INSHORE SOFT SUBSTRATA FISHES IN THE SOUTHERN CALIFORNIA BIGHT: AN OVERVIEW

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ABSTRACT

A series of bimonthly trawls was made at stations off three areas (Ormond Beach, Redondo Beach, and San Onofre) in the Southern California Bight. Three depths (6.1, 12.2, and 18.3 m) were sampled from 1982 to 1984. At all three areas, queenfish (*Seriphus politus*), white croaker (*Genyonemus lineatus*), and northern anchovy (*Engraulis mordax*) dominated the 6.1-m stations. Off the Ormond area, queenfish and white croaker were the important species out to 18.3 m. However, off Redondo and San Onofre, these two species became less dominant in deeper water, giving way to an assortment of flatfishes (particularly speckled sanddab, *Citharichthys stigmaeus*; hornyhead turbot, *Pleuronichthys verticalis*; and fantail sole, *Xystreurys liolepis*). Disregarding seasonality and yearly variation, we found that fish abundances off Redondo and San Onofre decreased with depth, but remained constant at Ormond. This latter phenomenon was due to large numbers of queenfish and white croaker found throughout the Ormond isobaths. For fish one year of age and older (with the partial exception of white croaker and queenfish), there was a decline in mean abundance over the three-year period, particularly from 1983 to 1984. There was an increase in abundance of some species, notably California barracuda (*Sphyraena argentea*) and spotted turbot (*Pleuronichthys ritteri*). Though recruitment of some species such as speckled sanddab and walleye surfperch (*Hyperprosopon argenteum*) declined from 1982 to 1984, a number of species (including queenfish, northern anchovy, California barracuda, and spotted sanddab) appeared relatively unaffected or even enhanced during the El Niño event.

RESUMEN

Una serie de arrastres bimestrales fue realizada en tres áreas (Ormond Beach, Redondo Beach, y San Onofre) en la Bahía del Sur de California. Tres profundidades (6.1, 12.2, y 18.3 m) fueron muestreadas en 1982-1984. En las tres áreas, *Seriphus politus*, *Genyonemus lineatus* y la anchoveta del norte, *Engraulis mordax*, dominaron a 6.1 m de profundidad. Frente a Ormond, *S. politus* y *G. lineatus* fueron las especies más importantes hasta 18.3 m. Sin embargo, frente a Redondo y San Onofre, estas dos especies fueron menos comunes en aguas profundas, siendo reemplazadas por un conjunto de lenguados (especialmente *Citharichthys stigmaeus*, *Pleuronichthys verticalis*, y *Xystreurys liolepis*). Sin considerar las variaciones estacionales y anuales, las abundancias de peces disminuyeron en profundidad frente a Redondo y a San Onofre aun cuando permanecieron constantes en Ormond. Este último fenómeno se debió al gran número de *S. politus* y *G. lineatus* presentes a todas profundidades. Las abundancias promedio de peces de un año o más (con la excepción parcial de *G. lineatus* y *S. politus*) disminuyeron durante el período de tres años, especialmente entre 1983 y 1984. La abundancia de algunas especies aumentó, en particular la barracuda *S. argentea* y *P. ritteri*. Aun cuando el reclutamiento de algunas especies, como por ejemplo *C. stigmaeus* e *Hyperprosopon argenteum*, disminuyó entre 1982 y 1984, otras especies (incluyendo a *S. politus*, *E. mordax*, *S. argentea*, y *P.*, *ritteri*) parecieron no ser afectadas e inluso favorecidas durante el evento El Niño.

INTRODUCTION

Knowledge of fish assemblages within the Southern California Bight is uneven. A considerable amount is known about pelagic assemblages, both offshore (Mais 1974) and nearshore (Allen and DeMartini 1983). There have been numerous surveys of inshore rocky reef communities (Ebeling et al. 1980; Stephens et al. 1984; Larson and DeMartini 1984), and something is known of the soft substrata fishes from 18 m down to about 900 m (Fitch 1966; Mearns 1979; DeMartini and Allen 1984; Cross[1]). There are no published studies on fish assemblages from the shallowest (< 18 m), open-coast, soft substrata habitats. In 1982 we initiated a survey of this inshore habitat. This report describes the results of this survey from 1982 to 1984.

[1]Cross, J. MS. Fishes of the upper continental shelf off southern California.

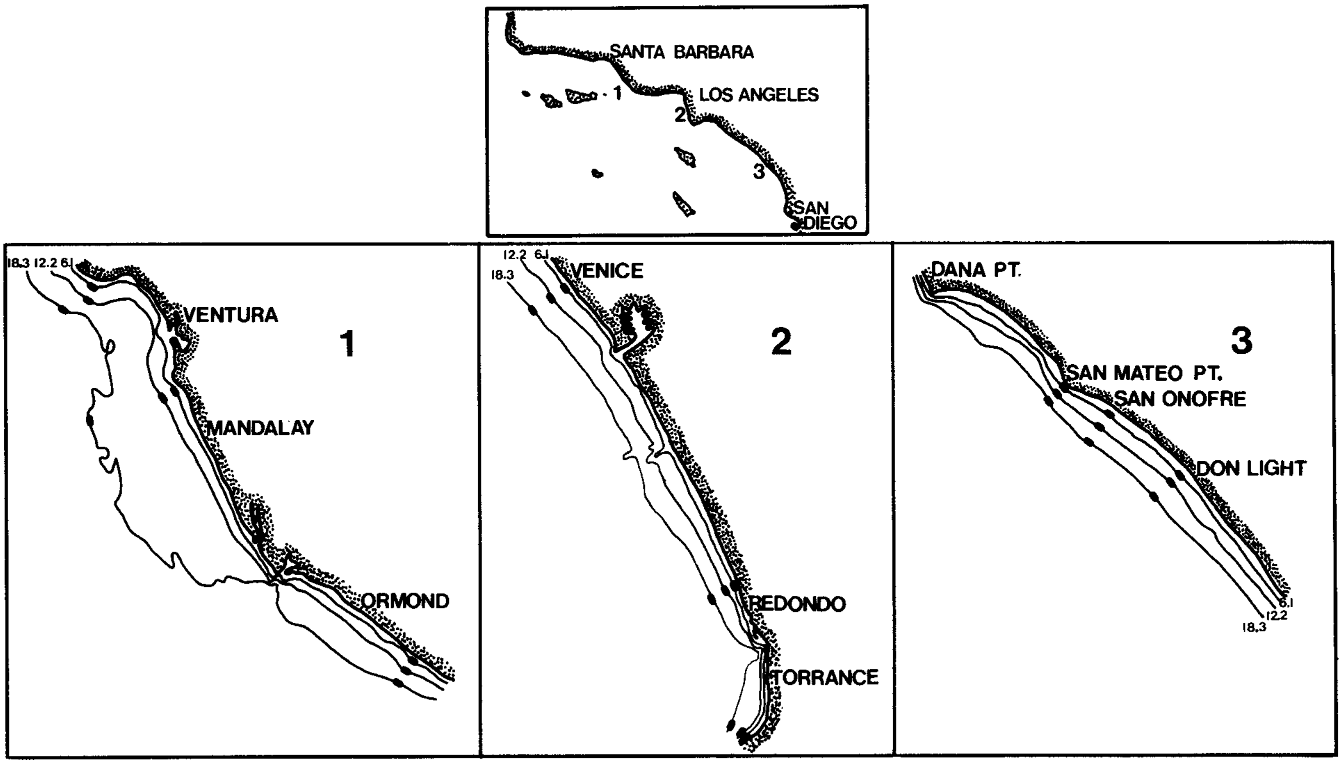

Figure 1. Location of trawling sites within the Southern California Bight. Sampling was conducted in three areas: *1*, Ormond; *2*, Redondo; *3*, San Onofre. Dark ovals indicate the stations—three each along the 6.1-, 12.2-, and 18.3-m isobaths in each area.

METHODS

Sampling was conducted bimonthly from February 1982 to December 1984 off three areas—designated San Onofre, Redondo, and Ormond (Figure 1). Within each area were trawling stations—three each along the 6.1-, 12.2-, and 18.3-m isobaths (Figure 1). In the San Onofre area the stations were San Mateo Point, San Onofre, and Don Light; in the Redondo area they were Torrance, Redondo, and Venice; and in the Ormond area they were Ormond, Mandalay, and Ventura. Table 1 gives precise locations of these stations. Because the study focused on area rather than station, we grouped our results by area. Throughout the paper the word *location* is used interchangeably with *area*.

Each survey consisted of two replicate trawls per day, for two successive days, at each depth and station. As an example, during the February 1982 survey, we made four trawls at 18.3 m off San Mateo Point over two days, two trawls per day. Sampling was conducted during daylight hours with a 7.6-m semiballoon otter trawl towed at two knots for five minutes. Trawls were made along an isobath parallel to shore, in an upcoast direction. All fishes collected were identified (based on Miller and Lea 1972), counted, and measured (standard length).

We used the index of community importance (ICI; Stephens and Zerba 1981) to estimate each species' contribution to its assemblage. ICIs were determined

TABLE 1
Latitude and Longitude of Trawling Stations within the Southern California Bight

Area	Station	Depth (m)	Latitude (N)	Longitude (W)
Ormond	Ventura	6.1	34°16.20′	119°18.34′
		12.2	34°16.03′	119°18.50′
		18.3	34°15.70′	119°18.74′
	Mandalay	6.1	34°13.16′	119°15.72′
		12.2	34°13.18′	119°16.20′
		18.3	13°13.19′	119°17.43′
	Ormond	6.1	34°06.87′	119°09.41′
		12.2	34°06.73′	119°09.61′
		18.3	34°06.30′	119°09.99′
Redondo	Venice	6.1	33°58.64′	118°28.20′
		12.2	33°58.40′	118°28.82′
		18.3	33°58.25′	118°29.24′
	Redondo	6.1	33°51.89′	118°24.39′
		12.2	33°51.76′	118°24.79′
		18.3	33°51.81′	118°24.95′
	Torrance	6.1	33°49.79′	118°23.56′
		12.2	33°49.90′	118°23.72′
		18.3	33°49.43′	118°24.44′
San Onofre	San Mateo	6.1	33°23.50′	117°25.11′
		12.2	33°23.20′	117°36.70′
		18.3	33°22.96′	117°37.13′
	San Onofre	6.1	33°21.19′	117°32.71′
		12.2	33°20.47′	117°34.34′
		18.3	33°21.09′	117°34.01′
	Don Light	6.1	33°19.21′	117°30.43′
		12.2	33°18.83′	117°30.95′
		18.3	33°18.35′	117°31.52′

in the following way. For each assemblage, species were ranked by percent abundance and percent frequency of occurrence. For each species, the two ranks were summed, and the species were reranked based on that sum. The respective ICIs were the sum of the two ranks. We compared the top ten species from each assemblage with Kendall's coefficient of concordance and Kendall's tau coefficient (Siegel 1956).

We tested whether there was an overall seasonal abundance pattern by using a crossed analysis of variance, performed on the log-transformed data for fish abundance (raw count + 1) (Afifi and Azen 1979). Fixed model was assumed with main effects being location, year, and season, with season nested within year. Type III sum of squares was used so that comparison of main effects could be made even in the presence of interactions (Freund and Littell 1981).

Using all data, we noted large interactions, which implied that there was no overall seasonal pattern. We then performed the analysis on three key species—*Engraulis mordax*, *Genyonemus lineatus*, and *Seriphus politus*—and on the rest of the species combined (predominantly various flatfish). In order to take an unbiased approach, we further separated the analyses by water depth (young-of-the-year and 1+ yr fish) and season: winter (December and February) and nonwinter (April, June, August, and October).

We determined fish recruitment patterns (by area, season, and depth) by ascertaining the geometric mean abundance per trawl of small (less than 5 cm SL) individuals by month over the three years. Six species, ranked highest on the ICI, were abundant enough to analyze. Similarly, we wished to exemplify the relative year-class strengths of important species over our three-year study. We selected 12 species and computed the geometric mean abundance per trawl per species, this time of young-of-the-year fishes. Concurrently, we analyzed the abundances of fishes older than one year and plotted this on the same figure.

RESULTS

Species Composition

6.1 m. Midwater, actively swimming species (mainly croakers—Sciaenidae; seaperches—Embiotocidae; and anchovies—Engraulidae) dominated the shallowest isobath and constituted most of the top ten ICI species (Table 2). In all, 82 species and 104,564 individuals were captured.

Queenfish (*Seriphus politus*) had the highest ICI ranking, followed by white croaker (*Genyonemus lineatus*) and northern anchovy (*Engraulis mordax*). These three species composed 86.9% of all fish captured on the 6.1-m isobath. However, *E. mordax*, though taken in high numbers, was encountered in about one-third of all trawls, far less often than *S. politus* or *G. lineatus*. When *E. mordax* was captured, it was often found in large numbers, as many as 7,000 per trawl. Both walleye seaperch (*Hyperprosopon argenteum*) and California halibut (*Paralichthys californicus*), though taken in comparatively low numbers, were caught with greater frequency.

12.2 m. Compared to 6.1 m, slightly more species (87) but far fewer individuals (53,594) were captured along the 12.2-m isobath (Table 3). Some midwater species, particularly *S. politus* and *G. lineatus*, were again very important constituents of this assemblage. However, benthic fishes (flatfishes and the California lizardfish, *Synodus lucioceps*) gained in importance among the top ten ICI species.

