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THE STORY OF THE BUREAU OF COMMERCIAL FISHERIES BIOLOGICAL LABORATORY WOODS HOLE, MASSACHUSETTS

By Paul S. Galtsoff

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By Paul S. Galtsoff

I. Early Years of Woods Hole

On a June day in 1871, a large, well-dressed, distinguished man in his fifties stepped briskly from the coach that brought the passengers of the Old Colony Railroad from Monument Beach to Woods Hole. The face of the newcomer, with his well-trimmed, slightly curly beard and shaved upper lip, was familiar to some of the local residents gathered to watch the daily arrival of the coach. They recognized him as an important person from Washington who, in 1863, came here to spend part of the summer fishing and resting. The visitor knew the location of the village's only inn; where most of the tourists stopped and waited for the steamer to take them to the islands. He walked rapidly carrying his briefcase and did not appear to be tired after the 20 mile ride on a dusty road. The train service to Woods Hole was not expected to begin before the next summer when the Old Colony Line promised to open the last section that was now under construction. The event seemed to be trivial, and the arrival of the newcomer was not reported in local newspapers. It marked, however, the beginning of a new era for Woods Hole; for his arrival initiated a long series of events which changed the destiny of a small New England fishing settlement into an internationally famous center of research in marine sciences and oceanic fisheries.

An observant person probably would have noticed on the face of the man the signs of dynamic power, determination, and perseverance which distinguished him from ordinary summer tourists who were coming to Cape Cod in ever increasing numbers. The newcomer was the famous zoologist and naturalist, Spencer Fullerton Baird, Assistant Secretary of the Smithsonian Institution and newly appointed, by President Ulysses Grant, first U. S. Commissioner of Fisheries (fig. 1). He faced the enormous task and great responsibility of organizing the new branch of government service dealing with the conservation of natural aquatic resources which appeared to decline under intensive exploitation.

Figure 1.--Spencer Fullerton Baird, Secretary of the Smithsonian Institution and first Commissioner of U. S. Commission of Fish and Fisheries, from 1871 to 1887. Photograph of a painting in the Regents Room of the Smithsonian Institution. Courtesy of A. Remington Kellogg.

During the following 16 years, the activities of Spencer F. Baird greatly influenced the course of biological research in the United States and put studies of the conservation of marine resources on a sound scientific basis. His achievements in zoological research and its application to conservation greatly advanced the progress of marine biology in the United States. In no other place in the country have the results of his work been felt as deeply as in Woods Hole, where a few years after his arrival the first marine laboratory in the United States was established. The laboratory thrived, and the community developed into one of the world's leading scientific research centers.

To understand this profound change in the destiny of Woods Hole it is necessary to visualize the local conditions as they existed at the time of Baird's arrival. The beginning of Woods Hole dates back to the early 17th century. Five years before the settlement of Jamestown, Virginia, and 18 years before the Pilgrims landed at Provincetown and Plymouth, Bartholomew Gosnold coasted along Cape Cod and Marthas Vineyard, and about May 31, 1602, he is believed to have landed at what is now known as Woods Hole. The Town of Falmouth, of which Woods Hole is presently a part, was first settled in 1659-61 when several persons were granted permission to purchase land. The date of the settlement of Woods Hole took place 17 years later. The town (Falmouth) was incorporated on June 4, 1686, and called Succonessett, the name which later, probably in 1694, was changed to Falmouth. On July 23, 1677, the land around Little Harbor of Woods Hole (fig. 2) was divided among the 13 settlers in "lots of 60 acres upland to a share" and an "Indian deed" confirming the land title was signed by Job Notantico on July 15, 1679 (Deyo, 1890). Fishing, hunting, and sheep breeding were the principal occupations of the early settlers and their descendents. Later on a grist mill was built and salt was made by solar evaporation of sea water in pans built along the banks of Little Harbor.

These quiet, rural conditions, devoid of adventure, persisted until about 1815, when Woods Hole became an important whaling station from which ships operated on the high seas. The whaling industry in the United States became a very profitable business, and Woods Hole was a part of it. In 1854, the total receipts for the American whaling fleet amounted to $10.8 million, the largest part of this amount resulted from whaling carried out by Massachusetts captains. Woods Hole participated in these activities and prospered. It is known that between 1815 and 1860, not less than nine whaling ships were making port at the Bar Neck wharf, which was located where the U.S. Navy building of the Woods Hole Oceanographic Institution now stands. The place was busy processing oil and whalebone and outfitting ships. A bake house for making sea biscuits for long voyages stood next to the present "Old Stone Building" built in 1829 as a candle factory. This conspicuous old landmark on Water Street of Woods Hole, identified by an appropriate bronze plaque,

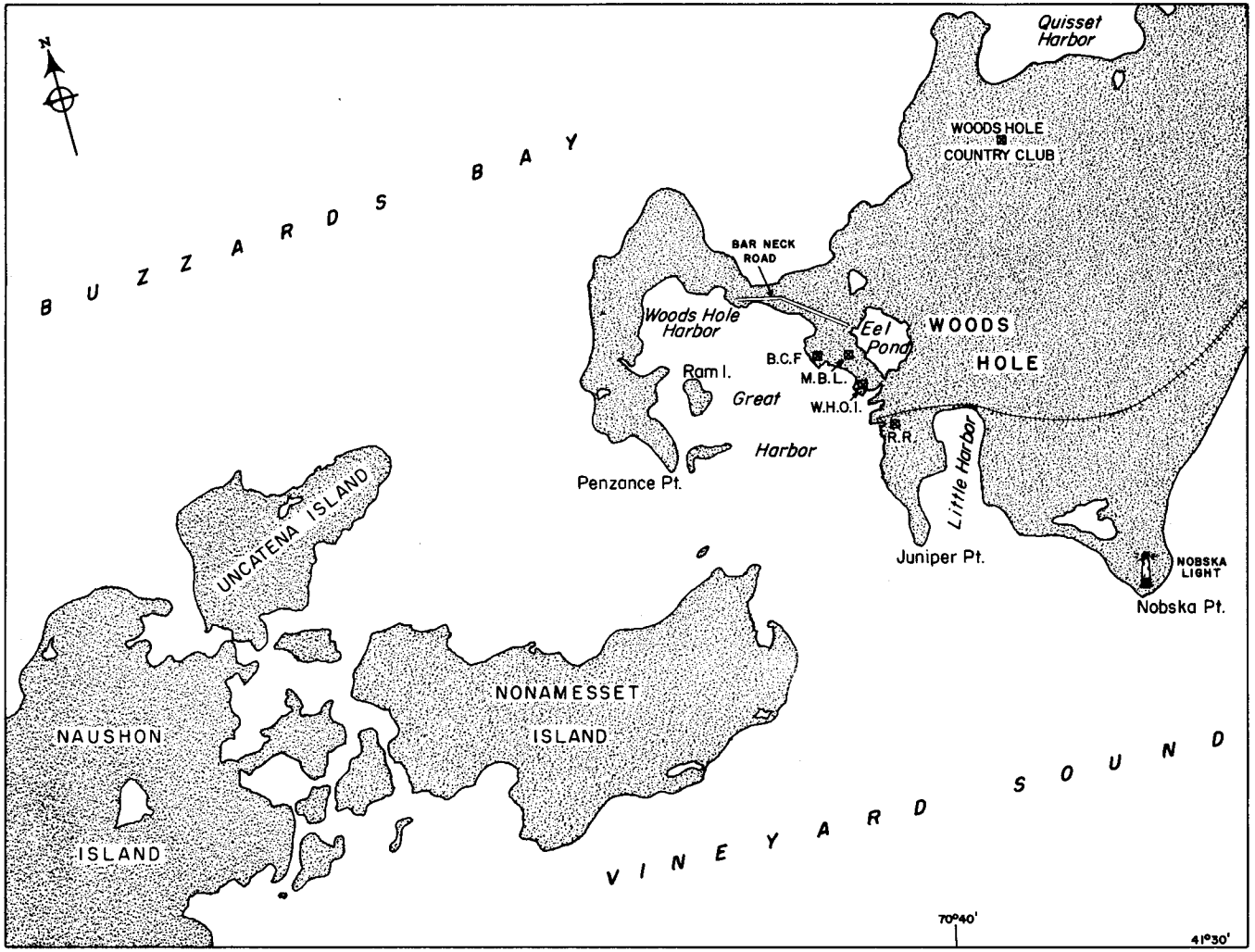

Figure 2.--Map of the present day Woods Hole area and adjacent islands.

Figure 3.--View of Woods Hole from Harbor Hill about 1880. Buildings of the Pacific Guano Works at upper right; candle house at left.

now serves as a warehouse for the Marine Biological Laboratory for storing preserved zoological specimens. About 1860, whaling became less profitable and Woods Hole entered into the second phase of its economic life which was dominated by the establishment and operation of a new commercial venture known as the Pacific Guano Works.

During the years from 1863 to 1889, when the Pacific Guano Works was in operation, the life of Woods Hole centered around the plant which was built at Long Neck near the entrance to what is known now as Penzance Point (fig. 3). Many large sailing vessels carrying sulphur from Italy, nitrate of soda from Chile, potash from Germany, and many schooners under the American flag loaded with guano and phosphorus from the Pacific Coast of South America were anchored in Great Harbor waiting for their turn to unload their cargoes. The number of laborers regularly employed by the Guano Company varied from 150 to 200 men, mostly Irishmen brought in under contract. Several local fishermen found additional employment as pilots for guano ships. The company

maintained a store where various goods such as leather, lead pipe, tin, coal, wood, and other items were bought and sold. The store acted also as a labor housing agency. Through efforts of the business manager of the Guano Company, the Old Colony Railroad was persuaded to extend its branch from Monument Beach to Woods Hole. The establishment of well-organized and reliable transportation to Boston was an important factor in the future life of the community.

The Pacific Guano Works was established by the shipping merchants of Boston who were seeking cargo for the return voyage of their ships (Pacific Guano Company, 1876). The guano deposits of one of the Pacific islands seemed to furnish this opportunity. As soon as the joint stock company was organized in 1859 with the capital of $1 million, arrangements were made almost immediately by which the newly formed concern came into possession and control of Howland Island. This island is located in the middle of the Pacific Ocean at longitude 177° W., a short distance north of the Equator, about 1,500 miles true south from Midway Island of the Hawaiian archipelago. At the same time appropriate plant and docking facilities were built at Woods Hole and 33 large sailing ships became available for hauling guano. Unlike the well-known guano islands off the coast of Peru, Howland Island is located in the zone of abundant rainfall. Consequently, the guano deposits of the island were leached of organic components and consisted of highly concentrated phosphate of lime.

Fertilizer produced by the company was made by restoring the lost organic matter of the phosphate rock by adding the right proportion of organic constituents which were obtained from menhaden, pogy, and other industrial fish which abound in Cape Cod waters. The rock was pulverized and purified by washing; fish brought in by local fishermen were first pressed to extract oil, and the residue digested with sulphuric acid, washed, and dried. Acid was produced locally from sulphur imported from Sicily, and the digestion of fish flesh was carried out in large lead-lined vats. The plant was well equipped with machinery needed for the process and even had a chemical laboratory where chemists made the necessary analyses. Various sheds for storage and drying, barracks for laborers, and a business office completed the facilities.

When the deposits of phosphate rock on Howland Island were exhausted, the company acquired title to the Greater and Lesser Swan Islands from the U.S. Government. These islands are located in the Caribbean Sea at latitude 17° N. and longitude 83° W. off the coast of Honduras. The islands are only 400 miles from Key West, Florida, and 500 miles from New Orleans. They contained good-quality phosphate rock and being much closer to Woods Hole greatly reduced the voyage time and cost of delivery.

Further expansion of the company consisted in the acquisition of Chisolm's Island near the coast of South Carolina, construction of a plant for cracking and washing phosphate rock on the Ball River side of the island, and establishment of a processing plant in Charleston, S. C. From the initial production (in 1865) of 7,540 sacks of fertilizer weighing 200 pounds each, the output reached 11,420 tons in 1871 (the year of Baird's arrival) and continued to grow until the combined annual production in 1879 of the works at Woods Hole and Charleston reached from 40,000 to 45,000 tons of guano fertilizer.

Baird was greatly impressed by the idea of utilizing menhaden and other fishes for the production of guano fertilizer and considered it a worthwhile project. In a letter dated October 18, 1875, to John M. Glidden, treasurer of the Pacific Guano Works Company, Baird urged him "to make a display of your wares at the centennial (in Philadelphia), as this is one of the most important interests in the United States." He writes further that "there is no species (of fish) worked up elsewhere comparable to the movement with the menhaden, or pogy, as to numbers and the percentage of oil. The combination, too, of the pogy scrap with the South Carolina phosphates and the guanos of the West Indies and of the Pacific, are also quite novel, and as being especially an American industry, are eminently worthy of full appreciation."

While the scientists, agriculturalists, and stockholders of the company thought very highly of the guano works, the existence of a malodorous plant was not appreciated by the residents of Woods Hole who suffered from a strongly offensive odor whenever the wind was from the west. Woods Hole might have continued to grow as one of the factory towns of Massachusetts but, fortunately for the progress of science and good fortune of its residents (except those who invested their savings in the shares of Pacific Guano Works), the company began to decline and became bankrupt in 1889.

Cessation of business and heavy monetary losses brought financial disaster to many residents of Woods Hole. The gloom prevailing in the village after the closing of the guano works began to dissipate, however, with the development of Woods Hole as a place of scientific research and with the increasing tourist trade. The factory buildings were torn down, the chimney which dominated the Woods Hole landscape was dynamited, and over 100,000 pounds of lead lining the acid chambers were salvaged (Crowell, 1961). Large cement vats and the remnants of the old wharf remained; in the following years the latter became a favored place for summer biologists to collect interesting marine animals and plants.

The years from 1871 to the death of Baird in 1887 were the formative period of the new era of Woods Hole as a scientific center.

In historical documents and in old books the present name Woods Hole is spelled in a different way. The old name "Woods Holl" is considered by some historians of Cape Cod (Conklin, 1944) to be a relic of the times prior to the 17th century when the Norsemen visited the coast. The "Holl", supposed to be the Norse word for "hill", is found in the old records. The early settlers gave the name "Hole" to inlets or to passages between the islands, such as "Robinson's Hole" between Naushon and Pasque Islands, or "Quick's Hole" between Pasque and Nashawena Islands, and Woods' Hole between the mainland and Nonamesset Island. In 1877 the Postmaster General ordered the restoration of the original spelling "Wood's Holl", which remained in force until 1896 when the United States Post Office changed it back to Woods Hole and eliminated the apostrophe in Wood's. The change was regretted by the old timers and by C. O. Whitman who had given the specific name "hollensis" to some local animals he described.

At the time of his arrival at Woods Hole in 1871, Baird was well known to the scientific circles of this country and abroad as a naturalist, student of classification and distribution of mammals and birds, and as a tireless collector of zoological specimens. He maintained voluminous correspondence with the scientists in the United States and Europe, and was Permanent Secretary of the recently organized American Association for the Advancement of Science. To the general public he was known as a contributor to a science column in the New York Herald and author of many popular magazine articles. His newly acquired responsibilities as Commissioner of Fisheries greatly added to his primary duties as Assistant Secretary of the Smithsonian Institution which was primarily responsible for the establishment of the National Museum in Washington. As a scientist, Baird belonged to the time of Louis Agassiz, Th. H. Huxley, and Charles Darwin. Like Agassiz he attended medical college but never completed his studies, although the degree of M. D. honoris causa was later conferred upon him by the Philadelphia Medical College.

In the words of Charles F. Holder (Holder, 1910), "he was a typical American of the heroic type. A man of many parts, virtues, and intellectual graces, and of all the zoologists science has given the world . . . . he was most prolific in works of practical value to man and humanity."

Commissioner Baird attended many Congressional hearings and conferences with state officials and fishermen at which the probable causes of the decline of fisheries were discussed and various corrective measures suggested. From the lengthy and frequently heated discussions and evidence presented by the fishermen and other persons familiar with the fisheries problems, he became convinced that an alarmingly rapid decrease in the catches of fish had continued for the last 15 or 20 years. Such a decline was particularly noticeable in the case of scup, tautog, and sea bass in

the waters of Vineyard Sound. It was logical, therefore, that the new Commissioner of Fisheries would select for his initial activities the New England coastal area where the fishing industry was of greatest importance as a politico-economical factor.

Woods Hole, however, was not a significant fishing center. In the "Fisheries and Fishing Industry of the United States" prepared and edited by Goode (1884-87) for the 1880 Census (fig. 4), the fishing activity at Woods Hole is described in the following words: "Of the male inhabitants only seven are regularly engaged in fishing, the remainder being employed in the guano factory, in farming and other minor pursuits . . . . There is one ship carpenter in Wood's Holl, but he finds employment in his legitimate business only at long intervals. Of sailmakers, riggers, caulkers, and other artisans there are none. Four men are employed by Mr. Spindel, during the height of the fishing season, in icing and boxing fish. The boat fishery is carried on by seven men from April until September, inclusive. Only three species of fish are usually taken, namely, scup, tautog, and sea bass. The total catch of each fisherman is about 15 barrels, or about 2400 pounds. In addition about 6,720 lobsters are annually taken."

Before selecting a location for permanent headquarters for the work on fishery management and conservation, Baird undertook extensive explorations of the fishing grounds off the entire New England Coast. Section 2 of the Joint Resolution Number 8 of Congress gave the Commissioner full authority to carry out the necessary research. In part it reads as follows: "and further resolved, That it shall be the duty of the said Commissioner to prosecute investigations and inquiries on the subject, with the view of ascertaining whether any and what diminution in the number of the food-fishes of the coast and the lakes of the United States has taken place; and, if so, to what causes the same is due; and also, whether any and what protective, prohibitory, or precautionary measures should be adopted in the premises; and to report upon the same to Congress." Section 4 of the same Resolution contains an important clause which authorizes the Commissioner of Fisheries "to take or cause to be taken, at all times, in the waters of the sea-coast of the United States, where the tide ebbs and flows, and also in the waters of the lakes, such fish or specimens thereof as many in his judgement, from time to time, be needful or proper for the conduct of his duties as aforesaid, any law, custom, or useage of any State to the contrary notwithstanding."

The significant words "where the tide ebbs and flows" were interpreted by Baird in a very broad scientific sense which extended the authority for his investigations to the offshore areas of the open ocean.

Pounds and weirs were most frequently accused by the public as destructive methods of fishing responsible for the decline in the abundance of food fishes along the coast. Although Baird gave very

Figure 4.--George Brown Goode, Director of the National Museum and assistant to Baird in Woods Hole.

serious consideration to the possible destructiveness of fixed nets, traps, pounds, pots, fish weirs, and other stationary apparatus, he was fully aware of the complexity of the factors which may cause the decline in fish populations. He discusses this difficult problem in a paper entitled "Report on the condition of the sea fisheries of the south coast of New England" and published as the first section of the voluminous First Report of the Commissioner of Fish and Fisheries for 1871. Of the causes which may have contributed to the decrease of summer shore fisheries of the south side of Massachusetts and Rhode Island, a fact which he considered as well established by the testimonies of competent persons, he lists the following: (1) decrease or disappearance of the food of commercial fishes; (2) migration of fishes to other localities; (3) epidemic diseases and "peculiar atmospheric agencies, such as heat, cold, etc."; (4) destruction by other fishes; (5) man's activities resulting in the pollution of water, in overfishing, and the use of improper apparatus.

The biologist of today will recognize in this statement Baird's broad philosophical approach to the major problem of fishery biology. The outlined program combined oceanographical and meteorological investigations with the studies of biology, ecology, parasitology, and population dynamics of various fish species. Baird's program of research is as comprehensive and valid today as it was 90 years ago.

No time was lost in initiating this program. Woods Hole was selected as the base of the sea coast operations during the first summer. In spite of the insignificance of local fisheries, this locality offered a number of advantages which were recognized by Baird. Communication with Boston, New York, and Washington was good and promised to be better with the expected opening of the railroad branch in 1872. Being centrally located in relation to principal fishing grounds of New England and having good dock facilities and water of sufficient depth for sea going vessels, Woods Hole was a suitable base for visiting the offshore grounds. Furthermore, it was believed that the alleged decrease in food fishes was most clearly manifested in the region around Vineyard Sound. The small yacht Mazeppa of the New Bedford Custom House and the revenue-cutter Moccasin attached to the custom-house at Newport, R.I., were placed at the disposal of Baird; and the Light-House Board granted permission to occupy some vacant buildings and the wharf at the buoy-station on the west bank of Little Harbor (fig. 5). The Secretary of the Navy came to Baird's assistance by placing at his command a small steam launch which belonged to the Boston Navy Yard and by giving many condemned powder tanks which could be used for the preservation of specimens. Nets, dredges, tanks, and other gear were provided by the Smithsonian Institution. Cooperation of the various governmental agencies was authorized

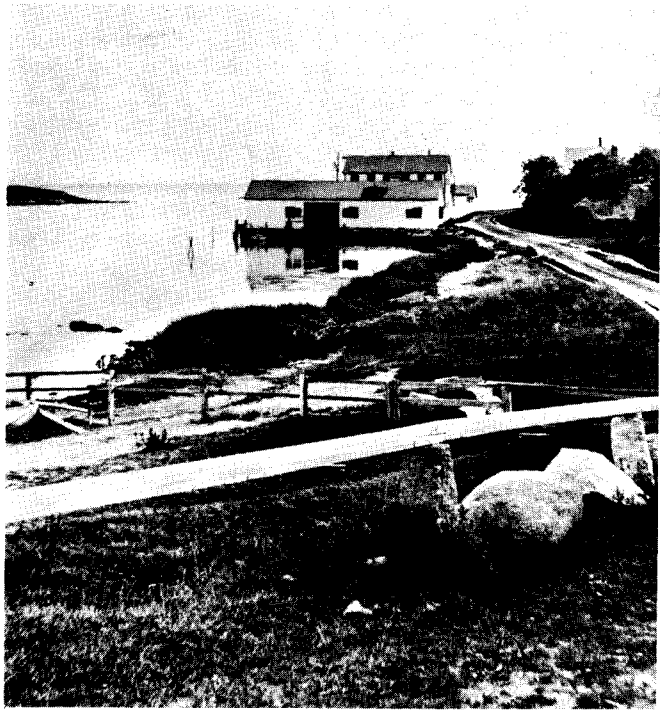

Figure 5.--Buildings of the Light-House Board on the west bank of Little Harbor used by Baird as temporary headquarters and laboratory. Courtesy of Norman T. Allen.

by Congress which in Section 3 of the Resolution specified that "the heads of the Executive Departments be, and they are hereby directed to cause to be rendered all necessary and practicable aid to the said Commissioner in the prosecution of the investigations and inquiries aforesaid."

This provision of the law was of great value. It is apparent, however, that the success in obtaining cooperation authorized by law depended a great deal on the personal characteristics of Baird, his great ability of getting along with people, and his remarkable power of persuasion. These qualifications played the major role in his success in organizing the Commission's work and also in obtaining the cooperation of scientists as well as that of fishermen and businessmen.

The investigation during the first summer consisted primarily in collecting large numbers of fishes and studying their spawning, rate of growth, distribution, and food. In the course of this work nearly all the fish pounds and traps, some 30 in number, in the

vicinity of Woods Hole, were visited and their location recorded. There was no difficulty in obtaining the owners' permission to examine these installations and to collect the needed specimens. Altogether 106 species of fish were secured, photographed, and preserved for the National Museum. Of this number 20 or more species had not previously been known from Massachusetts waters (Baird, 1873). Information gained in this manner was supplemented by the testimonies of various fishermen who presented their ideas either for or against the use of traps and pounds. Among them was Isaiah Spindel, who at the request of Baird, prepared a description of a pound net used at Woods Hole and explained its operation. In the following years Spindel became an influential member of the group of local citizens who supported Baird's plan of establishing a permanent marine station at Woods Hole.

The ship Moccasin under the command of J. G. Baker was engaged in taking samples of plankton animals, in determining the extent of beds of mussels, starfish, and other bottom invertebrates, and in making temperature observations.

One of the principal collaborators in the studies conducted at Woods Hole in 1871 was A. E. Verrill (fig. 6) of Yale University, a professor whom Baird appointed as his assistant and placed in charge of the investigations of marine invertebrates. Dredging for bottom animals during the first summer was carried out on a relatively small scale from a chartered sailing yacht Mollie and a smaller vessel used in the immediate vicinity of Woods Hole. Extensive collections were made by wading on tidal flats exposed at low water.

Zoological work attracted considerable interest among the biologists of this country. Many of them stopped at Woods Hole for greater or lesser periods and were encouraged by Baird to use the facilities of the Fish Commission. The group included such well known men as L. Agassiz, A. Hyatt, W. G. Farlow, Theodore Gill, Gruyure Jeffries of England, and many others.

The first year's work extended until the early part of October. Before returning to Washington, Baird commissioned Vinal N. Edwards (fig. 7) of Woods Hole to continue the investigation as far as possible. By the end of the first year a general plan of study of the natural histories of the fishes and the effect of fishing on fish populations was prepared with the assistance of the well-known ichthyologist, Theodore N. Gill. His old "Catalogue of the fishes of the Eastern Coast of North America from Greenland to Georgia", (Gill, 1861) was revised and the next text including the recently collected data concerning the Massachusetts fishes, appeared in the First Report of the U. S. Commissioner of Fish and Fisheries (Gill, 1873). The plan of investigation suggested by Gill was adopted by Baird (Baird, 1873) as a guide for the work of his associates for the purpose of "securing greater precision in the inquiries." The plan is composed of 15 sections, such as

Figure 6.--A. E. Verrill, Professor at Yale University and assistant to Baird at Woods Hole.

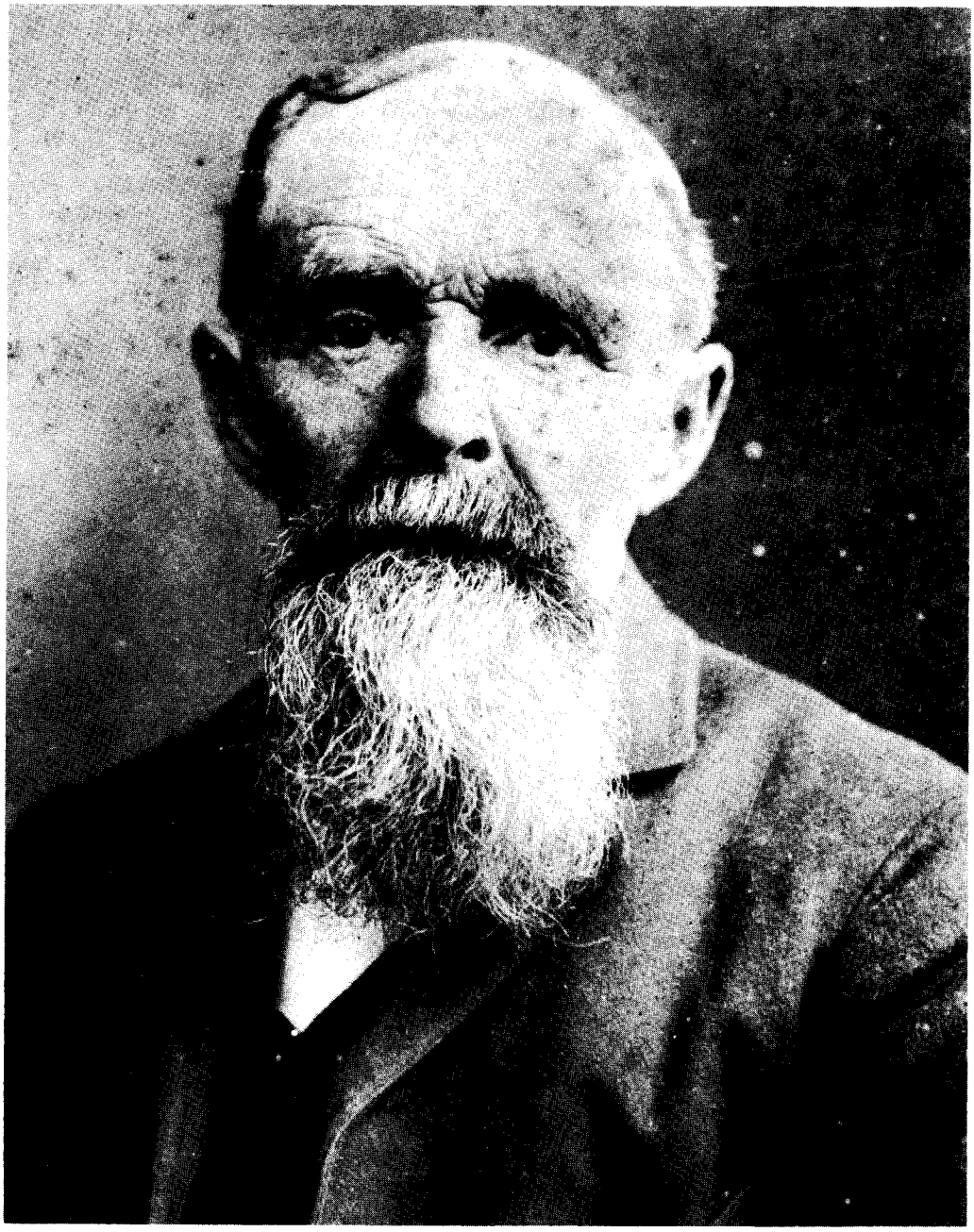

Figure 7.--Vinal N. Edwards, naturalist and collector for the U. S. Fisheries station at Woods Hole. About 1918.

