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FOODS OF COASTAL FISHES DURING BROWN SHRIMP, *PENAEUS AZTECUS*, MIGRATION FROM TEXAS ESTUARIES (JUNE-JULY 1981)

During May, June, and July, brown shrimp, *Penaeus aztecus*, migrate from Texas bays and estuaries to offshore waters. These shrimp are, for the most part, smaller than the 114 mm total length (TL) legal fishing limit. To prevent overfishing of these juvenile and subadult (60-130 mm TL) shrimps and to allow them to move farther offshore during this period, the Gulf of Mexico Fishery Management Council and the State of Texas simultaneously prohibited nocturnal shrimping from the shoreline out to 370 km. The closure remained in effect over the period 22 May through 15 July 1981. The rationale for the closure was an expected increase in yield from additional growth of the protected brown shrimp and from elimination of waste due to discarding of undersized brown shrimp (Gulf of Mexico Fishery Management Council 1980; Caillouet and Koi 1981).

NOAA's RV *Oregon II* conducted a trawl survey of shrimp size distribution and abundance by depth in the closure area from 4 June through 3 July 1981. The survey provided us the opportunity to describe the foods of Texas coastal fishes while evaluating the natural mortality of brown shrimp due to predation. This paper examines the foods of 81 species of fishes collected during the shrimp survey. We present size- and depth-related changes in diet for the more abundant fishes, and further examine predation on penaeid shrimps.

Materials and Methods

Fish samples were taken from trawl catches by the RV *Oregon II* on 100 stations in 9-64 m waters off the Texas coast (Fig. 1). The survey was conducted from 4 June through 3 July 1981. All trawls were made at night (brown shrimp are nocturnally active) with a 12.2 m semiballoon trawl rigged with a tickler chain and 2.4 m × 1.0 m wooden doors towed at 3 kn. Four stations south of Galveston Bay were repeated at 2-wk intervals; thus, a total of 108 trawl tows were made over the entire coastline. Details of the sampling strategy are given by Matthews (1982). Species composition, abundance, and biomass data for fishes and invertebrates were recorded and standardized to catch per 30-min tow for 89 of the 108 trawl catches. Only penaeid shrimp data were recorded for the other 19 catches. All fishes from each catch (up to a 45 kg maximum) were labelled and frozen for stomach contents analysis.

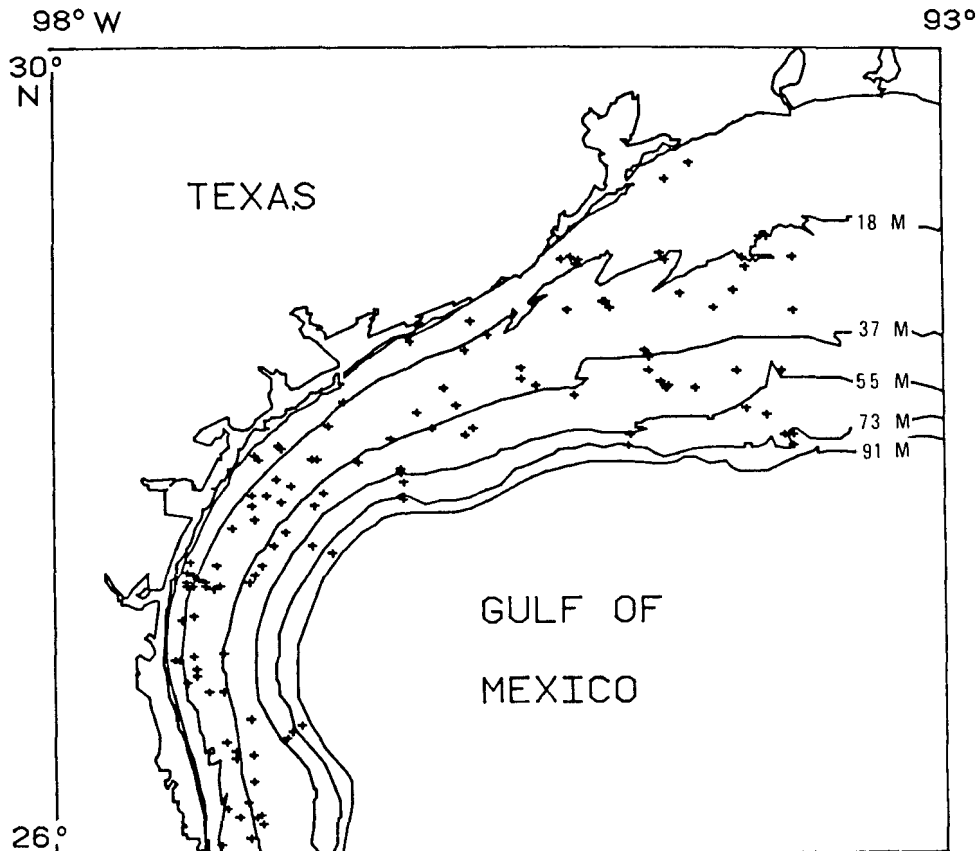


FIGURE 1.—RV *Oregon II* shrimp survey sites off the Texas coast, June–July 1981.

In the laboratory, each sample was thawed and the fishes were sorted and measured to the nearest millimeter (standard length for most genera; disc width or total length for others). In most cases, fishes <150 mm in length or width were discarded, since they were unlikely shrimp predators. However, in samples consisting of at least 75% potentially carnivorous fishes of <150 mm, a minimum of 50% of these fishes was examined. All discards were recorded.