Seriphus politus and *G. lineatus* composed 76.8% of all fish taken. However, *S. politus* was not the overwhelmingly dominant species, as it had been in 6.1 m. Here it was the most abundant species (though only about half as many fish were taken as were taken in 6.1 m), but it was encountered less often than along the shallower isobath (44.5% vs 66.6% of all trawls). *G. lineatus* occurred with about the same frequency as in the shallow depth, with somewhat greater abundance. Greatly increasing in frequency of occurrence and abundance over 6.1 m, the specklefin sanddab (*Citharichthys stigmaeus*) was an important member of this assemblage, having the same ICI as the former two species.

18.3 m. Fewest species (80) and lowest total abundance (39,178) occurred along the 18.3-m isobath (Table 4). Flatfishes, continuing the trend begun in 12.2 m, were the group most common among the top ten ICI species; six of the ten were flatfishes. Overall, midwater fishes declined in both abundance and frequency of occurrence.

Citharichthys stigmaeus, ranked first on the ICI, occurred in 64.1% of all trawls, though its percent abundance (7.2%) was nowhere near that of *Genyonemus lineatus*. *G. lineatus* was the most abundant species, constituting 43.4% of all fishes taken, though its frequency of occurrence dropped from what it had been at the 12.2-m stations (33.2% vs 51.6% of all trawls). *Paralichthys californicus*, though not as abundant as six other species, ranked third on the ICI because of its high frequency of occurrence (54.3%). *Seriphus politus*, second in total abundance (19.4%), was nonetheless far less abundant or frequently taken along this isobath than in shallower waters. A number of species (*S. lucioceps*; hornyhead turbot, *Pleuronichthys verticalis*; spotted turbot, *P. ritteri*; fantail sole, *Xystreurys liolepis*; and California tonguefish, *Symphurus atricauda*) that were uncommon in 6.1 m

TABLE 2
Composition of Trawl Catches in 6.1 m, off Three Areas in the Southern California Bight, 1982-84

Species	Numbers	Percent number	Percent frequency of occurrence	ICI	Species	Numbers	Percent number	Percent frequency of occurrence	ICI
Seriphus politus	48,610	46.49	66.5	2.0	*Heterodontus francisci*	10	0.01	1.5	90.5
Genyonemus lineatus	11,528	11.02	52.3	5.0	*Rhacochilus toxotes*	11	0.01	1.2	91.5
Engraulis mordax	30,702	29.36	34.3	7.0	Scianidae juveniles (unident.)	400	0.38	0.1	91.5
Hyperprosopon argenteum	2,257	2.16	39.5	8.0	*Squatina californica*	11	0.01	1.1	94.0
Paralichthys californicus	949	0.91	41.0	9.0	*Anisotremus davidsonii*	12	0.01	0.7	95.5
Amphistichus argenteus	768	0.73	32.3	15.0	*Mustelus henlei*	9	0.01	1.4	95.5
Phanerodon furcatus	867	0.83	24.9	15.0	*Hypsurus caryi*	9	0.01	0.9	101.5
Citharichthys stigmaeus	657	0.63	27.2	17.0	*Leptocottus armatus*	8	0.01	1.1	103.0
Anchoa compressa	2,084	1.99	12.3	19.0	*Pleuronichthys coenosus*	8	0.01	1.1	103.0
Menticirrhus undulatus	497	0.48	23.9	22.0	*Symphurus atricauda*	7	0.01	1.1	104.5
Peprilus simillimus	810	0.77	9.7	23.0	*Atherinops affinis*	9	0.01	0.6	105.0
Umbrina roncador	516	0.49	14.6	23.0	*Scomber japonicus*	9	0.01	0.6	105.0
Syngnathus leptorhynchus	394	0.38	18.9	26.0	*Paralabrax maculatofasciatus*	9	0.01	0.4	110.5
Cymatogaster aggregata	537	0.51	9.6	27.0	*Sebastes auriculatus*	4	<0.01	0.6	115.0
Pleuronichthys ritteri	213	0.20	14.5	31.5	*Squalus acanthias*	4	<0.01	0.6	115.0
Platyrhinoidis triseriata	158	0.15	14.5	32.5	*Oxyjulis californica*	9	0.01	0.3	116.5
Sphyraena argentea	343	0.33	9.4	34.5	*Gibbonsia elegans*	5	<0.01	0.4	117.5
Synodus lucioceps	255	0.24	8.8	38.0	*Stereolepis gigas*	5	<0.01	0.4	117.5
Rhinobatos productus	139	0.13	9.4	38.5	*Chromis punctipinnis*	4	<0.01	0.4	120.5
Paralabrax nebulifer	113	0.11	9.3	43.0	*Scorpaena guttata*	4	<0.01	0.4	120.5
Heterostichus rostratus	123	0.12	7.1	45.5	*Mustelus californicus*	3	<0.01	0.4	123.5
Urolophus halleri	106	0.10	7.5	47.0	*Porichthys myriaster*	3	<0.01	0.4	123.5
Embiotoca jacksoni	90	0.09	7.1	50.5	*Halichoeres semicinctus*	2	<0.01	0.3	134.0
Etrumeus teres	425	0.41	2.2	52.0	*Parophrys vetulus*	2	<0.01	0.3	134.0
Cheilotrema saturnum	107	0.10	4.4	54.0	*Raja binoculata*	2	<0.01	0.3	134.0
Roncador stearnsii	135	0.13	3.4	55.0	*Scorpaenichthys marmoratus*	2	<0.01	0.3	134.0
Cynoscion nobilis	57	0.05	5.6	56.0	*Chilara taylori*	2	<0.01	0.1	144.5
Syngnathus californiensis	72	0.07	5.0	57.0	*Citharichthys sordidus*	2	<0.01	0.1	144.5
Xystreurys liolepis	45	0.04	5.6	57.0	*Porichthys notatus*	2	<0.01	0.1	144.5
Myliobatis californica	40	0.04	5.6	58.0	*Amphistichus koelzi*	1	<0.01	0.1	154.0
Sardinops sagax	104	0.10	3.1	61.0	*Glyptocephalus zachirus*	1	<0.01	0.1	154.0
Otophidium scrippsi	62	0.06	3.9	61.5	*Gobiesox rhessodon*	1	<0.01	0.1	154.0
Hysopsetta guttulata	34	0.03	4.2	65.0	*Gymnura marmorata*	1	<0.01	0.1	154.0
Atherinopsis californiensis	35	0.03	3.9	65.5	*Hypsoblennius gentilis*	1	<0.01	0.1	154.0
Paralabrax clathratus	31	0.03	3.0	71.0	*Hypsoblennius gilberti*	1	<0.01	0.1	154.0
Xenistius californiensis	22	0.02	2.6	73.5	*Icelinus quadriseriatus*	1	<0.01	0.1	154.0
Trachurus symmetricus	22	0.02	2.3	74.5	*Leuresthes tenuis*	1	<0.01	0.1	154.0
Rhacochilus vacca	17	0.02	2.0	79.0	*Platichthys stellatus*	1	<0.01	0.1	154.0
Micrometrus minimus	19	0.02	1.8	79.5	*Raja inornata*	1	<0.01	0.1	154.0
Brachyistius frenatus	15	0.01	1.8	82.0	*Sebastes rastrelliger*	1	<0.01	0.1	154.0
Pleuronichthys verticalis	15	0.01	1.7	83.5	*Sebastes serranoides*	1	<0.01	0.1	154.0
Triakis semifasciata	12	0.01	1.5	87.0	Nothing retrieved		5.36		
					Total	104,564			

and 12.2 m were more abundant and more frequently encountered in 18.3 m.

Rank correlation tests between assemblages indicate a high degree of similarity between adjacent depths (6.1 vs 12.1, 12.1 vs 18.3 m), but little similarity between 6.1 and 18.3 m (Table 5). The tau coefficient showed close to zero relationship between the 6.1 and 18.3-m depths. Between 6.1 and 18.3 m, only five species were held in common among the top ten in ICI (*C. stigmaeus*, *G. lineatus*, *P. californicus*, *S. politus*, and *E. mordax*). Of these, only *G. lineatus*, *P. californicus*, and *S. politus* were found in the top five at both depths. As Table 6 indicates, there is not a significant relationship in the assemblages by depth. In general, there was a shift with depth from actively swimming, schooling species to benthic, solitary forms. Associated with this decline in schooling species was a decrease in the number of fish taken.

Kendall's coefficient of concordance was computed to determine whether the top ten species were the same for each of the years. It is obvious from Table 6 that the fish assemblages were similar to each other over the

TABLE 3
Composition of Trawl Catches in 12.1 m, off Three Areas in the Southern California Bight, 1982-84

Species	Numbers	Percent number	Percent frequency of occurrence	ICI	Species	Numbers	Percent number	Percent frequency of occurrence	ICI
Citharichthys stigmaeus	1,727	3.2	57.4	5.0	*Heterodontus francisci*	11	<0.1	1.4	94.0
Genyonemus lineatus	15,255	28.5	51.6	5.0	*Cynoscion nobilis*	9	<0.1	1.1	97.5
Seriphus politus	25,900	48.3	44.5	5.0	*Citharichthys sordidus*	10	<0.1	0.8	103.0
Paralichthys californicus	960	1.8	57.1	8.0	*Sebastes auriculatus*	7	<0.1	0.9	103.0
Phanerodon furcatus	1,428	2.7	29.7	11.0	*Mustelus henlei*	6	<0.1	0.9	106.0
Engraulis mordax	2,703	5.0	21.4	12.0	*Sebastes miniatus*	6	<0.1	0.9	106.0
Pleuronichthys ritteri	409	0.8	31.2	14.0	*Stereolepis gigas*	6	<0.1	0.9	106.0
Hyperprosopon argenteum	574	1.1	22.3	15.0	*Porichthys myriaster*	7	<0.1	0.8	106.5
Synodus lucioceps	855	1.6	19.9	17.0	*Etrumeus teres*	31	0.1	0.3	112.0
Xystreurys liolepis	290	0.5	22.2	20.0	*Roncador stearnsii*	5	<0.1	0.8	113.0
Heterostichus rostratus	303	0.6	16.9	24.0	*Raja inornata*	6	<0.1	0.6	114.0
Paralabrax nebulifer	281	0.5	19.1	24.0	*Parophrys vetulus*	8	<0.1	0.5	115.5
Pleuronichthys verticalis	201	0.4	18.8	27.0	*Atherinopsis californiensis*	5	<0.1	0.6	117.5
Peprilus simillimus	306	0.6	8.9	29.0	*Paralabrax maculatofasciatus*	5	<0.1	0.6	117.5
Plathyrhinoidis triseriata	150	0.3	16.3	31.0	Sciaenidae juveniles (unident.)	39	0.1	0.2	119.0
Cymatogaster aggregata	240	0.4	9.0	31.5	*Gymnura marmorata*	4	<0.1	0.6	121.5
Syngnathus leptorhynchus	109	0.2	10.8	34.5	*Sardinops sagax*	4	<0.1	0.6	121.5
Rhinobatos productus	97	0.2	10.8	36.5	*Squatina californica*	4	<0.1	0.6	121.5
Menticirrhus undulatus	103	0.2	9.0	37.5	*Scorpaenichthys marmoratus*	4	<0.1	0.5	127.5
Embiotoca jacksoni	90	0.2	7.0	44.5	*Semicossyphus pulchrum*	4	<0.1	0.5	127.5
Amphistichus argenteus	77	0.1	7.8	46.0	*Atherinops affinis*	3	<0.1	0.5	133.0
Hypsopsetta guttulata	63	0.1	8.7	49.0	*Hyperprosopon anale*	3	<0.1	0.5	133.0
Symphurus atricauda	85	0.2	6.0	49.0	*Leptocottus armatus*	3	<0.1	0.5	133.0
Halichoeres semicinctus	85	0.2	5.5	50.5	*Chromis punctipinnis*	3	<0.1	0.3	139.5
Scorpaena guttata	71	0.1	7.0	50.5	*Pleuronichthys decurrens*	3	<0.1	0.3	139.5
Anchoa compressa	165	0.3	3.0	53.5	*Citharichthys xanthostigma*	2	<0.1	0.3	145.5
Otophidium scrippsi	74	0.1	5.4	54.5	*Sebastes rastrelliger*	2	<0.1	0.3	145.5
Paralabrax clathratus	73	0.1	5.4	55.5	*Trachurus symmetricus*	2	<0.1	0.3	145.5
Pleuronichthys coenosus	48	0.1	6.0	58.5	*Triakis semifasciata*	2	<0.1	0.3	145.5
Xenistius californiensis	123	0.2	2.7	58.5	*Sebastes paucispinis*	3	<0.1	0.2	150.5
Myliobatis californica	45	0.1	6.3	59.0	*Chilara taylori*	2	<0.1	0.2	156.5
Syngnathus californiensis	50	0.1	4.3	61.5	*Hypsoblennius gilberti*	2	<0.1	0.2	156.5
Cheilotrema saturnum	56	0.1	3.2	65.0	*Caulolatilus princeps*	1	<0.1	0.2	165.0
Rhacochilus vacca	45	0.1	4.1	66.0	*Clupea harengus pallasii*	1	<0.1	0.2	165.0
Sphyraena argentea	50	0.1	3.2	66.5	*Gibbonsia metzi*	1	<0.1	0.2	165.0
Rhacochilus toxotes	34	0.1	3.8	72.0	*Girella nigricans*	1	<0.1	0.2	165.0
Raja binoculata	26	<0.1	3.3	76.0	*Medialuna californiensis*	1	<0.1	0.2	165.0
Hypsurus caryi	30	0.1	3.2	77.0	*Neoclinus uninotatus*	1	<0.1	0.2	165.0
Oxyjulis californica	45	0.1	2.2	78.0	*Odontopyxis trispinosa*	1	<0.1	0.2	165.0
Umbrina roncador	35	0.1	2.7	79.5	*Squalus acanthias*	1	<0.1	0.2	165.0
Urolophus halleri	21	<0.1	3.0	82.5	*Stellerina xyosterna*	1	<0.1	0.2	165.0
Brachyistius frenatus	36	0.1	1.1	85.5	*Torpedo californica*	1	<0.1	0.2	165.0
Porichthys notatus	23	<0.1	2.2	87.0	*Zalembius rosaceus*	1	<0.1	0.2	165.0
Gibbonsia elegans	17	<0.1	2.2	89.0	Nothing retrieved		2.8		
Anisotremus davidsonii	14	<0.1	1.7	92.0					
					Total	53,594			

three years. Similarly, it was found that the three areas (Ormond, Redondo, and San Onofre) were significantly similar in their fish assemblages (Table 6).

