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THE BOTTOM COMMUNITY OF IPSWICH BAY, MASSACHUSETTS

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Ralph W. Dexter
Kent State University, Kent, Ohio

Introduction

The marine communities of Cape Ann, Massachusetts, were studied during the summer months of 1933 to 1938 inclusive and in 1940. Intensive bio-ecological studies were made on the intertidal communities of a narrow tidal inlet which cuts through the Cape Ann promontory. In order to relate the communities of this inlet to those of the surrounding region, a general survey was made of the bottom communities occupying the rim of coastal waters surrounding Cape Ann. This report is concerned with that particular phase of the field work. Dredgings were made in the bays of Cape Ann during the summers of 1934 to 1937 inclusive and in 1940. Altogether, 58 dredge hauls were made in Ipswich Bay, 19 in Sandy Bay, 9 along the eastern shore of Cape Ann, and 2 in Gloucester Harbor. This report is confined to the bottom community of Ipswich Bay inasmuch as it is the one which is best known.

The bottom organisms were collected with a naturalist's dredge operated from either a dory or a sailboat propelled by an out-board motor. For the most part dredgings were made in depths between 12 and 80 feet at mean-low-water. Records were kept of each individual dredge haul for all except the first season. Two types of bottom were recognized, (1) hard sand and (2) rocky bottoms. Supplementary observations were made from a diving helmet during the seasons of 1935–1937. While the helmet was used most often in the tidal inlet, several dives were made in the shallow margin of Ipswich Bay to a depth of about 20 feet for general observations. The fish population was determined partly from dredging records and partly from information furnished by commercial and amateur fishermen. The plankton was not studied in detail. Several samples were collected, but plankton organisms were found to be sparse.

Coastal Communities of Cape Ann

Pelagic Community

Scomber-Calanus Biome.—The community of the ocean water has been designated by Shelford (Clements and Shelford, '39) as the Scomber-Calanus biome (mackerel-copepod), found extensively over sections of the North Atlantic Ocean. Dominants, according to Shelford (*ibid.*), include *Calanus finmarchicus* and other copepods, jellyfishes, mackerel (*Scomber scombrus*), herring (Clupea spp.), other pelagic fish, and whales (Balaenoptera, Megaptera, etc.). Bigelow ('24) refers to the plankton as a "Calanus community" in which *C. finmarchicus* is the most important in bulk and numbers. This dominates the zooplankton from the Grand Banks to Cape Cod and from the coast line to the edge of the continental slope. The pelagic community in the shallow water surrounding Cape Ann is recognized here as the Clupea-Siphostoma faciation (herring-pipefish) which consists chiefly of plankton organisms (see Bigelow, '24; Clements and Shelford, '39; Clarke, '40), fishes and aquatic mammals. The predominants of this community as determined by the present survey include the following organisms which are listed in order of relative importance in Ipswich Bay according to abundance and seasonal occurrence. *C. finmarchicus* is placed at the head of the list on the basis of studies made by Bigelow (*ibid.*).

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Calanus finmarchicus (Gunner) and other plankton organisms
Scomber scombrus L., mackerel
Clupea harengus L., herring
Siphostoma fuscom Storer, pipefish
Pollachius virens L., American pollock
Gadus callarias L., cod
Salmo salar L., salmon
Osmerus mordax Mitchill, smelt
Thunnus thynnus L., tuna
Isurus punctatus Storer, mackerel shark
Phoca vitulina L., harbor seal
Loligo pealei Lesueur, squid
Aurelia aurita (L.), jellyfish
Cyanea capillata (L.), jellyfish
Balaenoptera physalus (L.), finback whale

Bottom Community of Ipswich Bay

Strongylocentrotus-Buccinum Biome.— The Strongylocentrotus-Buccinum biome is characterized by submergence in shallow sea water at all times. It extends from spring-low-water line to an undetermined depth which will allow the predominant plants and animals of this community to persist and dominate. This biome was found to be fairly uniform in composition around the rim of coastal water surrounding the island portion of Cape Ann to a depth of about 80 feet at mean-low-water. This major community as found here probably extends for many miles north and south, possibly to the Gulf Stream deflection at Cape Cod and to the cold Labrador current off the coast of Maine.

