

UC San Diego



Could Kelp Aquaculture Have a Future in California? A State  
Policy Briefing Book

Kaira Wallace

Master of Advanced Studies – Climate Science and Policy

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## Capstone Advisory Committee

Committee Chair | Stephen Stohs, PhD | NOAA Fisheries Economist

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Signature

Committee Member | Luke Gardner, PhD | Moss Landing Marine Laboratories and California

Sea Grant Aquaculture Specialist

A solid black rectangular box used to redact the signature of the Committee Member.

Signature

Committee Member | Hunter Lenihan, PhD | Bren School of Environmental Science &

Management

A solid black rectangular box used to redact the signature of the Committee Member.







Signature

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## EXECUTIVE SUMMARY

Seaweed farming is the fastest growing aquaculture industry in the U.S., with kelp accounting for much of the sector. Yet the industry faces a multitude of roadblocks in California that have prevented successful expansion of the industry in productive waters and a wide-open market. The purpose of this policy briefing document is to bring together relevant information about kelp aquaculture in California, to succinctly summarize and analyze it in an accessible way, and to provide a variety of solutions to the barriers the activity has faced thus far. This document can act as a comprehensive guide for those interested in the topic, including, but not limited to, members of the public, state policymakers and decision makers, prospective kelp aquaculture farmers, kelp companies, or other relevant organizations. A StoryMap web page version of this report is also available online that acts as an overarching look at this issue for those more visually inclined. It can be found [here](#).

Kelp aquaculture is an important topic in relation to climate change, ecosystem health, regenerative agriculture, and sustainability generally. Some of the many potential benefits of cultivating kelp in the ocean include local buffering of ocean acidification, absorption of excess nitrogen and phosphate, creation of habitat, carbon drawdown, buffering wave action, and creation of climate resilient jobs. Farming kelp requires no fertilizers, pesticides, or freshwater, and can grow up to 18 inches in a single day under the right conditions. Kelp is already used in a variety of products such as food, fertilizers, cosmetics, bioplastics, animal feed, biofuels, and medicines.

Despite global demand for kelp increasing every year, and states like Maine and Alaska rapidly expanding farm production, California has fallen far behind in the nascent industry. The kelp aquaculture industry in the state faces obstacles such as a complex permitting process, inferior cost-competitiveness, negative social license, absence of marine spatial planning, and limited domestic markets for kelp products. Regardless, many commercial entities are actively pursuing the activity in the state and attempting to overcome these issues.

Action is needed from both state and private entities to bring together the resources necessary to surmount barriers to the industry and capture the many potential environmental benefits of kelp. A combination of cooperation within the industry to work collectively on market development and processing infrastructure along with funding from the state for a kelp subsidy, further research, and an improved permitting system would vastly improve the chances of industry success in California. Future policies should take into account relevant research, best environmental management practices, and local community input. While it is not clear if a prospering kelp aquaculture industry will arise in California, there is tangible interest from multiple types of stakeholders to try to make it happen.

# Could Kelp Aquaculture Have a Future in California? A State Policy Briefing Book

## INTRODUCTION

California is revered for its forward-thinking action on issues such as climate change and environmental protection. The state acts as a national leader, paving the way for ramping up renewable energy sources and investing in decarbonization measures. Such leadership matters because if California were its own country, it would be the 5<sup>th</sup> largest economy in the world (Hughes, 2021). The impacts of the state's choices on climate action, adaptation, mitigation, and environmental protection are felt globally. With California often being proclaimed a leader on environmental policy, there is one area where they fall far behind: kelp aquaculture.

At first glance, kelp aquaculture appears to have little to do with climate change, environmental protection, or resiliency. But cultivating kelp in the ocean has the potential to be an important tool for all those issues. Research has shown some promising benefits of growing kelp; from improving water quality, to providing habitat, to buffering ocean acidification, kelp is proving to be a unique asset for protecting our environment. Kelp also has a diversity of uses, such as food for human consumption, fertilizers, cosmetics, medicines, bioplastics, biofuels and more (Sharma et al., 2016).



*Figure 1: Summary of main uses of kelp*

California, at present, has no ocean-based kelp aquaculture facilities selling commercially on the market. Many see this as a missed opportunity for a multitude of reasons. While the kelp industry continues to grow each year, with regions like South America and Europe poised to scale the practice, California has failed to gain much traction due to a combination of several social, economic, and regulatory factors. This puts the state behind on reaping the long list of potential environmental and economic benefits that come from kelp, while other regions continue to capitalize on it.

The kelp aquaculture industry faces unique obstacles in California compared with other countries, and even other states. Coastal regulations and protections are robust in the state, for good reason, but often make permitting for any type of aquaculture difficult to pursue. The California Coastal Act, enacted in 1976, asserts the importance of public access to the coast, as well as preservation of marine and coastal ecosystems (An Introduction to the California Coastal Act, 2021). Enforced by the California Coastal Commission, the Act ensures that anything that may impact the coastal waters or shoreline be thoroughly reviewed and vetted. In addition, California's coast has a multitude of competing interests for use of its waters, such as recreation, commercial



fishing, shipping lanes, marine protected areas, and more. Finding a place for kelp to fit among these other uses is difficult. All these factors combine to make California a special case when it comes to kelp aquaculture. The question is whether California will support kelp aquaculture and what benefits may come from it.

The purpose of this policy briefing book is to bring relevant information about kelp aquaculture, as it pertains to California, into one place that succinctly summarizes it. Kelp aquaculture is still relatively new outside of Asia, and therefore is largely unknown to many outside the industry itself. This policy briefing book aims to clearly summarize what exactly kelp aquaculture is, why it is important, and where it may be heading. The various obstacles which have kept the industry from gaining traction in California will be explored and explained. Finally, several policy solutions will be proposed and analyzed based off the unique challenges that state faces. These recommended policies will be tailored specifically to the state of California, but some may also be relevant in other states or regions of the world. The goal is to create a useful reference to California kelp aquaculture, which can help inform choices about its future.

