Jeffrey N. Cross

INTERTIDAL FISHES OF SOUTHERN CALIFORNIA

Of all the coastal fish assemblages in southern California, the cryptic demersal fishes that inhabit the rocky intertidal (that region exposed during low tide) and the adjacent shallow subtidal are the least well known. Previous published studies include work on movement (Williams 1957, Richkus 1978), distribution (Williams 1954, Davis 1957), and life histories (Stephens *et al.* 1970, Wells 1979). Several unpublished life history studies exist (Wells 1974, Dayneko 1975). The objectives of this study are to document the species that occur in the intertidal, the habitats they occupy, and the foods they consume.

Ten species of fish were taken in over 50 collections; six species are residents of the intertidal, while the remaining species are infrequent intertidal visitors. The number of resident species collected at a site ranged from three to six; sites with fewer resident species had fewer available microhabitats. Habitat and, to a lesser extent, food separations were observed among the fishes. Compared with intertidal fish faunas from higher latitudes, there are fewer intertidal species in southern California, but the functional organization of the assemblages is similar.

STUDY AREA AND METHODS

Data were collected from eight mainland and two island stations (Figure 1). Collections were made on the lowest minus tides. In summer (April-September) low tides occurred at night and were lowest of the years; in winter (October-March) low tides occurred during the day.

Fish were collected in tidepools and beneath rocks outside of tidepools. In tidepools, fish were anesthetized with quinaldine diluted to 10% in ethanol and collected with small dip nets. Outside the tidepools, rocks were moved and the fish beneath them were collected by hand. Fish were fixed in 10% buffered formalin and preserved in ethanol. Stomachs were removed from selected specimens and the contents were identified using a binocular microscope.

RESULTS

Ten species of fish and 970 individuals were collected in 42 collections at 10 stations (Table 1, Figure 1). Ten species of fish occurred in 36 tidepool collections with a mean density of 17.3 fish/m^2 (SD = 16.3). Four species of fish occurred in 16 beneath-rock collections with a mean density of 0.3 fish/rock (SD = 0.6). Six species of fish (California clingfish, wooly sculpin, opaleye, rockpool blenny, reef finspot, and spotted kelpfish) were present in more than 30%

Table 1. Distribution of fishes collected in the rocky intertidal.

Family-scientific name	Common name	La Jolla	Corona del Mar	Palos Verdes-Pt. Fermin	Palos Verdes-White Point	Palos Verdes-Flat Rock Pt.	Malibu Creek	Pt. Dume	Ventura	Islands
Gobiesocidae										
Rimicola muscarum	kelp clingfish					X		X		
Gobiesox rhessodon	California clingfish	X	X	X		X		X		X
Cottidae										
Clinocottus analis	Wooly sculpin	X	X	X	X	X	X	X	X	X
Oligocottus rubellio	Rosy sculpin				X					
Artedius corallinus	Coralline sculpin		X							
Kyphosidae										
Girella nigricans	Opaleye	X	X	X	X	X	X	X	X	X
Embiotocidae										
Micrometrus aurora	Reef surfperch	X	X	X				X		X
Blenniidae										
Hypsoblennius gilberti	Rockpool blenny	X	X	X	X	X	X	X	X	X
Clinidae										
Paraclinus integripinnis	Reef finspot	X	X			X				
Gibbonsia elegans	Spotted kelpfish	X	X	X	X			X		X

of the collections (Table 2), comprised more than 98% of the individuals collected, and are considered intertidal residents. The remaining species were collected infrequently and are considered visitors or transients.

SPECIES ACCOUNTS

Kelp clingfish: Two individuals of this small clingfish were collected in the lower intertidal attached to *Egregia menziesii*.

California clingfish: This small clingfish was collected exclusively beneath rocks and boulders at most sites (Table 1). It occurred more frequently in the beneath-rock collections than in tidepools (Table 2). The diet of the clingfish was dominated by small crustaceans, primarily gammarid amphipods and harpactacoid copepods; gastropods and polychaetes were also consumed (Table 3).

Table 2. Frequency of occurrence and percent of the catch of intertidal fish in tidepools (N = 36) and beneath rocks (N = 16).

