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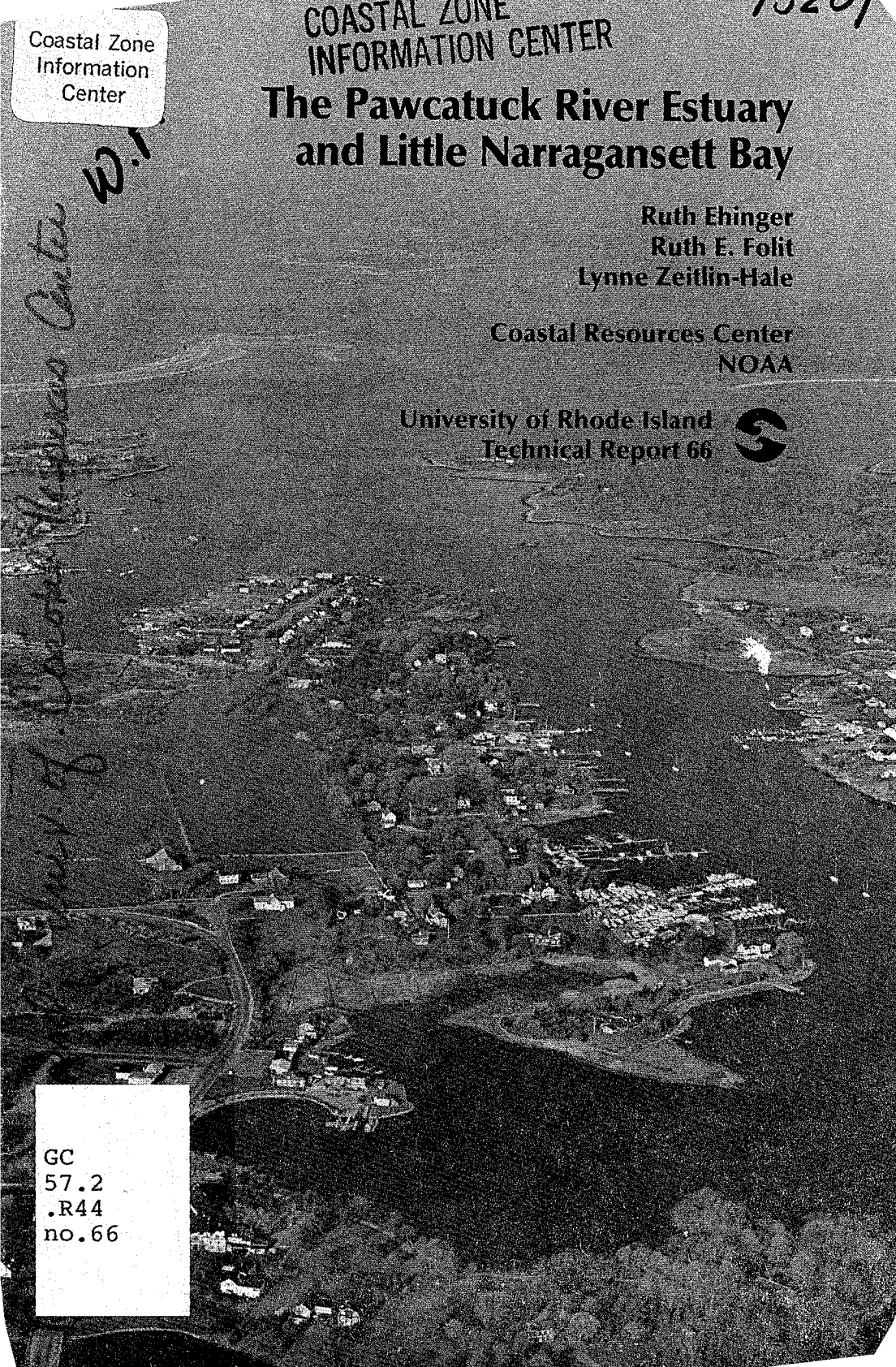
The Pawcatuck River Estuary and Little Narragansett Bay

Ruth Ehinger
Ruth E. Folit
Lynne Zeitlin-Hale

Coastal Resources Center
NOAA

University of Rhode Island
Technical Report 66



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COASTAL ZONE
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THE PAWCATUCK RIVER ESTUARY AND LITTLE NARRAGANSETT BAY: A Compilation of Available Information

U.S. DEPARTMENT OF COMMERCE NOAA
COASTAL SERVICES CENTER
2234 SOUTH HOBSON AVENUE
CHARLESTON, SC 29405-2413

Ruth Ehinger
Ruth E. Folit
Lynne Zeitlin-Hale

Coastal Resources Center
University of Rhode Island

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PREFACE

As part of the Coastal Resources Center's inventory of the coastal and marine resources of Rhode Island, this publication compiles all of the scientific information available to us on the Pawcatuck River Estuary and Little Narragansett Bay. This document is a first attempt at putting the information together, and undoubtedly some relevant work has been overlooked. We hope that people using this summary will inform us both of work we have omitted and of new work.

Stephen Olsen, Coordinator
Coastal Resources Center

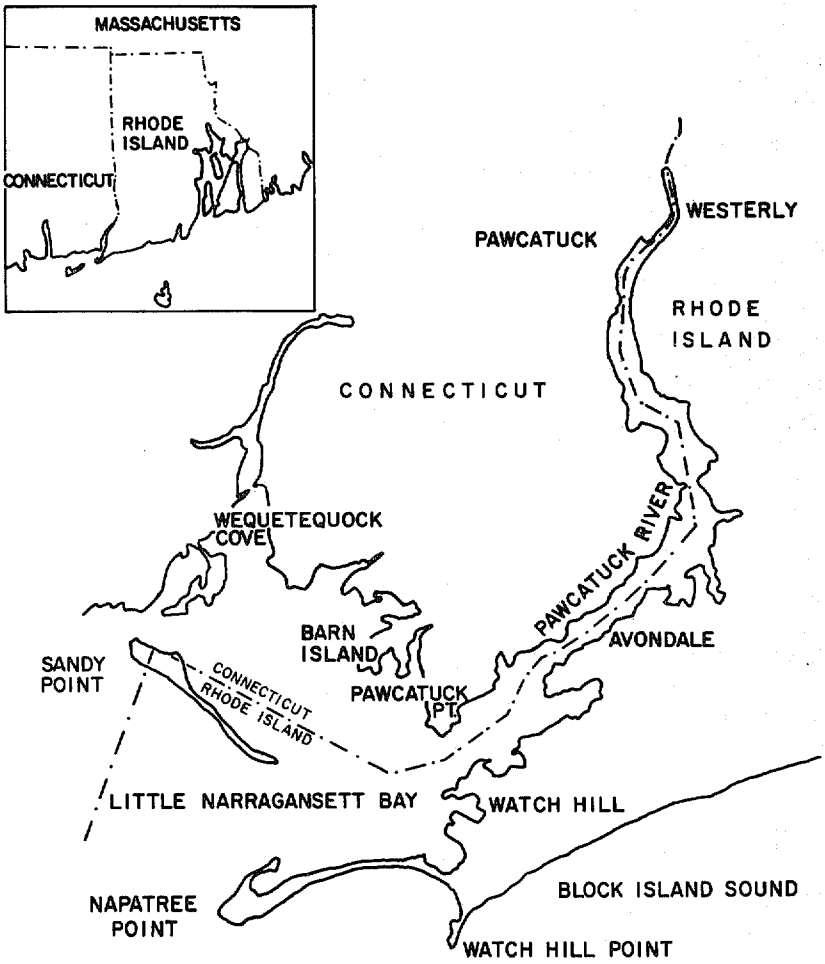


FIGURE 1

Pawcatuck River Estuary and Little Narragansett Bay Orientation Map

INTRODUCTION

The Pawcatuck River Estuary and Little Narragansett Bay compose a valuable, but little studied, estuarine system that forms Rhode Island's southwest border (Figure 1). The purpose of this report is to summarize available scientific data on the area and to give the sources of this information.

The Rhode Island Coastal Resources Management Council has designated the Pawcatuck River and Little Narragansett Bay a high-intensity recreation estuary (Type 3). Recreational boating, public access, maintenance and improvement of marinas and boatyards, hunting, sportsfishing, and wildlife management are listed as the highest priority uses for these waters.

PHYSICAL DESCRIPTION

The physical characteristics of the Pawcatuck River Basin, the estuarine reaches of the Pawcatuck River, and Little Narragansett Bay are summarized below.

The River Basin

The Pawcatuck River Basin is the largest in Rhode Island, draining 25 percent of the state. Most of the basin is forest, open, and agricultural lands. The 29-mile-long river is fed by 159 miles of tributaries running through eight communities in Rhode Island and four in Connecticut. All the freshwater streams in the basin are Class C or better (RISPP & RIDOH, 1976). The Pawcatuck's main tributaries are the Wood, Beaver, Queens, and Chipuxet rivers.

The Estuary

The Pawcatuck River Estuary forms where the freshwater of the Pawcatuck River mixes with the saltwater of Long Island Sound. Bordered by the town of Stonington, Connecticut, on the west and Westerly, Rhode Island, on the east, the estuary includes Little Narragansett Bay and extends five miles upstream from the mouth of the river to the Route 1 bridge at Westerly. The estuarine shoreline is composed of glacial till in the uplands, two to three miles of beaches and dunes (mostly in Rhode Island), and approximately 500 acres of salt marsh (mostly in Connecticut).

The Bay

Little Narragansett Bay is a two-square-mile estuary at the mouth of the Pawcatuck River. The bay averages six feet in depth and is protected on the seaward side by Napatree barrier beach and Sandy Point. The barrier is breached at two locations. One breachway, cut between Napatree and Sandy points by the 1938 hurricane, is about 1,000 yards wide and two to three feet deep. The other, bordered by Stonington, Connecticut, is the channel maintained for boating. The seven-mile-long channel is dredged to 10 feet from Stonington Point, Connecticut, upriver to Westerly, Rhode Island. There is also a ten-foot-deep dredged channel from the river mouth to Watch Hill Cove.

GEOMORPHOLOGY

The Pawcatuck River Estuary and Little Narragansett Bay are parts of a moraine system, glaciated during the

Wisconsin era. This region marks the farthest extension of the Laurentide ice sheet some 20,000 years ago (Napatree Point Conservation Committee, 1972). The glacier modified the preglacial surface by scraping it and leaving deposits. All unconsolidated deposits, except those most recently laid (beach and swamp deposits), were deposited by this ice sheet and its accompanying waters. Scattered ice blocks created kettle holes, and wave action formed terraces on the shore (Martin, 1925).

Napatree Point was once an island; sand deposited by littoral currents have created the beach, which now connects it to the mainland. The point and beach make up one arm of the double tombolo formation, a geologic term to describe two sand bars connecting an island with the mainland. The other arm is Sandy Point.

Coastal geomorphological processes are continuously occurring on Napatree barrier, but often at imperceptible rates. By overlaying navigation charts, the earliest of which date from 1847, Griscom (1976) monitored large-scale changes, indicating present trends of landform migration (Figure 2).

BEDROCK

A bedrock map of the Watch Hill quadrangle is available from the U.S. Geological Survey (Moore, 1967). Narragansett Pier granite of magmatic origin underlies Watch Hill, much of Westerly, and the eastern side of the Pawcatuck River south from Colonel Willie Cove. Metavolcanic rocks and pink and gray layered gneisses border most of the rest of the river. Interbedded rustyweathering, medium-grained, vitreous quartzite and quartz mica schist are found in a bed up to 12 feet thick on the river's west bank across from Ram Point. Bedrock outcrops are found in this small area. The U.S. Geological Survey bedrock map does not indicate the submarine bedrock of the Pawcatuck River or Little Narragansett Bay.