This policy briefing book is written for someone seeking a clear and concise summary of California kelp aquaculture, or the lack thereof. The book is intended to be accessible to those without a background in the subject matter who wish to learn more about why this is an important topic. Those who may find this report useful could include members of the public, state policymakers and decision makers, prospective kelp aquaculture farmers, kelp companies, and other interested stakeholders. One of the key issues around expanding kelp aquaculture outside of Asia is a lack of research and education around the subject. This report can act as one additional resource for those looking to gain insight into the industry, its obstacles, and the solutions.

California is poised to take advantage of the growing interest in kelp, which can provide a long list of benefits if the practice is implemented responsibly and managed properly. There is

expanding interest in kelp and its role in sustainability, and people have found a myriad of ways to incorporate the algae into food for human consumption, cosmetics, fertilizers, bioplastics and more. Kelp is being called, “the next superfood” for its rich nutrient content, and the market for superfoods in the U.S. was valued at \$137 billion in 2020 (Shahbandeh, 2021). If California can find a way to overcome some of the roadblocks the industry has faced thus far, it could be a part of the so-called “seaweed revolution” (“A deep dive into Zero Hunger,” 2020). The information that follows will aim to make this complex issue more digestible and explore the ways in which cultivating kelp could become a bigger part of California.

## FRAMING THE PROBLEM

### What is kelp aquaculture?

Aquaculture is defined by the National Oceanic and Atmospheric Administration (NOAA) as, “the breeding, rearing, and harvesting of fish, shellfish, algae, and other organisms in all types of water environments”. Kelp aquaculture specifically refers to cultivating brown macroalgae species, which can occur both in land-based tanks and in the open ocean. This report will be referring to kelp aquaculture that takes place in open waters, as opposed to land-based operations. Kelp is a subgroup of seaweed, and it is part of the overarching term of seaweed farming, though this report will be focusing specifically on kelp for establishment in California.

While kelp aquaculture is still a relatively new industry in the U.S., the use of seaweed-based products has been documented for centuries. The use of seaweed in foods and pharmaceuticals can be traced back as far as 1700 years ago in China (Yang et al., 2017). Today it has evolved into a global market that generated 35.8 million tons of seaweed production worldwide in 2019 (Cai, 2021).

The scale and style of kelp farms vary greatly depending on the country and location. The

largest scale facilities are found in China, with many small-scale operations found on the East Coast of the U.S. Typically, kelp aquaculture sites use a system of buoys and long lines suspended in the water. Kelp seedlings are produced in a hatchery and then attached to long lines for growout to harvest size, growing extremely quick, up to 18 inches per day under ideal conditions (NOAA, 2021). The low-tech approach of kelp farms makes it more accessible to smaller potential farmers without significant financial resources compared to other types of commercial agricultural or aquacultural endeavors.

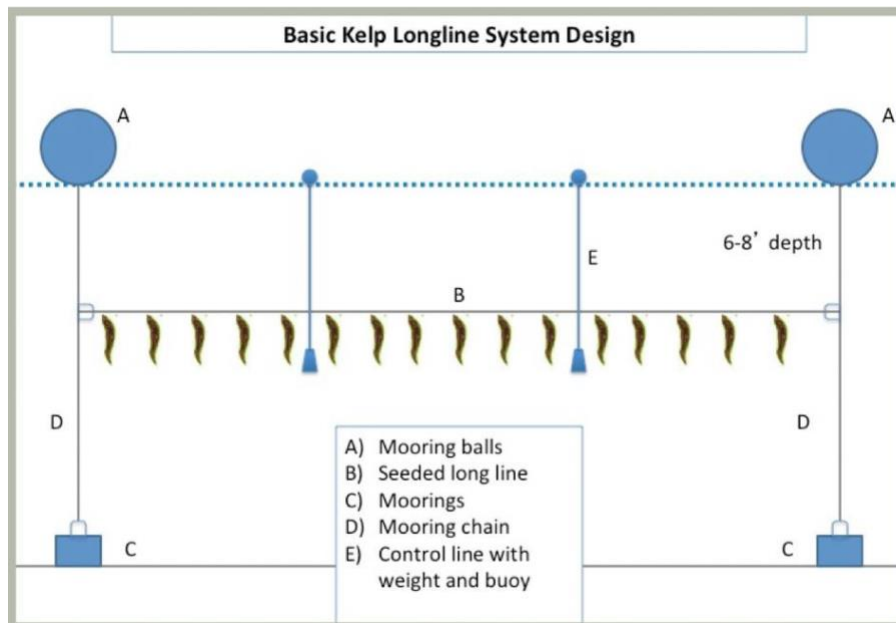


Figure 2: Example of kelp aquaculture design. Copyright 2015 by the Island Institute.

## What does the industry currently look like?

Kelp is cultivated across the world, but the industry is centered in Asia. China, Indonesia, the Philippines, Korea, and Japan produce 97% of all seaweed (Kim et al., 2019). Countries in Europe such as Norway and Denmark are gaining traction in the industry, as well as regions in South America including Chile.

