Economic Opportunities, Barriers, and Considerations for Seaweed Farming in California: Informing a Vision for a Sustainable Seaweed Sector

Proceedings from a workshop convened by the California Ocean Science Trust and California Sea Grant

January 2025

CALIFORNIA OCEAN SCIENCE TRUST

Sea Grant CALIFORNIA

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About California Ocean Science Trust

California Ocean Science Trust (OST) is an independent non-profit organization created by California legislation in 2000 to formally bridge the gap between cutting-edge research and sound ocean management. In service of our mandate to provide independent science advice, OST has been playing a proactive role in bridging the science-policy interface by equipping state decision-makers with the latest seaweed aquaculture science and information. By serving as a trusted science-policy intermediary, our goal is to explore the sustainable and responsible seaweed aquaculture sector in California.

About California Sea Grant

California Sea Grant (CASG) is a collaboration of the National Oceanic and Atmospheric Administration (NOAA), the State of California, and universities across the state. CASG's mission is to provide impartial integrated research, extension, outreach, and education to help Californians balance diverse interests that intersect with the coastal and marine environments, and adapt to changing conditions and needs. CASG accomplishes this by collaborating with a range of local, state, regional, national, and international partners to further the acquisition and application of relevant scientific knowledge.

Acknowledgments

Funding for this symposium was provided by the Grantham Foundation and California Sea Grant. We thank all of the workshop participants (see Appendix B) for their engagement throughout the symposium and insights shared that informed this report. We thank and acknowledge Dr. Rod Fujita (Ocean Innovations) for his thought leadership and support of the planning and facilitation of the symposium.

Authors:

Lauren Linsmayer, Ph.D.
Senior Science Officer, OST

Luke Gardner, Ph.D.
Aquaculture Extension Specialist, California Sea Grant

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Symposium Overview & Objectives

California has ambitious climate change, environmental protection, and economic development goals. The potential of seaweed farming to contribute to all three of these goals has garnered increasing attention in recent years, but it is not a large economic sector at present. New markets are emerging for seaweed, such as nutraceuticals, novel human food products, agricultural feedstuffs and biostimulants, bioplastics, and others, with research indicating these uses could contribute to climate mitigation while generating revenue and jobs. Despite new applications for seaweed uses and growing interest from prospective producers and consumers, there is no clear path for how to responsibly implement seaweed farming or processing in California. An examination of the economic opportunities, risks, barriers, and ways to overcome barriers is needed to inform a common understanding and vision for the responsible advancement of the industry.

On December 12, 2024, California Ocean Science Trust and California Sea Grant hosted a symposium in Sacramento, California that brought together government agencies, academic researchers, industry experts (from seaweed farmers to product developers), and investors to explore farmed seaweed's potential role in California's blue economy. The goal of this cross-sectoral conversation was to discuss the economic opportunities and risks associated with seaweed farming in California, identify knowledge gaps and barriers to these opportunities, learn from examples in other parts of the U.S. and globally, and ultimately explore different scenarios for seaweed farming's role as an economic engine for California.

The day was organized into a mix of short presentations, panel discussions, and interactive breakout groups to evaluate potential seaweed farming scenarios in California. Summaries and highlights from these talks and discussions are presented below.

Background: Seaweed Aquaculture Industry and Regulatory Framework in California

Presenters: Michael Graham, Monterey Bay Seaweeds; Randy Lovell, California Department of Fish & Wildlife

The symposium started with presentations on the seaweed farming industry and regulatory frameworks in California to provide context on the current scale, purpose, and regulatory requirements (primarily environmental review under the California Environmental Quality Act). Challenges facing the seaweed farming industry in California were also discussed.

Main takeaways from Session 1 include:

- U.S. cultivated seaweed is not currently competitive in some commodity markets (i.e., biomaterials) with imported dried seaweeds mainly from Asia, where production costs are much lower.
- There are only a small number of active seaweed farms in California state waters and in land-based cultivation systems, including Sunken Seaweed, Monterey Bay Seaweeds, Ocean Rainforest, and Cal Poly Humboldt's ProvidenSea. Most of these farms sell locally and/or to niche food markets.
- Seaweed farming in California is not currently a profitable industry at scale, and therefore companies should consider adding value to their operations, such as through vertically integrated processing of high value products, ecosystem services, and climate adaptation/mitigation. The small scale, high costs, and lack of high value markets associated with California's current set of seaweed farms create challenges for seeking funding for seaweed farming, which may not be seen as a good investment outside of the niche market for high-end fresh seaweed.

