Offshore Aquaculture Production

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Introduction

Interest in culturing fish in offshore cages began in Japan roughly 4 decades ago. From its inception, offshore cage culture has focused on high-value marine species that are in demand in the marketplace but are unsuited for aquaculture production in land-based ponds or tank systems. One fundamental goal of offshore aquaculture is to utilize the optimum environmental conditions found far from shore (sufficient water movement to continuously refresh oxygen levels within cages and disperse wastes) while minimizing conflicts with other user groups and avoiding many adverse conditions (pollution, marginal water quality, disease vectors, vandalism, etc.) associated with near-shore environments. A major problem faced by offshore producers, however, involves logistics – vessels are required for the transport of inputs (primarily feed and fingerlings) to offshore cages and bring harvested fish back to shore. In many regions, offshore farms also face seasonal risks from potentially catastrophic storms and hurricanes.

The practice of culturing aquatic species in offshore cages has been severely criticized in some circles, based on the potential for negative environmental impacts, but these impacts have not been sufficiently detrimental to prevent the industry from expanding in many areas of the globe. Offshore cage culture is an on-going commercial enterprise in Australia, Canada, Chile, China, Croatia, Greece, Ireland, Italy, Japan, Malta, New Zealand, Norway, Russia, the Shetland Islands, Spain, Turkey and elsewhere. Although the initial concept for offshore production focused on high-value marine species, salmon cage farming (found in cold climates in various parts of the world) and seabass/seabream production (concentrated in the Mediterranean Sea) have evolved to a point where these farmed species can be considered commodity products. Successful offshore aquaculture production involves expertise in many disciplines, including engineering, biology, logistics and marketing.

Technical Considerations

Cages – Two general classes of cage structures are used in offshore aquaculture: floating or submersible. Floating cages have been most commonly used up to this stage of industry development. Floating cage structures may be square, octagonal or circular, and constructed from a variety of materials. Smaller cages are usually square or polygonal in form. These cages are usually deployed in groups or clusters, sharing common walkways, work areas, and protective perimeter nets. Construction materials generally include metal couplings, plastic or rubber pipes, polyethylene floats, sheet metal, metal tubing, or some combination of these components.

Larger, circular structures are also widely used for floating cages. The Bridgestone Company was the first to commercialize designs for circular floating offshore cages in Japan in the early 1970's, converting large flexible hoses into floating rings from which cages could be hung and onto which walkways, hand rails and work areas could be attached. Modern circular cage designs incorporate two, three or even more concentric circular floats constructed from heavy walled HDPE pipe, with regularly-spaced stanchions to facilitate the attachment of walkways and hand-rails and reinforce the overall cage structure. Circular cages are available in a number of diameters and can be adapted to a variety of force tolerances depending on the sea and weather conditions where they will be deployed.

Be they square or round, deployed individually or in groups, floating cages are generally outfitted with an internally-hung net pen for fish culture, and a separate, externally hung heavy-duty net designed to exclude predators. Nets can extend to depths of 20 meters, depending on site-specific conditions. Nets can usually be treated with anti-fouling compounds, but they must be cleaned or replaced from time to time as a result of continuous colonization by marine animals such as mussels, barnacles and other creatures. Light-weight bird netting is also often suspended over the top of floating cages. Harvesting generally involves crowding harvest-sized fish into one portion of the net volume and loading unto a workboat tied on to the cage structure.

Submersible cages are also used under certain conditions, with the main rationale being the avoidance of storm effects at the water's surface, as well as minimizing conflicts with navigation. These cages have been designed in various shapes, but they all require some type of system for raising or lowering the entire structure within the water column. This may involve the use of ballast/flotation chambers incorporated into the cage structure, or a combination of cables and pulleys attached to anchors and floats. Submersible cages also use the same structure to support both the containment net (on the internal surface) and the predator netting (on the exterior). Harvesting takes place at the water's surface, and some submersible cages can be partially collapsed to allow for crowding of harvestable fish to facilitate their removal.

Mooring Systems – A complex system of anchors, chains, cables and buoys is usually required to hold offshore cages in place. Depending on the location and the typical weather and sea conditions, these systems may take the form of single attachments or complex webs. The most typical configuration involves a grid of regularly spaced anchors connected to each other and to the cage(s) through cables and chains with floating buoys attached in one or more locations along the length of the cables to maintain tension while allowing for flexibility in response to wind and wave action.

Feeding – Efficient feeding practices, including portion control and monitoring for the presence of uneaten feed, allow offshore producers to maximize harvests while minimizing feed costs. This strategy also reduces negative environmental impacts from uneaten feed and fish wastes. Feed is usually distributed to a number of cages from a central point using conveyor systems that deliver pre-programmed quantities to each cage through a system of tubes. Feed cannot be stored indefinitely, and it must be used before it begins to lose nutritional quality, so a balance must be struck between the amount of bulk storage area required at the offshore site and the need to minimize the frequency of deliveries by boat.

