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AQUACULTURE SITUATION AND OUTLOOK REPORT 2009: MAINE

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Industry Trends and Outlook

The Maine aquaculture industry is diverse, with a variety of marine and freshwater species raised. Atlantic Salmon (*Salmo salar*) production dominates in terms of value and pounds harvested. The 2008 data from the Maine Department of Marine Resources (DMR) estimate over 19 million pounds produced (<http://www.maine.gov/dmr/commercialfishing/documents/06-08LandingsBySpecies.pdf>) with a value of \$56.6 million. This figure is down from a high of over 36 million pounds in 2000.

Shellfish production is dominated by the eastern oyster (*Crassostrea virginica*) and the blue mussel (*Mytilus edulis*); DMR 2008 figures estimate landed values of \$2 million and \$640K USD for these species respectively (<http://www.maine.gov/dmr/aquaculture/HarvestData.htm>).

A separate 2007 study estimated the total value of all aquaculture species in the state at roughly \$30 million: \$22 million for finfish (salmon, trout, and baitfish), \$3 million for shellfish (oysters and mussels), \$2 million for hatchery production (shellfish and finfish for restocking) and over \$2 million for research and development (O'Hare, 2007). This indicates that salmon production more than doubled between 2007 and 2008, from over 8 million pounds to over 19 million, and the value rose in consequence. The increase in production is due to continued investment in salmon production as well as recovery from the drastic reductions that were caused by Infectious Salmon



John Whalen, owner of Harmon Brook Farms, displays some of his cultured baitfish. (Photo: Diane Whalen)

Anemia virus earlier in the decade. Now, effective management and biosecurity protocols are in place, and salmon production is back to where it was in 1996.

The same 2007 report indicated that "Maine's aquaculture industry creates \$50 million in business sales, 750 jobs, and \$22 million in personal income."

Recent events in the state's aquaculture industry include:

- investments to re-open a salmon processing plant that will employ 50 to 100 people
- the opening of the first Atlantic cod grow-out farm
- investment in the development of Atlantic halibut aquaculture

Emerging Issues and Critical Needs

- Workforce and professional development would facilitate the entry of prospective aquaculturists and advance the skills and abilities of existing industry members
- Capital is notoriously limited in the aquaculture industry, especially so for new start-ups and the early phases of commercial development
- The aquaculture industry in Maine is highly regulated and in many cases regulation constitutes a real obstacle to entry and to the development of new techniques, species, and equipment
- Despite many advances in waterfront access in Maine for marine businesses, access continues to be in critically short supply
- As competition for water resources intensifies, it is becoming necessary to develop new management strategies that support and encourage multiple uses of areas while reducing conflicts
- Development of a marketing program to promote the Maine brand identity as linked to sustainable farming methods
- In recent years, most new shellfish growers have come from the commercial fishing industry. This trend is expected to continue and brings with it issues of access to production areas and the transition of some submerged lands from open fishing areas to areas of limited access by others, e.g. leases
- Commercial culture of cod, halibut, sea scallops, and green sea urchin is developing in the State. Due to the unique growing conditions in the Gulf of Maine, producers must adapt, develop, and improve husbandry techniques from other locales
- Significant advances in the culture of various freshwater baitfish species have been made recently and with a vigorous market for such products growth in this industry is expected to continue
- Macroalgae culture is expected to take

more of a place in the overall aquaculture production in coming years

- Longline culture of mussels has been minimal, principally because of predation by eider ducks. Eider predation also continues to be a significant obstacle to higher production levels of blue mussels in raft and bottom culture
- There is an ongoing need for husbandry practices and equipment that would minimize negative environmental effects and accentuate positive effects. This is important not only for the continued viability of the aquaculture industry, but for the protection of natural resources that producers depend on
- The dynamics between eelgrass and shellfish culture is an area where study is strongly needed
- Biofouling is a long-standing problem for aquaculture producers and remains an area of critical need
- There is a need to assess the scientific validity of existing environmental indicators used to monitor the environmental impacts of aquaculture and evaluate new indicators which may be more applicable



Students from Lubec Consolidated High School and Washington Academy assist in an NRAC-funded research project to develop the culture of native wetland restoration species as a new aquaculture industry. (Photo: Mike Pietrak)

- an advance in the use of polyculture production
- the loss of a major mussel processor
- the formation of a new mussel grower co-operative.

