POLICY MEMO

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Advancing Regenerative Ocean Farming in the U.S.

URBAN OCEAN LAB

By Madeleine Traynor, Lauren Linsmayer, Margaret Morrison, and Lara Croushore.

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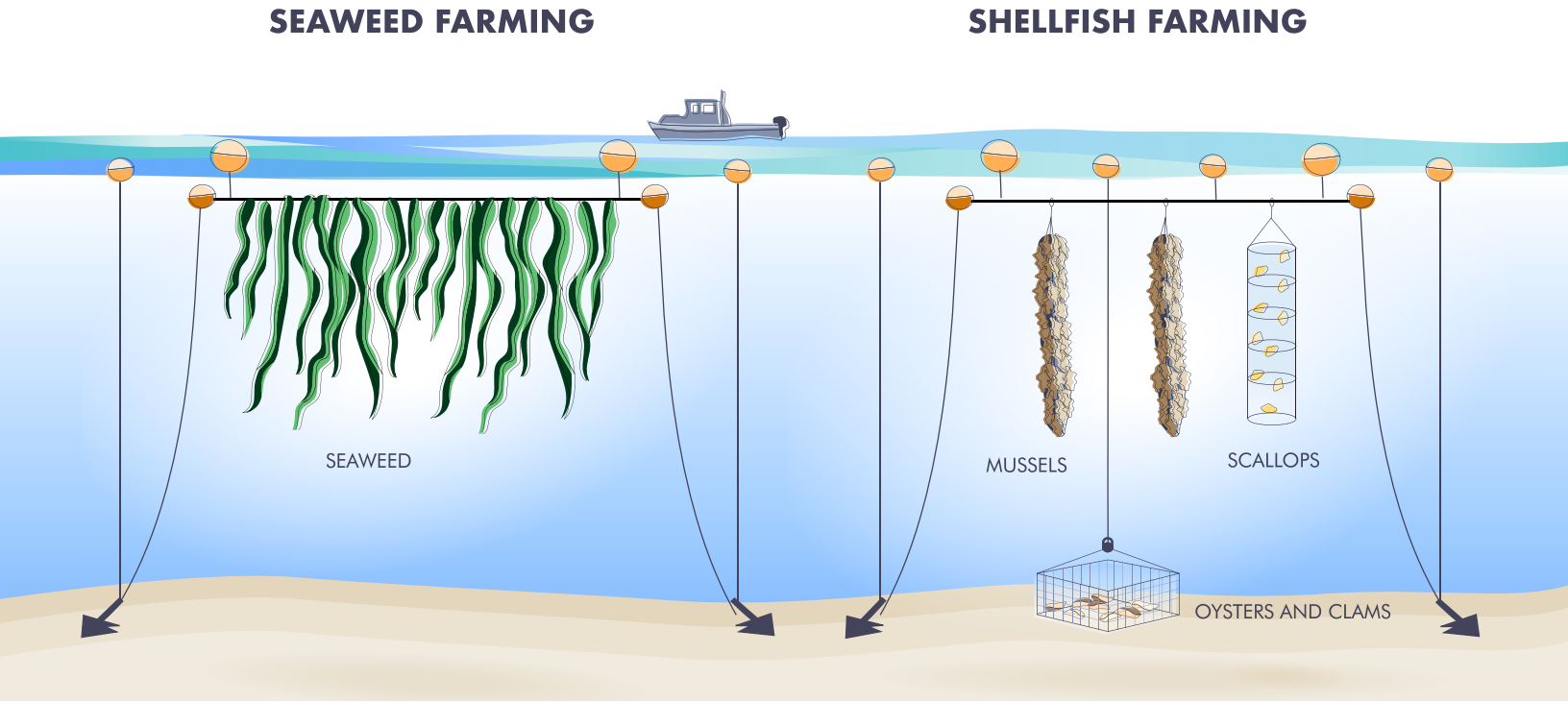
BACKGROUND

Regenerative ocean farming[1] is a climate-friendly model of aquaculture where seaweeds and/or shellfish are grown in a way that requires no freshwater, feed, or fertilizer. Expanding seaweed and shellfish farming in the U.S. can create jobs and wealth for coastal communities, and provide an opportunity for fishers to diversify their income. Regenerative ocean farms have the potential to increase local food security and nutrition by supplying a sustainable source of seafood rich in protein and nutrients. Farmed kelp and seaweed canopies can help dampen wave energy and protect coastlines from erosion and coastal storms. Regenerative growing practices can help improve coastal water quality and increase local biodiversity: Seaweed and shellfish can absorb excess nutrients (such as nitrogen, phosphorus, and carbon), and help to mitigate harmful algal blooms, deoxygenated dead zones, and local ocean acidification. Farmed seaweed and shellfish could also help mitigate climate change by absorbing carbon, though further research is needed on their long-term storage potential. In the future, farmed seaweed could possibly help to reduce our dependence on fossil fuel-based products via bioplastics and biofuels, though additional research is needed.

