OPINION

Offshore aquaculture in the United States: Untapped potential in need of smart policy

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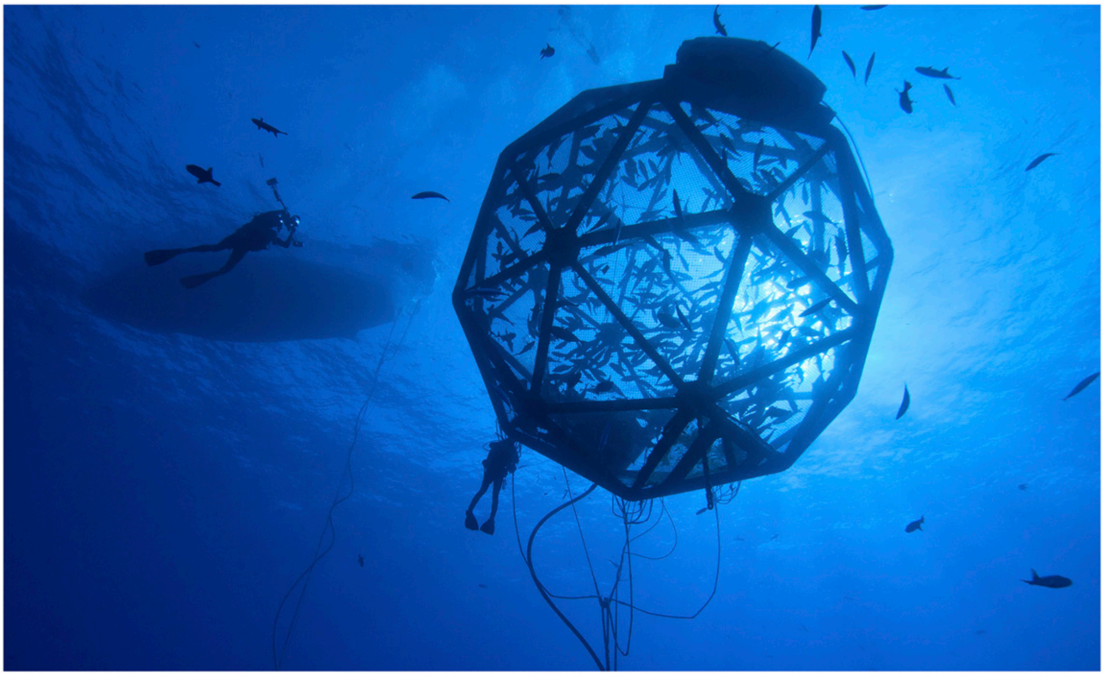
The United States had a $14 billion seafood trade deficit in 2016, importing more than 2.5 million tons of edible fishery products, 90% of the value of the seafood Americans eat (1). Half of those seafood imports are from aquaculture (2). Meanwhile, demand in the United States for local, fresh, and sustainably produced seafood is growing, and the absence of sufficient local supply to meet this demand clearly represents a lost opportunity for sustainability and economic growth. Expanded domestic seafood production in the United States could promote significant economic development and job creation. Yet, wild-fishery production has only a relatively modest potential for sustainable growth. Aquaculture, therefore, represents the only realistic option for expanding domestic production (3).

Indeed, the vast expanses of favorable growing areas with suitable depths, current speeds, temperatures, and access to ports give the United States some of the highest offshore aquaculture production potential in the world (4). And yet, despite huge potential benefits in terms of a reduced trade deficit, local job and revenue creation, and a domestic source of safe and sustainable seafood, marine aquaculture production in the United States lags far behind many other countries worldwide. This failure to realize offshore



With sufficient spatial planning, a significant expansion of offshore aquaculture in the United States—using, for example, underwater cage technologies such as this one off the coast of Hawaii—would boost not only the supply of sustainable fish but jobs as well. Image courtesy of Rick Decker (photographer).

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aquaculture potential is partially attributable to reasonable concerns over environmental impacts and the lack of a streamlined, objective, and predictable policy framework for offshore aquaculture permitting and regulation.

