

THE INCIDENTAL CATCH FROM COMMERCIAL SHRIMP TRAWLERS
OF THE SOUTH ATLANTIC STATES

A Co-operative State-Federal Study

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ABSTRACT

Fish:shrimp (heads-on) ratios ranged from a low of 1.2:1 to a high of 4.0:1. Expansion of ratios indicated that an average of 69.4 million lbs of fish were caught by shrimp trawlers each year from 1973-1975. This was more than 24 times the 2.9 million lbs reportedly landed each year. Flounders and edible-size kingfish, spot, and croaker were the predominant species landed, while industrial-size fish (primarily small sciaenids) were discarded.

INTRODUCTION

Shrimp represent the most valuable fishery resource of the South Atlantic states (North Carolina, South Carolina, Georgia, and Florida). Fishermen catch large quantities of fish in their shrimp trawls, most of which are small and suitable only for industrial use. Of the South Atlantic states, only North Carolina has facilities to process industrial fish and consequently, the majority of the incidental catch of the South Atlantic states is discarded.

The objectives of this report are to synthesize knowledge of the incidental catch and to assess the biological magnitude of the resource. Knowing the extent of the under-utilized resource will enable economists and industry to plan for its eventual utilization.

LITERATURE SURVEY

A fraction of the incidental catch of commercial trawlers consists of juveniles of commercial and sport fishes. In the 1930's, when the trawl fishery was in its infancy, Lindner (1936) discussed the possible consequences of shrimp trawling on commercial and sport fish stocks, and the dialogue continued through the 1950's (Latham 1951, Lunz et al. 1951, Lunz 1955, Gunter 1956, Roelofs 1950, and Tiller 1951). There is presently no evidence that shrimp trawling activities are depleting stocks of commercial fish. In fact, in the Gulf of Mexico, a 3-fold increase in fishing effort during the last 20 years has not been followed by a decrease in fish catches (Juhl 1974).

It was not until the 1940's that serious consideration was given to utilization of incidental or "trash" species. In 1946, Baughman (1950) estimated that over 1 billion lbs of scrap fish were caught along the South Atlantic and Gulf Coasts. He proposed on-board reduction of "scrap" fish to stickwater which could be further refined on land to fish meal, oil, and condensed fish solubles. Vincent (1951) estimated from landing data that 502 million lbs of trash fish were caught by the shrimp fleet along the Gulf Coast in 1949; utilization of by-catch as well as waste from shrimp canneries to produce fish meal for poultry, hog and dog food could yield more than \$3 million profit per year. Cornell (1948) investigated potential by-products of the South Carolina fishing industry. He estimated that in 1947 the shrimp industry produced more than 2000 tons of waste products which "should have been by-products".

In 1959, personnel of the Bears Bluff Laboratory, South Carolina, estimated that \$266,000 could have been realized by routinely processing fish scraps, crab scraps and shrimp heads (Anonymous 1959). These estimates did not include revenues that could be derived from landing the incidental catch from shrimp trawlers of between 37,500,000 and 40,000,000 lbs (Lunz 1960). Jones (1959a, 1959b, 1960) examined the potential of several areas of the United States to provide a source of industrial fish for the pet food industry. Fishermen along the South Atlantic coast of the United States claimed that they could produce up to 4 tons of fish daily while shrimping (Jones 1960). Beaumariage (1968) estimated that 1.3 million lbs of fish were discarded by the Florida shrimp fleet along the Northeastern coast. Bullis and Carpenter (1968) estimated that the United States Atlantic Coast south of Cape Hatteras has a resource potential of 2,790 million lbs of industrial fish annually; this was more than 300 times the 1968 level of commercial fishery production.

Since the 1950's, industrial fisheries have developed in the Gulf of Mexico (Gutierrez et al. 1975, Haskell 1961, Rothmayr 1965), California (Best 1959), New England (Edwards and Lux 1958) and North Carolina (Fahy 1966, Wolff 1972). In general, fish are canned for pet food or frozen for mink food and crab pot bait, although other markets and refining processes are being investigated. Holston (1960) explored potential markets for industrial fish products and discussed the nutritional value of fish meal in improving man's diet, and Beaumariage (1968) examined several industrial fish reduction processes and compared results obtained using trash fish with those obtained using other species. Pigott (1973) presented several experimental processes that would enable more efficient utilization of fishery by-products. Martinez (1977) described a new process developed in Colombia that produces blocks of minced fish from shrimp by-catch. The fish are headed and gutted by hand and fed into a deboning machine; minced flesh recovery is estimated at 80 to 90%.

METHODS

Fish:shrimp (heads-on) ratios were determined from examination of published and unpublished reports. Mean ratio estimates and associated 95% confidence intervals (calculated either from raw or logarithmically transformed data) are of little value to fishery managers because of their variability (Keiser 1976). Therefore a median fish:shrimp ratio was computed and its confidence interval defined as the range encompassing 50% of the individual ratios (i.e. 25th and 75th percentiles). These ratios were then multiplied times shrimp landings (heads-on) to estimate the amount of fish caught during shrimping operations. Percent utilization of the shrimp by-catch was computed by comparing the quantity of fish landed by shrimp trawlers to estimated fish catches. The fish landing data were obtained from National Marine Fishery Service (NMFS). The preciseness of these data cannot be determined since NMFS collected much of the landing statistics

using telephone surveys. Hence, percent utilization calculations are only approximate.

NORTH CAROLINA

Shrimp Fishery

Shrimp populations are discontinuous along the North Carolina coastline. The majority of shrimping is done in sounds and inlets with very little fishing activity conducted in offshore waters. Pamlico Sound produces approximately 50% of the state's shrimp with Core Sound, Bogue Sound, Beaufort Inlet, Ocracoke Inlet and the mouths of the Neuse River, Newport River, New River and Cape Fear River being other areas of fishing activity.

Production for 1971-75 fluctuated between 4.2 and 8.5 million lbs with average yearly landings of 6 million lbs (heads-on) shrimp (Table 1). Brown and pink shrimp comprise the majority of the landings, 62.2 and 26.2%, respectively, with white shrimp representing less than 12%. Night fishing is legal in North Carolina with night-time fishing directed at brown and pink shrimp. Although better catches of these species occur at night, brown shrimp, at least, are also vulnerable to the fishery during the day (Wolff 1972)

The shrimp season opens on January 1. The pink shrimp fishery generally peaks by mid-May, while the brown shrimp season extends from June till late fall. White shrimp occur primarily in the vicinity of the Cape Fear Estuary where they form the basis of a fall fishery offshore.

Literature Review

Latham (1951) sampled two shrimp seasons in Pamlico Sound to estimate the incidental catch of the fleet. Fish:shrimp (presumably heads-on) ratios ranged from 2.00:1 to 14.54:1 with a mean seasonal ratio of 4.46:1 in 1950 and 2.00:1 in 1951. He concluded that an estimated 12 million lbs of young fish were destroyed each year by the shrimp trawlers, and that at least one-half of these were young of commercial species. Roelofs (1950) sampled Core and Pamlico Sounds and found considerably lower ratios. In Core Sound, ratios ranged from 0.56:1 to 6.67:1 with a mean ratio of 1.99:1; Pamlico Sound was comparable with a mean ratio of 1.70:1. Tiller (1951) reported ratios of 6.54 and 8.41 during a one-day trip to Pamlico Sound in September, 1951. Wolff (1972) as part of a trash fish survey, also sampled shrimp catches to determine fish:heads-on shrimp discard ratios and calculated a mean fish:heads-on shrimp ratio of 5.41:1. Additional ratio information was recorded by Connell Purvis (Personal communication) during the Pamlico Sound shrimp survey during fall, 1976. Estimates of by-catch in terms of catch-per-hr are not available for the North Carolina fishery.

Several reports (Brown and McCoy, 1969, Fahy, 1965a, 1965b, Wolff 1972) have been published describing the North Carolina "trash fishery", a fishery based on fish caught incidental to fin-fishing activities

in the Atlantic Ocean between Cape Hatteras and Bogue Inlet. At the present time, the trash fish fishery is operating at lower levels than previously. Boats have diversified for flounder and scallop fishing and trawl as far away as Massachusetts for groundfish; previously, boats went further south during the winter or scrap fished. In 1977, several boats scrap fished to supply a demand for crab pot bait (Maury Wolff, personal communication, September 9, 1977). The finfish fleet lands at least some of its incidental catch, while the shrimp fleet discards the majority of its by-catch. Fully utilizing the incidental catch of North Carolina may require modification of the fishing laws which presently restrict the amount of non-food fish that can be landed (Section 0600, North Carolina Fishing Regulations for Coastal Water 1977).

