

Marine and Estuarine Environments,
Organisms and Geology
of the Cape Cod Region

an indexed bibliography, 1665-1965



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BOSTON UNIVERSITY
MARINE PROGRAM

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H A H N



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PREFACE

Since its incorporation at Woods Hole in 1888 the Marine Biological Laboratory traditionally has provided facilities and services to independent investigators for research, training and scientific communication in marine biology. It fosters maximum use of its facilities throughout the year. In the early decades research on the natural history of marine organisms was stressed, while the recent trend has been toward cellular and molecular investigations. The Systematics-Ecology Program was established by the Laboratory Trustees in September 1962 as a continuing program of basic research and training in the biology of the whole organism.

The aims of the Program are (a) to extend in a modern, integrated, continuing manner systematic and ecologic knowledge of the estuarine and coastal marine ecosystems of the Cape Cod Region, and thereby to contribute to the advancement of the systematic and ecologic sciences; and (b) to provide opportunities in year-round research and communications for advanced experience and study in the fields of estuarine and coastal marine systematics and ecology.

Within this context the Program from time to time issues publications which further the synthesis of knowledge of organismic biology of the region. The first of these publications, "Keys to Marine Invertebrates of the Woods Hole Region," was edited by Ralph I. Smith and appeared in 1964. The present volume, a second in the series, is intended as an introductory guide to the scientific literature of the region and covers a 300 year period from 1665 to 1965. It is intended to introduce scientists to major papers on the region and to provide the beginning for more intensive literature surveys. The emphasis is on works that relate to the biology of the whole organism, biotic factors of ecological significance, and physics, chemistry, climatology and geology of the region.

Preparation of the bibliography was begun in 1962-1963 by the junior authors who were joined by Anne E. Yentsch in 1964. The facilities of the Marine Biological Laboratory Library were used during the literature search and some work was done in the Boston Public Library and the Museum of Comparative Zoology, Harvard University.

The bibliographic form is that suggested in "Style Manual for Biological Journals, 2nd ed. (1960) prepared by the American Institute of Biological Sciences. Journal abbreviations were taken from the World List of Scientific Periodicals, 1900-1960, 4th ed. (1963).

An index was prepared from titles, abstracts and, in some cases, from the texts. An effort was made to include all known new species descriptions for the region and the scientific names of these are underscored in the index. Scientific names were indexed as they appeared in the original publication with no attempt to provide modern synonyms. Entries were made for phyla, classes (for the larger phyla), lesser taxa when these were given in the title of the paper, scientific names, key words, and geographic locations.

It is a pleasure to acknowledge the valuable contribution of Anne E. Yentsch whose painstaking search of the literature, double checking of the references, and compilation of the bibliography and its index provide the basis for this publication. We also express our thanks to Mrs. Barbara Webber who varityped the entire manuscript; Mrs. Ann Martin, Mrs. Robert N. Cram, Mrs. Joan Stimson, and Miss Constance Chadwick who aided in the checking of references; Dr. Mary Sears and Dr. K. O. Emery who suggested references; the Woods Hole Oceanographic Institution for permission to reproduce the photograph of a Cape Cod beach by Jan Hahn; Herbert A. Ashmore who prepared Figure 1; and the Library of the Marine Biological Laboratory where the bulk of the search for references was conducted.

Preparation of this publication was made possible by support to the Systematics-Ecology Program from the Ford Foundation; Public Health Service Research Grant DE 01870 from the National Institute of Dental Research; Grants GB-561 and GB-4509 from the National Science Foundation; Contract Nonr 3070(03) from the Office of Naval Research, Department of the Navy; and the Whitehall Foundation. This financial aid is gratefully acknowledged.

Woods Hole, Massachusetts
November, 1966

Melbourne R. Carriker, Director
Systematics-Ecology Program

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INTRODUCTION

Thoreau describes Cape Cod as "the bared and bended arm of Massachusetts: the shoulder is at Buzzards Bay; the elbow, or crazy bone, at Cape Mallebarre (Chatham); the wrist at Truro; and the sandy fist at Provincetown." It is an outpost of sand, gravel, stones and clay stretching into the North Atlantic between $41^{\circ}30' - 42^{\circ}5' \text{ N}$ and $69^{\circ}55' - 70^{\circ}46' \text{ W}$. The Cape Cod peninsula, or bent arm, partially encircles Cape Cod Bay which faces north and opens seaward into Massachusetts Bay and the Gulf of Maine. To the south the islands of Nantucket, Martha's Vineyard and the chain of the Elizabeth Islands form a barrier between the open ocean, Nantucket Sound, Vineyard Sound, and Buzzards Bay. At the base of the peninsula the Cape Cod Canal, officially opened in 1916, provides a channel between Cape Cod Bay and Buzzards Bay. This complex of cape, islands and sounds, an area roughly 90 x 100 kilometers, forms the Cape Cod Region.

