A STUDY OF THE MARINE RESOURCES OF WELLFLEET HARBOR

John R. Curley, Robert P. Lawton, David K. Whittaker and John M. Hickey

April, 1972

Monograph Series
Number 12

DIVISION OF MARINE FISHERIES
Department of Natural Resources
The Commonwealth of Massachusetts

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THE COMMONWEALTH OF MASSACHUSETTS

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DEPARTMENT OF NATURAL RESOURCES

Division of Marine Fisheries

Boston, Massachusetts

To the Commissioner and Board of Natural Resources:

Sirs:

I respectfully submit this report entitled "A Study of the Marine Resources of Wellfleet Harbor" for your consideration. This study was conducted by biologists of the Division of Marine Fisheries operating under the Estuarine Research Program.

Respectfully submitted,

Frank Grice
Director, Division of Marine Fisheries

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A STUDY OF THE MARINE RESOURCES OF WELLFLEET HARBOR

INTRODUCTION

The Massachusetts Division of Marine Fisheries has conducted an extensive estuarine research program since 1963. The program originated through the efforts of the Marine Fisheries Advisory Commission which reported its recommendations to the Governor in December, 1963. Recognizing the value of marine resources of the Commonwealth and the immediate need for pertinent information that would lead to a sound program of resource management, the Commission set forth certain objectives and guidelines which have become the basis for these studies (Massachusetts Division of Marine Fisheries, 1960).

Investigations have been completed in 17 major estuaries and coastal bays. Ten of these studies have been published by the Division, including the Merrimack River, Parker River-Plum Island Sound, Gloucester Harbor-Annisquam River, Beverly-Salem Harbor, Quincy Bay, North River, Pleasant Bay, Westport River, Waquoit Bay and Dorchester Bay.

This report presents the results of a study of Wellfleet Harbor in Barnstable County on the north side of Cape Cod (Fig. 1). Upper limits of the study area were established at Herring River Dike and the northern end of Duck Creek. Lower limits were set at a line extending from the tip of Jeremy Point eastward to the Wellfleet-Eastham town line at Hatches Creek in Sunken Meadow marsh. Sportfish data from the adjacent Billingsgate shoal area was also included. Field investigations were conducted from September, 1968 to August, 1969.

ACKNOWLEDGEMENTS

This study was performed by the South Shore Estuarine Team headquartered at Shawme-Crowell State Forest in Sandwich. H. Arnold Carr and Kenneth Reback contributed to the shellfish and anadromous fish sections, respectively. David L. Chadwick assisted in final preparation of the manuscript. In the summer of 1968, student assistants Gary Urquhart, Dudley Glover and Thomas Peterson assisted in preliminary sampling. Student assistants Louis H. Carufel III, Jeffery Reback and Dudley Glover assisted in field work in the summer of 1969.

We are indebted to Mr. Anthony Oliver, Town of Wellfleet Shellfish Constable, for sharing his knowledge of the resources of the area. Dr. Karl Deubert of the Wareham Cranberry Experimental Station performed all pesticide analysis.

The cooperation of sport and commercial fishermen, local residents, dealers and wholesalers in the study area is greatfully acknowledged.

OBJECTIVES

Objectives of this study were: to review the historical background of the study area with regard to finfish and shellfish resources; to obtain data relative to morphometry and water quality; to determine the number and relative abundance of finfish species and the extent and value of commercial and recreational fisheries; to determine the extent of economically important shellfish species and their current status and value; to inventory the more common species of algae and vascular marsh plants; and to determine the current status of salt marsh with respect to total acreage, ownership and protection.

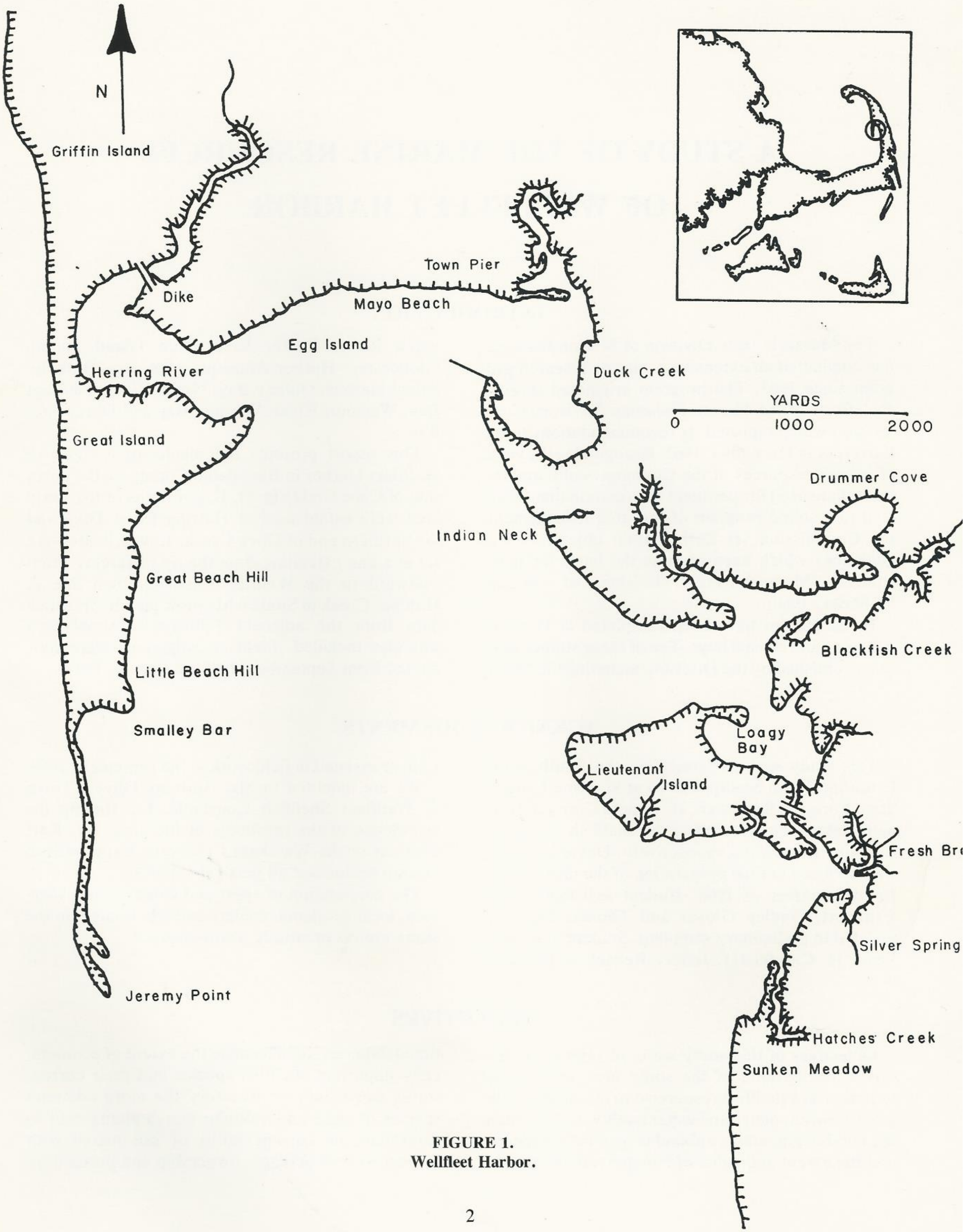


FIGURE 1.
Wellfleet Harbor.

METHODS AND MATERIALS

Morphometric data was taken from U.S.G.S. Topographic Map, Wellfleet Quadrangle. Linear and area measurements were obtained with a map rotometer and dot grid overlay. Water depth and volume were computed from data taken from United States Coast and Geodetic Survey Chart No. 581.

Four water quality stations were established. Salinity and water temperature were taken with a G.M. wide range hydrometer and thermometer. Salinities were standardized to 15 C. A Ryan 30-day recording thermograph was placed under the Town Pier from June to October to obtain a continuous record of water temperatures. A Hach Portable Water Analysis Kit Model CA10 was used to determine dissolved oxygen and hydrogen ion concentrations. Nitrate and phosphate measurements were taken with a Hach DR-E1 Direct Reading Portable Laboratory. Transparency was determined with a secchi disc. Sub-surface water samples were collected with a Nansen water bottle.

Pesticide samples were analyzed by gas chromatography at the Cranberry Experimental Station in Wareham. Residues from samples were not subjected to nitration (destruction of DDT, Dieldrin and DDE molecules) or dehydrohalogenation (conversion of DDT to DDE).

Nine finfish sampling stations were established. Ice prevented sampling in December except at Station 2. Stations 1 to 3 were sampled with a 60 ft by 4 ft beach seine of ⅛ inch bar mesh. A 30 ft otter trawl was used to sample stations 4 to 9. Trawl wings were 1½ inch bar mesh with ⅜ inch bar mesh liner. Trawl doors measured 15 inches by 32 inches. Each site was sampled once each month. Fish were classified according to the American Fisheries Society Special Publication No. 2, *A List of Common and Scientific Names of Fishes from the United States and Canada* (1970). Surface water temperature and salinity were recorded at each station at the time of sampling.

Sportfish statistics were obtained by personal interviews with boat captains and fishermen.

Quahogs and soft-shell clams on intertidal flats were sampled with a square foot quadrat frame and quahog and clam rakes. Oysters were sampled with a square yard quadrat sampler. Shellfish measurements were made to the nearest millimeter using vernier calipers. Identification was according to Abbott (1963) and Smith (1964). Shellfish harvest values were obtained from Town records.

The marsh flora inventory was conducted on the north side of Lieutenant Island adjacent to Loagy Bay. Plants were also collected at each finfish sampling station. Identification was according to Taylor (1957) and Fernald (1959).

PHYSICAL AND CHEMICAL CHARACTERISTICS

Geology

The Wellfleet area of Cape Cod was formed some 50,000 years ago during the final glacial era of the *Wisconsin Stage* of the Pleistocene Epoch (Strahler, 1966). Overlying the area's bedrock is approximately 400 feet of glacial sand and gravel (Chamberlain, 1964) (Fig. 2). Wellfleet is a plain resulting from morainal outwash. Strahler (1966) suggests there was an interlobate moraine between Cape Cod Bay and South Channel glacial lobes, which was situated east of the present arm of the Cape.

As the glacial ice mass receded, boulders and ice blocks were deposited on the scoured countryside. Granite rocks can still be seen scattered throughout Wellfleet. The larger ice blocks fromed kettle holes and hollows after glacial retreat. The ice blocks melted slowly and outwash materials deposited around them. The resulting depressions filled with water to form ponds. Hollows were open and were unable to retain water because of sectional erosion. Great Pond, Duck Pond, and the small ponds proximal to Pamet River are examples of the kettle ponds (Woodworth & Wigglesworth, 1934). Hollows are more numerous, and Dyer's Hollow, Cahoon's Hollow, and Snow's Hollow are typical examples.

Present geography is due to post glacial modifications. Flash flooding transformed streamlets into rivers such as Herring River and Blackfish Creek. Wave action cut deeply into the coastline forming the steep marine scarp of Indian Neck. Wave action introduced another modification — shore drifting. Originally, Bound Brook Island, Griffin Island, Great Island and Great Beach Hill were independent isalnds formed by glacial drift. However, due to a southerly shore drift, they were connected by narrow strips of land called tombolos. Jeremy Point was also formed by shore drift and constantly changes in configuration with storm action.

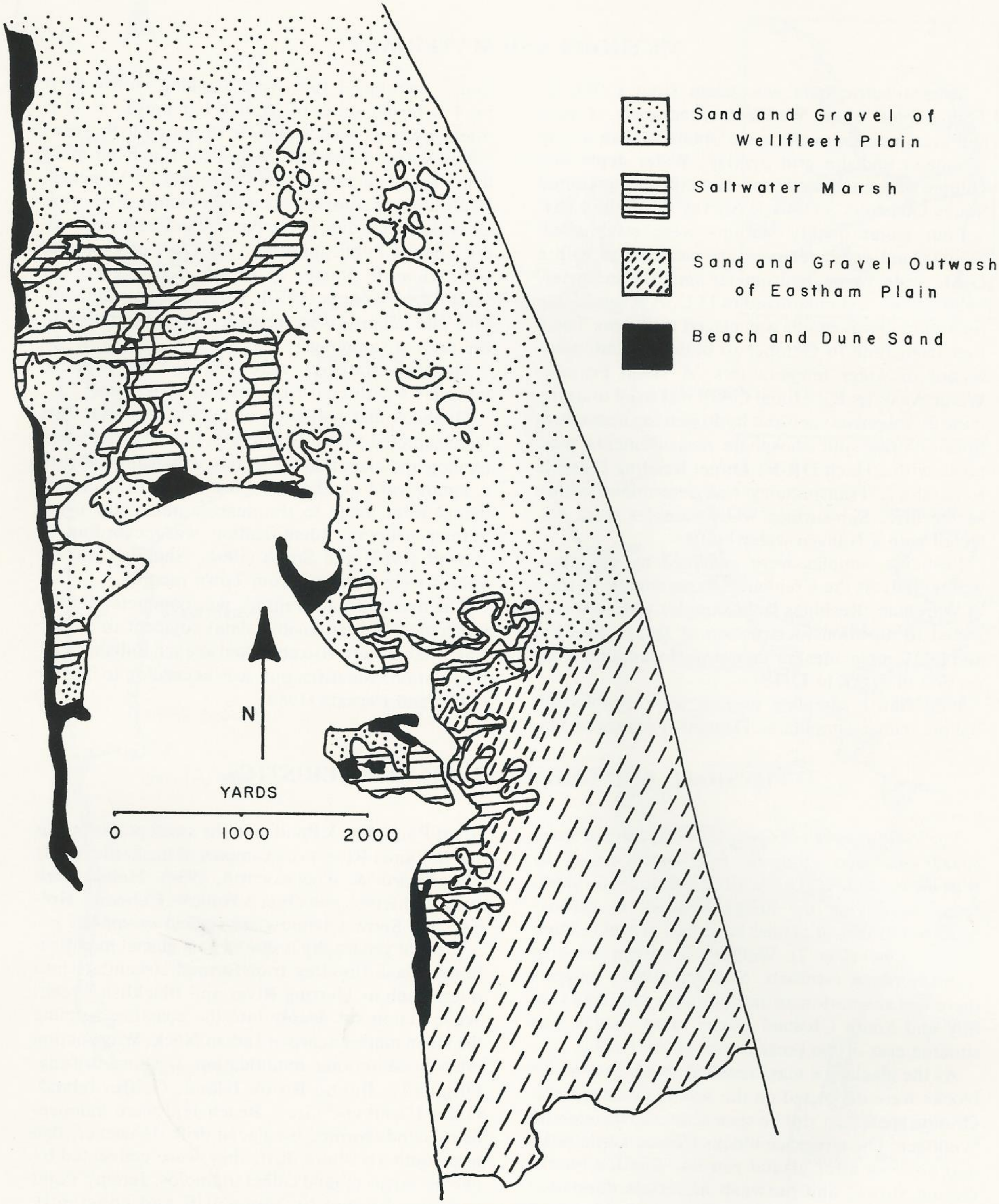


FIGURE 2.
Geologic Map of Wellfleet Area.
(Redrawn from J.B. Woodworth, 1916.)

Another modification of Wellfleet's morphometry was the formation of mud flats. River and tidal silts were deposited and densely compacted, resisting the effects of erosion. With time, the accumulation of deposits resulted in the formation of a supratidal area. Eventually the marsh grasses were established and formed the first stages of terrestrial succession.

Morphometry

Wellfleet Harbor is an open embayment entering southerly into Cape Cod Bay. Herring River, originating at Herring Pond, provides the only appreciable fresh water influence in the Harbor, and drains Bound Brook and surrounding marsh and lowland. The river enters the northwest corner of the harbor, flowing over and around Great Island tidal flats. Blackfish Creek, a small tributary, drains the marsh lands between Indian Neck and Lieutenant Island and flows past Drummer's Cove and Loagy Bay into the eastern portion of the harbor. Duck Creek drains the marshes in the northeast corner and enters the harbor at the Town Pier. Fresh Brook, Hatches Creek and Silver Brook are small tributaries draining fresh and salt marshes southeast of Lieutenant Island.

