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CHAPTER 6

Surf Zone, Coastal Pelagic Zone, and Harbors

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Introduction

The nearshore zone off the Californias includes a number of other unique, primarily soft-bottom habitats. This expansive area spans the exposed, sandy beaches to the water column above the inner shelf along the entire coastline of California and south into Baja California. The fishes common to this area typically occur over the shallower portions of the shelf (see chapter 7) and the soft bottom surrounding rock reef and kelp bed environments (see chapter 8). The fish assemblages of this area tie all of the shallow water habitats closely together (Allen, 1985). In this chapter, three of the more distinctive fish assemblages within this general area will be discussed: (1) fishes of the **surf zone** and **adjacent drift algal** habitat, (2) the **coastal pelagic fishes** that occupy the water column above the shallow soft bottom and shelf, and (3) fishes of the numerous **harbors** that have been formed by breakwater construction within this general zone.

Surf Zone and Adjacent Drift Algal Beds

The fishes living in the surf zone must contend with one of the most turbulent environments in the sea. Wave action, tidal exchange, and long-shore currents produce a high energy environment, which should require correspondingly high energy expenditure by the fishes just to maintain position (Romer, 1990; Clark, 1997). On the other hand, the surf zone is an interface between the sea and land and receives nutrient and detrital input from both (Robertson and Lenanton, 1984). The productivity from this flux supports large populations of small invertebrates, which are repeatedly uncovered by the shifting sands of the surf. Thus the surf zone can support surprisingly large populations of relatively few species on both a diel and seasonal basis (McFarland, 1963; Naughton and Saloman, 1978; Modde and Ross, 1981, Ross et al. 1987, Santos and Nash, 1995) and provides nursery habitat for a number of coastal fish species throughout the world (Modde, 1980; Lenanton et al, 1982; Ruple, 1984; Lasiak, 1986; Senta and Kinoshita, 1985, Harris and Cyrus, 1996; Beyst et al., 1999; Suda et al., 2002).

Worldwide, exposed beaches are occupied by the following types of fishes: (1) small, active planktivores; (2) roving substratum feeders; (3) benthic flatfishes; (4) migratory species; (5) beach spawners; and (6) piscivores (Moyle and Cech, 2000). Most species in the surf also occur in other coastal habitats, and a few species occur primarily in the surf. Small, silvery, streamlined planktivores, including silversides (Atherinidae and Atherinopsidae), anchovies (Engraulidae), and herrings (Clupeidae) are often the most abundant fishes that occupy surf zones. Croakers (Sciaenidae) represent roving substratum feeders, particularly those of the genus *Menticirrhus* known as kingfish (Atlantic and Gulf of Mexico) or corbina (Pacific). Many species of croakers, including members of the genus *Menticirrhus*, possess sensitive chin barbels for detecting prey in the substratum. Fishes of this genus lack swimbladders as adults as an adaptation for living in these turbulent environments (Eschmeyer et al, 1983). Flataegs can also minimize the effect of turbulence. Both flatfishes (pleuronectiforms) and rays (rajiforms) are suited for living in the surf and are well represented in this habitat in many parts of the world (McFarland, 1963; Robertson and Lenanton, 1984; Ross et al., 1987; Romer, 1990; Santos and Nash, 1995; Clark, 1997; Beyst et al., 1999). Many migratory species are found in the surf zone seasonally. Mullets (Mugilidae) whose large schools are often observed from shore throughout the warmer waters of the world are probably the best documented among the migratory species (Thomson, 1955; Chubb et al., 1981; Cech and Wohlschlag, 1982; Funicelli et al., 1989). Beach spawners are not common, but various species of silversides (Atherinopsidae), smelts (Osmeridae; Schaefer, 1936; Hart and McHugh. 1944), and some puffers (Tetraodontidae; Yamahira, 1997) deposit eggs either on or in the sand at or above the water line. The best known examples of beach spawners are the California and gulf grunion (*Leuresthes tenuis* and *L. sardina*) of the northeastern Pacific Ocean (Walker, 1952; Thomson and Muench, 1976). Finally, the large numbers of small forage fishes that occupy the surf zone throughout the world attract many piscivorous fishes. The best known examples of large piscivores entering the surf to feed as evidenced by surf fisheries are bluefish (*Pomatomus saltatrix*; Buckel et al., 1999), striped bass (*Morone*

TABLE 6-1

Relative Abundance of Fishes Collected by Beach Seine Along Orange and San Diego County Coasts

Common Name	*Scientific Name*	*Aliso Beach*	*Enlisted Man's Beach*	*San Onofre Beach*
Walleye surfperch	*Hyperprosopon argenteum*	33.7	11.6	37.2
California grunion	*Leuresthes tenuis*	14.6	39.2	13.8
Topsmelt	*Atherinops affinis*	6.7	10.5	19.7
Barred surfperch	*Amphisticus argenteus*	18.1	6.1	10.1
California corbina	*Menticirrhus undulatus*	16.9	3.1	4.2
Spotfin croaker	*Roncador stearnsii*	0.7	9	3.7
Queenfish	*Seriphus politus*	2	4.4	4.3
Yellowfin croaker	*Umbrina roncador*	2.1	3.5	2
Dwarf perch	*Micrometrus minimus*	0.3	3.9	1.5
Jacksmelt	*Atherinopsis californiensis*	1.7	1.6	0.1
Northern anchovy	*Engraulis mordax*	1.3	1.6	0.1
Round stingray	*Urolophus halleri*	0.3	1.5	0.2
Deepbody anchovy	*Anchoa compressa*		0.8	0.3
Kelp pipefish	*Syngnathus californiensis*		0.9	0.2
White seaperch	*Phanerodon furcatus*		0.5	0.4
Pacific sardine	*Sardinops sagax*	0.9		
White croaker	*Genyonemus lineatus*		0.7	
Giant kelpfish	*Heterostichus rostratus*		0.4	
Opaleye	*Girella nigricans*		0.1	0.3
Bat ray	*Myliobatis californica*		0.4	
Rock wrasse	*Halichoeres semicinctus*			0.4
Leopard shark	*Triakis semifasciata*		0.1	0.3
Calico surfperch	*Amphisticus koelzi*		0.2	0.2
Gray smoothhound	*Mustelus californicus*		0.1	0.2
Black perch	*Embiotoca jacksoni*			0.3
California barracuda	*Sphyraena argentea*			0.2

NOTE: Ranked by mean abundance. Collected at three stations along the open coast of southern Orange County and northern San Diego County between approx. 33° 21′ N; 117° 33′ W and 33 ° 12′ N; 117° 24′ (after Tetra Tech 1977).

saxatilus; Settler et al., 1980; Carmichael et al., 1998), sea trout (*Cynoscion* spp.; Moflett, 1961; Ditty et al., 1991), red drum (*Sciaenops ocellatus*; Mercer, 1984), and jacks (Carangidae; Thompson and Munro, 1974; Saloman, and Naughton, 1984) on the Atlantic and Gulf coasts of North America.

In California, the surf zone along sandy beaches is a major habitat. Sandy beaches make up approximately 57% of the coastline north of Pacific Transition Conception and almost 82% of the mainland coastline from Pacific Transition Conception south to the Mexican border (see chapter 1, this volume). Despite this, the fish assemblages of the surf zone have not received a great deal of attention in California mainly because it is a very difficult place to sample effectively. The turbulent environment of the surf zone presents problems to the fish, and it also makes seining difficult to impossible at times. The most consistent, and comprehensive study of this environment in California waters was carried out by Carlisle et al. (1960) during a 44-month period (February 1953 to September 1956) in conjunction with life-history studies on barred surfperch for the California Department of Fish and Game. This study included data from 451 beach seine hauls of various lengths at 11 locations from Carpinteria near Santa Barbara south to San Diego. Unfortunately, the original catch records from this monumental sampling effort were discarded; thus, a detailed analysis of the data is no longer possible. Nevertheless, Carlisle et al. (1960) reported more than 70 species of fish from the seine hauls. The top 10 species in order of abundance were northern anchovy (*Engraulis mordax*), queenfish (*Seriphus politus*), barred surfperch (*Amphisticus argenteus*), walleye surfperch (*Hyperprosopon argenteum*), shiner perch (*Cymatogaster aggregata*), topsmelt (*Atherinops affinis*), staghorn sculpin (*Leptocottus armatus*), white croaker (*Genyonemus lineatus*), California corbina (*Menticirrhus undulatus*), and deepbody anchovy (*Anchoa compressa*). However, Carlisle's summary table pooled the catch from beach seine hauls from the exposed coast with some from bays and estuaries which overemphasized the relative abundance of some species (e.g., Pacific staghorn sculpin) in the surf zone. Allen (1985) incorporated Carlisle's data along with more recent seine data from surf zone habitat in Orange and San Diego counties (table 6-1) and identified a distinct group of fishes that characterized the open coast environment. This group included barred surfperch, walleye surfperch, California grunion (*Leuresthes tenuis*), and three species of croakers, California corbina, spotfin croaker (*Roncador stearnsi*), and yellowfin croaker (*Umbrina roncador*) (fig. 6-1). The surf zone is the primary habitat for only two of these species, barred surfperch and California corbina. Not surprisingly, both have long been the primary target of surf anglers in Southern California for many years (Joseph, 1962).

Based on existing studies, the surf zone of southern California can be characterized as numerically dominated by silversides (topsmelt and jacksmelt, *Atherinopsis californiensis*), anchovies (northern anchovy), juvenile queenfish (a croaker), and walleye surfperch that represent small planktivores.