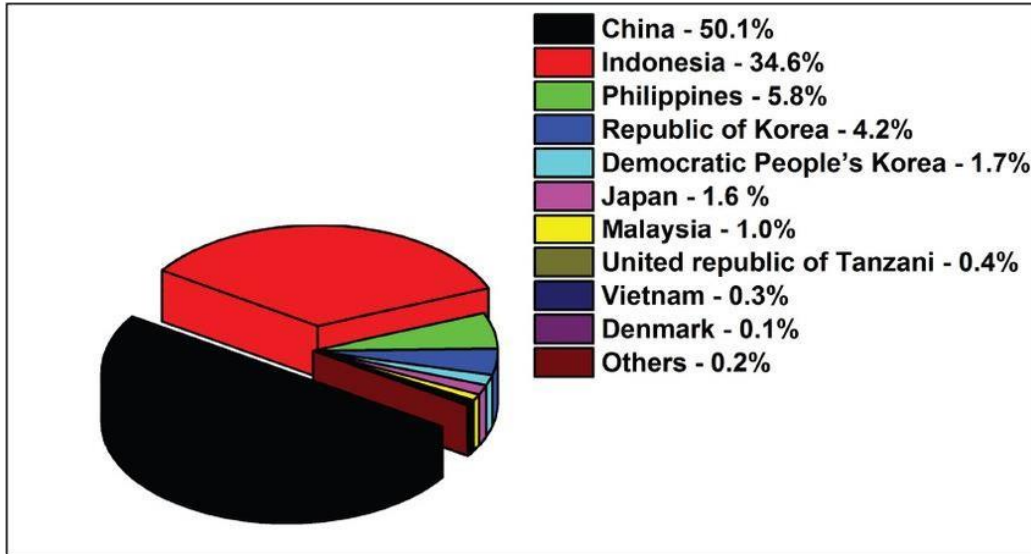


Figure 3: Seaweed production countries. From Food and Agriculture Organization of the United Nations, fisheries and aquaculture software. Copyright 2016 by FAO.

East Asia dominates consumption of seaweed, with a commercial market size of \$10.73 billion in 2020 (Business Wire, 2022). U.S. demand is rapidly growing though, projected to reach \$2.4 billion by 2027 (Business Wire, 2022). The U.S. currently ranks 3<sup>rd</sup> as a seaweed importer, importing 8.17% of the global share (Cai, 2021).

<b>Seaweeds<sup>1</sup></b>		
<b>Importer</b>	<b>Million USD</b>	<b>Share of world (%)</b>
1. China	342	29.47
2. Japan	241	20.80
3. United States of America	95	8.17
4. Thailand	55	4.74
5. Taiwan Province of China	48	4.15
6. France	35	3.02
7. Australia	30	2.57
8. Russian Federation	29	2.47
9. Republic of Korea	29	2.46
10. United Kingdom	21	1.83
<i>Rest of the world</i>	<i>236</i>	<i>20.34</i>
<b>World</b>	<b>1 159</b>	<b>100.00</b>

*Figure 4: Import of seaweeds and seaweed-based hydrocolloids, 2019. Source: UN Comtrade*

The global commercial seaweed market was worth \$15.01 billion in 2021 and is projected to reach \$24.92 billion by 2028, growing at an annual rate of 7.51% (Fortune Business Insights, 2021). This growth is being driven by several factors, including greater adoption of kelp in diets outside of Asia, diversification of uses of kelp, consumer preferences moving towards sustainable options (of which kelp consumption is perceived as sustainable), and interest in the environmental benefits of kelp aquaculture.

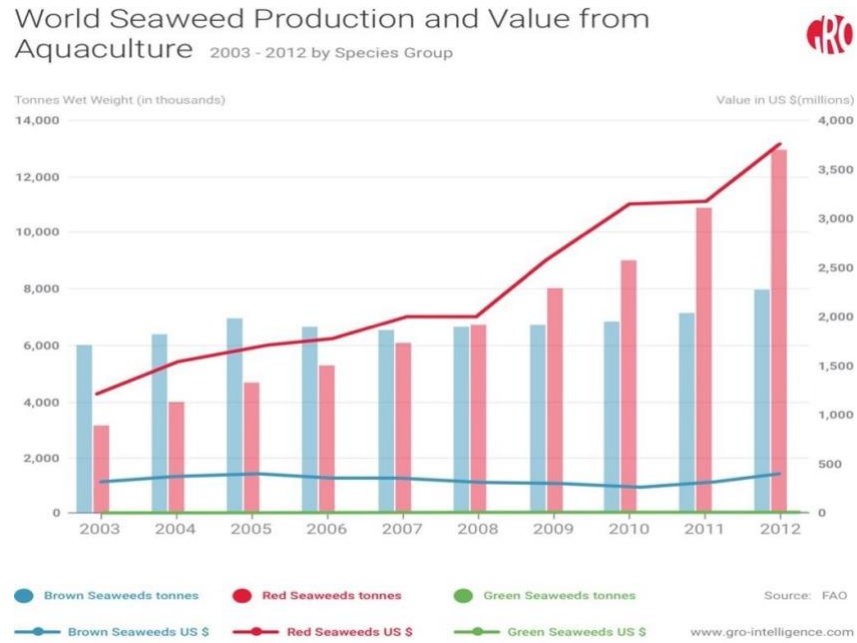


Figure 5: Graph shows overall increase in value and weight of seaweed production. Gro Intelligence and UN Comtrade. Copyright 2016 FAO.

The U.S. currently accounts for a very small percentage of global kelp production but is seeing expansion. Maine is seeing some of the most success, with over 200 sites permitted to grow and a harvest in 2019 of 325,000 pounds (*STATE of the STATES, 2020*). Connecticut, Rhode Island, and Massachusetts also have established permitted kelp farms with expectations of continued growth. New York and New Hampshire currently only operate research farms and have yet to permit any commercial operations. On the other side of the country, Alaska has 22 permitted sites with many more proposed. The state harvested 250,000 pounds in 2019 (*STATE of the STATES, 2020*) and is also expecting continued growth. Washington State has one commercially operating kelp farm and Oregon has no ocean-based farms.

