Open Ocean Aquaculture

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Summary

Open ocean aquaculture is broadly defined as the rearing of marine organisms in exposed areas beyond significant coastal influence. Open ocean aquaculture employs less control over organisms and the surrounding environment than do inshore and land-based aquaculture, which are often undertaken in enclosures, such as ponds. When aquaculture operations are located beyond coastal state jurisdiction, within the U.S. Exclusive Economic Zone (EEZ; generally 3 to 200 nautical miles from shore), they are regulated primarily by federal agencies. Thus far, only a few aquaculture research facilities have operated in the U.S. EEZ. To date, all commercial aquaculture facilities have been sited in nearshore waters under state or territorial jurisdiction.

Development of commercial aquaculture facilities in federal waters is hampered by an unclear regulatory process for the EEZ, and technical uncertainties related to working in offshore areas. Regulatory uncertainty has been identified by the Administration as the major barrier to developing open ocean aquaculture. Uncertainties often translate into barriers to commercial investment. Potential environmental and economic impacts and associated controversy have also likely contributed to slowing expansion.

Proponents of open ocean aquaculture believe it is the beginning of the "blue revolution"—a period of broad advances in culture methods and associated increases in production. Critics raise concerns about environmental protection and potential impacts on existing commercial fisheries. Potential outcomes are difficult to characterize because of the diverse nature of potential operations and the lack of aquaculture experience in open ocean areas.

On January 28, 2009, the Gulf of Mexico Fishery Management Council voted to approve a plan to issue aquaculture permits and regulate aquaculture in federal waters of the Gulf of Mexico. On September 3, 2009, the plan took effect because the Secretary of Commerce declined to oppose it within the required statutory period. Environmentalists and some fishing industry representatives have opposed the plan because of concerns related to environmental protection and potential negative effects on wild fish populations. Many who oppose the plan support a precautionary approach and development of national aquaculture standards. On September 8, 2009, H.R. 3534, the Consolidated Land, Energy, and Aquatic Resources Act of 2009, was introduced. Section 704 of the bill would have rescinded the authority of the Secretary of Commerce to develop or approve fishery management plans to permit or regulate offshore aquaculture. On July 30, 2010, H.R. 3534 was passed by the House, but the section related to offshore aquaculture was removed from the bill. H.R. 4363, the National Sustainable Offshore Aquaculture Act of 2009, introduced on December 16, 2009, would establish a regulatory system for offshore aquaculture in the U.S. Exclusive Economic Zone. S. 3417, the Research in Aquaculture Opportunity and Responsibility Act of 2010, introduced on May 25, 2010, would prohibit offshore aquaculture until three years after the submission of a report on the impacts of offshore aquaculture.

This report discusses four general areas: (1) operational and business-related challenges; (2) potential economic impacts; (3) potential environmental impacts; and (4) the legal and regulatory environment. Significant questions remain about whether an appropriate mechanism exists for any federal agency to provide an open ocean aquaculture lease with the necessary property rights to begin construction and operation. Policy makers and regulators will be challenged to weigh the needs of a developing industry against potential environmental and social impacts.

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Introduction

Open ocean aquaculture is broadly defined as the rearing of marine organisms in exposed areas beyond significant coastal influence. Open ocean aquaculture operations would be located at a considerable distance from shore and subject to relatively harsh environmental conditions resulting from wind and wave action. Open ocean aquaculture employs less control over organisms and the surrounding environment than do inshore and land-based aquaculture, which are often undertaken in enclosures such as ponds.

Development of offshore aquaculture has become a controversial topic for aquaculturalists, environmentalists, recreational fishermen, and commercial fishermen. Many environmentalists and fishermen have asserted that poorly regulated aquaculture development could degrade the environment and have negative affects on wild fish populations. Proponents of open ocean aquaculture believe it is the beginning of the "blue revolution"—a period of broad advances in culture methods and associated increases in production. Potential outcomes are difficult to characterize because of the diverse nature of potential operations and the lack of aquaculture experience in open ocean areas. However, most agree that industry regulation is needed for orderly development of aquaculture while minimizing its effects on the environment.

During the 110th Congress, the National Offshore Aquaculture Act of 2007 was introduced as H.R. 2010 in the House and as S. 1609 in the Senate, both by request of the Administration. Both bills focused on developing a framework to regulate aquaculture in the Exclusive Economic Zone (EEZ), generally 3 to 200 miles from the coastline.[1] A hearing concerning H.R. 2010 was held before the House Committee on Natural Resources, Subcommittee on Fisheries, Wildlife, and Oceans, but no further action was taken on either of these bills.

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[1] H.R. 2010 and S. 1609, the National Offshore Aquaculture Act of 2007, define "offshore aquaculture" as all activities, including operation of offshore aquaculture facilities, involved in the propagation and rearing, or attempted propagation and rearing, of marine species in the United States Exclusive Economic Zone. Open ocean aquaculture is a more general term for operations in exposed ocean areas beyond significant coastal influence and may include areas in state waters within 3 miles of the shoreline and beyond the 200-nautical mile EEZ.

introduced. It would prohibit offshore aquaculture until three years after the submission of a report on the impacts of offshore aquaculture.

Background

Several terms for open ocean aquaculture are used interchangeably, including *offshore aquaculture* and *offshore fish farming*.[2] Open ocean aquaculture facilities generally consist of systems (e.g., cages, net-pens, longline arrays) that can be free-floating, secured to a structure, moored to the ocean bottom, or towed by a vessel. Currently operating commercial aquaculture farms in nearshore waters and estuaries use a variety of methods including ponds with earthen dikes, cages and net-pens moored to the ocean bottom, enhancement and seeding of the bottom, and suspended lines. There has been some experimentation in offshore shellfish culture on the seabed and from suspended ropes and longlines.

Internationally, research and commercial open ocean aquaculture facilities are in operation or under development in Australia, Chile, China, France, Ireland, Italy, Japan, Mexico, and Norway.[3] Currently, four commercial open ocean facilities are operating in U.S. state/territorial waters. Cates International, Inc., cultivates moi (Pacific threadfin) near Hawaii, and Snapperfarms, Inc., cultivates cobia (ling) near Puerto Rico. In September 2005, Kona Blue Water Farms of Hawaii celebrated its first harvest of kahala reared in deepwater pens in state waters. In 2007, A. E. Lang Fisheries began cultivating blue mussels off the coast of New Hampshire in collaboration with the University of New Hampshire's Atlantic Marine Aquaculture Center. Although these are open ocean operations, all four are currently sited in waters under state or territorial jurisdiction. Thus far, only a few aquaculture research facilities have operated farther offshore in the U.S. EEZ. Should such operations be located beyond coastal state jurisdiction within the EEZ, they would be regulated primarily by federal agencies.[4]

Development of commercial aquaculture facilities in federal waters is hampered by an unclear regulatory process in the EEZ and technical uncertainties related to working in offshore areas. Regulatory uncertainty has been identified by the Administration as the major barrier to developing offshore aquaculture in the United States.[5] Uncertainty is one of the main barriers to commercial investment in many new industries. Potential environmental and economic impacts and associated controversy have also likely contributed to slowing potential expansion.

Proponents of open ocean aquaculture position it as the beginning of the "blue revolution"—broad advances in culture methods and application with resulting increases in marine aquaculture

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[2] *Marine aquaculture* and *mariculture* are broader terms, also referring to the land-based culture of marine organisms as well as their culture in nearshore, coastal, and exposed environments.

[3] For more information on international efforts, see Biliana Cicin-Sain et al., "Chapter 6: Lessons from the International Arena," *Development of a Policy Framework for Offshore Marine Aquaculture in the 3-200 Mile U.S. Ocean Zone* (Newark, DE: Univ. of Delaware, Center for the Study of Marine Policy, 2001), available at http://darc.cms.udel.edu/SGEEZ/SGEEZ1final.pdf.

