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VOLUME IX, ARTICLES 4 AND 5

STUDIES ON THE MARINE RESOURCES OF SOUTHERN NEW ENGLAND

IV THE BIOLOGY AND ECONOMIC IMPORTANCE OF THE OCEAN POUT, *MACROZOARCES AMERICANUS* (BLOCH AND SCHNEIDER)

BY YNGVE H. OLSEN AND DANIEL MERRIMAN
Bingham Oceanographic Laboratory

V. PARASITES AND DISEASES OF THE OCEAN POUT, *MACROZOARCES AMERICANUS*

BY ROSS F. NIGRELLI
New York Zoological Society

Issued June, 1946
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ABSTRACT

Ocean pout are abundant from the Gulf of St. Lawrence to Delaware and average 16–28 inches (0.7–4.0 lb.). In 1943 they were introduced to the market in fillet form, and over 10,000,000 pounds were landed in two years, the majority being taken by trawlers off southern New England in 15–25 fathoms. The major objectives of this work were: 1. to collect data on the life history, availability and catch statistics in order to provide a basis for the rational utilization of the stock; 2. to gather information on the parasites, their effect on the marketability of fillets, and the incidence of infections.

Economic considerations. Spectacular growth of the fishery is described, and its seasonal and geographical particulars are presented. The fishery is capable of producing far more than it did in 1943–1944. The catch of ocean pout, heretofore discarded, was significant because of the trend toward greater use of "trash" species, which implies a closer approach to optimal utilization of available marine resources. More extensive use of such resources provides wider assortment of fisheries products

and relieves the drain on primary stocks so that the economic security of members of the fishing industry is less hazardous. Attempts by the Office of Price Administration to control the ocean pout culminated in a 3-cent ceiling which reduced the landings to a relatively low level. An embargo in New York by public health officials as a result of its parasitization further reduced the landings. Judgment on the ocean pout fishery, which has much to recommend it if the parasitological and marketing problems can be overcome, was precipitous and inadequately considered. The present paper should provide a fairer basis of evaluation,.

Preliminary discussion. Literature is reviewed; common names, range in latitude, depth and bottom habitat are discussed. Ocean pout are abundant on southern New England fishing grounds during winter and spring, but are absent in summer and fall. There is no evidence of coastwise migrations. The major part of the population probably remains in the same general region in which it is taken in winter and spring, but moves into rocky areas where capture by trawl nets is fortuitous from June to December. Size and length-weight data are presented. Vitamin A analyses of livers from southern New England and the Bay of Fundy gave values of 607 and 16,500; possible causes for these differences are mentioned.

Classification, etc. Nomenclature, generic and specific characters and detailed descriptions are presented. Heterauxesis is demonstrated in the growth of different parts of the body, and the osteology of the caudal fin is described.

Life history. By contrast to the European *Zoarces*, American ocean pout are oviparous. The number of eggs varies from 1300 in intermediate sized fish to 4200 in large individuals. The percentage of the weight of the females occupied by the ovary at any particular date tends to increase in larger fish. Spawning probably occurs earlier in northern waters and progressively later in southern waters, where late September and October is the date for reproductive activity (bottom temperature approximately 10° C.). Eggs are laid in crevices in rocky areas, for the most part within the 30-fathom contour, and are protected by one or both parents. The period from fertilization to hatching is three and one-half months in northern waters, two and one-half months off southern New England. Length-frequency studies demonstrate selectivity of the trawl net for size *and* sex, and illustrate the possibilities for misinterpretation when the curves are not divided into male and female components; age determinations by this procedure have severe limitations. Otoliths do not grow in direct proportion to the fish, but can be used as age indicators. Southern New England ocean pout average roughly 5–8 cm. at six months, 11.5–15 at one year, 16–20 at 18 months, 31 at three years, 48 at five, 81 at 10, and 97 at 15. Northern fish grow much more slowly and do not attain as great a size. The commercial catch is composed mainly of four- to ten-year-olds. Age at maturity was determined by the study of sections, the estimation of the per cent of the weight of the fish occupied by the weight of the gonads over the size-range of the population at one date, comparative egg measurements from individuals of different sizes, and length-weight analyses of the separate sexes. Below 25 cm. all male ocean pout are immature; above 39 nearly all are mature. The smallest size at which females become mature is approximately 45 cm. (5th–6th year); all are mature at 65 (7th–9th year). There is a slight preponderance of males over females. Males leave the summer and fall habitat in advance of females; they probably also return to the rocky bottom in late spring and early summer first. Younger fish apparently do not take part in seasonal movements in large numbers until after the third year of life. Vertebral counts of individuals from different localities show significant differences, the means being progressively lower from northern Cape Cod (140.25) to Long Island Sound (136.11). However, the sample from the Bay of Fundy is the lowest of any (134.46); the possibility of two major genetically separate populations is discussed.

Feeding habits. Stomach contents of 21 samples (over 850 fish) have been analyzed in detail. Over 80 organisms were identified, and relative volumes of the major items are presented on a percentage basis. Among the more common forms are Gammaridae, *Echinarachnius parma, Cancer irroratus, Unicola, Cardium pinnulatum, Pecten* and *Yoldia.* Ocean pout are not piscivorous. The percentage of empty stomachs was generally low. Acanthocephala occurred with a fairly high degree of regularity; Nematoda were more common in northern than in southern fish. Search for secondary hosts or vectors of parasites should be facilitated by this study.

Incidence of parasites in the flesh. The microsporidian, *Plistophora macrozoarcidis* Nigrelli, is the parasite of greatest commercial importance. It may manifest itself as individual trophozoites or moderate and large lesions. Other parasites are *Chloromyxum clupeidae,* metacercarial cysts and *Porrocaecum decipiens* (?) Krabbe; yellow bodies of unknown function were also observed in numerous specimens. The incidence of infection was determined by detailed examination of individual fillets with the aid of transmitted illumination. Candling, as practiced commercially, is inadequate. There is no evidence from these studies that infections by *Plistophora* increase in size in frozen fillets. *Plistophora* was found only in muscle, and was detected in all samples from Canada to Long Island Sound. Large lesions were relatively few in fish from northern Cape Cod and much more common in areas to the south and west. Discussion as to how *Plistophora* may be transmitted is included. There is a higher incidence of infection anteriorly than posteriorly. Younger fish are less infected than older, but individuals apparently live for years while infected with *Plistophora.* The spores do not appear to be liberated through the skin of living ocean pout. There was no apparent correlation between incidence of infection and sex or vertebral counts, or between size of lesion and incidence of infection per sample. The time and situation in which infections are most likely to be contracted, the possibility of an intermediate host or vector, the question of whether or not *Plistophora* manifests itself in epidemic form, *etc.,* are discussed.

Conclusions. A combination of the seasonal movements, life history, general shape and hardiness of this fish assures it an unusual degree of security. Apparently the stock can be fished more intensively than the level resulting in the 1943–1944 catch without detriment. However, continued observation of landings and age composition of the catch is essential. Successful marketing is primarily dependent on efficient candling; this species should never be sold "round"; fillets should be skinned before examination. Small infections (individual trophozoites) appear to be inconsequential in relation to marketing. The northern Cape Cod fishery should continue to expand; once the standards of commercial candling have been raised, the whole fishery should proceed with the development begun in 1943–1944.

ACKNOWLEDGMENTS

Throughout this investigation we have received much assistance, and it is with great pleasure that we take this opportunity to express our appreciation to all those who have contributed to this paper in one form or another. Without the help so generously given by so many, the completion of the work would not have been possible at this time.

The Connecticut State Board of Fisheries and Game, through the interest of its Superintendent, R. P. Hunter, who early in 1943 called our attention to the need for work on this species, supplied funds for the purchase of the many samples of ocean pout needed in a quantitative study of this nature. Similarly the State Board made possible the employment of Dorothy A. Baitsell and W. H. Yudkin as temporary assistants who helped in the collection and analysis of the raw data in 1943 and 1944. Also Capt. Walter Palmer, Capt. Frank Banning and Mildred K. Bartle of the State Board rendered valuable advice and aid at various times in the course of the work.

The American Wildlife Institute, through its President, Senator F. C. Walcott, generously provided a grant for technical assistance in 1944 in order to expedite the completion of this and other researches of a similar nature. By this means the laboratory was fortunate in securing the services of Judith M. Humphrey, Josephine Burn and Alice D. Brain, as well as those of Elizabeth Howe, who has prepared most of the illustrations.

The Woods Hole Oceanographic Institution, which by its friendly interest and cooperation has done much to further our work on the utilization of marine resources, contributed indirectly to the progress of this investigation by awarding a fellowship at the Bingham Oceanographic Laboratory in the latter part of 1943 to H. E. Warfel, who subsequently became a member of the regular staff.

To W. C. Schroeder, Museum of Comparative Zoology at Harvard College, we owe thanks for much pertinent information and for the loan of embryos shown in Fig. 9 and discussed on page 77. W. H. Chute of the Shedd Aquarium in Chicago kindly provided the illustration for Fig. 8. A. W. H. Needler and E. G. Rigby, of the St. Andrews Biological Station, New Brunswick, Canada, arranged for the collection of the sample of ocean pout from the Bay of Fundy in the summer of 1943.

Without the close cooperation of the fishing fleet it would have been impossible to obtain the many samples and basic data which were essential in this investigation. In the present study we have had the benefit of generous assistance and oftentimes useful information from numerous individuals associated with the fishing industry. At Stonington, Connecticut, Capt. Ellery Thompson of the vessel "Eleanor," whose cooperation has been invaluable in much of the work of this laboratory in recent years, has collected many ocean pout from the Block Island area. Other captains and their crews in the Stonington fleet who have assisted materially are: W. H. McLaughlin of the "Marise," Aldo and Roscoe Bacchiocchi of the "Baby II," A. L. Roderick of the "Rita," and S. W. Stenhouse of the "Nathaniel B. Palmer."[1] We also acknowledge the help of J. B. Bindloss, John George, John Rogers, and Raymond Scheller. At New Bedford, Massachusetts, W. F. Royce, Warren Landers and Edmund O'Neil of the U. S. Fish and Wildlife Service aided in obtaining material and otherwise furthered the investigation on several occasions. To Capt. E. O. Sanchez and crew of the "Heedja" we are grateful for valuable small specimens. P. J. Murphy and Henry Carmos of the Dartmouth Fillet Co., William Curran of the Sea View Fish Co. and Leo Allen of the New Bedford Fillet Co. also cooperated in supplying specimens from the New Bedford region. At Provincetown, Massachusetts, Capt. Manuel Dutra of the "Viola D" provided important samples of ocean pout from time to time, and thus made possible the inclusion of highly significant data from northern Cape Cod in this paper. Also at this port, Samuel Kurz and Daniel Williams of the Star Fillet Co., as well as Frank Rowe of the Atlantic Coast Fisheries Co., gave much assistance.

A number of students have had a part in this investigation. We owe the detailed analysis of the stomach contents entirely to Pfc. F. E. Smith, who, with the assistance of L. C. Park and E. H. Uhlenhuth, did this study as a special problem in Zoology while at Yale as a member of the Army Specialized Training Program for premedical students. Without his careful work and identifications it would have been impossible to incorporate the material used in the section on Feeding Habits. Others who have contributed are Pfc.'s D. H. Glew, Jr., who is responsible for Fig. 10, G. E. Landis, Jr., and R. D. Metzger,

[1] Sunk at sea April 6, 1945, with the loss of three of her crew by an explosion caused by an aerial bomb which was brought up in the net.

as well as R. S. Cheves, Jr., O. D. Deex, and Hans Steinherz. A collection of unusual interest from the middle of Long Island Sound was made by J. E. Morrow, Jr., former graduate student now serving in the U. S. Marine Corps, on board the "Jane" under Capt. E. C. Post of West Haven, Connecticut.

We have also leaned heavily on the advice and help of the entire staff of the Bingham Oceanographic Laboratory. We are particularly grateful to the following: H. E. Warfel, for generous assistance both in the field and laboratory, as well as in the preparation of the length-weight equation and the analysis of the data presented in Table XI; Grace E. Pickford, who has given invaluable counsel in regard to the parasitological problems; Elizabeth A. Morrow, former secretary and now serving in the Women's Auxiliary Corps of the U. S. Army, for help in the laboratory, especially in relation to the infection study; Louva Henn, whose patience in the performance of far more than customary secretarial routine has been no small asset; and M. D. Burkenroad and E. F. Thompson, both of whom have given stimulating advice and assistance. We have been fortunate also in receiving the help of various members of the Osborn Zoological Laboratory and the Peabody Museum at Yale University; we wish especially to acknowledge our indebtedness to Mary Carbone for histological preparations, to Percy A. Morris for photographic work and identification of molluscs and to Eleanor Smith and Joyce E. Peck for secretarial assistance.

When this paper was in galley proof we also received the generous comments of C. L. Hubbs of the Scripps Institution of Oceanography, who made many pertinent suggestions and corrections for which we are most grateful.

Finally, we wish to make it clear that while we have had the benefit of many individuals' advice and help, we assume complete responsibility for the material presented herein.

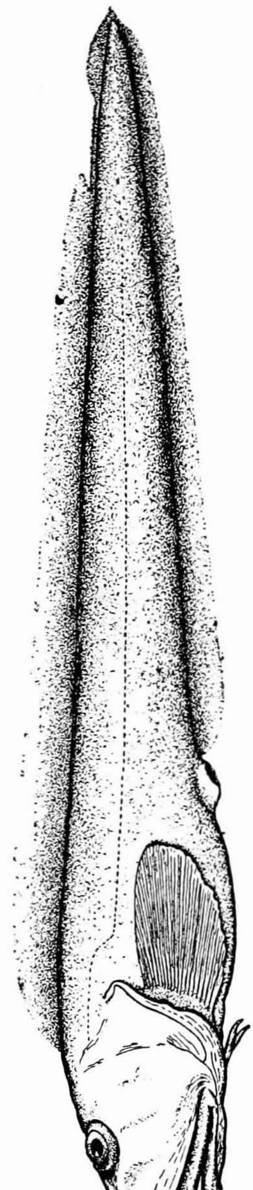

Figure 1. The ocean pout, *Macrozoarces americanus*. Drawn from a specimen 73.5 cm. long taken March 19, 1944, four miles NW. of Sandy Point, Block Island, Rhode Island, at approximately 20 fathoms.

THE PROBLEM

Although abundant and commonly taken by fishermen from New Jersey to the Bay of Fundy, the ocean pout, *Macrozoarces americanus* (Bloch and Schneider), never attained more than an extremely limited market status until 1943. In that year, partially as a result of war conditions, an attempt was made to market this species in fillet form. That this product met with immediate favor is clearly indicated by the fact that over 5,000,000 pounds of ocean pout per year were landed in 1943 and 1944. The most intensive fishing was carried on by relatively small trawlers and draggers in the coastal area between Provincetown, Massachusetts and New York City, and was confined in the main to the period from January to June.

Almost at the inception of the fishery and just as the landings of the fleet were reaching major proportions, it became apparent that the flesh of the ocean pout was not infrequently rendered unfit for market by the presence of large sores sometimes an inch or more in diameter. As always, under such conditions, rumor ran rife; the sores were described as "tumors," "cancers," "boils," *etc.*, and the consumption of flesh containing them was reputed to cause violent illness. Factual information regarding the sores was not available. Large shipments of ocean pout were declared unfit for human consumption by municipal and federal public health officials, and this in turn acted as a deterrent to the fishery so that the landings of ocean pout in 1943 and 1944 do not represent the extent to which this species could augment the nation's fisheries productivity under more intensive effort. Then in the spring of 1943 R. F. Nigrelli, Parasitologist of the New York Zoological Society, established the fact that the sores were caused by a protozoan parasite, tentatively identified as *Ichthyosporidium* sp., and subsequently (with more adequate material at hand) determined as a new species belonging to the subclass Cnidosporidia, order Microsporidia, genus *Plistophora.* It therefore became apparent that the danger of actual infection in humans from consuming the parasitized flesh of the ocean pout was slight, since there is no known case of a sporozoan of the sort indicated above which affects both cold- and warm-blooded vertebrates; furthermore, there is no evidence that such a disease can be transmitted from fish to man. On the other hand, it was recognized that there might be danger of mild illness with the typical symptoms of food-poisoning from the consumption of flesh in which the proteolytic action associated with major infections had gone sufficiently far. Probably the best evidence that ocean pout fillets are a product which can be marketed satisfactorily, and with no more danger than that from many other similarly parasitized and marketed fish, is provided by the magnitude of the catch, over 10,000,000 pounds in 1943 and 1944, and its subsequent consumption without apparent ill effects. Nevertheless, the infections present definite marketing problems. Thus it has been indicated by Sandholzer, Nostrand and Young (1945) (pp. 142, 199) that while some of the fillets that are frozen appear uninfected on inspection of the fresh flesh, these same fillets may show lesions on their removal from the freezer at a later date; the same workers also stated that lesions in fillets " . . . appear to continue to increase in size and number in fillets stored at 8° F. for two or more days." These unexpected findings, not duplicated by other investigators, do, however, point to the economic problems involved in handling this species. In all events, without careful inspection there is always the chance that infected and unsightly fresh fillets may reach the market. The adverse effect of the sale of a product of obvious poor quality to the fisheries industry as a whole cannot be over-emphasized.

In view of the foregoing and the dearth of information on the life history, habits and parasites of the ocean pout, it seemed imperative that a detailed investigation be initiated immediately. Federal and other organizations were apparently unable to give the matter the attention it merited, due to the man-power shortage and the pressure of other duties in the war emergency period. It seemed obvious, therefore, that the investigation should be undertaken by the Bingham Oceanographic Laboratory (whose geographical position was particularly fortunate for the study of this species), in cooperation with specialists who were able and willing to contribute to the solution of the whole problem.

The primary objectives were as follows. 1. To collect as much data as possible about the life history, availability and catch statistics of this species in order to provide information for the rational utilization of the stock. This information is essential as a basis for recommendations concerning the intensity of fishing that the stock can stand, both from the point of view of its present yield and its ultimate conservation. As pointed out previously (Merriman, 1944), the fact that work on this species was begun almost as soon as it became an important element in the commercial landings is of considerable significance in itself, since most fishery investigations in the past have been undertaken only when the stock concerned was so depleted as to cause alarm. 2. To gather as much information as possible about the protozoan parasite of this species and its effect on the marketability of ocean pout fillets, with particular reference to the seasonal and geographical incidence of infection. In regard to the second objective it was anticipated that the results might lead to one of the three following conclusions. a.) That the fishery need be in no way curtailed and that adequate inspection would eliminate the possibility of unsuitable fillets appearing on the market. b.) That the fishery should be limited to certain areas where the percentage of infection was sufficiently low to enable the sale of a product of high quality which would augment fisheries productivity as a whole, albeit to a lesser degree. c.) That the incidence of infection as well as the difficulties of proper inspection were such as to render the commercial exploitation of this species impractical. The opinion of certain officials and organizations to the contrary—witness the embargo placed on ocean pout either landed at or shipped to the City of New York in early 1945—it shortly became evident that the last conclusion could be reached only in the absence of full factual information or because of indifference toward attempts to effect the full utilization of available marine resources, even in emergency times.

While many questions and problems associated with the life history and economic aspects of the ocean pout still remain to be answered, we believe that sufficient basic information is presented herein to make possible sound conclusions based on fact as to the general utility and limitations of this species.

ECONOMIC CONSIDERATIONS

As indicated earlier (p. 9), prior to 1943 the market for ocean pout was restricted to a few thousand pounds which went primarily to the Italian trade.[1] Before this time it had been sold "round" under various names, all of which included the term "eel" (*e. g.*, "congo" or

[1] Fishing Gazette, *60* (3): 34, March, 1943. This article refers to the ocean pout as the "conger eel," and includes an illustration of the true conger, *Conger oceanicus*, although it deals solely with *Macrozoarces americanus*, thus affording an example of the confusion resulting from the careless use of common names mentioned on page 34.

"conger eel," "eelpout," *etc.*). The name alone was sufficient to place this species under a distinct handicap on the market, since many people have an aversion to anything eel-like; but its general appearance, even when gutted, was so unattractive as to limit its sale still further. Despite the fact that fishermen and others knew that the fish was available in large quantities in New England, New York and New Jersey coastal waters, no serious or concerted effort was made to use this resource until 1943, even though Clemens (1920) had pointed out its potentialities in Canadian waters. Some idea of the relatively unimportant market status and the obscurity of this species is afforded by the fact that from 1939 to 1942 its annual landings by Connecticut boats averaged roughly 1000 pounds, and that in 1942 its total receipts on the New York market amounted to only 5,535 pounds (Table I).

TABLE I. NEW YORK RECEIPTS OF OCEAN POUT BY MONTHS IN 1942, 1943 AND 1944*

	1942	*1943*	*1944*
January	4,965 lb.	12,612 lb.	776,723 lb.
February	147	75,700	456,365
March	100	375,660	339,001
April	100	287,588	98,562
May	—	27,830	1,325
June	—	1,183	—
July	—	—	—
August	—	—	—
September	31	—	—
October	100	—	—
November	92	—	—
December	—	36,876	100
Totals	5,535 lb.	817,449 lb.	1,672,076 lb.

* Data from U. S. Fish and Wildlife Service Market News Service sheets. Includes receipts by rail, truck and fishing craft as reported by the wholesale dealers in the Salt-water Market, New York City. Excluded are local cold-storage withdrawals and direct shipments to hotels, restaurants and retailers.

In January 1943, through the action of the Fishery Council of New York and other groups, this fish was placed on the market in fillet form, and in that year it was sold primarily under the name "ocean pout," thus eliminating the two most obvious elements preventing its wider acceptance. Well planned publicity further aided its sale. These actions met with immediate success.

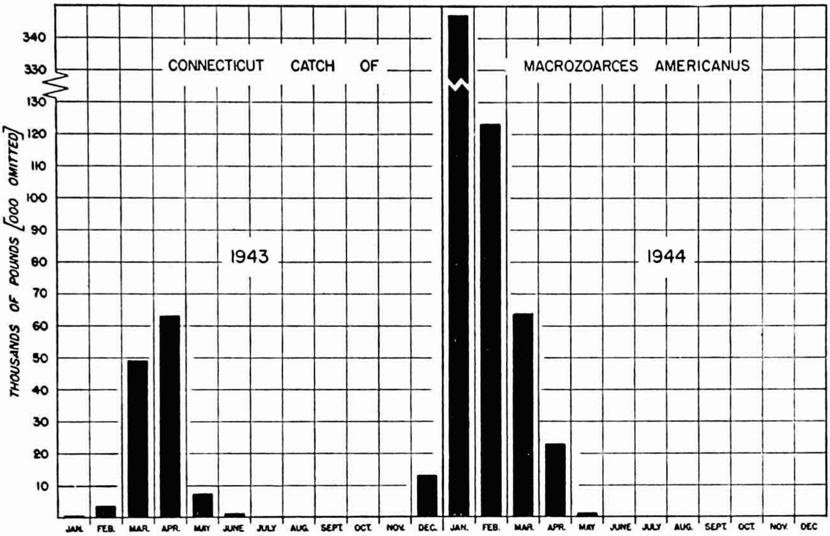

Figure 2. The Connecticut catch of ocean pout by months in 1943 and 1944 expressed in thousands of pounds (*i. e.*, 000 omitted). Data taken from U. S. Fish and Wildlife Market News Service sheets and Connecticut State Board of Fisheries and Game records.

Landings and availability. The increased demand resulted in a sudden, intensive fishery. The Connecticut fleet alone landed over 110,000 pounds of ocean pout in March and April of 1943; the receipts on the New York market jumped to over 800,000 pounds in 1943 and to nearly 1,700,000 pounds in 1944 (Table I). In considering these figures it should be realized that the fishery is highly seasonal, being confined essentially to the first six months of the year, so that the figures for any particular year actually represent the take in a six- or seven-month period (p. 40). Perhaps the most graphic illustration of the sudden magnitude and intensity of the ocean pout fishery is afforded by the figures from New Bedford, Massachusetts, the port at which the largest landings were made.[1] From January to June 1942 the ocean pout was not important enough to be listed as a separate species; instead it was included under "Miscellaneous," a category including "mostly unspecified species, but also some specified as cusk, eelpout, goosefish, rosefish, shad, sharks, skates, and squirrel hake,"

[1] Data from U. S. Fish and Wildlife Service Market News Service (Jan.–June, 1942, for New Bedford).

the sum total of which amounted to 16,825 pounds. In 1943 in the same period the landings of ocean pout at New Bedford were 3,179,129 pounds, valued at $100,057.[1] One reason why New Bedford became the leading port for ocean pout is because the major part of its large fleet concentrates on the yellowtail (*Limanda ferruginea*), a species of flounder which occupies grounds on which ocean pout are also particularly abundant.

Table II gives the landings of ocean pout at the major ports in Massachusetts, as well as the receipts on the New York market from Rhode Island, Connecticut, New York and New Jersey in 1944.[2] The total catch for 1944, 5,219,505 pounds, does not include the landings at certain smaller ports as well as shipments to markets other than New York, so that in round numbers the 1944 catch probably approximated 5½ million pounds.

It is quite certain, however, that the great majority of the ocean pout caught in states other than Massachusetts were shipped to the New York market. The totals shown at the bottom of Table II therefore provide evidence of a general sort on the relative productivity of the different areas in which they were caught, *under the conditions existing in 1944*. But these totals in no way indicate the volume which might have been taken under conditions conducive to a more intensive fishery. In fact there is much evidence that the stock of ocean pout is capable of producing far more than 5,500,000 pounds annually. For example, a comparison of the landings in 1943 and 1944 in March and April at New Bedford illustrates this point:

	1943	*1944*
March	983,400 lb.	1,033,600 lb.
April	1,424,377 lb.	216,800 lb.

The sharp drop in the New Bedford catch in April 1944, at a time of year when ocean pout are available in abundance, is attributable to

[1] The catch by months was: Jan., 6,940 lb.; Feb., 395,197 lb.; Mar., 983,400 lb.; April, 1,424,377 lb.; May, 369,215 lb.

[2] The New York market also had some receipts from Massachusetts, but these are not included in this table since the landings of that state are given by ports, and the inclusion of the monthly poundages received by New York from Massachusetts would introduce an error in the totals listed in the right-hand column because those amounts would be counted twice. The actual receipts on the New York market from Massachusetts in 1944 were: Jan., 119,535 lb., Feb., 144,065 lb., March, 121,111 lb., April, 12,425 lb.

TABLE II. MAJOR LANDINGS OF OCEAN POUT AT DIFFERENT PORTS IN MASSACHUSETTS, AND RECEIPTS ON THE NEW YORK MARKET FROM RHODE ISLAND, CONNECTICUT, NEW YORK AND NEW JERSEY BY MONTHS IN 1944 EXPRESSED IN POUNDS*

	Massachusetts				*New York Receipts*				
	Gloucester	*Provincetown*	*Woods Hole*	*New Bedford*	*R. I.*	*Conn.*	*N. Y.*	*N. J.*	*Totals*
January	25,500	284,000	59,500	547,500	125,155	346,960	152,837	16,236	1,557,688
February	5,000	66,000	174,100	1,158,630	87,464	123,045	83,433	18,358	1,716,030
March	1,000	92,000	175,300	1,033,600	31,685	63,896	113,099	7,855	1,518,435
April	300	52,000	24,600	216,800	1,117	22,591	44,877	1,817	364,102
May	100	16,000	......	46,000	......	1,000	50	.....	63,150
June	.....	......	......	....	......	......	......	.....	....
July	.....	......	......	....	......	......	......	.....	....
August	.....	......	......	....	......	......	......	.....	....
September	.....	......	......	....	......	......	......	.....	....
October	.....	......	......	....	......	......	......	.....	....
November	.....	......	......	....	......	......	......	.....	....
December	.....	......	......	....	......	......	......	100	100
Totals	31,900	510,000	433,500	3,002,530	245,421	557,492	394,296	44,366	5,219,505

* Data from U. S. Fish and Wildlife Service Market News Service sheets. See Table I for explanation of New York receipts.

the creation of a 3-cent ceiling price by the Office of Price Administration on March 23, 1944. It is a conservative estimate that the landings at this port alone would have been approximately 1,000,000 pounds higher in one month had it not been for this action. Further evidence that the stock is capable of producing much more than 5,500,000 pounds *per annum* comes from the fact that as a general rule this species was not the primary object of the fishing fleet. Rather, it was taken by trawlers which were principally after flounders (*L. ferruginea* or *Pseudopleuronectes americanus*), and instead of discarding most or all of the ocean pout as "trash," this species was brought to market at a time when the need for increased fisheries productivity was acute. There is no way of estimating what the potentialities of the stock might be if this species became the primary object of a large fishery, just as it would have been impossible to predict the present magnitude of the catch of the rosefish (*Sebastes marinus*) on the basis of information available in the early 1930's.[1]

"Trash" fish and latent resources. It is obvious from the foregoing account that in 1943 and 1944 much progress was made in utilizing the ocean pout, a fish which had been considered essentially as a "trash" species up to this time and had been discarded in large quantities. The fundamental importance of this increased utilization is two-fold.

First, the addition of approximately 10,000,000 pounds of ocean pout to the nation's fisheries productivity was a notable contribution in a wartime emergency period. The need for additional sources of fish and sea foods to meet wartime demands was acute, and the inability to meet those demands intensified existing and widespread critical shortages in the food industry as a whole.[2] Lack of manpower

[1] A decade and a half ago the rosefish was considered a "trash" fish. In 1932 and 1933 the landings averaged less than 200,000 lb. valued at just over $2000; in 1934 they were nearly 2,000,000 lb. valued at approximately $18,500; in 1935 and 1936 they averaged 17,000,000 lb. valued at $184,000; and in 1937 and 1938 they averaged over 60,000,000 lb. with a value of nearly $850,000 (Fiedler, 1934–1941). In the last three years the landings have exceeded 100,000,000 lb. annually (see Fishing Gazette, 1944 Annual Review Number, *61* [12]: 148, 1945).

[2] In 1941 the commercial fisheries of United States and Alaska produced their greatest total catch, approximately 5,000,000,000 lb.; in 1942 the figure dropped to 3,700,000,000 lb.; in 1943 United States and Alaska were called on to produce 6 to 7,000,000,000 lb. to supply the needs of the armed forces, allies and civilian population, but the catch amounted to only 4,000,000,000 lb.; and in 1944 the catch was of

and the reduction in the size of the fishing fleet due to the appropriation of vessels by the U. S. Navy were unquestionably contributory factors in the failure of the fisheries to produce the requisite amounts. But the saving of "trash" species at sea requires little more effort and no extra manpower under most circumstances, and most of the filleting and processing on shore is done as effectively by women as men.

Second, any tendency or trend toward the greater use of "trash" species is of the greatest significance because it implies a fuller and better utilization of available marine resourecs. It has long been recognized that the wastage in certain fisheries in terms of species that are discarded, but which can be used, is of major proportions, but accurate figures have been lacking for the most part. However, Merriman and Warfel (1944), in an analysis of a southern New England trawl fishery from July 1943 to January 1944, showed that only 36 per cent of the catch by weight were fish that were regularly marketed, 11 per cent were in an occasionally-marketed category, and 53 per cent were discarded as "trash." In other words, more pounds of fish were thrown away than were kept.[1] It should be added, however, that in 1944 the trend toward greater use of what were formerly considered as "trash" fish increased somewhat. Nevertheless, the fact remains that conservative estimates by the staff of the Bingham Laboratory place the volume of usable fish discarded by Stonington,

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much the same size, but still over a billion pounds short of wartime demands as stated by representatives of the War Food Administration [data from Fishing Gazette, *60* (8 and 9), 1943 and *61* (2 and 12), 1944]. In March 1945 Coordinator of Fisheries, Harold L. Ickes, reported that, "The United States Fishing industry, in spite of restoration of its fleet to nearly normal size, probably will be unable to produce enough fish and shellfish in 1945 to meet the goals established by the War Food Administration for the current year, ..." (U. S. Fish and Wildlife Service Market News Service, March 21, 1945).

[1] Of the discarded species, over 85 per cent were skates and sculpins (*Raja diaphanes, erinacea,* and *stabuliforis* and *Myoxocephalus octodecimspinosus*). That skates have long yielded over 50,000,000 pounds annually to England, Scotland, Wales and Ireland is well known (Howell, 1921 and Report of the U. S. Tariff Commission to the U. S. Senate on Subsidies and Bounties to Fisheries Enterprises by Foreign Governments, 116, Second Series, p. 96, 1936). That sculpin-like fish can be handled successfully is shown by the fact that *Scorpaena guttata,* a fish presenting marketing problems similar to those of *M. octodecimspinosus,* provides approximately 100,000 pounds annually from southern California waters (Barnhart, 1936, and 37th Biennial Report of the Division of Fish and Game, State of California Department of Natural Resources, pp. 96 and 111, 1944).

Connecticut vessels, a relatively small fleet, at approximately 5 to 10 million pounds annually in the first half of the present decade.

The subject of "trash" fish inevitably leads to the whole question of latent and unused fisheries resources. It is difficult to provide overall estimates as to what extent these relatively untapped resources could add to the nation's productivity, and how well the different stocks would stand the strain of exploitation. Croker (1942) and Chapman (1942) have discussed the problem on the Pacific coast and have indicated the possibilities for expansion in those waters.[1] While there is good reason to believe that there are not equivalent opportunities for expansion on the Atlantic coast, it is perfectly evident that the fisheries resources as a whole in this region have not even approached the level of utilization of which they are capable.

The factors which control the extent to which aquatic resources are utilized are many and complicated. Historically speaking, and in the most elementary terms, the development of the fisheries probably follows a fairly regular, broad pattern in different localities. The initial species of fish which are exploited are those that are abundant, easily available and of sufficient size and quality to make them immediately worth primary attention. These become best known to the consumer and almost always remain in demand. In the course of the development of these fisheries, two things are likely to occur. The first is the partial exploitation of other abundant and marketable species. The second, under the conditions of an intensive fishery, is an eventual lowered return per unit effort or decreased abundance of the primary species; this may simply be a manifestation of marked fluctuations in numbers due to natural phenomena over which man exerts no control, or it may actually reflect the result of overfishing. The second may accelerate the first process—*i. e.*, a causal relationship may exist. In all events, the result is that an increased number of different kinds of fish are landed. The length of time it takes to reach this condition and the extent of the variety of species used differ in each locality; these matters are dependent on many factors such as the demand, the ability of the primary species to stand intensive ex-

[1] For example, Chapman says, "We hear much of the tremendous fisheries of Alaska, but some 98 per cent of the product of those fisheries are salmon, herring, and halibut. Of the 500-odd species of fish, and numerous edible shell-fish, inhabiting the waters of Alaska and the Bering Sea only some 27 are fished upon commercially, and only 14 of these produce a million pounds or more annually."

ploitation, the availability of the secondary types, the progress in technological and marketing techniques which enables the wider distribution of fisheries products, *etc.* Little by little, then, the variety of fish reaching the public increases. The more this trend continues the more closely is the rational utilization of marine resources approached—at least in one sense of the word. Ideally the tendency would be to distribute the fishing effort more evenly over a wide variety of species; under these conditions there would be less chance of the depletion of certain species due to over-concentration on them, and the resultant economic distress for those engaged in the particular fisheries concerned. But in general the fisheries never really approach this ideal condition because attempts to catch and market new types are usually made only when the dread of depletion looms large with the primary species, or in emergency times (*e. g.*, ocean pout). In short, the stocks of the original species become unable to meet the demand, either because of overfishing (a lowered return per unit effort), or because of fluctuations in the natural supply which force an attempt to market new species. In practice, then, the exploitation of all the available species does not occur simultaneously, but only over long periods of time, and is conditioned by the primary supply and the demand. It would be unreasonable to expect that the ideal distribution of effort over all the available species would occur *ab initio*, or even at a very early stage in the development of the fisheries. But no matter what the stage of exploitation of the various species in any area, it is never too late to aim at the full and rational utilization implied by the distribution of effort over all the forms that are available.[1] The sooner this is done, the greater the chances that the individual stocks will stand the strain of the fishery better, because one or a few stocks need not be subject to such an intensive drain. In the case of the Atlantic coast trawl fisheries there is still ample opportunity for improvement along these lines. The history of the ocean pout in 1943 and 1944 affords a good case in point. Similarly, it is an

[1] We should add, however, that natural competition between species is probably a vital factor in this matter. Overfishing of a few species may lead to an increase in the unutilized forms. Partial equilibrium may then be restored by removing some of the excess of the previously unutilized species, so that there may actually be a gain in the total poundage taken through the "spread" of the fishing effort. Also, there may be an increase in the natural production and in the catch of the favored species.

obvious corollary of this discussion that once the prejudice of the fishermen against handling a "trash" species has been overcome, and once the marketing problems have been solved, it is extremely short-sighted to do anything that may act as a deterrent to the fishery or the market.

Before continuing with the application of these principles to the ocean pout, let us examine some of the reasons why the marketing of a great variety of species is so slow of accomplishment in the development of the fisheries in any particular region. One obvious reason is that the primary types, those that are exploited first, are usually abundant and prolific, so that in most cases they are able to supply the demand over long periods. Important as is this exploitation, it has two disadvantages to the ideal situation where the fishing effort is spread over a greater variety: 1.) the consumer does not become "educated" to the different flavors of many different species, and 2.) the fishermen tend to become prejudiced against other species than those they seek in particular, especially if these others must be sorted from the rest of the catch. An added reason why the secondary types are not exploited early in the development of the fishery is because they frequently require special handling of one sort or another, and the technological and marketing problems cannot be overcome immediately. Still another factor in the situation is to be found in the poor handling of fish between the net and the consumer. In this country the lack of effort and care in getting the fish to the consumer in as nearly a perfect condition as possible has been "the greatest single deterrent to the marketing of most fish, ..." (Chapman, 1942).[1] Only a relatively small fraction of the public appreciates the value of the really fresh product. Consumers often ask only for "fish," not for a particular kind whose flavor is especially attractive, because the condition of the product is so poor by the time it reaches the market that the different species are all too often indistinguishable in taste. This is likely to mitigate against the wide use of the *variety* of fish that are available. The whole future of the fisheries industries lies in their

[1] This is surprising because the success of the industry so obviously depends on getting its products, which at best are extremely delicate, to the consumer in prime condition. The careful handling of fish on British trawlers in the North Sea as contrasted with that on trawlers in the North Atlantic is striking (Merriman, 1932); the practice of letting fresh fish stand for several days in the barrels in which they are packed so that they get soft for easier filleting is another case in point.

ability to market quality products, and in the education of the public to the varieties and different flavors of fish. Competing foods have gained a great advantage by more extensive and better planned advertising. Just as the consumer asks for specific kinds of meats, vegetables, or even breads, because he has particular preferences, so should he ask for different kinds of fish because he knows and appreciates their special qualities and different flavors.

The gain to the fishing industry in this country from the wider utilization of available resources and the marketing of a greater variety of quality products should work in two directions. The first of these is the diffusion of fishing effort over more species so that the intensity of the drain on the primary stocks is alleviated and the economic security of the fishermen and others is therefore on a less hazardous basis. The second is the badly-needed education of the consuming public as to the wide assortment of fisheries products that exist so that these commodities can compete with other foods and the annual per capita consumption may be maintained at least at its present level.[1]

Price control and marketing problems. The economic factors governing the sale of ocean pout in the emergency period from 1943 to 1945 are highly significant in the light of the preceding discussion. Much of the following section is concerned with the efforts at price control by the Office of Price Administration. In any consideration of this subject, it is important to keep in mind both that the very nature of the industry made it among the most difficult to regulate (footnote, p. 26), and that the information on which ceilings were based was not immediately available but had to be obtained from a variety of sources in cooperation with the Office of the Coordinator of Fisheries.

As indicated earlier (p. 14), in 1943 the average price received by fishermen at New Bedford, the port where the largest landings were made, was 3.1 cents per pound; and in Boston in the period from February to April 1943 the price ranged from 1 to 6.1 cents per pound.[2] This was, of course, the first year that ocean pout came on the market in more than limited quantities, and it is therefore reasonable that the average price should have been relatively low until the fish became

[1] The annual per capita consumption of fish in United States is approximately 10 to 15 pounds, as contrasted to 35 in England and over 50 in Sweden.

[2] Data from Fishing Gazette, *60* (3, 4, and 5), 1943.

better known and the demand increased. Furthermore, *average* prices over long periods sometimes fail to provide a fair basis of evaluation, and obviously much depends on the precise manner in which the averages are determined. For example, ocean pout unquestionably have a higher value in February, when other species are relatively scarce, than they have in May and June when other fish are more available. Be this as it may, the Office of Price Administration in the spring of 1943 attempted to place a ceiling price on the frozen fillets of ocean pout with the results indicated below in an excerpt from the Fishing Gazette, *60* (5): 90, May, 1943.

> EELS GET FREE:—Ain't science wonderful? At least New Bedford's fishing industry thinks so.
>
> Gloom settled along the waterfront the other day when OPA announced price ceilings on the conger-eel (frozen variety) ranging from 15 to 19 cents. Fish buyers and filleters have been doing a landoffice business in conger-eels, ever since some bright lad discovered that this newly-known and palatable fish was abundant in certain areas along the Cape.
>
> But William F. Royce, area co-ordinator for the U. S. Fish and Wildlife Service, solved all their difficulties. It seems fishermen have been throwing the term "conger-eel" around for an entirely different species of fish, more accurately called the ocean pout.
>
> If OPA intended to put a ceiling on ocean pout, the Government boys haven't a leg to stand on according to Mr. Royce.
>
> OPA's conger-eel is definitely classified leptocephalus linnaeus, whereas the ocean pout caught locally is classified zoarces anguillaris. So—no zoarces on OPA's list, no ceilings!
>
> And all the fish dealers have gone back to freezing the good old eel pout like mad.
>
> OPA better get its anguillaris straightened out.

No further attempt to place ceiling prices on ocean pout was made in 1943.[1] This species disappeared from the catch in the late spring and did not reappear in significant numbers until the winter, thus following its regular pattern of seasonal abundance (p. 40). Ocean pout returned to the market again in December 1943, and the largest monthly landings of this species were made in January and February 1944 (Tables I, II). In this period the price to the fishermen ranged all the way from 1 cent to $2.50 per pound.[2] It was common practice on the part of the buyers at this time to bid fantastic prices for a

[1] But price ceilings were placed on many of the North Atlantic species on July 13, 1943, under Maximum Price Regulation No. 418.

[2] Data from U. S. Fish and Wildlife Service Market News Service sheets.

variety of species which were not under ceiling prices (among them ocean pout) in order to obtain the rest of the price-controlled catch. Thus Fishery Products Report No. 56 of the U. S. Fish and Wildlife Service Market News Service (March 9, 1944) stated:

> There was an instance in which a wholesaler had to pay as high as $500 for one fish (a skate) to obtain an entire boatload of a type of fish under price control. In several other instances a few pounds of uncontrolled fish were auctioned off to wholesalers from a boatload of fish otherwise under ceilings with the understated consideration that the highest bidder got the entire boatload at ceiling prices after being the high bidder for the few pounds of non-ceiling fish.

In an effort to curb this practice the Office of Price Administration issued Amendment No. 26 to its maximum Price Regulation No. 418. This amendment, effective March 13, 1944, established price limitations on the sales of fresh fish and seafood not under specific ceilings when sold by fishermen and wholesalers in combination with varieties for which maximum prices had been fixed. More specifically this amendment included a ceiling of the current market price, or 5 cents a pound (whichever was less) on sales or purchases of previously uncontrolled fish or seafood, by or from producers, if at least 25 per cent of the weight of the total fish or seafood involved was under price control.[1] This amendment was followed almost immediately by Amendment No. 27 to Maximum Price Regulation No. 418, issued and effective March 18, 1944; it placed a 3-cents-per-pound ceiling on ocean pout in the "round" (uncleaned). The U. S. Fish and Wildlife Service Market News Service for March 23, 1944, reported that:

> In recent weeks ocean pouts have sold at prices as high as $3 per pound ex-vessel. Exorbitant prices were paid fishermen for this fish in order to secure for the buyers supplies of controlled fish. Recently, Amendment No. 26 to the regulation set a ceiling of the current market price or 5 cents per pound, whichever is lower, for sales of uncontrolled species in combination with sales of controlled varieties. The 5 cent cover-all, however, *is far above the 1942 average for sales by producers* [italics ours]. This amendment brings

[1] U. S. Fish and Wildlife Service Market News Service, March 9, 1944. Other limitations included the following. 1.) A ceiling of the current market price for sales or purchases by or from wholesalers of previously uncontrolled fish when sold in combination with controlled fish. 2.) A prohibition against offering, selling or delivering of fresh fish or seafood on condition that the purchaser is required to purchase some other commodity or service. 3.) A prohibition against falsely or incorrectly invoicing fresh fish or seafood.

about a price reduction of 2 cents per pound in sales of the round and proportionately greater reductions in sales of fillets, which savings will be passed on to the consumer.

Judging from the above, this ceiling price of 3 cents a pound was based on data from 1942, which was, of course, *before* the substantial market for ocean pout was established in 1943 (p. 11); therefore 1942 was a period in which the demand for this species was extremely limited. The fish had not yet been "discovered," and the adoption of a ceiling based on 1942 prices was patently fallacious. The 3-cent ceiling had an immediate effect on the fishery. Some idea of the extent of the resultant drop in magnitude of the catch is apparent from a comparison of the 1944 figures for April with those of March in Tables I and II. But since the ocean pout landings have normally declined to a certain extent in April, a better indication of the extent of the reduction of this fishery by the 3-cent ceiling is afforded by a comparison of the receipts on the New York market in January 1944 (776,723 lb.) and January 1945 (66,446 lb.),[1] a drop *to* less than 10 per cent of the equivalent period in 1944.

As a result of this 3-cent ceiling price, therefore, a new fishery of considerable importance suffered drastic reduction in the spring of 1944 and in 1945. Quite apart from the consequent overall lowered fisheries productivity at a time when there was urgent need for increased landings, there were other adverse effects. As indicated earlier in this section (pp. 19–20), one of the chief obstacles in bringing about the full utilization of "trash" or little-marketed fish is reluctance on the part of the fishermen and other members of the industry to handle these species, either through prejudice or force of habit. Any added deterrent obviously magnifies the difficulties already inherent in the situation, not only with respect to the particular species concerned but also to other fish of potential value.

Communication with the Office of Price Administration in March 1945 established the propriety of the 3-cent ceiling on the basis of the 1943 open-market conditions at New Bedford where the average price received by fishermen was 3.1 cents per pound. Here again, however, the setting of a ceiling price on the basis of conditions in the *first year* of a fishery is at best a dubious procedure; not only is it likely to curtail the development of the fishery, but it also takes no account of

[1] Data from U. S. Fish and Wildlife Service Market News Service Monthly Summary, March 30, 1945.

possible increases in price as the species becomes better known and the demand rises. Some indication of the extent of the use of ocean pout in "tie-in sales" in 1944 was also provided by this Office, which showed that the average price paid to the fishermen in that year was 6.4 cents, a sum actually in excess of the average wholesale market price in New York. For example, in February 1944 ex-vessel prices averaged 9.1 cents per pound, while wholesale prices in New York City ranged from 1.5 to 8 cents per pound and averaged about 5 cents. Since wholesale prices normally include transportation and other costs as well as one wholesale mark-up, the conclusion was drawn that the legitimate price to fishermen could not have exceeded 3 cents per pound. Nevertheless, this price may have been unduly low. In February 1944, for instance, Massachusetts contributed 144,065 pounds to the New York market. This was only 10 per cent of the New Bedford catch in that month, and since a large proportion of the New Bedford ocean pout was filleted at the landing point, thus avoiding transportation costs and other mark-ups, the dealers there could well afford to pay a higher price to the fishermen. In other words, the estimate of what constituted a legitimate price to the fishermen in New Bedford on the basis of wholesale conditions in New York, when only a tenth or less of the New Bedford landings of ocean pout were shipped to New York and the majority were filleted[1] at the point of landing, may not have been reasonable.