The key to addressing both is scientifically informed, proactive spatial planning that identifies optimal locations for sustainable aquaculture development. This type of spatial planning could minimize negative environmental, social, and economic impacts on marine ecosystems and coastal communities while reducing uncertainty for investors and the industry. The opportunity is right beyond our shores. We just need to seize it.

The Promise of Offshore Aquaculture

Aquaculture is the fastest-growing food-production sector globally (5) and is increasingly seen as an important part of the solution to sustainably feeding a growing global population in the coming decades—one that's projected to reach nine billion people by 2050 (6, 7). Traditionally, many types of aquaculture have used wild fish as key inputs in feeds. But the development of alternative feed sources and husbandry techniques for lower trophic-level species—species that do not require feed—have removed this barrier to increasing production. Furthermore, recent research has demonstrated that increasing consumption of cultured seafood, as opposed to other types of meat, has the potential to reduce the amount of land required for growing animal feeds into the future and, thus, spare significant amounts of land from agricultural conversion (8).

The majority of current aquaculture production is for freshwater species, but freshwater aquaculture competes with many other uses for available land and water and often has high energy use and costs. As a result, the future of seafood production is likely to focus on marine aquaculture, or mariculture (6). To capitalize on the potential for mariculture, many nations are encouraging its economic development (5).

For example, mariculture is the fastest-growing primary industry in Australia and comprises 43% of the nation's seafood production by value (9). It is a diverse industry, raising a range of finfish and shellfish species, and state-level management has created a rational and efficient permitting and regulatory environment. In several Australian states, the establishment of aquaculture zones have been used to streamline development while minimizing the impacts of aquaculture on the marine environment and existing ocean users.

By contrast, the United States has only begun to explore more streamlined regulatory options, despite being one of the most promising nations for mariculture production potential (4). The United States ranks third globally in wild-marine–fisheries production but only 17th in total aquaculture production (freshwater and marine) and has a slower rate of growth than the global average (5). Of US aquaculture production, only 15% by volume and 29% by value is marine [as of 2014 (2)].

Until recently, marine aquaculture has primarily been located close to shore and in sheltered coastal waters—areas with high environmental sensitivity that are also already crowded with other ocean uses. Consequently, nearshore mariculture can have high potential for conflicts (e.g., with wild-capture fisheries) and higher risks of environmental impacts (e.g., on the marine benthos and coastal habitats such as mangrove forests). This leaves offshore aquaculture—defined here as farming beyond the nearshore and inshore coastal zone, which typically refers to waters greater than about 20 m in depth—as the most promising option for expanded sustainable seafood production.

Although offshore aquaculture presents some engineering challenges, technological advances have made its development more attractive, as demonstrated by its growth in a number of regions worldwide. However, in the United States, there is very limited commercial offshore aquaculture development, with farms located almost exclusively in state waters. The lone exception is Catalina Sea Ranch, which is located in federal waters off California and commenced mussel harvesting in 2017. The scope for growth is tremendous, with an outcome that could be transformative for the country. Recent estimates suggest that the United States could meet its entire current seafood demand with domestic production if finfish aquaculture were developed in just more than 0.01% of the country's exclusive economic zone (10).

Barriers to Entry

Despite the compelling arguments for development of a vibrant offshore aquaculture industry, the United States has not taken advantage of the opportunity, largely because of regulatory and policy failures. The United States' aquaculture regulation and permitting system is highly fragmented across multiple state and federal agencies and jurisdictions. The lack of a strong and streamlined policy framework causes regulatory uncertainty that deters potential developers (11). At the federal level and in many states, there is no clear roadmap for the permitting and leasing process, making offshore aquaculture permitting and leasing a lengthy and expensive procedure that's rife with uncertainty (12, 13).

