An Aquaculture Management Plan

for

Rhode Island Coastal Waters

prepared by: William J. Lapin
Marine Biologist
R.I. Div. of Fish & Wildlife

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FOREWARD

This plan for managing aquaculture in the coastal waters of Rhode Island was prepared in response to requests by the Department of Environmental Management, the Marine Fisheries Council, and the Coastal Resources Management Council.

The plan is dynamic; and as situations within the state's coastal waters change, and as more information concerning these areas becomes available, modifications to the plan will be made.

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Thanks also goes out to Paula Baczenski and Susan Farnham for assistance with cartographic work and to Patricia Sullivan for typing.

PURPOSE AND INTENT OF THE MANAGEMENT PLAN

The management plan for aquaculture in Rhode Island is to be used as a guideline for directing the growth of aquaculture within the state's coastal waters. It is designed to furnish both the state's Coastal Resources Management Council and the Marine Fisheries Council with information to aid them in making decisions regarding the approval of individual aquaculture permits and leases. It also provides the councils with information which can be considered when formulating future policies and regulations regarding aquaculture. In addition, prospective aquaculturists can benefit from the plan by using it as a guide to help them in selecting potential aquaculture sites.

Since the current major concern with the expansion of aquaculture in the state is its conflict with other traditional uses, the initial phase of this plan is to designate specific areas of the coastal waters where current, traditional uses would take precedence over aquaculture. Where obvious conflicts exist, recommendations have been made to restrict or discourage aquaculture activities. Those areas in which aquaculture activities are not recommended to be restricted or discouraged would be acceptable for application as proposed aquaculture sites. These areas, however, would still be subject to the decision-making process of the CRMC

as far as the determination of whether or not a permit for aquaculture would be granted. Applying for an aquaculture site in an area not restricted or discourage in the plan does not in any way imply that the applicant would be assured of being awarded an assent; it would only mean that many of the more obvious conflicts which would prevent the applicant from obtaining an assent would be avoided.

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SECTION A

INTRODUCTION

Aquaculture can be defined as the cultivation of aquatic plants or animals under either natural or artificial conditions. It can include the rearing of finfish in pens, tanks, impoundments, or raceways; the culture of shellfish on the sea bottom, suspended in the water column, or in tanks and raceways; or numerous other techniques employed to culture a variety of aquatic species.

The biological potential for certain types of aquaculture in Rhode Island is excellent. For example, many of the state's coastal ponds and estuaries, as well as many areas of Narragansett Bay, would provide an excellent habitat for the culture and rearing of various species of shellfish. The proper combinations of temperature, salinity, shelter, plankton, and other factors necessary for the culture of shellfish can be found in many locations. The most important factor limiting the expansion of aquaculture in Rhode Island is the conflict of aquaculture with other traditional activities in the coastal waters. Although other uses would prohibit the rampant proliferation of aquaculture, a limited, controlled growth of aquaculture within the coastal waters appears possible.

APPLICATION PROCEDURE

Any person or corporation wishing to conduct aquaculture within the coastal waters of Rhode Island must first obtain a permit from the R. I. Coastal Resources Management Council. Paragraph 3, Chapter 10, of Title 20 of the General Laws of Rhode Island entitled "Fish and Game" states in part that "the CRMC may grant permits for the conduct of aquaculture in the coastal waters of the state, including coastal ponds and estuaries to coastal rivers, to any person, or any corporation or business entity, chartered under the laws of this state, subject to the provisions of this chapter." Information concerning the application procedure can be obtained by writing to the Coastal Resources Management Council, 60 Davis Street, Providence, R. I. 02908.

Since the circumstances may vary greatly from one aquaculture application to another, the CRMC has elected to treat each application on an individual basis. In this way, all the facts pertinent to each application can be reviewed and a fair appraisal of the situation derived. A decision on whether to grant, modify, or deny permits for the conduct of aquaculture can then be made for each application.

Once an aquaculture permit is granted, the aquaculturist may obtain a special permit from the Director of the Department of Environmental Management which would exempt him from

certain R. I. Fish and Wildlife laws. This permit may allow the aquaculturist to possess controlled species out of season, to possess sub-legal sized species, to collect wild shellfish spat, or to perform other specific activities necessary to conduct the aquaculture activities allowed by his assent. This permit can be obtained from the R. I. Division of Fish and Wildlife, Washington County Government Center, Tower Hill Road, Wakefield, R. I. 02879.

POTENTIAL USE CONFLICTS

Aquaculture would not be compatible with several traditional activities within the state's coastal waters. In areas where certain types of aquaculture are shown to conflict with these activities, a permit for the conduct of that particular type of aquaculture would not be granted. Some of these activities include:

1. Fishing. The constitution of the State of Rhode Island guarantees the right of fishery to the people. This right is utilized by many commercial and recreational fishermen throughout the coastal areas. Aquaculture activities would not be allowed in areas where they would interfere with traditional fishing activities. Areas containing substantial natural shellfish resources are considered part of the state's free and common fishery and, as such, would preclude the introduction of any non-compatible aquaculture.
2. Recreation. Certain aquaculture activities would not be compatible with traditional areas of high recreational value (swimming, boating, sailing, SCUBA diving, etc.).
3. Navigation. Shipping lanes, channels, and other areas that accommodate heavy boat traffic would not be acceptble sites for many types of aquaculture which would present hazards to navigation.

4. Marinas. Various aquaculture activities would also conflict with anchorages, marinas, mooring sites, and other areas of concentrated boating activity.
5. Management Areas. The Department of Environmental Management has established management areas in various places within the state's coastal waters for the protection of various forms of marine life, including juvenile shellfish stocks. Certain types of aquaculture would be inconsistent with the goals of these management areas.
6. Water Quality. Certain types of aquaculture would not be allowed where water quality does not meet minimum DEM standards.

SECTION B

SPECIFIC AREA DESCRIPTIONS

OF

MAJOR COASTAL PONDS AND RIVERS

PAWCATUCK RIVER AND LITTLE NARRAGANSETT BAY

INTRODUCTION

In its lower reaches, the Pawcatuck River serves as the boundary line between Connecticut and Rhode Island. The river becomes intertidal south of the Towns of Westerly, R. I. and Pawcatuck, Conn.; and eventually empties into Little Narragansett Bay. Salinities range from fresh water just south of Westerly, R. I. to about 30 ppt as it approaches Little Narragansett Bay. A navigable channel extends from the bay up the river almost to the Main Street bridge of the twin Towns of Westerly-Pawcatuck. Boat yards, marinas, and private docks and moorings are located along this stretch of the river, on both the Rhode Island and Connecticut sides.

Little Narragansett Bay is a shallow body of water that extends across the Connecticut-Rhode Island border. It is about 2 miles long (north/south) by about 1.5 miles wide (east/west). It is bounded by Stonington Point (Conn.) and Sandy Point (R. I.) to the west, Napatree Beach (R. I.) on the south, Watch Hill (R. I.) and the Pawcatuck River to the east, and the Barn Island Hunting Grounds (Conn.) to the north (Dept. of the Army, 1977). A deep, navigable channel extends from Stonington Point at the northwest corner of the bay to the Pawcatuck River to the east. A channel has also been dredged in the southeastern portion of the bay to pro-

vide access for boats to enter Watch Hill Cove. A large mooring site exists along the southern portion of the bay, off Napatree Beach.

ACCESS

There is no public access to the river or the bay on the Rhode Island side. Several of the private boat yards and marinas, however, have launching facilities.

CURRENT USES

The waters of Little Narragansett Bay and the Pawcatuck River are extensively used for recreational sailing and boating. Five marinas, 3 boat yards, and a yacht club support this important recreational activity. Many private docks and mooring sites are also located along the river. Watch Hill Cove contains one private wharf, and 3 public landings owned by the Watch Hill Fire District; much of the cove is also utilized for boat moorings. There is a large boat anchorage area north of Napatree Beach, between Napatree Point and the jetty at the western end of Watch Hill Cove.

The Napatree Beach area (the southern boundary of Little Narragansett Bay) is extensively utilized for swimming in the summer months.

Sport fishing for winter flounder (Pseudopleuronectes americanus), striped bass (Morone saxatilis), and bluefish

(Pomatomus saltatrix) is popular here. There is also a limited amount of commercial fishing for eels (Anguilla rostrata), smelt (Osmerus mordax), and alewives (Alosa pseudoharengus).

POTENTIAL FOR AQUACULTURE

Currently, there are no active aquaculture operations in either Little Narragansett Bay or the lower Pawcatuck River. The salinity of the water drops off drastically north of Avondale, creating unfavorable conditions for shellfish culture. The waters southward from this area, however, are conducive to shellfish growth.

The water quality is classified as SB in Little Narragansett Bay and as SC in the lower Pawcatuck River. Shellfish, therefore, cannot be harvested from these areas for direct human consumption. The R. I. Divisions of Water Resources and Food Protection and Sanitation would have to be consulted for relaying and/or depurating procedures to render the shellfish safe for sale for human consumption.

RECOMMENDATIONS

1. No aquaculture on the north side of Napatree Beach out to a distance of 250 feet, from the northern tip of Napatree Point to the breakwater on the western side of Watch Hill Cove.

2. No off-bottom culture in the channel leading to Watch Hill Cove.
3. No off-bottom culture in the channel in the Pawcatuck River.
4. No aquaculture in Watch Hill Cove.
5. No aquaculture in the vacinity of the mooring sites in Colonel Willie Cove.
6. No aquaculture in the narrow portion of the river in the Avondale section north of Graves Neck.

EXPLANATION OF ABOVE RESTRICTIONS

1. Napatree Beach is a highly utilized recreation area. Bathers utilize the area near shore, while the area further out is used for a boat mooring site. Aquaculture would conflict with these activities.

2 & 3. Off-bottom structures in these areas would interfere with boat traffic.

4, 5, & 6. Mooring sites and boating activity would interfere with aquaculture activities in these areas.

In order to maintain a proper balance between aquaculture and other uses of the area in subject, it would be advisable to eventually establish a ceiling on the amount of aquaculture which the area could accommodate. Since no aquaculture is currently being conducted in this area, the arbitrary establishment of such a limit at the present time

would be a moot gesture. However, at a later date, when the desirability of the area for aquaculture is known and when the effect of any future aquaculture operations on the area can be evaluated, a ceiling should be set for the number of acres that could be allotted for aquaculture.

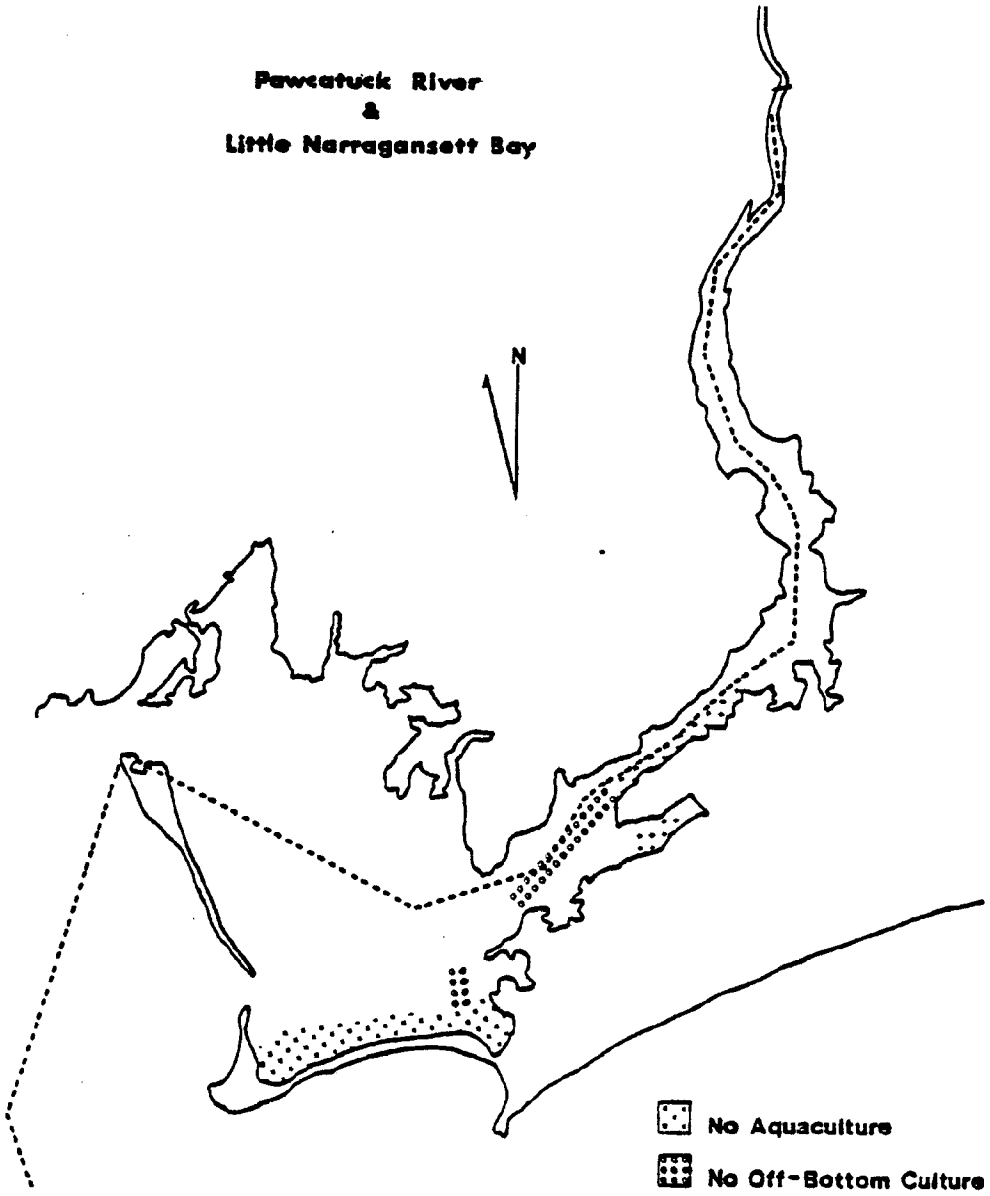

Figure 1. Recommended aquaculture restrictions for the Pawcatuck River & Little Narragansett Bay.

BRIGHTMAN'S (WINNAPAUG) POND

INTRODUCTION

Brightman's Pond is located in the Town of Westerly. It is approximately 1.9 miles long by 0.5 miles wide, at its widest point, and encompasses approximately 446 acres (Stolgitis et al. 1976). Although there are two small basins at the western end of the pond which are over 20 feet deep, the pond is generally shallow, the mean depth being less than 5 feet. A permanent breachway at the extreme eastern end of the pond connects it with the ocean. The southern portion of the pond, adjacent to the barrier beach, has a sandy bottom and is quite shallow; the eastern portion of the pond is characterized by shifting delta sand which is transported by water flowing and ebbing through the channel. Salinities in the pond remain consistently high at around 30 ppt.

ACCESS

Although there are several private docks and launching ramps on the pond, the only developed public access for boats is via the breachway.

IMPORTANT SHELLFISH AND FINFISH

Thirty-nine species of fishes were collected in Brightman's Pond from July 1969 to June 1970 (Stolgitis et al. 1976). Some of the more abundant species which provide a commercial and/or recreational fishery include winter flounder, eel, bluefish, striped bass, and tautog (Tautoga onitis).

