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FOOD HABITS OF DEMERSAL FISH IN SANTA MONICA BAY

The food habits of demersal fishes on the mainland shelf off southern California are not well known. Published food habits data often consist of taxonomic lists of prey (e.g. Kleppel *et al.* 1980) that, while exhaustively itemizing the diet of each predator, provide little information on where fish feed in their environment and the relationship of the diet of the predator to the potential available prey in the sediments. Our objectives were to increase the knowledge of the food habits of the common demersal fishes on the mainland shelf and compare the gut contents of the predators to the animals collected in sediment grab samples.

Instead of using a traditional taxonomic listing of invertebrates found in fish stomachs and grab samples, an alternative approach based on life history criteria was used. Invertebrates were classified into motility modes based on their life styles, i.e., surface-motile, burrowing, tubiculous, sessile and unclassified. The gut content and grab data were analyzed according to this scheme.

Longspine combfish, speckled sanddab, Pacific sanddab, and Dover sole consumed mostly surface-motile prey. California tonguefish preyed mainly on burrowing taxa. Hornyhead turbot ate mostly tubiculous prey. English sole and yellowchin sculpin consumed a variety of taxa from several motility groups. Most of the dominant organisms found in the fish guts were also present in the grab samples. The only fishes that preyed substantially on taxa not found in the grabs (mysids, copepods, and tunicates) were the sanddabs. Most of the organisms found in the grab samples were also present in the fish guts. Several taxa (e.g. gammarid amphipods) occurred at low frequencies in the grabs and high frequencies in the fish guts indicating positive selection by the fish. Alternatively, several taxa (e.g. bivalves) occurred at high frequencies in the grabs, but low frequencies in the fish guts indicating negative selection by the fish.

METHODS

Four trawls and four grabs were made at station 6-4 in Santa Monica Bay between 1900 on June 12 and 0700 on June 13, 1980. Station 6-4 is located on the 60 m isobath about 10 km north of the Hyperion 5-mile outfall. LORAN C coordinates for the station are 28161.6 and 41139.5. The trawls were made in the manner described by Word and Mearns (1979); the grabs were made in the manner described by Word (1977).

Eight species of fish were collected and preserved from each trawl: Dover sole, English sole, hornyhead turbot, California tonguefish, Pacific sanddab, speckled sanddab, longspine combfish, and yellowchin sculpin. A maximum of 10 individuals from each species was collected from each trawl and processed by the methods described by Kleppel *et al.* (1980). The grab samples were washed through a 1.0 mm screen and the retained contents were preserved.

Instead of taxonomically listing invertebrates found in gut and grab samples, we placed them in one of five motility classifications: surface-motile, burrowing, tubiculous, sessile, and unclassified. Motility determinations were based on reference material (Fauchald and Jumars 1979, Enequist 1950, and Thompson 1982) and personal communications with Project biologists. This approach was adopted because fish often have fixed foraging modes and consequently search only in specific parts of their total environment. In a traditional presentation of fish food habits, a species that consumes a wide variety of prey is termed a generalist, but if the prey all live in one of the available microhabitats (e.g. in tubes in the surface sediments) within the fish's environment, the species could also be described as a specialist. A similar approach was used by Hulberg and Oliver (1978).

RESULTS

Although the trawls and grabs were taken over a 12-hour period, preliminary data analyses showed that the composition and proportions of the gut and grab samples were very similar among the four samples. Thus, the samples were combined to make the gut analyses presented in Table 1 and grab analyses presented in Table 2.

A total of 161 taxa was identified from the alimentary tracts of all the fish examined. The total numbers of prey species consumed per predator ranged from 38 for Pacific sanddab to 93 for Dover sole. A total of 84 taxa was identified in the grab samples.

Dover sole consumed mainly crustaceans from the surface-motile group, primarily the ostracod *Euphilomedes* sp. (Table 1). Tubiculous and burrowing gammarid amphipods also comprised a substantial portion of the diet. Dover sole consumed far more prey taxa (93) than any of the other species examined.

Pacific sanddab consumed mostly surface-motile prey, primarily the mysid *Neomysis* sp. Several pelagic and planktonic items, including tunicates (Thaliacea), comprised a significant proportion of the diet.

The diet of English sole was comprised of tubiculous animals, primarily the polychaete *Cistena* sp., sessile organisms, primarily the bivalve *Tellina* sp., and surface motile prey. It was second to Dover sole in the number of prey items consumed (63).

