Special Progress Report on Foreign Fishing Program at Biological Laboratory, Woods Hole

Background. The groundfish of the Georges Bank-Gulf of Maine area have been heavily fished for many years - the landings averaging more than 600 million pounds annually - but the pelagic fishes have been exploited only to a minor degree. Since the decline of the mackerel fishery, the pelagic catch has consisted primarily of immature herring taken in Maine inshore waters to the extent of about 150 million pounds annually, and of school tuna taken in Provincetown traps to the extent of about one million pounds. There were also nearly one million pounds of basking mature swordfish taken annually.

A large fleet of USSR vessels moved into the area in 1961 and began an intensive exploitation of the stocks of mature herring on Georges Bank. In 1962, the USSR reported landing over 350 million pounds of herring and 80 million pounds of silver hake. Although the herring stock in itself is of no interest to U. S. fishermen, the intensive fishing activity of this foreign fleet immediately raised the question: "What effect does a decrease in herring abundance have on the species which have traditionally been of importance to the United States?" The Woods Hole Laboratory was allotted funds in fiscal year 1963 to investigate this question.

Program. The program set up to study this question assumes that the best answer lies in an understanding of the predator-prey relationships of the principal species of fish involved and in the matter of food competition. In other words, we must know the food habits of the species and how these may vary with changing abundance of other species.

The first step in the program was to determine what information is already available on the subject. To this end a bibliography was compiled; a copy of the pertinent literature is appended to this report.

The second step was to design a program for sampling which might reasonably be expected to provide the minimum necessary information required concerning our species in this area. Briefly this consists of observing at selected stations the amount of food available, the amount present in the stomachs of the principal species of fish, the rate of digestion, the rate of feeding, the rate of regeneration of available invertebrate food both benthic and planktonic, and the quantitative analysis of all the important interrelations. Hydrographic observations are made at the same stations concurrently.

Accomplishments. To date the work accomplished and being done may be briefly summarized as follows:

1. Albatross IV Cruise 63-4, 18-24 June 1963.

A study of the food items taken by 10 species, amounts taken, and behavioral aspects of feeding. Over 12,000 specimens examined,

3000 stomach contents analyzed and several hundred liver glycogen determinations made.

2. Albatross IV Cruise 63-5, 18 June to 19 August, 1963

Seventeen hundred stomachs from 41 species were examined during the survey portion of the cruise. In addition, over 500 stomachs were collected for detailed analysis in the laboratory. Five areas were studied in detail to determine the phyto- and zooplankton relationships to hydrography and fish feeding behavior. At each of these five areas, collections were made throughout the water column as well as at the bottom. One hundred and eighty samples of phyto- and zooplankton were brought back to the laboratory for further study.

3. Within the laboratory work is nearly completed on a study of the feeding of juvenile redfish. This species spends its first months of life at the surface and is one of the predominant forms from June to October.

4. Detailed analyses of stomach contents are continuing. To date more than 600 have been completed.

5. Laboratory studies of the changes in glycogen storage in the liver are underway in an effort to determine the relation of amounts eaten to the metabolic rates of various species. Ultimately these studies will make it possible to quantify food requirements and to more precisely determine the significance of competitive feeding.

6. The problems of distribution of food organisms are being studied to provide a basis for evaluating the feeding behavior of the fish species competing for various food species.

7. Large samples of squid (more than 1000) have been taken on various Albatross cruises for the purpose of stomach analysis.

Discussion. On the basis of feeding behavior, Gulf of Maine fishes may be divided into two categories. The first, represented by such species as the haddock, redfish, skates and certain flounders, depends primarily on the food organisms available on or within the bottom sediments; the second depends on food organisms generally available off the bottom. The available data are summarized in Table 1.

It is clear from the data presented in Table 1 that direct competitive feeding must occur between the species in group two. As well as competing for the euphaussid supply, some of them compete for fish, principally herring. To a limited extent herring, when pressed for food, feed upon larval and juvenile groundfish when they are present. The absence of herring diverts the attention of their predators to other fish species as prey. Silver hake is abundant and voracious. It is also cannabalistic. This characteristic probably functions as a built in control of its own density. The silver hake thus appears to be an extremely important "buffer" species in the community. The pollock, on the other hand, more noticeably shifts its attention to other species. When small haddock are abundant, as opposed to herring, pollock will gorge themselves accordingly.

The Atlantic mackerel occupies almost precisely the same ecological niche as the herring. These two species tend to occupy

Table 1.--Principal foods of Gulf of Maine fish.

SPECIES	ITEMS OF DIET		
	MAIN	SECONDARY	MINOR
GROUP ONE, Bottom Feeders			
Haddock	Amphipods	Decapods	Fish
Cod	Molluscs	Decapods	Fish
Red hake	Amphipods	Decapods	Fish
Yellowtail flounder	Amphipods	Decapods	Worms
Skates	Amphipods	Decapods	Fish
Dogfish	Decapods	Fish	Amphipods
Sculpin	Amphipods	Decapods	Molluscs
Blackback flounder	Amphipods	Worms	Decapods
Redfish	Euphaussids	Fish	Decapods
GROUP TWO, Pelagic Feeders			
Pollock	Euphaussids	Fish	Other large plankton
Silver hake	Euphaussids	Fish	Other large plankton
Atlantic herring	Euphaussids	Copepods	Other large plankton
Mackeral	Euphaussids	Copepods	Other large plankton
Tuna	Fish	Decapods	Other large plankton
Swordfish	Fish	Birds	--

different areas and thus do not usually compete directly to a significant extent in our waters today. At present the mackerel population is a shadow of its former self. When abundant, the mackerel would, at certain seasons on certain grounds, directly compete with the herring.