Each fish was examined by opening the abdomen and removing the stomach. Empty stomachs were recorded. Stomach contents were identified visually, in some cases with a dissecting microscope, to 10 broad taxonomic categories: polychaetes, molluscs, holothurians, mysids, stomatopods, shrimps, crabs, squids, fishes, and octopi. Detritus was also recorded as a discrete category. Penaeid shrimps and fishes were further identified to genus and species when possible. Tail lengths of *Trachypenaeus* and *Sicyonia* were recorded as falling into one of a series of 5 mm size classes, while those of *Penaeus aztecus* were measured to the nearest millimeter. Fishes were sub-

sequently grouped into about 25, 50, or 100 mm size classes to examine size- and depth-related differences in diet. However, many species were represented by too few individuals to justify comparison or showed no size-related diet changes; thus, data from only a few species are presented with size-class information. Results are presented as frequency of occurrence of the various food items in stomachs containing food. Food categories having a 30% or greater frequency of occurrence are referred to as “major,” while those having <30% frequencies are referred to as “minor.”

Results and Discussion

We examined the stomachs of 7,374 fishes of 81 species (11% of the total individuals collected). The frequency of occurrence of food items in stomachs is summarized in Appendix Table 1. A total of 61,385 fishes, including 17 more species, were discarded without examination for reasons presented in the previous section (Appendix Table 2). Shoal flounder,

Syacium gunteri, was discarded most frequently (10,725 individuals; 17% of total discards). Other frequently discarded fishes included longspine porgy, *Stenotomus caprinus*; Atlantic croaker, *Micropogonias undulatus*; Atlantic bumper, *Chloroscombrus chrysurus*; blackfin searobin, *Prionotus rubio*; and dwarf sand perch, *Diplectrum bivittatum*.

Fish stomach contents were examined according to six depth ranges: 9-17 m (18 stations), 18-26 m (31

stations), 27-36 m (27 stations), 37-45 m (15 stations), 46-54 m (6 stations), and 55-64 m (3 stations) (Tables 1-6). In all six depth ranges, detritus was the most frequently observed category, when data from all species were pooled. Among the 81 species examined from all depths, detritus was found in the stomachs of 62 species and was the most frequently observed category for 55 species. In contrast, Rogers (1977) listed detritus as occurring in stomachs of

TABLE 1.—Frequency of occurrence of food items (from stomachs containing food) in fishes from the Texas coast collected from 9 to 17 m water depths between 4 June and 3 July 1981. Fish sizes in mm SL. *N* = total stomachs examined, %E = percentage of empty stomachs, De = detritus, Sh = shrimp, Ho = holothurians, Cr = crabs, Fi = fishes, Ms = other taxa such as molluscs, mysids, octopi, and polychaetes. Frequency of occurrence of prey fishes and shrimps in parentheses. Prey shrimps denoted by T (*Trachypenaeus*), S (*Sicyonia*), or P (*Penaeus aztecus*), followed by frequency and size range (mm tail length).

Fish species	Size class	<i>N</i>	%E	% frequency of occurrence						Prey fishes	Prey shrimps
				De	Sh	Ho	Cr	Fi	Ms		
<i>Micropogonias undulatus</i>	95-124	602	33	81	11	8	1	1	4		T(21):10-25, 35, 45; S(2):15
	125-163	1,236	25	82	10	5	3	1	2	eel (2), <i>Ophichthus</i>	T(41):5-35; S(1):10; P(1):45
<i>Cynoscion nothus</i>	76-124	275	75	62	26			1	12	1	T(5):10, 20, 35
	125-149	95	77	55	18	5			27		<i>Anchoa</i> , <i>Prionotus</i> T(2):20, 25
	150-219	25	52	25	42			8	25		T(2):30, 35
<i>Menticirrhus americanus</i>	112-149	60	85	44	22	11	22	11	11		T(1):5
	150-199	88	69	41	37		15	4	4		T(5):10, 15, 30; S(1):20
	200-282	24	50	42	25		33	17	33	<i>Prionotus</i>	T(2):10, 15
<i>Leiostomus xanthurus</i>	86-164	64	62	100							
<i>Arius felis</i>	132-199	17	6	31	13	19	38		25		T(1):45
	200-293	13	0	38	15	38	31	8	15		T(2):10, 40
<i>Synodus foetens</i>	125-199	30	87	25	25			50			T(1):40
<i>Stellifer lanceolatus</i>	72-112	30	33	45	35			25		<i>Anchoa</i>	T(3):5, 10, 20
<i>Cynoscion arenarius</i>	134-239	26	38		88		6	12			T(9):20-45; P(3):57, 62, 62
Other species (31)	65-662	241	34	85	8	1	2	4	2	<i>Lutjanus</i>	T(5):5-25, 35; S(2):15, 25; P(1):60
Total		2,762	39	76	13	5	4	5	3		T(100):5-45; S(6):10-25; P(5):45-62

TABLE 2.—Frequency of occurrence of food items (from stomachs containing food) in fishes from the Texas coast collected from 18 to 26 m water depths between 4 June and 3 July 1981. Fish sizes in mm SL, except * = mm total length. *N* = total stomachs examined, %E = percentage of empty stomachs, De = detritus, Sh = shrimp, Fi = fish, Cr = crabs, Sq = squid, Ms = other taxa including molluscs, mysids, octopi, polychaetes, and holothurians. Frequency of occurrence of prey fishes and shrimps in parentheses. Prey shrimps denoted by T (*Trachypenaeus*), S (*Sicyonia*), or P (*Penaeus aztecus*), followed by frequency and size range (mm tail length).

