An Access System for Ocean Aquaculture: Influences of Current United States and International Law¹

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World seafood consumption is rising while the wild fish harvest remains stable.² Ocean aquaculture (mariculture) operations as alternatives to traditional harvests in the exclusive economic zones (EEZs) are being proposed in U.S. offshore areas and are well established in other countries, particularly in Europe and Southeast Asia. Mariculture operations, unlike marine fisheries, are designed to constrain the animals being raised using fixed nets or pens. The site-specific nature of these operations requires some form of property right to designated areas of ocean space similar to those rights granted to offshore oil, gas, and mineral resources developers. Without a guarantee of tenure, other ocean users (for example, navigation, commercial fish harvest, recreational boating and fishing, national defense, and mineral exploration and development) will invariably impinge upon mariculture. Further, the availability of investment capital for mariculture operations is likely to be limited in the absence of some form of lease guarantee.³

¹ Portions of this paper were abstracted from a proposal, Designing An Access System for Ocean Mariculture, by Porter Hoagland and Di Jin, researchers at the Marine Policy Center. 1996.


In its EEZ, and in some cases out to the extent of the continental shelf, the United States has sovereign rights for the purposes of exploring, exploiting, conserving, and managing both living and non-living natural resources of the seabed, subsoil, and ocean waters.\(^4\) Jurisdiction with regard to the establishment and use of installations and structures in navigable waters has been historically vested in the U.S. Army Corps of Engineers.\(^5\) The United States has exercised these rights through policies designed to manage wild fish stocks,\(^6\) oil, gas and mineral exploration,\(^7\) and other uses of the seabed and navigable waters.\(^8\) However, there are no specific policies in the United States that govern the use of the EEZ for mariculture.\(^9\) In particular, there are no policies providing security of tenure for mariculture operations.

In 1992, a Marine Board Committee of the National Research Council examined opportunities for growth in mariculture in United States federal waters.\(^10\) The Committee concluded that:

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\ldots\text{ no formal framework exists to govern the leasing and development of private commercial aquaculture activities in public waters.} \ldots
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Currently, offshore mariculture permits are proceeding on an ad hoc basis.


\(^5\) Rivers and Harbors Act, 33 USC 403, 504 et seq. (1899).

\(^6\) Magnuson Fisheries Conservation and Management Act, 16 USC 1801 et seq. (1994). (Department of Commerce, National Marine Fisheries Service, Regional Fishery Management Councils, managers)

\(^7\) Outer Continental Shelf and Submerged Lands Act, 43 USC 1301 et seq. (1953) (Department of Interior, Mineral Management Service, manager)

\(^8\) Ibid., Rivers and Harbors Act.

\(^9\) The Marine Aquaculture Act of 1995, S1192, was introduced in committee (Commerce, Science, and Transportation) to address the site permit and other off-shore issues. The bill did not leave committee.

As the aquaculture industry moves offshore to avoid inshore water use conflicts and other coastal concerns, certain aspects of international law may come into play. The Law of the Sea and the ocean dumping conventions and laws provide a legal framework for offshore operations. The Law of the Sea Convention identifies those species that are completely under the jurisdiction of the bordering nation-state. Often, some species like salmon (anadromous), eels (catadromous), and shellfish and crustaceans (sedentary) are of interest to aquaculturists. The dumping conventions and the U.S. Ocean Dumping Act address:

... the deposit of oyster shells or other materials when such a deposit is made for the purpose of developing, maintaining, or harvesting fisheries resources ...

This phrase, in any event, probably does not cover fish food waste or disease preventive drugs, necessary parts of a finfish mariculture operation. The United Nations Food and Agriculture Organization (FAO) recently issued a new code of conduct for responsible fisheries' management, that includes a

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12 Law of the Sea Convention (LOS), adopted by the UN, into force on July 28, 1994. President Clinton signed the convention on July 29, 1994, subject to ratification. The U.S. Senate is expected to take action on ratification in 1997.


14 LOS, Part V, article 66.

15 LOS, Part V, article 67.

16 LOS, Part V, article 68.

17 Ibid., the Ocean Dumping Act.

18 United Nations, Food and Agriculture Organization. 1996. Code of Conduct for Responsible Fisheries, adopted by the twenty-eighth session of the FAO Conference, October. See also. Edeson, W.R., Senior Legal Officer, FAO,
section (9) on environmentally acceptable aquaculture, in an attempt to set international voluntary standards for sustainable fisheries including aquaculture. In addition, aquaculture trade issues already involve the World Trade Organization. Other international bodies may become involved as the growth of the coastal and offshore aquaculture industry accelerates.

A first step toward a U.S. mariculture policy should be a review of existing access systems for scarce natural resources. There are lessons to be drawn from the design of access systems for public resources including offshore oil and gas; offshore hard minerals; natural resources in general; and cultural resources. A systematic approach to the design of an access system for U.S. mariculture should include a legal description of the ocean space and establishment of priorities and policies that include, among others, property rights; revenue generation; performance requirements (including time limits and fees); information management; environmental protection; and fairness or equity considerations.