Let us now turn briefly to the more general question of the efficacy of price regulation in controlling fish prices. The difficulties involved are readily apparent from even the most cursory survey of the activities of the Office of Price Administration (1943 to 1945), which at-

[1] According to information received from the U. S. Fish and Wildlife Service office at New Bedford, the recovery in ocean pout fillets in commercial practice during February and March 1944 varied from 23 to 36.5 per cent (averaged 27.75 per cent) of the weight of the whole fish. Filleting for optimal recovery under laboratory conditions, we recovered 47.8 per cent in unskinned and untrimmed fillets in a sample of 23 fish ranging from 56 to 75 cm. in length, well over half of the recovered portion by weight coming from the region posterior to the anus. At New Bedford fresh and frozen fillets generally brought an average price of 16 to 17 cents per pound in February and March of 1944, although one company reported an average of 23 cents for fresh fillets in this period. The fresh fillets generally were shipped to the Boston, New York and Philadelphia markets. About half of the fillets were frozen and shipped to the Middle West, principally Chicago. Referring to the Service's fear of overcrowding the freezers with ocean pout (p. 29), it is interesting to note from the above the very considerable magnitude of the market for fresh fillets.

tempted to work out the problems in conference with the Office of the Coordinator of Fisheries. The relatively small variety of fish which the Office of Price Administration had managed to place under ceilings by the spring of 1945, the interminable number of revisions and amendments which were necessitated, and the resultant confusion—sometimes causing a lowered fisheries productivity—indicate some of the complications in the attempts to effect price control of fish.[1] From the consumer's point of view, the effects of price control have been discussed by Kahn (1944) and Werner (1944). Kahn attempted to analyze the result of the original Maximum Price Regulation 507 controlling fresh fish prices at retail, and came to the conclusion on the basis of data collected several weeks before and after the enforcement (or attempted enforcement) that " . . . MPR-507 was a successful venture of the OPA, but still an adventure." He further pointed out that no conclusion was possible as to whether this regulation would continue to be salutary for production-consumer relations, and that in some instances, which were fortunately in the minority, the regula-

[1] Maximum Price Regulation 418 (July 7, 1943) established maximum prices for 48 kinds of fresh fish in the New England and West Coast areas in sales by producers and wholesalers. It also pointed to ". . . the highly fluctuating nature of the industry, its seasonal features and the high perishability of fish in general" as some of the obstacles in the matter of fish price control. MPR 439 (July 20, 1943) fixed maximum retail prices at which retailers might sell the same species listed in No. 418 by the following method: "Every retailer, in order to determine his maximum selling price . . . shall take the same cents per pound mark-up over net delivered cost, which he took on the most sales during the period July 5 to July 10, 1943, inclusive, for the same style and form of the species being priced." MPR 364 (effective April 13, 1943) fixed the maximum prices at which processors and wholesalers might sell frozen fish and seafood. However, this regulation had to be reissued September 6, 1944, to include Amendments 1–20, by which time it covered 77 kinds of frozen fish and seafood. On December 13, 1944, MPR 507 (originally effective January 27, 1944) was redesignated Revised Maximum Price Regulation No. 507, which included six outstanding amendments and fixed new ceiling prices for 52 kinds of fresh and 86 kinds of frozen domestic and imported fish and sea food items for all retail stores, retail route sellers and wagon retailers. RMPR 507 established cents-per-pound mark-ups for frozen fish and seafood for the first time in place of the application to "net cost" of a stated percentage mark-up. Apart from the obvious merit of simplicity of operation, this revision was necessary in order to " . . . make available to consumers many low-cost fish items not heretofore released from storage because retailers felt that the use of the percentage mark-up returned an unsatisfactory margin on such items." Finally, MPR 579 (effective March 9, 1945) provided a schedule of maximum prices for North Atlantic species of fresh (20 types) and frozen (22 types) fish and seafood for the various kinds of producers, processors and wholesalers.

tion actually *increased* the prices above the then existing market level. Werner compared the prices of 10 species of fish in the spring of 1942 with the prices of the same species in 1944, at which time five were controlled by MPR 418. These data indicated that although ceilings probably kept the price of certain species from skyrocketing in periods of scarcity, they also apparently had the effect of maintaining a high price in periods of abundance. Werner concluded that in the absence of some ceiling prices and a serious meat shortage, consumers might pay more for out-of-season fish, but that their *total annual expenditure would be less.* Werner also indicated some of the difficulties arising from price control, citing particularly the whiting. In this case the fishermen actually limited their landings of this fish when they did not get ceiling prices in the summer of 1944, stating that they would starve at the lower remuneration they were receiving. There were two adverse results: 1.) decreased landings at a time when more fish were needed, and 2.) higher prices to the consumer because, "When fishermen demand and get ex-vessel ceilings from primary wholesalers, each wholesaler along the way also demands his ceiling price." Thus not only did the action of the Office of Price Administration on the whiting partially defeat its own purpose, but it had the added effect of actually reducing the nation's fisheries productivity. Even granting that this was an exceptional case, and overlooking the somewhat negative conclusions of Kahn and Werner in their analyses of the effectiveness of price control in limited sections of the fisheries industries, it is evident that the Office of Price Administration encountered great difficulties in its attempt to regulate fish prices. We are in no position to evaluate the overall effect of the attempted price control of fish in the United States from 1943 to 1945, although it seems reasonable to suppose that it was beneficial, especially in the period of acute meat shortage in 1945. But it is abundantly clear that inadequate data was at hand to allow the Office of Price Administration to accomplish its tasks in the most effective manner.

In considering the specific effect of the enforcement of price control on the ocean pout, it is apparent at this writing that the 3-cent ceiling established on March 18, 1944 (p. 23), cut a newly-established and prolific fishery to a drastic degree.[1] The necessity of Amendment

[1] Receipts on the New York market in 1945 were: Jan., 66,446 lb., Feb., 4,400 lb.—embargo on ocean pout in New York effective in February. New Bedford landings in 1945 were: Jan., 12,500 lb., Feb., 79,400 lb., March, 126,600 lb. Provincetown

26 to MPR 418, including a ceiling of the current market price or 5 cents a pound (whichever was less) on previously uncontrolled species in order to curb the black-market practice of "tie-in sales" (p. 23) was obvious; however, it is probable that any form of price-control itself almost inevitably fosters black-market conditions and illegalities of one sort or another. But the further cut-back on ocean pout to 3 cents by Amendment 27 a week later appears to have been short-sighted in the extreme. Amendment 26 had sufficient teeth in it to accomplish its purpose, and Amendment 27 not only served no additional good cause but seriously damaged a fishery of considerable potentialities in time of a great need.

It is difficult to conceive of the reasoning behind the 3-cent ceiling on ocean pout—especially when we remember the variety of fish *not* under price control (fresh mackerel, scup, butterfish, *etc.*—MPR 579). It might have been a form of double insurance against the continued use of ocean pout in "tie-in sales," although this seems hardly possible in the light of all the restrictions listed in Amendment 26 as well as the fact that other non-controlled species beside ocean pout were used for the same illicit purpose. On the other hand, it might have been prompted by the desire to eliminate a species which presented preliminary difficulties in marketing owing to its associated parasites. In the latter case, if sufficient information were available to show that these problems were insurmountable, the action might be justifiable. But in the absence of such information the action would appear to reflect poor judgement on the part of the specialists and others who advised the Office of Price Administration.

Discussion. In February 1945 the majority of the information on which this paper is based was available.[1] At that time also it was obvious that the ocean pout fishery was fast declining, both because of the 3-cent ceiling and because of an embargo placed on this species in New York by federal and city public health officials. We felt that

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landings in 1945 were: Feb., 48,000 lb., March, 170,500 lb., April, 120,000 lb., May, 122,000 lb. Data from U. S. Fish and Wildlife Service Market Service sheets (January landings at Provincetown not given).

[1] As a result of conferences of the National Research Council committee on Food Resources of Coastal Waters, as well as extensive discussion and correspondence, it was known widely that this study was in progress. The data on which our work is based were not consulted by U. S. Fish and Wildlife Service officials.

this was unfortunate for a variety of reasons. First, it seemed to us that judgment by the Office of Price Administration and other agencies had been precipitous in view of the lack of specific information at their disposal; this was understandable in the difficult period in which this fishery had its inception, but to us, none the less regrettable. Second, providing the market problems associated with the ocean pout can be overcome, the fishery has much to recommend it. We need only cite specifically its potential magnitude as indicated by its contribution in the war emergency period, the closer approach to the optimal utilization of North Atlantic marine resources of which it is a part, and the fact that the major landings are made in the winter and early spring months when the quantity and variety of fish are frequently at a relatively low level and the demand is at its height. However, communication with U. S. Fish and Wildlife Service officials revealed a difference of opinion; they did not concur in the desirability of encouraging the ocean pout fishery on several grounds. The first of these lay in the problems associated with its parasitization—*i. e.*, the undesirability of fostering a product which might occasionally reach the market in objectionable form. As already indicated, it was difficult to accept this viewpoint because the parasitological difficulties raised by the ocean pout received extremely limited study (Fischthal, 1944, and Sandholzer, *et al.*, 1945). This position was rendered more untenable since this was a time when the demand for increased fisheries productivity was urgent. Such a policy carried to its extreme in the 1930's might have precluded the development of the fishery for redfish (footnote, p. 16), a fish which initially presented somewhat similar parasitization problems. No one will deny the necessity for building on quality in the fisheries industries. But when there is good evidence that the marketing problems can be partially or wholly overcome, every effort should be directed at surmounting the obstacles involved; inadequate attention to the problems which arise early in the development of a new fishery can be critical, not only to the particular species concerned, but also in the multiplicity of ramifications that arise therefrom.

The second ground for the Service's unwillingness to take action on the ocean pout in February 1945 lay in its fear of overcrowding the frozen storage facilities, due in part to the failure of less well-known species (*e. g.*, ocean pout) to move readily to market—*i. e.*, the fear that blocking freezers with substantial quantities of relatively slow-moving fish might prevent the distribution of greater quantities of more acceptable species. It need only be mentioned here that this viewpoint is extremely difficult to reconcile with the following statements appearing in the U. S. Fish and Wildlife Service Market News Service:

April 17, 1945 (p. 1): Because of the current shortage of other protein foods, demand for fish is exceptionally heavy, the Coordinator's office reports. Present landings are rapidly absorbed by the market and less than normal quantities are being frozen for storage.

May 14, 1945 (p. 4): Holdings of frozen fish in the United States dropped 70,000,000 pounds during the first three months of 1945 to the below normal total of 39,829,575 as of April 1, the Fish and Wildlife Service of the Department of the Interior reported May 11, 1945.

June 28, 1945 (p. 3): A severe shortage of fish next winter was predicted June 25 by the Fish and Wildlife Service of the Department of the Interior on the basis of current holdings of frozen fish, which on June 1 totaled only 40 million pounds or 25 per cent below average.

Similarly, the following excerpt from House Report No. 504 (79th Congress, 1st Session),[1] is not easy to reconcile with the above-stated point of view:

> Special inducements should be given . . . to the fishing industry to increase the supply of fish as quick sources of protein food to supplement dwindling meat supplies.

It should be clear from the preceding account that the issues concerning the ocean pout were controversial. We feel that a potential fishery of considerable magnitude was reduced to a relatively insignificant level on the basis of inadequate information. We cannot believe that the position taken by those who contributed to the reduction of this fishery, whether by their action or inaction, was well founded. Particularly is this so when we recall the limited data on which conclusions were based—for example, what was *not* known about the life history, the microsporidian parasite and even its identity (p. 9) (Sandholzer, *et al.*, 1945), the geographical and seasonal incidence of infection over the commercially fished range of this fish, and innumer-

[1] Food Shortages. Report of the Special Committee to Investigate Food shortages for the House of Representatives, 1945. May 1, 1945—Committed to the Committee of the Whole House on the state of the Union and ordered to be printed. U. S. Government Printing Office, Washington, 1945. P. 16. (Union Calendar No. 126).

able other factors.[1] If the present contribution plays some small part in rectifying existing conditions and in providing a more reasonable basis for judgment of the ocean pout fishery, either as a direct result of the information contained herein or indirectly because of research which follows, our efforts are justified.

Summary. Until recently the ocean pout (*Macrozoarces americanus*), although taken abundantly by commercial fishermen in the southern New England area from January to June, was generally discarded as a "trash" fish. However, this species suddenly attained prominent market status in 1943 when it was first marketed in fillet form. The landings amounted to over 10,000,000 pounds in two years.

There is considerable evidence that the stock of ocean pout is capable of making an even more notable contribution to the nation's fisheries productivity. Furthermore, any trend toward the greater use of trash species implies a closer approach to the rational utilization of marine resources. The factors which control the extent to which these resources are used are many and complicated, but it is clear that we have not even approached an overall optimal level of exploitation and that the fisheries industries have much to gain from progress in this direction. The diffusion of fishing effort over more species should not only relieve the drain on the primary stocks, but it should also place the economic security of those engaged in the industry on a less hazardous basis. Moreover, a wider assortment of quality fisheries products, coupled with increased awareness of the consuming public as to the *variety* that are available, should lead to the more favorable competition of these commodities with other foods.

Various attempts to control the ocean pout fishery were made by the Office of Price Administration. These culminated in a 3-cent ceiling which reduced the landings in 1945 to a relatively low level. There is good reason for thinking that the 3-cent ceiling was unduly low, and that its consequences were not adequately considered. It is also apparent that insufficient data were at hand to allow the Office of Price Administration to establish price controls on fish in the most effective

[1] It should not be necessary to add that combined and cooperative attack by federal, state and private organizations is essential to most efficient progress in fishery biology, and that the U. S. Fish and Wildlife Service should act as a clearing house for all sources of material that are pertinent to its specialties in dealing with restrictions and regulations which impinge on its sphere of activity.

manner—witness among other things the large number of species which were not placed under control in the war emergency period.

An added factor in the reduction of the landings of ocean pout in 1945 was the embargo placed on this species in New York by city and federal public health officials because of the marketing problems arising from its parasitization. Granting that ocean pout fillets present certain difficulties, it appears that the condemnation of this fish because of its parasites was based on extremely meagre information.

Discussion with U. S. Fish and Wildlife Service officials emphasized the controversial nature of the issues involved, but it did not alter the conclusion that judgment on the ocean pout fishery was precipitous and did not take into consideration all the available information. Providing that the marketing problems can be overcome, the fishery has much to recommend it. The present paper should provide a fairer basis of evaluation.

PRELIMINARY DISCUSSION OF THE FISH

Literature

Early accounts. The earliest American account of the ocean pout was given by Peck (1804), who very accurately described its principal characters and pictured it in unmistakable fashion from specimens taken mainly in March and April on haddock grounds near the Piscataqua River, New Hampshire. He further added the following comments:

> It feeds principally on echini and asteriae of several species. To collect its food, it is necessary that it should frequent rocky places, and to this it must be owing, that in the larger individuals, the ventral fins are entirely obliterated, except two small cicatrices; so that at first view they appear to be a species of Anarhicas. It is therefore from the younger fish only that the classical character can be determined. From the resemblance above mentioned it has probably obtained the name of Wolf, by which it is known to our fishermen. It is sometimes called Conger Eel. In the consistence of the muscles it is like the eel, and deprived of its head and skin, it is sometimes sold as such; but it is preferable to the eel, as it feeds on living food; whereas the eel feeds on carcasses. The largest I have seen was 31 inches in length.

Mitchill (1815), apparently unaware of Peck's (*loc. cit.*) account, also gave a description of one which was brought to the New York market. Storer (1839) elaborated on his predecessors' work and added:

> This species, which is incorrectly called by our fishermen "*ling*," sometimes attains the size of three and a half feet. It is seldom met with in Boston market. When young, its flesh is very sweet and palatable; I have repeatedly had it upon my table.

DeKay (1842) employed the English name *Eel-pout* (used for *Zoarces viviparus*) and commented on the fact that he had noticed this fish on the New York market most abundantly in February and March, that it is caught on the coast with cod, affords a very savory food, and that "It is called, absurdly enough, by the fishermen, *Ling* and *Conger-eel.*"

Holmes (1862), in his report on the Fishes of Maine, stated:

> Early in the spring and first of summer, the fishermen sometimes take, in company with cod, this fish to which, from its general resemblance to the Conger Eel, they frequently give the name of *Conger Eel and Ling.* It is also caught at other seasons of the year, but not so often. It is much prized by some people as a savory fish. Its common length is from one foot and a half to two feet. Occasionally one is caught from three to four feet long, but those of that size are rare.

Goode (1884) gave a general account of the fish based on the statements of earlier authors and compared it with its European counterpart, *Zoarces viviparus.* He wrote:

> The Mutton-fish, *Zoarces anguillaris,* called Congo Eel and Ling, and also Lamper Eel, especially by the Maine fishermen, is often seen near the shore north of Cape Cod, and in winter especially is frequently taken with hook and line from the wharves. This species occasionally attains the length of three feet and the weight of six or seven pounds.

He also spoke of the fish as one " . . . which, while possessing excellent qualities as a food-fish, is not generally eaten." However, "It is occasionally eaten by the Cape Ann fishermen, by whom it is known as the Mutton-fish, . . . and I can myself testify to the delicacy of its flavor."

Bean (1903) noted that, "It is rather common north of Cape Cod" and is a common resident of deep water in Massachusetts Bay, frequently approaching the shore; he also called attention to its prevalence in the region of Marthas Vineyard in the fall of the year, and off Sandy Hook, New York, where it was known as mutton-fish.[1]

[1] Nichols and Breder (1926) state that in the vicinity of New York it is almost universally known as "Conger eel."

Modern accounts. Comparatively recent discussions of this fish, although relatively few, substantiate many of the earlier observations and add further interesting information. Clemens (1920) and Clemens and Clemens (1921) worked on the life history and abundance of ocean pout in the Bay of Fundy with the primary object of providing information relative to placing it on the market in Canada. Apparently war-time conditions and the need for increasing food sources at that time also served as a stimulus for these researches. Huntsman (1922), Bigelow and Welsh (1925), Bigelow and Schroeder (1936) and others supply additional data. Since these works are quoted and discussed in the following pages they need no amplification here.

Common Names

In glancing through the foregoing excerpts from earlier accounts it is apparent that the popular names are many and have frequently led to confusion. As pointed out previously (p. 11), the terms "conger eel" and "congo eel" are particularly unfortunate owing to the difficulty of ascertaining whether the reference is to *Macrozoarces americanus* or to the unrelated *Conger oceanicus.* Similarly, "ling" is sometimes used, and this presents the possibility of confusion with the hakes (*Urophycis*); even "lamper eel" is unfortunate because of its similarity to the name "lampreys" (Cyclostomata). Storer (1857) stated: "At Bras d'Or it [*M. americanus*] is frequently taken . . . , and is confounded by the fishermen with the Lamprey." Fishermen also refer to them as plain "eels," "rock eels," "sea eels," "yowlers," "lipsyfish," "mother-of-eels," or "snake-fish." Fortin (1865) gave "chat de mer" and "congre" as common names in Canada, but he pointed to their inaccuracy and possible confusion with "*Anarrhichas Lupus*" and "*Conger Vulgaris.*" The English name "mutton-fish," used for the European *Z. viviparus*, is applied in certain coastal areas because of the supposed resemblance of its flesh to mutton. In fact, Clemens (1920) proposed that this name be used for market purposes in Canada. "Eelpout" has been used most commonly, and is unquestionably more appropriate and less confusing than any of the above-mentioned terms, but this name is also used occasionally for the burbot (*Lota lota*) in some regions, as pointed out by Goode (1884).

Early in 1943 an attempt was made by the Committee for Increased Utilization of Sea Food Resources under the sponsorship of the U. S.

Fish and Wildlife Service to adopt a standard popular nomenclature for relatively little known species which were expected to be landed and marketed in increasing quantities. The unanimous choice of this group was the name "ocean pout" because, as quoted from an abstract of a meeting held on February 1, 1943:[1] "The name eelpout was considered misleading since this species is not related to the eels. Dealers have found it difficult or impossible to market the species under any name including the term 'eel'." In the last two years the term "ocean pout" has received fairly wide and successful usage, although complete consistency with this recommendation has not been maintained, thus leading to difficulties in the tabulation and interpretation of data such as that found in the Market News Service of the U. S. Fish and Wildlife Service.

Characteristics

Distinctive features. The combination of heavy head and tapering elongate body, pointed tail, continuous dorsal, anal and caudal fins, *apparent* gap in the dorsal near the caudal fin, heavy thick lips, blunt conical teeth and eyes placed high on the head are characters which eliminate all other species in its range (Bigelow and Welsh, 1925). For further details see section on Taxonomy.

Observed behavior. Relatively few observations have been made on the habits and characteristic behavior of ocean pout, the fullest account having been given by Willey and Huntsman (1921):

> A muttonfish 45 cm. in length was kept in one of the flat tanks of the laboratory during the latter half of the season and proved to be quite hardy. It fed regularly on the fish and shell-fish given it, approaching from a distance of more than a foot to take food from the hand. The enormous thick lips were used more than the teeth for taking hold of the morsels and a strong inspiration of water carried the food in. Swallowing did not immediately follow the taking of food, but was preceded by a rather prolonged series of masticatory movements involving both mouth and throat, and in which the head was nodded vigorously by movements in the vertical plane, the downward ones being the more vigorous.
>
> The enormous pectoral fins were used in slow backward and forward locomotion, each fin being kept in a vertical position and slightly folded with the convex side in the direction of movement. At rest each fin is held out from the body almost in the horizontal plane and against the bottom, with the dorsal part posteriorly placed and somewhat raised. Rapid swimming is

[1] Fishing Gazette, *60* (4): 67, April, 1943. See also Fishing Gazette, *60* (10): 43, October, 1943.

accomplished by undulatory movements of the posterior part of the trunk and tail; the pectoral fins being extended to the fullest extent and held horizontally with the dorsal edge in front, while the dorsal and anal fins are kept close to the body, at least anteriorly.

Touching the side of the trunk or tail resulted in the erection of the dorsal fin. After repeated stimulation the response became rather local, extending both forward and backward from the level of the point touched, but chiefly backward. At the same time the fin was bent toward the side stimulated.

Clemens and Clemens (1921) noted that specimens in captivity tended to remain coiled up in the deepest parts of the tank, but that they swam swiftly and powerfully when disturbed. It is also obvious from Fig. 8 that ocean pout apparently coil around the eggs after the general manner of related members of this group. White (1939) described the recovery of two medium-sized ocean pout as well as a mass of eggs from a fisherman's rubber boot which was taken in a flounder trawl in January 1931 in the Bay of Fundy at about 10 meters depth, the water temperature being 0° C., and these observations fit the characteristic reproductive pattern of blennioid fishes. Most of the 842 eggs had hatched in the pan of sea water in which they were placed before the boat returned to dock a few hours later; White observed the rapid shrinkage of the yolk sac and the forcing of the yolk into the abdomen in not more than 20 seconds after hatching, which is in sharp contrast to the slowness of this process in salmonid species.

Nichols and Breder (1926) made the following comment on the behavior of this species: "the break in the contour of the shore eel-pout's vertical fins just over the tail . . . . is apparently a defense adaptation. We have had this in mind in taking one from a hook, and noticing how it coiled back on itself, jagging the hand with these spines." We have had similar experiences in tagging and measuring live ocean pout; the fish undulated vigorously and powerfully throughout the entire body length, sometimes coiling around the wrist or hand with spines raised in such a manner as to prick so sharply that it was next to impossible to retain a hold.

The feeding habits of the ocean pout have been described by a number of authors, and full reference to these accounts is made in a subsequent section devoted to this subject.

Distribution

Range in latitude. The general range of the ocean pout is usually given as the Atlantic coast of North America from the Straits of Belle

Isle and the Gulf of St. Lawrence southward to Delaware. Clemens and Clemens (1921) gave a complete table of the records of distribution of this species. Some authors have extended the southern limits to North Carolina, apparently on the basis of a statement by Smith (1907):

> The claim of this fish to a place in the North Carolina fauna is based on 2 small specimens said to have been caught by Dr. Yarrow with hook and line from the wharf at Fort Macon in May, 1871. The species has been observed by no one else, and must be regarded as a rare straggler so far south, assuming there has been no error in identification.

Range in depth. It is apparent from early and later literature, as well as from our own experiences, that this bottom-dwelling fish ranges from shallow intertidal zones down to very considerable depths, the capture of a number of specimens in July 1931 in the basin of the Gulf of Maine at 90 fathoms being reported by Bigelow and Schroeder (1936). In the northern areas around the Bay of Fundy, Clemens (1920) pointed to their being close to shore during the summer, at which time they are generally taken at depths up to 15 fathoms and sometimes 30, with one specimen recorded from 50 fathoms in April. He also stated that young specimens may be taken around rocks which are uncovered at low tide. According to Bigelow and Welsh (1925), ocean pout are taken in Penobscot Bay and Northeast Harbor in one to three fathoms and this probably applies all along the coast of Maine east of Cape Elizabeth. To the south, however, the picture is somewhat different, and ocean pout are not generally found in such shallow water. Goode (1884) reported a specimen taken in Gloucester Harbor at eight fathoms. In Massachusetts Bay Bigelow and Welsh recorded none at depths less than 10 fathoms, and in general it would appear that the majority of the stock of ocean pout is to be found between 10 and 45 fathoms in middle and southern New England waters. All of the collections on which this paper is based were made within the 30-fathom contour, the majority of fish being caught in 15 to 25 fathoms, with excellent hauls in as little as 10 to 12 fathoms (Fig. 3).

Bottom. Generally speaking ocean pout are found on all types of bottom, although there is good evidence that they prefer rocky areas at least during the summer and fall months in southern New England (p. 41). As pointed out by Clemens (1920) they are taken on every type of bottom in Passamaquoddy Bay; Huntsman (1922), on the other hand, specifically stated that they were taken on hard bottom.

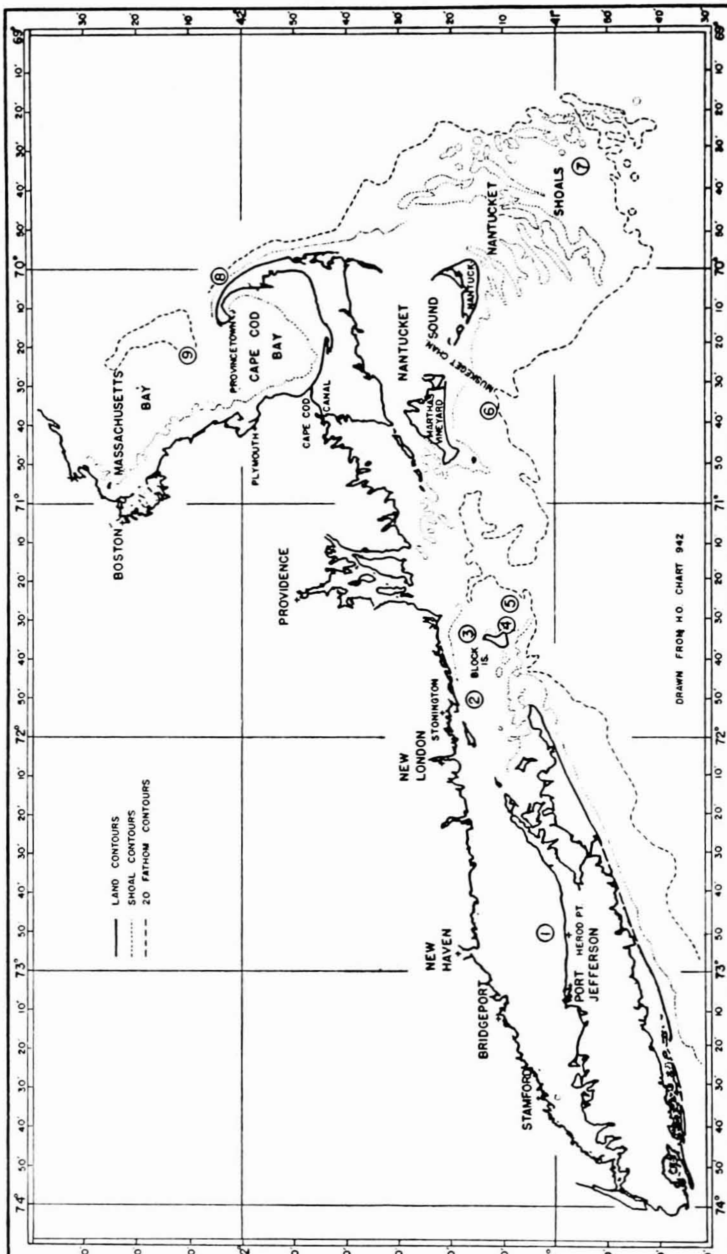

Figure 3. Major areas of collection of samples of ocean pout used in this study as indicated by encircled numbers 1 through 9. See also Table V.

According to Bigelow and Welsh they are hardly ever taken on stony or sandy fishing grounds, but rather on the soft sticky mud in the deeper parts of Massachusetts Bay. These authors also reported taking them on rather sticky sand in Ipswich Bay, on broken bottom at the mouth of Casco Bay, and on pebbles and mud in Penobscot Bay. To the east they are commonly caught on stony and rocky ground. All our own observations confirm the fact that ocean pout are taken on all types of bottom, although there appear to be seasonal preferences (pp. 40–42).

Seasonal Abundance and Movements

From their own observations, as well as the data of other workers, Bigelow and Welsh (1925) concluded that this species does not undertake coastwise migrations, but that there are irregular on and offshore movements which differ seasonally with respect to the geographical areas involved. They stated:

> The eelpout, broadly speaking, is a resident fish wherever found, its only migrations taking the form of on and offshore movements, and even these are irregular. In the Bay of Fundy, Huntsman describes them as working inshore in spring, moving out again into deeper water in October or early November, and as absent from the estuaries from January to April. Their abundance in Penobscot Bay in midsummer suggests that some of them perform a similar on and offshore migration there. However, this probably does not apply to the coast south of Cape Elizabeth and certainly not to Massachusetts Bay, where as careful an observer as Goode (et al., 1884) long ago described them as coming most often into shoal water in winter. Probably the truth is that their presence or absence close inshore, in any particular locality and season, depends not only on the local supply of food but on temperature, for the upper 10 to 15 fathoms in the southern part of the Gulf [of Maine] as a whole may well be too warm for them in summer, and estuaries particularly subject to severe chilling too cold in winter.

Clemens and Clemens (1921) in their studies of this species in the Bay of Fundy came to the following conclusions:

> The sexually mature muttonfish leave the St. Croix river and Passamaquoddy bay about the end of July, and the remainder probably have left by the end of October. The height of the outward migration therefore occurs at the period of highest temperature. The inward migration probably begins early in April, which is the time when the temperature of the water in the St. Croix river and Passamaquoddy bay goes above 0° C. Fertilization of the eggs probably occurs in September which is the period of highest bottom temperature. There is thus a coincidence between the temperature extremes and the

migration periods, but whether or not there is a causal relation it is impossible to decide at the present time.

Our own observations show that ocean pout are abundant on southern New England commercial fishing grounds during the winter and spring months, but absent in the summer and fall months when only an occasional stray is taken by the small draggers and trawlers which operate in these waters (Fig. 2, Tables I, II). Since there is absolutely no evidence to show that this is a species which engages in coastwise migrations[1] (and indeed considerable data to indicate that it does not, pp. 115, 167), it appears reasonable at first sight to suppose that when ocean pout disappear from the catch in this general area it is because they have moved further offshore. This would mean that the same general pattern of migration as that indicated above by Clemens and Clemens held true, the essential difference being a four-month lag in northern waters where the fish are present inshore from April through October.[2] Nichols and Breder (1926) in "The Marine Fishes of New York and Southern New England" substantiate this view when they say: "Permanent resident, abundant in fall and winter to the westward . . . . In Maine this fish comes close in to the shore and shallow water, more or less, in summer. In our region it is found in moderately deep water, with probably some inshore tendency in winter."

However, it should not be concluded that ocean pout necessarily move offshore into much deeper waters during the warmer months in southern New England just because they are absent from the trawl-net catch from June to December. Sampling fish populations and estimating abundance in any geographical area on the basis of the

[1] Some 54 ocean pout were tagged during the course of this study (Table V), but no returns were obtained. Standard celluloid discs connected by a nickel pin through the mid-dorsal musculature after the manner described by Merriman (1941) were used; however, this species is extremely difficult to handle alive, and an opercular or other type of tag might simplify matters somewhat—although not enough to make tagging or measuring live ocean pout anything but a tedious and harassing proposition!

[2] Another difference between northern and southern New England ocean pout is the fact that in northern waters the fish come into extremely shallow water close to shore (p. 37), whereas there is no evidence that this is so south of Cape Cod. However, Bigelow (1914) recorded the capture of a number of specimens in July from the Gulf of Maine (Mass. and southern Maine) approximately 8–10 miles off shore at depths from 22–30 fathoms with temperatures ranging from 41.3–44.4° F.

catch by one type of commercial gear has obvious limitations. For example, Clemens and Clemens (1921) concluded that ocean pout are apparently absent from Passamaquoddy Bay from January to April since they caught none on set lines in this area in the winter of 1918–1919. But, as pointed out by Bigelow and Welsh (1925), this species may be one which does not feed to any great extent during this period. At this time the adults, as is the habit among blennioid fishes, may devote themselves chiefly to the care of their developing offspring in these waters—a habit which may preclude extensive feeding. Or there may be a selectivity in their diet which would make their capture on hook and line unlikely. Good evidence that they are not wholly absent from this region in January is provided by White's (1939) capture of several specimens in a flounder trawl at 10 meters. Similarly in regard to the absence of ocean pout in the summer and fall from the southern New England ground on which small trawlers work, there is considerable evidence to show that these fish frequent rocky bottom at moderate depths in this season where trawl nets cannot operate successfully. Thus Smith (1898) stated that they are "Abundant in fall, off Gay Head and Cuttyhunk; caught while line fishing for cod, on rock bottom, . . ." And commercial fishermen have reported to us in careful interviews that Provincetown boats take some ocean pout in relatively shallow rocky areas in Cape Cod Bay (between the Cape Cod Canal and Plymouth) in the summer and fall, and that New Bedford vessels also take them at this season in or close to rocky areas southeast of Block Island near the 20-fathom contour. Furthermore, one of us was on board a small dragger out of Stonington, Connecticut, which took small numbers of ocean pout in August and September while working at approximately 20 fathoms as close as possible to a notoriously "bad" bottom off Block Island. It is thus clear that at least part of the ocean pout population in southern New England waters remain in the same general depth zone in which they are taken in winter and spring, but move into rocky areas where their capture by trawl nets is at best fortuitous. In the absence of more numerous captures at much greater depths off southern New England it seems unwise to assume that a marked offshore migration necessarily occurs. Further evidence on this matter is provided in subsequent sections (pp. 110, 115). The speculation that the preference for rock bottom at certain seasons is in part governed by the spawning habits of this species seems reasonable in view of knowledge of related forms.

Spawning occurs in October in the region under consideration (pp. 70–77), and the protection of the developing eggs quite probably continues through November and part of December, after which time the fish appear in the trawl-net catches. Finally, it is of some interest that the suddenness of their appearance indicates mass migrations and heavy schooling rather than individual movements. For example, boats fishing off Old Harbor, Block Island in middle and late December 1943 took few ocean pout—*i. e.*, usually less than a dozen per drag of an hour or more; but on December 30 and January 2, 1944, the boats averaged 10–15 barrels (200 lb. per barrel) per drag in exactly the same locality.[1]

Size

Such standard references as Bigelow and Welsh (1925), Breder (1929) and Nichols and Breder (1926) state that while this fish is said to reach a length of 3½ feet and a weight of 12 pounds, most of those caught are much smaller, the usual maximum being between 2½ and 3 feet. The largest specimen encountered in the present work, during which over 2500 individuals were examined, was a male 38½ inches (98 cm.) in total length which weighed 11¾ pounds (5321 g.). This fish was taken 8 miles NNW. of Racepoint Light near Provincetown, Massachusetts, by the commercial dragger "Viola D" on March 15, 1944. It was the only individual we have seen which exceeded three feet. In fact, it is readily apparent from Fig. 4 that relatively few ocean pout over 2½ feet in length were taken during the investigation, and that most of the individuals at the upper size limits were males. This latter fact provides evidence for the suggestion that the males tend either to live longer or grow faster than the females, thus attaining a greater size. The grouping of the points in Fig. 4 also makes it clear that the great majority of the fish fell in the one-foot interval between 16 and 28 inches (40.6–71.1 cm.).

The length-weight curve shown in Fig. 4 is based on the collections of ocean pout over a full year so that the relationship represents as nearly as possible an average condition which is not severely biased by the state of the gonads. If, for instance, the fish had all been taken in October just before spawning, the size of the ovaries would have

[1] The nets used were modified otter trawls with mouth widths of 80–120 feet. One of us was on board one of the boats on January 2 and saw 60 barrels taken in five hauls; most of the other vessels fishing the area were interviewed for corroborative data.

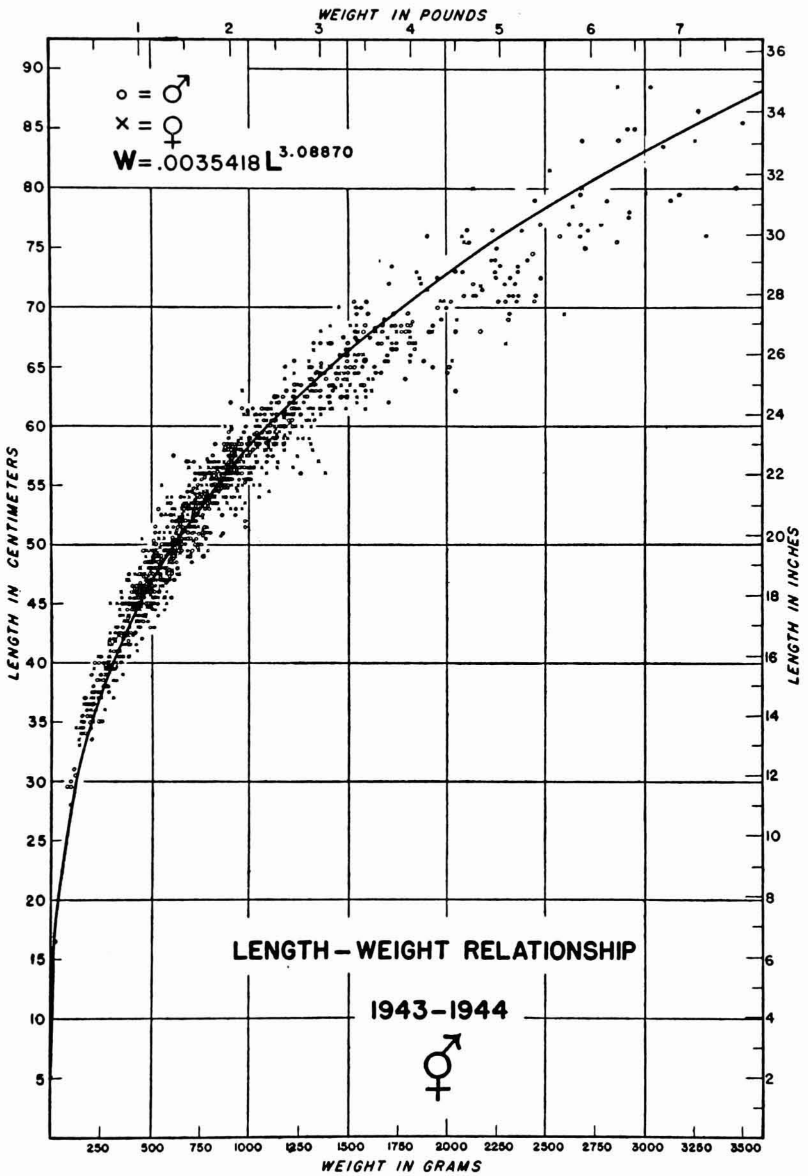

Figure 4. Regression curve showing the length-weight relationship of ocean pout of both sexes. Data based on 1114 individuals taken over a complete year from March 1943 to March 1944. See text for discussion; also Table III and Fig. 18. Not included in the figure, but used in the calculation of the formulae, were seven males (86 cm., 3629 g.; 88 cm., 3765, 3806, 4355 g.; 90 cm., 4241 g.; 91 cm., 3833 g.; 98 cm., 5321 g.) and one female (23 cm., 158 g.).

TABLE III. AVERAGE WEIGHTS OF OCEAN POUT FROM 25–100 CM. (10–39.5 IN.) IN LENGTH. DATA PRESENTED AT 5-CM. (2-IN.) INTERVALS FOR MALES, FEMALES, AND THE COMBINED SEXES IN GRAMS AND POUNDS. VALUES DERIVED FROM FORMULAE GIVEN IN FIG. 18.

Length		*Males*		*Females*		*Males and Females combined*	
Cm.	Nearest ½ inch	Nearest 0.1 Gram	Nearest 0.1 Lb.	Nearest 0.1 Gram	Nearest 0.1 Lb.	Nearest 0.1 Gram	Nearest 0.1 Lb.
25	10.0	66.6	.1	81.4	.2	73.6	.2
30	12.0	119.5	.3	139.2	.3	129.3	.3
35	14.0	195.9	.4	219.3	.5	208.2	.5
40	16.0	300.6	.7	324.9	.7	314.4	.7
45	17.5	438.7	1.0	459.8	1.0	452.4	1.0
50	19.5	615.1	1.4	627.1	1.4	626.4	1.4
55	21.5	835.2	1.8	830.4	1.8	840.8	1.8
60	23.5	1104.0	2.4	1049.0	2.3	1100.0	2.4
65	25.5	1427.0	3.2	1358.0	3.0	1409.0	3.1
70	27.5	1811.0	4.0	1690.0	3.7	1771.0	3.9
75	29.5	2259.0	5.0	2071.0	4.6	2191.0	4.8
80	31.5	2779.0	6.1	2505.0	5.5	2675.0	5.9
85	33.5	3376.0	7.4	2994.0	6.6	3226.0	7.1
90	35.5	4055.0	8.9	3543.0	7.8	3848.0	8.5
95	37.5	4823.0	10.6	4155.0	9.2	4548.0	10.0
100	39.5	5686.0	12.5	4833.0	10.7	5329.0	11.8

been such that the average weight of the individuals in the upper half of the curve (after sexual maturity has been attained) would have been considerably greater at each length interval. If, on the other hand, they had all been taken in January shortly after spawning, the average weight would have been less. It should be mentioned, however, that owing to the seasonal nature of the fishery by far the largest collections were made in the period from January to June, so that the values for the upper half of the curve are probably slightly less than they would have been if the sampling had been equivalent in each month of the year. A total of 598 males and 516 females were used in the preparation of the curve. The points plotted on the graph in Fig. 4 represent actual values and thus indicate in a general way the extent of the spread at the different length and weight intervals. The length-weight curve was fitted mathematically, the coefficient of regression being calculated by standard methods after Simpson and Roe (1939) to give the formula shown in the upper left corner of Fig. 4. Table III provides the average weights of ocean pout of each sex separately and of males and females combined at 5-cm. (approximately 2-in.) intervals over the full range of size. It is of considerable interest that from 25–55 cm. the males tend to weigh less than the females and that above 50 cm. this relationship appears to be reversed. Further discussion of this point is presented in the section on age at maturity, where the male and female length-weight curves are also graphed (Fig. 18).

Vitamin A Analyses

Analyses of two samples of ocean pout livers[1] were undertaken by the Research Laboratories of Distillation Products, Inc., Rochester, New York, through the kindness of Dr. K. C. D. Hickman and his staff.

It is well known that the Vitamin A potency of the livers of particular species of fish often varies over wide ranges. Brocklesby (1941) summarized some of the factors influencing these variations in Canadian fishes. Thus it has been shown that Vitamin A potency is related to size (the larger individuals yielding oil of higher value), color of the liver, season, *etc.* Templeman (1944) discussed the relation of the Vitamin A value of the oil from the livers of the spiny dogfish (*Squalus acanthias*) in relation to size, sex and degree of maturity. Any additional data obviously facilitates a clearer understanding and interpretation of the variations in Vitamin A potency of fish livers and also provides a better basis for establishing the fundamental principles which underlie its accumulation in animal tissues.

The first sample of ocean pout livers came from six fish taken on August 7, 1943, 15 miles SSE. of Point Judith, Rhode Island, at a depth of 20 fathoms. The size range of the fish was from 36 to 58.5 cm. (mean 50.0 cm.). The sexes were evenly divided—three males and three females. The livers were frozen and shipped from New Haven to Rochester packed in dry ice, where they were processed in their entirety. The per cent of oil by weight in these livers was 5.3, and the Vitamin A value 607 units per gram.

The second sample was composed of the livers from 27 ocean pout from a shipment of 100 specimens taken between June 15 and October 25, 1943, near St. Andrews, N. B., Canada. These fish were frozen as they were caught and shipped to New Haven for analysis in one lot in early November. The size range was from 28 to 54 cm. (mean

[1] The livers of ocean pout of marketable size average about 1.5 to 2.0 per cent of the weight of the whole fish.

43.5 cm.). The sexes were almost evenly divided—15 males and 12 females. The livers were refrozen, shipped and processed as was the first sample. The per cent of oil by weight in these livers was 0.7, and the Vitamin A value 16,500 units per gram.

If we now attempt to explain the differences in the livers of these samples, there are several matters to be taken into account. First, we should emphasize that the number of livers is extremely limited and that only two lots were tested. Furthermore, the difference in Vitamin A is not so great when considered in relation to the fat content, where a typical negative correlation exists, and variations of this magnitude are not uncommon in samples of this size. However, it is perhaps significant that we can eliminate a number of variables in comparing either the Vitamin A values or the fat content of these two samples. It seems evident that the differences are not attributable to the sex composition of the samples. It is also extremely unlikely that they were due to size or degree of maturity, since the differences between the two samples in these respects were not great, and especially since the sample from fish of *smaller* mean size had the higher Vitamin A potency. However, comparison of the feeding habits of ocean pout from the Bay of Fundy and southern New England (Table XII) does indicate certain differences which might possibly be significant. Thus in the northern fish, 18 per cent of the total volume of the stomach contents consisted of the remains of the green sea urchin, *Strongylocentrotus dröbrachiensis*, while in the fish from the Block Island Sound area this echinoderm was never present. Also, the Canadian fish showed a somewhat greater preference for a molluscan diet. It does not seem likely that these differences are sufficient to be of importance, but they cannot be excluded with certainty without further investigation. In regard to the physical environment,[1] the differences in depth and light between the two regions in which the fish were taken would not appear to be sufficient to warrant consideration; seasonal variations are also excluded. The most obvious factor is temperature, which on a year-round basis averages somewhat lower in Bay of Fundy waters than it does off southern New England. However, at depths of approximately 15 to 20 fathoms the differences between these two areas are usually only of the order of 3 to 5° C. (Bigelow, 1928). Speculation as to whether temperature differences of this sort could be significant in this

[1] Pugsley (1938) obtained no regularity of variation in Vitamin A potency of herring oils with respect to the locality of the catch in British Columbia.

regard is beyond the scope of this paper, but we wish to point out that this fish, by virtue of its size and general nature, is particularly well suited to study in aquaria or tanks and therefore to experimental approach on problems of the sort here indicated.

CLASSIFICATION, TAXONOMY AND OSTEOLOGY

Genus *Macrozoarces* Gill, 1864.

Macrozoarces Gill, Proc. Acad. Nat. Sci. Philad. (1863), 1864: 256–258; type, *Enchelyopus anguillaris* (Peck, 1804).[1]

When Gill concluded that Gronovius *Enchelyopus* had priority over, and with about the same limits as, *Zoarces* Cuvier, 1829, he created the subgenus *Macrozoarces* on the basis of the American form's larger head, much larger mouth, greater extent of the spinous portion of the dorsal fin, and the much larger number of caudal vertebrae compared with the European *Zoarces*. Jordan (1919: 325) subsequently raised *Macrozoarces* to generic rank. Most of Gill's generic differences may be questionable, but we believe there is ample justification for the separation of the two genera, particulary on the basis of the greater number of vertebrae in *Macrozoarces* (131–144), a correspondingly higher number of dorsal and anal fin rays and double rows of teeth in the front of both jaws (single in *viviparus*); furthermore, *Macrozoarces* is oviparous and attains a much larger size. Note, however, that this comparison is limited to a consideration of species in the North Atlantic only; species of the Pacific, and possibly elsewhere, now classified under *Zoarces*, have not been observed by us.

Generic characters. Head broad and heavy; body elongate and ensiform, tapering to a pointed tail; scales small and imbedded; lateral line arched anteriorly; lips large and fleshy; nares single; mouth large; upper jaw longer than lower; eyes high on head, more oval than round, and closely approximate; interorbital space narrow; teeth obtusely conical in both jaws, often worn and flat; branchiostegals 6; gills 4; rakers short, blunt and heavy, some with small terminal teeth; 4 to 6 on upper arch, 11 to 13 on lower; no palatine teeth; pharyngeal teeth stout, conical, some worn; vertebrae 131 to 144; dorsal, anal and caudal

[1] We regard Gill's type, *Enchelyopus anguillaris*, as a synonym of *Macrozoarces americanus* (Bloch and Schneider, 1801); likewise *Blennius anguillaris*, which Jordan (1919: 325) designated as the type for the genus *Macrozoarces*.

fins continuous; dorsal continuous from head to tail, of soft rays except for short series of spines in posterior part; anal fin continuous to tail, of soft rays only; ventrals small, of 3 multifurcate rays; pectorals broad and rounded, 18 to 21 rays; caudal very small and pointed.

