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The Political Economics of Marine Aquaculture in the United States

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ABSTRACT

Government regulatory policies and social acceptance are critically important to the growth of marine aquaculture in the United States. In much of the country, opposition to marine aquaculture by local and national interest groups and local, state, tribal, or national policies have limited marine aquaculture to a scale far below its potential. There are several reason for this: (1) Marine aquaculture is relatively small, diverse, and (with some notable exceptions) unproven; (2) marine waters are public resources; (3) some Americans perceive potential negative effects of marine aquaculture without offsetting positive effects; (4) aquaculture faces significant social opposition; and (5) the governance system for leasing and regulation hinders the development of U.S. marine aquaculture. This article discusses five broad strategies and recent efforts to advance marine aquaculture in the United States: (1) fixing problems, (2) creating benefits, (3) building partnerships, (4) arguing effectively, and (5) reforming governance.

KEYWORDS

Aquaculture; policies; economics

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Introduction

A recent study by the Food and Agriculture Organization (FAO) of the United Nations puts the United States toward the top of the list of countries with large marine aquaculture potential (Kapetsky et al., 2013). The FAO study and others point to the United States' long coastline, large marine Exclusive Economic Zone (marine waters three to 200 miles from shore), skilled labor, available technology and feeds, a stable legal and economic system, and a large seafood market (Nash, 2004; Rubino, ed., 2008; and Kite-Powell et al., 2013).

A small but vibrant and growing marine aquaculture industry in the United States has capitalized on these advantages: the half-shell oyster market is rapidly expanding, farmed salmon production in Maine and Washington State is at historic levels, and permit applications for new marine fish farms have been filed or proposed in Hawaii, New Hampshire, California, and the Gulf of Mexico region. But although the value of U.S. marine aquaculture production has grown about 8% per year during the past five years (National Marine Fisheries Service, 2014), its contribution to U.S. and world seafood supply is still small and well below its potential. The reasons include unfavorable government regulatory policies; opposition to fish and shellfish farms by some coastal landowners, environmental nongovernmental organizations (eNGOs), and fishermen; and lack of understanding about the benefits and risks of aquaculture. People will not invest in marine aquaculture if permit approval processes take too long, cost too much, or are too uncertain and risky, or if coastal landowners and fishermen do not want them as neighbors.

Supporters of U.S. marine aquaculture—those who believe that U.S. marine aquaculture can and should grow and that Americans would benefit from it—need to think carefully and clearly about *why* U.S. policies and public opinion have been unfavorable toward marine aquaculture, and what they can do to change those policies and perceptions. This means that they need to think about the *political economics* of U.S. marine aquaculture: what influences policies, public opinion, and politics, and how these dynamics are influenced by the economics of aquaculture and of businesses or economic interests that may conflict with aquaculture. Political economics is a branch of social science that studies the relationships between individuals and society and between markets and the state, using tools and methods drawn from economics, political science, and sociology.

This article outlines reasons why U.S. policies and public opinion have been unfavorable to marine aquaculture and what can and is being done to change these policies and perceptions.

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Why should we care?

Aquaculture already provides about half of the world's seafood supply, and future growth in supply will come from aquaculture (World Bank, 2013; FAO, 2014). Global harvest from wild capture fisheries reached a plateau in the mid-1980s and is not likely to increase significantly even with the adoption of smarter fishing practices and fish habitat conservation. Rising global demand for seafood along with technological and scientific innovations that allow for environmentally responsible aquaculture production are creating opportunities to produce nutritious food in a resource-efficient way, create jobs, and help maintain healthy oceans.

Why should we care specifically about advancing U.S. marine aquaculture? The United States, like Europe and Japan, is a large consumer of seafood, but does not produce enough to meet domestic demand. About 80% to 90% of seafood consumed in the United States by value is imported and over half of that is from aquaculture (National Marine Fisheries Service, 2014). The United States exports about half of its wild catch. But even if domestic markets were willing to purchase all U.S. wild catch, it would still be insufficient to meet current demand. Ending overfishing in the United States and letting wild stocks recover may eventually increase supply, but not enough to meet current demand. Dietary guidelines recommend that Americans eat twice as much seafood as they currently consume (from one meal to two meals a week) (U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services, 2010). Where would another roughly six million tons of seafood come from?

Should we be concerned about reliance on imported seafood? Many Americans benefit from imported seafood: consumers who can buy seafood year round, investors earning a return on foreign production, feed and equipment companies that sell products overseas, and food service companies that sell seafood. But recently, American seafood and food service companies have become concerned that the seafood they import may not be available or may only be available at higher prices due to the rise in seafood consumption in Asia and Latin America. Seafood prices in some countries have increased in recent years as demand for seafood grows with rising income levels, especially in Asia. Major U.S. seafood processors and food service companies have based their expansion plans on the availability of aquaculture products and domestic aquaculture production would be attractive (Engle and Stone, 2013; Cherry, 2014; Intrafish, 2014).

By importing so much of our seafood, we are also missing out on the benefits of local production and on domestic jobs created by that production, especially in rural communities such as coastal fishing towns and agricultural regions that produce aquaculture feed ingredients. This is a lost opportunity to supply locally grown seafood to American consumers and a lost opportunity to grow seafood in a responsible way under our strict environmental and food safety laws and regulations.

There are three basic methods and places to grow fish: in freshwater ponds, in tanks with partial or complete recirculation of water, and in cages in marine waters. If it is too difficult to obtain a lease or permit to grow seafood in state or federal waters due to conflicting uses and a complicated regulatory system, why not obtain supply from freshwater ponds and recirculating systems that can be set up on private property? Ponds and raceways still supply the largest share by weight of aquaculture products in the United States in the form of catfish, trout, and crayfish. But expansion of freshwater pond production is limited by access to fresh water, limits on discharge, and competing uses for agricultural land. In particular, catfish production has declined by about a third in recent years due to competing uses for land (growing corn or rice may be more profitable), high costs of feed, and competition from imported catfish and similar whitefish filets. The USDA and universities are working with the catfish industry to improve efficiency, reduce costs, develop hybrid species, and test other species in catfish ponds (shrimp, tilapia, marine fish, and algae). These efforts may stabilize production from catfish ponds and eventually increase domestic seafood supply.

