

of small absorption systems, such as would be suitable for use on small shrimp boats. One manufacturer has offered the information that absorption units of less than 10 tons capacity would not be as efficient as comparable size compression units. This has not been confirmed.

Split Absorption System

In addition to the complete absorption installation there is one method of using the absorption system on small boats which may be worth considering. It is the split absorption system. In this system, which has been used experimentally on refrigerated cars, only one half of the system is installed aboard the vessel, while the other half is operated ashore. The refrigerating equipment on the boat consists of only an ammonia pressure tank, evaporator coils, and a tank of water. At sea, when the boat requires refrigeration, the ammonia in the pressure tank is simply released through an expansion valve into coils to produce the cooling effect and is then passed into a tank of water, where it is absorbed to form aqua ammonia. The shore plant, which may serve many boats, removes the strong aqua ammonia from the boat, puts it through the heating cycle to boil off the ammonia gas from the solution and then condenses the gas to form liquid ammonia. The liquid ammonia is then used to recharge the system on the boats.

A report on a test of this system in railroad cars is described in an article which appeared in the June 1947 issue of *Quick Frozen Foods*.

For boats which will be at sea only a few days the split absorption system may be feasible. For those on long trips of 10 days or more, the size of the ammonia and water tanks required may occupy so much more space that the system would not be feasible. For example, to maintain a temperature of 0° F. in an insulated railroad car approximately 1000 pounds of liquid ammonia and 500 gallons of water were required for each 24-hour period. One advantage the split absorption system would have over ice is that the system need not be turned on until refrigeration is needed. However, the biggest advantage by far is that the system is practically fool-proof and has no moving parts on the vessel installation.

At this point a word of caution is in order. The purpose of this information on refrigeration is merely to offer suggestions as to what might be done aboard shrimp boats. Before any type of refrigerating equipment is installed on any type of fishing boat a competent refrigeration engineer should be consulted.

Future work on the freezing-fish-at-sea project will undoubtedly provide definite information which is applicable to the freezing of shrimp. The relatively small size of shrimp together with the limited amounts caught during a 24-hour period should make freezing shrimp at sea a feasible operation.

Exploratory Fishing for the Little Tuna (*Euthynnus alletteratus*) Off the Atlantic Coast of the United States

C. B. CARLSON, *Fishery Engineer, U. S. Fish and Wildlife Service,
College Park, Maryland.*

Introduction

INTEREST in the utilization of little tuna (*Euthynnus alletteratus*) began during World War II when several companies prepared packs from incidental

catches in an effort to develop new sources of food. The efforts of Mr. Cyrus Chilton of the Fish and Wildlife Service materially contributed toward developing interest in the species. While the flavor of the canned product was acceptable, the color, when processed by the usual procedures of the tuna industry, was somewhat darker than is desirable. Several years ago, the Fish and Wildlife Service and the Blue Channel Corporation independently conducted technological research to develop a better pack. In general, it was found that lower processing temperatures and increased cooking time enhanced both the color and flavor. Subsequently, commercial packs were prepared by the Blue Channel Corporation and were found to be quite acceptable to the trade. Since the catches of little tuna were seasonal and incidental to other fisheries, the need of obtaining a year-around supply was obvious.

Early in 1951 Mr. Sterling Harris of the Blue Channel Corporation, expressed interest in a cooperative arrangement with the Fish and Wildlife Service to explore for and to develop a little tuna fishery along the Atlantic Coast. The initial explorations were started on an informal basis to obtain preliminary information on problems which might be anticipated. In February 1951 the M. V. *Barbet*, owned by Mr. John Robas, was made available for exploratory work and about two week's time was spent in trolling and searching for surface indications of little tuna in the area from Savannah, Georgia to Cape Canaveral, Florida at distances from 5 to 150 miles offshore. No surface schools were sighted and only 5 little tuna were caught on trolling gear. These were taken in waters having a depth of approximately 23 fathoms on a north-easterly line running off Fernandina, Florida to Brunswick, Georgia and alongside schools of porpoise which were thought to be feeding. On one occasion, a little tuna was captured near a spot of "color" beside a school of porpoise but the spot quickly disappeared, thereby precluding positive identification. While little tuna appeared to be associated with porpoise during February, there was no evidence of such association during exploratory work in the summer and fall.

Because of the apparent scarcity of surface schools and the necessity of conserving limited funds, operations were suspended temporarily. The two weeks of exploration indicated that little tuna might be difficult to find in commercial quantities and demonstrated the need for information on the seasonal pattern of occurrence to plan a program.

