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First Annual Report on Aquaculture and Policy in the United States of America for the 2013 UJNR Panel

Marie L. Fujitani*, Robert C. Jones*, and Mike B. Rust*

Abstract: The first U.S. National Report on Aquaculture for the 41st U.S. Japan Natural Resources Panel on Aquaculture overviews major policy items, current trends in aquaculture production, and other important developments affecting contemporary U.S. aquaculture.

Policy- April 2013 saw the release of the National Ocean Policy Implementation Plan (NOP-IP), a document to translate President Obama's 2010 National Ocean Policy (Executive Order 13547 --Stewardship of the Ocean, Our Coasts, and the Great Lakes) to specific federal actions. Aquaculture featured prominently in the Implementation Plan. The Joint Sub-committee on Aquaculture (JSA) was re-named the Interagency Working Group on Aquaculture (IWG-A), and was tasked with identifying and supporting milestones in the NOP-IP. The NOP-IP also supported the National Shellfish Initiative to increase shellfish production and restoration in U.S. waters. NOAA and the Gulf of Mexico Fishery Management Council are working on a Fishery Management Plan to permit aquaculture in federal waters in the Gulf of Mexico. The U.S. currently does not have a framework to permit aquaculture in the EEZ, and this would be a first for the U.S. if it goes into effect.

Developments- For the first time in some years, in 2013 many new sites for shellfish aquaculture have been permitted. This is attributed to increased interest in shellfish aquaculture, particularly in the northwest and northeast, federal interagency and state efforts on behalf of the Washington Shellfish Initiative, and state-level successes at streamlining permitting. In September 2013, the California Shellfish Initiative was launched. A program is underway to permit and restore Hawaiian fishponds, a form of traditional Hawaiian aquaculture, for cultural heritage, subsistence, and possibly commercial production.

Production Trends- Aquaculture production in the U.S. is largely composed of catfish, crawfish, trout, salmon, oysters, mussels, clams, tilapia, and shrimp. For the 15-year period from 1996–2011, the value of U.S. aquaculture showed 3% average year-over-year growth, though total volume fell by an average of 0.5%. Mariculture (salmon and shellfish), on the other hand, showed robust 4% by volume and 5% by value year-over- year average growth in the same period. 2011 is the most current year published aquaculture statistics are available. From 2010 to 2011, total U.S. aquaculture went down –18.8% by volume (to 277,335 metric tons) but grew 4.2% by value (to 1.34billion dollars). From 2010 to 2011 mariculture decreased by –12.4% by volume (to 35,739 metric tons) while growing 0.3% by value (to 314 million dollars). However, in the previous year from 2009–2010, mariculture grew 21.6% by volume (to 40,823 metric tons) and 28.5% by value (to 312 million dollars). Most of the growth in value for marine aquaculture was from salmon (*Salmo salar*) and oyster (mainly *Crassostrea gigas* and *Crassotrea virginica*) production.

Keywords: aquaculture policy, aquaculture production, annual report

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* NOAA Office of Aquaculture, 1315 East-West Highway, Silver Spring, MD 20910
E-mail: NMFS.aquaculture.science@noaa.gov

Background

The U.S. imports over 90 percent of its seafood, half of which is a product of foreign aquaculture. While aquaculture produces 50 percent of all seafood eaten worldwide, in 2011 U.S. domestic aquaculture production was only 9% of total domestic landings. Total domestic aquaculture in the U.S. provided around 5% of the seafood supply; mariculture was the source of less than 1% of U.S. seafood.

Policy

The Department of Commerce, NOAA Fisheries, and Aquaculture: Marine aquaculture is an important part of the missions of the Department of Commerce (DOC) and the National Oceanic and Atmospheric Administration (NOAA). The DOC sees aquaculture as a way to create jobs and economic activity. A federal agency under the DOC, NOAA sees aquaculture as a critical component to meeting increasing global demand for seafood and maintaining healthy ecosystems.

The NOAA Office of Aquaculture is within the National Marine Fisheries Service (NMFS), a branch of NOAA. NMFS is involved in aquaculture from both science and policy perspectives: science to foster efficiency and sustainability and policy to enable marine aquaculture while ensuring environmental responsibility. Marine aquaculture is an increasingly important part of the NOAA NMFS mission. Marine aquaculture is providing a growing amount of seafood to U.S. consumers, and supports commercial and recreational fisheries and helps restore species and habitat.

Aquaculture is garnering increasing attention from Commerce, members of Congress, and the private business sector for its ability to provide economic opportunities (especially in fishing communities) and potential to grow more seafood domestically in a safe, sustainable way. In 2011, NOAA and the Department of Commerce released complimentary aquaculture policies (http://www.nmfs.noaa.gov/aquaculture/policy/2011_policies_homepage.html) supporting aquaculture to enable domestic production of seafood, maintain and restore healthy marine ecosystems, and create employment and business opportunities.

The National Ocean Policy Implementation Plan: In 2010 President Obama signed the National Ocean Policy (NOP; Executive Order 13547 --Stewardship of the Ocean, Our Coasts, and the Great Lakes, http://www.whitehouse.gov/the-press-office/executive-order-stewardship-ocean-our-coasts-and-great-lakes). In April 2013 the National Ocean Policy Implementation Plan (NOP-IP, http://www.whitehouse.gov/administration/eop/oceans/implementationplan) was released, which charges federal agencies to work together and take specific actions to address ocean issues of national importance. Aquaculture is featured prominently in the Implementation Plan.

