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COASTAL RESOURCES MANAGEMENT COUNCIL

Aquaculture in Rhode Island

2006 Yearly Status Report

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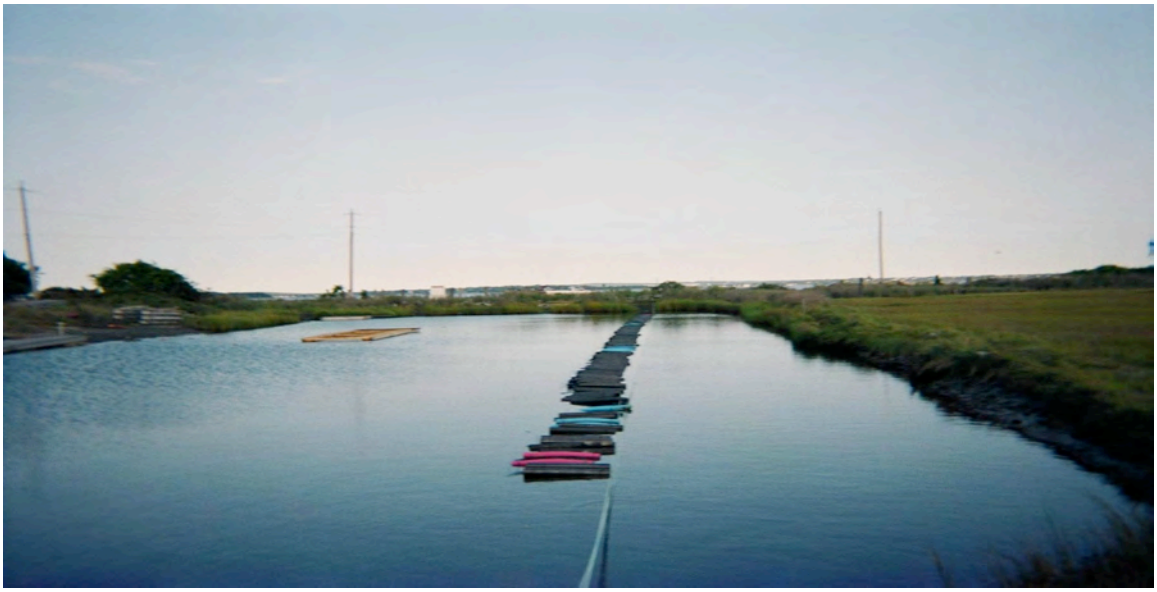

Photo Credits.
Front cover; Perry Raso, president of the OSAA, teaching students about aquaculture as part of a RIAI funded education grant. Photo courtesy of Mr. Raso.
This page: Oyster floats at sunset in the Blount Oyster Pond on Prudence Island. Funding by Ocean Trust Foundation and the national Fisheries Institute. Photo courtesy of Dr. Tim Scott, Roger Williams University.

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A snapshot of the Aquaculture Industry in Rhode Island

For the year 2006

- The 2006 farm gate value of Rhode Island aquaculture products rose an amazing 81%.
- This is the ninth double digit increase in the past 11 years.
- For the first time the total value of Rhode Island aquaculture exceeded 1 million dollars.
- The value of Rhode Island aquaculture per acre is an amazing $13,621.
- The number of farms in Rhode Island increased by three to 28.
- The total acreage under cultivation in Rhode Island rose to 99 acres.
- Aquaculture related industries in Rhode Island had gross revenue of $3.5 million dollars during the calendar year 2006.
- Regulatory agencies charged with responsibility for aquaculture continued to make progress in streamlining the permitting process.
- Regulatory agencies continued to involve stakeholders in the planning and regulation of aquaculture during the year 2006.
- The Rhode Island Aquaculture Initiative continued to make investments for the future of RI aquaculture.
- The first oyster aquaculture granted in Rhode Island was in 1798.
- Rhode Island's first aquaculture legislation was passed in 1844.

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Special Section:

Introduction

The year 2006 saw extraordinary growth of the Rhode Island Aquaculture industry. The farmgate value (the value for the product paid to the farmer) of the industry grew by a bit more than 81 percent. Aquaculture in Rhode Island continues to be a very dynamic, albeit small, and fast growing industry. It is interesting to note the increase in productivity per acre as this year's large increase in production (81 percent) was accomplished with a small increase, 16 percent in total area under lease. The American oyster was the predominate species of shellfish grown accounting for 97 percent of the total harvest. The hard clam being the only other species cultivated in any numbers making up 3 percent of the total harvest. The amount of oysters harvested increased 54 percent from the previous year. Clams production saw an increase of 158 percent compared to 2005. For the seventh consecutive year 100 percent of all Rhode Island-grown aquaculture products were shellfish. The number of farms under lease increased from 25 to 28, a 12 percent increase. The acreage under lease increased to from 85 acres to 99, a 16 percent increase.

The Rhode Island Aquaculture Initiative, established in 2002, continues to provide an investment in the future growth of the industry in Rhode Island. Competitions for research grants and mini-grants for growers were held with the best grants receiving funding. Two aquaculture extension positions that were funded in partnership with Roger Williams University and the University of Rhode Island provide very real benefits to the industry and to prospective participants. This initiative has been successful in helping the industry build infrastructure for continued growth.

Research at the universities continued to be an important part of aquaculture in Rhode Island. Excluding the money from the Rhode Island Aquaculture Initiative, the universities bring in outside grants and tuition for students studying aquaculture related subjects.

How the figures were derived

Harvest figures came from the yearly Rhode Island Coastal Resources Management Council (CRMC) aquaculture questionnaire distributed to all lease holders. All reports are taken as an accurate value value. Monetary figures for this report were calculated by averaging an estimated yearly average price from multiple sources. This figure was then multiplied by the numbers reported by growers in the yearly CRMC report to arrive at the figures used in this report. Figures from the aquaculture-associated industries came from the principals involved in these privately held companies. The figures cited are for gross sales of aquaculture-related products. The universities supplied their own statistics.

Farm Production

The farmgate value of Rhode Island-grown shellfish, in 2006, increased 81 percent from the previous year's growth rate of 30 percent. This increase shows a large jump from the average of the last 11 years of 30 percent (see Table 1 and Graph 5). In fact this is the largest percent increase in 11 years. The 2006 farmgate value is estimated to be $1,348,525, up from $744,319 in 2005, $572,994 in 2004, $563,891 in 2003 and $478,160 in 2002 (see Graph 1).

One hundred percent of all Rhode Island aquaculture production was shellfish in 2006. The dominant species was the American oyster, with 2,357,736 pieces being sold (see Graph 2). This is a 154 percent increase from the previous year, which resulted in an 181percent increase (see Graph 3) in value in oyster production. Clam production was up significantly with an extraordinary 258 percent increase in harvest (see Graph 2) which resulted in a 258 percent increase in value to $16,055 (see Graph 3).

The number of farms active in Rhode Island aquaculture increased in 2006 to 28 active farms, a result of three new farms joining the ranks. This led to an increase in acreage under cultivation to 99 acres (see Graph 4). The production per acre of aquaculture in Rhode Island was $13,621, a large increase from $8,757 in 2005 and from the $8,185 per acre value for 2004.

Farm-related employment increased slightly. In 2006 there were 17 full-time, year-round and 17 part-time, year-round seasonal employees in the industry. Employment increased slightly during the summer with Rhode Island aquaculture farms hiring 8 full-time seasonal and 15 part-time seasonal workers.

In 2003 the CRMC began polling farmers as to how much they invested in their farms. The reports indicate that growers are investing significant capitol; in 2006 growers invested a total industry wide figure of $886,288. This compares to $852,500 invested in 2005. This is in comparison to $377,472 in 2004 and $271,000 in 2003. In 2006 investments averaged $31,699 per lease holder. Farm returns averaged $13,621 per acre.

Table 1

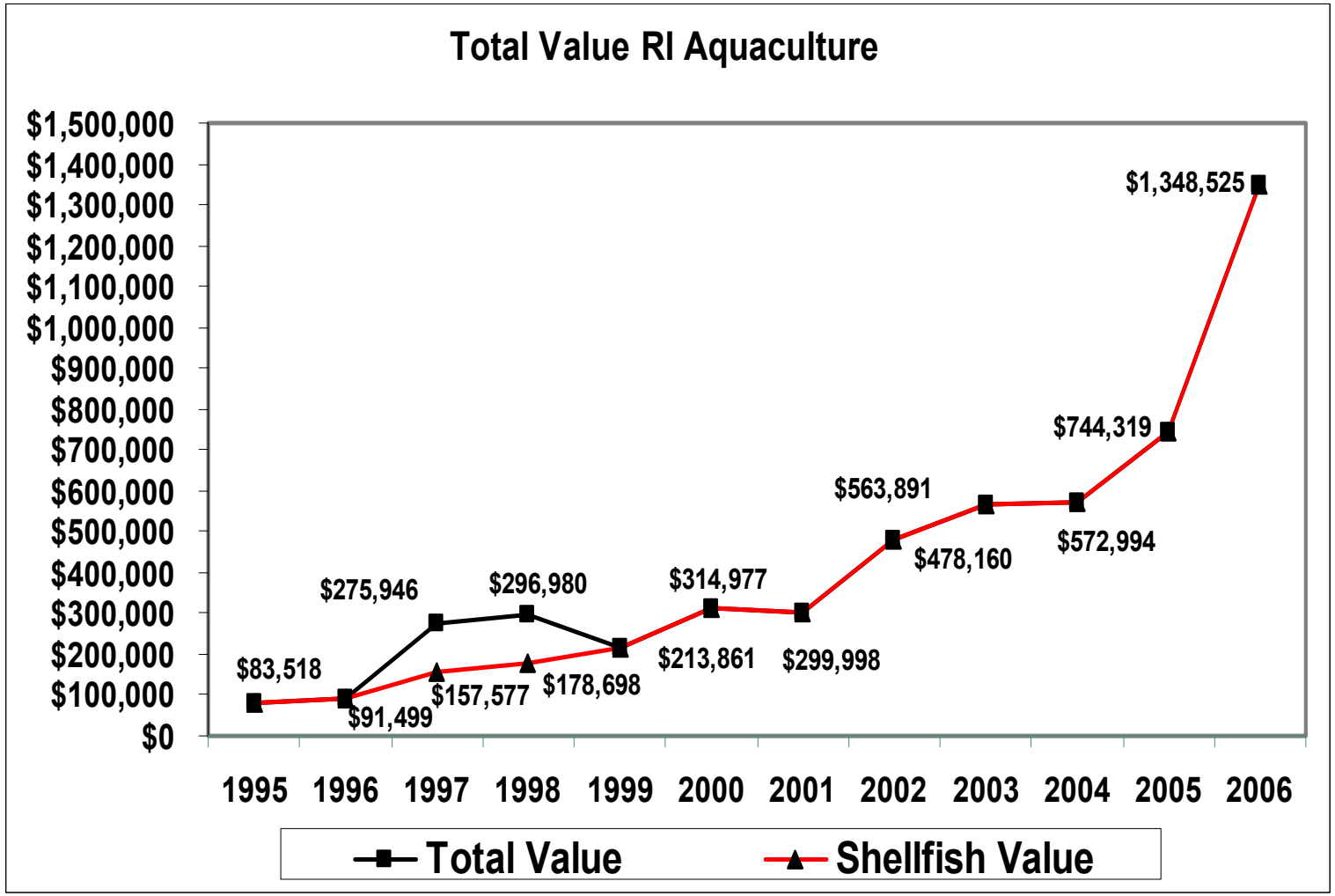
Year	Percent Change in Farmgate Value from Previous Year
1995-1996	9.6%
1996-1997	72%
1997-1998	13%
1998-1999	20%
1999-2000	47%
2000-2001	-4.7%
2001-2002	59%
2002-2003	16.5%
2003-2004	1.6%
2004-2005	29.9%
2005-2006	81.2%

Table 1 shows the percent change of the farmgate value of aquaculture shellfish production in Rhode Island. See Graph 1 for overall production value figures.