[4] Federal agencies also have regulatory authority over certain aspects of aquaculture development in nearshore waters under state/territorial jurisdiction.

[5] Written statement of Dr. William T. Hogarth, Assistant Administrator for Fisheries, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce, *Hearing on Offshore Aquaculture*, before the U.S. Senate, Committee on Commerce, Science, and Transportation, National Ocean Policy Study (April 6, 2006).

production. They tout open ocean aquaculture as an option for meeting consumer demand for marine products, providing new employment opportunities, decreasing the U.S. trade deficit in seafood products, and developing a new economically viable industry. It is also asserted by proponents that development of open ocean sites would have the advantages of avoiding inshore user conflicts and reducing environmental impacts.

Opponents raise a number of concerns related to environmental protection and potential impacts on existing commercial fisheries. They point to inshore aquaculture where mangrove forests have been replaced by shrimp ponds, and to waste from salmon culture that has harmed the seabed environment. Their environmental concerns include pollution from unused feed, fish wastes, and treatments (e.g., antibiotics); entanglement of marine wildlife in aquaculture gear; introduction of nonnative species; and escape of organisms that might affect the genetic makeup of wild species. They say that open ocean aquaculture could also have direct and indirect effects on commercial fisheries, such as degradation of wild fish habitat, preemption of commercial fishing grounds, and market competition between wild and cultured fish products.

The future of aquaculture in the EEZ is still an open question. A complex and unpredictable mix of technological, biological, and economic elements will likely determine the profitability of open ocean aquaculture. However, the future will also likely depend on the tradeoffs between benefits associated with aquaculture production and costs of potential environmental and social impacts.

Challenges of Open Ocean Aquaculture

A broad array of questions is associated with the viability and impacts of open ocean aquaculture initiation and expansion. These concerns are further complicated by factors such as evolving production technology, uncertain economic costs and benefits, and environmental and social impacts. Generalizations are also difficult to make because of the variety of candidate species, associated technologies, and potential scales of operation.

Major categories of concerns related to open ocean aquaculture development include (1) biological, operational, and business concerns related to development of a new industry; (2) potential social and economic impacts; (3) potential environmental impacts; and (4) the legal and regulatory environment.[6]

Biological, Operational, and Business Concerns

Species and Technology

Current species and culture techniques—including species selection, egg/larval production, and nutritional/dietary requirements—are somewhat limited. Development of open ocean aquaculture

[6] Detailed discussions of many of the issues discussed in this section are available in *Development of a Policy Framework for Offshore Marine Aquaculture in the 3-200 Mile U.S. Ocean Zone* (2001) by the University of Delaware's Center for the Study of Marine Policy, at http://darc.cms.udel.edu/sgeez/sgeez1final.pdf; and *Recommendations for an Operational Framework for Offshore Aquaculture in U.S. Federal Waters* (October 2005) by the University of Delaware's Gerard J. Mangone Center for Marine Policy, at http://darc.cms.udel.edu/sgeez/sgeez2final.pdf.

probably will need further research, and new culture techniques may be required for rearing species not presently grown.

Many economically important species are currently being studied at various universities and research institutes for possible culture, including amberjack, black sea bass, blue mussels, cobia, cod, corvina, flounder, haddock, halibut, mahimahi, mutton snapper, red drum, striped bass, tuna, and yellowtail snapper. Other research topics being investigated include hatchery culture technologies; automated feeder design; culture of new species; disease identification and control; cages and husbandry technology for rough water environments; identification of alternative food sources; nutrition requirements; definition of carrying capacity of offshore waters; appropriate mooring systems; drifting and self-powered cages; federal regulatory structure; and environmental monitoring technology.

Since open water aquaculture is a relatively new industry, many potential operators are inexperienced with the technical requirements for open ocean facilities. Historically, development has been limited by technology that requires water depths of 100-150 feet; this narrow band of acceptable depth exists from ¼ mile to about 50 miles offshore, depending on location. Open ocean aquaculture facilities, moored or floating miles off the coast in a high-energy environment, experience numerous environmental conditions that differ from nearshore aquaculture operations, including exposure to wind and wave action from all directions, short and steep wave patterns, strong currents, seasonal anoxic (oxygen-lacking) conditions, and other severe ocean conditions that can prevent operators from being able to access their cages for days to weeks.[7]

Systems have been developed to overcome these obstacles, including cage designs that do not deform under strong current and wave loads, submersible cages, and single-point moorings. Cage-mounted autonomous feeding systems have been developed that can operate both at the surface and submerged. Others have developed closed containment systems for open ocean use to address environmental concerns. Universities and private-sector research interests are developing automated buoys that can monitor the condition of stock and feed fish on a regular basis for weeks at a time. Other research groups are working on automated, floating cages that would travel with the currents and be tracked by satellite.[8] These ship-like structures could float on favorable oceanic currents or be held in the same location with low-energy thrusters.

Financing

Estimating profitability and securing financing is difficult for new open ocean aquaculture companies because of an uncertain regulatory environment, the risk associated with operating in exposed open ocean locations, the risk of catastrophic events (e.g., severe storms), limited operational experience, and high capital start-up costs. Proponents of open ocean aquaculture development assert that, without some form of long-term (at least 25 years) permitting or leasing of the water surface, water column, and seabed, open ocean aquaculture will have significant problems in securing capital from traditional funding sources and in obtaining suitable insurance

[7] For example, a pilot study cage in the Gulf of Mexico was torn from its mooring in December 2000 and was found off the coast of Louisiana after a long search.

[8] Critics question whether floating, unmanned, remote-control cages could ever be permitted, due to the major navigational hazard they could present.

on the capital investment and stock.[9] Such leasing may be problematic unless property rights beyond the territorial sea are clarified.

The availability of insurance on stock and equipment is relevant to, and can facilitate obtaining, front-end capital for open ocean aquaculture. The insurance sector has more than 30 years of experience in managing and insuring risks to conventional aquaculture stock and equipment for a variety of situations and conditions. Although the insurance industry is unlikely to view pilot projects favorably, many say that the earlier the insurance industry is brought into developing open ocean aquaculture, the earlier insurers are likely to be comfortable with the risks that must be insured.

Proponents of open ocean aquaculture suggest that, if profits are to be made, sufficient investment capital must be available as soon as property rights, permitting, and environmental concerns are resolved. More pessimistic critics suggest that open ocean aquaculture is unlikely ever to have an adequate economic return on investment, and that investment should rather be focused on improving nearshore or shore-based aquaculture. Eventually, the level of capital investment in open ocean aquaculture will likely depend on whether its rate of return is competitive with investment alternatives.

Economic Potential

The economic potential of U.S. aquaculture will likely depend on both operational costs and product prices. Costs will largely depend on several factors, including U.S. regulation, the technology adopted, and national and international economic conditions. Economic conditions will determine labor, energy, capital, and other input costs. Prices of U.S. aquaculture products will likely depend on world demand and the prices of competing products. Competing products include similar imported cultured products, similar wild species, and other agricultural product substitutes such as chicken, pork, and beef.

The level of government support in other countries is often greater than that provided in the United States. Some say that government assistance could promote the initial development of a U.S. open ocean aquaculture industry, but global market forces would likely determine whether it matures or withers.

The United States has been, for the most part, a technological innovator, and the use of marine resources to farm new species with high market value could give the United States a competitive edge. On the other hand, operating costs and environmental standards in other countries are often lower. In addition to capital costs, the location of aquaculture facilities further from shore will necessitate higher costs for fuel, security, and/or surveillance.