Description of Species Assemblages by and between Areas

Ormond area. Seriphus politus and *Genyonemus lineatus* were the dominant species in trawls along the three isobaths: *Seriphus* first in 6.1 m, *Genyonemus* in 12.2 and 18.3 m, (Table 7). Both species remained abundant throughout the depth ranges, *Genyonemus* increasing with depth, *Seriphus* decreasing. *Engraulis mordax*, *Paralichthys californicus*, and *Citharichthys stigmaeus* were important species at all depths. There was a gradual displacement of shallow-water species (such as *Amphistichus argenteus* and *Hyperprosopon*

TABLE 4
Composition of Trawl Catches in 18.3 m, off Three Areas in the Southern California Bight, 1982-84

Species	Numbers	Percent number	Percent frequency of occurrence	ICI
Citharichthys stigmaeus	2,830	7.2	64.1	5.0
Genyonemus lineatus	17,022	43.4	33.2	8.0
Paralichthys californicus	729	1.9	54.3	9.0
Seriphus politus	7,598	19.4	27.5	10.0
Synodus lucioceps	1,555	4.0	35.8	10.0
Pleuronichthys verticalis	651	1.7	44.6	11.0
Pleuronichthys ritteri	1,088	2.8	35.3	12.0
Xystreurys liolepis	624	1.6	39.2	13.0
Engraulis mordax	4,096	10.5	16.1	14.0
Symphurus atricauda	415	1.1	21.0	19.0
Pleuronichthys coenosus	383	1.0	18.5	21.0
Phanerodon furcatus	287	0.7	13.6	24.0
Otophidium scrippsi	212	0.5	8.5	30.0
Syngnathus leptorhynchus	110	0.3	10.4	30.0
Paralabrax nebulifer	106	0.3	10.6	31.5
Scorpaena guttata	107	0.3	8.7	33.0
Citharichthys xanthostigma	112	0.3	5.5	34.0
Peprilus simillimus	158	0.4	5.1	36.5
Hypsopsetta guttulata	62	0.2	9.3	37.0
Cymatogaster aggregata	106	0.3	5.1	41.0
Platyrhinoidis triseriata	55	0.1	7.6	41.0
Heterostichus rostratus	48	0.1	5.4	45.0
Citharichthys sordidus	72	0.2	3.3	50.0
Hippoglossina stomata	43	0.1	4.9	52.0
Porichthys notatus	69	0.2	3.0	52.5
Raja binoculata	35	0.1	5.2	53.0
Hyperprosopon argenteum	45	0.1	4.1	54.0
Pleuronichthys decurrens	46	0.1	3.6	55.0
Myliobatis californica	40	0.1	4.4	56.0
Porichthys myriaster	41	0.1	4.0	57.5
Rhinobatos productus	32	0.1	4.3	59.0
Paralabrax clathratus	41	0.1	2.2	64.5
Urolophus halleri	25	0.1	3.0	66.5
Rhacochilus toxotes	21	0.1	2.5	70.0
Menticirrhus undulatus	22	0.1	1.9	72.0
Parophrys vetulus	17	<0.1	2.4	72.5
Syngnathus californiensis	17	<0.1	1.6	75.5
Sardinops sagax	54	0.1	0.5	78.5
Icelinus quadriseriatus	14	<0.1	1.1	83.0
Sebastes miniatus	13	<0.1	1.3	83.0
Chilara taylori	16	<0.1	0.9	83.5
Heterodontus francisci	10	<0.1	1.3	84.5
Sebastes auriculatus	8	<0.1	1.1	88.0
Zalembius rosaceus	13	<0.1	0.8	90.0
Hypsurus caryi	7	<0.1	0.9	92.0
Amphistichus argenteus	8	<0.1	0.8	93.0
Brachyistius frenatus	27	0.1	0.3	94.0
Rhacochilus vacca	6	<0.1	0.8	96.5
Raja inornata	5	<0.1	0.8	98.0
Mustelus henlei	5	<0.1	0.6	102.0
Anchoa compressa	7	<0.1	0.5	103.0
Chitonotus pugetensis	4	<0.1	0.6	105.0
Squatina californica	4	<0.1	0.6	105.0
Torpedo californica	4	<0.1	0.6	105.0
Etrumeus teres	4	<0.1	0.5	109.0
Caulolatilus princeps	3	<0.1	0.5	112.0
Semicossyphus pulchrum	14	<0.1	0.2	114.0
Cheilotrema saturnum	2	<0.1	0.3	122.0
Cynoscion nobilis	2	<0.1	0.3	122.0
Embiotoca jacksoni	2	<0.1	0.3	122.0
Neoclinus uninotatus	2	<0.1	0.3	122.0
Platichthys stellatus	2	<0.1	0.3	122.0
Xenistius californiensis	2	<0.1	0.3	122.0
Sebastes dallii	3	<0.1	0.2	130.0
Zaniolepis latipinnis	2	<0.1	0.2	134.5
Chromis punctipinnis	1	<0.1	0.2	145.5
Coryphopterus nicholsii	1	<0.1	0.2	145.5
Glyptocephalus zachirus	1	<0.1	0.2	145.5
Gobiesox rhessodon	1	<0.1	0.2	145.5
Halichoeres semicinctus	1	<0.1	0.2	145.5
Hydrolagus colliei	1	<0.1	0.2	145.5
Lepidogobius lepidus	1	<0.1	0.2	145.5
Leptocottus armatus	1	<0.1	0.2	145.5
Mustelus californicus	1	<0.1	0.2	145.5
Odontopyxis trispinosa	1	<0.1	0.2	145.5
Paralabrax maculatofasciatus	1	<0.1	0.2	145.5
Scorpaenichthys marmoratus	1	<0.1	0.2	145.5
Sphyraena argentea	1	<0.1	0.2	145.5
Squalus acanthias	1	<0.1	0.2	145.5
Stereolepis gigas	1	<0.1	0.2	145.5
Nothing retrieved		0.0		
Total	3,978			

argenteum) by *Synodus lucioceps*, *Pleuronichthys verticalis*, and *Symphurus atricauda*.

Redondo area. As in the Ormond survey, *S. politus* and *G. lineatus* were the highest ranked species in 6.1 m (Table 8). *Paralichthys californicus*, *H. argenteum*, and *E. mordax* were also important. *Engraulis*, though second most abundant, was very patchy in its distribution. Most of the fish we report here were caught in a few trawls that captured thousands of individuals.

In contrast to the Ormond area, *S. politus* and *G. lineatus*, though important species in 6.1 m, were not dominant through all depths (Table 8). In 12.2 m, *C. stigmaeus* joined *G. lineatus* as the highest ranked on the ICI, though *Seriphus*, ranked fourth, was still most abundant. Flatfish dominated 18.3 m, with six species among the top ten. *C. stigmaeus* was again ranked first, though *Pleuronichthys ritteri* was taken with greater frequency (86.2%). In fact at Redondo in 18.3 m, *P. ritteri* was taken with the greatest frequency of any species at any area in our study. *Paralichthys californicus*, *Pleuronichthys coenosus*, and *S. lucioceps* were also important species. *Seriphus* and *Genyo-*

TABLE 5
Comparisons of Species Rankings (Using the Index of Community Importance) between Depths, All Areas and Years Combined

Depth vs Depth		Kendall's tau	P
6.1	12.2	0.372	0.002*
6.1	18.3	0.069	0.604
12.2	18.3	0.421	0.0002*

*Significant at $P \leq 0.5$

nemus were near or at the bottom of the top ten species. *Seriphus*, while still second in abundance, was infrequently (10.5) encountered.

San Onofre area. As at Ormond and Redondo, *Seriphus* and *Genyonemus* ranked first and second among species captured in 6.1 m (Table 9). *Engraulis mordax* ranked third; second in abundance (behind *Seriphus*); and was taken more consistently (40% of the trawls) than at the more northern stations. California corbina, *Menticirrhus undulatus*; deepbody anchovy, *Anchoa compressa*; and yellowfin croaker, *Umbrina roncador* (all ranked in the top ten at San Onofre) were absent from this list at Ormond and Redondo.

Citharichthys stigmaeus and *G. lineatus* tied for first ranking in 12.2 m (Table 9), though *Seriphus* was by far the most abundant. However, its frequency of occurrence declined markedly from 74.5% in 6.1 m to 39.8% in 12.2 m. *Paralichthys californicus*, as at every isobath and area, was an important constituent, and was taken in over half of the trawls (53.0%). As in 12.2 m, *C. stigmaeus* was ranked first in 18.3 m, followed by *Synodus lucioceps* and *G. lineatus*. *Genyonemus* was most abundant, though taken only about 28% of the time. As at Redondo, flatfishes (such as *P. verticalis*, *Xystruerys liolepis*, and *P. californicus*) were the most commonly taken group.

Compared to fish assemblages in 6.1 m, those of 12.2 m were somewhat more heterogenous. While *Seriphus* and *Genyonemus* continued to be dominant (both numerically and in occurrence) off Ormond, they were not as important off San Onofre and Redondo. They remained the most abundant, but were no longer the most frequently encountered species (these were *Citharichthys sordidus*, *P. californicus*, and also *P. ritteri* off Redondo).

In 18.3 m, densely aggregating, midwater fishes continued to decrease in abundance at Redondo and San Onofre. Off Redondo, *C. stigmaeus* was most abundant, and *P. ritteri* was third, close behind *Seriphus politus* (which was captured only 10.5% of the time). Off San Onofre, *G. lineatus* was taken in highest numbers, though captured in only 28.3% of the trawls. Five species *(C. stigmaeus, S. lucioceps, P.*

TABLE 6
Comparisons of the Top Ten Species (Index of Community Importance) between Locations, Years, and Depths, Using Kendall's Coefficient of Concordance

	W	K	N	X^2	DF	P	R
Location	.66	3	13	23.8	12	.022	.49
Year	.68	3	13	24.6	12	.025	.52
Depth	.50	3	15	21.1	14	.100	.25

TABLE 7
Composition of Ormond Area Trawl Catches (Top Ten Species, Based on Index of Community Importance), 1982-84

Species	Number	Percent number	Percent frequency of occurrence	ICI
6.1-m isobath				
1. *Seriphus politus*	10,088	44.2	73.6	2.0
2. *Genyonemus lineatus*	4,871	21.3	62.0	5.0
3. *Engraulis mordax*	4,883	21.4	34.6	7.0
4. *Hyperprosopon argenteum*	866	3.8	54.3	7.0
5. *Amphistichus argenteus*	498	2.1	48.6	9.0
6. *Paralichthys californicus*	125	0.5	27.4	14.0
7. *Phanerodon furcatus*	224	0.9	26.0	14.0
8. *Citharichthys stigmaeus*	122	0.5	25.4	17.0
9. *Peprilus simillimus*	304	1.3	13.4	19.0
10. *Syngnathus leptorhynchus*	92	0.4	19.2	20.0
12.2-m isobath				
1. *Genyonemus lineatus*	9,597	42.0	71.3	2.0
2. *Seriphus politus*	9,471	41.5	66.5	4.0
3. *Citharichthys stigmaeus*	419	1.8	50.4	7.0
4. *Engraulis mordax*	1,075	4.7	33.4	10.0
5. *Hyperprosopon argenteum*	351	1.5	37.8	11.0
6. *Phanerodon furcatus*	374	1.6	35.4	11.0
7. *Paralichthys californicus*	161	0.7	43.6	13.0
8. *Synodus lucioceps*	236	1.0	18.4	18.0
9. *Peprilus simillimus*	269	1.1	17.9	18.5
10. *Pleuronichthys verticalis*	91	0.4	24.7	19.0
18.3-m isobath				
1. *Genyonemus lineatus*	13,374	57.9	59.7	2.0
2. *Seriphus politus*	5,780	25.0	55.3	4.0
3. *Citharichthys stigmaeus*	940	4.0	47.5	8.0
4. *Engraulis mordax*	804	3.4	36.8	11.0
5. *Paralichthys californicus*	209	0.9	53.3	11.0
6. *Pleuronichthys verticalis*	248	1.0	51.9	11.0
7. *Symphurus atricauda*	354	1.5	41.7	12.0
8. *Synodus lucioceps*	356	1.5	27.7	13.0
9. *Otophidium scrippsi*	174	0.7	22.8	19.0
10. *Phanerodon furcatus*	125	0.5	19.4	22.0

