

containing from 65-70 per cent or from 95-98 per cent animal protein depending upon processing method, B-vitamins, calcium and phosphorous, would help to give the protein-deficient child the 10 to 15 grams (about one third to one half ounce) so necessary to keep him in nitrogen balance. This would be comparable to the 30 or 40 grams of skim-milk powder necessary to sustain him for the day. It would permit easy incorporation within the field ration of the soldier and of the airman on the fringes of space of the most nutritious and most concentrated form of protein known to man.

In general, fish flour is ideally suited for the diet of children. Its biologically complete, easily digestible protein is excellently adapted to their still immature digestive processes. Its incorporation in breads, cakes, cereals, pastries, etc. would permit the parent to give her child his daily protein requirement in a most pleasing form and would eliminate the fear of his "spoiling his appetite for dinner." Four "toll-house" cookies containing three per cent of fish flour by weight would supply approximately two-fifths of his daily protein requirement.

Fish flour is potentially an excellent addition to the geriatric diet. Believe it or not, many of our elder citizens are suffering from a sub-clinical protein deficiency. They refuse or are unable to chew the tougher meat products and content themselves with a badly unbalanced diet of potatoes, cereals, cakes, bread or eggs. Fish flour contains little or none of the sodium or carbohydrate trouble-makers for old folks. Inclusion of fish flour in food products utilized by elderly persons would do much to help their nutritional well-being.

In general, fish flour is applicable to any medical diet which is designed to yield (1) biologically valuable trace minerals, (2) high levels of B-vitamins, (3) reduction of sodium intake, (4) reduction in fat and carbohydrate intake as well as (5) high levels of easily digestible, biologically complete, readily available protein.

Rough estimates as to costs indicate that fish flour, when judged on a per-pound-of-protein basis is even now cheaper than dry milk solids and closely competitive with soyflour. The Bureau feels that an adequate study of the engineering requirements and of nutritional standardization of fish flour would reduce costs further, open a potentially limitless market in the American food manufacturing business and possibly make available to the underdeveloped countries a gift more valuable than all of our contributions to date.

Continuous Distribution of Menhaden Along the South Atlantic and Gulf Coasts of the United States

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Introduction

THE MENHADEN purse-seine fishery of the Atlantic and Gulf Coasts of the United States depends almost exclusively upon two distinct and geographically separated species: the Atlantic menhaden (*Brevoortia tyrannus*) and the Gulf menhaden (*B. patronus*). The Atlantic menhaden ranges from Nova Scotia to the central east coast of Florida, while the Gulf menhaden generally occurs from

the central west coast of Florida to the Mexican border. Landings of Atlantic menhaden have averaged well over one billion pounds annually for the past five years, while landings of the Gulf menhaden have averaged nearly a half a billion pounds annually during the same period.

The fishing grounds and the location of plants for processing the catch are determined by the seasonal occurrence and abundance of the fish. Annual, seasonal, and geographical fluctuations in fish availability and abundance have troubled the menhaden industry from its beginning. Thus the fundamental questions of this industry are these: (1) What is the nature and the extent of the resource? (2) What are the causes of fluctuations in the catch? and (3) Are fluctuations in the catch predictable?

The elucidation of the above questions requires a thorough knowledge of the species which constitute the resource, their distribution in time and space, and the extent of mixing between them. In the present discussion only the first question will be considered and this will be further confined to our recent work and findings concerning the species which occur over a relatively short area of the range, viz., the menhaden off the Florida peninsula.

Background

In addition to the Atlantic and Gulf menhaden, two other menhaden species have been reported from North American waters;¹ these include the yellowfin menhaden (*Brevoortia smithi*) and the fine-scaled Gulf menhaden (*B. gunteri*).

The Atlantic and Gulf menhaden are very similar; both have large scales arranged in regular rows, numerous black pigment spots are present along the sides of the body, prominent ridges occur on the opercle or upper part of the cheek, and head and body are elongated. As adults the Atlantic and Gulf menhaden school in open coastal waters and both apparently spawn in the ocean.

The yellowfin menhaden and the fine-scaled Gulf menhaden constitute a second pair of closely related species. They have fine scales which form no discernible pattern, there are no secondary black pigment spots on the sides of the body, opercular ridges are very faint or absent, and the head and body are shortened. As adults the yellowfin menhaden and fine-scaled Gulf menhaden aggregate in loose, scattered schools in tidal embayments and estuaries. Both yellowfin and fine-scaled Gulf menhadens apparently spawn in inland tidal waters.