Squid, a Major Group. All too frequently overlooked in the feeding economy of the Gulf of Maine species complex are the squids - principally represented by species of Ilex and Loligo. Preliminary studies at the Woods Hole Laboratory confirm the generally held opinion that these squids primarily feed upon fishes. Herring is probably their major food item in the area where herring is abundant.

Techniques for estimating the abundance of squid have not been developed. It is obvious that squid are, however, very abundant and must be considered as highly significant predators within the Gulf of Maine and Georges Bank, since seasonally at least they appear to be about as abundant as silver hake. In the event of a serious decline in abundance of the herring, squid would probably first turn to the juvenile groundfishes living near the surface. These species would include haddock, cod, silver and red hake, alewives, and other minor pelagic species. Squid themselves are preyed upon by many groundfish species, but hardly in proportion to their apparent abundance.

In broad terms, the herring are the "mice" of the ocean, serving as fodder to a very large number of other fishes, squid, whales, and porpoises. Any significant reduction in their numbers will inevidably increase the predator pressure on other species.

The silver hake is an "escape valve" species. Being voracious and widely distributed, it can quickly absorb any general increases in food organisms, and being markedly cannabalistic, similarly quickly adjust it's own population size to limitations in food supply when they occur. Accordingly, these two species contribute greatly to the stability and productivity of the marine fish community, and any undue fishing pressure on their populations can only lead eventually to major readjustments within the fish community. As yet it is impossible to say what these readjustments may be, but there is no evidence to suppose that they will be beneficial to the New England fisheries.

The primary goal of the Foreign Fishing Program for the immediate future is to develop some of the food relations on a quantitative basis in order to build up the body of information required to make valued judgements of the interspecific abundance relations.

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Anonymous.
1845. On the food of the herring and salmon.
By John Stark, Esq. Proc. Roy. Phys. Soc.
Edinburgh, vol. 1, p. 170-171.

Anonymous.
1962. Weight of head and digestive tract contents and remarks on feeding habits for certain species of industrial fish.
B.C.F. Biological Laboratory, Woods Hole.
Laboratory Rep. No. 62-4, June 1962.

Atwood, N. E.
1866. On the habits and distribution of the haddock.
Proc. Bost. Soc. Nat. Hist., 10: 322-323.

Baird, Spencer Fullerton
1871b. The food of the sea-herring.
Ann. Rec. Sci. Ind., 1871, p-208-210.

Bateson, W.
1890. The sense-organs and perceptions of fishes; with remarks on the supply of bait.
Journal of the Marine Biological Association of the United Kingdom, new series, vol. 1, no. 3, p. 225-256.

Battle, Helen I.
1934. Laboratory feeding of the herring. Effect of temperature on rate of digestion ("clearing") in herring.
Ann. Rept. Biol. Bd. Can., 1933 (1934), p. 14-15.

Battle, Helen I.
1935. Digestion and digestive enzymes in the herring (Clupea harengus L.).
Jour. Biol. Bd. Can., vol. 1, No. 3, p. 145-157.

Battle, Helen I., A. G. Huntsman, Anne M. Jeffers, G. W. Jeffers, W. H. Johnson, and N. A. McNairn.
1936. Fatness, digestion and food of Passamaquoddy young herring.
Jour. Biol. Bd. Can., vol. 2, No. 4, p. 401-429.

Bigelow, H. B. and W. C. Schroeder.
1939. Notes on the fauna above mud bottoms in deep water in the Gulf of Maine.
Biol. Bull. 76:

Bigelow, Henry B., and William C. Schroeder.
1953. Fishes of the Gulf of Maine.
U.S. Dept. Int., Fish Wildl. Serv., Fish. Bull. 74: vol. 53, viii 577 p.

Bigelow, Henry B., and W. W. Welsh.
1925. Fishes of the Gulf of Maine.
Bull. U.S. Bur. Fish., vol. 40, pt. 1, 567 pp.

Blaxter, J. H. and F. G. T. Holliday.
1958. Factors influencing feeding behavior of herring.
Proc. Roy. Philo. Soc. Lon., Vol. 27, p. 15-28.

Blegvad, H.
1917. On the food of fish in the Danish waters within the Skaw.
Report of the Danish Biological Station to the Board of Agriculture, 24, p. 17-72.

Boldovski, G. V.
1938. The food of the Murman herring in the fiords (In Russian).
Trans. Knipovich Polar Sci. Inst. Sea-Fish. Oceanogr., tom 1, p. 102-119.

Boldovski, G. V.
1941. The food and feeding of the Barents Sea herrings (In Russian).
Trans. Knipovich Polar Sci. Inst. Sea-Fish. Oceanogr., tom 7, p. 219-286.

Boldovskii, G. V.
1944. The food of the Norway haddock in the Barents Sea.
Trudy PINRO, 8: 307-330.

Borley, J. O., and D. E. Thursby-Pelham.
1926. Distribution of the food fishes in the North Sea during 1923 and 1924 with notes on the natural history of the food fishes of the North Sea.
Min. Agric. Fish. (Eng.), Fish. Invest., ser. 2, vol. 9, No. 4, 14 pp.

Bowman, Alexander.
1923. Spawny haddock: The occurrence of the "spawny" haddock and the locus and extent of herring spawning grounds.
Fisheries, Scotland, Sci. Invest., 1922, IV.

Breder, C. M.
1922. The fishes of Sandy Hook Bay.
Zoologica, 2 (15): 350.

Brook, George, and W. L. Calderwood.
1886. Report on the food of the herring.
Fish. Bd. Scot., 4th Ann. Rept., 1885 (1886), p. 102-128.

Brotskaja, V.
1931. Materials on the food of fish in the Barents Sea. II.
Rep. First Sess. State Oceanogr. Inst., Moscow, No. (English summary).