Geographical distribution, Abundance, Reproduction, etc., with detailed subdivisions under each one. A questionnaire containing 88 different items was included in order to facilitate the inquiries conducted among the fishermen. The scope of the highly comprehensive program is complete enough to be useful today; marine biologists of today would probably only rephrase it, using modern terminology. During the first year of operations conducted at Woods Hole, Baird and his associates laid down the foundation of the new branch of science which we now call fishery biology or fishery science.

Edwards, whom Baird appointed as pilot and collector to continue the work which started in June 1871 at Woods Hole, was a most remarkable man. Without a formal scientific education he was a born naturalist who possessed the essential characteristics of a true scientist, with great ability for accurate observation, correct recording of facts, and enthusiastic devotion to the study of nature. Since the time of his appointment until his death on April 5, 1919, Edwards remained in the continuous service of the Fisheries Station at Woods Hole and became the person most familiar to the biologists working there. Devoid of any vanity he unselfishly assisted many scientists engaged on various research problems. No wonder, therefore, that his name was frequently mentioned in the many papers, especially those dealing with the local marine fauna. For more than 30 years he kept daily records of sea-water temperature and density at Woods Hole, recorded the catches of fish from the pounds, noted the appearance of sea birds and their nesting, and recorded the results of seining and dredging. Shore seining seemed to be his favorite occupation in which he engaged with an unquenchable enthusiasm. He frequently rowed his heavy skiff, loaded with a 200-foot seine, five or six miles and after seining for several hours returned home in darkness.

In a letter on file in the U. S. Bureau of Fisheries, Edwin Linton writes that Edwards' ability to forecast the weather for many hours ahead seemed uncanny to inlanders not familiar with the sea. He adds that "I think of Vinal's mind, when dealing with nature, as mirroring . . . . the region from Narragansett Bay to Monomoy, and I do not know how much farther. The set of the tides seemed to be in his mind as a moving picture which he could refer to on the moment, so that it was much easier to ask Vinal when it would be low water at Katuma Bay, on the coming Saturday, or when the tide would begin to make to the eastward at Quick's Hole on the following Monday . . . . . than it would be to attempt to work it out from the tide tables."

Edwards' enthusiasm for observation and collecting was known to Baird. This probably explains that in making his appointment he stipulated that "Mr. Edwards was to do no regular work on Sunday." Edwards' services to the Fish Commission and to the biologists who came later to work at Woods Hole were recognized by many prominent

scientists. Their feelings are well summarized by the words of E. B. Wilson, who wrote on May 12, 1919 after the death of Edwards, as follows: "It is hard to realize that the familiar figure of Vinal N. Edwards will no longer be seen at Woods Hole, and he will be greatly missed, especially by all the earlier workers who had come to rely so often upon his advice and judgment. No one could know Vinal Edwards without having the kindliest feelings toward him personally and without coming to realize that he was a man of rare character and attainments. I always associated him with Spencer Baird who I know had a very high regard for him and fully appreciated his important services to the Fish Commission . . . . Woods Hole will not seem the same without him." A commemorative plaque for Edwards was presented by friends of Edwards to the Fisheries Laboratory at Woods Hole and was mounted on a wall at the entrance to the old aquarium building. It can now be seen in the lobby of the new laboratory.

In the years 1872-74 the operations of the Fish Commission were shifted northward to the Bay of Fundy with the special purpose to study the fisheries of Maine and the adjacent portion of the British Provinces. In 1872 the headquarters was established at Eastport, Maine, where Baird was permitted to use the U. S. Revenue cutter Mosswood. The vessel was armed with a small gun on the forward deck and carried a number of rifles and cutlasses. The arrangement with the revenue office specified that if a suspicious craft should be sighted the dredging must be suspended while the suspect was overhauled and investigated. The records fail to show that dredging and seining were interferred with, since most of the smuggling was done at night. As in the previous year, several scientists, including A. E. Verrill, S. I. Smith, G. Brown Goode, Th. N. Gill and others, assisted in the work and collaborated in the identification of collected materials. The Commissioner of the Dominion Fisheries, William F. Whitcher, and his staff showed great interest in the fishery investigations and gave Baird valuable assistance and cooperation. A biologically interesting conclusion was reached by Baird regarding the probable cause of the reduction of cod and river fishes, both of which have declined in equal ratio. He states in his report for 1872-73 (Baird, 1874) that "the reduction in the cod and other fisheries, so as to become practically a failure, is due to the decrease off our coast in the quantity, primarily of alewives; and secondarily, of shad and salmon, more than to any other cause."

Early in 1872, the American Fish Culturists Association at the February meeting in Albany, New York, passed a resolution urging the U. S. Government to take measures for the introduction and artificial propagation of shad, salmon, and other valuable food fishes throughout the country, especially in the waters common to several states. An appropriation of $15,000 for this purpose was

Figure 8.--Steam tug Bluelight assigned by U.S. Navy to Baird for sea explorations along the coast of Maine. Courtesy of Norman T. Allen.

given by the Congress and added new responsibilities to the Commission of Fisheries. This action greatly influenced the work at Woods Hole where a marine hatchery was established as an integral part of the station.

In 1873 the field operations were based at Peaks Island in Casco Bay, Maine, about three miles from Portland. The location was selected as the principal area of the herring and cod fisheries. A Navy steam tug Bluelight (fig. 8) which weighed about 100 tons and was 100 feet in length, was placed under the jurisdiction of the Commissioner. This vessel was sufficiently large to provide an opportunity of trying, for the first time, the steam windlass for hoisting the dredges and trawls. This improvement of technique attracted the attention of the Secretary of the Navy who visited the headquarters and spent several days in examining the operations at sea. The assignment of the U.S. Coast Survey steamer Bache to the Fisheries Commission gave

an opportunity to extend the operations farther offshore between Mount Desert and Cape Cod.

As in previous years many visitors, including several scientists who attended the Portland, Maine, meetings of the American Association for the Advancement of Science, Maine Commissioners of Fisheries, representative of the New York Tribune, and others came to see Baird's explorations.

For marine investigations in 1874, Baird selected a locality in the village of Noank, Conn. at the mouth of the Mystic River on Fishers Island Sound. The place was sufficiently remote from the previously explored areas of New England waters to permit the notice of some important zoological differences. In addition to the waters adjacent to Noank, the Bluelight visited Montauk Point on the eastern tip of Long Island, Gardiners and Peconic Bays, Block Island Sound, and the eastern part of Long Island Sound. Verrill and his associates reported that over 100 species of invertebrates new to the fauna of New England were found. They also reported that some of the more southern species of animals were discovered in localities which had a higher sea-water temperature than others. In addition, the party conducted experiments in artificial propagation of sea bass and attempted to introduce young shad into salt-water rivers. Valuable background information necessary for selecting a place for the permanent location of the laboratory and hatchery was obtained through the four years of studies of the abundance, habits, and distribution of the more important species of fishes and invertebrates. The final decision had to be postponed until later years.

Baird, with his assistants, returned to Woods Hole in 1875 with the idea that a second survey of local waters would provide a means for determining the variation in the abundance of fishes as compared with the conditions recorded four years previous, in 1871. The need for a more permanent field accommodation for the Commission became acute. It was solved by the authorization of the Light-House Board to convert the large shed on the banks of Little Harbor into a two-story laboratory (fig. 9) and to construct a 5,000-gallon reservoir and a windmill for pumping sea water. The regular appropriation of the Commission provided funds necessary to cover the cost of the alteration, but laboratory equipment, including tables, shelves, tanks, aquaria, and plumbing, for which Government funds were not available, was purchased with the liberal contributions made by Mr. and Mrs. John F. Forbes of Naushon Island and Robert L. Stuart of New York. This laboratory greatly facilitated the work of sorting, identification, and preservation of the material collected at sea and made it possible to observe the behavior of various animals, and to study their spawning and the hatching of eggs. The opportunities

Figure 9.--Temporary laboratory at Little Harbor established by Baird in 1875 on the grounds of the Light-House Board. Sea-water tank to supply the aquaria and water tables on the right. Courtesy of Norman T. Allen.

for research in marine biology offered by the new laboratory attracted many outstanding biologists from New England colleges, as well as State fisheries Commissioners and the general public. Baird realized the importance of public support of his venture and encouraged the visitors to come and see the laboratory and the collection of live fish and other animals kept in tanks. He was pleased when popular accounts of the activity of the new institution appeared in the New York Tribune under the signature of William C. Wyckoff, the scientific editor, who on several occasions was his guest at Woods Hole.

The year 1875 should be considered the year of the establishment of the Woods Hole laboratory, although the construction of a permanent building had to be postponed for several years. During 1875 and in the following years the biological investigations continued under the supervision of Baird and his principal collaborators, George Brown Goode and A. E. Verrill. A number of students

Figure 10.--Seining in Little Harbor. Baird with net at the stern, G. B. Goode standing in the boat. Courtesy of Norman T. Allen.

were attracted to the new institution which offered an opportunity to conduct scientific research under Baird, who liberally offered his guidance and advice. At this time he actively participated in dredging, seining, or in collecting material in shallow water. Being an enthusiastic collector, he enjoyed going aboard the vessels with his students and assistants. He was frequently seen wading along the beaches of Woods Hole or seining from a small boat in Little Harbor (figs. 10 and 11). The research work conducted in the temporary laboratory buildings was well organized. The first floor was utilized by those who worked with fishes; the second floor was used by the biologists studying invertebrates. The students employed by Baird spent the early morning hours collecting materials in nearby waters. Sometimes the steam launch Cygnet would take them to the "Hole". After several half-hour tows were made the material was brought to the laboratory and examined before the investigators left for the night. Edwin Linton in his recollection of life at Woods Hole in earlier days of the Fish

Figure 11.--Small boat ready for collecting trip in Little Harbor. Baird leaning over the stern (left); G. B. Goode rowing (right). Courtesy of Norman T. Allen.

Commission (Linton, 1927) remarks of the "total absence of anything in the way of play, other than the daily swim." However, it is known that a small part of the laboratory shed was set aside as a social hall used for discussions, conversation, reading, and relaxation. It was unofficially known in the village as "Sharks Parlor." A photograph (fig. 9) taken during this period shows a carriage standing near the shed entrance. The crate on the carriage apparently contained a piano.

For his family, Baird rented the house facing Little Harbor belonging to Miss J. Fish (fig. 12), but his associates were scattered in different dwellings throughout the village. When the number of Commission employees increased, a house was rented to provide office space, living quarters, and mess facilities. It burned in 1883, and the site is now occupied by the Woods Hole Public Library.

Figure 12.--Baird's residence at Woods Hole in the 1880's before the construction of government buildings. Formerly Miss J. Fish's house facing Little Harbor, now property of Paul J. Gulesian. Courtesy of Norman T. Allen.

The purpose of scientific investigations was little understood by the public. Their questions about what the biologists were doing in the laboratory were sometimes difficult to answer. Linton reported that on one occasion A. E. Verrill, who was in charge of the laboratory, found it impossible to enlighten his interlocutors. He had an inspiration and told them that he was paid for his work. This seemed to be accepted as quite a satisfactory explanation. Of course there were many laymen of better education and higher intelligence who were able to grasp the significance of research. Since Baird's time to the present, the problem of visitors and how to satisfy their natural curiosity and at the same time avoid interference with scientific work has been of great concern to all in charge of scientific institutions at Woods Hole. Baird encouraged the people to visit his laboratory because he was convinced that in a democratic society the people are entitled to know about the activities of the institutions which are maintained by expenditures of public funds.

He also thought that research and education should not be divorced. As a practical person he believed that public support would be effective in obtaining the necessary appropriations by Congress for the construction of a good marine station.

The scientific work conducted at the station during the ensuing years was carried out along the lines already established by exploratory studies of New England waters, with greater emphasis on developing practical methods of artificial propagation of fishes and in formulating a system for collecting statistical data. Zoological research was in the hands of specialists, with Verrill as head of the section of marine invertebrates and E. B. Wilson as his outstanding assistant (fig. 13). The fact that this eminent American embryologist and cytologist was associated with the laboratory during the earliest years of its existence has remained a source of pride to many biologists who during the past 80 years were employed by the U. S. Fisheries Laboratory at Woods Hole. Studies of fish and fisheries were continued under the supervision of Goode, while Baird concentrated his efforts in obtaining land and necessary funds for the laboratory.

In the scientific circles of his time Baird was recognized as an organizer and administrator of the highest rank. He had a rare faculty of adapting himself with unusual tact to subordinate positions, as can be seen from his work for nearly 30 years when he devoted his principal efforts to the organization of the National Museum. Moreover, through his position as Assistant Secretary of the Smithsonian Institution he obtained cooperation of nearly every branch of the Government. In spite of the well-known fact that his chief, I. Henry, Secretary of the Smithsonian Institution, a physicist, had little or no fondness for zoology, the relationship between the two men remained harmonious. Upon the death of Henry in 1878, Baird succeeded him as Secretary and assumed an even greater burden of administrative work. In his discussions he displayed a remarkable ability to convince his listeners and secure their assistance. This was so well known in Congressional circles, where Baird was a frequent witness at hearings of various committees, that one influential Senator was quoted as saying: "I am willing to vote the money asked for by Prof. Baird, for he will get two dollars worth for every dollar we give him, one-half by direct purchase and one-half by gift." This reputation helped Baird in obtaining Congressional appropriation for the construction of the Fisheries Station, since the increased scope of activities of the Fish Commission required larger and more permanent accommodations than those provided by the Light-House Board.

The power of persuasion of this remarkable man was so great that he was equally successful in dealing with college professors, students, local politicians, State Fish Commissioners, Senators, Congressmen, and business officials. In his attitude to others he was never condescending, vain, or "highbrow", but always tried to explain the merits of his point in terms understandable to others.

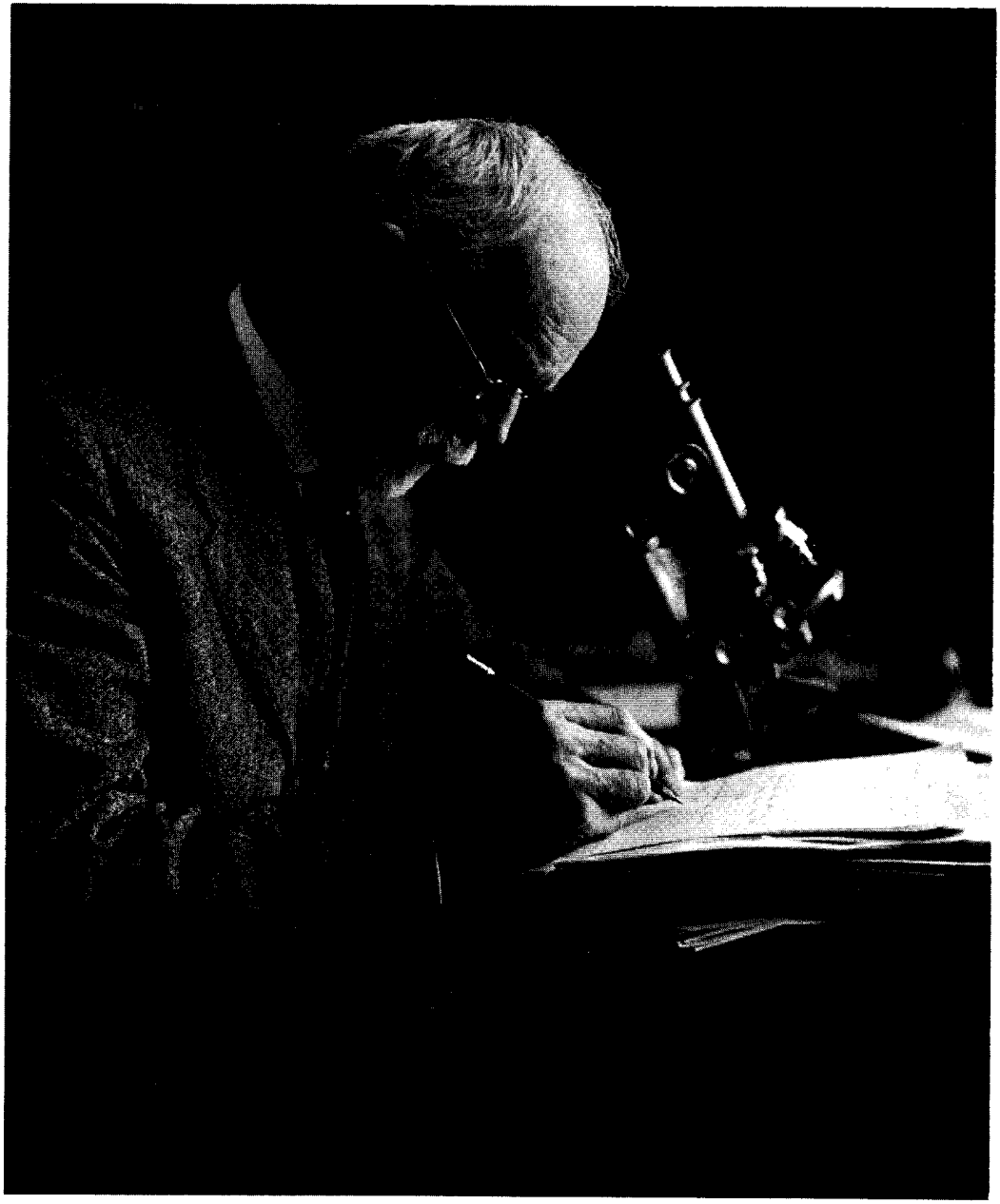

Figure 13.--E. B. Wilson of Columbia University, Professor and assistant to Verrill at Woods Hole. Photograph taken in 1924.

Since the Fish Commission became more and more involved in fish culture, it was necessary to find an inexpensive and safe method of transporting live fry to the place where they were to be released. It was not difficult for Baird to obtain full cooperation of the American railroads, who granted to the Fish Commission special low rates for travel of personnel and for delivery of large containers of water and young fishes. Later on, special railroad cars were built for this purpose. One such car was frequently seen at the railroad terminal at Woods Hole.

On July 18, 1872, the Old Colony Railroad opened its services to Woods Hole. This improvement was a great benefit to the village and of considerable convenience to the members of the Fish Commission. The first train conductor, Augustus S. Messer, remained in the service of the company for many years and became highly respected and known and loved by the residents and commuters for his friendliness and services which he was eager to extend. The administration of the railroad encouraged friendly relations with the travelling public; this policy was continued until the late 1950's when due to the financial adversity of the owners, the New York, New Haven, and Hartford Railroad, to which the Old Colony Railroad was leased in 1893, stopped passenger service between Boston and Woods' Hole. Good transportation facilities were an important factor in the growth of Woods Hole as a scientific center. At first the fastest train travelled from Boston to Woods Hole, a distance of about 80 miles, in 3 hours 10 minutes. Soon, however, the famous "Flying Dude" train was inaugurated. It made its first trip early in the spring of 1884 and cut the travel time to only 1 hour 47 minutes. The Old Colony Railroad "was the equal to any road and inferior to none." (Fisher, 1919).

At the request of Baird the Old Colony issued special tickets which facilitated transportation of the officers and employees of the Fish Commission to and from Woods Hole. An agreement with various other railroad companies authorized the Fish Commission to transport live fish in the baggage cars of passenger trains without extra charge and allowed the Commission messengers to have free access to them while en route.

During the formative years the final decision crystallized in Baird's mind regarding the location and character of the permanent laboratory of the Fish Commission. In 1882 he arrived at the conclusion that the proposed station was to be used both for research "and for propagation of the marine fishes and that the best conditions for the latter purpose were found on the south coast of New England because greater variety of fish can be found here and so far as the winter hatching was concerned, the cold being much less severe, and the other circumstances more favorable." The choice was between two locations: Newport, R. I., and Woods Hole. The citizens of Newport showed great desire to have the station and exerted their influence on Government authorities to induce the Fish Commission

to choose their town. Necessary buildings and the use of a suitable wharf were offered, and the Navy Department invited the Commission to establish its laboratory and hatchery on the northern end of Coasters Harbor Island, which was thought not to be required for the Naval Training School.

Experiments with hatching marine fish eggs during 1880 showed that the water around Newport contained an excessive amount of sediment which settled on the eggs and materially impaired their development. Furthermore, the water of this part of Narragansett Bay was polluted by the drainage of a number of large cities (Newport, Fall River, Bristol, Providence, and others). The water around Gloucester was also found unsuitable because of high turbidity caused by sediment. The conditions at Woods Hole were totally different. Baird (1884) describes them in the following words: "the water is exceptionally pure and free from sediment, and where a strong tide, rushing through the Woods Hole passage, keeps the water in a state of healthy oxygenation especially favorable for biological research of every kind and description. The entire absence of sewage, owing to the remoteness of large towns, as well as the absence of large rivers tending to reduce the salinity of the water, constituted a strong argument in its favor, and the station was finally fixed upon for the purpose in question." From a biological standpoint the decision was sound and, as further developments have shown, the laboratories at Woods Hole have been supplied with sea water of high purity. At the present time, however, due to the greater population density, increase in the size of the scientific institutions, and large numbers of pleasure boats visiting the harbor during the summer months, the water has become polluted to such an extent that the taking of shellfish from Woods Hole Harbor is no longer permitted by sanitary regulations and swimming in Great Harbor is discouraged.

Another biologically important characteristic of Woods Hole water mentioned by Baird remains unchanged. Due to the absence of large fresh-water streams, the salt concentration of Woods Hole sea water is nearly constant throughout the year and does not vary with the alternate changes of the tides. There are very few locations along the eastern coast of the United States and in the Gulf of Mexico where such a stability in the salinity of water can be found. As Baird visualized it many years ago, this constitutes a great advantage for "biological research of every kind and description."

The decision regarding the character of the marine laboratory to be established at Woods Hole was influenced by the success of the first laboratory of this type organized in 1870-74 by Anton Dohrn in Naples, Italy. The latter laboratory, which up to the present day remains a mecca for biologists working with marine material, was established as a private enterprise, financed primarily through subscriptions by different European colleges and universities for the use of laboratory facilities. Baird thought that the first permanent

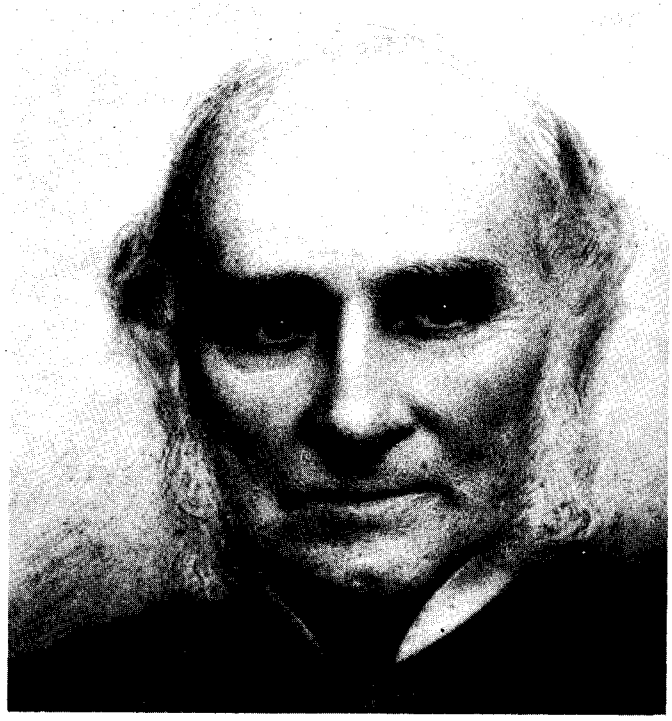

Figure 14.--Joseph S. Fay, citizen of Woods Hole who donated land for the U.S. Fisheries Station. Courtesy of the Church of the Messiah, Woods Hole.

marine laboratory in the United States should also include a school of marine biology. His plans had to be modified to conform with the policies of Congress. He realized great difficulties in obtaining Congressional appropriation for the purchase of land for the laboratory and entered into negotiations with the owners of most desirable tracts of land on the shore of Great Harbor in Woods Hole. At the same time he persuaded a number of influential and wealthy persons to give financial support to his project. Joseph S. Fay, a leading citizen of Woods Hole (fig. 14) donated three acres of land along North Street. The tract comprised a narrow strip between the shores of Great Harbor and North Street (present Bar Neck Road); it extended beyond the end of North Street in a northwesterly direction for about 425 feet along the breakwater on the northern shore of Buzzards Bay and ended at the boundary line of the Pacific Guano Company. Two other parcels of land not contingent with Fay's property, one along Water Street (known also as County Road) of 0.9 acres in area, and the larger piece of 1.5 acres along the east

shore of Great Harbor were acquired by purchase with the money contributed by various parties. The annual report of the Commissioner of Fish and Fisheries for 1883, lists the following parties who contributed the money:

Old Colony Railroad Company	$2,500
John M. Forbes	1,000
Alexander Agassiz	500
Johns Hopkins University	1,000
Princeton University	1,000
Williams College	500
Isaiah Spindel and Company	500
Mrs. Robert L. Stuart	250

The subscribed funds and the land donated by Fay were available to the Fish Commission only in the event of an appropriation by the U. S. Government for necessary improvements. The titles of the tracts of land to be conveyed to the U. S. Government were investigated by the U. S. District Attorney for Massachusetts and pronounced valid. Full jurisdiction over the land in question was ceded by the State of Massachusetts on March 30, 1882. The value of the property which the U. S. Fish Commission received as a gift from private citizens and organizations was estimated not less than $15,000.

To facilitate the transaction, the deed to Fay's land in consideration of one dollar and the funds contributed by others were turned over to Charles F. Choate and J. Malcolm Forbes as Trustees. They purchased the two smaller parcels from individual owners and, on April 20, 1883, conveyed all the acquired property, including the deed to Fay's land, to the United States Government.

To obtain the contributions, Baird offered the universities continuous use of research tables in the proposed laboratory. In a letter of September 3, 1881, to Forbes, Baird wrote as follows: ". . . . I have written to Alexander Agassiz (fig. 15) asking him if he would like to join in the enterprise and promising him a perpetual right to a table in the laboratory and the facilities of the station to be utilized by anyone he may designate. This is the system adopted at the Naples Aquarium, where establishment by this means has been successfully maintained."

Baird (1885, p. LIV) states: "The colleges in question and Mr. Agassiz made their contributions with the understanding that, as far as possible, they were each to be allowed to send one specialist to the station for the purpose of carrying on scientific research." This promise was continued to be honored by his successors. On one occasion, in May, 1895, Commissioner McDonald denied the privilege and stated "this agreement, as a matter of contract, is not authorized by law; as a matter of courtesy, it has been and will be carried out unless something intervenes to make it impossible." (Letter on file at the Bureau of Commercial

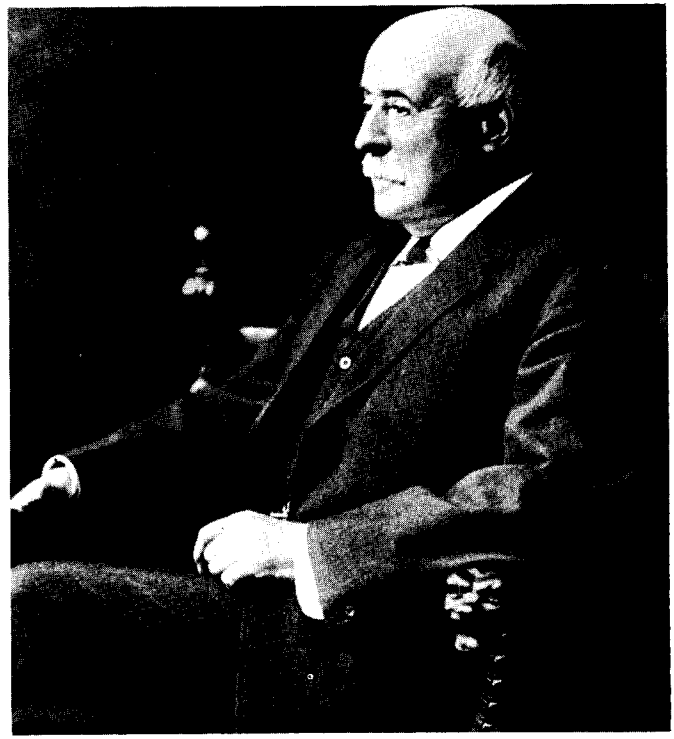

Figure 15.--Alexander Agassiz, Professor at Harvard University, conducted several oceanographic expeditions on the U. S. S. Albatross and one of the contributors to the fund to purchase land for the U.S. Fisheries Laboratory.

Fisheries Biological Laboratory at Woods Hole.) Conklin (1944) writes that "when, on one occasion, this privilege was cancelled by a Commissioner of Fisheries, Mr. Agassiz fought the order with characteristic vigor, and it was rescinded."

The grant of land belonging to Fay was made by him upon the following conditions: " . . . . and they are conveyed subject to the proviso in the deed to us that if hereafter they are not used for the purpose of the United States Commission of Fish and Fisheries nor by the United States of America, they shall revert to the said Joseph S. Fay, his heirs and assigns, and with the reservation of a perpetual right of landing for the said Fay, his heirs and assigns at any suitable landing place on the premises to be provided by the United States." The restriction remained in force until October 28, 1914, when as a result of lengthy litigations brought by the heirs of Joseph S. Fay, an agreement was reached

and a judgement of the Circuit Court of Appeals and a mandate of said court was reached by which the Fays received all the land west of the so-called "division line" near the corner of North Street and Gosnold Drive. The agreement established a 40-foot strip immediately to the west of the line as a permanent place of landing for all those people who had been conveyed such a right in the preceding real estate transactions. The United States was left with the remainder of the land deeded by J. S. Fay, free of all restrictions set out in the original deed. The agreement and judgement mentioned above were honored by the land court (Land Court Case No. 5985) and the certificate No. 457 in favor of the Fays was issued.