The aquaculture-specific actions in the NOP-IP relate to increasing efficiencies in the aquaculture permitting processes, coordinating agency participation, and providing jobs and economic value by protecting and restoring coastal wetlands, coral reefs, and other natural systems. Along with goals for commercial aquaculture, restoration is also specifically mentioned in the NOP-IP, to improve coastal and estuarine restoration efforts through better monitoring, coordination, and planning.

Agency Abbreviations:
NOAA: National Oceanic and Atmospheric Administration
USDA: U.S. Department of Agriculture
ARS: Agricultural Research Service
NIFA: National Institute of Food and Agriculture
APHIS: Animal and Plant Health Inspection Service
EPA: Environmental Protection Agency
USCG: U.S. Coast Guard
DOC: Department of Commerce
DOI: Department of the Interior
DOL: Department of Labor
USFWS: U.S. Fish and Wildlife Service
FERC: Federal Energy Regulatory Commission
DOE: Department of Energy
HHS: Department of Health and Human Services
FDA: Food and Drug Administration
ACOE: The U.S. Army Corps of Engineers

NOP-IP Actions Relating to Aquaculture, and Responsible Agencies:
By the end of 2013

- Develop and implement permitting regulatory efficiencies for aquaculture. [NOAA, USDA, EPA, USACE, USCG, DOI (USFWS)]

- Establish an interagency aquaculture initiative that supports jobs and innovation through the National Science and Technology Council's Interagency Working Group on Aquaculture and other partnerships. [DOC, NOAA, USDA (ARS, NIFA)]
- Through leveraging existing research priorities, provide scientific information on the environ-mental health effects of finfish aquaculture to streamline permitting and improve water quality monitoring. [Aquaculture Regulatory Task Force]
- Through the National Shellfish Initiative develop pilot projects to identify ways to both maxi-mize the environmental sustainability and ecosystem benefits (e.g., nutrient filtration, carbon sequestration, fish habitat) and the commercial value of shellfish aquaculture. This would help develop a comprehensive plan to sustainably increase shellfish production and restore popula-tions in U.S. waters. [NOAA, USDA (ARS, NIFA)]

By the end of 2015

- Identify and make available best management practices to inform and improve Federal permitting processes for aquaculture. [NOAA, USDA, EPA, USACE, USCG, DOI (USFWS)]
- Develop an analysis of the contribution and impacts (including job creation) of emerging uses—including renewable energy, aquaculture, and biotechnology—on the economies of the communities and regions dependent on marine and coastal resources. [NOAA, DOE, DOI, FERC, DOL, DOC]

By the end of 2016

- Develop and incorporate adaptation strategies for coastal and ocean species and habitats into future planning and management processes, such as fisheries, protected species, coral reefs, or shellfish aquaculture. [NOAA, DOI, EPA]

The Inter-Agency Working Group on Aquaculture (IWG-A): The Inter-agency Working Group on Aquaculture (IWG-A; formerly called the Joint Sub-committee on Aquaculture) is an inter-agency group under the auspices of the Life Sciences Sub-committee of the National Science and Technology council. The purpose of the working group is to increase the overall effectiveness and productivity of Federal aquaculture research, technology transfer, and technology assistance programs. Efficient, coordinated permitting processes will allow ocean industries, including commercial shellfish and finfish aquaculture, to save time and money and encourage economic growth without compromising federal agency responsibilities to protect health, safety, and the environment. Improved interagency coordination and reduced redundancy will decrease administrative waste, the burden on federal agencies, and the regulatory burden for industry.

Under the IWG-A, an Aquaculture Regulatory Task Force (hereafter 'task force') was created in 2013under the auspices of the National Aquaculture act of 1980, and will address specific milestones and activities in support of the Implementation Plan of the National Ocean Policy in consultation and partnership with the National Ocean Council and the IWG-A. The task force consists of the following federal agencies: The USDA: ARS, NIFA, and APHIS; DOC: NOAA; HHS: FDA; DOI: USFWS; EPA; and the ACOE. The task force also includes the following organizations in the Executive Office of the President: National Ocean Council;Office of Management and Budget; and Office of Science and Technology Policy. The task force will operate from 2013–2015 unless renewed.

In 2013 the task force assembled a draft charter to support aquaculture milestones in the NOP-IP, as well as a draft work plan identifying specific actions towards task force goals. Progress has been made on facilitating inter-agency communication, coordination to streamline multi-agency permitting processes, and increasing the ease of access to information about the permitting process.

The Gulf of Mexico Fishery Management Plan: The U.S. currently does not have a framework to permit long-term aquaculture projects in the Exclusive Economic Zone (federal waters), 3 to 200 miles (5 to 322 kilometers) offshore. This is despite the huge potential for offshore aquaculture in the U.S. A recent publication from the Food and Agricultural Organization (FAO) of the United Nations (Kapetsky *et al.*, 2013) listed the US as number one in the world for offshore marine production potential. Japan also ranked highly (fifth) in this category. The rankings were obtained by accounting for the area in each country's Exclusive Economic Zone with appropriate depth, currents, temperature, and distance to ports for finfish (e.g. salmon and cobia) and shellfish (e.g. mussels) production.