While California has no ocean-based kelp farms selling commercially, there are several companies working to establish operations off the state's coast. Ocean Rainforest, Primary Ocean, and Sunken Seaweed are a few that are working to become the first to commence open water operations and sell on the market. Projections for growth of the industry within California

are not available, as many variables will determine whether kelp aquaculture will be able to get off the ground in the state, but current demand for seaweed snacks alone is estimated at \$250 million in the U.S. (Mazza, 2017).



Figure 6: Various new kelp-based products on the market in California

There has been an increase in the availability of kelp-based products in California grocery stores, such as chips, noodles, fermented foods, and body care items, which attests to the rising consumer interest. Demand for kelp and kelp-derived products is increasing every year, but it is unclear if California based farms will contribute to meeting this demand.

### Kelp farming vs kelp harvesting

One important distinction to make is the difference between kelp farming and wild kelp harvesting. There can be confusion in conversations if the terms are used interchangeably. Kelp farming, or kelp aquaculture, as defined previously, is referring to the deliberate cultivation of algae species, usually using buoys and lines. This is different from wild kelp harvesting, which

comes in a few different forms. Kelp harvesting does not involve cultivating the species, rather it utilizes the natural kelp beds that occur off many coasts across the world. This can look like collecting kelp that has washed ashore, cutting a small percentage off a naturally occurring kelp bed in the ocean, or the complete removal of the kelp from the bedrock via a boat dredge (California Department of Fish and Wildlife). To harvest from kelp beds in California for commercial use you need to obtain a license as well as abide by regulations which specify which kelp beds are available for harvest (California Department of Fish and Wildlife).

Wild harvesting is how people originally procured the algae centuries ago in Asia. Kelp harvesting can be done sustainably in some places when growth rates are tracked, and the beds are not overharvested. However, many natural kelp beds around the world have been suffering due to changes in ocean temperatures and composition, as well as increases in urchin populations which eat the kelp. Northern California in particular saw a reduction in kelp bed size of 95% between 2008 and 2019 (Derham, 2021). Harvesting the natural kelp beds in cases like that is unsustainable while they are in a state of restoration, and the California Department of Fish and Wildlife significantly limited or restricted harvesting in those areas that saw the worst depletion in California. With growing worldwide demand for kelp, it simply is not feasible to supply only using natural kelp bed harvest techniques. For this reason, kelp aquaculture exists, as the natural kelp beds are unable to meet the rising demand. Cultivating the kelp and collecting from those man-made sources alleviates the pressure on the naturally occurring kelp stocks and protects them from depletion.



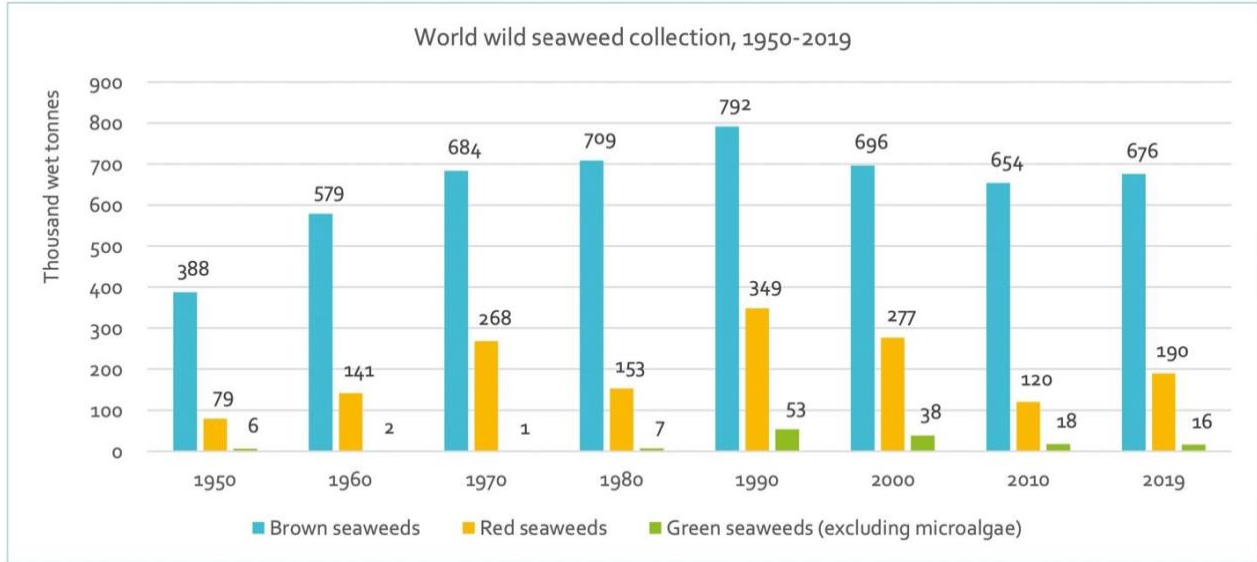


Figure 7: Global seaweed harvesting. Data source: FAO 2021. FAO Global Fishery and Aquaculture Production Statistics, 2021.