Table 2

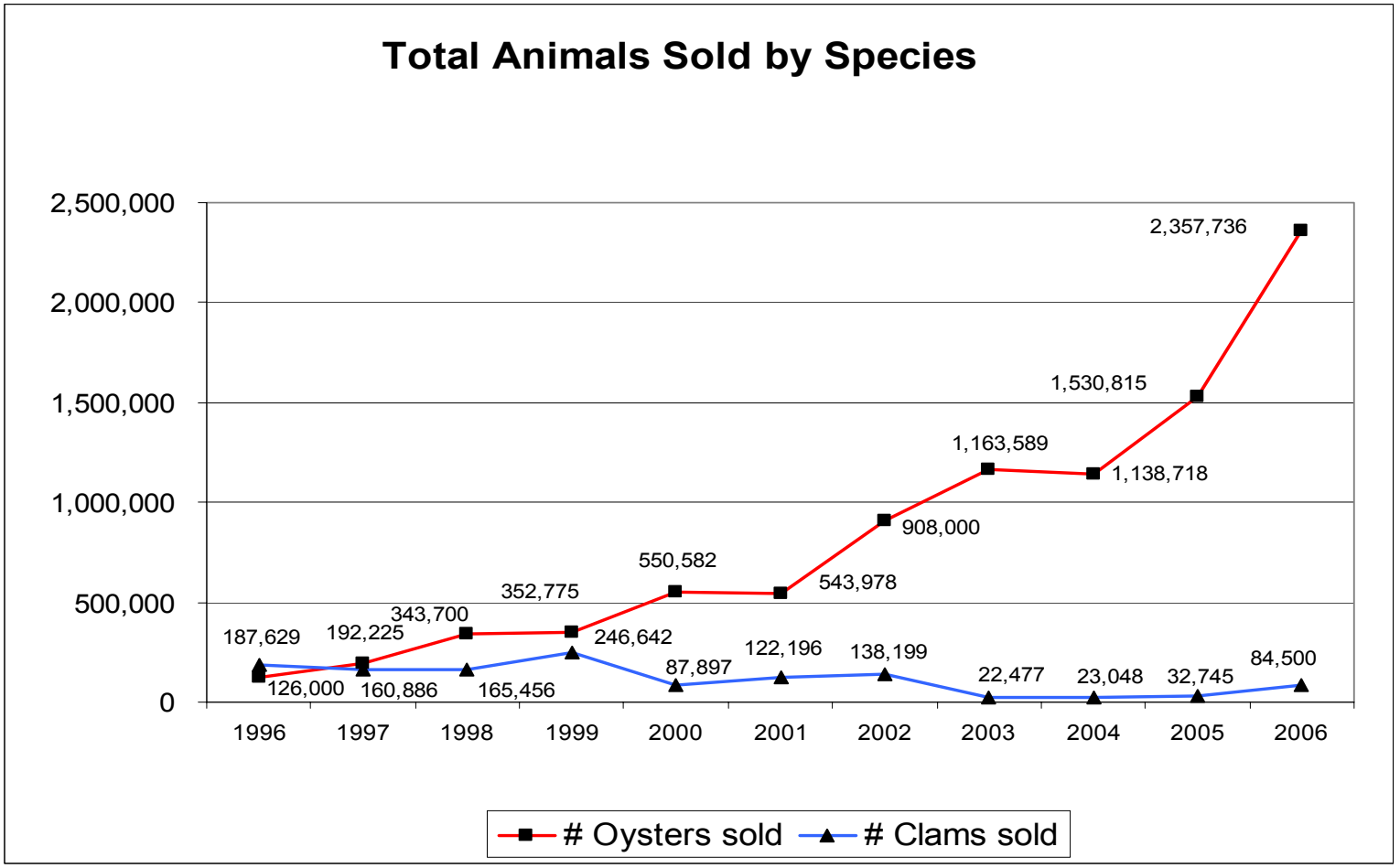
Year	Percent Change in Farmgate Production from Previous Year
1996-1997	52.6%
1997-1998	78.8%
1998-1999	2.6%
1999-2000	56.1%
2000-2001	-1.2%
2001-2002	66.9%
2002-2003	28.1%
2003-2004	-2.1%
2004-2005	34.4%
2005-2006	64.0%

Table 2 shows the percentage change of the farmgate production numbers of aquaculture shellfish production in Rhode Island. See Graph 2 for overall production figures.



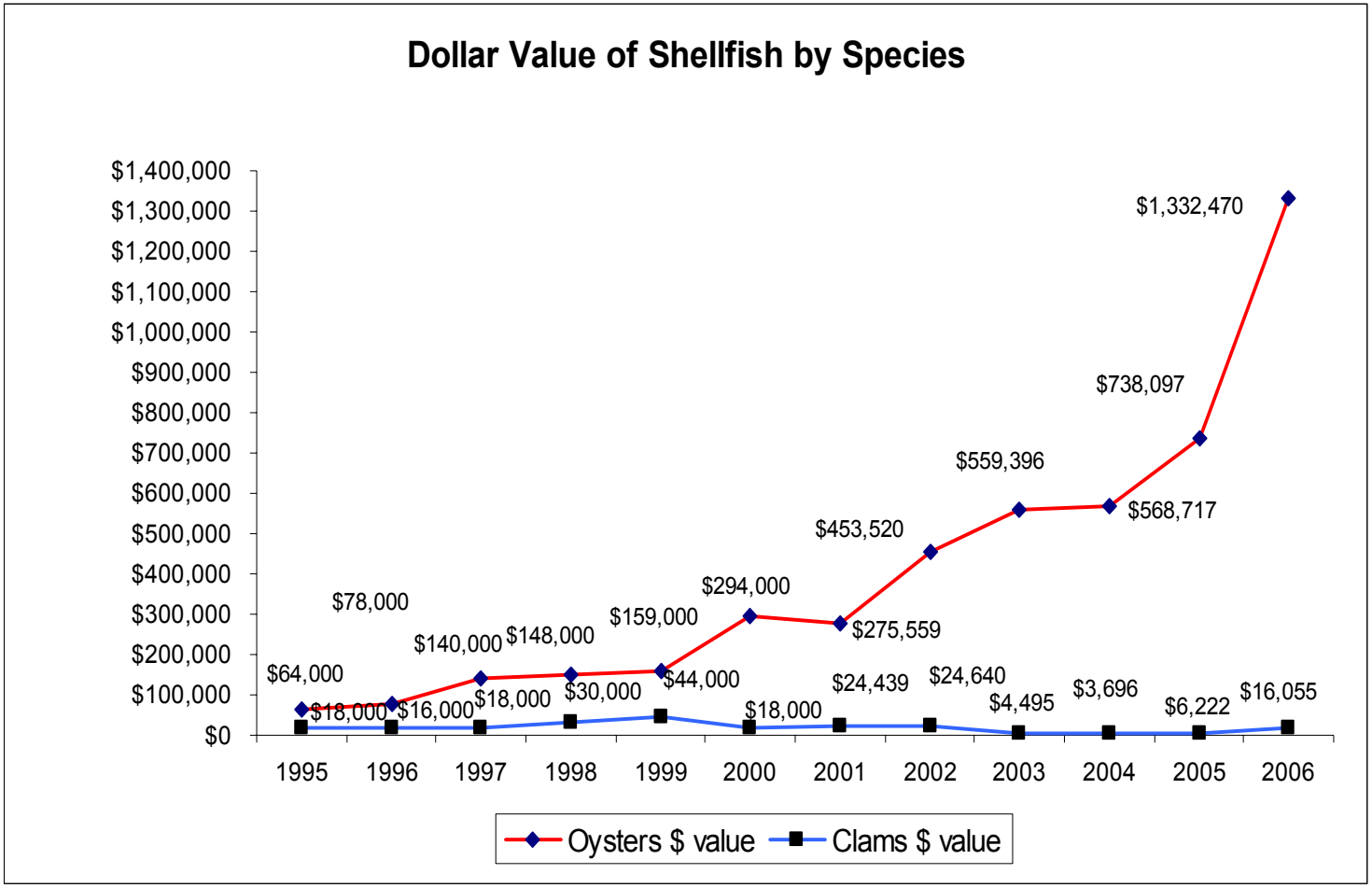
Graph 1

In 2006 total Rhode Island aquaculture production increased 81%. The total value indicated for the years 1997 and 1998 includes a retail ornamental finfish operation that was in business for those two years only. In all other years 100% of Rhode Island aquaculture production is in shellfish.



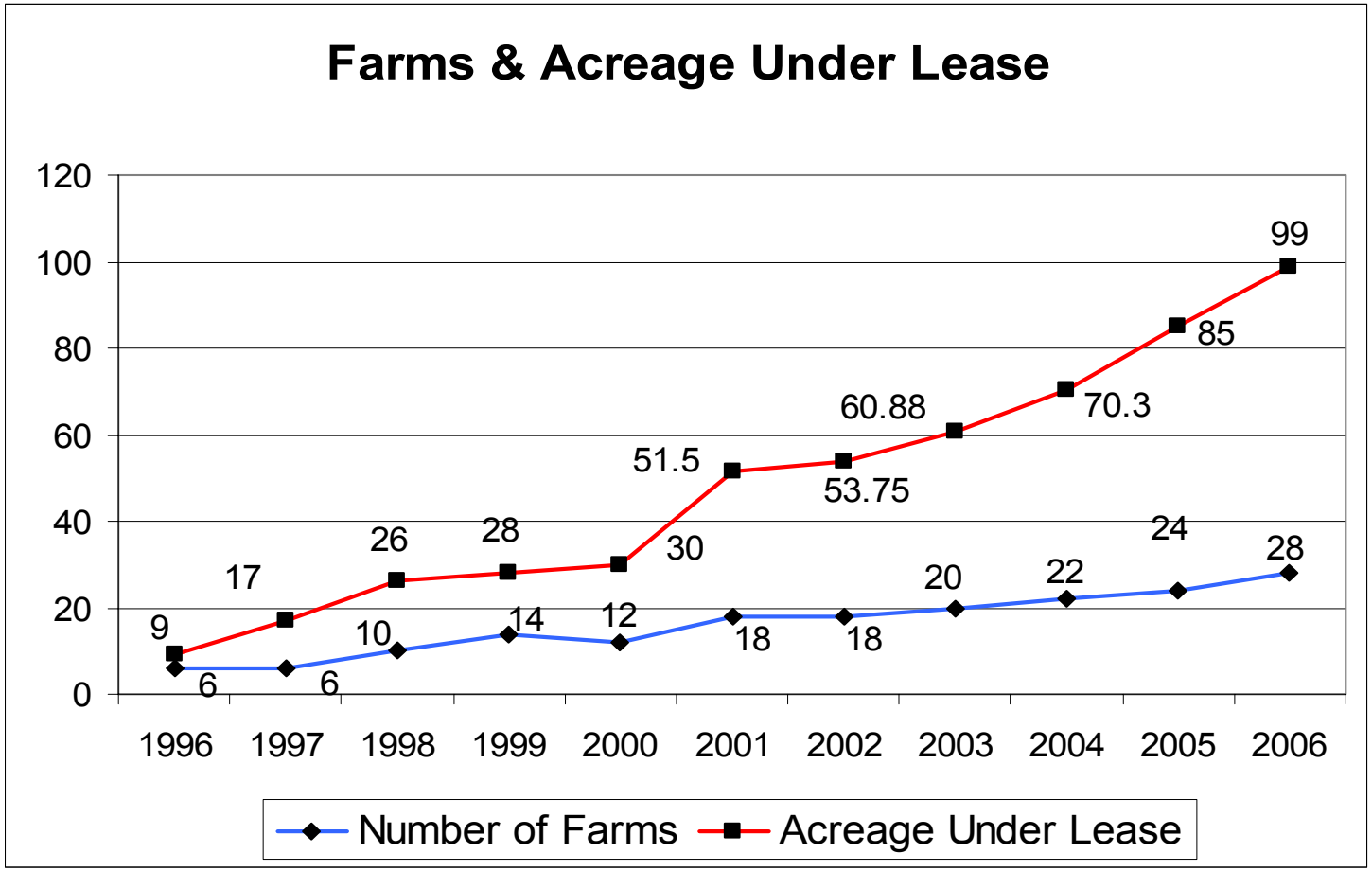
Graph 2

The American oyster is the dominant species cultured in Rhode Island waters. Oyster production accounted for 97% of the total Rhode Island aquaculture production. Growers reported 2,357,736 oysters sold in 2006, an incredible increase of 154% from 2005. The culture of quahogs has increased with approximately 84,500 being produced in 2006, an increase of 258% from 2005



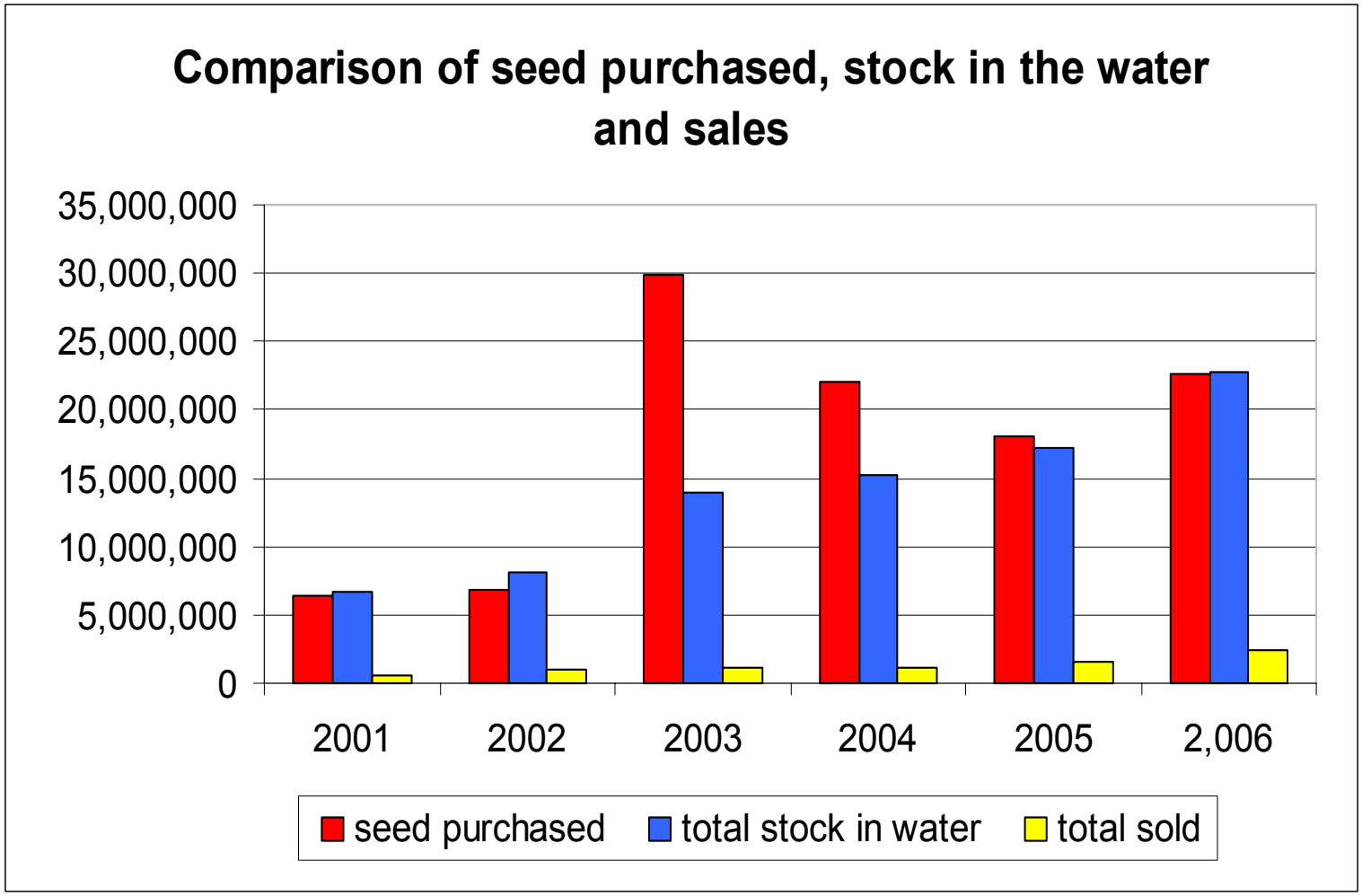
Graph 3

Graph 3 indicates the relative value of the shellfish production in Rhode Island for 2006.



