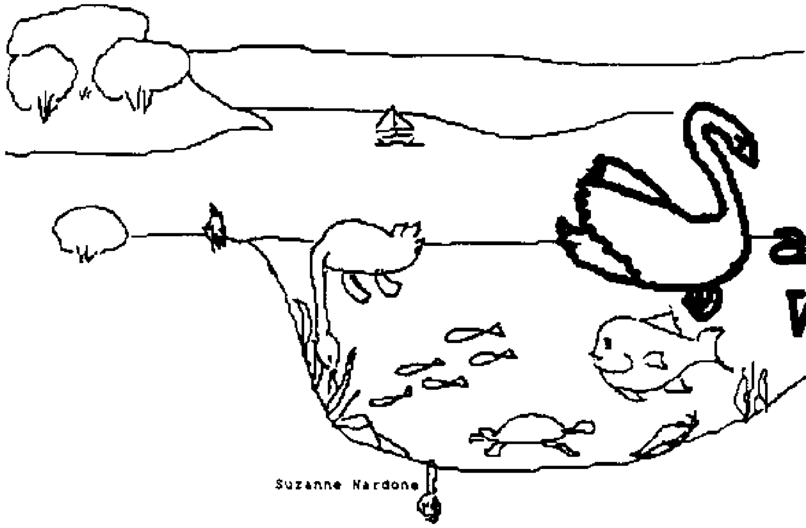


# Salt Pond Watchers

## Summary Data Report 1985-1987

Coastal Resources Center
University of Rhode Island
Technical Report No. 10
October 1990

Rhode Island Sea Grant

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# Salt Pond Watchers

## Summary Report
## 1985-1987

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April 1991

## SALT POND WATCHERS

| Pond | 1985 | 1986 | 1987 |
|---|---|---|---|
| **Point Judith Pond** | | | |
| | Phil Carpenter | Phil Carpenter | Phil Carpenter |
| | Fran Chisholm | Eric Schoonover | Eric Schoonover |
| | Elaine Stedman | Elaine Stedman | Elaine Stedman |
| | | | Walter Wall |
| | | | Virginia and Lars Larson |
| | | | Clint Higginbottom |
| **Potter Pond** | | | |
| | Ross Toney | Ross Toney | Ross Toney |
| | Ernie Kingman | Ernie Kingman | Ernie Kingman |
| | Lillian Westcott | | Zenas Bliss |
| | | | John Haden |
| | | | Robert Pratt |
| **Green Hill Pond** | | | |
| | John Baer | John Baer | John Baer |
| | Al Hale | Al Hale | Al Hale |
| | Bea Doyle | Bea Doyle | Bea Doyle |
| | | | George Griffin |
| **Ninigret Pond** | | | |
| | Ed Bliven | Ed Bliven | Gilbert Burdick |
| | Art Ganz | Art Ganz | Bessie McGonagle |
| | Thad Gruczka | Joe Krukowski | Joe Krukowski |
| | | | Henry Van Ackerman |
| | | | Cal Pearson |
| | | | Doug Mackey |
| | | | Dick Wood |
| **Quonochontaug Pond** | | | |
| | Webster Dodge | George Vinal | George Vinal |
| | Anne Preuss | Anne Preuss | Anne Preuss |
| | Fay Rand | Fay Rand | Fay Rand |
| | Jack Tobin | Jack Tobin | Jack Tobin |
| | Merry Platt | Merry Platt | Merry Platt |
| | Charles Hickox | Charles Hickox | Charles Hickox |
| | Harry Holland | Harry Holland | Harry Holland |
| | Bob Perry | Bob Perry | Bob Perry |
| | Nancy, Bob Wetherell | Nancy and Bob Wetherell | Nancy and Bob Wetherell |
| | | | Bob Phelan |
| | | | Peter Schipper |
| | | | Dale Morgan |
| **Winnapaug Pond** | | | |
| | Jack Barber | Nick Starinovich | Nick Starinovich |
| | Jeff Gardner | Jeff Gardner | Jeff Gardner |
| | Roger Laughlin | Roger Laughlin | Roger Laughlin |
| | Cy Morgan | Cy Morgan | Cy Morgan |
| | Virginia and Don Allison | | Bill Eschenfelder |
| **Maschaug Pond** | | | |
| | Clem Griscom | Clem Griscom | Clem Griscom |

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## ACKNOWLEDGMENTS

Many individuals and groups have contributed to the success of the Rhode Island Salt Pond Watchers Program.

First of all, the Salt Pond Watchers are to be applauded and thanked for their boundless enthusiasm, generosity, and dedication. Working with them has been extremely enjoyable, productive and inspiring.

The University of Rhode Island Sea Grant College Program has principally supported the project since it began in 1985. In addition, a grant provided by the Charles A. Lindbergh Fund in 1988, and directed by the Shelter Harbor Conservation Society, allowed the program to move towards greater self-sufficiency by broadening and strengthening our collaboration with pond area residents. Additional funding, obtained from the IBM Corporation in 1986 and 1987 through the Shelter Harbor Conservation Society, also provided vital funding for chemical analyses.

State and federal laboratory personnel have generously provided us with their time, expertise, equipment and laboratory facilities for bacteria analyses. In particular, we thank Louis Iacobucci, Pat McNulty, Ted Pliakas and their colleagues from the Rhode Island Department of Health (DOH); and Robert Wetherell, Diane Reitz, and the staff at the Federal Food and Drug Administration Laboratories (FDA) at Davisville. In addition to their major in kind financial contribution, they provided critical quality assurance for the bacteria monitoring.

Under Bob Bendick's leadership, the Rhode Island Department of Environmental Management, Division of Water Resources, has been very interested in and supportive of our project. Chris Deacutis, Joe Migliore, and John Speaker have worked productively with us to insure the data we collect is appropriate and useful to the state for management decisions and planning efforts. A joint, intensive shoreline survey of the ponds in 1986 was especially helpful.

Also, we thank the members of the Shelter Harbor Conservation Society for their assistance on this project. The Lindbergh staff associates who put in particularly long hours are Michael Van Vranken, Project Director; Suzanne Nardone, Data Manager; and Anne Preuss, Editor of the Salt Pond newsletter.

Thanks to Jean Krul and Annette Burgess of the Coastal Resources Center, The University of Rhode Island for considerable patience and nimble typing, for their help with organization and communication since the beginning of the Salt Pond Watchers, and for production of this document. Several graduate students at the URI Graduate School of Oceanography have done excellent work in day-to-day responsibility for the success of the project: Nancy Craig, Jim Fraher, Ana Thompson, Joe Tokos, Sharon Larimer, Veronica Berounsky, Margarida Castro, and Julia McMahon.

Paula Kullberg
Meredith Platt
Virginia Lee

# CHAPTER I: INTRODUCTION

## The Salt Ponds

Seven coastal lagoons, locally known as salt ponds, stretch along Rhode Island's ocean shore from Watch Hill on the Connecticut border northeastward to Point Judith (Figure 1). The salt ponds are beautiful and productive shallow estuaries connected to the sea by inlets or stabilized breachways through barrier beaches.

These small estuaries are valued for aesthetic, recreational, and economic reasons. They provide nursery grounds for many species of fish and shellfish and support intense commercial and recreational fishing. The tourist season attracts more than 165,000 people a day who use the area for swimming, boating, clamming, water skiing, and bird watching. The land around them is one of the most desirable places to live in Rhode Island and is being developed at a dramatic rate (Figure 2).

Ecological characteristics:

Each salt pond is unique in terms of depth, tidal flushing, and the kinds and intensity of development around its shores and within its watershed. A summary of basic characteristics of the salt ponds is presented in Table 1. However, the basic ecological processes at work in each pond are similar, as are the pollution problems resulting from intensifying use of the ponds and their watersheds.

For example, the growth of aquatic plants in response to the addition of nutrients is the same fundamental process in all the ponds. Inorganic nutrients, such as nitrates and phosphates, reach the pond from a variety of sources: via the sea, rainfall, stormwater runoff, stream flow, and ground water. Nutrients are even carried through the atmosphere from distant and nearby sources and drop out as fine particles throughout the watershed and the pond surfaces. Just as nutrients permit the growth of garden plants, they also enhance the growth of plant life in the salt ponds. These air- and water-borne nutrients are responsible for the growth of common seaweeds and also of the less visible microscopic plants called phytoplankton ("phyto"=plant; "plankton"=wanderer) which live in the water column and on the bottom of the ponds.

Phytoplankton are food to the filter-feeding shellfish, and crab and fish larvae. These animals in turn serve as food for other marine animals and birds as well as humans. However, an excess of nutrients can lead to too much phytoplankton or nuisance growth of large aquatic plants. In this situation, known as eutrophication, an overabundance of plants can drastically reduce the oxygen content of the water. If oxygen becomes too limited, plants, finfish, and shellfish suffocate and die.

The amount of chlorophyll a (a pigment in phytoplankton) and nitrates and phosphates (nutrients) can be used to indicate whether there may be biological stresses on the pond habitat. An additional measure of phytoplankton growth is the degree of turbidity or cloudiness of the water column. It is also possible to monitor the health of eelgrass by examining their blades for signs of disease.

The kinds and amount of bacteria in the ponds are also important constituents of the ecosystem because they can indicate potential risk to human health. For example, the fecal matter produced by humans and other animals contains whatever harmful viruses were present in the body. The presence of high concentrations of fecal coliform bacteria in water is commonly used as an indicator of fecal contamination. Sources may include failed or leaking septic systems, discharge from boats, fecal waste from water fowl such as swans, stormwater runoff carrying pet waste from roads and yards, or all of these sources. Humans can become infected by associated viruses by ingestion of contaminated water or shellfish. Gastroenteritis, hepatitis and similar illnesses can result. If high concentrations of fecal coliform bacteria are found, the state government can, if necessary, restrict the use of the ponds until sources of contamination are identified and cleaned up.