TOPOGRAPHY

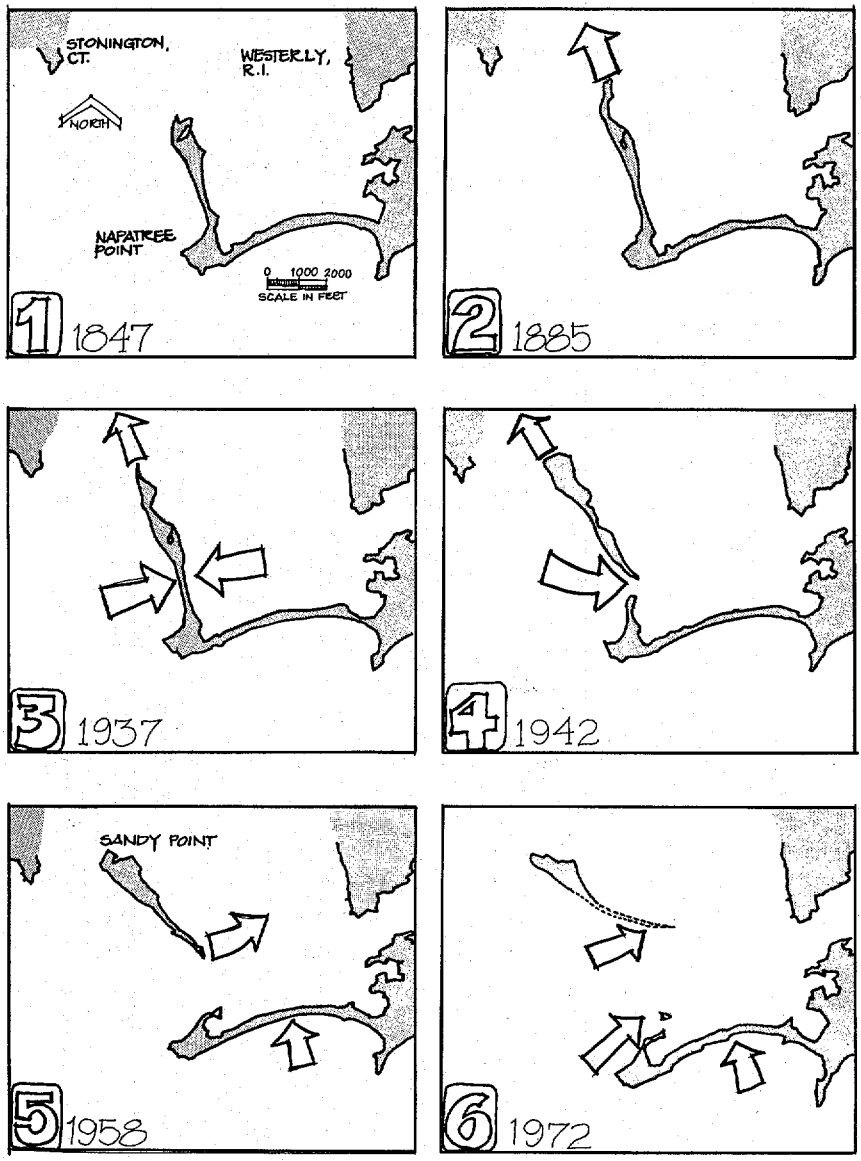
Elevation of most of the Pawcatuck River Basin is less than 200 feet (SENE, 1975). Napatree Point has an elevation of approximately 22 feet. The region contains two contrasting topographical types (Martin, 1925). Rough land, which marks the terminal moraine, extends east from Watch Hill and west from Fishers Island in small hills, irregular ridges,

FIGURE 2

Migration of Napatree Landform Over 125 Years

For the first 30 years very little change can be identified on the Napatree landform. However, between 1877 and 1885, the beach formation is beginning to move and thin out, showing the tendency to move westward toward Connecticut, to complete a double tombolo. By 1911, the migratory process is quite active, as it is still stretching and moving. By 1937, just before the hurricane, the process had progressed to a point that even a fresh water pond existed. However, the 1938 hurricane caused the newly formed deposits to be breached, and a new balance of forces came into being. By 1950, the sand spit had started to recurve at both ends of the beach - a well-known phenomenon in tidal inlets. By focusing on the more permanent part of the landform, the Point itself, one is able to identify how much movement has occurred to the spit, the more dynamic part of the system. Since the 1938 storm, the beach has become more concave, and has moved over 100 yards into the bay. The western end of the spit, Sandy Point, has moved some 1,200 yards (since 1877) toward Stonington.

From Griscom, 1976.



MIGRATION OF NAPATREE LANDFORM OVER 125 YEARS
SOURCE: TRACINGS FROM SAILING CHARTS

and undrained depressions. North of this narrow belt is a region of terraced bedrock hills covered with till. Five terrace elevations are identified, each seemingly produced by wave action when sea level was higher than it is today. Along the eastern side of the Pawcatuck River, one to three miles south of Westerly, are small, discontinuous sand and gravel terraces, rising 15-25 feet above the river. These were probably deposited as deltas in lakes (Martin, 1925). Westerly is built on one such terrace.

SEDIMENTS

The New England Division of the Army Corps of Engineers sampled sediments from Little Narragansett Bay in August, 1975 (U.S. Army Corps of Engineers, New England Division, 1977). Samples were analyzed for volatile solids, chemical oxygen demand (COD), total Kjeldahl nitrogen, hexane-soluble oil and grease, nine heavy metals, PCB's and DDT. This information is presented in Table 1; Figure 3 shows the Corps' sampling stations.

The Environmental Protection Agency (Wong, 1973-1974) examined sediments at the mouth of the Pawcatuck River (Figure 4). Samples collected on June 20, 1973 and March 13, 1974 were analyzed for seven heavy metals; those collected on May 26, 1974 were analyzed for pesticides. Table 2 gives the reported values.

The remainder of available information concerns intertidal and terrestrial areas. A surficial geologic map of the Watch Hill Quadrangle, RI - CT (Schafer, 1965) provides general information on surface sediments. Napatree Beach is covered by beach deposits. Moving north along the eastern shore of the Pawcatuck, one finds glacial till that is more sandy or gravelly than deposits on the western shore, along with generally well-sorted stream deposits. Glacial stream deposits and poorly sorted till (dominated by silt and sand) characterize the river's western shore. Further north, river terrace deposits border the Pawcatuck. For information on soils, see the recently completed soil survey for the town of Westerly (Spangler, 1975).

Most other sediment data is from the Napatree area, where sand is deposited by littoral currents (Sculco, 1972). Deposition and erosion periods alternate at Napatree; some geological features changing almost daily (Realini, 1972). The Army Corps of Engineers declared Napatree an area of critical coastal erosion (three feet/year) in 1971 (SENE, 1975), and the CRMC designated it an erosion-prone

TABLE 1

CHEMICAL ANALYSIS-BOTTOM SEDIMENTS
OF LITTLE NARRAGANSETT BAY

PARAMETER		GE-1	GE-2	PE-3	PE-4	PE-7
% Vol Solids-EPA		0.22	0.71	11.76	1.65	9.73
% Vol Solids-NED		0.13	0.55	10.27	1.47	8.43
% Tot Vol Sol-EPA		1.52	2.10	16.5	3.49	14.3
% Chem Oxygen Dem		0.20	0.80	15.5	2.21	13.2
% Tot Kjdl Nit		0.005	0.017	0.434	0.057	0.407
% Hex Sol-Oil & Grease		0.000	0.051	0.355	0.048	0.249
% Mercury	$X10^{-5}$	0.33	0.00	0.36	0.80	8.3
% Lead	$X10^{-3}$	0.65	0.78	6.9	2.0	7.6
% Zinc	$X10^{-3}$	0.87	2.60	15.1	2.8	15.8
% Arsenic	$X10^{-3}$	0.04	0.07	0.69	0.14	0.41
% Cadmium	$X10^{-3}$	0.09	0.10	0.48	0.11	0.04
% Chromium	$X10^{-3}$	0.50	1.1	7.8	1.7	8.7
% Copper	$X10^{-3}$	1.1	2.6	13.8	2.5	14.0
% Nickel	$X10^{-3}$	0.44	0.88	3.8	0.97	2.9
% Vanadium	$X10^{-3}$	1.3	1.6	0.0	1.7	7.0
% PCB	$X10^{-3}$	-	-	0.0	-	-
% DDT	$X10^{-3}$	-	-	0.02	-	-

From U.S. Army Corps of Engineers, 1977

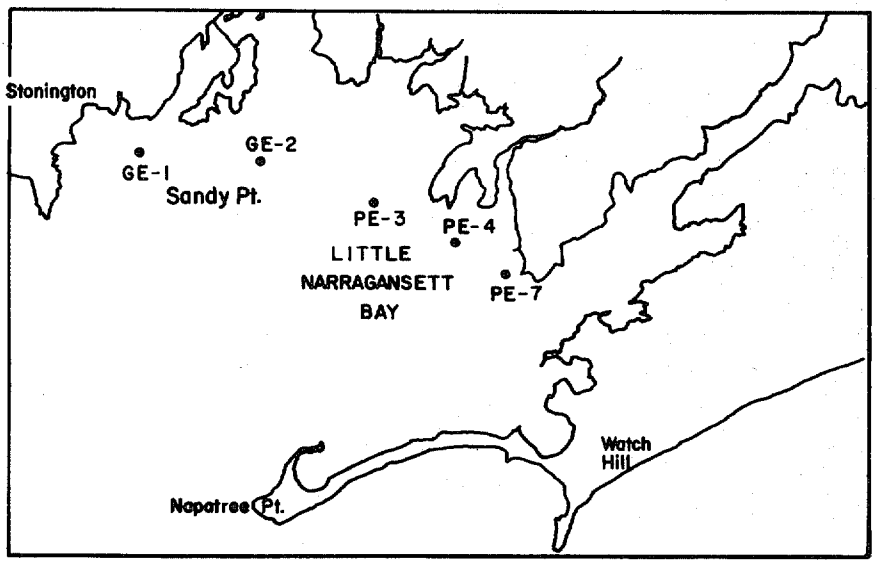


FIGURE 3

Army Corps of Engineers Sediment Sampling Stations in Little Narragansett Bay

From U.S. Army Corps of Engineers, 1977.

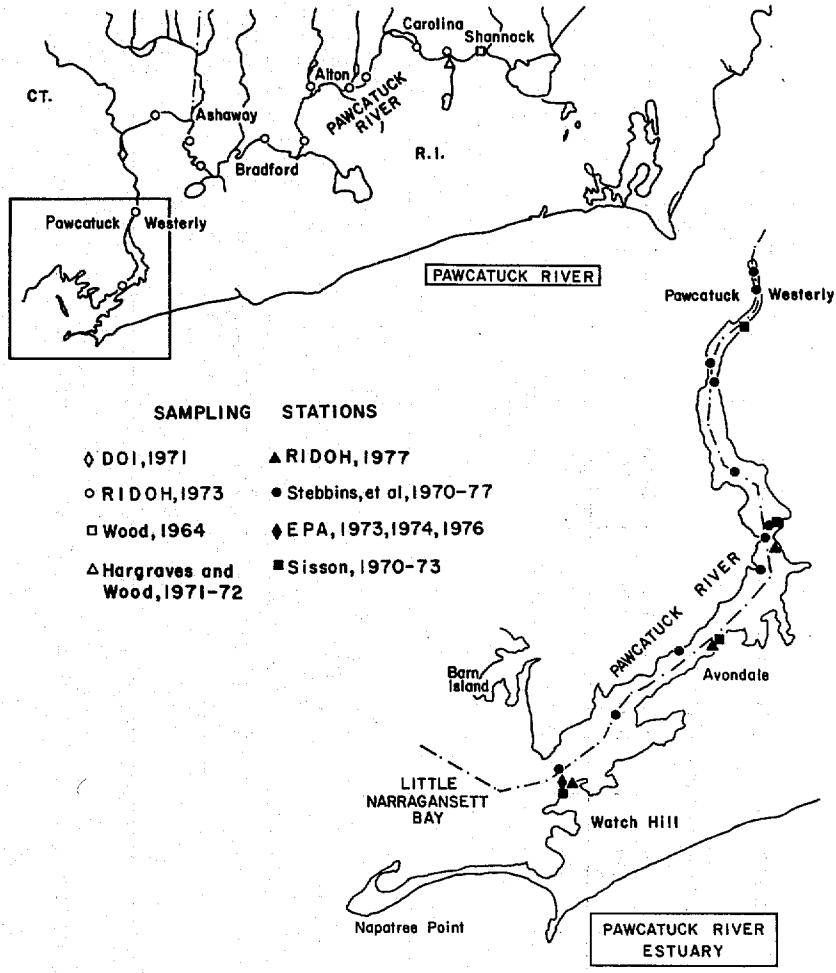


FIGURE 4

Sampling Stations for Selected Studies

TABLE 2

HEAVY METAL & PESTICIDE CONCENTRATIONS IN SEDIMENTS AT PAWCATUCK RIVER MOUTH

Amounts of Heavy Metals in mg/gm (oven dry weight)

Date	Mercury (Hg)	Zinc (Zn)	Copper (Cu)	Lead (Pb)	Cadmium (Cd)	Nickel (Ni)	Chromium (Cr)
6/20/73	--	34	20	25	--	5	21
3/13/74	0.11	15	9.08	8.9	0.2	--	--

Amounts of Pesticides in ppb

Date	P,P/DDE	O,P/DDE	P,P/DDT	Dieldrin	1254 PCB (arachlor)
5/26/74	28	ND	ND	ND	167

ND = not detectable (The sensitivity of the test no detectable levels is 10 ppb)

From EPA, unpublished data

area of environmental concern (CRMC, 1977). Erosion is caused both by wind and water. Snow fences have been effective in building sand dunes by capturing blowing sand (Quist and Benoit, 1972). In January and February of 1973, however, dune faces were receding (Realini, 1973).