Macrozoarces americanus (Bloch and Schneider), 1801

Ocean Pout

Figure I

Remarks on nomenclature. In spite of the fact that Bloch and Schneider were quite vague in their description, all indications point strongly to the acceptance of *Blennius americanus* as having priority over *Blennius anguillaris* Peck, 1804. The strongest argument for its acceptance is to be found in the fact that Bloch and Schneider listed *americanus* immediately after the European form, *viviparus,* in their genus *Blennius* ("Pinnae ventrales didactylae, dorsalis mutica vel partim aculeata"). They must have been well acquainted with *viviparus* and unquestionably noticed the similarity of the American form ("Habitat in mari Americano"). Furthermore, in considering their systematic arrangement it seems unlikely that they confounded the American ocean pout with other closely- or remotely-related species, especially as regards the ventrals and the continuous anal, caudal and dorsal fins. Both *Muraena* (a true eel without ventrals) and *Trichiurus* (likewise without ventrals) are placed in entirely different classes; *Anarrhichas,* which has neither ventrals nor pointed tail, and *Ophidium,* with which confusion was possible because of the barbel-like ventrals, are in still another class, well removed from *Blennius;* the brotulid *barbatus* was placed in their genus *Enchelyopus.* It is also unlikely that they were describing a specimen of *Cryptacanthodes,* which has no ventrals. That they had a blenniod fish seems quite apparent; blennies were available to them, and it is improbable that they were considering a true blenny as restricted today. It is conceivable that another zoarcid or lycodid was being described by these workers, but when we consider the relative abundance and availability of the ocean pout as compared to other species in these groups, and when we note the position of *americanus* next to *viviparus,* this seems to be a very remote possibility.

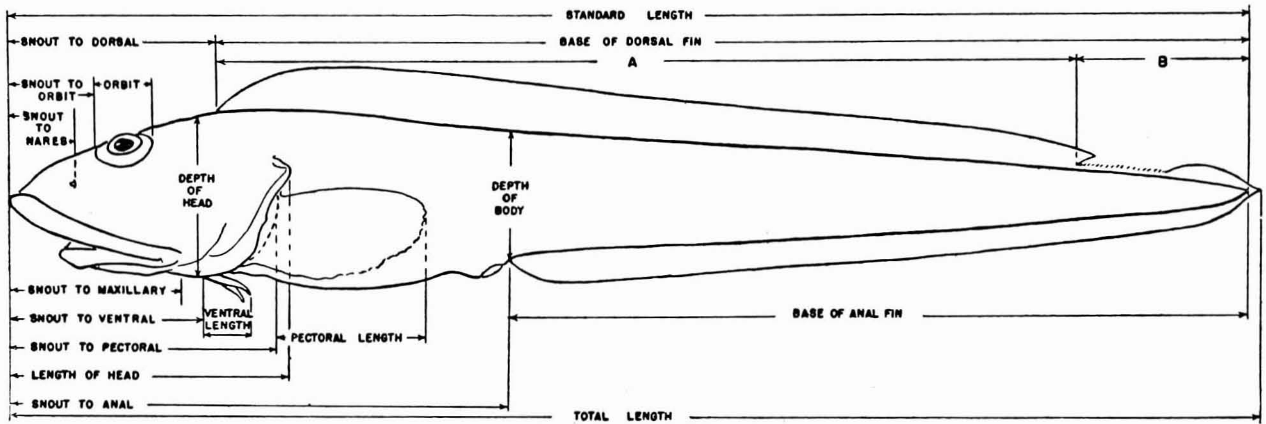

Figure 5. Illustration showing the extent and position of measurements made on the ocean pout. Specimens below 26 cm. in length were measured with dividers on a direct line (*e.g.*, head measurements taken from tip of upper lip to opercular flap—not between the verticals from these points). Above 26 cm. all measurements were made with dividers except for the following measurements taken on the measuring board: T. L., S. L., base of dorsal fin, base of anal fin and snout to anal. Except for the three smallest specimens, the following head measurements were made with skin removed from eye region and posterior part of maxillary: interorbital width, eye, snout to orbit and snout to maxillary.

Following Bloch and Schneider's binomial account,[1] the ocean pout was clearly described by Peck (1804: 52, pl. 2, fig. 3) as *Blennius anguillaris;* this specific name has been most commonly used. Mitchill (1815: 374, 375) gave two descriptions, *B. ciliatus* and *B. labrosus,* and Cuvier (1829: 240) included Mitchill's *labrosus* in his newly-created genus *Zoarces.* Cuvier and Valenciennes (1836: 468, 471) gave Mitchill's *ciliatus* the new name of *Z. fimbriatus* and at the same time gave Gronovius' polynomial description of 1763 a binomial name, *Z. Gronovii.* Gill (1864) unwisely proposed that the American species be named *M. labrosus.* Jordan (1919: 325) designated *Blennius anguillaris* Peck, 1804 as the type for the genus *Macrozoarces* Gill, 1864.

Study material. Sixty-one females, 7.2 to 86 cm., and 61 males, 15.9 to 93 cm., from northern Cape Cod and southern New England.

Range. Western North Atlantic, from Straits of Belle Isle and Gulf of St. Lawrence to Delaware; possibly, but unlikely, to North Carolina.

Distinctive characters. The heavy head, the tapering elongate body, the pointed tail, the continuous dorsal, anal and caudal fins, the spinous portion near the tail in the predominantly soft dorsal fin, the heavy thick lips, and the eyes high on the head serve to distinguish this species from other western Atlantic fishes. It is easily distinguished from the true eels by the heavy head and the presence of small jugular

[1] A description by Gronovius (1763, no. 266: 77, "Enchelyopus subfuscus unicolor: pinna dorsi ad caudam integerrima . . . Habitat in Mari Americano") has been considered as applicable to the American ocean pout by some earlier workers. Also, Walbaum (1792: 185, 186) gave a description which has been included in the accounts of the American ocean pout ("Blennius, *unicolor,* pinna dorsi, ani, caudaeque unitis. W.").

According to Article 25 of the International Rules of Zoological Nomenclature (Schenk and McMasters, 1936: 32) "The valid name of a genus or species can be only that name under which it was first designated on the condition: a) . . . . b) That the author has applied the principles of binary nomenclature." Therefore, the names of Gronovius and Walbaum, since they are not binary or binomial, have no priority over Bloch and Schneider, 1801. Referring in particular to Gronow, 1763, Opinion 89 stated, "Under suspension of the rules, in any case where such suspension may be considered necessary according to the interpretation now or hereafter adopted by the Commission, the following works or papers are declared eliminated from consideration as respects their systematic names as of their respective dates: Gronow, 1763; . . . ."

ventral fins; from the blennies in that it has soft rays in the dorsal fin except for a small spinous portion posteriorly; from wrymouths by the ventral fins as well as the predominantly soft rays of the dorsal; from the wolffish by a more slender body, ventral fins, smaller teeth and pointed tail; from *Lycenchelys verrillii*, *Lycodes reticulatus* and *Lepophidium cervinum* by the posterior spinous portion of the dorsal fin. Comparing specimens of approximately the same size, it is separable from the *Zoarces viviparus* (Linnaeus)[1] of Europe by the slightly shorter head, the somewhat less heavy and more elongate body, the double rows of teeth in the front of both jaws (single in *viviparus*), greater number of vertebrae, the longer spinous portion of dorsal, and a dark spot about the size of the eye on the anterior part of the dorsal fin.

Description. Specimens 30 to 94 cm. long (see p. 55 for description and measurements of specimens 7.4 to 29.5 cm.). BODY elongate and somewhat ensiform, tapering posteriorly from the broad, heavy head to a pointed tail; slightly compressed, more so posteriorly; dorsal and ventral profiles uniform and smooth; abdominal region tumid, very soft in fresh specimens, slightly shorter than head, about 14.8 to 20.4% (difference between measurements of head-length and snout-to-anus; Fig. 5); depth of body immediately posterior to anus, 8.9 to 12.9%.

Entire fish smooth. SKIN very tenacious and strong, covered with numerous small, white, cup-like depressions irregularly spaced. SCALES small, ovoid, separate, imbedded. LATERAL LINE of many small white pores, irregular in both shape and spacing, more distinct in preserved than in fresh specimens; commences above and anterior to posterior angle of operculum, proceeds for a short distance on a more or less straight line posteriorly, arches downward abruptly, levels off and continues on straight line to caudal; about 160 pores to point just anterior to spinous portion of dorsal. ANUS (with small urino-genital aperture on posterior margin) large, situated immediately anterior to anal fin. PORES visible on snout anterior, posterior and ventral to nares, below and posterior to eyes, on opercle and preopercle, on top of head anterior to dorsal and along body above lateral line to mid-body at least.

HEAD broader and heavier than body, length 15.6 to 24.6% in standard length, increasing in relative length with age, more so in males than in females (Table IV A and B, Fig. 6); depth 9.0 to 12.9%, in-

[1] We wish to express our appreciation to Leonard P. Schultz of the U. S. National Museum for the loan of a number of specimens.

creasing in relative depth with age; broad postero-ventrally, diminishing in width dorsally and anteriorly; dorsal profile somewhat angular (less so in older specimens), sloping gently from beginning of dorsal to point above eyes, then declining more abruptly to tip of snout; lower profile gently convex. SNOUT semi-blunt, with very fleshy appearance; tip of snout to anterior part of orbit (skin removed) 4.3 to 8.6%. NARES single, tubular, the posterior part longer than that anterior, located on line between lower eye and tip of snout, slightly nearer eye than snout; tip of snout to anterior part of nares, 2.9 to 6.4%. MOUTH large and almost horizontal. UPPER JAW strong, much longer than lower jaw, sloping downward at anterior end; tip of snout to posterior end of maxillary (skin removed) 7.9 to 16.8%. Maxillary extends posteriorly behind orbit in older specimens. LOWER JAW shorter, included in upper and sloping ventrally in anterior portion. LIPS heavy, fleshy and thick, the upper fleshier and heavier than lower, and protruding beyond the lower so that anterior part of lower lip generally coincides with inner posterior part of upper lip; upper lip heavier anteriorly than on sides; lower lip heavier on sides than anteriorly; both lips protrude well beyond skeletal structures. TONGUE sizeable, broad and fleshy, smooth. CHEEKS muscular and convex. EYES high on head, more oval than round, relatively small, approximate in smaller specimens, but less so in larger ones; horizontal diameter of orbit (skin removed) 2.9 to 4.8%. INTERORBITAL SPACE relatively narrow, 0.8 to 1.9% (skin removed). BRANCHIAL MEMBRANE fleshy, continuous and broadly united to isthmus, aperture moderate. BRANCHIOSTEGAL RAYS 6. GILLS 4; rakers on lower arch, commencing at angle, short, blunt and heavy, about as wide as long, each one bearing some small obtusely conical teeth at terminal ends; toward end of arch they diminish in size, the last one or two very small relatively and without terminal teeth; rakers on upper arch more pointed, not so heavy as lower ones, without terminal teeth, each one slightly longer than basal width; upper arch with 4 to 6 rakers, lower arch with 11 to 13.

TEETH obtusely conical in both jaws, but often worn flat anteriorly from grinding food; size range wide, from very small to large, the small ones placed irregularly between older teeth, probably to serve as replacements; most anterior teeth in upper jaw large, but in lower jaw smaller; lateral ones in upper jaw smaller than the lateral ones in the lower; in both jaws teeth are more approximate anteriorly; all slope inwardly except anterior lower teeth. The outer series in upper jaw continuous, extending posteriorly on each side to a point in advance of rear angle of mouth; 12 to 15 on each side; shorter row anteriorly behind longer row; 5 or 6 on each side. In the shorter lower jaw the continuous series consists of 11 or 12 teeth on each side; but unlike those of the upper jaw, the second row in front is anterior to the continuous series, with 5 or 6 on each side. The above pattern persists for the most part with minor variations in those specimens we have examined. No teeth on palate. PHARYNGEAL TEETH in upper throat stout, conical, some worn at end; all 3 series on each side curved rearward; most anterior single series with 9 teeth on a side, these diminishing in size toward outer extremities; second series double, longer, with about 8 teeth in front row and about 5 in rear row, the smaller ones at outer extremities as in first series; third series double also, about half as long as second series, the teeth in both rows small, about same size and smaller than those at outer extremities of other two series, 9 in front row and 6 in rear row. In lower throat double rows on each side, with from none to as many as 5 scattered teeth between the rows; teeth conical, and those in each row slightly curved toward the other row; teeth in innermost row generally about twice as large or larger than those in outermost row; 9 or 10 in inner row, about 9 to 12 in outer row.

FINS. Dorsal, anal and caudal confluent, enveloped in thick fleshy membrane. DORSAL commences on head and continues uninterrupted to caudal, with a low short spinous portion near posterior end; distance from tip of snout to beginning of dorsal (on a diagonal line) 12.7 to 20%; length along base of dorsal 82.1 to 91.0%;[1] rays generally higher anteriorly than posteriorly; first 2, 3 or 4 close together, those following much wider apart but gradually and uniformly becoming more approximate as vertebrae diminish in size posteriorly; few anterior rays simple, the rest bifurcate, except for short, sharp, posteriorly-curved spines near caudal; number of rays 132 to 147.[2] ANAL fin lower than

[1] Length along base of dorsal from beginning of fin to anterior part of spinous portion 68.6 to 76.2%; from beginning of spinous portion to caudal, 12.1 to 17.6%.

[2] It was impossible to count accurately the most posterior fin rays; therefore seven specimens were examined to determine the inter-relationship of rays to vertebrae. From two to four rays were present anterior to the first vertebra, after which there was one ray for each vertebra, with the exception of the penultimate, which supports no dorsal ray. Hence, a relatively accurate ray count may be obtained by merely adding one, two or three to the total vertebral counts. Since these range from 131

dorsal, commencing directly posterior to anus and continuing uninterrupted to caudal; snout to beginning of anal 30.9 to 40.7%; base of fin 59.4 to 68.7%; rays higher anteriorly than posteriorly; spacing attendant upon the diminishing size of vertebrae posteriorly; first two rays simple, the remainder bifurcate; estimated counts 109 to 124;[1] anal fin decreasing relatively in length with age concomitant to diminishing length of body and posterior part of dorsal. CAUDAL fin very small, pointed and continuous with posterior of dorsal and anal fins; 12 bifurcate rays, 3 of which emanate from the penultimate vertebra ventrally (Fig. 15, and description p. 62). PECTORAL fins large, broad, rounded and very fleshy, scalloped at extremities, the base under or immediately behind posterior edge of operculum, or both; snout to upper pectoral base 15.7 to 24.2%; fin length 8.9 to 13.5%; rays branched, 18 to 21, but most specimens with 19. VENTRALS short, small, jugular, situated anterior to vertical line from anteriormost dorsal ray; snout to ventral base 11.5 to 19.8%; fin length 2.6 to 4.2%; three rays, multifurcate, enveloped in fleshy sheath, unequal in length.

Color of Fresh Specimens. General overall color muddy yellow, with mottlings of darker gray or olive-green; top of head darker than body, grading to lighter hues on cheeks, which are variously mottled; white or light lavender, or both, below; lips dirty yellow; inside of mouth a light beige. Body colors range from white or pale lavender below in abdominal region through yellow or dirty salmon tints to olive-green dorsally, with darker patches along back extending onto dorsal fin; the white or lavender of abdomen also extends along either side of base of anal fin about 2/3 its length; edge of anal fin lemon yellow or sometimes a muddy pink; dorsal fin generally darker than anal, edged with yellow, changing to darker olive-green at base; pectorals generally red or orange, varying from olive-green at base to yellow-orange or reddish in marginal areas; ventrals yellow or pink. Pupil deep blue; iris orange flecked with brown.

Bigelow and Welsh (1925) stated:

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to 144, the dorsal count would be 132 to 147. In the seven specimens observed the number of rays anterior to the spinous portion ranged from 91 to 93, the spines from XVII to XXI.

[1] As in the case of the dorsal, the anal ray counts are estimated from the vertebral counts. There is one ray for each vertebra beginning with the 21st to 23rd vertebra; no ray is supported by the antepenultimate vertebra. Therefore, with vertebral counts of 131 to 144, these, less 20, 21 or 22, give ray counts of 109 to 124.

Although this fish has usually been described as reddish brown mottled with olive, or as salmon colored, most of those we have seen caught—a fair number—have been of some shade of muddy yellow, paler or darker, some with brownish, some with salmon, and some with orange tinge, while a few have been pure olive green; and since fishermen usually describe them as 'yellow', this is evidently the prevailing hue in the offshore parts of the Gulf. Other eelpouts that we have caught inshore along the coast of Maine, however, have shown yellow only on the margins of the fins, particularly the lower edge of the pectorals, the general ground tint of sides and back ranging from pale gray, sometimes with purplish tinge, to dull brown or dark dusky olive below as well as above.

The younger fish (7.4 to 29.5 cm.). By comparison with specimens over 30 cm. the younger ones are more elongate and slender; the head is shorter and noticeably less heavy (length 15.3 to 18.1%; depth 8.9 to 10.9%), the abdominal region is approximately the same but less tumid (length 14.1 to 19.6%) and the body length is proportionately greater but not so deep (depth posterior to anus, 8.7 to 10.8%). The snout is blunter, the lips not nearly so fleshy, the gill rakers very short, blunt and stubby, the teeth sharper and not worn as in older fish. The following measurements are relatively less than those of the older fish: tip of snout to anterior part of orbit 2.9 to 4.9%; snout to anterior part of nares 2.8 to 3.7%; snout to posterior end of maxillary 5.7 to 9.4%; interorbital space 0.24 to 1.06%; snout to beginning of dorsal fin 12.9 to 15.8%; snout to beginning of anal fin 30.8 to 37.2%; snout to upper base of pectoral 15.3 to 18.5%; snout to base of ventrals 11.9 to 15.9%. The following measurements are relatively greater: horizontal diameter of orbit 3.4 to 4.9%; base of dorsal fin 87.0 to 92.9%; base of anal fin 67.0 to 70.4%; length of ventrals 3.8 to 5.8%. The pectoral length is relatively the same, 9.9 to 13.2%.

Color of young ocean pout. We have seen no fresh specimens, but presumably the color pattern is somewhat similar to that of the older fish. In the preserved state (formalin 10%) they have a mottled appearance of light and dark brown on sides and back, with the suggestion of yellow-green on the dorsal fin, which also bears irregular blotches; a dark streak extends across the cheek from eye to posteroventral edge of operculum; the anal is light in color, with a suggestion of yellow; belly, ventrals, pectorals and ventral part of head also light.

Perhaps one of the most distinctive characters of the young is a dark spot on the anterior part of the dorsal fin. This was first observed by

Goode and Bean (1880), who noted its size as being about equal to the diameter of the eye. They also stated that it disappears with age, before or after the fish has attained a length of nine inches, and that there is no trace of this in young *Z. viviparus*. In our specimens we have observed that this spot, although less prominent, was present in specimens up to 30 cm. (12 in.) at least.

Heterauxesis. Table IV and Fig. 6 show that there is a proportionately greater growth of the head with age (tachyauxesis) and a proportionately diminishing growth with age in the body region posterior to the anus (bradyauxesis), while in the abdominal region there appears to be no relative change with age (isauxesis). Furthermore, the heterauxesis is probably more pronounced in males than in females, although more data is necessary to show this point conclusively. Fig. 6 shows the plottings of the lengths of the head, trunk and anal fin base (equal to the body length posterior to the anus) expressed in per cent of the standard length. In *A* the points are widely scattered, indicating isauxesis in the belly region; the measurements on which these percentages are based were obtained by deducting the head-length from the snout-to-anal-fin measurement. *B* shows tachyauxesis in the head region; although the points are scattered, a distinct trend is apparent. In *C* a similar trend is seen for the body region, but in this case the lengths diminish as the fish grows older (Needham 1942, Thompson 1942).

Osteology. Gregory (1933: 375) described the skull of *M. americanus* as follows:

> Even in the highly specialized *Zoarces anguillaris* (Figure 253) the skull retains most of the familiar landmarks. Apparently this is a predacious, eel-like form with narrow skull and fairly large biting teeth in the front of the jaws. The hyomandibular is much enlarged and forms a firm pivot for the jaws. The preopercular is closely appressed to the hyomandibular and the back of the quadrate. The upper part of the small triangular opercular is sharply truncated, perhaps to make room for muscles running obliquely above it.
>
> In the top view of the skull (Figure 254) we note the relative length and narrowness of the braincase, the large orbits and much constricted interorbital bridge, the relatively heavy muzzle formed by the stout prefrontals (parethmoids) and elongate mesethmoid, which widens in front, bearing a socket for the relatively strong ascending processes of the premaxillae.

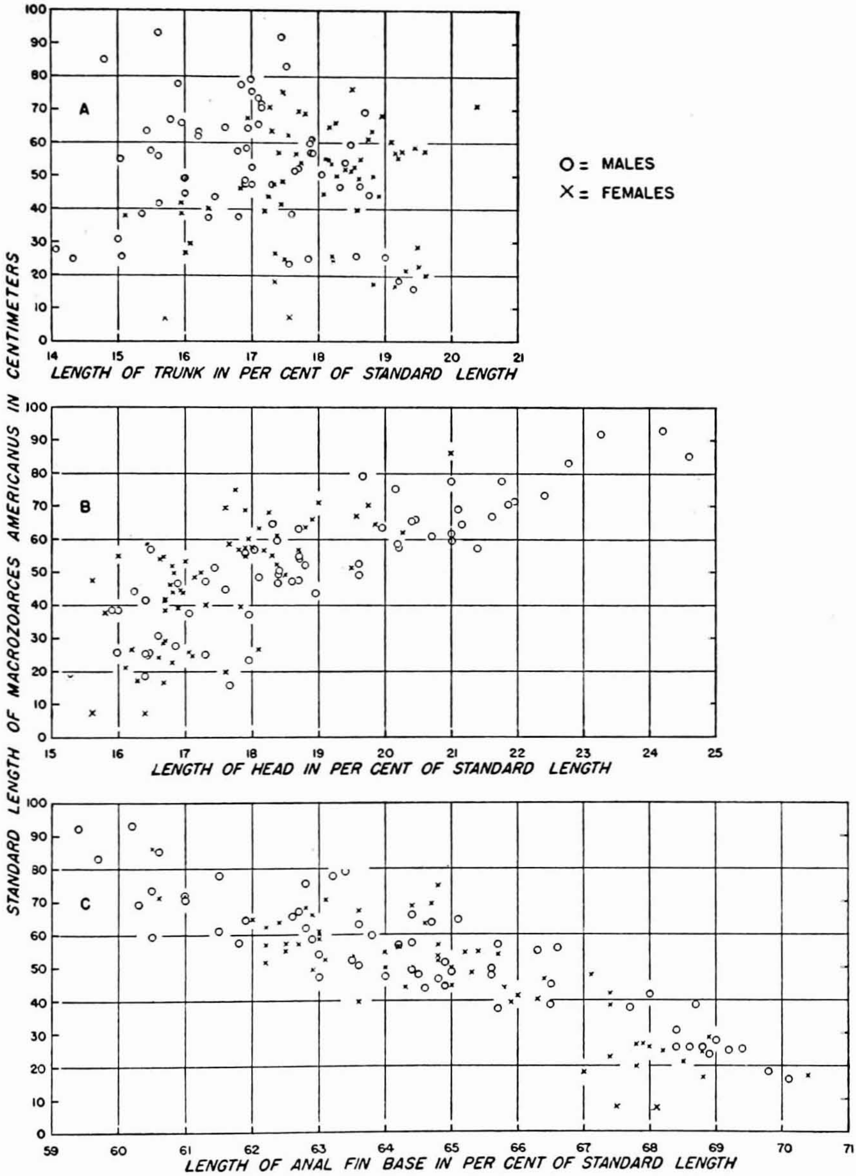

Figure 6. Heterauxesis in the ocean pout demonstrated by plotting the lengths of trunk (A), head (B) and anal fin-base or body (C) in per cent of the standard length (abscissae) against the standard length of the fish (ordinates) for both males and females.

TABLE IVA. MEASUREMENTS OF FEMALE OCEAN POUT IN PER CENT OF THE STANDARD LENGTH

Total Length (cm)	Standard Length (cm)	Total Weight (gm)	Head Measurements: Length	Depth	Inter-orbital	Orbit	Snout to Orbit	Snout to Maxillary	Snout to Nares	Snout to Dorsal	Snout to Ventral	Body Measurements: Depth	(Base of Dorsal Fin) A	B	A & B	Base of Anal	Length of Ventral	Length of Pectoral	Snout to Anal	Snout to Pectoral	Trunk
7.4	7.2	. . .	16.4	9.6	0.42	4.0	2.9	6.3	. .	13.8	12.4	8.8	67.2	20.1	87.3	68.1	5.8	13.2	32.1	16.7	15.7
7.8	7.7	. . .	15.6	9.4	0.39	4.9	2.9	5.7	. .	13.3	13.8	. . .	. . .	. . .	87.0	67.5	5.2	11.9	33.2	16.5	17.6
16.6	16.5	25	16.7	9.6	0.24	3.6	4.3	7.9	3.3	14.1	12.6	9.6	74.9	17.6	92.5	68.8	4.4	11.6	35.8	15.3	19.1
17.3	17.2	26	16.3	9.9	0.41	3.7	3.8	7.0	3.5	13.8	12.3	10.0	74.3	18.6	92.9	70.4	4.5	12.3	35.1	16.3	18.8
18.3	18.1	. . .	15.3	10.5	0.72	3.9	4.2	6.7	2.8	14.3	12.2	10.8	69.2	18.1	87.3	67.0	3.8	10.8	32.6	15.3	17.3
20.0	19.9	36	17.6	10.1	0.50	4.5	4.8	8.0	3.4	15.1	14.2	9.5	71.3	17.1	88.4	67.8	. .	11.3	37.2	17.9	19.6
21.3	21.2	44	16.1	9.2	0.52	4.2	4.2	7.6	2.8	13.3	13.0	8.9	72.7	18.4	91.1	68.5	4.3	. . .	35.4	16.1	19.3
22.7	22.6	63	16.8	9.7	0.80	4.2	4.0	8.3	. .	15.4	14.8	10.0	73.9	16.8	90.7	67.4	4.9	11.5	36.3	17.3	19.5
24.2	24.1	70	16.6	9.8	0.75	3.9	4.4	8.3	3.4	13.8	13.8	9.1	72.2	17.6	89.8	68.8	4.6	11.2	34.8	17.3	18.2
24.7	24.6	72	17.1	10.0	0.81	3.9	4.3	7.9	. .	14.2	14.4	9.8	73.5	17.3	90.8	68.2	4.5	10.6	34.6	17.5	17.5
25.9	25.8	83	17.1	9.7	0.85	3.9	4.6	8.1	3.4	14.3	12.5	10.1	73.6	17.8	91.4	68.0	4.3	9.9	35.3	16.5	18.2
26.6	26.4	80	16.2	9.1	0.83	3.8	4.5	7.5	. .	12.9	12.5	9.8	74.3	17.1	91.4	67.8	3.9	10.3	32.2	16.9	16.0
26.7	26.5	102	18.1	10.6	1.06	4.3	5.1	9.4	3.7	15.8	13.6	10.2	75.8	14.7	90.5	67.9	4.5	10.9	35.5	18.5	17.4
28.7	28.5	120	16.7	10.2	0.77	3.5	4.2	8.2	. .	13.8	13.3	10.2	75.0	16.1	91.1	68.9	4.3	11.7	36.2	16.9	19.5
29.5	29.3	104	16.7	8.9	0.85	3.4	4.9	7.9	. .	14.0	12.7	8.8	74.5	16.0	90.5	. . .	4.1	10.0	32.8	16.5	16.1
38.3	37.9	218	15.8	9.5	0.85	3.2	4.7	7.9	. .	12.7	13.3	9.3	75.2	15.6	90.8	. . .	3.6	10.2	30.9	16.7	15.1
38.6	38.3	317	16.7	9.9	1.31	3.5	5.2	8.1	3.5	14.1	13.1	11.7	75.2	14.9	90.1	67.4	. .	10.6	32.7	16.5	16.0
39.7	39.3	343	16.9	9.4	1.07	3.4	4.9	9.0	2.9	14.0	14.2	11.2	73.8	15.8	89.6	65.9	4.1	11.4	34.1	17.2	17.2
40.2	39.8	360	17.8	11.3	1.06	3.4	4.5	8.6	2.9	13.8	13.9	11.3	73.6	15.8	89.4	63.6	3.8	11.3	36.4	17.8	18.6
40.5	40.1	325	17.3	9.8	1.24	3.3	4.7	. . .	3.1	14.2	13.7	10.7	74.8	15.2	90.0	66.3	4.0	12.0	33.7	17.4	16.4
41.8	41.4	387	16.7	10.6	1.18	3.4	5.0	8.8	3.3	14.3	11.8	11.2	74.5	14.7	89.2	66.0	3.4	10.7	34.1	16.7	17.4
42.3	42.0	367	16.7	9.7	1.12	3.4	5.1	8.6	. .	13.5	12.4	10.5	73.8	14.5	88.3	67.4	3.7	10.9	32.6	16.6	15.9
44.3	43.9	444	17.0	10.2	1.14	3.2	5.3	8.4	3.5	14.8	12.8	10.9	75.2	13.7	88.9	65.8	3.4	10.7	34.2	17.1	17.2
44.3	44.0	506	16.8	11.0	1.02	3.2	5.0	8.6	3.4	14.1	13.7	11.8	73.0	16.8	89.8	64.3	3.4	10.6	35.7	17.3	18.9
44.7	44.3	502	16.9	10.4	1.02	3.0	5.0	8.6	3.2	14.1	13.3	11.4	73.3	15.4	88.7	65.0	3.4	9.9	35.0	17.4	18.1
46.4	46.2	590	16.8	10.1	1.04	3.2	5.0	8.6	. .	14.1	13.5	11.9	74.0	15.6	89.6	66.4	3.3	11.9	33.6	15.9	16.8
48.1	47.7	506	15.6	9.4	1.01	3.6	4.7	8.4	. .	13.4	11.6	9.8	75.3	15.1	90.4	67.1	3.7	10.0	33.0	15.7	17.3
48.7	48.2	666	17.1	10.0	1.24	3.1	5.4	9.0	3.4	14.3	13.5	11.1	73.6	15.3	88.9	65.3	3.5	10.4	34.6	17.2	17.5
49.7	49.3	746	18.5	11.2	1.20	3.6	5.9	9.9	4.3	14.5	15.0	11.2	74.0	15.2	89.2	62.9	3.6	12.5	37.1	18.7	18.6
50.3	49.9	720	17.2	9.7	1.00	3.1	5.2	9.3	3.3	14.4	13.4	11.4	74.6	14.8	89.4	64.0	4.0	11.2	36.1	16.9	18.8
50.3	49.9	785	16.8	10.7	1.24	3.0	5.0	8.3	3.5	13.5	13.6	11.2	74.2	14.8	89.0	65.0	3.6	11.2	35.1	16.6	18.3
51.9	51.4	870	19.5	11.7	0.99	3.6	5.7	10.3	3.3	15.6	13.0	10.9	74.5	13.8	88.3	62.2	3.7	11.9	38.0	18.3	18.5
52.5	52.0	785	16.8	10.6	1.21	3.2	5.2	8.9	3.7	14.3	13.5	10.6	73.0	15.6	88.6	64.8	3.3	10.6	35.2	16.9	18.4

TABLE IVA (cont.). MEASUREMENTS OF FEMALE OCEAN POUT IN PER CENT OF THE STANDARD LENGTH

Total Length (cm)	Standard Length (cm)	Total Weight (gm)	Head Measurements: Length	Depth	Inter-orbital	Orbit	Snout to Orbit	Snout to Maxillary	Snout to Nares	Snout to Dorsal	Snout to Ventral	Body Measurements: Depth	(Base of Dorsal Fin) A	B	A & B	Base of Anal	Length of Ventral	Length of Pectoral	Snout to Anal	Snout to Pectoral	Trunk
52.7	52.3	998	18.4	11.0	1.24	3.6	5.7	10.4	..	15.9	14.2	11.5	73.3	14.3	87.6	63.1	2.9	10.0	36.9	18.4	18.5
54.0	53.5	814	17.0	10.8	1.20	2.9	5.2	9.3	3.9	14.8	12.1	10.5	72.5	15.7	88.2	64.8	3.4	10.0	35.2	16.7	18.2
54.3	53.9	1043	16.6	11.3	1.10	3.0	5.4	8.5	..	13.8	12.4	11.5	75.8	14.1	89.9	65.7	3.3	10.4	34.4	16.7	17.7
55.0	54.6	918	16.7	10.1	1.13	2.9	5.1	9.3	..	14.2	11.5	11.0	74.4	14.5	88.9	65.2	3.1	10.4	34.8	16.5	18.1
55.1	54.7	1007	17.9	10.1	1.04	3.0	5.6	9.4	..	14.1	14.0	12.0	75.9	13.2	89.1	64.0	3.7	10.9	36.0	17.6	18.1
55.2	54.9	1012	16.0	10.6	0.97	3.0	4.7	8.4	..	13.3	...	12.4	75.6	14.7	90.3	65.4	..	...	34.6	...	18.6
55.5	55.2	1089	18.3	11.1	1.09	3.2	5.7	10.0	..	15.3	14.5	12.0	72.4	15.2	87.6	62.5	3.8	11.1	37.5	18.4	19.2
56.8	56.4	1066	18.2	11.1	1.67	3.3	5.3	9.8	..	13.9	14.8	11.4	75.0	14.5	89.5	64.2	3.2	11.6	35.9	17.8	17.7
57.2	56.8	1093	17.8	11.4	1.06	3.3	5.6	9.5	..	14.6	13.7	11.9	72.6	15.1	87.7	64.8	3.9	11.6	35.2	17.8	17.4
57.2	56.8	1034	18.7	11.4	1.23	3.7	5.8	10.6	4.2	15.2	14.4	10.6	73.0	14.6	87.6	62.2	3.5	11.1	37.9	17.9	19.2
57.6	57.2	1275	18.0	10.5	1.05	3.2	5.6	10.0	..	14.3	14.5	12.3	74.6	14.0	88.6	62.7	2.6	10.7	37.3	18.2	19.3
57.8	57.3	868	17.9	10.2	1.17	3.4	5.6	9.6	4.0	15.0	14.0	9.4	72.7	15.4	88.1	62.5	2.9	10.3	37.5	18.3	19.6
59.0	58.6	1302	17.7	10.7	1.20	3.1	5.1	9.7	3.2	14.0	14.2	12.1	73.5	14.7	88.2	63.0	3.1	...	37.1	16.9	19.5
60.7	60.2	998	17.9	10.1	1.00	3.2	5.8	10.1	4.2	14.8	14.5	10.3	73.5	14.8	88.3	63.0	3.5	8.9	37.0	18.0	19.1
61.4	61.0	1270	18.4	10.8	1.15	3.2	5.5	10.5	3.5	15.1	13.9	10.8	76.2	14.8	91.0	63.0	3.7	11.5	37.1	18.2	18.7
62.7	62.2	1769	20.3	11.4	1.09	3.5	6.6	11.6	..	16.5	14.4	12.9	72.8	14.3	87.1	62.2	3.5	11.9	37.8	19.0	17.6
64.0	63.6	1438	18.1	11.0	1.18	3.3	5.3	10.2	..	14.1	13.7	11.0	75.4	13.7	89.1	64.6	3.5	10.7	35.4	17.4	17.3
64.2	63.8	1542	18.8	11.4	1.22	3.3	6.4	11.1	3.8	15.5	14.2	11.7	72.9	15.4	88.3	62.4	3.4	11.3	37.6	18.1	18.8
64.9	64.5	1778	19.9	12.4	1.24	3.9	5.5	11.6	..	15.2	14.4	11.5	73.6	13.8	87.4	62.0	3.4	11.2	38.0	18.9	18.2
66.5	66.0	1270	18.9	10.7	1.44	3.1	6.0	10.4	3.9	15.5	13.3	12.3	73.1	14.1	87.2	62.9	3.3	10.5	37.2	18.5	18.3
67.6	67.2	1769	19.6	11.6	1.49	3.8	6.6	11.5	..	15.6	14.4	10.7	74.1	13.8	87.9	63.6	3.4	12.0	36.5	18.3	16.9
68.5	68.1	2046	18.3	11.2	0.90	3.7	5.1	10.4	..	14.1	13.9	11.6	74.5	14.1	88.6	62.8	3.4	10.7	37.2	17.5	18.9
69.0	68.7	1805	17.9	10.8	1.19	3.2	5.9	9.7	..	14.6	14.8	11.2	75.0	12.1	87.1	64.4	3.4	10.9	35.7	18.9	17.8
69.8	69.5	1805	17.6	10.9	1.18	3.2	5.5	9.6	..	14.5	13.1	10.6	73.4	15.0	88.4	64.7	3.4	10.8	35.3	17.2	17.7
70.8	70.4	1896	19.8	10.4	1.31	3.6	6.5	11.5	..	15.6	14.8	10.4	74.8	13.1	87.9	63.1	3.2	10.9	37.0	19.8	17.3
71.7	71.1	2381	19.0	11.3	1.28	3.4	6.1	10.4	..	15.2	15.0	11.7	72.4	14.2	86.6	60.6	3.7	11.0	39.4	18.6	20.4
75.7	75.2	2508	17.8	10.0	1.17	3.2	5.3	9.4	..	14.1	14.2	10.9	73.0	15.0	88.0	64.8	3.1	9.8	35.2	17.4	17.5
86.9	86.2	4137	21.0	10.2	1.34	3.7	6.9	12.9	4.8	16.3	16.2	11.0	73.4	13.2	86.6	60.5	2.8	...	39.5	20.8	18.5
7.4 to 86.9	*7.2 to 86.2*	*25 to 4137*	*15.3 to 21.0*	*9.1 to 12.4*	*0.24 to 1.49*	*2.9 to 4.9*	*2.9 to 6.9*	*5.7 to 12.9*	*2.8 to 4.8*	*12.7 to 16.5*	*11.5 to 16.2*	*8.8 to 12.9*	*67.2 to 76.2*	*12.1 to 20.1*	*86.6 to 92.9*	*60.5 to 70.4*	*2.6 to 5.8*	*8.9 to 13.2*	*30.9 to 39.5*	*15.3 to 20.8*	*15.1 to 20.4*

Table IVB. Measurements of Male Ocean Pout in per cent of the Standard Length

Total Length (cm)	Standard Length (cm)	Total Weight (gm)	*Head Measurements* Length	Depth	Inter-orbital	Orbit	Snout to Orbit	Snout to Maxillary	Snout to Nares	Snout to Dorsal	Snout to Ventral	*Body Measurements* Depth	(Base of Dorsal Fin) A	B	A & B	Base of Anal	Length of Ventral	Length of Pectoral	Snout to Anal	Snout to Pectoral	Trunk
16.0	15.9	20	17.7	10.3	0.31	4.7	4.5	7.9	3.6	14.5	14.5	9.4	72.9	17.6	90.5	70.1	4.5	10.7	37.1	17.6	19.4
18.4	18.3	29	16.4	9.9	0.44	4.1	4.5	7.7	3.3	14.2	12.4	9.3	71.5	19.2	90.7	69.8	4.4	...	35.6	16.4	19.2
23.6	23.4	67	18.0	10.9	0.77	3.9	4.8	8.6	3.3	14.3	15.9	10.3	72.8	17.2	90.0	68.9	4.4	11.5	35.5	18.5	17.6
24.8	24.7	61	16.4	9.3	0.73	3.6	4.5	8.0	..	14.0	12.9	8.9	74.0	15.8	89.8	69.2	4.8	10.5	30.8	16.8	14.3
25.3	25.1	75	17.3	10.4	0.60	3.8	4.9	8.8	..	14.7	15.6	9.2	73.6	18.3	91.9	69.4	4.0	10.9	35.2	18.2	17.9
25.6	25.4	71	16.4	9.8	0.71	3.9	4.3	8.0	3.6	13.8	15.0	9.4	73.8	18.0	91.8	68.8	4.3	10.6	35.4	17.7	19.0
25.9	25.7	68	16.5	9.7	0.78	3.5	4.6	8.1	..	14.0	12.8	8.7	73.8	17.1	90.9	68.4	4.1	10.9	31.5	16.3	15.0
25.9	25.8	80	16.0	9.5	0.85	3.9	4.2	7.6	3.5	13.0	11.9	9.7	74.4	16.2	90.6	68.6	4.0	10.0	34.6	15.9	18 6
27.9	27.8	99	16.9	9.1	0.79	3.8	4.7	7.9	..	13.4	13.4	10.1	74.8	16.2	91.0	69.0	4.3	10.4	30.9	16.9	14.1
30.9	30.7	127	16.6	9.3	1.14	3.6	4.8	8.0	..	13.1	12.7	9.2	73.3	17.6	90.9	68.4	4.2	10.6	31.6	16.6	15.0
37.7	37.3	232	18.0	10.2	1.29	3.7	5.4	9.6	3.5	15.0	15.0	9.5	73.2	16.1	89.3	65.7	3.9	10.5	34.3	18.3	16.4
38.1	37.8	244	17.1	9.9	1.06	3.6	4.5	9.1	..	13.5	13.0	9.4	74.5	14.8	89.3	67.7	3.7	11.8	33.9	16.7	16.8
38.6	38.3	228	16.0	9.2	0.78	3.6	5.0	8.4	..	13.1	13.2	8.9	74.4	15.7	90.1	68.7	3.4	9.8	31.4	15.7	15.4
38.7	38.5	255	15.9	10.2	0.96	3.4	4.3	8.1	3.4	13.2	12.3	9.7	74.4	16.1	90.5	66.5	3.9	9.6	33.5	16.2	17.6
41.7	41.5	298	16.4	9.5	1.08	3.4	4.9	8.6	..	13.0	12.3	9.9	74.7	16.2	90.9	68.0	3.4	10.1	32.0	16.6	15.6
44.1	43.8	504	19.0	10.5	1.14	3.6	5.7	11.4	..	15.4	15.1	11.6	71.9	15.8	87.7	64.6	3.5	10.5	35.4	18.6	16.5
44.5	44.2	388	16.2	9.1	1.08	3.4	5.4	9.4	3.6	14.7	14.6	10.2	73.0	15.4	88.4	64.9	3.2	10.8	35.0	17.5	18.8
45.0	44.7	529	17.6	10.7	1.16	3.2	5.4	9.4	3.8	14.3	13.3	11.6	74.0	15.7	89.7	66.5	3.6	10.1	33.6	16.5	16.0
46.7	46.3	548	16.9	9.9	1.08	3.3	5.2	9.1	3.7	13.8	13.8	11.0	73.8	15.3	89.1	64.8	3.0	10.8	35.2	17.3	18.3
47.1	46.8	614	18.4	10.7	1.18	3.4	5.8	10.5	3.8	15.6	15.4	11.4	72.6	15.4	88.0	63.0	3.3	10.3	37.0	18.7	18.6
47.6	47.3	627	18.6	10.9	1.44	3.5	5.5	10.1	3.9	14.6	14.5	10.6	74.2	15.0	89.2	64.0	3.8	11.0	35.9	18.2	17.3
47.8	47.5	506	17.3	10.1	1.05	3.6	5.7	9.5	..	14.4	13.9	9.3	...	15.2	....	65.6	3.4	10.8	34.3	17.5	17.0
48.1	47.8	591	18.7	10.3	1.21	3.5	6.5	10.8	4.2	16.3	14.7	10.8	73.2	14.9	88.1	64.5	3.4	10.5	35.6	18.6	16.9
48.9	48.6	700	18.1	10.7	1.09	3.3	5.6	10.3	4.0	14.9	13.6	11.5	74.0	15.0	89.0	65.0	3.8	10.9	35.0	16.9	16.9
49.7	49.2	876	19.6	11.3	1.28	3.6	6.0	12.2	..	15.6	15.3	12.6	75.2	13.2	88.4	64.4	3.9	11.8	35.6	18.4	16.0
49.9	49.5	656	18.4	9.7	1.33	3.2	5.9	10.5	..	14.9	13.7	10.1	72.0	16.2	88.2	65.6	3.2	9.7	34.4	18.0	16.0
50.9	50.5	717	18.4	11.4	1.48	3.2	6.0	9.7	4.0	15.1	14.4	10.6	74.2	13.5	87.7	63.6	3.3	10.8	36.5	18.0	18.1
52.0	51.6	668	17.4	9.9	1.16	3.1	5.5	10.1	3.9	14.4	14.2	9.9	72.7	15.7	88.4	64.9	3.1	10.3	35.1	17.8	17.7
52.5	52.1	819	18.8	10.9	1.29	3.3	6.5	10.9	4.2	15.5	14.5	11.9	71.0	16.3	87.3	63.5	3.5	10.6	36.5	18.8	17.7
53.1	52.5	776	19.6	11.4	1.52	3.5	6.6	12.0	4.4	16.4	15.4	10.9	71.6	15.6	87.2	63.5	3.3	10.7	36.6	19.5	17.0
54.3	54.0	1025	18.7	10.5	1.39	3.2	6.2	11.5	..	15.6	14.8	11.7	73.7	13.9	87.6	63.0	3.3	10.7	37.1	18.9	18.4
55.3	54.9	1021	18.7	11.8	1.48	3.3	6.3	10.6	3.9	16.1	14.6	11.4	72.9	14.9	87.8	66.3	3.6	12.0	33.7	18.5	15.0
56.3	55.9	1075	17.9	10.3	1.07	3.1	6.1	10.2	..	15.1	12.4	...	71.8	...	....	66.6	3.6	10.3	33.5	17.8	15.6

TABLE IVB (*cont.*). MEASUREMENTS OF MALE OCEAN POUT IN PER CENT OF THE STANDARD LENGTH

Total Length (cm)	Standard Length (cm)	Total Weight (gm)	Head Measurements: Length	Head: Depth	Head: Inter-orbital	Head: Orbit	Head: Snout to Orbit	Head: Snout to Maxillary	Head: Snout to Nares	Head: Snout to Dorsal	Head: Snout to Ventral	Body Measurements: Depth	Body: (Base of Dorsal Fin) A	Body: (Base of Dorsal Fin) B	Body: (Base of Dorsal Fin) A & B	Body: Base of Anal	Body: Length of Ventral	Body: Length of Pectoral	Body: Snout to Anal	Body: Snout to Pectoral	Body: Trunk
57.2	56.8	964	16.5	9.9	1.16	3.4	5.0	9.5	..	13.6	13.9	10.7	74.8	14.1	88.9	65.7	3.0	10.1	34.4	16.2	17.9
57.2	56.9	828	18.0	10.6	1.16	3.3	6.3	10.7	..	15.3	14.8	9.6	73.3	13.9	87.2	64.2	3.9	11.5	35.9	18.6	17.9
57.9	57.5	1111	20.2	11.7	1.48	3.5	6.7	12.0	..	16.4	15.7	11.3	73.7	13.9	87.6	64.4	3.7	11.3	35.7	19.8	15.5
57.9	57.6	1134	21.4	11.5	1.18	4.2	6.8	13.9	..	17.5	17.5	10.4	70.8	14.7	85.5	61.8	..	11.1	38.2	21.4	16.8
58.9	58.5	1196	20.2	11.1	1.01	..	6.6	12.7	..	16.4	14.9	11.2	70.0	14.5	84.5	62.9	3.6	10.9	37.1	20.3	16.9
59.9	59.5	1361	21.0	11.6	1.23	4.0	7.2	13.6	..	17.3	16.7	11.4	70.3	14.8	85.1	60.5	..	11.1	39.5	20.9	18.5
60.2	59.9	1311	18.4	11.3	1.42	3.0	6.1	11.3	4.0	15.4	15.4	12.0	72.6	14.9	87.5	63.8	3.6	11.2	36.3	18.3	17.9
61.3	60.9	1220	20.7	11.2	1.20	3.8	7.2	13.5	5.3	17.1	14.6	10.3	72.2	13.8	86.0	61.5	3.0	9.7	38.6	19.8	17.9
62.3	61.9	1538	21.0	11.9	1.13	3.7	7.4	14.4	..	17.1	17.0	11.9	72.3	14.9	87.2	62.8	3.5	10.3	37.2	20.9	16.2
63.5	63.1	1624	18.7	10.9	1.25	3.7	5.9	11.3	..	15.1	14.4	11.1	73.7	14.4	88.1	63.6	3.4	11.3	34.9	17.8	16.2
64.0	63.7	1383	19.9	11.1	1.33	3.8	6.3	11.5	..	15.8	15.9	10.2	72.4	14.6	87.0	64.7	3.3	11.6	35.4	19.6	15.4
64.8	64.3	1724	21.2	11.8	1.40	3.6	7.3	14.2	..	18.1	17.8	11.5	70.7	14.6	85.3	61.9	3.4	10.2	38.1	20.8	17.0
64.8	64.5	1270	18.3	10.6	1.32	3.4	5.9	10.7	..	15.1	14.3	10.1	72.3	15.4	87.7	65.1	3.3	11.1	34.9	18.7	16.6
65.8	65.4	1778	20.4	11.2	1.22	3.2	6.7	13.0	..	16.1	15.4	12.1	71.9	14.4	86.3	62.6	3.4	10.7	37.5	19.4	17.1
66.5	66.0	1506	20.5	10.6	1.38	3.7	6.2	12.4	..	...	15.4	10.8	72.0	14.2	86.2	64.4	3.6	11.1	36.4	20.2	16.0
67.3	66.9	1805	21.6	11.7	1.42	3.9	7.5	14.6	..	17.1	17.4	11.2	71.4	14.5	85.9	62.7	3.7	11.5	37.4	21.6	15.8
69.6	69.2	2059	21.1	11.7	1.17	4.1	7.2	14.1	..	17.5	16.5	11.0	71.2	14.5	85.7	60.3	3.6	11.6	39.8	20.6	18.7
71.0	70.5	1896	21.9	11.5	1.70	3.7	7.8	14.2	5.6	18.0	16.5	10.4	71.0	14.2	85.2	61.0	3.3	11.0	39.0	21.7	17.2
72.0	71.6	2223	22.0	12.0	1.33	4.1	8.2	15.6	5.5	18.7	18.6	11.7	70.2	14.5	84.7	60.9	3.4	10.3	39.1	23.1	17.2
73.9	73.4	2350	22.4	12.9	1.50	3.9	8.0	15.5	5.7	18.8	17.1	10.1	70.0	14.6	84.6	60.5	3.1	12.4	39.5	21.5	17.1
75.8	75.4	2304	20.2	11.4	1.51	3.8	6.8	13.4	..	16.2	16.8	10.1	72.7	13.3	86.0	62.8	3.5	11.4	37.2	20.1	17.0
78.2	77.8	2536	21.0	11.2	1.54	3.7	7.0	12.4	4.6	16.6	16.6	10.0	71.5	14.3	85.8	63.2	3.3	...	36.9	20.2	15.9
78.2	77.8	2486	21.8	11.7	1.44	3.8	7.6	14.3	4.8	17.4	18.7	10.4	69.8	14.4	84.2	61.5	2.7	9.9	38.6	22.1	16.9
79.6	79.1	2877	19.7	10.6	1.39	3.5	6.7	13.0	..	16.5	15.5	10.6	72.0	14.0	86.0	63.4	3.4	11.6	36.7	19.2	17.0
83.6	83.1	3402	22.8	12.0	1.77	4.2	7.5	16.3	5.2	18.1	19.8	9.9	71.6	12.8	84.4	59.7	3.9	12.4	40.3	23.1	17.5
85.6	85.1	4364	24.6	12.8	1.88	4.8	8.3	16.6	..	19.0	19.5	10.6	70.5	12.5	83.0	60.6	3.4	13.5	39.4	23.9	14.8
92.8	92.1	4699	23.3	12.1	1.86	4.3	8.6	16.1	6.4	19.5	18.6	10.2	68.6	13.5	82.1	59.4	3.3	11.7	40.7	22.8	17.5
93.5	93.0	4890	24.2	12.2	1.67	4.4	8.6	16.8	..	20.0	19.2	10.4	69.4	12.9	82.3	60.2	3.1	11.2	39.8	24.2	15.6
16.0 to 93.5	*15.9 to 93.0*	*20 to 4890*	*15.9 to 24.6*	*9.0 to 12.9*	*0.3 to 1.9*	*3.0 to 4.8*	*4.2 to 8.6*	*7.6 to 16.8*	*3.3 to 6.4*	*13.0 to 20.0*	*11.9 to 19.8*	*8.7 to 12.6*	*68.6 to 75.2*	*12.5 to 19.2*	*82.1 to 91.9*	*59.4 to 70.1*	*2.7 to 4.8*	*9.6 to 13.5*	*30.8 to 40.7*	*15.7 to 24.2*	*14.1 to 19.4*

Although the tails of some other blennioids have been examined, no work, so far as we know, has been done on *M. americanus*. Therefore, six tails were cleared and stained after the method of Cumley, Crow and Griffen (1939). This caudal fin (Fig. 15 C) is obviously a highly specialized homocercal type, and its general features compare closely with that of another blennioid fish, *Cristiceps argentatus*, described by Whitehouse (1910). The urostyle is inconspicuous. Hypaxially the last vertebral segment possesses two hypural plates, of which the uppermost is the longer and generally less stout, extending posteriorly on a direct line with the vertebral axis. There is a prominent dorsal caudal radial, not to be confused with the uroneurals of Hollister (1936), since it is unpaired. The penultimate vertebra possesses a strong hypural, whose much smaller dorsal counterpart, unlike that in *C. argentatus*, cannot be considered an epural because it does not bear any fin rays at its distal end. The small ray-bearing cartilages described by Whitehouse as lying dorsal and ventral to the distal portions of the last two hypurals in *C. argentatus* are not apparent in *Macrozoarces americanus*.

