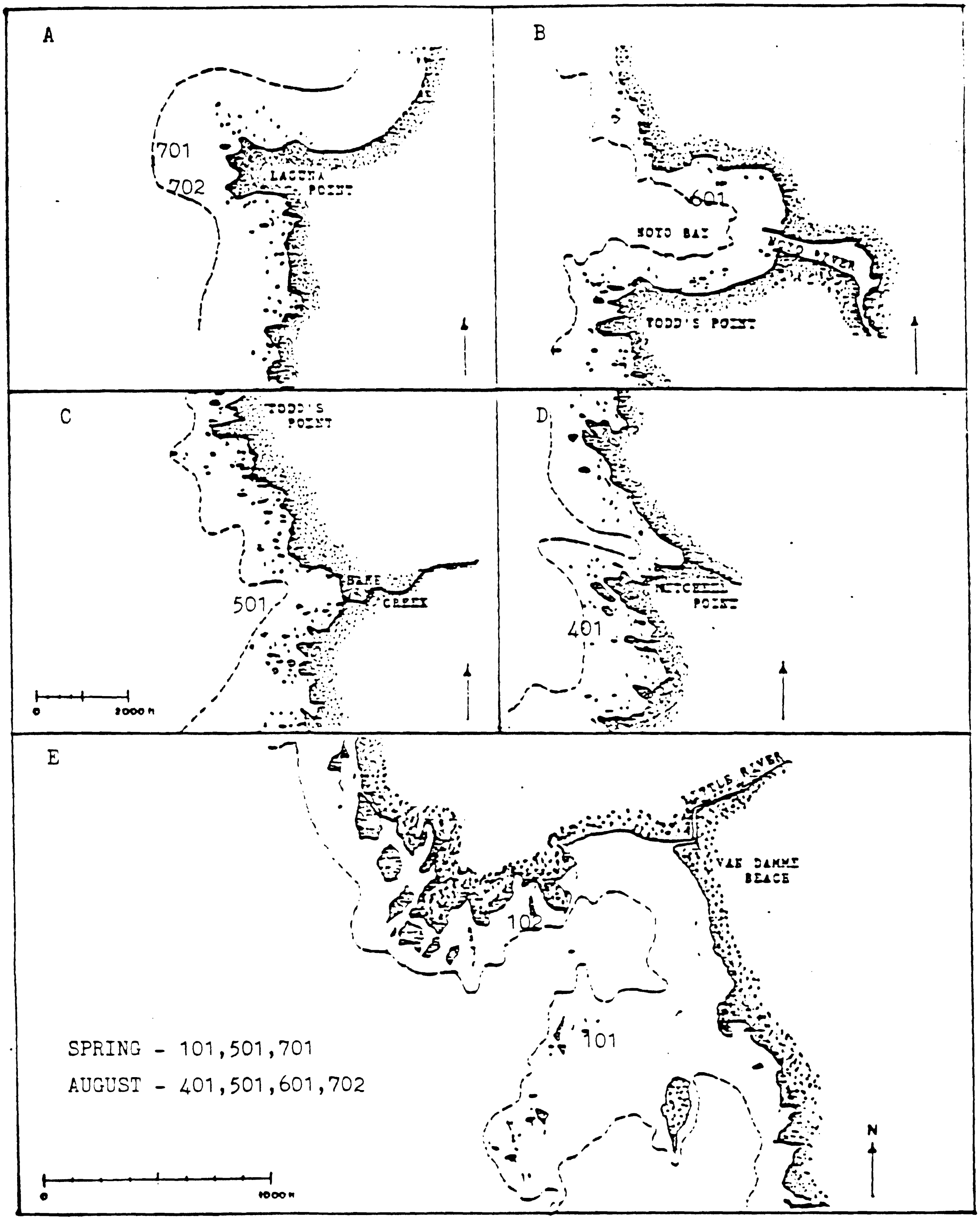

FIGURE 18. Individual fine scale study sites: Laguna Point (A), Noyo Bay (B), Hare Creek (C), Mitchell Point (D), and Van Damme Bay (E). Dashed lines represent 30ft contour. Site numbers represent approximate transect locations.

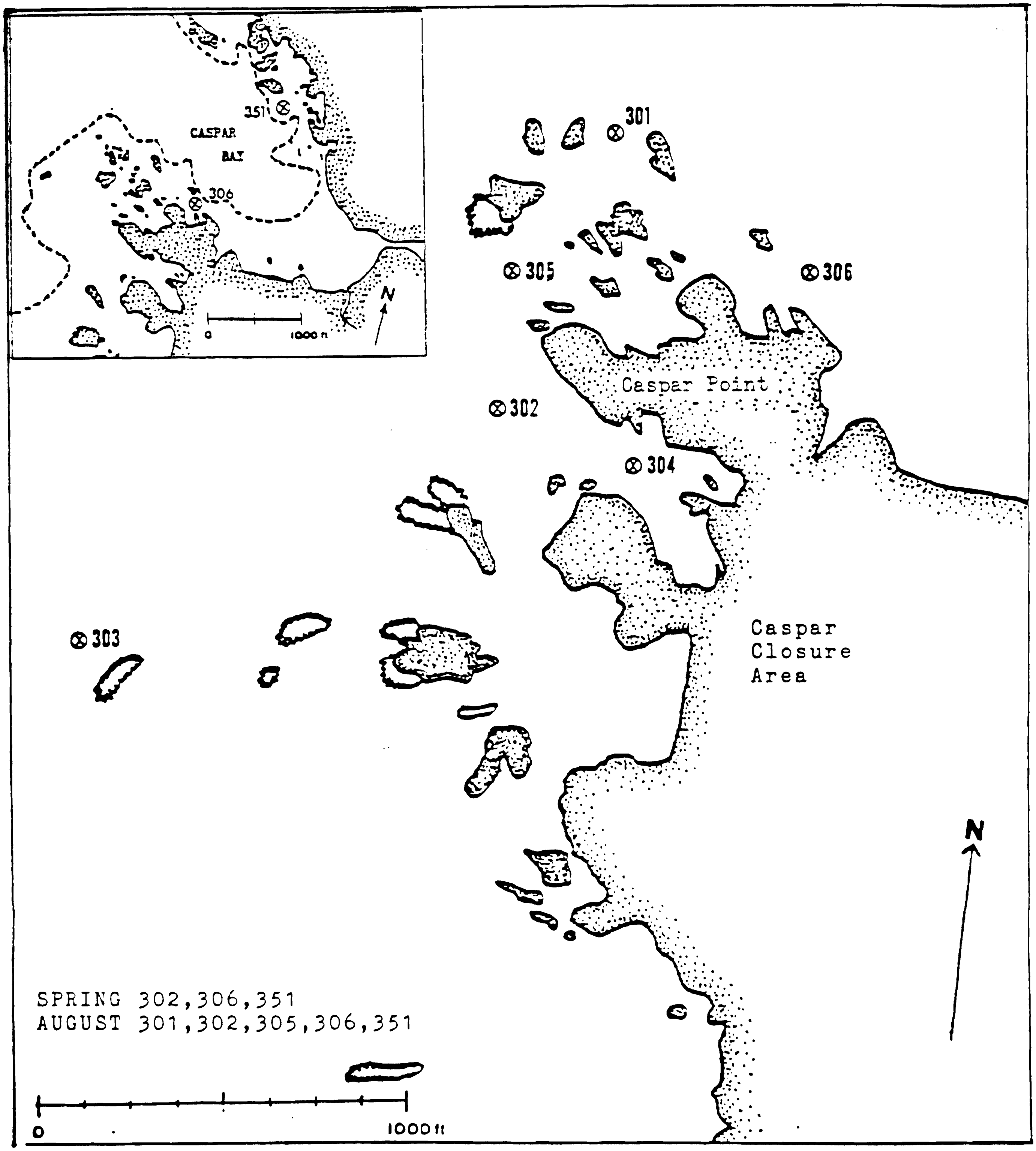

FIGURE 19. Caspar Closure Area fine scale study subsites showing approximate transect locations, 1989.

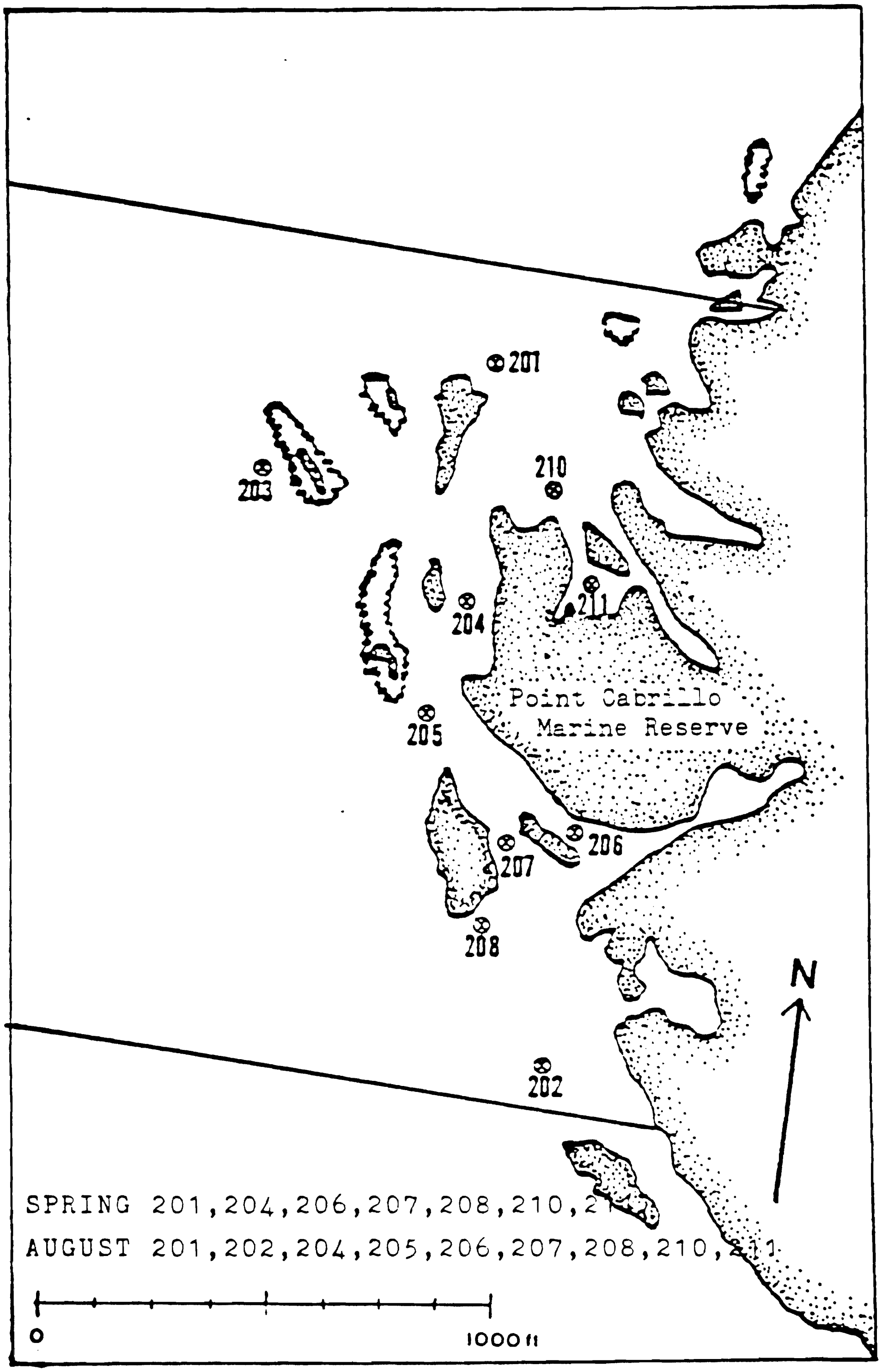

FIGURE 20. Point Cabrillo Marine Reserve fine scale study subsites showing approximate transect locations, 1989.

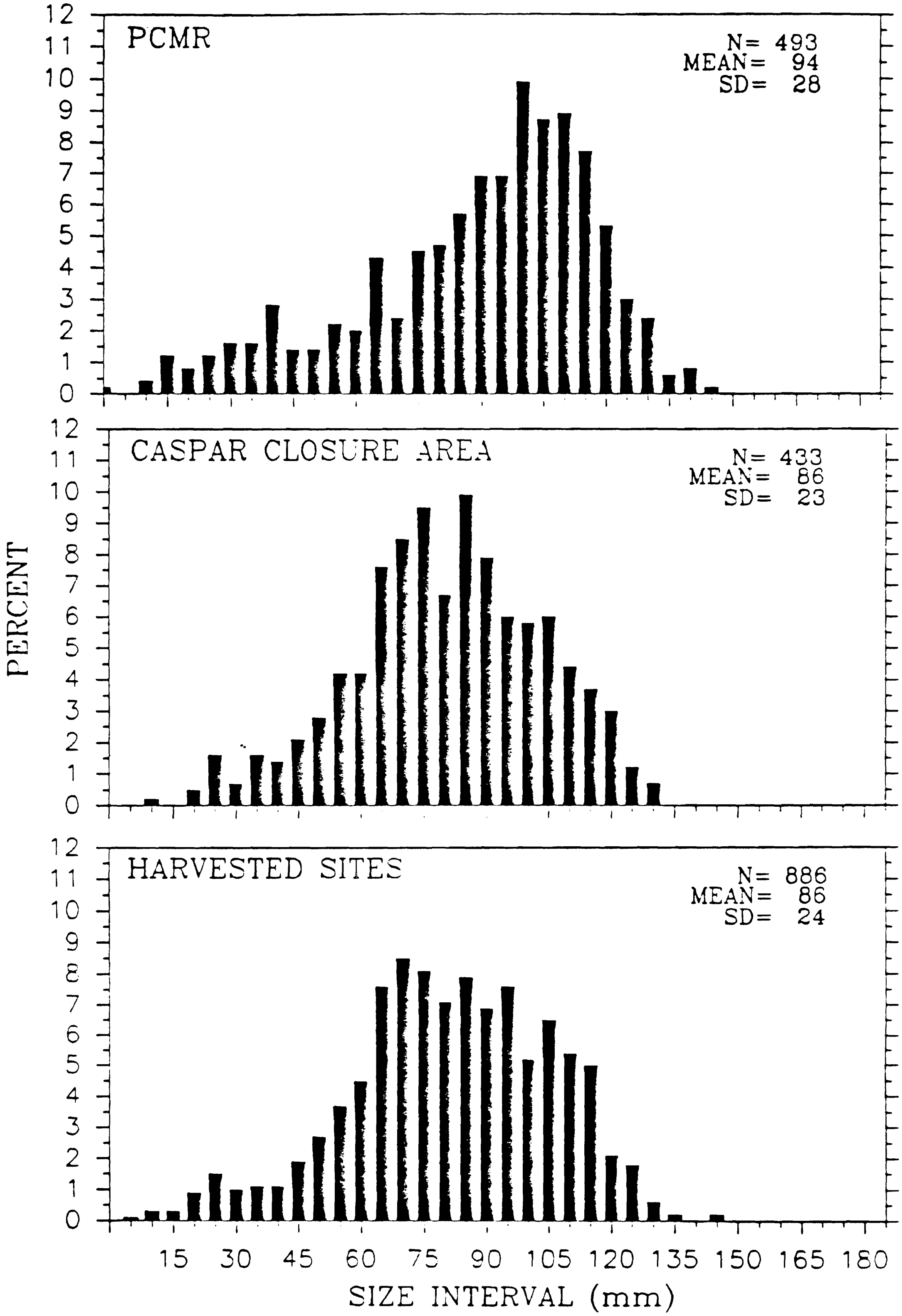

FIGURE 21. **Frequency distribution of red sea urchin test diameters from Point Cabrillo Marine Reserve, Caspar Closure Area, and combined harvested sites, fine scale survey, summer 1989.**

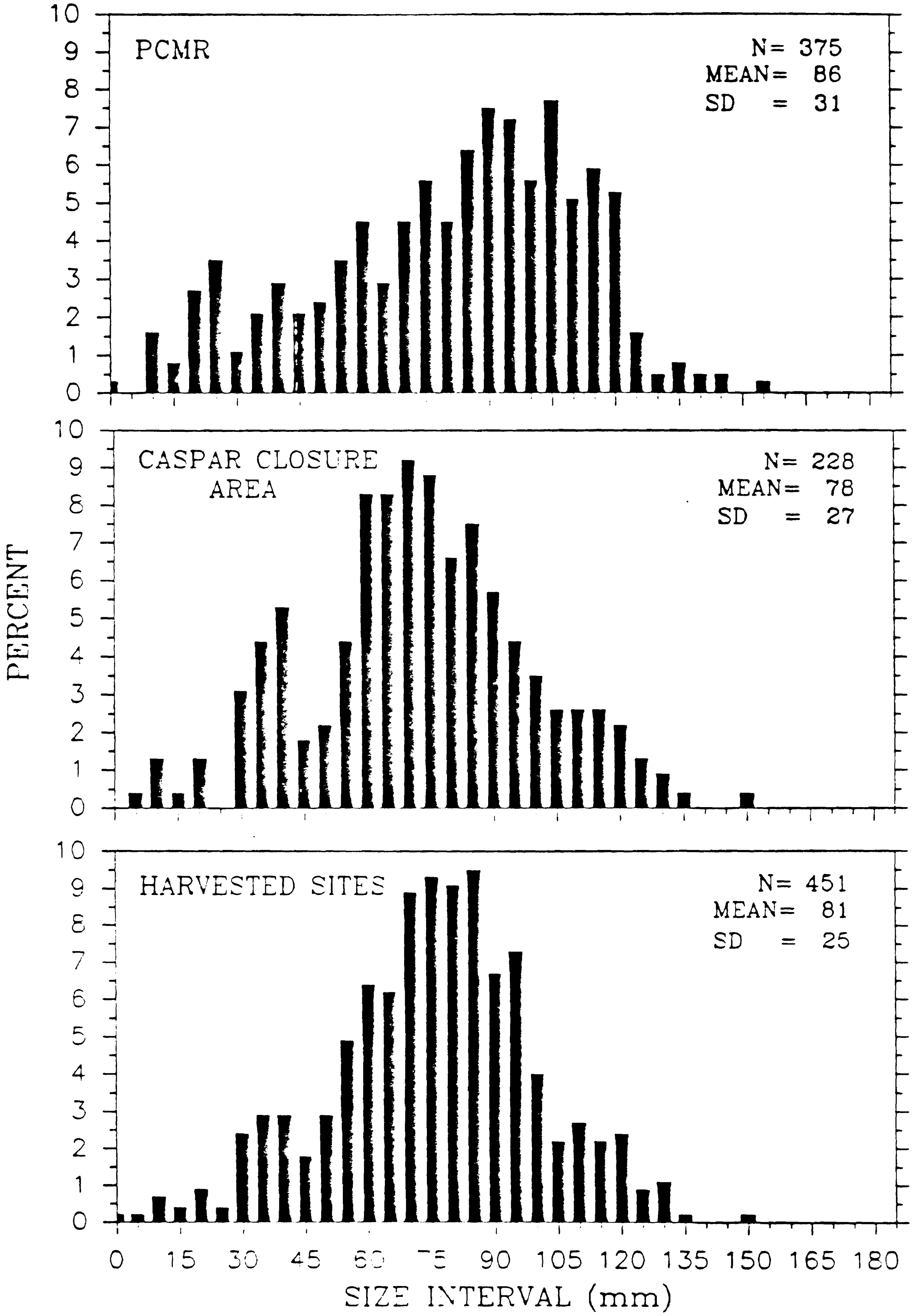

FIGURE 22. Frequency distribution of red sea urchin test diameters from Point Cabrillo Marine Reserve, Caspar Closure Area, and combined harvested sites, fine scale survey, Spring 1989.

