Abstract.–We studied the food habits of the California sea lion *Zalophus californianus* at San Clemente Island, California, from September 1981 through September 1986 using fish otoliths, cephalopod beaks, and other prey remains we recovered from 1476 fecal samples (i.e., scats). We identified 44 types of prey to species and 8 types of prey to genus. Seven types of prey occurred in at least 10% of scats: northern anchovy *Engraulis mordax* (51.3%); jack mackerel *Trachurus symmetricus* (24.6%); pelagic red crab *Pleuroncodes planipes* (21.2%); Pacific whiting *Merluccius productus* (19.6%); rockfishes, *Sebastes* spp. (19.0%); market squid *Loligo opalescens* (16.3%); and blacksmith *Chromis punctipinnis* (10.7%). We examined trends in the occurrence of these seven species and of Pacific mackerel *Scomber japonicus* and octopus (*Octopus* spp.) in scats of California sea lions. We found significant differences among seasons and years, and season-year differences in the occurrence of northern anchovy, jack mackerel, Pacific whiting, and octopus ($P<0.01$). Significant effects due to year and season-year interaction were found for pelagic red crab, rockfish, market squid, and blacksmith. Pacific mackerel showed a significant difference only among years. Significant differences in the occurrence of Pacific whiting, northern anchovy, jack mackerel, Pacific mackerel, market squid, octopus, and pelagic red crab ($P<0.01$) were found during pre-El Niño, El Niño, and post-El Niño periods.

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Food Habits of California Sea Lions *Zalophus californianus* at San Clemente Island, California, 1981–86

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Knowledge of California sea lion *Zalophus californianus* food habits in the Southern California Bight (SCB, Fig. 1) has come from stomach content analysis by Scheffer and Neff (1948), and Fiscus and Baines (1966); and from the 1978–79 spring and summer study at San Miguel Island from scat (i.e., fecal) analysis by Antonelis et al. (1984). These studies identified a wide variety of prey. Antonelis et al. (1984) reported that Pacific whiting, market squid, juvenile rockfish, and northern anchovy were the four most important prey at San Miguel Island. A 4-year study at the Farallon Islands in northern California (outside the breeding area) found that sea lions switched between Pacific whiting and juvenile rockfish (Bailey and Ainley 1982).

From 1981 to 1986, we examined prey consumed by California sea lions using the shoreline located at and south of Mail Point, San Clemente Island (SCI, Fig. 1). San Clemente Island has one of the smallest rookeries in the SCB (producing approximately 666 pups in 1981) as compared with San Miguel and San Nicolas islands (producing approximately 8255 and 6704 pups, respectively, in 1981; DeMaster et al. 1982, Stewart and Yochem 1984, Oliver and Lowry 1987). We analyzed fecal samples (scats) to identify prey composition and temporal changes in the diet. This period was characterized by an abnormal influx of warm water into the SCB during the 1982–83 El Niño/Southern Oscillation (McGowan 1984). Effects of this El Niño within the SCB became evident in October 1982, when sea-surface temperatures were 1–2°C above normal, and zooplankton levels declined (McGowan 1984). Water temperatures returned to normal in October–November 1984 (F. Miller, Inter-Am. Trop. Tuna Comm., La Jolla, CA 92038, pers. commun., Oct. 1986). This warm-water period off California has been referred to as the California El Niño (McGowan 1984, Fiedler et al. 1986).

Methods

Sample collection

We collected fresh and dry scats during 40 trips to SCI with between-trip intervals ranging from 2 weeks to 3 months. Scats were separated into one of three categories: (1) fresh

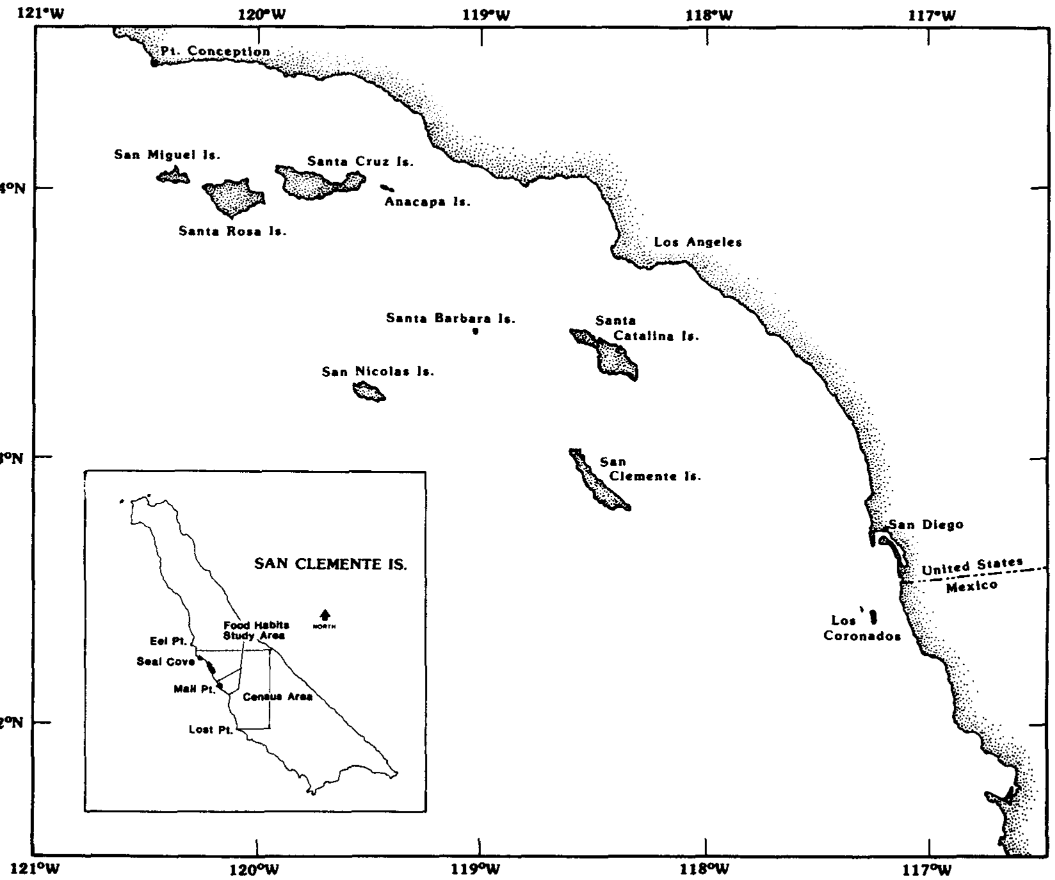


Figure 1
Map showing Southern California Bight (SCB) and San Clemente Island (SCI).