Logistics - Feed is not the only transport requirement for offshore aquaculture facilities. In fact, transport boats are an integral part of day-to-day operations, hauling fingerlings for stocking, supplies, fuel, equipment, personnel and their provisions, and harvested fish. For this reason, boats must be properly sized to meet the demands of the operation, but no larger than necessary to efficiently move materials and personnel. Although moving farther offshore can offer advantages in terms of optimizing production conditions and minimizing user conflicts and negative environmental impacts, these gains are somewhat offset by fuel costs and vessel depreciation charges.

Offshore Support Facilities – Sufficient housing must be available to allow for cages to be manned 24 hr. per day for both regular operations and maintenance as needed. Key equipment components, such as cages, moorings and feeding systems must be inspected at least once daily and environmental parameters and fish health must be monitored, recorded and reported via electronic communications. The size of the crew quarters will be dictated by the scale of the operation, as well as any local or federal regulations that might apply to similar work environments, such as offshore oil and gas facilities.

Equipment at the site usually will include a crane, a generator, diesel storage, bulk feed storage and distribution, a full complement of tools, fire extinguishers, fish culture equipment such as nets and baskets, and other miscellaneous gear. Several authors have proposed development of offshore aquaculture facilities in conjunction with inactive oil and gas platforms, or possibly with offshore wind farms, in order to take advantage of existing available space and facilities for storage and crew quarters.

Onshore Support Facilities – At the very least, most offshore operations will require an office/administrative facility on shore near the dock being used by the transport boat(s) to facilitate logistics and sales. This site can also serve for warehousing of regularly-used supplies, fuel, and back-up equipment. Depending on the degree of vertical integration, most operations will require facilities for holding and acclimating fingerlings prior to transport to cages offshore. Larger operations should consider the benefits and costs of developing their own hatchery facilities depending on location and the species to be cultured.

Business Considerations

Offshore aquaculture requires very high initial investments. But the very nature of offshore aquaculture production suggests the potential for economies of scale as well. Securing high quality inputs, such as feed and fingerlings, is crucial to the success of any aquaculture enterprise, but the need to program growth cycles, harvests and net maintenance make the timing of fingerling and feed purchases a critical aspect of management in offshore aquaculture. As a result, vertically-integrated companies dedicated to offshore aquaculture have emerged in various regions including Norway, the Mediterranean, Chile and Australia and New Zealand. These corporations control crucial inputs to allow for smoother operations on the cages themselves, and to respond more quickly to market demands.

Marketing is another important consideration in aquaculture, and offshore aquaculture is no exception. Although profitable offshore aquaculture enterprises will probably require some fairly large threshold in terms of volume, this also opens the door for branding, entry into regional niche markets, and differentiation from commodity competition. It may make sense to explore the possibility of in-house processing, but many coastal regions of the U.S. and other countries have an over-capacity of processing infrastructure, so contract processing might make more sense in many situations.

Management in every sense – procurement, inventory, human resources, fish husbandry, financial, marketing, logistics, and scheduling, are all critical to the success of an offshore aquaculture operation. This requires a well-considered management structure, as well as a disciplined corporate culture with regard to information sharing and collaboration. Monitoring, evaluation and reporting are also important aspects of offshore aquaculture management, and requirements for these activities are often incorporated into permits and financing agreements.

Should a U.S. offshore aquaculture industry eventually develop, competition from other regions with similar potential for industry development will be a reality. Many of these competing countries will benefit from lower labor costs and friendlier regulatory environments. While the list of candidate finfish species for offshore aquaculture operations in the U.S. seems quite large, many of these species are readily available already from sources in other countries. For example Red Drum, widely cited as a promising candidate species for initial development of offshore aquaculture in the northern Gulf of Mexico, has been cultured for approximately two decades in southern China, Taiwan and northern Vietnam. It has been exported to the U.S. for many years in the form of IQF fillets.

Socio-political Considerations

The development of an offshore aquaculture industry in the continental United States and Alaska has been hindered, if not altogether prevented, by a maze of local, state and federal regulatory considerations. Although a number of observers have observed that U.S. law need not pose a permanent roadblock to offshore aquaculture development, most policy makers lack the political incentive to promote this industry. Additionally, the general public's perception of offshore aquaculture has been influenced by widespread criticism of the potential negative environmental impacts this type of production might cause. These include potential degradation of water quality in the vicinity of a cage farm, potential spread of disease to wild fish, potential for negative genetic impacts should fish escape from cages, degradation of the sea floor environment from accumulation of wastes and physical interference with the normal behavior of other sea life such as dolphins or turtles. While these concerns are certainly valid, industry observers generally regard them as often exaggerated or presented from a biased perspective.