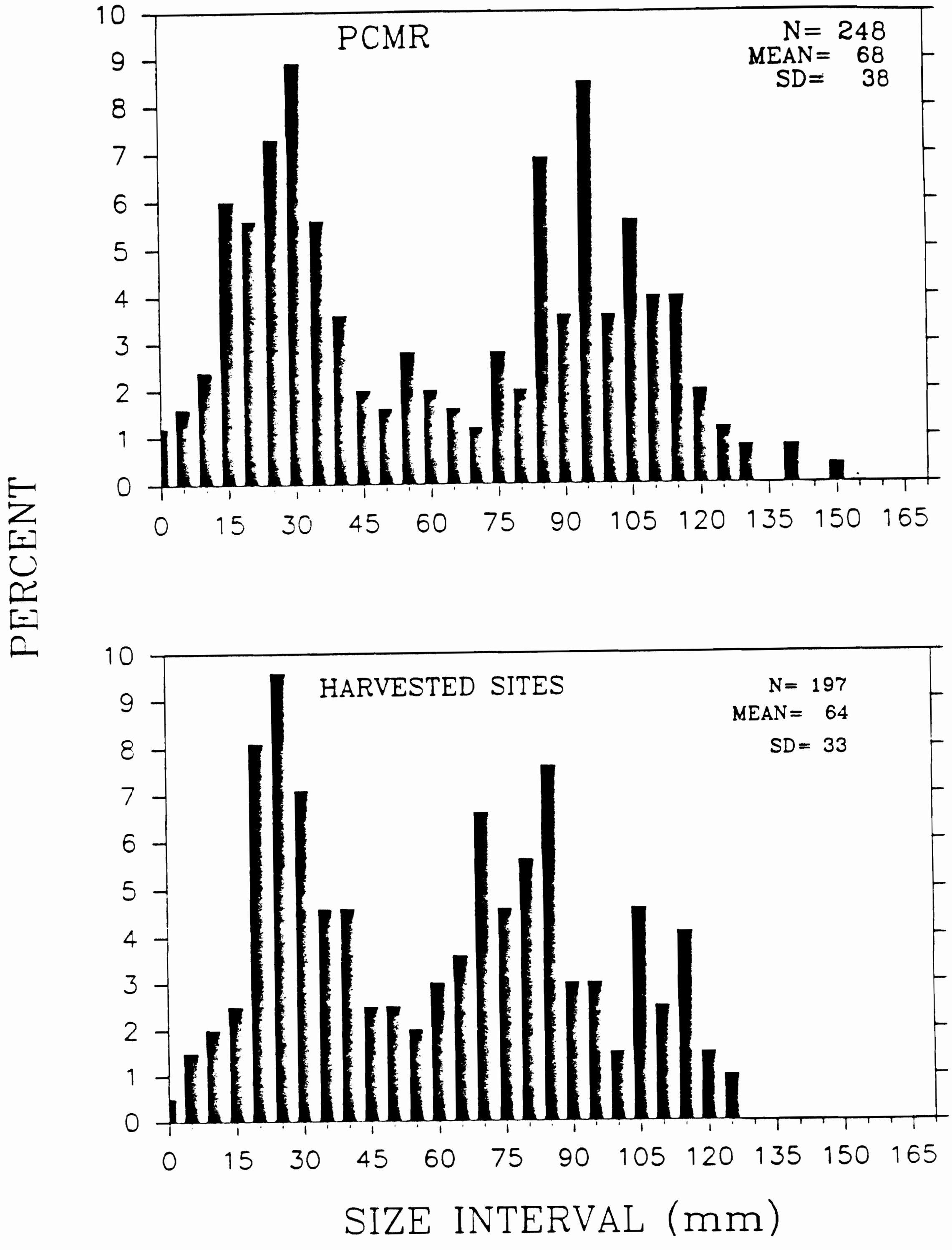

FIGURE 23. Frequency distribution of canopy grouped red sea urchin test diameters from Point Cabrillo Marine Reserve and combined harvested sites, fine scale survey, summer 1989.

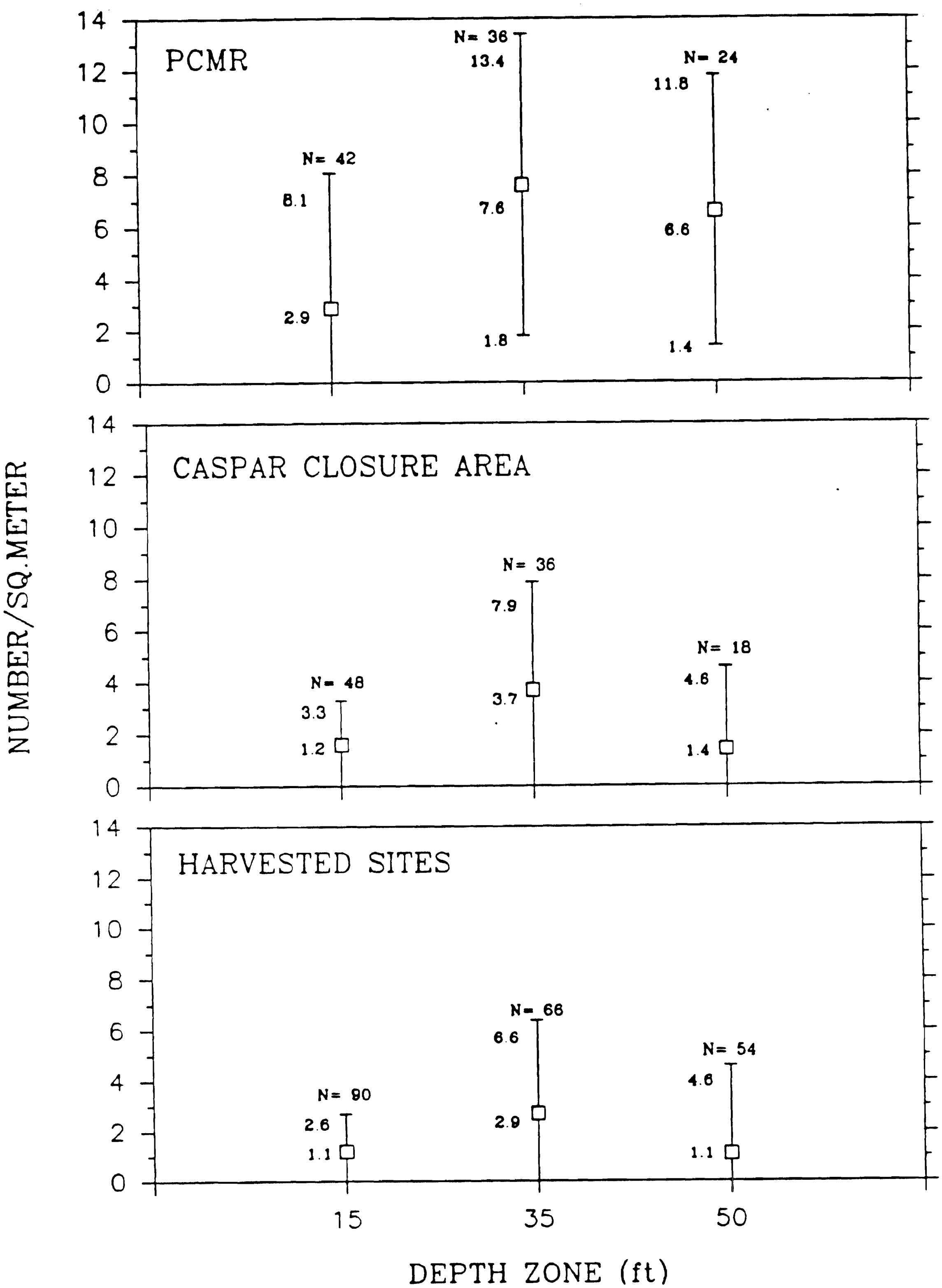

FIGURE 24. Mean and SD of red sea urchin densities (number per square meter) by depth zone from Point Cabrillo Marine Reserve, Caspar Closure Area, and combined harvested sites, fine scale survey, summer 1989.

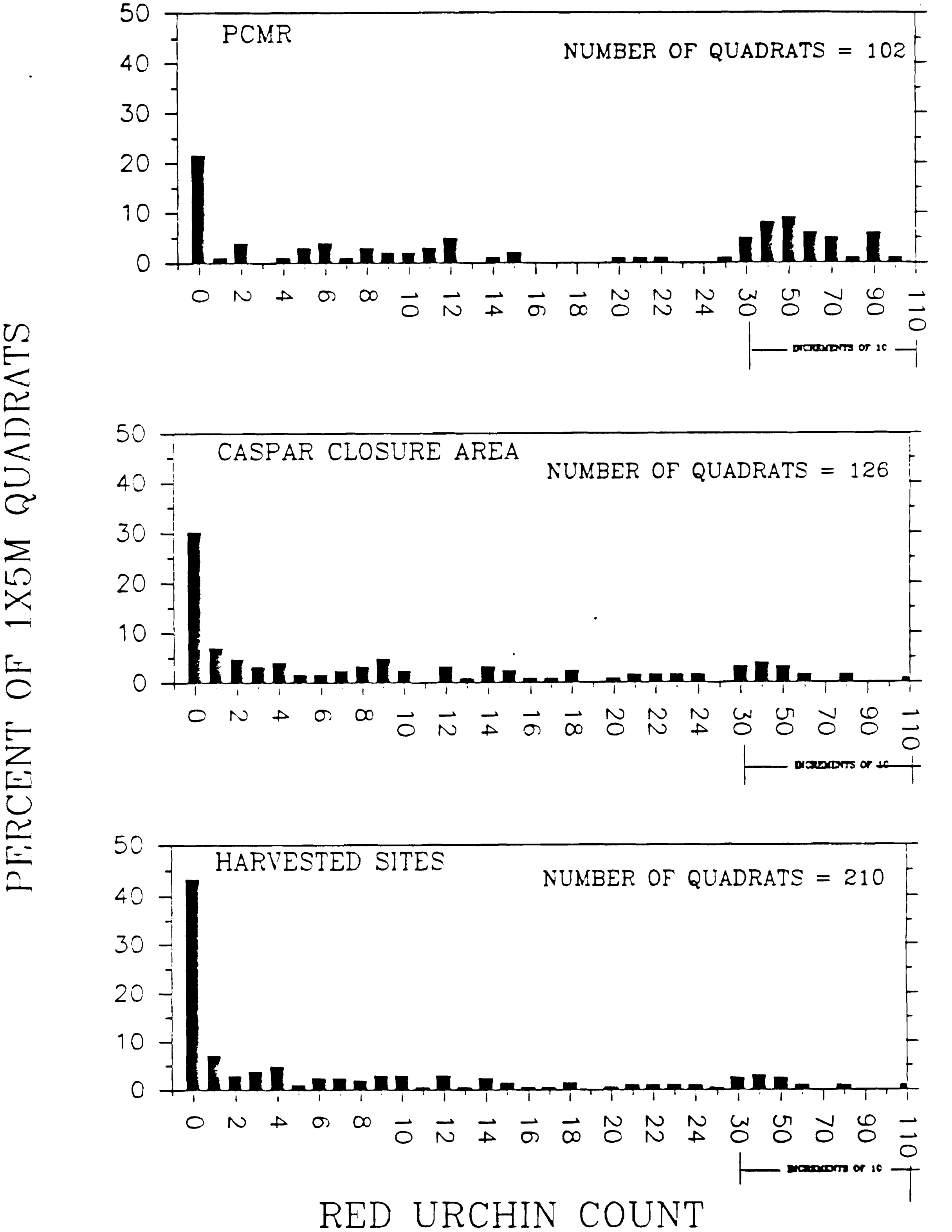

FIGURE 25. Frequency distribution of red sea urchin counts for Point Cabrillo Marine Reserve transect quadrats, Caspar Closure Area transect quadrats, and combined harvested site transect quadrats, fine scale survey, summer 1989.

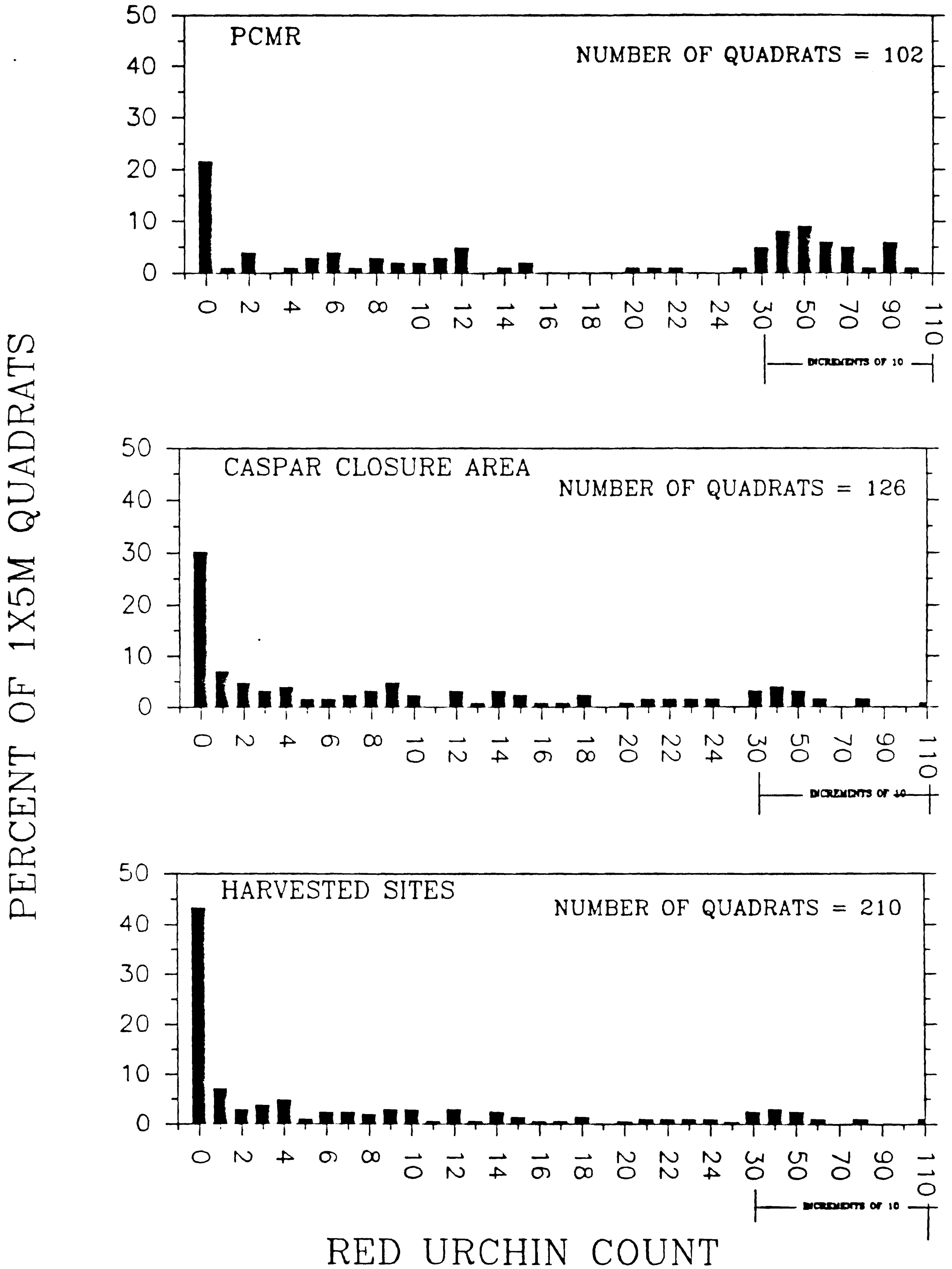

FIGURE 26. Frequency distribution of red sea urchin counts for Point Cabrillo Marine Reserve transect quadrats, Caspar Closure Area transect quadrats, and combined harvested site transect quadrats, fine scale survey, Spring 1989.