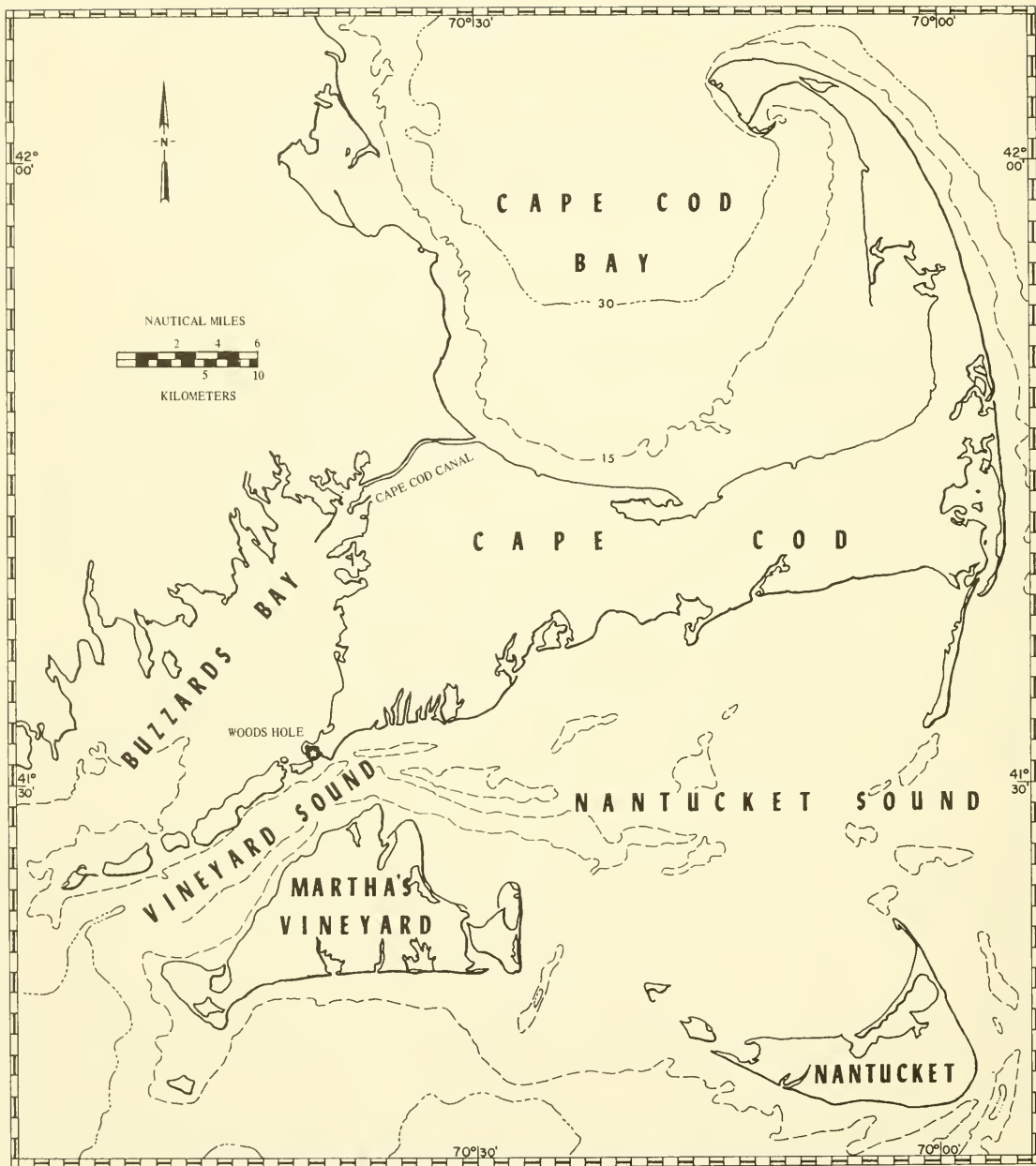
Sediments, predominately gravel, sands and shell fragments, are coarsest and relatively free of organic detritus in tidal scoured Vineyard Sound and grade into finer particles in Nantucket Sound and portions of Cape Cod Bay. Much of Buzzards Bay and the central regions of Cape Cod Bay support extensive soft mud bottoms whereas broad intertidal sand flats bound southeastern Cape Cod Bay and wide intertidal mud bottoms characterize northwestern Buzzards Bay.

Small estuaries, often constricted and intermittently cut off from outside water by barrier beaches, dissect the southern coasts of both the Cape and islands. Tidal marshes fringe the shore line and reach impressive acreages, especially at the outer end of the Cape behind the barrier beaches and at Barnstable along the southern shore of Cape Cod Bay. Intertidal boulders dot exposed beaches, high colorful sea cliffs mark Gay Head, and the long straight shore of the outer Cape faces the North Atlantic Ocean.

The Gulf Stream lies some 150 kilometers southeast of Woods Hole. As a result of cold water masses north of the Cape, the temperature of the seawater in Cape Cod Bay in late summer is several degrees lower than that in the southern sounds. Cape Cod forms the rough boundary between two major marine provinces, and most of the organisms found in the western North Atlantic, from Nova Scotia to Cape Hatteras, are represented in the Cape Cod Region.

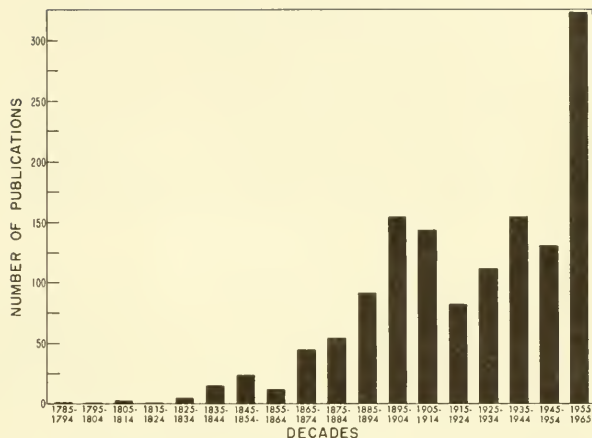
Serious study of the Region began in the early 1800's, and as indicated by the frequency of publication of the 1,360 literature references in this Bibliography, has intensified with the decades.

Henry David Thoreau, 1864. Cape Cod. Houghton Mifflin Co., Boston, Mass.



Map of the Cape Cod region.

ASHMORE



Frequency of publication of literature references cited in the Bibliography shown for ten year intervals.

Edward Hitchcock (1833) discussed the formation of Cape Cod in his preliminary report on the geology of Massachusetts, a publication believed by Chamerslain (1964) "to have been the first state geology report in the nation." Among the reasons why geologists have studied the Region is the observation by Woodworth and Wigglesworth (1934) that "Cape Cod more than any other part of southeastern New England shows the changes due to the ravages of the sea since the glacial epoch."

Early naturalists were attracted to Cape Cod by the intrinsic natural beauty of the terrain, the varied wildlife inhabiting the bogs, ponds, salt marshes, dunes, beaches and waters, and by the often tempestuous interplay of land and sea. The U. S. National Park Service recognized the uniqueness of the Cape when it established the Cape Cod National Seashore, noting "The combination of these features cannot be matched anywhere on the Atlantic Coast." Thoreau was also well aware of it when he wrote "We went to see the Ocean, and that is probably the best place of all our coast to go to."

Biologists started describing the biota of the Cape Cod Region prior to 1844 when A. A. Gould recognized Cape Cod as a natural faunal boundary between Arctic and temperate organisms. In a long list of papers, for example, Storer (1839-1859) provided records of fish; Desor (1851) described the distribution of animal life among Nantucket shoals and observed that "modern investigations merely go to confirm the great idea which was vaguely anticipated by the ancient poets and philosophers, that the Ocean is the origin of all things;" Stimpson (1854) named new species of mollusks; Atwood (1861-1873) wrote on the habits of bluefish, cod and mackerel and discussed the fisheries; and A. Agassiz (1862-1877) reported on invertebrates.

Spencer F. Baird's activities in the Region in 1871 including his founding of the Bureau of Fisheries Laboratory in Woods Hole in 1875, establishment of the first American seaside laboratory on Penikese Island by Louis Agassiz in 1873, and incorporation of the Woods Hole Marine Biological Laboratory in 1888, provided a catalyst for further research in the Cape Cod Region. The number of publications during the period 1885-1914 undoubtedly reflects this scientific activity.

