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AQUACULTURE SITUATION AND OUTLOOK REPORT 2009: MASSACHUSETTS

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Industry Trends and Outlook

Commercial aquaculture in Massachusetts occurs in freshwater and marine waters. Freshwater finfish and marine shellfish are also cultured by governmental agencies for release into public waters. In 2007, Massachusetts was the seventh largest producer of cultured shellfish in the U.S. with almost 1,500 acres cultivated. Reported sales topped \$11.2 million and over 172 million oysters and quahogs were marketed by over 230 shellfish farmers. According to the Census of Aquaculture (2005), the number of shellfish farms in Massachusetts grew by 47% from 1998 to 2005 with an increase in sales of 57% over the same time period. Oyster sales, in particular, exploded, increasing 165% during that time, reflecting production from both established and new farms. Since 1996, oysters have been the primary cultured species contributing to the establishment of a number of new shellfish farming communities in Barnstable Harbor, Duxbury Harbor, Katama Bay in Edgartown and the Dennis flats, as well as by the Wampanoag Tribe of Aquinnah. A modest, but growing softshell clam industry and experimental culture of blue mussels are also being pursued.

There are a dozen freshwater finfish producers in Massachusetts. These growers utilize ponds, flow-through systems, and recirculating aquaculture systems to grow fish for the food, live bait, ornamental, and



Cape Cod oyster farmer. (Photo: Bill Walton)

recreational markets. Among these producers is Australis Aquaculture, Ltd., which employs 50 workers to operate one of the largest indoor aquaculture facilities in the world, growing 1,000 metric tons (2.2 million lbs) of barramundi annually valued at \$8 million in 2009. The total value of commercial aquaculture in Massachusetts in 2007 exceeded \$18 million.

Addressing Industry Needs

Researchers, extension specialists, resource managers, industry associations, and concerned

Emerging Issues and Critical Needs

- The public is often ill-informed regarding many aquaculture issues, resulting in resistance to industry and market growth. Education of the public and policy-makers is crucial to continued growth of aquaculture in Massachusetts.
- Because of coastal demographics and current use patterns, significant industry growth in Massachusetts will require (1) recognition that a working waterfront is integral to coastal states and aquaculture is a proper, sustainable pursuit and (2) the adoption of offshore aquaculture techniques. Opportunities currently exist that produce high value products for niche markets such as oysters and quahogs, and for larger-scale production such as submerged longline mussel culture, but technology transfer and is needed.
- Space allocations will be needed for any activities in State waters, and will require outreach to other user groups and to the general public. Partitioning a traditionally, and often constitutionally, designated common resource for the greater common good is needed. An Ocean Management Planning group has been established by Chapter 114 of the Acts of 2008 by the Massachusetts Senate and House of Representatives; aquaculture is identified as an approved activity in coastal waters of the Commonwealth.
- Inadequate permitting processes in both Commonwealth and federal waters are hampering growth in the offshore fish-farming sector. These inadequacies include a lack of clarity with respect to conflicts with traditional users and a lack of tenure rights needed to secure investment capital. These issues are being tackled at both the State and federal level. The Massachusetts ocean planning process will hopefully recognize the economic opportunities associated with offshore aquaculture and result in the needed clarifications. At the federal level, legislation is being proposed that would foster the growth of aquaculture in the U.S. Exclusive Economic Zone (EEZ). It is essential that aquaculture interests represent their needs in both of these on-going processes.

- As the farmed oyster industry has grown, aquaculturists have become increasingly concerned about finding and maintaining markets. It will be critical that Massachusetts shellfish producers establish a niche as a premium product with a high market value.
- The majority of the members of the Massachusetts aquaculture community are small, family-run farms, often operated on slim margins. Any improvements in profitability (e.g., production of triploid oysters, disease resistance stocks, alternate species) can have dramatic effects upon this community, and therefore warrant our attention.
- Freshwater aquaculture is mainly pursued by small, family-run farms that grow finfish for live-bait and stocking in public/private waters. There exists a need to diversify and expand this industry.
- Both large- and small-scale finfish operators have expressed a need for workers with training in basic aquaculture skills.



High school students seining pond. (Photo: Joe Buttner)

stakeholders all play a role in addressing industry needs. The following sections outline new initiatives and recent accomplishments in these areas.