scats, (2) dried scats representing one between-trip interval, and (3) dried scats representing more than one between-trip interval. Fresh scat samples represented the diet of sea lions within 3 to 4 days of the collection. The second category provided dietary information from the previous scat collection period to the time represented by fresh scats. The third category represented a much longer period.

Each scat was placed in a plastic bag, stored in an air-tight plastic container, and frozen until processed. Scats were soaked in a mild soap solution for 1–5 days, and then rinsed with water through two or three nested sieves. During September 1981–March 1983 we used three sieves (mesh sizes 2.8 mm, 1.5 mm, and 1.00 mm) and during April 1983–September 1986 we used two sieves (mesh sizes 2.8 mm and 0.710 mm). After rinsing, we collected fish otoliths, cephalopod beaks, shark teeth, and cartilaginous vertebrae. Otoliths, shark teeth, and cartilaginous vertebrae were air dried and stored in gelatin capsules; cephalopod beaks were stored in vials containing 70% ethanol. We noted the presence or absence of fragments of pelagic red crabs *Pleuroncodes planipes*.

Sample analysis

Prey items were identified to the lowest taxon possible from comparative specimens and drawings (Iverson and Pinkas 1971, Eschmeyer et al. 1983). We used sagittal otoliths to identify teleost fishes, cephalopod beaks to identify squid and octopus, teeth to identify elasmobranchs, and exoskeletal fragments to identify pelagic red crabs. We counted left and right sagittal otoliths, and upper and lower cephalopod beaks.

Table 1
California sea lion *Zalophus californianus* scat samples collected seasonally from San Clemente Island, California, 1981–86.

Year	Season	Number of collection trips	Number of scats collected: Fresh	Dry: 1 between-trip interval	Dry: >1 between-trip interval	Total collected
1981	Autumn	3	22	19	7	48
1981–82	Winter	1	0	3	0	3
1982	Spring	4	27	80	52	159
1982	Summer	4	76	67	7	150
1982	Autumn	1	1	53	0	54
1982–83	Winter	2	3	56	0	59
1983	Spring	3	37	73	60	170
1983	Summer	2	6	71	10	87
1983	Autumn	1	22	56	17	95
1983–84	Winter	3	93	51	4	148
1984	Spring	2	81	20	16	117
1984	Summer	3	88	1	0	89
1984	Autumn	2	13	40	0	53
1984–85	Winter	1	0	16	0	16
1985	Spring	1	11	1	0	12
1985	Summer	2	60	0	0	60
1985	Autumn	1	25	0	0	25
1986	Spring	1	44	0	0	44
1986	Summer	2	65	0	0	65
1986	Autumn	1	22	0	0	22
Total		40	696	607	173	1476

We used indices of occurrence, composition, and number to quantify prey taxon consumed by sea lions. Only scat samples containing otoliths, cephalopod beaks, shark teeth, cartilaginous vertebrae, or pelagic red crab fragments were used in the analysis. The occurrence index, or percent occurrence (PO), is a measure of the percentage of scat samples in which a prey taxon occurred. The composition index, or percent prey composition (PPC), is a measure of the percentage of occurrences for each prey taxon from a tally of occurrences from all prey taxa found in a group of samples. The number index, or percent minimum number (PMN), measures the percentage of numbers of individual prey taxon. To compute the number index, we used the maximum count of either left or right otoliths, or upper or lower beaks, which represent the minimum number of individual prey taxon. The counts for all prey taxa are summed and the percentage of each prey taxon is determined from the sum of all counts. The number index is, then, the percentage represented by each prey taxon from the sum of all maximum counts taken of all prey taxa found in a group of samples.

Interpretation of the number index is limited because it excludes (1) all prey hard parts found that were broken or digested, and not categorized as either left or right otoliths or upper or lower beaks, and (2) prey that lacked otoliths or beaks (e.g., pelagic red crabs and sharks). However, we think that this index is useful because fish and cephalopods represented the majority of prey in scat samples.

Percent occurrence indicates prey consumption without regard to other prey, and may indicate temporal availability, selectivity, or ease of capture of individual prey. Percent prey composition indicates the relative proportions of prey consumed. Percent minimum number of prey indicates numbers of prey consumed and is an index of the rate of consumption of individual prey.

Statistical analysis

We used all scats to determine what prey taxa were consumed, and then limited our examination of temporal variations in prey consumption to prey that occurred in at least 10% of these scats, were found in at least 80% of the seasons, or were occasionally very abundant. Only fresh scats and dried scats representing one between-trip interval were used in the temporal analyses of sea lion diets. We combined the 40 collection trips (Table 1) by season into winter (December–

Table 2

Number of prey occurrences (*n* Occur), percent occurrence (PO), percent prey composition (PPC), minimum number of individual prey (*n* Ind.), and percent minimum number (PMN) of prey found in 1309 California sea lion scats collected at San Clemente Island, California, 1981–86.

