C R M C

Coastal Resources Management Council

Aquaculture in Rhode Island

2007 Yearly Status Report

Aquaculture in Rhode Island

2007 Yearly Status Report

Photo Credits.
Front cover; Clown fish in the state's newest fin fish farm which is the first spin off from the RIAI. Photo courtesy of Mr. Brad Bourque.
This page: The RV Jack Reed. The new CRMC research vessel has become a regular visitor to aquaculture sites in Rhode Island. CRMC Photo.

Prepared by:
David Alves
Aquaculture Coordinator
Coastal Resources Management Council
4808 Tower Hill Rd.
Wakefield, RI 02879-1900

A snapshot of the Aquaculture Industry in Rhode Island

For the year 2007

- The 2007 farm gate value of Rhode Island aquaculture products rose 18%.
- This is the 10th double digit increase in the past 12 years.
- For the second year in a row the total value of Rhode Island aquaculture exceeded 1 million dollars.
- The value of Rhode Island aquaculture per acre is an amazing $12,862.
- The number of farms in Rhode Island increased by two to 30.
- The total acreage under cultivation in Rhode Island rose to 123 acres.
- Aquaculture related industries in Rhode Island had gross revenue of $4.3 million dollars during the calendar year 2007.
- 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 2007.
- The Rhode Island Aquaculture Initiative finished in 2007. Investments made have enabled one new finfish farm to be established.
- Aquaculture of lobsters began in Rhode Island in 1898.
- In 1920 more than a million lobsters were released into the wild.

Table of Contents

Special Section:

Introduction

The year 2007 showed continued growth of the Rhode Island Aquaculture industry. Aquaculture in Rhode Island continues to be a very dynamic – albeit small - and fast growing industry. For the first time in eight years Rhode Island has a commercial finfish farm, which produces marine ornamental fishes for the aquarium trade. The farmgate value (the value for the product paid to the farmer) of the industry grew by slightly more than 18 percent. It is interesting to note that this year's increase in value, 18 percent, was accomplished with a small increase of 8percent in oyster sales and a large decrease of 60 percent, in clam sales. The increase appears to stem from a number of factors: higher price paid to the farmer, more farmers selling to the retail market and the addition of a finfish farm to the totals. The American oyster was the predominate species of shellfish grown accounting for 99 percent of the total harvest; the hard clam was the only other species cultivated, making up 1 percent of the total harvest. The amount of oysters harvested increased 8 percent from the previous year. Clam production saw a decrease of 60 percent in 2007 compared to the previous year. The number of farms under lease increased from 28 to 30, an increase of 7 percent. The acreage under lease increased to from 99 acres to 123, a 24 percent increase.

During the past year the CRMC Working Group on Aquaculture Regulations reconvened due to concerns about the lack of a long term plan for aquaculture development. The group first formed in 2000 and met until 2001, when the participants decided the issues had been explored and resolved. This series of meetings did result in changes in CRMC regulations and increased communication between the industries and regulators. This increased communication served the process well until 2007.

In early 2007 questions arose regarding increased aquaculture leasing in the salt ponds. The Rhode Island Marine Fisheries Council (MFC) and the RI Department of Environmental Management (DEM) Division of Fish & Wildlife voiced concerns on this topic. After a series of discussions and meetings between the CRMC and the MFC, the Council decided to withhold all opinions on aquaculture leases until a plan was in place. CRMC regulations require the agency to solicit opinions on all aquaculture leases from the Marine Fisheries Council and the DEM director. Communication was again needed, so the CRMC reconvened the working group in the hope that this important function could be restored. *(It is also important to note that the first series of working group meetings concerned Narragansett Bay and not the salt ponds. This round would focus on the salt ponds.)*

The Rhode Island Aquaculture Initiative, established in 2002, finished its funding this year. Growers competed for research grants and mini-grants, and the best grants received funding. Two aquaculture extension positions 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. 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 2007, increased 18 percent from the previous year's growth rate of 81 percent. Despite the increase, the overall trend is downward from the average of the last 11 years of 30 percent (see Table 1 and Graph 5). The 2007 farmgate value was estimated at $1,587,857, up from $1,348,525 in 2006, $744,319 in 2005, $572,994 in 2004, $563,891 in 2003 and $478,160 in 2002 (see Graph 1).

For the first time since 1999, shellfish did not comprise 100 percent of all Rhode Island aquaculture production in 2007. The first finfish farm in eight years opened in Warren to grow marine ornamental fishes for the aquarium trade. During the first year of operation the owners contributed a small amount to the industry. Considering the potential and the quality of the product grown this operation should substantially increase the overall industry value quickly. Industry-wide, the dominant species was the American oyster, with 2,551,493 pieces sold (see Graph 2). This is an 8 percent increase from the previous year, which resulted in an 18 percent increase (see Graph 3) in value in oyster production. Clam production was down significantly with an unusual 60 percent decrease in harvest (see Graph 2) which resulted in a 36 percent decrease in value (see Graph 3).

The number of farms active in Rhode Island aquaculture increased in 2007 to 30 active farms, as a result of growers establishing three new farms. This growth led to an increase in acreage under cultivation to 123 acres (see Graph 4). The production per acre of aquaculture in Rhode

Island was $12,862, a decrease from 2006 when it was $13,621, but still a large increase from $8,757 in 2005 and from the $8,185 per acre value for 2004.

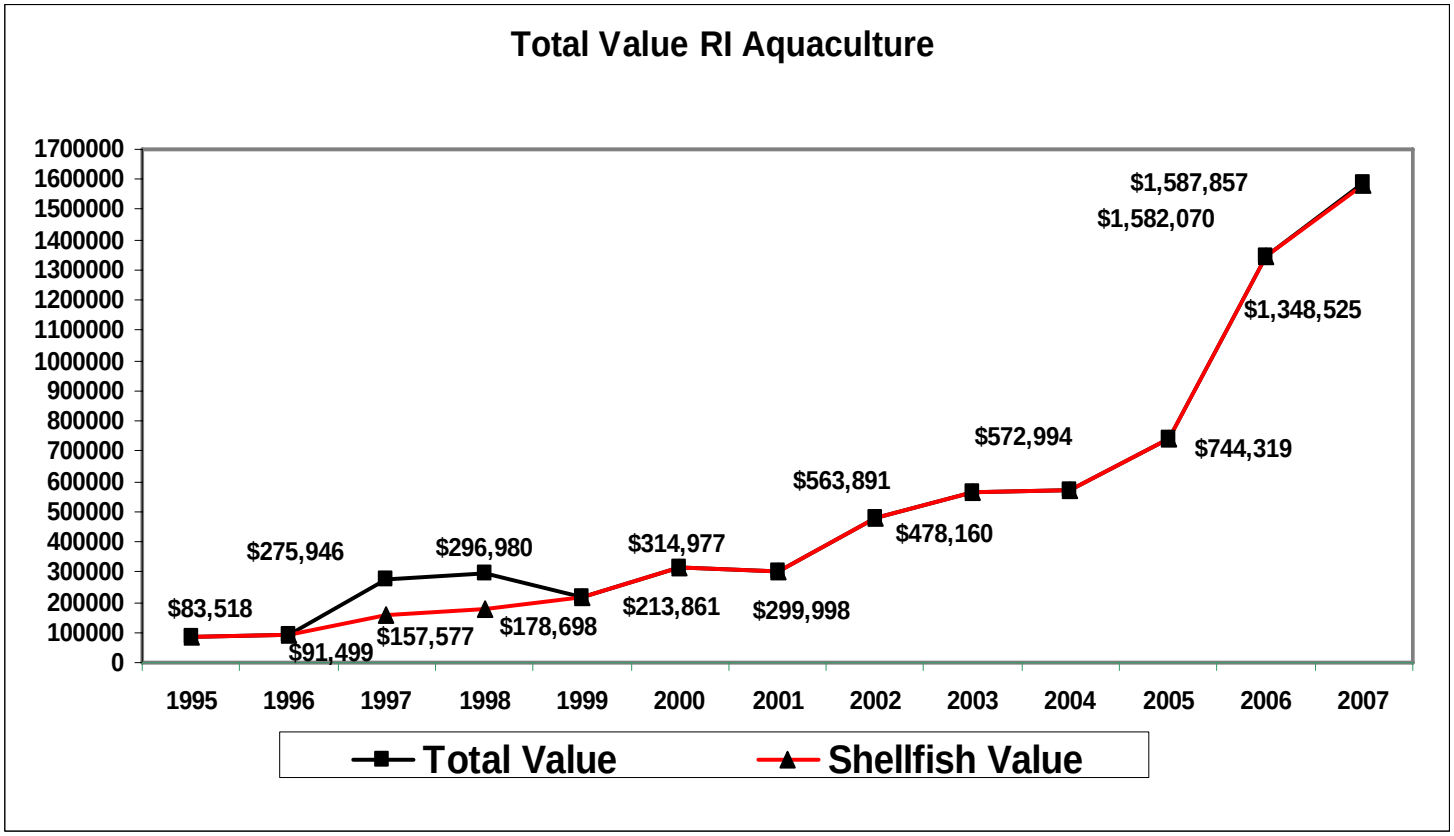
Farm-related employment increased slightly to 14 full-time, year-round and 28 part-time, year-round seasonal employees in the industry. Employment increased slightly during the summer with Rhode Island aquaculture farms hiring two full-time seasonal and 17 part-time seasonal workers.

In 2003 the CRMC began polling farmers on how much they invested in their farms. The reports indicate that growers are investing significant capitol; in 2007 growers invested $1,033,662 in their farms. This shows a large increase from 2006 when growers invested a total industry-wide figure of $886,288, and $852,500 in 2005. These figures are significantly larger than the $377,472 growers invested in 2004 and $271,000 in 2003. In 2007 investments averaged $34,455 per farm compared to $31,699 in 2006 per lease holder. Farm returns averaged $12,862 per acre.

