A STUDY OF THE MARINE RESOURCES

of

PLEASANT BAY

John D. Fiske, Clinton E. Watson

and Philip G. Coates

MAY, 1967

Monograph Series
Number 5

DIVISION OF MARINE FISHERIES
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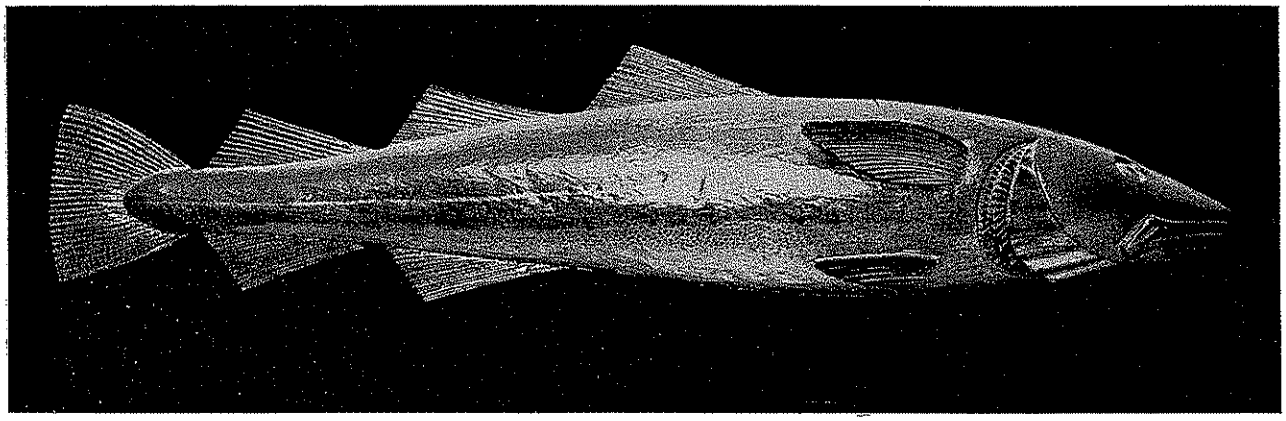

On March 17, 1784, Mr. John Rowe, of Boston, merchant, arose from his seat in the Representatives' Hall of the Old State House, and offered a motion. "That leave might be given to hang up the representation of a Codfish in the room where the House sits, as a memorial of the importance of the Cod-Fishery to the welfare of this Commonwealth, as had been usual formerly". Leave was accordingly granted; and the same wooden emblem presented by genial Johnny Rowe, having followed the Great and General Court to Beacon Hill, still faces the Speaker's desk.

SAMUEL ELIOT MORISON

The cod is no longer, "as had been usual formerly", preeminent in the fisheries of Massachusetts. Yet this does not indicate that the fisheries have lost any of their importance in the economic life of the Commonwealth. Approximately 500 million pounds of fish, with a dock-side value of nearly 50 million dollars, are landed annually by commercial fishermen at Massachusetts ports. Boston, Gloucester, New Bedford and Provincetown each land more than one million dollars worth of fish yearly. About 85% of the total fish landed are represented by species normally fished in offshore waters; namely: haddock, whiting, ocean perch, flounder, cod, pollock, and other species which are used for reduction or animal food. Seasonally or periodically some of these species move into inshore waters and contribute to the inshore fishery. Also, millions of pounds of alewives, winter flounder (blackback), fluke, mackerel, menhaden, scup, shad, tuna and many other species are commercially harvested annually within the so-called three-mile limit. In addition to the commercial interests, each year more than two hundred and fifty thousand Massachusetts salt water sport fishermen take better than ten million pounds comprised of striped bass, winter flounder, tuna, mackerel, smelt, bluefish, fluke, pollock, cod, shad, tomcod, white perch and scup.

The Division of Marine Fisheries is charged with the responsibility of preserving, protecting and managing the marine fishery resources of the Commonwealth of Massachusetts. The marine resources of the Commonwealth include shellfish (soft shell clam, scallop, oyster, quahog, etc.), fishes (cod, haddock, blackback flounder, striped bass, silver hake, pollock, alewife, shad, scup, menhaden, etc.) crustaceans (lobsters, sea crab, etc.), worms (sea worms, etc.) and others. It is the duty of the Director of Marine Fisheries to issue licenses, certificates, or permits or provide for the issuance, prescribed by Legislature, for the taking of the products or any or all such fisheries and the processing at sea or on shore within the Commonwealth; to secure and maintain statistical records of the catch of each species by various gear, by areas, and by other appropriate classifications; to conduct scientific, economic and other studies and research, all of which duties and operations shall be directed to the broad objective of managing such fisheries in the interest of all the people of the Commonwealth, to the end that they shall produce the maximum sustained yield consistent with the preservation and protection of the breeding stock.

One of the most interesting programs, and one which the public can see and have explained, is that of lobster rearing, conducted at the State Lobster Hatchery and Research Station, located at Oak Bluffs on Martha's Vineyard. Although the Hatchery was established on the theory that mass production of juvenile lobsters and their subsequent release in coastal waters would help sustain, and perhaps materially benefit, the Massachusetts lobster fishery, the Hatchery has proved of tremendous value to the fishery by virtue of its scientific studies on lobster fecundity, growth rates, distribution, food and feeding, statistics, reproduction, disease and movements.

The Division carries on a program for the improved handling of fish and the maintenance of high standards of sanitation on vessels and in processing plants.

Of three-fold benefit is the construction and maintenance by the Division of fishways for the passage of anadromous fish, such as alewives, from salt water to their spawning grounds in fresh water. When these fish are in the coastal streams they are taken in large quantities, for food, bait and for conversion to fish meal and other products. In the fresh water ponds and streams the eggs and young fish furnish food to other fish native to those waters, while the adults, in their migration along shore, attract such game fish as striped bass, bluefish and pollock.

With a growing awareness of the tremendous economic importance of the marine sport and commercial fisheries to the Commonwealth, the Massachusetts Legislature in 1962 passed Chapter 715. This act has to do with the promotion and development of the marine fisheries of the Commonwealth, and provides for certain penalties and administrative control of the fisheries, a Marine Fisheries Advisory Commission, a marine fisheries fund, and a public access board. Thus, the most intensive marine fisheries research and management program ever experienced by the Commonwealth was initiated. An investigation of the coastal wetlands in the Commonwealth, with respect to their location, ownership and value to fish and wildlife, was included as an integral part of the program. The results of this investigation were submitted to the Legislature in the form of two published documents. The Division is continuing its scientific investigations of the coastal wetlands, estuaries, and coastal waters to establish more precisely the values and relative importance to the fisheries of particular areas. The results of all research conducted will be published for the information and benefit of everyone. Thus, scientific information will be available to those concerned with individual, corporate, state, regional, federal, and international resource planning, and hopefully this will result in the maximum beneficial use of our coastal areas and marine waters.

The Commonwealth of Massachusetts

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF MARINE FISHERIES

Boston, Massachusetts

May, 1967

To the Commissioner and Board of Natural Resources:

Sirs:

We respectfully submit this report entitled "A Study of the Marine Resources of Pleasant Bay" for your consideration. This study was conducted by biologists of the Division of Marine Fisheries operating under the Estuarine Research Account.

Respectfully submitted,

FREDERICK C. WILBOUR, JR.
Director, Division of Marine Fisheries

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INTRODUCTION

Since 1963, the Massachusetts Division of Marine Fisheries has been intensively engaged in an estuarine research program. This program had its origin with the efforts of the Marine Fisheries Advisory Commission which was formed in 1960. The Commission is composed of nine members, each of whom is an authority on one or more aspects of marine fishing activities. At the conclusion of a series of public hearings and private sessions, the Commission in December of 1960 submitted to the Governor its final report upon the status of Massachusetts' marine fisheries. The following was contained within the recommendations section of this report:

> "The Commonwealth has only limited knowledge as to the physical conditions and basic productivity of its many harbors, bays, river mouths and other estuaries. As these serve as key areas of productivity for many species of marine organisms important to the commercial and recreation industries, it would appear of paramount importance to initiate this basic survey as rapidly as possible.
>
> An additional factor lending further emphasis to the need for detailed studies is the rapid rate of change evident along much of the Massachusetts coastline involving the dredging of channels, construction of hurricane barriers, and filling of tidal marshlands for commercial purposes. The Commission recognizes the urgent necessity of prompt investigation before such changes become irrevocable."

In view of the above, the commission recommended; "A Proposed Program of Marine Research in the Inshore Waters of Massachusetts."

In the spring of 1963, the Legislature passed Chapter 181 of the Acts of 1963 which provided appropriations for the prompt implementation of this program. By the summer of 1963, field studies had been initiated in four of the major estuaries of our coastline. As of December, 1966, field studies had been completed in eight of the major estuarine areas of the Commonwealth. Pleasant Bay was the first major estuary to be evaluated in Barnstable County. Field studies in the bay were initiated during the spring of 1965 and terminated during the summer of 1966.

PERSONNEL AND ACKNOWLEDGMENTS

The estuarine team which conducted this study consisted of Marine Biologist and Project Leader, John D. Fiske, and Assistant Marine Biologists, Clinton E. Watson and Philip G. Coates. During the summer of 1965, the team was supplemented with Assistant Student Biologists, David Daisy, William Finn, Charles Hall, and Stephen Handy. In cooperation with the Thayer Academy Summer Science Program, the estuarine team supervised the activities of two science students during the summer months. Thomas Petersen was assigned the project of collecting and identifying mollusks from Pleasant Bay, and Douglas Pinney was supervised in analyzing the stomach contents of flounders collected in the bay. Assistant biologists Robert Lawton and John Curley of the Division of Marine Fisheries were helpful in the preparation of final tables and figures of this report.

Completion of this study was facilitated by the excellent cooperation and assistance of the Shellfish Officers, Albert Norgeot (Orleans), Roger Munsey (Harwich), and Edmund Harding (Chatham). These officers were especially helpful in maintaining monthly shellfish harvest records.

Stephen Onysko of the U. S. Corps of Engineers in Waltham, Mass., has generously shared data from his hydrographic study of Pleasant Bay, which was conducted during the same period of this estuarine study. Similarly, the Massachusetts Department of Public Health has shared its findings of a water quality survey conducted in Pleasant Bay during the summer of 1965.

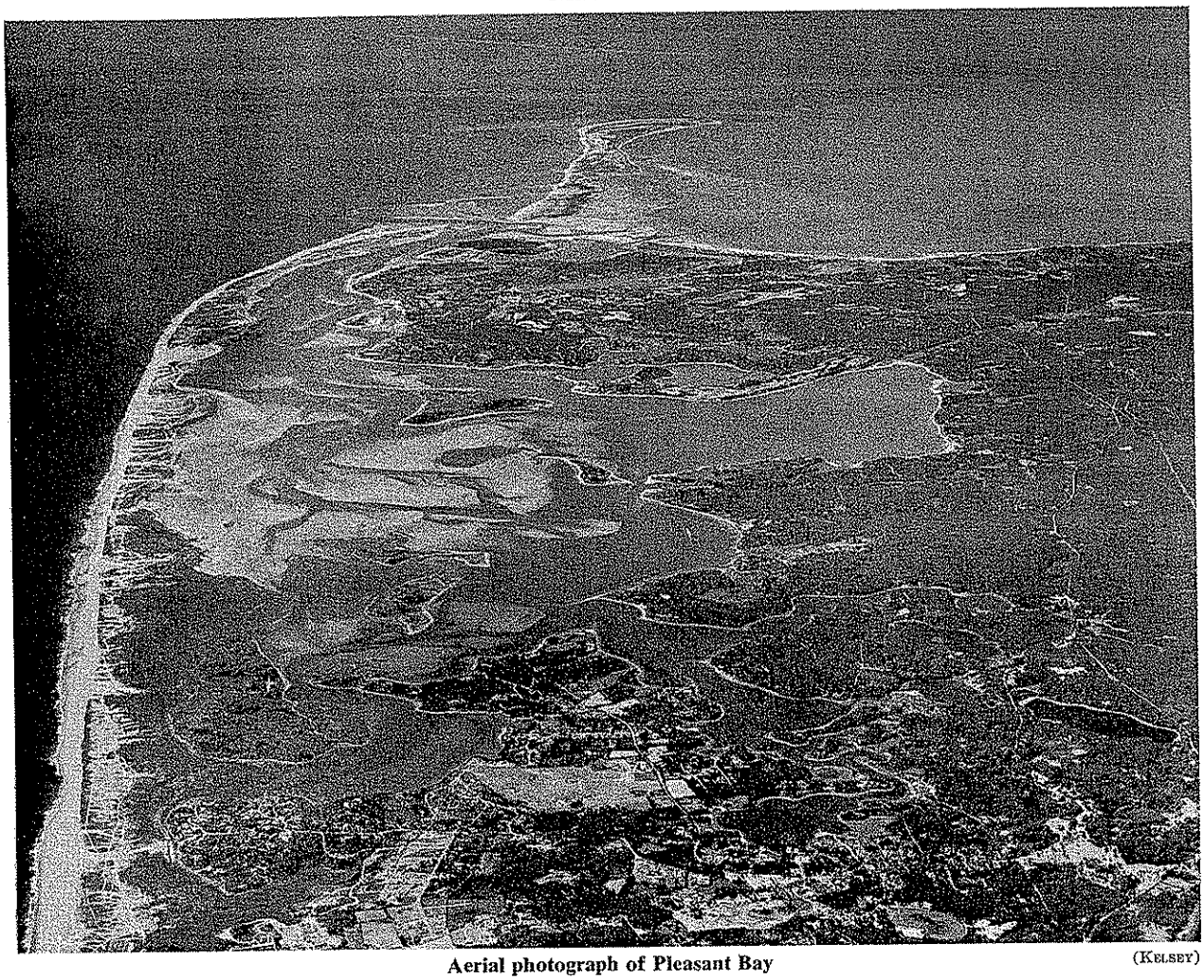
The Division of Marine Fisheries gratefully acknowledges the cooperation of the many commercial fishermen and wholesalers of the Pleasant Bay area who have supplied information relative to the volume and value of marine resources harvested from the bay.

THE PHYSICAL AND CHEMICAL CHARACTERISTICS OF PLEASANT BAY

Methods and Materials

The Pleasant Bay estuary in Barnstable County is situated at the easternmost point in Massachusetts. The shallow saline waters of the bay are completely bounded to the east by a 23 mile long beach of dune sand and gravel known as Nauset Beach. The estuary is encompassed by the towns of Orleans, Harwich, and Chatham. The northernmost limit of the study area was designated as the origin of Pochet Creek. The lower limit was established as a line drawn west-northwest from the southernmost tip of Nauset Beach to Morris Island.

PLATE 2.



Aerial photograph of Pleasant Bay (KELSEY)

Morphometric data was obtained from topographic maps printed by the United States Geological Survey. Pleasant Bay is contained within the Orleans and Chatham Quadrangles, which have a scale of 1:24,000. Linear distances were obtained with a map rotometer and the USGS maps. Area measurements were computed by using a dot grid. Methods for calculating morphometric data were taken from Welch (1948). Depth data and bottom contour profiles were obtained from the hydrographic map of Chatham Harbor and Pleasant Bay, printed by the U. S. Coast and Geodetic Survey.

Geological information was obtained from information compiled and published by Bennet T. Gale of the National Park Service, Washington, D. C.

Tidal data was taken from information supplied by the U.S. Army Corps of Engineers.

In June of 1965, the Massachusetts Department of Public Health conducted a survey of the waters of Pleasant Bay relative to their suitability for the utilization of shellfish. Information from the study is included in this report.

At each of the six finfish sampling stations and the three chemistry stations, surface temperatures and salinities were recorded using a GM Thermometer and wide range hydrometer. Braincon Type 146 Continuous Recording Thermographs were installed at two locations in Pleasant Bay from December 22, 1964, to May 10, 1965. The units were self-contained and battery powered. Temperatures are obtained from the hourly photograph of a column of mercury on a continuous film strip. Both units were secured to 4″ x 4″ timbers. One was attached to a piling in Meetinghouse Pond, Orleans, and the other to a piling at the Chatham Fish Pier.

Hach Portable Water Analysis Kits were used to

obtain water chemistry data. Model CA10 Kit was used for the determination of dissolved oxygen, carbon dioxide, and hydrogen ion concentration. Model ABS2 Kit was used for the determination of alkyl benzine sulfonate (detergent). One station was established for monthly water analysis on the beach at the northeast part of Meetinghouse Pond, Orleans. A second station was located at the outflow of Frostfish Creek in Chatham Port off Route 28. A third station was established one third mile south of the Chatham lighthouse near the entrance to Chatham Harbor.

Morphometric Data

Geological Background

The Pleasant Bay area was formed as the result of glaciation that occurred near the end of the Pleistocene Era. From 600,000 to 10,000 years ago when continental glaciers advanced and retreated over the region, gravel, sand, and clay were deposited by the moving masses of ice and their subsequent melting. Once deposition took place, further alteration was accomplished by wind, streams, ocean currents, and wave action.

The northern topography of Pleasant Bay in Orleans is characterized by Sandwich Moraine deposits, which slope to the sea near Nauset Beach. The irregularity of the western shoreline of Little Pleasant Bay is typical of the uneven border of the drift caused by glaciation. The islands within Pleasant Bay (Sampson's Island, Pochet Island, Hog Island, and Sipsons Island) are small morainal islands (Chamberlain, 1964). The eastern shore of Pleasant Bay is protected by an extensive sand beach. Nauset Beach was formed after the glacial period by the action of the sea loosening the Pleistocene clay, sand, and gravel deposits and subsequent transportation and deposition by offshore currents (Gale, 1958). The extensive salt marshes of the bay were also formed in postglacial times.

Chamberlain (op. cit.) describes the percentages of rock types in the Sandwich Moraine (east) as being 48% granite, syenite, gneissoid granite, pegmatite; 1% quartz-feldspar gneiss; 13% diorite, gabbro, dark gneiss; 7% basalt; 11% light colored volcanics; 2% schist; 1% slate, shale; 5.5% quartzite; 7% milky quartz in veins; 2% sandstone; 1% conglomerate; and 1% miscellaneous.

The eastern shoreline of Pleasant Bay has been altered significantly since the eighteenth century when early charts show the Upper Cape as an island separated from the Lower Cape by Boatmeadow Creek. Nauset Beach extended only as far south as Allens Point, Chatham, by 1898. Wind and wave action have since extended the beach, until at the present time the southernmost tip lies southeast of Morris Island, Chatham. Several times in the last century the storm-whipped sea has opened and closed beaches from the ocean to Pleasant Bay. At the present time, the shifting sand and shoals within the entrance provide very difficult navigational access to the bay itself.

Findings

The more pertinent morphometric measurements of Pleasant Bay are presented as follows:

Maximum length:
9.8 statute miles (8.6 nautical miles)

Maximum effective length:
6.6 statute miles (5.7 nautical miles)

Maximum width:
3.4 statute miles (3.0 nautical miles)

Maximum effective width:
4.0 statute miles (3.5 nautical miles)

Mean width:
Mean high water 1.2 statute miles (1.0 nautical miles)
Mean low water 0.8 statute miles (0.7 nautical miles)

Total surface area:
Mean high water 7,285 acres (11.4 sq. miles)
Mean low water 5,393 acres (8.4 sq. miles)

Salt marsh area:
1,203 acres (1.9 sq. miles)

Shoreline length:
Mean high water 55.1 statute miles (48.2 nautical miles)
Mean low water 11.6 statute miles (10.1 nautical miles)

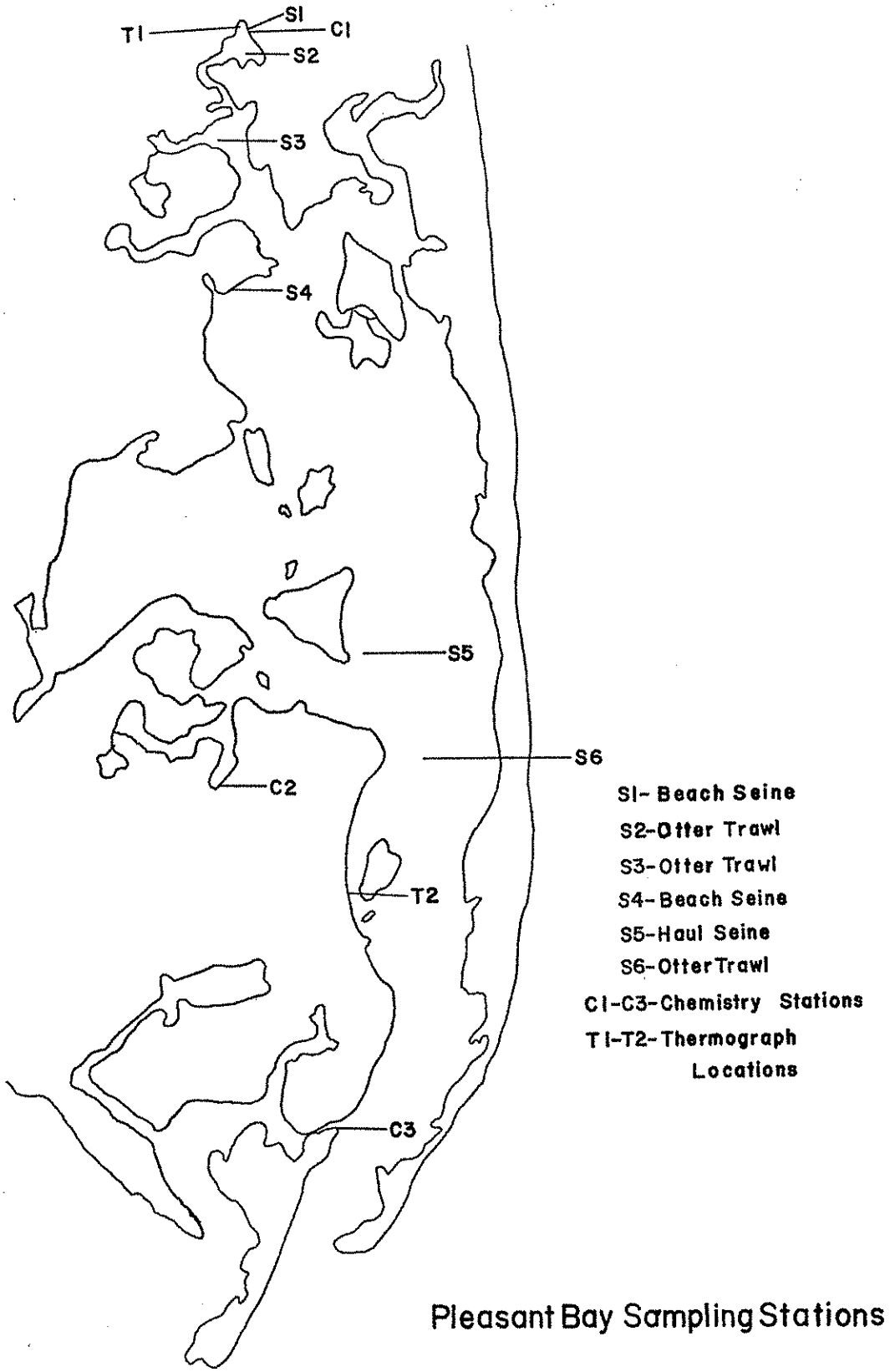
Maximum depth:
Mean high water 25.2 feet
Mean low water 22.0 feet

Volume:
Low tide — 1,346,491,872 cu. ft.
High tide — 2,208,815,036 cu. ft.

DISCUSSION

An estuary is generally characterized as a coastal arm of the sea which is measurably diluted by freshwater runoff, especially in the upper, headwater portions of the estuary. Pleasant Bay, which might be described as a tidal lagoon, varies from the typical estuary in that it receives very little freshwater drainage and reflects little change in salinity from the uppermost salt pond to the entrance of the bay.

Figure 1.



Pleasant Bay Sampling Stations

Pleasant Bay is one of the larger estuaries of the coast of Massachusetts. At mean high water, the surface area of the bay is 7,285 acres. At mean low water, there is an approximate 26% loss in water surface area. As compared to three other estuaries which have been evaluated and reported upon by the Division of Marine Fisheries, Pleasant Bay is the second largest. The following table lists the surface acreage of the four study areas at both mean high and mean low tide:

	Mean High Tide	*Mean Low Tide*
Quincy Bay	7,772 acres	6,854 acres
Pleasant Bay	7,285 acres	5,393 acres
Merrimack River	3,957 acres	2,110 acres
North River	533 acres	382 acres

As indicated in Figure 4, Pleasant Bay is a relatively shallow estuary. At mean low water, nearly 65% of the water area is six feet or less in depth. Less than 15% of the area exceeds 12 feet in depth at low tide. The shallowness of the bay is undoubtedly an important factor in the primary biological production of the estuary. Shallow depths result in a high photosynthetic rate and consequent rapid production of the aquatic plants which are basic nutrient contributors in the estuarine system. The shallow water depths also sustain warm water temperatures during the spring-fall period. The extended period of warm water is extremely beneficial to the reproduction and growth of such economic species as the quahog and scallop.

While shallow depths are in many ways beneficial to the ecology of the estuary, accelerated shoaling of the bay in recent years has hampered man's activity in the area. At the entrance of the bay, sand deposits have built up to the extent where they are seriously impeding navigation. Fishing vessels which dock within the bay at the Chatham Fish Pier are able to move safely in and out of the bay only at the higher stages of the tide. Within the bay, windblown sand from Nauset Beach has caused extensive shoaling on the east side of the bay (Plate No. 2). Because of the serious navigation problem which has developed at the mouth of the bay, the U.S. Army Corps of Engineers has been conducting an extensive hydrographic study to determine the most economically feasible method of stabilizing and maintaining an entrance to the bay. Consideration is also being given to the dredging of interior channels in the bay. It is expected that the engineering report with its recommendations will be released during the summer of 1967.

The percentage of change in water volume between high and low water in Pleasant Bay is 58.3 percent. This percentage is considerably larger than that encountered in the North River (40.7 percent), and similar to that of the Merrimac River (54.7 percent). Tidal exchange in the Pleasant Bay estuary is estimated at 7,100,000,000 gallons during a mean tidal cycle. Maximum tidal exchange occurs in the lower portion of the estuary. Extensive shoaling north and east of Sipson Island (Plate 2) greatly restricts volume outflow from the time these shoals are bared to low tide. The tidal range of only 2.6 feet at the upper limit of the estuary (Meetinghouse Pond), compared to 4.4 feet at the entrance reemphasizes the fact that tidal exchange is less in the upper limits of the estuary. A preliminary current study by the U.S. Army Corps of Engineers revealed that incoming tides flood the estuary within a 5½ hour period and the ebbing tide runs for 6½ hours before low slack. On the day of this particular study, tidal volume entering the bay was greater than that which flowed out. One possible cause of this anomalous occurrence was a strong southwest wind which may have held back tidal outflow. At the entrance to the estuary, maximum current velocity (2.7 knots) occurred about three hours after high tide.

The total salt marsh acreage within the Pleasant Bay estuary was 1,203 acres. The importance of the salt marsh areas of the bay and their present protective status is discussed in a later section of this report.

