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California Department of Fish and Game

Compilation and Analysis of CIAP Nearshore Survey Data

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Submitted to:

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(To be included in final draft)

1.0 Project Background and Objectives

This report presents the results of underwater visual surveys of fishes and invertebrates that were done in 2004 at eighty-eight sites in central and southern California. Also included is historical information from some of the sites for which time series data were available from earlier or ongoing monitoring projects. This project was funded and organized by the California Department of Fish and Game (CDF&G) which has an agreement with the California Resources Agency under the Coastal Impact Assistance Program (CIAP) to undertake a project entitled "Infrastructure for a Marine Life Management Act Nearshore Ecosystem Assessment Program". The project, which involved numerous researchers at several institutions (**Table 1-1**), was also referred to as the Cooperative Resource Assessment of Nearshore Ecosystems (CRANE). It included a one-season scuba survey with the objective of providing baseline information on habitat conditions and stock densities of ecologically and economically important fishes and invertebrates in nearshore rocky reef and kelp habitats. The surveys included sites within fully-protected marine reserves and sites outside of reserves where sport and commercial fishing activities were allowed within the scope of applicable CDF&G regulations.

The geographic scope of the survey included the coastal area between Monterey Bay and San Diego, as well as the Southern California Channel Islands. The objectives of the study were to:

1) measure the population density and size structure of all conspicuous non-cryptic fishes, urchins and abalone, and

2) collect information on habitat characteristics and benthic communities that could be used to evaluate species density and size characteristics.

The surveys add to a growing database of information on nearshore species that has been developed by long-term ecological studies such as the Channel Islands National Park Service's Kelp Forest Monitoring Program, and the Packard Foundation's Partnership for the Interdisciplinary Study of Coastal Oceans (PISCO).

The concept behind the surveys was to develop a standardized data collection protocol among all participating researchers that would allow direct comparisons of rocky subtidal communities across a wide geographical area. The focus was on species of recreational or commercial value, and other selected kelp, invertebrate, and fish species common to the rocky nearshore zone. Sampling protocols were developed in a collaborative process that involved CDF&G, participating researchers, and interested stakeholders, and were based largely on existing PISCO subtidal sampling protocols. In 2003, Drs. Mark Carr, Craig Syms, and Jenn Caselle presented a preliminary proposal that described the background, sampling rationale and methods for a coast-wide cooperative subtidal survey (**Appendix A**). The final CRANE protocols that emerged from the technical workgroup meetings resulted in a statistically robust dataset that maximized the number of sites surveyed, given the scope and funding of the project.

The following report presents the results of the 2004 surveys, identifies geographical patterns of species abundances, and describes relationships among biological and physical factors that may explain some of the observed patterns. Also included are historical data from several long-term marine monitoring programs in California that have provided valuable information on fishery species using direct underwater observation methods similar to those used for the CRANE surveys. Overall data summaries among all sites and the results of the various analyses are presented in the body of the report. The appendices present detailed results of the surveys for each sampling site and summaries of data by species for selected species of interest. The complete 2004 data set is in an electronic database maintained by CDF&G.

The present report does not include any discussion or interpretation of the survey results. Additional analyses, interpretation and discussion are expected to appear in subsequent reports.

Table 1-1. Principal investigators, data reviewers and field biologists participating in the 2004 CRANE study.

	San Diego State University	**Tenera Environmental**	**University of California Santa Barbara (CRANE)**	**University of California Santa Barbara (PISCO)**	**University of California Santa Cruz**	**Occidental College -Vantuna Research Group**
Principal Investigator	Todd Anderson, Ph.D.	Jay Carroll	Donna Schroeder, Ph.D.	Jenn Caselle, Ph.D.	Mark Carr, Ph.D.	Dan Pondella, Ph.D.
Data Review/ Analysis*	Andres Deza	John Steinbeck	Donna Schroeder, Ph.D.	Mark Readdie, Ph.D.	Dan Malone	John Froeschke
Field Data Collection**	Damien Cie	Jay Carroll	Dawn Bailey	Chad Burt	Aurora Alifano	Jana Cobb
	Andy Davenport	Chris Ehrler	Joshua Carter	Don Canestro	Dave Benet	Lanny Flaherty
	Andres Deza	Andrew Harmer	Marie Ferguson	Joshua Carter	Patrick Berk	John Froeschke
	Carey Galst	Scott Kimura	Eric Hessell	Jenn Caselle, Ph.D.	Natalie Bollinger	Brent Haggin
	Matt lacchei	Steve Pengilley	Merit McCrea	Marie Ferguson	Mark Carr, Ph.D.	Ernest Li
	Eric Lewallen		Mike Moss	Chris Gotschalk	Diana Churchill	Josh Lindsay
	Paul Matson		Donna Schroeder, Ph.D.	Sean Hoobler	Jahnava Duryea	Lea Meideiros
	Patrick Robinson		Amber Simpson	Mike Moss	Terril Efird	Bridgette Nace
			Jennifer Tarmann	Jesse Patterson	Jonna Engel	Christopher Oakes
				Mark Readdie	Jaime Grover	Dan Pondella, Ph.D.
				Bonnie Rogers	Amanda Jensen	Dylan Simonson
				Thom Young	Kristen Kusic	Darrin Topping
					Selena McMillan	Johnathan Williams
					Jennifer O'Leary	Julie Wooten
					Wyatt Patry	Beth Young
					Randolph Skrovan	
					Colby Smith	
					Paul Tompkins	

* The principal contact for review and analysis of the data sets is listed although several biologists from each group, including all principal investigators, were involved in data review. Mr. David Osorio of CDF&G was the principal reviewer of all data sets.

** The biologists listed are those who participated in the 2004 data collection effort. Many other biologists from several institutions contributed to the collection of historical data that are also presented in this report.

2.0 Methods

2.1 Biological Sampling - General

A total of ninety sites along the central and southern California coast, including the Channel Islands, was sampled by diver-biologists directly counting selected species of fishes, invertebrates, and algae along underwater transects. These sites are all rocky reef habitats, most of which support forests of giant kelp, *Macrocystis pyrifera*. The sites were distributed from Santa Cruz to San Diego and therefore included a range of oceanographic conditions (e.g., north-south of Pt. Conception and island vs. mainland sites) as well as sites within established "no-take" marine reserves and at adjacent less-protected areas of similar habitat (**Table 2-1, Figure 2-1**). Sampling was distributed within (areas and depth strata) and among sites in order to adequately characterize each site and facilitate analysis of spatial patterns. The sampling protocol was adapted from the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) and modified by CDF&G to focus on species with sport or commercial fishery value and common nearshore macro-invertebrate species and kelps.

All divers taking data on fish and invertebrates had prior experience in conducting underwater biological surveys. Since it was important that protocols were consistently applied, all divers also participated in training exercises, including identification of fish and target invertebrate species and in the field practice of the protocols. All divers were given a field examination by a Fish and Game staff person prior to conducting the actual surveys.

Surveys were only conducted in conditions that were safe for diving and between 0800 and 1600 hrs when there was adequate daylight. Sampling was not attempted if horizontal visibility was less than 2.5 m (8.2 ft) or if surge prevented the diver from staying on the transect line. Since the protocol depended on a complete site survey, site conditions in shallow water were checked prior to initiating sampling. If conditions in shallow water did not meet the minimum requirements, the sampling was cancelled. To the extent possible, all transects were georeferenced in NAD 83.

2.1.1 Study Site Sampling Design

The surveys were generally conducted during the summer or fall of 2004 and quantified the abundance and size of fishes, substrate type and relief, benthic cover, and abundance of major groups of macroalgae and invertebrates. The original PISCO sampling was a multi-year project and the spatial allocation of sampling was designed to measure year-to-year site-wide variability in community structure and the spatial scales at which such variation occurs. For the CRANE surveys, a 'site' was defined as a fixed stretch of coastline, occupying at least 500 m (**Figure 2-2**). Each site was generally divided into two or three sections (sides), which were used in stratifying sampling over the entire site. Within each side, two (benthic sampling) and four (fish sampling) non-fixed randomly-allocated replicates were sampled in each of three depth zones. If the reef had no appreciable depth stratification, then the stratification was based on proximity to the outer edge of the reef and the shore. Transect strata included the offshore edge of the reef, middle of the reef, and an inshore stratum. The basic sample unit was a 30 m x 2 m (98.4 ft x 6.6 ft) long transect. Transects were interspersed across the reef to a maximum depth of approximately 20 m (65 ft).

Many reefs at the Channel Island sites do not extend very far away from the shoreline and it was found unsuitable to sample three depth or distance strata because each transect would be immediately adjacent to or overlapping other transects. This was especially true at reefs on Anacapa and Santa Cruz Islands. In these cases, each site was divided into three**,** rather than two, sides (**Figure 2-2**). Within each side, two (benthic sampling) and three (fish sampling) non-fixed randomly allocated replicates were sampled in each of two (benthic sampling and fish sampling) depth zones on the offshore and inshore sections of the reef.

Other sampling configurations were also used depending on the specific distributions of rock reefs and depth profiles at a site (**Appendix Table A1**). In most cases, however, the same number of paired bottom and mid-water fish transects (24) and benthic transects (12) were done as at the sites with typical layouts.

2.1.2 Fish Sampling

The purpose of the fish sampling was to estimate fish density, size, and vertical distribution in the water column. Within each half (‘area’) of a site, twelve 30 m x 2 m (98.4 ft x 6.6 ft) replicate transects were sampled in three or four zones depending on the seaward extent of the reef. The sampled target depths for sites with three zones were approximately the 15 m (49.2 ft), 10 m (32.8 ft), and 5 m (16.4 ft) depths (or equivalent outer-edge, middle, and inshore portion), respectively. A deeper 20 m (65.6 ft) sampling zone was added in some instances for sites with greater offshore areas. Each replicate sample at a site was comprised of a paired ‘mid-water’ and ‘bottom (benthic)’ transect. The two 2 m wide x 2 m tall x 30 m long (120 m^3) transects were sampled simultaneously by a pair of divers; one along the bottom 2 m of the water column, contiguous with the reef surface, and the other just above, slightly offshore and forward of the first (**Figure 2-3**). The height of the ‘mid-water’ transect varied as a function of (1) bottom depth: 4-6 m above the bottom for bottom depths of 10 m or greater, 2-4 m above the bottom for bottom depths of 6 m or less, and (2) closer to the bottom if visibility did not allow divers to maintain visual contact.

The benthic observer began the transect by loosely clipping the end of the transect measuring tape to a kelp frond or placing it beneath a rock. They then swam in the pre-arranged compass direction for a distance of 30 m while counting and estimating the sizes of the fish. If there was an intervening obstacle, the transect continued over it so long as the depth change was less than 2.5 m. If the obstacle was greater than 2.5 m in height, the transect circumvented it.

Transects were completed even if sand was encountered. When there was sand for more than 5 m and it appeared that the habitat continued primarily as sand, the direction of the transect was changed to the minimum necessary to remain on rocky habitat. The preferred distance between transects was at least 30 m, but distances of 10 m or more could be used if necessary.

Table 2-1. Sampling sites for CRANE subtidal sampling. Latitudes and longitudes were measured from the center of each site. 'MPA' refers to 'Marine Protected Area' and includes management areas designated by the State of California with a range of restrictions and allowable uses.

Site Number	Site Name	Code	County or Island	Institution	Latitude (N)	Longitude (W)	MPA
1	Sandhill Bluff	SB	Santa Cruz	UCSC	36.97357	122.15054	N
2	Terrace Point	TP	Santa Cruz	UCSC	36.94489	122.06528	N
3	MacAbee	MC	Monterey	UCSC	36.61767	121.89627	N
4	Hopkins	HK	Monterey	UCSC	36.62199	121.90227	Y
5	Pescadero	PS	Monterey	UCSC	36.56029	121.95706	N
6	Stillwater Cove	ST	Monterey	UCSC	36.56022	121.94587	Y
7	Monastery	MN	Monterey	UCSC	36.52533	121.93190	Y
8	Bluefish Cove	BL	Monterey	UCSC	36.52369	121.94614	Y
9	Weston	WS	Monterey	UCSC	36.51149	121.94727	Y
10	Andrew Molera	AM	Monterey	UCSC	36.27831	121.87013	N
11	Esalen	ES	Monterey	UCSC	36.12626	121.64898	N
12	Big Creek	BC	Monterey	UCSC	36.06912	121.60656	Y
13	Lopez Rock	LP	Monterey	UCSC	36.02532	121.58134	N
14	Lucia	LU	Monterey	UCSC	36.01611	121.56149	N
15	Wild Cattle	WC	Monterey	UCSC_CRANE	35.97610	121.49337	N
16	Plaskett Rock	PK	Monterey	UCSC_CRANE	35.91585	121.47868	N
17	Duck Pond	DK	Monterey	UCSC_CRANE	35.85775	121.42562	N
18	Salmon Creek	SC	Monterey	UCSC	35.80915	121.37762	N
19	La Cruz	LC	San Luis Obispo	UCSC_CRANE	35.71172	121.32473	N
20	San Simeon	SS	San Luis Obispo	UCSC_CRANE	35.63073	121.19296	N
21	Cambria Rock	CR	San Luis Obispo	UCSC	35.56919	121.12573	N
22	White Rock	WR	San Luis Obispo	UCSC	35.52637	121.08726	N
23	Cayucos	CY	San Luis Obispo	UCSC_CRANE	35.43463	120.94861	N
24	Point Buchon	PB	San Luis Obispo	Tenera	35.24009	120.89333	N
25	Diablo Canyon	DC	San Luis Obispo	Tenera	35.20366	120.84890	Y
26	Sal [1]	SL	Santa Barbara	UCSB_C	34.87187	120.62967	N
27	Purisima	PU	Santa Barbara	UCSB_C	34.73037	120.62333	N
28	Jalama	JL	Santa Barbara	UCSB_C	34.48280	120.49078	N
29	Cojo	CJ	Santa Barbara	UCSB_C	34.44508	120.41583	N
30	Naples[2]	NP	Santa Barbara	UCSB_C	34.42218	119.95187	N
31	Cuyler	MGCY	San Miguel Island	UCSB_C	34.05027	120.34587	N
32	Harris Point	MGHP	San Miguel Island	UCSB_C	34.05278	120.33738	Y
33	Tyler Bight	MGTB	San Miguel Island	UCSB_C	34.02653	120.40670	N
34	Crook Point	MGCP	San Miguel Island	UCSB_C	34.01718	120.32888	N
35	Rodes Reef	SRRR	Santa Rosa Island	UCSB_S	34.03250	120.10720	N
36	Beacon Reef	SRBR	Santa Rosa Island	UCSB_S	34.04920	120.04320	Y
37	Monacos[2]	SRMN	Santa Rosa Island	UCSB_S	33.98450	120.00870	N
38	Bee Rock	SRBE	Santa Rosa Island	UCSB_S	33.95390	120.21190	N
39	Cluster Point	SRCP	Santa Rosa Island	UCSB_S	33.92380	120.18945	N
40	Chickasaw	SRCK	Santa Rosa Island	UCSB_S	33.89990	120.13610	Y
41	Johnsons Lee	SRJL	Santa Rosa Island	UCSB_S	33.89410	120.10790	N
42	Jolla Vieja	SRJV	Santa Rosa Island	UCSB_S	33.90920	120.06770	N
43	Forney	CRFR	Santa Cruz Island	UCSB_C	34.05303	119.90693	N
44	Painted Cave	CRPC	Santa Cruz Island	UCSB_C	34.07287	119.87098	Y
45	Hazards	CRHZ	Santa Cruz Island	UCSB_C	34.05658	119.82117	N
46	Pelican	CRPL	Santa Cruz Island	UCSB_C	34.03065	119.69665	N
47	Coche Point	CRCP	Santa Cruz Island	UCSB_C	34.04497	119.60153	N

(table continued)

Table 2-1 (continued). Sampling sites for CRANE subtidal biological sampling.

Site Number	Site Name	Code	County or Island	Institution	Latitude (N)	Longitude (W)	MPA
48	Scorpion	CRSP	Santa Cruz Island	UCSB_C	34.04847	119.54637	N
49	Gull Isle	CRGI	Santa Cruz Island	UCSB_C	33.94990	119.82360	Y
50	Valley	CRVY	Santa Cruz Island	UCSB_C	33.98433	119.64148	N
51	Yellowbanks	CRYB	Santa Cruz Island	UCSB_C	33.99037	119.55450	N
52	Anacapa West Isle	ANWI	Anacapa Island	UCSB_C	34.01698	119.43292	Y
53	Anacapa Middle Isle	ANMI	Anacapa Island	UCSB_C	34.00932	119.38877	Y
54	Anacapa East Isle	ANEI	Anacapa Island	UCSB_C	34.01767	119.36368	Y
55	Cat Rock	ANCR	Anacapa Island	UCSB_S	34.00350	119.42410	N
56	Southwest Lighthouse	ANLT	Anacapa Island	UCSB_S	34.01160	119.36610	N
57	Malibu[2]	MB	Los Angeles	VRG	34.02785	118.69552	N
58	King Harbor	KH	Los Angeles	VRG	33.84143	118.39492	N
59	Rocky Point	RK	Los Angeles	VRG	33.78053	118.42793	N
60	Point Vicente	PV	Los Angeles	VRG	33.74410	118.41962	N
61	Dana Point	DP	Orange	SDSU	33.47962	117.72570	Y
62	San Mateo	MT	Orange	SDSU	33.38842	117.60080	N
63	San Onofre	SO	San Diego	SDSU	33.34445	117.55735	N
64	Barn Kelp	BK	San Diego	SDSU	33.28935	117.48980	N
65	Carlsbad	CB	San Diego	SDSU	33.12792	117.33693	N
66	Encinitas	EN	San Diego	SDSU	33.03408	117.29655	N
67	Cardiff	CF	San Diego	SDSU	32.99540	117.27813	N
68	La Jolla	LJ	San Diego	SDSU	32.82090	117.28505	N
69	Point Loma North	PLN	San Diego	SDSU	32.72382	117.25965	N
70	Point Loma South	PLS	San Diego	SDSU	32.68668	117.26618	N
71	Sand Spit	SNSS	San Nicolas Island	VRG	33.21622	119.44362	N
72	Dutch Harbor	SNDH	San Nicolas Island	VRG	33.21288	119.47053	N
73	Arch Point	SBAP	Santa Barbara Island	VRG	33.48633	119.02793	N
74	South Kelp	SBSK	Santa Barbara Island	VRG	33.47085	119.02932	Y
75	West Kelp[2]	CTWK	Santa Catalina Island	VRG	33.47180	118.60447	N
76	Johnson's Rocks[2]	CTJR	Santa Catalina Island	VRG	33.47673	118.58887	N
77	Isthmus Reef	CTIR	Santa Catalina Island	SDSU	33.44782	118.48932	N
78	Intakes	CTIN	Santa Catalina Island	SDSU	33.44708	118.48510	Y
79	West Quarry[2]	CTQW	Santa Catalina Island	VRG	33.44245	118.47143	N
80	Ripper's Cove	CTRC	Santa Catalina Island	VRG	33.42857	118.42992	N
81	East Quarry	CTQE	Santa Catalina Island	VRG	33.31570	118.30333	N
82	Lobster Bay	CTLB	Santa Catalina Island	SDSU	33.42760	118.52032	N
83	Catalina Harbor[2]	CTCH	Santa Catalina Island	VRG	33.42620	118.51145	N
84	Pin Rock[2]	CTPR	Santa Catalina Island	VRG	33.42352	118.50433	N
85	Little Harbor	CTLH	Santa Catalina Island	SDSU	33.38925	118.48088	N
86	Little Flower	CLLF	San Clemente Island	VRG	32.84023	118.36855	N
87	Pyramid Cove	CLPC	San Clemente Island	VRG	32.81768	118.36065	N
88	China Point	CLCP	San Clemente Island	VRG	32.81833	118.36170	N

[1] invertebrate sampling only
[2] fish sampling only

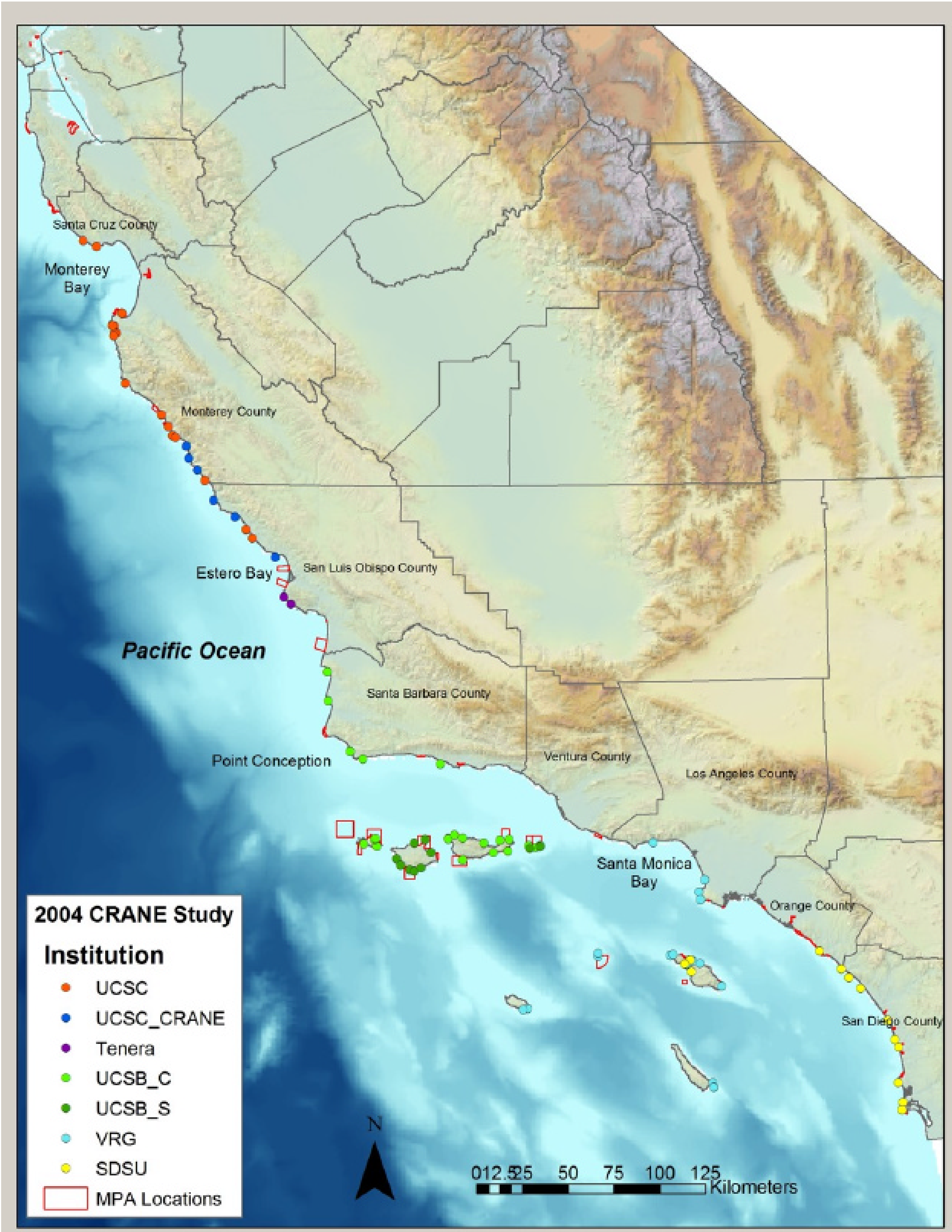

Figure 2-1. Map of CRANE sampling sites in central and southern California.

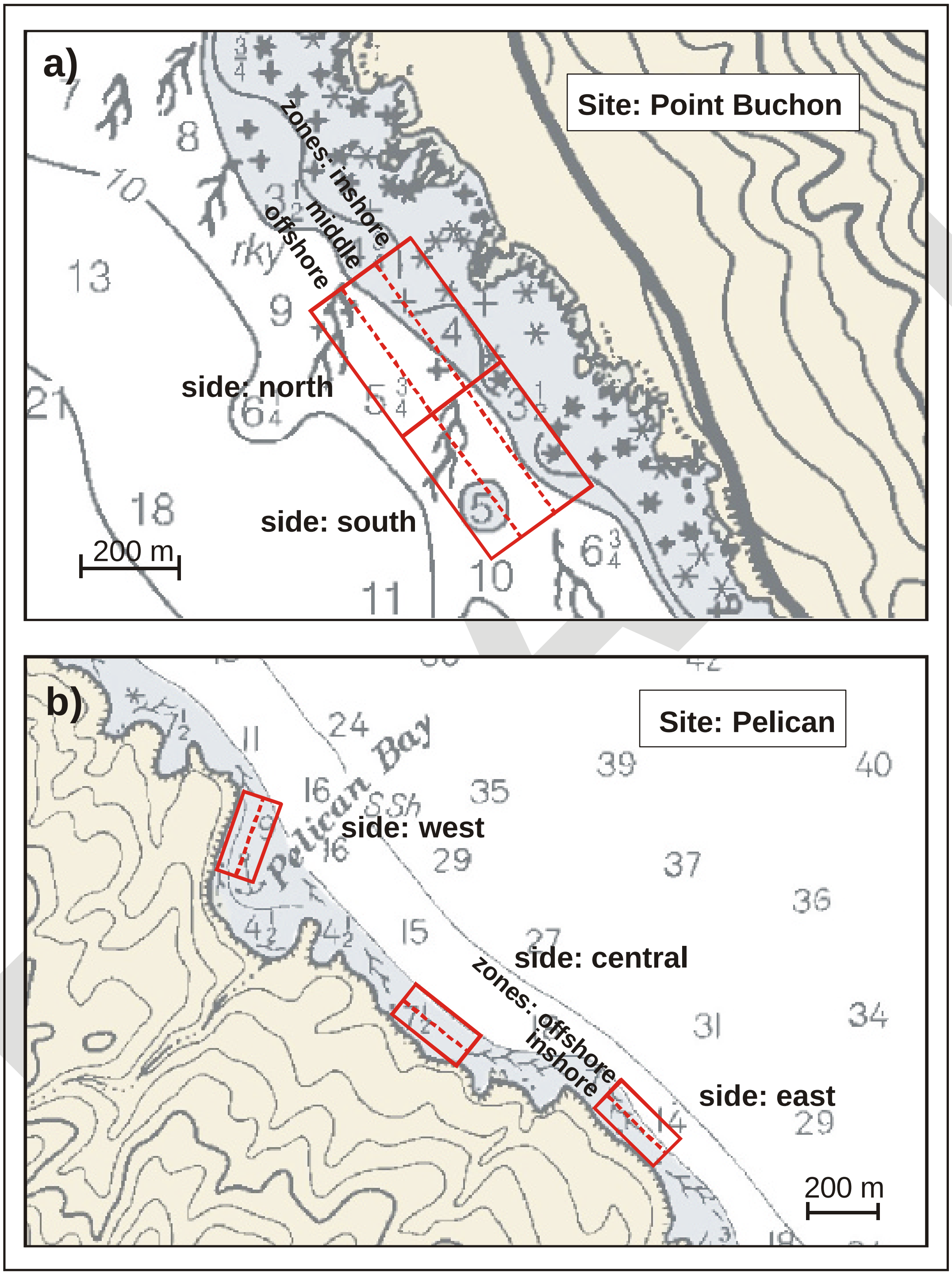

Figure 2-2. Examples of sampling layouts at two types of sites: a) reef with wide shelf and extensive depth range; b) reef with narrow shelf and sand–rock interface close to shoreline.