Considerable confusion in the title of the U. S. Fisheries property at Woods Hole was caused by the lack of clarity in the original title and by the informal agreements made by Baird with the selectmen of the Town of Falmouth. These parties agreed to exchange a portion of the western end of Water Street, owned by the town, for an equivalent area of Fisheries land, 40 feet wide, extending from Center Street to the water. This arrangement enabled the Town of Falmouth to construct a wharf which is used now as a public landing. The private exchange made between Commissioner Baird and the Town of Falmouth remained without proper legal action until 1956 when the real estate holdings were reviewed by the Branch of Lands of the Regional Office of the Fish and Wildlife Service (Ennis Abbiati's report on file in the Bureau of Commercial Fisheries Regional Office in Gloucester) and the necessary legal action was made to convey the title to a short portion of Water Street owned by the Town of Falmouth to the U. S. Government.

The western end of the Commission's property along North Street, consisting of approximately 1.03 acres in area, was for many years rented by the Government to the Woods Hole Yacht Club. In 1958 the parcel was declared surplus property and in accordance with Private Law 85-367 was transferred for $6,000 to the Woods Hole Yacht Club with the provision that the conveyed property is to be used only by the Club and for the purposes "to which it is now put, namely, the usual activities of a non-commercial yacht club." The property cannot be transferred or assigned in any manner to other parties without the prior consent of the U. S. Government and cannot be used for any activities that may be detrimental, as determined by the Government, to the operation of the Bureau of Commercial Fisheries Biological Laboratory. The conveyance was made for only as long as the Woods Hole Yacht Club remains in existence, and in case of its dissolution the property with all improvements shall revert to the United States. The deed executed by the Administrator of General Services has been recorded on February 1, 1961, in the land records of Barnstable County, Mass. in Book 1104, page 129.

Through the efforts of various business firms in Massachusetts, insurance companies, and masters of many coastal vessels, a bill was introduced in the House requesting an appropriation of $52,000 for the construction of a refuge in the Great Harbor of Woods Hole to permit vessels of 20-foot draft to come in and remain in perfect safety in severe storms and to furnish the basins for keeping live fish. The magnitude of the appropriation induced President Chester A. Arthur to defer approval for one year. The refuge was built in 1884 (fig. 16) and proved to be a valuable asset to the station, not only as a safe shelter for small boats, but also as a convenient place to keep live-cars containing fish and invertebrates and conduct observations and experiments.

Before commencing the construction of the necessary buildings, Baird engaged the services of E. W. Bowditch, a well-known landscape architect and engineer, to make a careful survey of the land and prepare a map (scale of 20 feet to one inch) including the contour lines at one-foot intervals over the entire surface. Plans for the buildings were made by Robert H. Slack, Boston archietct, and the contract for the erection of the first building was given to W. R. Penniman of South Braintree (Boston).

Drawings made under Baird's guidance showed his full understanding of the station's needs and his great ability to visualize minute details in planning the laboratory and in designing water tables, chemical benches, and other laboratory furniture. He was assisted in this work by Verrill.

With the appropriation of $25,000 by Congress for construction purposes, the first building to be erected was the "quarters" for the personnel. Upon completion the structure became an outstanding landmark of Woods Hole and was always called the "Residence." Concurrently with the work on the foundation of the residence building, the excavation and dredging for the piers was carried out. In addition to the residence building, the station plans included the laboratory and hatchery building, the pump house with a sea-water reservoir, a coalshed, and a storehouse.

Construction of the laboratory building, 120 x 40 feet, began in 1884 and was partly finished that same year. Serious difficulties were encountered in laying the foundation, which had to be erected on unstable grounds regularly covered by water at high tide. It was necessary to drive wooden pilings upon which the structure rested. In February 1885, the construction of the laboratory and hatchery was completed by Brightman, a New Bedford contractor, and was accepted by the Commission. For nearly three-quarters of a century the building withstood the violence of Cape Cod storms and

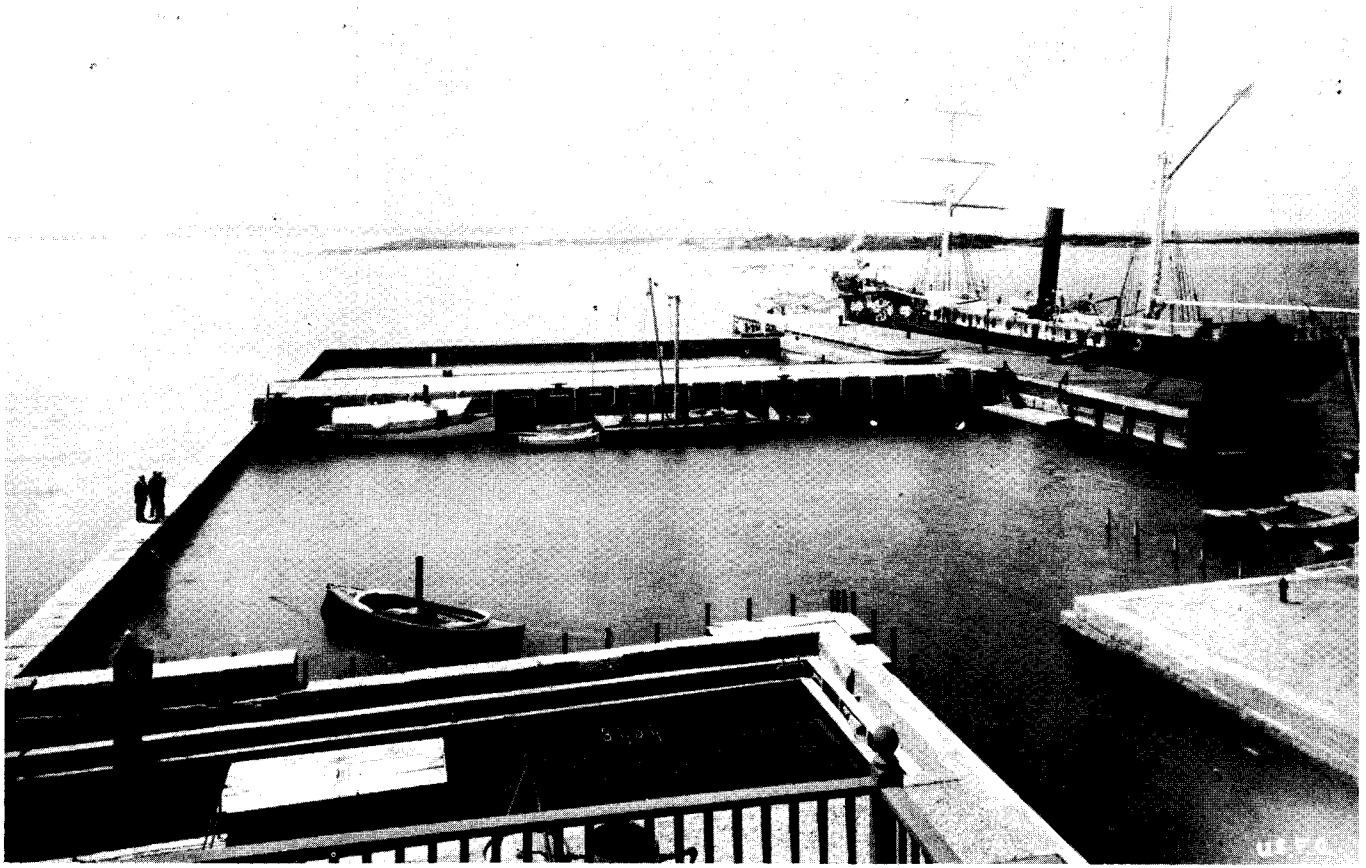

Figure 16.--Small boat refuge shortly after its construction in 1885. Seal pool in foreground; draw bridge at right; and U. S. S. Albatross at the dock. The wharf across the refuge was used for docking launches and suspending live-cars.

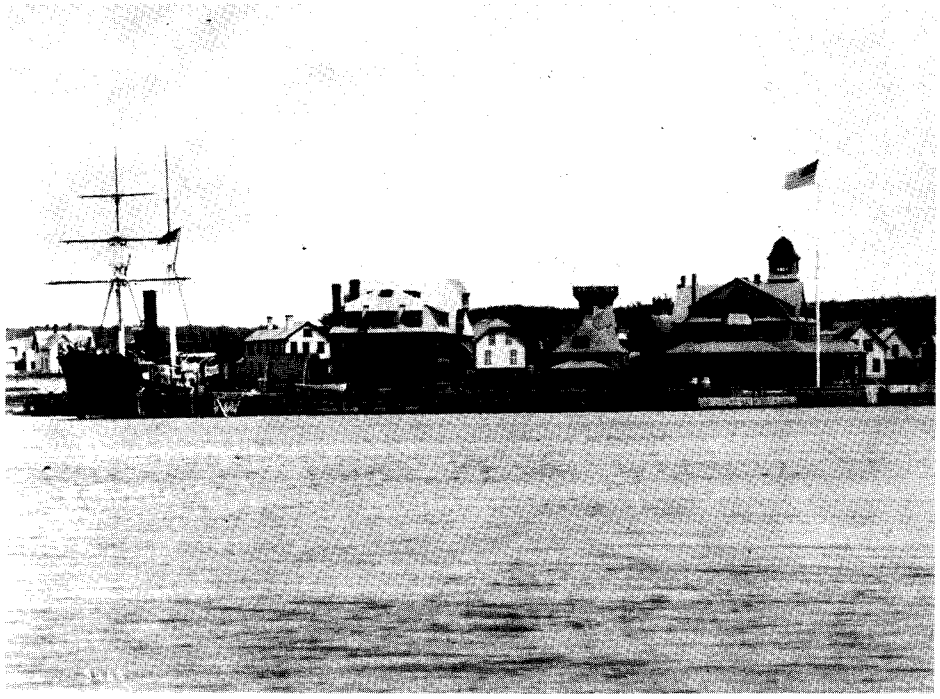

Figure 17.--Residence (right) and laboratory of the Woods Hole Station shortly after their construction. Pumphouse, machine shop and sea-water tank (towerlike structure) are in the middle. About 1890.

hurricanes. Although the ravages of old age were noticeable, the structure remained strong. Old pilings pulled out of the ground when the building was demolished in 1958 showed no signs of deterioration.

The total amount of money appropriated from time to time by Congress for the Woods Hole Station buildings and their equipment amounted to $70,000. The completion of the laboratory with auxiliary structures and wharf greatly changed the face of Woods Hole. Photographs taken at this time (fig. 17) show the imposing three-story brick and frame structure of the residence, crowned with cupola and set on the shores of Great Harbor at the end of Water Street. Several letters exchanged between Baird and town officials refer to the grounds as "Refuge Point." The name was not officially recognized, it did not appear on any charts or documents and was later abandoned.

In the summer of 1885, Baird with his staff of assistants and several clerks moved into the new building. A. E. Verrill was in charge of the laboratory and with other biologists continued investigations on the habits and development of fishes and marine invertebrates. The following biologists not employed by the Fish Commission used the facilities of the newly established American marine laboratory: Richard Rathbun, Sidney I. Smith, Sanderson Smith, E. Linton, B. F. Koons, Harrison Allen, William Libbey, Jr., and Walter Heape of Cambridge, England.

An interesting experiment of introducing marine species into a new environment was carried out. For the first time, a lot of young shad were transported in a railroad car to the Pacific Coast and planted in the waters of Washington Territory and Oregon. In return, G. H. H. Moore who was entrusted with the task, collected and brought back to Woods Hole a large number of clams, Tapes staminea. A great many clams perished enroute, but several hundred which survived and appeared to be in good condition were planted in various locations in the vicinity of the station. Shad transplanting was continued in later years, and the Atlantic species is now well established on the Pacific Coast, but Tapes staminea apparently did not survive and was never found in Woods Hole waters.

A series of oyster breeding experiments were made that summer by John A. Ryder, using the ponds constructed on private grounds near Eel Pond, Woods Hole, owned by J. H. and Camilla J. Kidder.

Jerome H. Kidder, medical officer of the U. S. S. Albatross, made a detailed chemical study of the fresh-water supply to the new laboratory and found it to be "potable and of good quality." The source of fresh water available at that time was a small spring or well located at Bar Neck. The water level in the well ordinarily stood at a height of about four feet above mean low water. To one analysis, Kidder attached the following statement: "The sediment (of water from the well) contains unicellular algae, rotifers, paramecium, amoeba, and woody fiber. No evidence of impurity injurious to health" (Kidder, 1886). The reference to Paramecium and Amoeba make one suspicious about the quality of drinking water available at that time.

Another interesting and comprehensive study, also by Kidder, deals with the accuracy of the thermometers used by the Fish Commission in marine exploration. Of particular significance are the tests of Negretti-Zambra deep-sea reversing thermometers and maximum and minimum thermometers made by Miller-Casella. This type of thermometer is provided with short steel rods which are pushed by a column of mercury and can be reset by using a small magnet. The reversing and

maximum/minimum thermometers were not free from certain defects and peculiarities which often lead to erroneous readings. These difficulties are fully discussed in Kidder's paper (Kidder, 1887). Baird himself contributed to the technique of temperature observations by designing, in 1873, a protected thermometer, enclosed in cylindrical copper cases with a hinged door in front. This type was devised for reading water temperatures at lighthouses and at shore stations. The instrument is still being used for observations in shallow waters when great accuracy is not needed.

The thoroughness shown by Baird in every detail pertaining to the operation of the station speaks for his versatility and ingenuity. The equipment of the laboratory and hatchery was designed by Baird with the assistance of Verrill. Both men had considerable experience in that type of work. Verrill was particularly skillful in designing aquaria tanks and tables. Baird was well known by the designs of storage cabinets for the specimens in the National Museum which were made to save valuable museum space and fit exactly between the supporting wall columns. The actual construction and materials used by the contractor for laboratory benches, chemical and office tables, and of other equipment were meticulously scrutinized and personally approved by Baird.

The new laboratory building was three stories high. The entrance hall on the first floor separated the hatchery, on the south side of the building, from the public aquarium on the north. Large sea-water tanks of the aquarium were mounted along the outside walls, while the center was equipped with cabinets for preserved specimens of fish, invertebrates, and birds. The hatchery equipment consisted of a series of tanks containing floating frames, each frame having the bottom covered with cloth for holding fish eggs (fig. 18), and batteries of McDonald hatching jars. The excellent supply of sea water and good equipment insured successful hatching operations. A wide stairway led to the second floor. The northern half of the second floor was occupied by a large laboratory equipped with tables for biological research (fig. 19). The tables were the last word in laboratory furniture. They were covered with thick birch planks painted black, with acid and alcohol-resistant paint. Each table contained a stack of deep drawers on one side. The southern side of the second floor contained three offices, a farily large chemical room equipped with two chemical tables, accommodating eight persons, and a fume hood. There was a small storage room for stationery and office supplies. The third floor was occupied by the library, two large stockrooms (one for chemicals and one for glassware and scientific instruments) and several small rooms in which the fish culturists and janitor lived. In later years these rooms were converted into laboratories.

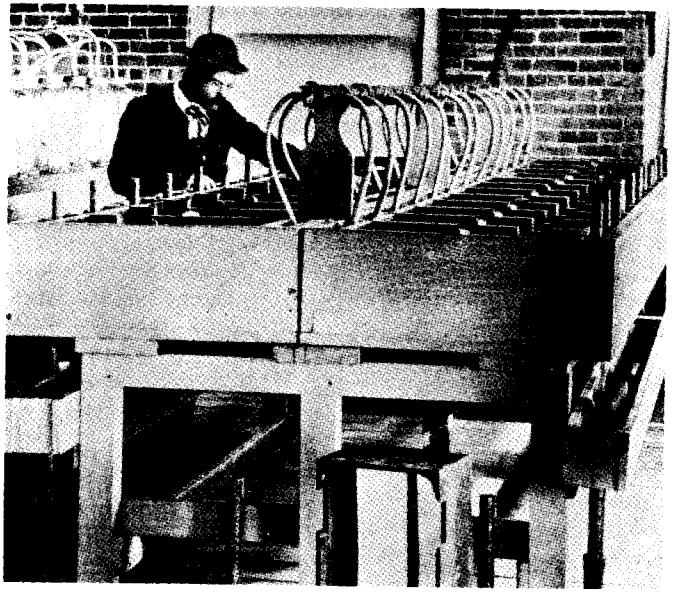

Figure 18.--Interior of the hatchery. Sea water is supplied to each of the tanks individually and fills it from the bottom and is drained from the top through an overflow into a trough seen at right. A wooden frame (standing in front) with cloth bottom for holding eggs floats freely in each tank.

Figure 19.--Interior of the laboratory shortly after its construction in 1885. Laboratory tables and other furniture were designed by Baird and Verrill.

The hatchery was a great asset to biological research. Some of the hatching tanks, not needed for current hatching operations, were at the disposal of the biologists for keeping animals and for studying the development of marine eggs. Outdoor tanks and live-cars anchored inside the protected area of the boat refuge (fig. 16) were of great convenience. An examination of old plans and photographs of the laboratory will show how much of Baird's thinking, experience, and imagination went into the implementation of his dream. At the time of its opening in 1885 the Fisheries Station at Woods Hole was an excellently equipped institution for marine research, equal to or better than any laboratory of this type in Europe.

Good docking facilities at the Fisheries Station made possible the full use of the Fish Commission ships. Two large vessels, the Fish Hawk and the Albatross, frequently used Woods Hole as a base of their operation. The ships were not permanently assigned to the station but from time to time were ordered by the Commissioner of Fisheries to proceed to the areas where in his opinion they were needed for conducting sea explorations. It was Baird's plan, however, to use Woods Hole as the home base for the ships, and both the Albatross and Fish Hawk were frequently seen at the Fisheries dock at Woods Hole.

U. S. S. Fish Hawk

The Fish Hawk (fig. 20) was a coal-burning steamer of 156-1/2 feet overall length. She was registered at 484 tons displacement and had a rig of "a fore-and-aft schooner with pole topmasts." She was built according to specifications and plans made by C. W. Copland, naval architect of the Light-House Board. It was a special vessel to serve as a floating hatchery for the production of shad, herring, striped bass, etc., and was capable of being moored almost anyplace where breeding fish could be found in sufficient quantity (Tanner, 1884).

A considerable portion of the deck space and hull was occupied by hatching equipment and laboratory. The laboratory was 10 feet, 7 inches long, 9 feet wide and 7 feet 3 inches high. It was provided with a laboratory table, specimen case, box for microscope, and the necessary shelves and drawers. Sea water was supplied by a steam pump capable of delivering 10,000 gallons per hour. Hatching equipment consisted of 36-inch cone-shaped containers each capable of holding 7,200,000 shad eggs. These hatching cylinders were suspended from beams outside of the vessel.

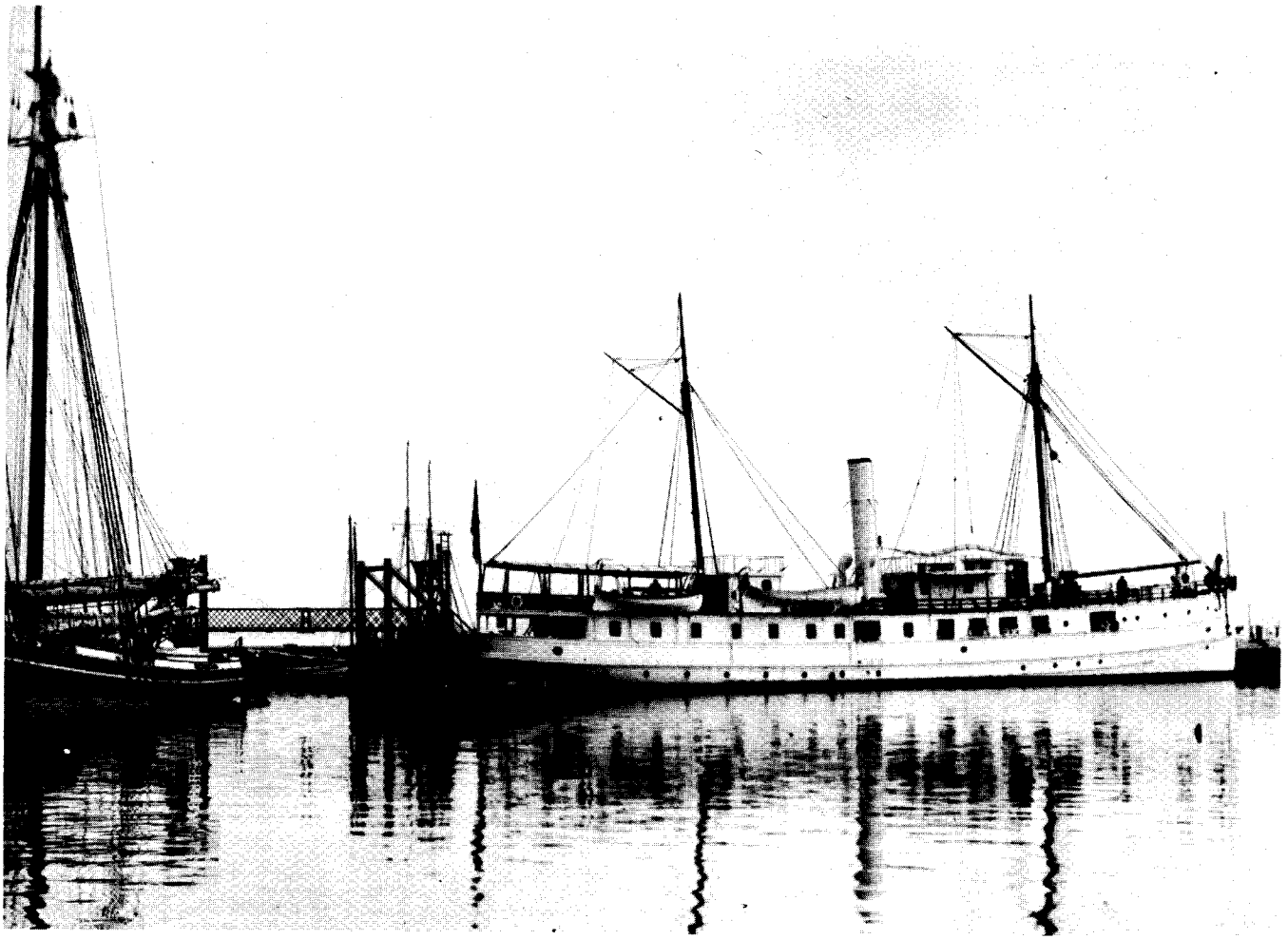

Figure 20.--U. S. S. Fish Hawk at Woods Hole.

The ship was equipped with the most up-to-date gear for trawling and dredging. There was a drum or reel holding 1,000 fathoms of steel-wire dredge rope 1/3-inch in diameter (1-1/8 inch in circumference) with breaking strain of 8,750 pounds; the wire rope weighed 1.14 pounds per fathom. The dredging boom was 36 feet long and 10 inches in diameter. It was used for operating beam trawls of three different sizes (9 feet, 11 feet, and 17 feet long beams), otter trawls, and various dredges (fig. 21).

Other types of collecting gear such as tangle bars, rake dredges, and various sieves (so-called table sieve and cradle sieve) were designed by Verrill. The sounding machine consisted of a cast brass reel 11.43 inches in diameter and 600 fathoms of piano wire of 0.0028 inch diameter, having a tensile strength of 200 pounds.

Built primarily as a "hatchery ship" the Fish Hawk was not suitable for offshore work but was intensively used in dredging and trawling in Vineyard Sound, around Cape Cod, in the Gulf of Maine, Long Island Sound, and other coastal waters. The ship made her last two cruises in October-December, 1925, and was decommissioned in January 1926.

U. S. S. Albatross

The Albatross (fig. 22) was an iron-hull, twin-screw vessel of 234 feet overall length and 1,034 tons displacement (registered net tonnage 384 tons). She was built by the Pasey and Jones Company of Wilmington, Del., according to the plans drawn by Charles W. Copland of New York; aggregate cost was $145,000. She was launched in March 1882, and made her first cruise in April 1883.

According to Lt. Com. Tanner, her first commanding officer (Tanner, 1885), she was rigged "as a brigantine, carrying sail to a foretop-gallant sail." She had comfortable cabins, had water distilling equipment for drinking water, electric lights, and elaborate equipment for oceanographic research. There were two laboratories. The upper one, 14 feet long and occupying the whole width of the house, had a square work table for four persons centrally located. Each working place was provided with a tier of drawers under the table. Attached to the walls were two hinged side tables, a sink, water and alcohol tanks, wall cabinets for instruments and glassware, and books. A medical dispensary occupied a corner of the room. The lower laboratory, immediately below the upper one extended across the ship 20 feet fore and aft. It was supplied with long working tables and a lead-lined sink with running water. Part of the space was used as a

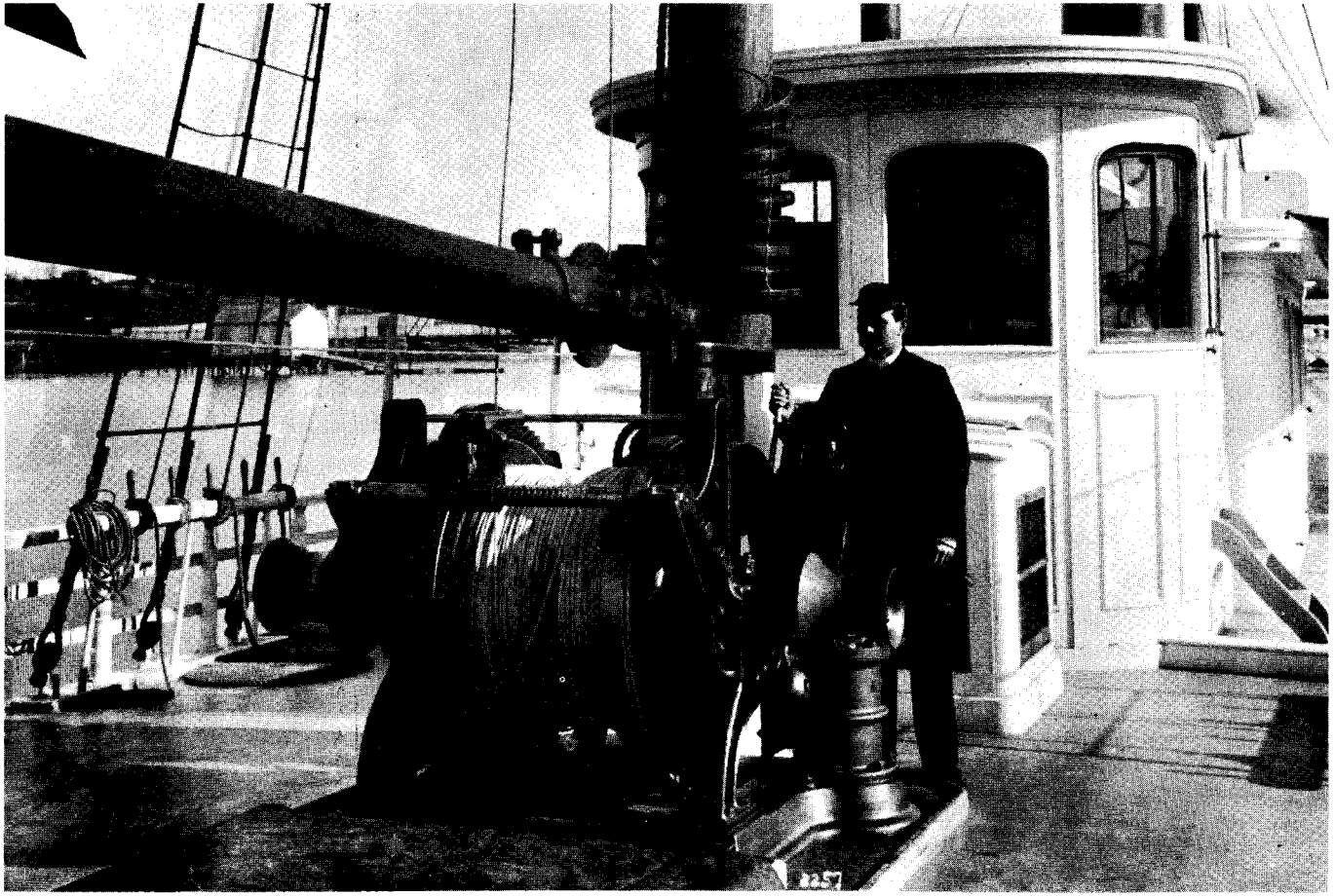

Figure 21.--Deck of the Fish Hawk showing hoisting and reeling engine and winch used by Baird and Verrill in the exploration of New England Coast. About 1885.