Each pair of similar species (*Brevoortia tyrannus*-*B. patronus* and *B. smithi*-*B. gunteri*) also have other structural and biological features in common including: shape of the fins and scales, body texture and color, maturation of gonads, and behavior.

Until recently, our knowledge of the distributions of the foregoing species was based entirely on Hildebrand (1948) and may be summarized as follows:

- (1) Atlantic menhaden (*Brevoortia tyrannus*)—Nova Scotia to Daytona Beach, Fla.
- (2) Gulf menhaden (*Brevoortia patronus*)—Tampa, Fla. to the Mexican border
- (3) Yellowfin menhaden (*Brevoortia smithi*)—Cape Lookout, N. C. to Cape Canaveral, Fla.

¹A fifth species, *B. breviceaudata*, was described by Goode (1878) on the basis of a single collection from Noank, Connecticut; however, this species has not been reported since.

(4) Fine-scaled Gulf menhaden (*Brevoortia gunteri*)—Grand Isle, La. to the Mexican border

Hildebrand (1948) stated that menhaden did not occur off southern Florida and substantiated this belief by observations from the Keys made by himself, Isaac Ginsburg, and Charles M. Breder, Jr. Hildebrand's conclusions, that separated and isolated species occurred in the Gulf of Mexico and along the East Coast of the United States, was not challenged by any reported occurrence of menhaden off the southern peninsula of Florida for nearly a decade. It was not until Suttkus (1958) recorded the occurrence of the yellowfin menhaden from Placida (between Sarasota and Fort Myers on the west coast of Florida) that the hypothesis of a complete separation of menhaden from the Atlantic and Gulf Coasts was subject to doubt. Especially noteworthy was the claim by Suttkus (1958) that the occurrence of yellowfin menhaden in the Gulf of Mexico was known to Hildebrand (personal communication from Dr. Henry B. Bigelow).

It is of further interest to note that small quantities of menhaden were recorded in the commercial landings of southern Florida for 1957. Rosen and Ellis (1958) reported the following: Dade County—184 pounds; Monroe County—222 pounds; and Collier County—96 pounds. These three counties compose the southern peninsula of Florida, including the Keys. Although the report did not identify the menhaden by species, nor specify the area of capture, it is known that commercial fishing for fin fishes in this area usually is conducted in close proximity to the ports of landing. Although the quantities of fish caught are not impressive, this report furnishes evidence of a continuous distribution of menhaden around the peninsula of Florida.

The foregoing review pointed out the need for a reconsideration of the identity, distribution, and abundance of menhaden species, with particular reference to the coast of Florida.

Field Studies

Results of our Atlantic Coast menhaden catch-sampling program, conducted over the past five years, showed the presence of yellowfin menhaden in Florida and Georgia waters, both as juveniles in the estuarine nurseries and as adults in the commercial purse-seine catches landed at Fernandina Beach, Florida. Juveniles have been relatively common in haul-seine collections in the area. Adults, on the other hand, were rarely encountered among the commercial purse-seine catches of Atlantic menhaden, although occasional small landings consisting entirely of yellowfin menhaden were reported.

Farther southward, a commercial gill-net fishery on menhaden for bait purposes is conducted in Indian River from Ponce de Leon Inlet to St. Lucie Inlet. The bulk of the catches are made in the central part of the area in the vicinity of Sebastian, Florida. Because of the selectivity of the gear used, the size of fish taken by this fishery is uniformly large, ranging from about 8 to 12 inches, fork length.

Samples of menhaden landings at Sebastian have been obtained at infrequent intervals since 1956. Resulting data have shown that the catch through most of the year was composed principally of yellowfin menhaden. During the late fall and winter, however, Atlantic menhaden frequently appeared in the catches. Most often there were only a few scattered individuals of the latter species present, but occasionally they constituted from 10 to 15 per cent of the landings. It was also found that the field identification of individual fish by species, at

times, was difficult or virtually impossible. The characters which distinguish the individual species are not qualitative and discrete, but consist entirely of a series of quantitative and continuous features such as body and head lengths, scale size, body texture, shape of paired fins, etc. Thus it soon became evident that the recognition of the described species was not a simple matter of applying usual field identification procedures.

