

V(A). Planned Program (Summary)

Program # 8

1. Name of the Planned Program

Global Food Security and Hunger - Aquaculture

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
135	Aquatic and Terrestrial Wildlife	100%		100%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2012	Extension		Research	
	1862	1890	1862	1890
Plan	3.0	0.0	4.8	0.0
Actual Paid Professional	6.0	0.0	3.0	0.0
Actual Volunteer	230.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
37989	0	96375	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
508046	0	918377	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
115477	0	951543	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Investigate the genetic mechanisms for disease resistance and improved quality in economically important shellfish
- Create a dynamic and cooperative partnership with faculty, staff, businesses, regulatory/advisory

councils and the government to research best management practices and discover effective solutions and management practices to address threats to NJ aquaculture as well as investigate opportunities to increase the quality and quantity of the aquaculture harvest.

- Collect and analyze data on how communities and businesses are affected by the aquaculture industry management practices.
- Examine the presence of unhealthy levels of contaminants in aquaculture products.
- Determine best techniques for shellfish hatcheries on and off shore.

2. Brief description of the target audience

- Aquaculture related businesses and employees
- State Department of Environmental Protection
- State Department of Agriculture
- Industry partners who learn ways to improve or protect their harvests
- Communities who depend on aquaculture-related revenue
- NJAES faculty and staff involved in water research/outreach
- Consumers of aquaculture products, including recreational fishing

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2012	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	144	83	0	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year: 2012
 Actual: 1

Patents listed

8183395 B2

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2012	Extension	Research	Total
Actual	2	48	50

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- A variety of strategies will be implemented to reach target audiences. This will include and not be limited to workshops, field visits, classes, newsletters, media releases, electronic communications, publications. In addition a trained volunteer teaching base will be developed. Quantitative reports of participation will be collected.

Year	Actual
2012	0

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Short Term - Knowledge of seasonal variations for shellfish diseases. Create census data on communities involved in aquaculture. Determine the level of pollutants in economically important fish species. Develop markers and maps of important genetic traits. Knowledge of shellfish hatchery techniques that decrease time for growth to market size.
2	Medium Term - Identify spatial and temporal relationships between patterns of shellfish diseases in NJ and environmental correlates. To develop disease-resistant strains of shellfish. Develop superior disease-resistant and larger genetic lines of shellfish. Measure the impact of communities on the aquaculture industry. Knowledge of the feasibility of off-shore shellfish farming.
3	Long Term - Clear and comprehensive understanding of community, environmental, genetic and physical regulators of aquaculture quality and quantity. A safe and secure aquaculture industry that can meet consumer demands for high-quality products and also be environment friendly and economically viable. Creation of superior aquaculture products that will be of high demand outside NJ.
4	Shellfish Genetics and Breeding for Aquaculture: Medium Term - Identify spatial and temporal relationships between patterns of shellfish diseases in NJ and environmental correlates. To develop disease-resistant strains of shellfish. Develop superior disease-resistant and larger genetic lines of shellfish. Measure the impact of communities on the aquaculture industry. Knowledge of the feasibility of off-shore shellfish farming.
5	Development and Testing of Modern Biological Reference Point Management Techniques for Diseased Oyster Populations: Medium Term - Identify spatial and temporal relationships between patterns of shellfish diseases in NJ and environmental correlates. To develop disease-resistant strains of shellfish. Develop superior disease-resistant and larger genetic lines of shellfish. Measure the impact of communities on the aquaculture industry. Knowledge of the feasibility of off-shore shellfish farming.
6	Marine Natural Product Discovery in Extreme Environments: Medium Term - Identify spatial and temporal relationships between patterns of shellfish diseases in NJ and environmental correlates. To develop disease-resistant strains of shellfish. Develop superior disease-resistant and larger genetic lines of shellfish. Measure the impact of communities on the aquaculture industry. Knowledge of the feasibility of off-shore shellfish farming.
7	Barnegat Bay Shellfish Restoration Program: Medium Term - Identify spatial and temporal relationships between patterns of shellfish diseases in NJ and environmental correlates. To develop disease-resistant strains of shellfish. Develop superior disease-resistant and larger genetic lines of shellfish. Measure the impact of communities on the aquaculture industry. Knowledge of the feasibility of off-shore shellfish farming.

