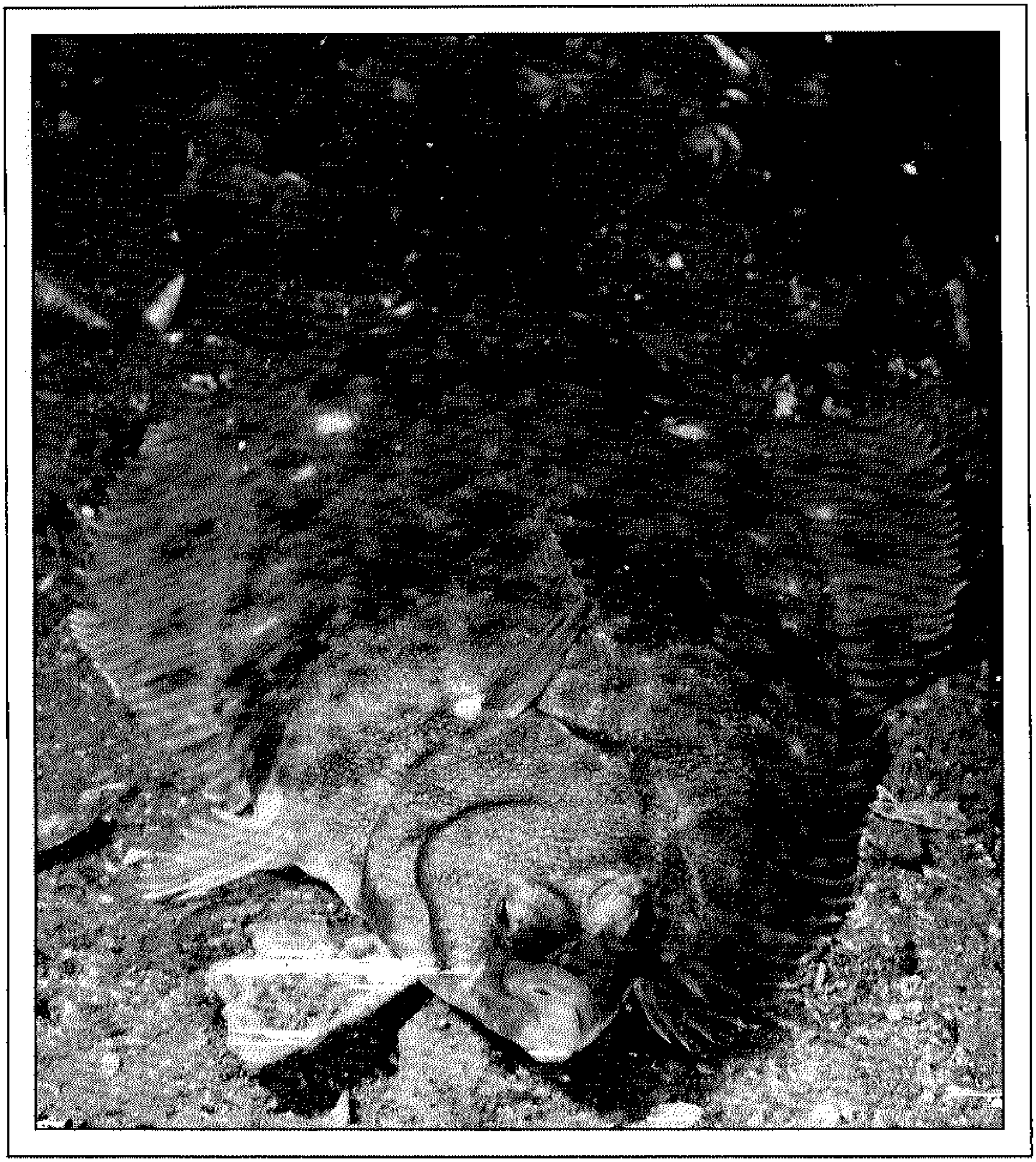
RIU-G-90-001 C2

Winter Flounder in Rhode Island Coastal Ponds

Richard Crawford



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Cover photo: An adult winter flounder lying in the sand. The winter flounder's cryptic coloration allows it to blend inconspicuously into its environment, thus protecting it from predators. Photograph by Harold Wes Pratt.

Table of Contents

PREFACE

This work was part of the University of Rhode Island (URI) Salt Ponds Study. Information from this study was used in the preparation of the Rhode Island Coastal Zone Management Plan and the Special Area Management Plan for Rhode Island's coastal pond regions. The Salt Ponds Study was a very successful multidisciplinary investigation that has been adopted as a model for similar studies elsewhere in the United States and abroad. One reason for its success was the involvement of the people who use the resources. This involvement continues today in the Rhode Island Sea Grant Pond Watchers Project, in which local residents monitor the use and abuse of the resources for which they have shown such great concern.

This paper reports the results of the finfish segment of the Salt Ponds Study. It was written for the users of Rhode Island's coastal ponds, in the continued belief that without informed stewardship of resources by local users those resources are in danger of being lost. That such stewardship can occur has been demonstrated by the involvement of Rhode Island's coastal pond watchers. This paper was written for them and for those who share their concern for the sustained well-being of these resources.

ACKNOWLEDGEMENTS

This paper reflects the labors of many people who worked on the fisheries component of the URI Salt Ponds Study. It also includes insights gained by other research teams in the study, as well as ideas gleaned from innumerable conversations with fishermen while on the ponds. I am gratefully indebted to all of the contributors, and some warrant special mention.

Many students at the URI Graduate School of Oceanography worked on this project. Without their participation this work would never have been accomplished. Constance (Carey) Grove and Mary Worobec became accomplished draggerwomen and prepared graduate theses from stock assessments of flounder in Point Judith and Ninigret ponds, respectively. Kim Billington, Leslie Bulion, Mary Fabrizio, Bob Sand, Skip Cynar, Lynne Hanson, and others provided excellent support in various capacities during the project. Numerous students, URI staff members, Department of Environmental Management personnel, and colleagues at the Coastal Resources Center also assisted in numerous ways during the five years of research. A special thank you goes to the local residents who volunteered as "pond watchers." From vantage points around the ponds, they kept records of fishing activity and other noteworthy events to keep me better in touch with the happenings on the ponds. I also want to thank commercial fishermen Richard Johnstone and William Sieczkiewicz for providing me with their observations and catch records and for assisting with the Ninigret Pond stock assessment.

Finally, my heartfelt appreciation is extended to Stephen Olsen, Director of the Coastal Resources Center. As coordinator of the Salt Ponds Study, he provided the glue that so successfully held together the various components of that eclectic investigation. He also gave invaluable advice during the preparation of this paper and it has benefited immensely from his comments.

This work was administered by the Rhode Island Sea Grant office and was financed in part by NOAA Office of Sea Grant, U.S. Department of Commerce, under Grant #NA79AA-D-00096, and in part by the National Oceanic and Atmospheric Administration, under the provisions of the Coastal Zone Management Act of 1972 (Public Law 92-583). This publication was produced under NOAA Office of Sea Grant, U.S. Department of Commerce, under Grant #NA89AA-D-SG-082.

INTRODUCTION

During the 1960s and early 1970s, Point Judith Pond and Ninigret Pond (Figure 1) rated very high among recreational fishermen as exceptionally good fishing areas. Some claimed that on a good day you could catch as many fish there as you could at the well-known regional "hot spot" off Quincy, Massachusetts.

By the mid 1970s, however, there were signs that not all was well with this popular fishery. Recreational fishermen recalled years when they had caught more fish and complained that the fish they now caught were smaller. Previously productive places such as Green Hill Pond channel (Figure 3) did not seem to yield as many fish as they once did. Old-timers who used to spear a bushel-basketful of flounder off the channel's sand flats didn't even bother to go out any more. There was no doubt in their minds that there were not as many fish as there used to be.

There were many opinions about the cause for the perceived decrease in winter flounder landings. At the time of our surveys between 1978 and 1983, the most frequently expressed belief among recreational fishermen was that the problem was the impact of commercial harvests within the ponds. Two men operated small otter trawls there, as they had done during the previous decade. To recreational fishermen, they were a visible source of competition and potential impact on the winter flounder. Less conspicuous was the commercial fyke-net fishery. A fyke net is a funnel-shaped trap made of fish net. Fish are typically guided to the

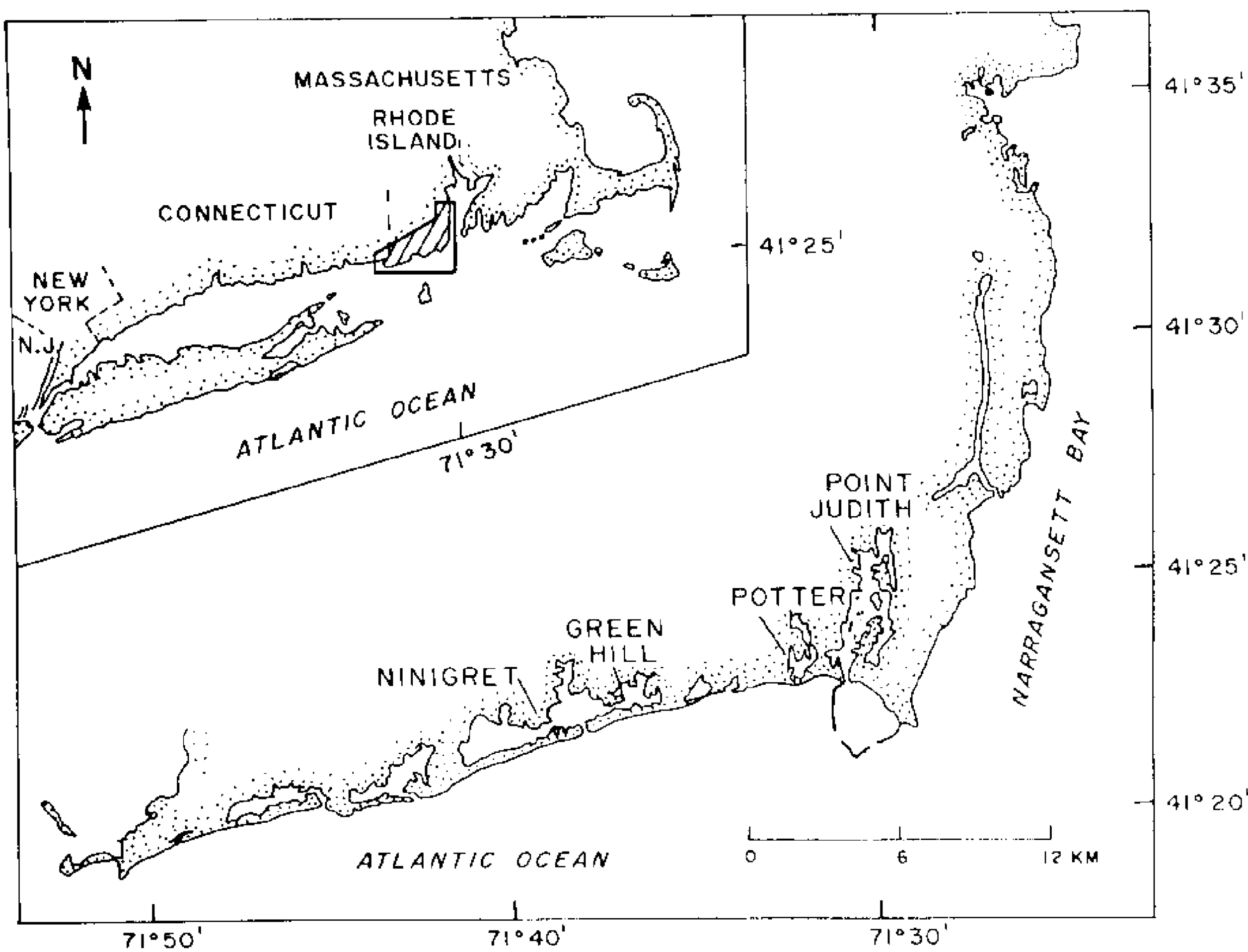


Figure 1. *The four Rhode Island coastal ponds studied during the URI Salt Pond Study.*