Newcombe ('35) designated, but neither described nor discussed, this community as the Strongylocentrotus-Asterias biome. Because *Asterias vulgaris* is a predominant in the ecotone between this community and the Balanus-Mytilus-Littorina intertidal biome, it seems best not to use it in the designation of the community. Dredging studies in Ipswich Bay indicate that this community is comparable to the Strongylocentrotus-Argobuccinum biome (large echinoderm-gastropod) on the Pacific coast of North America as described by Shelford ('35). For that reason this biome on the western North Atlantic is designated here as the Strongylocentrotus-Buccinum biome.

Ipswich Bay, Sandy Bay, and similar ones nearby contain two bottom types—hard sand and rocky outcrops. (See U. S. Coast and Geodetic Survey map No. 243, Ipswich Bay to Gloucester Harbor.) Both types were dredged, and while a few organisms were found to be more or less abundant on one or the other, the total surface assemblages on both were quite comparable. A more thorough study with more elaborate equipment might disclose sufficient differences to recognize distinct associations. The results of the investigation thus far indicate that over the broad, gently sloping, hard sand bottom there is an epifauna of scattered invertebrates and bottom fishes. These consist chiefly of echinoderms, gastropods, crustacea, skates, sculpins, flounders, and other bottom fishes.

In many areas the concentration of animal life is not very great as shown by observations from the diving helmet and from the fact that occasionally the dredge failed to capture anything in its path of several hundred yards. At other times abundant collections were made in a single haul. In a few instances a rather large collection was made of a certain species. The most notable case of this was the capture of 531 specimens of the sand dollar *Echinarachnius parma* in a single dredging. Blegvad ('14) has shown that the bottom fauna feeds basically on detritus, and secondly on benthic algae and on other animals. The writer has reached the same conclusion in regard to the coastal communities studied at Cape Ann because of the paucity of plankton organisms and the abundance of detritus found in the water. The basis of the food chain of the bottom community is probably particulate organic matter from the decomposition of macroscopic organisms plus the bottom-living algae.

The animals within the bottom sediments were not thoroughly studied, although frequently the dredge would dig into the bottom sufficiently to bring up a sample of the bivalves and annelids which compose the greater part of such communities. A number of various empty shells taken in the dredge indicate the presence of certain species of bivalves which are probably present but were not dredged alive. (See Dexter, '42 for complete list of marine mollusks collected in this survey.)

Also scattered over this floor of hard sand were islets of algae with an assemblage of invertebrates. On the kelps and seaweeds were gastropods, coelenterates, bryozoans, and tunicates.

In the holdfasts of Laminaria and enmeshed in the fronds of the red algae were amphipods, isopods, annelids, bivalves, turbellarians, nematods, nemerteans, and small decapods and echnoderms. Such aggregations were developed on a nucleus of shells, small stones, etc. which served for attachment, or on algae which had been partly buried in the sand. The rocky bottom assemblages were essentially of the same character as those of the islets of algae and associated invertebrates on the sandy bottom. The rock surfaces served for attachment, making possible a concentration of algae and sedentary invertebrates. Sumner, Osburn, and Cole ('11), Allee ('23), and Miura ('29) have stressed the effects of bottom materials on such assemblages. Kitching ('41), however, has called attention to the importance of illumination and wave action in such communities. Molander ('28) considered hydrographic conditions and depth most important in explaining the distribution and composition of subtidal communities, while Petersen ('18) believed that biological interactions, especially competition, was the main factor in operation with hydrographic conditions. Shelford ('31) has pointed out that at times physical forces control and at other time biological forces control. It seems evident that in the case under discussion the solid substratum offering ample opportunity for attachment is of greatest importance. The rocky outcrops in Ipswich Bay were found for the most part in a narrow rim in shallow water along the shoreline of the rock-bound coast.