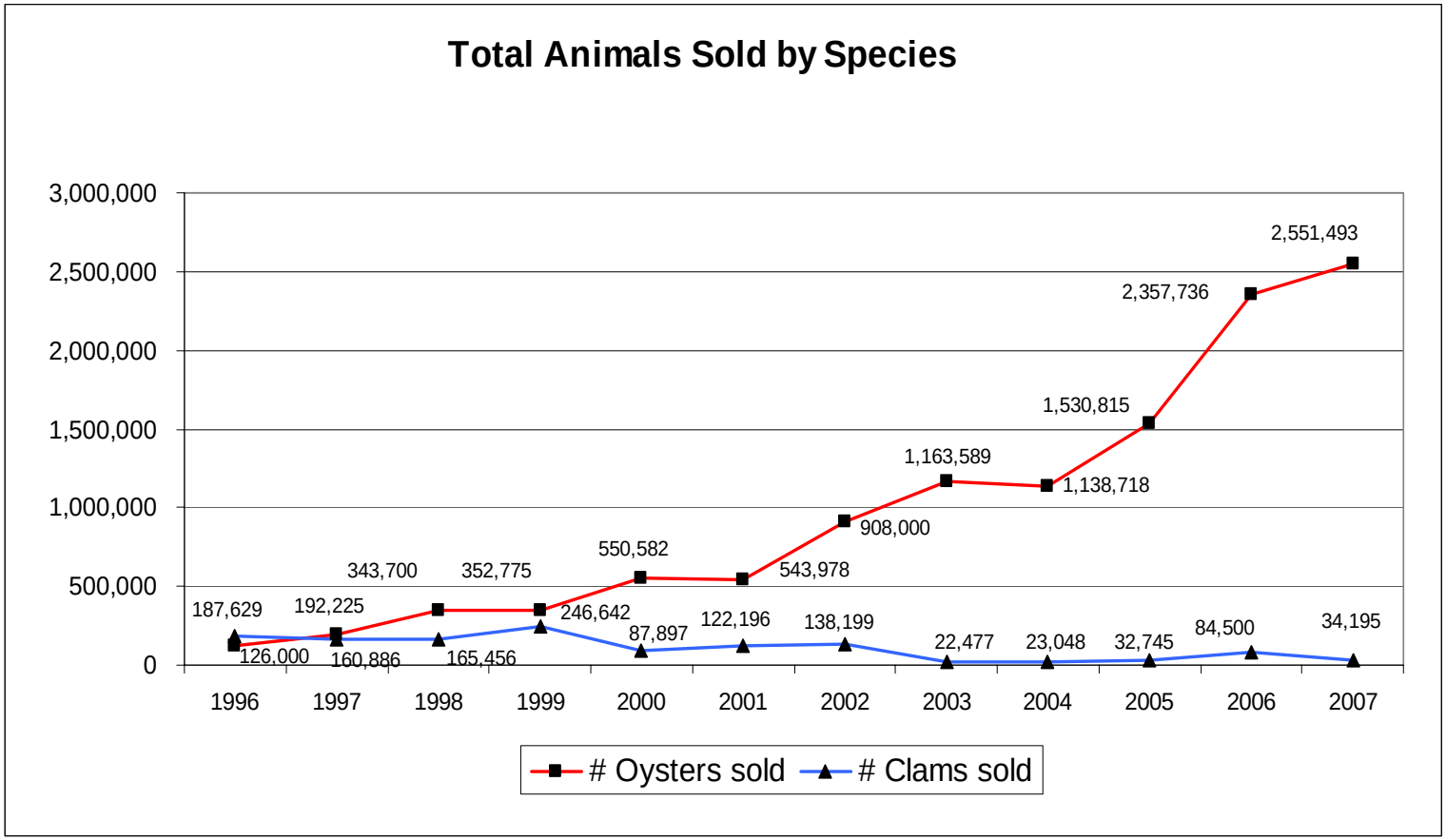
Table 1

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%
2006-2007	17.75%

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

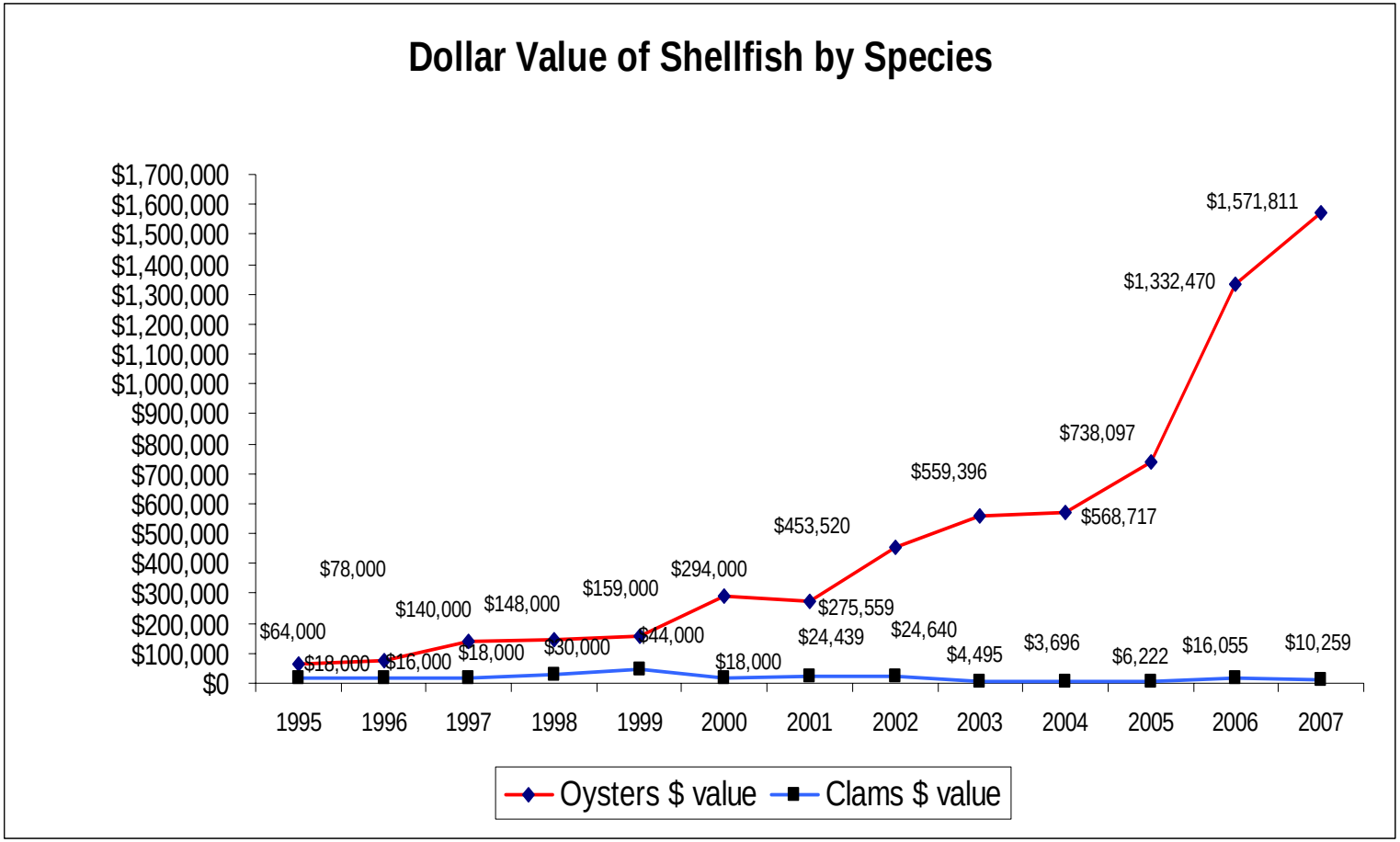


Graph 1
In 2007 total Rhode Island aquaculture production increased 18 percent. The total value indicated for the years 1997 and 1998 includes a retail ornamental finfish operation that was in business for those two years only. In all other years up to 2006 100 percent of Rhode Island aquaculture production is in shellfish. The two numbers for 2007 reflect the total value of all aquaculture products (the larger number) and the total shellfish value (the lesser number).



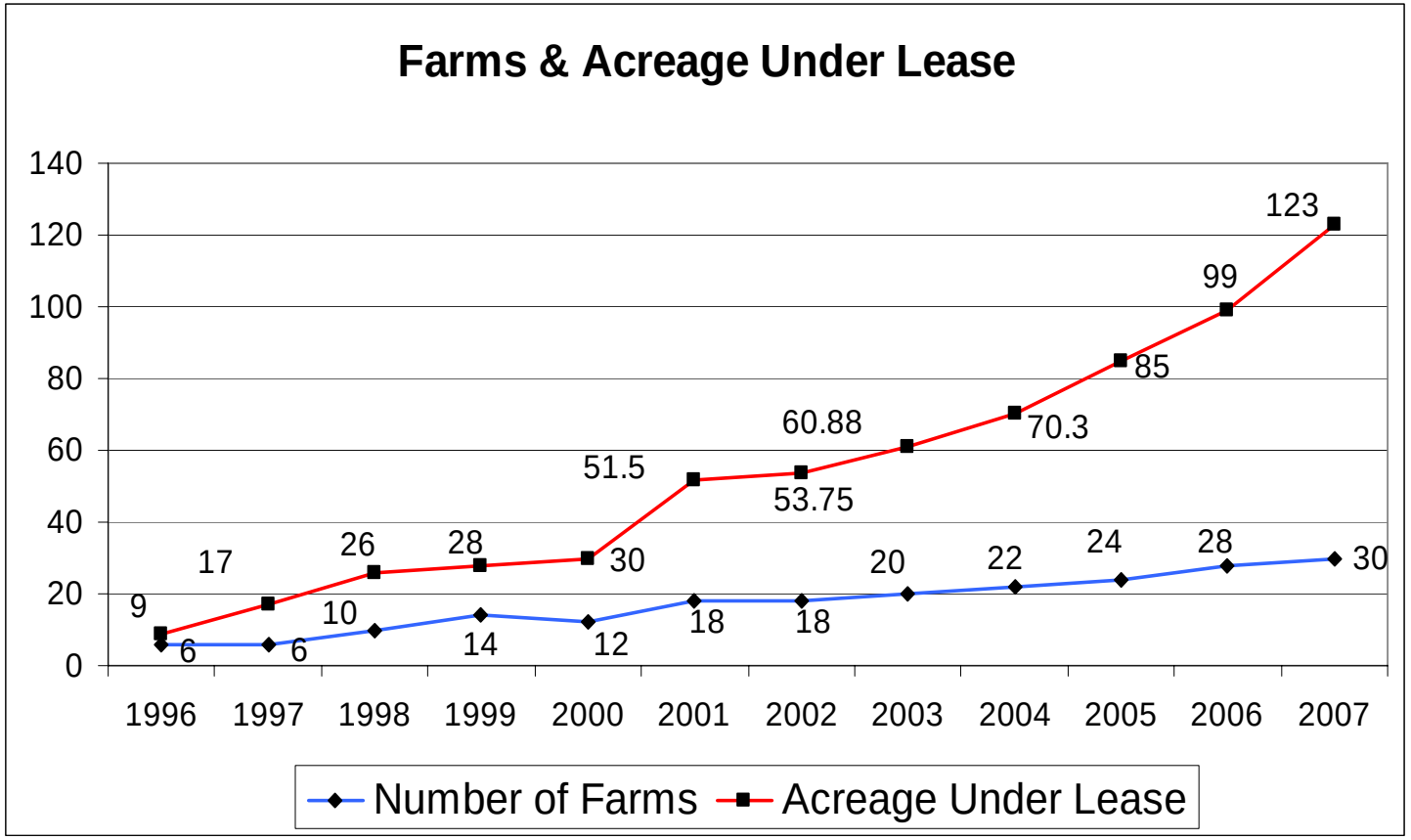
Graph 2

The American oyster is the dominant species cultured in Rhode Island waters. Oyster production accounted for 99 percent of the total Rhode Island aquaculture production. Growers reported 2,551,493 oysters sold in 2007, an increase of 8 percent from 2006. The culture of quahogs has decreased with approximately 34,000 being produced in 2007, a decrease of 60 percent from 2006.