mouth of the net by wings of netting stretching out from either side. Fish entering the fyke net are trapped until a fisherman removes them. Several people set these portable fish traps in Point Judith, Green Hill and Potter ponds. These nets were placed in areas less frequented by recreational fishermen, so the fyke-netters received less vocal opposition than the Ninigret Pond draggermen.

Some recreational fishermen also believed that increased fishing pressure by the commercial fleet operating outside the ponds in Rhode Island and Block Island sounds may have had an impact on the winter flounder resource. Others attributed the fluctuations in flounder abundance to a natural phenomenon regulated by changes in temperature and other environmental variables (Jeffries and Johnson 1974). There was plenty of discussion but little agreement. No one could even say for sure whether the perceived problem with the resource was real.

There is a long history of concern for the winter flounder in Rhode Island waters. Prior to the turn of the century, biologists recognized our estuaries and coastal ponds as places where winter flounder spawn and their young develop. In fact, during the first several decades of this century the state of Rhode Island operated a winter flounder hatchery in Wickford. Its purpose was to augment the natural supply of young flounder so that populations supporting the important inshore commercial flounder fishery would be maintained or perhaps increased. It was never conclusively demonstrated that hatchery production influenced commercial fishery landings, and the hatchery closed in the late 1930s.

That a single, small hatchery had little impact on the numbers of young flounder developing in our coastal waters is really no surprise. We now know that, in addition to the vast numbers of young flounder produced in Narragansett Bay and its estuaries, millions are produced in our coastal ponds each year. Nature has provided her own hatcheries. The quantities produced by the hatchery in Wickford pale in comparison to nature's efforts.

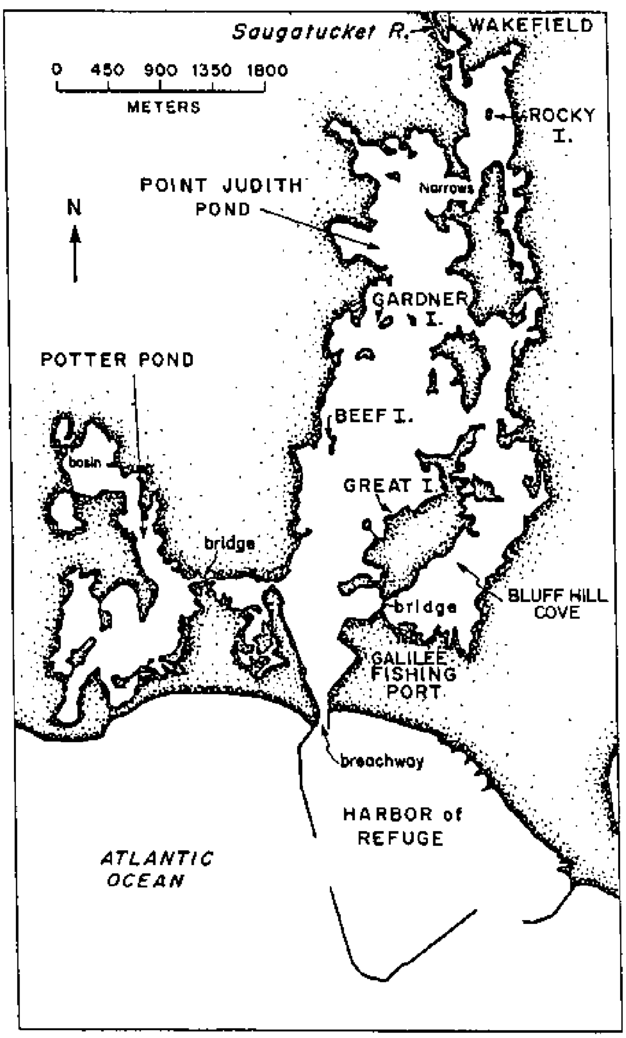


Figure 2. *Point Judith and Potter ponds study area features.*

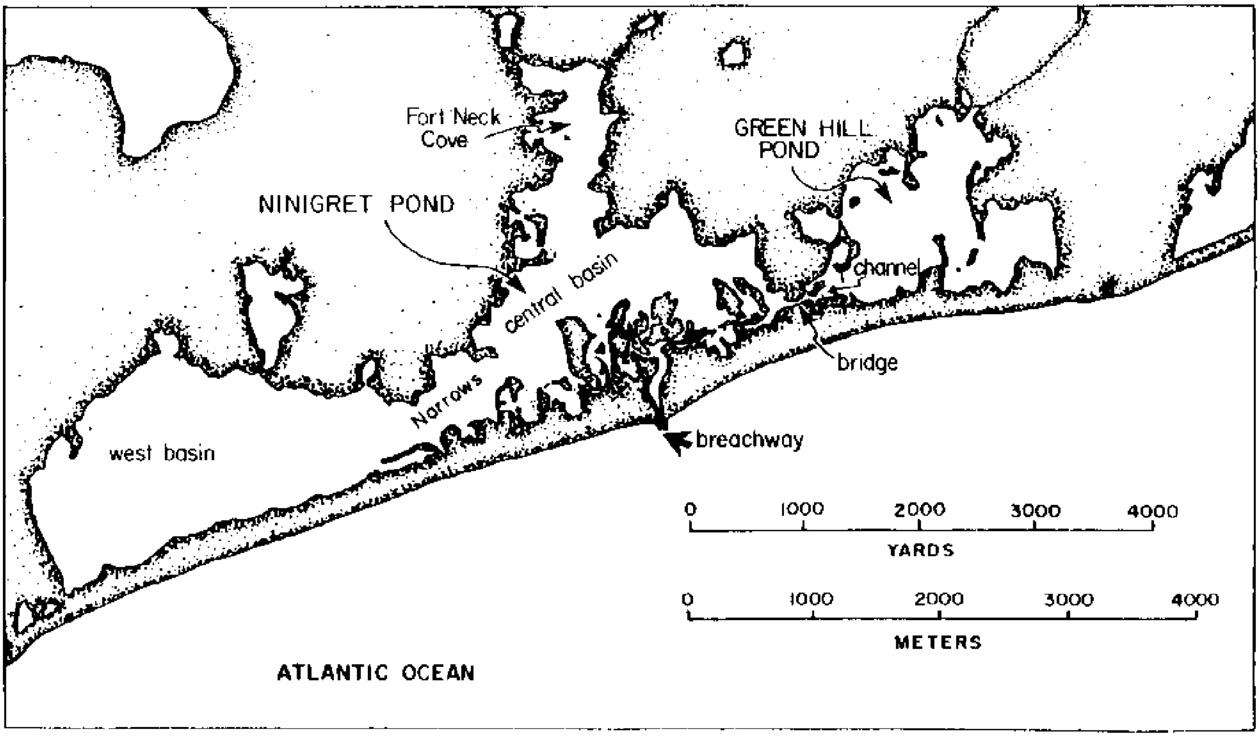


Figure 3. *Ninigret and Green Hill ponds study area features.*

Table 1. *Characteristics of the four Rhode Island study ponds and their watersheds.*

	Point Judith	Potter	Ninigret	Green Hill
Ponds:				
Hectares	638	137	713	180
Average depth (meters)	2	1.2	1.2	0.8
Average salinity (o/oo)	29	28	28	24
Breachway dimensions (meters)				
width	50	7	34	7
depth	8	1.5	2	1
Watersheds (1980):				
Hectares	2245	1068	3058	1700
Land use (%)				
developed	34.6	21.5	16	28
agricultural	3.9	10.4	3.2	5
woodland/open space	54.9	63	66.1	65
conservation	1.7		15	2
houses	2028	755	1215	1223
projected houses at full development	6828	1902	4816	3850
Freshwater input (10^6 m^3/yr)	25.3	5	15	6.8

HABITS OF COASTAL POND WINTER FLOUNDER

The winter flounder, *Pseudopleuronectes americanus* (also known locally as blackback or simply "flounder"), is a cold-water species with a special ability to withstand near-freezing temperatures. During winter months, these fish produce within their tissues an organic antifreeze compound similar to glycoproteins found in certain species of Antarctic fish (Duman and deVries 1974). This antifreeze lowers the freezing point of a fish's body fluids and allows it to live in waters that would kill species without this protection. Although exceptions to the following account are known to occur due to vagaries in water temperature and other natural phenomena, the life habits of winter flounder inhabiting Rhode Island's coastal ponds can be generalized as follows (Bigelow and Schroeder 1953; Klein-MacPhee 1978).

Preparation for spawning season

During September, as water temperatures cool, adult flounder enter Rhode Island's coastal ponds. Often the first arrivals are males, with females arriving in October. Flounder are extremely adaptable in their eating habits, and the abundance and diversity of food organisms in these productive estuaries put large amounts of energy for growth readily at hand. The fish expend little energy foraging and their utilization of these food resources is highly efficient and productive. During this period of active feeding, winter flounder in the ponds are vulnerable to fishermen who catch them with baited hooks or trap them in nets.