Graph 4

Three new leases were established during 2006. Farm totals for 2006 are 99 acres under cultivation and 28 permit holders (not including commercial viability, educational and research permits).



Graph 5

This graph shows the relationship between seed bought in a single year, the number of animals in the water on aquaculture farms and the numbers of shellfish sold. This graph indicates possible future animals available for harvest in coming years. Mortality of 40-50% per year is not uncommon in the shellfish industry.

Aquaculture-Related Industries

The other aquaculture related industries in Rhode Island are the largest contributors to aquaculture's state and economic bottom line. These industries include distribution of aquaculture products (fish and shellfish), and the manufacturing of aquaculture products to be used on farms. There are a number of small privately held companies in the state that fit into this category. These companies produced a gross total of $3.5 million in business in the state. These companies employ 25 full-time employees, which did not change from 2005.

Not only do these companies serve local and regional farmers, but they also export internationally. The aquaculture-associated industries within Rhode Island have contributed to the economic well-being of the state. As the industry grows in Rhode Island, the nation and the world, this sector of the industry will continue to contribute economically.

The Universities

The State of Rhode Island is home to two universities that conduct aquaculture education and research-the University of Rhode Island and Roger Williams University. Each is recognized for quality education and research. This recognition results in grant monies flowing into the state in order to conduct aquaculture related research.

The universities continue to be centers of excellence in the field of aquaculture. The University of Rhode Island employs internationally-known and respected researchers in the field. Roger Williams University continues to compliment the efforts of URI in the aquaculture arena and is growing into a center of excellence on its own. Both universities contribute greatly to the state's economic bottom line and support a viable aquaculture industry.

The University of Rhode Island has professors that are recognized as world class in many fields of aquaculture research. The university is a great resource to the state and brings in research dollars, undergraduate and graduate students from around the world. We are fortunate to have Dr. David A. Bengtson, Chair of the Department of Fisheries, Animal and Veterinary Sciences, contribute the following description of the aquaculture research and projects that URI conducted in 2006.

Aquaculture Activities at the University of Rhode Island - 2006

David A. Bengtson
Department of Fisheries, Animal and Veterinary Science

The University of Rhode Island continued in 2006 to pursue its traditional mission of teaching, research, and service in the area of aquaculture. Once again, aquaculture activities were spread over many URI departments in the College of the Environment and Life Sciences: Fisheries, Animal and Veterinary Science (FAVS); Environmental and Natural Resource Economics (ENRE); Cell and Molecular Biology (CMB); Natural Resources Science (NRS); and Nutrition and Food Science (NFS); as well as in the Coastal Resources Center (CRC) at the Narragansett Bay Campus.

Teaching

URI offers a variety of aquaculture courses in its Aquaculture and Fisheries Technology major. In 2006, they included Introductory Aquaculture, Finfish Aquaculture, Crustacean Aquaculture, Shellfish Aquaculture, Salmonid Aquaculture, Diseases of Cultured Fish, Pathobiology, Advanced Aquaculture Systems, and Aquaculture and the Environment. In addition, undergraduate students take Special Projects courses to take advantage of research opportunities in aquaculture. At the graduate level, URI awarded two Master of Science degrees, one Master of Environmental Science and Management degree, and one Doctor of Philosophy degree to students who worked on aquaculture topics.

Research

Researchers at URI brought in over $600,000 in new funding for aquaculture research in 2006, in addition to existing funding for ongoing projects. A brief listing of projects follows; please note that each professor mentioned leads a group of graduate students, post-doctoral fellows, and/or undergraduate students in the conduct of the research project indicated.

New projects include:

Role of matrix metalloproteinases in immune defense: Dr. Marta Gomez-Chiarri (FAVS) will examine these molecules in relation to shellfish diseases.

Role of follistatin in the regulation of muscle growth: Dr. Terry Bradley (FAVS) will expand his previous research on myostatin in an effort to improve the growth of finfish in aquaculture.

Activation of virulence factors in Vibrio anguillarum: Dr. David Nelson (CMB) will expand his research on regulation of genes that control the virulence of this bacterium that infects finfish in aquaculture.

Existing projects include:

Investigation of disease-resistant strains of oysters for RI: Dr. Gomez-Chiarri and Dr. Dale Leavitt (Roger Williams University) continue this RIAI-funded research.
Investigation of pea crab infestations of mussels: Dr. Barry Costa-Pierce (FAVS) seeks a way to rid RI mussels of pea crabs to promote the possibility of development of a RI mussel industry.
Assessment of the value of aquaculture gear as fish habitat: Dr. Graham Forrester (NRS) completed this project, which demonstrated that oyster aquaculture gear is at least as valuable for fish habitat as is the natural habitat that they normally occupy, and is publishing the results in the Transactions of the American Fisheries Society.
Investigations of seafood markets and consumer choices for wild vs. farmed products: Drs. Jim Anderson and Cathy Roheim (ENRE) study world markets for both shrimp and salmon to identify trends in consumer choices, demand for eco-friendly products, and market supply-demand issues.
Plant proteins as replacement for fish meal: Drs. David Bengtson (FAVS) and Chong Lee (NFS) investigate the use of soybeans, corn, and canola to reduce the costs of diets for summer flounder and therefore overall production costs.
Environmental impacts of tuna culture: Dr. Costa-Pierce studies the cage culture of tuna off the coast of Mexico to improve it ecologically.
Aquaculture policy in the coastal zone of developing countries: The Coastal Resources Center works with scientists and policy makers in developing countries with U.S. AID funding to ensure that aquaculture there does not degrade the coastal zone.

Service

URI researchers provide outreach to those in industry or regulatory agencies as part of their work. A major effort during 2006 was assistance given to the USDA Natural Resources Conservation Service (see associated report by Andy Lipsky) in the implementation of their EQIP program for aquaculture farmers. This was a joint effort with Dale Leavitt (RWU) that included work by recent graduates Kate Rossi-Snook (RWU) and Kate Markey (URI) to monitor environmental conditions at oyster farms and to gauge amount of fouling material that is removed from oyster bags/cages. Dr. Gomez-Chiarri is monitoring the disease status of oysters at the various participating farms and the long-term goal is to try to relate disease incidence to environmental conditions
During 2006, Drs. Bengtson, Costa-Pierce and Dr. Richard Rhodes (URI) were elected to the Board of Directors of the Northeastern Regional Aquaculture Center by the Northeast Agricultural Experiment Station Directors, Northeast Regional Sea Grant Directors, and Northeast Extension Directors, respectively. In addition, Dr. Costa-Pierce was elected Vice-President of the World Aquaculture Society.

Roger Williams University has been investing in the future of Rhode Island aquaculture. This university is fast becoming a recognized center of excellence in the field, giving the state two universities active in aquaculture. We are fortunate to have the Director of the Roger Williams University Center for Economic and Environmental Development, Dr. Timothy M. Scott, provide this report with the following project summary for the activities conducted during 2006.

Roger Williams University
Center for Economic and Environmental Development (CEED)

Dr. Timothy M. Scott, CEED Director

Aquaculture research activity at Roger Williams University is conducted through the Center for Economic and Environmental Development (CEED). The mission of CEED is to promote economic development in an environmentally sustainable manner, and for the past several years this has included an active and innovative aquaculture research program. In addition, CEED supports the well-respected RWU Marine Biology Program by involving many of our undergraduate students in research intended to promote aquaculture development in the state. In 2006, these projects included:

■ **Shellfish Hatchery:** Most coastal states support commercial and/or municipal shellfish hatcheries for local production of shellfish seed. Since Rhode Island lacked this resource, CEED opened the state's only shellfish hatchery in 2004. Since then, the hatchery has produced millions of shellfish seed including quahogs, oysters, steamers and bay scallops. In 2006, this included a million clam seed planted into the bay in a continuing public benefit aquaculture project with the RI Shellfishermen's Association. In addition, over half a million young oysters were planted into a shellfish management area around Prudence Island. On-going projects that rely on our hatchery include:

- ■ Developing disease resistant oysters for Narragansett Bay;
- ■ Culturing alternative species (e.g., surf clams and razor clams);
- ■ Restoring shellfish at locations throughout Rhode Island;
- ■ Providing aquaculture extension and education opportunities;
- ■ Promoting the environmental services provided by shellfish cultivation.

■ **Oyster Gardening:** With funding from the RI Aquaculture Initiative, CEED instituted a pilot-scale oyster gardening project for Rhode Island. Eighteen waterfront landowners from around the state volunteered to became oyster gardeners. Young oysters, called spat, were reared in the CEED hatchery and set onto shell. Each oyster garden consisted of a floating raft that contained roughly 10,000 young oysters. The volunteers placed these

rafts at available docks or moorings and maintained the rafts as the oysters grew over the summer. In the fall, all of the oysters were collected by CEED Staff and planted at the restoration site on Prudence Island. This program provides nursery sites for oyster growth, but also offers abundant opportunities to educate the public about the shellfish aquaculture and harvest industry and the positive environmental benefit of a healthy shellfish population.

■ **Tropical Fish Breeding:** An on-going study in which CEED Staff conduct a variety of research projects (e.g., larval rearing techniques; food quality studies) while investigating the potential for the development of a local tropical fish production facility. Preliminary studies suggest that the added cost of local production is offset by a decrease in mortality associated with shipping as the Northeast is the largest US market for these products. In addition, many tropical fish destined for the aquarium trade are harvested from live coral reefs using harmful techniques. By developing hatchery protocols for many of these fish, and working to restore endangered species, this effort will promote the conservation of these species.

■ **Large Mouth Bass Production:** This pilot project funded by the RIAI, is attempting to introduce a freshwater fee fishing industry to existing farm ponds in Rhode Island. Three farmers have agreed to participate in this trial phase where large mouth bass are obtained from a hatchery, held in the CEED wet lab facilities prior to a grow-out phase at participating farms. Once of sufficient size, these fish will be stocked in ponds to establish a fee fishing operation. This is intended to diversify and enhance small farm production in the state.

■ **Additional Projects in 2006 included:**

- Administration of Grant Programs funded by the RI Aquaculture Initiative
- Hydroponics Demonstration Facility
- Conversion of Cranberry Bogs to Fish Production

RI-OGRE Update

Oyster Gardening has arrived in Rhode Island! In the spring of 2006, Roger Williams University and the Rhode Island Aquaculture Initiative, administered through the RI-CRMC, proposed to develop, implement and evaluate a Rhode Island Oyster Gardening Program to test the merit of utilizing public participation in statewide oyster restoration efforts. The Rhode Island Oyster Gardening for Restoration and Enhancement (RI-OGRE) Program provides

a multitude of benefits to the state and to the mission of the Rhode Island Aquaculture Initiative. These include assisting in the oyster restoration program currently underway in Narragansett Bay, expanding an awareness of the role that shellfish play in coastal marine systems to enhance the environmental understanding in an important sector of our state residents, and developing a deeper appreciation of the role that shellfish aquaculture might play in the maintenance and improvement of our coastal ecosystems.

Oyster gardening is a popular tool to aid in local oyster restoration efforts while simultaneously educating the public about the benefits of a healthy oyster population in local waters. Having originated in the Chesapeake Bay region in the early 1990's, the concept of oyster gardening is centered on the volunteer efforts of coastal landowners in rearing juvenile oysters to be utilized in endeavors to restore oysters to their former level of production in the bays. The RI program is designed to raise juvenile oysters in waters adjacent to volunteer coastal landowners along the shores of Narragansett Bay and the Rhode Island coastal ponds. The oysters will be used in an ongoing and expanded oyster restoration program.

Volunteer OGRE's received several thousand young oysters to grow from their docks or shoreline in wire cages or floating bags. With local community members raising juvenile oysters bred in the RWU Shellfish Hatchery from native broodstock, state shellfish specialists involved with this program hope to raise community awareness on the importance of utilizing oyster beds as a means of filtering large quantities of seawater while supplying oysters for restoration in local waters. Oyster feeding behavior leads to decreased nitrogen levels in the state's waters and increased water clarity necessary for aquatic vegetation to thrive. In addition, once the restored oysters have matured within designed restoration areas, the Rhode Island shellfishing community can anticipate increased oyster availability as they reproduce naturally.

During the summer of 2006, the RI-OGRE Program accepted 18 volunteer landowners to participate, all of whom have land adjacent to waters classified as open for shellfish harvesting. Each landowner received a floating cage for holding the oysters and, in July, six bags of oyster cultch with attached oyster spat produced in the RWU shellfish hatchery. In total, each gardener received about 1,500 small (1-2mm) oysters to rear. Following a summer of good growth, the OGRE oysters returned to the restoration program from the landowners had grown to about 25mm (1-inch) or more and were planted at two oyster restoration sites in Narragansett Bay. In total, about 25,000 OGRE oysters were planted in the pilot year for this program.