The hornyhead turbot fed mainly on tubiculous polychaetes, especially onuphids (*Nothria* sp.), maldanids, and spionids. The number of prey taxa consumed (46) was among the lowest of the species examined.

California tonguefish fed primarily on burrowing crustaceans, primarily phoxocephalid amphipods. Surface-motile crustaceans also contributed substantially to the diet. The number of taxa consumed (50) placed tonguefish in the middle of the range of species examined.

The diet of speckled sanddab was dominated by surface-motile crustaceans, particularly the ostracod *Euphilomedes sp.* Planktonic crustaceans, especially calanoid copepods, and tubiculous crustaceans comprised a significant part of the diet. The number of taxa consumed (54) fell near the middle of the range for the species examined.

Table 1. Mean composition (percent) of identified prey items based on motility modes.

	Surface-motile	Burrowing	Tubiculous	Sessile	Unclassified	Total
Dover sole						
(Microstomus pacificus)						
(N = 38)						
% Crustacea	50.7	18.5	10.7	0.4	0.2	80.5
% Polychaeta	5.3	0.7	10.2	0	0	16.2
% Mollusca	0.2	0.5	0	2.5	0	3.2
% Misc.	0	0.2	0	0.2	0	0.4
TOTAL %	56.2	19.9	20.9	3.1	0.2	~100
No. of Prey Taxa	29	19	31	12	2	93
"Dominant" Taxa	*Euphilomedes* sp. (43.8)	Phoxocephalidae (17.7)	*Photis* sp. (8.0)	*Tellina* sp. (1.4)	*Euphausia* sp. (0.2)	
Pacific sanddab						
(Citharichthys sordidus)						
(N = 40)						
% Crustacea	54.2	3.9	2.0	0	8.0	68.1
% Polychaeta	3.1	1.4	3.8	0	0	8.3
% Mollusca	0	0	0	1.9	0	1.9
% Misc.	0.5	2.1	0	0	19.0	21.6
TOTAL %	57.8	7.4	5.8	1.9	27.0	~100
No. of Prey Taxa	12	7	6	2	11	38
"Dominant" Taxa	*Neomysis* sp. (34.9)	Phoxocephalidae (1.6)	*Spionidae* (1.6)	*Tellina* sp. (1.3)	Thaliacea (8.2)	
English sole						
(Parophrys vetulus)						
(N = 31)						
% Crustacea	13.0	3.7	5.2	0.2	0	22.1
% Polychaeta	4.6	6.3	39.1	0	0	50.0
% Mollusca	0	0.5	0	20.6	0	21.1
% Misc.	0	0.5	0	0	6.8	7.3
TOTAL %	17.6	11.0	44.3	20.8	6.8	~100
No. of Prey Taxa	19	13	19	9	3	63
"Dominant" Taxa	*Euphilomedes* sp. (5.7)	Capitellidae (3.6)	*Cistena* sp. (25.6)	*Tellina*, sp. (17.2)	Nematoda (6.7)	
California tonguefish						
(Symphurus atricauda)						
(N = 39)						
% Crustacea	20.3	56.0	10.5	0.4	0.5	87.7
% Polychaeta	7.3	0	4.0	0	0	11.3
% Mollusca	0	0	0	0.8	0	0.8
% Misc.	0	0	0	0	0	0
TOTAL %	27.6	56.0	14.5	1.2	0.5	~100
No. of Prey Taxa	24	10	10	4	2	50
"Dominant" Taxa	*Euphilomedes* sp. (4.4)	Phoxocephalidae (37.2)	*Ampelisca* sp. (6.0)	*Tellina* sp. (0.4)	*Candacia* sp. (0.3)	
Longspine combfish						
(Zaniolepis latipinnis)						
(N = 30)						
% Crustacea	53.8	9.9	3.9	0	1.5	69.1
% Polychaeta	14.9	1.0	10.9	0	0	26.8
% Mollusca	0.2	0	0	0	0	0.2
% Misc.	0	2.4	0	1.3	0	3.7
TOTAL %	68.9	13.3	14.8	1.3	1.5	~100
No. of Prey Taxa	25	12	10	1	2	50
"Dominant" Taxa	*Gnathia* sp. (14.6)	Phoxocephalidae (2.7)	*Cistena* sp. (4.5)	Anthozoa (1.3)	*Calanus* sp. (0.9)	
Yellowchin sculpin						
(Icelinus quadriseriatus)						
(N = 26)						
% Crustacea	31.2	21.8	23.2	0	10.7	86.9
% Polychaeta	8.9	0	3.8	0	0	12.7
% Mollusca	0	0	0	0	0	-
% Misc.	0	0	0	0	0	-
TOTAL %	40.1	21.8	27.0	0	10.7	~100
No. of Prey Taxa	22	8	6	-	3	39
"Dominant" Taxa	Cylindroleberidae (10.8)	Phoxocephalidae (8.7)	*Photis* sp. (15.0)		Calanoida (7.7)	