Synonyms and References

Blennius americanus Bloch and Schneider, 1801: 171 (Latin descr.).

Blennius anguillaris Peck, 1804: 52, pl. 2, fig. 3 (descr., food); Jordan, 1919: 325 (orthotype for *Macrozoarces* Gill, 1864).

Blennius labrosus Mitchill, 1815: 375, pl. 1, fig. 7 (descr., color); Gill, 1898: Concordance (name).

Blennius ciliatus Mitchill, 1815: 374, pl. 1, fig. 6 (descr., color, N. Y.); Gill, 1898: Concordance (name).

Zoarces labrosus, Cuvier, 1829: 240 (comment on larger specimens in America); Cuvier and Valenciennes, 1836: 466, fig. 342 (Le Zoarcès a grosses lèvres, descr.); Richardson, 1836: 93 (name); Richardson, 1837: 207 (name); Cuvier, 1836–1849, *7:* 175 (same as above).

Zoarcus labrosus, M'Murtrie, 1831: 177 (after Cuvier, in Eng.); Carpenter and Westwood, 1878: 294 (after Cuvier, 1829).

Blennius anguillarius, Williamson, 1832: 151 (Snakefish).

Blennius viviperus, Smith, J. V-C., 1833: 553, (name).

Blennius viviparus, Smith, J. V-C., 1835: 537 (name, Mass.).

Zoarces Gronovii Cuvier and Valenciennes, 1836: 469 (Le Zoarcès de Gronovius); Richardson, 1837: 207 (name); Storer, 1846: 375 (descr.).

Zoarces fimbriatus Cuvier and Valenciennes, 1836: 468 (Le Zoarcès frangé, descr., notes possibility of its being same as *labrosus*); Richardson, 1837: 207 (name); DeKay, 1842: 156, pl. XVI, fig. 44 (descr., color, finds scarcely any difference between this and *anguillaris* except in color; notes smaller size of *fimbriatus* compared with *anguillaris*.); Storer, 1846: 375 (descr.); Gill, 1864: 259 (mentioned in relation to *Z. anguillaris*).

Zoarceus labrosus, Cuvier, 1836–1849, *8:* pl. 79, fig. 1 (Le Zoarcès au grandes lèvres).

Zoarchus labrosus, Storer, 1837: 348 (comment, Mass. Bay), 356 (name only).

Zoarcus anguillaris, Storer, 1839a: 66 (color, descr., food, palatability); Storer, 1839b: 374 (same as above).

Zoarces anguillaris, DeKay, 1842: 155, pl. XVI, fig. 45 (color, descr., appearance in commercial market, *etc.*); Storer, 1846: 375 (descr., loc.); Storer, 1855: 263, pl. XVII, fig. 4 (color, descr., food, seasons, Mass. and N. H.); Günther, 1861: 296 (color, range); Gill, 1862: 45 (common names); Holmes, 1862: 101 (seasonal abund., color, descr.); Gill, 1864: 259 (mentioned in relation to *fimbriatus*); Abbott, 1868: 818 (abund., associates, N. J.); Gill, 1873: 797 (range); Yarrow, 1877: 206 (original Fort Macon, N. C. record); Jordan and Gilbert, 1879: 371 (N. C., after Yarrow); Jones, 1879: 90 (common, Nova Scotia); Goode and Bean, 1880: 9 (coloration of young and black spot on dorsal); Günther, 1880: 498 (size, general discus.); Bean, 1881: 82 (duplicate specimens from Me. and Mass., distrib. by Smithson. Inst.); Jordan and Gilbert, 1882: 784 (descr., color, range); Goode, 1879: 31; Goode, 1884: 236, pl. 67 (top fig.) (common names), 247 (common names, commercial position, general discus.); Bean, 1884: 340 (name); Gill, 1885: 179 (used for descr. of Lycodoidea); Kingsley, 1885: 259 (general comment); Whiteaves, 1886: 151 (Canad.); Jordan, 1887b: 912 (name); Jenkins, 1887: 92 (name, after Yarrow); Jordan, 1887a: 29 (name); Nelson, 1890: 755 (color, descr., abund., N. J.); Cox, 1895a: 40 (Canada); Cox, 1895b: 73 (New Brunswick, Canada); Jordan and Evermann, 1896: 478 (check-list, range); Bean, 1897: 371 (appear. in fall and winter); Jordan and Evermann, 1898, *3:* 2457 (descr., synon.), *4:* pl. 348, fig. 850; Gill, 1898: Concordance (name); Smith, H. M., 1898: 106 (abund. in fall, Vineyard Sound, Mass.); Southwick, *et al.*, 1900: 52 (name); Bean, 1903: 674 (descr., color, abund., food, range, N. Y.

and elsewhere); Schmitt, 1904: 286 (Anticosti I., Gulf of St. Lawrence); Jordan, 1905: 518, fig. 468 (general discus. of Zoarcidae); Fowler, 1906: 406, fig. (descr., N. J.); Halkett, 1906: 364 (Gulf of St. Lawrence); Tracy, 1906: 85 (R. I.); Halkett, 1907: 340 (Canada); Smith, H. M., 1907: 378, fig. 173 (characters, N. C.); Kendall, 1908: 135 (common names, New Eng.); Fowler, 1909: 407 (name); Kendall, 1909: 224 (Labrador), 228, 229, 236, 241 (Anticosti I.); Tracy, 1910: 152 (R. I.); Fowler, 1911: 15 (name); Cornish, 1912: 80 (P. E. I., Canada); Halkett, 1913: 113, pl. XII, figs. 146, 147 (Canada); Sumner, Osborn and Cole, 1913: 768 (loc., south. Cape Cod); Nichols, 1913: 104 (abund., season, N. Y.); Bigelow, 1914: 113 (loc., depth, abund., Gulf of Maine); Kendall, 1914: 63 (range, coll., Me.); Nichols, 1916: 10 (caught throughout year 1915, off N. Y.); Nichols, 1918: 116 (name, abund., N. Y.); Clemens, 1920: 3 (see Clemens and Clemens); Clemens and Clemens, 1921: 69–83, Fig. 1 and tables (histor., distrib., refs., migration, age and growth, reproduction, temp. relation to migration, food, associates, parasites); Willey and Huntsman, 1921: 6 (observ. on fish in aquarium, feeding habits, swimming movements, reactions to touch); Huntsman, 1922: 67 (abund., habits, loc., Bay of Fundy); Jordan, 1925: 728, fig. 636 (same as above); Bigelow and Welsh, 1925: 378, fig. 190 (descr., color, size, range, occur. in Gulf of Maine, habits, food, growth, breeding, commercial importance); Manter, 1926: 9 (trematodes); Nichols and Breder, 1926: 161, fig. (distrib., occur., observ. on use of dorsal spines, food, life history, size, N. Y., Me.); Borodin, 1928: 34 (young, Panama Atlantic; no doubt a misidentification); Jordan, 1929: 204 (common names, range); Breder, 1929: 277, fig. (occur., spawn.); MacKay, 1929a and b: 8, and figs. (digestive action) 24 (bile); Schroeder, 1931: 44 (name, loc.); Roule and Angel, 1933: 85 (name, loc.); Gregory, 1933: 374, 376, figs. 253, 254 B. (osteology, class.); Vladykov, 1934: 107 (footnote); Vladykov and McKenzie, 1935: 107, fig. CXX (abund., Nova Scotia); Vladykov and Tremblay, 1935: 81 (Canada); Bigelow and Schroeder, 1936: 337 (observ. on coll. of young, breeding, spawning, depth, growth, color, Gulf of Me.); White, 1939: 337, fig. 1 and 2 (observations on eggs, embryos and hatching, Bay of Fundy; not viviparous); Fischthal, 1944: 35 (observ. on parasite); Merriman and Warfel, 1944: 231–237 (relation to analysis of total fish populations and marketing); Sandholzer, Nostrand and Young, 1945: 1–12 (Ichthyosporidian-like parasite's abund., *etc.*).

Zoarchus anguillaris, Linsley, 1844: 64 (Block I., R. I. specimen, comments on larger size compared to specimens from within Long I. Sound); Storer, H. R., 1857: 263 (Bras d'Or, Labrador).

Zoarchus fimbriatus, Linsley, 1844: 64 (Long I. Sd., comments on smaller size of Sound specimens and probable identity with *anguillaris*).

Enchelyopus americanus, Gray, 1854: 101 (name).

Zoarcus viviparus, Bell, 1859: 208 (Marcouin, Gulf of St. Lawrence).

Zoarces ciliatus, Gill, 1862: 45 (common names); Abbott, 1868: 818 (abund., N. J.); Cox, 1895a: 40 (Canada); Cox, 1985b: 73 (New Brunswick, Canada).

Macrozoarces labrosus, Gill, 1864: 258 (suggested this name for American species).

Zoarces labrasus, Fortin, 1865: 65 (descr., Gulf of St. Lawrence).

Enchelyopus anguillaris, Gill, 1864: 258 (synon., proposed type of subgenus *Macrozoarces*); Fowler, 1916: 42 (N. J.); Fowler, 1917: 137 (Me. and Mass.); Fowler, 1920: 167 (N. J.); Fowler 1927: 116 (N. J.); Fowler, 1929: 613 (loc., time); Fowler, 1938: 308 (name only).

Eelpout, Nichols, 1918: 91 (descr., fig.).

Macrozoarces americanus, Jordan, Evermann and Clark, 1930: 473 (range, classif., synon.).

Ocean Pout, Merriman, 1944: 455, 456 (relation to marine resources; marketing and parasite).

Zoarces angularis, Fantham and Porter, 1943: 25, 27–29 (*Sarcocystis* in ocean pout).

? Postulated Blenny, Pennant, 1787: 115 (". . . whole body spotted in form of small pustules: color pale dull yellow. Inhabits the sea off *Newfoundland*." No other characters are given, but color and postulated appearance suggest the possibility of its being *Macrozoarces americanus*.); Richardson, 1836: 93 (comments on inadequate description by Pennant, for which reason its position cannot be determined).

TABLE V. PERTINENT DATA ON THE COLLECTIONS OF OCEAN POUT (INVOLVING 2772 INDIVIDUALS) USED IN THIS STUDY. ALL CATCHES MADE BY MODIFIED OTTER TRAWL, UNLESS OTHERWISE STATED

Date	*Locality*	*No. of Fish*	*Depth (fathoms)*	*Bottom Temp. (°C.)*	*Remarks*
III–30–'43	Landed at Stonington, Conn.	5	.....	....	Sent by Conn. State Bd. of Fish & Game
IV–7–'43	2½–4 mi. off Watch Hill, R. I.	52	15–30	....	......
IV–22–'43	2½–3 mi. off Watch Hill, R. I.	13	15–30	....	......
V–11–'43	3–5 mi. W. of Montauk Pt., N. Y., 1 mi. off S. shore.	5	7–9	....	......
V–11–'43	8 mi. SSE. of Montauk Pt., N. Y.	6	21	....	......
V–11–'43	Landed at New Bedford, Mass.	49	.....	....	Caught in Nantucket Sd. (?)
V–25–'43	3–5 mi. W. of Montauk Pt., N. Y., 1 mi. off S. shore	6	7–9	....	......
V–25–'43	3 mi. NNE. of Block I., R. I.	85	24–26	....	5 tagged
VI–15–'43	3 mi. NNE. of Block I., R. I.	67	24–26	....	......
VI–15 to 16–'43	St. Andrews, N. B., Can.	4	.....	....	Line trawl
VI–15 to X–25–'43	St. Andrews, N. B., Can.	100	.....	....	Line trawl
VIII–7–'43	15 mi. SSE. of Pt. Judith, R. I.	6	20	....	......
IX–9–'43	14 mi. SSE. of Pt. Judith, R. I.	4	22	....	......
IX–12–'43	10 mi. S. by E. of Pt. Judith, R. I.	13	25	14.3	......
XI–25–'43	12 mi. S. of Block I., R. I.	18	25	....	......
XII–19–'43	5–8 mi. ESE. of Watch Hill, R. I.	2	10–14	6.3	......
XII–30–'43	Old Harbor, Block I., R. I.	255	.....	....	......
I–2–'44	Old Harbor, Block I., R. I., ½ mi. from shore	837	23	4.7	......
I–19–'44	Landed at New Bedford, Mass. Caught 6 mi. S. of Block I., R. I.	61	.....	....	......
I–20–'44	Landed at Provincetown, Mass. Caught 10 mi. SW. of Wood End Light, Mass.	151	6	....	......
II–20–'44	2 mi. S. of Green Hill, R. I.	2	12	1.5	......
II–29–'44	8 mi. S. of Block I., R. I.	21	20–22	3.4	......
III–12–'44	5 mi. SW. of Block I., R. I.	163	22	....	......
III–10 to 13–'44	Landed at New Bedford, Mass. Caught at S. end of Nantucket Shoals	52	.....	....	......
III–15–'44	Landed at Provincetown, Mass. Caught 8 mi. NNW. of Racepoint Light, Mass.	72	30	....	......
III–19–'44	4 mi. N. of Block I., R. I.	4	20	2.4	......

TABLE V. PERTINENT DATA ON THE COLLECTIONS OF OCEAN POUT (INVOLVING 2772 INDIVIDUALS) USED IN THIS STUDY. ALL CATCHES MADE BY MODIFIED OTTER TRAWL, UNLESS OTHERWISE STATED (*cont.*)

Date	*Locality*	*No. of Fish*	*Depth (fathoms)*	*Bottom Temp. (°C.)*	*Remarks*
IV–6–'44	3½ mi. N. of Pt. Herod, L. I., N. Y.	150	22	....	......
IV–19–'44	3–4 mi. S. of Watch Hill, R. I.	95	17–25	3.8	45 tagged
IV–23–'44	3½ mi. S. of Watch Hill, R. I.	21	20	....	......
V–18–'44	2 mi. SE. of New London, Conn.	5	10	8.7	4 tagged
V–30–'44	3–4 mi. ENE. of Block I., R. I.	123	25	....	......
V–30–'44	Landed at New Bedford, Mass. Caught 8 mi. SW. of entrance to Muskeget Chan.	105	18–19	....	......
V–30–'44	Landed at Provincetown, Mass. Caught 2 mi. E. of Peaked Hill Buoy, Mass.	102	25	....	......
X–26–'44	5–6 mi. off Charleston, R. I.	1	.....	14.4	......
XII–18–'44	2 mi. S. of Charleston Inlet, R. I.	61	14	6.5	......
II–4–'45	5 mi. SSW. of Charleston, R. I.	24	.....	....	......
III–5–'45	4 mi. S. of Green Hill, R. I.	9	20	1.8	......
IV–16–'45	1–3 mi. NNE. of Block I., R. I.	23	20	4.6	......

LIFE HISTORY

INTRODUCTION

Approximately 2800 ocean pout have been used as a basis for this study (Table V). The great majority of these specimens were collected from the catches of commercial fishermen from 1943 to 1945, and in most instances the gear used was a modified otter trawl. Wherever possible random samples were obtained by taking whole hauls from the day's catch, thus avoiding any bias which might arise from picking out the individuals to be studied; this also insured fair samples of the catch and, at least within the range of the selectivity of the gear, of the population. At the time of most of the collections an investigator from the laboratory was on board the vessel in order to assure accuracy and make pertinent field notes and observations; the samples were iced and barrelled on board and trucked to New Haven shortly after landing. Data were usually taken on the fresh fish in the laboratory within 24 hours; these included length, weight, otoliths, sex (gonads preserved), stomach contents (preserved), vertebral counts, examination for parasites, *etc.* At times the samples were so large as to make it impossible to take full data, and in such instances various observations were omitted as dictated by necessity. On occasions, parts of the sample were frozen and withdrawn for study day by day, and sometimes extra data, such as that used for taxonomic purposes, were taken.

Lengths were recorded in half centimeters on a measuring board with an offset vertical head piece. It was standard practice to measure from the tip of the snout (which protrudes well in advance of the lower jaw) to the end of pointed caudal fin, there being no other convenient method. Slight inconsistencies in measuring undoubtedly occurred owing to the size of the fleshy upper lip and the degree to which the specimen was pushed against the head board; also on the few occasions when living fish were measured we found extreme difficulty in obtaining accurate length measurements (p. 40). But these errors were minimal, and variations of this sort are inconsequential as compared to the natural variability of fish populations as studied from large samples (Ricker and Merriman, 1945).

Further description of materials and methods are given under the appropriate sections in this paper. It should also be added that Table V does not include a number of specimens which were borrowed for study or specially preserved for us by different commercial fishermen; these were all small individuals which aided immeasurably in age and growth-rate determinations, but were not products of the more standard collections on which this work is chiefly based.

Spawning Habits

Comparatively little information is available from previous workers as to the spawning habits of ocean pout. The period over which spawning takes place has been in doubt, and until recently it has been a matter of conjecture as to whether or not this species is ovoviviparous like its European counterpart (*Zoarces viviparus*). Goode (1884) believed that spawning occurred in mid-summer in Massachusetts Bay, but Clemens and Clemens (1921), Bigelow and Welsh (1925) and Nichols and Breder (1926), on the basis of more adequate information, inclined to a fall reproductive period. White's (1939) observations on the nesting and embryos of the ocean pout were the first to provide clear proof that the young are not born alive, but rather that the egg masses are deposited in cavities and guarded by one or both parents.

In fact, apart from the close relationship of the North American *Macrozoarces americanus* to the European *Z. viviparus*, there is nothing to indicate anything but normal teleostean oviparity in the former species.[1]

As pointed out previously, the collections were from the catches of commercial vessels and were in large majority confined to the months from December to June. No spawning populations were available for observations regarding the time and duration of the spawning period, age at maturity, *etc.* In fact, in the period from July through November only five samples of ocean pout involving 42 individuals were collected in 1943 and 1944 in southern New England waters (Table V). It is therefore necessary to reconstruct the events in the life history of the ocean pout in the summer and fall on the basis of extremely limited data.

In an attempt to determine the number of eggs produced each year by ocean pout of different sizes, counts were made on a series of six ovaries taken from fish of 55–87.5 cm. in length from the May 30, 1944, collection from the southern Cape Cod area. This particular collection was used because the maturing eggs were well developed by that date and were therefore easier to count without danger of confusing them with the extremely small eggs which presumably would have matured for a succeeding spawning. Apart from size, it was also possible to distinguish these two categories of eggs in the formalin-preserved ovaries on the basis of color (the maturing eggs being yellow, the others more nearly white) and texture (the maturing eggs being hard, the others being soft and flabby). The volume of the whole ovary was first obtained by water displacement, and the ovary was

[1] However, almost every conceivable grade of maternal dependence occurs in teleosts—for example, *Z. viviparus* "secretes a very fatty and mucous uterine fluid" which is probably absorbed by the developing embryo as in the sting-ray, *Trygon* (Needham, 1942). It is possible, therefore, that fertilization is internal and the early stages of development are ovarian in *M. americanus* for the eggs have only been taken late in development; but here again there is no evidence that this is the case, either from direct observation or from any anatomical modifications for internal fertilization and incubation, unless the median unpaired ovary be considered such. Instead it would seem that a high degree of parental care has been developed in the closely-related European and North American species by different methods—the former accomplishing this end by ovoviviparity, the latter by one or both parents guarding the developing embryos closely, the eggs being deposited in crevices and cavities as indicated by White's (*loc. cit.*) discovery of a mass of eggs and two adults in a rubber boot taken in a trawl.

then cut into several parts, each of whose volume was similarly determined. Counts were then made on one or several parts of each ovary and the number of eggs in the whole gonad calculated accordingly. To check the accuracy of this method, individual calculations of the total number of eggs in each ovary were made from actual counts on each of the parts into which three of the ovaries had been cut. This obviously enabled a comparison of the estimates of the total number from the counts on the different parts, as well as a comparison of the number calculated with the total number actually counted in these three specimens. It was apparent that calculations of total numbers based on parts of an ovary which constituted less than approximately one-third of the whole were subject to a possible error of as much as 15 per cent. But when counts were made on pieces that were between one-third and one-half of the whole gonad, the estimates of the total number of eggs were accurate to less than two per cent (*i. e.*, 2% variations between the different calculations as well as between the calculations and the actual total count). The number of maturing eggs showed a clear-cut tendency to increase with increase in size of the individual as shown by the actual lengths and counts listed below:

Length of fish	*Number of eggs*
55.0 cm.	1306
59.0 cm.	1362
67.5 cm.	1902
68.0 cm.	1673
72.5 cm.	2260
87.5 cm.	4161

Fig. 7 provides evidence that spawning occurs in southern New England waters in late September and October. The upper graph shows the seasonal trend of the percentage of the weight of the fish occupied by the ovary in mature individuals over a full year. Ovaries from representative samples of the ocean pout in most of the collections were dissected out, labelled individually, and preserved in the course of the routine analyses of fresh material. Subsequent inspection of this material indicated that in general all females above 57.5 cm. were mature in the sense that the larger eggs in the ovary would have been spawned in the next season. Therefore, the ovaries from individuals over this length in a series of collections over the year were weighed and the percentage of the weight of fish occupied by the gonad at different dates was calculated. The figures obtained are inserted next to the appropriate points on the graph, and the broken line drawn through the points indicates the general trend. It is apparent from these data that spawning probably occurs between mid-September and late November, and since the gonads from fish in the November collection showed none of the characteristics of recently "spent" reproductive organs, it seems reasonable to infer that spawning had been completed some weeks previously—probably in October. However, the number of specimens at each point on the upper graph in Fig. 7 varies from as few as one in several samplings (unfortunately at the critical dates in August, September and November) to as many as 48. It is therefore evident that conclusions as to the exact time and duration of the spawning season based on these data are subject to possible error and should not be regarded as more than tentative. The chances are that the points in August and September are reasonably accurate indications of the general trend; this is especially true because the percentage variation in different individuals from large samples was not of sufficient magnitude to indicate that the points in the late summer would have been changed enough to alter the general slope of the curve materially had there been larger numbers involved. On the other hand, the point in late November may or may not be an accurate indication of the general ovarian condition of the population at that time. The single female on which this point is based might have been an exceptionally early spawner so that the general curve as drawn may place the spawning period somewhat too early. However, although there was only one female out of the collection of 18 individuals on this date which was over 57.5 cm. (the arbitrary limit of maturity as determined by inspection for this immediate purpose, p. 70), there were a number of females from 48–57 cm. in length. It is highly probable that some of these individuals were mature—*i. e.*, had spawned in the preceding month (see section on Age at Maturity). Since they showed essentially the same ovarian status as the single female on which the November point is based, it is reasonable to infer that this point is probably representative of the general condition of the population.

Several other matters in regard to the upper graph in Fig. 7 deserve consideration. First, on the basis of the available data there is good indication that the percentage of the weight of the females occupied by the ovary at any particular date tends to increase with increase in

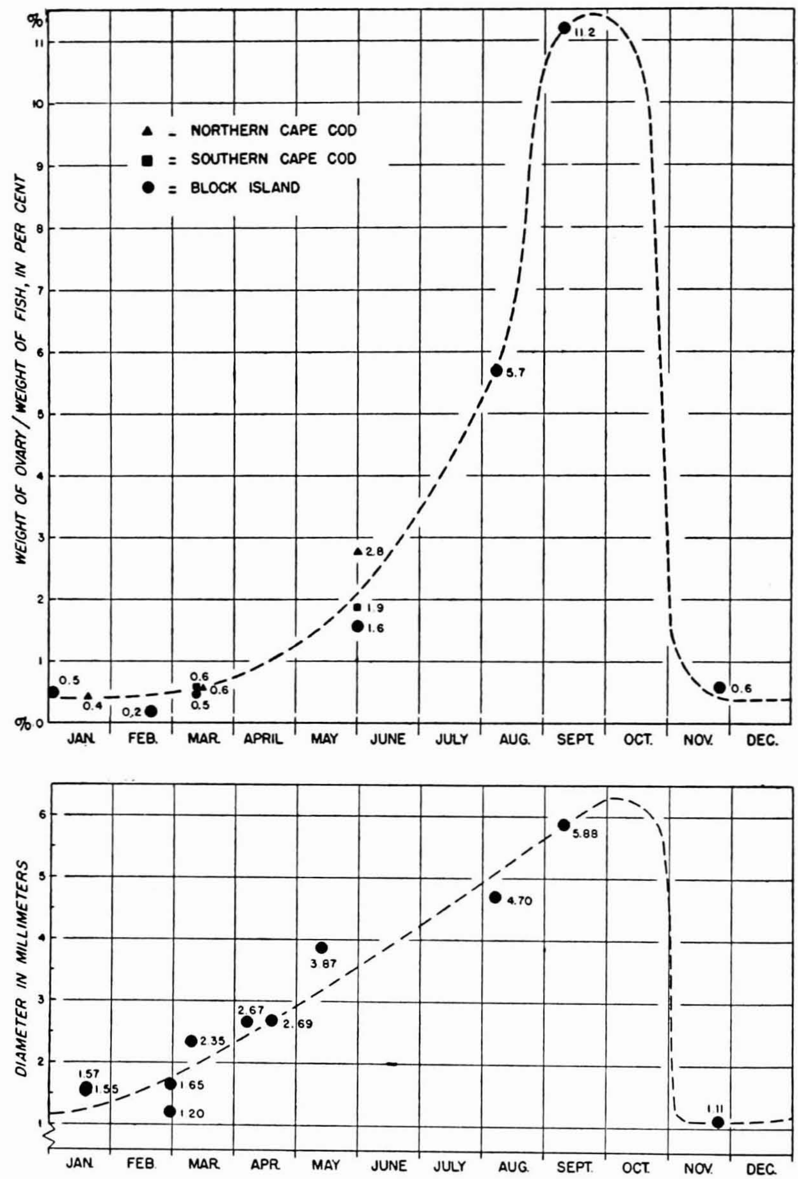

Figure 7. Seasonal trends in the percentage of the weight of mature ocean pout occupied by the ovaries (upper graph), and in egg diameters (lower graph). See text.

size of the fish. This trend, although small, was apparent in most of the samples on which the points in Fig. 7 are based where there were sufficient numbers of individuals. For example, the ovaries of fish from 57.5–62.0 cm. in length in one of the March collections occupied an average of 0.43 per cent of the weight of the fish, while those in the 62.5–67.0 cm. group in the same collection occupied an average of 0.54 per cent. Similarly, the ovaries in the 57.5–62.0 cm. group in another of the March collections averaged 0.42 per cent, while those in the 67.5–72.0 cm. interval averaged 0.79 per cent. The average percentages from the three May 30, 1944, collections, tabulated below with the numbers of individuals in each case enclosed in parentheses, provide further evidence of this trend:

Locality	*Length intervals (cm.)*		
	57.5–62.0	*62.5–67.0*	*67.5–72.0*
Northern Cape Cod	1.1% (5)	3.2% (6)	3.9% (5)
Southern Cape Cod	1.8% (15)	1.7% (15)	2.4% (5)
Block Island	1.6% (22)	1.5% (8)	......

It thus appears that ovarian growth in mature individuals is not directly proportional to the growth of the fish. Put another way, it might be said that ovarian growth apparently fails to slow down at a rate commensurate with the successively smaller annual growth increments of the adults; instead, as might be expected from the fact that the ovaries develop and become functional later than other organs, growth continues in them at a rate which is faster than that of the rest of the fish.

The upper graph in Fig. 7 also provides some evidence that there may be slight differences in rates of maturation (and therefore possibly in times of spawning) in different geographical localities. Thus it will be seen that in the May 30, 1944, collections the values for the percentage of weight of the fish occupied by the ovaries decrease from north to south. While the differences are relatively small, it is significant that these figures are based on good-sized samples (17 from northern Cape Cod, 35 from southern Cape Cod, and 30 from the Block Island Sound area). If this conception is correct, and if the trend here indicated were maintained throughout the period of maturation, it would mean that spawning probably occurs earlier in northern waters and progressively later in southern waters. This in turn might be taken as evidence that spawning is, in part at least, either directly or indirectly temperature-controlled—*i. e.*, reproduction takes place within certain temperature limits which are attained later in the year from north to south. In this connection, Clemens and Clemens (1921) believed that fertilization in the Bay of Fundy occurred in mid-September where the temperature of the water is roughly 9–11° C. This is somewhat earlier than our own evidence for the southern New England area as a whole and tends to substantiate further the conception of a correlation of spawning with temperature. It is significant in this connection that at the time of the collection of September 12, 1943 (when ocean pout approaching full maturity were taken), the bottom temperature was 14.3° C., while on December 19, 1943 (when spawning had been completed), the bottom temperature was 6.3° C. (Table V).

Added evidence that the spawning period in southern New England waters occurs in late September and October is provided by the seasonal trend in the diameters of maturing eggs (lower graph, Fig. 7). Eggs were dissected out of the mid-region of a series of ovaries from fish 57.5 cm. or more in length which had been taken in different months during 1943 and 1944. Each point on the graph is the average of measurements on 50 eggs from one ovary; these measurements were made on each egg separately with a pair of dividers to the nearest 1/64th of an inch, the longest axis being taken when the eggs were not perfectly spherical. The majority of this work was done without the aid of magnification and is therefore subject to a certain amount of error. However, the constancy of the individual measurements on the maturing eggs in different ovaries, and the small range in the diameters at any particular date as opposed to the seasonal differences in egg size, indicate that the errors from this method of measurement are insignificant in their effect on the general trend. Objection to this method can also be made on the basis that single ovaries were used in order to obtain each point at each particular date in most instances. The possibility of this method giving rise to serious error was precluded by the examination of all the ovaries in each of the collections before egg measurements were made, and the selection of a maturing organ which was typical of the sample. Also, in the collection of January 19, 1944, the eggs from the two ovaries were measured and the same average figure was obtained (Fig. 7). The fish whose ovaries were used for the egg-diameter studies were all taken south and west of Cape Cod. It is thus clear that this method of

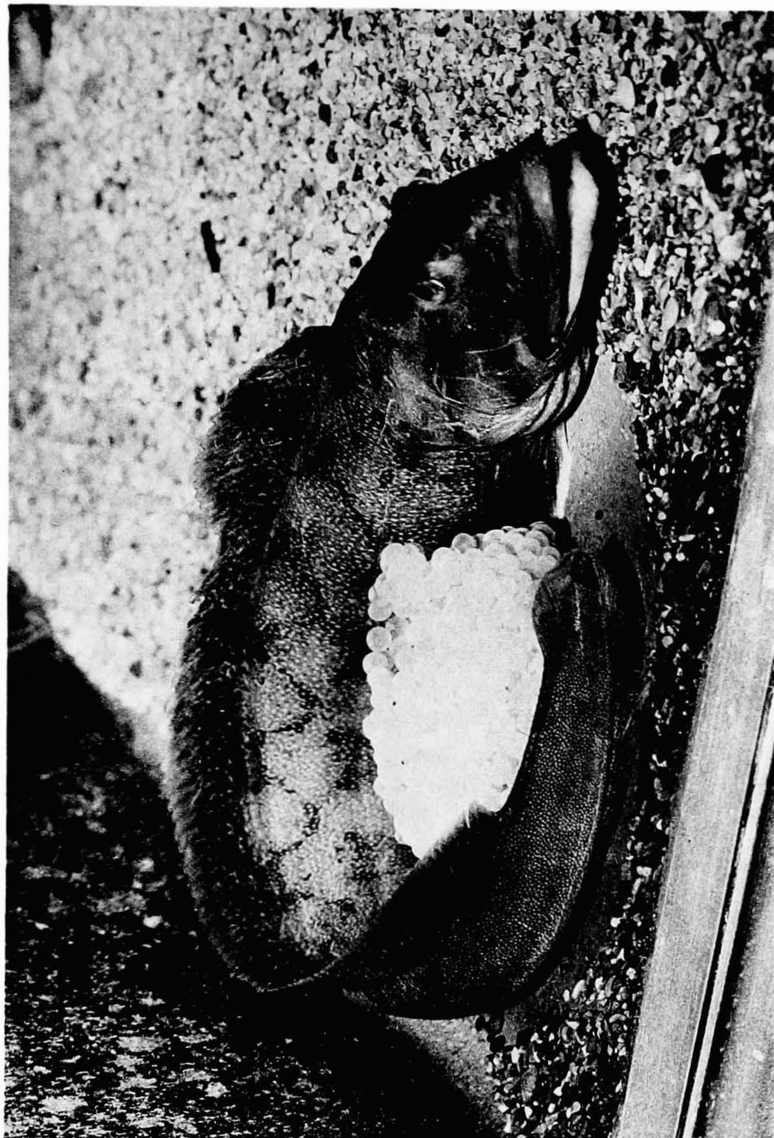

Figure 8. Female ocean pout coiled around its infertile eggs. This photograph is reproduced here by kind permission of the Director of the John G. Shedd Aquarium, Chicago, Illinois.

Figure 9. Developing embryos of the ocean pout. Material loaned by the Museum of Comparative Zoology, Harvard College, and originally recovered from the stomach of a cod taken on Cholera Bank, N. Y., November 16, 1927. Egg shells have been removed, and in the upper picture the embryos have been dissected away from the yolk sac.

determining the spawning period corroborates the information derived from plotting the seasonal trend of the percentage of the weight of mature individuals occupied by the ovaries, and that the two graphs in Fig. 7 in general agree closely.

Summing up the available evidence, it seems probable that spawning occurs in late September and October in southern New England waters. There is also good reason to believe that spawning takes place at progressively later dates from north to south over the range of this species, so that the period of reproduction along the Atlantic coast extends from mid-September in the north (Bay of Fundy) to at least late October in the south (New York and New Jersey waters). It is evident from the paper by White (1939) (see discussions on pp. 36 and 68) that the eggs are laid in crevices and protected by one or both parents. That the female gives the eggs close protection is further demonstrated in Fig. 8, which shows an individual coiled around a batch of infertile eggs it laid in captivity. Evidence is presented that spawning occurs on rocky bottom for the most part within the 30-fathom contour (p. 41), and it seems probable that reproductive activity takes place when the bottom temperature reaches approximately 10° C.

Age and Rate of Growth

Developmental period and growth of the young. Evidence has been presented in the preceding section to show that ocean pout spawn in September and October. Little information is available on the length of time from fertilization to hatching other than that provided by White (1939) and by the embryos pictured in Fig. 9. White collected a mass of eggs in the Bay of Fundy in early January which hatched within several hours, thus indicating an advanced developmental stage. If Clemens and Clemens (1921) are correct in their assumption that spawning occurs in this region in September, the period of development in these waters must occupy roughly three and a half months. The young were approximately 30 mm. in length at the time of hatching.[1] The embryos shown in Fig. 9 were removed from the stomach of a cod taken on Cholera Bank off New York on November 16, 1927. That they were well advanced in development is obvious from the

[1] By contrast to the condition in salmon and trout, White noted that immediately upon hatching the yolk sac began to shrink, forcing the yolk into the abdomen. "The time from the moment of hatching to the complete external disappearance of the yolk did not exceed twenty seconds."

plate.[1] As a matter of fact, in order to be certain of the identity of these eggs, fin-ray counts were made on several individuals after removing the egg shell and dissecting the embryos away from the yolk. These counts (dorsal, 133–135; anal 110), the typical ocean-pout appearance of the head, lips, *etc.*, as well as the size of the egg (6–7 mm.) and the season at which they were taken, eliminated all other known species in the region. These embryos measured roughly 15.0–17.5 mm. in length (little more than half the length of White's newly hatched individuals), and they had not yet developed the typical apparent gap in the dorsal fin which White shows in his illustration. It seems clear that the eggs from Cholera Bank had some time to go before hatching—at least a month or more in all probability. If the view of later spawning in more southern waters (p. 73) be accepted, however, the developmental period from fertilization to hatching must be considerably shorter than in the Bay of Fundy region. The stage of the Cholera Bank embryos, as well as the fact that mature ocean pout have presumably completed the parental care of their eggs by late December (p. 42), indicate that the developmental period occupies approximately two and one-half months in southern New England, New York and New Jersey waters. This would mean that the period from fertilization to hatching extended roughly from early October to mid- or late December, approximately a month less than in the Bay of Fundy.

Only limited information is available in regard to the growth of the young after hatching. Bigelow and Schroeder (1936) stated:

> Many small specimens from 1.8 inches long upward, have recently been collected along our coast between Maine and New Jersey, including (within the gulf) Mount Desert, Stellwagen Bank, Georges Bank, and the vicinity of Chatham, suggesting that the eelpout breeds successfully throughout this range. And as all the young thus far taken have been caught in depths of 20 to 45 fathoms, probably this is the usual spawning zone.
>
> The sizes, in different months, of the young fry show that eelpouts in the Gulf of Maine grow to a length of about 2 inches in the first 6 months of their lives, and 3 inches in 9 months, agreeing in this respect with the growth-schedule of Bay of Fundy eelpouts derived by Clemens and Clemens (1921, p. 74) from the annual rings on the otoliths. Small specimens 5 to 6½ inches long taken from February to May are probably about 1½ years old.

Apart from the newly-hatched individuals described by White (1939),

[1] Note that the developing embryos are not consistently sinistral or dextral in their coiling—*i. e.*, they apparently coil indiscriminately to left or right.

the smallest ocean pout reported in the literature are those of Clemens and Clemens (1921), who recovered one 37 mm. in length from the stomach of a sculpin (*Myoxocephalus octodecimspinosus*) seined in St. Andrews Bay on April 15, 1919, and another imperfect specimen 25 mm. long from the contents of a shrimp trawl which was operated in the Bay of Fundy on April 21, 1919. There seems to be " . . . no doubt but that these small specimens were produced during late fall or early winter."

The following records of capture were provided through the kind interest of W. C. Schroeder, and represent a partial summarization of the data available to him from the collections at the Museum of Comparative Zoology and his own field notes.

Month	*Locality*	*Depth (fathoms)*	*Temp. (°C.)*	*Length (mm.)*
Feb.	73° 14′, 40° 04′	28	...	154, 167
Apr.	73° 21′, 40° 05′	...	...	41, 58
	71° 45′, 40° 41′	31	...	48, 51, 54, 55, 60
	3 mi. S. Great Duck Is., Me.	28–33	2.7	41, 45
	2½ mi. ESE. Little Duck Is., Me.	20	2.7	48, 52, 127
May	73° 27′, 39° 05′	35	...	70
	70° 47′, 41° 05′	23½	...	64
	69° 41′, 41° 38′	28	...	45, 46, 50, 52, 53
June	69° 41′, 41° 39′	29	...	63, 75, 125, 150, 174
	Off Long Is., N. Y.	...	...	54, 62, 63, 66
July	70° 19′ 30″, 42° 17′	17–25	...	70, 73, 73
Aug.	66° 18′, 41° 51′	45	...	101

Assuming that the smallest individuals in these records were products of the previous fall's spawning—an inescapable conclusion in view of the information at hand (*e. g.*, White's observation that the embryos were roughly 30 mm. long at hatching), it is possible to estimate the rate of growth of the juveniles from the length data shown above. In April the range is from 41–60 mm., the average being approximately 50 mm. In May the range is from 45–70 mm., with the average falling close to 55 mm. In June the range is from 54–75 mm., the average length being nearly 65 mm. In July the 0+ fish are roughly 70 mm. or more in length. The two individuals taken in February in the above records were almost certainly 1+ fish, and this would mean that in general a 14-month ocean pout was 150–170 mm. long. There can be no doubt that the growth rates of ocean pout in different areas differ materially (Fig. 13), so that the above estimates, based on limited data, are no better than broad generalizations.

Our own collections of small ocean pout have been limited, but they substantiate the conclusions reached from other sources of information. In the period from May 20–27, 1944, we obtained five small ocean pout from 71° 37′, 40° 50′ in 28 fathoms; these individuals were 72, 73, 77, 81, and 180 mm. in length; obviously the collection was composed of four 0+ and a single 1+ fish. The average length of the 0+ fish from this collection is somewhat above that derived from Schroeder's records, but is sufficiently close to indicate that the difference is no more than that which would be expected from seasonal, geographical, or other variations. Another collection of 14 small ocean pout from 170–295 mm. in length was made in June and July off Provincetown, Massachusetts. Of these, five were 1+ fish from 170–193 mm. in length and the remainder were apparently 2+ individuals as indicated both by the size grouping and otolith studies (p. 85). No other 0+ or 1+ ocean pout were obtained in our collections.

On the basis of these data it appears that ocean pout, with the possible exception of northern fish which apparently grow more slowly, are roughly 5–8 cm. (2–3 in. or more) approximately six months after hatching, 11.5–15 cm. (4½–6 in.) in length when they are one year old, and about 18 cm. (± at least 2 cm.) (6½–8 in.) long 18 months after hatching. For the estimated average lengths at subsequent ages see Table VI. Fig. 10 is a drawing of a 73 mm. ocean pout in which careful attention has been paid to body proportions and general pattern. Note that there are regularly-spaced dark patches along the sides of the body, and that these decrease in intensity and pigmentation posteriorly. The black spot on the anterior part of the dorsal (p. 55) is also apparent, and observation of other specimens show that this ocellus is also prominent in 1+ fish but tends to fade out in 2+ fish; in other words, it is less and less conspicuous in individuals over 20 cm. and to all intents and purposes disappears in fish over 30 cm.

Length-frequency studies. In regard to the growth rate of older ocean pout which are taken in the commercial fishery, an attempt was made to derive information from the distribution and progression of the modes of length-frequency curves from a series of 11 random samples at different dates in various localities. These samples are graphed in Fig. 11. As indicated earlier (p. 67), in order to insure

Figure 10. Drawing of an ocean pout 73 mm. in total length after preservation in formalin. Specimen taken between May 20 and 27, 1944, near "G" buoy, 71° 37′ W. and 40° 50′ N.

random samples, all the ocean pout in at least one complete trawl haul were measured with two exceptions. On one occasion (Fig. 11D) the catch was so large that it was impossible to measure more than a small fraction of any single haul. Therefore, when the contents of the net were dumped onto the deck only the fish in a single checker (rectangular areas marked off by vertical partitions) were set aside and barrelled for subsequent analysis in the laboratory. This method of selection provided against any bias that might arise from an attempt to pick the sample by hand.[1] After this sample of 127 ocean pout had been set aside, those which spilled over into certain checkers in subsequent hauls throughout the day were measured on the boat. In Fig. 11D the solid line connecting the circles represents the random sample which was taken from the first haul; the dotted line connecting the black circles represents the 707 fish which were measured from subsequent hauls during the rest of the day. It is apparent from a comparison of the two length frequencies that there is close agreement between them. The faithful repetition of the irregularities in the smaller sample by those in the large sample provides good evidence for the adequacy of both the method used and number of individuals in the lot which was picked for laboratory analysis. There is, of course, a somewhat greater spread in the larger sample, but this is to be expected and in no way invalidates the conclusion as to the adequacy of the random sample taken from the first haul. The other occasion on which a length-frequency curve was not based on measurements of all the fish in one or more trawl hauls is shown in Fig. 11K. This lot of fish from the Bay of Fundy area was collected during the summer by set trawls (hook and line), and it therefore represents a different and incommensurable method of sampling the ocean pout population. In some ways the hook-and-line method offers advantages as a method of sampling the actual population in that it probably takes a better proportion of smaller individuals which are usually lost through the meshes of a trawl net. On the other hand, the hook-and-line method offers all sorts of chances for inaccurate sampling due to hook size, differential food preference of small and large individuals, *etc.* These inaccuracies are far less serious in the trawl net

[1] In selecting the sample by hand there is usually a tendency to favor the larger fish, since they are easier to pick up, and it is also difficult to avoid picking fish off the top of a pile with the result that the smaller individuals, which usually end up near the bottom of the pile, are inadequately represented in the sample.

method with demersal species above the size which can escape through the mesh.