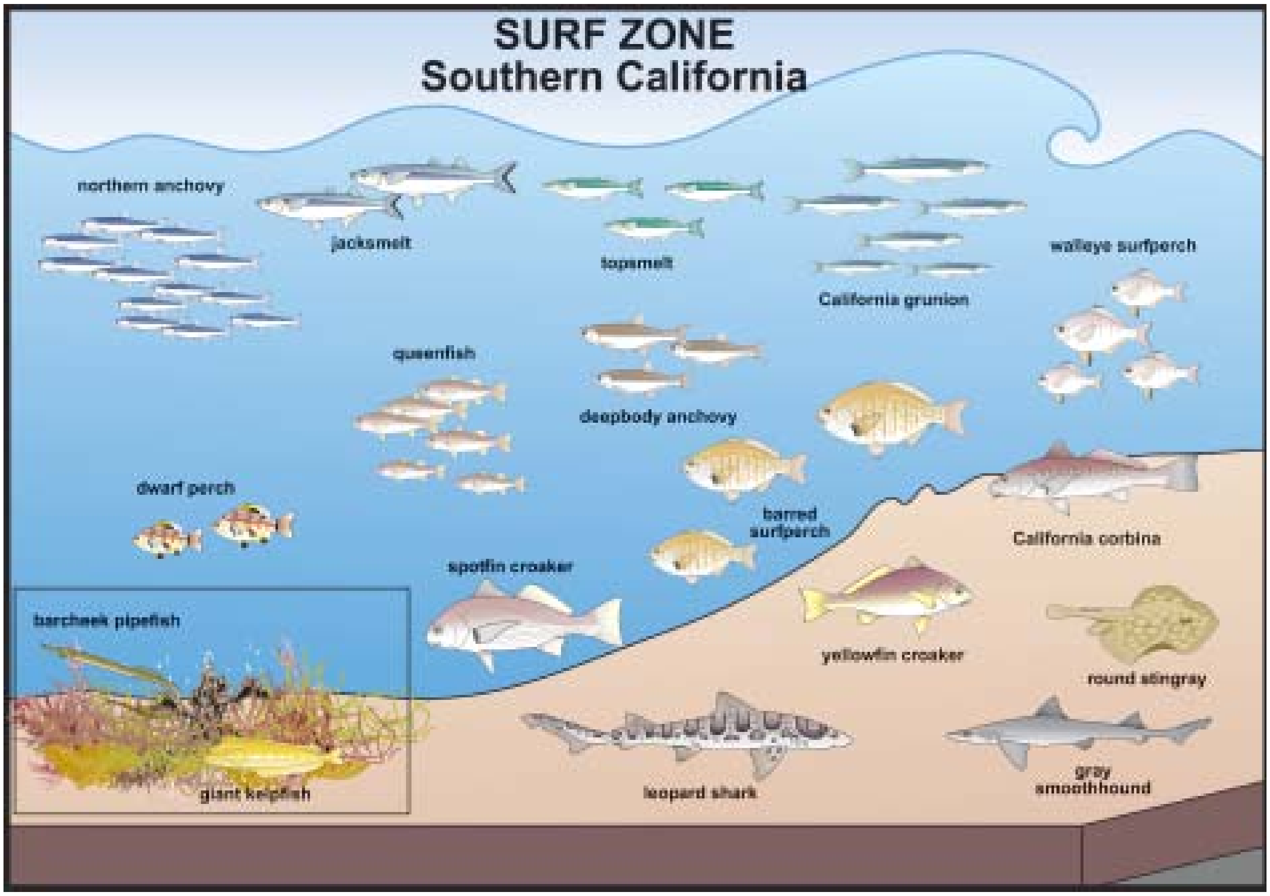

FIGURE 6-1 Common fish species of the surf zone in Southern California (see figure 6-3 for an enlargement of drift algal associates).

Queenfish and walleye surfperch are nocturnal planktivores that inhabit the surf zone during the day (Hobson and Chess, 1976). The three species of croaker, including the California representative of the genus *Menticirrhus,* the California corbina, qualify as roving substrate feeders along with barred surfperch, leopard shark (*Triakis semifasciata*), and gray smoothhound (*Mustelus californicus*)(Carlisle et al., 1960; Joseph, 1962; Russo, 1975, Talent, 1982; Haeseker and Cech, 1993, Webber and Cech. 1998). Round stingrays (*Urobatis halleri*) are the most common "flatfish" in the southern California surf zone, although spotted turbot (*Pleuronichthys ritteri*) also frequent this area. California grunion represents the surf spawner group. The piscivorous species that frequent the surf zone in California waters are not well documented but undoubtedly include two species of commercially important fishes, white seabass (*Atractoscion nobilis*—actually a croaker) and California halibut (*Paralichthys californicus*). Both are large, mobile, predatory fishes that frequent the surf zone in southern California seasonally (Pondella and Allen 1999) and have, historically been targeted there by both commercial and recreational fishers (Thomas, 1968; M. J. Allen 1990).

Recently, Mulligan and Mulligan (in prep) found that the surf zone of northern California is numerically dominated by true smelts (e.g., surf smelt, *Hypomesus pretiosus* and night smelt, *Spirinchus starksi),* silversides (topsmelt), and surfperches (shiner perch and calico surfperch, *Amphisticus koelzi*) (fig. 6-2). Furthermore, the overwhelming majority (92%) of all individuals captured in the surf zone at two sites in Trinidad Bay were juveniles (table 6-2). This investigation also identified a number of species that were closely associated with the mixed algal and debris mats that are common in this northern surf zone. These algal-associated species included a number of cryptically colored fishes that occur more frequently in shallow rocky habitats, including striped seaperch (*Embiotoca lateralis*), black rockfish (*Sebastes melanops*), slimy snailfish (*Liparis mucosus*), pricklebreast poacher (*Stellerina xyosterna*), bay pipefish (*Syngnathus leptorhynchus*), cabezon (*Scorpaenichthys marmoratus*), silverspotted sculpin (*Blepsias cirrhosus*), and penpoint gunnel (*Apodichthys flavidus*).

Drift algae has been recognized as an important component of the surf zone in other parts of the world (Robertson and Lenanton, 1984; Romer, 1990) but was largely overlooked in California for many years. This important nursery area was largely unstudied until the 1980s when the search for the nursery grounds for the two commercially important species, the white seabass and California halibut was undertaken within the southern California Bight (Allen, 1988; Allen and Franklin, 1988; 1992; Allen and Herbinson, 1990). Beam trawl studies identified the beds of drift algae adjacent to the surf line as the primary settlement areas for white seabass during the summer months. The cryptic coloration of settling juveniles is particularly well suited for this habitat by providing necessary camouflage (fig. 6-3). These surveys (Allen et al, 1990) and those conducted by Kramer (1990, 1991) and Allen and Herbinson (1990) in the southern portion of the Bight also concluded that in certain, protected areas (e.g., Malaga Cove north of the Palos Verdes Peninsula), this subhabitat consti-

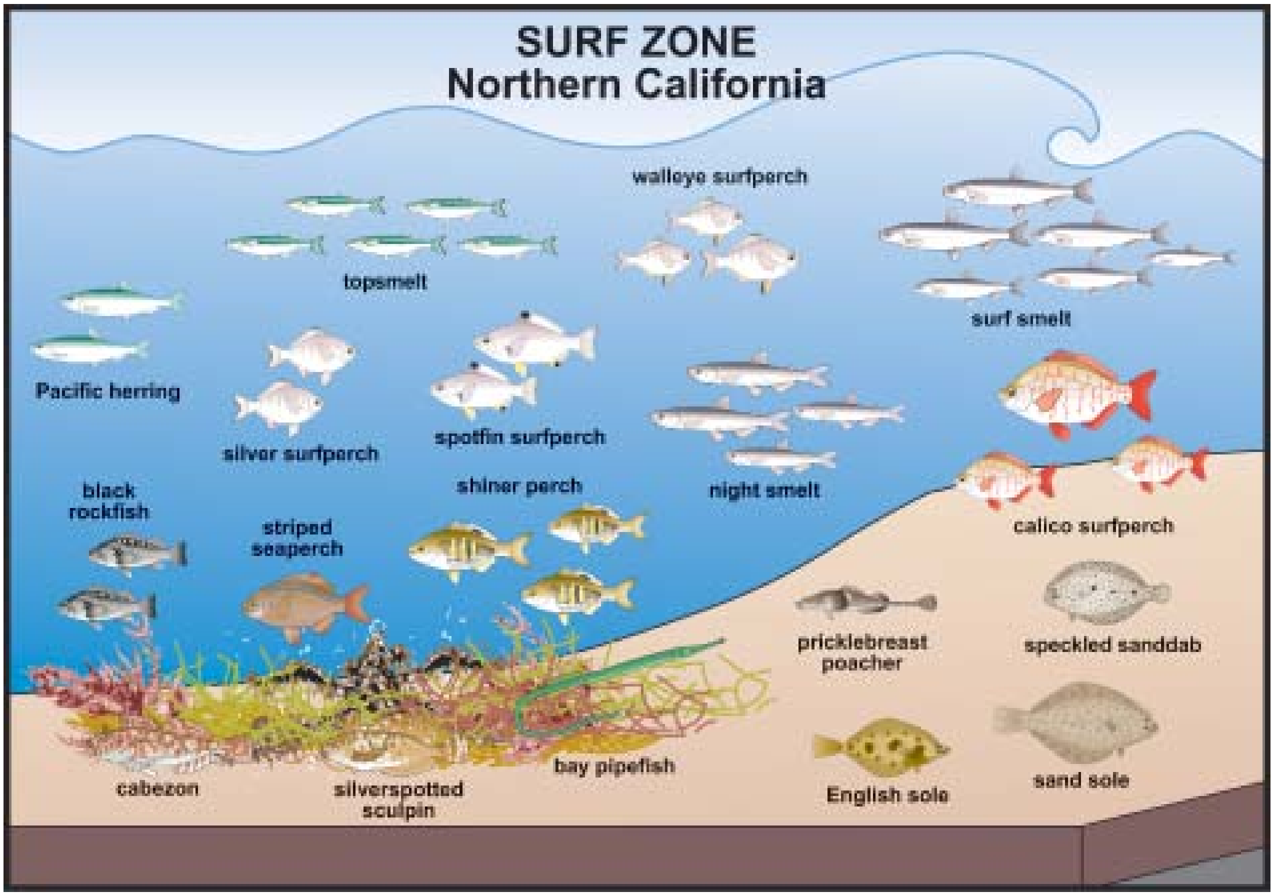

FIGURE 6-2 Common fish species of the surf zone in Trinidad Bay, northern California (after Mulligan and Mulligan, in prep).

tuted an important secondary settlement area along the open coast for California halibut, which settle primarily in bays and estuaries (see chapter 5). Similarly, the juveniles of an important recreational species, kelp bass (*Paralabrax clathratus*), also recruit to these southern drift beds (Cordes and Allen, 1997) during the summer months. Although kelp bass settle out primarily in kelp beds, drift beds probably attract a significant proportion of recruiting kelp bass because these beds occur over extensive stretches of the exposed coastline.

Furthermore, an assessment of the other fishes captured in these beam trawl surveys indicated that algal beds also are nursery areas for many species of coastal marine fishes. Most species captured in these surveys were represented solely by juveniles (table 6-3). In central California, juveniles of seven species of surfperches (barred, spotfin (*Hyperprosopon anale*), black (*Embiotoca jacksoni*), shiner, white (*Phanerodon furcatus*), rainbow (*Hypsurus caryi*), and dwarf (*Micrometrus minimus*); Embiotocidae), four species of rockfishes (copper, *Sebastes caurinus*; brown, *S. auriculatus*; black, and grass, *S. rastrelliger*; Scorpaenidae), giant kelpfish (*Heterostichus rostratus*), English sole (*Pleuronectes vetulus*), and cabezon were also commonly encountered in drift algal beds.

Southern California drift algal beds harbored the juveniles of six species of surfperches (barred and walleye surfperch, white and rainbow seaperch, and dwarf and black perch). These southern beds and surrounding areas, however, were numerically dominated by the juveniles of northern anchovy and two croakers (queenfish and white croaker) that are three of the most abundant species farther offshore (Allen and DeMartini, 1983). The drift algal beds off the beaches of central and southern California appear to be the primary habitat for a single species, the barred pipefish (*Syngnathus exilis*) (See chapter 4 and Allen and Herbinson, 1991). This species is rarely encountered anywhere outside this specialized habitat.