Outcome #1

1. Outcome Measures

Short Term - Knowledge of seasonal variations for shellfish diseases. Create census data on communities involved in aquaculture. Determine the level of pollutants in economically important fish species. Develop markers and maps of important genetic traits. Knowledge of shellfish hatchery techniques that decrease time for growth to market size.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

{No Data Entered}

What has been done

{No Data Entered}

Results

{No Data Entered}

4. Associated Knowledge Areas

KA Code	Knowledge Area
135	Aquatic and Terrestrial Wildlife

Outcome #2

1. Outcome Measures

Medium Term - Identify spatial and temporal relationships between patterns of shellfish diseases in NJ and environmental correlates. To develop disease-resistant strains of shellfish. Develop superior disease-resistant and larger genetic lines of shellfish. Measure the impact of communities on the aquaculture industry. Knowledge of the feasibility of off-shore shellfish farming.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

National Animal Genome Research Project (NRSP-*): Aquaculture Genomics (Oysters)

New Jersey's aquaculture resources are finite and can sustain on fixed harvests, while the demand for quality fish and seafood continues to climb. Threats from disease and environmental contaminants and conditions provide additional challenges to producers to meet the demand for quality aquaculture products. In particular, shellfish resources along much of the Atlantic Coast have been devastated by diseases.

What has been done

This project is part of the USDA National Research Support Project (NRSP-8) on animal genomes. The national project is designed to coordinate research efforts in animal genomics and facilitate exchanges of ideas and data. NJAES conducted research on genomics of molluscs under projects funded by National Oceanic and Atmospheric Administration (NOAA) Sea Grant, United State Department of Agriculture (USDA), National Science Foundation (NSF) and Rutgers University, in collaboration with colleagues in 2011: 1) we identified and mapped disease resistance genes and makers, and used them to model disease resistance in eastern oyster populations; 2) we worked on the development of Single-Nucleotide Polymorphism (SNP) marker and a cytogenetic map for the Pacific oyster; 3) we worked on assembly and annotation of the Pacific oyster genome; and 4) we attended the annual meeting of NRSP-8 held in San Diego, January 2011. The outputs have been disseminated to the research community through workshops, meeting presentations and publications.

Results

Identified 14 loci for Dermo disease resistance, which improved our understanding of genetics of Dermo resistance. A preliminary cytogenetic map has been developed for the Pacific oyster, which is the first for this species. This map will provide physical anchors of the genetic and sequence maps of this species. We have assembled and annotated the Pacific oyster genome, which will provide a valuable resource for the scientific community.

4. Associated Knowledge Areas

KA Code	Knowledge Area
135	Aquatic and Terrestrial Wildlife

Outcome #3

1. Outcome Measures

Long Term - Clear and comprehensive understanding of community, environmental, genetic and physical regulators of aquaculture quality and quantity. A safe and secure aquaculture industry that can meet consumer demands for high-quality products and also be environment friendly and economically viable. Creation of superior aquaculture products that will be of high demand outside NJ.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

{No Data Entered}

What has been done

{No Data Entered}

Results

{No Data Entered}

4. Associated Knowledge Areas

KA Code **Knowledge Area**
135 Aquatic and Terrestrial Wildlife

Outcome #4

1. Outcome Measures

Shellfish Genetics and Breeding for Aquaculture: Medium Term - Identify spatial and temporal relationships between patterns of shellfish diseases in NJ and environmental correlates. To develop disease-resistant strains of shellfish. Develop superior disease-resistant and larger genetic lines of shellfish. Measure the impact of communities on the aquaculture industry. Knowledge of the feasibility of off-shore shellfish farming.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Shellfish Genetics and Breeding for Aquaculture

Molluscan shellfish are important marine resources, supporting major aquaculture and fishery industries in the US and around the world. There are a number of problems and challenges facing the shellfish aquaculture industry, where genetics can be part of the solution.

What has been done

NJAES researchers: 1) developed disease-resistant and fast-growing strains by hybridization and selective breeding; 2) developed sterile and superior stocks using the triploid-tetraploid technology; 3) molecular tools for the genetic mapping and improvement of commercially important traits. In 2012, NJAES conducted research under support from USDA/Northeastern regional Agriculture Center (NRAC) and NSF: 1) we continued selective breeding of disease-resistant eastern oysters and performed field evaluations; 2) we provided the latest disease-resistant tetraploid eastern oysters to the industry for triploid production; 3) we identified disease-resistance genes in the eastern oyster; 4) we studied population genetics of oysters in Delaware Bay; and 5) we participated in the international oyster genome project, which completed the sequencing of the Pacific oyster genome. The outputs were published and/or presented to the shellfish research and culture community at meetings including the annual meetings of the

National Shellfisheries Association and the Milford Aquaculture Seminar.