Let it be clearly understood that the random samples of the catch of the commercial trawlers which form the basis of all the length-frequency curves in Fig. 11, except K, are *not* random samples of the population. In a completely random sample of the population, including all the age classes, the whole curve would be skewed heavily to the right; that is, the slope near the left ordinate would be abrupt and steep to the peak, and the slope to the right of the peak would tend to be gradual and probably undulating. The more symmetrical or "normal" the length-frequency curves, the less random they are in terms of the total population. It is evident from the curves in Fig. 11 that nothing approaching a random sample of the population was taken in the commercial gear. The reason for this lies in the size of the mesh, which, below the maximum size of escapement, allows for an increasingly greater loss of the successively smaller individuals and therefore the more recent year-classes. The stretched mesh-size in the cod-ends of the trawl nets on the boats which made most of the collections used in this work varied from 3½–4½ inches. A 40-cm. ocean pout can escape through a 4-inch mesh without great difficulty, and it seems probable that some 50- to 60-cm. individuals would normally escape from a cod-end with a 4½-inch mesh. Under these circumstances the sampling of the population below 55 or 60 cm. is increasingly inaccurate for the successively younger age groups. From the information already presented on the growth of young ocean pout (p. 80), as well as from the corroborative data from otolith studies (p. 85), it is clear that a large number of 3+ fish normally escape from the commercial gear. Indeed it seems probable that 4+, 5+, and even some 6+ and 7+ individuals might escape under some conditions (see Table VI for average lengths at different age categories). In the light of these considerations it would appear that sampling of the ocean pout population by commercial trawlers only approaches reasonable accuracy after the sixth or seventh year of life.

In view of these limitations it is to be expected that the length-frequency method of age and growth determination from samples of ocean pout from the commercial trawler catches will not be highly productive. This is especially true since the length-frequency method is usually most applicable for age and growth studies of the *younger* year-classes. There is an increasing tendency after the first several years for the modes to overlap to such an extent that they are not distinguishable unless year-class dominance or some other phenomenon makes the identity of a particular group possible. Examination of the curves in Fig. 11 shows that they provide only the most meager information as to age and rate of growth of the ocean pout. Taken as a group, they give clear indication of comparatively slow growth rate and the overlap of the modes of successive year-classes—indications which are borne out by otolith studies (p. 90). Neither do they give any consistent evidence of the phenomenon of year-class dominance having occurred in any of the age categories available to the commercial fishery in 1943 and 1944; this is not surprising, since the exceptional success of occasional broods is far more characteristic of species with large numbers of eggs and no parental care than it is of forms that produce limited numbers of eggs which are carefully guarded. The only possible indication of a dominant year-class is the recurring peak between 55 and 60 cm. in A, C, D, E and G; more probably, however, these peaks are emphasized by the above-mentioned errors in sampling the population, and contribution to them is almost certainly from at least several age groups as indicated by their failure to progress in orderly fashion over the period from April 1943 to May 1944. The graphs in Fig. 11 do show the general size range of ocean pout in the commercial catch, and it is clear from them that the vast majority of fish fall between 40 and 80 cm., with the peaks of abundance occurring between 45 and 65 cm.

Note also that the length-frequency curves have been broken down into their male and female components as indicated by the black and the diagonally lined bars respectively, with the totals of both sexes being shown by the solid lines connecting the circles. The general utility of this procedure is illustrated by Fig. 11C, where, in the absence of other data, the length-frequency curve for the whole sample might be considered as highly suggestive of separate modes which indicate different age groups. However, it is apparent from the composition of these modes that at least one is made up of a predominance of males, while another is made up of an overwhelming majority of females. Since the sex ratios from one year-class to another could hardly be expected to change from one extreme to the other, it seems more reasonable to suppose that the successive modes are the result of pure chance in this somewhat inadequate collection which consisted of only 64 fish. In the larger samples there are no comparable or consistent modes. The recurring peaks between 55 and 60 cm. in A, C, D, E and G, which are almost universally composed of a heavy dominance of females, are peculiar. Here again a possible explanation may be found in the selectivity of the trawl net. As is shown later (p. 94), the length at maturity of the females is mainly between 45 and 60 cm. It is conceivable that the large ovary in the spring months makes the females just enough bigger around to prevent their escape through the meshes of the net, while males of similar lengths are thin enough to get out in relatively larger numbers. This would mean that the gear was actually selective for sexes at the length interval between 45 and 55 cm., and perhaps slightly above this level. The validity of this hypothesis is indicated by the situation in Fig. 11D, where the sex ratios of the fish comprising the 55–60-cm. peak are more normal. It so happens that the cod-end mesh used on this occasion was comparatively small (3½ in.), as compared to the 4–4½ inch mesh used on the other collection dates. Furthermore, this collection was made on January 2, 1944—at a time when the ovary had not yet increased to such a great size preparatory to spawning; the other collections (A, C, E and G) were made later in the spring when the ovaries are much larger (Fig 7).

Otolith studies. Since age determinations of individuals above the 2+ category were not possible by length studies, and since scales of the ocean pout are so small and deeply imbedded as to make their use impractical (quite apart from the fact that on superficial examination they do not appear to be legible), otoliths were taken from the majority of fish in the different collections. Furthermore, the otolith method had already been used to good advantage by Clemens (1920) and Clemens and Clemens (1921) on this species in the Bay of Fundy. Otoliths were removed from the fresh specimens and placed in envelopes as part of the regular laboratory analysis; although these ear "bones" are small as compared to those of many species, they were not difficult to remove with practice.

The particular otolith studied was the sacculith (Adams, 1940) or sagitta; the utriculith (lapillus) and lagenalith (asteriscus) were much smaller and apparently illegible. The gross anatomy of the internal ear was found to be generally similar to that of *Zoarces viviparus* as described by Retzius (1881), whose illustration shows the general contour of the sacculith to approximate that of the American ocean pout. On the other hand, the sacculith is quite different from that described and pictured by Frost (1929) for *Z. viviparus*, who stated " . . . the sagitta is narrow and flat." It may be that Frost's specimen was abnormal (and indeed the otoliths of the American ocean pout show great variation and many irregularities), or it may be that the mode of preservation caused some alteration in its morphology. In all events, the otolith of *Macrozoarces americanus*, as shown in Fig. 15B, is more or less circular in outline, with a characteristic notch and a somewhat variably pointed projection on its anterior margin. The extent of the notch and the size of the projection tend to increase with size, but here again there may be considerable differences between individuals of approximately the same length. The less obvious notch and projection in the otolith of a small individual (18.5 cm.) is shown in Fig. 15A. The medial surface of the otolith is flat or even slightly concave, with a shallow antero-posterior sulcus running through its center, while the lateral surface is distinctly convex with definite concentric layers, which, under magnification, give a descending staircase effect from the original center to the periphery of the otolith.

In general the surrounding membranous material was picked off at the time the otoliths were removed. Later the otoliths were examined under low magnification by transmitted or direct illumination, but most frequently by a combination of both. After a certain amount of experimentation it became standard practice to examine and measure each otolith dry as it rested in a watch glass on its medial surface. There seemed to be no apparent advantage from having the otoliths immersed in fluid, a variety having been tried; the sacculiths were more legible when viewed from the lateral surface. Measurements were made through the longest axis (from the projecting tip to the most posterior margin) by means of a micrometer ocular.

Before considering the age determinations resulting from the otolith studies, a few remarks on the relation of growth of the otolith to growth of the fish are in order. Attempts to obtain consistent and accurate measurements on otoliths are rendered difficult by the irregularities and variations in shape, even from fish of the same general size. The upper graph in Fig. 12 shows the length of the otolith plotted against the length of the fish in a typical sample of approximately 100 specimens; this provides a good indication of the range in size of the otoliths from fish of any particular length. Citing an extreme,

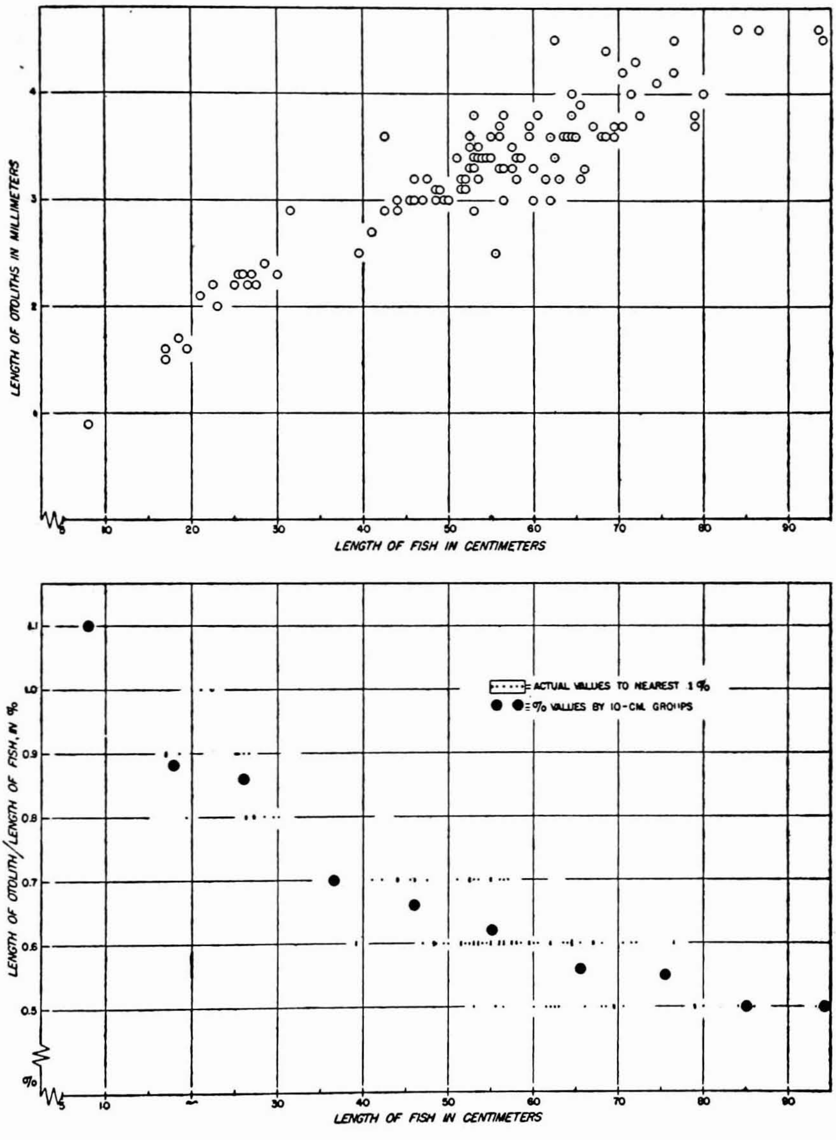

Figure 12. The relationship of the length of the otolith to the length of the fish. See text.

the range of otolith size in 62–62.5-cm. ocean pout is from 3–4.5 mm. Despite the spread at the different lengths, however, it is possible to establish the general trend of the relation of the growth of the otolith to that of the fish. This is more clearly indicated in the lower graph in Fig. 12, where the same data are plotted on the basis of the percentage of the length of the fish occupied by the otolith. It is obvious from these data that the fish grows proportionately faster than the otolith, and that the relationship appears to be exponential. Here again, the variability of the otolith is evident; for example, despite the fact that the growth of the otolith is apparently not proportional to the growth of the fish, individuals whose otoliths are 0.6 per cent of the length of the fish range all the way from 39–76.5 cm. It is perhaps true that the method of measurement, which included the anterior projection, introduced an error, since the projection may not grow at the same rate as the body of the otolith. But it seems unlikely that this would alter the general conclusion that the growth of the otolith is not directly proportional to the growth of the fish. Furthermore, reference to the middle graph in Fig. 6 indicates that the head grows faster than the body of the fish; that is, it occupies a considerably lower percentage of the standard length in smaller individuals than it does in larger fish. This would indicate that the relationship between the growth of the otolith and the growth of the head is even more disproportionate than that between otolith-growth and the growth of the whole fish. Of course it would be possible on the basis of more data to calculate a regression coefficient for the relationship between the growths of the otolith and the fish. However, for a solution of the ocean pout's life history this would appear to have limited utility, particularly because of the difficulty of obtaining accurate measurements from one ring to another on the otoliths when compared with the relative simplicity of measuring from one annulus to another on scales which grow proportionately to the growth of the fish.

As is evident from Fig. 15A and B, the otoliths show reasonably clear alternate dark and light bands which are capable of interpretation and enumeration after certain facts have been established. The method of computation used here has been much the same as that of Clemens and Clemens (1921), who noted the similarity of their own interpretation to that of Fryd (1901) for *Zoarces viviparus*. Clemens and Clemens were particularly careful to qualify their results, quoting the work of Lea (1919), who in reference to the analysis of herring scales stated, "As a matter of fact, we are hardly justified in using the term 'age-determination' . . . ; 'estimate' would be more correct, for there will always be found, whatever may be the material under consideration, a greater or less number of individuals . . . where the decision must be based more or less upon personal judgment." We agree with this qualification; nevertheless the results of our work seem to substantiate the findings of Clemens and Clemens (Table VII). The regularity of the results and the agreement obtained from other lines of evidence indicate the reasonable accuracy of this means. There are many confusing matters, including the variation in the distinctness of the bands, the presence of secondary lines or false bands, and the crowding at the margins (Clemens and Clemens); but the greatest obstacle lies in the interpretation of the center of the otoliths of fish above 40 cm. in length. Without smaller individuals in which the kernel and surrounding areas are sufficiently clear to be diagnosed, it would be extremely difficult to know how to evaluate the center of the otolith. In only a few of the otoliths from fish over 40 cm. was the center legible, since this region becomes increasingly thick in older individuals and is therefore likely to be more and more indistinct no matter what type of illumination is used. In actual practice in our work the average diameters of the kernel and surrounding areas were established by the examination of otoliths from small fish. These values were then checked against the measurements of the similar region on otoliths from older individuals which could be interpreted. Since they agreed within reasonable limits throughout, it was possible to use these figures as a point of departure in less legible otoliths from larger fish. Referring to Fig. 15A, the central kernel appears to represent the winter in which the fish was born, the surrounding light area the spring and summer (?), the dark band the fall and winter, and the peripheral light region the spring. The fish from which this otolith was taken was caught in June and was approximately a year and one-half old at that time. It is interesting that the light "summer" band is so well formed by June, and it seems reasonable to think it may start to be laid down at least as early as April. In general in otoliths in which the central portion was legible, the winter kernel ranged between 0.67 and 0.95 mm. through its long axis, and the long diameter to the outer margin of the second winter band was 1.14–1.86 mm. Using these approximate values as indicators, it was usually possible to establish the position of either the second winter or summer with a fair degree of certainty, and then to count the alternate light and dark bands with reasonable accuracy. In older fish the interpretation of the peripheral bands was sometimes confusing, so that it was difficult to be certain of the precise age, but even in fish over ten years old it was often possible to derive clear indications of the exact number of bands. The interpretation of the otoliths of the smaller fish agrees well with the information on age and rate of growth derived from the lengths of these individuals (p. 80), and there is every reason to suppose that the general method here used is valid within the limits of its accuracy.

Table VI shows the size-ranges at different ages, as well as the estimated average lengths of 1- to 17-year-olds. It is immediately obvious that this is a slow-growing species, and that the size-ranges of the different age categories overlap above the 4+ group, thus providing further evidence that the length-frequency curve method is not likely to be applicable (p. 83). On the average ocean pout in southern New England waters attain a length of 6 inches shortly after they become

TABLE VI. SIZE-RANGES OF OCEAN POUT AT DIFFERENT AGE CATEGORIES (0+ TO 16+), AND ESTIMATED AVERAGE LENGTHS OF 1- TO 17-YEAR-OLD INDIVIDUALS. DATA BASED ON OTOLITH ANALYSIS OF APPROXIMATELY 350 SPECIMENS FROM MASSACHUSETTS AND CONNECTICUT TAKEN DURING LATE MAY AND JUNE, 1944. SEE TEXT

Age Group				*Estimated Average Lengths at different ages*		
	Age	*Cm.*	*Inches*	*Age*	*Cm.*	*Inches*
0+	½ yr. old	7–8	2.8–3.1	1 yr. old	13	5.1
1+	1½ yrs. old	17–19	6.7–7.5	2 yrs. old	22	8.7
2+	2½ yrs. old	21–29	8.3–11.4	3 yrs. old	31	12.2
3+	3½ yrs. old	30–39	11.8–15.4	4 yrs. old	40	15.7
4+	4½ yrs. old	39–51	15.4–20.1	5 yrs. old	48	18.9
5+	5½ yrs. old	45–61	17.7–24.0	6 yrs. old	56	22.0
6+	6½ yrs. old	50–68	19.7–26.8	7 yrs. old	63	24.8
7+	7½ yrs. old	53–71	20.9–28.0	8 yrs. old	70	27.6
8+	8½ yrs. old	53–80	20.9–31.5	9 yrs. old	76	29.9
9+	9½ yrs. old	58–84	22.8–33.1	10 yrs. old	81	31.9
10+	10½ yrs. old	62–68	24.4–26.8	11 yrs. old	85	33.5
11+	11½ yrs. old	87	34.3	12 yrs. old	89	35.0
12+	12½ yrs. old	94	37.0	13 yrs. old	92	36.2
13+	13½ yrs. old	84	33.1	14 yrs. old	95	37.4
14+	14½ yrs. old			15 yrs. old	97	38.2
15+	15½ yrs. old			16 yrs. old	99	39.0
16+	16½ yrs. old	93	36.6	17 yrs. old	100	39.4

TABLE VII. RANGE IN SIZE OF OCEAN POUT OF DIFFERENT AGES IN THE BAY OF FUNDY AREA AS BASED ON OTOLITH READINGS ON 91 SPECIMENS BY CLEMENS AND CLEMENS (1921) AND 99 SPECIMENS TAKEN FROM JUNE–OCTOBER, 1943, BY OLSEN AND MERRIMAN

		Clemens and Clemens		*Olsen and Merriman*	
Age Group	*Age*	*Number of Specimens*	*Length (cm.)*	*Number of Specimens*	*Length (cm.)*
0+	1st year	7	3.7–10.0		...
1+	2nd year	3	12.0–14.7		...
2+	3rd year	7	17.5–21.0	1	16.5
3+	4th year	5	21.8–26.2		...
4+	5th year	4	25.5–30.9	2	23.0–28.0
5+	6th year	7	31.3–34.7	17	35.0–43.0
6+	7th year	2	34.3–35.2	26	33.5–47.0
7+	8th year	6	37.5–47.0	25	40.5–53.5
8+	9th year	10	41.0–50.0	9	41.0–56.0
9+	10th year	21	43.4–53.7	5	50.0–54.0
10+	11th year	5	45.5–56.0	2	50.5–51.0
11+	12th year	2	56.5–57.0	4	51.5–64.0
12+	13th year	1	59.8	1	64.5
13+	14th year	1	59.0	1	56.5
14+	15th year	2	59.0	3	62.0–69.0
15+	16th year	4	60.0–73.0	2	65.0–70.5
16+	17th year	3	61.5–68.0	1	59.0
17+	18th year		...		...
18+	19th year	1	67.5		...

one year old, 12 inches when they are three years old, 24 inches a little before they become seven years old, and 36 inches when they are approximately 13 years old. Although detailed comparisons have not been made, there appear to be no striking differences between the growth rates of ocean pout from different localities in the general southern New England area. There is some indication that those from Connecticut and New York waters grow slightly faster than those from Massachusetts, but with the overlap in size-ranges at different age categories which occurs in any locality it would take large quantities of data to demonstrate constant and significantly different growth rates from the different localities in this area. There is also some slight indication that the females tend to grow a little slower than the males, since, in examining typical samples, the females of any age category show a tendency to predominate in the lower part of the size-range; but to establish this fact would require far more data than it has been possible to analyze in this study.

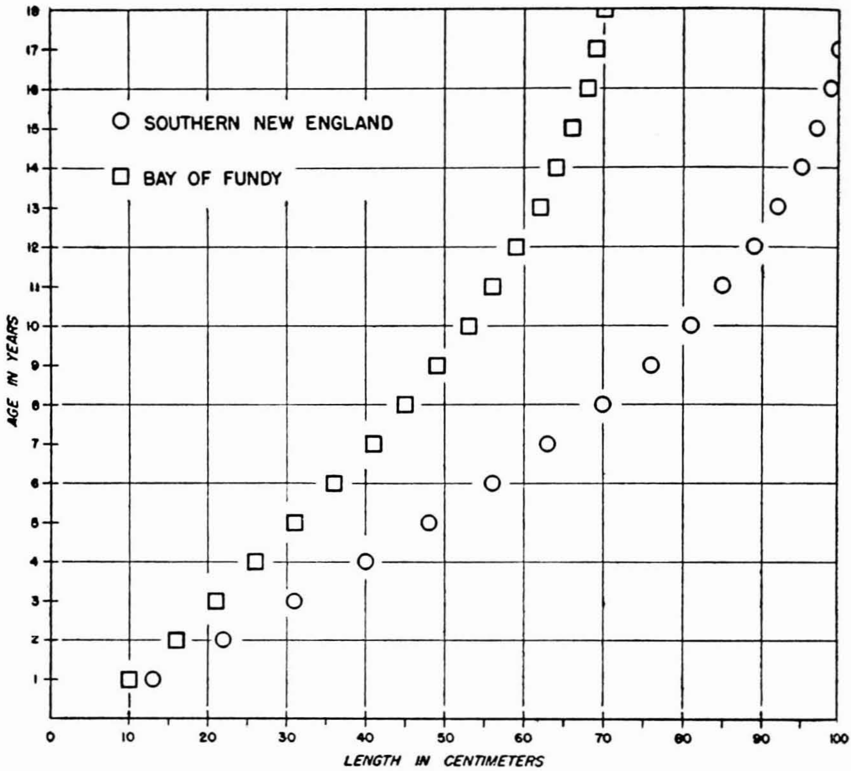

Figure 13. Average growth rates of ocean pout from the Bay of Fundy and from southern New England. Data based on estimated average lengths on 1- to 18-year-olds. See Tables VI and VII.

Comparison of the general growth rates of ocean pout in southern New England (Table VI) with those established by Clemens and Clemens (1921) for the Bay of Fundy revealed that the Canadian fish grow at a considerably slower rate. In order to make certain that our method of estimating age agreed with that of Clemens and Clemens we determined the size-range at different age categories from the otoliths of the collection of June–October, 1943, from St. Andrews, New Brunswick. This analysis was performed without reference to Clemens and Clemens table, and the results are listed on the right hand side of Table VII. Comparing these data with those of Clemens and Clemens, it is evident that there is close agreement between the

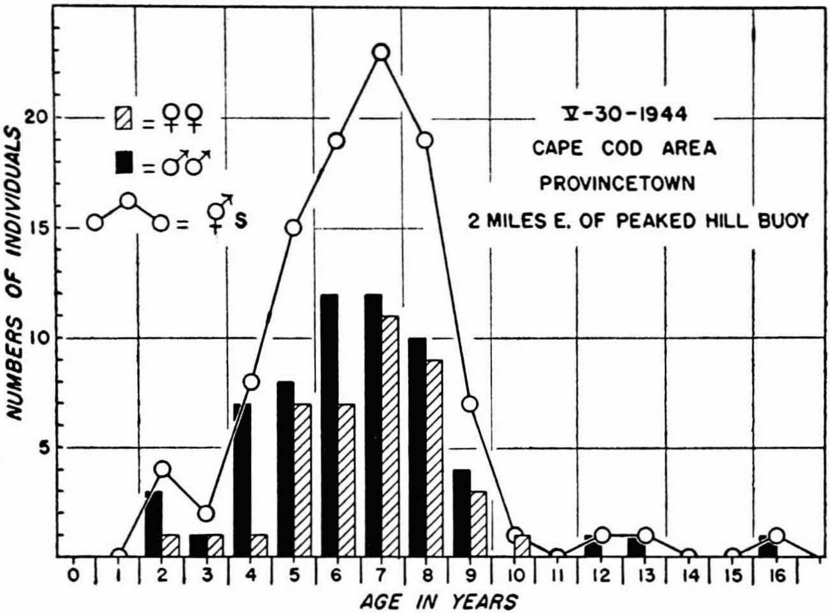

Figure 14. Age composition of a typical haul of ocean pout by a commercial trawler.

two independent analyses, especially considering the limited size of the samples. Fig. 13 shows the comparative average growth-rates from southern New England and the Bay of Fundy. Note that it takes the northern fish seven years to attain a length of 40 cm. while the southern fish reach the same length in four years, and that northern ocean pout average approximately 12 years old at 60 cm., while southern individuals attain a similar length in six and one-half years. Note also that the northern fish apparently do not reach as great a length as the southern ones, the upper limit in the former being 70–75 cm., while in the latter it is well over 90 cm.; however, larger samples from the north might alter this impression.

Finally, Fig. 14 shows the age composition of a typical commercial catch in southern New England, in which the four- to 10-year-old fish make up the great majority of the haul. Further discussion of this material appears in the following section.

Age at Maturity

Since no spawning populations of ocean pout were available for study because this species does not appear in the commercial catch in September and October, except as occasional strays, it was impossible to determine the age at maturity from direct observation. The only previous studies on the age at maturity are those of Clemens and Clemens (1921), who stated that " . . . the fish do not become sexually mature until they have attained a length of about 40 to 45 cm.," at which time, according to their age estimates, Bay of Fundy ocean pout would be about eight years old.

The first method used in our attempts to establish the age at maturity involved the study of sections of 42 gonads from fish of different sizes taken at various times during the year from the southern New England area (Fig. 16). The results of the study of the ovaries provided a general indication that approximately 50 per cent of the 54.5–57.0 cm. female ocean pout were mature in the sense that they were apparently going to spawn in the following season. The criteria used in establishing approaching maturity were those which have been observed in other species by Hann (1927), Bullough (1939), and Merriman and Schedl (1941). These included especially the increase in diameter of eggs, the differential staining properties, and the marked changes in degree and type of vacuolization of the yolk as shown in Fig. 16 E, F, G and H. According to the evidence derived from these observations, roughly half of the females in the population are mature in their sixth or seventh year of life. The results of the study of the testes indicated that all the male ocean pout below 25 cm. were immature, while above 39 cm. nearly all were mature, although one individual at 57 cm. appeared not to have reached maturity. The criteria for establishing approaching maturity—*i. e.*, the fact that the fish would spawn in the next season—were the relative number of cells in the different spermatogenic stages and the gross arrangement of the sex cells in either a compact (Fig. 16A) or a more diffuse, radial (Fig. 16B, C, D) manner. The majority of males examined were from the May 30, 1944, collections, which were the largest samples taken nearest to the time of the spawning season. Individuals judged to be immature showed a predominance of spermatagonia with occasional primary spermatocytes, while those which were apparently maturing had secondary spermatocytes, spermatids and, in one instance, a few sperma

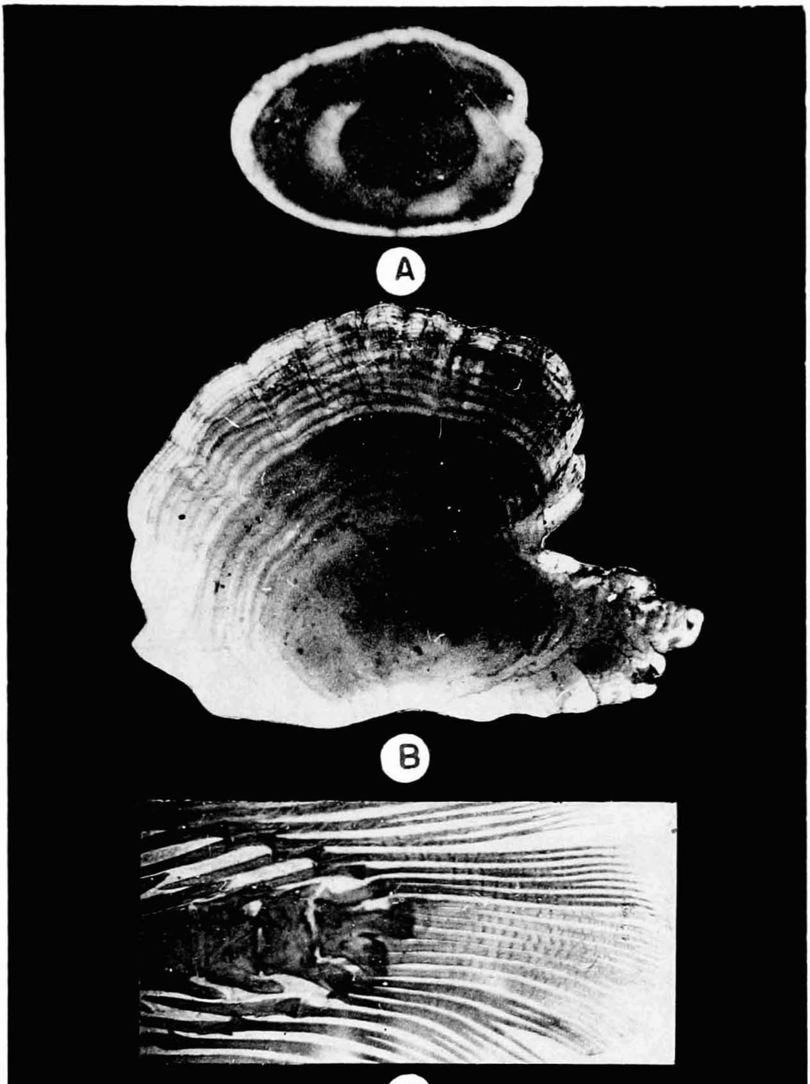

Figure 15. *A*. Lateral view of the right otolith (sacculith or sagitta) from a 1+ ocean pout 18.5 cm. long taken June 1944. Magnification x24.7. *B*. The same view of the right otolith from a 16+ individual 93.5 cm. long taken May 30, 1944. Magnification x16.3. *C*. Caudal vertebrae and associated rays stained by Alizarin Red S after the method of Cumley, Crow and Griffen (1939).

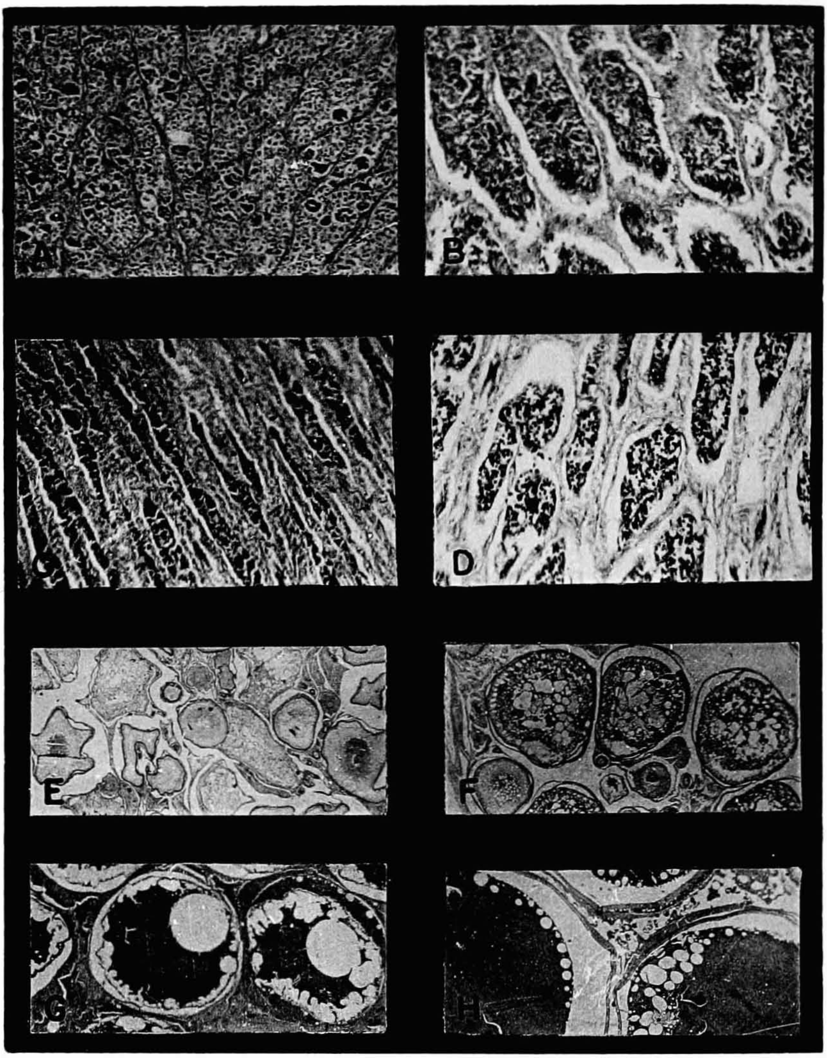

Figure 16. Sections of testes and ovaries of the ocean pout. *A*. Immature male; 26.5 cm.; June 1944. *B*. Mature male; 52 cm.; May 30, 1944. *C*. Mature male; 56 cm.; April 6, 1944. *D*. Mature male; 57 cm.; April 22, 1943. *E*. Immature female; 55 cm.; Aug. 7, 1943. *F*. Mature female; 55.5 cm.; April 22, 1943. *G*. Mature female; 54.5 cm.; April 23, 1944. *H*. Mature female; 54.5 cm.; Sept. 9, 1943.

tozoa. On the basis of this distinction, which agreed well with the gross appearance of the testis (compact or more diffuse distribution of the sex cells), roughly half of the males are probably mature in their third year of life and the great majority are mature in their fourth year, although some apparently do not mature until they are five or more years old.

Another possible means of determining the age at maturity lies in the estimation of the percentage of weight of the fish occupied by the weight of the gonads. These data must be available over the greater part of the size-range of the population at a single date; if the gonads have increased in size in preparation for spawning in the season to come so that the change can be detected, they should provide an indication of the approximate length at maturity. The gonads of those individuals which are not maturing should show a relatively low percentage value, while the ovaries or testes of those that are going to spawn in the coming season should have a higher percentage value, the degree of difference depending on the proximity to the spawning season. For this purpose we have used the three large collections of May 30, 1944 (Table VIII, Fig. 17). Comparison of the data from Block Island Sound, Muskeget Channel and Provincetown indicate slight differences in these three localities, but there is no consistent trend that can be taken as evidence that the ages at maturity in the regions within the general southern New England area differ. It is more probable that these differences are indicative of the normal variation within the species, and the results from the three localities have therefore been averaged together to give the figures on which Fig. 17 is based. It is also probable that the method of weighing the gonads[1] resulted in slight inconsistencies, since it is difficult to weigh each in an exactly comparable manner due to variations in the amount of fluid, extraneous tissue, *etc.*; but these differences were so small as to be of little or no significance in the analysis of the material. From Fig. 17 it becomes obvious that below 40 cm. the values for the females were consistently low, indicating immaturity up to this length. From 40–69 cm. the values show a progressive and rather sharp increase, with

[1] The fish were weighed fresh and the gonads were preserved in formalin and weighed at a later date. The percentage values in Table VIII and Fig. 17 are therefore probably not accurate indications of the true relationship of gonad to fish. But since the method of procedure was always the same, the validity of the data for the determination of length and age at maturity was not impaired.

TABLE VIII. AVERAGE PERCENTAGE WEIGHT OF GONADS (WEIGHT OF GONAD DIVIDED BY WEIGHT OF FISH) AT 5-CM. INTERVALS BASED ON COLLECTIONS FROM THREE LOCALITIES ON MAY 30, 1944

Block Island			Muskeget Channel			Provincetown			Summary		
Average Length (Cm.)	*Number of Specimens*	*Aver. % Weight of Gonads*	*Average Length (Cm.)*	*Number of Specimens*	*Aver. % Weight of Gonads*	*Average Length (Cm.)*	*Number of Specimens*	*Aver. % Weight of Gonads*	*Average Length (Cm.)*	*Number of Specimens*	*Aver. % Weight of Gonads*
	♂			♂			♂			♂	
38.6	1	0.120	....	..	.....	39.1	2	0.083	39.0	3	0.095
45.2	6	0.098	....	..	.....	44.9	5	0.093	45.1	11	0.095
50.1	7	0.100	50.7	5	0.106	50.2	7	0.089	50.3	19	0.097
54.9	7	0.150	55.9	5	0.124	54.8	13	0.116	55.0	25	0.127
60.1	9	0.152	59.5	9	0.124	60.2	8	0.117	59.9	26	0.131
64.4	10	0.152	65.3	5	0.145	65.0	8	0.155	64.7	23	0.152
69.9	8	0.152	70.1	1	0.170	69.0	3	0.167	69.7	12	0.158
74.0	1	0.210	....	..	.....	74.4	3	0.173	74.3	4	0.182
....	..	.....	....	..	.....	79.2	2	0.200	79.2	2	0.200
....	..	.....	....	..	.....	85.1	2	0.260	85.1	2	0.260
....	..	.....	....	..	.....	93.7	2	0.270	93.7	2	0.270
	♀			♀			♀			♀	
....	..	.....	....	..	.....	26.4	1	0.070	26.4	1	0.070
....	..	.....	....	..	.....	30.0	1	0.100	30.0	1	0.100
39.5	1	0.190	....	..	.....	39.9	2	0.130	39.8	3	0.150
44.4	2	0.765	....	..	.....	42.5	1	0.140	43.8	3	0.557
50.0	8	0.920	....	..	.....	49.8	4	0.570	49.9	12	0.801
55.3	12	1.750	55.1	11	1.420	54.5	11	0.940	55.0	34	1.380
59.7	22	1.600	60.1	15	1.830	58.5	5	1.118	59.8	42	1.625
64.0	8	1.540	64.4	15	1.720	64.1	6	3.200	64.2	29	1.980
....	..	.....	68.4	5	2.400	69.9	5	3.900	69.1	10	3.150
....	..	.....	....	..	.....	76.2	1	3.100	76.2	1	3.100

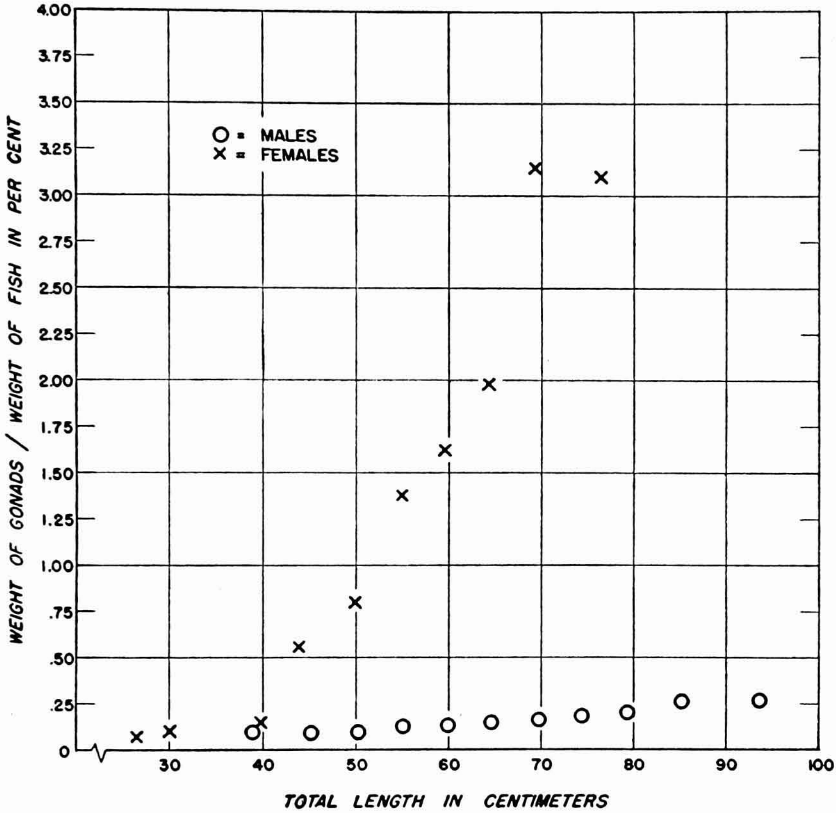

Figure 17. Average values for the percentage of the weight of the fish occupied by the weight of the gonad plotted against length (5-cm. intervals). Data based on the collections of May 30, 1944, from three localities in the southern New England area. See text and Table VIII.

a tendency to level off above 69 cm. This indicates that females first become mature at approximately 45 cm. (in their 5th and 6th year of life), and that all of them are mature at 69 cm. (in their 8th and 9th year of life). It also bears out the conclusion drawn from the study of the sectioned material that approximately 50 per cent of the females are mature by the time they reach the 55–60-cm. interval. However, the data on the males give no clear indication of the age at maturity; the values are consistently low from 39–94 cm., although they do show a gradual tendency to increase over this range. There are two reasons why the curve for the males does not show a definite "break" or sharp change in percentage values. First, the increase in size of the testis in maturing individuals does not take place as far ahead of the spawning season as does the increase in the ovary. Since the collections on which these data are based were made approximately four months ahead of the spawning season, it was to be expected that the increase in size of the testes would not yet be manifest. Second, if the conclusions drawn from the examination of sectioned material are correct, and if nearly all males above 39 cm. are mature, the individuals providing the present data were all too large to give information on the length and age at maturity. Finally, note that the tendency toward an increasing *percentage* of the weight of the fish occupied by the weight of the gonad in *mature* individuals (indicated previously, pp. 71–73) is evident from Table VIII and Fig. 17. This is particularly true with the males, but shows also in the females. If this phenomenon be accepted as fact in the females, it alters our estimates as to the length at which all female ocean pout are mature. Thus the two points at 69 and 76 cm. may be interpreted as being so high because of this phenomenon rather than because all the females are mature only by the time they reach 69 cm. Under the circumstances it seems reasonable to lower the length at which all of the females in the population are mature to 65 cm. (probably their 7th to 9th years of life).

Still another means of determining the age at maturity of the females is provided by comparative egg measurements from individuals over a wide size-range at a period approaching the spawning season. For this purpose also we used the three collections of May 30, 1944, because they were the last large samples available before spawning. Even though spawning was still four months away at this period, the eggs which were developing for reproduction in the fall were large and conspicuous as opposed to those that were being held in reserve for subsequent spawning seasons. Usually there was also a marked difference in color, appearance and structure between the maturing and immature eggs as indicated previously (p. 69). However, some ovaries contained eggs of intermediate size, so that it was impossible at this period to be certain whether or not they were eggs which were maturing for the approaching spawning season. Table IX shows the average diameters[1] resulting from measurements of 25 eggs from each of the ovaries of females from 42.5–76 cm. in length; these fish were taken in Block Island Sound, Muskeget Channel, and off Provincetown on

[1] Chain series of five and ten eggs were lined up and measured by dividers.

Table IX. Range in Size of Ova from Individual Ocean Pout Taken from Three Localities on May 30, 1944. 25 Eggs from Each Ovary Measured.

Block Island				*Muskeget Channel*				*Provincetown*			
Total Length (Cms.)	Total Weight (Gms.)	Average Diameter of Eggs	Average Actual Size	Length Total (Cms.)	Total Weight (Gms.)	Average Diameter of Eggs	Average Actual Size.	Total Length (Cms.)	Total Weight (Gms.)	Average Diameter of Eggs	Average Actual Size
42.8	367	1.22	●	...	...	...	...	42.5	277	0.98	●
46.0	525	2.37	●	...	...	...	...	46.0	377	1.24	●
47.5	590	2.30	●	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	48.5	523	1.51	●
49.0	637	1.34	●	49.5	622	1.97	●	...	...	...	...
50.0	749	2.23	●	50.0	645	2.26	●	50.0	657	2.36	●
51.5	700	1.81	●	...	...	...	...	...	...	...	...
52.0	801	3.06	●	52.5	873	2.43	●	52.0	680	1.52	●
53.0	788	1.84	●	53.0	852	2.46	●	53.0	708	1.25	●
53.2	998	2.64	●	...	...	...	...	53.0	732	2.70	●
...	...	...	...	53.5	963	2.94	●	53.5	739	1.48	●
54.0	927	2.45	●	54.0	848	1.72	●	...	...	...	...
54.8	1043	2.67	●	55.0	885	2.57	●	55.0	812	1.56	●
55.5	1225	3.12	●	55.5	994	1.65	●	...	...	...	...
56.0	1089	2.14	●	56.0	862	2.02	●	56.0	840	1.58	●
57.0	1247	2.22	●	56.5	1043	2.83	●	57.0	1089	3.56	●
57.3	1066	2.76	●	57.5	1048	2.80	●	57.5	913	2.55	●
57.7	1093	1.36	●	58.0	1093	3.28	●	...	...	...	...
58.0	1043	2.23	●	58.0	970	1.86	●	...	...	...	...
58.5	1188	2.04	●	58.5	1270	2.35	●	58.5	921	2.59	●
59.0	1252	2.66	●	59.0	1025	2.44	●	...	...	...	...
59.0	1225	1.94	●	59.0	1084	3.18	●	...	...	...	...
60.0	1157	2.55	●	60.0	1043	3.41	●	60.0	1139	2.56	●
60.5	1452	3.26	●	60.5	1225	2.00	●	60.5	1238	1.57	●
60.5	1270	2.13	●	60.5	1415	3.12	●	...	...	...	...
61.0	1452	2.80	●	61.0	1179	2.36	●	...	...	...	...
62.0	1492	2.52	●	62.0	1238	3.06	●	...	...	...	...
62.5	1270	2.14	●	62.5	1315	1.14	●	62.5	1270	3.80	●
...	...	...	...	63.0	1465	2.45	●	62.5	1370	3.58	●
63 5	1792	2.96	●	63.5	1510	4.16	●	...	...	...	...
64.0	1438	2.59	●	64.0	1510	3.23	●	...	...	...	...
64.0	1497	2.67	●	...	...	...	...	...	...	...	...
...	...	...	...	64.5	1551	3.01	●	64.5	1710	3.77	●
...	...	...	...	64.5	1497	2.48	●	64.5	1452	3.86	●
65.0	1633	2.40	●	65.0	1905	2.62	●	65.0	1374	3.77	●
65.0	1542	2.41	●	65.5	1606	2.76	●	65.5	1315	3.24	●
67.0	1796	2.35	●	66.5	1470	2.30	●	...	...	...	...
...	...	...	...	67.5	1733	3.43	●	...	...	...	...
...	...	...	...	68.5	1796	2.71	●	68.1	1769	3.33	●
...	...	...	...	69.0	2046	3.25	●	...	...	...	...
...	...	...	...	...	...	...	...	70.3	1805	3.44	●
...	...	...	...	...	...	...	...	72.0	2046	4.27	●
...	...	...	...	...	...	...	...	76.2	2508	3.70	●

May 30, 1944. Accompanying the lists of measurements are drawings to scale of the actual eggs (the average size of each sample of 25) in order to facilitate visual interpretation of the material. The eggs measured were, of course, from the larger size category in each ovary, provided a distinction could be made. It seems clear from Table IX that all females 63 cm. long or above were preparing to spawn that fall—*i. e.*, they were mature. Below that length an increasing number of immature individuals with small eggs are evident, particularly in the Provincetown collection, although it appears that some females in the 46–50-cm. interval had eggs in the process of preparation for release four months hence. A number of the eggs from fish in the general 45–60-cm. range were of indeterminate nature; they were of such a size that it was impossible to predict with certainty whether or not they were maturing for the oncoming spawning season. It is of interest that fewer female ocean pout below 63 cm. were mature in the Provincetown than in the Block Island and Muskeget Channel collections; it may be that a smaller proportion of the individuals in the 40–60-cm. group mature in northern Cape Cod waters than further to the south and west. The results of this analysis bear out the conclusions derived from other methods, namely that the first females to mature are approximately 45 cm. in length (4+ years old), and that all the females in the population are mature by the time they are approximately 65 cm. long (6–8+ years old). These data could also be taken to indicate that female ocean pout do not necessarily spawn every year, a possibility which Clemens and Clemens (1921) suggested. Thus the eggs of intermediate and indeterminate size could be construed as belonging to females, some of which had already spawned at least once, which were going to spawn some 16 months hence. It is impossible to settle this matter on the basis of the present material, and more adequate samples, preferably of the whole population at the time of spawning, would be necessary to answer the question.