Likewise, there is an increased interest in expanding the existing freshwater finfish industry, both in terms of new baitfish producers and fee fishing operations. Overall, the industry seems poised for a period of growth in the state.

Commercial Species List

- American shad (*Alosa sapidissima*)
- Atlantic salmon (*Salmo salar*)
- Atlantic cod (*Gadus morhua*)
- Atlantic halibut (*Hippoglossus hippoglossus*)
- Bay scallop (*Argopecten irradians*)
- Blue mussel (*Mytilus edulis*)
- Brook trout (*Salvelinus fontinalis*)
- Brown trout (*Salmo trutta*)
- Cinnamon clownfish (*Amphiprion melanopus*)
- Clarkii clownfish (*Amphiprion clarkii*)
- Common seahorse (*Hippocampus kuda*)
- Eastern oyster (*Crassostrea virginica*)
- Emerald shiner (*Notropis atherinoides*)
- European oyster (*Ostrea edulis*)
- Golden shiner (*Notemigonus chrysoleucas*)
- Green sea urchin (*Strongylocentrotus droebachiensis*)
- Neon dottyback (*Pseudochromis aldabraensis*)
- Nori seaweed (*Porphyra* sp.)
- Northern quahog (*Mercenaria mercenaria*)
- Orchid dottyback (*Pseudochromis fridmani*)
- Ocellaris clownfish (*Amphiprion ocellaris*)
- Percula clownfish (*Amphiprion percula*)
- Rainbow smelt (*Osmerus mordax*)
- Rainbow trout (*Oncorhynchus mykiss*)
- Sandworm (*Nereis virens*)
- Sea scallop (*Placopecten magellanicus*)
- Softshell clam (*Mya arenaria*)
- Splendid dottyback (*Pseudochromis splendens*)
- Sunrise dottyback (*Pseudochromis flevivertex*)
- Tomato clownfish (*Amphiprion frenatus*)
- Whitenose sucker (*Catostomus commersonii*)

Addressing Industry Needs

Researchers, extension specialists, resource managers, industry associations, and concerned stakeholders all play a role in addressing industry needs. The following sections highlight the major accomplishments of aquaculture research, extension, and education facilities, and organizations in Maine. In particular, representatives from each of these entities

Henry (Hank) Stence, manager of the urchin hatchery housed at the RJ Peacock Canning Company facility in Lubec, Maine, with some juvenile green sea urchins (*Strongylocentrotus droebachiensis*) he's raised. (Photo: Dana Morse)



came together in 2008 to develop a Statewide Economic Development and Research Priority Strategic Plan for the aquaculture industry over the next 10 years. The final plan will be released in 2010.

Aquaculture Research Facilities

The University of Maine (UMaine) has a number of research facilities throughout the State including the Darling Marine Science Center (DMC), the Center for Cooperative Aquaculture Research (CCAR), the Aquaculture Research Center, the Food Sciences Lab, and the Maine Aquatic Animal Health Lab (MAAHL). The School of Marine Sciences, within the University, supports several faculty members who have aquaculture research and teaching responsibilities.

Research at the Darling Marine Science Center, located in Walpole on the Damariscotta River, is focused on the development of sustainable shellfish culture techniques and is the home of the oyster broodstock program. This facility also has incubation space that can house start-up shellfish, invertebrate, algal, or finfish businesses. A recent upgrade in infrastructure included a greenhouse that supports the state-of-the-art SeaCaps algal production system, which came on-line in 2008.

The Center for Cooperative Aquaculture Research, located in Franklin on Taunton Bay, is a commercial-scale applied aquaculture R&D facility and business incubator space. Facilities include a variety of rearing tanks, over a dozen marine and freshwater recirculating systems, a new state-of-the-art multi-species marine finfish hatchery, and a water system that allows for rearing of marine, estuarine, and freshwater species. The facility currently houses halibut and cod broodstock and juveniles, the world's only indoor recirculating marine polychaete worm farm, a green sea

urchin hatchery, and culture and net seeding facilities for nori (edible red algae).