Table 1. *Wellfleet Harbor Morphometric Data*

	MHW	MLW
Maximum length (mi)	4.8	4.8
Maximum width (mi)	3.3	2.0
Mean width (mi)	1.4	0.9
Width at entrance (mi)	3.2	2.8
Shoreline length (mi)	30.9	19.3
Maximum depth (ft)	43.0	33.0
Mean depth (ft)	6.2	3.5
Total surface area (ac)	6094	3815
Volume (cu ft)	17.1×10^8	6.3×10^8
Total amplitude (ft)	10	
Salt marsh area (ac)	1117	

Morphometric data were computed for the general harbor area including Herring River, Blackfish Creek and Duck Creek (Table 1). Total water surface area at mean high water (MHW) was 6,094 acres and 3,815 acres at mean low water (MLW), a difference of 37%. There was a 6:1 ratio of water surface area to salt marsh area (1117 acres) at MHW. Shoreline length increases by 20% from MLW to MHW. MLW depth was 3.5 ft resulting in a volume of 6.3×10^8 cu ft (Fig. 3). The 10 ft tidal amplitude and 6.2 ft mean depth at MHW result in a high tide volume of 17.1×10^8 cu ft. Tidal exchange is approximately 63% of the water volume.

Temperature

Effects of temperature on the solubility of gases, water density and viscosity influence such life processes as growth, reproduction and metabolism of estuarine organisms (Hutchins, 1947; Kinne, 1967; Moore, 1965; Thorsen, 1946 and Umminger, 1969). These factors are important in determining geographic distribution of species, seasonal migrations and distribution of organisms within the estuary.

Recorded water temperatures in Wellfleet Harbor ranged from a high of 81°F in July, 1969 at Herring River to a low of 31°F at Loagy Bay and Herring River in January and March, respectively (Tables 2 and 3; Figs. 4 and 5). Floe ice filled the harbor on many occasions in December and January depending on wind and tide conditions. The temperature extremes at Herring River and Loagy Bay are attributed to the effects of air temperature on exposed shoals.

Thermograph recordings were taken at the Town Pier from June through September, 1969 (Fig. 6). The highest temperature (77°F) was recorded on August 9; the lowest temperature (63°F) was noted from September 24 to 30. Monthly mean temperatures for June through September were 70°F, 71°F, 74°F and 68°F, respectively.

The thermograph was also utilized at the same location in the summers of 1967 and 1968. In 1967, temperatures ranged from 80°F on August 2 to 64°F on September 4. In 1968, a maximum of 80°F on August 8 and a minimum of 61°F on June 28 were recorded. Mean summer temperatures (June to September) for 1967, 1968 and 1969 differed by only 1 to 3 degrees F.

On September 4, 1968 surface and bottom water temperatures were recorded at six stations throughout the harbor on high and low tides (Table 4, Fig. 7). The greatest surface to bottom temperature difference on either tide was 2°F. Average differential on both tides was 0.8°F. Average difference in water temperature from high tide to low tide was 1.2°F for the surface and 10.0°F for the bottom. On July 14, 1969, surface and bottom water temperatures were recorded at 11 stations from Billingsgate Island to Herring River Dike (Table 5; Fig. 1). Only 1 and 2 degree F differences were noted from surface to bottom at all stations except those proximal to Herring River Dike where a 5 F difference was recorded. This phenomenon was attributed to the warm fresh water from the shallow Herring River becoming superimposed over the colder bay water.

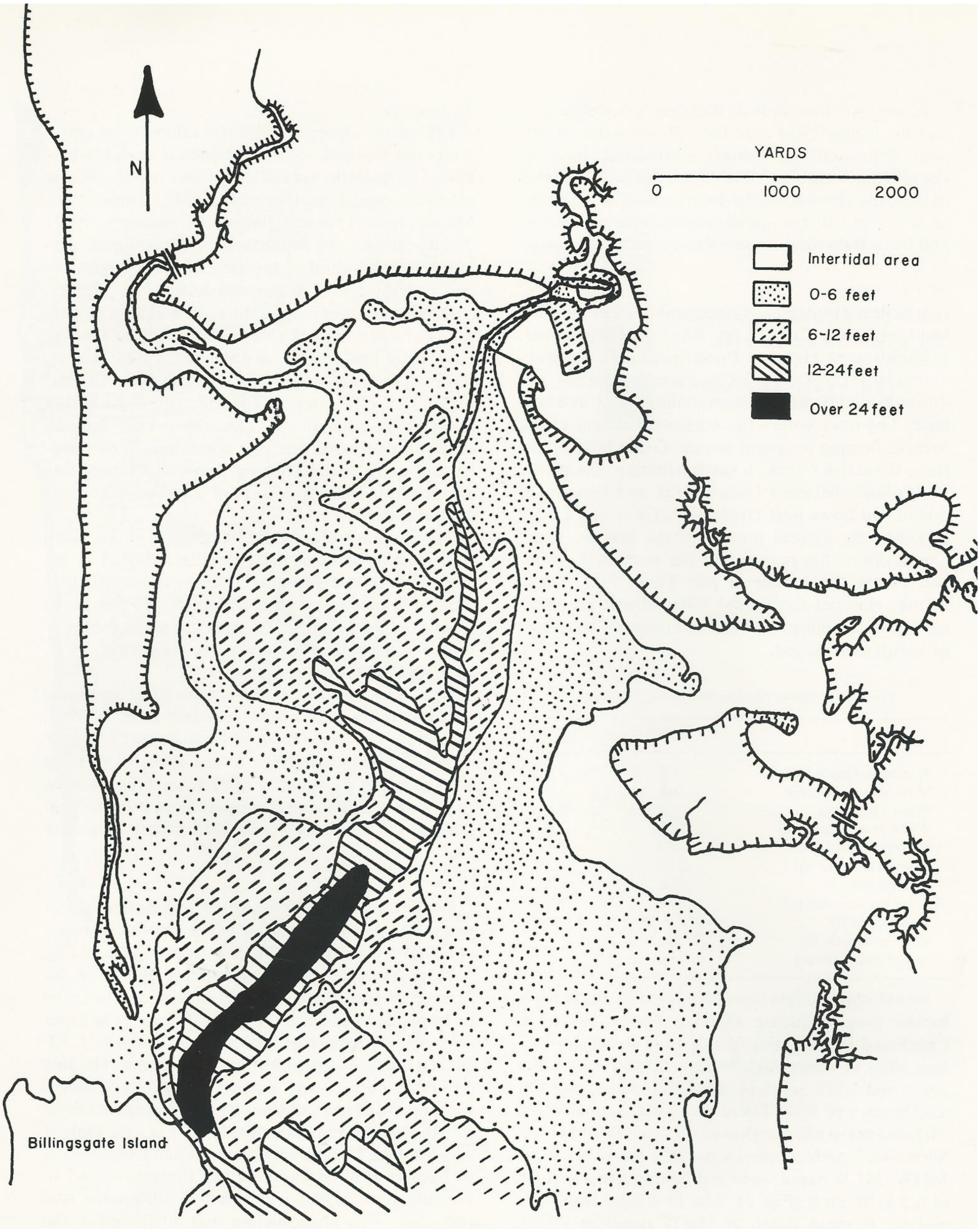


FIGURE 3.
Depth Contours of Wellfleet Harbor (MLW).

Table 2. *Water Quality Data Recorded at Four Stations (Fig. 4) in Wellfleet Harbor, 1968 – 1969*

		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Boat Ramp	Tide hr	L +2	L	H +1	L	L +3	H +3	H +5	H	L +5	L +4	L +5	H
(C1)	Air Temp F	75	66	47	50	42	34	33	68	56	-	74	80
	Water Temp F	69	59	45	33	33	34	33	58	60	71	72	75
	0/00	28	31	28	29	30	29	31	32	31	30	33	29
	O_2	6	8	5	10	7	9	7	8	8	5	8	8
	pH	8	8	8	9	8	8	8	8	8	8	8	8
Jeremy Point	Tide hr	L +3	L +5	H	L	L	H +2	H +4	L +5	H +1½	L +3½	H	L +1
(C2)	Air Temp F	68	66	46	47	28	33	33	64	59		67	
	Water Temp F	71	59	44	34	32	33	32	52	54	71	67	72
	0/00	33	32	28	30	30	29	29	29	29	29	32	32
	O_2	8	10	8	10	10	10	10	9	9	8	8	8
	pH	8	8	8	8	8	8	8	8	8	8	8	8
Herring River	Tide hr	L +4½	L	H +2	L	L +3½	H +2	H +4	L +5½	L +5½	H	L +4½	H +4½
(C3)	Air Temp F	78	66	47	50	32	34	33	68	60	-	75	80
	Water Temp F	70	62	45	38	32	34	31	61	54	74	73	77
	0/00	29	26	28	20	30	28	28	28	29	30	33	31
	O_2	9	8	6	10	7	10	10	8	6	10	9	9
	pH	8	8	7	7	8	8	8	8	8	8	8	8
Loagy Bay	Tide hr	H	H +4	H +2	L +3	L +4½	H +1½	H +3	L +4½	H +2	L +5	L +4	H +1
(C4)	Air Temp F	78	65	47	43	41	33	54	80	60	-	82	78
	Water Temp F	71	59	46	41	31	33	49	61	59	73	79	75
	0/00	31	30	30	27	28	29	30	29	29	30	31	32
	O_2	6	8	10	9	5	6	7	7	4	8	7	5
	pH	8	8	8	8	8	8	8	8	8	8	8	8

Table 3. *Surface Temperatures and Salinities Recorded at Eight Finfish Sampling Stations in Wellfleet Harbor, 1968 – 1969*

Station		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Boat Ramp	F	70	59	43		31	34	33	58	59		70	75
F1	0/00	30	32	29		29	29	31	32	30	28	31	30
Herring River	F	70	62	44	38	33	34	31	61	54	74	70	77
F2	0/00	29	26	30	20	29	28	28	28	29	30	31	31
Loagy Bay	F	71	59	44			33	49	61	59	73	67	78
F3	0/00	31	30	29			29	30	29	29	30	29	32
Loagy Bay	F	63	62	39		31	34	43	57	59	72	71	75
F4	0/00	30	30	29		28	28	31	29	30	31	32	32
Indian Neck	F	63	62	40		32	33	43	56	58	71	74	76
F5	0/00	30	30	29		29	28	30	30	31	32	32	32
Jeremy Point	F	62	61	39		32	33	41	55	57	68	68	76
F6	0/00	30	31	29		30	29	30	30	30	33	32	34
Smalley Bar	F		61	40		32	34	44	56	58	69	70	75
F7	0/00		31	29		28	29	30	29	30	32	32	31
Great Island	F	63	61	40		32	34	43	56	59	70	71	78
F8	0/00	30	29	29		28	30	29	29	29	31	32	32
Inner Harbor	F		63	39		32	34	44	57	60	71	71	79
F9	0/00		30	28		28	28	30	29	31	31	33	32

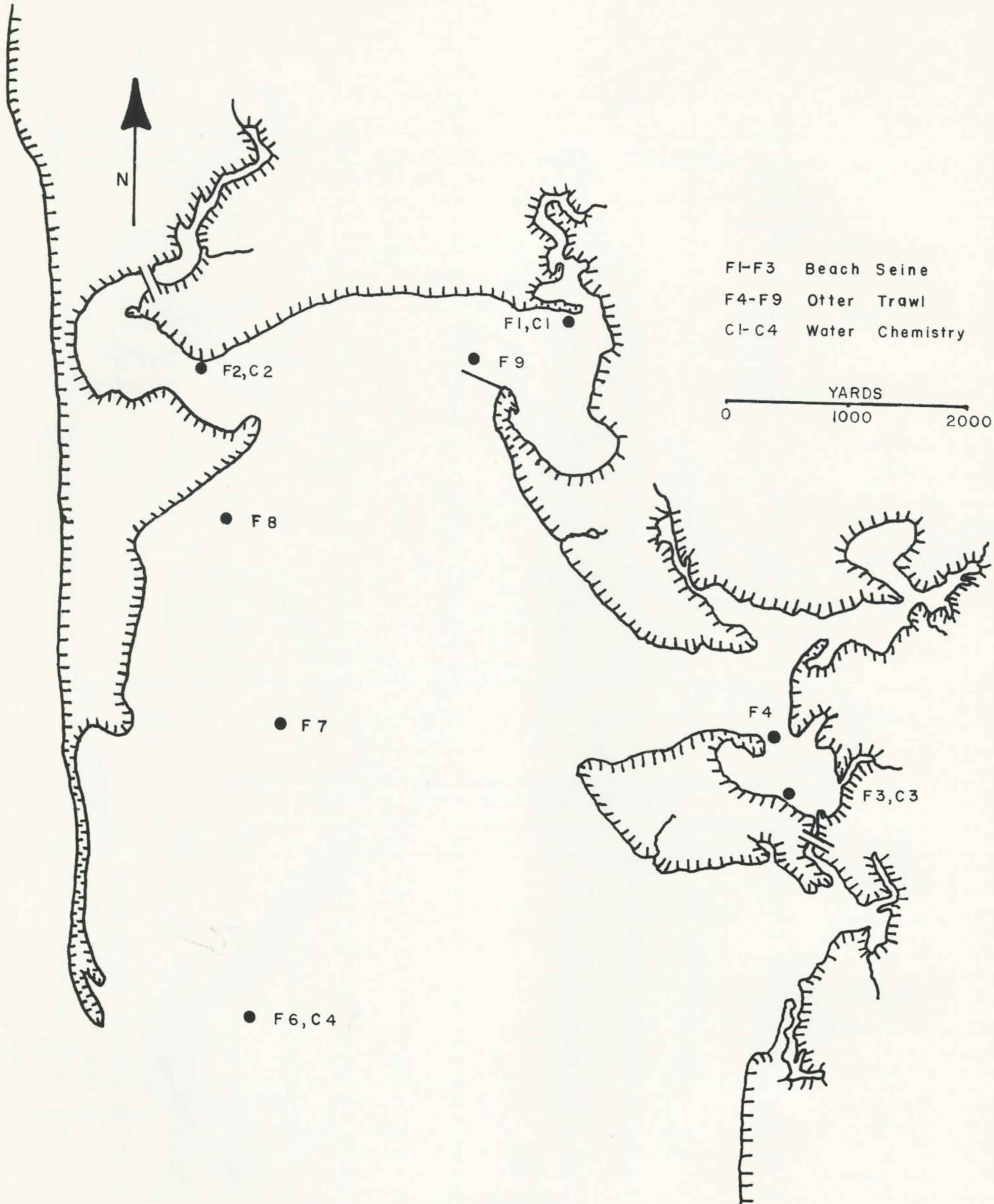


FIGURE 4.
Wellfleet Harbor Water Quality and Finfish Sampling Stations, 1969.