In cold December waters, the fish cease feeding and spend an increasing amount of time lying inactive on soft sediments. They are no longer easy to catch, and fishing activity also ceases. During this period, the life processes of the fish are sustained by energy reserves stored in their tissues. Winter is the breeding season for this cold-water species, and even though the fish are not feeding, their gonads continue to develop in preparation for spawning.

Beneath the frozen surface of the coastal ponds, approximately half a million eggs in each large, sexually mature female winter flounder develop into tiny spheres about 0.6 mm (0.02 inch) in diameter. As the eggs are developing in the females, the bellies of males also become distended from the swelling of maturing milt sacs. By mid-February, the gonads of both sexes are fully developed, but the energetic cost of this development to other tissues is apparent in the skinny and flaccid quality of the musculature. A fillet from a fish in this condition is of noticeably poorer quality than one from a fish of similar size captured the previous fall.

Spawning and early life history

Spawning usually takes place in February and March, frequently in brackish areas. Spawning is thought to occur at night. Unlike eggs of most other flatfishes, winter flounder eggs are more dense than seawater and sink to the bottom rather than floating near the surface. The eggs are sticky and clump together on whatever surface they land on. Those eggs that fall into soft, fine sediments are less likely to develop because poor water circulation in the sediment results in a lack of oxygen for the embryo.

Eggs hatch about two or three weeks after spawning, when water temperatures in the pond are typically between 3° and 5°C (37–41°F). Newly hatched larvae are only about 3.2 mm (0.13 inch) long. They drift in the plankton for about a month, upright, with one eye on each side of the head like other fishes. At the end of that month, when they are about 6 mm (0.25 inch) long, there is loss of pigment on the left side of the body and the left eye migrates to the right side of the head. The fish now become horizontally oriented as flatfish and are no longer planktonic. They have become bottom dwellers and by the end of their second month resemble the adult form (Figure 4).

During this time the post-spawning adults resume feeding. The warming water stimulates the growth of food organisms and the fish rapidly restore their body tissues.

Summer water temperatures in shallower areas of coastal ponds can be lethal to adult winter flounder. By May and June, many of these fattened fish leave the ponds and return to the cool summer waters of Rhode Island and Block Island sounds, where they continue to grow. They are once again vulnerable to fisheries and many are captured in the nets of inshore draggers as the fish move offshore.

Because young fish are more tolerant of warmer temperatures, they may remain in the ponds throughout their first year or two. However, during the warmest portion of the summer they can survive only in the cooler, well-flushed waters of deeper basins and channels. The coolest basins may also support a small population of adults that remain in some ponds throughout the year. In certain estuaries, these cooler areas are limited or unavailable and the quality of the estuary as a winter flounder nursery habitat is therefore diminished. Occasionally, a usually suitable nursery ground will become too warm. Fish that are trapped there may die if they cannot find their way to cooler waters.

By September, young flounder are 7.5 to 12.5 cm (3 to 5 inches) long. They continue their rapid growth until cold waters diminish their activity for the winter. Also in September, the first adults return from their offshore summer grounds, their gonads already developing in preparation for the upcoming breeding season. With very few exceptions, these fish return to the same pond in which they spawned in previous years (Perlmutter 1947; Saila 1962).

Fishermen have been aware of these movements of coastal pond winter flounder for as long as the ponds have been fished — probably since before recorded history. The recreational fishery there is relatively new, in comparison, but today constitutes a most popular activity. The flounder's habit of entering the ponds in the fall means that this delectable species is plentiful and accessible when other fish species have left our waters for warmer seas.

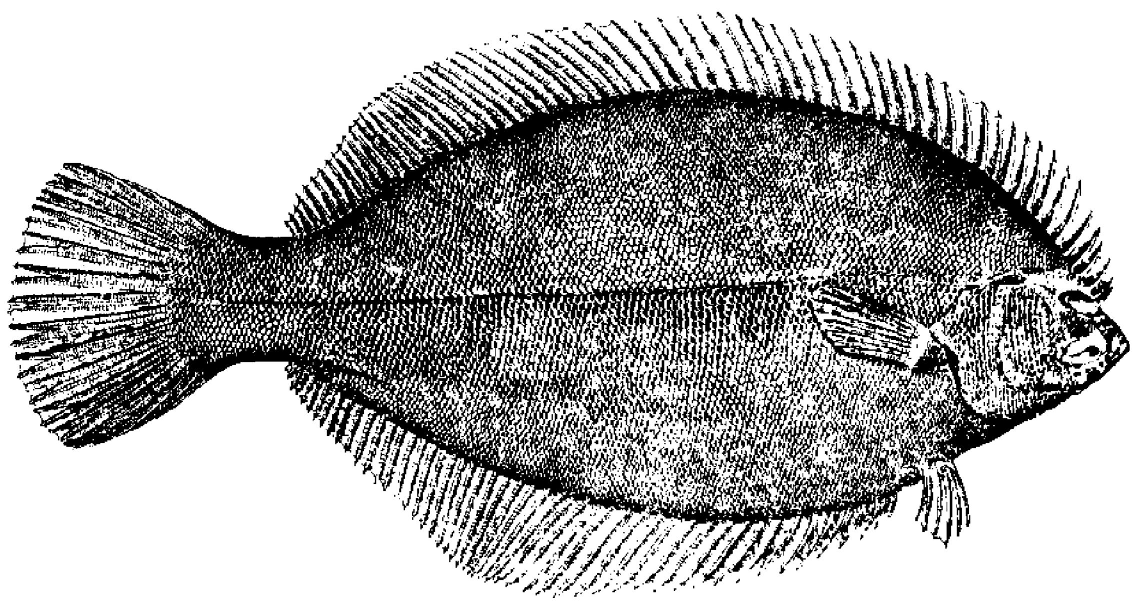


Figure 4. *Winter flounder,* Pseudopleuronectes americanus. *From Bigelow and Schroeder (1953). Drawing by H.L. Todd.*

COASTAL POND WINTER FLOUNDER FISHERIES

Prior to the existence of permanent breachways and channels into Point Judith and Ninigret ponds, winter flounder could enter only when the barrier beach had been breached, whether through natural events or by plow and shovel. These early unstabilized channels were sometimes broad and deep, making them difficult to fish and allowing flounder to pass relatively unnoticed. At other times the channels were shallow enough for flounder to be easily speared as they passed through on their way into or out of the ponds. Fishermen in skiffs drifting in the channels or across the flats would fill barrels with flounder they had speared with long-handled "gigs." This practice is now rarely seen on the tidal deltas of Ninigret, Green Hill, and Potter ponds, a sharp contrast to those days a century ago when pond flounder were salted and exported to Jamaica and Haiti (Lee 1980). In the deeper parts of the ponds, flounder were also captured in trap nets and haul seines, activities that occupied several "gangs" of commercial fishermen who relied on the bounty of the ponds for their livelihood (Lee 1980).

Recreational fishery

Today, flounder are taken by hook and line in a very popular recreational fishery and also by otter trawls and fyke nets in a small commercial fishery. According to a URI study (Smith and McConnell 1980), recreational fishermen made over 30,000 fishing trips on Point Judith, Potter, Ninigret and Green Hill ponds between April 1978 and January 1979. They caught more than 60,000 flounder (about 30,000 pounds), and most of these were landed in April and May. The recreational fishery attracted people from more than five states and their efforts were apportioned fairly evenly between the two pairs of ponds.

During another recreational fishery survey of the four coastal ponds conducted between March and September 1979, we noted that the average daily recreational fishing effort for winter flounder (expressed as number of person-hours fished each day plus or minus the standard deviation) was similar for Point Judith and Ninigret ponds: 58 ±355 and 50 ±201, respectively. The large standard deviations indicate large day-to-day variability in the number of person-hours per day. Fishing effort was about 20 percent higher on weekend days than on weekdays (Figure 5).

As noted above, Smith and McConnell (1980) estimated that more than half of the annual catch of all species taken in Point Judith Pond in 1978 was taken during April and May. We recorded that fishing effort during these months was centered near the Narrows (Figure 6) and made up only about 10 percent of that pond's annual recreational fishing effort. Thus a minor portion of the fishing effort resulted in a major portion of the catch.

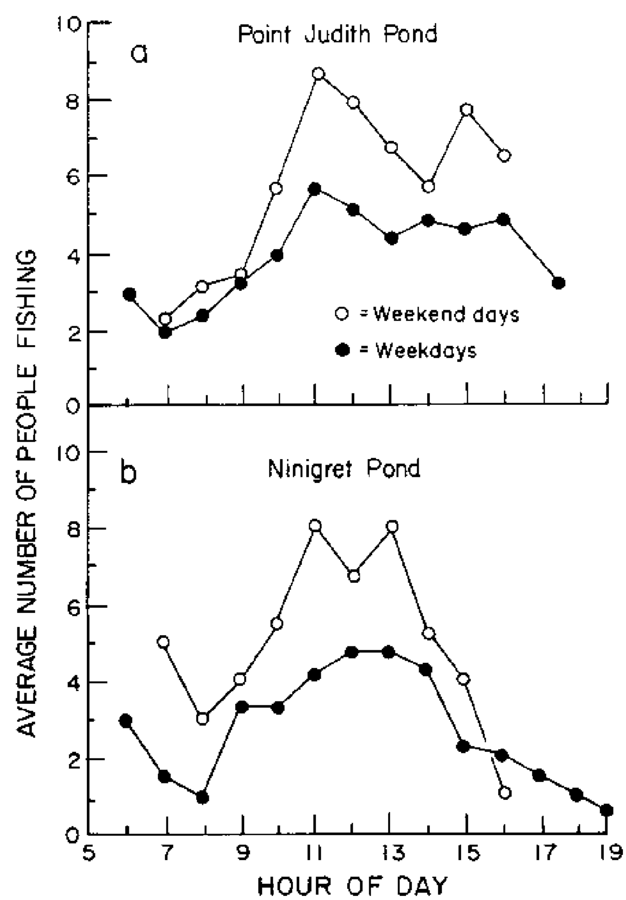


Figure 5. *Daily pattern of recreational bottom fishing effort on two Rhode Island coastal ponds between March and September 1979, expressed as the average number of people observed bottom-fishing relative to the hour of the day.*

Table 2. *Winter flounder recreational fishery catch rate and landings in two Rhode Island coastal ponds in 1979. Average fish weight was 8 ounces (224 g).*

	POINT JUDITH POND				NINIGRET POND			
	Sample size	Mean catch per hour	Catch rate range	Fish caught	Sample size	Mean catch per hour	Catch rate range	Fish caught
Time period:								
Mar–Apr	58	2.7	0 – 16.0	9,267[a]	5	0.7	0 – 3.3	3,500[b]
May–Jun	53	0.9	0 – 5.9	4,020	49	1.5	0 – 8.0	2,715
Jul–Aug	85	0.5	0 – 5.6	3,758	18	1.8	0 – 8.0	6,107
Sep–Oct	20	2.4	0 – 8.0	2,000[c]	3	2.0	1.0 – 3.0	11,646
Nov–Dec	29	1.7	0 – 5.0	1,000[c]	15	1.0	0 – 6.0	585
Mar–Dec	245	1.4	0 – 16.0	20,045	90	1.5	0 – 8.0	24,553
Weekday	169	1.3	0 – 13.3		71	1.4	0 – 8.0	
Weekend	76	1.6	0 – 16.0		19	1.8	0 – 8.0	

Notes:

[a]Fishing effort in one popular area was not monitored during this time. 1,000 fish were attributed to this area and were added to the landings.