Soft-shelled clams (Mya arenaria), quahaugs (Mercenaria mercenaria), and bay scallops (Argopecten irradians) are found in the pond in varying densities. Oysters (Crassostrea virginica) and mussels (Mytilus edulis) are present in smaller quantities. Blue crabs (Callinectes sapidus) are also present in limited quantities.

CURRENT USES

Swimming, boating, and sailing are common activities at Brightman's Pond during the summer season. The majority of the boating traffic is confined to the breachway and the northern and western portions of the pond.

There is a commercial eel fishery in the pond, as well as some commercial scalloping activity. Recreational fishermen catch winter flounder and eels in the pond. Striped bass, bluefish, and tautog are caught in and around the vicinity of the breachway. Recreational shellfishermen dig for soft-shelled clams and quahaugs on the tidal flats along the southern and western portions of the pond.

POTENTIAL FOR AQUACULTURE

At this point, the potential for aquaculture in Brightman's Pond is generally unknown. Although no supporting data is available, shellfish may do well with raft-culture in the deeper waters in the northern and western portions of the pond.

RECOMMENDATIONS

The following limitations are recommended:

1. No off-bottom culture within the breachway or in the channel leading from the breachway to the central portion of the pond. This winding channel follows the approximate three foot depth contour along the north shore of the eastern portion of the pond.
2. No bottom culture within the confines of the management area in the central portion of the pond.
3. No bottom culture along the western and southern shoreline west of the management area boundary out to a depth of approximately four feet.

EXPLANATION OF THE ABOVE RESTRICTIONS:

1. Heavy boat traffic in this area would render off-bottom culture unfeasible.
2. The management area was set aside by DEM for the protection of juvenile shellfish stocks. Any bottom cul-

ture activities within this area would be inconsistent with the goals and policies of the management plan.

3. The shallow areas along this portion of the shoreline contain substantial amounts of quahaugs and soft-shelled clams which are harvested by recreational diggers.

Since there have been no requests for assents to conduct aquaculture in Brightman's Pond thus far, it is suggested that any attempt at establishing a ceiling on the number of acres to be apportioned for aquaculture be postponed to a later date when the desirability of the pond for aquaculture becomes more evident and when the effects of any future aquaculture operations on the pond can be evaluated.

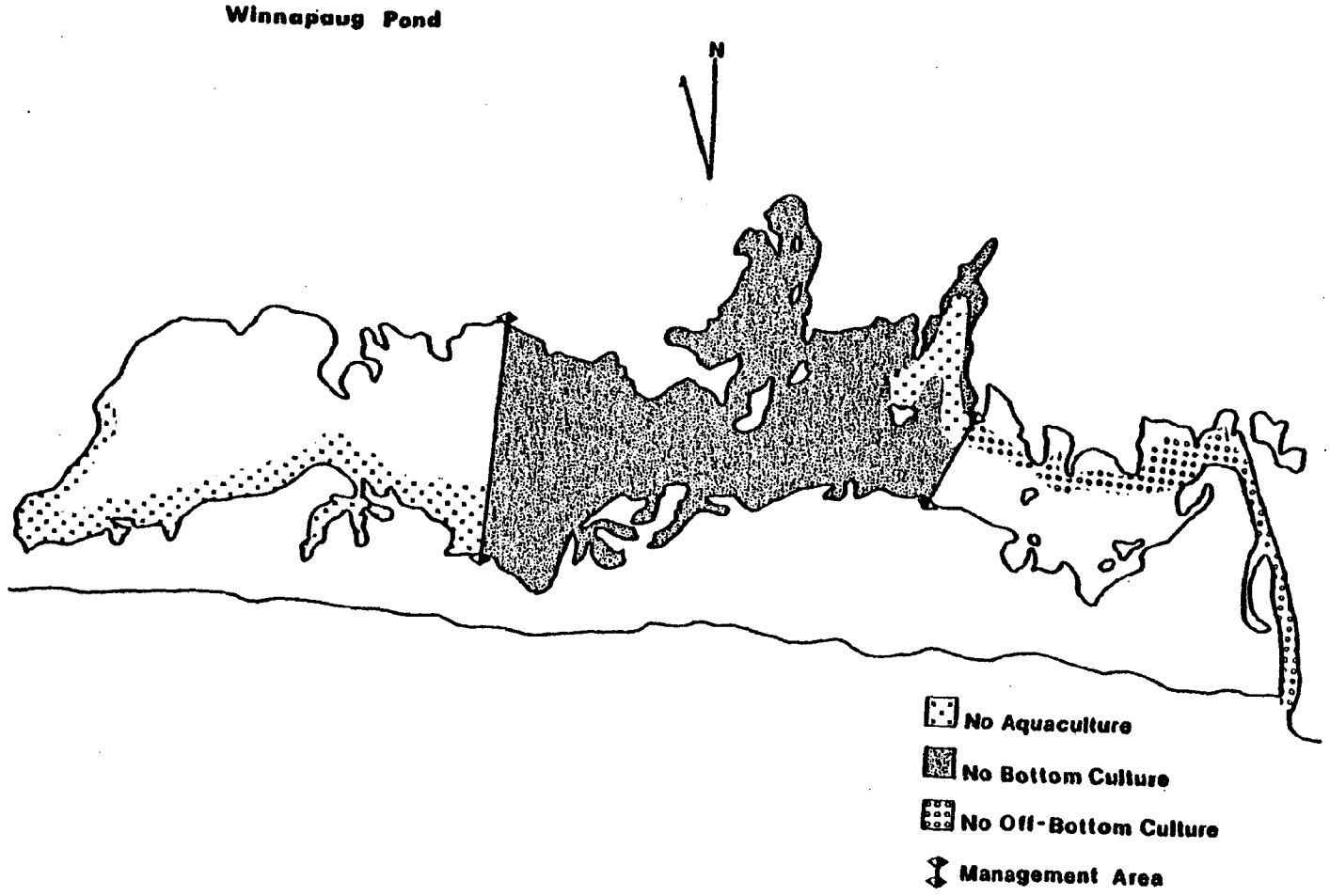

Figure 2. Recommended aquaculture restrictions for Brightman's Pond.

QUONOCHONTAUG POND

INTRODUCTION

Quonochontaug Pond is located in the Towns of Charlestown and Westerly. It is approximately 2½ miles long by 3/4 of a mile wide and occupies about 732 acres. The maximum depth is about 14 feet, while the average depth is approximately 6 feet (Stolgitis et al. 1976). The portion of the pond adjacent to the southern shore is generally shallow and is made up of sand bars, deltas, and tidal flats. There is also a 200 acre salt marsh located at the southeastern end of the pond. The central and northern portions of the pond are moderately deep; much of this area has a depth in excess of 12 feet. There is a permanent breachway that connects to the ocean, allowing for a large amount of tidal flushing. Salinities range from 27.5 to 34.0 ppt.

ACCESS

The general public can launch boats at the state boat ramp adjacent to the breachway. Boats can also enter the pond via the permanent breachway connecting with Block Island Sound.

IMPORTANT SHELLFISH AND FINFISH

Quahaugs, soft-shelled clams and scallops are abundant

in the pond. Two management areas have been established in the pond by DEM for the protection of juvenile shellfish stocks. To a lesser extent, there are oysters scattered throughout several areas of the pond. Small amounts of blue crabs are also present. Surf clams (Spisula solidissima) are located in the pond in the vicinity of the breachway.

Fifty species of fishes were collected in the pond from July 1969 to June 1970 (Stolgitis et al. 1976). Some of those important to recreational fishing in the pond include striped bass, bluefish, weakfish (Cynoscion regalis), and winter flounder.

CURRENT USES

Boating is a major activity in the pond. There are two yacht clubs, several mooring sites, and many private docks located on the pond. Boats from these areas plus boats that are launched at the state ramp combine to make traffic on the pond very heavy during the summer months.

Recreational shellfishermen dig for soft-shelled clams and quahaugs in the tidal flats, deltas, and salt marsh areas along the southern portion of the pond in the spring and late fall (the management areas are closed to shellfishing from 1 June to 1 October). Scallops are harvested by hand and with dredges in the fall by both recreational and commercial shellfishermen. A small surf clam fishery is located in the pond near the breachway. There is also a

limited amount of lobstering carried out in the pond. Sport fishing is another popular activity in the pond where striped bass, bluefish, and winter flounder are some of the species caught.

POTENTIAL FOR AQUACULTURE

Although there is currently no aquaculture activity in the pond, several species of shellfish may do very well here with culture techniques. This is evidenced by the large numbers of naturally occurring shellfish found in the pond.

RECOMMENDATIONS

Because of potential use conflicts, certain portions of Quonochontaug Pond are not recommended for aquaculture:

1. No bottom culture in the management area west of the breachway.
2. No aquaculture in that portion of the western management area which lies south of a line drawn from the management area marker on the north shore along the shoreline to Wheat Point, from Wheat Point to Quahaug Point, and from Quahaug Point due west to the western shore; and which lies north of a line that generally follows the 4 foot depth contour along the southern shore of the pond from the management area boundary near the mouth of the breachway westward to the proximity of the Weekapaug Yacht Club.

3. No aquaculture in the channel that connects the pond with Block Island Sound.
4. No aquaculture in the vicinity of Shady Harbor within the area generally bounded by a line drawn from the mouth of the small cove at the southwestern end of the harbor to the exposed rocks approximately 100 meters offshore, and by a line drawn from these rocks to the tip of the peninsula approximately 600 meters northeast of the cove.
5. No aquaculture in the immediate vicinity of the Quonochontaug Yacht Club at the extreme northeastern end of the pond.
6. No aquaculture within the general vicinity of the boat mooring site on the eastern shore of the pond, opposite Bill's Island.
7. No bottom culture within the shellfish management area east of the breachway.
8. No bottom culture on the delta adjacent to the mouth of the breachway.

EXPLANATION OF RESTRICTIONS:

1. The shellfish management area has been established for the protection of juvenile shellfish stocks. Bottom culture in this area would be inconsistent with the purposes of the management area.
2. This is an area of heavy boat traffic. Any off-bottom structures in this location would pose navigation problems.

3. There is an exploitable surf clam resource in and around the vicinity of the breachway, eliminating the possibility of bottom culture. Boat traffic would rule out any off-bottom structures in the channel.
4, 5, & 6. These areas accommodate docking and/or mooring facilities for a number of boats. Any aquaculture activities within these areas would cause conflicts.
7. This area has been set aside for the protection of juvenile shellfish stocks.
8. These shallow, sandy areas contain quahaug, surf clam, and soft-shelled clam resources which are harvested by hand diggers.

Since there have been no requests for assents to conduct aquaculture in Quonochontaug Pond thus far, it is suggested that any attempt at establishing a ceiling on the number of acres to be apportioned for aquaculture be postponed to a later date when the desirability of the pond for aquaculture becomes more evident and when the effects of any future aquaculture operations on the pond can be evaluated.

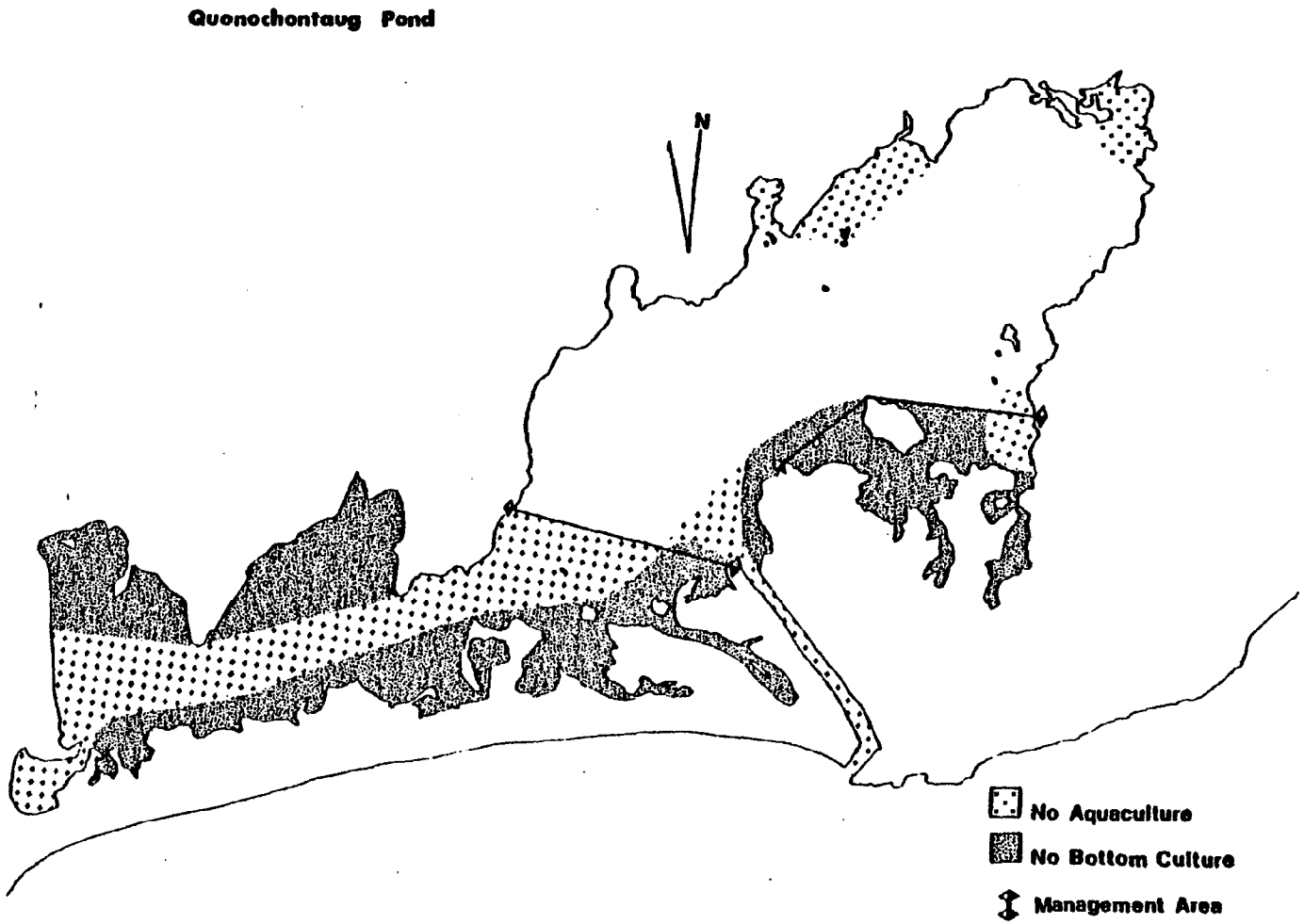

Figure 3. Recommended aquaculture restrictions for Quonochontaug Pond.

CHARLESTOWN (NINIGRET) POND

INTRODUCTION

Charlestown Pond is located adjacent to the Rhode Island shoreline in the Town of Charlestown. It is the largest of the R. I. coastal ponds, covering 1,711 acres (Stolgitis et al. 1976). The average depth of the pond is roughly 3-4 feet; the deepest part is about 8 feet. It is approximately four miles long and from 1/4 to 3/4 miles wide. There is a permanent breachway to the ocean which allows for a large amount of tidal flushing. There is also a channel connecting the eastern portion of the pond to Green Hill Pond. The salinities vary from 30 ppt near the breachway to 4 ppt in the upper reaches of the pond.