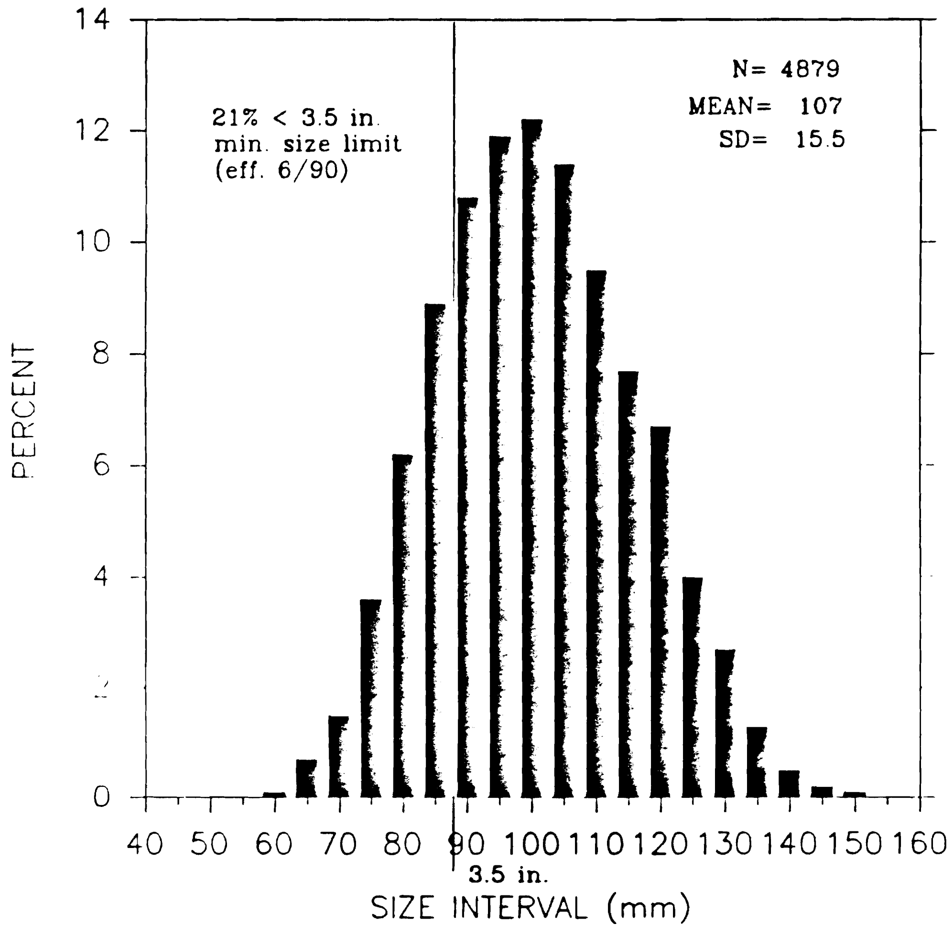

FIGURE 27. **Frequency distribution of red sea urchin test diameters from commercial fishery samples harvested in northern California, predominantly in the Fort Bragg vicinity, during 1989.**

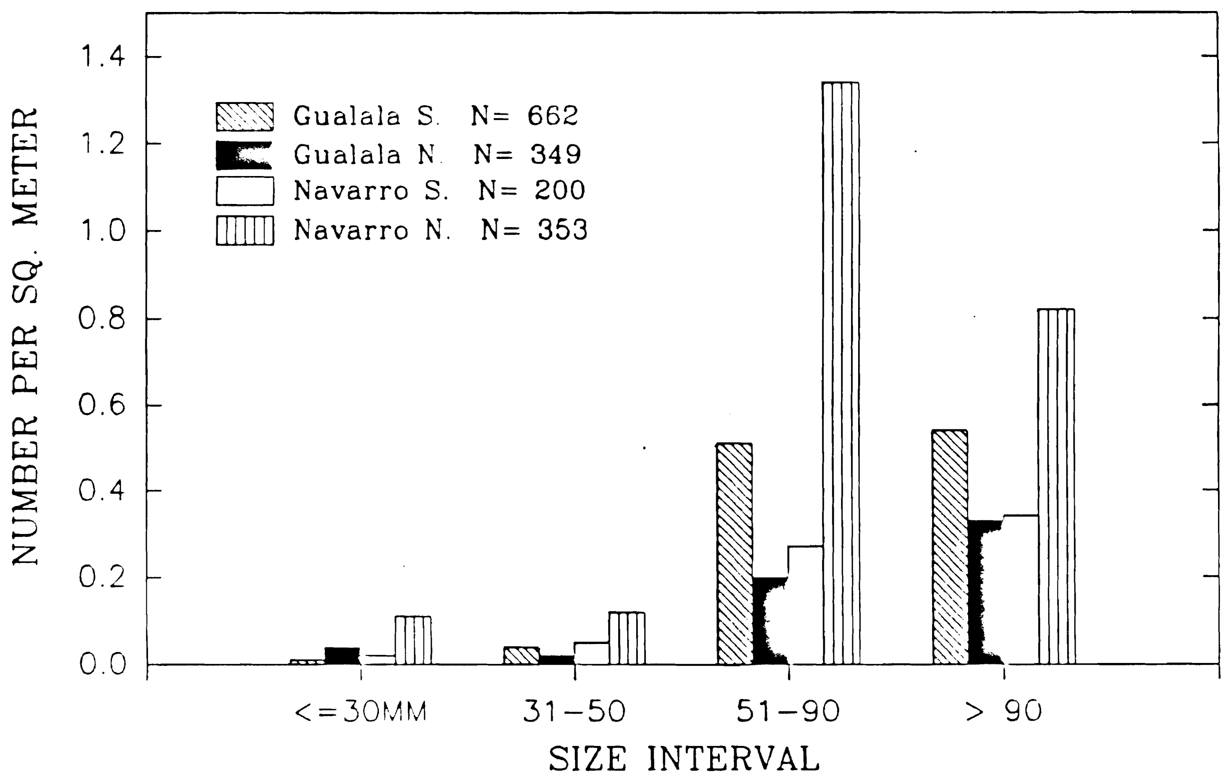

FIGURE 28. Red sea urchin densities by size category for each coastal zone, broad scale survey, 1989.

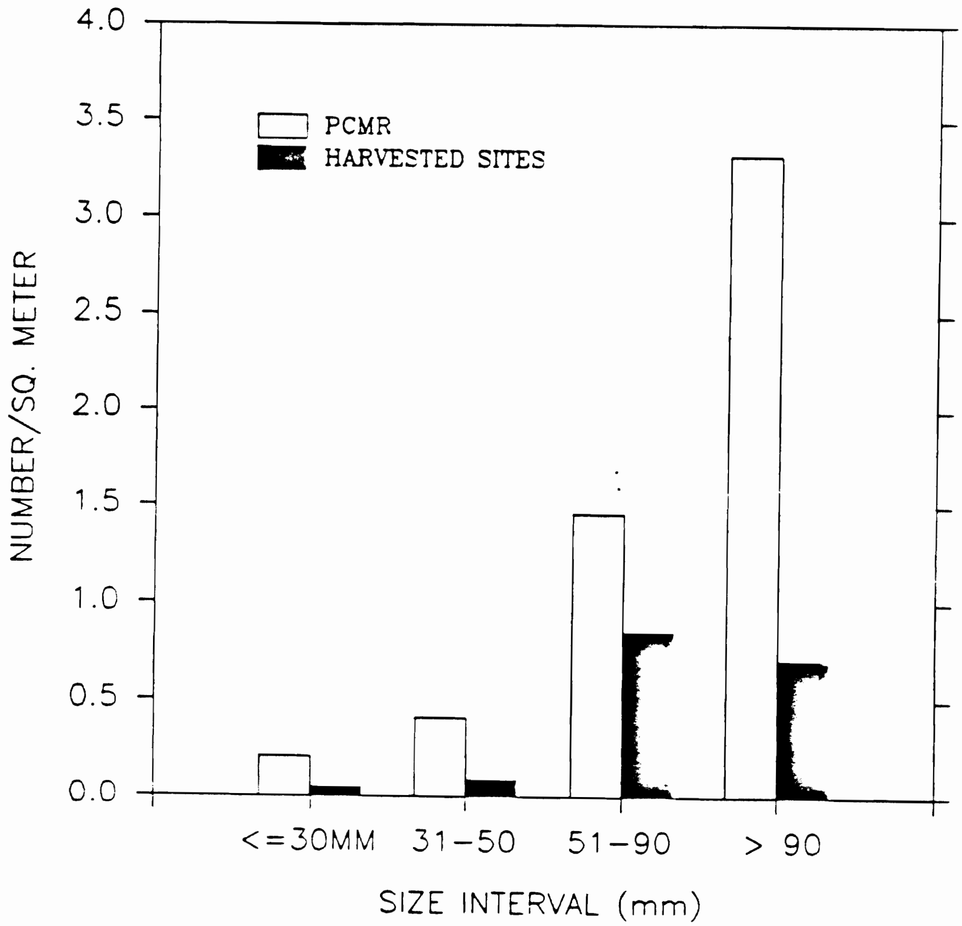

FIGURE 29. Red sea urchin densities by size category for Point Cabrillo Marine Reserve and combined harvested sites, fine scale survey, summer 1989.

TABLE 1. Broad Scale Survey Site Descriptions and Locations, Summer 1989.

Site Number	Description	Depth Zones Surveyed	Approximate Location (Lat./Lon.)	Date
1	Fort Ross Reef	15,35,50	38.30.01 N x 123.13.43 W	07/31/89
2	Timber Cove	15,35,50	38.31.46 N x 123.15.55 W	07/31/89
3	Brown House	15,35,50	38.33.28 N x 123.18.16 W	08/06/89
4	Fisk Mill Cove	15,35,50	38.37.40 N x 123.20.23 W	08/01/89
5	Rocky Point	15,35,50	38.37.57 N x 123.22.53 W	08/02/89
6	S. of Black Pt.	15,35,50	38.40.25 N x 123.24.44 W	08/02/89
7	Sand Beach, Sea R.	15,35,50	38.42.58 N x 123.27.16 W	08/03/89
8	Cypress Pt, Sea R.	15,35,50	38.44.21 N x 123.29.41 W	08/03/89
9	Robinson Reef	15,35,50	38.45.55 N x 123.32.40 W	08/06/89
10	Haven's Neck	15,35,50	38.48.30 N x 123.36.50 W	08/08/89
11	Sail Rock	15,35,50	38.49.55 N x 123.38.30 W	08/08/89
12	Schooner Gulch	15,35,50	38.51.45 N x 123.40.00 W	08/09/89
13	High Bluff	15,35,50	38.53.40 N x 123.41.55 W	08/04/89
14	S. Sea Lion Rocks	15,35,50	38.56.10 N x 123.43.35 W	08/04/89
15	Irish Gulch	15,35	39.01.25 N x 123.42.00 W	08/10/89
16	Bridgeport Landing	15,35,50	39.04.10 N x 123.42.50 W	08/10/89
17	Elk Rock	15,35,50	39.06.30 N x 123.43.30 W	08/11/89
18	Cavanaugh Gulch	15,35,50	39.08.55 N x 123.45.00 W	08/11/89
19	N. Navarro Pt.	15,35,50	39.11.45 N x 123.45.50 W	08/22/89
20	N. Albion Pt.	15,35,50	39.14.10 N x 123.46.50 W	08/22/89
21	Van Damme Hdlnd.	15,35,50	39.16.30 N x 123.48.05 W	08/12/89
22	Jack Peters Creek	15,35,50	39.19.10 N x 123.48.10 W	08/12/89

Table 2. Pairwise Kolmogorov-Smirnov Tests of Observed Red Sea Urchin Size Frequency Distributions by Coastal Zone, Broad Scale Survey, Summer 1989.

Coastal Zones	N	Deviation from Mean at Max	Kolmogorov-Smirnov Test
Point Arena South Pooled A and B	1011	-1.460	KS Statistic 0.062073
Point Arena North Pooled B and C	553	1.974	D = 0.129838
			Critical Value - D 0.0343 (alpha=0.05
	1564		D > Critical D *

Coastal Zones	N	Deviation from Mean at Max	Kolmogorov-Smirnov Test
A Gualala South	662	1.004	KS Statistic 0.053723
B Gualala North	349	-1.382	D = 0.112999
			Critical Value - D 0.0427 (alpha=0.05
	1011		D > Critical D *

Coastal Zones	N	Deviation from Mean at Max	Kolmogorov-Smirnov Test
C Navarro South	200	-1.639	KS Statistic 0.087229
D Navarro North	353	1.234	D = 0.181544
			Critical Value - D 0.0577 (alpha=0.05
	553		D > Critical D *

TABLE 3. Analysis of Variance of Red Sea Test Diameters by Coastal Zone, Including 'A Posteriori' Comparisons, Broad Scale Survey, Summer 1989.

ANOVA

Source of Variation	DF	SS	MS	F	Prob.
Coastal Zone	3	26320	8773.4	13.3722	0.0000
Residual	1560	1023509	656.096		
Total	1563	1049829			

TEST DIAMETER

Coastal Zone	Mean (mm)	SD	N
Gualala South (A)	92	23	662
Gualala North (B)	93	30	349
Navarro South (C)	90	26	200
Navarro North (D)	82	25	353
Total	90	26	1564

Scheffe 'A Posteriori' Test for Groups with Significant Differences

Group One	Group Two	Mean Diff.	Prob. (alpha=0.05)
A	D	9.58	0.0000
B	D	10.70	0.0000
C	D	7.86	0.0075

Table 4. Pairwise Kolmogorov-Smirnov Tests of Observed Red Sea Urchin Size Frequency Distributions by Depth Zone, Broad Scale Survey, Summer 1989.

Depth Zone	N	Kolmogorov-Smirnov Test Deviation from Mean at Max	
15	363	-3.264	KS Statistic 0.151198
35	466	2.881	D = 0.304756
			Critical Value - D 0.0472 alpha=0.05
	829		D > Critical D *

Depth Zone	N	Kolmogorov-Smirnov Test Deviation from Mean at Max	
15	363	-3.973	KS Statistic 0.146564
50	735	2.792	D = 0.311553
			Critical Value - D 0.0410 alpha=0.05
	1098		D > Critical D *

Depth Zone	N	Kolmogorov-Smirnov Test Deviation from Mean at Max	
35	466	0.519	KS Statistic 0.01915
50	735	-0.413	D = 0.039298
			Critical Value - D 0.0392 alpha=0.05
	1201		D = Critical D ns

TABLE 5. Analysis of Variance of Red Sea Urchin Test Diameters by Depth Zone, Including 'A Posteriori' Comparisons, Broad Scale Survey, Summer 1989.

ANOVA

Source of Variation	DF	SS	MS	F	Prob.
Depth Zone	2	85187	42593.6	68.9256	0.0000
Residual	1561	964642	617.964		
Total	1563	1049829			

Cell Means (mm)

Depth Zone	Mean	SD	N
15	103	22	363
35	86	26	466
50	86	26	735
Total	90	26	1564

Scheffe 'A Posteriori' Test for Groups with Significant Differences

Group One	Group Two	Mean Diff.	Prob. (alpha=0.05)
15	35	17.24	0.0000
15	50	17.63	0.0000

TABLE 6. Comparison of Red Sea Urchin Size Categories by Coastal Zone and Depth Zone, Broad Scale Survey, Summer 1989.

		Red Urchin				Red Urchin <=90mm		
			Size Category				Size Category	
Coastal Zone	Site Nos.	N	% 0-30mm	0-50mm	0-90mm	N	% 0-30mm	0-50mm
Gualala South (A)	1 - 8	662	0.8	4.2	50.9	337	1.5	8.3
Gualala North (B)	9 - 14	349	6.6	9.5	43.8	153	15.0	21.6
Navarro South (C)	15 - 18	200	2.5	9.5	50.0	100	5.0	19.0
Navarro North (D)	19 - 22	353	4.5	9.6	66.0	233	6.9	14.6
TOTAL	1 - 22	1564	3.1	7.3	52.6	823	6.0	13.9

	Red Urchin				Red Urchin <=90mm		
		Size Category				Size Category	
Depth Zone (ft)	N	% 0-30mm	0-50mm	0-90mm	N	% 0-30mm	0-50mm
15	363	0.3	1.7	32.2	117	0.9	5.1
35	466	3.2	8.4	60.1	280	5.4	13.9
50	735	4.5	9.4	58.0	426	7.8	16.2
TOTAL	1564	3.1	7.3	52.6	823	6.0	13.9

TABLE 7. Comparison of Red Sea Urchin Raw Counts, Mean Sizes, and Canopy and Non-Canopy Grouped Red Urchins by Site and Coastal Zone, Broad Scale Survey, Summer 1989.