Commercial Species List

- Barramundi (*Lates calcarifer*)
- Bay scallops (*Argopecten irradians*)
- Brook trout (*Salvelinus fontinalis*)



Cape Cod research farm. (Photo: Carrie Slone)

- Brown Bullhead (*Ameiurus nebulosus*)
- Brown trout (*Salmo trutta*)
- Goldenshiner (*Notemigonus crysoleucas*) and other baitfish
- Northern quahog (*Mercenaria mercenaria*)
- Koi (*Cyprinus carpio*)
- Largemouth bass (*Micropterus salmoides*)
- Rainbow trout (*Oncorhynchus mykiss*)
- Softshell clams (*Mya arenaria*)
- Sunfish (*Lepomis* sp.)
- Tilapia (*Oreochromis niloticus*)

Aquaculture Research

Commercial aquaculture was largely confined to small-scale shellfish farming until the early 1990s, with most farms located within Barnstable County. Small numbers of freshwater fish were also grown in ponds as live-bait and for stocking. Cape Cod Cooperative Extension's (CCCE) Marine Program has been working with these shellfish farmers for almost 40 years, with most research being field-based. With the increase in offshore fishery closures and mounting interest in aquaculture, the Commonwealth of Massachusetts established and funded three aquaculture centers in 1996: the Southeastern Massachusetts Aquaculture Center (SEMAC), the Northeastern Massachusetts Aquaculture Center (NEMAC), and the Western Massachusetts Center for Sustainable Aquaculture (WMCSA).

CCCE and SEMAC have lab and work space at the Marine Program Field Station, located in Barnstable, Massachusetts, primarily for conducting research in conjunction with shellfish farmers and local natural resource managers. In addition, SEMAC and CCCE maintain a shellfish research and demonstration site in the town of Dennis. Space is also utilized at the Eastham Aquaculture Technology Training Center,

which houses a large recirculating system. SEMAC and CCCE also work closely with MBL on a number of projects, which allows for research access to a highly sophisticated marine animal holding facility and marine pathology lab. The following research projects are being conducted:

- Development of a quantitative measure of shellfish habitat
- Identification of factors affecting QPX disease prevalence in northern quahogs
- Shellfish Research Farm Network (research conducted in collaboration with farmers). Projects include assessing triploid oyster growth, testing alternative species, testing disease resistance in local strains of oysters, and testing of brine-dipping methods to control biofouling of shellfish and shellfish gear
- Use of experimental underwater fencing as bay scallop spawning sanctuaries and for aquaculture applications
- Disease testing and direct technical response to unexplained mortalities of northern quahogs
- Community-based oyster remote-set projects as a potential method to improve marine water quality
- Potential use of crabs and other grazers to control biofouling of shellfish gear
- Utilization of microsatellite genetic markers to differentiate offspring of bay scallop broodstock
- Quantifying prevalence and intensity of shellfish diseases
- Characterizing populations of shellfish predators, such as green crabs, on the South Shore
- Testing of barriers to shellfish predators such as oyster drills
- Use of eelgrass seeding for habitat restoration
- Potential use of recycled plastic lumber in aquaculture applications



Shellfishers install predator exclusion net to protect juvenile clams stocked in Boston Harbor. (Photo: Joe Buttner)



Aquadome assembly in Woods Hole. (Photo: Cliff Goudey)

- Comparison of the various methods used for overwintering oysters

NEMAC is based at the Cat Cove Marine Laboratory, operated by Salem State College. The 5,500 square foot laboratory rests on a 16-acre site adjacent to Smith Pond. The Laboratory includes a classroom, analytical lab, shellfish hatchery, algal culture room, and finfish culture system. A 400ft² auxiliary hatchery was constructed and first operated in 2007. The new facility allows for expansion of production and research capabilities. Smith Pond is an 8-acre tidal pool where water flow in and out is controlled by a dam. Most research efforts have focused on softshell clams, however, mussels, green crabs, urchins, striped bass, summer and winter flounder, cod, rainbow trout, tilapia, largemouth bass and yellow perch have been examined. The following research projects are being conducted:

- Development of culture protocols for softshell clam spawning, nursery, and growout
- Restoration and enhance softshell clam populations in Boston Harbor in collaboration with the Massachusetts Division of Marine Fisheries (DMF)
- Spawning and nursery success of softshell clams from Cape Cod and Cape Ann
- Open ocean culture of blue mussels in coastal waters off Cape Ann
- Assessing survival and growth of triploid oysters (SEMAC collaboration)
- Assessing survival and growth of softshell clams as an alternate species south of Boston (NEMAC and grower collaboration)
- Characterizing populations of shellfish predators, such as green crabs, North of Boston
- Use of macroalgae as a lipid and protein substitute in salmonid rations

WMCSA supports and promotes the development of the freshwater finfish aquaculture industry in the

State, facilitating industry expansion and educating the public about the opportunities and benefits of aquaculture. Collaborations have been developed with U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey, Massachusetts Department of Agricultural Resources and Massachusetts Division of Fish and Game.

