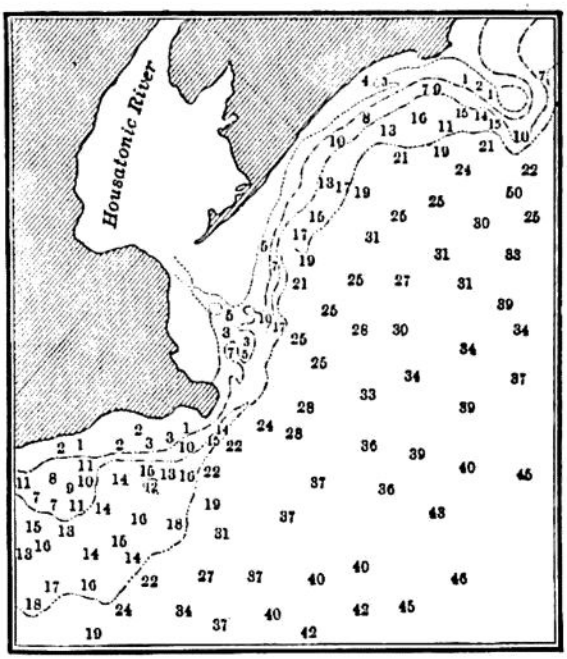
But the wave-and-current drift, moving westward, finds its mouth open; and the sand-bars there made are so high and large that the greatest depth in the channel at low tide is only 7 feet.

The mouth of the Housatonic River, west of New Haven (a stream 100 miles long) is in a worse plight; for it gapes open directly eastward and faces the drift movement. The greatest depth over the bar at low water is consequently only 3 feet. The tide is 7 feet; but the tidal grounds are small.

200.



Mouth of the Housatonic.

The harbor of New Haven (Fig. 199) receives 3 rivers, the longest only 35 miles. But, in contrast with the other cases, there is a prolonged eastern cape of gneissoid granite, and this forces the wave-and-current drift to take a course more to the southward over deeper water. The drift chokes up the mouth of "West River" (the westernmost of the three), but leaves the rest of the harbor mostly unharmed. Although the tidal grounds are not large, the entrance to the harbor has a depth over the bar of 20 feet; and this it owes chiefly to its *eastern* cape.

Harbor-improvement.—The principle at the basis of improvements of harbors at the mouths of tidal rivers is made plain by the preceding illustrations. It requires that there should exist for each the largest possible tidal grounds, in order that there may be the largest possible outflow of waters for channel scouring; and where not existing, that they should be obtained by the construction, from the capes either side of the entrance, of a breakwater or levee as far out as the depths will allow; that the breakwater should rise so little above low-tide level that the tide may freely enter over it and fill the bay; that the windward side of the breakwater should have such a position and extent as will carry the wave-and-current drift far enough out to clear the leeward cape, if possible. A harbor with a large breakwater receives great aid for channel scouring from the waters that are piled in by the storm-winds. These winds sometimes keep driving in water, and making an undercurrent out of the channel, through all states of the tide. As to one or more additional channels to the harbor, the engineer has to decide after examination. In the case of a tideless river, like the Mississippi, the channel may be improved by embankments alongside of it; but not so that of a tidal river.

The harbors made by coral-reef barriers about Pacific islands are in accordance with the best models; and an atoll with a ship entrance to the lagoon is such a harbor isolated in midocean. The outflowing tidal waters keep the channel in good condition.

The formation of sand-bars in Long Island Sound, and the variations in depth, are due mainly to variations in the velocity of the outflowing tide, as partly explained on page 216, the rivers being the chief source of new material. But the position of the deeper channel has come down to a large extent from preceding geological time, and especially from the Glacial and Champlain periods, when depositions were on an enormous scale. In other cases over the coast region the shoals indicate the forms, and partly the positions,