Land-based aquaculture products are also likely to compete with offshore aquaculture. Most aquaculture production in the United States originates in freshwater ponds and raceways, such as catfish in the southern United States and trout farms in Idaho and North Carolina. Advances in

[9] Some nations (e.g., Canada) lease nearshore areas with implied automatic renewal of tenure as long as the lessee meets current licensing requirements. Alternatives on leasing for short time periods include issuing research permits or vesting tenure in a federal or state agency initially to streamline the process and allow greater control over eventual ownership.

more intensive culture techniques such as closed systems[10] are another means to increase production with minimal environmental impacts. Cobia, a candidate species for offshore aquaculture, is currently being cultured in land-based tanks 300 miles from the ocean in freshwater by regulating its physiology.[11] Initial reports documenting production are optimistic, but the commercial viability of this particular type of aquaculture is unknown.

Shoreside Infrastructure

Supportive shoreside infrastructure, including hatcheries and nurseries, does not exist and would need to be developed. Support industries have the potential to provide employment and other economic benefits to coastal communities. If open ocean aquaculture becomes viable, these businesses should also grow. However, the relatively high value of shoreline property could be an impediment to finding appropriate sites, especially waterfront sites in coastal areas.

Development and Partnerships

Fostering industry/academic partnerships may benefit open ocean aquaculture development.[12] Some suggest that, for development to occur, open ocean aquaculture should be considered "big science" along the lines of atomic/nuclear physics research and the Human Genome Project. In this light, the developing open ocean aquaculture industry may benefit by seeking and promoting partnerships with multinational industrial, agricultural, and pharmaceutical corporations.[13] Proponents argue that this is the most likely way for open ocean aquaculture to obtain the ocean engineering, marine technology, and floating platform infrastructure at the necessary scale of production. The developing industry will also need to refine biological methods related to commercial-scale hatchery and grow-out facilities. They also state that, without domestic financial support, aquaculture innovation will likely come from other countries already providing greater investment in technology development.

Social and Economic Impacts

Trade Related Issues

In 2008, the United States imported approximately 5.2 billion pounds of edible seafood worth a record $14.2 billion.[14] After accounting for exports valued at $4.3 billion, there was a trade deficit of approximately $9.9 billion in edible seafood products. The two largest components of U.S. seafood imports are shrimp and salmon. Shrimp accounted for $4.1 billion and salmon accounted

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[10] In closed aquaculture systems water is cleaned with biological filters and re-circulated.

[11] Virginia Farm Raises Marine Fish 300 Miles From Nearest Ocean, *PR Newswire Association* (April 4, 2007).

[12] Critics caution that funding open ocean aquaculture development through universities has the potential to slow commercial development if academic solutions are insufficiently pragmatic for commercial applications.

[13] Potential partners include oil and gas companies with related support industries, defense contractors developing large floating structure technology and platforms, and ocean engineering companies laying submarine cable and developing affiliated technology for telecommunications corporations. Others may include corporations exploring wind and/or wave-energy generation, ocean thermal energy conversion and related deep ocean water upwelling systems, carbon sequestration and mitigation, and ocean fertilization.

[14] U.S. Dept. of Commerce, National Marine Fisheries Service, *Fisheries of the United States, 2008,* Current Fishery Statistics No. 2008 (Washington, DC: July 2009), p. 48.

for $1.6 billion of total U.S. imports.[15] In contrast to the increasing level of seafood imports and the growing proportion of imports produced through aquaculture, the value of annual U.S. aquaculture production of edible fish appears to have leveled off at approximately $672 million in 2005.[16]

Proponents claim that development of open ocean aquaculture would narrow the U.S. deficit in seafood trade. However, many economists would counter that the seafood trade deficit is not a sufficient reason to advocate for development of a new industry. According to economic theory, countries gain from free trade when they specialize in products that they are best at producing.[17] If other countries have an absolute or comparative advantage in aquaculture, the United States would likely benefit from specializing in other industries. Others assert that in reality, most trade is not strictly free as economic theory might assume. It is also often difficult to determine how technological development and future economic conditions will affect comparative advantages of different nations or regions.

Although shrimp and salmon account for a large portion of the seafood trade deficit, they appear to be poor candidates for open ocean aquaculture. Most shrimp aquaculture is carried out in ponds in tropical coastal areas. Salmon aquaculture operations generally use net-pens in protected areas such as fjords or bays. It is questionable whether open ocean aquaculture can be competitive with established inshore aquaculture of these species. One of the current offshore aquaculture operators foresees future investment focusing on new species in tropical and subtropical regions.[18]

If many of the proposed species for open ocean aquaculture are carnivores, it is likely that the demand for fishmeal produced from low-value wild fish will increase. If domestic supplies are insufficient, imports of fishmeal could increase the U.S. trade deficit. However, these imports may be beneficial to the overall national economy, if the domestic aquaculture industry is economically viable.

Interactions with Commercial Fisheries

Some Members of Congress, especially those from coastal areas with strong fishing communities, are interested in better understanding the social and economic effects of open ocean aquaculture development. If open ocean aquaculture supplied a significant level of production at lower cost, it could supplement commercial fishery production and provide greater quantities of products at lower prices. Lower prices would benefit U.S. consumers, who would likely increase consumption.

However, aquaculture production could supplant commercial fishery production. The lower prices (and revenues to fishermen) for commercial landings could result in the failure of least efficient businesses, loss of commercial fishery-related employment, and disruption of fishing

[15] Ibid., p. 48.

[16] U.S. Dept. of Agriculture, National Agricultural Statistics Service, "Census of Aquaculture (2005)," *2002 Census of Agriculture*, Volume 3, Special Studies Part 2, (Washington, DC: October 2006), p. 1.

[17] A basic discussion of absolute and comparative advantage can be found at http://internationalecon.com/v1.0/ch40/40c000.html.

[18] Written statement of John R. Cates, President of Cates International, *Hearing On Offshore Aquaculture*, before the U.S. Senate, Committee on Commerce, Science, and Transportation, National Ocean Policy Study (April 6, 2006).

communities. However, the degree of displacement would depend on the similarity of products, the scale of aquaculture production, and the characteristics of associated markets for seafood products.

Imports of shrimp and salmon have resulted in lower prices and greater consumption. Over the last 30 years, domestic shrimp production from the wild fishery has remained relatively constant while imports of aquaculture shrimp have increased. In 2007, over 90% of all shrimp consumed in the United States were imported.[19] Prices and associated vessel revenues have also decreased resulting in fewer active commercial fishing vessels in the Gulf of Mexico fishery.[20]

During the last two decades, the salmon industry has also experienced major changes related to aquaculture. Farmed fish production has significantly increased total salmon supply and been responsible for much of the observed decline in prices.[21] Because of lower prices, the value of Alaskan wild salmon landings decreased from approximately $800 million per year in the late 1980s to approximately $300 million per year for the period from 2000 to 2004.[22] The income of many Alaska fishermen also declined, as well as permit and boat values. From 2000 to 2004 about two-thirds of U.S. salmon consumption was farmed and one-third was from capture fisheries targeting wild stocks.[23]

Although the Gulf of Mexico shrimp fisheries and Alaska salmon fisheries have been harmed by lower prices, these commercial fisheries were not replaced by aquaculture. The precise levels of impacts are difficult to quantify because of differences in product form, relationships among products, and the general complexity of these seafood markets. In some cases, competition could provide incentives to improve the quality of the wild product, wild fishery management institutions, and marketing. Greater efficiency in the wild fishery and consumer benefits related to greater supplies and lower prices from aquaculture production would be likely to provide net benefits to the national economy, say proponents.

Whether the United States permits or denies open ocean aquaculture development, some of the socioeconomic impacts of open ocean aquaculture production (e.g., changes in prices and markets) are likely to result from foreign production. To improve understanding of gains and losses to specific sectors and local and national economies, concerned parties suggest that social and economic impact assessments should be part of aquaculture development plans from the onset.