All conspicuous fishes encountered along the transects were recorded. Divers counted and estimated total length (TL) of small fish (< 15 cm [5.9 in] TL) to the nearest cm, and larger fish (> 15 cm) to the nearest 5 cm (2.0 in) interval,. If a school of fish (>10 fish) was encountered, the number of fish was estimated within each size group. The diver maintained a steady pace such that a transect was completed in 3–6 minutes. Altogether, divers generally sampled 24 "mid-water" and "bottom" transects each at one site within one or two days.

Table 2-2. List of example fish species sampled in subtidal community surveys. Some species were targeted for the following reasons: A=Abundant, F=Fishery, P=Protected, R=Recruitment studies. However, all conspicuous species encountered on transects were recorded.

Scientific Name	Common Name	Rationale
Chromis punctipinnis	blacksmith	A
Embiotocidae	All surfperch species	F, A, R
Girella nigricans	opaleye	A
Halichoeres semicinctus	rock wrasse	A
Heterostichus rostratus	giant kelpfish	R
Hexagrammos decagrammus	kelp greenling	F
Hexagrammos superciliosus	rock greenling	F
Hypsypops rubicundus	garibaldi	P
Medialuna californiensis	halfmoon	A
Ophiodon elongatus	lingcod	F
Oxyjulis californica	senorita	A
Oxylebius pictus	painted greenling	A
Paralabrax clathratus	kelp bass	F, A, R
Scorpaena guttata	California scorpionfish	F
Scorpaenichthys marmoratus	cabezon	F
Sebastes spp.	All rockfish species	F, A, R
Semicossyphus pulcher	California sheephead	F

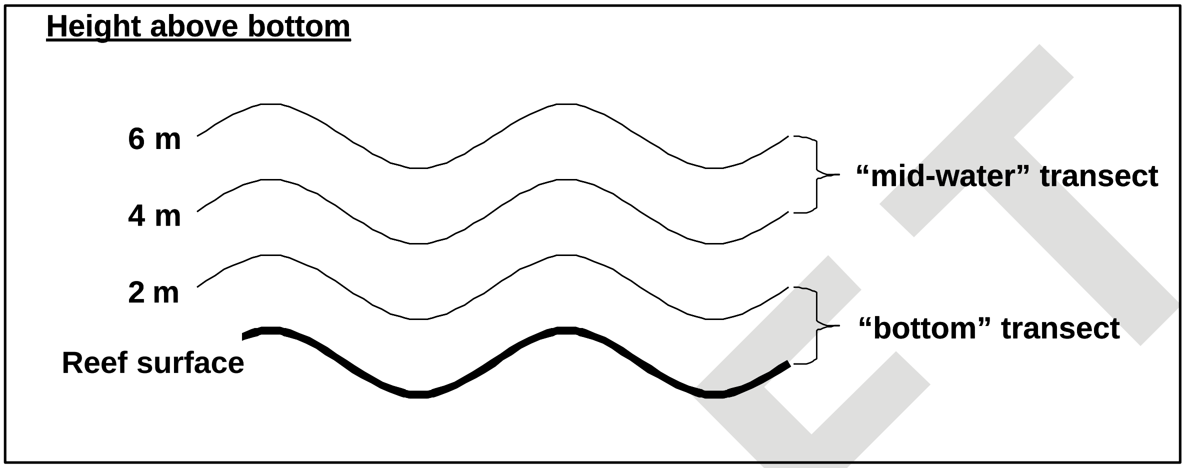

Figure 2-3. Stratification of “bottom” and “mid-water” transects for fish surveys. One diver samples fish in the bottom transect while the other diver simultaneously samples fish in the mid-water transect. See text for variation in depth stratification of transects depending on bottom depth and visibility.

2.1.3 Swath Sampling

The purpose of the swath sampling was to estimate the density of conspicuous, solitary and mobile invertebrates as well as specific macroalgae. Individual invertebrates and plants were counted along the entire 30 m x 2 m transect. Within each half (i.e. “area”) of a site, six 30 m x 2 m replicate transects were sampled—two at each of 20 m, 12.5 m, and 5m depths (or equivalent outer edge, mid-reef, and inshore portion), respectively. Transects were deployed parallel to the bathymetry and maintained within ± 2.5 m. As with the fish transects, if there was an intervening obstacle, the transect continued over it unless it was greater than 2.5 m in height, in which case the transect circumvented it. Transects were completed even if sand was encountered but when there was sand for more than 5 m, the direction of the transect was changed to the minimum necessary to remain on rocky habitat.

A diver slowly swam one direction counting targeted invertebrates and then swam back counting targeted macroalgae. Cracks and crevices were searched and understory algae pushed aside. No organisms were removed. Any organism with more than half of its body outside the swath was not counted. Transects were divided into three, ten meter segments. Target species recorded within the swaths are listed in **Table 2-3**. Some conspicuous species not on the target species list (e.g. octopus, giant gumboot chiton) were also recorded by some investigators, but these species were not consistently recorded among all groups and therefore could not be compared among all sites.

The following size criteria applied to counting macroalgal species:

- *Macrocystis* plants taller than 1 m (3.3 ft), and number of stipes per plant at 1 m above the substrate
- *Nereocystis*, *Pterygophora*, *Laminaria setchellii* and *Eisenia arborea* taller than 30 cm (11.8 in)
- *Laminaria farlowii* with blade greater than 10 cm (3.9 in) wide
- *Cystoseira osmundacea* greater than 6 cm (2.4 in) wide
- *Costaria* and *Alaria* no size restrictions

Species that occurred in high densities (e.g., purple urchins) were sub-sampled if greater than 30 individuals occurred within any of the three 10 m segments on a transect. Normally a diver counted all target species within each 10 m segment, but when 30 individuals of one species were counted, the diver recorded the meter mark at which the threshold abundance was reached and then stopped counting that species for the remainder of that segment. The species continued to be counted on the following segments and the same threshold abundance rule was applied. The subsampled abundances were then extrapolated per segment to calculate an estimated total abundance per transect.

2.1.4 Urchin sampling

In areas where urchins were abundant, at least 100 red and 100 purple urchins were collected and test diameter measured. Urchins were collected in the areas on and around each transect. However, if possible, they were collected from each depth zone, not just from one area of the site. To avoid bias, all emergent urchins were collected from each patch unless the patch was very large in which case only a portion of the patch was completely collected. Urchins were measured either in the water or on the boat. Small urchins under or in the spine canopy were not measured. If it was not possible to collect 100 of each species within a total dive time of one hour, the search for urchins was suspended.

Table 2-3. List of target species sampled using the swath survey method. Some species were targeted for a specific rationale: F= Fishery, G= Grazer, H= Habitat Former, P= Protected. The general rationale (not indicated) for selecting a target species was that it was conspicuous and widely distributed.

Group	Scientific Name	Common Name	Rationale
Kelps			
	Agarum fimbriatum	shotgun kelp	H
	Macrocystis pyrifera	giant kelp	H
	Pterygophora californica	tree kelp	H
	Cystoseira osmundacea	bladder chain kelp	H
	Laminaria farlowii	oar kelp	H
	Laminaria setchellii	oar kelp	H
	Eisenia arborea	tree kelp	H
	Alaria marginata	kelp	H
	Nereocystis luetkeana	bull kelp	H
	Costaria costata	ribbed kelp	H
Coelenterates			
	Anthopleura elegantissima	aggregating anemone	
	Anthopleura sola	sunburst anemone	
	Lophogorgia chilensis	red sea whip	
	Muricea californica	California golden gorgonian	
	Muricea fruticosa	brown gorgonian	
	Urticina spp.	anemone	
Echinoderms			
	Centrostephanus coronatus	crowned sea urchin	G
	Dermasterias imbricata	leather star	
	Lytechinus anamesus	white urchin	G
	Orthasterias koehleri	rainbow star	
	Parastichopus californicus	California sea cucumber	F
	Parastichopus parvimensis	warty sea cucumber	F
	Patiria miniata	bat star	
	Pisaster brevispinus	short spined sea star	
	Pisaster giganteus	giant sea star	
	Pisaster ochraceus	ochre sea star	
	Pycnopodia helianthoides	sunflower star	
	Strongylocentrotus franciscanus	red urchin	G, F
	Strongylocentrotus purpuratus	purple urchin	G
Mollusks			
	Aplysia californica	California sea slug	G
	Crassodoma gigantea	rock scallop	F
	Haliotis spp.	abalones (all species)	P
	Kelletia kelletii	Kellet's whelk	F
	Lithopoma gibberosa	red top snail	F
	Megastrea undosa	wavy top snail	F
	Megathura crenulata	keyhole limpet	F
Crustaceans			
	Cancer spp.	rock crabs	F
	Loxorhynchus crispatus/Scyra acutifrons	decorator crabs	
	Loxorhynchus grandis	sheep crab	F
	Panulirus interruptus	California spiny lobster	F
	Pugettia productus	northern kelp crab	
	Pugettia richii	cryptic kelp crab	
Other Invertebrates			
	Styela montereyensis	stalked tunicate	
	Tethya aurantia	orange puffball sponge	

2.1.5 Uniform Point Contact Benthos Sampling

Percent cover of substrate type, substrate relief and benthic organisms were recorded at each meter mark along the 30 m transect tape. Substrate percentages in the following categories were estimated within each 10 m segment: bedrock ($\geq$ 1 m), boulder (1 m), cobble ($\leq$10 cm), and sand. Substrate relief was the maximum relief within a rectangle centered on the point that is 0.5 meter along the tape and 1 meter wide (**Figure 2-4**). To contact benthic organisms, the line was pushed down and the species under the tape was recorded. If the line could not contact the substrate, the diver's finger was used to mark the spot. Epiphytes, epizooids and mobile organisms were not recorded. If the contact point was on a blade of *Laminaria*, brittlestars or the sea cucumber *Pachythione rubra*, the organism under the point was recorded and it was noted that the point was under one of these organisms. In addition to quantifying benthic organisms, the following types of bare substrate were recorded, if contacted: rock, sand, shell debris, and mud. A list of the organism contact categories is shown in **Table 2-4**.

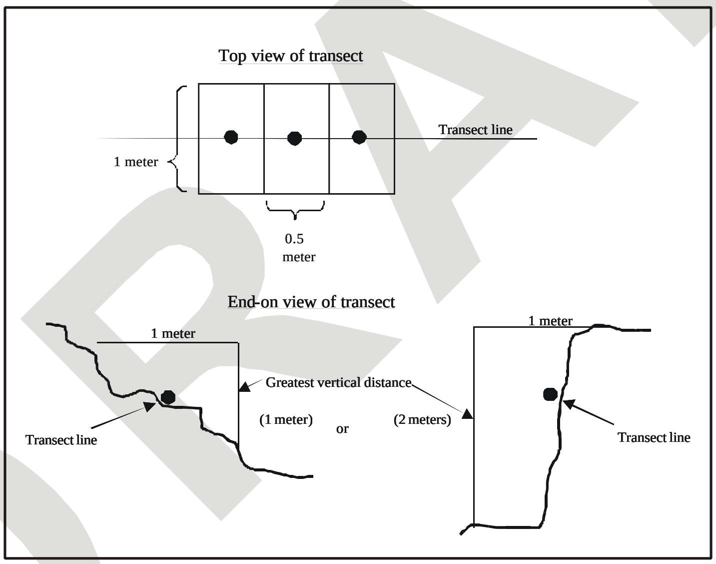

Figure 2-4. Vertical relief estimates at uniform point contacts (UPC) along transect line.

Table 2-4. List of contact categories sampled using the uniform point contact (UPC) survey method. See text for a description of the substrate type and relief category data.

Group	Scientific name	Common name
Algae		
	Cystoseira osmundacea	bladder chain kelp
	Desmarestia spp.	acid kelp
	Dictyoneuropsis/Dictyoneurum	ribbed kelp
	Egregia menziesii	feather boa kelp
	Rhodophyta, encrusting	encrusting red algae
	Corallinaceae, erect	erect coralline algae
	Corallinaceae, crustose	coralline crust
	holdfast, unid. (dead)	unid. holdfast (dead)
	Rhodophyta, erect	erect red algae
	Pterygophora californica holdfast	tree kelp holdfast
	Chlorophyta	unid. green algae
	Laminariales holdfast	tree kelp holdfast
	Macrocystis holdfast	giant kelp holdfast
	Phyllospadix spp.	surfgrass (flowering plant)
	Sargassum spp.	Japanese seaweed
	Phaeophyta	unid. brown algae
	Bacillariophyta	diatomaceous scum
Coelenterates		
	Balanophyllia/Paracyathus/Astrangia	cup corals
	Corynactis californica	strawberry anemone
	Gorgonacea	sea fans
	Hydroida	hydroids
	Anthozoa	unid. sea anemone
	Stylaster californicus	California hydrocoral
Mollusks		
	Serpulorbis squamigerus	tube worm
	Pholadidae	unid. boring clam
	Mytilus spp.	unid. mussel
	Pectinidae	unid. scallop
	Pelecypoda	unid. bivalve
Polychaetes		
	Chaetopterus/Diopatra	tube worm
	Dodecaceria fewkesi	tube worm
	Phragmatopoma californica	sand tube worm
	Salmacina tribranchiata	tube worm
	Polychaeta, solitary tubicolous	unid. solitary tube worm
Other invertebrates		
	Porifera, encrusting	unid. encrusting sponge
	Cucumaria spp.	sea cucumber
	Echinoidea	unid. urchin
	Tunicata, colonial	unid. colonial tunicates
	Bryozoa	unid. moss animals
	Animalia, turf	unid. animal turf
	Balanomorpha	unid. barnacle
	Tunicata, solitary	unid. solitary tunicate
	Polychaeta/Amphipoda, tube mat	unid. tube mat

2.2 Data Analysis

One of the study objectives was to collect data that were consistent among the various sampling groups and ensure that they were reported accurately. Standardized sampling protocols, pre-printed data sheets and initial training exercises as well as good communication among the principal investigators and their teams combined to produce a very high quality data set for analysis. There were several stages of data review beginning at the data entry level with verification between field sheets and data printouts after the data were entered into an electronic spreadsheet. The principal investigator or designated reviewer from each institution then transmitted the data to CDF&G for the next review stage. Any questions concerning data inconsistencies, data ranges, species codes, formats or potential data omissions were directed back to the group that submitted the data. As final reviews of each data set were completed by CDF&G, the data were transmitted to the analysis contractor for compilation into a master database. Additional checks revealed a few inconsistencies among the data sets once they were appended into a single file for each sampling method and these were resolved in most cases by communicating directly with each principal investigator. Finally, a master database for the 2004 CRANE data was produced by the analysis contractor. A similar review cycle was initiated for the historical databases submitted by the various institutions, but these were not appended into a single uniform database due to dissimilarities among some of the long-term sampling programs.

The objectives of the analysis were to determine geographic and temporal patterns in species composition, density and size of fish in the sampling area, and to evaluate associations between species distributions and factors such as latitude, kelp abundance and fishing pressure. The following sections list the types of descriptive statistics used to summarize the data and the methods used for the various levels of analysis.

2.2.1 Site Data

Basic site information that was compiled included the following: a listing of each site name, location (county or island), dates sampled, sampler, latitude, longitude, depth (range), number of sampling zones, number of replicates (benthic), number of replicates (midwater), temperature (range), visibility (range), surge (range), and percent canopy (range).

For the fish data sets, the following basic species information was compiled for each site for benthic and midwater data sets separately: taxon, total abundance, mean density, standard error, frequency of occurrence (per number of replicates at a site), average size and size range. For each site the following information was also calculated: number of transects completed, number of species, total number of individuals, Shannon's diversity, dominance, and evenness (Simpson index). The data collected using the swath and UPC protocols was summarized similarly, except that no diversity or evenness indices were calculated due to the limited taxa lists used in the methods.

For common species and species of special concern, changes in fish density over time (mean density ± standard error) were plotted at sites that had five or more years of data. If data were sufficient, mean sizes of select species were also plotted over time to illustrate changes.

2.2.2 Site Patterns and Associated Factors

In order to evaluate patterns among sites, a hierarchical cluster analysis (CA) using group-average linkage of Bray-Curtis measures of similarity was used—the most common method of cluster analysis that has proven useful in a number of studies (Clarke and Warwick 2001). The data were also analyzed using the ordination technique of non-metric multidimensional scaling (MDS) to help verify the patterns revealed in the CA, to determine if there were higher dimensional relationships among the sites, and to identify the species responsible for the patterns in the CA and MDS analyses.

CA results can be ambiguous when there is a gradient of change in community structure across sites (Clarke and Warwick 2001). Across the latitudinal gradient there will be other differences among sites due to substrate, relief, exposure, etc. that will represent additional sources of variation that may not be shown in CA, which only presents the relationships among sites in one-dimension (Pimentel 1979). These additional sources of variation are best represented in an ordination technique such as MDS that can present a multi-dimensional picture of the relationships among sites. Even when the relationships among sites form distinct clusters it is often best to confirm the relationship from CA using an ordination technique such as MDS.

PRIMER Ver. 5.2.0 (Clarke and Gorley 2001) was used to run the CA and MDS analyses. PRIMER has an analysis procedure (SIMPER) for determining the species responsible for the pattern among sites when the sites can be separated into groups. This technique, in addition to CA of species similarities, and rank correlation between individual species abundances and MDS coordinates, was used to identify species that may be contributing to the differences among sites.

Associations between biological and other important environmental data were also examined using a combination of univariate and multivariate analyses. The environmental variables were plotted against standard biological indices such as species richness, diversity, and total abundance. The environmental variables were also analyzed using principal component analysis (PCA), which provides for standardization of variables measured using different scales. The BIO-ENV procedure in PRIMER was used to examine possible associations between similarities among sites based on biological data and the environmental variables. This analysis uses an iterative analysis of the rank ordering of the sites from the MDS analysis of the biological data and the PCA analysis of the environmental variables to determine the suite of environmental variables that maximize the correspondence between the data sets. Other analyses in PRIMER were used to determine if there is a systematic relationship between the biological pattern and a specific abiotic trend.

Community Analysis Dataset Filtering

Before analyzing the fish data for patterns among sites, it was necessary to apply certain filter criteria to remove species or size classes that would weight the data toward a certain site. For example, pelagic species such as northern anchovy and sardine occurred infrequently on the transects but were very abundant when they were encountered and would have a tendency to associate sites based on the abundance of that species alone. Similarly, young-of-the-year (YOY) could be abundant in early season at some sites but decline as a result of natural mortality later in the year. Because sites were sampled over a time period of several months, new recruits could numerically dominate the assemblage at some sites and thus disproportionately affect the outcome of the analysis. Therefore, prior to community analysis the data were filtered to exclude YOY and pelagic species. Species that were recorded at less than 5% of all the sites were also omitted regardless of abundance. Separate analyses were done that included both midwater and benthic datasets combined, benthic data only, and a subset of data ("historical species list" [**Table 2-6**]) that included fishery species and species that were routinely counted in most long-term monitoring studies.

Correlation of fish abundance and physical site variables

Physical variables and patterns of fish abundances were tested for correlations at 62 sites and included the following factors: transect depth range, substrate type (bedrock, boulder, cobble, sand), substrate relief (high, moderate, slight, flat), percent uncolonized (bare) space, and structural components including understory algal (non-stipitate kelp) coverage, understory kelp counts, and total giant kelp count. These variables were quantified using either the swath or UPC transect methods (Section 2.1.3 - *Swath Sampling*, Section 2.1.5–*Uniform Point Contact Benthos Sampling*, and **Appendix D**). Data were not available for 17 Monterey area sites (UCSC-PISCO), and eight sites in the SCB.

Data were standardized to account for the different units of measurement and used to calculate Euclidean distances among the sites. The rank order of sites using the Euclidean distances derived from the site characteristics and the Bray-Curtis distances from the fish data were compared using the RELATE procedure in PRIMER. This permutation procedure iteratively calculates numerous random orderings of the sites from the two sets of distances and then compares the observed Spearman rank correlation to the distribution of correlations calculated from the distribution derived from the randomization process.

The same sets of biological and site characteristics were analyzed using the BIOENV procedure in PRIMER to determine if some subset of variables improved the rank correlation between site distances. This procedure is a similar permutation procedure to RELATE but alters the number of site characteristic variables used in calculating the Euclidean distance matrix. The results provide the subset of variables that provide the highest correlation between data sets.

<u>Reserve effects</u>

Fish assemblage composition and mean sizes of select species were compared between pairs of reserve and non-reserve sites. The length of time during which sites had been in a protected status, as of the 2004 study, ranged from as little as a year (several sites in the Channel Islands) to as long as 31 years (three sites near Point Lobos). To explore the effects of reserve status on fish abundance and size, a set of northern mainland sites and a set of southern island sites were analyzed that included long-established reserves and adjacent reference areas. The average Bray-Curtis distance between paired reserve and non-reserve sites that were located in close proximity to one another was calculated separately for reserve sites in northern and southern California. This average distance was compared against a distribution of 1000 average distances calculated using random selection of ten pairs of sites from the remaining possible site pairs. The average from the paired reserve and non-reserve sites was compared with the distribution of randomly generated average distances based on a null hypothesis that the average Bray-Curtis distance among the paired reserve and non-reserve sites is not significantly different from the randomly generated distances. An average exceeding 95% of the randomly calculated values would indicate that the average Bray-Curtis distance among the paired reserve and non-reserve sites was significantly greater than the average distances calculated using randomly selected pairs of sites. This would be expected if the fish communities at the reserve sites had changed relative to other nearby non-reserve sites.

One long-established protected area, the Anacapa Island Ecological Reserve was sampled with a single CRANE site (ANEI). However, the site was not examined statistically for reserve effects because the recent designation of other adjoining no-take areas around the island limited the number of unfished comparison sites in the analysis. The site was compared with other sites around Anacapa Island in terms of fish diversity and the abundance of two fishery species, sheephead and kelp bass.

2.2.3 Historical Data Sets

Abundance over time, size changes for data sets with greater than 5-year time history. Length frequency and abundances for species in the NFMP. TO BE COMPLETED.

Table 2-5. List of institutions contributing historical data sets for analysis of long-term abundance trends including study locations and durations.

Group

Table 2-6. List of fish and invertebrate species used for analysis of historical data sets from various long-term monitoring projects, including the 2004 data from UCSC-PISCO sites.

Group	Scientific name	Common name
Fishes		
	Anisotremus davidsoni	sargo
	Caulolatilus princeps	ocean whitefish
	Chromis punctipinnis	blacksmith
	Rhacochilus vacca	pile surfperch
	Embiotoca jacksoni	black surfperch
	Embiotoca lateralis	striped surfperch
	Girella nigricans	opaleye
	Hermosilla azurea	zebra perch
	Hexagrammos decagrammus	kelp greenling
	Hexagrammos superciliosus	rock greenling
	Hyperprosopon argenteum	walleye surfperch
	Hypsurus caryi	rainbow surfperch
	Hypsypops rubicundus	garibaldi
	Medialuna californiensis	halfmoon
	Ophiodon elongatus	lingcod
	Oxyjulis californica	señorita
	Paralabrax clathratus	kelp bass
	Paralabrax maculatofasciatus	spotted sandbass
	Paralabrax nebulifer	barred sandbass
	Rhacochilus toxotes	rubberlip surfperch
	Scorpaena guttata	California scorpionfish
	Scorpaenichthys marmoratus	cabezon
	Sebastes atrovirens	kelp rockfish
	Sebastes auriculatus	brown rockfish
	Sebastes carnatus	gopher rockfish
	Sebastes caurinus	copper rockfish
	Sebastes chrysomelas	black-and-yellow rockfish
	Sebastes dalli	calico rockfish
	Sebastes melanops	black rockfish
	Sebastes mystinus	blue rockfish
	Sebastes nebulosus	china rockfish
	Sebastes rastrelliger	grass rockfish
	Sebastes serranoides	olive rockfish
	Sebastes serriceps	treefish
	Sebastes atrovirens/carnatus/chrysomelas/caurinus	YOY kelp/gopher/black-and-yellow (KGB)
	Sebastes carnatus/chrysomelas/caurinus	YOY gopher/black-and-yellow/copper (GBY)
	Sebastes entomelas	widow rockfish
	Sebastes flavidus	yellowtail rockfish
	Sebastes maliger	quillback rockfish
	Sebastes miniatus	vermilion rockfish
	Sebastes paucispinis	bocaccio
	Sebastes pinniger	canary rockfish
	Sebastes saxicola	stripetail rockfish
	Sebastes serranoides/flavidus	YOY olive/yellowtail (OYT)
	Sebastes serranoides/flavidus/entomelas/mystinus	YOY blackspot
	Sebastes serranoides/flavidus/melanops	YOY olive/yellowtail/black (OYB)
	Semicossyphus pulcher	California sheephead
	Stereolepis gigas	giant sea bass
Invertebrates		
	Parastichopus californicus	California sea cucumber
	Parastichopus parvimensis	warty sea cucumber
	Strongylocentrotus purpuratus	purple urchin
	Strongylocentrotus franciscanus	red urchin
	Haliotis spp.	abalone (all species individually)
	Kelletia kelletii	Kellet's whelk

3.0 Results

3.1 Data Set Description - General

Data from a total of 88 study sites ranging from Santa Cruz County in central California to San Diego County in southern California, including all the Channel Islands, were collected by 67 researchers from 6 institutions. Most sites were sampled in August–November 2004 although sampling dates ranged from April 2004 through January 2005 during the project (**Figure 3-1**). Invertebrate sampling generally occurred on the same days as the fish sampling, or if not, on a closely following date. The entire complement of sampling protocols was done at all stations with the following exceptions: fish sampling was not done at the Sal site in Santa Barbara County, and invertebrate sampling (swath and UPC) was not done at 8 of the 60 sites south of Point Conception (**Table 2-1**). Data from 17 sites in the Monterey Bay area and along the Big Sur coastline that were sampled by University of California at Santa Cruz as part of the PISCO program only included summarized data on a subset of fishery species and other species of interest (**Table 2-6**).