Reconnaissance Survey

A reconnaissance survey was made by interviewing various persons associated with commercial fishing and by consulting the meager literature on the species. It was surprising that many fishermen, interviewed along the coast from the Carolinas to Mississippi and having offshore experience, had observed little tuna at some time or other. The reconnaissance indicated a wide and seasonable distribution of surface schools along the Atlantic and Gulf Coasts. Schools are normally seen over and outside the Dry Tortugas shrimp grounds with a degree of frequency from April through November and throughout the remainder of the year occasionally come to the surface for the waste discarded by shrimp trawlers. An analysis of observations by fishermen indicated that surface schools show progressively further northward along both the Gulf and Atlantic Coasts as the spring and summer advance followed by a southward regression as the fall and winter develop and that considerable variations of the sizes of the schools could be expected. It also developed that weather conditions might be a controlling factor on the occurrence of surface schools. Fishermen usually

observed the schools during calm weather and bright sunshine but surface indications were rare if the chop exceeded two or three feet, although tuna were known to be present because of catches on trolling gear.

Exploratory Trolling Operations

In June of 1951 a formal cooperative agreement was executed between the Fish and Wildlife Service and the Blue Channel Corporation, whereby the Service contributed fishing gear, technical supervision and a limited portion of the operating costs while the Corporation furnished a vessel, crew and the balance of all expenses. It was obviously impossible to investigate the large area of distribution of little tuna as revealed by the reconnaissance survey in the time available. Consequently, the exploratory work was limited to the Atlantic Coast from Fort Pierce, Florida to Cape Hatteras, North Carolina and along the east coast of New Jersey.

Approximately two months were spent between Cape Hatteras and Fort Pierce in a preliminary searching for surface schools; in trolling to obtain specimens for identification and to locate little tuna when schools were not visible. Activities from June 10 through June 21 were in the area from Port Royal Sound, South Carolina to Fort Pierce, Florida, where little tuna were taken in varying numbers in random trolling during each day's operation at distances of 5 to 50 miles offshore. The most consistent fishing was found off the area from Cape Canaveral to Fernandina, Florida in depths of water between 10 and 15 fathoms, which, over much of the area, generally lies between 10 and 15 miles offshore. On occasions fish would be caught on all four lines from a given spot while from others the number varied from 1 to 3 fish but usually, when making repeated passes over the spot, few if any additional little tuna were caught nor could any surface signs be observed. This condition could be interpreted to imply scattered fish or small schools and was a general condition when the height of the sea exceeded three feet. Surface schools were sighted on four occasions off Fernandina, St. John's Lightship, Flagler Beach, Florida and off Brunswick, Georgia. Of these only the school off Flagler Beach showed evidence of having extensive tonnage. Whenever surface signs, ranging from a single fish to finning and jumping schools or schools working small fish were seen, the height of the sea was less than three feet.

Since the surface signs of little tuna off Georgia and Florida were not impressive from the viewpoint of a purse seine operation, the explorations from June 26 through July 13 were directed to areas between Port Royal Sound, South Carolina and Cape Hatteras, North Carolina. The weather with the exception of four days was generally unfavorable for purse seining but trolling was possible. Here again scattered fish were frequently taken by trolling and the best fishing grounds were between depths of 10 and 15 fathoms. Furthermore, the little tuna were usually found where the depth of water changed rather abruptly by one to several fathoms as appeared to be the case between Fernandina and Cape Canaveral. Interviews with several party boat operators revealed similar impressions and their belief that feed congregated over these spots of uneven bottom. The best trolling was found in the area between Cape Lookout Shoals and New River, North Carolina and near the 2CR Buoy off Cape Romaine, South Carolina. One compact school showing evidence of extensive tonnage was found over an edge varying in depth from 9 to 14 fathoms southwestward of Cape Lookout. Several small schools were seen near the 2CR Buoy and one was registered on the automatic depthmeter. The scarcity of surface schools and the predominant southwest winds coupled with

rough seas which are common during the summer render that season unsuitable for consistent purse seining operations.

Explorations from July 17 through August 3 were directed to the southward from Port Royal Sound to Cape Canaveral. Schools of little tuna had been reported for two weeks prior to July 20 in locations first south and later north of Cape Canaveral. These, or perhaps different schools, were located on July 25 outside of St. Augustine and many schools were seen during the next 7 days as far north as Brunswick, Georgia, when adverse weather prohibited explorations. Areas from 2 to 5 miles wide and from 5 to 10 miles long over depths of water from 10 to 14 fathoms appeared to be literally alive with schools of little tuna varying in size from a few fish to extensive tonnage. The schools were only seen during calm weather but none were seen in choppy weather. Very few fish were caught from the schools by trolling but many individuals were taken in areas between the schools.

