PLANKTON OF THE OFFSHORE WATERS OF THE GULF OF MAINE : : : : : : : By Henry B. Bigelow

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Errata.

Page 33: Footnote 16, drift should read drifts.

Page 93: Line 11, p. 92 should read p. 96.

Page 239: Under the heading "Halithalestris croni (Kroyer)", paragraph 1, line 4, tables, p. 207 should read tables, p. 297.

Page 267: Last line before table, p. 298 should read p. 297.

Page 330: Legend for Figure 92, contour should read contours.

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PLANKTON OF THE OFFSHORE WATERS OF THE GULF OF MAINE

By HENRY B. BIGELOW

Museum of Comparative Zoology, Harvard University

With tables of copepods by C. B. Wilson, and tables of diatoms by Albert Mann

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INTRODUCTION

This memoir is the second part of the report on the oceanographic and biologic survey of the Gulf of Maine, the account of the fishes [1] forming the first.

The vessels of the bureau have carried out the following oceanographic and plankton cruises in the Gulf of Maine since 1912, when the systematic survey was begun:

Schooner *Grampus:* July to August, 1912; July to August, 1913; July to August, 1914; May to October, 1915; and July, August, and October–November, 1916.

Steamer *Albatross:* February to May, 1920.

Steamer *Halcyon:* December–January, 1920–21; March, 1921; and August, 1922.

In addition, tows were taken at intervals during the winter of 1912–13 off Gloucester and between Cape Ann and Cape Elizabeth in April and May, 1913. The *Fish Hawk* also carried out an extensive program of towing in Massachusetts Bay during the winter and spring of 1924–25, but only a few of the catches have been examined.

The locations, hydrographic data, and types of nets employed, and the depths of the hauls have been published for all the stations up to May, 1920, in the following reports:

July–August, 1912, stations 10001 to 10046, in Bigelow, 1914, p. 135.

November, 1912–May, 1913, stations 10047 to 10056, in Bigelow, 1914a, p. 416.

July–August, 1913, stations 10057 to 10061 and 10085 to 10112, in Bigelow, 1915, p. 342.

July–August, 1914, stations 10213 to 10264, in Bigelow, 1917, p. 330.

May–October, 1915, stations 10266 to 10339, in Bigelow, 1917, p. 331.

July–November, 1916, stations 10340 to 10355, 10398, and 10399 to 10404, in Bigelow, 1922, p. 176.

February–May, 1920, stations 20044 to 20129, in United States Bureau of Fisheries Document No. 897 (1921).

For ready reference the locations of all the tow-net stations for these cruises are given on the accompanying charts (figs. 1 to 6); also on figures 7 and 8, the *Halcyon* tow-net stations of the winter and spring of 1920 and 1921, and of August, 1922, the data for which have not yet been published.

As the value of any regional account of the plankton depends largely on the amount of data available, it may be of interest to add that more than 1,000 tows have been made in the Gulf of Maine region since 1912, at various depths from the surface down to the bottom, some with horizontal and others with vertical nets. In a few cases the tows were made with the horizontal closing net (Bigelow, 1913a).

The area covered in this report is the same as that covered in the report on the fishes; that is, the oceanic bight from Nantucket on the west to Cape Sable (Nova

[1] Fishes of the Gulf of Maine, by Henry B. Bigelow and William W. Welsh. Pt. I, Vol. XL, Bulletin, U. S. Bureau of Fisheries, 1924 (1925), 567 pp., 278 figs. Washington. Bureau of Fisheries Document No. 965.

Scotia) on the east. These natural boundaries are continued offshore by Nantucket Shoals on the one side and by Browns Bank on the other, which roughly demark the boreal waters of the gulf from the warmer coastal water off southern