Water Analysis

Water Temperature

Water temperatures observed in Pleasant Bay during 1965 ranged from a low 29°F. in February to a high of 78°F. in July. The effect of solar radiation upon shallow estuaries is demonstrated in Pleasant Bay where summer water temperatures are elevated considerably higher than those of the adjacent coastal waters. Figure 9 illustrates surface water temperatures observed at three sites in the Pleasant Bay and adjacent Monomoy Island area during 1965. Meetinghouse Pond, the uppermost point in the bay, receives little cool ocean water through tidal exchange. Water temperatures recorded in this salt pond regularly exceeded 70°F. during the summer months, and it is likely that similarly high temperatures occur in the other upper ponds and inlets. Observed water temperatures in the lower part of the bay at Little Beach, Chatham, reflect the presence of both bay and ocean waters; the relative contribution of each being determined by tidal stage. Considerably cooler summer water temperatures were noted at the Pendleton Wreck, three miles south of the Pleasant Bay entrance. During June and September, water temperatures at

Figure 2 Geologic Map of Pleasant Bay Area

(Taken from Gale, 1958)

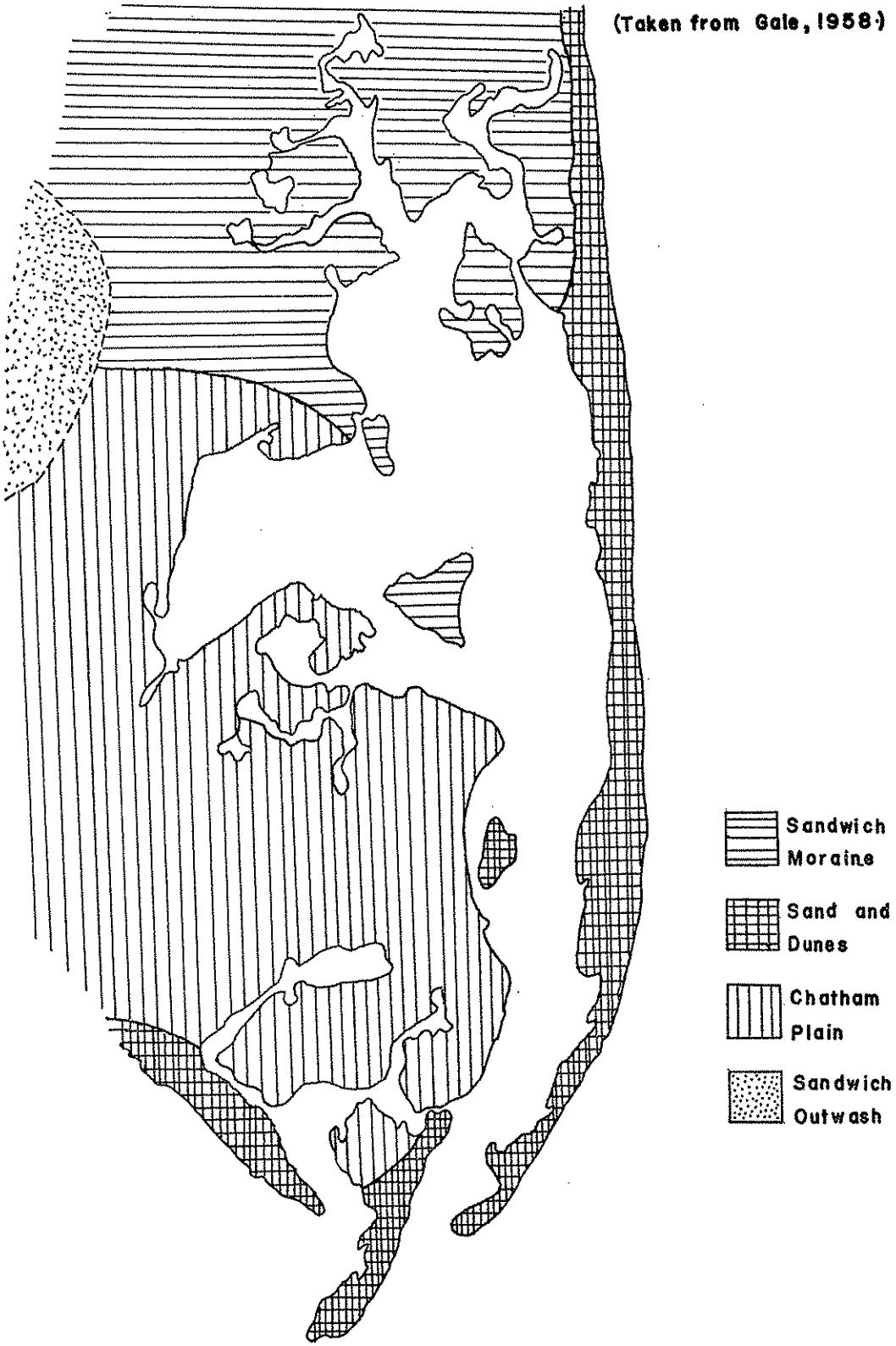


Figure 3.

Fifty Year Change in the Entrance to the Pleasant Bay Estuary

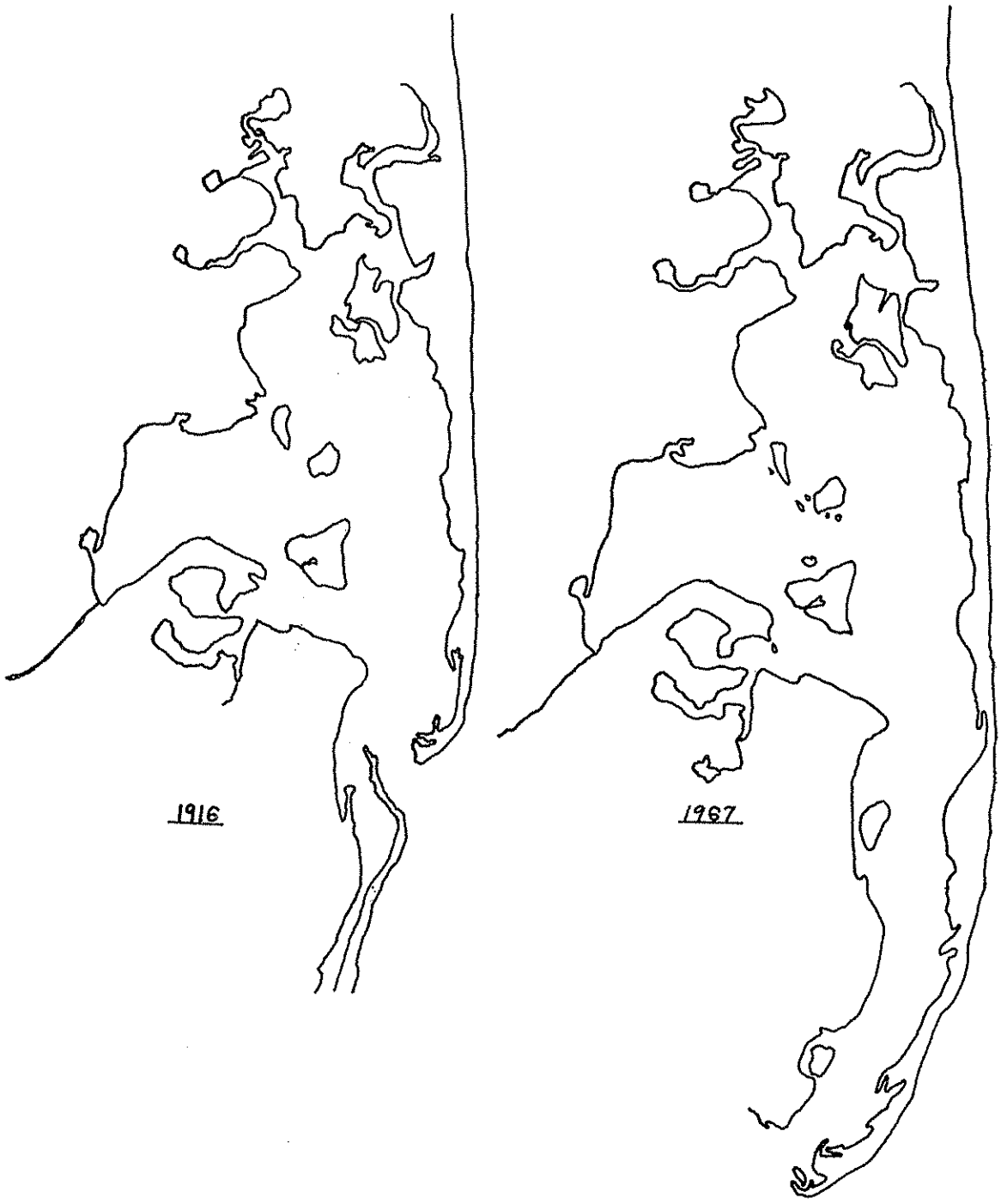
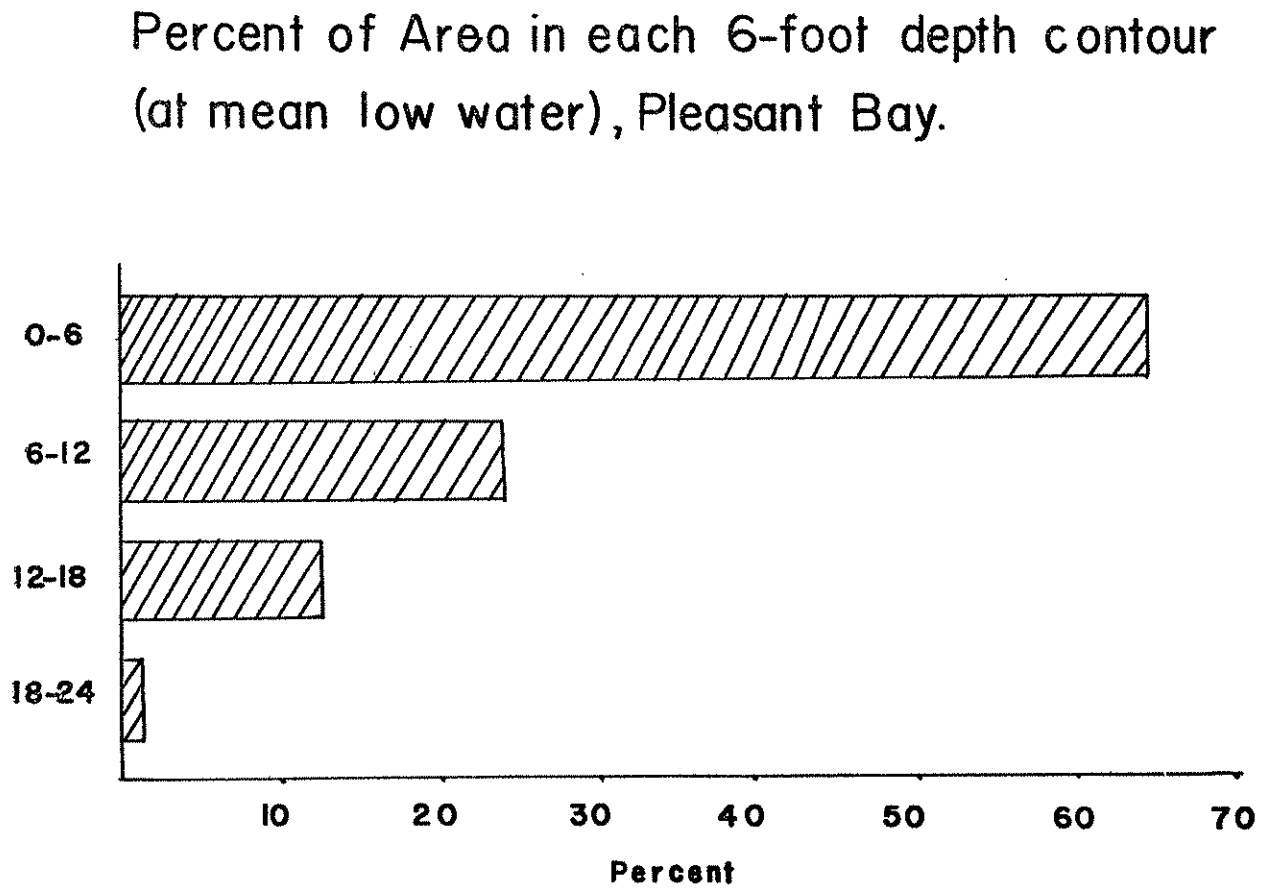


Figure 4.
Outline Map of the Pleasant Bay Estuary showing depth contours.

Figure 5.



the Pendleton Wreck ranged 15°-25°F. cooler than bay water temperatures.

To determine daily temperature fluctuations at selected sites in Pleasant Bay, recording thermographs were installed in Meetinghouse Pond and at the Chatham Fish Pier. The Meetinghouse Pond unit failed to operate, but the thermograph installed at Chatham recorded from late December through late May. Figure 6 summarizes the daily maximum and minimum recorded temperatures at day intervals. Daily temperture differentials become greater during the spring as the bay water of relatively small volume warmed more rapidly than the large volume of coastal ocean water.

The thermograph unit installed at Chatham recorded the lowest water temperature (29°F.) of the study period. During the winter season, water temperatures regularly drop below 31°F.; and in the upper portion of the bay particularly, ice commonly occurs despite the high water salinities.

Since summer water temperatures in the upper portions of Pleasant Bay regularly exceed 70°F., it is

Figure 6.

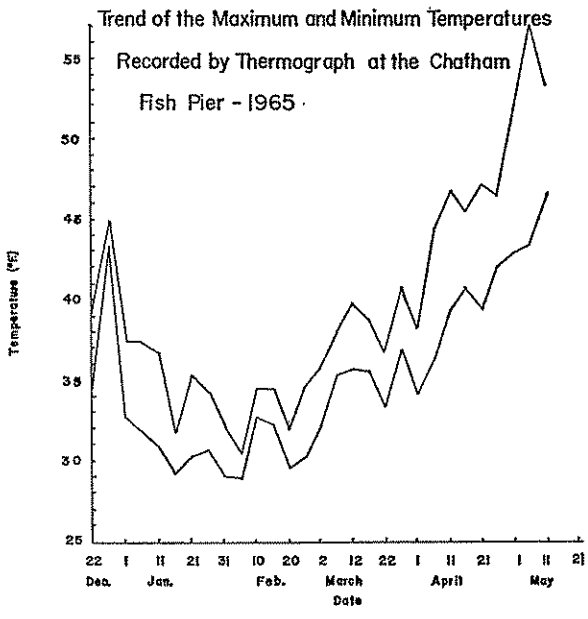


Table 1. Water Analysis Data Collected at Meetinghouse Pond, Orleans — 1965.

Date	pH	Dissolved Oxygen (ppm)	Detergent (ppm)	Water Temperature (°F.)	Salinity 0/00	Tidal Stage
3/8/65	8.0	11.0	0.1	40.1	25.2	High +4 hrs.
4/28/65	8.0	9.0	0.1	49.1	24.8	Low +4½
5/18/65	8.0	8.0	0.0	61.3	26.0	High +5½
6/8/65	8.0	8.5	0.1	72.6	26.2	High +1
7/12/65	8.0	6.0	0.0	75.0	26.7	Low +2
8/6/65	8.0	9.0	0.0	75.5	28.0	High +1
9/8/65	8.0	7.0	0.1	69.8	27.5	Low +3
10/6/65	8.0	9.0	0.1	52.3	26.3	Low +5
11/9/65	8.0	9.0	0.0	48.3	26.7	Low +2
12/7/65	8.0	10.0	0.05	39.2	25.0	Low +4

Water Analysis Data Collected at Frostfish Creek, Chatham — 1965.

Date	pH	Dissolved Oxygen (ppm)	Detergent (ppm)	Water Temperature (°F.)	Salinity 0/00	Tidal Stage
4/28/65	8.0	10.0	0.1	50.0	9.0	High +1 hrs.
5/18/65	8.0	8.0	0.1	61.7	11.3	Low +4
6/8/65	8.0	8.0	0.1	67.4	26.8	High +1½
7/12/65	8.0	9.0	0.1	78.8	17.0	High +2
8/9/65	8.0	9.0	0.1	78.9	15.1	Low +5½
9/8/65	8.0	8.0	0.1	66.2	7.2	Low +4½
10/6/65	8.0	10.0	0.1	47.1	13.1	High +1½
11/9/65	8.0	9.5	0.0	49.1	19.7	Low +4½
12/7/65	8.0	7.5	0.1	38.3	21.0	High +2

Water Analysis Data Collected at Little Beach Marina, Chatham — 1965.

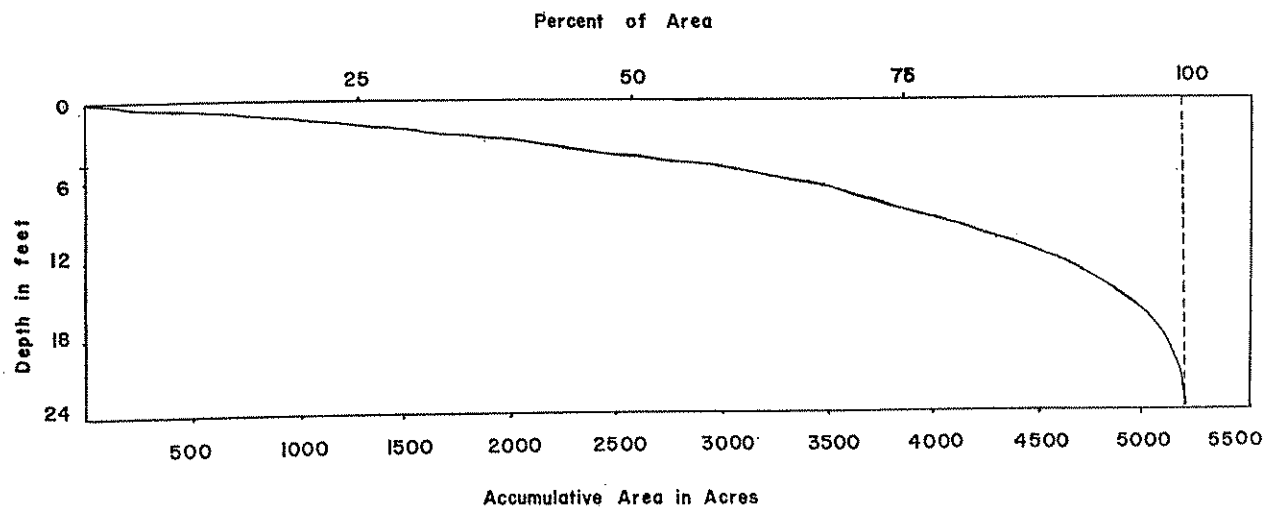
Date	pH	Dissolved Oxygen (ppm)	Detergent (ppm)	Water Temperature (°F.)	Salinity 0/00	Tidal Stage
3/19/65	8.0	10.4	–	39.2	29.8	Low +5½ hrs.
4/28/65	8.0	8.0	–	45.5	29.0	High +3
5/18/65	8.0	10.0	0.1	53.6	30.5	Low +3½
6/8/65	8.0	7.0	0.1	60.2	30.5	High +1½
7/12/65	8.0	6.0	0.1	66.2	29.7	High +3
8/9/65	8.0	7.0	0.1	73.4	31.3	High +1½
9/8/65	8.0	6.0	0.0	62.6	30.5	Low +4½
10/6/65	8.0	10.0	0.1	47.1	31.0	High +2
11/9/65	8.0	8.0	0.1	47.6	30.2	Low +5½
12/7/65	8.0	9.0	0.1	39.2	27.0	High +2½

likely that these areas are thermally inhospitable to certain marine organisms. In the finfish section of this report, a decrease in the relative abundance of winter flounder in Meetinghouse Pond during the warmer months is noted. Although these high water temperatures possibly limit the occurrence of certain organisms in the upper portions of the bay, they undoubtedly aid the growth of valuable shellfish species such as quahogs, oysters, and the bay scallop. The value of Pleasant Bay as a nursery area for various finfish species is also probably related to the warm water temperatures of the area.

Salinity

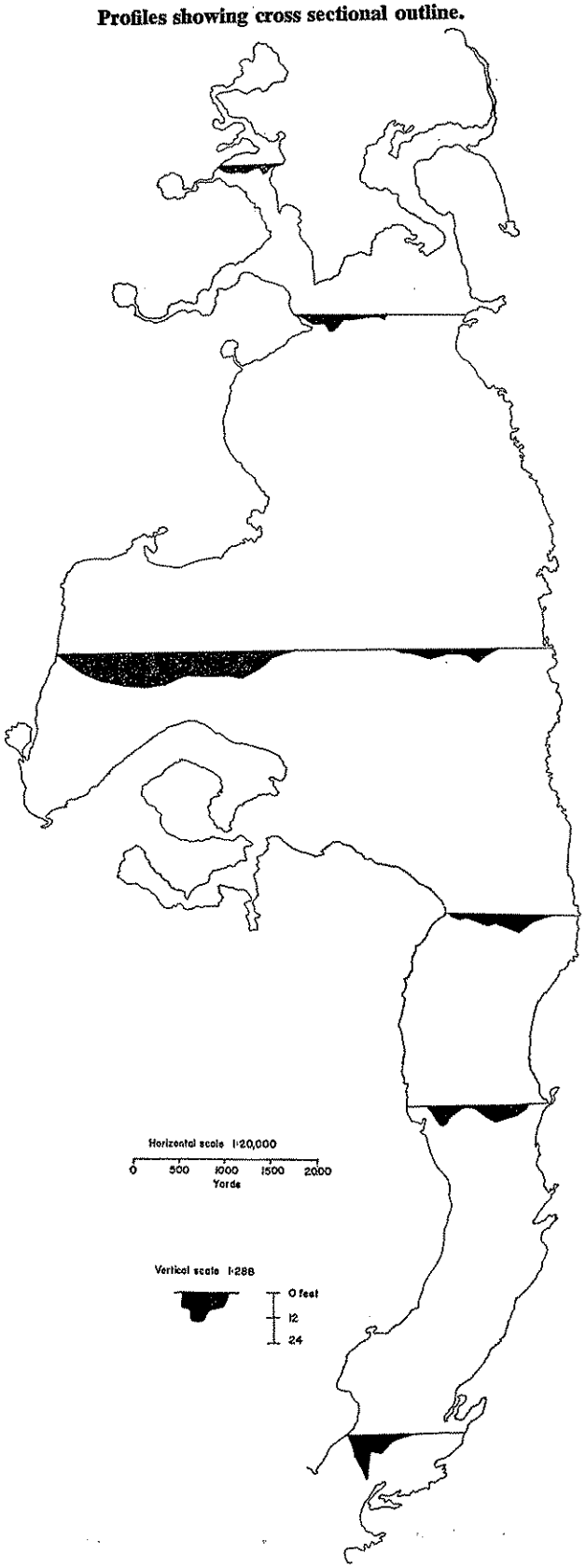
The coastal waters adjacent to Pleasant Bay are of high salinity, 30 0/00 or greater. Little dilution of this saline water occurs in the bay since the volume of fresh water discharge, comprised mainly of the outflow of several small streams, surface runoff and springs, is relatively small. Observed surface salinities at the finfish and chemistry sampling stations were generally high with little fluctuation, except for one station. Frostfish Creek, a water chemistry sampling station, is a small stream draining old cranberry bogs and marsh. During 1965, salinities observed at this station ranged from 7 0/00 to 27 0/00. Frostfish Creek was the only area sampled where fresh water discharge was of sufficient volume to appreciably dilute the saline bay water. Localized dilution of bay water, although not observed, likely occurs in other areas such as Kescayo Gansett Pond, Ryder's Cove, Muddy Creek, and Quanset Pond where small streams discharge into the bay. With the exception of the salinity variation at these stream outlets, the high salinities observed throughout the bay during 1965 suggests that, from the standpoint of salinity, Pleasant Bay is more uniform throughout its area than the "normal" estuary where salinities range from low at the headwaters to high at the entrance. The absence of extensive fresh water dilution possibly extends the range of marine stenohaline (high salinity tolerant) organisms to the upper portions of the bay. Stenohaline organisms are restricted to a narrow salinity range while euryhaline organisms tolerate wide salinity variations. Marine finfish more commonly associate with waters of higher salinity such as Atlantic herring (*Clupea harengus*), scup (*Stenotomus chrysops*), and white hake (*Urophycis tenuis*) were captured on several dates in the upper bay area during 1965. The quahog (*Venus mercenaria*), a shellfish best adapted to waters of higher salinity, is found in harvestable concentrations throughout the bay, including the uppermost area, Meetinghouse Pond.

Figure 7.



This curve shows the surface area which is above or below any given depth.

Figure 8.
Profiles showing cross sectional outline.



Water Quality

Pollution of our coastal waters is one of the greatest menaces confronting marine resources and their utilization. In Massachusetts, approximately 25% of the coastal shoreline has already been closed to the harvesting of shellfish because of the careless discharge of domestic sewage and industrial wastes. The devastating effect that such pollution can have upon the utilization of marine resources is documented in two estuarine studies conducted on the north shore of Massachusetts. In a 1964 study of the marine resources of the Merrimack River (Jerome et. al., 1964), it was revealed that approximately 30,000 bushels of clams valued at $300,000 were annually going to waste because of gross pollution which prohibits their utilization. Similarly, in a report upon Quincy Bay (Jerome et. al., 1966), it was noted that because of gross pollution in the bay, about $100,000 worth of clams are wasted annually.

To date, pollution and its destructive aspects have been most profound on the north shore of Massachusetts, paralleling intensive shoreline settlement of man and his industries. However, nine locations in Barnstable County have been designated as polluted and have been closed to shellfishing. Two of these locations are in Pleasant Bay.

Coliform bacteria counts provide public health workers with criteria for determining various water uses. This method is widely used in determining the safe utilization of shellfish such as the soft shell clam and quahog. Under the standards established by the Cooperative Interstate Shellfish Program, the following designations regarding shellfish areas have been made:

Degree of Contamination of Overlaying Water:
(Coliform bacteria content)

0 — 70/100 ml — clean
71 — 700/100 ml — moderately contaminated
over — 700/100 ml — grossly contaminated

During June and July of 1965, workers of the Department of Public Health collected numerous water samples throughout the Pleasant Bay estuary. Each sample was examined for the presence of coliform bacteria. The findings of this survey are listed in Table 2. Of the 45 locations sampled, nine contained coliform bacteria, indicative of moderate contamination, and eight suggested gross contamination.

Figure 9.

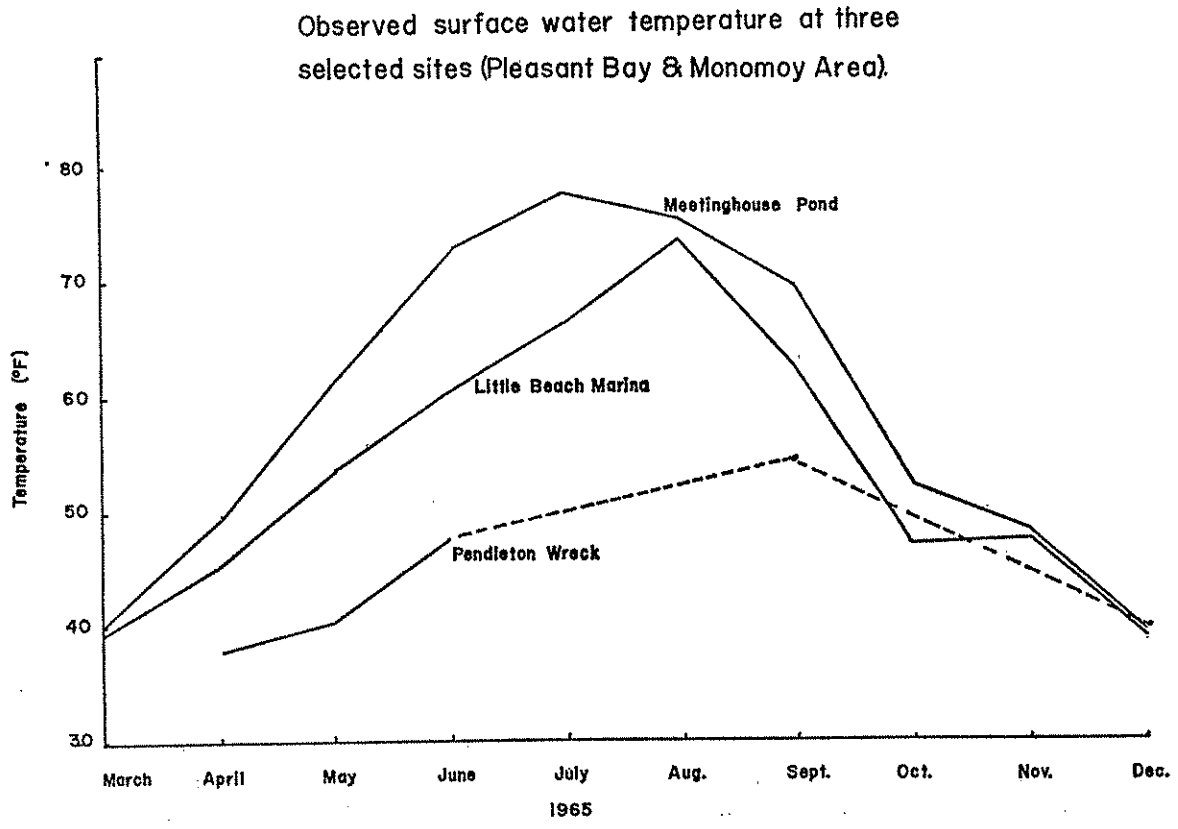


Table 2. Department of Public Health Water Analysis Data, Pleasant Bay, 1965.