ACCESS

There are three marinas located on the pond: the Ocean House Marina at the northern end of Fort Neck Cove, the Sportsman's Cove Marina at the northwestern end of the pond, and the Creek Bait Shop at the easternmost end of the pond. The public also has access to launch boats at the state launching ramp located near the breachway. Boats can also enter the pond through the breachway or through the channel from Green Hill Pond.

IMPORTANT SHELLFISH AND FINFISH

Several species of valuable shellfish are found in the pond in abundance. These include American oysters, quahaugs, soft-shelled clams and bay scallops. These shellfish are harvested by both commercial and recreational shellfishermen. DEM maintains a shellfish management area in the center portion of the pond to protect scallop and other shellfish stocks.

A total of forty species of adult and juvenile finfish were reported collected in Charlestown Pond (Stolgitis et al. 1976). Some of these, including eels and winter flounder, are harvested commercially.

Green crabs (Carcinus maenas) and blue crabs are two other marine species that are harvested both commercially and recreationally.

CURRENT USES

Recreational hand-digging for soft-shelled clams is profuse in the summer months on the southeastern and southwestern portions of the pond. Scalloping is an important activity in the central and western portions of the pond in the fall. There is a small amount of quahauging activity throughout the year. The native oyster population also supports a small amount of harvesting.

Commercial fishermen drag for winter flounder during the fall and winter months and set eel pots throughout most

of the year. Anglers fish the pond for several species of fish, the most important being winter flounder.

The southern portion of the pond is utilized for bathing in the summer months. Boating, sailing, and water skiing activities are also prevalent throughout the pond during the warmer months.

Oyster culture and oyster spat collecting are also important current uses of the pond.

POTENTIAL FOR AQUACULTURE

Charlestown Pond has the potential of supporting a substantial amount of aquaculture. Experimental oyster culture operations in the pond have indicated that oysters can be cultured very successfully in several locations. Since the pond supports large populations of scallops, quahaugs, and soft-shelled clams, it can be reasonably deduced that these species could also be cultivated. It has been demonstrated that oyster spat can also be collected successfully.

Although aquaculture could probably be carried out successfully in many areas of the pond, conflicts with other uses would limit its expansion.

RECOMMENDATIONS

Considering the fact that other uses would supercede aquaculture in certain portions of the pond, the following

recommendations are made, delineating those areas of the pond where aquaculture would not be feasible.

All areas of the pond would be open to consideration for aquaculture permits except as noted:

1. No bottom culture in the management area in the center portion of the pond as delineated by the management signs on the shoreline.
2. No aquaculture west of the management area from the southern shoreline northward to a line that approximately follows the 4' depth contour.
3. No bottom culture in Foster Cove.
4. No aquaculture in that portion of the pond which lies east of the management area.
5. No aquaculture along the edges of Fort Neck Cove where the mean depth is shallower than three feet.
6. No off-bottom culture within a one hundred foot wide area in the center of Fort Neck Cove, extending from the Ocean House Marina to the central basin of the pond.
7. No off-bottom culture in the narrows where the mean water depth is greater than four (4) feet.
8. No off-bottom culture in the channels leading from the breachway to the center portion of the pond and to Green Hill Pond.

EXPLANATION OF THE ABOVE RESTRICTIONS:

1. The shellfish management area in Charlestown Pond has

been set aside for the protection of juvenile stocks of shellfish. Any bottom culture activities within that area would be inconsistent with the goals and purposes of the management plan.

2. The southwestern portion of the pond contains natural sets of quahaugs and soft-shelled clams. Their resources are heavily exploited by handrakers during the summer months.
3. Foster Cove contains a substantial oyster resource, thereby eliminating its use as a site for bottom culture. The area, however, could support a limited amount of spat collecting and off-bottom culture.
4. That portion of the pond east of the management area is principally composed of clam flats which provide a resource for recreational fishermen. In addition, off-bottom culture in the deeper portions of this area would interfere with boat traffic.
5. The areas along the shoreline of Fort Neck Cove to a depth of approximately three feet support a substantial oyster resource.

6, 7, & 8. These are areas where boat traffic is heavy during the summer season. Off-bottom structures would pose navigation problems.

Currently, there are five aquaculture operations, comprising a total of 22 acres, located in Charlestown Pond.

All of these operations are relatively recent and are still considered to be in the experimental stage.

It is suggested that once 5% of the total acreage of the pond (86 acres) is leased or permitted for aquaculture, no further assents be issued until the compatibility of aquaculture with other uses and aesthetics of the pond can be determined.

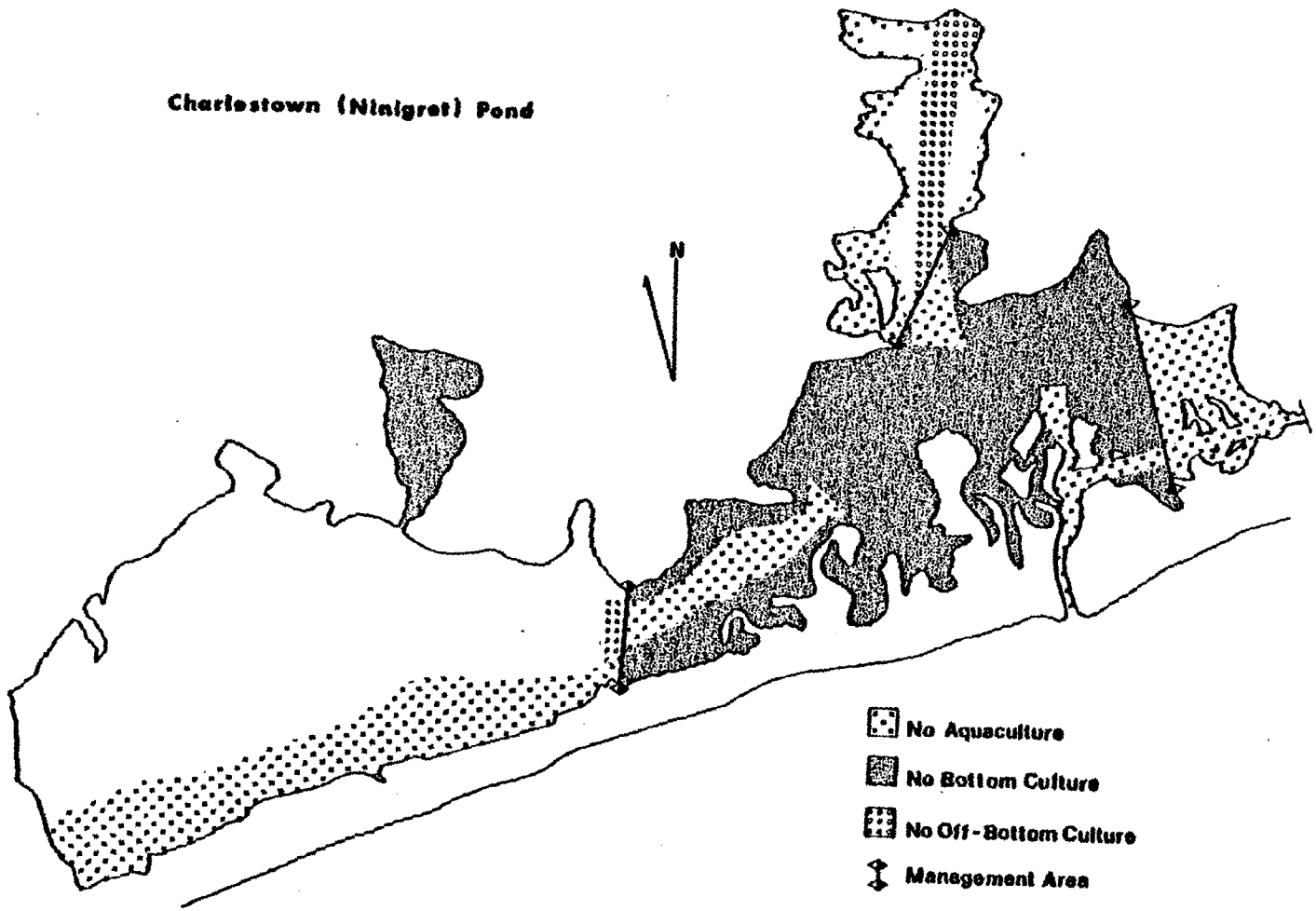

Figure 4. Recommended aquaculture restrictions for Charlestown Pond.

GREEN HILL POND

INTRODUCTION

Green Hill Pond is located east of Charlestown Pond in the Towns of Charlestown and South Kingstown. The 430 acre pond is approximately 1 mile wide and 1 1/2 miles long. The maximum depth is 6 feet, while the average depth is from 2-3 feet. It has no direct opening to the ocean; however, it connects with Charlestown Pond through a channel which allows salt water to enter Green Hill Pond via Charlestown Pond. Fresh water enters from two sources in the northern portion of the pond: Teal Lake and Factory Pond Brook. The average salinity is approximately 23 ppt (Zuraw et al. 1969), with a variation between 3 ppt in the northern portions of the pond to 29 ppt near the channel connecting to Charlestown Pond. Salinities in the majority of the pond are fairly homogeneous.

ACCESS

The only public access for boats is through the channel connecting with Charlestown Pond. There are at least two private access areas on the pond where small boats can be launched.

IMPORTANT SHELLFISH & FINFISH

Oysters, soft-shelled clams and quahaugs are found in

the pond. The quahaugs are confined to the southwest portion of the pond near the channel where the salinity is proportionally higher than the rest of the pond. Oysters and soft-shelled clams are found in several locations within the entire pond.

Thirty-two species of juvenile and adult fishes were collected in the pond during 1970-1971 (Stolgitis et al. 1976). Two of the more important species are eels and winter flounder.

CURRENT USES

One of the major activities in Green Hill Pond is recreational boating. Although there are no marinas on the pond, there are numerous small, private docks belonging to waterfront property owners. Many boats also enter the pond via the channel connecting with Charlestown Pond.

Recreational shellfishermen harvest soft-shelled clams, quahaugs, and oysters. Blue crabs are also caught throughout most of the pond. Many people also fish for winter flounder and eels.

Another important activity in the pond is the collecting of oyster spat for use in aquaculture. Green Hill Pond is currently the best area in Rhode Island for collecting oyster spat; in fact, the majority of oyster culturists in the state utilize this pond to obtain their stock.

POTENTIAL FOR AQUACULTURE

Although there is currently no aquaculture being conducted in Green Hill Pond, the potential for it does exist. The water throughout most of the pond may be too brackish for cultivating quahaugs; however, the salinity is well within the tolerance limits for soft-shelled clams and oysters.

RECOMMENDATIONS

No aquaculture in that portion of the pond south of a line drawn from Potato Point (south of Allen Cove) to the southernmost tip of Hog Hill Island. This area contains a substantial quahaug and soft-shell clam resource which is utilized as part of the state's free and common fishery. Off-bottom culture apparatus would also interfere with boat traffic in the vacinity of the channel.

All areas north of this line should open to consideration for aquaculture.

Since there have been no requests for assents to conduct aquaculture in Green Hill Pond thus far, it is suggested that any attempt at establishing a ceiling on the number of acres to be apportioned for aquaculture be postponed to a later date when the desirability of the pond for aquaculture becomes more evident and when the effects of any future aquaculture operations on the pond can be evaluated.

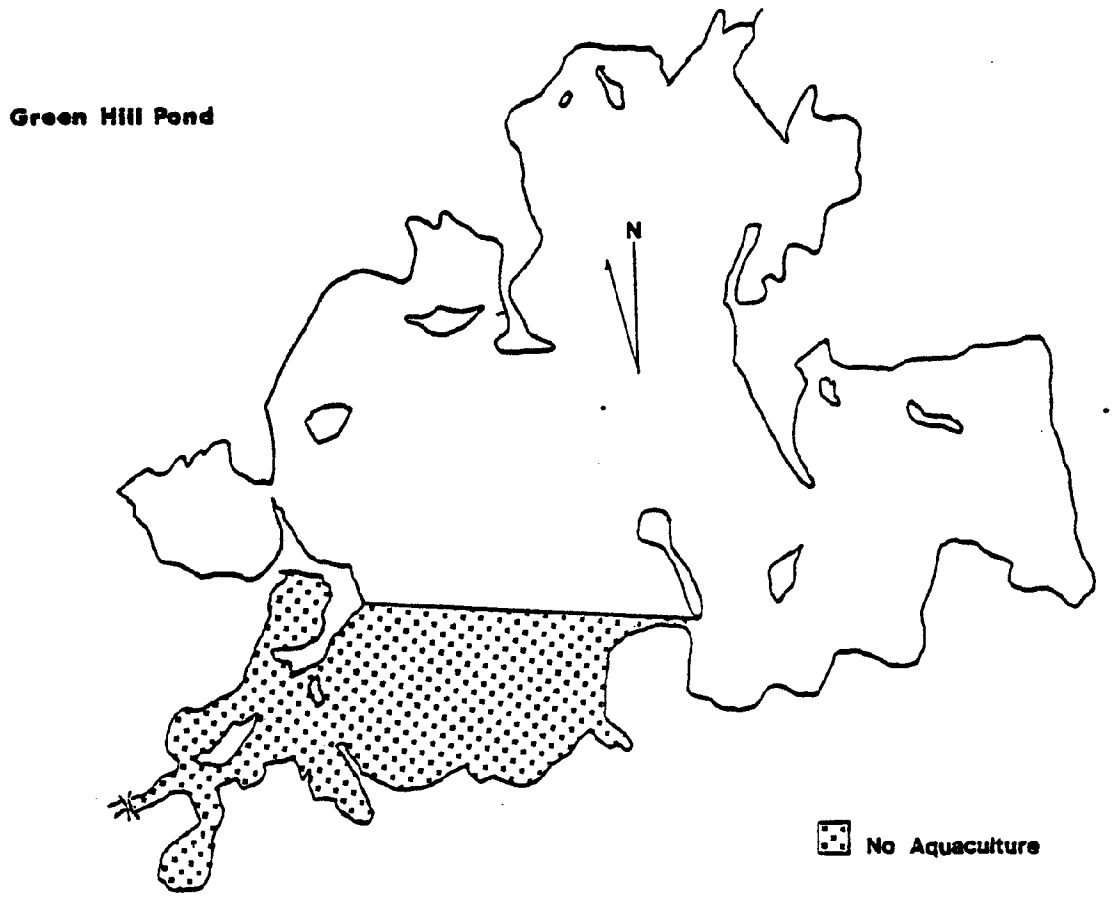

Figure 5. Recommended aquaculture restrictions for Green Hill Pond.

TRUSTOM POND

Located in the Town of South Kingstown, Trustom Pond is one of the smaller of the South County coastal ponds. It occupies 160 acres and is roughly one-half mile square (Wright et al. 1949). Although the pond has no permanent breachway to the ocean, it occasionally breaches naturally.

The land surrounding the pond is owned in part by the U. S. Fish & Wildlife Service and in part by the Audubon Society of Rhode Island. There is no public access to the pond except by permission from either of these two agencies.

The policy of both of these agencies, which in effect control the utilization status of the pond, is to preserve the pond as a pristine and natural area. It is one of Rhode Island's prime overwintering areas for migratory waterfowl. It is also one of the state's only remaining coastal ponds which is devoid of human exploitation. As such, it is currently not suitable for use as an area to support aquaculture.

