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Open Ocean Aquaculture

Harold F. Upton and Eugene H. Buck, Resources, Science, and Industry Division

Updated June 12, 2008

Abstract. This report discusses four general areas: (1) operational and business-related challenges; (2) potential environmental impacts; (3) potential economic impacts; and (4) the legal and regulatory environment. It then summarizes recent executive and legislative actions. 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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CRS Report for Congress

Open Ocean Aquaculture

Updated June 12, 2008

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**Prepared for Members and
Committees of Congress**

Open Ocean Aquaculture

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.

The Natural Stock Conservation Act of 2007 was introduced as S. 533 on February 8, 2007. This legislation would amend the National Aquaculture Act of 1980 to prohibit the issuing of permits for marine aquaculture in the EEZ until requirements for permits are enacted into law. The National Offshore Aquaculture Act of 2007 was introduced as H.R. 2010 in the House on April 24, 2007, and as S. 1609 in the Senate on June 13, 2007, both by request of the Administration. The legislation focuses on the development of a framework for issuing permits to operate in the EEZ. At the time S. 1609 was introduced, four amendments were referred to the Committee on Commerce, Science, and Transportation concerning environmental risks, comprehensive research and development, domestic ownership, and a prohibition on finfish aquaculture off the coast of Alaska.

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. It summarizes recent executive and legislative branch actions. 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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Open Ocean Aquaculture

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.

The National Offshore Aquaculture Act of 2007 was introduced as H.R. 2010 in the House on April 24, 2007, and in the Senate as S. 1609 on June 13, 2007, both by request of the Administration. This legislation focuses on the need for a framework for issuing permits to operate in federal waters of the U.S. Exclusive Economic Zone (EEZ), generally 3 to 200 miles from the coastline.¹ A similar bill, S. 1195, was introduced in the 109th Congress, but was not enacted. In redrafting the bill, the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce has sought to strengthen environmental provisions, clarify the role of states and fishery management councils, and extend the duration of permits, as these were issues raised in connection with the previous proposal.

However, at the time that S. 1609 was introduced, four amendments were referred to the Committee on Commerce, Science, and Transportation by the committee chairman and vice chairman to:

- strengthen requirements to address potential environmental risks;
- require a more comprehensive research and development program;
- ensure that permits could only be provided to citizens, residents, or business entities of the United States; and
- prohibit offshore aquaculture of finfish in the EEZ off the coast of Alaska.

Concerns related to aquaculture also surfaced in S. 533, the Natural Stock Conservation Act of 2007, which was introduced on February 8, 2007. This

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.

legislation would amend the National Aquaculture Act of 1980 (16 U.S.C. §§ 2801-2810) to prohibit the issuing of permits for marine aquaculture in the EEZ until requirements for permits are enacted into law.

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, three 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. Although these are open ocean operations, all three 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 open ocean aquaculture in the United States.⁵ Uncertainty is one of the main barriers to commercial investment in

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 Biliiana 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.

(continued...)

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 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

⁵ (...continued)

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).

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 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

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>].

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.

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, obtaining suitable insurance on the capital investment and stock, and protecting investments from vandalism and other property threats.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

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

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.

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 more intensive culture techniques such as closed systems¹⁰ 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

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.

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 2006, the United States imported approximately 5.4 billion pounds of edible seafood worth \$13.4 billion.¹⁴ After accounting for exports valued at \$4.2 billion, there was a trade deficit of approximately \$9.2 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 for \$1.5 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

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, 2006*, Current Fishery Statistics No. 2006 (Washington, DC: July 2007), p. 48.

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>].

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. For example, 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 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 thirty years, domestic shrimp production from the wild fishery has remained relatively constant while imports of aquaculture shrimp have increased. In 2006, 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

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).

¹⁹ U.S. Dept. of Commerce, National Marine Fisheries Service, *Fisheries of the United States, 2006*, Current Fishery Statistics No. 2006 (Washington, DC: July 2007).

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

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 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

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.

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, (continued...)

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

Other Effects. Open ocean aquaculture development also has the potential to interfere with maritime transportation and commercial fisheries, with potential

²⁴ (...continued)

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.

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 benthic³⁰ 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

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>].

appropriate for nearshore operations where waste diffusion is slower and nutrient concentrations are higher.³²

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.

Two or more pounds of wild fish are usually 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

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.

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.

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.

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.

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]).

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.

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-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

⁴² Rebecca J. Goldberg, 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.

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?," (continued...)

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 is likely to be legally 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.

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

⁴⁶ (...continued)

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 Aaron M. Flynn.

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

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.