- The primary challenges of seaweed farming in California are the complex permitting and regulatory process and high startup costs (in part due to permitting and California Environmental Quality Act (CEQA) analysis preparation). While the timeline is not well defined, it can take multiple years to obtain all of the necessary permits to deploy a farm in the water. The process involves multiple state, federal, and local agencies and requires interagency coordination. Due to challenges of getting a lease and permits in State marine waters, it is more cost effective to do seaweed farming on land (pre-permitted seawater intake) or at ports (pre-permitted open water parcels).
- CEQA is a necessary step in permitting a seaweed farm or amending an existing permit to add species or culture systems/techniques that requires government agencies to disclose environmental impacts of farming actions to the public and to reduce or mitigate significant impacts. As a self-executing statute, there is no single agency responsible for overseeing CEQA. Because oversight of the CEQA process is achieved via the public, CEQA has become a costly and slow process to navigate as agencies must consider not only the environmental impacts of their actions but also potential legal challenges to their determinations. As a consequence of this, a small ancillary industry has grown around providing legal counsel for navigating the CEQA process.
- Possible solutions to approaching the CEQA process more efficiently were discussed, including:
  - ◊ CEQA could be done in a programmatic way. This would consolidate similar seaweed aquaculture projects and analyze environmental impacts together in one CEQA process, which would create cost-sharing.
  - ◊ Create a revolving loan fund as a self-replenishing financial mechanism that provides loans or funding for seaweed aquaculture and is continuously funded through repayments, fees, or other income.
  - ◊ Consolidate costs through private aquaculture business parks, joint power authorities, or other collectives with expertise in CEQA and funds to defray the costs of farmers.

Session 1: Traditional and Alternative Seaweed Uses/ Markets

Presenters: Rod Fujita, Ocean Innovations; Sergey Nuzhdin, University of Southern California; Kayla Barker, Loliware; Sachi Singh, Rootless; Jennifer Smith, Scripps Institution of Oceanography

Session 1 consisted of short presentations on the conventional and alternative uses and markets of seaweed, followed by a panel discussion with the speakers. Speakers discussed the main global seaweed markets (human food, colloid extraction) and largest producers (Asian countries). While seaweed farming has been a significant driver of economic development in many of these countries, it also reported that (under some conditions) seaweed farming has ecosystem benefits, including nutrient removal, carbon sequestration, bioremediation, ocean acidification remediation, and biodiversity enhancement. Potential risks of seaweed farming (competition for nutrients, entanglement in gear, spatial conflicts with other ocean users) were acknowledged. Research and development on seaweed uses has led to a variety of emerging or alternative markets. Markets for nutraceuticals, animal feed, and pharmaceuticals are likely to accelerate over time and perhaps are already outpacing human food markets. Emerging markets for seaweed as a low-carbon feedstock include biostimulants, bioplastics, construction materials, and livestock feed supplementation to reduce methane emissions. Presenters from academic research laboratories and companies at the forefront of developing innovative seaweed products and uses discussed these emerging seaweed products.

Biostimulants: Whole seaweed and extracts have been shown to encourage plant growth and reduce the plant's need for water, but are not considered fertilizers. Research shows that applying giant kelp biostimulants to plants results in a 24% increase in yield, three times more root growth, increased water use efficiency, and soil stabilization. The World Bank identified biostimulants as a promising market for

macroalgae with high probability of success ($2 billion/year), and while it is produced commercially in other countries, it has yet to be commercialized at large scales in the U.S.

Bioplastics: The chemical diversity of seaweed-derived polymers are being investigated to develop a range of bioplastics, from rigid to flexible. Some companies are seeking to reduce plastic waste through developing biodegradable seaweed products such as straws and other utensils. Companies are also in the process of developing seaweed based plastic feedstock pellets that can be used in manufacturing processes in place of conventionally used plastic nurdles.