Earliest comprehensive contributions to the systematics and ecology of the marine biotic communities of the Region were made by Verrill (1873), S. I. Smith (1873) and Verrill, Smith, and Harger (1873) in their census of the invertebrate animals of Vineyard Sound and adjacent waters during the summer of 1871. Their first field studies included some 400 dredgings, principally in Vineyard Sound, and to a lesser extent in southern Buzzards Bay, western Nantucket Sound, and northeastern Rhode Island Sound, and ranged bathymetrically from the high water line outward. Lists and illustrations of the macroscopic species encountered and descriptions of the major habitats of the area are given.

Later Sumner (1910) and Sumner, Osburn, Cole and Davis (1913) published the results of a detailed qualitative systematic study of the distribution of macroscopic benthic plants and animals of Vineyard Sound and Buzzards Bay in relation to the gross nature of the bottom and the temperature and salinity of the water. Investigations were carried out by means of dredging operations in open waters during the summers of 1903-05, with supplementary work during the following four summers; intertidal and shallow waters were excluded. This useful publication supplemented the reports of Verrill and associates and added a detailed catalog and distributional charts of many of the macroscopic species reported for the area.

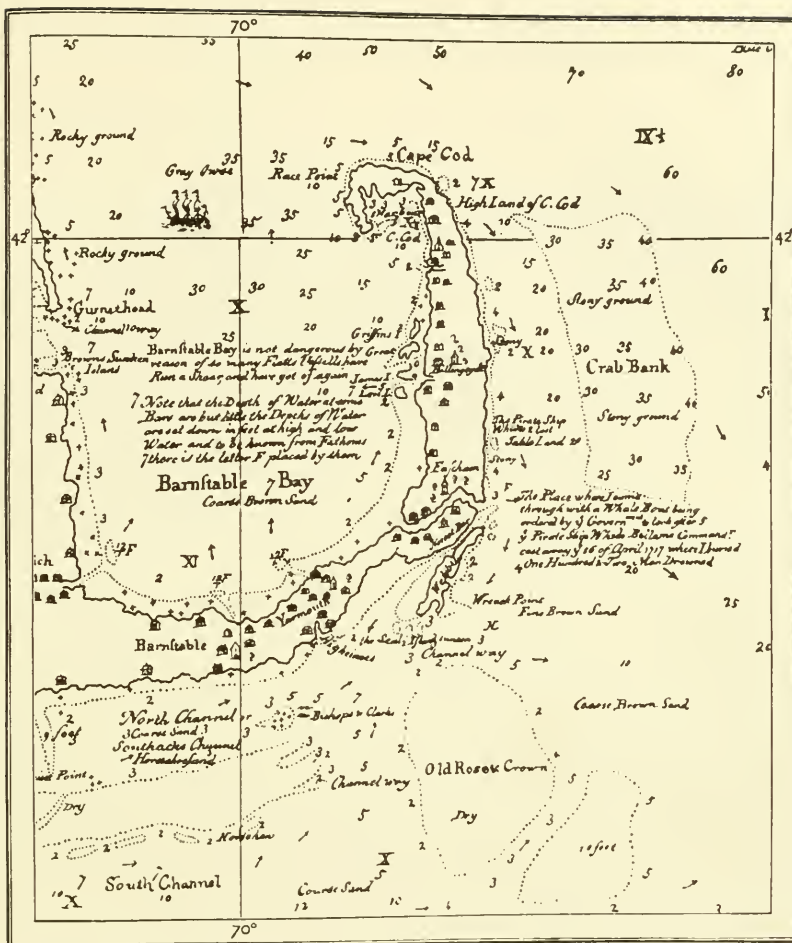
The number of new species which has been described in the Cape Cod Region is over 500. In terms of the estimated total number of 10,000 species probably occurring in the Region, this is a sizeable contribution, and one made primarily through the indefatigable efforts of early systematists. New species are still being described in the Region as field biologists pursue their investigations.

As an introduction to the Bibliography, we have selected excerpts from various publications and matched the quotations with appropriate photographs taken in the region within the last five years. These excerpts describe in the author's own words the diversity of the Cape and islands and suggest the many reasons why this Region drew their attention.

M. R. Carriker

A. E. Yentsch

December 1966



Early map of Cape Cod apparently drawn around 1720 by a Boston pilot named Cyprian Southack. Plate 71 from Ann. Rept. U. S. Cst. Geod. Surv., 1890.

The fifteenth day we had again sight of the land, which made ahead, being as we thought an island, by reason of a large sound that appeared westward between it and the main, for coming to the west end thereof, we did perceive a large opening, we called it Shoal Hope. Near this cape we came to anchor in fifteen fathoms, where we took great store of codfish, for which we altered the name, and called it Cape Cod. Here we saw sculls of herring, mackerel, and other small fish, in great abundance.

John Archer, 1602.

Henry Beston, 1929. *The Outermost House*. Doubleday, Doran & Co., Inc.
Garden City, New York.

East and ahead of the coast of North America, some thirty miles and more from the inner shores of Massachusetts, there stands in the open Atlantic the last fragment of an ancient and vanished land. . . . a great ocean beach runs north and south unbroken, mile lengthening into mile. Solitary and elemental, unsullied and remote, visited and possessed by the outer sea, these sands might be the end or the beginning of a world. Age by age, the sea here gives battle to the land; age by age, the earth struggles for her own, calling to her defence her energies and her creations, bidding her plants steal down upon the beach, and holding the frontier sands in a net of grass and roots which the storms wash free. The great rhythms of nature, . . . have here their spacious and primeval liberty; cloud and shadow of cloud, wind and tide, tremor of night and day. Journeyming birds alight here and fly away again all unseen, schools of great fish move beneath the waves, the surf flings its spray against the sun.

Often spoken of as being entirely glacial, this bulwark is really an old land surfaced with a new. The seas broke upon these same ancient bounds long before the ice had gathered or the sun had fogged and cooled. There was once, so it would seem, a Northern coastal plain. This crumbled at its rim, time and catastrophe changed its level and its form, and the sea came inland over it through the years. Its last enduring frontier roughly corresponds to the wasted dyke of the cliff. Moving down into the sea, later glaciations passed over the old beaches and the fragments of the plain, and, stumbling over them, heaped upon these sills their accumulated drift of gravels, sand, and stones. The warmer sea and time prevailing, the ice cliff retreated westward through its fogs, and presently the waves coursed on to a new, a transformed and lifeless, land.

Outer beach of Cape Cod at Nauset.



YENTSCH

The east side of the cape, through Wellfleet and Truro, is a nearly continuous bluff, one hundred to one hundred and sixty feet high, horizontally stratified, being evidently a remnant of a nearly level plain, the east part of which has been washed away by the sea. This process is still going forward.

Warren Upham, 1879.



Eroding sea cliffs along the shore of Outer Cape Cod.