Ratio Estimates

Examination of the above studies shows that fish:shrimp ratios were highly variable. Because of the differences in gear from the 1950's to the present, data before 1960 were excluded from ratio estimate computations. Ratios ranged from 0.6:1 to 192.3:1 with day-time ratios consistently higher than night-time ratios (Table 2). Wolff (1972) noted that the lower ratios at night resulted from higher shrimp catches rather than lower fish catches; shrimp accounted for 13.7% of the catch by weight during the day compared to 17.7% by weight at night. It is not possible to allocate pink, brown and white shrimp catches from landing records to day or night, therefore, night and day ratios were pooled to provide a combined ratio estimate despite night/day differences. The combined estimate from each study was similar and accordingly, data were pooled to provide an overall median ratio estimate of 4.1:1 with confidence limits of 1.7 and 15.1. Of the 62 ratios in the pooled sample, 3 ratios exceeded 100:1 (5%) whereas 9 were between 20:1 and 100:1 (15%). It appears, therefore, that while ratios greater than 100:1 are relatively infrequent, ratios less than 100:1 should be considered representative of the fishery and included. Exclusion of ratios greater than 100:1 resulted in a combined day/night overall ratio of 4.0:1 with confidence limits of 1.7 and 10.5.

Species Composition of Trawl Samples

Ten species or assemblages of species accounted for 90.2% of the shrimp by-catch with spot, Atlantic croaker, pigfish and edible flounder comprising 75.3% of the total (Table 3). Species composition of landings was similar to that of the by-catch. Spot, flounder, Atlantic croaker, weakfish and kingfish accounted for 96.4% of landings (Table 4) and 72.2% of trawler catches (Table 3); however, the percentage of flounder and pigfish in trawl catches differed greatly from that in the landings.

By-catch Utilization

Shrimp trawlers caught an estimated 73.2 million lbs of fish between 1973 and 1975; of these, 3.8 million lbs were reportedly landed (Table 5). Monthly landings were highest between July and October

Table 1. Shrimp (heads-on) and fish landed by shrimp trawlers in North Carolina between 1971 and 1975. (Source: North Carolina landings and unpublished NMFS data).

	Shrimp	Landings (lbs)	Percent by Species	Fish Landings (
1971	brown	5,111,811	66.9	
	pink	1,926,623	25.2	
	white	603,550	7.9	
	TOTAL	7,641,984		*
1972	brown	3,203,846	76.5	
	pink	793,203	19.0	
	white	189,948	4.5	
	TOTAL	4,186,997		*
1973	brown	1,696,660	33.5	
	pink	1,525,330	30.1	
	white	1,843,065	36.3	
	TOTAL	5,065,055		809,282
1974	brown	6,132,690	72.5	
	pink	2,125,313	25.1	
	white	200,486	2.4	
	TOTAL	8,458,489		1,308,067
1975	brown	2,578,038	54.3	
	pink	1,525,330	32.1	
	white	644,482	13.6	
	TOTAL	4,747,850		1,708,534
1971- 1975	brown	18,723,045	62.2	
	pink	7,895,799	26.2	
	white	3,481,531	11.6	
	TOTAL	30,100,375		

*Indicates Data not Presently Available

TABLE 2. Median fish:heads-on shrimp ratio and confidence intervals (25th and 75th percentiles) determined from North Carolina data.

(Source: Wolff 1972)

1970-1971 DAY	<u>n</u>	NIGHT	<u>n</u>	COMBINED	<u>n</u>
3.3 < 9.1 < 19.2	16	1.2 < 2.6 < 17.8	19	1.3 < 5.2 < 17.8	35
2.1 < 8.8 < 19.2	15*	1.2 < 2.6 < 17.8	19	1.3 < 4.9 < 13.6	34*
2.1 < 5.9 < 9.7	12**	1.2 < 1.7 < 3.8	15**	1.2 < 2.9 < 7.3	27**

September to October, Pamlico Sound
(Source: Purvis, personal communication)

1976 DAY	<u>n</u>	NIGHT	<u>n</u>	COMBINED	<u>n</u>
1.5 < 15.6 < 90.1	6	2.2 < 3.7 < 5.7	21	1.9 < 4.0 < 15.8	27
1.5 < 15.1 < 26.0	5*	2.0 < 3.7 < 4.3	20*	2.1 < 3.9 < 9.2	25*
1.5 < 8.3 < 15.6	4**	2.0 < 3.7 < 4.2	19**	1.9 < 3.6 < 8.0	23**

Pooled Data

DAY	<u>n</u>	NIGHT	<u>n</u>	COMBINED	<u>n</u>
2.3 < 9.2 < 30.3	22	1.2 < 3.9 < 23.1	40	1.7 < 4.1 < 15.1	62
2.3 < 9.2 < 15.6	20*	1.7 < 3.7 < 11.4	39*	1.7 < 4.0 < 10.5	59*
1.5 < 5.5 < 9.8	16**	1.7 < 3.6 < 5.1	34**	1.5 < 3.6 < 6.5	50**

* Ratios > 100:1 excluded

** Ratios > 20:1 excluded

Table 3. Species composition and percent by weight in shrimp catches in North Carolina. (Source: Wolff, 1972).

<u>Rank</u>	<u>Species</u>	<u>Percent by Weight of Discard</u>
1	<u>Leiostomus xanthurus</u> (spot)	38.7
2	<u>Micropogon undulatus</u> (Atlantic croaker)	24.2
3	<u>Orthopristis chrysoptera</u> (pigfish)	8.4
4	<u>Paralichthys</u> sp. (2) (Edible flounders)	4.0
5	<u>Cynoscion regalis</u> (weakfish)	3.9
6	(*) (Inedible flounders)	3.1
7	<u>Lagodon rhomboides</u> (pinfish)	2.8
8	<u>Synodus foetens</u> (inshore lizardfish)	2.0
9	<u>Calamus</u> sp. and <u>Stenotomus</u> sp. (porgies)	1.7
10	<u>Menticirrhus</u> sp. (2) (kingfishes)	1.4

(*) Inedible flounders consisted of blackcheek tonguefish (Symphurus plagiusa), fringed flounder (Etropus crossotus), windowpane (Scophthalmus aquosus), spotted whiff (Citharichthys macrops), hogchoker (Trinectes maculatus), ocellated flounder (Ancylopsetta quadrocellata), and naked sole (Gymnachirus melas).

Table 4. Species of fish landed by shrimp trawlers in North Carolina, 1973-1975. (Source: NMFS)

Species	1973	1974	1975	Total	Percent
Spot	250,685	412,577	749,882	1,413,144	37.0
Flounder	244,518	398,271	379,794	1,022,583	26.8
Atlantic croaker	163,146	255,596	330,061	748,803	19.6
Weakfish	40,060	123,290	124,674	288,024	7.5
Kingfish	90,999	70,755	48,596	210,350	5.5
Bluefish	8,151	29,831	36,822	74,804	1.9
Butterfish	1,507	6,453	31,744	39,704	1.0
Pigfish	4,509	4,322	3,940	12,771	0.3
Spanish mackerel	1,213	3,251	360	4,824	0.1
Black mullet	1,700			1,700	<0.1
Spotted seatrout	120	743	630	1,493	<0.1
Blowfish	1,220			1,220	<0.1
King mackerel		644		644	<0.1
Black drum	126	200	228	554	<0.1
Sturgeon	141	142		283	<0.1
Red drum		95		95	<0.1
Sand perch		118		118	<0.1
TOTAL FISH	808,095	1,306,288	1,706,731	3,821,114	100.0%

Table 5. Comparison of estimated fish catches by shrimp trawlers in North Carolina with reported landings.

	<u>FISH LANDINGS</u> (1000's of lbs)	<u>ESTIMATED FISH CATCHES</u> (1000's of lbs)	<u>PERCENT OF ESTIMATED FISH</u> <u>CATCH REPORTEDLY LANDED</u> ¹
1973	808.1	8610.6 ≤ 20260.2 ≤ 53183.1	4.0%
1974	1306.3	14379.4 ≤ 33833.9 ≤ 88814.1	3.9
1975	1706.7	8071.3 ≤ 18991.4 ≤ 49852.4	9.0
1973-1975	3821.1	31061.3 ≤ 73085.5 ≤ 191849.6	5.22

¹Based on median catch

(Table 6). Although percent utilization of by-catch increased during this time, an estimated 95% of the by-catch was discarded.