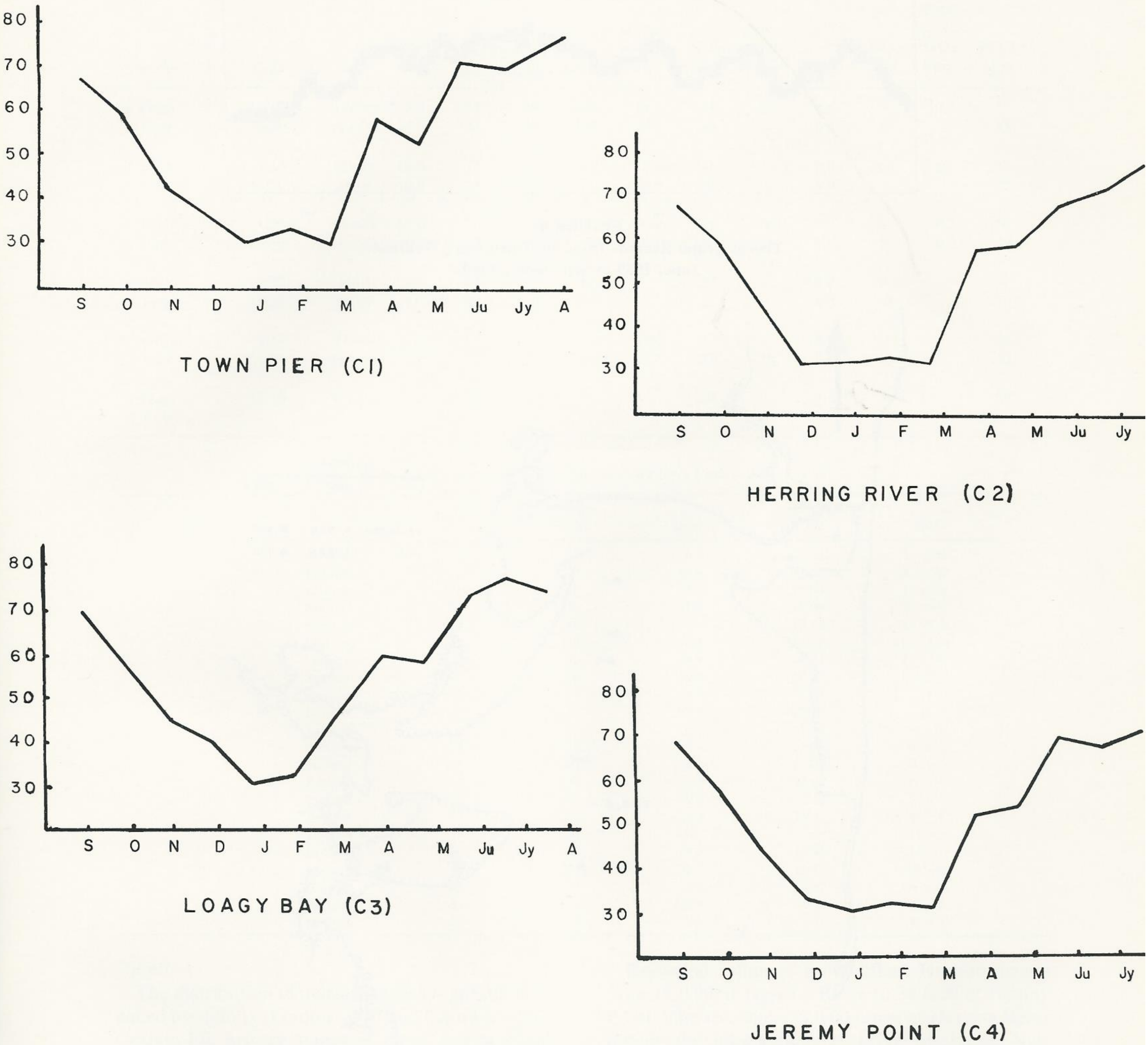


FIGURE 5.
Surface Water Temperatures (°F) recorded at four Stations (C_1-C_4, Fig. 4) in Wellfleet Harbor, 1968 — 1969.

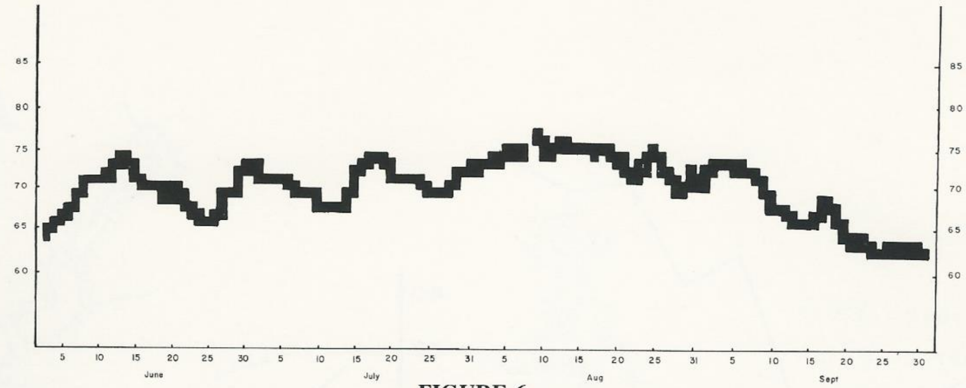


FIGURE 6.
Thermograph Records from the Town Pier, Wellfleet.
June, 1969 to September, 1969.

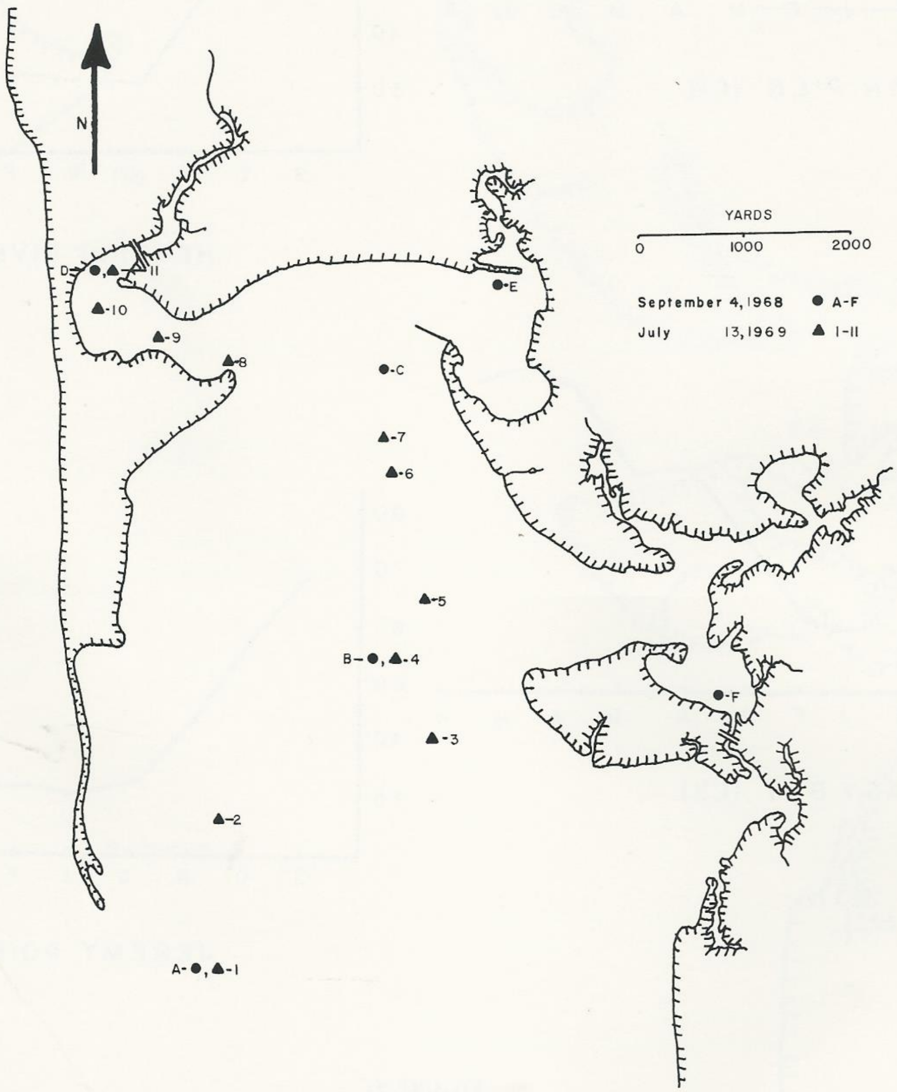


FIGURE 7.
Supplemental Water Quality Stations in Wellfleet Harbor, 1968 and 1969.

Table 4. *Water Quality Data from Wellfleet Harbor, September 4, 1968*

Station	Time	Tidal Stage	Depth (ft)	Temperature (F) Air	Surface	Bottom	Trans-parency (ft)	Corrected Salinity 0/00 Surface	Bottom	pH	DO ppm	Total N, NO_2 NO_3 ppm	PO 4 ppm
1 High	10:15	L+5¾	25.0	74	68	68	19.0	33	32	8.0	9	10.2	.57
Low	15:10	H+5¾	14.0	74	70	70	9.5	30	30	8.0	8		.35
2 High	10:40	H+¼	18.0	72	67	69	12.0	31	30	8.0	8	8.9	.42
Low	15:30	H+5	10.0	73	69	70	8.5	30	32	8.0	8		.52
3 High	11:06	H+½	10.0	72	70	70	9.0	29	30	8.0	8	8.2	.50
Low	15:50	H+5½	5.0	73	70	71	5.0	31	33	8.0	9	6.2	.49
4 High	11:30	H+1	8.5	64	70	68		30	30	8.8	8		.40
Low	15:20	H+5	1.0	68	70			15		8.5	10		.70
5 High	9:54	H+½	15.0	67	71	71	8.0	30	29	8.8	9		.51
Low	14:55	H+4½	8.0	76	70	71	6.0	31	30	8.6	8		.62
6 High	12:10	L+4½	1.0	72	69			30		8.6	9		.69
Low													

Table 5. *Water Temperature and Salinity Data from Wellfleet Harbor, July 14, 1969*

Station		Temp (F)	Salinity 0/00	Depth	Time	Tide
1	Surface	71	31	0.5	11:50	L +5½
	Bottom	71	32	30.0	11:50	L +5½
2	Surface	71	31	0.5	12:00	L +5½
	Bottom	71	33	31.0	12:00	L +5½
3	Surface	72	30	0.5	12:15	L +5 ¾
	Bottom	73	33	18.5	12:15	L +5 ¾
4	Surface	72	32	0.5	12:23	L +5¾
	Bottom	72	30	16.0	12:23	L +5 ¾
5	Surface	73	31	0.5	12:32	H
	Bottom	71	31	15.0	12:32	H
6	Surface	72	31	0.5	13:00	H +½
	Bottom	73	32	17.0	13:00	H +½
7	Surface	72	32	0.5	13:05	H +½
	Bottom	74	33	18.5	13:05	H +½
8	Surface	73	31	0.5	13:25	H +1
	Bottom	74	32	8.5	13:25	H +1
9	Surface	75	31	0.5	13:36	H +1
	Bottom	74	30	8.5	13:36	H +1
10	Surface	78	31	0.5	13:47	H +¾
	Bottom	75	31	9.5	13:47	H +¾
11	Surface	81	20	0.5	13:57	H +2
	Bottom	76	32	8.5	13:57	H +2

Salinity

The distribution of marine species is greatly influenced by salinity (Gunter, 1967 and Carriker, 1967). Certain life history stages of many marine plants and animals are dependent on low estuarine salinities (June and Chamberlin, 1959; Legendre, 1921 and Hill and Shearin, 1970). Only those species capable of tolerating a wide range in salinity (euryhaline) are able to live in the estuarine environment (Gunter, 1961 and Clarke, 1967).

Recorded salinities in Wellfleet Harbor ranged from 15 0/00 at Herring River to 34 0/00 at Jeremy Point. The 15 0/00 to 33 0/00 range at Herring River reflects the direct influence of river discharge. Narrow salinity ranges of 28 0/00 — 33 0/00, 27 0/00 — 32 0/00 and 28 0/00 — 34 0/00 were observed at Town Pier, Loagy Bay and Jeremy Point (Tables 2 and 3).

On September 4, 1968, salinities were recorded at six locations throughout the harbor at high and low tides (Tables 2 and 3). Salinity difference was never greater than 3 0/00 except at Herring River Dike where a 15 0/00 difference (15 0/00 to 30 0/00) existed. The mean difference, not considering Herring River, was 1.8 0/00 on the surface and 2.5 0/00 on the bottom. On July 14, 1969, surface and bottom salinities were recorded at 11 locations from Billingsgate Island to Herring River (Table 5, Fig.7). Stratification greater than 3 0/00 was noted only at Herring River Dike where there was a 12 0/00 difference (20 0/00 to 32 0/00). Average stratification, except for Herring River, was 1.2 0/00.

Dissolved Oxygen and pH

Dissolved oxygen (D.O.) concentrations from 5 ppm to 8 ppm are satisfactory for the growth and development of marine fishes and it is probable that many marine animals can live for long periods of time at much lower levels (Anon., 1968). In Wellfleet Harbor only one reading below 5 ppm was recorded (4 ppm). The mean D.O. concentration of 48 samples was 8 ppm (Table 2).

The relative acidity and alkalinity of water is obtained through analysis of its hydrogen ion concentration (pH). Observed pH values in Wellfleet Harbor ranged from 7 ppm — 9ppm. All pH values recorded at the four water chemistry stations were 8 with the exception of one reading of 9 at the Town Pier and two readings of 7 at Herring River (Table 2). Most marine organisms can tolerate a pH range of 5.0 — 9.0 (Doudoroff, 1957). The pH values observed in Wellfleet were considered to be compatible with marine life.

Pesticides

Use of chemical pesticides has caused concern because of their deleterious effects on biota other than target organisms. Secondary toxic effects occur when pesticides applied at low rates are concentrated as they pass through the food chain until reaching a level that is toxic to higher forms of animal life (Butler, 1966; Carson, 1962 and Litchtenstein and Polivka, 1959). Pesticides may also inhibit reproduction and maturation of eggs or exert an indirect influence through reduction of lower food-chain organisms (Butler, 1966).

Tissue residues in biological samples less than 10 parts per billion (ppb) apparently constitute no direct health hazard to either vertebrate or invertebrate fauna, however, concentrations of this level in estuarine waters may be detrimental (Butler, 1966). Butler (1966) found that under controlled laboratory conditions, 7 to 10 ppb of DDT in water will inhibit shell deposition in oysters by 50% and within 24 hours kill 50% to 100% of eight species of finfish and crustaceans tested. Even at concentrations less than 10 ppb in water, most chlorinated hydrocarbon pesticides (DDT, Aldrin, Dieldrin, Heptachlor, Chlordane, Endrin and Lindane) inhibit bivalve growth and decrease phytoplankton productivity by 50% to 90% when exposed for 4 hours (Lichtenstein and Polivka, 1959).

Water, mud and oysters were collected approximately every 2 weeks from June through August, 1969 in Wellfleet Harbor at Herring River, Duck Creek and Blackfish Creek, and analyzed for chlorinated hydrocarbon pesticides (Tables 6,7,8).