There is the need for an innovative approach to derive the best value from a marine resource harvest, (salmon and scallops are good candidates for a study), while creating sustainable development opportunities. An economic and policy analysis should include the place of mariculture in the wild fisheries

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management program. A government advocate, a single coordinating agency with enabling legislation, could avoid the protracted and often very expensive permit process. The various government agencies, responsible for federal maritime activities, have different, and often conflicting, agendas. An assessment of alternative management systems and resolution of user conflicts should be included. Like the mineral access systems, there is a need to develop cost-effective approaches for advancing environmentally sound private aquaculture that include regulatory requirements. The time has come to establish a priority for mariculture among the other open ocean uses.

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The Importance of Secure Marine Tenure

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Open ocean aquaculture offers many engineering and biological challenges, but the linchpin for the industry is surely the issue of marine tenure. The legal and social institutions that define marine tenure are what will set the rules of the game, and these rules will determine just how every other challenge will be addressed (publicly, privately or not at all).

Aquaculture output has boomed in recent years while wild fisheries have stagnated exactly because they play by different sets of rules. But without secure marine tenure, the difference between aquaculture and traditional marine fisheries begins to fade.

When Garret Hardin first coined the phrase “The Tragedy of the Commons” he used the oceans as an example of an unowned resource destined for overexploitation. Thirty years later, little has changed, and many of the ocean’s fish stocks are faring poorly. But aquaculture is different. Output is rising because entrepreneurs are trying to produce as many fish as possible instead of simply trying to catch as many as possible. The reason — private ownership and secure tenure.

Wild fisheries and aquaculture are two perfect examples of the importance of institutions. They operate under two very different sets of rules and produce two wildly different results.

The institutions that govern most fisheries tend to be either open-access or government control. That is beginning to change in some cases with the introduction of transferable quotas for fisheries, most notably in New Zealand, but the norm is still the rule of capture. Until a fish is hauled up on deck, it is fair game for everyone. Understandably, this does not encourage people to husband resources. If every fish that one person lets go is simply grabbed by someone else, then everyone will try to catch as many fish as they can, as quickly as they can. This is the tragedy of the commons.
Fortunately, there is no tragedy of the commons in an aquaculture facility. Fish can be left to safely mature because they will still be there tomorrow if they aren’t harvested today. The difference is private ownership. It is the single most important predictor of resource productivity and conservation.

Technology has played a large part in the increases in aquaculture output, but only because private ownership encouraged this kind of innovation. Traditional fishers are rewarded for innovation as well, but only by allowing them to circumvent the latest regulation or to harvest fish faster than their competitors. Instead of increasing fish populations, traditional fishers only try to increase their own harvests, often destroying fish stocks and landing lower quality, smaller fish. It sounds crazy, but it is the natural result of poor institutional arrangements.

Technological innovation will be a crucial factor in the development of an offshore aquaculture industry, but secure tenure is paramount, for it is what will drive much of this technological advancement. The frontier American West offers an interesting parallel. Much like the oceans today, when the first settlers arrived and began to use the land, the West’s natural resources seemed inexhaustible. But sure enough, before long, they began running out of space. One of the biggest problems they faced was how to keep track of their cattle. They all looked pretty much the same and it was impossible to fence in one’s land — the raw materials to do so were simply not there.

But because they owned the cattle, and the land, frontier entrepreneurs were encouraged to come up with innovative, effective solutions to this problem. Their first innovation was to devise complex branding systems and to organize cattlemen’s associations to keep track of branding registries that identified cattle. The second, and most significant development, was the invention of barbed wire. Suddenly, land could be fenced inexpensively, and the character of the frontier landscape changed dramatically.
A little ownership begets more. Initially in the West, boundaries could not be enforced, but because there was clear title to the land (no question of tenure), owners invested in and devised ways to effectively define and enforce those boundaries.

The open ocean is a harsh, rugged environment, much like the frontier American West was not so long ago. In many cases the technology may not quite be there yet for offshore aquaculture, but with the proper ownership arrangements in place, it will come quickly, and offshore aquaculture will surely have its own version of barbed wire before long.

The ownership of marine resources is rare, but not without historical precedent. Throughout Oceania coral reefs have been protected and productive for centuries due to a clear notion of marine tenure. Robert Johannes, an Australian who has studied coral reef conservation around the Pacific, found that many cultures clearly understood the link between exclusive control and stewardship. The complex arrangements that evolved to control the harvest of marine species around these coral reef communities may be the oldest example of a private (albeit community controlled) aquaculture operation. After all, a coral reef is essentially a natural fish farm.

In the United States, the Washington state oyster industry has also benefited from secure tenure. Washington is the only state with fee-simple ownership of subtidal lands, and the oyster industry there has been incredibly innovative. They have withstood the decline of the native Olympia oyster, introduced new varieties and weathered some very serious pollution problems in the 1940s and 50s, to become leading oyster producers in the United States.