Mills and Sisson (1972) conducted soil analyses on Napatree and found three zones: a sandy beach, a transition zone, and an upland region. Results of their analyses are as follows:

Zone	Texture	pH	Phosphorus	Potassium	Nitrate
sandy beach	sand	6.2	VL	VL	VL
transitional	fine sandy loam	7.0	VL	VL	VL
upland	loamy sand	5.9	L	VL	VL

VL = Very Low
L = Low

HYDROGRAPHY

Little Narragansett Bay is generally well flushed; the flushing factor has been calculated at 33 percent. The tidal prism is estimated at 250 x 10^6 ft.^{3}, mean tidal range of about 2.5 feet, and average depth of less than six feet at mean low water (Hale et al., 1975). In contrast, the "kitchen" area of the bay, a small cove (three to four acres) near Napatree Point, is poorly flushed, being shallow and well sheltered (Phelps and Griscom, 1973). Additional research is needed to determine circulation patterns in the bay. Preliminary data indicate that most water transport is in the channel and, furthermore, that the direction of water movement is significantly affected by wind stress (Hale et al., 1975).

Bathymetric data collected by the Corps of Engineers and on file at the National Geophysical and Solar-Terrestrial Data Center (NGSDC) are available for 1961, 1962, and 1966 for Little Narragansett Bay and the Pawcatuck River up to Westerly. The data are not mapped, but listed by the depth meters at locations described by longitude and latitude.

Average water flow in the Pawcatuck River is 550 to 600 cubic feet per second; the recorded maximum and minimum are 4,000 ft.^{3}/sec. and 70 ft.^{3}/sec., respectively (Phelps and Griscom, 1973). The same report states that, in 1969, maximum flows of 1,100 ft.^{3}/sec. were observed in the spring (April) and minimum flows (95 ft.^{3}/sec.) in the fall (October). Seasonal river discharge at Westerly has been measured by the U.S. Geological Survey since 1940. An example of their annual records is shown in Table 3.

Table 3

MEAN WATER DISCHARGE (IN CUBIC FEET PER SECOND) OF PAWCATUCK RIVER-OCTOBER 1975 TO SEPTEMBER 1976

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	244	354	985	1460	2040	768	730	501	320	152	171	134
2	225	336	918	1340	2130	738	888	655	342	155	174	130
3	212	315	842	1250	2160	738	932	842	354	155	163	130
4	204	304	768	1250	2050	752	880	842	342	148	148	134
5	186	304	700	1140	1860	775	805	738	320	144	137	130
6	178	289	655	918	1680	790	745	648	299	141	130	127
7	182	289	627	910	1460	775	662	592	283	141	127	124
8	199	294	599	1270	1370	730	662	557	273	134	199	124
9	204	325	599	1430	1230	692	641	529	273	134	550	120
10	195	348	775	1290	1160	708	613	501	259	127	842	113
11	186	388	860	1170	1090	678	599	473	244	120	738	127
12	199	414	820	1080	1060	700	571	494	239	124	529	124
13	225	880	760	970	1020	865	564	550	225	124	359	124
14	254	1490	720	1360	970	1160	550	543	221	117	278	120
15	254	1450	685	1600	932	1180	536	515	216	113	225	117
16	244	1310	648	1520	925	1120	529	473	212	113	204	120
17	230	1130	620	1460	940	1230	522	522	208	113	182	120
18	263	932	606	1290	970	1210	513	550	208	120	174	127
19	426	805	599	1080	985	1100	508	557	199	120	163	130
20	494	715	557	1030	985	1030	494	564	199	113	152	134
21	459	662	536	948	962	992	487	529	205	110	144	130
22	401	888	536	880	970	940	480	529	199	107	141	124
23	365	1000	543	730	1130	880	473	473	195	104	137	120
24	336	985	550	798	1140	828	466	432	178	117	134	120
25	342	940	550	798	1070	782	480	401	174	120	134	117
26	550	872	700	798	992	745	557	388	167	110	137	120
27	564	865	1660	1060	925	722	592	376	163	98	137	124
28	515	1110	1740	2130	865	730	578	365	167	95	152	127
29	445	1160	1610	2630	812	760	543	348	152	95	155	124
30	395	1080	1450	2520	---	752	515	336	155	98	152	124
31	376	---	1460	2310	---	715	---	325	---	120	144	---
TOTAL	9552	22234	25678	40420	35883	26585	18117	16148	6991	3782	7212	3739

MEAN	308	741	828	1304	1237	858	604	521	233	122	233	125
MAX	564	1490	1740	2630	2160	1230	932	842	354	155	842	134
MIN	178	289	536	730	812	678	466	325	152	95	127	113
CFSM	1.04	2.51	2.81	4.42	4.19	2.91	2.05	1.77	.79	.41	.79	.42
IN.	1.20	2.80	3.24	5.10	4.52	3.35	2.28	2.04	.88	.48	.91	.47

CAL YR 1975 TOTAL 213590 MEAN 585 MAX 1740 MIN 95 CFSM 1.98 IN. 26.93
WTR YR 1976 TOTAL 216341 MEAN 591 MAX 2630 MIN 95 CFSM 2.00 IN. 27.28

LOCATION -- Lat 41°23'01", long 71°50'01", Washington County, Hydrologic Unit 01090005, on left bank at Westerly, 2.1 mi (3.4 km) downstream from Shannock River.
DRAINAGE AREA -- 295 mi^2 (764 km^2).
PERIOD OF RECORD -- Discharge: November 1940 to current year.
Chemical analyses: Water years 1953, 1963 (partial-record station).
REVISED RECORDS -- WSP 1051: Drainage area.
GAGE -- Water-stage recorder. Datum of gage is 1.76 ft (0.536 m) below mean sea level.
REMARKS -- Records good. Diurnal fluctuation at low flow prior to 1962 by mills upstream; regulation much greater prior to 1958. Diversion upstream for municipal supply of Westerly. Several observations of water temperatures were made during the year.
AVERAGE DISCHARGE -- 35 years (water years 1942-76), 566 ft^3/s (16.03 m^3/s), 26.06 in/yr (662 mm/yr).
EXTREMES FOR PERIOD OF RECORD -- Maximum discharge, 4,470 ft^3/s (127 m^3/s) Mar. 18, 1968, gage height, 10.49 ft (3.197 m); maximum gage height, 12.16 ft (3.706 m) Aug. 31, 1954, backwater from tide; minimum daily discharge, 25 ft^3/s (0.71 m^3/s) Aug. 17, 1941.
EXTREMES OUSIDE PERIOD OF RECORD -- Flood in March 1936 reached a discharge of 3,150 ft^3/s (89.2 m^3/s), by computation of flow over dam 1.5 mi (2.4 km) upstream. Maximum discharge since 1886 occurred in November 1927 and was possibly more than twice that in March 1936. Maximum stage since at least 1935, 15.0 ft (4.57 m) Sept. 21, 1938, due to hurricane tidal wave.
EXTREMES FOR CURRENT YEAR -- Maximum discharge, 2,670 ft^3/s (75.6 m^3/s) Jan. 29, gage height, 7.57 ft (2.307 m); maximum gage height, 7.62 ft (2.233 m) Feb. 2, backwater from tide; minimum daily discharge, 95 ft^3/s (2.69 m^3/s) July 28, 29.

From USGS, 1976

STORMS

Storms have resulted in dramatic changes to Napatree. The Hurricane of 1938 killed 18 people on Napatree, destroyed the 39 homes located on the point, the yacht club, the beach club, and the bathing pavilion. A number of inhabited houses were washed across the bay; 27 people survived the trip (Seaside Topics, 1968). Winds were estimated to reach 185 mph during that hurricane (Sculco, 1972). The 1938 hurricane also separated Sandy Point from Napatree Point, a separation that not only has been maintained but is increasing. The only land on Napatree which came through the hurricane unscathed was the point near the fort. The rest - the dunes and the beach - was eroded away by waves washing over the point and the beach. Public and private bath houses, cabanas, and a beach club were rebuilt on Napatree after 1938; all but the beach club were subsequently washed away by the 1954 hurricane (Seaside Topics, 1954). The beach has been left in a natural state since 1954; however, approximately 30 washover or blow-out areas remain.

WATER CHEMISTRY

Several studies have been performed on the Pawcatuck River, including measurements of chemicals (Table 4, Figure 4). The Water Resources Report (U.S. Department of Interior, USGS, 1971) gives maximum and minimum dissolved oxygen and temperature values for May to October of 1971 at White Rock (Tables A-1 and A-2). Average maximum dissolved oxygen levels increased from May to a high in August (14.0 mg/l) followed by a gradual decrease to a low value in October of 10.7 mg/l. Minimum levels did not show the same trend, being lowest in July and August (4.0 mg/l) and highest in May (6.0 mg/l). Average maximum temperatures were highest in July, at 29.5^{o}C. (August value is missing).

Two studies were conducted for the upstream area, well into the freshwater portion of the river. Richard Wood (1972) made measurements at Kenyon, RI (at Route 2), where a textile dyeing factory is located. Temperature, coliform, and phosphate all peaked in summer, in inverse relation to discharge (Table A-4). Another study (Hargraves and Wood, 1967) included one station on a tributary of the Pawcatuck (at Usquepaug River). Both phosphate and nitrate were always detectable at the station when sampled (March to October of 1964). Maximum phosphate values were observed in early summer, and maximum nitrate in late summer. Silicate remained high throughout the study period. Dissolved oxygen levels varied with temperature, oxygen saturation values being more constant.

Table 4

WATER CHEMISTRY DATA BASE

Investigator	Sampling Period	River Location	Parameters Sampled
U.S. Dept. of Interior*	5/77-10/77	Freshwater-White Rock, RI	dissolved oxygen, temperature
Richard Wood*	1971-1972	Freshwater-Kenyon, RI	temperature, pH, alkalinity, dissolved oxygen, % oxygen saturation, conductivity, phosphate, nitrate, color, turbidity, velocity, discharge, coliform
Hargraves and Wood	1964	Freshwater-at Usquepaug River	phosphate, nitrate, silicate, dissolved oxygen, temperature
Rhode Island Department of Health*	8/22/73	Estuary & freshwater - from river mouth upstream to Richmond, RI	flow, temperature, dissolved oxygen, biochemical oxygen demand, total coliform, fecal coliform, ammonia, nitrite, nitrate, total copper, total zinc
Rhode Island Department of Environmental Mgmt.*	1970-1973	Estuary	temperature, salinity, dissolved oxygen
Henry Stebbins & Wheeler High School Students**	1970-1977	Estuary	temperature, density, salinity, acidity, alkalinity, dissolved oxygen, fecal coliform

*data in tables in Appendix

**data on file in Coastal Resources Center

The Rhode Island Department of Health conducted a Water Quality Survey on the Pawcatuck River Basin on August 22, 1973. Values for temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD), total coliform, fecal coliform, ammonia nitrogen, total copper, and total zinc were collected at 12 stations, from the mouth of the river, upstream to the Shannock Dam in Richmond, RI (Table A-3, Figure 4). Nitrate and nitrite values are also listed at these 12 stations in the New England River Basins Modeling Project - Final Report. They found that water quality varies with adjacent land use.

The Wickford Marine Fisheries Laboratory of the Department of Environmental Management collected temperature, salinity, and dissolved oxygen data at four stations in the Pawcatuck River Estuary (Table A-5 and Figure 4) from 1970 to 1973 (Sisson, unpublished data). All stations were in the saline portion of the river. Dissolved oxygen values were lowest in July, August, and September, and highest in March and April.