Real-world examples can be cited to partially or fully dispute many of these negative perceptions. Offshore aquaculture has been practiced for many years with minimal, localized environmental impacts in many parts of the world. During a 16-month study evaluating open-ocean submersed cage culture of mutton snapper and cobia, Alston et al. (2005) documented 1) no evidence of anaerobic sediments beneath cages, 2) inorganic nitrogen measurements near cages that were similar to background levels, and 3) altered macroinvertebrate populations and sediments only directly beneath cages and immediately prior to harvests when feeding rates were at their highest. In shallower, near-shore environments however, much more care must be taken to identify suitable sites in order to avoid localized impacts on benthic communities (Lee et al. 2006, Lin and Bailey-Brock 2008).

Any form of food production will inevitably result in changes to the immediate environment – soil invertebrates and micro-organisms found in a field of corn will certainly deviate from those found in adjacent, fallow land. However, in the U.S. offshore aquaculture has been forced by many of its opponents to meet higher environmental standards than traditional agriculture. For this reason, industry observers suggest most growth in offshore aquaculture over the coming decades will occur in other parts of the world. Nonetheless, methods to minimize or eliminate negative environmental impacts are being continuously developed and evaluated. These include the use of polyculture strategies incorporating seaweed and mollusk culture to utilize nutrients released from cages (Aguilar-Manjarrez et al. 2010), as well as the deployment of artificial habitats below cages to serve as substrate for invertebrate "fouling" organisms that assimilate wastes from cages and serve as fish aggregating structures (Aguado-Gimenez et al. 2011).

The Mediterranean region has been the home of successful offshore cage industries for the production of seabream and seabass for several decades, with little documented environmental impact, even by European Union standards. For example, during the years 2003-2010, regional annual production of these two species ranged between 360 million pounds and 598 million pounds, with no reports of significant or widespread environmental degradation resulting from cage farming operations (FAO 2011). These offshore aquaculture harvests were worth between roughly $1 billion and $1.7 billion annually. From 1997 to 2002, although offshore cage production of seabass and seabream in the Mediterranean region doubled, wild fishery harvests of these species did not decline. On the contrary, they exhibited steady growth during this period (FAO 2007).

Nonetheless, for the time being those opposed to the development of offshore aquaculture in the U.S. have effectively shut down any debate on whether to promote a regulatory framework and best management practices that would allow its establishment. In the future, as more data is generated to accurately characterize the actual degree of environmental impacts that could be expected from domestic offshore aquaculture, coupled with the recognition of the economic activity the industry can support in coastal communities, there may be a renewed interest in offshore aquaculture in many regions of the U.S.

Sources and Suggested Web Sites

F. Aguado-Gimenez, M.A. Piedecausa, C. Carrasco, J.M. Gutierrez, V. Aliaga and B. Garcia-Garcia. 2011. Do benthic biofilters contribute to sustainability and restoration of the benthic environment impacted by offshore cage finfish aquaculture? Marine Pollution Bulletin, 62:1714-1724.

J. Aguillar-Manjarrez, J.M. Kapetsky and D. Soto. 2010. The potential of spatial planning tools to support the ecosystem approach to aquaculture. FAO/Rome, Expert Workshop, 19-21 November 2008. FAO Fisheries and Aquaculture Proceedings No. 17. 178 pages.

Dallas E. Alston, Alexis Cabarcas, Jorge Capella, Daniel D. Benetti, Sarah Keene-Meltzoff, Janet Bonilla, and Ricardo Cortés. 2005. Environmental and Social Impact of Sustainable Offshore Cage Culture Production in Puerto Rican Waters. NOAA Federal Contract Number: NA16RG1611, Final Report. 208 pages.

FAO 2007. Marketing of aquacultured seabass and seabream from the Mediterranean Basin. Studies and Reviews, No. 82. General Fisheries Commission for the Mediterranean. FAO, Rome.

FAO 2011. Seabass and seabream market report.

Han W. Lee, Julie H. Bailey-Brock, and Michelle M. McGurr. 2006. Temporal changes in the polychaete infaunal community surrounding a Hawaiian mariculture operation. Marine Ecology Progress Series, 307:175-185.

David T. Lin and Julie H. Bailey-Brock. 2008. Partial recovery of infaunal communities during a fallow period at an open-ocean aquaculture operation. Marine Ecology Progress Series, 371:65-72.

NOAA 2008. Offshore Aquaculture in the United States: Economic Considerations, Implications & Opportunities. U.S. Department of Commerce; Silver Spring, MD; USA. NOAA Technical Memorandum NMFS F/SPO-103. 263 pages.

Offshore Mariculture in the Gulf of Mexico: a Feasibility Report by Waldemar Nelson International Inc. for Louisiana Sea Grant.