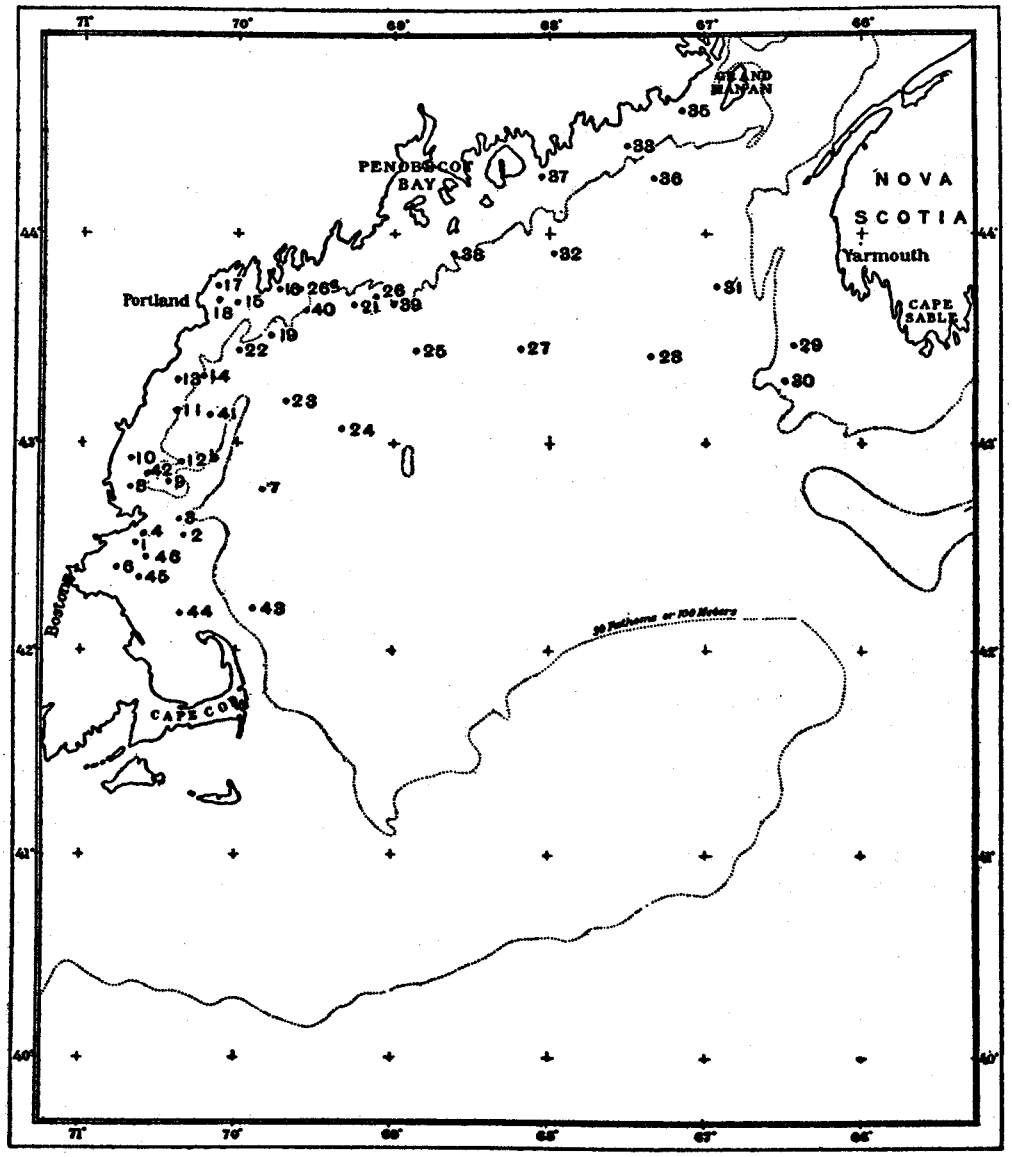

FIG. 1.—Locations from *Grampus* stations 10001 to 10046, July 9 to August 21, 1912

New England, on the one hand, and from the lower sea temperatures along southern Nova Scotia, on the other. Longitudes 65° and 70° W. have been taken as the definite limits east and west. The edge of the continent, at the 200-meter contour, is chosen as the arbitrary offshore boundary, because this zone marks the transition

from the characteristic boreal plankton of the banks water to the tropical oceanic plankton of the much warmer and more saline waters of the so-called "inner edge of the Gulf Stream." The reader will note that, as defined here, the Gulf of Maine