Henry Stebbins and his biology students at Wheeler High School in North Stonington, Connecticut, are currently involved in a study of the estuarine portion of the Pawcatuck River. Temperature, density, salinity, acidity, alkalinity, dissolved oxygen, and fecal coliform were measured from 1970 to 1977. Copies of the data are on file at the Coastal Resources Center.

POLLUTION

In the Pawcatuck River Basin Water Quality Management Plan (RISPP and RIDOH, 1976), the Pawcatuck River has been divided into segments for planning purposes. Each segment is a section of a water body with common water-quality characteristics and use classification. The first three segments of the Pawcatuck River Basin include Little Narragansett Bay and the Pawcatuck River Estuary.

The first segment, Little Narragansett Bay from Napatree Point to Rhodes Point at the mouth of the river, is designated Class SA by the Department of Health. It is not in compliance with its water-quality designation, however, and therefore is closed to shellfishing. Sources of pollution are upstream industrial, municipal, and individual discharges from Westerly and Pawcatuck, Connecticut.

The 2.3-mile segment of the estuary from Rhodes Point to Pawcatuck Rock is classified SB. This segment is also not in compliance with its water-quality designation, because of upstream discharges.

The upper reach of the estuary, the third segment, extends from Pawcatuck Rock to the Stillmanville Dam in Westerly. It is in compliance with its class designation of SC. However, the amount of polluted discharge is greater than the assimilative capacity in the segment. This results in the degradation of downstream areas. The three major sources of effluent in this segment are the Westerly Municipal Sewage Treatment Plant, the Yardney Electric Corporation, and the Harris Intertype Corporation.

PLANKTON

No studies have been conducted on phytoplankton or zooplankton in the Pawcatuck River Estuary or in Little Narragansett Bay. However, a survey of phytoplankton and zooplankton has been made in a small stream and estuary, adjacent to Barn Island Reserve Area in Wequetequock, Stonington, Connecticut (Blackstone, 1970). The 0.7-mile stream empties into Little Narragansett Bay on the Connecticut side of Pawcatuck Point.

Blackstone collected plankton from three upstream stations. A survey examining the vertical zonation of algae and invertebrates was conducted at the three most downstream saline stations. The list of plankton reported is too extensive to reproduce here; the paper is on file at the Coastal Resources Center.

BIOTA

Macroflora

Macroalgae: A bottom survey conducted in April 1970 of the Kitchen area off Napatree Point (White, 1972) indicated the presence of five macrofloral species: *Zostera marina* (eel grass), *Ulva lactuca*, *Laminaria saccharina*, *Codium fragile*, and *Dulse* (species name not given). Relative abundances were not recorded.

Salt Marsh: An in-depth investigation of the Wequetequock-Pawcatuck tidal marsh on the Connecticut side of Little Narragansett Bay was undertaken by Miller and Egler (1950) some 30 years ago. They describe several different plant communities and give lists of flora and relative abundance for each community. Their results are probably representative of the other coastal wetlands and uplands in the area. The vegetation community found furthest inland was an oak-sprout forest that included much hickory; more shoreward was an upland shrub border, followed by the tidal marsh (Figure 5). Miller and Egler classified the marsh in three sections: a narrow upper border (up to 20 m. wide)

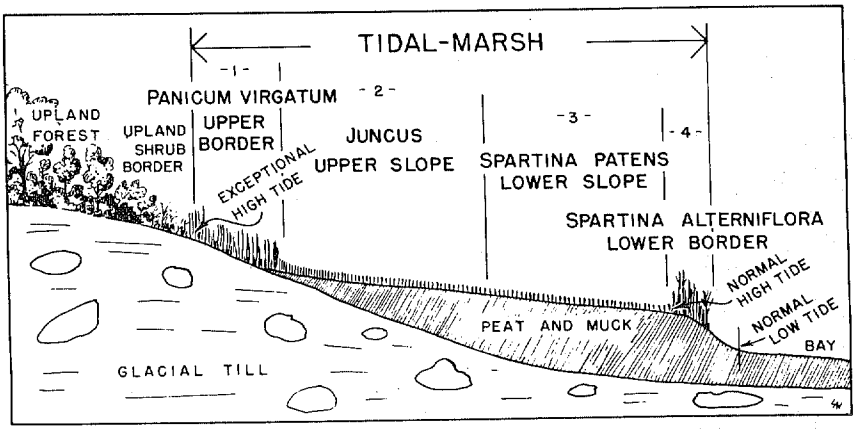


FIGURE 5

Upland-to-Bay Vegetation Sequence of Wequetequock-Pawcatuck Tidal Marsh

Diagrammatic cross-section of the upland-to-bay sequence, showing the characteristics of the major vegetational units. Vertical scale is greatly exaggerated.

From Miller and Egler, copyright 1950 by the Ecological Society of America.

dominated by Panicum virgatum and Spartina pectinata; a 7-to-10-meter-wide upper slope covered with dense Juncus vegetation (Figure 6); and a Spartina patens lower slope; where few species other than S. patens occur (Figure 7). Sometimes Distichlis spicata is abundant in this last zone, but rarely does it gain over 50 percent coverage. The S. patens community is similar to the Juncus community. Finally, a thin (2 m. wide) line of Spartina alterniflora is found on the water's edge both along the bay and along mosquito ditches. Coverage by species other than S. alterniflora is even less frequent here than in other zones (Figure 8).

In addition to the aforementioned communities, panne communities are found on the marsh which are surrounded by S. alterniflora and then by Forb pannes. The structure and appearance of these panne communities are quite different though the species present are nearly the same, with one exception (Figures 9 and 10).

Miller and Egler also discuss the estuaries of this region. Zostera marina is often found at the estuary mouth and S. alterniflora along the edge. These estuaries are characterized by natural levees caused by the deposition of sediment as currents slowed by grasses overflow the banks.

Barrier Beach: Vegetation on the barrier beach at Napatree was studied by Mills and Sisson (1972). Sampling along a transect, they found that 75 percent of the area was beach grass habitat, 15 to 20 percent was upland vegetation, and salt marsh covered 5 to 10 percent of the area. A list of species, by zone, is included in Table 5. The beach grass zone, dominated by beach grass, also included much beach pea and seaside goldenrod. The transition zone, which begins behind the Kitchen area, was vegetated with bayberry, poison ivy, spike grass, sea rose, and other scrubby vegetation. The soil here is sandy to silty, and, because of its higher organic content, retains more water than soil in the beach grass zone. Also located in this zone is a small salt marsh, at the base of the fort, that is colonized by Spartina pectinata, Spartina patens, Spartina alterniflora, Panicum virgatum, Distichlis spicata, and Phragmites communis. Salt water seeps up from under the ground to supply this marsh. A small drainage channel from the Kitchen area also supplies salt water during perigee tides. The third community of upland vegetation includes many species, which have probably been imported by birds or humans. At the fort, the soil is organically rich and plant life includes bayberry, European grasses, ox-eye daisies, black-eyed susans, red cedar, Queen Anne's lace, sumac, and wild grape.

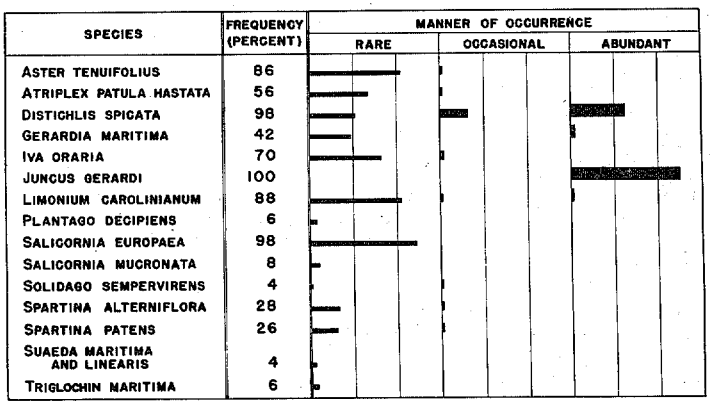


FIGURE 6

Vegetation of Juncus Upper Slope

Frequency and manner-of-occurrence of the species of the Juncus upper slope. The length of the bar is proportional to the number of quadrats showing the respective degree of occurrence.

From Miller and Egler, copyright 1950 by the Ecological Society of America.

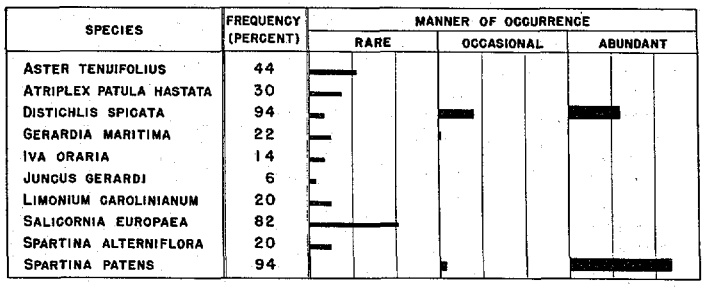


FIGURE 7

Vegetation of Spartina patens Lower Slope

Frequency and manner-of-occurrence of the Spartina patens lower slope. The length of the bar is proportional to the number of quadrats showing the respective degree of occurrence.

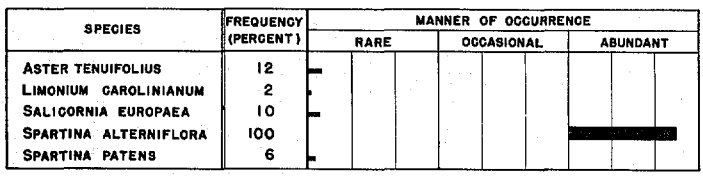


FIGURE 8

Vegetation of Spartina alterniflora Lower Border

Frequency and manner-of-occurrence of the species of the Spartina alterniflora lower border. The length of the bar is proportional to the number of quadrats showing the respective degree of occurrence.

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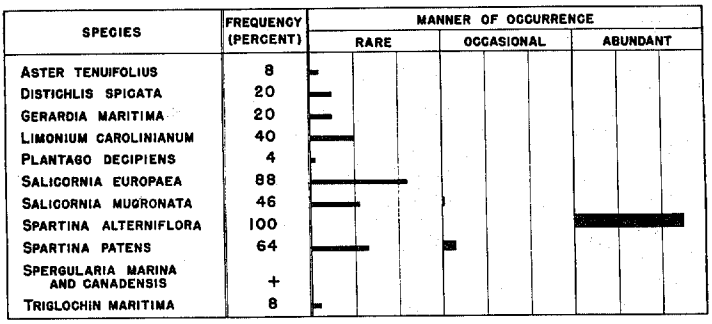

FIGURE 9

Vegetation of the Stunted Spartina alterniflora Community

Frequency and manner-of-occurrence of the species of the stunted Spartina alterniflora community. The length of the bar is proportional to the number of quadrats showing the respective degree of occurrence.

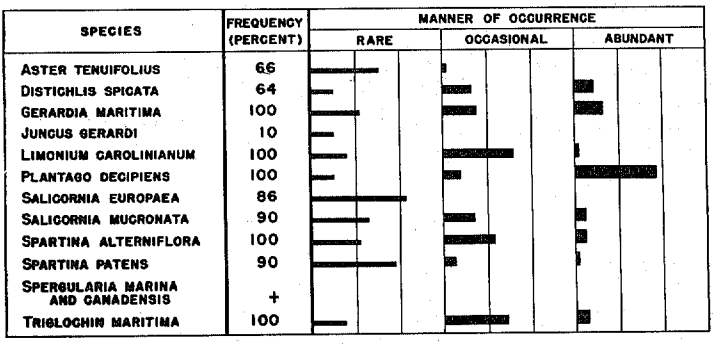

FIGURE 10

Vegetation of the Forb Panne

Frequency and manner-of-occurrence of the species of the Forb panne. The length of the bar is proportional to the number of quadrats showing the respective degree of occurrence.

From Miller and Egler, copyright 1950 by the Ecological Society of America.