One final source of information which can be used in attempts to estimate the average length and age at maturity of female ocean pout is derived from length-weight analyses of the separate sexes. The length-weight curve for the combined sexes, as well as the coefficient of regression, has been shown in Fig. 4, and a discussion of this subject appears on pages 42–45. The same data, with *separate* fitted curves and regression coefficients for each sex, are shown in Fig. 18. Note again that some 598 males and 516 females were used in the preparation of

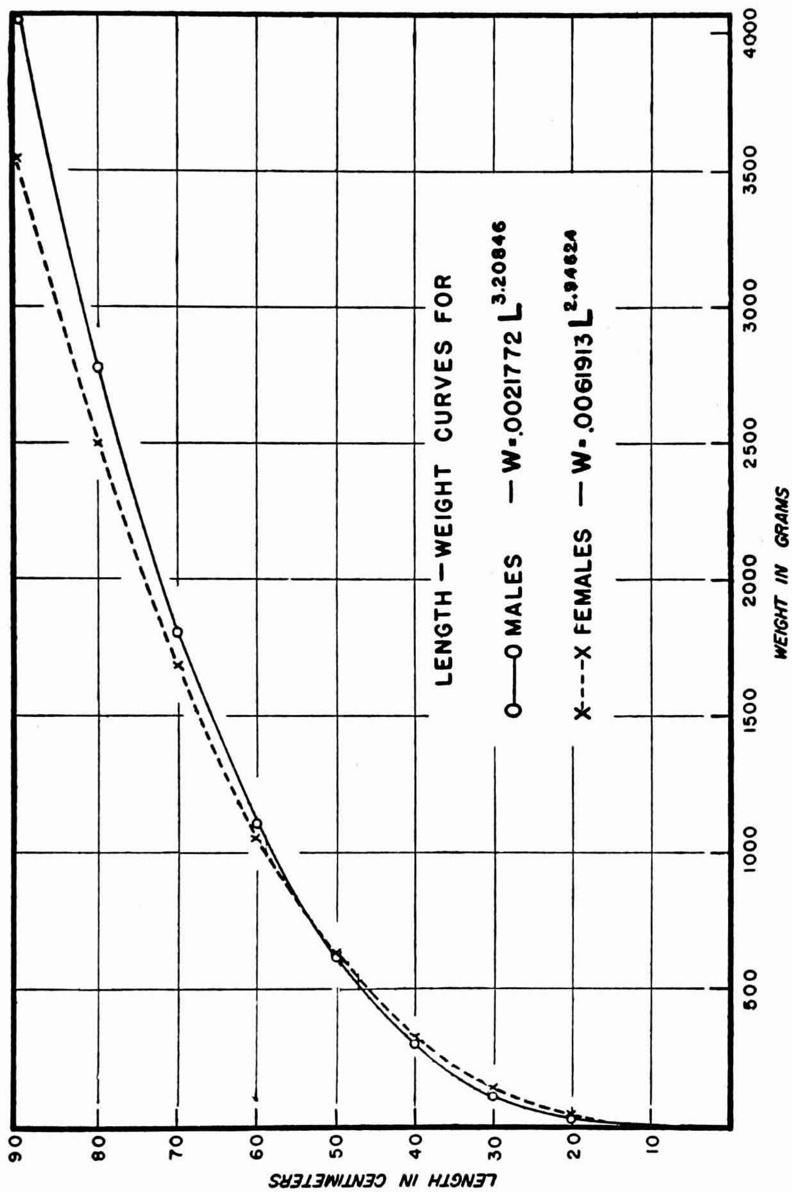

Figure 18. Regression curves showing the length-weight relationships of male and female ocean pout. See text for discussion.

each curve, and that the collections from which these data were taken were made over the period of a full year; therefore the weights represent as nearly as possible an average condition. It is of interest that below 55 cm. on the average the females apparently weigh somewhat more than the males of similar length. Conversely, at any length above 55 cm. the females weigh increasingly less than the corresponding males. The reason for this may perhaps be due to the gonadal differences between the two sexes; the point of crossing of the curves would thus indicate the average length at maturity of the females. Below 55 cm. the males tend to weigh less because they mature and spawn earlier in life. Over the period of a year some of their food is converted into testicular material, much of which is lost during spawning. However, in the majority of females below 55 cm. the food is converted into ovarian material which is not lost since they are not yet mature and do not spawn—that is, their conversion of food into gonadal tissue is, for the time being, on a permanent basis. Above 55 cm. the situation is reversed. The females weigh less than the males of the same length because by this time the great majority are mature. Thus, proportionately more food is converted into ovarian tissue and yolk material, due to the exceptionally large size of the gonad, than is converted into testicular tissue by the male; since this material is lost in the process of spawning, the average weight of the females over a full year is less than that of the corresponding males. Put in another way, the conversion of food into ovarian and yolk material in mature females is relatively much greater than the conversion of food into testicular material in mature males; since a large proportion of this gonadal material in both sexes is lost at spawning it follows that the gain in total weight of the fish over the period of a year is, on the average, less in the female than in the male. However, another reason for the greater weight of the males at the larger sizes might lie in the greater size of the relatively larger head. And a further explanation of the lower average weight of the mature females might be that they do not feed as much as the males during the reproductive season; but if this were true they probably would not grow quite as fast as the males, so that a comparison of weights at comparable lengths should not show any differences; moreover, there appears to be no great differential in the growth rates of the two sexes. Therefore it seems quite likely that the explanation lies in the gonadal differences between the two sexes. The fact that the crossing of the two length-weight curves occurs at the point which represents the average length at which maturity is attained by the females (55 cm.) as determined by all *other* methods at our disposal lends strength to the validity of this interpretation. It is of interest in this connection that Thompson (1942), in his discussion of the "ponderal index" or weight-length coefficient, used the changes in k (where $W = kL^3$) at different lengths of the plaice to determine the size at sexual maturity. He further pointed out that, "A step towards further investigation would be to determine k for the two sexes separately, . . . " and cites the work of d'Ancona (1928) who has done this for the shad (*Alosa finta*).

Sex Ratios and Seasonal Movements

Studies on the sex ratios of ocean pout in the available samples, which were almost entirely from the commercial catch, are subject to error from the inadequacy of the sampling of the population in somewhat the same way as the length-frequency curves discussed previously (p. 83). With certain exceptions (see below), however, the trawl net is probably not seriously selective for sex. While it is highly selective for size, those ocean pout which could escape through the mesh but which happen to be taken in the trawl net are probably the result of pure chance so that their sex ratios should not be distorted. In other words, these small fish are only caught at all because the cod-end becomes so full that means of escape through the mesh is partially blocked; these small individuals, if taken in sufficient quantities, should offer adequate sex-ratio data. But at certain sizes (in the 50–60-cm. interval) there is good evidence that the gear *is* selective for sex (p. 85). We need only repeat here that more females than males of this length are retained in the net because their ovaries are sufficiently distended in the spring months to make them bigger enough around so that they do not escape as easily as males of a corresponding length. Thus the peak of female preponderance at the 55–60-cm. interval in Fig. 19 is, in all probability, due to the selectivity of the gear.

The data for sex ratios at 5-cm. intervals in ocean pout from 30–90 cm., as plotted in Fig. 19, seem to indicate a fairly general preponderance of males. Eliminating the major peak of females in the middle of the graph on the basis of selectivity of the gear, there remains only one point at which there are more females than males. This is in the

30–35-cm. interval and the sample includes but 13 individuals (6 males and 7 females); obviously the numbers involved are inadequate. Therefore, it seems most reasonable to assume a slight preponderance of males over females throughout the majority of the life of this species. This preponderance apparently increases at the larger size categories, although the data on this point are limited. This fact is also apparent from Fig. 4, where it is obvious that the males make up the major part

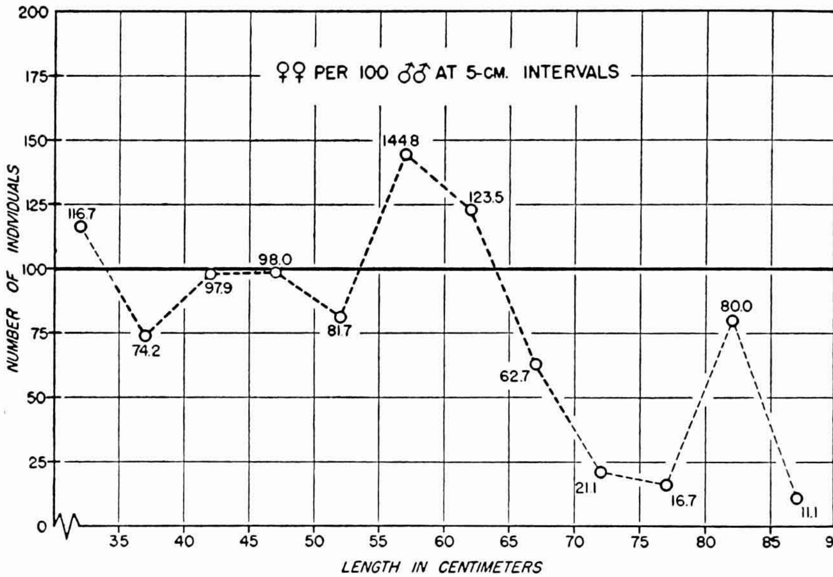

Figure 19. Sex ratios at 5-cm. intervals from 30–90 cm., as indicated by number of females per 100 males. Data based on collections of approximately 1100 ocean pout from southern New England over a complete year from April 1943 to April 1944. Points connected by light broken line involve a total of less than 50 specimens. See text for further discussion.

of the upper limits of the length-weight curve. Even granting that the last four points in Fig. 19 are made up of a total of only 93 individuals, the trend is so consistent as to leave little doubt that there are actually more males than females in the largest size groups of the population. The explanation of this could lie in a faster and greater growth by males, so that if death occurred at approximately equal rates for both sexes over the age-span, the largest individuals of the population would usually be males. But while there is some hint that the males may grow slightly faster than the females (p. 91), it does not seem likely that this is sufficient to produce the end result here indicated. More probably the explanation lies in the simple fact that as a general rule the males live longer than the females. Note that the collections for the data in Fig. 19 were made over a full year in an effort to eliminate any seasonal effects, such as the separate migration of sexes, which might produce a wholly false picture of the true sex ratio of the total population. Ideally for this purpose large samples of equal size should be collected at fairly frequent intervals. Unfortunately this was impossible since the ocean pout is taken by the commercial fishery only from December to June. The majority of our data is derived from the winter and spring months, although some small collections were made in the summer and fall (Table V). However, the sampling in point of time is probably sufficiently accurate to validate the conclusions outlined above.

The analysis of the sex ratios of the population of ocean pout in different regions at different times of year is shown in Fig. 20 and Table X. These data are based on samples which of course included fish from the 45–60-cm. interval, so that if the net is selective for sex as indicated above, the figures derived are unduly weighted on the female side of the population as a whole. The precise amount of distortion obviously depends on the proportion of individuals in each sample which fall between roughly 45 and 60 cm. It is possible, therefore, that the dominance of females at four points in the Block Island Sound area sex ratios in Fig. 20 is not a true representation of the condition in the population. Similarly, the preponderance of females in the May collection from southern Cape Cod is probably not a fair indication of the sex ratio of the population at that time. It is significant in this connection that all the collections in which female dominance occurs were taken at a time of year when the ovary had attained a relatively large size and might make the females just enough bigger around so that individuals of the proper size would be retained by the net, while males of corresponding lengths would escape (p. 105). However, where there is a dominance of males there can be no question that individuals of this sex are more abundant than the females, although it may well be that, due to the selective nature of the gear, the data presented in Fig. 20 and Table X do not indicate the proper *extent* of male dominance. It is of interest that the males are predominant in the December and January samples—particularly so at the former date. This is the time of year at which ocean pout first

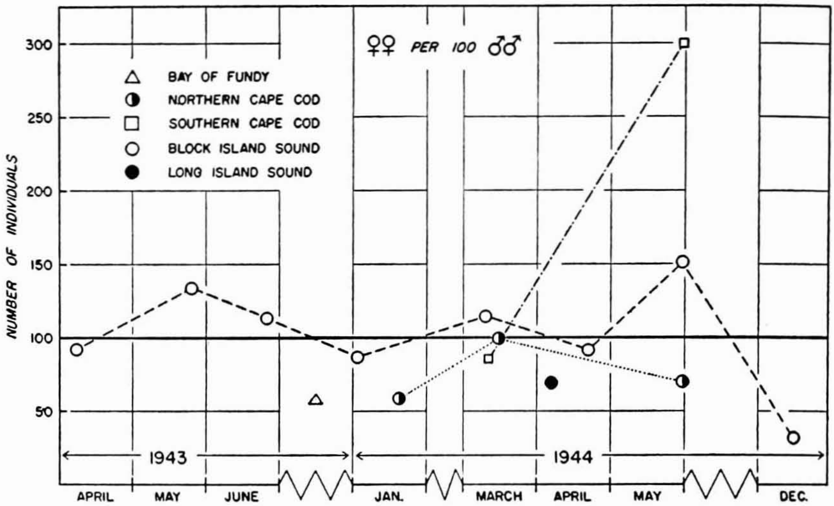

Figure 20. Sex ratios of ocean pout in the commercial catch by months in 1943 and 1944 expressed as number of females per 100 males. All samples involve 50 or more specimens, with the exception of the mid-March collection of 44 individuals from Block Island Sound. See Table X.

appear in the commercial catch, and a period during which they apparently migrate from the rocky areas in which they have spent the preceding summer and fall and have spawned. It thus appears that the males leave the rocky habitat first and are shortly followed by the females. White (1939) pointed to the possibility that both parents protect the developing eggs (p. 68). According to our estimates, hatching in southern New England waters occurs in December; the departure of the males from the rocky bottom probably coincides with the late egg and early larval stage of the embryos, which would indicate that the males, if indeed they do have any role in protecting the eggs, abandon their parental duties before the females do. In all events there seems to be little doubt that the males leave the rocky areas shortly before most of the females and therefore appear on the grounds worked by the commercial trawlers first. Conversely, there is some indication that the males leave the smoother areas and return to the rocky habitat first in May and June. Fig. 20 shows the dominance of females in two out of three of the May 1944 collections, as well as in the June 1943 sample. The extreme in female dominance was in the collection of May 30, 1944, from southern Cape Cod, where there

TABLE X. NUMBER OF MALE AND FEMALE *Macrozoarces americanus* IN DIFFERENT SAMPLES FROM VARIOUS LOCALITIES IN 1943 AND 1944

Locality	*Date*	♂♂	♀♀	*Total*	♀♀ *per 100* ♂♂
BAY OF FUNDY:					
Within 5 mi. of St. Andrews, New Brunswick	June 15 to Oct. 25, 1943	63	37	100	58.7
NORTHERN CAPE COD					
10 mi. SW. of Wood End Light	Jan. 20, 1944	95	56	151	59.0
8 mi. NNW. of Race Pt. Light	Mar. 15, 1944	36	36	72	100.0
2 mi. E. of Peaked Hill Buoy	May 30, 1944	60	42	102	70.0
SOUTHERN CAPE COD					
Nantucket Shoals, 40° 55′ N., 69° 35′ W.	Mar. 10–13, 1944	28	24	52	85.8
8 mi. SW. of entrance to Muskeget Channel	May 30, 1944	26	78	104	300.0
BLOCK ISLAND SOUND:					
2½–4 mi. off Watch Hill, R. I.	Apr. 7, 1943	26	24	50	92.4
2½ mi. NNE. of Block Island	May 25, 1943	32	43	75	134.3
2½ mi. NNE. of Block Island	June 15, 1943	30	34	64	113.3
Old Harbor, Block Island	Jan. 2, 1944	70	61	131	87.2
5 mi. SW. of Block Island	Mar. 12, 1944	76	87	163	114.5
3 mi. S. x E. of Watch Hill, R. I.	Apr. 19–23, 1944	23	21	44	91.3
3–4 mi. ENE. of Block Island	May 30, 1944	49	74	123	151.0
2 mi. S. of Charlestown Inlet, R. I.	Dec. 18, 1944	44	14	58	31.8
LONG ISLAND SOUND:					
3½ mi. N. of Pt. Herod, N. Y.	Apr. 6, 1944	88	61	149	69.4

were three times as many females as males. However, the conclusion that the males lead the way in returning to the rocky habitat in the spring does not rest on secure evidence. Quite apart from the previously indicated error in sampling the different sexes, note that the collection of May 30, 1944, from northern Cape Cod had a dominance of males. The hypothesis that the males leave for the summer and fall rocky habitat first therefore needs confirming evidence. On the other hand, the movement of the males from the areas of spawning and early development in the winter is more firmly established, although additional data would be necessary to settle the regularity and extent of this trend.

Both in the present section and elsewhere (pp. 39–42, 115) we have provided evidence to show that the general pattern of the movements of the ocean pout is seasonal. In southern New England waters this species appears in the catch of trawlers which work on relatively smooth bottom at depths of from 10–30 fathoms in late December and January; in the late spring (May and June) it essentially disappears from the catch, probably returning to rocky areas mostly within the 30-fathom contour for the period from June to December. The question now arises as to the extent and magnitude of these movements. Do they include the entire population or do they involve only the fish above a certain size and age? This is a point on which we have little information, for the trawl nets by which most of our collections were made were of such large mesh that they took relatively few small individuals. It is very seldom that ocean pout below 25–30 cm. are taken by such gear, but fish of this size and age (2+ and 3+ groups) are taken often enough to justify the conclusion that at least some of them are involved in the movements of the larger individuals. The capture of the smallest fish (0+ and 1+ groups) is so rare as to indicate that they probably do not, for the most part at least, take part in the movements of the larger elements of the population. If these young fish were present in large quantities they would be taken far more commonly than is actually the case, and they would almost certainly be found in the stomach contents of sculpins (*Myoxocephalus octodecimspinosus*) and angler fish (*Lophius americanus*[1]) taken in these hauls. Both of these fish, which are excellent living "bottom samplers," have been examined in detail in considerable numbers, but

[1] See Bigelow and Schroeder (1936) for the use of the specific name *americanus* as opposed to *piscatorius*.

neither of them have yielded a single ocean pout, although the rather closely related rock eel, *Pholis gunnellus*, has been recovered from them on several occasions. Thus, the almost complete absence of small ocean pout from the catch of the trawl net (which takes comparably small whiting, hakes, *etc.* rather profusely at certain seasons) and the failure to find them in the stomachs of sculpins or anglers provides evidence for believing that these small individuals are only present in limited numbers on the commercially trawled smooth bottom as strays from a more rocky habitat. Probably the majority of 0+ and 1+ fish, some 2+ and possibly older individuals, do not take part in the typical seasonal movements of the larger ocean pout. After the completion of the third year, however, great numbers of ocean pout undertake these movements, although it is impossible to say whether or not the total "adult" stock is involved, or what proportion, if any, remains in the rocky habitat on a year-round basis.

Racial Analyses

Racial studies on the American ocean pout should be of particular interest because of the classical work of Schmidt (1917a, b, 1918, 1920, 1921a, b) and Smith (1921, 1922) on the European *Zoarces viviparus*, as well as the more general studies of Hubbs (1922, 1924, 1926, 1934) and others on racial and individual variations in fishes. Probably the most concise statement of these researches is that of Hubbs (1934), who stated:

> The most extensive and best known race investigations with fishes are those of Johannes Schmidt (1917 to 1930) on *Zoarces* and other fishes . . . Schmidt's results are too well known to require much review. The analysis of thousands of specimens of *Zoarces* showed that this relatively stationary fish exhibits marked local variations, which are inherited though slightly modifiable; that the variations are correlated with hydrographic conditions, but not perfectly so correlated; and that the variations show annual fluctuations. Schmidt also obtained valuable results with individual modifications and inheritance in *Lebistes* and *Salmo*. In a more recent work (1930), a masterly investigation on the variation of the cod in the North Atlantic showed so strikingly the correlation of structural characters with water temperatures that the author placed more emphasis on this correlation than previously. In his *Zoarces* investigation, Schmidt made a rather strained effort to minimize the relation of the environment to the racial characters.
>
> . . . in my laboratory, we have stressed geographic and climatic trends in variation; parallel raciation; the correlation between rate of development and meristic characters; the probably indirect, adaptive significance of most

racial distinctions; the parallel but presumably unrelated racial and individual modifications, especially those determined by temperature acting during development; the great modification of characters by such factors as early parasitization and siltiness of water . . .

. . . Signs are not lacking that the study of variation in fishes and other animals is being rejuvenated into a live division of zoology. This study may well assume such a position, if it is prosecuted not as an end in itself, but as a tool to be used in solving problems in systematics, economic zoology, zoogeography and evolution.

As the various samples of ocean pout came to the laboratory, it was a routine part of the analysis to count the vertebrae. The flesh was filletted off one side so that the vertebral column was exposed, and counts were usually made without the aid of magnification, although it was easier to enumerate the last 10 or 15 caudal vertebrae with the help of powerful illumination from the uncleaned side of the fish. It was readily apparent on inspection of the data that the counts from any particular region were inaccurate at first; they showed consistent trends toward a more regular pattern as the accuracy of counting increased, and all the accumulated material before the attainment of constancy was therefore eliminated. Nevertheless, the number of vertebrae on which Fig. 21 and Table XI are based is 128,356. It is not surprising that inaccuracies in counting occur at first, for the difficulty is great because of the large number of vertebrae (131–144) and their relatively small size. In order to insure accuracy and constancy, one person did the vast majority of the counting. The hypural (Fig. 15C) was included throughout, and individuals with fused vertebrae (not uncommon) were noted but not included in the final analysis. Careful study of the data showed no consistent or significant difference between the individuals at the lower end of the length range and those at the intermediate and upper limits of size. Comparison of the counts in male and female individuals also showed no significant differences.

The summarization of the data in Fig. 21 and Table XIA and B shows that within the area studied it is possible to demonstrate significant differences in the vertebral counts of individuals from different localities. The right hand side of Fig. 21 shows the summaries of the frequency distribution of the vertebral counts from samples of ocean pout from five major regions—the Bay of Fundy, northern Cape Cod, southern Cape Cod, Block Island, and Long Island Sound. Table XIB shows the means and other pertinent data on the same material. The details of the individual samples are shown in the smaller frequency distributions on the left side of Fig. 21 and in Table XIA.

TABLE XI A. MEAN VERTEBRAL COUNTS AND NUMBERS OF INDIVIDUALS IN SAMPLES OF OCEAN POUT FROM DIFFERENT LOCALITIES. LETTERS BEFORE EACH AREA CORRESPOND TO THOSE IN FIG. 21. FOR RANGE IN VALUES SEE FIG. 21. NUMBERS IN PARENTHESES AFTER MAJOR AREAS CORRESPOND WITH THOSE SHOWN IN FIG. 3.

		♂♂		♀♀		♂♂ and ♀♀	
Locality	*Date*	*No.*	*Mean*	*No.*	*Mean*	*No.*	*Mean*
BAY OF FUNDY:							
Near St. Andrews, N. B.	VI–15 to X–25–1943	60	134.25	32	134.84	92	134.46
NORTHERN CAPE COD (8, 9):							
A. 10 mi. SW. of Wood End Light	I–20–1944	56	139.80	32	139.19	88	139.58
B. 8 mi. NNW. of Racepoint Light	III–15–1944	35	140.09	35	140.26	70	140.17
C. 2 mi. E. of Peaked Hill Buoy	V–30–1944	55	140.91	42	141.00	97	140.95
SOUTHERN CAPE COD (6, 7):							
D. Nantucket Shoals 40° 55′ N., 69° 35′ W.	III–10 to 13–1944	27	140.11	23	140.48	50	140.28
E. 8 mi. SW. of Muskeget Channel	V–30–1944	26	137.77	77	138.10	103	138.02
BLOCK ISLAND (3, 4, 5):							
F. ½ mi. SE. of Block Island	I–2–1944	67	137.97	60	138.30	127	138.13
G. 5 mi. SW. of Block Island	III–12–1944	72	138.07	86	138.00	158	138.03
H. 3–4 mi. ENE. of Block Island	V–30–1944	46	137.74	70	138.70	116	138.32
LONG ISLAND SOUND (1):							
3 mi. N. of Pt. Herod, L. I.	IV–6–1944	83	136.28	59	135.88	142	136.11

TABLE XI B. SUMMARY OF VERTEBRAL COUNTS OF FISH FROM MAJOR AREAS. SEE RIGHT HAND SIDE OF FIG. 21

	♂♂		♀♀		♂♂ and ♀♀				
Major Area	*No.*	*Mean*	*No.*	*Mean*	*No.*	*Mean*		*Deviation*	
Bay of Fundy	60	134.25	32	134.84	92	134.46	±0.204	1.96	±0.145
Northern Cape Cod	146	140.29	109	140.23	255	140.25	±0.111	1.78	±0.079
Southern Cape Cod	53	138.96	100	138.65	153	138.76	±0.174	2.15	±0.123
Block Island	185	137.95	216	138.31	401	138.14	±0.078	1.56	±0.055
Long Island Sound	83	136.28	59	135.88	142	136.11	±0.156	1.86	±0.110

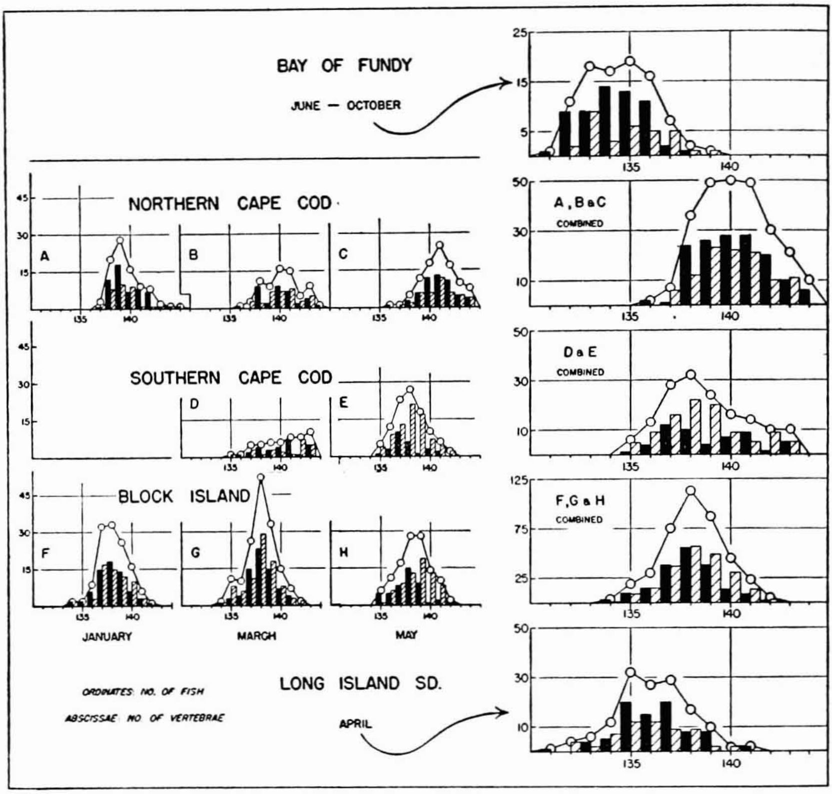

Figure 21. Frequency distributions of the vertebral counts of ocean pout from different localities. Black columns represent males, diagonally lined columns females, and the circles connected by lines are the totals of both sexes. Right side of graph shows the summarization of the data from the Bay of Fundy, northern Cape Cod, southern Cape Cod, Block Island, and Long Island Sound in that order reading down. The frequency distribution of the individual samples is shown in the smaller graphs on the left. See also text and Table XI A and B.

Note in Fig. 21, that with the exception of the sample from the Bay of Fundy, the summaries of the frequency distribution of the vertebral counts (reading from north to south) show a steady trend towards progressively lower levels. The sample from northern Cape Cod has a peak at 140 (mean 140.25), that from southern Cape Cod 138 (mean 138.76) with the curve skewed heavily to the right, that from Block Island 138 (mean 138.14) with the curve "normal," and that from Long Island Sound 135 (mean 136.11). The application of standard significance tests to these data indicates that the populations from northern Cape Cod are distinct from those of southern Cape Cod as regards vertebral count $\left(\frac{d}{\sigma d} = 7.6\right)$, that those from southern Cape Cod and Block Island probably show some intergradation, although they tend towards being distinct $\left(\frac{d}{\sigma d} = 3.6\right)$, and that those from Block Island and Long Island Sound are clearly different populations $\left(\frac{d}{\sigma d} = 12.5\right)$. It is of considerable interest that the Long Island Sound population is so distinct from the others. Ocean pout from this region are apparently much smaller on the average than those from other areas (Fig. 11F), a fact which was noted by DeKay (1842) and Linsley (1844), and which led these naturalists to consider these fish a different species (*Z. fimbriatus*). The general decrease in the number of vertebrae in the samples from northern Cape Cod to Long Island Sound is in all probability a reflection of slightly and progressively higher temperature conditions from north to south and west over this range during the fall and early winter months when spawning and early development occur. It is also a clear indication that relatively little coastwise migration occurs in the southern New England area. Rather, it seems that ocean pout move to and from their summer and fall rocky habitat (pp. 40, 110) within somewhat limited and circumscribed regions. The entire life history of this fish is apparently spent in the same general area, and there is relatively little interchange even between closely approximating regions. Within the four localities under discussion, the northern Cape Cod and the Long Island Sound regions are clearly distinct from the two intermediate areas (southern Cape Cod and Block Island); within the latter two regions there is probably some intermixture.

The sample from the Bay of Fundy is of particular interest. If temperature alone were the controlling factor in the number of vertebrae, the vertebral counts should be highest in fish from this area.[1] Actually they are lowest, with a mean of 134.46. There are two pos-

[1] The data of Clemens and Clemens (1921) and White (1939) indicate that the bottom temperature in the Bay of Fundy drops fairly rapidly from approximately 10° C. in mid-September to low levels (0° C.) by January. Our own data (Table V), as well as that of Bigelow (1933), show that the decline in bottom temperature over the same period in southern New England is in no way so rapid.

sible alternative explanations for this. The first could lie in the fact that the gradation of meristic counts from high (at low temperatures) to low (at high temperatures) only occurs within certain thermal limits, and that below and perhaps above this range in the American ocean pout the number of vertebrae is extremely low. But this hypothesis would be at variance with the findings of Schmidt (1921a) for *Salmo trutta*, where " . . . the lowest number of vertebrae was produced at intermediate temperatures, the value rising both with higher and with lower temperatures."[1] The other explanation is that the Bay of Fundy ocean pout are actually genetically different. Under the circumstances, this seems to us the more logical hypothesis. Additional data are needed to confirm this finding, especially since only one sample from the Bay of Fundy has been examined. There is no evidence from the present data that the number of vertebrae in fish from the same locality varies with the year in which they were born as demonstrated by Schmidt (*loc. cit.*); this is probably because the time of spawning of the American ocean pout coincides with a fairly regular temperature—a temperature which may vary in the different localities over the range of this species, but which, in combination with other factors, may control (in part at least) the time of spawning (pp. 73–77). It would be of great interest to carry this study further by filling in the gaps with samples from Maine, New Hampshire, northern Massachusetts and New Jersey waters and by obtaining additional collections from locations already sampled. Our own suspicion is that there are two major genetically separate populations of ocean pout, one in the northern part of the range including at least the Bay of Fundy, and one in the more southern part of the range at least from northern Cape

[1] Just at the time this paper was going to press, an article by Å. Vedel Tåning reached this country (Experiments on meristic and other characters in fishes. 1. On the influence of temperature on some meristic characters in sea-trout and the fixation-period of these characters. Medd. Komm. Havundersøg., Fisk., *11* [3]: 1–66. 1944). This work confirms Schmidt's (*loc. cit.*) findings that the highest number of vertebrae occur in fish raised at high and low temperatures, and that the lowest values are obtained at intermediate temperatures. Tåning demonstrates further that the number of rays in the dorsal and pectoral fins *increase* with rising temperatures. In regard to the fixation-period of the number of vertebrae, he states that it is presumably ". . . situated about the days or perhaps the hours, when the cell groups of the mesoderm segments in the tip of the tail have been separated." Usually the number of myotomes specific to the species is developed prior to hatching; but there are exceptions, *e. g.*, several oceanic muraenoid fishes which add numerous myotomes after hatching.

Cod south. Within these two divisions there are minor sub-populations which probably vary in their degree of distinctness; for example, the Long Island Sound sub-population is apparently set off from neighboring groups so that there is no intermixture, while the Block Island and southern Cape Cod ocean pout probably intergrade to some degree. Just where the dividing line between these two major genetically separate populations might occur is questionable, but clearly it should be somewhere between northern Cape Cod and the Bay of Fundy. The importance of additional collections and further investigation, both as a contribution to the life history of the ocean pout and because of the general implications of the subject to theoretical biology, needs no emphasis.[1, 2]

[1] After the present work had gone to press a paper by Vilh. Ege came to our attention (A transplantation experiment with *Zoarces viviparus* L. C. R. Lab. Carlsberg. Physiol. *23* [17]: 271–384. 1942). Ege's paper presents information on the relation between hereditary differences and differences produced by the environment. Characters investigated are the numbers of vertebrae, hard rays in the dorsal, and pectoral rays. The nature of the annual variations in vertebral number as reactions to the environment is illustrated by the parallel fluctuations of the values in the successive year-classes of two different populations over a period of years; it is also demonstrated by comparison of the embryos of the different year-classes with their mothers. The effects of genotypical influences are also demonstrated. The dorsal rays are not suitable for similar detailed analysis, but the results of pectoral fin-ray counts lead to the conclusion that the differences in value in this case are not hereditarily conditioned, but are exclusively of phenotypical nature.

[2] C. L. Hubbs, on reading this section on racial analysis in galley proof, suggested an alternate explanation of the material. He is inclined to interpret the data to indicate four races as follows: (1) An ocean race with about 140 vertebrae represented by samples A, B, C and D in Fig. 21 and Table XIA; sample A may represent a mixture of Massachusetts Bay and ocean fish. (2) An intermediate inshore race with about 138 vertebrae represented by samples E, F, G and H including the Martha's Vineyard and Block Island areas; the normal dispersion indicates that the samples are not mere mixtures of the two races on either side. (3) A Long Island Sound race with 136 vertebrae, comparable with fjord races of *Z. viviparus*. (4) A Bay of Fundy (Passamaquoddy Bay) race with 134–135 vertebrae, even more comparable with a fjord race. It seems clear that marine species in enclosed waters often have reduced numbers of vertebrae, although the factors involved (possibly higher temperatures, reduced salinities, or other physical and chemical or mere space factors) are unknown. If this interpretation is correct, the apparently parallel variation of the oviparous and viviparous species is most notable.

FEEDING HABITS[1]

Comments on the feeding habits of the ocean pout were made as long ago as 1804 by Peck, who noted a preponderance of echinoderm material in the specimens he examined (p. 32). Storer (1839, 1855) listed 16 molluscan shells from their stomachs. Goode (1884) stated that the ocean pout "feeds upon crustaceans and mollusks . . . ," and similar generalities are to be found throughout the literature. Clemens (1920) noted that the chief article of food in the Passamaquoddy Bay region is sea-urchins; other less abundant forms were barnacles, snails, small clams, hermit crabs, whelks, serpent stars and annulate worms. Clemens and Clemens (1921) recorded the identifiable stomach contents of 75 ocean pout in detail and came to the conclusion that this fish draws on molluscs (23 species), echinoderms (3 species), and Crustacea (12 species) almost exclusively for its food; they also listed three Annelida and a number of Chordata, including two small fish. The most common items of diet, in descending order, were: 1.) sea-urchin (*Strongylocentrotus dröbrachiensis*), 2.) whelk (*Buccinum undatum*), 3.) barnacle (*Balanus balanoides*), 4.) black mussel (*Mytilus edulis*) and tunicates, and 5.) mussels belonging to the genus *Modiolaria*. Bigelow and Welsh (1925) sum up the feeding habits as follows: "The American eelpout feeds on shelled mollusks, both bivalve and univalve, crustaceans large and small, echinoderms and other invertebrates, and less often on fish. . . . A large specimen caught in Massachusetts Bay, January, 1924, was packed full of brittle stars (ophiurans), spider crabs, and small sea scallops (*Pecten magellanicus*)."

Willey and Huntsman's (1921) observations on feeding habits are quoted on page 35. The work of MacKay (1929a) on the digestive system of the ocean pout also deserves mention. After a brief account of the anatomy of the alimentary tract and its appendages, this author discussed gastric digestion. Although it was possible to extract a proteolytic enzyme from the gastric mucosa, there is good evidence that this enzyme does not play an important role in gastric digestion. The difficulty of extraction, indicating its paucity, and the insufficiently acid reaction of the stomach (pH 6.5–8.4 in both fasting and fed animals) for the activity of a pepsin-like enzyme, provide evidence that this proteolytic enzyme is unimportant. "These facts show that if

[1] In presenting this account, we wish to reaffirm (p. 6) our indebtedness and gratitude to Pfc. F. E. Smith.

peptic digestion takes place in the stomach of the eel-pout it plays a subordinate or secondary part. The protein substances in the food of this animal are digested chiefly by the trypsin of the pancreatic juice, which probably regurgitates into the stomach." In a second paper on the bile in different fishes, MacKay (1929b) notes that in contrast to the neutral or slightly alkaline condition in warm-blooded animals, the bile in a series of fishes investigated, although sometimes neutral, tended toward the acid side. Thus the pH of gall-bladder bile in the ocean pout ranged from 5.4–6.2.

By way of comparing our ocean pout with the European *Zoarces viviparus*, the detailed work of Blegvad (1917) on the food of fish in Danish waters is of particular interest. Blegvad states that the viviparous blenny is one of the most common fishes in the plant region of the Kattegat Sound, Belts and Baltic, and contrasts it with other species which seek their food almost exclusively among the small fish and crustacea of the weed vegetation as follows:

> . . . Zoarces, on the other hand, although devouring a quantity of small crustaceans, which . . . make up almost half the entire stomach content, subsists to an essential degree upon the molluscs found in or on the bottom, or on the leaves of plants, such as *Macoma baltica*, *Cardium*, *Mytilus*, *Modiolaria discors*, *Rissoa* and *Hydrobia*, likewise various worms, especially *Pectinaria Koreni*, insect larvae, both the green ones living in the weed, and the red *Chironomide* larvae which live in the bottom. Finally, some few Ascidians (including *Ciona canina*), and a not inconsiderable amount of vegetable remains, but only a very slight quantity of small fish (abt. 1/35th of the weight of content of stomach). Among crustaceans, *Idothea* and *Gammaridae* are predominant, these two together making up about half the total content. The young of Zoarces eat not only copepods (*Harpacticoida*) but will immediately after birth (at which stage they have, however, already attained the comparatively large size of 4–5 cm.) attack *Diastylis*, ostracods, young *Gammaridae* and *Idothea*, and also young molluscs. Zoarces procures its food by a slow and methodical examination of every weed clump. The observer chancing to come upon one of these fish in search of prey among the *Zostera* will notice that it glides along with a very slow and easy undulating movement close to the bottom. Now and again it will take a great mouthful of weed, whence it might seem to be grazing, so to speak, on the vegetation, this constituting its food; as a matter of fact, however, one may soon discover that the fish, shortly after having taken such a mouthful, ejects the greater part of the vegetable mass, which it has only taken for the sake of the crustaceans and molluscs living thereon. As a rule, they do not succeed in separating the vegetable matter completely from the animal, especially the finest threads of algae; . . . no less than 106 gr. or 1/9th of the total stomach content examined consisted of algae, remains of *Zostera*, and plant detritus. A further

32 gr. consisted of detritus and sand, evidently swallowed involuntarily together with animals living buried in the bottom, such being found therewith in the stomach content. Zoarces masticates its food very thoroughly; on investigating a portion of the stomach contents by mixing it with clear water, the surface will be found covered with tiny fragments of the empty skeletal parts of small crustaceans; even the small *Rissoa* and *Hydrobia* are as a rule found crushed in the stomach contents. On examining Zoarces in the morning, before daylight, they will be found empty, or at any rate with very little in the stomach . . . It would thus seem that Zoarces do not feed at night, or if at all, less than during the day.

Methods

As the various samples of ocean pout listed in Table V were "processed" through the laboratory (p. 67), the contents of the stomachs (as well as a variable but small amount of neighboring intestinal material) were removed and preserved together in 10 per cent formalin. Each jar was fully labelled with the corresponding laboratory serial numbers so as to enable reference to all other data for each collection. After a certain amount of experimentation several methods were adopted as standard practice in analyzing the stomach contents and obtaining the relative proportions of the different components.

Small samples. When the preserved sample was less than a half pint, or if it contained a single food item in heavy predominance, it was analyzed completely. Quite frequently the sample was divisible into two components—heavy (shells, tests, sand, *etc.*) and light (most Crustacea, worms, flesh of molluscs and echinoderms, mucous fixed by formalin, *etc.*). These two parts were separated by adding water, stirring and pouring off the top fraction before it settled. Two or three such fractionings produced virtually complete separation and resulted in washing the material sufficiently to facilitate analysis. Each fraction was then resolved as far as possible into its component groups without the aid of magnification in flat enamel pans under water. Shells and tests were for the most part sorted to species at this time; Crustacea were separated into Peracarida, Natantia and Reptantia (Pratt, 1935), and such unique forms as caprellids, Cumacea and most of the crabs were sorted out if recognized. By this process the heavy component was often fully resolved, whereas the lighter fraction never reached that condition. The recognition of the different and new divisions with the naked eye, as well as the identification of fragments, of course improved rapidly with experience. Unrecognizable items were set aside for more detailed examination. Such material as remained after sorting was further searched under the binocular microscope, spoonfull at a time; all strange or new items were removed, and all sizable pieces of standard forms such as Crustacea or sand dollars were picked out. An estimation of the amount of the remaining material that was recognizable was then made; for instance, the quantity of echinoderm spines or the amount of crustacean legs and sclerites occasionally reached an appreciable percentage. In cases where one food was heavily predominant in the whole sample, a particular mollusc perhaps, the soft material that was obviously molluscan was assumed to be that of the particular species identified from the shell, and the percentage estimated. Finally a considerable proportion of the sample remained as an unidentifiable component—the digested and otherwise amorphous material including mucous from the fish.

The various groups resulting from the sorting described above were next examined in detail and identified as far as possible. After the sorting of the sample had been completed as far as was practical, the component parts were compared volumetrically. At first such hard, loose items as sand dollar tests, scallop shells, *etc.*, were measured by adding the drained material to a known amount of water and noting the increase in volume. But it was impractical to drain the fluid from the soft material in a comparable manner, so that the various components of this lighter fraction could only be measured directly in water by how high each came in a graduate after reasonable settling; thus the water included between the particles was also measured by this method. It was therefore decided that the same error should be included in the estimates of shells and tests if *comparable* measurements were to be obtained. In actual practice a graduate was rarely used. As a result of sorting the various items into vials it was possible to compare the relative amounts directly. A medium-sized item was chosen as equal to one, and other items were then compared with it and determined to be relatively 1½, 3, 1/6, *etc.* of the temporary standard, thus enabling the calculation of percentage values for each component. The percentage of unsortable material was further divided on the basis of the estimated percentages of recognized materials in it. In almost every sample a number of odd items were found that had inconsiderable percentage values. These were entered as "Miscellany," with the notation of any appreciable percentage, as judged by comparison with the rest of the sample, or a notation of negligible quantity. The successive steps in the actual analysis of a typical sample (the collection of II–29–'44, 8 mi. S. of Block I., R. I.) illustrate the methods outlined above.

No. 1. Sample divided by fractioning process into light and heavy portions.

No. 2. Each portion searched and separated as far as possible with the naked eye. In this instance the heavy fraction was completely resolved with the following components: Unsortable soft material; Sand dollar tests; Amphipods; *Cancer irroratus;* 8–10 miscellaneous items, some such as *Pecten magellanicus*, caprellids, hydroids, *etc.*, known and labelled, others unknown.

No. 3. Microscopic examination followed. Several new items were discovered in the soft material, as well as pieces of forms already known to be present. The amphipods were sorted as far as possible, yielding *Unicola*, gammarids, a few more pieces of caprellids, and stray bits of a shrimp. Unknown items were identified as far as possible. The sample was now divided fully and stood in 18 different containers.

No. 4. The relative volumes were next determined. The unsortable light material filled four vials; one of these was taken as a unit of one, yielding the following results:

Item	*Relative Volume*	*Percentage*
Light material	4	48.0
Unicola	1/8	1.5
Cancer irroratus	1/2	6.0
Nudibranchs (sp.)	5/8	8.0
Sand dollars	2 3/4	33.0
Miscellany (13 items)	1/4	3.0

No. 5. Analysis of the light material under the binocular microscope resulted in the following estimates:

Sand dollar (spines)	10%
Unicola	17%
Gammaridae	3%
Unidentifiable material (mucous, digested sand-dollar flesh, *etc.*)	70%

No. 6. Combining Nos. 4 and 5 gave the total analysis of the sample as follows:

Unidentifiable material	33.5%
Gammaridae	1.5%
Unicola	10.0%
Cancer irroratus	6.0%
Nudibranchs	8.0%
Echinarachnius parma	38.0%
Miscellany	3.0%

1. Sand....................trace
2. Hydroid..................2 fragments
3. Parasitic Acanthocephala....1 specimen
4. Unidentifiable Annelida.....1 fragment
5. Worm tubes (one containing annelid)..................2 specimens
6. *Phascolion strombi*..........1 specimen
7. Caprellidae................8–10 pieces
8. *Crago septemspinosus*........parts of 4 specimens
9. *Pagurus longicarpus*.........1 specimen
10. *Cardium pinnulatum*........1 shell
11. *Pecten magellanicus*.........several pieces
12. *Ensis directus*..............1 small specimen
13. Eggs (crab?)...............circa 50

Large samples. Many samples were so large that, unless they were composed almost entirely of one species, the time consumed in sorting would have been so great as to make impractical the analysis of the whole as described above. In such instances, two or three representative portions of the total sample were taken for sorting. Such portions were taken by first mixing the whole gently but thoroughly, and then spreading it out in a pan, surplus fluid first having been drained off. Two or three rectangular areas were next enclosed by microscope slides set into the material on edge so that they went clear to the bottom. The contained material was then entirely removed by spoon and pipette. By this method the relative proportions of heavy and light material were maintained—a necessary qualification since some settling was unavoidable. Each portion was then treated in the manner previously described for "Small samples," each being resolved into its component parts and the percentages determined. The various portions from each sample agreed with one another reasonably well throughout, the percentage variation being relatively small. They were therefore assumed to be representative of the whole, and the percentages of the different portions were averaged to obtain final estimates.