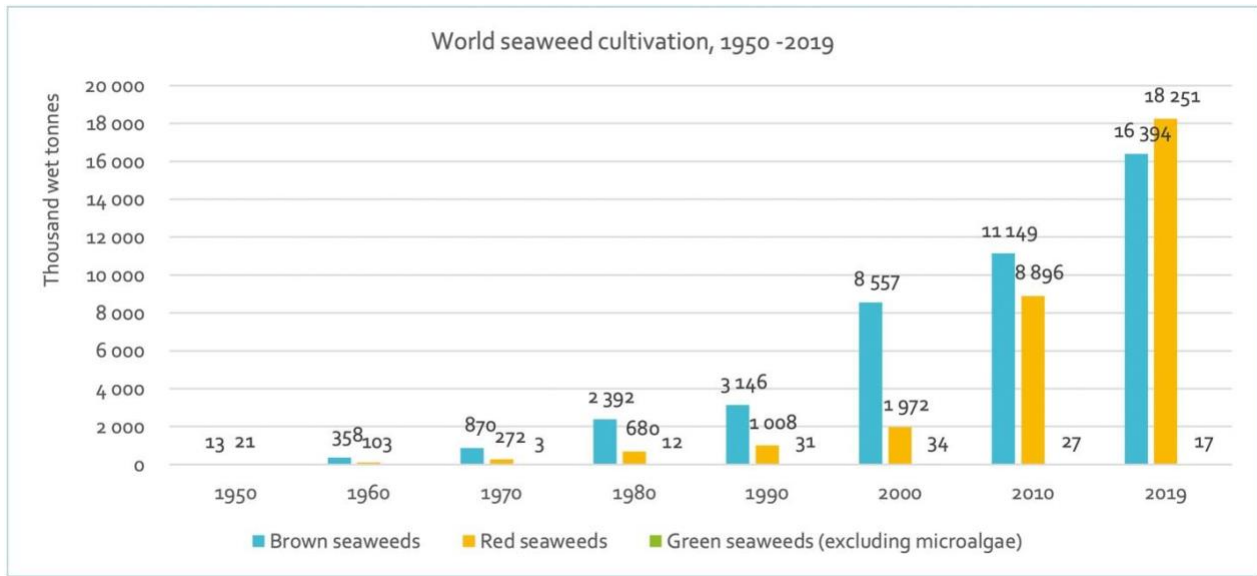


Figure 8: Global seaweed cultivation. Data source: FAO 2021. FAO Global Fishery and Aquaculture Production Statistics, 2021.

As seen in Figure 7, global seaweed harvesting has stagnated since the 1990s, as available kelp beds and regrowth rates place limits on harvest volume. Alternatively, Figure 8 shows the continual growth of cultivated seaweed which can keep up with global demand without depleting naturally occurring sources.

Pursuing kelp aquaculture in California by no means prevents the current wild harvest from occurring. While current kelp restoration projects are slowly helping to bring back the natural kelp beds and therefore potentially increasing the volume available for harvest in the future, kelp farming can be used to supplement what cannot be met by harvest. Additionally, not every kelp bed can be harvested in the state; 18 are currently prohibited to be used for harvesting. Climate change has negatively impacted kelp beds from Tasmania to Norway (Raybaud et al., 2013; Smale, 2019), and solely relying on harvesting the natural beds may become more difficult in the future as temperatures continue to rise in the ocean. To effectively capture the potential benefits of increasing kelp, scale is needed. The scale of wild harvest is limited though, and kelp bed area can vary dramatically year by year based on oceanic conditions. If kelp's popularity increases domestically in the way that various companies and stakeholders are advocating for, farming kelp will be necessary to consistently keep up with demand.

#### What are the benefits of kelp aquaculture?

Growing kelp comes with a myriad of benefits for both humans and the environment. This is the reason that so many investors, companies, and organizations are interested in expanding the kelp aquaculture industry in the U.S. With climate change worsening each year and widespread environmental degradation impacting ecosystems and biodiversity, kelp has emerged as one of the many potential solutions that could be utilized to face those issues.

The ocean is a massive carbon sink, absorbing about a third of all emissions ever produced. This uptake of vast amounts of carbon has consequentially caused a decrease in the pH of the entire ocean, a process known as ocean acidification (NOAA). Ocean acidification negatively impacts many organisms and can seriously damage ecosystems such as coral reefs. Kelp can locally **combat ocean acidification** due to its ability to remove excess carbon from the

water via photosynthesis. Fernández et al. (2019) suggests that there is a macroalgal ocean acidification buffering effect, in which areas with kelp can create a buffer zone with a higher pH level which provides important reprieve for organisms sensitive to acidification. One 2021 study confirmed this, finding that seaweed farms in China were able to increase local pH levels by 0.10 units, effectively reversing local ocean acidification (Xiao et al., 2021). Thus, kelp farms could become a tool for combating ocean acidification on a local scale, protecting species and ecosystems alike.

Kelp farms may also serve as a **carbon sequestration tool**, in which the carbon that is removed from the ocean via photosynthesis may be stored long term, preventing it from reentering the atmosphere and contributing to climate change. Kelp is an emerging type of “Blue Carbon”, which refers to carbon captured by ocean and coastal ecosystems such as mangroves and marshes (International Union for Conservation of Nature, 2017). While the length of time this carbon is stored in the seaweed biomass varies depending on its end of life, there is promising research emerging to confirm its sequestration abilities. One study in Korea found that about 10 tons of carbon dioxide per hectare could be drawn down by kelp each year (Chung et al., 2013). There have been proposals to grow seaweed, harvest it, and sink it in the deep ocean for long-term carbon burial and storage, but the strategy presents significant economic and technological barriers that have yet to be overcome.

There is still much debate about whether farmed kelp has the same sequestration powers as naturally occurring kelp beds, since harvesting the kelp for use in things like food products ultimately will not store the carbon long term. Several studies have addressed these kinds of questions, suggesting that the carbon taken up by farmed seaweed enters the fast carbon cycle, as opposed to the slow carbon cycle which carbon offset projects fall under. If it either decomposes

or is used as food, the carbon will be cycled back into the system (Troell et al., 2022). Some have argued that the majority of seaweed's carbon mitigation impact comes from avoided emissions rather than sequestration. Agriculture has a large carbon footprint globally, and if seaweed-based foods, which have much lower life-cycle carbon emissions, replace some percentage of grain-based foods, significant carbon emissions could be avoided (Duarte et al., 2017). Additionally, if technology develops to use seaweed for biofuels on a larger scale, seaweed biomass could directly replace some fossil fuel use, creating further carbon emission reductions. Much more research is needed to confirm the carbon capturing implications of kelp aquaculture, but many are optimistic about its future role in sequestration or mitigation.