Potential Community Effects

Proponents of open ocean aquaculture assert that socioeconomic benefits will result from the development of this industry. For example, they view open ocean aquaculture as an additional means to support the domestic seafood industry, which in many regions has decreasing levels of

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[19] U.S. Dept. of Commerce, National Marine Fisheries Service, *Fisheries of the United States, 2008*, Current Fishery Statistics No. 2008 (Washington, DC: July 2009).

[20] Linda Breazeale, *Fuel Costs, Low Prices Reduce Shrimp Boats,* Mississippi State University Crop Report (July 30, 2004).

[21] Gunnar Knapp, Cathy A. Roheim, and James L. Anderson, *The Great Salmon Run: Competition Between Wild and Farmed Salmon*, TRAFFIC North America, (Washington DC: Jan. 2007). Hereafter referred to as Great Salmon Run.

[22] Great Salmon Run.

[23] Ibid.

employment. With appropriate research support, open ocean aquaculture might provide opportunities for commercial fishermen who no longer pursue harvests in managed capture fisheries. Advocates of open ocean aquaculture assert that people with commercial fishing skills will be needed to tend offshore aquaculture operations. Employment also would be required for much more than tending to offshore farms—support roles are required in land-based hatcheries to provide sufficient numbers of fingerlings; feed mills are necessary to provide feed for the fish; manufacturing is essential to fabricate the cages and other culture materials; maintenance, logistics, and transportation are critical; and finally, all the fish raised in offshore farms would need to be harvested, processed, and sold, thereby potentially increasing the use of presently underutilized fish processing plants along much of the coast.[24] In general, aquaculture advocates believe that open ocean aquaculture could help to preserve working waterfronts that have suffered from commercial fishing declines and increasing industry regulation.

Individuals familiar with the experiences of coastal aquaculture, however, have raised questions about the sustainability of offshore fish farming and its impact on local communities. They assert that, in many cases, shrimp and salmon have been produced at the expense of local communities and the environment.[25] Based on the history of salmon farming, some have questioned the claims of aquaculture as a jobs creator, especially since it seems likely to become a highly automated industry. Critics of aquaculture also argue that the potentially higher cost of tending fish far from shore means these facilities are likely to be automated, and local employment benefits may be minimal.[26] Additionally, little evidence has been provided for the economic benefits of open ocean aquaculture beyond the general acknowledgment that marine aquaculture has proven profitable elsewhere, especially in inshore areas with relatively little environmental regulation and/or enforcement (e.g., Chile). Some commercial fishery advocates counter that unemployment in the seafood industry/wild fisheries is also partly the result of the development of aquaculture, especially salmon farming. For example, in Alaska many fishermen stopped fishing and salmon processing plants closed resulting in job losses and declining tax bases for communities.[27]

[24] The Gulf of Mexico Offshore Aquaculture Consortium estimated that, for a 12-cage offshore production system, eight individuals would be required to tend a sophisticated, automated offshore facility. However, they forecast that such an operation would produce an additional annual regional economic output reaching more than $9 million and provide additional employment for at least 262 persons, when all shoreside support was included. Although some suggest that, for every dollar of fish landed from fishing, there is a multiplier of as much as 5-7 in the shoreside economy (with the implication that this relationship would be roughly equivalent for aquaculture), others argue that these extreme multipliers may be suspect since the multiplier for the entire U.S. economy is around 2—meaning that a new dollar entering the economy manages to generate an additional dollar's worth of goods and services before the demand "leaks out" (i.e., gets spent on imports). See http://www.choicesmagazine.org/2003-2/2003-2-06.htm.

[25] Norwegian Directorate of Fisheries, Dept. of Aquaculture, *Key Figures from Norwegian Aquaculture Industry, 2000* (Bergen, Norway: 2001), 15 p.; Neal Gilbertson, "The Global Salmon Industry," *Alaska Economic Trends*, v. 23, no. 10 (October 2003): pp. 3-11; Rosamond L. Naylor et al., "Salmon Aquaculture in the Pacific Northwest: A Global Industry with Local Impacts," *Environment*, v. 45, no. 8 (October 2003): pp. 18-39.

[26] Many are researching ways to increase automation, especially with feeding and harvesting, such that few workers may be needed. At the extreme, all the work may be able to be done from a computer in a shoreside office with a satellite-controlled robotic system attached to the offshore cages. Also, the history of salmon farming indicates that, as the industry becomes more efficient, production per unit labor increases and employment decreases, especially compared to commercial fishing.

[27] Great Salmon Run.

Other Effects

Open ocean aquaculture development also has the potential to interfere with maritime transportation and commercial fisheries, with potential conflicts over access and transit rights.[28] Because of this potential for conflict, a process would need to be developed to identify the more suitable areas in federal waters for open ocean aquaculture development and/or to mediate disputes. Also, safety issues with offshore facilities may need to be addressed.

Environmental Impacts

Proponents of open ocean aquaculture suggest that open ocean finfish aquaculture systems may produce fewer and less severe environmental impacts than those caused by nearshore aquaculture systems. This may be in part because dissolved and particulate waste products and excess feed may be assimilated and recycled more efficiently in the open ocean environment. However, the scope of any effects may vary greatly, depending on the culture technique, location, size/scale, and species raised.[29] The present lack of knowledge—owing to limited experience, lack of research funding, and few studies focusing specifically on open ocean aquaculture—limits understanding of potential environmental concerns. Open ocean aquaculture pens would be open to the surrounding environment. Some critics of open ocean aquaculture cite concerns with the escape of fish, water pollution from uneaten feed and waste products (including drugs, chemicals, and other inputs), use of antibiotics and other animal drugs, alteration of benthic[30] habitat by settling wastes, and the spread of waterborne disease from cultured to wild fish.[31] Because of these concerns, critics of open ocean aquaculture hope that regulation of this emerging industry will be stringent.

Proponents hold that open ocean waters are normally nutrient-deficient, and nutrients released from open ocean aquaculture operations may increase wild production in adjacent areas. Waste settling from large operations could alter benthic habitat. However, research indicates that, in some areas, currents keep water around fish cages well circulated, dissipating waste products quickly, resulting in minimal impact of open ocean aquaculture facilities on water quality. Critics question whether the experience with experimental facilities is relevant to future commercial operations, which will need to operate at a larger scale to be profitable. A possible solution might be to combine finfish operations with seaweed or bivalve aquaculture to consume the excess nutrients. This approach is being tested by the University of New Hampshire at its open ocean aquaculture research project, but may be more appropriate for nearshore operations where waste diffusion is slower and nutrient concentrations are higher.[32]

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[28] Submerged technologies for open ocean aquaculture may reduce or eliminate some of these concerns.

[29] An extended discussion of most of the issues summarized in this section can be found in *Guidelines for Ecological Risk Assessment of Marine Fish Aquaculture* (December 2005) by the National Marine Fisheries Service, available at http://www.nwfsc.noaa.gov/assets/25/6450_01302006_155445_NashFAOFinalTM71.pdf.

[30] The term benthic refers to anything associated with or occurring on the bottom of a body of water.

[31] Institute for Agriculture and Trade Policy, *Open Ocean Aquaculture*, at http://www.environmentalobservatory.org/library.cfm?RefID=37057.

[32] Critics of this approach point out that, because of the practical limits of seaweed growth rates and filtering rates of bivalves, such a nutrient recycling system might have to be 50 or more times the size of the finfish operation to handle the anticipated nutrient loads.