Results

The disease-resistant eastern oysters developed from our research program have become valuable stocks for oyster farming along the northeastern coast. We distributed disease-resistant broodstock in both diploid and tetraploid forms. The tetraploids are used to produce triploid oysters which grow significantly faster than diploids. The oyster genome has been published in a recent article in Nature, which is a significant milestone in oyster genomics and will enable a wide range of genetic research and analyses.

4. Associated Knowledge Areas

KA Code	Knowledge Area
135	Aquatic and Terrestrial Wildlife

Outcome #5

1. Outcome Measures

Development and Testing of Modern Biological Reference Point Management Techniques for Diseased Oyster Populations: Medium Term - Identify spatial and temporal relationships between patterns of shellfish diseases in NJ and environmental correlates. To develop disease-resistant strains of shellfish. Develop superior disease-resistant and larger genetic lines of shellfish. Measure the impact of communities on the aquaculture industry. Knowledge of the feasibility of off-shore shellfish farming.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Development and Testing of Modern Biological Reference Point Management Techniques for Diseased Oyster Populations

New Jersey's aquaculture resources are finite and can sustain on fixed harvests, while the demand for quality fish and seafood continues to climb. Threats from disease and environmental

contaminants and conditions provide additional challenges to producers to meet the demand for quality aquaculture products. In particular, shellfish resources along much of the Atlantic Coast have been devastated by diseases.

What has been done

NJAES researchers developed and tested numerical models designed for bivalves to address challenges specific to the management of these species. Gene-based population dynamics models were developed and used to evaluate genetic effects of management options on stocks. A gene-based population dynamics model, configured for *C. virginica*, was used to simulate the development of disease resistance using mortality as a selection agent. Simulated populations were exposed to four levels of mortality covering the range in mortality observed in Delaware Bay in the 1990s.

In conjunction with our research, we implemented annual stock assessment surveys that encompassed oyster beds in Delaware Bay. Analyses included quantitative abundance, size frequency, condition, and mortality at 160 randomly selected sites among these beds. We convened a Stock Assessment Workshop each February to review the assessment and develop a status of the stock report and management advice. During this assessment process, biological reference points are reviewed and revised, and management recommendations were formulated for the next New Jersey oyster harvest.

Results

The scientific data generated by this research program has permitted increased accuracy in the survey and stock assessment that supports the Delaware Bay oyster industry. By informing sound aquaculture management methods, this research, in conjunction with federal and state actions and activity and improved consumer demand for oysters, helped to bring the oyster industry in the Delaware Bay back from a near collapse resulting from the impact of Dermo, a parasitic pathogenic oyster disease, that struck bay oyster beds in the 1990s. Oyster production over the last ten years in the bay averaged 72,000 bushels per year, compared to 36,600 bushels per year in the 1990s. Today, the oyster industry generates \$4 million in revenues each year for oyster growers in the Delaware Bay area, as well as a combined total of \$20 million each year in economic activity in Southern New Jersey among the state's poorest counties.

4. Associated Knowledge Areas

KA Code	Knowledge Area
135	Aquatic and Terrestrial Wildlife

Outcome #6

1. Outcome Measures

Marine Natural Product Discovery in Extreme Environments: Medium Term - Identify spatial and temporal relationships between patterns of shellfish diseases in NJ and environmental correlates. To develop disease-resistant strains of shellfish. Develop superior disease-resistant and larger genetic lines of shellfish. Measure the impact of communities on the aquaculture industry. Knowledge of the feasibility of off-shore shellfish farming.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Marine Natural Product Discovery in Extreme Environments

Cancer is a major disease affecting a larger portion of the American population resulting in high mortality rates for both men and women. Deep sea habitats have the potential for commercial development of pharmaceuticals, particularly those with anti-cancer activity.