Brown, W. W., and C. Cheng.
1946. Investigations into the food of the cod (Gadus callarias L.) off Bear Island, and of the cod and haddock (G. aeglefinus L.) off Iceland and the Murman coast.
Hull Bulletins of Marine Ecology, vol. 3, no. 18, p. 35-71.

Bullen, G. E.
1912. Some notes upon the feeding habits of mackerel and certain clupeoids in the English Channel.
Jour. Mar. Biol. Assoc. U. K., n.s., vol. 9, No. 3, p. 394-402.

Carr, A. M.
1908. Food of fishes.
Northumberland Sea Fish. Comm. Rpt., Sci. Invest., 1907: 68-71.

Carr, A. M.
1909. The food and condition of fish obtained from the north-east coast.
Northumberland Sea Fish. Comm. Rpt., Sci. Invest., 1908: 41-50.

Chaianova, L. A.
1939. The food of the White Sea herring according to samples taken in 1932 (In Russian).
Inst. Mar. Fish. Oceanogr., Memorial to Knipovich, p. 279-299.

Chang, C.
1941. Ecological relations between the herring and the plankton off the northeast coast of England.
Hull Bull. Mar. Ecol., vol. 1, No. 5, p. 239-254.

Clemens, W. A.
1920. The mutton fish.
Bull. Biol. Bd. Can., No. IV, p. 10.

Connolly, C. J.
1920. The angler.
Bull. Biol. Bd. Canada, No. III, p. 15.

Cox, P.
1920. The lumpfish.
Bull. Biol. Bd. Canada, No. 2, p. 10.

Cunningham, Joseph T.
1896. The natural history of the marketable marine fishes of the British Islands.
London, Macmillan and Co., Ltd., xvi 368 pp.

Cushing, D. H.
1956. Phytoplankton and the herring. Part V.
Gt. Brit. Min. Agric. Fish. Food, Fish. Invest.,
ser. II, vol. 20, No. 4, 19 pp.

Day, F.
1882a. On the food of the herring.
Zoologist, ser. 3, vol. 6, p. 268-269.

Day, F.
1882b. On the food of sea fishes.
Zoologist, ser. 3, vol. 6, p. 235-236.

Day, Francis.
1884. Fishes of Gt. Britain and Iceland.
Williams and Norgate, 2 vols., 179 litho.
London and Edinburgh.

Dunn, Matthias.
1885a. Food of mackerel, pilchards, and herring.
Bull. U. S. Fish Comm., vol. 5, No. 20, 1885, p. 305.

Dunn, Matthias.
1885b. Food of sea fishes.
Zoologist, ser. 3, vol. 9, p. 236-237.

Eggert, M. B.
1953. The food of herring from Sorok Bay (White Sea) (In Russian).
Zool. Zhur., vol. 32, No. 3, p. 490-494.

Ellson, J. B., D. E. Powell, and H. E. Hildebrand.
1950. Exploratory fishing expedition to the northern Bering Sea
in June and July, 1949.
U.S. Fish and Wildlife Service, Fishery Leaflet 369, 56 p.

Evans, H. M.
1935. The brain of Gadus, with special reference to the medulla
oblongata and its variations according to the feeding habits
of different Gadidae--I.
Proceedings of the Royal Society of London, Series B-Biological
Sciences, vol. 117, no. B805, p. 367-399.

Field, I. A.
1907. Unutilized fishes and their relation to the fishing industries. Rept. U. S. Fish. Comm. (1906), Doc. 622, p. 39.

Fridriksson, A., and G. Timmermann.
1950. Notes on the food of haddock (Gadus aeglefinus L.) at Iceland. Ann. Biol. Cons. Int. Explor. Mer., 7: 34-36.

Gill, T. N.
1905. The life history of the angler. Smithsonian Misc. Coll. 47: 352.

Hadfield, Henry.
1885. Food of the basking shark and herring. Zoologist, ser. 3, vol. 9, p. 352.

Hahn, E. E.
1901. Gadus callarias, cod. In Biological notes, Bulletin of the U. S. Fish Commission, vol. 19, for 1899, p. 307.

Hansen, H. J.
1915. The crustacea Euphausiacea of the U.S. Nat. Mus. Proc. U. S. Nat. Mus. 48: 94.

Hansen, Vagn.
1955. The food of herring on the Bloeden ground (North Sea) in 1953. Cons. Perm. Int. Expl. Mer., Jour. du Cons., vol. 21, no. 1, p. 61-64.

Hardy, A. C.
1924a. The herring in relation to its animate environment. Part I. The food and feeding habits of the herring with special reference to the East Coast of England. Min. Agric. Fish. (Eng.), Fish. Invest., ser. 2, vol. 7, No. 3, 53 p.

Hart, J. L.
1949. Food of fish of the cod family. Fisheries Research Board of Canada, Progress Reports of the Pacific Coast Stations, Nanaimo and Vancouver, B. C., no. 79, p. 35-36.

Hertling, H.
1928. Untersuchungen über die Ernährung von Meeresfischen. I. Quantitative Nahrungsuntersuchungen an Pleuronektiden und einigen anderen Fischen der Ostsee. Berichte der Deutschen Wissenschaftlichen Kommission für Meeresforschung, neue Folge, Band 4, heft 2, p. 21-124.

1940. Untersuchungen über die Ernährung von Meeresfischen. II. Quantitative Nahrungsuntersuchungen an Schellfischen (Gadus aeglefinus), Wittlingen (G. merlangus) und Dorschen (G. morrhua) aus der Nordsee unter besonderer Berücksichtigung des Wärmewertes der Nahrung. Berichte der Deutschen Wissenschaftlichen Kommission für Meeresforschung, neue Folge, Band 9, heft 2, p. 274-317.

Homans, R. E. S., and A. W. H. Needler.
1944. Food of the haddock. Proc. N. S. Inst. Sci., 21, Pt. II, p. 15-49.