Coastal Zone	Site No.	Depth Zones	No. 30x1m Transects	Urchin Count	Mean Count per sq. m	No. Urch Measured	Mean Size (mm)	% Juvenile+	% Canopy Juvenile	Canopied* No. Urch Measured	Canopied* Mean Size (mm)	Canopied* Juv Urch Measured	Canopied* Juv Mean Size (mm)	Non-Canopied No. Urch Measured	Non-Canopied Mean Size (mm)	Non-Canopied Juv Urch Measured	Non-Canopied Juv Mean Size (mm)
Gualala S	1	15,35,50	5	206	1.4	131	98	3.1	0.0	2	60	1	25	131	98	4	38
	2	15,35,50	6	84	0.5	66	108	1.5	0.0	2	65	1	25	66	108	1	35
	3	15,35,50	4	68	0.6	41	99	0.0	0.0	0	-	0	-	41	99	0	-
	4	15,35,50	3	320	3.6	97	80	5.2	0.0	7	79	3	45	97	80	5	35
	5	15,35,50	5	204	1.4	109	81	9.2	0.9	2	45	1	35	107	82	9	44
	6	15,35,50	5	226	1.5	105	99	1.9	0.0	0	-	0	-	105	99	2	50
	7	15,35,50	5	12	0.1	7	70	14.3	0.0	0	-	0	-	7	70	1	45
	8	15,35,50	4	136	1.1	106	89	4.7	3.4	7	76	3	37	99	90	2	48
Subtotal			37	1256	1.1	662	92	4.2	0.6	20	41	9	37	653	92	24	41
Gualala N	9	15,35,50	7	49	0.2	41	104	2.4	0.0	0	-	0	-	41	104	1	50
	10	15,35,50	4	130	1.1	70	106	2.9	2.9	7	69	3	22	65	109	0	-
	11	15,35,50	4	66	0.6	43	91	11.6	3.3	7	67	4	30	38	94	2	45
	12	15,35,50	5	25	0.2	37	82	16.2	16.2	12	72	6	25	25	87	0	-
	13	15,35,50	4	135	1.1	86	92	12.8	9.8	14	59	9	27	72	99	2	50
	14	15,35,50	5	96	0.6	72	83	11.1	2.8	4	58	2	33	68	84	6	37
Subtotal			29	501	0.6	349	93	9.5	6.3	44	54	24	27	309	97	11	42
Navarro S	15	15,35	5	0	0.0	0	-	0.0	0.0	0	-	0	-	0	-	0	-
	16	15,35,50	3	218	2.4	92	99	5.4	3.3	21	66	9	29	86	102	2	43
	17	15,35,50	4	137	1.1	100	81	14.0	2.0	8	79	3	38	94	81	11	41
	18	15,35,50	6	8	0.0	8	104	0.0	0.0	0	-	0	-	8	104	0	-
Subtotal			18	363	0.7	200	90	9.5	3.0	29	36	12	31	188	91	13	42
Navarro N	19	15,35,50	3	234	2.6	90	85	8.9	8.9	25	59	12	24	75	91	0	-
	20	15,35,50	3	371	4.1	80	78	11.3	5.0	22	50	13	25	72	80	5	34
	21	15,35,50	4	442	3.7	111	81	9.0	4.5	45	60	21	34	99	83	5	46
	22	15,35,50	6	88	0.5	72	87	9.7	4.6	10	62	4	24	62	91	3	43
Subtotal			16	1135	2.4	353	82	9.6	6.3	102	58	50	28	308	86	13	41
TOTALS	22		100	3255	1.1	1564	90	7.3	3.3	195	63	95	29	1458	92	61	41

+ Juveniles are red urchins with test diameter <= 50mm

* Canopied urchins in this column include those encountered after initial random urchin measurements were completed

TABLE 8. **Distribution of Canopied Juvenile Red Sea Urchins by Depth and Coastal Zone, Broad Scale Survey, Summer 1989.**

AREA	N	JUVENILES* n	JUVENILES* mean size (mm)	JUVENILES* % of total	CANOPY JUVENILES n	CANOPY JUVENILES mean size (mm)	CANOPY JUVENILES % of total	CANOPY JUVENILES % of juveniles
All	1564	114	35	7.3	52	28	3.3	45.6
Depth Zone(ft)					relative % by depth			
15					3	35	5.8	
35					20	30	38.5	
50					29	26	55.8	
Coastal Zones					relative % by coastal zone			
Gualala South					4	36	7.7	
Gualala North					22	26	42.3	
Navarro South					6	35	11.5	
Navarro North					21	27	40.4	

* Juveniles are <=50mm test diameter

TABLE 9. Analysis of Variance of Red Sea Urchin Densities by Depth Zone, Including 'A Posteriori' Comparisons, Broad Scale Survey, Summer 1989.

	ANOVA (log transformed densities)				
Source of Variation	DF(1x5m quads)	SS	MS	F	Prob.
Depth Zone	2	21.4698	10.7349	27.5425	0.0000
Residual	597	232.6860	0.3898		
Total	599	254.1550			

	Cell Means (untransformed no./sq.meter)		
Depth Zone	Mean	SD	N (1x5m quads)
15	0.54	1.52	216
35	1.32	3.34	210
50	1.47	1.79	174
Total	1.09	2.41	600

Scheffe Test for Groups with Significant Differences (log transformed)			
Group One	Group Two	Mean Diff.	Prob.
15	35	-0.2054	0.0033
15	50	-0.4720	0.0000
35	50	-0.2665	0.0002

TABLE 10. Analysis of Variance of Red Sea Urchin Densities by Site, Including 'A Posteriori' Comparisons, Broad Scale Survey, Summer 1989.

	ANOVA (log transformed densities)				
Source of Variation	DF(1x5m quads)	SS	MS	F	Prob.
Site	21	74.2009	3.5334	11.3489	0.0000
Residual	578	179.954	0.3113		
Total	599	254.155			

	Cell Means (untransformed number/sq.m)		
Site No.	Mean	SD	N (1x5m quads)
1	1.37	1.18	30
2	0.47	1.10	36
3	0.57	0.90	24
4	3.56	3.07	18
5	1.36	2.26	30
6	1.51	2.07	30
7	0.08	0.25	30
8	1.13	2.06	24
9	0.23	0.83	42
10	1.08	1.95	24
11	0.55	0.89	24
12	0.17	0.36	30
13	1.13	2.03	24
14	0.64	0.92	30
15	0.00	0.00	30
16	2.42	2.70	18
17	1.14	1.19	24
18	0.04	0.14	36
19	2.60	4.76	18
20	4.12	3.89	18
21	3.68	6.51	24
22	0.49	1.60	36
Total	1.09	2.41	600

Scheffe Test for Sites with Significant Differences (log trans.)			
Group One	Group Two	Mean Diff.	Prob.(alpha=0.0005)
4	7	1.21	0.0003
4	9	1.14	0.0003
4	15	1.26	0.0000
4	18	1.23	0.0000
7	20	-1.28	0.0000
9	20	-1.21	0.0000
12	20	-1.22	0.0002
15	20	-1.34	0.0000
18	20	-1.30	0.0000
20	22	1.14	0.0005

Table 11. Substrate and Algae Area and Selected Invertebrates Counts by Site and Depth Zone, Broad Scale Survey, Summer 1989.

SITE	DEP ZONE	SUBSTRATE (% area) bldr	cbl	snd	ALGAE (% area) cpy	scpy	trf	encr	INVERTEBRATES (count/30m2 transect) purps	abs	pycn	urch
1	15	100	0	0	0	0	85	90	0.5	15.5	2.0	20.5
	35	100	0	0	0	5	40	70	0.0	0.0	2.0	37.0
	50	100	0	0	0	0	0	75	0.0	0.0	11.0	64.0
2	15	60	0	40	5	35	25	10	0.5	12.0	1.0	8.5
	35	25	0	0	0	40	50	100	0.0	19.7	0.0	3.7
	50	100	0	0	0	50	50	50	0.0	7.0	3.0	56.0
3	15	95	10	0	5	90	20	20	43.0	21.0	3.0	3.0
	35	50	0	0	0	10	20	30	0.0	25.0	0.5	3.5
	50	90	10	0	0	5	20	100	1.0	0.0	0.0	58.0
4	15	100	0	0	75	60	40	40	5.0	11.0	0.0	83.0
	35	100	0	0	20	50	20	40	3.0	0.0	2.0	192.0
	50	90	10	0	0	0	20	60	0.0	0.0	0.0	45.0
5	15	100	0	0	13	0	78	83	3.0	102.0	3.0	9.0
	35	90	10	0	90	80	60	70	0.0	8.0	2.0	17.0
	50	100	0	0	0	0	50	60	1.5	2.0	0.5	84.5
6	15	98	3	0	15	18	75	90	1.5	42.0	1.5	40.0
	35	100	0	0	80	20	0	60	60.0	10.0	0.0	10.0
	50	100	0	0	0	5	50	50	0.0	0.0	1.0	68.0
7	15	63	0	38	8	8	90	65	0.0	1.0	4.0	0.0
	35	70	0	30	8	30	40	50	0.0	0.0	0.0	0.0
	50	100	0	0	0	5	30	100	0.0	1.0	3.0	12.0
8	15	65	0	35	3	0	80	60	0.0	7.0	1.0	1.0
	35	100	0	0	0	75	50	75	0.0	1.5	2.0	60.0
	50	50	0	50	0	0	10	60	0.0	0.0	1.0	15.0
9	15	100	0	0	5	0	50	90	0.0	5.3	1.7	0.1
	35	95	10	0	70	30	30	30	1.5	13.0	1.0	18.0
	50	85	8	8	0	0	38	90	0.0	0.0	1.0	5.5
10	15	100	10	0	0	0	35	30	95.0	3.0	0.0	93.0
	35	70	18	13	0	0	30	70	1.0	9.0	2.0	5.0
	50	95	0	2	0	25	20	15	0.0	0.0	0.0	27.0
11	15	100	0	0	10	30	75	85	0.0	5.5	0.0	3.0
	35	75	15	10	0	5	35	70	0.0	2.0	1.0	8.0
	50	100	0	0	0	50	70	20	0.0	0.0	0.0	52.0
12	15	100	0	0	10	30	75	85	0.0	2.0	0.0	0.0
	35	95	5	0	5	0	0	100	0.0	11.5	0.0	6.0
	50	80	10	10	0	0	15	80	0.0	0.0	0.0	13.0

Table 11. (Continued)

SITE	DEPTH	ZONE bldr	cbl	snd	cpy	scpy	trf	encr	purps	abs	pycn	urch
		-SUBSTRATE- (% area)			-----ALGAE----- (% area)				----INVERTEBRATES----- (count/30m2 transect)			
		bldr	cbl	snd	cpy	scpy	trf	encr	purps	abs	pycn	urch
13	15	65	35	0	10	20	30	30	0.0	22.0	0.0	1.0
	35	75	25	5	25	25	10	50	0.0	6.0	3.0	22.0
	50	92	5	8	5	70	15	15	0.0	3.5	2.5	56.0
14	15	98	3	0	1	0	35	90	0.0	42.0	0.0	2.0
	35	100	0	0	5	5	50	75	0.0	12.0	2.0	22.0
	50	100	0	0	0	5	10	30	0.5	0.5	0.0	35.0
15	15	65	0	35	0	0	20	65	0.0	0.0	1.5	0.0
	35	92	3	7	3	30	30	47	0.0	0.0	0.7	0.0
16	15	100	0	0	5	10	65	90	0.0	1.0	0.0	88.0
	35	90	10	0	0	5	20	70	1.0	0.0	1.0	98.0
	50	100	0	0	0	20	50	5	0.0	0.0	3.0	32.0
17	15	100	0	0	0	5	50	90	0.0	4.0	15.0	57.0
	35	100	0	0	0	0	60	40	0.0	5.0	1.0	4.0
	50	100	0	0	0	23	10	10	0.0	0.0	1.5	38.0
18	15	85	0	15	0	38	85	80	0.0	0.0	2.0	0.0
	35	95	0	5	0	70	50	40	0.0	2.0	3.0	2.0
	50	70	30	0	0	20	10	60	0.0	0.0	4.0	2.0
19	15	90	10	0	5	10	60	70	0.0	6.0	2.0	10.0
	35	100	0	0	70	10	5	100	8.0	0.0	3.0	201.0
	50	95	0	5	0	10	20	20	3.0	6.0	1.0	23.0
20	15	85	10	5	0	0	80	50	0.0	2.0	2.0	19.0
	35	100	0	0	20	50	50	50	2.0	0.0	2.0	229.0
	50	90	10	0	20	0	2	80	7.0	2.0	4.0	123.0
21	15	53	48	0	15	13	80	73	12.0	5.5	3.0	29.0
	35	100	0	0	0	20	20	70	208.0	11.0	1.0	285.0
	50	100	0	0	5	0	15	85	7.0	0.0	0.0	99.0
22	15	75	23	3	25	5	78	70	0.0	3.5	1.0	1.0
	35	100	0	0	15	0	0	80	0.0	3.0	1.0	31.5
	50	50	20	30	30	25	18	10	0.0	3.5	0.5	11.5

TABLE 12. Test Diameter and Percentage of Red Urchin Juveniles by Study Site and Depth Zone, Fine Scale Survey, Spring 1989.

Site	N	Size (mm) Mean	Size (mm) Range	One Year Old <= 30 mm %	One Year Old <= 30 mm n	Juvenile* <= 50 mm %	Juvenile* <= 50 mm n
All Sites	826	83	5-160	5.6	46	14.8	122
Depth (ft)							
15	258	87	5-140	1.9	16	3.3	27
35	329	82	5-160	3.4	28	6.7	55
50	239	80	20-155	0.2	2	4.8	40
Point Cabrillo Reserve	375	86	5-160	8.8	33	17.1	64
15	124	85	15-140	3.2	12	5.3	20
35	156	87	5-160	5.3	20	7.5	28
50	95	85	20-145	0.3	1	4.3	16
Harvested Sites**	451	81	5-155	2.9	13	12.9	58
15	134	89	5-135	0.9	4	1.6	7
35	173	78	15-135	1.8	8	6.0	27
50	144	76	20-155	0.2	1	5.3	24
Caspar Closure Area	228	78	10-155	3.5	8	18.0	41
15	67	88	10-135	1.3	3	2.2	5
35	98	71	15-125	1.8	4	8.8	20
50	63	77	20-155	0.4	1	7.0	16
Headland(H)	203	83	5-135	2.5	5	10.8	22
Cove(C)	248	78	10-155	3.2	8	14.5	36
Individual Sites							
Laguna Pt(H)	88	84					
Hare Crk(H)	49	94					
N.Caspar(C)	54	73					
S.Caspar(C)	162	79					
S.Casp.Pt(H)	66	75					
Van Damme(C)	32	84					

* Juvenile category includes one year olds
** Includes Caspar Closure Area

TABLE 13. Test Diameter and Percentage of Red Urchin Juveniles by Study Site and Depth Zone, Fine Scale Survey, Summer 1989.

		Size (mm)		One Year Old <= 30 mm		Juvenile* <= 50 mm	
Site	N	Mean	Range	%	n	%	n
All Sites	1379	89	5-150	3.4	47	9.4	130
Depth (ft)							
15	577	94	5-150	2.6	15	6.1	35
35	522	86	15-150	3.6	19	10.9	57
50	280	86	10-150	4.6	13	13.6	38
Point Cabrillo Reserve	493	94	5-150	3.9	19	11.4	56
15	170	93	5-145	6.5	11	12.9	22
35	197	94	15-145	1.5	3	7.1	14
50	126	96	15-150	4.0	5	15.9	20
Harvested Sites**	886	86	10-150	3.2	28	8.3	74
15	407	94	30-150	1.0	4	3.2	13
35	325	81	15-150	4.9	16	13.2	43
50	154	79	10-135	5.2	8	11.7	18
Caspar Closure Zone	433	86	15-135	2.3	10	8.1	35
15	208	91	30-135	1.9	4	5.3	11
35	183	81	15-135	3.3	6	12.0	22
50	42	79	35-115	0.0	0	4.8	2
Headland(H)	641	87	10-150	3.9	25	10.0	64
Cove(C)	245	86	20-135	1.2	3	4.1	10
Individual Sites							
Laguna Pt(H)	88	83	20-150				
Noyo Bay(C)	59	90	50-125				
Hare Crk(H)	76	91	15-130				
MitchelPt(H)	107	96	10-150				
N/SCasp.(C)	186	84	20-135				
S.Casp.Pt(H)	370	84	15-135				

* Juvenile category includes one year olds
** includes Caspar Closure Zone

TABLE 14. Distribution of Canopied Juvenile Red Sea Urchins by Depth Zone, and within Combined Harvested Sites and Point Cabrillo Marine Reserve by Depth Zone, Fine Scale Survey, Spring 1989.

SITE	N	JUVENILES* n	JUVENILES* mean size (mm)	JUVENILES* % of total	CANOPY JUVENILES % of juvs.	CANOPY JUVENILES n	CANOPY JUVENILES mean size (mm)	CANOPY JUVENILES % of total
All Sites	826	122	35	14.8	41.8	51	28	6.1
Depth (ft)								
15		27	30	3.3		14	21	1.7
35		55	33	6.7		29	27	3.5
50		40	42	4.8		8	41	1.0
Harvested Sites**	451	58	37	12.9	32.8	19	32	4.2
Depth (ft)								
15		7	25	1.6		5	19	1.1
35		27	37	6.0		7	31	1.6
50		24	41	5.3		7	44	1.6
PCMR	375	64	34	17.1	50.0	32	25	8.5
Depth (ft)								
15		20	32	5.3		9	23	2.4
35		28	29	7.5		22	26	5.9
50		16	44	4.3		1	20	0.3
Caspar Closure Zone	228	41	37	18.0	24.4	10	31	4.4
Depth (ft)								
15		5	26	2.2		3	17	1.3
35		20	38	8.8		3	30	1.3
50		16	40	7.0		4	43	1.8

* Juveniles are <=50mm test diameter
** Includes Caspar Closure Zone

TABLE 15. Distribution of Canopied Juvenile Red Sea Urchins by Depth Zone, amd within Combined Harvested Sites and Point Cabrillo Marine Reserve by Depth Zone, Fine Scale Survey, Summer 1989.

SITE	N	JUVENILES*						
		n	mean size (mm)	% of total	CANOPY JUVENILES			
					% of juvs.	n	mean size (mm)	% of total
All Sites	1379	130	36	9.4	62.3	81	31	5.9
Depth (ft)								
15		35	36	2.5		24	32	1.7
35		57	38	4.1		32	32	2.3
50		38	35	2.8		25	30	1.8
Harvested Sites**	886	74	37	8.3	66.2	49	32	5.5
Depth (ft)								
15		13	41	1.5		7	39	0.8
35		43	37	4.9		29	33	3.3
50		18	33	2.0		13	27	1.5
PCMR	493	56	94	11.4	57.1	32	31	6.5
Depth (ft)								
15		22	33	4.5		17	29	3.5
35		14	40	2.8		3	30	0.6
50		20	37	4.1		12	33	2.4
Caspar Closure Zone	433	35	39	8.1	57.1	20	36	4.6
Depth (ft)								
15		11	41	2.5		6	39	1.4
35		22	39	5.1		13	34	3.0
50		2	43	0.5		1	35	0.2

* Juveniles are <=50mm test diameter
** Includes Caspar Closure Zone

TABLE 16. Red Sea Urchin Densities (number per sq. meter) by Site and Depth Zone, Fine Scale Survey, Summer 1989.