Observers quantified fishes on a total of 1,955 benthic transects and 1,774 midwater transects. Macroinvertebrates, algae, substrate composition and bottom relief were quantified on 915 transects.

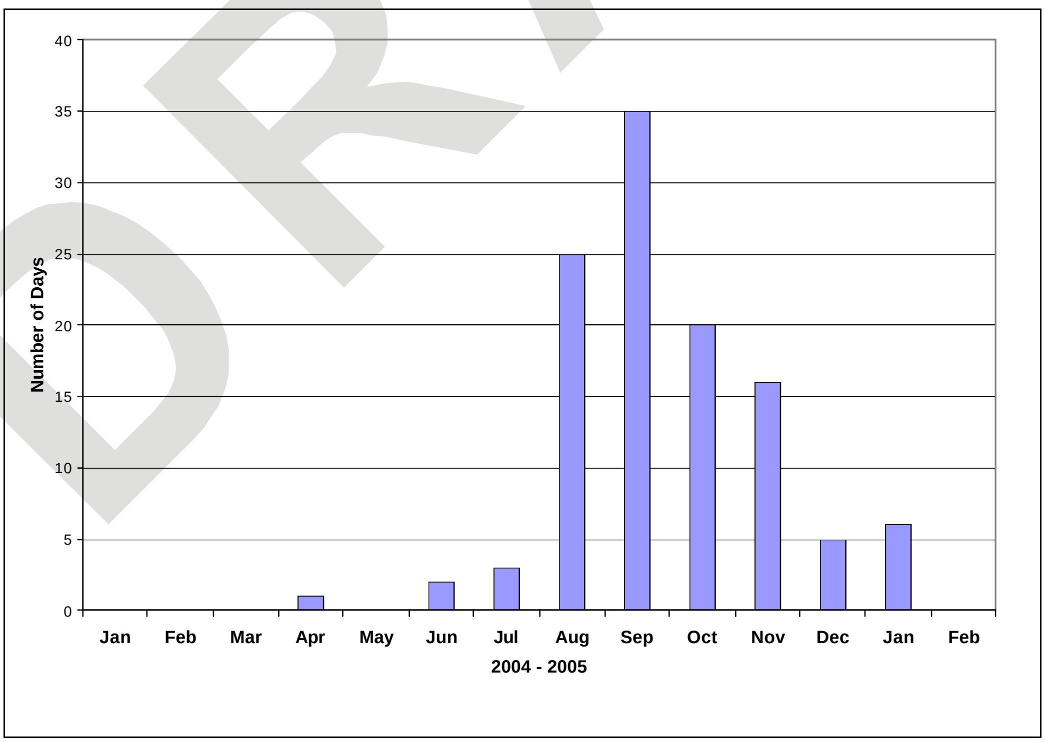

Figure 3-1. Distribution of sampling days by month for CRANE fish surveys.

Physical data on water temperature and underwater visibility were recorded at most sites during the surveys. Mean temperatures ranged from lows of 10°C (50°F) at several sites in Monterey County to highs over 21°C (70°F) at Catalina Island (**Figure 3-2a**). Although sampling was conducted over a period of several months during which regional water temperatures fluctuated on a seasonal basis, there was clear trend of increasing mean temperature with decreasing latitude. Mean underwater visibility during sampling ranged from less than 4 m (13 ft) at some mainland sites to over 10 m (33 ft) at many island sites (**Figure 3-2b**). The average visibility among sites was approximately 8 m (26 ft).

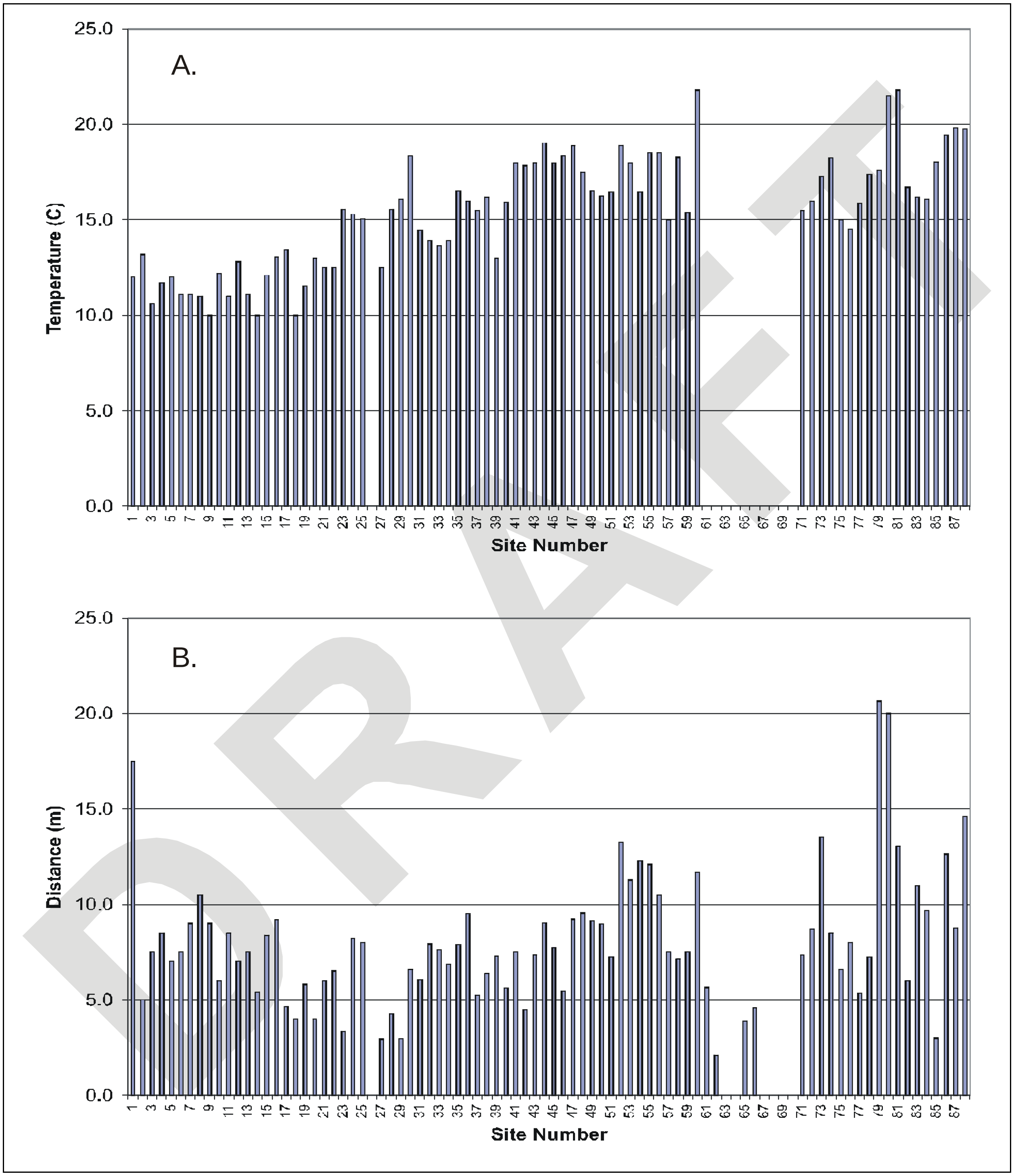

Figure 3-2. a) Mean water temperature, and b) underwater visibility recorded on benthic transects from 88 sampling sites. Blanks indicate no data recorded. Refer to Table 2-1 for names and locations of site numbers.

3.2 Fish

A total of 83 distinct species of fishes, sharks and rays representing 40 families was observed at all sites combined. Several additional taxa that included multiple species, either at the family or genus level, were also recorded. The observed species represented the conspicuous, non-cryptic ichthyofauna at each site and did not include, or underestimated, many of the smaller cryptic species present at a site. Rockfishes (Scorpaenidae) included the most species (14) of all families, followed by surfperches (Embiotocidae) with ten species and sculpins (Cottidae) with six species. Data were obtained on 17 of the 19 species of nearshore finfishes proposed for management under the CDF&G Nearshore Fisheries Management Plan (**Table 3-1**) with two of the species (quillback rockfish and rock greenling) not observed in the study. A list of all fishes, sharks, and rays observed, ordered by family, is presented in Appendix **Table C1**, followed by an alphabetical listing of the species (**Table C2**).

Consistency in identifying and classifying species was generally very good among observers and institutions, but some differences required that the data be combined into broader categories for analysis. Recently settled or "young of year" (YOY) rockfishes can be difficult to identify to the species level in the field, and researchers have different groupings for identifying similar species. In compiling the data, all YOY kelp, gopher, black and yellow, copper, and grass rockfishes were designated as *Sebastes atrovirens/S. carnatus/S. chrysomelas* (YOY). Any specimens that could be positively identified to species were recorded and measured as such. Although newly settled olive, yellowtail and black rockfishes can also be difficult to identify to species in the field and are often grouped, some researchers used the olive/yellowtail combination category for adults as well. Almost all larger specimens of this species-pair occurring in shallow water are olive rockfishes, but the combination category was retained on species lists for the individual sites regardless of size. One other combination category was necessary because of uncertainties in field identifications for silversides (Atherinopsidae) that included all recorded observations of silversides (family), topsmelt, jacksmelt and grunion.

3.2.1 Site Data

Mean abundances and frequencies of occurrence for taxa across all sites are presented separately for the benthic and midwater transects (**Tables 3-1** and **3-2**). Benthic transects included 86 taxa and the midwater transects included 55 taxa. The benthic and midwater transects had 48 taxa in common, with an additional 38 taxa that were unique to the benthic transects and 7 taxa that were unique to the midwater transects. The most abundant species observed across all sites in both the midwater and benthic transects was northern anchovy although this resulted from very high counts of several thousand individuals at only two of the sites. Señorita (*Oxyjulis californica*), blacksmith (*Chromis punctipinnis*), and blue rockfish (*Sebastes mystinus*) were among the most abundant species at all sites with señorita occurring at approximately 90% of the sites. Black surfperch (*Embiotoca jacksoni*) was the most frequently occurring species on benthic transects (95%), followed by señorita, California sheephead (*Semicossyphus pulcher*) (82%), pile surfperch (*Rhacochilus vacca*) (77%), and kelp surfperch (*Brachyistius frenatus*) (74%). Silversides (Atherinopsidae) and jack mackerel (*Trachurus symmetricus*), both open-water schooling species, were among the most abundant species observed on midwater transects while kelp surfperch, a canopy-associated species, was the second most frequently occurring midwater species (73%).

Geographical distribution plots are presented for several species to illustrate their abundances within the entire study region. Detailed graphical presentation of abundances, frequencies of occurrence, and size distributions within sites for 42 species are included in **Appendix C**. Examples of the two types of plots are shown for California sheephead, a species that has a predominantly southern distribution in the study region (**Figure 3-3**), and that also has a gradient in size distribution with larger mean and maximum sizes at the northern mainland sites and northern Channel Islands as compared with southern sites (**Figure 3-4**). Blue rockfish (**Figure 3-5**) and kelp rockfish (*Sebastes atrovirens*) (**Figure 3-6**) represent species with primarily northern distributions while kelp bass (*Paralabrax clathratus*) (**Figure 3-7**) represents a species with a primarily southern distribution. Black surfperch occurred at nearly all sites north and south of Point Conception, while the closely-related striped surfperch (*Embiotoca lateralis*) occurred from Monterey Bay to the northern Channel Islands (**Figure 3-8**). Of the 41 common species abundances plotted in **Appendix C** (not including YOY rockfish complex), 14 had strong northern (cooler water) affinities (i.e., population distributions within the study region from Point Conception and San Miguel Island north), 15 had strong southern (warmer water) affinities, and 12 had eurythermal distributions that generally extended throughout the study region (**Table 3-3**).

Table 3-1. Mean abundance and percent frequency of fishes counted on benthic transects for all sites combined. N=87 sites for taxa listed in Table 2-6; N=70 sites for all other taxa. Bold lettering denotes species that are among the 19 nearshore species considered for management under the CDF&G NFMP.

Taxon	Common Name	Grand Mean	Rank Mean	Percent Frequency	Rank Frequency
Engraulis mordax	northern anchovy	28.2738	1	1.43	66
Oxyjulis californica	senorita	10.5952	2	91.95	2
Chromis punctipinnis	blacksmith	9.6382	3	62.07	9
Sebastes mystinus	**blue rockfish**	**3.3875**	**4**	**54.02**	**12**
Paralabrax clathratus	kelp bass	1.7804	5	60.92	10
Sebastes serranoides*	**olive rockfish**	**1.1688**	**6**	**63.22**	**8**
Embiotoca jacksoni	black surfperch	1.1571	7	95.40	1
Embiotoca lateralis	striped surfperch	1.1109	8	54.02	12
Semicossyphus pulcher	**California sheephead**	**1.0836**	**9**	**81.61**	**3**
Aulorhynchus flavidus	tubesnout	0.9903	10	20.00	30
Brachyistius frenatus	kelp surfperch	0.9477	11	74.29	5
Hypsypops rubicundus	garibaldi	0.7803	12	52.87	14
Sebastes atrovirens	**kelp rockfish**	**0.7290**	**13**	**70.11**	**6**
Lythrypnus dalli	bluebanded goby	0.7077	14	7.14	45
Girella nigricans	opaleye	0.6028	15	51.72	15
Oxylebius pictus	painted greenling	0.5675	16	65.71	7
Hypsurus caryi	rainbow surfperch	0.5047	17	58.62	11
Rhacochilus vacca	pile surfperch	0.4862	18	77.01	4
Sebastes melanops	**black rockfish**	**0.4757**	**19**	**34.48**	**25**
Trachurus symmetricus	jack mackerel	0.3436	20	11.43	41
Halichoeres semicinctus	rock wrasse	0.3252	21	47.14	17
Rhinogobiops nicholsi	blackeye goby	0.3235	22	37.14	22
Xenistius californiensis	salema	0.2847	23	5.71	49
Sebastes carnatus	**gopher rockfish**	**0.2759**	**24**	**44.83**	**19**
Cymatogaster aggregata	shiner surfperch	0.2339	25	12.86	39
Paralabrax nebulifer	barred sand bass	0.2203	26	19.54	32
Phanerodon furcatus	white surfperch	0.1953	27	20.00	30
Sebastes chrysomelas	**black and yellow rockfish**	**0.1748**	**28**	**48.28**	**16**
Hexagrammos decagrammus	**kelp greenling**	**0.1613**	**29**	**31.03**	**28**
Medialuna californiensis	halfmoon	0.1491	30	37.93	21
Rhacochilus toxotes	rubberlip surfperch	0.1265	31	47.13	18
Heterostichus rostratus	giant kelpfish	0.0995	32	35.71	23
Hyperprosopon argenteum	walleye surfperch	0.0986	33	4.60	50
Atherinopsidae	silversides	0.0954	34	8.57	43
Anisotremus davidsoni	sargo	0.0745	35	12.64	40
Sebastes miniatus	vermilion rockfish	0.0603	36	29.89	29
Sebastes caurinus	**copper rockfish**	**0.0598**	**37**	**33.33**	**26**
Sebastes atro./ S. carn./ S. chryso. (yoy)	kelp/ gopher/ black & yellow r.f. (yoy)	0.0594	38	16.09	35
Ophiodon elongatus	lingcod	0.0536	39	39.08	20
Sebastes serriceps	**treefish**	**0.0503**	**40**	**35.63**	**24**
Sebastes paucispinis	bocaccio	0.0489	41	13.79	38
Sebastes pinniger	canary rockfish	0.0453	42	16.09	35

* includes YOY specimens classified in the olive/yellowtail rockfish category

(table continued)

Table 3-1 (continued). Mean abundance and percent frequency of fishes counted on benthic transects for all sites combined. N=87 for taxa listed in Table 2-6; N=70 for all other taxa.

Taxon	Common Name	Grand Mean	Rank Mean	Percent Frequency	Rank Frequency
Caulolatilus princeps	ocean whitefish	0.0350	43	18.39	33
Scorpaenichthys marmoratus	**cabezon**	**0.0315**	**44**	**33.33**	**26**
Sebastes rastrelliger	**grass rockfish**	**0.0163**	**45**	**16.09**	**35**
Myliobatis californica	bat ray	0.0142	46	17.14	34
Sebastes auriculatus	**brown rockfish**	**0.0054**	**47**	**10.34**	**42**
Alloclinus holderi	island kelpfish	0.0054	47	8.57	43
Galeorhinus galeus	soupfin shark	0.0048	49	1.43	66
Scorpaena guttata	**California scorpionfish**	**0.0044**	**50**	**5.75**	**47**
Triakis semifasciata	leopard shark	0.0036	51	2.86	55
Sebastes nebulosus	**China rockfish**	**0.0033**	**52**	**3.45**	**54**
Hermosilla azurea	zebra perch	0.0029	53	2.30	65
Pleuronichthys coenosus	c-o turbot	0.0029	53	7.14	45
Paralichthys californicus	California halibut	0.0029	53	4.29	51
Stereolepis gigas	giant sea bass	0.0024	56	5.75	47
Sebastes spp.	rockfishes	0.0024	56	1.43	66
Anarrhichthys ocellatus	wolf-eel	0.0020	58	4.29	51
Jordania zonope	longfin sculpin	0.0019	59	1.43	66
Cheilotrema saturnum	black croaker	0.0018	60	2.86	55
Gymnothorax mordax	California moray	0.0018	60	4.29	51
Orthonopias triacis	snubnose sculpin	0.0018	60	2.86	55
Prognathodes falcifer	scythe butterflyfish	0.0018	60	1.43	66
Artedius corallinus	coralline sculpin	0.0014	64	2.86	55
Artedius spp.	sculpins	0.0014	64	2.86	55
Cephaloscyllium ventriosum	swell shark	0.0014	64	2.86	55
Urolophus halleri	round stingray	0.0013	67	1.43	66
Embiotocidae	surfperches	0.0012	68	1.43	66
Gibbonsia spp.	clinid kelpfishes	0.0012	68	2.86	55
Leiocottus hirundo	lavender sculpin	0.0012	68	1.43	66
Platyrhinoidis triseriata	thornback	0.0012	68	2.86	55
Seriola lalandi	yellowtail jack	0.0012	68	1.43	66
Squatina californica	Pacific angel shark	0.0012	68	2.86	55
Torpedo californica	Pacific electric ray	0.0012	68	1.43	66
Heterodontus francisci	horn shark	0.0011	75	2.86	55
Cebidichthys violaceus	**monkeyface eel**	**0.0006**	**76**	**1.43**	**66**
Citharichthys stigmaeus	speckled sanddab	0.0006	76	1.43	66
Hyperprosopon anale	spotfin surfperch	0.0006	76	1.43	66
Neoclinus stephensae	yellowfin fringehead	0.0006	76	1.43	66
Ronquilus jordani	northern ronquil	0.0006	76	1.43	66
Syngnathus spp.	pipefishes	0.0006	76	1.43	66
unidentified fish	unidentified fish	0.0006	76	1.43	66
Gibbonsia elegans	spotted kelpfish	0.0005	83	1.43	66
Myctoperca xenarcha	broomtail grouper	0.0005	83	1.43	66
Pleuronichthys ritteri	spotted turbot	0.0005	83	1.43	66
Sebastes dalli	**calico rockfish**	**0.0005**	**83**	**1.15**	**86**

Table 3-2. Mean abundance and percent frequency of fishes counted on midwater transects for all sites combined. N=87 for taxa listed in Table 2-6; N=70 for all other taxa. Bold lettering indicates species among those considered for management under the CDF&G NFMP.

Taxon	Common Name	Grand Mean	Rank Mean	Percent Frequency	Rank Frequency
Engraulis mordax	northern anchovy	34.8940	1	2.86	34
Chromis punctipinnis	blacksmith	8.7002	2	58.62	3
Oxyjulis californica	senorita	8.5871	3	89.66	1
Atherinopsidae	silverside	6.1392	4	38.57	9
Sebastes mystinus	**blue rockfish**	**2.8881**	**5**	**48.28**	**6**
Trachurus symmetricus	jack mackerel	2.0859	6	27.14	14
Xenistius californiensis	salema	1.7857	7	1.43	40
Brachyistius frenatus	kelp surfperch	1.6237	8	72.86	2
Aulorhynchus flavidus	tubesnout	0.7451	9	20.00	18
Paralabrax clathratus	kelp bass	0.6297	10	54.02	5
*Sebastes serranoides/S. flavidus**	olive/yellowtail rockfishes	0.4763	11	55.17	4
Sardinops sagax	Pacific sardine	0.2863	12	4.29	29
Engraulidae/Atherinopsidae/Clupeidae	unidentified baitfish	0.2381	13	1.43	40
Scomber japonicus	Pacific mackerel	0.1947	14	4.29	29
Girella nigricans	opaleye	0.1510	15	29.89	13
Sebastes atrovirens	**kelp rockfish**	**0.1371**	**16**	**48.28**	**6**
Medialuna californiensis	halfmoon	0.1257	17	41.38	8
Heterostichus rostratus	giant kelpfish	0.0902	18	37.14	10
Sebastes atro./ S. carn./ S. chryso. (yoy)	kelp/ gopher/ black & yellow r.f. (yoy)	0.0745	19	16.09	20
Hypsypops rubicundus	garibaldi	0.0701	20	19.54	19
Embiotoca lateralis	striped surfperch	0.0639	21	31.03	12
Sebastes melanops	**black rockfish**	**0.0546**	**22**	**24.14**	**15**
Semicossyphus pulcher	**California sheephead**	**0.0513**	**23**	**21.84**	**16**
Rhacochilus vacca	pile surfperch	0.0469	24	34.48	11
Sebastes paucispinis	bocaccio	0.0440	25	8.05	23
Embiotoca jacksoni	black surfperch	0.0327	26	21.84	16
Hypsurus caryi	rainbow surfperch	0.0200	27	6.90	27
Anisotremus davidsoni	sargo	0.0196	28	8.05	23
Phanerodon furcatus	white surfperch	0.0191	29	7.14	25
Rhacochilus toxotes	rubberlip surfperch	0.0154	30	11.49	21
Sphyraena argentea	California barracuda	0.0131	31	1.43	40
Cymatogaster aggregata	shiner surfperch	0.0129	32	4.29	29
Halichoeres semicinctus	rock wrasse	0.0084	33	10.00	22
Rhinogobiops nicholsi	blackeye goby	0.0083	34	1.43	40
Sebastes pinniger	canary rockfish	0.0067	35	1.15	50
Myliobatis californica	bat ray	0.0062	36	7.14	25
Syngnathus spp.	pipefishes	0.0062	36	4.29	29
Paralabrax nebulifer	barred sand bass	0.0062	36	4.60	28
Seriola lalandi	yellowtail jack	0.0036	39	2.86	34
Oxylebius pictus	painted greenling	0.0024	40	2.86	34
Caulolatilus princeps	ocean whitefish	0.0019	41	3.45	33
Sebastes carnatus	**gopher rockfish**	**0.0018**	**42**	**2.30**	**37**

* includes YOY specimens classified in the olive/yellowtail rockfish category

(table continued)

Table 3-2 (continued). Mean abundance and percent frequency of fishes counted on midwater transects for all sites combined. N=87 for taxa listed in Table 2-6; N=70 for all other taxa.

Taxon	Common Name	Grand Mean	Rank Mean	Percent Frequency	Rank Frequency
Gibbonsia elegans	spotted kelpfish	0.0012	43	1.43	40
Rimicola muscarum	kelp clingfish	0.0012	43	1.43	40
Ophiodon elongatus	lingcod	0.0010	45	2.30	37
Hexagrammos decagrammus	**kelp greenling**	**0.0010**	**45**	**2.30**	**37**
Apodichthys flavidus	penpoint gunnel	0.0008	47	1.43	40
Embiotocidae	surfperches	0.0006	48	1.43	40
Triakis semifasciata	leopard shark	0.0006	48	1.43	40
Synchirus gilli	manacled sculpin	0.0006	48	1.43	40
Sebastes rastrelliger	**grass rockfish**	**0.0006**	**48**	**1.15**	**50**
Sebastes miniatus	vermilion rockfish	0.0005	52	1.15	50
Sebastes chrysomelas	**black and yellow rockfish**	**0.0005**	**52**	**1.15**	**50**
Hermosilla azurea	zebra perch	0.0005	52	1.15	50
Scorpaenichthys marmoratus	**cabezon**	**0.0005**	**52**	**1.15**	**50**

Table 3-3. Distribution affinities for 41 taxa surveyed in nearshore areas from Santa Cruz County to San Diego County.