No information on seasonality and other forms of temporal variability, spatial variation, or productivity of the fishes in the surf zone is available at this time. A great deal of information does exist, however, on the life histories and basic ecology of several species occupying this habitat primarily because they are important sport fishes. Information on growth rates, reproduction, movements, and food habits exists for barred surfperch (Carlisle et al., 1960), spotfin croaker, and California corbina (Joseph, 1962). The reproductive and growth dynamics of walleye surfperch from waters near San Diego were studied by DeMartini et al. (1983). The tide-related reproductive biology of California grunion has been well known for many years and was summarized by Walker (1952).

Large, mobile fishes of the surf zone and shallow soft bottom, such as sharks and large croakers, have always presented major problems for quantitative assessment. Abundances of these species are routinely underestimated because they are adept at avoiding most types of sampling gear. These species can easily outswim and escape most seines and trawls. Passive samplers such as gill nets, trammel nets, and traps capture these fishes effectively but provide poor quantification. In recent years, gill nets have been used to assess populations of large, mobile fishes in the Gulf of Mexico (summarized in

TABLE 6-2
Fishes Collected at Two Sites in Trinidad Bay, California, April 1993 to March 1994

Common Name	*Scientific Name*	*Number*	*%Total*	*%Juveniles*	*%Adults*
Surf smelt	*Hypomesus pretiosus*	3878	51.6	100	0
Shiner perch	*Cymatogaster aggregata*	1511	20.1	95	5
Topsmelt	*Atherinops affinis*	771	10.3	100	0
Night smelt	*Spirinchus starksi*	458	6.1	44.1	55.9
Calico surfperch	*Amphistichus koelzi*	321	4.3	76.3	23.7
Speckled sanddab	*Citharichthys stigmaeus*	96	1.3	84.4	15.6
Striped seaperch	*Embiotoca lateralis*	63	0.8	50.8	49.2
Black rockfish	*Sebastes melanops*	61	0.8	100	0
Sand sole	*Psettichthys melanostictus*	48	0.6	100	0
Slimy snailfish	*Liparis mucosus*	46	0.6	0	100
Spotfin surfperch	*Hyperprosopon anale*	40	0.5	30	70
Walleye surfperch	*Hyperprosopon argenteum*	35	0.5	97.1	2.9
Pricklebreast poacher	*Stellerina xyosterna*	30	0.4	36.7	63.3
Bay pipefish	*Syngnathus leptorhynchus*	27	0.4	48.1	51.9
Cabezon	*Scorpaenichthys marmoratus*	25	0.3	100	0
Pacific herring	*Clupea pallasi*	24	0.3	91.7	8.3
Silver surfperch	*Hyperprosopon ellipticum*	19	0.3	100	0
Silverspotted sculpin	*Blepsias cirrhosus*	11	0.1	81.8	18.2
Pacific sardine	*Sardinops sagax*	10	0.1	100	0
Penpoint gunnel	*Apodichthys flavidus*	9	0.1	100	0
English sole	*Pleuronectes vetulus*	7	0.1	100	0
California halibut	*Paralichthys californicus*	6	0.1	100	0
Tubenose poacher	*Pallasina barbata*	5	0.1	0	100
Grass rockfish	*Sebastes rastrelliger*	4	0.1	100	0
Pacific sand lance	*Ammodytes hexapterus*	3	0	100	0
Pacific tomcod	*Microgadus proximus*	3	0	33.3	66.7
Jacksmelt	*Atherinops californiensis*	2	0	100	0
Bonehead sculpin	*Artedius notospilotus*	1	0	100	0
Threespine stickleback	*Gasterosteus aculeatus*	1	0	100	0
Pacific staghorn sculpin	*Leptocottus armatus*	1	0	100	0
Chinook salmon	*Oncorhynchus tshawytscha*	1	0	100	0
Saddleback gunnel	*Pholis ornata*	1	0	100	0
TOTALS		7518	100	92.4	7.6

NOTE: Number of individuals, percent of the total fish sampled, and percent juveniles and adults are given for each species. After Mulligan and Mulligan, in prep.

Hueter, 1994) and along the Pacific coast of Mexico (Godinez-Dominguez et al., 2000). A recent sampling survey for juvenile white seabass along the southern California coast has provided the first, long-term assessment of large, mobile fish species in California waters. This nighttime, gill-net survey has been conducted at 19 stations from throughout the Southern California Bight from April through October since 1996.

The total catch of all species during the first two years (1996–97) was reported in Pondella and Allen (1999). Overall, the collections contained a "cross section" of fish species that frequent nearshore, soft-bottom areas, including bay and estuary, surf zone, coastal pelagic, and inner shelf habitats, as well as the rock/sand interfaces of rocky reefs and kelp beds. Characteristic assemblages were dominated numerically by various species of croakers including yellowfin croaker, white croaker, queenfish, black croaker (*Cheilotrema saturnum*), white seabass, and California corbina (fig. 6-4), probably as a result of their nocturnal activities (see chapter 20).

On the other hand, several species of elasmobranchs heavily dominated the catch in biomass (Pondella and Allen, 1999). The most numerous of the elasmobranchs were the horn shark (*Heterodontus francisci*), brown smoothhound (*Mustelus henlei*), gray smoothhound, leopard shark, swell shark (*Cephaloscyllium ventriosum*), angel shark (*Squatina californicas*), and bat ray (*Myliobatis californica*) (table 6-4). Further, the average weight of the individuals of these species ranged from 1.2 kg up to 6.2 kg making them easily the largest among the species encountered (table 6-5). Although these species are also often recorded in other nearshore habitats, they are usually listed as rare and periodic. This appears to reflect a sampling bias; clearly, elasmobranchs are much more abundant in the nearshore environment than previously recorded.

Pondella and Allen (1999) concluded that the assemblage of large, mobile fishes in the nearshore area around the channel island of Santa Catalina differed from those of the mainland in diversity, abundance, richness, and biomass mainly because of habitat differences. The nearshore environment of the mainland is dominated by sand that separates the widely spaced rocky reefs. In contrast, the nearshore habitats at Santa Catalina Island are primarily reefs with relatively small expanses of sand.

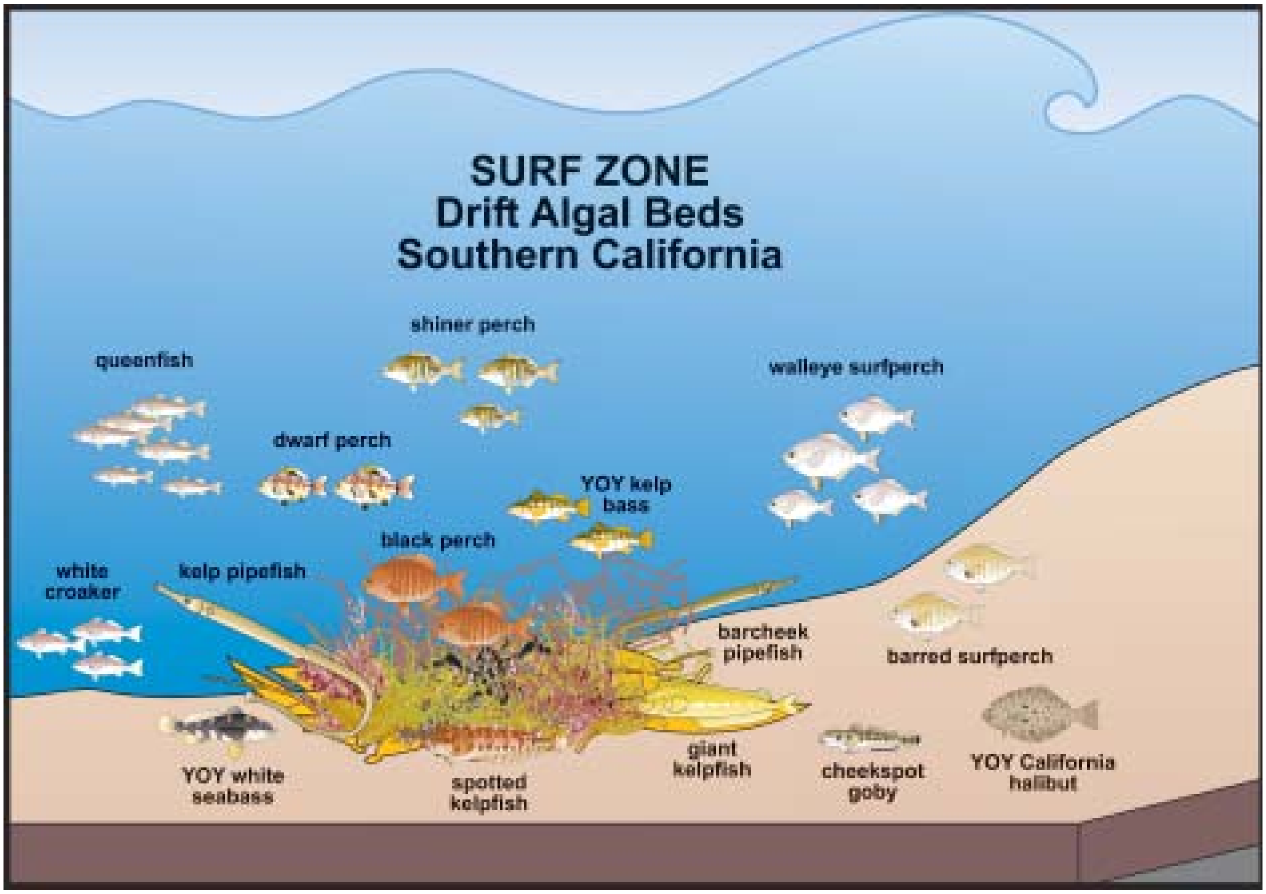

FIGURE 6-3 Common fish species of the drift algal beds of the surf zone throughout the Southern California Bight (see text for explanation).

Coastal Pelagic Zone

The coastal pelagic zone technically encompasses open water environment extending out from the surf zone to the continental shelf break. Many of the coastal pelagic species usually occur within a few kilometers of the shore. The fish assemblages of this zone are largely unstudied in California waters, except for the results reported by Cailliet et al. (1979) from Monterey Bay and by Allen and DeMartini (1983) off northern San Diego County between San Onofre and Oceanside.

Cailliet et al. (1979) reported that commercial purse-seine hauls made at night in the surface waters of Monterey Bay contained 99.9% northern anchovies, which were the target species. In addition to anchovies, Pacific herring (Clupea pallasi) were captured in low abundance along with night smelt (*Spirinchus starksi*) and Pacific sauries (*Cololabis saira*). Largely benthic species, such as plainfin midshipman (*Porichthys notatus*) and Pacific electric ray (*Torpedo californica*), composed a surprisingly large portion of the remaining catch in these night hauls; this supports the hypothesis that they probably rise into the water column at night to feed.