Site	Depth Zone (ft)	No. of 1mx5m Quads	Mean Density	SD
All Sites		432	2.6	4.1
Point Cabrillo Reserve		102	5.4	5.8
	15	42	2.9	5.2
	35	36	7.6	5.8
	50	24	6.6	5.2
Subsites				
201,210,211-North Cove		24	6.9	7.3
202-South		24	4.3	4.5
204-Reef Pool		18	4.6	5.6
205-Maytag		18	5.7	6.5
206-Inner Surge Channel		6	4.8	3.3
207,208-Outer Surge Chanel		12	6.1	4.8
Harvested Sites		210	1.7	3.0
	15	90	1.1	1.5
	35	66	2.9	3.7
	50	54	1.1	3.5
Laguna Pt		36	0.5	0.8
Noyo Bay		18	1.4	2.3
Hare Creek		30	0.4	1.6
Mitchell Pt		30	0.9	1.2
N. Caspar Cove		24	2.8	4.7
Caspar Closure Zone		102	2.3	3.2
Subsites				
301-North		30	3.0	4.0
302-West		24	3.7	3.7
305-Caspar Pool		24	1.8	2.0
306-Steamer Pt		24	0.6	1.3

TABLE 17. Red Sea Urchin Densities (number per sq. meter) by Site and Depth Zone, Fine Scale Survey, Spring 1989.

Site	Depth Zone (ft)	No. of 1mx5m Quads	Mean Density	SD
All Sites		226	3.5	5.5
Point Cabrillo Reserve		70	7.8	7.3
	15	24	7.7	7.3
	35	30	8.3	7.8
	50	16	6.9	6.4
Subsites				
201,210,211-North Cove		18	12.5	10.0
202-South		0	-	-
204-Reef Pool		30	4.9	4.0
205-Maytag		0	-	-
206-Inner Surge Channel		6	8.5	6.8
207-Outer Surge Channel		12	8.2	6.3
208-Slot		4	6.3	7.7
Harvested Sites		156	1.5	2.8
	15	48	2.3	3.9
	35	72	1.0	2.1
	50	36	1.4	1.5
Laguna Pt		30	0.9	1.2
Noyo Bay		0	-	-
Hare Creek		24	0.6	1.3
Mitchell Pt		0	-	-
N. Caspar Cove		18	1.4	2.2
Caspar Closure Zone		72	2.1	3.5
Subsites				
301-North		0	-	-
302-West		12	7.1	4.2
305-Caspar Pool		0	-	-
306-Steamer Pt		60	1.2	2.4
Van Damme		12	1.3	2.6

TABLE 18. Analysis of Variance of Log Transformed Red Sea Urchin Densities, by Depth Zone from Point Cabrillo Marine Reserve, Fine Scale Survey, Summer 1989.

ANOVA (log transformed densities)

Source of Variation	DF(1x5m quads)	SS	MS	F	Prob.
Depth Zone	2	24.720	12.357	14.943	0.0000
Residual	99	81.886	0.827		
Total	101	106.605			

Cell Means (untransformed number/sq.m)

Depth Zone	Mean	SD	N (1x5m quads)
15	2.9	5.2	42
35	7.6	5.8	36
50	6.6	5.2	24

Scheffe Test for Groups with Significant Differences (log transformed)

Group one	Group two	Mean Diff.	Prob. (alpha=0.05)
15	35	-1.02	0.0000
15	50	-0.97	0.0003

TABLE 19. Analysis of Variance of Log Transformed Red Sea Urchin Densities, by Depth Zone from Combines Harvested Sites, Fine Scale Survey, Summer 1989.

ANOVA (log transformed densities)

Source of Variation	DF(1x5m quads)	SS	MS	F	Prob.
Depth Zone	2	13.703	6.852	13.095	0.0000
Residual	207	108.312	0.523		
Total	209	122.015			

Cell Means (untransformed number/sq.m)

Depth Zone	Mean	SD	N (1x5m quads)
15	1.1	1.5	90
35	2.9	3.7	66
50	1.1	3.5	54

Scheffe Test for Groups with Significant Differences (log transformed)

Group one	Group two	Mean Diff.	Prob. (alpha=0.05)
15	35	-0.42	0.0018
35	50	0.66	0.0000

TABLE 20. Analysis of Variance of Log Transformed Red Sea Urchin Densities, by Depth Zone from Point Cabrillo Marine Reserve, Fine Scale Survey, Spring 1989.

ANOVA (log transformed densities)

Source of Variation	DF(1x5m quads)	SS	MS	F	Prob.
Depth Zone	2	0.520	0.260	0.282	0.7550
Residual	67	61.758	0.922		
Total	69	62.2784			

Cell Means (untransformed number/sq.m)

Depth Zone	Mean	SD	N (1x5m quads)
15	7.7	7.3	24
35	8.4	7.8	30
50	6.9	6.4	16

TABLE 21. Analysis of Variance of Log Transformed Red Sea Urchin Densities, by Depth Zone from Combined Harvested Sites, Fine Scale Survey, Spring 1989.

ANOVA (log transformed densities)

Source of Variation	DF(1x5m quads)	SS	MS	F	Prob.
Depth Zone	2	3.389	1.694	3.114	0.0473
Residual	153	83.252	0.544		
Total	155	86.641			

Cell Means (untransformed number/sq.m)

Depth Zone	Mean	SD	N (1x5m quads)
15	2.3	3.9	48
35	1.0	2.1	72
50	1.4	1.5	36

TABLE 22. Analysis of Variance of Log Transformed Red Sea Urchin Densities, by Site, Fine Scale Survey, Summer 1989.

ANOVA (log transformed densities)

Source of Variation	DF(1x5m quads)	SS	MS	F	Prob.
Site	6	59.996	9.999	15.1511	0.0000
Residual	335	221.093	0.660		
Total	341	281.089			

Cell Means (untransformed number/sq.m)

Site	Mean	SD	N (1x5m quads)
1-Pt Cabrillo	5.4	5.8	102
2-S Caspar	2.3	3.2	102
3-N Caspar	2.8	4.7	24
4-Mitchell Pt	0.9	1.2	30
5-Hare Creek	0.4	1.6	30
6-Noyo Bay	1.4	2.3	18
7-Laguna Pt	0.5	0.8	36

Scheffe Test for Groups with Significant Differences (log transformed)

Group one	Group two	Mean Diff.	Prob. (alpha=0.05)
1	2	0.55	0.0008
1	4	0.92	0.0000
1	5	1.22	0.0000
1	6	0.87	0.0083
1	7	1.07	0.0000
2	5	0.66	0.0188

TABLE 23. Substrate and Algae Area and Selected Invertebrates Counts by Site and Depth Zone, Fine Scale Survey, Summer 1989.

SITE*	DEPTH ZONE	NUMBR TRANS	|-SUBSTRATE-| (% area)			|-----ALGAE-----| (% area)				|-----INVERTEBRATES---| (count/30m2 transect)			
			bldr	cbl	snd	cpy	scpy	trf	encr	purps	abs	pycn	urch
1	15	7	96	4	0	4	11	52	51	59.4	18.9	3.3	87.2
	35	6	89	9	2	15	14	15	73	42.7	11.2	2.3	227.8
	50	4	91	4	5	0	3	28	53	8.8	68.0	1.8	199.3
2	15	8	73	28	0	4	9	77	59	7.4	2.1	2.0	47.1
	35	6	92	4	4	17	20	32	67	0.3	4.8	2.2	110.2
	50	3	83	7	10	8	5	33	77	0.0	0.7	1.3	42.3
3	15	2	90	10	0	5	10	55	55	0.0	5.0	1.0	12.5
	35	1	100	0	0	20	0	50	100	0.0	0.0	1.0	122.0
	50	1	80	10	10	10	40	30	30	0.0	0.0	3.0	133.0
4	15	2	45	55	0	5	18	55	40	0.5	1.0	3.0	37.5
	35	1	100	0	0	10	0	20	100	0.0	0.0	2.0	7.0
	50	2	100	0	0	5	60	30	30	0.0	0.0	0.0	25.5
5	15	2	95	5	0	10	0	85	80	0.5	0.0	0.5	5.0
	35	1	100	0	0	10	0	20	100	0.0	6.0	3.0	43.0
	50	2	80	0	20	0	75	30	40	0.0	5.5	2.0	6.0
6	15	1	90	10	0	0	10	60	50	0.0	7.0	0.0	0.0
	35	1	95	0	5	10	20	20	100	0.0	5.0	2.0	91.0
	50	1	85	5	10	20	75	30	30	0.0	3.0	0.0	31.0
7	15	2	55	45	0	0	10	73	50	0.0	7.5	1.5	24.0
	35	2	100	0	0	5	35	35	30	0.5	2.0	2.0	22.0
	50	2	90	0	10	20	0	30	90	0.0	0.0	2.0	2.0

*1=PCMR,2=S.Caspar,3=N.Caspar,4=Mitchell Pt,5=Hare Crk,6=Noyo,7=Laguna P

TABLE 24. Substrate and Algae Area and Selected Invertebrates Counts by Site and Depth Zone, Fine Scale Survey, Spring 1989.

SITE *	DEPTH	ZONE	NUMBRS	TRANS	SUBSTRATE (% area) bldr	cbl	snd	ALGAE (% area) cpy	scpy	trf	encr	INVERTEBRATES (count per 30m2 transect) purps	abs	pycn	urch
1	15		1		60	40	0	20	15	70	55	0.0	3.0	0.0	1.0
	35		1		40	10	50	1	0	50	45	6.0	10.0	0.0	75.0
2	15		4		93	8	0	1	3	16	90	23.8	6.5	1.5	231.8
	35		5		94	6	1	3	0	3	54	25.0	4.5	4.6	250.0
	50		3		88	7	5	0	0	8	48	14.0	19.0	4.3	184.7
3	15		4		88	11	1	1	8	15	85	2.0	14.0	6.0	100.8
	35		6		79	8	12	2	13	14	64	2.2	3.2	1.7	38.5
	50		2		95	0	8	0	0	10	10	1.5	1.0	0.0	68.0
4	15		1		90	10	0	20	15	10	60	8.0	5.0	4.0	77.0
	35		1		85	15	0	5	0	0	85	0.0	30.0	1.0	0.0
	50		1		100	0	0	5	0	0	0	0.0	3.0	1.0	48.0
5	15		1		100	0	0	1	0	30	100	1.0	4.0	2.0	51.0
	35		2		95	0	5	3	5	70	65	0.0	8.0	1.0	10.5
	50		1		100	0	0	5	15	15	100	0.0	1.0	3.0	0.0
6	15		1		100	0	0	0	0	35	100	0.0	0.0	5.0	21.0
	35		2		100	0	0	5	5	15	100	2.5	0.5	3.5	24.0
	50		2		100	0	0	3	0	0	45	0.0	0.0	3.0	35.5

* 1=Van Damme, 2=PCMR, 3=S.Caspar, 4-N.Caspar, 5=Hare Crk, 6=Laguna Pt

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APPENDIX A

TRANSECT DATA FROM BROAD SCALE SURVEY SITES, SUMMER 1989

Explanation of Transect Data Display Format

Transect Counts: 'a' and 'b' are counts for each transect side by 5 meter segments.

Red Urchin Measurements (mm): Test diameters for approximately first 30 red urchins, classified as random solitary (S), canopy adult (CA) and canopy juvenile (CJ). Asterisk signifies CA or CJ as randomly encountered.

DATE: 07/31/89
LOCATION: Fort Ross Reef
SITE NO: 1

TRANSECT COUNTS

DEPTH ZONE(FT)

QUADRATS (1mx5m)

	15						35			50					
	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	8	7	15	12	9	21	11	5	16
6-10	0	0	0	0	2	2	5	1	6	3	4	7	0	6	6
11-15	3	1	4	2	7	9	6	2	8	6	6	12	8	0	8
16-20	2	6	8	2	1	3	4	3	7	7	9	16	8	7	15
21-25	0	1	1	1	5	6	1	0	1	1	0	1	5	0	5
26-30	0	0	0	2	6	8	0	0	0	5	11	16	2	3	5
			---			---			---			---			---
			13			28			37			73			75

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
90	-	-	35	-	-	15	-	-	50	-	-	60	95	25
90			75			50			55			60		
105			85			65			65			70		
105			90			65			70			70		
110			90			70			75			75		
115			90			80			80			75		
115			90			80			80			80		
120			95			90			80			85		
125			95			90			80			85		
140			95			90			100			85		
			95			90			100			85		
			95			90			100			85		
			100			95			100			85		
			100			95			100			90		
			100			100			105			90		
			105			100			105			90		
			110			100			105			95		
			110			100			105			95		
			115			100			105			95		
			120			105			110			95		
			120			105			110			100		
			120			110			110			105		
			125			110			115			105		
			125			110			115			105		
			125			110			115			105		
			130			110			125			105		
			130			110			125			110		
			130			110			125			110		
			130			110						115		
			135			110								
			140			110								

DATE: 07/31/89
LOCATION: Timber Cove
SITE NO: 2

TRANSECT COUNTS

DEPTH ZONE(FT)

QUADRATS (1mx5m)

	15						35									50		
	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
6-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3
11-15	0	8	8	0	0	0	0	0	0	0	0	0	0	0	0	5	6	11
16-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	7	23
21-25	0	0	0	0	0	0	0	0	0	0	0	0	0	11	11	18	0	18
26-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			---			---			---			---			---			---
			17			0			0			0			11			56

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
35	-	-	-	-	-	-	-	-	-	-	-	60	-	-	75	105	25
80												70			80		
90												80			80		
95												85			80		
95												100			90		
100												100			90		
105												105			95		
110												105			100		
110															100		
115															105		
115															105		
115															105		
120															110		
120															110		
120															110		
120															110		
120															115		
125															115		
125															115		
125															115		
125															120		
125															120		
130															120		
130															120		
135															120		
															120		
															120		
															125		
															125		
															125		
															130		
															130		

DATE: 08/06/89
LOCATION: Brown House
SITE NO: 3

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS
(1mx5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	3	3	2	0	2	0	0	0	2	7	9
6-10	0	0	0	3	0	3	0	0	0	6	2	8
11-15	0	0	0	1	0	1	0	0	0	4	3	7
16-20	0	0	0	0	0	0	0	0	0	10	0	10
21-25	0	0	0	0	0	0	0	0	0	6	1	7
26-30	0	0	0	1	0	1	0	0	0	9	8	17
			---			---			---			---
			3			7			0			58

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	S	CA	CJ
70	55	15	95	-	-	-	-	-	75	135	-	-
70	120	35	95						75	140		
70		35							75			
80		30							85			
80									85			
90									85			
									90			
									95			
									95			
									95			
									95			
									95			
									95			
									95			
									105			
									105			
									110			
									115			
									115			
									115			
									115			
									120			
									120			
									120			
									120			
									125			
									125			
									130			
									135			

DATE: 08/01/89
LOCATION: Fisk Mill Cove
SITE NO: 4

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS
(1mx5m)

	a	b	tot	a	b	tot	a	b	tot
0-5	2	24	26	13	24	37	3	9	12
6-10	28	0	28	17	39	56	5	1	6
11-15	29	0	29	0	31	31	4	5	9
16-20	0	0	0	6	20	26	1	3	4
21-25	0	0	0	2	19	21	5	1	6
26-30	0	0	0	9	12	21	2	5	7
			---			---			---
			83			192			44

RED URCHIN MEASUREMENTS (mm)

S	S	CA	CJ	S	S	CA	CJ	S	S	CA	CJ
50	115	140	50	40	95	-	-	20	95	-	-
55	120	80	45	55	100			30			
60		95	202	60	100			35			
65		100		60	100			55			
70				65	109			60			
70				70	105			60			
80				70	115			65			
80				70				65			
80				75				65			
80				75				70			
80				75				70			
80				75				70			
80				75				70			
85				80				70			
85				80				75			
85				80				80			
85				80				80			
85				85				80			
90				85				80			
90				85				80			
90				85				85			
90				90				85			
90				90				85			
90				90				85			
90				90				90			
100				90				90			
100				90				90			
100				95				90			
100				95				95			

DATE: 08/02/89
LOCATION: Rocky Point
SITE NO: 5

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS (1mx5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	14	2	16	2	4	6	33	21	54
6-10	0	0	0	0	1	1	0	0	0	3	2	5	14	17	31
11-15	3	0	3	8	1	9	0	0	0	2	8	10	5	12	17
16-20	0	0	0	5	0	5	1	0	1	4	5	9	1	6	7
21-25	0	0	0	0	0	0	0	0	0	1	3	4	3	9	12
26-30	0	0	0	0	0	0	0	0	0	1	5	6	3	5	8
			---			---			---			---			---
			3			15			17			40			129

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	S	CA	CJ	S	S	CA	CJ
70	-	-	80	-	-	25	-	-	45	95	55*	35*	55	120	-	-
90			90			40			45	95			55	130		
95			100			40			55	100			55			
100			100			50			55	110			65			
			105			50			60	115			65			
			105			50			60	115			70			
			120			50			45	120			70			
			125			55			50	125			70			
			130			55			50				70			
			135			55			65				70			
						60			65				75			
						60			70				75			
						60			70				75			
						60			70				80			
						65			70				80			
						75			70				80			
						80			70				80			
						80			75				80			
						80			75				80			
						85			75				85			
						85			75				85			
						85			75				85			
						90			80				90			
						100			80				100			
						100			80				105			
						100			80				115			
						120			80				115			
						140			85				115			
									90				120			

DATE: 08/02/89
LOCATION: S. Black Point
SITE NO: 6

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS (1mx5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	2	6	8	0	0	0	0	6	6	12	16	28	7	9	16
6-10	21	0	21	0	0	0	0	0	0	1	1	2	7	4	11
11-15	0	2	2	0	0	0	0	0	0	9	14	23	3	1	4
16-20	0	0	0	0	0	0	2	2	4	8	5	13	8	4	12
21-25	0	5	5	0	0	0	0	0	0	4	5	9	1	3	4
26-30	23	21	44	0	0	0	0	0	0	0	1	1	7	6	13
			---			---			---			---			---
			80			0			10			76			60

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	S	CA	CJ	S	S	CA	CJ
85	-	-	100	-	-	75	-	-	50	115	-	-	55	115	-	-
90						80			50	115			60	115		
95						95			55				60			
95						100			60				60			
100						100			65				70			
100						105			65				70			
100						120			70				70			
105						120			70				70			
105						120			75				70			
110						135			80				80			
120									80				85			
120									80				85			
125									80				85			
125									80				90			
125									85				90			
125									90				90			
125									90				90			
130									95				100			
130									95				100			
130									95				100			
130									95				100			
130									95				105			
130									95				105			
130									100				105			
135									100				105			
135									100				105			
140									110				105			
145									110				105			
155									110				110			
									115				110			