Below are listed the controlling and characteristic organisms of the bottom community of Ipswich Bay during the summer months. The organisms are grouped according to their ecological evaluation based upon the following criteria: (1) Relative abundance, (2) size, (3) controlling influence—the area covered and held by sedentary or slow-moving forms which thus exclude a second type, but may make it possible for a third to be present in the same grouping through the creation of micro-habitats, (4) distribution throughout the area investigated, (5) seasonal occurrence, (6) motility and range of movement, (7) reactions on the physical environment including effects on tidal currents, sedimentation, and illumination; (8) coactions, especially the food coactions so far as they are known. Knowledge of coactions was secured from observation and reports in the literature. Consideration was given to the following: *a.* To the type of food eaten, whether plant, animal, or detritus, and its availability; *b.* To the importance of individuals of each species as food for others; *c.* To their means of protection against predators; and *d.* To the question as to whether individuals of certain species can control populations through predation (Petersen, '18: 17).

The ecological categories set up as a result of these considerations are similar to those used by Shelford ('35). The assignments of populations of the species to the categories shown in the lists is necessarily preliminary. Further research on the nature of the interrelations is essential to the establishment of the suggested evaluation. Those species of ecological importance, i.e., those for which there is some evidence of an influence on control of the habitat or community are listed along with some of unknown influence which definitely characterize a community, probably due to a special physiological fitness.

Altogether 110 identified species of the benthic communities were recorded in this study. A number of fishes known to occur in the bay are not listed here for various reasons. Undoubtedly many species could be added, although the writer believes that most of the ecologically important members of the epifauna have been determined in this preliminary survey. Much, however, remains to be done on the dredging of this region.

The order in which the species are listed within each group is of no great significance, although in general an attempt is made to place the most important and characteristic ones first according to the writer's analysis of the community in question during the period of this study. It is recognized that population changes occur from time to time which would necessarily alter the relative significance of many species in their community relations. The animals are in each case listed before the plants because they are more numerous over the greater part of the floor of the bay. On hard surfaces and in the islets of attached organisms, however, the plants are equally important and often more important than many of the animals as the plants furnish a seat of attachment for a great many of the sedentary animals as well as furnishing food for the herbivorous forms.

The first figure following each species represents the largest number of that species taken in a single dredge-haul covering approximately 100 square meters. The second number is the percentage of occurrence in the dredge hauls for all except the first year's records which were not kept in sufficient detail to include. While these data do not represent the actual abundance on the area involved, they are an indication of relative abundance. Bottom dredges of the type used are very inefficient. Many of the fishes were not dredged because of their size and activities. Those listed below which were not captured in the dredge are commonly taken by fishermen.

I. Dominants and slow-moving influents.

A. Dominants. These are the most characteristic members of the community. They are species which are common, large, sedentary or slow-moving and exert control over the bottom community by occupying and holding space. Plants provide space for attachment, or shelter; in some cases animals control the size of the population by predation.

Strongylocentrotus drobachiensis, green sea urchin, 12/44
Buccinum undatum, English whelk, 5/12
Echinarachnius parma, sand dollar, 531/48
Asterias vulgaris, common starfish, 93/96
Raja erinacea, little skate, 1/4
Myoxocephalus octodecemspinosus, longhorn sculpin
Urophysis chuss, squirrel hake, 2/8
Pseudopleuronectes americanus, winter flounder, 1/8
Laminaria saccharina, kelp, 11/56
L. longicruris, kelp, 2/12
Agarum cribrosum, kelp, 3/28
Euthora cristata, red alga, 16/68
Ulva lactuca, sea lettuce, 12/68
Chrondrus crispus, Irish moss, 5/44

B. Subdominants—species exerting less control than dominants. They are not as abundant or they are not as uniformly distributed as the Dominants, but locally they may take the place of Dominants.

Raja diaphanes, big skate
Myoxocephalus scorpius, shorthorn sculpin, 1/4
M. aeneus, little sculpin, 1/4

Paralichthys dentatus, summer flounder, 1/4
Caraharias taurus, sand shark
Neptunea decemcostata, ten-ribbed snail, 3/8
Colus stimpsoni, snail, 4/4
Polinices heros, sand collar snail, 4/24
Laminaria digitata, kelp, 2/12
Callithamnion sp., red alga, 10/20

C. Influents—chiefly medium or large sized, common species which have a limited range of movement. In general they are intermediate in the food chain between the plants and detritus eaters on one hand and the predators on the other, although some detritus eaters are included here.