Another concern is whether the use of pharmaceuticals, antibiotics, growth-enhancing chemicals, other animal drugs, and antifouling agents used on gear and enclosures will adversely affect open water environments. Chemicals used in fish foods are regulated by the U.S. Food and Drug Administration, and veterinarian oversight might encourage proper application and minimize environmental impact. Drugs such as antibiotics, some of which were developed and approved for use in a contained or controlled environment, are often introduced to cultured fish in their feed. Unconsumed feed and fish waste products can pass through the containment system and be consumed by wild organisms. The use of some of these products may be declining, as efficacious vaccines eliminate the need for antibiotics and other drugs. Proponents of open ocean aquaculture suggest that, because of the more pristine and better oxygenated water conditions offshore, the use of antibiotics has not been necessary in any of the offshore areas being tested in the United States.[33]

Most fish currently proposed for open ocean aquaculture are carnivorous and require feeds containing fishmeal and fish oil, which are obtained from wild stocks. Fishmeal and oil are produced from species such as anchovies and menhaden that are not usually used for direct human consumption. These species have a low per unit value, but large volumes can be caught and reduced (dried) to fishmeal, usually because they occur in large schools. Ecologically forage species serve as prey for many wild carnivorous fish species such as striped bass and for sea birds.

Although the ratio is falling, generally one to two pounds of wild fish are typically required to produce one pound of farmed fish. Environmentalists question whether aquaculture production could exacerbate pressures and cause overfishing of the ocean fish stocks harvested to produce fishmeal.[34] Others also assert it is wasteful to use fish for animal feeds instead of consuming them directly.[35] Yet, markets for direct consumption of most species harvested in industrial fisheries do not exist. Proponents of aquaculture counter that wild fish stocks can be well managed and commercial harvest for fishmeal would occur with or without demand from open ocean aquaculture.[36] They insist that, "Fish meal is a standard ingredient in livestock feed, and farmed fish are far more effective at converting it to edible protein than their terrestrial counterparts."[37] In addition, a feed conversion rate of two pounds feed to one pound of farmed product is favorable compared to conversion rates for wild species.[38] Use of a less desirable commodity to produce a more highly valued product is the basis of most livestock and aquaculture operations.

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[33] Personal communication from Dr. James P. McVey, Aquaculture Program Director, National Sea Grant College Program, NOAA, September 2005.

[34] Rosamond L. Naylor et al., "Effect of Aquaculture on World Fish Supplies," *Nature*, v. 405 (June 29, 2000): 1017-1024. Others, however, point out that industrial fisheries may be mismanaged regardless of the demand for fishmeal use in aquaculture.

[35] "Save Our Oceans, Eat Like a Pig," *The Tyee* (June 12, 2007), available at http://thetyee.ca/Views/2007/04/17/EatLikePigs/.

[36] Clifford A. Goudey, "Letters: Aquaculture in Offshore Zones," *Science*, v. 314 (December 22, 2006): p. 1875.

[37] Cliff Goudey, Letters to the Editor, U.S. Aquaculture Vital in Global Market, *The Boston Globe* (March 26, 2007), p. A8.

[38] Actual feed conversion rates can range widely, with wild production often considered to be around 10 pounds of feed per pound of growth. At one extreme, a feed conversion rate of 20 pounds of feed per pound of farmed tuna is reported (Sergi Tudela, "Tuna Farming: Grab, Cage, Fatten, Sell," *Samudra*, no. 32 (July 2002): 9-17). At the other extreme, feed conversion rates approaching 1.2 pounds of feed per pound of farmed Atlantic salmon have been reported (British Columbia Environmental Assessment Office at http://www.eao.gov.bc.ca/epic/output/documents/p20/1051572085662_da81e53841c84e47b5ea9ab15075741a.pdf).

The prices of fishmeal and fish oil are likely to increase if large quantities are required for open ocean aquaculture. In 2006, the price of fishmeal nearly doubled because of lower anchovy catches in Peru and the growing demand for fishmeal from China.[39] Concerns with price are likely to encourage researchers and aquaculturalists to improve feeding techniques to reduce waste, modify feed formulations, utilize alternatives such as waste from fish-processing plants, and experiment with herbivorous fish. Plant protein sources, such as canola, algae, or soybean meal, are being used to partially replace fishmeal, with significantly positive results emerging, especially where soybean meal is supplemented with certain essential amino acids. In some operations, the feed may contain as little as 30% fishmeal. An obstacle to increasing the amount of plant material that can be substituted for fishmeal appears to be the presence of anti-nutritional factors in the plant-derived materials.[40] The choice of species and feeds will likely depend on profitability, and since many high-value candidate fish or shellfish species are carnivorous, the demand for fishmeal and fish oil is likely to increase in the foreseeable future.

Another concern involves the spread of fish-borne disease from aquaculture to wild populations. For example, problems with the transfer of sea lice from salmon farms to wild salmon have been reported.[41] Disease may also spread from wild populations to farmed fish. A 2003 outbreak of infectious hematopoietic necrosis virus in British Columbia farmed salmon was confirmed to be a virus that had been circulating in wild fish for many years.

Genetic anomalies could occur if wild fish are exposed to or interbreed with hatchery-raised fish. This issue might arise if genetically modified or non-native fish escape from aquaculture facilities and interbreed with wild fish.[42] The potential interbreeding problem can be greatly reduced if only sterile fish are farmed; fairly simple technology exists to accomplish such sterilization. Critics speculate that, since selectively bred and genetically modified fish may grow faster and larger than native fish, they could displace native fish in the short term (both through competitive displacement and interbreeding), but might not be able to survive in the wild for the long term.[43] This is especially a concern of states (e.g., California, Maine, Maryland, and Washington) where genetically modified fish are banned within state waters but could be grown in offshore federal waters.

A related concern is the introduction of exotic species into non-native waters, such as Atlantic salmon in British Columbia. Exotic fish may escape from open ocean facilities that may be particularly vulnerable to storms, although recent hurricanes and tropical storms in Hawaii, Puerto Rico, and the Bahamas have caused no reported damage or loss of fish in submerged cage-

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[39] Farming Fish No Longer Relies on Fish Meal Prices, *The Fish Site* (February 20, 2007), available at http://www.thefishsite.com/fishnews/3690/farming-fish-no-longer-relies-only-on-fish-meal-feeds.

[40] G. Francis, H. P. S. Makkar, and K. Becker, "Antinutritional Factors Present in Plant-Derived Alternate Fish Feed Ingredients and Their Effects in Fish," *Aquaculture*, v. 199, no. 3-4 (2001): 197-227.

[41] Alexandra Morton et al., "Sea Lice (*Lepeophtheirus salmonis*) Infection Rates on Juvenile Pink (*Oncorhynchus gorbuscha*) and Chum (*Oncorhynchus keta*) Salmon in the Nearshore Marine Environment of British Columbia, Canada," *Canadian Journal of Fisheries and Aquatic Sciences*, v. 61 (2004): 147-157.

[42] Rebecca J. Goldburg, Matthew S. Elliott, and Rosamond L. Naylor, *Marine Aquaculture in the United States: Environmental Impacts and Policy Options*, Pew Oceans Commission (Arlington, VA: July 2001), pp. 6-9. See http://www.pewtrusts.org/pdf/env_pew_oceans_aquaculture.pdf.

[43] The *Trojan gene* hypothesis; William M. Muir and Richard D. Howard, "Possible Ecological Risks of Transgenic Organism Release When Transgenes Affect Mating Success: Sexual Selection and the Trojan Gene Hypothesis," *Proceedings of the National Academy of Sciences of the United States*, v. 96, no. 24 (November 23, 1999): 13853-13856.

culture operations. The escape of Atlantic salmon has been documented in the Pacific Northwest and escapees have been recaptured in Alaskan commercial fisheries.[44] Escapes are also common in the Atlantic where 40% of the Atlantic salmon caught in the North Atlantic are of farmed origin.[45] The experience with salmon farming indicates that escaped fish could be a problem, either through interbreeding with closely related native species (genetic interactions) or through competitive displacement of native species. Although management techniques at net pen sites are improving and modified cage designs better prevent escapes, closed containment systems may be the only way to fully address this problem.