The U.S. has considerable potential to increase aquaculture production; seaweed production in the U.S. is the fastest growing aquaculture sector. Maine and Alaska are the leading producers of edible seaweed, contributing to more than 85 percent of the domestic supply.

In Maine, the number of active Limited Purpose Aquaculture (LPA)[2] licenses increased from 44 in 2007 to 804 in 2021. In Alaska, commercial farmers have increased production 30-fold in the last five years (from an estimated 18,000 to 570,000 wet pounds). Globally, a fully scaled regenerative ocean farming industry has the potential to generate 50 million direct jobs and 100 million associated jobs. Despite this potential, ocean farmers in the U.S. face challenges in establishing and operating farms. And growing the regenerative ocean farming industry as a whole will require enabling policies and programs, as well as further research on potential benefits and negative impacts.

It is important to acknowledge that regenerative ocean farming, like any form of aquaculture, can have negative impacts including trampling and/or shading native habitats, marine debris, microplastic pollution, marine species entanglement, and the introduction of invasive species. As the industry expands, it will be increasingly important to use farming methods that reduce potential risks and negative environmental impacts. Responsibly growing the regenerative ocean farming industry requires a thoughtful, balanced, and precautionary approach that



prioritizes ecological and socio-economic health, minimizes negative impacts, and supports small to medium-sized farms, as well as family-run and minority-owned businesses.

In this memo, we examine some of the barriers, knowledge gaps, and potential impacts of the regenerative ocean farming industry in the U.S., and make recommendations at the local (county, city, municipality, and town), state, and federal levels to address these challenges and research needs. While we focus primarily on shellfish and seaweed farming in state waters (up to three nautical miles from shore, in most places) we also discuss the potential for expansion offshore (from state waters up to 200 nautical miles from shore). This memo and its recommendations were informed by interviews with 65 stakeholders from 45 organizations across industry, government, academia, and the nonprofit sectors, as well as a literature review.

CHALLENGES AND RESEARCH NEEDS

Supporting the growth of the regenerative ocean farming industry requires policies, programs, and investment designed to help address key challenges facing ocean farmers and the industry, as well as research needs on the potential positive and negative environmental impacts of seaweed and shellfish farming.

Challenges facing ocean farmers

Complex permitting process

Permitting and regulatory processes can be complex, making entry into ocean farming confusing and costly to farmers, and limiting overall industry growth. Operating shellfish and seaweed farms involves two types of authorization: a lease for the farm site, and permits for structures and/or modifications to the seafloor. The kinds of permits required vary depending on the location, type and scope of activity, and the potential for environmental and social impacts, and involve multiple agencies across all levels of government. At present, almost all shellfish and seaweed farming is done in state waters, therefore, jurisdiction over ocean farming is largely managed at the state level. This results in regulations that vary from state-to-state. In 11[3] of the 23 U.S. coastal states, local governments also have some level of permitting or leasing authority. The federal government also requires various permits for seaweed and shellfish farming. Poor coordination between permitting agencies combined with inadequate staffing can slow processing times and create bottlenecks. Taken together, in some states, like California, at least 11 agencies (state, federal, local and tribal authorities) can be involved in the permitting process and it can take up to five years to complete (see diagram below). Nevertheless, interest in ocean farming is increasing: In 2022, the state of Alaska received 20

CALIFORNIA'S PERMITTING AND LEASING PROCESS IN STATE WATERS, AT A GLANCE

The current permitting and leasing process in California's state waters is multi-phased and complex, and can vary based on species and location. This diagram[4] outlines some of the steps, requirements, and agencies that can be involved in applying for permits and leases.

PROCESS CAN TAKE UP TO 5 YEARS

GETTING STARTED

First, regenerative ocean farmers need to:

- Contact the State Aquaculture Coordinator
- Talk to their communities
- Understand if local level authorization is needed
- Develop a business plan
- Select a location for the proposed operation

A California Environmental Quality Act (CEQA) study is required to identify and mitigate the farm's potential environmental impacts. This can cost farmers anywhere from $25K to $500K.

LOCAL AUTHORITIES

In some areas, like the Port of San Diego, local entities have jurisdiction over processes that would normally be handled by the state.

STATE AGENCIES

- Fish and Game Commission
- California Department of Fish and Wildlife
- California Coastal Commission
- California State Lands Commission
- California Department of Public Health
- California State Water Resource Control Board
- California Regional Water Quality Control Boards

FEDERAL AGENCIES

- NOAA National Marine Fisheries Service
- U.S. Coast Guard
- U.S. Army Corps of Engineers

TRIBAL AUTHORITIES

Tribal authorities should be engaged early and often. CEQA guidelines require communication and consideration from tribes (both federally recognized and not) throughout the process.

AT LEAST 11 AGENCIES CAN BE INVOLVED

applications[5] for seaweed and shellfish farms—the most applications submitted in a single year in the last 17 years.