TABLE 8
Composition of Redondo Area Trawl Catches (Top Ten Species, Based on Index of Community Importance), 1982-84

Species	Number	Percent number	Percent frequency of occurrence	ICI
6.1-m isobath				
1. *Seriphus politus*	17,393	45.9	51.4	3.0
2. *Genyonemus lineatus*	1,668	4.4	43.3	6.0
3. *Paralichthys californicus*	620	1.6	55.7	6.0
4. *Hyperprosopon argenteum*	995	2.6	35.7	9.5
5. *Engraulis mordax*	13,834	36.5	28.0	10.0
6. *Citharichthys stigmaeus*	429	1.1	35.7	11.5
7. *Phanerodon furcatus*	341	0.9	29.0	16.0
8. *Pleuronichthys ritteri*	195	0.5	37.6	16.0
9. *Sphyraena argentea*	240	0.6	13.8	21.5
10. *Paralabrax nebulifer*	82	0.2	19.5	25.0
12.2-m isobath				
1. *Citharichthys stigmaeus*	814	6.4	61.4	6.1
2. *Genyonemus lineatus*	1,613	12.7	36.6	6.0
3. *Paralichthys californicus*	550	4.3	74.2	7.0
4. *Seriphus politus*	5,724	45.3	27.6	9.0
5. *Pleuronichthys ritteri*	306	2.4	62.3	10.0
6. *Phanerodon furcatus*	669	5.3	23.3	13.0
7. *Heterostichus rostratus*	242	1.9	35.2	14.0
8. *Xystreurys liolepis*	174	1.3	33.3	16.5
9. *Synodus lucioceps*	492	3.8	20.9	17.0
10. *Paralabrax nebulifer*	174	1.3	30.4	17.5
18.3-m isobath				
1. *Citharichthys stigmaeus*	1,141	14.8	71.4	4.0
2. *Pleuronichthys ritteri*	1,032	13.4	86.1	5.0
3. *Paralichthys californicus*	356	4.6	66.1	10.0
4. *Pleuronichthys coenosus*	377	4.9	52.8	10.0
5. *Synodus lucioceps*	439	5.7	32.8	11.5
6. *Xystreurys liolepis*	286	3.7	50.4	13.0
7. *Pleuronichthys verticalis*	176	2.2	32.8	16.5
8. *Seriphus politus*	1,125	14.6	10.4	18.0
9. *Scorpaena guttata*	105	1.3	25.2	19.0
10. *Genyonemus lineatus*	265	3.4	12.3	21.5

TABLE 9
Composition of San Onofre Area Trawl Catches (Top Ten Species, Based on Index of Community Importance), 1982-84

Species	Number	Percent number	Percent frequency of occurrence	ICI
6.1-m isobath				
1. *Seriphus politus*	21,129	48.0	74.5	2.0
2. *Genyonemus lineatus*	4,989	11.3	51.8	5.0
3. *Engraulis mordax*	11,985	27.2	40.2	6.0
4. *Menticirrhus undulatus*	362	0.8	41.2	10.0
5. *Anchoa compressa*	2,070	4.7	31.9	11.0
6. *Hyperprosopon argenteum*	396	0.9	29.1	14.0
7. *Paralichthys californicus*	204	0.4	39.8	17.0
8. *Amphistichus argenteus*	183	0.4	32.8	19.0
9. *Syngnathus leptorhynchus*	272	0.6	25.0	19.0
10. *Umbrina roncador*	299	0.6	24.5	19.0
12.2-m isobath				
1. *Citharichthys stigmaeus*	494	2.7	60.1	5.0
2. *Genyonemus lineatus*	4,045	22.2	47.2	5.0
3. *Seriphus politus*	10,705	58.9	39.8	5.0
4. *Paralichthys californicus*	249	1.3	53.2	8.0
5. *Phanerodon furcatus*	385	2.1	30.5	10.0
6. *Engraulis mordax*	972	5.3	19.9	13.0
7. *Paralabrax nebulifer*	103	0.5	24.5	15.0
8. *Synodus lucioceps*	127	0.6	20.3	17.0
9. *Pleuronichthys ritteri*	78	0.4	22.6	19.0
10. *Xystreurys liolepis*	81	0.4	21.2	19.0
18.3-m isobath				
1. *Citharichthys stigmaeus*	749	8.9	72.6	5.0
2. *Synodus lucioceps*	760	9.0	46.2	6.5
3. *Genyonemus lineatus*	3,383	40.2	28.2	7.0
4. *Pleuronichthys verticalis*	227	2.7	49.0	9.0
5. *Xystreurys liolepis*	246	2.9	46.2	9.5
6. *Paralichthys californicus*	164	1.9	43.5	13.0
7. *Seriphus politus*	693	8.3	17.5	13.0
8. *Engraulis mordax*	1,624	19.3	8.7	16.0
9. *Citharichthys xanthostigma*	111	1.3	15.7	18.0
10. *Symphurus atricauda*	52	0.6	18.0	18.0

verticalis, *X. liolepis*, and *P. californicus*) were taken more frequently. *Genyonemus* and *Seriphus* were still the major species off Ormond, constituting 82.9% of all fishes taken. *Genyonemus* was captured more often in 18.3 m (57.9%) than along the shallower isobaths; *Seriphus* (25.0%) dropped in occurrence. *Paralichthys californicus*, as at every isobath and area, was among the top ten species. It did not contribute large numbers, but was usually taken in at least 50% of the trawls.

Abundance

Off San Onofre and Redondo (discounting variability in fish sizes and seasonal abundances), fishes were most abundant in 6.1 m, declining sharply in 12.2 and 18.3 m (Figure 2). In contrast, fish abundances were constant through the three isobaths off Ormond. As discussed previously, *Seriphus* and *Genyonemus lineatus* were the dominant species in 6.1 m throughout the bight, accounting for an overwhelming percentage of the total catch. Off San Onofre and Redondo, these species declined in importance with depth, and no other species replaced them in numbers. Off Ormond, croakers remained abundant at all three isobaths. However, there was a shift with depth in the relative number of *Seriphus* and *Genyonemus*. *Seriphus* was most common in 6.1 m, and *Genyonemus* in 18.3 m.

Discounting seasonal variability, abundance along

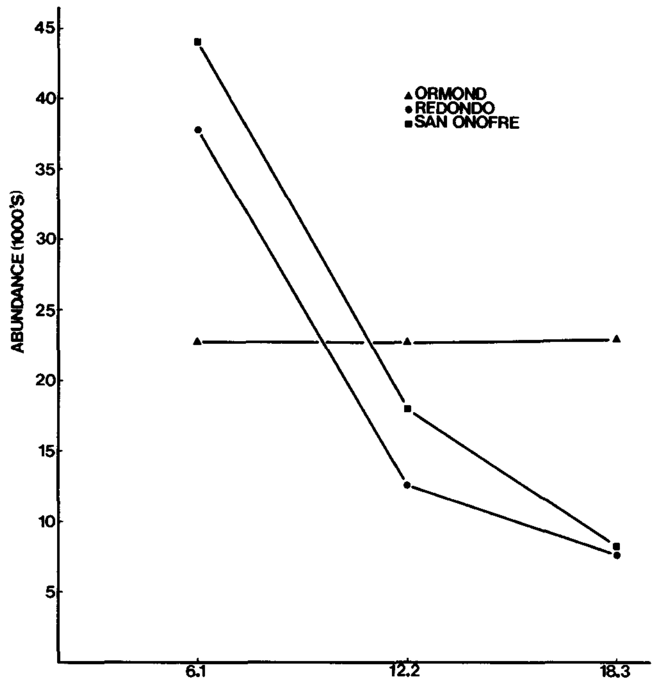

Figure 2. Abundance of fishes taken by trawl at the Ormond, Redondo, and San Onofre areas, along three isobaths—all years combined.

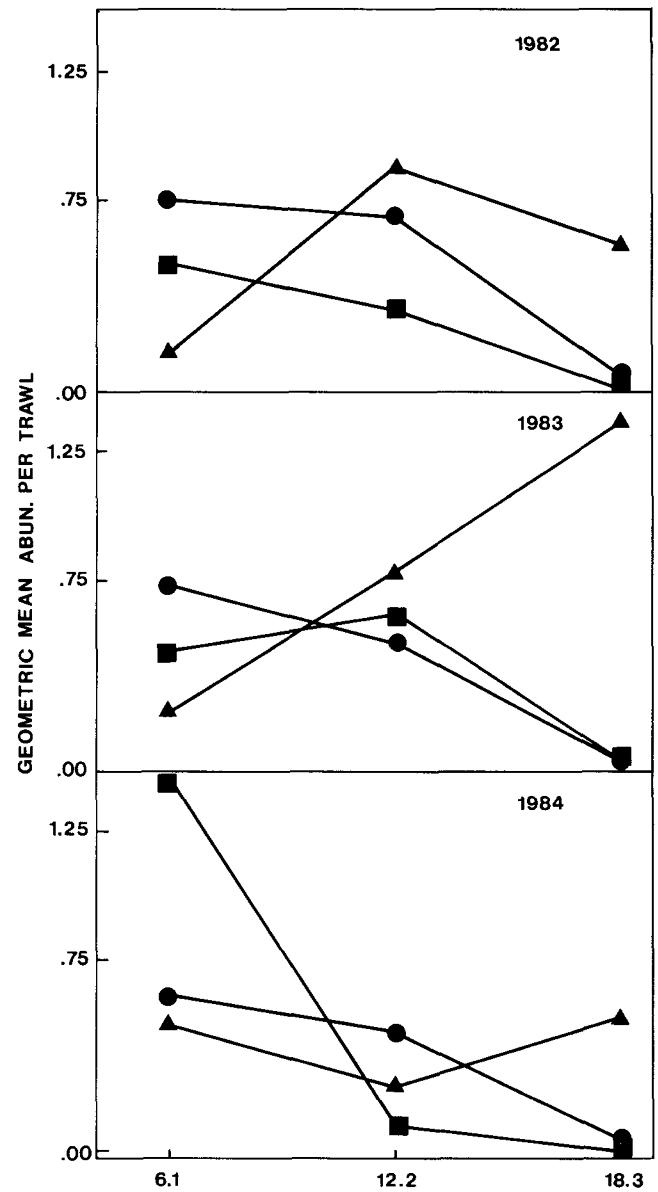

Figure 3. Yearly abundances of fishes taken by trawl, along three isobaths, all areas combined.

these isobaths varied with year and area (Figure 3). With a few exceptions, there was little consistency in these patterns. In all years, catches were highest in 12.2 and 18.3 m off Ormond. In these two depths, catches off Redondo and San Onofre tended to be similar. Overall, catches were lowest in 1984, with the exception of 6.1 m off San Onofre, where there was a strong recruitment of *S. politus*, *E. mordax*, and *G. lineatus*.

The cross-nested analysis of variance (Tables 10-13) represent the main effects—location or area (San Onofre, Redondo, Ormond), year (1982-84), and season (nonwinter, winter)—nested within year, and the amount of interactions between these effects. Interactions tend to be significant where patterns are not consistent at every level, i.e., where trends are not parallel (e.g., Figure 4, Table 10, *S. politus*, young-of-the-year, 12.2 m). Inconsistencies such as these sometimes suppress the interpretation of main effects, whereas nonsignificant interactions (e.g., Figure 4, Table 10, *S. politus*, young-of-the-year, 6.1 m) help interpret the main effects. We also performed the Duncan multiple range test (Steel and Torrie 1980) to gain better insight of the ANOVA; this test is presented in the Appendix.

Table 10 (*S. politus*, young-of-the-year, 6.1 m) indicates that all main effects are significant. At each location, *S. politus* young-of-the-year showed similarity in mean abundance within season. Generally, fewer fish inhabited these waters in winter; the fish were significantly most abundant off San Onofre (Figure 4; Appendix). By contrast, a less coherent pattern was evident with significant interactions in 12.2-and 18.3-m depths. There were some seasonal similarities for both depths, particularly off Ormond and Redondo (Figure 4; Appendix). This reverse of the 6.1-m pattern implies that young-of-the-year *S. politus* may seek the deeper isobath during winter off Ormond and Redondo. However, this was not seen for San Onofre, perhaps because of the relatively few fish taken off this location.