Projects in progress at CCAR include:

- Development of broodstock diets for Atlantic halibut
- Development of sea urchin aquaculture in Maine

The Aquaculture Research Center, located on the University of Maine campus in Orono, has a laboratory system used for small-scale marine, brackish, and freshwater research. It specializes in recirculation technology. The Center also houses a wave tank that is used for engineering and testing of new aquaculture equipment. Current work at the Center includes breeding and rearing of new tropical marine species.

The Food Sciences Laboratory, located at the University of Maine Orono, is a completely equipped facility including a twin screw extruder. This lab participates in fish nutrition studies and manufactures trial diets as needed. They work cooperatively with other university facilities to conduct feeding trials and develop new diets for aquaculture and other species.

The Maine Aquatic Animal Health Lab, located at the University of Maine Orono campus, is designed as a shared-user magnet research facility for aquatic animal health and disease research. The MAAHL is a program of the University of Maine Cooperative Extension and the Department of Animal and Veterinary Sciences. The mission of the MAAHL is to foster applied aquatic animal health research and diagnostics, along with providing outreach with education to address the needs of Maine's aquaculture and fisheries communities. Private and public entities are encouraged to collaborate in the activities of the MAAHL. The laboratory is equipped with state-of-the-art imaging, culture, and molecular equipment needed to conduct cutting-edge research on aquatic animal pathogens of any nature. In particular, the lab is currently home to the only disease isolation wet lab in the State for conducting experimental infectiousness trials.

Examples of current aquaculture projects at MAAHL:

- Determining the health risks of lobster bait to marine animals
- A multi-state collaborative to develop and implement a conservation program for three anadromous finfish species of concern in the Gulf of Maine
- Development of tools and techniques to recognize lobster stressors throughout the supply chain and the development of Best Management Practices

(BMP) to reduce or eliminate stress on lobsters

- Investigations on the potential health and economic benefits of finfish and shellfish polyculture

The Maine Aquaculture Innovation Center (MAIC) is housed at the University of Maine in Orono. The mission of MAIC is to assist in the development of economically viable aquaculture opportunities along the coast of Maine and at appropriate inland sites by:

- Sponsoring and facilitating innovative research and development projects involving food, pharmaceuticals, and other products from sustainable aquatic systems
- Investing in the enhancement of aquaculture capacity in Maine
- Serving as a clearinghouse of educational information to enhance public visibility and acceptance of aquaculture
- Encouraging strategic alliances tasked with promoting research, technology transfer, and the commercialization of aquaculture research

Examples of recent MAIC-funded aquaculture research:

- European oyster cultivation in midcoast Maine: development of improved hatchery techniques and disease resistant lines
- Reducing impacts from predators on cultured hard clams in eastern Maine

The U.S. Department of Agriculture operates its National Cold Water Marine Aquaculture Center (NCWMAC) research facilities in Franklin, with additional research facilities planned in Orono. The Franklin facility is the home of the USDA Atlantic Salmon Broodstock program. NCWMAC has been conducting research since 2003 in Franklin, using two temporary greenhouses prior to the construction of permanent facilities. The permanent research facilities were completed in 2007 and consist of a 42,000 square



Young urchins of different sizes raised at the RJ Peacock Canning Co. facility in Lubec, Maine, held by the chief scientist, Michael (Mick) Devin. (Photo: Dana Morse)

foot main research building with approximately 300 research tanks and two, approximately 3,000 square foot, research buildings.

The Downeast Institute for Applied Marine Research and Education (DEI) is located on Great Wass Island in Beals. This education and research facility produces commercially important marine shellfish in a commercial-scale hatchery facility. DEI is best known for the annual production of millions of softshell clam seed for public stock enhancement for Maine coastal communities. In addition, research projects at the facility include regional growth of hatchery-reared lobster juveniles, growth/survival of hard clams in the cold waters of eastern Maine, and an examination of the efficacy of closed bottom areas with respect to managing wild populations of sea scallops.