Fish species	Size class	<i>N</i>	%E	% frequency of occurrence						Prey fishes	Prey shrimps
				De	Sh	Fi	Cr	Sq	Ms		
<i>Micropogonias undulatus</i>	95-124	352	37	91	4		1		3		T(3):5, 10, 30; S(1):15
	125-149	582	55	87	7	3	3		2	<i>Anchoa</i> , <i>Saurida</i> , eel	T(13):5-15, 25-30, 45
	150-163	14	79	67	33						T(1):5
<i>Cynoscion nothus</i>	76-124	88	65	61	13	23		3		<i>Anchoa</i>	T(2):35, 40
	125-149	89	45	71	18	16	2	2	4	<i>Anchoa</i> (4)	T(3):10, 20, 35
	150-219	192	55	63	40	13		1		<i>Anchoa</i> , <i>Centropristis</i> , eel, <i>Monacanthus</i>	T(19):10-45; S(2):20
<i>Leiostomus xanthurus</i>	100-164	250	14	100							
<i>Lepophidium graellsii</i>	100-149*	15	40	89	22						T(1):15
	150-199*	79	54	78	28		3				T(3):10, 30, 40
	200-240*	46	61	83	11		17				T(1):10
<i>Synodus foetens</i>	100-149	23	48	25	16	58					T(1):20
	150-199	77	62	17	38	48			10	<i>Anchoa</i> (2)	T(6):15-25, 40-45; P(3):40, 46, 53
	200-244	20	50	40	10	50				<i>Anchoa</i> , <i>Citharichthys</i>	P(1):44
<i>Centropristis philadelphica</i>	85-124	71	51	66	29	6	6				T(6):5-15, 35, 40; S(2):20
	125-199	17	53	50	50		13				T(2):5, 20; S(1):15
<i>Cynoscion arenarius</i>	135-239	78	88	11	77	22	11			<i>Centropristis</i> , <i>Cynoscion</i>	T(6):15, 30, 40; P(1):60
<i>Menticirrhus americanus</i>	112-199	52	63	37	42	11	16		11	<i>Saurida</i>	T(6):20, 25, 40; S(2):20-25
	200-249	20	40	42	42	8	17		8		S(2):30, 45
<i>Larimus fasciatus</i>	78-135	70	36	98	2						
<i>Lutjanus campechanus</i>	65-149	50	52	46	17	17	17	17	8		
Other species (40)	48-450	253	49	70	22	5	5		2	<i>Anchoa</i> (2)	T(14):10, 20, 35; S(3):15
Total		2,436	48	79	15	6	3	1	2		T(87):5-45; S(13):15-25; P(5):40-60

only 5 of the 26 species he examined from Texas and Louisiana shelf waters. Of the 17 species held in common, we found detritus in the stomachs of 15 species, while rogers found detritus in only 4 species. We believe such differences are derived from differing

methodologies (visual identification of stomach contents by us and microscopic examination by Rogers), but we suggest that ingestion of detrital matter by fishes remains widespread.

Fishes were found in stomachs of 30 species from all

TABLE 3.—Frequency of occurrence of food items (from stomachs containing food) in fishes from the Texas coast collected from 27 to 36 m water depths between 4 June and 3 July 1981. Fish sizes in mm SL, except * = mm total length. *N* = total stomachs examined, %E = percentage of empty stomachs, De = detritus, Fi = fish, Sq = squid, Sh = shrimp, St = stomatopods, Cr = crabs, Ho = holothurians, Po = polychaetes. Frequency of occurrence of prey fishes and shrimps in parentheses. Prey shrimps denoted by T (*Trachypenaeus*), S (*Sicyonia*), or P (*Penaeus aztecus*), followed by frequency and size range (mm tail length).

Fish species	Size class	<i>N</i>	%E	% frequency of occurrence								Prey fishes	Prey shrimps	
				De	Fi	Sq	Sh	St	Cr	Ho	Po			
<i>Synodus foetens</i>	125-149	37	65	31	62		15						<i>Saurida</i> (?), <i>Anchoa</i> , eel	T(2):15,45
	150-199	139	67	22	52	4	20						<i>Saurida</i> (4), <i>Anchoa</i>	T(8):5, 20-35, 50
	200-299	28	64	20	60	10	10							T(1):15
<i>Centropristis philadelphica</i>	85-124	99	42	54	5		37	2	4				<i>Bollmannia</i>	T(8):10-20, 35; S(2):15-20; P(1):20
	125-199	23	43	54			46							T(1):15; S(3):10, 35
<i>Lepophidium graellsii</i>	95-149*	12	42	86					14					
	150-199*	49	67	56	13			25		25				
	200-240*	21	76	60	20				20					T(3):5-10; S(1):5
<i>Diplectrum bivittatum</i>	87-99	23	74	50				50						
	100-115	53	68	35				59	6	6				T(3):10, 25, 40 T(6):10-20
<i>Micropogonias undulatus</i>	95-124	51	73	43				29			36	7		
	125-163	24	62	44							33	22		T(4):10, 30
<i>Cynoscion nothus</i>	100-149	31	87	50	50	25							<i>Stenotomus</i>	
	150-219	23	70	14	14		71							T(3):20, 30; P(1):45
<i>Urophycis floridana</i>	114-124	7	28	20				60	40					
	125-149	28	29	15	30			55	5			5	<i>Ophichthus</i> , eel	T(1):5; S(1):10 T(5):5, 15, 25, 40; S(3):10-15
	150-199	5	40		33			67						T(3):5-15
<i>Lutjanus synagris</i>	82-124	6	100											
	125-190	11	73	67				33						T(2):35
<i>Calamus nodosus</i>	121-162	13	100											
<i>Menticirrhus americanus</i>	112-249	13	92									100		
Other species (33)	48-655	84	48	66	5	2	32				2		<i>Saurida</i>	T(12):5,20-45
Total		780	61	44	19	2	32	2	2	4	1			T(62):5-45; S(10):5-35; P(2):20, 45

TABLE 4.—Frequency of occurrence of food items (from stomachs containing food) in fishes from the Texas coast collected from 37 to 45 m water depths between 4 June and 3 July 1981. Fish sizes in mm SL, except * = mm total length. *N* = total stomachs examined, %E = percentage of empty stomachs, De = detritus, Fi = fish, Sq = squid, Cr = crabs, Sh = shrimp, St = stomatopods, Ms = other taxa including polychaetes, mysids, and molluscs. Frequency of occurrence of prey fishes and shrimps in parentheses. Prey shrimps denoted by T (*Trachypenaeus*), S (*Sicyonia*), or P (*Penaeus aztecus*), followed by frequency and size range (mm tail length).