Through a NOAA General Counsel opinion,⁵⁰ NMFS assumed the lead in promoting open ocean aquaculture development and has supported this developing industry. In some cases, NMFS has authorized open ocean aquaculture operations for scientific purposes through an exempted fishing permit and 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.).⁵¹ The Magnuson-Stevens Act also requires the federal permitting agency for any aquaculture facility

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 p.

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 "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. Federal exempted fishing permits are required to conduct scientific activity such as marine aquaculture in the EEZ (50 C.F.R. §600.745).

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. These reviews could impede or prevent open ocean aquaculture development in some areas.

Also under the authority of the Magnuson-Stevens Act, several regional fishery 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.⁵² 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. The Gulf of Mexico Council has drafted a generic offshore aquaculture amendment that would establish permits to conduct marine aquaculture in the Gulf of Mexico EEZ. However, 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.

Establishing separate ocean areas or zones for specific activities has received greater attention as ocean uses have increased in the EEZ. Appropriate ocean 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 specifically identified 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

⁵² “Agency Sinks Proposal for Gulf Fish Farm,” *St. Petersburg Times* (December 30, 2003), at [http://www.sptimes.com/2003/12/30/Southpinellas/Agency_sinks_proposal.shtml].

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

national policy 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

The National Offshore Aquaculture Act of 2007 was introduced as H.R. 2010 in the House on April 24, 2007, and as S. 1609 in the Senate on June 13, 2007, both by request of the Administration. A similar bill, S. 1195, was introduced in the 109th Congress, but was not enacted. The main features of both the original and current bills involve establishing a regulatory framework for aquaculture in federal waters. These bills would:

- authorize the Secretary of Commerce to issue open ocean aquaculture permits and to establish environmental requirements where existing requirements under current law are inadequate;
- exempt permitted open ocean aquaculture from legal definitions of fishing that restrict size, season, and harvest methods;
- authorize a research and development program to support open ocean aquaculture;
- require the Secretary of Commerce to work with other federal agencies to develop and implement a streamlined and coordinated permitting process for aquaculture in the EEZ; and
- offer certain exemptions for foreign ownership.

Other provisions retained from the earlier bill would include requiring a bond or other form of financial guarantee from the aquaculturalist; monitoring and collecting data; clarifying that the bill does not supersede other laws or jurisdiction of other agencies; and providing authority for NOAA to address more detailed environmental requirements through rulemaking. This legislation would also implement a U.S. Commission on Ocean Policy recommendation to designate NOAA as the lead federal

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

agency for marine aquaculture and create an Office of Sustainable Marine Aquaculture in NOAA.⁵⁵ Such an effort within NOAA could result in one agency being responsible for both promoting and regulating the industry. Several sections in the earlier version (S. 1195) that were modified in both H.R. 2010 and S. 1609 seek to:

- strengthen the environmental provisions;
- clarify the role for fishery management councils and states;
- substitute a single offshore aquaculture permit for separate site and operating permits; and
- extend the duration of offshore aquaculture permits to 20 years rather than 10 years.

However, at the time that S. 1609 was introduced, concerns of the Committee on Commerce, Science, and Justice chair and vice chair prompted them to file several amendments to:

- strengthen requirements to address potential environmental risks;
- require a more comprehensive research and development program;
- ensure permits could only be provided to citizens, residents, or business entities of the United States; and
- prohibit offshore aquaculture of finfish in the EEZ off the coast of Alaska.

Concerns related to aquaculture also surfaced in S. 533, the Natural Stock Conservation Act of 2007, introduced on February 8, 2007. This legislation would amend the National Aquaculture Act of 1980 (16 U.S.C. §§ 2801-2810) to prohibit the issuing of permits for marine aquaculture in the EEZ until requirements for permits are enacted into law.

On July 12, 2007, a hearing on H.R. 2010 was held before the House Committee on Natural Resources, Subcommittee on Fisheries, Wildlife, and Oceans. NOAA provided testimony that supported H.R. 2010 and stressed the potential contributions of offshore aquaculture to seafood supply and the national economy. The testimony also expressed NOAA's willingness to work with all interests to craft an offshore aquaculture regulatory framework.⁵⁶

Testimony of the Ocean Conservancy concluded that H.R. 2010 represents an improvement from legislation introduced in the Senate in 2005 (S. 1195) because it includes mandatory rulemaking, requirements to prevent disease and escapes, and a

⁵⁵ The U.S. Commission on Ocean Policy, *An Ocean Blueprint for the 21st Century*, available at [http://oceancommission.gov/documents/full_color_rpt/welcome.html].

