numbers of the smaller group were lost while the lines were being hauled. Had no individuals been lost by tearing of hooks from their mouths, it is quite probable that the percentage in the smallest group would have been somewhat higher. A rough analysis of the catches by sportsmen, who were trolling slower, using lead, and fishing deeper than our surface trolled lures, as well as exercising great care in playing the fish, indicated a higher proportion of large fish than is shown in Table I. A considerable number of larger fish as indicated by the heavy strike were also lost. These factors may in part account for the apparent low percentage in the largest fish group.

Spawning Season

During a period of taking data from July 3 to August 1, all of the fish examined showed evidence of being sexually mature or near that condition. On July 13, about 10 miles due east of St. Helena Sound, three females were taken which were partially spawned. From then until August 1, the gonads of the females were very full and individual eggs could be distinguished, or the gonads were partially collapsed. Many of the males taken between July 3 and August 1 were observed to have freely running milt. Of the 226 fish examined, 53 per cent were found to be males and 47 per cent were females. The gonads of fish taken in February and in October were very small.

The exploratory expedition when considered from the commercial viewpoint was not successful; however, a great deal was learned about the habits of the species and their seasonal distribution which should prove of great value in the collecting of sufficient information to eventually lead to the exploitation of this resource.

Studies of "Trash" Caught by Shrimp Trawlers in Florida

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Introduction

A MATTER OF PRACTICAL CONCERN is the present large waste of trash caught in the course of shrimp trawl operations. Besides shrimp, this gear catches considerable quantities of fish and invertebrates which are now discarded.

This waste material can be converted into valuable meal, which is used in poultry and stock feeding. Wide interest has been expressed in the possibility of utilizing the waste. Estimates have been made of the amount of waste available but little is known of the true amounts caught, the relative amounts of the various components of the trash, nor the seasonal variation. The present study has as its object the investigation of these matters as well as a study of the economic feasibility of establishing reduction plants to process the shrimp trash.

The present report deals with observations from March 1951 to February 1952 carried out in behalf of the Florida State Board of Conservation.

Methods

Four series of observations on a bi-monthly basis have been made in the Mayport-Fernandina fishing area and five series were made on the Tortugas grounds. A total of 58 hauls have been examined.

Observations have been made aboard the shrimp vessels. Information collected on each haul consisted of the amount and size of marketable shrimp,

* Contribution No. 63 from the Marine Laboratory, University of Miami.

the weight of game and commercial fish, and the amount of trash. The trash was divided into the components that could be used to produce meal and other useful by-products, and the non-usable part. The latter is composed chiefly of sponges, holothurians and shells. The useful trash includes shrimp heads, undersized shrimp, fish and miscellaneous crustaceans other than shrimp.

When the contents of the shrimp net were dumped on deck the pile was roughly divided into the various catagories listed above. Because of the large volume of material involved actual weights could not be obtained, but estimates were made of the weight of each lot. The advice of the fishermen was obtained in making these estimates, since these men are experienced in approximating the weight of their catch and usually can guess with some accuracy. Checks were made on the accuracy of the estimates by actual weighing of portions of the material, in some cases. The reported weights are, therefore, not exact, but should be sufficiently accurate for the present purpose. Specimens of the organisms caught were preserved for specific identification.

Results

The ratio of total trash (including miscellaneous crustaceans, shrimp heads and fish) to headed shrimp averaged 2 to 1 on the Key West grounds. On the East Coast of Florida the ratio of total trash to shrimp averaged about 6 to 1.

On the Tortugas grounds the only game and commercial fish were taken in March. An average of 8 pounds of spanish mackerel per drag, or 2.5 per cent of the total catch, were caught. In the Mayport area the game and food fish caught were at a maximum in May, with an average of 32 pounds, or 6.7 per cent of the total catch, taken per drag. In September only 3 pounds, or 0.9 per cent, were caught in an average haul. Whiting, blue crabs, flounder, spanish mackerel, spots, bluefish and pompano comprised the catch of game and commercial fish at Mayport.

On the Tortugas grounds an average of 10 pounds of undersized shrimp were discarded per drag, in August. In October an average of 212 pounds were discarded. About 3 pounds of small shrimp per drag were caught on the Mayport grounds in July. No undersized shrimp were seen in other observations there.