Limited financial assistance

There are several costs associated with starting and operating an ocean farm, including purchasing equipment (such as boats and gear); permit and lease fees; insurance premiums; and ongoing investments in equipment, seed(s), processing, and marketing. The total cost to farmers varies by region. For shellfish farmers, depending on the state, the application process can cost between $25 and $1,500; rent can cost between $1.50 and $1,375 per acre; and lease terms can range from one year to an indefinite amount of time. Limited awareness and/or availability of financial incentives (such as loans, grants, and crop insurance) can create a barrier to entry for new ocean farmers and limit expansion of existing farms. Federal funding programs largely support land-based agriculture, and ocean farmers are not always eligible to receive assistance through these programs. Payments for ecosystem services[6] (such as Maryland's Water Quality Trading Program that gives oyster farmers credits for sequestering nitrogen and phosphorus) have the potential to provide additional income for farmers. However, further research is needed on connecting the environmental benefits of regenerative ocean farming to market-based instruments, and to understand the economic impact that payments for ecosystem services may have on the industry.

Difficulty with site and species selection

The process of site and species selection for regenerative ocean farms can be challenging, given the range of considerations to be taken into account and the need to conduct environmental impact assessments. Site selection considerations include assessing potential interactions with other ocean users (such as commercial fisheries and shipping routes); the biological and physical conditions necessary for species cultivation (such as water temperature, salinity, and water quality); the potential impacts on native species (such as from shading or the introduction of invasive species); and the proximity of an ocean farm site to onshore facilities to process and distribute their crops. In Alaska, for example, farmers must select a site that has good oxygen exchange and flushing, adequate salinity (above 28 parts per trillion (ppt)), adequate temperatures (to prevent problems such as contamination from Vibrio bacteria or to lower the probability of winter icing), and is at least 300 feet from any anadromous waters[7] (such as where herring spawn), among other considerations.

Regulations for sourcing seed and broodstock[8] can also be complicated, vary state-by-state, and differ for shellfish and seaweed species. For example, states vary in their restrictions on importing seed from out of state. This can create a challenge for ocean farmers, which can be compounded by a lack of access to local nurseries and hatcheries. In New Jersey, imported shellfish larvae, seed, or broodstock must receive approval from the Commissioner of the New Jersey Department of Environmental Protection (NJDEP) before being planted in state waters. In Alaska, shellfish seed imported from out of state must come from a facility that has received a seed source certificate from the Alaska Department of Fish and Game (ADF&G). And while regulations are more established for shellfish nurseries and hatcheries, more research is needed for the seaweed industry to better understand the circumstances under which the introduction of non-native strains could be a concern.

Need for training and workforce development programs

As the industry grows, there is a need for more training and workforce development programs for prospective and established farmers. Programs are needed that offer hands-on training on establishing and operating an ocean farm (including site and species selection; planting, harvesting, processing and handling crops; and operating and maintaining equipment); navigating permitting and regulations; connecting with supply chains; marketing and sales; developing sustainable business plans; and more. With the proper training and resources, regenerative ocean farming for kelp can be a lucrative countercyclical business, for example, for lobster fishers seeking additional income during winter months. While estimates vary, one study found that fishers who farm kelp in the off season can realize an estimated eight percent return on investment after three years, and earn $13.50 per hour greater income as compared to other off season jobs.

Need for greater worker protections

To responsibly grow the industry, regulators must ensure safe working conditions and livable wages. Shellfish and seaweed farming requires physically-demanding work in often challenging conditions, which poses a risk for occupational safety. This is compounded by climate change (which will make weather more extreme) and a lack of affordable housing and immigration policies (which can preclude workers from taking jobs in certain areas). While some protections are in place, such as workers' compensation programs (which aim to protect

workers injured on the job), many states exempt agricultural and aquacultural workers from participating in these programs, and foreign aquaculture workers in the U.S. are not always covered by workers' compensation or informed of their eligibility.

Public opposition

Public misconception or bias against seaweed or shellfish farming can create conflict within coastal communities. Social license to operate remains a challenge, frequently resulting from "Not-in-My-Backyard" (NIMBY) perspectives among coastal landowners. Objections from coastal landowners, whose concerns can be unfounded, can sometimes lengthen the permitting timeline for ocean farms. In Maine, riparian landowners[9] within 1,000 feet of a proposed Standard or Experimental lease (or within 300 feet of an LPA lease) can intervene on applications for farm sites. Competition for water access and use—for fishing, recreation, and other uses—can also result in diminished community support for the local expansion of regenerative ocean farming.

