

and 1915 she ran oceanographic profiles across the slope abreast of Marthas Vineyard in August and October, mentioned above (p. 517). In 1916 she again made summer and November cruises from Gloucester to Chesapeake Bay (Bigelow, 1922).

## TOPOGRAPHY

The indentation of the coast between Cape Sable, at the southeast angle of Nova Scotia on the east, and Cape Cod and Nantucket Island, on the west, seems to have gone unnamed until late in the last century, when it was christened "Gulf of Maine." As outlined by the coast, the gulf is roughly rectangular, much wider (about 200 miles) than deep (about 120 miles). It is a far better marked natural province below the surface of the sea than the shallow recession of its shore line would suggest, for its southern boundary is marked by a shallow rim, or "sill," pierced by three narrow passages only. Passing eastward from Nantucket, with its off-lying shoals, these, successively, and the banks that separate them, are: The South Channel (not very well defined and only 40 to 50 fathoms deep), Georges Bank, the Eastern Channel, Browns Bank, the Northern Channel, and finally the Seal Island or coastal bank off Cape Sable. This rim, as Mitchell (1881) long ago pointed out, 259 miles in length from Nantucket to Cape Sable, follows, in its main outlines, the arc of a circle whose radius is about 167 miles. Along this arc the length of Georges Bank, from the deepest trough of the South Channel to the 50-fathom contour on the slope of the Eastern Channel, is about 140 miles, with a greatest breadth of about 80 miles from north to south between the 50-fathom contours. Between these same contours of the Eastern Channel and of the Northern Channel each occupies about 25 miles of the arc. In round figures, the area of Georges Bank is 10,000 square miles; that portion of Browns Bank west of longitude  $65^{\circ} 30' W.$  (taken as the arbitrary boundary of the region under discussion) is about 550 square miles.

The area of the gulf north of the rim is given by Mitchell as about 36,000 square miles. The coast line of the gulf, as it would appear on a small-scale chart, follows a fairly regular curve, but in detail it is extremely complex; for the northern and eastern shores are not only frequently and deeply embayed, but are bordered by a perfect labyrinth of islands, large and small, extending in places 10 to 20 miles seaward from the mainland. Its largest bays (Massachusetts on the southwest and the still larger Bay of Fundy on the northeast) are too well known to need more than passing mention.

The coast of the Gulf of Maine falls into two main types, Cape Elizabeth marking the transition from one to the other. South of this headland the shore line is characterized by a succession of sand beaches alternating with bold headlands, notably Cape Ann, and with rocky stretches, which in Cape Cod Bay give place to the continuous sand strand of the cape. Along this part of the coast there are but few islands, except in Boston Bay, and the fjord type of indentation is notably absent. East of Cape Elizabeth, on the contrary, the shores of the State of Maine are almost continuously rocky, as are the islands of the outlying archipelago already mentioned; and deep bays succeed each other in close succession as far as the mouth of the Bay of Fundy. As a whole, the shores of the gulf are low, seldom rising to more than 100 to 200 feet in the immediate neighborhood of the sea; but the Camden hills

and the mountains of Mount Desert (with the maximum elevation of 1,500 odd feet) are exceptions to this rule, while the cliffs of the north shore of Grand Manan rise to a height of 200 to 300 feet, almost sheer from the water.

### DEPTH OF THE GULF<sup>a</sup>

If we take the 50-fathom (virtually the 100-meter) contour as marking the confines between the peripheral and central parts of the gulf (a natural boundary, because this level not only outlines the northern slope of Georges Bank but includes virtually all the outlying islands), the coastal shallows to the east, north, and west and the rim on the south inclose a bottle-necked basin that communicates with the open sea by two narrow channels only—the eastern and northern. The Eastern Channel, at its narrowest point between Georges and Browns Banks, is about 140 fathoms (256 meters) deep along its trough; the Northern Channel is 65 to 80 fathoms (120 to 145 meters), with a maximum of 78 fathoms (143 meters) in the narrows between Browns Bank and the Coast Bank. North of the rim the deepest water (100 fathoms, or 200 meters and over) takes roughly the form of a Y, with its two arms extending westward and northeastward. As these two troughs apparently were unnamed, I have christened them the “western” and “eastern” basins. They join in the southeast corner of the gulf, where they are continuous with the Eastern Channel. As Mitchell (1881) has pointed out, more than 10,000 square miles of the gulf are deeper than 100 fathoms. The gulf is deepest just inside the entrance to the Eastern Channel and close to the northern slope of Georges Bank as a trough some 50 miles long (west and east), with 150 fathoms (275 meters) or more, and a maximum of 184 fathoms (336 meters). There is also a second, smaller bowl, deeper than 150 fathoms (180 fathoms, or 329 meters, maximum) in the inner part of the western branch of the Y, off Cape Ann.