Prey						
Scientific name	Common name	*n* Occur	PO	PPC	*n* Ind.	PMN
Engraulis mordax	northern anchovy	672	51.3	24.7	9,398	54.4
Trachurus symmetricus	jack mackerel	322	24.6	11.8	1,220	7.1
*Pleuroncodes planipes**	pelagic red crab	277	21.2	10.2	—**	—
Merluccius productus	Pacific whiting	256	19.6	9.4	2,110	12.2
Sebastes spp.	rockfish	249	19.0	9.2	1,245	7.2
Loligo opalescens	market squid	214	16.3	7.9	1,516	8.8
*Chromis punctipinnis**	blacksmith	140	10.7	5.1	580	3.4
Scomber japonicus	Pacific mackerel	125	9.5	4.6	215	1.2
Octopus spp.	octopus	67	5.1	2.5	523	3.0
Onychoteuthis borealijaponicus	squid	39	2.2	1.1	33	<0.5
Lyopsetta exilis	slender sole	11	0.8	<0.5	19	<0.5
*Oxyjulis californica**	señorita	14	1.1	0.5	20	<0.5
Porichthys notatus	plainfin midshipman	9	0.7	<0.5	11	<0.5
Abraliopsis spp.*	squid	9	0.7	<0.5	11	<0.5
Gonatus spp.	squid	9	0.7	<0.5	11	<0.5
*Lycodes cortezianus**	bigfin eelpout	7	0.5	<0.5	8	<0.5
*Sebastolobus alascanus**	shortspine thornyhead	6	0.5	<0.5	7	<0.5
Microstomus pacificus	dover sole	6	0.5	<0.5	8	<0.5
Glyptocephalus zachirus	rex sole	6	0.5	<0.5	7	<0.5
Icichthys lockingtoni	medusafish	5	<0.5	<0.5	7	<0.5
*Xeneretmus ritteri**	stripefin poacher	3	<0.5	<0.5	5	<0.5
Citharichthys sordidus	Pacific sanddab	4	<0.5	<0.5	5	<0.5
*Atherinops affinis**	topsmelt	3	<0.5	<0.5	4	<0.5
*Semicossyphus pulcher**	sheephead	3	<0.5	<0.5	3	<0.5
Seriphus politus	queenfish	2	<0.5	<0.5	26	<0.5
*Cypselurus californicus**	California flying fish	2	<0.5	<0.5	8	<0.5
Genyonemus lineatus	white croaker	2	<0.5	<0.5	6	<0.5
*Galeorhinus zyopterus**	soupfin shark	2	<0.5	<0.5	—	—
Symbolophorus californiensis	California lanternfish	2	<0.5	<0.5	2	<0.5
*Paralabrax clathratus**	kelp bass	2	<0.5	<0.5	2	<0.5
Chilara taylori	spotted cusk-eel	2	<0.5	<0.5	2	<0.5
Cymmatogaster aggregata	shiner surfperch	2	<0.5	<0.5	2	<0.5
Stenobrachius leucopsarus	northern lampfish	2	<0.5	<0.5	2	<0.5
Paralabrax sp.*	seabass	1	<0.5	<0.5	3	<0.5
*Ocythoe tuberculata**	squid	1	<0.5	<0.5	2	<0.5
Girella nigricans	opaleye	1	<0.5	<0.5	2	<0.5
Zalembius rosaceus	pink surfperch	1	<0.5	<0.5	1	<0.5
Zaniolepis sp.*	combfish	1	<0.5	<0.5	1	<0.5
Xeneretmus sp.*	poacher	1	<0.5	<0.5	1	<0.5
*Prionace glauca**	blue shark	1	<0.5	<0.5	—	—
*Argentina sialis**	Pacific argentine	1	<0.5	<0.5	1	<0.5
*Hippoglossina stomata**	bigmouth sole	1	<0.5	<0.5	1	<0.5
Parophrys vetulus	english sole	1	<0.5	<0.5	1	<0.5
*Xeneretmus triacanthus**	bluespotted poacher	1	<0.5	<0.5	1	<0.5
*Ceratoscopelus townsendi**	dogtooth lampfish	1	<0.5	<0.5	4	<0.5
Citharichthys sp.	sanddab	1	<0.5	<0.5	1	<0.5
*Careproctus melanurus**	blacktail snailfish	1	<0.5	<0.5	1	<0.5
*Medialuna californiensis**	halfmoon	1	<0.5	<0.5	3	<0.5
*Synodus lucioceps**	California lizardfish	1	<0.5	<0.5	1	<0.5
*Octopoteuthis deletron**	squid	1	<0.5	<0.5	1	<0.5
Unid. Myctophidae	lanternfish	17	1.3	0.6	29	<0.5
Unid. Embiotocidae	surfperch	4	<0.5	<0.5	7	<0.5
Unid. Atherinidae	silverside	3	<0.5	<0.5	3	<0.5
Unid. Labridae	wrasse	3	<0.5	<0.5	8	<0.5
Unid. Cottidae	sculpin	2	<0.5	<0.5	2	<0.5
Unid. Zoarcidae	eelpout	2	<0.5	<0.5	2	<0.5

Table 2 (continued)

Prey						
Scientific name	Common name	*n* Occur	PO	PPC	*n* Ind.	PMN
Unid. Gonatidae	squid	1	<0.5	<0.5	1	<0.5
Unid. Scombridae	mackerel or tuna	1	<0.5	<0.5	2	<0.5
	Unid. flatfish	5	<0.5	<0.5	6	<0.5
	Unid. cephalopod	31	2.4	1.1	19	<0.5
	Unid. cartilaginous fish	2	<0.5	<0.5	—	—
	Unid. fishes	83	6.3	3.1	62	<0.5

*Not previously reported as prey of California sea lions.
**Data impossible to compute in fields marked with a dash (—).

February), spring (March–May), summer (June–August), and autumn (September–November). We also categorized our sample into three groups related to the California El Niño: (1) pre-El Niño (September 1981–August 1982), (2) El Niño (November 1982–September 1984), and (3) post-El Niño (November 1984–September 1986).