An ongoing development for U.S. offshore aquaculture is the Fishery Management Plan for Regulating Offshore Marine Aquaculture in the Gulf of Mexico (Aquaculture FMP). The Gulf of Mexico Fishery Management Council proposed regulations for an Aquaculture FMP, the first time that a regional fishery management council has approved a comprehensive regulatory program for offshore aquaculture in U.S. federal waters. NOAA is currently reviewing the proposed regulations that would implement the Aquaculture FMP. The Fishery Management Plan authorizes NOAA Fisheries to issue permits to culture species managed by the Gulf of Mexico Fishery Management Council, with the exception of shrimp and corals. We expect final regulations to be effective sometime in 2014.

Recent Key Developments in U.S. Aquaculture

National and Regional Shellfish Initiatives: The National Shellfish Initiative is a policy created in conjunction with the 2011 DOC and NOAA Aquaculture Policies. The goal of the initiative is to support increases in shellfish production and restoration in U.S. waters. In 2013 the Office of Aquaculture and aquaculture regional coordinators supported a number of actions for the National Shellfish Initiative in partnership with other NOAA offices, industry, the restoration community, and state and tribal partners in California, Washington State, the Northeast, and Hawaii.

The Washington State Shellfish Initiative, through the actions of the Washington State Shellfish Initiative Inter-agency Working Group, completed several products to streamline the site permitting process. Due to many factors (for example regulatory complexities and social license), for a number of years there have been difficulties with permitting new sites for shellfish aquaculture in some regions of the United States, particularly in the Pacific Northwest. Actions by the Washington State Shellfish Initiative Inter-agency Working Group to coordinate and streamline the permitting process in that state led to 7 new shellfish site permits, the first issued by the ACOE in six years.

The Washington State Shellfish Initiative also led to the Ocean Acidification Blue Ribbon panel report and new funding from the State of Washington for shellfish ocean acidification research. The Blue Ribbon Panel gave a summary of ocean acidification research, and a summary of recommendations for shellfish hatcheries and growers. Ocean acidification is of major concern on the west coast, particularly in the Pacific northwest. In previous years before ocean acidification was identified as the culprit and mitigation measures were employed, some hatcheries experienced up to 80% larval mortality. Research led to the finding that acidic water from upwelling put stress on larval shellfish, rendering them unable to build shells in a critical point in their development. Hatcheries now have sensors and only draw seawater when the pH level is 'safe' for larvae. However, this does not help with shellfish in the wild, and some bays have not seen a natural set in almost ten years. The Washington Shellfish initiative also led to funding construction of a hatchery in Manchester, WA, for native Olympia oyster seed.

In September 2013, the California Shellfish Initiative was launched with a kickoff meeting involving agencies and stakeholders to identify key actions for expanded shellfish farming and restoration to support and conserve California's unique ecosystem. Over 70 people attended. One outcome of this meeting was coordination between NMFS staff and the Humboldt Harbor District on shellfish aquaculture in Humboldt Bay, California. The Harbor District is pursuing an innovative approach for permitting, where the Harbor District owns a regional permit for the entire bay, bears the cost of the permitting process, and then issues leases to individual growers. This will allow small businesses to participate in shellfish aquaculture, because the permitting process can be too expensive and uncertain for a small business to navigate alone.

The Northeast U.S. has been very successful in streamlining the permitting process, and is seeing impressive growth in the shellfish sector. For example, over the last two years in Maryland, 1,100 acres have been leased for shellfish aquaculture, and 1,500 more acres are in the process. Over the same period in Virginia, over 5,000 oyster acres were permitted. The New England region (Maine, Vermont, New Hampshire, Massachusetts, Connecticut, and Rhode Island) is working on a general regional permit to streamline the permitting process for new shellfish aquaculture operations. In the state of Maine, state agencies and the ACOE are also pursuing a streamlined permitting system. Further, due to economic and fishery conditions, there are a growing number of fishermen and fishing families in the Northeast who are starting aquaculture in addition to or instead of fishing.

In Hawaii there is growing interest in raising oysters. The Hawaii State Department of Health just developed a process to certify waters to raise shellfish. The growth rate for oysters in Hawaii is high, taking only 6-8 months to reach market size. In fact, there is at least one major land-based oyster hatchery operating in Hawaii, which benefits from these high growth rates.

Native Hawaiian Aquaculture Site Permitting: Fishponds built by the original inhabitants of Hawaii were among the most sophisticated examples of aquaculture used by pre-historic native Pacific peoples. Rock walls were built along the shoreline to form ponds. The walls were made of porous lava rock, and allowed for saltwater from the ocean to enter and exit the ponds, cleaning them through tidal flushing while preventing fish from escaping. The most widely cultivated species were flathead mullet (*Mugil cephalus*), milkfish (*Chanos chanos*) and moi (*Polydactylus sexfilis*). There were once hundreds of fishponds in use across the Hawaiian Islands, but by the turn of the 20^{th} century only about a hundred remained. Today, most fishponds are in disrepair.

The State of Hawaii, the NOAA Pacific Regional aquaculture coordinator, and various federal agencies and the environmental non-governmental organization Conservation International are collaborating on a general permit to make it possible to restore Hawaiian fishponds for cultural heritage, subsistence, and commercial production. The next step is to develop a general permit from the ACOE to allow pond restoration.

Part of the goal of this project is to introduce a broad segment of the population to aquaculture, through cultural and outreach activities, and foster grass-roots familiarity and support for aquaculture in Hawaii, a state with great marine aquaculture potential.