**Figure 1. Map of the Salt Pond Region**

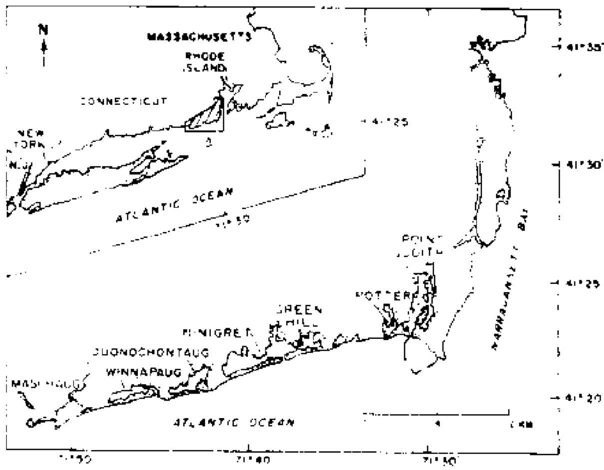
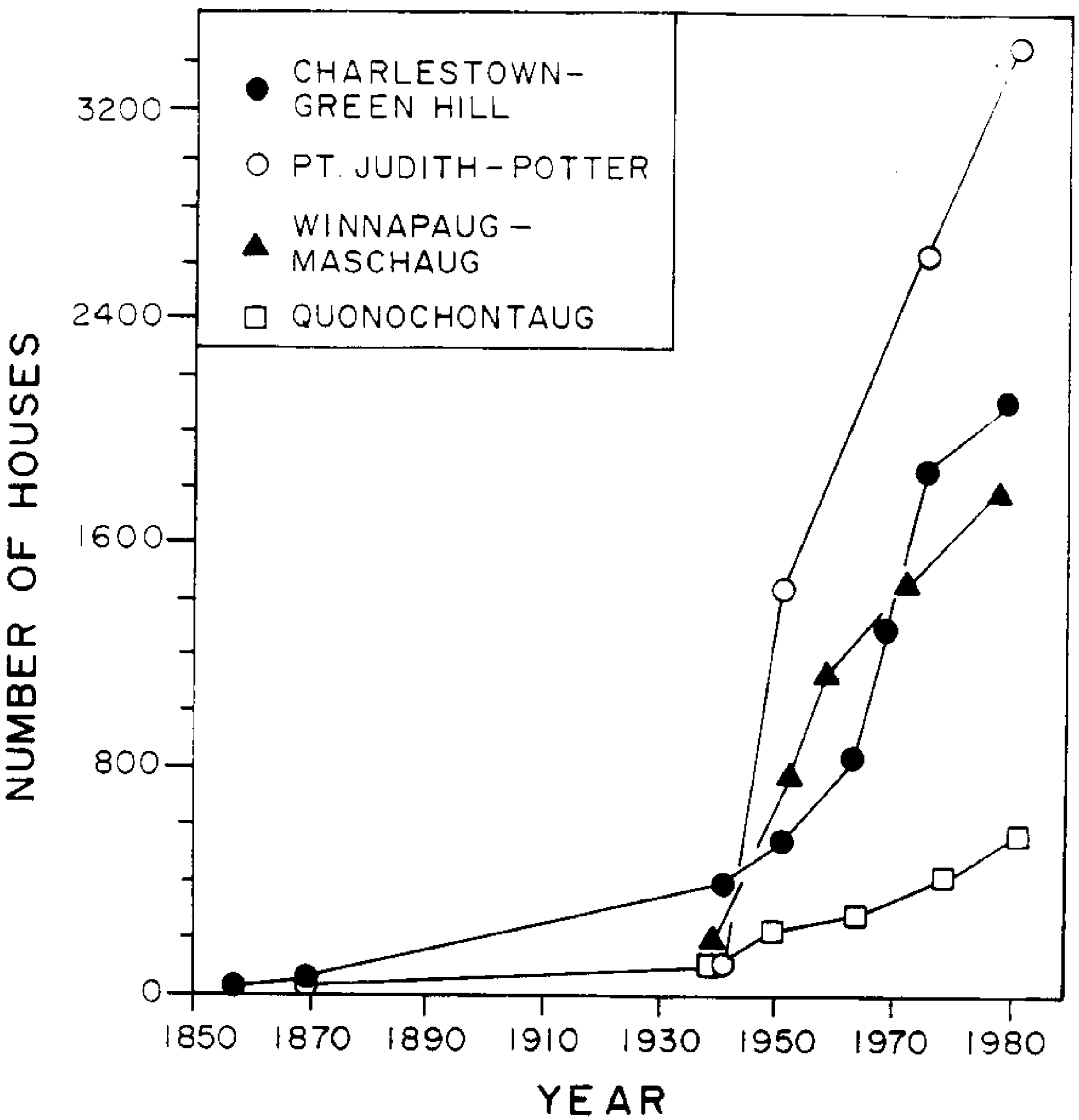



**Table 1. Characteristics of Rhode Island's Salt Ponds**

| | Point Judith | Potter | Green Hill | Ninigret | Quonochontaug | Winnapaug | Maschaug |
|---|---|---|---|---|---|---|---|
| Area ($km^2$) | 6.2 | 1.3 | 1.7 | 6.9 | 3.0 | 1.8 | 0.2 |
| Length (km) | 5.5 | 1.1 | 1.9 | 5.8 | 3.7 | 3.4 | 0.6 |
| Depth (m) | 1.8 | 0.6 | 0.8 | 1.2 | 1.8 | 1.5 | 2.1 |
| Salinity (ppt) | 28 | 26 | 18 | 24 | 29 | 27 | 9 |
| Temp. ($^oC$) | 18 | 18 | 18 | 18 | 17 | 18 | 20 |
| Chlorophyll a (µg chl a/l) | 3.4 | 5.1 | 7.0 | 5.9 | 2.4 | 6.1 | 3.8 |
| Nitrate (µM N/l) | 1.2 | 1.9 | 5.1 | 2.3 | 0.6 | 1.3 | 0.2 |
| Phosphate (µM P/l) | 0.8 | 0.6 | 0.7 | 0.5 | 0.6 | 0.9 | 0.2 |

Note: Salinity, temperature, and nutrient and chlorophyll concentrations are averaged values May-October, 1987.

Figure 2. Trends in Housing Development Around the Salt Ponds South of Route 1 and Shore Road



Physical aspects of the ecosystem include water temperature, depth, and degree of salinity or saltiness (Table 1). Temperature, among other factors, influences the development and migration of fish, shellfish, and crustaceans into and out of the pond. In the shallow salt ponds, unlike the deeper water offshore, sunlight penetrates through the water all the way to the bottom. As a consequence, sea grasses such as eel grass in the saltier areas and widgeon grass in the more fresh water areas, grow rooted in the bottom. Eelgrass beds provide shelter for flounder, scallops, eels, and a multitude of small marine life. If nutrient levels are high, other plants actually grow on the grass blades, accelerating the process of eutrophication. The amount of salt in the water (the salinity) affects which plants and animals thrive there. Increases in fresh water due to runoff, streams, or drinking water supplied from other watersheds will alter the kinds of animal and plant life that can inhabit the salt pond. Each of these basic aspects of the Salt Pond ecosystem is being monitored by the Salt Pond Watchers.

The ecosystem of a pond is neither "good" nor "bad." The term refers to all that comprises the physical and biological environment acting together as a system or unit. To speak of a "balanced" ecosystem suggests that changes in one element of the system may affect all the others, but not in a disruptive way. Many small changes in all the elements occur all the time, but within a given range. An extreme event or catastrophe may alter the characteristics of the ecosystem and establish a new balance. For example, if people were to drag extensively for clams and uproot the eelgrass, the eelgrass may be destroyed. If this happens, the flounder and shellfish may eventually cease to use the area as a nursery. This, in turn, can affect offshore fishing if there are no fish to return to the Sound upon maturity. Life will continue in the ponds but in forms that may not be desirable for the people who use them or live near them. Many coastal waters around the world are heavily polluted with bacteria and toxins, creating unswimmable water and the loss of desirable fish. In many cases, people living beside these water bodies have accepted this limited use, perhaps because they use the water for commercial shipping purposes and don't perceive a greater need to use it for recreational or food supply purposes.

Human beings are by far the most powerful factor in the ecosystem. The destiny of the salt ponds is in our hands. Land use around the ponds has been changing dramatically as more people move to the coast. Agricultural fields and forests are being replaced by houses, condominiums, and associated commercial development. In addition, there is an influx of tourists that at least doubles the population in the summer. Accompanying this growth are more and enhanced sources of pollution which have the potential to dramatically alter the balance of the ecosystem in the ponds. Since most road drainage flows to nearby streams and then to the salt ponds, and because virtually all domestic and commercial sewage within the watershed of the ponds is disposed of on-site into the ground water via individual sewage disposal systems, the threat of pollution to the salt ponds is growing. Whatever value system prevails, it will not be possible to have all options in the future. Trade-offs will have to be made.