YENTSCH

The wind loosens and tears down the incoherent gravel and sand in the coastal bluffs. On fair days when dry winds are blowing in a favorable direction, pebbles loosened by the blowing out of the sand at their bases roll down to a sandy talus. Many of these pebbles take somewhat curved courses, ricocheting so as to leave a series of pits on the beach sand leading to the resting place of the spent pebble. Hundreds of small streams of dry sand run out from incoherent layers to add their contribution to the growing fan of talus that rises between the beach and the top of the wasting cliff. When very high winds are blowing inland, sand and dust are carried up the slope and on to the surface back of the cliff.

J. B. Woodworth. In Woodworth & Wigglesworth, 1934.

The dunes or sand hills, which are often nearly or quite barren of vegetation, and of snowy whiteness, forcibly attract the attention on account of their peculiarity. . . . As we approach the extremity of the Cape, the sand and the barrenness increase; and in not a few places, it would need only a party of Bedouin Arabs to cross the traveler's path, to make him feel that he was in the depths of an Arabian or Lybian desert.

Edward Hitchcock, 1833.



Sand dunes on the southwest shore of Nantucket Island.

VAN ZANDT

Sand is frequently thrown by the spray, or waves, during a storm, so high upon the shore, that the reflux waves do not carry it back. This being dried by the sun, is driven inwards by the sea breezes, and in the course of time forms hills of considerable elevation. Or sometimes the wind from the sea raises the sand from a cliff or tertiary formation and carries it inland. Thus are formed those moving sand hills, which on the eastern continent, are called dunes or downs, and which have excited so much interest near the banks of the Nile. . . . They may be seen in the greatest perfection and on the largest scale, on Cape Cod; particularly near its extremity. They are frequently as high as 60 or 70 feet, and on the east end of the Cape, they move towards the west, . . . A series of these dunes, several miles long, threatens the village and bay of Provincetown, and large quantities of the beach grass have been transplanted to their ridges for the purpose of arresting their progress.

Edward Hitchcock, 1833.

Even where this artificial modification of the swamps has changed the regimen of their lesser creeks, this water system remains one of the most beautiful exhibitions of natural forces which the sea shore affords. There being everywhere the same pressure of the growing sod against their streams, they are free to cast their curves into exactly the form which the pendulum motion of their currents demands. . . . The only likeness in symmetry to these tidal rivers is found in the fresh-water swamps, whose clear natural streams flow through matter resembling in its process of growth the peat of the salt-water swamp, but even there the changes in the volume of the current make its curves less beautiful than those of the tidal marshes.

N. S. Shaler, 1885



Tidal marsh in Pleasant Bay.

OLDHAM

The reconstructions provide a picture of the ontogeny of the Bamstable marsh which is orderly and plausible. They indicate that the sand spit has grown eastward during a period of about 4000 years. The marsh, which consisted at first of isolated pockets in protected indentations of the upland, became continuous and began to spread into the enclosure from along the upland margin as sediment accumulated in its shallower parts and protection from the sea became more complete. The development of marsh along the margin of the sand spit proceeded more slowly, perhaps because the basin deepened with distance from the upland and more time was required for sedimentation to reduce its depth. The broad sounds between the advancing tongues of marshland became the site of the future creeks, and the meandering channels in the sand which formed their bottom defined the final pattern which these creeks assumed. High marsh has now extended to the margin of these channels and at present the creeks are in quasi-equilibrium with the hydraulic forces which arise from the quantity of water which they must carry in response to the rhythm of the tide.

Alfred C. Redfield, 1965

There is, however a more definite limit to the encroachment of these upper-level salt marshes upon the tidal streams. As the marshes extend they narrow the channels occupied by the free-running tide until they reduce its flowage-ways to very limited bounds, the lines of which are determined by a delicate adjustment of the forces which extend the marsh area and the destructive scouring action of the tide exercised on its growing edge. There is no other case in nature, save in the coral reefs, where the adjustment of organic relations to physical conditions is seen in such a beautiful way as in the balance between the growing marshes and the tidal streams by which they are at once nourished and worn away.

N. S. Shaler, 1885.



Tidal stream in western Nantucket Island.

VAN ZANDT

Sediment layers, streaked like bright finger-smearred dyes, show red, green, tan, gray, yellow, brilliant white and nearly coal black across the face of the cliffs and give this foreland its name.

Some layers are primarily sand, others mainly gravel, others compact clay. Some are full of fossils; large glacial boulders protrude like bony knuckles from others. This colorful confusion of sediments, the creased and shuffled pages of an ancient manuscript, contains New England's most complete record of its past hundred million years. It tells a story of a land first covered with ancient forests, then engulfed by seawaters, laid bare and engulfed again; of giant sharks swimming over what are now the meadows of Chilmark, of camels and horses roaming the plains where Gay Head now rises; of a series of overpowering invasions by ice floes from the north.

Barbara Chamberlain, 1964.



Sea cliffs of Gay Head, Martha's Vineyard.

YENTSCH

Ever since Baird's time it has been generally known that this is the best place on the Atlantic coast for the study of marine biology. Indeed, Wood's Holl has become a strong biological center by virtue of the exceptional opportunities for work here offered in a varied and extensive shore fauna and flora, in numerous accessible islands rich in forms of peculiar interest, and in many perfectly isolated fresh-water ponds, brackish ponds, and salt-water ponds of easy control.

C. O. Whitman, 1902.



CARRIKER

Aerial view of the Woods Hole scientific community, showing U. S. Bureau of Commercial Fisheries Biological Laboratory on the left, the Marine Biological Laboratory in the center, and the Woods Hole Oceanographic Institution on the right.

A totally different condition of things was found at Woods Hole where 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 specially 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 this station was finally fixed upon for the purpose in question.

Spencer F. Baird, 1881

The Marine Biological Laboratory had its origin in the latter part of the last Century when naturalists came to appreciate the vast variety of life in the sea. Since then, biology has evolved very rapidly and has come to include a number of more or less specialized subdivisions. Great departments of biology have grown up at our universities.

In this great development, the Marine Biological Laboratory played a leading role. It became the summer meeting ground for professors and students of all branches of biology from all over the Country. It acquired an outstanding scientific library. It became a headquarters for experimental physiology. It is still a beehive of scientific activity, but its sea-side location has become almost incidental.

At Woods Hole, the late 1920's also marked the beginnings of another step forward in North Atlantic oceanography. A special committee of the National Academy of Sciences had been at work studying the national needs in marine science. This committee recommended the establishment of a new facility . . .

Thus, in 1930, it seemed advisable to establish a new laboratory at Woods Hole that would have as its objectives the study of the oceans as a whole: their physics, their chemistry, their geology, and their meteorology, as well as some aspects of their biology, in particular, their ecology.

By the Summer of 1931, the Woods Hole Oceanographic Institution was a going concern, with a sea-going vessel and a small part time staff recruited largely from eastern university campuses.