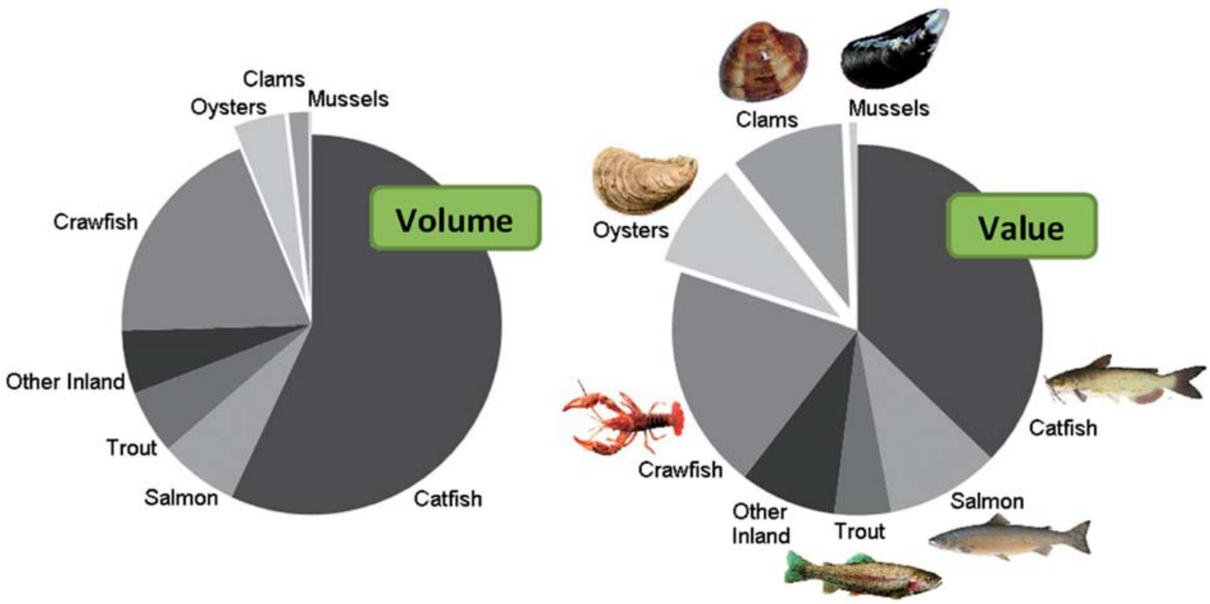


Fig. 1.

Production Trends

The main species for aquaculture production in the U.S. are trout, tilapia, catfish, crawfish, shrimp, salmon, oysters, mussels, and clams. The value of U.S. aquaculture showed 3% average year-over-year growth over the last 15 years, though total volume fell by an average of 0.5%. The last year data are available is for 2011. From 2010 to 2011, total U.S. aquaculture went down -18.8% by volume (to 277,335 metric tons) but grew 4.2% by value (to 1.34billion dollars).

By volume, most of U.S. aquaculture is from land-based ponds growing catfish, crawfish, and trout. Marine species make up a very small proportion of aquaculture production by volume. However, marine species make up a disproportionately large part of the value of aquaculture in the U.S. Shellfish in particular are produced in relatively smaller quantities but are high-value products.

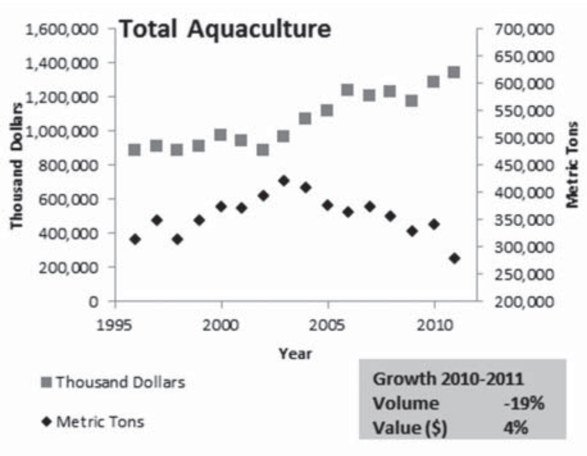


Fig. 2.

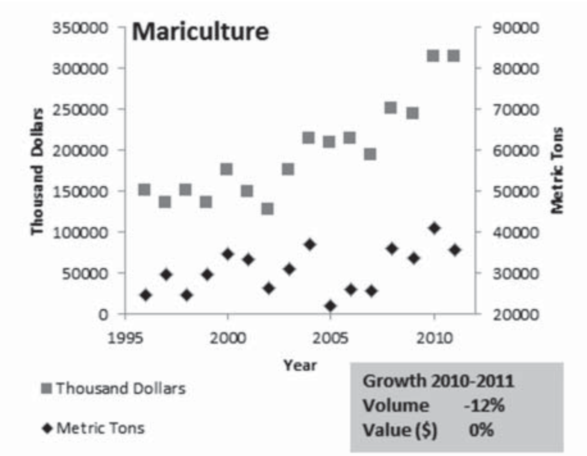


Fig. 3.

Mariculture[*1]: Major U.S. marine species are Atlantic salmon (*Salmo salar*), mussels (mainly blue mussels, *Mytilus edulis*), clams (largely hard clams *Mercinaria mercinaria* and Manila clam *Venerupis philippinarum*, and geoduck *Panopea generosa*), and oysters (mainly *Crassostrea gigas* and *Crassotrea virginica*). Saltwater shrimp are excluded from mariculture because they are raised in inshore ponds.