The Maryland oyster industry, on the other hand, has proceeded down a very different path. Since the 1800s watermen in Maryland have relied on the state to manage their harvests, with the predictable result that harvests have been falling for almost a century. Even before the onset of disease in the 1970s, the Maryland oyster industry was crumbling. Watermen were more interested in government sponsored
bailouts and subsidies for oyster bed maintenance than in taking steps to improve their harvest. In the 1970s, before the diseases, two economists from the University of Delaware compared the Maryland and Virginia oyster industries (Virginia is another Chesapeake Bay state) and found that in Virginia, where leased oyster beds were common, the oysters produced tended to be larger, healthier, and of better quality than their Maryland counterparts.

The Maryland government responded to this crisis by continuing to limit the harvest. As a result, while the Washington state oyster growers have improved their beds and increased their harvests with high-tech hatcheries, Maryland is left with the only commercial fishing fleet left in the country still powered by sail. People have been clamoring for Maryland to lease more of its oyster beds since before the turn of the century, but to little avail.

The Maryland oyster industry demonstrates that no matter how flawed a system is, changing it is difficult. There will always be people doing well under any given system or, at least, a large number of people who do not believe that they will be better off under a new system, which creates vehement opposition to change. This underscores how crucial it is for the offshore aquaculture industry to demand secure tenure arrangements from the get go. Barring outright ownership agreements, offshore entrepreneurs should fight for leases that last as long as possible, and for a minimum of political or regulatory intervention.

Political assistance is often very attractive, especially for a burgeoning industry, but in the long run it rarely pays off. Maintaining subsidies and beneficial regulations requires constant attention and creates an outlook for the future fraught with uncertainty and the potential for a reversal of fortune.

Such was the case for Pacific Ocean Farms Ltd., an open ocean abalone farming company that used to operate in California. Ocean Farms leased about 50 acres $2^{1/2}$ miles offshore of Monterey, where in 100 feet of water they anchored a series of fiberglass boxes to rear abalone that they called
condominiums. The company started off well, not only producing a valuable species, but counting among its allies groups like the Friends of the Otter, who hoped that the farm would increase the numbers of their namesake’s favorite delicacy.

Then, the state of California stepped in. First, they rejected a bid to increase the number of Ocean Farm condominiums because they did not have garages. Then they required all of Ocean Farms’ divers to use the same gear required of oil rig welders. And the final straw came when, according to the owner, the state demanded that the farm reveal its trade secrets to renew its permit, then turned around and set up its own hatchery operation. No wonder the business packed up and left.

Certainly regulators are not always such a problem, but even when they do try to craft institutional arrangements that encourage innovation and stewardship, things often go awry. Transferable quotas for fisheries have been one such attempt to change the system to get the incentives right. These quotas, or ITQs, assign the right to harvest a certain percentage of a total catch, encouraging fishers to behave more responsibly. Unfortunately, trying to institute this kind of system has proved very tricky. In the United States a broad coalition of fishers, managers and environmentalists believe that ITQs would be good for the fisheries, but there has been so much haggling over the initial allocation process that very little progress has been made.

Even in New Zealand, where the quota system has been in place for over ten years, many problems persist. One study of the paua (abalone) industry determined that “the spectre of too many fishermen chasing too few fish has been removed by the ITQ system, only to be replaced by special interest groups fishing politically on land for a share of the resource. The spectre now is of government carving and recarving a pie whose worth is diminishing steadily in proportion to the time and effort spent squabbling over who is to get what.”
Economists call this behavior rent seeking, and it occurs everywhere that valuable resources are allocated politically. Aquaculture facilities may not be subject to the same kinds of harvest allotments that traditional fisheries are, but any sort of favorable regulatory environment or generous subsidy program could be a ripe target for political redistribution.

Considering the interest that environmentalists have recently taken in the aquaculture industry, the vagaries of political control should be obvious. Much of the environmentalists' attention has focused on near shore aquaculture, particularly in developing countries, over the issue of pollution and habitat destruction. Fortunately, secure ownership arrangements can address these problems as well.

Of course, aquaculture operations not only create some pollution, but are subjected to it as well. In Washington state, the oyster growers have long had title to their tidelands, which turned them into the staunchest defenders of water quality in that state long before anyone had even heard of the word environmentalist. Their industry, like every marine farming industry, depends on clean water to produce a quality, edible product. So in one sense, the creation of any aquaculture operation also creates a pollution watchdog.

On the other hand, aquaculture does produce some byproducts of its own. Moving operations offshore addresses many of these problems, but many in the environmental community will not be satisfied until there is zero discharge from a facility, so the problem will continue to haunt the aquaculture industry wherever it goes.

At the heart of the matter is liability, or a lack of it. An example is the artificial reef program in the state of Alabama, where private individuals can create artificial reefs in certain designated areas. Reefs may be privately created, but as soon as they hit the water, the reefs become public property and the state assumes all liability. Not surprisingly, reef creators have devised very effective artificial reefs for attracting and producing fish, but have taken little interest in the long term effects of these reefs. Many of them disintegrate quickly or get
blown away in storms, much to the dismay of the local shrimpers when they rip their nets on stray shopping carts and automobile hoods.