The Massachusetts Institute of Technology Sea Grant College Program developed two initiatives dealing with aquaculture issues. The first is the Offshore Aquaculture Engineering Center (OAEC), which is developing many of the key technologies for growth in the offshore aquaculture sector. The second is the Marine Finfish Hatchery (MFH), located in Gloucester, Massachusetts.

The OEAC at MIT specializes in the development of innovative technologies for offshore aquaculture. Currently this industry is flourishing in other countries, particularly in warmer tropical waters. However, there are species and technologies that can bring similar economic opportunities to Massachusetts and this is an important focus for OAEC. The following research projects are being conducted:

- Pilot-scale testing of a mobile fish cage
- Assessing underwater acoustic deterrent against duck predation at mussel farms
- Developing techniques for diverless rotation of an offshore cage for cleaning and harvesting
- Testing an auto-submerging 100 cubic meter cage for offshore aquaculture in China
- Developing and testing of a wave-powered air compressor to power offshore aquaculture
- Acoustic biomass assessment in spherical cages
- Investigating systems for ocean ranching and stock enhancement



A 600m³ cage on a single-point mooring. (Photo: Chris Bridger)



Single meat from a blue mussel. (Photo: Rick Karney)

MIT's Marine Finfish Hatchery (MFH) develops and maintains recirculating and flow-thru aquaculture systems to conduct research on egg, larval, and juvenile life stages of marine fishes. Winter flounder and black sea bass are the species of focus. The MFH has also developed an eelgrass cultivation program for Massachusetts.

Several private hatcheries also conduct research. In 2007, SEMAC and NEMAC partnered with the Massachusetts Aquaculture Association, the Martha's Vineyard Shellfish Group, and the Marine Biological Laboratory to form the Massachusetts Shellfish Aquaculture Innovation Consortium (MSAIC).

Martha's Vineyard Shellfish Group (MMSG) is a consortium of the Shellfish Departments of the six towns on Martha's Vineyard. It operates both a solar-assisted shellfish hatchery on Lagoon Pond in Tisbury and a shellfish nursery on Chappaquiddick Island in Edgartown. The following research projects are being conducted:

- Development of triploidy in bay scallops
- Production of a Dermo disease-resistant strain of oyster
- Development of cageless culture of shellfish with marine adhesives
- Investigation of the feasibility of offshore mussel culture

The Marine Biological Laboratory (MBL) in Woods Hole has both a world-class pathology laboratory and an animal holding facility. The pathology lab is equipped for histopathology, disease testing and analysis capabilities. The Marine Resources Center of MBL is a 32,000 square foot state-of-the-art facility capable of housing and culturing a number of vertebrate and invertebrate marine organisms. An 800 square foot research shellfish

hatchery and floating upweller shellfish nursery are located at the MBL. The following research projects are being conducted:

- Development of a fast, sensitive assay for QPX disease in northern quahogs
- QPX disease genetic analysis
- Locally developed oyster broodstock
- Restoration of the surf clam fishery
- Production of alternative species
- Demonstration of acoustic sea ranching of black sea bass

Aquaculture research is also conducted at Woods Hole Oceanographic Institution (WHOI) and the University of Massachusetts (UMASS) at Dartmouth's School for Marine Science and Technology.

Aquaculture Extension

Extension is the major focus of the three Massachusetts regional aquaculture centers, which often collaborate together on inter-regional projects. Extension activity is also an integral part of the MITSG/MEC program.

SEMAC, working with Cape Cod Cooperative Extension and Woods Hole Oceanographic Sea Grant, has offered a number of workshops and courses specifically targeting shellfish farmers. A recent 8-week course, *Fundamentals of Shellfish Farming*, was offered and included field trips to local shellfish farms as well as presentations from local growers. SEMAC offered a number of workshops specifically targeting shellfish farmers. This series, *Improving Shellfish Production*, focuses on applied information and has been very successful. SEMAC has also developed water-proof, glove-compartment-sized brochures for shellfish farmers, describing common predators, pests and diseases. Additionally, SEMAC and Cape Cod Cooperative Extension have provided workshops and meetings which allowed industry members to obtain information about the US Department of Agriculture Risk Management Agency (USDA RMA) crop insurance program for hard clams, and the potential use of USDA RMA Adjusted Gross Revenue-Lite insurance by shellfish farmers.

SEMAC works closely with the region's shellfish farmers and natural resource managers to provide technical assistance. The first manual, *Best Management Practices for the Shellfish Culture Industry in Southeastern Massachusetts*, was produced and distributed by SEMAC, NEMAC, and the Massachusetts Aquaculture Association to the aquaculture industry as well as municipal offices throughout the southeastern Massachusetts region.