SOUTH CAROLINA

Shrimp Fishery

In South Carolina, the major commercial shrimping area extends from Georgetown south to Calibogue Sound. Boats trawl for shrimp along the coastline out to 3 miles from shore in depths of 3 to 10 m. In late summer and early fall some sounds and bays are usually opened for commercial shrimping. Night trawling is illegal from September 1 to December 31. Between 1971 and 1975, shrimp production averaged 8.8 million lbs per year ranging from 7.6 million lbs in 1974 to 11.0 million lbs in 1971 (Table 7). White shrimp comprised 74.7% of landings and brown shrimp 25.3%; pink shrimp accounted for an insignificant part of the catch. The shrimp season extends from May to December. Large "rou" white shrimp support the fishery from May to June, young-of-the-year brown shrimp from July to early August, and young-of-the-year white shrimp from mid-August to the end of the season.

Literature Review

Comparatively little research has been directed towards the fish fauna of South Carolina's nearshorewaters. Investigators have surveyed South Carolina's estuaries (Curtis, 1971, 1972; Shealy, Miglarese and Joseph, 1974), the surfzone (Anderson *et al.*, 1977; Cupka, 1972), the offshore waters (Barans and Burrell, 1976, Bearden and McKenzie, 1971, Struhsaker, 1969), and studied individual species -- Atlantic croaker (Bearden, 1964), king whiting (Bearden, 1963), sea trout (Lunz and Schwartz, 1970) and spot (Dawson, 1958). Anderson (1968), in the 1930's, identified and enumerated fish caught in trawls during a survey of white shrimp grounds; catch rates were presented as the number of fish caught per hr. In the 1940's, Lunz (1944) sampled several shrimp trawlers and reported that 36% of the catch consisted of "non-usable fish, crabs, and other scrap". Keiser (1976) presented the results of a 2-yr study designed to estimate the quantity of fish caught by the shrimp fleet and to determine the species composition of the catch. Fish:shrimp (heads-on) ratios determined from 280 samples were used to estimate the total fish catch; catch rates were presented in terms of kg hr⁻¹.

Ratio Estimates

Results of 280 trawl samples indicated that the median ratio varied seasonally -- 2.58:1, May to August; 1.20:1, September to December; confidence limits (25th and 75th percentiles) were 1.24 to 5.43 and 0.56 to 2.66, respectively. Multiplication of these ratios times shrimp landings indicated that in 1975, 15.9 million lbs of fish were caught by shrimp trawlers.

Fish Catch Rates

Catch-per-hr data exhibited wide monthly variation. In January, March,

April, October, and December, fish catches averaged 90 lbs hr⁻¹, whereas in all other months, catches averaged over 119 lbs hr⁻¹. Peak catches occurred in May and November. The wide monthly fluctuations in catch-per-hr data probably reflect: 1) differences in the efficiency of different classes of fishing boats, 2) differences in the skill of various boat captains in avoiding schools of fish, 3) non-random distribution of fish, and 4) gear modifications in bottom line, net design and flotation (Keiser, 1976).

Species Composition of Trawl Samples

Anderson (1968) and Keiser (1976) provide information on the species composition of shrimp trawl catches. Anderson reported that 6 families (sciaenids, gadids, clupeids, engraulids, carangids, and cynoglossids) represented 93.5% of the shrimp trawl catch. In Keiser's study, 11 families represented 97.5% of the catch. In both investigations, sciaenids were the most abundant fish in trawl samples with six species of sciaenids comprising 63.9% of trawl samples during the shrimping season; menhaden, catfish, cownose rays and Spanish mackerel accounted for 18.0% (Table 8).

Fish Landings by South Carolina Trawlers

Annual fish landings by South Carolina shrimp trawlers ranged from 210,706 to 356,528 lbs between 1973 and 1975. Landings were generally highest between July and October (Table 9). Monthly landings ranged from a high of 69,791 lbs in September 1973, to a low of 615 lbs in April 1974. Kingfish, flounder and spot were predominant species in landings comprising 84.9% of the 3-yr total (Table 10).

By-catch Utilization

Of an estimated 39.7 million lbs of fish caught by shrimp trawlers between 1973 and 1975, 0.8 million lbs or 2% of the catch was reportedly landed (Table 11). Utilization of some species approached 50% (Table 12). The small size of spot and croaker explains their not being landed, whereas marketable mackerel were discarded for lack of selection by fishermen and/or buyers. At the present time, most fish utilized are sold in the round for direct human consumption. Any significant increase in utilization would require processing of industrial-size fish.

GEORGIA

Shrimp Fishery

Shrimp trawling is conducted along the entire Georgia coastline from the sounds and bays to 5 to 7 miles offshore. Some bays and sounds are open from September 1 to December 31, but night trawling for shrimp is illegal. Between 1971 and 1975, shrimp production averaged 8.1 million lbs (heads-on) per year ranging from 7.4 million lbs in 1972 to 9.1 million lbs in 1971 (Table 13). White shrimp comprised 85% of landings during this period, and brown shrimp the remaining 15%. The shrimp season extends from June to December with

TABLE 6. Pounds of fish landed monthly by shrimp trawlers in North Carolina, 1973-1975. (-) Indicates none landed. (Source: NMFS)

	<u>1973</u>	<u>1974</u>	<u>1975</u>
Jan	-	8,900	-
Feb	-	3,500	-
March	-	4,056	-
April	-	14,619	393
May	21,218	65,554	78,171
June	45,529	75,619	54,781
July	87,089	89,510	107,763
Aug	93,752	285,783	185,763
Sept	166,657	375,598	228,662
Oct	300,594	311,059	1,002,571
Nov	93,995	73,869	48,971
Dec	448		1,459
TOTAL	<u>809,282</u>	<u>1,308,074</u>	<u>1,708,534</u>

Table 7. Shrimp (heads-on) and fish landed by shrimp trawlers in South Carolina between 1971 and 1975. (Source: South Carolina landings and unpublished NMFS data).

	Shrimp	Landings (lbs)	Percent by Species	Fish Landings (lbs)
1971	brown	2,753,251	25.1	
	pink			
	white	8,207,147	74.9	
	TOTAL	10,960,398		*
1972	brown	2,246,790	27.3	
	pink			
	white	5,989,195	72.7	
	TOTAL	8,235,985		*
1973	brown	1,719,267	20.4	
	pink			
	white	6,706,653	79.6	
	TOTAL	8,425,920		356,528
1974	brown	2,077,977	27.5	
	pink			
	white	5,490,009	72.5	
	TOTAL	7,567,986		210,706
1975	brown	2,380,937	26.4	
	pink			
	white	6,641,873	73.6	
	TOTAL	9,022,810		247,178
1971- 1975	brown	11,178,222	25.3	
	pink			
	white	33,034,877	74.7	
	TOTAL	44,213,099		

*Indicates Data not Presently Available

Table 8. Species composition of South Carolina shrimp trawl samples
 May to December 1974 and May to mid-August 1975.

<u>Rank</u>	<u>Species</u>	<u>Percent by Weight of Discard</u>
1	<u>Leiostomus xanthurus</u> (spot)	40.2
2	<u>Brevoortia tyrannus</u> (Atlantic menhaden)	10.3
3	<u>Micropogon undulatus</u> (Atlantic croaker)	8.8
4	<u>Stellifer lanceolatus</u> (stardrum)	5.0
5	<u>Menticirrhus americanus</u> (Southern kingfish)	5.0
6	<u>Arius felis</u> (sea catfish)	3.4
7	<u>Cynoscion regalis</u> (weakfish)	3.0
8	<u>Rhinoptera bonasus</u> (cownose ray)	2.2
9	<u>Scomberomorus maculatus</u> (Spanish mackerel)	2.1
10	<u>Larimus fasciatus</u> (banded drum)	1.9
	TOTAL PERCENT	81.9

TABLE 9 . Pounds of fish landed monthly by shrimp trawlers in South Carolina, 1973-1975. (-) Indicates none landed. (Source: NMFS)

	<u>1973</u>	<u>1974</u>	<u>1975</u>
Jan	-	-	-
Feb	-	-	-
March	-	-	-
April	-	615	-
May	8,191	18,590	32,979
June	33,543	10,785	29,148
July	41,252	48,953	49,137
Aug	57,879	38,480	16,648
Sept	61,005	38,098	39,418
Oct	69,791	38,078	36,770
Nov	45,666	15,103	34,514
Dec	39,201	2,004	8,564
	<hr/>	<hr/>	<hr/>
TOTAL	356,528	210,706	247,178

Table 10. Species of fish landed by shrimp trawlers in South Carolina, 1973-1975. (-) Indicates none landed. (Source: NMFS)

SPECIES	1973	1974	1975	TOTAL	PERCENT
Kingfish	193,419	109,119	92,756	395,294	48.54
Flounder	74,406	45,036	58,411	177,853	21.84
Spot	58,880	23,742	36,003	118,625	14.56
Shark	16,069	24,209	31,054	71,332	8.76
Spotted seatrout	4,683	656	8,229	13,568	1.66
Spanish mackerel	2,094	632	8,049	10,775	1.32
Atlantic croaker	2,339	3,346	3,280	9,015	1.11
Menhaden	-	1,585	5,738	7,323	0.90
Pompano	3,568	109	1,199	4,876	0.60
Red drum	620	-	1,336	1,956	0.24
Atlantic sheepshead	350	1,342	50	1,742	0.21
Blackdrum	-	495	500	995	0.12
Gray seatrout	50	-	573	623	0.08
King mackerel	-	234	-	234	0.03
Bluefish	-	142	-	142	0.02
Sturgeon	-	59	-	59	0.01
TOTAL FISH	356,528	210,706	247,178	814,412	100.00%

TABLE 11. Comparison of estimated fish catches by shrimp trawlers in South Carolina with reported landings.