POTTER POND

INTRODUCTION

Located in the Town of South Kingstown, Potter Pond covers approximately 329 acres. It has an irregular shape with a 20-foot deep basin at the northern end. A narrow neck, generally less than an eighth of a mile wide, connects the upper basin to the shallow southern portion of the pond, where the average depth is approximately 2 feet. A navigable channel connects Potter Pond with Point Judith Pond. Salinities in the pond vary from 23 ppt to 31.3 ppt (Stolgitis et al. 1976).

ACCESS

The only public boat access to Potter Pond is through the channel that connects with Point Judith Pond.

IMPORTANT SHELLFISH AND FINFISH

Soft-shelled clams and quahaugs are found in the pond. To a lesser extent, bay scallops are also present.

Twenty-nine species of fishes were collected in Potter Pond in 1971-1972 (Stolgitis et al. 1976). Two of those important to recreational fishing are white perch (Morone americana) and winter flounder.

CURRENT USES

Recreational boating activity in the pond is ongoing during the summer months. Although many people keep boats moored at their private docks on the pond, the majority of boats probably enter the pond via the channel connecting with Point Judith Pond. Water skiers can also be found utilizing the pond during the summer months, especially in the deeper, northern reaches.

Recreational clamming and quahauging are major activities along the tidal flats and shallower areas in the southern portion of the pond during the summer. To a lesser extent, the pond also supports some recreational fishing, crabbing and eeling.

POTENTIAL FOR AQUACULTURE

Currently there is an experimental, off-bottom oyster culture project being carried out in the deep basin at the northern end of the pond. Although it is still too early to determine the exact success of the operation, it looks very promising at this point. Indications are that off-bottom culture techniques for oyster culture could be quite successful in the northern portions of the pond. Other shellfish, including soft-shelled clams and quahaugs, should also do well with culture techniques.

RECOMMENDATIONS

All areas of the pond would be open to consideration for aquaculture permits except as noted:

1. No aquaculture south of a line running due west from the northern shore of the channel to Pt. Judith Pond, and east of a line from the southern tip of Ram Point to the northeastern tip of Gardner Island.
2. No off-bottom culture in water which is generally 4 or more feet deep which lies between the channel to Point Judith Pond and the deep northern basin.

EXPLANATION OF THE ABOVE RESTRICTIONS:

1. The tidal flats in the southeastern portion of the pond contain soft-shelled clam and quahaug resources which are part of the state's free and common fishery. Recreational shellfishermen dig in these areas during the summer months.
2. This narrow portion of the pond, linking the deep basin at the northern end of the pond to the channel connecting with Point Judith Pond, sustains heavy boat traffic during the summer season. Any off-bottom structures in this area would pose navigation problems.

Since there is only one, relatively new aquaculture operation located in the pond, it is recommended that the establishment of a ceiling on the amount of acreage that could be allotted for aquaculture be postponed to a later point in time when a more meaningful determination can be made.

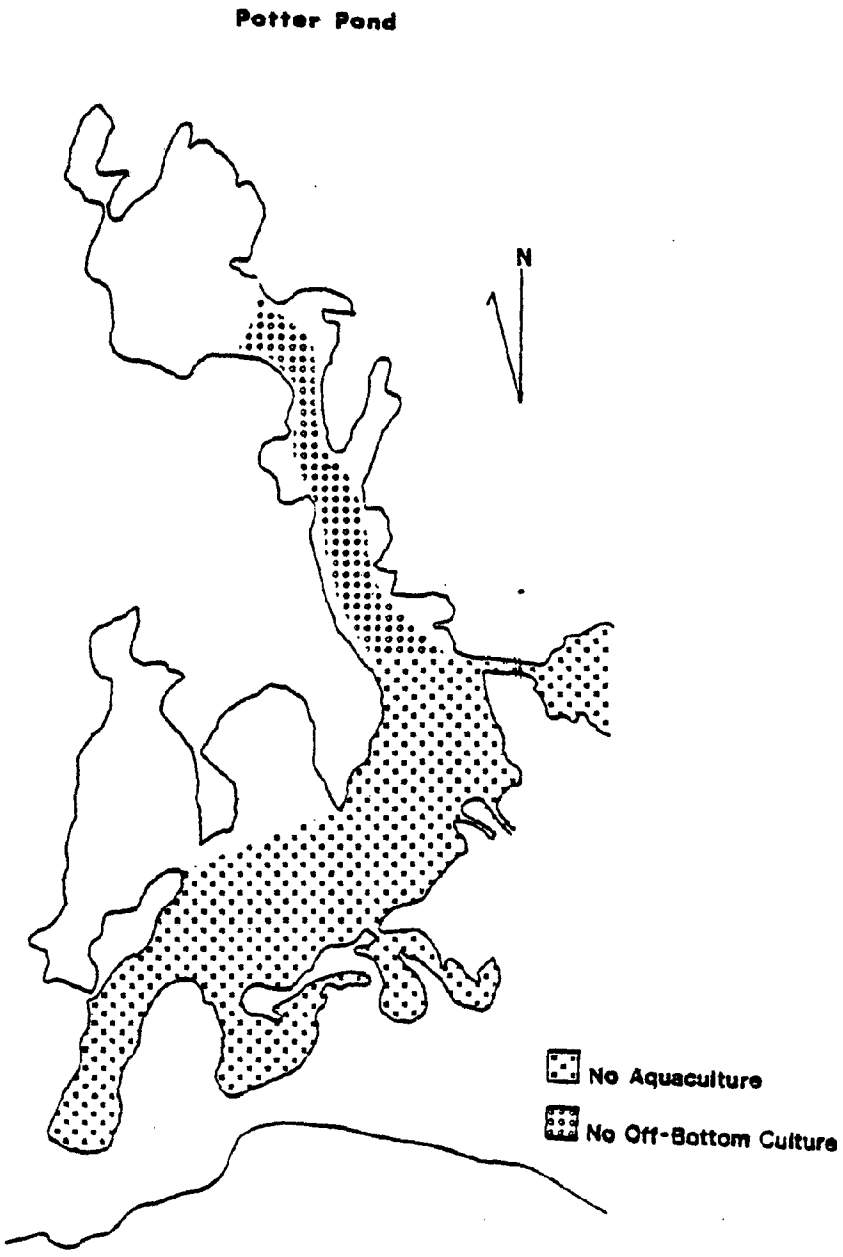

Figure 6. Recommended aquaculture restrictions for Potter Pond.

POINT JUDITH POND

INTRODUCTION

Point Judith Pond is located in the Towns of Narragansett and South Kingstown. It is almost four miles long and 1/2 mile wide, and comprises approximately 1,530 acres. It is the second largest of Rhode Island's coastal ponds. The greatest depth (27 feet) is in a small basin at the southern end of the pond; however, the average depth is approximately 6 feet. A large permanent breachway at the southern tip of the pond, connecting to the Harbor of Refuge, provides a means of ingress and egress for the large vessels of the commercial fishing fleet of Point Judith as well as for hundreds of smaller boats. There is also a channel connecting the pond with the Succotash Salt Marsh and Potter Pond. Due to the large volume of tidal flushing through the breachway, the pond almost takes on the characteristics of a small bay. Salinities from The Narrows in the northern portion of the pond to the breachway vary from 25 ppt to 32 ppt; the upper pond, north of The Narrows which is fed by the Saugatucket River, has salinities ranging as low as 8 ppt.

ACCESS

There are four public boat launching areas on Point Judith Pond. Ten marinas provide docking as well as boat

launching facilities. The state pier at the Port of Point Judith provides a deep water port for vessels which can enter the pond through the large breachway. Small boats can also enter the pond through the channel connecting with Potter Pond.

IMPORTANT SHELLFISH AND FINFISH

Several important shellfish are found in this pond. They include: the bay scallop, the blue mussel, the quahaug and the soft-shelled clam. By far, the most important of these is the bay scallop which provides a large commercial and recreational fishery.

Several of the 48 species of fishes found in the pond (Stolgitis et al. 1976) are valuable to the sport fishing industry in the pond. Some of these include: the American eel, the Atlantic tomcod (Microgadus tomcod), the pollock (Pollachius virens), the striped bass, the bluefish, the weakfish, the summer flounder (Paralichthys dentatus) and the winter flounder.

CURRENT USES

Point Judith Pond is the most heavily utilized of all of Rhode Island's coastal ponds. The Port of Point Judith, located at the southern end of Point Judith Pond, is home to the largest commercial fishing fleet in Rhode Island and the

third largest in New England. It also accommodates several charter boats.

With four public launching ramps, ten marinas, and numerous private docks, boating and sailing activity throughout the pond is extremely heavy.

For the past several years, Point Judith Pond has been one of the most productive scallop producing areas in New England. Commercial and recreational scalloping is a major activity during the fall season. To a lesser extent, other commercial and recreational shellfishing occurs throughout the year in the lower half of the pond. Sport fishing and commercial eeling are also important activities in the pond.

POTENTIAL FOR AQUACULTURE

The biological potential for the culture of shellfish in Point Judith Pond is excellent. The pond's high productivity supports a substantial amount of indigenous shellfish, illustrating an excellent opportunity for aquaculture. The problem, however, is that the high incidence of other traditional activities throughout the pond takes precedence over the introduction of aquaculture. Due to the current use conflicts, any attempt to encourage aquaculture in Point Judith Pond would be futile.

RECOMMENDATIONS

No aquaculture should be allowed in Point Judith Pond.

Heavy boat traffic throughout the pond would eliminate any off-bottom culture. Scalloping activities in the pond would eliminate any bottom culture as far north as The Narrows. Congestion, boat moorings, and SC classified waters would eliminate bottom culture in the Upper Pond. Soft-shelled clams and quahaug resources in East Pond and other shallow coves would eliminate bottom culture in those areas.

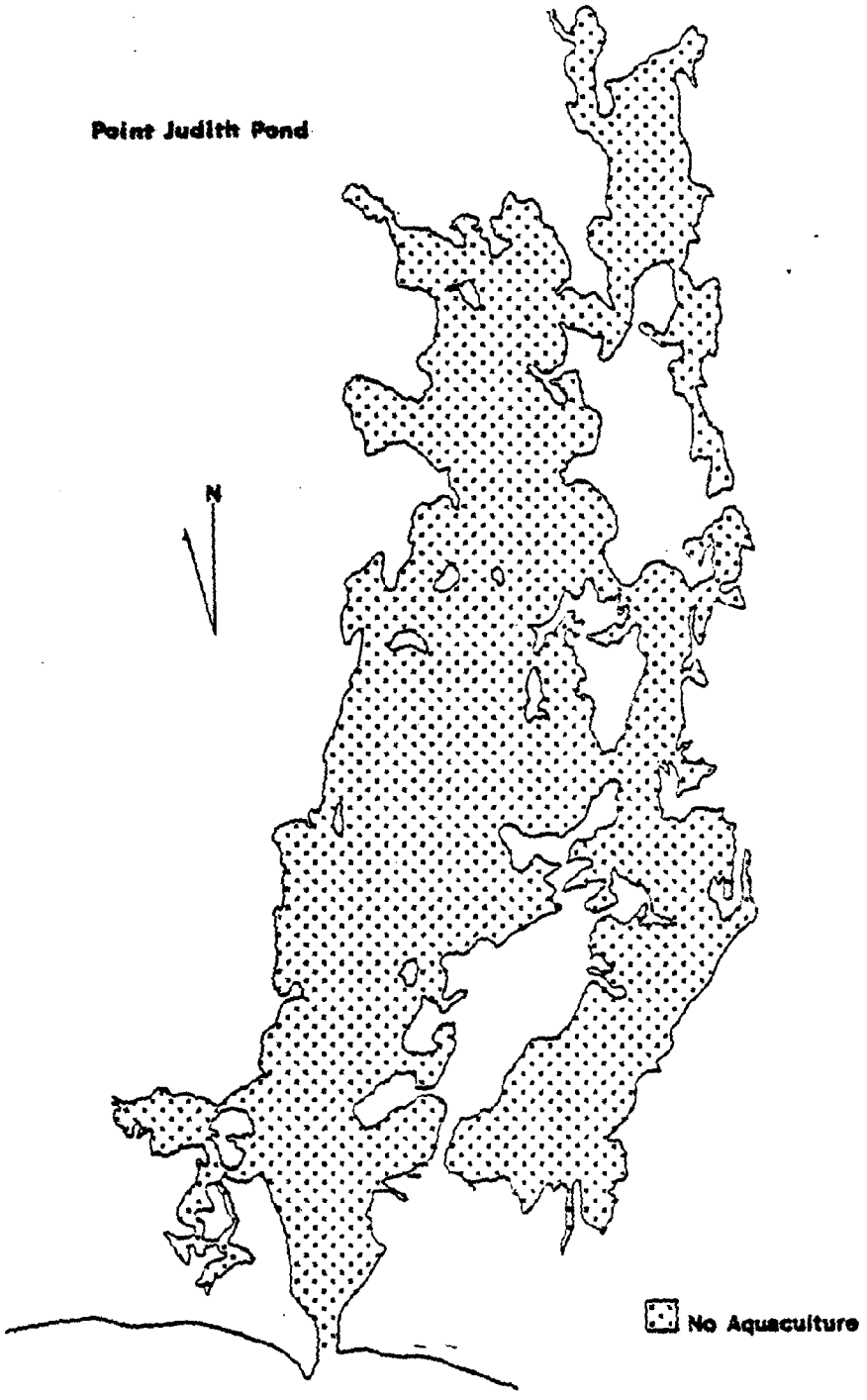

Figure 7. Recommended aquaculture restrictions for Point Judith Pond.

PETTAQUAMSCUTT RIVER

INTRODUCTION

The Pettaquamscutt River originates in the Town of North Kingstown and flows southward, forming part of the boundary between the Towns of South Kingstown and Narragansett. It joins Pettaquamscutt Cove in South Kingstown and flows into the Narrow River, which flows out to the ocean. The distance from the northern-most part of the river to the ocean is 6.5 miles.

The upper portion of the river is made up of two ponds which are 40 and 60 feet deep (Gains 1975). The river is navigable from the upper-most pond to the mouth, although only boats with a shallow draft are able to negotiate some of the shallower areas. Pettaquamscutt Cove occupies an area of 194 acres (Gains 1975), and is shallow, averaging less than two feet deep. The entire river system covers 560 acres with an additional 260 acres of associated salt marsh (Gains 1975). Salinities range from 32 ppt at the mouth of the river to approximately 13 ppt in the upper ponds.

ACCESS

A public launching ramp and parking area, maintained by DEM, is located on the western side of the river, approximately 1/2 mile north of Middlebridge. There is another

ramp on the eastern side of the river, just south of the Lacey Bridge at the end of Pettaquamscutt Avenue. An unimproved area near Sprague Bridge can be utilized to launch small boats. Several private launching ramps are also located along the river.

IMPORTANT FINFISH AND SHELLFISH

Blue mussels are found in abundance in the lower portion of the river (The Narrows) where the salinity is high. Quahaugs and soft-shelled clams are found in varying densities throughout the cove and the middle portion of the river. Oysters are concentrated primarily in the upper ponds. Blue crabs are also abundant in many parts of the river.