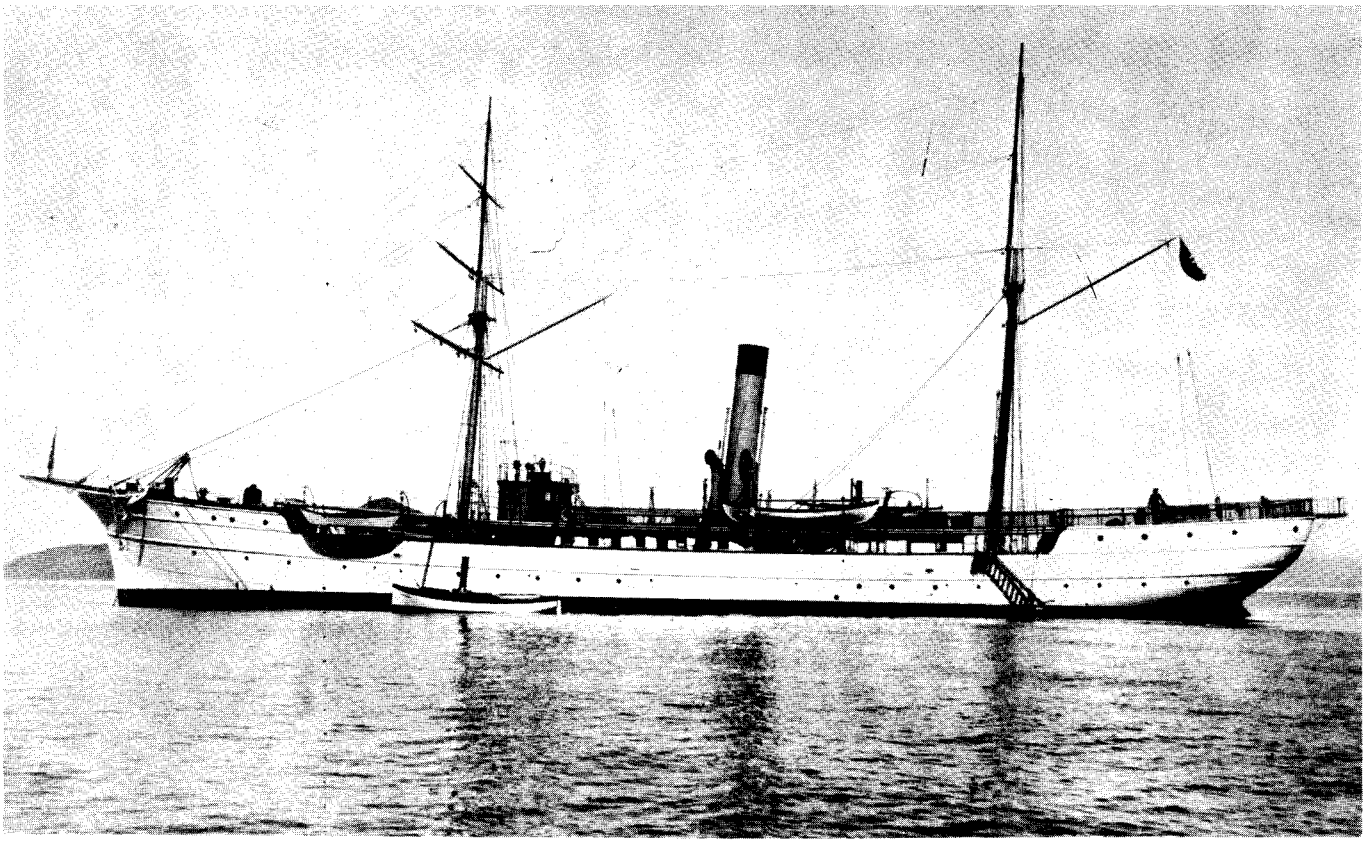

Figure 22.--U. S. S. Albatross. Photograph from the National Archives.

photographic dark room and chemical laboratory. There was plenty of storage cases and lockers for jars, bottles, and various collecting gear. A supply of alcohol was stored under the laboratory in an iron-walled room which could be isolated from the rest of the ship. In case of fire, this room could be quickly filled with steam.

The dredging engine was provided with additional "gypsy heads" for hoisting boats, and was equipped with a friction brake to regulate the paying out of the rope. The dredging wire was 3/8-inch diameter galvanized steel. It was composed of six strands wound around a tarred hemp heart; each strand consisted of seven wires. The wire weight was 1.32 pounds per fathom in air, and 1.2 pounds in water. The ship carried 4,000 fathoms in one length and later on received additional reels in 500-fathom lengths. A newly designed sounding reel, various trawls, dredges, nets, and recording thermometers were on board the Albatross for conducting oceanographic research. Every technical detail of the laboratory arrangement and equipment indicated good planning and understanding of technical research problems by Baird and his principal collaborators. Tanner incorporated many original ideas into the design, construction, and operation of the ship and its naval equipment; Verrill was primarily concerned with the laboratories and their equipment.

In 1883 the Albatross was prepared to undertake oceanographic investigations in any part of the world. Her explorations made a glorious chapter of U.S. marine research, and the name Albatross became famous in all civilized parts of the world. It is interesting to read the comments about this ship written by the famous American explorer, Alexander Agassiz, who in 1890 was asked by Marshall McDonald, at that time the U. S. Commissioner of Fish and Fisheries, to take charge of deep-sea exploration off Panama. The Albatross was offered under the conditions that Agassiz should supply the coal, thoroughly re-equip the ship, and pay part of the running expenses. In return, he was to get first choice of the collections that were of special interest to him. Upon reaching Panama late in February 1891, Agassiz boarded the Albatross, and in his letter home described the ship in the following words: "The working accommodations are fine, an upper room 20 feet x 20 feet for rough work and general laboratory, and a second floor below for storing the collection in racks. We ought to do well. . . . . My cabin opens out into a good-sized dining room and sitting room of about 12 feet by the width of the ship, where Tanner and I sit and take our meals. It has large portholes, a fine skylight, and is very airy and comfortable." Upon completing a preliminary trip and returning to Panama after an absence of 20 days, Agassiz wrote: "The Albatross is an excellent sea boat and she rides the sea wonderfully well, and really much better than many

large ocean steamers I have been on. . . . . You can have no idea how comfortable the trip has been. . . . . The accommodations for work and for taking care of the collections are excellent. . . . . The laboratory, with its ingenious arrangements and its excellent accommodations for work by day and night, was to me a revelation." (Agassiz, 1913). Agassiz usually made three or four deepwater dredging or trawling hauls every day, and at the same time the surface net was towed.

The seaworthy qualities of the Albatross and the comfort of its laboratory facilities and living quarters were admired by a number of other scientists who, in following years, took part in her deep-sea explorations.

Occasionally the Albatross was detailed to Woods Hole, but she never became an integral part of the station. Her life ended here. The ship was decommissioned in October 1921, and laid up at the Bureau's dock at Woods Hole. On June 5, 1924, she was sold at public auction. When the old and friendly ship was being towed away a few older members of the Bureau of Fisheries, who in previous years had been associated with her, watched her final departure with their hearts filled with sadness.

In issuing orders to the commanding officers of the Commission's ships, it was Baird's policy to outline a precise program of the proposed operations and explain their purpose. The following document issued on April 10, 1883, to the commanding officer of the Albatross is a good example of the thoroughness of his planning (Tanner, 1885, p. 119-20).

"Sir: As soon as you can be ready for the service (of which you will give me a week's notice), you will go to sea for the purpose of investigating the conditions which govern the movements of the mackerel, menhaden, bluefish, and other migratory species along the coast of the United States in the spring, commencing your investigations off Hatteras, or in the region where these fish usually make their first appearance, and following up the schools in their movements.

"The special work to be performed will be to determine the rate of progress of the fish along the coast, their comparative abundance and condition, the places where they first show themselves, the physical condition of their surroundings as to temperature and currents of the water, its chemical and biological peculiarities, etc.

"You will endeavor to ascertain whether the appearance of the fish at or near the surface depends upon the condition of temperature, wind or sky, and also, by the use of the apparatus at your command, what character of food in the water seems to determine their movements. You will cause examination to be made of the stomachs of such of these fish as you can capture and carefully preserve a portion at least of the contents of the stomach for immediate or future examination.

"Should you deem it expedient you will cruise off the coast a sufficient distance to determine the outward line of motion of the fish, and you will communicate to such fishing vessels as you may meet any information that may enable them the more successfully to prosecute their labors. The time of this work is left to your discretion. You will whenever you touch at any port of the United States send a telegram to me and await instructions as to further operations, if there be nothing to detain you.

"You will give to the naturalist of the expedition all possible facilities for collecting and preserving such specimens as you may meet during the cruise.

Very respectfully,
Spencer F. Baird, Commissioner

P. S. --The operations of dredging and trawling should be carried on as frequently as opportunity offers; and if no suitable bait can be had, the trawling line should be used for the purpose of determining the currents of desirable fishing grounds."

Baird considered that explorations in the sea should be conducted simultaneously with the laboratory studies on reproduction, development, behavior, and growth of commercially important marine species. He was proud to explain the significance of such research and to demonstrate its methods to other scientists, government officials, and laymen. Being well known and highly respected both in the Congressional and administrative circles of Washington, he was in a position to invite the highest officials to visit Woods Hole. The report of the commanding officer of the Fish Hawk for 1882 (Tanner, 1884b, p. 9-10) contains the following interesting references: "At 9:00 on the morning of the 28th (of June, 1882) the U. S. Steamer Tallapoosa arrived, having on board the Hon. W. E. Chandler, Secretary of the Navy, and chiefs of bureaus. At meridian we left the harbor with Prof. Baird, the Secretary, and the chiefs of bureaus, for a short trip to show the manner of working the various apparatus used on board. Three casts of the dredge and trawl were made in Vineyard Sound, and at 4:30 p. m. we returned to Woods Holl. The Tallapoosa left the harbor at 9:15 the next morning."

On September 6 of the same year, Woods Hole was visited by the President of the United States, Chester A. Arthur. The official report of the Commanding Officer records this event in the following words: "At 9:30 a. m., September 6, The United States Steamer Despatch, having on board the President of the United States, and accompanied by the Fish Commission steamer Lookout, arrived in the harbor. At meridian we left the harbor with the President, Professor Baird, and others on board. To show the former the manner of working the various apparatus, three hauls of the trawl and dredge were made in Menemsha Bight. We reached port at 5:55 p. m., when the President returned to

the Despatch. At 5:00 the next morning the Despatch, with the President on board, got under way and left the harbor." Edwin Linton (1927), at that time a beginner-biologist employed by the Fish Commission, described this event in his reminiscences of the Fish Commission: "I remember, on one occasion, the President of the United States was there over night, was given an exhibition trip on the Fish Hawk, and the process of operating the beam trawl was shown him. Now we young assistants, coming as we did from inland, knew nothing at first hand about Presidents and their ways, or of the ways of those who were accustomed to be about them. When we were told that there was to be a collecting trip in the morning we reported for duty in our usual unconventional attire. By the time the Fish Hawk was steaming out into Vineyard Sound we made the discovery that officers and crew, and everybody else on board, were each and all dressed in honor of the Chief Executive, all bravely clad, and easy in their minds, except three young men who were having all the disagreable sensation peculiar to those who dream of like unpleasant experience. I remember yet quite vividly, the appraising look which the Professor gave us just before, as it seemed to us, he decided not to present us to President Arthur."

The work of the Fisheries Laboratory and the operations of the Fish Hawk continued to arouse public curiosity excited by the visits of high officials. Local papers faithfully reported the sailing and returning of the ships and the successes of the collecting as well as the arrivals and departures of Baird. Thus the Cape Cod Item of July 15, 1881, contains the following note: "Our streets present a very animated and business-like appearance with the arrival of the U.S. Fish Commission under the supervision of Prof. Spencer F. Baird of the Smithsonian Institute, Washington, D. C., who with his family and corps of attendants is quartered in the Webster House, among which are the following: Dr. Tarlton H. Bean, J. Paul Wilson, Herbert Gill, Prof. C. Deering, Capt. Herbert Chester of U. S. F. C., Prof. J. Emerton, Prof. A. E. Verrill, Sydney L. Smith, New Haven. The Commission have at their command two steamers, one the Fish Hawk, Z. L. Tanner U. S. N., Commander, for the purpose of going to various points to dredge for specimens, and the Lookout, a fine steam yacht for the purpose of accommodating distinguished visitors. Various lines of telephone will connect the depot, post office, hotel, wharves, and buildings used by the Commission."

In the following days of summer the paper reported (August 19, 1881) that "among important specimens obtained by the U. S. Steamer 'Fish Hawk' on the last trip to Gulf Stream, was a fine octopus or devil-fish, a number of tile fish weighing about 35 pounds each, was also secured, the same being a very rare specimen." From miscellaneous news items in the paper we learn that Assistant U.S. Fish Commissioner T. B. Ferguson arrived in port

on board the U. S. S. Lookout and brought "a large sunfish weighing 300 pounds which was dissected by Dr. Bean who also found many parasites attached to gills." On the 14th of July, we read that the steamer Fish Hawk went to No Mans Island securing four ground fishes. During the trip a trawl net was used collecting many fish, mollusks, crabs, etc. The large number of specimens collected by biologists apparently incited the imagination of the local reporter who on July 29 wrote (Cape Cod Item) that "on last dredging expedition of the U.S.F.C. Steamer Fish Hawk 172 barrels of alcohol were used in preserving specimens." In the next issue of this weekly paper a correction was printed which said "our correspondent wrote 1-1/2 but types read it 172--quite a difference."

News items appearing in the local press are indicative of public interest in the new laboratory, which offered new opportunities for employment and trade, attracted tourists, and in this way became an important factor in the economy of the small village. At the same time the press emphasized the importance of the tourist trade and encouraged the owners of "farm houses to make them attractive to summer visitors." The number of tourists was rapidly increasing as can be judged, for instance, from the following lines in an August 19, 1881, issue of the Cape Cod Item: "Last week Saturday the 4:10 train started from Boston with 18 cars loaded with passengers and about every train since has been filled. Undoubtedly many of them took advantage of the opportunity to visit the marine laboratory of the Fish Commission."

Probably the most significant achievements of marine exploration in the vicinity of Cape Cod were the studies of the invertebrate fauna conducted by Verrill, and described by him in a large number of papers. He strongly believed it to be a duty of a scientist to publish the results of his investigation for the benefit of other scientists. Following this conviction, he produced nearly a hundred scientific articles based on the collections accumulated during his association with the U. S. Fish Commission. The majority of the papers appeared in reports attached to the annual reports of the Commissioner of Fish and Fisheries; others were published in the American Journal of Science, the Transactions of the Connecticut Academy of Arts and Sciences, and other journals. The collection of invertebrates made by the Fish Commission from 1871 to 1887 at over 3,000 localities within New England waters comprised several hundred thousands of specimens of more than 2,000 species (Verrill, 1958). The huge collection was taken by Verrill to Yale University in New Haven where he continued to work on it during the winters. As a partial compensation for his work he received the duplicates after the first set of specimens

containing all the type specimens and any unique forms had been deposited with the National Museum in Washington, D. C. The second set of duplicates was given to the Museum of Comparative Zoology of Harvard University. Verrill completed the study of the Fish Commission collection only in 1908 and, according to the information given in his biography, he sold his set of duplicates to the Peabody Museum of Yale University.

Verrill's work provided a basis for our knowledge of bottom invertebrates in the immediate vicinity of Woods Hole and the adjacent areas extending to the 100-fathom line or farther offshore to some extent. His report upon the invertebrate animals of Vineyard Sound and the adjacent waters with an account of the physical characters of the region, published in 1871, has not lost its scientific value to the present day, and remains a major source of information about bottom communities of this area. Likewise, are his "Report on the Cephalopoda of the Northeastern Coast of America" (Verrill, 1882), "Results of the Explorations made by the Steamer 'Albatross' off the Northern Coast of the United States" (Verrill, 1885), and "Notice of a Remarkable Marine Fauna Occupying the Outer Banks off the Southern Coast of New England, and of some Additions to the Fauna of Vineyard Sound" (Verrill, 1884). In the latter paper he describes the rich fauna in the region about 105 miles along the 100 fathom line between latitudes 35°40' and 40°22' N. and longitudes 69°15' and 71°32' W. According to his conclusion, the number of species and the abundance of individuals in this area "is due very largely to the annual uniformity of the temperature enjoyed at all seasons of the year, at all those depths that are below the immediate effects of the atmospheric changes. The region . . . . is subject to the combined effects of the Gulf Stream on one side and the cold northern current of the other, together with the gradual decrease in temperature in proportion to the depth."

He describes also the effects of the Gulf Stream in bringing "vast quantities of free-swimming animals which furnish an inexhaustable supply of food for many bottom animals". After Verrill's time, the study of bottom invertebrate communities on the offshore areas along the New England Coast was discontinued and was resumed only in 1954, in connection with recent investigations of groundfishes of Georges Bank. Verrill's conclusion about the condition responsible for the abundance of life along the 100-fathom line in an area south of Woods Hole shows a highly developed power of observation and the ability of the author to visualize a general ecological picture from the multitude of detached observations. Verrill never lost sight of the forest because of the trees.

His work on cephalopods contains the descriptions of gigantic squids, Architeuthis and their allies. Their existence

in the waters not far from Woods Hole is rarely suspected by summer tourists and boatmen. The efficiency of Verrill's field explorations was facilitated by his skill in devising or modifying collecting instruments and perfecting methods of dredging and trawling. He remarks (Verrill, 1883, p. 65) that the adoption of steel-wire rope for dredging from the Fish Hawk greatly expedited the work. He was fully acquainted with the latest improvements, in sounding, dredging, and trawling techniques made in Europe. He immediately adopted the new methods for the operations of the Fish Hawk. He must be credited for designing new forms of traps for capturing bottom animals, the "trawl wings" for catching free-swimming forms close to the bottom, and many other devices. The mop-tangles that Verrill devised for catching spiny animals were later adopted by the oyster growers in Long Island Sound for removing starfish; this device is still used at the present time.

Other important contributions of the Woods Hole Laboratory made during the first years of its existence are the three papers by Edwin Linton (1889, 1891, 1892) on entozoa of marine fishes. These publications were the first in a long series of papers on parasitic worms which Linton produced during more than 50 years as a voluntary collaborator at the laboratory.

The works of Harger (1880) on marine Isopoda and of Farlow (1873, 1882) on marine algae were the result of careful taxonomic studies of the material collected by the station's vessels.

The work on fishes dealt primarily with the occurrence, distribution, and development of the more important species. Among the valuable contributions originated at the Woods Hole Laboratory between the years 1871-87 were: "List of Fishes Collected at Wood's Hole" (Baird, 1873), "The Scup, The Blue-Fish" (Baird, 1873), "The Sea Fisheries of Eastern North America" (Baird 1889); "Catalogue of the Fishes of the East Coast of North America" (Gill, 1873); "The Natural and Economical History of the American Menhaden" (Goode, 1879), "Materials for a History of the Sword-Fish" (Goode, 1883); "Materials for a History of the Mackerel Fishery" (Goode, Collins, Earll, and Clark, 1884); "Embryography of Osseous Fisheries, with Special Reference to the Development of the Cod" (Ryder, 1884). The principal question regarding the causes of the decline in commercial fish catches and fluctuations in their abundance, could not be answered by these investigations and with the methods available at Baird's time. Even at the present time, in spite of the outstanding progress made in fishery biology and the development of statistical methods of studying fish populations, the causes responsible for the wide fluctuations in the abundance of fish remain undiscovered.

The experience of many European biologists in artificial propagation of fresh-water fish showed that the populations of fish in streams and ponds could be maintained by restocking with artificially raised young fish. Various organizations in the United States and state officials urged the U. S. Commissioner of Fisheries to initiate artificial cultivation of marine species and to introduce foreign species of fish into American waters. The construction of a marine hatchery at Woods Hole was made in response to these requests. The problem of maintaining a fish population at a desired level of abundance appeared to be a simple one. In general, the fecundity of oceanic food fishes is very high, the adult female (depending on species) producing every year from several hundred thousand to several million eggs. Inference was made that by means of artificial propagation it would be possible to increase the supply of such fish as cod, flounder, shad, mackerel, halibut, and other species, and also to transport them to other localities where they were not present. Baird, in accord with the opinion of other biologists of his time, believed that artificial propagation might be effective, and put his full energy in establishing new hatcheries along the coast and over the mainland of the United States. Technical progress in the design of various hatching jars, boxes, and other equipment made in the United States was so rapid that as early as 1881 the U. S. Fish Commission participated with great success in the Berlin Fishery Exhibition, showing the progress of fish culture in the United States. A considerable part of this exhibit was prepared at Woods Hole.

D. Haack (1882, p. 57) summarizes a German appraisal of the American section in the Exhibition in the following words: "Everything which America had sent was on a magnificent scale. The American exhibit was distinguished by the neat workmanship of all the objects. But best in astonishment we stand before the large model of the Fish Hawk, a large steamship especially constructed by the American Government for the purpose of pisciculture. The steamship contains, both in its interior and its sides, hundreds of large pieces of apparatus for hatching fish eggs. The steam engine partly serves for pumping of water and partly for moving to and fro in the water the apparatus attached to the sides of the vessel, thus vivifying the germs of the eggs. . . . . With all our piscicultural efforts we must confess that we felt very small when viewing this grand American exhibit; and the magnificent results obtained in America are sufficient guarantee that this is no American humbug. For the present we can certainly do no better than to strain every nerve and imitate the example set us by the Americans." In recognition of his achievements at the Berlin Exhibition, Baird received from the Emperor of Germany the "Erster Ehrenpreiz" of the International Fisherei-Ausstellung at Berlin. Previously he had received the silver medal

of the Acclimatization Society of Melbourne in 1878, and the gold medal of the Society of Acclimatization in France in 1879. The honors bestowed by these European organizations clearly show that artificial propagation of fish, including oceanic fishes, was considered to be practical and should be encouraged. These ideas greatly influenced the work of the Woods Hole station and its laboratory.

Numerous papers in the annual reports of the Commissioner of Fisheries describe many technical improvements in the method of hatching eggs. One of the earlier papers on oyster culture by Ryder (1887) summarizes the results of practical experiments, made at Woods Hole and in other parts of the Eastern Coast, in obtaining oyster spat.

Since 1873, Baird had suffered from irregular heart action. This did not prevent him from leading an extraordinarily active life and personally conducting many sea explorations around Woods Hole. The increased burden of work overtaxed his strength during the period of the station construction. His periods of sickness became more frequent, and in the summer of 1886 his doctors recommended that he reduce his work as much as possible. In July 1886, the Bairds, as usual, went to Woods Hole and here held the last four informal receptions in the Residence for the members of his staff. During the following winter his condition became worse and he was advised to take a complete rest for at least a year. Retirement to the Adirondack region in the State of New York somewhat improved his health, and in July 1887, he returned to the Woods Hole Laboratory.

The last days of Baird are described by Mayor J. W. Powell in his address at the memorial meeting of Scientific Societies of Washington in January 1888 (Dall, 1915). Three days before his death, Baird asked to be placed in a wheelchair and moved around the pier past the vessels and through the laboratory. For everyone he had a word of good cheer, though he knew it was the last. He died on August 19, 1887, and was buried at Oak Hill Cemetery in Washington, D. C. A granite boulder with a bronze tablet, in honor of the first United States Commissioner of Fisheries and founder of the Woods Hole Station, was placed at the station in 1902 by the American Fisheries Society; it remains in its original location.

At the time of Baird's death the scientific work of the Woods Hole Laboratory was already on a sound foundation. Research was conducted along several principal lines which can be grouped under the following general headings: taxonomy and distribution of fishes; composition of communities of bottom organisms; reproduction, embryology, and movements of principal food animals of the sea; fish culture as a means of maintaining the abundance of fish populations; parasites and diseases of fishes. The work was balanced

as far as possible with the available funds and personnel. The major part of the general program was carried out by independent investigators. Many distinguished scholars were attracted by the facilities of the laboratory, but even more by the scientific standing and dynamic personality of its director.

Baird's guiding spirit in the study of fisheries problems was not lost with his death. With modifications and changes his spirit has continued to the present time. He undoubtedly was the first fishery biologist in this country. His understanding of fishery problems is clearly expressed in the following excerpts from his paper read at the International Commission held at Halifax in 1877 (Baird, 1889).

"While it is probable that the supply of fish on the outer banks and in the deep sea, away from the immediate coast, is as great as that of former years, a lamentable falling off is to be appreciated in the capture of anadromous fish, such as the shad, salmon, and the alewife, as well as of many species belonging immediately to the coast, such as the striped bass, the scup, and other fish.

"Fortunately, it is believed they are capable of remedy by proper legislation and protection, artificial propagation, etc., and that we may look forward in the distant future to a very considerable return to the former very desirable state and condition of the fisheries. . . . . The status of fish in the sea is very largely determined by the question of temperature.

"The human race is more concerned in the movements and migrations of fish than in the question of their permanent abode. It is when they are aggregated in large bodies, and moving from place to place, either under the stimulus of search for food or other causes, that they furnish the best opportunity to man for their capture and utilization.

"That fish of many varieties have decreased greatly in abundance within the historic period in all parts of the world is well established, the reduction in some cases being truly enormous. This, however, applied only to certain varieties, especially of the anadromous fish, or those running up the rivers from the sea to spawn, and to the more inshore forms. The most indubitable cases of diminution are those of the shad, fresh-water herring, salmon, and striped bass. On the other hand, there is no reason to suppose that the cod, mackerel, bluefish, and the sea herring have been reduced essentially, if at all, in numbers, the stock of these fishes being from year to year about the same, and an apparent diminution in one region being balanced by a greater supply in another.

"The causes of this variation in abundance, so far as they can be detected, may be considered under two heads: first, the natural, or uncontrollable; and, second, the artificial, or those connected with the interference of man. Where the former alone are responsible there may be a hope of a return to original abundance; man's influence acts persistently and with increasing effect throughout long continued years."

II. The Next 64 Years (1887 to 1951)

In March 1888 a new institution was incorporated in Woods Hole under the name of the Marine Biological Laboratory (MBL). On July 17 of that same year, a modest shingled building was erected on a piece of land in close proximity to the U. S. Fisheries grounds. The new institution was established at Woods Hole by a group of university professors with very meagre financial assets. They met with cordial support from the Fisheries Laboratory. For many years the sea water for the new laboratory was supplied from the Fisheries pumping house and practical assistance was given in the use of wharves, floating equipment, and interchange of other services. Many of the MBL scientists who became leaders of American biology spent several summers working at the Fisheries Laboratory. The MBL rapidly outgrew the Fisheries Laboratory and became the leading marine research institute of the country, but the spirit of cooperation which prevailed throughout the history of Woods Hole has persisted and greatly contributed to its growth as the scientific center of marine research.

Shortly after the death of its first Commissioner, the U. S. Fish Commission was reorganized. As stated in the enabling act of Congress, passed and approved in 1871, "the Commissioner should be a civil officer of the Government, of proved scientific and practical acquaintance with the fishes of the coast, who should serve without additional compensation." The text was drawn jointly by Senator G. F. Edmunds and Baird, who insisted on the inclusion of the noncompensation clause with the idea that the phraseology of the bill would preclude the appointment of a mere political candidate and eliminate any suggestion that recommending the passage of the resolution was not voted by selfish consideration of the first Commissioner (Dall, 1915). The responsibilities of the Commissioner and the increased duties of organizing the laboratory and research program imposed a heavy financial burden on Baird. His request for an appropriation for furnishing adequate office space and living quarters for his personnel at Woods Hole was denied, and before the Government quarters were built he had to pay, out of his own money, the rentals for an office building and for housing facilities for his assistants. Shortly after his death, Congress corrected the oversight by an appropriation of $25,000 for the support of Baird's invalid widow and his daughter.

Baird was succeeded as Commissioner of Fisheries by George Brown Goode, his most competent assistant, an outstanding ichthyologist and Director of the National Museum. The appointment was a temporary one. In six months Goode (fig. 3) voluntarily resigned his Commissionership in order to devote all his time to the duties in the Museum. In January 1888, an act of Congress

established the U. S. Fish Commission as a separate bureau of the government and terminated its formal relationship with the Smithsonian Institution. The bill also authorized the President to appoint the Commissioner of Fish and Fisheries and also established the salary at $5,000 per year. The bill was approved on January 20, 1880, and Marshall McDonald was appointed Commissioner. He was a practical fish-culturist and inventor of important mechanical appliances for hatching fish eggs which were widely used in this country and in Europe. McDonald served as Commissioner until his death on September 1, 1895. The Fish Commission continued as an independent, government institution that was responsible directly to Congress until 1903, when it was included in the new Department of Commerce and Labor.

Baird's administration of the Fish Commission and of the Woods Hole station was essentially paternal. With the increased activity and greater complexity of administrative responsibility more formal organization became imperative. The duties were divided among several divisions each headed by an "Assistant in charge of the division". During the first year of McDonald's administration, Hugh M. Smith was appointed an Assistant in charge of the Division of Fisheries. The scope of work of this division covered "all matters specially pertaining to commercial fishing, including statistics". Smith also directed the work of the Washington office and supervised correspondence and preparation of special records. In 1885, R. Edward Earll directed the preparation of statistics. The fish culture activities remained under the direct supervision of McDonald until 1895. After his death, the Division of Propagation and Distribution of Food Fishes was established, with W. deRavenal as Assistant in charge.

In the years following Baird's death the major emphasis in the work of the Woods Hole Station was placed on fish culture and routine administration rather than on scientific investigations. Because of this trend the Woods Hole Station became the principal hatchery for artificial propagation of marine fish species. Administratively, the Station was under the Division of Propagation and Distribution of Fishes, and the Superintendent of the Station became responsible for the operation of the hatchery, maintenance of buildings and grounds, and expenditures of funds allocated to the institution. The Report of the Fish Commission shows that in the year of 1887, C. G. Atkins was Superintendent and William P. Seal was in charge of the aquaria. The scientific work was divided between J. N. Kidder, in charge of the physical and chemical laboratory, and A. E. Verrill, --assisted by Richard Rathbun--who was in charge of the biological laboratory. Among the 16 persons attending the summer session, 10 were engaged in research work, 4 can be listed as assistants to the investigators, 1 was an artist, and Vinal N. Edwards was the collector. The division of responsibilities as well as the titles of the positions occupied by various

persons was not definitely established. In 1888 John A. Ryder was in charge of the laboratory with 23 biologists in attendance. In the spring of the following year, H. V. Wilson was appointed "resident naturalist" and remained in this position until the summer of 1892. The number of investigators in this period varied between 12 and 16.