What does the future hold for RI-OGRE's? For 2007, plans are underway to expand the program to 50 or more landowners, to increase the number of oysters being reared to one-half million and to expand into a third oyster restoration area in Narragansett Bay. In the meantime, our currently restored bay oysters are being watched carefully to determine the best strategies for planting in order to assure that oysters will once again flourish in Narragansett Bay and the coastal ponds.

Rhode Island Shellfisherman's Association

One of the newest developments in Rhode Island aquaculture is the participation of traditional fishing groups. The Rhode Island Shellfisherman's Association has been particularly active in using aquaculture to enhance populations of shellfish in Narragansett Bay. Mr. Michael McGiveney, president of the association, was gracious enough to provide the following description of their activities.

Rhode Island Shellfisherman's Association (RISA)

Michael McGiveney, President

The Association continued a cooperative venture of growing shellfish in upwellers for public enhancement. This effort, using funding from the Rhode Island Aquaculture Initiative, involved RISA working with Roger Williams University, CRMC, DEM, RI Sea Grant and Save The Bay to begin using aquaculture technology to grow clam seed to a predator proof-size, where they can safely be transplanted into public waters.

Our public enhancement project planted 500,000 seed in Green's River this yr with the help of Dr. Dale Leavitt and Roger Williams University.

Currently the association is operating two upwellers in Warwick Cove and another this year at Save The Bay's headquarters using seed from Roger Williams University. We would like to thank Owen Kelly for all of his hard work in keeping the upwellers running in the past. This year Steve DiPetrillo will be finding out first hand how much work this can be. We are looking for continued success in this project that will benefit all resource users.

RISA received a $5,000 grant from the Narragansett Bay Commission toward this project and hope to secure more funding from DEM. We also plan on working with Roger Williams University on shelling and oyster repopulation of Narragansett Bay.

The involvement of the commercial fishermen using aquaculture technology to enhance a public resource is an important step in incorporating traditional harvesters into the aquaculture community.

RISA is now working on another project involving shellfish upwellers combined with an educational component and is working with Save The Bay.

RISA remain committed to working with CRMC on properly locating future leases in the Bay and ponds to reduce conflict among user groups.

United States Department of Agriculture

We are fortunate to have a report this year from the USDA Rhode Island Natural Resources Conservation Service office in Warwick. The local USDA office has been working with the aquaculture industry in Rhode Island and produced the following progress report. We are fortunate to have Mr. Andy Lipsky provide the following. We are fortunate to have Andy Lipsky provide the following report.

Rhode Island Natural Resources Conservation Service

Putting the Farm Bill to Work Underwater—*Adapting the nation's largest conservation cost-share program to meet the needs of the aquaculture industry in Southern New England.*

Assistance to aquaculture growers, including shellfish farms, was authorized through the 2002 Farm Bill in the Environmental Quality Incentives Program (EQIP) final rule, stating "Livestock means animals produced for food or fiber such as dairy cattle, beef cattle, poultry, turkeys, swine, sheep, horses, fish and other animals raised by aquaculture." With over 1 billion dollars in 2007, EQIP is one of our nation's largest conservation cost share programs.

Through the EQIP program, agricultural producers may voluntarily apply to the program to help them improve environmental quality in concert with agricultural production on their farms. In 2006, The Rhode Island office of the USDA Natural Resource Conservation Service (NRCS) opened its EQIP Program for the first time to aquaculturists in the state.

RI-NRCS's EQIP Shellfish Management program builds upon the highly successful Massachusetts EQIP pilot project on Cape Cod; which made cost-share assistance available to shellfish farms in 2005. NRCS in partnership with Roger Williams University & the University of Rhode Island adapted the Massachusetts program to fit the unique resource conditions and industry technology in Rhode Island waters. For the RI

EQIP program, funding is provided to assist growers to achieve higher levels of environmental stewardship. This is done by providing cost incentives to a) protect water quality by controlling oil and gasoline emissions from outboard motors and biofouling residue discharges from cage culture wash operations; b) protect endangered species through gear management, and c) improve the health of wild and farmed shellfish populations through record keeping and disease monitoring.

In 2006 NRCS funded 40% (11 growers) of all Rhode Island shellfish farms for a total of $290,000 in financial assistance. RI NRCS is currently in the process of ranking and reviewing EQIP applications for 2007 funding. The program received a total of eight applications from shellfish farmers in Rhode Island, with four applicants who were currently not enrolled in the 2006 EQIP sign up. Total requested funding for shellfish farmers for 2007 now under consideration is $180,000. If this years' new growers are awarded funding, the EQIP program will have a bit more than 50% of all Rhode Island shellfish farmers enrolled in cost share conservation programs.

All of the shellfish farmers involved in the EQIP program are now implementing Shellfish Aquaculture Conservation Management Plans that include best practices and incentives for Gear Waste Disposal, Outboard Engines, Fuel/Oil spill prevention, Gear cycling, Record Keeping for disease management and environmental monitoring, and Lease delineation and demarcation. Some of these contracts and 2007 applications also include other types of conservation treatment systems to fully address resource concerns, such as processing biofouling residues in a waste transfer facility.

Rhode Island Sea Grant

Rhode Island Sea Grant has been very active in promoting aquaculture in Rhode Island. We are fortunate to have the following contributed by the executive director, Dr. Barry Costa-Pierce.

Rhode Island Sea Grant (RISG) Aquaculture Engagements, 2006

Dr. Barry Costa-Pierce., Executive Director

In cooperation with the Rhode Island Coastal Resources Management Council, the Rhode Island Sea Grant College Program has administered the approximately $1.4 million Rhode Island Aquaculture Initiative. Major elements of that administration during 2006 have been:

- Continuing oversight of research awards as they wind down towards completion. The total award program is slated for closure 30 September, 2007. A final/completion report to NOAA will be developed and submitted by 30 November, 2007, ending RISG administration and management responsibilities.
- Input and collaboration with RIAI Executive Committee members in developing final project activities and functions. Two final projects were decided upon for funding:
- Oyster Gardening Initiative; Dale Leavitt at Roger Williams University;
- Experimental Mussel Culture; John King at University of Rhode Island Graduate School of Oceanography.
- 41°N issue dedicated to the Rhode Island Aquaculture Initiative

Other RISG efforts in aquaculture during 2006 have been:

- Sponsorship of the 2006 NACE event held in Mystic, CT.
- Continuing management of the Husbandry & Management Section of the international journal Aquaculture (Elsevier Press, Amsterdam, The Netherlands). RISG processed ~500 international, scientific manuscripts for Aquaculture in 2006.
- Development of a new Rhode Island Sea Grant Fellow in Aquaculture Journal Management position to provide graduate students with a focus in the field of aquaculture the opportunity to assist in the management of the leading scientific journal in the field. The initial Fellow is Ms. Kendall Gadomski; MS Candidate, URI Fisheries & Aquaculture.
- Rhode Island Sea Grant continues is support of an in formational web site for POI (Partnership in Ocean Instrumentation, which has a focus area in Fisheries & Aquaculture.
- Dr. Costa-Pierce is supervising a URI Master's Student who is researching the effects of pea crabs on blue mussels and how that affects aquaculture production possibilities in RI waters.
- Rhode Island Sea Grant hosted an international workshop for the World Wildlife Fund to develop a White Paper on the Impacts of Nutrients from Salmon Aquaculture on Water Column Ecosystems. A presentation of findings from the workshop/white paper has been presented by Dr. B.A. Costa-Pierce at the World Aquaculture Society conference in San Antonio, TX in February 2007.
- As part of the Sustainable Seafood forum, Dr. Costa-Pierce attended

the Boston Seafood Show and presented a paper on Sustainable Shrimp.
- Dr. Costa-Pierce taught AFS426 "Ecological Aquaculture" at URI FAVS in the spring semester 2007.

The Rhode Island Aquaculture Initiative

In November 2001, at the 2nd Southern New England Aquaculture Conference it was announced that $1.5 million, secured through the efforts of Senator Jack Reed, had been appropriated for planning and advancement of aquaculture in Rhode Island. The project has been named the "Rhode Island Aquaculture Initiative." During 2002 a memorandum of understanding was reached with Rhode Island Sea Grant, Roger Williams University and the University of Rhode Island to oversee the day-to-day management of the grant. A multi-institutional executive committee comprised of Rhode Island state, university, industry, and other aquaculture leaders was formulated to determine priorities for projects to be funded with the $1.5 million that Senator Jack Reed obtained for aquaculture development in Rhode Island. Funds are routed from the National Oceanic and Atmospheric Administration (NOAA) Office of Oceanic and Atmospheric Research to the Rhode Island Sea Grant College Program at the University of Rhode Island (URI) and managed by David Alves, Coastal Resources Management Council (CRMC) state aquaculture initiative coordinator, assisted by Barry Costa-Pierce, Rhode Island Sea Grant director, and Ames Colt, Rhode Island Sea Grant associate director. Rhode Island Sea Grant reports to the NOAA-Sea Grant Project Manager, Jim McVey, in Washington, DC. CRMC has signed a memorandum of understanding with Rhode Island Sea Grant, the University of Rhode Island, and Roger Williams University to manage this project.

RI Sea Grant has built and hosted a web page to encourage all who might be interested to keep abreast of the developments with the initiative. The address is:
http://www.crmc.state.ri.us/riai/

Ocean State Aquaculture Association

Rhode Island is fortunate to be one of the few states in the region with an active aquaculture association. The Ocean State Aquaculture Association President, Perry Raso, provided the CRMC with the following State of the Farm report.

Ocean State Aquaculture Association
Perry Raso, President

The Ocean State Aquaculture Association took part in the 2006 International Boston Seafood Show as a group with funds from the Reed Aquaculture Initiative. The show

exposed Rhode Island grown product to customers in the northeast region and across nation. The show was followed by record production and sales of oysters for OSAA members as a group as new growers began producing and selling volumes of oysters and existing growers increased production as well.
Several growers benefited from taking part in the USDA EQUIP programs which assisted growers in making their farm more environmentally sustainable. USDA also assisted growers in an environmental monitoring program which will help growers to identify seasonal patterns on their farm.

The East Coast Shellfish Grower's Association

We are fortunate to have Dr. Robert Rheault, the president of the east Coast grower's Association provide this contribution on the ECSGA activities.

The East Coast Shellfish Growers Association is a non-profit corporation chartered in 2002 to promote responsible commercial shellfish aquaculture by:

- Improving public relations by providing accurate information for media and the public,
- Participating in policy formation at the state and national levels,
- Advising federal funding agencies on the research needs of the industry,
- Conducting market research and promotion

The East Coast Shellfish Grower's Association

Dr. Robert Rheault, President

Report from the ECSGA

As I write this, several members of the ECSGA are poised to make a fourth annual lobbying trip to DC. Again we will join with our Gulf and West Coast industry partners for a week of discussions with our Congressional delegates and with Federal agencies on issues important to the shellfish industry.

Our trip is coordinated and facilitated by the National Fisheries Institute. They help us focus our national agenda and organize dozens of meetings for us ensuring that we make the most of our trip.

The ECSGA "legislative agenda" this past year was led by issues relating to the Army Corps' permitting issue, successfully seeking NRAC funding for our Best Management Practices (BMP) proposal, shellfish marketing and crop insurance. The Army Corps permit issue has really blown up into a potential nightmare over the past several months. The Corps' contention that cultch and spat on shell qualify as "fill" which is a pollutant under the Clean Water Act is both mystifying and gravely concerning. Their proposed revision of Nationwide Permit 4 (posted in the federal register this fall for comment) suggests the shellfish aquaculture industry is in for a whole new layer of permitting.

The Corps wants to protect eelgrass from aquaculture, but it would be more appropriate if they recognized that it is not the eelgrass itself that they cherish, but rather it is the ecosystem services rendered by the eelgrass that need to be protected. Eelgrass provides excellent habitat for many other species, stabilizes the bottom and helps remove excess nutrients from eutrophic coastal waters.

In most cases the ecosystem services provided by shellfish farms are at least as good or better than the services rendered by eelgrass. Most types of shellfish aquaculture provide a superior habitat and attract a diverse population of juvenile fish, crustaceans, fouling organisms and forage species. Fish abundance in and around shellfish farms is often far greater than in eelgrass. Shellfish actively filter the water, improving clarity and quality, and when the animals are harvested nitrogen and phosphate are removed from the ecosystem. If the Corps were to acknowledge that it is these ecosystem services that they seek, then they would be promoting the expansion of shellfish aquaculture instead of creating limits on us.

ECSGA Accomplishments

- In 2005 we successful beat back the effort to have the Eastern oyster listed as an endangered species last year

- In 2005 we helped defeat a "Sewage Blending" proposal by the EPA that would have okayed the release of millions of gallons of raw sewage during heavy rainfall events.

- One of the most significant achievements of our combined shellfish industry groups (ECSGA, PCSGA and GOIC), working with NFI, has been the creation of the Congressional Shellfish Caucus. The Caucus has 6 co-chairs, and more than 35 other members. The Caucus can provide focus for our shellfish issues, and gives us better access to House members with an interest in the shellfish industry.

- This year the ECSGA is proud to announce that it received NRAC funding for our project to develop Coastwide Best Management Practices. Ed Rhodes, Sandy MacFarlane and Gef Flimlin will be leading workshops up and down the coast to identify differences in methods and accepted practices for our industry.

- This year we have been working hard to ensure that those who will be writing the Army Corps permit conditions are informed enough to craft workable regulations.

- We are also helping establish the non-profit (501-c3) East Coast Shellfish Research Institute (ECSRI) for research and education. The ECSRI is seeking funds from government agencies and private foundations to fund research and educational projects of high priority for industry. The ECSRI will also help develop and disseminate shellfish-related scientific and technical information of value to shellfish farmers, the general public, and public officials.

The ECSGA has come a long way in four years. We have had a major impact on several important issues that impact our industry. The organization continues to grow both in membership and professionalism. The Cedar Key Aquaculture Association (with 90 Floridian clam farmers) joined the association, but we need the support of more of our industry if we are to become truly effective.