We tested for seasonal and yearly differences in presence or absence of each prey taxon using two-way ANOVA (Program 7D of BMDP-87; Dixon 1985) in the binomial format. Two data sets were identified with full cells in order to meet the requirements of the test: (1) all seasons for the years 1982–85 (called four-season-four-year data set); and (2) three seasons (spring, summer, and autumn) for 1982–86 (called three-season-five-year data set). We identified prey taxa that showed significant season, year, and season-year interaction differences in their occurrence through time using Browne-Forsythe analysis of variance for unequal variances. For the pre-El Niño, El Niño, and post-El Niño comparisons, we tested for differences in presence or absence of the same nine prey taxa using two-way Browne-Forsythe ANOVA (Dixon 1985) in the binomial format.

We also examined temporal differences in the relative number of different prey taxa found per scat (1, 2, 3, 4, 5, or >5). Pearson's chi-square test (Dixon 1985) was used to test for differences among numbers of prey occurring per scat.

Results

Identification of prey remains

In the 1476 scats collected (Table 1), we found the following: (1) 1455 scats (98.5%) contained fish remains (i.e., bones, otoliths, or eye lenses); (2) 525 scats (35.5%) contained cephalopod remains (i.e., beaks or eye lenses); (3) 1309 scats (88.6%) contained fish otoliths, cephalopod beaks, or other prey remains that were used to identify prey; (4) 1271 scats (86.1%) contained fish otoliths; and (5) 344 scats (23.3%) contained cephalopod beaks.

We identified 95.4% of 2647 prey occurrences to species, genus, or family (Table 2). Of the 2,647 prey occurrences, 75.2% were bony fishes, 14.1% were cephalopod, 10.5% were crustacea (99.3% of crustacea were pelagic red crab), and 0.2% were cartilaginous fish. We identified 44 prey taxa to species level and 8 to genus level. Seven prey taxa occurred in >10% of scats: northern anchovy *Engraulis mordax* (51.3%); jack mackerel *Trachurus symmetricus* (24.6%); pelagic red crab *Pleuroncodes planipes* (21.2%); Pacific whiting *Merluccius productus* (19.6%); rockfishes, *Sebastes* spp. (19.0%); market squid *Loligo opalescens* (16.3%); and blacksmith *Chromis punctipinnis* (10.7%). Two prey taxa occurred in 5.0–10.0% of the scats: Pacific mackerel *Scomber japonicus* (9.5%) and octopus, *Octopus* spp. (5.1%). We identified 17 species and two genera of fish, and two species and one genus of cephalopod not reported previously as prey of California sea lions (Table 2).

Nearly half of the scats (46.1%) contained only one prey taxa (Fig. 2). Northern anchovy constituted 56.2% of 603 scat samples with single prey taxa (Fig. 3).

Variability in diet through time

We found differences in distributions of occurrence (occurrence and composition indices) and numbers of individuals (number index) for nine prey taxa examined for temporal variability during the pre-El Niño, El Niño, and post-El Niño periods (Fig. 4). The distributions of occurrence were significantly different for Pacific whiting, northern anchovy, jack mackerel, Pacific mackerel, market squid, octopus and pelagic red crab ($P<0.01$). Northern anchovy occurred frequently and in the highest numbers of any prey taxa in all three periods. During the pre-El Niño period, jack mackerel occurred in the scat samples more often than the other prey; and jack mackerel and market squid were found in greater indi-

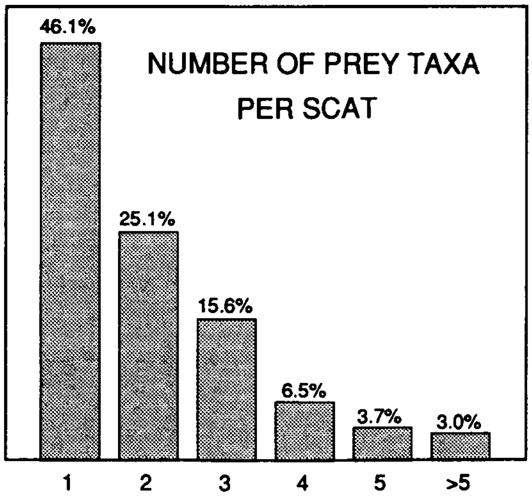


Figure 2
Occurrence of single and multiple prey taxa in 1309 California sea lion scats collected at San Clemente Island, California.