The dominant species taken in the Tortugas catches were mojarras, swimming

TABLE 1

SEASONAL COMPOSITION OF THE TRASH PER DRAG, IN POUNDS

Date	*Quantity Useable Trash*	*Quantity Shrimp Heads**	*Percent Shrimp Heads*	*Quantity Fish*	*Percent Fish*	*Quantity Crabs & Misc. Crustacea*	*Percent Crabs & Misc. Crustacea*
			MAYPORT—1951				
May	405	19	4.7	244	60.2	142	35.1
July	325	52	16.0	160	49.2	110	33.8
Sept.	238	53	22.3	114	47.9	71	29.8
Nov.	337	171	50.8	138	40.9	28	8.3
			KEY WEST—1951-1952				
March '51	202	52	25.7	142	70.3	8	4.0
June '51	159	57	35.8	69	43.4	33	20.8
Aug. '51	258	77	29.8	118	45.7	63	24.4
Oct. '51	423	346	81.8	35	8.3	42	9.9
Jan. '52	292	144	49.3	127	43.5	21	7.2

* Includes undersize shrimp

crabs, bronze grunts, rockfish and cuban snappers. Blue crabs, weakfish, croakers and spots dominate the catch on the upper East Coast grounds.

Only in May was any appreciable amount of unusable trash taken on the Mayport grounds. An average of 10 pounds per drag, or 2.1 per cent of the total catch, was caught. A maximum of 64 pounds, or about 21 per cent of the total catch, was taken in June. Eleven pounds, or 1.7 per cent, was caught per drag in the month of October at Tortugas.

On the Mayport grounds the amount of trash varied from an average of 405 pounds per drag in May to a minimum of 238 pounds in September (Table 1). Assuming that each boat makes 3 drags per day, the total trash caught ranged from a minimum of 714 pounds to a maximum of 1,215 pounds per day per vessel. On the Tortugas grounds the daily catch of trash per vessel was lowest in June, when an average of 477 pounds was caught, and highest in October, the average catch being 1,269 pounds in that month.

The weight of shrimp landed monthly in the Key West and Mayport-Fernandina areas separately is shown by statistical reports issued by the Marine Laboratory for the State Board of Conservation, in cooperation with the Fish and Wildlife Service (Florida Landings). Using the ratios for the amounts of shrimp to trash, the total amount of the latter has been estimated from these landings in the two areas, by months (Table 2).

TABLE 2

ESTIMATED AMOUNTS OF TRASH CALCULATED FROM FLORIDA LANDINGS

Month	*Year*	*East Coast*	*Tortugas*
February	1951	300,000	2,519,721
March	1951	640,823	3,313,570
April	1951	1,024,570	3,024,790
May	1951	1,216,564	3,548,012
June	1951	1,132,711	2,329,990
July	1951	1,039,881	1,154,370
August	1951	1,252,762	437,308
September	1951	1,411,743	363,518
October	1951	2,593,995	523,404
November	1951	1,920,792	649,542
December	1951	817,212	1,117,050
January	1952	325,179	2,647,934
Estimated Totals		13,676,232	21,629,209

On the East Coast the amount of trash is estimated at about 2.5 million pounds in October, the peak month. In December through March the amounts ranged from about 300,000 to 800,000 pounds. The annual estimated total for the East Coast is about 13.7 million pounds.

From August to December the trash available in the Tortugas area was low, ranging from 350,000 to 650,000 pounds per month. The peak was reached in May, with an estimated 3½ million pounds being caught. The total trash would amount to about 21.6 million pounds annually from this area.

These annual figures have been broken down into the amounts of shrimp heads, fish and miscellaneous crustacea. According to Vincent (1950) it requires about 3 pounds of crab waste to produce one pound of crab meal. The ratio is about 4 to 1 for trash fish and 5 to 1 for shrimp heads. Using these figures, the amount of meal which could be produced annually at Mayport are as follows: shrimp bran, 321 tons; fish meal, 849 tons and crab meal, 616

tons. From the Tortugas grounds the quantities would be: shrimp bran, 1,095 tons; fish meal, 994 tons and crab meal, 450 tons.

The market value of fish meal is about $135 per ton at present. Shrimp bran brings about $100 per ton and crab meal about $60 per ton. Vincent (1950) has calculated the cost of producing a ton of meal to be $17.60. Before deducting the cost of the raw material, a "profit" is shown of $117.40 for the fish meal, $82.40 for the shrimp bran and $42.40 for the crab meal per ton of finished product. However, if the raw material were bought at one cent per pound (which is the approximate price paid for scrap fish in New England) its cost per ton of finished product would be about $80 for the fish, $100 for the shrimp heads, and $60 for the Crustacean material. It now becomes apparent that a reduction plant would operate at a loss of $17.60 per ton on the shrimp heads and the crabs. On the fish meal a profit of $37.40 per ton could be expected, if the operating prices quoted are accurate, and if present prices prevailed. To insure a profitable operation it would appear that less than one cent per pound could be paid to the fishermen. Alternately, only fish scrap might be bought, with the shrimp heads and crustacean scrap being discarded. In either case it might be unattractive for the fishermen to handle the scrap. Further, since the shrimp heads and miscellaneous crustacea amount to over half the useable trash, if they are not used the totals of available scrap set forth above would have to be greatly reduced.