Exploratory Purse Seining Operations

Exploratory operations were temporarily suspended until August 27 while a converted aircraft rescue craft, 104 feet in length, was being rigged for purse seining. Exploratory purse seining was attempted between Port Royal Sound and Cape Canaveral until September 7 but consistency of operations was impossible because of mechanical difficulties. However, on August 29 many schools of little tuna were seen off the St. John's Lightship and one set was made. Inexperience of the crew and delays in starting the seine overboard resulted in missing the school but approximately 50 fish were caught. Further sets were prohibited because of failure of the main engine also used for pursuing the seine.

Exploratory work was again resumed on September 13 and continued until November 3. The passage of two hurricanes coupled with the normal amount of adverse weather, usually expected during the fall, left only 6 days suitable for operating a tuna purse seine in offshore waters, although scouting and trolling was conducted whenever possible. It was planned initially to work off Morehead City, North Carolina where little tuna had been abundant in the fall of 1950, but unfavorable weather there and reports of little tuna off New Jersey caused operations to be shifted. For two weeks prior to our arrival at Manasquan Inlet, New Jersey, a substantial portion of the catches in the pound nets were little tuna and numerous schools appeared from the beach to a distance of 5 miles offshore between Manasquan Inlet and Sandy Hook. From September 21 through October 9 winds from all quarters, varying from moderate to gale in force, were prevalent on all but two days. With the exception of four days, when a hurricane passed offshore, the vessel was at sea in search of little tuna but only an occasional fish was taken on trolling gear and no schools were observed.

The base of operations was shifted to Morehead City, North Carolina on October 12 and explorations were terminated on November 1. During this time the weather was only suitable for offshore explorations on two days, consequently the research was confined to the area between Cape Lookout and New River which afforded some lee from the predominant northerly winds. Small schools were seen nearly every day within four miles of shore and three sets were made. On the first set the inexperience of the crew resulted in loss of the fish. The other two sets made on surface signs of 3 to 10 fish resulted in catches of 30 to 40 fish.

Very favorable reports on the presence of little tuna between Fernandina and St. Augustine were received on November 1. It was intended to shift operations to this area but a week of stormy weather resulted in a decision to terminate

the project. The most regrettable feature of the entire project other than the unfavorable weather, was that the purse seiner was not available during mid-summer when many surface schools were seen. Had the converse been true, it is firmly believed that substantial catches could have been made.

The information gathered during the reconnaissance survey, the wide distribution of the species as shown during trolling work, the heavy concentration of surface schools observed during the latter part of July and early August off Florida, tends to the conclusion that little tuna are abundant. The limited number of sets made indicates that little tuna are quite susceptible to capture by purse seines when surface schools can be found. Far more work is required to establish the pattern of occurrence and to correlate this with weather conditions to provide a sound basis for exploiting the fishery.

Biological Information

Mr. Warren Rathjen, an undergraduate student in zoology at the University of Miami, participated in the exploratory trolling phase of the project and was delegated the responsibility of collecting a limited amount of biological information with the view of obtaining preliminary ideas on the types of food, size distribution of the species, and spawning season.

Types of Food

Many of the stomachs were opened in an effort to determine the feed of the little tuna. Small herring-like fish constituted the largest portion of the stomach contents which could be identified in the field, and squid were also present in considerable quantities. In many instances when herring were found in the stomachs and little tuna were numerous, large masses of algae were observed on the surface giving the water a light brownish-green appearance. This algae was identified as *Trichodesmium* (*Skujaella*), and possibly played some part in the feeding habits of the herring. Table I presents the recognizable items and their frequency of occurrence in the stomach of a number of fish.

TABLE I

Species	Number of Item Identified
Round herring— <i>Etrumeus teres</i>	46
Squid	33
Spanish sardine— <i>Sardinella anchovia</i>	14
Unidentified fish	13
Round scad— <i>Decapterus punctatus</i>	9
Spanish mackerel— <i>Scomberomorus maculatus</i>	1
Mud parrotfish— <i>Sparisoma flavescens</i>	1

Size Distribution

A total of 226 fish were measured and a rough analysis aboard the vessel indicated three general size groups as shown in Table II.

TABLE II

Size Range Inches	Percentage
15.4 to 19.9	15
20.0 to 24.9	68
24.9 to 32	17

These data were taken from fish caught on trolling gear from Cape Canaveral, Florida to Cape Lookout, N. C. Because of the tender mouths, considerable

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

J. B. SIEBENALER, *The Marine Laboratory, University of Miami*

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.