Henry Van Peters Wilson (fig. 23) was a man of dynamic personality. In a biographical sketch published by D. P. Costello (1961) Wilson is described as a small man, 5 feet 6-1/2 inches tall and never weighing more than 120 pounds, with piercing blue eyes. "He was not a man lightly to tolerate fools among his colleagues, assistants or students. He expected efficiency approaching perfectionin others as well as in himself, and worked with tireless energy to attempt to achieve this end." Unfortunately, the records of the Bureau of Fisheries contain no personal notes, letters, or other materials which would indicate his attitude toward his assistants and personnel of the Woods Hole Laboratory. During the first year at Woods Hole he devoted himself to the study of embryology of the sea bass. He described the development of the sea bass egg from fertilization to the free-swimming larva, about 160 hours old (Wilson, 1889). It is a classic contribution to fish embryology which has not lost its usefulness to the present day, and remains one of the chief reference books for students and researchers engaged in embryological investigations. Another valuable contribution by Wilson was the important discovery of regeneration of sponges from dissociated tissue cells. Wilson's interest in the structure, development, and taxonomy of sponges began in 1890. In 1891 he resigned from the Bureau of Fisheries and joined the faculty of the University of North Carolina at Chapel Hill, N. C., but he continued to work on the sponges collected during the Albatross expedition off the west coast of Mexico and those collected by the Fish Hawk in the vicinity of Puerto Rico. He induced the Bureau of Fisheries to establish a biological laboratory at Beaufort, N. C., where he completed his detailed study of the development of sponges from dissociated tissue cells. Wilson's report on sponges (Wilson, 1912) opened a new approach to the problem of regeneration and initiated many investigations conducted in American laboratories and abroad. Interest in the problem was revived in 1921-24 by experimental work conducted by P. S. Galtsoff, first at the Marine Biological Laboratory and later at the Bureau of Fisheries Laboratory at Woods Hole (Galtsoff, 1925).

At the time of H. V. Wilson's separation from the Bureau of Fisheries in 1891, the work of the Fishery Laboratory at Woods Hole assumed a distinct pattern. One of the biologists of the Bureau was assigned to Woods Hole "in charge of the Laboratory", or some outstanding zoologist outside of the Government service received a temporary appointment as "summer director". From time to time one or several biologists of the Bureau used the facilities of the Woods Hole Station for work on special problems related to

Figure 23.--H. V. Wilson, Professor at North Carolina University and Director of the U. S. Fisheries Laboratory at Woods Hole.

commercial fisheries. At the same time the facilities of the laboratory were made available without charge to professors of various colleges and their students or to other qualified investigators. With a few exceptions the Laboratory was open only during the summer and the major part of the Station's activities were concerned with hatching eggs of marine fishes. Vinal N. Edwards was employed as "permanent collector", helping the investigators by his knowledge of local fauna and assisting them in obtaining the needed material. During the years of 1893 to 1896, inclusive, the following persons, listed in chronological order, were in charge of the laboratory: James L. Kellogg, J. Percy Moore, serving two years, and James L. Peck. In 1898 H. C. Bumpus was appointed as "Director of the Laboratory", and remained in charge until 1901. The number of biologists

engaged in independent research work varied from year to year and attained the largest number of 61 in 1901. Also, that year, six laboratory assistants were employed to help the Director.

After the death of McDonald, the position of the Commissioner was occupied for two years (1896-97) by John J. Brice, retired Naval officer. The next Commissioner was George Meade Bowers. During the 13 years of his administration, from 1899 to 1912 inclusive, the activity of the Bureau of Fisheries greatly expanded in all branches, including the services rendered by the Woods Hole Laboratory. The policies with regard to the operation of the laboratory and its availability to independent investigators have not been formally established. Continuing the tradition initiated by Spencer F. Baird the Bureau of Fisheries allowed a number of investigators to work in the laboratories on various problems of their own choice. Sometimes this created difficulties for the Commissioner in justifying the request for funds made to the Appropriation Committee of Congress. To overcome this complication, Commissioner Bowers defined the Bureau's policy regarding this matter. In his report for the year 1909 he wrote (Bowers, 1911, p. 16-17): "The marine biological stations of the Bureau at Woods Hole, Massachusetts, and Beaufort, North Carolina, primarily established and maintained for study and experimentation in the interests of the fisheries and fish culture, have as usual been resorted to by competent investigators from all parts of the country. While the Bureau provides ample facilities for qualified students and does not attempt to dictate the scope and character of their researches, it is noteworthy that a large percentage of the men of science who avail themselves of the laboratory privileges are engaged in work having more or less direct relation to practical questions, and in the past year an unusual amount of attention was given on the commercial fisheries and the cultivation of marine creatures." As a matter of interdepartmental courtesy the facilities of the laboratory were available to the government scientists of the Department of Agriculture, Public Health Service, and other agencies.

Scientific accomplishments of the Woods Hole Laboratory made by its staff and by independent investigators have been published in many volumes of Government reports and scientific journals. A comprehensive review of these investigations is beyond the scope of the present historical sketch. It is sufficient, for the purposes of this report, to give a general outline of the research projects carried out in the laboratory and mention the more important contributions during the period.

Scientific problems of a general biological nature were studied by a number of eminent zoologists who were either guests of the Fishery Laboratory or were temporarily appointed by the Bureau to investigate a special research problem. The long list of scientists mentioned in the annual reports of the Commissioner

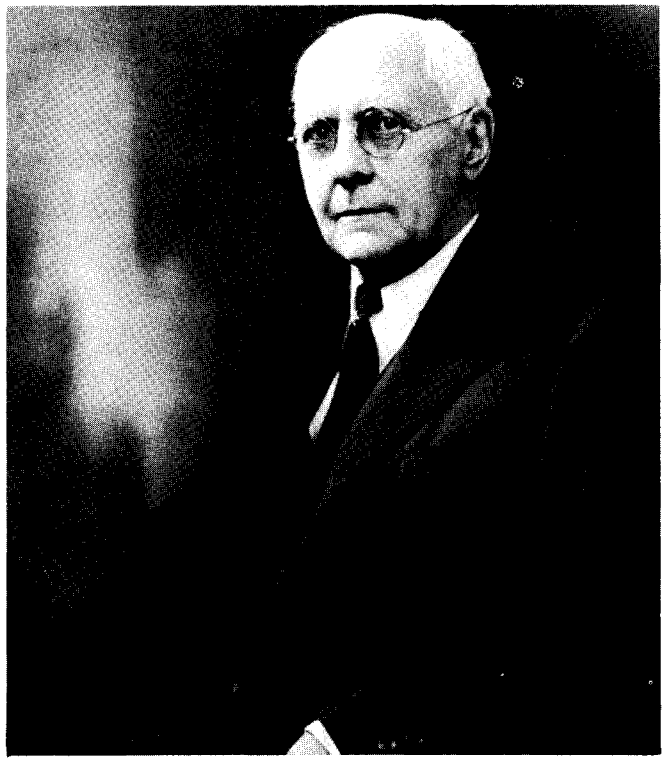

Figure 24.--Edwin Linton, Professor at Pennsylvania University. Was associated with the Fisheries Laboratory as an independent investigator from 1882 to 1941.

of Fisheries from 1884 to 1920 contains the names of persons who later attained great prominance and became leaders of American biology. For some of them the work at the Fisheries Laboratory was a starting point of their career. The following names, selected from the annual reports of the Bureau, are associated with the development of marine sciences at Woods Hole. The years after the names indicate the time they worked at the Fisheries Laboratory. W. K. Brooks (1888-90) biology of the oyster; Gary N. Calkins (1902) protozoologist, investigation of marine protozoa of Woods Hole region; Wesley R. Coe (1899, 1901) structure, biology, taxonomy of nemertines; Edwin G. Conklin (1890-94) embryologist, cell lineage and development of molluscan eggs; Charles B. Hargitt (1902-03) taxonomy and structure of coelenterates; Francis H. Herrick (1889-1895) biology of the American lobster; Edwin Linton (fig. 24) (1882-1941) parasitic worms in fishes; Jacques Loeb (1895) physiology of fertilization of marine eggs; T. H. Morgan (1889)

embryology of marine invertebrates and regeneration; Raymond Osburn (1904) taxonomy and distribution of Bryozoa; George H. Parker (1888-1903) fish behavior and physiology of hearing and lateral line; William A. Patten (1893-99) morphology of Limulus, ancestry of vertebrates; William M. Wheeler (1900-02) free-swimming copepods of the Woods Hole region; E. B. Wilson (1877-1886) embryology of mollusks, cell lineage; and many others.

The work of a few zoologists on the staff of the Woods Hole Station was concerned with practical fishery problems and various scientific pursuits. The authority of the biologist in charge, who sometimes was called "Director" or "Summer Director" of the Laboratory, was somewhat limited. Administrative responsibility for maintenance of the buildings, grounds, and small boats, as well as hatchery operations, were the duties of the Superintendent, who took orders directly from the Washington office.

From 1898 to 1901 the Laboratory was under the directorship of H. C. Bumpus. In addition to his other researches, Bumpus made observations on the reappearance of the tilefish, Lopholatilus chamaeleonticeps. In 1879, large schools of tilefish were discovered in the waters south of Nantucket Shoals. Three years later, multitudes of dead fish of this species were found on the surface throughout its entire area of its distribution north of Delaware Bay. This mass mortality attracted a great deal of public attention and was studied by the Fish Commission every year from 1882 to 1887. Not a single tilefish was found during this period. In 1898, however, the tilefish had become numerous again, and the Fish Commission schooner Grampus on three short trips caught several hundred fishes each weighing from 1/2 to 29 pounds. The mortality in 1879-80 was attributed to the influx of abnormally cold water, but this explanation has not been definitely substantiated.

During Bumpus' directorship, a new investigation of parasitic copepods infesting common food fishes was undertaken. Little was known at that time about this important group of Crustacea. Charles B. Wilson (fig. 25) was invited to undertake the study. He resolved to make it his life's work, and began a painstaking determination and description of parasitic species. Since the year 1899, his first summer at Woods Hole, C. B. Wilson continued his association with the Bureau of Fisheries working on copepod collections he made himself or those which were assembled for nearly 25 years by the U. S. S. Albatross. The importance of his undertaking was such that in 1901 the entire collection of parasitic copepods in the National Museum in Washington, D. C., was turned over to him, also the various stations and hatcheries of the Bureau of Fisheries were instructed to collect this material and forward it to him for identification. Being a man of broad scientific background, he was placed in charge of the economic survey of Lake Maxinkuckee, Indiana. Here he obtained the material for his monographic

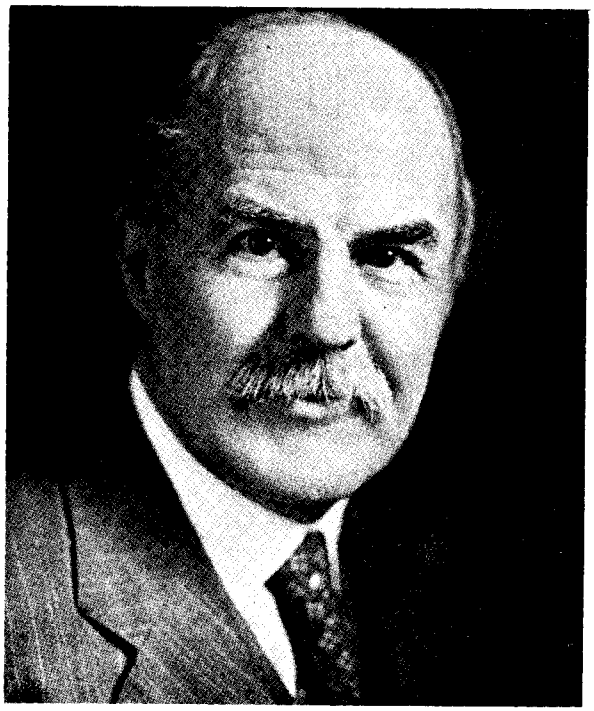

Figure 25.--Charles B. Wilson, Professor at State Teacher's College in Westfield, Mass. For many years studied parasitic and free-living copepods of the Woods Hole area and other parts of the United States. About 1930.

studies published as his doctoral thesis under the title "North American Parasitic Copepods. Part 9, The Lerneopodidae." He participated in economic surveys of Lake Maxinkuckee; the Mississippi River; and the Maumee, Kankakee, and Cumberland Rivers. Between 1913 and 1923 he was economic investigator for the Bureau of Fisheries at Fairport, Iowa, and in the summers of 1924-27 and 1931 he again worked at Woods Hole. Those who saw him every day in the laboratory remember him as very industrious, patient, and at the same time a cheerful man. During one summer he concentrated his efforts on the study of fresh-water copepods of numerous fresh-water ponds and lakes on Cape Cod, and was frequently seen rowing a small skiff towing a plankton net. Playing golf was his principal recreation, and he was a familiar figure on the Woods Hole golf course. He also liked bowling and watching baseball, but most of the time he was seen sitting at his laboratory desk patiently dissecting and mounting copepods with the aid of a binocular microscope. Among

Figure 26.--Francis B. Sumner, Director of the Laboratory, 1904-1910. Photograph made in 1937.

his many contributions "The Copepods of the Woods Hole Region Massachusetts" (Wilson, 1932) is the most valuable book for students of marine copepods. His large library of copepod literature, probably the most complete in existence, he bequeathed to the National Museum. Until his retirement in 1932, C. B. Wilson was Professor of Biology at the State Normal School (later State Teacher's College), Westfield, Mass.

In 1902, H. M. Smith was the Director of the Laboratory. The following year he was appointed to the newly created administrative position of Deputy Commissioner of the Bureau. One of his actions was the appointment of Francis B. Sumner (fig. 26) as the Laboratory Director, who held this summer position until 1910. Sumner's reports (Sumner, 1904, 1905) indicate that in addition to the large laboratory room with nine tables, the Woods Hole station had 14 private rooms equipped for research. Certain parts of the hatchery plant and the aquarium were also available to the investigators. The permanent

collection of the library at that time comprised 16,000 titles; mostly reports of the U. S. and foreign governments and reprints donated by the authors. A large number of books were loaned by Brown University (650 volumes) and 100 volumes by the College of the City of New York for use during the summer. An author catalog of the library books was supplemented by a subject catalog that was commenced by Miss R. MacDonald, the librarian.

From 25 to 30 investigators worked at the Laboratory each summer. Sumner gives an interesting tabulation of the subjects of research which he more or less arbitrarily classified as follows:

Relations to stimuli, animal behavior, etc.	9
Faunal and floral distribution	7
Taxonomy	6
Embryology	3
Ecology (exclusive of distribution)	2
General physiology (exclusive of behavior)	2
Regeneration	2
Miscellaneous	6

Biological material for research was regularly supplied by dredgings of the Fish Hawk and Phalarope (fig. 27) and by selecting needed fish from several traps at Menemsha Bight, and Marthas Vineyard. Besides two steam launches, a catboat, an abundance of rowboats were available for short trips. A daily record was kept by Vinal N. Edwards of the species taken. One of the investigators for the Bureau was George Parker of Harvard University, who conducted a study of the lateral line physiology. He used for this purpose dogfishes, skates, killifish, scup, toadfish, and winter flounder. One of the conclusions reached was that the lateral line organs are stimulated by water vibrations of low frequency (six per second). Interesting observations were made by Lynds Jones on the food of marine birds. He counted the number of terns, Sterna hirundo and S. dougallii, nesting at Weepecket, Penikese, and Muskeget Islands near Woods Hole and calculated the number of fish they consumed. His results showed that in the course of one day 92,000 terns ate 736,000 small fish, Ammodytes americanus, and 184,000 fish of other species. The consumption of food fishes by terns appeared to be insignificant, and the birds were exonerated as an important destructive agency.

The principal feature of the work of the Woods Hole Laboratory undertaken by Sumner was the biological survey of the bottom animals and plants of Buzzards Bay and Vineyard Sound. The incentive for this project was Sumner's desire to use the Fish Hawk which, as he states, was customarily "parked" at Woods Hole during the summer. Having started on the project, he and his associates found themselves deeply involved in the work in which dredging was made at several

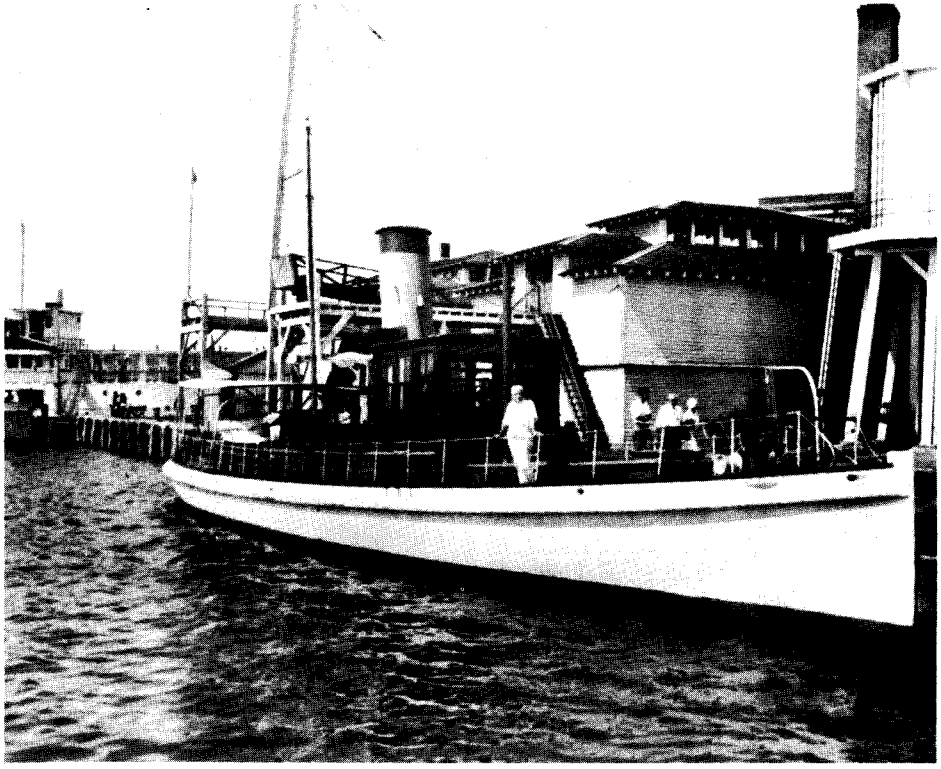

Figure 27.--Steamer Phalarope at the Fisheries dock, Woods Hole. The small vessel was used for daily collection of biological material in 1930's.

hundred stations. The distribution of about 250 species of animals and plants is shown on many maps accompanying the report of this survey. Osburn and Cole collaborated with Sumner in the study of animal populations; Bradley M. Davis, Professor of Botany at the University of Chicago and later at the University of Pennsylvania, studied the distribution of marine algae. Temperature and salinity of the water were recorded, and all collected material was carefully catalogued. The completed report on this monumental undertaking was published in two volumes of the Bulletin of the Bureau of Fisheries (Sumner, Osburn, and Cole, 1913a, 1913b; Davis, 1913a, 1913b). The survey contains valuable information on the distribution of various animals, and to this day remains the main source of information about marine life on the bottom of the principal bodies of water near Woods Hole.

Sumner introduced weekly meetings of a "research club" for general discussion of scientific problems of mutual interest. This practice has been continued by all his successors.

On Sunday, August 25, 1907, the Laboratory was visited by the members of the Seventh International Zoological Congress held in Washington. The group that accepted the Bureau of Fisheries invitation included 13 scientists from Russia, who were given overnight accommodations in the residence building of the Laboratory. The party was carried next day by the Fish Hawk to New Bedford, and one dredging was made en route as a demonstration of the American technique of oceanic research.

One of the Russian delegates was G. A. Koshewnikow, professor and Director of the Zoological Museum and Laboratory of the Imperial Moscow University. Upon his return he told the group of advanced students, which included the author of this paper, a glorifying account of the work of the Fisheries Laboratory. His talk about the research conducted at Woods Hole and the photographs of the Fisheries Laboratory made a deep impression on the minds of the young zoologists.

Sumner's acquaintance with Woods Hole covered a period of 14 years. His first visit was in 1897 when he was a graduate student at Columbia University. In his autobiography Sumner (1945a) refers to that period as the "Golden Age" of the Woods Hole colony, when the most insignificant beginner in biology came into intimate contact with men whom he had long heard cited as authorities by his professors at college. He describes the days when the MBL was housed in a few small buildings, when almost every point on the beach could be reached without "violating the 'trespass' warnings; the automobiles were scarce even in 1911 (fig. 28) the pleasure boats and yachts were seldom seen". In 1903 he received the summer appointment as Director of the Laboratory at the maximum salary of $100 per month. The Laboratory of the Bureau of Fisheries had at that time much better basic equipment, larger collecting boats, and more attractive living quarters than those available at the MBL. Although the MBL lacked funds for equipment and facilities, it already enjoyed a high scientific reputation for basic research. In addition to the survey of Buzzards Bay and Vineyard Sound, Sumner carried on a number of investigations, some of which were the continuation of the experimental embryology of fishes he started at Naples, Italy. One of them was an experimental study of selection in fishes, in which he attempted to demonstrate measurable differences between the survivors and nonsurvivors of killifish, Fundulus, that were transferred to fresh water. During his spare time he initiated the study of the differences induced in a population of white mice by low temperature, and their possible transmission by heredity. This work was a stepping stone to his fundamental research in genetics, distribution, and evolution of the subspecies of deer mice Peromyscus carried on in later years at Scripps Institution at La Jolla, Calif.

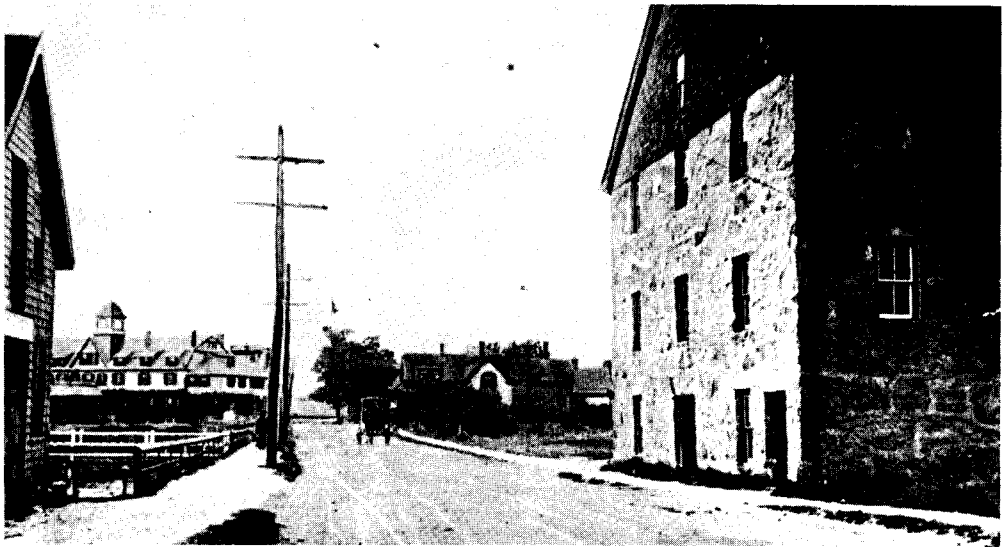

Figure 28.--Water Street of Woods Hole at the beginning of the 20th century. Former Candle House at right. Fisheries Residence at upper left.

In the fall of 1911 he accepted the position of "Naturalist of the Albatross". For the next two years he was engaged in a survey of San Francisco Bay, which was a cooperative study supported by the Bureau of Fisheries and the University of California. Upon completion of this work he joined the staff of Scripps Institution for Biological Research, as that institution was then known (later renamed Scripps Institution of Oceanography).

Sumner's contribution to the biology of fishes includes a valuable study of adaptive color changes in flatfishes. In later years, this work was continued and expanded by Mast who was a guest investigator at the Woods Hole and Beaufort Laboratories of the Bureau. Sumner's work on oxygen consumption and acclimatization of fishes greatly advanced our knowledge of the oxygen demand by various species and provided background information for devising bioassay tests that are now used to determine the toxicity of polluted

waters. The technique of maintaining living organisms in aquaria was benefited by his recommendation to de-aerate sea water, which sometimes becomes oversaturated with oxygen during pumping.

Sumner was deeply interested in the philosophy of science, particularly the relationship between religion and science and in the social responsibility of scientists (Sumner, 1937, 1939, 1940). One of his last papers entitled "A biologist reflects upon old age and death" (Sumner, 1945b) written when he reached "the biblical milestone of three-score years and ten", shows that the years did not diminish his reasoning power or his ability to present his ideas in a lucid and emphatic manner.

One of Sumner's remarks about the scientific method is of particular significance to those biologists who fail to recognize the true meaning of the so-called statistical probability. He states that "statistically speaking 'certainty of some differences' and a 'statistical significance too high to attribute to chance' creates no presumption in favor of the particular interpretation which the author gives to that difference". This pertinent remark by Sumner refers to his own experiments with white mice, made at the time when the application of statistical analyses to experimental data was at the early stages of development.

In 1913, H. M. Smith (fig. 29) was appointed Commissioner of the Bureau of Fisheries. During his administration, which terminated with his resignation in 1922, he retained his interest in the Woods Hole Laboratory. He spent many summers at the Laboratory, escaping from administrative burdens of the Washington office and continuing to work on fishes. He never ceased to be active in ichthyological and fisheries research, and his personal contact with the field employees frequently was helpful to them. In many respects Smith was a remarkable person. He began his work in the fishery service in 1886 under Spencer F. Baird, whom he always held in highest respect as a man and scientist. Upon graduation from medical school in 1888 he was appointed to the staff of the Medical School of Georgetown University, teaching anatomy, histology, pathology, and medicine. Increasing interest in ichthyology and fisheries work compelled him to stay in the fishery service. His medical training, however, remained very useful, especially after his resignation from the Government service in 1922. At that time he began a 12-year residence in Siam as Expert Advisor in Fisheries to the King of Siam. In his many trips to the interior of the country he came in close contact with the people in the dense jungles, and treated many of them suffering from various tropical diseases. A born naturalist, with a deep love for study of animal life, Smith loved to come to Woods Hole where he enjoyed informal meetings with many biologists, saw many old friends, and was visited by many zoologists coming to see him from Europe, Siam, Japan, and India.

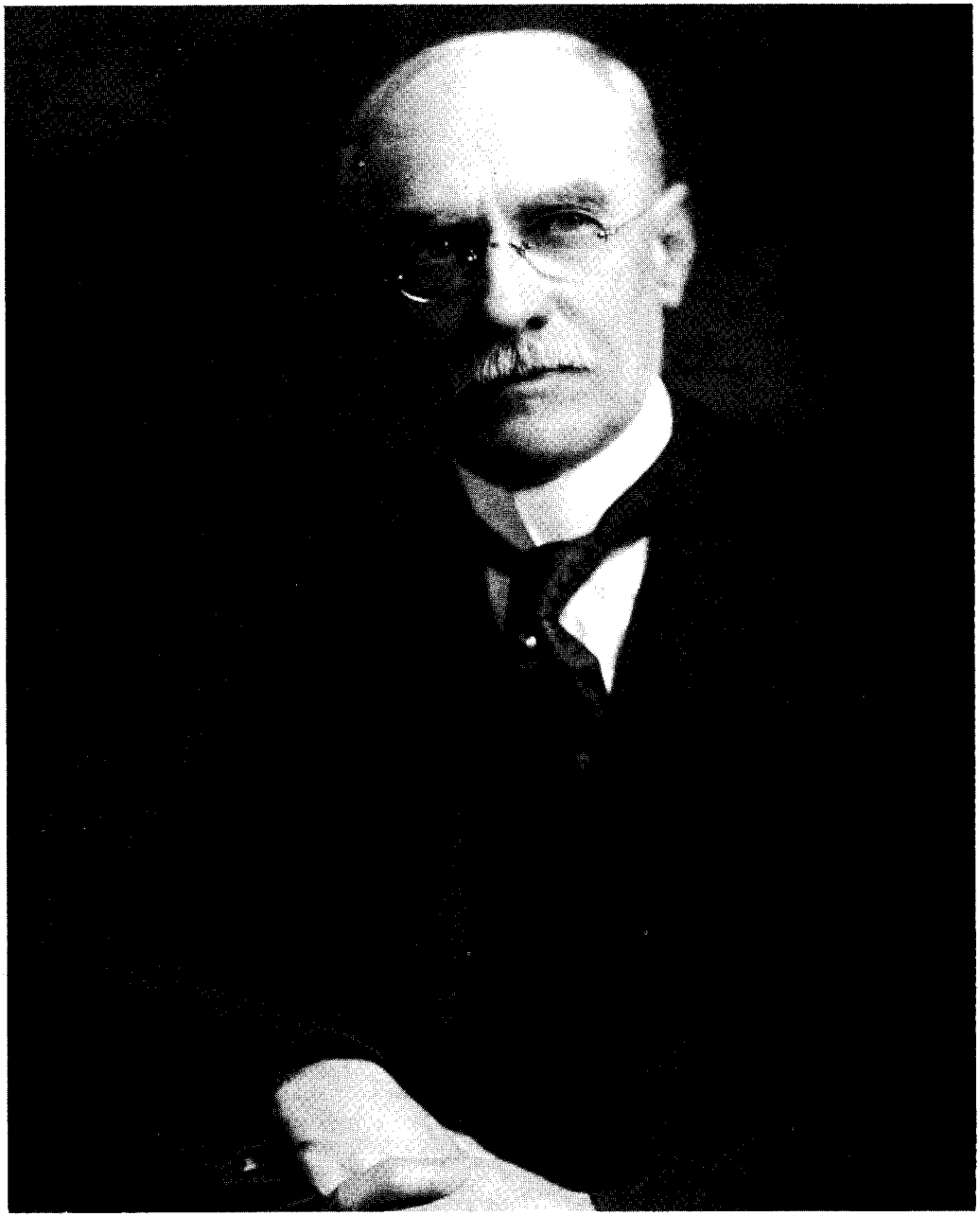

Figure 29.--Hugh M. Smith, ichthyologist, Commissioner of Fisheries, 1913-22. Courtesy of his daughter, Mrs. J. E. Claudy. About 1935.