Various policies and initiatives indicate an interest in aquaculture development, such as the National Oceanic and Atmospheric Administration's (NOAA's) Marine Aquaculture Policy of 2011, the National Shellfish Initiative, and a federal Interagency Working Group on Aquaculture that includes a task force attempting to coordinate the permitting process across agencies. None of these has complete authority to create a streamlined and efficient pathway for permitting—they may yet help improve coordination across agencies, but no meaningful changes have resulted thus far. (The exception might be the regionally focused Gulf of Mexico Fishery Management Plan for offshore aquaculture, which is currently subject to a lawsuit filed by organizations with environmental, economic, or food safety concerns.) Attempts at an actual overarching law dedicated to offshore aquaculture have failed to pass in

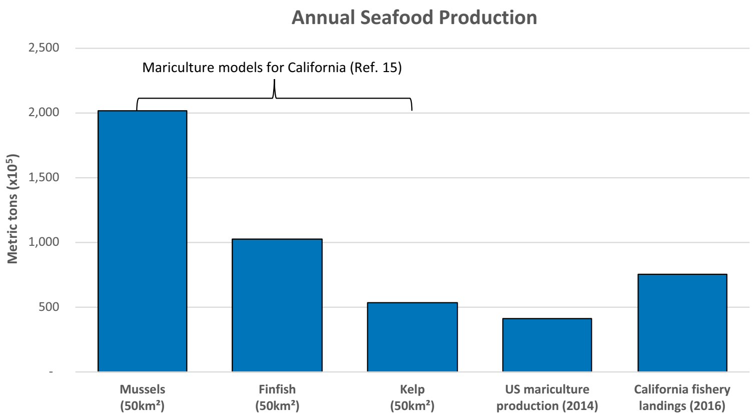

Fig. 1. Mariculture sited using optimized spatial planning can yield significant levels of seafood production with a small spatial footprint and minimal impacts on the environment or other ocean uses. For example, modeled mariculture in Southern California, farming only a very small total area (50 square kilometers), can produce a quantity of seafood that surpasses all US mariculture production combined and all wild-fishery landings for state waters along California's approximately 1,350-kilometer coastline. Data from mariculture models for California from ref. 15. Image courtesy of S.E.L.

Congress (e.g., National Offshore Aquaculture Acts of 2005 and 2007), leaving the United States with piecemeal laws and fragmented oversight (12).

American aquaculture entrepreneurs, companies, and investors are looking to overcome these hurdles, but many have turned to development opportunities outside of the United States, likely to places with weaker environmental and food safety standards, rather than dealing with the cumbersome and risky regulatory process at home. Growth of marine aquaculture is happening on a global scale with or without the United States as a major player, and exporting our production is a lost opportunity for economic development and for promoting sustainable food systems.

Spatial Planning

To spur offshore aquaculture in the United States, we need a more unified policy framework that specifies how permitting will work across agencies and jurisdictions while creating clear and rigorous standards to protect ocean ecosystems and other ocean uses. Scientifically informed, proactive spatial planning should drive this process by identifying prime locations for aquaculture development—locations that will be productive and profitable while minimizing negative environmental, social, and economic impacts.

Marine spatial planning has gained more traction in the United States over the last decade. This includes state-level marine plans implemented in Massachusetts, Rhode Island, and Oregon and a 2010 executive order by President Obama establishing a National Ocean Policy that, among other priorities, called for regional planning bodies responsible for developing coastal and marine spatial plans for each of nine regions. Although the science needed to define such plans is increasingly available (14, 15), progress toward this goal has been highly variable. Only the Northeast and Mid-Atlantic have implemented plans, with funding and coordination challenges and lack of political will limiting progress in other regions. The states and regions that have taken the greatest strides toward coordinated ocean planning share a common thread: increasing interest in other new ocean industries, namely offshore wind and wave energy. This raises the possibility that we could see amendments to existing plans to better accommodate aquaculture development, as well as growing momentum for spatial planning in new locations where there's interest in offshore aquaculture.

A proactive planning process for offshore aquaculture, conducted at the national level and spanning state and federal waters, could reduce investor and industry risk. Much of the regulatory red tape that exists now is motivated by good intentions, because stakeholders seek to prevent development that would result in significant negative impacts on existing uses or to the marine environment. And although such safeguards are essential when developing new uses that may have unanticipated consequences, it is also important to weigh negative impacts of aquaculture relative to negative impacts of other food-production systems.