Allen and DeMartini (1983) summarized the results of a 19-month study involving 643 lampara net hauls partitioned among three depth blocks and day/night periods from 1979 to 1981. As in Monterey Bay, the hauls off San Onofre-Oceanside were overwhelmingly dominated by silvery, schooling fishes (fig. 6-5). Northern anchovy, queenfish, white croaker, Pacific pompano (*Peprilus simillimus*), and a species complex of silversides accounted for >98% of the individuals sampled (table 6-6). Northern anchovy, the dominant offshore pelagic species in California waters at the time of sampling (Mais 1974), was also numerically dominant nearshore. Queenfish and white croaker, the two most abundant croakers in this assemblage, are best characterized as demersal (bottom) fishes that rise into the water column at night. Both of these species are well represented in bottom trawls in the area (DeMartini and Allen, 1984). White croakers are generally more abundant in trawls, indicating that they are more closely associated with the bottom than queenfish. The silverside complex consisted of three species (jacksmelt, California grunion and topsmelt) that were not readily distinguishable in the field. Subsamples of the "atherinopsid spp." taxon in field lampara catches contained about 48% jacksmelt, 42% grunion, and 10% topsmelt (Allen and DeMartini, 1983).

Two groups of species were identified as seasonal components within the assemblage. Pacific bonito (*Sarda chiliensis*), Pacific mackerel (*Scomber japonicus*), and jack mackerel (*Trachurus symmetricus*) composed a group of pelagic carnivores that generally occurred in the offshore portion of the study area during the warmer months (spring-summer). On the other hand, four species (California barracuda, *Sphyraena argentea*; deepbody anchovy; salema, *Xenistius californiensis;* and yellowfin croaker) were more abundant at shallow depths during the colder water months (fall-winter). Two of these species, the deepbody anchovy and the yellowfin croaker, occur in bay-estuarine habitats such as Newport Bay during the summer months (Horn and Allen, 1981; Allen et al., 2002) and belong primarily to tropical families. The presence of

TABLE 6-3

Relative Abundance of Fishes Collected by Beam Trawl Sampling along the Coast of Central and Southern California from 1988 to 1993

Common Name	*Scientific Name*	*Mean %*	*> 90% Juv.*
Central California			
Speckled sanddab	*Citharichthys stigmaeus*	66.7	
English sole	*Pleuronectes vetulus*	9.3	*
Barcheek pipefish	*Syngnathus exilis*	4.1	
Barred surfperch	*Amphisticus argenteus*	2.2	*
Bay goby	*Lepidogobius lepidus*	2.1	
Giant kelpfish	*Heterostichus rostratus*	1.5	*
Staghorn sculpin	*Leptocottus armatus*	1.3	
Spotfin surfperch	*Hyperprosopon anale*	1.3	*
Black perch	*Embiotoca jacksoni*	1.0	*
California tonguefish	*Symphurus atricauda*	0.9	
Copper rockfish	*Sebastes caurinus*	0.8	*
Cabezon	*Scorpaenichthys marmoratus*	0.7	*
Shiner perch	*Cymatogaster aggregata*	0.5	*
Sand sole	*Psettichthys melanostictus*	0.5	
California lizardfish	*Synodus lucioceps*	0.5	
White seaperch	*Phanerodon furcatus*	0.4	*
Brown rockfish	*Sebastes auriculatus*	0.4	*
Spotted kelpfish	*Gibbonsia elegans*	0.3	
Kelp clingfish	*Rimicola muscarum*	0.3	
Black rockfish	*Sebastes melanops*	0.3	*
California halibut	*Paralichthys californicus*	0.2	
Striped kelpfish	*Gibbonsia metzi*	0.2	
Rainbow seaperch	*Hypsurus caryi*	0.2	*
Dwarf perch	*Micrometrus minimus*	0.2	*
Grass rockfish	*Sebastes rastrelliger*	0.2	*
Southern California			
Queenfish	*Seriphus politus*	44.6	*
Speckled sanddab	*Citharichthys stigmaeus*	20.0	
White croaker	*Genyonemus lineatus*	10.2	*
Northern anchovy	*Engraulis mordax*	5.2	*
Barcheek pipefish	*Syngnathus exilis*	2.6	
Giant kelpfish	*Heterostichus rostratus*	2.3	*
California halibut	*Paralichthys californicus*	2.0	*
White seabass	*Atractoscion nobilis*	1.2	*
Fantail sole	*Xystreurys liolepis*	0.8	*
Spotted turbot	*Pleuronichthys ritteri*	0.6	*
Kelp pipefish	*Syngnathus californiensis*	0.6	
California lizardfish	*Synodus lucioceps*	0.5	
Spotted kelpfish	*Gibbonsia elegans*	0.5	
English sole	*Pleuronectes vetulus*	0.4	*
Dwarf perch	*Micrometrus minimus*	0.4	*
Walleye surfperch	*Hyperprosopon argenteum*	0.4	*
White seaperch	*Phanerodon furcatus*	0.3	*
California barracuda	*Sphyraena argentea*	0.2	*
Staghorn sculpin	*Leptocottus armatus*	0.2	
Kelp bass	*Paralabrax clathratus*	0.2	*
Black croaker	*Cheilotrema saturnum*	0.1	*
Cheekspot goby	*Ilypnus gilberti*	0.1	
Barred surfperch	*Amphisticus argenteus*	0.1	*
Black perch	*Embiotoca jacksoni*	0.1	*

NOTE: L. Allen, unpublished data.

these two species in the study area during fall and winter suggested that they seasonally migrate out of embayments and into shallow coastal waters in response to cooler water temperatures. Many demersal fishes were also captured because the nets extended from the surface to the bottom. Most of these benthic fishes were relatively rare in catches except for the bat ray. Spatially, California barracuda, salema, jack mackerel, and atherinopsids were more abundant in the proximity of the San Onofre kelp bed during the study. All of these species associate with kelp beds or rocky reefs at some time during the year (Feder et al. 1974; Hobson and Chess 1976; Mais 1974).

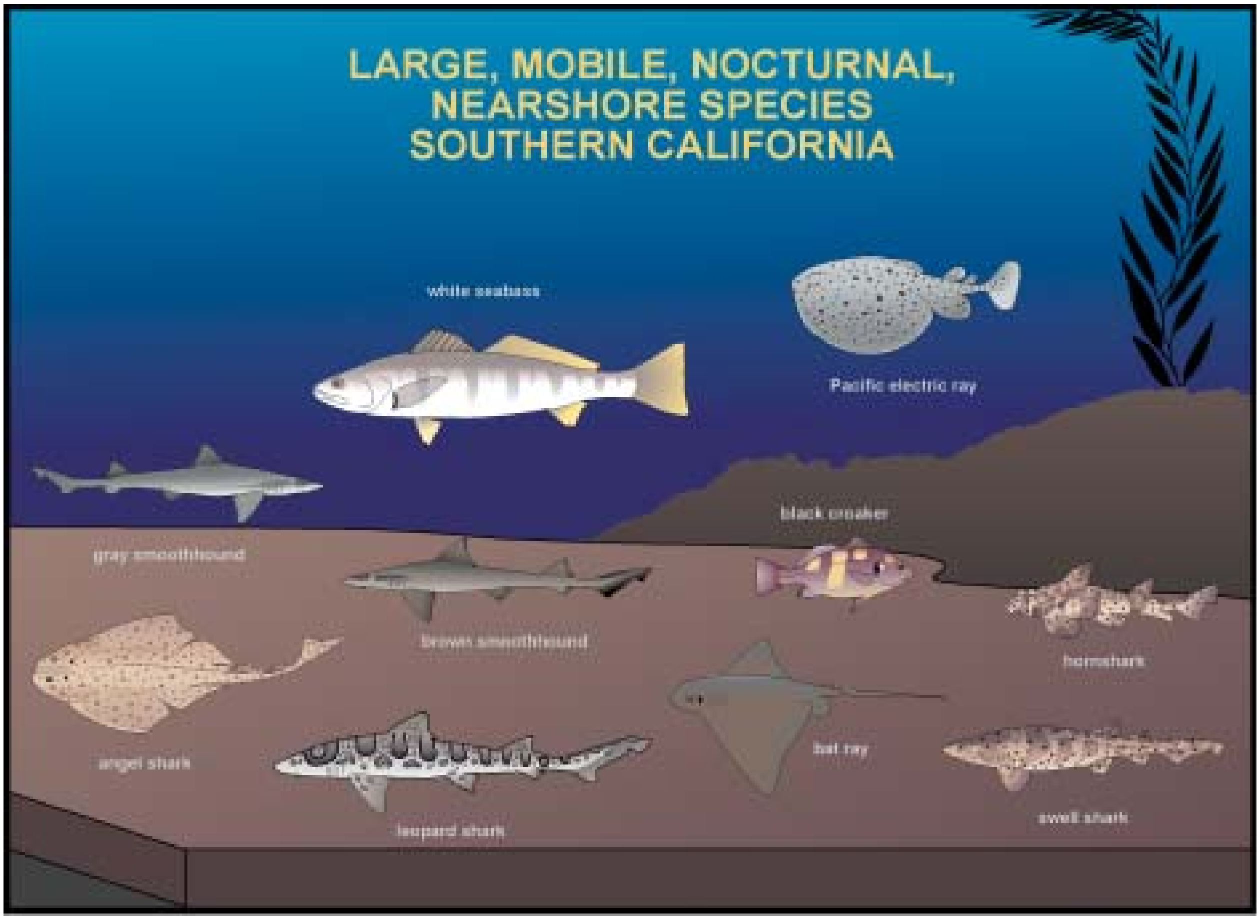

FIGURE 6-4 Large mobile, nocturnally active fishes of the inner shelf in southern California (after Pondella and Allen, 1999).

The coastal pelagic fish assemblage off San Onofre-Oceanside varied greatly over time. Some of the notable differences were attributed to spatial patchiness and sampling error, but others undoubtedly reflected short-term, temporal changes in the environment. Upwelling was probably a major factor that contributed to short-term variation in the abundance and distribution of these fishes. The waters within the Southern California Bight are often subjected to bouts of upwelling anytime during the year, although upwelling is most likely from March to July (Parrish et al. 1981). Both short-term temperature variations due to upwelling and long-term seasonal warming and cooling of coastal waters probably exerted strong influences on the abundance of individual taxa in this assemblage. Abundances of only two of the top five taxa, however, were significantly correlated with sea surface temperature (northern anchovy were positively correlated, whereas atherinopsids were negatively correlated). Although the fourth most abundant species captured, Pacific pompano, varied significantly among samples, it showed no significant relationship to temperature. Extremely patchy distributions and high vagility might account for the observed short-term variation in the abundance of this species. Neither queenfish nor white croaker varied greatly in seasonal abundance, although queenfish did show significant variation that was apparently unrelated to temperature. The only major change in catches of queenfish and white croaker occurred during the fall and early winter, when adults of both species presumably migrated out of the sampling area into deeper water. Observed temporal differences in the abundances of the major higher carnivores of the assemblage (Pacific bonito, Pacific mackerel, and California barracuda) probably reflected differences in general long-shore migratory patterns and residence times of juveniles within the study area. Adults of these species were generally more abundant in the summer and fall, whereas juveniles could occur year-round (Allen and DeMartini, 1983).