[b]This fishery was not monitored during this period. Historically, it is as active in March and April as in September and October. As an approximation, landings for the former period were estimated to equal those for the latter less the breachway channel landings.

[c]Due to a very active bay scallop (*Argopectin irradians*) fishery during this time, accurate fishing effort estimates were not obtained. Fishing effort was observed to be less than it had been in March through June and these figures are estimates based on those data.

There was a decline in Point Judith Pond landings during the summer (Table 2), a seasonal effect reflecting the behavior of this cold-water species. By July, fishing effort near the Narrows had declined to less than 1 percent. Most of the few flounder taken in the summer were caught in the cooler, southern portion of the pond.

This summer decline was less severe in Ninigret Pond because flounder remain in its cool, tidally flushed central basin throughout the year (Worobec 1982). Recreational fishing effort in this pond was largely confined to this basin near the Narrows and the breachway channel (Figure 7a).

In the spring, fishing effort in Ninigret Pond was 135 person-hours per day. During the summer, the channel was the most popular area (about 35 person-hours per day) while effort in the basin declined (25 person-hours per day). In the fall, a substantial proportion of the catch was taken in the channel, especially when fish passed through on their way into Ninigret and Green Hill ponds and the weather was comfortable for the campers who frequented the area.

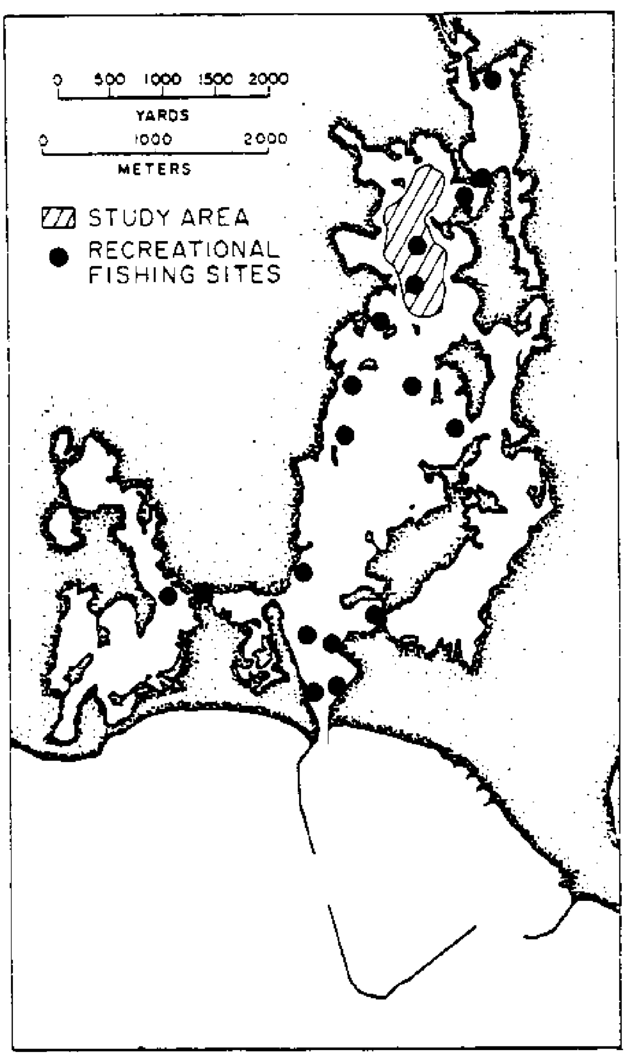
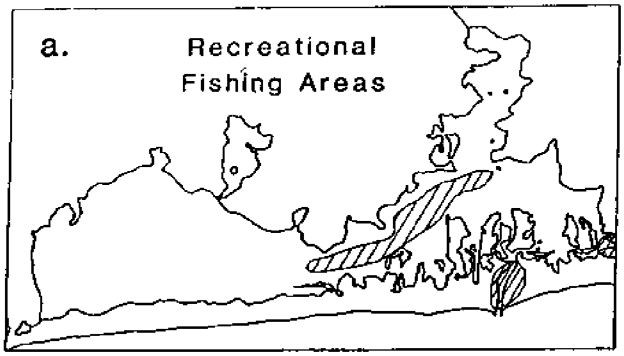


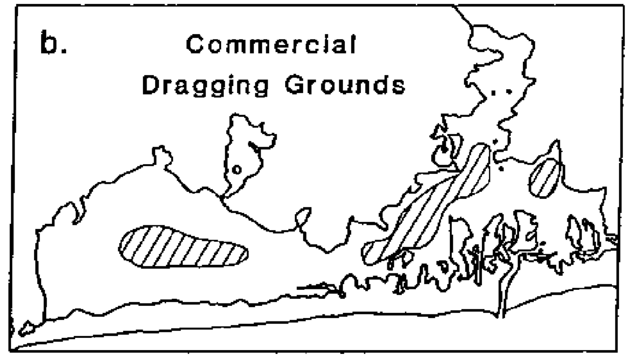
Figure 6. *Popular recreational bottom fishing sites in Point Judith and Potter ponds. The study area for the 1981 winter flounder tag/recapture population assessment is also indicated.*

Commercial fishery

During the 1970s, the Ninigret Pond commercial fishery consisted largely of the efforts of two individuals who exhibited a remarkable degree of awareness and adaptability to the available resources. They trawled for flounder in the spring and fall and used other methods to fish for other species as well. Although they were competitors in the highly restricted physical confines of small trawlable grounds (Figure 7b), they respected each other's rights of access to the resource. This mutual respect avoided the sort of competition that could have resulted in fishing too many hours per day in a contest for the larger catch. Each man landed only what he knew he could satisfactorily handle in order to bring a high-quality product to market.

Because both men were active in three or four inshore fisheries, their annual efforts directed at flounder varied with the abundance and economic potential of the various resources available to them. For example, in 1977 they had an excellent flounder harvest of approximately 20,000 pounds (almost 40,000 fish). In the fall of 1978, scalloping was more profitable so they spent little time dragging for flounder. In 1981 the increase in the price paid for quahogs made it more profitable to shellfish. During this five-year period, commercial winter flounder landings fluctuated greatly.





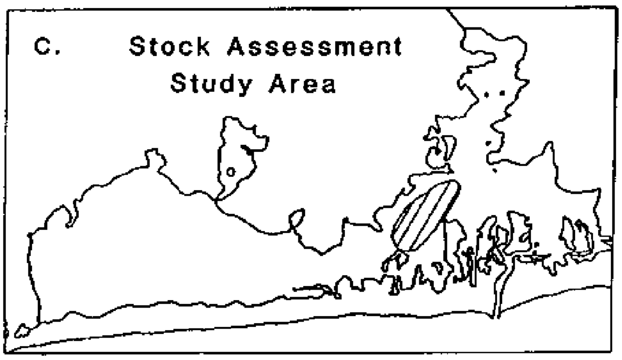


Figure 7. *Ninigret Pond fishing areas. (a) Recreational bottom fishery; (b) 1970s and early 1980s commercial winter flounder bottom trawl fishery; (c) Study area for 1980 mark/recapture winter flounder population assessment.*

NEW KNOWLEDGE OF WINTER FLOUNDER BEHAVIOR

The results of the Coastal Ponds Study, especially regarding those characteristics of our ponds that winter flounder exploit when they use the ponds as spawning grounds and nursery habitat, provide important new information that will be important in protecting the flounder.

Winter flounder spawning areas

It is generally accepted that flounder spawn in "the shallows" and deposit their eggs on algal mats or on firm bottom (Bigelow and Schroeder 1953). There are many areas within each pond that are candidates for such spawning habitat. If such spawning areas were in locations that were altered by dredging or other construction projects, this could seriously decrease the amount of breeding habitat available and thereby reduce the flounder population. Furthermore, towing scallop dredges in these areas might destroy winter flounder eggs if the scallop dredging season were extended to overlap with the winter flounder spawning season, an event that occurred in these ponds in 1979.

The first step in evaluating whether winter flounder spawning grounds are at risk from dredging operations is to determine where the spawning grounds are located. To do this, we devised a special sled to survey for winter flounder eggs lying on the bottom (Crawford and Carey 1985). As the sled is towed along the bottom, a wing on its front creates turbulence. This sweeps eggs lying on the bottom up into the water where they are captured in a fine mesh net at the rear of the sled. The sled was towed in many locations in Point Judith Pond between March 7 and April 2, 1981 (Figure 8). From earlier work, we knew that the bottom in these areas was of the type reported to be suitable as winter flounder spawning habitat.