	Frequency of Occurrence (%)		Percent of Catch (%)	
	Tidepools	Beneath Rocks	Tidepools	Beneath Rocks
Kelp clingfish	6		1	
California clingfish	14	38	2	46
Wooly sculpin	86	19	68	9
Rosy sculpin	3		1	
Coralline sculpin	3		1	
Opaleye	31		6	
Reef surfperch	11		1	
Rockpool blenny	53	19	6	7
Reef finspot	36	31	15	35
Spotted kelpfish	42		4	

Wooly sculpin: This was the most abundant and frequently collected species in the intertidal; it occurred primarily in tidepools and was present in more than 85% of the pools sampled (Table 2). Wooly sculpins were associated with a variety of substrates, including sand, mixtures of gravel and small rocks, and bedrock, and was frequently observed in open areas of tidepools. Its diet consisted of a wide variety of crustaceans (especially gammarid amphipods and sphaeromatid isopods) and several families of tube-dwelling and errant polychaetes (Table 3).

Table 3. Frequency of occurrence (%) of major prey taxa in intertidal fish stomachs. Min = minimum size (mm TL) of fish examined; max = maximum size; N = sample size.

	Algae	Polychaeta	Gastropoda	Copepoda	Cirripedia	Isopoda	Amphipoda	Decapoda	Insecta	Osteichthyes	Min.	Max.	N
California clingfish		8	23	38	8	23	69				29	50	14
Wooly sculpin		48	12	30	9	45	79	18		3	16	106	44
Opaleye	77	16	8	31	8	8	38		8		28	90	24
Rockpool blenny	29	29	57	14			43				39	104	22
Reef finspot						64	76				26	60	38
Spotted kelpfish	16	16	32	11		32	79	21			39	123	27

Rosy sculpin: One individual was collected at White Point (Table 1).

Coralline sculpin: One individual was collected at Corona del Mar (Table 1).

Opaleye: Small, juvenile opaleyes were collected at all sites in relatively deep tidepools with small boulders (Table 1). This laterally compressed fish occurred in loose aggregations in the water column; when disturbed, the fish would dash for cover beneath boulders. With increasing size opaleye move into the subtidal and eventually take up residence as adults in kelp beds. The diets of intertidal opaleye were dominated by algae (primarily *Rhodophyta*); crustaceans (gammarid amphipods and harpactacoid copepods), polychaetes, gastropods, and insects were also consumed (Table 3).

Reef surfperch: Juvenile reef surfperch were collected only during the summer (July-August). Schools of adults were commonly observed in the shallow subtidal at many sites; females apparently release their live young in very shallow water. The stomachs of most individuals examined were empty; a few contained algae and crustacean fragments.

Rockpool blenny: This small, cryptic blenny was present at all sites (Table 1) and was the second most frequently collected intertidal fish (Table 2). It was associated predominantly with crevices and holes in and amongst rocks, cobble, and bedrock and was occasionally collected beneath rocks outside of tidepools (Table 2). Rockpool blennies consumed a wide variety of foods including gastropods (limpets and chitons), crustaceans (primarily gammarid amphipods), polychaetes, and algae (Table 3).

Reef finspot: This small, cryptic clinid was collected at only a few sites (Table 1), but was second in abundance after the wooly sculpin (Table 2). It occurred in tidepools associated with coralline algal (*Bossiella* spp., *Callithamnion* spp., *Corallina* spp., *Lithothamnium* spp., and

Lithothrix sp.) and less frequently with the red algal turf (*Gastroclonium* sp., *Gelidium* spp., *Gigartina* spp., *Laurencia* spp., and *Polysiphonia* spp.). Reef finspots were also collected beneath rocks outside of tidepools (Table 2). The diet of the reef finspot consisted almost exclusively of crustaceans (gammarid amphipods and sphaeromatic isopods) (Table 3).

Spotted kelpfish: This medium-sized clinid was the third most frequently collected species (Table 2). It occurred primarily in tidepools with a red algal turf and, less often, coralline algae. The diet of the spotted kelpfish was dominated by crustaceans (gammarid amphipods, idoteid and sphaeromatid isopods, and decapods of the suborder *Reptantia*); gastropods (limpets and snails), polychaetes, and algae were also consumed (Table 3).

DISCUSSION

Intertidal fishes in southern California generally occupy separate microhabitats; some species have more restricted distributions among the microhabitats than others. For example, the spotted kelpfish occurs primarily in the red algal turf and was not collected at sites lacking the turf. The wooly sculpin, on the other hand, occurs on virtually all intertidal substrates not covered with algae. The spotted kelpfish is a habitat specialist relative to the wooly sculpin.