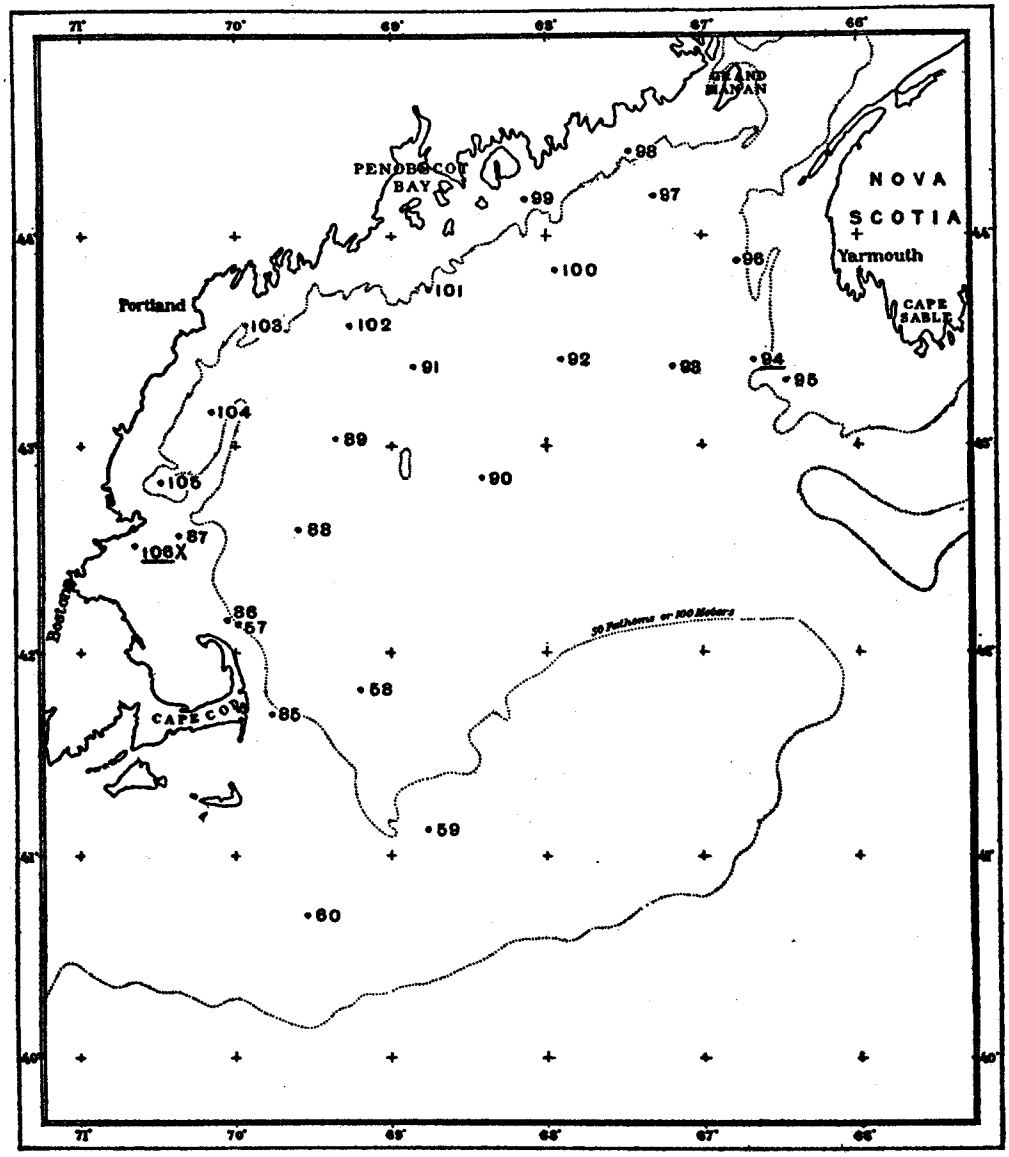

FIG. 2.—Locations of *Grampus* stations 10057 to 10060 and 10087 to 10106, July 8 to August 22, 1913, and general location of stations 10047 to 10056 and 10053 to 10056, November 20, 1912, to April 14, 1913 (X)

includes the whole of the offshore rim formed by Georges and Browns Banks and the two main deep channels—Eastern and Northern—that pierce it.

Brief notes on the plankton collected on the several cruises have already been published (Bigelow, 1914, 1914a, 1915, 1917, and 1922).

The present report gives a general account of the planktonic communities (animal and plant) of the open waters of the gulf outside the outer headlands (such as must precede the intensive survey of the plankton of any region), with such

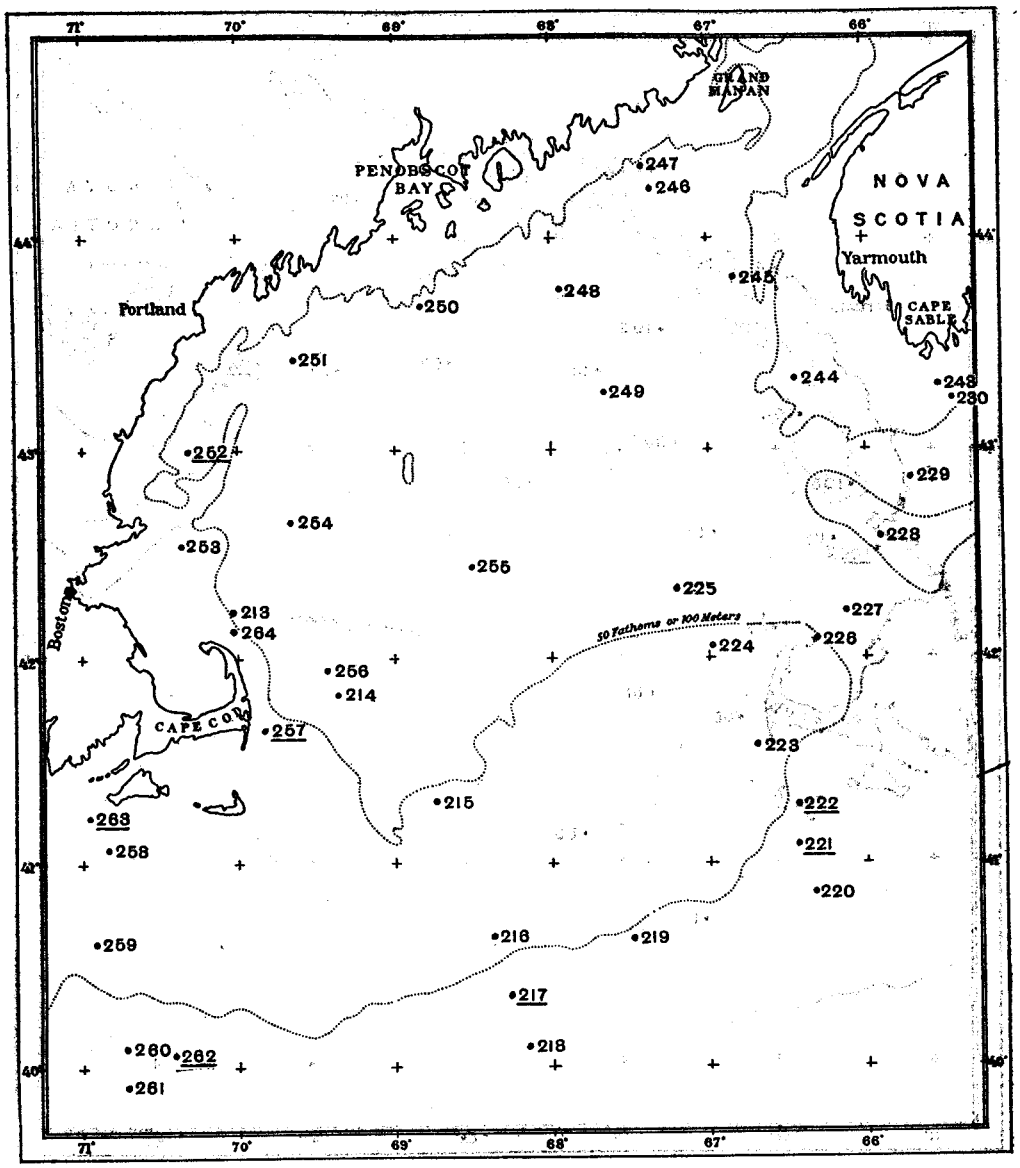

FIG. 3.—Locations of *Grampus* stations 10213 to 10263, July 19 to August 28, 1914. Stations where no tows were made are underlined

notes on the occurrence of the more important groups and species as a preliminary examination of the large amount of material collected has afforded. The plankton of the many harbors and estuarine situations around the shore line of the gulf, and within 1 to 5 miles of the land generally, is barely touched on. almost all our towing

having been done well out at sea; and when this is studied the communities will no doubt prove quite different from those of the open gulf, with neritic forms dominating instead of oceanic, and with larval forms of various parentage playing a far