Kelp aquaculture operations can also provide refuge for certain species. Visch et al. (2020) found that seaweed farm sites **created habitat or shelter** for a multitude of organisms. This is key because many naturally occurring kelp beds have seen recent reduction in size due to several environmental factors, climate change being a major one. Kelp aquaculture has the potential to provide some of that missing habitat to threatened species, and kelp forests are widely considered to be one of the most productive ecosystems on the planet. The habitat that kelp farms create could also bolster the stock of certain fish species for commercial or recreational fishing.

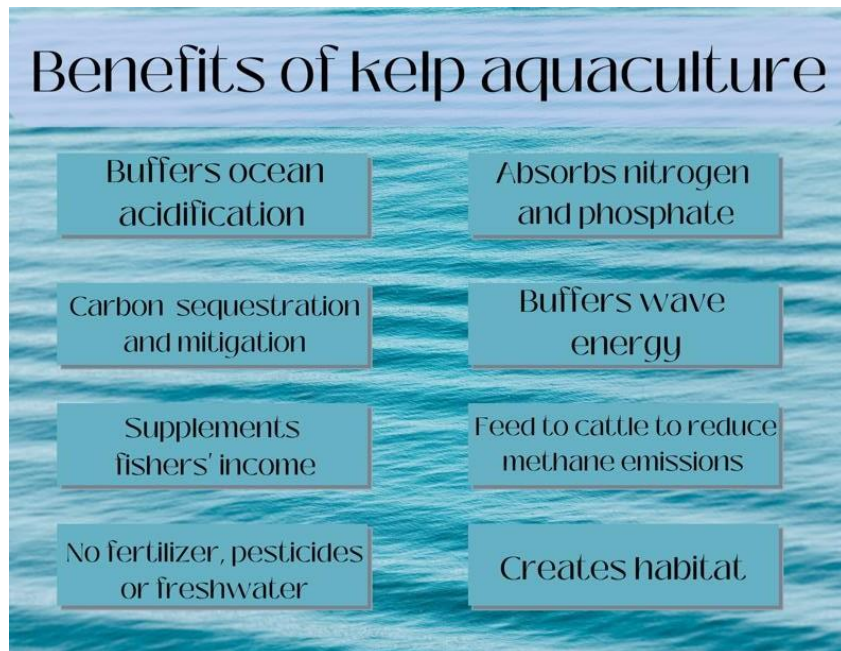
An advantage of farming kelp, as opposed to farming most anything else, is that it **requires no inputs, such as fertilizers, pesticides, or freshwater**. It simply uses the dissolved nutrients available in the ocean without the need for any kind of additive. Furthermore, kelp can **absorb excess nitrogen and phosphorus from the water** (Racine et al., 2021; Kim et al., 2015; Neori et al., 2004), which typically enters the ocean via runoff from agriculture, septic systems, urban areas, and landfills (Minnesota Pollution Control Agency, 2008). The agricultural sources

of nitrogen and phosphate pollution are particularly hard to control as it is a non-point source of pollution, coming from dispersed locations (Nutrient Pollution: Causes and Solutions). Using kelp aquaculture to mitigate this kind of pollution is cost-effective and could be incorporated into nutrient pollution control measures (Racine et al., 2021). Kelp essentially cleans up the water around it as it grows, taking up nutrients that could otherwise contribute to harmful algae blooms and low dissolved oxygen conditions.

Kelp can also provide a **physical buffer for the coastline from wave action**. One 2018 study found that kelp aquaculture farms can reduce wind wave energy by 30 to 50% during storm conditions (The University of Maine, 2018). This means that kelp aquaculture could potentially help stabilize coastal erosion and be integrated into shoreline protection measures. Climate change will be increasing the frequency of storms in some regions and raising sea levels, therefore utilizing all tools available to protect our coasts will be essential.

In terms of social impacts, kelp aquaculture can **supplement fishers' incomes** during their off seasons. Some lobstermen in Maine have been hired by Atlantic Sea Farms to grow kelp, which the company says can provide \$40,000 to \$110,000 in supplemental income (Fantom, 2022). With many fish stocks becoming depleted and some industries collapsing all together, it is important to consider what will happen to those making a living as fishers. Diversifying what they farm or catch can protect fishers' livelihoods from future ecological disruptions or moratoriums. Additionally, kelp aquaculture is more accessible and familiar to fishers as they already have the gear and experience necessary to operate in an open water environment. The establishment of kelp aquaculture in California would also support the creation of jobs in other parts of the industry such as kelp processors or packagers.

Seaweed can also feed more than just humans. It can be **incorporated into the diets of livestock**, which has been shown to reduce the enteric methane, created in the cattle's digestive tract, which is belched out, by over 80% (Roque et al., 2021). Reducing methane emissions is extremely important, as it is 80 times more powerful at warming the planet than carbon dioxide over the first 20 years of its lifespan (Environmental Defense Fund). There are already several companies looking to cultivate the specific type of seaweed needed for the feed, as well as research being done on finding strains that can grow in new regions. Although kelp has yet to be used for this purpose, it is possible that this seaweed will be grown in California in the future, either in land-based or ocean-based aquaculture. California would benefit greatly from this use of seaweed as it eventually could be used to feed some of the 5 million cattle that reside in the state, reaping the potential methane reductions.