If you would like more information on any of the issues above I encourage you to go to our website www.ECSGA.org . Please consider joining our association and enroll in our lively online discussion group; the ECSGA LISTserve. It is free and instructions on enrolling are on our website.

Regulatory Agencies

The Coastal Resources Management Council (CRMC), Department of Environmental Management (DEM) and the Department of Health (DOH) continue to work closely together during the year. The staff members who deal with the day-to-day regulations concerning aquaculture in Rhode Island continue to work toward streamlining the permitting process. The staffs are also active in continuing to monitor the industry and are able to respond quickly to unforeseen contingencies that may arise.

We are fortunate to have the Chief of the Division of Agriculture, Ken Ayars, submit the following update of their aquaculture related activities.

DIVISION OF AGRICULTURE, RIDEM

Ken Ayars, Chief

The Division of Agriculture, RIDEM formed the RI Farm Viability Committee in 2002 to coordinate and enhance efforts within Rhode Island relating to the long term viability of agriculture in Rhode Island. These efforts include aquaculture, and a particular objective is the recognition of aquaculture as agriculture, and the inclusion of aquaculture into agricultural programs and promotions in Rhode Island. The Division sponsors each year Rhode Island Agricultural Day at the State House which since its inception in 2001 has included aquaculture among the many exhibitors and highlights. The Division has provided funding assistance to the Ocean State Aquaculture Association regarding development and publication of a new RI Shellfish brochure and assists the Association with other RI shellfish marketing efforts, has provided farm viability grants funds to enhance aquaculture in RI, serves on the USDA/NRCS State Technical Team which helps direct USDA funds toward implementation of farm best management practices – including aquaculture, and assists aquaculture farmers with environmental and regulatory issues. These efforts are collaborative with USDA, CRMC, the RI Aquaculture Initiative, RI Rural Development Council etc, and our objective remains the enhancement and promotion of aquaculture as a vital Rhode Island agricultural industry.

Conclusion

Aquaculture in Rhode Island is a small, diverse and very dynamic industry which is making a real contribution to the economic health of the state. The companies, farmers and universities involved will readily admit that the situation could be much improved, but they are showing their trust in the future of the industry by investing time and capital towards increasing their competitiveness now and into the future. Aquaculture in Rhode Island is an industry that is taking advantage of the state's assets, its clean waters, its many universities and a well trained populace.

Acknowledgments

Thanks to: Mr. M. Tikoian, Chairman CRMC; Mr. G. Fugate, Executive Director, CRMC; Ms. Laura Ricketson, CRMC; Mr. R. Silkes, American Mussel Harvesters Inc.; Mr. Perry Raso and Dr. R. Rheault, OSAA; Mr. P. Sebring, Atlantic Aquaculture Supply; Mr. M. McGiveney, Rhode Island Shellfishermen's Association; Dr. T. Scott, Roger Williams University; Dr. D. Bengtson, University of Rhode Island; Dr. B. Costa-Pierce, Director RI Sea Grant;Dr. Marta Gomez-Chiarri; and all of the aquaculture lease holders for their help in putting this report together.

A Brief History of Oyster Aquaculture in Rhode Island

Michael A. Rice
University of Rhode Island

Shellfishing and consumption of shellfish from Narragansett Bay and Rhode Island's coastal salt ponds has been known to be an important part of Rhode Island's history from pre-colonial times. Roger Williams in a chapter on fish and fishing in his 1643 treatise on the language of the Narragansett Indians, noted that during the summer months they would wade and dive deep for shellfish.[i] During the early colonial period, extensive oyster reefs were harvested for the consumption of the meats, but the oyster shells had higher value as a raw material for the manufacture of lime for use in masonry mortar. Limestone, a traditional raw material for lime kilns, is not readily available in
southern New England, and surely contributed to the value of oyster shell as a source of calcium carbonate. By the early 1700s, the harvest of oysters exclusively for use as a raw material for lime production was a wasteful use of the marine resource so the Colonial Assembly outlawed the practice by statute in 1734 noting the unacceptable waste of oyster meats as unshucked oysters were fed into the kilns.[ii] This may well be the first instance of legislative action to promote conservation of Rhode Island's marine resources.

During the later colonial period, oysters were not considered a luxury food as they are today, but growing populations in Rhode Island's coastal towns provided a ready market. By 1766 the Colonial Assembly recognized that the oyster beds were being overfished and as a result they promulgated a statute specifying that oysters could only be taken by tongs.[2] This early instance of the Colonial Assembly managing the shellfishery by specifying a specific fishing gear type certainly presages our modern fishery management protocols of restricting shellfishing effort by regulation of gear type. After the Revolution, the Rhode Island General Assembly enacted laws aimed at restricting harvest of oysters during the spawning season to further protect the resource. In 1798, a law mandating a seasonal closure of the oyster beds from May 1 to September 30 was enacted.[2]

All of the early legislation by both Rhode Island's Colonial Assembly and the post-Revolution General Assembly to regulate the oyster fisheries led to the state issuing the first grants of exclusive private harvest grants of the oyster banks. The first of these grants was to Samuel Thurber who petitioned the General Assembly in June 1798 for a two-acre grant near Sabin Point for the purpose of cultivating oysters. The General Assembly provided a renewable charter to Mr. Thurber for the term of six years and forbade the general public from "molesting or disturbing the said Samuel in his enjoyment of the provisions of his charter."[iii] It is unclear if Mr. Thurber was successful in his oyster farming venture, but his pioneering charter was not

renewed in 1804 upon its expiration. In 1822, the General Assembly granted another 2 acre charter in the Providence River to Mr. Earl Carpenter and Mr. Leonard Wilcox for their oyster farm. The success of Carpenter and Wilcox in their oyster farming is attested by the 1828 renewal of their charter.[iv] Another early grant in 1827 was to Mr. Ephraim Gifford of Bristol who was granted several acres near Common Fence Point in Mount Hope Bay.[v] Despite the granting of the exclusive rights to cultivate oysters on their grant areas, Thurber, Carpenter and Wilcox, and Gifford were not charged a lease fee for their grants. This fact of no lease fees and the exclusion of the public from harvesting in the grant areas generated considerable controversy among fishermen.[5] At this time prior to the adoption Rhode Island's 1843 constitution, the colonial King Charles Charter of 1646 was considered the unofficial constitution of Rhode Island. Fishermen seized upon the Charter provision:

> *Our Express Will and Pleasure is and we do by these Presents for Us our Heirs and Successors, ordain and Appoint, that these Presents shall not in any manner hinder any of our Loving Subjects whatsoever from using and exercising the trade of Fishing upon the Coast of New England in America; But that they, and every, or any of them shall have full and free power and liberty to Continue and use the Trade of Fishing upon the said Coasts in any of the Seas thereunto adjoining, or any Armes of the Seas, or Salt Water, Rivers and Creeks when they have been accustomed to Fish.*

Despite the context of this 1646 passage referring to a statement that marine fisheries were to be treated as a common property resource, as opposed to long-standing common English law that game and wildlife was the property of the landowner (i.e. the King), the fishermen took this as evidence that the General Assembly had no right to make grants of commonly held fishing grounds or to regulate the fisheries. However the common property principle and the States' right to manage their resources were reinforced by the 1842 U.S. Supreme Court decision in the case of *Martin v. Lessee of Waddell*:

> *When the revolution took place the people of each state became themselves sovereign; and in that character hold the absolute right to their navigable waters and the soils under them for their own common use, subject only to the rights since surrendered by the Constitution to the general government*.[vi]

One year later in 1843, Rhode Island adopted its new Constitution in which the special status of the fisheries was set forth:

> *The people shall continue to enjoy and freely exercise all the rights of fishery, and the privileges of the shore, to which they have been heretofore entitled under the charter and usages of this state. But no new right is intended to be granted, nor any existing right impaired, by this declaration*.[vii]

In light of the controversy surrounding the early aquaculture leases and the U.S. Supreme Court decision in the *Martin v. Lessee of Waddell* case, the General Assembly passed the Oyster Act of 1844, which was Rhode Island's first aquaculture law. The Act established a system of leasing tracts of submerged land for the purpose of culturing oysters, as well as setting up a board of three shellfishery commissioners who served without salary and a fee structure for the leases. The fee structure ranged from a high of $10 per acre per year to a low of $1 per acre per year for larger multiple acre leases. During that first year of leasing in 1844, $60 was generated in lease fees.[viii] One of the first lessees under the Oyster Act was Mr. Robert Pettis of Providence who by 1890 became one of the largest leaseholders in the state.[8]

Despite the clarity of legislative intent of the 1844 Oyster Act to enhance oyster production and to establish a clear set of leasing protocols, the newly established Rhode Island Shellfisheries Commission got off to a very rocky start. The fishermen on the public oyster grounds became openly rebellious. Stealing of oysters from the leases became rampant and arrests were made leading to a number of court cases in the 1850s that upheld the power of the General Assembly to grant the leases.[ix] By 1855, the General Assembly authorized the use of lease fees for the purchase of a patrol boat to watch the leases, but this also proved to be unsuccessful as those willing to lease new grounds were few and lease income declined in the 1850s.[x] Further laws were passed in the 1850s aimed at improving the climate for shellfish aquaculture. An 1852 statute required all shell to be returned to beds to serve as setting substrate for oysters, and an 1854 statute allowed private aquaculture lessees to harvest five bushels of oysters per day from public beds to serve to seed the leased farms.[11] Despite these legislative actions, by the end of the decade lease fees declined to zero prompting the General Assembly to require a report from the Commissioners as to the reasons. That report made in 1859 made reference to the above poaching problems and mentioned possible pollution of the oyster grounds by the Providence Gas Works.[xi] This was the first mention by any official publication of the state about possible deleterious effects of pollutants on oyster beds and a presaging of later (1905-1910) legal actions to be taken by oyster farmers and the Commissioners against the Providence Gas Company.

In 1864, the General Assembly amended the 1844 Oyster Act to improve the operations of the Shellfisheries Commission. The number of commissioners was reduced to one who would be elected to a five year term. Professionalization of the Commission was promoted by initiating an annual salary of $400 per annum for the Commissioner, and to increase the level of accountability and oversight, an annual report to the General Assembly was required.[xii] The first Commissioner of Shellfisheries after the 1864 restructuring of the Commission was the Honorable Judge John P. Knowles (later to be appointed Federal District Judge in Providence). During his five year tenure, Judge Knowles improved the performance of the office by improving collection of lease fees, terminating leases of lessees for non payment of fees, and

establishing the annual report to the General Assembly. In that period of time from 1864 to 1869, confidence was restored and oystermen began taking out leases and the lease fees collected increased from $61 to $1,949.15.[xiii]

Judge Knowles was replaced as Commissioner in 1869 by three elected commissioners with the Honorable James C. Collins serving as chairman. Collins served as a commissioner until his death in 1910. Under the able leadership of Collins, the oyster industry in Rhode Island grew into a multi-million dollar operation with lease fees paid to the State exceeding $100,000 (Figures 1 & 2). The amount of submerged lands leased for aquaculture peaked in 1911 & 1912 at about 21,000 acres or about 20 percent of the entire bottom of Narragansett Bay.

During the growth of the oyster aquaculture industry in the 1890s and 1900s the Shellfisheries Commissioners became concerned about the application of scientific methods to improve the production of the oyster farms. The annual reports of the Commissioners to the General Assembly became a primary outlet for the dissemination of studies contracted by the Commissioners aimed at improving oyster production. Studies included population surveys of starfish in Narragansett Bay, studies on oxygen levels in Narragansett Bay waters, studies on pollutants in Narragansett Bay and studies on oyster spatfall rates.

During this period of time, scientists at the newly established (1888) Rhode Island Agricultural Experiment Station (RIAES) and the Rhode Island College of Agriculture and Mechanical Arts (founded in 1892 & forerunner of the University of Rhode Island) became involved with the activities of the Shellfisheries Commissioners. Oyster farmers with leases in Point Judith Pond noticed that oyster production was declining in the pond for several years, so in 1895 they approached marine scientist Dr. George W. Field of the RIAES about investigating the reason for the decline in oyster production while at the same time production in Narragansett Bay was substantially increasing. As a result of these meetings, College President John H. Washburn authorized the establishment of Rhode Island's first marine laboratory in the village of Jerusalem on Point Judith Pond in July 1896 (Figure 3). This laboratory is the third oldest marine laboratory in the United States, only preceded by the U.S. Fisheries Commission Laboratory founded in Woods Hole in 1875, and the Marine Biological Laboratory also founded in Woods Hole by famed Harvard naturalist Louis Agassiz in 1888. The Jerusalem Laboratory building has long been demolished, but the original site is now the Coastal Fisheries Laboratory of the Department of Environmental Management Division of Fish and Wildlife.

During the summer of 1896, Dr. Field measured oxygen levels in Point Judith Pond and measured rates of siltation on the oyster beds and measured levels of ammonia in the water as well as determining dissolved oxygen levels in the pond using the then new Winkler titration method. Dr. Field then reported his finding in an Agricultural Experiment Station Annual Report[xiv] concluding that the oyster beds were being smothered by silt being deposited on the

oyster beds from the Saugatucket River and low oxygen conditions caused by lack of a permanent breachway in the pond and thus the lack of adequate tidal flushing. Interestingly, the 1896 RIAES report made no mention of the fact that two major textile mills in Peace Dale and Wakefield on the Saugatucket River were known to discharge a variety of ammonia and dye-laden effluents as a byproduct of their manufacturing processes. Never-the-less, Dr. Field concluded that a solution to the problem of declining oyster production would be to open and maintain a permanent breachway in Point Judith Pond. The Commissioners invited Dr. Field to abstract his findings in the 1899 Annual Report to the General Assembly.[xv] As a result of these reports, the General Assembly began the process to raise funds to open the permanent breachway into Point Judith Pond. A 1901 statute moved the responsibility of leasing oyster farms in Point Judith Pond from the Shellfisheries Commission to the Towns of South Kingstown and Narragansett (provided that they use the funds to open and maintain the breachway). Of course these early actions eventually led to the initial opening of a permanent breachway in the early 1900s and the build up of the major fishing port at the village of Galilee.