In Japan, on the other hand, fishing cooperatives often have clearly established subtidal rights. They are very active artificial reef builders, and over the years have developed an amazing array of specialized reef designs, all of which are very durable and closely monitored. Some reefs close to shore even have guards watching over them 24 hours a day, and the cooperatives are vigilant of any pollution problems.

Unfortunately, Japan is the exception and most aquaculture facilities are subjected to the same kinds of rules as the reef creators in Alabama are. Any pollution created generally enters an unowned commons, and so there is no one like the oyster growers in Washington to take any directed action. When no one owns a resource, for example clean water in a river, a bay or part of the ocean, individuals do not bear the costs of depleting that resource.

When shrimp farmers in developing countries destroy mangrove forests, even when it is clearly in their best interests to have them around to provide broodstock and clean water, the tragedy of the commons must be at work. When no one can be held liable for destroying the mangroves, they will quickly disappear. Statutes and regulations are one way to impose liability and impose costs on producers, but another, more effective way is to increase ownership rights and rely on the common law to resolve conflicts.

The common law states that any damage to another’s property must be fully compensated and that the offending activity must cease immediately. Common law suits are between two private parties. If, for example, it could be proved that someone was breaking someone else’s windows, under the common law they would have to cease and desist the offending activity (breaking windows) and replace the broken ones, not because there was a specific law against breaking windows, but simply because property was damaged. In England and Wales the right to fish for salmon in many rivers and streams has been
well defined for centuries, and the owners of these rights have used the common law to prevent pollution. In many cases the worst polluters were municipalities — the very people charged with keeping the water clean.

Oyster growers in Washington are beginning to learn the limitations of statutory pollution control right now. When they first began to fight pollution they relied on the state to set and enforce strict guidelines. This worked well for point-source pollution, such as the outfall from a lumber mill, but now that most pollution problems stem from non-point sources of pollution such as agricultural runoff or leaky septic tanks, they have little recourse. It is too difficult to apply any regulations on this type of activity across the board, so that even though in most cases the oyster growers know exactly where the offending pollution is coming from, there is nothing they can do about it, as statute law supersedes the common law in the U.S.

The common law relies heavily on precedent and can help to resolve causes and effects. Such was the case in Ireland when riparian river owners sued nearby offshore aquaculture operations, claiming that they were responsible for decreasing their trout runs. This turned out not to be the case, and so the suit was eventually dropped. Now a precedent has clearly been established and any similar suits in the future are unlikely.

One advantage of the common law is it allows precedents and rules to evolve over time. It also does not stipulate that there must be zero pollution, only that it may not damage someone else's property. This may sound vague but in the United States at least, strict pollution control regulations often turn out simply to be a license to pollute. And even if pollution does cause harm, it does not necessarily have to stop as long as the two parties involved can come to an agreement.

To conclude, offshore aquaculture entrepreneurs should push for as much private ownership and responsibility as possible. The fewer restrictions the better — subsidies should be spurned today for they can easily become restrictions tomorrow, and pollution control should be left to the market
and the common law doctrine of nuisance. When no one owns any part of the seas, Greenpeace can claim to be the guardian of the seas and target aquaculture with fears about pollution and escapes. No one knows where political power will reside in the future, and no doubt the aquaculture industry would not fare very well if that power rested with Greenpeace.

Clear ownership rights preclude political redistribution. Commercial and recreation fishers are always fighting over fish stocks, and today the anglers are winning. There are simply too many of them, and when resources are allocated from the ballot box, sheer numbers are the best indicator of success. If all the SCUBA divers in Hawaii decided they didn’t like offshore aquaculture, the prospects would be dim indeed.

Both government managers and aquaculture entrepreneurs need to realize the importance of ownership and the danger that a reliance on political control presents. If offshore aquaculture is to be a success, ocean farmers must be able to rely on secure marine tenure.
Current and Potential Regulation of Open Ocean Aquaculture

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Regulation of open ocean aquaculture in the United States is one of the largest hurdles facing open ocean aquaculture in the U.S. and, I suspect, elsewhere. Advances in both engineering and culture practices now make open ocean aquaculture feasible. Fixed gear, or moored farms, are now operational in several locations around the world. In a new development since last year's conference, unmoored or drifting farms are in the design stage. It is anticipated that such farms would be employed in oceanic gyres. They may be manned or fully automated. They may have some form of propulsion or be completely free floating and redirected by boat as necessary.

The following are advantages of open ocean aquaculture:

- economies of scale can be achieved with open ocean aquaculture, an important factor for those species sold in competitive global markets;
- there is no organic enrichment due to the volume of water available for dilution; and
- there is less predation if facilities are sufficiently removed from shore.

This should make it easier to permit open ocean aquaculture but this is not likely to be the case. Permitting has been and will be difficult because state and federal agencies have not developed regulations that specifically address open ocean aquaculture. Ironically, this lack of regulation is an even greater obstacle to the establishment of offshore farms than the regulatory burden felt by inshore farmers. Without guidance on how to proceed, regulatory agencies are and will be reluctant to act on requests for open ocean farms.