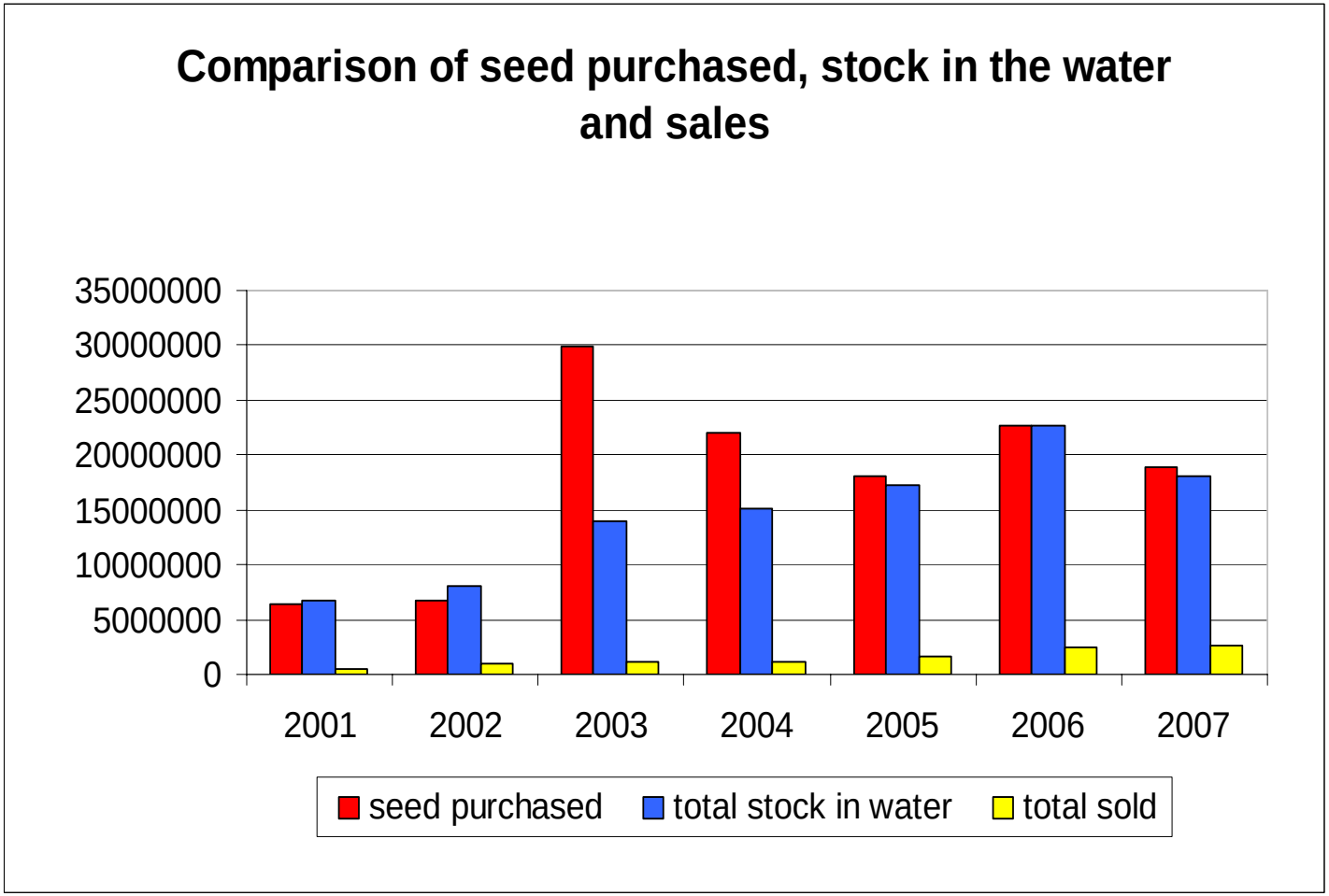
Graph 3

Graph 3 indicates the relative value of the shellfish production in Rhode Island for 2007.



Graph 4

Two new leases were established during 2007, and a couple of existing farms expanded. Farm totals for 2007 are 123 acres under cultivation and 30 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 40-60 percent per year is not uncommon in the shellfish industry.

CRMC Working Group on Aquaculture Regulations

During the past year the CRMC Working Group on Aquaculture Regulations began meeting again due to concerns about the lack of a long term plan for aquaculture development. The group first formed in 2000 and met until 2001, when the participants decided the issues had been explored and addressed. The meetings resulted in changes in CRMC regulations and increased communication between the industries and regulators. This increased communication served the process well until 2007.

In early 2007 the Rhode Island Marine Fisheries Council (MFC) and the RI Department of Environmental Management (DEM) Division of Fish & Wildlife questioned the increased aquaculture leasing in the salt ponds. After extensive communication between the CRMC and the MFC, the MFC decided to withhold all opinions on aquaculture leases until a plan was in place. CRMC regulations require the Council to solicit opinions on all aquaculture leases from the Marine Fisheries Council and the DEM director. Communication was a problem, so the CRMC decided to reconvene the working group to restore communication. (*It is also important to note that the first series of working group meetings concerned Narragansett Bay and not the salt ponds. This round would focus on the salt ponds.*)

The working group began meeting in the spring of 2007. The group was comprised of representatives from:

- NGOs: Save The Bay, Salt Ponds Coalition, The Sierra Club;
- Industry representatives: RI Farm Bureau; OSAA, RISA, RISAA, MFC
- Academia: URI, RWU
- USDA, State legislators
- Regulatory agencies: DEM F&W, DOH, CRMC

There are a total of 28 members, more than half of which attend the monthly meetings.

The extent of aquaculture leasing in the state is quite small. As of fall 2007:

- Total in all RI waters = 110 acres = 0.037% of total State waters
- Salt ponds = 5,387 acres/55 acres aquaculture = 1.0%
- Narragansett Bay = 87,723 acres/55 acres of aquaculture = 0.062%
- Combined Salt Ponds and Narragansett Bay = 0.12%

Because of concerns about the expansion of aquaculture in the salt ponds, the amount of aquaculture in the ponds as of 2007 is:

- Ninigret Pond = 0.25%
- Winnapaug Pond = 1.91%

- Potters Pond = 1.81%
- Pt. Judith Pond = 2.54%

The CRMC has been very enthusiastic in supporting the transition of the participants of the traditional shellfishing industry. As a result, the percentage of leases held by shellfishermen is significant: 57 percent of leases in the salt ponds and 39 percent of all aquaculture leases throughout the state.

Armed with this information, the working group has been meeting monthly, and has met a number of significant goals. One of these is the report for the Biology Subgroup, chaired by Dr. David Bengtson, which was issued in the fall of 2007. The working group had three months to review and make suggestions before the report was unanimously accepted by the full working group in January 2008. The full report can be viewed on the CRMC web site at: http://www.crmc.ri.gov/projects/aquaculture.html. The web page also contains an extensive list of peer-reviewed scientific articles on the impacts of aquaculture and the environment, presentations and reports.

The biology report suggested a number of scientifically defensible changes including:

- Limit shellfish aquaculture to 5 percent of any water body
- Seek funding for research into interactions between aquaculture and the environment.
- Establish inter-agency board to make disease recommendations
- Fund disease monitoring in wild and cultured populations
- Continued participation in Aquatic Nuisance Species Committee and further activities
- Continue to protect natural resources in leasing process
- Encourage BMPs for aquaculture industry

A second significant achievement of the working group has been to conduct a charting project for all of the Rhode Island salt ponds, thanks to Mr. David Beutel, who also conducted the charting project for Narragansett Bay during the first working group meetings. The working group has also approved a standardized marking for aquaculture farms, and is working on suggested program changes for the CRMC and DEM regulations concerning aquaculture. As in the first series of working group meetings, the most important achievement has been increased communication between all of the industry groups.

The working group hopes to finish its work this summer. As to what remains to be done, a consensus is being forged on suggested regulatory changes. Once these are made an aquaculture development plan will be drafted, and then submitted to the regulatory agencies.

Aquaculture-Related Industries

The other aquaculture related industries in Rhode Island are the largest contributors to the state's 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 $4.3 million in business in the state in 2007. These companies employ 25 full-time employees, from the same number as in 2006.

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 nationally-recognized for quality education and research, which results in grant monies flowing into the state for 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 complement the efforts of URI in the aquaculture arena and is growing into a center of excellence in its own right. Both universities contribute greatly to the state's economic bottom line and support a viable aquaculture industry. URI has professors who are recognized as experts 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 2007

Aquaculture Activities at the University of Rhode Island - 2007

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

As reported in this space last year, the University of Rhode Island pursues a traditional mission of teaching, research, and service in the area of aquaculture. The activities are spread among a variety of departments at two campuses of the University, but more importantly are conducted around the state and the world.

Teaching

URI offers a variety of aquaculture courses in its Aquaculture and Fisheries Technology major. In 2007, they included Introductory Aquaculture, Finfish Aquaculture, Crustacean Aquaculture, Shellfish Aquaculture, Ecological Aquaculture, Marine Finfish

Aquaculture, Salmonid Aquaculture, Applied Physiology of Fish, Shellfish Aquaculture Laboratory, Pathobiology, Advanced Aquaculture Systems, and Fish Nutrition. In addition, undergraduate students take Special Projects courses to take advantage of research opportunities in aquaculture. At the graduate level, URI awarded three Master of Science degrees and one Doctor of Philosophy degree to students who worked on aquaculture topics in 2007.

Research

URI researchers bring in considerable funding each year to support aquaculture research projects involving both graduate and undergraduate students, as well as post-doctoral fellows.

New projects include:

• *Bivalve Disease survey, State of Rhode Island*: Dr. Marta Gomez-Chiarri will conduct disease surveys of both wild and cultured bivalves for RI DEM.

• *Improving oyster aquaculture in Rhode Island: development and testing of the Rhodoyster*: Working with Dr. Dale Leavitt (RWU) and RI oyster farmers, Dr. Gomez-Chiarri will develop a disease-resistant strain of oysters for RI.

• *Matrix metalloproteinases and hemocyte migration in oysters*: Dr. Gomez-Chiarri and Dr. Mercedes Rivero-Hudec will expand an existing project to study (see below) specific mechanisms by which these molecules help shellfish defend against disease.

• *Alternative feeds for freshwater aquaculture species*: Drs. David Bengtson and Chong Lee will work with a UConn colleague and scientists in Vietnam to develop feeds for fish in freshwater culture there.

• *Economic analysis of offshore bluefin tuna aquaculture in the U.S.*: Dr. James Anderson and graduate student Gina Shamshak try to determine whether tuna culture along the East Coast of the U.S. will be economically feasible.

Existing projects include:

• *Role of matrix metalloproteinases in immune defense*: Dr. Gomez-Chiarri will examine these molecules in relation to shellfish diseases.

• *Role of follistatin in the regulation of muscle growth*: Dr. Terry Bradley 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 will expand his research on regulation of genes that control the virulence of this bacterium that infects finfish in aquaculture.

• *Investigation of disease-resistant strains of oysters for RI*: Dr. Gomez-Chiarri and Dr. Dale Leavitt (Roger Williams University) completed this RIAI-funded research.

• *Investigations of seafood markets and consumer choices for wild vs. farmed products*: Drs. James Anderson and Cathy Roheim 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 and Chong Lee 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 completed a study of the cage culture of tuna off the coast of Mexico and its environmental impacts.
• *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 aquaculture faculty participated in the CRMC Working Group on Aquaculture Regulations during 2007. Dr. Bengtson chaired the Biology Subcommittee, which produced a report to which Drs. Gomez-Chiarri, Costa-Pierce and adjunct faculty member Dr. Robert Rheault contributed heavily. Dr. Michael Rice served on the Regulations Subcommittee of the Working Group as well.
• URI continued to provide technical assistance 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 Kate Markey (URI) to monitor environmental conditions at oyster farms. Also as part of that program, Dr. Gomez-Chiarri and Ms. Markey are 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.
• Dr. Rice's outreach roles also included service as a member of the steering committee for the next Northeast Aquaculture Conference and Expo, a participant in the Northeast Aquaculture Extension Network (funded by the Northeastern Regional Aquaculture Center), and a stint for the U.S. Agency for International Development assisting the Republic of Georgia with development of shellfish aquaculture.
• Drs. Bengtson, Costa-Pierce and Dr. Richard Rhodes served on the Board of Directors of the Northeastern Regional Aquaculture Center and Dr. Costa-Pierce served as Vice-President of the World Aquaculture Society.

Roger Williams University has been investing in the future of Rhode Island aquaculture. The Director of the Roger Williams University Center for Economic and Environmental Development, Dr. Timothy M. Scott, provided this report with the following project summary for the activities conducted during 2007.