Although location differences and temporal changes were evident for some species within this Southern California assemblage, the dominant pattern was a general dispersal offshore at night from nearshore diurnal schools. Significant day/night interactions with depth were found for the total number of individuals, total individuals minus northern anchovy, species counts, numbers of northern anchovy, and numbers of queenfish (Allen and DeMartini, 1983). Further, adult queenfish of both sexes made diel, onshore, and offshore migrations, but juveniles did not (DeMartini et al. 1985). Both juvenile and adult queenfish occurred in demersal, resting schools in shallow water during the day. At night, adult queenfish dispersed up to 3.5 km offshore. A greater fraction of adult male queenfish migrated offshore at night than did mature females. The majority of immature fish stayed inshore of the 10-m depth contour.

Various diel and/or depth effects were also found for other taxa, including Pacific pompano, white croaker, silversides, and Pacific mackerel. These results plus the significant correlations between species abundances and time of collection and depth underscored the general importance of diel and depth factors to the abundance and distributions of fishes in this assemblage (Allen and DeMartini, 1983).

TABLE 6-4

Large, Mobile Nearshore Soft-bottom Fishes Captured by Gill Net from 1996 to 1998 in Southern California Ranked by Number and Biomass

Common Name	*Scientific Name*	% *Number*	*Common Name*	*Scientific Name*	% *Biomass*
Yellowfin croaker	*Umbrina roncador*	9.7	* California hornshark	*Heterodontus francisi*	16.3
* California hornshark	*Heterodontus francisi*	8.9	* Brown smoothhound	*Mustelus henlei*	13.6
Queenfish	*Seriphus politus*	6.1	* Bat ray	*Myliobatis californica*	12.4
* Brown smoothhound	*Mustelus henlei*	5.3	* Angel shark	*Squatina californica*	6.4
White croaker	*Genyonemus lineatus*	5.0	* Swell shark	*Cephaloscyllium ventriosum*	6.0
California corbina	*Menticirrhus undulatus*	4.9	* Leopard shark	*Triakis semifasciata*	4.9
* Bat ray	*Myliobatis californica*	3.8	* Gray smoothhound	*Mustelus californicus*	4.1
Black croaker	*Cheilotrema saturnum*	3.7	California corbina	*Menticirrhus undulatus*	3.6
Walleye surfperch	*Hyperprosopon argenteum*	3.6	Yellowfin croaker	*Umbrina roncador*	3.4
Kelp bass	*Paralabrax clathratus*	3.5	Opaleye	*Girella nigricans*	2.9
Opaleye	*Girella nigricans*	3.3	* Spiny dogfish	*Squalus acanthias*	2.8
Sargo	*Anisotremus davidsoni*	2.9	Sargo	*Anisotremus davidsoni*	2.3
Pacific sardine	*Sardinops sagax*	2.8	White seabass	*Atractoscion nobilis*	2.2
White seaperch	*Phanerodon furcatus*	2.6	Kelp bass	*Paralabrax clathratus*	1.6
Pacific mackerel	*Scomber japonicus*	2.5	Black croaker	*Cheilotrema saturnum*	1.5
White seabass	*Atractoscion nobilis*	2.5	Pacific mackerel	*Scomber japonicus*	1.5
Salema	*Xenistius californiensis*	2.1	California halibut	*Paralichthys californicus*	1.4
* Swell shark	*Cephaloscyllium ventriosum*	2.1	* Thornback	*Platyrhinoides triseriatus*	1.3
Spotted scorpionfish	*Scorpaena guttata*	2.0	* Shovelnose guitarfish	*Rhinobatis productus*	1.2
* Thornback	*Platyrhinoides triseriatus*	1.9	Queenfish	*Seriphus politus*	0.9
Black perch	*Embiotoca jacksoni*	1.8	California barracuda	*Sphyraena argentea*	0.9
Jacksmelt	*Atherinopsis californiensis*	1.6	White croaker	*Genyonemus lineatus*	0.9
Rock wrasse	*Halichoeres semicinctus*	1.6	Spotted scorpionfish	*Scorpaena guttata*	0.7
* Gray smoothhound	*Mustelus californicus*	1.4	* Round stingray	*Urolophus halleri*	0.6
California halibut	*Paralichthys californicus*	1.3	Halfmoon	*Medialuna californica*	0.6
* Leopard shark	*Triakis semifasciata*	1.3	Black perch	*Embiotoca jacksoni*	0.5
Barred sand bass	*Paralabrax nebulifer*	1.1	Jacksmelt	*Atherinopsis californiensis*	0.5
Halfmoon	*Medialuna californica*	1.1	Barred sand bass	*Paralabrax nebulifer*	0.5
* Round stingray	*Urolophus halleri*	0.9	Rubberlip seaperch	*Rhacochilus toxotes*	0.4
California barracuda	*Sphyraena argentea*	0.8	White seaperch	*Phanerodon furcatus*	0.4
Blacksmith	*Chromis punctipinnis*	0.7	Rock wrasse	*Halichoeres semicinctus*	0.4
Rubberlip seaperch	*Rhacochilus toxotes*	0.7	Pacific sardine	*Sardinops sagax*	0.3
* Angel shark	*Squatina californica*	0.7	Specklefin midshipman	*Porichthys myriaster*	0.3
* Spiny dogfish	*Squalus acanthias*	0.6	Pile perch	*Rhacochilus vacca*	0.3
Pile perch	*Rhacochilus vacca*	0.6	Salema	*Xenistius californiensis*	0.3
Jack mackerel	*Trachurus symmetricus*	0.6	Zebraperch	*Hermosilla azurea*	0.3
Garibaldi	*Hypsypops rubicundus*	0.6	Walleye surfperch	*Hyperprosopon argenteum*	0.3
Specklefin midshipman	*Porichthys myriaster*	0.5	Garibaldi	*Hypsypops rubicundus*	0.3
California sheephead	*Semicossyphus pulcher*	0.4	California sheephead	*Semicossyphus pulcher*	0.3
Kelp rockfish	*Sebastes atrovirens*	0.4	Jack mackerel	*Trachurus symmetricus*	0.2
Zebraperch	*Hermosilla azurea*	0.3	Kelp rockfish	*Sebastes atrovirens*	0.1
* Shovelnose guitarfish	*Rhinobatis productus*	0.3	Blacksmith	*Chromis punctipinnis*	0.1
Kelp perch	*Brachyistius frenatus*	0.3	California moray	*Gymnothorax mordax*	0.1
Spotted turbot	*Pleuronichthys ritteri*	0.3	Striped mullet	*Mugil cephalus*	0.1
American shad	*Alosa sapidissima*	0.2	American shad	*Alosa sapidissima*	0.1
Staghorn sculpin	*Leptocottus armatus*	0.2	Pacific bonito	*Sarda chiliensis*	0.1
Grass rockfish	*Sebastes rastrelliger*	0.2	Grass rockfish	*Sebastes rastrelliger*	0.1
Pacific bonito	*Sarda chiliensis*	0.1	Spotted turbot	*Pleuronichthys ritteri*	0.1
Pacific sanddab	*Citharichthys sordidus*	0.1			

NOTE: After Pondella and Allen, 2000.* = elasmobranchs.

Harbors

Artificial harbors have been placed at the mouths of many of the natural bay and estuarine habitats within California in the last century. As of 1970, more than 60% of the original estuarine areas had either been highly modified into harbors or destroyed (Frey et al., 1970). Despite this, systematic studies of these altered habitats are largely limited to those in the Southern California Bight. The ichthyofauna of several southern California harbors have been the subject of past studies including those in Newport Harbor (Allen, 1976), King Harbor, Redondo Beach (Stephens, 1978), Marina del Rey (Stephens et al., 1992), and especially the Los Angeles–Long Beach Harbor complex (Stephens et al., 1974; Horn and Allen,

TABLE 6-5

Large, Mobile Nearshore Soft-Bottom Fishes Captured by Gill Net from 1996 to 1998 in Southern California Ranked by Biomass Per Individual

Common Name	*Scientific Name*	*Number of Individuals*	*Biomass (kg)*	*Kg/ind*
* Angel shark	*Squatina californica*	128	799	6.2
* Spiny dogfish	*Squalus acanthias*	119	352	3.0
* Leopard shark	*Triakis semifasciata*	245	608	2.5
* Shovelnose guitarfish	*Rhinobatis productus*	62	148	2.4
California moray	*Gymnothorax mordax*	5	12	2.3
* Bat ray	*Myliobatis californica*	754	1555	2.1
* Gray smoothhound	*Mustelus californicus*	271	507	1.9
* Swell shark	*Cephaloscyllium ventriosum*	416	756	1.8
* Brown smoothhound	*Mustelus henlei*	1035	1709	1.7
Striped mullet	*Mugil cephalus*	7	10	1.4
* Horn shark	*Heterodontus francisi*	1744	2045	1.2
California barracuda	*Sphyraena argentea*	155	110	0.7
California halibut	*Paralichthys californicus*	248	171	0.7
Zebraperch	*Hermosilla azurea*	63	38	0.6
Opaleye	*Girella nigricans*	641	361	0.6
White seabass	*Atractoscion nobilis*	492	273	0.6
Pacific bonito	*Sarda chiliensis*	15	8	0.5
Sargo	*Anisotremus davidsoni*	576	291	0.5
Fantail sole	*Xystreurys liolepis*	5	3	0.5
California corbina	*Menticirrhus undulatus*	954	455	0.5
* Round stingray	*Urolophus halleri*	169	73	0.4
* Thornback	*Platyrhinoides triseriatus*	372	161	0.4
Rubberlip seaperch	*Rhacochilus toxotes*	139	55	0.4
California sheephead	*Semicossyphus pulcher*	88	34	0.4
Specklefin midshipman	*Porichthys myriaster*	104	39.6	0.4

Note: After Pondella and Allen, 2000: * = elasmobranchs.

1981b; Allen et al., 1983; MBC, 1984; and MEC, 1988). These studies have found that harbor habitats generally contain relatively diverse and abundant fish assemblages compared to equivalent, undeveloped, nearshore habitats. The richness of these areas can probably be attributed to their protected nature, high nutrient loads from runoff and upwelling, presumed high productivity and abundant food supply, adequate circulation and, most importantly, variety of substrata (Stephens, 1978). Adequate circulation and good water quality are unquestionably important to the health of harbor fish populations. Poor water quality apparently contributed to the very "poor condition" of many fishes trawled (Young 1964) from Los Angeles–Long Beach Harbor before pollution abatement was begun in 1968 (Reish et al., 1980).