Huntsman, A. G.
1918. Histories of new food fishes. I. The Canadian Plaice. Bull. Biol. Bd. Can., No. 1, p. 18.

Idelson, M. S.
1929. On the nourishment of the food fishes in the Barents Sea. Russk. gidrobiol. Zh., 7, p. 269-285.

Jensen, A. C., and R. L. Fritz.
1960. Observations on the stomach contents of the silver hake. Trans. Amer. Fish. Soc., vol. 89, no. 2, p. 238-240.

Jesperson, Poul.
1928. Investigations on the food of the herring in Danish waters. Medd. Komm. Havundersoeg., Ser. Plankton, Band 2, Nr. 2, 150 p.

1932. On the food of the herring in Icelandic waters. Medd. Komm. Havundersoeg., Ser. Plankton, Band 2, Nr. 3, 34 p.

1936. The food of the herring in the waters round Bornholm. Medd. Komm. Dan. Fish.-Havundersoeg., Ser. Plankton, Band 3, Nr. 2, 40 p.

1944. Investigations on the food of the herring and the macroplankton in the waters round the Faroes. Medd. Komm. Dan. Fish.-Havundersoeg., Ser. Plankton, Band 3, Nr. 7, 44 p.

Johnson, W. H.
1934. Herring food in Passamaquoddy Bay. Biol. Bd. Can., Ann. Rept. for year 1933 (1934), p. 24.

1939b. Feeding of the herring. Jour. Fish. Res. Bd. Can., vol. 4, No. 5, p. 392-395.

1942. Effect of light on copepods as food for Passamaquoddy herring. Jour. Fish. Res. Bd. Can., vol. 5, No. 4, p. 365-376.

Jones, R.
1954. The food of the whiting, and a comparison with that of the haddock. Mar. Res. Scot., 1954 (2).

Jordon, David Starr, and Barton Warren Evermann.
1896. The fishes of North and Middle America: A descriptive catalogue of the species of fish-like vertebrates found in the waters of North America, north of the Isthmus of Panama. Part I. U. S. Nat. Mus. Bull. No. 47, lx 1, 240 p.

1902. American food and game fishes. A popular account of all the species found in America north of the equator, with keys for ready identification, life histories, and methods of capture. Doubleday, Page, and Co., New York, 573 p.

Karpevitch, A., and E. Bokoff.
1937. The rate of digestion in Marine fishes. Zoologicheskii Zhurnal, tom 16, vyp 1, p. 38-44. Moscow. (English summary).

Kendall, William Converse.
1898. Notes on the food of four species of the cod family. Rept. U. S. Comm. Fish and Fisheries, 1896, 22: 177-186.

Kyle, H. M.
1926. The biology of fishes. MacMillan Co., New York.

Lambert, D. G.
1960. The food of the redfish Sebastes marinus (L.) in the Newfoundland area. Jour. Fish. Res. Bd. Can., 17 (2): 235-243.

LeBour, Marie V.
1924a. The food of young herring. Jour. Mar. Biol. Assoc. U. K., n. s., vol. 13, No. 2, p. 325-330.

1924b. The Euphausiidae in the neighbourhood of Plymouth and their importance as herring food. Jour. Mar. Biol. Assoc. U. K., n. s., vol. 13, No. 2, p. 402-420.

Linton, E.
1901. Fish parasites collected at Woods Hole in 1898. Bull. U. S. Fish Comm., 19, p. 267-304, 10 plates.

1901. Parasites of fishes of Woods Hole region. Bull. U. S. Fish Comm., 19, p. 405-501, 34 plates.

1921. Food of young winter flounders. Rept. U. S. Comm. Fish., Bur. Fisheries Doc. 907, Appendix IV.

Lucas, C. E.
1936 b. The ecological relations between the herring and the plankton investigated with the plankton indicator. Part II. Zooplankton-herring correlations in the English fisheries. Jour. Mar. Biol. Assoc. U. K., n.s., vol. 21, No. 1, p. 176-242.

MacIntosh, W. C.
1874. On the invertebrate marine fauna and fishes of St. Andrews. Ann. Nat. Hist. Mag., 13, p. 204.

Martin, W. R., and F. D. McCracken.
1954. Relative efficacy of baits for groundfish. Fisheries Research Board of Canada, Progress Reports of the Atlantic Coast Stations, no. 58, p. 17-20.

McIntyre, A. D.
1952. The food of halibut from North Atlantic fishing grounds. Scottish Home Dept. Mar. Research, 1952, No. 3.

McKenzie, R. A.
1938b. Cod take smaller bites in ice-cold water. Fisheries Research Board of Canada, Progress Reports of Atlantic Biological Station, St. Andrews, N. B., and Atlantic Fisheries Experimental Station, Halifax, N. S., no. 22, p. 12-14.

Medcof, J. C., and J. S. MacPhail.
1952. The winter flounder--a clam enemy. Prog. Rept. No. 52, Fish. Res. Board of Canada, Jan. 1952, p. 3-8.

Meschkat, A.
1936. Untersuchungen über den Aufbau der Kabeljaunahrung im Bereich der Vestmannainseln. Conseil Permanent International pour l'Exploration de la Mer, Rapports et Proces-Verbaux des Reunions, vol. 99, no. 3, p. 1-10.

Moore, Emmeline.
1947. Studies of the marine resources of southern New England. VI. The sand flounder Lophopsetta aquosa (Mitchill); a general study of the species with special emphasis on age determination by means of scales and otoliths. Bull. Bing. Oceanog. Coll. 11 (3): 1-79.

Moore, Henry F.
1898. Observations on the herring and herring fisheries of the Northeast coast, with special reference to the vicinity of Passamaquoddy Bay. Rept. U. S. Comm. Fish. (1896-98), No. 402.