Seriphus politus of 1+ yrs exhibited a pattern similar to younger fish in 6.1 m; in most cases, winter lows (Figure 4; Table 10) were significantly greater in 1982 and 1984 (Appendix). Mean abundances off San

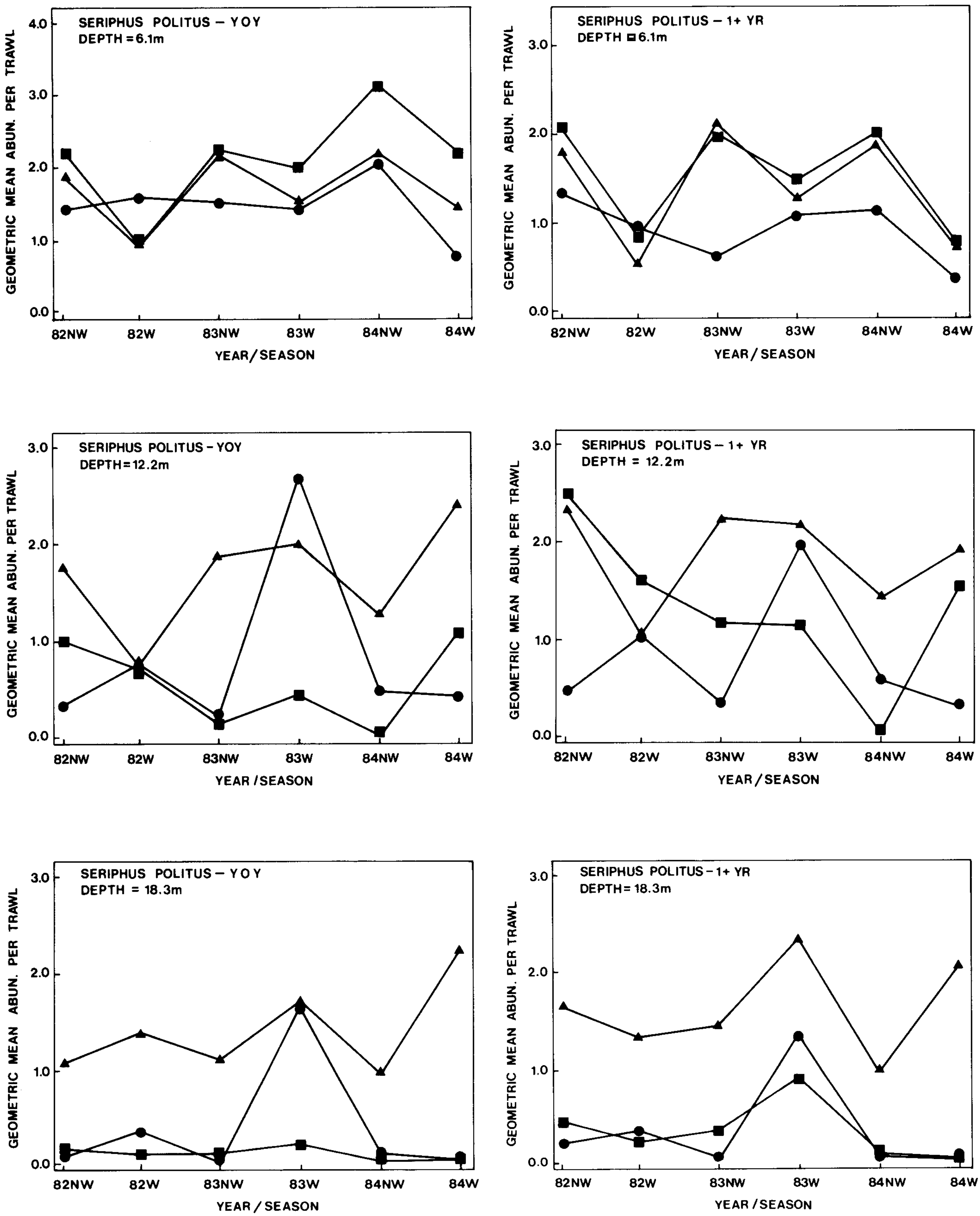

Figure 4. Catch per trawl of young-of-the-year and 1+ yr *Seriphus politus* at three areas and three depths during winter (December and February) and nonwinter (April, June, August, October) 1982-84. Squares = San Onofre, circles = Redondo, triangles = Ormond.

TABLE 10
Cross-Nested ANOVA of *Seriphus politus* (Young-of-the-Year and 1+ Yr) Log Abundance, Southern California Bight, 1982-84

	1+ yr				YOY			
Source	DF	Sum of squares	Mean square	*F* value	DF	Sum of squares	Mean square	*F* value
6.1-m depth								
Location	2	37.33		6.12 **	2	38.76		5.78 **
Year	2	6.68		1.09 NS	2	22.55		3.36 **
Season(year)	3	99.41		10.86 ****	3	72.98		7.26 ****
Location*year	4	10.58		0.87 NS	4	24.88		1.86 NS
Location*season(year)	6	23.60		1.29 NS	6	25.34		1.26 NS
Model	17	209.50	12.32	4.04 ****	17	204.90	12.05	3.59 ****
Error	616	1880.26	3.05	—	616	2065.28	3.35	—
12.2-m depth								
Location	2	102.85		18.82 ****	2	123.31		33.82 ****
Year	2	31.73		5.81 **	2	12.24		3.36 **
Season(year)	3	39.42		4.81 **	3	68.47		12.52 ****
Location*year	4	44.34		4.06 **	4	49.72		6.82 ****
Location*season(year)	6	83.45		5.09 ****	6	77.56		7.09 ****
Model	17	403.15	23.72	8.68 ****	17	339.59	19.98	10.96 ****
Error	614	1678.00	2.73	—	614	1119.20	1.82	—
18.3-m depth								
Location	2	198.79		76.40 ****	2	169.52		80.60 ****
Year	2	27.30		10.49 ****	2	7.81		3.71 **
Season(year)	3	43.88		11.24 ****	3	37.32		11.83 ****
Location*year	4	2.26		0.43 NS	4	15.24		3.62 **
Location*season(year)	6	18.11		2.32 **	6	33.96		5.38 ****
Model	17	299.28	17.60	13.53 ****	17	239.33	14.08	13.39 ****
Error	614	798.84	1.30	—	614	645.72	1.05	—

**** $P < .0001$
** $P < .05$
NS $P > .05$

Onofre and Ormond were quite similar, whereas Redondo was significantly lower. For 12.2 and 18.3 m, interactions were significant, and not too many patterns emerged (Table 10). But among years, average abundance was significantly lower for 1984 and, in 18.3 m, Ormond was considerably higher (Figure 4; Appendix).

Young-of-the-year *G. lineatus* exhibited a pattern similar to *S. politus* in 6.1 m. Again there were winter lows and nonwinter peaks, and young fish were higher in mean abundance off San Onofre (Table 11; Figure 5; Appendix). Young-of-the-year mean abundance decreased in 12.2 and 18.3 m, except off Ormond, where it was significantly higher than in the other two areas. There was no single seasonal pattern in 12.2 m, and too few fish were taken at San Onofre and Redondo in 18.3 m. However, as with *S. politus, G. lineatus* young-of-the-year had higher mean abundance in 6.1 m.

There was relatively little similarity in abundance of 1+ yr *G. lineatus* between areas over time (Figure 5). Redondo did not exhibit cycles similar to the other areas, and—as can be noted from the ANOVA (Table 11)—the interaction was significant. Mean abundance is significantly greater for Ormond and generally lower in winter (Appendix). For 12.2 m, the only pattern apparent is that Ormond has significantly higher mean abundance (Appendix). In 18.3 m, mean abundance patterns were generally similar over time, since there were no interactions (Table 11). The multiple range test yielded significance in mean abundance for winter 1983 and for Ormond. The most striking finding for *G. lineatus*, 1+ yr, is that Ormond was the highest in mean abundance at all depths and generally at all locations.

Young-of-the-year *E. mordax* exhibited similar patterns off Ormond and Redondo, generally having winter lows (Figure 6). The ANOVA showed interactions, and the multiple range test revealed that San Onofre was higher in mean abundance and that abundances in 1982 were significantly lower (Table 12, Appendix). In general, *E. mordax* increased in abundance in 1983.

For the remaining species, the ANOVA showed that, although there were interactions, the main effects were interpretable (Table 13). The strongest pattern was that for both young-of-the-year and 1+ yr fishes there were consistently lower mean abundances for the

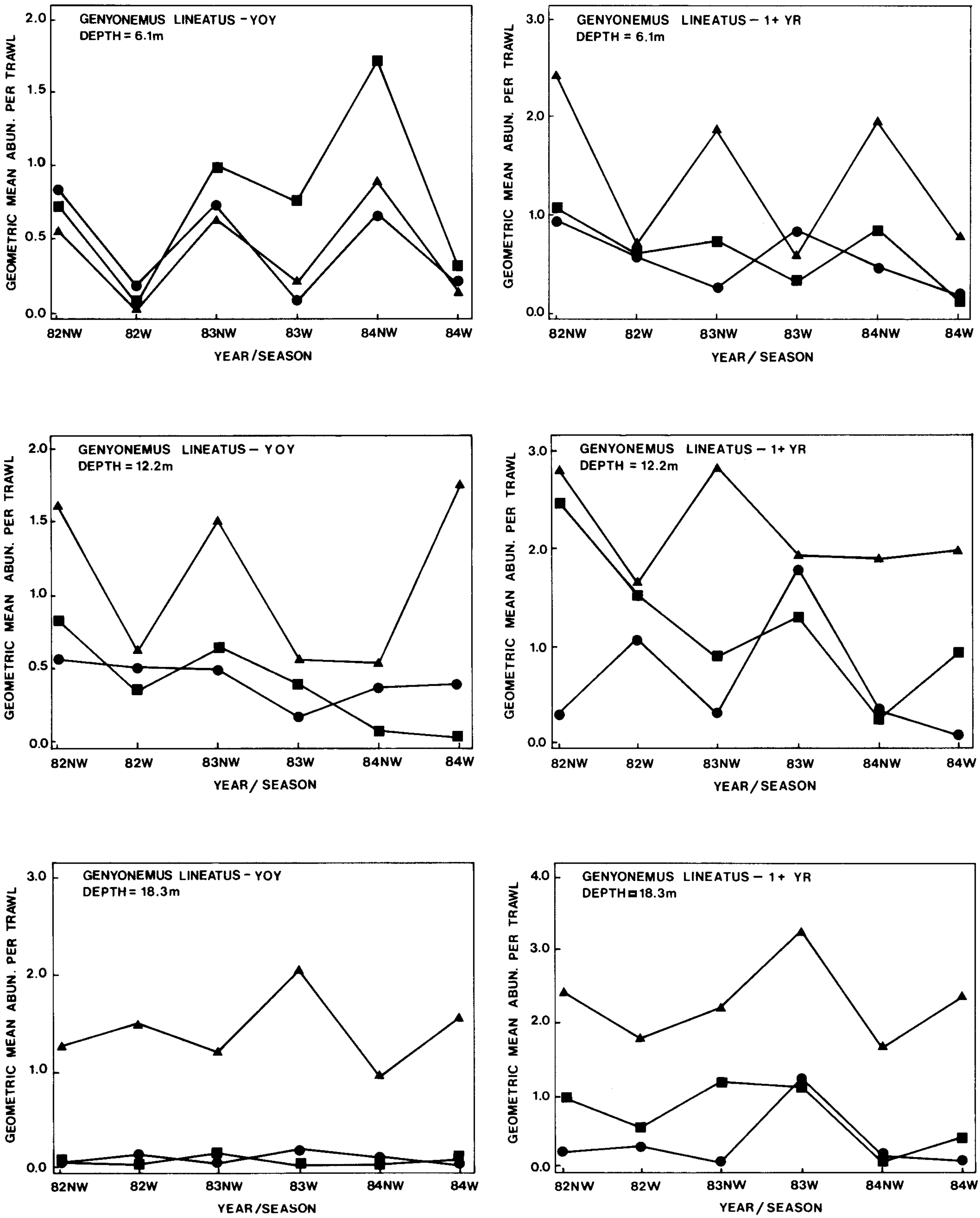

Figure 5. Catch per trawl of young-of-the-year and 1 + yr *Genyonemus lineatus* at three areas and three depths during winter (December and February) and nonwinter (April, June, August, October) 1982-84. Squares = San Onofre, circles = Redondo, triangles = Ormond.

TABLE 11
Cross-Nested ANOVA of *Genyonemus lineatus* (Young-of-the-Year and 1+ Yr) Log Abundance, Southern California Bight, 1982-84

	1+ yr				YOY			
Source	DF	Sum of squares	Mean square	*F* value	DF	Sum of squares	Mean square	*F* value
6.1-m depth								
Location	2	76.75		23.50 ****	2	13.94		5.13 **
Year	2	11.03		3.38 **	2	7.53		2.77 NS
Season(year)	3	64.09		13.08 ****	3	61.72		15.13 ****
Location*year	4	2.00		0.31 NS	4	8.73		1.60 NS
Location*season(year)	6	49.80		5.08 ****	6	8.48		1.04 NS
Model	17	275.79	16.22	9.94 ****	17	113.89	6.70	4.93 ****
Error	616	1005.79	1.63	—	616	837.70	1.36	—
12.2-m depth								
Location	2	207.83		49.36 ****	2	56.61		21.51 ****
Year	2	49.50		11.75 ****	2	3.57		1.36 NS
Season(year)	3	15.72		2.49 NS	3	30.49		7.72 ****
Location*year	4	35.54		4.22 **	4	7.49		1.42 NS
Location*season(year)	6	87.37		6.92 ****	6	24.65		3.12 **
Model	17	560.42	32.97	15.66 ****	17	139.41	8.20	6.23 ****
Error	614	1292.75	2.105	—	614	808.11	1.32	—
18.3-m depth								
Location	2	387.54		88.00 ****	2	219.00		134.88 ****
Year	2	50.63		11.50 ****	2	2.20		1.36 NS
Season(year)	3	35.14		5.32 **	3	5.76		2.36 NS
Location*year	4	4.75		0.54 NS	4	1.97		0.61 NS
Location*season(year)	6	22.25		1.68 NS	6	12.06		2.48 **
Model	17	571.07	33.59	15.26 ****	17	242.39	14.26	17.56 ****
Error	614	1352.06	2.20	—	614	498.48	0.81	—
					631	740.87		

**** $P < .0001$
** $P < .05$
NS $P > .05$

winter season throughout, and Redondo was generally higher in mean abundance (Figure 7; Appendix).