Central/Northern	Southern	Widely Distributed
black rockfish	barred sandbass	black surfperch
black-and-yellow rockfish	blacksmith	brown rockfish
blue rockfish	calico rockfish	cabezon
bocaccio	California scorpionfish	kelp rockfish
canary rockfish	California sheephead	kelp surfperch
china rockfish	garibaldi	pile surfperch
copper rockfish	giant sea bass	rainbow surfperch
gopher rockfish	halfmoon	rubberlip surfperch
grass rockfish	kelp bass	senorita
kelp greenling	ocean whitefish	silversides
lingcod	opaleye	striped surfperch
olive/yellowtail rockfish	rock wrasse	walleye surfperch
painted greenling	sargo	
vermilion rockfish	treefish	
	zebraperch	

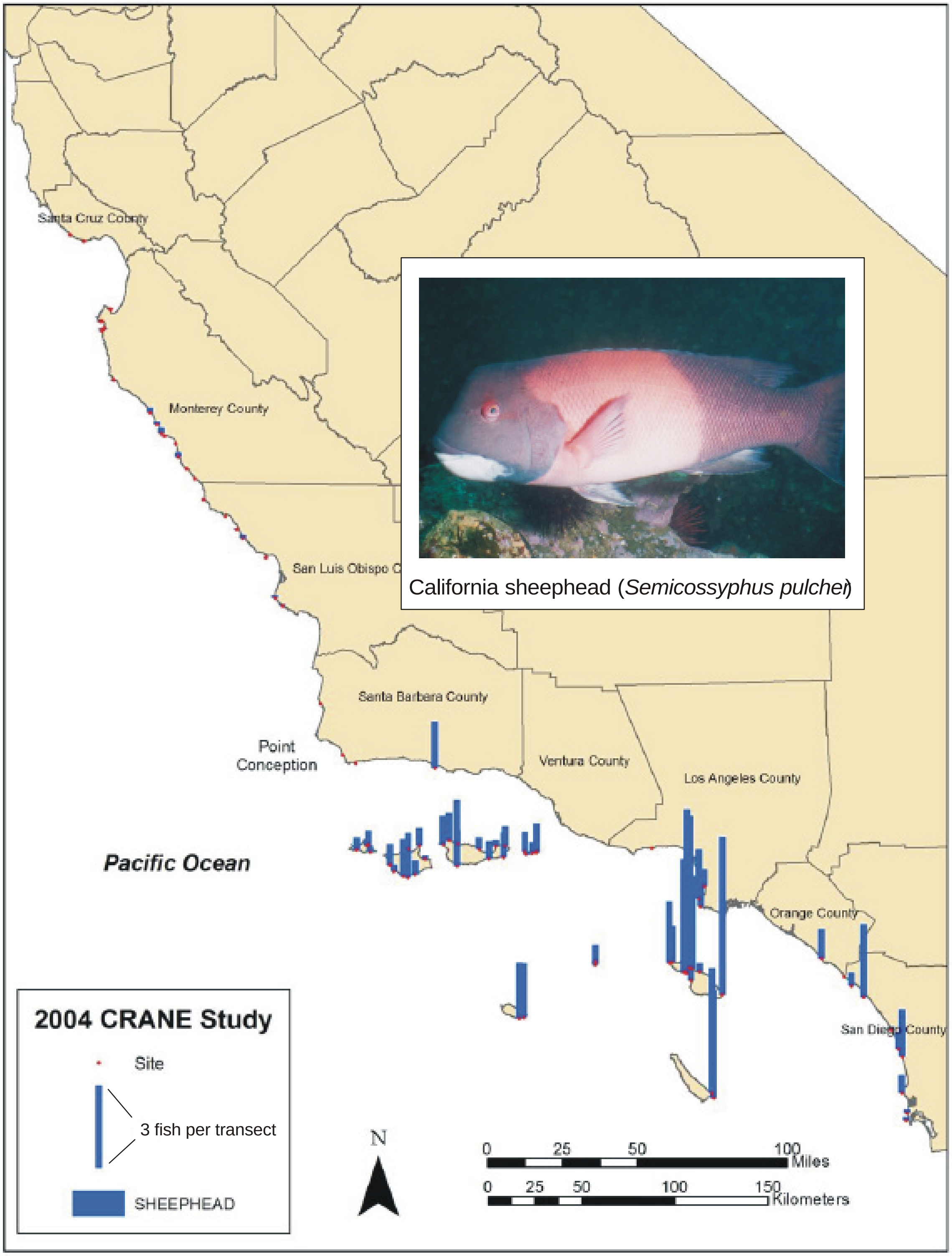

Figure 3-3. Abundance of California sheephead (mean # per transect, benthic only) at 87 sites in central and southern California.

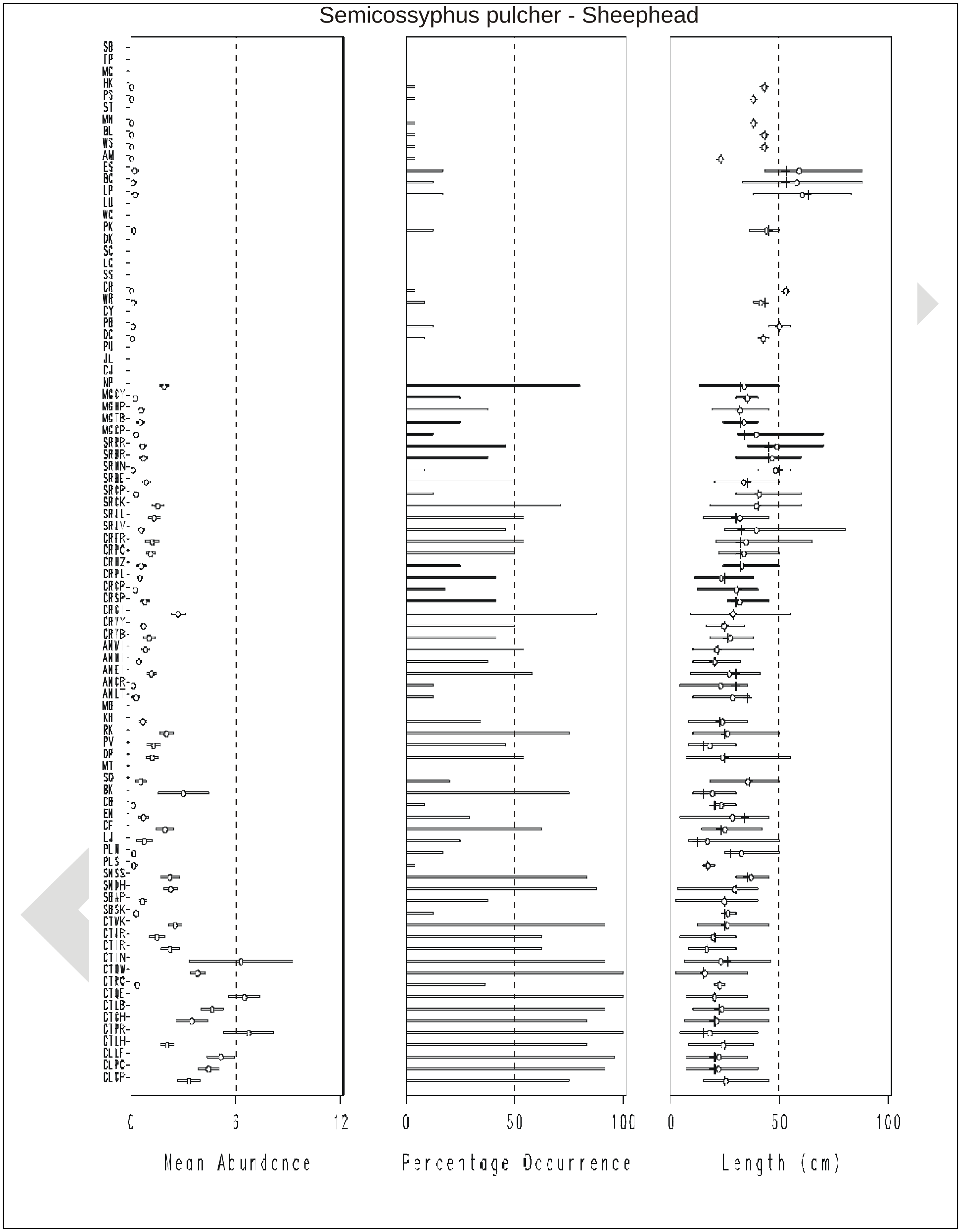

Figure 3-4. Mean abundance (+ 1 standard error), percentage occurrence, and length (mean [symbol], median, and range) of California sheephead at 87 sites in central and southern California.

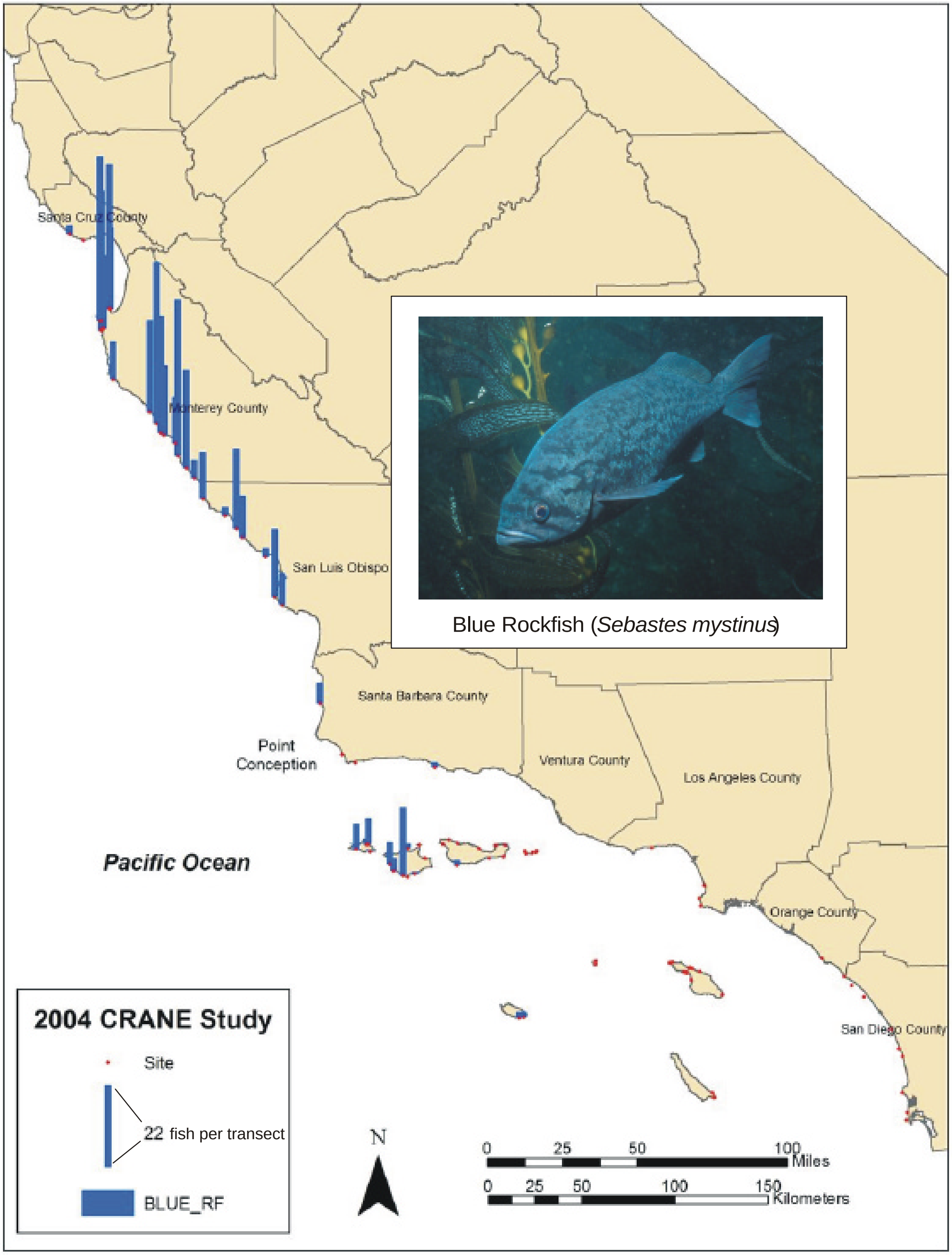

Figure 3-5. Abundance of blue rockfish (mean # per transect, benthic and midwater combined) at 87 sites in central and southern California.

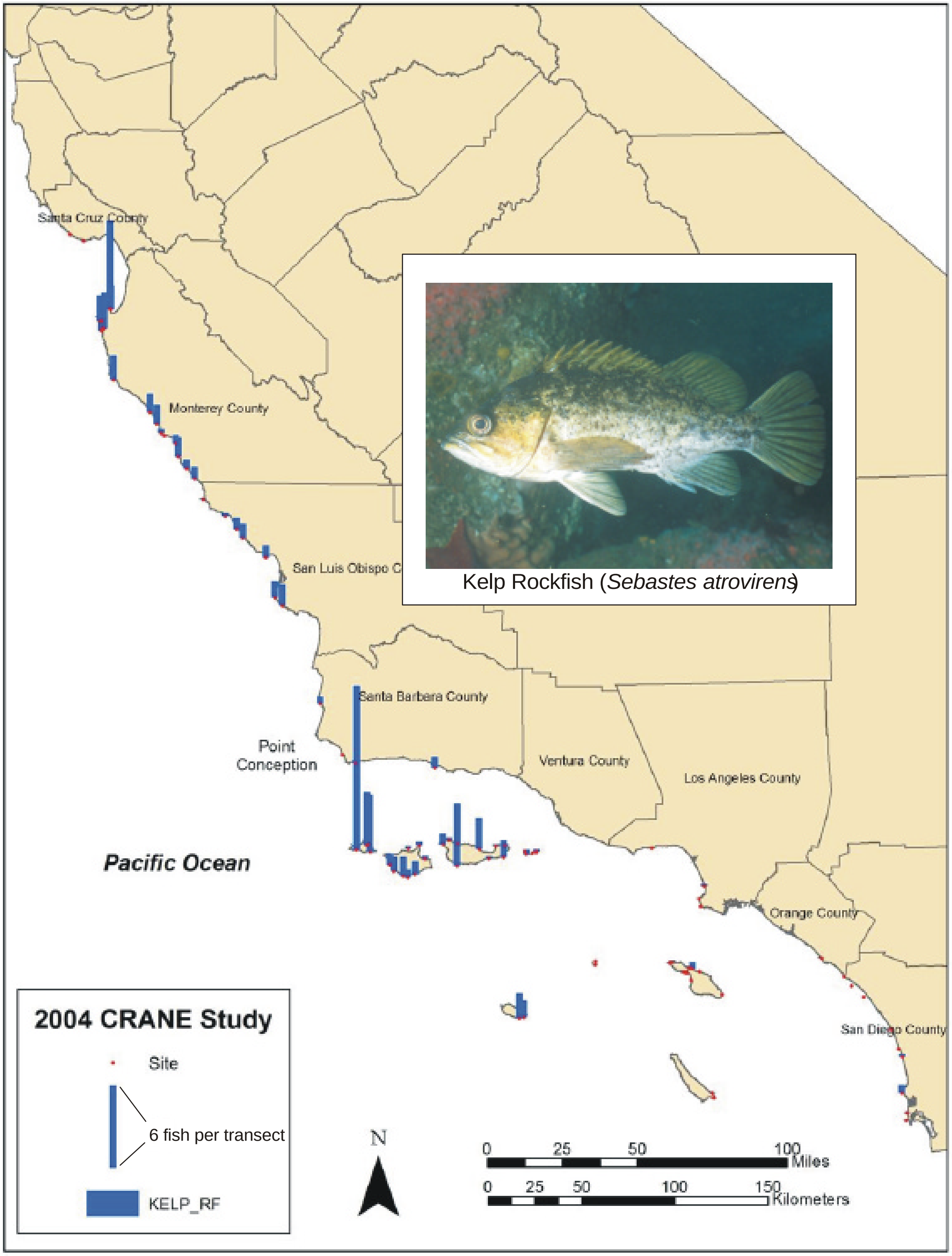

Figure 3-6. Abundance of kelp rockfish (mean # per transect, benthic and midwater combined) at 87 sites in central and southern California.

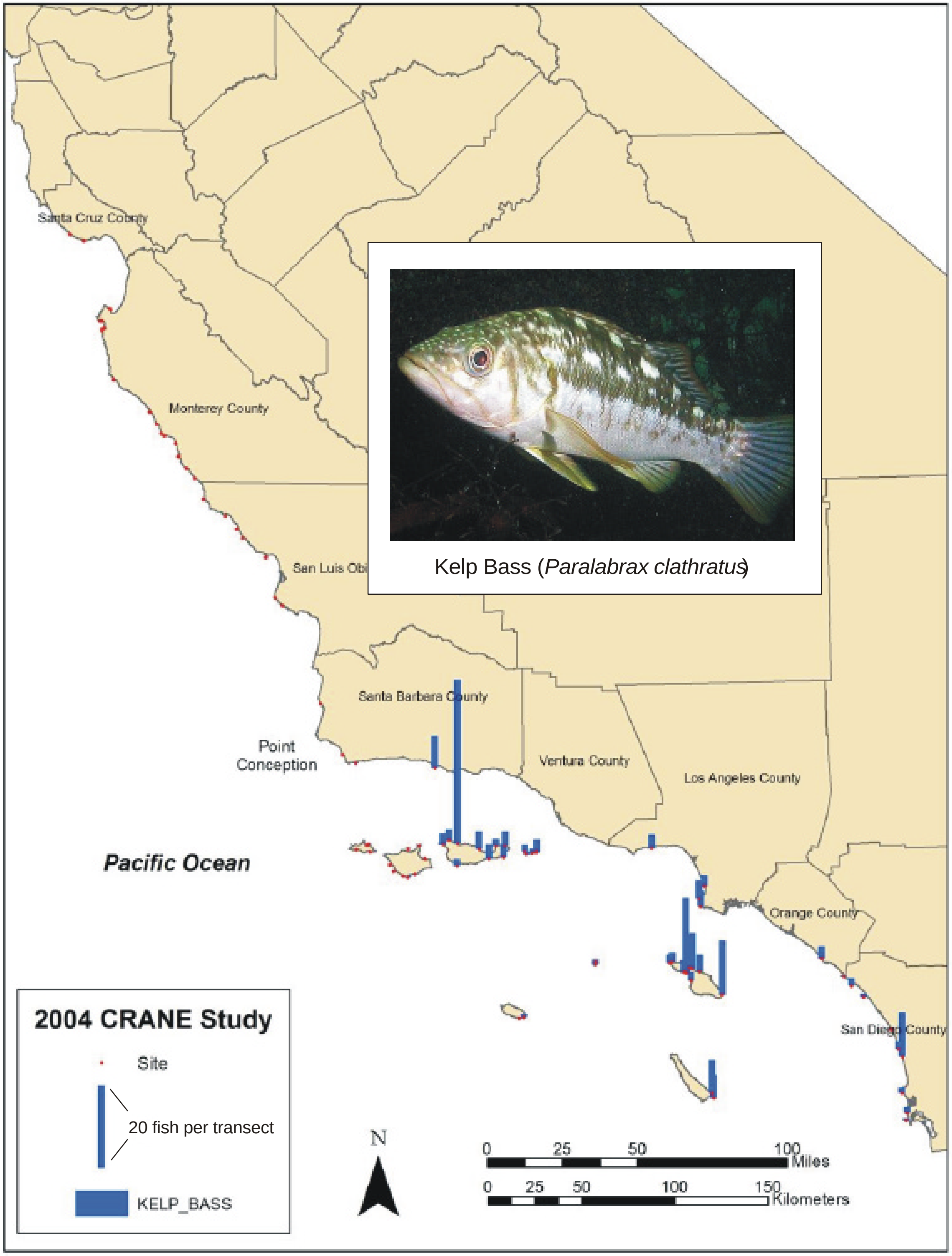

Figure 3-7. Abundance of kelp bass (mean # per transect, benthic and midwater combined) at 87 sites in central and southern California.

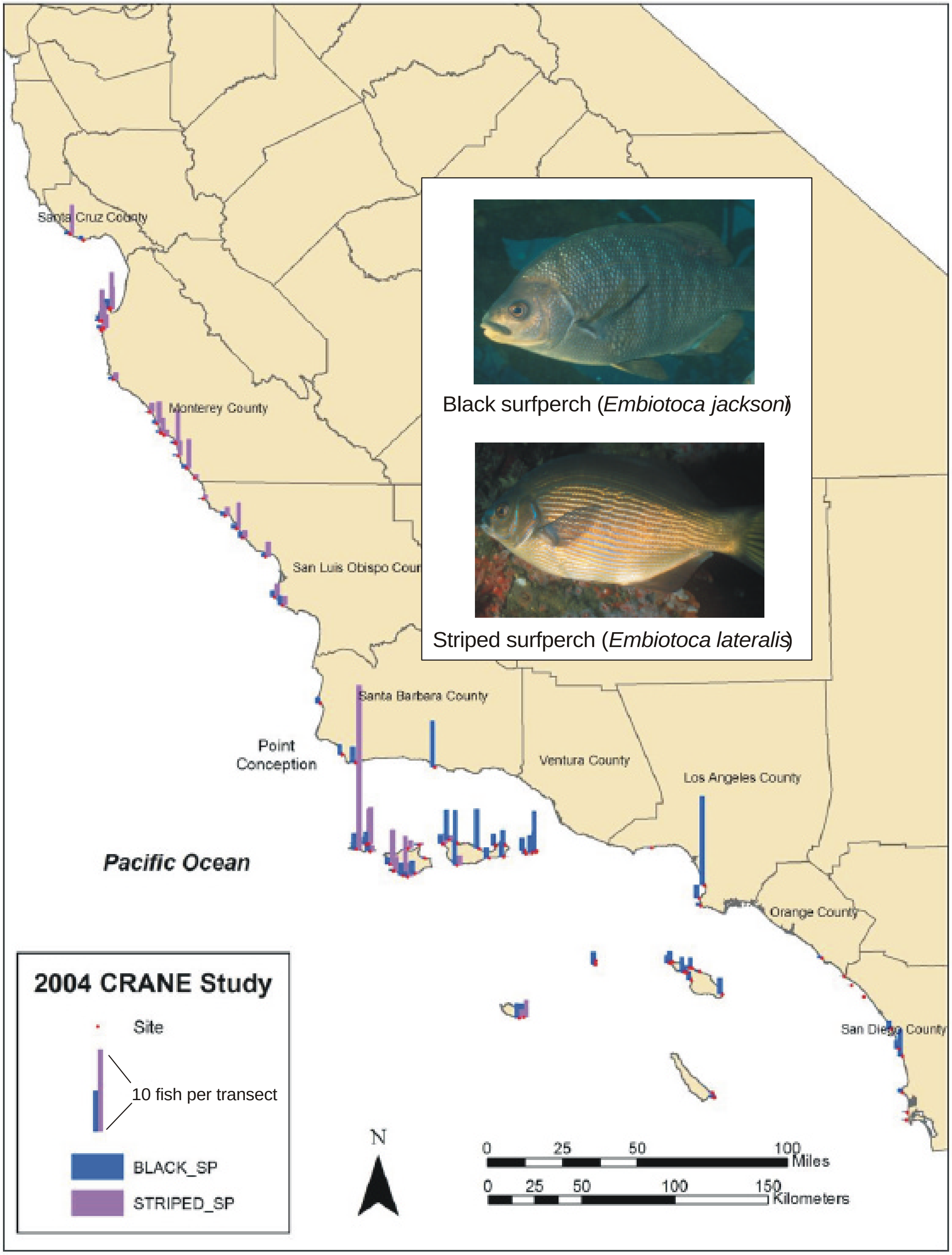

Figure 3-8. Abundance of black surfperch and striped surfperch (mean # per transect, benthic only) at 87 sites in central and southern California.

Most sites were surveyed in late summer or fall when cohorts of YOY rockfishes (*Sebastes* spp.) have recruited into kelp forest habitats. For the purposes of distributional analysis, YOY were defined as individuals less than 11 cm total length, and were combined into two main groups: one comprised of species that mainly occur in the midwater habitat (olive, yellowtail, blue, and black rockfishes ['OYB']), and a second group comprised of primarily demersal or substrate-oriented species (kelp, gopher, black and yellow, copper, canary, and treefish rockfishes ['KGB']). Northern sites, particularly Sandhill Bluff, MacAbee, and Hopkins had large numbers of YOY rockfishes (**Figure 3-9**) with the OYB group more abundant at the first site and the KGB group more abundant at the other two sites. YOY rockfish abundance gradually declined at more southerly sites except for moderate numbers of the KGB group at San Miguel Island. Both groups had only sporadic occurrences or were absent entirely from most sites south of Anacapa Island and Santa Barbara reflecting to a large degree the distribution of adult nearshore rockfishes in the study region.

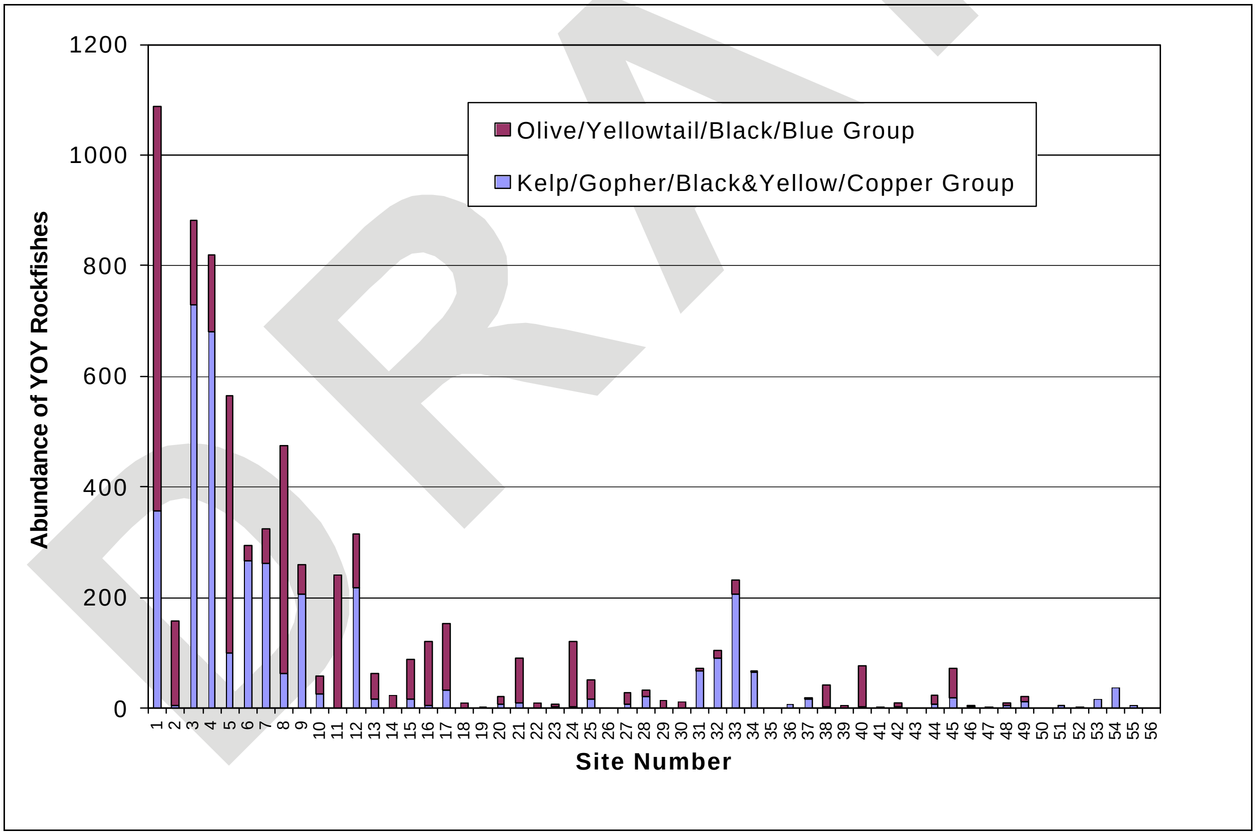

Figure 3-9. Total number of YOY rockfishes (*Sebastes* spp.) from two species groups counted at sites from Santa Cruz to Santa Barbara, including the northern Channel Islands. Refer to Table 2-1 for site names and locations associated with each site number.