*Figure 9: Summary of benefits of kelp aquaculture*

### What are the critiques?

While there is significant research emerging that is confirming the many theorized benefits of cultivating kelp, there are still several critiques and concerns around the practice. A few ecological concerns include potential for marine mammal entanglement in the lines and buoys, shading of the seafloor by the kelp farm which can impact the benthos (organisms on the seafloor), and use of non-native species which could unintentionally spread from the cultivation site and impact local ecosystems (Grebe et al., 2019). Many of these concerns could be mitigated with proper spatial planning and implementation of regulations.

Some are concerned about kelp aquaculture encroaching on commercial or recreational fishing areas, but studies have shown kelp farms' ability to create habitat, which could potentially boost local fish stocks thereby improving fishing conditions. Economically, concerns primarily have to do with the relatively high cost of kelp farming in the U.S. compared to Asia, leading to an inability to compete with overseas products in a commodity market. This could be addressed by accessing different markets in the U.S. and focusing on higher value specialty products, as well as financially compensating farmers for the ecosystem services that kelp provides.

### What are the roadblocks?

There are some significant obstacles which have prevented California from developing a thriving commercial kelp aquaculture industry. One major roadblock has been the current **permitting process**. The process for obtaining a permit for kelp aquaculture involves many agencies, is multi-phased, expensive, and time consuming, taking years in many cases. There is no kelp-specific permit, therefore prospective farmers must navigate a system that was originally

designed for commercial shellfish operations (GreenWave). The application for a permit also triggers an Environmental Impact Report (EIR) under the California Environmental Quality Act (CEQA) which adds additional time and cost. EIRs can range from a few thousand to a few hundred thousand dollars. The timeline of obtaining the necessary permits from the multiple agencies involved can take several years in many cases, which delays profits and presents a significant barrier to small scale operations who may lack the resources necessary to complete the process. This complex and often-frustrating bureaucratic system is one of the main contributors to the lack of kelp farming off the California coast, and many do not even bother starting the permitting process as it is easier to obtain permits in other states or regions.

The only successful cases of permit approval in California so far have been under either federal or local jurisdiction. In Humboldt Bay in Northern California, two small-scale kelp farms run by Humboldt State University and GreenWave obtained commercial permits under the jurisdiction of the Humboldt Bay Harbor District and are mainly being used for research purposes. Catalina Sea Ranch was the first ever to get an aquaculture permit in federal waters, with operations located 7 miles offshore from Los Angeles. They intended to cultivate a variety of species, such as mussels, oysters, and kelp. Unfortunately, due to lack of compliance with regulations and permitting, and an equipment failure that led to the death of a 70-year-old man, the company had to file for bankruptcy in 2020 (Cart, 2020).



## PERMITTING AGENCIES

Permitting Agency	Acronym	Type of Requirement
<b>STATE AGENCIES</b>		
California Department of Fish and Wildlife	CDFW	Approved species, methods, lease details (in no-granted state tidelands only), aquaculture registration
Fish and Game Commission	FGC	Bottom Lease Approval
California Coastal Commission	CCC	Coastal Development Permit/Consistency Determination Letter
US Army Corp of Engineers	ACOE	ACOE regulates wetlands and other waters of the United States per Clean Water Act (CWA)
Regional Water Quality Control Board	RWQCB	401 Water Quality Cert or Waste Discharge Requirement i.e. Clean Water Act (CWA)
State Water Resources Control Board	SWRCB	Water Rights Permit/ General Industrial Stormwater Permit
State Lands Commission	SLC	During initial FGC process to consider state water bottom leases, SLC needs to confirm no conflicting land use at site. Permit required if using State owned property i.e. above mean high tide line (MHTL).
California Dept of Public Health	CDPH	Operators License
<b>LOCAL AND REGIONAL GOVERNMENT PLANNING AGENCIES (as applicable)</b>		
Harbor or Port District		Use Permit or equivalent
City/County		Environmental Health Department
City/County		Public Notice. Local review process. Building permits

*Figure 10: Permitting agencies for kelp aquaculture in California. Copyright GreenWave.*

**Spatial planning** presents another obstacle that is a result of the multitude of uses of California coastal waters. The waters within state jurisdiction, everything within 3 miles of the coast, have competing interests such as recreational use, shipping lanes, marine protected areas, commercial fishing zones, oil drilling, military uses and more. Prospective kelp farmers must navigate all those factors, in addition to considering adequate oceanic conditions conducive to kelp growth. To avoid conflicts of use and ensure environmental preservation, comprehensive marine spatial planning is needed to open the door for the industry and integrate kelp cultivation into the current roster of marine uses.

Because the farms and markets for kelp are so established in Asia already and environmental regulations are less stringent, the production costs are typically significantly lower