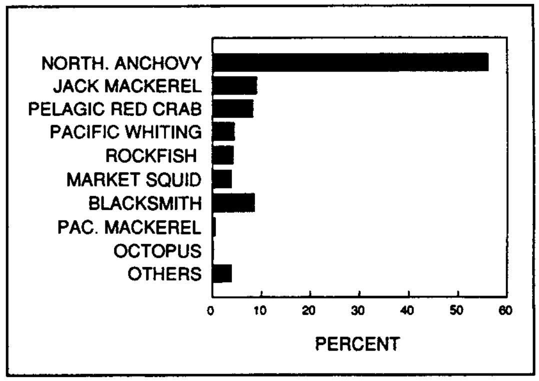
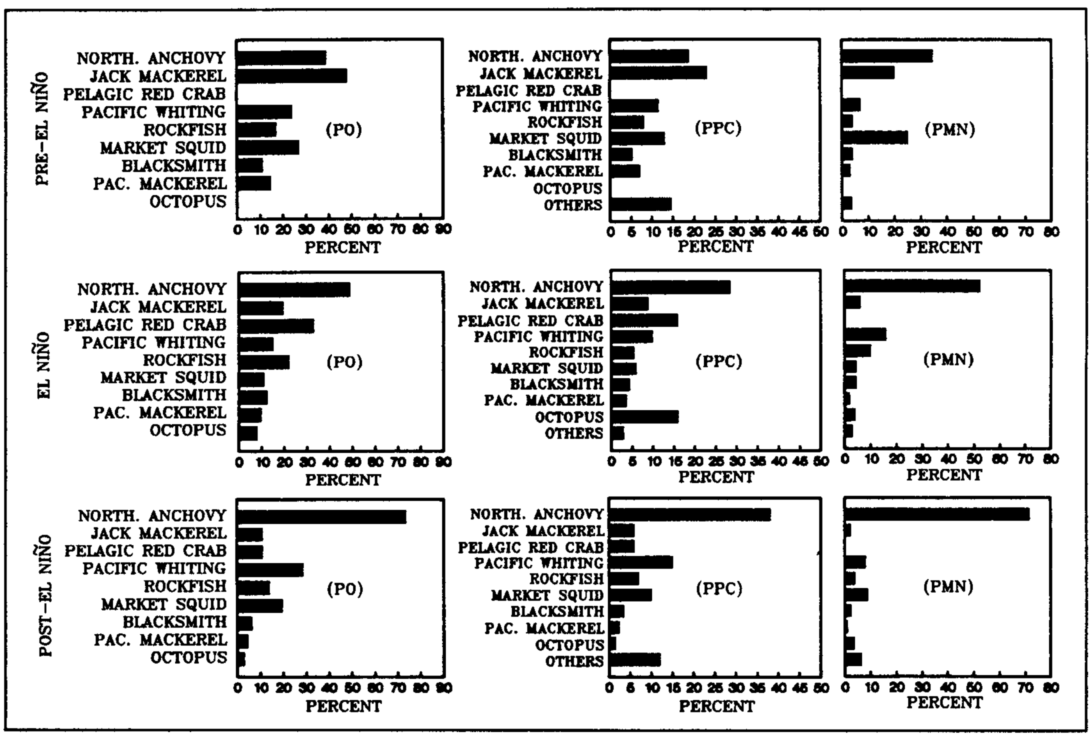


Figure 3
Percent prey found in 603 California sea lion scats with single prey taxon.

Figure 4
Occurrence (PO), composition (PPC), and number (PMN) indices of 9 prey taxa found in 1309 California sea lion scats collected at San Clemente Island, California, 1981–86, which are divided into pre-El Niño (September 1981–August 1982), El Niño (November 1982–September 1984), and post-El Niño (November 1984–September 1986) periods. The number index (PMN) could not be determined from fragments of pelagic red crab.



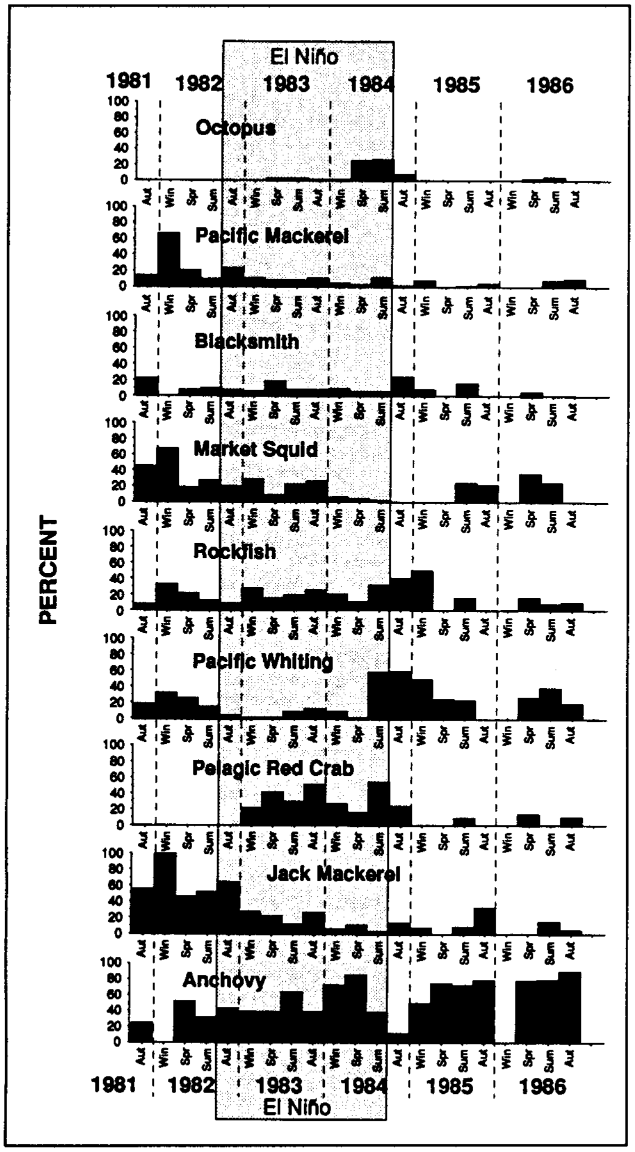


Figure 5
Seasonal percent occurrence (PO) of 9 prey taxa found in 1304 California sea lion scats, 1981–86. No samples were collected in winter 1986.

vidual numbers than other prey taxa, except northern anchovy. During the El Niño period, pelagic red crab were the second most frequently occurring prey in scat samples. During the post-El Niño period, the diet was dominated by northern anchovy.

We found yearly and seasonal variability in the relative proportions represented by the three indices for 9 prey taxa examined (Figs. 5–7). Northern anchovy was consistently found in scats throughout the study at varying occurrence, composition, and number index levels. However, during summer and autumn 1984 we noted a drop in the three indices compared with 1982, 1983, 1985, and 1986; and it did not occur as often in 1982 as in 1983, 1985, and 1986. Jack mackerel was the most frequent prey during 1981–82, but after that period it was found infrequently, represented a very small proportion of the diet, and few individuals were found in the scats. An increase in the occurrence of