Roger Williams University
Center for Economic and Environmental Development
Dr. Timothy M. Scott, Director

The mission of the Center for Economic and Environmental Development (CEED) is to promote the development of the marine economy in an environmentally sustainable manner. For the past several years this has included an active and innovative aquaculture research program that includes operating Rhode Island's only shellfish hatchery and conducting a variety of creative programs on shellfish restoration.

Hatchery Production Summary: The CEED hatchery operates on a seasonal basis (January to August) in order to produce the shellfish seed to be used in a variety of shellfish restoration efforts and research projects. The hatchery relies on our students who are trained in all aspects of shellfish culture, from algae production to nursery culture. This year, seventeen students worked directly in the hatchery, with five staying over the summer to ensure the successful completion of our production schedule. In 2007, the hatchery produced native bay scallops (*Argopecten irradians*), quahogs (*Mercenaria mercenaria*) and oysters (*Crassostrea virginica*). In addition, the hatchery is one of the most highly visible and active venues on campus, and as in the past, we were involved in numerous public education workshops.

Bay Scallops: This year the hatchery received many inquiries from those interested in obtaining bay scallops. We produced ~ 80,000 (10-30 mm) seed, which were disbursed among shellfish farmers in Rhode Island through the North Cape Shellfish Restoration Project, and on Cape Cod through the Barnstable (Massachusetts) Cooperative Extension. We also provided seed to the University of Rhode Island for use in their shellfish aquaculture course.

Bay Scallop Research: Undergraduate Students were involved in research projects to investigate bay scallop algal diets (supported by the RI-EPSCoR program) and settlement on artificial surfaces (supported by the EPA's bay scallop habitat suitability model). Internal CEED Research funds continue to support these investigations, and student research findings will be presented at the 2008 Milford Aquaculture Seminar, the National Shellfisheries Association Annual Meeting, and the Benthic Ecology Meeting in April.

Quahog Seed: This year we produced about ~680,000 seed of which ~450,000 were provided to the Rhode Island Shellfishermen's Association (RISA) whose members operate a nursery upweller in Greenwich Bay. For four years now, we have been providing quahog seed to RISA members who have grown the seed in their nursery until it reaches a size suitable for planting. For the first time this year, we are seeing a large return on this investment. Young clams planted in 2004 near the mouth of the Green River are now showing up in the bull rakes of RISA members. These clams have a distinctive shell marking, which is how we know that roughly one third of the clams being harvested from the original planting site were hatchery raised.

Quahog Research: In 2007, we assisted with the quahog production at a community shellfish hatchery operated by the Town of Westport, Massachusetts. In partnership with the Westport Shellfish Constable, RWU students spawned and successful produced ~ 200,000 quahog seed which have been planted (at an undisclosed location!) in the Westport River Estuary. We continue to collaborate with colleagues at URI, the MBL and Rutgers in studies to elucidate the impact of QPX on local clam stocks.

Oysters: The CEED hatchery produced eyed-oyster larvae using a technique known as *remote setting* for the Oyster Gardening Program. In all, ~25 million eyed larvae were set onto 400 bags of shell cultch that had been obtained from the Blount Seafood Company. Once set, these bags were placed into the Blount Oyster Pond on Prudence Island and also provided to the 58 members in our 2007 Oyster Gardening Program. Oyster growth and survival was exceptional this year, and on December 8, 2007 we planted ~400,000 juvenile oyster seed. One third of these were planted in Jenny's Creek to continue the restoration efforts at the location, with the remainder divided between artificial oyster reefs in Bristol Harbor (the second year of planting at this location) and a new site at High Banks, outside of Greenwich Bay.

Oyster Research - Jenny's Creek Oyster Pond:

With the ongoing support of the Shellfish Restoration Foundation of Narragansett Bay and the Blount Family, CEED staff and students continued to maintain the oyster rafts and string culture arrays that Luther Blount established on Prudence Island, In 2007, we gain used the Blount Oyster Pond as a nursery for many of the young oysters produced by remote setting. Two year old oysters in the pond were transferred to newer culture rafts and older raft systems were removed from the pond for rehabilitation. As the oysters grow larger, their weight strains the raft system, and as a consequence three year old oysters were removed from the string system and placed into an alternative floating line-bag culture system. These oysters will be planted onto the bottom free of gear during the spring of 2008.

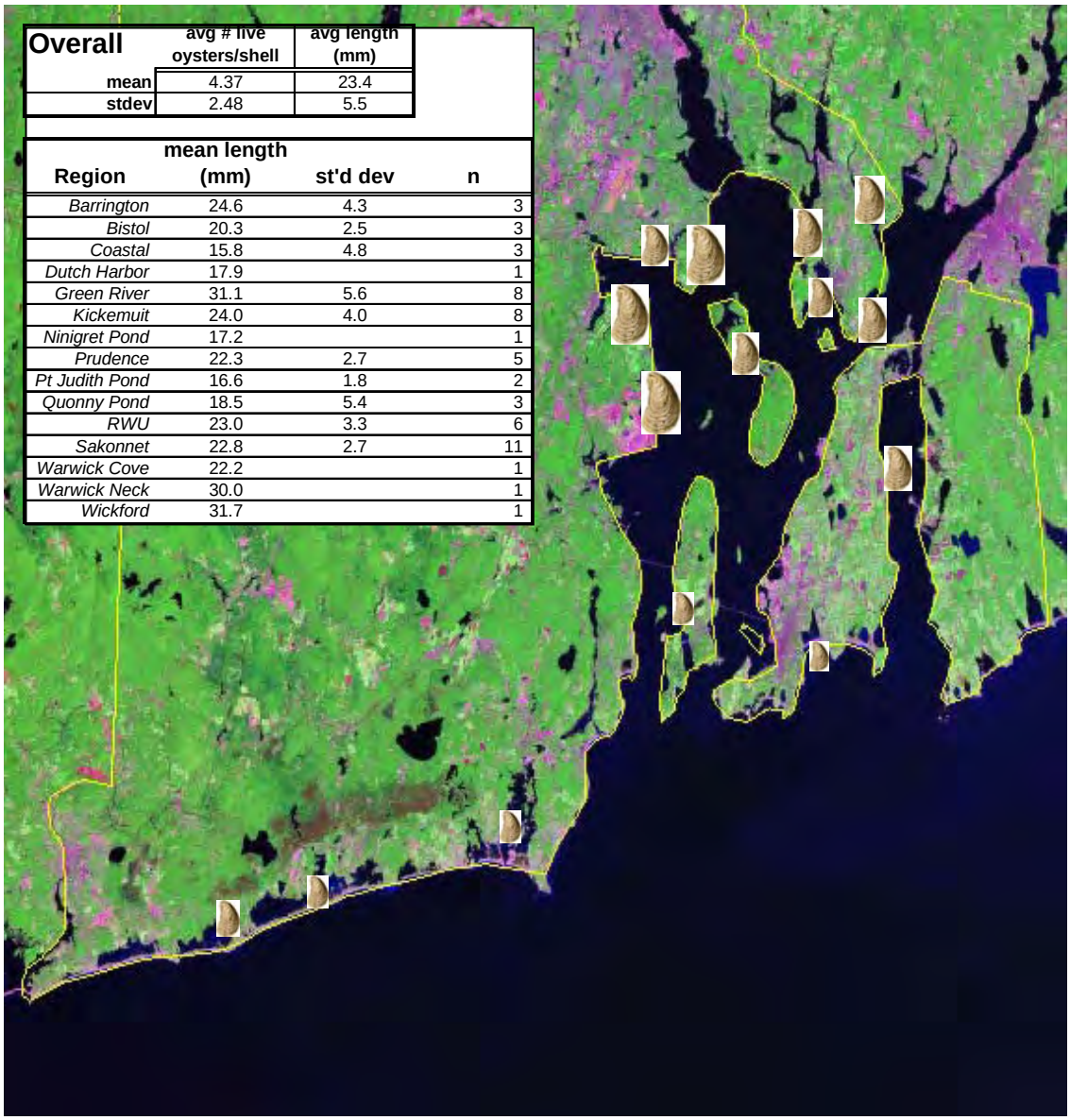
Additional Shellfish Projects:

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. Ongoing research projects that rely on our hatchery production include: Developing disease resistant oysters for Narragansett Bay; Culturing alternative species (e.g., surf clams and razor clams); Examining the effectiveness of "Reef Balls" in fish and shellfish restoration; Providing aquaculture extension and education opportunities; Promoting the environmental services provided by shellfish cultivation.

Oyster Gardening:

With initial funding from the RI Aquaculture Initiative, CEED instituted a pilot-scale oyster gardening project in 2006 for Rhode Island. The 18 waterfront landowners that participated that year grew to 58 in 2007 as participants from around the state volunteered to become OGREs (Oyster Gardening for Restoration and Enhancement) in the expanding program. Young oysters, called spat, are reared in the CEED hatchery and set onto shell. Each oyster garden consists of a floating raft that holds roughly 6,000 young oysters. The volunteer OGREs place these rafts at available private docks or moorings and maintain the rafts as the oysters grow over the summer. In the fall, all of the oysters are collected by CEED Staff and planted at restoration sites around the bay. For 2007, we planted approximately 350,000 juvenile oysters throughout the state.

This program provides nursery sites for oyster growth but also offers abundant opportunities to educate the public about shellfish aquaculture and the harvest industry as well as about the positive environmental benefit of a healthy shellfish population. CEED also collects data from the sites to add to a continuing record of oyster growth and production in the state. The figure below is a scaled representation of the final juvenile oyster sizes at planting in RI waters, following the 2007 oyster gardening season.



Overall	avg # live oysters/shell	avg length (mm)
mean	4.37	23.4
stdev	2.48	5.5

Region	mean length (mm)	st'd dev	n
Barrington	24.6	4.3	3
Bistol	20.3	2.5	3
Coastal	15.8	4.8	3
Dutch Harbor	17.9		1
Green River	31.1	5.6	8
Kickemuit	24.0	4.0	8
Ninigret Pond	17.2		1
Prudence	22.3	2.7	5
Pt Judith Pond	16.6	1.8	2
Quonny Pond	18.5	5.4	3
RWU	23.0	3.3	6
Sakonnet	22.8	2.7	11
Warwick Cove	22.2		1
Warwick Neck	30.0		1
Wickford	31.7		1

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.

In 2007, this project led to the formation of **New England Marine Ornamentals, Inc.**, a private company in Warren, RI that is producing marine ornamental species for the aquarium trade.

Acknowledgements: Our successful 2007 season would not have been possible without the generous assistance and/or support from: Shellfish Restoration Foundation of Narragansett Bay and the Blount Family, Island Foundation, USDA Sustainable Agriculture Research and Education Program, Narragansett Bay National Estuarine Research Reserve, Dr. Marta Gomez-Chiarri, Town of Westport, Mass., the Women's Fisheries Network, the RI Aquaculture Initiative, RI Department of Environmental Management, RI Shellfisherman's Association, the Ocean State Aquaculture Association and the RI Coastal Resources Management Council.

The 2nd Annual RWU ***Oyster Fest***, December 8, 2007 - A chance to thank everyone involved for a terrific season and a celebration of all things shellfish!

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, has provided the following description of their activities.

Rhode Island Shellfisherman's Association (RISA)

Michael McGiveney, President

RISA looks forward to continuing, expanding and improving the seed program under the guidance of Owen Kelly and Dr. Dale Leavitt and Roger Williams University. We plan on operating two upwellers in Warwick cove and growing an estimated 2 million clam seed. RISA also is pursuing funding from DEM F&W and plan on working with them more extensively this year to come up with a more comprehensive Shellfish restoration program. We were also happy to show results from previous plantings.