Over the three years, recruitment patterns varied little throughout the bight (Figure 8). Recruits of nine species were taken in sufficient quantity to assess recruitment patterns with depth (Figure 9). Three patterns emerged. Four species (*S. politus*, *E. mordax*, *Phanerodon furcatus*, and *Hyperprosopon argenteum*) recruited predominantly in 6.1 m. Four other species (*Citharichthys stigmaeus*, *Synodus lucioceps*, *Pleuronichthys verticalis*, *Xystreurys liolepis*) settled out

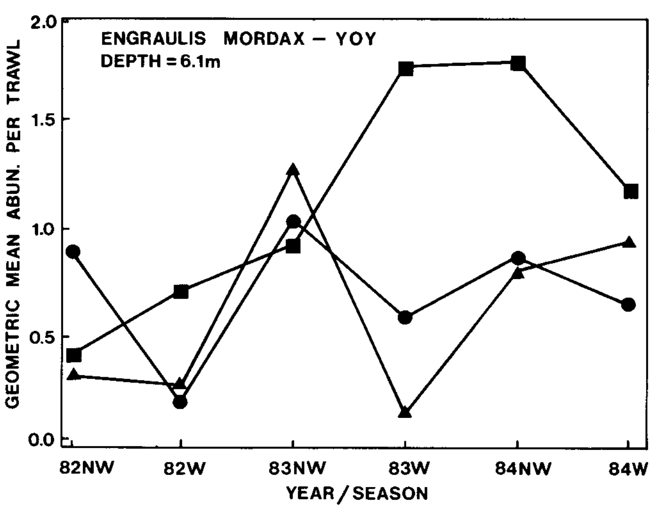

Figure 6. Catch per trawl of young-of-the-year *Engraulis mordax* at three areas and three depths during winter (December and February) and nonwinter (April, June, August, October) 1982-84. Squares = San Onofre, circles = Redondo, triangles = Ormond.

TABLE 12
Cross-Nested ANOVA of *Engraulis mordax* Young-of-the-Year Log Abundance, Southern California Bight, 1982-84

6.1-m depth Source	DF	Sum of squares	Mean square	*F* value
Location	2	27.79		5.29 **
Year	2	38.91		7.40 **
Season(year)	3	6.50		0.82 NS
Location*year	4	9.17		0.87 NS
Location*season(year)	6	45.40		2.88 **
Model	17	137.61	8.09	3.08 ****
Error	616	1618.96	2.63	

****$P<.0001$; **$P<.05$; NS $P>.05$

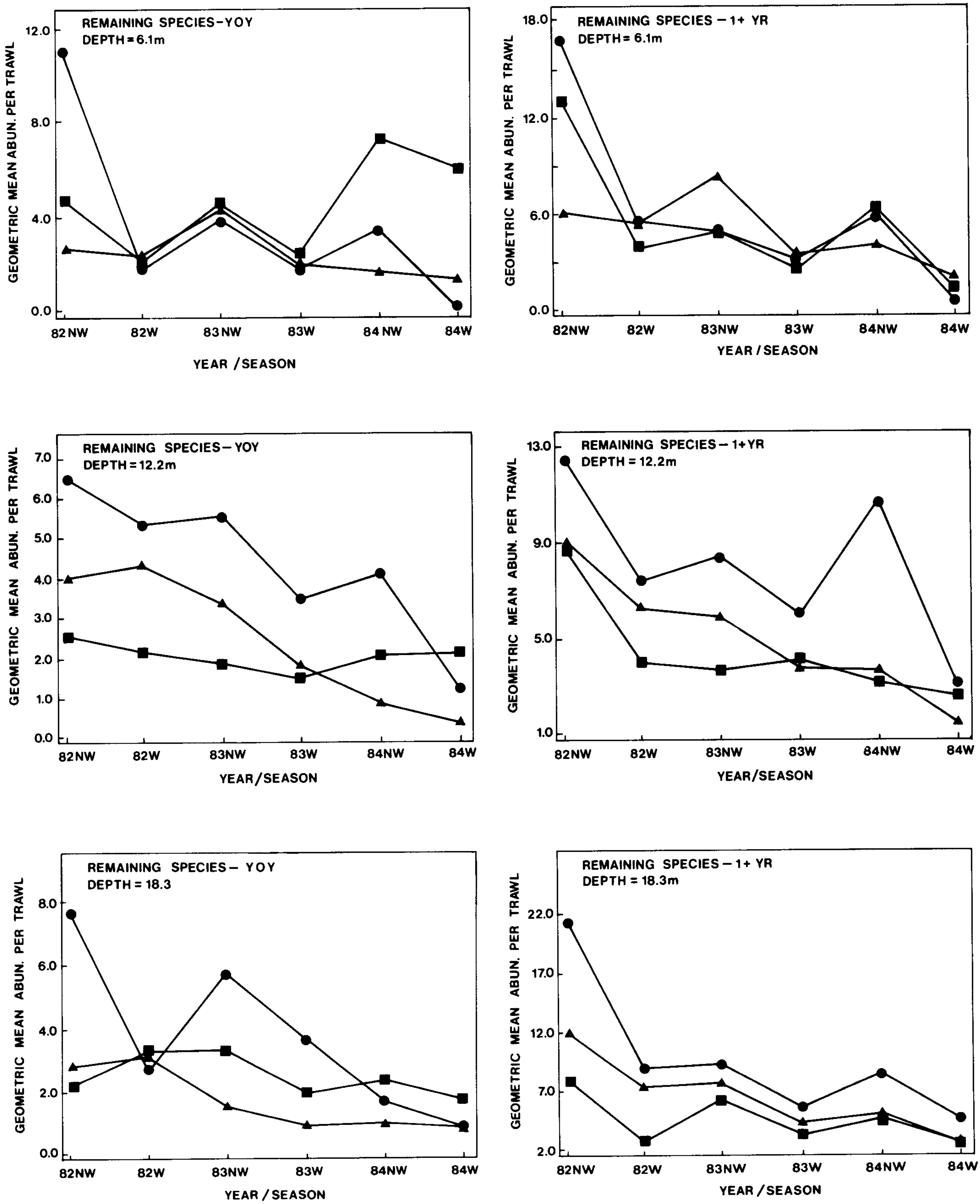

Figure 7. Catch per trawl of young-of-the-year and 1 + yr fishes (except for *Engraulis mordax*, *Genyonemus lineatus*, and *Seriphus politus*) at three areas and three depths during winter (December and February) and nonwinter (April, June, August, October) 1982-84. Squares = San Onofre, circles = Redondo, triangles = Ormond.

TABLE 13
Cross-Nested ANOVA of Young-of-the-Year and 1+ Yr (Except for *E. mordax*, *G. lineatus*, *S. politus*) Log Abundance, Southern California Bight, 1982-84

	1+ yr				YOY			
Source	DF	Sum of squares	Mean square	*F* value	DF	Sum of squares	Mean square	*F* value
6.1-m depth								
Location	2	0.12		0.06 NS	2	20.65		7.07 ****
Year	2	57.53		30.52 ****	2	4.68		1.60 NS
Season(year)	3	87.62		30.99 ****	3	52.78		12.05 ****
Location*year	4	11.98		3.18 **	4	44.79		7.67 ****
Location*season(year)	6	16.99		3.00 **	6	31.67		3.62 **
Model	17	187.49	11.03	11.70 ****	17	163.29	9.60	6.58 ****
Error	616	580.56	0.94	—	616	899.08	1.46	—
12.2-m depth								
Location	2	25.27		17.65 ****	2	29.44		15.23 ****
Year	2	38.62		26.98 ****	2	41.17		21.30 ****
Season(year)	3	30.03		13.99 ****	3	12.01		4.14 **
Location*year	4	3.90		1.36 NS	4	21.13		5.46 **
Location*season(year)	6	9.11		2.12 *	6	7.77		1.34 NS
Model	17	121.06	7.12	9.95 ****	17	118.97	7.00	7.24 ****
Error	614	439.46	0.72	—	614	593.46	0.97	—
18.3-m depth								
Location	2	31.88		23.99 ****	2	19.73		10.33 ****
Year	2	30.85		23.21 ****	2	33.19		17.38 ****
Season(year)	3	46.74		23.44 ****	3	8.60		3.00 **
Location*year	4	7.88		2.96 *	4	17.71		4.64 **
Location*season(year)	6	1.82		0.46 NS	6	13.22		2.31 **
Model	17	131.76	7.75	11.66 ****	17	111.98	6.59	6.90 ****
Error	614	408.02	0.66	—	614	586.11	0.95	—

**** $P < .0001$
** $P < .05$
NS $P > .05$

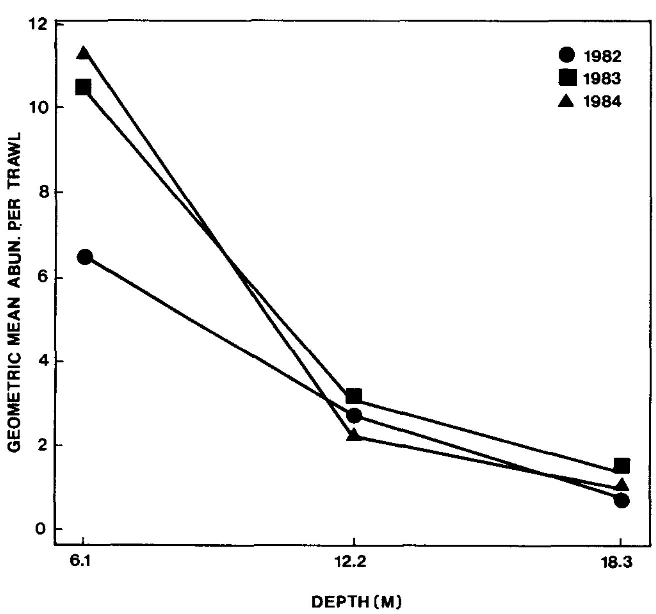

Figure 8. Abundance by depth of recruits taken by trawl, areas and months combined.

primarily in 18.3 m. *Genyonemus lineatus* recruited about equally to 6.1 and 12.2 m, declining somewhat in 18.3.

Generally, the patterns exhibited in Figures 10 and 11 accurately reflect the underlying patterns at all three areas. However, there are two exceptions—*G. lineatus* and *S. politus*. Off San Onofre and Redondo, most *G. lineatus* recruited to 6.1 and (occasionally) 12.2 m (Figure 10). Very few fish settled out in 18.3 m. Recruitment patterns off Ormond were different: here the deeper two stations were favored, with heaviest concentrations in 12.2 m (1982) and 18.3 m (1983-84). Few recruits were taken in 6.1 m in 1982-83. To a certain extent, this phenomenon held true for *S. politus*. At both San Onofre and Redondo, the bulk of recruitment occurred in 6.1 m—generally followed by steep declines in 12.2 and 18.3 m. Off Ormond, this decline was more gradual. In fact, there was no decline in abundance between 6.1 and 12.2 m in 1982 and very little between all depths in 1984.

Additionally, as noted below, there appeared to be

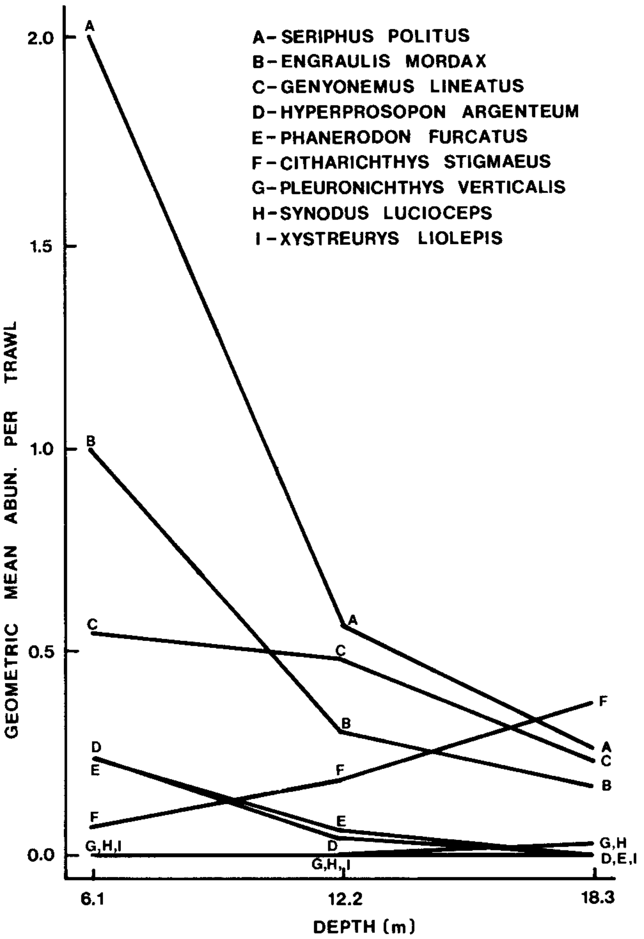

Figure 9. Recruitment depth of nine fish species taken by trawl in the Southern California Bight.

variability between areas in recruitment strength and season (based on Figure 11 only) for many of these species.