Challenges facing the industry

Market asymmetry for seaweed

Despite increased activity in regenerative ocean farming domestically, supply is not sufficient to meet demand, and the U.S. imports more than 95 percent of its edible seaweed. Research and investment are needed to increase domestic production of seaweed-based food products using native species, such as sugar kelp. Beyond being a food source, there are many potential uses for seaweed—such as for cattle feed, fertilizer, biofuels, and bioplastics. However, challenges remain that impact U.S. producers'[10] ability to increase supply, such as a lack of safe long-term storage, a lack of biorefineries, as well as a need to increase the shelf life of local seaweed species beyond the short harvest season. As seaweed production expands across the U.S., it will be important to ensure domestic supply can keep pace with increasing demand.

Loss of working waterfronts

Ocean farmers are losing access to working waterfronts due to increased development and competition for coastal real estate. In Maine, less than 20 miles of the state's 3,478 mile shoreline remains as a working waterfront. This is limiting farmers' ability to access the water and processing and storing harvests, and creating logistical and operational challenges that can limit industry growth.

Need for continued research on environmental impacts and possible benefits

Further research is needed on the benefits of regenerative ocean farming, and the potential positive and negative ecological impacts and trade-offs—such as providing habitat while also possibly altering ecosystem dynamics. While there is an existing body of research for the industry, the environmental benefits of ocean farms are context-specific and can be difficult to monitor, measure, and validate—though efforts are underway. Questions remain as to how farmed seaweed or shellfish species may compete for nutrients with wild species and other organisms (such as plankton), what diseases non-native species could introduce to native habitats, and how genetic contamination of wild stocks can be prevented. There also remains scientific uncertainty around the carbon sequestration potential of farmed seaweed and shellfish, particularly regarding their long-term storage potential.

Need for industry standards and improved food safety regulations

Best management practices are needed for sourcing seed; selecting and designing farm sites; selecting, cleaning, and operating environmentally-friendly equipment; harvesting and processing crops; navigating ocean traffic and safety laws; and monitoring ongoing environmental impacts.

There is also a need for improved food safety regulations that are informed by hyperlocal data on potential hazards —which can vary from place-to-place. While regulations for shellfish are more established, food safety guidelines for seaweed are inadequate and inconsistent, and need to be improved for traceability and quality control, as well as practices for handling, storing, and processing seaweeds —such as air drying, freeze drying, and storage temperatures. The need to improve and develop consistent food safety regulations is increasingly important, particularly as climate change and pollution increase pathogens, such as Vibrio, which is becoming more prevalent as the ocean warms. And while seaweed can improve water quality through nutrient uptake, it can also absorb harmful materials like heavy metals (such as arsenic, cadmium, or lead) and marine biotoxins—which can lead to human illness, if consistently ingested.

Lack of a regulatory framework for offshore aquaculture

With one of the largest Exclusive Economic Zones (EEZ) in the world, the U.S. has a significant opportunity to increase the production of shellfish and seaweed in offshore waters. Offshore waters are regulated by the federal government; aquaculture applicants are required to apply for separate permits from multiple federal agencies[11] for various types of aquaculture activities. As a result of a fragmented federal policy and permitting landscape, there are only two offshore seaweed and shellfish farms in the U.S.—both located off the coast of California. Interest is growing in industry expansion offshore, including efforts by National Oceanic and Atmospheric Administration (NOAA) to develop Aquaculture Opportunity Areas in federal waters. However, the lack of a comprehensive federal regulatory framework has been a barrier. Further, like aquaculture in state waters, there are ecological risks (such as wildlife entanglement, marine debris, and microplastic pollution) associated with growing seaweed and shellfish offshore. More research on the potential negative and positive impacts of offshore ocean farming, and rigorous evaluation of on-the-water pilot projects are needed to inform the development of the offshore industry.

POLICY RECOMMENDATIONS

To address these challenges and research needs and support the growth of the regenerative ocean farming industry in the U.S., we recommend local, state, and federal policymakers take the following actions.

Local recommendations

1. Protect working waterfronts and invest in waterfront infrastructure

Regenerative ocean farmers need access to coastal waters as well as waterfront infrastructure to process, store, and transport seaweed and shellfish products. Coastal cities and towns can help protect and revitalize industrial waterfronts and invest in waterfront infrastructure, including docks and marinas, co-operative spaces with shared equipment (hoists, cranes, and refrigeration), and transportation needs (such as access to commercial vehicles and loading docks).

A working waterfront where ocean farmers and fishers rely on coastal access and infrastructure in New Bedford, MA.

© Massachusetts Office of Travel & Tourism/Mike Estabrook

One avenue for local investment is through public grants for improvements or renovations to waterfront infrastructure. Cities can also protect and invest in waterfronts through local tax policies that generate revenue for waterfront initiatives or by the purchase and acquisition of coastal property, including docks and marinas, for public use. Carteret County, North Carolina recently approved a plan to develop a Mariculture[12] Hub at a county-owned and operated boat ramp that will provide space for communal refrigeration, processing, and gear storage. Through land use planning and zoning, local governments can protect and revitalize infrastructure needed for the regenerative ocean farming industry. For example, the City of Portland, Maine implemented mixed-use zoning to create a more vibrant working waterfront that prioritizes water-dependent and marine-related businesses, with flexibility for non-marine uses to occupy second-floor units of waterfront buildings, which increased income for pier and wharf owners.