## The Salt Pond Watchers

In order to know whether conditions are getting better or worse, long-term monitoring is necessary. In these days of shrinking federal and state funding, volunteers provide an opportunity to cost-effectively conduct reliable water quality monitoring. Since 1985, a group of dedicated volunteers has been monitoring water quality in seven of the nine coastal salt ponds from Point Judith to Watch Hill. The Salt Pond Watchers have proven that volunteers are a reliable, cost-efficient, and effective way to monitor water quality trends. Trained and outfitted with sampling kits, they sample a variety of aspects of the ecosystem (Table 2) every other week from May through October.

Accomplishments to date

The project began in 1985 with 23 Pond Watchers monitoring 22 bacteria and water chemistry stations. By 1987, there were 33 Pond Watchers monitoring a total of 67 bacteria and about 29 water chemistry stations. At the end of the 1987 season, almost 1800 samples had been collected over a three year period. In 1988 and 1989 there were 45 pond watchers sampling 8 to 12 bacteria stations and 3 to 4 water chemistry stations per pond for a total of 440 water chemistry and 795 bacteria samples each year.

**Table 2. Water Quality Parameters Sampled by Salt Pond Watchers**

| .Problem | Parameter | Analysis |
|---|---|---|
| Basic ecological trends | Depth | Salt Pond Watchers |
| | Water temperature | Salt Pond Watchers |
| | Weather observations | Salt Pond Watchers |
| | Rainfall | U.S. Weather Station, Kingston, RI |
| | Salinity | URI Grad School of Oceanography |
| Bacterial contamination | Coliform bacteria | U.S. Food and Drug Administration |
| | (total and fecal) | R.I. Department of Health |
| Eutrophication | Nutrients | URI Grad School of Oceanography |
| | (nitrates and phosphates) | |
| | Phytoplankton | URI Grad School of Oceanography |
| | (chlorophyll a) | |
| | Turbidity | Salt Pond Watchers |
| | (secchi disk) | |
| | Dissolved oxygen | Salt Pond Watchers |
| Eelgrass wasting disease | Eelgrass blade discoloration | Salt Pond Watchers |

Our funding sources also have grown. The RI Sea Grant College Program has supported the project since it began. In addition, private funds from the IBM Corporation, obtained through the Shelter Harbor Conservation Society, provided funds for chemical analyses each year. In 1988, a grant from the Charles A. Lindbergh Foundation allowed the program to move towards greater self-sufficiency by broadening and strengthening our collaboration with pond area residents.

The results of the Salt Pond Watchers monitoring are already being utilized. In addition to the collaboration that has been established between pond area residents, the university, and state and federal agencies, Pond Watcher data led to decisions by the RI DEM to seasonally close Green Hill Pond to shellfishing in 1987 and 1988. Salt Pond Watcher data are also being used for zoning decisions in local municipalities.

As the program has grown, so has its visibility. From 1985 to 1987, local newspapers (The Narragansett Times, Westerly Sun, Providence Journal and others) have followed the progress of the Pond Watchers, and in 1988, graduate assistant Jim Fraher was interviewed with several Pond Watchers by Rhode Island's TV Channel 10. Following the example of the Salt Pond Watchers Project, other volunteer citizen monitoring programs have been initiated around the state and in the New England region.

The Salt Pond Watchers program then received national attention. Papers were presented at national conferences; at the Coastal Society Conference in New Orleans in 1986; at the Lindbergh Grants Presentations in Minnesota in 1988 and an article was published in Oceanus in 1988, a widely-distributed publication of the Woods Hole Oceanographic Institution. In May of 1988 the first National Workshop on the Role of Citizen Volunteers in Environmental Monitoring, sponsored by R.I. Sea Grant College Program and the USEPA Office of Water, was convened by Virginia Lee at the URI Bay Campus in Narragansett. Members of more than 80 volunteer environmental monitoring groups from around the country attended. A network of programs was formed and a directory published of the names, addresses, contact persons, and descriptions of lake, stream, and coastal volunteer monitoring programs coast to coast.

## Future Outlook

While the accomplishments achieved by the Pond Watchers program thus far have been formidable, continuing the work will depend upon the amount of support by the communities, organizations, and individuals living around the ponds and their watersheds.

The Pond Watchers Project is highly cost-effective due to the volunteer efforts of citizens and in-kind contributions of services from government agencies and from the University of Rhode Island. However, it is not cost-free. Between $20,000 and $30,000 per year is needed for equipment, lab analyses, mailings, and data management. Because Sea Grant funding was intended to support just the pilot phase of development, the Shelter Harbor Conservation Society, a volunteer conservation group, has been working with URI personnel to shift management and funding of the Pond Watchers from the university to a self-sustaining citizen-based organization. Ideally, the Pond Watchers should be managed by a coalition of citizens from all the ponds working in close coordination with URI staff. Steps have been taken toward this transition. A computer has been purchased and a volunteer data manager trained. The newsletter, Salt Ponds, written and edited primarily by volunteers, continues. For the first time, in 1989 there is a volunteer coordinator for the Salt Pond Watchers assisting Virginia Lee at the URI Coastal Resources Center.

Local fund-raising is proceeding. Through the efforts of Michael Van Vranken, president of the Shelter Harbor Conservation Society and Project Director on the Lindbergh Grant, annual donations totalling nearly $3,000 have been pledged by communities and groups in the pond area beginning in 1989. While the pledges are encouraging, we have a long way to go. This is a crucial and paradoxical moment in the Pond Watchers Project's history. At a time when there is sufficient data to begin actively influencing environmental policy, we are facing a transition time in need of financial support to keep the project alive and vigorous. Perhaps the key element which will determine if the Pond Watchers continue is the willingness of local towns, organizations, and individuals to provide a small amount of financial support on an annual basis. We believe this kind of participation is a basic expression of stewardship and in some cases will represent an important shift in values.

## The Summary Data Report and Future Implementation

A technical summary of water quality monitoring data is presented here for the years 1985-87. Although three years is too little time to determine long-term trends, it is important that results of salt pond monitoring be made available for decisions that are occurring now. It is intended that a technical report will be prepared annually in the hope that the information will be useful for making informed decisions about the future of the salt ponds by planning boards, conservation commissions, zoning boards, town staff and town councils in each of the four towns that encompass the salt ponds: Narragansett, South Kingstown, Charlestown, and Westerly. The information should also be useful for state government decision-making and environmental strategies by the Rhode Island Department of Environmental Management and the Coastal Resources Management Council. Moreover, this information should be accessible and useful for the many concerned and active citizens who are advocates for the future of the salt ponds.

Copies of the technical report will be provided to any state and local officials as well as any interested citizen upon request to the Coastal Resources Center, University of Rhode Island, Narragansett, Rhode Island,
02882.

# CHAPTER II: MONITORING RESULTS

## Overview, 1985-1987

### Bacterial Contamination

Measurement of total and fecal coliform concentrations in water are the standard used by the Rhode Island Department of Health to determine the potential risk to human health incurred by various uses such as swimming in and eating shellfish from a water body. The Division of Water Resources of the RI DEM, therefore, bases its regulations on what are deemed acceptable levels of coliform bacteria to make decisions about closure of water bodies to shellfishing or swimming (Table 2).

The Salt Pond Watcher bacteria results presented in this report are those for fecal coliforms, because fecal coliforms are more diagnostic of sewage contamination than are total coliforms. Stations marked by a dash (-) indicate that water quality safety standards are not exceeded.

Throughout the ponds, trends in fecal coliform bacteria generally exhibited two patterns. The first was a peak during mid-June through mid-July, when most summer residences are occupied and pond boating activity increases. The second peak appeared in late September through October, when fall rains leach summer sewage into the ponds and waterfowl congregate in the ponds during their fall migrations. Beginning in 1987, Pond Watchers kept records of waterfowl abundance and proximity to stations. Numbers of swans have been increasing in recent years (Pond Watcher observations); many choose to nest around the ponds.

Fecal coliform concentrations in 1986 were especially high. These increases may be related to higher rainfall, which increases surface runoff and leaching from individual sewage disposal systems (ISDS). As a result of the high concentrations in 1986, DEM requested that bacteria sampling be intensified in 1987. In 1987 and subsequent years, Pond Watchers adopted the DEM stations, tripling their sampling load. New station numbers were assigned to correspond to DEM water quality sampling stations.

The tables presented in the text show that for every pond except Winnapaug (and Maschaug, for which coliforms were not measured at all), shellfishing safety (SA) water quality regulations were exceeded in at least two areas of the pond each year. Swimming safety (SB) regulations were exceeded in some areas of Point Judith, Ninigret and Winnapaug Ponds in 1985 and 1986, but not in 1987. Coliform bacteria concentrations are highly variable in both fresh and marine waters over both time and space. It is therefore important to have a long-term monitoring program in order to assess whether conditions have momentarily changed or there is a long-term trend.

### Nutrient Enrichment

Another potential pollution problem in the salt ponds is nutrient enrichment. In many cases, this problem is related to bacterial contamination; both have their source in sewage leaching into the ponds from old and dysfunctional individual sewage disposal systems (ISDS). Rainfall events do not necessarily mean increased nutrient levels for the ponds; however, in small pond basins with reduced circulation, nutrients, like coliform bacteria, can be measured in high concentrations after recent precipitation. Generally, freshwater inputs such as groundwater seeping into the ponds through springs on the bottom or river and stream runoff serve as major sources of nutrients to the ponds.

Phosphate

Phosphate levels are usually quite low in the salt ponds. Concentrations typically range from almost undetectable levels (less than 0.1) to 1 or 2 μM phosphate per liter of water. In lakes and freshwater bodies, productivity and biomass of phytoplankton and other aquatic plants are strongly related to phosphate levels.