From 2010 to 2011 mariculturewent down -12.4% by volume (to 35,739 metric tons) while growing 0.3% by value (to 314 million dollars). However, from 2009-2010, mariculture grew 21.6% by volume (to 40,823 metric tons) and 28.5% by value (to 312 million dollars). The 15-year average growth for mariculture is 4% by volume and 5% by value.

1. Finfish

Atlantic salmon mariculture in the U.S. takes place in Maine and Washington State. Salmon from hatcheries are raised in tanks until they reach 40-120 grams, and then are transferred to marine net-pens for grow-out. From 2010-2011 salmon production decreased -4.8% to 18,595 metric tons, and grew 5.1% by value to 104 million dollars. The average year-over-year growth over the last 15 years is 6% by volume and 11% by value.

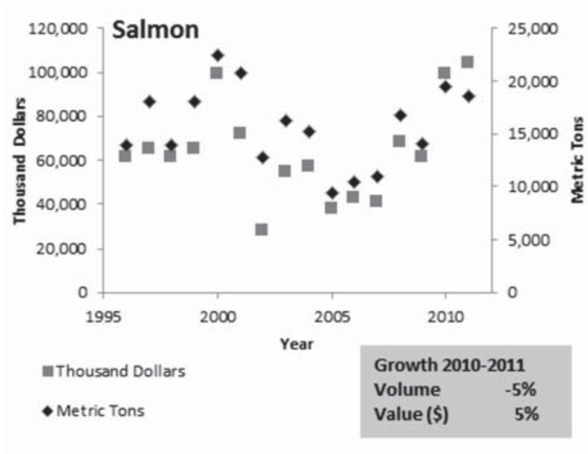


Fig. 4.

[*1] We define Mariculture in this section as species cultured in the marine environment (e.g. oceans, bays, salt-water estuaries).

Other marine finfish species are cultured, but due to issues such as the small number of farms, consistent data are not available. To protect the privacy of businesses, the USDA ARS cannot report detailed statistics on farms when there are so few of them that it would be possible to identify individual farms from the data. White sturgeon are cultured (*Acipenser transmontanus*). Species in the early stages of commercializationor in research and development include sixfinger threadfin (*Polydactylus sexfilis*), commonly known in Hawaii as moi, cobia (*Rachycentron canadum*), yellowtail amberjack (*Seriola rivoliana*), Atlantic cod (*Gadus morhua*), yellowtail amberjack (*Seriola lalandi*), red drum (*Sciaenops ocellatus*), sablefish (*Anoplopoma fimbria*), California flounder (*Paralichthys californicus*), summer flounder (*Paralichthys dentatus*), yellowfin tuna (*Thunnusalbacares*) and Florida pompano (*Trachinotus carolinus*).

2. Shellfish

Clam culture in the U.S. is largely hard clam (*Mercinaria mercinaria*) and Manila clam (*Venerupis philippinarum*), with some native geoduck clams (*Panopea generosa*) grown in the Pacific Northwest. Hard clam culture in the U.S. involves seed production, nursery stage, and final grow-out. Producers rely on seed from hatcheries. At the nursery stage, juvenile clams have a protected environment where they can grow to a size that provides optimum success for survival once placed into a natural setting for grow-out. Once juvenile clams are 7-15 mm, they are placed into the final grow-out system until they reach a harvest size of 50 mm. For grow-out, clams are placed into different structures (e.g. trays, pens, bags) and secured to the substrate of intertidal or subtidal areas. Harvesting occurs by either collecting trays/bags or by raking the substrate.

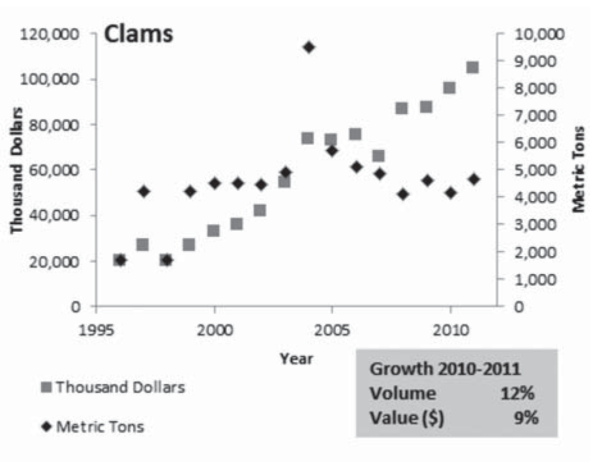
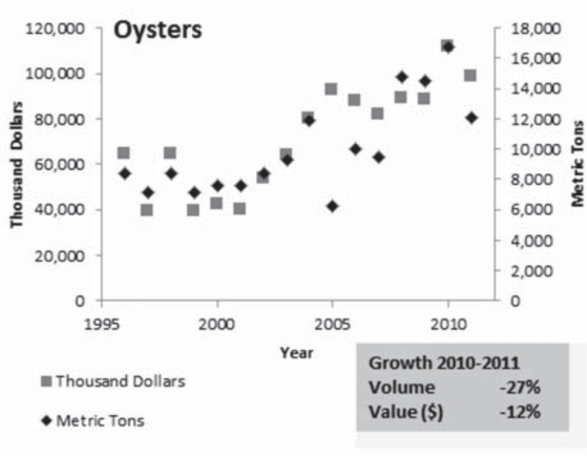


Fig. 5.