It is in the interest of open ocean aquaculturists to anticipate the issues regulators will face. Proposals for offshore
farms must provide credible, scientific support for their claims that the activity will not have adverse impacts.

Current regulations address navigational and environmental issues, and at the state level, the transfer of property rights that allows the aquaculturist exclusive use of an area. They do not address transfer of property rights in federal waters or regulate unmoored pens in either state or federal waters. With regard to the transfer of property rights in federal waters: At last year’s conference in Portland, we heard a presentation from Cliff Goudey regarding the experimental Westport scallop project proposed for federal waters off of Massachusetts. The project was permitted fairly rapidly by the Army Corps of Engineers because of the short-term nature of the project (18 months) and because its use of native, filter feeding species eliminated most environmental concerns. The hang up for this project was transfer of property rights: they needed exclusive use of the project area. They planned to seed the bottom with juvenile scallops and didn’t want draggers going through it. In August of 1994 they applied to the New England Fisheries Management Council for closure of the area to fishing activities. They chose the Fisheries Management Council because the wild fishery for scallops is managed by the Council. In addition, the fisheries management councils are the only bodies able to deal with conflicts associated with use of federal waters. However, the Council had no experience with aquaculture and was forced to address the application for closure on an ad hoc basis. In a process that took 2-1/2 years, the closure was granted this past February and the project is finally underway.

What about unmoored pens? What should you do if you want to put fish in a pen and set it adrift? I have talked to some who feel you would be home free because there are no regulations addressing unmoored aquaculture facilities. It would be a big mistake to assume, however, that because there aren’t any regulations no one is going to care. Putting an unmoored facility in the water under this assumption would give new meaning to the phrase: “if you build it they will
come.” If regulations are not currently in place to address unmoored pens they will be almost as soon as the need arises. I believe that the Coast Guard already has the authority to regulate unmoored pens because of the hazard they pose to navigation. And the National Marine Fisheries Service has the authority to regulate activities whose impact “may” affect endangered marine species, such as whales.

State and federal regulations are in place for moored facilities but criteria for judging permit and lease applications have been based on nearshore facilities. Regulators will need to reassess these criteria in light of the different circumstances posed by open ocean versus nearshore facilities. In order to anticipate regulators’ concerns regarding open ocean aquaculture it is important to review government’s interest in aquaculture. This past year I had the opportunity to help draft a strategic plan for aquaculture for the State of Maine. The State’s interest in aquaculture was defined and is probably representative of governmental interest in aquaculture generally. It consists of two parts: stewardship of publicly owned resources including marine waters and living marine resources; and promotion of economic development.

These two responsibilities can and do conflict. As a result, regulators must carefully balance environmental protection and economic development. Where uncertainty exists about environmental impacts or impacts on politically powerful traditional uses, regulators are reluctant to permit new activities.

What about aquaculture in international waters, that is, 200 miles offshore? I think it is fair to say that of the hundreds of bilateral, regional and international agreements addressing the marine environment, none directly address open ocean aquaculture. However, I think the same principle applies here as well as in waters under national jurisdiction: lack of existing regulation does not mean that no one will care if you want to farm in international waters.

The United Nations Convention on the Law of the Sea, which entered into force in 1994, establishes a comprehensive
framework for the regulation of all ocean space and resources. Its most well known provisions address limits of national jurisdiction over ocean space, establishing the 12 mile territorial sea and the 200 mile exclusive economic zone. By laying down the basic legal regime for the conservation and utilization of marine resources, the convention provides a basis for regulating aquaculture in international waters, should the need arise. The Convention has addressed other specific high seas issues including highly migratory fish stocks and the large-scale pelagic drift net fishery. The Convention also includes a Code for the Responsible Conduct of Fisheries. So there is precedent for addressing issues such as open ocean aquaculture.

The following are regulatory issues likely to be raised by open ocean aquaculture:

**Navigation**

Navigational issues inshore relate to protecting ingress and egress from anchorages. Offshore, the issue is likely to be interference with shipping. If an unmoored facility is proposed, will it drift into sea lanes or otherwise be a hazard to navigation? In a storm will it be driven into shore, anchorages or other facilities?

**Environmental**

Nearshore farms are scrutinized for their potential contribution to organic enrichment. Offshore farms are more likely to be reviewed regarding release of disease organisms and therapeutics.

**Impacts on marine mammals and other organisms**

This has the potential to be real trouble for offshore farms. The humpback whale is an issue here in Hawaii. In the Gulf of Maine we are currently experiencing a crisis over the right whale. There are only 300 right whales remaining; apparently only a very small number of these are breeding females. A law suit by a local activist has forced the National Marine Fisheries Service to develop regulations reducing the risk of lethal take of right whales by lobster gear to less than one per year. The
proposed regulations call for drastic regearing, including use of break away buoys, replacement of floating line with sinking line and limits on the number of buoys on trawls. The cost of implementation is estimated to be up to $70 million and many feel that the industry may go under as a result. We are talking about Maine’s lobster industry, a cultural heritage and important economic activity that is synonymous with the State. Can you imagine what they would say about a new and little known idea such as open ocean aquaculture? Moored pens would have to be sited away from known or suspected whale habitat. Unmoored pens would need a system of relocation to keep them out of such areas.