	<u>FISH LANDINGS</u> (1000's of lbs)	<u>ESTIMATED FISH CATCHES</u> (1000's of lbs)	<u>PERCENT OF ESTIMATED FISH</u> <u>CATCH REPORTEDLY LANDED</u> ¹
1973	356.5	6951.2 ≤ 14642.2 ≤ 46060.9	2.4%
1974	210.7	8031.0 ≤ 9081.6 ≤ 36507.0	2.3
1975	247.2	7338.0 ≤ 15948.9 ≤ 33434.0	1.5
1973-1975	814.4	22320.2 ≤ 39672.7 ≤ 116001.9	2.0

¹Based on median catch

TABLE 12. Comparison of estimated catches and reported landings for selected species caught by South Carolina shrimp trawlers between 1973 and 1975.

	PERCENT IN CATCHES	ESTIMATED TOTAL FISH LANDINGS (1000's of lbs)	ESTIMATED CATCHES OF SELECTED SPECIES (1000's of lbs)	REPORTED LANDINGS OF SELECTED SPECIES (1000's of lbs)	% UTILIZATION
Edible Flounders	1.0	39672.7	397.7	177.8	44.8%
Kingfish	5.0	39672.7	1983.6	395.3	19.9
Spanish Mackerel	2.1	39672.7	833.1	10.8	1.2
Spot	40.2	39672.7	15948.4	118.6	0.7
Atlantic croaker	8.8	39672.7	3491.2	9.0	0.2

Table 13. Shrimp (heads-on) and fish landed by shrimp trawlers in Georgia between 1971 and 1975. (Source: Georgia landings and unpublished NMFS data).

	Shrimp	Landings (lbs)	Percent by Species	Fish Landings (lbs)
1971	brown	1,152,835	12.7	
	pink			
	white	7,909,838	87.3	
	TOTAL	9,062,673		*
1972	brown	1,704,196	23.0	
	pink			
	white	5,697,957	77.0	
	TOTAL	7,402,153		*
1973	brown	608,157	7.2	
	pink			
	white	7,838,021	92.8	
	TOTAL	8,446,178		382,745
1974	brown	1,414,905	19.2	
	pink			
	white	5,963,370	80.8	
	TOTAL	7,378,275		313,831
1975	brown	1,295,992	15.8	
	pink			
	white	6,920,444	84.2	
	TOTAL	8,216,436		372,941
1971- 1975	brown	6,176,085	15.2	
	pink			
	white	34,329,630	84.8	
	TOTAL	40,505,715		

*Indicates Data not Presently Available

overwintered "roe" white shrimp fished in June, young-of-the-year brown shrimp in July and August, and young-of-the-year white shrimp in autumn.

Literature Review

Anderson (1968) reported on fish caught incidental to a white shrimp survey conducted between 1931 and 1935 in Georgia's inshore and offshore waters. The Bureau of Commercial Fisheries at Brunswick, Georgia, surveyed the fish of the beachfront and marsh in the mid-1960's (Jorgensen and Miller 1968, Miller and Jorgensen 1969). Knowlton (1972) conducted a survey of fish caught incidental to shrimping operations between 1969 and 1971. Hoese (1973) reported on a trawl study conducted on the central Georgia inshore continental shelf and adjacent Doboy Sound from 1966 to 1967. Mahood *et al.* (1974a, 1974b, 1974c, 1974d) inventoried estuarine and inshore oceanic waters of Georgia using trawls, seines, and gill nets from October 1970 to September 1973.

Ratio Estimates

Knowlton (1972) presents the most recent by-catch information of the Georgia shrimp fleet. Fish:heads-on shrimp ratios were calculated for 195 trawl samples from Knowlton's raw data. Ratios ranged from a low of 0.11:1 to a high of 49500:1; the latter resulted from a catch containing 495 lbs of fish and 0.01 lbs of shrimp. Eleven ratios (5.6%) exceeded 20:1 with 72% of high ratios occurring on the first tow of the day. Because subsequent tows by the same boat had ratios less than 20:1, the high ratios were considered not to be representative of the shrimp fleet and were excluded from ratio calculations.

Ratios varied greatly from year-to-year and from month-to-month. In general fish:heads-on shrimp ratios were more variable in 1970 than in 1969 (Figure 1). Monthly mean ratios ranged from 1.2:1 to 5.4:1 with one exception, December, 1969, which was based on only one sample (Table 14). Knowlton analyzed his data by regions corresponding to the three NMFS statistical districts, however, my analysis of mean ratios calculated from each district revealed no statistical differences among mean ratios. This suggests that one ratio estimate is adequate for the entire Georgia coastline.

The distribution of the ratios was markedly skewed (Figure 2), and the data were logarithmically transformed to obtain a more normal distribution (Figure 3). A mean ratio of 2.55:1 with 95% confidence limits of 0.33:1 and 19.54:1 was calculated from the log-transformed data. The median of 184 ratios was 2.56:1 with confidence limits of 0.98:1 to 4.43:1. Expansion of the median ratio reveals that in 1975 an estimated 21 million lbs of fish were caught by shrimp trawlers incidental to shrimping activities.

Fish Catch Rates

Knowlton, Anderson, and Hoese presented their findings as catch-per-unit

effort (cpue). Anderson reported that the number of fish hr^{-1} increased gradually from a low of 800 to 900 fish hr^{-1} in February and March to approximately 2400 in November and December. Knowlton's cpue rates are more variable. Catch rates were highest in May, 250 lbs hr^{-1} decreasing to 140 lbs hr^{-1} in June to 80 lbs hr^{-1} in October and again increasing to 200 lbs hr^{-1} in November; overall cpue for the study averaged 128.7 lbs hr^{-1} . In an earlier study, Hoese (1973) reported that catches with a 40 ft balloon shrimp trawl towed for 10-20 min along the beach averaged 180 lbs of fish hr^{-1} with two catches exceeding 500 lbs hr^{-1} . These rates are considerably higher than those reported by Knowlton. Hoese's data, however, cannot be compared directly to Knowlton's as 1) Hoese did not fish his gear in a commercial manner and 2) Hoese did not indicate monthly variation in cpue data.

As part of a statewide survey of estuarine and inshore waters, Mahood *et al.* (1974a, 1974b, 1974c, 1974d) sampled close inshore oceanic waters with a 40 ft flat shrimp trawl for a 1 yr period. An overall average of cpue for the coast was not provided, but yearly catch rates ranged from 23.5 lbs hr^{-1} in the Northern Section to 41.2 lbs hr^{-1} in the Southern Sector. These catch rates are considerably lower than those published by either Knowlton or Hoese.

Species Composition of Trawl Samples

Anderson 1968, Dahlberg and Odum 1970, Hoese 1973 and Knowlton 1972 provide information on species composition of near-shore waters. These studies cannot be directly compared as Knowlton's data were presented as percent by weight whereas both Hoese's and Anderson's are in terms of percent by number (Table 15). The samples were quite similar at the family level. Sciaenids were the predominant family in the four studies comprising between 63.5 and 72.5% of the total catch. Many of the apparent differences in ranking predominant species may be attributed to differences in data presentation. Hoese noted several differences between his findings and those of other studies: 1) Anderson caught fewer *Symphurus plagiusa* but relatively more *Etropus crossotus*; 2) Anderson caught large numbers of *Chloroscombrus chrysurus* in outside waters "perhaps indicating a greater abundance at that time"; and 3) Anderson as well as Dahlberg and Odum commonly found *Arius felis* in the catches which was taken only occasionally by Hoese.