Geoduck seed are produced in hatcheries, and juveniles are raised in the hatchery until they reach about 5-12mm in size. Geoduck are next raised in a nursery where they grow large enough for survival outdoors. Geoduck seed are planted on intertidal beach in PVC pipes. The pipe is placed in the sediment, about 30cm deep, with 10 cm left at the surface. Juvenile geoducks are very susceptible to predators and the pipe protects them until they are large enough to evade predators on their own. On many farms, a net is placed over all of the tubes to provide further protection from predators. Two to three juveniles are placed into each pipe. While protected, the geoduck will grow and burrow itself into the sediment. After 1-2 years, the netting is removed since the geoducks are large and deep enough to be safe from predators. The grow-out stage can take 4 to 7 years for a geoduck to reach harvest size of 2 pounds.

From 2010-2011 clam production increased 12% to 4,683 metric tons, and grew 9.3% by value to 104 million dollars.The average year-over-year growth over the last 15 years is 18% by volume and 13% by value.

Oyster culture in the U.S. mainly consists of two species. The Pacific oyster *(Crassostrea gigas)* is the predominant oyster grown on the west coast, and the Virginia oyster (*Crassotrea virginica*) is the most commonly raised oyster on the east coast. However, on both coasts other species are raised in smaller numbers, such as the native Olympia oyster (*Ostreola conchaphila*) on the west coast. The majority of oyster farms rely on hatchery production of seed, though wild seed collection also occurs. Oysters are grown by on-bottom, off-bottom, or suspended-culture techniques. On-bottom culture is used when a site has a suitably firm substrate in an intertidal or sub-tidal area. Off-bottom culture requires seed to be put into mesh bags or trays and attached to rope and wood frames in the intertidal zone to be



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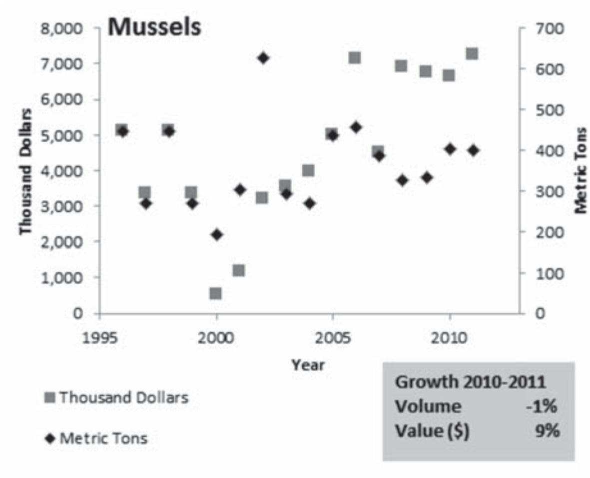


Fig. 7.

grown to market size. Suspended culture is where oyster seed is hung from longlines and attached to horizontal lines or rafts in deeper waters. Harvest typically occurs at a size of around 75mm.

From 2010-2011 oyster harvest dropped -27.8% to 12,062 metric tons, and -11.9% by value to 98.4 million dollars. However, in the previous year, compared to 2009, 2010 saw 15.0% growth by volume to 16,721 metric tons, and 26.4% growth by value to 111.7 million dollars. The average year-over-year growth over the last 15 years is 6% by volume and 6% by value.

Mussels are farmed either on- or off-bottom. On-bottom mussel farming involves seeding sea bottom areas, and dredging mussels for harvest. There are several methods of off-bottom farming, including longline culture and raft culture. From 2010-2011 mussel production decreased -0.7% to 402 metric tons, and grew 9.3% by value to 7.2 million dollars. The average year-over-year growth over the last 15 years is 8% by volume and 20% by value.

Inland Aquaculture[*2]: Major U.S. inland finfish aquaculture species are channel catfish (*Ictalurus punctatus*), Rainbow trout (*Oncorhynchus mykiss*), hybrid striped bass (*Morone saxatilis x M. chrysops*), and tilapia (*Tilapia spp.*). Farmed shellfish include the red swamp crawfish (*Procambarus clarkii*) and whiteleg shrimp (*Litopenaeus vannamei*).

From 2010 to 2011 inland aquaculture went down

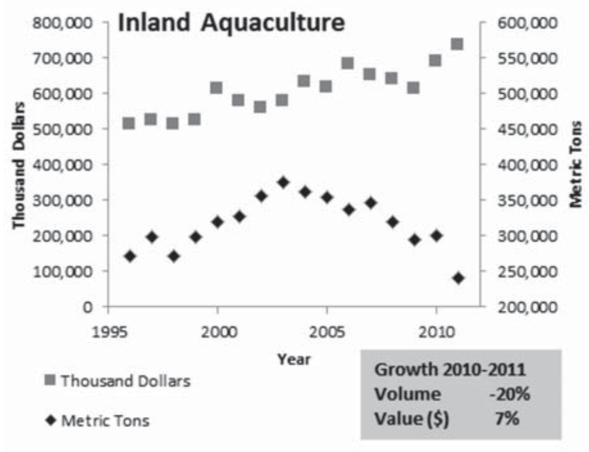


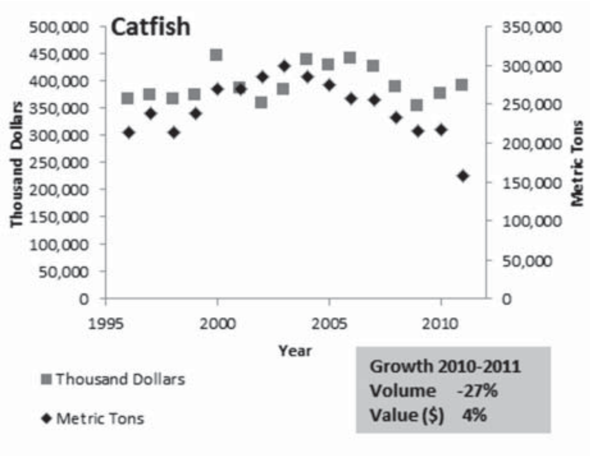
Fig. 8.