Columbus O'Donnell Iselin, 1957. Matthew Fontaine Maury (1806-1873).
"Pathfinder of the Seas" -- The Development of Oceanography.

The marine life of the Woods Hole region is more fully and accurately known than is that of any other region of similar extent on the western shore of the Atlantic, and there are but few regions anywhere in the world where such knowledge is more complete. Of marine animals alone, approximately 1700 species are known from Vineyard Sound and Buzzards Bay, and the marine plants are correspondingly numerous.

Edward Linton, 1915.

Dredge haul taken in Vineyard Sound at a site where *Arbacia*, *Amaroucium* and *Aequipecten* were abundant.



CARRIKER



CARRIKER

Collecting at a rock jetty at low tide, at the eastern entrance of the Cape Cod Canal.

In prosecuting our explorations we soon found that there are, in the waters of this region, three quite distinct assemblages of animal life, which are dependent upon and limited by definite physical conditions of the waters which they inhabit. The first of these includes all those kinds which inhabit the bottom and shores of Vineyard Sound, Buzzard's Bay, and the other similar bodies of shallow water along this coast from Cape Cod westward and southward. These shallow waters consist of nearly pure sea-water, which has a relatively high temperature, especially in summer, for it is warmed up both by the direct heat of the sun, acting on the shallow waters spread over broad surfaces of sand, and by water coming directly from the Gulf Stream, and bringing not only its heat, but also its peculiar pelagic animals. . . .

The second assemblage is a very peculiar one, which inhabits the estuaries, ponds, lagoons, harbors, and other similar places, where the water is shallow and more or less brackish, and very warm in summer, but cold in the winter. The third group inhabits the shores of the outer islands and headlands and the bottoms in moderately deep water, outside of the bays and sounds. These outer waters are comparatively cold, even in summer, and are no doubt derived from an offshoot of the arctic current, which drifts southward along our shores in deep water and always has a tendency to crowd against and up its submarine slopes, in which it is also aided in many cases by the tides.

A. E. Verrill, 1873.



Sand flats exposed at low tide along a Cape Cod Beach.

But the influence of the Gulf Stream extends much nearer to the coast than the edge of the continental shelf, and without doubt affects our local faunal conditions. The presence nearly every year in Vineyard Sound of considerable masses of the Sargassum bacciferum, with its attendant fauna, shows that strong southerly winds may drive the surface water of the Gulf Stream as far as the mainland of Massachusetts. And, apart from these occasional and obvious effects, it is probable that the warm current exerts a constant influence upon the coastal waters of southern New England, the two undergoing a certain degree of intermingling as a result of winds and tides.

Sumner, Osborn, Cole & Davis, 1913.



CARRIKER

Edgartown Great Pond estuarine system seen from the air; barrier beaches have closed off the inlets.



CARRIKER

A rocky intertidal area at Sesuit Harbor, Cape Cod Bay, where the macroscopic algae *Fucus* and *Ascophyllum* were abundant.

The northern shore of Cape Cod, from its sandy character, is practically destitute of all species of algae, except a few forms which are here and there found growing on the eel-grass. As soon as we pass to the south of Cape Cod, however, the flora assumes an entirely different aspect. . . . It will be seen that Cape Cod is the dividing line between a marked northern and a southern flora. In fact, the difference between the floras of Massachusetts Bay and Buzzards Bay, which are only a few miles apart, is greater than the difference between those of Massachusetts Bay and the Bay of Fundy, or between those of Nantucket and Norfolk. This difference in the flora corresponds precisely with what is known of the fauna.

W. G. Farlow, 1882a.

The boring gastropod *Eupleura caudata*.



OLDHAM



The hydroid *Pennaria tiarella*.

OLDHAM

Abundant on the piles of Fish Commission dock at Woods Hole, and also growing profusely on eel grass near the Hole. One of the most abundant and beautiful species on our coasts.

C. C. Nutting, 1899



Apeltes quadracus, a small fish of the eel grass community.

AMOS



AMOS

Algae, hydroids and *Spirorbis* on blade of eel grass, *Zostera marina*.

. . . for while the nature of the sea water governs the lives of the animals and plants that inhabit it, at the same time the functions of the latter are as constantly altering the nature of their environment in a way to which we see nothing comparable on land.

Henry B. Bigelow, 1931. *Oceanography, Its Scope, Problems, and Economic Importance*. Houghton Mifflin Company, Boston, Mass.



The barnacle *Balanus balanoides*.

OLDHAM

. . . the surface of the sea is sometimes covered for thousands of square yards with great submerged rafts of *Mnemiopsis leidyi*, the individuals touching one the other . . .

A. G. Mayer, 1912.



OLDHAM

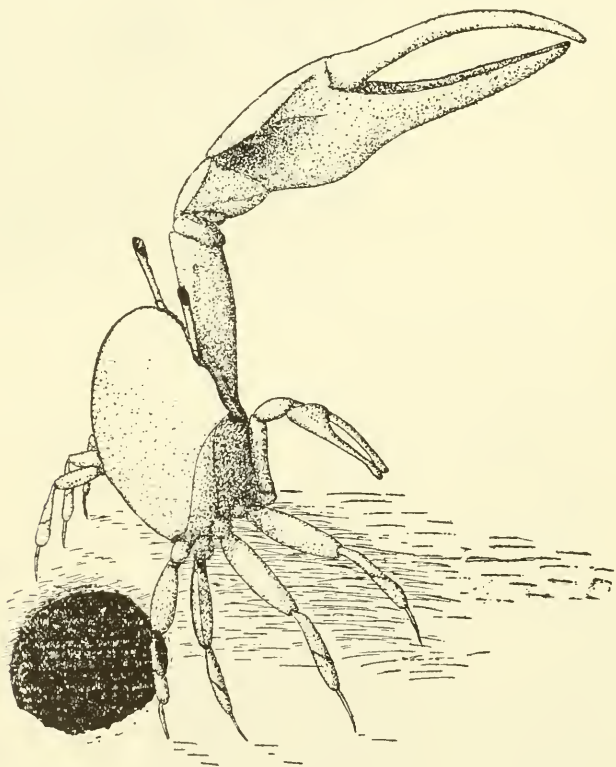
The ctenophore *Mnemiopsis leidyi*.