Some are concerned that offshore and underwater facilities may harm or disturb marine mammals and other wildlife. To address these concerns, current cage designs avoid the use of small diameter or loose lines or loosely hung netting to prevent the entanglement of sea turtles and marine mammals in net-pens and associated gear. Since net-pens would be under tension, the possibility that a turtle flipper or whale fluke would get tangled in lines or nets is unlikely. However, experience has shown that dolphins and other marine mammals do get entangled in fish farms.[46] In addition, some types of shellfish farms may use ropes/longlines for settling and grow-out that could be problematic. Sound devices at farms to keep animals away could harass or harm marine mammals. Open ocean facilities could potentially affect some endangered species, such as North Atlantic right whales as they migrate, or alter essential habitat for feeding, breeding, and nursing. Also, there could be renewed interest in killing “nuisance” animals, as has been the case with salmon farmers killing seals and sea lions. There could be problems with other predatory animals, such as sharks, as well.

Legal and Regulatory Environment

Using offshore waters for a private activity such as aquaculture is likely to be controversial. Traditionally, nearshore waters and their resources under state jurisdiction are considered to be held and managed “in the public trust.” Open ocean aquaculture may be perceived by some as de facto privatization of the ocean, which has historically been considered a common property resource.[47] Precedents in leasing offshore areas for developing oil and gas resources may be relevant to these concerns. However, significant questions remain concerning whether an appropriate mechanism exists for any federal agency to provide an open ocean aquaculture permit or lease applicant with the necessary property rights to begin construction and operation. Siting and site tenure in federal waters are important issues for development and private investment—without assurances and protection of exclusive rights, there is little incentive for financial investment.

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[44] Marine Aquaculture Task Force, Sustainable Marine Aquaculture: Fulfilling the Promise: Managing the Risk (Woods Hole, MA: January 2007), p. 45.

[45] Rosamond L. Naylor, Susan L. Williams, and Donald M. Strong, “Aquaculture—A Gateway for Exotic Species,” *Science,* v. 294 (November 23, 2001) p. 1656.

[46] See C. M. Kemper et al., “Aquaculture and Marine Mammals: Coexistence or Conflict?,” *Marine Mammals and Humans: Towards a Sustainable Balance,* N. Gales, M. Hindell, and R. Kirkwood, eds. (CSIRO Publishing: 2003). However, bycatch also occurs in many harvest fisheries, where its extent may be greater and its control may be more difficult than at stationary aquaculture facilities.

[47] The government regularly grants exclusive use of public resources when there are public benefits, establishing a precedent for ocean leasing for commercial aquaculture to increase domestic fish supply. For a more detailed discussion of these issues, see CRS Report RL32658, *Wind Energy: Offshore Permitting,* by Adam Vann.

The legal and regulatory framework for open ocean aquaculture will, in large part, determine whether private industry succeeds in establishing commercial operations. Legal and regulatory challenges may be particularly time-consuming and costly, although some suggest that moving aquaculture away from the coast, and out of the view of the majority of coastal residents, could alleviate some public concerns. The complexities of multi-agency permitting are not clearly understood by all interested parties, leading to uncertainty for the open ocean aquaculture industry and making it difficult to plan and finance operations. Current permitting requires approval by at least three federal agencies that have jurisdiction over various aspects of aquaculture—the U.S. Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers, and the National Marine Fisheries Service (NMFS).[48] The review required under each of these agencies' responsibilities can delay a permit or deny it if the expected effects are too great. These agencies would likely be involved in future decisions to provide permits or leases to open ocean aquaculture operators.

For aquaculture projects in offshore federal waters, the lead federal permitting agency must assure consistency with approved programs in adjacent states under the Coastal Zone Management Act (16 U.S.C. §§1451, et seq.). In addition, state waters would be traversed both to operate open ocean aquaculture sites and to bring harvested fish ashore for processing. States with approved Coastal Zone Management plans may veto federal permits for activities that are inconsistent with the state's federally approved plan. This oversight ensures that operations in federal waters will neither harm the state's interests nor be inconsistent with state policies.

EPA regulates the discharge of pollutants into waters of the United States from finfish aquaculture facilities under the Clean Water Act (CWA; 33 U.S.C. §§1251, et seq.). Under the CWA's National Pollutant Discharge Elimination System, such facilities are regulated under the category "concentrated aquatic animal production facilities."[49] For aquaculture facilities located in offshore federal waters, §403(c) of the CWA requires an additional review to prevent unreasonable degradation of the marine environment. Discharges that cause unreasonable degradation are prohibited, and are evaluated according to ocean discharge criteria established by EPA.

Because of navigation concerns, the Army Corps of Engineers has jurisdiction over permanent or temporary "devices" used to explore, develop, or produce resources on or around the seabed in federally controlled waters (33 C.F.R. Part 322). The Coast Guard, in the Department of Homeland Security, regulates vessel traffic and dictates safety measures (lights and signals) for aquaculture structures to ensure safe vessel passage under the Rivers and Harbors Act of 1899 (33 U.S.C. §407). In addition, the Department of Defense may become involved, reviewing proposals that might interfere with naval operations.

NOAA has defined marine aquaculture as fishing, under the authority of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. §§1801, et seq.).[50] NMFS has assumed the lead in promoting open ocean aquaculture development and has supported this developing industry.[51] Under the authority of the Magnuson-Stevens Act, several regional fishery

[48] NMFS (also popularly called "NOAA Fisheries") is part of the National Oceanic and Atmospheric Administration (NOAA) in the U.S. Dept. of Commerce.

[49] 40 C.F.R. Part 451; see 69 *Federal Register* 51891-51930 (August 23, 2004).

[50] Jay S. Johnson and Margaret F. Hayes, *Regulation of Aquaculture in the EEZ*, Memorandum, Office of the General Counsel, NOAA (Washington, DC: February 7, 1993), 5 pp.

[51] Based on a legal opinion by NOAA General Counsel, landings or possession of fish in the EEZ from a commercial marine aquaculture operation producing species managed under fishery management plans (FMPs) constitutes (continued...)

management councils have exercised regulatory oversight over open ocean aquaculture. The New England and Gulf of Mexico Councils have been particularly active in this respect. The New England Council has established evaluation criteria for open ocean aquaculture proposals that encourage the use of best management practices aimed at reducing environmental and fishery impacts. For the last several years, the Gulf of Mexico Fishery Management Council (GMFMC) has been developing a generic offshore aquaculture fishery management plan (FMP) to regulate aquaculture in the Gulf of Mexico EEZ. On January 28, 2009, the FMP was approved by the GMFMC, and on September 3, 2009, the plan took effect.

In some cases, NMFS has authorized open ocean aquaculture operations in federal waters for scientific purposes through an exempted fishing permit. Exempted fisheries permits are of limited duration, and are not intended to apply to commercial aquaculture. The Magnuson-Stevens Act also requires the federal permitting agency for any aquaculture facility to consult with NMFS for potential impacts to essential fish habitat (EFH). EFH is designated for all marine species for which there is a federal fishery management plan (FMP). NMFS also has responsibilities under the Marine Mammal Protection Act (16 U.S.C. §§1361, et seq.) and the Endangered Species Act (16 U.S.C. §§1531, et seq.) to review proposals for projects that might affect marine mammals or threatened and endangered species. NMFS marine mammal regulations include aquaculture activities in the definition of commercial fishing operations.[52] These reviews could impede or prevent open ocean aquaculture development in some areas.