19.7% by volume (to 241,596 metric tons) while growing 7.2% by value (to 737 million dollars). The average year-over-year growth over the last 15 years is -0.3% by volume and 3% by value.

1. Finfish

Channel catfish (*Ictalurus punctatus*) are the predominant aquacultured species in the U.S., and only Channel catfish can be sold as 'catfish' in U.S. markets. Catfish are grown primarily in embankment or levee ponds, where the earth that is removed to dig the ponds is used to build levees or embankments to encircle the ponds. Ponds range in size from 0.04 km^2 and 2m deep to 0.1 km^2 and 1m deep.

[*2] In this section, inland aquaculture refers to the culture of freshwater species as well as marine species grown in land-based systems.



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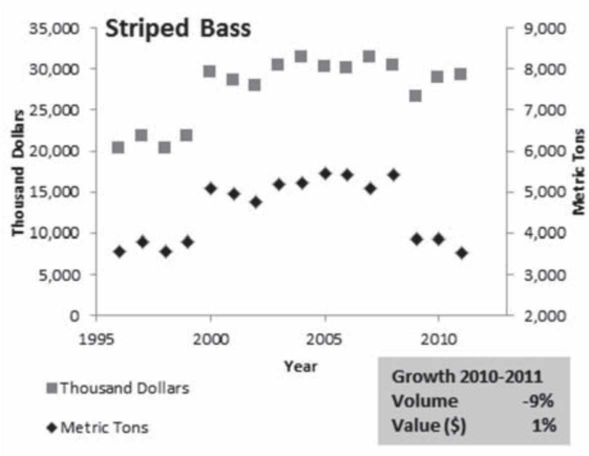

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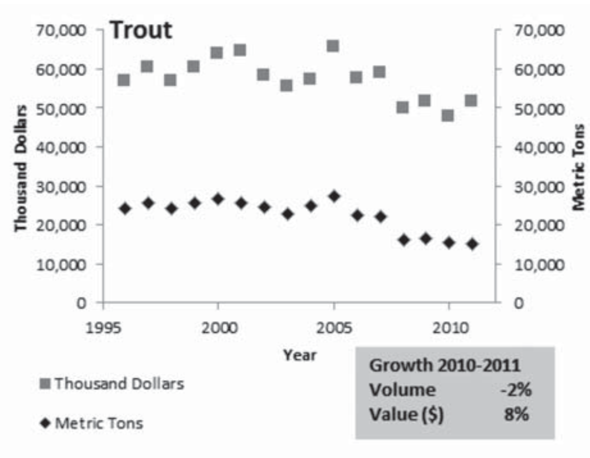

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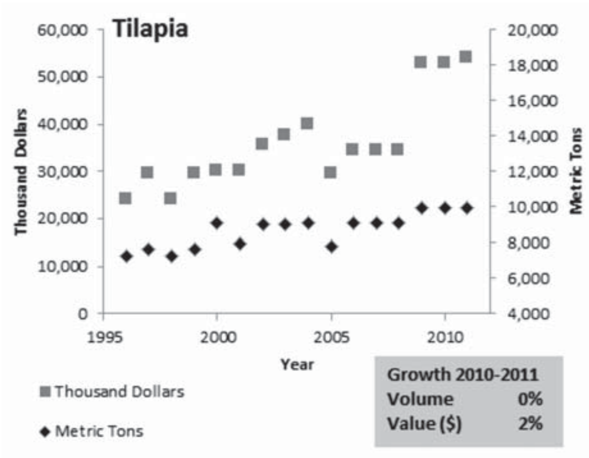

Fig. 12.

From 2010 to 2011 catfish production went down-27.3% by volume (to 157,942 metric tons) while growing 4.2 % by value (to 391 million dollars). The average year-over-year growth over the last 15 years is -1% by volume and 1% by value.

Rainbow trout (*Oncorhynchus mykiss*) are predominantly raised in raceways, though some farms use ponds or recirculating systems. Raceways, also known as flow-through systems, are essentially artificial streams. Gravity flows water from natural streams through the concrete raceways, and the water is often filtered to remove waste products before being released back into the natural stream. Steelhead trout (*Oncorhynchus mykiss*) are sea-run rainbow trout, and can be raised in net-pens in rivers and the marine environment. From 2010 to 2011 trout production went down -1.8% by volume (to 15,112 metric tons) while increasing 7.9% by value (to 51 million dollars). The average year-over-year growth over the last 15 years is -3% by volume and 0% by value.

Hybrid striped bass are produced in the hatchery by fertilizing female white bass (*Morone chrysops*) eggs with sperm from male striped bass (*Morone saxatilis*). Hybrid striped bass have greater tolerance to extremes in temperature and dissolved oxygen than either of its parents and is thus better suited for pond culture.The majority of hybrid striped bass producers in the southern region raise their fish in freshwater ponds, but cages and tanks are also used for hybrid striped bass production.

From 2010 to 2011 hybrid striped bass production decreased 9.1% by volume (to 3,516 metric tons) while growing 1.4% by value (to 28 million dollars). The average year-over-year growth over the last 15 years is 1% by volume and 3% by value.