Nutraceuticals: These products are derived from food sources like seaweeds and provide additional health benefits beyond basic nutrition. While seaweed has been consumed as a human food for millenia, challenges of commercial use include lack of food safety regulations and the inconsistency of nutrients levels (like iodine) in seaweeds (depending on species, growth conditions). In addition, marketing has shown that consumers are less compelled by the sustainability aspect of seaweed-based nutraceuticals.

Methane suppression: The livestock industry is responsible for approximately 14% of global greenhouse gas emissions, mainly due to enteric methane production (from cow burps). Extensive research has shown that the red algae *Asparagopsis spp*. reduces methane emissions by up to 95% when fed to cattle. Use of *Asparagopsis* in animal feed has been approved in Australia and the E.U., but it has not yet been approved for use in commercial systems in the U.S. Feeding trials have commenced in California, and *Asparagopsis* extracts appear to be more effective at suppressing enteric methane emissions than isolated bromophores or other methanogenesis inhibitors. Despite promising research, challenges include scaling production, limitations of cultivation in land-based systems only (due to fragility of *Asparagopsis*), studying potential livestock and human health impacts, small profit margins the livestock feed industry, and getting regulatory approval for adoption.

Main takeaways from Session 1:

- Supply chain challenges with sourcing seaweed for emerging markets: Due to relatively low and unreliable production in the U.S., not many seaweed farmers can supply at the volumes required by manufacturers of seaweed-based products. Some companies are seeking to overcome sourcing issues by diversifying the seaweed species or compounds they use in their products.
- Research and development needs: More R&D is needed to identify alternative seaweed species for methane emissions reductions in livestock, understand the mechanisms of kelp biostimulant action on crops, and develop seaweed derived pellets for bioplastic manufacturing.
- Major barriers to scaling: Scaling seaweed production for innovative markets would be aided by innovating new seaweed-based materials, fostering investment, clarifying regulatory requirements, developing new sensing and modeling tools to assess the environmental benefits of seaweed cultivation, validating claims about seaweed efficacy with research, and ensuring sustainability of scaling through conducting Life Cycle Analysis.

Session 2: Lessons from Seaweed Farming Industries Outside of California

Panelists: Nick Mangini, Southwest Alaska Municipal Conference; Hugh Cowperthwaite, Coastal Enterprises, Inc.; Zach Gordon, Connecticut Sea Grant; Rod Fujita, Ocean Innovations

The goal of Session 2 was to hear perspectives from seaweed farming industries in regions where the industry has experienced more growth or maturity in order to learn what has contributed to the economics of those industries and explore lessons that could be applied in California. Panelists represented perspectives on the industries in Alaska, Maine, Connecticut, and internationally. The panelists discussed

factors that led to the development of the industry in their regions, areas of economic success, barriers to creating economic viability, building economic resilience, and advice for the development of the industry in California.

Alaska: Alaska's seaweed farming industry is a growing sector aimed at tapping into Alaska's vast coastline to cultivate kelp and other seaweed species for various markets. The expansion of the industry has benefited from support from the state government, federal funding, and availability of grant funding. However, several challenges hinder its growth. The remote coastline of the region complicates product distribution, while reliance on diesel for power generation makes drying and processing kelp costly. Land-based aquaculture is also prohibitively expensive due to the infrastructure required for seawater intake. Regulations requiring seed collection within 50 miles of farms add logistical complexity. Additionally, the recent consolidation of the seaweed farming sector has reduced the number of processors, further impacting profitability. Aggregating cultivated kelp across farms to ensure a reliable supply and developing clear market pathways could help overcome these barriers and boost the industry's viability.

Maine: The seaweed industry in Maine has been around for about 15 years, having developed through technology transfer from other parts of the world. The diverse and long coastline is home to 35 active leases and 15 awaiting approval. Maine has a limited purpose aquaculture (LPA) permit, which has a lower bar to entry for testing out small scale farms up to 400 square feet. The industry primarily consists of small (a couple of acres) owner operations farming native sugar kelp. Seaweed farming is seen as a way for lobstermen to diversify their income sources, and an alternate income stream in place of traditional fisheries that may have been overfished or impacted by climate change. Two larger companies are buying and processing most of the seaweed in Maine, which has supported product and market development. While production methods have been established, challenges that persist include finding consistent buyers of seaweed.