DATE: 08/03/89
LOCATION: Sand Beach, Sea Ranch
SITE NO: 7

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS (1mx5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6-10	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5
11-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-25	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3
26-30	0	0	0	0	0	0	0	0	0	0	0	0	4	0	4
			---			---			---			---			---
			0			0			0			0			12

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
-	-	-	-	-	-	-	-	-	-	-	-	45	-	-
												55		
												60		
												70		
												70		
												85		
												105		

DATE: 08/03/89
LOCATION: Cypress Point, Sea Ranch
SITE NO: 8

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	13	4	17	0	3	3	5	0	5
6-10	0	0	0	0	0	0	1	4	5	0	2	2
11-15	1	0	1	0	0	0	3	11	14	2	0	2
16-20	0	0	0	0	46	46	18	0	18	0	0	0
21-25	0	0	0	0	4	4	0	0	0	1	0	1
26-30	0	0	0	0	0	0	0	13	13	5	0	5
			---			---			---			---
			1			67			53			15

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	S	CA	CJ	S	CA	CJ	S	CA	CJ
70	-	-	65	110	65*	35*	5	140*	30*	45	-	-
85			65	110	110*	45*	65			50		
90			65	110	110*		65			55		
110			70	110			65			60		
125			70	120			65			60		
125			75	135			65			60		
135			80				70			65		
135			80				70			75		
135			80				70			75		
135			85				70			75		
140			85				70			80		
140			85				70			80		
			85				75			80		
			85				75			80		
			85				80			80		
			90				80			85		
			90				80			95		
			95				80			100		
			95				80			105		
			95				80			110		
			95				95			110		
			100				100			110		
			100				100			115		
			100				105			115		
			100				115			140		
			100				115					
			105				120					
			105									
			110									

TE: 08/06/88
CATION: Robinson Reef
TE NO: 9

ANSECT COUNTS

PTH ZONE(FT) 15 35 50

JADRATS
1mx5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
6-10	0	0	0	1	0	1	0	0	0	0	0	0	4	0	4	0	0	0	0	0	0
11-15	0	0	0	0	0	0	0	0	0	0	0	0	26	0	26	7	0	7	0	0	0
16-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0
21-25	0	0	0	0	0	0	0	0	0	1	0	1	1	1	2	1	0	1	0	0	0
26-30	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0
			---			---			---			---			---			---			---
			0			1			1			4			32			11			0

ED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
-	-	-	115	-	-	88	-	-	50	-	-	55	-	-	80	-	-	-	-	-
									100			65			80					
									120			70			105					
									125			80			115					
									90			80			115					
									90			80			125					
									95			80			125					
									100			80			130					
									100			85			135					
									100			85			145					
									105			90			145					
									110			90								
									125			105								
									125			105								
												105								
												110								
												110								
												120								
												125								
												125								
												125								
												125								
												135								
												135								

DATE: 08/08/89
LOCATION: Ravens Neck
SITE NO: 10

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35

QUADRATS
(1mx5m)

	a	b	tot	a	b	tot	a	b	tot
0-5	7	5	12	0	0	0	0	7	7
6-10	1	0	1	0	0	0	0	0	0
11-15	2	0	2	0	0	0	0	0	0
16-20	3	15	18	0	0	0	0	0	0
21-25	20	5	25	0	0	0	3	0	3
26-30	8	27	35	0	0	0	0	0	0
			---			---			---
			93			0			10

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ
90	125	25	-	-	-	55	70*	15*
100						70	110*	25*
100						90	115*	
105						90		
105						105		
110						115		
110						120		
115						120		
115						125		
115						125		
120						130		
120								
120								
120								
120								
125								
125								
125								
125								
125								
130								
130								
130								
135								
135								
140								
140								
140								
140								

DATE: 08/08/89
LOCATION: Sail Rock
SITE NO: 11

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS (1mx5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	1	1	3	0	3	5	5	10
6-10	2	0	2	0	0	0	0	0	0	4	1	5
11-15	0	0	0	0	0	0	0	0	0	7	6	13
16-20	0	0	0	0	0	0	4	0	4	2	5	7
21-25	0	0	0	0	0	0	0	0	0	0	1	1
26-30	2	1	3	0	0	0	1	0	1	5	11	16
			---			---			---			---
			5			1			8			52

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
80	-	-	-	-	-	75	110*	30*	40	115	40
125						95	125*	25*	50		
						100		25*	60		
						105			65		
									65		
									75		
									80		
									80		
									85		
									90		
									95		
									95		
									95		
									95		
									100		
									100		
									100		
									105		
									105		
									105		
									105		
									105		
									105		
									110		
									110		
									110		
									110		
									110		
									110		
									110		
									115		
									115		

DATE: 08/09/89
LOCATION: Schooner Gulch
SITE NO: 12

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS (1mx5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	2	1	3	0	2	2	8	0	8
6-10	0	0	0	0	0	0	1	0	1	3	0	3	0	0	0
11-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-20	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5
21-25	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
26-30	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0
			---			---			---			---			---
			0			0			4			8			13

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
-	-	-	135	-	-	70	105*	25*	60	110*	30*	60	125*	20*
			135			80			70			60	115*	25*
						80			75			60	130*	25*
						110			90			60	125*	25*
									95			65		
									95			70		
									100			75		
									100			100		
									100			105		
												130		

DATE: 08/04/89
LOCATION: High Bluffs
SITE NO: 13

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS (1mx5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	0	2	2	0	0	0
6-10	0	0	0	0	0	0	6	3	9	31	17	48
11-15	1	0	1	0	0	0	0	0	0	4	3	7
16-20	0	0	0	3	6	9	0	6	6	0	13	13
21-25	0	0	0	0	11	11	3	4	7	1	13	14
26-30	0	0	0	0	2	2	6	0	6	0	0	0
			---			---			---			---
			1			22			30			82

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
85	-	-	75	-	-	50	115*	20*	55	75*	40*
105			100			50	120*	25*	55	135*	25*
			100			60		25*	65	130*	30*
			100			60		25*	70		25*
			100			70			75		30*
			105			70			75		
			110			70			75		
			110			70			75		
			110			70			75		
			110			70			80		
			115			80			80		
			120			80			85		
			120			90			85		
			130			90			85		
			130			90			100		
			130			95			100		
			135			95			105		
			135			110			105		
			140			110			110		
			140			120			115		
			150			120			120		
			150			120			120		
			160			130			130		
						135					

DATE: 08/04/89
LOCATION: Sea Lion Rock
SITE NO: 14

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS (1mx5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	1	1	4	0	4	5	2	7
6-10	0	0	0	0	1	1	0	0	0	8	10	18
11-15	0	0	0	0	1	1	3	10	13	6	5	11
16-20	1	0	1	0	0	0	0	0	0	3	2	5
21-25	0	0	0	0	0	0	0	0	0	0	1	1
26-30	0	0.	0	0	0	0	0	5	5	0	0	0
			---			---			---			---
			1			3			22			42

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	S	CA	CJ
100	-	-	140	-	-	40	-	-	25	125	80*	20*
140						45			30	125		
						50			30			
						55			65			
						55			70			
						55			75			
						55			75			
						60			80			
						60			80			
						60			80			
						65			80			
						65			80			
						75			85			
						75			85			
						75			85			
									85			
									85			
									90			
									105			
									105			
									105			
									105			
									105			
									105			
									105			
									105			
									110			
									110			
									110			
									115			

DATE: 08/10/89
LOCATION: Irish Gulch
SITE NO: 15

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35

QUADRATS
(1mx5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			---			---			---			---			---
			0			0			0			0			0

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

DATE: 08/10/89
LOCATION: Bridgeport Landing
SITE NO: 16

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS
(1mx5m)

	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	6	8	14	0	1	1
6-10	0	5	5	7	9	16	1	0	1
11-15	0	0	0	3	6	9	4	1	5
16-20	0	4	4	10	9	19	0	0	0
21-25	34	20	54	12	11	23	17	3	20
26-30	5	20	25	9	8	17	4	1	5
			---			---			---
			88			98			32

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ
55	110	70	65	75*	25*	40	120*	25*
60	120		65	125	25	75	110*	50*
70			70	50	20	60	90	30
70			95	75	20	70		
75			95	75	40	70		
75			100	110	25	85		
85			100			90		
90			100			90		
90			100			90		
90			100			90		
90			105			95		
105			105			100		
105			110			110		
110			110			110		
110			110			110		
110			110			110		
110			110			110		
115			110			110		
115			110			110		
115			115			115		
115			115			115		
115			115			115		
115			115			115		
115			115			115		
120			115			120		
120			120			140		
120			120					
120			120					
125			125					
125			130					

DATE: 08/11/89
LOCATION: Elk Rock
SITE NO: 17

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS (1mx5m)	a	b	tot	a	b	tot	a	b	tot	a	b	tot
DEPTH ZONE(FT)	15			35			50					
0-5	0	0	0	1	1	2	4	3	7	1	4	5
6-10	16	4	20	1	1	2	0	0	0	4	9	13
11-15	0	16	16	0	0	0	2	0	2	5	4	9
16-20	5	11	16	0	0	0	0	2	2	1	3	4
21-25	1	4	5	0	0	0	2	6	8	5	4	9
26-30	0	0	0	0	0	0	6	5	11	4	2	6
			---			---			---			---
			57			4			30			46

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	S	CA	CJ	S	S	CA	CJ
55	130*	50*	90	-	-	50	100	-	-	20	100	45*	15*
65	115*	50				55	105			30			
65	115*					65	115			35			
65	110					65				40			
65						65				40			
70						70				40			
80						70				50			
80						75				50			
90						75				50			
90						75				50			
95						75				60			
95						75				60			
95						75				60			
95						75				60			
100						75				75			
100						80				75			
100						80				75			
105						80				80			
110						80				80			
110						80				80			
110						85				80			
110						85				80			
115						85				80			
115						85				85			
120						85				85			
125						85				85			
130						90				85			
130						95				85			
135						95				85			
						95				100			

DATE: 08/11/89
LOCATION: Cavanaugh Gulch
SITE NO: 18

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS (1mx5m)	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	0	0	0	0	4	4	0	0	0	0	0	0
6-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
21-25	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
26-30	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	1
			---			---			---			---			---			---
			0			0			1			5			0			2

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
-	-	-	-	-	-	100	-	-	100	-	-	60	-	-	95	-	-
									140			70					
												160					

DATE: 08/22/89
LOCATION: Navarro Point
SITE NO: 19

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS (1mx5m)

	15			35			50		
	a	b	tot	a	b	tot	a	b	tot
0-5	5	0	5	6	0	6	1	6	7
6-10	0	1	1	1	0	1	0	0	0
11-15	0	1	1	17	0	17	3	0	3
16-20	1	0	1	53	33	86	0	0	0
21-25	2	0	2	40	22	62	0	0	0
26-30	0	0	0	26	3	29	8	5	13
			---			---			---
			10			201			23

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ
65	120*	70*	60	100*	20*	60	80*	15*
65			60	75	15	60	105*	20*
70			70	85	30	60	105*	20*
75			70	75	25	60	120*	20*
75			70	90		65	80	10*
75			75			65	90	40*
80			75			70		45*
80			75			70		25
85			75			70		
85			80			75		
100			80			80		
100			80			80		
105			80			95		
105			80			95		
105			85			100		
105			85			110		
110			85			115		
110			85			125		
110			90			140		
115			90					
115			90					
120			90					
125			95					
125			100					
130			100					
130			100					
130			120					
135			125					

DATE: 08/22/89
LOCATION: Albion Point
SITE NO: 20

TRANSECT COUNTS

DEPTH ZONE(FT) 15 35 50

QUADRATS (1mx5m)

	15			35			50		
	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	39	39	9	1	10
6-10	1	0	1	8	26	34	8	10	18
11-15	4	6	10	18	27	45	7	10	17
16-20	0	2	2	26	3	29	15	13	28
21-25	0	0	0	5	3	8	5	27	32
26-30	0	6	6	18	56	74	18	0	18
			---			---			---
			19			229			123

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ
70	100*	40*	55	75*	45*	15	110*	15*
70			55	60*	30*	20	120	10
75			55	75	25	35	100	20
80			55	70	30	50		30
80			60	65	20	50		20
100			60			60		25
110			60			60		15
110			60			65		
110			65			65		
110			65			70		
110			70			70		
115			70			70		
115			70			75		
120			70			75		
125			75			80		
			75			80		
			75			80		
			75			85		
			75			90		
			80			95		
			80			95		
			80			95		
			85			95		
			90			100		
			90			100		
			95			105		
			95			105		
						115		
						115		
						120		

DATE: 08/12/89
LOCATION: Van Damme Headland
SITE NO: 21

TRANSECT COUNTS

DEPTH ZONE(FT)	15						35			50		
QUADRATS (1mx5m)	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	1	1	2	0	2	2	20	39	59	10	2	12
6-10	0	0	0	0	0	0	49	98	147	35	7	42
11-15	0	0	0	0	0	0	2	48	50	7	0	7
16-20	0	0	0	0	0	0	3	4	7	0	0	0
21-25	1	4	5	0	14	14	8	10	18	25	5	30
26-30	1	36	37	0	0	0	2	2	4	7	1	8
			---			---			---			---
			44			14			285			99

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	S	CA	CJ
70	-	-	75	-	-	40	80*	30*	40	100	100*	20*
70			95			50	70*	35*	55	100	100*	40
75			95			50	80*	35*	55	110	90	30
75			100			50	80*	35*	60		70	45
80			100			65	60*	30	60		95	50
80			105			65	75	25	65		95	30
80			105			65	70	35	65		110	35
85			105			65	65	25	65		120	40
85			105			65	75	35	65		65	20
90			110			65	70		65		80	50
90			110			70			70		75	30
90			110			70			75		90	30
90			115			70			75		90	
90			115			75			75		70	
90						75			75			
90						75			75			
90						80			75			
90						80			80			
90						85			80			
95						85			85			
95						90			85			
95						90			85			
95									85			
95									85			
95									90			
95									90			
95									95			
100									95			
100									95			
105									95			

DATE: 08/12/89
LOCATION: Jack Peters Creek
SITE NO: 22

TRANSECT COUNTS

DEPTH ZONE(FT)	15						35						50		
QUADRATS (1mx5m)	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
6-10	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0
11-15	0	0	0	2	0	2	18	24	42	0	0	0	0	0	0
16-20	0	0	0	0	0	0	5	0	5	0	0	0	0	0	0
21-25	0	0	0	0	0	0	0	0	0	6	5	11	0	0	0
26-30	0	0	0	0	0	0	0	0	0	2	0	2	0	23	23
			---			---			---			---			---
			0			2			55			13			23

RED URCHIN MEASUREMENTS (mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
-	-	-	100	80*	15*	50	95*	25*	75	-	-	30	110*	20*
			120			60	85*	35*	75			50		
						65	85*		80			55		
						65	75*		85			70		
						70			90			70		
						70			95			75		
						75			100			80		
						75			115			80		
						75			130			80		
						75			130			85		
						80			140			85		
						80						90		
						85						95		
						85						95		
						85						100		
						85						105		
						90						115		
						90						115		
						90						115		
						90						120		
						95						120		
						100						120		
						110						125		
						115								
						115								
						130								

APPENDIX B

TRANSECT DATA FROM FINE SCALE SURVEY SITES, SPRING 1989 AND SUMMER 1989

Explanation of Transect Data Display Format

Transect Counts: 'a' and 'b' are counts for each transect side by 5 meter segments.

Red Urchin Measurements (mm): Test diameters for approximately first 30 red urchins, classified as random solitary (S), canopy adult (CA) and canopy juvenile (CJ). Asterisk signifies CA or CJ as randomly encountered.