3.2.2 Site Groups Based on Fish Assemblages

Five main groups of sites were identified based on clustering of sites shown in MDS (**Figure 3-10**) and CA (**Figure 3-11**) using Bray-Curtis similarities among sites using data on benthic fish assemblages. The groups were comprised of geographically-related sites that had high degrees of within-group similarity in their fish assemblages. As expected, the greatest dissimilarity among groups was between the north mainland group (Group1) and the southern SCB group (Group 5) with a dissimilarity of 82% (**Table 3-4**). Several outlier sites, indicated in **Figures 3-10** and **3-11**, had unique assemblages that differentiated them from the core groups. Further *a posteriori* analysis identified the fish species that had the greatest contribution to the differences among the five main groups of sites (**Table 3-5**). Fishes that were primarily distributed either north or south of Point Conception, such as blue rockfish, blacksmith, and striped surfperch, had the highest average contribution to the differences among groups. Lists of fish abundances by site can be found in **Appendix C**.

Site similarities generally followed a north-south gradient that was strongly associated with latitudinal variations in water temperature. The north mainland cluster (Group 1) was mostly comprised of sites in the Monterey Bay and northern Big Sur area that were characterized by blue rockfish, copper rockfish, cabezon, and striped surfperch, among others (**Figure 3-12**). Blue rockfish had the highest average percent contribution of any species in separating the north mainland group from the other groups (**Table 3-5**). Two of the sites in the north mainland group, Cambria Rock (CR) and White Rock (WR), were located in San Luis Obispo County but had a high affinity with northern sites near Monterey. Unusual outliers included Terrace Point (TP) in Santa Cruz County which had relatively low numbers of blue rockfish compared to the other sites in the vicinity, and Lucia (LU) and Salmon Creek (SC) both of which were sampled in early June, two to three months earlier that other nearby sites. The differences at LU and SC likely reflected seasonal changes in the composition of the fish assemblage although the analysis accounted for recruitment events by filtering out occurrences of YOY.

Mainland sites from the southern Big Sur coastline, San Luis Obispo County, and south to Point Purisima formed a central mainland cluster (Group 2). These sites held some similarities to the Group 1 sites with assemblages that had several species of rockfishes and surfperches. There was also a close affinity between the mainland sites of Point Buchon (PB) and Diablo Canyon (DC) and sites from the northern Channel Islands (Group 3) at San Miguel Island and the south side of Santa Rosa Island. The dissimilarity between these two site groups (32%) was the lowest of any of the group comparisons (**Table 3-4**). All of the Group 3 sites typically had assemblages dominated by colder water species such as blue rockfish, painted greenling, and striped surfperch as compared to the more southerly islands of Santa Cruz and Anacapa. Group 4 sites, which included all nine sites on Santa Cruz Island along with the distant San Nicholas Island sites and the mainland Naples Reef (NP) site, were characterized by a blend of northern and southern species. Greater abundances of opaleye, kelp bass, and blacksmith, in particular, contributed to differentiating the Group 4 sites from the Group 3 sites (**Table 3-5**). Three sites on the north side of Santa Rosa Island (SRMN, SRBR and SRRR) and the mainland sites at Cojo (CJ), Jalama (JL), and Malibu (MB) formed a loose group of outliers that had stronger affinities with the Group 4 sites at Santa Cruz Island than the cooler–water sites comprising Group 3 (**Figure 3-10**).

The largest group delineated by the MDS analysis (Group 5) was comprised of sites in the southern California bight at Anacapa Island, Santa Catalina Island, Santa Barbara Island, and mainland sites from Santa Monica Bay to northern San Diego County. All of these sites were characterized by relatively high numbers of blacksmith, opaleye, kelp bass, and garibaldi, among others. A dendrogram of species similarities based on site occurrences (**Figure 3-12**) clearly separates the main species in the analysis comprising the SCB nearshore fish assemblage from species comprising the northern nearshore assemblages, primarily rockfishes and greenlings.

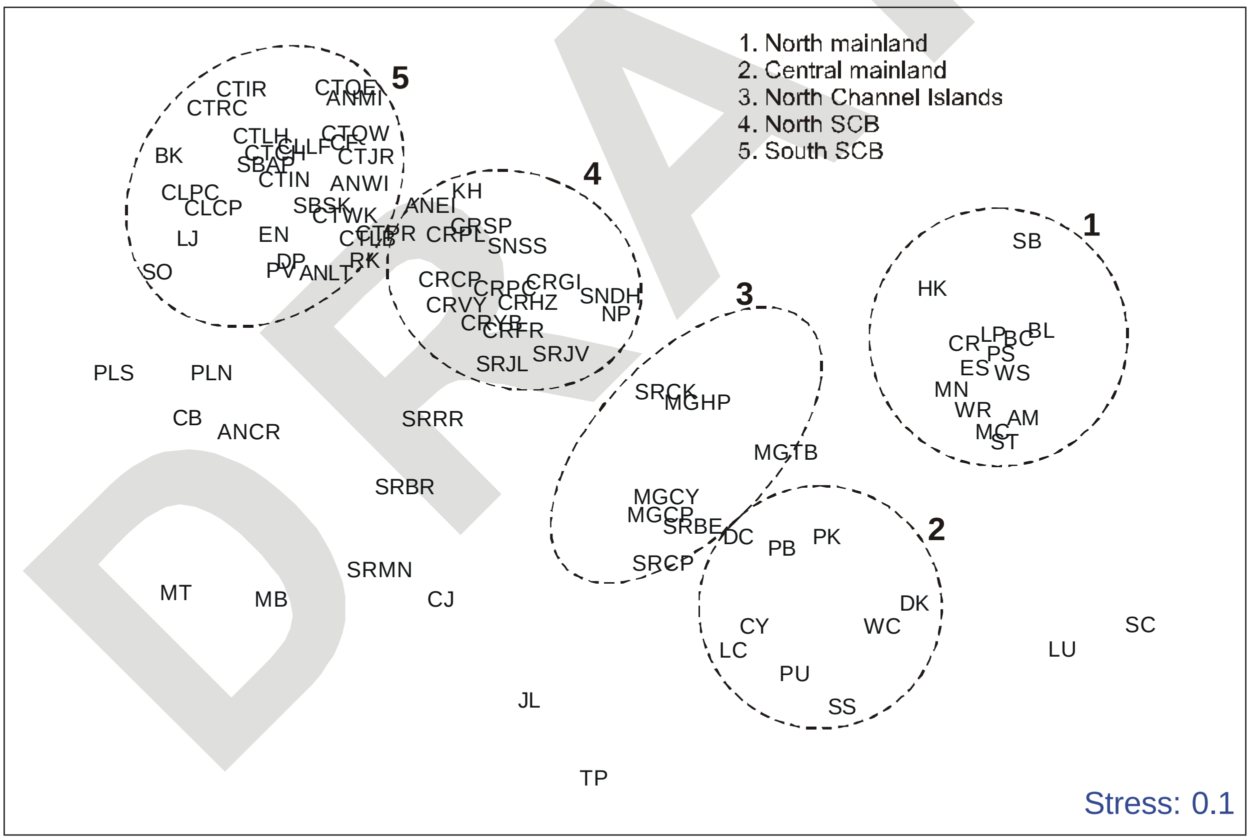

Figure 3-10. Primary site groups based on MDS scores of fish assemblages. Refer to Table 2-1 for site abbreviations and locations, and Appendix B for site maps.

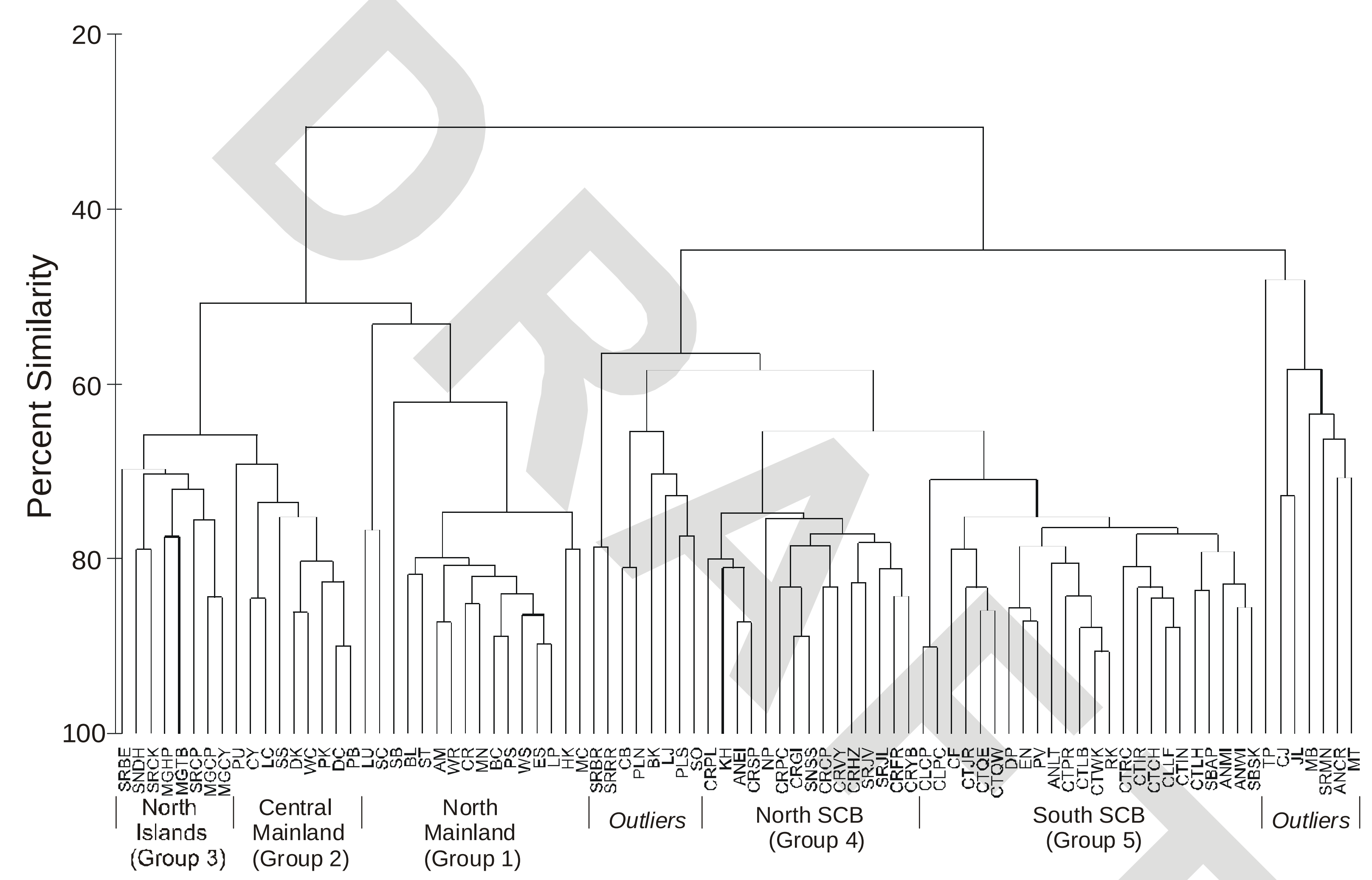

Figure 3-11. Dendrogram of Bray-Curtis site similarities based on the abundances of 24 species of nearshore fishes. Group clusters correspond to MDS plot groups depicted in Figure 3-10. Outlier sites had relatively low similarities to adjacent groups.

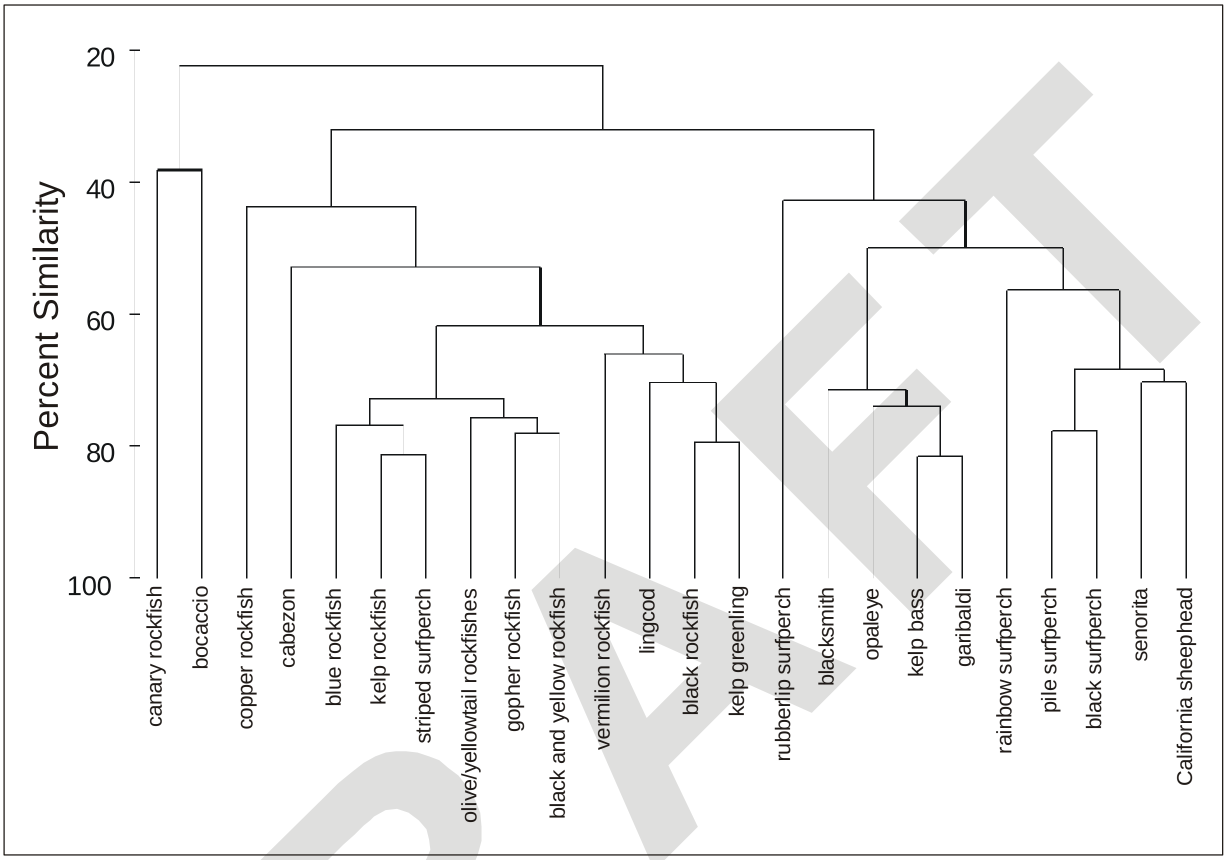

Figure 3-12. Dendrogram of Bray-Curtis species similarities based on abundances at 70 sites.

Table 3-4. Percent dissimilarity between site groups delineated in MDS analysis.

	North Mainland	**Central Mainland**	**North Channel Islands**	**North SCB**	**South SCB**
North Mainland	0.00	48.17	50.11	62.68	81.88
Central Mainland	–	0.00	32.48	53.61	79.02
North Channel Islands	–	–	0.00	40.52	64.47
North SCB	–	–	–	0.00	36.69
South SCB	–	–	–	–	0.00

Table 3-5. Species percent contributions to site group differences based on SIMPER analysis. A null value indicates that the species was absent from both groups being compared.

Species	North Main - Central Main	North Main - North CI	North Main - North SCB	North Main - South SCB	Central Main - North CI	North SCB - Central Main	South SCB - Central Main	North SCB - North CI	South SCB - North CI	North SCB - South SCB	Average
blue rockfish	10.02	10.48	10.83	10.97	4.74	6.77	8.62	6.74	8.50	5.80	**8.35**
striped surfperch	6.98	4.72	6.62	7.72	5.84	4.08	6.13	7.49	10.07	7.33	**6.70**
blacksmith	0.38	2.19	4.46	3.60	5.40	9.11	7.09	8.16	6.14	7.66	**5.42**
kelp rockfish	7.54	6.31	5.67	6.71	3.04	1.91	4.20	3.09	6.33	8.28	**5.31**
senorita	6.37	4.86	2.96	2.92	7.55	6.67	4.54	5.57	3.84	5.26	**5.05**
gopher rockfish	6.33	6.88	6.50	6.31	3.88	4.23	5.07	3.93	4.17	2.86	**5.02**
kelp greenling	5.58	8.86	6.96	6.10	9.46	5.56	4.79	–	–	–	**4.73**
black and yellow r.f	4.81	5.94	5.13	5.73	4.16	3.21	5.05	2.68	3.70	4.74	**4.52**
kelp bass	–	0.44	3.84	3.84	1.12	7.53	7.37	8.89	7.99	3.82	**4.48**
olive and yellowtail r.f.	5.93	5.01	4.13	5.75	3.07	1.67	3.76	1.70	5.21	8.19	**4.44**
rainbow surfperch	4.90	5.12	4.12	4.33	3.42	3.10	3.98	3.96	3.52	6.12	**4.26**
pile surfperch	5.48	4.94	3.65	4.53	2.93	2.33	3.37	2.47	4.04	8.26	**4.20**
opaleye	0.34	0.63	3.93	2.38	0.92	8.15	4.71	9.73	5.11	5.47	**4.14**
black rockfish	5.00	6.22	5.47	4.97	6.29	4.30	3.88	2.43	1.79	0.81	**4.12**
garibaldi	–	–	3.05	3.47	–	5.98	6.63	7.64	7.79	4.80	**3.94**
California sheephead	4.00	2.11	1.53	1.55	8.33	6.00	5.95	1.96	2.40	3.32	**3.72**
vermilion rockfish	4.13	4.38	4.10	3.64	4.55	3.68	3.24	3.17	2.57	0.35	**3.38**
lingcod	3.66	3.37	3.85	3.52	3.04	3.28	3.15	4.40	3.80	1.15	**3.32**
black surfperch	4.32	3.24	1.81	2.72	2.79	3.23	1.85	2.78	2.31	5.76	**3.08**
rubberlip surfperch	2.50	2.75	2.43	1.46	4.43	3.13	1.91	3.47	2.70	5.77	**3.06**
copper rockfish	2.95	2.94	2.13	1.75	4.75	2.23	1.67	3.78	3.42	2.29	**2.79**
cabezon	3.60	3.40	3.11	2.82	3.93	2.28	1.89	2.89	2.18	1.61	**2.77**
bocaccio	2.22	2.59	1.67	1.43	4.02	0.20	–	3.06	2.39	0.34	**1.79**
canary rockfish	2.96	2.62	2.06	1.79	2.34	1.38	1.17	–	–	–	**1.43**

3.2.3 Association of Fish Assemblages with Physical Variables

The correlations between patterns of fish abundances and physical and biological site characteristics were calculated using the average values from 62 of the sites. The following physical and biological site characteristics were used in the analysis: transect depth range, substrate type (bedrock, boulder, cobble, sand), substrate relief (high, moderate, slight, flat), percent uncolonized (bare) space, and structural components including understory algal (non-stipitate kelp) coverage, understory kelp counts, and total giant kelp count. Average values from the transects at each site were calculated for these variables from the UPC and swath data for the 62 sites (**Table 3-6**). Data were not available for 17 Monterey area sites (UCSC-PISCO), and eight sites in the SCB. Temperature and visibility per site (**Figure 3-2**) were not included in the analyses because temperature is already known to have a strong latitudinal gradient that would mask any associations with other factors, and visibility was highly dependent on transient conditions even though it can affect observational data.

Preliminary to the analysis, the mean abundances for 22 taxonomic groups of fishes were analyzed from the 62 sites at which all CRANE sampling procedures were done (fish transects, UPC data on algae and transect characteristics, and swath count data on select invertebrates and kelps). The results of the MDS for these data showed a good fit between Bray-Curtis similarities and the configuration of the site distances resolved by the analysis (**Figure 3-13**). The analysis showed a gradient in fish communities from central mainland and northern Channel Islands to southern California that was similar to the earlier analysis of fish data from 87 sites extending north to Monterey Bay. The relationship of the fish communities among the 62 sites to various biological and physical characteristics of the sites was analyzed using several techniques described in Section 2.2.2–*Site Patterns and Associated Factors*.

The RELATE procedure in PRIMER was used to examine the overall correlation between the site ranking based on fish abundance and the ranking based on physical variables. The Spearman rank correlation between the two data sets was only 0.07, indicating little correlation between the two data sets. The BIO-ENV procedure in PRIMER was used to identify total understory kelp count, total understory algal cover, and bedrock as the best subset of variables that maximized the rank correlation between the biological and physical variables. With this subset of variables the rank correlation was increased to 0.23, which the RELATE procedure identified as significant with a p-value of 0.05%.

Table 3-6. Range and average values of physical variables used in testing correlations with fish abundance.

Variable	Units	Range	Average
Total Understory Kelp Count	number	972.08	107.30
Total Canopy Kelp	number	332.00	61.11
Total Understory	percent coverage	0.68	0.27
Bare Space	percent coverage	0.36	0.10
Substrate, flat relief	percent coverage	0.85	0.35
Substrate, high relief	percent coverage	0.20	0.04
Substrate, moderate relief	percent coverage	0.50	0.11
Substrate, slight relief	percent coverage	0.73	0.50
Bedrock	percent coverage	0.99	0.54
Boulder	percent coverage	0.67	0.18
Cobble	percent coverage	0.77	0.13
Sand (shell gravel)	percent coverage	0.85	0.26
Depth Range	feet	17.07	10.65

The weak relationship between the site characteristics and fish community is shown when individual variables were plotted against the MDS site scores, using the diameter of the circles to show the relative values for the variables among sites. As an example, there was a wide range of kelp overstory and understory among sites but the northern Channel Islands in the middle of the MDS gradient typically had the greatest amount (**Figure 3-13**, Section 3.4–*Algal Abundance*). Understory algae (primarily erect red algae) had a smaller range among sites with the least amounts generally at the Santa Rosa and San Miguel Island sites but a weak correlation with the MDS dispersion pattern.

3.2.4 Comparison of Fish Assemblages at Sites in Reserve and Non-Reserve Areas.

Eighteen of the CRANE sampling sites (20%) were located within designated marine protected areas and fourteen of the sites (16%) were within no-take reserves (**Table 3-7**). Recently established reserve sites in the Channel Islands and sites in conservation areas where some type of fishing was allowed were not included in the analysis. An analysis of Bray-Curtis distances (community measure) of fish assemblages in established reserves and paired non-reserves, and a Monte Carlo simulation of 1,000 random pairs of non-reserve CRANE sites did not detect a significant difference between the Bray-Curtis distance between reserve non-reserve pairs, and the set of randomly generated non-reserve site pairs. The power of this analysis to detect any difference could be affected by the geographical separation of the non-reserve site pairs used in the comparison that increased the Bray-Curtis distance relative to the average distance for the reserve non-reserve pairs. Therefore, subsequent analyses focused on differences in fish abundances between adjacent site pairs to minimize potential differences that may have been caused by comparing widely–separated sites.

A subsequent statistical analysis compared mean abundance and mean length of eight species of fish between sites in reserves and adjacent sites where fishing was allowed. There was no measure of the amount or frequency of fishing that occurred at the adjacent sites—they were simply the closest sites sampled to the reserve sites. Pairs of adjacent non-reserve sites were also tested for differences (**Appendix C**). Of the four species of rockfishes tested, vermilion rockfish was the only species where no significant difference in mean abundance between reserve sites and non-reserve sites was detected (**Table 3-8**). Blue rockfish was significantly more abundant at two of the six reserve sites but was significantly less abundant at four of the reserve sites. Mean sizes were significantly smaller at three reserve sites than their non-reserve counterparts and larger at one site (i.e., Hopkins compared to MacAbee). Black rockfish was more abundant at two of the reserve sites and was less abundant at three sites.

There were more significant differences found in species that were abundant, such as blue rockfish. Bottom-dwelling fishery species such as lingcod and cabezon were typically not abundant on the CRANE transects and this may have increased the variation among sites, thereby reducing the power of the tests to detect a difference between sites. A large number of significant differences in mean abundance and mean length were detected between adjacent non-reserve pairs indicating the importance of site-specific differences in these comparisons. When sites were pooled and the average deltas were compared, there were no significant differences in either mean abundance or mean length of eight species between reserves and non-reserves along the north-central mainland coastline (**Table 3-8**). A comparison of maximum sizes of the eight species at reserve and non-reserve site pairs showed that cabezon ranged from 5 to 20 cm larger at the reserve sites. Reserve status was not a factor determining maximum observed sizes of other species.