Table 6. *Chlorinated Hydrocarbon Pesticides Detected in Water, Oyster and Mud Samples Collected from Herring River, Wellfleet, 1969*

Date	Tide	Air Temp °F	Water Temp °F	Salinity 0/00	Water ppb	Oysters ppb	Mud ppb
6/5	H +4½	66.0	62.5	14.0	Dieldrin 0.03 DDT 0.36	Dieldrin 9 DDT 6	Dieldrin 23 DDT 220
6/18	L	62.5	64.5	14.0	Dieldrin 0.07 DDT 0.83	0	0
7/1	H +5	74.0	72.0	15.0	Dieldrin 0.03 DDT 0.19	Dieldrin 21 DDT-Trace	Dieldrin 20 DDT 250
7/16	L	72.0	73.0	13.5	Dieldrin 0.04 DDT 0.01	0	0
7/31	H +5	71.5	71.5	15.5	Dieldrin 1.01 DDT 0.04	Dieldrin 30 DDT 9	Dieldrin 29 DDT 190
8/14	L +4½	72.0	76.0	11.0	Dieldrin 0.008 DDT 0.17	No Sample Taken	No Sample Taken
8/28	L +½	72.5	68.5	21.0	Dieldrin 0.019 DDT 0.09	0	0
9/17	L	77.5	71.0	13.0	Dieldrin 0.091 DDT 0.21	No Sample Taken	No Sample Taken
9/23	L	72.4	70.1	13.0	Dieldrin-Trace DDT 0.048	No Sample Taken	No Sample Taken

Table 7. *Chlorinated Hydrocarbon Pesticides Detected in Water, Oyster and Mud Samples Collected from Duck Creek, Wellfleet, 1969*

Date	Tide	Air Temp °F	Water Temp °F	Salinity 0/00	Water ppb	Oysters ppb	Mud ppb
6/5	H +4	62.0	64.0	30.0	Dieldrin-Trace DDT 0.48	Dieldrin 2 DDT 3	Dieldrin 30 DDT 200
6/18	H +5½	62.0	64.5	29.0	Dieldrin 0.04 DDT 0.71	0	0
7/1	H +5½	69.5	71.1	24.5	Dieldrin 0.001 DDT 0.39	Dieldrin 19 DDT-Trace	Dieldrin 31 DDT 260
7/16	H +5½	72.0	73.0	28.0	Dieldrin 0.001 DDT 0.01	0	0
7/31	H +4½	72.0	70.0	23.5	Dieldrin 0.01 DDT 0.03	Dieldrin 10 DDT 14	Dieldrin 61 DDT 320
8/14	L +3	72.0	76.0	23.0	Dieldrin 0.008 DDT 0.21	No Sample Taken	No Sample Taken
8/28	L	68.5	69.5	25.0	Dieldrin 0.009 DDT 0.11	0	0
9/17	H +5½	75.8	73.6	24.5	Dieldrin 0.073 DDT 0.31	No Sample Taken	No Sample Taken
9/23	H +5	72.0	70.0	24.0	Dieldrin-Trace DDT 0.08	No Sample Taken	No Sample Taken

Table 8. *Chlorinated Hydrocarbon Pesticides Detected in Water, Oyster and Mud Samples Collected from Blackfish Creek, Wellfleet, 1969*

Date	Tide	Air Temp °F	Water Temp °F	Salinity 0/00	Water ppb	Oysters ppb	Mud ppb
6/5	H +5½	67.0	63.0	15.0	Dieldrin 0.02 DDT 0.74	Dieldrin 8 DDT 6	Dieldrin 38 DDT 210
6/18	H +5	64.0	65.8	14.5	Dieldrin 0.05 DDT 0.80	0	0
7/1	L	74.0	72.0	25.0	Dieldrin 0.001 DDT 0.46	Dieldrin 16 DDT-Trace	Dieldrin 30 DDT 240
7/16	H +5	72.0	71.0	26.5	Dieldrin 0.009 DDT 0.41	0	0
7/31	H +5½	71.0	70.2	27.0	Dieldrin 0.015 DDT 0.04	Dieldrin 24 DDT 10	Dieldrin 60 DDT 170
8/14	L +2½	72.0	75.0	28.0	Dieldrin 0.014 DDT 0.15	No Sample Taken	No Sample Taken
8/28	H +5½	71.0	67.0	28.0	Dieldrin 0.008 DDT 0.06	0	0
9/17	H +5	71.5	71.0	29.0	Dieldrin 0.021 DDT 0.29	No Sample Taken	No Sample Taken
9/23	H +5	65.0	70.0	28.0	Dieldrin-Trace DDT 0.07	No Sample Taken	No Sample Taken

The highest reading from a water sample was 0.83 ppb DDT at Herring River on June 18. The 30 ppb dieldrin reading on July 31 at Herring River was the highest level of pesticide found in oysters. The highest mud sample reading was 320 ppb DDT in Duck Creek on July 31. It is unknown whether these values are high enough to have sublethal effects.

FINFISH

History

During the years preceding the Revolutionary War, Wellfleet devoted almost her entire energy to whaling. A total of 420 men and approximately 30 vessels were whaling out of Wellfleet up to the beginning of the war. As a result of war in 1775, British ships blockaded Cape ports and the town was near ruin. With the conclusion of the war, Wellfleet attempted to launch her fleet again, but none of the citizens could finance the building of new vessels. The old fleet had perished during the seven years of disuse (Enoch, 1884).

In 1802, the town's whaling fleet was reduced to five schooners, and these men were as much fishermen as whalers. At this time, Wellfleet also had four vessles engaged in offshore cod and mackerel fishing, four oyster carriers with a 30 ton capacity each, and a dozen smaller craft engaged in handlining at Billingsgate (Kittredge, 1930). Bigelow and Schroeder (1953) reported that in 1839, a considerable hook and line fishery existed for tautog in Wellfleet. By 1889, the town had a fleet of 13 'seiners' and 8 'handliners' (Kittredge, 1930).

Wellfleet specialized in mackerel fishing and barreled more of these fish annually than Provincetown. In 1833, Wellfleet's catch was 12,811 barrels of mackerel; in 1845 — 19,900 barrels; and in 1848 — 28,219 barrels (McFarland, 1911). In 1851, the mackerel catch from Wellfleet was second only to Gloucester in national importance. Herring River, Blackfish Creek, and Duck Creek Harbor, were taxed to accomodate the fleet of mackerel schooners and cod fishing boats.

As the Civil War ended, a fleet of 100 vessels set out for Billingsgate in search of mackerel. 'Chaulkers' and 'Riggers' were busy at work year round; salt makers had a ready market for their products. The most important establishments on dockside were the 'outfitters'. They outfitted the ships and owned shares in many of the vessels (Kittredge, 1930).

In 1885, a school of 1,500 blackfish entered Wellfleet Harbor. Hundreds of townsmen in boats drove them into Blackfish Creek where they beached themselves. They were immediately killed and sold. The profit from this venture was $14,000.00 (Deyo, 1890).

In the 1880's a fleet still sailed to the Grand Banks, Labrador, and the Bay of Chaleurs. "One of these ships, the T.Y. Baker, built in Wellfleet about the time of the Civil War, is described by one of her crew as being 'so blunt at the nose she would butt a sea about twice and then fall back and go around it'" (Kittredge, 1930). She was not alone in her class. A small fleet of similar ships was launched at Duck Creek.

Deep-sea fishing on the Cape was eventually abandoned for economic reasons. All the villages except Provincetown were reducing their fleets as the demand came for larger vessels and better harbors (Deyo, 1890).

Station Description

Nine finfish stations (Fig. 4) were sampled monthly from September, 1968 to August, 1969. Stations F1-F3 were intertidal locations sampled by 60' beach seine; stations F4-F9 were in deeper water and sampled by otter trawl. (Tables 9 to 17) The substrate at Town Pier (F1) was coarse sand except at low tide where sampling extended into the soft bottom at the edge of the channel. The sand at the mouth of Herring River (F2) was kept smooth and clean by swift tidal and river currents. The station established inside Loagy Bay (F3) was adjacent to an intertidal salt marsh. The bottom was soft mud covered with detritus. At the mouth of Loagy Bay (F4) the water depth was 11 ft. at MHW. Substrate consisted of coarse sand and was devoid of attached plant life. The mouth of Blackfish Creek (F5) was 14 ft in depth (MHW) and the bottom was composed of coarse sand and rubble covered with algae. Depths in the channel at Jeremy Point (F6) ranged from 17-30 ft (MHW). The bottom was hard, shell covered and relatively free of attached vegetation. At Smalley Bar (F7) the substrate was coarse sand and depth averaged 14 ft (MHW). Trawling near Great Island (F8) was conducted on smooth sand in 12 ft of water (MHW). The substrate in the Harbor Channel (F9) inside the Indian Neck Breakwater was a mixture of sand and soft black mud. Water depth averaged 19 ft (MHW).

Table 9. *Numerical Rank of Finfish Species Taken in Wellfleet Harbor During Monthly Sampling* at the Town Pier (F1), 1968-1969*

	Sept	Oct	Nov	Jan	Feb	Mar	Apr	May	June	July	Aug	Total
Atlantic silverside	238	184	23				5	28	62	90	314	944
mummichog	239	167	6					10	70	44	220	756
striped killifish	160	261	62				3	39		15	7	547
northern kingfish										1	8	9
winter flounder	1							4	3			8
windowpane								2	2			4
bluefish											3	3
alewife								1				1
Atlantic menhaden		1										1

*December samples not taken due to ice.

Table 10. *Numerical Rank of Finfish Species Taken in Wellfleet Harbor During Monthly Sampling* at Herring River (F2), 1968-1969*

	Sept	Oct	Nov	Jan	Feb	Mar	Apr	May	June	July	Aug	Total
Atlantic silverside	14	1950+	138				256	4	9	292	2500+	5163+
striped killifish	165	29	3						54	0	600+	851+
alewife	1										500+	501+
mummichog	262	27	7				9		55	134		494
Atlantic menhaden	24	2								82		108
tidewater silverside			42									42
winter flounder	36								1	2	1	40
northern kingfish	2									16	2	20
tautog	8											8
fourspine stickleback			3									3
blueback herring	2											2
northern pipefish	1											1
threespine stickleback						1						1

*December samples not taken due to ice.

Table 11. *Numerical Rank of Finfish Species Taken in Wellfleet Harbor During Monthly Sampling* Inside Loagy Bay (F3), 1968-1969*

	Sept	Oct	Nov	Jan	Feb	Mar	Apr	May	June	July	Aug	Total
Atlantic silverside	191	15	290		4		505	6	1	7	2000+	3019+
mummichog	1	1165			1			7	257	292	16	1739
striped killifish		209	2		4			11	15	44	82	367
Atlantic menhaden	34										115	149
threespine stickleback							7					7
alewife											4	4
Atlantic tomcod					1							1

*December samples not taken due to ice.

Table 12. *Numerical Rank of Finfish Species Taken in Wellfleet Harbor During Monthly Sampling* at the Mouth of Loagy Bay (F4), 1968-1969*

	Sept	Oct	Nov	Jan	Feb	Mar	Apr	May	June	July	Aug	Total
winter flounder	29	71				1	13	2	3	5	7	131
Atlantic menhaden										12	1	13
Atlantic silverside	3	3							1	5		12
northern kingfish	1									1		2
northern pipefish									2			2
alewife	1											1
goosefish		1										1
windowpane							1					1

*December samples not taken due to ice.

Table 13. *Numerical Rank of Finfish Species Taken in Wellfleet Harbor During Monthly Sampling* at the Mouth of Blackfish Creek (F5), 1968-1969*

	Sept	Oct	Nov	Jan	Feb	Mar	Apr	May	June	July	Aug	Total
Atlantic silverside		1	10							117	1	129
winter flounder	5	8				1	6			6		26
Atlantic menhaden										6		6
tautog		1								4		5
northern kingfish	3									1		4
alewife	3											3
windowpane	1						1					2
cunner											1	1
northern pipefish										1		1
smooth dogfish											1	1

*December samples not taken due to ice.

Table 14. *Numerical Rank of Finfish Species Taken in Wellfleet Harbor During Monthly Sampling* at Jeremy Point (F6), 1968-1969*

	Sept	Oct	Nov	Jan	Feb	Mar	Apr	May	June	July	Aug	Total
northern pipefish	8										1	9
cunner										1	1	2
Atlantic silverside										1		1
little skate								1				1
Atlantic menhaden											1	1
northern puffer	1											1
winter flounder								1				1

*December samples not taken due to ice.

Table 15. *Numerical Rank of Finfish Species Taken in Wellfleet Harbor During Monthly Sampling* at Smalley Bar (F7), 1968-1969*

	Sept	Oct	Nov	Jan	Feb	Mar	Apr	May	June	July	Aug	Total
winter flounder		17				3	16	5	1			42
tautog								4				4
little skate		2										2
windowpane		1						1				2
northern pipefish										1		1
northern searobin		1										1

*No samples taken during September and December.

Table 16. *Numerical Rank of Finfish Species Taken in Wellfleet Harbor During Monthly Sampling* Off Great Island (F8), 1968-1969*

	Sept	Oct	Nov	Jan	Feb	Mar	Apr	May	June	July	Aug	Total
Atlantic silverside			1							500+		501+
winter flounder	31	109					24	3				167
windowpane		5					3	1	1			10
northern pipefish							1	1	6		1	9
tautog	2	2							1	1		6
smooth dogfish	2											2
Atlantic menhaden										1		1
striped searobin	1											1

*December samples not taken due to ice.

Table 17. *Numerical Rank of Finfish Species Taken in Wellfleet Harbor During Monthly Sampling* in the Harbor Channel (F9), 1968-1969*

	Sept	Oct	Nov	Jan	Feb	Mar	Apr	May	June	July	Aug	Total
winter flounder	17	9	14			118	3				7	168
Atlantic silverside			60			2				100+		162+
northern pipefish	1						2	4			3	10
cunner	3	2										5
windowpane		1	2				2					5
grubby			2									2
little skate							1	1				2
tautog	1	1										2
lumpfish						1						1
striped searobin	1											1

*December samples not taken due to ice.

Findings and Discussion

Thirty five species of finfish were recorded in Wellfleet Harbor. The largest number (15) was taken in September. No finfish were taken in January (Fig. 8). Atlantic silverside (scientific names of all finfish species are given in Table 18) was the most abundant species captured by both beach seine (55.5%) and other trawl (52.6%) (Table 19). Of the 16 species taken at beach seine stations, Atlantic silversides, mummichogs and striped killifish accounted for 94.-5% of all individuals captured (Table 20). Atlantic silversides and winter flounder accounted for 88.2% of all fish (18 species) taken by otter trawl. Striped bass, Atlantic mackerel and bluefish were more common than indicated. These strong pelagic swimmers are capable of avoiding the sampling gear employed.

Because Division sampling in estuaries throughout the Commonwealth varied with respect to fresh water and oceanic environments, species lists from each estuary were compiled and compared using species in catagories 2-5 according to McHugh's (1967) classification (Table 21). Wellfleet Harbor ranked fifth in number of estuarine associated species (24) among the 11 areas studied to date (Table 22).

Table 18. *Scientific and Common Names of Fish Taken or Observed from Wellfleet Harbor, 1968-1969 (A.F.S., 1970)*

Family	Scientific Name	CommonName
Carcharhinidae:	*Mustelus canis* (Mitchill)	smooth dogfish
Rajidae:	*Raja erinacea* Mitchill	little skate
	Raja ocellata Mitchill	winter skate
Anguillidae:	*Anguilla rostrata* (Lesueur)	American eel
Clupeidae:	*Alosa aestivalis* (Mitchill)	blueback herring
	Alosa pseudoharengus (Wilson)	alewife
	Brevoortia tyrannus (Latrobe)	Atlantic menhaden
	Clupea h. harengus Linnaeus	Atlantic herring
Lophidae:	*Lophius americanus* Valenciennes	goosefish
Gadidae:	*Gadus morhua* Linnaeus	Atlantic cod
	Microgadus tomcod (Walbaum)	Atlantic tomcod
Cyprinodontidae:	*Fundulus heteroclitus* (Linnaeus)	mummichog
	Fundulus majalis (Walbaum)	striped killifish
Atherinidae:	*Menidia beryllina* (Cope)	tidewater silverside
	Menidia menidia (Linnaeus)	Atlantic silverside
Gasterosteidae:	*Apeltes quadracus* (Mitchill)	fourspine stickleback
	Gasterosteus aculeatus Linnaeus	threespine stickleback
Syngnathidae:	*Syngnathus fuscus* Storer	northern pipefish
Percichthyidae:	*Morone americana* (Gmelin)	white perch
	Morone saxitilis (Walbaum)	striped bass
Pomatomidae:	*Pomatomus saltatrix* (Linnaeus)	bluefish
Carangidae:	*Decapterus macarellus* (Cuvier)	mackerel scad
Sparidae:	*Stenotomus chrysops* (Linnaeus)	scup
Sciaenidae:	*Menticirrhus saxatilus* (Bloch & Schneider)	northern kingfish
Labridae:	*Tautogolabrus adspersus* (Walbaum)	cunner
	Tautoga onitis (Linnaeus)	tautog
Scombridae:	*Scomber scombrus* Linnaeus	Atlantic mackerel
Triglidae:	*Prionotus carolinus* (Linnaeus)	northern searobin
	Prionotus evolans (Linnaeus)	striped searobin
Cottidae:	*Myoxocephalus aenaeus* (Mitchill)	grubby
Cyclopteridae:	*Cycolpterus lumpus* Linnaeus	lumpfish
Bothidae:	*Scophthalmus aquosus* (Mitchill)	windowpane
Pleuronectidae:	*Pseudopleuronectes americanus* (Walbaum)	winter flounder
Tetraodontidae:	*Sphoeroides maculatus* (Bloch & Schneider)	northern puffer
Molidae:	*Mola mola* (Linnaeus)	ocean sunfish

Table 19. *Percent Species Composition of Fish Collected by Beach Seine and Otter Trawl at Nine Locations* in Wellfleet Harbor September, 1968 – August, 1969*