Salmon provide another example of the potential impact of open ocean aquaculture on other species. Transmission of disease, disruption of spawning areas by escaped fish and the introduction of non-native genes are all concerns regarding the impact of salmon aquaculture on wild stocks. Aquaculture is prohibited altogether in Alaska over concern regarding potential impacts on a significant wild fishery. In Maine, salmon aquaculture is under siege from groups seeking to restore Atlantic salmon to former habitat. International law recognizes the right of the nation of origin to prohibit harvesting of its salmon on the high seas. Would it therefore allow such nations to regulate open ocean aquaculture to protect wild populations of salmon? It remains to be seen.

Use conflicts

Will the farm interfere with commercial or recreational fishing or other use of offshore waters? Fishermen in Maine and elsewhere are extremely leery of aquaculture because they see it as an infringement on the commons. Aquaculture statutes in Maine prohibit farms from areas where traditional fishing occurs and Maine fishermen are growing accustomed to farms in nearshore waters. The prospect of open ocean aquaculture may raise anew the specter of privatization of the ocean and get fishermen up in arms. In some areas, charter boat captains have the same concerns.
Yesterday, Jim McVey called for the development of an integrated marine policy, one that would result in the comprehensive, ecosystem-based management of coastal waters and resources. I second Jim on this; such management would go a long way towards resolving the regulatory hurdles described above. Comprehensive management of marine resources will have to be conducted at the scale of large marine ecosystems. If such an ecosystem is not wholly within a nation’s jurisdiction, the Law of the Sea Convention provides the legal framework for bilateral or regional agreements on conservation of living marine resources within the ecosystem.

Examples of ecosystem level management include the convention for the conservation of Antarctic Living Marine Resources and management of the Great Barrier Reef. Management should be based on knowledge of the structure and function of the ecosystem including its carrying capacity. Conflicting uses must be balanced based on their sustainability, exclusivity and benefits provided. Socioeconomic and cultural factors must be considered as well. Very importantly, stakeholders, including aquaculturists, fishermen and environmentalists, must participate in the development of comprehensive management plans.

The advent of geographic information systems (GIS) has made comprehensive marine management feasible. GIS is useful for analyzing complex factors synoptically, including physical, chemical, biological, economic, social and cultural data. GIS can be used in problem solving where diverse factors have to be considered, where these factors differ in importance, and where the factors are quite variable.

Nova Scotia, in the Canadian Maritimes, has initiated comprehensive coastal management using GIS. Generation of maps identifying potential and existing aquaculture sites in relation to traditional fishing grounds has allayed many fears regarding development of aquaculture. Public opposition to new farms has dropped dramatically since the effort began.

Comprehensive management can also identify suitable sites for aquaculture. In Scotland, using biological and physical
criteria, data on bathymetry, current, shelter and water quality were used to determine the suitability of a given site for finfish aquaculture.

Such analyses could also incorporate areas where aquaculture is inappropriate such as near endangered species habitat, shipping lanes, etc.

Economic data can be a factor in comprehensive management. On Prince Edward Island, the potential value of shellfish in closed areas is used to prioritize removal of pollution sources.

In conclusion, open ocean aquaculture would do well not only to anticipate the concerns of regulatory agencies but to initiate discussions with government officials and other stakeholders regarding the need for a comprehensive management plan in their area.

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Selecting Nearshore and Open Ocean Mariculture Technologies for Hawaii

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Abstract

The State of Hawaii places a premium on maintaining its ocean environments in a sustainable condition for future generations. Given this philosophical approach and a strict regulatory climate to support it, as well as incomplete knowledge of nearshore and offshore oceanography and topography by farmers, the aquaculture industry has developed exclusively on land. With the increasing cost limitations for onshore sites and declining capture fisheries feeding local markets, nearshore and offshore marine technologies and sites must be carefully chosen for the next stage of the industry’s development.

Considering the Hawaii marine environment and the host of technologies available worldwide, we describe a few deep water culture systems and species for future consideration. Our approach in our choice of systems is to anticipate potential problems and suggest credible solutions. Of great importance is whether the cage systems can withstand Hawaii ocean conditions. The existence and ease of transferring marine biotechnologies that foster species with short development times are critical for success and potential profitability.

Introduction

One aspect of the aquaculture industry, which has not been tried within the State of Hawaii, is that of ocean cage culture. Pen or cage culture is most familiar to aquaculturists when done within lake or ponds for a variety of species worldwide. The movement of this production system to
sheltered nearshore and more recently into exposed offshore areas has been limited initially to Japan and Europe (Norway, UK, Ireland). The next wave of development has occurred on the western coasts of South American (Chile) and most recently, Singapore and others in Southeast Asia (http://www.sea-world.com/hotnews/singapore/january.htm) have tried these large-scale cages in more exposed situations. The commercial species of choice has been salmon in Europe and South American or yellowfin tuna in Japan. A novel concept with much commercial success is the culture of wild capture bluefin tuna in cages located offshore (http://www.nexus.edu.au/Schools/PLHS/tuna).