	Surface-motile	Burrowing	Tubiculous	Sessile	Unclassified	Total
Speckled sanddab *(Citharichthys stigmaeus)* (N = 39)						
% Crustacea	41.1	2.7	16.6	0.2	23.3	83.9
% Polychaeta	6.3	0.2	4.5	0	0	11.0
% Mollusca	0	0	0	0.4	0	0.4
% Misc.	0	0	0	0.2	4.3	4.5
TOTAL %	47.4	2.9	21.1	0.8	27.6	~100
No. of Prey Taxa	24	6	13	3	8	54
"Dominant" Taxa	*Euphilomedes* sp. (24.0)	Phoxocephalidae (1.5)	*Photis* sp. (6.4)	Pelecypoda (0.4)	Calanoida (15.7)	
Hornyhead turbot *(Pleuronichthys verticalis)* (N = 39)						
% Crustacea	7.9	7.8	4.8	0	0	20.5
% Polychaeta	3.4	1.4	73.6	0	0	78.4
% Mollusca	0	0	0	0.7	0	0.7
% Misc.	0	0	0	0.3	0	0.3
TOTAL %	11.3	9.2	78.4	1.0	0	~100
No. of Prey Taxa	15	5	24	2	-	46
"Dominant" Taxa	*Euphilomedes* sp. (3.9)	Phoxocephalidae (7.8)	*Nothria* sp. (19.1)	*Modiolus* sp. (0.7)		

Longspine combfish preyed primarily on surface-motile organisms, particularly the isopod *Gnathia* sp. (Table 1). Tubiculous and burrowing animals contributed a small portion of the diet. The number of taxa consumed (50) was near the middle of the range for the species examined.

Yellowchin sculpin primarily consumed crustaceans from several motility groups; surface-motile organisms especially ostracods, and tubiculous and burrowing amphipods dominated the diet. They consumed the second lowest number of prey taxa (39) of the species examined.

The grab samples were dominated by the burrowing bivalve *Parvilucina* sp., the surface-motile ostracod *Euphilomedes* sp., and several tubiculous polychaetes (Table 2).

DISCUSSION

Based on the prey-motility approach, the diets of the eight species of fish examined can be classified as follows: Dover sole, Pacific sanddab, speckled sanddab, and longspine combfish consumed primarily surface-motile prey. Dover sole and longspine combfish took most of their prey from the sediment surface, while the sanddabs took a substantial amount from the overlying water. California tonguefish preyed mainly on burrowing crustaceans and hornyhead turbot ate primarily tubiculous polychaetes. Yellowchin sculpin and English sole preyed on a variety of taxa from several motility groups; surface-motile prey predominated in the diet of the yellowchin sculpin and tubiculous prey predominated in the diet of the English sole.
face-motile prey predominated in the diet of the yellowchin sculpin and tubiculous prey predominated in the diet of the English sole.

Based on a traditional approach, the diets of the fish can be classified as follows: crustaceans were the principal prey of six species (California tonguefish, speckled sanddab, Dover sole, yellowchin sculpin, longspine combfish, and Pacific sanddab). Polychaetes were the principal prey of hornyhead turbot and English sole. Molluscs did not dominate the diet of any species and contributed significantly only to the diet of English sole.

Table 2. Mean composition (percent) of grab sampled organisms (retained on 1.0 mm screen) based on motility mode.