	Sampling Location (Fig. 4)								
	Beach Seine			Otter Trawl					
	F1	F2	F3	F4	F5	F6	F7	F8	F9
	Percent of Total Catch								
Atlantic silverside	41.5	71.4	57.1	7.4	72.5	6.3		71.9	45.3
winter flounder				80.4	14.6	6.3	80.8	24.0	46.9
mummichog	33.3	6.8	32.9						
northern pipefish				1.2		56.3		1.3	2.8
striped killifish	24.1	11.8	6.9						
Atlantic menhaden		1.5	2.8	8.0	3.4	6.3			
cunner						12.5			1.4
tautog					2.8		7.7	0.9	0.6
little skate						6.3	3.8		0.6
alewife		6.9			1.7				
northern puffer						6.3	1.9		
windowpane					1.1		3.8	1.4	1.4
northern kingfish				1.2	2.2				
northern searobin							1.9		
grubby									0.6
miscellaneous	1.1	1.6	0.2	1.8	1.7			0.6	0.6
Number of Fish	2273	7234	5286	163	178	16	52	697	358

*Including supplemental sampling at these stations

Table 20. *Species Composition of Fish Collected by Beach Seine (60') and Otter Trawl at Nine Sampling Stations* in Wellfleet Harbor from September, 1968 to August, 1969*

Seine 36 hauls, 16,838 fish		Trawl 70 tows, 1,530 fish	
Species	Percent of Total Catch	Species	Percent of Total Catch
Atlantic silverside	55.5	Atlantic silverside	52.6
mummichog	24.2	winter flounder	35.6
striped killifish	14.8	Atlantic menhaden	2.4
alewife	3.0	northern pipefish	2.2
Atlantic menhaden	1.5	Atlantic herring	2.0
winter flounder	0.3	tautog	1.8
northern kingfish	0.2	windowpane	1.3
tidewater silverside	0.2	cunner	0.6
miscellaneous:	0.2	northern kingfish	0.4
blueback herring		alewife	0.3
bluefish		little skate	0.3
fourspine stickleback		smooth dogfish	0.2
tautog		goosefish	0.1
threespine stickleback		grubby	0.1
tomcod		lumpfish	0.1
northern pipefish		northern puffer	0.1
windowpane		northern searobin	0.1
		striped searobin	0.1

*Including supplemental sampling at these stations

Table 21. *Categories (McHugh, 1967) of Fish Species Taken From Eleven Massachusetts Estuaries*

1. Freshwater fishes that occasionally enter brackish waters:

banded killifish	carp	redfin pickerel
black crappie	chain pickerel	spottail shiner
bluegill	golden shiner	white sucker
brook trout	johnny darter	yellow perch
brown bullhead	largemouth bass	
brown trout	pumpkinseed	

2. Truly estuarine species which spend their entire lives in the estuary:

*Atlantic silverside	ninespine stickleback	*striped killifish
blackspotted stickleback	northern pipefish	*threespine stickleback
*fourspine stickleback	oyster toadfish	*tidewater silverside
hogchoker	rainwater killifish	
*mummichog	sheepshead minnow	

3. Anadronmous and catadromous fish species:

*alewife	Atlantic sturgeon	sea lamprey
*American eel	*blueback herring	*striped bass
American shad	rainbow smelt	*white perch

4. Marine species which pay regular seasonal visits to the estuary usually as adults:

American sand lance	*northern kingfish	striped mullet
Atlantic needlefish	*northern puffer	*striped searobin
flying gurnard	*northern searobin	summer flounder
*grubby	orange filefish	*windowpane
inshore lizardfish	*scup	
longhorn sculpin	striped anchovy	

5. Marine species which use the estuary primarily as a nursery ground usually spawning and spending much of their adult life at sea, but often returning.

*Atlantic menhaden	red hake	white hake
*Atlantic tomcod	smooth flounder	*winter flounder
*cunner	*tautog	

6. Adventitious visitors, which appear irregularly and have no apparent estuarine requirements:

American plaice	*goosefish	sea snail
*Atlantic cod	haddock	shorthorn sculpin
*Atlantic herring	*little skate	silver hake
*Atlantic mackerel	*lumpfish	*smooth dogfish
Atlantic wolffish	*mackerel scad	spiny dogfish
barndoor skate	ocean pout	spiny lumpsucker
black seabass	*ocean sunfish	*winter skate
*bluefish	pollock	witch flounder
conger eel	radiated shanny	yellowtail flounder
crevalle jack	rock gunnel	
fourspot flounder	sea raven	

*Species taken in Wellfleet Harbor

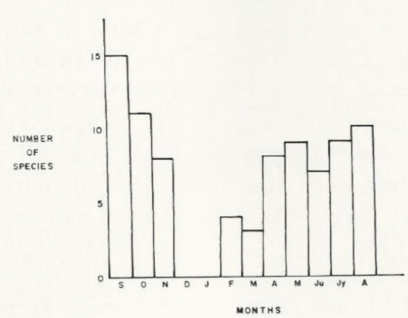


FIGURE 8.

Total Number of Finfish Species Collected at Stations 1 — 9 in Wellfleet Harbor. September 1968 — August, 1969.

Table 22. *Numbers of Estuarine Fishes Sampled in Coastal Study Areas of Massachusetts*

	Species Captured in Groups 2-5 (McHugh, 1967)	Total Number of Species Captured
Waquoit Bay	35	46
Westport River	34	39
Pleasant Bay	30	34
Merrimack River	26	50
Wellfleet Harbor	24	45
North River	23	32
Gloucester Harbor	20	33
Beverly-Salem Harbor	19	31
Parker River	19	27
Dorchester Bay	18	26
Quincy Bay	18	27

Of the 93 species from the 11 study areas, two (mackerel scad and smooth dogfish) were taken exclusively in Wellfleet Harbor. Both species generally range northward only to the southern shore of Cape Cod and are found only as strays in Cape Cod Bay (Bigelow and Schroeder, 1953). Four other species taken in Wellfleet: northern kingfish, northern puffer, northern searobin and scup also have northern limits generally restricted to the south side of Cape Cod.

An ocean sunfish, a rare visitor to the estuary, was observed swimming on the surface near Lieutenant Island in July.

Table 23. *Surface Water Temperature and Salinity Ranges of Juvenile Fish, Sampled in Wellfleet Harbor, 1968-1969.*

Species	Number	Size (mm)	Temp.(F)	Salinity (0/00)
Atlantic menhaden	64073	32-78	59-78	25-33
winter flounder	936	23-200	39-82	27-32
alewife	513	29-97	59-78	29-33
northern kingfish	89	30-157	58-77	28-32
windowpane	78	24-183	39-82	28-32
tautog	40	22-163	58-78	28-32
Atlantic herring	33	68-82	70-73	29-30
cunner	20	23-172	63-76	29-33
American eel	11	58-183	68-72	8-30
Atlantic mackerel	9	67-106	70-72	29-30
bluefish	4	77-99	72-75	29-30
blueback herring	2	73-74	70	29
grubby	2	62-89	39	28
scup	2	110-113	63	30
Atlantic tomcod	1	149	33	29
mackerel scad	1	51	82	29
northern puffer	1	78	62	30
northern searobin	1	64	61	30
striped searobin	1	51	63	30

Juveniles of many sport and commercial finfish utilize Wellfleet Harbor as a nursery area (Table 23). Juvenile Atlantic menhaden were caught throughout the harbor. In early July over 50,000 juvenile menhaden were taken in one beach seine haul in supplemental sampling at Duck Creek. This species supports the largest commercial fishery in the United States and is also an important forage species (Reintjes and Pacheco, 1966). Adult menhaden spawn over the Continental Shelf and, after hatching, the juveniles move into the estuaries where they spend most of their first year of life.

Juvenile winter flounder (under 200 mm) were encountered in all seasons. A total of 103 was taken in one trawl off Great Island in October (average size 114 mm) and 116 were taken in the Harbor Channel in March (average size 88 mm). The greatest catch at a beach seine station occurred at the Town Pier in July. This sample was taken on a low tide and extended further into the soft mud at the channel edge than any other sample at this site. A total of 146 juvenile flounder, with an average size of 48 mm, were taken. The high percentage (94%) of juvenile winter flounder caught in the Harbor compared to the number of adults captured suggests that this area is primarily used as a nursery.

Juvenile northern kingfish were captured in July, August and September with 53 of the 89 individuals occurring at the Town Pier. Young windowpane were captured at all stations except the beach seine stations at Herring River and Loagy Bay. Juvenile tautog were encountered at all stations except in Loagy Bay. One small bluefish was taken by beach seine in the Duck Creek area. Schools of snapper blues were observed in the harbor during August. Young mackerel were collected in July at Duck Creek during supplemental sampling. Juvenile alewives and blueback herring were taken in Herring River in August and September. One alewife (90 mm) was taken at the Town Pier in May. (Tables 9 to 17)

A number of invertebrate species were taken in the finfish sampling gear. These species, representing only a partial list of invertebrates inhabiting the estuary, were: the rock crab, *Cancer irroratus;* green crab, *Carcinus maenas;* sand shrimp, *Crangon septimspinosus;* grass shrimp, *Hippolyte zostericola;* common spider crab, *Libinia emarginata;* mud crab, *Neopanopeus texana sayi;* broad claw hermit crab, *Pagurus longicarpus;* hermit crab, *Pagurus pollicaris;* common prawns, *Palaemonetes spp.;* fiddler crab, *Uca spp.;* calico crab, *Ovalipes ocellatus;* horseshoe crab, *Limulus polyphemus;* bay scallop, *Aequipecten irradians,* jingle shell, *Anomia simples;* eastern oyster, *Crassostrea virginica,* soft-shell clam, *Mya arenaria;* channeled whelk, *Busycon canaliculatum,* thick-lipped oyster drill, *Eupleura caudata;* amethyst gem clam, *Gemma gemma;* mud snail, *Nassarius obsoletus;* shark eye, *Polinices duplicatus;* common squid, *Loligo pealei;* moon jelly, *Aurelia aurita;* bryozoan, *Bugula, spp.;* sea gooseberry, *Pleurobrachia pileus;* green sea urchin, *Strongylocentrotus drobachiensis;* red beard sponge, *Microciona prolifera;* plumed worm, *Diopatra cuprea.*

Sport Fishery

An active sport fishery occurs in Wellfleet Harbor and nearby at Billingsgate Shoal from May to October. Winter flounder, tautog, striped bass, bluefish, Atlantic mackerel, northern kingfish and cunner are sought from shore sites at the Town Pier and Indian Neck breakwater. Lieutenant Island and Jeremy Point are fished for striped bass and occasionally bluefish. Striped bass and white perch are taken from the Herring River Dike.

A small boat fishery is carried on primarily outside of the Indian Neck breakwater. Lieutenant Island Bar, Smalley Bar, the mouth of Loagy Bay and off Indian Neck are fished for striped bass, bluefish, mackerel, winter flounder, tautog and in the spring for cod. An estimated 1700 boats were launched from the boat ramp at Wellfleet Town Pier between June 1 and November 1, 1968. Launching fee revenues totaled $1,700. Boats were also launched from ramps at Rock Harbor and Sesuit to fish Billingsgate Shoal and other offshore sites.

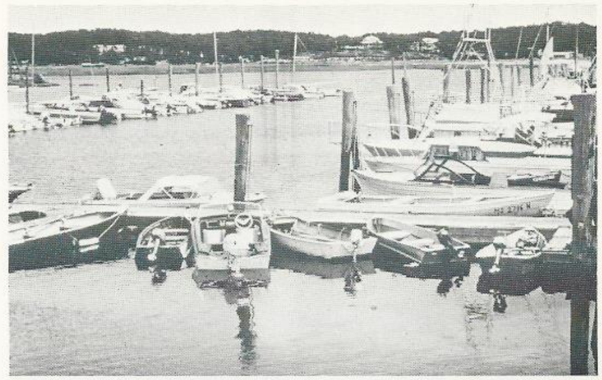


PLATE 1.
Recreational boats at the Wellfleet Town Pier.

No fees were charged at these ramps.

Billingsgate Shoal at the entrance to Wellfleet Harbor provides some of the finest sport fishing for striped bass, mackerel and bluefish in Cape Cod Bay. Striped bass, are taken from June to October on the Shoal and nearby at Stony Bar, Sunken Meadow and near the Target Ship. Single day catches of over 30 fish weighing from 20 to 40 pounds are not uncommon.

In the spring of 1969, mackerel, weighing from 1 to 3 lbs, appeared off Brewster and Eastham and worked their way along the shore to Billingsgate by June. Early in July, dense schools of tinker mackerel arrived in the Wellfleet area. Good catches of mackerel continued until late fall. Bluefish, although not plentiful, were caught from late July through September. Most of these fish weighed from 1 to 3 lbs, but fish from 5 to 10 lbs were occasionally taken.

One party boat operated from the Town Pier from June through September. This boat made approximately 156, four hour trips averaging six people per trip, and grossed $4,000. Eleven charter boats from Rock Harbor, Orleans, four from Sesuit Harbor, Dennis and three from Wellfleet fished Billingsgate Shoal and adjacent offshore waters from early June through October in 1969. Charters were for 4 to 8 hours at $60 and $100 per trip. Approximately 1700 trips, averaging 5 people per trip, grossed approximately $130,000.

Alewives

In the 1880's alewives were plentiful in Wellfleet and supported a profitable fishery on Herring River. Three headwater ponds provide 156 acres of spawning area. Originally the River's source was in Higgins Pond (33.5 acres) and Herring Pond (18.5 acres). In 1893 a sluiceway was cut between Higgins and Gull Ponds increasing the spawning area by 104 acres.

PLATE 2.
Recreational shellfishing on the Town grant in Wellfleet Harbor.

A Special Act of the General Court of 1865, Chapter 85, granted Wellfleet the right to lease the fishery within the town. Fishing rights, located at Bound Brook Island, were sold each year at public auction. The years 1888 to 1898 were very profitable for the town. In 1893, the fishery was sold for $1,053 compared to $25 in 1911 (Belding, 1921). Belding (1921) attributed the decline to over exploitation resulting from annual leases. In addition tidegates in the culvert beneath the Herring River Dike (built in 1909) seriously limited the number of adults reaching the spawning grounds.

Chapter 85 no longer applies to alewives since the Director of Marine Fisheries has exercised his power under Section 17A of Chapter 130 and eliminated Special Acts in 1971 which grant local authority for regulation of alewife fisheries. Regulation is now subject to State control.

SHELLFISH

History

When settlers first arrived at Wellfleet in 1664, oysters were abundant on the intertidal flats. By 1772, the population of Wellfleet had increased to a size, where it was necessary for the General Court to pass an act prohibiting the taking of oysters for Boston markets during the summer months and townspeople from harvesting oysters for home consumption during the spawning season of July and August (Belding, 1909).

After the Revolutionary War, the oyster industry declined rapidly. The decline was partially attributed to a lack of shells for spat collection. Shells had been used for lime extraction in the manufacture of fertilizer and plaster (Enoch, 1884).

With the depletion of natural beds in 1793, oysters were brought in from the south under grants obtained by area commercial firms (Field, 1909). By 1802, Wellfleet had 4 ships with a carrying capacity of 60,000 pounds of oysters per vessel. Wellfleet sent vessels to Buzzards Bay and Connecticut in 1825 to obtain oyster seed. By 1884, a total of 60,000 bu had been shipped to Wellfleet; and between 1850 and 1860, 100,000 to 150,000 bu of oysters were transplanted annually from Chesapeake Bay (Enoch, 1844). The Civil War ended the Chesapeake Bay shipments and Wellfleet lost its position as an oyster center. By 1880, business had declined to a value of a few hundred dollars. Oysters were used for experimental propagation and bedding. Adult stock was valued at $5,000.

From 1906 to 1907, 22,500 bu of marketable oysters valued at $24,800 and 1,000 bu of seed valued at $1,000 were harvested in Wellfleet by tonging from gasoline powered boats. In 1908, 68,000 bu of 3 year old oysters and 2,000 bu of seed were planted. In 1910, the 1,473 acres of oyster grants were valued at $19,500. By 1915, 8,000 barrels of oysters valued at $7.50/barrel were harvested. In 1916, the harvest doubled (Field, 1909). From 1916 to 1962, there is a gap in available information. In 1962, the Wellfleet oyster industry could no longer rely on other states for seed oysters.