Furthermore, many of the potential negative effects of offshore aquaculture can be mitigated by smart spatial planning (16), especially because the amount of area needed for large volumes of production are surprisingly small. Interactions with other uses and the environment—both positive and negative—and the productivity of an aquaculture farm are all highly dependent on where aquaculture is located. Therefore, a policy framework that includes scientifically informed spatial planning is much more likely to result in positive outcomes that satisfy a diverse suite of marine management and economic-development objectives.

The science and analytical tools needed to define such plans are robust. Using predictive models that account for biological, environmental, and socioeconomic interactions between aquaculture and the ecosystem and between aquaculture and other ocean uses, researchers and policymakers can identify appropriate types of aquaculture and locations for farms to help maximize benefits and minimize negative impacts and tradeoffs (14, 15).

As an example, a recent study developed such models for siting offshore aquaculture farms for mussel, finfish, and kelp in state and federal waters off the coast of Southern California (15). Southern California offers prime ocean conditions, good port infrastructure, and large demand for fresh seafood; yet there is very little marine aquaculture in the region. The analysis predicted high levels of potential seafood production and revenue from very modest levels of aquaculture development (50 square kilometers or less; Fig. 1). Through spatial planning, the set of projected impacts on the environment and existing uses (the impact on scenic views, risk of disease outbreak, effects on the benthic ecosystem, and wild-fishery impacts) that were analyzed were kept at very-low to nonexistent levels (15).

These spatial plans will certainly not perform perfectly, because the underlying models are limited by the quality of existing data and our ability to accurately represent all of the important interactions. For example, the study mentioned above for Southern California did not consider the risk of genetic pollution of wild populations nor the interactions of farms with marine mammals, seabirds, or recreational boaters. Nonetheless, although there will always be scope for improved science, there's a rich body of expertise and knowledge to forge effective planning. All environmental and economic development decision making comes with uncertainty. But that uncertainty should not prevent the use of available science to guide the development of more sustainable food production systems.

We have the scientific capacity, expertise, and data to conduct analyses, similar to the one described for California (Fig. 1), across all US waters. The timing is ripe to scale up offshore aquaculture planning to the national level. These analyses could be conducted for the entire United States or within large regions (e.g., using the eight fishery-management council regions), identifying locations that would be most favorable for different types of aquaculture while minimizing negative impacts on other uses and the environment. This process could include pre-permitting for these locations, for example, conducting site or regional environmental impact assessments rather than the permit-by-permit approach currently used (11), thereby increasing efficiency and cost savings.

A more proactive approach to spatial planning for offshore aquaculture could help facilitate the sustainable development of a new industry. In particular, this would lower the barriers for small business ventures that lack the resources to participate in the current time-consuming, uncertain, and costly permitting process. Coordinated planning can achieve better outcomes in terms of minimizing environmental impacts and conflicts with other uses while still resulting in productive and profitable farms. When industry is responsible for site selection from a blank slate, there is a larger barrier to entry, and industry is less likely to propose locations that balance the concerns of multiple stakeholders.

Political Win–Win

Under an administration that is reticent to combat climate change or environmental degradation but has pledged to revitalize the economy and create more jobs, offshore aquaculture might be an issue where partisan politics does not stand in the way of progress and where the United States can create the enabling conditions to be a global leader in sustainable mariculture production. As the global population increases and becomes wealthier, demand for animal protein and seafood is increasing dramatically. The question is not if the world will need and demand more seafood, but how that seafood gets produced—and whether the United States plays a significant role in that production. US commercial wild-capture fishery landings peaked in 1992, have since plateaued (1), and have little potential for significant growth.

Offshore aquaculture, on the other hand, has massive growth potential, in part because it is an incredibly space-efficient way to produce seafood. This is not a call to blanket our oceans with new development, and we must be clear-eyed about the limits of scientific understanding, particularly regarding potential cumulative impacts of overtaxing the seas. We can, however, site farms in select locations that have high yields while taking care to minimize negative impacts on the environment or other economic sectors. With an overarching policy framework guided by scientifically informed spatial planning, we can make America a global leader in sustainable marine aquaculture development.

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