The importance of marine life for the study of general biology depends on several circumstances. . . . the oceans, which now constitute about two-thirds of the earth's surface, contain forms of animal life never found on continents or in their fresh waters. Many of these are the most ancient forms, in a geological sense, in the world. The entire phylum of Echinodermata is exclusively marine; so, with minor exceptions, are the sponges and coelenterates. Among the mollusks the cephalopods (squids and octopi) are exclusively marine; and among the vertebrates the Selachia (sharks, rays, etc.) are practically exclusively marine. Apart from such great and zoologically important groups, the oceans contain myriads of forms representing every phylum of the animal kingdom specially adapted to various oceanic environments, such as those of the almost infinitely diversified shore or littoral regions, of the pelagic (lighted) and the abyssal (unlighted) zones of the free oceans to the floor at great depths, and of great oceanic territories such as those of the Gulf Stream and other ocean currents and of the arctic and antarctic cold and of the tropics.

Frank R. Lillie, 1944. The Woods Hole Marine Biological Laboratory
University of Chicago Press, Chicago.

From June 28 to August 13, 1912, the writer occupied a room in the Marine Biological Laboratory at Woods Hole, Massachusetts, and had opportunity to extend his observations on fiddler-crabs. . . . Fiddlers seemed to feel that the necessity for having their burrows closed when the tide came in was very urgent. Once I pulled up all the grass on a thickly populated area about six feet square and chased all the crabs into their holes; then I sat in front of this open space while the tide came in and covered the mouths of the burrow. Though the crabs were timid, and apparently feared me, several of them rushed out when the water came near, and, after hastily grabbing one or more pellets of mud, plugged their holes. Other animals that were observed to be active when the tide came in, and which might have harmed the fiddlers, were ribbon-fish, minnows, green crabs, and prawns.

A. S. Pearse, 1914b.



Uca pugilator. Waving at mouth of burrow (from Pearse, 1914b).

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seasonal distribution

Lillick, L. C., 1937

Dibothrium aluteraeparasite of *Alutera schoepfi*

Linton, E., 1889-1891

Dibothrium manubriforme

Linton, E., 1889-1891

parasite of *Histiophorus gladius*

Linton, E., 1894

parasite of *Tetrapturus albidus*

Linton, E., 1889-1891

Dibothrium microcephalumparasite of *Mola rotunda*

Linton, E., 1889-1891

Dibothrium plicatumparasite of *Xiphias gladius*

Linton, E., 1889-1891

Dibothrium punctatumparasite of *Bothus maculatus*

Linton, E., 1898b

parasite of *Limanda ferruginea*

Linton, E., 1889-1891

parasite of *Lophosetta maculata*

Linton, E., 1889-1891

Dibothrium restiformeparasite of *Tylosurus caribbaeus*

Linton, E., 1889-1891

Dibothrium nigosumparasite of *Gadus callarias*

Linton, E., 1898b (1897)

parasite of *Gadus cestoda*

Linton, E., 1894

parasite of *Gadus morrhua*

Linton, E., 1889-1891

seasonal distribution in *Gadus*

Linton, E., 1914

Dichelesteidae

development

McClendon, J. F., 1906-1907

Dichelestium sturionisparasite of *Acipenser oxyrhynchus*

Rathbun, R., 1885

Dictyocha

Peck, J. I., 1896

Dictyocha fibula

Margalef, R., 1960a

Dictyocha fibula var. *pentagona*

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Fundulus

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Linton, E., 1922a

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Verrill, A. E., 1874

Dinophyceae

new species

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unarmoured

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Dinophysis

Peck, J. I., 1896

Diodon hystrix

Smith, H. M., 1898a, 1898b

Diopatra cuprea

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Pearse, A. S., 1928

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Diplodus argyrops

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Discocephalum pileatumhost of *Carcharias obscurus*

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Margalef, R., 1960a
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parasite of *Paralichthys dentatus*
Linton, E., 1901a
parasite of *Prionotus carolinus*
Linton, E., 1901a
parasite of *Stenotomus chrysops*
Linton, E., 1901a
seasonal distribution in *Microgadus tomcod*
Linton, E., 1914
- Distomum appendiculatum*
parasite of *Paralichthys dentatus*
Linton, E., 1901a
- Distomum areolatum*
parasite of *Morone americana*
Linton, E., 1901a
- Distomum dentatum*
parasite of *Paralichthys dentatus*
Linton, E., 1901a
- Distomum faecundum*
parasite of *Lopholatilus chamaeleonticeps*
Linton, E., 1901a
- Distomum foliatum*
parasite of *Mola mola*
Linton, E., 1898c
- Distomum fragile*
parasite of *Mola mola*
Linton, E., 1901a
- Distomum grandiporum*
parasite of *Anguilla chrysoptera*
Linton, E., 1898c
- Distomum gulosum*
parasite of *Rhombus triacanthus*
Linton, E., 1901b
- Distomum lageniforme*
parasite of *Remora remora*
Linton, E., 1898c
- Distomum macocotyle*
parasite of *Mola mola*
Linton, E., 1898c
- Distomum monticelli*
parasite of *Remora remora*
Linton, E., 1898c
- Distomum nigroflavum*
parasite of *Mola mola*
Linton, E., 1898c
- Distomum nitens*
parasite of *Tyosurus caribbeus*
Linton, E., 1898c
- Distomum ocreatum*
parasite of *Pomatomus saltatrix*
Linton, E., 1898c
parasite of *Merluccius bilinearis*
Linton, E., 1901a
parasite of *Pollachius virens*
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parasite of *Sagitta*
Linton, E., 1927
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parasite of *Alutera schoepfi*
Linton, E., 1898c
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parasite of *Paralichthys dentatus*
Linton, E., 1901a
- Distomum pyriforme*
parasite of *Palinurichthys perciformis*
Linton, E., 1901a
- Distomum rufoviride*
parasite of *Roccus lineatus*
Linton, E., 1898c
- Distomum simplex*
parasite of *Microgadus tomcod*
Linton, E., 1898c
- Distomum tenue*
parasite of *Roccus lineatus*
Linton, E., 1898c
- Distomum tenue tenuissimum*
parasite of *Morone americana*
Linton, E., 1898c
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parasite of *Alutera schoepfi*
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geology
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temperature, water
Matthiesen, G. C., 1960
water density
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Provenzano, A. J., Jr., 1961
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host for *Cyclopsinema mordens*
Cobb, N. A., 1928 (1927)
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Smith, S. I., 1877-1882b
- Pachystomos clisthus*
Rudzinska, M. A., 1952
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parasite of *Pagurus longicarpus*
Reinhard, E. G., 1945
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with *Hydractinia*
Bunting, M., 1894
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Benedict, J. E., 1901
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host for *Gymnodinioides inkystans*
Trager, W., 1957
host for *Paguritherium alatum*
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Thompson, M. T., 1902
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Fraenkel, G., 1960
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Lyman, T., 1861
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heliotropism
Lyon, E. P., 1906b
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behavior, larval
White, G. M., 1924
breeding
Thompson, M. T., 1899
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Webb, H. M., F. A. Brown, Jr. & R. C. Graves, 1952
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larval
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Smith, H. M., 1898a, 1921
host for *Distomum pyriforme*
Linton, E., 1901a