Fish Landings by Georgia Trawlers

Annual fish landings by Georgia shrimp boats have fluctuated between 313,831 and 382,735 lbs during the last three years (Table 16). Monthly landings for the shrimping season ranged from 30,942 to 80,854 lbs; highest landings occurred between September and November. Kingfish and flounder were the predominant species, together comprising 81% of the 3 year landings, whereas "industrial fish" represented less than 1% (Table 17).

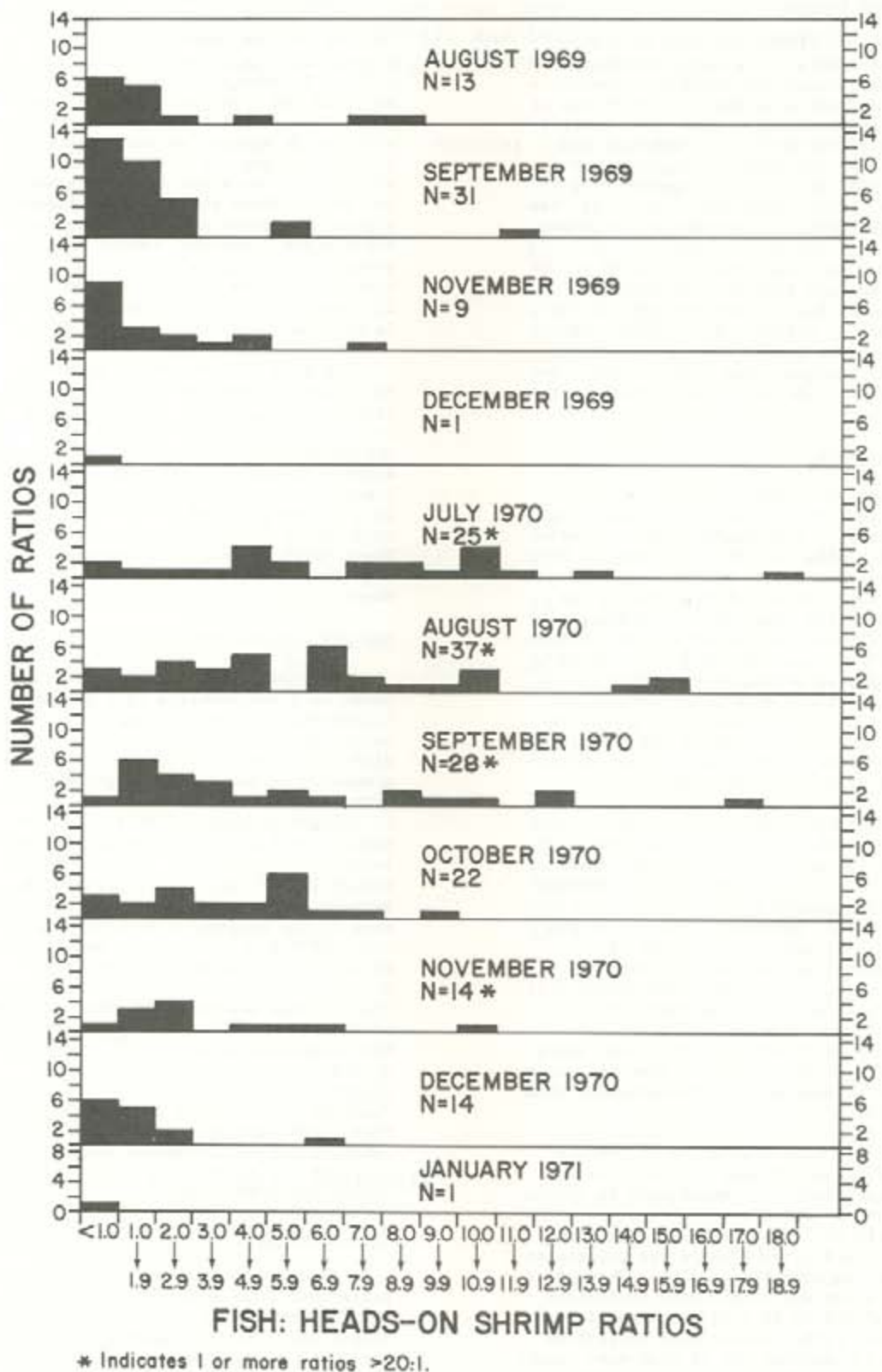


FIGURE 1. MONTHLY VARIATION IN FISH:HEADS-ON SHRIMP RATIOS DERIVED FROM COMMERCIAL SHRIMP TRAWLER CATCHES.

TABLE 14. Average monthly fish:heads-on shrimp ratio estimates in Georgia and associated 95% confidence intervals ($t_{.05}$ standard deviations) calculated from \log_{10} transformed data; ratios greater than 20:1 excluded from computations.

YEAR	MONTH	$-t_{.05}s$	MEAN	$+t_{.05}s$	MINIMUM RATIO	MAXIMUM RATIO	n
1969							
	August	.12	1.40	16.85	0.26	8.11	13
	Sept	0.20	1.19	6.96	0.23	11.55	31
	Oct						
	Nov	0.47	1.81	6.98	0.76	6.21	9
	Dec		0.87				1
1970							
	July	0.89	5.37	32.32	0.75	18.00	23
	August	0.51	4.16	34.02	0.11	15.30	33
	Sept	0.52	3.59	25.00	0.36	17.60	25
	Oct	0.59	3.05	15.75	0.67	9.62	22
	Nov	0.53	2.71	13.96	0.73	10.50	12
	Dec	0.22	1.18	6.37	0.26	6.30	14
1971							
	Jan		1.51				1