Grading barramundi at Australis Aquaculture, Turners Falls, MA. (Photo: Fred Collins)

SEMAC, along with CCCE, currently maintains four water quality monitoring stations outfitted with state of the art 'YSI' instruments to record water condition data every 20 minutes. Two of the sites relay real-time data via satellite to the Web. SEMAC publishes a periodic newsletter as well as maintaining it's presence through a website.

Since 1996, a large portion of the SEMAC outreach budget has been directed toward direct industry support with financial assistance provided through both mini-grant and scholarship programs.

NEMAC extension efforts focus on the North Shore of Massachusetts. With NEMAC assistance, a fledgling softshell clam aquaculture effort has materialized, initially on the North Shore and subsequently throughout the entire coastline. Over two dozen Towns in Massachusetts have obtained and stocked clams produced at NEMAC's Cat Cove Marine Laboratory for commercial, restoration and/or enhancement purposes. Technical assistance provided Towns varies, ranging from providing supplies (e.g., netting, clams) to hands-on instruction and informational meetings with prospective culturists and Town Officials. Best management practices for softshell clam culture as well as marketing materials have been developed collaboratively by NEMAC and industry. A website and newsletter are produced and disseminated, and list-serves are managed by NEMAC staff. Workshops are periodically offered, often through collaboration with SEMAC and NEMAC, on topics proposed by the industry. Recent workshops targeted mussel culture.

WMSCA and NEMAC assist growers producing fish in ponds and schools using aquaria in classrooms. On-site assistance with stocking and water quality management are provided.

WMSCA provided leadership for the renovation of an abandoned USFWS hatchery in Monterey. The Berkshire Fish Hatchery, which cultures brown and rainbow trout and Atlantic salmon, is now the only USFWS hatchery staffed entirely by volunteers.

WMSCA has also been active in the design and technical operation of two new aquaculture facilities in the state: a largemouth bass fingerling operation in Northfield and a bass/trout aquaponics facility in East Sandwich. A publication, *Best Management Practices for Finfish Aquaculture*, was developed and published by WMSCA and is currently available on its website.

MITSG's MFH offers extension through the demonstration of larval culture and the integration of aquaculture into classrooms throughout the state. Eelgrass culture has also become a large part of these extension efforts due to the City of Gloucester's sewer pipe upgrades in Gloucester Harbor. In collaboration with the U.S. EPA, the Massachusetts Coastal Zone Management and the Massachusetts DMF, the MFH provides assistance in eelgrass culture and research protocols as well as facilitates the experimental systems used to overwinter eelgrass.

MITSG's Offshore Aquaculture Engineering Center (OAEC) is a research and technology transfer center that focuses on the development of technologies for industrial-scale aquaculture in the U.S. Exclusive Economic Zone. OAEC provides engineering support to U.S. companies and consortia engaged in offshore fish and shellfish farming and to U.S. companies providing hardware and systems for offshore aquaculture worldwide.

Aquaculture Education

Education is a critical component of each of the Massachusetts Aquaculture Centers and considerable collaboration occurs with workshops and demonstration projects. Each Center maintains a website (see "Aquaculture Resources" at the end of this report) and several facilities open their doors for tours. For instance, the MITSG Marine Education Center (MEC) in Gloucester, Massachusetts has over 10,000 visitors annually. Extensive curricular materials for the integration of aquaculture into K-12 classrooms have been cooperatively produced (authored by NEMAC, New England Board of Higher Education, SEMAC, Roger Williams University, Massachusetts Department of Agricultural Resources) and published.

SEMAC, working with Cape Cod Cooperative Extension and Woods Hole Oceanographic Sea Grant, routinely gives lectures and hosts field trips. In addition, formal courses are offered periodically, often



Juvenile softshell clams used to restore and enhance populations in Boston Harbor, 2007. (Photo: Joe Buttner)

through Massachusetts Maritime Academy, including a state certification course for Massachusetts Shellfish Officers. Recently, the DVD *Shellfish Aquaculture: Tools, Tips, and Techniques*, was released as a tool for new shellfish farmers and others working with shellfish.

NEMAC, through Salem State College, offers undergraduate training in aquaculture as a concentration in the Department of Biology. Graduate courses and opportunities for Directed and Independent Studies (for non-traditional students such as high school students, displaced fishers and pensioners) are also offered. Graduates from the Aquaculture Concentration are employed at aquaculture operations or attend graduate schools in Massachusetts, throughout northeast, and across the United States. During the 2008-2009 academic year, three high school students pursued internships at NEMAC's Cat Cove Marine Laboratory.