Station	Approximate Location	Date (1965)	Tide	Temperature (°F.)	Chlorides (mg/L)	Coliform Bacteria (MPN/100ml)
1	Barley Neck, West shore	6/22	ebb		16,600	4,000
	Barley Neck, West shore	6/29	–		15,000	10
2	Meetinghouse Pond boatyard	6/22	ebb		16,000	20
	Meetinghouse Pond boatyard	7/14	flood	78	16,400	10
3	Meetinghouse Pond drain at boatyard	6/22	ebb		2,800	10,000
	Meetinghouse Pond drain at boatyard	6/29	–		5,600	300,000
	Meetinghouse Pond drain at boatyard	7/14	–		1,850	12,000
4	Lucy Point	6/22	ebb		15,200	10
5	Pilgrim Lake Stream	6/22	ebb		44	400
	Pilgrim Lake Stream	6/29	–		11,000	8,000
	Pilgrim Lake Stream	7/24	ebb	76	4,000	500
6	Kescayo Gansett Pond — inlet	6/22	flood		14,800	10
7	Namequoit River — mouth	6/22	ebb		16,400	5,000
	Namequoit River — mouth	6/29	–		15,600	10
8	Areys Pond — stream	6/22	low		256	60
9	Namequoit Point	6/22	ebb		16,400	10
9A	Paw Wah Pond — entrance	7/16	ebb	74	14,200	10
10	4 inch pipe from banking	6/23	ebb		194	10
11	Stream at Narrows	6/23	ebb		12,600	20
12	Quanset Pond — entrance	6/23	ebb	74	16,600	10
13	Stream from pond at Tar Kiln Road	6/23	ebb		2,800	50
14	Buoy #5 at Narrows	6/23	ebb	76	17,400	10
15	Round Cove — stream	6/24	ebb		168	30
16	Muddy Creek	6/24	ebb		5,000	20
17	Foot Bridge	6/24	ebb	72	12,800	100
18	Pochet Creek	6/24	ebb	72	12,600	350
19	Pochet Creek	6/24	ebb	72	11,400	2,000
20	Pochet Creek	6/24	ebb	74	12,000	80
21	Pochet Creek	6/24	ebb	72	13,000	150
22	Pochet Creek	6/24	ebb	72	13,600	40
23	Pochet Creek	7/16	ebb	74	11,500	400
24	Pochet Creek	7/16	ebb	74	13,000	60
25	Pochet Creek	7/16	ebb	74	15,500	<10
26	Pochet Creek	7/16	ebb	74	16,000	<10
27	Pochet Creek	7/16	ebb	74	17,000	<10
28	Pochet Creek	7/16	ebb	74	17,000	<10
29	Pochet Creek	7/16	ebb	74	17,000	<10
30	Pochet Creek	7/16	ebb	74	17,000	<10
31	Crows Pond	6/28	ebb	72	17,500	<10
32	Stream entering pond	6/28	ebb	72	16,400	30
33	Stream entering pond	6/28	ebb	72	5,200	100
34	Ryder Cove — marsh drain	6/28	ebb	72	16,600	340
35	Frostfish Creek	6/28	ebb	72	9,800	<10
36	Ground water from bank of stream	6/28	ebb	72	44	3,000
37	Bassing River	6/28	ebb	72	12,200	30

Among the noted potential sources of pollution were drainage from a duck farm, from cesspools constructed in close proximity to tidal waters, and from storm drains and swamps.

While several of the high coliform counts occurred in areas which had previously been designated as contaminated, high counts also occurred in several areas generally considered to be clean. The three highest counts were obtained from a pipe located at the East Orleans boat yard in Meetinghouse Pond. The reason for the high counts from this street drain were not established but were believed to be associated with drainage from either the boat yard or a nearby inn.

It should be noted that intermittent high coliform bacteria are commonly encountered in water which is generally believed to be free of pollution. High counts may be attributable to either multiplication of bacteria within the sample from the time of collection to time of analysis or to localized concentration in the water of organic substances. The classifying of water use on the basis of coliform bacteria is finally accomplished only when relatively consistent results are obtained from a substantial number of samples. However, when known constant sources of pollution exist, the area is automatically designated as polluted.

The survey conducted by the Massachusetts Department of Public Health was a re-evaluation of areas of known pollution and also an inventory of conditions existing throughout the estuary. Instances of high coliform bacteria in areas monitored for the first

time suggest a trend of increasing pollution of bay waters.

With increased building of shorefront homes, there will be the possibility of further pollution from subsurface sewage disposal. Increased boating activity is another potential source of pollution, especially when there is the danger of untreated sewage being released from toilets on the larger pleasure crafts.

The primary responsibility in guarding against careless discharging of domestic sewage lies with the local boards of health.

Determination of dissolved oxygen, pH, and detergent (ABS) concentration was conducted at three sampling stations (Table 1). The lowest dissolved oxygen concentration recorded was 6 ppm., which is above the level generally considered to be detrimental to fish life. All pH (hydrogen ion concentration) readings were 8.0. This slightly alkaline condition is normal for sea water and corresponds to the generally high salinity levels which are maintained throughout the estuary. Recorded levels of ABS (alkyl benzene sulfonate) were low and did not indicate any significant detergent pollution.

FINFISH

OBJECTIVES

In view of the increasing recreational and commercial importance of the marine finfisheries of Massachusetts, an examination of this resource in Pleasant Bay is included in this report. The major objectives of this study were: to determine the number and relative abundance of finfish species occurring in the estuary; to evaluate the extent and value of the commercial and recreational fisheries of the area; to assess the status of the existing anadromous fishways within the bay area with regard to limitations and possible improvements; and to evaluate the finfish resource with regard to proper conservation and utilization to insure its availability to future generations.

METHODS AND MATERIALS

Six finfish sampling stations (Figure 1) were established within the estuary and were sampled monthly from January through December, 1965. One offshore station (S7) approximately 4 miles south-southwest of the entrance to the estuary was sampled on an intermittent basis during 1965.

At the shore stations, S1 and S4, sampling was accomplished by hauling a 60-foot beach seine along the shore for a distance of 100 feet. This seine was 4 feet deep and had a mesh size of ⅛ of an inch. At shore station S5, a tow was made with a 120-foot haul seine which was 6 feet deep and had a mesh size of ⅜ of an inch. This seine was used with 40-foot bridles and was set with the aid of a small boat. Stations S2, S3, and S6, which were subtidal, were sampled with an otter trawl, which was towed for a distance of 200 yards from a 16-foot boat. The trawl had 25-foot headrope and a 30-foot footrope. The 10-foot cod end was equipped with a liner, which had a mesh size of ⅜ of an inch. This otter trawl was also used at station S5 during November and December for the monthly sampling.

Finfish and other species captured during sampling operations were placed in a 10 percent formalin solution and returned to the laboratory for identification, numerical counts, and length measurements.

Sampling at the offshore station was done with a 52-foot commercial dragger under contract to the division. This dragger used an otter trawl which had a 38-foot headrope and a mesh size of 4 inches. The trawl was towed for 20 minutes. Finfish captured were examined to determine size distribution, relative abundance, and species composition. Other organisms collected were returned to the laboratory for examination and processing.

A winter flounder tagging program was carried out in the Pleasant Bay area in 1965 with the cooperation of the U. S. Fish and Wildlife Service Bureau of Commercial Fisheries at Woods Hole. Data on this study is included in this report.

FINDINGS

The 6 finfish sampling stations within the Pleasant Bay study area included Meetinghouse Pond Beach, S1; Meetinghouse Pond, S2; Kescayo-Gansett Creek, S3; Paw Wah Pond Creek, S4; Strong Island, S5; and Old Harbor, S6. One offshore station, Pendleton (S7), was sampled on an intermittent basis.

Thirty-eight species of finfish were taken in the sampling of these stations in 1965. A list of species taken including scientific and common names is shown in Table 3. The relative abundance of species at each sampling station is shown in Table 12. The sampling results are presented as follows by station.

Table 3. Classification of Fish Species Captured in the Pleasant Bay Area, 1965-1966.

Class: CHONDRICHTHYES
- Order: Rajiformes (Batoidei)
  - Family: Rajidae
    - *Raja erinacea* Mitchill — little skate
    - *Raja ocellata* Mitchill — big skate

Class: OSTEICHTHYES
- Order: Clupeiformes (Isospondyli)
  - Family: Clupeidae
    - *Alosa pseudoharengus* (Wilson) — alewife
    - *Alosa aestivalis* (Wilson) — blueback herring
    - *Clupea h. harengus* (Linnaeus) — Atlantic herring
    - *Brevoortia tyrannus* (Latrobe) — Atlantic menhaden
  - Family: Osmeridae
    - *Osmerus mordax* (Mitchill) — American smelt
- Order: Anguilliformes (Apodes)
  - Family: Anguillidae
    - *Anguilla rostrata* (LeSueur) — American eel
- Order: Beloniformes (Synentognathi)
  - Family: Belonidae
    - *Strongylura marina* (Walbaum) — Atlantic needlefish
- Order: Cyprinodontiformes (Microcyprini)
  - Family: Cyprinodontidae
    - *Fundulus heteroclitus* (Linnaeus) — mummichog
    - *Fundulus majalis* (Walbaum) — striped killifish
    - *Cyprinodon variagatus* (Lacepede) — sheepshead minnow
- Order: Gadiformes (Anacanthini)
  - Family: Gadidae
    - *Microgadus tomcod* (Walbaum) — Atlantic tomcod
    - *Gadus morhua* Linnaeus — Atlantic cod
    - *Urophycis tenuis* (Mitchill) — white hake
- Order: Gasterosteiformes
  - Family: Gasterosteidae
    - *Apeltes quadracus* (Mitchill) — fourspine stickleback
    - *Gasterosteus aculeatus* Linnaeus — threespine stickleback
    - *Gasterosteus wheatlandi* Putman — twospine stickleback
  - Family: Syngnathidae
    - *Syngnathus fuscus* (Storer) — northern pipefish
- Order: Perciformes (Percomorphi; Acanthopterygii)
  - Family: Serranidae
    - *Roccus saxatilis* (Walbaum) — striped bass
  - Family: Pomatomidae
    - *Pomatomus saltatrix* (Linnaeus) — bluefish
  - Family: Carangidae
    - *Caranx hippos* (Linnaeus) — crevalle jack
  - Family: Sparidae
    - *Stenotomus chrysops* (Linnaeus) — scup
  - Family: Labridae
    - *Tautogolabrus adspersus* (Walbaum) — cunner
    - *Tautoga onitus* (Linnaeus) — tautog
  - Family: Cottidae
    - *Hemitripterus americanus* (Gmelin) — sea raven
    - *Myoxocephalus aenus* (Mitchill) — grubby
    - *Myoxocephalus octodecemspinosus* (Mitchill) — longhorn sculpin
  - Family: Ammodytidae
    - *Ammodytes americanus* DeKay — American sand lance
  - Family: Atherinidae
    - *Menidia menidia* (Linnaeus) — Atlantic silverside
- Order: Pleuronectiformes (Heterosomata)
  - Family: Pleuronectidae
    - *Limanda ferruginea* (Storer) — yellowtail flounder
    - *Pseudopleuronectes americanus* (Walbaum) — winter flounder
  - Family: Soleidae
    - *Trinectes maculatus* (Block and Schneider) — hogchoker
- Order: Batrachoidiformes (Haplodoci)
  - Family: Batrachoididae
    - *Opsanus tau* (Linnaeus) — oyster toadfish

STATION #1. MEETINGHOUSE POND BEACH, ORLEANS (60′ BEACH SEINE)

This station was located at the northernmost extremity of the estuary, approximately 9.8 miles from the mouth. The gently sloping beach at this site consisted of coarse sand in the intertidal area and soft mud subtidally. The subtidal bottom was covered with an extensive growth of eelgrass (*Zostera marina*). Salt water cord grass (*Spartina alterniflora*) was common along the high tide mark. The station was seinable in all stages of the tide. Sampling was conducted in every month except February, when thick ice formed along the shore of the pond.

A total of 17 species of finfish were collected at this station. Atlantic silversides, which were the most abundant species taken, ranged in size from 27 mm. to 132 mm. Other common fish species were the mummichog, ranging in size from 31 mm. to 119 mm., fourspine stickleback (13 mm. to 57 mm.), and striped killifish (40 mm. to 92 mm.). Two species were captured only at this station in the estuary. They were the sheepshead minnow, which was collected in October and ranged from 24 mm. to 47 mm., and the crevalle jack (45 mm. to 62 mm.), which was captured in August. Winter flounder were taken in March, April, and June and ranged in size from 34 mm. to 230 mm. Four small specimens, ranging in size from 34 mm. to 42 mm., were taken during the June sampling.

Invertebrates collected during finfish sampling at this location included the prawns *Crangon septemspinous* and *Paleomonetes vulgaris;* the mysids *Mysis stenolepis* and *Mysis mixta;* the rock crab (*Cancer irroratus*), the mud crab (*Neopanope texana*), and the spider crab (*Libinia sp.*).

STATION #2. MEETINGHOUSE POND, ORLEANS (OTTER TRAWL)

At this station, the bottom consists of soft mud. Eelgrass was very common, as was sea lettuce (*Ulva lactuca*) and the red algae *Agardhiella tenera.* Tows were made with the otter trawl in depths ranging from 4 to 22 feet and at all tidal stages. Sampling was conducted during each month throughout the year.

Eighteen species of finfish were captured at this station. The most abundant species was the winter

Table 4. Total Number of Each Species Taken During Monthly Sampling at Meetinghouse Pond Beach in 1965 (60' Beach Seine).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
American eel				3		1			3	3			10
Atlantic needlefish							8		1				9
Atlantic silversides	17					3	>1,000	>1,000	>300	4	>100	8	>2,440
Atlantic tomcod										1			1
crevalle jack								3					3
cunner								1					1
fourspine stickleback	26		2	97	66	16		7	2	6		6	228
grubby									1				1
longhorn sculpin	1												1
mummichog				2	104	18	10	16	>200	32	>100	4	>486
northern pipefish						3	6	2	5	4			20
northern puffer								1					1
sheepshead minnow										9			9
striped killifish	1		1						4	4	>100	50	>160
threespine stickleback	3			3	26	4			1				37
winter flounder			2	1		4							7

Table 5. Total Number of Each Species Taken During Monthly Sampling at Meetinghouse Pond in 1965 (Otter Trawl).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
alewife										1			1
American eel		1	2			2	2	4	6	2			19
American sand lance			1										1
American smelt	3		1										4
Atlantic silversides								54	3	8	6	3	74
Atlantic tomcod	19	1	1										21
cunner	1				1							1	3
fourspine stickleback		5	1	18		2					1		27
grubby			1									1	2
hogchoker					1		2		1		1		5
longhorn sculpin	1	1										1	3
mummichog									5	1	1		7
northern pipefish				2							1	1	4
oyster toadfish		1				1		3					5
scup									4	1			5
striped killifish	1												1
twospine stickleback		1											1
winter flounder	165	31	104	66	1	8	14	29	5	33	107	51	614

Table 6. Total Number of Each Species Taken During Monthly Sampling at Kescayo-Gansett Creek in 1965 (Otter Trawl).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
alewife											2		2
American eel						3	2	2	2	1			10
American smelt					5							5	10
Atlantic silversides								32	50	18	43	16	159
Atlantic tomcod				2	19		7		1		5	2	36
blueback herring								18					18
cunner			1		3			1	2				7
fourspine stickleback			>100	>100	116		45	28	7	6	>100	>100	>600
mummichog								25	17	1	1		44
northern pipefish					1		1		1				3
oyster toadfish		1			1								2
scup								30	14				44
sea herring						4				1	8		13
threespine stickleback					68		15		2				85
white hake					5								5
winter flounder		98	104	153	52		1	4	27	167	84	2	692

flounder, which was taken in every month during the year. This species amounted to 78 percent of the total number of fish collected at this location. The size range of the winter flounder collected was 76 mm. to 414 mm. They were most abundant during the months of January through April when over 50 percent of the total were captured. Many of these fish were in spawning condition. The second most abundant species was the Atlantic silverside, which was taken from August through December. This species ranged in size from 34 mm. to 110 mm. Atlantic tomcod were taken in the first three months of the year and ranged in size from 141 mm. to 267 mm. American smelt, ranging in size from 67 mm. to 72 mm., were captured in January and March.

Invertebrates collected during finfish sampling at this station included the shrimp *Crangon septemspinosus*, the scale worm (*Lepidonotus squamatus*), the moon shell (*Lunatia heros*), the common squid (*Loligo pealei*), the rock crab, the green crab (*Carcinus maenas*), and the spider crab (*Libinia sp.*).

STATION #3. KESCAYO-GANSETT CREEK, ORLEANS (OTTER TRAWL)

This subtidal station was established at the entrance to the creek leading to Kescayo-Gansett Pond. The bottom at this location, from 3 to 6 feet deep at low tide, consisted of soft mud. Eelgrass and the red algae *Agardhiella tenera* were common subtidal algal species. The shoreline was bordered by an extensive growth of salt water cord grass. Sampling was possible during all stages of the tide, and trawls were made in every month except January during 1965.

Sixteen species of finfish were collected during sampling operations at this station. Winter flounder, ranging in size from 81 mm. to 386 mm., were the most abundant species taken. This species made up 40 percent of the total number of fish captured at this station. They were collected in each month except June and were most numerous during the spring and fall. Fourspine sticklebacks were the second most abundant species taken and ranged in size from 25 mm. to 53 mm. Forty-four scup (40 mm. to 103 mm.) were collected during August and September. Blueback herring, captured in August and ranging in size from 33 mm. to 46 mm., were taken only at this station in the sampling area. Sea herring (50 mm. to 94 mm.) collected in June, October, and November were also taken only at this station within the estuary. American eels, captured from June through October, were all of relatively large size, ranging from 300 mm. to 610 mm. in length.

Invertebrates collected during finfish sampling at this station included the channeled whelk (*Busycon canaliculatum*); the oyster drill (*Urosalpinx cinerea*); the mud snail (*Nassarius trivittatus;* the prawns *Paleomonetes vulgaris, Crangon septemspinosus,* and *Hippolyte zostericola;* the amphipod *Amphithoe longimana;* the isopod *Idotea baltica,* the common squid, the Jonah crab (*Cancer borealis*), the mud crab, and the spider crab (*Libinia sp.*)

STATION #4. PAW WAH POND CREEK, ORLEANS (60' BEACH SEINE)

This station was located on a sandy beach, 50 yards north of the creek which enters Paw Wah Pond. The bottom was hard sand, and the beach area was very shallow and flat. Salt water cord grass grew along scattered sections of marsh which were located at the high tide mark. Seining was possible during all stages of the tide except low. Sampling was conducted during all months other than January and February, when ice formation prevented using the seine in this location. No finfish were taken during the March sampling.

Eleven species of finfish were captured at this station. The greatest number of fish taken at any one station in the estuary were taken here. The most abundant species was the Atlantic silverside, which ranged in size from 23 mm. to 132 mm. They were most abundant during July and August. Mummichogs were the next most numerous species taken and occurred in greatest abundance in May. The overall size range of this species was 28 mm. to 117 mm. Atlantic needlefish (70 mm. to 294 mm.) were taken from July to October.

Invertebrate species collected during finfish sampling included the prawns *Crangon septemspinosus, Paleomonetes vulgaris, Paleomonetes pugio,* and *Hippolyte zostericola;* the mysid *Mylil stenolepis;* the Jonah crab; the green crab; the isopod *Idotea baltica;* the amphipod *Amphithoe longimana;* the mud snail; and the bay scallop (*Aquipecten irradians*).

Table 7. Total Number of Each Species Taken During Monthly Sampling at Paw Wah Pond Creek in 1965 (60' Beach Seine).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
American eel							3	3	3	1			10
Atlantic needlefish							53	10	5				68
Atlantic tomcod								1					1
Atlantic silversides				50	25	2	>1,000	>1,000	>100	42	20	>300	>2,500
fourspine stickleback				25	3	10	12	21	48	53	41	6	219
mummichog					>1,000	15	30	13	17	>100	9	1	>1,185
northern pipefish						1	3	13	24	50			91
northern puffer								1					1
oyster toadfish										1			1
striped killifish				13		1			186	>100	5	6	>300
winter flounder				4			1		1	3			9

Table 8. Total Number of Each Species Taken During Monthly Sampling at Strong Island in 1965 (120' Haul Seine).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.[1]	Dec.[1]	Total
American eel						2		3	2				7
Atlantic cod						19							19
Atlantic menhaden								1					1
Atlantic needlefish							6	2	1				9
Atlantic silversides						4	4	39	79	2			128
Atlantic tomcod					15	17		25	7	2			66
cunner						8			2	2			12
fourspine stickleback						7	4	12	3	10			36
grubby						1	1						2
longhorn sculpin											2	1	3
mummichog							7	8	9				24
northern pipefish						3	3	9	13	3			31
northern puffer								1	3				4
striped bass					2								2
striped killifish						7			1				8
tautog						1		2		1			4
threespine stickleback					1	14		12	2	1			30
white hake					27	36	2	1	2				68
winter flounder					4	15	6	6	8	2	2	8	51

[1] Otter Trawl

Table 9. Total Number of Each Species Taken During Monthly Sampling at Old Harbor in 1965 (Otter Trawl).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
American eel						1	2						3
Atlantic cod						1							1
Atlantic tomcod					5	9	4						18
cunner						6	7	18	28	38		3	100
grubby									1	1		4	6
little skate				1	1						1		3
longhorn sculpin					1						1	4	6
northern pipefish									9	15			24
sea raven				1									1
tautog							1	3	24				28
white hake					3	25	7	3					38
winter flounder				185	95	96	62	51	49	24	5	26	593
yellowtail flounder				1									1

STATION #5. STRONG ISLAND, CHATHAM (120′ HAUL SEINE)

This station was located on the edge of a sand bar extending easterly from the southeast corner of Strong Island. The bottom, from 7 to 12 feet deep at low water, consisted of hard sand. Submerged plants included eelgrass; sea lettuce; and the red algae *Agardheilla tenera* and *Ceramium sp.* It was possible to sample with the large seine only at low tide at this station. Slack water and exposure of the adjacent sand bar were necessary for setting the seine and hauling back effectively. Sampling was conducted from May through December. The November and December sampling was accomplished with the small otter trawl.

Nineteen species of finfish were captured at this location. This was the largest number of species taken at any station within the estuary. The most abundant species collected was the Atlantic silverside, which ranged in size from 29 mm. to 170 mm. White hake, ranging in size from 50 mm. to 210 mm., were the second most abundant species taken. Winter flounder (30 mm. to 329 mm.) were captured during every month sampled. Nineteen Atlantic cod (60 mm. to 112 mm.) were collected in June. Two striped bass were captured in May at this station. One Atlantic menhaden (66 mm.) was taken in August.

Invertebrates collected during the finfish sampling included the prawns *Crangon septemspinosus* and *Paleomonetes vulgaris;* the green crab; the common squid; the thick lipped drill (*Eupleura caudata*); the oyster drill; the isopods *Idotea baltica* and *Idotea phosphorea;* and the amphipod *Aeginella longicornis.*

STATION #6. OLD HARBOR, CHATHAM (OTTER TRAWL)

The hard sand bottom at this location is from 5 to 11 feet deep at low tide. Sampling could be accomplished during all tidal stages. Tows were made with the otter trawl in all months other than January, February, and March. Submerged plants at this station included the red algae *Agardhiella tenera,* sea lettuce, and eelgrass.

Thirteen species of finfish were collected during sampling at this location. Winter flounder, which made up 72 percent of the total number of fish captured, were the most abundant species taken. They ranged in size from 50 mm. to 392 mm. This species was captured during each month sampled and was most abundant from April through June when 63 percent of the total were collected. The second abundant species captured was the cunner, which ranged in size from 50 mm. to 162 mm. This species was most numerous during October. Other species taken at this station included white hake (65 mm. to 157 mm.), tautog (52 mm. to 228 mm.), and one specimen of yellowtail flounder, the only recorded occurrence of this species in the estuary.

Invertebrates collected during finfish sampling included the horseshoe crab (*Limulus polyphemus*); the spider crab (*Libinia sp.*); the rock crab; the Jonah crab; the green crab; the mud crab; the American lobster (*Homarus americanus*); the amphipods *Caprella geometrica* and *Aeginella longicornis;* and the isopods *Idotea phosphorea* and *Idotea baltica.*

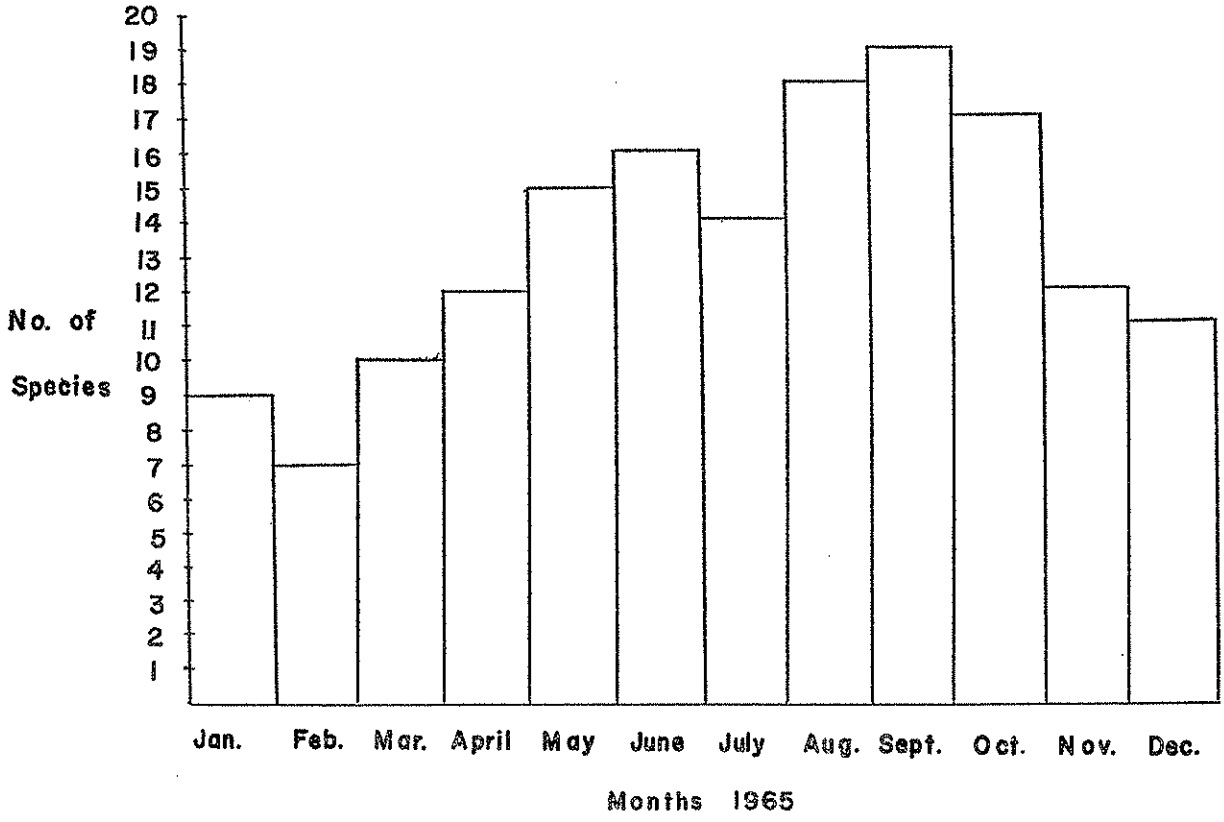
STATION #7. OFFSHORE SAMPLING, PENDLETON (OTTER TRAWL)

One offshore station was established north of the *Pendleton* wreck. The bottom at this location was hard sand and from 24 to 36 feet deep. This station was sampled in April, May, June, September, and December during 1965. Water temperatures at this station ranged from 38.0°F. to 54.5°F.