The distribution of resident species among the sites reflects the distribution of available microhabitats; sites with fewer microhabitats produced fewer resident species. While some microhabitats were not present in the intertidal, diving observations revealed that the microhabitats and their respective species were present in the shallow subtidal. Physical and environmental differences among the sites (different rock types, exposure, sedimentation, etc.) play a major role in determining which microhabitats are available, and thus, account for differences in the number of resident species collected.

When the intertidal fish assemblage of southern California is compared with assemblages found in central California and Washington, one finds that the number of species in southern California is less than half that found at the other locations (Table 4). Tidepool fish densities are similar at the three locations (Table 4), but several microhabitats present in the intertidal in central California and Washington (*Mytilus, Phyllospadix, Chlorophyta,* and *Phaeophyta*) are rare or absent in the intertidal in southern California (they are present at several sites in the subtidal). Beneath-rock densities and the proportion of rocks rolled yielding fish are much lower in southern California than at the other locations (Table 4).

Table 4. Comparison of intertidal fish assemblages in southern California, central California (Piedras Blancas; Cross, unpubl. data), and Washington (Strait of Juan de Fuca; Cross 1981). $\bar{X}$ = mean, SE = one standard error. Two types of intertidal sites were sampled in Washington.

		Southern California	Central California	Washington rocky headlands	Washington cobble beaches
Number of resident species		6	14	16	12
Tidepool fish densities (fish/m^2)	$\bar{X}$	17.3	15.1	28.0	18.5
	SE	2.7	1.8	2.6	1.4
Beneath-rock fish densities (fish/rock)	$\bar{X}$	0.3	1.4	3.2	1.2
	SE	0.2	0.2	0.4	0.2
Percent of rocks rolled yielding fish		8	73	87	56

Several hypotheses can be suggested to account for the low number of species and beneath-rock densities in southern California and they fall into two categories: 1) Environmental variability, and 2) human disturbance. Communities inhabiting environmentally variable areas generally contain fewer species than communities inhabiting environmentally stable areas. The number of intertidal fish species collected at sites in Washington was directly correlated with the number of available microhabitats and environmental predictability (Cross 1981). In southern California, nearshore surface water temperatures in Santa Monica Bay have an annual range of 14°C (11°-25°C) (Hyperion Treatment Plant Annual Reports) while the range is only 7°C (7°-14°C) in Washington (Cross 1981). Interestingly, five of the six resident species in southern California are from families with tropical affinities, while only one species (wooly sculpin) is from a family with temperate affinities. Santa Ana winds frequently blow offshore in southern California in the winter when low tides occur during the day; these hot, dry winds cause an increase in tidepool temperatures and may, through increased respiration, drive the dissolved oxygen cencentration low enough to be limiting to the fishes (L. Allen, pers. comm.). Increases in sedimentation and substrate instability were correlated with low numbers of intertidal fish species in Washington (Cross 1981); periodic accumulations of sediments were observed at several sites in southern California. Environmental variability can limit the number of intertidal species directly by imposing conditions beyond the physiological tolerances of fish, or indirectly by imposing conditions beyond the physiological tolerances of the algae and invertebrates that comprise the microhabitats.

Human disturbance may also be responsible for the reduced number of intertidal fish species in southern California. The decrease in abundance of kelp *Macrocystis pyrifera* off the Palos Verdes peninsula was partially attributed to increases in the amount of sewage solids discharged on the Palos Verdes Shelf; likewise, the return of kelp and increase in the number of intertidal algal species at Palos Verdes was partially attributed to decreases in sewage solid emissions (Wilson *et al.* 1980, Harris 1980). Historically, an extensive series of fish collections (now deposited at the Los Angeles Museum of Natural History) was made by Boyd Walker of UCLA in the 1950's at Palos Verdes. Unfortunately, Walker's collections are not directly comparable with these because of differences in sampling methodology. Walker used rotenone and collected from a larger area that often included the subtidal. Consequently, Walker's species lists are more extensive, but the fishes I call intertidal residents are among his most abundant species.

Other types of human disturbance that may have contributed to a reduction in number of intertidal fish species include collecting and trampling. Rocky headlands in southern California are popular areas for sightseeing and food gathering; Impacts from human usage may be substantial. Twenty years ago mussel beds were thick and extensive in the intertidal at Pt. Fermin (H. Schafer, pers. comm.); today mussels grow individually and in small scattered clumps and do not form even small beds. Removal of mussels for food and fish bait may have contributed significantly to their decline. In central California and Washington, the distributions of several species of fish are centered in mussel beds.