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 host for *Ligula*
 Linton, E., 1941
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 Linton, E., 1901a
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 Cole, L. J., 1901
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 Wilson, E. B., 1880
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 Butler, P., 1959
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 parasite of *Carcharinus obscurus*
 Rathbun, R., 1885
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 Rathbun, R., 1887a
 development
 McClendon, J. F., 1906-1907
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 parasite of *Odontaspis littoralis*
 Rathbun, R., 1887a
- Pandocia*
 Van Name, W. G., 1907-1912b
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 Wilson, J. H., 1905
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 Sharpe, R. W., 1911
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 Hargitt, C. W., 1914
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 Pettibone, M. H., 1956
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 Pennak, R. W., 1942a
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 host for *Anisoporus manteri*
 Hunninen, A. V. & R. M. Cable, 1940, 1941
 host for *Chondracanthus galeritus*
 Rathbun, R., 1887a
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 Linton, E., 1901a
 host for *Distomum appendiculatum*
 Linton, E., 1901a
 host for *Distomum dentatum*
 Linton, E., 1901a
 host for *Distomum pundens*
 Linton, E., 1901a
 host for *Echinorhynchus sagittifer*
 Linton, E., 1889
 host for *Ichtheonema sanguineum*
 Linton, E., 1901a
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 Linton, E., 1898c
 host for *Pontobdella rapax*
 Linton, E., 1901b
 parasites of
 Linton, E., 1901a
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 Harger, O., 1880a
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 Smith, S. I., 1878-1882
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 Illg, P. L., 1955
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 Provenzano, A. J., Jr., 1961
 Reinhard, E. G., 1945
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 Linton, E., 1889, 1892a
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 Allen, M. J., 1952
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 Linton, E., 1915b, 1915c
- cestode
 Linton, E., 1889, 1889-1891, 1897, 1898b, 1898 (1897) 1905, 1907a

Parasites

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Hahn, C. W., 1918
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Connolly, C. J., 1929
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Summers, F. M. & G. W. Kidder, 1936
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Linton, E., 1901a
McClendon, J. F., 1906-1907
Rathbun, R., 1885, 1887a, 1888
Willey, C. H., 1958
Wilson, C. B., 1903b 1905b, 1906, 1921, 1925, 1932
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Curtis, W. C., 1903
- Cyclopsinema mordens*
Cobb, N. A., 1928 (1927)
- entozoan
Linton, E., 1889-1891, 1910a
- fish
Linton, E., 1894, 1898a, 1898c, 1901a
1901b, 1914, 1941
Wilson, C. B., 1905a
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Linton, E., 1934c
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Linton, E., 1892b
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Reinhard, E. G., 1949
Thompson, M. T., 1902
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Hunninen, A. & R. M. Cable, 1943a
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Osburn, R. C., 1912
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Stunkard, H. W., 1950b
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Calkins, G. N., 1915
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Hahn, C. W., 1917a, 1917b
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Rogick, M. D., 1945-1949
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Wheeler, W. M., 1894a
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Kudo, R., 1923
Renn, C. E., 1935
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Reinhard, E. G., 1946
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Meinkoth, M. A., 1956
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Ryder, J. A., 1884b
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Linton, E., 1915c
- sporozoan
Linton, E., 1915c
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Cable, R. M., 1954
Cable, R. M. & A. V. Hunninen, 1939, 1940, 1941, 1942
Cable, R. M. & H. W. Stunkard, 1931
Hsiao, S. C., 1941

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Hunninen, A. V. & R. M. Cable, 1940, 1941, 1943b
Linton, E., 1898
Manter, H. W., 1926
Martin, W. E., 1938, 1939, 1940, 1944
Miller, H. M., Jr. & F. E. Northup, 1926
Stunkard, H. W., 1936, 1938, 1943, 1950a, 1951, 1953, 1957, 1960, 1961, 1962a, 1962b, 1964
Stunkard, H. W. & R. M. Cable, 1932
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Hargitt, C. W., 1902a
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Hexamatia, parasite of *Deropristis inflata*
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parasite of *Dasyatis centrura*
Linton, E., 1889, 1898b
parasite of *Trygon centrura*
Linton, E., 1889-1891
- Paratanais algicola*
Harger, O., 1878
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life history
Stunkard, H. W. & R. M. Cable, 1931, 1932
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in Asteroidea
Greeley, A. W., 1902
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host, intermediate
Stunkard, H. W., 1962a
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development
Allen, C. M., 1900
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flora
Fogg, J. M., Jr., 1939
nudibranch fauna of salt marsh
Russell, H. D., 1946
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on *Sargassum*
Hargitt, C. W., 1908
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see *Pinnotheres*
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Barnstable Marsh
Redfield, A. C., 1965b, 1965c
Redfield, A. C. & M. Rubin, 1962a, 1962b
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Redfield, A. C., 1965a
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fossiliferous
Woodworth, J. B., 1892
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Julien, A. P., 1907
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autecology
Belding, D. L., 1910b
- fishery
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Lyman, T., 1861
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natural history
Posgay, J. A., 1950, 1953
- respiration
Van Dam, J., 1954

Pecten irradians

- Plaine, H. L., 1952
 Turner, H. J. & J. E. Hanks, 1960
- hermaphroditism
 Grave, B. H. & J. Smith, 1936a
- host for Trematode sporocysts & cercariae
 Linton, E., 1915c
- infested by *Polydora ciliata*
 Plaine, H. L., 1952
 Turner, H. J., Jr. & J. E. Hanks, 1959
- respiration
 Van Dam, L., 1954
- Pecten magellanicus*
 Wilson, J. H., 1905
- Pecten tenuicostatus*
 evolution
 Drew, G. A., 1907a
- morphology
 Drew, G. A., 1907a
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 behavior
 Miner, R. W., 1912
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 fossil
 Raup, D. M. & D. R. Lawrence, 1963
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 Rogick, M. D. & H. Croasdale, 1949
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 Hargitt, C. W., 1902b
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 Desor, E., 1851d
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 Adams, C. B., 1839a, 1941b
 Belding, D. L., 1910a, 1910b, 1914, 1916, 1930
 Clench, W. J. & C. G. Aquayo, 1931
 Drew, G. A., 1899
 Field, I. A., 1922
 Grave, B. H., 1928a
 Jackson, R. T., 1888a
 Johnson, C. W., 1932
 Lyman, T., 1861
 Matthiessen, G. C., 1960
 Orr, P. R., 1946
 Plaine, H. L., 1952
 Ropes, J. W., 1963
 Ropes, J. W. & C. E. Martin, 1960
 Stimpson, W., 1854a, 1854b
 Storer, D. H., 1839
 Turner, H. J., Jr., 1951, 1957
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 Verrill, A. E., 1872, 1873
 Winkley, H. W., 1907
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 Stephens, G. C. & R. A. Schinske, 1958
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 Clarke, G. L., 1947
- behavior
 Bennett, M. F., 1954
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 Drew, G. A., 1907b