The same type of analysis, but testing a different suite of species typical of the SCB fish assemblage, was applied to a single reserve site on Santa Catalina Island (Intakes) paired with an adjacent non-reserve site (Isthmus Reef), and seven pairs of non-reserve sites around Santa Catalina and San Clemente Islands. There were no significant differences in mean abundances detected for species common to Intakes and Isthmus Reef, but the mean lengths of kelp bass and sheephead were significantly greater ($p<.05$) at Intakes (**Appendix C**). Maximum sizes of the two species were also larger at Intakes. When Intakes and Isthmus Reef mean abundance and mean size differences were compared to the pooled differences (deltas) at seven non-reserve site pairs, there were still no significant differences in abundance attributable to reserve status, although sheephead and black surfperch were significantly larger in the reserve while blacksmith was smaller (**Table 3-9**).

A comparison of kelp bass and sheephead abundance at the Anacapa East Isle site (long-established reserve) with four other sites around Anacapa Island (recently established reserves or fishing allowed), showed that kelp bass were approximately twice as abundant and sheephead three times as abundant at the reserve site (**Appendix C**). Mean lengths of the two species were not substantially different between the sites although the maximum lengths of observed specimens were generally greater at Anacapa East Isle than at other Anacapa Island sites. East Isle also had the highest H’ diversity of benthic fishes (2.27) and midwater fishes (1.61) among all Anacapa sites compared with an average diversity of 1.48 for benthic transects and 0.84 for midwater transects at other sites.

Table 3-7. State marine reserves, state marine conservation areas, and state marine parks with CRANE sampling sites.

Marine Reserve	County/Island	Year Est.	Shoreline dist. (km)	CRANE Reserve Site	CRANE Comparison Site	Separ. Dist. (km)	Fishing Restrictions
Hopkins SMR	Monterey	1984*	1.76	Hopkins	MacAbee	0.7	No take
Carmel Bay SMCA	Monterey	1976	10.74	Stillwater Cove	Pescadero	1.0	Recreational finfishing only
Point Lobos SMR	Monterey	1973*	12.41	Monastery	Pescadero	4.5	No take
Point Lobos SMR	Monterey	1973*	12.41	Bluefish Cove	Pescadero	4.2	No take
Point Lobos SMR	Monterey	1973*	12.41	Weston	Pescadero	5.5	No take
Big Creek SMR	Monterey	1994*	5.00	Big Creek	Lopez Rock	5.4	No take
DCPP Security Zone	San Luis Obispo	2001*	3.20	Diablo Canyon	Point Buchon	5.7	No take
Harris Point SMR	San Miguel I.	2003	11.67	Harris Point	Cuyler	0.8	No take
Carrington Point SMR	Santa Rosa I.	2003	9.82	Beacon Reef	Rodes Reef	6.2	No take
South Point SMR	Santa Rosa I.	2003	7.04	Chickasaw	Cluster Point	5.6	No take
Painted Cave SMCA	Santa Cruz I.	2003	3.71	Painted Cave	Hazards	5.0	Lobster and pelagic finfish
Gull Island SMR	Santa Cruz I.	2003	5.37	Gull Isle	Valley	17.3	No take
Anacapa Island SMR	Anacapa I.	2003†	6.11	Anacapa East Isle	Southwest Lighthouse	2.0	No take
Anacapa Island SMR	Anacapa I.	2003	6.11	Anacapa Middle Isle	Southwest Lighthouse	5.0	No take
Anacapa Island SMCA	Anacapa I.	2003	4.08	Anacapa West Isle	Cat Rock	4.1	Lobster and pelagic finfish, Nov-Dec
Santa Barbara Island SMR	Santa Barbara I.	2003	1.85	South Kelp	Arch Point	1.8	No take
Dana Point SMP	Orange	1969	1.04	Dana Point	San Onofre	22.0	Recreational lobster and finfish
Catalina Marine Science Center SMR	Catalina I.	1988*	2.00	Intakes	Isthmus Reef	0.4	No take

* CRANE reserve site analyzed for differences with comparison site.
† Established as no-take natural area shallower than 60 ft prior to 2003 designation.

Table 3-8. Comparison of mean abundances and mean lengths of eight fish species between pairs of sites in no-take marine reserves and sites where fishing is allowed in central California. P-values are based on T-tests between site pairs with significant differences (p<0.05) indicated in boldface type. Underlined values in Reserve – Non-Reserve Comparisons (shaded area) indicate that the non-reserve mean was significantly greater than the reserve mean. Refer to Table 2-1 for site abbreviations.

	Reserve/Non-Reserve Site Comparisons						Non-Reserve / Non-Reserve Site Comparisons													
Site Pairs	HK-MC	MN-PS	BL-PS	WS-PS	BC-LP	DC-PB	SB-TP	AM-ES	LP-LU	LU-WC	WC-PK	PK-DK	DK-SC	SC-LC	LC-SS	SS-CR	CR-WR	WR-CY	CY-PB	T-test P value for Avg Delta
Mean Abundance																				
black rockfish	**<0.01**	<u>**<0.01**</u>	<u>**<0.01**</u>	<u>**<0.01**</u>	**<0.01**	0.49	**<0.01**	0.31	0.39	0.45	0.41	0.07	0.08	0.08	0.07	0.77	0.06	0.85	0.25	0.25
blue rockfish	**<0.01**	<u>**<0.01**</u>	<u>**<0.01**</u>	<u>**<0.01**</u>	**<0.01**	<u>**<0.01**</u>	**<0.01**	**<0.01**	**<0.01**	0.47	**0.03**	0.37	**0.01**	0.24	**0.05**	**<0.01**	**<0.01**	0.18	0.35	0.31
gopher rockfish	1.00	<u>**0.02**</u>	0.24	**0.01**	**<0.01**	0.79	–	**0.05**	0.36	0.92	0.32	0.49	0.65	0.06	0.29	0.07	0.12	**<0.01**	0.61	0.54
vermilion rockfish	0.77	0.55	1.00	0.12	0.44	1.00	–	0.74	0.44	0.20	0.79	0.66	**0.02**	–	0.32	0.32	–	–	0.16	0.57
kelp greenling	0.29	0.43	0.88	0.10	**<0.01**	0.54	**<0.01**	1.00	0.92	0.13	**<0.01**	**<0.01**	0.20	0.06	0.65	0.82	0.41	0.73	0.43	0.97
lingcod	–	0.82	0.45	0.84	1.00	0.56	1.00	0.82	0.80	0.61	0.32	0.15	0.37	0.22	0.14	0.62	0.86	0.91	0.43	0.52
cabezon	0.84	0.41	1.00	0.67	0.84	1.00	0.77	0.41	0.77	0.16	0.70	0.96	0.91	0.61	–	–	0.77	0.77	0.08	0.43
striped surfperch	**<0.01**	<u>**<0.01**</u>	<u>**<0.01**</u>	<u>**<0.01**</u>	**0.02**	0.24	**<0.01**	0.51	**0.03**	**<0.01**	**0.02**	**0.01**	**<0.01**	0.91	0.17	**<0.01**	**<0.01**	0.23	0.79	0.21
Mean Length																				
black rockfish	0.32	**<0.01**	0.25	0.21	0.45	0.39	0.31	0.61	0.11	0.15	0.44	0.26	0.92	–	–	**<0.01**	0.36	0.10	**0.04**	0.54
blue rockfish	**<0.01**	<u>**<0.01**</u>	<u>**<0.01**</u>	0.55	<u>**<0.01**</u>	0.38	**<0.01**	0.31	**<0.01**	**<0.01**	**<0.01**	**<0.01**	0.66	0.09	0.16	0.67	0.06	**<0.01**	**0.03**	0.2
gopher rockfish	0.52	0.34	0.86	0.40	0.40	0.96	–	**0.03**	0.99	0.62	0.33	0.13	0.10	0.17	0.09	**0.01**	0.59	0.73	0.86	0.87
vermilion rockfish	–	0.35	1.00	0.82	0.06	0.70	–	**0.05**	–	–	0.22	0.29	–	–	–	–	–	–	–	0.56
kelp greenling	0.10	0.73	0.60	0.12	0.09	0.78	0.30	0.86	**0.01**	**<0.01**	0.15	0.61	**<0.01**	**<0.01**	0.16	0.71	0.91	0.84	0.95	0.67
lingcod	–	0.49	0.35	0.84	0.25	0.50	0.38	0.14	0.30	–	–	0.39	0.07	**0.03**	0.85	0.08	0.34	0.89	0.20	0.95
cabezon	1.00	–	0.40	**0.05**	–	0.44	–	–	–	–	0.32	0.60	0.98	–	–	–	–	–	–	0.37
striped surfperch	0.16	**<0.01**	**<0.01**	**<0.01**	0.50	**0.01**	**<0.01**	0.96	**<0.01**	**<0.01**	0.11	0.29	**<0.01**	0.82	**<0.01**	**<0.01**	0.99	**0.01**	0.61	0.06

Table 3-9. Comparison of reserve (CTIN) / non-reserve (CTIR) site deltas in mean abundance and mean length (log transformed) to the upper and lower 95% confidence intervals of the same parameters at seven non-reserve site pairs on Santa Catalina and San Clemente Islands. Significant differences are indicated in boldface type.

Species	Mean Abundance			Mean Length		
	Reserve	Non-reserve		Reserve	Non-reserve	
	delta	upper 95%	lower 95%	delta	upper 95%	lower 95%
Kelp bass	-0.06	0.41	-0.26	0.12	0.18	-0.19
Blacksmith	-0.19	1.13	-0.55	**-0.24**	0.00	-0.19
Cal. sheephead	0.35	0.43	-0.11	**0.14**	0.06	-0.10
Rock wrasse	0.06	0.15	-0.13	-0.03	0.05	-0.12
Garibaldi	-0.13	0.35	-0.23	-0.02	0.05	-0.14
Black surfperch	0.11	0.16	-0.13	**1.18**	0.10	0.00

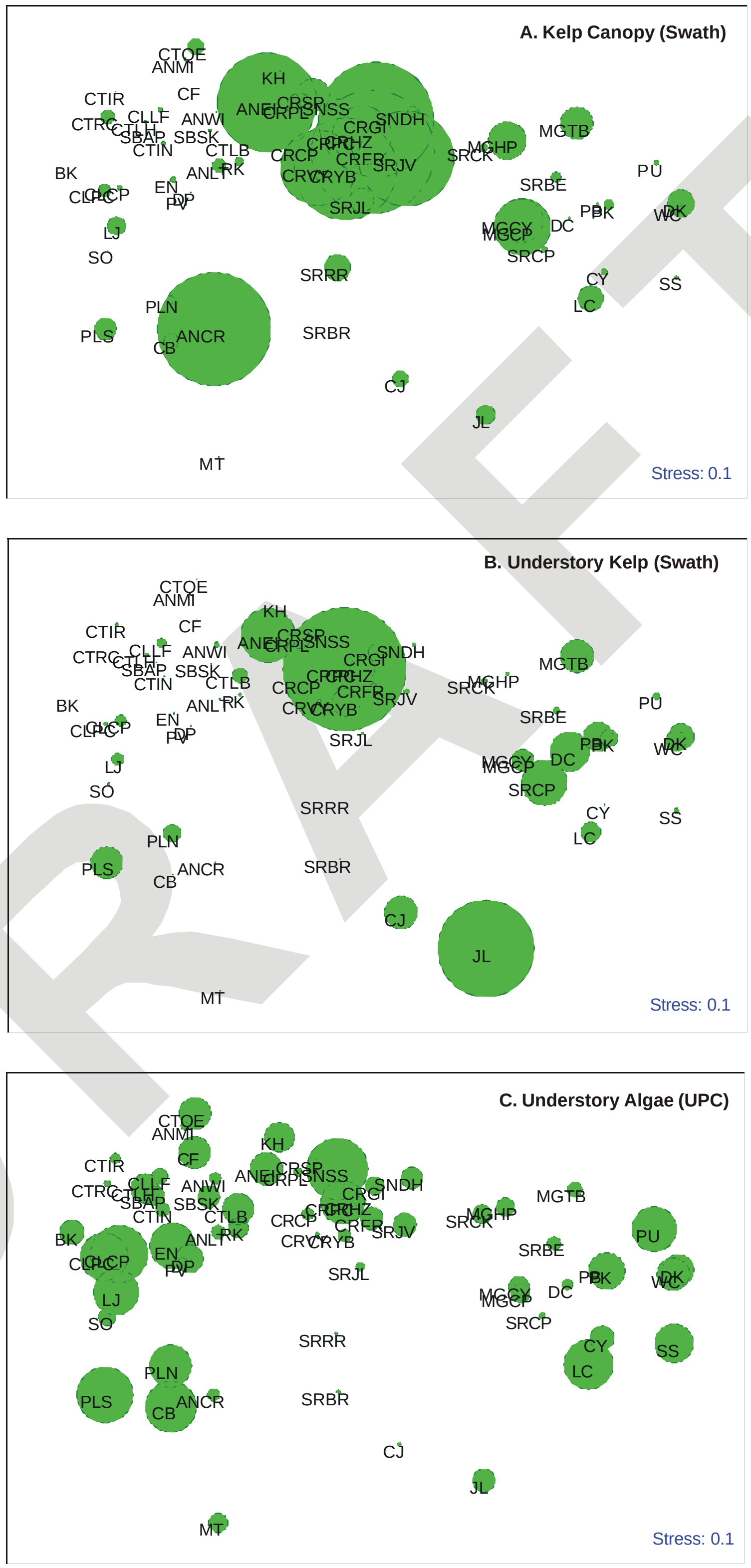

Figure 3-13. Site dispersion based on MDS scores of fish assemblages with corresponding relative abundances of a) canopy kelp, b) subcanopy kelp, and c) understory algal cover.

3.3 Invertebrates

Densities of selected motile or solitary macroinvertebrates (e.g., urchins, sea stars, anemones) were obtained from swath counts while percent cover estimates of certain sedentary or encrusting colonial invertebrate forms (e.g., sponges, tunicates) were obtained from the uniform point contact (UPC) method, both on the same 30 m x 2 m transects at each site. In almost all cases, 12 replicate transects were sampled at each site. A complete data set using the CRANE methodology was obtained at 63 sites extending from the Big Sur coastline to San Diego County, including the Channel Islands. A partial data set of densities on urchins, abalone, sea cucumbers, and Kellet's whelk was obtained from the 17 UCSC–PISCO sites in the Santa Cruz and Monterey area. Invertebrate data were not collected at the following CRANE sites: Naples, Monacos, Malibu, West Kelp, Johnson's Rocks, West Quarry, Catalina Harbor, or Pin Rock.

3.3.1 Community Data

Abundances were recorded for 37 swath invertebrate taxa and 23 UPC invertebrate taxa (including two "superlayer invertebrate taxa") at all sites. The mean abundances and frequencies of occurrence for these taxa across all sites are presented separately for the swath and UPC sampling methods (**Tables 3-10** and **3-11**). Several other taxa were counted incidentally on swath transects at some sites because they were conspicuous, but since they were not taxa that were pre-printed on the data sheets and were not counted consistently at all sites they are not included in the summarized data. Abundances and percent frequencies of occurrence, including those of incidental species, are presented for each site in **Appendix D**.

Sea urchins were the most abundant macro-invertebrate observed across all sites with purple, red, and crowned sea urchin species comprising over 75% of all invertebrates counted. High densities of purple urchins, in particular, required that segments of some transects be sub-sampled according to the swath protocols. The means, therefore, were based on extrapolated values at some sites. Bat star was the third most abundant macro-invertebrate with an mean density of 58.9 individuals per transect. Abundances and size frequencies of sea urchins and abalones by site are presented in greater detail in Section 3.3.2–*Sea Urchins* and Section 3.3.3–*Abalone.*

The most ubiquitous species was the giant-spined sea star with a 95% frequency of occurrence among sites (**Table 3-10**). Sea urchins also had a high frequency of occurrence among all sites, although the crowned sea urchin was restricted to the more southerly sites. Other widely-distributed species included orange puffball sponge, Kellet's whelk, sunburst anemone, giant keyhole limpet, and warty sea cucumber.

Geographical distribution plots are presented for several species of interest to illustrate their abundances within the study region. Abundances and frequencies of occurrence within sites for all invertebrates sampled are included in **Appendix D**. Sea cucumbers (*Parastichopus parvimensis* and *P. californica*) were counted at 80 sites from Monterey Bay to San Diego and had the highest abundances around the eastern portion of the northern Channel Islands group (**Figure 3-14**). The wavy top snail (also known as the wavy turban snail—*Megastrea [Lithopoma] undosa*) also had highest abundances around the eastern portion of the northern Channel Islands group while the red top snail (*L. gibberosa*) had highest abundances at San Miguel Island and a few occurrences at northern mainland sites (**Figure 3-15**). Bat star (*Patiria miniata*) was also abundant around the northern Channel Islands but had a distribution that extended north along the mainland through the Big Sur coastline (**Figure 3-16**). There were no data available for bat star abundance at sites in the Monterey Bay area. Spiny lobster (*Panulirus interruptus*) was exclusively a southern species that was abundant at the islands of Anacapa, Catalina, and San Clemente, and at mainland sites in the San Diego area (**Figure 3-17**).

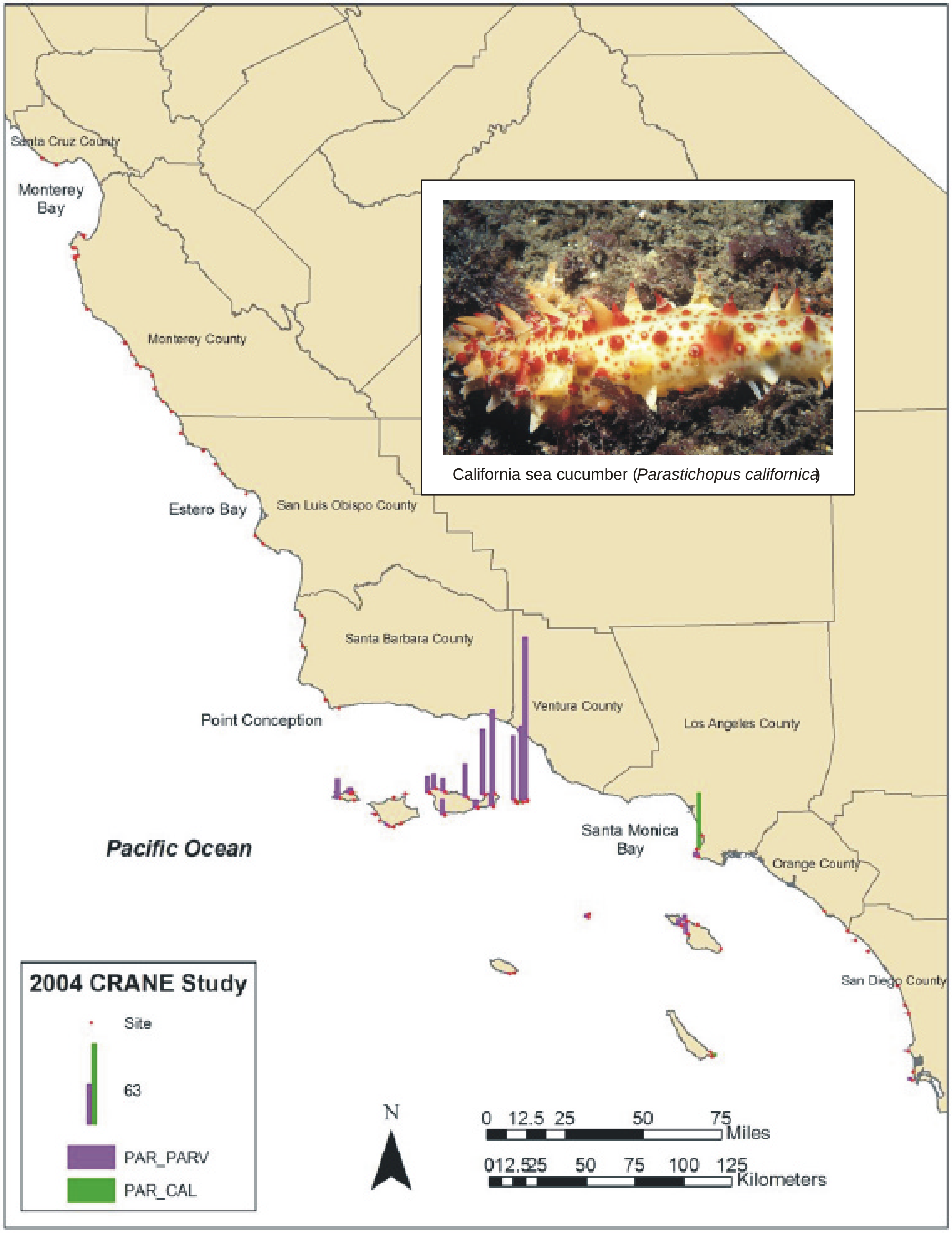

Figure 3-14. Abundance of sea cucumbers (mean # per 30 m x 2 m transect) at 80 sites in central and southern California.

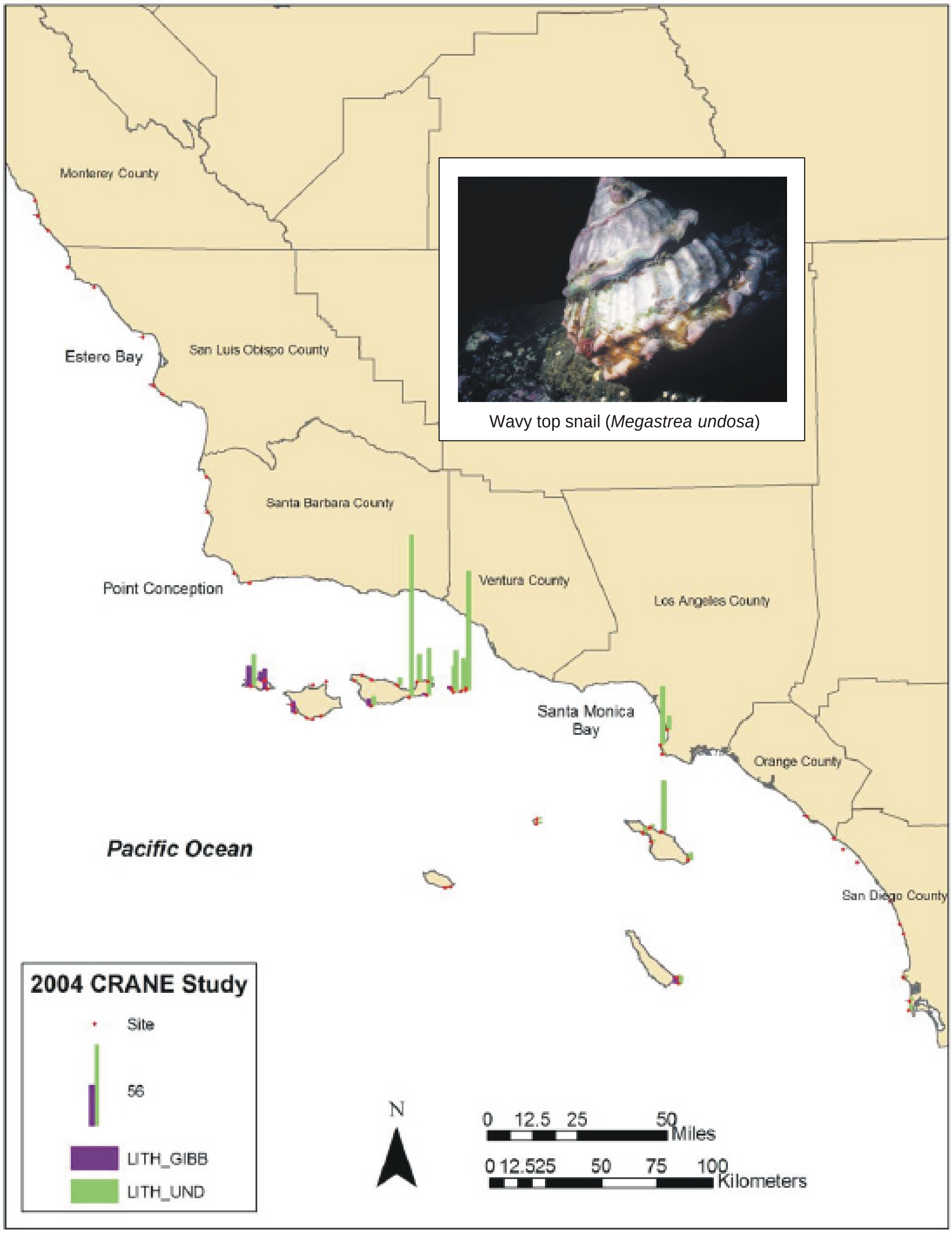

Figure 3-15. Abundance of top snails (mean # per 30 m x 2 m transect) at 63 sites in central and southern California.