⁵⁶ Written statement of Vice Admiral Conrad C. Lautenbacher, Jr., Under Secretary for Oceans and Atmosphere, National Oceanic and Atmospheric Administration, *Hearing on H.R. 2010, The National Offshore Aquaculture Act of 2007*, before the Fisheries, Wildlife, and Oceans Subcommittee of the Committee on Resources, U.S. House of Representatives (July 12, 2007).

limitation to raising native species.⁵⁷ Yet the testimony was generally critical of offshore aquaculture, and concluded by stating that the Ocean Conservancy has joined 30 other fishing, conservation, consumer safety, and farming organizations in opposing H.R. 2010. A partial list of specific concerns cited by the Ocean Conservancy includes the rulemaking process, use of local genotypes and genetically modified species, monitoring, permit duration, liability, pollution, sensitive habitat, and the use of fishmeal.⁵⁸

Most environmental and commercial fishing interests have been skeptical of or opposed to plans for offshore aquaculture development and most also opposed S. 1195 in the 109th Congress, because they believed it contained weak environmental provisions.⁵⁹ 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.⁶⁰ Commercial fishing interests also voiced concerns related to potential impacts on markets and coastal communities.⁶¹ 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.

A representative of the Alaska Department of Fish and Game also provided testimony at the July 12, 2007, hearing.⁶² The testimony supported a cautious approach to aquaculture depending on the nature of the operation, its relationship to commercial capture fisheries, and potential impacts on wild fish populations. The representative specifically recommended:

- a five year period of evaluation and analysis prior to new aquaculture operations;
- state determination of the types of aquaculture that may occur off their states' coastlines;
- regional fishery management council jurisdiction over aquaculture operations;
- permit durations of no longer than 10 years;
- prohibition of aquaculture for certain species; and
- programs to maintain the economic vitality of wild capture fisheries.⁶³

⁵⁷ Written statement of Tim Eichenberg, Pacific Regional Director, Ocean Conservancy, *Hearing on H.R. 2010, The National Offshore Aquaculture Act of 2007*.

⁵⁸ *Ibid.*

⁵⁹ P. N. Spotts, "Fish Farms in the Ocean? Group Pushes Congress to Pass Tough Rules," *The Christian Science Monitor* (January 10, 2007).

⁶⁰ *Ibid.*

⁶¹ 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).

⁶² Written statement of Sue Aspelund, Special Assistant, Alaska Department of Fish and Game, *Hearing on H.R. 2010, The National Offshore Aquaculture Act of 2007*.

⁶³ *Ibid.*

The National Aquaculture Association representative also testified at the July 12, 2007, hearing and focused on the potential opportunities related to offshore aquaculture development such as jobs in coastal communities and improved availability of seafood. His testimony countered concerns related to environmental stewardship by stating that aquaculture requires good water quality.⁶⁴ He stressed that profitable aquaculture requires management practices that maintain environmental quality, prevent fish escapes, and produce a wholesome product. He also stated that U.S. aquaculture is distinctly different from aquaculture occurring in other parts of the world because of existing U.S. environmental standards. He suggested that the legislation should allow for the use of vessels as offshore production platforms, and expressed concern that potential market impacts related to competition with capture fisheries should not be an evaluation requirement for siting aquaculture facilities.

Current aquaculturalists and related industries have been supportive of offshore aquaculture expansion. 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.⁶⁵

Agency and Fishery Management Council Actions

NOAA Aquaculture Plan. In October 2007, NOAA released a 10-Year Plan for its aquaculture program.⁶⁶ 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

⁶⁴ Written statement of John R. MacMillan, President, National Aquaculture Association, *Hearing on H.R. 2010, The National Offshore Aquaculture Act of 2007*.

⁶⁵ 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).

⁶⁶ NOAA's program planning and support includes both inshore and offshore ocean aquaculture.

approximately 1.51 million metric tons by 2025, with over 90% attributable to anadromous species⁶⁷ and marine aquaculture production.⁶⁸ 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.⁶⁹

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

Council Actions. The Gulf of Mexico Fishery Management Council (GMFMC) has developed a draft fishery management plan generic amendment for regulating offshore marine aquaculture in the Gulf of Mexico EEZ. Currently, the National Marine Fisheries Service requires an exempted fisheries permit to conduct aquaculture in federal waters. Exempted fisheries permits are of limited duration, and are not intended to apply to commercial aquaculture in federal waters.⁷⁰ The amendment includes eight action items with alternatives related to each. The action items include:

- establishing a permit to conduct aquaculture in the Gulf of Mexico EEZ;
- proposing permit durations;

⁶⁷ Anadromous species such as salmon, shad, and sturgeon reproduce in rivers (inland waters) and spend their adult life in the sea.