As an additional note, the 1901 delegation of leasing authority by the legislature to the towns led to yet another court challenge of oyster leases. In *State v. Nelson* (1910)[xvi] the defendant Nelson was arrested for taking a peck of oysters from the lease of George Griffin of South Kingstown. Nelson alleged that there was an unlawful delegation of authority by the legislature under the aegis of RI Constitution Article I Section 17 because the towns did not reserve any part of the pond for the free and common fishery. The court found yet again that the General Assembly was well within its right to delegate authority to the towns and further that it was proper for the towns to raise funds from benefiting parties to recoup expenses for opening and maintaining the breachway.

During the decades of the 1900s through the 1920s the Shellfisheries Commissioners reports began to show greater concern about the chemical and bacteriological integrity of shellfish growing waters. In 1905, a landmark court case was first brought by oyster lease holders Payne and Butler against the Providence Gas Company for discharging coal tar and other noxious pollutants on their oyster leases thereby killing the oysters.[xvii] In the case the Court reaffirmed that the oyster leases granted by the General Assembly or the Shellfisheries Commission were valid but in the trial there was considerable back and forth expert testimony about the actual toxicity of the discharged chemical wastes on the oyster health. Dr. George Field (who gained notability for his 1896 RIAES recommendations about pollution abatement in Point Judith Pond, but he had since moved to Massachusetts to work on other water quality projects) served as a consultant to the plaintiffs and the Shellfisheries Commissioners.[xviii] Field reported his findings on the toxicity of coal tar to oysters to the Court and the ultimate 1910 Court finding was that the destruction of the shellfish bed by pollution did in fact constitute a nuisance.

Growing interstate trade of shellfish and documented outbreaks of various illnesses associated with consumption of raw shellfish since the late 19th Century led to national effort to develop a National Shellfish Sanitation Program.[xix] Prior to the adoption of the NSSP nationwide in 1925, the RI Shellfisheries Commissioners undertook pioneering of bacteriological studies in 1910 on water and shellfish meat quality to assess Rhode Island's sanitary water quality status. Oyster beds north of Conimicut Point were shown to be most contaminated.[xx]

Peak production of oysters in Rhode Island occurred around 1911 with 1,394,983 bushels of oysters landed, with an additional 1,331,192 gallons of shucked oyster meats sold as well.[xxi] Assuming 80 pieces per bushel, 8 lbs/gallon and today's retail prices of 75 cents apiece and $5.00/lb shucked meats, these oysters would collectively be worth about $135 million. It was a substantial industry in its day (Figure 4).

The decline of the oyster industry was evident to the Shellfisheries Commissioners by the early 1920s. According to an account in the 1921 Annual Report:

> *The main cause for our decline of our oyster industry is large quantities of oil floating on the waters of our rivers, bay and tributaries; but all authorities agree that the instant spawn come in contact with any oil, it is instantly killed.*[xxii]

Despite the Commissioners' recognition that oil pollutants might have a negative effect on oyster larvae, there were other potential pollutants discharged in the 1920s that could have affected the shellfish. For example, the modern electroplating process invented in England in the 1840s is well known to have been adopted as an industrial process in Providence.[xxiii] Heavy metal ion effluents from waste electroplating baths are known to have deleterious effects on oyster and other bivalve larvae.[xxiv] Alternatively, the sewering of Providence during the 1910s has lead to greater nutrient and carbon loading to the Upper Bay that could lead to hypoxic events.[xxv] Silt-laden runoff from deforested upland farm areas common in the 1920s and 1930s could be another explanation. Whatever the exact cause or combination of causes, pollution of some form was likely to have been the reason for the oyster industry decline in the 1920s.

In the 1921 report, the Commissioners made lengthy note of Dr. William F. Wells' successful establishment of an oyster hatchery in West Sayville, New York,[xxvi] and suggested that artificial propagation of seed oysters might be a means to escape pollution's effects on larval and juvenile oysters. Clearly finances were a barrier to establishing an oyster hatchery in the 1920s, but in the following decade, famed oyster biologist Dr, Paul S. Galtsoff of the U.S. Bureau of Commercial Fisheries was invited in 1936 to the Rhode Island State College's Narragansett Marine Laboratory (now URI's Narragansett Bay Campus) to experiment with the propagation of oysters. Rhode Island's first oyster hatchery was established by Galtsoff in a small building known as the North Laboratory near the end of South Ferry Road that is now

known as the Helen Mosby Center (Figure 5). Dr. Galtsoff's very valuable collection of oyster literature and scientific reprints is now housed in the Challenger Room of URI's nearby Pell Marine Science Library.

The Rhode Island oyster industry continued its decline into the 1930s, with the great depression taking its toll on marketing and sales. Political change in Rhode Island during the mid-1930s may also have had a negative impact on the oyster industry. A major shift in the political landscape of Rhode Island occurred with the 1932 election of Governor T.F. Green and a subsequent shift in the General Assembly to be dominated by more populist policies. A number of social historians suggested that the demise of Rhode Island's textile industry and the 'mill town' system were brought about as a result of the policy shifts and this is likely to be so for the oyster industry as well. The industry was dealt a crushing blow on September 21, 1938 when the Great Hurricane roared up Narragansett Bay damaging shucking houses, shipping wharves and the oyster vessels (Figure 6). Many oyster companies never reopened as a result of the hurricane. In addition to the 1938 Hurricane, the onset of World War II in 1941 deprived the remaining oyster companies of able-bodied labor, further eroding the business.

In 1949, there was a major shift in the governance of the oyster leasing system. The Commissioners of Shellfisheries was abolished and their function was subsumed into the newly formed Department of Fish and Wildlife, which continues on to the present as a division within the Department of Environmental Management. By the early 1950s there were only two of the remaining oyster companies in business. The Blount Oyster Company of Warren transformed itself into the Blount Seafood Corporation processing offshore ocean quahogs for the manufacture of soups, and the last remaining oyster lessee, the Warren Oyster Company ceased operations in 1954.

For the next two decades there was very little interest in any aquaculture and the state's aquaculture leasing system became moribund. In 1971, the Coastal Resources Management Council was established by the General Assembly and the Council took office in August of that year.[xxvii] Among the responsibilities of the CRMC was the processing of leases for aquaculture. Beginning in 1976, there was a renewed interest in shellfish leases beginning with Mr. Luther Blount, a Warren Shipbuilder and member of the Blount family who was prominent as oyster growers during the heyday of the industry. On December 14, 1976, the CRMC granted permission to Mr. Blount to construct two tidally flushed 'oyster ponds' on the north end of Prudence Island along Jenny's Creek.[xxviii] As an educational program, Mr. Blount worked with the curation staff of the Roger Williams Park Museum to create a model of the farm for display. Although few oysters grew to salable size in the ponds, they did serve to educate the public about the potential for restoring shellfish aquaculture to Rhode Island. Between 1977 and 1980, under the old oyster leasing permit laws CRMC granted 13 more aquaculture permits, most of them small 1 acre or less plots in the coastal salt ponds. The exception to this was the 1978 granting

of 60 acres to Blue Gold Mussel Farm in the East Passage adjacent to the old Navy Base facilities in Middletown.[xxix]

This granting of a 60 acre lease for aquaculture under the old leasing system caused a storm of protest by quahoggers, who pointed out that the leasing of such public trust land was done with not so much as a formal public hearing. The controversy prompted then-Governor J. Joseph Garrahy in 1980 to ask CRMC to issue a moratorium on aquaculture leases and to conduct a study on aquaculture as a compatible use in the Bay.[29] After a year's study there was a conclusion that aquaculture was indeed a compatible use, but there was a complete rewrite of the aquaculture laws (Chapter 20-10 of the General Laws) to include a system of public hearings and review of all aquaculture lease applications by the Rhode Island Marine Fisheries Council.[xxx] In 1983, the CRMC published their Coastal Resources Management Program (CRMP) or 'red book' which contained Section 300.11 that outlined procedures for aquaculture lease application. After the promulgation of the revised aquaculture laws and CRMP, there were few new aquaculture applications received by CRMC, and most of the aquaculture leases granted during the 1977 to 1980 time period were left to expire and were not renewed. By 1990 there were only four small leases left in the coastal ponds. The Blue Gold Company moved their operations to New Bedford in 1988 and ceased growing mussels in Rhode Island.[xxxi]

Renewed interest in aquaculture leasing began in 1988 when Robert B. Rheault, Jr. and his partner Robert Bergen of Spatco Ltd. submitted an application for a very small 50 ft by 50 ft aquaculture lease in Point Judith Pond. This was the first real 'test case' of the revised 1981 aquaculture laws. The Spatco (*aka* Moonstone Oysters) application was finally approved in 1990 but only after 14 different public hearings by several different agencies and boards.[xxxii] The whole process of multiple hearings and nearly two-year time frame to obtain an aquaculture lease was seen as an impediment to the promotion of Rhode Island's nascent aquaculture industry.[xxxiii] The year 1993 brought the incorporation of the Ocean State Aquaculture Association and the publication of its *OSAA Newsletter*, aimed at educating the policy makers and the public about the benefits of a Rhode Island aquaculture industry. A year later, a report by URI Resource Economists James Anderson and Mark Spatz provided a comprehensive review policy and economic constraints faced by Rhode Island's aquaculturists.[xxxiv] As a result of the findings in this report and other publications, CRMC member Rep. Eileen S. Naughton of Warwick created the Legislative Commission on Aquaculture with a charge to investigate the means to promote and foster environmentally sound forms of aquaculture in Rhode Island. The first act of the Commission was to further study the opportunities and constraints of aquaculture. During the 1995 & 1996 legislative sessions, the Aquaculture Commission held televised hearings on the opportunities and constraints of aquaculture and heard from a wide variety of witnesses ranging from regulators, fishermen, seafood marketers, economists, gear suppliers and aquaculture practitioners.[xxxv] As a result of the Commission's work, legislation was passed in 1996 that established CRMC as the coordinating agency for the permitting of all aquaculture

projects in the state regardless of location and type.[xxxvi] Further, it streamlined the hearing process and created a coordinated application process and required annual reporting to the General Assembly. As part of this legislative package, funds were appropriated to CRMC to create a position of 'Aquaculture Coordinator'.

Since the implementation of the 1996 revisions to the aquaculture laws, aquaculture has grown in value of product sales from $83,518 in 1995 to $744,319 in 2005 and the number of farms has grown from six to 24.[xxxvii] The Rhode Island aquaculture industry is no longer moribund as evidenced by this steady and healthy rate of growth. But the industry is still dominated by the aquaculture of oysters that goes to what the old oystermen knew, which is, there was no better place to grow oysters but in Rhode Island.

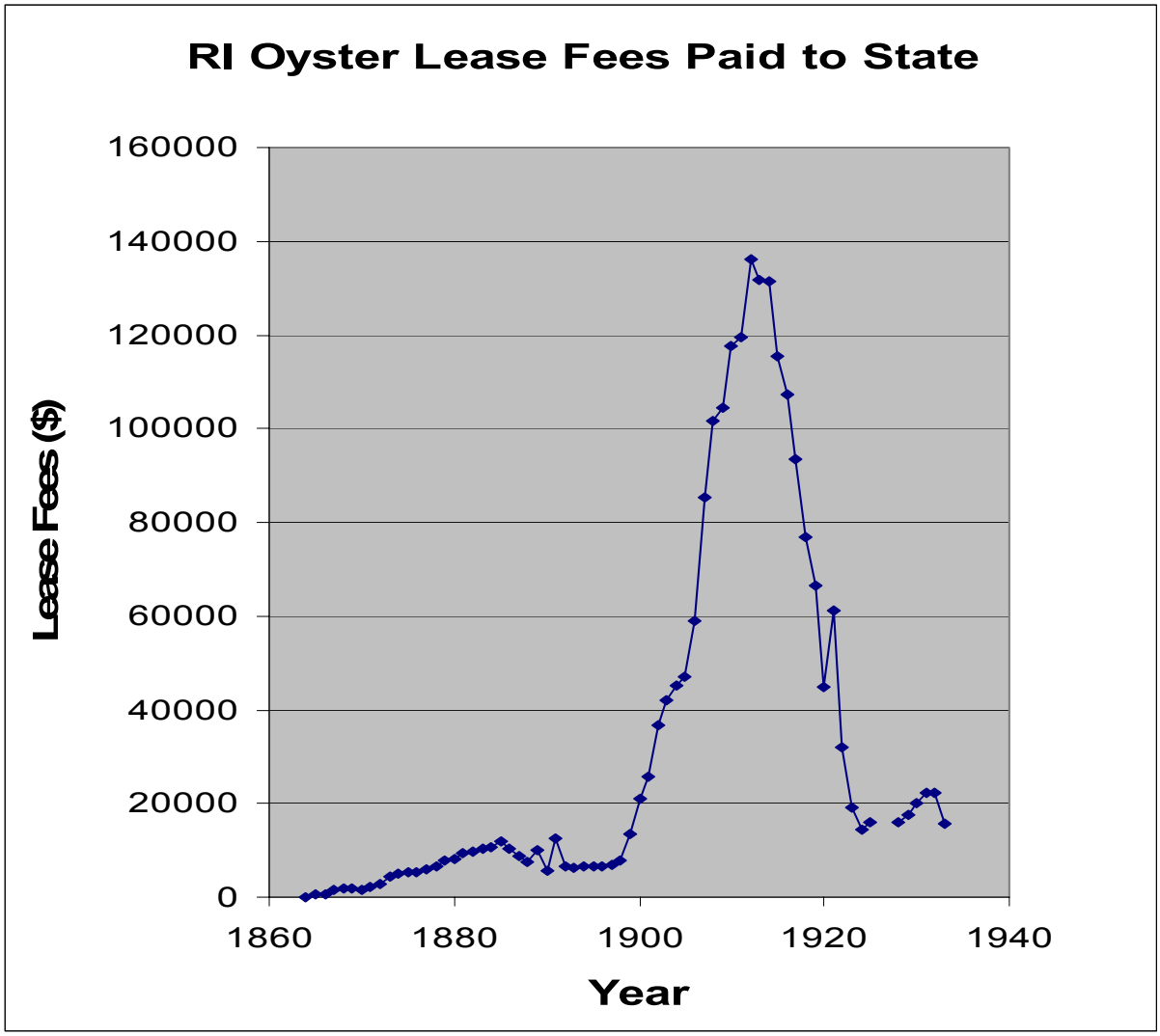


Figure 1. Growth and decline of Rhode Island's oyster aquaculture industry between 1864 and 1933 as evidenced by oyster lease fees paid to the state. Data from Annual Reports of the Rhode Island Commissioners of Shellfisheries 1864 to 1933. Data are actual fees paid by lessees without correction for inflation.