Similar to local governments, states can also play a role in protecting working waterfronts. The state of Maine has developed a Working Waterfront Access Protection Program that provides matching funds for businesses, co-ops, nonprofits, and municipalities committed to supporting and providing coastal access to commercial fisheries and aquaculture. Several additional grant and program opportunities exist for both municipal and state governments to protect and invest in coastal infrastructure that supports aquaculture.

2. Provide funding and technical assistance to farmers

Local governments can provide financial assistance and technical support to new and prospective farmers.

Incubator programs, like the Port of San Diego's Blue Economy Incubator, can help accelerate the growth of the regenerative ocean farming industry by providing subject matter expertise, marine spatial planning[13] tools, market access and connections to potential customers, and funding. Additionally, the development of aquaculture parks, such as Deer Island Commercial Aquaculture Park in Mississippi, can provide new farmers with a site for hands-on learning combined with training and support.

3. Create local incentives and programs to increase demand for domestically farmed seafood

Local governments and public institutions (such as schools and hospitals) can adopt procurement[14] policies and use their purchasing power to create demand for locally-farmed seafood. Such policies and practices can also benefit public health and equity by increasing access to sustainable healthy seafood. Local governments can also strengthen connections within the supply chain through programs such as Farm to Institution, which connects growers with government agencies and institutions, and by developing easy-to-use tools that help connect seaweed and shellfish farmers with prospective buyers, such as restaurants and grocery stores.

Local and state governments can also help increase demand for regenerative ocean farming products by funding programs that market seaweed and shellfish products to consumers. For example, by promoting and/or funding community supported fisheries (CSFs),[15] local governments can increase community access to nutritious food while creating a market for locally-farmed seafood. Cities and states can also fund and develop programs like the Alaska Fisheries Development Foundation's Alaska Symphony of Seafood competition, which incentivizes businesses to create products from locally farmed seafood. Programs that help restaurants and chefs to serve shellfish and seaweed products, such as kelp burgers and salsa, would also help increase demand. Supporting collaborations, such as the Maine Oyster Trail (created by the Maine Aquaculture Association and Maine Sea Grant) and the North Carolina Oyster Trail (created by the North Carolina Coastal Federation, North Carolina Sea Grant, and the North Carolina Shellfish Growers Association), can also help to grow and sustain the demand for shellfish in the region by providing oyster tourism experiences along the coast.

4. Build local and regional industry networks

Local governments can help facilitate information sharing by using their convening power to bring stakeholders together to create networks for the regenerative ocean farming industry. The creation of local networks is also valuable for advocacy and information sharing at regional and national levels. For example, the Shellfish Growers Climate Coalition is a group of more than 250 shellfish businesses, across 25 U.S. states and Canada, that has partnered with The Nature Conservancy to collectively advocate for climate policy. At the state level, the State Marine Aquaculture Network was created to be an interstate information exchange in an effort to bring state officials and extension[16] personnel (who provide support to ocean farmers) together to discuss best management practices for aquaculture.

An ocean farmer preparing rope-grown mussels.
©iStock.com/Antonia Cos

5. Educate the public about regenerative ocean farming

To improve public perception of aquaculture and the social license to operate an ocean farm, local and state governments can educate coastal communities about regenerative ocean farming and its potential benefits. Outreach efforts that include a diverse set of stakeholders will be crucial to fostering community support for the successful growth of the industry. Local and state governments can create stakeholder forums and provide opportunities for farmers to discuss their projects and respond to concerns, in order to help reduce opposition and appeals. Alaska supports a 'Talk to Your Community' program, which advises prospective farmers to speak directly with property owners and ocean users about their

farm plans in an effort to reduce potential conflict. Rhode Island requires a preliminary determination meeting that convenes stakeholders and the general public, to share input and concerns on a proposal prior to the submission of a full application. And public demonstration facilities, such as the Maine Aquaculture Innovation Center, can also help to inform the public about regenerative ocean farming.

State recommendations

1. Improve state permitting processes and increase staffing at state agencies

The permitting process is complex, inefficient, and understaffed. As applications for aquaculture permits increase, it is important for state agencies[17] with permitting authority to accommodate this growth with better processes, increased staffing, and state-specific regulations that address the geographic and environmental characteristics of the state. Although most coastal states have established their own permitting process for seaweed aquaculture, some states, like Mississippi, have not, and fall back on federal requirements.

States can improve efficiencies in the permitting process in a few key ways: They can designate a single state agency to coordinate and review aquaculture applications; improve coordination with local and federal aquaculture permitting agencies; create joint agency permits and interagency permit review teams; develop state-specific leasing and permitting portals (like the Alaska Aquaculture Permitting portal); and increase staffing at state agencies. When the state of Alaska added two additional full-time positions at the Alaska Department of Natural Resources and conducted a review of its systems and processes, permit processing time decreased from 572 days to 274 days per application.