Table 5

VEGETATION ON NAPATREE

Common Name	Latin Name	Sand	Trans	Upl	Marsh
Adams Flannel	*Verbasaum thapsus*		x		
Bayberry	*Myrica pensylvanica*		x	x	
Beach Grass	*Ammophila breviligulata*	x			
Beach Pea	*Lathyrus japonicus*	x			
Beach Plum	*Prunus maritima*		x		
Black-eyed Susan	*Rudbeckia hirta*		x	x	
Canadian Thistle	*Cersium arvense*			x	
Common Evening Primrose	*Oenothera biennis*		x		
Common Saltwort	*Salsola kali*	x			
Dew Berry	*Rubus flagellarum*		x		
Dusty Miller	*Artemisia stelleriana*	x			
English Plaintain	*Plantago lanceolata*		x	x	
European Grasses	*spp.*			x	
Glassworts	*Salicornia spp.*	x			
Lichens (on drift-wood)	*spp.*	x			
Ox-eye Daisy	*Chrysanthemum leucanthemum*		x	x	
Panic Grass	*Panicum virgatum*		x		x
Poison Ivy	*Rhus radicans*		x	x	
Queen Anne's Lace	*Daucus carota*			x	
Red Cedar	*Juniperus virginiana*		x	x	
Red Soldier (lichen)	*Cladonia christatella*	x			
Salt Meadow Cord-grass	*Spartina patens*		x		x
Sea Beach - Sand-wort	*Arenaria peploides*	x			
Sea Oats	*Uniola paniculata*	x			
Sea Rocket	*Cakile edentula*	x			
Sea Rose	*Rosa rugosa*	x			
Seaside goldenrod	*Solidago sempervirens*	x			
Seaside spurge	*Euphorbia polygonifolia*	x			
Sumac	*Rhus spp.*			x	
Spike grass	*Distichlis spicata*		x		x
Tall Cordgrass	*Spartina pectinata*		x		x
Tall Reed	*Phragmites communis*		x		x
Wild Grape	*Vitis rupestris*			x	
Wormwood	*Artemisia caudata*	x			
Wood Lily	*Lilium philadelphicum*		x		

Algae and sea grasses observed along the outer beach:

Ascophyllum modosum-rockweed
Chondrus crispus-Irish moss
Codium fragile-Japanese oyster weed
Enteromorpha intestinalis
Fucus vesiculosis-rockweed
Laminaria agardhii-kelp
Rhodyomenia palmata-dulse
Ulva lactuca-sea lettuce
Zostera marina-eel grass

From Mills and Sisson, 1972

Sculco (1972) studied revegetation in the beach grass zone. He observed that beach grass first ventured into an unvegetated but protected area by spreading rhizomes. Following some stabilization of the substrate, beach pea moved in, growing higher as the beach grass grew more dense. Lastly, seaside goldenrod colonized the area.

Periphyton

Studies of periphyton* and water chemistry have been performed in two freshwater sections of the Pawcatuck River, one at Kenyon (Wood, 1972) and one in the Usquepaug River (Hargraves and Wood, 1967). At Usquepaug, a total of 24 species were found with diatoms dominant in the spring, followed by green algae and some blue-green algae. A seasonal species list for the Kenyon and Peace Dale stations is included in Table 6.

Benthos

Many commercially valuable shellfish inhabit the Little Narragansett Bay and Pawcatuck River Estuary. The estuary is presently closed to shellfishing, however, because of pollution. Quahaugs (*Mercenaria mercenaria*) and a productive population of oysters (*Crassostrea virginica*) are found in the Pawcatuck (Olsen and Stevenson, 1975). Surf clams (*Spisula solidissima*) and soft-shelled clams (*Mya arenaria*) have also been reported in Little Narragansett Bay (Mills and Sisson, 1972). In 1975, scallops (*Aequipecten irradians*) were abundant in Little Narragansett Bay between Westerly and Stonington after being absent for several years. This area had been seeded one year earlier. Blue mussels (*Mytilus edulis*) are found on the west side of Napatree Point and on Sandy Point.

Beginning in April 1970, Ronald White (1972) made qualitative surveys of benthic life in the Kitchen area off Napatree Point by visual observation using SCUBA. At that time, the only infaunal organisms seen were quahaugs. The epifauna observed are listed in Table 7. Numerous benthic species were undoubtedly missed by White's sampling technique.

White observed dramatic changes in the Kitchen's benthic fauna during the two years of his survey. In May 1971, the number of quahaugs seemed the same as in April 1970, but by August numbers had decreased. By November 1971, periwinkles had greatly increased in number, looking like a "continuous carpet of snails" from a distance greater than four feet. The final observations for this survey

---

*periphyton is a term which applies to the total assemblage of sessile, or attached, flora on any substrate.

Table 6

SEASONAL PERIODICITY AMONG THE MORE PREVALENT PERIPHYTON SPECIES IN THE PAWCATUCK RIVER AT KENYON AND IN THE SAUGATUCKET RIVER AT PEACE DALE, R.I.

Permanent flora (present throughout the year):

Achnanthes linearis var. *pusilla*
Cocconeis placentula
Eunotia elegans
E. pectinalis
E. pectinalis var. *biarcuata*
E. pectinalis var. *minor*
Fragilaria virescens
Gomphonema angustatum var. *producta*
Melosira ambigua
Meridion circulare var. *constricta*
Nitzschia sublinearis
Pinnularia biceps
Stigeoclonium subsecundum (prostrate colonies)
Tabellaria fenestrata
T. flocculosa

Spring flora (increasing in spring, some (marked S or F) continuing into the summer and/or fall):

Asterionella formosa +S
Coleochaete sp. no. 1 +S,F
Cymbella ventricosa
Eunotia elegans
E. exigua
Fragilaria crotonensis
Gloeothece sp. no. 1
Gomphonema acuminatum var. *coronata* +F
G. parvulum +S,F
Melosira granulata
Navicula mutica
Pinnularia viridis
Scenedesmus quadricauda
Surirella sp. +S

Summer flora (increasing in summer, some (marked F) continuing into fall):

Achnanthes lanceolata
Coleochaete orbicularis
C. sp. no. 1 +F
Eunotia naegelii
Navicula cryptocephala
Nitzschia vermicularis +F
Oscillatoria princeps +F
O. sp. no. 2

Fall flora (increasing in fall, some (marked Sp) continuing into spring):

Achnanthes minutissima
Cymbella ventricosa +Sp
Eunotia incisa
Navicula rhynchocephala

From Wood, 1972.

Table 7

BENTHIC FAUNA OF THE PAWCATUCK RIVER ESTUARY
AND LITTLE NARRAGANSETT BAY

COMMON NAME	LATIN NAME
INFAUNA	
Quahaug	*Mercenaria mercenaria*
Soft-shelled clam	*Mya arenaria**
Surf clam	*Spisula solidissima**
EPIFAUNA	
Bay scallop	*Aequipecten irradians*
Blue crab	*Callinectes sapidus*
Rock crab	*Cancer irroratus*
Green crab	*Carcinus maenas*
Oyster	*Crassostrea virginica* **
Mole crab	*Emerita talpoida*
Mud crab	*Eurypanopeus sp.*
Lobster	*Homarus americanus*
Spider crab	*Libinia emarginata*
Horseshoe crab	*Limulus polyphemus*
Periwinkle	*Littorina littorea*
Mussel	*Mytilus edulis*
Lady crab	*Ovalipes ocellatus*
Moon snail	*Polenices duplicatus*
Oyster drill	*Urosalpinx cinerea*

*not listed by White but reported by Mills and Sisson

**not listed by White but reported by Olsen and Stevenson

Adopted from White, 1972

were made from April through June of 1972. At that time, the number of blue, lady, and rock crabs, as well as of scallops and lobsters, had decreased. A number of dead blue and rock crabs were seen, and quahaugs were observed to be dead or dying. Periwinkles, moon snails, and hermit crabs were all more abundant than before. White attributed these population changes to increased silt and decaying matter on the bottom, which results in the production of hydrogen sulfide.

Artificial Reef Biota: Alfieri (1975) studied the growth of attached biota to two artificial reefs placed in Little Narragansett Bay off the west coast of Napatree Point in July, 1972 and June, 1973. Five species of macroalgae became permanent residents on an automobile tire reef, with *Polysiphonia* the dominant species throughout the experiment. In addition to macroalgae, a number of invertebrates colonized the reef and three species of fish commonly associated with the reef. A list of permanent, part-time, and visitor species found on or around the reef is shown in Table 8.

Metals and Pesticides in Shellfish: The New England Regional Laboratory of the Environmental Protection Agency (Wong, 1973-1976) collected oysters and quahaugs at the mouth of the Pawcatuck River (see Figure 4) in 1973, 1974, and 1976. The shellfish were analyzed for seven heavy metals and for pesticides. Tables 9 and 10 present the results of the chemical analyses.

In addition, the Rhode Island Department of Health collected data in the fall of 1977 on three heavy metals (lead, cadmium, and chromium) in oysters at three stations (see Figure 4) in the estuary. The reported values are shown in Table 11.

Birds

Napatree is an excellent area for bird watching, due to its location on the migration route and its diversity of habitats.

More than 125 bird species (Table 12) have been observed there, including many nesting shore and land birds.

Mammals

Eleven mammal species have been reported on Napatree (Table 13). Small mammals are present, particularly in upland regions where food and cover are available. White-tail deer occasionally visit Napatree. Other mammals probably inhabit shore areas, but have not been reliably reported.

Table 8

LIST OF SPECIES FOUND ON OR AROUND THE ARTIFICIAL REEF WEST OF NAPATREE POINT IN LITTLE NARRAGANSETT BAY

Latin Name	Common Name
Rhodophyceae	Red algae
**Polysiphonia sp.*	
-Dasya pedicellata	
+Gracilaria sp. and family	
-Porphyra sp.	Dulse, purple laver
+Ceramium sp. and family	
Chlorophyceae	Green algae
**Enteromorpha sp.*	
+Ulva sp.	Sea lettuce, sea laver
**Cladophera sp.*	
-Codium sp.	Sea moss
Phaeophyceae	Brown seaweed
**Laminaria sp.*	Kelp
**Chordaria sp.*	Bootlace weed
Protozoa	
+Foraminifera	Foraminiferans
*Hydrozoa**	
Ectoprocta	
**Schizoporella sp.*	
+Bugula sp.	Bryozoan
Pelecypoda	Bivalves
+Mytilus edulus	Blue mussels
-Anomia sp.	Jingle shells
Gastropoda	Snails
+Littorina obtusata	Periwinkles
+Crepidula sp.	Slipper shells
+Eupleura caudata	Oyster drills
-Urosalpinx sp.	Oyster drills
Annelida	Segmented worms
+Polychaeta	Marine worm
Crustacea	
**Caprella geometrica*	Amphipod
+Callinectes sapidus	Blue crab
+Homarus americanus	Lobster
-Libinia emerginata	Spider crab
**Balunus sp.*	Barnacle
+Cancer borealis	Jonah crab
Asteroida	Starfish
**Asterias forbesi*	Starfish
Ascidiacea	
+Botryllus sp.	Sea squirt
Pisces	Fish
**Tautogolabrus adspersus*	Tautog
-Hemitripterus americanus	Sea raven
+Tautoga onitis	Tautog

*= permanent += part time -= visitor

From Alfieri, 1975

Table 9

AMOUNTS OF HEAVY METALS IN OYSTERS & QUAHAUGS IN ppm (DRY WEIGHT)

Collection Date	Benthic Organism	Mercury (Hg)	Zinc (Zn)	Copper (Cu)	Lead (Pb)	Cadmium (Cd)	Nickel (Ni)	Chromium (Cr)
6/20/73	Oyster	--	4500	230	--	7.0	2	2
3/13/74	Oyster	.87	4700	200	20	4.0	--	-
5/26/74	Oyster	.52	4600	220	10	---	10	-
5/12/76	Quahaug	.8	7580	326	10	7.9	--	2

from EPA, unpublished data

Table 10

PESTICIDE CONCENTRATION IN OYSTERS & QUAHAUGS IN ppb (20 GRAMS OF SHELLFISH MEAT)

Collection Date	Benthic Organism	P,P/DDT	O,P/DDT	P,P/DDE	O,P/DDE	Dieldrin	PCB'S (arachlor) 1248	1254	1260
5/20/73	Quahaug	ND	ND	ND	ND	ND	<100	<40	<50
5/26/74	Oyster	ND	--	28	ND	ND	--	167	--

ND = not detectable (The sensitivity of the test no detectable levels is 10 ppb.)
from EPA, unpublished data

Table 11

AMOUNTS OF HEAVY METALS IN OYSTERS IN ppm (WET WEIGHT*)- FALL, 1977

Stations	Lead (Pb)	Cadmium (Cd)	Chromium (Cr)
Avondale Boat Yard	1.06	.31	.32
South of Pawcatuck Rock	.56	.78	.31
Mouth of Pawcatuck River (Breen Rd.)	trace	.23	.15

*Wet weight measurements can be roughly compared to dry weight values by multiplying by 10, i.e. wet weight x 10 = dry weight.