Gammarus spp., amphipod, 52/64
Lacuna vincta, snail, 18/68
Caprella acutifrons, amphipod, 27/40
Aeginella longicornis, amphipod, 10/28
Carinogammarus sp., amphipod, 9/8
Idothea baltica, isopod, 4/36
Henricia sanguinolenta, starfish, 4/24
Spirorbis spirorbis, serpulid worm, 110/68
Lepidonotus squamatus, annelid, 8/20
L. sublevis, annelid, 4/8
Lumbrinereis sp., annelid, 15/8
Pholis gunnellus, rock eel, 1/12
Arctica islandica, clam, 6/4
Modiolus modiolus, horse mussel, 2/3
Siliqua costata, sand bar clam, 1/12

D. Subinfluents—less important than influents because of lesser abundance, smaller size or lesser importance in the food chain.

Neomenia sp., chiton, 15/12
Sertularia pumila, hydroid, 100/21
Bugula flabellata, bryozoan, 3/20
Hydroides sp., annelid, 3/12
Crepidula fornicata, boat shell, 2/8
Gigartina stellata, red alga, 3/28
Rhodymenia palmata, red alga, 3/28
Chaetomorpha spp., green algae, 3/28
Enteromorpha. sp., green alga, 10/24
Lomentaria sp., red alga, 3/8
Corallina officinalis, coralline red alga, 6/8
Chordaria flagelliformis, sea chord, 3/8
Porphyra umbilicalis, red alga, 1/4

II. Permeant influents—large, wide-ranging motile species which are chiefly predators. Many of them are not always present and move freely between this and other marine communities.

Melanogrammus aeglifinus, haddock
Merluccius bilinearis, silver hake
Hippoglossus hippoglossus, halibut
Tautogolabrus adspersus, cunner, 2/4
Tautoga onitis, tautog
Poronotus triacanthus, butterfish
Pagurus longicarpus, hermit crab, 10/36
P. pollicaris, hermit crab, 4/8
Cancer irroratus, rock crab, 3/32
C. borealis, Jonah crab, 2/6
Homarus americanus, lobster, 1/2
Crago septemspinosus, shrimp, 3/20
Libnia emarginata, spider crab, 2/4
Palaemonetes vulgaris, prawn, 1/8
Chelonia mydas, green sea turtle

III. Secondary forms. These are believed to be less important than subinfluents. Small organisms which are common or larger forms which are not common are included here. They are chiefly detritus and plankton feeders and serve as food for larger forms. For the most part they are attached to other organisms, and in themselves are of little importance to the community.

Saxicava arctica, boring clam, 4/8
Ophiopholis aculeata, brittle star, 3/6
Metridium dianthus, sea anemonie, 1/4
Membranipora spp. and similar bryozoans, 14 col./75
Chalina oculata, finger sponge, 3/2
Botryllus schlosseri, sea squirt, 23/8
Molgula manhattensis, sea squirt, 25/20
Leptoplana variabilis, flatworm, 4/4
Tubularia spp. and similar hydroids, 10/12
Obelia spp., hydroids, 15/20
Corymorpha pendula, 5/4
Abietinaria abietina, hydroid, 3/4
Ectocarpus sp., brown alga, 4/8

In the shallow portions of the bays and in the adjacent inlets there existed prior to 1932 an eel-grass community (Zostera faciation) sometimes known as Zosteretum. This community disappeared as such with the almost complete destruction of the eel-grass as the result of a wide-spread disease. Its elimination has had far-reaching effects on the marine communities of the Atlantic Coast. A report on this problem in the Cape Ann region is in press (Dexter, '44).