Save The Bay

In continuing the effort to bring all of the interested stakeholders into the discussion on the future of aquaculture in Rhode Island, Save The Bay has taken an active role. In addition to participating in the discussions about the future of aquaculture in Rhode Island, Save The Bay is also conducting restoration projects, summarized below.

Save The Bay

Save The Bay supports aquaculture but also recognizes the need for a state-wide plan that balances biological, economic and social impacts including the Public Trust. We are an active member of the CRMC Aquaculture Working Group collaborating to define a rational framework whereby new applications and expansions of aquaculture lease areas shall be evaluated. Additionally, Save The Bay specifically engages in shellfish restoration with caged scallop spawning sanctuaries. The bay scallop (*Argopecten irradians*) was historically a prevalent native species in Narragansett Bay, but has since declined over the last several decades. Habitat loss and overfishing are believed to be potential factors in the decline of the scallop population in

Narragansett Bay. Improvements in water quality and recent eelgrass mapping efforts indicate suitable habitat for shellfish species may exist in the southern end of Narragansett Bay. This project enhances our education and habitat restoration programs as well.

United States Department of Agriculture

The USDA Rhode Island Natural Resources Conservation Service office in Warwick has also provided a report this year. The local USDA office has been working with the aquaculture industry in Rhode Island.

USDA Natural Resources Conservation Service (NRCS)
Shellfish Management Program Update

Mr. Andy Lipsky

USDA NRCS is continuing to serve the conservation needs of Rhode Island waters and the production needs of Rhode Island's growing shellfish aquaculture industry. The Rhode Island NRCS Shellfish Aquaculture Management Program turns two years old on April 24, 2008. Since 2006, NRCS has been assisting shellfish farmers efforts to implement conservation practices on Rhode Island shellfish farms, providing over $435,000 in conservation cost share assistance. Our 2008 Environmental Quality Incentives Program (EQIP) sign up has led to some very exciting and innovating projects that will result in increasing conservation implementation on farms as well as tapping into the "know-how" of our growers to ramp up oyster restoration programs in Rhode Island.

EQIP Overview:

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. 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.

Shellfish farmers who are 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 also include other types of conservation treatment systems to fully address resource concerns, such as processing biofouling residues in a waste transfer facility.

Summary of RI NRCS EQIP Shellfish Management Funding

- **2006** - 11 growers out of approximately 30 in the state signed contracts for the newly developed program. A total of $282,212 was obligated to help implement best management practices on approximately 55 acres of shellfish farms in almost every county across the state.

- **2007** - 4 additional growers, as well as well as one 2006 EQIP contract holder applied and received funding to implement shellfish BMPs. A total of $132,472 was obligated on 13 additional acres of the bay and coastal ponds.

- **2008 (Sign Up 1)** – 1 additional grower and two 2006 EQIP contract holders applied and received funding to implement additional shellfish BMPs. A total of $20,749 was obligated on 4 additional acres.

- **2008 (Sign Up 2)** – 8 applications with a total request of approximately $1,000,000 to restore oyster habitat is now under consideration for funding.

Program Performance:

The good news is that our shellfish industry has been extremely motivated to implement their shellfish management conservation plans and conservation best management practices (BMPS) that we have contracted with them to implement. This has resulted in getting conservation on the ground and in the water and providing the cost share necessary to make the economics work for the producer. Over all, approximately 73 percent of the total funds we have obligated in FY 2006, FY2007, and FY2008 or $318,000 has been paid out to RI shellfish farmers to implement a wide range of conservation BMPs.

What's new in 2008:

In 2008, the RI NRCS Shellfish Aquaculture Program has grown to include a shellfish restoration component. Eligible shellfish farmers will be able to participate in oyster habitat restoration under the EQIP programs, by growing oysters on cultch and planting them at designated and approved restoration sites. The goal of this effort is to increase essential oyster

habitat to benefit a wide range of aquatic organisms as well as improve water quality simultaneously.

Thanks in large part to Dave Alves, CRMC; Dale Leavitt, Roger Williams University; Caroly Shumway & Boze Hancock, The Nature Conservancy; and the Ocean State Aquaculture Association and its member farmers, NRCS was able to develop a shellfish restoration management practice to meet the program requirements of EQIP and the realities of building a successful oyster restoration in Rhode Island.

In March 2008 NRCS received EQIP applications from eight shellfish farms seeking financial assistance to restore oyster reef habitat throughout Rhode Island waters. In total approximately $1,000,000 is being requested by these applicants to transplant 4 million oysters/year at oyster reef restoration sites for three years, or a total of 12 million oysters. NRCS will be notifying applicants by April 7, 2008 whether or not they will be funded. Many of the details to implementing these oyster restoration contracts remain to be worked out, but much progress has already been achieved in a recent shellfish restoration workshop hosted by RWU on March 27, 2008. NRCS will continue to work with these growers and the recently formed shellfish restoration collaborative now emerging between the wild and commercial industries, regulatory authorities, NGOs, and the academic community to develop a successful oyster restoration program in Rhode Island.

Rhode Island Sea Grant

Rhode Island Sea Grant has been very active in promoting aquaculture in Rhode Island, and has contributed this report for 2007.

Rhode Island Sea Grant (RISG) Aquaculture Engagements, 2007

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 2007 have been:

- Continuing oversight of research awards as they wind down towards completion. The total award program closed on 30 September, 2007. A final/completion report to NOAA was

developed and submitted by 30 November, 2007, ending RISG administration and management responsibilities.

Other RISG efforts in aquaculture during 2007 have been:

- Continuing management of the Husbandry & Management Section of the international journal Aquaculture (Elsevier Press, Amsterdam, The Netherlands). RISG processed ~400 international, scientific manuscripts for Aquaculture in 2007.

- Continuation of the Rhode Island Sea Grant Fellow in Aquaculture Journal Management, providing 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. Mr. Kifle W. Hagos, Ph.D. Candidate, URI Fisheries & Aquaculture/IGERT Program, currently is serving in this position.

- As part of the RISG 2008-2010 Omnibus, Cathy Roheim will receive funds to support work in Sustainable Seafood, developing a Sustainable Seafood website and supporting several Sustainable Seafood Fellows over the grant period.

- Rhode Island Sea Grant completed activities associated with the World Wildlife Fund in developing a White Paper on the Impacts of Nutrients from Salmon Aquaculture on Water Column Ecosystems.

- Rhode Island Sea Grant completed activities associated with an assessment of tuna ranching in Mexico. A final report "MARINE SCIENCE ASSESSMENT OF CAPTURE-BASED TUNA (*Thunnus orientalis*) AQUACULTURE IN THE ENSENADA REGION OF NORTHERN BAJA CALIFORNIA, MEXICO" was submitted as part of project completion.

- The Rhode Island Sea Grant Director completed a major global review for the FAO titled, "An Ecosystem Approach to Marine Aquaculture".

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 U.S. Senator Jack Reed (D-RI), had been appropriated for planning and advancement of aquaculture in Rhode Island. The project was called the "Rhode Island Aquaculture Initiative." During 2002 Rhode Island Sea Grant, Roger Williams University and the University of Rhode Island signed a memorandum of understanding 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 formed to determine which projects would make use of the $1.5 million in funding. 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.

RI Sea Grant manages a web page to encourage all who might be interested to stay advised 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 focus of the Ocean State Aquaculture Association members in 2007 was working with the Rhode Island Shellfisherman's Assoc., CRMC, DEM, Save The Bay, URI, RWU and members of the Aquaculture Working Group to develop a plan for aquaculture in Rhode Island. During this process Association members had the opportunity to thoroughly describe culture methods to the wide range of user groups involved. Growers and other members of the Aquaculture Working Group are researching the impacts of methods used for shellfish aquaculture in Rhode Island as well as other aspects of the aquaculture industry in order to develop the plan for aquaculture. Ocean State Aquaculture Association members have continued to work towards increasing its contribution to sustainable agriculture in Rhode Island.

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.

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 and others, 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. Michael M. Tikoian, CRMC Chairman; Mr. Grover J. Fugate, CRMC Executive Director; Ms. Laura Ricketson-Dwyer, CRMC; Mr. Bill Silkes, American Mussel Harvesters Inc.; Mr. Perry Raso and Dr. Robert Rheault, OSAA; Mr. Peter Sebring, Atlantic Aquaculture Supply; Mr. Michael McGiveney, Rhode Island Shellfishermen's Association; Dr. Tim Scott, Roger Williams University; Dr. David Bengtson, University of Rhode Island; Dr. Barry 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.

Survey of major diseases affecting Rhode Island cultured bivalves

Kathryn R. Markey and Marta Gómez-Chiarri
University of Rhode Island

Introduction

Problems associated with disease constitute the largest single cause of economic losses in aquaculture (Meyer 1991). Shellfish disease not only affects cultured shellfish in Rhode Island, but also wild populations. Four major diseases have been found in oysters in Rhode Island waters. The most prevalent disease in Rhode Island oysters is dermo disease, caused by a protozoan parasite, *Perkinsus marinus.* Originating the in the Gulf of Mexico, dermo disease has migrated up the Atlantic Coast of the United States reaching Delaware Bay by 1950 and New England by the early 1990's (Ewart and Ford 1993). Presently Dermo has been found as far north as Maine (Barber, 2000). Two other protozoan parasites, *Haplosporidium nelsoni*, causative agent of Multinucleated Sphere X (MSX) disease, and *Haplosporidium costale*, causative agent of seaside organism (SSO) disease, have also been detected in Rhode Island oysters in the recent past (1998 – 2001). MSX disease outbreaks resulted in large scale mortalities in Connecticut in the late 1990s (Sunila et al., 1999). Mortalities from these diseases have resulted in record low landings and severely affect restoration efforts in the Mid-Atlantic region (Ewart and Ford, 1993). Typically the proliferation of these parasites in oyster tissues is observed when the warmer water temperatures of the year occur (above 20°C) along with high salinities (above 18 psu). The intensity and prevalence of these diseases show seasonal cycles, with increases throughout the summer and a peak in late summer or early fall. Mortalities are usually seen in the late summer and fall (Ford and Tripp, 1996).

Another disease observed in oysters in Rhode Island is *Roseovarious* Oyster Disease (ROD), formerly known as Juvenile Oyster Disease (JOD). ROD is caused by a proteobacterium, *Roseovarious crassostreae*. This disease was first discovered in Maine in the mid-1980s. Recently it is becoming more prevalent in the southern New England region, causing recurrent mortalities in different areas of the Northeast (Boettcher et al., 2006). Mortalities due to ROD are usually observed during the nursery phase of the oyster grow-out process, when shellfish are less than 25 mm in shell height. These small oysters appear to be especially susceptible when seawater temperatures reach greater than 20°C at sites with water salinity above 20 psu (Boettcher et al., 1999; Bricelj et al., 1992; Ford and Borrero, 2001).