Over the south-central region of the gulf (that is, the region of union of the two arms of the basin) the depth is generally from 100 to 120 fathoms (180 to 220 meters), varied, however, by many shoaler spots of 90 to 100 fathoms and by occasional deeper soundings of 120 to 135 fathoms (220 to 250 meters). The configuration of the bottom makes the fathom a more instructive basis for contour lines than the meter in just this region; for whereas the 100-fathom curve includes the whole basin, the 200-meter contour, though differing so little in actual depth, is much interrupted here by ridges of 180 to 190 meters, obscuring the essential troughlike conformation of the basin. In the western arm of the basin the water is deepest 45 miles east of Cape Ann; in the eastern arm it is deepest in the extreme northeast corner (145 fathoms, or 265 meters). In both branches the general level of the basin floor is from 115 to 130 fathoms (210 to 238 meters).

### BANKS AND SINKS

Isolated sinks or pot holes are numerous; indeed, the deeps of the two basins just mentioned are such. Most of these do not fall deep enough below the surrounding bottom to call for any special comment, but three such bowls are so deep

<sup>a</sup> On the ordinary navigational charts of the region, published by the United States Coast and Geodetic Survey and the United States Hydrographic Office, the depths are given in fathoms. Consequently, the following discussion is also in fathoms, but with the equivalents in meters also stated.

and are inclosed by rims so much shallower that they have been made the field of considerable hydrographic investigation. These, for want of better names, I may christen (1) the Cape Ann sink, lying near Stellwagen Bank, centering about 12 miles southeast of Cape Ann, having a general depth of 50 to 70 fathoms (91 to 128 meters) and a greatest depth of 99 fathoms (181 meters), and inclosed by a continuous rim of 40 fathoms (70 to 75 meters) or shallower; (2) the Isles of Shoals sink, centering 28 miles northeast of Cape Ann, having a general depth of 80 to 100 fathoms (146 to 183 meters), and inclosed on the south and east by the shallows of Jeffreys Ledge and on the north by depths of 60 to 70 fathoms (110 to 128 meters). The Fundy deep, south of Grand Manan Island at the mouth of the Bay of Fundy, is a basin some 27 miles long, with 100 to 112 fathoms (183 to 205 meters) and its deepest spot 165 fathoms (302 meters).

The two arms of the deep trough or basin of the gulf are separated by a roughly triangular area, with depths ranging generally from 70 to 90 fathoms (128 to 165 meters) but rising at its apex (roughly, in the center of the gulf) to within  $4\frac{1}{2}$  fathoms (8 meters) of the surface, as the dangerous, rocky shoal known as Cashes Ledge, the patch less than 30 fathoms (55 meters) deep being about 6 miles long in a southwest-northeast direction. Other offshore shoals in the gulf proper, which deserve mention here because I shall have occasion to refer to them later as landmarks, are as follows:

1. Stellwagen Bank, lying between Cape Cod and Cape Ann at the entrance to Massachusetts Bay, 9 to 20 fathoms (16 to 37 meters), with deeper channels north and south of it.

2. Jeffreys Ledge, a narrow ridge extending northeasterly from Cape Ann for about 45 miles, with depths less than 50 fathoms (91 meters), shoalest place 18 fathoms (33 meters).

3. Platts Bank, situated about 34 miles east-southeast from Cape Elizabeth, which rises to within 29 fathoms (53 meters) of the surface.

4. Jeffrey Bank, off Penobscot Bay, some 26 miles south of the outermost islet (Matinicus Rock), where there is a small area within the 50-fathom curve with a shallowest depth of 46 fathoms (84 meters).

5. Grand Manan Bank, a small shoal about 7 miles long lying about 18 miles south of Grand Manan Island; general depth 30 to 40 fathoms (55 to 73 meters).