Eels, striped bass, winter flounder, bluefish, and white perch are frequently caught in the river. One of the best alewife runs in the state is up the Pettaquamscutt River.

CURRENT USES

The Pettaquamscutt River is an area of high recreational usage. Boating, water skiing, and swimming are major activities. An estimated 600 boats use the river (River Landscapes 1976). There are four beaches and a boys club camp located on the river. In addition to the Bob Eddy Marina and the Mettatuxet Yacht Club, there are almost 100 private docks scattered along the length of the river (the highest concen-

tration of docks is in the middle portion of the river between Middlebridge and Bridgetown).

An extensive amount of recreational shellfishing exists in the river. Quahaugs, soft-shelled clams, oysters, and mussels are harvested. There is also a limited amount of commercial shellfishing. Sportfishing, eeling, and crabbing are other popular activities.

POTENTIAL FOR AQUACULTURE

The potential for aquaculture in the Pettaquamscutt River does not appear to be very promising. Pettaquamscutt Cove is very shallow and has an unsuitable bottom substrate for most types of aquaculture. The main portion of the river from Bridgetown to the ocean abounds with recreational activities which would conflict with aquaculture. The ponds in the upper portion of the river may support some aquaculture activities; however, the salinities are somewhat low for most species of marine shellfish.

RECOMMENDATIONS

No aquaculture in the Pettaquamscutt River from an area approximately 300 yards north of the Lacey Bridge to Middlebridge, and in the navigable portion of the river from Middlebridge southward to the mouth of the Narrow River.

Explanation:

Recreational activities such as boating, swimming, fishing, and shellfishing in this area would conflict with aquaculture activities. The existing eel fishery in the shallow coves of the river would also conflict with aquaculture within this area.

Since there are presently no aquaculture activities located in this area, and since a heavy demand for aquaculture sites here seems unlikely, it does not appear prudent to impose any limitations on aquaculture in this area at the present time. Such a quota can be established at a later time if and when it becomes necessary.

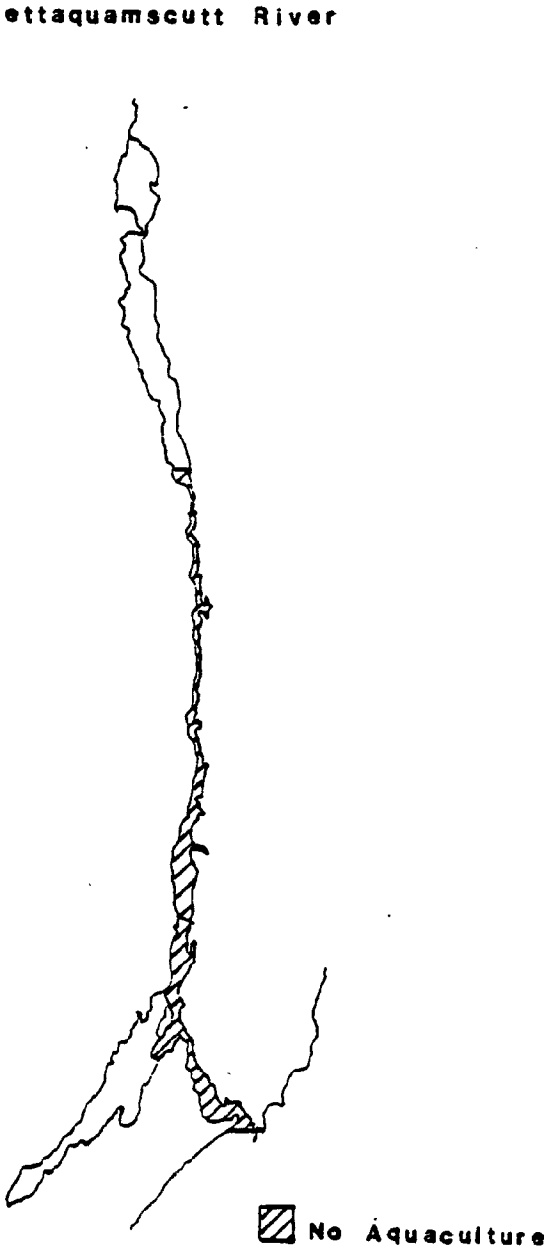

Figure 8. Recommended aquaculture restrictions for the Pettaquamscutt River.

LITTLE COMPTON'S COASTAL PONDS

There are five coastal ponds located in Little Compton between Sakonnet Point and the Massachusetts border. The ponds are all relatively undeveloped, and human activity in these ponds is minimal. With the exception of Tunipus Pond, there is virtually no public access to any of these bodies of water.

ROUND POND

This small pond, covering an area of 37 acres (Wright et al. 1949), is located just east of Sakonnet Point. Although only a narrow barrier beach separates it from the ocean, there is no apparent evidence of the pond breaching in the recent past. The salinity of the pond (measured in July 1981) was only 1 ppt, rendering mariculture unfeasible at this location.

LONG POND

Long Pond is located a short distance east of Round Pond. Although it is somewhat larger than Round Pond, it is still relatively small in surface area with an average depth of only 3-4 feet. The pond is relatively pristine, with virtually no development, beaches, or launching areas along its shoreline. There is no public access to the pond, and human

activity here is negligible. Cattails (Typha latifolia), reed grass (Phragmites communis), and chair-maker's rush (Scirpus americanus) line the immediate shoreline, with adjacent woodland, brush, marsh, and back dunes surrounding the pond.

A small, natural breachway to the ocean, located at the southern tip of the pond, was observed to be open in June, but closed in July 1981. Salinities sampled throughout the pond during June and July 1981 were consistently measured at 5-6 ppt. Except for a sandy area at the southern end of the pond and a small patch of cobble along the west shoreline, the bottom type was observed to be soft mud interspersed with many large rocks. Wigeon grass (Ruppia maritima) was abundant throughout the pond.

Random sampling with tongs throughout the pond did not produce any shellfish, nor did sampling with a shovel and mesh basket in the sandy areas in the southern portion of the pond. Blue crabs, however, were observed in the southern portion of the pond.

In general, the pond appears unsuitable for aquaculture, and it would therefore be advisable not to introduce any such activities into this area.

BRIGGS MARSH

East of Long Pond lies Briggs Marsh, a 206 acre coastal pond (Wright et al. 1949). The deepest portion of the pond

is about 4 feet, while the average depth is generally around 2 feet. Reed grass and cattails are located around most of the shoreline, with the surrounding upland consisting of scrub woodland and a couple of farms. There is no public access to the pond, and human activity here is minimal. There is a substantial tern colony located on the barrier beach adjacent to the pond, while many swans and other waterfowl were observed on the pond itself. Briggs Marsh, in fact, is recognized as being one of the best waterfowl areas in the state (Wright et al. 1949).

A natural breachway to the ocean, located at the southwestern corner of the pond, was not open when observed in early July 1981, although it appeared to have been open in the recent past. Salinities were 11-12 ppt measured along the southern portion of the pond. The upper portion of the pond assumably has a lower salinity due to the influx of fresh water from two streams that feed it from the north.

The bottom type is generally soft mud except near the barrier beach where wind-blown sand had covered the mud. Random sampling with a basket rake did not produce any shellfish in the pond.

Due to its shallow water depth, soft bottom, and relatively low salinity, Briggs Marsh is not well suited for aquaculture. It would be more useful to maintain this pond as a waterfowl area.

TUNIPUS POND

Tunipus is essentially a fresh-water pond. Although there is a breach to the ocean, enough headwater is built up in the pond from a stream entering at its northern end to keep the water flowing out of the breachway. The salinity of the pond was measured at 0.5 ppt.

It is a small pond consisting of only 49 acres (Wright et al. 1949). A dairy farm is located on its eastern shore, while woodland, interspersed with a couple of houses surrounds the northern and western shores. A town beach located along the oceanfront on the adjacent barrier beach provides the public with access to the pond. The lack of salt-water in this pond renders it unsuitable for mariculture.

QUICKSAND POND

Quicksand Pond is the largest of Little Compton's coastal ponds. It is located at the eastern extremity of the town: a small portion of the pond, in fact, extends into Massachusetts. The pond covers an area of 376 acres (Wright et al. 1949) and reaches a maximum depth of about 9 feet. A natural breach at the south-central portion of the pond periodically opens to the ocean, allowing brackish water to leave the pond and sea water to enter. The salinity of the pond water, measured in December 1979, was 15-17 ppt.

There is no public access to the pond. Farms and undeveloped brush and woodland surround the pond, although

several houses have recently been built or are being built along its shores. The southern portion of the pond is bordered by a barrier beach which separates it from the ocean. The Audubon Society of Rhode Island has an easement on 25 acres of land abutting the pond. The Society's interest in the pond is for its preservation as a pristine and valuable waterfowl area.

The bottom ground under the pond consists of hard-packed sand in the lower fourth of the pond and mud in the upper portions. A cobble and gravel bottom is found along the eastern shoreline. Many small boulders up to about two feet in diameter are found along the edges of the upper portions of the pond: they were presumably dumped there when adjacent fields were cleared for farming. Oysters are abundant in the upper two-thirds of the pond, and a few soft-shelled clams are found in the sandy bottom in the lower part of the pond. Although there has been a small amount of commercial perch fishing, eeling, and oystering in the past, commercial activity in the pond today is minimal to non-existent. There is a small amount of recreational oystering, crabbing and fishing in the pond, but human activity in general is minimal.

Quicksand Pond is the only one of Little Compton's coastal ponds which could conceivably support any mariculture activity. Currently there is a small-scale oyster culture experiment being conducted in the pond. At this point,

however, it is too early to make an evaluation of the success of this experimental project.

Since Quicksand Pond is a relatively pristine area with a minimal amount of human encroachment, it is recommended that aquaculture activity here be kept to a minimum. Only low intensity type aquaculture operations should be allowed in the pond to ensure that the integrety of this natural area is not disrupted.

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SECTION C

NARRAGANSETT BAY

AND

ASSOCIATED COVES AND ESTUARIES

NARRAGANSETT BAY

INTRODUCTION

Narragansett Bay is one of Rhode Island's most prominent features: a large estuary opening into R. I. Sound (Figure 9). Its total area, including the Sakonnet River and Mount Hope Bay is 174 square miles (measured from the Point Judith - Sakonnet Point closing line), and has a shoreline of approximately 250 miles (Alexander 1966). The Bay is approximately 26 miles long by 4-5 miles wide (Alexander 1966). The average depth of both the West Passage and the Sakonnet River is 24.5 feet at mean low water, while depths in excess of 100 feet are found in the East Passage as far north as midway along the Prudence Island shore (Hale 1980). The deepest portion of the Bay is located off Castle Hill at the mouth of the East Passage where the water depth is in excess of 180 feet.

Two large islands, Conanicut (Jamestown) and Aquidneck (Rhode) Islands separate the mouth of the Bay into three passages: the West Passage, the East Passage, and the Sakonnet River. Another large island, Prudence Island, is located in the center of the Bay. Several smaller islands are also present.

Although several rivers and streams empty into the Bay, the largest volume of fresh water entering the Bay is via

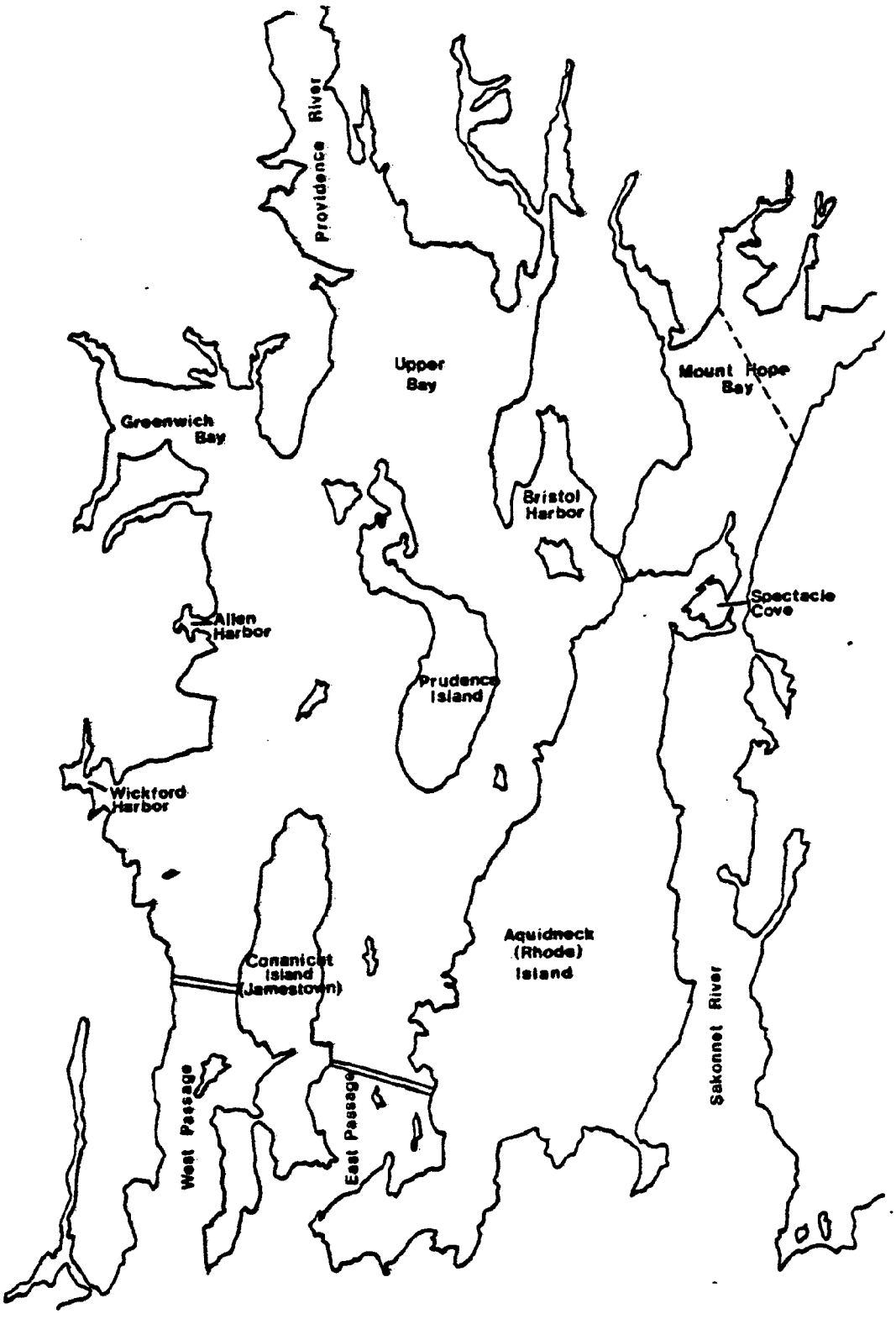

Figure 9. Narragansett Bay.

the Blackstone, Pawtuxet, and Taunton Rivers. It has been calculated that with the flushing rates in Narragansett Bay, it would take from 42 to 59 days for a particle of water to travel from Providence to the mouth of the Bay (Hale 1980). Salinities range from 0 ppt at the head of the Bay to 34 ppt at the mouth.

CURRENT USES

Narragansett Bay is an extremely heavily utilized body of water. Both recreational and commercial activities abound throughout the Bay where countless thousands of people utilize this body of water in one aspect or another.