In every case the whole sample was scanned for obvious discrepancies in the percentage values and for odd items. If a particular species that had not been present in the analyzed portions appeared in an appreciable percentage, its value was estimated and the other figures raised accordingly. Sometimes it was necessary before sampling to remove a few large items such as sea mice (*Aphrodita*), fair-sized spider crabs, large clams, *etc.* The percentages of these items

Table XII. Analysis of Stomach Contents from 21 Samples of Ocean Pout from Different Areas. For Detailed Locality Data See Table V. The Number of Stomachs in the Different Samples Ranges from 1–100. The Percentage Values Are in Terms of Volume. Plus Signs Mean That the Item Was Less Than 1% of the Whole Sample; for Sum Total Percentages of These Minor Items See Under "Miscellany" (bottom of table)

Locality	Bay of Fundy	Northern Cape Cod			Southern Cape Cod		Block Island Sound Area		Block Island Sound Area—*Continued*													L. I. Sound
Date	VI-15 to X-25, '43	I-20-'44	III-15-'44	V-30-'44	III-10 to 13-'44	V-30-'44	IV-7-'43	V-11-'43	V-11-'43	IX-9, 12-'43	XI-25-'43	XII-19-'43	I-2-'44	I-19-'44	II-20-'44	II-29-'44	III-12-'44	IV-19-'44	IV-23-'44	V-18-'44	V-30-'44	IV-6-'44
Number of stomachs preserved	73	90	71	86	49	93	15	4	5	6	10	1	128	?	2	21	51	23	21	1	100	75
UNIDENTIFIABLE MATERIAL	25.0%	28.0%	43.0%	29.0%	....	26.0%	14.0%	33.0%	31.0%	9.0%	....	....	49.0%	13.0%	+	33.0%	7.5%	22.0%	25.0%	25.0%	20.0%	17.0%
MISCELLANEOUS:																						
Sand and/or stones	+	....	....	2.0%	....	1.0%	9.0%	4.0%	1.0%	+	....	....	....	2.0%	....	+	2.0%	+	+	....	2.0%	....
Algae (several spp.)	+	....	....	....	....	....	....	+	+	+	....	....	....	....	....	....	+	....	....	....	....	....
Mud tubes	....	....	+	+	....	+	....	....	....	+	....	+	+	....	....	....	6.0%	1.5%	4.0%	5.0%	2.0%	+
Membranous tubes	....	+	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....
Sand tubes (small and brittle)	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....
HYDROIDS	+	....	+	+	+	+	....	....	....	....	....	....	....	....	....	+	+	+	+	+	+	+
ACANTHOCEPHALA (PARASITES)	+	....	....	....	+	+	+	....	....	+	....	....	+	+	....	+	+	+	+	+	+	....
NEMATODA (PARASITES)	+	+	+	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....	....	....	....
ANNELIDA:																						
Aphrodita hastata	6.0%	+	4.5%	....	....	0.5%	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.0%	+
Lepidonotus squamatus	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Terebellidae?	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+
Cistenides (tube)	....	....	+	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Spirorbis	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sabellariidae?	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Other annelids	1.0%	+	+	....	....	....	....	....	....	+	....	+	+	....	....	+	+	....	....	....	+	+
SIPUNCULIDA:																						
Phascolion strombi	+	....	....	+	....	....	....	....	....	....	....	....	....	....	....	+	+	....	....	....	....	....
MYSIDACEA:																						
Heteromysis formosa	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....
CUMACEA:																						
Diastylis bispinosus?	....	....	+	....	....	....	....	....	....	+	....	....	....	....	....	....	....	....	+	....	....	....
Other Cumacea	....	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....	+	+	....	....	....	....
AMPHIPODA:																						
Gammaridae	13.0%	....	9.0%	+	19.0%	25.0%	1.0%	+	+	56.0%	42.0%	....	47.0%	70.0%	....	1.5%	31.0%	47.0%	35.0%	52.0%	51.0%	+
Ampelisca?	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+	+	....	....	....
Unicola	....	....	+	18.0%	....	+	4.0%	42.0%	....	4.0%	+	....	+	+	....	10.0%	8.0%	5.0%	7.0%	5.0%	6.0%	+
Caprellidae	+	5.0%	+	+	....	....	+	+	....	+	+	....	+	....	....	+	8.0%	3.0%	+	....	+	....
Other amphipods	....	+	....	+	....	....	....	....	....	....	....	....	+	....	....	....	+	....	+	....	....	....
ISOPODA:																						
Edotea triloba?	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....
Cirolana concharum?	....	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
STOMATOPODA:																						
Chloridella	....	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....	....	....	....
DECAPODA:																						
Crago septemspinosus	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....	+
Pandalidae	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Upogebia	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+
Pagurus longicarpus	....	....	6.0%	+	....	....	....	+	....	....	....	....	....	....	....	+	+	....	....	....	....	....
Pagurus pollicaris	....	....	1.0%	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Libinia	....	....	4.5%	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Cancer irroratus	....	....	2.0%	+	....	2.0%	9.0%	....	....	30.0%	57.0%	99.0%	1.0%	+	....	6.0%	3.0%	5.0%	7.0%	....	15.0%	2.5%
Pinnixia?	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+	....	+	....	+
PYCNOGONIDA:																						
Tanystylum?	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Nymphonidae	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
GASTROPODA:																						
Pteropoda	....	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....	....	....	....
Nudibranchiata	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8.0%	5.0%	....	....	....	+	....
Retusa pertenuis	....	....	+	+	....	....	....	....	....	....	....	....	+	+	....	....	....	....	....	....	....	....
Acteocina canaliculata	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+
Margarites groenlandicus	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Margarites cinerea	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

TABLE XII. ANALYSIS OF STOMACH CONTENTS FROM 21 SAMPLES OF OCEAN POUT FROM DIFFERENT AREAS. FOR DETAILED LOCALITY DATA SEE TABLE V. THE NUMBER OF STOMACHS IN THE DIFFERENT SAMPLES RANGES FROM 1–100. THE PERCENTAGE VALUES ARE IN TERMS OF VOLUME. PLUS SIGNS MEAN THAT THE ITEM WAS LESS THAN 1% OF THE WHOLE SAMPLE; FOR SUM TOTAL PERCENTAGES OF THESE MINOR ITEMS SEE UNDER "MISCELLANY" (BOTTOM OF TABLE)

Locality	Bay of Fundy	Northern Cape Cod			Southern Cape Cod		Block Island Sound Area		Block Island Sound Area—*Continued*													L. I. Sound
Date	VI–15 to X–25, '43	I–20–'44	III–15–'44	V–30–'44	III–10 to 13–'44	V–30–'44	IV–7–'43	V–11–'43	V–11–'43	IX–9, 12–'43	XI–25–'43	XII–19–'43	I–2–'44	I–19–'44	II–20–'44	II–29–'44	III–12–'44	IV–19–'44	IV–23–'44	V–18–'44	V–30–'44	IV–6–'44
Number of stomachs preserved	73	90	71	86	49	93	15	4	5	6	10	1	128	7	2	21	51	23	21	1	100	75
GASTROPODA—Cont.:																						
Odostomia seminuda	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Polynices triseriata	....	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Polynices heros	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....
Polynices groenlandicus?	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+	....
Velutina laevigata	....	....	+	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Lamellaria	....	....	+	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Urosalpinx	2.5%	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Mitrella lunata	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....
Anachis avara	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....
Nassarius trivittatus	+	....	....	+	....	+	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....
Colus pygmaeus	+	....	+	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Lora nobilis	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Lora harpularia?	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Hydrobia minuta	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+
Unidentifiable	....	....	....	+	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....	....	....	....
PELECYPODA																						
Nucula proxima	....	....	....	....	....	+	....	....	....	+	....	....	+	....	....	....	+	+	....	....	+	+
Nucula delphinodonta?	+	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....
Nuculana tenuisulcata	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Yoldia sapotilla	+	+	....	....	....	+	....	....	....	+	+	....	....	....	....	....	+	....	....	....	+	....
Yoldia limulata	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	78.0%
Pecten islandicus	10.0%	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pecten magellanicus	....	....	6.0%	29.0%	....	....	6.0%	....	....	....	....	....	....	....	....	+	....	....	....	....	....	....
Mytilus edulis	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Modiolus modiolus	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Modiolus byssus	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....
Modiolaria nigra	+	....	....	+	....	+	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....
Crenella glandula	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Astarte castanea	....	....	....	+	....	....	....	+	....	....	....	....	....	+	....	....	....	....	....	....	....	....
Astarte	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+	....
Cardium pinnulatum	1.7%	+	+	3.0%	....	+	....	....	....	+	....	+	+	+	....	+	2.0%	+	+	7.0%	+	....
Mulinia lateralis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+
Venus?	+	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....	+
Callocardia convexa	....	....	+	....	....	....	....	....	....	+	....	....	+	....	....	....	....	....	....	....	....	....
Ensis directus	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+	+	+	+	+	....	....
Mya arenaria	7.0%	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Saxicava	+	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Cochlodesma leanum	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Lyonsia hyalina	....	....	....	+	....	+	....	....	....	....	....	....	....	....	....	....	+	+	+	+	....	+
Pandora	+	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Myrtaea	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....
ECHINODERMATA:																						
Solaster endeca	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Asterias vulgaris?	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Ophiura robusta	....	67.0%	13.0%	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Ophiurae	1.0%	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Strongylocentrotus drōbrachiensis	18.0%	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Echinarachnius parma	+	....	9.0%	16.0%	81.0%	44.0%	34.0%	18.0%	68.0%	+	....	....	+	12.0%	....	38.0%	20.0%	14.0%	18.0%	....	+	....
TUNICATA:																						
Molgula?	1.3%	....	+	....	....	+	21.0%	+	....	....	....	....	....	....	....	....	+	+	....	+	....	....
VERTEBRATA:																						
Clupeidae	7.0%	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Myoxocephalus octodecimspinosus (eggs)	....	....	....	....	....	....	....	....	....	....	....	....	....	....	100%	....	....	....	....	....	....	....
MISCELLANY	5.0%	+	2.0%	3.0%	+	1.5%	2.0%	3.0%	+	1.0%	1.0%	1.0%	2.0%	3.0%	+	3.0%	8.0%	2.0%	4.0%	6.0%	2.0%	2.5%

were determined by the relative volume process (No. 4, p. 122). Portions of the remaining sample were then analyzed, and the values of the different items calculated on a correspondingly lowered percentage basis.

In certain groups it was impossible to identify the items to species or even genus. Referring to the Gammaridae, this group in our listing probably includes several species and possibly other closely allied Amphipoda. Even if these were identifiable, any estimate of the relative quantities of each of the types involved would have been virtually impossible since too many of the individuals were fragmented.

Furthermore, the accuracy of the percentage figures derived for each item in the separate stomach content samples (Table XII) is not very high in certain respects. For instance, if food as such be considered, identical values of nudibranchs or amphipods on the one hand, and *Pecten* shells or sand dollar tests on the other, must differ considerably in food content. Even the volumes of the different animals before digestion would differ considerably, and not all the items would change volume in the same direction or degree. But in comparing the relative percentage of one item through a series of samples, the figures are probably fairly accurate. For example, if in one sample the value assigned to *Pecten* was 15 per cent, and in another it was 30 per cent, the second sample would have very close to twice as much *Pecten* as the first. The same item was always measured in the same way. Thus the percentages obtained for any particular item bear proper relation to each other throughout. It is for this reason that the percentage figures in Table XII read at times to the nearest 0.5 per cent and were not rounded to the nearest 5.0 per cent. The accuracy of the absolute values is approximately ±5.0 per cent.

Results of Analysis

The analysis of the stomach contents from 21 samples of ocean pout from different localities are shown in Table XII. Note that the stomach contents of over 850 ocean pout were examined in the course of this work, and that the identifiable forms include a wide variety of invertebrates as well as a number of chordates.

The most common item of diet is to be found in the Gammaridae, with the sand dollar (*Echinarachnius parma*), the crab (*Cancer irroratus*) and *Unicola* running close seconds. Among the molluscs, *Cardium pinnulatum* appears with surprising regularity, although in minimal quantities, while members of the *Pecten* and *Yoldia* genera are occasionally eaten in large quantities. Tunicates also make up a portion of the stomach contents with considerable frequency. The eggs of the sculpin (*Myoxocephalus octodecimspinosus*) are sometimes taken in great quantity (Block Island Sound area, II–20–'44); these eggs are often laid in the dead man's finger sponge (*Chalina*) in the winter and afford a good source of food to those fish which are capable of exploiting it. We have found large masses of sculpin eggs in the cod (*Gadus morhua*), along with stray pieces of sponge which they also ingest, but no such pieces of sponge were found in the stomachs of ocean pout which had fed on these eggs—a probable indication that the mode of feeding described by Blegvad (1917) on page 119 for *Zoarces viviparus* holds true for its American counterpart. The eggs of the sea raven (*Hemitripterus americanus*), are also laid in association with this sponge (Warfel and Merriman, 1944); we have found these eggs in the stomachs of ocean pout which were not included in the detailed analyses in Table XII, as well as in the stomachs of cod.

Bigelow and Welsh (1925) indicate their belief that ocean pout not infrequently feed on other fish, but the results of the present study do not confirm this. Apart from demersal eggs, fish remains were found in only one of the 21 samples; these were in the collection from the Bay of Fundy and were probably herring which had sunk to the bottom after death. In short, it seems most unlikely that ocean pout feed on living fish to any appreciable extent; rather, it appears that this species is essentially a bottom feeder, and that the only fish it takes are those that have recently fallen to the bottom dead, or that live in the shelter of plants which the fish masticates for associated animal life, as indicated by Blegvad (1917). Conclusions as to the piscivorous habits of this species are dubious when based on its capture with fish-baited lines and on the evidence from Willey and Huntsman (1921), who fed fish to ocean pout in captivity; in view of the data here presented, these observations are more likely to indicate that this species is at times a scavenger, a fact which would appear to be wholly compatible with its catholic choice of bottom and near-bottom fauna.

In general, the number of empty stomachs in the samples listed in Table XII was small. With the exception of the small samples in the fall and early winter of 1943 (Table V) and the three hauls on May 30, 1944, the percentage of recorded empty stomachs varied from 0.7–7.0

per cent of the total number examined. In the May 30, 1944, collections the percentage of empty stomachs ranged from 10.5–18.7 per cent, and it is conceivable that the consistently higher proportion of empty stomachs in these samples is significant; this may be indicative of a change of feeding habits preliminary to movement to the rocky habitat for the summer and fall months (p. 110). Indeed, it may possibly be that movement to these rocky areas is governed by choice of food in the late spring and early summer. In the fall and early winter the percentage of empty stomachs varied from 38.4–75.0 per cent. This might be taken as an indication that there is a tendency to stop feeding in the period preceding and during spawning, but the small size of the samples precludes any possibility of a well substantiated generalization on this matter. Moreover, in the sample of 18 fish taken on November 25, 1943, which was well after the conclusion of spawning, eight (44.4%) had empty stomachs. This fact might also be taken as evidence that movement from the rocky habitat in December is governed by food conditions. But here again, the small size of the sample makes this hypothesis mere speculation. Furthermore, the wide variety of food which this species takes makes it seem unlikely that any particular item or combination of items of diet would control its movements. Finally, in explanation of Table XII note that the figures after the entry, "Number of stomachs preserved," refer only to the stomachs which contained food material—*i. e.*, they do not include those which were empty.

The present data are inadequate to confirm Blegvad's (1917) conclusion regarding *Zoarces viviparus* that feeding, if it occurs at all at night, is less than during the day. All the samples comprising our material were taken in the daytime. However, one (January 2, 1944) was taken during the first hour and one-half of daylight, and the number of empty stomachs constituted only 1.6 per cent of the sample.

Finally, this analysis of the stomach contents is of interest because of its parasitological implications. Cross reference should be made to the succeeding section as well as to the paper by Nigrelli in this issue for further information on the subject. In regard to the parasites of the digestive tract, the presence of Acanthocephala and Nematoda in the stomach contents has been noted in Table XII. The Acanthocephala occurred with a fairly high degree of regularity in the collections from the different regions, except for the three samples from northern Cape Cod and the one from Long Island Sound. Nematodes, on the other hand, while present in the Bay of Fundy collection[1] and in two out of three samples from northern Cape Cod, were absent in all other collections except one from the Block Island Sound area on January 19, 1944.

On the matter of the discovery of possible intermediate hosts or vectors for certain of the parasites of the ocean pout, the data presented in Table XII provide clear indication of the relative frequency with which different organisms are eaten by *Macrozoarces americanus;* they thus offer direct clues in any investigation directed toward this end. However, where intermediate hosts are concerned the degree of parasitization of the final host may depend on the *frequency* with which the organisms are eaten and not on their size; the percentages in Table XII are volumetric, so that a low value opposite an amphipod probably represents more individuals than a much higher value for certain molluscs. Furthermore, the dates of the collections on which the stomach content analyses are based are not strictly comparable. Thus the sample from the Bay of Fundy was taken in the summer months, while all other samples were from winter and spring months. We have already stressed the seasonal movements of ocean pout in southern New England waters (p. 110), and it may well be that the feeding habits are different in the summer and fall rocky environment from what they are in the winter and spring when the fish are on relatively smooth bottom. Therefore, the possibility of parasitization resulting from the injestion of a particular intermediate host found in the summer and fall rocky habitat should not be excluded; our data are inadequate to establish whether or not the feeding habits are significantly different in the summer and fall from those in the winter and spring.

[1] Clemens and Clemens (1921) stated: "Of 44 specimens examined for intestinal parasites, 45 per cent contained nematodes and 35 per cent tapeworms." They made no mention of Acanthocephala, and we encountered no tapeworms (*Bothrimonus intermedius* Cooper). The nematodes were identified as *Kathleena* sp. (see Nigrelli) and *Echinorhynchus* sp.

INCIDENCE OF *PLISTOPHORA MACROZOARCIDIS* NIGRELLI AND OTHER PARASITES[1]

When this microsporidian parasite was first called to our attention by R. P. Hunter of the Connecticut State Board of Fisheries and Game, little or nothing was known about it. Consequently the following major objectives were recognized.

1) To provide data on the percentage of infections by *Plistophora macrozoarcidis* Nigrelli and other parasites in population samples from as many scattered localities at different times as possible, thereby determining whether or not seasonal and regional differences existed.

2) To obtain an approximate estimation of the efficiency of the candling method (by transmitted light) used in the commercial filleting houses.

3) To determine the percentage of infections detected by gross examination and candling.

4) To observe whether or not the infections are more prevalent in one part of the body of the fish as compared with another.

5) To detect, if possible, any relation of infection to size, sex, stomach contents, *etc.*

Although these infection studies are primarily concerned with *Plistophora macrozoarcidis* Nigrelli, we observed and noted as many other infections of the *flesh* as possible, but neither assistance nor time were adequate to make more than preliminary observations on some of these parasites. Nigrelli has identified and described some of this material; our considerations are confined mostly to macroscopical observations. He has also dealt with the parasites from the digestive tract (refer to his paper, as well as to our section on the stomach contents), and has given an account of the parasites described previously for *M. americanus* by other workers.

In a study of this nature, where large quantities of material were handled, most of the *Plistophora* and nematodes were quite easily determined by their distinctive characters, but some bodies in the flesh were encountered which could not be identified without histological study. Time for this was not available. Therefore any questionable material (probably less than 5%) was noted and preserved. Some *Plistophora* are unquestionably among this material, as well as

[1] We wish to acknowledge our particular appreciation to Grace E. Pickford for her generous assistance and counsel in this study.

Chloromyxum and other bodies. In the following accounts and discussion only positively identified infections are considered.

Plistophora macrozoarcidis Nigrelli is a parasite of very great abundance in ocean pout from southern New England and appears to a lesser degree in the region of northern Cape Cod and St. Andrews, New Brunswick, Canada (Tables XIII, XIV, XVIII, Fig. 22, 23, pp. 138, 167). Sandholzer, Nostrand and Young (1945) report it as far south as New Jersey. The incidence varies considerably in different areas and at different seasons of the year. Although large infections may be found very occasionally in the round fish by palpation,[1] most of them are detected in the skinned fillets. Some of the larger ones on the surface of the fillets are readily apparent and others more deeply imbedded in the flesh are palpable, but for the most part candling is necessary to detect most of the infections, particularly the smaller ones. Of course the light must be adequate and the flesh not too thick if all are to be located (p. 136). These microsporidian parasites, which are intramuscular and appear to have a distinct specificity for the ocean pout's muscle (p. 152), may be found either anterior or posterior to the anus, or both (Tables XV–XVII, p. 156), and are often more numerous and of a larger size anteriorly than posteriorly. *Plistophora* vary in size as well as shape, depending on their age and stage of development (pp. 144–151). In the same collection, fish may be found with only a minute individual trophozoite as small as 0.5 mm., while others may contain numerous large and well-established lesions of many centimeters in length and width.

The *minute* infections, which involve only a single muscle, are either whitish, cylindrical and quite flaccid (presumably an early stage of infection when no spores or only immature ones are present) or cream-colored, smoothly ovoid to fusiform and firmer (a later stage with more advanced spore development). In candling, the former appear whitish and transparent, while the latter appear darker and opaque in contrast to the flesh, as do the larger ones also. A fish may show only one of these minute individual trophozoites, or more, but occasionally the flesh of the entire host is peppered with countless

[1] In the Block Island area, where the incidence was very high, we examined 707 specimens externally by palpation. Only 11 fish were determined as infected by this method (about 1½ %). In each case the infection was close to the skin and sufficiently large to distend it.

numbers of either the light or dark forms, or both. The light form was much more abundant in our January collections than later in the season (p. 168). Two, three or more of these minute fusiform trophozoites in adjacent muscles form *small* lesions. *Moderate* lesions (1 to 2 cm.) and *large* (2 or more cm.) are either firm or soft, light or dark; some are darker in the center and light on the periphery, sometimes oozy and pus-like. Considering the varying three dimensional aspects of the infections, our estimates of size are subject to a large degree of error and therefore they must be considered as very approximate. Partly or completely encrusted infections were observed occasionally, suggesting a host reaction to the infection (p. 155).

Metacercarial Cysts. Time permitted no more than a survey of the incidence of these parasites (Table XIII, pp. 144–151). They were abundant in all our collections of 1944 from northern Cape Cod to Long Island Sound. They can be observed only by candling clean skinned fillets, and then sometimes only by careful scrutiny. They appeared in the flesh as small round dots (not ovoid or fusiform as in *Plistophora*) somewhat larger than the head of a common pin, some of which were light, others dark, presumably depending on their stage of development or location (p. 204); some hosts showed only a few while others contained large numbers of them. They were present in any or all parts of the flesh but were most easily observed by transmitted light in the tail region, from the skinned side, where the flesh is thin. Foreign substances may have been interpreted as metacercarial cysts in some cases, but for the most part the figures stated in the data give a fair indication of the incidence.

Chloromyxum clupeidae Hahn was observed very occasionally in the muscles; we can give no data on its actual abundance, since the positive identification of this parasite requires microscopical examination. Those which were positively identified were somewhat whiter than *Plistophora*, softer and more smoothly ovoid, without the papillary features which are characteristic of *Plistophora*. Those that we have observed do not reach a size of much more than one cm. When ruptured they are very oozy and pus-like, more so than *Plistophora* (see p. 190).

Porrocaecum decipiens (?) Krabbe. These round worms were present in all collections from Canada to Long Island Sound (Table XIII, pp. 144–151). The infestation was much heavier than *Plistophora* in the St. Andrews collection of 1943 (p. 138), but on the other hand they were present to a much lesser degree in the more southerly parts of the range, where the protozoan parasite was predominant. They were not as easily detected as the microsporidians unless they were present in large quantities; this difficulty of detection probably arises from the fact that their color for the most part is closely akin to that of the flesh. These nematodes are most efficiently detected by candling the skinned fillets, but oftentimes they were observed only when slight clouded areas indicated their presence. Some were observed when the flesh was cut, but they were most often deeply imbedded, coiled, and encapsulated; groups of two or three of varying sizes were occasionally found together. In Canada the worms are unquestionably detrimental to the marketability of the ocean pout, as judged by our sample, but from northern Cape Cod to Long Island they are not as significant as *Plistophora.*

Yellow bodies of a fatty nature were observed in numerous specimens, but their nature and function are not known. These were seen in the muscle of the abdominal region next to the skin, none being seen posterior to the anus. Macroscopically they appeared yellowish to orange, small and ovoid to large and irregular in shape; under the binocular these masses showed great numbers of small oily globules which floated to the surface of the water when separated from the mass. They were observed in specimens with or without *Plistophora;* sometimes microsporidian parasites and these masses were in close proximity; nematodes were present in a few specimens possessing fatty bodies. The incidence of these bodies was relatively low in the Provincetown and Long Island areas, higher in the Block Island and southern Cape Cod regions (Table XIII, pp. 144–151, 155).

Methods Used in Determining Infections

Candling Technique. This method of examining the flesh for infections by transmitted light was consistently maintained. As much of the flesh as possible was removed by cutting close to the pectoral girdle and then lengthwise along the vertebral column to the tail; each fillet was then skinned. The carcass and fillets were examined for any infections which were large and obvious enough to be seen without candling (gross examination) and these were noted. The fillets of each specimen were kept separate so that specific data could be recorded for each individual. They were thoroughly washed, since foreign substances on the surface reduced the efficiency of detecting small infections. The possibility of overlooking parts of *entire* fillets was early recognized, and therefore each one was cut into smaller sections. Since the anterior sections were much thicker than those posterior, they were sliced to as near the thickness of the posterior pieces as possible, but considerable variation still persisted. However, we are quite certain that few infections, if any, were overlooked because of the thickness of the fillets.

The candling was performed against a 10-inch diameter drop shade at eye level, a 100-watt bulb being used as a light source. The drop shade protected the eyes against the direct glare of the light, but the fillet, which was held at the lower edge of the shade, received the full strength of the light so that even the smallest infections could be detected easily. Each piece was subjected to candling from both sides, since infections embedded in the flesh often may be seen from one side only. Furthermore, the number of observers was limited to two, with the final decision regarding all infections resting with one worker. Only fresh material was used; much of it had to be placed in a freezer for varying periods because of the fact that it took many days to handle a large collection. Material preserved in formalin or alcohol is unsatisfactory, inasmuch as the flesh becomes relatively opaque and the parasites, particularly the minute ones, cannot be seen easily. The heads and viscera of specimens were not examined for infections as carefully as the flesh. In view of the fact that the candling method was new and unfamiliar, a few large collections taken in early January 1944 were used for experimentation and practice, thus making it possible to obtain consistent and accurate data on the subsequent collections.

Cubing Methods. The collections of 1943 were examined for infections in a very incomplete manner. Each specimen was filleted on both sides, but the skin was left attached, and the flesh was then severed over its entire length by numerous horizontal cuts down to the skin, these cuts being parallel and close to each other. Sometimes longitudinal cuts were made also which gave the flesh the appearance

TABLE XIII. *Plistophora macrozoarcidis*, *Porrocaecum decipiens* (?), METACERCARIAL CYSTS, AND YELLOW BODIES DETECTED IN THE MUSCLE OF OCEAN POUT

Locality	*Northern Cape Cod*				*Southern Cape Cod*				*Block Island*				*Long Island Sound*	
Date	*III/15/44*		*V/30/44*		*III/10–13/44*		*V/30/44*		*III/12/44*		*V/30/44*		*IV/6/44*	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total number of specimens in sample	72	—	102	—	52	—	104	—	162	—	123	—	150	—
Specimens infected with:														
Plistophora macrozoarcidis	21	29.0	4	3.9	21	40.4	48	46.2	105	64.8	53	43.1	70	46.6
Porrocaecum decipiens (?)	11	15.3	15	14.7	5	9.6	5	4.8	3	1.8	8	6.5	10	6.7
Metacercarial cysts	69	96.0	81	79.0	38	73.0	54	52.0	150	93.0	88	72.0	143	95.0
Yellow bodies	1	1.4	3	2.9	23	44.3	22	21.2	30	18.5	57	46.4	5	3.3

of being cubed. Thus it was possible to observe both the infections on the cut surface as well as the larger ones within the flesh. However, by this method minute infections and probably some of the larger ones could not be detected. To add further to the inaccuracy, numerous persons worked on the examination of the fillets, the horizontal and longitudinal cuts were irregular, and the observations were generally inconsistent. Since no conclusions can be drawn from these data which are not obtainable from the collections of the following year, they are omitted except for the collections taken at St. Andrews, New Brunswick, Canada.

The St. Andrews' Collection of 1943

Of the 98 specimens[1] from St. Andrews which were examined by the *cubing technique*, only five were infected with *Plistophora* (about 5%); obviously all infections were large enough to be seen without the aid of transmitted light and were present in specimens over 40 cm. Four specimens had only one concentration of trophozoites per fish, each located anterior to the anus in the abdominal region; in the fifth specimen the infections were small and scattered in the flesh posterior to the anus. But this same collection was highly infected with nematodes; these were found in 58 specimens (about 60%), ranging from 35.5 to 70.5 cm., and in many instances the infestation per specimen was so heavy that the flesh had a porous appearance. Of all collections studied, this one contained the highest nematode infections by far.[2]

It is of interest to mention here that Clemens and Clemens (1921) observed the flesh of 41 specimens from this same area and reported no *Plistophora*, although they obtained an incidence of nematodes which was similar to that found in our collection (about 60%).[3] How-

[1] Two additional small specimens of this collection were preserved *in toto* and not examined for infection. However, these fish were so small that it is very unlikely that they contained any *Plistophora*, since specimens of approximately the same size in other collections contained no obvious parasites.

[2] Four specimens, taken in this same region on June 15–16, 1943 (Table V), which ranged in size from 59 to 74 cm., were also examined for parasites by the cubing method. All of these fish were infected with nematodes, and two were infected with *Plistophora*, of which one specimen contained only one infection of moderate size, while the other had three large ones anteriorly and a smaller one posteriorly.

[3] Clemens (1920) stated:

> Similar worms have been found in the muscles of flounders and cod taken in the same region and possibly this parasitism may be only local and only occur to any

ever, the largest number of nematodes which they noted in any one specimen was three, whereas in many of our specimens there were countless numbers. Unfortunately these authors did not state by what method they examined their specimens for parasites, but judging from the fact that they found no *Plistophora*, and only three worms at most in a fish, it is very probable that their examination was even more incomplete than ours. It is possible also that none of their specimens contained *Plistophora*, for their total sample of 41 specimens was less than half the number in our collection, and we obtained only a five per cent incidence in 98 specimens, which is relatively low. But there is also the possibility that their sample, as well as ours, may have had minute *Plistophora* in the muscle which were too small to be observed by the methods employed.

If Clemens and Clemens were accurate in their observations, and if no *Plistophora* were present in their sample, then it is suggested that the incidence of this microsporidian may be more abundant in some years than in others, it may have infested the ocean pout of the Bay of Fundy in recent years only,[1] the incidence may vary within the local populations of the Bay, or it may vary seasonally. Unknown factors, such as the feeding habits, may also be related to the incidence. Although no vectors are known for microsporidians, they may conceivably exist. The stomach contents of our specimens, when compared with Clemens and Clemens observations, suggest that the Gammaridae, *Aphrodita hastata* and *Urosalpinx* (Table XII) might serve as secondary hosts.

Commercial Candling

At both New Bedford and Provincetown, Massachusetts, observations were made at commercial filleting plants which showed that commercial candling is inadequate and that infected fillets were being shipped to market in spite of the apparent precautions.

A sample of 61 specimens (122 fillets) was observed at a processing plant at New Bedford on January 19, these fish having been taken

extent in certain years. Authorities on fish parasites are agreed that there is no evidence that these round worms can live in the human body and when the fish is cooked there is absolutely no danger. The worms do not render the fish unfit for food and if flounders and cod so parasitized find ready sale, the muttonfish need not be condemned.

[1] Sandholzer, *et al.* (1945), also suggested the possibility "that *Ichthyosporidium* [*Plistophora macrozoarcidis*] may be a recent parasite of this fish."

about six miles due south of Block Island. The specimens were fresh, and the viscera showed no signs of deterioration. The skinner, when culling, discovered sizeable infections in 15 of the fillets, all of which were discarded. The 107 fillets which remained were candled at the plant in the general routine manner on a rectangular box with frosted glass such as that used for candling *Sebastes marinus* (p. 141); two more fillets were found to contain infections. The remaining 105, which presumably would have gone to market, were than candled more thoroughly at our laboratory, and a large number of additional infections were observed as follows:—10 minute trophozoites; 13 small to moderate *Plistophora;* 12 questionable infections; and 1 nematode. Metacercarial cysts were also present in the flesh.

At Provincetown 61 specimens were observed at a processing plant the following day, these specimens having been taken about 10 miles SW. from Wood End Light in Massachusetts Bay on January 19, 1944, at a depth of about six fathoms on rocky, sandy bottom. The fish were in excellent condition and somewhat larger generally than those at New Bedford, the size range being 44 to 87 cm. Only one sizeable infection was detected by the cutter in the 122 fillets, and two more were found in the skinning process. The remaining fillets, which would have been marketed, were then taken to New Haven and placed in a commercial freezer for six days at a temperature somewhere between 0° and 10° F. These 119 fillets contained only minute trophozoites, the total number of which could not be ascertained, since two fillets had them scattered in great numbers throughout the flesh. A number of nematodes, five questionable infections and numerous metacercarial cysts were also observed.

Considering the inefficiency of the candling procedure at the New Bedford plant, it is not surprising that a large number of infections should pass unobserved, although none of them were of a large size. A limited amount of help for the number of fillets to be examined was obvious, and consequently fillets were usually passed over the candling box rapidly and mechanically without careful observation, or in such large bunches that infections might well pass unseen. However, it must be pointed out that these were the only observations made at a plant where candling was performed, and it may be highly unjust to base an appraisal on this one instance, since the results of further observations might give a much more favorable picture. At the Provincetown processing plant the fillets were not subjected to candling, presumably on the basis that the ocean pout in the northern Cape Cod region are much "cleaner" than those from southern Cape Cod and Block Island, which is true.

Therefore it is concluded from the above observations that fillets infected with *Plistophora* were being shipped to market from both New Bedford and Provincetown, with those from the New Bedford area containing larger infections than those from Provincetown.

Fischthal (1944) observed 100 ocean pout fillets from Cape Cod Bay to determine the relative effectiveness of various methods of candling by the use of the same candling apparatus as that employed in detecting parasitic copepods or lesions in the rosefish, *Sebastes marinus*. This consisted of a rectangular wooden frame with a lightly frosted plate glass resting on it, and two or more electric light bulbs beneath the glass; he made no mention of the wattage used. It is obvious from his data that rapid candling, as performed commercially on ocean pout, detects only the larger concentrations and therefore only a part of the infected fillets or specimens, thus substantiating our observations at New Bedford and Provincetown. He obtained the following results by both rapid and detailed candling of the same lot of 100 fillets. By rapid candling both sides of the fillets with the skin removed he obtained a 21 per cent incidence, which included all the larger concentrations of trophozoites and some scattered individuals. By detailed candling of these same fillets he obtained a 34 per cent incidence, or an added 13 per cent due solely to additional individual trophozoites which had apparently passed unobserved in rapid candling.

Sandholzer, *et al.* (1945), used a candling box 18 x 6 x 6 inches with four 50-watt bulbs, a reflector and frosted glass. These workers examined a number of fillets on both sides to detect the lesions and concluded that, "In this investigation there was little difficulty in detecting lesions 10 mm. and over in diameter, although it was necessary to examine the fillets very closely on both sides in the case of the smaller lesions." Our own work confirms the need for careful observations to detect lesions of all sizes, for we found that some of the larger infections, well imbedded in the thick flesh of the abdominal region, were not discernible until the flesh was subjected to the light. By recandling commercially candled fish Sandholzer, *et al.*, found that about 60 per cent of the parasitized fillets had been overlooked, which is a much higher percentage than that obtained by our observations.

However, with the wide fluctuation in incidence in different areas, together with the fact that commercial candling was probably less thorough in 1943 than in 1944, a wide range of variation is highly probable.

Frozen Fish, Fillets and Infections

The problem of obtaining some indication of the validity of a rumor which reported that *Plistophora* infections increase in size during storage was given only cursory consideration by us in view of the fact that the U. S. Fish and Wildlife Service was reported to be engaged in studies on this subject. Although our own work was by no means exhaustive or conclusive, certain features are of interest and appear to refute the conclusions reached by Sandholzer, *et al.*

These workers carried out experiments to determine if "individual lesions continued to increase in size and undergo degeneration in fillets under the usual conditions of storage," to determine if "non-infected flesh could become parasitized from contact with contaminated cutting tables, knives, or other objects," and whether or not "such fillets would develop lesions during storage." "The conditions of storage were comparable to those used in commercial cold storage." According to them,

> The results obtained in the experiments that were conducted to determine the increases in areas of lesions in fillets clearly show that even with careful candling and proper storage, lesions will continue to develop. The data also indicate that flesh which appeared to be normal upon candling may develop lesions during storage.

In their discussion they stated further:

> From a strictly practical viewpoint it is almost impossible to eliminate the parasite from fillets, at present. Should the high incidence of infection continue, normal fillets are certain to become contaminated during processing, and storage will permit the organism to develop. It is true, of course, that in none of the experiments was the fish subjected to quick freezing, nor were they held at extremely low temperatures. It may be that a commercial quick-freezing type of treatment might have held the parasite in check or killed it. However, the conditions held during the course of the experiments were probably superior to those employed in plants that do not produce frozen fish, and the results reflect what may be expected in ordinary commercial practice.

For our own observations we obtained 90 specimens (size range 46 to 91 cm.) from Provincetown which were placed in the freezer in the round on January 21. These were from the same lot as the 119 fillets from 61 fish which had been observed at the processing plant in Provincetown and which had been taken 10 miles SW. of Wood End Light on January 19 (p. 140). Both the fillets and the round fish were placed in the freezer at the same time, and the latter were removed for examination on February 1, 3 and 7. When placed in the freezing plant the fish were in excellent condition and when removed from cold storage they were frozen solid and had to be thawed for many hours. No thermographic record was kept of the temperature at the freezer, but according to the officials at the freezing plant the temperatures vary from 0° to 8° F., with the temperature usually about 5° or lower in the winter. These conditions are similar to those of other freezing plants.

A thorough examination of these 90 fish by candling showed that infections were present in 46 (51%) but we found only one large infection in a male 75 cm. long. Of the remaining 45 specimens infected with *Plistophora,* 30 contained only one minute trophozoite, five had a few scattered minute or small ones, and 10 contained numerous minute or small concentrations of trophozoites, some of which had the parasites distributed throughout the flesh.[1] On the other hand, the 119 fillets which were candled after six days in the freezer contained minute trophozoites only, the three fillets with large infections having been discarded at Provincetown when they were found to be infected. Note that only *one large infection* was present in 90 fish (180 fillets) after 11 to 17 days in the freezer, and *no sizeable infection* appeared in the 119 fillets after six days in the freezer. When we consider the abundance of minute infections from which larger infections might have developed, it seems highly unlikely that infections increase in size during cold storage; it seems equally improbable that

[1] Except for the one large concentration, all of the infections were detected by candling. Obviously many of these fish had parasites located both anterior and posterior to the anus, particularly in those which had large quantities scattered throughout the flesh; in many instances the trophozoites were of both the light and dark form. Fifteen of the 33 females were infected, as compared to 31 of the 57 males, the incidence being higher in the males by only about eight per cent. The flesh of 18 specimens (about 20%) contained at least one or more nematodes: 11 had 1, 6 had 2 and 1 had 7 worms; this percentage was much lower than that obtained for the collection from St. Andrews, but it was the highest nematode count obtained in any of the collections from northern Cape Cod to Long Island Sound. Sixty-four of the 90 specimens (about 71%) appeared to be infested with metacercarial cysts.

lesions spread from an infected fillet to an uninfected piece of tissue if infections *in situ* do not spread. On the other hand, judging from our own data on the incidence as well as that of Fischthal (1944) and Sandholzer, *et al.* (1945), who observed minute trophozoites in the Cape Cod specimens, it is hardly conceivable that all the minute and small infections developed from sporoplasms while frozen.

Data on the Incidence of Plistophora and Other Parasites

The following accounts of the parasites in seven collections taken in March, April and May 1944 form the basis upon which most of the discussion and conclusions are based. The procedure in handling these collections was identical in all instances, and therefore it is possible to make a direct comparison of one sample with another. Candling was performed throughout as outlined previously (p. 135). The data are recorded and listed by geographical areas for direct comparison with both the tables and figures.

Northern Cape Cod

A.

Date: March 15, 1944.
Location: about 8 miles NNW. of Racepoint Light (Table V).
Number of specimens: 72.
Size-range of specimens: 45 to 98 cm. in total length.
Number of fish infected with *Plistophora:* 21 (about 29%), ranging in size from 52.5 to 76 cm. in length.
Number of males: 36; infected: 11.
Number of females: 36; infected: 10.
Specimens infected with nematodes: 11 (15.3%).
Specimens containing metacercarial cysts: 69 (96%).

All infections were either minute individual trophozoites or small concentrations; none large or moderate. Trophozoites of both the light and dark form varied in abundance from a single individual per host to countless numbers scattered throughout the flesh in two specimens. Only two ocean pout had small lesions, the highest number being three in one fish. A single infection was found in 12 specimens, multiple infections in 9. In all cases the infections were observed by candling. One female of 75.5 cm. showed yellow bodies, but there were no *Plistophora* in this specimen.

B.

Date: May 30, 1944.
Location: about 2 miles E. of Peaked Hill Buoy (Table V).
Number of specimens: 102.
Size-range of specimens: 25.5 to 94 cm. in total length.
Number of fish infected with *Plistophora:* 4 (about 4%), in specimens 51.5, 80.5, 93.5 and 94 cm. long.
Number of males: 60; infected: 4.
Number of females: 42; infected: 0.
Specimens infected with nematodes: 15 (14.7%).
Specimens containing metacercarial cysts: 81 (81%).

No large lesions; two moderate infections, one in the second specimen and one in the fourth; a single trophozoite in the first and a small concentration in the third. No light trophozoites. All infections detected by candling. Three females, 68 to 76 cm., contained yellow bodies, but no *Plistophora.*

Summary. Data from these two samples, as well as those of January 19 (p. 143), showed wide variation in the infestation by *Plistophora.* In January it was 51 per cent, in mid-March 29 per cent and at the end of May only 4 per cent, decreases of 22 and 25 per cent for the relative periods. Most of the hosts had only single trophozoites or small concentrations, with only one large infection in the January collection and two moderate ones in that of May. However, note that these collections were not obtained at the same locality, and that the samples varied with 90, 72, and 102 specimens, the May collection having a wider size-range than the other two.

Also, the light trophozoites were very abundant in January, noticeably less in March and entirely absent in the May collection; in January, 42 specimens (about 47%) showed these white forms, in March, 10 (about 14%). No *Plistophora* were observed in specimens below 51 cm., but larger samplings from below 51 cm. would probably reveal at least a few infections. There appeared to be no significant difference in the incidence by sex.

SOUTHERN CAPE COD[1]

C.

Date: March 10–13, 1944.
Location: S. end of Nantucket Shoals (Table V).
Number of specimens: 52.
Size-range of specimens: 53.5 to 90 cm. in total length.
Number of fish infected with *Plistophora:* 21 (about 40%), all these over 59.5 cm.
Number of males: 27; infected: 11.
Number of females: 25; infected: 10.
Specimens infected with nematodes: 5 (9.6%).
Specimens containing metacercarial cysts: 38 (73%).

Smallest lot examined, with infections of all sizes in large numbers present. Six ocean pout had large concentrations, four of which showed additional moderate and small infections. Five fish harbored one or more moderate *Plistophora* and additional small or minute infections. The remaining infected ones had anywhere from one to many single trophozoites or small concentrations. A single infection was present in seven specimens and multiple in 14. No light trophozoites. Below 70 cm. a relatively greater number of fish were uninfected; above 70 cm. the inverse obtained, with infections more abundant in both size and number.

[1] Fischthal (1944) observed 4,152 fillets from Cape Cod Bay and southern New England, as well as a small collection from Casco Bay, Maine, from March 28 to August 18, 1943, and some infections were found in all collections regardless of where the fish were caught.

Since his percentages are based on the number of *fillets* infected, and ours on the *specimens* infected, a direct comparison is impossible. However, from the area below Cape Cod, extending from Block Island to No Man's Land, he examined 2,032 fillets (representing 1,016 fish), of which 138 (6.8%) were infected, with a variation of 3.9 to 10.5 per cent in the three samples. Of the 2,074 fillets (representing 1,037 fish) which he examined from Cape Cod Bay, 142 (6.8%) were infected, the percentage in the six samples verying from 1.0 to 34.0 per cent.

Even if one takes into consideration the fact that he based his estimates on the number of fillets rather than on the number of fish, his percentages still appear very low by comparison with our figures, particularly in the southern New England area (Table XIV). This worker does not state by what method these particular fillets were examined, but it is presumed from his figures that they were done by rapid candling comparable to the methods used in the commercial filleting houses. The figures he obtained in the Cape Cod area are more nearly comparable to ours.

By gross examination (*i. e.*, the rough examination when the fillets were cut and skinned) a total of 16 small to large lesions were found, by candling an additional 38, not counting the minute trophozoites; all infections were detected by gross examination in four fish, those in the other 17 by gross examination or candling. Five specimens were infected only anterior to the anus, one posterior, four both anterior and posterior, and in 11 the locations of the infections were mostly questionable. Twenty-seven infections were positively located, 21 being anterior to the anus, the other 6 posterior, all of varying sizes, omitting individual trophozoites. Yellow bodies were found in 13 females and 10 males, 53.5 to 88.5 cm. in length; 12 had *Plistophora*, 11 none.

D.

Date: May 30, 1944.
Location: about 8 miles SW. of the entrance to Muskeget Channel (Table V).
Number of specimens: 104.
Size-range of specimens: 48 to 72.5 cm. in total length, except for one specimen 87.5 cm.
Number of fish infected with *Plistophora:* 48 (about 46%), specimens from 53 cm. upward.
Number of males: 26; infected: 7.
Number of females: 78; infected: 43.
Specimens infected with nematodes: 5 (4.8%).
Specimens containing metacercarial cysts: 54 (52%).

This was a larger sample than the one for March, but the range was somewhat narrower and the fish were generally of a smaller size. Infections were present in all sizes and in large numbers, one specimen having as many as four large and two moderate concentrations; four fish had one or two large concentrations and additional moderate or small infections; fourteen had one or more moderate lesions, about half of which had additional smaller infections; the remaining infected individuals showed *Plistophora* varying from one individual trophozoite up to numerous small infections. A single infection was present in 25 fish, multiple in 23. Only one light trophozoite seen. Below 60 cm. the uninfected fish outnumbered the infected, but above that the latter were more numerous, as well as more abundant and larger.

By gross examination 23 infections were observed, and by candling

39, individual trophozoites not included. All infections in 10 fish were detected by gross examination only, and in the remaining 38 by gross examination or candling. Thirty-three small to large infections were anterior, 15 posterior. Nine fish were parasitized only in the abdominal region, nine posterior, five both anterior and posterior, and in the remaining 25 the parasites were mostly of undetermined position. Yellow bodies were found in 21 females and one male, 17 of which showed *Plistophora* and five none.

Summary. These two collections showed not only a high incidence in both samples, but it was actually higher in May than in March by about six per cent; the infections were very abundant and large in many specimens. The March collection consisted of only 52 specimens; that of May, 104; there was considerable difference in the size-range of the two collections. Both samples were obtained from fillet houses where grading and selection may have been employed, and therefore these two collections are not representative of the catch. Only one light trophozoite was present in the May sample. Both collections showed higher infection percentages in the abdominal region. A correlation of incidence to sex showed no difference in the March collection; in the May sample there was a much higher incidence in the females, which may be due in part to the uneven sampling of males (26) and females (78).

BLOCK ISLAND AREA.

E.

Date: March 12, 1944.
Location: about 5 miles due SW. of Block Island off the "SW Ledge."
Number of specimens: 162.[1]
Size-range of specimens: 45 to 78 cm. in total length.
Number of fish infected with *Plistophora:* 105 (about 64%), from 49 to 78 cm. in length.
Number of males: 76; infected: 49.
Number of females: 87; infected: 55.
Specimens infected with nematodes: 3 (1.8%).
Specimens containing metacercarial cysts: 150 (93%).

[1] The two fillets of a 54-cm. specimen were accidentally destroyed and therefore are not included in the tabulations.

Largest collection studied, and the most heavily infected of all samples, with large and moderate lesions extremely numerous, not to mention smaller infections. Infections were abundantly represented in all size categories. They were generally more numerous and larger above 52 cm., but too few specimens below this length were studied to make this point conclusive. Many specimens were so completely infected that it was difficult at times to determine where one infection began and the other ended. The most heavily parasitized specimen had 15 large and four moderate concentrations, this individual being a male 65.5 cm. long. Twenty-six had anywhere from one to as many as 12 large *Plistophora*, with some fish having additional moderate, small and minute infections; 25 specimens had from one to three moderate concentrations with small and minute infections; the other infected specimens contained only small or minute *Plistophora*, these being present in numerous combinations and quantities. A single infection was found in 32 specimens, multiple infections in 73. Only seven contained one light trophozoite each.

A total of 130 infections were positively located as anterior and posterior to the anus, mostly of large and moderate sizes; 79 anterior to anus, 51 posterior, the individual trophozoites not included. Eleven specimens had infections only anterior, 4 posterior, 21 both anterior and posterior, and 69 specimens had infections whose locations were undetermined. The total number of large, moderate and small lesions was 220, 107 being detected by gross examination and 113 by candling, minute trophozoites not included. All lesions in 21 fish were detected by gross examination only, in 84 specimens by gross examination or candling. Yellow bodies were found in 25 females and 5 males, from 50 to 69 cm.; 19 contained *Plistophora*, 11 none.

F.