During the second week of March we found eggs in the upper pond near the mouth of the Saugatucket River, around a submerged gravel bar labeled on old charts as Rocky Island (Figure 3). This small bar has all the characteristics of a suitable spawning habitat and was the only area where eggs were found at that time. Earlier routine

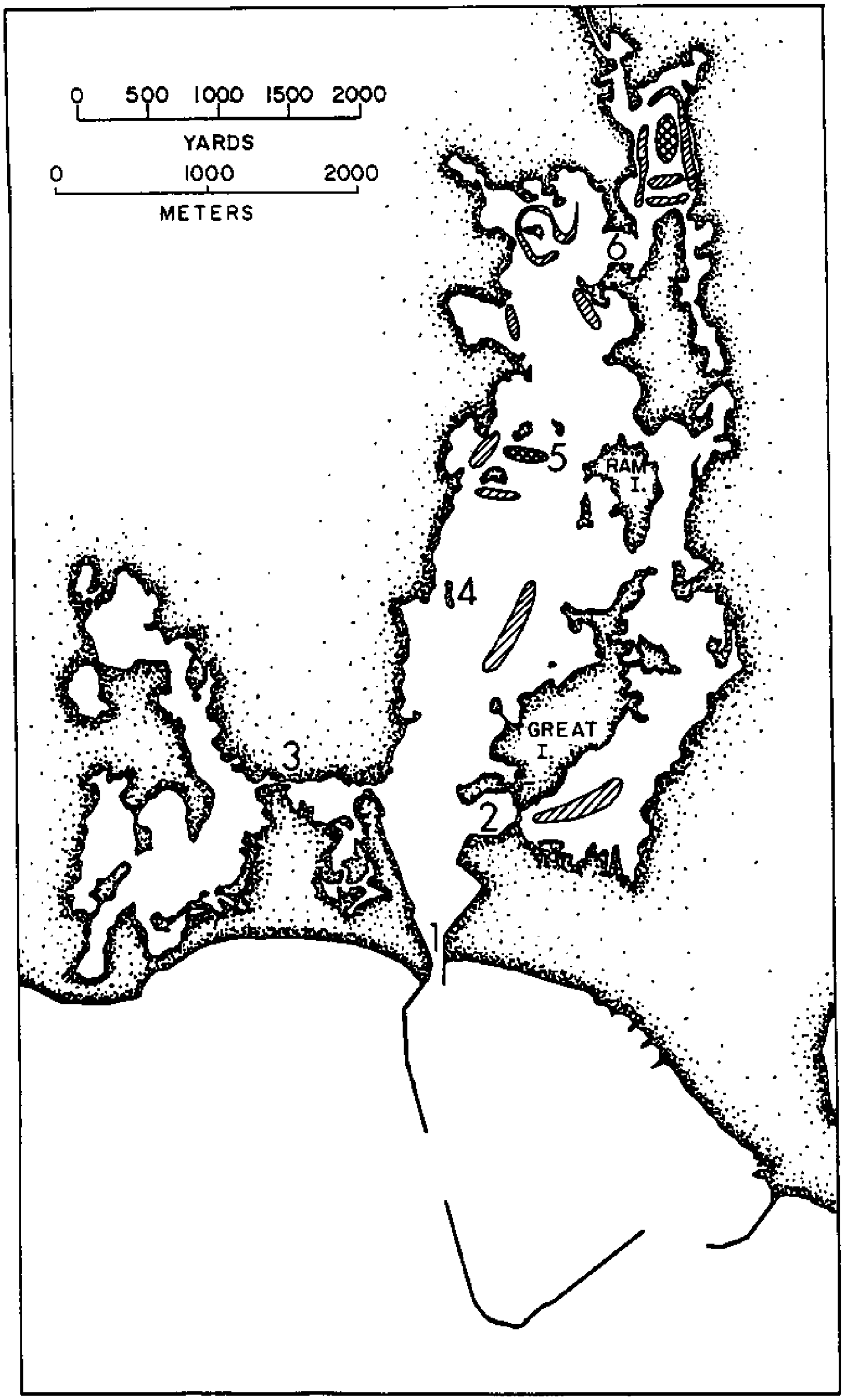


Figure 8. *Cross-hatched areas show locations where we searched for winter flounder eggs in Point Judith Pond in March and April 1981. Eggs were common in the northern portion of the pond near Rocky Island (see Figure 2). The numbers here indicate the location of sampling sites where we also sampled for winter flounder larvae (see Figure 10).*

sampling for ichthyoplankton (fish larvae) at several places within the pond had revealed that winter flounder larvae first appeared, and were generally most abundant, in the vicinity of this area. We surmised that the area near this gravel bar was a major winter flounder spawning site.

Two weeks later, we discovered a smaller spawning site near Gardner Island. Because of the absence of eggs in samples taken elsewhere in the pond, we concluded that most of that pond's winter flounder spawning activity occurs in its northern part. Sampling during 1983 and 1984 confirmed this.

During studies of the ichthyoplankton in Ninigret Pond between 1978 and 1981, we repeatedly observed the highest density of young winter flounder larvae in the northwest portion of the west basin (Figure 9). The gravel and cobble bottom of this region of the pond is densely covered with algae and eelgrass, prime winter flounder spawning habitat. Surveys of likely spawning areas with the egg sled in March of 1983 and 1984 found eggs only in the west basin. The largest source of fresh water into this pond is at the head of Fort Neck Cove, but no eggs were found there during either year. There are freshwater springs that discharge into the west basin where we found eggs.

Distribution of winter flounder larvae

If flounder are laying their eggs only in certain areas of the ponds, we can ask to what extent the larvae also remain in those areas. That is, are larvae always more prevalent in certain areas of the ponds, or do the forces of the tides and winds act to mix and distribute them throughout each pond? The answer to this question would be important in the consideration of water quality goals and priorities for habitat protection.

As a first approximation, Point Judith Pond can be divided into a southern portion and a northern portion. The southern portion has characteristics of a well-mixed estuary (Licata 1981). The dimensions of its breachway and a typical tidal range of 1 meter (3 feet) result in high current velocities and thorough mixing of water (Friedrich 1982). There is also a phase lag in the tides along a north-south transect from the breachway northward toward the central portion of the pond. This results in a time-delay in the timing of the tides progressing further up the pond away from the breachway.

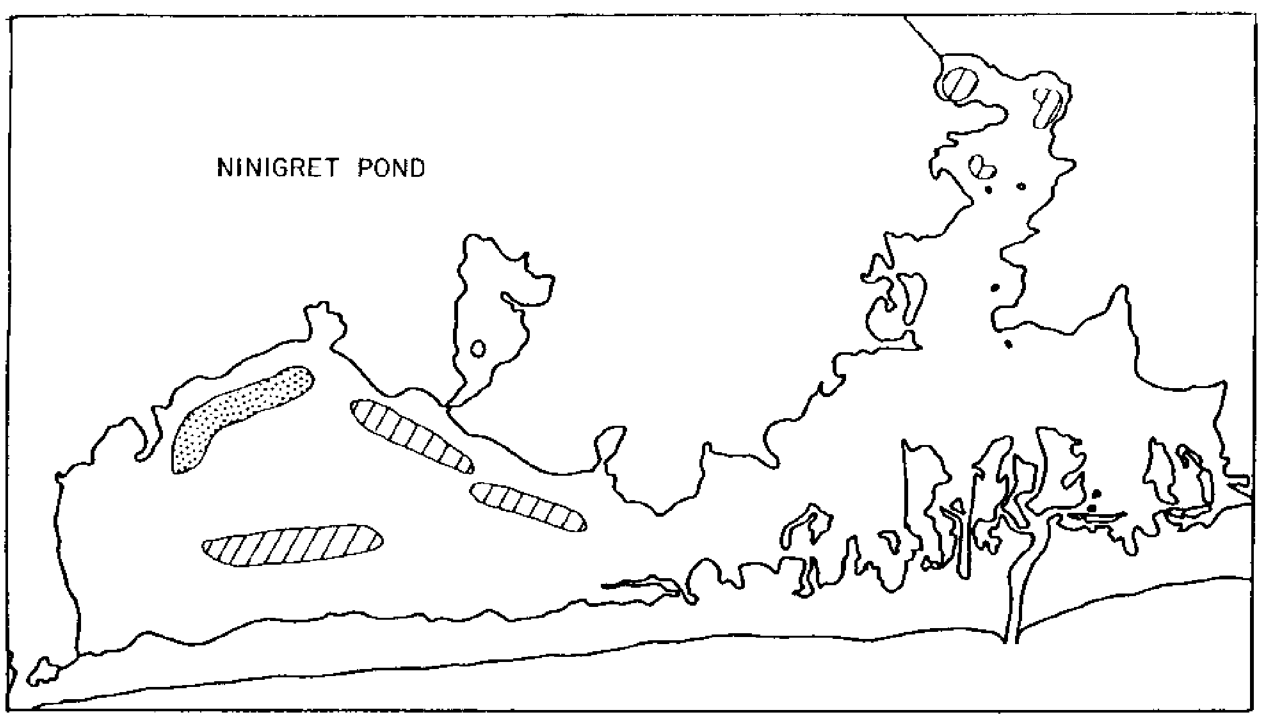


Figure 9. *Locations in Ninigret Pond surveyed for winter flounder eggs in March 1983 and 1984. Eggs were found in the stippled area in 1984.*

The northern portion of the pond, on the other hand, approximates a two-layered system where brackish water lies on a wedge of denser, more saline oceanic water. The thickness of the brackish layer varies with the amount of freshwater input to the system, principally from the Saugatucket River. Freshwater flow results in a net seaward drift of surface waters toward the breachway. Tidal current velocities are low, tidal range is low (typically 0.5 meter or 1.5 feet), and there is little tidal phase lag.

On two dates in the spring of 1981, we collected samples of plankton hourly from six locations in Point Judith Pond during the 13-hour period of a tidal cycle. (The six sampling sites are indicated by numbers in Figure 8.) We used fine-mesh nets that filter small organisms from the water. During sampling, the nets were lowered to the bottom and then raised to the surface again, ensuring that the entire water column was sampled. The amount of water filtered each time was recorded by meters inside each net. The winter flounder larvae in each sample were later counted, and the counts were adjusted according to the amount of water filtered so that samples taken at similar hours in different locations could be compared (Crawford and Carey 1985). The results of these larvae counts are shown in Figure 10.

The March 27 collections contained winter flounder larvae that were only several days old. The larvae were most abundant in the Narrows near the spawning area discussed above, around the submerged gravel bar. Tidal influence in this portion of the estuary is minimal; as a result, these recently hatched larvae had not been displaced very far by the tides. By April 27, there was a mixture of sizes of larvae in the pond and they were much more dispersed. These findings suggested that hatching had occurred over several weeks and that by late April there had been sufficient time for the tides to distribute older larvae throughout the pond.

Because each survey was brief, we could not directly predict the effect of more than one tidal cycle on the movement of planktonic larvae within the pond. To investigate this question, we used a computer simulation (Licata 1981). The model predicted that it would take more than 10 days for larvae to be displaced from the Narrows to Gardner Island during a period of high freshwater runoff (Crawford and Carey 1985). This prediction was based only on the hydrodynamics of the system and did not consider the larvae's swimming behavior, which may also tend to keep them in this portion of the estuary. (As larvae grow they tend to spend more time near the bottom, away from the influence of southward-flowing surface waters that would sweep them into the sea.)

We concluded that larvae hatched in the northern portion of the pond, especially north of the Narrows, would be unlikely to be flushed out of the pond during their period of planktonic larval development. This results in young flounder being effectively retained within the estuary where there is an abundance of food and habitat for their development.

The computer model also predicted that 20 tidal cycles would be sufficient to sweep larvae hatched in the vicinity of the Gardner Island spawning site through the breachway. Larvae hatched in this area would be less likely to be in the pond at the end of their planktonic period of development.