Recirculating production systems also have some appeal: using private land may pose fewer regulatory hurdles than obtaining a marine site, and allow more technological control and biosecurity. Interaction between the farming operation and marine waters and species would be limited, and farm locations could be near major consumer markets. Some eNGOs and foundations have promoted and invested in land-based recirculating aquaculture systems as an alternative to aquaculture in marine waters (e.g., Ecoplan International, Inc., 2008). Recirculating systems are already in use in many hatcheries. Some species may be well suited to rearing in tanks. Fish farmers are also experimenting with head-starting fish in recirculating systems (growing them to about 500 g to 800 g) before transferring the fish to net pens to grow them to market size. The high costs of building and operating recirculating systems have so far limited their use to a few high value species (Boulet et al., 2010). Dealing with off-flavor issues (also present in some pond systems) remains a challenge. Also, although recirculating systems allow for greater biosecurity or control than open pond or marine systems, it is

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difficult to eliminate pathogens and parasites from of a closed system once they get in. Recirculating systems can also have environmental impacts (as there are with all systems) including energy usage, use of land, production and use of materials, and waste discharge. Despite these challenges, the costs and operational disadvantages of recirculating systems are likely to come down or be overcome with experience and innovation.

However, the use of pond and land-based systems for aquaculture will not make using public waters unnecessary any time soon. Given the enormous and growing demand for seafood, all forms of aquaculture production will be needed to grow fish: ponds, tanks, and net pens. All of these methods have environmental advantages and disadvantages that need to be addressed and managed. U.S. marine aquaculture could expand production using species with proven track records and existing technologies and methods, suitable for Northern Hemisphere growing conditions, and established markets: salmon, oysters, clams, and mussels.

Challenges to U.S. marine aquaculture

Aquaculture in the U.S. marine environment faces multiple political economics challenges. Knapp (2012) identified five contributing factors:

1. Marine aquaculture is relatively small, diverse, and (with a few exceptions) unproven.
2. Marine waters are public resources.
3. Some Americans fear potential negative effects of marine aquaculture without offsetting benefits.
4. Aquaculture faces significant social opposition.
5. The governance system for leasing and regulation hinders the development of U.S. marine aquaculture.

1. *Marine aquaculture is relatively small and diverse*

U.S. marine aquaculture production accounted for 15% by volume (25% by value) of U.S. aquaculture production or 41,326 metric tons valued at $327 million (farm-gate sales) in 2013 (National Marine Fisheries Service, 2014) and supplies about 3% of U.S. seafood consumption.[1] By contrast, commercial fishing had an annual landed value of $5.5 billion in 2013. The six major sectors of the ocean economy (Living Resources, Marine Transportation, Ship and Boat Building, Marine Construction, Offshore Mineral Resources, Tourism and Recreation) are far larger still, with a combined annual contribution to GDP of $258 billion.

Although salmon have been farmed in Maine and Washington State for 40 years and oysters have been farmed for much longer, the industry is still economically small and disaggregated relative to commercial fishing, shipping, tourism, real estate, and recreation. Being relatively small creates economic challenges for U.S. marine aquaculture. Individual firms cannot achieve economies of scale in production, processing, transportation, and marketing. But being small also raises *social and political* challenges. Fish and mussel farms are being proposed in areas dominated by existing fishing or recreation and real estate (viewscape) interests in communities that fear potential adverse impacts of aquaculture. The prospect of jobs and local seafood supply is not enough to overcome the opposing interests. As a non-traditional use of marine waters or as a use opposed by more established economic sectors, aquaculture faces some of the same challenges as wind farms. It is more difficult to marshal political support for a salmon farm in Washington State from consumers who buy salmon in Kansas than it is to secure vocal opposition to a fish farm from coastal residents near the proposed farm.

Because marine aquaculture is small, it is easier to exaggerate its risks and harder to demonstrate its benefits. As noted by Tiersch and Hargreaves (2002), new resource industries such as aquaculture face a different political playing field than older resource industries. Aquaculture proponents face the burden of showing that an aquaculture venture would *not* be a problem, while for established industries it is industry opponents who must show that a project *would* be a problem. Newer industries lack the financial and political resources and long track record of industries such as terrestrial farming, logging, mining, and petroleum extraction. Thus, it can be easier to restrict or stop aquaculture projects, despite their arguably limited environmental risk, than it is to attempt to deter established industries that may be potentially more environmentally damaging.

Because U.S. marine aquaculture is small, relatively few Americans have—or realize they have—a direct stake in it. That means that it has few committed supporters, and relatively little money and political influence. In much of the United States, marine aquaculture is still below a threshold scale necessary for people to understand, accept, and effectively advocate for marine aquaculture. Achieving this scale will be critical to overcoming political economics challenges. Marine

[1] Marine aquaculture and freshwater aquaculture each account for about 3% of U.S. seafood consumption. U.S. wild fisheries account for about 14% and imports account for about 80% (figures are authors' rough estimates based on National Marine Fisheries Service, 2014). While data are available for production and for exports, no data are available for the share of domestic production, which is consumed domestically. Production volumes are typically reported on a round weight basis while export volumes are reported on a product weight basis (after processing). Processing yields vary widely for different species and products—making it difficult to estimate domestic consumption by subtracting exports from production.

aquaculture will become politically stronger as it grows—but it is difficult for it to grow without being politically stronger.

The marine aquaculture industry in the United States is also diverse. The industry is composed of diverse interests by species, technology, region, or market perspective (shellfish and finfish; freshwater and marine; net pens, ponds, and recirculating systems; importers and domestic producers). The industry has no common voice, message, or well-funded lobby group such as those which exist for soybean, beef, dairy, or pork farmers. There are national, regional, and state aquaculture industry associations. But their membership base is small relative to other lobby groups representing established political and economic interests.

Other than Atlantic salmon, oysters, and clams, production of marine species in the United States is also a relatively unproven business proposition. The farming of marine fish other than salmon, in particular, is still experimental, with only a few small, fledgling, or proposed operations around the United States (in cages, ponds, or tanks).

2. *Marine fish and waters are public resources*

The concept of private ownership of land is fully accepted in American law and culture. Although many Americans might argue that governments should restrict certain uses of private land, few would argue that private ownership is wrong in principle. In contrast, marine fish or waters in America are public resources (agricultural tidelands in Washington State for shellfish farming and some colonial deeds along the East Coast are exceptions). Many Americans, especially those with vested real estate or commercial interests in coastal areas, oppose private exclusive use of rights to marine waters and resources. These sentiments reflect the basic principles of the public trust doctrine that have a long, well-established history in U.S. case law dating back to seminal cases in the 19th century (Illinois Central Railroad vs. Illinois). For some states, such as Alaska, these principles are explicit: the Alaska Constitution states that "… in their natural state, fish, wildlife and waters are reserved to the people for common use."