Boating

Rhode Islanders own some 25,000 boats, and the number is increasing steadily (R. I. Statewide Planning 1979). The vast majority of these boats are sailed on the waters of Narragansett Bay. In the summer of 1979, there were an estimated 13,000 recreational craft at slips and moorings in R. I. waters (Olsen et al. 1980). About 60% of the recreational fleet in 1979 were power boats (Olsen et al. 1980). Power boat activities include sport fishing, cruising, and water skiing. Sailing activities also abound where races and regattas are a common site on the waters of Narragansett Bay during the summer months.

The densest concentrations of boating facilities in the Bay are located in Newport Harbor, Wickford Cove, Greenwich

Cove, Appanaug Cove, Warwick Cove, Bullock Cove, Warren River, Bristol Harbor, and the area outside of Spectacle Cove (Figure 10). Many other marinas, yacht clubs, docks, launching areas, and mooring areas are found scattered throughout the Bay.

Shipping

The Bay also supports a substantial amount of commercial shipping. In 1977, 12.5 millon tons of cargo came into the Bay (Olsen et al. 1980). The main shipping channels in the Bay begin at the East Passage. One channel runs from the East Passage to the Port of Providence; the other from the East Passage to Fall River via Mount Hope Bay (Figure 11). The run from Brenton Point to the Port of Providence is 23.6 miles (Hale 1980). The main cargo of vessels utilizing these channels is petroleum. The West Passage is used only by smaller vessels which generally have a draft of less than 20 feet. Large vessels do not use the Sakonnet River either, due to a lack of deep water in the upper part of the River.

In order to accommodate vessels in the Bay and surrounding waters, several anchorages have been designated in the lower part of the Bay (Figure 12). These anchorage grounds are defined and established pursuant to the authority of the Secretary of the U. S. Department of Transportation, and the rules and regulations thereto enforced by the Coast Guard under the direction of the Secretary of Transportation

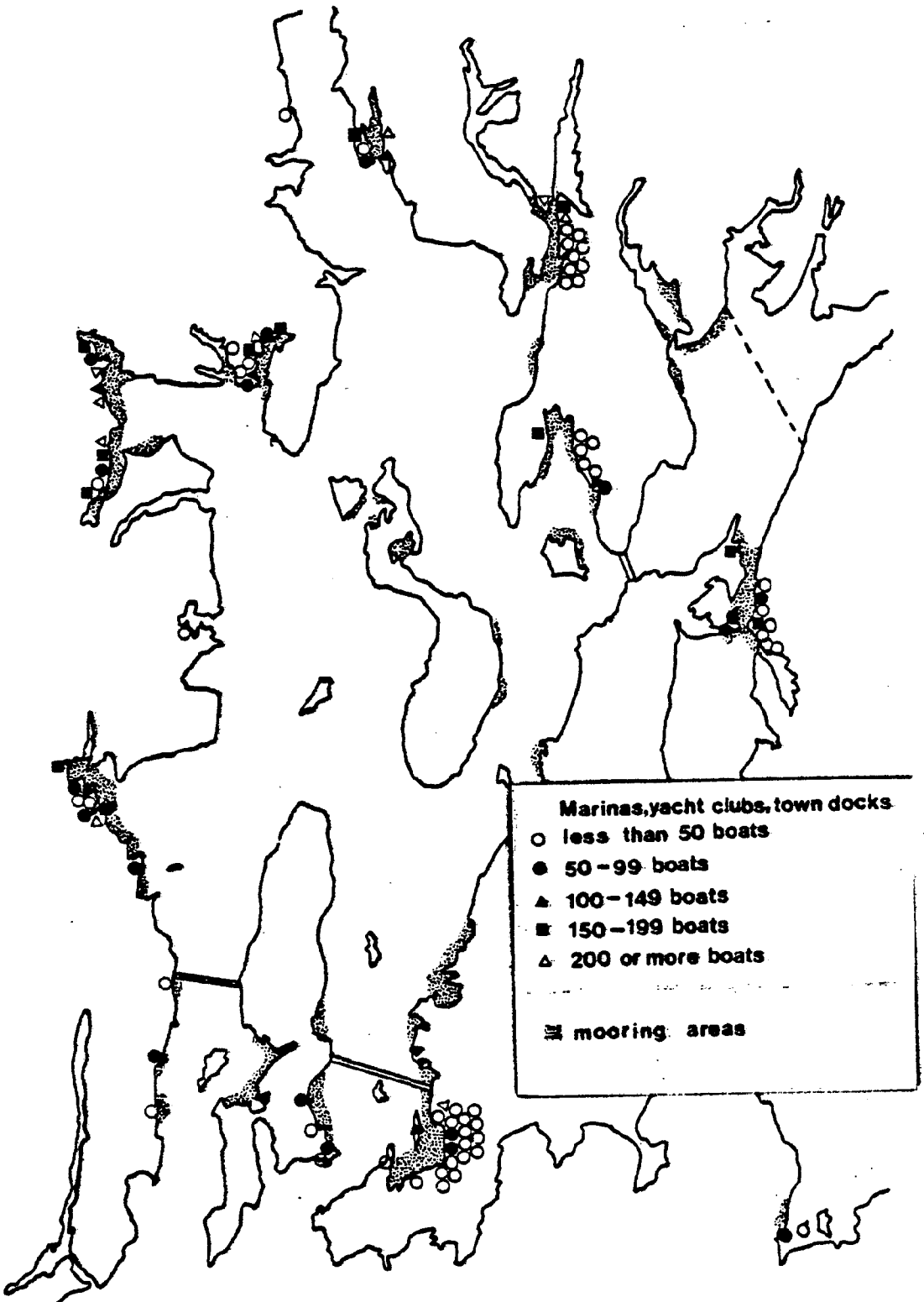

Figure 10. Marinas, yacht clubs, town docks, and mooring areas in Narragansett Bay. Partially adopted from R.I. Statewide Planning Program, 208 Water Quality Management Plan for R.I., 1979.

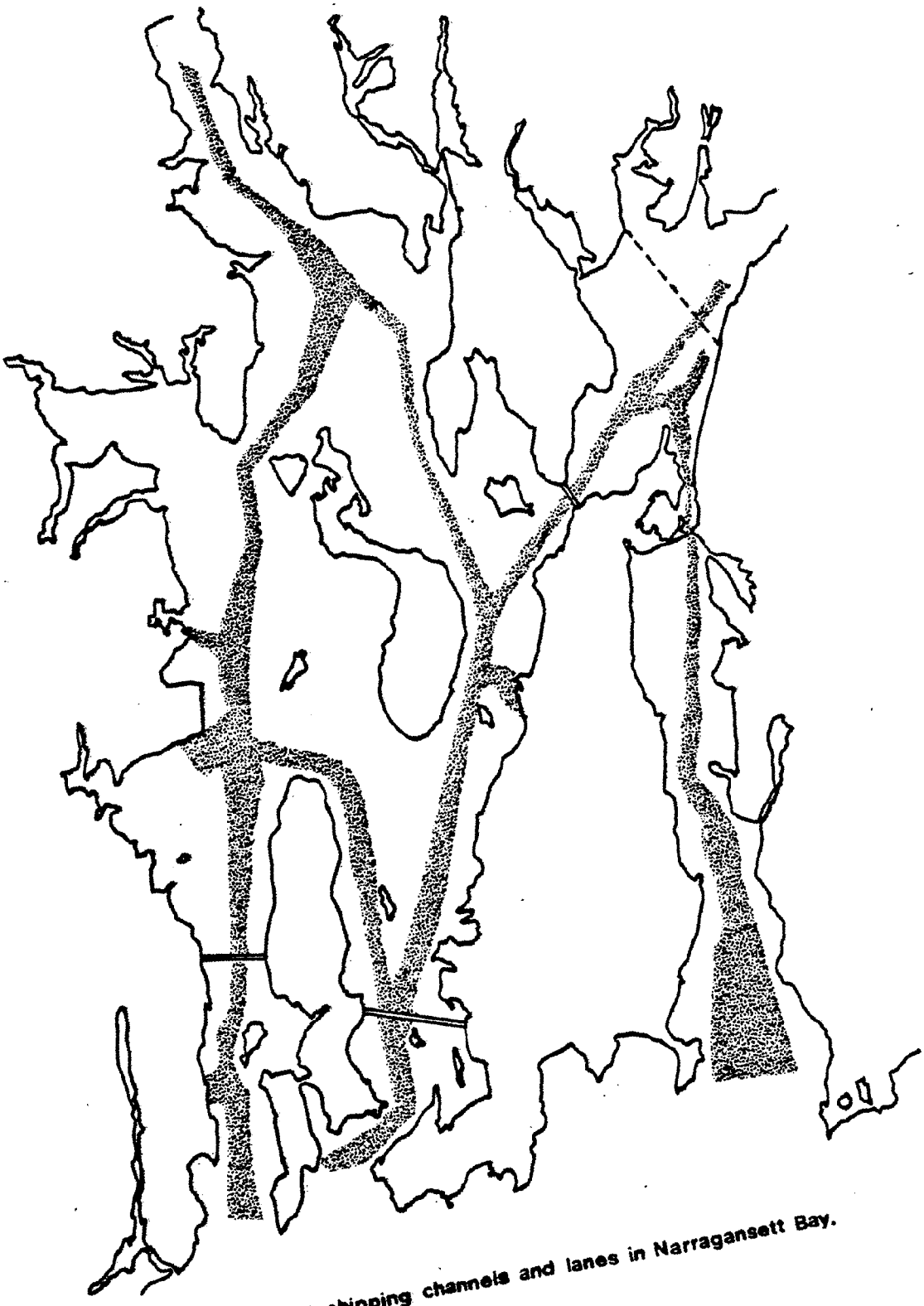

Figure II. Principal shipping channels and lanes in Narragansett Bay.

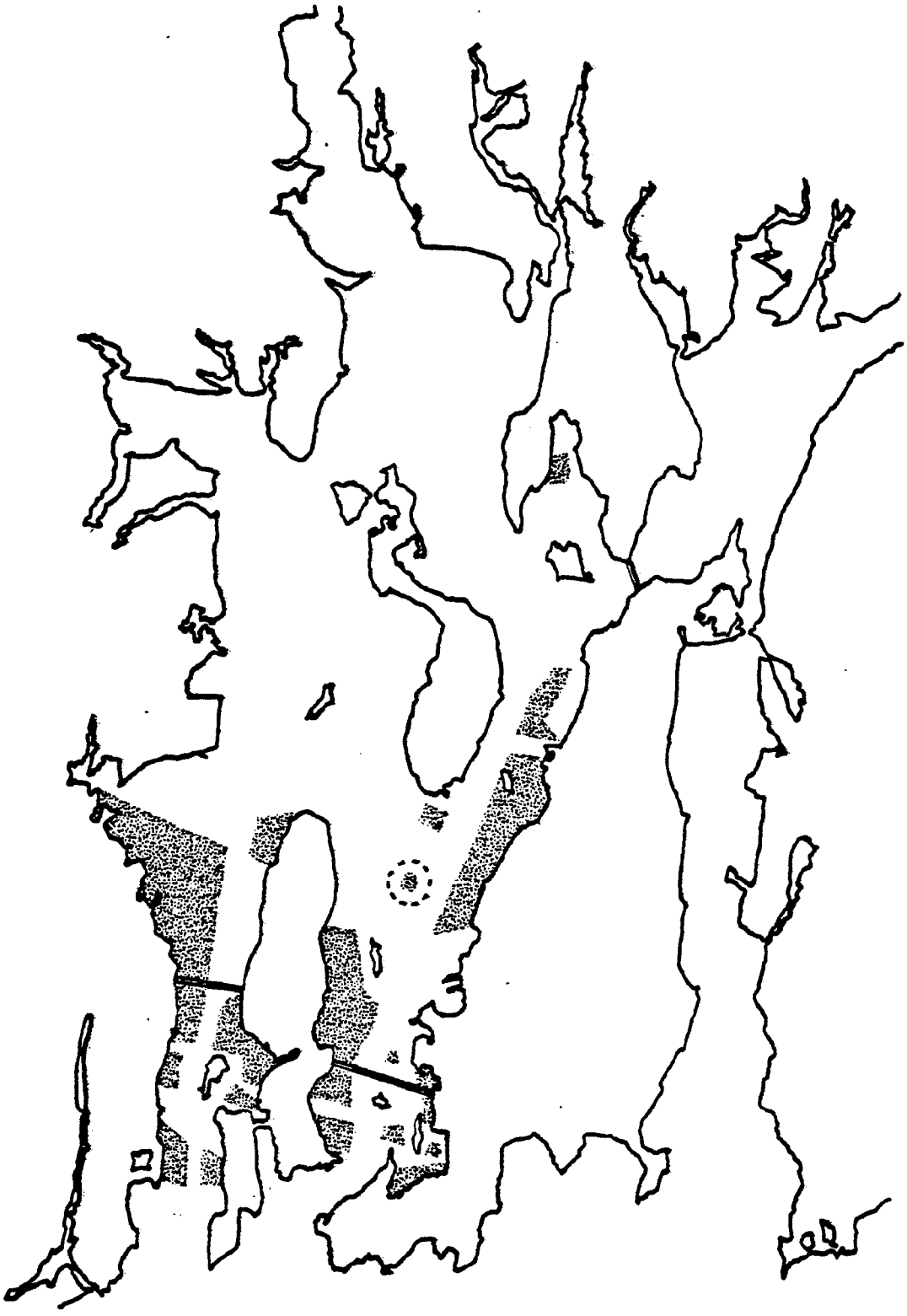

Figure 12. Designated anchorages in Narragansett Bay.

(USC 1915). The most actively utilized anchorages are those located in the East Passage along the Jamestown shore and in the vacinity of Newport Harbor.

Fishing

Fishing, both commercial and recreational, is a major activity in Narragansett Bay. Of the various commercial fisheries in the Bay, quahauging is the most important. In 1979, a total of 26,235,324 pounds of quahaugs, yielding 2,186,277 pounds of meats worth $6,345,215 dollars were harvested in Rhode Island (NMFS 1980). A total of 2,517 commercial shellfish licenses were issued in 1979. In 1980, there were 3,462 licenses issued, and it is projected that the number will increase still further in 1981. The principal quahaug grounds in the Bay, as illustrated in Figure 13, were derived from interviews with several conservation officers who have observed commercial shellfishing activity in the Bay for many years and from information derived from the State's Division of Fish & Wildlife.