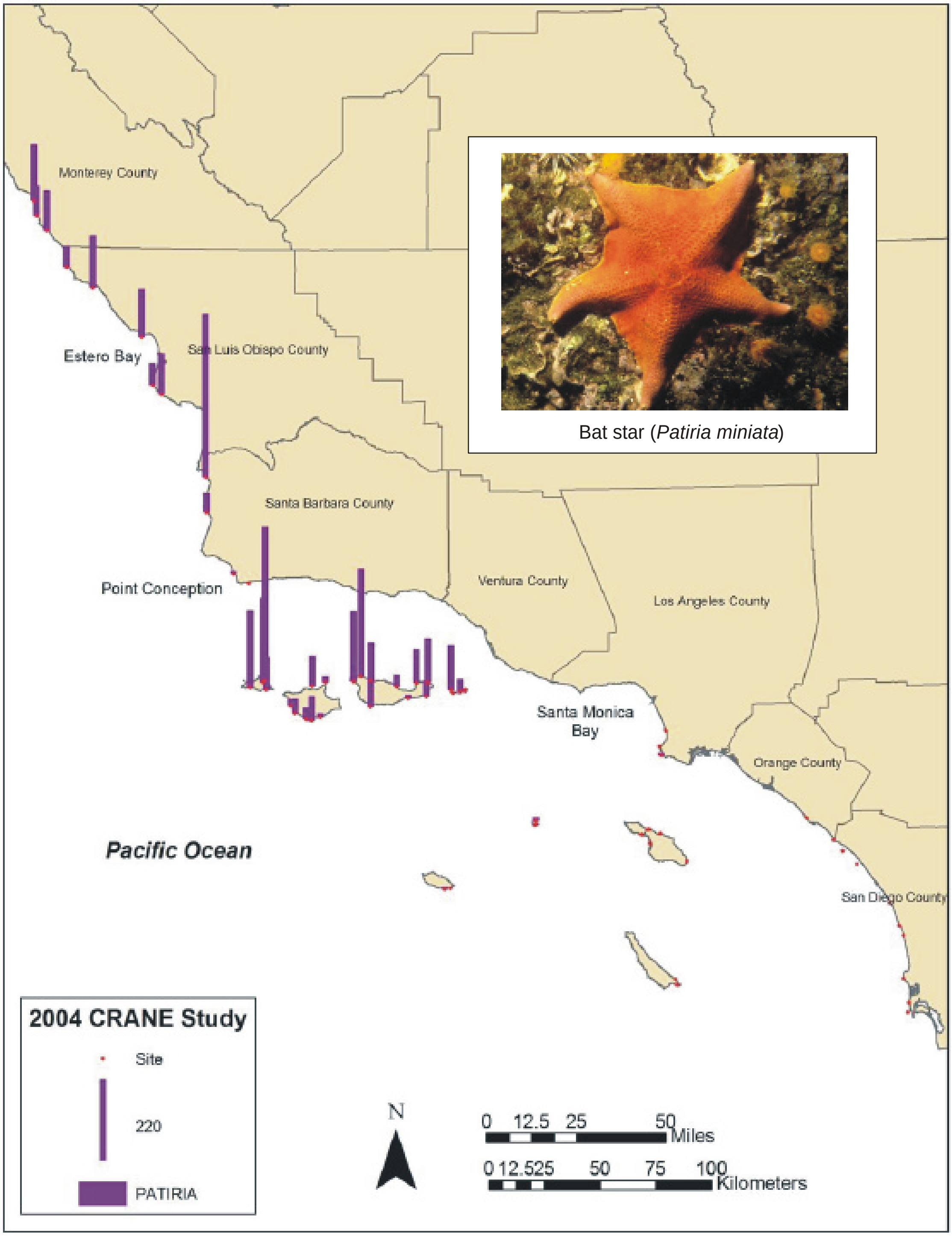

Figure 3-16. Abundance of bat star (mean # per 30 m x 2 m transect) at 63 sites in central and southern California.

Figure 3-17. Mean abundance per transect of California spiny lobster at CRANE sites in the southern California bight.

Table 3-10. Mean abundance and percent frequency of occurrence of selected macroinvertebrates sampled on benthic transects using the swath methodology; all sites combined, N=63 sites.

Taxon	**Common Name**	**Mean Across Sites**	**Rank**	**Percent Frequency**	**Rank**
Strongylocentrotus purpuratus	purple sea urchin	375.2401	1	79.37	3
Strongylocentrotus franciscanus	red sea urchin	165.6267	2	85.71	2
Patiria miniata	bat star	58.9445	3	76.19	4
Centrostephanus coronatus	crowned sea urchin	30.3006	4	49.21	15
Anthopleura sola	sunburst anemone	22.7897	5	68.25	7
Pisaster giganteus	giant-spined sea star	15.4352	6	95.24	1
Megastrea undosa	wavy top snail	7.9196	7	61.90	12
Parastichopus parvimensis	warty sea cucumber	7.9142	8	63.49	10
Urticina spp.	anemone	6.9299	9	68.25	8
Styela montereyensis	stalked tunicate	6.8280	10	46.03	18
Lophogorgia chilensis	red gorgonian	6.0558	11	49.21	16
Tethya aurantia	orange puffball sponge	4.9516	12	74.60	5
Pisaster ochraceus	ochre star	4.5086	13	42.86	20
Pisaster brevispinus	short-spined sea star	4.1766	14	33.33	22
Lytechinus anamesus	white urchin	4.0648	15	25.40	26
Muricea californica	California golden gorgonian	4.0509	16	52.38	14
Pycnopodia helianthoides	sunflower star	2.3483	17	57.14	13
Kelletia kelletii	Kellet's whelk	2.2821	18	73.02	6
Crassadoma gigantea	giant rock scallop	2.2112	19	63.49	11
Megathura crenulata	giant keyhole limpet	1.4509	20	66.67	9
Muricea fruticosa	brown gorgonian	1.3731	21	30.16	23
Lithopoma gibberosum	red top snail	1.0404	22	47.62	17
Aplysia californica	sea hare	0.8929	23	28.57	25
Parastichopus californicus	sea cucumber	0.8234	24	20.63	28
Haliotis rufescens	red abalone	0.6693	25	14.29	31
Dermasterias imbricata	leather star	0.6625	26	34.92	21
Panulirus interruptus	California spiny lobster	0.6071	27	46.03	19
Orthasterias koehleri	rainbow sea star	0.2831	28	30.16	24
Cancer spp.	cancer crabs	0.1587	29	25.40	27
Loxorhynchus grandis	sheep crab	0.0847	30	15.87	29
Loxorhynchus crispatus	moss crab	0.0807	31	15.87	30
Pugettia richii	cryptic kelp crab	0.0794	32	4.76	36
Anthopleura xanthogrammica	anemone	0.0397	33	7.94	34
Pugettia producta	northern kelp crab	0.0357	34	9.52	33
Haliotis spp.	abalone	0.0291	35	14.29	32
Haliotis corrugata	pink abalone	0.0159	36	3.17	37
Anthopleura elegantissima	anemone	0.0132	37	6.35	35

Table 3-11. Mean percent cover and percent frequency of occurrence of selected invertebrate taxa sampled on benthic transects using the UPC methodology; all sites combined, N=63 sites.

Taxon	Common Name	Grand Mean	Rank Mean	Percent Frequency	Rank Frequency
bryozoa unid. (encrusting)	bryozoan	4.69	1	88.89	1
Chaetopterus / Diopatra	tube worms	2.92	2	65.08	9
Balanophyllia / Paracyathus / Astrangia	cup corals	1.76	3	79.37	3
Phragmatopoma californica	sand tube worm	1.60	4	41.27	12
tunicates, colonial/social unid.	tunicate	1.60	5	66.67	8
solitary tube worm	solitary tube worm	1.58	6	71.43	5
Porifera unid. (encrusting)	sponge	1.56	7	84.13	2
Corynactis californica	strawberry anemone	1.48	8	68.25	6
Hydroida	unidentified hydroid	1.09	9	74.60	4
Cirripedia unid. a	barnacle	0.99	10	52.38	10
under *Pachythione rubra*	aggregating sea cucumber	0.75	11	9.52	20
Anthozoa unid.	anemone	0.65	12	68.25	7
Holothuroidea unid.	sea cucumber	0.42	13	28.57	13
tunicate, solitary unid.	tunicate	0.39	14	47.62	11
Dodecaceria fewkesi	tube worm	0.26	15	25.40	16
unidentified tube mat	unidentified tube mat	0.19	16	26.98	14
under brittlestars (*Ophiothrix spiculata*)	brittlestars	0.17	17	4.76	22
Gorgonacea	gorgonian	0.13	18	26.98	15
Serpulorbis squamigerus	tube snail	0.12	19	23.81	17
Salmacina tribranchiata	tube worm	0.08	20	19.05	18
Pelecypoda unid. boring	unidentified boring clam	0.08	21	15.87	19
Stylaster californicus	California hydrocoral	0.02	22	6.35	21
Pectinidae	scallops	0.01	23	4.76	23

3.3.2 Sea Urchins

The highest concentrations of purple urchins and red urchins generally occurred at sites around the northern Channel Islands (**Figure 3-18**). Mean abundance per transect was generally lower at mainland sites than island sites although high concentrations were measured at some mainland sites, notably Point Loma South, Palos Verdes, and Sandhill Bluff in Santa Cruz County. Purple urchins were more abundant than red urchins at most sites except at San Miguel and Santa Rosa Islands where red urchins were the more abundant species. Mean urchin densities by site are reported in **Appendix D**.

The size frequency of red and purple urchins was measured at most sites where they were present. The overall size distribution of purple urchins was unimodal with a peak size class at 3 cm test diameter (**Figure 3-19**). Red urchins had a bimodal distribution with peaks at 4 cm and 8 cm. Size frequencies by site in **Appendix Tables D3** and **D4** for purple and red urchins, respectively. Sites on the south side of Santa Rosa Island had a high abundance of the largest size classes although a few very large individuals were reported from Dutch Harbor on San Nicolas Island.

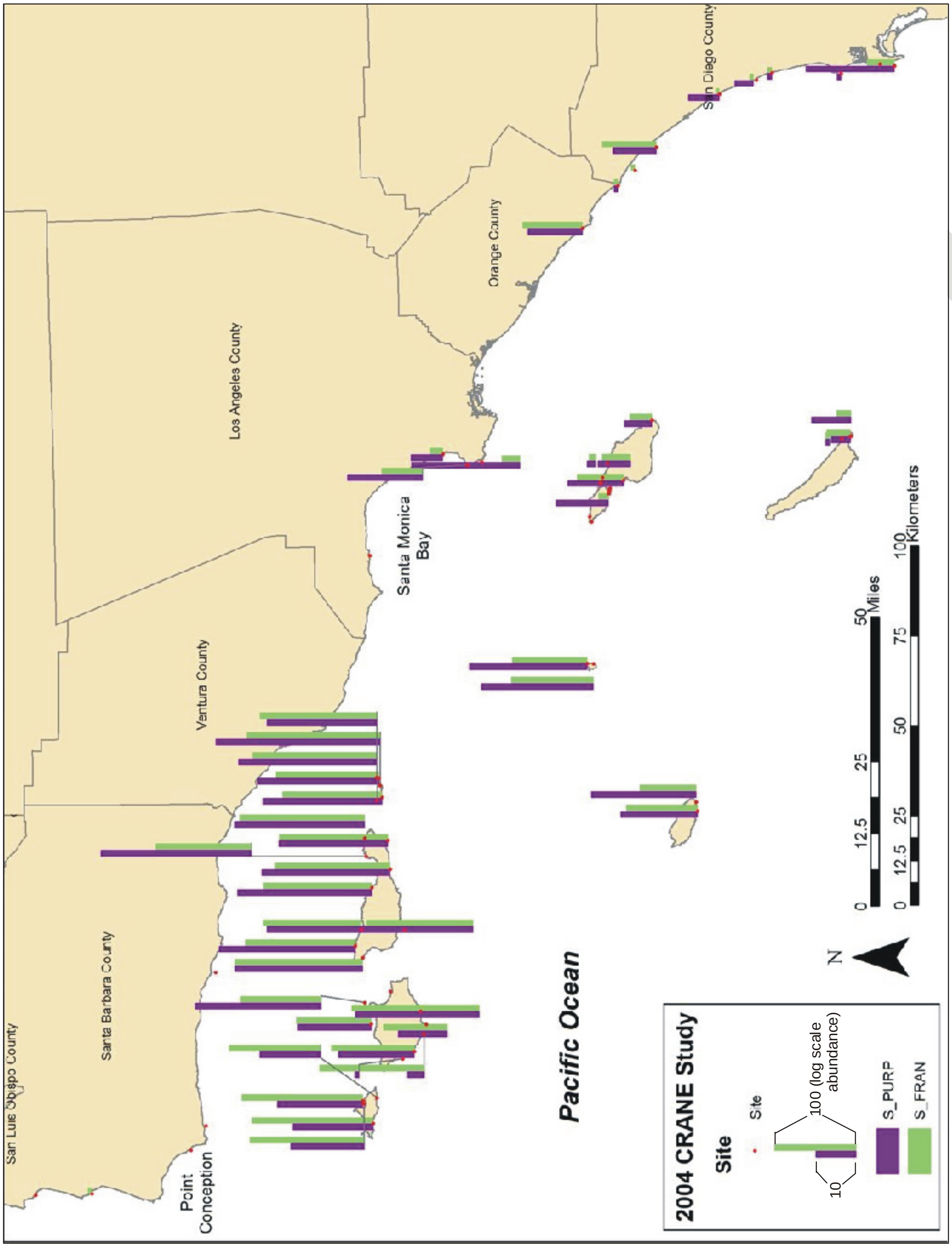

Figure 3-18. Mean abundance per transect of purple urchin and red urchin at CRANE sites in the southern California bight. Note $\log_{10}$ scale abundance.

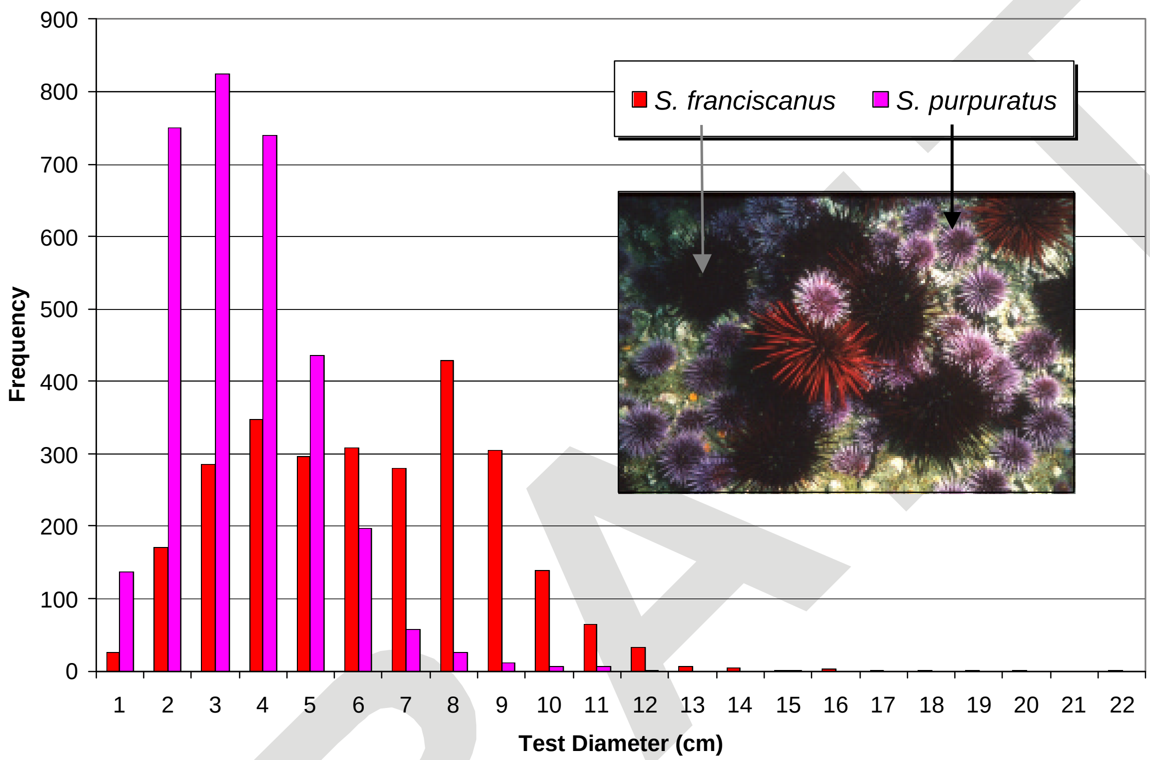

Figure 3-19. Size frequency distribution of red urchin (*Strongylocentrotus franciscanus*) measured at 41 sites (N=2,707), and purple urchin (*S. purpuratus*) measured at 38 sites (N=3,195).

3.3.3 Abalone

Abalone were recorded on transects at 22 of the 80 sites sampled (27.5%) from Santa Cruz County to San Diego County. High concentrations of red abalone (*Haliotis rufescens*) were only found at the Tyler Bight site on San Miguel Island (**Table 3-12**). Pink abalone (*H. corrugata*) were recorded from two sites on Santa Cruz Island and several abalone were counted at other sites but could not be positively identified to species.

Abalone were also measured during random searches at most sites to obtain size frequency information over a broader area than that covered by the 30 m x 2 m swath transects. A total of 183 measurements was made on red abalone with the greatest number (54) from the Tyler Bight population (**Figure 3-20**). The average size was 15.0 cm TL (6.0 in) with the largest individual at 30.0 cm TL (12 in). Forty-three flat abalone were also measured at nine sites in Monterey and San Luis Obispo counties. The average size of flat abalone was 9.7 cm TL (3.8 in) with the largest individual at 22.0 cm TL (8.6 in). Sizes were obtained on two pink abalone from Little Harbor (Catalina Island) with shell lengths of 12 cm (4.7 in) and 18 cm (7.1 in).

Table 3-12. Densities of abalone (*Haliotis* spp.) at all sites sampled using the swath method; N=80 sites (including UCSC-PISCO sites). Sites not listed had no abalone recorded on transects.

Site	County or Island	Red abalone (*H. rufescens*)	unid. abalone	Pink abalone (*H. corrugata*)
Hopkins	Monterey	0.06	–	–
Stillwater	Monterey	0.08	–	–
Wild Cattle	Monterey	–	0.33	–
Plaskett Rock	Monterey	–	0.08	–
Cayucos	San Luis Obispo	–	0.08	–
La Cruz	San Luis Obispo	–	0.42	–
Point Buchon	San Luis Obispo	0.67	–	–
Diablo Canyon	San Luis Obispo	0.50	–	–
Crook Point	San Miguel Island	1.75	–	–
Tyler Bight	San Miguel Island	37.50	–	–
Chickasaw	Santa Rosa Island	1.08	–	–
Johnsons Lee	Santa Rosa Island	0.08	–	–
Jolla Vieja	Santa Rosa Island	0.17	–	–
Forney	Santa Cruz Island	0.25	–	–
Pelican	Santa Cruz Island	–	–	0.50
Yellowbanks	Santa Cruz Island	–	–	0.50
Intakes	Santa Catalina Island	–	0.25	–
Lobster Bay	Santa Catalina Island	–	0.25	–
Little Harbor	Santa Catalina Island	–	0.25	–
San Mateo	Orange	–	0.08	–
Point Loma North	San Diego	–	0.08	–
Pyramid Cove	San Clemente Island	0.17	–	–

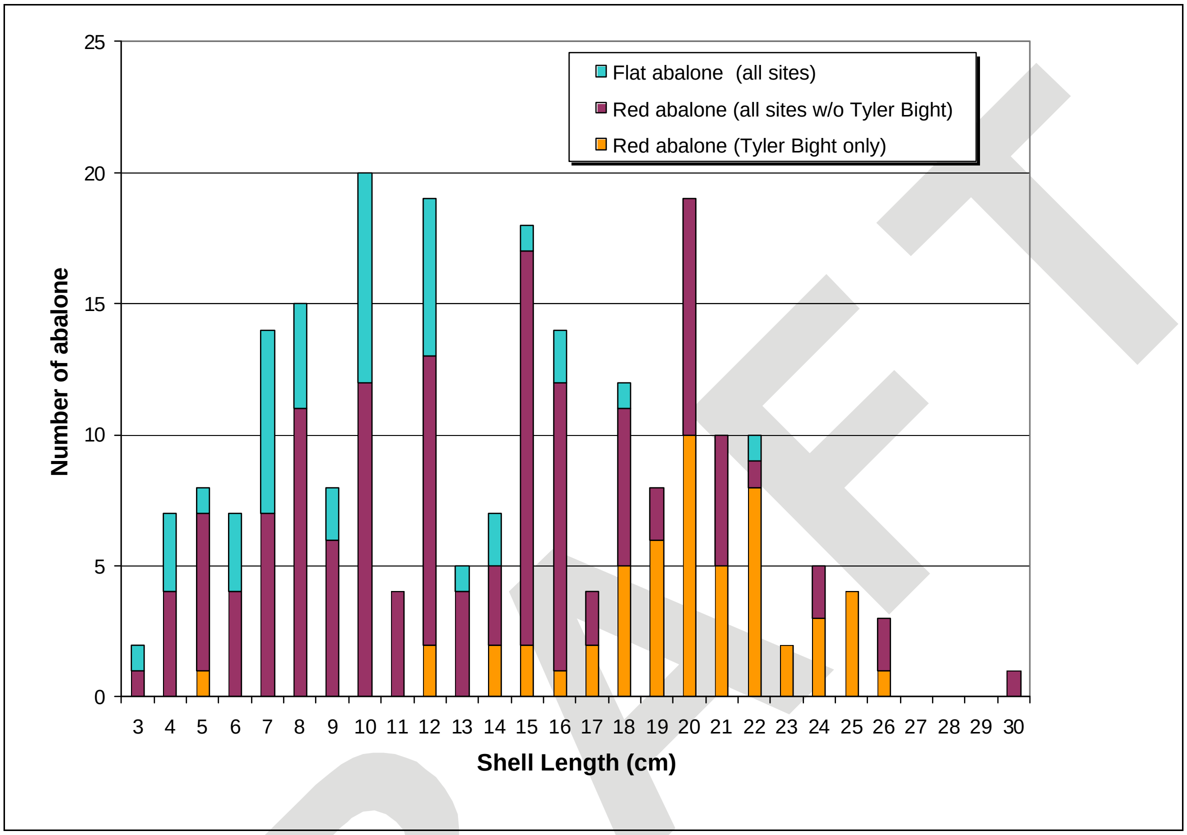

Figure 3-20. Size frequency distribution of red abalone (*Haliotis rufescens*) measured at 16 sites (N=183), and flat abalone (*H. wallalensis*) measured at 9 sites (N=43).

3.3.4 Site Groups Based on Invertebrate Assemblages

Invertebrate assemblages at 62 sites were analyzed for similarities using a combination of MDS plots (**Figure 3-21**) and site clustering of Bray-Curtis similarities (**Figure 3-22**). The MDS plot had a stress value of 0.15 indicating that there was a moderate amount of separation among the site scores that could not be portrayed in a two-dimensional plot. Many of the invertebrate species had a high frequency of occurrence among sites (**Table 3-10**) which generally resulted in less separation among groups of sites as compared to those based on fish abundances (see Section 3.2.2 - *Site Groups Based on Fish Assemblages*). In addition, there was a narrower geographic range of sites tested than in the previous analysis based on fish. The MDS and cluster analysis generally portrayed geographic groupings of sites (**Table 3-13**), although the assignment of sites to various groups involved some subjectivity.

Five main groups emerged from the two analyses that largely separated the sites into natural geographic units. The most distinct cluster encompassed central mainland sites in Monterey and San Luis Obispo Counties (Group 1), with sites at Purisima (PU), Jalama (JL), and Cojo (CJ) having weaker affinities with this group (**Figure 3-21**). The northern and central Channel Islands sites formed a large cluster in the MDS plot but could be further subdivided into northwest island (Group 2) and northeast island (Group 3) sites based on the dendrogram clustering. Santa Barbara Island shared similarities in the invertebrate assemblage with Anacapa Island while the two sites at San Nicholas Island had affinities with both San Miguel Island and southern Santa Rosa Island, similar to the fish assemblages. Catalina Island sites shared similarities with many of the mainland sites in the SCB and formed Group 4, while Group 5 was formed from the remaining southern sites at San Clemente Island and those in the San Diego area.

Several sites had weak affinities with two or more groups and were not included in the cluster boundaries depicted in the MDS plots. Two of the anomalous sites, Barn Kelp (BK) and Ripper's Cove (CTRC), only consisted of two and four transects, respectively, instead of the twelve transects used to characterize most of the other sites. This resulted in a limited species list from each site, and coupled with relatively high abundances of gorgonian sea fan (*Muricea* spp.) at Barn Kelp and wavy top snail (*Megastrea undosa*) at Ripper's Cove, accounted for their separation from the groups. The other sites not included in the MDS cluster groups, Bee Rock (SRBE) and Point Loma South (PLS), both had a full complement of transects sampled and relatively high species richness, but had assemblages that placed them in an intermediate position between groups. Finally, the unusual similarity between Rocky Point (RK) located in Los Angeles County and the Group 5 sites in San Diego County appeared to be caused by high numbers of purple urchins and crowned urchins (*Centrostephanus coronatus*) at the sites. Complete species lists of all invertebrate abundances by site are included in **Appendix D**. Purple urchins had the greatest effect on separating site groups (average contribution of 7.69 %), followed by red urchin and bat star (**Table 3-14**).

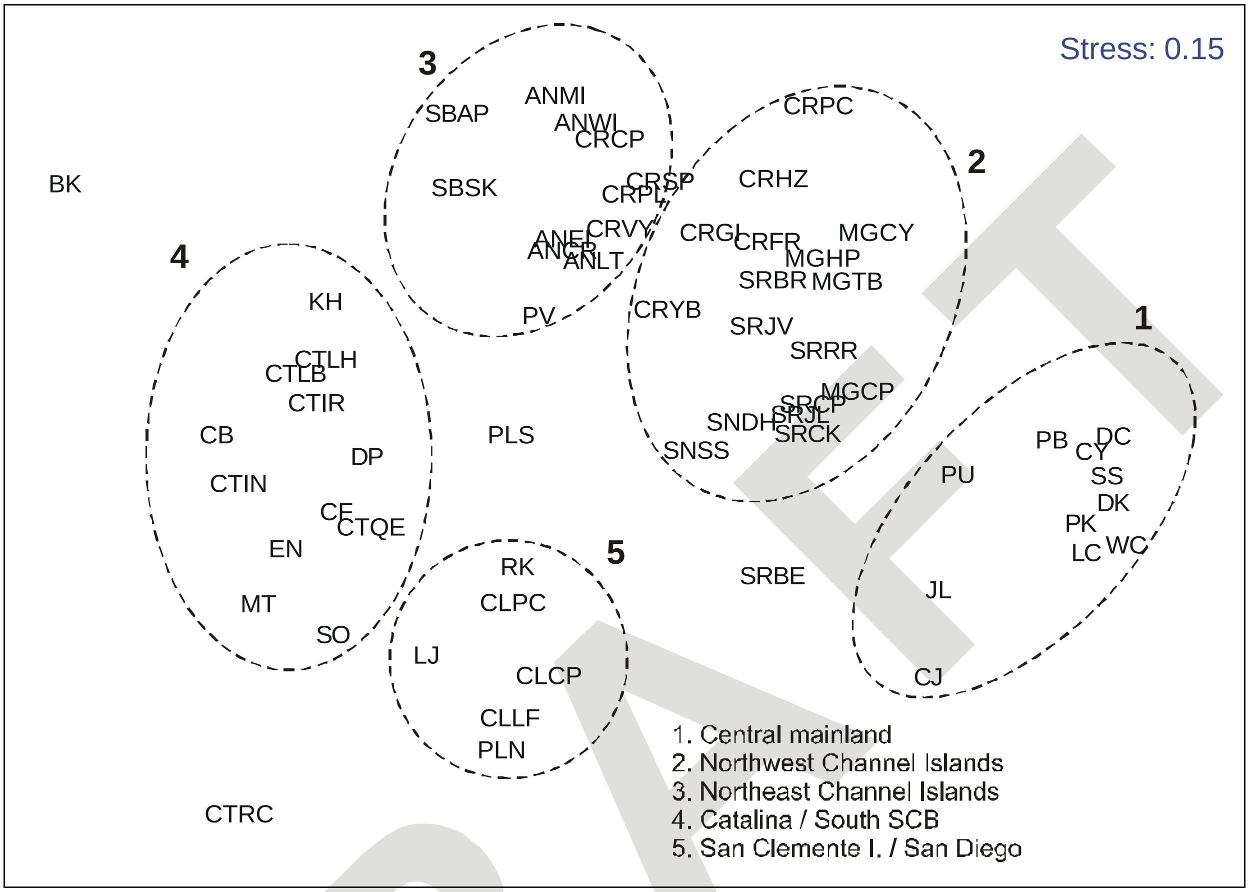

Figure 3-21. Primary site groups based on MDS scores of invertebrate assemblages. Refer to Table 2-1 for site abbreviations and locations, and Appendix B for site maps.