The bottom fishes of harbors include most of the common species of the inner shelf as represented by the inclusion of harbors and nearshore soft bottom into one type of habitat by Allen (1985). Harbors, however, also include various rock substrates, most notably, the rocky shoreline, jetties, bulkheads, floats and pilings, and, in some cases, sandy beaches with sea grass or algal beds. Fish assemblages of the rocky shorelines and jetties of harbors were indistinguishable from those and other shallow rock reefs in southern California and were, therefore, classified as shallow rock reef fishes (SRRF) by Allen (1985).

The Los Angeles–Long Beach Harbor complex is the most intensively studied harbor in California. This complex now sits on what was once the site of the largest bay and estuarine system between San Francisco Bay and San Diego Bay (fig. 6-6). Most of the studies of the fish populations have been unpublished surveys and environmental impact analyses. Comprehensive studies of both Long Beach Harbor (MBC, 1984) and Los Angeles Harbor (MEC, 1988) have been completed; however, most of the information remains unpublished except for Allen et al. (1983).

The fish assemblages of Los Angeles-Long Beach Harbor are diverse. Chamberlain (1974) listed 132 species of fish that had been reported from Los Angeles–Long Beach Harbor. Horn and Allen (1981b) reported that 113 species had been collected in the harbor in studies conducted between 1971 and 1979. Otter trawl and gill-net collections (table 6-7) of the fish populations of harbors in the Bight in general and of Los Angeles–Long Beach Harbor in particular are numerically dominated by two species of croaker, white croaker and queenfish and juveniles of northern anchovy. Other common species included white seaperch, California tonguefish (*Symphurus atricauda*), speckled sanddab (*Citharichthys stigmaeus*), shiner perch, specklefin midshipman (*Porichthys myriaster*), black perch, walleye surfperch, and bay goby (*Lepidogobius lepidus*) (Horn and Allen, 1981b). More recently, as suggested by Horn and Allen (1981b), investigations have also used beach seines and purse seines (table 6-7) in addition to otter trawls (MBC, 1984) and gill nets (MEC, 1988) to characterize the harbor fish fauna more thoroughly.

Beach seine catches along sandy beaches within the harbor have reported shoreline fish assemblages that are distinctive within the harbor, yet very similar in many respects to those

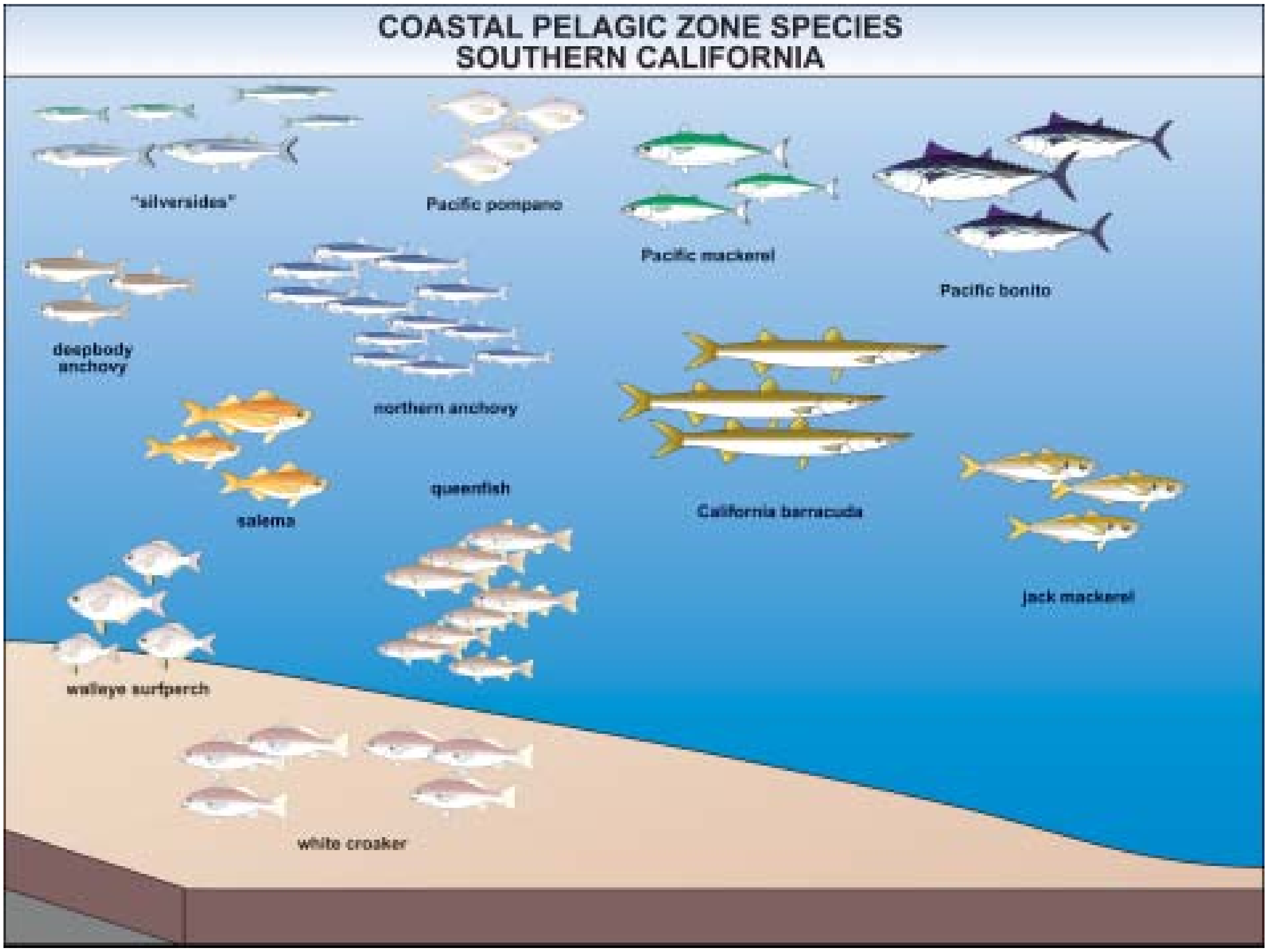

FIGURE 6-5 Common fish species of the coastal pelagic zone in southern California (After Allen and DeMartini, 1983).

from bay and estuarine and exposed coast surf zone habitats. Numerically abundant species taken in beach seines include topsmelt, arrow goby (*Clevelania ios*), cheekspot goby (*Ilypnus gilberti*), northern anchovy, queenfish, white croaker, and grunion (Allen et al., 1983; MBC, 1984). The Cabrillo Beach area of the harbor contained a unique group of fishes, which were associated with algal beds (*Gracillaria* sp.) along the sandy shoreline. This group included dwarf perch, spotted kelpfish (*Gibbonsia elegans*), giant kelpfish, and barcheek pipefish (Allen et al., 1983). Purse-seine hauls (MBC, 1984) captured mainly fishes from the water column within the harbor. The ten most abundant species captured in Los Angeles–Long Beach Harbor in order of abundance were northern anchovy (45%), queenfish (19%), Pacific sardine (*Sardinops sagax*) (12%), white croaker (4%), Pacific pompano (2%), jack mackerel (1%), California barracuda (1%), jacksmelt (0.5%), grunion (0.4%), and Pacific mackerel (0.2%). This list and the relative abundances of fishes from Long Beach Harbor was virtually indistinguishable from that reported by Allen and DeMartini (1983) from the coastal pelagic zone off San Onofre-Oceanside, California.

The similarities among the fishes of harbors and the surf zone, inner shelf, coastal pelagic, and bay/estuarine habitats noted above are largely responsible for the close association among these four types of habitats reported in Allen (1985) and Allen and Pondella, (chapter 4, this volume). The species abundances reported in four studies from various parts of the Los Angeles–Long Beach Harbor complex occur across three major nearshore habitats (fig. 6-7). The fishes reported from trawls by Stephens et al. (1974) were those common on the inner shelf of southern California. The relative abundances of species reported in both Allen et al. (1983) and MEC, 1988 were more closely allied to those of the coastal pelagic zone off southern California, due largely to the high abundance of northern anchovies in seine hauls in these studies. Finally, the fish assemblages from the Los Angeles Federal Breakwater (table 6-8) are indistinguishable from those of natural rocky reef habitats within Southern California. They are dominated numerically by blacksmith (*Chromis punctipinnis*), black perch (*Embiotoca jacksoni*), pile perch (*Rhacochilus vacca*), kelp bass (*Paralabrax clathratus*), and senorita (*Oxyjulis californica*) (Froeschke et al., in press).

Therefore, the fish assemblage within the Los Angeles–Long Beach Harbor complex is a composite of those from various nearshore habitats (fig. 6-8). This harbor sits at the mouth of the Los Angeles and San Gabriel Rivers. The interior of this facility was created in part by the filling of an expansive wetland that historically met the Ballona Wetlands to the north. Bay and estuarine fishes are distributed along the interior portions of the harbor in what is the remnant of the estuary habitat. A few areas in the harbor support marcrophytes (algae and eelgrass) and associated fishes. Rocky groins, breakwaters, and jetties that have been used to construct most of the harbor bracket this habitat and include a diverse assemblage of reef

TABLE 6-6

Frequency of Occurrence of the Top 23 Fishes in 643 Lampara Net Samples from September 1979 to March 1981

Common Name	*Scientific Name*	*Number*	*% Number*	*Frequency*	*% Frequency*
Northern anchovy	*Engraulis mordax*	819,872	80.79	440	68.4
Queenfish	*Seriphus politus*	80,513	7.93	413	64.2
White croaker	*Genyonemus lineatus*	53,994	5.32	335	52.1
Pacific pompano	*Scomber japonicus*	26,003	2.56	238	37.0
Atherinopsidae	silversides	16,811	1.56	326	50.7
Pacific mackerel	*Scomber japonicus*	7,386	0.73	194	30.2
Jack mackerel	*Trachurus symmetricus*	2,750	0.27	92	14.3
Deepbody anchovy	*Anchoa compressa*	1,915	0.19	85	13.2
Pacific bonito	*Sarda chiliensis*	1,394	0.14	115	17.9
California barracuda	*Sphyraena argentea*	1,066	0.11	99	15.4
Walleye surfperch	*Hyperprosopon argenteum*	936	0.09	106	16.5
White seaperch	*Atractoscion nobilis*	665	0.07	101	15.7
Bat ray	*Myliobatis californica*	455	0.04	212	33.0
California corbina	*Menticirrhus undulatus*	412	0.04	117	18.2
Yellowfin croaker	*Umbrina roncador*	269	0.03	38	5.9
Barred surfperch	*Amphisticus argenteus*	211	0.02	51	7.9
Salema	*Xenistius californiensis*	182	0.02	25	39.0
California halibut	*Paralichthys californicus*	139	0.01	79	12.3
Pacific sardine	*Sardinops sagax*	130	0.01	15	23.0
Barred sand bass	*Paralabrax nebulifer*	108	0.01	56	8.7
Shiner perch	*Cymatogaster aggregata*	86	0.01	34	5.3
Spiny dogfish	*Squalus acanthias*	66	0.01	23	3.6
Spotted scorpionfish	*Scorpaena guttata*	57	0.01	28	4.3

NOTE: Species (and one family) are ranked by total number of individuals. After Allen and DeMartini, 1983.