Fish species	Size class	<i>N</i>	%E	% frequency of occurrence								Prey fishes	Prey shrimps	
				De	Fi	Sq	Cr	Sh	St	Ms				
<i>Synodus foetens</i>	100-149	14	50	43	57								<i>Saurida</i> , <i>Stenotomus</i>	
	150-199	151	66	37	53	2			8				<i>Saurida</i> (6), <i>Anchoa</i> , <i>Mullus</i> , <i>Serranus</i>	T(3):20, 40
	200-249	81	73	5	64	14			18				<i>Saurida</i> , <i>Trachurus</i> , <i>Scomber</i>	T(2):40, 50; P(1):53
<i>Centropristis philadelphica</i>	250-444	17	53	50	50								<i>Serranus</i> , Bothid	
	85-124	78	38	67	6	2	2	27			4			T(5):5-15, 30, 40; S(9):10, 20-30
	125-149	21	43	58	17			8	17	2			<i>Antennarius</i> , <i>Serranus</i>	T(1):10; S(2):20, 30
	150-224	5	60	50						50				
<i>Lepophidium graellsii</i>	125-199*	50	24	92					8					T(2):10-15
	200-240*	11	55	80	20									
<i>Urophycis floridana</i>	100-149	25	4	38	17			8	42				<i>Bollmannia</i> , eel	T(4):15-40; S(1)
	150-199	8	25		50			17	50	17			<i>Ophichthus</i>	T(1):40; S(1):10
<i>Cynoscion nothus</i>	125-149	9	22	57	43									
	150-219	12	25	33	33					33			<i>Saurida</i> (2), <i>Trachurus</i>	T(3):15, 40
<i>Lutjanus synagris</i>	82-124	19	58	88					12					T(1):15
<i>Centropristis ocyurus</i>	92-175	12	42		29			57	14		29			
<i>Cyclosetta chittendeni</i>	150-224	12	67	50	50								<i>Saurida</i> , Bothid	
<i>Diplectrum bivittatum</i>	100-115	12	58	60					40					T(1):5; S(1)
Other species (27)	75-527	87	47	63	15			7	24	4	4		<i>Saurida</i>	T(4):5, 20, 30; S(4):15, 40
Total		624	50	53	26	2	4	19	2	2				T(27):5-50; S(18):10-40; P(1):53

TABLE 5.—Frequency of occurrence of food items (from stomachs containing food) in fishes from the Texas coast collected from 46 to 54 m water depths between 4 June and 3 July 1981. Fish sizes in mm SL, except* = mm total length. *N* = total stomachs examined, %E = percentage of empty stomachs, De = detritus, Cr = crabs, Fi = fish, St = stomatopods, Sh = shrimp, Sq = squid. Frequency of occurrence of prey fishes and shrimps in parentheses. Prey shrimps denoted by T (*Trachypenaeus*) or S (*Sicyonia*), followed by frequency and size range (mm tail length).

Fish species	Size class	<i>N</i>	%E	% frequency of occurrence						Prey fishes	Prey shrimps
				De	Cr	Fi	St	Sh	Sq		
<i>Synodus foetens</i>	100-149	7	71			100					
	150-199	43	60	53		35		12	18	<i>Saurida</i>	T(2):20, 35
	200-249	45	80	22		67		11			T(1):30
	250-299	10	80			100					
<i>Centropristis philadelphica</i>	85-99	7	57	33	33			33			
	100-124	32	34	33	14	5	5	48			T(5):5, 20-25, 40; S(2):20
	125-149	27	26	65	10	5		25			T(3):10, 30, 40; S(2):20
	150-199	11	0	55	27	9	9				
<i>Urophycis floridana</i>	125-149	20	15	76		18		35			T(3):20, 45
	150-249	21	10	63	5	26		11		<i>Prionotus</i>	S(1):25
<i>Prionotus rubio</i>	100-149	24	96					100			
<i>Micropogonias undulatus</i>	100-149	23	96	100							
<i>Lutjanus campechanus</i>	100-200	20	95					100			T(1):10
<i>Lutjanus synagris</i>	82-149	17	65	50				50			T(3):10, 20, 45
<i>Lepophidium graellsii</i>	150-240*	17	29	100							
<i>Saurida brasiliensis</i>	78-125	16	19	15		54		15	15	<i>Saurida</i> (2)	T(2):15, 25
Other species (19)	75-400	76	70	78		17		13		<i>Saurida</i> , <i>Ophichthus</i>	T(1):20
Total		416	57	56	6	21	2	20	3		T(21):5-45; S(5):20-25

TABLE 6.—Frequency of occurrence of food items (from stomachs containing food) in fishes from the Texas coast collected from 55 to 64 m water depths between 4 June and 3 July 1981. Fish sizes in mm SL. *N* = total stomachs examined, %E = percentage of empty stomachs, De = detritus, Fi = fish, Sh = shrimp, Cr = crabs, Sq = squid, Ms = other taxa including polychaetes, molluscs, and mysids. Frequency of occurrence of prey fishes and shrimps in parentheses. Prey shrimps indicated by T (*Trachypenaeus*) followed by frequency and size range (mm tail length).

Fish species	Size class	<i>N</i>	%E	% frequency of occurrence						Prey fishes	Prey shrimps
				De	Fi	Sh	Cr	Sq	Ms		
<i>Synodus foetens</i>	100-149	8	75		100						<i>Saurida</i> (2)
	150-199	17	76	25	75						
	200-249	108	69	30	67			12			<i>Saurida</i> (12)
	250-400	38	66	23	69			8			<i>Saurida</i> (3)
<i>Centropristis philadelphica</i>	100-124	9	89	100					100		
	125-149	15	67	40			20	60		20	
	150-199	11	27	13	25			63	25		
<i>Prionotus rubio</i>	100-149	21	62	75			25				T(2):20, 25
<i>Micropogonias undulatus</i>	125-160	18	0	100							
<i>Lutjanus campechanus</i>	125-199	14	71	75	25						<i>Halieutichthys</i>
<i>Lagodon rhomboides</i>	91-147	13	69	100							
<i>Centropristis ocyurus</i>	92-149	11	27	88				12			
<i>Priacanthus arenatus</i>	150-205	11	73	67	33	33	33				T(1):10
<i>Prionotus salmonicolor</i>	98-155	11	18	78	11	11			11		T(1):15
Other species (17)	100-279	51	31	91	3	3			3		T(1):10
Total		356	58	65	28	4	7	5	1		T(5):10-25