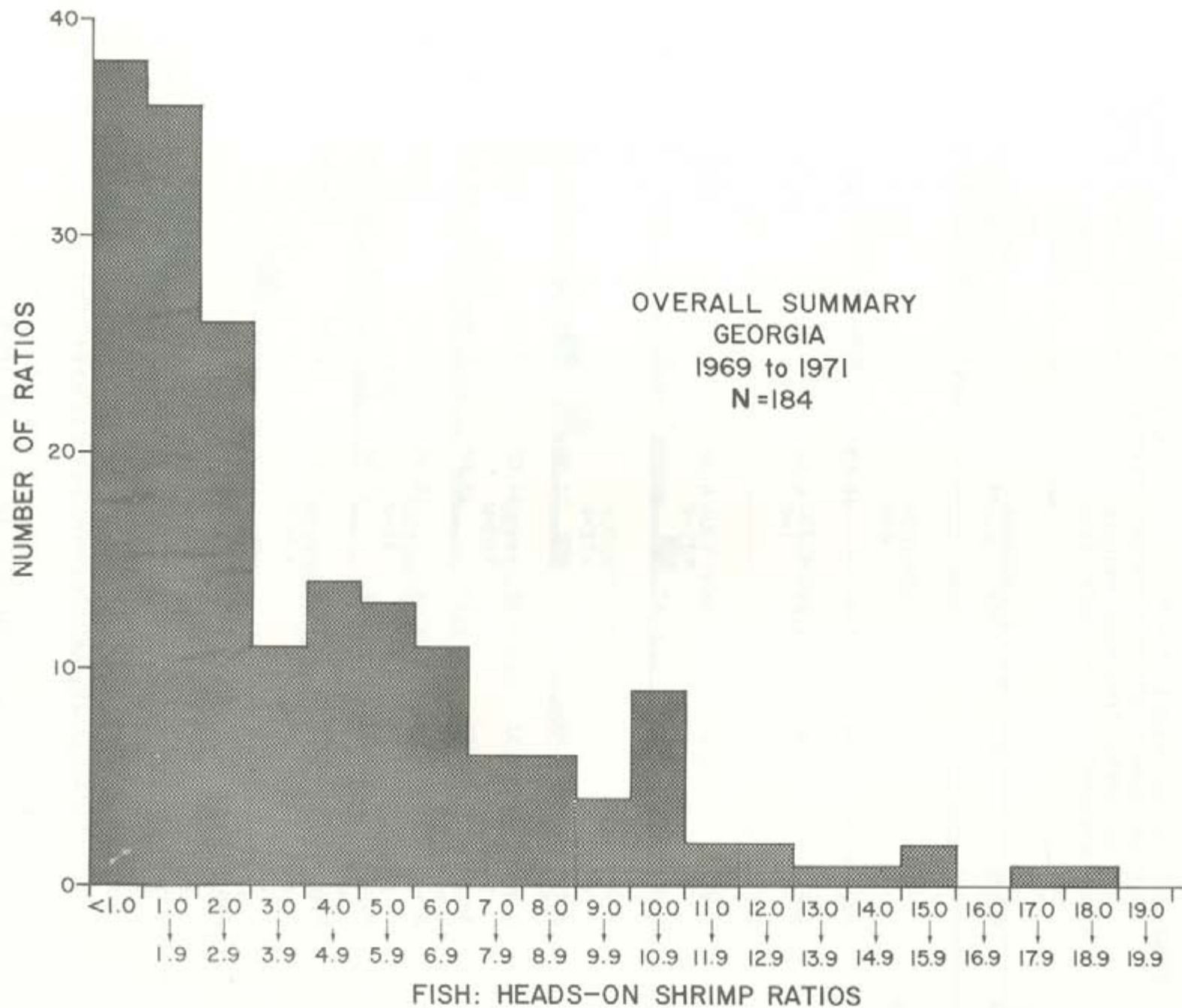


FIGURE 2. DISTRIBUTION OF FISH:HEADS-ON SHRIMP RATIOS (BY WEIGHT) CALCULATED FROM COMMERCIAL SHRIMP TRAWLERS AUGUST TO DECEMBER 1969 AND JULY 1970 TO JANUARY 1971 (10 HIGHEST RATIOS EXCLUDED).

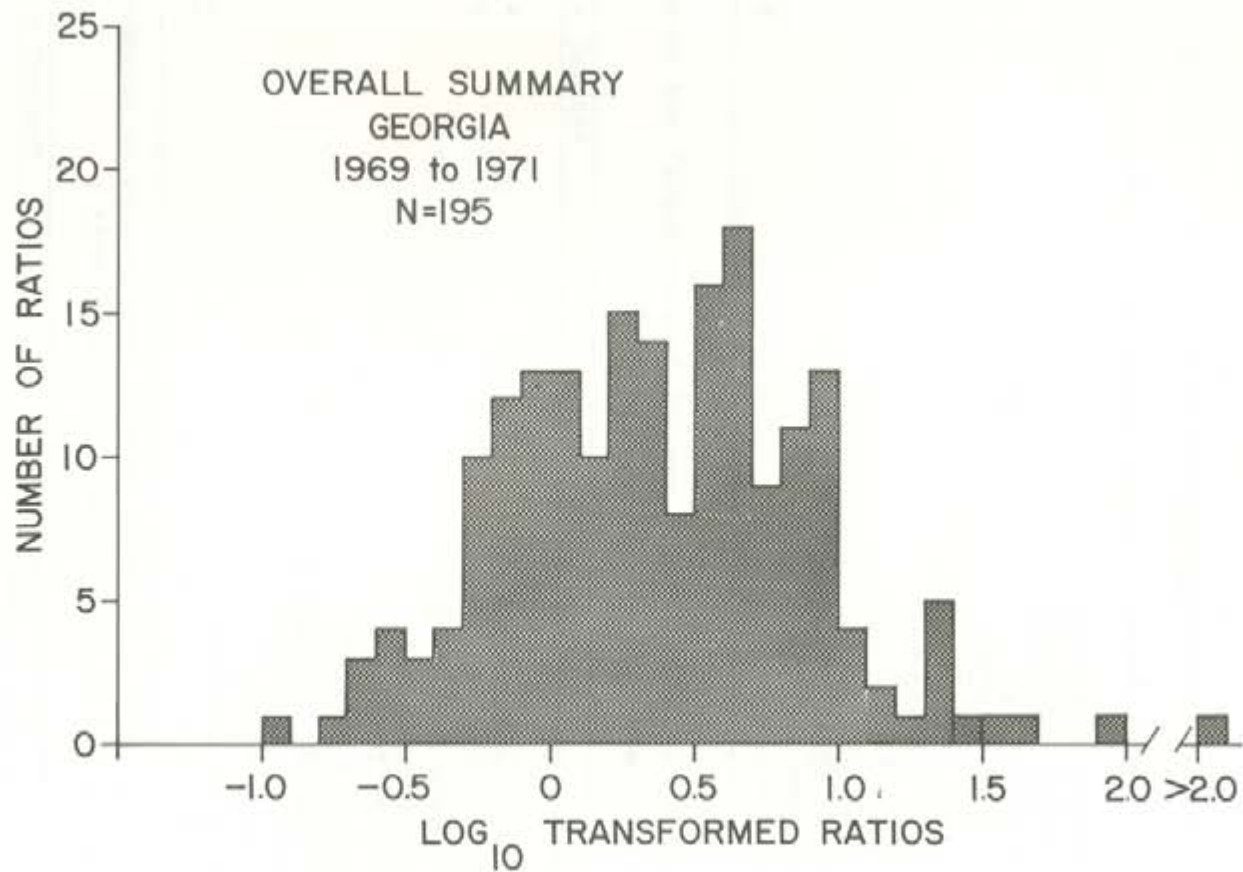


FIGURE 3. PLOT OF LOG₁₀ TRANSFORMED FISH:HEADS-ON SHRIMP RATIOS (BY WEIGHT) FROM COMMERCIAL SHRIMP TRAWLERS FROM AUGUST TO DECEMBER 1969 AND JULY 1970 TO JANUARY 1971.

TABLE 15. Comparison of the 10 most abundant species in trawls sampled in Georgia.

Species composition of Georgia shrimp trawl samples from July 1969 to June 1971 (Source: Knowlton, 1972)

RANK	SPECIES	PERCENT BY WEIGHT OF DISCARD
1	<u>Leiostomus xanthurus</u>	28.0
2	<u>Micropogon undulatus</u>	20.9
3	<u>Menticirrhus spp</u>	8.9
4	<u>Brevoortia tyrannus</u>	7.0
5	<u>Cynoscion regalis</u>	6.9
6	<u>Stellifer lanceolatus</u>	4.6
7	<u>Dasyatis spp</u>	3.6
8	<u>Arius felis</u>	3.3
9	<u>Larimus fasciatus</u>	3.2
10	<u>Trichiurus lepturus</u>	2.8
	Total Percent	89.2

Species composition of Georgia trawl samples between August and December, 1965, and January, June, and July, 1966 (Hoese 1973)

RANK	SPECIES	PERCENT BY NUMBER
1	<u>Stellifer lanceolatus</u>	47.3
2	<u>Anchoa mitchelli</u>	29.2
3	<u>Micropogon undulatus</u>	6.6
4	<u>Symphurus plagiusa</u>	5.2
5	<u>Cynoscion regalis</u>	4.9
6	<u>Bairdiella chrysura</u>	1.4
7	<u>Menticirrhus americanus</u>	1.4
8	<u>Leiostomus xanthurus</u>	1.1
9	<u>Cynoscion nothus</u>	0.8
10	<u>Trichiurus lepturus</u>	0.6
	Total Percent	98.5

Species composition of Georgia trawl samples from January to December, 1931-35 (all months and years combined) (Anderson 1968)

RANK	SPECIES	PERCENT BY NUMBER
1	<u>Stellifer lanceolatus</u>	38.0
2	<u>Micropogon undulatus</u>	10.1
3	<u>Leiostomus xanthurus</u>	7.8
4	<u>Menticirrhus spp</u>	7.1
5	<u>Chloroscombrus chrysurus</u>	6.7
6	<u>Cynoscion regalis</u>	3.6
7	<u>Brevoortia spp</u>	3.1
8	<u>Bagre marinus</u>	2.4
9	<u>Etropus crossotus</u>	2.2
10	<u>Trichiurus lepturus</u>	2.0
	Total Percent	83.0

TABLE 16. Pounds of fish landed monthly by shrimp trawlers in Georgia, 1973-1975. (-) Indicates none landed. (Source: NMFS)

	<u>1973</u>	<u>1974</u>	<u>1975</u>
Jan	3,049	7,265	4,455
Feb	2,015	-	5,088
March	4,868	-	4,763
April	6,173	13,845	1,913
May	8,264	26,344	32,515
June	37,756	30,942	35,717
July	40,395	38,208	46,649
Aug	51,157	31,708	27,665
Sept	80,854	42,902	57,986
Oct	53,844	48,248	53,578
Nov	57,407	36,356	62,578
Dec	36,953	38,013	40,034
	<hr/>	<hr/>	<hr/>
TOTAL	382,735	313,831	372,941