2. Create more flexible permit and lease options

States can develop a tiered permitting system that includes an easy point of entry for new or prospective farmers who would like to try out ocean farming without a large initial investment. For example, Maine's LPA pilot license grants the licensee a small area, up to 400 square feet of ocean, to cultivate certain species of shellfish and seaweed. The LPA is a useful stepping stone to Experimental or Standard Aquaculture Leases for farmers that are just getting established. Similarly, Rhode Island offers a Commercial Viability Permit (CVP) for prospective ocean farmers, giving them up to three years to conduct a study to determine if a particular site will be suitable for commercial production. However, for these kinds of innovative permitting models to be successful, adequate funding and staffing at state agencies to process applications will be important.

3. Establish pre-permitted farm sites and provide tools to help with siting

States can conduct regional environmental impact assessments and establish pre-permitted grounds[18] for regenerative ocean farming. These pre-permitted areas should be determined through a science-based approach that takes into account the potential impacts on native habitats, the viability of the farm site for specific crops, and access to necessary waterfront and onshore infrastructure for farmers. Establishing pre-permitted grounds that are suitable for seaweed and shellfish aquaculture would be more efficient than the current permit-by-permit approach, and would save farmers time and money.

For areas that are not pre-permitted, tools to help guide ocean farmers through the siting process, while also helping to support coastal managers and other stakeholders with decision-making have proven successful in some states. These include user-friendly online maps to inform regenerative ocean farming expansion in state waters, modeled after Alaska's Mariculture Map or Connecticut's Aquaculture Mapping Atlas. Maps should be regularly updated and maintained and include information on coastal management plans, native shellfish beds, areas designated for recreational and commercial use, tideland ownership, and land use plans and zoning.

4. Create state-specific industry development plans

States can create and adopt comprehensive, science-based strategic development plans for the regenerative ocean farming industry. The plans should be informed by an interdisciplinary task force of ocean farmers, marine scientists, academia, relevant state agencies and regulators, industry groups, and other stakeholders. Together, the task force should assess the current state of the industry, identify barriers, and set targets for industry growth with a roadmap of key strategies for how to get

there, while providing environmental, economic, and community benefits. For example, the Alaska Mariculture Task Force developed recommendations that informed a five-year Alaska Mariculture Development Plan. Similarly, Massachusetts developed the Mass Shellfish Initiative which formed a task force of key stakeholders to provide guidelines and create a strategic plan to enhance the shellfish industry's economic, environmental, and social benefits in the state.

Task forces should also collaboratively develop best management practices, informed by the global principles of regenerative ocean farming. In Florida, the state worked with the aquaculture community to develop best management practices that benefit both the commercial interests of ocean farmers and efforts to protect natural resources across the state.

5. Create financial incentives and funding opportunities

Providing equitable funding and low-interest loans can make regenerative ocean farming more accessible to new and prospective farmers, especially low-income farmers and fishing families. Tax incentives such as abatements, credits, and/or deductions, for both farmers and producers, could further bolster market growth by reducing tax payments for individual businesses. States can also create revolving loan funds—which are self-replenishing pools of funding—as an opportunity to provide a flexible source of working capital for the regenerative ocean farming industry. For example, the Alaska Mariculture Revolving Loan Fund provides seaweed and shellfish farmers with an opportunity to get a loan for up to $100,000 per year, with a maximum of $300,000 to cover planning, construction, and operation of permitted farms.

6. Invest in a skilled workforce and ensure safe working conditions

As part of their climate and workforce development plans, states can support paid apprenticeship programs that prepare workers for high-quality jobs (that offer livable wages, benefits, and opportunities for growth) while advancing climate goals. To implement these programs, states can partner with workforce development providers, academia, industry groups, and others. The creation of training programs should start with an assessment of workforce needs and training gaps. The Maine Aquaculture Association and the Gulf of Maine Research Institute conducted a systematic workforce needs assessment for the aquaculture industry, culminating in a workforce training strategy for the state. The strategy includes the establishment of regional vocational hubs, an aquaculture apprenticeship program, an Occupation Standards Coordinator role to ensure collaboration with industry, as well as marketing for the vocational training programs. A similar process can be conducted by other states to identify local and regional workforce needs.

There are several public and private programs that can serve as models for regenerative ocean farming workforce development programs, such as the oyster aquaculture certificate program at the Wakulla Environmental Institute and UMass Boston's online course in Sustainable Marine Aquaculture. Maine Sea Grant's Aquaculture in Shared Waters program gives fishers the necessary skills to get started in ocean farming. GreenWave has created the Ocean Farming Hub as an online training and resource center for regenerative ocean farmers across the U.S.

To help ensure access, workforce training programs would ideally be paid opportunities and offer wraparound services—such as funding to subsidize and/or provide childcare and transportation. In California's construction sector, state-certified and industry-funded apprenticeship programs include "earn-while-you-learn" opportunities that combine both class time and paid apprenticeships.