water depths and were classified as major prey of 9 species, including inshore lizardfish, *Synodus foetens*; largescale lizardfish, *Saurida brasiliensis*; big-eye, *Priacanthus arenatus*; Atlantic cutlassfish, *Trichiurus lepturus*; Mexican flounder, *Cyclopsetta chittendeni*; knobbed porgy, *Calamus nodosus*; black-edge moray, *Gymnothorax nigromarginatus*; bonnethead, *Sphyrna tiburo*; and Atlantic sharpnose shark, *Rhizoprionodon terraenovae*. Fishes were a major food category for all size classes of *Synodus foetens* in all six depth ranges. For all species examined, predation on fishes was more frequent in the

four offshore depth ranges (19-28% occurrence) than in the two inshore depth ranges (5 and 6% occurrence). Nineteen taxa of prey fishes were identified, with anchovies, *Anchoa* spp., the primary target in 9-26 m waters and *Saurida* the most frequent in 27-64 m waters. Rogers (1977) found fish in the stomachs of 23 out of 26 fish species from Texas and Louisiana shelf waters. Prey fish comprised at least 48% by volume of the diets of eight of those species: *Saurida brasiliensis* and *Synodus foetens* (as we found); Atlantic midshipman, *Porichthys plectrodon*, sand sea-trout, *Cynoscion arenarius*, and silver seatrout, *C.*

nothus (we found 12-18% occurrence in these species); and roughback batfish, *Ogcocephalus parvus*, shortwing searobin, *Prionotus stearnsi*, and sash flounder, *Trichopsetta ventralis* (which we did not examine). Rogers also identified *Saurida* and *Anchoa* as primary prey species.

Crabs occurred in the stomachs of 21 fish species and, over all depths, were categorized as a major food of bank sea bass, *Centropristis ocyurus*; smooth dogfish, *Mustelus canis*; sharksucker, *Echeneis naucrates*; and barred grunt, *Conodon nobilis*, though few individuals of the latter three species were examined. In 9-17 m waters, crabs were a major food of hardhead catfish, *Arius felis*, and large (≥ 200 mm SL) southern kingfish, *Menticirrhus americanus*. No major crab predators were found in 18-45 m waters, but crabs were a major food of rock sea bass, *Centropristis philadelphica*, and *Priacanthus arenatus* in 46-64 m waters. Rogers (1977) noted that crabs occurred in stomachs of 20 of the 26 fish species he examined but comprised at least 20% by volume of the diets of only 3 species: *Centropristis philadelphica*, blackear bass, *Serranus atrobranchus*; and ragged goby, *Bollmanina communis*.

Among other prey types, stomatopods were eaten by 11 species, squid by 6 species, and holothurians by 5 species. These taxa were occasionally major foods of one or two species in a given depth range. Polychaetes, molluscs, mysids, and octopi were also found in fish stomachs, though only rarely.

We found 38 species of shrimp predators from all depths. Seventeen species were classified as having shrimp as a major prey, but 9 of these were represented by data from fewer than 20 individuals. The 8 remaining species, in decreasing order of shrimp occurrence in stomachs from all depths, included *Cynoscion arenarius*; bighead searobin, *Prionotus tribulus*; *Diplectrum bivittatum*; *Prionotus rubio*;

southern hake, *Urophycis floridana*; star drum, *Stellifer lanceolatus*; *Priacanthus arenatus*; and *Centropristis philadelphica*. Shrimp were major foods of *Cynoscion nothus*, *C. arenarius*, and *Menticirrhus americanus* from the two shallower depth ranges (9-26 m) and of *Cynoscion nothus*, *Centropristis philadelphica*, *Diplectrum bivittatum*, *Urophycis floridana*, and lane snapper, *Lutjanus synagris*, from 27 to 64 m depths. The overall frequency of occurrence of shrimps in fish stomachs increased from 13% in 9-17 m waters to 32% in 27-36 m waters, then declined to 4% in 55-64 m waters. Penaeid shrimps were identified in stomachs of 31 fish species. The penaeids included *Trachypenaeus* spp. (302 occurrences in 28 species), *Sicyonia* spp. (52 occurrences in 13 species), and *Penaeus aztecus* (13 occurrences in 6 species). Rogers (1977) found shrimp in stomachs from all 26 species examined, of which 8 species contained at least 20% by volume of shrimps in their diets. These included *Prionotus rubio*, *Diplectrum bivittatum*, and *Centropristis philadelphica* (classified as major shrimp predators by us); *Serranus atrobranchus* and blackedge cusk-eel, *Lepophidium graellsii* (classified as minor shrimp predators by us); bay whiff, *Citharichthys spilopterus* (in which we found no shrimp); and *Syacium gunteri* and speckled trout, *Cynoscion nebulosus* (which we did not examine). Rogers frequently identified *Trachypenaeus* spp. and *Sicyonia* spp., but did not find any *Penaeus aztecus* in the 4,550 stomachs he examined.

Species composition, abundance, and biomass data for all fishes and invertebrates were recorded from 89 of the 108 trawl catches collected during the shrimp survey. We compared the observed abundances and distributions of fishes and penaeid shrimps with our data on the occurrence of penaeids in fish stomachs (Table 7). Fishes were most abundant in the 9-17 m depth range (mean: 1,424/30-min

TABLE 7.—Comparison of catch per 30-min tow and size of fishes and penaeid shrimps by depth range with frequency of occurrence of shrimps in fish stomachs from collections off the Texas coast between 4 June and 3 July 1981. N = number of trawl-tows in each depth range.