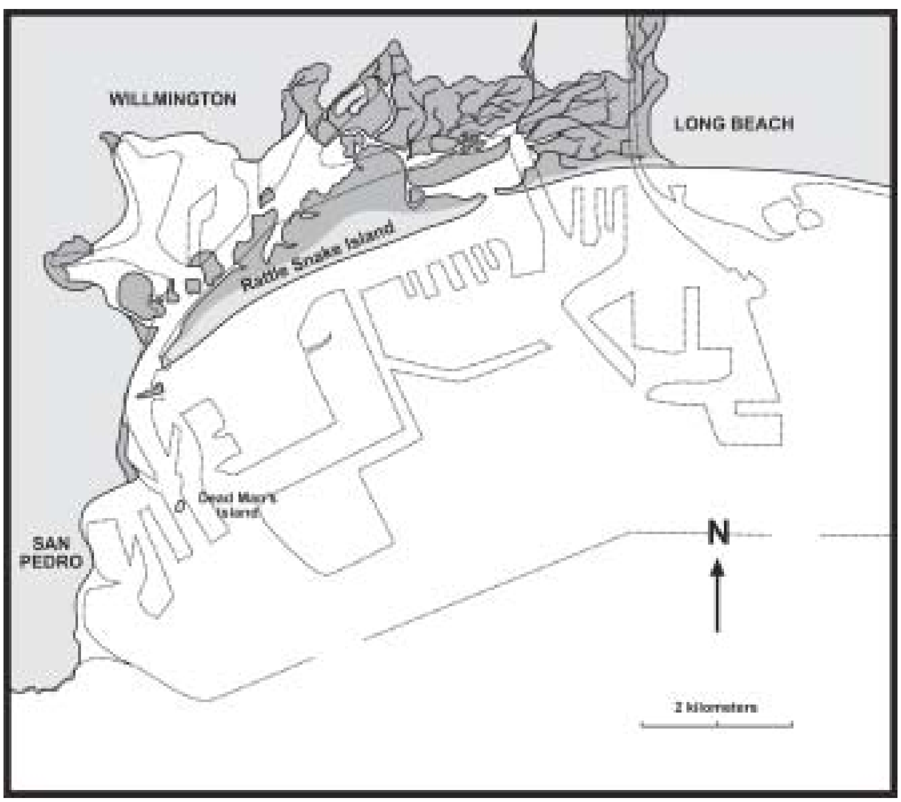

FIGURE 6-6 Reproduction of an 1895 chart of San Pedro Bay, California. The superimposed outline traces the current 2005 shoreline and associated structures of the present Los Angeles–Long Beach Harbor complex.

TABLE 6-7

Relative Abundance of Fishes in Four Sampling Gears in the Los Angeles–Long Beach Harbor Complex

Common Name	*Scientific Name*	*Otter Trawl*	*Gill Net*	*Purse Seine*	*Beach Seine*
Northern anchovy	*Engraulis mordax*	15	7	45	24
White croaker	*Genyonemus lineatus*	41	25	4	1
Queenfish	*Seriphus politus*	9	13	19	4
Topsmelt	*Atherinops affinis*		1	1	41
White seaperch	*Phanerodon furcatus*	8	16		1
Arrow goby	*Clevelandia ios*				14
Pacific sardine	*Sardinops sagax*		1	12	
Shiner perch	*Cymatogaster aggregata*	3	7		1
Walleye surfperch	*Hyperprosopon argenteum*	1	5		1
Cheekspot goby	*Ilypnus gilberti*				7
California tonguefish	*Symphurus atricauda*	7			
Jacksmelt	*Atherinopsis californiensis*		4	1	1
Pacific pompano	*Peprilus simillimus*	1	3	2	
Black perch	*Embiotoca jacksoni*		4		1
Speckled sanddab	*Citharichthys stigmaeus*	5			
Bay goby	*Lepidogobius lepidus*	3			1
California grunion	*Leuresthes tenuis*			1	2
California halibut	*Paralichthys californicus*	1	1		1
Threadfin shad	*Dorosoma petenense*				2
Pile perch	*Rhacochilus vacca*		2		
California barracuda	*Sphyraena argentea*		1	1	
Jack mackerel	*Trachurus symmetricus*		1	1	
California corbina	*Menticirrhus undulatus*		1		
Dwarf perch	*Micrometrus minimus*				1

NOTE: Percentage of total. After Horn and Allen, 1981b; Allen et al.; 1983; and Marine Biological Consultants, 1984.

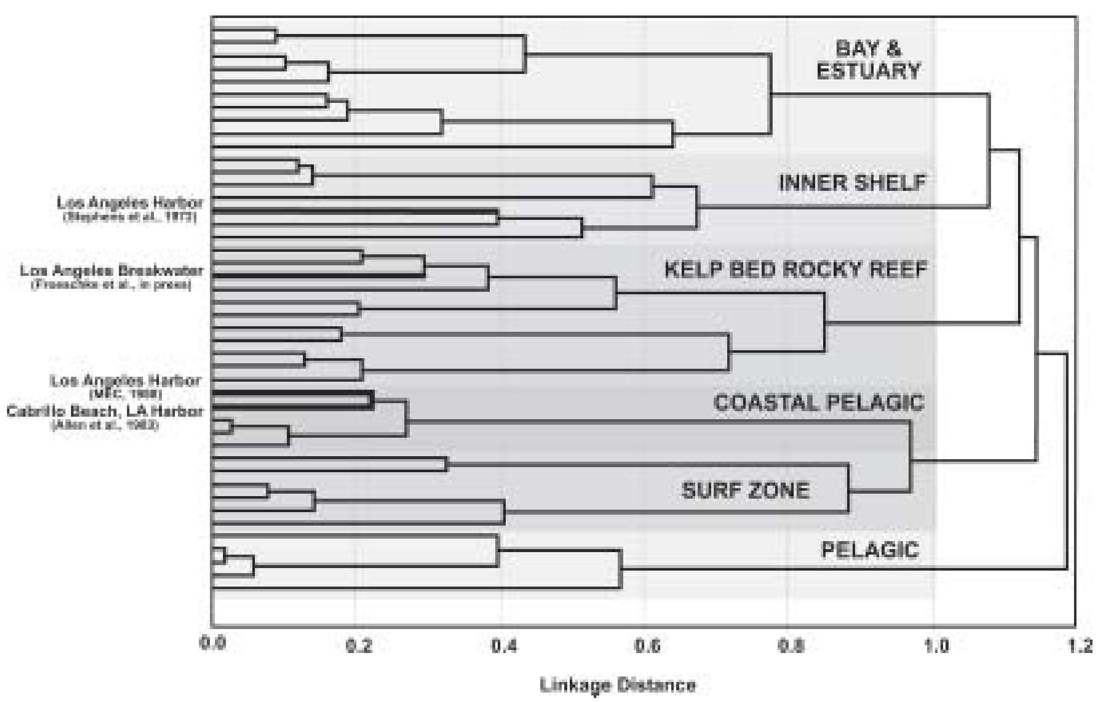

FIGURE 6-7 Specific placement of four site samples from within the Los Angeles–Long Beach Harbor complex based on species composition among 41 nearshore fish assemblage studies from the Southern California Bight. Five studies from the pelagic realm were also included for comparison (to "root" the tree). The species composition reported in Stephens et al. (1974) is grouped with inner shelf samples. The assemblages reported in Allen et al. (1983) and MEC (1988) were closely associated with coastal pelagic and surf zone samples. Fishes reported from the Los Angeles Federal Breakwater (Froeschke et al., in press) were indistinguishable from samples from other kelp bed and rocky reef habitats.

TABLE 6-8

Relative Abundance of Conspicuous Fishes in Dive Surveys of the Los Angeles Federal Breakwater from October 2002 to November 2003 (after Froeschke and Allen, in Press)

Common Name	*Scientific Name*	*Percent Abundance*
Blacksmith	*Chromis punctipinis*	56.60%
Black perch	*Embiotoca jacksoni*	11.95%
Pile perch	*Rhacochilus vacca*	5.51%
Kelp bass	*Paralabrax clathratus*	3.48%
Senorita	*Oxyjulis californica*	3.26%
Kelp perch	*Brachyistius frenatus*	3.05%
Zebraperch	*Hermosilla azurea*	2.44%
California sheephead	*Semicossyphus pulcher*	1.59%
Painted greenling	*Oxylebius pictus*	1.55%
Opaleye	*Girella nigricans*	1.46%
Barred sand bass	*Paralabrax nebulifer*	1.46%
Garibaldi	*Hypsopops rubicundus*	1.17%
Halfmoon	*Medialuna californiensis*	1.08%
Olive rockfish	*Sebastes serranoides*	0.93%
Rock wrasse	*Halichoeres semicinctus*	0.87%
Rubberlip seaperch	*Rhacochilus toxotes*	0.83%
Kelp rockfish	*Sebastes atrovirens*	0.81%
Blackeye goby	*Rhinogobiops nicholsi*	0.53%
Rainbow seaperch	*Hypsurus caryi*	0.49%
Giant kelpfish	*Heterostichus rostratus*	0.38%
Sargo	*Anisotremus davidsoni*	0.15%
Island kelpfish	*Alloclinus holderi*	0.13%
White seaperch	*Phanerodon furcatus*	0.11%
Spotted scorpionfish	*Scorpaena guttata*	0.04%
Cabezon	*Scorpaenichthys marmoratus*	0.04%
Black-and-yellow rockfish	*Sebastes chrysomelas*	0.04%
California hornshark	*Heterodontus francisci*	0.02%
Tree rockfish	*Sebastes serriceps*	0.02%

fishes. There is also one long stretch of sandy beach and associated fishes along the Long Beach portion of the harbor. This heterogeneous collection of habitats has been artificially placed within the inner shelf and coastal pelagic (CP) zones creating a very dynamic ecosystem.

Harbor fish populations, like those of other nearshore habitats, are markedly seasonal (Stephens et al., 1974; Allen et al., 1983). The greatest number of species, individuals, and biomass usually occur in the summer and early fall (fig. 6-9). This pattern is mainly the result of (1) the high abundance of juvenile resident fishes, including northern anchovy, white croaker, queenfish, and various species of surfperches in the inshore areas during the summer months; and (2) the presence of warm-water, seasonal species, such as Pacific bonito, California barracuda, gray smoothhound, and leopard shark (Allen et al., 1983). The seasonal patterns in abundance and biomass at Cabrillo Beach differ chronologically from those observed in Upper Newport Bay (Horn and Allen, 1981a; Allen, 1982). Peak abundance in Newport Bay occurred in the spring and early summer followed by biomass peaking in mid summer and early fall (fig. 6-8). The abundance and biomass peaks of the harbor fishes were delayed compared to those in Newport Bay of southern California and were greatest in midsummer and fall, respectively.