Dr. and Mrs. Smith occupied a five-room apartment, the so-called Commissioner's quarters, on the second floor of the residence building and frequently held receptions for the scientists in the large sitting and dining rooms of the first floor. This practice, established by Baird and continued by Commissioner McDonald, became a regular feature during the ensuing years. It gave a chance to beginners in science to meet and talk to the men who had already achieved success and occupied positions of importance and influence. The affairs, as I remember them, were informal, simple, gay, but at the same time dignified. Of small stature, always neatly dressed and speaking with a soft voice, Smith at Woods Hole seemed to us a different man from the person we saw occasionally in his imposing office in Washington. He received visitors and employees sitting in a large black leather chair behind a highly polished mahogany desk. As an official of high rank, he seemed polite but reserved, almost to the point of being cold and forbidding. At Woods Hole he was a different man--a fellow zoologist, with an inner drive to see nature with his own eyes; a person who loved to go in a small boat to seine for fishes or to observe the birds, which he knew as well as fishes and snakes. It was an inspiring experience to accompany Smith on a collecting trip to Menemsha Bight at Marthas Vineyard Island. He loved to go collecting there, particularly in August when southeastern winds brought in a number of southern fishes not found around Woods Hole at the other times of the year. Dressed in an old blue sweater, weather-beaten hat, and in long rubber boots, and a notebook with pencil stuck into the right boot leg, he was ready for action (fig. 30). He showed us how to use the small hand seine most effectively. The material was sorted on the beach right after each haul. The needed specimens were preserved, and the rest thrown back into the water while they were still alive. Upon returning to the Laboratory, the entire afternoon was spent in studying, measuring, sometimes in dissecting, the morning's catch. Fine points of taxonomy or structural peculiarities of fish were often explained. All his associates in the Laboratory of Woods Hole soon recognized the high mental and spiritual qualities that inspired respect and admiration. This feeling is well expressed in a letter sent to Smith by one of his subordinates (the Superintendent of the Woods Hole Station) on the occasion of his resignation. One sentence of the message reads as follows: "Here your visits have been looked forward to with pleasure, I think, because the MAN was so much larger than the boss, this notwithstanding the fact that the boss is one of the greatest in his class".

As a Commissioner of Fisheries from 1913 to 1922, Smith on several occasions defined the role of the Woods Hole Laboratory as a research institution for the Bureau. In the annual report

Figure 30.--H. M. Smith (center) on collecting trip to Marthas Vineyard. Left to right: F. E. Chidester, P. S. Galtsoff, H. M. Smith, R. A. Goffin, C. J. Fish.

of the Commissioner for 1916 (Smith, 1917, p. 45) he wrote: "The Woods Hole, Massachusetts, Laboratory is intended to serve as a nucleus for investigations of more direct reference to the New England and Middle Atlantic fisheries as well as for more technical investigations of general application. In some respects this establishment is better adapted for technical studies than any other laboratory of the Bureau, and it is hoped to improve the facilities for biophysical and biochemical studies that form essential phases of certain fishery investigations. The lack of a permanent scientific staff for this station causes its scientific operations to be confined largely to the summer season, when temporary professional services are most readily available." Consequently, the months of June to the first half of September were the period of greatest scientific activities. Inasmuch as the new fiscal year in the Government service begins on July 1 and the passage of the appropriation bill is frequently delayed, it is impossible to operate the laboratories on the prorated allowance made by Congress until the passage of the regular appropriation. On several occasions the situation became acute; for instance, at the beginning of the fiscal year 1913 the difficulty is described as follows: "A number of investigators had already reached the laboratories before it became apparent that the appropriations would not be available. Some of these were employed at reduced salaries and others elected to carry on work under the authority possessed by the Bureau to afford facilities to properly qualified investigators." (Smith, 1914, p. 31). The policy with respect to permanent scientific personnel remained unchanged until the reorganization of the Bureau after World War II.

Smith's association with the Woods Hole scientific community was resumed upon his return from Siam in 1935, when he became Associate Curator in Zoology in the Smithsonian Institution. He acquired property at the corner of Millfield and Gardiner Streets in Woods Hole and established a summer home there. Even while working on his monumental monograph of the fresh-water fishes of Siam, he had not lost interest in the Woods Hole fauna, and he was frequently seen in the laboratory of the Bureau of Fisheries. The descriptions of Leiostomus xanthurus and Alectis crinitus, both species new to Massachusetts Bay, were his last contributions to the ichthyology of the Cape Cod area.

Biologists working at Woods Hole during the summer of 1935 recall the interesting evening lecture delivered by Smith at the MBL auditorium. He described the aquatic life of Siam he had observed during the 12 years of his explorations. He gave vivid accounts of his close encounters with many poisonous snakes and of the biology of the Siamese fighting fish. Snakes frequently invaded his bedroom at night and found shelter in the sleeves of his coat. He told about the 12-foot python that lived under the

house but for more than two months could not be seen, although its presence was known by the tracks left on the sand and by the continuous disappearance of chickens.

Smith's friends throughout the world were saddened by his sudden death on September 29, 1941, from an attack of coronary thrombosis. The appraisal of Smith as a scientist and man given after his death in 1941 by L. Stejneger, Chief Curator of the National Museum, is shared by many zoologists who were privileged to know him personally. "As U. S. Commissioner of Fisheries", writes Stejneger (1941) "Dr. Smith was Baird's worthiest successor . . . . In my heart two pictures stand side by side, Spencer Fullerton Baird and Hugh McCormick Smith; higher tribute I cannot conceive!"

Extensive repairs to the buildings and renovation of equipment were necessary by 1915. This need is reported in the following excerpt from the annual Report of the Commissioner (Smith, 1917, p. 34) which states: "The Woods Hole Laboratory is the oldest station of the Bureau. Its history and its public service are closely linked with that of the Bureau and the earlier Fish Commission for which it once served as temporary quarters. After more than 30 years of usefulness the laboratory building and equipment are not in a commendable state of repair. It is desirable that suitable provision be made for its renovation."

In 1916, R. E. Coker was appointed "Assistant in charge of inquiry respecting food fishes", and later on served as temporary summer Director of the Laboratory. The effects of World War I and the impending participation of the United States in the conflict began to exert their influence on scientific activities. Various investigations at the Woods Hole Laboratory that were in progress in June 1917, were continued only during part of the year. Before the end of the fiscal year a new policy was adopted with regard to the operation of the Bureau's laboratories because "of the necessity of concentrating all efforts, as far as possible, upon the immediate increase of aquatic food supply." In the following two years, 1918 and 1919, the Laboratory was not opened for general investigations, but concentrated its effort on improvement of methods of preserving fish and on a study of nematode infestation, a question which had a direct bearing on the marketing of fish.

The laboratory was largely occupied by the Navy in 1917-18, and the investigations normally conducted at the station were discontinued or transferred to other points. In 1919, the Navy Department withdrew from the Woods Hole Laboratory and it was reopened under the directorship of P. H. Mitchell. Research activities of this year were concerned primarily with the physiology of oysters, reddening of salt fish caused by bacterial contamination. Edwin Linton was engaged in the studies of fish parasites, and F. E. Chidester carried on laboratory experiments on the behavior of fishes and their migrations.

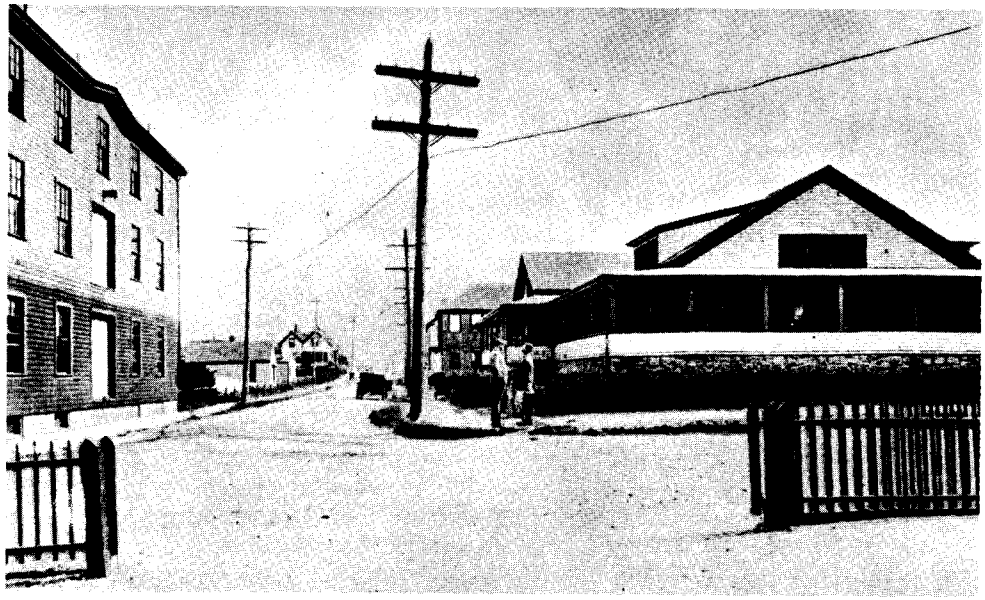

Figure 31.--Corner of Water and Albatross Streets before the fire of 1920. Old machine shop of the Bureau of Fisheries on the left, MBL mess at right corner.

In March 1920, a wooden building (fig. 31) containing the steam boiler, engineroom, and machine shop burned down. The fire spread accross the street and destroyed the dining hall of the Marine Biological Laboratory. Plans for a new brick building were made, and the contract for the construction of a fireproof structure to house the boiler, machine shop, and sea-water pump --at the cost of $51,000--was signed on January 6, 1921. The building, with equipment, was completed during the fiscal year of 1921. Because of the lack of funds for research activities, however, the laboratory was not opened.

In that year Henry O'Malley became the new Commissioner of Fisheries and appointed R. E. Coker Director of the Laboratory for the summer of 1922. Administrative responsibility of the Washington office necessitated Coker's presence at the headquarters, and he spent only the month of July at Woods Hole. The

laboratory record for the summer 1922 contains the names of 19 guest investigators working on a great variety of biological problems. Subjects of their inquiry ranged from the studies of diatoms, regeneration of sponges, fish histology, physiology of vision in lobster, parasites of fishes, and haematology of fishes, to the study of the anatomy and genetics of the fruit fly. The Bureau biologists were engaged in two research projects: hydrographic and biological survey of Long Island Sound conducted by P. S. Galtsoff (recently appointed Naturalist of the Albatross) and seasonal variations in the composition of plankton of Woods Hole waters by Charles J. Fish (instructor in embryology at Brown University and aquatic biologist of the Bureau). The Woods Hole station was used as a base for the operation of the U. S. S. Fish Hawk in Long Island Sound.

One of the guest investigators, Miss Marie Dennis Poland, began a study of the methods of identifying fish eggs and larvae. In 1923 she continued the work as field assistant of the Bureau. And in 1924, while still working with Charles J. Fish on the identification of larval fishes found in plankton, joined him in matrimony. The team of Charles and Marie Fish became well known to the biological community of Woods Hole as a couple deeply devoted to marine research. The paper describing the seasonal distribution of plankton of Woods Hole region (Fish, 1925), summarizes the observations made from samples collected throughout the years by the simple device of suspending a large plankton net from the corner of the wharf where the tides kept it in a horizontal position for several hours.

R. E. Coker resigned his Bureau position in 1923 to become Professor of Zoology in the University of North Carolina at Chapel Hill. He continued, however, as a summer Director of the Laboratory from June 22 to September 8. Among the temporary appointees of the Bureau were Charles B. Wilson, working on the collection of copepods of Chesapeake Bay; Paul Visscher of Johns Hopkins University, studying the nature and extent of ship's fouling with special reference to biological aspects (Visscher, 1928); James I. Penney, working on the biology of the wood destroying crustacean Limnoria. The scope of research, as in previous years, covered a very wide range of problems; from the diatom flora of Woods Hole, by Paul S. Conger of the Carnegie Institution in Washington, to structural development of oral glands of snakes by Albert M. Reese, Professor of Zoology of West Virginia University. A considerable part of the Laboratory space on the second floor was occupied by N. A. Cobb, nematologist of the Department of Agriculture in Washington, and his assistants.

The laboratory and living accommodations of the Woods Hole Station were used to their full capacity in 1923. Every working table and every room in the residence were occupied. It was a policy of the Bureau of Fisheries to encourage biological research

at the Laboratory, not only by offering laboratory tables free of charge, but also in providing living accommodations for guest investigators that were not needed by the government employees. Because of the increasing scarcity of housing facilities in the village, the privilege of having a room in the residence was highly attractive and the number of summer applicants always exceeded the space available in the laboratory and in the residence. It was a difficult duty for the Director to assign the residence rooms. Some of them being large and facing the sea were eagerly sought for, while others--small and facing the street were much less desirable. Somehow the Director was able to distribute the guest investigators in accordance with their scientific status and age. Dissatisfaction and hard feeling were avoided, since the task was performed skillfully and with great tact. As I remember, there was a remarkable spirit of cooperation and friendship among the biologists gathered for a summer session. A great deal of that attitude originated from the summer Director of the Laboratory who, with his family, usually occupied an apartment on the second floor of the residence and used the three large living rooms on the first floor for social gatherings, scientific meetings, and card or chess games enjoyed by the staff and their guests. Meals were taken at the MBL dining hall across the street, where the Fisheries investigators enjoyed the same privileges as those the MBL offered to its research scientists and students. Relationships between the two institutions were friendly, and the spirit of cooperation prevailed in the entire scientific community.

The MBL meals were inexpensive, $7.00 a week in the 1920's, and adequate. They were served three times a day, according to a timetable which was strictly observed. It was a serious matter to be late for breakfast, since the village had no restaurants or lunch counters. The doors were promptly closed, and late comers were not admitted. The arrangement was necessary because many of the waiters and waitresses were students of the MBL courses and could not be late for their classes. Meals were served in a family style, each person occupying his assigned place at a table set for 12. Seating arrangements were the responsibility of Miss Isobelle Downing, affectionately known to everybody as Miss Belle, who for several decades supervised the messhall, directed the serving, and maintained strict discipline. The allocation to different tables required tact and a remarkable memory which helped Miss Belle to arrange her customers in congenial groups. The MBL messhall was an important social factor in the life of Woods Hole, since there was no other place where the people could meet and chat. By 7:00 p.m., when the doors were closed and only a few persons remained inside finishing their dinner, several groups were formed on the porch to spend about an hour in conversation and relaxation.

The working day at the Fisheries Laboratory usually started with a collecting trip to fish traps, or for dredging or taking plankton samples. The small coal-burning steamer Phalarope (fig. 27), under the command of Capt. R. N. Veeder, was used for this purpose. Fisheries biologists and MBL investigators interested in making a trip were welcome. A group desiring to get aboard usually gathered by 9:00 a.m. at the Fisheries dock. Many persons wanted to watch the dredging or seining and were not concerned with obtaining the material. Robert A. Goffin, collector for the Fisheries Laboratory, and two fish culturists formed the collecting crew.

With the exception of long trips, which sometimes lasted the whole day, the Phalarope would return about noontime; early enough for the participants to change and be ready for their luncheon, which was served by the MBL messhall sharply at 1:30 p.m. The collecting trip became so popular, especially when the weather was good, that the number of passengers on board had to be restricted to conform to safety regulations enforced by the Coast Guard. If something exciting happened during the trip, for instance the catch of a big shark or large moonfish, everybody would dash to one side of the vessel and cause a dangerous list. In later years, Capt. Veeder refused to take more than 20 persons aboard.

In addition to the material needed for research at the Fisheries and collected by the scientists themselves or under their supervision, the Phalarope brought live fishes for the aquarium, which was open to the public every day of the week. The aquarium was operated by the Superintendent of the Station with the assistance of R. A. Goffin.

Among the most spectacular persons occupying laboratory space during this period was Nathan Augustus Cobb (fig. 32), acting Assistant Chief of the Bureau of Plant Nutrition of the Department of Agriculture and later principal nematologist of the Bureau. His outstanding contributions to the taxonomy, anatomy, and microscopic structure of nematodes made him known to a wide circle of scientists in the world. From 1924 to the last year of his life in 1932, he worked every summer at Woods Hole, spending long hours at the microscope and often quitting only late at night. He is remembered by his friends and acquaintances as a tall, slender man with thick moustaches, always clad in a khaki laboratory coat. His scientific interests centered around the nematodes, a group of animals which he probably knew better than any other nematologist of his time. To those in the Laboratory who were interested in his work, he revealed his ideas of the tremendous importance of this group of worms. The highly specialized nature of his work did not narrow his point of view as a scientist but permitted him to use nematodes for attacking major biological problems such as heredity, phylogeny, adaptation,

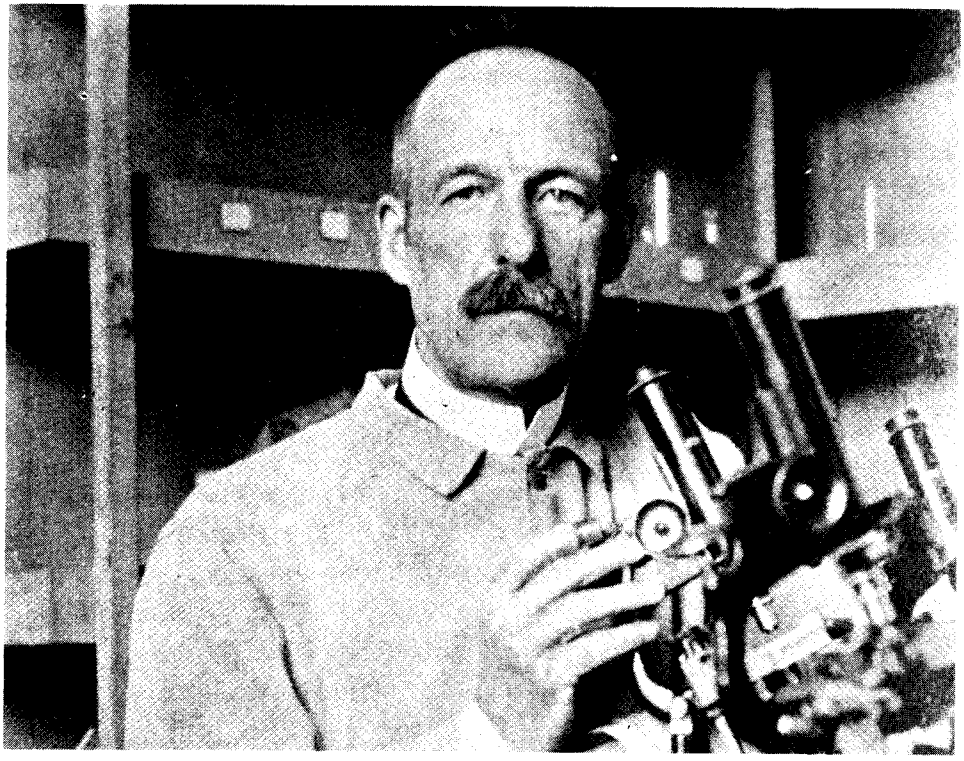

Figure 32.--N. A. Cobb, nematologist of the U.S. Department of Agriculture and summer investigator at Woods Hole Laboratory.

and parasitism. A scientific discussion with Cobb revealed his broad philosophical approach to science. Nemas to him were not the goal but only the means and tools for seeking solutions to broad scientific problems.

Every summer toward the end of June the arrival of Cobb at Woods Hole was preceded by the appearance of two men from the Department of Agriculture, one of them a carpenter, the other a mechanic. Their duty was to set up equipment consisting of specially constructed rotating tables divided into several sectors for microscopes with lamps, and open compartments for notebooks and pencils. An elaborate system of black curtains having certain parts that opened and closed by pulling a rope, placed within easy reach of the microscopist, was set in a corner of the room. This section of the room was reinforced with paired steel girders driven through the first floor and foundation of the laboratory and into the ground. Vibrations of the building caused

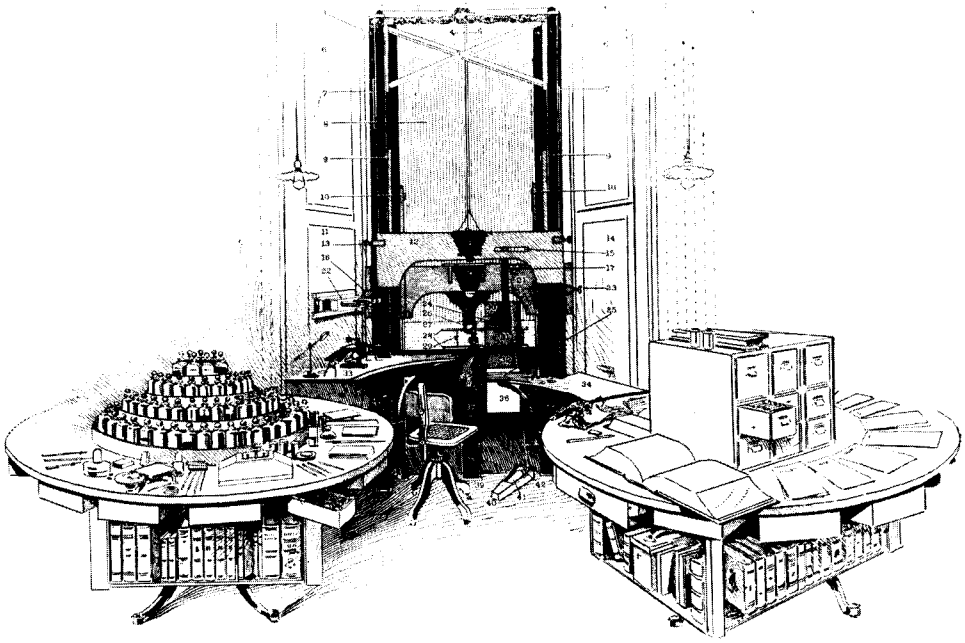

Figure 33.--Sketch of Cobb's equipment for microscopic work on nematodes at Woods Hole.

by passing automobiles were completely eliminated by this arrangement. The columns supported a heavy board for the microscope and camera lucida. One of the unique features of the equipment was a specially designed head rest, molded individually to support the head in a fixed position while making camera lucida drawings. Cobb's equipment, assembled every summer in the Fisheries Laboratory, looked exactly like that shown in the drawing that accompanied the publication (fig. 33) describing this technique (Cobb, 1916). By the time the complex installation was finished, Cobb appeared, accompanied by his assistants (junior nematologists) Edna M. Buhrer, Charlotte E. Sprennel, Josephine F. Danforth and others. Since no living accommodations were available for girls in the government quarters, the charming ladies rented rooms in the village but participated in the social gatherings which were held about once a week at the residence.

Cobb's laboratory work was extraordinarily well organized, and various operations were divided among his assistants. He developed special techniques for examining live or unstained material, and for making whole mounts of worms made transparent by glycerin or other media. One of the assistants was busy in making such preparations and placing them on stages of the microscopes set on the round table. When this was done, Cobb began examining them one after another and pushing the table around. The notes referring to each slide were placed in a compartment under each microscope. They were immediately collected by one of the girls, typed, and placed in the same order on another round table. Cobb developed great skill in the use of camera lucida for illustrating the minute details of structure, which are usually destroyed by ordinary reagents. The artist assisting him worked on drawings which later appeared in his papers. One of these illustrations attracted attention of all the members of the Laboratory. It was an anatomical drawing of a free-living marine nematode, Metoncholaimus pristiurus, common in the muddy bottom of Woods Hole harbor a little below low tide level. This nema is particularly suitable for use in laboratory courses in zoology because it can be examined alive or in temporary mounts in lactophenol and five percent potassium hydrate. The original drawing consisted of a number of sheets, each about two feet long. By the end of the summer they were all pasted together making a composite more than 12 feet long in which structural details of highly complex systems of organs were depicted in various colors. The black and white reproduction of this illustration can be found in the Journal of the Washington Academy of Sciences (Cobb, 1932). It is hoped that the original masterpiece has not been lost. The anatomical description of this nema, accompanied by drawings, is used at the summer course of Invertebrate zoology given by the MBL, and several bound copies of this paper are kept in the library as an aid to the students.

Daily contact with this remarkable man showed other facets of his personality--unshaken dignity, frankness combined with courtesy, and a keen sense of humor. He frequently composed delightful verses which, to the extreme joy of his audience, he read at the end of his scientific addresses.

In 1924 and 1925, Willis H. Rich, in charge of the Division of Inquiry, was the summer Director. He remained at Woods Hole for the entire summer season, from June 22 to September 12. Among the new persons who availed themselves of the use of the Fisheries Laboratory were F. G. Hall of Milton College, Wisc., who, with his collaborators Samuel Lepkofsky and I. E. Gray, started a long-continued program of studies of fish respiration. Gray's work was primarily concerned with the chemical composition of fish blood. Baldwin Lucke, Professor of Pathology, School of Medicine of the University of

Pennsylvania, an outstanding student of fish tumours, worked on the mechanism of vital staining and cellular degeneration.

Investigations for the Bureau of Fisheries were carried on by P. S. Galtsoff, who studied the effect of external factors on survival of oyster larvae and continued to work with the assistance of Eugenia Galtsoff on regeneration and dedifferentiaton in sponges. The work on oyster larvae was the result of observations made during the survey of Long Island, which showed that industrial pollution may be a factor in the failure of setting of oysters in the waters along the northwestern shores of the Sound. Dr. and Mrs. Charles J. Fish remained in residence the year around and continued their studies of seasonal distribution of plankton and the identification of young fishes. During the month of July (1925), O. E. Sette, Assistant in charge of Fishery Industries of the Bureau of Fisheries, carried on laboratory and field investigations of mackerel. Francis Staff, Director of Fisheries in Warsaw, Poland, visited the Laboratory and spent 10 days acquainting himself with American fishes and methods of fishing.

In the summer of 1926, the position of the Director of the Laboratory was occupied by J. O. Snyder, Professor of the Department of Zoology of Stanford University. Research on mackerel was conducted by Sette; C. J. Fish started a study of the life history of young cod fish. Galtsoff, with the assistance of Henry Federighi and H. Richard Seiwell, initiated experimental studies on the physiology of oyster feeding. They gave special attention to the effect of temperature on the ciliary motion of the gill epithelium (Galtsoff, 1928) and made observations on oyster culture in Wellfleet Harbor, Mass. Laboratory facilities were again made available to Cobb, Wilson and Linton for their respective work. W. C. Schroeder, aquatic biologist of the Bureau, stationed at the Museum of Comparative Zoology in Cambridge, worked on the life histories of the Gadidae and migrations of the cod (Schroeder, 1930).

In 1927-28, the newly appointed Assistant in charge of the Division of Scientific Inquiry, Elmer Higgins, served as Director of the Laboratory. He worked on the material previously collected by him on the life histories of shore fishes of the South Atlantic states. The new fishery project initiated in this period was the study of life histories of Sciaenidae, by John C. Pearson. The mackerel investigation by Sette was conducted with the assistance of Edward W. Bailey, Lee G. Kendall, Samuel L. Leonard, James A. Halstead, and Elizabeth Deichmann of Radcliffe College.

Oyster research under Galtsoff was expanded in 1927 to include observations on the effect of free chlorine on water propulsion, and on sensory stimulation by chemicals. The latter part was conducted by A. E. Hopkins, who continued this work through the winter. Oyster cultural investigation

in the field was carried on by Earle B. Perkins.

Studies of oyster physiology conducted in 1928 were concerned primarily with the metabolism of normal and green colored oysters. Dorothy V. Whipple of Johns Hopkins Medical School and H. B. Pease, student at Harvard University, assisted Galtsoff with the laboratory work.

Numerous repairs and improvements were made during the season. A new laboratory room for biochemistry was equipped on the third floor of the building; an oceanographical laboratory was refinished and the storeroom entirely rebuilt and re-equipped. All these alterations materially increased the usefulness and efficiency of the Laboratory.

The summer season of 1928 was marked by a series of special lectures given in the living room of the residence and attended by a large and appreciative audience of Woods Hole biologists. The lectures were by Galtsoff on "The Chemistry of the Sea"; F. G. Hall on "Respiration of Fishes"; A. G. Huntsman, Director of the Atlantic Biological Station at St. Andrews, New Brunswick, on "Limiting Factors in the Sea"; and H. B. Bigelow on "Oceanography and Fisheries." This very successful season ended with the Annual Convention of the National Association of Fishery Commissioners, held on September 7 and 8. The sessions were attended by 75 persons from various Atlantic states. Hon. Charles W. Gifford, congressman of the Cape Cod district and a good friend of the Laboratory, addressed the opening session. Exhibits arranged for the occasion by the Laboratory comprised 29 different items showing the method of studying the physiology of feeding and reproduction of the oyster; oyster culture; anatomy of the oyster; and depredation caused by oyster drills.