Wellfleet once had more men in the quahog industry with quahog production larger than any other town in Massachusetts (Field, 1909). Early productivity of Wellfleet Harbor is indicated by the presence of numerous shellfish heaps left by Indians and early settlers (Enoch, 1844).

From 1863 to 1869, 2,500 bu of quahogs were harvested per year. From 1870 to 1876, this figure declined to 1800 bu. In 1879, 1,800 bu were again harvested with a value of $990 (Field, 1909).

Quahog flats of Wellfleet comprised about 2500 acres in 1906. The best quahoging was found in the channel from Lieutenant's Island and Great Beach Hill south to Billingsgate Island. Quahogs were also abundant south of Great Island, north of Billingsgate on the west side of the harbor, on Lieutenant's Bar, and at the mouth of Blackfish Creek. The annual production that year was 33,000 bu valued at $41,250. There were 140 men engaged in the fishery in 1906 and 145 permits were granted in 1907, when the fishery was declining (Belding, 1909).

There is no further record of the quahog fishery until 1957 when the Wellfleet Town Report stated that 6,000 bu of quahogs were taken. The harvest remained about the same until 1960 when 10,000 bu were harvested. The reported crop has remained essentially stable since 1960.

The soft-shell clam has always been harvested on a limited scale in Wellfleet. Clams were obtained from the flats at Billingsgate Island, Blackfish Creek, Herring River and Duck Creek (Belding, 1912). In 1906, $1,000 was appropriated for restocking clams on 15 acres. The following year 8 men harvested 800 bu at $.95/bu (Belding, 1912). The 1947 Wellfleet Town Report indicates that 15 acres of flats produced 800 bu of clams at $4.05/bu. By 1957, only 200 bu were harvested. The years 1959 to 1962 saw an increase in the harvest to 1000 bu, but in 1963 the harvest declined to 500 bu valued at $6,200.

Bay scallops were scarce in the Wellfleet area in the early 1900's. Belding (1931) found a few scallops near Billingsgate Island, on the north side of the harbor and east of Jeremy Point. Town records are incomplete but show that scallops crops were poor in the 1940's. Apparently harvests improved during the 1950's with good harvests in 1951 and 1954. A decline occurred again in the mid-fifties and in 1957, for the first time in 16 years, there was no scallop harvest. The following year, 1958, an unusually good harvest of 12,500 bu was realized. Over the next four years the commercial take fluctuated between 3,000 and 4,000 bu. From 1962 to 1969 harvests have been very poor or non-existant with the exception of 1,216 bu in 1967.

Findings and Discussion

Wellfleet Harbor provides an abundant shellfish resource for both commercial and recreational fishermen. In 1969, Wellfleet issued 42 commercial shellfish licenses ($420), 1,344 resident licenses ($1,344) and 856 non-resident licenses ($1,712) providing a total revenue of $3,476 to the town. The estimated wholesale value of shellfish harvested was $319,140 (Table 24).

Table 24. *Wellfleet Shellfish Harvest – 1969*

	Bushels	Value
Commercial Fishery		
Quahogs	22,900	$274,800
Oysters	1,800	18,000
Soft-shell Clams	360	4,320
Family Fishery		
Quahogs	975	11,700
Oysters	600	6,000
Soft-shell Clams	360	4,320
Total Wholesale Value:		$319,140

Quahog

The quahog is the most economically important shellfish species in Wellfleet Harbor, although annual harvests have declined from the 30,000 bu yields of the early 1900's. The 1969 commercial harvest, estimated at 10,500 bu by the Town Shellfish Constable, was valued at $126,000.

Commercial fishing took place on approximately 3,000 acres encompassing most of the subtidal portion of the harbor from a line between Great Island and the Indian Neck breakwater to the Eastham-Wellfleet line south of Jeremy Point. (Fig. 9). This is the same general area utilized in the early 1900's (Belding, 1912). Greatest fishing pressure was in the 1000 acres along the channel. From 6 to 10 commercial quahog draggers fish the area through most of the year until the bottom hardens in the winter.

PLATE 3.
Oyster flats along Mayo Beach, Wellfleet.

In 1969, family fishermen, utilizing quahog rakes on intertidal flats, harvested 975 bu of quahogs valued at $11,800. Quahogs were found on the flats of Indian Neck, Duck Creek, Mayo Beach, Herring River and Great Island. A few square yard samples in all these areas had concentrations of 7 or 8 quahogs, however, the average concentration was less than $1/yd^2$. The exception was the town grant on Mayo Beach which is planted annually with 100 to 200 bu of quahogs obtained from local commercial fishermen and utilized by recreational fishermen on a put and take basis.

Environmental conditions in the Harbor were favorable for quahog growth and development. Ten foot tides move large volumes of water over quahog beds providing sufficient food, oxygen and waste removal. The salinity range of 20 0/00 to 34 0/00

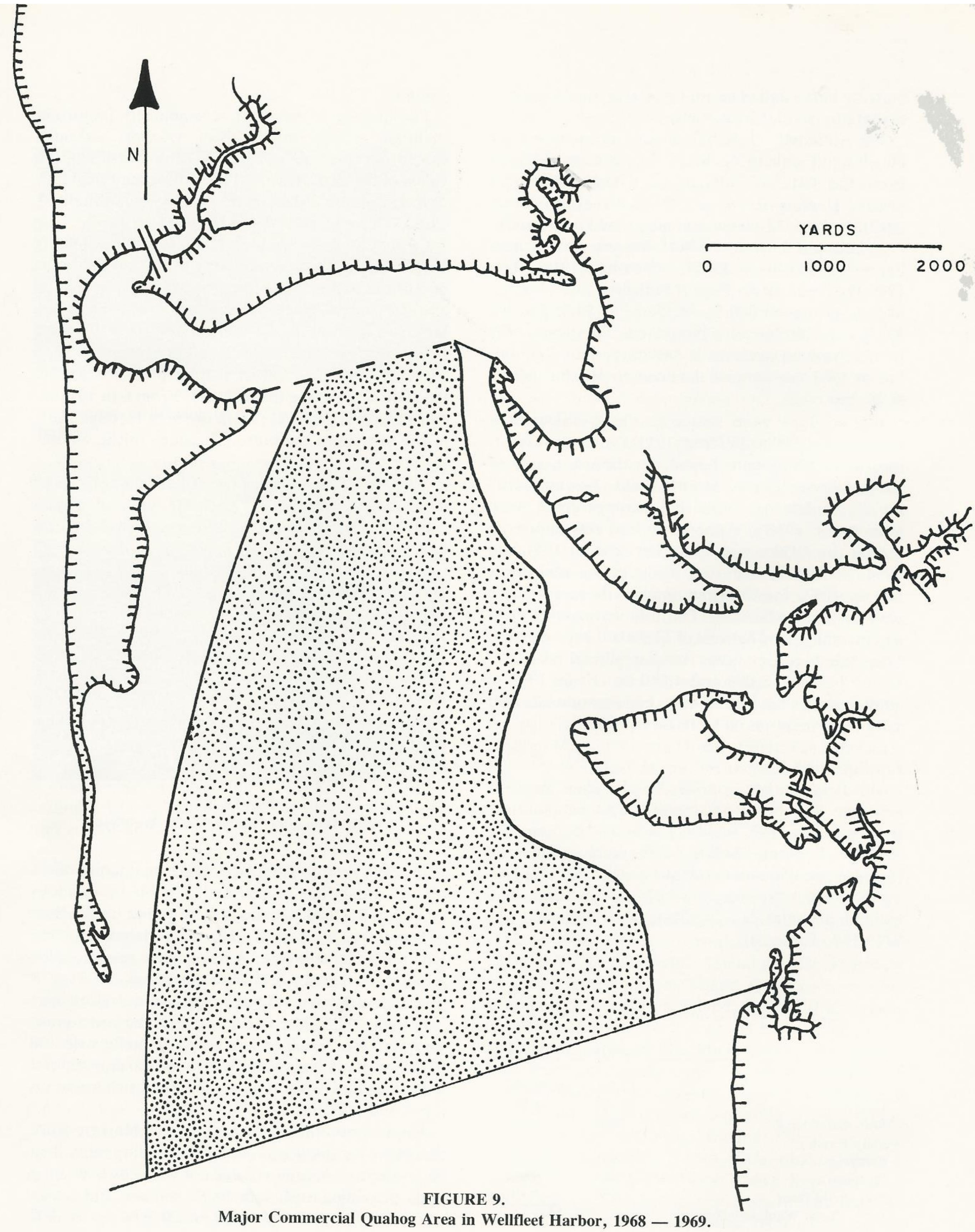


FIGURE 9.
Major Commercial Quahog Area in Wellfleet Harbor, 1968 — 1969.

recorded in the major quahog areas of the harbor was similar to the 20 0/00 to 33 0/00 range found by Davis (1953) to be suitable for quahog development. Water temperatures exceeding 49°F were observed from April through October indicating a seven month growing season (Belding, 1912). Sea water temperatures in the low 70's during the summer months were sufficiently warm for successful spawning. Wellfleet Harbor is on the perimeter of the quahog's range, and is the most northern area to support a continuously active commercial fishery.

PLATE 4.
Commercial quahog dragger at Wellfleet Town Pier.

Oysters

The 1969 standing crop of oysters in Wellfleet Harbor was estimated at 12,600 bu of legals and 14,650 bu of sublegals. Oysters were found on the flats from south of Lieutenant Island around the harbor to south of Great Island (Fig. 10). Greatest concentrations were found in Herring River and on privately operated grants along Mayo Beach, Duck Creek and Blackfish Creek. Densities as large as 34 legals and 49 sublegals per square yard were found on an 8 acre section of a Mayo Beach grant. Several areas less than 0.5 acres were observed with up to two legals and 74 sublegals per yard square. Large areas around Lieutenant Island and Great Island had less than one per yard square (Table 25).

The 1969 commercial oyster harvest of 1,800 bu valued at $18,000 was taken almost exclusively from grants. The recreational harvest of 600 bu valued at $6,000 was taken from the town grant and non-grant areas throughout the harbor.

Oysters are not generally found north of Cape Cod because of cool water temperatures. In the Wellfleet area, however, the large area of intertidal flats provides suitable temperatures for oysters in the warmer months of the year. Galtsoff (1964) found

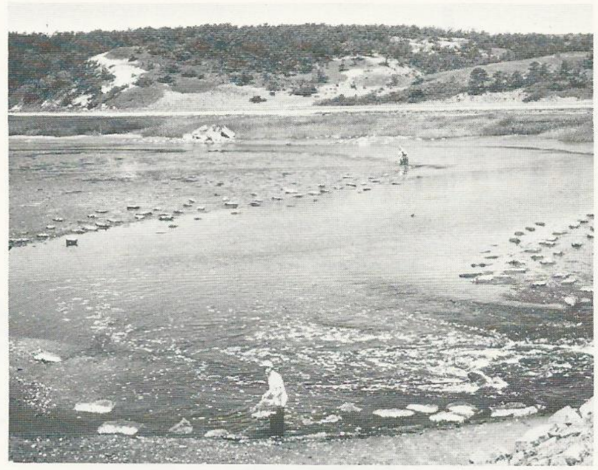


PLATE 5.
Placing experimental cultch bags below the Herring River Dike.

that oyster growth occurs at temperatures above 45F. Water temperatures remained above 45 F from April through October providing a 7 month growing season. Recent observations by Division personnel confirm Belding's (1909) findings that oysters spawn at water temperatures above 70 F, and spawning occurs from early July through August with peak activity in mid-July and early August. Thermograph recordings at the Town Pier in 1969 showed mean temperatures for July and August of 70 F or above (Fig. 6). In winter, the intertidal flats are a hostile environment. Oysters are subject to freezing temperatures and heavy ice that periodically cause large mortalities.

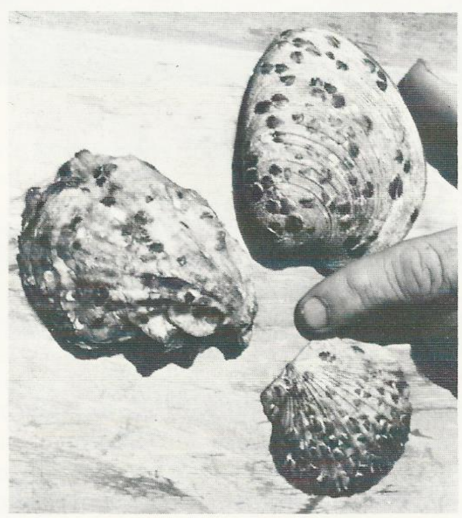


PLATE 6.
New oyster set on shells from Wellfleet Harbor.

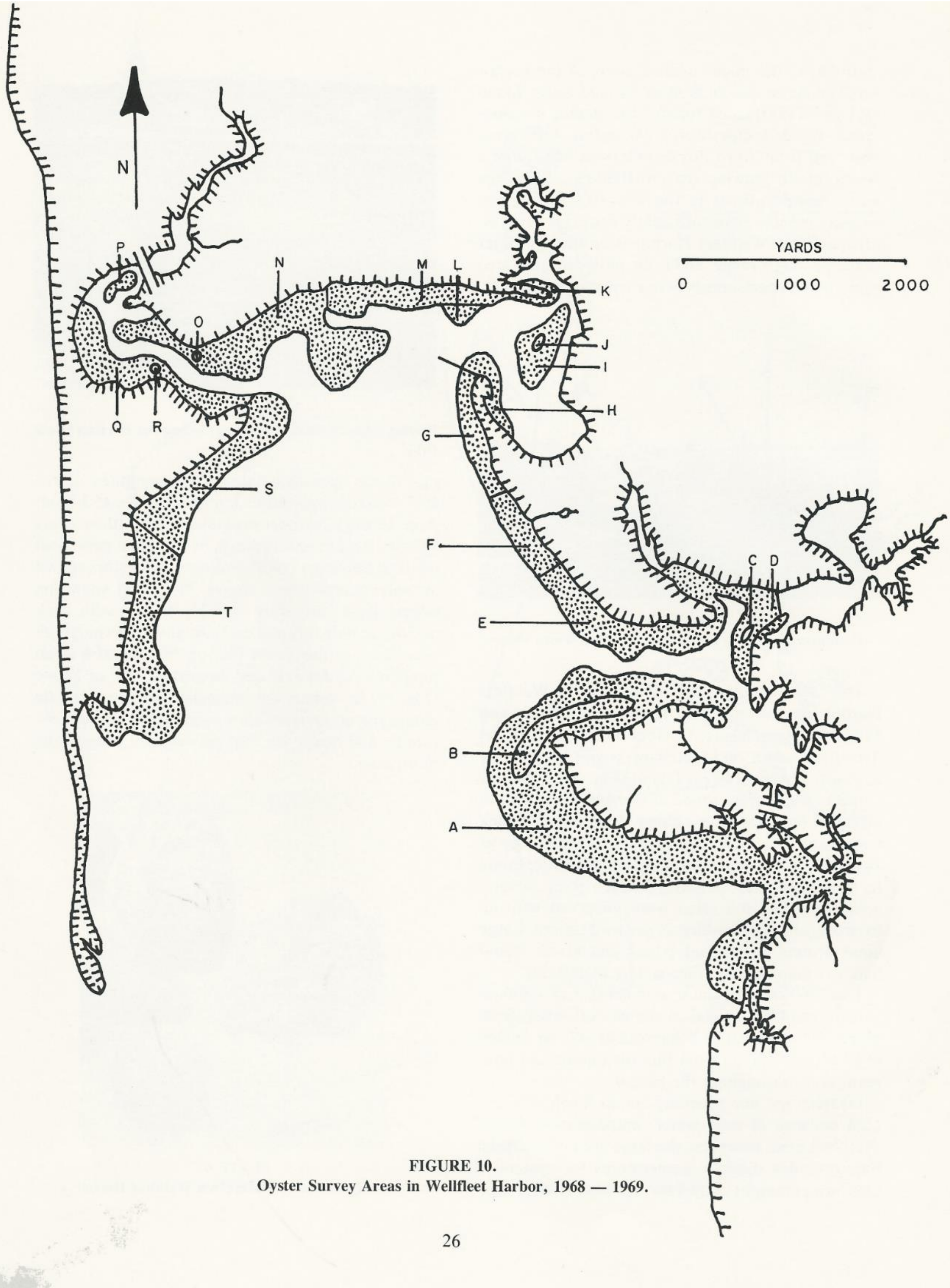


FIGURE 10.
Oyster Survey Areas in Wellfleet Harbor, 1968 — 1969.