The tradition that wild organisms and waters are public resources imposes extra political and regulatory hurdles for commercial aquaculture. Exclusive use of public waters for shellfish or net pen farming requires some sort of leasing or permit scheme analogous to those which exist for other public resources such as fishing, range land, forests, and mineral resources. But while leasing mechanisms are well-established for other resources, aquaculture proponents have faced philosophical, social, or institutional resistance and to using public waters to grow aquatic species (Rubino and Wilson, 1993; Engle and Stone, 2013). Efforts to implement "rights-based" management regimes for wild fisheries, such as individual fishing quotas, face similar strong philosophical resistance from many Americans.

If new management regimes are put in place for aquaculture in the United States and if the number of aquaculture farms grows, public attitudes are likely to shift as the economic logic and advantages of exclusive use rights become more apparent. For example, shellfish farming in some state waters operates under well-established and publicly accepted leasing programs. But the acceptance of new management regimes will take time. Regulatory, social, and political familiarity must exist for new forms of aquaculture to expand.

3. *Some Americans perceive potential negative effects of marine aquaculture*

Groups that perceive potential negative effects of marine aquaculture include commercial fishermen who fear economic competition; coastal residents who fear loss of access to waterfront, changes in the views they enjoy, and reduced real estate values; and people who worry that marine aquaculture might cause pollution, harm marine ecosystems, or increase pressure on global wild fish stocks harvested for production of fish meal and fish oil used in fish feeds. These perceptions persist despite a significant scientific literature (referenced in sections below) that contradicts the extent or existence of risk to the values these groups want to protect. These groups play significant roles in the politics of U.S. marine aquaculture at local, state, and national levels.

Some commercial fishermen fear that aquaculture will compete with their products in the market, use space traditionally used for fishing, harm wild fish stocks, and be culturally different than fishing (in the same way that farming differs from hunting) (Chu et al., 2010; Tiller et al., 2013). For example, Alaska salmon fishermen spearheaded the Alaska legislature's 1990 ban on finfish farming, and continue to oppose finfish net pen aquaculture. Salmon fishermen remember that the rapid increase in salmon farming initially contributed in part to declines in dockside prices of wild and hatchery-raised salmon in Alaska (Knapp et al., 2007). Alaska salmon fishermen have since benefited from new markets created by the availability and affordability of farmed salmon (Knapp et al., 2007; Valderrama and Anderson, 2010). But Alaska salmon fishermen remember the initial price cuts and perceive that they continue to benefit from distinguishing wild versus farmed fish in the market.

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Owners of coastal vacation homes and real estate and recreational interests fear that aquaculture will spoil the view, reduce property values, or interfere with their recreational experience. Some coastal residents have strongly and effectively opposed marine aquaculture in states such as Maine, Washington, and California (Northern Economics, 2010; Lapointe, 2013; Greenberg, 2014; Future of Fish, 2014). Demographic shifts in coastal communities create new challenges, as vacation and retirement communities replace working waterfronts (Thomas, 2011).

Opposition to marine aquaculture by coastal residents, fishermen, and eNGOs is not unique to the United States. Regions of Canada, New Zealand, Australia, and European countries have had similar experiences (Culver and Castle, 2008; Mazur and Curtis, 2008; Whitmarsh and Palmieri, 2009; Young and Matthews, 2010). In British Columbia, for example, the interests of some vacation homeowners, fishermen, boaters, and First Nations have collided with foreign and Canadian owned salmon farms. In contrast, in New Brunswick, where the collapse of cod fishing created significant unemployment, aquaculture is appreciated for its job creation (Culver and Castle, 2008) although aquaculture still faces opposition from some eNGO and fishing groups in Eastern Canada. A survey of public perceptions of shellfish farming in British Columbia found that most respondents agreed that shellfish farming has positive effects on the economy, but non-industry participants expressed concern about environmental and visual effects (D'Anna and Murray, 2015).

4. *Aquaculture faces significant social opposition*

Many people have heard from eNGOs or the media that marine aquaculture will cause pollution, harm marine ecosystems, or increase pressure on global wild fish stocks harvested for production of fish meal and fish oil used in fish feeds (Goldburg and Trippett, 1997; Marine Aquaculture Task Force, 2007; Ocean Conservancy, 2011). The eNGOs have been partly or largely supported by private foundations that have invested significant funding and effort to advocate banning, delaying, restricting, or regulating U.S. marine aquaculture in ways that increase the risks and costs of investment (Krause, 2010a, b, 2011). Collectively these organizations have played a role in influencing the public, the press, politicians, and regulators in ways which have contributed to unfavorable regulatory policies toward marine aquaculture (Lockwood, 2001; Chu et al., 2010; Nadkarni, 2014a). The scale, objectives, strategies, and arguments of these groups vary widely, making it difficult to generalize about their motives, methods, and effects. As noted by Tiersch and Hargreaves (2002), "advocacy groups can provide a valuable service by acting as an impartial watchdog of environmental issues and calling attention to legitimate concerns." But some eNGOs continue to criticize marine aquaculture rather than recognize the huge improvements in performance over the past 30 years (Bricknell and Langston, 2013; Future of Fish, 2014).

Amplifying the efforts of eNGO aquaculture advocacy are the popular media and scientific press that can in turn amplify political opposition to marine aquaculture. Most mass media articles in the past about the benefits and risks of eating farmed fish in the United States, for example, focused on the risks, while few articles reported on the benefits (Amberg and Hall, 2008).

With the public, politicians, and regulators facing, until recently, a barrage of negative messages from eNGOs and the popular press, fish farmers face an uphill political battle. Adding to the challenge is that although much of the eNGO opposition has been targeted at shrimp and salmon, the two largest sectors of marine aquaculture, enough of it is directed generally at all "fish farming" to negatively influence perceptions and policies for all marine aquaculture—all species, nationwide (Chu et al., 2010; Young and Matthews 2010; Hall and Amberg, 2013).

5. *The governance system for leasing and regulation hinders the development of U.S. marine aquaculture*

The political economics challenges to marine aquaculture contribute to and are compounded by the wide range of policies and regulations of multiple agencies, at federal, state, and local levels (Engle and Stone, 2013). Conceptually, these may be divided into three broad types: leasing or permit policies, regulatory policies, and other policies. See Table 1.

It is not just the policies that matter. It is also how stable and predictable they are, and how long it takes to secure leases and regulatory approval. Risk and time are critical to business decisions. "Take the time to get it right" and "keep trying to make it better" might sound like reasonable ways to make public policies. But too much time or too many changes can stifle investment that depends on those policies. If no projects are allowed to start, adaptive learning and improvement will have no chance to make better policies.