Connecticut: The industry in Connecticut has seen rapid growth in the last couple of years, which produces approximately 70,000 pounds of seaweed annually across 12 permitted farms (11 active). The state pioneered sugar kelp farming. Historically, farmed kelp has been used as a food product, but the state is exploring other uses such as biostimulants or extracting polymers for food additives and bioplastics. Seaweed farming is usually not a full-time occupation for practitioners; it is treated as a supplemental crop to diversify agriculture to increase resilience to uncertainty and disasters. Recently, there has been a harvested seaweed surplus due to challenges with selling the wet product into markets. Other challenges to expanding the industry include scalability, seed production and availability, lack of food safety regulations, and lack of permitting and regulations for newer seaweed products.

International: The global seaweed industry is well-established and based on hundreds of years of traditional knowledge. Most seaweed farms are located in Asia, and most are small-scale producers; however, some large-scale farms exist in China. Seaweed farms currently focus mostly on export-based commodity markets for food and colloids. Processing is concentrated in China, South Korea, and Indonesia with some in North America and Europe. Issues being faced include disease, climate change impacts, and low wages creating a "poverty trap" for small-scale producers. Efforts are underway in countries like India, where incentives encourage new entrants to the sector, and Indonesia, where an innovation center is exploring profitable business models and novel applications for seaweed. These initiatives highlight the potential for growth and diversification within the industry, despite ongoing obstacles.

Main takeaways from Session 2:

- While Maine, Connecticut, and Alaska have expanded seaweed production in the last 15 years, barriers to scaling their industries persist, including from a lack of centralized processing, regulatory uncertainty, and lack of market demand.
- Diversifying the species cultivated or supplementing seaweed farming with fishing or other industries can create more financial stability for seaweed farmers through diversifying income streams. Multitrophic aquaculture (cultivating seaweed with other species like shellfish) can also offer additional benefits to the ecosystem.
- Social license is critically important to cultivate for gaining public acceptance for seaweed farming, especially in populated places or for larger operations.

Session 3: Evaluating Seaweed Farming Scenarios for California

Session 3 was designed as an interactive session to discuss potential farming scenarios to aid in identifying opportunities, barriers, and science/information needs to achieve different potential development pathways for a seaweed farming in California amongst symposium participants. Organizers presented three hypothetical "scenarios" for small-scale, mid-scale, and large-scale seaweed farming companies, and three randomly assigned groups were each charged with evaluating at least one of the scenarios. Scenario descriptions evaluated by participants can be found in Appendix C. Each scenario included information about the desired production scale and market(s), and available resources (funding and human resources).

Each group discussed and developed lists of pros and cons for the scenario(s) as it relates directly or indirectly to economics with special consideration given to solutions that can be improved at a California level to help develop seaweed aquaculture in the state. The following results of the scenario evaluations summarize the strengths, weaknesses and potential solutions for developing hypothetical companies - Company A (small-scale), Company B (mid-scale), and Company C (large-scale).

Company A - Small Scale Seaweed Farm Selling to Local Markets:

Strengths	*Weaknesses*	*Solutions*
• Developing culture systems on land would be an easier permitting process, more controlled environment for product consistency, and simpler infrastructure • Cost efficiency: High value product that can be produced in a small amount of space • Access to accelerator funds • Competitive: Fresh product may make business more competitive with international markets • Potential to scale	• Time and cost of potential permits, such as seawater intake, broodstock collection permits • Lack of knowledge about seaweed aquaculture • Lack of information about the customer base • Too small of a return on investment (ROI) to receive venture capital • Limited coastal space and infrastructure • Niche restaurants do not represent a huge market • Limit to scalability	• Co-locating the farm at a site with pre-permitted seawater intake or business/research park to lower financial barrier • Co-locating the farm near the niche markets they intend to sell to • Understand the customer base • Reduce the permitting and regulatory burdens • Create local training in aquaculture • Getting mentors/advisors to help them deploy more quickly

• Small scale and tank-based likely would not have to source seed	• Lack of clarity around food safety regulations and burden of testing on farmer	• Small business loan • Diversify income streams • Create a nonprofit seed bank to supply seed

Company B - Medium-Scale Seaweed Farming Selling to Regional Biostimulant Market:

Strengths	*Weaknesses*	*Solutions*
• Potential access to carbon finance • Potential for gaining institutional support in the region • Could yield more carbon benefits by being in water • Could be more profitable than small-scale farm due to business model • Potential to locate the farm in the Southern California Bight Aquaculture Opportunity Area	• Complexity and cost of developing biostimulants • Need for processing facility like cascading biorefinery • Possibly lower social capital than small-scale farm • Might require their own hatchery • Ensuring nutrient availability • Regulatory and permitting costs • Lack of skilled workforce • Lack of open-source research and potential intellectual property (IP) risks for any discoveries they make	• Take a phased approach to scaling from pilot- to mid-scale to learn about the market • Basic research to validate biostimulant trials (could access USDA funds) • Explore diverse funding • Cooperative or franchised model • Vertically integrate the operation • Conduct research & development • Use robots to lower production costs • Diversity seaweed uses using a refinery

Company C - Large-Scale Seaweed Farm Selling to Pharmaceutical Industry:

Strengths	*Weaknesses*	*Solutions*
• Established market (pharmaceuticals) that is large scale • Job creation • Potential for carbon credits and investors that are seeking that type of environmentally-friendly investment • Vertically integrated operation creates control over raw materials and upstream manufacturing • Potential to market a green	• Lack of certainty in demand from the pharmaceutical industry • Risks of replacing a specific ingredient in a pharmaceutical and need to prove the same functionality • Burden of sufficient scientific evidence and clinical trials to meet claims and skee federal approval • Risks associated with vertical integration	• Use sporeless kelp to reduce risks of introducing a genetically selected strain into the environment • Diversify into different products or cultivating multiple species • Partner with workshop development programs or the state to create jobs • Create regulatory certainty, which will increase likelihood of securing investments

product that is replacing a conventional input	• Site selection limitation for large-scale farm • Lack of social license	• Create state funding opportunities like matching grants • Focus groups or test marketing to improve marketability

Each group reported on their assessment of the strengths, weaknesses, and potential solutions for the scenarios they evaluated, and the organizers facilitated a large group discussion on the overall takeaways and themes toward informing a statewide economic vision. To note, there was some discussion about the lack of clear definitions for what constitutes "small," "medium," and "large" scale seaweed farms. Despite the lack of clear scale distinctions, different scales of production have different advantages and disadvantages. Participants generally agreed that small- and medium-scale farms seem like the most likely path for successful seaweed aquaculture development in California state waters until well defined markets emerge for seaweed based products. While small-scale farms are closest to the status quo in California and nationally, and require lower startup costs than larger farms, they will likely need institutional/government support and resources in order to be profitable, as operations at this scale still face many of the same permitting costs as larger scale farms but will have lower financial return on investment. These smaller scale farms are also likely to be limited in market penetration initially without the development of cooperative styles of resource and product pooling. Small-scale farms should tailor their production to meet consumer demand and market needs, as opposed to focusing on production and hoping to find markets later.

Participants generally considered that medium-scale farms supplying to regional markets could be viable for development in California. An example that was discussed as a readily apparent opportunity was using farmed seaweed to meet an existing market need for seaweed-based biostimulants. Cultivated seaweed could be used to replace existing wild-grown seaweed biostimulants but also expand the market.

Larger scale farms may be possible in federal waters but would require established markets that could support large-scale production. Overcoming the costs to scaling would be difficult without government subsidies and incentives for seaweed farmers (similar to land-based agriculture).

In order to achieve a broader vision for seaweed farming in California beyond the current status quo of evaluating individual seaweed farms, there was discussion of the value of taking a holistic approach to understanding the drivers behind the industry in order to build an industry that can match production/supply with demand. Establishing goals or a vision of the industry could guide efforts to develop the industry such as through subsidies or policy development.

Session 4: Creating an Enabling Environment in California

Presenter: Manjeet McCarthy, Governor's Office of Business and Economic Development

Panelists: Paula Sylvia, Port of San Diego; Jade Clemons, AltaSea at the Port of Los Angeles; Dylan Howell, HATCH Blue; Luke Gardner, California Sea Grant.