In the years between 1912 and 1928, a great deal of research in oceanic fisheries was conducted for the Bureau of Fisheries by Henry B. Bigelow of Harvard University (fig. 34). Although not employed by the Bureau, he was a frequent visitor to the Fisheries Station and exerted a great deal of influence on the type of research conducted by the Bureau. To the members of the Laboratory he was known as a witty person and devoted scientist, determined to conduct observations in the open ocean in spite of the great personal discomfort of working on small vessels in bad winter storms. He was a pioneer explorer of physical oceanography, plankton, and fishes of the Gulf of Maine. The results of his explorations published by the Bureau (Bigelow, 1926, 1927, 1931) and fundamental work on fishes of the Gulf of Maine made jointly with Schroeder (Bigelow and Schroeder, 1953) remain a source of most valuable information. From 1931 to 1940 he was the first Director of the Woods Hole Oceanographic Institution (WHOI).

Figure 34.--Henry B. Bigelow, Professor at Harvard University on the deck of the U. S. S. Grampus during the explorations in the Gulf of Maine (1912-14) conducted for the Bureau of Fisheries.

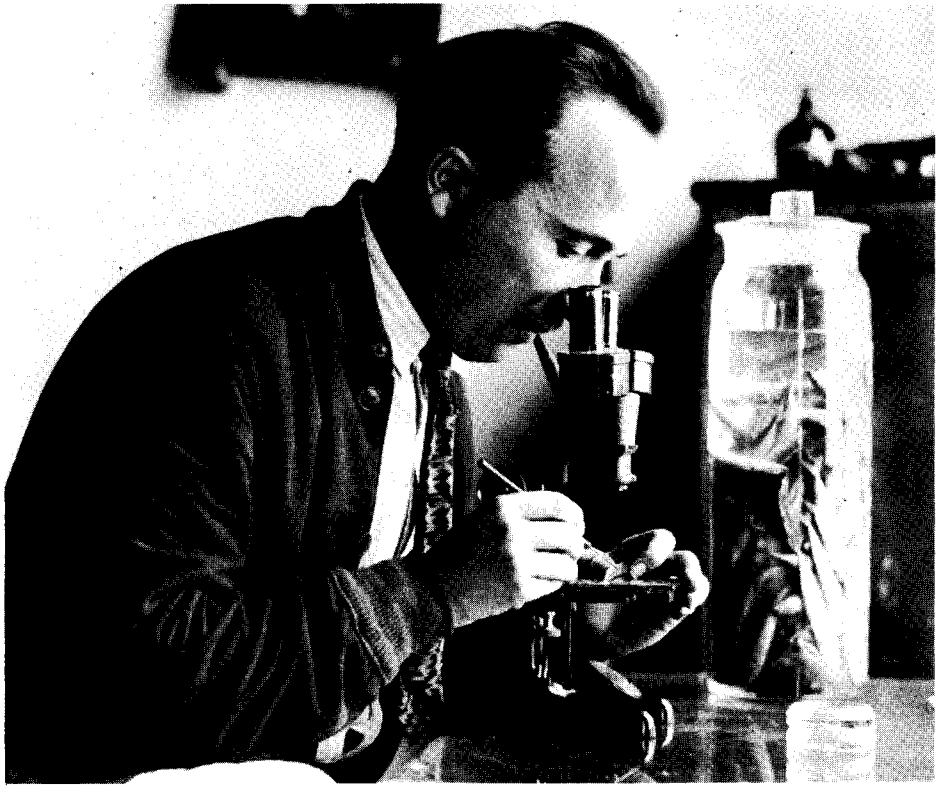

Figure 35.--O. E. Sette, Director of the Laboratory in 1929, examining larval mackerel.

In 1929, Sette (fig. 35), in charge of the North Atlantic Fishery Investigations, became Director of the Laboratory and served in this capacity until 1931. His laboratory studies on young mackerel and experimental tagging and schooling of mackerel comprised a part of a comprehensive investigation which later on was summarized in two large papers (Sette, 1943, 1950). The permanent office of the North Atlantic Fisheries Investigation was located at Cambridge, Mass. and Woods Hole was used as temporary headquarters for the mackerel investigations, which Sette conducted with the assistance of E. W. Bailey and George L. Clarke.

Studies on the physiology of oyster and oyster culture by Galtsoff and experiments on respiration in fishes by Hall and his group were continued. As usual, Cobb with a large staff occupied part of the laboratory, and Paul S. Conger pursued taxonomic studies of local diatoms. The laboratory

accommodations were extended gratis to several independent investigators not connected with the government institutions: A. J. Dalton--development of pelagic fish eggs; K. W. Foster --adaptation of Fundulus to a blue background; R. Macdonald, Mary Sears, and Alice Beale--coastal plankton; W. E. Bullington --spiral movements of the ciliate Frontonia; E. Linton--parasites of fishes; J. C. Hemmeter--histology of pancreas in Lophius; and C. E. Cummings with two assistants used the Laboratory for making wax models of local fishes.

In 1931, an unusually large number of fishery biologists of the Bureau were detailed for summer work at the Station. Among them were R. O. Smith (oyster investigation); Louella E. Cable (larval fishes); William C. Herrington (haddock investigation); L. Worley, Ernestine Jaffe, and H. J. Kumin (mackerel investigation under Sette). A. E. Parr, curator of Bingham Oceanographic collection of Yale University, spent several days gathering material for studies of the biology of young fish.

In the summer of 1931 the Woods Hole Oceanographic Institution, a new research organization, sponsored by the National Academy of Sciences, began its worldwide exploration of the sea.

The Act of Incorporation and the recommendation of the Committee on Oceanography of the Academy of Sciences state the following purposes of the institution: "Research and instruction in all branches of oceanography and allied subjects; coordination of the activities of governmental and private organizations in oceanography; and providing facilities for visiting investigators." From the very beginning there was close cooperation between the new organization and the Bureau of Fisheries, and many research projects were carried out jointly.

A steady decrease in the research activities of the Fisheries Laboratory began in 1932 and continued for many years. The Laboratory still served the needs of the Bureau's investigators, but lack of funds prevented the extension of its facilities to guest investigators. The long-established policy of the Bureau in supporting basic research in marine sciences established by Baird began to decline and no clear-cut policy with regard to the use of the station was formulated. As a result of the new attitude toward the oldest marine station, no summer Director was appointed. The Station was used by the section of Shellfisheries, Galtsoff in charge; North Atlantic Fishery Investigations, under Sette; and Middle Atlantic Fisheries Investigation, R. A. Nesbit in charge. Since no appropriations were available for running the Laboratory as an independent unit, the current expenses were absorbed by the three investigations. The oyster investigations, conducted by Galtsoff, were concerned primarily with the effect of the time of day on oyster activity, and with the control of starfishes. Sette used the Albatross II for a study of survival of

mackerel larvae on the offshore grounds; Nesbit conducted investigation of the year-mark formation on fish scales. L. G. Worley used hatchery equipment for an experimental study of the effect of temperature on the incubation of mackerel eggs. Experiments in rearing fish larvae were conducted jointly by Cable and Galtsoff. Parr used the Bureau's vessels in a study of the abundance and growth of young scup, sea bass, and squeteague.

The Albatross II was the reconditioned ocean tug Patuxent. It was obtained from the Navy Department shortly after the Bureau of Fisheries steamer Fish Hawk was relinquished on January 30, 1926. The first Albatross was decommissioned several years before, on October 29, 1921. The Patuxent, renamed Albatross II, was a two-masted steel steamer weighing 521 gross tons; her overall length was 150 feet; and her header was 29 feet 6 inches. She had a mean draft of 12 feet 3 inches.

In the summer of 1933 the activities of the Laboratory were even more restricted than before. Galtsoff with the assistance of R. O. Smith, conducted laboratory experiments on the growth and fattening of oysters, and Sette studied various methods of marking mackerel (fig. 36). Large schools of tagged mackerel were kept under observation in the outdoor pool of the Laboratory and in the aquarium, where the injuries caused by tagging could be easily watched.

Lack of funds for the operation of the Laboratory prevented the Bureau from providing facilities for independent investigators. At the same time the deterioration of the laboratory buildings and equipment steadily progressed. At this time, large research projects conducted by the Bureau in the North Atlantic were concerned primarily with the populations of oceanic fishes. The major emphasis was devoted to the statistical aspects, such as the analysis of catches, determination of the abundance of year classes, rates of growth and mortality, and movements or migrations of fishes. Laboratory work played a minor role in these investigations and, consequently, the demand for laboratory space by the Bureau's biologists diminished.

Fish hatching was still the major year-round operation while the Laboratory, having no permanent personnel, functioned principally during the summer. The division of administrative responsibility added to the difficulty, since the hatchery operation and maintenance of all buildings and grounds at Woods Hole were the duties of the Division of Propagation and Distribution of Fishes, while the operation of the summer Laboratory was under the Division of Inquiry. As a result, the Laboratory could not develop its own program of research and acquire solidarity as a scientific research unit.

Some of the members of the Bureau of Fisheries even suggested that the Woods Hole Station be declared "surplus property". This view was strongly opposed by Galtsoff, who on many occasions

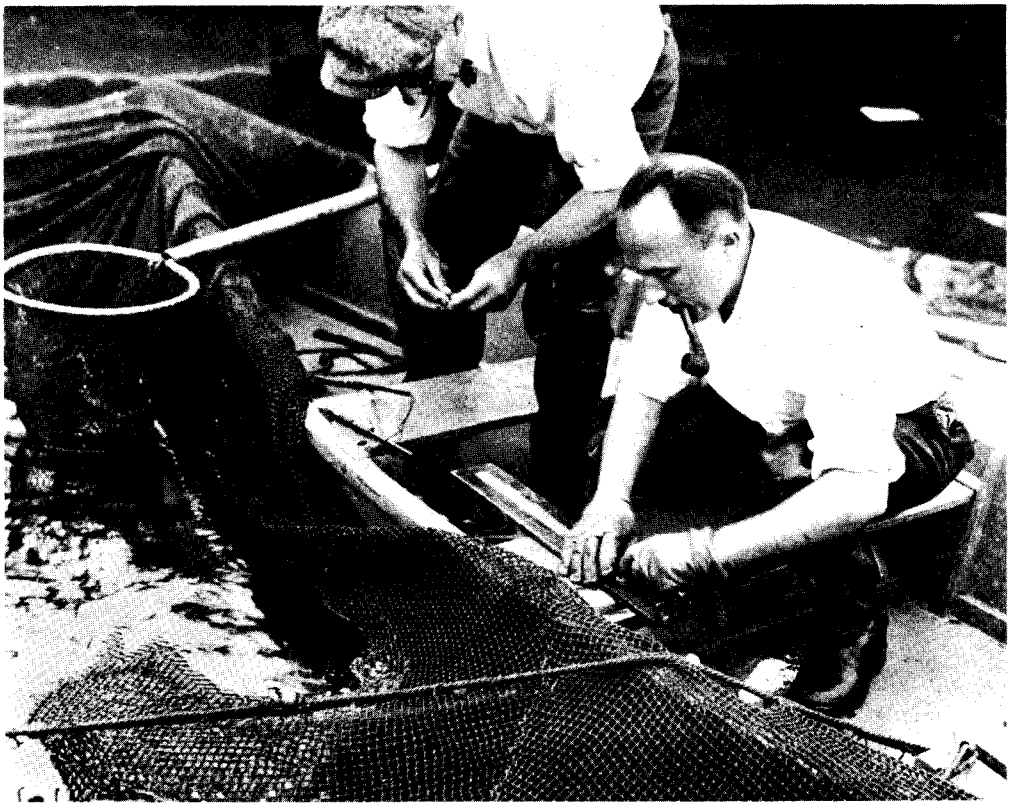

Figure 36.--O. E. Sette measures and marks small mackerel (not seen under his gloved hands) assisted by R. A. Goffin (at left). Summer of 1933.

pointed out the unique advantages of a place having sea water with uniform salinity, absence of wide daily fluctuations in temperature, safe anchorage for small boats and live-cars, and good docking facilities for sea-going vessels. The scientific climate of Woods Hole, the access to the best biological library in the country, lectures, discussions, conferences, and the presence of many outstanding scientists are conditions highly conducive to research. Futhermore, friendly cooperation with the MBL and the newly established Oceanographic Institution makes it possible, in emergencies, to borrow equipment and use the facilities of these institutions. Fortunately, the arguments were effective and the Shellfisheries Section was permitted to use the Laboratory for rapidly expanding work on oysters, but very little money was made available for repairs and rehabilitation purposes.

From 1935 to 1938 the Laboratory was without a formal Director, and administrative responsibility for the work of the Laboratory was assumed by Galtsoff. Experimental oyster investigations at this time dealt with the physiology of spawning, accumulation and storage of heavy metals in the oyster, seasonal fluctuations in the concentration of glycogen and heavy metals, oxygen consumption of oysters, and sex change. The latter study was continued for five consecutive years before its completion. In 1935-36, in connection with a special appropriation for oyster pest control, a survey was made of the distribution of starfish and drills in Buzzards Bay and Narragansett Bay. Under the supervision of Galtsoff, the survey was carried on by K. S. Rice and temporary assistants C. F. Reppun, G. Mishtowt, B. Boving, and C. D. Weber, who also assisted in the experimental study of metabolism and storage of metals in oyster tissues. Rice and Weber remained in the residence for the entire year in order to extend their observations throughout all seasons. Independent investigators were: H. M. Smith, F. G. Hall, F. H. McCutchin, J. W. Wilson, and E. Linton. In the summer of 1938 the following investigations indirectly related to fishery problems were conducted: R. Maluf--osmoregulative mechanism in crayfish; R. B. Root and H. Brown--effect of carbon dioxide on the respiratory function of blood of marine fishes; and J. M. Odiorne--behavior of melanophores of Fundulus.

The 1938 Hurricane

On September 21, 1938, the Station suffered a severe blow from a tropical hurricane and the storm wave which accompanied it. In the report to the Commissioner the damages caused by the hurricane are described by Galtsoff, acting Director, as follows: "Fisheries grounds littered with debris, boats, cars and silt present probably the most convincing picture of the ferocity of the tidal waves and wind that struck Woods Hole. The most serious destruction was done to the pier, three-quarters of which was carried away and deposited on the grounds nearby. Not only the wooden upper structures and planks were demolished, but the heavy stones forming the wall were lifted and tossed away. . . . Water filled the basements of the Laboratory and residence buildings and undermined the foundation, smashed the windows and considerably damaged materials and equipment stored there. Tile roofs of both buildings were ripped leaving several large holes, some of them about 10 feet square. . . . Fortunately the Laboratory boats and scientific equipment were not damaged". A rough estimate indicated that about $100,000 would be required to rehabilitate the Station. Such funds were not available, and in view of the uncertain future of the Station no efforts were made to request the necessary Congressional appropriation for rehabilitation. A sum of about $5,000 for the immediate and most urgent

repairs was allocated. It was sufficient to repair the roof, replace broken windows, and do other minor jobs. The seawall and wharf remained badly damaged.

In the summer season of 1940, two interesting projects were carried out at the Laboratory. Arthur Shlaifer of the New York Aquarium studied the social and respiratory behavior of young tarpon, and P. F. Scholander of the University of Oslo, Norway, jointly with L. Irving and S. W. Grinell conducted research on the respiratory adjustment to diving and asphyxia in harbor seals (Scholander, Irving, and Grinell, 1942). Half of the hatchery floor was set aside for bulky equipment, which included respirometers, electrocardiograph, and instruments for the automatic recording of pulse and respiration rates in seals. The animals were strapped to a special holder and were kept in air first, then they were automatically submerged into water. From 10 to 16 seals were kept in a fenced enclosure along the beach and boat slip. The experiments provided valuable information for understanding the physiology of diving, but the problem of maintaining and feeding a large number of seals presented many unexpected headaches to the Station personnel.

In the summer of 1941 the study on the deposition rate of shell material in oysters was undertaken by Galtsoff and Dorothy H. Algire. At the invitation of the Bureau, Chester I. Bliss conducted a seminar on statistical methods in biology and worked on the problem of standardization of toxicity experiments.

Shortly after the beginning of hostilities in December 1941, the Station was closed and the buildings were occupied by the U.S. Navy until the spring of 1944. The library, large stock of laboratory equipment, and chemicals were transferred for storage to the basement of the MBL. During the ensuing years shellfishery research, mostly dealing with the study of life history of the mud worm, Polydora ligni, and with physiology of the feeding of oysters, was conducted by Galtsoff and Edith Morrison in a laboratory room rented in the main building of the MBL.

During the war years Woods Hole presented an unfamiliar picture. The Fisheries grounds and the adjacent buildings of the MBL were surrounded by high fence, and became inaccessible to civilians. The gay crowd that used to assemble near the aquarium and around the seal pool was no longer there. Less than half of the MBL laboratory rooms were occupied. Bright-looking pleasure boats were gone, and very few fishing vessels were seen in the harbor. Even the New Bedford-Nantucket steamer lost its smart appearance under a coat of gray paint. At night everything was pitch dark and the streets were deserted.

The 1944 Hurricane

The Station was released by the Navy in 1944, and shortly after that (September 14) it was struck by a vicious hurricane. This storm did more serious damage to the buildings and grounds than those inflicted in 1938. Large sections of the roofs of the residence and Laboratory buildings were carried away; all chimneys were demolished; about 160 windows were broken in the residence. Damages caused by high water and storm waves were even greater. Sea water filled up the basement of the residence to the depth of about 7 feet, destroying the oil furnace, supplies, and equipment which were stored there. The seawall at the eastern side of the Fishery grounds was demolished and a deep gulley extended from the beach to the sidewalk, undermining the Spencer F. Baird monument. Porches, railings, and outside stairways were demolished, and the entire grounds were covered with slimy debris. At the height of the hurricane, which struck Woods Hole after darkness, the water at the southern end of the Laboratory stood about 6 feet above street level and a strong current was sweeping the grounds. All employees of the station and their families assembled in the corridor of the second floor of the residence, which was considered to be the safest place, and were strictly forbidden to go outside. Soon the chimneys began to collapse with a roaring noise, the roof was blown off, and all the windows facing the sea were smashed either by wind or by flotsam thrown by waves; it seemed that the old residence was going to collapse at any moment. Fortunately, the old, well-built structure withstood the onslaught of water and wind. Panic which threatened to develop among the children and some hysterical women, who wanted to run away from the building, was prevented and all were persuaded to remain indoors. Those of us who had previous experience knew that flying pieces of tile and strong currents running over the fishery grounds constituted the greatest danger. The next day many pieces of broken tiles were found embedded about one-half inch deep in the wooden buildings across the street, several hundred feet away from the residence. Fortunately no lives were lost and nobody sustained any injury.

The violence of the wind subsided about 5:00 a.m. and it was possible to step outside and examine the wreckage (fig. 37). For nearly a week Woods Hole was without electric power and gas. The highways were blocked by fallen trees, and the railroad tracks between Woods Hole and Falmouth had been washed away. The basement of the MBL buildings, where laboratory equipment was stored, was flooded but fortunately only the glassware placed on the floor and on the two lower shelves was under water. Optical equipment, analytical balances, and other more expensive apparatus were stored away in the cupboards and were undamaged. There

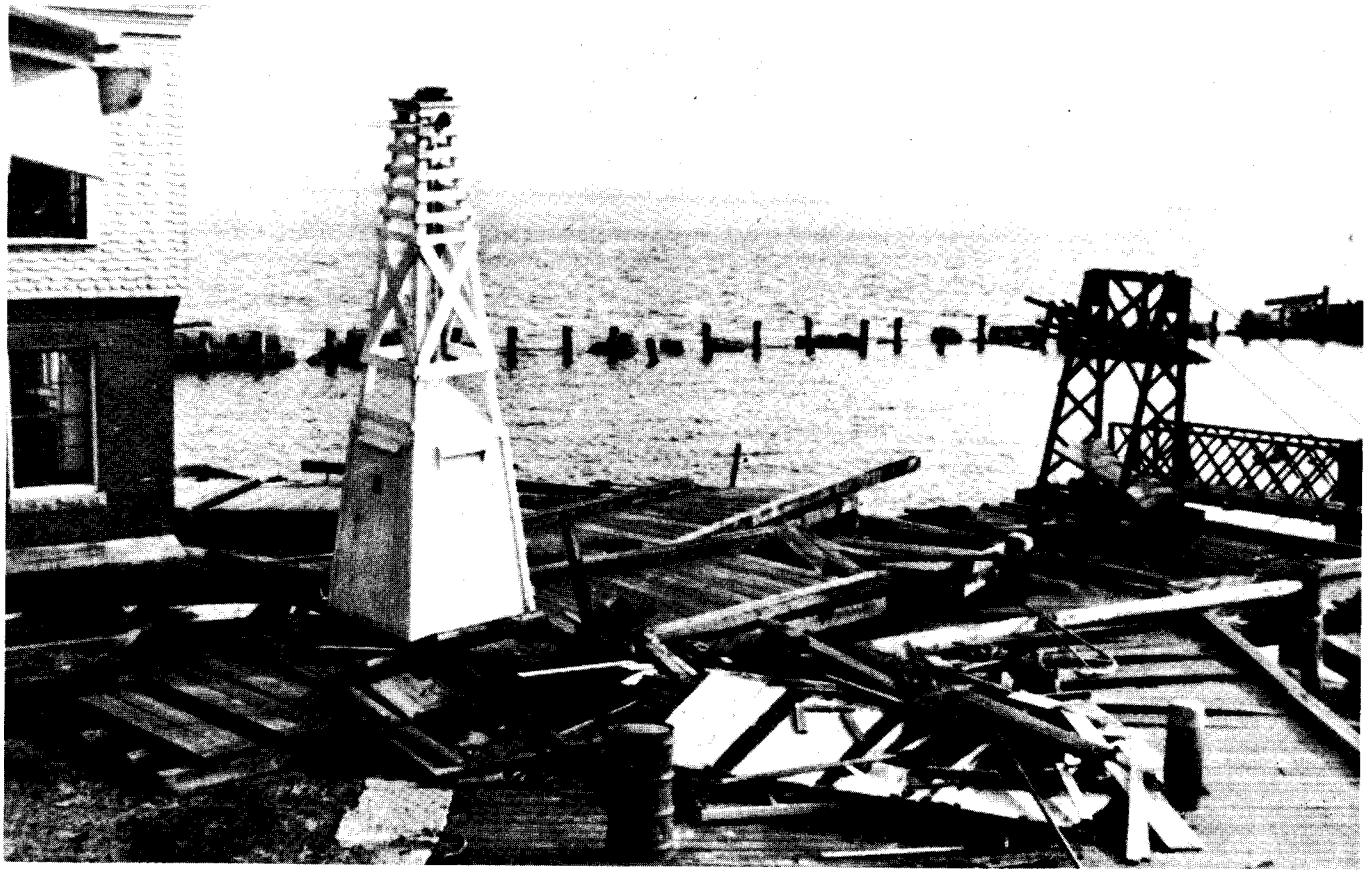

Figure 37.--The morning after the hurricane of September 14, 1944. Corner of damaged laboratory building (left), range light (white towerlike structure) washed from its base on the stone jetty which was destroyed by waves (background); remnants of swinging bridge (right).

were a multitude of problems to be solved right away. The most urgent ones were the general cleaning of the grounds, temporary patching of the destroyed portions of the roofs, and the boarding of broken windows.

Some of the alterations made by the Navy were very useful to the Station. For a long time the U. S. Coast Guard maintained a structure along the northern part of the Fishery grounds which was used as a messhall for the sailors on the Coast Guard ships, when the latter were in port. The Navy transformed this structure into a small hospital and dispensary and along side of it constructed an adjoining wooden barrack as quarters for WAVES. The barrack was not occupied, however, when the Navy returned the property to the Fish and Wildlife Service. The hospital building and WAVES quarters were rebuilt as apartments, which in the following years were occupied by the Superintendent, the Director, and the Administrative Officer of the Station To alleviate the acute shortage of housing facilities at Woods Hole, the residence building was turned over to the Woods Hole Oceanographic Institution as a dormitory for its wartime employees.

Operation of the hatchery, which was interrupted at the beginning of World War II, was now permanently discontinued. The personnel were retired or transferred, and the responsibility for maintaining the buildings and grounds was turned over to the Branch of Fishery Biology (formerly Division of Scientific Inquiry). The disaster at Woods Hole again raised the acute question of whether or not the Bureau should close the Station and dispose of the land. With the exception of the Shellfisheries Section, no other section of the Bureau at this time was interested in Woods Hole or considered that the Station was needed for their work. The great potential usefulness of the Station in connection with the rapidly increasing scope of scientific research in fishery biology and oceanography was again emphasized by Galtsoff in several memoranda submitted to the Director of the Service. Fortunately the Station had a good friend in Albert M. Day (fig. 38), who from 1945 to 1952 was Director of the Fish and Wildlife Service, U. S. Department of the Interior. The Fish and Wildlife Service was an agency formed by combining the Bureau of Fisheries and the Biological Survey. Thanks to his wisdom and foresight the Station was saved from approaching doom. Careful survey of the buildings indicated that in spite of old age and inroads of several severe storms and two hurricanes, the old structures were still sound and could be reconditioned and re-equipped at the estimated cost of about $175,000 to $200,000. The Director considered, however, that it was unwise to ask for such a large sum of money to be put in the old and inflammable buildings, and thought that eventually they should be replaced by modern structures. Small amounts of money were made available for the reconstruction of the seawall, new roofs, repairs to a portion of the Fishery dock, etc.

Figure 38.--Albert M. Day, Director of the Fish and Wildlife Service, 1945 to 1952.

A great deal of the work inside the building was made by the Superintendent and Station carpenter.

By the summer of 1947, the Station was sufficiently restored as a laboratory to be used by a small number of investigators. During that year Galtsoff, acting Director of the Laboratory, assisted by J. Griggs, made observations on the density of oyster blood under various environmental conditions, and made toxicity tests of the water and plankton associated with the blooming of Gymnodinium brevis, a microorganism which causes "red tide" along the west coast of Florida (Galtsoff, 1948). Development of the nervous system and the reactions of fishes were studied by H. C. Tracy and a group of his students, supported by a grant from the U. S. Navy. For brief periods the Laboratory space was used by two visitors from South America: Horacio Rosa, Jr., of the Division of Protection of Fishes in Sao Paulo, Brazil, and Antonio Landa, of the Guano Company in Lima, Peru. Landa was a Peruvian fishery trainee, studying the problems and methods of investigation in fishery problems in the United States. Other visitors to the Laboratory were: Jacques Monod of the Pasteur Institute, Paris, France; George Teissier, Director of the Biological Station at Roscoff; Paul Tchernia, Major General of the French Navy in charge of fishery investigations; and G. N. Mitra, Assistant Director of Fisheries, Cutack (orissa), India.

The major investigation carried on in the Laboratory in 1948 was an experimental study of the toxicity of crude oil absorbed by carbonized sand. This investigation was undertaken at the request of the U. S. Navy. The technique of using carbonized sand in combatting fire of oil spilled from naval ships was developed during the war and proved to be effective as a fire prevention measure. A heavy slick of crude oil on the water's surface can be eliminated in a few minutes by sprinkling it with carbonized sand. Granules of this specially prepared sand readily absorb oil; they form large lumps and sink to the bottom carrying with them oil globules. The experimental work conducted for the Navy by Galtsoff and Walter Chipman showed that the oil absorbed by sand remains toxic and that water soluble materials which are gradually extracted from oil affect bottom animals in varying degrees (Chipman and Galtsoff, 1949). This work lead to the development of the method of bioassay which later on was employed in the toxicity tests of all pipes and materials used for the construction of the new Fisheries Laboratory. Study of the respiration and sex change in oysters was continued by Galtsoff, and the exhibits of the Public Aquarium were prepared by him with the assistance of A. R. DeMetriff (fig. 39).