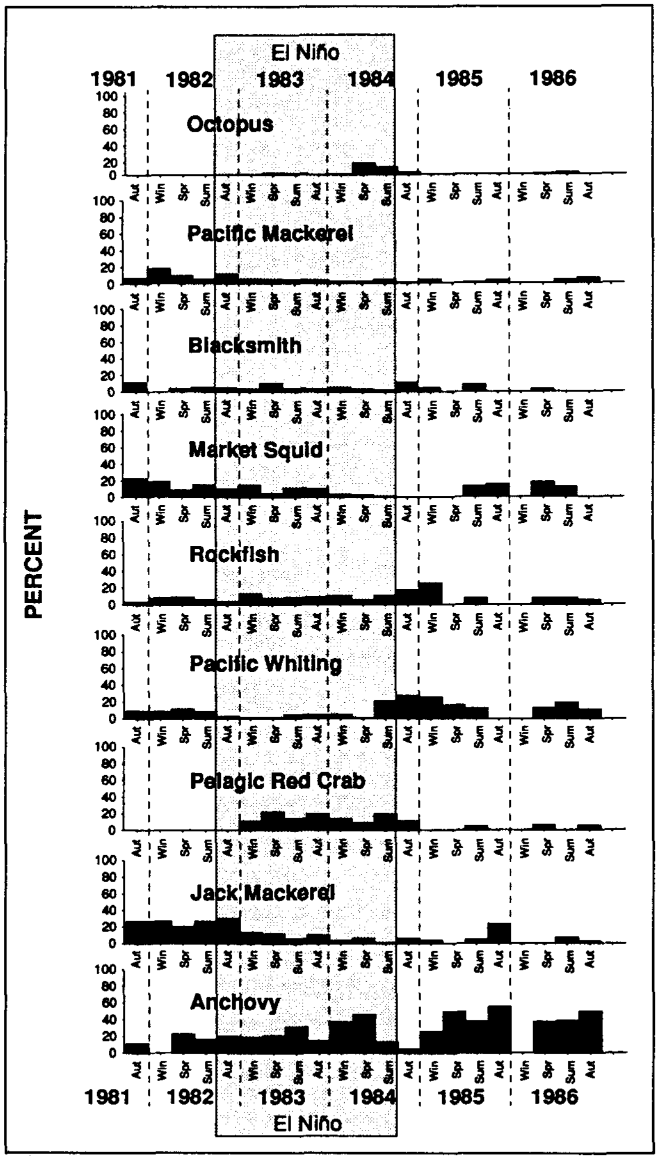


Figure 6
Seasonal percent prey composition (PPC) of 9 prey taxa found in 1304 California sea lion scats, 1981–86. No samples were collected in winter 1986.

Pacific whiting was found during summer–autumn 1984 and winter 1985 when many individuals were found in scats. Rockfish was consistently found in scats throughout the study, but more individuals were represented during summer–autumn 1984 and winter 1985 than other times. Market squid was found in extremely low occurrence, composition, and number index levels (≤5.6%) or was absent from scat samples from winter 1984 through spring 1985. Pelagic red crab occurred primarily during the 1983–84 California El Niño period. Pacific mackerel occurred in the scat samples more often in 1982 than during the following years, but was represented by few individuals from 1981 to 1986. Blacksmith occurred in scat samples throughout the 1981–84 period, but during the 1985–86 period it occurred inconsistently in the diet. Octopus appeared in the samples from spring 1983 to autumn 1984, and spring–summer 1986.

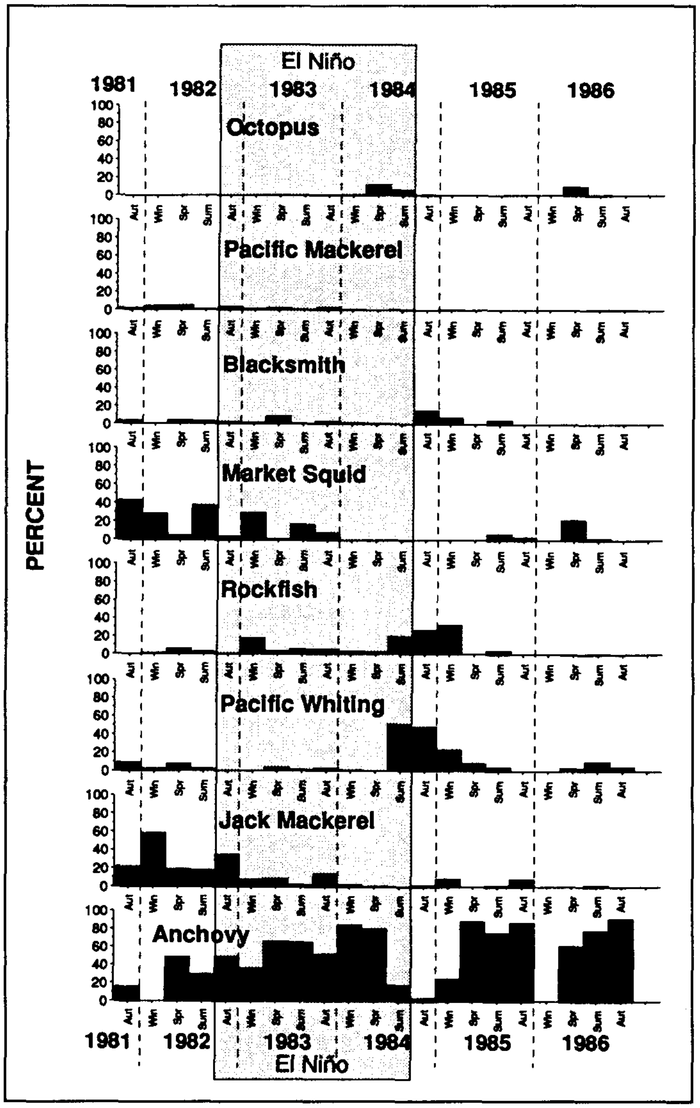


Figure 7

Seasonal percent minimum number (PMN) of 8 prey taxa found in 1304 California sea lion scats, 1981–86. No samples were collected in winter 1986. PMN could not be determined from fragments of pelagic red crab.