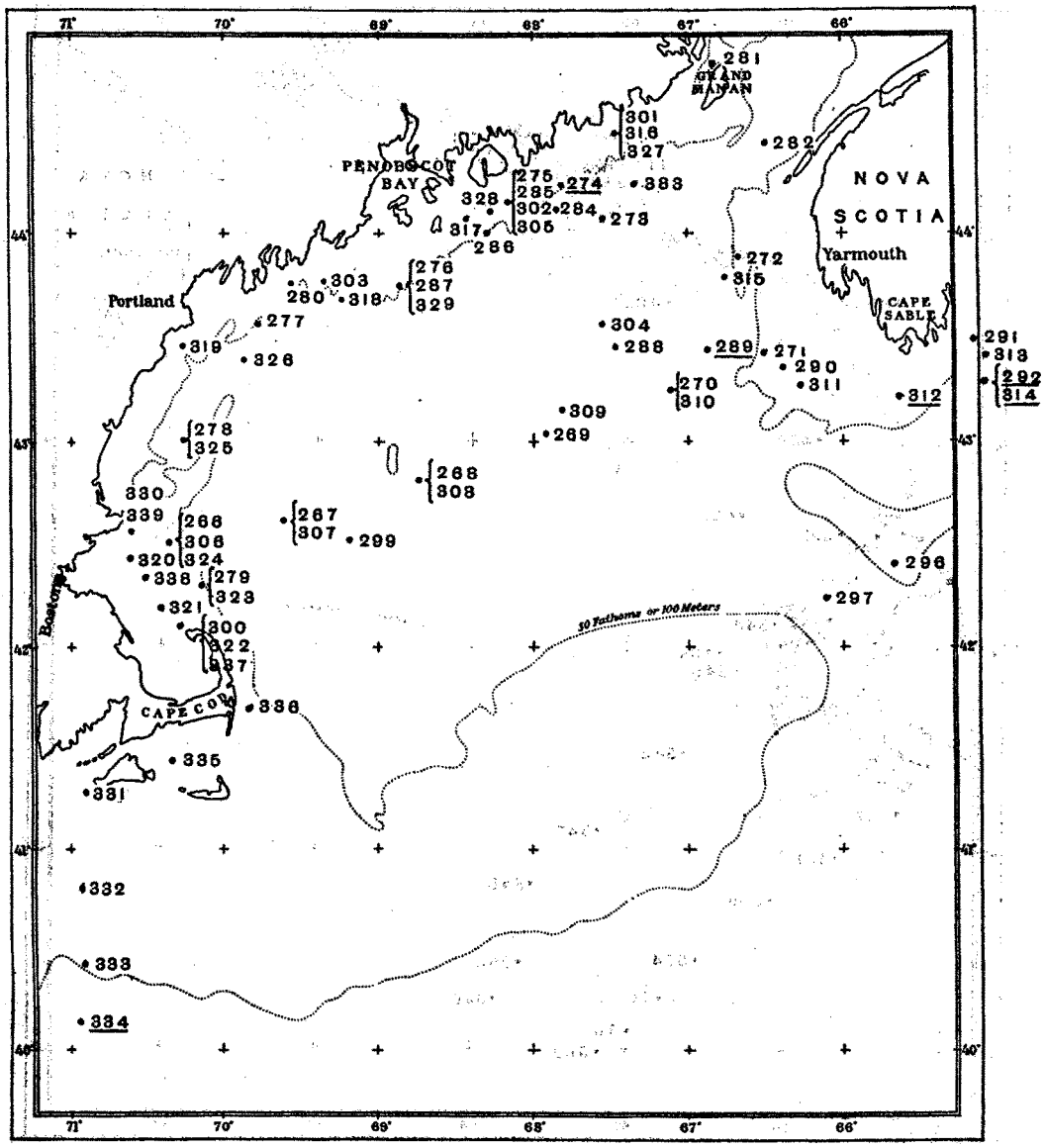

FIG. 4.—Locations of *Grampus* stations 10266 to 10339, May 4 to October 27, 1915. Stations where no tows were made are underlined

more important rôle. This is touched upon later. Fish eggs and larval fishes are not included because they have been already discussed in the first part of this volume.[2]

[2] Fishes of the Gulf of Maine (Bigelow and Welsh, 1925).

It is a pleasure to acknowledge afresh the assistance rendered by the following collaborators, who have undertaken the identification of different groups: W. F. Clapp, the pelagic mollusks of the cruises of 1912 to 1916; Dr. S. F. Clarke,