**Table 3: Water Quality Regulations for Bacterial Contamination, Rhode Island Department of Environmental Management**

1. Safety standards for Shellfishing (SA water quality)

   Total coliforms: not to exceed a median value of 70 MPN/per 100 ml water; or not more than 10% of the samples shall exceed 330 MPN/per 100 ml of water.

   Fecal coliforms: not to exceed a median value of 15 MPN/per 100 ml water; or not more than 10% of the samples shall exceed 50 MPN/per 100 ml water.

2. Safety standards for water contact recreation (SB water quality)

   Total coliforms: not to exceed a median value of 700 MPN/per 100 ml of water; or not more than 10% of the samples shall exceed 2300 MPN/per 100 ml of water.

   Fecal coliforms: not to exceed a median value of 50 MPN/per 100 ml of water; or not more than 10% of the samples shall exceed 500 MPN/per 100 ml of water.

The MPN, or "most probable number," is a statistical measure of the coliforms that are likely to be present in water based on the laboratory test used. The water quality classification SA means that water is considered safe for shellfishing and swimming. A classification of SB indicates that water is considered safe for swimming but not for shellfishing. SC water is deemed unsafe for either activity.

Nitrate

In marine or estuarine systems, such as the salt ponds, low concentrations of nitrogen are thought to limit aquatic plant productivity. Nitrate concentrations often vary seasonally by as much as 10 to 100 fold. Concentrations are low in summer when plants are using up any available nutrients in the water; concentrations are higher in the winter when aquatic plant growth is slow and nutrients can accumulate in the water.

Table 1 shows the mean values for the period from May through October 1987. Nitrate levels were lowest in Quonochontaug and Maschaug Ponds. Chlorophyll a levels were also low in these two ponds (Point Judith Pond was lower). Green Hill Pond had the highest nitrate concentrations and also the highest chlorophyll a concentrations; the potential for eutrophication in this small pond may be greater than for the other ponds.

Phytoplankton

As a result of high nutrient loading, algae blooms can occur. In 1985, an unusual, widespread nuisance phytoplankton "bloom" occurred in estuaries along the eastern coast of the U.S., including Long Island bays and Narragansett Bay. As a consequence of the nuisance bloom, scallops and shellfish died. It appears from Pond Watchers' data that such a bloom occurred the following year in the salt ponds. Most ponds showed threefold increases in chlorophyll a levels in 1986. In 1987, chlorophyll returned to much lower levels except in Green Hill Pond, where chlorophyll a levels actually increased, suggesting the potential for eutrophication in this salt pond as mentioned above.

Salinity

Salinity measurements may be used as an index of freshwater input to a pond. In estuaries, such as Narragansett Bay and the salt ponds, freshwater and saltwater mix along a gradient. The salinity of freshwater is zero; in Block Island Sound salinity is likely to be 32 parts per thousand (ppt). In estuaries, then, salinities typically range between these values in an increasing gradient from the area of freshwater input to the area of ocean water input. In well-mixed estuaries with ample tidal flushing and low freshwater input, salinities are usually high. This is the case in many of the larger salt ponds.

Of the salt ponds, Maschaug Pond typically was most brackish (low salinity). Green Hill Pond became very brackish during winter 1986-1987, when a temporary road dammed the inlet linking Green Hill and the sea allowing a relative increase in freshwater input. Point Judith Pond and Quonochontaug Pond, on the other hand, had high salinities because they are well mixed tidally with water from Block Island Sound.

Temperature

Temperatures in all the ponds had wide seasonal variations, which ranged from about 2$^{o}$C in winter to 26$^{o}$C in summer.

## Point Judith Pond

### Description

Point Judith Pond is one of the largest and most heavily used of all the salt ponds. There is a diverse mixture of development around the shores of the pond, ranging from commercial to residential and open areas. In the urban center of Wakefield at the head of the pond, and at the port of Galilee at the mouth of the pond, there is intense commercial development. Galilee is Rhode Island's largest commercial fishing port and terminal for the passenger ferry to Block Island. In addition, it is a center for charter boats and recreational boating facilities. Marinas are also located in the upper basin and around Snug Harbor in the lower pond. The harbor is dredged approximately every five years by the US Army Corps of Engineers, and a dredged channel extends from the harbor up the western side of the pond to provide access to marinas in the northern basin. Harbor Island, Great Island, Jerusalem, and Snug Harbor are developed residential communities. State ocean beaches at the mouth of the pond attract thousands of tourists each summer. North of the state beaches are areas of relative open space, including state wildlife refuges of salt marshes on the tidal flats. Rhode Island's most intensively fished recreational shellfish area is located in East Pond tidal flats. Politically, the pond is divided down the middle. The eastern side is under the jurisdiction of the town of Narragansett and the western side is under the jurisdiction of South Kingstown.

The natural configuration of Point Judith is distinct from the other ponds. A drowned valley, its axis is perpendicular to the ocean shore instead of parallel to it, and it is the only pond with a relatively large river, the Saugatucket, flowing into it. It is also the only pond with sizable islands within it. The combination of the river flowing into the upper pond and restricted circulation through the narrows around Harbor Island make the upper basin very susceptible to pollution. This is evidenced in the routinely high bacteria concentrations measured there by Pond Watchers and by DEM. The upper basin has been closed to shellfishing for years.

Point Judith is an important spawning ground for winter flounder and for bay scallops and supports abundant fish and shellfish populations. Pond Watchers are monitoring stations in the east pond recreational clamming flats, in the upper pond near important fish and shellfish spawning grounds, and in the lower channel near the marinas.

### Fecal coliform bacteria concentrations (see table)

The number of stations monitored for fecal coliform bacteria has increased from just two stations in 1985 (one in the Upper Pond and one in Bluff Hill Cove in the east pond), to five stations in 1986, to 19 stations beginning in 1987.

These data are notable for the following reasons:

a. During all three years, samples in the upper pond exceeded shellfishing safety standards (SA standards), corroborating the decision made by the Water Resources Division of DEM to close this area to shellfishing each year.

b. Not only were SA (shellfishing safety) standards exceeded, but SB (water contact recreation) standards were also exceeded in the northern basin of the pond in 1985 and 1986.

c. In Bluff Hill Cove off the Fishermen's Memorial Campground, fecal coliform levels also exceeded SA criteria at station 16A in 1985 and 1986 and at station 16B in 1987. This tidal flat is a popular recreational shellfishing area; if trends in fecal coliform levels continue, its safe use for shellfish harvesting is threatened.

Chlorophyll a concentrations

Three stations were monitored during the 1985 and 1986 sampling seasons. Four more stations were added in 1987.

The most striking aspect of the data is the minimum four fold--increase in chlorophyll a levels in the upper basin (station 1) between August and October in 1986 (mean ~ 39 μg chl a/l) relative to those months in 1985 and 1987 (1985 mean ~ 9 μg chl a/l; 1987 mean ~ 5 μg chl a/l). This finding is indicative of the nuisance algae bloom; many bay scallops died in Point Judith Pond in 1986. A similar result was seen off Snug Harbor at station 3 where, between May and October, mean chlorophyll a concentrations were higher in 1986 (4.90μg chl a/l) than in 1987 (1.57 μg chl a/l). Chlorophyll a levels at the four new stations in 1987 (nos. 2a, 2b, 2c and 4) were similar to 1985 and 1987 levels measured at other stations in Point Judith Pond.

Phosphate and Nitrate

Nutrient concentrations are available for three stations in 1985, three stations in 1986, and seven stations in 1987.

It is difficult to discern trends from the present data set. Both minimum and maximum nutrient concentrations were measured in 1987. Phosphate concentrations in Point Judith Pond ranged from a minimum of 0.13 μM/l at station 1, in the upper pond, to a maximum of 2.00 μM/l at station 2B in Congdon Cove in late August. This range appears to be typical of pond variations.

Nitrate concentrations were highest (maximum = 25.58 μM/l in May 1987) at station 1 in the upper basin for most of each year. The upper pond is near a freshwater source, which also carries nutrients into this basin.

Salinity

Salinities were usually lowest at station 1 north of Harbor Island in the upper basin of the pond, nearest to major sources of freshwater input. Mean salinities at station 1 (3 years) averaged 23 parts per thousand (ppt). This is 4 to 9 ppt less than mean salinities at other stations on Point Judith Pond.

Station 2b northwest of Harbor Island in the upper basin, had a mean salinity of 23 ppt during 1987.

Mean salinities south of Harbor Island (stations 2, 2a, 2c, 3 and 4) ranged between 29 and 31 ppt in 1987; these areas are nearer to and mix more with the high salinity water of Block Island Sound.

Water temperature

Seasonal variations in water temperature ranged between 6°C (late November 1985) in the upper basin and 25°C at station 2a (north of Ram Island, outside Champlin Cove) in June and July 1987, and also in Bluff Hill Cove at station 2 (September 1985) and at station 3 (August 1985) off Snug Harbor.

Temperature varied by only a few $^{o}C$ from station to station; the pond is shallow and well-mixed by winds and tides.