Seriphus politus. There was some fluctuation in month of peak recruitment between years. In 1982, we captured almost all small *S. politus* in August (Redondo) or October (San Onofre and Ormond). In 1983, peak catches were in August, whereas in 1984 June was highest off San Onofre and August at Redondo and Ormond. Peak catches off Ormond tended to be later than either Redondo (1982) or San Onofre (1984), or coincided with them (1983). In no year did catches peak off Ormond before the other two areas.

Genyonemus lineatus. Peak catches of small *G. lineatus* occurred between April and August, depending on area and year. In two of three years (1983-84), recruitment peaks were sequential from south to north, beginning at San Onofre, continuing at Redondo, and ending off Ormond. For 1983 and 1984, these peaks occurred in April, June, and August. In 1982, highest catches were again earliest off San Onofre, but both Redondo and Ormond peaked the following month.

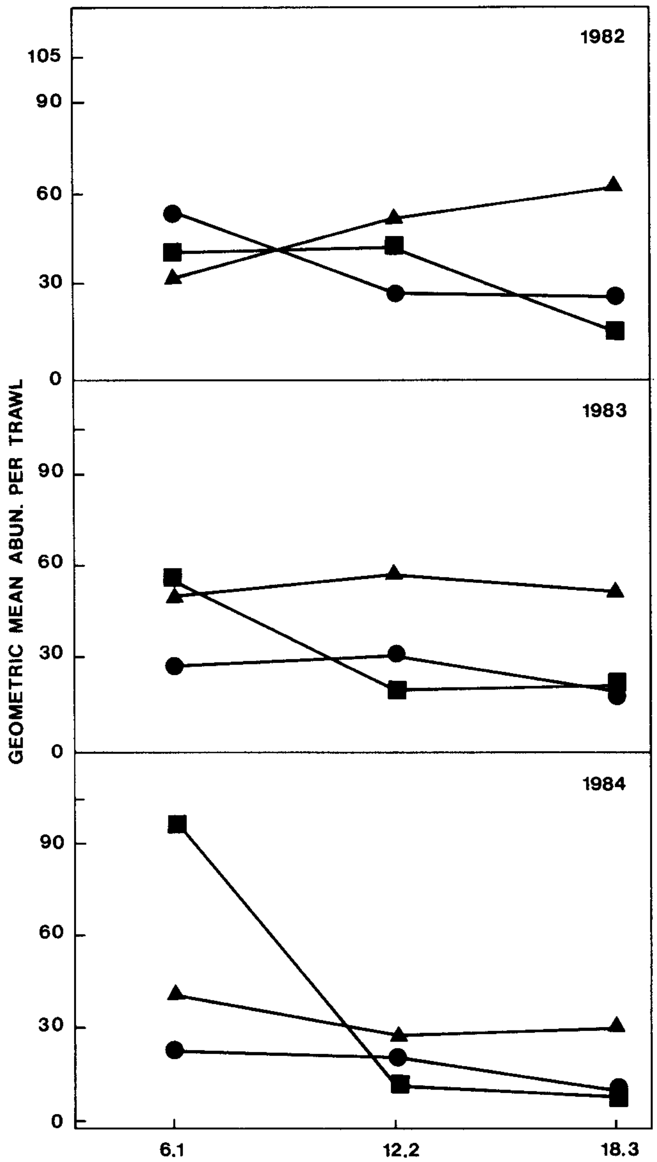

Figure 10. Yearly recruitment depth of *Genyonemus lineatus* off three areas in the Southern California Bight. Squares = San Onofre, circles = Redondo, triangles = Ormond.

Citharichthys stigmaeus. Between 1982 and 1984, most small *C. stigmaeus* were taken off Redondo. Almost all recruitment occurred between June and October. June was the peak month during 1982 and 1983, whereas August catches were highest in 1984. We captured very few small fish in 1984.

Phanerodon furcatus. In all three years *P. furcatus* recruited almost completely during June. Recruitment levels were similar in 1982 and 1983 but were reduced in 1984. No young *P. furcatus* were taken off Ormond in 1984.

Hyperprosopon argenteum. As with *P. furcatus*, recruitment of *H. argenteum* was restricted to a very few, primarily spring, months. April and June were the only

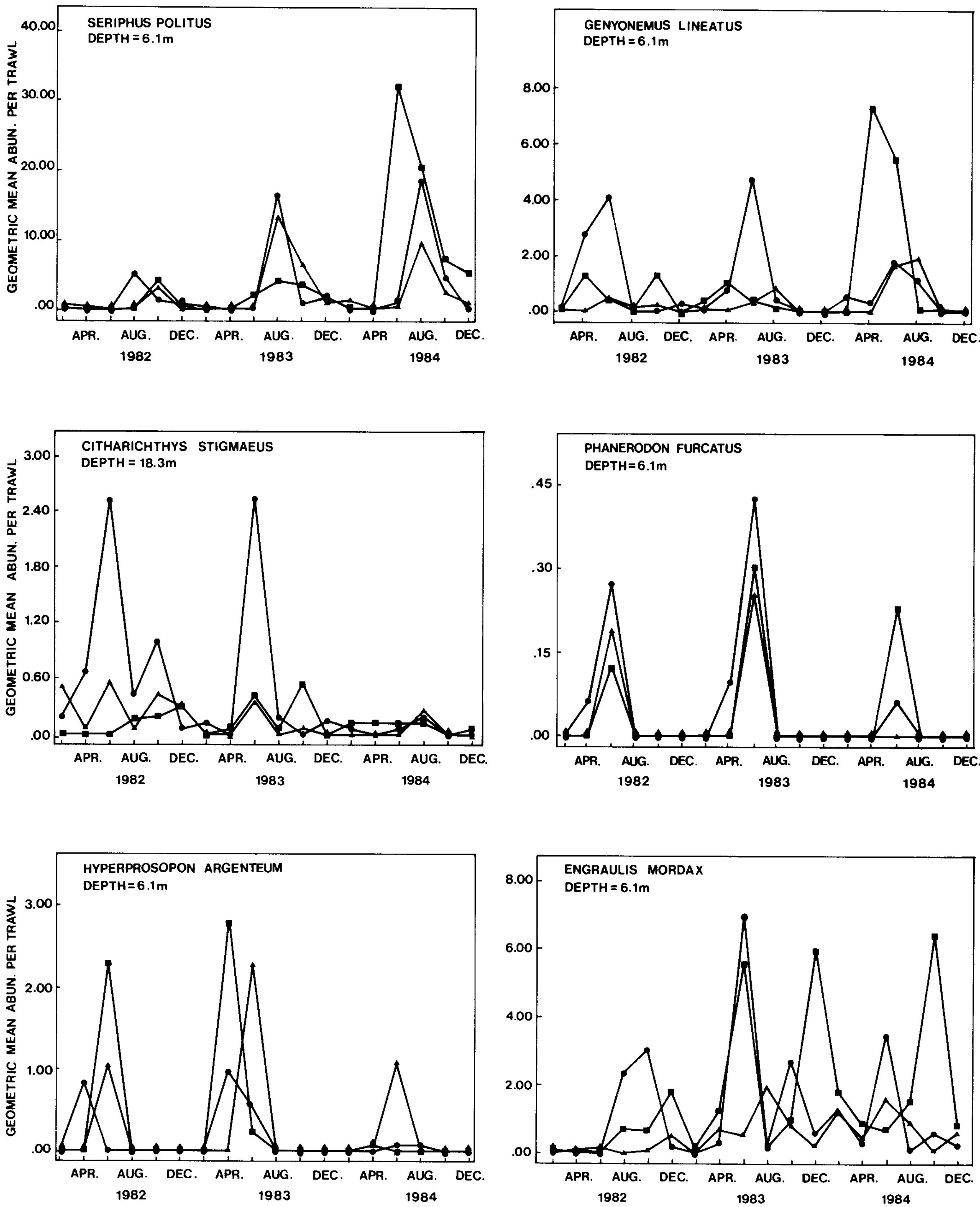

Figure 11. Recruitment strength and season at three areas in the Southern California Bight—all years combined. Depth figured is that where maximum number of recruits were taken.

months in which the youngest fish were taken. As with *P. furcatus*, recruitment was of similar levels in 1982 and 1983, but reduced in 1984. In that year we took young *H. argenteum* off Ormond only.

Engraulis mordax. We took small *E. mordax* in all seasons, though peaks varied with area and year. No single pattern was evident; however, largest catches were made between June and December.

Abundance of 1+ Year and Young-of-the-Year

Of the 12 species we examined, the majority of 1+ yr fishes declined in abundance over the three-year period (based on Figure 12 alone) or at least between 1982 and 1983. *Citharichthys stigmaeus*, *Phanerodon furcatus*, and *Synodus lucioceps* showed sequential declines in abundances from 1982 to 1984 (Figure 12). *Genyonemus lineatus*, *Seriphus politus*, and *Symphurus atricauda* increased in abundance from 1982 to 1983 but declined beginning in mid-1983. The abundance of 1+ yr *Hyperprosopon argenteum* declined gradually from 1982 to 1984. Compared to 1982, 1+ yr *Paralichthys californicus* and *Pleuronichthys verticalis* were less abundant in 1983 but seemed to increase or remain constant in 1984. *Pleuronichthys ritteri* and *Sphyraena argentea* increased in abundance between 1982 and 1984, while 1+ yr *Engraulis mordax* abundance was relatively stable. The *Engraulis* population was not sampled effectively, so this assessment may be inaccurate.

The widespread decline in 1+ yr fishes that began in 1983 was not so apparent in young-of-the-year individuals. Young-of-the-year of several species exhibited stronger first-year classes in 1983, 1984, or both. One species, *G. lineatus*, declined sequentially from 1982 to 1984. *Citharichthys stigmaeus* declined sharply between 1982 and 1983; 1984 levels were similar to 1983. *Hyperprosopon argenteum* declined in mid-1983 and remained low in 1984. The young-of-the-year of the remainder of the 12 species either increased in 1983 or 1984 or remained fairly constant.

DISCUSSION

Between 1982 and 1984, we sampled fishes living on or over the inshore soft substrata of the Southern California Bight. Our analysis indicates that the fish assemblages form a dynamic system with considerable seasonal, annual, and spatial heterogeneity.

The fish assemblages along the 6.1-m isobath are quite similar throughout the bight, dominated by the midwater schooling croakers, *Seriphus politus* and *Genyonemus lineatus*. A number of other species, such as *Engraulis mordax, Hyperprosopon argenteum*, and *Paralichthys californicus*, were common in these assemblages in all survey areas. With increasing depth, bathymetric and geographic differences in species composition occurred. Croakers decreased in importance in 12.2 and 18.3 m off San Onofre and Redondo; they were replaced by various flatfishes (notably *Citharichthys stigmaeus*, *Pleuronichthys* spp., and *Xystreurys liolepis*) and *Synodus lucioceps*. However, these species do not form the large schools characteristic of croakers; hence the total number of fish along the deeper isobaths was low when compared to 6.1 m. In contrast, croakers remained abundant off the Ormond area down to at least 18.3. *Seriphus politus* was abundant in 6.1 m, giving way to *G. lineatus* in 18.3 m. Here too, flatfishes increased their numbers with depth, but they were overshadowed by *Genyonemus*.

Not only were the 6.1-m assemblages similar at all three areas, but many of the fishes also exhibited similar seasonal fluctuations. There were considerable annual fish movements into and out of this isobath all along the Southern California Bight. In 6.1 m, we took very few fish per trawl (occasionally none) during December and February. Catches increased in April and generally peaked in summer and early fall. Most species, both motile midwater and benthic forms, declined in abundance or disappeared from our shallowest stations. It is likely that fishes moved offshore, though we are not sure into what depth. Catches of *S. politus* and *G. lineatus* increased (at least off some areas) during winter, indicating that these species had moved into the 18.3-m isobaths.

It is not completely clear why fishes would leave the shallows during winter. A plausible explanation is that they are driven out as increasing water motion, caused by winter storms, requires greater energy for keeping stations or for finding and capturing prey. It is interesting that zooplankton, the prey of some species (such as *S. politus*) increases in inshore biomass in winter (Barnett and Jahn, in press); thus diminished prey availability may not fully explain the offshore movement.