On March 27 there were also significant numbers of young larvae in the Potter Pond channel. But larvae did not appear at this sampling site in any quantity until one to two hours prior to low tide. The fact that it took approximately four hours of tidal flow for them to reach the channel suggests that they may have traveled from the back waters of Potter Pond. Although we did not sample this pond for eggs, we did learn that freshwater springs and suitable spawning habitat are plentiful along the shoreline of its deep northern basin. These larval collections suggest that there may also be a winter flounder spawning site in this portion of Potter Pond.

Significance of larval retention in coastal ponds

The conservative nature of certain areas of Point Judith Pond in retaining winter flounder larvae rather than flushing them out to sea was most clearly demonstrated in the March 27 samples. A month later, larvae in various stages of development were well mixed in the lower reaches of the pond (Figure 10), and it was during this time that the largest number of larvae entering Block Island Sound due to tidal flushing would have occurred.

The survival of larvae that get flushed out of the

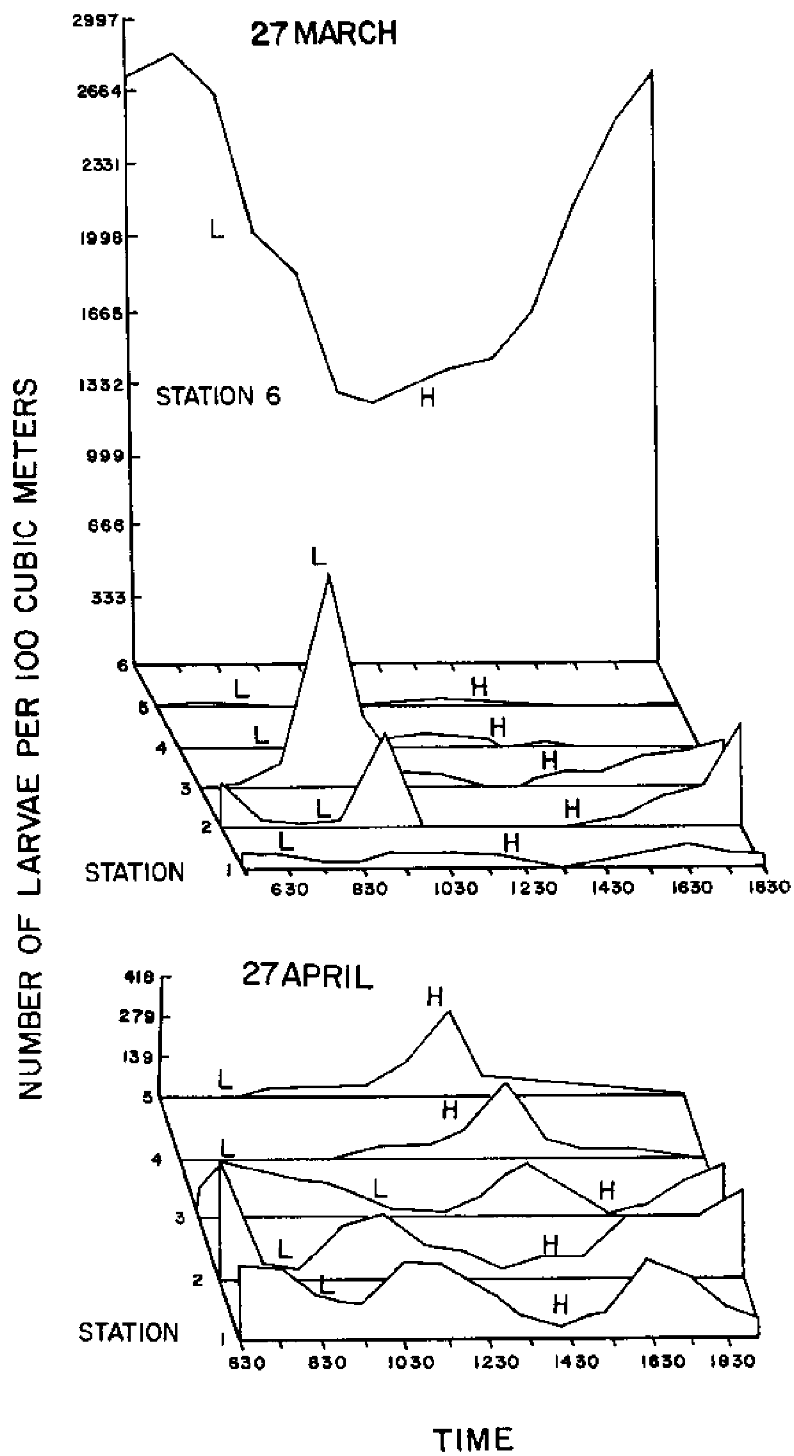


Figure 10. *Winter flounder larval densities observed during two surveys on Point Judith Pond, March 27 and April 27, 1981. Those observed at Station 6 on March 27 were recently hatched and were near the Rocky Island spawning site located earlier (see Figure 8). Station 6 could not be sampled effectively in April because of high concentrations of jellyfish which clogged the nets. Larvae were not common there at that time. "L" indicates time of low tide; "H," time of high tide. Note the different vertical axes. Refer to Figure 8 for station locations. (Figure from Crawford and Carey 1985).*

ponds is thought to be greatly diminished. By spawning in areas of the ponds away from tidal influences, winter flounder may be exploiting the hydrodynamics of the ponds to help ensure that their progeny are retained in these systems long enough for adequate growth and development.

Due to the tidal phase lag between Point Judith Pond and Potter Pond, it is possible for larvae leaving Potter Pond to become mixed with larvae in Point Judith Pond. There may also be mixing and conservation of larvae in Bluff Hill Cove due to complexities of currents and phase lags caused by the constriction at the bridge to Great Island. We have concluded that although flounder may spawn in fairly restricted areas, larvae can get mixed throughout each pond and between contiguous ponds. However, this mixing may occur more slowly than one would at first expect.

Movements of adult winter flounder

It has been known for years that winter flounder return to the same coastal pond they left after the previous spring's spawning season. In fact, this phenomenon was discovered in Point Judith Pond in 1937 by Perlmutter (1947). He reported that the majority of tagged fish he had released near Beef Island the previous spring were recovered by Point Judith fishermen the following fall. Dr. Saul Saila of the University of Rhode Island recorded a similar observation in Green Hill Pond years later (Saila 1961).

In the spring of 1980 and 1981, we surveyed Ninigret Pond (Worobec 1982) and Point Judith Pond (Grove 1982) for the purpose of estimating the number of adult winter flounder in each pond. We marked or tagged several thousand fish in each pond during the course of these surveys (Figures 6 and 7c). Anticipating the return of these marked fish to each pond the following fall, we asked the coastal pond commercial and recreational fishermen, as well as commercial fishermen working in the sounds, for reports indicating the date and location of their capture of marked fish.

The bulk of flounder landings from Rhode Island's coastal pond recreational fishery are taken during two distinct seasons: the post-spawning season (March through June), when adults are leaving the pond for cooler waters after spawning, and the pre-spawning season (September through November), when adults are entering the pond prior to the next spawning season. For these studies most fish were tagged during the post-spawning season.

In Ninigret Pond, the commercial fishermen did not capture any marked fish outside the study area. There were no returns reported by recreational fishermen during that study, but this was probably because the mark we used to identify fish was difficult for an untrained eye to detect. The commercial fishermen knew what to look for.

We used much more visible tags during the Point Judith Pond study. For the first few weeks after tagging, tagged fish were caught in only two areas: south of the Narrows in the study area, or out of the pond, presumably when fish were on their way offshore (Figure 11a). During the subsequent pre-spawning season in the fall, most returns were taken within the study area once again (Figure 11b). After being tagged, many of these fish had left the pond, spent two or three months in the sea, and then returned.

But what about some of the other areas of the pond that are popular in the rod-and-reel fishery (Figure 6)? Almost all tags were returned from an area where our recreational fishery survey indicated that only about 40 percent of the annual catch was taken. If tagged fish were randomly dispersed throughout the pond, it would seem likely that a few would have been caught among the remaining 60 percent of the catch that was taken elsewhere. For example, the popular fishing spot at the Great Island bridge can be very productive. Only one small tagged fish was caught there and that was during August. The fish probably never left the pond but likely sought out cooler water in the channels at its southern end. There were no tag returns from this popular fishing spot during either major flounder fishing season. There was also a recreational fishery as well as a commercial fyke-net fishery in Potter Pond. No returns were reported from this area either, although fishermen there were also checking for tags.

From these observations, we concluded that winter flounder not only return to the same pond but also return to the same general area of that pond. We also believe that Point Judith Pond fish do not enter Potter Pond with any great frequency.