## Fecal Coliform Bacteria, Point Judith Pond*

| 1985 | | | | 1986 | | | | 1987 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Safety standards exceeded for: | | | | Safety standards exceeded for: | | | | Safety standards exceeded for: | |
| Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) | Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) | Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) |
| 1A | 9 | 11% | 11% | 1A | 13 | 62% | median = 93 | 1 | 10 | 20% | – |
| 16A | 7 | 29% | – | 5A | 9 | 11% | 11% | 2 | 10 | 20% | – |
| | | | | 15C | 10 | – | – | 3 | 10 | median = 16 | – |
| | | | | 16A | 9 | 22% | – | 4 | 10 | – | – |
| | | | | 3A | 10 | 20% | – | 5 | 10 | – | – |
| | | | | | | | | 6 | 10 | | |
| | | | | | | | | 7 | 10 | – | – |
| | | | | | | | | 8 | 10 | – | – |
| | | | | | | | | 9 | 10 | | |
| | | | | | | | | 10 | 10 | – | – |
| | | | | | | | | 12 | 10 | – | – |
| | | | | | | | | 15 | 8 | – | – |
| | | | | | | | | 16 | 8 | – | – |
| | | | | | | | | 16A | 7 | – | – |
| | | | | | | | | 16B | 5 | 20% | – |
| | | | | | | | | 17 | 10 | – | – |
| | | | | | | | | 19 | 9 | 11% | – |
| | | | | | | | | 20 | 10 | – | – |
| | | | | | | | | 21 | 10 | – | – |

* On this and following tables, only those stations for which analyzed data was available are presented.

## Potter Pond

### Description

Potter Pond, once known as Fish Pond because of its unusually productive fishery resources, is connected by a tidal inlet to Point Judith Pond. As a consequence, pollution problems in the Snug Harbor area of Point Judith Pond may be carried in on flood tide and have an impact on Potter. The southern end of the pond is characterized by sand flats created by wash-over from the barrier beach during hurricanes, and these are used for recreational clamming. The northern basin is a deep "kettle hole" left by the retreating glacier. Low oxygen conditions develop naturally in bottom water as less dense fresh water seepage flows over and "seals off" the saltier water deeper in the hole. As a result, circulation is restricted, and bottom water oxygen becomes depleted as the season warms and plant and animal matter is metabolized.

Potter Pond is entirely within the jurisdiction of South Kingstown. With the exception of the villages of Snug Harbor and Matunuck, most of the land around Potter and much of its shoreline is sparsely developed and maintains a sense of open space. No rivers flow into Potter Pond; instead, as mentioned above, most of the freshwater input flows in from underground springs seeping in around the edges of the pond. In addition to the northern basin, there are two coves on the southern end that are vulnerable to increasing pollution loads from surrounding development or road drainage. Pond Watchers are monitoring these three areas as well as the area of the shellfish flats.

### Fecal coliform bacteria (see table)

Four stations were monitored in 1985 and 1986. In 1987, the nine DEM stations were adopted.

Important aspects of these data are:

a. The safe shellfishing (SA) criteria were exceeded in at least 3 basins in Potter Pond during all 3 years.

b. However, unlike Point Judith Pond, safe swimming (SB) criteria were not exceeded in Potter Pond.

c. During all 3 years, high fecal coliform concentrations occurred around mid-July, when the summer population around the pond was high and water fowl numbers were low.

d. During 1986 and 1987, fecal coliform concentrations also showed peaks in September or October. These peaks may be related to the presence of populations of waterfowl such as ducks and Canada geese, which often seek refuge in Potter Pond during the fall.

### Chlorophyll a concentrations

Chlorophyll a concentrations were monitored at three stations in 1985, two stations in 1986, and four stations in 1987. The two stations monitored all three years were stations 5 and 6.

In 1986, a major phytoplankton bloom occurred in Potter too: mean chlorophyll a levels were tenfold higher from late July through October at station 5 off Meadow Point in 1986

(26.79 µg chl a/l) than in 1987 (1.92 µg chl a/l). At station 6 in Segar Cove, mean chlorophyll a concentrations from May through October were five fold higher in 1986 (38.55 µg chl a/l) than in 1987 (7.93 µg chl a/l).

Phosphate and Nitrate

Nutrients were analyzed for three stations in 1985, three stations in 1986, and four stations in 1987.

Phosphate was highest at station 6, in the southern basin, 2.36 µM/l, in August 1986. The next highest value was measured at Station 7 in August 1987. The lowest phosphate concentration measured was 0.15 µM/l at station 6 in Segar Cove in 1985 and 1986. No clear trend is apparent from the data set; more data are needed.

Maximum concentrations of nitrate were observed at station 6 (Segar Cove) in 1985 (12.88 µM/l) and in 1987 (13.30 µM/l). Nitrate concentrations were much lower at this station in 1986 (2.03 µM/l average) as the nuisance phytoplankton bloom took up more available nitrogen. Again, more data are needed to document a trend. However, nitrate concentrations in Segar Cove were generally 2 or 3 times higher than in other areas of Potter Pond.

Salinity

Salinity and temperature were measured at three stations in 1985 and 1986, and four stations in 1987.
Mean salinities for all stations (3 years) ranged between 25 and 28 ppt. Salinities were often slightly higher at station 5, which is near the inlet to Point Judith Pond and the tidal influence of ocean water.

Water temperature

Both minimum and maximum temperatures were recorded in 1985. Seasonal temperatures varied from a minimum of 5$^{o}$C in Segar Cove in November to a maximum 26$^{o}$C off Whalebone Point (upper Potter Pond) in early August. Mean water temperatures were 1-4$^{o}$C lower at station 5, near Block Island Sound.

# Fecal Coliform Bacteria, Potter Pond

| 1985 | | | | 1986 | | | | 1987 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Safety standards exceeded for: | | | | Safety standards exceeded for: | | | | Safety standards exceeded for: | |
| Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) | Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) | Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) |
| 5 | 7 | 14% | – | 5 | 13 | 15% | – | 23 | 8 | 25% | - |
| 27 | 8 | 13% | – | 27 | 13 | – | – | 24 | 8 | 25% | - |
| 29 | 8 | – | – | 29 | 13 | 15% | – | 25 | 8 | – | – |
| 31 | 8 | 13% | – | 31 | 13 | 23% | | 26 | 8 | 13% | – |
| | | | | | | | | 27 | 8 | 13% | - |
| | | | | | | | | 28 | 8 | | |
| | | | | | | | | 29 | 8 | – | - |
| | | | | | | | | 30 | 8 | 13% | |
| | | | | | | | | 31 | 8 | 25% | |

## Green Hill Pond

### Description

Green Hill Pond is a relatively small pond with a very densely developed residential shoreline and watershed. It is located mainly within the jurisdiction of South Kingstown. Its connection to tidal waters is not direct but, like Potter Pond, occurs via a breachway from the sea to another larger pond (Ninigret). As a result, tidal flushing is reduced and pollution problems are magnified compared to most of the other ponds. Factory Brook, a major source of fresh water flowing into the Pond, originates at Factory Pond, a former stream that was dammed more than a century ago to provide water power for local mills. South Kingstown's water supply wells are situated adjacent to Factory Pond in the Green Hill Pond watershed. These wells supply public water for the most of the south shore area, including communities as far as Jerusalem on Point Judith Pond.

Since tidal flushing is quite restricted, salinity is lower in this pond than in the others. For this reason it is one of the few coastal areas in the state that still sustains an annual set of young seed oysters. In 1987, a tide gate was installed in the inlet so that pond conditions could be manipulated to enhance the fishery resources, should there be interest in doing so.

Pond Watchers have stations located in each of the three general regions on the pond: one near the tidal inlet, one in the northeast section (where the brook influences pond water quality) and one in the eastern cove at the foot of Green Hill.

### Fecal coliform bacteria (see table)

Key points to note about these data are:

a. Most of the stations sampled in Green Hill Pond exceeded safe shellfishing (SA) water quality standards in 1985 and 1986, and some in 1987. These data led DEM to seasonally close Green Hill Pond to shellfishing in 1987.

b. Safe swimming (SB) water quality standards were not exceeded.

### Chlorophyll a concentrations

During 1985 and 1986, chlorophyll a levels were measured at three standard locations: stations 9, 10, and 11A. In 1987, station 11 was taken in Allen Cove and 11A was discontinued after April 24.

Also in 1987, sampling locations were changed during the winter because of the longer sampling season. The sampling season in 1987 was extended to measure changes in water chemistry in Green Hill Pond, due to the damming effect of a temporary road across the tidal inlet to the pond during winter and spring. Water chemistry sampling in Green Hill Pond began early in January 1987. Samples were taken from accessible locations near shore, not far from the usual sites, until the spring thaw as follows:

Station 9: Monitored from a boat as usual through February. During most of March through April 10, sampling was conducted off Laitinen Point, about 900 feet from station 9. Sampling resumed at station 9 on April 17 and continued through the latter part of October.

Station 10: Winter samples were collected off the Lombardo Dock, not more than 200 feet from station 10, until the beginning of May. Thereafter, samples were collected from a boat at the usual site.

Station 11: From February through March 19, samples were collected off John Baer's dock, about 400 feet from Station 11A, outside Allen Cove. Subsequently from March 27 through April 24, samples were collected from station 11A as in the previous two years. Beginning in May, station 11 was taken in Allen Cove.

The following table shows changes in mean chlorophyll a concentrations at stations 9, 10 and 11 during similar time periods:

Mean (x) Chlorophyll a (µg chl a /l)

Green Hill Pond

n = no. of observations

| | Station 9 | x | Station 10 | x | Station 11A | x | Station 11 | x |
|---|---|---|---|---|---|---|---|---|
| 1985 | 29 July-21 Oct. (n=6) | 1.79 | 29 July-21 Oct. (n=7) | 3.83 | 29 July-21 Oct. (n=7) | 1.47 | | |
| 1986 | 28 July-15 Oct. (n=7) | 5.68 | 28 July-20 Oct. (n=6) | 33.50 | 31 July-21 Oct. (n=6) | 6.20 | | |
| | *5 May - 15 Oct (n=13)* | *4.16* | *5 May - 20 Oct. (n=11)* | *19.73* | *7 May - 21 Oct. (n=11)* | *4.31* | | |
| 1987 | 26 July-19 Oct. (n=7) | 10.07 | 27 July-19 Oct. (n=7) | 13.40 | | | 27 July-22 Oct. (n=7) | 8.75 |
| | *4 May - 19 Oct. (n=13)* | *6.30* | *4 May - 19 Oct. (n=13)* | *8.80* | | | *8 May - 22 Oct (n=13)* | *6.83* |

Chlorophyll a levels increased at least threefold in 1986 relative to 1985 concentrations. Unlike other ponds, chlorophyll a concentrations in Green Hill appear to be rising over time. In 1987, concentrations increased again, except at station 10 in the northern basin (where Factory Brook flows into the pond) where chlorophyll levels fell to less than half of 1986 levels.