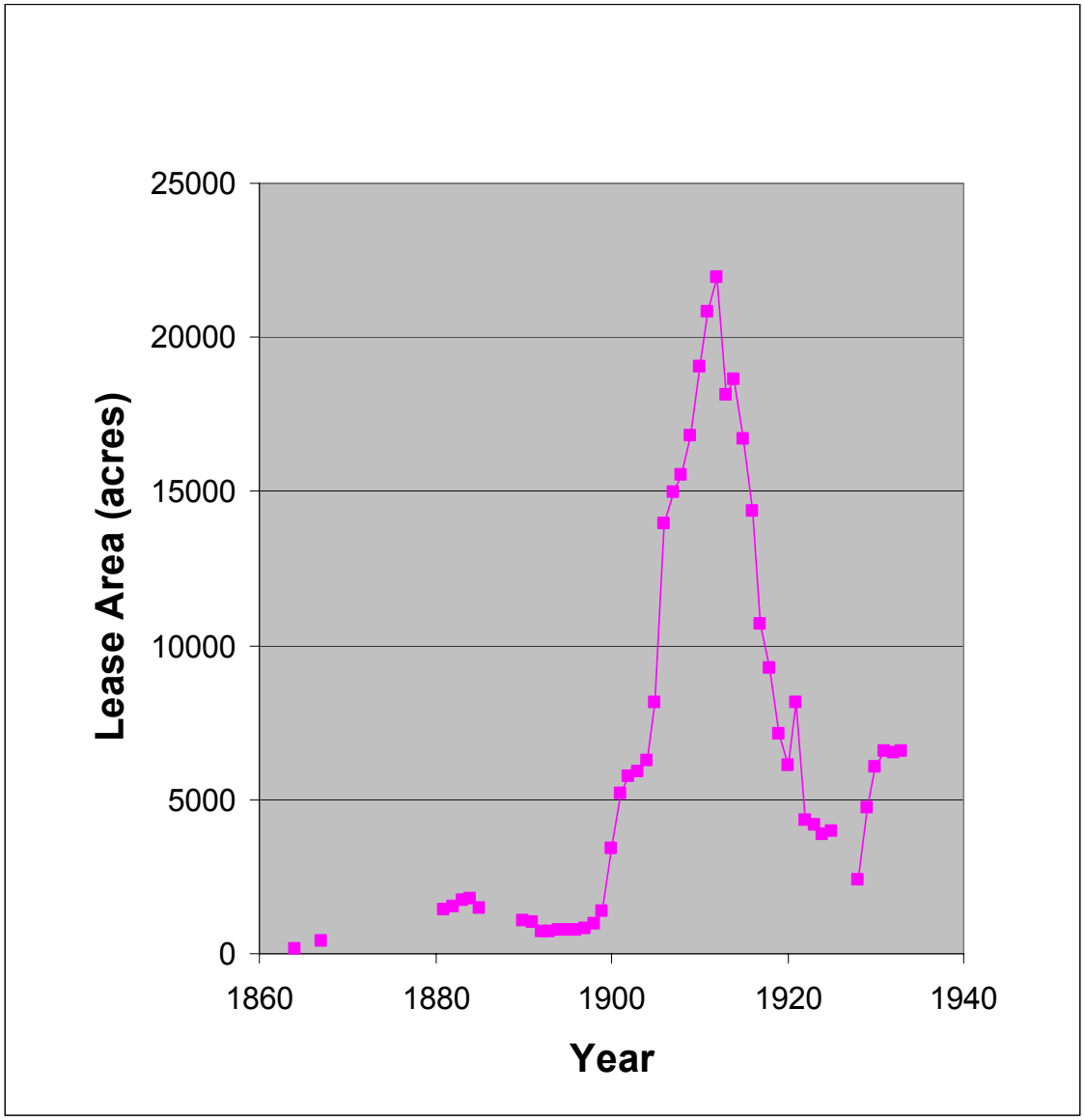


Figure 2. Growth and decline of Rhode Island's oyster aquaculture industry between 1864 and 1933 as evidenced by area of oyster farming leases. Data from Annual Reports of the Rhode Island Commissioners of Shellfisheries 1864 to 1933.

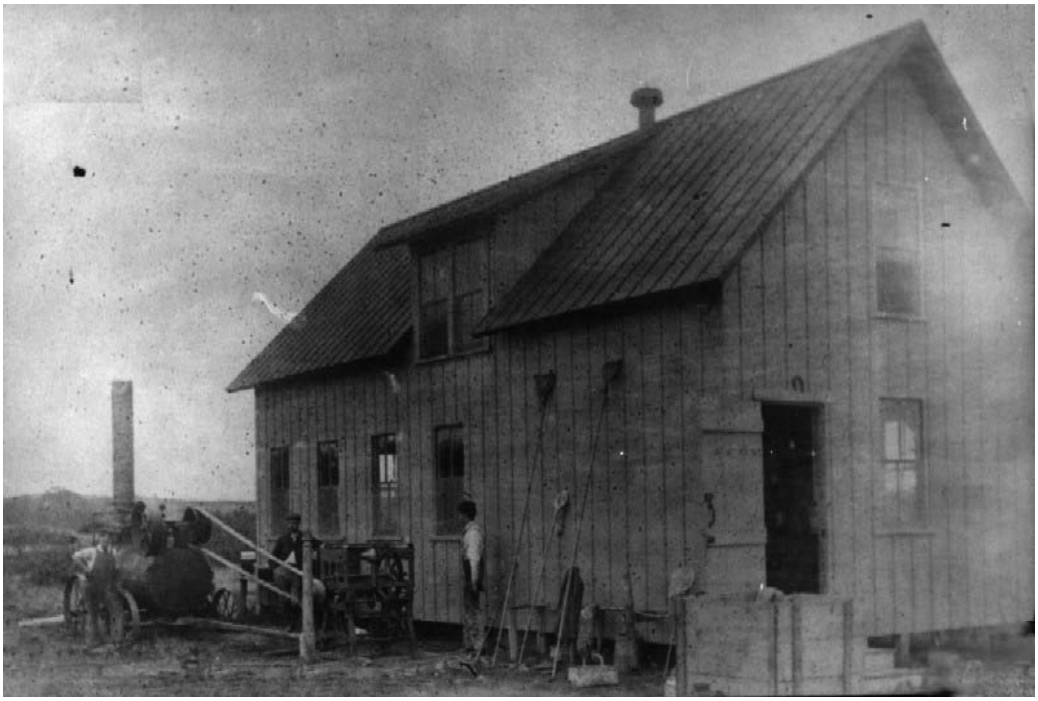


Figure 3. Rhode Island Agricultural Experiment Station Marine Laboratory at Jerusalem on Point Judith Pond. Photo taken in 1897 shows a steam tractor and nets for sampling the pond bottom. (Photo courtesy of University of Rhode Island Special Collections)

Figure 4. Oyster shell piles from two oyster shucking houses at Fields Point, Providence 1911. (Photo from 1912 Annual Report of the RI Shellfisheries Commissioners).

Figure 5. Building at the URI Narragansett Bay Campus that was used by oyster biologist Dr. Paul S. Galtsoff to establish Rhode Island's first oyster hatchery in 1936. (Photo by M.A. Rice 2005)

Figure 6. The Great Hurricane of 1938 severely damaged wharves, warehouses and other shoreside facilities throughout the state. (Photo by *Providence Journal*)

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Survey of major diseases affecting Rhode Island cultured bivalves

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Introduction

Disease has been identified as one of the major constrains to the expansion of the bivalve aquaculture industry in Rhode Island (Leavitt, personal communication). Several diseases affect bivalves in the East Coast of the United States (Ford and Tripp, 1996). The devastating effects of Multinucleated Sphere X (**MSX**, caused by the parasite *Haplosporidium nelsoni*) and **Dermo** (caused by the parasite *Perkinsus marinus*) on wild and farmed oyster populations in the Mid-Atlantic region have led to record low landings and severely affect restoration efforts (Ewart and Ford, 1993). Although both MSX and Dermo originated in waters south of Rhode Island (MSX in Delaware Bay and Dermo in the Gulf of Mexico), they have recently spread northward. Currently Dermo has been identified as far north as Maine, arriving in 1995 (Barber, 2000), while MSX was recently discovered in an oyster farm in Bras D'Or Lakes in Nova Scotia during the summer of 2002 (Burreson and Ford, 2004). MSX also caused large scale mortalities in Connecticut in the late 1990s (Sunila *et al.*, 1999). **SSO** (seaside organism), a disease caused by *Haplosporidium costale,* a protozoan parasite related to the causative agent of MSX, has caused mortalities in oysters from high salinity sites in Virginia and Delaware (Ford and Tripp, 1996). In general, the proliferation of these parasites in oyster tissues is favored by warm water temperatures (above 20°C) and high salinities (above 18 psu). Therefore, these parasitic diseases show seasonal cycles, in which prevalence and intensity increase throughout the summer and peak in late summer or early fall. Mortalities are usually observed in the late summer and fall (Ford and Tripp, 1996).

A fourth oyster disease, Juvenile Oyster Disease or **JOD,** is becoming more prevalent in the southern New England region (Bricelj *et al.*, 1992). JOD was first noted in Maine in the mid-1980s and caused significant mortalities in the Long Island area of New York. Since then, if has caused recurrent mortalities in different areas of the Northeast (Boettcher *et al.*, 2006). Mortality episodes due to JOD are usually reported during the nursery phase of the oyster grow-out process; animals less than 25 mm in shell height appear to be especially vulnerable when seawater temperatures reach more than 20°C at sites with water salinity above 20 psu (Boettcher *et al.*, 1999;Bricelj *et al.*, 1992;Ford and Borrero, 2001). Lastly, but not least, **QPX** (Quahog Parasite Unknown), a disease of the Northern quahog, has been associated with mortalities in cultured quahogs in Canada, Massachusetts, Virginia, New York (Hickey *et al.*, 2002), and most recently in Rhode Island (Lyons *et al.* submitted). Quahogs affected by QPX show a variety of gross signs of disease, including decreased new shell growth, swollen retracted mantle, and occasional small round yellow-tan nodules in the mantle tissue (Ragone Calvo *et al.*,

1998;Smolowitz *et al.*, 1998). Infected quahogs populations can exhibit high mortality, usually just before quahogs reach market size (Hickey et al. 2002).

Since no treatments are available for these diseases, adequate management of the infected populations is the most reasonable way of controlling the disease (Ford and Tripp, 1996). In order to be effective, management recommendations and regulations should be based on current scientific knowledge on the environmental and biological conditions that result in disease, as well as accurate data on disease prevalence and intensity in wild and farmed bivalve populations (Anderson *et al.*, 2002). In order to protect Rhode Island's valuable bivalve wild and cultured populations, the Rhode Island Department of Environmental Management (RIDEM) funded a survey of bivalve diseases from 1998 to 2002, and then again in 2004. The survey was also performed in 2005 thanks to funds provided by the Rhode Island Aquaculture Initiative (RIAI), and in 2006 in selected farms thanks to funds provided to farmers by the USDA EQIP program. These surveys have resulted in a wealth of information on prevalence and intensity of major diseases affecting Rhode Island bivalves, and have been used in management decisions, such as the transfer of seed and adult bivalves within state waters.