Table 25. *Wellfleet Harbor Oyster Survey Data, 1969*

Location	Area (Fig. 10)	Acres*	No/yd² Legals	No/yd² Sub Legals	Bushels Legals	Bushels Sub Legals
Lieutenant Island	A	501	0.1	0.6	808	145
Lieutenant Island	B	27	0.0	1.7	0	222
Blackfish Creek	C	2	15.8	39.0	510	378
Blackfish Creek	D	133	0.0	0.0	0	0
Indian Neck	E	29	0.2	8.2	94	1151
Indian Neck	F	19	0.0	2.3	0	212
Indian Neck	G	27	0.0	1.0	0	131
Indian Neck	H	19	5.9	11.0	1809	1012
Duck Creek	I	34	0.3	6.8	165	1119
Duck Creek	J	0.5	2.4	57.3	19	139
Town Pier	K	1.4	6.0	16.0	136	108
Mayo Beach	L	8	34.0	49	4388	1897
Mayo Beach	M	38	0.7	3.0	429	552
Egg Island, Herring River	N	141	0.2	4.7	455	3207
Herring River	O	0.4	2.0	74.0	13	143
Herring River	P	7	7.8	38.5	881	1304
Herring River	Q	65	0.1	7.3	105	2297
Herring River	R	0.1	1.5	14.4	2	70
Great Island	S	84	0.1	0.5	136	203
Great Island	T	125	0.1	0.6	202	363
Total					10,152	14,653

*Areas less than 2 acres were measured to the nearest 10th of an acre.

Salinities in Wellfleet Harbor approximated the higher values of the 5 0/00 to 30 0/00 range favorable for oyster growth and survival reported by Galtsoff (1964). With the exception of Herring River, recorded salinities ranged from 27 0/00 to 34 0/00. Salinities as low as 15 0/00 were recorded at the mouth of Herring River. In our opinion the low salinity is the reason that Herring River is one of the best spawning and setting areas in the Harbor.

The major environmental factor limiting the Wellfleet oyster resource is the lack of clean, hard bottom suitable for setting oyster larva. This is the same problem that faced the Wellfleet oyster industry 60 years ago, when Dr. Belding (1909, 1912) made his investigations. The mud flats of Herring River and Duck Creek are examples of areas with under-utilized setting potential. Beldings studies and more recent investigations by Division personnel (Carr and Flagg, unpublished) have shown that these areas produce large sets when provided with suitable substrate or cultch. In a 1968 cooperative oyster propagation program, 274 cultch bags and 111 bushels of loose scallop shells were placed in these areas. An estimated 500,000 oyster larvae set on this cultch. Studies by Division personnel utilizing wooden stakes and oyster cultch rafts have shown the water column as well as the substrate can be utilized for setting to realize the full potential of these areas (Carr and Flagg, unpublished).

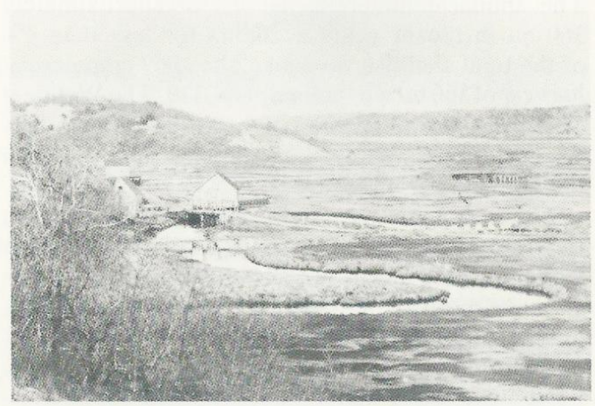


PLATE 7.
Herring River Fishery Station and saltmarsh in the early 1900's.

There is some local feeling that construction of the Herring River Dike in 1909 caused a decline in oyster production. An examination of Dr. Belding's findings (1909 and 1912, unpublished notes), however, indicates that todays problems are similar to those that existed prior to dike construction. The major effect of the dike on this species appears to be the removal of upper Herring River as oyster producing ground. Conditions below the dike do not appear to have been impaired by dike construction. The area has high potential if properly managed.

It is only through a well managed grant system and a sound town management program that the potential of the Wellfleet oyster will be realized. In 1971, Town records showed that 13 parties had interests in private oyster culture in Wellfleet. Only two had written contracts, one of which was technically forfeited because of non-payment. The status of the remaining 11 parties varied from town approval without contract, to no record of status.

The major problem in expanding the resource is the lack of an adequate town management program of securing and distributing cultch. The cooperative inter-town program through which Wellfleet obtained cultch in exchange for allowing other towns to propagate seed in the harbor no longer exists because of the possibility of spreading MSX disease. Cultch must be obtained from other sources.

Soft-shell Clams

In 1960 soft-shell clams were taken commercially from Wellfleet Harbor for the first time in 20 years. With the decline in bay scallops, soft-shell clams became the third most important shellfish species. The annual commercial harvest of approximately 360 bu in recent years accounts for less than 4% of the total shellfish revenue. The 1969 commercial harvest of 360 bu was valued at $4,320. The Wellfleet Shellfish Constable estimated the recreational harvest at approximately the same size and value as the commercial harvest.

The major area of commercial fishing was along the shore of Blackfish Creek just south of Drummers Cove. On the north side of the creek there was an average of 3.7/ft^2 (32% legal). The south shore averaged 3.5/ft^2 (40% legals). Largest concentrations on both sides of the creek were found in a narrow band close to the marsh edge. Limited commercial claming took place along the southeast shore of Lieutenant Island. Clam concentrations in these areas were less than 1/ft^2 with the exception of a small section along the marsh edge in the latter area, where concentrations of 3.9/ft^2 (28% legal) were encountered.

Most recreational claming was in the cove at the mouth of Duck Creek. This area was set aside for recreational digging and has been closed periodically to manage the resource. Densities were less than 1/ft^2 except for a narrow band along the marsh edge where there were 36/ft^2. Average size was 34 mm, and only 13% were legal. Clams were also available to the recreational fishery in the tidal creeks of Indian Neck, mud flats of Loagy Bay, flats south of Lieutenant Island and scattered sections of Mayo Beach. Concentrations in all of these locations averaged less than 1/ft^2.

Bay Scallops

Bay scallops are occasionally important to the Wellfleet shellfishery. Occurrence of the scallops is characteristically erratic even in areas that are naturally accomodating. In Wellfleet conditions are not ideal and scallop harvests have been sporadic over the past three decades.

There are several conditions in Wellfleet Harbor that are unfavorable to scallop growth and survival. Belding (1910) stated that tidal amplitude (10 ft) which exposes large areas of flats in winter, and tidal action which washes scallops onto the exposed flats are limiting factors.

Water temperatures were suitable (over 45 F) for scallop growth from April to October. Summer temperatures in the low 70's are suitable for growth, but not optimal growth that could be expected from a warmer environment. A salinity range from 10 0/00 to 27 0/00 is conducive to good scallop growth and survival (Belding, 1910). Of approximately 170 salinity samples, only 12 were within this range. All others were greater than 27 0/00.

With naturally limiting conditions and the problem of mechanical damage due to extensive quahog dragging, it is doubtful that Wellfleet Harbor will ever support a substantial bay scallop fishery. Scallops will probably continue to appear sporadically, with peak years occurring when several conditions are favorable for survival. There was no bay scallop harvest from Wellfleet Harbor in 1969.

MSX

In 1967, a high mortality was reported on one of the oyster grants in Wellfleet Harbor. Investigations revealed the presence of *Minchinia nelsoni* (MSX). However, this haplosporidian had not previously been reported as far north as Wellfleet. In its plasmodial stages, MSX is usually found associated with the connective tissue of the mantle, gills and body, as well as between the epithelial cells of the digestive diverticula of the oyster (Couch, Farley and Rosenfield, 1966). Farley (1965) documented that the initial infectious stage is found most commonly in July, August and early September when water temperature and salinity are high. The intermediate infectious stage, is characterized by localized lesions and recessive shell growth, and also occurs from July through September. In the advanced infectious stage the protozoan invades oyster tissue in massive numbers. This occurs during fall and winter months. Most of the preceding symptoms cannot be detected without microscopic aids and a knowledge of the life cycle of the organism. It is emphasized that while the protozoan is pathogenic to oysters, it is not harmful to humans.

Table 26. *Occurrence of Minchinia nelsoni (MSX) in Wellfleet Harbor, Massachusetts, 1969*

Location	Date	No. Examined	MSX
Flats Cove	4//21/67	25	8
Private Bed	6/19/69	25	8
Herring River	10//29/69	25	24
Herring River	10/29//69	25	0
Town Pier	10/29/69	25	20
Mayo Beach	10/29/69	25	8
Blackfish Creek	12/4/69	50	10

Oyster samples were taken from seven areas in Wellfleet Harbor as well as ten other Massachusetts towns, and shipped to the U.S. Bureau of Commercial Fisheries Biological Laboratory at Oxford, Maryland for histological examination. Only oysters from Wellfleet Harbor were found to be infected (Table 26).

Laboratory examination indicated that the pathogen was in natural oyster stocks in the harbor. However, no further abnormal oyster mortalities were observed, and harvesting of this shellfish has continued. There is no indication that the disease has spread. This may be a result of disease resistance in oyster stock, limiting temperatures to the species, or a combination of factors.

It is believed that the MSX was introduced into Wellfleet through an oyster transplant from an infected area south of New England. Detection of the disease prompted the Division of Marine Fisheries to prohibit any oyster transplants in the Commonwealth without State permission. Permits for oyster transplants are now only issued after certification by the National Marine Fisheries that the animals and source are disease free.

Marine Vegetation And Marsh Life

Estuaries and adjacent tide marshes are among the most naturally fertile areas of the world. Odum (1961) and Teal (1962) have shown that salt marsh is prodigious in its production of organic matter and essential nutrient salts. Production and utilization of organic matter are the result of complex interactions involving tides, nutrients, plants and animals of the estuarine ecosystem (Teal, 1962). Tide marshes and tidal creeks provide spawning, nursery and feeding areas for many important forage, sport and commercial finfish, and shellfish. In addition they provide nesting and feeding habitat for waterfowl and other wildlife.

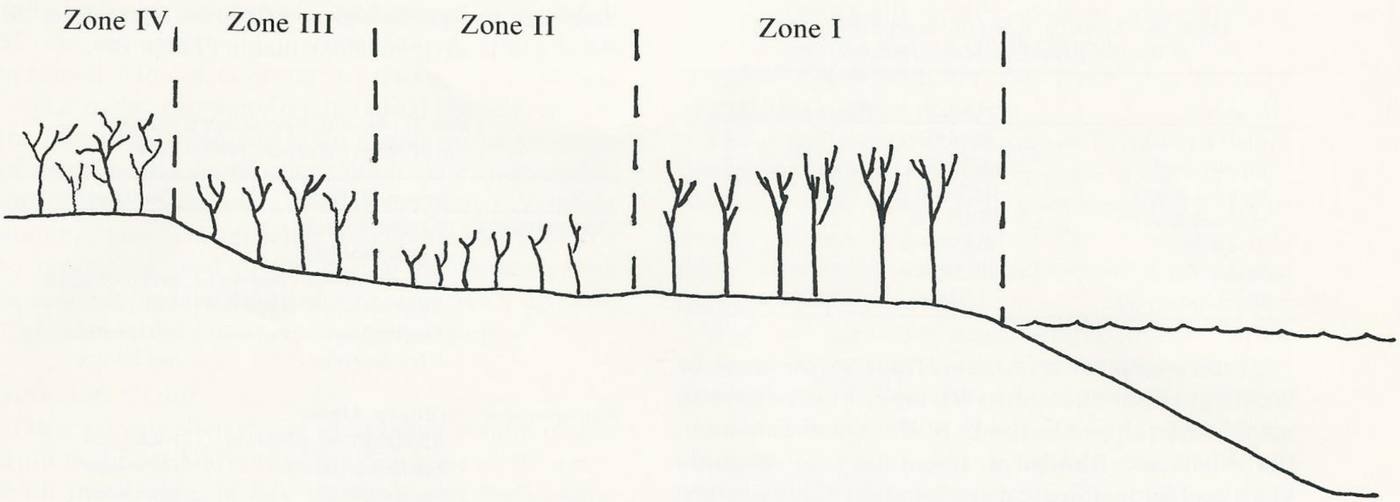
Findings

Twenty-eight species of plants were collected including five green algae, six brown algae, five red algae and twelve vascular plants (Table 27).

Table 27. *Marine Vegetation Collected in Wellfleet Harbor, 1968 – 1969*

Class	Scientific Name	Common Name
Chlorophyceae	(Green Algae)	
	Cladophora sp	
	Enteromorpha compressa	green confetti
	Enteromorpha intestinalis	link confetti
	Enteromorpha plumosa	silk confetti
	Ulva lactuca	sea lettuce
Phaeophyceae	(Brown Algae)	
	Ascophyllum nodosum	rockweed
	Fucus edentatus	rockweed
	Fucus spiralis	rockweed
	Fucus vesiculosus	rockweed
	Laminaria agardhii	kelp
	Sargassum filipendula	
Rhodophyceae	(Red Algae)	
	Agardhiella tenera	
	Ceramium rubriforme	
	Chondrus crispus	Irish moss
	Polysiphonia nigrescens	
	Porphyra umbilicalis	red jabot laver
Vascular Plants	*Ammophila breviligulata*	beach grass
	Atriplex patula	orack
	Distichlis spicata	spike grass
	Juncus gerardi	black grass
	Limonium carolinianum	marsh rosemary
	Salicornia europaea	annual glass wort
	Salicornia virginica	perennial glass wort
	Solidago sempervirens	sea side golden rod
	Spartina alterniflora	saltwater cord grass
	Spartina patens	salt meadow grass
	Suaeda maritima	sea blite
	Zostera marina	eelgrass

The salt marsh on the north side of Lieutenant Island bordering Loagy Bay was chosen for a survey of marsh flora. The dominant species was salt water cord grass *(Spartina alterniflora)* extending from the water's edge to approximately the middle of the marsh; the area submerged every high tide. Salt meadow grass *(Spartina patens)*, covered less frequently by the tides, formed a band of shorter, thickly matted grass above the cord grass. Spike grass *(Distichlis spicata)* was found growing just above the salt meadow grass.



Zone I		*Spartina alterniflora*
	Scattered	*Salicornia europaea*
		Limonium carolinianum
Zone II		*Spartina patens*
	Abundant	*Salicornia europaea*
		Limonium carolinianum
	Scattered	*Atriplex patula*
		Salicornia virginica
		Suaeda maritima
Zone III		*Distichlis spicata*
		Juncus gerardi
	Scattered	*Atriplex patula*
		Salicornia virginica
		Solidago sempervirens
		Suaeda maritima
Zone IV		Upland

FIGURE 11.
Plant Zonation in a Wellfleet Harbor Tidemarsh.

Black grass *(Juncus gerardi)* was the uppermost on the marsh, near the upland border and was seldom covered by the tide (Fig. 11). Beach grass *(Ammophila breviligulata)* was growing on the upland border. The plant species described are typical of salt marsh throughout the Wellfleet Harbor area.

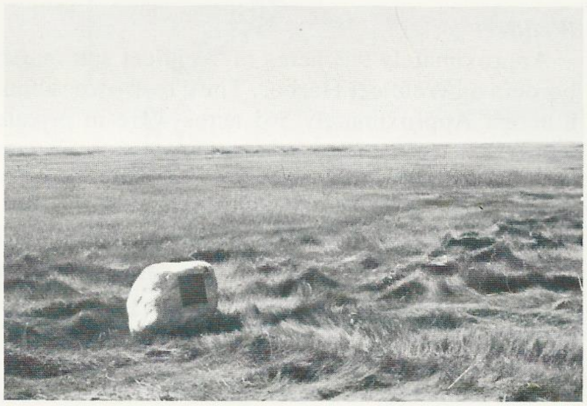


PLATE 8.
Lieutenant Island saltmarsh at Wellfleet Harbor.