Phosphate and Nitrate

Nutrients were measured at three stations in 1985 and 1986; see previous section for site changes in 1987.

Phosphate data do not indicate a clear trend from year-to-year. 1987 data do show seasonal trends, however. Generally, phosphate concentrations are higher in the winter and early spring, decrease during the late spring and summer growing season for aquatic plants, and begin to increase again during late summer and through the fall. Phosphate ranged from 0.03 to 1.5 μM/l in Green Hill Pond.

As with phosphate, year-to-year trends of variations in nitrate are difficult to detect. Seasonal differences are more pronounced than for phosphate. Nitrate concentrations ranged from below detectable levels (less than 0.1 μM/l) to 26.17 μM/l on station during the growing season, and even higher, to 106.62 μM/l during winter collections. In other words, nitrate increased 100 fold during the winter of 1987 when tidal flooding was restricted.

Salinity

Salinity and water temperature measurements were recorded for three stations in 1985, four stations in 1986, and "winter" and standard stations (three each) in 1987. Mean salinities at stations 9 and 11 showed little or no change between 1985 and 1986, despite offsets in the sampling periods at these two stations. A much greater difference between 1985 and 1986 means (22 vs 17 ppt) at station 10 may be related to differences in rainfall. Station 10 is nearest to a freshwater runoff source, and effects of precipitation would cause greater range of salinities (brackish to estuarine).

In 1987, the damming effect of a temporary road across the tidal inlet was associated with a dramatic drop in salinity throughout Green Hill Pond. Salinity values at the "winter" sampling sites were extremely low--between 0 and 10 ppt. These very brackish conditions extended from early in January until mid-May, when the inlet was opened and tidal flushing resumed. Subsequently, more typical salinities were recorded (18 ppt) at the usual stations and within Allen Cove. Field observations indicate that on March 19, water on the Green Hill side of the temporary road dam was 1 to 1 1/2 feet higher than on the Ninigret side, indicating that freshwater runoff was trapped in the pond.

These data provide extremely valuable snapshots of short-term effects. Documentation of such hyposaline events is important to developing a more complete picture of the larger changes which may be occurring in the pond habitat. For example, in Flat Meadow Cove (near station 9), an oyster set was observed in August 1987, compared to an almost non-existent set the previous year. Long-term Wakefield resident and oyster fisherman, Charlie Potter, also observed an oyster set in 1987, while he saw no set in 1986. A survey by DEM Fisheries Biologist, Art Ganz, reported the best oyster set in years in 1987 in Green Hill Pond. A brief pulse of lower salinities may have discouraged oyster predators, or may have cleaned rock surfaces of fouling plant growth to allow a better oyster set.

Water temperature

Temperature variations ranged $2^{o}$ to $26^{o}C$ (depending on the season) during the three year period. In most instances, temperatures varied only a few $^{o}C$ throughout Green Hill Pond, when sampling dates matched closely.

Fecal Coliform Bacteria, Green Hill Pond

| 1985 | | | | 1986 | | | | 1987 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Safety standards exceeded for: | | | | Safety standards exceeded for: | | | | Safety standards exceeded for: | |
| Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) | Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) | Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) |
| | | | | | | | | 14 | 11 | – | – |
| 10 | 8 | – | – | 10 | 17 | – | – | 14B | 11 | | – |
| 14A | 8 | 13% | – | 14A | 17 | 12% | – | 14C | 11 | 36% | – |
| 18 | 9 | 11% | – | 14C | 7 | 14% | – | 15 | 11 | – | – |
| | | | | 18 | 17 | 18% | – | 16 | 11 | 36% | |
| | | | | | | | | 16A | 11 | – | – |
| | | | | | | | | 16B | 11 | – | – |
| | | | | | | | | 17 | 10 | | – |
| | | | | | | | | 18 | 11 | – | – |

# Ninigret Pond

Description

One of the largest salt ponds, Ninigret Pond lies within the Town of Charlestown. Land use within the pond watershed and along its shoreline is principally residential with some light commercial. There are three small marinas on the pond. The size of the boats which can navigate it is limited by the extensive shoals and the narrow winding channel that connects to the sea through the breachway. Ninigret Pond is host to a wide variety of intensifying summertime uses, including sport and commercial fin and shellfishing, water skiing, wind surfing, oyster and hard clam aquaculture, boating, and birding. More than the other salt ponds, Ninigret is surrounded by large tracts of publicly owned land: former Naval Air Station land along the north shore, a state beach along the barrier at the west side of the breachway, and a town beach with parking on part of the eastern barrier.

Like the other salt ponds, Ninigret Pond provides important spawning and nursery grounds for a variety of fish and shellfish, whose abundance shifts with the seasons. Intensifying use with its attendant conflicts and pollution problems are challenging the traditional ecosystem balance in the pond.

Pond watchers are sampling each of the two northern coves and the large basins.

Fecal coliform bacteria (see table)

Important points regarding Ninigret Pond are:

a. Four sites in Ninigret Pond exceeded safe shellfishing (SA) standards each year. Of those, Foster Cove, (station 14 in 1985 and 1986 and station 4 in 1987), Fort Neck Cove (station 12A in 1985 and 1986 and stations 9 and 10 in 1987), and Tockwotten Cove (station 13 in 1985 and 1986; station 11 in 1987) had excessive coliform levels three years in a row. As a result, DEM seasonally closed Fort Neck Cove to shellfishing in 1987.

b. Safe swimming (SB) standards were exceeded in upper Fort Neck Cove in 1985 and 1986, and at Tockwotten in 1985.

c. During the winter of 1987-88, the Ocean House Marina upgraded its septic system. Subsequently, coliform levels dropped in Fort Neck Cove and DEM re-opened it to shellfishing in 1988.

Chlorophyll a

Chlorophyll a data are available for four stations in 1985, three station in 1986, and four stations in 1987.

Again, the 1986 nuisance phytoplankton bloom also appeared throughout Ninigret Pond. Mean chlorophyll a concentrations from June through October were three times higher in upper Fort Neck Cove (STN 12) in 1986 (37.81 μg chl a/l) than in 1987 (11.57 μg chl a/l). In Foster Cove (STN 14) from late July through October, mean chlorophyll levels fell from 16.93 μg chl a/l in 1986 to 3.57 μg chl a/l in 1987. Concentrations were also high in Tockwotten Cove in 1986.

In the fall of 1985, chlorophyll a concentrations were higher in upper Fort Neck Cove and in Foster Cove than during the same period in 1986 and 1987. These coves are isolated from the main body of the pond, and therefore minor washout of phytoplankton may occur, allowing phytoplankton to build up to higher concentrations than in other pond areas. Mean salinities were lower in these coves than in other areas of the pond in 1985, indicating freshwater input.

Phosphate and Nitrate

Nutrient data are available for four stations in 1985, three stations in 1986 and four stations in 1987.

Phosphate concentrations were highest (maximum = 2.32 μM/l) all three years at station 12 in upper Fort Neck Cove near a source of freshwater input. However, nitrate concentrations were generally low in this cove, indicating uptake by phytoplankton (chl a levels were high). Nitrate was also relatively low in Foster Cove, which had high chlorophyll a levels, in 1985.

Salinity

Salinity and water temperature were measured at four stations in 1985 and 1987 and three stations in 1986.

Ninigret Pond experienced a wide range of salinities, between 8 and 32 ppt. Mean salinities were highest near the breachway and over the flats at the western end of the pond (3 and 2 year means, respectively, = 25 ppt). Lowest mean salinities (3 years, mean = 20 ppt) were in Foster Cove (station 14), which is an enclosed basin and has somewhat restricted tidal circulation. Mean salinities (over 3 years) were 24 ppt at station 12 in upper Fort Neck Cove near a source of freshwater input.

Water temperature

Water temperature varied seasonally between 2°C (early December 1985, Foster Cove) and 26.5°C (late July 1985, over the western flats). Three year mean temperatures over similar growing season periods were slightly higher in upper Fort Neck and Foster Coves (18 and 19°C) than in Tockwotten Cove (16°C) which is nearer to the breachway. Temperatures were also high in the shallow water over the western flats (station 15). Higher temperatures in the sheltered Foster and Fort Neck Coves, together with higher nutrient uptake by phytoplankton may be creating bloom conditions in these areas. Hence, these coves could be particularly vulnerable to eutrophication if these conditions persist.