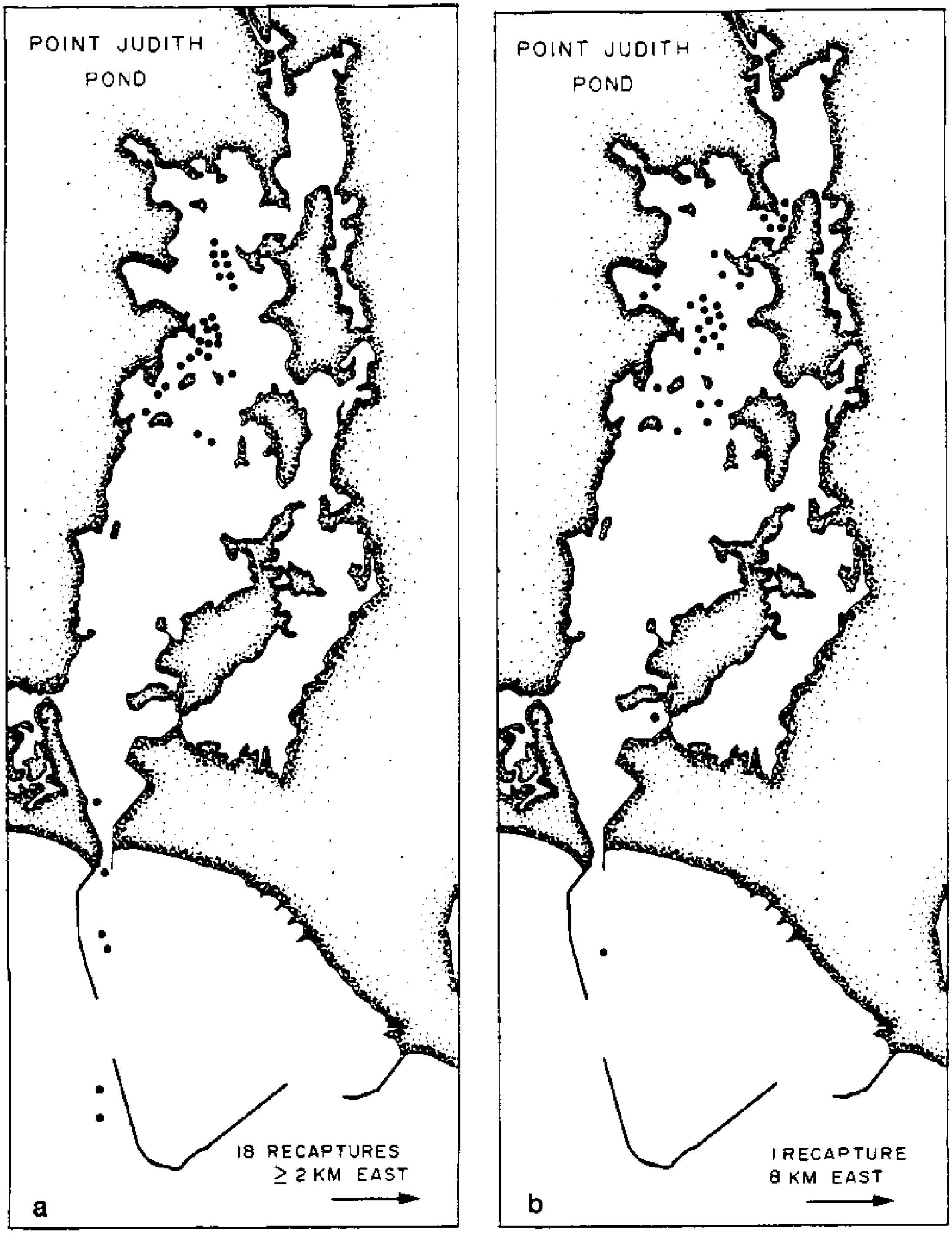


Figure 11. *Recapture locations, reported by recreational and commercial fishermen, of winter flounder that were tagged in Point Judith Pond during a 1981 population assessment (see Figure 6). Tag returns have been separated into two groups: (a) Springtime recaptures taken during the time when adult flounder normally migrate out of the pond (maximum time since tagging = 54 days), and (b) Fall recaptures taken when the fish are normally returning to the pond (minimum time since tagging = 95 days). During the fall, two strays were reported: one fish had entered Narragansett Bay and the other was caught off North Carolina.*

Moreover, the abundance of winter flounder in Potter Pond makes it seems likely that these fish constitute a separate population. Whether or not fish entering the eastern part of Point Judith Pond under the Great Island bridge are also part of a separate population cannot be clearly deduced at this time, but the question is worthy of future examination. If there is a separate group of fish in this area, their spawning activity could have been the source of larvae observed there during our larval surveys (Figure 10).

CONFLICTS BETWEEN THE RECREATIONAL AND COMMERCIAL FISHERIES

After we considered all of the evidence we had gathered during our five years of research, we concluded that much of the controversy concerning otter trawling for flounder in the ponds at the time we did our studies was a result of overlap of the commercial fishing grounds with those of the recreational fishery. In 1979, when we monitored both fisheries, we found the landings of the two in Ninigret to be about the same — about 10,000 to 15,000 pounds. The principal difference was that a recreational fisherman's typical catch was on the order of two fish per hour while a draggerman could land 300 to 500 fish per day. In 1978, Smith and McConnell (1980) estimated that more than 12,000 recreational fishing trips were taken on Ninigret and Green Hill ponds. The commercial catches were much more visible than the recreational landings but the aggregate catch of thousands of recreational trips rivaled that of the two draggermen.

In 1982, recreational fishermen argued that Ninigret Pond landings were below normal, although no data existed to either support or refute their claims. We conducted a brief survey in the spring of 1983, using the otter trawl we used in our earlier resource surveys. We found an abundance of robust, well-fed winter flounder in the recreational fishing grounds. These fish had been feeding on a variety of food organisms, including worms and crustaceans. Why these fish were not being caught by recreational fishermen at the time was not readily apparent, although we conjectured that they simply were not tempted by the fishermen's bait. Reports from Point Judith Pond at the same time indicated that recreational catches there were also below par, but we did not examine that flounder resource. Fishermen at Point Judith Pond also argued that increased commercial landings were the problem, but again there were no data to support or refute this claim.

RECENT CHANGES IN THE COMMERCIAL FISHERY

During the time of the Coastal Ponds Study, the two trawl fishermen previously discussed accounted for virtually all the commercial fishing effort on Ninigret Pond. However, shortly after the study ended, changes in Rhode Island's fyke-netting regulations led to major changes in the coastal pond commercial fishery.

Fyke-netting has been allowed for years on some Rhode Island coastal ponds (e.g., Potter and Point Judith), but traditionally only a few nets have been used and they have been set rather infrequently. The target species has often been white perch (*Morone americana*), less common than winter flounder but of much higher value. A large number of flounder are often taken as well. A fyke-net fishery is different from a trawling fishery because fyke nets fish continuously, are not as affected by eelgrass and algae, and can be used in places otter trawls cannot. They are known to be far more efficient and effective in certain applications.

Furthermore, because fyke nets are passive fishing gear, they are less expensive to operate, although their purchase price is high.

In 1982, Rhode Island fishery regulations were modified to allow fyke-netting in *all* coastal ponds. This activity had been prohibited in Ninigret Pond for many years. During the public hearing process that preceded this change, the potential of the Ninigret Pond fisheries was brought to public attention. There was a subsequent increase in otter trawling there as well as rapid expansion in the fyke-net fishery. These events resulted in increased fishing pressure for the Ninigret Pond fisheries.

After an initial period of relatively intense activity, the new draggermen assumed a more modest level of effort in the Ninigret fishery. Coastal pond trawling is made difficult by the abundance of sea grass and algae, which must be culled from the trawling grounds for a profitable operation. To effectively accomplish the job, a fisherman needs an understanding of the currents in the pond. Newcomers without this knowledge may underestimate the size of this task.

The increase in Ninigret Pond commercial fishing activity stimulated a vigorous response from those who considered the pond's resources threatened by overfishing. In 1983, otter trawling in Ninigret Pond was banned on weekends and prohibited completely within a management area that included the Narrows and grounds immediately to the west. Fyke-netting was allowed to continue.

Throughout this period, catches of Rhode Island's coastal pond winter flounder continued to be perceived as declining. Although this perception could have been tested by repeating the type of angler survey we had done earlier, no data were collected. However, state and federal commercial catch statistics indicated that there had been a decline in the number of flounder caught by the commercial fleet working in Rhode Island and Block Island sounds. By 1989, these commercial catches had declined sufficiently to cause some fishermen to sell their boats and leave the fishery altogether.

In response to this decline, an 11-inch minimum length regulation was imposed in 1986 for all of Rhode Island's winter flounder fisheries. This regulation probably had more impact on the recreational fishery, where we had observed fish as small as 5 inches long in the catch. Fish in the commercial catch were generally not smaller than about 10.5 inches since smaller fish do not yield a fillet of marketable size.

The decline in flounder landings also stimulated the initiation of several new studies by the Rhode Island Department of Environmental Management's (RIDEM) Division of Fish and Wildlife. Some of these studies were designed to learn more about the habits of winter flounder in Rhode Island's waters and how winter flounder are affected by fisheries (Gibson 1987, 1989a, 1989b; Powell 1988a, 1988b). Three ongoing RIDEM studies are focused on characterizing the finfish, shellfish, and plankton resources in all of Rhode Island's coastal ponds; these 10-year studies began in 1989. Results of some of this work have suggested that the total mortality of winter flounder in Ninigret Pond is similar to that for fish in Narragansett Bay; the estimated mortality of flounder in Point Judith Pond is lower. (Total mortality is the combined effects of mortality from fishing and from natural causes.)

Another change that occurred was in regard to the people participating in the Ninigret Pond commercial fishery. The two men who had previously used otter trawls in the pond left the fishery soon after fyke-netting began. They explained that when it had been just the two of them, they had found a way to share a resource rather noncompetitively. The tranquillity of this arrangement was a benefit they neither overlooked nor ignored. But the influx of fyke-netters and others to the fishery stimulated competition for access to the small resource. The serenity the draggermen had enjoyed was gone. They both expressed the sentiment that if they had to fish in a competitive atmosphere, they preferred to participate in a fishery based on a larger resource where the potential reward was greater. Both had been willing to sacrifice the "big payday" for steady, "hassle-free" work. But now that fishing pressure had increased on the pond, they looked elsewhere for their living.

In spite of the efforts to increase the catch of winter flounder, catches have not improved. The take in the Ninigret Pond recreational fishery has declined to the point that fishermen are rarely seen on that pond today. Those that persist are often highly skilled: the type who typically catch fish when others do not. For example, in the spring of 1989, one individual speared "two bucketsful" of flounder in less than three hours along Ninigret's rocky shoreline, when rod-and-reel fishing effort was essentially nil. The trawl fishery there has also collapsed. In the spring of 1988, three tows through the traditional commercial fishing grounds produced only one fish in a commercial fisherman's net.

The only Ninigret Pond fishery that continues to consistently produce flounder is the fyke-net fishery, and much of this activity is the result of the efforts of a local high school class to learn traditional fishery skills. In general, fyke-netting on the ponds continues to be sporadic. When the nets are used, however, they continue to catch fish.

We do not know the exact impact fyke-netting has had on the Ninigret Pond winter flounder resource. We also do not know how many of the fyke nets were obtained specifically for the new fishery or how many were relocated nets that had been previously used in other coastal ponds or estuaries. If the nets in the Ninigret Pond fishery are new, they represent an increase in fishing effort over Rhode Island's south shore. If the nets were previously in use elsewhere, their presence in Ninigret is a reallocation of effort temporarily directed at the pond's resource to the exclusion of the resources elsewhere. In either case, the earlier fluctuations in commercial fishing pressure on Ninigret Pond due to the economic considerations of two draggermen have been replaced by a more sustained fishing effort since the fyke-net fishery was established.

We do know that, during the 1980s, the landings of the whole state of Rhode Island's commercial winter flounder fishery have steadily declined. Moreover, during this time the catch has consisted primarily of cohorts of the strong 1978 year class (fish hatched that year) — fish that first appeared in the commercial landings in 1982. There has not been a good year class of flounder in Rhode Island waters since.