From R.I. Department of Health, unpublished data

Table 12

BIRDS OF NAPATREE POINT

Group Name / Common Name	Latin Name	Water	Beach	Trans	Upl	Nest
Loons	*Gaviidae*					
Common Loon	*Gavia immer*	x				
Red-Throated	*Gavia stellata*	x				
Grebes	*Colymbidae*					
Horned	*Colymbus auritus*	x				
B Pied-Billed	*Podilymbus podiceps*	x				
Shearwaters	*Procellariidae*					
S Sooty	*Puffinus griseus*	x				
Cormorants	*Phalacrocoracidae*					
Great	*Phalacrocorax carbo*	x				
Double-Crested	*Phalacrocorax auritus*	x	x			
Herons	*Ardeidae*					
Great Blue	*Ardea herodias*		x	x		
Green	*Butorides virescens*		x	x		
Common Egret	*Casmerodius albus*		x	x		
S Snowy Egret	*Leucophoyx thula*		x			
Black-Crowned Night	*Nycticorax nycticorax*		x			
Bitterns	*Ardeidae*					
S American	*Botaurus lentiginosus*		x			
Swans	*Cygninae*					
Mute	*Cygnus olor*	x	x			
Geese	*Anserinae*					
Canada	*Branta canadensis*	x	x			
Brant	*Branta bernicla*	x	x			
S Snow	*Chen hyperborea*	x				
Surface Ducks	*Anatinae*					
Mallard	*Anas platyrhynchos*	x	x			
Black	*Anas rubripes*	x	x			
S Gadwall	*Anas strepera*	x				
B American Widgeon	*Mareca americana*	x				
Diving Ducks	*Aythyinae*					
Canvasback	*Aythya valisineria*	x				
Greater Scaup	*Aythya marila*	x				
Lesser Scaup	*Aythya affinis*	x				
Common Goldeneye	*Glaucionetta clangula*	x				
Bufflehead	*Glaucionetta albeola*	x				
Oldsquaw	*Clangula hyemalis*	x				
SB Harlequin	*Histrionicus histrioncus*	x				
Common Eider	*Somateria mollissima*	x				
SB King Eider	*Somateria spectabilis*	x				
White Winged Scoter	*Melanitta fusca*	x				
Surf Scoter	*Melanitta perspicillata*	x				
Common Scoter	*Oidemia nigra*	x				
S Ruddy Duck	*Erismatura jamaicensis*	x				
Mergansers	*Merginae*					
Red-Breasted	*Mergus serrator*	x				

Table 12 (cont.)

Group Name / Common Name	Latin Name	Water	Beach	Trans	Upl	Nest
Hawks	*Accipitrinae, Buteoninae Falconinae, Circinae, Pandionidae*					
S Sharp-Shinned	*Accipiter striatus*		x	x	x	
B Bald Eagle	*Haliaeetus leucocephalus*		x	x	x	
Marsh Hawk	*Circus cyaneus*		x	x	x	
SB Osprey	*Pandion haliaetus*		x	x	x	
Peregrine Falcon	*Falco peregrinus*		x	x	x	
S Pigeon Hawk	*Falco columbarius*		x	x	x	
Sparrow Hawk	*Falco sparverius*		x	x	x	
Oyster-catchers	*Haematopodidae*					
American	*Haematopus palliatus*	x	x			
Plovers	*Charadriidae*					
Semipalmated	*Charadrius hiaticula*		x			
Piping	*Charadrius melodus*		x			x
Killdeer	*Charadrius vociferus*		x			
SB Golden	*Pluvialis dominica*		x			
Black-Bellied	*Squatarola squatarola*		x			
Ruddy Turnstone	*Arenaria interpres*		x			
Sandpipers	*Scolopacidae*					
Common Snipe	*Capella gallinago*		x			
B Whimbrel	*Numenius phaeopus*		x			
Spotted Sand.	*Actitis macularia*		x			x
S Willet	*Catoptrophorus semipalmatus*		x			
Greater Yellow Legs	*Totanus melanoleucus*		x			
SB Knot	*Calidris canutus*		x			
Purple Sand.	*Erolia maritima*		x			
White Rumped Sand.	*Erolia fuscicollis*		x			
S Baird's Sand.	*Erolia bairdii*		x			
Least Sand.	*Erolia minutilla*		x			
Dunlin	*Erolia alpina*		x			
SB Dowitcher	*Limnodromus griseus*		x			
Semipalmated Sand.	*Ereunetes pusillus*		x			
S Buff-Breasted Sand.	*Tryngites subruficollis*		x			
Sanderling	*Crocethia alba*		x			
Phalarope	*Phalaropodidae*					
S Wilson's	*Steganopus tricolor*		x			
Jaegar	*Stercorariidae*					
S Parasitic	*Stercorarius parasiticus*	x				
S Long-Tailed	*Stercorarius longicaudus*	x				
Gulls	*Larinae*					
Great Black-Backed	*Larus marinus*	x	x			
Herring	*Larus argentatus*	x	x			
Ring-Billed	*Larus delawarensis*	x	x			
S Laughing	*Larus atricilla*	x	x			
Bonaparte's	*Larus philadelphia*	x	x			
Terns	*Sterninae*					
S Forster's	*Sterna forsteri*	x	x			

Table 12 (cont.)

Group Name / Common Name	Latin Name	Water	Beach	Trans	Upl	Nest
Common	*Sterna hirundo*	x	x			
Roseate	*Sterna dougallii*	x	x			
Least	*Sterna albifrons*	x	x			
S Royal	*Thalasseus maximus*	x	x			
S Caspian	*Hydroprogne caspia*	x	x			
S Black	*Chlidonias nigra*	x	x			
Skimmers	*Rynchopidae*					
S Black	*Rynchops nigra*	x				
Alcids	*Alcidae*					
S Razorbill	*Alca torda*	x				
S Dovekie	*Plautus alle*	x				
Doves	*Columbidae*					
B Mourning	*Zenaidura macroura*		x			
Owls	*Tytonidae & Strigidae*					
SB Snowy	*Nyecta scandiaca*		x	x	x	
Short-eared	*Asio flammeus*		x	x		
Woodpeckers	*Picidae*					
Yellow-shafted flicker	*Colaptes auratus*		x	x	x	
B Downy	*Dendrocopus pubescens*				x	
Flycatchers	*Tyrannidae*					
Eastern Kingbird	*Tyrannus tyrannus*			x	x	
Eastern Phoebe	*Sayornis phoebe*			x	x	
Larks	*Alaudidae*					
Horned	*Eremophila alpestris*		x			x
Swallows	*Hirundinidae*					
Tree	*Iridoprocne bicolor*		x	x	x	
Bank	*Riparia riparia*		x	x	x	x
Barn	*Hirundo rustica*		x	x	x	x
Cliff	*Petrochelidon pyrrhonota*				x	
Jays-Crows	*Corvidae*					
Blue Jay	*Cyanocitta cristata*				x	
Crow	*Corvus brachyrhynchos*		x	x		
Fish Crow	*Corvus ossifragus*		x			
Titmice	*Paridae*					
Black-Capped Chickadee	*Parus atricapillus*			x	x	
Wren	*Troglodytidae*					
S Short-Billed Marsh	*Cistothorus platensis*			x		
Mimics	*Mimidae*					
Catbird	*Dumetella carolinensis*				x	x
Brown Thrasher	*Toxostoma rufum*				x	x
Thrushes	*Turdidae*					
Robin	*Turdus migratorius*			x	x	
Kinglets	*Sylviidae*					
SB Golden-Crowned	*Regulus satrapa*				x	
SB Ruby-Crowned	*Regulus calendula*				x	
Pipits	*Motacillidae*					
SB American	*Anthus spinoletta*		x	x		

Table 12 (cont.)

Group Name / Common Name	Latin Name	Water	Beach	Trans	Upl	Nest
Starlings	*Sturnidae*					
Starling	*Sturnus vulgaris*			x	x	
Warblers	*Parulidae*					
Yellow	*Dendroica petechia*			x	x	x
Myrtle	*Dendroica coronata*			x	x	
S Palm	*Dendroica palmarum*			x	x	
Yellow-throat	*Geothylpis trichas*			x	x	x
Weaver Finches	*Ploceidae*					
House Sparrow	*Passer domesticus*		x		x	x
Blackbirds	*Icteridae*					
Eastern Meadowlark	*Sturnella magna*		x			
Redwinged	*Agelaius phoeniceus*		x	x	x	x
Common Grackle	*Quiscalus quiscula*		x	x	x	
S Cowbird	*Molothrus ater*		x			
Finches	*Fringillidae*					
Purple	*Carpodacus purpureus*		x	x	x	
House	*Carpodacus mexicanus*		x	x	x	
Gold	*Spinus tristis*			x	x	
S Pine Siskin	*Spinus pinus*			x	x	
S Redpoll	*Acanthis flammea*			x	x	
Sparrows	*Fringillidae*					
Rufous-Sided Towhee	*Pipilo erythrophthalmus*			x	x	
Ipswich Sparrow	*Passerculus princeps*		x			
S Savannah Sparrow	*Passerculus sandwichensis*		x	x		x
Song Sparrow	*Melospiza melodia*		x	x	x	x
Slate-colored Junco	*Junco hyemalis*				x	
S Snow Bunting	*Plectrophenax nivalis*		x	x	x	

S Observed by Eloise Saunders of Westerly, RI

B Observed by Lawrence E. Brooks of Stonington, CT

From Mills and Sisson, 1972

Table 13

MAMMALS OF NAPATREE POINT

	Common Name	Latin Name	Beach Grass	Transition	Upland
	Opossum	*Didelphis marsupialis*			x
	Little Brown Bat	*Myotis lucifugus*	x	x	x
	Raccoon	*Procyon lotor*		x	x
*	Long Tail Weasel	*Mustela frenata*	x	x	x
	Skunk	*Mephitis mephitis*	x	x	x
*	Red Fox	*Vulpes fulva*		x	x
o	Gray Squirrel	*Sciurus carolinensis*			x
	White Footed Mouse	*Peromyscus leucopus*			x
	Meadow Vole	*Microtus pennsylvanicus*	x		x
	Eastern Cottontail	*Sylvilagus floridans*		x	x
*	White Tail Deer	*Odocoileus virginianus*			x

* Not verified by survey observations but likely visitors or residents of Napatree

o Observed by Eloise Saunders in a year of high populations

From Mills and Sisson, 1972

Fish

The most extensive fish survey of Little Narragansett Bay and the Pawcatuck River was conducted at the mouth of the River with a 50-foot, 1/4-inch-mesh minnow seine (Gordon, 1958). The American eel (*Anguilla rostrata*) was abundant both in the river and in Little Narragansett Bay, in sizes ranging from 6 to 36 inches. Other species found were striped bass (*Morone americana*; range of 7-12 inches; river), anchovy (*Anchoa mitchilli*; abundant; river mouth), pipefish (*Syngnathus fuscus*; bay), sea sturgeon (*Acipenser oxyrhyncus*; one 6'4", 7 miles upriver), and brook trout (*Salvelinus frontinalis*; in tidal reaches of the river, although it is primarily a freshwater species). Three anadromous species were also identified: smelt (*Osermus mordax*; there is a small gill net fishery), alewife shad (*Alosa sapidissima*), and alewife (*Alosa pseudoharengus*). Five ponds associated with the river were stocked with alewives in the early 1970s and the run is now the best in the state. The Department of Environmental Management has begun a program to reestablish shad and to introduce steelhead trout into the Pawcatuck River. The observations made by Mills and Sisson (1972) and White (1972) indicate that winter flounder (*Pseudopleuronectes americanus*), striped bass (*Morone saxatilis*), bluefish *Pomatomus saltatrix*), tautog (*Tautoga onitis*), scup (*Stenotomus chrysops*), and sand dab (*Scopthalmus aquosus*) are present in Little Narragansett Bay near Napatree Point. Certainly other fish species are present, but no records are available (see Table 14 for a summary species list).

WORK IN PROGRESS

A study to determine the effects of land use on water quality in the Pawcatuck River Estuary, and to develop techniques for managing the estuary, is in progress at the University of Rhode Island. The purpose of this study which is being conducted by the Department of Community Planning and Area Development (Kupa *et al.*) is to analyze three growth and development models for the communities of Westerly and Stonington and their subsequent effects on the water quality of the Pawcatuck River Estuary. In addition, plans will be developed for carrying out an interstate estuarine management program that will maintain state standards for water quality and sustain the functional nature of the shared estuarine ecosystem.