## Fecal Coliform Bacteria, Ninigret Pond

| 1985 | | | | 1986 | | | | 1987 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Safety standards exceeded for: | | | | Safety standards exceeded for: | | | | Safety standards exceeded for: | |
| Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) | Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) | Sta | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) |
| 7 | 5 | 20% | - | 3 | 11 | - | - | 2 | 11 | - | - |
| 12A | 6 | 33% | 17% | 7 | 11 | - | - | 3 | 10 | - | - |
| 13 | 6 | 50% | median = 96.5 | 12A | 11 | 82% | 18% | 4 | 11 | 18% | - |
| 14 | 5 | 40% | - | 13 | 11 | 46% | - | 5 | 10 | - | - |
| | | | | 13A | 10 | median=23 | - | 6 | 9 | - | |
| | | | | 14 | 11 | 36% | - | 7 | 9 | | |
| | | | | 15A | 11 | - | - | 8 | 10 | - | - |
| | | | | | | | | 9 | 10 | 20% | |
| | | | | | | | | 10 | 10 | - | - |
| | | | | | | | | 11 | 10 | 40% | |
| | | | | | | | | 12 | 10 | 20% | - |

## Quonochontaug Pond

### Description

Quonochontaug Pond is the deepest and most saline of the salt ponds. It is connected directly to the sea by a breachway that, as was the case for most of the other ponds, was stabilized with rock jetties by the U.S. Army Corps of Engineers in the 1950s. And, as in the other ponds, sand eroding from the ocean side of the barrier beach is transported through the breachway into the pond where it settles and creates expanding shoals. In contrast to the other ponds, however, much of "Quonnie's" western barrier beach remains in a protected, undeveloped state even though it is privately owned.

The town boundary between Westerly and Charlestown cuts through the middle of the pond. Water quality in past years has been very good because the pond is relatively deep, well flushed by the tides, and development has been limited. Quonnie is the least intensely developed of any of the ponds (Figure 2.). Most of the development is residential and much of it is occupied only seasonally. Like all the ponds, Quonnie is an important nursery for winter flounder, young striped bass, blue fish, and tautog. Bay scallops fluctuate in abundance from year to year, but in a good year, they are often found in this salt pond.

In the past few years, development pressures have increased dramatically, even though the watershed area is relatively small and a large portion of it is comprised of wet, red maple swamps. Much of the available remaining land is being subdivided into building lots.

Pond Watchers are sampling water quality in each basin of the pond as well as in the shellfish flats. They are also sampling areas near the mouths of two small streams that flow into the northern shore of the ponds to monitor the impact of new development occurring along these streams.

### Fecal coliform bacteria (see table)

Coliform concentrations were monitored at five stations in 1985, six stations in 1986, and ten stations in 1987.

Fecal coliform bacteria data on Quonochontaug Pond indicate the following:

a. Of all the salt ponds, Quonochontaug had among the lowest concentrations of fecal coliform bacteria over three years.

b. Shellfishing safety (SA) water quality standards were exceeded by at least two stations each year. Most often higher coliform levels occurred in two areas: the cove on the north shore west of Shelter Harbor, which receives runoff from a small stream; and off Shady Harbor.

c. Swimming safety (SB) standards were not exceeded.

### Chlorophyll a

Chlorophyll a concentrations are available for four stations in 1985 and five in 1986 and 1987.

Although there is evidence of a nuisance phytoplankton bloom in 1986, chlorophyll levels in Quonochontaug Pond were generally lower than in other ponds. From May through October, mean chlorophyll a levels decreased from 1986 to 1987: at station 16, from 9.72 to 2.75 μg chl a/l; at station 16a, from 6.49 to 1.52 μg chl a/l. The highest measured value in Quonochontaug was 26.26 μg chl a/l (at station 17 off Wheat Point in 1986). This is the lowest maximum measured in any of the seven ponds, and it is also an order of magnitude lower than maximum values in four of the ponds (Potter, Green Hill, Ninigret, and Winnapaug Ponds).

Phosphate and Nitrate

Measurements of phosphate and nitrate were recorded for five stations in 1985, 1986, and 1987.

Mean phosphate concentrations (3 years) were comparable to other ponds. However, mean nitrate concentrations are an order of magnitude lower than at some stations in all the other ponds except Maschaug, during the same time frame. Freshwater input is less important in Quonochontaug Pond (see below). Therefore, low nutrient input and colder temperatures may explain why chlorophyll a (phytoplankton content) was lowest in Quonochontaug Pond.

Salinity

Records of salinity are available for five stations in 1985 and 1987, and four stations in 1986.

Salinities in Quonochontaug Pond were higher and more stable than for other ponds. Mean salinities over three years were 29 or 30 ppt at all stations. Quonochontaug Pond is one of the deepest, with more tidal flushing and little freshwater input relative to the other ponds. Therefore, salinity is moderated by greater oceanic influence rather than exhibiting fluctuations associated with large volumes of land-derived storm water or riverine input.

Water temperature

Temperature measurements were taken at five stations in 1985, 1986, and 1987. Variations ranged from a winter minimum of 3°C to a summer maximum of 27°C. Variation between stations was approximately 1 to 5°C during any given week. Quonochontaug Pond also has fewer extremes in temperature than the other ponds due to the moderating oceanic influence (see Table 1).

## Fecal Coliform Bacteria, Quonochontaug Pond

| 1985 | | | | 1986 | | | | 1987 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Safety standards exceeded for: | | | | Safety standards exceeded for: | | | | Safety standards exceeded for: | |
| Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) | Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) | Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) |
| 16 | 8 | median=16 | - | 16 | 13 | 23% | – | 19 | 11 | – | – |
| 22 | 9 | 11% | – | 22 | 13 | – | – | 20 | 12 | – | |
| 23 | 9 | – | – | 18A | 10 | 30% | – | 21 | 10 | – | – |
| 27 | 6 | median=19 | - | 23 | 13 | – | – | 22 | 12 | 17% | – |
| 28 | 9 | 22% | – | 27 | 13 | – | – | 23 | 12 | – | – |
| | | | | 28 | 13 | 31% | – | 24 | 11 | | |
| | | | | | | | | 25 | 11 | 18% | – |
| | | | | | | | | 26 | 11 | – | |
| | | | | | | | | 27 | 12 | – | – |
| | | | | | | | | 28 | 12 | – | – |

## Winnapaug Pond

Description

Winnapaug or Brightman's Pond, in Westerly, has one of the more densely developed shorelines. There is a concentration of commercial hotels, restaurants and amusement rides adjacent to a major state beach on the western end of the barrier beach. Dense residential development lines the ocean and pond shores. Compared to the other ponds the watershed of this pond is relatively small, and development within it is proceeding rapidly. Open space and areas that were once golf courses along the northern shore are being converted to housing developments and condominium clusters.

Winnapaug Pond has very little fresh water input from stream flow and a very high volume of tidal flushing which produces extensive shoaling. Sand erodes from the ocean side of the barrier beach, flows into the pond through the breachway on flood tide, and is distributed far inside the pond. In spite of the shoaling, the large volume of tidal flushing is helping to keep the water quality high. There are also expansive sandy shoals along the southern shore. The sand swept over the barrier beach into the pond during past hurricanes. Although the pond is much more shallow, and cannot support the abundance of finfish seen in some of the other ponds, finfish populations appear to be healthy and there are abundant shellfish resources in the shoals.

Pond Watchers are monitoring each basin of the pond, the two small northern coves, and the western end where there is much public concern about pollution of the pond associated with the dense development in the Misquamicut area.

Fecal coliform bacteria (see table)

Four stations were monitored in 1985 and 1986, and nine stations in 1987.

Points to note about Winnapaug Pond data are:

a. Shellfishing safety (SA) criteria were exceeded by at least one station each year, mostly in the northern coves.

b. Swimming safety (SB) criteria were exceeded by one station in 1985 and 1986. These stations were located very near populated areas on the pond shoreline and in a cove on the north shore where tidal flushing of pond water is slow, and where waterfowl congregate in the fall.

Chlorophyll a

Chlorophyll a data are available for one station in 1985, four stations in 1986, and five stations in 1987.

Station 21 was the only station for which we have chlorophyll a data for all three years. Means of the longest time series data for stations 20 and 21 in 1986 and 1987 are shown below.

Mean (x) chlorophyll a (µg chl a/l)

n = no. of observations

| | Station 20 | x | Station 21 | x |
|---|---|---|---|---|
| 1986 | 21 July-21 Sept. (n=5) | 9.66 (n=5) | 15 July-9 Sept. | 6.11 |
| 1987 | 13 July-11 Sept. (n=5) | 2.49 | 16 July-12 Sept. (n=5) | 5.14 |

This table shows that chlorophyll a concentrations declined from the bloom year of 1986 to 1987, during mid-July to mid-September at these two stations. A trend towards eutrophication is not apparent.

Phosphate and Nitrate

Nutrient data are available for one station in 1985 and five stations in 1986 and 1987. Mean phosphate concentrations (3 years) were higher than for other ponds. 1987 mean nitrate values were in the middle range of the seven ponds, at 1.3 µM/l (see Table 1).

Salinity

Salinity records are available for one station in 1985 four stations in 1986 and five stations in 1987. Values ranged from a minimum of 20 ppt (late July 1986, at station 20) to a maximum of 31 ppt (early December 1985, at station 21), from estuarine to oceanic salinity ranges. Mean salinities were high (27 ppt, 1987 mean) in Winnapaug Pond due to extensive tidal flushing with Block Island Sound waters.

Water temperature

Measurements of water temperature were made at four stations in 1985, five stations in 1986, and three stations in 1987.

Seasonal temperatures varied from 6°C (late November 1985, at station 21) to 27°C (mid-August 1987, at station 21). 1987 mean growing season temperature was similar to most other ponds, at 18°C.