⁶⁸ 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.

⁶⁹ For a copy of the plan see [<http://aquaculture.noaa.gov/>].

⁷⁰ Gulf of Mexico Fishery Management Council, *Public Hearing Draft to the Generic Amendment to: Coral and Coral Reef FMP, Coastal Migratory Pelagics FMP, Red Drum FMP, Reef Fish FMP, Shrimp FMP, Spiny Lobster FMP, and Stone Crab FMP to Provide for Regulation of Offshore Marine Aquaculture* (Tampa, FL: October 2007).

- instituting conditions that aquaculture operations would have to meet for an operational permit;
- considering species that would be allowed for aquaculture;
- specifying the types of systems that would be allowed for culture;
- designating sites or areas for aquaculture;
- establishing buffer zones around aquaculture facilities; and
- proposing recordkeeping and reporting requirements.⁷¹

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.⁷² The GMFMC initiated this proposal because several firms have proposed development of aquaculture in the region.

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.

The GMFMC has held a series of public hearings to solicit comment on the draft amendment. The majority of comments have cited environmental concerns such as the escape of farmed fish, water pollution from concentrated fish-feeding operations, and the spread of disease.⁷³ Some who support offshore aquaculture claim that, “as long as you site the farms properly and manage them properly, there is no detrimental environmental impact.”⁷⁴ Others support 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.

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 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. Other interests are considering alternative uses as energy generation platforms and aquaculture support facilities. Some 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

⁷¹ Ibid.

⁷² Ibid.

⁷³ 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>].

⁷⁴ Ibid.

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).⁷⁵ This decision sets up a program for issuing leases, easements, and rights-of-way for alternative uses of offshore oil and gas production platforms.⁷⁶ It also provides MMS with the option of authorizing individual projects on a case-by-case basis until the final rule is promulgated. Offshore aquaculture is identified as one of the activities that could be authorized to use existing OCS facilities. MMS is also developing a proposed rule for regulating AEAU activities on the OCS.

Funding. Sporadic federal funding has been provided for open ocean aquaculture. Under NOAA's Ocean and Atmospheric Research budget, \$1.7 million was appropriated in FY1998, followed by \$2.4 million annually in FY1999-FY2001 for the open ocean aquaculture demonstration project at the University of New Hampshire. Some critics of federal funding argue that aquaculture development funds should be awarded competitively and that directly allocating funds to specific projects should be avoided.

As part of a National Marine Aquaculture Initiative (NMAI), the National Sea Grant College Program has initiated research throughout the United States on open ocean aquaculture.⁷⁷ For several years, NMAI also funded the Gulf of Mexico Offshore Aquaculture Consortium, whose research program was sited in federal waters beyond state jurisdiction. In addition, NMAI, through competitive grants, supported policy and regulatory analysis, as well as pilot studies in Puerto Rico and Hawaii, research into fishmeal alternatives, and investigations of potential new species for culture.⁷⁸ Specific NMAI funding included \$800,000 annually in FY1999 and FY2000; \$5.6 million in FY2001; \$2.6 million in FY2002; \$700,000 in FY2004; and \$4.6 million in FY2006. Most of the NMAI-funded research has been conducted to support and help promote the aquaculture industry and often has been done in collaboration with the industry.

Proponents of development also contend that there has been inadequate federal research funding of the amount and duration needed to develop and demonstrate suitable technologies for meeting open ocean aquaculture's technical challenges. Private industry has often been at the forefront in addressing and solving pragmatic

⁷⁵ 73 *Federal Register* 1894-1895 (January 10, 2008).

⁷⁶ For the Final Programmatic Environmental Impact Statement and other background information, see [<http://www.ocsenergy.anl.gov/>].

⁷⁷ Charles E. Helsley, "Open Ocean Aquaculture — a Venue for Cooperative Research Between the United States and Japan," *Ecology of Aquaculture Species and Enhancement of Stocks*, Y. Nakamura et al. (eds.), Proceedings of the Thirtieth U.S. — Japan Meeting on Aquaculture, UJNR Technical Report No. 30 (Mote Marine Laboratory: Sarasota, FL, 2003), pp. 1-6.

⁷⁸ For a list of funded projects, see [<http://www.lib.noaa.gov/docaquadocresearch.html>].

technical issues in a new field. Yet there generally has been minimal public or private research, especially on environmental and socioeconomic impacts.

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.⁷⁹ 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 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 needs for profitability and flexibility of the aquaculture industry with public concerns related to environmental and social impacts.

⁷⁹ Alaska allows salmon aquaculture in cooperative hatcheries that raise and release salmon smolts (young salmon) to the wild to supplement harvest.