Protections are also needed to ensure safe working conditions for regenerative ocean farmers. States should ensure that aquaculture workers are protected under state workers' compensation programs. Additionally, states should improve their data collection on the regenerative ocean farming workforce and occupational safety, to better inform rules and regulations.

7. Protect the rights of Indigenous communities and subsistence economies

Policies and programs to expand the ocean farming industry must include protections for Indigenous treaty rights while acknowledging traditional cultivation practices. Collaborations and projects such as the Indigenous Aquaculture Collaborative in the Pacific Northwest and the Indigenous-community partnership project funded by Michigan Sea Grant bring together state Sea Grant offices, Indigenous communities, local organizations, and universities to share knowledge and resources to promote Indigenous aquaculture practices. Additionally, creating co-management[19] models between

Oysters being cleaned and sorted by ocean farmers after harvest.
© Matthew Novak courtesy of GreenWave

state and tribal governments, such as Canada's Torngat Joint Fisheries Board, can help create more collaborative management and decision-making practices.

State and federal funding can help support the revitalization of Indigenous cultural practices, food sovereignty, and environmental governance. For example, the Bureau of Indian Affairs (BIA), Northwest Climate Adaptation Science Center, Washington Sea Grant, NOAA's Saltonstall-Kennedy Competitive Grants Program, and the EPA have funded the Swinomish Indian Tribal Community's project of reviving clam gardens. For at least 3,500 years, coastal Indigenous peoples have employed ancient systems of aquaculture—northwest coastal Indigenous peoples constructed clam gardens to optimize clam production, increase species diversity, and fortify intertidal zones.

8. Enhance food safety regulations for seaweed and shellfish

While the U.S. has some of the strongest food safety standards in the world, states can provide additional state- and species-specific[20] guidance and resources to help ensure the health and safety of consumers, and the responsible growth of the industry.

Clear food safety guidance for seaweed, that is based on state- or region-specific potential hazards, can help inform growers, producers, and consumers of industry standards and better ensure food safety. Through a collaboration between Connecticut Sea Grant and the Connecticut Department of Agriculture Bureau of Aquaculture, the state of Connecticut developed the first state-based guidelines on food safety practices for seaweed. These guidelines give both farmers and consumers information on harvesting and processing standards, such as temperature controls and guidelines for a safe growing environment. Similarly, the New York Sea Grant launched the Seaweed Processing and Marketing Task Force that includes stakeholders from industry, academia, and regulatory agencies to share information about food safety best practices, which can serve as a model for other states.

For shellfish, while regulations are more established than for seaweed, states can develop and implement regional plans to help prevent outbreaks of pathogens and bacteria, such as Vibrio. For example, the Maine Department of Marine Resources has a Vibrio Control Plan to reduce the risk of infections caused by oysters or clams.

Federal recommendations

1. Fund research on the climate mitigation potential of farmed seaweed and shellfish

Despite seaweed being increasingly touted as a climate solution, its potential to mitigate climate change depends on its cultivation, production, and end-use. The federal government, particularly NOAA, U.S. Department of Agriculture (USDA), and National Science Foundation (NSF), should fund more research into the carbon sequestration potential of regeneratively farmed seaweed and shellfish, following global research guidelines developed by leading experts.

2. Improve data collection on seaweed farming

The Census of Aquaculture, run by the USDA, collects data on the state of the aquaculture industry in the U.S., which can then be used by decision-makers to shape policies for the industry. However, as of the most recent Census in 2018, seaweeds were counted as a "miscellaneous" aquaculture product. Separating seaweeds into their own reporting

category—and conducting outreach to seaweed farmers to participate in the Census—would improve the availability of data, and enable more informed decision-making and allocation of resources.

In addition to the Census, states have their own state-specific reporting requirements for seaweed harvests. Creating consistent reporting across states, would also improve the availability of data on the industry.

3. Fund federal research and development (R&D) programs for shellfish and seaweed

R&D programs for shellfish- and seaweed-based products —like biofuels, fertilizers, bioplastics, and other new products—could help increase the domestic supply of farmed seaweed and shellfish. The federal government should increase funds to existing federal research programs—such as the USDA's Agricultural Research Service—and set research priorities to address challenges in farm-scale seaweed and shellfish production and market innovation.

The federal government should also create new R&D programs for specific potential end-uses of seaweed and shellfish. For example, the Advanced Research Projects Agency - Energy (ARPA-E) Macroalgae Research Inspiring Novel Energy Resources (MARINER) program is developing innovative technologies and systems to scale macroalgae biomass production as a cost-competitive fuel.