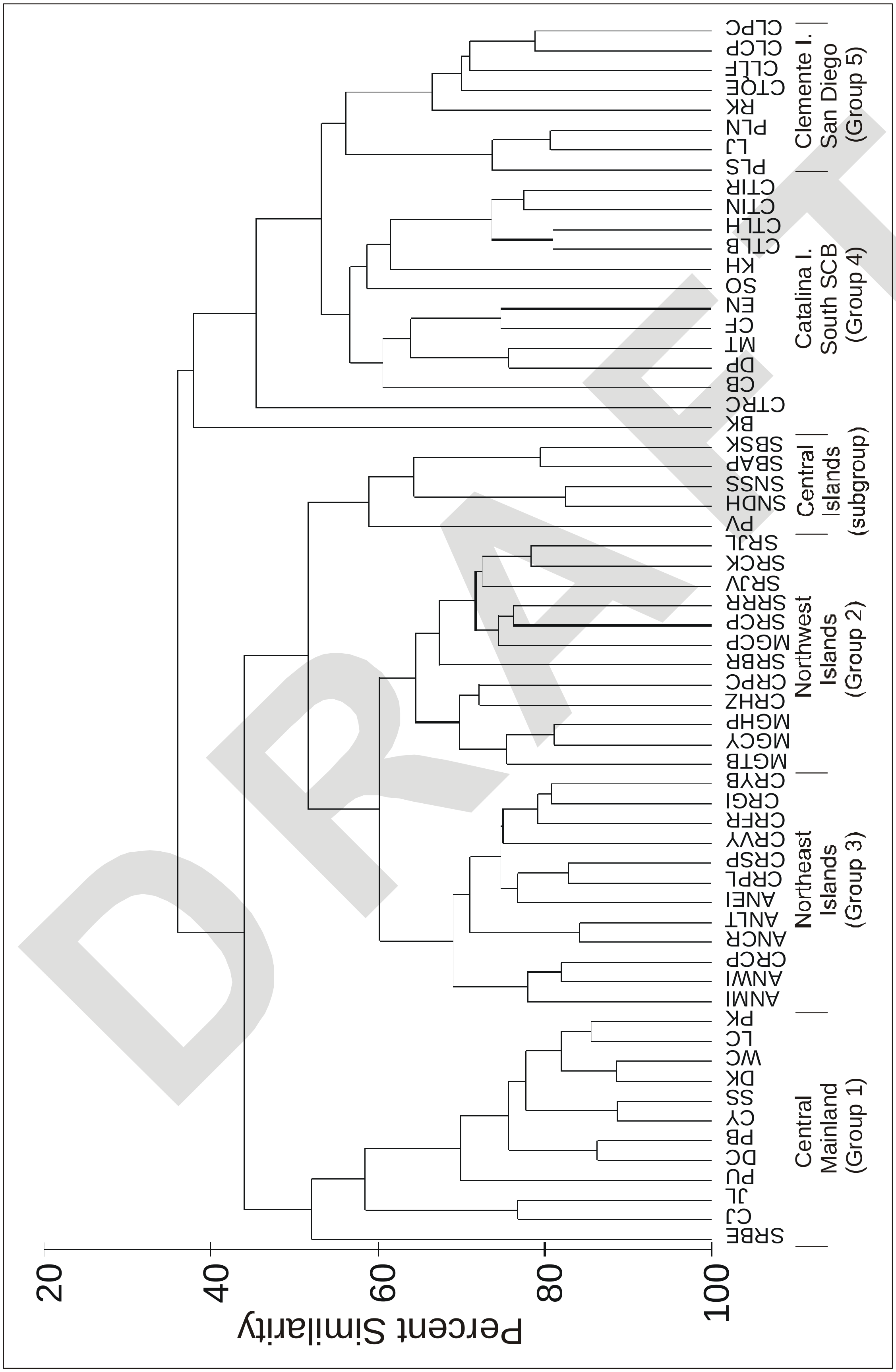

Figure 3-22. Dendrogram of Bray-Curtis site similarities based on the abundances of swath invertebrates. Group clusters correspond to MDS plot groups depicted in Figure 3-21. Outlier sites had relatively low similarities to adjacent groups.

Table 3-13. Percent dissimilarity between site groups delineated in MDS analysis of invertebrates.

	Central Mainland	Northwest Channel Islands	Northeast Channel Islands	South SCB	San Clemente/ San Diego
Central Mainland	0.00	48.03	65.04	77.12	68.29
Northwest Channel Islands	–	0.00	43.48	64.75	58.15
Northeast Channel Islands	–	–	0.00	57.56	56.00
South SCB	–	–	–	0.00	49.53
San Clemente I. / San Diego	–	–	–	–	0.00

Table 3-14. Species percent contributions to site group differences based on SIMPER analysis of invertebrate data. A null value indicates that the species was absent from both groups being compared.

Species	NE Islands / South SCB	South SCB / NE Islands	Central Main/ South SCB	Central Main/ NE Islands	Clem-SD/ South SCB	Clem-SD/ Central Main	Clem-SD/ NE Islands	NW Islands/ South SCB	NW Islands/ Central Main	NW Islands/ Clem-SD	Average
Strong. purpuratus	11.98	11.59	3.54	11.63	5.46	3.73	7.87	5.69	9.48	5.91	**7.69**
Strong. franciscanus	9.12	8.29	2.29	9.40	3.65	2.22	4.32	6.42	9.36	7.24	**6.23**
Patiria miniata	6.00	2.18	6.90	5.73	1.73	7.16	3.24	7.20	3.12	7.43	**5.07**
Centrostephanus cor.	4.64	3.72	3.80	4.62	6.38	5.89	5.35	4.47	1.71	6.06	**4.66**
Anthopleura sola	4.71	1.65	3.17	4.64	0.75	3.40	2.83	5.66	3.24	5.99	**3.60**
Megastrea undosa	3.34	3.89	2.33	2.22	3.96	3.65	4.79	2.41	1.26	3.42	**3.13**
Muricea californica	2.79	1.84	4.64	1.86	7.31	1.03	2.64	5.14	0.31	1.10	**2.87**
Parastichopus parv.	3.89	3.94	1.68	3.94	3.17	1.35	3.31	2.17	3.03	2.05	**2.85**
Styela montereyensis	0.84	3.84	4.74	0.47	0.83	5.46	3.02	2.76	3.11	3.16	**2.82**
Tethya aurantia	2.51	1.42	3.02	2.87	2.01	3.73	2.46	3.51	1.81	4.10	**2.74**
Pisaster giganteus	2.70	1.34	2.59	2.67	2.51	2.77	2.64	3.45	1.96	3.63	**2.63**
Lophogorgia chilensis	3.63	3.66	1.61	4.45	2.77	0.43	4.43	1.84	1.23	1.30	**2.54**
Urticina spp.	1.98	2.17	3.51	1.53	2.88	3.00	2.51	3.17	1.44	2.57	**2.48**
Pycnopodia helianth.	1.36	1.73	3.05	1.34	0.41	3.14	3.08	4.03	1.30	4.14	**2.36**
Kelletia kelletii	1.89	1.84	2.07	1.60	2.85	2.27	1.96	1.78	2.50	1.69	**2.05**
Crassadoma gigantea	2.95	2.15	1.09	3.17	1.79	1.00	2.30	1.72	1.75	1.99	**1.99**
Panulirus interruptus	1.70	1.20	1.94	1.89	2.36	3.01	1.68	1.96	0.33	2.94	**1.90**
Megathura crenulata	2.39	2.22	1.38	2.23	2.21	1.50	2.17	1.44	2.14	1.12	**1.88**
Muricea fruticosa	2.66	0.95	2.81	1.38	4.87	0.58	1.34	3.02	0.12	0.68	**1.84**
Pisaster brevispinus	0.46	2.73	3.17	0.19	0.98	3.45	1.25	1.31	3.38	1.28	**1.82**
Lithopoma gibberosum	1.62	1.21	1.13	1.58	1.25	1.20	2.18	2.02	2.03	2.18	**1.64**
Pisaster ochraceus	1.30	1.32	2.14	1.21	0.77	2.28	1.54	1.24	2.23	1.24	**1.53**
Dermasterias imb.	0.69	1.70	2.07	0.74	1.39	2.12	1.39	1.35	2.30	1.37	**1.51**
Aplysia californica	3.29	2.52	0.11	3.32	0.20	–	3.12	0.48	0.45	0.42	**1.39**
Parastichopus cal.	0.53	0.43	0.33	1.86	3.16	1.80	0.90	0.70	0.83	1.94	**1.25**
Orthasterias koehleri	0.35	1.34	1.75	0.27	0.16	1.90	1.29	1.16	1.85	1.20	**1.13**
Cancer spp.	0.44	0.84	1.02	0.43	–	1.08	1.17	0.97	1.44	1.02	**0.84**
Haliotis rufescens	0.12	0.40	0.42	0.32	0.40	0.59	1.12	1.00	1.35	1.14	**0.69**
Henricia leviuscula	0.11	1.07	1.33	0.18	0.46	1.39	–	0.11	1.59	0.19	**0.64**
Loxorhynchus grandis	0.55	0.81	0.80	0.71	0.46	0.91	0.59	–	0.96	0.28	**0.61**
Loxorhynchus crisp.	0.27	0.86	1.07	0.26	–	1.12	0.46	0.20	1.34	0.21	**0.58**
Mediaster aequalis	0.43	0.70	0.63	0.42	–	0.67	0.56	0.13	0.82	0.14	**0.45**

3.4 Algae

The abundance of habitat-forming kelp species at each site was determined using the swath method, and percent cover of selected algal categories was determined from the UPC method. *Pterygophora californica* was the most abundant species with a mean across 63 sites of 68.25 plants per transect, followed by *Cystoseira osmundacea* (29.88), and *Eisenia arborea* (29.26) (**Table 3-15**). *Macrocystis pyrifera* (giant kelp), which is an ecologically important species because of its dominant biomass and structural architecture, was the fourth most abundant kelp species (27.10 plants per transect) although it occurred on transects at 73% of the sites. *Cystoseira* was the most frequently occurring kelp species among sites (89%). *Nereocystis luetkeana* and *Laminaria setchellii* occurred mainly at sites north of Point Conception while *Eisenia arborea* and *Laminaria farlowii* mainly occurred at sites south of Point Conception. In addition to the species listed in **Table 3-15**, there were five other species with mean abundances less than 0.15 plants per site. Complete swath data by site are presented in **Appendix D**.

The UPC method was used to estimate the percent cover of various taxa on each benthic transect. Coralline crust and erect red algae were the two most abundant taxa recorded overall (18% and 16%, respectively) and both were present at all sites sampled (**Table 3-16**). Although most of the 17 recorded algal taxa occurred at over half of the sites, only the top three taxa had mean coverages that exceeded 3%. The mean percent cover for six of the most abundant algal categories sampled are listed by site in **Table 3-17**. Erect red algae was substantially higher at the following sites than most others: La Cruz, Sal, Purisima, Painted Cave, Sand Spit, and China Point. Erect corallines were very abundant at Point Loma South while crustose coralline algae was abundant at Point Buchon, Bee Rock, and Arch Point.

Table 3-15. Mean abundance per transect for kelp taxa sampled using the swath method; N=63 sites.

Site #	Site	*Cystoseira osmundacea*	*Eisenia arborea*	*Laminaria farlowii*	*Laminaria setchellii*	*Macrocystis pyrifera*	*Nereocystis luetkeana*	*Pterygophora californica*
15	Wild Cattle	1.92	–	–	110.67	3.92	196.17	52.58
16	Plaskett Rock	0.67	0.50	–	56.17	7.17	163.67	77.00
17	Duck Pond	0.17	–	–	135.42	4.75	282.42	72.08
19	La Cruz	3.50	–	–	89.25	0.83	227.00	62.33
20	San Simeon	1.42	–	–	25.92	9.17	51.58	14.67
23	Cayucos	5.25	–	–	16.83	9.92	33.92	0.25
24	Point Buchon	0.75	–	–	98.17	2.25	238.58	135.08
25	Diablo Canyon	0.67	–	–	57.67	–	320.83	255.25
26	Sal	–	–	–	159.25	–	–	–
27	Purisima	7.75	–	–	8.75	6.25	–	48.75
28	Jalama	23.00	16.75	32.00	10.75	29.00	–	702.83
29	Cojo	10.25		56.42	–	34.00	–	205.33
31	Cuyler	4.50	0.25		–	113.00	–	–
32	Harris Point	1.50	19.75	9.50	1.00	101.00	–	0.25
33	Tyler Bight	42.58	106.83		3.50	44.25	–	152.42
34	Crook Point	88.33		86.25	–	64.50	–	89.42
35	Rodes Reef	58.50	0.17	1.83	–	12.83	–	–
36	Beacon Reef	0.50	8.25	0.58	–	0.42	–	0.08
38	Bee Rock			18.50	–	28.67	–	35.58
39	Cluster Point	0.58	0.83	0.17	–	16.67	–	358.67
40	Chickasaw	6.08	0.67	1.67	0.42	15.83	–	42.08
41	Johnsons Lee	8.17	0.08	6.50	1.58	56.58	–	13.25
42	Jolla Vieja	230.33	0.25	3.92	0.25	26.58	–	41.42
43	Forney	241.50	16.42	17.50	–	90.50	–	4.50
44	Painted Cave	0.75	956.33		15.75	5.25	–	–
45	Hazards	0.50	170.42	27.17	–	159.00	–	–
46	Pelican	21.50	72.25	90.67	–	44.00	–	–
47	Coche Point	4.00	11.75		–		–	–
48	Scorpion	12.75	1.50	0.25	–	75.50	–	–
49	Gull Isle	135.33	123.92	1.75	–	174.50	–	3.00
50	Valley	55.00	9.00		–	147.50	–	22.50
51	Yellowbanks	167.83	13.50	37.25	–	108.00	–	170.08
52	Anacapa West Isle	2.50	–	0.50	–		–	–
53	Anacapa Middle Isle	3.75	42.42		–	3.25	–	–
54	Anacapa East Isle	213.42	64.25	361.25	–	53.50	–	3.00
55	Cat Rock	247.92	8.33	0.08	–	57.75	–	–
56	Southwest Lighthouse	13.58	12.42	2.08	–	24.17	–	–
58	King Harbor	2.00	–		–	1.10	–	–
59	Rocky Point	5.25	0.42	2.00	–	18.50	–	25.92
60	Point Vicente	–	–		–	–	–	0.33
61	Dana Point	1.25	2.17	1.67	–	2.25	–	6.92
62	San Mateo	3.58	1.58	1.58	–	0.17	–	0.67
63	San Onofre	1.80	–	18.90	–	–	–	2.70
64	Barn Kelp	–	–	0.50	–	–	–	–

(table continued)

Table 3-15 (continued). Mean abundance per transect for kelp taxa sampled using the swath method.

Site #	Site	*Cystoseira osmundacea*	*Eisenia arborea*	*Laminaria farlowii*	*Laminaria setchellii*	*Macrocystis pyrifera*	*Nereocystis luetkeana*	*Pterygophora californica*
65	Carlsbad	36.08	4.50	–	–	–	–	–
66	Encinitas	16.00	9.67	0.33	–	–	–	0.33
67	Cardiff	1.50	2.50	0.92	–	–	–	0.33
68	La Jolla	49.75	37.75	33.00	–	–	–	28.88
69	Point Loma North	21.25	13.83	77.33	–	–	–	49.25
70	Point Loma South	59.67	51.58	174.92	–	–	–	26.58
71	Sand Spit	–	–	–	0.50	18.00	–	3.83
72	Dutch Harbor	–	–	0.08	0.75	29.17	–	28.50
73	Arch Point	–	6.00	–		0.08	–	0.17
74	South Kelp	2.25	–	–	0.08	6.00	–	8.42
77	Isthmus Reef	2.42	13.17	12.25	–	–	–	–
78	Intakes	10.92	10.33	4.50	–	–	–	–
80	Ripper's Cove	17.50	0.25	–	–	20.25	–	–
81	East Quarry	8.33	–	6.92	–	37.33	–	1.08
82	Lobster Bay	0.25	19.67	101.92	–	8.58	–	–
85	Little Harbor	9.50	12.92	15.50	–	–	–	–
86	Little Flower	4.00	0.08	2.75	–	–	–	74.50
87	Pyramid Cove	6.83	–	9.08	0.17	27.33	–	26.33
88	China Point	5.50	–	28.92	0.92	7.92	–	62.00
	Mean Across Sites	**29.88**	**29.26**	**19.82**	**12.60**	**27.10**	**3.08**	**46.18**
	Freq of Occurrence	88.89	63.49	63.49	34.92	73.02	12.70	68.25

Table 3-16. Mean percent cover and percent frequency of occurrence of selected algal taxa sampled on benthic transects using the UPC methodology for all sites combined; N=63 sites.

Taxon	Common Name	Mean Percent Cover	Rank Mean	Percent Frequency	Rank Frequency
coralline algae (crustose)	coralline crust	17.94	1	100.00	1
red algae (erect)	erect red algae	16.37	2	100.00	2
coralline algae (erect)	erect coralline algae	7.80	3	96.83	3
non-coralline algae (crustose)	non-coralline crust	2.99	4	77.78	5
red algae (turf)	red algal turf	2.98	5	57.14	7
Macrocystis spp. (holdfast)	Giant kelp (holdfast)	2.31	6	87.30	4
Phaeophyta unid.	kelp unid.	2.30	7	73.02	6
Chlorophyta unid.	green algae unid.	1.28	8	52.38	8
under *Laminaria* spp.	*Laminaria* kelp	1.12	9	28.57	13
Laminariales (holdfast)	Laminarian (holdfast)	0.84	10	50.79	9
Cystoseira osmundacea	bladder chain kelp	0.69	11	50.79	10
Phyllospadix spp.	surfgrass	0.57	12	19.05	15
diatomaceous scum	diatomaceous scum	0.46	13	31.75	12
holdfast, unid. (dead)	unid. algal holdfast (dead)	0.42	14	50.79	11
Desmarestia spp.	acid kelp	0.30	15	25.40	14
Sargassum spp.	Japanese seaweed	0.23	16	14.29	16
Egregia menziesii	feather boa kelp	0.16	17	14.29	17

Table 3-17. Mean percent cover of algal taxa sampled using the UPC method; N=63 sites. Total brown algal cover includes the combined abundance of all brown algal taxa shown in Table 3-15.

Site #	Site	Erect Red Algae	Red Algal Turf	Total Brown Algae	Total Green Algae	Erect Corallines	Crustose Corallines
15	Wild Cattle	29.00	-	3.08	-	4.25	6.75
16	Plaskett Rock	14.25	0.58	3.83	-	26.17	18.08
17	Duck Pond	21.83	0.58	0.17	-	13.58	21.75
19	La Cruz	47.50	-	4.08	-	8.17	11.00
20	San Simeon	36.75	-	0.83	2.50	4.00	16.92
23	Cayucos	22.83	-	0.33	0.17	4.92	25.75
24	Point Buchon	1.08	-	0.50	-	0.25	43.33
25	Diablo Canyon	2.75	-	0.50	-	9.58	23.67
26	Sal	48.58	-	-	-	0.83	3.83
27	Purisima	47.67	-	-	-	3.67	7.75
28	Jalama	22.75	-	2.67	-	0.83	11.58
29	Cojo	4.50	-	-	-	-	7.50
31	Cuyler	19.58	2.92	2.67	0.17	1.42	27.83
32	Harris Point	19.25	0.17	0.33	0.50	1.33	27.92
33	Tyler Bight	7.58	-	0.17	0.17	10.17	23.92
34	Crook Point	14.67	-	1.00	-	6.50	25.17
35	Rodes Reef	0.25	3.17	1.33	0.67	2.00	22.67
36	Beacon Reef	3.00	4.25	0.50	0.25	1.58	39.25
38	Bee Rock	3.58	0.25	2.42	-	1-	47.25
39	Cluster Point	0.83	0.75	5.00	-	4.67	18.25
40	Chickasaw	11.17	5.25	1.25	0.75	9.92	8.00
41	Johnsons Lee	8.67	2.50	1.83	-	1.25	7.17
42	Jolla Vieja	10.75	8.17	5.75	-	11.33	5.17
43	Forney	15.42	-	7.67	-	3.67	17.92
44	Painted Cave	46.75	-	0.33	1.17	1.83	10.58
45	Hazards	7.92	-	0.17	1.75	3.50	12.92
46	Pelican	6.50	0.33	1.25	-	3.33	14.42
47	Coche Point	11.08	0.83	0.83	0.33	1.58	37.00
48	Scorpion	6.08	2.17	2.92	1.25	0.25	25.83
49	Gull Isle	15.50	1.33	3.00	0.42	3.75	26.92
50	Valley	1.33	1.50	2.67	0.17	1.58	14.58
51	Yellowbanks	5.42	0.17	2.92	0.17	6.67	22.67
52	Anacapa West Isle	9.58	1.42	4.92	1.00	1.67	25.17
53	Anacapa Middle Isle	7.08	6.58	4.25	0.33	0.42	39.25
54	Anacapa East Isle	13.17	0.75	9.33	0.92	17.33	15.67
55	Cat Rock	1.92	3.33	9.08	0.25	7.00	16.83
56	Southwest Lighthouse	4.42	0.50	9.67	0.50	11.08	23.92
58	King Harbor	27.30	-	6.70	2.00	4.10	8.60
59	Rocky Point	15.25	-	8.50	-	7.67	20.17
60	Point Vicente	12.11	-	-	-	-	30.00
61	Dana Point	13.67	7.00	7.08	-	15.58	9.25
62	San Mateo	19.92	17.67	0.25	-	2.00	12.00
63	San Onofre	17.80	7.00	5.50	-	2.00	3.40
64	Barn Kelp	27.00	16.50	-	-	1.50	1.50

(table continued)

Table 3-17 (continued). Mean percent cover of algal taxa sampled using the UPC method; N=63 sites.

Site #	Site	Erect Red Algae	Red Algal Turf	Total Brown Algae	Total Green Algae	Erect Corallines	Crustose Corallines
65	Carlsbad	23.08	10.33	8.17	0.25	13.92	0.75
66	Encinitas	19.33	10.33	10.67	-	26.17	0.50
67	Cardiff	27.75	14.92	4.83	2.00	3.00	0.50
68	La Jolla	29.25	4.13	8.38	-	20.63	4.63
69	Point Loma North	8.83	3.67	2.00	-	32.58	16.17
70	Point Loma South	8.92	10.08	4.58	-	44.08	12.00
71	Sand Spit	62.00	-	2.17	1.00	6.50	10.00
72	Dutch Harbor	19.67	-	1.08	0.50	4.75	9.92
73	Arch Point	11.25	-	2.50	4.42	6.92	41.83
74	South Kelp	2.42	-	2.83	10.25	13.08	35.17
77	Isthmus Reef	1.92	7.50	15.00	4.17	4.17	6.17
78	Intakes	10.67	8.00	4.58	-	5.42	20.67
80	Ripper's Cove	1.75	-	6.50	-	2.50	25.00
81	East Quarry	14.08	-	9.42	19.92	2.75	25.67
82	Lobster Bay	12.25	9.08	6.58	-	22.25	16.58
85	Little Harbor	9.75	14.25	2.50	0.25	23.58	16.75
86	Little Flower	6.83	-	7.42	7.50	1.42	28.92
87	Pyramid Cove	31.33	-	9.17	9.17	13.33	12.67
88	China Point	46.42	-	0.83	5.83	11.58	7.50

3.5 Substrates and Bottom Relief

Substrate type and bottom relief were each recorded as four separate categories on each transect using the UPC method. Overall, bedrock comprised nearly half the area of all transects sampled while sand comprised approximately one-fourth of the area, and boulder and cobble comprised the remainder (**Table 3-18**). Average bottom relief on the transects was generally flat or slight (less than 1 m), with high relief comprising less that 5% of the points sampled. Complete substrate and bottom relief data by site, including the percentages of bare substrate contacted, are presented in **Appendix D**.

Table 3-18. Substrate composition and bottom relief averaged for 63 sites.

Attribute	Mean Percent Cover	Frequency of Occurrence
Substrate Type		
Bedrock	48.85	98.41
Sand (shell gravel)	23.71	100.00
Boulder	15.85	95.24
Cobble	11.59	98.41
Bottom relief		
Flat (< 10 cm)	34.72	98.41
Slight (10 cm – 1 m)	50.00	100.00
Moderate (1 m – 2 m)	11.27	90.48
High (> 2 m)	4.02	73.02

4.0 Discussion

(To be included in final draft)

5.0 Literature Cited

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