The Army Corps of Engineers is in the process of writing a Draft Environmental Impact Statement (DEIS) evaluating the impacts of maintenance dredging in Little Narragansett Bay, the Pawcatuck River Estuary, and Watch Hill Cove. This document is scheduled for release in 1978.

Table 14

FISH OF THE PAWCATUCK RIVER ESTUARY AND LITTLE NARRAGANSETT BAY

Common Name	Latin Name
Sea sturgeon	*Acipenser oxyrhyncus*
Alewife	*Alosa pseudoharengus*
Shad	*Alosa sapidissima*
American eel	*Anchoa mitchilli*
Anchovy	*Anguilla rostrata*
Weakfish	*Cynoscion regalis*
Smelt	*Osmerus moidax*
Bluefish	*Pomatomus saltatrix*
Winter flounder	*Pseudopleuronectes americanus*
Striped bass	*Morone saxatilis*
Brook trout	*Salvelinus frontinalis*
Sand dab	*Scophthalmus aquosus*
Scup	*Stenotomus chrysops*
Pipefish	*Syngnathus fuscus*
Tautog	*Tautoga onitis*

Henry Stebbins, a biology teacher at Wheeler High School in North Stonington, Connecticut, and his students are continuing their study of the water chemistry of the Pawcatuck River Estuary. Parameters to be examined include temperature, salinity, density, and coliform count.

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APPENDIX

Table A-1

PAWCATUCK RIVER AT WHITE ROCK, R.I.
DISSOLVED OXYGEN (DO), (MILLIGRAMS PER LITER), MAY TO OCTOBER 1971

	May		June		July		August		September		October	
Day	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
1	10.5	9.2	12.0	9.1	10.1	7.8	8.0	5.2	10.4	6.2	10.0	6.6
2	10.1	9.2	13.4	9.2	10.0	7.8	8.7	5.0	10.4	6.9	9.9	6.5
3	9.7	9.5	11.1	8.5	10.7	7.7	10.6	5.3	10.0	5.5	10.3	6.5
4	10.4	9.6	10.1	7.0	10.8	8.4	7.0	4.5	10.0	5.5	10.7	6.9
5	10.8	10.0	10.5	8.5	12.4	8.4	9.6	4.5	10.5	5.6	10.4	6.6
6	10.0	9.2	12.2	9.0	10.5	6.8	9.9	5.2	10.5	5.5	8.1	5.6
7	10.0	9.1	--	--	10.8	6.8	9.9	5.1	9.4	5.5	9.0	5.7
8	9.5	9.2	--	--	9.3	6.0	10.2	4.9	9.7	5.4	9.2	6.0
9	9.6	9.1	--	--	8.0	4.0	10.2	5.1	10.0	5.6	9.9	6.3
10	10.5	9.6	--	--	9.2	5.0	10.9	5.1	10.4	5.5	7.2	6.2
11	10.7	10.1	--	--	8.7	5.5	11.8	6.2	9.0	5.8	7.2	6.2
12	10.1	9.0	--	--	10.1	5.5	12.2	7.1	10.1	5.6	8.3	6.6
13	9.0	8.3	--	--	10.2	7.8	11.9	7.4	9.2	6.0	9.1	7.6
14	8.8	8.4	--	--	9.6	7.0	14.0	6.0	9.3	5.8	9.2	7.5
15	8.7	8.0	--	--	10.0	7.0	13.1	7.0	10.0	5.3	9.1	7.4
16	8.5	8.0	--	--	10.0	6.9	12.5	6.4	8.5	5.6	9.1	7.0
17	9.5	8.4	--	--	10.0	7.0	13.5	6.9	8.2	4.6	9.2	6.8
18	10.0	9.0	--	--	10.7	7.0	12.4	6.1	8.0	5.2	9.2	6.4
19	9.0	8.7	--	--	9.0	7.1	10.0	4.9	9.3	5.8	9.4	6.3
20	8.7	8.3	--	--	8.1	7.0	9.7	5.6	8.4	5.9	9.4	6.2
21	8.4	7.5	--	--	8.3	7.0	9.5	5.0	10.0	5.1	9.0	6.3
22	8.0	7.3	--	--	8.4	6.5	9.3	4.0	10.0	6.0	9.0	6.3
23	8.4	7.5	--	--	8.4	6.5	9.5	4.0	10.0	6.2	9.6	6.4
24	9.2	8.0	--	--	8.6	6.5	9.5	5.5	10.0	5.9	8.1	6.6
25	9.5	9.0	8.1	5.5	7.1	5.9	11.3	6.7	10.4	6.7	7.2	5.7
26	8.2	6.0	7.9	5.4	7.1	5.6	11.5	7.3	10.5	7.0	7.2	5.4
27	9.3	6.8	10.0	6.7	8.0	5.8	8.4	6.4	11.0	7.5	5.8	4.5
28	9.8	6.8	11.0	7.1	8.5	5.3	9.5	5.5	10.3	7.0	6.1	4.4
29	10.3	7.4	12.2	9.4	8.0	5.2	9.4	5.3	11.0	6.9	7.0	5.1
30	9.8	7.9	11.6	8.8	8.2	6.0	9.7	4.9	10.4	4.9	7.4	5.1
31	9.6	8.0	--	--	8.3	5.5	10.0	5.4	--	--	7.2	5.5
Month	10.8	6.0	--	--	12.4	4.0	14.0	4.0	11.0	4.6	10.7	4.4
Period	14.0	4.0										

Location -- Lat 41°23'51", long 71°50'33", Washington County, two parameter monitor on old trolley bridge 0.2 mile southwest of White Rock and 1.2 miles upstream from gaging station at Westerly.

Period of Record -- Chemical analyses: May to October 1971.
Water temperatures: May to October 1971.

Extremes -- May to October 1971:
Dissolved oxygen: Maximum, 14.0 mg/l Aug. 14; minimum, 4.0 mg/l July 9, Aug. 22, 23.
Water temperatures: Maximum, 30.0°C Aug. 14; minimum, 9.5°C May 4, 5.

From U.S. Department of Interior, Geological Survey, 1971

Table A-2

PAWCATUCK RIVER AT WHITE ROCK, R.I.

TEMPERATURE (°C) OF WATER, MAY TO OCTOBER 1971

	May		June		July		August		September		October	
Day	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
1	12.0	11.0	19.0	14.5	24.5	24.0	26.0	24.0	--	--	20.5	17.5
2	12.0	11.0	18.5	13.5	27.5	24.0	26.0	24.0	23.5	21.5	20.5	17.0
3	11.0	10.0	18.0	13.5	26.0	23.5	26.0	24.0	23.0	21.0	19.5	17.0
4	10.0	9.5	21.0	12.5	25.5	23.0	25.0	21.0	24.5	21.5	17.5	16.5
5	11.0	9.5	19.0	14.0	25.0	23.0	24.5	21.0	25.0	22.0	19.0	16.5
6	12.5	11.0	20.0	13.0	26.0	23.0	23.5	22.0	23.5	22.5	24.0	17.5
7	14.0	12.5	--	--	26.0	23.0	24.0	22.0	22.5	21.5	20.0	15.5
8	14.0	13.0	--	--	28.0	21.0	25.0	22.5	25.0	22.0	17.0	12.5
9	13.0	11.5	--	--	25.5	23.0	26.5	24.0	25.5	22.5	13.0	11.0
10	11.5	11.0	--	--	25.0	23.5	27.0	25.0	25.0	22.5	17.0	12.0
11	15.0	11.0	--	--	24.5	23.0	28.0	26.5	23.0	22.0	15.5	11.5
12	15.0	14.5	--	--	25.0	22.0	29.0	27.0	25.0	22.5	--	--
13	15.0	14.0	--	--	25.0	22.5	28.0	23.5	24.0	22.5	--	--
14	16.0	14.0	--	--	25.5	24.0	30.0	22.0	23.0	22.5	--	--
15	19.5	16.0	--	--	26.5	23.5	28.0	27.0	--	--	--	--
16	21.0	19.5	--	--	26.0	24.5	28.0	25.5	25.0	20.5	--	--
17	20.0	17.0	--	--	29.5	24.5	27.0	24.0	23.0	20.5	--	--
18	19.0	16.5	--	--	27.0	24.0	26.5	24.0	23.0	21.0	--	--
19	19.0	17.0	--	--	25.0	22.5	25.5	23.5	26.0	21.0	--	--
20	19.0	18.0	--	--	23.0	21.5	--	--	21.5	21.0	14.5	13.5
21	19.0	18.0	--	--	22.5	22.5	--	--	--	--	15.0	14.5
22	19.0	17.5	--	--	23.0	22.0	--	--	23.5	20.0	15.0	14.0
23	20.0	18.0	--	--	24.0	22.0	--	--	22.5	19.5	14.5	13.5
24	19.0	18.0	--	--	24.0	23.0	--	--	22.0	19.5	14.5	14.0
25	19.0	17.5	26.5	23.5	24.0	23.0	--	--	20.0	18.0	14.0	14.0
26	21.5	18.0	26.5	24.5	24.0	23.0	--	--	18.0	18.0	15.0	14.0
27	20.0	17.0	26.5	24.5	25.5	23.5	--	--	18.0	17.5	15.5	14.5
28	19.0	16.0	26.0	24.0	26.5	24.0	--	--	18.0	17.5	16.5	15.5
29	20.0	15.0	24.5	23.5	26.0	24.0	--	--	19.0	17.5	17.0	15.5
30	18.5	17.0	25.5	23.5	25.0	24.0	--	--	20.5	17.5	17.0	16.0
31	20.0	17.0	--	--	26.0	24.0	--	--	--	--	17.0	16.0
Month	21.5	9.5	--	--	29.5	21.0	--	--	26.0	17.5	--	--
Period	30.0	9.5										

From U.S. Department of Interior, Geological Survey, 1971

TABLE A-3

Rhode Island Department of Health Water Quality Survey Data

Pawcatuck River Basin

August 22, 1973 (unless otherwise noted)

Location	River Mile	Flow (mgd)	Temp.[a] (°F)	DO[a] (mg/l)	BOD_5[a] (mg/l)	Total[a] Coliform (MPN/100ml)	Fecal[a] Coliform (MPN/100ml)	Ammonia[b] Nitrogen (mg/l)	Total[b] Copper (mg/l)	Total[b] Zinc (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)
Green Haven Road Stonington, CT	1.3	Tidal	73 76 79	6.1 7.4 10.3	1.2 2.4 4.2	2,100 3,350 4,300	150 840 930	0.44	0.47	0.32	0.400	0.010
Main Street Bridge Westerly, RI	4.8	157	71 75 79	4.4 4.6 6.2	1.6 2.5 3.3	230 2,615 9,300	230 430 4,300	0.18	0.10	0.06	---	0.004
Boom Bridge Highway Bridge Westerly, RI	8.4	141	72 75 77	3.3 4.2 4.5	1.6 3.0 5.3	430 2,415 9,300	150 930 930	0.14	0.07	0.06	---	0.010
Meeting House Bridge (RI Route 3) Hopkinton, RI	11.6	138	72 75 78	3.1 3.5 3.7	1.9 3.0 3.7	750 930 4.600	73 290 430	0.16	0.07	0.06	0.100	0.010
Narragansett Electric Company Substation Hopkinton, RI	13.3	137	72 74 77	3.6 3.8 4.6	2.0 3.0 4.6	1,500 2,400 2,400	230 680 930	0.16	0.05	0.06	0.000	0.100
Bradford Road Bridge Westerly, RI	17.0	126	71 72 76	5.9 6.2 6.6	1.1 2.2 3.8	2,400 3,500 15,000	43 585 2,400	0.11	0.05	0.07	0.100	0.002
Burdickville Road Bridge Hopkinton, RI	20.5	c	65 65 66	6.5 6.9 7.2	1.1 1.9 3.1	9,300 33,500 43,000	9,300 19,500 43,000	0.13	0.08	0.10	0.000	0.000
Same - August 30, 1973		118	71 74 76	6.4 6.8 7.5	1.3 1.4 4.4	3,050 4,600 1,500	460 460 460	0.14	0.08	0.14	0.100	0.002
Wood River Alton-Carolina Road (RI Route 91) Richmond, RI	21.6+ 0.6	67	66 67 68	6.6 7.4 7.8	0.5 2.1 4.0	390 840 2,400	240 315 930	0.09	0.03	0.09	---	---

TABLE A-3 (cont'd)

Location	River Mile	Flow (mgd)	Temp.[a] (°F)	DO[a] (mg/l)	BOD_5[a] (mg/l)	Total[a] Coliform (MPN/100ml)	Fecal[a] Coliform (MPN/100ml)	Ammonia[b] Nitrogen (mg/l)	Total[b] Copper (mg/l)	Total[b] Zinc (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)
Kings Factory Road			65	5.8	1.5	15,000	7,500					
Wood River Junction, RI	24.0	92	65	6.6	1.8	68,000	15,000	0.17	0.05	0.07	0.000	0.000
			65	6.9	3.0	390,000	43,000					
Alton-Carolina Road			64	6.4	1.7	23,000	≤ 2,300					
(RI Route 91)	25.3	85	65	6.5	1.8	43,000	33,000	0.20	0.07	0.10	0.000	0.000
Charlestown, RI			66	7.0	2.5	150,000	75,000					
Carolina Dam			64	5.7	1.9	15,000	9,100					
Charlestown, RI	27.1	82	66	7.2	2.0	84,000	32,000	0.23	0.04	0.07	0.000	0.000
			67	7.4	2.4	460,000	43,000					
Shannock Dam			65	4.8	2.1	430,000	240,000					
Richmond, RI	29.0	78	66	5.0	2.6	430,000	315,000	0.23	0.05	0.10	0.000	0.010
			67	5.3	3.0	750,000	430,000					

[a] Data tabulated presented in order: Minimum, Median, and Maximum of values obtained during a twenty-four-hour sampling period. Samples taken at two-hour intervals.