Nine species of finfish were taken at this location during the five months sampled. Winter flounder were the most abundant species, ranging in size from 249 mm. to 496 mm. They were most numerous in April when many spawning individuals were taken in the sample. This species was captured during each month sampled. The second most abundant species captured were skates (including both winter and little skates), which ranged in size from 358 mm. to 855 mm. Skates were collected during each month sampled and were most numerous in December. Yellowtail flounder, which also were taken during each month when tows were made, ranged in size from 229 mm. to 465 mm. They were most numerous in April. Windowpane flounder were also taken during all five months and ranged in size from 156 mm. to 355 mm. in length. This species was most abundant in September. Longhorn sculpin (258 mm. to 330 mm.) were captured in May, September, and December. Atlantic cod (591 mm. to 601 mm.) and one sea raven (450 mm.) were collected in December. One spiny dogfish was taken in September and one ocean pout in April.

Figure 10.

Total Number of Finfish Species Collected at Sampling Stations 1-6, Jan.-Dec. 1965



Discussion

A total of thirty-six fish species were taken from the seven sampling stations established within Pleasant Bay and the immediate offshore area. The most abundant species collected was the Atlantic silverside, which was taken at each of the stations within the estuary except the otter trawl station at Old Harbor. This shore zone species was found in its greatest abundance at the beach stations during the summer months. The mummichog was the next most numerous species collected. This species was captured at five of the six inshore sampling stations. Striped killifish, as well as fourspine and threespine sticklebacks, were among other shore zone species that were taken in abundance at the inshore stations. The northern pipefish, taken at each station within the estuary, was common in the collections during the summer and early fall months. This species ranged in size from 52 mm to 228 mm.

In addition to the common shore zone species, the juvenile forms of several commercially important species were encountered during finfish sampling operations. In the lower estuary, juvenile white hake (50 mm. to 210 mm.) were captured from May to October. Small tautog (52 mm. to 250 mm.) were also common in this area from June through September. Juvenile scup (40 mm. to 105 mm.) were collected within the upper estuary from August through October.

The winter or blackback flounder was captured at all of the finfish sampling stations. This species was most abundant in the collections during April. The

Table 10. Total Number of Each Species Taken During Sampling at Pendleton Offshore Area in 1965 (Otter Trawl).

	Apr.	May	June	Sept.	Dec.	Total
Atlantic cod					2	2
longhorn sculpin		3		5	4	12
ocean pout	1					1
sea raven					1	1
skate	22	8	20	34	90	174
spiny dogfish				1		1
windowpane	2	3	5	13	12	35
winter flounder	69	35	60	41	20	225
yellowtail flounder	61	36	32	3	35	167

size range of winter flounder taken within the estuary ranged from 34 mm. to 414 mm. The size range of winter flounder taken offshore was comparably larger — 249 mm. to 496 mm. Ripe specimens were collected in the estuary from December through March, and eggs and larvae were taken at Station 2 during March. In addition, the occurrence of juvenile winter flounder encountered within the estuary throughout the year emphasized the importance of Pleasant Bay as a nursery area for the young of this species. Further discussion of this flatfish is contained in a later section of this report.

Atlantic tomcod were captured at all of the finfish sampling stations. This species was most numerous during the summer months and ranged in size from 22 mm. to 328 mm. During the month of December, tomcod were observed spawning in the Muddy Creek area in Harwich. At the time, water temperature had dropped to 36.5°F. Many fish had swarmed into the area under the bridge, as well as up into the extreme high tide zone of the marsh.

The crevalle jack and the Atlantic needlefish were captured at Station 1. Three crevalle jack (45 mm. to 62 mm.) were collected in August. Although only juveniles were taken in Pleasant Bay, this species may attain a maximum weight of 36 pounds. Atlantic needlefish were captured at Stations 1, 4, and 5 in July and September and Stations 4 and 5 in August. The size range of this species, which may attain a maximum length of 4 feet, was 52 mm. to 294 mm.

The recorded collection of certain finfish species such as alewives and striped bass did not reflect the actual relative abundance of these species within the estuary. This was due primarily to limitations of the sampling gear used, as well as selectivity of the gear itself.

The only anadromous fish species collected during finfish sampling was the alewife. One specimen of 195 mm. in length was taken at Station 2 in October, and two juveniles (76 mm. and 80 mm.) were captured at Station 3 in November. The latter two specimens were possibly young of the year fish from one of the alewife runs in Pleasant Bay.

The American eel was captured at each of the sampling stations. This species was collected primarily from June through October and ranged in size from 54 mm. to 744 mm. The object of a minor commercial fishery, the American eel is harvested for both bait and foodfish purposes.

Of all the finfish collected at the sampling stations within the estuary, over eighty percent were captured

Table 11. Minimum and Maximum Recorded Water Temperatures and Salinities at the Finfish Sampling Stations of Pleasant Bay.

Station	Temperature (°F.) Min.	Max.	Salinity (Corr.) Min.	Max.
Meetinghouse Pond Beach (S1)	32.9	75.2	23.5	27.9
Meetinghouse Pond (S2)	32.0	75.2	23.5	27.9
Kescayo-Gansett River (S3)	37.3	74.1	26.3	29.8
Paw Wah Pond Creek (S4)	40.5	76.1	25.2	29.9
Strong Island (S5)	36.5	78.3	27.4	31.4
Old Harbor (S6)	37.8	69.8	28.7	31.0

during the period from April to November. The largest number of finfish species collected occurred during the month of September. Fewer fish were taken during the winter months when water temperatures were lowest. Only 14 species were captured during the period from December through February.

Finfish captured at the offshore station were representative of many of those species which make up the intensive offshore commercial fishery. Winter flounder and yellowtail flounder, which were taken during each month sampled, are two of the most important commercial flatfishes in Massachusetts. U.S. Bureau of Commercial Fishery statistics indicate that the combined value of the 1965 annual landings of these two species in Massachusetts was well over $8,400,000. Atlantic cod, which were captured in December, also represent an important commercial species. Winter and little skate were taken in each month sampled.

Salinity values at the finfish sampling stations exhibited little variation. Minimum and maximum salinities ranged from 22.4 0/00 to 31.4 0/00. The minimum and maximum temperatures and salinities encountered in association with collection of finfish species are shown in Table 11.

Table 12. The Rank of Fish According to Their Abundance at Each Station in the Pleasant Bay Study Area in 1965 and 1966.

Meetinghouse Pond (Beach Seine)

Atlantic silverside
mummichog
fourspine stickleback
striped killifish
threespine stickleback
northern pipefish
American eel
Atlantic needlefish
sheepshead minnow
winter flounder
crevalle jack
longhorn sculpin
cunner
northern puffer
grubby
Atlantic tomcod

Meetinghouse Pond (Otter Trawl)

winter flounder
Atlantic silverside
fourspine stickleback
Atlantic tomcod
American eel
mummichog
hogchoker
scup
oyster toadfish
northern pipefish
American smelt
longhorn sculpin
cunner
grubby
American sand lance
alewife
striped killifish
twospine stickleback

Kescayo-Gansett Creek (O. T.)

winter flounder
fourspine stickleback
Atlantic silverside
threespine stickleback
blueback herring
mummichog
scup
Atlantic tomcod
Atlantic herring
American eel
American smelt
cunner
northern pipefish
alewife
oyster toadfish
white hake

Paw Wah Creek (Beach Seine)

Atlantic silverside
mummichog
striped killifish
fourspine stickleback
northern pipefish
Atlantic needlefish
American eel
winter flounder
northern puffer
Atlantic tomcod
oyster toadfish

Strong Island (Otter Trawl and Haul Seine)

Atlantic silverside
white hake
Atlantic tomcod
winter flounder
fourspine stickleback
northern pipefish
threespine stickleback
mummichog
Atlantic cod
cunner
Atlantic needlefish
striped killifish
American eel
northern puffer
tautog
longhorn sculpin
striped bass
grubby
Atlantic menhaden

Nauset Beach (Otter Trawl)

winter flounder
cunner
white hake
tautog
northern pipefish
Atlantic tomcod
grubby
longhorn sculpin
American eel
little skate
Atlantic cod
sea raven
yellowtail flounder

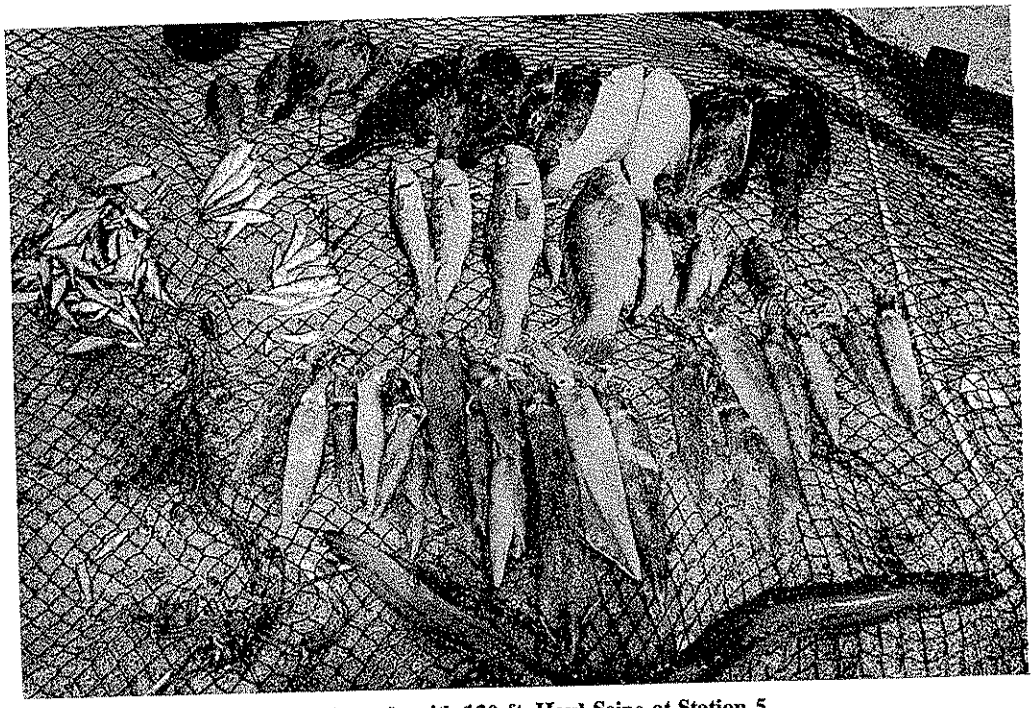
Pendleton Offshore Area (Otter Trawl)

winter and little skate
winter flounder
yellowtail flounder
windowpane flounder
longhorn sculpin
Atlantic cod
ocean pout
sea raven
spiny dogfish

WINTER FLOUNDER FISHERY

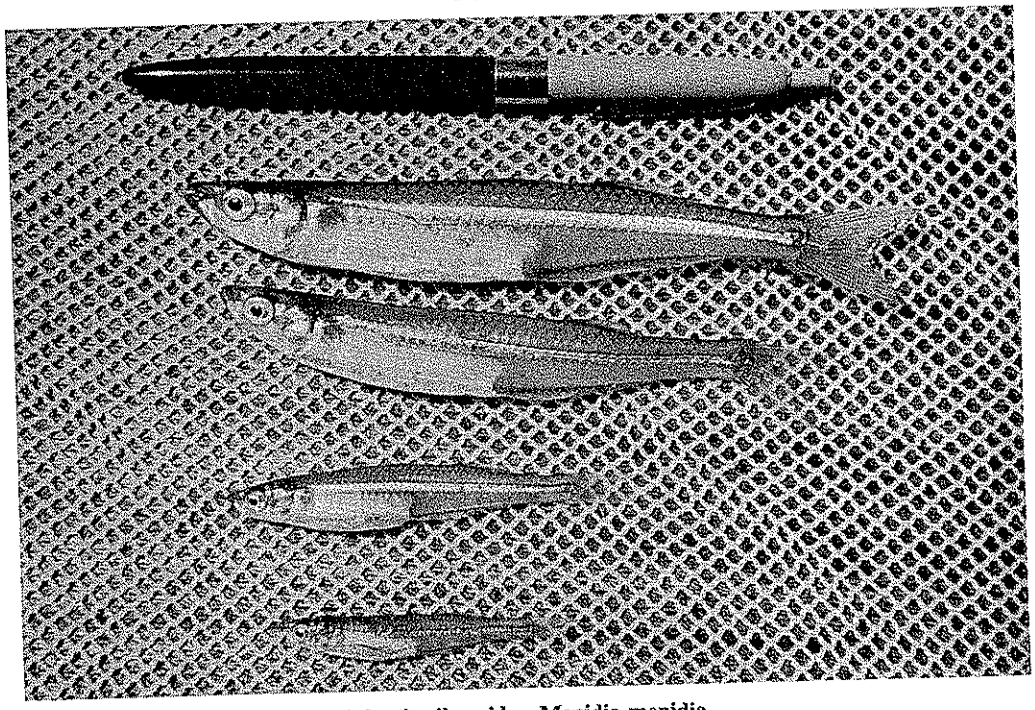
The winter flounder (*Pseudopleuronectes americanus*) occupies a high position in the list of valuable marine finfish species resident to the waters of Massachusetts. The coastal bays and estuaries of the Commonwealth support populations of this flatfish which are subject to exploitation by both commercial and recreational fishermen. In recent years the commercial landings of winter flounder in Massachusetts' waters have exceeded 15,000,000 pounds annually. The territorial waters of the Commonwealth and the offshore fishing grounds such as Georges and Stellwagen Banks contribute to this substantial poundage. The otter trawl is the most effective means of capturing winter flounder; and it has largely replaced the traps, seines, and hand lines previously used by commercial fishermen. In addition to the important commercial

PLATE 3.



Catch made with 120 ft. Haul Seine at Station 5.

PLATE 4.



Atlantic silversides, Menidia menidia.

The most abundant species taken in Pleasant Bay.

Table 13. Minimum and Maximum Surface Water Temperatures and Salinities Recorded at the Sampling Stations of Pleasant Bay When the Various Fish Species Were Taken.

Species	Water Temperatures, (°F.) Min.	Max.	Salinities, 0/00 Min.	Max.
alewife	44.8	54.5	26.7	
American eel	40.1	78.3	24.6	31.4
American sand lance	40.1		24.6	
American smelt	36.5	62.6	26.0	28.0
Atlantic cod	63.0	69.8	22.4	29.5
Atlantic herring	44.8	54.3	26.7	27.8
Atlantic menhaden	78.3		29.7	
Atlantic needlefish	68.0	78.3	27.5	31.4
Atlantic silversides	32.9	78.3	23.7	31.4
Atlantic tomcod	33.1	78.3	24.6	31.4
blueback herring	74.3		29.8	
bluefish	75.0		25.5	
crevalle jack	75.2		27.0	
cunner	38.3	75.2	22.4	31.4
fourspine stickleback	32.9	78.3	23.7	31.4
grubby	38.3	69.8	24.5	29.5
hogchoker	44.8	75.2	25.3	27.9
little skate	38.8	55.4	26.8	28.7
longhorn sculpin	32.9	38.8	23.5	30.0
mummichog	39.2	78.3	23.5	31.4
northern pipefish	44.8	78.3	25.9	31.4
northern puffer	75.2	78.3	27.0	31.4
oyster toadfish	41.0	74.0	27.2	27.8
scup	54.5	69.1	27.5	29.8
sea raven	55.4		28.7	
sheepshead minnow	58.5		25.9	
striped bass	57.2			
striped killifish	39.2	68.0	23.5	31.4
tautog	50.0	78.3	29.5	30.5
threespine stickleback	32.9	78.3	23.7	31.4
twospine stickleback	33.1			
white hake	62.6	78.3	27.5	31.4
winter flounder	33.1	78.3	23.5	31.4
winter skate	57.2		29.9	
yellowtail flounder	55.4		28.7	

flounder fishery, a recreational fishery for the species has developed to the extent that the winter flounder is now numerically the number one marine sport fish caught in Massachusetts' waters. During 1960-1961 for example, over 1,000,000 pounds of winter flounder were landed by sport fishermen alone. The average marine sport fishermen utilizing relatively unsophisticated tackle and casually fishing from piers, jetties, beaches, and bridges soon learn that the availability of the winter flounder combines with excellent quality to provide both gastronomical and recreational pleasures.

Pleasant Bay supports a seasonable commercial winter flounder fishery. State statutes, which regulate otter trawling, and the movements of the winter flounder both contribute to the seasonable nature of the fishery. For example, Ryders Cove in Chatham, Round Cove in Harwich, and Quanset Pond in Orleans are closed to otter trawling throughout the year (Statute 1950 Chap. 69). In addition to these regulations, Statute 1936 Chap. 238 closes the entire bay to otter trawling from May 1 to October 31. The success of the fishery is largely dependent upon the extent of movement of the flounder into the upper part of the bay during their spawning period. The main efforts of the commercial fishermen are concentrated in the upper portion of the estuary and unless ice formation precludes otter trawling, the season generally extends from November to April.

The fishery is mainly conducted with small individually operated otter trawls with mesh openings ranging from 3 to 5 inches. These trawls are towed behind outboard powered skiffs and an occasional small inboard dragger. In general, larger mesh sizes are preferred due to the extensive weed growths in the bay which have a tendency to foul the smaller meshes. All but the smallest flounders are retained by the fishermen. The price differential which favors the larger fish encourages the fishermen to grade his catch according to size.

Meetinghouse Pond, Kescayo Gansett Pond, and the Namequoit area in Little Pleasant Bay are the

main locations of commercial activity. During 1965, approximately 500 boxes or 60,000 pounds of winter flounder were taken from Pleasant Bay. At an average of 15¢ per pound, the wholesale value of the flounder fishery in Pleasant Bay was $8,750.00.

Otter trawl samples collected by Division personnel during exploratory sampling of Pleasant Bay in early 1965 indicated that a population of ripe winter flounder were present in the upper bay. Within the coastal waters of Massachusetts, the winter flounder is known to spawn from mid-winter (December) through spring (May). Spawning activity in southern Massachusetts' waters is generally earlier than in the more northerly latitudes although localized variation to the general trend sometimes occurs. Observations made in Pleasant Bay indicated that the larger maturing flounder move into the upper portion of the bay during fall. This movement coincides with the expected seasonal drop in water temperature. The fish remain in the upper portion of the bay until spawning is completed. In an effort to determine the peak period of spawning activity in the upper bay area during 1965, periodic comparison was made of the relative percentages of ripe and spent flounder captured by otter trawl. The observations indicated that most of the flounder in the Meetinghouse Pond area spawned between late February and mid-March of 1965. Although efforts to observe the spawning activity of flounder were primarily concentrated in the Meetinghouse Pond area, the presence of ripe and spent fish in the other coves and inlets throughout the bay as revealed by exploratory trawling confirmed the fact that flounder spawn in these areas as well as the uppermost portion of the estuary.

Comparison of quantitative trawl samples, however, revealed that the heaviest concentration of spawning took place in the upper portion of Pleasant Bay during 1965.

As would be expected for a fish resident to a fluctuating estuarine environment, the inshore winter flounder spawns in water of variable salinity. In Pleasant Bay, however, there is little appreciable dilution of the sea water by fresh water discharge; and observed salinities remained above 25 0/00 from January through May.

According to Bigelow and Schroeder (1954), the winter flounder spawns at inshore water temperatures of 37–38°F., and the eggs incubate for a period of 15–18 days. Winter flounder eggs and larvae were collected with a benthic plankton sampler on several days in March, 1965.

Young of the year flounder generally remain resident to the immediate estuarine environment where they were spawned. Perlmutter (1946) partly attributes this early localized residency to the demersal, adhesive characteristics of the flounder eggs which place them less at the mercy of tide and wind than the buoyant marine eggs of other finfish species.

According to Perlmutter (op. cit.), as winter flounder develop, they tend to scatter from the population centers in a characteristic dispersal pattern common to many organisms. In general, however, except for dispersal and certain seasonal movements related to spawning and water temperature, the winter flounder is a relatively stationary species, exhibiting no extensive migrational movement.

Water temperature is one of the primary environmental factors affecting the movements of winter flounder. Within Pleasant Bay, there was an observed movement of winter flounder from the shallow waters of the upper estuary to the deeper cooler waters of the lower bay and adjacent coast in late spring. Figure 11 compares the number of flounder captured monthly by trawl and the surface water temperatures at the finfish sampling stations (Sta. 13) during 1965. McCraken (1963) refers to winter flounder movement out of bays and estuaries when summer water temperatures exceed 59°F. In upper Pleasant Bay, summer surface water temperatures regularly exceed 70°F. and these high temperatures contribute significantly to the absence of flounder in the upper bay during the milder months. In the fall of the year, as water temperatures lower to a tolerable level, the flounder return to the upper portion of the bay; there to remain until they spawn.

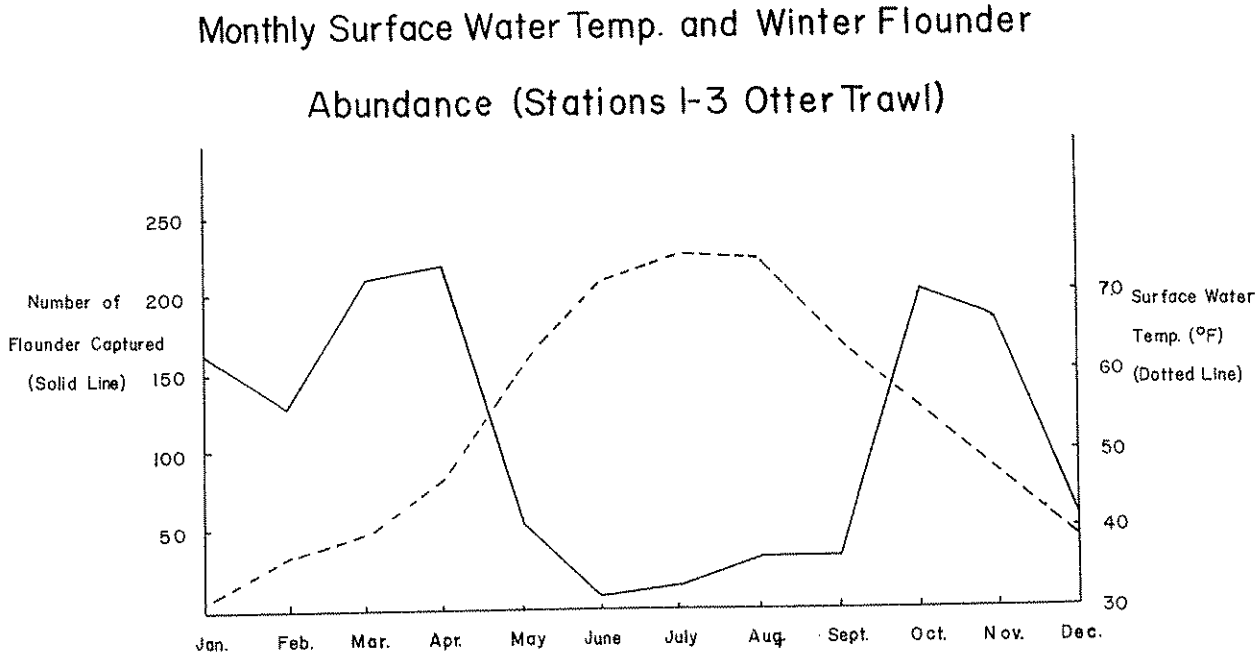
The tagging and marking of finfish is one of the more important tools utilized by the fisheries biologist to gain knowledge of movements, growth, mortality, and the level of exploitation of the various finfish populations inhabiting the sea. Since 1960, the Massachusetts Division of Marine Fisheries has been engaged in an extensive tagging program involving the winter flounder. This program, in which the Division and the U. S. Bureau of Commercial Fisheries at Woods Hole have cooperated to tag over 11,700 offshore and inshore winter flounder from 1960 to 1964, was extended on March 8, 1965, when 508 additional flounder were tagged in Meetinghouse Pond, Orleans. It was hoped that information would be obtained concerning the movements and the level of exploitation of this group of spawning flounder, which are subject to a winter commercial fishery.

The flounder were tagged with easily visible, yellow Petersen disc tags. The numbered tags contain notice

PLATE 5.

Small dragger in Pleasant Bay landing a catch of winter flounders.

Figure 11.



of a reward and the Woods Hole address of the U. S. Bureau of Commercial Fisheries. The finder is eligible for a $1.00 reward upon returning the tag and a reward of $2.00 for returning the tag and fish intact to a representative of either the Bureau of Commercial Fisheries or the Division of Marine Fisheries.

Approximately two years have elapsed since the tagging operation in Meetinghouse Pond, and of the 508 winter flounder originally tagged, a total of only 18 have been recaptured. The percentage (3.5%) of flounder recaptured from the Meetinghouse Pond group is one of the lowest returns of any of the tagging areas, but it should be noted that the Meetinghouse Pond fish were tagged only two years ago as compared to the three or more year period that has elapsed since tagging in the other areas.

Figure 12 illustrates the recapture locations of the flounder tagged in Meetinghouse Pond. Most of the recaptures occurred in Pleasant Bay itself (11 recaptures). All but two of the remainder were recovered within ten miles of the tagging site. One of these exceptions was a fish recaptured twenty miles from Meetinghouse Pond in Town Cove, Orleans, thirteen months after having been tagged. The other flounder that moved in excess of ten miles was recaptured south southeastward of Monomoy Island, approximately twenty miles from the tagging site, one year after having been tagged.