Establishing separate ocean areas or zones for specific activities has received greater attention as ocean uses have increased in the EEZ. Appropriate uses for areas or zones would depend on the compatibility of proposed activities with the biological and physical characteristics of the area as well as with other activities. Some have suggested that as an initial step, areas could be identified specifically for aquaculture development. A public process could identify areas with the greatest aquaculture potential, the least environmental sensitivity to potential impacts from aquaculture, and the most community support. Some planning efforts have considered defining the extent and location of aquaculture activities before permitting is initiated.[53] This could be especially important during early stages of development to allay fears that aquaculture might directly interfere with commercial or recreational fishing. Pre-approved areas could also streamline the aquaculture permitting process if social and environmental factors were already fully studied and documented by environmental assessments or environmental impacts statements.

Marine Aquaculture Task Force

In 2005, the Pew Charitable Trusts and Lenfest Foundation requested the Woods Hole Oceanographic Institution to convene a task force to examine the potential risks and benefits of open ocean aquaculture. The nine-member panel developed a set of national policy

(...continued)

"fishing" as defined in the Magnuson-Stevens Act. Therefore, to allow commercial aquaculture production in the EEZ, FMPs must be amended to allow for regulation of the activity by NMFS. Otherwise a federal exempted fishing permit is required to conduct scientific activity such as marine aquaculture in the EEZ (50 C.F.R. §600.745).

[52] 50 C.F.R. § 229.2

[53] Colin Nash, *Appendix I: Draft NOAA Aquaculture Matrix Operational Standards for Marine Aquaculture,* Gulf of Mexico Fishery Management Council (Tampa Bay, FL: 2006).

recommendations to guide future development of the industry.[54] The panel concentrated on potential environmental impacts with recommendations related to:

- escapes resulting in introduction of nonnative species;
- disease and parasite spillover into natural ecosystems;
- aquacultural waste resulting in water pollution; and
- market-based incentives to reward environmental protection.

The panel also provided a general governance framework to address environmental impacts that would provide clear federal leadership and standards to protect the marine environment. The framework would assign NOAA a lead role in planning aquaculture in federal marine waters, with emphasis on related activities such as evaluating environmental risks, consulting with regional and state bodies, and developing environmental standards.

Federal Action

Legislative Efforts

During the 110th Congress, the National Offshore Aquaculture Act of 2007 was introduced as H.R. 2010 in the House and as S. 1609 in the Senate, both by request of the Administration. Both bills focused on the need for a framework to regulate aquaculture in federal waters of the U.S. Exclusive Economic Zone (EEZ), generally 3 to 200 miles from the coastline.[55] A hearing concerning H.R. 2010 was held before the House Committee on Natural Resources, Subcommittee on Fisheries, Wildlife, and Oceans, but no further action was taken on either of these bills.

On September 8, 2009, H.R. 3534, the Consolidated Land, Energy, and Aquatic Resources Act of 2009, was introduced. Section 704 of the bill would have rescinded the authority of the Secretary of Commerce, the Administrator of the National Oceanic and Atmospheric Administration, or Regional Fishery Management Councils to develop or approve fishery management plans to permit or regulate offshore aquaculture. The bill also would have invalidated permits issued for conducting offshore aquaculture under the Magnuson-Stevens Fishery Conservation and Management Act. It appears that the goal of this legislation was to prevent offshore aquaculture development until comprehensive legislation could be passed. On July 30, 2010, H.R. 3534 was passed by the House, but the section related to offshore aquaculture was removed from the bill.

On December 16, 2009, H.R. 4363, the National Sustainable Offshore Aquaculture Act of 2009 was introduced. Key provisions of the legislation include:

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[54] A copy of the 128-page Task Force report is available at http://www.whoi.edu/cms/files/mcarlowicz/2007/1/Sustainable_Marine_Aquaculture_final_1_02_07_17244.pdf.

[55] H.R. 2010 and S. 1609, the National Offshore Aquaculture Act of 2007, define "offshore aquaculture" as all activities, including operation of offshore aquaculture facilities, involved in the propagation and rearing, or attempted propagation and rearing, of marine species in the United States Exclusive Economic Zone. Open ocean aquaculture is a more general term for operations in exposed ocean areas beyond significant coastal influence and may include areas in state waters within 3 miles of the shoreline and beyond the 200-nautical mile EEZ.

- establishing a regulatory process for offshore aquaculture in the United States EEZ;
- requiring coordinated regional programmatic environmental impact statements; and
- authorizing funds for research to develop environmentally sound management.

H.R. 4363 would prohibit the siting of offshore aquaculture facilities on or attached to any portion of an oil or gas platform, including one that is no longer in service. Some have raised concerns that this provision could hurt Gulf of Mexico aquaculture and have a potentially negative impact on the economy.[56]

On May 25, 2010, S. 3417, the Research in Aquaculture Opportunity and Responsibility Act of 2010 was introduced. The bill would prohibit offshore aquaculture until three years after the submission of a report to Congress on the impacts of offshore aquaculture. This legislation would also require a report on land-based recirculating aquaculture systems.

Most environmental and commercial fishing interests have been skeptical of or opposed to plans for offshore aquaculture development, and most also opposed aquaculture legislation, largely because they believed it contained weak environmental provisions.[57] Conservation-related concerns include the use of wild species for fishmeal, fish escapement, threat of disease and parasites, impacts on marine wildlife, and ecosystem impacts.[58] Commercial fishing interests also voiced concerns related to potential impacts on markets and coastal communities.[59] In most cases, neither group has been opposed to all development, but both have showed concern regarding how aquaculture expansion will proceed. A precautionary approach has been advocated by most commercial fishing and environmental interests.

Current aquaculturalists and related industries have been supportive of offshore aquaculture legislation. They have voiced a general belief that offshore aquaculture can be established in a manner that minimizes potential environmental and commercial fishing impacts while providing a valuable source of seafood. Aquaculture industry representatives expressed concern that the 10-year site permit and five-year permit renewals were too short because of the need for a longer investment time frame. Another common concern involved the need for public investment to support and promote aquaculture development.[60]

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[56] Ben Raines, "Bill Banning the Use of Offshore Platforms for Fish Farms Could Affect Gulf Aquaculture," *Press-Register*, December 31, 2009.

[57] P. N. Spotts, "Fish Farms in the Ocean? Group Pushes Congress to Pass Tough Rules," *The Christian Science Monitor* (January 10, 2007).

[58] Ibid.

[59] Written statement of Mark Vinsel, *Hearing on Offshore Aquaculture*, before the U.S. Senate, Committee on Commerce, Science, and Transportation, National Ocean Policy Study (April 6, 2006).

[60] Written statements of Sebastian Belle and John R. Cates, *Hearing on Offshore Aquaculture*, before the U.S. Senate, Committee on Commerce, Science, and Transportation, National Ocean Policy Study (April 6, 2006).

Agency and Fishery Management Council Actions

NOAA Aquaculture Plan

In October 2007, NOAA released a 10-Year Plan for its aquaculture program.[61] The plan provides a blueprint of likely NOAA involvement in marine aquaculture over the next decade, including program goals and strategies, outcomes, budget and staffing requirements, potential benefits of aquaculture, and associated challenges. The plan was prepared at the request of the agency's Marine Fisheries Advisory Committee (MAFAC), which advises the Secretary of Commerce on living marine resource matters that are the responsibility of the Department of Commerce. According to the plan, NOAA will:

- establish a comprehensive regulatory program for marine aquaculture;
- develop commercial marine aquaculture and enhance wild stocks;
- improve public understanding of marine aquaculture; and
- increase collaboration and cooperation with international partners.