In tandem with the annual fluctuations in fish numbers along the coast was general movement of many (though not all) species out of inshore waters during 1983 and 1984. It is likely that the El Niño influx of warm water, with attendant environmental perturbations, was responsible. The El Niño phenomenon reached its peak in 1983-84: the maximum temperature anomaly (with surface waters as much as 4°C above normal) began in August 1983 and peaked in October of the same year. Coincident was a decline in total zooplankton abundance; this decline began in 1982 and intensified in June 1983 (Peterson et al. 1986). However, not all zooplankton declined. For instance, although populations of the adult mysid *Metamysidopsis elongata* decreased markedly in August 1983, a num-

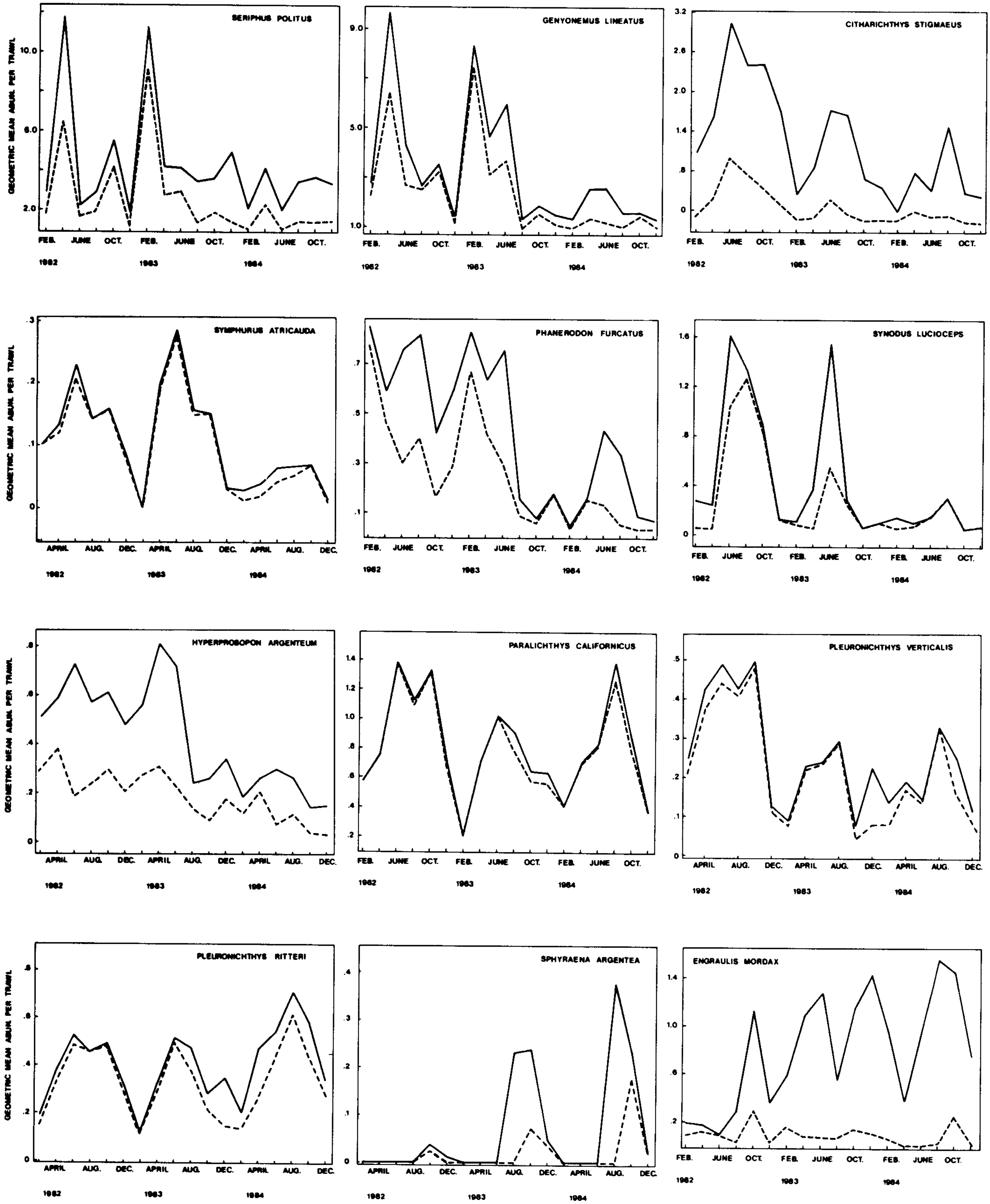

Figure 12. Monthly abundance of young-of-the year and 1+ yr fishes of 12 species, taken by trawl in the Southern California Bight. Broken lines represent abundance of 1+ yr fishes; solid lines represent abundances of both young-of-the-year and 1+ yr fishes. Thus the abundance of young-of-the-year fishes equals the distance between broken and solid lines.

ber of other species did not (A. Barnett, pers. comm.).

It does not seem reasonable to point to any one factor as decisive in this exodus. For instance, it is not clear why a 4° rise in ambient temperature would cause so many fish species to move away. Water 4° above normal is not unusually warm for some of these species and is similar to temperatures encountered in the more southerly parts of their ranges. However, it is possible that the rapid onset of peak temperatures prompted the departure.

Similarly, decreases in food availability might account for some movement, but not all. The species we examined represent a variety of predator types, including midwater planktivores, substrate-oriented microcarnivores, and piscivores. It is unlikely that the prey of all these species declined. Moreover, some fish species, such as *Pleuronichthys ritteri*, increased in abundance. If food availability alone were responsible, we would not expect to see any increases.

Regardless of the reason, it is undeniable that the abundance of older juveniles and adults of many fish species declined markedly during mid-1983. We do not believe this decline was due to die-offs. The temperatures experienced were well within physiological limits, and no die-offs (such as occasionally occur in embayments during dinoflagellate blooms) were observed.

It is more likely that fish moved to cooler conditions. Some may have traveled northward along the coast. From commercial fishery data, there is evidence that adult *Paralichthys* moved north (R. Collins, pers. comm.), because *Paralichthys* landings declined in southern California and increased substantially in central California.

Equally plausible is an offshore movement by some species. If it occurred off San Onofre and Redondo, we can be sure this movement continued into waters deeper than 18.3 m, because we observed no abundance increase in our deepest stations. We do not know how deep the fishes moved. During this period, a similar offshore migration occurred in somewhat deeper waters; E. DeMartini (pers. comm.) noted a bathymetric shift within the bight in populations of pink seaperch (*Zalembius rosaceus*) and Pacific sanddab (*Citharichthys sordidus*). Both species generally inhabit depths below those of our survey; that these species also exhibited offshore movements indicates that warming occurred to considerable depths.

Though the El Niño phenomenon drove many fishes away from the immediate coast within the bight, not all species departed. Species whose populations might have been predicted to remain stable, based on geographic range (i.e., *P. ritteri*, *Sphyraena argentea*) remained stable or increased in numbers. While increases in *P. ritteri* were due to adult movements, increases in *S. argentea* resulted from an unusually successful recruitment of young fishes.

For the species we examined, there was considerable variability among areas in recruitment season and strength. For instance, *C. stigmaeus* recruited primarily to the Redondo area; we captured few recruits off San Onofre and Ormond. At the other extreme, virtually all *Phanerodon furcatus* recruited in June at all three stations during 1982 and 1983.

For at least some species (notably *G. lineatus*), there appears to be sequential recruitment from south to north; fishes tend to settle out earliest at San Onofre, followed by Redondo and Ormond. A similar pattern may exist with the kelp bass, *Paralabrax clathratus*, a southern California reef species (M. Carr, pers. comm.).

There are several possible explanations for this phenomenon. A species may delay spawning in the northern part of the bight if conditions favorable to larval recruitment occur later in the year. Some northeast Pacific rockfishes have later spawning seasons in the northern part of their range than in the south (T. Echeverria, pers. comm.). Second, a species may spawn synchronously throughout the bight, but various factors may differentially affect the larvae. For instance, cooler waters in the northern part of the bight may extend the larval stage, leading to later recruitment. Or perhaps conditions in the north are such that only those larvae spawned late in the season survive. Lastly, recruitment may derive from larvae generated in the southern part of the bight (or even farther south). As the larvae drift north, they leave the plankton later and later. This implies that some species may not spawn in the northern part of the bight (or if they do, their offspring do not survive to recruitment). An example is the moray eel, *Gymnothorax mordax*, which does not spawn in southern California even though abundant there (McGleneghan 1973). Rather, the population is replenished through larvae drifting north from Baja California.

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APPENDIX A
Duncan's Multiple Range Test

	Seriphus politus				*Genyonemus lineatus*			
	1 + Yr		YOY		1 + Yr		YOY	
Depth	*Location*	*Log mean*	*Location*	*Log mean*	*Location*	*Log mean*	*Location*	*Log mean*
6.1m	San Onofre	1.711	San Onofre	2.242	Ormond	1.625	San Onofre	.907
	Ormond	1.595	Ormond	1.832	San Onofre	.708	Redondo	.575
	Redondo	.964	Redondo	1.537	Redondo	.543	Ormond	.524
	Year		*Year*		*Year*		*Year*	
	1983	1.494	1984	2.149	1982	1.185	1984	.846
	1982	1.431	1983	1.885	1984	.842	1983	.669
	1984	1.349	1982	1.600	1983	.827	1982	.507
	Season-year		*Season-year*		*Season-year*		*Season-year*	
	NW82	1.760	NW84	2.465	NW82	1.464	NW82	1.124
	NW84	1.685	NW83	1.994	NW84	1.084	NW83	.801
	NW83	1.583	NW82	1.835	NW83	.953	NW84	.718
	W83	1.304	W83	1.649	NW82	.627	W83	.385
	W82	.773	W84	1.473	W83	.555	W84	.251
	W84	.632	W82	1.132	W84	.326	W82	.086
Depth	*Location*	*Log mean*	*Location*	*Log mean*	*Location*	*Log mean*	*Location*	*Log mean*
12.2m	Ormond	1.915	Ormond	1.648	Ormond	2.306	Ormond	1.144
	San Onofre	1.295	Redondo	.595	San Onofre	1.224	Redondo	.460
	Redondo	.642	San Onofre	.507	Redondo	.514	San Onofre	.454
	Year		*Year*		*Year*		*Year*	
	1982	1.571	1983	1.021	1982	1.700	1982	.833
	1983	1.408	1982	.933	1983	1.446	1983	.751
	1984	.846	1984	.767	1984	.857	1984	.449
	Season-year		*Season-year*		*Season-year*		*Season-year*	
	W83	1.748	W83	1.638	NW82	1.844	NW82	1.002
	NW82	1.745	W84	1.198	W83	1.675	NW83	.905
	NW83	1.252	NW82	1.022	W82	1.412	W84	.652
	W82	1.223	W82	.755	NW83	1.341	W82	.494
	W84	1.208	NW83	.742	W84	.940	W83	.416
	NW84	.675	NW84	.564	NW84	.819	NW84	.353
Depth	*Location*	*Log mean*	*Location*	*Log mean*	*Location*	*Log mean*	*Location*	*Log mean*
18.3m	Ormond	1.526	Ormond	1.254	Ormond	2.226	Ormond	1.304
	San Onofre	.320	Redondo	.234	San Onofre	.714	Redondo	.053
	Redondo	.220	San Onofre	.097	Redondo	.211	San Onofre	.034
	Year		*Year*		*Year*		*Year*	
	1983	.896	1983	.632	1983	1.387	1983	.546
	1982	.728	1982	.494	1982	1.095	1982	.453
	1984	.410	1984	.431	1984	.627	1984	.361
	Season-year		*Season-year*		*Season-year*		*Season-year*	
	W83	1.544	W83	1.151	W83	1.928	W83	.782
	NW82	.769	W84	.624	NW82	1.205	W82	.524
	W82	.644	W82	.619	NW83	1.140	NW83	.439
	NW83	.599	NW82	.432	W82	.875	W84	.431
	W84	.556	NW83	.394	W84	.817	NW82	.418
	NW84	.340	NW84	.340	NW84	.538	NW84	.328

Means with the same bracket are not significantly different. Geometric mean = 2.7182*log mean − 1
NW = nonwinter; W = winter

APPENDIX A (continued)
Duncan's Multiple Range Test

	Remaining species				*Engraulis mordax*	
	1 + Yr		YOY		YOY	
Depth	*Location*	*Log mean*	*Location*	*Log mean*	*Location*	*Log mean*
6.1m	Redondo	1.893	San Onofre	1.710	San Onofre	1.110
	San Onofre	1.838	Redondo	1.488	Redondo	.800
	Ormond	1.815	Ormond	1.259	Ormond	.678
	Year		*Year*		*Year*	
	1982	2.250	1982	1.603	1984	1.103
	1983	1.757	1983	1.488	1983	1.020
	1984	1.524	1984	1.370	1982	.486
	Season-year		*Season-year*		*Season-year*	
	NW82	2.502	NW82	1.848	NW84	1.177
	NW83	1.928	NW83	1.653	NW83	1.100
	NW84	1.863	NW84	1.552	W84	.945
	W82	1.748	W83	1.133	W83	.847
	W83	1.391	W82	1.114	NW82	.537
	W84	.800	W84	.980	W82	.383
Depth	*Location*	*Log mean*	*Location*	*Log mean*		
12.2m	Redondo	2.241	Redondo	1.686		
	Ormond	1.820	Ormond	1.194		
	San Onofre	1.685	San Onofre	1.111		
	Year		*Year*			
	1982	2.244	1982	1.608		
	1983	1.846	1983	1.348		
	1984	1.637	1984	1.019		
	Season-year		*Season-year*			
	NW82	2.410	NW82	1.636		
	W82	1.910	W82	1.551		
	NW83	1.910	NW83	1.460		
	NW84	1.827	NW84	1.138		
	W83	1.704	W83	1.103		
	W84	1.233	W84	.767		
Depth	*Location*	*Log mean*	*Location*	*Log mean*		
18.3m	Redondo	2.384	Redondo	1.514		
	Ormond	2.052	San Onofre	1.252		
	San Onofre	1.791	Ormond	.989		
	Year		*Year*			
	1982	2.397	1982	1.494		
	1983	2.005	1983	1.327		
	1984	1.804	1984	.926		
	Season-year		*Season-year*			
	NW82	2.636	NW82	1.545		
	NW83	2.165	NW83	1.449		
	NW84	1.962	W82	1.393		
	W82	1.918	W83	1.062		
	W83	1.654	NW84	.994		
	W84	1.470	W84	.781		

Means with the same bracket are not significantly different. Geometric mean = 2.7182*log mean − 1
NW = nonwinter; W = winter