Although the recapture level of the Pleasant Bay flounder group points toward a low level of exploitation, there are possible factors which might have contributed to this low recapture level. For example, the flounders tagged in Meetinghouse Pond were considerably smaller than those tagged elsewhere along the coast. Although the Petersen tag is one of the most reliable tags presently being utilized for flatfish, the possibility of a high degree of tagging mortality cannot be entirely disregarded. Excessive tagging mortality, if undetected, would erroneously suggest a low exploitation rate in the Pleasant Bay flounder group. Another possible explanation for low tag recovery is that some of the recaptured fish and tags were not returned to Division or BCF personnel. Generally, however, the fishermen are conscientious in returning tags.

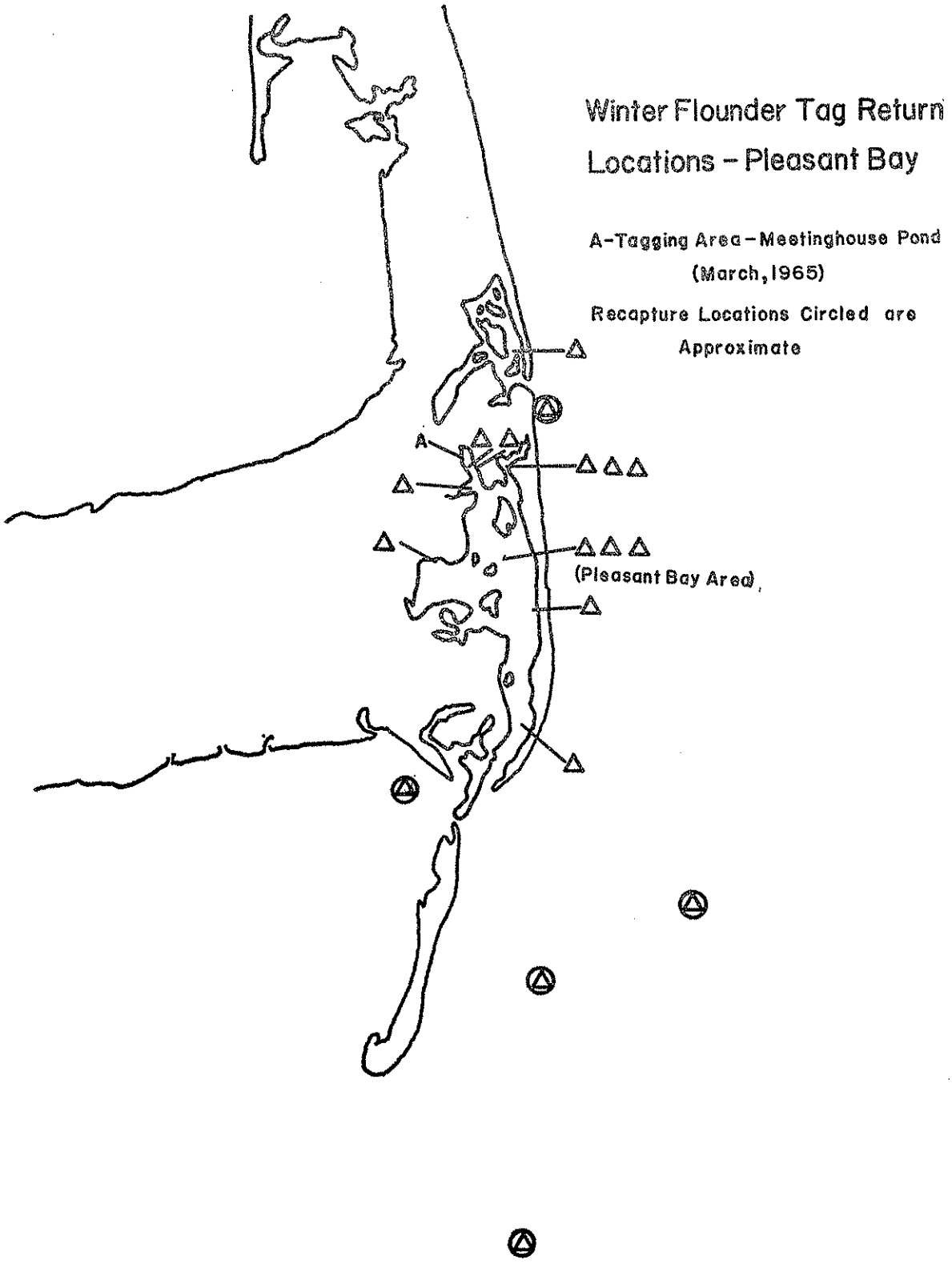
If excessive tagging mortality and/or other factors which might contribute to an abnormally low recapture level (3.5%) did not occur in Pleasant Bay, then evidence points to a low exploitation level. As previously discussed, commercial activity in Pleasant Bay is primarily concentrated in the upper bay area only for 4 to 5 months of the year. The recreational fishery for flounder is not as intensive as in other areas along the Massachusetts coast, such as Quincy Bay and Salem Harbor where there has been a relatively high return on tagged fish. The waters adjacent to Pleasant Bay, however, (Rogers, Handkerchief Shoals, and Pollock Rip) are subject to an intensive otter trawl fishery. Six of the eighteen recorded tag recoveries were captured from these areas. Although the number of tag returns is too low to draw any definite conclusions regarding the contribution of Pleasant Bay flounders to the adjacent fisheries, this possibility cannot be ignored. As has been the case in earlier tagging operations, it may be anticipated that tag returns from Pleasant Bay will continue to be received, and these recaptures will provide a basis for a more accurate evaluation of the flounder tagged in that area.

This study revealed that an extensive area in the upper portion of Pleasant Bay serves as flounder spawning environment. Included in this area are tidal salt ponds such as Meetinghouse Pond and Kescayo Gansett Pond. In recent years, concern has been expressed by various local citizens and fishery biologists that dragging (otter trawling) in such areas during the spawning season might be detrimental to these flounder stocks. However, there is no conclusive evidence that exploitation of these stocks has resulted in a decline in the resource. It is not known to what degree flounder populations can be exploited prior to spawning without interfering with the perpetuation of the stock, nor is it known whether or not otter trawling has any real effect upon the eggs and larvae of the flounder. To date, the return of fish that were tagged in Meetinghouse Pond does not indicate a high degree of exploitation. Conversely, on the basis of fishermen reports, there has been a downward trend of the flounder fisheries in Pleasant Bay. However, before there is more conclusive evidence as to the trend of the fishery and the degree of exploitation, no new regulatory fishing measures should be adopted. Pleasant Bay provides an excellent area for the study of winter flounder populations and the relationship of seasonal estuarine flounder populations to the adjacent coastal waters. Flounder studies in Pleasant Bay should be continued by the Division of Marine Fisheries. Such study should include further tagging of local stocks.

Eel Fishery

The American eel (*Anguilla rostrata*) was taken at each of the finfish sampling stations in the estuary. This common estuarine species spends most of its

Figure 12.


Winter Flounder Tag Return
Locations - Pleasant Bay
A-Tagging Area - Meetinghouse Pond
(March, 1965)
Recapture Locations Circled are
Approximate
A
B
(Pleasant Bay Area)

life in fresh or brackish water or in the vicinity of estuaries and tidal areas along the coast. As the eels reach sexual maturity, they migrate to the open sea. Eels spawn in the oceanic basin well beyond the range of the continental shelf. It is believed that the adult fish die after spawning. The young elvers which reach our shores in the spring are from 2 to 3½ inches long. Although they have a slow growth rate, eels may reach a maximum size of 4 feet and attain a weight of 16½ pounds. Although commonly thought of as scavangers, they will feed on almost any dead or living animal matter such as small fishes, crustaceans, shrimps, crabs, lobsters, or refuse. The species is tolerant of a wide range of temperature and salinity and is a common inhabitant of the estuaries of Massachusetts.

A small fishery exists in Pleasant Bay for the American eel. During the winter months, live eels are speared from boats or through the ice, using a special "eel spear," which can capture the eel without injury (Plate 6). This fishery is primarily a family type fishery.

A commercial fishery for eels is carried on during the summer months. Adult eels are captured in specifically designed pots baited with crushed berried (egg-bearing) female horseshoe crabs or dead fish. The live eels are stored in holding boxes or live cars and held for peak market demand. Small eels (up to 12 inches long) are sold locally as bait for striped bass. The price per eel for bait during 1965 was $0.25. Large live eels are held and shipped to the Boston market during the Christmas holiday season. They are sold for food purposes at $0.10 to $0.30 per pound. During 1965, two fishermen from Pleasant Bay shipped approximately 4,000 pounds of eels to market at $0.30 per pound for a total value of $1,200.00.

According to statistics compiled by the U.S. Bureau of Commercial Fisheries, the total catch of the eel fishery in Massachusetts during 1965 was 21,000 pounds. The value of this fishery was approximately $6,000.00.

Alewife Fishery

The most important anadromous fish species in Massachusetts is the alewife, commonly referred to as "herring." During the early spring, alewives enter coastal streams and ascend to headwater lakes and ponds to spawn. The young fry, which have reached a length of 2 to 4 inches, migrate to the sea in the late summer and fall. Many of the coastal towns of Massachusetts regulate and sell the fishing rights to this important marine fishery resource. The considerable poundage landed and its dollar value reflect the economic importance of the fishery. U.S. Bureau of Commercial Fisheries statistics show that in 1965 a total of 6,935,000 pounds were landed in the state by haul seines, purse seines, otter trawls, pound nets, and dip nets. The total value of the catch was $80,000.

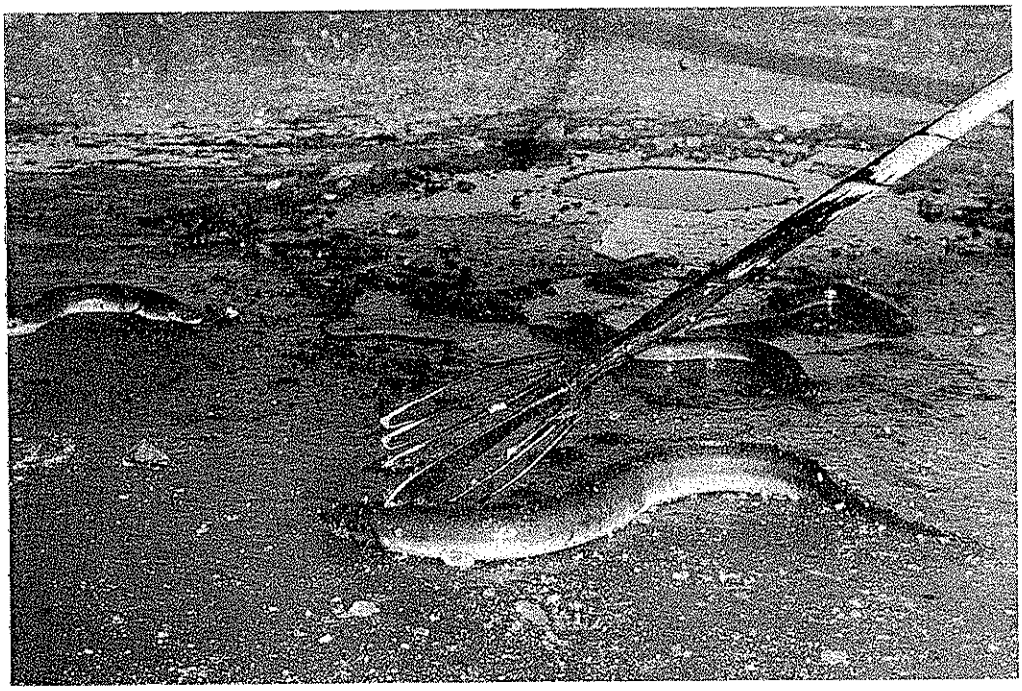
Within the Pleasant Bay estuary, a survey was made of the existing alewife fisheries with regard to their present condition and possible improvement. The survey was carried on during 1965 and continued through 1966 because of existing drought conditions which could severely affect the fishery. Historical information concerning the alewife runs was obtained primarily from Belding (1921).

Two alewife runs were in operation in the Pleasant Bay area during the early 1900's. Belding (op. cit.) reported that a fishery existed in Orleans in a stream connecting Sparrow Pond (Crystal Lake) with Pleasant Bay. At the time of his report, this fishery was a public one and was estimated to have a possible annual production of 400 barrels, worth about $200 to the town. At the present time there is no connection between the lake and Pleasant Bay, and the fishery no longer exists at this location. The other fishery mentioned by Belding (op. cit.) was on "Chathamport Alewife Brook." This small stream, which flowed through cranberry bogs, connected "Smiths Pond" and Ryders Cove. The fishery was small and privately owned and had no possibility for development. It is thought that what is now known as Lovers Lake was "Smiths Pond", and if such is the case, this fishery also is no longer in existence.

Presently, within the Pleasant Bay area, there are two existing alewife spawning runs. In the town of Orleans, a fishway extends between Kescayo-Gansett Pond, a tidal pond near the northern extremity of the estuary, and Pilgrim Lake, a freshwater pond of approximately 38 acres. The fish ladder in this run was constructed in 1959. The estimated annual production of alewives in this run is 400 barrels or approximately 120,000 fish.

During the spring of 1965, water flow was very poor in this run. Adult alewives had difficulty in migrating to the spawning area. Young fry were hampered by inadequate runoff in returning to the sea. In the spring of 1966, a fair run of alewives was observed migrating to the pond. Spawning did occur, but due to the continuation of drought conditions during the summer, escape of the fry to the sea was doubtful. When the

PLATE 6.



Eel spearing through the ice.

PLATE 7.

Fisherman with eel pot.

area was examined in October of 1966, the water level of the lake was about one foot below the entrance to the run. Small schools of juvenile alewives were observed in the lake, but it was obvious that escape to the sea at this time was impossible since there was no water in the run. Considerable rainfall is necessary in the late fall or early winter months to raise the level of the lake and permit some runoff in order to allow the young fry to migrate to the sea.

The second existing fishway in Pleasant Bay is in Chatham between Ryders Cove and Stillwater Pond. The pond (approximately 20 acres) supports a small seasonal population of alewives. The estimated annual production of alewives in this run is 50 barrels or 15,000 fish. When examined in the fall of 1966, many small fry of 2″ to 3″ were observed migrating to the sea. Proposals to construct a two foot culvert under Old Comers Road from Stillwater Pond to adjacent Lovers Lake would more than double the available spawning area. This would provide opportunity for a potentially larger alewife population in the run. In order to further improve the fishery, it is recommended that the present wooden structures used to control water flow in the fishway be replaced by concrete baffles. The relative permanency of concrete construction would reduce the amount of maintenance necessary for the perpetuation of this fishway.

Although there are several locations in Pleasant Bay where alewife runs could be established, one of the most promising areas is the stream which runs from Quanset Pond in Orleans through a submerged cranberry bog to Sarah's Pond. This latter pond, approximately six and one-half acres in size, has relatively cold water and good depth (10 to 12 feet) and appears to be a satisfactory spawning area for alewives. Establishment of a spawning run in this area would necessitate opening of the ditch between Sarah's Pond and Quanset Pond, as well as enlargement and lowering of the culvert connecting Quanset Pond and the submerged bog. Water flow would have to be regulated at the two pond outlets, and Sarah's Pond would have to be stocked with spawning alewives. The establishment of a run in this location appears to be both feasible and desirable and could provide a fair-sized alewife fishery.

With the passage of the Anadromous Fish Act (P.L. 89–304) in October, 1965, by the United States Congress, provision was made for Federal monetary assistance to the states for the conservation, development, and enhancement of anadromous fish. It is anticipated that the Commonwealth of Massachusetts will take advantage of this Act in promulgating work relative to the improvement of the alewife fisheries of Massachusetts.

Pleasant Bay Sport Fishery

Pleasant Bay is one of the most productive marine sportfishing areas along our coast. It is noted primarily for striped bass fishing which takes place from May to November. Sport fishermen also frequent the area in the summer months seeking other fish species such as pollock, tautog, cod, winter flounder, bluefish, scup, and tomcod.

The occurrence of the larger desirable predatory species such as striped bass and bluefish is due principally to the abundance of baitfish inhabiting the estuary. The most numerous fish species taken in finfish sampling was a common baitfish, the Atlantic silverside. Approximately fifty percent of the total number of finfish captured during sampling were of this species. Specimens were captured at five of the six finfish sampling stations.

Other populous baitfish included the mummichog, striped killifish, northern pipefish, and sticklebacks. The juveniles of larger species such as the winter flounder, alewife, scup, sea herring, and American eel contribute to the baitfish population of the estuary. In June and September of 1965, many common squid (*Loligo pealei*) were noted in the estuary. This pelagic invertebrate is especially attractive to striped bass as a forage food. The many small crustaceans and worms inhabiting the area also provide food for the larger fish species which enter the bay.

Striped bass, which migrate to the area in the spring, are the most sought after sport fish species in Pleasant Bay. School bass are usually plentiful in the estuary, and individual large bass are taken occasionally. On June 16, 1966, a 56 pound striped bass was taken from Pleasant Bay by a sport fisherman. This fish, one of the largest striped bass taken in Massachusetts during 1966, was kept alive in a fish tank at a Chatham fish market. The 49 inch bass was tagged by Division biologists with Tag Number 48042 and released in Pleasant Bay on June 28. At the end of 1966, the fish had not as yet been recaptured or reported.

Striped bass may be taken using live bait, such as alewives or eels, as well as with worms, squid, or plugs. Most of the fishing that takes place in the bay is conducted from boats, since access to deep water by shore fishermen is limited.

Striped bass that are at least 16 inches long (fork

length) can be kept by the fishermen. Any legal sized striped bass taken by hook and line may be sold. During 1965, it was estimated that 86,100 pounds of striped bass were sold by fishermen to the Chatham fish dealers. At an average price of $0.15 per pound, the total value of fish caught amounted to $12,915.00. This value of the fish that are sold is small when compared with the total expenditure of the individual fishermen for such items as boats, motors, tackle, and bait, as well as food, gasoline, and oil.

There are three major boat liveries in Pleasant Bay that rent a total of 28 boats. These 14 to 16 foot skiffs with motor rent for about $15.00 per day. It is estimated that the total income from these rentals for the year amounted to $6,600.00. In addition, some liveries charge a launching fee of $2.00 for the use of their launching ramps, and all dealers have an incidental income from the sale of bait such as sea worms, eels, and clams.

Commercial Fisheries

A commercial fishery for winter flounder exists within Pleasant Bay. During the winter months, one or two man boats equipped with small otter trawls fish the waters of the estuary. Several of the tidal ponds within the bay provide large concentrations of winter flounder during the spawning season. In 1965, 60,000 pounds of winter flounder were caught, worth approximately $8,750.00.

The catch of a large and valuable fishery for ground fish which exists outside the bay is landed and marketed at the Chatham fish pier. The fish are taken either by line trawling or hand lining. About 8 party boats operate from Chatham and contribute to the total landings of the hand liners. The party boats usually operate from June to November on the offshore grounds. These boats charge $10.00 per day per man for a minimum of six men, and some boats can carry as many as 17 fishermen. During 1965, party boats and hand liners combined made about 829 trips and landed 1,115,164 pounds of fish. Line trawlers, which fish throughout most of the year, made 1,736 trips and landed 2,013,131 pounds of fish. The most abundant species taken by the commercial fishermen was the Atlantic cod. The next most abundant species taken was the haddock. Other species taken include pollack, cusk, white hake, halibut, wolffish, striped bass, bluefish, red hake, yellowtail flounder, grey sole, dab, winter flounder, ocean perch, whiting, and tautog. A total of 3,173,245 pounds of fish were landed during 1965. The importance of this valuable marine resource is reflected by the catch value of the fishermen of $333,842.00.

At the present time, the extreme shoaling of the entrance to Pleasant Bay creates a hazardous passage for all boats. Proposed dredging and improved access to the bay would not only provide safer passage for the many boats that use the area, but would also increase fishing effort on the part of the commercial fishermen.

LAWS WHICH REGULATE FISHING IN PLEASANT BAY

Acts of 1937: Chapter 349

AN ACT REGULATING THE TAKING BY SEINES OF BLUEFISH, STRIPED BASS AND WHITE PERCH OFF THE SHORES OF BARNSTABLE COUNTY.

SECTION 1. No person shall, except as hereinafter provided, take with a seine any bluefish, striped bass or white perch within three miles of the shore of Barnstable County. It shall not be a violation of this act for any person using a seine in fishing for mackerel or other fish for the catching of which its use is permitted to take therewith bluefish, striped bass and white perch in the aggregate to a number not exceeding ten per cent if such excess is immediately returned alive to the water whence it was taken. The coastal wardens and the local shellfish wardens and their deputies, if any, within their respective jurisdictions, shall enforce the provisions of this act. Violation of any provision of this act shall be punished by a fine of not less than fifty nor more than three hundred dollars.

SECTION 2. This act shall take effect upon its passage.

Acts of 1904: Chapter 118

AN ACT RELATIVE TO FISHERIES IN THE WATERS OF PLEASANT BAY AND ITS TRIBUTARIES IN THE TOWN OF ORLEANS.

SECTION 1. No purse or sweep seines, set nets or gill nets, for the taking of fish shall be set, drawn, used or maintained in the waters of Pleasant Bay or its tributaries in the town of Orleans; but nothing herein contained shall be construed to forbid or make un-law ful the maintaining of traps, pounds or weirs under licenses granted in accordance with Section one hundred and sixteen of Chapter ninety-one of the Revised Laws, or dragging for flounders by the beam trawl or otter trawl, the minimum mesh to be three inches.

SECTION 2. Any person who shall set, draw, use or maintain a purse or sweep seine, set net or gill net in violation of this act shall be punished by a fine of not less than one hundred nor more than five hundred dollars, or by imprisonment for a term not exceeding six months.

SECTION 3. Chapter one hundred and sixty-three of the acts of the year nineteen hundred and one is hereby repealed.

SECTION 4. This act shall take effect upon its passage.

Acts of 1950: Chapter 69

AN ACT PROHIBITING THE TAKING OF FISH BY OTTER TRAWLING IN CERTAIN WATERS IN BARNSTABLE COUNTY.

SECTION 1. Any provision of general or special law to the contrary notwithstanding, no person shall take fish by otter trawling in the waters of Round Cove in the town of Harwich, Ryder's Cove in the town of Chatham, or Quonset Pond in the town of Orleans. Whoever violates this section shall be punished by a fine of not less than twenty nor more than fifty dollars.

SECTION 2. This act shall take effect upon its passage.

Acts of 1936: Chapter 238

AN ACT PROHIBITING, DURING CERTAIN MONTHS OF THE YEAR, THE USE OF BEAM OR OTTER TRAWLS IN TAKING FISH FROM CERTAIN TERRITORIAL WATERS OF THE COMMONWEALTH.

SECTION 1. It shall be unlawful, between May first and October thirty-first, both dates inclusive, in any year, for any person to use beam or otter trawls to drag for fish in that part of the territorial waters of the commonwealth within an area bounded by a line from Nauset Light following the coast line of Cape Cod to Monomoy Point and thence along an imaginary line forming the easterly boundary of the area specified in section one of chapter sixty-six of the acts of nineteen hundred and thirty-one, as amended by chapter fifty-nine of the acts of nineteen hundred and thirty-two, to its intersection with the marine boundary of the commonwealth, thence extending along said marine boundary to its intersection with an imaginart line running due east from said Nauset Light, and thence extending along said imaginary line due west to the point of beginning.

SECTION 2. Violation of this act shall be punished by a fine of not less than five hundred nor more than one thousand dollars.

SECTION 3. This act shall take effect upon its passage.

SUMMARY

A total of 36 fish species were encountered within the study area. The species taken in greatest abundance were — the Atlantic silverside, mummichog, striped killifish, and sticklebacks.

Sampling revealed that during the summer months the bay serves as a nursery area for the juvenile forms of important recreational and commercial fishes such as white hake, tautog, scup, cod, pollock, and alewives.

During the winter and spring, the bay harbours large numbers of spawning flounders. These fish are subjected to a limited commercial dragging fishery.

The alewife runs of Pleasant Bay were adversely affected by the drought which occurred throughout the Cape in 1964 and 1965. Water runoff in the fishways was slight due to the low water levels of the headwater ponds and migration of fry to the sea was limited. The effect of poor spawning success may become evident in three to four years when fish of the 1964 and 1965 year classes return to the spawning grounds. A proposal to connect Lovers Lake in Chatham to Stillwater Pond would greatly increase this spawning area and favor a potentially larger alewife population in this run.

An intensive sport fishery takes place in Pleasant Bay for striped bass, bluefish, and winter flounder. During 1965, approximately 86,100 pounds of striped bass were sold to wholesale fish dealers in the area. This represented a total value of $12,915.00 to the fishermen. Skiff rentals within the bay reflected a total of $6,600.00 for the year. In addition, the sale of bait, gasoline, oil, and other items to the fishermen increased the total value of the sport fishery to the area.

Two significant commercial fisheries are carried on within the bay. Landings of winter flounder taken by otter trawling during the winter months amounted to 60,000 pounds worth a total of $8,750.00. A commercial fishery for the American eel amounted to a total of 4,000 pounds landed worth approximately $1,200.00.

The offshore commercial fishery which operates from Pleasant Bay represents a significant economic resource to the town of Chatham. During 1965, 3,173,245 pounds of fish were landed worth a total of $333,842.00. This is groundfishery, for the most

part, and is carried on by long-lining and line-trawling. Proposals to provide unobstructed access to the sea from Pleasant Bay would almost certainly increase fishing effort in this groundfishery and could augment the value of this important marine resource to the the local economy.

THE SHELLFISHERIES OF PLEASANT BAY

Objectives

The primary considerations of the shellfish phase of this resource study were the inventory of the kind and extent of existing shellfish populations in the bay and the annual volume and value of the shellfish harvest to fishermen, both family and commercial.

Secondary considerations included evaluation of environmental factors affecting shellfish populations, critique of local shellfish management practices, and inventory of the associated flora and fauna on the shellfish beds.

A final consideration was to determine the variety of bivalve and gastropod mollusks occurring in Pleasant Bay by means of a specific survey.

Historical Background

For many years, the shoal waters of Pleasant Bay have supplied citizens of Orleans, Harwich, and Chatham with quahogs, soft-shell clams and bay scallops. For brief periods, natural oyster populations have also supported a limited family fishery. While no written record prior to 1879 was found concerning the shellfish populations of Pleasant Bay, the discovery of relic shell piles along the shores indicate that even before the arrival of the white man, indians of the area found sustenance from this food resource.

One of the earliest and most complete records of the condition of the Pleasant Bay shell fishery is that made by Belding (1909) in *A Report Upon the Mollusk Fisheries of Massachusetts.* In that study, Belding indicated that quahogs constituted the most abundant and most utilized shellfish resources of Pleasant Bay. The following extract from that report discusses the status of the Orleans quahog fishery in Pleasant Bay in 1907 and makes some comparison to the fishery of 1879.

> "*Pleasant Bay Industry* — About 25 men dig here from ordinary dories, using short rakes and tongs. The average wages are $2 to $3 per day, which is considerably less than the high wages of the Cape Cod Bay fishery; but many more days can be utilized during the year, while the work is much easier and the necessary outlay of capital is slight. Here the quahaugs run about one-half 'little necks,' and the proportion of blunts is small.
>
> Little evidence of decline can be seen in Pleasant Bay, where the bed of quahaugs, although raked for a long time, still shows few signs of decrease. On the Cape Cod Bay side the reverse is true, and the supply is gradually diminishing.
>
> The main historical features of the quahaug industry at Orleans have been similar to Wellfleet, the industry lying practically dormant until 1894, when it rapidly reached its present production. Unfortunately, but little data can be obtained for comparison of the industry of 1879 with 1907. Ernest Ingersoll reports, in 1879: —
>
> > 'At Orleans, some few men who go mackereling in summer stay at home and dig clams in winter, getting perhaps 50 barrels of quahaugs among others, which are peddled in the town.' "

Comparing the two years by table, we find: —

	1879	1907
Annual production	150 bushels	33,000 bushels
Value of production	$82.50	$41,350
Number of men	A few	75
Location:		
Quahaug beds	Pleasant Bay	Cape Cod and Pleasant Bay
Market	Home consumption	New York and Boston

Belding (op. cit) noted that while Orleans had 500 acres of quahog grounds in the Bay, Harwich had 100 acres, only 10 acres of which supplied quahogs in commercial abundance. The following gives indication of the condition of the Harwich quahog fishery in Pleasant Bay prior to 1900, as well as accurately summing up the status of the fishery in 1907.