Morrow, J.
1951. Studies on the marine resources of southern New England. VIII. Biology of the Longhorn Sculpin (Myoxocephalis octodecimspinosus (Mitchill)). With a discussion of the New England (trash) fishery. Bull. Bing.Oceanogr. Coll., 13 (2), p. 1-89.

Motoda, Shigeru, and Takeshi Sakai.
1946. Feed of the spring herring. (In Japanese). Hokkaido Suisan Shikenjo Geppo, vol. 3, No. 9-10, p. 155-165.

Motoda, Shigeru, and Isamu Takeuchi.
1949. Investigation of the food of spring herring (in 1948). (In Japanese). Hokkaido Fish. Sci. Inst. Sci. Papers, No. 1, p. 32-44.

Needler, A. W. H.
1929. Unpigmented elvers (Anguilla rostrata Lesueur) in haddock stomachs at Ingonish, Cape Breton. Copeia, vol. 171, p. 41-42.

Nichols, J. T., and C. M. Breder, Jr.
1927. The marine fishes of New York and southern New England. Zoologica, vol. 9, p. 163-164.

Nye, W.
1887. The habits of whiting or frost-fish. Bull. U. S. Fish Comm. 1886 (1887), 6, p. 208.

Ogilvie, H. S.
1934. A preliminary account of food of herring in the N. W. North Sea. Rapp. Cons. Explor. Mer., vol. 89, p. 85-92.

Olsen, Yngre H., and Daniel Merriman.
1946. Studies on the marine resources of So. New England. IV. The biology and economic importance of the ocean pout, Macrozoarces americanus (Bloch and Schneider). Bull. Bing. Oceanogr. Coll., 9 (4), p. 124-129.

Parrish, B. B., J. H. Blaxter, and F. G. T. Holliday.
1958. Herring (Clupea harengus L.) in aquaria. II. Feeding. Scottish Home Dept. Mar. Res. No. 6.

Pavshtiks, E. A.

1956. Seasonal changes in plankton, and feeding migrations of herring (In Russian).

Poliarnyi Nauchno-issledovatel'skii Inst. Moskovo Rybn. Khoz, Okeanogr. Murmansk., Trudy, vyp 9, p. 93-123

Pchelkin, N. V.

1939. The relations between the herring and the zooplankton in the Barents Sea (In Russian).

Trans. Knipovich Polar Sci. Inst. Sea-Fish Oceanogr., vol. 4, p. 109-128.

Pearcey, Fred G.

1885. Investigations on the movements and food of the herring, and additions to the marine fauna of the Shetland Islands. Proc. Roy. Phys. Soc. Edinburgh, vol. 8, p. 389-415.

Pearcy, W. G.

1962. Ecology of an estuarine population of winter flounder, P. americanus (Walbaum). Pt. IV. Food habits of larvae and juveniles. Bull. Bingham Oceanogr. Coll. 18: 5-78.

Petrova-Grinkevich, N. S.

1944. The feeding competition between the haddock and cod in the Barents Sea. Transactions of the Knipovich Polar Scientific Institute of Sea-Fisheries and Oceanography, Murmansk, vol. 8, p. 416-427. (Available in U.S. Fish and Wildlife Service Translation Reprint Series.)

Popiel, Jozef.

1951. Feeding and food of the herring (Clupea harengus L.) in the Gulf of Gdansk and in adjoining waters (In Polish). Bull. Inst. Peches Mar. Gdynia, Nr. 5, p. 103-113.

Poulsen, Erik M.

1928. The haddock in the Belt Sea and the western Baltic during the years 1926-28. Rpt. Dan. Biol. Sta., 34: 99-121.

Reimann, Z.

1955. Odzywianie sie i pokarm mlodocianego dorsza (Gadus callarias L.) Poludniowegol Baltyku. (Nutrition and food of young cod (Gadus callarias L.) of the southern Baltic.) Prace Morskiego Instytutu Rybackiego w Gdyni, Nr. 8, p. 171-185. (English Summary.)

Ritchie, Alfred.

1937. The food and feeding habits of the haddock (Gadus aeglefinus) in Scottish waters. Fisheries, Scotland, Sci. Invest., 1937, II.

Savage, R. E.

1931. The relation between the feeding of the herring off the east coast of England and the plankton of the surrounding waters. Min. Agric. Fish. (Eng.), Fish. Invest., ser. 2, Vol. 12, No. 3, 88 pp.

Savage, R. E.

1937. The food of the North Sea herring, 1930-34. Brit. Fish. Invest. London, Ser. 2, 15 (5): 1-60.

Schaefer, R.

1960.

New York Fish and Game, 7 (2): 85-98.

Scott, Andrew.

1896. Examination of food in fishes' stomachs. Proc. Lpool Biol. Soc., 10: 108-114.

Scott, Thomas.

1888. Notes on the contents of the stomachs of herring and haddocks. Fish. Bd. Scot., 6th Ann. Rept., 1887 (1888), pt. III, p. 225-231.

Scott, Thomas.

1902. Observations on the food of fishes. Fish. Bd. Scot., 20th Ann. Rept., 1901 (1902), pt. III, Sci. Invest., p. 486-538.

Scott, Thomas.

1907. Some observations on the food of the herring. Fish. Bd. Scot., 25th Ann. Rept., pt. 3, Sci. Invest., p. 260-271.

Sharp, B.

1901. The food of the cod. Proceedings of the Academy of Natural Sciences of Philadelphia, Vol. 53, p. 2.

Smith, W. R.

1889. On the food of fishes. Seventh Annual Report of the Fishery Board for Scotland being for the year 1888, part III, Scientific Investigations, p. 222-258.

Smith, W. R.