Analyses of the three-season-five-year and four-season-four-year data sets indicated significant differences ($P \leqslant 0.05$) in the occurrence of some, but not all, of the nine prey tested. Variances of occurrence were significantly different for all nine prey (Levene's test, $P \leqslant 0.05$). The three-season-five-year data set showed 21 significant differences in year, season, or season-year interactions, and the four-season-four-year data set showed 14 significant differences in year, season, or season-year interactions. Because the three-season-five-year data set included more of the post-El Niño period, results from that data set were used to interpret seasonal and yearly changes in prey items. Northern anchovy, jack mackerel, Pacific whiting, and octopus showed significant seasonal, yearly, and season-year interaction differences ($P < 0.01$). Pelagic red crab, rockfish, market squid, and blacksmith showed only significant yearly and season-year interactions differences ($P < 0.01$). Pacific mackerel had a significant difference only among years ($P < 0.01$).

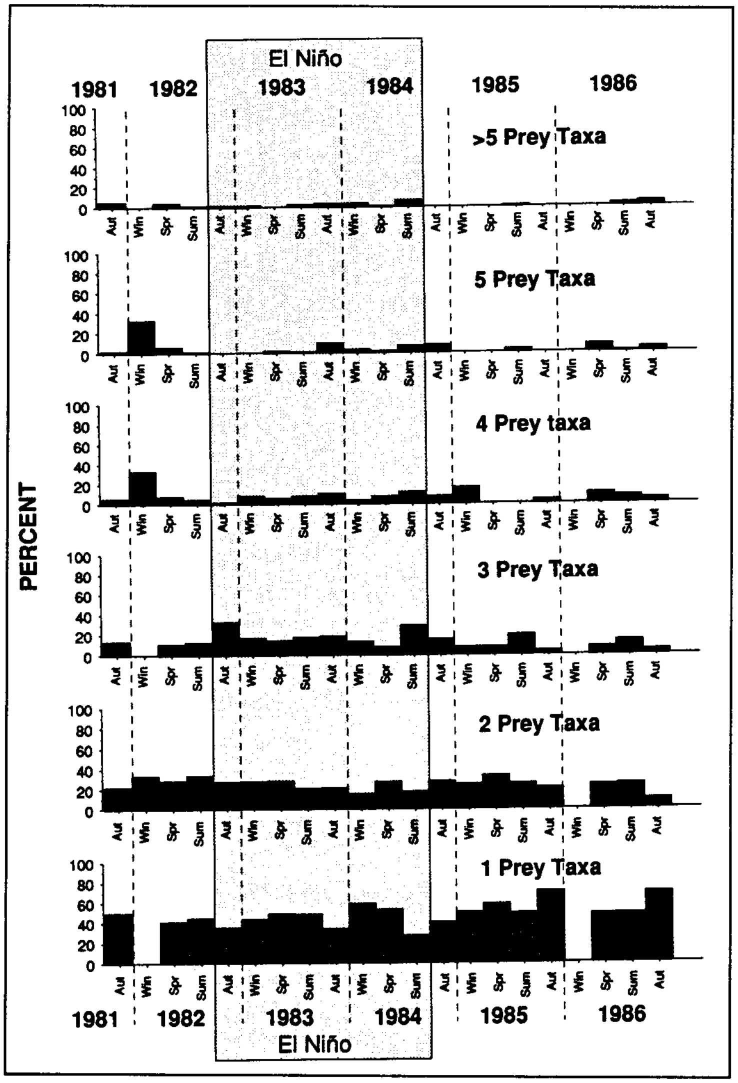


Figure 8
Seasonal occurrence of single and multiple prey taxa found in 1304 California sea lion scats, 1981–86. No samples were collected in winter 1986.

The relative frequencies of different prey taxa per scat varied among seasonal sampling periods during the study period (Fig. 8). Relative frequencies of prey taxa per scat for years 1982–85 were the same for all seasons in 1983 ($\chi^2 = 22.067$, df = 15, $P = 0.1061$) and 1985 ($\chi^2 = 18.219$, df = 15, $P = 0.2513$), but greater numbers of prey taxa were found in scats in 1982 ($\chi^2 = 35.892$, df = 15, $P = 0.0018$) and 1984 ($\chi^2 = 44.046$, df = 15, $P = 0.0001$).

Discussion

California sea lions using SCI consumed a variety of prey, consisting primarily of fish and cephalopods as indicated by the presence of fish remains in 98.5% of the scats and cephalopod remains in 35.5% of the scats. They fed on schooling fishes (e.g., northern anchovy, jack mackerel, Pacific mackerel, Pacific whiting, blacksmith, and rockfish), schooling cephalopods (e.g., market squid; Hurley 1978), and pelagic crustaceans that drift in large swarms (e.g., pelagic red crab; Boyd 1967). Our temporal analysis of nine prey taxa indicated seasonal and yearly variability in the diet of SCI sea lions. Northern anchovy apparently was the major food source because it was represented by high index values and consistently occurred in the sea lions' diet during the 5-year period. Pelagic red crab, jack mackerel, Pacific whiting, rockfish, market squid, blacksmith, and Pacific mackerel appear to supplement the diet of California sea lions.

A major uncertainty with using scat analysis to study pinniped food habits is how these results reflect what was initially consumed by the animals. Studies on captive pinnipeds indicate that recovery rates are (1) lower than ingestion rates for all prey; (2) lower for prey species with small otoliths than prey with large otoliths; and (3) lower for young (i.e., small) prey than for older (i.e., large) prey of the same species (Hawes 1983, da Silva and Neilson 1985, Murie and Lavigne 1986, Dellinger and Trillmich 1988, Harvey 1989). Proportions of different prey species in scats were found to correspond to proportions of prey fed (Dellinger and Trillmich 1988). Pitcher (1980) found no difference between occurrence of fish in stomachs and feces of harbor seals *Phoca vitulina*, but cephalopods were under-represented in their feces.