The reasons for this lack of reproductive success remain unclear but the implications are many. No one knows what proportion of the total Rhode Island landings are or could be produced on the spawning grounds in the coastal ponds, but it is unlikely that the entire cause for the decline in landings of Rhode Island's commercial winter flounder fishery can be found in the ponds. However, the numbers of fish in the ponds have apparently decreased as well, while residential and commercial development near the ponds have increased tremendously. Samples gathered by the Pond Watchers (citizen volunteers who routinely monitor Rhode Island's coastal ponds) indicate that fecal coliform counts in certain areas of Ninigret and Green Hill ponds have risen concomitantly. There is a suspicion among some residents that this evidence of increased discharge of domestic effluent into the ponds (either directly or indirectly, via surface runoff or in groundwater passing through saturated individual sewage disposal systems) flags an increase in the amounts of toxic agents entering the ponds. The agents of concern include pesticides, herbicides and components of modern exotic household cleaners. These residents suggest that domestic effluent and runoff have decreased the reproductive success of winter flounder that spawn in the ponds. To date, this assertion is unproven and remains speculation.

What cannot be argued, however, is the fact that since the days of our Coastal Ponds Study, Ninigret Pond has changed. Recreational finfishing and commercial trawling there have essentially ceased and fyke-netting has replaced them. Another remarkable change is the proliferation of waterfowl, particularly the cormorant. During our study, it was common to find no more than one or two of these fish-eating birds on the pond. More recently, it would not be uncommon to count more than 50 of them. This number of cormorants eats a large number of fish each day. If they are feeding in the pond, their predation on young winter flounder could be significant.

To date, the only proof we have of a decline in the number of winter flounder in the ponds is the decline in the catch of the coastal pond commercial fishermen. The reduction in catch-per-unit-of-effort is a good indication of diminished abundance. Even without broader-based indicators, there is general agreement that there is a problem with the number of flounder in the ponds and that measures taken to change the situation have not had an appreciable effect.

It has been suggested that a 12-inch minimum length regulation is necessary in order to give a larger proportion of the spawning population an opportunity to reproduce before becoming vulnerable to the fishery. Although this might be effective, a large increase in minimum length (one inch is considered a large incremental increase) is usually unpopular within a fishery because of the immediate decrease in the availability of legal-size fish in the population. In this case, the fishery might have to wait about one year for the 11-inch fish to grow an inch and become legal size again. A compromise would be to proceed in smaller size increments in order to minimize the economic impact of fishery management. So, while a larger minimum size may be in the future for Rhode Island's winter flounder fishery, it may take a while to reach the goal of the fishery managers.

A more immediate measure would be to exclude the fyke-net fishery from winter flounder spawning and nursery areas, such as Ninigret Pond. When this fishery was allowed to expand in 1982, Rhode Island's winter flounder landings were at their highest in many years. Because landings have declined steadily since then, it is time to reconsider the potentially devastating effects the efficient fyke nets can have on a fishery. To allow their continued use in our flounder spawning grounds during a period when commercial fishermen are going broke is shortsighted indeed.

SUMMARY AND RECOMMENDATIONS

Flounder enter Rhode Island's coastal ponds to spawn in the winter, a time of year when most other inhabitants of the ponds are inactive and competition is minimal. They lay eggs that sink, thus avoiding the ice that often covers their breeding grounds. In places such as upper Point Judith Pond, the chances of their planktonic larvae getting flushed out of the nursery estuarine system are minimal, and these regions support most coastal pond spawning activity. All of these behaviors are special adaptations that enhance the survival of progeny from a breeding season. These adaptations exploit characteristics of our coastal ponds. We must avoid deleteriously altering these characteristics if we are to ensure that our ponds thrive in their role as winter flounder spawning and nursery areas. Some specific points to consider in this regard are:

1. Two winter flounder spawning sites in Point Judith Pond and Ninigret Pond are in areas that are apparently hydrodynamically conservative, a characteristic which tends to increase estuarine larval retention time. Hydraulic modifications, such as dredging to facilitate navigation or to enhance flushing, may affect the larval retention characteristics of these and other estuaries and could diminish their quality as spawning and nursery habitat. Hydrodynamic conservation may occur in many coastal ponds, and any modification project must address potential impacts on the early life history of fish resources within these areas.

2. Within coastal ponds, there appear to be relatively discrete spawning areas, and flounder appear to return to the same spawning area year after year. These important areas need to be identified and must be protected. Eutrophication in these areas is also a major concern, because high summer temperatures and low concentrations of dissolved oxygen can stress not only young flounder but also their food resources.

3. Scallop dredging should not be allowed during the winter flounder spawning season, since winter flounder deposit their eggs in localized areas and dredging in these locations is likely to destroy spawning habitat and resources when eggs are present.

4. Although we did not find evidence during the time of our observations that typical Ninigret Pond commercial landings constituted a much greater proportion of the total harvest of flounder than the recreational landings, this may no longer be the case. The introduction of fyke-netting in that pond may have increased commercial landings.

Our observations of the limited movements of flounder within coastal ponds suggest that it may be possible to temporarily remove a large portion of flounder from a given area of a pond if sufficient fishing effort is applied. If these fish had been supporting a locally popular recreational fishery, then their removal could cause a short-term negative impact until flounder from other areas move into the habitat. A more serious long-term consequence would result if sufficient fish were removed by the fisheries to significantly reduce the size of the spawning stock so that the reproductive potential of the resource was diminished.

5. Because winter flounder landings in the 1980s have consisted primarily of fish from the 1978 year class, the landings of winter flounder have steadily decreased as the numbers remaining of that year class have decreased. Management efforts to protect spawning stock should be encouraged. Accordingly, fyke-netting should not be allowed in winter flounder spawning and nursery habitat, such as coastal ponds. Also, coastal pond flounder fisheries and landings should be more closely monitored than they have been in the past, and a record of trends should be established to help formulate future management decisions.

6. Finally, before further attempts at assessing the abundance of winter flounder in coastal ponds are made, the patterns of distribution of the groups of these fish in the ponds should be determined. Fish caught, marked, and released in an area tend to stay in the vicinity rather than mixing with fish throughout the pond. A population assessment made in only one area of the pond results in an assessment of only the group of flounder occupying that area. Such is the case with our assessments in Ninigret and Point Judith ponds. In order to assess the entire winter flounder population within a coastal pond, it is necessary to establish whether individual groups are present; if so, they must be assessed separately.

CONCLUSION

A winter flounder that a fisherman catches at his favorite flatfish hole is there as part of a complex life cycle with definite patterns and behaviors similar to the instincts that cause salmon to return to their home streams to spawn. An awareness of this instinct in winter flounder provides a strong impetus for thoroughly examining potential effects of alterations to our coastal ponds in the name of "development."

As we have shown, the consequences of dredging new navigation channels, for example, might have a serious impact on the role of a pond as a hatchery. In the past, such changes were made with little regard or understanding of the part our coastal ponds play in the maintenance of our exploitable resources.

Now that we are becoming increasingly aware of the limited nature of these resources, we must be vigilant to preserve what nature has so abundantly provided. The lesson of the Wickford flounder hatchery should not be forgotten: The natural bounty of our coastal ponds is not easily replaced.

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APPENDIX

Listed below are seventy-six species of fish that have been found within Rhode Island's coastal ponds during some stage of their life cycle. This list was compiled from Bigelow and Schroeder (1953), Gordon (1960), and Stolgitis et al. (1976).

Odontaspis taurus - Sand tiger shark
Mustelus canis - Smooth dogfish
Anguilla rostrata - American eel
Alosa aestivalis - Blueback herring
Alosa pseudoharengus - Alewife
Brevootia tyrannus - Atlantic menhaden
Clupea harengus harengus - Atlantic herring
Sardinella anchovia - Spanish sardine
Anchoa mitchilli - Bay anchovy
Osmerus mordax - American smelt
Opsanus tau - Oyster toadfish
Enchelyopus cimbrius - Four-bearded rockling
Gadus morhua - Atlantic cod
Microgadus tomcod - Tomcod
Pollachius virens - Pollock
Urophycis chuss - Red hake
Urophycis tenuis - White hake
Strongylura marina - Atlantic needlefish
Cyprinodon variegatus - Sheepshead minnow
Fundulus heteroclitus- Mummichog
Fundulus majalis - Striped killifish
Menidia beryllina - Tidewater silverside
Menidia menidia - Atlantic silverside
Apeltes quadracus - Four-spined stickleback
Gasterosteus aculeatus - Three-spined stickleback
Gasterosteus wheatlandi - Blackspotted stickleback
Pungitius pungitius - Nine-spined stickleback
Fistularia tabacaria - Bluespotted coronetfish
Hippocampus hudsonius - Sea horse
Syngnathus fuscus - Northern pipefish
Morone americana - White perch
Morone saxatilis - Striped bass
Centropristis striata - Black sea bass
Lepomis macrochirus - Bluegill sunfish
Pristigenys alta - Short big-eye
Pomatomus saltatrix - Bluefish
Caranx crysos - Blue runner
Caranx hippos - Crevalle jack
Naucrates ductor - Pilotfish
Selar crumenophthalmus - Big-eye scad
Selene vomer - Lookdown
Seriola zonata - Banded rudderfish
Trachurus lathami - Rough scad
Archosargus probatocephalus - Sheepshead
Stenotomus chrysops - Scup
Bairdiella chrysura - Silver perch
Cynoscion regalis - Squeteague (weakfish)
Leiostomus xanthurus - Spot
Menticirrhus saxatilis - Northern kingfish
Mullus auratus - Red goatfish
Chaetodon ocellatus - Spotfin butterflyfish
Tautoga onitis - Tautog
Tautogolabrus adspersus - Cunner
Mugil cephalus - Striped mullet
Mugil curema - Silver mullet
Sphyraena borealis - Northern sennet
Ammodytes americanus - Sand lance
Pholis gunnellus - Rock gunnel
Gobiosoma bosci - Naked goby
Gobiosoma ginsburgi - Seaboard goby
Scomber scombrus - Atlantic mackerel
Peprilus triacanthus - Butterfish
Prionotus carolinus - Northern sea robin
Prionotus evolans - Striped sea robin
Myoxocephalus aenaeus - Grubby
Myoxocephalus octodecimspinosus - Longhorn sculpin
Cyclopterus lumpus - Lumpfish
Dactylopterus volitans - Flying gurnard
Paralichthys dentatus - Summer flounder
Scophthalmus aquosus - Windowpane
Pseudopleuronectes americanus - Winter flounder
Trinectes maculatus - Hogchoker
Alutera schoepfii - Orange filefish
Balistes capriscus— Grey triggerfish
Monacanthus hispidus - Planehead filefish
Sphoeroides maculatus - Northern puffer