4. Expand federal grant programs for aquaculture to include regenerative ocean farming

There are a number of federal grant programs that support aquaculture, administered by NOAA (such as the Sea Grant and Saltonstall-Kennedy programs), USDA, EPA, and NSF, among others. While some grant programs fund shellfish and seaweed farming, others do not, or they disproportionately fund land-based farming. For example, the USDA's Climate Smart Commodities Program only offered funding to two projects that involve aquaculture, out of the 141 projects in their 2022 funding pool. The federal government should expand eligibility of existing programs to include seaweed and shellfish farming, and dedicate funding within these programs for regenerative ocean farming to ensure parity. To help improve access to grant opportunities, the federal government should create an online platform to help farmers and producers navigate the various grant programs.

5. Increase access to federal loan programs for regenerative ocean farmers

Eligibility for all USDA loan and insurance programs should be reviewed to ensure that regenerative ocean farmers, particularly low-income farmers, qualify for existing low-interest and forgivable loans and crop insurance. Since these programs were developed for land-based agriculture, not all are readily accessible for ocean farmers. An internal task force at USDA could lead the review process and would help to streamline efforts across the many USDA offices that offer programs for aquaculture, such as the Agricultural Research Service (ARS), National Institute of Food and Agriculture (NIFA), and National Resources Conservation Service (NRCS). Other federal agencies also offer loan programs, such as NOAA's Fisheries Finance Program, and funding should be allocated within these programs for shellfish and seaweed farmers. Federal agencies should invest in outreach to ensure that both agency staff and ocean farmers are aware of existing programs.

CONCLUSION

Regenerative ocean farming offers great potential to help meet the growing demand for local, sustainable seafood while creating jobs and offering a range of ecological and environmental benefits. Local, state, and federal policymakers have an opportunity to play a role in shaping the future of this industry, and ensure the equitable distribution of benefits by prioritizing small to medium-sized farms, as well as family-run and minority-owned businesses. This memo addresses many, but not all, of the challenges and research needs for the regenerative ocean farming industry. These recommendations provide a pathway to continue to responsibly grow the industry, while minimizing potential negative impacts and maximizing ecological and socio-economic benefits.

ENDNOTES

1) While terminology varies, Urban Ocean Lab's definition for 'regenerative ocean farming' closely aligns with the practices of restorative aquaculture. Although 'regenerative ocean farming' is a newer term, Indigenous communities have been farming oysters and seaweed regeneratively for thousands of years.

2) Maine's LPA license permits farmers to lease a 400 square foot area for farming certain species of seaweed and/or shellfish for up to one year.

3) Alaska, California, Connecticut, Florida, Hawaii, Maine, Massachusetts, New York, Oregon, Rhode Island, and Washington.

4) Source: GreenWave (Kendall Barbery, Karen Gray, Lindsay Olsen, Krizl Soriano), CA Office of Aquaculture.

5) Including 16 seaweed farms, 2 shellfish farms, and 2 polyculture farms.

6) Payments for ecosystem services provide compensation for actions that increase the provision of ecosystem services, such as removing nitrogen and improving water quality.

7) 'Anadromous waters' are waters that are important for spawning, rearing, or migration of anadromous fish, which are fish that spend most of their life in saltwater, but return to freshwater to spawn.

8) 'Broodstock' is a collection of specimens of a species that produce seed stock.

9) Shorefront property owner.

10) Businesses that use shellfish and seaweed to create products such as biofuels, bioplastics, cosmetics, and food.

11) Federal agencies requiring permits include, but are not limited to, the U.S. Army Corps of Engineers (USACE), the Environmental Protection Agency (EPA), and the National Oceanic and Atmospheric Administration (NOAA).

12) Mariculture is the cultivation of aquatic species in a marine environment.

13) Marine spatial planning is defined as a public process that distributes human activities in marine areas to achieve ecological, economic, and social objectives. The goal of the process is to minimize environmental impacts and conflicts between different ocean users to achieve the sustainable use of coastal and marine resources.

14) The act of sourcing and purchasing goods and services, typically for business purposes.

15) Community Supported Fisheries, such as Thimble Island Ocean Farm, are similar to "Community Supported Agriculture" (CSAs). In CSFs, consumers are able to purchase a share of local harvest or catch in advance, decreasing the financial risk for ocean farmers and fishers.

16) Extension personnel are specialists who provide technical and science-based expertise on topics such as fisheries management, sustainable aquaculture, and habitat restoration.

17) State agencies that lead the permitting process vary by state for both seaweed and shellfish aquaculture. For example, in Alabama, the Department of Conservation and Natural Resources (ADCNR) Marine Resources Division leads shellfish permitting and regulations. In Florida, the shellfish permitting and regulatory process is led by the Department of Agriculture and Consumer Services (FDACS) Division of Aquaculture.

18) Pre-permitting is when government entities with jurisdiction over a body of water undertake the necessary environmental impact assessments and reviews.

19) Co-management is defined as "formal arrangements between the state and community for the management of common pool resources."

20) Seaweed and shellfish food safety should be distinct and considered separately. This is because the risks associated with growing and consuming each species differ.

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