Diel variability in the Cabrillo Beach fish assemblages was also evident when day and night catches were compared (Allen et al., 1983). The great majority (88%) of fishes were collected during the day, whereas a slightly greater proportion (56%) of the biomass was captured at night. The predominance of young-of-the-year northern anchovy in daytime beach seine hauls and the large nighttime catches of white croakers in both otter trawls and gill nets contributed greatly to these diel differences. Four of the five most abundant species, northern anchovy, queenfish, California grunion, and white seaperch, which comprised 85% of the total number of individuals, were caught in greater numbers during the day. Only white croakers were more numerous at night. All five species, however, had greater mean weights in nighttime collections. In most cases, no significant differences in number of species, number of individuals, or biomass were detected between day and night samples taken with the three types of gear. The two exceptions were that nighttime otter trawl samples captured significantly greater numbers of individuals and biomass than day samples. Despite the apparent lack of statistical differences, individual species varied greatly in their day versus night occurrences in samples. Variability was probably the result of diel activity patterns, patchy distributions, and visually mediated gear avoidance. Behavior patterns undoubtedly contribute to differences in day-night catches. Juvenile northern anchovy formed dense schools nearshore during the day where they were susceptible to capture by beach seines. At night, these schools dispersed from the shoreline and were no longer accessible to beach seines. White croakers appeared to be more active and more widely dispersed at night, presumably in search of food.

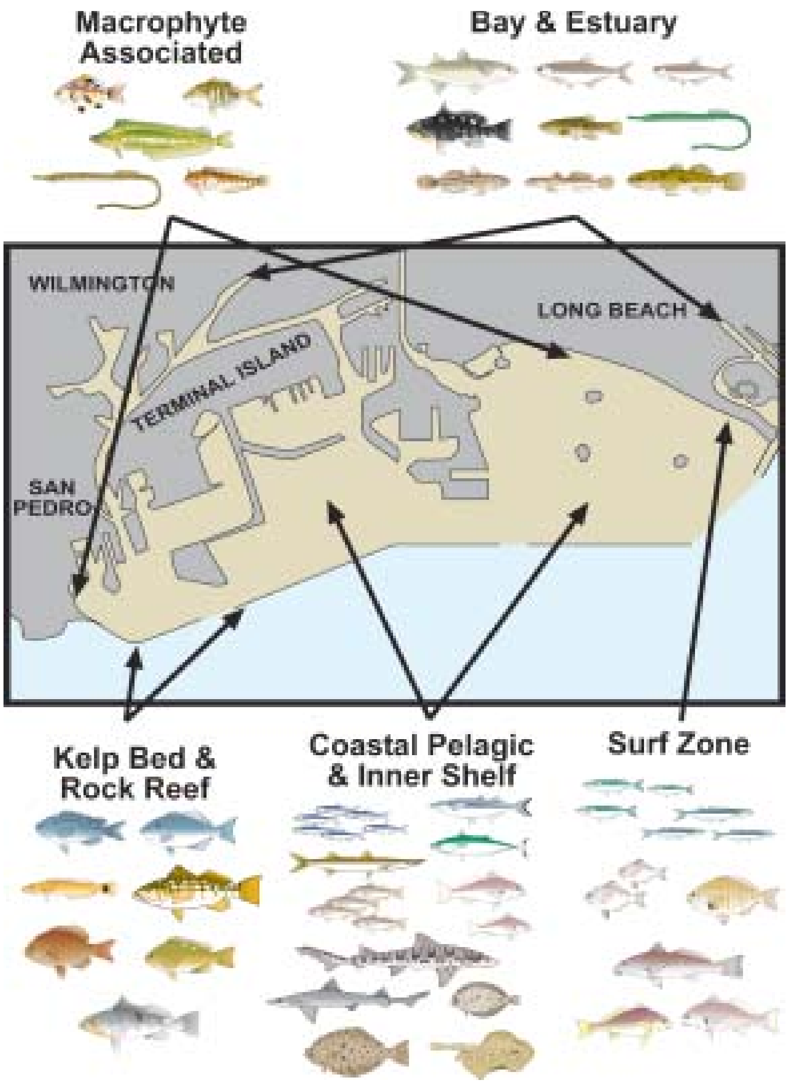

FIGURE 6-8 A representation of the distributions of the diverse fish assemblages of the Los Angeles–Long Beach Harbor complex. The relatively high diversity in harbors results from of the combination of multiple habitats suited for nearshore soft-bottom, coastal pelagic, kelp bed and rocky reef, surf zone, bay-estuary, and macrophyte associated species.

Similar activity patterns have been reported for these species in the nearshore coastal waters (Allen and DeMartini, 1983). The increased numbers of other nocturnally active species such as basketweave cusk-eel (*Ophidion scrippsae*) and spotted cusk-eel (*Chilara taylori*), specklefin midshipman, and California tonguefish in the night catches also made an important contribution to the day-night differences (Greenfield, 1968; DeMartini and Allen, 1984).

The high abundance of low trophic level fishes (e.g., northern anchovy, queenfish, and juvenile white croaker) in the Los Angeles–Long Beach Harbor complex results in a relatively high standing stock and production potential. Total annual productivity of trawl-captured species in Long Beach Harbor from March 1983 to April 1984 was estimated at 1.7 to 1.9 g DW/m^2 based on a realistic capture efficiency of 10% (MBC, 1984). These values were substantially less than the earlier production estimate of 4.0 g DW/m^2 by Stephens et al. (1974). The causes of this relatively large discrepancy are not clear. Nevertheless, these estimates are approximately one-fourth to one-half of that (9.4 g DW/m^2) estimated for the littoral fishes of Upper Newport Bay (Allen, 1982). Overall, the annual production estimates for Long Beach Harbor are low compared to those of various marine and estuarine studies summarized by Allen (1982). However, the harbor productivity estimate was for trawl-captured fishes only and excludes a major component of the harbor ichthyofauna, the water column fishes. The inclusion of this important component would undoubtedly increase production estimates substantially. Given this caveat, the assertion that harbors are productive fish habitats in southern California is still reasonable.

In summary, southern California harbors, particularly the Los Angeles–Long Beach Harbor complex, are productive and heterogeneous environments that can support abundant, diverse fish assemblages if good water quality is maintained. Harbors combine the attributes of extensive, nearshore soft-bottom habitat with those of coastal pelagic, sandy and rocky shores, and shallow rock reefs. Not surprisingly, California harbors represent composite habitats with fish assemblages sharing close affinities to those of bay and estuarine, exposed coast surf zone, inner shelf, and coastal pelagic habitats. In addition, hard substrates provided by harbor development add a variety of reef species to the mix. Last, note that most of what we know about the fish assemblages of harbor environments is restricted to southern California sites. Quantitative studies of harbors and marinas in northern and central California are virtually nonexistent in the literature and would be excellent subjects for future investigations and publications.

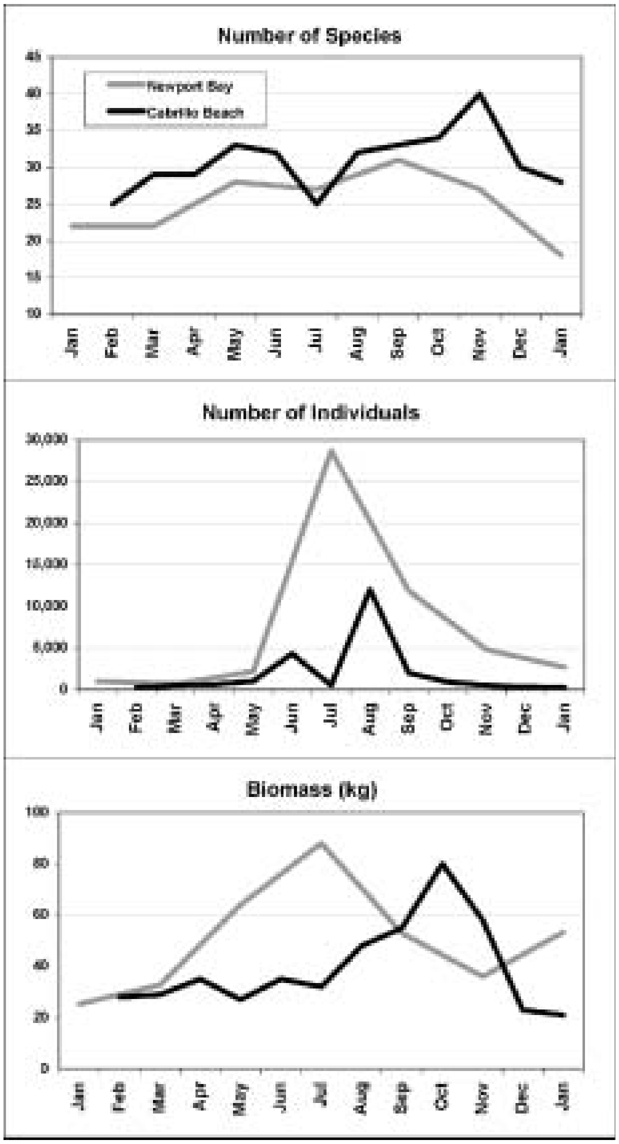

FIGURE 6-9 Seasonal trends in species richness, abundance, biomass of fishes at Cabrillo Beach, Los Angeles Harbor and Upper Newport Bay (after Allen et al., 1983 and Horn and Allen, 1981).

Recommendations for Future Studies

As with most other California marine fish habitats, many studies are needed if we are to deepen our understanding of the structure and function of nearshore fish assemblages in California and Baja California. Future investigations worthy of attention include, but are certainly not limited to the following:

1. Conduct comprehensive surveys in the surf zone and adjacent drift algal beds, coastal pelagic zone and harbors in selected areas representing central, southern, and Baja California to establish baseline information on their fish assemblages using an array of the most effective types of sampling gear. We believe that it is particularly critical that new surveys of surf zones in Southern California are undertaken to update that reported, incompletely, decades ago in Carlisle et al. (1960).
2. Initiate long-term surveys (of 5 or more years) for juvenile-adult assemblages in all of the nearshore habitats discussed in this chapter. Such studies yield an understanding of interannual variability and the effects of pulsed disturbances such as flooding or ENSO events on these assemblages.
3. Estimate production for fish populations in a variety of nearshore systems, particularly in harbors. Such information is critical to our understanding of ecosystem function and is also important in the estimation of "habitat value" for mitigating of habitat loss from human activities.
4. Determine the sources of nutrient enrichment (e.g., runoff, upwelling, pollution) in harbor environments and their impacts on harbor fish assemblages in California.

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