A small grants program is available for teachers (K-12) to secure supplies, equipment and other resources to facilitate integration of aquaculture into the classroom. On-site technical assistance is also available for schools. For instance, NEMAC assisted Gloucester High School with construction and setup of a wet lab where algae, clams, and mummichogs are cultured. Over 90 teachers have participated in summer workshops and over a dozen schools have established some form of aquaculture-based instruction. Many Massachusetts schools (and NEMAC) are part of the National Aquaculture Education Network based at Auburn University. Guided tours of the lab attract 100-200 students annually.

Essex Technical and Agriculture High School in collaboration with MITSG and NEMAC, is conducting

aquaculture research on marine and freshwater fish and invertebrate species in their Fish Barn. They raise red bellied turtles, Atlantic salmon, winter flounder and largemouth bass. In addition to the Fish Barn, an integrated polyculture system has been developed to grow fish and plants.

MITSG's MEC, in collaboration with the Gloucester Maritime Heritage Center, strives to educate the public about aquaculture: what it is, how are species raised, what systems are used, and what role aquaculture plays in our society. Education activities include: 1) field trips focusing on measurement, system design, water quality, animal husbandry, finfish development and eelgrass, and 2) teacher professional development workshops on eelgrass, marine finfish culture and monitoring the marine environment. The MEC also hosts high school and undergraduate internships year-round for students seeking to learn more about aquaculture and the marine environment.

WMCSA, through the University of Massachusetts, offers an undergraduate practicum in aquaculture and aquaponics each semester and seeks to place student interns from vocational schools and the University with local aquaculture operations.

Aquaculture Resources

SouthEastern Massachusetts Aquaculture Center

<http://www.capecodextension.org/semac/>

NorthEastern Massachusetts Aquaculture Center

<http://www.salemstate.edu/academics/schools/1028.php>

MIT Sea Grant Marine Finfish Hatchery and Education Center

<http://seagrant.mit.edu/hatchery/>

<http://seagrant.mit.edu/eelgrass/>



Local volunteers help with oyster remote-set project (Photo: Diane Murphy)

Research Contact Information		
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Mark Fregeau	Northeastern Massachusetts Aquaculture Center Salem State College, Department of Biology (978) 542-6705 mfregeau@salemstate.edu	bivalve molluscs
Rebecca Gast	Woods Hole Oceanographic Institution (508) 289-3209 rgast@whoi.edu	QPX, genetics
Rick Karney	Martha's Vineyard Shellfish Group (508) 693-0391 mvsg@comcast.net	shellfish biology
Scott Lindell	Marine Biological Laboratory (508) 289-7097 slindell@mbl.edu	finfish and shellfish aquaculture
Diane C. Murphy	Cape Cod Cooperative Extension and Woods Hole Oceanographic Institution Sea Grant (508) 375-6953 dmurphy@whoi.edu	fisheries and aquaculture, shellfish biology, and estuarine ecology
Extension Contact Information		
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Joseph K. Buttner	Northeastern Massachusetts Aquaculture Center Salem State College, Department of Biology (978) 542-6703 jbuttner@salemstate.edu	finfish / shellfish aquaculture, water quality, business plan development, grant writing, permit acquisition
Craig Hollingsworth	University of Massachusetts Extension Aquaculture Program (413) 545-1055 chollingsworth@umext.umass.edu	freshwater finfish culture
Diane Murphy	Cape Cod Cooperative Extension and SouthEastern Massachusetts Aquaculture Center (508) 375-6953 dmurphy@cape.com	shellfish aquaculture, shellfish habitat assessment, freshwater wetlands
Scott Weston	Northeastern Massachusetts Aquaculture Center and Department of Biology, Salem State College (978) 542-6821 sweston@salemstate.edu	shellfish orders, culture protocols, tour of Cat Cove Marine Laboratory

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Sarah Olivo	Massachusetts Institute of Technology Sea Grant (617) 253-5944 office / (978) 283-6275 hatchery olivo@mit.edu	K-12 marine education
State Aquaculture Specialist		
Sean Bowen	Massachusetts Department of Agricultural Resources 617-626-1724 office Sean.Bowen@state.ma.us	permitting and development
Aquaculture Industry Association		
Steven Wright	Massachusetts Aquaculture Association (508) 241-7503 chathamoysters.com@gmail.com	shellfish industry networking and information transfer

MIT Sea Grant Offshore Aquaculture Engineering Center

<http://seagrant.mit.edu/research/currentresearch.php?CAT=fa>

Western Massachusetts Center for Sustainable Aquaculture

<http://www.umass.edu/aquaculture>

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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