To date, inquiries for offshore development projects in Hawaii have been minimal, but this trend will change within the next few years. Clearly, offshore aquaculture is growing in other countries, but has not taken off within the United States. This discussion is a broad brushstroke forecast of the challenges and evolution of a land-based Hawaii aquaculture industry moving offshore. Briefly we examine the advantages and disadvantages of open ocean aquaculture; positive solutions as related to site selection considerations; stepwise solutions for this kind of development; technology available and thoughts for a demonstration project.

**Toward Distinctive Challenges**

The Hawaii aquaculture industry will be faced with distinct problems and challenges for innovative solutions when going offshore. This step represents a movement away from an easier working environment to one where planning and logistics are very important. These technical problems will not be unique to Hawaii, and have been met by the offshore aquaculture industry in other parts of the world (see McElwee, 1997 in this volume). Rather than re-inventing the wheels, Hawaii ought to critically evaluate what is good and in actual use, prior to expending capital investments.

To be sure, the industry will be using an existing biological knowledge base developed from ongoing
laboratories and research efforts to raise high-valued products. However to take advantage of unlimited space for expansion and to surmount the previously limiting factors, we also need to incorporate new perspectives and skills. The active workforce will be more nautically inclined and knowledgeable about working at sea. There will be need for site specific oceanographic knowledge and interpretative skills, for example, in site selection or facility design and maintenance. Of great important would be a system of forecasting and alerts of incoming climatic conditions that would adversely affect an offshore farm of cages. Thus, we can move away from land-based projects to go to offshore-based aquaculture production.

Hawaii has stringent environmental regulations based upon a strict interpretation of Federal regulations. Our offshore State waters are classed as AA or A class waters owing to the oligotrophic waters in the tropics. On the continental U.S., the offshore waters are not as restrictive. More difficult hurdles to overcome are the public use customs and perspectives which become more stringent when incorporating Native Hawaiian access and gathering rights. As you travel along the shoreline note that property owners can not block access to the shore. This is for the use by all people for swimming, surfing and other water-recreational activities. Tied to many permitting procedures are public hearing processes. Gather enough negative declarations and one watches a project go down in flames or be regulated to a gulag.

The high business cost of offshore aquaculture must be offset by a new paradigm. The volume of production must be high, as well as, the value of the products and their market, substantial. In addition any methods or conditions, which can lead to a short and quick turnover rate, will allow for greater cashflow and project longevity. Yet what is most important is that the consumer demand for the products produced or niche markets where the supply is insufficient, will increase over time.

To date, the only successful species produced using open ocean aquaculture technology has been salmon, and on land,
shrimp. In Japan, the focus is for yellowfin tuna production and in Singapore, sea bass. The world market is glutted with aquaculture salmon and with a depressed price for wild caught salmon. For Hawaii to enter this market where one cage will produce upward to 300 to 400 mT of finfish, salmon as a culture species is not a logical choice. Rather, we should capitalize on the strengths of our research and develop methods for species found in Hawaii. Thus, we can market new species in a non-competitive mode, as compared to salmon. Mahimahi and moi are on the horizon and ready for technology transfer, and other species have already been targeted for future research, if not already in progress. This is a similar pattern of research for finfish biology in Europe.

**Issues**

Positive incentives for offshore development would lead to new opportunities for fishermen on limited seasonal catches or closed fisheries; opening of positions requiring more technical skills; relief from limited sites for land-based development; and most importantly, increased revenues from expansion of an ocean-based industry sector.

Disincentives can include potential for nutrient loading owing to farm location and currents; conflicting uses of a proposed site; high startup costs; and risks inherent to the industry.

Currently no laws permit individuals or companies from using a common resource for private ends, nor protect the property rights and interests of an open ocean farm. A review of the Hawaii statues governing the leasing of ocean bottoms has been reviewed by Corbin and Young (1997) elsewhere in this volume. To be able to lease or use a site for a set amount of time is incomplete. For a farm to be created on the open ocean, there need to be rules for ownership over the resources created onsite whether by culturing and holding finfish in cages; ranching free roaming finfish held to one location by conditioning and a feeding station; or by artificially enriching a localized area (see Markels [1997] in this volume).
Site Considerations

A large part of establishing an enterprise will include finding a site to farm. The technical overview for a good site will require information on depth, bottom composition, winds, and current patterns. A general indication of where to pinpoint a site can be found using information from http://satftp.soest.hawaii.edu/atlas.html. The physical parameters for site selection are critical for risk reduction. The next stage potentially can include an environmental assessment or impact statement with public inputs. The problem solving aspects of coping with these "market forces" of public concerns, governmental concerns — Federal and State — and physical environment realities may be overwhelming. We need to determine means of reducing conflicting uses through dialogue and public forums, a very difficult process. Government regulations should meet the public good, but sometimes at great expense. The current status for securing a lease or an easement for a site is costly and lengthy. This process is not the feint-hearted, nor easily fatigued investor.