Other commercial shellfisheries in the Bay include the lobster, soft-shelled clam, conch, mussel and surf clam fisheries. The lobster pot fishery is generally located in the southern half of the Bay (Figure 14). It is a seasonal fishery extending from late spring through the fall. In the Bay, pots are set either individually or in short trawls. Conchs are also harvested in the Bay with the use of pots. This fishery is also seasonal and widely scattered throughout

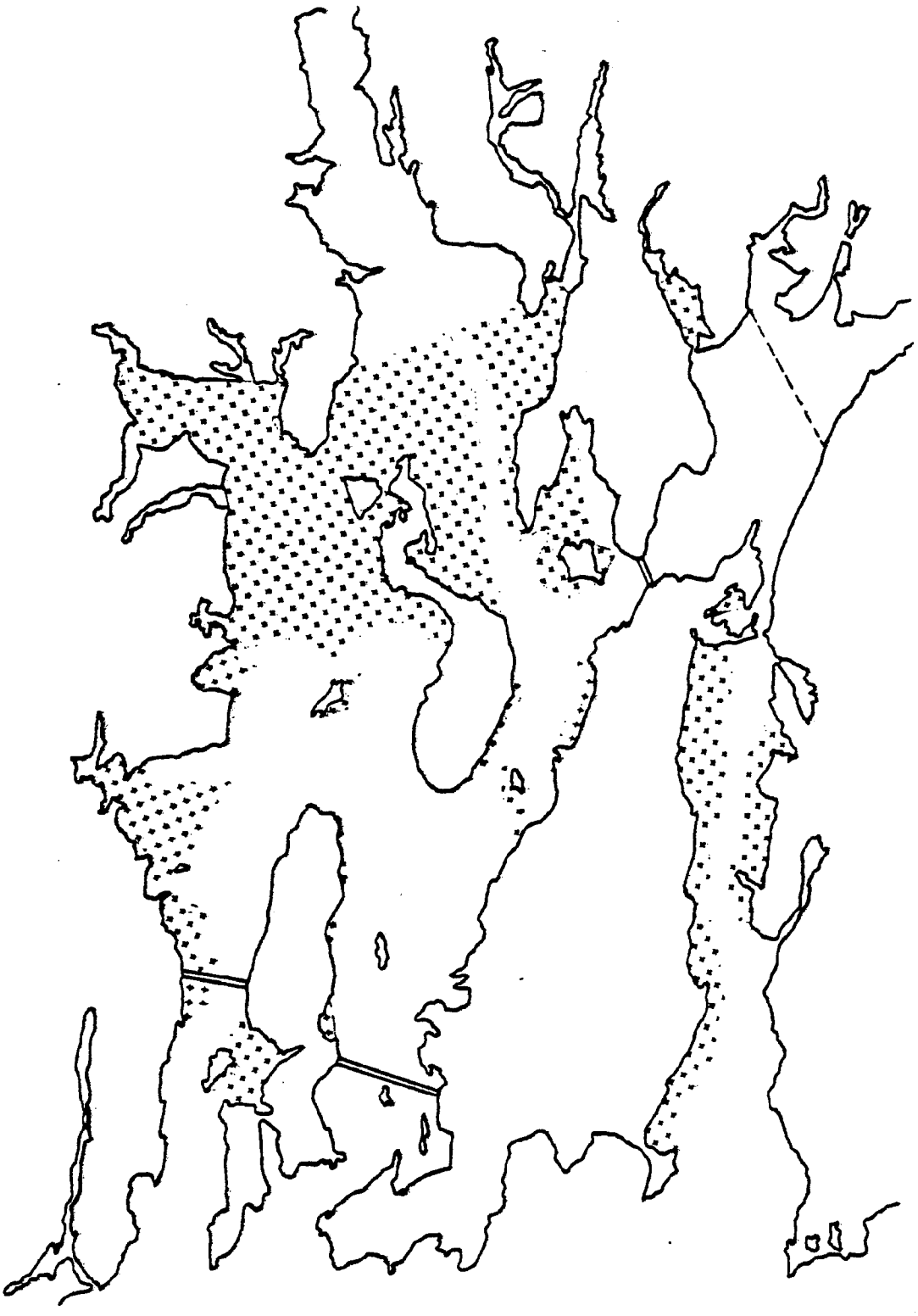

Figure 13. Principal quahaug fishery grounds in Narragansett Bay.

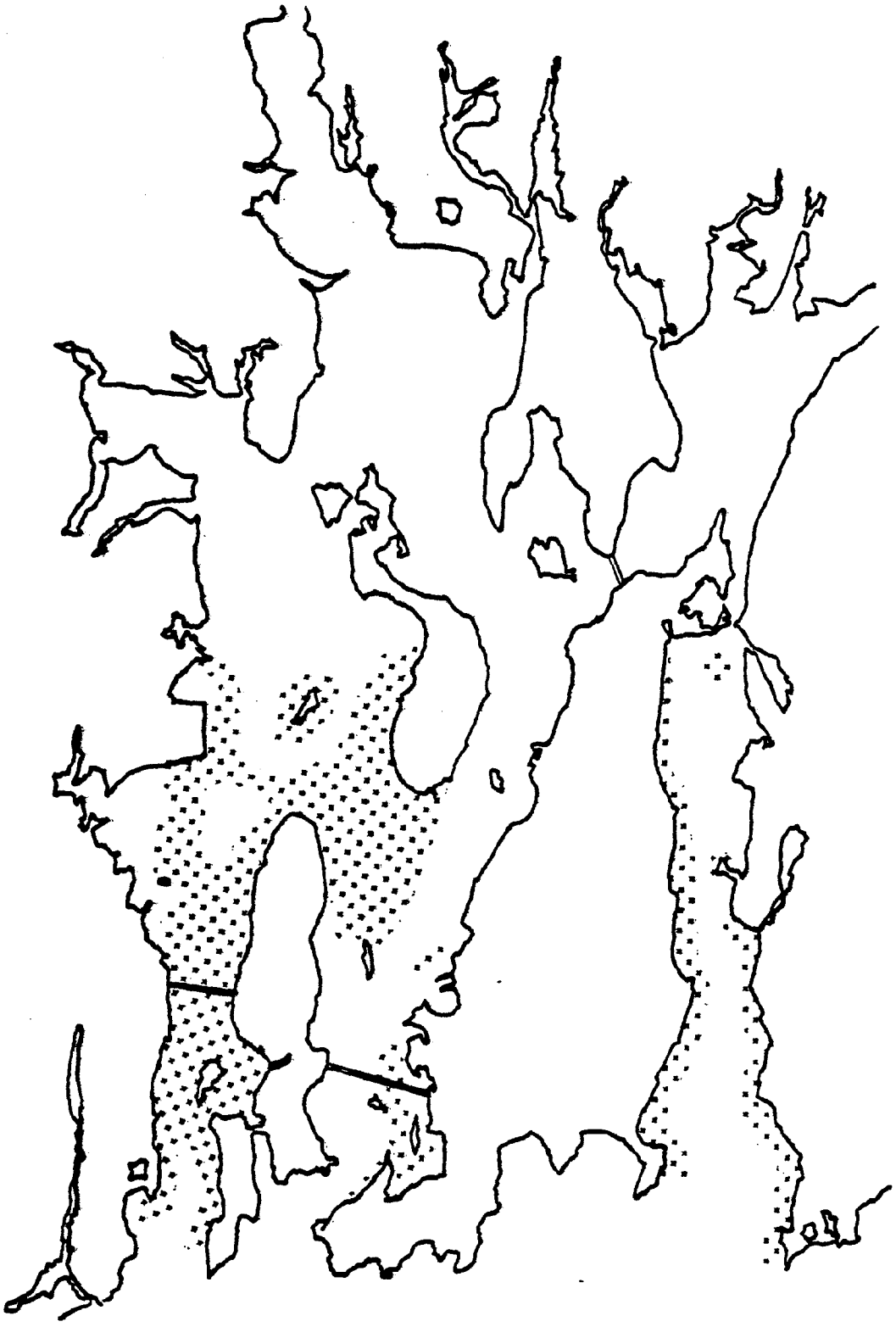

Figure 14. Lobster pot fishery in Narragansett Bay.

the Bay where single pots are generally set (R. Sisson, R. I. Div. of Fish & Wildlife, personal communication, 1981). In 1979, a total of 68,656 pounds of conchs (meats) with a value of $49,400 dollars were harvested (NMFS 1980). Of lesser importance are the soft-shelled clam, mussel and surf clam fisheries.

Recreational shellfishermen harvest all of the above mentioned species. They generally harvest shellfish without the use of a boat in the shallow waters along the Bay's shoreline. Recreational shellfishing is considered a major activity in the Bay in which thousands of people partake each year.

Several management areas have been established in the Bay by DEM for the protection and control of shellfish stocks (Figure 15). These areas include: Hundred Acre Cove, Barrington; Mill Gut, Bristol; Mary's Creek, Warwick; Greenwich Bay; Duck Cove and Bissel Cove, North Kingstown; and a portion of the lower Sakonnet River. Special shellfishing regulations apply to these areas.

Today, finfishing in the Bay is dominated by recreational fishermen using hook and line (Olsen et al. 1980). The most sought after gamefish are striped bass and bluefish. Winter flounder, scup, and tautog are also caught in substantial numbers.

Commercial finfishing in the Bay is a moderate, seasonal activity. Sportfishermen who sell their catch play a

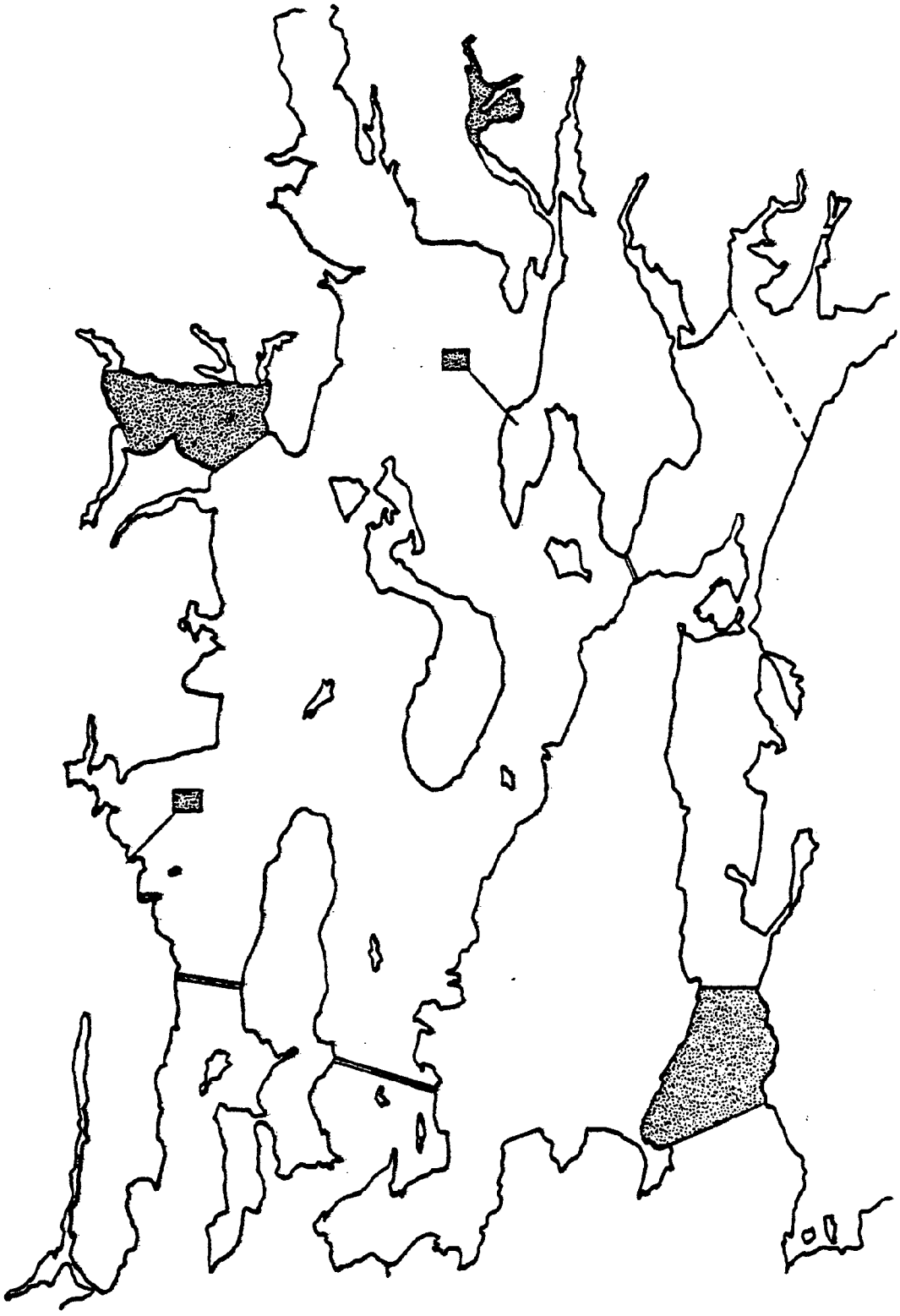

Figure 15. Shellfish management areas in Narragansett Bay.

major role in the Bay's commercial finfishery. A handful of small draggers operate in certain parts of the bay on a seasonal basis (Figure 16), where they trawl for flounder and other less important bottom fish. There is also a menhaden fishery where purse seiners (mostly from out-of-state) follow schools of menhaden into the Bay. Although once a major industry in Narragansett Bay, fish traps in the Bay are now confined to the Sakonnet River where only a few are in operation.

Waste Disposal

Another major use of the Bay, unfortunately, is for waste disposal. It is a receptacle for both sewage and industrial waste. Twelve sewage treatment plants discharged 126 million gallons of effluent into Narragansett Bay in 1977; half of the discharge came from the Providence plant (Olsen et al. 1980). Other sewage, much of it raw, enters the Bay via rivers and streams that enter the Bay.