Tilapia are grown in ponds or tanks in the U.S., and production did not change between 2010 and 2011, though there was an increase in value of 1.7%. In 2011, 9,979 metric tons of tilapia worth 54 million dollars were produced. The average year-over-year growth over the last 15 years is 2% by volume and 7% by value.

2. Shellfish

Crawfish are the predominant cultured crustacean in the U.S., and are cultivated and consumed for food in several southern states. Louisiana dominates the aquaculture and wild harvest crawfish industry. Crawfish are grown in shallow ponds 20 to 60 cm deep, and ponds are flooded and drained each year. Crawfish in the U.S. are not fed formulated feeds, and instead primarily consume plant material as forage. In order to provide crawfish with plant material to feed upon, they are often double-cropped or rotated with field crops, most commonly rice but also soybeans and sorghum. From 2010 to 2011 crawfish production grew 0.9% by volume (to 53,435 metric tons) while growing 15.9% by value (to 206 million dollars). The average year-over-year growth over the last 15 years is 13% by volume and 17% by value.

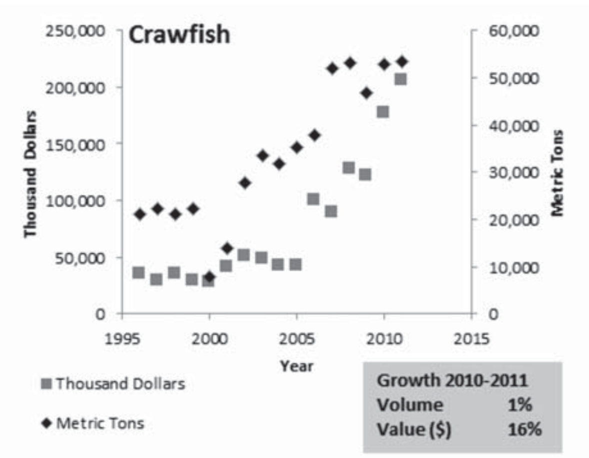

Fig. 13.

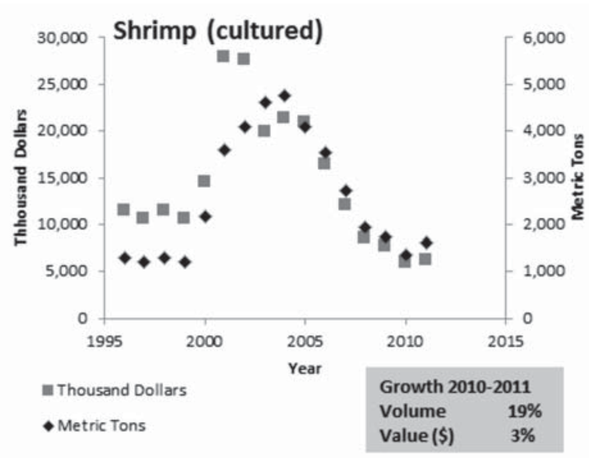

Fig. 14.

Shrimp in the U.S. are mostly wild-caught. However, both marine (penaeidae) and freshwater shrimp species are grown in ponds, tanks, and recirculating systems. Whiteleg shrimp (*Litopenaeus vannamei*) are the most commonly cultured shrimp species, though culture of the Malaysian prawn (*Macrobrachium rosenbergii*) in land-based systems is increasingly popular. From 2010 to 2011 shrimp aquaculture grew 19% by volume (to 1,612 metric tons) while growing 3.2% by value (to 6.1 million dollars). The average year-over-year growth over the last 15 years is 5% by volume and −0.6% by value.

3. Other land-based culture of marine species

There are several ongoing experimental and commercial land-based marine finfish culture operations in the U.S.: notably barramundi (*Lates calcarifer*) has been commercialized in a large land-based facility in Massachusetts. Several non-native species of sturgeon (*Acipenser baeri, A. gueldenstaedtii*) have been cultured in commercial and demonstration projects in Florida (e.g. Mote Marine Laboratory). Additionally, work to commercialize cobia (*Rachycentron canadum*) and black sea bass (*Centropristis striata*) continues in land based recirculating systems in Virginia.

Annotated Bibliography

Lowther A. (editor), 2013: Fisheries of The United States 2012. Current Fishery Statistics No. 2012. National Marine Fisheries Service Office of Science and Technology. http://www.st.nmfs.noaa.gov/Assets/commercial/fus/fus12/FUS2012.pdf

The annual Fisheries of the United States is the official published source of fisheries statistics for the US. The 2012 report gives preliminary 2012 data on US commercial fisheries, and the final report for

2012 on US recreational fisheries. US aquaculture statistics are reported for 2011. Summary statistics are also provided on US production of processed fishery products, domestic supply and per capita consumption, foreign trade, and world fisheries production.

Kapetsky J. M., Aguilar Manjarrez J., and Jenness J., 2013: A global assessment of potential for offshore mariculture development from a spatial perspective. FAO Fisheries and Aquaculture Technical Paper No. 549. Rome, FAO. 181 pp

The FAO produced this document to highlight that mariculture, specifically offshore aquaculture, offers significant opportunities for sustainable food production but is underutilized worldwide. The report states that offshore aquaculture could foster development of many coastal communities, especially in regions with limited freshwater and arable land. This report measures and compares for all maritime nations the current status and potential for offshore mariculture development from a spatial perspective, and identifies nations with high but unrealized offshore potential.