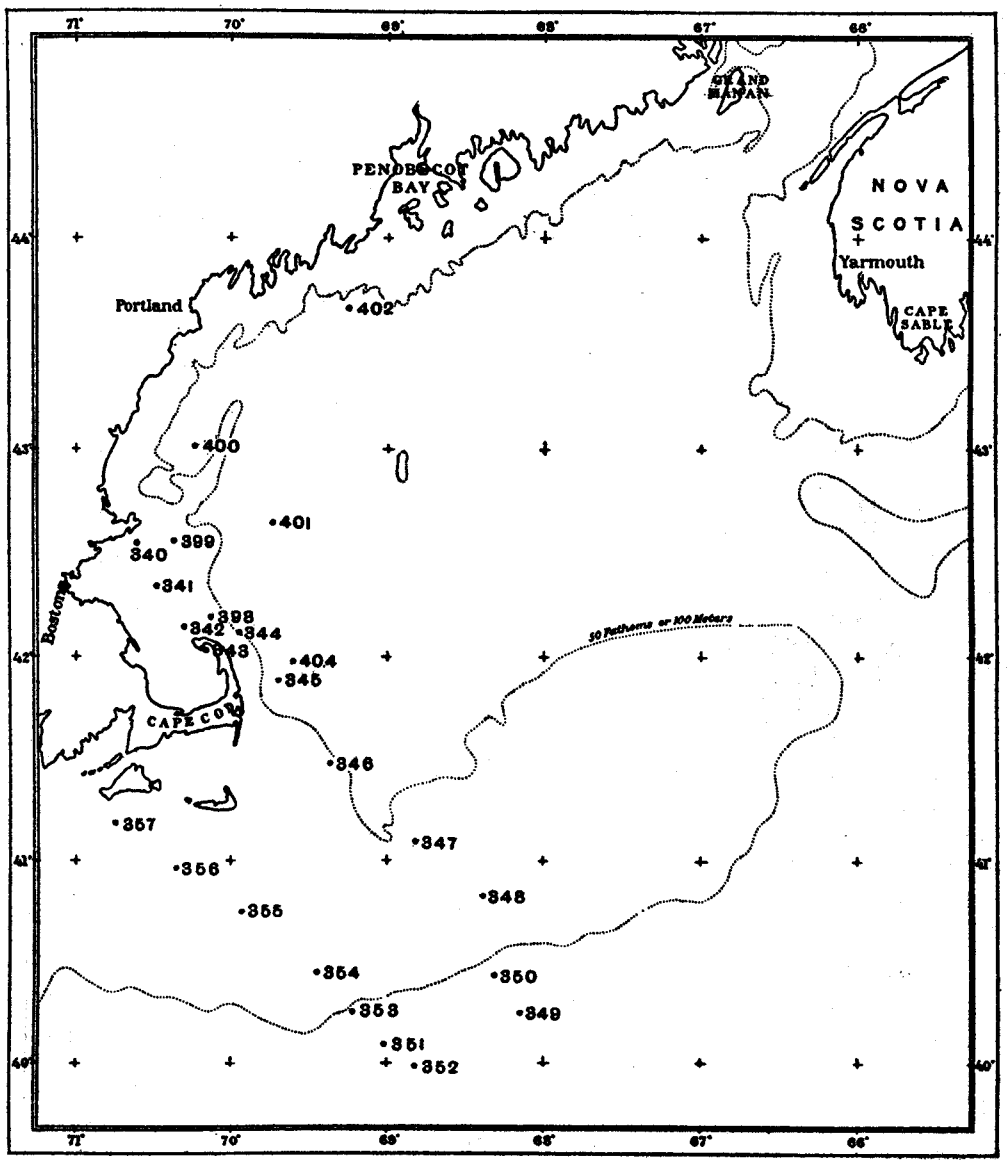

FIG. 5.—Locations of *Grampus* stations 10340 to 10357, July 19 to 26; station 10398, August 29; and stations 10399 to 10404, October 31 to November 8, 1916

floating hydroids, spring of 1913 (in Bigelow, 1914a, p. 415); Dr. C. O. Esterly, the copepods of 1912, 1913, and 1914 (in Bigelow, 1914, p. 115; 1914a, p. 409; 1915, p. 287; and 1917, p. 290); Dr. C. McLean Fraser, floating hydroids, summer of 1913 (in Bigelow, 1915, p. 306); Dr. H. J. Hansen, the euphausiids of 1912 and of

the winter of 1912–1913 (in Bigelow, 1914a, p. 411); Dr. Albert Mann, samples of diatoms at representative stations, listed below (p. 423); A. Pringle-Jameson, the Sagittæ of 1912 and 1913 (in Bigelow, 1914, p. 121; 1914a; and 1915, p. 294); Dr.