> "Harwich shares with Chatham and Orleans the quahaug fishery of Pleasant Bay, but has a more limited territory, as only a small portion of Pleasant Bay lies within the town limits. Practically all this territory, comprising 100 acres, is quahauging ground, though the commercial quahauging is prosecuted over an area of 10 acres only. Scattering quahaugs are found over an area of 100 acres.
>
> As the waters of Pleasant Bay are sheltered, the fishing is all done from dories, with basket rakes having 20 to 25 foot poles. The depth of water over the quahaug beds is from 6 to 16 feet.
>
> In regard to the quahaug fishery in Pleasant Bay, Mr. Warren J. Nickerson of East Harwich, who has

been acquainted with the industry for many years, says: —

'Pleasant Bay is and has been a very valuable quahaug ground. Some fifty years ago there were shipped in vessels in New Haven and other places 13,000 bushels in one year from its waters. Since then there has been more or less taken from these waters by fishermen from the towns of Orleans, Chatham and Harwich. During the last few years there have been 25 regular fishermen and perhaps 12 transient. Probably 8,000 bushels a year for the last five years would be a fair estimate of the catch. Thirty per cent of these were "little necks". ' "

Summary of Harwich Quahog Industry — 1907

Area of Quahaug territory (acres)	100
Number of men	7
Number of boats	–
Value of boats	–
Number of dories	7
Value of dories	$100
Value of implements	$100

Production

"Little necks": —	
Bushels	700
Value	$1,750
Quahaugs: —	
Bushels	800
Value	$800
Total: —	
Bushels	1,500
Value	$2,550

In 1907, quahog fishing in the Pleasant Bay estuary by Chatham fishermen was confined mainly to Crows Pond.

Since 1909, there has been only spotty record made of quahog harvests from Pleasant Bay. For the most part, past town shellfish reports indicate only the combined shellfish harvests as obtained from all areas of the town. However, extraction and review of that information from the reports of Orleans, Harwich, and Chatham that is specific to Pleasant Bay indicates that the trend of the quahog resource for the past fifty years has been one of long term gradual increase with only intermittent and brief declines. Increased utilization of the resource has paralleled increased market demand for quahogs.

Greater utilization of the quahog resource was reflected in early efforts by the towns to increase the quahog supply through propagation efforts. For instance, from 1928 to 1936 a total of 835 bushels of quahogs were planted in Crows Pond and Ryders Cove by the town of Chatham. In 1936, a shellfish predator control project was exercised by Chatham as supported by WPA funds. The shellfish officer reported that the following shellfish predators were destroyed: 3,758 "horsefeet" (horseshoe crabs), 944 sand collars, 111 bushels of "winkles" (whelks) and 143 bushels of starfish.

Town records indicate that from about 1940 to 1956, natural setting of quahogs was low; consequently, the fishery did not show any noted increase. During this period, Pleasant Bay quahog populations were often supplemented with stock transplanted from other waters. However, in about 1957 excellent sets began to occur; and since that time, natural propagation has been quite consistent. In recent years, certain areas in the bay have supported exceptionally dense populations of seed quahogs. These populations of overcrowded and often slow-growing quahogs have provided stock for planting of less populated areas in the bay. During the spring of 1965, the towns of Harwich and Chatham transplanted a total of 1,130 bushels of seed quahogs which were dug by means of a hydraulic dredge.

Since about 1961, excellent natural sets and sound regulation of the fishery have sustained annual quahog harvests valued in excess of $100,000.

Scallops play a greater role in the shellfishery of Pleasant Bay today than they did at the turn of the century. According to Belding (op. cit.), no significant scallop fishery existed in the bay in 1907. At that time, scalloping was nearly as important in Chatham as the lobster and cod fishery. In 1907, Chatham shipped 34,615 gallons of scallops valued at $45,345 to Boston and New York. However, these scallops were reportedly harvested only from waters on the south shore of Chatham and not from Pleasant Bay. While bay scallops may have constituted a significant fishery in Pleasant Bay prior to the nineteen thirties, little record concerning this resource was made by the towns until about 1944.

It is generally known that coincident with the eelgrass (*Zostera marina*) blight of 1931 bay scallops virtually disappeared from our coast.

In 1944, the shellfish officer of Orleans reported planting nine bushels of seed scallops in Pleasant Bay. The scallops were obtained from the Town of Bourne. This planting was most likely made in an attempt to re-establish scallop populations which had been eliminated. In 1946, the Orleans shellfish officer reported that natural scallop seed had been observed in eelgrass patches within Little Bay. In 1948, Chatham reported good scalloping within its section of the bay. Apparently, the scallop resource gradually improved after 1948. In 1953, Orleans reported a record scallop harvest from the bay valued at $35,000. However, in 1954 the Orleans harvest was even higher with a value of $45,000.

Records suggest that soft shell clams have never constituted a major shellfishery in Pleasant Bay. Belding's 1909 report indicated that at that time very little clamming occurred in the bay waters. He pointed out that in Harwich and Chatham clams were found only in very limited localities and that of four general clamming areas in Orleans, Pleasant Bay was economically the least important of the four.

The town records of Orleans and Chatham make little mention of the status of the soft clam resource in the bay until about 1930. For the period from 1930 to 1934, the Chatham shellfish officers noted making numerous plantings of seed and adult clams in Ryders Cove and Crows Pond in an attempt to increase the clam supply in these areas of the bay. The plantings made during 1934 were supported by ERA funds.

In 1946, both Orleans and Chatham began to report that clams were rapidly disappearing from bay waters. The clam resource remained in very short supply until about 1954 when it began to increase. In recent years, clam setting and survival has been moderately good, providing enough clams to satisfy the family fishing demand and, on occasion, limited commercial fishing.

Relic oyster shell piles that have been discovered at various locations in proximity to the shoreline of Pleasant Bay suggest that at one time Indians of the area harvested oysters from the bay waters. However, records indicate that during the present century, at least, oysters have not occurred in numbers substantial enough to support a public fishery. Belding (op. cit.) for instance, in discussing the shellfisheries of Orleans, Chatham, and Harwich at the turn of the century, makes no mention of oysters being obtained from Pleasant Bay. He did note, however, that although oyster grants were not at that time allotted in the bay there did appear to be considerable territory in the bay area that would be suitable to oyster culture.

The earliest mention that has been found of attempted oyster propagation within bay waters was in the 1938 annual report of the Town of Orleans. During that year, the shellfish officer reported planting about 400 bushels of oysters in Meetinghouse River, Little Bay, and Pleasant Bay proper. In 1940, about 200 bushels of large oysters were planted in Little Pleasant Bay. Apparently, no natural setting of oysters resulted from these plantings. However, in 1949 the Orleans shellfish officer reported that considerable spat was found from Meetinghouse Pond to Pleasant Bay proper. In 1950, much of this seed was transplanted to a town bed off Barley Neck shore No further oyster sets were recorded in the bay proper until 1956 and 1957 when the Chatham shellfish officer reported a small natural seed oyster population growing on the rocky northern shore of Nickersons Neck. Since no further mention of this population was made in the shellfish officer's annual report, it is assumed that the population did not survive to maturity.

While the potential oyster waters in the Harwich section of Pleasant Bay are extremely limited, the Harwich Shellfish Officer has advantageously used that which is available. Since about 1950, an oyster transplant project has been maintained under which oysters from areas in Harwich of marginal natural production and limited public access are transplanted to Round Cove. In regulated season, these oysters are available to family fishermen. On occasion, early summer plantings of mature oysters in Round Cove have resulted in spat settling upon the adult oysters during the late summer period.

Through the efforts of the shellfish officer, this propagation program has been very successful in maintaining a limited supply of oysters for family use.

Methods and Materials

Shellfish beds were surveyed utilizing a variety of sampling methods. A steel square foot frame, which measured 12 inches $\times$ 12 inches $\times$ 4 inches deep, was used to sample soft shell clam densities. Within intertidal clam populations, the frame was tossed at random and pressed into the sediment at its striking point. The sediment and clams were removed from within the frame and placed on nylon netting and then shaken and washed in adjacent bay waters. The clams in each sample were placed in individual plastic bags and returned to the laboratory for counting and measuring. The anterior-posterior length of the clams was measured to the nearest millimeter with vernier calipers. Note was made of associated fauna, clam mortality, and sediment type.

The square foot sampler was also used on one date by biologists utilizing SCUBA gear to sample a subtidal bed of quahogs in the Harwich section of Pleasant Bay. The frame was dropped on the substrate at random and the quahogs removed from within the frame by hand. The quahogs from each square foot sample were placed in a diver's collecting bag and then brought to the surface where they were counted and measured by biologists in an attending boat.

Bay scallops were sampled with a conventional scallop bar dredge.

In the summer of 1964, the town of Orleans conducted an intensive survey of quahog densities in the Orleans section of Pleasant Bay. The results of that survey have been incorporated with the findings of the study conducted by the Division of Marine Fisheries.

Findings

Quahogs

Quahogs constitute the major shellfish resource of Pleasant Bay. At the present time, Pleasant Bay probably produces more quahogs than any other area in Barnstable County. This fishery occurs on about 640 acres of subtidal bottom in Little Pleasant Bay and in the large cove area formed on the west side of what is commonly referred to as Big Pleasant Bay. Water depths range from 1–16 feet. Since most of the best quahog beds are in the deeper waters of the bay, commercial fishing is by means of the long-handled basket rake.

The most productive quahog bottom is characterized by sandy mud covered with a thin silt accumulation. In one area where diver biologists found quahogs to be exceptionally thick, the bottom was covered with great numbers of empty quahog shells. These mats of empty shells were indicative of extensive mortality which occurs in this crowded population of quahogs. In many areas, especially the upper portion of the estuary, rapidly spreading eelgrass growth was noted to be taking over quahog setting and growing bottom.

Water temperatures observed in the general area of quahog populations during the spring through fall period were conducive to the spawning and growth of quahogs. Belding (1931) noted that quahogs spawn when the water temperature has reached about 76°F. and that growth continues during the period that the temperature is above 49°F.

A review of water temperatures collected at various stations throughout the estuary during 1965 indicates that by late April bay waters had reached temperatures above 50°F. Water temperatures remained above 50°F. through the month of October. This suggests an approximate 5 month growing season. Temperatures favorable to spawning (76°F.+) were prevalent during the latter part of June through July.

Salinities ranged from 24 $^0/_{00}$ to 29 $^0/_{00}$. Belding (op. cit.) has indicated that the growth of the quahog is best in slightly diluted ocean water with a salinity of 24–28 $^0/_{00}$.

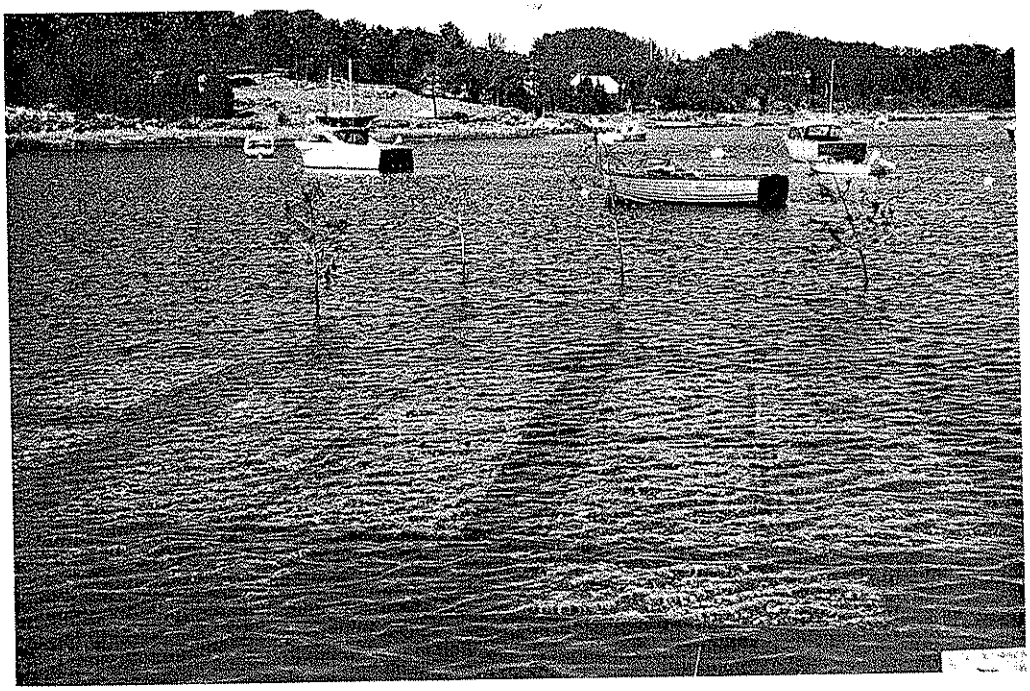
Since quahogs occur subtidally, it is difficult to estimate population densities. While it is possible to obtain accurate bottom samples utilizing SCUBA gear and a steel square foot frame, the extensive area involved prohibited a satisfactory inventory of this type. On one date, however, SCUBA divers of the Division of Marine Fisheries investigated a specific area in the Harwich section of the bay in regard to a quahog transplant project proposed by the towns of Chatham and Harwich. This project will be discussed in further detail later in this report.

During the summer of 1964, the town of Orleans conducted a rather intensive evaluation of its quahog resource in Pleasant Bay. Quahog densities were determined by gathering square foot samples utilizing SCUBA equipment. Quahog densities ranged from 9 to 180 per square foot. On the basis of these samples, the workers estimated that the 27 acres supported a potential 68,365 bushels of harvestable quahogs with a wholesale value of $1,025,485 ($15/bus.). It should be noted, however, that about 90% of the quahogs sampled were still below legal size (2″) and that this estimate of the potential harvestable population does not take into account the expected natural mortality which would occur within this population prior to all quahogs attaining legal size.

An important observation of this study was that in the most dense concentrations, individual quahogs showed considerably less new shell growth then individuals in lesser concentrations. Because of this, one of the major study recommendations was that dense populations of sub-legal size quahogs be thinned out and transplanted to other areas in the town.

The high concentration of seed quahogs in the bay and the problem of overcrowding is further pointed out by a transplant project conducted in waters of Harwich and Chatham. For many years, fishermen of both towns have been aware of a large bed of seed quahogs located along the Harwich shore of Pleasant Bay. This bed is on the edge of the major area worked by Chatham and Harwich fishermen. Fishermen generally avoid this bed of quahogs because the number of legal-sized quahogs are relatively few in comparison to the great number of seed quahogs present. Oddly, the general condition of this bed continues without any noted change in the ratio of legal-sized quahogs to sub-legal size. The reason for the unchanging character of this overcrowded bed has been attributed to the fact that competition for food results in very slow growth and that natural mortality occurs prior to their attaining harvestable size. While mortality among the larger quahogs appears to be high, the condition of the bed is perpetuated by excellent natural setting.

PLATE 8.

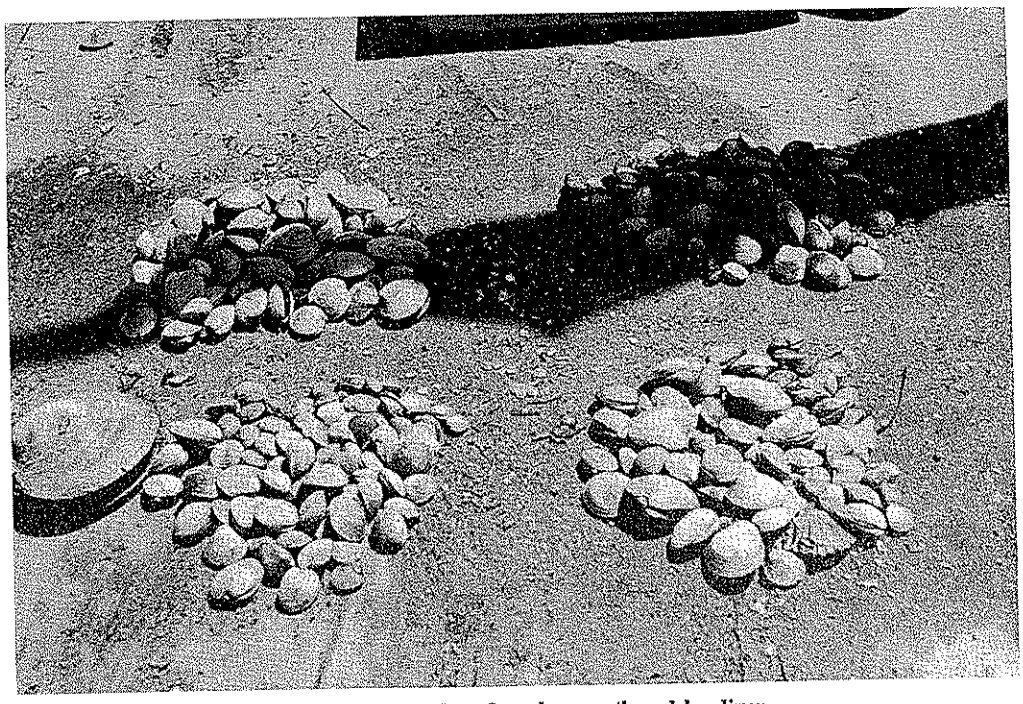


Oysters growing on raised trays in Meetinghouse Pond.

PLATE 9.

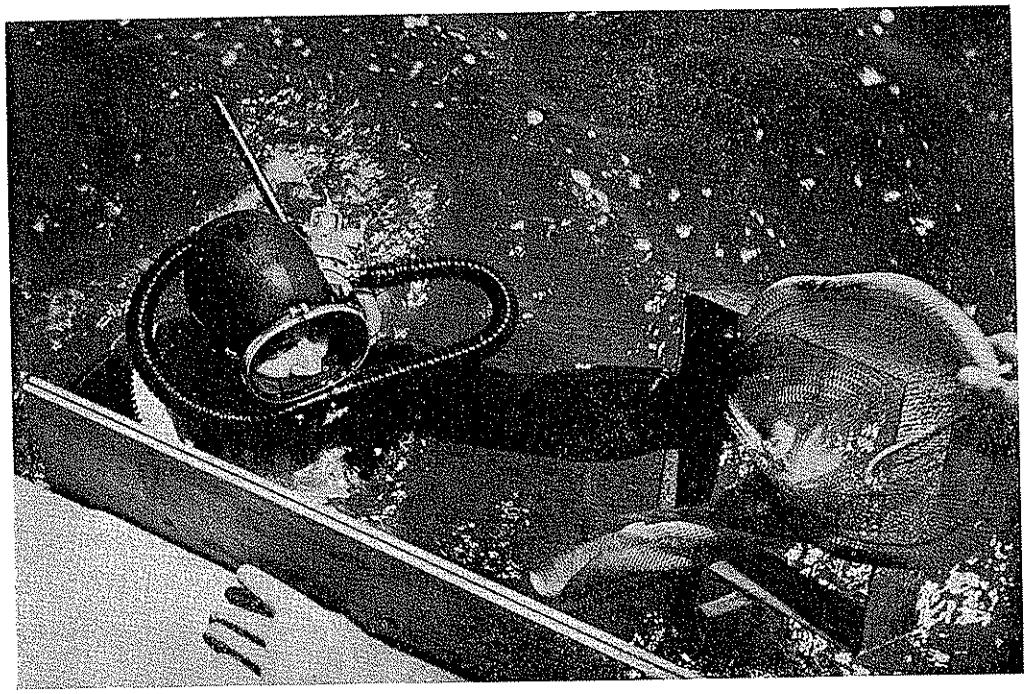
Fishermen Harvesting Quahogs with Bull Rake.

PLATE 10.



Square foot samples of quahogs gathered by diver.

PLATE 11.

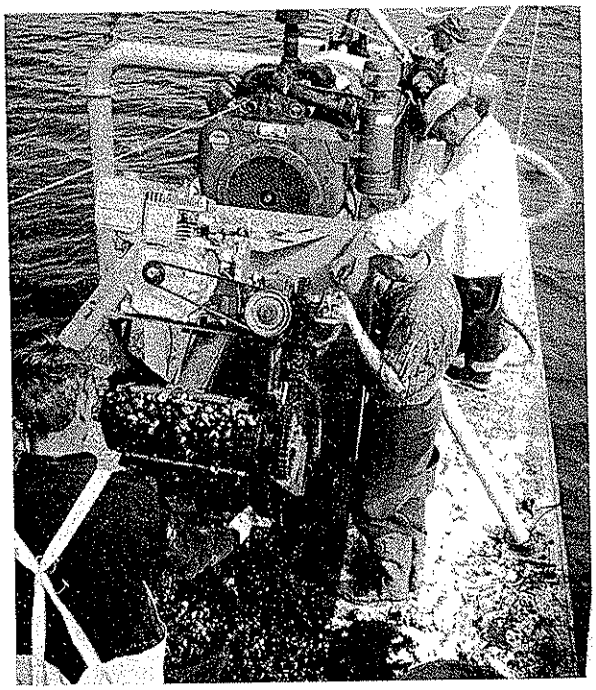


Diver with square foot sampler and collecting bag.

In April of 1965, biologists made a general underwater survey of this bed. Buoys were utilized to mark transects across the narrow width of the bed. Two one square foot bottom samples were taken on each of four transects dividing the area into approximate equal parts. Biologists randomly dropped a square foot sampler to the bottom and then removed all live shellfish and empty shells within the frame. Sample contents were placed in a diver's collecting bag and then brought to the surface for analysis by biologists in an attending boat. The samples ranged from 64 to 137 live quahogs per square foot. Individuals ranged in size from 19 mm to 47 mm (¾" to 1⅞" approx.). The average size of quahogs was about 1¼". Empty shells from each substrate sample were also counted. Empty pairs of shells ranged from 7 to 78. Many paired shells were still joined at the hinge, suggesting relatively recent mortality. Many empty shells bore drill holes typical of those left by the clam drill (*Polynices duplicatus*), and others had the obvious v-shaped notch on the edge of the shell left by the whelk (*Busycon carica*) when prying open a quahog. While surveying the bottom, one diver observed a whelk in the process of feeding on a quahog. In the surrounding area of each square foot sample, the divers randomly probed the bottom with their hands to determine whether or not the quahogs occurred in scattered patches or more or less in a solid carpet. No appreciable gaps in concentrations were noted.

On the basis of the square foot samples and the observations of the divers, the shellfish officers of Harwich and Chatham decided to conduct a cooperative transplanting project utilizing a hydraulic dredge similar to the type used in Maryland for the harvesting of subtidal soft shell clams (Plate #12). This project was conducted in the early fall of 1965. The quahogs harvested by the dredge were transplanted to the better fishing grounds by hired commercial fishermen. A total of 1,130 bushels of seed quahogs were transplanted from an estimated 18 acres of bottom. The cost of digging and transplanting of the quahogs amounted to $2.50 per bushel for a total project cost of $2,825. Based on a seed bushel value of $30.00, the total value of quahogs transplanted was $33,900. This value, as ascertained by the Harwich shellfish officer seems quite reasonable since the quahogs transplanted averaged about 1¼" in size and would more than triple in volume by the time they attained legal size. Ideally, for every bushel of seed planted, 3½ bushels would ultimately be harvested. This, does not allow for natural mortality which would very likely reduce the transplanted stock to some

PLATE 12.



Seed quahogs being harvested with a hydraulic escalator dredge.

degree before it is harvested. Considering the transplant project on an acreage production basis, an average of 63 bushels of seed were harvested from each with a corresponding value of $1,890 per acre.

It was concluded by biologists of the Division of Marine Fisheries and by the local shellfish officers that this project would be beneficial in improving the growth of quahogs in the seed area by reducing the competition for space and food, as well as providing more stock for the eventual harvesting by fishermen on the better quahog growing bottom.

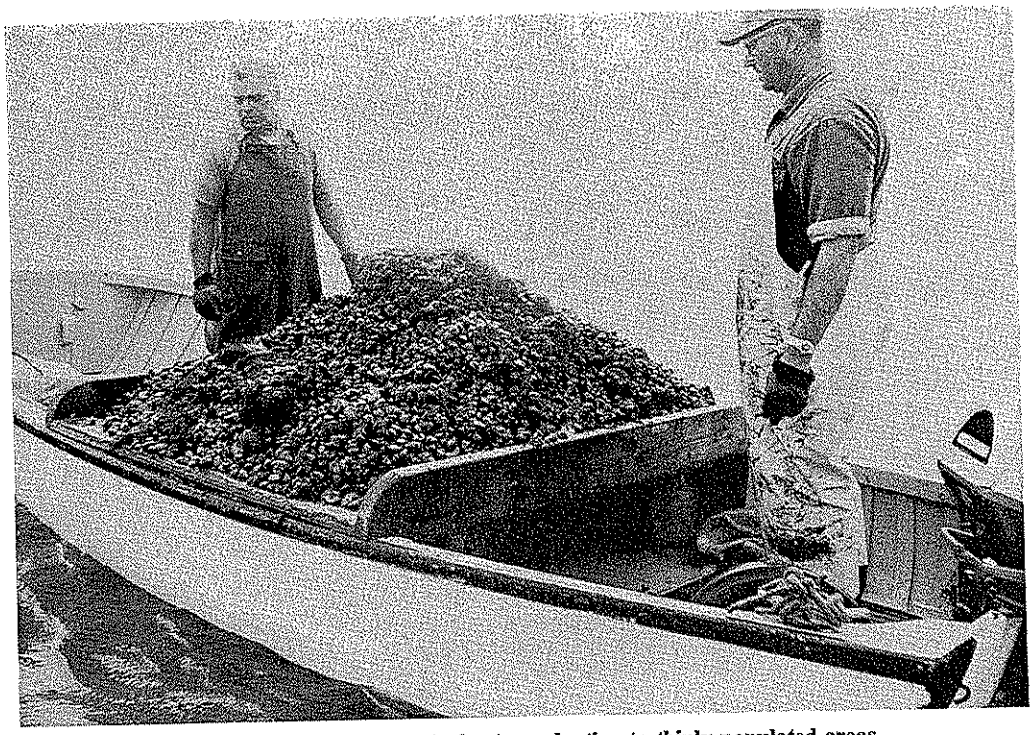
The following table summarizes the quahog harvests for 1965 as reported by the towns of Orleans, Harwich, and Chatham:

Town	*Family Harvest*	*Commercial Harvest*	*Value ($5.60–$12.00/bus.)*
Orleans	32 bus.	3500 bus.	$39,587
Harwich	–	3067 "	$45,372
Chatham	–	4656 "	$52,121
TOTAL VALUE			$137,080

Bay Scallops

Bay scallops are the second most valuable shellfish resource of Pleasant Bay. While the location of the best scallop concentrations may vary from year to year, commercial concentrations generally occur within the area locally referred to as "Big Pleasant

PLATE 13.



Quahogs from dredge ready for transplanting to thinly populated areas.