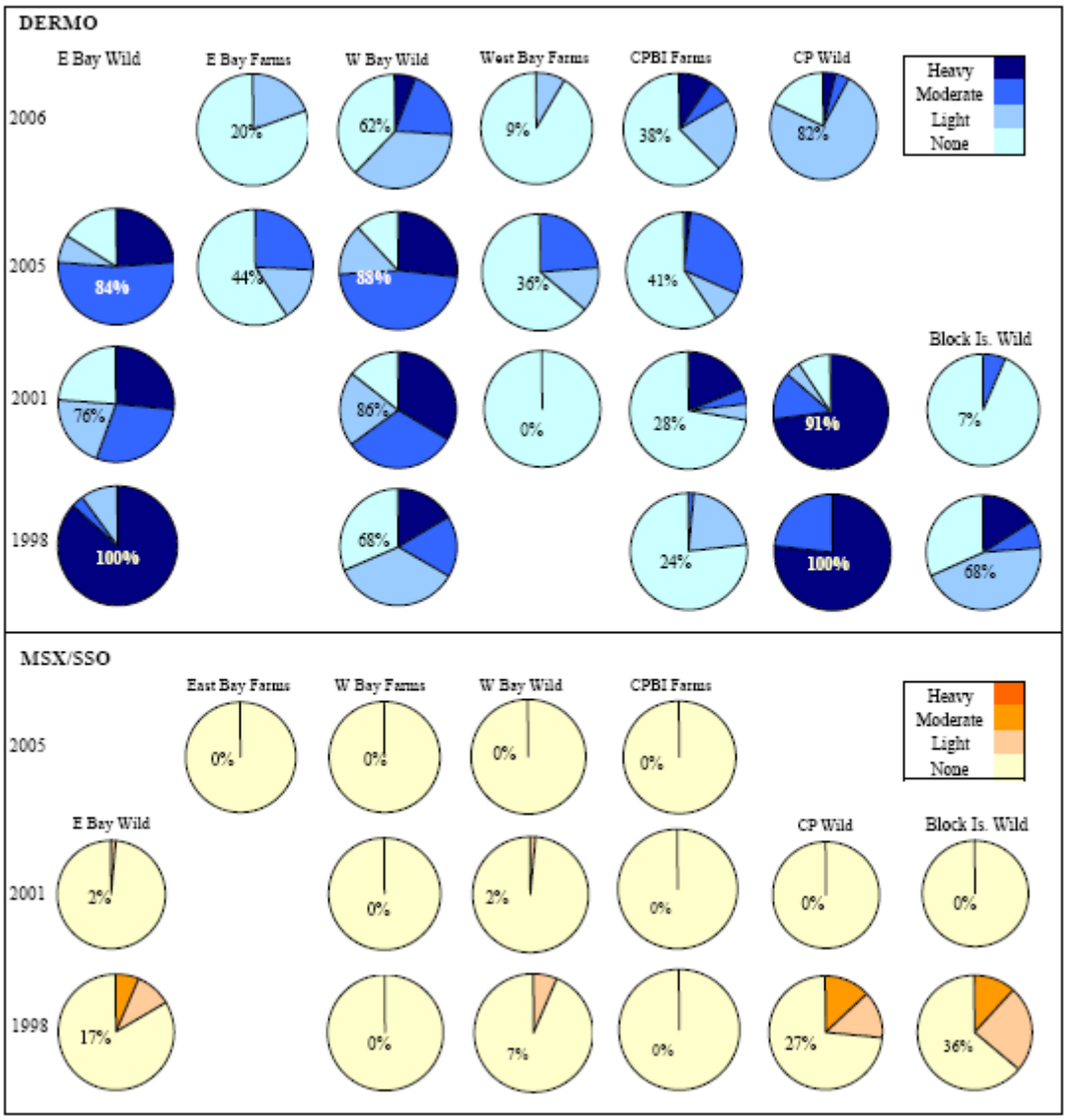
Summary of results from the surveys

Oysters (25 per site) from selected farmed and wild populations in Rhode Island were collected in August – September of each year and processed for disease diagnosis using standard techniques (culture in thioglycollate medium for Dermo and histopathology for all other diseases). The age of the oysters collected from farms ranged from 24 to 36 months old. Quahogs (25 – 50 per site) were collected in May – July and QPX was diagnosed using histopathology. To ensure farmers' privacy, we have aggregated the results for each main geographical area in Rhode Island (Figure 1). Results for Dermo and MSX prevalence in each area and year are represented using pie charts showing: 1) the percent prevalence of disease in the site (100 x number of oysters infected divided by the total number of oysters sampled at the site, number inside the pie chart); and 2) the relative percentage of oysters that show either no infections (area of the pie chart with the lightest color), light infections (slightly darker color), moderate infections (darker color), and heavy infections (darkest color) (Figure 2). QPX data is provided in table format, showing the percent prevalence of QPX at each site (Table 1).

Dermo disease in wild oysters

Dermo disease was found to be present in all wild locations sampled in Rhode Island from 1998 to 2006; percent prevalence ranged from 3-100%, with an average and standard deviation of 72 ± 28%. The most infected wild oysters were found in Barrington River (NE Bay), Ninigret Pond (Coastal Pond), and Greenwich Bay (NW Bay), these sites exhibited a prevalence of 90% or greater during each of the periods for which oysters were collected. The lowest levels of infection were found in Block Island (CPBI, 3% in 2000) and Prudence Island

(W Bay, 3% in 2000). A combination of factors, including disease, fishing pressure, and lack of successful sets, has led to a significant decrease in oyster densities at most wild populations, to the point that it was not possible to collect oysters at most locations in recent years. Dermo disease is still prevalent in the few remnant wild oysters (from 28% in Potowomut River, NW Bay, to 96% in Wickford, W Bay in 2006), but overall the intensity of the disease has decreased since 1998. The decrease in intensity of Dermo in wild oysters in recent years could be due to decreased disease pressure (due to environmental conditions or to decreased oyster densities in wild populations) or to development of Dermo resistance in wild populations.



Dermo disease in cultured oysters

Levels of Dermo in cultured oysters have remained low to moderate throughout the survey; the percent prevalence ranged from 0% (W Bay farms in 2001) to 44% (E Bay farms in 2005, Fig. 2). The highest levels of Dermo in 2006 were observed in some farms in the Coastal Ponds/Block Island region. Dermo could be responsible for low levels of oyster mortality at these farms, since 8 – 20% of oysters had high levels of infection, and these levels of infection are commonly associated with oyster mortalities. When two year classes were tested (oysters planted in 2004 and 2005 were tested in 2006), levels of Dermo were highest in the older oysters in the lease (not shown). Average intensity of Dermo disease in cultured oysters was significantly lower than that in wild oysters for all sampling seasons.

MSX and SSO in Rhode Island oysters.

Due to low levels of prevalence, MSX and SSO are reported in aggregate (no distinction is made between MSX and SSO). The prevalence of MSX/SSO in oysters is restricted to a few wild locations distributed throughout Rhode Island, including Barrington River (NE Bay), Wickford Cove (W Bay), Ninigret Pond (Coastal Ponds), and Block Island. The highest prevalence of MSX/SSO in Rhode Island oysters was observed in 1998 (36%), suggesting that an outbreak of MSX/SSO occurred in Rhode Island oyster populations at about the same time it was affecting populations in Connecticut (Karolus *et al.*, 1999). Since then, the prevalence of MSX/SSO has decreased to levels of prevalence below 2% at infected sites. **No MSX/SSO has been detected in Rhode Island cultured oysters.**

Summary and recommendations for the management of oyster diseases

- Dermo disease, caused by the protozoan parasite *Perkinsus marinus*, is widespread and established in wild Rhode Island oysters, and has probably been a major contributor to the demise of several wild populations.
- Prevalence of Dermo disease remains low or moderate in oysters from aquaculture leases, but a few oysters with heavy infections were detected at some farms in certain years, especially in the older oysters in the lease. These results indicate that, if not properly managed, Dermo could have some impact on oyster aquaculture in Rhode Island.
- Appropriate management of Dermo disease is based on current knowledge on the disease. The parasite that causes Dermo starts proliferating in infected oysters located in areas of salinity higher than 18 psu when water temperatures are higher than 18°C. Therefore, parasite levels in oysters increase through the summer, and the highest levels of the disease and mortalities are seen in late summer and early fall, usually in oysters that are more than 18 months old but sometimes in younger oysters when environmental conditions are favorable.

The parasite is released into the water column by infected oysters, especially when heavily infected oysters die in the late summer and fall. The parasite is then transmitted to oysters in the vicinity, which acquire the parasite while feeding.

- Therefore, removal of older, heavily infected oysters before they die is the best strategy to minimize transmission of the disease to other oysters in the lease. We recommend that farmers take advantage of monitoring programs to determine the health of their oysters and use that information to manage their production. Currently (2006 – 2009), monitoring of selected farms is performed in August through the USDA EQIP program. If moderate to high levels of Dermo are detected in a particular farm in August, the farmer is notified immediately so he can sell the largest (and usually most infected) oysters in the lease before mortalities occur in the late-summer or fall. This strategy minimizes losses due to mortality and reduces the chances of transmission of the disease to other oysters when infected oysters die.
- Other management practices includes planting seed free of Dermo and the use of strains of oysters well adapted to local conditions, that show fast growth (the longest an oyster stays in the water, the highest the chances it has to be infected), and/or that are more tolerant/resistant to the disease.
- Information about the USDA EQIP program and about oyster strains is available from farmers in the area, the RI shellfish aquaculture extension agent (Dr. Leavitt at RWU, dleavitt@rwu.edu), and Dr. Gómez-Chiarri at URI, gomezchi@uri.edu.
- Although MSX/SSO is not a problem currently in Rhode Island, disease outbreaks of MSX and SSO have occurred in Rhode Island in the past, and have been recently reported in farmed oysters in Cape Cod in 2006 (Smolowitz, personal communication). Therefore, we will continue to watch for the presence of MSX/SSO in Rhode Island oysters. Farmers experienced heavy mortalities during the late summer-fall and affecting 1 year old oysters should immediately contact Dr. Gómez-Chiarri or other qualified shellfish pathologist to determine the cause of mortalities.
- No gross signs of JOD have been detected in the oysters tested in our surveys. However, no oysters in the most susceptible size (10 – 25 mm) have been tested.
- Information from this survey is also used by managers and regulators to make decisions on the transfer of seed and adult bivalves within Rhode Island waters. It can also be used by future farmers in site selection, so farmers can avoid areas with heavily infected wild oyster populations.

Quahog Parasite X (QPX) in Rhode Island hard clams

Wild and cultured quahogs collected in a farm located in one of the RI coastal ponds in May 2003 showed no signs of QPX and no unusual mortality (Table 1, next page). However, an outbreak of QPX in farmed quahogs in Rhode Island was detected in this farm in July 2003 by

Dr. Inke Sunila (CT Department of Agriculture, personal communication). Undersized clams that had been returned to the plot after harvesting market-sized clams remained on the surface. The presence of empty shells still connected by the hinge indicated recent mortality. Dr. Sunila collected 30 clams each from several plots and made histological slides, diagnosing the presence of QPX. QPX mostly affected clam seed from South Carolina that had been planted in 2001. Prevalence ranged from 80 – 90% in South Carolina seed, causing 44 – 47% mortality in clams in the 27 – 48 mm range. Clams from Hawaii (produced from broodstock originally from Massachusetts) planted in 2002 showed 17% prevalence and no mortality. This is consistent with results from following year surveys (Table 1) and previous findings showing that clams of intermediate size (sublegal, usually more than 18 months old) are the most affected by QPX (Lyons *et al*. submitted). For any particular year, there was no statistical difference in the prevalence of QPX in clams from different seed sources (South Carolina or Hawaii) planted in the same year. No QPX has been detected in any other location sampled in Rhode Island, including one farm and five wild populations (Table 1).

Based on available information from the literature and results from our surveys, we hypothesize that the outbreak in the coastal pond farm was favored by the use of clams from southern origin. It has been shown that clams from southern stocks (south of Virginia) are more susceptible to QPX than clams from northern stocks, probably due to poor adaptation to local growing conditions leading to stress (Ford *et al.*, 2002;Kraeuter *et al.*, 1998;Ragone Calvo and Burreson, 2002). However, our data also indicates that, once the disease is established in a farm and the disease pressure is high, all seed stocks (northern or southern origin) can be affected (for example, seed from Massachusetts planted in 2005 showed 21% prevalence of QPX in 2006).

Therefore, we recommend that farmers use only seed from northern origin, and preferably from a hatchery in the Northeast, so it is well adapted to local conditions. We also recommend that farmers watch plots for signs of QPX, including presence of large amounts of clam shell in the surface of the substrate and the presence of gaping clams. Farmers experiencing high levels of mortality due to QPX should harvest all clams from affected plots and allow these plots to fallow for at least two years (Hickey *et al.*, 2002).

Table 1. Percent prevalence of QPX in Rhode Island quahogs. *Modified from Lyons et al. (submitted for publication). * sampled in May. ** sampled in July by Dr. Inke Sunila. nr: not reported. Mean size (mm) corresponds to the thickness of the hinge.*

Location	Seed origin	Year planted	Year tested	Mean size (mm)	Number of clams tested	QPX Prevalence
Farm 1	South Carolina (I)	2001	2003*	12.9	30	0%
Farm 1	South Carolina (II)	2001	2003*	12.7	27	0%
Farm 1	Hawaii	2001	2003*	9.0	30	0%
Farm 1	South Carolina	2001	2003**	nr	60	85%
Farm 1	Hawaii	2002	2003**	nr	30	17%
Farm 1	South Carolina (I)	2001	2004	29.3	26	38%
Farm 1	South Carolina (II)	2001	2004	27.1	24	29%
Farm 1	Hawaii	2002	2004	22.9	25	32%
Farm 1	South Carolina (I)	2002	2004	24.9	25	28%
Farm 1	Hawaii	2003	2004	7.3	4	25%
Farm 1	South Carolina (I)	2003	2004	14.4	25	4%
Farm 2	Massachusetts	nr	2004	30.8	60	0%
NE Bay	Wild	unknown	2004	35.5	60	0%
NW Bay	Wild	unknown	2004	42.5	60	0%
W Bay	Wild	unknown	2004	53.6	30	0%
W Bay	Wild	unknown	2004	54.4	27	0%
Farm 1	South Carolina (I)	2002	2005	34.7	25	16%
Farm 1	Hawaii	2003	2005	29.2	50	16%
Farm 1	South Carolina (I)	2003	2005	26.4	25	20%
Farm 1	South Carolina (I)	2004	2005	20.7	50	8%
Farm 2	Connecticut	2004	2005	45.6	27	0%
NE Bay	Wild	unknown	2005	43.8	50	0%
NW Bay	Wild (relay)	unknown	2005	33.7	50	0%
Farm 1	South Carolina (I)	2004	2006	23.0	25	64%
Farm 1	Massachusetts	2005	2006	14.0	33	21%
Farm 2	Connecticut	2003	2006	57.0	50	0%

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