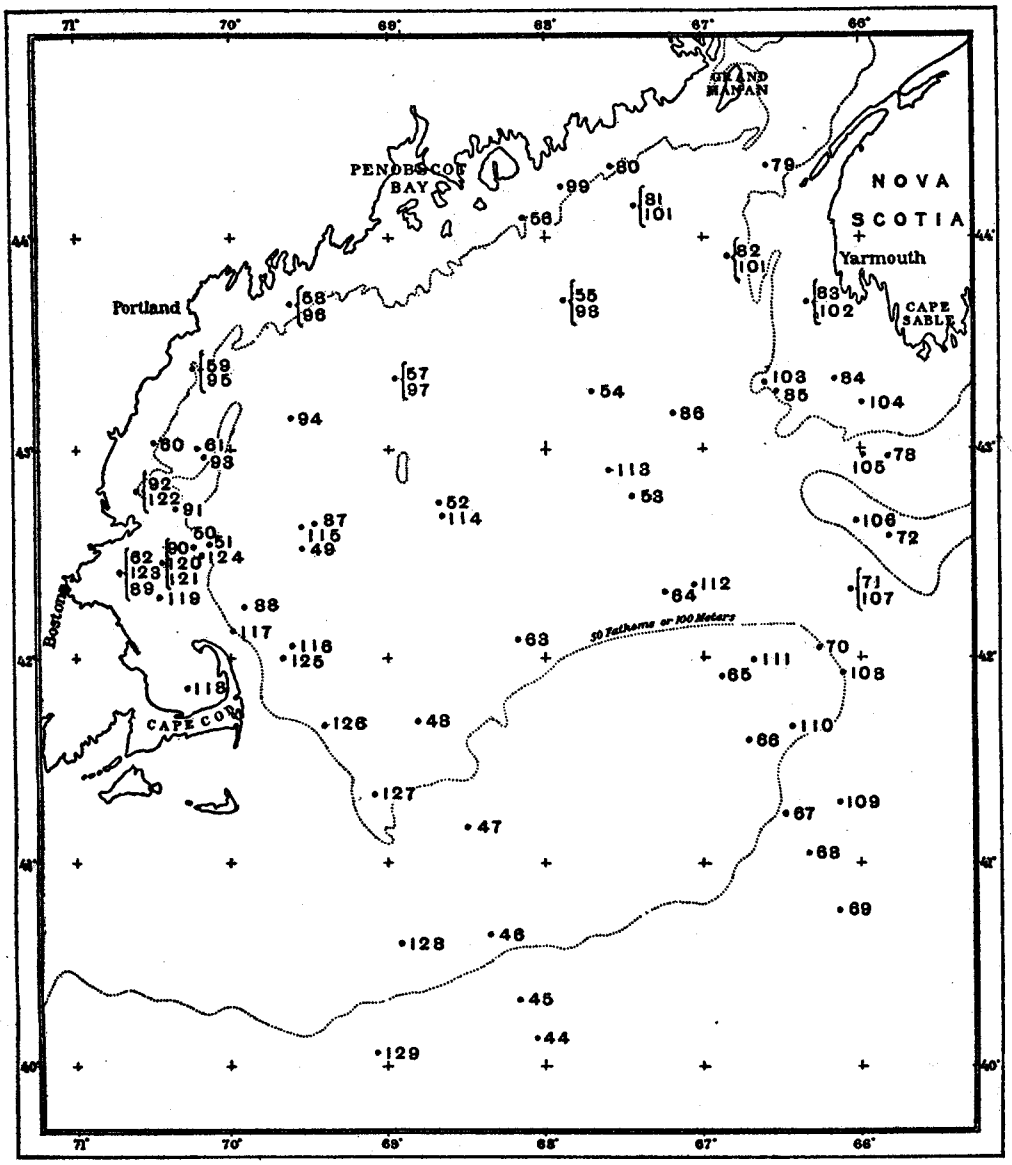

FIG. 6.—Location of *Albatross* stations 20044 to 20129, February 22 to May 17, 1920

William Tattersall, the euphausiids of 1914 (in Bigelow, 1917, p. 281); Dr. C. B. Wilson, lists of the copepods for 1915, 1920, and 1921 (p. 297). Their friendly cooperation lends authority to the following pages.

Dr. W. C. Kendall has contributed his field notes on the towings carried out from the *Grampus* in various parts of the Gulf of Maine during August and September, 1896. Dr. J. P. McMurrich has most generously allowed the use of his