	Depth range (m)					
	9-17 (N = 16)	18-26 (N = 27)	27-36 (N = 22)	37-45 (N = 17)	46-54 (N = 5)	55-64 (N = 2)
Density (#/tow) ($\bar{x} \pm SE$):						
Fishes	1,424±1,755	588±428	510±336	708±478	951±329	600±343
<i>Trachypenaeus</i>	65±123	608±536	872±651	481±469	125±206	0
<i>Sicyonia</i>	12±23	62±128	95±170	126±181	201±220	74±104
<i>Penaeus aztecus</i>	472±486	1,254±799	1,134±699	284±260	37±26	4±3
Wet weight (G) ($\bar{x} \pm SE$):						
Fishes	29.7±10.2	23.2±11.8	19.3±6.4	24.2±6.9	30.5±10.4	49.9±13.6
<i>Trachypenaeus</i>	3.8±3.7	3.9±2.0	4.4±1.6	4.8±4.0	5.5±5.2	—
<i>Sicyonia</i>	9.0±3.7	7.4±7.5	4.5±3.4	5.7±3.1	6.3±5.4	21.1
<i>P. aztecus</i>	9.7±5.3	11.5±2.5	11.7±2.9	14.2±8.2	36.5±3.6	63.5
Total fish stomachs examined:	1,663	1,733	550	573	418	164
% with <i>Trachypenaeus</i>	3.13	3.87	11.45	4.89	4.07	1.02
% with <i>Sicyonia</i>	0.36	0.52	2.18	2.97	0.48	0.00
% with <i>P. aztecus</i>	0.18	0.17	0.18	0.17	0.00	0.00

tow) and second most abundant in 46-54 m waters (mean: 951/tow). Largest fishes were collected in deepest waters. *Trachypenaeus* spp. and *P. aztecus* catches were highest in 18-36 m waters, and both species increased in size with increasing depth. *Sicyonia* spp. catches were highest in 46-54 m waters and lowest in 27-36 m waters. We found the highest frequency of occurrence of *Trachypenaeus* spp. in fish stomachs occurred in the same depth range (27-36 m) as their maximum catch per tow. Predation upon *Sicyonia* spp. was highest where these penaeids were smallest and moderately abundant (27-45 m depths). Predation upon *P. aztecus* was similar (low to none) in all depth ranges. We also examined data from 30 individual stations where relatively high catches (exceeding 1,000 individuals/tow) of fishes or penaeids were made. We postulated that if the fishes were actively seeking penaeid prey, the frequency of shrimps in fish stomachs from such stations would be higher than the average frequency for all stations in the corresponding depth range. However, we found no indication that locally high abundances of shrimps elicited greater predation by fishes nor any indication that concentrations of fishes at a given location were preying more frequently on penaeids as compared with the average predation frequency of a given depth range. Apparently, the trawl-susceptible fishes preyed in a nondirected, opportunistic manner upon *Trachypenaeus* spp. and *Sicyonia* spp. which were smaller and generally less abundant than *P. aztecus*.

A literature review revealed that the foods of 51 of the 81 fish species examined here have been reported previously to some degree, mainly from inshore and estuarine studies. The major exception is the work of Rogers (1977), as discussed in previous paragraphs. Thirteen of the species we examined yielded no data due to empty stomachs. Forty-seven species were represented in our study by 25 or fewer individuals, and we categorize these data as preliminary

until more specimens are analyzed. However, this paper presents new information on the foods of 21 abundant Gulf of Mexico continental shelf fish species by depth range and size class whenever possible.

The analysis of fish stomach contents reported here indicates that brown shrimp stocks are not subjected to heavy predation pressure as the juveniles and subadults migrate offshore. Fifty of the 81 species of trawl-susceptible fishes we examined did not feed on penaeid shrimps, and only 6 species had eaten brown shrimp. The shrimp predators instead preferred smaller penaeids, in part due to the small sizes of the fishes, themselves. Future stomach contents studies, in addition to analyses of trawl-susceptible fishes, should include larger fishes captured by methods such as long lines, gill nets, and fish trawls.

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APPENDIX TABLE 1.—Frequency of occurrence of food items (from stomachs containing food) in fishes from the Texas coast collected between 4 June and 3 July 1981. Depth range in meters. *N* = total stomachs examined. Size in mm SL except where indicated by * (mm total length) or ** (mm disc width). %E = percentage of empty stomachs, De = detritus, Fi = fish, Sh = shrimp, Cr = crabs, St = stomatopods, Sq = squid, Ms = other foods including polychaetes, molluscs, mysids, holothurians, and octopi. Prey shrimps denoted by T (*Trachypenaeus*), S (*Sicyonia*), or P (*Penaeus aztecus*), followed by frequency of occurrence in parentheses and size range (mm tail length).