[b] Composite of all samples collected at station

c Error in calculation suspected

From Rhode Island Statewide Planning Program and Rhode Island Department of Health, 1976

Table A-4

CHEMICAL-PHYSICAL, HYDROLOGIC AND COLIFORM DATA IN THE PAWCATUCK RIVER AT ROUTE 2, KENYON, R.I.

	March	April	May	June	July	August
Temperature, °C	2.0	9.1	13.0	19.0	22.3	25.2
pH	5.28	6.10	5.85	6.10	6.25	6.15
Alkalinity, ppm	0.7	2.7	2.5	4.4	6.0	4.1
Dissolved oxygen, ppm	9.72	8.64	7.62	5.20	4.20	4.04
% oxygen saturation	---	75	72	55	52	49
Conductivity, u mhos	55	71	---	80	97	90
PO_4, ppm	---	0.008	0.026	0.091	0.076	0.071
NO_3, ppm	---	0.000	0.000	0.000	0.128	---
Color	60	65	100	130	80	80
Turbidity, JTU	---	---	---	---	3.1	---
Velocity, ft/sec	---	---	0.55	0.55	0.39	0.39
Discharge, ft^3 sec	---	---	113.96	85.84	56.67	56.63
Coliform, cells/100 ml	---	336.8	---	2496.1	3095	3215

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Temperature, °C	19.0	13.0	3.2	3.0	0.0	0.0
pH	6.41	6.41	6.60?	5.88	5.20	5.30
Alkalinity, ppm	6.2	4.1	5.0	1.8	1.4	1.2
Dissolved oxygen, ppm	6.08	6.40	11.20	10.40	11.04	10.80
% oxygen saturation	65	60	83	---	---	---
Conductivity, u mhos	90	99	115	98	91	70
PO_4, ppm	0.028	0.002	0.010	0.021	0.017	0.008
NO_3, ppm	0.407	0.191	0.518	0.000	0.226	0.010
Color	35	50	30	60	40	45
Turbidity, JTU	---	---	---	1.0	1.0	1.0
Velocity, ft/sec	0.20	0.22	0.14	0.37	0.61	1.22
Discharge, ft^3/sec	27.94	30.78	20.34	62.84	105.05	232.5
Coliform, cells/100 ml	2200	3379	1222	60	111	104

From Wood, 1972

Table A-5

TEMPERATURE, SALINITY, AND DISSOLVED OXYGEN (DO) OF THE PAWCATUCK RIVER ESTUARY

Date*	Westerly Marina			Westerly Yacht Club			Avondale Town Dock			Watch Hill (Breen Road)		
	temp C	sal o/oo	DO ppm	temp	sal	DO	temp	sal	DO	temp	sal	DO
2/22/70	4.0	<1.0	--	2.0	1.0	--	2.0	2.0	--	2.0	5.5	--
3/08/70	5.0	1.5	--	5.0	2.0	--	4.0	12.5	--	4.0	22.5	--
3/22/70	7.0	2.2	13.0	6.0	3.0	13.0	6.0	10.0	14.0	6.0	24.8	14.0
4/05/70	6.0	0.0	12.0	6.0	<1.0	10.0	7.0	2.0	11.0	7.0	1.5	11.0
4/20/70	10.0	1.5	9.0	9.0	2.0	10.0	8.0	16.4	7.0	10.0	21.2	11.0
5/04/70	14.0	1.0	11.0	14.0	3.0	9.0	13.0	17.8	8.0	12.0	17.0	9.5
5/18/70	14.5	1	12.0	14.5	2	11.0	14.0	5	9.0	13.0	12.5	6.0
6/02/70	18	3.0	12.0	18	3.0	8.0	14	5.0	8.0	18	11.8	12.0
6/15/70	17.0	1.5	7.5	19.0	2.5	7.0	19.0	6.5	6.5	18.0	12.0	8.0
6/30/70	17	4.0	10.0	18	2.0	9.0	18	7.0	6.0	18	11.5	13.0
7/18/70	22.0	2.0	8.0	23.0	5.5	8.0	23.0	11.5	6.0	22.0	26.5	8.0
8/03/70	23.5	2.0	5.0	21.0	2.0	8.0	24.5	10.5	10.5	24.0	17.5	11.0
8/17/70	24	0.0	6.5	25.0	11.0	7.5	24	21.0	6.5	23.5	22.5	--
8/19/70 2330 hrs	24.5	--	8.0	24.0	--	9.0	22.6	--	8.0	21.5	--	8.5
8/20/70 0800 hrs	22.8	--	5.0	23.2	--	7.5	22.0	--	8.0	22.5	--	7.5
8/21/70 0445 hrs	23.0	--	5.0	21.5	--	5.5	21.0	--	6.5	20.8	--	5.0
8/31/70	23.0	0.0	6.5	22.5	5.5	9.0	22.0	22.0	7.5	22.0	26.5	7.5
9/11/70	18.0	3.5	7.5	17.5	--	8.5	18.0	13.5	8.5	17.5	21.8	7.5
9/28/70	17.0	4.0	6.0	16.5	4.4	7.0	17.5	--	7.5	17.0	--	8.0
10/26/70	15.0	5.0	8.0	14.0	5.5	8.0	14.0	9.0	7.5	15.0	23.6	7.0
11/24/70	7	2.4	8.0	5	<1.0	7.0	5	1.6	7.0	6	6.4	--
1/07/71	0	< 1	--	0	1.4	--	ice	--	--	0	5.4	--
4/05/71	8	2.2	12.0	8	<1.0	11.0	8	7.8	11.0	8	9.8	11.0
4/19/71	8.5	2.2	8.5	7.0	4.8	8.5	7.0	11.2	9.5	7.0	18.8	11.5
4/30/71	8.0	1.8	8.5	8.0	3.1	8.5	8.0	8.6	9.0	8.0	12.0	9.5
5/17/71	12.5	0.5	8.0	12.5	4.1	7.0	12.5	10.8	7.5	13.0	12.7	9.5
6/07/71	18.0	0.5	6.5	17.0	1.0	7.0	19.0	4.6	7.0	19.0	11.9	9.0
6/21/71	20.0	0.0	5.5	22.0	4.6	7.0	22.0	7.6	7.5	20.0	17.4	9.0
7/06/71	24.0	0.0	6.5	24.0	0.0	9.5	24.0	8.6	12.0	23.5	15.6	12.0
7/20/71	21	0.0	5.0	21	2.4	5.5	21	10.8	3.5	22	16.7	5.5
8/03/71	25.0	0.0	3.5	26.0	0.0	6.5	26.0	0.0	6.5	24.0	10.5	8.0
8/16/71	22	3.8	8.5	21	12.0	11.0	21	17.8	7.5	21.5	26.3	8.5
8/30/71	23	3.9	6.5	23	5.4	7.0	22	16.2	7.0	22	21.2	8.0
9/16/71	--	3.9	6.5	28.0	6.2	10.0	26.0	16.6	11.5	23.5	20.1	11.5
9/28/71	20	2.6	9.0	20	25.6	7.5	19	26.3	10.0	18.5	29.0	9.5
10/26/71	13.0	5.5	6.5	15.0	11.2	7.5	15.0	21.2	6.5	15.0	27.6	7.5
11/15/71	4.0	3.7	10.5	1.0	5.5	10.5	4.0	15.2	10.0	5.0	27.4	10.0
11/30/71	5.0	2.5	12.0	5.5	3.9	11.5	5.5	10.1	11.5	7.0	20.6	10.5
12/13/71	5.0	1.7	11.5	6.0	1.6	11.5	5.0	5.2	12.0	5.0	12.8	12.0

Table A-5 (cont.)

TEMPERATURE, SALINITY, AND DISSOLVED OXYGEN (DO) OF THE PAWCATUCK RIVER ESTUARY

Date*	Westerly Marina			Westerly Yacht Club			Avondale Town Dock			Watch Hill (Breen Road)		
	temp C	sal o/oo	DO ppm	temp	sal	DO	temp	sal	DO	temp	sal	DO
1/04/72	2	0.0	14.0	2	0.0	12.0	2	3.0	12.5	5	12.8	12.5
1/17/72	ice			ice			ice			ice		
1/31/72	ice			ice			ice			ice		
+2/14/72	0.5	1.6	13.5	ice			ice			ice		
+2/28/72	1.3	0.0	10.2	1.0	0.0	10.2	1.2	0.0	10.0	--	--	--
3/13/72	2.9	0.5	13.5	3.2	0.3	14.0	3.5	3.2	13.0	4.0	13.3	13.5
3/23/72	4.0	0.0	12.0	4.2	0.0	12.0	3.9	0.0	12.0	3.8	6.5	13.0
4/10/72	5.0	0.0	14.0	4.0	0.5	14.0	4.5	4.5	13.0	5.0	7.0	13.5
4/24/72	10.0	2.2	11.5	9.9	2.5	10.3	10.4	5.5	10.6	10.2	8.0	11.6
5/08/72	14.0	0.4	9.0	14.0	0.4	8.6	13.5	3.2	8.7	8.0	11.4	9.9
5/22/72	16.9	5.5	9.0	16.8	6.0	8.8	17.0	9.5	8.8	17.5	21.0	9.7
6/05/72	18.0	0.9	7.8	18.0	0.9	7.4	17.8	2.8	7.5	17.8	8.9	8.2
6/19/72	16.2	0.2	7.4	16.0	2.0	7.4	16.5	5.2	6.2	15.7	12.2	6.7
7/05/72	19.3	0.5	6.4	19.2	1.0	6.2	18.6	5.0	5.9	18.6	14.0	5.9
9/01/72	22.0	8.0	9.0	24.0	10.5	8.0	24.0	22.0	8.5	22.5	24.5	9.5
9/19/72	18.8	9.0	5.9	19.3	9.0	6.3	20.4	14.0	7.0	21.0	20.5	6.0
9/28/72	22.5	0.0	2.8	23.0	3.0	2.9	23.0	14.0	3.6	22.5	9.5	6.4
11/13/72	8.6	<1.0	10.5	8.6	1.0	10.5	8.9	1.0	10.5	9.2	8	9.5
4/18/73	14.5	0.0	--	14.5	1.0	10.0	14.5	2.0	10.5	15.5	8.0	9.0
6/07/73	18.8	0	6	20.5	6.3	7	20.0**	12.8**	6**	20.5***	28.9***	5 ***
6/21/73	19.0	3.0	7.0	19.0	3.0	7.5	19.0	8.0	7.5	17.0	30.0	9.0

*unless otherwise noted samples taken between 7-8 a.m.

**Frank Hall Boat Yard

***Watch Hill Boat Yard

+Ice breaking up in river-fresh water lens apparent

Compiled from unpublished data by the Department of Environmental Management - Wickford Laboratory

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