Beginning in 1958, a reliable identification of individual specimens was achieved based entirely upon the enumeration of scales and vertebrae. This work also demonstrated the presence of a third species in the area, in addition to the yellowfin menhaden and the Atlantic menhaden. This third species was found to possess characters which were exclusively neither those of the yellowfin nor the Atlantic menhaden. Thus the accurate field identification of North American menhadens on the basis of easily recognized qualitative characteristics became more remote. It should be noted here that the third species encountered along the central Atlantic coast of Florida could be the Gulf menhaden (*Brevoortia patronus*), either of the South American menhaden (*B. pectinata* or *B. aurea*), or a new, unreported species.² It is possible, but unlikely, that the unclassifiable fish encountered are the result of hybridization. However, because sufficient comparative material is not yet in hand, and because of an overlap of characters, a decision concerning the identity of this third species has not been reached. Suffice it to say that collections of menhaden from the Gulf of Mexico and South America are being obtained, and efforts made to solve as quickly as possible the species problem which exists in the tropical waters of North America.

The foregoing findings indicated that menhaden distribution along the Atlantic Coast of the United States does not terminate in central Florida as was thought, but continues farther southward. In an attempt to learn more about the identity and seasonal occurrence of menhaden in Florida waters, two survey trips were made to the area in 1959. It was learned that there is little or no utilization of menhaden in areas south of Sebastian. The blue crab fishery, for example, the principal market for menhaden bait in the Indian River area, is of minor importance from Palm Beach County southward. Furthermore, there is little fishing with gears capable of catching menhaden within the inland coastal waters south of Indian River. Although menhaden occasionally occur in cast-net, otter or shrimp-trawl, and haul-seine catches—gill or trammel nets which are fished in the oceanic waters of southern Florida are the only gears employed which are capable of catching menhaden in any quantity. At present there is a winter fishery (December through March) for king and Spanish mackerel (*Scomberomorus cavalla* and *S. maculatus*) in the coastal waters from Palm Beach to Fort Myers, and on the first survey trip in early January 1959, interviews with twenty mackerel fishermen disclosed the following information:

- (1) Menhaden or "fatbacks" were known to all but two of the fishermen, either by name or were recognized on being shown fresh specimens.
- (2) Menhaden frequently were encountered in the vicinity of king and Spanish mackerel schools and, in general, the fish were believed to follow somewhat the same seasonal movements as the mackerel. On occasions menhaden had been so numerous as to disrupt mackerel fishing, and

²Two small menhaden specimens were received by the Museum of Comparative Zoology, Harvard University, in 1872 from Poey, the Cuban ichthyologist. The locality was recorded as Cuba, and the tentative identification was given as *B. tyrannus*, the Atlantic menhaden.

their presence among the mackerel was looked upon as a nuisance.

- (3) Localities of greatest abundance of menhaden were reported to be (a) from Miami to the northern end of Key Largo, (b) in the vicinity of Shark and Lostman's Rivers, and (c) off Cape Romano in the vicinity of the Ten Thousand Islands. Localities of least abundance were along the Keys, both on the Atlantic side and in Florida Bay on the Gulf of Mexico.
- (4) Because no market exists for menhaden in this region, no attempt has been made to exploit the fish.

No specimens were obtained during the initial trip to the area, since mackerel fishing was temporarily suspended due to a northeast storm. On the second trip to the area in mid-February 1959, nine menhaden specimens were obtained from a gill-net catch taken in the vicinity of Cape Romano. Of these, eight were yellowfin menhaden and one was provisionally identified as the Gulf menhaden.

In summary, the results of field observations and preliminary studies have shown that the menhaden stocks of the Atlantic and Gulf Coasts are not isolated and separated from each other, but are distributed continuously around the Florida peninsula. It is further suggested that commercial quantities of menhaden may be available at certain times of the year in the tropical waters of North America.

While these preliminary findings are incomplete and inconclusive, they are of significance to the scientific studies which are now being conducted on the Atlantic Coast and will be of greater importance when the work is expanded in the Gulf of Mexico. Continuing information on these matters will be of considerable help in solving several of the most perplexing problems which still confront us. These include: (1) the habits and places of occurrence of the main body of adult Atlantic menhaden during several of the winter months, (2) the existence and whereabouts of the older and larger Gulf menhaden, and (3) the size of the yellowfin menhaden resource. I do not mean to infer that these stocks of fish are in the lower Gulf of Mexico or the Caribbean Sea. However, until more is known of their movements and distribution, any conclusion concerning these stocks is speculative.

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