Fish species	Depth range	<i>N</i>	Size		%E	% frequency of occurrence of food items							Prey shrimps
			Mean	Range		De	Fi	Sh	Cr	St	Sq	Ms	
<i>Micropogonius undulatus</i>	9-64	2,903	127	95-163	36	86	1	9	2	1	1	6	T(84):5-45; S(4):15; P(1):45
<i>Synodus foetens</i>	9-64	893	192	48-444	73	33	69	16				7	T(27):5-50; P(5):40-53
<i>Cynoscion nothus</i>	9-46	839	135	76-219	65	53	18	28	1			1	T(42):10-45; S(2):20; P(1):45
<i>Centropristis philadelphica</i>	9-64	437	120	85-224	43	59	6	30	11	3	1	2	T(32):5-40; S(25):10-30; P(1):20
<i>Lepophidium graellsii</i>	9-64	317	183*	95-240	52	83	3	13	5	1			T(10):5-15, 30, 40; S(1):5
<i>Leiostomus xanthurus</i>	9-54	316	134	86-164	23	100							
<i>Menticirrhus americanus</i>	9-36	257	174	112-282	75	40	9	20	20	6		8	T(14):5-30, 45; S(5):20-30, 45
<i>Diplectrum bivittatum</i>	9-45	134	101	87-115	66	49		44	4	2			T(13):5-25, 40; S(1):10
<i>Urophycis floridana</i>	18-64	128	143	114-277	21	41	22	41	4	4		1	T(19):5-20, 35-45; S(7):10-15, 25
<i>Lutjanus campechanus</i>	9-64	118	107	65-200	59	60	13	13	10	2	8	6	T(2):10, 20
<i>Cynoscion arenarius</i>	9-26	105	177	134-239	76	4	16	84	8				T(16):15-45; P(4):57-62
<i>Larimus fasciatus</i>	9-36	84	116	78-135	44	94	4	2					
<i>Prionotus rubio</i>	9-64	73	124	72-163	67	54		42	4				T(8):10-45
<i>Lutjanus synagris</i>	9-54	66	114	82-190	67	68	5	27	5				T(6):10-20, 35, 45; P(1):60
<i>Arius felis</i>	9-36	43	192	132-293	16	44	3	17	28	11		17	T(4):10, 40, 45; S(1):10
<i>Polydactylus octonemus</i>	9-36	42	110	72-130	31	79	7	14					
<i>Prionotus salmonicolor</i>	9-64	33	130	98-155	39	70	5	20	5				T(1):15
<i>Chloroscombrus chrysurus</i>	18-26	32	126	99-172	78	100							
<i>Stellifer lanceolatus</i>	9-17	30	86	72-112	33	45	25	35					T(3):5, 10, 20
<i>Saurida brasiliensis</i>	18-54	28	99	78-125	21	36	50	9				9	T(2):15, 25
<i>Centropristis ocyurus</i>	27-64	27	125	92-175	41	50	12	6	31			13	
<i>Lagodon rhomboides</i>	18-64	23	120	91-147	74	100							
<i>Stenotomus caprinus</i>	18-26	23	69	54-122	0	100							
<i>Prionotus tribulus</i>	18-64	21	122	100-145	57	33		67					T(4):20; S(2):15
<i>Decapterus punctatus</i>	18-64	20	151	133-170	85	100							
<i>Orthopristis chrysoptera</i>	9-54	20	136	112-176	50	100							
<i>Priacanthus arenatus</i>	27-64	20	183	150-205	55	44	33	33	11				T(2):10-15
<i>Cyclosetta chittendeni</i>	37-54	20	179	100-224	60	63	37						
<i>Ophidion welsbi</i>	9-26	19	200*	174-236	42	100							
<i>Parichthys pleurodon</i>	9-64	17	134	109-161	53	100	12						
<i>Scomber japonicus</i>	9-64	17	159	130-326	18	93	7						
<i>Ophidion holbrooki</i>	18-54	16	204*	173-235	69	100							
<i>Calamus nodosus</i>	27-64	15	138	121-162	87	33	33					33	
<i>Paralichthys lethostigma</i>	9-45	14	217	138-265	36	56		44					T(3):20, 30, 40
<i>Serranus atrobranchus</i>	37-64	13	80	71-88	15	91		9					S(1):15
<i>Prionotus parvulus</i>	46-54	12	121	113-133	100								
<i>Gymnothorax nigromarginatus</i>	18-54	11	374*	240-463	82	50	50						
<i>Brotula barbata</i>	9-64	11	149*	120-170	55	40		60					T(3):5, 20
<i>Trichiurus lepturus</i>	9-36	11	446*	372-560	55	20	60	20					T(1):35
<i>Citharichthys spilopterus</i>	18-45	10	91	70-119	0	100							
<i>Cyclosetta fimbriata</i>	37-64	10	184	118-227	20	75	12	12					
<i>Mullus auratus</i>	9-64	10	116	92-146	10	78		22					T(2):10
<i>Chaetodipterus faber</i>	9-17	9	128	118-140	78	100							
<i>Equetus umbrosus</i>	9-17	8	124	114-134	0	100							
<i>Trachurus lathami</i>	37-45	8	150	142-156	75	100							
<i>Prionotus roseus</i>	27-64	7	122	112-144	0	71		43					T(2):20, 30
<i>Raja texana</i>	27-45	7	348**	260-527	14	50		50					T(1):44
<i>Rhizopronodon terraenovae</i>	9-36	7	268	140-600	0	57	29	14					
<i>Sardinella anchovia</i>	18-36	7	177	173-186	86	100							
<i>Scorpaena calcarata</i>	18-36	7	62	48-111	29	100					20		
<i>Peprilus burti</i>	18-26	6	89	72-136	0	83		17					
<i>Urophycis cirratus</i>	37-45	6	125	111-140	17	20	60	60			40		T(2):5, 20; S(1):15
<i>Odontoscion dentex</i>	9-17	5	109	105-117	0	60	20	20					T(1):5
<i>Ancylopsetta quadrocellata</i>	18-64	4	176	123-197	75	100							
<i>Balistes capriscus</i>	9-45	4	197	189-210	100								
<i>Mustelus canis</i>	9-45	4	359	342-375	0	25		25	75	25			S(1):40
<i>Opisthonema oglinum</i>	18-26	4	164	162-166	100								
<i>Sphyrna guachancho</i>	27-36	4	230	220-234	50	50		50					T(1):20
<i>Sphyrna tiburo</i>	9-26	4	471	343-662	0		50		25	50			
<i>Trachinocephalus myops</i>	18-45	4	124	118-130	50	100							
<i>Bairdiella chrysoura</i>	9-17	3	114	109-119	67	100							
<i>Echeneis naucrates</i>	27-45	3	467	189-655	33	50			50			50	
<i>Haemulon aurolineatum</i>	46-54	3	138	136-140	100								
<i>Congrina flava</i>	27-45	2	238*	175-300	50	100							
<i>Conodon nobilis</i>	9-17	2	140	128-152	50				100				
<i>Diplectrum formosum</i>	27-36	2	164	163-166	0	100							
<i>Prionotus scitulus</i>	27-36	2	108	100-115	0			100					T(1):30; S(1):20
<i>Ancylopsetta dilecta</i>	55-64	1	174		100								
<i>Archosargus probatocephalus</i>	9-17	1	191		0	100							
<i>Brevoortia gunteri</i>	9-17	1	160		0	100							
<i>Carcharhinus limbatus</i>	18-26	1	133		100								
<i>Carcharhinus porosus</i>	18-26	1	330		100								
<i>Caulolatilus microps</i>	46-54	1	190		100								
<i>Chilomycterus schoepfi</i>	18-26	1	141		100								

APPENDIX TABLE 1.—Continued.