Downeast Institute staff work with scientists and students from the nearby University of Maine at Machias (UMM), which considers the facility its marine field station. In addition, DEI staff and UMM scientists work in conjunction with fishermen, entrepreneurs, and educators to develop programs and projects that have both educational and economic benefits to the residents of coastal Maine. The Downeast Institute is a non-profit organization administered by a 15-member Board of Directors. The mission of DEI is to improve the quality of life for the people of downeast and coastal Maine through applied marine research, technology transfer, and public marine resource education.

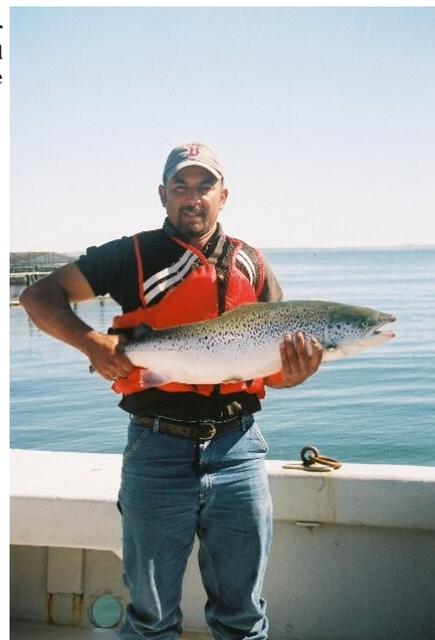
Current research and extension projects at DEI include the following work:

- Softshell seed clams for stock enhancement and research
- Using closed areas to enhance the scallop fishery
- Farming hard clams (*Mercenaria mercenaria*)

The Maine Aquaculture Association (MAA) conducts applied research on member farms that addresses industry issues and supports the development of sustainable husbandry techniques. Recent and ongoing research includes:

- Development of an independent third party verified containment management system for all salmon culture facilities in the state
- Development of Best Management Practices
- Development of composting techniques for fish waste from freshwater hatcheries
- Demonstration of plant culture techniques to reduce nutrients in hatchery effluent
- Development of inventory system for bottom cultured oysters

A Maine salmon farmer displays a farm-raised salmon. (Photo: Cooke Aquaculture)



The above examples of aquaculture research in Maine are only a partial list. Details for other aquaculture projects in Maine can be found by checking with the principal funding agencies including: the USDA Northeast Regional Aquaculture Center, the Maine Sea Grant College Program, the Maine Technology Institute, the Maine Aquaculture Innovation Center, and the Northeast Sustainable Agriculture Research and Education Program. Projects range from deterrent devices for eider predation on mussels, to broodstock development in oysters, and improvements in baitfish production.

Aquaculture Extension

Extension programs include: technical assistance and husbandry, permitting and licensing, Hazard Analysis and Critical Control Points (HACCP) certification, public demonstrations and presentations, improving links between researchers and industry members, and development of applied research projects.

There are several centers of extension activity in Maine and programs within these centers are described in the following section.

Extension activities for Maine Sea Grant (MESG) include: programs for technology transfer and professional development within the industry as well as those to educate or connect citizens to the aquaculture industry and its products in various ways. Partners in these efforts include the Maine Aquaculture Association, Maine Aquaculture Innovation Center, Maine Department of Marine Resources, and other institutions and citizen groups. Examples of activities include: hosting industry meetings to discuss important



Sea scallops (*Placopecten magellanicus*) raised at the Darling Marine Center in Walpole, Maine, for education and demonstration. Shucked individual is female; note the orange roe sac. Scallops are not fully developed as an aquaculture species in Maine, although the wild fishery uses aquaculture techniques such as spat collection for wild stock enhancement. (Photo: Dana Morse)

issues and solutions, collaborating with regional partners on the biannual Northeast Aquaculture Conference and Exposition (NACE), convening forums where industry and concerned citizens can work on issues of concern, organizing visits to aquaculture sites and facilities, and various speaking engagements. ME SG also produces publications relevant to the aquaculture industry.

The Maine Aquaculture Association focuses its extension and outreach efforts in two primary directions. Staff provide various professional development opportunities to existing growers in the State. These efforts focus both on improved husbandry and/or management skills and improved business skills. MAA frequently works with partners such as Maine Sea Grant or the Maine Aquaculture Innovation Center in these efforts. MAA also directs significant efforts toward educating the general public about aquaculture in the State. This is accomplished through several methods including an Association website, public presentations, and outreach efforts at public trade shows and events. Staff members often lecture to various civic organizations or school groups, and have recently concluded a series of public lectures that were hosted along the entire coast. MAA can also be seen at numerous trade events such as the Maine Agricultural Trade Show, the Maine Fisherman's Forum, tourism shows, local festivals, and the Big E in Springfield, Massachusetts.