TABLE 17. Species of fish landed by shrimp trawlers in Georgia, 1973-1975. (-) Indicates none landed. (Source: NMFS)

SPECIES	1973	1974	1975	TOTAL	PERCENT
King fish	216,607	189,903	221,530	628,040	58.72
Flounder	77,304	74,340	89,988	241,632	22.59
Spotted seatrout	24,413	14,467	26,079	64,959	6.07
Spot	33,937	16,368	8,925	59,230	5.54
Atlantic croaker	14,679	8,388	4,104	27,171	2.54
Atlantic sheepshead	5,205	7,022	5,525	17,752	1.66
Red drum	1,453	1,795	8,302	11,550	1.08
Spanish mackerel	4,755	255	5,130	10,140	0.95
Black drum	4,048	857	-	4,905	0.46
Gray seatrout	200	-	2,137	2,337	0.22
Sturgeon	-	436	333	769	0.07
Catfish	-	-	489	489	0.05
Bluefish	-	-	399	399	0.04
Uncl. industrial/bait fish	144	-	-	144	0.01
TOTAL FISH	382,745	313,831	372,941	1,069,517	100.00%

By-catch Utilization

Of an estimated 61.5 million lbs of fish caught between 1973 and 1975, 1.7% were reportedly landed (Table 18). Although the proportion of sciaenids in the catches (72.5%) (Table 15) approximated that in the landings (73.6%) (Table 17), there were some striking differences at the species level. Croaker, for example, accounted for only 2.5% of the landings, but 20.9% of the fish caught, whereas kingfish accounted for 58.7% of landings, but only 8.9% of catches. The percentage of bothids in landings is far greater than that in catches. A comparison of estimated catches by species to actual landings (Table 19) show that flounder have the highest rate of utilization (32.7%) followed by kingfish with 11.5%. Croaker and spot, although predominant in catches (48.9%) account for less than 9% of landings. Market acceptability especially interspecies size differences probably explains the differential selectivity by fishermen for these species.

FLORIDA

Shrimp Fishery

Shrimping along the east coast of Florida (Florida Keys excluded) is restricted to areas north of Ft. Pierce Inlet; further south, the continental shelf becomes too narrow and the bottom is not suitable for trawling. Shrimp landings have remained relatively constant during the last five years, ranging from 2.6 million pounds in 1975 to 4.3 million pounds in 1972 (Table 20). Between 1971 and 1975, white shrimp comprised 77.2% of total shrimp landings, brown shrimp: 22.4% and pink shrimp: 0.4%. Night trawling is illegal in all counties bordering the Atlantic except during the months of June, July and August.

Literature Review

By-catch information pertaining to the northeast coast of Florida is limited to three studies (Anderson, 1968, Beaumariage, 1968, and Siebenaler, 1952). Joyce (1965) described the fishery of the northeastern coast of Florida and the results of a biological survey conducted between 1961 and 1962; however, no by-catch information was included in the report. Anderson and Gehringer (1965) described the fishery of the Cape Canaveral area; by-catch information presented was based on the 1930's survey by Anderson later published in Anderson (1968).

Ratio Estimates

Siebenaler (1952) sampled boats at Mayport and Key West, Florida between March and November 1951, to determine the amount of "usable trash" caught by shrimp boats. Information obtained from sampling at Mayport was used to derive estimates for the east coast of Florida. "Usable trash" was defined as shrimp heads, undersized shrimp, fish, and crustaceans other than shrimp. The fish component of the "trash fraction" in Mayport averaged 50.3%, ranging from 40.9% in November to 60.2% in May. The overall ratio of "trash":shrimp

(heads-off) was approximately 6:1. This corresponds to a fish:shrimp (heads-on) ratio of 3.8:1. Siebenaler estimated that 13.7 million lbs of usable trash was caught by the Northeast Florida shrimp fleet in 1951.

Fish Catch Rates

There is very little information pertaining to catch rates of incidental species by Florida trawlers. Siebenaler estimated that daily catches of shrimp trawlers ranged from a high of 732 lbs of fish day⁻¹ in May to a low of 342 lbs day⁻¹ in September. Anderson's (1968) yearly average catch rate was 2700 fish hr⁻¹ ranging from approximately 200 fish hr⁻¹ in April, May and June to 4500 to 5500 fish hr⁻¹ between October and November.

Species Composition of Trawl Samples

Siebenaler reported that at Mayport, whiting, blue crabs, flounder, Spanish mackerel, spot, bluefish and pompano were the predominant species caught by trawlers. Catches of game and commercially exploited fish species were highest in May, comprising 6.7% of the trawl catch of fish and shrimp and lowest in September, 0.9%. No information was published pertaining to the relative proportion of each species in the samples. The only other study that included catch composition information is from the 1930's (Table 21). The family Sciaenidae was the largest component of the catch comprising between 47.1% in December to 79.8% in July. Carangids comprised 16.5% of yearly samples and were more abundant in October, December, January, April and May than at other times of the year. Ariidae represented 4.6% of yearly catches comprising between 0.4% of the catch in May to 8.7% in January.

In addition to the fishery for *Penaeus*, a rock shrimp fishery has recently developed at Cape Canaveral, Florida (Kennedy et al., In press). Important components of the by-catch of this fishery include scallops and portunid crabs (Kennedy, personal communication).

Fish Landings by Florida Trawlers

Of an estimated 13.4 million lbs of fish caught incidental to shrimping in 1974, approximately 980,000 lbs (7.2%) was landed (Table 22). Kingfish and flounder comprised 83.5% by weight of fish landed and sciaenids as a group, 70.5% (Table 23).

DISCUSSION

Ratios determined from shrimp trawl catches in North Carolina were more variable than those calculated from catches in South Carolina, Georgia and Florida (Table 24). Examination of fishing activities may offer an explanation for the wider variation in North Carolina: 1) fish catches may be more variable in sounds than in nearshore waters -- 50% of North Carolina production comes from Pamlico Sound in contrast to other states where fishing is conducted generally within 1 to 3 miles of shore; and 2) the pink shrimp by-catch may be more variable than those of the white

TABLE 18. Comparison of estimated fish catches by shrimp trawlers in Georgia with reported landings.

	<u>FISH LANDINGS</u> (1000's of lbs)	<u>ESTIMATED FISH CATCHES</u> (1000's of lbs)	<u>PERCENT OF ESTIMATED FISH</u> <u>CATCH REPORTEDLY LANDED¹</u>
1973	382.7	8,277.2 < 21,622.2 < 37,416.6	1.8%
1974	313.8	7,230.7 < 18,888.4 < 31,800.4	1.7%
1975	372.9	8,052.1 < 21,034.1 < 32,685.8	1.8%
1973-1975	1069.4	23,560.0 < 61,544.7 < 101,902.8	1.7%

¹Based on median estimated catch.

TABLE 19. Comparison of estimated catches and reported landings for selected species caught by Georgia shrimp trawlers between 1973 and 1975.

	<u>PERCENT IN CATCHES</u>	<u>ESTIMATED TOTAL FISH CATCHES (1000's of lbs)</u>	<u>ESTIMATED CATCHES OF SELECTED SPECIES (1000's of lbs)</u>	<u>REPORTED LANDINGS OF SELECTED SPECIES (1000's of lbs)</u>	<u>% UTILIZATION</u>
Flounders	1.2%	61,544.7	738.5	241.6	32.7%
Kingfish	8.9%	61,544.7	5,477.5	628.0	11.5%
Spot	28.0%	61,544.7	17,232.5	59.2	0.3%
Atlantic croaker	20.9%	61,544.7	12,862.8	27.2	0.2%

Table 20. Shrimp (heads-on) and fish landed by shrimp trawlers in Florida between 1971 and 1975. (Source: Florida landings and unpublished NMFS data).

	Shrimp	Landings (lbs)	Percent by Species	Fish Landings (lbs)
1971	brown	746,560	22.4	
	pink			
	white	2,578,347	77.6	
	TOTAL	3,324,907		*
1972	brown	570,589	13.2	
	pink			
	white	3,749,907	86.8	
	TOTAL	4,320,496		*
1973	brown	478,816	17.0	
	pink	7,121	0.3	
	white	2,327,558	82.7	
	TOTAL	2,813,495		*
1974	brown	1,463,084	41.4	
	pink	6,187	0.2	
	white	2,068,892	58.4	
	TOTAL	3,538,163		979,517
1975	brown	458,381	17.5	
	pink	47,588	1.8	
	white	2,117,464	80.7	
	TOTAL	2,623,433		*
1971- 1975	brown	3,717,430	22.4	
	pink	60,896	0.4	
	white	12,842,168	77.2	
	TOTAL	16,620,494		*

*Indicates Data not Presently Available

TABLE 21. Principal fish comprising the white shrimp by-catch of the northeastern coast of Florida, 1931-35 (Source: Anderson 1968).