	Surface-motile	Burrowing	Tubiculous	Sessile	Unclassified	Total
% Crustacea	24.3	1.5	1.1	0.1	0.7	27.7
% Polychaeta	2.4	2.0	19.4	-	-	23.8
% Mollusca	2.1	31.5	-	14.4	-	48.0
% Misc.	0.1	0.4	0.1	-	-	0.6
TOTAL	28.9	35.4	20.6	14.5	0.7	~100
No. of Taxa	16	9	19	9	2	55
"Dominant" Taxa	*Euphilomedes* sp. (34.5)	*Parvilucina* sp. (31.5)	*Spiophanes* sp. (7.4)	*Axinopsida* sp. (7.9)	Copepoda (0.7)	
	Bittium sp. (1.8)	Phoxocephalidae (1.5)	*Prionospio* sp. (3.8)	*Tellina* (4.1)		
	Chaetozone sp. (0.8)	*Mediomastus* sp. (1.1)	*Cistena* sp. (3.0)	*Mysella* sp. (0.9)		

Differences in the information content of the two approaches are apparent. For example, according to the traditional approach, California tonguefish are classified as crustacean feeders along with five other species of fish. Using the prey-motility approach, California tonguefish is the only crustacean feeder that preys primarily on burrowing taxa.

Most of the dominant organisms found in the fish guts were also present in the grab samples. Only the sanddabs consumed a substantial amount of prey not represented in the grab samples: mysids and pelagic tunicates comprised 43% of the diet of the Pacific sanddab and calanoid copepods comprised 16% of the diet of the speckled sanddab.

Most of the organisms found in the grab samples were also present in the fish guts. Several taxa (e.g. gammarid amphipods: Phoxocephalidae and *Photis* sp.) occurred at low frequencies in grab samples and high frequencies in the gut samples indicating positive selection on the part of the fishes. Positive selection may result because the organisms are more available to the predators than other prey, or the organisms are preferred over other more available prey and are actively sought by the fishes. Several taxa (e.g. bivalves: *Parvilucina* sp.) occurred at high frequencies in the grab samples, but low frequencies in the fish guts indicating negative selection on the part of the fishes.

Bivalves may be negatively selected by the fish because they have hard shells and only predators with specialized dentition can feed on them, or because bivalves are buried in the sediments and only predators with specialized digging behaviors can reach them. English sole, the only fish that consumed bivalves to any extent, showed positive selection for *Tellina* sp. and negative selection for *Parvilucina* sp. (which was an order of magnitude more abundant than *Tellina*) and *Axinopsida* sp. (which was equal in abundance to *Tellina*). *Tellina* has a longer, flatter, and thinner shell than the other species and, in core samples of the top 10 cm of bottom sediments, 52% of the individuals collected occurred in the top 2 cm. Eighteen percent of the *Parvilucina* collected and 90% of the *Axinopsida* collected occurred in the top 2 cm of sediments. *Parvilucina* may escape predation by living deeper in the sediments; *Axinopsida* may escape predation by having valves that are difficult to crush.

CONCLUSION

The approach taken in this study of classifying invertebrates by life history criteria is quite useful in identifying not only what fish eat, but also where they forage and what their interspecific trophic relationships are. While our approach requires more effort (to obtain life history information for the invertebrates) than a taxonomic list of prey, the information gain (increased understanding of fish-benthos and fish-fish relationships) outweighs the costs.

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REFERENCES

Enequist, P. 1950. Studies on the soft-bottom amphipods of the Skagerrak. Zool. Bidrag fran Uppsala. 28:297-492.

Fauchald, K., and P. A. Jumars. 1979. The diet of worms: A study of polychaete feeding guilds. Oceanogr. Mar. Biol. Ann. Rev. 17:193-284.

Hurlberg, L. W., and J. S. Oliver. 1978. Prey availability and the diets of two co-occurring flat fish. pp. 29-36, *In*: Fish food habits studies. S. J. Lipovsky and C. A. Simenstad, eds.; University of Washington, Sea Grant, Seattle, WA.

Kleppel, G. S., J. Q. Word, and J. Roney. Demersal fish feeding in Santa Monica Bay and off Palos Verdes, in SCCWRP Bien. Rep. 1979-1980; Bascom, W., ed.; Long Beach, CA, pp. 309-318.

Thompson, B. E. 1982. Food resource utilization and partitioning in macrobenthic communities of the southern California borderland. Ph.D. dissertation, University of Southern California, Los Angeles, CA

Word, J. Q. 1977. An evaluation of benthic invertebrate sampling devices for investigating feeding habits of fish. *In* Fish food habits studies. C. A. Simenstad and S. J. Lipovsky, , eds.; University of Washington, Sea Grant, Seattle, WA; pp. 43-45.

Word, J. Q., and A. J. Mearns. 1979. 60-meter control survey off southern California. T. M. 229. Southern California Coastal Water Research Project, Long Beach, CA