1890. On the food of fishes. Eighth Annual Report of the Fishery Board for Scotland being for the year 1889, part III, Scientific Investigations, p. 230-256.

Smith, W. R.

1891. On the food of fishes. Ninth Annual Report of the Fishery Board for Scotland being for the year 1890, part III, Scientific Investigations, P. 222-242.

Smith, W. R.

1892. On the food of fishes. Tenth Annual Report of the Fishery Board for Scotland being for the year 1891, part III, Scientific Investigations, p. 211-231.

Smitt, F. A.

1892. A history of Scandanavian fishes. Stockholm and London, 2nd ed., Vol. I, 566 pp.

Steven, A. C.

1930. Bottom fauna and the food of fishes. J. Mar. Biol. Assoc. U.K., n. s., 16 (3): 677-705.

Suyehiro, Y.

1934. Studies on the digestive system and the feeding habit of the important fishes of the North Pacific. I. The cods, Gadus macrocephalus Tilesius and Theragra chalcogramma (Pallas). (Jananese with English synopsis and tables.) Bulletin of the Japanese Society of Scientific Fisheries, vol. 3, no. 1, p. 8-16. Tokyo.

Tester, Albert L., and Rex V. Boughton.

1939a. Herring and herring food at Klemtu Passage. Fish. Res. Bd. Can., Prog. Repts. Pac. Biol. Sta. and Pac. Fish. Exp. Sta., No. 39, p. 21-22.

Todd, R. A.

1905. Report on the food of fishes collected during 1903. Marine Biological Association of the United Kingdom, International Fishery Investigations. First Report on Fishery and Hydrographical Investigations in the North Sea and adjacent areas (southern area), 1902-1903, p. 227-287. London.

Todd, R. A.

1907. Second report on the food of fishes (North Sea, 1904-1905). Marine Biological Association of the United Kingdom, International Fishery Investigations. Second Report (southern area) on Fishery and Hydrographical Investigations in the North Sea and adjacent waters, 1904-1905, part 1, p. 49-163. London.

Trechmann, Charles O.

1888. Voracity of the haddock. Nature (London) 39: 9.

Trout, G. C.

1961. Bibliography on Redfish. I.C.N.A.F. Spec. Pub. No. 3, p. 303-311.

Verrill, A. E.

1871. On the food and habits of some of our marine fishes. Amer. Nat., 5: 397-400.

Verrill, A. E.

1873. Lists of species found in the stomachs of fishes - food of fishes. Rept. U. S. Comm. Fish and Fisheries, 1871-1872, 1: 514-521.

Vladykov, V. D. and R. E. S. Homans.

1935. Do haddock feed during the spawning period? Prog. Rpt. Atlant. Biol. Sta., 15: 10-11.

Weber, F. C., and J. B. Wilson.

1920. The food of the small sea herring and ammonia and amines as end products of its decomposition. Jour. Amer. Chem. Soc., Vol. 42, No. 4, p. 841-849.

Wiborg, K. F.

1948b. Some observations of the food of cod (Gadus callarias L.) of the 0-II-group from deep water and the littoral zone in northern Norway and from the deep water at Spitzbergen.

Fiskeridirektoratets Skrifter, Serie Havundersøkelser (Reports on Norwegian Fishery and Marine Investigations), vol. 9, no. 4, p. 1-19.

Wigley, R. L.

1956. Food habits of Georges Bank haddock. U. S. Bur. Com. Fish., SSR Fish. No. 165, Jan. 1956, 26 pp.

Willey, A.

1921. Arctic copepods from Passamaquoddy Bay. Proc. Amer. Acad. Arts. Sci. 56: 192.

Zatsepin, V. J., and N. S. Petrova.

1939. The feeding of the cod in south part of the Barents Sea. Transactions of the Knipovich Polar Scientific Institute of Sea-Fisheries and Oceanography, Murmansk, USSR, vol. 5, p. 1-171. (English abstract.)

Regional Director, BCF Region 3
Gloucester, Mass.

4 November 1963

Laboratory Director, BCF Biol. Lab.
Woods Hole, Mass.

Foreign Fishing Program

Replying to your memorandum of 25 October, I have re-read the special progress report since talking with Bernie and am a little surprised that he feels the opinion is expressed so emphatically there that a reduction in herring population would be deleterious to the groundfish populations. Certainly this Laboratory is taking no such stand.

The statements made regarding the predator-prey relations are all based either on published reports or on our own stomach analyses. The interspecific relationships are pretty well known now on a qualitative basis but, as pointed out in the last paragraph of the report, our job now is to build up enough quantitative data so that we can make some valued judgements on the interspecific abundance relations.

Depleting the herring stocks might have a harmful or a beneficial effect on the groundfish stocks, or might have no effect at all. We simply don't know at this stage of things. It is the purpose of the program to seek the answer. If we had the answer, we would close out the program.

Herbert W. Graham

Foreign Fishing Program

Regional Director, BCF
Gloucester, Massachusetts

October 23, 1963

Laboratory Director, BCF Biol. Lab.
Boothbay Harbor, Maine

Foreign Fishing Program

Following the request from your office, a copy of the Woods Hole Progress Report on Foreign Fishing was forwarded to me. This report, the recent publicity in TIME magazine, and the statements in Boston newspapers all emphasize an aspect of the problem which I cannot defend and do not support. Specifically, this is the implication that the offshore herring fishery will be detrimental to the commercially important groundfish species. I am enclosing a verifax copy of the article in TIME for your reference.

I have discussed the Woods Hole Report with Dr. Graham on the telephone and outlined to him the particular aspects with which I am concerned. Essentially, my objections are directed to statements which suggest that with the removal of herring from Georges Bank, predators normally feeding on this species will turn to the groundfishes as a source of food. The report alludes to readjustments within the fishing community resulting from "undue fishing pressure" on herring and follows with a statement that ". . . there is no evidence to suppose that they will be beneficial to the New England fisheries." I see no reason that these adjustments will be any more serious than those experienced with undue pressure on groundfishes, and argue that there is no evidence to suppose that these readjustments will be detrimental.