Regulatory authority for aquaculture in marine waters is divided among multiple branches of government (executive, legislative, and judicial) at multiple levels of jurisdiction (local, state, and federal; Engle and Stone, 2013). Federal agencies with regulatory authority for

Table 1. Selected government policies affecting marine aquaculture.

Types of policies	Selected key issues
Leasing or permitting policies	Is there a process by which farmers may lease or obtain a permit for sites? How predictable is the process? How long does it take? How legally secure are sites? How flexible are permitted uses of sites? Can sites be transferred? What do sites cost?
Regulatory policies	What regulations do governments impose on farmers? How costly are the regulations? What is the process for developing regulations? How stable and predictable are the regulations? What are the objectives of the regulations? How efficient are the regulations: could the same objectives be achieved at lower cost?
Other policies	How is aquaculture taxed? What kinds of subsidies are available for the aquaculture industry? To what extent and how does government support research, education and marketing? What are trade policies towards farmed fish? What kinds of infrastructure (roads, ports, etc.) does government provide for aquaculture?

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marine aquaculture include but are not limited to the Army Corps of Engineers, the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), the Fish and Wildlife Service, USDA, and the Food and Drug Administration. Similarly, at the state level, environmental and fisheries agencies typically have regulatory authority. Local and tribal governments may exercise additional authority, such as zoning regulations or territorial rights to fishing waters. The U.S. Congress and state legislatures enact laws affecting aquaculture, and many issues are decided by the courts at both state and federal levels.

Most agencies have a limited focus: they are charged with specific mandates, such as protecting water quality or endangered species or managing wild fish stocks. A single agency—at any level—can stop an aquaculture project even if all other agencies are willing to allow it. A single regulatory standard can make farming technically or economically impossible. If a single agency establishes unobtainable water quality standards or delays issuing regulations or processing permits, it can stop or delay aquaculture investments.

There are many good reasons to conserve natural resources and to protect the public's interest in public waters. But the dozens of approvals at federal, state, and local levels required to farm seafood create a complex, time consuming, costly, and uncertain permit process (National Research Council, 1978, 1992; Getchis et al., 2011; Engle and Stone, 2013; Kite-Powell et al., 2013). Some shellfish farms in the Pacific Northwest have been waiting over 15 years to obtain permits (Margaret Barrette, Pacific Coast Shellfish Growers Association, personal communication). Finfish farmers have tried unsuccessfully for years to obtain permits to start or expand operations in state waters in Washington State, Hawaii, Puerto Rico, and California, and in federal waters in the Gulf of Mexico and off California (Cates, 2010, Engle and Stone, 2013).

The most extreme example of hindrance of marine aquaculture by the governance system is the Alaska finfish farming ban. Although Alaska accounts for more than half of U.S. capture fisheries production and more than half of the U.S. coastline, all finfish net pen farming is banned by the State of Alaska.[2] From a technical perspective, salmon farming in Alaska might be one of the best aquaculture opportunities in the United States: salmon farming uses proven technology, the United States imports huge quantities of farmed salmon, and Southeast Alaskan waters are similar to those where salmon is raised in British Columbia, Chile, and Norway. But for social, cultural, and economic reasons Alaskans have chosen not to pursue this opportunity (Knapp et al., 2007).

Another major regulatory barrier is the absence of an enabling regulatory mechanism for marine aquaculture in federal waters (generally defined as from three to 200 miles offshore). Although a potential applicant might be able to obtain a permit from the U.S. Army Corps of Engineers (structure, location) and the U.S. Environmental Protection Agency (discharge), no agency has the authority to issue a lease for aquaculture in federal waters and there is no systematic way to apply for or obtain a permit to farm species of fish in federal waters that are regulated by a federal fishery management plan under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act; Cicin-Sain

[2] According to the U.S. Census Bureau's Statistical Abstract of the United States 2011, Table 360, the "general coastline" of the United States is 12,383 miles, of which Alaska accounted for 6,650 miles (54%). The "tidal shoreline" of the United States is 88,633 miles, of which Alaska accounted for 33,904 miles (38%). Total U.S. capture fisheries production in 2013 was 4.5 million metric tons, of which fisheries off Alaska accounted for 2.6 million metric tons (52%) (National Marine Fisheries Service, 2014).

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et al., 2001; Rubino, ed., 2008; Corbin, 2010; Emmett Environmental Law and Policy Clinic et al., 2013). Administration bills containing a regulatory framework for aquaculture in federal waters were introduced but not enacted in Congress in 2005 and 2007. Subsequently, the Gulf of Mexico Fishery Management Council approved a Fishery Management Plan for Offshore Aquaculture in 2009 under the authority of the Magnuson-Stevens Act. The National Marine Fisheries Service issued implementing regulations in January 2016.

American aquaculture producers and investors have been investing in other countries for years because they cannot get access to marine sites in the United States (National Research Council, 1992; Anderson and Bettencourt, 1993; Lockwood, 2001; Chu et al., 2010; Forster, 2010; Lockwood, 2013; Engle and Stone, 2013). For example, a cobia farm in Puerto Rico moved to Panama in part because obtaining state and federal permits to expand operations became too onerous and time consuming (Brian O'Hanlon, personal communication) and another one in Florida moved to Belize for similar reasons (World Fishing and Aquaculture, 2014). These operations also moved in part to seek a more favorable temperature regime for cobia and to get out of hurricane paths. Taylor Shellfish has purchased shellfish farms in Canada to supply their customers because they could not obtain new leases in the Pacific Northwest (Bill Dewey, Taylor Shellfish, personal communication). Chu et al. (2010) note that the United States acts as an incubator: small innovative firms start here, and if they want to grow, they leave the country and expand abroad in part due to regulatory constraints.

In a survey of U.S. molluscan shellfish growers, Rioux (2011) found that growers perceived significantly higher institutional risks associated with regulation and leasing than risks associated with markets, the environment, or climate. She noted "through discussions with growers as well as their answers to [an] open ended question, that… regardless of the state or locale, the highest risk is the rate at which [regulations] are changed. Growers find that state and local regulations are constantly changing and it is difficult to keep up with them."

Strategies for U.S. marine aquaculture

The opposition of fishermen, landowners, and eNGOs is frustrating to marine aquaculture supporters who feel that the objections and fears of aquaculture opponents are exaggerated, unfounded, or simply irrational. However, the political economics reality is that it is rational for groups that perceive only negative potential effects of marine aquaculture to oppose it. Why accept *any* risk if there is nothing to be gained? There *are* many things to be gained from marine aquaculture, including stable jobs, tax revenues, synergy with other marine industries including commercial fishing, good food, healthy oceans, and a reduction in import dependence. But these benefits are more widely spread and may be less evident to the people who benefit from them. And in many areas, aquaculture supporters have until recently failed to make the case effectively that aquaculture has these positive benefits (Bricknell and Langston, 2013; Future of Fish, 2014).