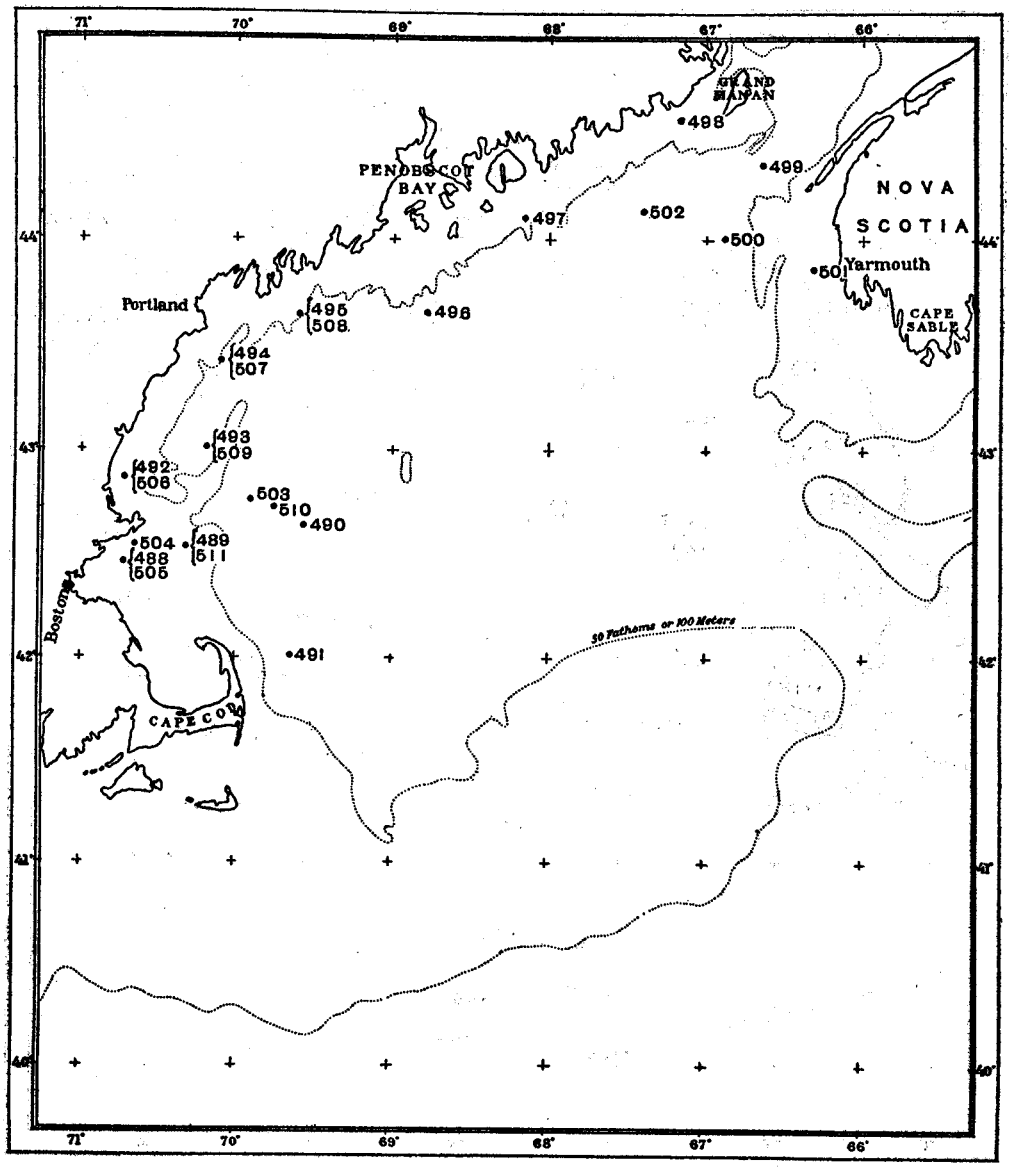

FIG. 7.—Locations of *Halcyon* stations 10488 to 10503, December 29,1920, to January 9, 1921; station 10504, February 9, 1921; and stations 10505 to 10511, March 4 and 5, 1921

unpublished lists of the plankton taken in towings at frequent intervals at St. Andrews, New Brunswick, from November, 1915, to October, 1916, data repeatedly referred to below. I also owe thanks to Dr. A. G. Huntsman, who has offered many

unpublished notes and much information on conditions in the Bay of Fundy region; to Dr. C. J. Fish, who has contributed a preliminary note on the phytoplankton

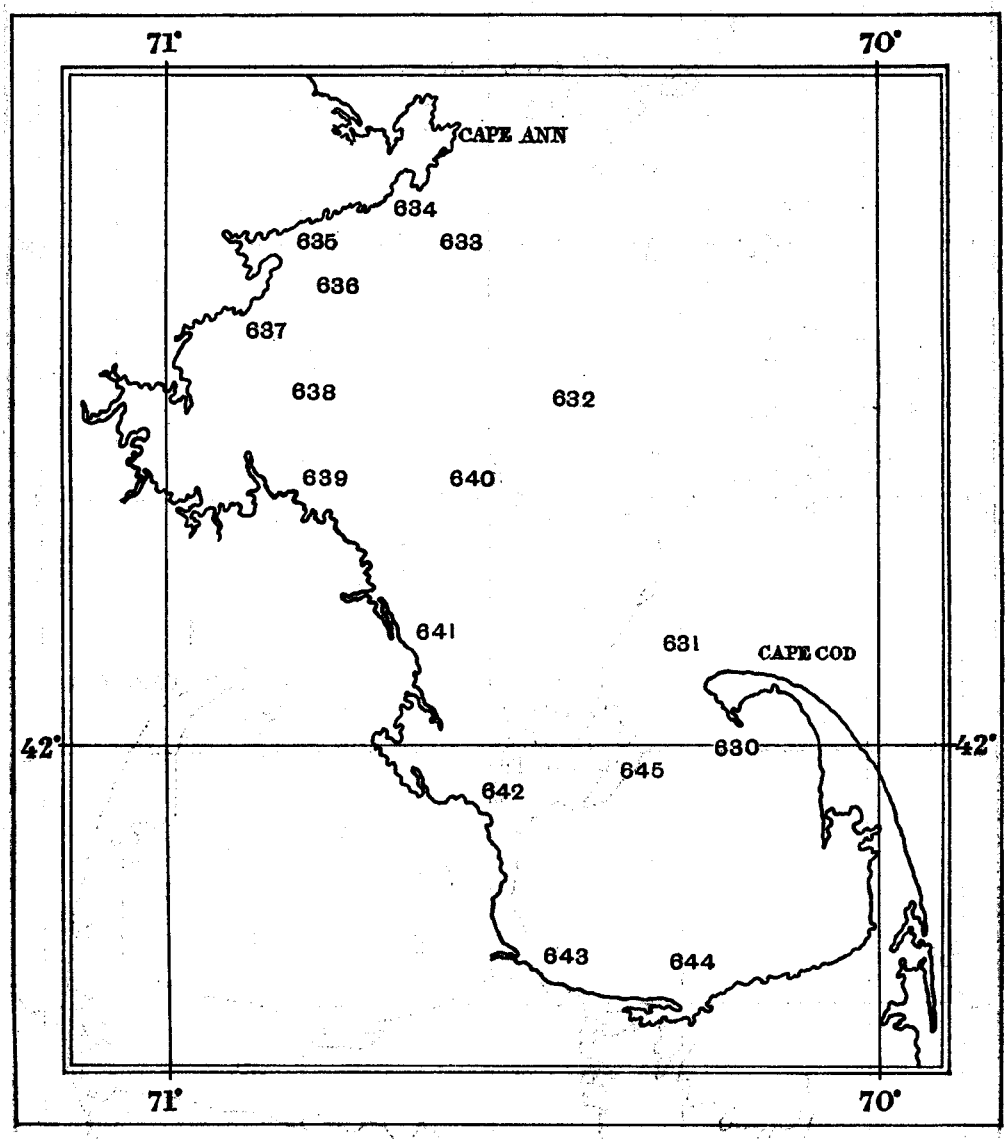

FIG. 8.—Location of *Halcyon* stations 10631 to 10645, August 22 to 24, 1922

collected by the *Fish Hawk* in Massachusetts Bay during the winter and spring of 1924 and 1925; to Dr. A. H. Leim; and to Capt. John McFarland for towings taken from his schooner *Victor*.