Bay." In some years, excellent scallop beds also occur north of Sipsons Island in "Little Pleasant Bay" (Orleans). Figure #13 designates major scallop concentrations as they occurred in 1965.

Sampling with a scallop dredge was conducted by biologists during various periods of the study year. In most areas, sampling was hampered by thick concentrations of eelgrass. This condition also proved a handicap to scallop fishermen during the regular fall-winter scallop season.

During April of 1965, dredge sampling was conducted in Crows Pond, Chatham. In a total of ten 200 yard tows, 115 seed scallops were captured. Six legal size scallops which had survived the winter were also caught. The average size of the seed was approximately 52.1 mm (2″ approx.). While sampling in Crows Pond on this same date, a few seed scallops were captured in the otter trawl. At the time of sampling, a commercial dragger was working the area for flounders and it was noted by biologists that the activity was most likely detrimental to seed scallops.

On July 14, 53 scallops were captured in four dredge hauls north of Sipsons Island, Orleans. These scallops ranged in size from 47 to 72 mm (2–3″ approx.).

In September, a total of 132 scallops were taken in seven tows made between Paw Wah Pond (Orleans) and Strong Island (Chatham). The average size of the scallops was 35 mm (1½″ approx.) indicating that they represented set of that summer (1965). No adult scallops were taken.

Many of the environmental factors such as water temperature and salinity which favor the success of the quahog in Pleasant Bay similarly benefit bay scallops. Belding (1910) noted that scallop growth occurs in water temperatures above 45°F. Bay water temperatures during 1965 exceeded 45°F. from April to about mid November. From June through August, the water temperatures were usually in excess of 70°F. The extended period of warm bay waters provides the scallop with a long growing season.

Scallops are tolerant of a wide range of salinities. Belding (op. cit.) noticed that scallops survive and grow equally well between the salinity limits of 10 0/00 and 27 0/00. As noted earlier, no salinities below 24 0/00 were noted in the study area.

Although natural enemies of the scallops such as starfish and oyster drills occur in the bay, no significant predation upon scallops has been noted.

During 1965, an estimated 2,765 bushels of scallops valued at $19,705 ($7.00/bus.) were harvested from Pleasant Bay waters. The greatest part of this crop

(2,700 bus.) was harvested by Chatham fishermen in the vicinity of Strong Island. The volume of the 1965 scallop harvest was considered below the average annual production of Pleasant Bay.

Soft Shell Clams

The soft shell clam resource of Pleasant Bay generally supports only limited family fishing. As pointed out by Belding (1909), Pleasant Bay waters are considerably less important in the production of clams than other waters in the towns of Orleans, Harwich, and Chatham. The study survey of clam populations indicated that the bulk of the clam resource occurs in the more protected shoreline of the upper portion of the estuary (Little Pleasant Bay). Within this area, clams were found to occur sporadically in narrow veins along the intertidal shoreline. These veins varied in width from 4′ to 20′. In many areas, clams also occurred subtidally, extending 5′ to 10′ beyond low water mark. For the most part, these subtidal clams are not utilized because of their inaccessibility to fishermen who dry dig with a clam fork.

Within the beds surveyed, clams occurred at an average density of 12.5 per square foot. Fifty-four percent of the clams were of harvestable size (2″+). Sediments encountered in the intertidal area where clams occurred varied from fine sandy mud to mixtures of sand and gravel.

Few significant clam populations were found to occur in the lower portion of the bay. A major limiting factor to the setting and survival of clams in the lower estuary is the lack of stable mud flats. The west shoreline of Pleasant Bay proper is characterized by relatively steep sloping shoreline which is subject to considerable wave action. The east side of the bay is characterized by shoal sand flats which are constantly shifting. Scattered populations of clams were, however, noted along the protected shorelines of Round Cove, Crows Pond, and Ryders Cove.

The Orleans shellfish officer reported that a total of 75 bushels of clams were harvested from bay waters in 1965. Chatham reported 50 bushels harvested. No clams were reportedly harvested from the Harwich section of the bay. The total estimated wholesale value of clams harvested from the bay in 1965 was $1,500 ($12.00/bus.).

Oysters

During the course of shellfish sampling, only scattered adult oysters were found growing naturally in the public waters of the bay. These oysters were found mainly in the upper estuary (Little Pleasant Bay) and in the protected waters of Round Cove, Crows Pond and Ryders Cove of Pleasant Bay proper. With the exception of Round Cove, natural concentrations were not found in an abundance to satisfy even a meager family fishery. The scattered distribution of these adult oysters suggested that at least a portion of these were remnants of a past natural set. Some may have been survivors of plantings by man. The anterior-posterior shell length (3″+) and the thickness of the valves suggested that all of the oysters found were more than four years of age. No natural set was observed during 1965 nor any seed oysters which would suggest setting after 1961.

As mentioned earlier, the shellfish officer of Harwich maintains an oyster planting program in Round Cove. During the summer of 1965, 250 bushels of oysters were moved to Round Cove from other areas in the town. The shellfish officer reported that survival of oysters was excellent during the summer months and that with opening of Round Cove to family fishing in the fall, at least 90% of the original planting was harvested. Accordingly, 225 bushels of oysters valued at $2,250 were harvested.

During the summer of 1964, the town of Orleans attempted to increase the abundance of oysters in Pleasant Bay by experimenting with the raft culture method. In the early summer, a 16′ x 8′ raft was placed in Pah Wah Pond. At that time, this pond supported a small number of native oysters. It was assumed that these oysters represented a past natural set in the pond. Three sides of the raft were fitted with outriggers for suspending the cultch stringers. A thermograph was mounted on the raft to maintain a continuous record of water temperatures.

At the beginning of the project, about four bushels of mature native oysters were placed in the trays on the raft. These oysters were obtained both from Pah Wah Pond and Hog Island. In August, an additional bushel of seed oysters from New Hampshire were placed on the raft. Strings of shells were suspended from the outriggers and loose shells and chicken wire cultch bags were placed in the pond and in the small creek connecting the pond with Pleasant Bay proper. It was hoped that spawning and some degree of setting would be achieved within the pond. However, cultch bags were also placed on oyster setting bottom in Wellfleet and on Marthas Vineyard to insure a supply of seed oysters for further experimentation.

It was noted that oysters placed on the raft showed excellent growth and survival. Although spawning of the raft oysters was observed on several dates during

the last week of June, no set was attained on the cultch shells. In late fall, oysters growing on the raft were transplanted to favorable bottom in the bay.

In early May of 1966, the Chatham Shellfish officer planted ten bushels of seed oysters in Crows Pond. The oysters were obtained from Fishers Island, New York, and were made available to Chatham and other towns by the Division of Marine Fisheries. A portion of the oysters placed in Crows Pond were suspended by strings from a small raft, while the remainder were planted on subtidal bottom. The oysters were sampled monthly from May through October by the Shellfish Biologist for the Division of Marine Fisheries. At each sampling, the average growth of the oysters was determined and note made of general mortality and predation. At planting, the seed oysters averaged 20 mm (.8″) in shell length (height). By the end of October, the oysters suspended on stringers had attained an average length of 78 mm (3.1″), while those growing on the bottom had reached an average length of 66 mm (2.6″). The average total growth in length of suspended and bottom lying oysters for the five-month period was 58 mm (2.3″) and 46 mm (1.8″) respectively. It is obvious that suspended oysters grew at a faster rate than those growing on the bottom. It was also noted that the suspended oysters tended to be round in shape while those on the bottom tended to be long and slender. It is interesting to note that the seed in Crows Pond grew at a faster rate, both suspended and on the bottom than in five other coastal areas where plantings of this stock were made. The following table lists the average growth during the five month period for each location:

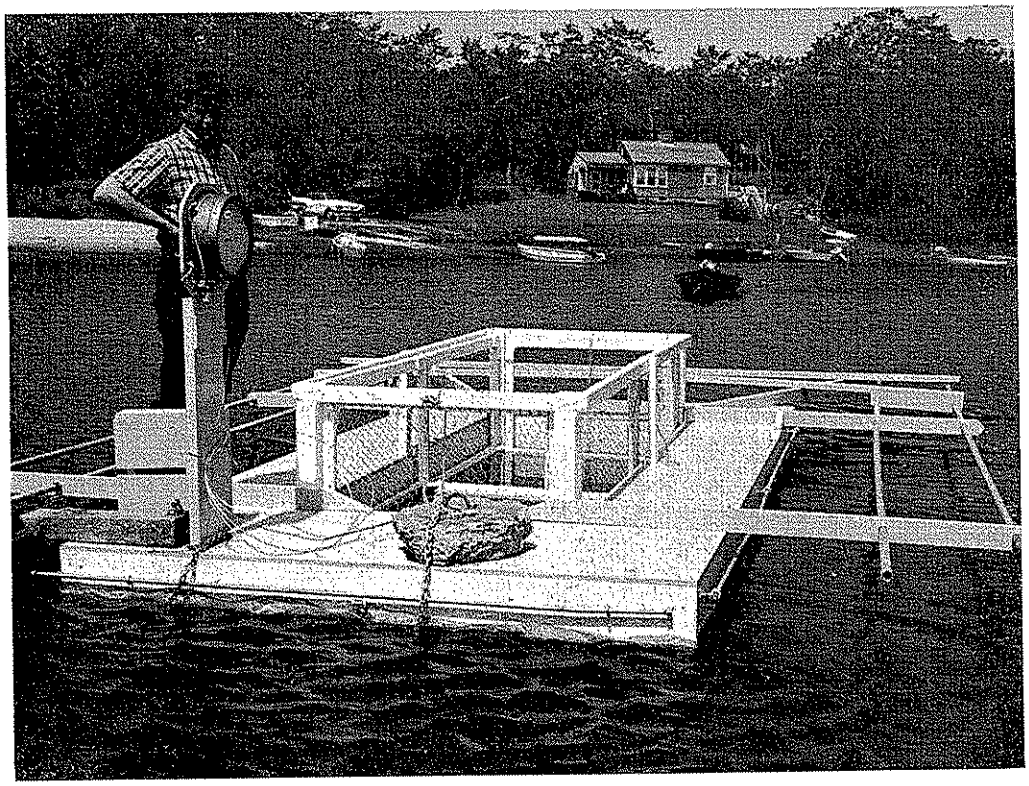
Location	*Total Growth (Height)*
Bourne — Pocasset River	28mm. (1.1 in.)
Chatham — Crows Pond (raft)	58mm. (2.3 in.)
Crows Pond (bottom)	46mm. (1.8 in.)
Eel Pond	24mm. (1.0 in.)
Falmouth — Childs River	39mm. (1.5 in.)
Little Pond	26mm. (1.0 in.)
Westport — east branch of the Westport River	38mm. (1.5 in.)

The above project further indicated that environmental factors in the waters of Pleasant Bay are favorable to the growth and survival of oysters.

Private Grants

During 1965, three private shellfish grants were operated in the Orleans section of the bay. The grant in Meetinghouse Pond was maintained pri-

PLATE 14



Raft constructed by the Town of Orleans for the suspension of seed oysters.

marily for oysters. The owner of this grant reported planting twenty bushels of purchased oysters.

During 1965, he harvested and sold ten bushels of oysters valued at approximately $140.

Both clams and quahogs were raised on the grant in Kescayo Gansett Pond. Only 5½ bushels ($66) of soft shell clams were reported sold from this grant during the study year.

The third grant, located in the Barley Neck area, was managed for quahogs. No shellfish harvest was reported for this grant during 1965. The total value of shellfish harvested from all grants in 1965 was $206. Grant production figures are presumed to be conservative.

Associated Fauna

The following invertebrate were encountered while sampling the intertidal and subtidal clam beds.

Mollusca

Macoma balthica, little macoma
Petricola pholadiformis, false angel wing
Mercenaria mercenaria, quahog
Nassarius obsoletus, common mud snail
Crassostrea virginica, oyster
Ensis directus, common razor clam
Busycon canaliculatum, channelled whelk
Aequipecten irradians, bay scallop
Urosalpinx cinerea, oyster drill
Modiolus demissus, ribbed mussel
Polinices duplicatus, moon shell

Crustacea

Libinia spp., spider crab
Limulus polyphemus, horseshoe crab
Carcinus maenas, green crab
Cyathura polita, isopod

Annelida

Nereis spp., sea worm
Cistenides gouldii, trumpet worm
Harmothoe extenuata, polychaete

Sipunculoidea

Golfingia gouldi

Mollusks of Pleasant Bay

As a supplement to the overall resource study, a specific survey was made to determine the variety of mollusk species occurring in Pleasant Bay. Thomas Petersen, a student of the Thayer Academy Summer Science Program, was assigned the project of collecting and identifying mollusks. Collecting methods included the sieving of sediment samples in the intertidal zone and subtidal bottom sampling with a conventional bay scallop dredge. Subtidal collections were also made utilizing SCUBA equipment. The following is a complete list of the mollusks collected within Pleasant Bay. The reference "Keys to Marine Invertebrates of the Woods Hole Region" was used as a guide to identification and classification of species. It is hoped that this list will provide comparison for other such surveys conducted in various areas of the Massachusetts coastline.

PELECYPODA
- Eulamellibranchia
  - Tellinidae
    - *Macoma balthica*, Balthic macoma
  - Astartidae
    - *Astarte castanea*, smooth astarte
  - Cardiidae
    - *Laevicardium mortoni*, Morton's egg cockle
  - Mesodesmatidae
    - *Mesodesma arctata*, Arctic wedge clam
  - Myacidae
    - *Mya arenaria*, soft-shell clam
  - Petricolidae
    - *Petricola pholadiformis*, false angel wing
  - Solenidae
    - *Enis directus*, razor clam
  - Veneridae
    - *Mercenaria mercenaria*, northern quahog
    - *Gemma gemma*, amythest gem clam
- Filibranchia
  - Anomiidae
    - *Anomia simplex*, common jingle shell
  - Arcidae
    - *Anadara ovalis*, blood ark
    - *Anadara transversa*, transverse ark
  - Ostreidae
    - *Crassostrea virginica*, eastern oyster
  - Pectinidae
    - *Aequipecten irradians*, Atlantic bay scallop
- Palaeoconcha
  - Solemyacidae
    - *Solemya velum*, common Atlantic awning clam

GASTROPODA
- Mesogastropoda
  - Capulidae
    - *Crepidula fornicata*, common Atlantic slipper shell
    - *Crepidula plana*, white slipper shell
  - Littorinidae
    - *Littorina littorea*, common periwinkle
    - *Littorina saxtilis*, northern rough periwinkle
  - Naticidae
    - *Lunatia heros*, common northern moon-shell
    - *Polinices duplicatus*, moon-shell
- Neogastropoda
  - Melongenidae
    - *Busycon canaliculatum*, channelled whelk
    - *Busycon carica*, knobbed whelk
  - Muricidae
    - *Eupleura caudata*, thick-lipped drill
    - *Urosalpinx cinerea*, Atlantic oyster drill
  - Nassariidae
    - *Nassarius obsoletus*, eastern mud snail
    - *Nassarius trivitatus*, New England nassa

Discussion

Pleasant Bay is one of the most productive shellfish areas in Massachusetts. During 1965, the total wholesale value of shellfish harvested from the bay amounted to about $160,535. The following table summarizes the shellfish harvest by town during 1965:

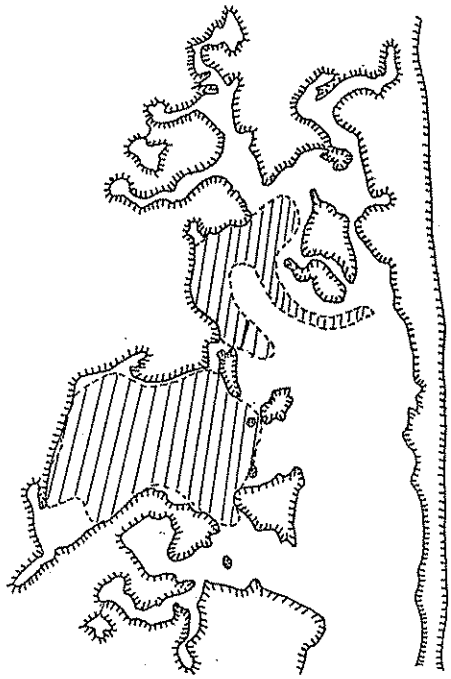
Pleasant Bay Shellfish Harvest — 1965

	Orleans	Harwich	Chatham	Value
	Bushels			
Clams				
Family	25	—	50	$900 ($12/bus.)
Commercial	50	—	—	$600
Quahogs				
Family	32	714	—	$8,952
Commercial	3,500	3,067	4,656	$128,128 ($5.60—$12.00/bus.)
Scallops				
Family and Commercial (combined)	25	40	2,700	$19,705
Oysters				
Family	—	225	—	$2,250
Total Wholesale Value				$160,535

It was estimated that 210 part time or full time shellfishermen derived income from the shellfish resource of the bay during 1965. In addition, about 1,300 family license holders gathered shellfish from the bay.

At the present time, the shellfish resources of the bay are being wisely managed under the shellfish programs of the towns of Orleans, Harwich, and Chatham. Dense sets of quahogs, which sustain an intensive commercial fishery, also provide surplus seed stock for transplanting to less productive areas in the estuary. The town of Orleans annually employs local bullrakers to harvest quahogs for transplanting to thinly populated areas. During 1965, Harwich and Chatham cooperated in hiring a hydraulic dredge and local fishermen to transplant stock from a densely crowded population of seed quahogs. This project indicated that quahogs can be harvested more rapidly and economically by hydraulic escalator dredge than by hand raking. Since exceptionally dense seed quahog populations occur in both the Orleans and Harwich-Chatham section of the bay, it would be economically advantageous for the three towns to cooperate each year in employing a dredge to transplant seed stock.

Figure 13.

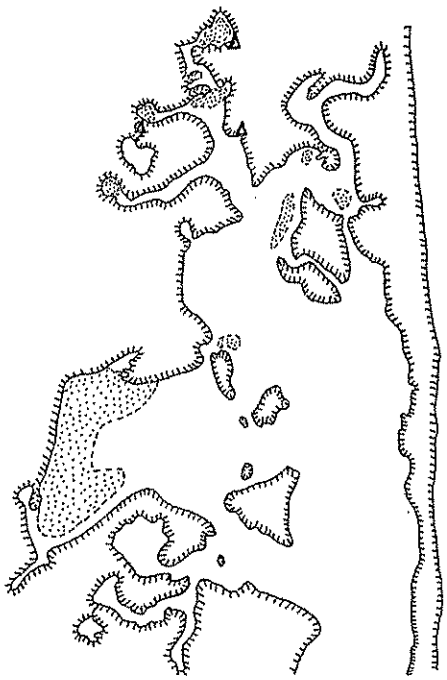


MAJOR BAY SCALLOP BEDS

Bay scallop production has remained high in recent years. Being short lived (20–26 months) the scallop does not lend itself to propagative management. Good harvests depend primarily upon the success of spawning and setting of juvenile scallops from the previous year.

A main problem facing scallop fishermen is the rapid spread of eelgrass. While eelgrass provides anchorage and protection for juvenile scallops, in dense growth it hinders dredging operations and adversely affects scallop growth by retarding water circulation. The eelgrass problem, which is not

Figure 14.



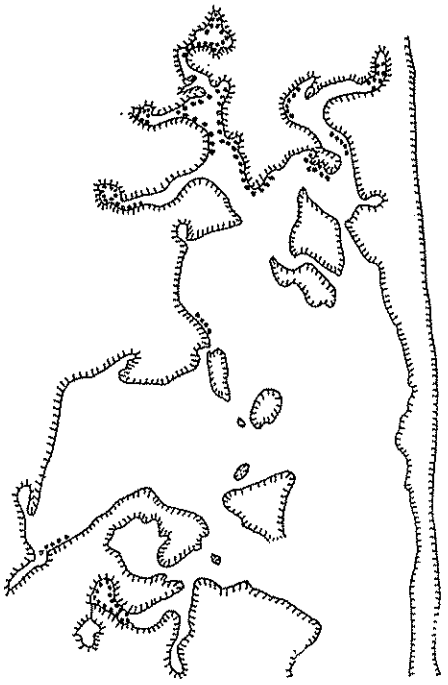
MAJOR QUAHOG BEDS.

unique to Pleasant Bay, has become common in practically all bay waters on the south shore of Massachusetts. Unfortunately there is no practical method of controlling eelgrass at the present time.

Oysters do not occur in quantities to support a fishery, either family or commercial, but some production does occur on private grants. Stock sold from these grants originates from seed oysters purchased from areas outside Pleasant Bay. The occurrence of very thinly scattered adult oysters throughout the estuary and past records of natural sets does indicate that the bay is a potential area for the development of the oyster resource.

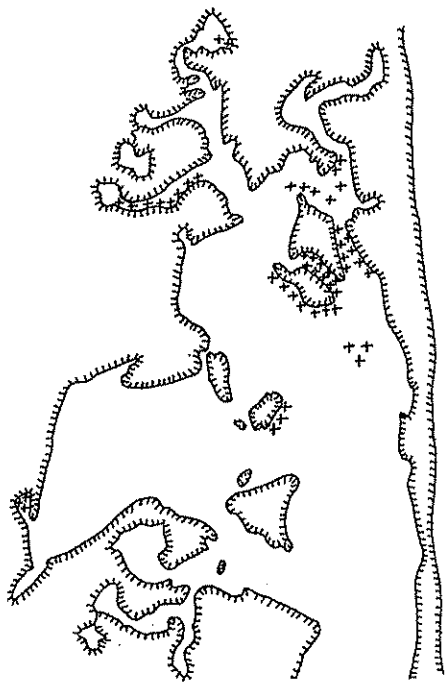
Of all the economic shellfish species in Massachusetts, oysters constitute the most neglected and diminished resource. Since the turn of the century, the oyster industry has been in almost constant decline. The need for intensive propagation of native oyster stocks in Barnstable County was emphasized in the comprehensive report, *A Study of the Marine Resources of Barnstable County, Massachusetts*, Matthiessen and Toner (1963). Since Pleasant Bay is the largest estuary on the south side of Cape Cod, it would seem wise to make every possible effort to establish oysters in these waters. Future plantings of mature oysters by local shellfish officers should be

Figure 15.



SOFT SHELL CLAMS.

Figure 16.



OYSTER PLANTINGS, 1965.

encouraged as well as further experimentation with the suspension method of growing oysters. Records should be kept by the officers as to the amount and location of the plantings. Since the lack of natural setting is the main limiting factor to the development of the oyster resource in the bay, cultch bags should be set out experimentally at various points along the shoreline. During the late summer, officers should inspect the bags and survey the shoreline for the occurrence of setting. Once potential setting areas have been discovered, the cultch program should be expanded in order to provide adequate material for the young oysters to set upon.

As several investigators have pointed out, encouragement of the grant system is probably the only way the oyster industry in Massachusetts will ever be revived. Successful oyster culture involves considerable human effort and only when an individual is guaranteed exclusive right to his crop is he willing to gamble the effort, time, and usually, considerable investment on such culture. At the present time, there are several grants located in the upper portion of the bay. Private oyster grants should be encouraged as long as the grants are not located in major commercial quahog or scallop fishing areas.

The soft clam fishery in the bay is primarily a family one and is limited by the lack of suitable inter-

tidal flats. It was noted that in many areas, clams occurring in narrow veins subtidally are not utilized because of their inaccessibility to conventional dry fork digging. The major factor affecting the present and future utilization of clams in Massachusetts is water cleanliness. As discussed earlier in this report, most of the water area of Pleasant Bay is considered to be clean. However, because of several constant sources of pollution, two areas in the bay which harbour soft shell clams have been closed to shellfishing. In Orleans, drainage from a commercial duck farm has resulted in closure of the upper portion of Pochet Creek. In Chatham, discharge of waste water from a laundromat has caused closing of a small portion of the Ryders Cove area. Every effort should be made to eliminate these present sources of pollution and to guard against creation of any new sources.

Summary

The total wholesale value of the 1965 shellfish harvest in Pleasant Bay was about $160,535. Approximately 200 commercial shellfishermen gained livelihood from the bay in 1965 on either a part time or full time basis. An additional 1,600 family license holders gathered shellfish from the bay. The present major economic shellfish species in Pleasant Bay are the quahog (hard shell clam) and the bay scallop. Quahogs and scallops are harvested by both family and commercial fishermen. Soft shell clams support a minor family fishery. In recent years, numerous plantings of oysters have been made at various locations in the bay in the attempt to create an oyster fishery. However, to date these plantings of mature oysters have not resulted in any significant natural setting of seed oysters in the bay.

The shellfish resources of the bay are presently being wisely managed under the shellfish management programs of Orleans, Harwich, and Chatham.

The main threat to present and future utilization of the shellfish resources of Pleasant Bay is the possibility of increased contamination of bay waters.

Lobster and Crab Fishery

A limited lobster fishery occurs in the lower portion of Pleasant Bay and extends generally about four miles to the south and east of the bay entrance. On three different sampling dates, biologists captured a single sub-legal size lobster at the lowermost otter trawl station (Sta. 6). All three specimens had a carapace length of about 1½″.

Catch reports submitted to the Division of Marine Fisheries by licensed fishermen indicated that seven lobstermen worked in the Pleasant Bay area during 1965. These lobstermen reported setting a total of 755 pots with a corresponding total catch of 26,593 lobsters (30,419 lbs.). This total catch was valued at about $21,061. On the basis of the reported total number of legal size lobsters caught and the total number of pots fished, Pleasant Bay lobstermen caught an average of 35 lobsters per pot during 1965.

Five fishermen reported liberating a total of 895 short lobsters and 215 egg lobsters. Two of the fishermen did not report upon the number of short and egg lobsters liberated.

No significant bait or edible crab fishery exists in the bay; however, an unconfirmed report by the Harwich Shellfish Officer suggested that a few blue claw crabs (*Callinectes sapidus*) were taken by family fishermen in the area of Muddy Creek, Harwich. It should be noted that during the 12-month sampling period biologists did not capture or observe any blue claw crabs in the estuary. During the course of interviews, many local fishermen expressed concern over the disappearance of blue claw crabs in the bay. In recent years, there have been similar reports from many areas along the southern shore of Massachusetts. The cause for the general decline of this species in Massachusetts is unknown. Until recently, many bays and tidal rivers supported substantial family fishing for these edible crabs. Since this species appears to be in marked decline, specific investigation should be conducted to find the cause of this decline and to determine possible methods of rehabilitating the crab stocks.

THE PLEASANT BAY TIDEMARSHES

The Pleasant Bay Tidemarshes

Introduction

Coastal wetlands, or tidemarshes, serve as natural buffer zones between the land and the sea and provide unique and irreplaceable habitat for many species of plant and animal life. The arterial creeks of the marsh provide essential spawning, feeding, or nursery grounds for a variety of commercial, sport, and forage fish species. The intertidal shores and shoal waters of the tidemarsh estuary support populations of many important mollusks, crustaceans, and worms which are either harvested by man or which provide food

for the larger fish inhabitants of the estuary. The sheltered waters and grasses of the tidemarsh are a vital nesting and wintering habitat for many species of shorebirds or waterfowl.

The tidemarsh plays an important role in the over-all biological productivity of the estuary and its adjacent coastal waters. Ecological studies have shown that the tidemarsh is prodigious in its manufacture of organic matter and essential nutrient salts. The production and utilization of these products involves a complex web of interactions between nutrients, plants and animals of the estuarine system. This cycle may be summarized in the following manner:

As marsh plants die and decompose, detritus (fine particles of organic matter) is formed. This material may be utilized directly in the food chain by various mollusks, crustaceans, or worms, or may break down further into nutrient salts such as nitrates and phosphates which are essential to the total productivity of the estuarine environment.