DATE: 02/25/89
LOCATION: Van Damme South
SITE NO: 101

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35

QUADRATS
(1mX5m)

	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0
6-10	0	0	0	22	13	35
11-15	0	0	0	7	25	32
16-20	0	0	0	0	0	0
21-25	0	0	0	0	0	0
26-30	1	0	1	0	0	0
			---			---
			1			75

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ
75	-	-	60	90*	20*
			65	80*	30*
			70	60*	
			75		
			75		
			75		
			75		
			85		
			85		
			85		
			85		
			90		
			90		
			90		
			95		
			95		
			95		
			95		
			100		
			100		
			100		
			105		
			105		
			110		
			110		
			115		

DATE: 03/21/89
LOCATION: West Caspar
SITE NO: 302

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35

QUADRATS
(1mX5m)

	a	b	tot	a	b	tot
0-5	35	-	35	4	10	14
6-10	27	-	27	34	13	47
11-15	25	-	25	11	3	14
16-20	76	-	76	21	12	33
21-25	57	-	57	2	0	2
26-30	26	25	51	26	19	45
			---			---
			271			155

RED URCHIN MEASUREMENTS(mm)

S	S	CA	CJ	S	S	CA	CJ
40	115	85	40	25	85	55*	25*
40	115	90	35	40	85	75	30
70	120	75	25	40	85	85	10
70		90		40	90	90	20
70				45	95	75	10
75				45			
75				45			
75				50			
75				60			
75				60			
80				65			
85				65			
85				65			
85				65			
85				65			
85				65			
90				70			
90				70			
90				70			
90				70			
95				75			
95				75			
95				75			
95				75			
100				80			
100				80			
:::				80			
105				80			

DATE: 02/25/89, 04/21/89
LOCATION: Steamer Point Caspar
SITE NO: 306

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS
(1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	1	1	0	0	0	0	0	0	0	1	1	0	1	1	2	1	3	0	0	0	0	0	0	14	5	19	0	1	1
6-10	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	4	3	7	0	4	4	0	0	0	9	5	14	0	0	0
11-15	0	0	0	2	0	2	0	0	0	0	0	0	1	1	2	11	16	27	0	0	0	0	0	0	1	5	6	1	1	2
16-20	0	3	3	59	10	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	3	5	8	15	17	32
21-25	0	0	0	37	5	42	0	0	0	0	0	0	4	0	4	0	0	0	0	0	0	0	0	0	8	7	15	13	8	21
26-30	0	0	0	9	3	12	0	0	0	4	4	8	11	4	15	0	0	0	0	0	0	0	0	0	10	8	18	0	0	0
			---			---			---			---			---			---			---			---			---			---
			7			125			0			9			22			37			4			4			80			56

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ
120	135*	25*

S	CA	CJ
65	95*	15*
65		10*
70		
70		
70		
75		
75		
85		
85		
85		
85		
90		
90		
90		
95		
95		
95		
100		
100		
100		
100		
105		
105		
110		
110		
115		
115		
125		
125		
125		

S	CA	CJ
-	-	-

S	CA	CJ
60	-	-
65		
65		
75		
120		
125		

S	CA	CJ
15	80*	15*
35	50*	
40		
40		
45		
50		
55		
60		
60		
65		
65		
65		
70		
75		
75		
80		
80		
80		
80		
95		
105		
105		

S	CA	CJ
35	-	-
35		
60		
60		
65		
70		
70		
70		
75		
75		
80		
80		
80		
80		
80		
90		
90		
90		
95		
95		
95		
100		
110		
125		

S	CA	CJ
45	-	-
70		
85		
100		

S	CA	CJ
60	-	-
90		
110		
115		

S	CA	CJ
40	110*	45*
40	90*	50*
45		
45		
55		
55		
60		
65		
65		
65		
65		
70		
70		
70		
75		
80		
85		
85		
90		
90		
100		
105		
105		
110		
115		
120		
120		
140		
155		

S	CA	CJ
20	60*	35*
35	55*	40*
35	70*	
35		
45		
45		
45		
45		
65		
75		
75		
75		
75		
80		
80		
80		
80		
90		
90		
105		
120		
130		
130		
130		
135		

DATE: 03/21/89, 04/16/89
LOCATION: Point Cabrillo North
SITE NO: 201, 210, 211

TRANSECT COUNTS

DEPTH ZONE(ft)	15			35			50		
QUADRATS (1mX5m)	a	b	tot	a	b	tot	a	b	tot
0-5	32	24	56	22	57	79	2	0	2
6-10	52	47	99	60	64	124	32	9	41
11-15	75	62	137	69	63	132	4	0	4
16-20	7	3	10	67	65	132	41	34	75
21-25	0	0	0	8	42	50	41	59	100
26-30	0	0	0	10	9	19	39	23	62
			---			---			---
			302			536			284

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ
35	80*	25*	40	110*	25*	40	140*	20*
45	80	30	60	90*	40*	40	105*	35
50	75	45	85	95*	35*	45	110	25
60	95	25	85	90*	55*	45	95	40
60	90	35	95	110*	25*	50	80	35
65	90	30	95	90*	40	60	95	40
65	65		95	115	30	65	105	20
70	60		95	95	50	65	110	45
70	90		100	60	20	70	105	25
70	115		100	110	15	80	95	30
75			100	85	30	80	110	15
75			105	100	35	85	90	15
75			105	70	30	85	110	
75			105	100	40	85		
75			110	95	45	85		
75			115	85	30	90		
75			115	90	25	90		
75			115	70	20	90		
75				70	15	95		
75				80	20	100		
80				70		100		
80				105		100		
80				100		105		
80				90		110		
80						110		
85						115		
85						115		
90						130		
95								
95								

DATE: 02/26/89
LOCATION: North Caspar Cove
SITE NO: 351

TRANSECT COUNTS

DEPTH ZONE(ft)	15			35			50		
QUADRATS (1mX5m)	a	b	tot	a	b	tot	a	b	tot
0-5	3	17	20	0	0	0	1	0	1
6-10	1	10	11	0	0	0	0	0	0
11-15	13	28	41	0	0	0	10	0	10
16-20	4	0	4	0	0	0	8	0	8
21-25	0	1	1	0	0	0	4	15	19
26-30	0	0	0	0	0	0	8	2	10
			---			---			---
			77			0			48

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ
60	75*	40*	-	-	-	40	80*	50*
75	70*					45	75	55*
75						55	65	25
75						55	65	35
80						55	110	45
80						55	110	65
85						55		
90						55		
90						60		
90						60		
90						60		
90						60		
90						60		
90						60		
95						60		
100						60		
100						65		
105						65		
105						65		
						65		
						65		
						75		
						80		
						80		
						85		
						90		
						90		
						100		
						100		

DATE: 04/16/89
LOCATION: Point Cabrillo Reef Pool
SITE NO: 204

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS (1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	23	13	36	4	25	29	11	2	13	23	16	39	9	3	12
6-10	38	29	67	3	3	6	0	2	2	16	13	29	20	17	37
11-15	30	32	62	1	3	4	0	0	0	4	8	12	32	17	49
16-20	30	25	55	1	1	2	0	0	0	7	18	25	13	3	16
21-25	23	16	39	4	10	14	10	6	16	6	13	19	6	1	7
26-30	30	25	55	0	0	0	11	17	28	15	29	44	23	0	23
			---			---			---			---			---
			314			55			59			168			144

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	S	CA	CJ
20	105*	20*	40	125*	30*	50	120*	25*	55	105*	30*	45	115	105	40
30	120*	55*	45	120*	15*	55	85*	25*	80	115*	30*	50	120	90	35
30	110*	30*	55	110*		55	105*	25*	80	100*	30*	50	125	110	25
70	125*	15*	55			60	115*	25*	85	95*	30*	50	130	110	20
75	100	15	60			60	120*	15*	85	65*	30*	55		110	
95	115	15	65			60	110	40	90	130*	30*	55			
95	120	20	70			65	70	35	90	125*	30*	60			
100	120	45	85			70	110	50	95	120	30	65			
105	110	25	85			75	100	10	100	135	30	65			
110	90	25	90			80	130		100	130	15	65			
110	100	20	90			85	90		105	120	25	65			
110	115	35	95			90	110		105	110	25	70			
120	120	15	95			105			110			75			
120	115	45	95			105			115			80			
120	120	25	100			110			115			90			
120	85	25	100			110			120			90			
120	110	50	100			110			120			95			
125	120	45	100			115			120			95			
125	85		100			120			125			95			
125	85		110			120						95			
135			115			125						105			
140			115			125						105			
			120			135						110			
			125									110			
			130									110			
												110			
												115			
												115			

DATE: 04/07/89
LOCATION: Point Cabrillo Surge Channel
SITE NO: 206, 207, 208

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS (1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	13	10	23	4	0	4	11	17	28	-	-	-
6-10	39	27	66	3	15	18	53	17	70	-	-	-
11-15	53	39	92	33	14	47	19	10	29	12	0	12
16-20	38	16	54	5	13	18	40	3	43	4	5	9
21-25	19	2	21	7	17	24	11	25	36	13	3	16
26-30	0	0	0	29	19	48	75	49	124	56	33	89
			---			---			---			---
			256			159			330			126

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
40	75*	30*	35	100*	25*	60	80*	25*	40	-	-
45	120*	15*	35	80*	30*	60	105*	15*	45		
45	85*	25*	40	120*	45	75	100*	15*	45		
65	125*	40	45	65	40	80	30*	5*	45		
65	90	30	65	95	20	85	105	15*	50		
70	100	25	65	105	25	90	110	20	60		
75	105	25	65	145		90	120	20	60		
75	90	25	70	100		90	60	15	65		
80	95	25	90			90	140	20	65		
85	85	15	90			100	130	20	70		
90	100	25	95			100		15	80		
95	85	45	95			100		60	80		
100	130		95			100		15	80		
100	95		105			105		30	80		
100			105			110			80		
105			110			110			90		
110			110			110			90		
110			110			110			90		
115			115			120			95		
120			115			130			95		
120			120			130			95		
125			125			140			95		
125			125			150			100		
125			125			150			100		
						160			100		
									105		
									110		
									115		
									125		
									145		
									145		

DATE: 04/15/89
LOCATION: Ware Creek
SITE NO: 501

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS
(1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	4	1	5	0	5	5	0	0	0	0	0	0
6-10	2	0	2	0	0	0	0	0	0	0	0	0
11-15	1	3	4	0	0	0	0	0	0	0	0	0
16-20	1	2	3	0	0	0	0	0	0	0	0	0
21-25	17	13	30	4	0	4	0	0	0	0	0	0
26-30	0	7	7	8	0	8	0	4	4	0	0	0
			---			---			---			---
			51			17			4			0

RED URCHIN MEASUREMENTS(mm)

S	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
55	130	95*	5*	70	-	-	85	90*	40*	-	-	-
70	135			80			90	70*				
75				85			90					
80				85			95					
80				90			105					
85				100			115					
85				100								
85				125								
85												
90												
95												
95												
100												
100												
100												
100												
105												
105												
105												
105												
110												
115												
115												
120												
120												
120												
125												
125												

DATE: 04/15/89
LOCATION: Laguna Point Outside
SITE NO: 701

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS
(1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	4	5	9	17	0	17	0	0	0	3	1	4	5	4	9
6-10	6	6	12	0	0	0	0	0	0	7	1	8	4	5	9
11-15	0	0	0	0	0	0	0	0	0	0	0	0	3	5	8
16-20	0	0	0	0	0	0	0	0	0	2	1	3	3	10	13
21-25	0	0	0	0	0	0	0	0	0	3	0	3	2	4	6
26-30	0	0	0	21	1	22	7	2	9	3	0	3	2	3	5
			---			---			---			---			---
			21			39			9			21			50

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	S	CA	CJ
70	-	-	25	-	-	50	135*	35*	65	-	-	35	100	75*	35*
75			30			60	140*		65			35	110	85*	50*
80			70			115			80			50			
85			70			125			80			65			
90			80			125			85			65			
90			80			135			85			70			
90			80						85			75			
95			80						90			75			
95			85						90			75			
95			85						90			75			
100			90						95			75			
100			95						100			75			
			100						105			80			
			100						115			80			
			100						125			80			
			100									80			
			100									80			
			100									80			
			120									85			
												85			
												85			
												85			
												85			
												85			
												90			
												95			
												95			
												95			

DATE: 08/11/88
LOCATION: Van Damme South
SITE NO: 101

TRANSECT COUNTS

DEPTH ZONE(ft) 15 / 35 / 50

QUADRATS (1mX5m)

	15						35						50					
	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	7	15
6-10	0	0	0	0	0	0	0	0	0	0	32	32	0	3	[illegible]	15	25	40
11-15	0	0	0	0	0	0	0	0	0	0	13	13	0	0	0	14	3	17
16-20	0	0	0	5	1	6	0	0	0	0	0	0	0	0	0	14	5	19
21-25	0	0	0	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0
26-30	0	0	0	13	8	21	0	0	0	7	1	8	0	0	0	15	13	28
			---			---			---			---			---			---
			0			30			0			53			3			119

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ
-	-	-

S	CA	CJ
50	90*	30*
55		
60		
65		
80		
85		
85		
90		
90		
90		
90		
95		
100		
100		
105		
110		

S	CA	CJ
-	-	-

S	S	CA	CJ
55	95	85*	35*
60	95	85*	35*
65		90*	40*
65			
70			
70			
75			
80			
80			
80			
85			
85			
85			
85			
85			
85			
85			
85			
85			
85			
85			
85			
85			
90			
90			
90			
90			
90			
95			
95			
95			

S	CA	CJ
30	-	-
45		
55		
65		

S	S	CA	CJ
35	105	85*	20*
40	110	95*	
50	110		
50	110		
55			
55			
55			
55			
55			
60			
65			
70			
70			
75			
75			
75			
75			
80			
80			
80			
80			
80			
80			
85			
85			
90			
90			
90			
100			
100			
100			

DATE: 08/11/88
LOCATION: Van Damme North
SITE NO: 102

TRANSECT COUNTS

DEPTH ZONE(ft) 15 / 35 / 50

QUADRATS (1mX5m)

	15						35						50					
	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56	48	104
6-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1	8
11-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			---			---			---			---			---			---
			0			0			0			0			0			112

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

S	CA	CJ
50	90*	35*
60	95*	40*
65	90*	40*
65	80*	40*
65	90*	35*
70	90*	
70	80*	
80		
80		
80		
80		
85		
90		
90		
90		
95		
95		
100		
100		
110		
120		
120		

DATE: 08/21/89
LOCATION: Point Cabrillo North
SITE NO: 201, 210, 211

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS
(1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	4	6	10	0	0	0	22	13	35	10	1	11
6-10	7	0	7	0	0	0	33	50	83	30	40	70
11-15	0	10	10	0	0	0	26	34	60	45	39	84
16-20	4	4	8	0	0	0	48	52	100	39	16	55
21-25	0	0	0	5	0	5	11	1	12	31	53	84
26-30	0	0	0	17	10	27	30	58	88	61	22	83
			---			---			---			---
			35			32			378			387

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ	S	S	CA	CJ	S	CA	CJ
65	100*	25*	45	120*	35*	75	130	90	30	45	135*	20*
70	110*	35	50	105*	25*	80		80	30	45	125*	30*
95	110*		60	110*	70*	80		50	10	55	115*	45*
100	100		65			80		60	25	60	80	35
105			80			85		70	30	85	110	40
105			85			85		60	25	105	110	45
105			90		40*	85		65	30	105	90	30
110			90		45*	85		95	55	105	105	25
110			95			85		80	50	110	105	35
110			100			90		100	50	110	110	30
110			100			95		75	25	115	115	30
110			105			95		90	35	115	120	40
115			105			95		110		115	110	25
115			105			95				115	115	
115			105			100				120	120	
115			105			100				120		
115			105			105				120		
115			105			105				125		
120			105			110				125		
120			110			110				125		
120			110			110				125		
120			115			115				125		
120			115			115				125		
125			120			115				130		
125			120			115				130		
125			120			120				135		
130			125			120				150		
145			130			125						
						130						
						130						

DATE: 08/21/89
LOCATION: Point Cabrillo South
SITE NO: 202

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS
(1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	30	32	64	10	23	33
6-10	0	0	0	2	0	2	40	7	47	9	20	29
11-15	0	2	2	0	0	0	26	5	31	26	24	50
16-20	0	0	0	0	0	0	15	36	51	13	16	29
21-25	0	0	0	0	0	0	37	8	45	19	14	33
26-30	2	0	2	0	0	0	44	8	52	15	29	44
			---			---			---			---
			4			2			290			472

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	S	CA	CJ	S	CA	CJ	S	CA	CJ
95	125*	20*	45	115	-	-	30	100	40	45	90*	35*
100			55	120			40	110	15	45	110*	40*
100			60	120			50	95	20	65	75*	35*
105			60				50	105	35	70	110	35
105			60				60	85	20	70	90	15
105			65				70			80	60	10
110			70				70			85	115	15
115			70				75			90	115	30
120			70				80			95	80	40
120			70				80			95	90	15
			70				85			100		
			70				90			105		
			70				90			105		
			75				90			110		
			75				90			110		
			75				95			110		
			80				100			120		
			80				110			120		
			85				110			120		
			90				110			125		
			90				115			125		
			90				120			125		
			90				125			135		
			90				130			140		
			90									
			90									
			95									
			100									
			105									
			105									

DATE: 08/16/89
LOCATION: Point Cabrillo Reef Pool
SITE NO: 204

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS
(1mX5m)

	15			35			50		
	a	b	tot	a	b	tot	a	b	tot
0-5	43	48	91	8	0	8	19	25	44
6-10	6	9	15	53	31	84	3	17	20
11-15	0	6	6	62	0	62	9	0	9
16-20	1	0	1	14	0	14	3	8	11
21-25	4	8	12	5	0	5	7	5	12
26-30	0	0	0	6	0	6	2	10	12
			---			---			---
			125			179			108

RED URCHIN MEASUREMENTS(mm)

15			35			50		
S	CA	CJ	S	CA	CJ	S	CA	CJ
45	100*	30*	50	95*	25*	45	120	20
45	115*	30*	75	95*	35*	60	125	20
65	145*	20*	80	95*	30*	65		
70	90	25*	80	115	35	75		
70	115*	10	85	100	65	90		
80	125	50	85	60	25	95		
85	130	35	95	80	45	95		
90	145	30	100	105	60	100		
95	90	10	105	100	55	100		
95			105	75	45	105		
100			105	85	40	105		
105			105			105		
105			105			105		
110			110			105		
110			110			105		
110			110			110		
120			115			110		
120			115			115		
120			115			115		
125			115			115		
125			120			115		
125			120			120		
135			130			120		
140			130			120		
						120		
						120		
						120		
						125		
						125		
						130		
						130		

DATE: 08/16/89
LOCATION: Point Cabrillo Surge Channel
SITE NO: 206, 207, 208

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS
(1mX5m)

	15			35			50		
	a	b	tot	a	b	tot	a	b	tot
0-5	28	3	31	33	40	73	4	0	4
6-10	4	4	8	42	25	67	0	6	6
11-15	36	1	37	19	22	41	2	30	32
16-20	[illegible]	[illegible]	11	10	44	54	0	27	27
21-25	9	0	9	10	11	21	0	0	0
26-30	47	0	47	13	14	27	3	12	15
			---			---			---
			143			283			84

RED URCHIN MEASUREMENTS(mm)

15				35			50		
S	CA	CJ	S	S	CA	CJ	S	CA	CJ
55	105*	30*	15	135	-	-	45	120*	35*
55	55*	35*	60	135			85	130*	30*
60	70*	55*	65	135			90	120	25
70	100*	35*	65	135			90	115*	35
70	100*	50*	95	140			95	120*	30*
80	65*	45	95	145			95	100*	35*
85	80*	45	95				95		15*
95	95	15	100				100		15*
100	105	40	100				105		30*
105	115	35	105				110		
110	105	60	110				115		
110	110	35	110				115		
110	105	15	110				120		
		45	110				120		
		50	110				135		
			115				135		
			115				135		
			115						
			115						
			115						
			115						
			115						
			115						
			115						
			:::						
			120						
			125						
			125						
			130						
			130						

DATE: 08/20/89
LOCATION: Point Cabrillo Maytag
SITE NO: 205

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35

QUADRATS (1mX5m)

	a	b	tot	a	b	tot	a	b	tot
0-5	0	22	22	5	0	5	17	15	32
6-10	40	56	96	17	26	43	11	1	12
11-15	47	47	94	0	50	50	0	2	2
16-20	29	29	58	5	20	25	6	0	6
21-25	0	0	0	30	34	64	0	0	0
26-30	0	0	0	0	0	0	0	0	0
			---			---			---
			270			187			52