Less numerous marsh plants were also found in the vegetation zones. Common marsh rosemary *(Limonium carolinianum)* and annual glass wort *(Salicornia europaea)* were abundant throughout salt meadow grass, and a few specimens of both were found in the upper portion of the cordgrass zone. Sea blite *(Suaeda maritima)*, orach *(Atriplex patula)* and the perennial glass wort *(Salicornia virginica)* were found scattered in meadow and spike grass areas. Along the upland edge, individual specimens of seaside goldenrod *(Solidago sempervirens)* were found interspersed in the black and spike grass. The common rock weed *(Fucus spiralis* and *Fucus vesiculosus)* were found attached to cord grass stems and other substrata in the tidal pools of the lower marsh. Only isolated patches of eelgrass *(Zostera marina)* were found below mean low water in the tidal creeks and adjacent flats. Tidal flats were generally devoid of attached vegetation.

Invertebrates and small fishes were noted within the mosquito ditches and tide pools. Mummichogs, *Fundulus heteroclitus;* striped killifish, *Fundulus majalis;* two species of fiddler crabs, *Uca pugnax,* and *Uca pugilator;* the marsh snail *Melampus bidentatus;* three species of periwinkles *Littorina littorea, Littorina saxatilis,* and *Littorina obtusata;* three species of prawns *Crangon septemspinosus, Palaemonetes intermedius,* and *Hippolyte zostericola;* the mud snail *Nassarius obsoletus;* and the ribbed mussel *Modiolus demissus,* were abundant. Oysters *Crassostrea virginica* and blue mussels *Mytilus edulis* were found scattered in the cord grass.

Numerous species of birds were observed in and around the salt marshes. Nine waterfowl species, 18 shorebirds, and 34 other common species were noted to be dependent on the marsh and adjacent intertidal flats and open water (Table 28).

Table 28. *Birds of the Wellfleet Harbor Area (Mass. Audubon Society, ——)*

Area	Area Utilized	Nesting Area	Season Present
Waterfowl			
American Eider	O		W
American goldeneye	O		W
black duck	IMO	X	A
brant	IO		W
bufflehead	O		W
Canada goose	IMO		A
mallard	IMO	X	A
red breasted merganser	O		W
white winged scoter	O		W
Shore Birds			
black bellied plover	I		S
clapper rail	IM		A
common snipe	IM		S
common tern	O		S
great black backed gull	IO		A
great blue heron	IM		A
greater yellowlegs	IM		S
green heron	IM	X	S
herring gull	IO		A
least sandpiper	I		S
least tern	O		S
lesser yellowlegs	IM		S
roseate tern	O		S
ruddy turnstone	I		S
sanderling	I		A
semipalmated plover	I		S
Other Common Species			
American red start	M	X	S
Baltimore oriole	M	X	S
belted kingfisher	M		A
black capped chickadee	M		A
blue jay	M		A
bobwhite quail	M	X	A
brown headed cowbird	M		S
brown thrasher	M		S
catbird	M	X	S
chipping sparrow	M	X	S
common crow	IM		A
common grackle	M	X	S
field sparrow	M	X	S
gold crowned kinglet	M		W
great crested flycatcher	M	X	S
great horned owl*	M		A

Table 28 (continued)

	Area Utilized	Nesting Area	Season Present
horned lark	IM		A
house sparrow			
kingbird	M		S
marsh hawk*	M		A
mockingbird	M		A
myrtle warbler	M		W
redtail hawk*	M	X	A
redwing blackbird	M	X	S
ringneck pheasant	M	X	A
robin	M		A
Savanna sparrow	M	X	S
slate colored junco	M		W
song sparrow	M	X	S
sparrow hawk*	M		A
tree sparrow	M		W
tree swallow	M	X	S
yellowshafted flicker	M		A
yellowthroat warbler	M	X	S

Key
I — Intertidal
M — Marsh
O — Open water
S — Summer
W — Winter
A — All year resident
* — Birds of prey

Marsh Ownership and Protection

There were approximately 1,117 acres of Wellfleet and Eastham salt marsh bordering on the study area (Fig. 12). There was no protective bylaw exercising local control over wetland alterations, or zoning regulation restricting marsh usage in either town.

Wellfleet

Approximately 993 acres of Wellfleet salt marsh borders on Wellfleet Harbor. The Town owns about 8 acres. Approximately 565 acres were in private ownership and the Massachusetts Audubon Society owns about 270 acres of marsh north of Hatches Creek. All the marsh around Great Beach Hill, Great Island and the west side of Herring River to the dike, totalling 150 acres, is included in the Cape Cod National Seashore Park.

Eastham

Approximately 124 acres of salt marsh bordering the study area lie in Eastham. In 1970, 14.4 acres of marsh in Sunken Meadow were taken by eminent domain for conservation. Conservation easements on 28 acres were being negotiated by the Conservation Commission. Approximately 30 acres was owned by the Massachusetts Audubon Society and the remaining acreage was in private ownership.

State Coastal Wetland Legislation

Recognizing the value of the Commonwealth's irreplaceable salt marshes, the Massachusetts General Court enacted legislation regulating tide marsh alteration.

Chapter 130, Section 27A, was adopted by the Legislature in 1963. This law prohibits alteration of salt marsh, tidal flats, and banks bordering on coastal waters without prior written application to and approval by city or town authorities, the State Department of Public Works and the Division of Marine Fisheries. If marine fisheries resources are endangered by the proposed alteration, the Director of Marine Fisheries can impose conditions to protect these resources.

Although Section 27A has been successful in retarding indiscriminate destruction of tide marsh, it was felt that further protection was needed. In 1965 the Legislature passed Chapter 130, Section 105 of the General Laws. This law is a more comprehensive coastal wetlands protection bill which allows the Commissioner of Natural Resources to regulate the use of coastal wetlands by establishing coastal wetland protective areas. Large acreages of salt marsh, contiguous fresh marsh, tidal flats and barrier beaches, collectively owned by private citizens may be restricted to prevent any use which would destroy the land form or endanger public health, safety, public or private property, wildlife and marine fisheries. Traditional wetland uses are permitted that have little or no effect on the wetland environment.

Public hearings were held under Section 105 early in 1971 regarding proposed Coastal Wetland Restrictive Areas in both towns. Included within these proposed restrictive areas are 993 acres of Wellfleet salt marsh and 3,540 acres of salt marsh in Eastham. This includes all of the Eastham salt marsh bordering Wellfleet Harbor. It is expected that the Coastal Wetland Restriction in both towns will take effect in the near future, substantially as proposed.

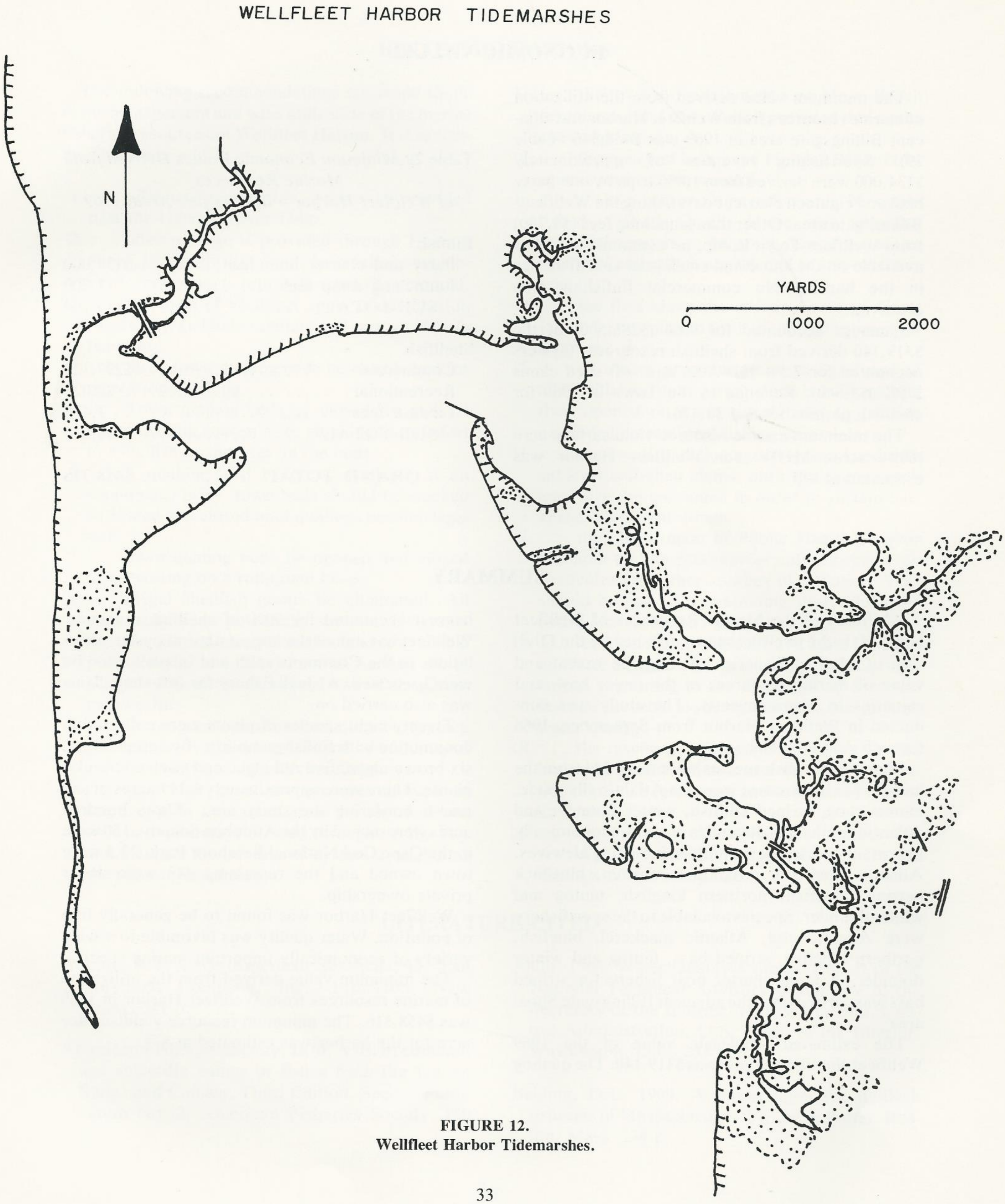


FIGURE 12.
Wellfleet Harbor Tidemarshes.

ECONOMIC VALUES

The minimum value derived from the utilization of marine resources from Wellfleet Harbor and adjacent Billingsgate area in 1969 was $458,316 (Table 29). Sportfishing revenues of approximately $134,000 were derived from 1,856 trips by one party boat and eighteen charter boats fishing the Wellfleet-Billingsgate area. Other than launching fees ($1,700) from Wellfleet Town Ramp, no economic data was available on the shore and small boat sportfisheries in the harbor. No commercial finfishing was observed.

Quahogs accounted for 90% ($286,500) of the $319,140 derived from shellfish resources. Oysters accounted for 7.5% ($24,000) and soft-shell clams 2.5%)$8,640). Revenue to the Town in 1969 for shellfish permits totaled $3,476.

The minimum marine resource yield/surface acre (6094 acres MHW) for Wellfleet Harbor was estimated at $75.

Table 29. *Minimum Economic Values Derived from Marine Resources of Wellfleet Harbor – Billingsgate Area, 1969*

Finfish	
Party and charter boat fees	$134,000
Launching ramp fees	1,700
SUB-TOTAL	$135,700
Shellfish	
Commercial	$297,120
Recreational	22,020
License fees	3,476
SUB-TOTAL	$322,616
GRAND TOTAL	$458,316

SUMMARY

"A Study of the Marine Resources of Wellfleet Harbor" is the twelfth report published by the Division of Marine Fisheries relating the extent and value of marine resources in the major bays and estuaries in Massachusetts. The study was conducted in Wellfleet Harbor from September, 1968 through August, 1969.

Thirty-five finfish species were recorded from the harbor. Most abundant were the Atlantic silverside, mummichog, striped killifish, winter flounder and Atlantic menhaden. Juveniles of many economically important species were sampled including alewives, Atlantic mackerel, Atlantic menhaden, blueback herring, bluefish, northern kingfish, tautog and winter flounder. Species available to the sportfishery were Atlantic cod, Atlantic mackerel, bluefish, northern kingfish, striped bass, tautog and winter flounder. A large charter boat fishery for striped bass was carried on at the adjacent Billingsgate Shoal area.

The estimated wholesale value of the 1969 Wellfleet shellfish harvest was $319,140. The quahog harvest accounted for 90% of shellfish revenues. Wellfleet has one of the largest natural oyster populations in the Commonwealth and in 1969 2,400 bu were harvested. A small fishery for soft-shell clams was also carried on.

Twenty-eight species of plants were collected in conjunction with finfish sampling: five green algae, six brown algae, five red algae and twelve vascular plants. There were approximately 1,117 acres of salt marsh bordering the study area. Three hundred acres were owned by the Audubon Society, 150 were in the Cape Cod National Seashore Park, 22.4 were town owned and the remaining 443 were under private ownership.

Wellfleet Harbor was found to be generally free of pollution. Water quality was favorable to a wide variety of economically important marine species.

The minimum value derived from the utilization of marine resources from Wellfleet Harbor in 1969 was $458,316. The minimum resource yield/surface acre for the harbor was estimated at $75.

RECOMMENDATIONS

The following recommendations are made to aid in the management and wise utilization of the marine fisheries resources of Wellfleet Harbor. It is recommended that:

1. . . . adequate passage for alewives be provided past the Herring River Dike.
2. . . . after passage is provided through Herring River, the headwater ponds be stocked with alewives for 4 years to return the run to its potential.
3. . . . the town of Wellfleet apply under Section 94 of Chapter 130 to regulate and control alewife fisheries.
4. . . . three town quahog beds be established for recreational fishing.
5. . . . Town quahog beds be closed for at least one spawning season after stocking in an effort to establish quahog set on the beds.
6. . . . if quahog seed becomes available at an economical price, town beds should be stocked with seed and closed until quahogs become legal size.
7. . . . town quahog beds be opened and closed to harvesting on a rotational basis.
8. . . . illegal shellfish grants be eliminated. All areas suitable or potentially suitable, for grants be surveyed and grants leased only to responsible people under the provisions of Section 57 of Chapter 130 of the General Laws of the Commonwealth.
9. . . . oyster grant operators be required to replace all shell removed from grants and add additional cultch to alleviate the cultch deficiency.
10. . . . seed that grant owners are allowed to remove from non-grant areas be restricted to reduce exploitation of seed throughout the bay and increase the number of oysters available to the recreational fishery.
11. . . . the town propagation area on Mayo Beach be enlarged and more cultch provided during the spawning season.
12. . . . the area just below the Herring River Dike remain under town control.
13. . . . a town oyster propagation area be established at Duck Creek, where spat collecting potential appears to be great. Large quantities of gravel and cultch are needed to improve this area.
14. . . . the flats along the eastern shore of Great Island be considered for a town oyster propagation area.
15. . . . all oyster propagation areas be closed to all shellfishing until parent stock is built up, and then opened on a rotational basis to provide expanded recreational fishing area.
16. . . . the practice of closing areas populated with sublegal soft-shell clams, until the clams reach legal size, be continued in order to sustain harvestable concentrations.
17. . . . the Department of Public Health monitor this area for the presence of coliform bacteria, pesticides and other sources of pollution. This should be part of a continuing study along the entire Massachusetts coastline.
18. . . . the local Board of Health and State Division of Water Pollution Control rigidly enforce regulations pertaining to the discharge of domestic sewage thereby assuring continuance of high water quality.
19. . . . the discharge of sewage from boats in the harbor be prohibited to insure maximum utilization of marine resources, and to protect the public health.
20. . . . within 10 years Wellfleet Harbor be restudied and the findings compared with the findings of this study and its recommendations.

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