The prey that occurred in 10% or more of scat samples ranged from small-sized (i.e., northern anchovy, market squid, and pelagic red crab) to prey that, when mature, could be potentially large-sized (i.e., Pacific whiting, jack mackerel, rockfish, and Pacific mackerel). Northern anchovy, being small-sized with small otoliths, would probably represent a higher proportion of the diet than indicated in scat samples. Market squid would also represent a higher proportion of the diet because beaks are often regurgitated and would be underrepresented in scats.

Results from SCI indicated differences in both prey composition and temporal variability from those described by Bailey and Ainley (1982) for sea lions at the Farallon Islands off central California. We found that several prey were consistently consumed (e.g., northern anchovy, jack mackerel, Pacific whiting, rockfish, market squid, blacksmith, and Pacific mackerel), whereas they reported only two prey (Pacific whiting and rockfish) that were regularly eaten. They found Pacific whiting to occur in the sea lions' diet during spring and summer, and juvenile rockfish during the fall and winter. At SCI we found that the presence of various types of prey in the diet of sea lions fluctuated year-to-year and sometimes seasonally within the same year. These differences between two island areas may be due to differences in the sampling periods (1981–86 for our study; 1974–78 for the Farallon Island study), to differences in prey availability in each area, or to differences in the sexual composition of animals inhabiting each area.

We would expect similar diets for sea lions using islands within close proximity of each other. Data from a study of food habits on San Miguel Island (SMI) during spring and summer in 1978–79 by Antonelis et al. (1984) were compared with our results. Four types of prey taxa (Pacific whiting, rockfish, northern anchovy, and market squid) were consistently found in scats of SCI and SMI sea lions. Jack mackerel, consistently found at SCI, was a minor prey item at SMI. The presence of pelagic red crab at SCI was due to the California El Niño, which did not occur during the SMI study. Blacksmith were not found in the diet of sea lions at San Miguel Island, but occurred frequently in the SCI study. Because the distribution and availability of these prey differ over time, we are unable to test our expected similarities in prey consumption until concurrent studies are conducted.

Availability and abundance of sea lion prey have been demonstrated by Bailey and Ainley (1982) and Antonelis et al. (1984) to influence diet of California sea lions. Evidence that abundance, if not availability, of prey influences consumption is also found from our study at SCI when we compare anchovy occurrence in scats with anchovy biomass estimates for each year (Bindman 1986, Methot and Lo 1987). The decline in the occurrence of anchovy in the scats during 1982 and 1984 coincided with lower estimates of anchovy biomass of 415,000 mt for 1982 and 309,000 mt for 1984 (Bindman 1986). Increased occurrence of anchovy in scats during 1983, 1985, and 1986 coincided with greater estimates of anchovy biomass: 623,000 and 522,000 mt (Bindman 1986), and 764,000 mt (Methot and Lo 1987), respectively. Decline in anchovy biomass may have caused SCI sea lions to consume other species in 1982 and 1984, resulting in increased occurrence in the latter.

There was more variability in occurrence of different prey taxa per scat in 1982 and 1984 when the estimated population biomass of anchovy was low, and less variability in 1983 and 1985 when there was a greater biomass. The diet of SCI sea lions, therefore, may be strongly affected by the abundance of northern anchovy. As anchovy becomes scarce, we expect SCI sea lions to consume other types of prey and exhibit greater variability in the number of different prey consumed.

We expected the non-El Niño periods to have similar occurrences of prey taxa consumed, which would differ from the El Niño distribution. In fact, all three periods exhibited significantly different distributions of prey taxa and in their occurrence.

The pattern in the commercial harvest of market squid (which is not affected by regulations and quotas) observed in California before, during, and after El Niño (Worcester 1987) closely resembled the pattern observed in the occurrence of this prey in the diet of SCI sea lions. During the El Niño in 1983 and 1984 the commercial catch of market squid was 2010 and 622 short tons, respectively; prior to the El Niño it was 25,915 and 17,951 short tons for 1981 and 1982, respectively; and, after the El Niño it was 11,326 and 23,124 short tons for 1985 and 1986, respectively. The presence of market squid in the diet of sea lions during 1983 indicates the availability of this prey to sea lions, despite low availability to commercial catches. However, in 1984 when the commercial harvest was at its lowest, market squid was not detected in the sea lions' diet. Both the sea lions' consumption of market squid and the commercial catch were apparently affected by availability.

The effect of El Niño on the diet of SCI sea lions is also demonstrated by the presence of remains from pelagic red crabs in scat samples. Pelagic red crabs are normally found over the continental shelf of southern Baja California, and are sometimes transported into the SCB and further northward by the Davidson and California Countercurrents in January and February (Boyd 1967). These currents intensified as a result of the 1982–83 El Niño/Southern Oscillation, affected water temperatures in the SCB from late 1982 to October–November 1984, and carried pelagic red crabs from southern Baja California to the SCB where they were eaten by California sea lions.

The food consumed by the U.S. population of California sea lions could have an impact on the ecosystem and be in direct competition with commercial and sport fisheries. Six of the common prey of California sea lions identified at SCI (jack mackerel, northern anchovy, market squid, Pacific mackerel, Pacific whiting, and rockfish) are of value to commercial or sport fisheries. DeMaster (1983) estimated that California sea lions in U.S. waters (estimated population size 69,700) consumed roughly 115,000–295,000 mt of biomass per year. The present consumption would be greater than in 1983 because of the estimated 5% annual increase in the U.S. population (DeMaster et al. 1982). The growth in the sea lion population, and its estimated consumption, raises questions. Will there be greater competition between sea lions and fishermen for fish and squid as a result of increased numbers of sea lions? What will be the effect of population growth of sea lions on other elements of the SCB ecosystem?

Observed temporal differences in diet of sea lions from SCI during the California El Niño of 1982–84 clearly indicate the need for long-term studies of food habits of this predator throughout its range. Short-term studies may reflect oceanographic conditions of relatively short duration, such as El Niño, that strongly influence food supply and sea lion diet.

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