Date: May 30, 1944.
Location: 3 to 4 miles ENE. of Block Island.
Number of specimens: 123.[1]
Size-range of specimens: 39 to 74 cm. in total length.
Number of fish infected with *Plistophora:* 53 (about 43%), ranging in size from 44.5 to 71.5 cm.
Number of males: 49; infected: 19.

[1] One female with a stub tail was not included in the tabulations for Table XVIII, Fig. 23.

Number of females: 74; infected: 34.
Specimens infected with nematodes: 8 (6.5%).
Specimens containing metacercarial cysts: 88 (72%).

A smaller sample than that of March, with the range in size slightly lower. These fish also were heavily parasitized. Above 60 cm. infections of all sizes were more abundant and larger, and were present in all size categories. Below 60 cm. the uninfected specimens were dominant. The most heavily infected individual was a female 69 cm. long with nine large concentrations. Thirteen additional specimens had one to three large infections per fish with additional moderate or small concentrations; in one case as many as six moderate and five small *Plistophora* were present in addition to a large one. Twelve specimens contained from one to three moderate infections, with a few additional small infections and individual trophozoites. The remaining parasitized specimens contained only small or individual infections. A single infection was found in 26 specimens, multiple infections in the same number. No light trophozoites were observed.

Twenty-three specimens had infections anterior, 13 posterior, 12 anterior and posterior, and 5 had them indeterminate in position. At least 107 large, moderate and small concentrations were definitely located, 69 being anterior to the anus and 38 posterior. The anterior *Plistophora* were more numerous and larger. A total of 110 large, moderate and small lesions were detected; 49 of these were discovered before candling, 61 after. All concentrations in 12 specimens were detected by gross examination, in 41 by gross examination or candling. Yellow bodies were present in 41 females and 16 males, from 45 to 71 cm.; 29 specimens with *Plistophora,* 28 without.

Summary. The March collection was more heavily infected than that of May and was the most heavily parasitized of any that was examined; this was the only one in which the infection was above 50 per cent. The incidence was lower in the May sample by about 21 per cent. Only a few light trophozoites were seen in the March collection, none in the May sample. These two collections also showed a high incidence anterior to the anus. The correlation of infections to sex showed no appreciable difference in males or females.

LONG ISLAND SOUND.

G.

Date: April 6, 1944.
Location: 3½ miles N. of Pt. Herod, in Long Island Sound.
Number of specimens: 150.[1]
Size-range of specimens: 33 to 62 cm. in total length.
Number of fish infected with *Plistophora:* 70 (47%), 37 to 62 cm. in length.
Number of males: 88; infected: 42.
Number of females: 61; infected: 27.
Specimens infected with nematodes: 10 (6.7%).
Specimens containing metacercarial cysts: 143 (95%).

Next to the largest sample studied, but with relatively few infections per specimen; no heavy preponderance of parasites in the upper reaches of the size-range, either in quantity or size. Up to about 47 cm. there were more uninfected than infected fish, but above this the infected specimens were more numerous except between 52 and 57 cm. Only four fish contained a single large concentration. Twelve other specimens had moderate infections, with additional small or minute *Plistophora.* The remaining infected specimens contained single minute trophozoites or small lesions. A single infection was found in 36 specimens, multiple infections in 34. The light trophozoites appeared singly in only two specimens.

Twenty-eight fish were infected anterior, 5 posterior, 6 both anterior and posterior, and 31 had *Plistophora* in questionable locations. A total of 55 infections were situated anterior to the anus and 12 posterior, not including minute trophozoites. Eleven small to large infections were detected by gross examination, 94 by candling. All the infections in eight were found by gross examination only, and in 62 specimens by gross examination or candling. Yellow bodies were seen in one female and four males, from 40.5 to 52.5 cm. in length; three had *Plistophora,* while two had none.

DISCUSSION

Marketing ocean pout. From observations made in January 1944 it was pointed out that thorough candling is essential in all areas if a clean product is to be marketed (p. 139), and the data obtained in the

[1] One specimen with sex undetermined omitted from Fig. 22 (series 3).

spring of the same year confirm this point. An examination of samples from Canada to Long Island Sound showed that the protozoan parasite appeared in at least some specimens from all localities. However, relatively few fish from the Provincetown samples showed larger lesions, whereas in the southern New England collections many fish contained one or more large concentrations. Furthermore, a much greater percentage of the infections were detected by candling than by gross examination (Table XIV, Fig. 22). In the March and May samples from Provincetown all parasites were detected by candling. In southern New England 5.3 to 13.0 per cent of the total samples contained specimens with infections which were detected by gross examination only, while 32.7 to 51.8 per cent showed *Plistophora* which were detected partly or entirely by candling.

Recently Sandholzer, *et al.*, in some controlled feeding tests on newly weaned kittens and pigs, stated, "The results of the feeding tests employing cats and pigs *indicate* [italics ours] that there is very little, if any, danger to their health in eating oceanpout parasitized with Ichthyosporidium [*Plistophora macrozoarcidis* Nigrelli]." Kudo (1924) reported that Microsporidia have been found only in invertebrates, fishes, amphibians and reptiles, and so far as known no microsporidian has been found which infects human beings. Furthermore, it is very unlikely that *Plistophora* is injurious to man, since thousands of ocean pout have been consumed in recent years by the public, and for many decades by fishermen without any apparent harm.

In view of these facts it seems reasonable to assume that the flesh can be eaten without much danger. But in order to market a clean product it is highly essential that only *skinned fillets* be sold and that candling be performed carefully and thoroughly in all areas, particularly in southern New England.[1]

The parasite and its relation to the host body. From our own observations it appears that *Plistophora* has a distinct specificity for only the muscle of the ocean pout. In no instance has it been seen in the skin or body cavity wall, although numerous concentrations were im-

[1] However, before a final decision is arrived at regarding the market status of the ocean pout the metacercariae should be taken into account. These parasites are present in other regularly marketed marine products which are eaten in large quantities by the public, but presumably cooking destroys them and eliminates danger of infection in humans.

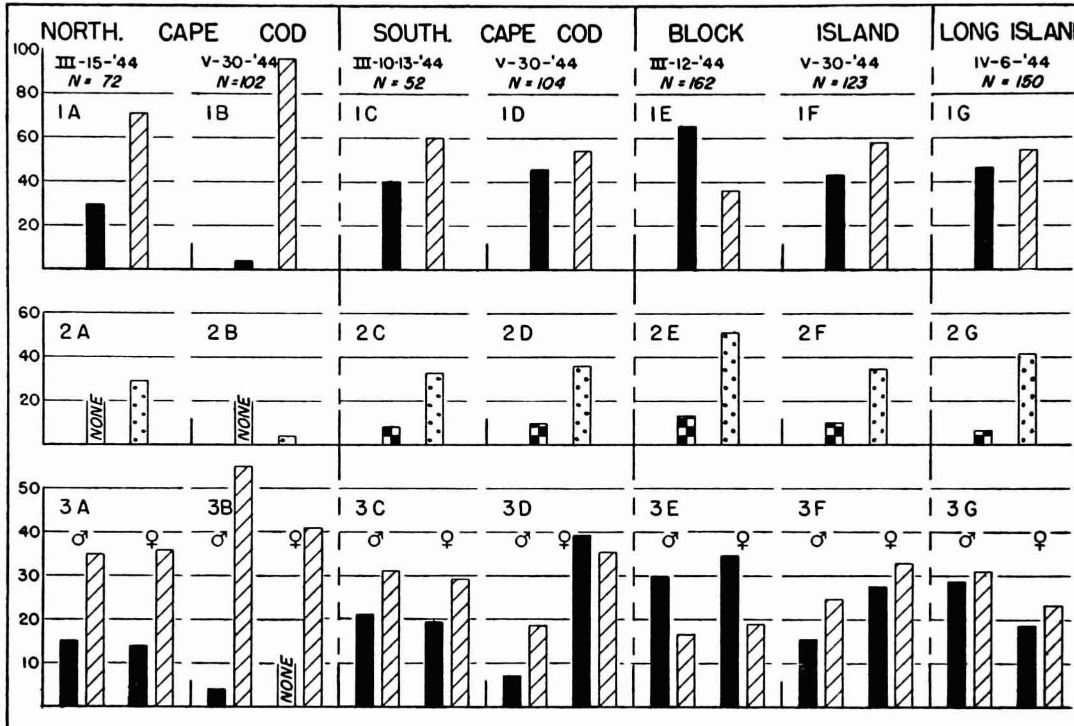

Figure 22. Series 1. ocean pout infected (black) and uninfected (shaded) by *Plistophora macrozoarcidis;* series 2. the infections detected by gross examination only (checkerboard) and by both gross examination and candling (polka dots); series 3. the infected (black) and uninfected (shaded) by sex (one specimen omitted from E and G, footnotes, pp. 148, 151). All tabulations are expressed in per cent of total samples.

TABLE XIV. DATA SHOWING TOTAL NUMBER OF INFECTED AND NON-INFECTED OCEAN POUT BY AREA AND DATE; ALSO SPECIMENS WITH INFECTIONS DETECTED ONLY BY GROSS EXAMINATION AND BY CANDLING. ONE SPECIMEN OMITTED FROM COLLECTION OF MARCH 12. SEE FIG. 22.

Locality	*Northern Cape Cod*				*Southern Cape Cod*				*Block Island*				*Long Island Sound*	
Date	*III/15/44*		*V/30/44*		*III/10–13/44*		*V/30/44*		*III/12/44*		*V/30/44*		*IV/6/44*	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Number of Specimens	72	—	102	—	52	—	104	—	162	—	123	—	150	—
Specimens uninfected with microsporidia	51	71.0	98	96.1	31	59.6	56	53.8	57	35.2	70	56.9	80	53.4
Specimens infected with microsporidia	21	29.0	4	3.9	21	40.4	48	46.2	105	64.8	53	43.1	70	46.6
Specimens with all infections detected only by gross examination	0	—	0	—	4	7.7	10	9.6	21	13.0	12	9.8	8	5.3
Specimens with infections detected by gross examination or candling	21	29.0	4	3.9	17	32.7	38	36.6	84	51.8	41	33.3	62	41.3

mediately adjacent to these tissues. Furthermore, no positively identified *Plistophora* were seen in the viscera or heart, nor in any of the ocean pout's associates which have been studied in this laboratory.[1]

Also, it is indicated that there may be mono- or multi-infection, as well as auto-infection, and that multi-infection may occur simultaneously or at different times. Judging by those fish with trophozoites scattered throughout the entire fish, it would seem that multi-infection on a large scale had taken place at approximately the same time. In specimens where a minute individual trophozoite was found there may have been mono-infection. In others, where minute as well as larger infections were present, there may have been multi-infection at different times, or sporoplasms from an older infection may have migrated and sited themselves at new locations.

We do not know whether or not complete immunity occurs. There is certainly no deterrent to the development of at least some infections into huge lesions. But it is apparent that the host reacts to some infections by an encapsulating process. Fischthal (1944) mentions this in his paper and we have observed such in our specimens; but relatively few encapsulated *Plistophora* were seen, and it is probable that this particular reaction of the host is not very significant except when the infections are small. Nigrelli (p. 199) suggests that phagocytic action takes place. There is only a slight suggestion that the host is refractory to *Plistophora* due to nematodes; much more material would have to be studied to obtain convincing data on this point (Table XIII). Yellow bodies (Table XIII, p. 135) were found next to the skin in numerous specimens; it is not known what the function of these bodies may be, but it is conceivable that they may be the result of a host's reaction to infections.

How is *Plistophora* transmitted? The answer to this question is highly problematical in view of the limited knowledge regarding the parasite's habits and its life cycle. The first question that may be asked is: how are the parasites liberated? In all probability most of them are set free when infected specimens die and decompose. But it is also possible that sporoplasms may leave a host through the di-

[1] Kudo (1924: 51, 52) lists *Plistophora typicalis* as being found in the following fish: *Blennius pholis, Cottus bubalis, C. scorpius* and *Gasterosteous pungitius.* Most of these fish, like *Macrozoarces americanus*, not only frequent the bottom, but probably exist among rocky areas to a great extent. Furthermore, in all instances the parasites were found in the muscle of the hosts.

gestive tract, gills or external surface. Predators may assist in releasing the spores or sporoplasms through their digestive tracts. What happens to the parasites after they leave the host body, and what their habits are when liberated, we do not know. They may exist free in the water, they may be associated with a vector, or they may have to pass through some phase of a cycle in an intermediate host. We do know, however, that spores were liberated in sea water (Nigrelli, p. 194) in the laboratory.

The parasite's entry to the host body is most likely made through the digestive tract, as suggested by Kudo (1931),[1] although it is also possible that parasites may gain entry through the gills. If sporoplasms enter the host through the gills, it is very likely that they are conveyed to the muscle through the blood. If they entered through some part of the alimentary tract, then they may be distributed 1) by the blood, 2) through the gut epithelium and body cavity directly to the flesh, or 3) by both of these methods. That they gain access to the flesh through the blood, as well as through the body cavity, seems most likely from our observations.

The data on infections anterior and posterior to the anus show clearly that a higher incidence of *Plistophora* appears in the muscle of the abdominal region than in that posterior to the anus. From a commercial point of view this suggests only that the anterior parts of the fillets are more likely to contain infections. On the other hand, these data do form the basis for a purely academic consideration of how the abdominal region becomes more heavily infected.

Although only a certain percentage of the total number of infections

[1] Kudo (1931) stated, regarding the order Microsporidia:

When such spores are taken into the digestive tract of a specific host, the polar filaments are extruded and perhaps anchor the spores to the gut-epithelium. The sporoplasms emerge through the opening after the filaments become completely detached. By amoeboid movements they penetrate through the intestinal epithelium and enter the blood stream or body cavity and reach their specific site of infection. They then enter the host cells and undergo schizogonic multiplication at the expense of the latter. The schizonts become sporonts, each of which produces a number of spores characteristic of each genus. Some spores seem to be capable of germinating in the same host body, and thus the number of infected cells increases. When heavily infected, the host animal dies as a result of the degeneration of enormous numbers of cells thus attacked. Such fatal infections may occur in an epidemic form, as is well known in the case of the pébrine disease of silkworms, the nosema-disease of honey bees, microsporidiosis of mosquito larvae, etc.

TABLE XV. DATA SHOWING NUMBER AND PERCENTAGE OF SPECIMENS WITH INFECTIONS DETERMINED ANTERIORLY, POSTERIORLY AND IN UNDETERMINED LOCATIONS. PERCENTAGES BASED ON NUMBER OF INFECTED SPECIMENS ONLY

Locality	*Northern Cape Cod*				*Southern Cape Cod*				*Block Island*				*Long Island Sound*	
Date	*III/15/44*		*V/30/44*		*III/10–13/44*		*V/30/44*		*III/12/44*		*V/30/44*		*IV/6/44*	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Number of specimens in sample	72	—	102	—	52	—	104	—	162	—	123	—	150	—
Total number of infected specimens	21	—	4	—	21	—	48	—	105	—	53	—	70	—
Specimens infected:														
on, above or anterior to anus	0	—	0	—	5	23.8	9	18.7	11	10.5	23	43.4	28	40.0
posterior to anus	0	—	0	—	1	4.8	9	18.7	4	3.8	13	24.5	5	7.1
both anterior and posterior to anus	0	—	1	25.0	2	9.5	3	6.3	14	13.3	9	17.0	4	5.7
anterior and posterior to anus and at undetermined location	0	—	0	—	2	9.5	2	4.2	7	6.7	3	5.7	2	2.9
mostly of undetermined location	21	100	3	75	11	52.4	25	52.1	69	65.7	5	9.4	31	44.3

TABLE XVI. ANTERIOR INFECTIONS VERSUS POSTERIOR INFECTIONS. SPECIMENS FROM SEVEN HAULS (MARCH–MAY, 1944)

Specimens Infected Only Anterior to Anus

Number of Specimens	*Size and Number of Infections per Specimen* Large	Moderate	Small	Minute
11*	1	—	—	—
2*	2	—	—	—
2	1	1	—	—
2	1	—	1	—
1	1	—	2	—
15	—	1	—	—
3	—	2	—	—
2	—	1	1	—
1	—	1	2	—
19	—	—	1	—
6	—	—	2	—
1	—	—	3	—
1	—	—	4	—
2	—	—	5	—
1	—	—	few	—
4	—	—	—	1
1	—	—	—	3
1	—	—	—	few
1	—	—	—	many
Total...76				

Specimens Infected Only Posterior to Anus

Number of Specimens	Large	Moderate	Small	Minute
7	1	—	—	—
1	3	—	3	—
9	—	1	—	—
1	—	2	—	—
13	—	—	1	—
1	—	—	2	—
Total...32				

* In these tabulations the numbers listed in the columns under the "Size and Number of Infections" represent the infections *per fish*. For example, in the first line, one large infection was present in each of the 11 specimens; in the second line two large infections were present in each of the two specimens, etc.

were positively located as anterior and posterior to the anus (Table XV, pp. 144–151), those that were definitely sited were in no way selected and therefore should give a fair indication of the overall relative infections in these two body areas.[1] For the discussion, therefore, we

TABLE XVII. TABULATION OF SPECIMENS IN WHICH INFECTIONS WERE PRESENT BOTH ANTERIORLY AND POSTERIORLY. SPECIMENS FROM SEVEN HAULS (MARCH–MAY, 1944).

Number of Specimens	*Size and Number of Infections per Specimen* — *Anterior*				*Posterior*			
	Large	*Moderate*	*Small*	*Minute*	*Large*	*Moderate*	*Small*	*Minute*
3	1	—	—	—	1	—	—	—
2	1	—	—	—	—	1	—	—
1	1	—	—	—	—	—	1	—
2	3	—	—	—	1	1	—	—
1	4	—	—	—	1	—	—	—
1	5	—	—	—	7	1	1	—
1	6	—	—	—	3	—	—	—
1	1	2	—	—	1	—	—	—
1	1	3	—	—	—	1	2	—
1	1	4	3	—	—	2	2	—
1	2	1	—	—	1	—	—	—
1	3	2	—	—	1	—	—	—
1	—	1	—	—	1	—	—	—
1	—	1	—	—	—	1	—	—
3	—	1	—	—	—	—	1	—
1	—	1	—	—	—	—	—	1
1	—	1	1	—	—	—	1	—
1	—	1	1	—	—	1	—	—
1	—	1	2	—	1	—	—	—
1	—	1	2	—	—	1	—	—
2	—	—	1	—	—	—	1	—
1	—	—	2	—	—	—	1	—
1	—	—	4	—	—	—	—	some
1	—	—	1	few	—	—	1	—
1	—	—	—	2	—	—	2	1
1	—	—	—	many	—	—	—	many
Total 33								

[1] As a further indication of the predominance of the incidence in the abdominal region, see Tables XVI, XVII. In the former are listed a total of 108 specimens with a tabulation of their infections: 76 showed *Plistophora* only anteriorly, while 32 had infections only posteriorly. In Table XVII are tabulated the infections of only those specimens which were infected both anteriorly and posteriorly. Of the

will confine our consideration to only the small, moderate and large infections which were definitely sited and exclude the minute ones. The total number located anterior to the anus was 257, posterior 122. The relative weight and volume of the fillets anterior to the anus was 20.6 per cent of the total weight of the fish, the posterior weight 27.2 per cent (footnote, p. 25). Theoretically, if the blood distribution is relatively the same in all parts of the muscle and if *Plistophora* has a preference for the muscle, blood should distribute the sporoplasms on an average in relatively the same proportions throughout the entire flesh of the animal. Also, we will consider that all of the parasites posterior to the anus have been distributed by the blood stream, and that those infections in the abdominal region might arise from sporoplasms in the blood stream as well as from those which pass through the gut epithelium and body cavity directly to the muscle. Therefore, considering that all infections posteriorly emanate from sporoplasms in the blood stream, which would be 122 infections for a 27.2 per cent volume of the flesh, then 92 infections for a 20.6 per cent volume of flesh would arise from the blood stream anteriorly. The balance of 165 infections anteriorly would presumably gain entrance to the flesh directly through the gut epithelium and body cavity, this being roughly 64 per cent of the anterior infections only.

Obviously this estimation does not take into consideration numerous questionable factors, such as infections which probably arise from older well-established concentrations in the muscle, host reactions, regional preferences such as *Trichinella* has for particular muscles, the blood distribution which may influence the incidence in the anterior part of the fish, *etc.*

That the blood stream does enter into the distribution seems quite certain, considering the uniform distribution of trophozoites throughout the muscle of *some* specimens, but if the blood distributes all of the sporoplasms, then there is probably some peculiarity which results in a much higher percentage of infections in the anterior muscle. If auto-infection takes place sporoplasms from older infections may spread more generally anteriorly, with a smaller number of sporoplasms passing to the posterior muscle. The preponderance of infec-

33 specimens thus infected, 22 have larger and more numerous infections in the abdominal region, 3 posteriorly and 8 have infections approximately equal in both areas. In these two tables are excluded all infected specimens which had one or more infections of a questionable location.

tions in the anterior part of the fish may suggest that the parasite has a preference for this location, but since infections were found only in the posterior part of a number of specimens, this would seem highly improbable. Unless the sporoplasm has a peculiar preference for distribution by the blood stream, and since the sporoplasms must enter into the blood stream and cells by amoeboid movement, there seems little reason to suppose that these amoeboid organisms cannot pass through the gut epithelium and possibly through the body wall directly to the flesh.

The size-range of infected fish. The data indicate clearly that the younger fish were proportionately less infected than the older ones, and that infections were more numerous and larger in the older fish (Table XVIII, Fig. 23, pp. 144–151).[1] In regard to the proportion of infected versus uninfected fish, using the term "infected" to mean anything from a single trophozoite to multiple lesions, Fig. 23 shows the percentage of infected and uninfected specimens at each 5-cm. length interval in each sample from different localities. Thus in sample E from Block Island the 60-cm. interval (57.5–62.5 cm.) contained 21 per cent of the specimens in the sample infected and 9.5 per cent uninfected. In other words, 30.5 per cent of the total sample fell in this length group, of which over two-thirds were infected.

If we look at the proportions of infected versus uninfected fish at each 5-cm. length interval it is apparent: a) that at the lower levels there were more uninfected than infected specimens;[2] b.) that at the intermediate and higher length intervals there were more infected than uninfected fish, with the highest percentage of infected fish in each sample tending to fall at the intermediate length intervals, where there were the most fish. This, of course, does not obtain in cases where the total percentage of infection is low (*e. g.*, northern Cape Cod.)

These data point to several interesting considerations. First, they

[1] Sandholzer, *et al.*, also noted a correlation between the degree of infection and the age, using Clemens' age determinations on Bay of Fundy fish for specimens for southern New England.

[2] Note that few specimens, or none at all, below 50 cm. were taken in some samples. However, in the Long Island sample numerous specimens below 50 cm. were taken, and it is clear that the proportion of infected versus uninfected specimens was low among the smaller fish. A similar pattern would be expected if greater samplings had been obtained in the lower size categories of other collections (see p. 83 for discussion of selective sampling by the trawl nets).

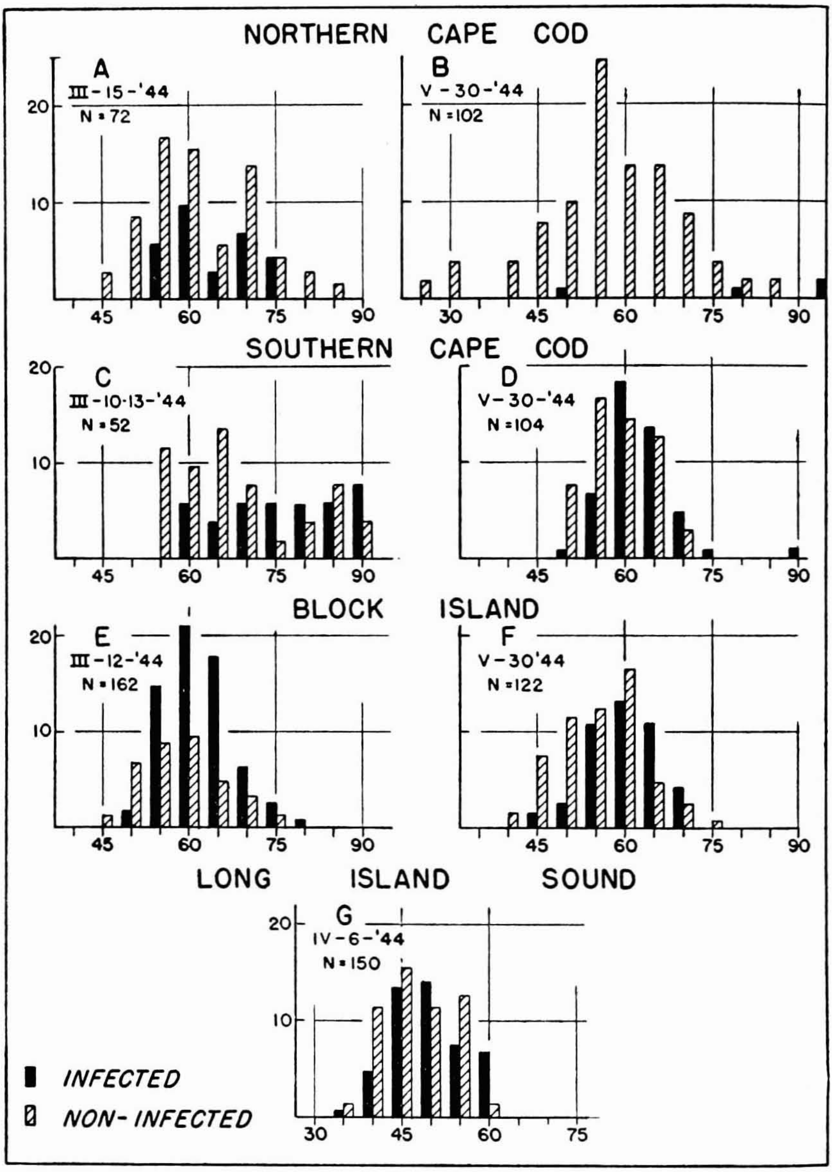

Figure 23. Ocean pout infected and uninfected with *Plistophora macrozoarcidis* tabulated by 5-cm. length intervals, expressed in per cent of sample. One specimen omitted from E and F (footnotes, pp. 148, 149).

Table XVIII. Specimens of Infected and Non-infected Ocean Pout Tabulated by 5-cm. Length Intervals (See Fig. 22)

5-cm. Length Inter-vals	Northern Cape Cod								Southern Cape Cod								Block Island								Long Island Sound				5-cm. Length Inter-vals
	III/15/44				V/30/44				III/10–13/44				V/30/44				III/12/44				V/30/44				IV/6/44				
	I	%	N	%	I	%	N	%	I	%	N	%	I	%	N	%	I	%	N	%	I	%	N	%	I	%	N	%	
25	0	—	0	—	0	—	2	2.0	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	25
30	0	—	0	—	0	—	4	3.9	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	30
35	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	1	0.7	2	1.3	35
40	0	—	0	—	0	—	4	3.9	0	—	0	—	0	—	0	—	0	—	0	—	0	—	2	1.6	7	4.7	17	11.3	40
45	0	—	2	2.8	0	—	8	7.8	0	—	0	—	0	—	0	—	0	—	2	1.2	2	1.6	9	7.4	20	13.3	23	15.3	45
50	0	—	6	8.3	1	1.0	10	9.8	0	—	0	—	1	1.0	8	7.7	3	1.8	11	6.8	3	2.5	14	11.5	21	14.0	17	11.3	50
55	4	5.6	12	16.7	0	—	25	24.5	0	—	6	11.5	7	6.7	17	16.3	24	14.8	14	8.7	13	10.7	15	12.3	11	7.3	19	12.7	55
60	7	9.7	11	15.3	0	—	14	13.7	3	5.8	5	9.6	19	18.2	15	14.4	34	21.0	15	9.3	16	13.1	20	16.4	10	6.7	2	1.3	60
65	2	2.8	4	5.6	0	—	14	13.7	2	3.8	7	13.5	14	13.5	13	12.5	29	17.9	8	4.9	13	10.7	6	4.9	0	—	0	—	65
70	5	7.0	10	13.9	0	—	9	8.8	3	5.8	4	7.7	5	4.8	3	2.9	10	6.2	5	3.1	5	4.1	3	2.5	0	—	0	—	70
75	3	4.1	3	4.1	0	—	4	3.9	3	5.8	1	1.9	1	1.0	0	—	4	2.5	2	1.2	0	—	1	0.8	0	—	0	—	75
80	0	—	2	2.7	1	1.0	2	2.0	3	5.8	2	3.8	0	—	0	—	1	0.6	0	—	0	—	0	—	0	—	0	—	80
85	0	—	1	1.4	0	—	2	2.0	3	5.8	4	7.7	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	85
90	0	—	0	—	0	—	0	—	4	7.7	2	3.8	1	1.0	0	—	0	—	0	—	0	—	0	—	0	—	0	—	90
95	0	—	0	—	2	2.0	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	95
Total	21	29.2	51	70.8	4	4.0	98	96.0	21	40.5	31	59.5	48	46.2	56	53.8	105	64.8	57	35.2	52	42.7	70	57.4	70	46.7	80	53.2	

I—Infected specimens
N—Non-infected specimens

indicate that the infections develop into larger lesions over a long period of time and probably into more lesions of a smaller size, that perhaps the intermediate sized fish are more susceptible to initial infection, or that both of these conditions obtain. We believe that the fish probably live for years while infected with *Plistophora*, and that the infection is not generally contracted as readily by younger fish as by the older, probably because of differences in their habits; *e. g.*, the sharp teeth of the young, as compared with the blunt worn teeth of older specimens, suggest different feeding habits.

The second consideration is that infection by *Plistophora* is not a significant cause of premature mortality. If this were so we would expect to find the uninfected specimens dominant at the upper length intervals, which is not the case. Therefore, we believe that the infections are not usually the cause of premature mortality, although they may enlarge and increase in numbers (in the same fish) and probably persist throughout the life of the individual. The fact that we have not seen any evidence that the spores are liberated through the skin of living ocean pout is a further indication that the infection is of long duration.

A third possibility is also suggested by the data in Fig. 23. The most apparent change in the proportions of infected and uninfected fish (from *less* infected than uninfected to *more* infected than uninfected) occurs in general at the intermediate length intervals from 50 to 65 cm. Although this is not so in all the samples, and although the data are insufficient to settle the point conclusively, it appears that dominance of infected over uninfected fish, once established at the intermediate length intervals, does not tend to become more dominant at the higher length intervals. If true, this might mean that the older and larger fish were less susceptible to infection than the individuals of small and intermediate size. It would also suggest that an equilibrium between the infected and uninfected fish was reached, either because of the lower susceptibility of larger ocean pout, or because of increased mortality among the larger infected specimens. There is a strong suggestion in these data that such an equilibrium is attained.

The incidence in relation to sex, vertebral counts, etc. All collections but one showed relatively the same percentage of infection for males as females (Fig. 22).[1] The only exception was the May sample from

[1] Sandholzer, *et al.*, found "no apparent difference in the degree of parasitism be-

southern Cape Cod, in which about 27 per cent of the males were infected as compared to about 55 per cent of the females. However, this uneven distribution of infections by sex may be due to the uneven sampling of the sexes (76 females and only 26 males). The incidence was also tabulated against vertebral counts, but no correlation seemed to be apparent.

Sandholzer, *et al.*, stated:

> A correlation seemed to exist between the size of the lesion and the degree of infection. In areas where the incidence of parasitism ranged from 27 to 33 percent, the majority of the lesions were 15 mm. or over in diameter, whereas in areas where the incidence was below 27 percent, most of the lesions were under 15 mm. It was also observed that in zones of high incidence, multiple lesions were present in most of the parasitized fish, but single lesions predominated in specimens taken from waters where the lower incidence prevailed.

It is not clear to us whether these authors meant the majority of *all* lesions in the entire infected sample, or the majority of lesions in *each* infected fish. At any rate, our data do not support these conclusions, for we are unable to find a correlation between the size of the lesions and the incidence per sample. If we consider all *Plistophora* infections from minute to large in all the infected fish of a sample (*i. e.*, all infections of the entire sample) we obtain the results given in the following table.

Sample	*Incidence in per cent of sample*	*Total Number of Infections*	
		Large and moderate	*Small and minute*
A	4	3	2
B	29	0	23+(4)*
C	40	14	44+(2)*
D	43	58	63
E	46	28	54+(6)*
F	47	16	109+(5)*
G	64	130	145+(11)*

* + in final column indicates many additional infections which are not included in the total; these trophozoites were too numerous to count, and they can only be indicated. The figures in parentheses show the number of specimens which contained trophozoites too numerous to count.

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tween sexes. However, individual catches occasionally showed a higher parasitic incidence in one or the other of the sexes."

It will be noted that only the sample with the lowest incidence of four per cent contained more than 50 per cent of the large and moderate infections, while in all other samples the majority of the infections were small or minute. If we consider the number of specimens infected with one or more large or moderate lesions as compared with those having only minute or small infections, we find that there appears to be no correlation with the incidence in this case either.

Sample	*Incidence in per cent of sample*	*Approximate Percentages of Infected Specimens with only:* *Large and moderate Plistophora*	*Small and minute Plistophora*
A	4	50	50
B	29	0	100
C	40	50	50
D	43	50	50
E	46	40	60
F	47	25	75
G	64	50	50

It will be seen that in no sample was the percentage of specimens with one or more large or moderate lesions greater than those with only minute or small infections.

Single and multiple lesions[1] were found in specimens from all collections of all localities. Whether or not there is a correlation of single lesions with a low incidence or multiple lesions with a high incidence we do not know. Such determinations would require more data, but it appears that such a correlation is unlikely.

Sample	*Incidence of Plistophora in per cent of sample*	*Number of Specimens with Single Infections*	*Number of Specimens with Multiple Infections*
A	4	3	1
B	29	12	9
C	40	7	14
D	43	26	26
E	46	25	23
F	47	36	34
G	64	32	73

[1] Single lesion here means one infection of any size per specimen; multiple means two or more of any size per specimen.

Seasonally the incidence varied within the same general area, such as that of northern Cape Cod or Block Island (Table XVIII, Fig. 23), but we have no data which determine conclusively whether or not the incidence varies from time to time at a given location within a general area. All of our collections were taken at different locations. However, we believe it is very likely that a varying incidence would be found at different times in the same location. Explanations for these varations in the incidence have not been found, but they are unquestionably complex. No doubt local populations, which probably exist in an area such as northern Cape Cod, move from one place to another in search of optimum conditions in response to stimuli such as temperature, food, spawning urge, *etc.*, a case in point being the annual movements to and from the commercial fishing bottoms (p. 110). The incidence of *Plistophora* in these populations probably varies, and these movements may be at least a partial explanation for the differences which were obtained in our samples. Also, a certain amount of intermingling of populations may take place.

On the basis of vertebral counts, it has been pointed out that regional populations exist (p. 115), and this viewpoint is further substantiated by the data on *Plistophora* as well as the nematodes. The St. Andrew's fish appear separate from those of northern Cape Cod because of the abundance of nematodes in the former (60%) and the relatively small number in the latter (13% on an average for March and May). Furthermore, the northern Cape Cod specimens, with a relatively low *Plistophora* count, are set apart from those of southern New England.[1] Although the populations in the three southern New England areas are not as clearly separable from each other as those mentioned above, the specimens from within Long Island were smaller and less heavily infected than those of Block Island and southern Cape Cod, thus sug-

[1] Sandholzer, *et al.*, stated:

"The lowest incidence was observed off the southern shore of New Jersey and increased in the more northerly water. Extensive sampling in the area from the eastern end of Long Island to Nantucket showed that parasitized fish comprised from 4½ to 38 percent of those examined, the greater number of infected fish being taken from the deeper water. The areas of lowest infection were those adjacent to Block Island and in Muskeget Channel."

Our studies do not include ocean pout from New Jersey waters, but our findings do indicate that the incidence was lower at northern Cape Cod than in the southern New England areas, where a comparatively high incidence was found adjacent to Muskeget Channel and Block Island.

gesting that they represent a separate population. The southern Cape Cod and Block Island stocks seem to be separate, but the evidence from the incidence of *Plistophora* does not appear to support such a contention.

In what situations are the infections likely to be contracted? In the Accounts of the Data (pp. 144–151) it was noted that the minute whitish trophozoites were fairly abundant in January and were no longer apparent in the May collections. This seems to indicate that sporoplasms gain entry to the fish on a larger scale at one time of the year than at another. If the sporoplasms gained access to the muscle in the same relative amounts at all times of the year we would expect to find the minute light trophozoites in all other samples on more or less the same scale as in January, but such is not the case. Therefore, we believe that a higher period of infection may be likely in the fall of the year among rocky areas. The ocean pout presumably spends a larger part of its life in rocky areas, like other blennies, with a probable resultant higher mortality and subsequent liberation of spores in these locations. Also, it is in these areas that the ocean pout spawns in the fall, at which time it probably leads its most sedentary existence. Also, at this time it is largely dependent on the food available among the rocks, and it is possible that a vector may be more abundant on these situations.

Although no secondary host has been found for a microsporidian, this does not necessarily preclude the possibility of there being one. As pointed out earlier, infections may be contracted haphazardly, but it is also possible that the incidence is linked to some factor such as the feeding habits, possibly on certain types of bottom and at a certain time of year. If a vector exists it must be available to the host to a certain degree in all areas where the actual infection takes place, seemingly more so in some locations than in others when we consider the varying incidence. The thermal and other physico-chemical conditions, the degree to which the vector might maintain or support the parasite for transmission to the host, the size and abundance of the secondary host and the frequency with which it is eaten, may also have a bearing on the parasitization. From a consideration of the stomach contents (Table XII, pp. 118–131) we are able to find no positive answers to the numerous problems mentioned above; but we are able to obtain at least some indication of what organisms might serve as a possible secondary host for microsporidians and for other parasites of the ocean pout.

First, if we consider each area as a separate entity, we find that the most likely possibilities from northern Cape Cod appear to be the Gammaridae, *Ophiura robusta, Echinarachnius parma, Pecten magellanicus, Aphrodita hastata,* the decapods, *Cardium pinnulatum* and *Unicola;* in the southern Cape Cod area there are the Gammaridae and *Echinarachnius parma, Aphrodita hastata* and *Cancer irroratus.* The Block Island area stomach contents suggest the Gammaridae, *Unicola,* the Caprellidae, *Echinarachnius parma* and *Cancer irroratus* as well as *Cardium pinnulatum, Pecten magellanicus,* Tunicata and Nudibranchiata. The most likely from Long Island Sound would be *Yoldia limulata* and *Cancer irroratus.* In an overall consideration, including St. Andrews, New Brunswick, the Gammaridae are the most prevalent generally, following which are *Unicola, Cancer irroratus, Echinarachnius parma, Cardium pinnulatum, Aphrodita hastata, Yoldia* and *Pecten* species.

Does Plistophora macrozoarcidis manifest itself in epidemic form? As indicated by Kudo (footnote, p. 156) it is not uncommon for some Microsporidia to appear in epidemic form. The data available here are insufficient to answer this question in relation to the ocean pout, but the problem of fluctuation in the incidence of infection deserves further consideration in the future. From an economic point of view this factor might be of the greatest significance, especially if the incidence diminished, for the fish might then be marketed more readily without the deterrent factors which are inherent at present.

We have noted that previous workers (p. 138) made no mention of the parasite; furthermore, this microsporidian was not discovered by any parasitologists or other workers previous to 1943, although other parasites were observed in the ocean pout (Nigrelli). This indicates that the parasite may be recent in this fish. However, from our data it is clear that at present the incidence is generally high in some areas while relatively low in others, and that it even varies within these areas. If the parasites develop slowly, as has been suggested (p. 164), and do not create a sudden change in the mortality of a population within a year or two, it seems unlikely that the infection would manifest itself in acute epidemic form. On the other hand, it is possible that long range increases and decreases in the incidence may take place. Such changes might result from any number of causes. For example, the host's reactions to the infection may vary; the availability of the parasite, whether free or in relation to a vector, may change and may be related to the mortality of infected hosts with the subsequent liberation of parasites by decomposition; or the concatenation of a variety of environmental factors which are conducive to parasitization may have a bearing on the incidence.

CONCLUSIONS

The original objectives of this study on the biology and economic importance of the ocean pout were twofold—to provide information for the rational utilization of the stock by investigation of the life history, catch records, abundance, *etc.*, and to add to our knowledge of the parasites with particular reference to their effect on the marketability of the fillets and the seasonal and geographical incidence of infection. Such a study, while placing emphasis on the applied aspects, almost inevitably includes matters whose implications are in the field of pure and theoretical biology. The present work often drew us far from our primary objectives, and as is so frequently the case, it has opened up a series of new problems for subsequent investigation. We have made no effort to separate the "pure" from the "applied" results in the text; indeed we believe that the two are inseparable in any study of adequate breadth, and that they are mutually dependent on each other so that no clear line of division is possible or practicable. For example, the description of a new species of parasite, the interpretation of its life cycle, the mode and duration of infection, *etc.*, may be considered as pure biology; but when that parasite manifests itself in such form as to affect the marketability of ocean pout fillets, this information then becomes of the utmost practical importance. Similarly, the use of length-weight curves of the separate sexes as a means of determining the average age at maturity, the interpretation of length-frequencies or of vertebral counts, are primarily problems in theoretical biology; but when the matter of optimal utilization of the stock is considered, it then becomes of practical significance to know when this species first spawns, how fast it grows, as well as the age composition and racial make-up of the commercial catch. The abstract at the beginning of this paper presents a brief summary of our conclusions; the present section confines itself to the immediate objectives that prompted us to undertake this study.

Problems involving the rational utilization of a stock of fish of a particular species are extremely complicated. For their solution it becomes necessary to provide estimates of the magnitude and age composition of the population, the production and survival of young in successive years under varying conditions, the natural and artificial mortality of the stock as a whole as well as of its different age categories, growth rates and rate of replacement from below, migratory habits and a host of other matters. To add to the difficulties already inherent in such problems, work is not usually undertaken until the supply has given some indication of diminution so that there is cause for alarm; seldom does the biologist have the opportunity to observe the stock from the inception of the fishery. Seldom also are adequate catch statistics available, so that the tools which are essential to the completion of work are not ready for immediate use. It is small wonder, therefore, that these problems are slow of solution.

We have shown that the catch of ocean pout in 1943–1944 would have been considerably higher had it not been for a variety of factors which reduced the landings. While there is no way of estimating what volume the annual catch might reach under conditions of a more intensive fishery, there is good evidence that the stock is capable of producing much more than 5,500,000 pounds *per annum.* The consistent level at which the landings might be *maintained* is beyond conjecture in the present state of our knowledge; this can be determined only as subsequent exploitation takes place, since we have no estimate of the total magnitude of the stock. However, the seasonal nature of the fishery affords this species a rather high degree of protection. The population is not subject to the inroads of the commercial fishery in the period before, during and immediately after reproduction; in other words, there is no opportunity for the fishery to concentrate on spawning fish to the detriment of over-all productivity. Furthermore, the shape and nature of this species, contrary to many others, assures the escape of a large proportion of the young from the trawl net so that the mortality of the smaller size categories as a result of the fishery is apparently negligible. We have no evidence as to what proportion of the total stock leaves the summer and fall rocky habitat in December and January, but there is some indication that the majority of the younger fish remain there during their first years, and it is possible also that some of the adults stay there. In all events, a combination of circumstances which involve the seasonal movements, life history, general shape and hardiness assures this fish a degree of security in relation to the operations of trawlers and draggers that is unusual. For these and other reasons it appears that there is little to be feared in fishing the stock more intensively than at the level which gave rise to the 1943–1944 catch.

Careful and continued observation of the landings and the age composition of the catch should be maintained as a check against the future possibility of over-fishing, not only to safeguard the industry, but also since such investigation would provide a continuous record of man's exploitation of the stock from the beginning of a fishery of major proportions. Particularly should such observations be made because this is not a species in which the phenomenon of year-class dominance (the production of exceptionally large numbers of young in any one year) can reasonably be expected to occur. In other words, it is extremely unlikely that the stock would get occasional sudden increments from unusually large year-classes, as with species whose reproductive potential is extremely high. If the fishing mortality became too high, and if the spawning stock were reduced to such a level that its sum total productivity suffered, the slow growth rate of this species would cause two particular difficulties. First, it would take the stock a long time to recover since replacement by increased numbers of young would be slow. Second, the result of the reduction of the spawning stock, *i. e.*, diminished productivity, would not be obvious at first and would take a number of years to manifest itself. For these reasons it is especially important that the age composition of the catch, the total landings, and the return per unit of effort should be subject to close and continouus scrutiny. Only in this way can subsequent development and expansion of this fishery be safeguarded adequately.

We have also indicated previously that, apart from other considerations, the ocean pout fishery is important because the major landings are made in the winter and early spring months; this is a period when the available quantity and variety of fresh fish are relatively small, and when the demand is high. For these and other reasons cited in the section on Economic Considerations, it seems clear that every effort should be made to overcome the marketing problems stemming from the parasites of this fish.

In regard to the protozoan parasite, *Plistophora macrozoarcidis*, which is responsible for the "sores" in the flesh, there is no evidence that it, or any other member of the group to which it belongs, ever parasitizes a warm-blooded host; therefore, the chances of actual infection of man appear to be negligible. Furthermore, feeding tests and other evidence provide no indication of serious illness from the consumption of flesh which harbors this parasite. The fact that ocean pout have been eaten for generations by fishermen and others without apparent detriment, and that the fillets enjoyed such wide sale in 1943–1944, is further indication—albeit of a negative sort—of its innocuity. However, more stringent feeding tests should probably be undertaken, not only as an extra precautionary measure, but also because of their value in discussion with uninformed skeptics.

Another problem involves the effect of the parasite on the marketability of ocean pout fillets. We have already emphasized the necessity for *quality* products in the fisheries industries, and it is clear that the sale of fillets which occasionally have prominent lesions is detrimental, not only to the marketing of that particular species, but also to the trade as a whole. Imperfect ocean pout fillets did appear on the market in 1943–1944 and were in turn partly responsible for the curtailment of the fishery. Our own observations show that candling (examination by transmitted light) as practiced commercially was inadequate for the elimination of unclean fillets. However, we believe that more careful candling and improved technique would be feasible, and that a clean and acceptable quality product could then be marketed. We need not dwell on the absolute necessity of rigorous inspection of this and all other fisheries products, for its paramount importance to the industry is obvious. In the case of the ocean pout it is clear that this species should *never* be sold "in the round" and that the careful candling of *skinned* fillets is essential in order to insure a clean product.

It has been reported by other workers that infections by *Plistophora* spread and increase in size in frozen fillets in storage; even if this is accepted as fact, it is not necessarily detrimental to the marketing of ocean pout. Our own evidence indicates that the small infections (individual trophozoites which might not be detected in commercial candling) do *not* increase in size or spread in frozen fillets; since the moderate and large infections should be eliminated by proper inspection, their behavior in frozen flesh is of little or no concern in practice.

The successful marketing of clean ocean pout fillets is therefore primarily dependent on efficient candling; this method of examination is practiced successfully with other species which present similar problems, and there seems to be no reason why it cannot be applied to the ocean pout.

Indeed, there is incontrovertible evidence from the course of the fishery in 1945 that clean ocean pout fillets can be marketed successfully and without detriment to the trade under proper conditions. Our own investigations have shown important differences in the incidence of infection in ocean pout from various localities. Thus, the number of large infections was consistently low in fish from northern Cape Cod (Provincetown) as opposed to those from areas to the south and west; it was in the Provincetown area that the fishery continued to operate in spite of the 3-cent ceiling (which was not consistently maintained[1]), after the embargo in February 1945 in New York City had reduced the landings in New Bedford and other ports to relatively low levels. As a matter of fact, the landings at Provincetown during March, April and May 1945 totalled 412,500 pounds, as against 160,000 pounds in the same three months in 1944. Our studies show further that the Provincetown ocean pout, although having a low incidence of large infections, possessed many individual trophozoites. It seems clear, therefore, that the small infections are inconsequential. The primary problem is to be certain that no fillets with moderate or large infections are marketed.

We believe that every incentive should be given to the fishery off northern Cape Cod to continue and to expand. The standards of commercial candling should be raised, and, once they are perfected, there seems to be no reason why the fishery in all southern New England waters should not proceed with the development begun in 1943–1944—always, however, under conditions of careful inspection and constant observation.

[1] For example, see U. S. Fish and Wildlife Service Market News Service, May 2 and 22, 1945 (p. 1).

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[1] Abbreviations used in this bibliography taken whenever possible from "A world list of scientific periodicals published in the years 1900–1933," Oxford Univ. Press, London.

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