CONCLUSIONS

Despite the differences in the number of species collected in southern California, central California, and Washington, the functional organization of the three assemblages is quite similar. Sixty to 70% of the species in each assemblage spend all but their larval existence in the intertidal (primary residents). Thirty to 40% of the species in each assemblage spend part of their lives in the intertidal and part of the subtidal (secondary residents). In each assemblage there are habitat generalists and specialists; there are more specialist species than generalist species, but on a per species basis the generalists are more abundant. Approximately 70% of the species in each assemblage are carnivores and about 30% are omnivores; in about half of the omnivores, algae comprises more than 50% of the diet. Extension of these studies to the Pacific coast of Baja would provide further useful comparisons.

Intertidal fish are important for several reasons. Living in a patchy and temporally dynamic environment, intertidal fish exhibit a variety of interesting adaptations. Because they are small, easily collected, and adaptable, intertidal fish have profitably served as laboratory animals for experiments on, for example, habitat-selection (Nakamura 1976), physiological adaptations (Graham 1970), and reproduction (Hubbs 1966). Experiments to elucidate aspects of their ecologies also have been conducted in the field (Khoo 1974). Intertidal fish occur in small, isolated populations and are, therefore, excellent models of evolution, an aspect that has been largely overlooked in the past.

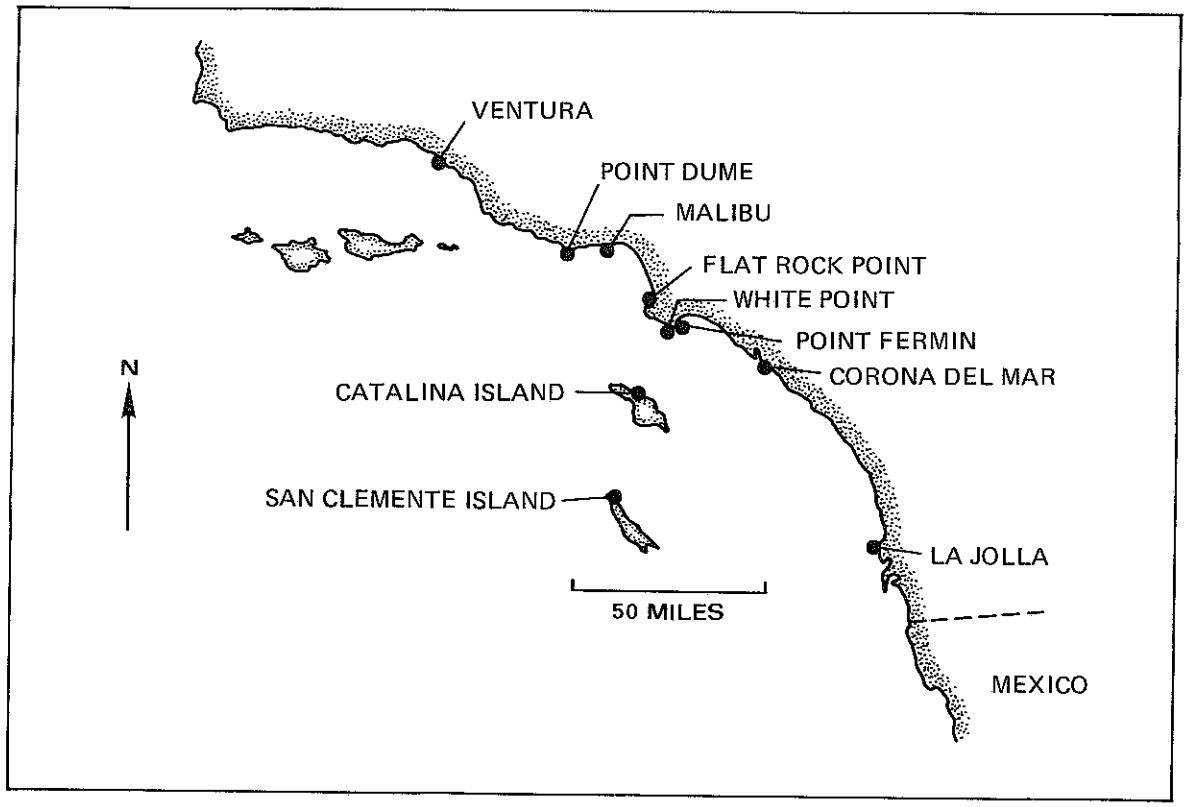

Figure 1. Sampling Locations

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