The goals of Session 4 were to discuss how California could harness a sustainable or regenerative seaweed farming sector in California and begin to synthesize the previous discussions and insights from earlier in the day. The session began with a presentation on the business development resources currently available to seaweed farmers in California through the Governor's Office of Business and Economic Development (GO-Biz). The office's role is to serve as California's leader for job growth, economic development, and business assistance efforts. The services that may be available to seaweed farms include permit assistance (including

through serving as an arbiter between permitting agencies and the applicant) and small business loans. The goal of direct permit assistance is to increase accountability, consistency, and transparency. Examples of how permit streamlining can be achieved include: working with agency partners to help ease the burden on businesses, and training to create shorter permitting timelines. An example of a consolidated permitting program is CalEPA's, which provides a single point of contact for multiple environmental permits. Other resources and services for small businesses provided by GO-Biz were also discussed.

The session concluded with a panel discussion on creating an enabling environment in California with perspectives from an investment firm, port district, incubator program, and extension program. Panelists discussed how these programs are supporting seaweed farming through funding, development, education, developing social license, and other types of support. Panelists were also asked to reflect on their vision for the seaweed industry in California.

Ports / Harbor Districts: Ports and harbor districts have special jurisdiction over their granted tidelands and economic and sustainability goals that align with supporting seaweed aquaculture. Local governments and harbor districts can take the burden off applicants through undertaking a programmatic Environmental Impact Review (EIR), which involves performing a broad CEQA analysis and pre-permitting for in-water projects. This allows applicants to only have to do project-level CEQA. The Port of San Diego is undertaking a programmatic CEQA process to develop a seaweed and shellfish aquaculture program that will be able to issue leases and Coastal Development Permits directly. The Humboldt Bay Harbor and Conservation District has also pre-permitted sites for seaweed and shellfish farming.

Extension Programs: Extension programs can serve as a helpful connection between industry and academia to support multi-disciplinary solutions to industry challenges. The Aquaculture Extension program at California Sea Grant (CASG) works as a bridge between the academic research and industry worlds to understand how science can help inform and advance the industry. They also fund applied research to help address industry needs through science. CASG additionally provides training programs to support workforce development, including through partnering with community colleges like Mira Costa to provide practical aquaculture training.

Investors / Funders: Investments and funding plays a critical role in the growth and development of the seaweed farming industry by providing the capital and resources needed to scale operations, improve infrastructure, drive innovation, and de-risk investments. Hatch Blue is a global venture and advisory firm dedicated to supporting sustainable aquaculture innovation and development through investments, media marketing, consulting, and providing aquaculture expertise.

Incubator Programs: Incubators programs help startups and early-stage businesses develop their ideas, business models, and products. AltaSea at the Port of Los Angeles supports business innovation and accelerates scientific collaboration for the Blue Economy. They are working on getting a seawater intake permit that can support tenants like seaweed farms; they also keep rent prices affordable to decrease upfront costs. They foster innovation by having partners on site that can fund or support seaweed farmer tenants. Another example is the Port of San Diego's blue economy incubator program, which has supported pilot scale farms Sunken Seaweed and a shellfish nursery.

The panelists discussed their vision for seaweed farming in California, which included providing a framework to grow the industry sustainably, seeing the growth of good jobs to replace those that may be lost with climate change, integrating seaweed into school curricula and society, and creating accessibility and equity in the industry to lower barriers to entry and generate profitability.

Main takeaways from Session 4 on ways to create an enabling environment in California for seaweed farming include:

- Market research is needed to understand alternative markets for seaweed and equip seaweed farmers and companies with market knowledge.
- There is an opportunity for California to leverage its strength in technology innovation and finance to develop, own, and license technology to other regions while also developing and broadening seaweed farming in California.
- A programmatic approach to CEQA for all of California state waters could help provide a more predictable pathway to obtain permits for seaweed farms.
- Improving the public perception of seaweed aquaculture through public facing educational and outreach products would aid in developing social license and increase investor and regulator confidence for seaweed farming.
- Identifying funding and investment models and organizations to support development of the sector could help create a more profitable and sustainable seaweed farming industry in alignment with California's goals.

Conclusion

This symposium highlighted the potential of seaweed farming as a driver of the blue economy while addressing challenges related to climate change, environmental sustainability, and economic development. Key takeaways include:

1. **Diverse Economic Opportunities:** Seaweed farming offers opportunities across traditional food markets and emerging sectors such as bioplastics, nutraceuticals, biostimulants, and methane-reducing animal feeds. Developing regional and international markets would be needed for scaling these opportunities.