A profitable scrap fish industry exists in New England despite a cost of raw materials of one cent per pound. However, the large volume of scrap available, consisting almost entirely of the more valuable fin fish, is undoubtedly a major factor here. According to Sayles (1950) almost 90.3 million pounds of trash fish were landed in New England during 1950. Here invertebrates were only 1.2 per cent of the total trash landings. In the two areas in Florida under consideration there is a potential availability of about 34.3 million pounds but about 21.9 million pounds, or 63.9 per cent of this would be shrimp heads and other crustaceans. Snow (1950) reports that in an 8 to 18 hour fishing day in New England an average catch for a vessel would be about 30,000 to 35,000 pounds. This is about 30 times what could be expected on the Florida grounds.

There is some possibility that trash utilization would be economically more feasible if the end-product were high-priced condensed solubles (stickwater) instead of the lower-priced meal. Baughman (1950) has examined the possibility of manufacturing stickwater with meal and oil as the by-products. He also suggests the use of "buying boats," equipped with macerating machines and refrigerated tanks in the hold, capable of carrying up to 100 tons of liquid gurry. These vessels could follow the fleet on the shrimping grounds and collect at periodic intervals. A representative of the Sharples Corporation, commenting on this idea, doubted that the fish could be liquified without being cooked. This problem would seem to justify some investigation.

The following conclusions are drawn as a result of this investigation. It would probably be possible to establish a successful trash fish industry in Florida if: (1) the plant could operate profitably on a seasonal basis. There are several months in the year when most of the fleet is either concentrated at Key West or on the East Coast of Florida; (2) if efficient methods are devised for collecting the scrap. This would probably be best accomplished by a run boat, collecting from the shrimpers when they are concentrated at anchorage. In Key West several hundred boats anchor in two general areas. It would be possible to collect from the boats at the anchorage each morning. It would be somewhat more difficult for a run boat to operate on the East Coast, since the fleet generally operates along the whole coast from Jacksonville to

Fort Pierce for a few months of the year. However, if quick and convenient provisions are made for unloading at the docks, the fishermen would bring in the catch. It may be possible, then, to truck the scrap to the reduction plant. When the boats are away from port from two to four days they could only bring in the last day's catch. In such an event, the total scrap potential must again be reduced. The fishermen state that they will not collect scrap if they are forced to wait at the unloading platform for any length of time. Therefore, efficient unloading appears to be of prime importance to the establishment of the industry.

In a recent interview with a North Carolina fisherman, prices for trash were discussed. He stated that some North Carolina fishermen were willing to collect scrap for six-tenths of a cent a pound, for a plant in that area. It may be possible to interest the Florida fishermen at this price, if the unloading is handled in a swift and efficient manner.

List of Fishes and Invertebrates Caught
Shrimp Trawl Operations—Upper Florida East Coast

FISHES

Clear-nosed skate	*Raja eglanteria*	Banded croaker	*Larimus fasciatus*
Cow-nosed ray	*Rhinoptera quadriloba*	Mademoiselle	*Bairdella armata*
Gaff-topsail catfish	*Felichthys marinus*	Star drum	*Stellifer lanceolatus*
Sea catfish	*Galeichthys felis*	Spot	*Leiostomus xanthurus*
Thread herring	*Opisthonema oglinum*	Croaker	*Micropogon undulatus*
Menhaden	*Brevoortia tyrannus*	Southern kingfish	*Menticirrhus americanus*
Spanish mackerel	*Scomberomorus maculatus*	Gulf kingfish	*Menticirrhus littoralis*
King mackerel	*Scomberomorus cavalla*	Spade fish	*Chaetodipterus faber*
Cutlass fish	*Trichiurus lepturus*	Common triggerfish	*Balistes carolinensis*
Moonfish	*Vomer setapinnis*	Southern stargazer	*Astroscopus y-graecum*
Look-down	*Selene vomer*	Toadfish	*Opsanus tau*
Common pompano	*Trachinotus carolinus*	Midshipman	*Porichthys porosissimus*
Bluefish	*Pomatomus saltatrix*	Earl's ling	*Urophycis earlli*
Harvest fish	*Rhombus paru*	Ocellated fluke	*Ancylopsetta quadrocellata*
Butterfish	*Rhombus tricanthus*	Flounder	*Syacium papillosum*
Rock sea bass	*Centropristes philadelphicus*	Window pane	*Scophthalmus aquosus*
Common sea bass	*Centropristes striatus*	Tonguefish	*Symphurus plagiusa*
Sand fish	*Diplectrum formosum*	Sole	*Trinectes maculatus*
Weakfish	*Cynoscion regalis*		