Discussions with Pierre Flament (Dept. of Oceanogr., Univ. of Hawaii at Manoa, pierre@soest.hawaii.edu) on the physical environment for cage culture suggested these following sites. Bathymetry and wave activity as related to seasonality, are calmest on the leeward side of all islands. Potential areas for development within the State include protected embayments, the Penguin Banks area, and the ocean area encompassed by Molokai, Maui, Lanai and Kahoolawe.

Stepwise Development and Technology Considerations

The question at this point is how to incorporate a will for development which allows for offshore aquaculture to begin? Ultimately, the process begins with and involves ocean bottom leasing and the State law has not been fully tested, nor defined. The logistics and integration with the State, county and Federal regulation must be worked out.

We propose to begin with Hawaiian fishpond sites. Where a firm could work within or offshore from a fishpond. This area
would provide a staging site for on-land planning and logistics for moving offshore. There a firm could locate hatchery, nursery ponds, storage for equipment, supplies and personnel. These areas are generally within protected offshore areas of the coastline. Fishponds could represent a small jump to an offshore site. These areas unfortunately may or may not be within view planes where resorts and private homes are located. As experience is accumulated, more exposed offshore and oceanic areas could be utilized.

Alternatively as in the case of industrial or agricultural parks which exist in many places, an offshore site could be readily demarcated and permitted ahead of time. Thus an enterprise coming to Hawaii can lease a portion of an offshore aquaculture park site for its activities with minimal costs for meeting regulatory requirements. Staging areas could also include planning for waterfront wharfage and warehouse space to be leased. This turnkey process and infrastructure building by local government would require some insight and commitment for future prospects. Such actions would allow for companies to have a quick startup with lower costs in a short period, all factors portending likely success.

We have identified five kinds of technologies to consider. Within the fishpond or in shallow nearshore and protected embayments, one can use pen enclosures continuous with the bottoms. Moving to areas of greater depth, floating cages can be used in places where the sites are protected and not exposed to fast currents or much wave activity. Floating cages can be made with easily replaced local materials (see http://www.anse.purdue.edu/aquanic/images/photos/sing/ flfarm.htm as an example). In higher energy environments, the floating cages are engineered to withstand the physical environment and materials and designs may need to be imported. There are proven ocean cage designs by Bridgestone Corporation (Japan), Dunlap Corporation (UK) and others. An example is a salmon farm in Maine with onshore and offshore facilities and various kinds of floating cages related to their experiences (http://www.MajesticSalmon.com). In yet more exposed and open
ocean areas, one uses submersible cages, which can take the violent environment (see http://www.interviz.com/editions/World-Aid/82351.htm as an example). More complete information is found elsewhere in this volume (Bougrova, Matveev and Bugrov, 1997) for submersible cage systems.

Another alternative is to consider an offshore location for logistics as in a Spanish floating platform, which is designed to sustain upward of 450 mT on finfish production per year (see http://pegasus.cambrascat.es/msi/msi_fish.htm). Platforms can serve as a center for holding supplies and managing various cage systems anchored offshore in proximity. There are many oil production platforms in the Gulf of Mexico, Europe and elsewhere in Southeast Asia. Elsewhere in this volume are the experiences of a Texas group in using oil platforms (Chambers, 1997). A more extreme example of intensive capital investment is the example of converted ships or barges for finfish production. Like the platforms, motorized vessels can serve as a staging area and have the added advantage of being mobile. Thus, prior to a severe storm arriving at a site, the vessel can tow its cages to a more protected area — minimizing the risks of losses.

To efficiently pursue development, all technology, experts and material parts ought to be taken off the shelf from where it is being used successfully. This will cut down the cost of development and startup. There can be an infinite variety of design and solutions for problems, but the pilot-scale, field testing and modification processes are expensive costs.

**Future Action**

With this rapid review of issues and technology, what is immediately possible? The State has a research corridor of NELHA, at Keahole Point, perhaps a less desirable demonstration site for scaling a pilot project. Alternative sites upon consultation with many interested parties ought to be pursued. The best approach is to engage fishermen with boats and others with experience in aquaculture, not unlike the South Australian farming of bluefin tuna. These companies corral fish
at sea and rear them for growout in more sheltered bays. This practice has spread to the Mediterranean and Croatia.

Prior to getting started, individuals ought to generate a business plan and examine the numbers for profitability and sustainability. If the internal and external factors do not have profit to support the project for longevity, it is not sustainable. There is no need to expend money for a project without positive cashflow other than validating its potential. Important is the selection of a local species with known biological characteristics and closed lifecycle methods for entry into a world market. The point is not to compete against other countries where production costs may be lower for what is a commodity product like salmon. Offshore aquaculture can be a sustainable activity which will require working out technical, legal, political and social details (Stickney, 1997).

References