Intensified interest on the part of the New England fishing industry on the depletion of groundfish resources and renewed interest on the part of the Fish and Wildlife Service on the value of oceanographic studies on fishery resources resulted in a rebirth of the Laboratory. A new era started with the transfer of

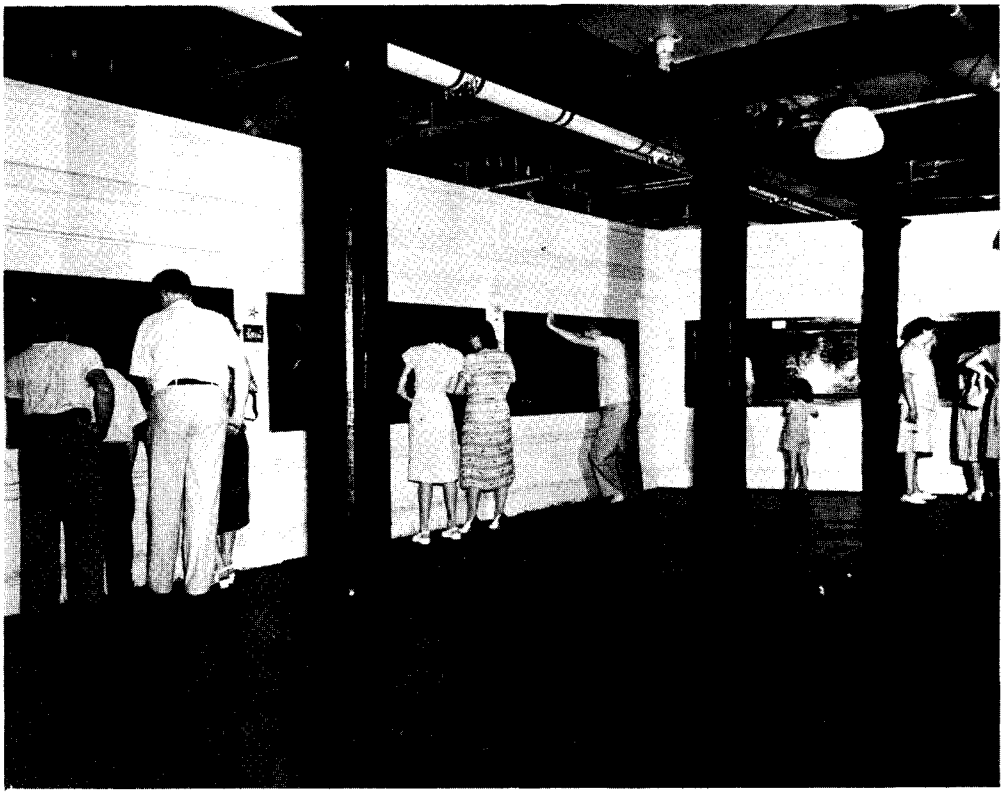

Figure 39.--Old aquarium of the Fisheries Station restored after the hurricane of 1944.

the office of the New England Banks Fishery Investigations (previously called North Atlantic Fishery Investigations) from Cambridge to Woods Hole. A new vessel, Albatross III (fig. 40), was available for the explorations of offshore fishing grounds. The vessel was commissioned at ceremonies held at Boston Fish Pier on March 19, 1948. Formerly named Harvard, she was built in 1926 as a steam trawler and before being "sold" to the Fish and Wildlife Service for $1 she was credited with catching and landing about 35 million pounds of groundfish. When World War II broke out, the Harvard was in a shipyard being converted into a research vessel. She was immediately requisitioned by the U.S. Navy for the Coast Guard, renamed Bellefonte, and returned to the Service in 1944. The Bellefonte was laid up at Woods Hole in semi-operative condition until plans were made and funds allocated to reconvert her back to a fishery research vessel under the name Albatross III. Due to insufficient funds she was operated only intermittently

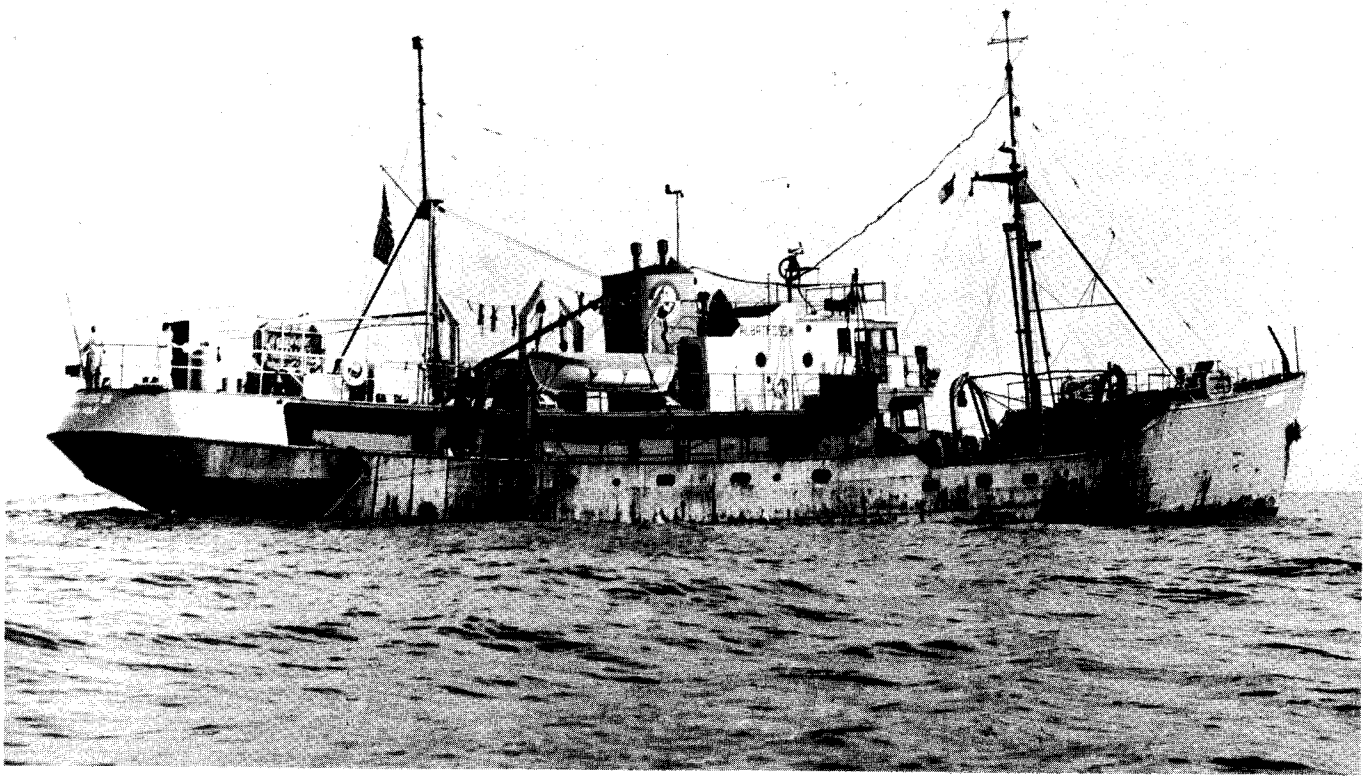

Figure 40.--Research vessel Albatross III assigned to the Woods Hole Station in 1948.

during the period 1948-54. In 1955 the Saltonstall-Kennedy funds made possible the full-time operation that lasted until 1959, when she was decommissioned. During that period of service she made 128 cruises, most of them to Georges Bank and adjacent waters. In 1951-52 the Albatross III was loaned to WHOI for trans-Atlantic hydrographic cruises.

The principal activities of the Albatross III that were started in 1948 were concerned with a census of groundfish on the New England banks. The results of these surveys provided a basis upon which prediction of abundancy are now being made to the fishing industry.

The determination of natural mortality and growth rates, essential in all population studies, formed an essential part of this research. Previous investigations conducted by the Bureau showed the necessity of protecting small haddock (two years old or less) from destruction, which during the war years reached enormous proportions. It was estimated that at least 17 million baby haddock were killed during this period and discarded on the New England banks by the otter trawl fleet using small (three-inch) mesh nets.

William F. Royce, Chief of North Atlantic Fisheries Investigations, became Director of the Laboratory in 1948. Part of the Laboratory was set aside for shellfish investigations under Galtsoff. The number of investigators working at Woods Hole year-round was materially increased. The following principal projects were carried out: effect of otter trawling on productivity of the bottom by Royce; study of the population of haddock by H. Schuck; and abundance and yield of groundfish by A. Perlmutter. Seven other investigators and fishery aids were engaged in various phases of fishery research. A small number of independent investigators used the facilities of the Laboratory: H. C. Tracy and his associates continued a study of the development of nervous system and behavior in larval and young toadfish; Dr. and Mrs. J. Lein of Syracuse University studied the clotting mechanism of lobster blood; A. Goldstein and Dora Goldstein of Harvard University Medical School investigated the cholinesterase in marine bacteria and invertebrates. Eugenia Galtsoff of George Washington University, in cooperation with P. S. Galtsoff, made experiments in transplantation of toadfish embryos (Galtsoff and Galtsoff, 1959).

In 1949 Albatross III completed 23 cruises before being laid up from January to May because of the shortage of funds. The main research project for which the ship's operations were required concerned the haddock fishery and movements of haddock on Georges and Browns Bank. The effect of the commercial catch on changes in the size and composition of the stock

of New England haddock was demonstrated by the analysis of the data accumulated in previous years (Schuck, 1949). Other investigations were concerned with the flounder fishery, census of all fish populations over the entire New England banks area, and hydrography of fishing areas.

Shellfish investigations were conducted by Galtsoff only during the summer. These studies pertained to the physiology of feeding of the oyster and with the fertilization and cleavage of oyster eggs. All cytological work was performed by Eugenia Galtsoff. The Laboratory was also used for the study of the material collected by Galtsoff during his expedition to the Gulf of Panama and Gulf of Chiriqui to determine the cause of the precipitous decline in the pearl fishery. Tissues of the pearl oyster, preserved during the expedition, were microscopically examined, and the mollusks and other invertebrates found in association with the pearl oyster were identified. Only four independent investigators used the facilities of the laboratory.

Pending the proposed transfer to Boothbay Harbor, the administrative headquarters of the Clam Investigations were located at the Woods Hole Station. Observations on the feeding of the soft-shell clam were made jointly by John Barlow and personnel at WHOI.

The headquarters of the shellfishery investigation at College Park, Md., were closed in 1950 and Galtsoff, former chief of the section, was permanently assigned to the Woods Hole Laboratory to conduct research necessary for the preparation of a comprehensive treatise on oyster biology. The Woods Hole Laboratory was also used in the preparation of a comprehensive book about the origin, waters and marine life of the Gulf of Mexico. In connection with this undertaking, a large bibliography comprising several thousand cards was prepared and is now kept in the library of the Fisheries Biological Laboratory and in the library of the MBL at Woods Hole. Additional copies were distributed among the participating institutions of the Gulf area.

III. Woods Hole Laboratory, Center for International Fisheries Research

In 1951, Herbert W. Graham replaced Royce as Chief of North Atlantic Fishery Investigations and Director of the Laboratory. This year marks the beginning of new work for the Fisheries Laboratory at Woods Hole. In addition to its function as a fishery research center for the North Atlantic area, it became the center of American research activities in relation to the International Commission for the Northwest Atlantic Fisheries (ICNAF). The International Commission originated with the convention of 11 countries in Washington, D. C., in January 1949. They entered into an agreement which was ratified on July 3, 1950, by four signatory governments, namely, Canada, Iceland, the United Kingdom, and the United States of America. At present (1962) 12 participating governments comprise the Commission.

The activities of ICNAF extend over a huge area, nearly two million square miles, of the ocean west of longitude 42° W. and north of latitude 39° N. Along the west coast of Greenland the area covers about one-half of the width of Davis Strait and extends in a northwesterly direction into Baffin Bay where it terminates at the point of latitude 78°10" N. and longitude 73°30" W. The entire area is subdivided into five subareas. In order to carry out the Commission's objectives for the investigation, protection and conservation of fisheries, a panel has been established for each subarea. The representation of governments on each panel is reviewed annually by the Commission on the basis of "current substantial exploitation in the sub-area concerned with fishes of the cod group (Gadiformes), of flat fishes (Pleuronectiformes), and of rosefish (genus Sebastes) except that each contracting government with coast line adjacent to a sub-area shall have the right of representation of the panel of sub-area" (Article IV, International Commission for the Northwest Atlantic Fisheries, Report No. 1, 1951). The United States is primarily concerned with sub-areas four and five, and has membership in panels three, four, and five. Subarea five, in which the U.S. Government conducts extensive studies on haddock and sea scallop, covers the entire area of Georges Bank. Since the organization of ICNAF, the Fisheries Biological Laboratory at Woods Hole entered into a new phase of activities as research agency for the international organization concerned with the management of oceanic food resources.

The Commission is a voluntary international organization, and no government is compelled to join or to abide by its regulations. The participating governments are honor-bound to respect the conservation measures that may be designed by the Commission, to provide the statistical data requested, and to participate in the program of research activities agreed upon at the annual meetings

of the convention. It is understood that the participating governments share substantial interest in the conservation and in maintenance of a sustained catch from these fisheries. Its success is an outstanding example of the benefits derived from international cooperation.

As the work of ICNAF was organized, additional projects were added to the program outlined during the first ICNAF meeting. Correspondingly, the staff of the Laboratory was increased. In 1952, 19 service biologists (including the Director) and laboratory or fishery aids were on the Federal payroll at the Station. By 1962 the number of biologists and aids increased to 37.

After the first meeting of ICNAF in Washington, the Canadian and American advisers met at Woods Hole in 1952 to formulate a program of research which included the study of: the quantity of small haddock destroyed at sea; mortality rates (fishing, natural and total) of fish before and after regulation; total contributions (in pounds) of year classes of groundfish species of known abundance before and after regulation; growth rates of young fish before and after regulation. It was decided also to undertake the following studies: determination of a mesh size which would permit escapement of small fish which are destroyed by small mesh nets; and preparation of regulatory measures for the consideration of the Commissioner.

The use of Albatross III made it feasible to resume the observations necessary for various research projects. Since March 3, 1953, cruises have been devoted to the collection of redfish, surveying the distribution of haddock and cod eggs and larvae, taking groundfish censuses, and conducting experiments in mesh selectivity.

Haddock research reached the stage at which it was possible to predict the relative abundance of each year class of fish with a high degree of accuracy, although the causes of the fluctuations in the abundance of fish of each year class are still unknown (Taylor, 1953). On the basis of the analysis of research data, an international mesh regulation was adopted. After it became effective in this country on June 1, 1953, the fishing for haddock on Georges Bank or in the Gulf of Maine with a net having meshes less than 4-1/2 inches (inside diameter) was illegal (Graham, 1952).

A new project concerned with the whiting fishery was initiated with the view of determining the species involved and developing the technique of age determination.

In 1950-53 the Station's chemical laboratory and part of the general laboratory on the second floor were occupied by the Public Health unit for the study of bacteriological aspects of shellfish sanitation. Also, an office was provided for the use of George A. Rounsefell, in charge of the editorial services of the Branch.

In the shellfish laboratory, studies were made of the movements of drills and conchs in search of food; and the spawning and setting of oysters in Onset and Chatham Bays. A survey of tidal waters of Cape Cod was made with reference to determining the extent of setting of oysters in the estuaries; results showed that oysters set prolifically in almost all protected bays and ponds. Because of the lack of interest and jurisdictional policies exercised by local communities over shellfish grounds, this latent oyster resource is not utilized.

During the summer of 1952, 10 independent investigators spent several weeks each in special studies of various physiological problems. The aquarium and other exhibits, prepared in cooperation with WHOI, were opened to the public during the summer months. The research vessel Albatross III was loaned to WHOI for the year.

The Laboratory continued to attract scientists from foreign countries. The list of visitors includes marine biologists from Canada, England, Scotland, Thailand, Peru, Norway, Iceland, and India. Nine independent investigators used the facilities of the Laboratory to conduct research on problems of physiology of marine organisms. Six of these received accommodations through an agreement with the MBL for the exchange of facilities of the two institutions.

On August 31, 1954, hurricane "Carol", the third since 1938, struck Woods Hole and caused extensive damages to the Fisheries grounds and buildings. Albatross III, which was moored to the dock when the hurricane struck, was fortunately saved by determined members of the Laboratory staff. The salt-water system, already deteriorated by previous hurricanes, was badly damaged again. No funds were available for a complete rehabilitation of the salt-water pipes and pumps. The aquarium was closed and not reopened until the new one was constructed a few years later.

The new project undertaken in connection with the study of oceanic fisheries was the investigation of sea scallop, supported by Saltonstall-Kennedy funds. The rapidly expanding scallop fishery reached such proportions that it is now one of the major fish industries in New England. Extensive population studies of sea scallop were instituted under the direction of J. A. Posgay.

Plankton surveys of the Gulf of Maine and Georges Bank were continued by J. Colton and R. Marak with the view of determining the drift of eggs and larvae in the area studied (Colton and Temple, 1961). These observations were supplemented by the release of drift bottles and their returns. To learn about the food habits of haddock, the contents of stomachs of 2,000 fishes taken from 41 locations were studied.

The haddock investigation was particularly concerned with determining the type of tag most suitable for marking fish and

with determining the percent escapement of each size through the net. To improve the observation technique, an underwater camera of special design was constructed and tested. Also several biologists of the Laboratory took training in sustained underwater swimming with the aqualung.

In the shellfish program, studies were made of the structure and elastic properties of shell ligament and on the rate of deposition of shell materials during different seasons. The electron microscope available at the MBL was used for these studies.

In the following years, 1955-57, the program of groundfish investigations was continued for the purpose of suggesting to ICNAF further regulations. The following research projects were conducted: mesh regulation for haddock fishery; population biology of haddock (Taylor, 1958); redfish (Kelly, et al., 1959, 1961a, 1961b), whiting, yellowtail flounder, industrial fish, and sea scallop; fisheries of Delaware Bay; and plankton ecology with reference to the abundance and dispersal of haddock eggs and larvae. Study of bottom organisms over the Georges Bank was undertaken in order to determine the relationship between the distribution of fish to the availability of the food supply. Various types of gear, such as scoops, dredges, and a ring net mounted on a sled were used to collect animals attached to, or burrowing in the bottom and those which live in water close to the bottom. Tools of research were augmented by the use of an underwater television camera, the specifications for which were drawn up by the electronics equipment specialist who was added to the Laboratory staff.

For the preparation of a treatise on oyster biology, several physiological and histological studies were made regarding the structure and function of the mantle, labial palps, and gills. On the basis of physiological and ecological investigations, a method was advanced for a quantitative evaluation of oyster bottoms. With the cooperation of the West Chatham, Mass. oystermen, an experimental study of raft culture of oysters was undertaken in Oyster Pond River near Chatham, Mass. This project demonstrated that oysters suspended from a raft may reach marketable size in 2-1/2 years instead of the usual 4 or 5 years, and that their mortality due to drills and other enemies may be reduced to a minimum. The method is particularly suitable to the inshore waters of Cape Cod which are well protected from storms and surf.

Efforts for complete rehabilitation of the Station initiated after the hurricane of 1944 by the Director of the Fish and Wildlife Service, A. M. Day, and continued by his successor John L. Farley brought results in 1955 when Congress voted $930,000 for the replacement of the old buildings with a modern laboratory and aquarium. The reconstruction of the breakwater and rebuilding

of docks had been made possible by a separate appropriation of $160,000; the Dane Construction Company of Sommerville, Mass. was awarded the contract for this work. In 1957 the Director's residence (former Coast Guard bungalow) was moved to a new site and the barrack-type frame building (former WAVES quarters) was given to the MBL and moved away. On December 27, 1957, the Government entered into a contract with Mishara Construction Company, Inc., of Brighton, Mass. for the razing of the old laboratory, residence building, and maintenance shop and for the construction of a three-story 44 feet x 190 feet masonry building. The old buildings were vacated, and the Laboratory personnel occupied temporary quarters in a private estate midway between Falmouth and Woods Hole. The shellfish investigations were conducted in a laboratory at the MBL.

Early in 1958 the old buildings were demolished. The staff of the Laboratory consisted at this time of Director, Herbert W. Graham, Assistant Director, the late Clyde C. Taylor, 21 fishery research biologists, 21 fishery aids, 6 technical assistants, and 16 persons employed in administration and maintenance. The Albatross III, with a crew of 24 officers and men, was attached to the Laboratory.

New and important changes in the research program and administrative functions of the Laboratory, which became effective since 1950, resulted from the reorganization of the Fish and Wildlife Service. As previously mentioned, under the authority of the President's Reorganization Plan III, the Bureau of Fisheries was merged with the Bureau of Biological Survey to form the Fish and Wildlife Service under the U. S. Department of the Interior. A new Fish and Wildlife Act was passed during the second session of the 84th Congress and on August 8, 1956, was approved by President Eisenhower. The "Declaration of Policy" of the Act states that "Congress hereby declares that the fish, shellfish, and wildlife resources of the Nation make a material contribution to our natural economy and food supply, as well as a material contribution to the health, recreation, and well-being of our citizens" (Sater, 1960). The law established the Bureau of Commercial Fisheries and the Bureau of Sport Fisheries and Wildlife as two independent components of the new Service. The Bureau of Commercial Fisheries under a Director (the position at present is occupied by Donald L. McKernan) consists of four divisions: Biological Research, Industrial Research, Resource Development, and Administration. At the same time the Bureau's field activities, formerly under the direct supervision of the central office in Washington, have been decentralized by establishing five regional offices, and two area offices, each headed by a Regional Director and assisted by an administrative staff. In accordance with the new plan, the Bureau of Commercial Fisheries Biological Laboratory at Woods Hole and other Bureau laboratories in the area, are under the administrative supervision of the Director of Region 3, with headquarters at Gloucester, Mass. John Gharrett

is Regional Director of Region 3 which extends over the New England area and southward including the states of New York, New Jersey, Delaware, Maryland, and Virginia.

Under the new administrative scheme, the general term "field station" applies to any field office of the Bureau other than Regional or area offices, and the term "Biological Laboratory" is used to designate a major research center engaged in biological investigations. The official full title of the Woods Hole Laboratory according to Amendment Two of Reorganization Memorandum No. 10 of November 18, 1958, is as follows: Bureau of Commercial Fisheries Biological Laboratory, Woods Hole, Massachusetts. The major activities of a laboratory are called programs each headed by a program leader. The Laboratory Director has supervision of all the functions of the Laboratory.

On March 1, 1960, when Laboratory personnel moved back to Woods Hole and occupied the new laboratory building, the staff comprised H. W. Graham, Director; Robert L. Edwards, acting Assistant Laboratory Director (now Assistant Director); and the following program leaders: Cod--J. P. Wise; Flounder--F. E. Lux; Haddock--J. R. Clark; Hake--R. L. Fritz; Industrial Fishery--R. L. Edwards; Redfish (formerly called rosefish)--G. F. Kelly; Sea Scallops--J. A. Posgay; Benthic Ecology--R. L. Wigley; Fish Behavior--R. Livingstone; Plankton Ecology--R. R. Marak; Aquarium and Experimental Studies--C. L. Wheeler; Instrumentation and Underwater Television--J. M. Crossen; Port Samples Pool (to obtain data on the commercial landing of fish)--L. H. Couture. The work on estuarine ecology conducted in the past years has been discontinued, and the activities of the Laboratory focused on oceanic fisheries and development of practical measures of management in relation to the U. S. responsibilities to ICNAF.

IV. The Aquarium

The aquarium has always been a vital part of Woods Hole as a scientific and educational center. It was organized by Baird, who strongly believed in the necessity of popularizing marine biology and explaining to the general public the aims and achievements of government research in conservation. No appropriations were made, however, for the operation of the aquarium. It was assumed that this work would be performed voluntarily and jointly by the Director and Superintendent of the Station. For many years R. A. Goffin, collector for the Laboratory and later its Superintendent until 1941, took care of the aquarium to the best of his ability and with limited funds. In arranging the aquarium material, emphasis was placed on New England food fishes and on invertebrates commonly found along the shores and used in the MBL classes and for research. The aquarium doors were open every day from 8:00 a. m. to 8:00 p. m. in order to give the MBL investigators a chance to visit the exhibits between breakfast time and the beginning of morning classes at 9:00 a. m. Another favored time was between 7:00 and 8:00 p. m. The tourists and other visitors usually came between 10:00 a. m. and 5:00 p. m. The aquarium was frequently crowded on holidays, especially when bad weather kept the tourists from the beaches. The visitors were invited to register and write their impressions. Spot checks conducted at various times of the day showed that in the morning and late afternoon hours the ratio of those who signed their names and those who disregarded the request was 1 to 10. During other hours it varied from 1 to 3 to 1 to 5. From these and other checks it was possible to estimate that the number of visitors exceeded 1,000 per day on rainy days and holidays. In 1945-50 the average number of aquarium visitors for the entire 90-day period it was open was about 250 per day.

With the organization of the School of Science for the boys and girls of the parents doing research work at Woods Hole, arrangements were made for the children to have their own tanks for keeping and watching the animals they collected in the sea. The old hatchery provided plenty of room for this purpose. By this policy many acts of juvenile delinquency were prevented since the participants of the "aquarium projects" acted as voluntary guards.

It was my practice to mingle with the crowd and learn directly their reactions to our display. It was a surprise to find out how many college instructors in biology had never seen live dogfish, squid, or other common animals. Some of them admired the graceful movements of the fish, the continuous color change of the squid, the sliding motion of starfish, and the brilliance of our common red sponge. Their previous acquaintance with these

forms of life was only through the unattractive specimens preserved in formalin and used for dissection

On many occasions the aquarium supplied the MBL classes with material for experimentation and dissection. The demonstration of electric discharges by the large electric ray was the most spectacular event carried out for several consecutive seasons on Fisheries grounds by William R. Amberson for the students of his physiology class. The ray was placed on a wide copper plate to which an electrode was attached. The second electrode was placed on the ray's dorsal side, over its electric organ. A chain was formed of 40 to 50 volunteers holding hands and two at the ends touching the poles. The fish was then disturbed, and at the discharge of an electric shock all the hands jerked up simultaneously with loud screams of the participants. The event always attracted numerous spectators.

Many curious remarks were heard and comic incidents happened around the outdoor pool. By long-established tradition, two young harbor seals were kept every summer in a large sea-water pool behind the sea wall. The lovable animals, adored by the public, spent most of their time on a small raft anchored in the pool. They became tame within a short time of their capture and came close to the wall to accept mackerel or other fish offered to them. At feeding time a large crowd would always be standing on the walls of the pool. Besides the seals, sea turtles and large sharks occasionally were placed in the pool. There was always a discussion about the dangers of sharks, their attacks on humans and questions why the seals were not afraid of them. I noticed late one afternoon, a large group of men loudly arguing some question and refreshing themselves with frequent excursions to hip-pocket flasks. To prevent possible unpleasantries I moved close to the group and heard how one rather fat and vociferous fellow proposed a bet of $5 to $25 that he would enter the water where sharks were swimming and remain there immobile for 10 minutes. The bet was accepted, and the man stripped to his bathing trunks, stepped into the water while his companions anxiously looked at their watches. When he successfully emerged from the pool and collected his bet, I quietly remarked that the large sand sharks in the pool are sluggish animals which subsist on small fish and never attack humans. Since the explanation was not appreciated by the winner, I hastily retreated to my quarters.

The seals were the darlings of Woods Hole. People loved them, and used thousands of films photographing them and asked endless questions about their habits. There were many visitors to the aquarium, including some local fishermen

who with great regularity came to see the exhibits and always commented on the condition or rarity of the specimens they saw. Who knows how many of them became naturalists and conservationists as a result of these first impressions of life in the sea?

The aquarium serves educational purposes by emphasizing to the public the value and necessity of conservation of aquatic resources. In designing the new aquarium the Bureau attempted to carry on the tradition of Spencer F. Baird. It is housed in a modern building and uses modern techniques for exhibiting fish and telling the story of conservation of marine resources. There are 16 tanks for display of local marine animals and plants, and no attempt is made to entertain the visitors with trained animals or to show exotic species. As in the past, the aquarium is open only during the summer. Shortly after Labor Day its facilities are used for experimental research.

In spite of the very modest character of the aquarium it attracted over 200,000 visitors in the summer of 1961. This tremendous interest in marine science on the part of the American public points up the need for more marine museums and aquaria in accessible places to satisfy the desire to learn about the sea. The Bureau's aquarium is designed to tell the story of marine conservation and to give to the public an idea of the research being conducted at Woods Hole. It cannot do more than this. The usefulness of the public exhibits of the Fisheries Biological Laboratory and their educational value cannot be denied.

V. Outlook for the Future

Effective management of fisheries resources of the open ocean presents a great challenge that can be met by well-planned, year-round observations conducted without interruption for a number of years. The most important scientific phase of this research is concerned with the causes of the great fluctuations in the abundance of fish stocks. For the past hundred or more years these fluctuations have greatly affected the fishing industries of this country and in Europe. Frequently the cause was attributed to one or another factor--such as overfishing, changes in ocean currents, or temperature deviations from the expected average--without actually ascertaining all the complicated interrelationships between the welfare of a fish population, environmental changes, and the effects of man's activities. The intricate picture of life in the open ocean cannot be elucidated by a single short-term observation in a restricted area. The census of fish populations should be taken from year to year together with measurements of changes that may occur in the oceanic environment, particularly in climate and weather, observing the pattern of currents, and determining the abundance of the food supply for different species. Life in the ocean does not remain stable. Contrarily, it is in a state of unstable equilibrium in which the struggle for existence gives temporary predominance to one group which in turn may be replaced by another. For an understanding of such interactions, long-continued and well-planned observations are needed.

An evaluation of the events that take place among free-living and rapidly moving marine populations cannot be made by studying a single species of commercially important fish. All species of fish compete for space and food and are directly or indirectly dependent on the abundance of zooplankton and bottom organisms which in turn are controlled by the abundance of microscopic plants and bacteria. In final analysis the entire food chain in the ocean from mineral salts, necessary for microscopic plants, to the abundance of the giants of the sea--sharks, tunas, and whales--depends on sun energy absorbed by the surface of the ocean. Therefore, it is clear that biological observations on a marine population must be based on detailed oceanographic studies. The needs and tolerances of various species for temperature, salinity, oxygen, and food must be known in order to interpret possible effects of slight changes in the environment. To this long array of particulars must be added the study of the behavior of fish, and diseases which sometimes decimate the entire population. This type of work requires the facilities of a modern laboratory and

availability of a sea-going research vessel. Continued and uninterrupted observations in the open ocean are essential for the success of this work. It is apparent that the work of such magnitude can not be carried on by a single institution. Together with a number of organizations and agencies concerned with marine sciences, the Fisheries Biological Laboratory at Woods Hole is ready to contribute its share in oceanographic research and to assume a leading role in the studies of fisheries, their conservation and utilization, the goal which was formulated 90 years ago by Baird. It is remarkable that the present day ideas of oceanic research are essentially those which the great founder of this Laboratory so eloquently expressed in his reports, in his statements to Congress, and in his remarkable instructions to the men he sent to explore the secrets of the ocean.

Let us hope that the ideals of Spencer F. Baird shall remain alive and will continue to stimulate the young generation of scientists who have now at their disposal the wonderful tools of research that could not have been imagined at the time the first marine biological station in the United States was founded.

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