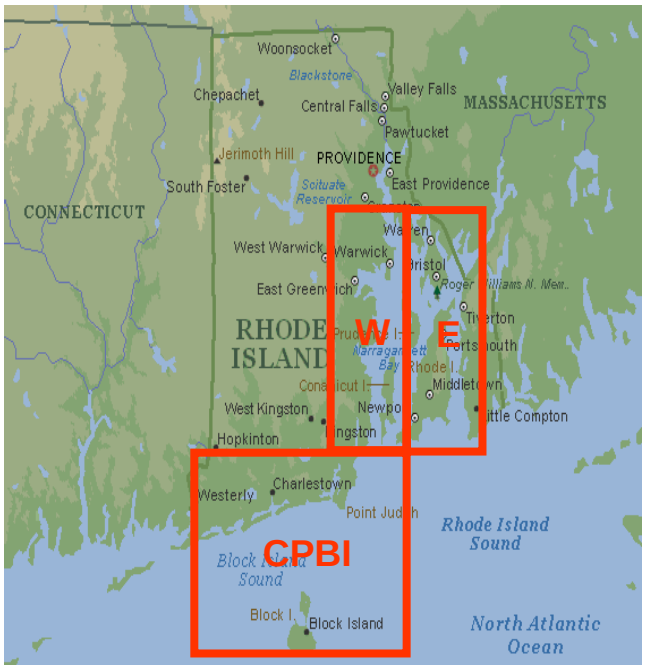
With no treatments available to eliminate these diseases from infected individuals, proper management of shellfish populations, both wild and cultured, is critical in the control of the spread of these diseases (Ford and Tripp, 1996). Seasonal monitoring of the prevalence and intensity of infections can provide an adequate description of locations and populations which are at the greater risk of infection or at risk of spreading infections.Here in the Ocean State, the Rhode Island Department of Environmental Management (RIDEM) funded a survey of diseases affecting bivalves from 1998 to 2002, and then again in 2004. This survey was important in order to protect priceless wild and cultured shellfish populations. The survey was also performed in 2005 thanks to funding by the Rhode Island Aquaculture Initiative (RIAI), and in 2006 and 2007 in selected farms who participate in the USDA/NRCS EQIP program. These surveys have

resulted in valuable information on prevalence and intensity of these major diseases affecting Rhode Island bivalves, and are being used in management decisions, such as the transfer of seed and adult shellfish within state waters.

Summary of results from the 2007 bivalve disease survey

Oysters (25 per site) from two year classes (approximately 1-year old and 2-year old oysters) were collected from 14 farms in Rhode Island in August – September. Twenty five oysters were also collected from selected wild locations. These samples were processed for disease diagnosis using standard techniques (culture in Ray's fluid thioglycollate medium for dermo disease and histopathology for all other diseases). In order to maintain farmers' privacy, we have combined the results for each main geographical area in Rhode Island (Fig. 1). Results on the prevalence and intensity of dermo disease in 2 year-old oysters collected in 2007 are compared here to levels of prevalence and intensity of dermo and MSX diseases from previous surveys (1998-2006) (Figure 2).

Figure 1. Geographical areas included in the survey. W: West Narragansett Bay; E: East Bay; CPBI: Coastal Ponds and Block Island.



Dermo disease in wild oysters

Dermo disease was found to be present in all wild locations sampled in Rhode Island from 1998 to 2007; percent prevalence ranged from 3-100%. In 2007, five wild sites were sampled, all of which were found to be affected by dermo disease. The most infected wild oysters were from the Saugatucket River (Point Judith Pond) and Spectacle Cove (Northeast Bay) with each site exhibiting 100% prevalence. Most of the oysters sampled from these two sites had light to moderate infections. The lowest levels of infections were seen in oysters from Bissel Cove with 79% prevalence. There is a combination of factors, which includes disease, fishing pressure, and lack of successful sets, which has led to a decrease in most wild populations. For this reason it was not possible to sample oysters at many locations where they were collected in previous years. Although dermo disease is still prevalent in these wild populations, the intensity has decreased since 1998. This decrease in intensity could be related to decreased disease pressure from various environmental conditions, decreased oyster densities in these wild populations, or to development of resistance to dermo disease in wild populations.

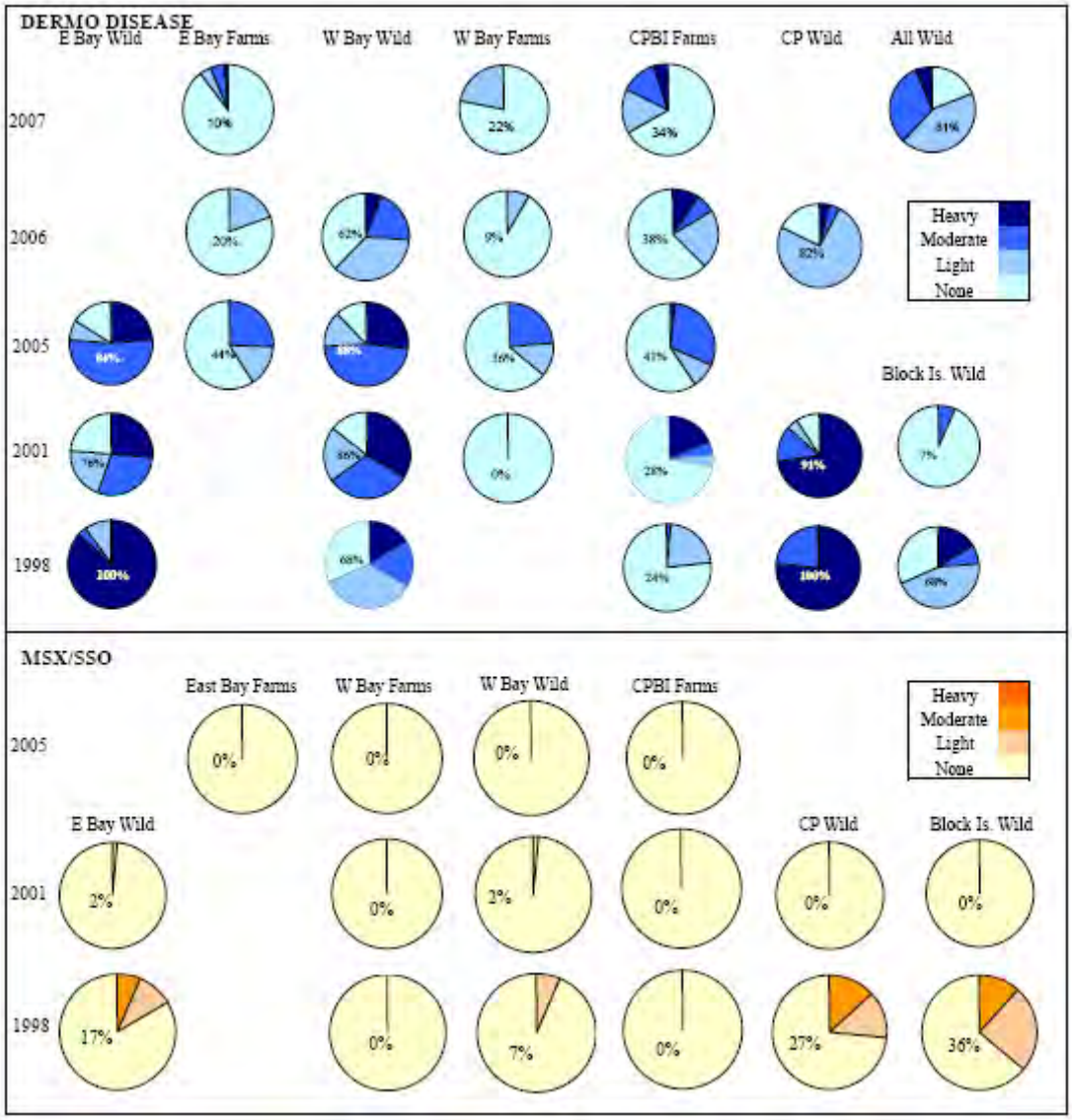


Figure 2. Prevalence and intensity of dermo and MSX/SSO diseases in Rhode Island oysters. Pie charts show: 1) the percent prevalence of disease in the grouped sites (number inside chart), and 2) the relative intensity of the infections, showing the percentage of oysters that show either no infections (lightest blue color), light infections (slightly darker blue color), moderate infections (darker blue color), and heavy infections (darkest blue color).

Dermo disease in cultured oysters

Levels of dermo disease in cultured oysters have remained low to moderate throughout the recent years in most farms; ranging in prevalence from 0% (West Bay farms in 2001) to 34% (Coastal Ponds and Block Island). The prevalence and intensity of dermo disease in farmed populations is highly variable among sites, with the highest levels in 2007 seen in Coastal Salt Ponds and Block Island. In general, levels of dermo disease at particular farms remained unchanged or increased slightly. Low levels of oyster mortality observed by farmers at a few farms in coastal ponds and Block Island could be related to dermo disease, since 20 – 32% of oysters sampled at these sites had moderate-high levels of infection, and these levels of

infection are frequently associated with oyster mortalities. When two year classes were tested, 1-year old and 2-year old (oysters planted in 2005 and 2006, sampled in 2007), levels of dermo disease prevalence and intensity were highest in the older oysters in the lease (not shown). Overall, and as shown in previous years, the average prevalence and intensity of dermo disease in cultured oysters was significantly lower than that in wild oysters for the 2007 sampling season.

ROD Prevalence in cultured oysters

During one of the hottest weeks of the summer of 2007 (end of July), mortalities ranging from 4 to 100% occurred in several upwellers located in local coastal ponds holding seed oysters less than 25 mm in shell height. Oysters in the upwellers experiencing mortalities ranged from 4 to 12 mm of shell height, and heavy mortalities were observed in the smaller oysters (4 – 9 mm in shell height). A high percentage of live seed showed signs of cupping of the left valve, although conchiolin deposits were not observed. *Roseovarius crassostreae* was isolated from all oysters sampled (100% prevalence), confirmed by bacteriological analyses. This outbreak was most probably triggered by the small oyster seed exposed to high water temperatures greater then 25°C during the previous days. Temperature of 30.5°C was observed in one of the upwellers on the date the mortalities were reported.

Other diseases

No MSX or SSO was detected in Rhode Island farmed oysters in 2006. Samples for histological analysis for the 2007 survey are currently being analyzed, and data will be available by July 2008.

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 disease 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 disease 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 disease are detected in a particular farm in August, the farmer is notified immediately so he/she 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 disease 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.
- *Roseovarius* oyster disease (ROD, formerly known as Juvenile Oyster Disease) has been responsible for losses of seed in upwellers located in coastal ponds in Rhode Island. Farmer may be able to avoid losses due to ROD by ensuring that seed maintained in the upwellers reaches a size larger than 25 mm (about 1 inch) before water temperatures reach 25°C (mid – end of July).
- 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 diseases are 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 diseases 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.
- 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.

Cited Articles:

Barber BJ. A guide to bivalve diseases for aquaculturists in the northeastern U.S. and Atlantic Canada. 2000. University of Maine, Orono, ME, ME/NH Sea Grant Program

Boettcher KJ, Barber BJ, Singer JT (1999) Use of antibacterial agents to elucidate the etiology of juvenile oyster disease (JOD) in *Crassostrea virginica* and numerical dominance of an alphaproteobacterium in JOD-affected animals. Appl Environ.Microbiol 65:2534-2539

Boettcher KJ, Smolowitz R, Lewis EJ, Allam B, Dickerson H, Ford SE, Huq A, Reece KS, Rivara G, Woodley CM (2006) Juvenile Oyster Disease (JOD) in *Crassostrea virginica*: Synthesis of knowledge and recommendations. J.Shellfish Res. in press:

Bricelj VM, Ford SE, Borrero FJ, Perkins FO, Rivara G, Hillman RE, Elston RA, Chang J (1992) Unexplained mortalities of hatchery-reared, juvenile oysters, *Crassostrea virginica* (Gmelin). J.Shellfish Res. 11:331-347

Ewart JW, Ford SE (1993) History and impact of MSX and Dermo diseases on oyster stocks in the Northeast region. Northeastern regional aquaculture center 200:1-8

Ford SE, Borrero FJ (2001) Epizootiology and pathology of juvenile oyster disease in the Eastern oyster, *Crassostrea virginica*. J.Invertebr.Pathol. 78:141-154

Ford SE, Tripp MR (1996) Diseases and Defense Mechanisms. In: Kennedy VS, Newell RI, EbleAE (eds) The Eastern Oyster, *Crassostrea virginica*. Maryland Sea Grant, College Park, MD, pp 581 - 660.