Dr. Graham pointed out that he intended the report to be speculative and I can understand his reasoning in this regard; however, the text is not always properly qualified and statements that were apparently intended as speculative have been presented as truisms which are misleading. I am in full agreement with the importance and need for studying the inter- and intra-specific relationships of fishes in the Gulf of Maine and am in agreement with the approach to the problem, but care must be exercised so that conclusions are not made prematurely or without proper evidence. Dr. Graham and I have decided that we shall increase our contacts on these matters of importance to both laboratories, and I judge that this will provide a worthwhile review of each laboratory's efforts and eliminate any misunderstandings that might otherwise develop.

Bernard E. Skud

Enclosure
cc: Dr. Graham

badgered by the Russians in the North Pacific. Irish corvettes have scattered Dutchmen and Belgians from Ireland's herring grounds, and Canada last year ordered a Russian fleet out of the Bay of Fundy. Even the conference table can become chilly; last week in Tokyo, Japanese, U.S. and Canadian delegates labored through the fifth week of a conference stalemated by a U.S.-Canadian refusal to let Japanese fishermen fish for trout, halibut and salmon east of the 175th longitude.

Cannon Law. Behind most of the fish wars is a confusing juridical problem that three international conferences since 1930 have failed to solve. Since 1703, when they based original measurements on 18th century naval cannon ranges, major nations generally have established their territorial limits at three miles offshore. But fishing limits are something else, and more and more nations are pushing their boundaries beyond three miles—Mexico nine miles, Canada to twelve, and such nations as Chile, Peru and Ecuador to an imperious 200 miles offshore. Many nations have settled on a twelve-mile limit, but the U.S. up to now has refused to recognize any jurisdiction beyond the traditional three-mile limit.

International feuding has flared because the oceans, from which primeval life came, have become more and more an important source of food for a world faced with the prospect of overpopulation. Since the beginning of the century, the fishing yield of the world has increased tenfold, from 4,400,000 tons to 45 million tons; by 1970, the catch is expected to equal 61 million tons. More than 200 countries send fishing boats to sea to help feed their populations, and 48 of these countries account for the great bulk of the world's fish catch, amounting to more than $3 billion worth a year. There are 4,967,000 commercial fishermen at work, and in the U.S. alone well over half a million people are employed in fishing and related fields—cleaning, canning, packing, distributing. But fishing ranks far, far down on the list of U.S. industries; in 30 years, meat-eating Americans have kept their consumption of fish unchanged at short of eleven pounds per person.

Just as bread or meat is the staff of life for many nations, for others fish is the very stuff that life is made of. Fishing plays a vital role in the economies of dozens of nations, such as Japan, Ecuador, Peru, Canada and Norway. For many food-short nations, the "panic for protein" to feed their people leads only to the sea, which now contributes a meager 12% of the supply of animal protein consumed by the human race. Throughout the world, the fishing industry not only supports thousands of fishermen—who lead probably the roughest and most ill-paid lives of any workers—but countless satellite industries. From Madagascar to Greenland, the catch of the sea, ranging from the lordly tuna through the pedestrian cod and herring to the rarer but often treasured whale and shark, is industriously smoked, fried, salted, baked, dried, roasted, stewed, pickled, casseroled or even eaten half-rotten (as in Iceland) or quite raw (as in Japan).

Reshuffled Ranks. Despite this, only about 15% of the world's edible fish stock is being fully exploited. The trouble is that the exploitation has taken place in the known and favored areas, mostly within 100 miles of land, where a concentration of effort has often led to a depletion of valuable fish. The Russians off Cape Cod, for example, are out for herring rather than the hake, haddock and cod that most American fishermen are after—but the other species tend to disappear after the herring, their natural food, becomes scarce. Industrial pollution in such nations as Japan and the U.S. has tended to drive the fish farther from shore and to make worse the lot of the smaller inshore fisherman.

HENRY GROSSMAN

SERVING FISH AT MANHATTAN'S MEDITERRANEE
Out of a vast wilderness.

Scientists like to talk of the sea's "harvest," but the sea is a vast wilderness, and fishing is essentially a hunt for an unstable and unpredictable commodity. Despite its importance to so many nations, fishing is still one of the world's most backward industries, estimated to be about at the stage that agriculture was a thousand years ago. To fisherman and scientist alike, the 139 million square miles of ocean are still mostly a mystery—but the mystery at last is being approached in a more scientific way. Today's fishing boats have doubled in size, and they are built so that they can haul their nets over the stern instead of hoisting them alongside in the laborious old "otter" process that tired crews, reduced fishing time and endangered fishermen in heavy weather. They are routinely equipped for better fishing with such sophisticated electronic devices as Fathometers and radar, sonar and loran.

U.S. tuna men have changed their ways—and increased catches—by using giant purse seine nets instead of old-fashioned baited hooks. The Japanese have pioneered in a new and promising field called pelagic—or oceanic—fishing. Almost all fishing is now carried out at the surface or on the bottoms of the continental shelves that jut from the world's mainlands. By experimenting with trawling at mid-water reaches, and gauging depths by telemetry and echo soundings, Japan and such other nations as Iceland are opening up a whole new field of mid-ocean fishing.

The changes in technique have already reshuffled rankings among fishing nations. Before World War II, the U.S. was second, behind Japan. The Japanese, who consume five times as much fish per person as Americans, still lead everyone. But Japan is followed by Peru, which has forged an incredible industry (7,000,000 tons last year) almost totally out of the anchovies that are borne up the Peruvian coast on water currents, and Red China and Russia are now third and fourth. The U.S. has sagged to fifth place by allowing its fishing fleet to atrophy—even though it imports more fish than any other nation in the world.