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	S	CA	CJ	S	S	CA	CJ
40	90*	5*	35	125	155	40	40	110	100	20
65	90*	30*	40	140	90	20	45	125	100	20
70	80*	20*	45	145	100	15	50	125		
75	70*	25	50			25	50	135		
80	105	35	55				78			
85	70	40	55				75			
85	65		60				75			
85			65				80			
95			70				80			
95			70				80			
100			70				80			
100			75				80			
100			80				80			
100			85				85			
100			85				85			
100			85				90			
105			85				90			
105			90				95			
105			90				95			
115			95				95			
115			95				95			
115			100				100			
120			105				100			
125			105				100			
			110				105			
			110				105			
			110				105			
			110				105			
			110				105			
			120				105			
							9C			

DATE: 08/20/89
LOCATION: Caspar Pool
SITE NO: 305

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35

QUADRATS (1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	1	1	18	3	21	6	39	45	7	7	14
6-10	0	0	0	13	5	18	0	1	1	0	0	0
11-15	14	1	15	14	3	17	4	5	9	2	0	2
16-20	4	3	7	9	5	14	0	0	0	0	9	9
21-25	4	6	10	2	6	8	0	0	0	3	5	8
26-30	10	0	10	0	1	1	0	0	0	4	0	4
			---			---			---			---
			43			79			55			37

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	S	CA	CJ	S	S	CA	CJ	S	CA	CJ
60	120*	45*	55	120	-	-	60	130	85*	45*	45	125*	25*
70	95*	30*	55	135			70		120*	40*	70		
80	120*	60	60				75		120*	30*	70		
80	115		60				80		125*	25*	70		
85	100		60				80		130	25	75		
85			65				80				80		
85			70				80				85		
90			75				80				85		
95			75				90				85		
95			75				90				90		
95			80				90				90		
95			80				90				100		
100			80				95				105		
105			80				95				105		
105			90				95				110		
110			90				100				115		
115			90				100				115		
120			90				105				120		
120			90				105				125		
120			95				110				125		
120			100				110				135		
125			100				115						
125			100				115						
130			100				115						
130			105				120						
			105				125						
			110				125						
			110				125						
			110				125						
			115				125						

DATE: 08/18/89
LOCATION: West Caspar
SITE NO: 302

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35

QUADRATS (1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	2	2	4	0	3	3	24	20	44	0	12	12
6-10	2	0	2	7	0	7	8	1	9	33	21	54
11-15	2	4	6	8	12	20	13	3	16	15	3	18
16-20	0	0	0	2	10	12	20	3	23	23	0	23
21-25	0	0	0	5	0	5	51	24	75	21	13	34
26-30	0	22	22	1	6	7	12	6	18	7	19	26
			---			---			---			---
			34			54			185			167

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
55	110*	70*	30	90*	50*	30	75*	40*	50	100*	15*
75	110*		70	90*	55*	45	55*	40*	50	85*	40*
80			70	85*		50	110*	30*	65	75*	40*
80			75			50	90*	35*	65	80	30
80			80			55	95*	35*	65	95	30
80			80			60	70*	25	75	75	45
90			85			60	90*	25	75	105	
90			85			60	60	30	75	85	
90			85			60	90	15	75		
90			90			60	65	2	75		
90			90			60	110	20	75		
90			90			70	90		75		
90			[illegible]			70	[illegible]		[illegible]		
95			90			75			80		
95			95			75			80		
100			95			80			80		
100			95			80			85		
100			95			80			85		
100			100			100			85		
100			100			105			85		
100			100			110			90		
105			105			125			90		
110			105						90		
120			110						95		
120			110						95		
120			110						95		
130									95		
									95		
									100		
									105		
									105		

DATE: 08/18/89
LOCATION: North Caspar
SITE NO: 301

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS (1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	14	20	34	6	0	6	54	23	77	0	0	0
6-10	0	14	14	6	2	8	14	34	48	0	0	0
11-15	14	0	14	0	1	1	1	8	9	0	0	0
16-20	14	10	24	0	2	2	11	32	43	0	0	0
21-25	5	4	9	0	0	0	13	0	13	3	0	3
26-30	0	4	4	3	0	3	2	10	12	0	0	0
			---			---			---			---
			99			20			202			3

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
40	75*	30*	45	-	-	40	65	45	75	-	-
50	75*	30*	45			50	80	50	80		
55	110*	50*	70			55	80	10	90		
55	115*	60	75			55	55	25			
65	110	55	75			55	65	35			
70	75		80			55	85	35			
70	90		85			60	65	30			
70			85			65	85	40			
75			90			65	75	40			
75			95			65	80				
75			95			65	70				
75			95			65					
75			100			70					
80			100			70					
80			100			70					
90			105			70					
90			105			70					
95			110			70					
95			110			70					
95			115			75					
110			120			75					
115						75					
						75					
						75					
						75					
						80					
						80					
						80					
						85					
						85					

DATE: 08/19/89
LOCATION: Steamer Point Caspar
SITE NO: 306

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS
(1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	0	0	0	0	0	0
6-10	6	3	9	3	1	4	0	0	0	0	3	3
11-15	12	17	29	0	0	0	0	0	0	1	0	1
16-20	0	4	4	1	1	2	0	0	0	0	0	0
21-25	0	0	0	0	0	0	0	0	0	0	0	0
26-30	0	0	0	0	0	0	15	0	15	0	1	1
			---			---			---			---
			42			6			15			5

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
60	105	30	95	-	-	60	100	25	50	-	-
70	115	75	105			65			60		
70		75	105			65			65		
70		25	115			65			85		
70			115			70			95		
85			115			70			105		
85			135			80			110		
90						80			115		
95						80					
95						85					
95						85					
95						85					
100						85					
100						90					
105						90					
105						95					
105						100					
105						105					
110						110					
110											
110											
110											
110											
110											
115											
115											
120											
125											
130											

DATE: 08/19/89
LOCATION: North Caspar Cove
SITE NO: 351

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS
(1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	0	0	0	1	0	1	67	41	108
6-10	2	10	12	1	4	5	15	22	37	21	3	24
11-15	0	15	15	0	0	0	21	0	21	1	0	1
16-20	5	3	8	0	2	2	10	0	10	0	0	0
21-25	0	0	0	0	0	0	14	8	22	0	0	0
26-30	0	2	0	17	14	31	12	19	31	0	0	0
			---			---			---			---
			35			38			122			132

RED URCHIN MEASUREMENTS(mm)

S	S	CA	CJ	S	CA	CJ	S	S	CA	CJ	S	CA	CJ
50	100	-	-	65	-	-	45	90	90	35	55	90*	30*
55	100			65			50	90	70	20	60	80*	20*
55				70			60	100	85	35	65	85*	25*
55				75			60		90	25	65	70*	35*
65				75			60		80		65	80	35*
70				75			60		80		65	55	25
70				85			60		100		65	65	10
70				90			60		75		65	95	45
70				95			65				70	75	45
75				95			65				70	60	45
75				95			65				70		
75				100			70				75		
75				105			70				80		
75				105			70				85		
75				105			70				85		
75				110			70				95		
75				110			70				95		
80				110			70				95		
80				115			70				100		
80				115			75				100		
80				115			75				100		
85				115			80				110		
85				115			80						
90				115			80						
90				[illegible]			80						
90				120			80						
90				130			80						
95							80						
95							80						
100							85						

98

DATE: 08/17/89
LOCATION: Hoyo Bay North
SITE NO: 601

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS (1mX5m)

	15			35			50		
	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	2	1	3	24	1	25
6-10	0	0	0	6	30	36	5	1	6
11-15	0	0	0	8	2	10	0	0	0
16-20	0	0	0	0	0	0	0	0	0
21-25	0	0	0	17	13	30	0	0	0
26-30	0	0	0	10	2	12	0	0	0
			---			---			---
			0			91			31

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ	S	S	CA	CJ
-	-	-	60	-	-	50	120	70	30
			70			60			
			70			60			
			70			60			
			75			65			
			75			65			
			75			70			
			75			70			
			75			70			
			80			75			
			80			80			
			85			80			
			85			80			
			90			85			
			90			85			
			95			90			
			95			90			
			[illegible]			95			
			100			95			
			100			100			
			100			100			
			105			100			
			110			105			
			110			105			
			110			110			
			115			110			
			120			110			
			125			115			
			125			120			
						120			

DATE: 08/17/89
LOCATION: Hare Creek
SITE NO: 501

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS (1mX5m)

	15						35			50		
	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	0	0	1	0	1	0	0	0	0	0	0
6-10	0	0	0	1	0	1	0	0	0	0	0	0
11-15	1	2	3	0	0	0	0	0	0	1	0	1
16-20	3	1	4	0	1	1	0	0	2	0	0	0
21-25	0	0	0	0	0	0	0	0	0	0	1	1
26-30	0	0	0	0	0	0	10	33	43	0	0	0
			---			---			---			---
			7			3			43			2

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
55	-	-	75	-	-	55	110*	25*	70	-	-
75			95			55	110*	20*	95		
80			110			60	120*	30*			
85			110			70	130*	35*			
90			115			75	120*	35*			
90			120			80					
90						85					
95						85					
100						85					
100						90					
100						95					
100						100					
100						105					
100						105					
100						110					
105						115					
105						115					
110						115					
110						120					
115						120					
115						130					
120											
120											
120											
130											
130											

DATE: 08/23/89
LOCATION: Mitchell Point
SITE NO: 401

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS (1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	2	0	2	1	0	1	1	3	4	7	14	21	0	3	3
6-10	1	1	2	0	0	0	0	0	0	7	13	20	1	0	1
11-15	4	13	17	6	8	14	0	0	0	1	0	0	0	0	0
16-20	1	2	3	2	2	4	1	0	1	0	0	0	0	0	0
21-25	2	7	9	5	8	13	2	0	2	0	0	0	4	0	4
26-30	6	0	6	0	4	4	0	0	0	0	1	1	0	0	0
			---			---			---			---			---
			39			36			7			42			8

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
55	125*	40*	80	125	-	-	45	-	-	50	85*	15*	40	75*	10*
55			85				70			60	115*	25*	75		
75			90				70			65	45*	25*	85		
80			90				80			65			90		
100			100				85			70			105		
100			100				90			75					
100			100				90			75					
100			105				95			80					
105			105				95			85					
105			105				100			85					
105			110				100			85					
110			110				110			90					
110			110				130			95					
115			110							95					
115			110							100					
115			110							100					
115			115							100					
120			115							110					
120			115							110					
120			115							115					
120			115							130					
120			115												
125			120												
130			120												
130			120												
130			120												
140			120												
150			120												

DATE: 08/23/89
LOCATION: Laguna Point Wash Rock
SITE NO: 702

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS (1mX5m)

	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6-10	0	0	0	0	0	0	0	7	7	0	0	0	0	0	0	2	2	4
11-15	1	10	11	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0
16-20	5	1	6	0	0	0	0	7	7	0	6	6	0	0	0	0	0	0
21-25	4	6	10	0	4	4	0	14	14	0	0	0	0	0	0	0	0	0
26-30	3	1	4	8	4	12	0	3	3	0	4	4	0	0	0	0	0	0
			---			---			---			---			---			---
			32			16			34			10			0			4

RED URCHIN MEASUREMENTS(mm)

S	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
60	100	90	50	65	-	-	50	90*	30*	70	105*	30*	-	-	-	70	-	-
65	100			65			50	100*	20*	75	120*	50*				75		
70				95			55	80*	25*	110	95*	35*				110		
75				95			55	65*	30*	115	120*	30*				135		
75				100			55	70*	45*	120								
75				105			65		25*	150								
75				105			70		40*									
75				105			70											
75				110			80											
75				110			100											
80				115														
80				115														
80				120														
80				125														
85				130														
85				135														
85				140														
85																		
85																		
85																		
85																		
90																		
90																		
90																		
90																		
95																		
95																		
95																		
95																		

DATE: 08/05/89
LOCATION: Saunders Reef Shallow
SITE NO: 901

TRANSECT COUNTS

DEPTH ZONE(ft) 35

QUADRATS (1mX5m)	a	b	tot	a	b	tot
0-5	11	6	17	0	0	0
6-10	0	1	1	12	0	12
11-15	10	1	11	0	6	6
16-20	14	0	14	0	0	0
21-25	15	12	27	0	0	0
26-30	2	14	16	0	0	0
			---			---
			86			18

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ
70	-	-	60	-	-
80			70		
80			70		
80			70		
90			70		
90			70		
90			80		
100			80		
100			90		
100			100		
100			100		
120			100		
120			110		
120			110		
130			110		
130			110		
130			110		
140			120		
140			120		
140			120		
140			130		
140			130		
150			130		
150			150		
160			150		
160			150		
160					
160					
160					
180					

DATE: 08/05/89
LOCATION: Saunders Reef Buoy
SITE NO: 902

TRANSECT COUNTS

DEPTH ZONE(ft) 50

QUADRATS (1mX5m)	a	b	tot	a	b	tot
0-5	1	5	6	12	27	39
6-10	0	0	0	23	35	58
11-15	1	0	1	4	2	6
16-20	0	0	0	0	1	1
21-25	0	0	0	0	0	0
26-30	0	0	0	3	0	3
			---			---
			7			108

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ
50	-	-	40	115*	20*
			40	75*	40*
			50	70*	50*
			60	85*	
			60	75*	
			60		
			65		
			65		
			65		
			65		
			65		
			65		
			65		
			70		
			70		
			70		
			70		
			75		
			75		
			80		
			85		
			85		
			100		
			105		
			120		

DATE: 08/05/89
LOCATION: Saunders Reef South Middle
SITE NO: 903

TRANSECT COUNTS

DEPTH ZONE(ft) 35

QUADRATS (1mX5m)	a	b	tot	a	b	tot
0-5	1	0	1	7	8	15
6-10	0	4	4	9	13	22
11-15	0	0	0	3	28	31
16-20	0	1	1	1	1	2
21-25	0	2	2	1	0	1
26-30	0	2	0	0	0	0
			---			---
			8			71

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ
40	-	-	25	45*	25*
55			50	60*	20*
70			55	85*	15*
70			55	100*	15*
80			55	125*	15*
90			65	75*	20*
90			65	65*	30*
90			70	55*	20*
100			105	70*	40*
100				85*	20*
110					15*
140					20*
					20*
					25*

DATE: 08/09/89
LOCATION: Saunders Reef
SITE NO: 905, 906

TRANSECT COUNTS

DEPTH ZONE(ft) 35

QUADRATS
(1mX5m)

	a	b	tot	a	b	tot	a	b	tot
0-5	40	33	73	3	5	8	4	0	4
6-10	14	23	37	0	1	1	2	0	2
11-15	8	5	13	0	6	6	9	0	9
16-20	3	23	26	4	2	6	2	0	2
21-25	26	23	49	2	0	2	0	19	19
26-30	9	5	14	4	0	4	1	35	36
			---			---			---
			212			27			72

RED URCHIN MEASUREMENTS(mm)

S	S	CR	CJ	S	CR	CJ	S	CR	CJ
55	120	90*	50*	90	-	-	60	130*	15*
55	120	70*	40*	95			80	110*	60*
55		100*	35*	95			80		
65		70	20*	105			85		
65		100	35	105			85		
65			40	110			85		
65				110			90		
65				115			95		
70				115			100		
70				115			100		
70				120			100		
70				120			100		
75				120			105		
75				120			105		
75				120			110		
75				130			115		
75				130			115		
75				130			115		
80							115		
80							120		
80							125		
85							125		
90							130		
90							130		
90							135		
95							140		
95							140		
100									
100									

DATE: 08/09/89
LOCATION: Saunders Reef North
SITE NO: 907

TRANSECT COUNTS

DEPTH ZONE(ft) 50

QUADRATS
(1mX5m)

	a	b	tot
0-5	10	14	24
6-10	3	0	3
11-15	20	0	20
16-20	1	3	4
21-25	4	2	6
26-30	4	4	8

			65

RED URCHIN MEASUREMENTS(mm)

S	S	CR	CJ
50	115	90	25
55	115	85	30
65	125	100	40
65	135	60	
65		90	
65			
65			
70			
75			
75			
75			
75			
75			
85			
85			
95			
95			
95			
95			
100			
100			
100			
105			
105			
105			
105			
110			
110			
110			
115			

DATE: 08/01/89
LOCATION: Salt Point Closure Area
SITE NO: 001

TRANSECT COUNTS

DEPTH ZONE(ft) 15 35 50

QUADRATS
(1mX5m)

	15						35						50		
	a	b	tot	a	b	tot	a	b	tot	a	b	tot	a	b	tot
0-5	0	2	2	0	6	6	4	2	6	0	4	4	13	9	22
6-10	0	15	15	0	5	5	0	0	0	0	0	0	8	6	14
11-15	18	34	52	C	2	2	0	0	0	0	0	0	7	5	12
16-20	11	0	11	0	0	0	0	C	0	0	2	2	7	1	8
21-25	0	0	0	0	0	0	1	0	1	0	7	7	11	7	18
26-30	0	0	0	0	0	0	0	9	9	0	23	23	4	4	8
			---			---			---			---			---
			80			13			16			36			82

RED URCHIN MEASUREMENTS(mm)

S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ	S	CA	CJ
60	130	65	85	-	-	65	-	-	50	85*	30*	25	-	-
70	95	70	85			70			60	95*	30*	45		
75	140	60	85			70			65	100*	40*	60		
80	90	60	90			70			70	65*	50*	65		
85	140		90			80			75	80*	35*	65		
85	110		90			90			75	85*		65		
90			95			95			75	80*		75		
95			95			95			75			75		
100			95			95			80			75		
100			105			105			80			75		
100			110			130			85			80		
105			120			135			85			80		
105			135						90			80		
105			145						90			85		
110			150						90			85		
110									90			90		
115									90			90		
120									95			90		
125									10C			90		
125									100			95		
125									100			95		
125									105			100		
130									105			100		
130												100		
130												100		
130												100		
135												105		
135												110		
140												120		
150												120		