What has been done

Research under the auspices of the Center for Deep-Sea Ecology and Biotechnology of the New Jersey Agricultural Experiment Station and the School of Environmental and Biological Sciences are as follows: (1) screening extracts of cultured novel species bacteria from deep-sea hydrothermal vents, as well as screening extracts of invertebrate mussels from hydrothermal vent habitats for bioactive compounds; (2) performing cytotoxic and induction of apoptosis assay of extracts, fractions and isolated molecules in conjunction and collaboration with the Cancer Institute of NJ and the University of Medicine and Dentistry of NJ; (3) isolation and culturing numerous micro-organisms from a variety of extreme deep-sea hydrothermal vent environments; (4) identifying the structure of bioactive compounds and specifically those with apoptosis induction activity; (5) synthesizing new and unusual molecular structures with potential anticancer activity for drug development and pharmaceuticals in conjunction with the Department of Chemistry at Rutgers University. Our ongoing search for marine natural product development initiatives continues to focus on discovering new anti-bacterial and anti-cancer leads. During 2012, a paper was published in the high impact journal "Marine Drugs" (Ammonificins C and D, Hydroxyethylamine Chromene Derivatives from a Cultured Marine Hydrothermal Vent Bacterium, *Thermovibrio ammonificans*). A new US patent has been issued on our work for "composition and methods for treating cancer". Educational outreach efforts continue to be focused on distribution of Blu-ray, NTSC and 8/70 formatted version of the IMAX film "Volcanoes of the Deep Sea" to museums, science centers and zoos that have not yet featured the film at their institutions. The film played for a period of a year (2011-2012) at the Tom Ridge Environmental Center MEGA Theater in Erie, PA and the Clay Center for the Sciences in Charleston, WV has agreed to show the film beginning in March 2013. The film continues to be shown on a wide variety of PBS and other channels, including Discovery Canada, Discovery USA, Direct TV, Comcast, Echo Star and CBS affiliate stations in the US and it is estimated that the film has been viewed to date by in excess of 175 million individuals worldwide.

Results

Various outcomes and impacts of this project are featured on the following Rutgers/NJAES website: <http://deepseacenter.rutgers.edu/>. The issuance of the US patent for our work and our ongoing search for new natural product discovery have generated interest on the part of major pharmaceutical companies in NJ regarding potential development and commercialization of the results for the treatment of wide variety of cancers such as breast and cervical cancers. The continuing distribution of DVD copies of our Rutgers-produced IMAX film "Volcanoes of the Deep Sea"; viewings on a wide variety of television broadcasts worldwide; and continued showings of the film at major science centers should expose additional millions of individuals to our ongoing initiatives under this NJAES Project.

4. Associated Knowledge Areas

KA Code	Knowledge Area
135	Aquatic and Terrestrial Wildlife

Outcome #7

1. Outcome Measures

Barnegat Bay Shellfish Restoration Program: Medium Term - Identify spatial and temporal relationships between patterns of shellfish diseases in NJ and environmental correlates. To develop disease-resistant strains of shellfish. Develop superior disease-resistant and larger genetic lines of shellfish. Measure the impact of communities on the aquaculture industry. Knowledge of the feasibility of off-shore shellfish farming.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Barnegat Bay Shellfish Restoration Program

New Jersey's aquaculture resources are finite and can sustain on fixed harvests, while the demand for quality fish and seafood continues to climb. Threats from disease and environmental contaminants and conditions provide additional challenges to producers to meet the demand for

quality aquaculture products. In particular, shellfish resources along much of the Atlantic Coast have been devastated by diseases.

What has been done

The mission of the Barnegat Bay Shellfish Restoration Program (BBSRP), and ReClam The Bay, Inc. (RCTB), the volunteer organization which supports the efforts of BBSRP, is to teach about the coastal bay, its watersheds and peoples' impact on these natural resources by using the hard clam and oyster as living representatives of the bay ecosystem. The program uses typical commercial shellfish aquaculture techniques to produce the clams and oysters used as teaching tools for the public.

2012 saw a big increase of outreach to school children. The public schools that have participated in our "Shellfish in the Classroom" are very enthusiastic. This program brings baby clams and oysters into the classroom so students can learn about how those creatures live and what needs to be done to increase the populations of shellfish in Barnegat Bay and why that is important.

Results

Mainly through communication with stakeholders at the upweller boxes and at the fairs and festivals, and from responses from agencies or groups with whom the program is involved, it is quite evident that the message about how actions of the public in the watershed can impact the bay itself is getting across. Public sentiment about helping the Barnegat Bay is growing because of the numerous articles that are being produced by the local print media helps to spread the message and educate about water quality and how people should change their behavior.

BBSRP/RCTB members are really environmental stewards. They reached out to about 9,500 people in 2011. In all, 5,120 hours are reported. That correlates to over \$128,000 in volunteer services.

4. Associated Knowledge Areas

KA Code	Knowledge Area
135	Aquatic and Terrestrial Wildlife

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

See Qualitative Outcomes

Key Items of Evaluation

See Qualitative Outcomes