Factories at Sea. Armed with modern methods, the fleets of the world's major fishing powers roam far from their homelands in search of a good catch. The Russians and the Japanese have perfected deep-freeze factories right on board ship that enable them to stay at sea for up to six months. The Russians lead in oceanographic studies that help them find good fishing grounds, and have perhaps the world's most modern fishing fleet. They fish in fleets shepherded by 15,000-ton mother ships that carry helicopters to spot fish schools and frogmen to untangle nets; occasionally, the Russians even use submarines to lead their trawlers to happy hunting grounds.

The future of fishing is even more exotic, to judge by the U.N. fishing congress held recently in London. Japan is trying out salt-pond "farms" on the Inland Sea, where yellowtail and sea bream are raised and dumped into the adjacent sea when grown. England is farming plaice somewhat in the manner that trout rivers are restocked. The 600 delegates from 50 fishing nations at the congress also saw the coming use of underwater television, fish hunts by submarine, fish herding by means of electric fences or bubble barriers, unattended sonic devices that could float like logs and signal the approach of schools—and even fish mating calls simulated by scientists as potent lures. Some day, as countries turn more and more to the sea to feed their growing population, the hunters may all become scientists, and the ancient sea may finally be persuaded to yield a harvest.

The Director, Bureau of Commercial Fisheries October 16, 1963
Attn.: Chief, Branch of Marine Fisheries

Acting Regional Director
Gloucester, Massachusetts

Special Reports on Foreign Fishing Program

Attached you will find narrative reports on the status of the foreign fishing program at the Woods Hole and Boothbay Harbor Biological Laboratories. These reports include general information on the purpose of the program and preliminary views on the results that are taking shape. They are not intended for publication but are designed to keep you and your staff up-to-date on our work.

It is suggested that the reports be circulated to Mr. John Gharrett for his information and interest.

H. B. Allen

Attachments

cc: Dr. Graham
Mr. Skud

BOOTHBAY HARBOR, ME.

PROGRESS REPORT--FOREIGN FISHING--October 1, 1963

Foreign Fishing funds at Boothbay Harbor support a research program which is designed (1) to determine the effects of U.S.S.R. fishing on Georges Bank herring stocks, and (2) to determine the relationship, if any, between Georges Bank and coastal populations of herring, particularly Maine sardines. Since July 1962, there have been six cruises on Georges Bank to sample adult herring and collect related environmental data. Additional Georges Bank herring have been obtained from cruises conducted by other Bureau programs. Adult herring have also been collected from the Gulf of Maine and Nova Scotia to compare spawning time, age structure, growth rates, meristic characters, and blood groups. Collections which date to 1955, prior to U.S.S.R. exploitation, are also being examined and utilized in the comparisons. Analysis of maturity stages indicates that spawning time varied slightly from year to year, Georges Bank and Gulf of Maine herring spawned principally during late September and early October. Occasional spawning occurred during late August and early November. There has been no evidence of spring spawning on Georges Bank, but a few running fish were taken in April, 1955 and May and June, 1963 in the Gulf of Maine. Nova Scotia herring spawned from May to October. Spring spawning occurred from May to early July, and fall spawning from late August or early September to October. Georges Bank, Gulf of Maine, and Nova Scotia herring are at least 22 cm. (standard length) by their first spawning, and maturity is usually reached during the fourth year of life.

Larval studies have also been conducted on Georges Bank. Number of larvae obtained, their mean lengths, and their distribution are being studied to note and assess any changes that might have occurred since 1956. No larvae were obtained on the banks in early September 1962-1963; in 1956-1957

large numbers of 5 and 7 mm. herring were obtained. In November of 1956-1957 the number of larvae caught per tow was greater than the number obtained in 1962, while in December of 1962, the number per tow was greater than in 1957 but fewer than in 1956.

Ages have been determined using scales and otoliths. In past years, Georges Bank herring consisted primarily of fish in their fourth, fifth, sixth, and seventh year of life, the five and six-year-old fish being the most abundant. The mean lengths of these fish were: fourth year, 24 cm.; fifth year, 25 cm.; sixth year, 26 cm.; and seventh year, 27 cm. Preliminary analysis of 1963 adult herring samples from Georges Bank suggest that the most abundant year classes are those of 1957 and 1958, five and six-year-olds.

Comparison of fin ray counts for Georges Bank and Nova Scotia herring disclosed significant differences between these major spawning groups. No significant difference was found for any of the ray counts between samples of adult herring obtained from Georges Bank and the Gulf of Maine. Attempts to identify spawning populations and their offspring with blood typing methods have indicated four subtypes in the C blood group system of herring. Frequencies of each subtype in Georges Bank samples have been determined, and have been found to be quite different from those in Gulf of Saint Lawrence herring. Other spawning populations in the Gulf of Maine will be tested similarly.

A meeting with Russian herring scientists at Boothbay Harbor in May, 1963 provided the first opportunity of comparing efforts directed toward biological studies. The Russians are, of course, conducting a far superior sampling program, and indications were that intensive migration and hydrographic studies would be initiated in the near future. Our present funding

does not allow more than 18 days of sea sampling. This limitation influences our coverage in both area and time and forces us to rely on Russian data for much of our analysis. Russian fishing effort has increased substantially and catches of herring have risen from 67,000 metric tons in 1961 to more than 150,000 metric tons in 1962. In a multiple-age fishery such as this one, the effects of fishing can be masked for several years or until the progeny of the exploited year classes are recruited to the fishery. To date, there is no evidence to determine whether the exploitation is endangering the Georges Bank herring stocks.