6. Lurcher Shoal, a patch of broken, rocky bottom 1.5 to 20 fathoms (3 to 37 meters) deep, 15 miles off Yarmouth, Nova Scotia.

7. German Bank, a considerable but vaguely defined area west of Cape Sable, with depths of 30 to 35 fathoms (55 to 64 meters) bounding the debouchment of the Northern Channel into the basin of the gulf.

Mitchell (1881) has calculated that the mean depth of the gulf north of the sill, including its navigable bays and tributaries, is about 75 fathoms (137 meters).

The banks that form the southern sill of the gulf have been described frequently, and because of their importance in navigation their main features are summarized in the coast pilots issued by the British and United States Governments. The dimensions and area of Georges Bank, one of the most famous and productive fishing grounds in the North Atlantic, are mentioned above (p. 518). On the southern and eastern parts the depths range, in round numbers, from 30 to 40 fathoms (55 to 73 meters). Over its northwestern one-third the water is shallower, with a consider-

able but much broken area shallower than 20 fathoms (37 meters), culminating in the dangerous "Georges" and Cultivator Shoals, the former with only  $2\frac{1}{2}$  to 10 fathoms ( $4\frac{1}{2}$  to 18 meters), the latter with 3 to 10 fathoms (6 to 18 meters). Both of these shoals break heavily in stormy weather, and both have proved graveyards for many fishing vessels. According to early rumor (Mitchell, 1881), Georges Shoal has been awash or even dry within historic times; but even as early as 1776 Hollingsworth decided that this tradition had no basis. It is worth noting that there is one well-marked sink situated on the northeast part of Georges Bank, centering at latitude  $41^{\circ} 59' N.$ , longitude  $67^{\circ} W.$  Prior to the spring of 1920 this was known (at least officially) from one sounding of 83 fathoms (152 meters) only, with neighboring depths of 30 to 40 fathoms (55 to 73 meters). On March 11 of that year the U. S. S. *Albatross* developed the region by a series of soundings, finding a maximum depth of 120 fathoms (220 meters) and an area of about 27 square miles deeper than 75 fathoms (about 140 meters).

Inside the 50-fathom (90-meter) contour Browns Bank is about 55 miles long from east to west, with an area about 700 square miles and a general depth of 30 to 50 fathoms.

Around most of the periphery of the basin of the gulf the slope is gradual, the 100-fathom (183-meter) curve lying about 12 miles from shore at its closest (off Cape Cod and about as near the outer islands in the northeast corner). The northern slope of Georges Bank is much more abrupt, falling from about 40 fathoms (73 meters) to 100 fathoms (183 meters) in a distance of only 3 to 5 miles.

The Gulf of Maine, with its southern sill, occupies the whole breadth of the Continental Shelf off northern New England and western Nova Scotia, with the south slopes of Georges and Browns Banks falling so steeply to the abyss of the North Atlantic that the zone between the 100 and 1,000 fathom contours (the "Continental Slope") is at one point (longitude about  $66^{\circ} W.$ ) only 4 or 5 miles broad and not more than 20 miles anywhere abreast the mouth of the gulf between the longitudes of  $65^{\circ}$  and  $71^{\circ}$ .

#### WATERSHED

In more or less inclosed coastal seas, where the salinity of the water is influenced greatly by the amount of inflow from rivers and smaller streams, the extent of the watershed and amount of run-off of fresh water demand consideration. The land area tributary in this way to the Gulf of Maine includes something over one-third of the State of Massachusetts, two-thirds of New Hampshire, the entire State of Maine, half of the Province of New Brunswick, a small part of the Province of Quebec, and the north-western and western coastal strips of Nova Scotia—altogether, in round numbers, some 61,300 square miles. No large rivers empty into the gulf south of Cape Ann; north of that point the chief tributaries, with their approximate drainage areas in square miles, are (1) the Merrimac, 4,553; (2) the Saco, 1,758; (3) the Presumpscot, 470; (4) the Androscoggin, 3,700; (5) the Kennebec, 6,380; (6) the Penobscot, 8,550; (7) the Machias, 800; (8) the St. Croix, 1,630; and (9), chief of all, the St. John, draining no less than 26,000 square miles. That is to say, the nine principal tributaries drain together over 53,000 square miles, or five-sixths of the total watershed.