2. **Lessons from Other Regions:** Growing seaweed industries in Maine, Connecticut, Alaska, and international markets demonstrate the importance of diversification, government support, access to markets, and innovative financing. These lessons provide valuable insights for adapting strategies in California.

3. **Barriers to Growth:** Key challenges include complex regulatory frameworks, high startup costs, competition with seaweed production in other parts of the world, and a lack of scalable infrastructure in California. Addressing these barriers through streamlined permitting, programmatic CEQA evaluations, and incubator support could enable broader industry growth.

4. **Scalable Production Scenarios:** Small and medium-scale farms were identified as the most viable options for California in the short to medium term, with opportunities to scale up if established markets and supportive policies emerge.

5. **Enabling Environment:** Strategic investments, improved public perception, workforce training, and partnerships among academic, governmental, and private sectors would be needed to foster an enabling environment for sustainable seaweed farming.

Appendix A: Agenda

8:30 AM **Arrivals, Breakfast, Networking**

9:00 AM **Welcome, Charge, and Introductions**
Lauren Linsmayer, California Ocean Science Trust
Luke Gardner, California Sea Grant

Session 1: Economic Opportunities and Barriers in California

9:15 AM **The Seaweed Aquaculture Industry in California**
Mike Graham, Monterey Bay Seaweeds

Regulatory Regime in California: the CEQA Process
Randy Lovell, California Department of Fish & Wildlife
Audience Q&A

9:45 AM **Current/Traditional Uses and Markets of Seaweed**
Rod Fujita, Ocean Innovations

10:00 AM **Short Talks on Alternative Seaweed Uses/Markets**
Biostimulants: Sergey Nuzhdin, University of Southern California
Bioplastics: Kayla Barker, Loliware
Nutraceuticals: Sachi Singh, Rootless
Methane suppression: Jennifer Smith, Scripps Institution of Oceanography
Audience Q&A

10:45 AM **Break**

11:00 AM **Panel Discussion: Opportunities and Barriers of Traditional vs Alternative Markets**
Same panelists as above

12:00 PM **Lunch & Seaweed Product Showcase**

Session 2: What Can We Learn from Seaweed Farming Elsewhere?

1:00 PM **Panel Discussion: Lessons from Seaweed Farming Outside of California**
Alaska: Nick Mangini, Southwest Alaska Municipal Conference
Maine: Hugh Cowperthwaite, Coastal Enterprises, Inc.
Connecticut: Zach Gordon, Connecticut Sea Grant
International: Rod Fujita, Ocean Innovations

Session 3: Evaluating Farming Scenarios in Calfironia

1:45 PM **Seaweed Farming Scenarios Overview**
Luke Gardner

2:00 PM **Table Discssions: Evaluate Scenarios**
Table 1: small-scale, localized farming for niche markets
Table 2: mid-sized farms supplying regional markets
Table 3: large-scale industrial farming
Table 4: OPTIONAL additional scenario

3:00 PM **Scenario Evaluation Results & Visioning**
A lead from each group reports out
Group discussion on scenario results and informing a vision

3:20 PM **Break**

Session 4: Looking Forward: Harnessing a Regenerative Seaweed Sector in California

3:30 PM **Business Development Resources in California**
Manjeet McCarthy, Governor's Office of Business and Economic Development
Audience Q&A

3:50 PM **Panel Discussion: Creating an Enabling Environment, Including Through Investment and Financing**
Paula Sylvia, Port of San Diego
Jade Clemons, AltaSea at the Port of Los Angeles
Dylan Howell, HATCH Blue
Luke Gardner, California Sea Grant

4:50 PM **Closing Remarks & Next Steps**

5:00 - 8:00 PM **Reception**

Appendix B: Participants

Organizers:

Lauren Linsmayer, California Ocean Science Trust
Luke Gardner, California Sea Grant
Rod Fujita, Ocean Innovations

Participants:

Randy Lovell, California Department of Fish and Wildlife
Edie Marshall, California Department of Food and Agriculture
Katie Cieri, California Ocean Protection Council
Manjeet McCarthy, Governor's Office of Business and Economic Development
Kate Uyeda, Governor's Office of Business and Economic Development
Shauna Oh, California Sea Grant
Simona Augyte, California Sea Grant
Brie Lindsey, California Ocean Science Trust
Monica LeFlore, California Ocean Science Trust
Brian Donovan, Cal Poly Humboldt
Sergey Nuzhdin, University of Southern California
Phillip Tahimic, Cal Poly Humboldt
Melissa Ward, Silvestrum Climate Associates
Monica Moritsch, Silvestrum Climate Associates
Thiago Correa, UC Berkeley
Sophia Siegel, Stanford University
Janet Kubler, CSU Northridge
Doug Bush, Ocean Rainforest
Kayla Barker, Loliware
Sachi Singh, Rootless
Gabie Carne, Rootless
Michael Williamson, Cascadia Seaweed
Charli Seyler, Ola Farms
Mike Blakeley, Seagreen Insights
Anisha Jagtap, Marine Biologics
Ismael Montanez, Marine Biologics
Martha Blanchfield, SF Blue Tech
Paula Sylvia, Port of San Diego
Renee Angwin, Port of San Diego
Sarah Donald, Port of San Diego
Jade Clemons, AltaSea at the Port of Los Angeles
Hugh Cowperthwaite, Coastal Enterprises, Inc.
Nick Mangini, Southwest Alaska Municipal Conference
David Lee, Booz Allen Hamilton ARPA-E support contractor
Dylan Howell, HATCH Blue
Lauren Smith, UC Santa Barbara
Michael Graham, Monterey Bay Seaweeds
Stephanie Mitchell, California Assembly Committee on Water, Parks, and Wildlife
Jennifer Smith, Scripps Institution of Oceanography (remote)
Zach Gordon, Connecticut Sea Grant (remote)

Appendix C. Seaweed Farming Scenarios

Company A has read some books and seen some news articles on seaweed farming and wants to transition from their current unrelated aquaculture jobs to growing and selling native seaweed locally in California but are only a 2 person team currently. They are trailblazers in the sector in California and so are largely unique in their business concept with no other similar farms nearby. They want to stay local to where they live and want to manage the farm and sales by themselves at least initially. They don't have any practical experience in seaweed culture but think they have a seaweed product that they can sell fresh locally to niche markets including white tablecloth restaurants. They are thinking that they want to have a land-based tank farm operation initially. The company is thinking that they want to produce around 5-10 tons of wet weight seaweed per year and want to fund it themselves with their personal savings consisting of around $100,000. Please identify the pros and cons of the company's seaweed farming concept as it pertains to economics directly or indirectly and what solutions may be needed to position the company for future success.

Company B wants to grow seaweed in California to supply regional markets across the state. In particular a scientist is part of the founding members of the company and believes they can produce a biostimulant for the organic agriculture sector to promote better crop growth, etc. Due to the novelty of the product, the company isn't sure that their biostimulant will be profitable by itself initially and wants to maximize their outputs by selling additional products from their seaweed in a cascading biorefinery, producing things like bioplastic resins and construction materials. The company has done some basic calculations and thinks they need to grow seaweed in about 500 acres of open water with a staff of around 20 people. The company will be looking for private investors to support this venture as they don't think their idea is palatable for conventional finance organizations. Please identify the pros and cons of this business proposal. What are some economic drivers that would increase the likelihood that this company would be profitable in 5 years?

Company C wants to go big and grow and sell their seaweed into a commodity market. The team can currently extract a compound (at a laboratory scale) that is produced at a particularly high concentration in a California native seaweed that has been genetically selected for high concentrations of the compound. They believe that their product would be useful in the pharmaceutical industry as a gelling agent with superior qualities to existing compounds but need to produce a lot to be able to get initial market penetration. They estimate they would need an open water farm approximately 2000 acres in size that is staffed by around 100 employees. The company is hoping to make the most of their product by also seeking to market ancillary outputs of their seaweed growing operation including selling carbon credits and other potential ecosystem services and climate benefits. The management team wants to seek traditional finance to fund the venture. Please identify the pros and cons of this business proposal. What are some economic drivers that would increase the likelihood that this company would be profitable in 5 years.