Pelecypoda

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 Grave, B. H., 1927a, 1927b, 1928b
 Merrill, A. S. & R. D. Turner, 1963
 Turner, H. J., Jr. & C. J. George, 1955
- feeding
 Blake, J. W., 1961
 Jørgensen, C. B., 1952
- sexual
 Coe, W. R., 1934, 1936a
- breeding
 Thompson, M. T., 1899
- commensalism
 Linton, E., 1910c
 Patterson, J. T., 1912
- development
 Galtsoff, P. S., 1954
 Grave, B. H., 1926
 Jackson, R. T., 1888b
 Kellogg, J. L., 1905
 Richards, O. W., 1935, 1946
 Turner, H. J., Jr., 1950
- distribution
 Carpenter, H. F., 1889
 Connell, J. H., 1955
- evolution
 Drew, G. A., 1907a
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 Galtsoff, P. S., H. F. Prytherch & H. C. McMillin, 1930
 Posgay, J. A., 1950, 1953
 Turner, H. J., Jr., 1949b
 Wheeler, C. L., 1948
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 Lyell, C., 1844
 Merrill, F. J. H., 1890
 Sanford, S. N. F., 1934
 Scudder, S. H., 1877
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 Turner, H. J. & J. E. Hanks, 1960
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 Pierce, M. E. & J. E. Currier, 1951, 1952
- hermaphroditism
 Grave, B. H. & J. Smith, 1936a
- intertidal freezing
 Kanwisher, J. W., 1955
- life history
 Kellogg, J. L., 1901
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 Dall, W. H., 1894
- morphology
 Ryder, J. A., 1889
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 Hunter, W. R. & D. C. Grant, 1962
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 Burnett, A. L., 1955, 1960
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 Boss, K. J. & A. S. Merrill, 1965
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 Cable, R. M., 1954
 Linton, E., 1915c
 Martin, W. E., 1940
- periodicity
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 Ayers, J. C., 1956
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 Lavoie, M. & G. G. Holz, Jr., 1955
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 Turner, H. J., Jr., 1949a
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 Shaw, W. N., 1962
 raft grown
 Shaw, W. N., 1963
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 Van Dam, L., 1954
 seasonal growth
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 Rhoads, D. C., 1963
 sex inversions
 Grave, B. H. & J. Smith, 1936b
 sexual cycle
 Grave, B. H., 1942
 shell inclusions
 Merrill, A. S., 1960
 symbiosis
 Gray, G. M., 1933
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 Reinhard, E. G., 1946
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 Croasdale, H., 1948
 Doty, M. S., 1948
 Jordan, D. S., 1874
 Lewis, I. F., 1924
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 Zinn, D. J., 1954
 palynology
 post glacial sea level
 Deevey, E. S., Jr., 1948
 Protozoa
 Croasdale, H., 1948
 Zinn, D. J., 1954
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 Lochhead, J. H., 1954
 distribution
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 Jenner, C. E., 1936a
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 Jenner, C. E. & N. A. Chamberlain, 1955
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 morphology, variation
 Hargitt, C. W., 1901
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 breeding
 Thompson, M. T., 1899
 development
 Hargitt, C. W., 1900a, 1904b
 morphology
 Smallwood, M., 1899
 natural history
 Hargitt, C. W., 1900a
 nematocysts, manipulation
 Kepner, W. A., 1943
 ontogeny
 Hargitt, C. W., 1911
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 Lackey, J. B., 1940
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 distribution
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Peridinium triquetrum
 seasonal distribution
 Hulburt, E. M., 1956b
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 Fingerman, M., 1957a
 Stier, T. J. B., 1933
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 Fingerman, M., 1955
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 Faure-Fremiet, E., 1951b
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 Haseman, J. D., 1911
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 Barnwell, F. H. & F. A. Brown, Jr., 1963
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Periodicity

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daily
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Fingerman, M., 1955
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Stephens, G. C., J. P. Greene, B. Guttman & R. A. Schinske, 1958
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Fingerman, M., 1957b
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Webb, H. M. & F. A. Brown, Jr., 1965
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Stephens, G. C., 1955
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Bennett, M. F., 1954
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Rathbun, R., 1888
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Rudzinska, M. A., 1947
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development
Jackson, S. F., 1958
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Van Name, W. G., 1907-1912a
Verrill, A. E., 1871b
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Metcalf, M. M., 1895
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see *Littorina* (3 species)
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Hartman, O., 1942b, 1944
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Sparrow, F. K., 1936
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distribution, spatial
Connell, J. H., 1955
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Schalk, M., 1938
faceted pebbles
Davis, W. M., 1895
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systematics
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Thivy, F., 1943
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Collins, F. S., 1906, 1908b, 1914, 1918
Farlow, W. G., 1882b
Schuh, R. E., 1900a
Taylor, W. R., 1928, 1941
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Wieser, W. & J. Kanwisher, 1959
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Rogick, M. D. & H. Croasdale, 1949
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Papenfuss, G. F., 1935
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Collins, F. S., 1891, 1896
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Simons, E. B., 1906
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method of determination by fluorescence
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Van Name, W. G., 1907-1912b
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behavior
Miner, R. W., 1912
tolerance to low salinity
Pearse, A. S., 1928
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parasite of *Xiphias gladius*
Linton, E., 1901b
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Harger, O., 1880a
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U. S. Fish Commission, 1901
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stomach contents
Griffin, D. R., 1936

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fossil
Gould, A. A., 1841
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Wilson, J. H., 1905
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Smith, H. M., 1898a
- Phoreiobothrium exceptum*
parasite of *Cestracion zygaena*
Linton, E., 1925
- Phoreiobothrium lasium*
parasite of *Carcharias obscurus*
Linton, E., 1889 - 1891
parasite of *Prionace glauca*
Linton, E., 1898b
- Phoreiobothrium pectinatum*
parasite of *Cestracion zygaena*
Linton, E., 1925
- Phoreiobothrium triloculatum*
parasite of *Carcharinus obscurus*
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- Phoresis
Remora
Spaeth, R. A., 1921
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seasonal cycle
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Rhynchobothrium longispine

parasite of *Trygon centrura*
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Rhynchobothrium speciosum

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parasite of *Trygon centrura*

Linton, E., 1889-1891

Rhynchobothrium tumidulum

parasite of *Dasyatis centrura*

Linton, E., 1898b

parasite of *Mustelus canis*

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Rhynchobothrium wagneri

parasite of *Trygon centrura*

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