INVERTEBRATES

White shrimp	*Penaeus setiferus*	Squid	*Loligo pealii*
Spotted shrimp	*Penaeus duorarum*	Squid	*Loligo brevis*
Blue crab	*Callinectes sapidus*	Whelk	*Busycon sp.*
Calico crab	*Arenarius cribrarius*	Tulip shell	*Fasciolaria tulipa*

VERTEBRATES

Loggerhead turtle *Caretta caretta*

List of Fishes and Invertebrates Caught
Shrimp Trawl Operations—Key West

FISHES

Sharp-nose shark	*Scoliodon terrae-novae*	Littlehead porgie	*Calamus proridens*
Skate	*Raja texana*	Pinfish	*Lagodon rhomboides*
Ocellated moray	*Gymnothorax ocellatus*	Mojarra	*Eucinostomus argenteus*
Sardine	*Sardinella anchovia*	Ribbonfish	*Eques lanceolatus*
Thread herring	*Opisthonema oglinum*	Common triggerfish	*Balistes carolinensis*
Lizard fish	*Synodus foetens*	Fringed filefish	*Monocanthus ciliatus*
Northern barracuda	*Sphyraena borealis*	Orange filefish	*Alutera schoepfi*
Goatfish	*Upeneus maculatus*	Cowfish	*Lactophrys tricornis*
Spanish mackerel	*Scomberomorus maculatus*	Southern blowfish	*Spheroides spengleri*
Common jack	*Caranx hippos*	Scorpionfish	*Scorpaena calcarata*
Common pompano	*Trachinotus carolinus*	Sea robin	*Prionotus sp.*
Banded rudderfish	*Seriola zonata*	Shark remora	*Echeneis naucrates*
Cobia	*Rachycentron canadus*	Midshipman	*Porichthys porosissimus*
Rockfish	*Diplectrum formosum*	Cusk eel	*Lepophidium sp.*
Lane snapper	*Lutianus synagris*	Soles	*Family - Soleidae*
Bronze grunt	*Bathystoma striatum*	Batfish	*Ogcocephalus radiatus*

INVERTEBRATES

Sponge	*Verongia longissima*	Squilla	*Squilla empusa*
Loggerhead sponge	*Spheciospongia verparia*	Spiny lobster	*Panulirus argus*
Russian helmet sponge	*Ircinia campana*	Stone crab	*Menippe mercenaria*
Spotted shrimp	*Penaeus duorarum*	Squid	*Doryteuthis plei*
Stone shrimp	*Eusicyonia sp.*	Fighting conch	*Strombus pugilis*
Spanish lobster	*Scyllarides aequinoctalis*	Chinese alphabet	*Conus spurius*
Box crab	*Calappa flammea*	Tulip shell	*Fasciolaria tulipa*
Box crab	*Hepatus epheliticus*	Pecten	*Pecten gibbus*
Swimming crabs	*Cronius ruber*	Lion's paw	*Pecten nodosus*
Squilla	*Lysiosquilla maculata*	Star fish	*Oreaster reticulatus*

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Methods of Capturing Flying Fish

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BARBADOS is one of the few places in the world where the flying fish industry constitutes over 80 per cent of the fishery. The species sought is *Hirundichthys speculiger* which averages about one-third pounds in weight. At the present time they are sold for 6c each in the local market. In glutted periods this price is often reduced to 1½c each or less.

The boats used in Barbados are almost all sail boats of about 22-26 feet overall length, having a large oversized jib and an equally large mainsail. These boats are relatively fast sailers, and the ballast, which is usually all inboard, is shifted from side to side. Such boats carry a crew of three men.

Boats put to sea during the very early hours of the morning and generally endeavour to follow the prevailing current, since the flying fish are usually to be found travelling in the direction of the current. Up to 1949 observation of the current was the only method used to trace the movements of the flying fish.

In December of 1949 a Government research boat was added to the Fishery Department, and research work was started for the purpose of finding better methods for locating flying fish. This program is under the writer's direction.

The old methods for spotting and capturing fish were tried for some weeks with moderate success, following which new methods were tested. First, an examination was made of the plankton occurring in areas where flying fish were prevalent. To do this a small cylindrical plankton indicator was put over and towed at half speed (4½ knots) astern of the boat for periods of twenty minutes about 5-7 miles off-shore. The indicator screen was then inspected under the microscope to determine the occurrence of indicator species. There were often thirty or more types on the four-inch screen.

After some weeks of this plankton collecting it was evident that certain kinds of plankton were associated with the flying fish. Examination of the gills and upper stomach of freshly captured flying fish showed certain plankters to recur frequently. Henceforth, particular attention was paid to the numbers