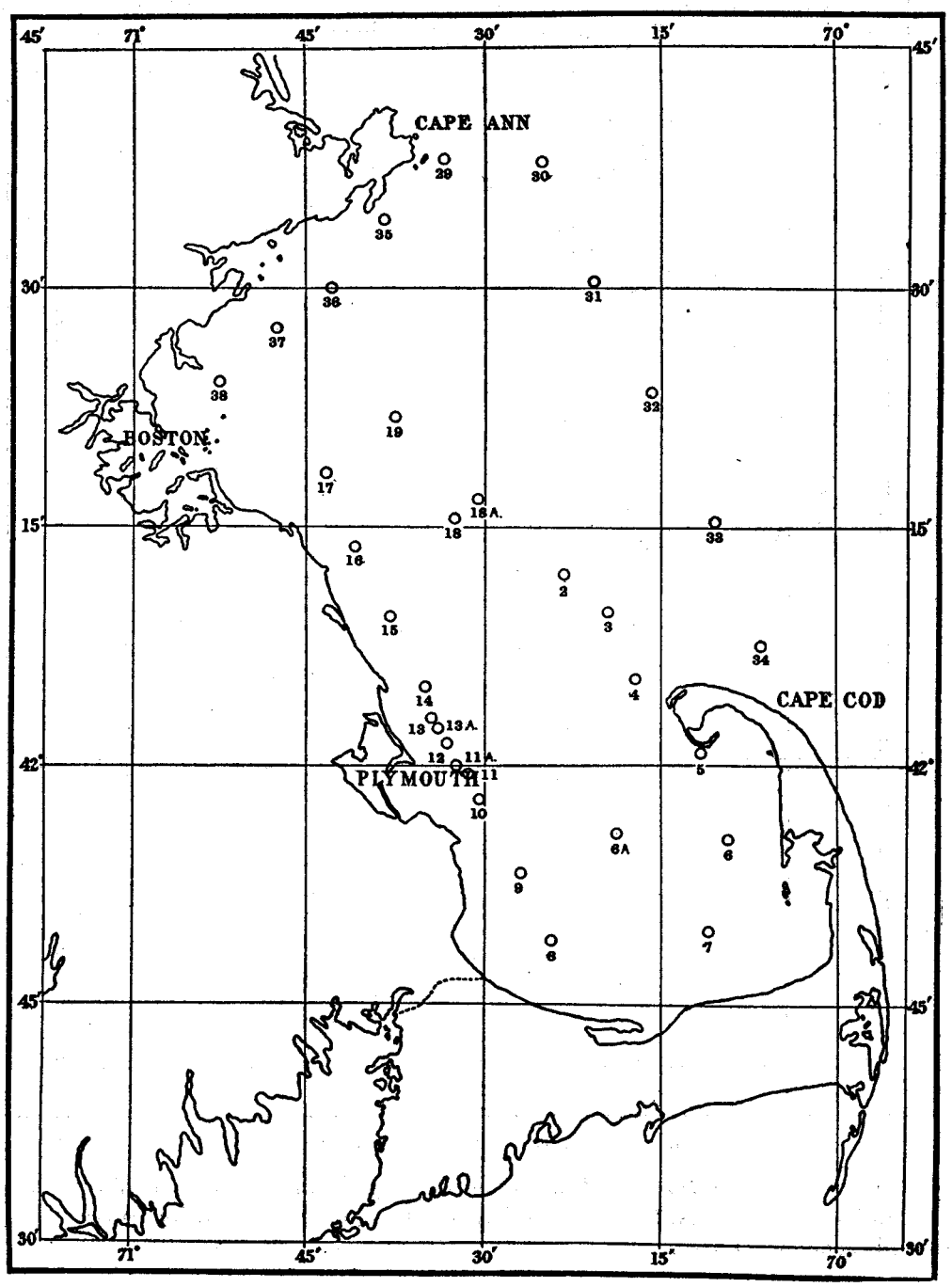

FIG. 9.—Location of *Fish Hawk* stations, 1924–25

THE PLANKTON

Although of rather recent birth as words go,[3] the term "plankton" filled so obvious a need that it is now in general use to cover a whole assemblage of organisms, plant and animal, related by their manner of life though they may be far apart in the systematic scale. By it we understand all such forms as float or swim freely in the water, but which, however active, are unable to carry out voluntary horizontal journeys of any extent, though certain of them perform considerable vertical migrations under the directive influence of sunlight or of some other physical stimulus. Among the three major faunistic groups into which the inhabitants of the sea may be divided—bottom dwellers, free swimmers, and plankton—the importance of the last in the economy of nature was slowest in gaining general appreciation. Within the last half century, however, biologists have come to realize both that the number of species of this category is past all counting and that the microscopic pelagic plants are the chief producers—that is, are capable of elaborating simple inorganic compounds into complex organic matter—in the sea. They serve as food supply for many larger marine animals at one stage or another, and thus play a most essential rôle in the general nutritive scheme of marine life. As it chances, the planktonic plants (producers) as a whole are unicellular and microscopic; the planktonic animals (consumers) are multicellular and comparatively large, so that the oft-employed terms "microplankton" and "macroplankton" are not empiric, but do classify the plankton roughly as vegetable or animal, more technically as phytoplankton or zoöplankton.

In the following pages I have attempted to place before the reader a general survey of these two great planktonic divisions as they occur in the Gulf of Maine, followed by more particular accounts of the status of such groups of each as loom large in its pelagic communities at one time or another. Many other groups are also represented in the tow nettings, but time and the assistance available have so far allowed examination of those only that are dominant or numerically important in the Gulf at one time or place or another.

Study of the occurrence of buoyant fish eggs is not sufficiently advanced to warrant more than a few preliminary notes here. The present knowledge of the breeding grounds and seasons and of the distribution of the eggs and larvæ of Gulf of Maine fishes is summarized by species in the first part of this report (Bigelow and Welsh, 1925).

[3] The term was coined in 1886 by Hensen.