Fish species	Depth range	N	Size		%E	% frequency of occurrence of food items						Prey shrimps	
			Mean	Range		De	Fi	Sh	Cr	St	Sq		Ms
<i>Dasyatis sabina</i>	9-17	1	245**		0			100					
<i>Lagocephalus laevigatus</i>	18-26	1	103		100								
<i>Myrophis punctatus</i>	18-26	1	400*		100								
<i>Rypticus maculatus</i>	9-17	1	116		0	100							
<i>Scomberomorus maculatus</i>	27-36	1	345		100								
<i>Syacium papillosum</i>	37-45	1	206		0	100	100				100		
<i>Symphurus plagiusa</i>	18-26	1	114		100								
TOTAL		7,374											T(302);5-50; S(52);5-45; P(13);20-62

APPENDIX TABLE 2.—Fishes collected from the Texas coast between 4 June and 3 July 1981 which were excluded from stomach analyses because of small size (<150 mm in length).

Species	Number	Species	Number
<i>Syacium gunteri</i>	10,756	<i>Ancylopsetta dilecta</i>	65
<i>Stenotomus caprinus</i>	8,563	<i>Priacanthus arenatus</i>	53
<i>Micropogonias undulatus</i>	6,787	<i>Brotula barbata</i>	50
<i>Chloroscombrus chrysurus</i>	4,352	<i>Centropristis ocyurus</i>	48
<i>Prionotus rubio</i>	2,895	<i>Antennarius radiatus</i>	44
<i>Diplectrum bivittatum</i>	2,699	<i>Brevoortia patronus</i>	43
<i>Pepilus burti</i>	2,631	<i>Scomber japonicus</i>	42
<i>Cynoscion nothus</i>	2,206	<i>Selene setapinnis</i>	40
<i>Sphaeroides parvus</i>	1,662	<i>Prionotus carolinus</i>	35
<i>Citharichthys spilopterus</i>	1,621	<i>Upeneus parvus</i>	31
<i>Halieutichthys aculeatus</i>	1,315	<i>Urophycis floridana</i>	31
<i>Parichthys plectrodon</i>	1,307	<i>Menticirrus americanus</i>	28
<i>Lutjanus synagris</i>	1,161	<i>Prionotus ophrys</i>	28
<i>Serranus atrobrenchus</i>	1,123	<i>Prionotus scitulus</i>	26
<i>Etropus crossopus</i>	1,106	<i>Etropus microstomus</i>	19
<i>Saurida brasiliensis</i>	1,088	<i>Synodus foetens</i>	19
<i>Centropristis philadelphica</i>	993	<i>Equetus umbrus</i>	18
<i>Lutjanus campechanus</i>	739	<i>Caulolatilus intermedius</i>	16
<i>Prionotus parvulus</i>	665	<i>Decapterus punctatus</i>	15
<i>Prionotus tribulus</i>	629	<i>Pepilus paru</i>	15
<i>Prionotus salmonicolor</i>	595	<i>Hoplunnis tenuis</i>	14
<i>Trachurus lathemi</i>	587	<i>Sardinella anchovia</i>	14
<i>Cyclosetta chittendeni</i>	570	<i>Neomerinthe hemingwayi</i>	13
<i>Stellifer lanceolatus</i>	531	<i>Paralichthys squamilentus</i>	11
<i>Larimus fasciatus</i>	458	<i>Serraniculus pumilio</i>	11
<i>Mullus auratus</i>	446	<i>Syacium papillosum</i>	11
<i>Bollmannia communis</i>	422	<i>Balistes capricus</i>	10
<i>Lepophidium graellsii</i>	362	<i>Histrio histrio</i>	9
<i>Scorpaena calcarata</i>	357	<i>Raja texana</i>	9
<i>Polydactylus octonemus</i>	328	<i>Trichiurus lepturus</i>	9
<i>Prionotus stearnsi</i>	319	<i>Anchoa mitchilli</i>	8
<i>Leiostomus xanthurus</i>	318	<i>Congrina flava</i>	8
<i>Cynoscion arenarius</i>	291	<i>Engyophrys senta</i>	7
<i>Ogcocephalus radiatus</i>	266	<i>Brevoortia gunteri</i>	5
<i>Lagocephalus laevigatus</i>	209	<i>Etrumeus teres</i>	5
<i>Synodus poeyi</i>	203	<i>Cyclosetta fimbriata</i>	4
<i>Prionotus roseus</i>	187	<i>Eucinostomus gula</i>	4
<i>Opisthonema oglinum</i>	183	<i>Aluterus schoepfi</i>	3
<i>Symphurus plagiusa</i>	156	<i>Bairdiella chrysoura</i>	3
<i>Monacanthus hispidus</i>	128	<i>Paralichthys lethostigma</i>	3
<i>Hoplunnis macrurus</i>	111	<i>Serranus subligarius</i>	3
<i>Lagodon rhomboides</i>	108	<i>Calamus nodosus</i>	2
<i>Harengula jaguana</i>	106	<i>Sphaeroides dorsalis</i>	2
<i>Gymnachirus texae</i>	98	<i>Lactophrys quadricornis</i>	1
<i>Anchoa hepsetus</i>	96	<i>Epinephelus flavolimbatus</i>	1
<i>Orthopristis chrysoptera</i>	89	<i>Kathetostoma albigutta</i>	1
<i>Urophycis cirratus</i>	80	<i>Myrophis punctatus</i>	1
<i>Bellator militaris</i>	76	<i>Antennarius scaber</i>	1
<i>Ancylopsetta quadrocellata</i>	67	<i>Scomberomorus maculatus</i>	1
		Total	61,385