There are many activities that fall into the category of 'extension' by other groups throughout the State. The Maine Aquaculture Innovation Center hosts 'lunch and learn' professional development activities for

growers throughout the State. The Downeast Institute transfers technology to others in marine industries regarding the culture of softshell clams and development/operation of lobster hatcheries. The Center for Cooperative Aquaculture Research works with growers on culturing new species in Maine waters. The Maine Department of Marine Resources uses its aquaculture staff to deliver outreach and educational programming to the citizens of Maine, as well as incorporating an extension aspect into its biological monitoring and regulatory roles.

Aquaculture Education

The University of Maine in Orono has undergraduate and graduate programs in freshwater and marine aquaculture, including species such as finfish, shellfish, and algae. Faculty members within the School of Marine Science teach and conduct research in topics ranging from culture of marine macroalgae, to salmon feeds, oyster broodstock development, and design of aquaculture equipment.

The Darling Marine Center is an established center for shellfish culture education at both formal and informal levels. Researchers, industry members, extension personnel, and members of the public are involved in such educational programs as Shellfish Mariculture Techniques, Oyster Gardening, and lectures by guest speakers. The DMC also serves as a central meeting space where shellfish growers gather to learn and discuss programs including Crop Damage Insurance, water quality, and the progress of the Oyster Broodstock Program.

Southern Maine Community College (SMCC) offers the Applied Marine Biology and Oceanography program. This program provides students with the academic background and applied skills required for employment as research assistants and technicians, or for transfer into a four-year baccalaureate program. The curriculum emphasizes hands-on laboratory and field procedures. Special attention is given to collecting and identifying marine organisms, oceanographic sampling aboard the school's research vessel, aquaculture, and service projects in the southern Maine community.

Unity College has an integrated aquaculture and fisheries program that combines the tradition of preparing fisheries biologists and technicians for employment with government agencies and conservation groups, with an education in the multi-faceted aspects of aquaculture. Students are sought by employers and graduate schools because the curriculum provides opportunities for students to become proficient in basic biological and physical sciences while giving them theoretical and practical exposure to

the fields of aquaculture and fisheries sciences. Students also develop an appreciation for the intricacies of aquaculture production, fisheries management, and fish pathology.

The University of New England (UNE) has an Aquaculture and Aquarium Science major that is designed so that graduates will have the skills required to work in either private or governmental sectors, including owning their own businesses or working at a public aquarium. There are four specialized classes and two business classes plus plenty of opportunity to gain hands-on experience maintaining both captive tropical reef fish and local Gulf of Maine species. The students learn to grow phytoplankton and zooplankton and to design and build recirculating systems and exhibit tanks. Students get a good overview of the state of aquaculture in Maine, as well as the world, and the role that aquariums and aquarium science will take in the future of marine science and conservation.

The University of Southern Maine (USM) has a modest link to aquaculture with some biology classes, and at least one faculty member involved in aquaculture research.

The Herring Gut Learning Center (HGLC) is a non-profit marine education and resource center located in the small fishing village of Port Clyde, Maine. Staff members at HGLC teach marine science, aquaculture, geology, and coastal ecology to students of all ages through a variety of hands-on, school-based community outreach and summer camp programs.

Lubec Consolidated School Aquaculture Lab is a state-of-the-art science center that teaches applied biological sciences to students in grades six through twelve. The lab has over 7000 gallons of recirculating

aquaculture systems raising tilapia, brook trout, and various ornamental fishes. The tilapia are reared in an environmentally friendly, simulated-wetland aquaponics system, which utilizes plants growing in an 800 square-foot greenhouse to purify the fish tank effluent. The aquaponic greenhouse has the capability to grow enough vegetables to serve the students a salad bar in the cafeteria every day. The lab also conducts distance learning courses to any interested schools, and is regularly hosting virtual field trips via a T.V. polycom system. Classes are interactive, utilizing five fixed and mobile cameras around the class in microscopes, as well as in the tanks themselves. The students at Lubec Consolidated School and other interested schools can take courses in Vocational Aquaculture, Aquaponics, Botany, Aquaculture, Aquascience, and in the middle school, Applied Science.