Fecal Coliform Bacteria, Winnapaug Pond

| 1985 | | | | 1986 | | | | 1987 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Safety standards exceeded for: | | | | Safety standards exceeded for: | | | | Safety standards exceeded for: | |
| Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) | Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) | Sta. | No. of samples collected | Shellfishing (SA) | Water Contact Recreation (SB) |
| 19 | 6 | - | - | 19 | 10 | - | - | 27 | 11 | - | |
| 20A | 4 | median = 23 | - | 32 | 10 | - | - | 28 | 11 | - | - |
| 32 | 5 | 20% | 20% | 33 | 10 | - | - | 29 | 11 | - | - |
| 33 | 6 | - | - | 35 | 8 | 38% | 13% | 30 | 11 | median= 18 | - |
| | | | | | | | | 31 | 11 | median=18 | |
| | | | | | | | | 32 | 11 | 18% | |
| | | | | | | | | 33 | 11 | median=18 | - |
| | | | | | | | | 34 | 11 | 18% | - |
| | | | | | | | | 35 | 11 | - | - |

## Maschaug Pond

Description

Maschaug Pond is a small, brackish water pond located in the Town of Westerly. It is the only one of the ponds being monitored that is not connected by a permanent inlet or breachway to the sea. Salt water enters the pond only in spray and overwash, so the salinity is very low (about 9 ppt). Freshwater flows into the pond via groundwater springs, and in the wet season the pond often overflows onto portions of the adjacent golf course.

This pond is representative of many small coastal ponds throughout Rhode Island and New England that are not permanently connected to the sea. Other local examples include Trustom and Cards Ponds, which are part of the U.S. Fish and Wildlife Service National Wildlife Refuge in South Kingstown, and Briggs Marsh in Little Compton. Although the land around Maschaug pond is developed, there is little boating or other human disturbance so the pond is a haven for wildlife and waterfowl. There was one Pond Watcher's station in Maschaug (no. 30).

Bacteria

Bacteria were not monitored in Maschaug Pond, from 1985-1987 because it is not used for shellfishing or water contact recreation.

Chlorophyll a

The following table shows a reduction in mean chlorophyll a concentrations during similar sampling periods from 1986 to 1987:

Mean (x) chlorophyll a (μg chl a/l)

n = no. of observations

| | Station 30 | x |
|---|---|---|
| 1986 | *15 June - 1 Sept. (n=7)* | *23.77* |
| 1987 | *7 June - 30 Aug. (n=7)* | *4.13* |

Even though Maschaug does not have an inlet to the sea and is consequently very brackish compared to the other ponds, it appears that a phytoplankton bloom also occurred in Maschaug Pond in 1986. The relationship of this bloom to phenomena in other ponds is not known, but would indicate that the bloom was a widespread phenomenon, not triggered by very local conditions. Perhaps resting spores of plankton responded to unusual climatic conditions, such as drought followed by heavy rain as occurred in 1986.

Maschaug Pond, like Quonochontaug, had lower nutrient concentrations than the other ponds.

Salinity

Maschaug Pond is more brackish than the other ponds. Mean salinities ranged from 7 to 9 ppt over three years. The lowest salinity was recorded in 1985, at 3 ppt. The highest salinity measured was 12 ppt. These conditions determine the flora and fauna that can live in Maschaug Pond, so that different species inhabit Maschaug as opposed to the more saline ponds. Maschaug does not have a permanent breachway, and salinity influxes are infrequent, such as when a major storm creates a natural breach in the barrier dune.

Water temperature

Temperature variations were seasonal, with a low winter temperature of $1^{o}C$ (in December 1985), and a high summer temperature of $26.5^{o}C$ in late July 1986. Less oceanic flushing results in greater temperature extremes in Maschaug Pond. Mean temperature for the months sampled was high ($21^{o}C$) in 1986, the bloom year.

# CHAPTER III: METHODS

## Bacteria

### Field Sampling

During 1985 and 1986, bacteria sampling was conducted at approximately 25 stations (total per year). These stations were chosen, primarily for two reasons--to correspond to water chemistry stations and to augment the existing database of previous salt pond research. In 1987, sampling was expanded to include stations that corresponded to DEM's water quality monitoring program sites at the request of the Division of Water Resources.

In 1985, which was the first year of the Pond Watcher program, sampling began in July. In subsequent years, it has extended from May through October. Sampling frequency has been bi-weekly, each year.

Field sampling occurred in accordance with DEM methodology. All samples were taken from a boat. Samples of 150 ml of pond water were collected in sterile plastic jars by unwrapping the sterile bag and uncapping the bottle on station, then plunging the bottle six inches below the surface and inverting towards the direction of water current, taking care to avoid surface slicks or surface debris of any kind and taking care not to stir up the pond bottom. Sample jars were then capped and stored in a cooler on ice and picked up by a URI graduate student for transport to the DOH and FDA labs for analysis. Sampling was conducted early Monday mornings in 1985 and 1986 and early Monday, Tuesday, and Wednesday mornings in 1987 and subsequent years to accommodate laboratory schedules.

### Laboratory Analysis

Samples were transported to the lab on ice and tested within six hours of collection. Prior to 1987, all bacteria samples were tested at the Rhode Island Department of Health Laboratories (DOH), in Providence. In 1987, two widely-accepted standard laboratory methods were used, at two different, intercalibrated labs (DOH and FDA) in order to accommodate the increased sample load. That year, Point Judith, Potter, Green Hill and Ninigret Ponds continued to be tested at RI DOH labs using the lactose-fermentation method which tests for both fecal and total coliform bacteria. Samples from Quonochontaug and Winnapaug Ponds were tested at the Federal Food and Drug Administration labs in Davisville, using the modified A-1 method which tests for fecal coliform bacteria only. Both labs generously contributed their personnel, equipment and supplies free of charge in support of the Salt Pond Watchers Project. A GSO graduate student transported the samples to the lab and set up the initial inoculations. The lab staff completed the analyses including the final reading and reporting of results to URI.

### Data Reduction

The labs mailed the official results of each analysis to the Coastal Resources Center at URI, and a GSO graduate student converted the lab values to standard fecal coliform units of Most Probable Number of bacteria per 100 milliliters of pond water (MPN/100 ml). The results were interpreted according to state water classification standards (see table 3). Values were entered into a computer database by a graduate student or, in 1988, by the volunteer data manager, Suzanne Nardone. Results were mailed to Joe Migliore and John Speaker, DEM, Division of Water Resources, at the end of each season and the implications discussed with them. The DEM used Salt Pond Watchers data combined with DEM independent surveys to make decisions about shellfish bed closures.

## Water Chemistry

### Field Sampling

Inorganic nutrients and chlorophyll a as well as salinity, temperature, depth and secchi disk depth (for deep stations) were measured at approximately 25 stations throughout the coastal ponds from 1985 through 1987. Approximately four stations were established in each pond to represent each major cove or basin. Where possible, these were located near stations of previous research projects. As with bacteria, water chemistry sampling was conducted on a bi-weekly basis from May through October. Water chemistry parameters were not always monitored concurrently with bacteria sampling; bacteria sampling required a more fixed schedule because of collaborations with state and federal laboratories.

For water chemistry sampling, Pond Watchers were outfitted with plastic tackle boxes and equipment provided by URI Sea Grant. Parameters that were measured entirely by Pond Watchers were: water depth, secchi disk depth (light extinction or turbidity--in 1987), and water temperature. Water samples were collected by Pond Watchers for chlorophyll a (phytoplankton biomass), nutrient and salinity analyses by trained technicians at URI. Field observations recorded include: recent precipitation (up to 24 hours before sampling), presence of nearby waterfowl and, beginning in 1987, changes in algae/eelgrass cover and incidence of eelgrass wasting disease. Additional field observations were made of recreational and fishing pressures on the ponds, such as amount of boating activity, and presence of fyke nets or "draggers" looking for scallops or other shellfish. Evidence of recent or ongoing construction in the pond watershed also was noted.

Water samples for chlorophyll a, nutrients, and salinity measurements were collected from approximately one foot below the water surface using a plastic syringe, filter holder and plastic tubing. Chlorophyll samples were filtered onto Whatman glass fiber filters, then folded in half, placed in labelled foil packets and frozen for later analysis at URI. Exactly 50 mls of water were filtered, and the filtrate stored in 60 ml plastic bottles, labelled and frozen upright for nutrient and salinity measurements.

Temperature measurements were made using field thermometers (accurate to $1^{o}C$). Depth was measured with a lead line or meter stick and recorded to 0.1m. Secchi disks were constructed by Pond Watchers, to a standard size. Turbidity or light extinction was estimated if there was sufficient water depth for the disk to disappear.

### Laboratory analysis

Samples were transported, on ice, to URI and kept in frozen storage until analyzed. Chlorophyll a analyses were performed by a graduate student lab technician using a fluorometer, according to the standard methods of Strickland and Parsons[1] , with the modifications of Lorenzen.[2]

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[1] Strickland, J.D.H., and T.R. Parsons. 1968. A practical handbook of seawater analysis. Bull. Fish. Res. Board Can. 167:1-310.

[2] Lorenzen, C.J. and S.W. Jeffrey. 1978. Determination of chlorophyll in sea water. UNESCO Technical Papers in Marine Science
#35. Report of Intercalibration Tests.

Inorganic nutrients ($NO_2 + NO_3$ and $PO_4$) were analyzed using a Technicon Autoanalyzer, modified to measure low levels of nutrients typical of the coastal lagoon ecosystems. Salinity was measured using a light refractometer (accurate to 0.5 ppt).

Data Management

Data for water chemistry parameters were entered by a graduate student onto a computerized data matrix and cross-checked thoroughly by other graduate students. Tables of data for each pond are included in the Appendix.