Meyer, F.P. (1991 Aquaculture disease and health management. Journal of Animal Science, Vol 69, Issue 10, American Society of Animal Science U.S. Fish and Wildlife Service, pp 4201-4208.

Sunila I, Karolus J, Volk J (1999) A new epizootic of *Haplosporidium nealsoni* (MSX), a *haplosporidian* oyster parasite, in long island sound, Connecticut. J.Shellfish Res. 18:169-174

Pioneering Lobster Aquaculture in Rhode Island

Michael A. Rice
University of Rhode Island

One of the pioneering agencies charged with managing Rhode Island's fisheries resources was the Rhode Island Commission on Inland Fisheries (hereafter the RI Fish Commission or simply 'the Commission'). The RI Fish Commission was formed as a sister agency of the Commission on Shellfisheries by an act of the General Assembly in 1869 to manage and enhance the state's various fisheries, including freshwater trout and bass fisheries and the marine fisheries in Narragansett Bay and the coastal salt ponds. The Commission consisted of a minimum of five commissioners appointed by the General Assembly serving three-year terms. There were additional staff members in the employ of the Commission from time to time. The Commission was obliged to provide an annual report to the General Assembly in January. Early work of the Commission chronicled in the annual reports of the Commission included the purchase of trout from the fish hatchery owned by the Rowland G. Hazard family in Carolina, RI for the restocking of lakes and streams around the state, as well as experiments into the reproductive biology and artificial propagation of the steamer clam, *Mya arenaria*, and the quahog *Mercenaria mercenaria*. One of the Commission's key contributions to the science and practice of marine aquaculture was their early experiments to hatch and rear larval lobsters for the purpose of restocking the fisheries of Narragansett Bay.

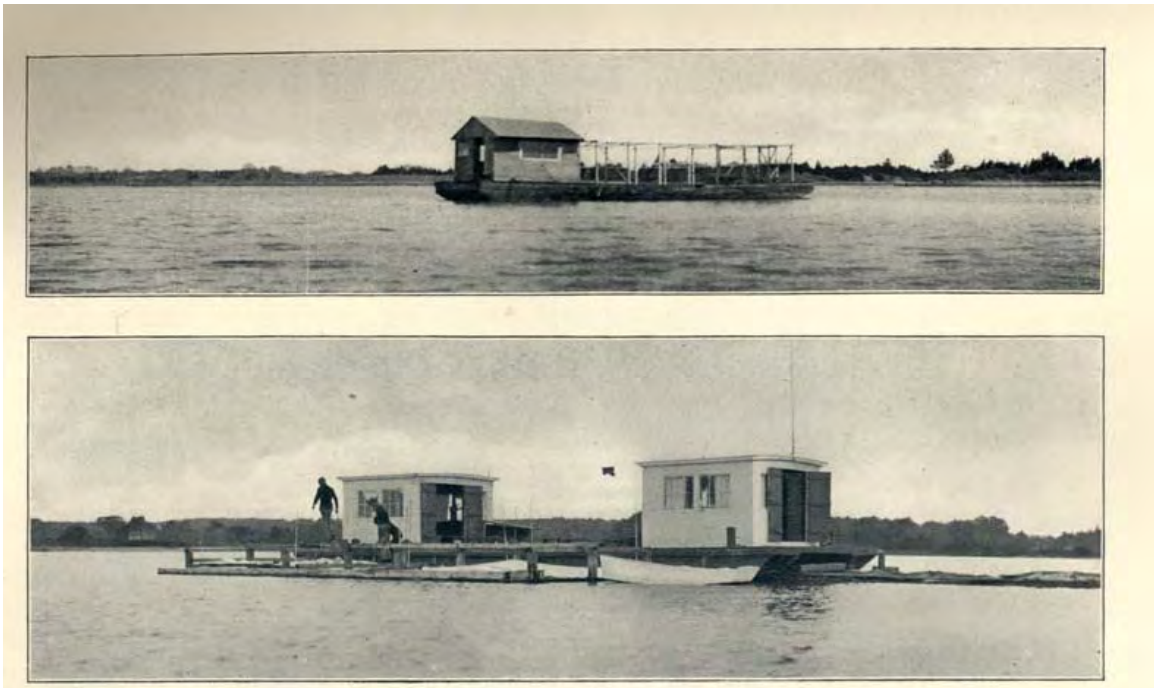


FIG. 1.—The old and new floating laboratories (house-boats) of the Commission of Inland Fisheries at Wickford, R. I. The upper picture represents the house-boat reconstructed from an old scow which served the Commission as a laboratory in the summer of 1899. The new house-boat is shown in the lower figure, with two of the floats attached. It has been in use since the spring of 1900.

Figure 1 A & 1B. *The old and new floating laboratories (house boats) of the Commission of Inland Fisheries at Wickford, R.I. The upper picture represents the house boat reconstructed from an old scow which served the Commission as a laboratory in the summer of 1899. The new house boat is shown in the lower figure, with two of the floats attached. Photos and original caption is from the 1902 32nd Annual Report of the RI Commission of Inland Fisheries.*

Aquaculture of lobsters in Rhode Island began in 1898 as a result of the appointment of Dr. Hermon Carey Bumpus, Jr. a professor of biology at Brown University as one of the inland fishery commissioners in 1897.[1] The very next year, Bumpus was appointed as the director of the United States Fisheries Commission (now National Marine Fisheries Service) Laboratory at Woods Hole. The three-way partnership of the Commission, Brown University, and the U.S. Fisheries Commission allowed for input of academic researchers and graduate students and partial federal funding of the project.

Figure 2. *Lobster hatchery staff cleaning the canvas rearing bags for culturing lobster larvae. Photo is from the 1905 35th Annual Report of the Commission for Inland Fisheries.*

The work on culturing lobster larvae began modestly on a modified barge floating in Mill Cove near Wickford (Figure 1A) during the summer of 1899, which was quickly replaced by a larger barge that provided a greater amount of working space (Figure 1 B). Lobster larvae were held in canvas bags suspended from the floating laboratories (Figure 2), which improved survival greatly over the use of tanks in 1898, but it was quickly realized that the survival of lobster larvae was very low due to their cannibalistic tendencies. The larvae needed to be kept in motion to prevent the larvae from eating themselves, so the staff of the laboratory was augmented and deployed around the clock to stir the water in the culture bags.[2] A great technical improvement occurred when Dr. Albert D. Mead and his graduate student George H. Sherwood inspired by a ceiling fan in a restaurant designed an propeller apparatus that lifted agitated the water through the bags (Figures 3 & 4), thereby saving a considerable amount of staff time and labor.
The feeding of the lobster larvae was rather labor intensive by current standards and involved the grinding of fish offal and waste meat products and hand feeding the material to the lobsters (Figure 5) on a periodic basis.[3] Undoubtedly the purchase, preparation and feeds was a major part of the expenses of the hatchery, and given the methods they used, it would have been a pretty 'messy' process, not only in the feed handling but in the amount of uneaten waste feed escaping from the farm and fouling the waters.

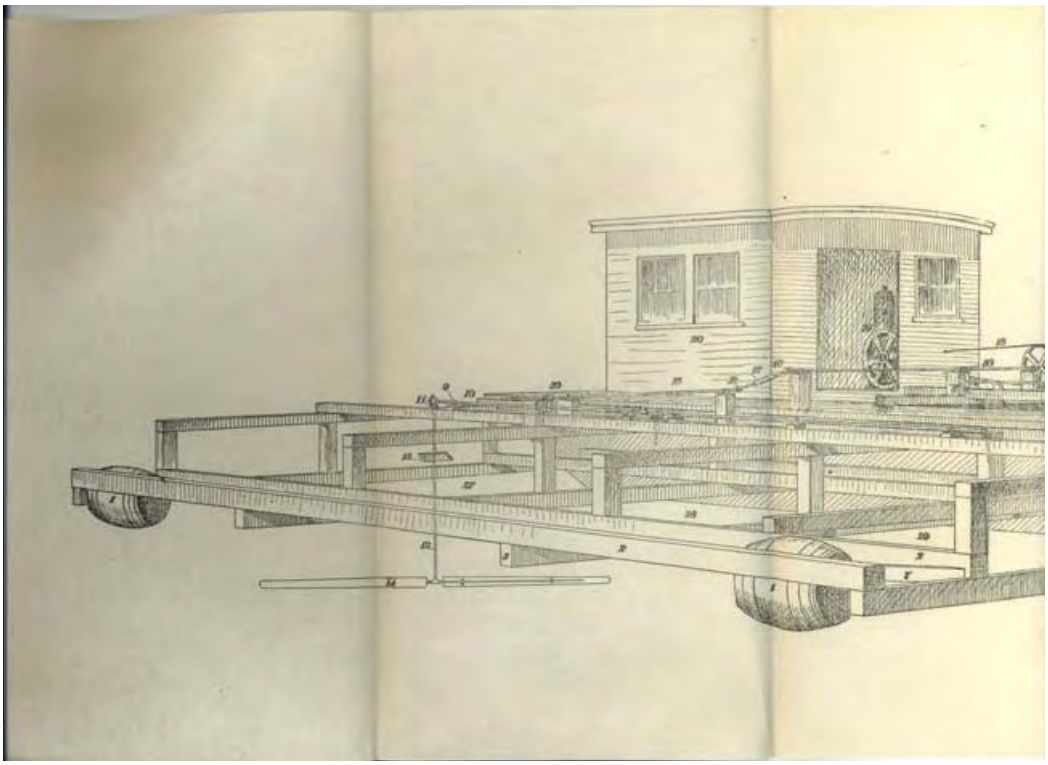


Figure 3. *Schematic drawing of the water propeller-agitator designed by Mead and Sherwood for use at the Wickford Lobster Hatchery. The figure shows part of the drive mechanism, the impellor blades, tarred barrel floats and the cabin serving to house the engine to drive the mechanism. This figure is part of the complete schematic drawing in the 1903 33rd Annual Report of the RI Commission of Inland Fisheries.*