<u>Species</u>	<u>Percent</u> (by number)
Star drum	28.4%
Atlantic croaker	17.5
Atlantic bumper	10.1
Silver seatrout	9.6
Kingfish	7.3
Spot	5.7
Sea catfish	4.5
Moonfish	4.1
Banded drum	1.6
Gafftop catfish	<u>1.2</u>
Total	90.0%

Table 22. Comparison of estimated fish catches by shrimp trawlers in Florida with reported landings.

	<u>FISH LANDINGS</u> (1000's of lbs)	<u>ESTIMATED FISH CATCHES</u> (1000's of lbs)	<u>PERCENT OF ESTIMATED FISH CATCH</u> <u>REPORTEDLY LANDED¹</u>
1973	*	10691.3	-
1974	979.5	13445.0	7.3%
1975	*	99690.4	-
1973-1975	*	34105.3	-

¹Based on median catch

*No landing data available

TABLE 23. Species of fish landed by shrimp trawlers on the east coast of Florida, 1974. (Source: NMFS)

SPECIES	TOTAL POUNDS	PERCENT
Kingfish	662,014	67.58
Flounder	156,382	15.96
Bluefish	31,740	3.24
Gray seatrout	20,460	2.09
Spanish mackerel	7,000	0.71
Spotted seatrout	3,104	0.32
Amberjack	2,700	0.28
Atlantic croaker	2,685	0.28
Spot	2,528	0.26
Food fish (unclassified)	8,440	0.86
Industrial/bait fish	<u>82,464</u>	<u>8.42</u>
TOTAL	979,517	100.00%

Table 24. Estimated fish catches of the commercial shrimp fleet for the South Atlantic Region between 1973 and 1975

State	Median Fish/Heads-on Shrimp Ratios	n	Shrimp Landings (1000's of lbs)	Estimated Fish Catches (1000's of lbs)	Fish Landings (1000's of lbs)
North Carolina	P ₂₅ P ₅₀ P ₇₅ 1.7<4.0<10.5	59	18271.4	73108.5	3821.1
South Carolina	1.2<2.6<5.4 ^{1/} 0.6<1.2<2.7 ^{2/}	280	25016.7	39672.7	814.4
Georgia	1.0<2.6<4.4	184	24040.9	61544.7	1069.4
Northeastern Florida	3.8 ^{3/}	^{4/}	8975.0	34105.0	3000.0 ^{5/}
TOTAL				208430.9	8704.9
Yearly Average				69477.0	2901.6

1/ Median Ratio - May to August

2/ Median Ratio - September to December

3/ Mean Ratio

4/ n Unknown

5/ Estimated

or brown shrimp fisheries-- North Carolina is the only state in the region with a fishery directed at pink shrimp.

The median ratio values calculated from available data suggest that the by-catch of trawlers fishing in the South Atlantic Region is less than that of similar boats fishing in the Gulf of Mexico. Juhl (1974) reported that in the Gulf of Mexico, fish:heads-on shrimp ratios ranged from 4.1:1 to 20.0:1. He used an average ratio of 10.0:1 to estimate annual incidental fish catches on shrimping grounds. Chittenden and McEachran (1975) calculated a ratio of 11.35 volumes of discard (approximately 90% fish) to 1 volume of shrimp (heads-off) from 60 shrimp-trawl catches; 95% confidence limits were 9.7:1 and 13.0:1. The overall fish:shrimp (heads-off) ratio was approximately 10.0:1. This corresponds to a fish:shrimp (heads-on) ratio of approximately 6.2:1.

Fish:shrimp (heads-on) ratios ranged from a low of 1.2:1 during part of the shrimping season in South Carolina to a high of 4.0:1 in North Carolina. Using data assembled during this investigation, I estimate that the shrimp fleet in the South Atlantic Region caught an average of 69.5 million lbs of fish per year from 1973 through 1975 (Table 24). This was approximately 24 times the average yearly landings for this period (2.9 million lbs). At the present time, only food fish for which there is a traditional market (e.g. whole or filets) are landed and the remainder of the by-catch, which potentially could be marketed as minced fish or meal, is discarded.

Presently only North Carolina has facilities for processing industrial-size fish. Lack of processing facilities, however, is not the only factor preventing increased utilization of the resource. On-board reduction of fish was proposed as early as 1950 (Baughman 1950) and more recently, Georgia's Sea Grant Program has investigated this possibility (S.A. Vezey, D.V.M., personal communication, December 21, 1976). Another factor is the traditional preference by shrimpers for the higher-priced penaeid shrimp. In fact, reduction plants in the Gulf of Mexico are supplied by a fishing fleet which is independent of the shrimping fleet (Guthertz, *et al.* 1975) because the price paid to shrimpers for incidental species failed to provide them with sufficient incentive to land a dependable supply of fish.

The biggest problem may be ensuring a year-round supply of fish for the processing plants. The few trawls made during non-shrimping months (Anderson 1968; Keiser 1976; Knowlton 1972) appear to indicate that the largest biomass of fish coincides with the shrimping season. Detailed surveys must be made to determine the seasonal nature of the nearshore fishery resource.

Increasing the use of blue crabs, which at times comprise a large part of shrimp trawler catches, offers another possibility for increasing shrimp trawler landings. The quantity of blue crabs caught by trawlers is not known. Attempts to

quantify blue crab catches in South Carolina employing methods used to sample the fish by-catch were unsuccessful (Keiser 1976). The quantity of blue crabs landed in South Carolina depends on market price and the inclination of the individual shrimper; often large quantities of marketable crabs are shoveled overboard (R. K. Keiser, Jr., personal observation). Shrimp trawlers account for only a small part of the total blue crab landings (Table 25). The landings attributable to shrimp trawlers varied considerably from state to state; in Georgia, trawlers accounted for more than 11% of 1975 landings compared to less than 0.1% of South Carolina landings. In general, the relative amount of blue crabs landed by shrimp trawlers has declined during the period 1973 to 1975.

Several differences between the Gulf of Mexico and the South Atlantic Region suggest that it may not be wise to develop an industrial fleet to exploit nearshore fishery resources. In the Gulf of Mexico, the shrimp and industrial fishery resource extend much further offshore and are to some extent independent because fishing activities do not occur in close proximity to shrimp and sciaenid nursery areas. In contrast, along the South Atlantic coast, the shrimp fishery is conducted within 6 miles of shore and overlaps the sciaenid resource. Furthermore, Hoese (1973) doubted that the nearshore region would provide sufficient quantities of fish to support profitable harvesting operations. He noted that catch rates close to the beach in Georgia with a 40-ft balloon shrimp trawl only twice exceeded 500 lbs hr⁻¹ and averaged 180 lbs hr⁻¹; catch rates in the sounds were twice those of inshore waters, but fishing there would destroy large numbers of juvenile shrimp. Hoese's average catch rates were higher than those determined by Knowlton, 120 lbs hr⁻¹, for the Georgia commercial shrimp fleet, but lower than that estimated by Keiser, 272 lbs hr⁻¹ for the South Carolina shrimp fleet. Knowlton (personal communication, September 2, 1977) indicated that his data probably represented the lowest estimates of fish catch rates for shrimp trawlers. Nevertheless, catch rates from his study are considerably below those of 1209 lbs hr⁻¹ estimated for the industrial fish fishery of the Gulf of Mexico (Rothmayr 1965). In conclusion, it seems that increasing fishing production in the South Atlantic Region should focus first on utilizing shrimp by-catch before encouraging development of a separate industrial fishery.

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Table 25. A comparison of the amount of blue crabs landed by shrimp trawlers to that landed by all gear types. (Source: NMFS, unpublished data; North Carolina landings, 1973-75; South Carolina landings, 1973-75; Georgia landings, 1973-75)

State	LANDINGS (1000's of lbs)		Percent Landed By Shrimp Trawlers
	Shrimp Trawlers	All Gear	
North Carolina			
1973	236.8	12,008.4	2.0%
1974	221.0	13,196.8	1.7
1975	247.5	11,087.6	2.2
South Carolina			
1973	44.6	7,952.0	0.6
1974	0.0	7,547.6	-
1975	1.0	6,565.2	<0.1
Georgia			
1973	1,446.6	7,984.2	18.1
1974	1,480.8	10,130.8	14.6
1975	990.4	8,865.4	11.2

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