What can the "community of interest" in U.S. marine aquaculture do to overcome the political economics challenges faced by U.S. marine aquaculture? This question is being raised, with increasing urgency, within the industry and among supporters in government, science, and the broader public. Below we discuss five broad strategies for addressing these challenges, and recent progress with respect to each strategy. Although their relative importance varies for different types of marine aquaculture and in different regions, all five strategies are necessary for U.S. marine aquaculture to achieve its full economic potential.

1. *Fix real environmental problems and address misconceptions*

Environmental groups and others have raised both environmental and resource efficiency concerns about aquaculture (Clay, 1997; Naylor et al., 2000; Naylor et al., 2005). Social acceptability of marine aquaculture has been linked to its perceived environmental impacts in several studies (Whitmarsh and Palmieri, 2009; Hall and Amberg, 2013). Over the past 30 years, the United States aquaculture industry has done much to address these concerns. Working with scientists and government agencies, the industry has learned much from salmon, shrimp, and oyster farming about what to do and what not to do (Forster, 2010 ; Shumway, 2011). Efficient and environmentally responsible management practices are now in place driven by innovation ("smart" design) to reduce costs and increase yields and profitability, informed regulations, and market demands for "sustainably" produced products.

Environmental concerns raised by aquaculture include excess waste discharge, disease transfer or genetic effects on wild stocks, and interactions with marine mammals (Duarte et al., 2009, Hall et al., 2011). During the past 30 years, management practices and scientific innovation have reduced, eliminated, or minimized many of these environmental risks at responsibly managed farms (National Research Council, 2010; Hall et al., 2011; Shumway 2011; Price and Morris 2013; Rust et al., 2014). Seafood grown in the United States, like in Norway, Canada, the United Kingdom, Australia, New

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Zealand, and some other countries, is required to meet federal and state environmental laws concerning effluents, siting, endangered species, marine mammals, essential fish habitat, and other factors affecting environmental quality (Cicin-Sain et al., 2001; Shumway, 2011; Engle and Stone, 2013). These laws are reinforced by management practices and smart design aimed at "responsible" or "sustainable" production methods (Stickney and McVey, 2002; Tucker and Hargreaves, 2008).

In Maine, for example, practices at salmon farms include use of local genetic stock (coordinated with conservation biologists and stocking programs for endangered salmon), genetic marking to trace any escapes, few escapes and little to no use of antibiotics for the past decade, underwater cameras to monitor feeding, use of more efficient feeds, fallowing between crops, and experimentation with adjacent culture of mussels and seaweed to take up excess nutrients (termed integrated multi-trophic aquaculture; Price and Morris, 2013; Rust et al., 2014).

Resource efficiency concerns focused on feeding fish meal and oil from wild caught fish to cultured fish and shrimp that could put undue pressure on wild stocks of small pelagic fish such as anchovies, sardines, menhaden, and herring. So far these claims have been unfounded (Naylor et al., 2009; Jackson, 2010; Tacon, 2011; Rust et al., 2014; Torrisson et al., 2011). The supply of fish meal and fish oil on the market has been relatively constant for 30 years while aquaculture production has increased. The percentage and the actual amount of fish meal and oil consumed by aquaculture is decreasing and becoming a smaller component of fish feeds for several reasons. Increased demand with fixed supply has caused prices of fish meal and oil to triple in recent years spurring development of replacements for and complements to forage fish in fish feeds and a greater recovery of fish trimmings from aquaculture and wild capture fisheries.

Aquaculture is increasingly recognized as one of the most resource-efficient ways to produce protein relative to other animal proteins in terms of feed conversion and use of space (Bartley et al., 2007; Hall et al., 2011; Torrisson et al., 2011; Rust et al., 2014). Fish are more efficient at converting feed into meat than most terrestrial animals. And mollusks and seaweeds do not have to be fed artificial feeds (at least once they are out of a hatchery). Fish also require very little space to produce (Nash, 2004). Icicle Seafoods, for example, grows an estimated 6,800 tons of salmon per year in five seawater farms covering less than 9 hectares, or about half the size of Seattle's Fishermen's Terminal (Cherry, 2014).

That U.S. marine aquaculture is resource efficient and has improved its environmental performance is being recognized by environmental and international organizations, aquariums, chefs, universities, and the press (Haspel, 2013; Future of Fish, 2014; Howard, 2014). Aquaculture products are now featured on lists of recommended seafood (including farmed salmon in some cases). See, for example, seafood buying recommendations of NOAA's Fish Watch, Seafoodhealthfacts.org (a project of several Sea Grant College programs), and the Aquarium of the Pacific.

Aquaculture laws, regulations, and management practices in countries like the United States and Norway often form the basis of or are used as a reference point for the standards developed by private certification groups (FAO, 2011). Despite their limitations (Bush et al., 2013), certification standards and supermarket and buyer supply chain requirements may be giving consumers greater confidence in the environmental responsibility and food safety of aquaculture products (Washington and Ababouch, 2011).

Reflecting the success of aquaculture in addressing environmental concerns, some foundations and eNGOs have softened their stance on aquaculture, discontinued anti-aquaculture campaigns, become engaged in finding ways to encourage and invest in responsible aquaculture, and recognized that adverse public opinion on aquaculture and opposition from coastal landowners and fishermen needs to change (Mantra Consulting, 2013; Future of Fish, 2014; Howard, 2014).

Progress on fixing environmental issues in U.S. aquaculture does not mean that responsible aquaculture practices are used everywhere in the world. Nor does it mean that U.S. aquaculture can rest on its laurels. A recent report by the World Bank and FAO cautions that supplying fish responsibly through capture fisheries and aquaculture remains a huge challenge and that excessive and irresponsible harvesting in capture fisheries and aquaculture continues (World Bank, 2013). Potential risks cannot all be eliminated even in countries with well-developed aquaculture practices and environmental laws and years of research on environmental effects (Jensen et al., 2010; Johansen et al., 2011; Torrisson et al., 2011). As with any food production, there will be environmental risks that require attention, monitoring, avoidance, and fixing (Diana et al., 2013). For example, pathogens and parasites will always have the potential to create disease outbreaks in farmed and wild animals. Aquatic health management in the form of biosecurity,

integrated pest management, fallowing, and monitoring and reporting requirements greatly reduce, but do not eliminate risks (see Rust et al., 2014).