The plan cites a forecast that projects increases in annual domestic aquaculture production of edible seafood from current levels of 468,000 metric tons to approximately 1.51 million metric tons by 2025, with over 90% attributable to anadromous species[62] and marine aquaculture production.[63] The projection of future production depends on changes in the current institutional framework that governs marine aquaculture. According to NOAA, challenges to achieving these production levels include:

- a complicated, inefficient, and uncertain federal regulatory process to permit marine aquaculture facilities;
- the need for additional research on environmental implications and ecosystem carrying capacity of marine aquaculture;
- the lack of an adequate research, development, and technical infrastructure;
- the need to improve communication and foster understanding of the environmental, economic, and social implications of marine aquaculture;
- the lack of access to coastal sites for marine aquaculture facilities because of competing high-value uses for housing and tourism; and
- rapid international growth of worldwide aquaculture with supply, demand, and price implications for U.S. consumers and seafood producers.[64]

All six program challenges are directly related to open ocean aquaculture. Since inshore marine aquaculture production has been stagnant over the last decade, a large proportion of future

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[61] NOAA's program planning and support includes both inshore and offshore ocean aquaculture.

[62] Anadromous species such as salmon, shad, and sturgeon reproduce in rivers (inland waters) and spend their adult life in the sea.

[63] C. E. Nash, "Achieving policy objectives to increase the value of the seafood industry in the United States: the technical feasibility and associated constraints," *Food Policy,* v. 29 (2004): 621-641.

[64] For a copy of the plan see http://aquaculture.noaa.gov/.

production increases, if they occur, would be likely to result from open ocean aquaculture production.

Council Actions

On January 28, 2009, the Gulf of Mexico Fishery Management Council (GMFMC) approved a fishery management plan to regulate offshore marine aquaculture. On September 3, 2009, the plan took effect because the Secretary of Commerce declined to oppose it within the required statutory period. The purpose of the aquaculture amendment is to develop a regional permitting process for regulating and promoting environmentally sound and economically sustainable aquaculture in the Gulf of Mexico EEZ.[65] The GMFMC initiated development of the amendment because several firms have proposed development of aquaculture in the region.

The GMFMC held a series of public hearings to solicit comments on the draft plan. The majority of comments cited environmental concerns such as the escape of farmed fish, water pollution from concentrated fish-feeding operations, and the spread of disease.[66] Some who supported offshore aquaculture claim that, "as long as you site the farms properly and manage them properly, there is no detrimental environmental impact."[67] Others supported the plan because they are concerned with the growth of seafood imports, believing that domestic production would provide a more stable and wholesome supply of fish.

Some worry that regional management of open ocean aquaculture under the Magnuson-Stevens Act may add another layer of bureaucracy, especially if several regional fishery management councils develop their own, possibly contradictory, open ocean aquaculture management policies.[68] Currently commercial aquaculture is less likely to occur in other offshore federal waters because other regional fishery management councils have not prepared aquaculture FMPs or generic aquaculture amendments to the appropriate FMPs for species that could be cultured. In addition, it is unclear what regulatory authority NMFS and the regional councils might have over species, such as mussels, that are not managed under a federal FMP.

Also on September 3, 2009, NOAA announced that it is developing a comprehensive national policy for marine aquaculture. According to NOAA, the policy will provide a framework for addressing aquaculture activity in federal waters and a context for regulating offshore aquaculture in the Gulf of Mexico under the GMFMC FMP. The policy will also include development of federal standards for permitting aquaculture facilities and strategies to generate scientific information needed for permitting decisions.

Use of Oil Platforms

In addition to environmental issues, the potential use of decommissioned oil platforms for aquaculture is another issue of interest, especially in the Gulf of Mexico region. As thousands of

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[65] Ibid.

[66] Debra Kahn, *Aquaculture Plan for Gulf of Mexico Needs More Review—Fishing, Enviro Groups* (December 13, 2007). See http://www.eenews.net/Landletter/2007/12/13/archive/10?terms=aquaculture.

[67] Ibid.

[68] Gulf of Mexico Fishery Management Council, *Fishery Management Plan for Regulating Aquaculture in the Gulf of Mexico* (Tampa, FL: January 2009).

oil platforms in the Gulf of Mexico near the end of their productive lives, oil and gas operators are required to plug all wells, sever all structures below the mud line, and physically remove the structures from the lease. Instead of removing structures, the Rigs-to-Reefs program allows operators to convert obsolete platforms into artificial reefs to enhance recreational and commercial fisheries. Some interests are considering alternative uses as energy generation platforms and aquaculture support facilities. They speculate that these structures could be used as staging areas for aquaculture operations by providing a base to attach net enclosures, house workers, and store tools, feed, and other aquaculture infrastructure needs. However, if aquaculture businesses were to fail, many have expressed concern that responsibility for platform removal and liability for accidents and lease abandonment are clearly defined. They contend that if platforms are reassigned to aquaculture operators, end-of-lease obligations and issues related to bonding would need to be satisfied.

The Mineral Management Service (MMS) announced the record of decision for establishing an alternative energy and alternative use (AEAU) program on the outer continental shelf (OCS).[69] This decision sets up a program for issuing leases, easements, and rights-of-way for alternative uses of offshore oil and gas production platforms.[70] It also provides MMS with the option of authorizing individual projects on a case-by-case basis. Offshore aquaculture is identified as one of the activities that could be authorized to use existing OCS facilities.

Discussion

Proponents of aquaculture development questioned what might have happened if Alaska—with its processing plants, distribution system, infrastructure, excellent water quality, and extensive coastline—had decided to embrace rather than prohibit intensive salmon aquaculture.[71] These proponents suggest that, if Alaska had decided differently, Alaska might still "own" the world salmon market and enjoy a major source of employment and economic development, rather than having to watch wild Alaskan salmon compete with aggressive salmon aquaculture development by Chile, Norway, and others. The Alaska case is cited to illustrate that regardless of whether the United States permits or denies open ocean aquaculture development, some of the potential socioeconomic impacts of open ocean aquaculture production on wild fisheries (e.g., changes in prices and markets) are likely to result from greater production, whether domestic or foreign.

However, environmentalists and commercial fishermen might view the absence of salmon aquaculture in Alaska differently. Potential environmental and social problems may have been avoided by concentrating on traditional wild fisheries. Wild salmon populations have been maintained at high levels and much of the Alaska coastline is pristine. Although competition from aquaculture salmon imports may have hurt Alaska salmon fisheries, improvements in marketing and product quality have kept many market segments competitive.

The future of aquaculture in the U.S. EEZ is still an open question. Setting a regulatory framework might be necessary but not necessarily sufficient to spur development of an open

[69] 73 *Federal Register* 1894-1895 (January 10, 2008).

[70] Mineral Management Service, *OCS Alternative Energy and Alternate Use Final Environmental Impact Statement (EIS)*, Washington, DC, October 2007, http://ocsenergy.anl.gov/documents/fpeis/index.cfm.

[71] Alaska allows salmon aquaculture in cooperative hatcheries that raise and release salmon smolts (young salmon) to the wild to supplement harvest.

ocean aquaculture industry. Aquaculture in other countries may have advantages related to lower costs and superior sites. Although it might be argued that a highly regulated U.S. industry is unlikely to be competitive with aquaculture in other countries, minimal regulation does not guarantee that the U.S. aquaculture industry will succeed. A complex and unpredictable mix of technological, biological, and economic factors will also determine the future profitability of open ocean aquaculture. Although government may play a role in funding research and pilot projects, large-scale production will likely depend on private initiatives and innovation.

Environmental effects of aquaculture in coastal and inland areas have been documented, especially in other parts of the world, and potential environmental concerns related to development of aquaculture in open ocean areas will need to be addressed. One of the main challenges for policy makers is to balance the need to provide flexibility for the aquaculture industry with public concerns related to environmental and social impacts.

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