Industrial wastes resulting from the production of textiles, metals, chemicals, and jewelry are also dumped into the Bay in vast quantities. The Blackstone River receives large quantities of untreated textile and industrial wastes from Worchester, Woonsocket, Pawtucket, and several other smaller industrial centers and dumps them into the Bay (Alexander 1966). The Taunton River discharges industrial wastes from Taunton and Fall River into Mt. Hope Bay. The Pawtuxet River adds industrial waste from West Warwick, War-

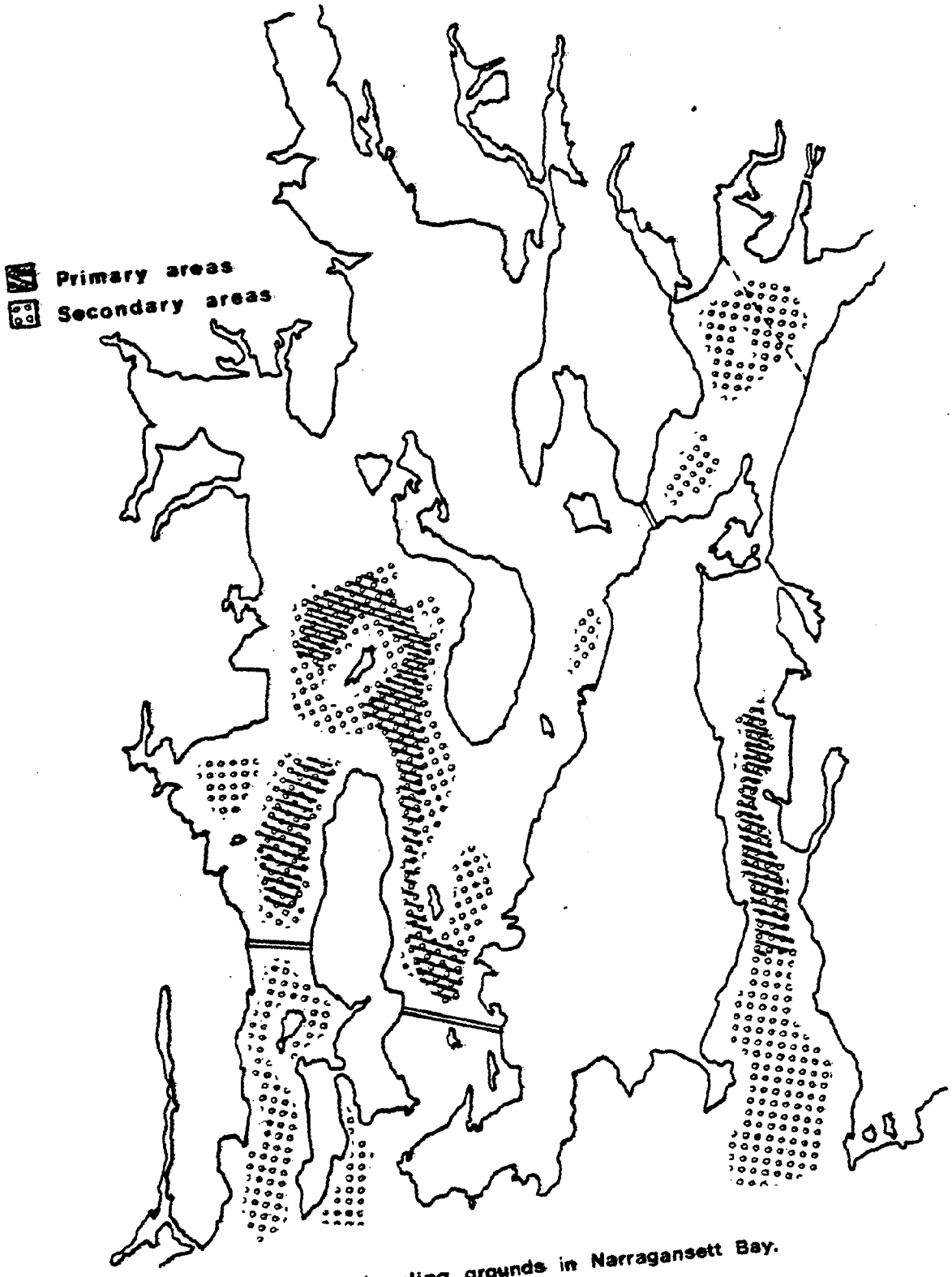

Figure 16. Principal trawling grounds in Narragansett Bay.

wick, and Cranston. These and other pollutants including petroleum hydrocarbons make their way into the Bay via rivers and streams and general run-off.

DEM's Division of Water Resources has adopted the following criteria for the classification of the marine waters of the state (Figure 17): SA (suitable for all sea water uses including shellfish harvesting for direct human consumption approved shellfish areas , bathing, and other water contact sports); SB (suitable for bathing, other recreational purposes; industrial cooling and shellfish harvesting for human consumption after depuration restricted shellfish area , excellent fish and wildlife habitat, good aesthetic value); and SC (suitable fish, shellfish, and wildlife habitat; suitable for recreational boating and industrial cooling; good aesthetic value) (R. I. Dept. of Health 1967).

POTENTIAL FOR AQUACULTURE

In 1864, new state statutes governing the leasing of sections of the Bay bottom for private oyster cultivation were adopted (Hale 1980). In the years that followed, oyster culture developed into a major R. I. industry. The peak was reached during the 1910-1912 period when nearly 1,500 persons were employed in the industry, and over 20,000 acres of ground were owned or leased (Alexander 1966). The industry then began to decline, and in 1957, the last oyster company went out of business.

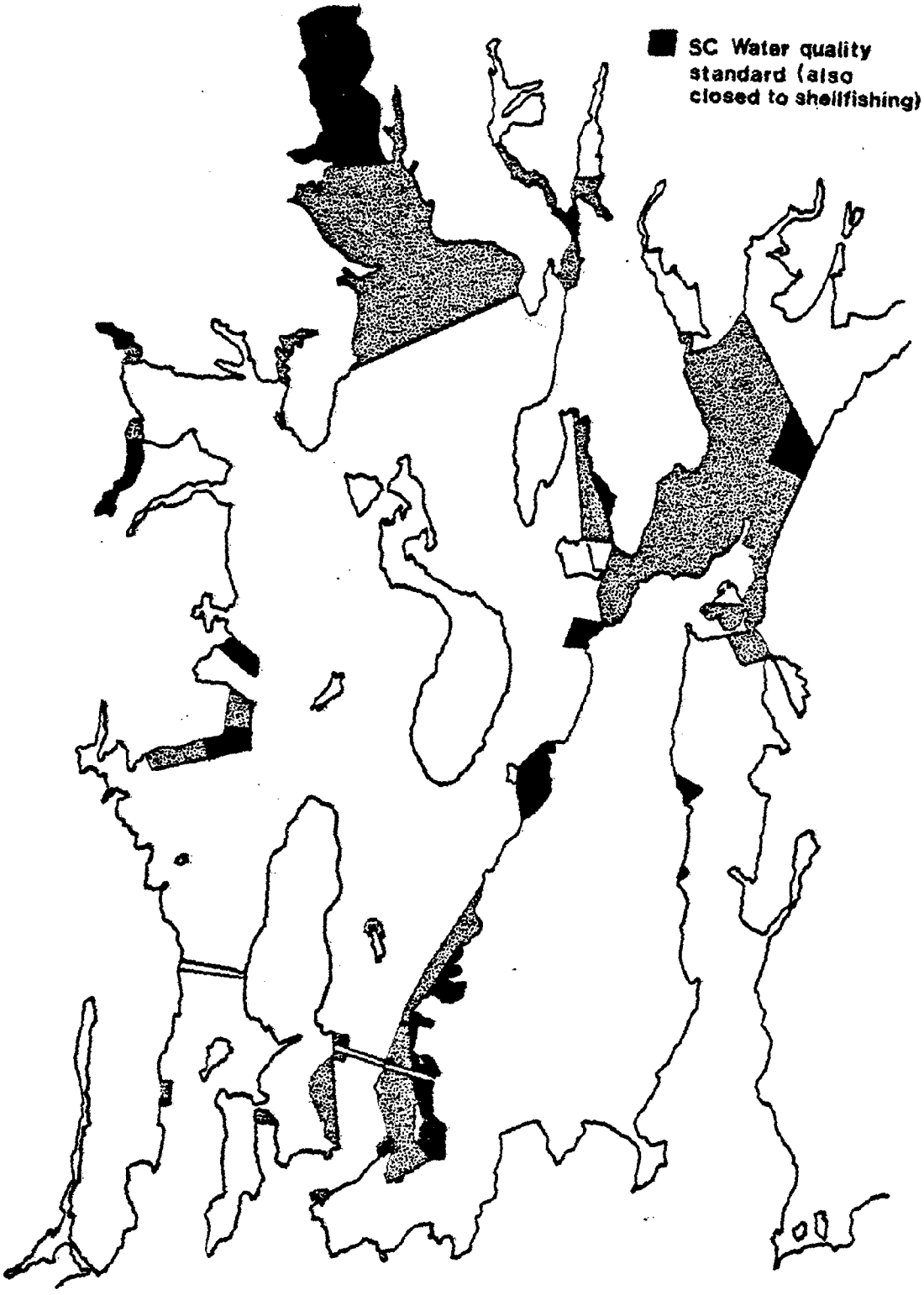

Figure 17. Areas permanently closed to shellfishing in Narragansett Bay.

Vast expanses of bottom culture are a thing of the past. Pollution, an alteration of bottom conditions from siltation, and an increase in use conflicts have permanently put an end to this type and expanse of oyster culture in Narragansett Bay. New techniques in off-bottom culture, however, look promising. By suspending animals in the water column, a high productivity can be reached while using a relatively small area.

Species which appear to be well suited to culture in the Bay are American oysters, quahaugs, mussels, and possibly bay scallops. These are all indigenous species and should grow well with off-bottom techniques.

Currently there are only two active aquaculture operations in the Bay: Blue Gold Sea Farms and the Prudence Island Oyster Farm. The Prudence Island Oyster Farm is an ingenious example of raft-culture operated by Luther Blount of Warren, R. I. Blue Gold Sea Farms is a long-line mussel culture operation located in the East Passage, near Middletown. Both operations are relatively new to the Bay but show much promise for success.

The biological potential for aquaculture in the Bay is excellent, but finding a suitable area in which to locate aquaculture operations is a major problem. Use conflicts severely limit those areas where aquaculture ventures can be located. In spite of these limitations, there is still a place for a certain amount of aquaculture in Narragansett Bay.

RECOMMENDATIONS

The following guidelines are recommended for issuing assents for aquaculture in Narragansett Bay:

1. Quahaug grounds. No leasing of acreage for the purpose of bottom culture in those areas generally considered to be traditional quahaug harvesting grounds as illustrated in Figure 13. A limited amount of off-bottom culture could be permitted in specific areas within the traditional quahaug grounds where shellfish surveys by qualified DEM personnel indicate a low density or lack of a standing crop of quahaugs. In the event that such a permit is issued, provisions must be made to mandate that the aquaculturist relocate his apparatus in the event that quahaugs become abundant on the ground below his apparatus in future years. This would allow access for shellfishermen to harvest the quahaugs which would be otherwise inaccessible.

2. Trawling grounds. No bottom culture which could obstruct or impede trawling operations nor any off-bottom culture inclusively in areas considered to be primary traditional trawling grounds as indicated in Figure 16. Aquaculture operations in areas designated as secondary trawling areas (those areas less extensively utilized than primary areas) should be limited in size and number contingent upon the potential they could have to conflict with the traditional trawl fishery and upon the extent of that conflict. An equitable decision to grant, deny, or modify assents for

aquaculture operations in these areas would have to be made on individual bases by the MFC and ultimately the CRMC after careful deliberation of the evidence presented by all interested parties.

3. Shipping lanes and channels. No aquaculture in the main shipping channel running through the East Passage to the dredged channel from the east side of Prudence Island to Providence. This area supports the heaviest concentration of large vessels traffic in the Bay. Aquaculture is also not recommended in the dredged channel in Mount Hope Bay and within the natural channel connecting it with the East Passage.

Off-bottom culture in less used shipping lanes such as the West Passage and the Sakonnet River should be restricted and carefully located to avoid problems with navigation.

4. Recreational boating. No aquaculture in the immediate vacinity of marinas, yacht clubs, town docks, or mooring areas where there would be a conflict with boating activities (Figure 10).

5. Water quality. No culturing of shellfish in waters classified as SC by the state's Division of Water Resources. Aquaculturists rearing shellfish in SB waters would have to comply to regulations mandated by the state's Divisions of Water Resources and Food Protection and Sanitation regarding depuration.

6. Lobster fishery. Off-bottom aquaculture operations within areas generally considered to be part of the state's

lobster fishery (Figure 14) should be restricted in size and scope so as not to unduly obstruct or impede lobstermen from access to their fishing grounds. Off-bottom culture operations occupying more than an acre should be arranged to provide access lanes through the arrays of apparatus in order to allow access for lobstermen to set pots within the leased area.

7. Government property. The US Navy's torpedo testing range around and north of Gould Island (Figure 18) is a restricted area. Any activity such as aquaculture within this area would have to have clearance from the Dept. of the Navy.

8. Shellfish management areas. No bottom culture in shellfish management areas as designated by DEM. Although bottom culture would be inconsistent with the goals of the management areas, certain types of off-bottom culture operations would not be precluded.

9. Anchorages. Although large areas in the southern portion of Narragansett Bay are designated as anchorages, only certain ones are used on a regular basis. However, since the anchorages are officially designated, the US Coast Guard would have to be consulted before any structures could be placed within these areas.

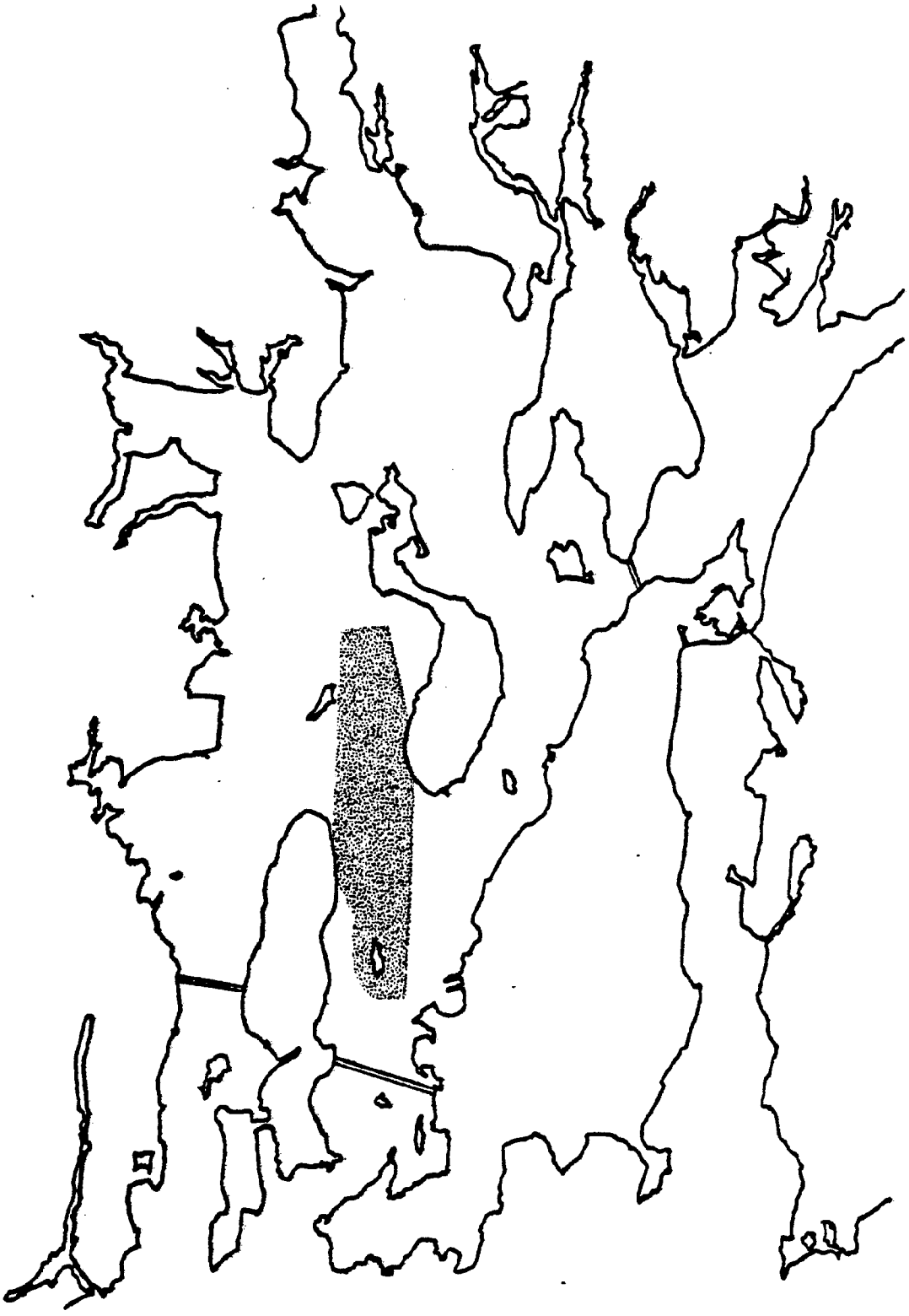

Figure 18. Torpedo testing range (restricted area).

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