2. *Create and demonstrate social benefits*

In many areas, aquaculture supporters have failed to make the case that aquaculture has positive potential benefits (Bricknell and Langston, 2013; Future of Fish, 2014). To overcome the political challenges it faces, marine aquaculture needs to do more than demonstrate that it does no environmental harm. Gaining committed support will require making the case that aquaculture offers significant social and economic benefits at the local, state, and national levels, including benefits for groups that have tended to oppose aquaculture.

One of the significant national and local benefits of aquaculture is public health. Doctors, nutritionists, and government agencies are recognizing the health benefits of eating more seafood, wild and farmed (Mozaffarian and Rimm, 2006; Hibbeln et al., 2007). The U.S. government's 2011 dietary guidelines set a goal of doubling the average intake of seafood in the U.S. diet (USDA and U.S. Department of Health and Human Services, 2010) and that goal has been reaffirmed by the Dietary Guidelines Advisory Committee (USDA and U.S. Department of Health and Human Services, 2015).

Although not significant relative to total national employment, marine aquaculture income and jobs are important in several local economies. In the Northeast (Maine to Virginia), marine aquaculture—mostly salmon, oysters, clam, and mussels—was the third largest source of seafood harvested by dockside value ($218 million) in 2013 after scallops ($466 million) and lobsters ($461 million) and ahead of all groundfish combined (at $61 million) (National Marine Fisheries Service, 2014; USDA, 2014). Aquaculture jobs are important in the Northwest (Washington, Oregon, and California) and in Maine and Virginia. Shellfish farming in the Northwest directly employed over 2,000 full time and seasonal workers in 2010 generating over $125 million in sales (Northern Economics, 2013). In Maine, 150 aquaculture producers generate farm-gate sales estimated at $100 million a year and employ over 600 people at those farms (Maine Aquaculture Association, 2015). The market boom in half-shell oysters is supporting new oyster and other shellfish farming operations on the East Coast, providing local food to farmers markets and restaurants in the region, and contributing to social acceptance of aquaculture in the region.

Aquaculture jobs are being created in traditional fishing communities that have been losing commercial fishing jobs, such as on the East Coast (Lapointe, 2013). From Maine to North Carolina, many people engaged in aquaculture are from fishing and seafood families. Some are moving beyond the "fished or farmed dichotomy" (Klinger et al., 2013) and view aquaculture as another technology to produce seafood. Aquaculture and fishing interests are collaborating to maintain working waterfronts in states such as Maine (Costa-Pierce and Pendleton, 2014). In the Northeast, for example, the commercial fishing sector has lost jobs in recent years due to declining stocks for some commercially important species like cod in the Gulf of Maine and lobsters in Long Island Sound. Some of these fishermen are now growing oysters, mussels, seaweed, and fish. These fishermen are following the successful example of the early 1990s in Florida where underemployed oyster harvesters and net fishermen were retrained to be clam farmers (Ruth et al., 2005). Clam farming contributes $35 million annually to the local Florida economy by one estimate (Philippakos et al., 2001).

This convergence of aquaculture and fishing also reflects a generational change. The average fisherman in Maine is in his mid-50s; most working in aquaculture (many from same fishing families) are in their mid-30s (Sebastian Belle, personal communication). State and federal agencies (especially state Sea Grant programs) and local foundations are training fishermen in finfish, shellfish, and seaweed aquaculture in Maine (Time Videos, 2013), Connecticut, Maryland, and New Hampshire (Macalaster, 2014). The Maryland Agricultural and Resource-Based Industry Development Corporation, a state agency, set up a shellfish aquaculture revolving loan program to provide financing to watermen and others for oyster farming startups using funds from a blue crab fishery disaster declaration.

By one estimate, a doubling of U.S. aquaculture production to about 1 million tons could create an additional 50,000 direct and indirect jobs, assuming 20 direct jobs per 1,000 tons produced and five total jobs (including jobs in equipment, feeds, processing, marketing, and food service) for each direct job (Knapp, 2008). While this is a small increase in jobs relative to the national labor market, the context of the location of these jobs and who might be employed is critical. These jobs could provide stable, year-round employment opportunities in coastal and fishing communities, where opportunities are often limited and seasonally dependent.

Major players in U.S. seafood, an industry long dominated by commercial fishing and seafood importers, are investing in U.S. aquaculture production. Three of the large integrated West Coast seafood companies are now major aquaculture producers: Icicle Seafoods owns the Atlantic salmon farms in Puget Sound, Pacific Seafoods

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owns Coast Oysters and steelhead farms on the Columbia River, and Trident Seafoods owns an abalone farm in Hawaii. Atlantic Cape Fisheries, which operates a scallop fleet on the East Coast, also owns oyster farms in New Jersey.

Seafood companies and fishermen are also realizing that wild capture and aquaculture products can co-exist in the marketplace and that aquaculture products have expanded the market for wild fish (Knapp et al., 2007; Valderrama and Anderson, 2010). Ocean Beauty Seafoods, half owned by the Bristol Bay Economic Development Corporation and a supplier to the U.S. seafood market, is co-marketing Alaska salmon and imported farmed salmon to its customers (Restino, 2013).

3. *Build partnerships*

To overcome the political challenges it faces, U.S. marine aquaculture will need committed supporters at all levels of the political and policy process. It will need seafood farmers and employees who tell their friends and neighbors and elected officials about the benefits of aquaculture including health benefits, jobs, maintenance of working waterfronts, and local food supply. It will need supporters who testify at local public meetings, write letters to the editor, and are elected to local, state, and federal office. It will need organized outreach efforts to influence state and federal agencies, politicians, and opinion makers like chefs and journalists. All of this takes committed people and money.

The aquaculture industry is still relatively new, fragmented, diverse, and without a unified well-funded outreach or lobbying organization. Efforts, however, are currently underway by the aquaculture community to engage with the broader seafood industry and with sectors that are part of the aquaculture supply chain. For example, the National Fisheries Institute, an industry association, launched the Salmon Council in 2013 to promote both wild and farmed salmon (National Fisheries Institute, 2013). The Salmon Council included 18 major wild catch and fish farming companies in 2014 (World Fishing and Aquaculture, 2014).

Another example is collaboration with the feed industry. The Soy Aquaculture Alliance, started by the United Soybean Board (which represents 80,000 farmers) and several aquaculture producers and suppliers, is working with universities and government agencies on plant-based feeds for aquaculture such as combining agricultural products and byproducts, fish processing trimmings, algae, yeasts, and insects to solve feed limits standing in way of aquaculture expansion globally (Barrows et al., 2008).