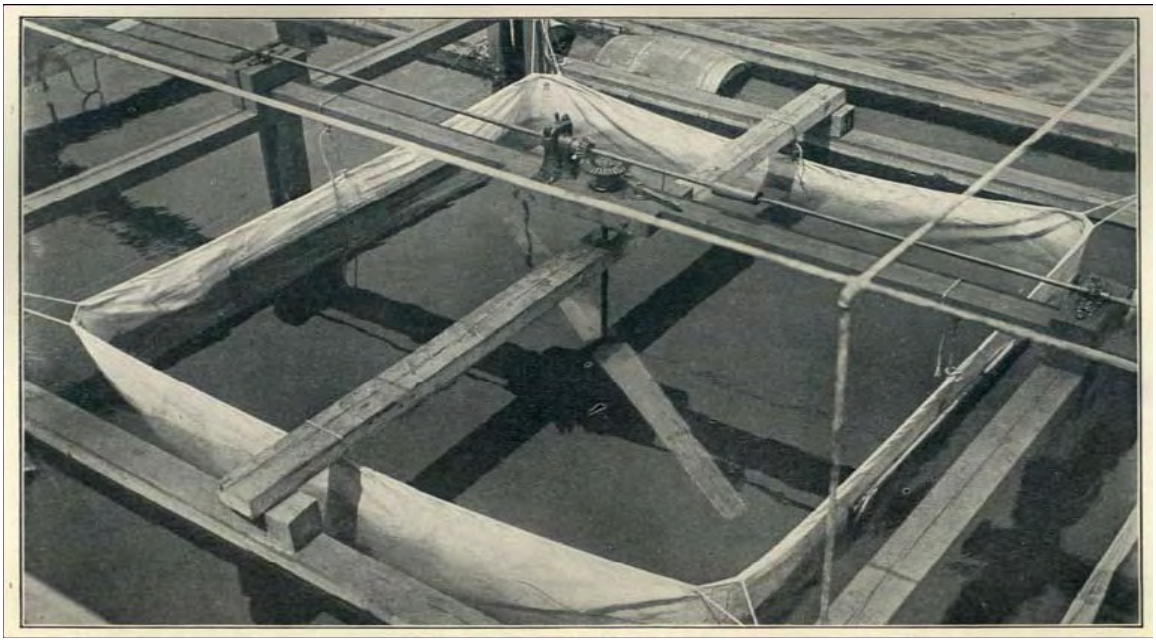


Figure 4. *Canvas Bag Rearing chamber for lobsters showing agitator and geared drive mechanism. Photo is from the 1905 35th Annual Report of the RI Commission of Inland Fisheries.*

Figure 5. *A 1904 photograph of the lobster larval feeding method. Photo is from the 1905 35th Annual Report of the RI Commission of Inland Fisheries.*

Figure 6. *The dock and lobster hatchery building at the end of Fowler Street in Wickford, RI. The historic postcard photo is from the collection of the author.*

A major part of the work on site at the hatchery was performed by the assistant superintendent Ernest S. Barnes beginning in 1901 and continuing after his appointment in 1906 to serve as superintendent of the hatchery. By 1908 the numbers of lobsters being produced at

the hatchery were outstripping the size of the facilities, requiring the establishment of a permanent shore-side support laboratory and docks for the work boats supporting the project (Figure 6). Currently, the location of the old lobster hatchery at the end of Fowler Street in Wickford is occupied by the Department of Environmental Management Division of Enforcement to dock their patrol vessels.

Figure 7. *Hand stocking of lobster larvae into Narragansett Bay. Photo is from the 1905 35th Annual Report of the RI Commission of Inland Fisheries.*

The main purpose of the lobster hatchery was to produce stage 4 and stage 5 lobster larvae for release into Narragansett Bay (Figure 7), for the purpose of enhancing the fisheries. As the lobster hatchery program progressed and the operators developed the expertise in rearing lobsters, the number of larvae stocked n Rhode Island waters grew considerably (Figure 8). As the techniques for rearing larvae became routine by 1936, 1.7 million stage IV larvae were being released by the hatchery annually.[4] Adjunct to the larval stocking program research was undertaken beginning 1900 on methods to culture lobsters from egg to adult. The 1900-1901 growing seasons produced encouraging results with lobsters ranging in size from 106 to 159 mm total length, with a mean of 122 mm. While these experiments were exploratory and inconclusive, they did demonstrate the biological feasibility of lobster aquaculture. They showed great variability in growth rates among communally reared lobsters, and that greatest growth rates occurred among lobsters reared at lower densities.[5]

The larval lobster stocking program was very popular with the lobster fishing industry and the hatchery program continued until the late 1940s, when a number of convergent circumstances led to the project's discontinuation. First, in 1935, there was a major change in priorities and reorganization of fisheries management in Rhode Island by the abolition of the Commission and formation of the Department of Fish and Wildlife. Second, hurricanes in 1938 and 1944 severely damaged the hatchery facilities, and third, it was unclear to members of the legislature as to whether stocking of lobster larvae actually made any difference in enhancing lobster fisheries.

Despite the closing of Rhode Island's lobster hatchery, it served an important purpose in providing a vehicle for increasing our understanding of lobster biology and behavior, and it served as a good example of state, federal and academic cooperation in practical problem solving. Ironically, as the lobster hatchery in Rhode Island was being dismantled, with the last lobsters spawned in 1951, a successor hatchery in Martha's Vineyard began operations that same year by the State of Massachusetts, resulting from post-war state appropriations based on recommendations in a 1939 report by the Wickford Lobster Hatchery Superintendent Ernest Brown.[7] Over the years, leading lobster aquaculturists John Hughes[8] and Michael Syslo[9] working at the Martha's Vineyard hatchery followed in the innovative traditions of the Wickford Hatchery in further developing the state of the art of lobster culture. From 1951 through 1963, 2 million Stage IV lobsters were reared and released, averaging 150,000 annually, with a survival rate of about 30%[10]. Although annual releases increased to about 500,000 annually in the 1970s, the Massachusetts hatchery's lobster propagation and seeding operations were terminated in 1997 as a shift toward utilizing the facility for other fisheries research projects.

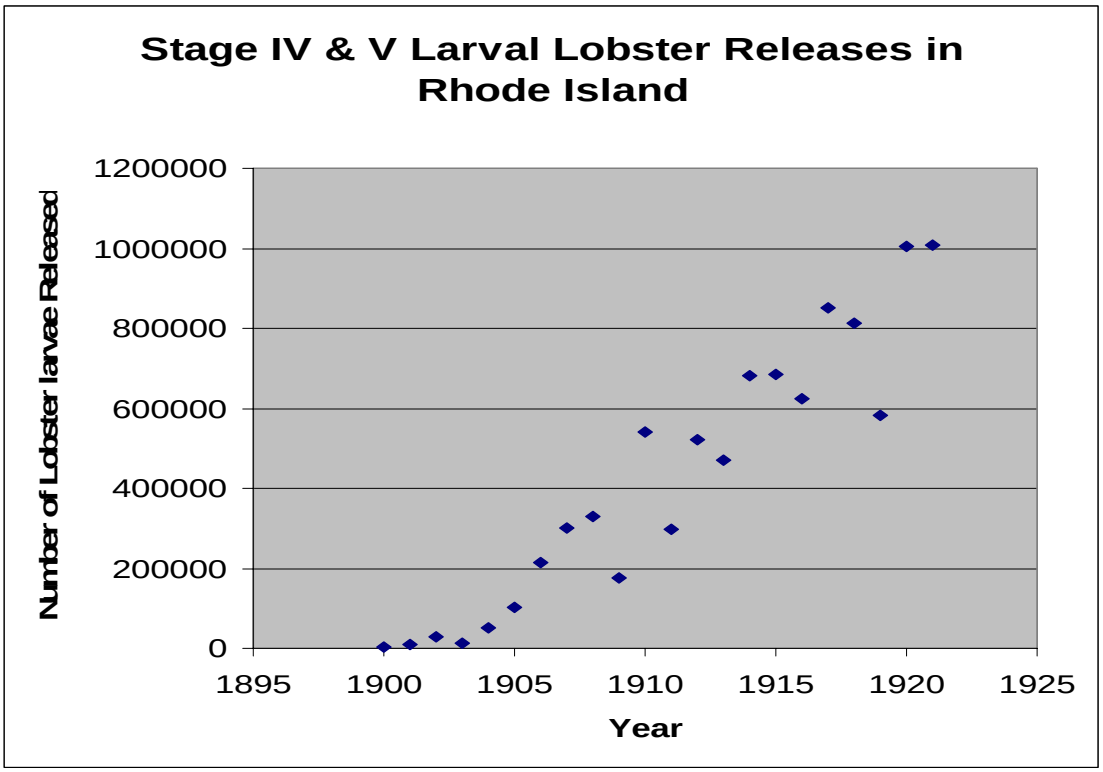


Figure 8. *The production of larval lobsters in Rhode Island using the technique of floating rearing chambers grew considerably during the first quarter of the 20th Century. Data from table in the 52nd Annual Report of the RI Commissioners of Inland Fisheries (1922).*

As the fortunes of the lobster industry wax and wane, there are perennial expressions of interest in establishing hatcheries similar to the one pioneered right here in Rhode Island. But the nagging problem of clearly demonstrating the efficacy of such projects continues to be an open question. Most recently, Kathleen M. Castro of the University of Rhode Island and co-workers has investigated this problem by stocking artificial and natural reefs with hatchery-reared and

wild lobsters.[12] Their finding strongly suggest that hatchery reared lobsters may have behavioral characteristics that subject them to predation at much higher rates than wild juveniles, thereby calling into question the value of larval stocking to restore or enhance capture fisheries. Although it is doubtful that the Wickford Lobster Hatchery or its successor on Martha's Vineyard ever did very much to enhance lobster populations in Southern New England, their pioneering science and technology development did advance our knowledge about this very economically important fisheries species. Who knows the future? If capture fishery supply of lobsters were short and there were sufficient market demand, the economics of growing lobsters using methods pioneered in the Rhode Island and Massachusetts hatcheries might be borrowed to build a new aquaculture industry at some time.

---

[1] Bumpus, H.C. 1899. 29th Report of the Rhode Island Commission of Inland Fisheries

[2] Mead, A.D. 1901. Habits and growth of young lobsters and experiments in lobster culture. 31st Annual Report of the RI Commission of Inland Fisheries;

[3] Barnes, E. W. 1906a. Methods of protecting and propagating the lobster, with a brief outline of its natural history. Annu. Rep. R.I. Comm. Inland Fish. 32:120-152; Barnes, E.W. 1906b. The propagation of lobster fry for the purpose of increasing the supply of lobsters in the waters of the state. Methods of artificial propagation and cultivation. R.I. Comm. Inland Fish. Annu. Rep. 36:111-119; Barnes, E.W. 1907. Lobster culture at Rhode Island in 1906. R.I. Comm. Inland Fish., Annu. Rep. 37:88-94.

[4] Carlson, F. T. 1955. Evaluation of the artificial propagation of the American lobster with special reference to the Connecticut lobster fishery. Yale Univ. Conservation Program, New Haven. 132 p.

[5] Mead, A.D. and L.W. Williams. 1903. Habits and growth of the lobster and experiments in lobster culture. R.I. Commission of Inland Fisheries, Annual Report 33:57–86.

[6] Mitchell, Martha. 1993. "Biology" in *Encyclopedia Brunoniana*. Brown University Library, Providence, RI. 629pp.; Nicosia, F., and K. Lavalli 1999. Homarid lobster hatcheries: Their role in research, management and aquaculture. Marine Fisheries Review 61(2):1-57.

[7] Barnes, E. W. 1939. An analysis of the objectives of lobster rearing and problems of reinvigorating the lobster industry. In Special report of the development of conservation relative to the feasibility and cost of propagation of lobsters by the Commonwealth of Massachusetts, Appendix A, p. 10-32. Mass. House Doc. 2051, State Library, Boston, Mass.

[8] Hughes, J.T. , R. A. Shleser, and G. Tchobanoglous. 1974. A rearing tank for lobster larvae and other aquatic species. Progressive Fish Culturist 36:129–132.

[9] Syslo, M. 1986. Getting the "bugs" out. Massachusetts Wildlife 36(3):4–10.

[10] Division of Marine Fisheries annual report for 1962–1963. Commonwealth Mass., Dep. Nat. Resour., Div. Mar. Fish., Annu. Rep. 500-10-63-355:17–28 (1963).

[11] Syslo, Michael. (1997) Personal Communication, Oak Bluffs, MA.

[12] Castro, K.M, J.S. Cobb, R.A. Wahl, and J. Catena. 2001. Habitat addition and stock enhancement for American lobsters, *Homarus americanus.* Marine and Freshwater Research 52:1253–1261.