Presque Isle Regional Career and Technical Center offers a one-year elective course to tenth, eleventh, and twelfth graders. It is designed to introduce the students to the growing of freshwater and tropical fish under controlled conditions.

The Maine Sea Grant College Program is involved in aquaculture education through the Marine Extension Team, a partnership with University of Maine Cooperative Extension, and through its Communications Department. The MET works with other groups and agencies to develop and implement informational educational programs such as tours, workshops, seminars, speaking engagements, and conferences, and collaborates with the Communications Department to produce items such as fact sheets, research briefs, and other documents and publications. The Maine Sea Grant Program also funds research in aquaculture through its bi-annual Research Program, and projects funded by MESHG are required to have an extension and education component.

Aquaculture Resources

Maine Aquaculture Innovation Center

<http://www.maineaquaculture.org>

Maine Aquaculture Association

<http://www.maineaquaculture.com>

Maine Department of Marine Resources

<http://www.maine.gov/dmr/aquaculture>

Red Tide and Shellfish Sanitation Hotline

http://www.maine.gov/dmr/rm/public_health/closures/shellfishhotline.htm

Maine Department of Environmental Protection

<http://www.maine.gov/dep/>



Researchers conduct Atlantic salmon disease resistance trials at the University of Maine Cooperative Extension, Maine Aquatic Animal Health Laboratory. (Photo: Debbie Bouchard)

Research Contact Information		
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Nick Brown	University of Maine Center for Cooperative Aquaculture Research (207) 422-9096 npbrown@maine.edu	recirculation technology, marine fish and invertebrate rearing technology, broodstock management, live feed production
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Ira Levine	University of Southern Maine (207) 753-6588 ilevine@usm.maine.edu	algal mariculture, physiological ecology, plant osmoregulation
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Chris Davis	Maine Aquaculture Innovation Center (207) 581-2263 cdavis@midcoast.com	shellfish aquaculture, environmental monitoring, genetics
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Dana Morse	Maine Sea Grant / UMaine Cooperative Extension (207) 563-3146 x205 dana.morse@maine.edu	shellfish aquaculture, stock enhancement
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Shelly Gross	Presque Isle Regional Career and Technical Center (207) 764-1356 Shelly.Gross@sad1.org	freshwater and ornamental fish culture
Elaine Jones	Maine Department of Marine Resources (207) 633-9500 elaine.jones@maine.gov	K-12 education
Linda Kling	University of Maine (207) 581-2735 lkling@maine.edu	feed development for marine finfish
Ira Levine	University of Southern Maine (207) 753-6588 levine@usm.maine.edu	algal mariculture, physiological ecology, plant osmoregulation
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Jane Aiudi	Maine Department of Agriculture (207) 287-3491 jane.aiudi@maine.gov	market and production development
Don Hoenig	Maine Department of Agriculture (207) 287-7615 Donald.E.Hoenig@maine.gov	State Veterinarian

Maine Sea Grant College Program

<http://www.seagrants.umaine.edu>

Maine Oyster Broodstock Program

http://www.marine.maine.edu/~rawsonp/oyster_broodstock/start.htm

National Oceanographic and Atmospheric Administration - Aquaculture Program

<http://aquaculture.noaa.gov>

Center for Cooperative Aquaculture Research

<http://www.ccar.um.maine.edu/>

Maine Legislature: Joint Standing Committee on Marine Resources

http://janus.state.me.us/house/jt_com/mar.htm

Maine Technology Institute

<http://www.mainetechnology.org/>

Gulf of Maine Ocean Observing System

<http://www.gomoos.org>

Army Corps of Engineers, New England District

<http://www.nae.usace.army.mil/>

Northeastern Regional Aquaculture Center

The NRAC is one of five Regional Aquaculture Centers established by the U. S. Congress which supports research and outreach efforts to promote the development of the aquaculture industry.

<http://www.nrac.umd.edu>

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