These nutrients nourish the living marsh grasses and the microscopic phytoplankton which constitute the primary step in the food chain of the sea. The phytoplankton is consumed by many types of organisms from tiny zoo-plankters to the larger fishes of the sea. Mollusks and finfish which are utilized by man might be considered end products of this complex food chain.

With the realization that our tidemarshes have been indiscriminately altered or destroyed in the past by private or commercial exploitation, citizen and professional conservationists of Massachusetts have acted concertedly with legislators to enact laws which regulate the dredging and filling of our tidemarsh areas. Studies have been conducted by the Department of Natural Resources to evaluate the extent and status of all our coastal wetlands and to perfect programs of tidemarsh protection (Fiske, 1964).

Objectives

The main objectives of this survey were as follows:

1. To determine the amount of salt marsh acreage involved in the Pleasant Bay study area.
2. To inventory the typical flora and fauna of the marsh and its adjacent tidal creeks.
3. To determine the present status of the tidemarsh with regard to its ownership and protection.

Methods and Materials

The acreage of the Pleasant Bay marshes was obtained from U. S. Geological Survey topographic maps. Linear distance was measured with a map rotometer and surface area was calculated by the dot-grid method. The amount and type of ownership of marsh property was obtained from the administrative offices of the towns involved.

The field investigation of a Pleasant Bay tidal marsh consisted of collecting samples of the flora growing on a randomly selected section of marsh and observing and collecting specimens of the fauna present in the intersecting ditches and creeks.

Botanical identification references included Fernald, (1959); Fassett, (1960); and Meunscher, (1944).

Findings and Discussion

An area of salt marsh on the west shore of Pleasant Bay in Orleans was chosen for examination of marsh fauna and flora. A tidal creek winds through the marsh and provides drainage for the many mosquito ditches which further transect the area. The most predominant plant species found on the marsh was salt meadow grass (*Spartina patens*). Salt water cord grass (*Spartina alterniflora*) was noted growing as a narrow border along the tidal creek and the marsh ditches. Spike grass (*Distichlis spicata*) was common mixed in with the salt meadow grass, and was fairly abundant. Both marsh samphire (*Salicornia europea*) and woody glasswort (*Salicornia virginica*) were common scattered throughout the marsh. Seablight (*Suaeda maritima*) and marsh rosemary (*Limonium carolinianum*) were also growing scattered within the salt meadow grass zone. Along the upland edge of the marsh were found isolated clumps of panic grass (*Panicum longifolium*); individual specimens of seaside goldenrod (*Solidago sempervirens*); and occasional patches of newly emergent black grass (*Juncus Gerardi*). Along the sandy upper limit of the marsh, beach grass (*Ammophila brevigulata*) was very common. Within the tidal creek itself scattered growths of eelgrass (*Zostera marina*) were noted. A common rockweed, *Fucus spiralis*, was collected from the creek bank where it grew abundantly. This species was also scattered within the drainage ditches of the marsh.

It is interesting to compare the dominant vegetation of this tidal marsh of Pleasant Bay with that of the North River marshes. Within the North River, salt water cord grass was predominant. (Fiske, Watson, and Coates, 1966). The occurrence of salt meadow grass as the primary species of the Pleasant Bay marsh area would suggest a less frequent submersion of the marsh by the tide than occurs in North River. This supposition is further substantiated by a

Figure 17.

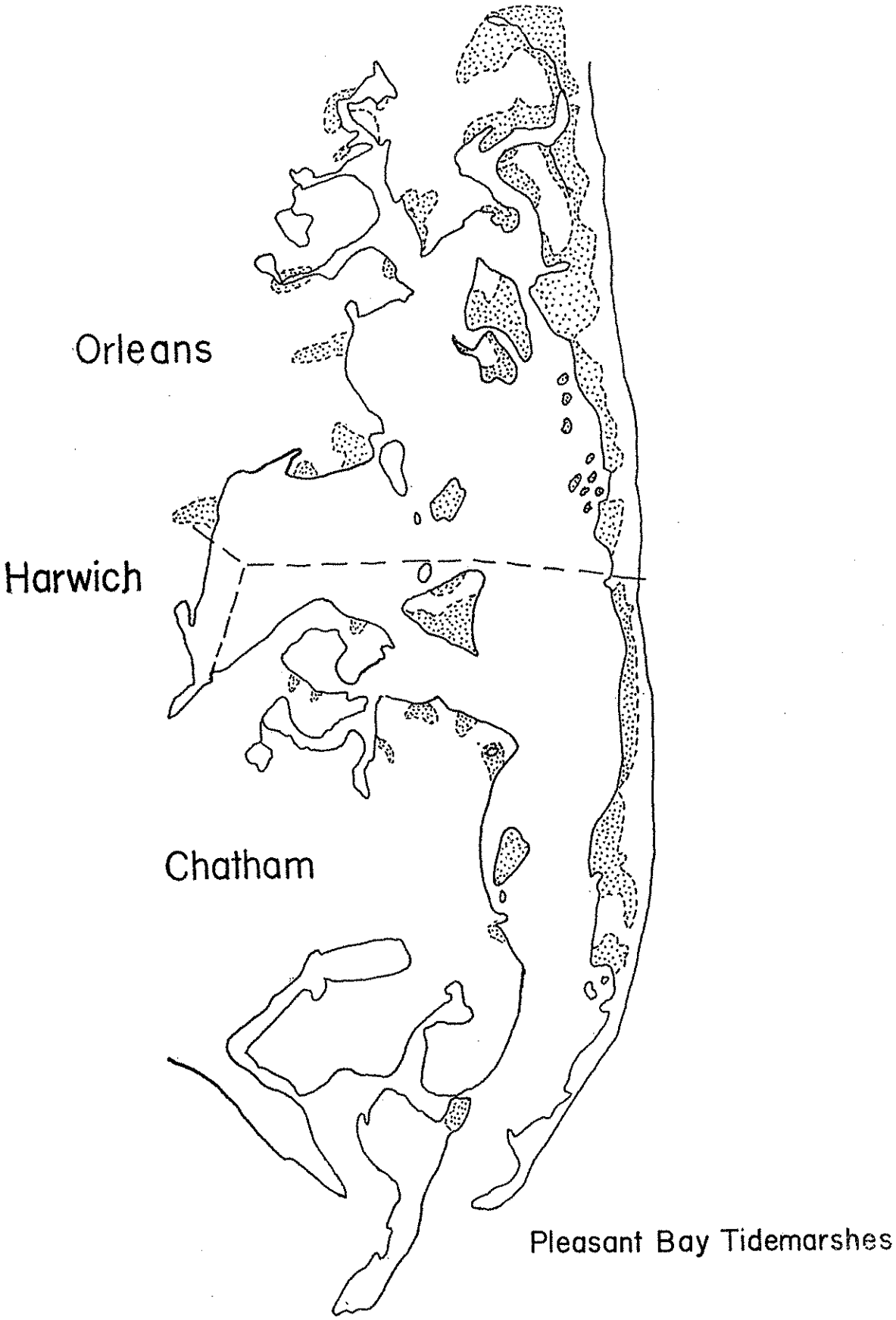
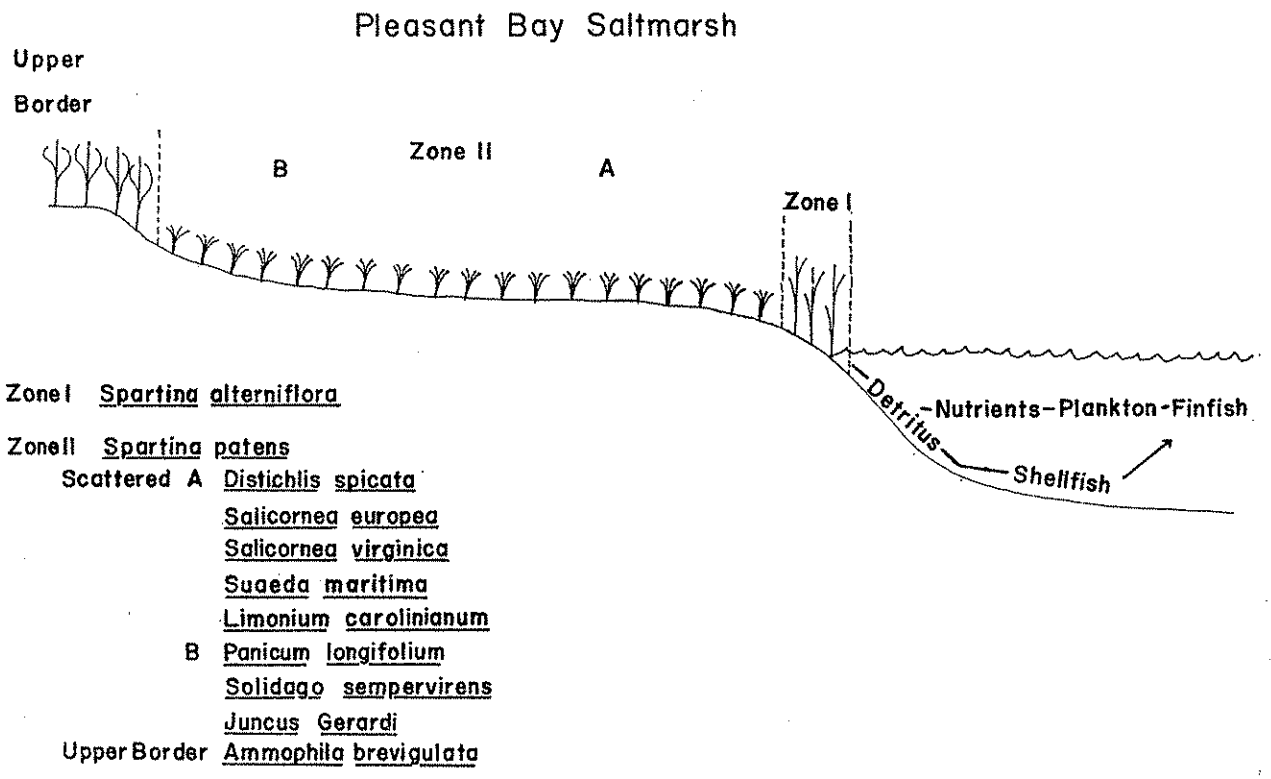


Figure 18.



comparison of tidal rise and fall; 2.8 ft. in upper Pleasant Bay and 8.8 ft. in North River.

Many small fishes and invertebrates were noted within the marsh tidal creek. Fundulus *sp.* were very common as was the mud snail (*Nassarius trivittatus*). The common periwinkle (*Littorina littorea*) was abundant on the marsh banks. *Littorina saitilis* was numerous along the marsh within the salt water cord grass zone. Other common mollusks were the ribbed mussel (*Modiolus demissus*) and the salt marsh snail (*Melampus bidentatus*) which was abundant in the upper zone of the marsh.

Current Ownership and Protection

There is a total of approximately 1,200 acres of tidal marsh within Pleasant Bay. For the most part, the marsh is divided between Orleans and Chatham, and relatively little lies within the town of Harwich. All of the marsh along Nauset Beach as well as that on Pochet Island and Sampson Island is included with the Cape Cod National Seashore Park. Any future construction on this marsh is prohibited, but ownership and regulation of the area remains with the individual towns and private property owners.

The following information concerning the ownership and protective status of the Pleasant Bay Marshes is presented for the two towns.

Orleans

There are approximately 804 acres of Pleasant Bay tidemarsh within Orleans. The town has purchased about 316 acres of marsh on Nauset Beach and placed it under protection for conservation purposes. The remaining 487 acres, which are privately owned, are taxed at a relatively low rate. The town exercises authority over alterations under a dredge and fill by-law, and a protective by-law which restricts salt marsh usage. Orleans also has a zoning regulation for the protection of the tidal marshes.

Chatham

Approximately 400 acres of Pleasant Bay salt marsh lie within the town of Chatham. About 145 acres are privately owned; 70 are under the protection of the town Park Commission; and the remainder (185 acres) is included in the Chatham Conservancy District. Regulation of this district land prohibits filling, dumping, excavating, draining, and building thereon. The town also exercises a protective by-law prohibiting the dredging and filling of salt marsh areas.

State Legislation Affecting Coastal Wetlands

An act relative to dredging or filling in coastal waters (Section 27A of Chapter 130) was passed by the legislature in 1963. The law prohibits alteration of salt marsh without prior written application to the city or town authorities, the State Department of Public Works, and the Director of the Division of Marine Fisheries. If marine fisheries or shellfish would be affected by the proposed alteration, the director may impose conditions for their protection. Since the passage of this bill in 1963, many salt marsh areas have been spared from indiscriminate destruction.

Within the Pleasant Bay area, eight applications have been submitted since 1963 for the alteration of tidal areas. Most of these projects involved pier construction, the installation of pilings or jetties, or repair of existing facilities and would have had little effect on marine fisheries in the area. The applications were approved without objection or imposed restriction by the Division of Marine Fisheries. No significant area of tidal marsh was involved in any of the proposed projects.

Chapter 768 of the General Laws was passed by the Massachusetts Legislature in 1965. This law is a comprehensive coastal wetlands protection bill. Among the major provisions of this act were the following:

1. Granting the Department of Natural Resources greater authority in regulating the uses of coastal wetlands.
2. Providing towns with the authority to take conservation lands by eminent domain after approval of a two-thirds vote by the townspeople.

From July 1965 to July 1966, 141 applications for marsh alteration throughout the state were processed by the Division of Marine Fisheries. This figure represented an increase of 65% in the number of applications received and processed during the previous year. Of the 141 applications received, conditions were imposed on 28, and total objections were registered on 3 projects. The increase in the trend toward development of salt marsh areas reemphasizes the need for more rapid implementation of the legislative programs that have been established for the protection of the coastal marshlands of Massachusetts.

Summary

The salt marshes of Pleasant Bay contribute not only aesthetically to the beauty of the bay, but also biologically to the total productivity of the estuary. The area has been rated high in marine fisheries and waterfowl resource and utilization (Fiske, op. cit.). The towns of Chatham and Orleans are to be commended for their foresight in passing protective measures to ensure against the indiscriminate destruction or alteration of the salt marsh area within their boundaries. Practically all of the salt marsh within Pleasant Bay is under some form of protection, either federal or local. However, isolated encroachments on the natural aspects of marsh areas have occurred which should have required compliance with state regulations (Chapter 130). It is recommended that stricter local attention be given to shoreline house construction, creation of bathing beaches, and other alterations where such projects require compliance with existing state and local regulations concerning tidal areas.

Chapter 130.

Section 27A.

AN ACT RELATIVE TO REMOVAL, FILLING AND DREDGING IN COASTAL WATERS.

(Chapter 426, Acts of 1963) (Amended by Chapter 375, Acts of 1965).

No person shall remove, fill or dredge any bank, flat, marsh, meadow or swamp bordering on coastal waters without written notice of his intention to so remove, fill or dredge to the board of selectmen in a town or to the appropriate licensing authority in a city, to the state department of public works, and to the director of marine fisheries. Said notice shall be sent by registered mail at least fourteen days prior to any such removing, filling or dredging. The selectmen or, in the case of a city, the licensing authority, shall hold a hearing on said proposal within twenty days of the receipt of said notice, notice of which hearing shall be given by them by publication in a newspaper published in such town or city, or if there be no newspaper published in such town or city, then in a newspaper published within the county, and shall notify by mail the person intending to do such removing, filling or dredging, the department of public works and the director, of the time and place of said hearing. The cost of such publication of notice shall be borne by the person filing the notice of intention to so remove, fill or dredge. The selectmen or licensing authority as the case may be, may recommend the installation of such bulkheads, barriers or other protective measures as may protect the public interest. If the department of public works finds that such proposed removing, filling or dredging would violate the provisions of sections thirty and thirty A of chapter ninety-one, it shall proceed to enforce the provisions of said sections. If the area on which

the proposed work is to be done contains shellfish or is necessary to protect marine fisheries, the said director may impose such conditions on said proposed work as he may determine necessary to protect such shellfish or marine fisheries, and work shall be done subject thereto.

Whoever violates any provision of this section shall be punished by a fine of not more than one hundred dollars or by imprisonment for not more than six months, or both, and the superior court shall have jurisdiction in equity to restrain a continuing violation of this section.

This section shall not affect or regulate the ordinary and usual work of any mosquito control project operating under chapter two hundred and fifty-two, or under the provisions of a special act. (Effective date: May 22, 1963.)

CHAPTER 768

THE COMMONWEALTH OF MASSACHUSETTS

(In the Year One Thousand Nine Hundred and Sixty-five)

AN ACT PROVIDING FOR THE PROTECTION OF THE COASTAL WETLANDS OF THE COMMONWEALTH.

Whereas, The deferred operation of this act would tend to defeat its purpose, which is in part to immediately provide for the protection of coastal wetlands against the imminent threat of the development of such lands for industrial and other uses detrimental to their preservation in their natural state, therefore it is hereby declared to be an emergency law, necessary for the immediate preservation of the public convenience.

Be it enacted by the Senate and House of Representatives in General Court assembled, and by the authority of the same, as follows:

SECTION 1. Chapter 130 of the General Laws is hereby amended by adding the following section: —

Section 105. The commissioner, with the approval of the board of natural resources, may from time to time, for the purpose of promoting the public safety, health and welfare, and protecting public and private property, wildlife and marine fisheries, adopt, amend, modify or repeal orders regulating, restricting or prohibiting dredging, filling, removing or otherwise altering, or polluting, coastal wetlands. In this section the term "coastal wetland" shall mean any bank, marsh, swamp, meadow, flat or other low land subject to tidal action or coastal storm flowage and such contiguous land as the commissioner reasonably deems necessary to affect by any such order in carrying out the purposes of this section.

The commissioner shall, before adopting, amending, modifying or repealing any such order, hold a public hearing thereon in the municipality in which the coastal wetlands to be affected are located, giving notice thereof to the state reclamation board, the department of public works and each assessed owner of such wetlands by mail at least twenty-one days prior thereto.

Upon the adoption of any such order or any order amending, modifying or repealing the same, the commissioner shall cause a copy thereof, together with a plan of the lands affected and a list of the assessed owners of such lands, to be recorded in the proper registry of deeds or, if such lands are registered, in the registry district of the land court, and shall mail a copy of such order and plan to each assessed owner of such lands affected thereby. Such orders shall not be subject to the provisions of chapter one hundred and eighty-four. Any person who violates any such order shall be punished by a fine of not less than ten nor more than fifty dollars, or by imprisonment for not more than one month, or by both such fine and imprisonment.

The superior court shall have jurisdiction in equity to restrain violations of such orders.

Any person having a recorded interest in land affected by any such order, may, within ninety days after receiving notice thereof, petition the superior court to determine whether such order so restricts the use of his property as to deprive him of the practical uses thereof and is therefore an unreasonable exercise of the police power because the order constitutes the equivalent of a taking without compensation. If the court finds the order to be an unreasonable exercise of the police power, as aforesaid, the court shall enter a finding that such order shall not apply to the land of the petitioner; provided, however, that such finding shall not affect any other land than that of the petitioner. The commissioner shall cause a copy of such finding to be recorded forthwith in the proper registry of deeds or, if the land is registered, in the registry district of the land court. The method provided in this paragraph for the determination of the issue of whether any such order constitutes a taking without compensation shall be exclusive, and such issue shall not be determined in any other proceeding, nor shall any person have a right to petition for the assessment of damages under chapter seventy-nine by reason of the adoption of any such order.

The department may, after a finding has been entered that such order shall not apply to certain land as provided in the preceding paragraph, take the fee or any lesser interest in such land in the name of the commonwealth by eminent domain under the provisions of chapter seventy-nine and hold the same for the purposes set forth in this section.

No action by the commissioner or the department under this section shall prohibit, restrict or impair the exercise or performance of the powers and duties conferred or imposed by law on the department of public works, the state reclamation board or any mosquito control or other project operating under or authorized by chapter two hundred and fifty-two.

No order adopted hereunder shall apply to any area under the control of the metropolitan district commission.

SECTION 2. Section 8C of chapter 40 of the General Laws, as amended by chapter 258 of the acts of 1961, is hereby further amended by adding the following four sentences: — For the purposes of this section a city or town may, upon the written request of the commission, take by eminent domain under chapter seventy-nine, the fee or any lesser interest in any land or waters located in such city or town, provided such taking has first been approved by a two-thirds vote of the city council or a two-thirds vote of an annual or special town meeting, which land and waters shall thereupon be under the jurisdiction and control of the commission. The commission may adopt rules and regulations governing the use of land and waters under its control, and prescribe penalties, not exceeding a fine of one hundred dollars, for any violation thereof. No action taken

under this section shall affect the powers and duties of the state reclamation board or any mosquito control or other project operating under or authorized by chapter two hundred and fifty-two, or restrict any established public access.

Lands used for farming or agriculture, as defined in section one A of chapter one hundred and twenty-eight, shall not be taken by eminent domain under the authority of this section.

SECTION 3. (This section has been omitted since it particularly concerns the North River in Plymouth County and is inapplicable to Pleasant Bay.

SECTION 4. Expenses incidental to adopting and recording orders, and awards of damages for lands taken by eminent domain, under section one hundred and five of chapter one hundred and thirty of the General Laws, as appearing in section one of this act, may be paid out of funds made available under the provisions of chapter five hundred and seven of the acts of nineteen hundred and sixty-four for carrying out the provisions of section three of chapter one hundred and thirty-two A of the General Laws.

Approved November 23, 1965

ECONOMIC VALUES

The marine resources of the bay support a variety of recreational and commercial industries. It was estimated that during 1965 about 1,600 family permit holders gathered shellfish from the bay. About 200 commercial fishermen derived income from shellfishing on either a part-time or full-time basis. The total wholesale value of the 1965 shellfish harvest was $160,535. Quahogs (hard shell clams) and bay scallops constituted the major portion of this harvest

Several commercial finfisheries also occur in the bay. Approximately 60,000 pounds of flounders were landed during the winter by fishermen utilizing small otter trawls. The total value of this catch to the fishermen was estimated to be $8,750.

A commercial fishery for eels resulted in the harvest of 4,000 pounds with a value of $1,200 to the fishermen.

A limited lobster fishery occurs in the lower portion of the bay and in adjacent waters outside the bay. This fishery was valued at about $21,061 during 1965.

In addition to the above commercial fisheries, over 86,000 pounds of striped bass taken by rod and reel fishermen in the bay were sold to wholesale fish dealers. The value of this catch to the anglers was approximately $12,915. An unknown number of striped bass, bluefish, and flounder were retained by anglers for home consumption.

Sport fishermen paid a total of $6,600 to three boat liveries in the area as rental fees for boats and launching ramp privileges. It was not possible to estimate the total number of sport fishing trips in the bay because of the size of the area, multiple access points and the limitations of time and the number of personnel assigned to the study. Sport fishing values listed are, therefore, only a small portion of the actual expenditures for this activity.

The large line trawl and charter boat fisheries which take place off Chatham are not included as economic values of Pleasant Bay since it is believed that the existence of these fisheries is not primarily dependent upon the bay.

This study revealed that the total value of marine resource utilization in the bay during 1965 was $211,061.

Minimum Economic Values of the Marine Fisheries Resources of the Pleasant Bay Study Area During 1965.

Income		
Shellfisheries	$160,535	
Flounders	8,750	
Eels	1,200	
Lobsters	21,061	
Striped bass	12,915	
SUBTOTAL		$204,461
Sport Fishery Fees		
Skiff rentals and launch fees	$6,600	
SUBTOTAL		$6,600
GRAND TOTAL		$211,061

When the total resource value is related to the total mean high tide acreage of the bay (7,285 acres), a value of $29 per acre is derived. It should be noted that this acreage includes extensive intertidal shoal areas of shifting sand on the east side of the bay which are relatively unproductive in marine resources. In terms of acreage of specific high production, exceptionally high valuation is exhibited. For instance, it was estimated that the quahog harvest valued at $127,463 occurred on about 640 acres of bottom. Correspondingly, the value of this quahog producing ground is $2,141.88 per acre.

SUMMARY

In 1963 an estuarine research program was initiated by the Division of Marine Fisheries. This program was designed to gather information relative to the extent and value of the marine resources of our major bays and estuaries. The investigation of Pleasant Bay, which was completed in 1966, was the seventh estuary to be evaluated under this program.

A total of 36 fish species were encountered within the study area. It was noted that during the summer months the bay serves as a nursery area for the juvenile forms of important recreational and commercial fishes such as white hake, tautog, scup, cod, pollock, and alewives. During the winter and spring, the bay provides spawning habitat for large concentrations of of winter flounders. An intensive sport fishery occurs within the bay for striped bass, bluefish, and winter flounder.

During 1965, the minimum value of marine resource utilization in the bay was estimated to be about $211,061. Shellfish accounted for 74% ($156,785) of this total value.

The water quality of Pleasant Bay was found to be generally favorable to a wide variety of economic marine species. However, existing and potential sources of organic pollution threaten the continued public utilization of shellfish.

RECOMMENDATIONS

The following recommendations are made to aid in the management and wise utilization of the marine resources of Pleasant Bay:

1. . . . that the Division of Marine Fisheries in cooperation with the Division of Sanitary Engineering, Department of Public Health continue to monitor the bay for the presence of coliform bacteria and sources of pollution. This should be part of a continuing study along the entire Massachusetts coastline.
2. . . . that the local boards of health rigidly enforce regulations pertaining to the discharge of domestic sewage. Where shorefront home construction is to occur, it should be required that cesspools or septic tanks be located within the lot at the maximum practical distance from tidal waters.
3. . . . that a continuing effort be made by the towns of Orleans, Harwich and Chatham and the Division of Marine Fisheries to expand the oyster resource of Pleasant Bay. Propagation methods should include the following: (1) concentrated plantings of mature oysters in sheltered ponds; (2) observation of growth and mortality rates; (3) periodic inspection of shoreline for the occurrence of natural oyster setting; (4) placing of cultch in potential oyster setting areas and (5) growing of oysters by the raft suspension method. Shellfish officers should maintain complete written records of their individual oyster propagation projects.
4. . . . that the Division of Marine Fisheries conduct specific investigation of the environmental conditions associated with exceptionally dense beds of seed quahogs. Such a study would lead to a better understanding of the conditions required for optimal setting, survival and growth of the quahog.
5. . . . that the shellfish officers of Orleans, Harwich and Chatham continue to record the volume and value of annual shellfish harvests from Pleasant Bay.
6. . . . that investigation of winter flounder occurrence and movement in Pleasant Bay be continued. Such study should include tagging of large fish (12 inches and greater) in the upper portions of the estuary in order to gain more information concerning the movements and exploitation rate of these fish which spawn in the bay.
7. . . . that repairs be made to the fishway linking Ryders Cove to Stillwater Pond. Wooden baffles presently controlling water flow are in disrepair and should be replaced with concrete structures.
8. . . . that adequate passage be provided for alewives between Stillwater Pond and Lover's Lake in order to increase the spawning and nursery area of the reproductive run.
9. . . . that repair be made to the concrete fishway at Pilgrim Lake, Orleans. Because of poor production from this run in recent years due to low water conditions, stockings of ripe alewives should be made in Pilgrim Lake by the Division of Marine Fisheries.
10. . . . that an all-tide, paved boat launching

ramp with adequate parking facility be created in the Chatham section of Pleasant Bay.

11. . . . that the towns of Orleans and Chatham continue to acquire tidemarsh areas of Pleasant Bay to protect them from alteration or destruction.
12. . . . that within 10 years another study of Pleasant Bay be conducted to determine the status and value of marine resources. The results should be compared with those of the present report and recommendations made for the future management and utilization of the estuary.

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