American seafood and food service companies, aquaculture producers, equipment and feed suppliers, aquaculture associations, and an aquarium launched the Coalition for U.S. Seafood Production in 2014 to push for domestic aquaculture production of all types (Forristall, 2014; Nadkarni, 2014b). The coalition aims to create a "big tent" for U.S. aquaculture to include freshwater and marine; finfish and shellfish; a range of technologies (ponds, net pens, and recirculating); the whole value chain from equipment suppliers to processors, food service companies; large U.S. seafood companies, research institutes; and NGOs. The coalition members are concerned about seafood supply and security—specifically, that seafood currently imported from Asia will stay in Asia or become prohibitively expensive for U.S. consumers as Asia's middle class buys more seafood.

A variety of initiatives are underway in local communities to engage partners with mutual interests to demonstrate benefits, build support, gain trust, and social license, and change public perceptions about aquaculture. For example, aquaculture growers are benefiting from local food initiatives, community supported fisheries programs, and the demand for local foods as restaurants and chefs like to feature local farmers (Stabiner, 2014). The Carteret County, North Carolina community-supported fisheries program includes farmed shellfish, and farm-raised oysters are "making a splash" at Maryland restaurants (Kobel, 2013). A study of six coastal fishing communities in South Carolina and Florida found moderate support among local residents and tourists for marine farming as a means to boost local supply of seafood and economic resilience of the fishing industry (Jodice and Norman, 2015). The Washington and California shellfish initiatives, encouraged in part by the National Shellfish Initiative started by NOAA and partners, have brought together federal, state, and local agencies, tribes, the shellfish industry, and restoration NGOs to work together to increase the number of mollusks via farming and restoration projects (Pacific Coast Shellfish Growers Association, 2013).

Aquaculture and seafood associations and companies are engaging in the political process, and they are working with partners from interest groups that have opposed aquaculture in the past. However, more concerted and better funded efforts will be needed to secure broader public support and to effect an order-of-magnitude increase in U.S. marine aquaculture production.

4. *Argue effectively*

To overcome vocal and well-funded opposition, U.S. marine aquaculture supporters need to argue their case much more effectively than they have in the past. They need to educate

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and to communicate more effectively with the public, the press, politicians, and regulators (Bricknell and Langston, 2013). They need to more effectively understand and counter the arguments and tactics of anti-aquaculture advocacy groups at local, state, national, and international levels. This will require more resources and coordination.

Many books and articles offer advice on how to respond to criticism by advocacy groups, change public perceptions, and win support for projects or causes (Heath and Heath, 2007). Some are specific to aquaculture (Tiersch and Hargreaves, 2002; Costa-Pierce, 2010; Quigley and Baines, 2014). Sebastian Belle, Executive Director of the Maine Aquaculture Association, offered practical advice gained from years of experience:

> "Over the last 20 years, we've learned that it takes basic common sense, hard work, and a lot of time to win the social license to operate… You'll never get 100% acceptance, but if you can get locals to feel that it is "their" neighborhood farm, by sharing holiday seafood, becoming a part of their lives, helping them to be familiar with operations, they can change their attitudes. It doesn't happen with outside lawyers or environmental groups who come to town for their own agenda, with no vested interest in finding solutions. We talk directly to the people who are local and close to us, and avoid gatekeepers and external stakeholders… You're only as good as your last failure, so admit your mistakes and learn from them. … Get to know the community and your audience, and talk to them… The best thing is to be good at listening to people. All concerns are legitimate by definition. Listen to every one of them, respond to every one of them. Always follow through. Never mislead or be evasive. Be polite. Avoid being defensive. Form strategic partnerships. Communicate, use visual aids, show what a farm looks like to dispel fear of the unknown. Do your homework: find out what to do to make the community, the locals, comfortable with aquaculture." (Thomas, 2011).

Despite the recognized challenges for the aquaculture industry of working with critics, Tiersch and Hargreaves (2002) argue that aquaculturalists and environmental advocates share values at the heart of most issues and that "the best approach to dealing with advocacy groups is to devote effort in gaining a strong personal understanding of the relevant issues, and to be proactive in addressing problems and communicating solutions."

5. *Reform governance*

Ultimately, political challenges to U.S. marine aquaculture cannot be overcome solely by arguing more effectively. It will also require reforming governance so that leasing and regulatory policies are based on consideration of both costs and benefits, and accommodate the legitimate interests and concerns of farmers, environmentalists, coastal residents, and other stakeholders. Countries such as New Zealand and Norway used stakeholder engagement to set up efficient permitting processes for marine aquaculture in a way that addresses environmental and social issues (New Zealand Aquaculture Council, 2006; Norwegian Ministry of Fisheries and Coastal Affairs, 2009; Engle and Stone, 2013; Department of Fisheries and Oceans Canada, 2014). U.S. aquaculture advocates need to learn more about how they have done so and to give thoughtful consideration to new forms of governance based less on confrontation and more on marine spatial planning and consensus (Cicin-Sain et al., 2001; Costa-Pierce, 2010; Organization for Economic Cooperation and Development, 2014). Rayner (2008) suggested that reform of aquaculture governance should include "the creation of more sophisticated aquaculture policy networks," "more use of tools of self-regulation," and more "open coordination and benchmarking."

Several of these approaches have been implemented or are underway in the United States. For example, the design of Maryland's oyster leasing and oyster sanctuary programs included a report by an Oyster Advisory Commission, coastal spatial planning to identify suitable sites, and "one stop" permitting for state and federal permits coordinated by the Maryland Department of Natural Resources. In Maine, state agencies, industry associations, the University of Maine, and other groups have collaborated to foster aquaculture development. Components include state legislative funding and state bond issues, a university graduate program in aquaculture, university finfish and shellfish research stations, co-location of aquaculture research with USDA's Agricultural Research Service, Sea Grant extension, training programs, business incubators, community development funds, and relatively simple and expedited permitting for experimental operations.

State and regional shellfish initiatives inspired by NOAA's National Shellfish Initiative have brought together local, state, and federal agencies, industry, shellfish restoration NGOs, and others to identify priorities and to execute specific actions to get more oysters, clams, and mussels into coastal waters through commercial and restoration projects. Washington, California, Oregon, and Connecticut have launched shellfish initiatives. The Washington Shellfish Initiative resulted in the first shellfish permits issued by the state and Army Corps of Engineers in seven years, design of a streamlined federal and state permit process for shellfish farms, and new funding for ocean acidification research appropriated by the state legislature (National Marine Fisheries Service, 2013).