In the shallow inlets and channels which run inland from the bays, the hard sand and rocky bottoms give way very largely to black, muddy sediments. In the very shallow regions and in the intertidal zone these sediments become very soft and sticky with large quantities of organic matter mixed with silt. Because the subtidal communities (Laminaria-Cancer faciation) of these inlets are very closely related to those of the intertidal region, they will be discussed in another paper. The major food chains of the Laminaria-Cancer faciation have been determined in part and are probably very similar to those of the more shallow bay regions.

By comparing the results of the present dredging study with the reports of Sumner, Osburn, and Cole ('11), Davis ('11), and Bigelow and Welch ('24), it becomes evident that the bottom community of Ipswich Bay differs in many respects with that of the Woods Hole region on the southern coast of Cape Cod. The following organisms are apparently more significant in the community at Cape Ann than at Vineyard Sound and Buzzards Bay:

Neptunea decemcostata, ten-ribbed snail
Colus stimpsoni, snail
Lacuna vincta, snail
Melanogrammus aeglifinus, haddock
Agarum cribrosum, kelp
Laminaria longicruris, kelp (Not found at Woods Hole)
L. saccharina, kelp
Euthora cristata, red alga

On the other hand, the following are among those which are more important at Cape Cod than at Cape Ann. Those which are starred were not collected at all at Cape Ann.

**Arbacia punctulata*, sea-urchin
**Busycon canaliculatum*, pear couch
**Urosalpinx cinereus*, oyster drill
Nassa trivittata, sand snail
**Anachis avara*, snail
**Astyris lunata*, snail
**Pagurus annulipes*, hermit crab
Neopanopius sayi, mud crab
Balanus eburneus, barnacle
**Paralichthys oblongus*, four-spotted flounder
Tautoga onitis, tautog

**Stenotomus chrysoys*, scup
**Sargassum filipendula*, sargasso weed
**Laminaria agardhii*, kelp

A comparison of the Cape Ann study with the dredging survey of the Mount Desert region conducted by Procter ('33) shows but few important differences between Ipswich Bay and the bays of the Maine coast in the vicinity of Mount Desert Island. The following species, however, appear to be of greater ecological importance at Cape Ann:

Lacuna vincta, snail
Gammarus locusta, amphipod
Pagurus longicarpus, hermit crab
Siphostoma fuscum, pipefish

In the Mount Desert region, the following are common, important bottom forms which were not collected at Cape Ann:

Solaster endeca, sun-star
Cucumaria frondsosa, sea-cucumber
Pagurus acadianus, hermit crab

The bottom community of Ipswich Bay is much more closely related to the bottom communities of the coast of Maine than to those south of Cape Cod. Sumner, Osburn, and Cole (*ibid.*) early pointed out the importance of Cape Cod as a barrier to coastal marine life.

Present knowledge of subtidal bottom communities is very much confined to dredging records and helmet diving observations on the assemblages of marine plants and animals and their relative abundance with special reference to bottom materials, depth, and temperature, and secondly to the food of certain species, particularly fishes of commercial importance. Other than these studies, very little is known concerning the dynamics of marine coastal communities. Dredging and diving studies have contributed much to our understanding of the organization of benthic marine communities which will form a basis for future research on the dynamics of such communities.

Summary

The bays of Cape Ann, especially Ipswich Bay, were dredged during the summers of 1934–37 and in 1940. The bottom community is here designated as the Strongylocentrotus-Buccinum biome which is similar to the Strongylocentrotus-Argobuccinum biome of the Pacific coast of North America as described by Shelford ('35).

An attempt is made to evaluate the relative importance of the predominant members of the bottom community during summer months according to present knowledge of this community. The bottom community of Ipswich Bay is characterized and controlled by echinoderms, large gastropods, skates, sculpins, flounders, and decapod crustaceans over the sandy sediments. Scattered about are islets of algae serving as a focus for the attachment of many small invertebrates, especially snails, amphipods, isopods, coelenterates, bryozoans and tube-building annelids. On solid surfaces the algae and other attached organisms form a solid mat.

This community is closely related to the bottom community found along the middle Maine coast, and somewhat related to the bottom community of the Woods Hole region. At the latter locality, however, there are many predominants which are not found north of Cape Cod, and several of the predominants found at Cape Ann are either lacking or are of but minor importance at Woods Hole.

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