After 15 years of planning and debate, federal agencies are moving to set up a coordinated process to

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permit fish and shellfish farms in federal waters for the first time. A NOAA rule to implement the Gulf of Mexico Fishery Management Plan for Offshore Aquaculture was issued on January 13, 2016. Concurrent with the rule making process, the federal agencies that issue permits for offshore aquaculture (the Army Corps of Engineers, EPA, and NOAA) are working on a coordinated process to issue permits for aquaculture in the Gulf of Mexico under the aegis of the federal Interagency Working Group on Aquaculture. Three mussel farms in federal waters, two off Massachusetts, and one off California received permits from the Army Corps of Engineers in 2014 and 2015 (Shekhtman, 2014; Salem State University, 2015). Also, Rose Canyon Fisheries, Inc. applied for Army Corps of Engineers and EPA permits in late 2014 to farm fish in federal waters off San Diego, California (Leschin-Hoar, 2014). Rose Canyon, Inc. has reached out to state, federal, nonprofit, and university partners to design the venture (Aquarium of the Pacific, 2015).

Although some progress has been made on improving regulatory efficiency, the regulatory process and the factors that prolong permit applications (opposition from landowners, eNGOs, or others; delays at regulatory agencies; and legal proceedings) or create regulatory uncertainty (such as lack of clarity on permits in federal waters) are still among the greatest obstacles to the expansion of marine aquaculture in the United States. President Obama, responding to stakeholders' concerns, listed improving permit efficiency for shellfish farming as one of eight oceans priorities in June 2014 (The White House, 2014). The Administration's National Ocean Policy Implementation Plan (National Ocean Council, 2013) includes several directives on improving permit efficiency for aquaculture. Regional or bay-wide planning to identify and pre-permit suitable areas for aquaculture, regional environmental impact analyses to satisfy National Environmental Policy Act requirements (rather than permit-by-permit environmental impact statements), greater use of general permits by the Army Corps of Engineers (quicker permit processing for proposed projects that meet certain guidelines), and a coordinated permit process for federal waters are among the actions that may speed up permitting without compromising government marine stewardship mandates.

Conclusion

The aquaculture community in the United States is aware of the political challenges facing domestic marine aquaculture. They are using the five broad strategies outlined in this article to address these challenges. They and the global drivers reshaping aquaculture are gradually changing the old political paradigm of "aquaculture is a problem" to "aquaculture is part of the solution." The 8% per year growth of U.S. commercial marine aquaculture since 2008 reflects and is likely contributing to increased support for marine aquaculture.

Although environmental considerations must always be evaluated and addressed, known environmental issues have largely been resolved. There is both measurable and anecdotal evidence of the benefits of U.S. marine aquaculture as more people are employed in the sector, marine aquaculture production increases, the nutritional benefits of seafood are recognized, and the demand for local food increases.

The aquaculture community is working with partners in interest groups previously opposed to aquaculture to find win-win solutions: jobs for displaced fishermen, co-marketing of wild and farmed local seafood, recognition of the industry's improved environmental performance and ecosystem service benefits by eNGOs, shellfish farmers and eNGOs collaborating on shellfish restoration, and use of gear types and siting to avoid viewscape and recreational conflicts. The aquaculture community is also organizing and engaging in outreach and political action. Examples include the Shellfish Caucus in Congress, the Coalition for U.S. Seafood Production, lobbying by aquaculture associations, and state shellfish initiatives. Mobilizing political support for domestic aquaculture from consumers and a wider public will continue to be a challenge: the supermarket shopper has less at stake than interest groups opposed to aquaculture.

Efforts are also being made to reform aquaculture governance. Maine (aquaculture development initiatives), Washington State (shellfish permitting), and Maryland (new oyster leasing program) are among the states improving the efficiency of permitting within the context of stewardship responsibilities. At the federal level, the NOAA Rule for the Fishery Management Plan for Offshore Aquaculture in the Gulf of Mexico is a critical step toward the first coordinated federal regulatory framework for aquaculture in federal waters.

Developments during the past ten years in Maine provide examples of what can be done to grow U.S. marine aquaculture: support from governors, the state legislature, and Congressional delegations; issuance of state bonds; the expansion of a university aquaculture program at the University of Maine along with coastal finfish and shellfish research facilities; innovative permitting; working waterfront collaboration with fishermen; technology transfer (including three Sea Grant extension agents dedicated to aquaculture); community and nonprofit financing; federal funding for finfish research facilities; the awards of federal grants to launch seaweed farming; and a 2014 National Science

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Foundation award to the University of Maine and University of New England (a $20 million aquaculture grant partly used to fund the next generation of graduate students and associated research). Over 600 people attended the Northeast Aquaculture Conference in Portland, Maine in January 2015. Half of the conference participants were under the age of 40 (author's observation) and included sons and daughters of fishermen engaged or seeking to engage in aquaculture. Salmon farming and processing in Maine has been revived by Cooke Aquaculture and production is back to historical levels. The dockside value of Maine's aquaculture production was reported as $57 million in 2013 by USDA (USDA, 2014); the Maine Aquaculture Association puts the figure at $100 million (Sebastian Belle, Maine Aquaculture Association, personal communication).

Despite these advances, much remains to be done. The potential production and ecosystem service benefits of marine aquaculture remain largely untapped in the United States, as noted in a FAO report (Kapetsky et al., 2013) and by others (Nash, 2004; Corbin, 2010; Wright, 2015). Although shellfish farming and rebuilding of oyster reefs provide food, jobs, storm protection, and fish habitat and water quality benefits, obtaining permits for shellfish farms and restoration sites remains difficult in some states and localities. Although the United States could greatly increase its production of finfish using a tiny fraction of our coastal and offshore marine waters, opposition from coastal landowners and fishermen deters U.S. seafood companies from submitting permit applications, and farmed salmon remains on the avoid lists of some environmental NGOs and aquariums (Stilts, 2014), despite the resource efficiency and environmental improvements made in salmon farming. Finfish, shellfish, and algae culture in federal waters is just getting started, and government aquaculture budgets and science and research programs to support the growth of commercial and restoration aquaculture are still small. Investors remain skeptical and are likely to seek supply elsewhere until business conditions for marine aquaculture improve in the United States.

Nevertheless, it seems likely that progress in overcoming the political challenges to U.S. marine aquaculture will gradually continue. The reality is that aquaculture provides an ever-growing share of both global and U.S. seafood consumption. The more Americans understand and appreciate the benefits of domestic aquaculture, the more they are likely to accept and embrace the idea that we should farm seafood in U.S. marine waters.

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