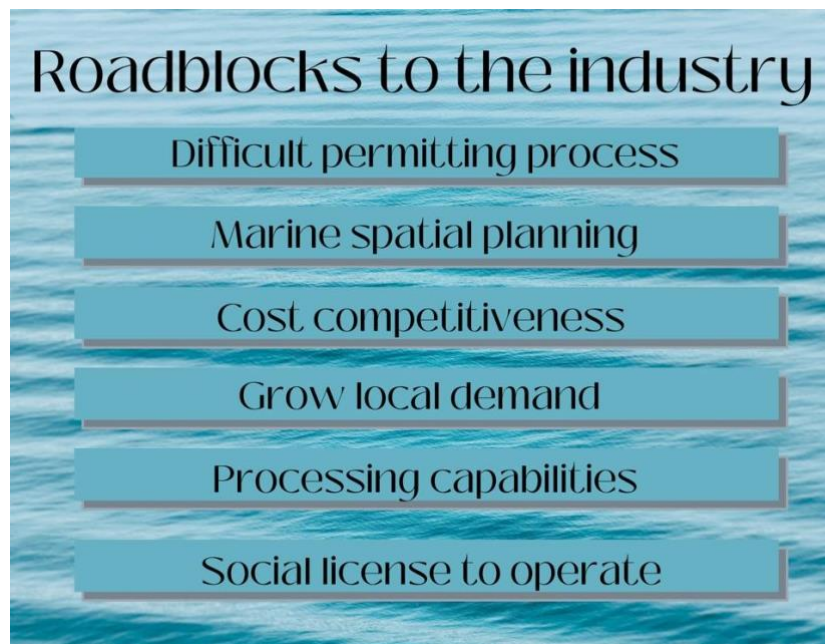
than what is possible for California. Kelp aquaculture facilities operate on a large scale in many Asian countries such as China and Indonesia, which means operating costs are lower and prices can be cheaper. Even if kelp aquaculture could similarly scale up in the U.S., the tighter environmental regulations and higher cost of living prevent comparative prices from being realized. The current import price for seaweed from Asia is \$3.45 per dried kilo, and current export prices for seaweed from the U.S. is \$10.55 per dried kilo (US Seaweed Prices). It is unlikely that California will ever be able to achieve similar **cost competitiveness on a global scale**, which means that farmers will have to tap into different kinds of higher-end markets than what Asia is currently serving.

There also needs to be significant **growth in domestic demand** for kelp-based products to create a larger market. If the production can scale up, demand should as well to ensure that farmers can make a profit. The domestic market for kelp is comprised mainly by Asian ethnic markets and Asian restaurants, in the form of sushi, seaweed salads, and seasonings (Island Institute, 2020). The use of kelp needs to expand to value-add and higher priced specialty products beyond the current uses. Many companies are working on creating exactly those types of products, such as chips, beer, sauces, skincare and more. For the industry to thrive, kelp needs to become a more frequent part of the U.S. to create lasting demand. Because kelp is incredibly nutrient dense and healthy, marketing of kelp-based products should capitalize on that, tapping into the popular “superfood” sector.

The kelp industry lacks domestic infrastructure in the form of **processing facilities**. Unless the harvested kelp is sold to local markets, it will need to be quickly processed to preserve it. This can include drying and then grinding it into a powder, extracting liquid, or flash freezing it for a variety of uses. Since California has yet to start commercially growing kelp,

large scale processing capacity does not exist. Processing hubs need to be established near areas of kelp aquaculture to limit time between harvest.

The last roadblock to the industry is obtaining the **social license to operate**, which refers to the informal approval for a project by the local community and other stakeholders. Public perception of aquaculture in the Western world has typically leaned towards negative (Froehlich et al., 2017; Mazur & Curtis, 2008; Bacher et al., 2016), with most aquaculture occurring in the developing world. There may be NIMBY (“Not In My Back Yard”) reactions to proposed kelp aquaculture plans in which locals oppose an aquaculture facility due to visual obstruction or other perceived inconveniences, which introduces local politics and public interest debate into an already complicated permitting process (Hansen). Ensuring that public perceptions of kelp aquaculture are shaped by accurate information and avoiding misconceptions will be key to gaining the social license to operate in a state that takes its coastal protection measures very seriously.



*Figure 11: Summary of main roadblocks to the kelp industry in California.*

## What policy is already implemented?

There are several policy changes in the U.S. that relate to kelp aquaculture which have occurred over the last few years. While these represent a positive shift in attitude towards the industry, much more progress that is needed in the policy realm if the kelp industry is to gain significant traction in California.

The Farm Bill is federal legislation which covers policy related to agriculture in the U.S. and is renewed and revised every five years. The 2018 version dramatically expanded support for algae agriculture and technology (Agriculture Improvement Act of 2018). A key part of that support is the expansion of crop insurance to algae, which is now considered an agricultural commodity. This opens the doors for kelp aquaculture to be federally protected, allowing farmers to mitigate financial risk if their harvest is lost due to factors beyond their control. This may encourage participation in the industry if prospective farmers know they have a certain degree of protection from these risk factors.

Executive Order 13921, Promoting American Seafood Competitiveness and Economic Growth, is another example of aquaculture prioritization in the U.S. This order states that measures should be taken to ensure food security, remove unnecessary regulatory burdens, and provide environmentally safe and sustainable seafood, all of which apply to the kelp aquaculture industry (Executive Order 13921). This Executive Order directly led to the creation of Nationwide Permit 55 from the Army Corp of Engineers. Nationwide Permits (NWP) are, “designed to streamline authorization of projects that produce minimal impact on the nation’s aquatic environment” (Section 404 CWA Permit, 2020). NWP 55 extended this streamlined permit to seaweed mariculture activities, creating opportunity for kelp aquaculture in federal waters. Currently though, nearly all proposed farms have been within 3 miles of the coastline,

which is under state jurisdiction and therefore NWP 55 cannot be applied in those cases. If the technology for offshore kelp aquaculture in federal waters is developed in the future, this new permit may become key in those enterprises.

## PROPOSED SOLUTIONS

The goals of any policy which increases the amount of kelp aquaculture in California should be to:

- better capture the ecosystem services associated with farming kelp
- increase the availability of a low carbon footprint food source
- provide coastal jobs and protect fishers' ability to make a living on the ocean
- aid in boosting the industry nationally and create space for sharing industry knowledge
- improve collaboration across agencies and with stakeholders.

The suggestions that follow keep these underlying goals in mind.



### Streamlined permitting system

A major bottleneck occurs with the permitting process in California. Kelp aquaculture has yet to be commercially permitted within state waters and as such there is not existing examples to reference nor specific pathways accounting for the differences associated with the practice. Creating a specific permit pathway that is tailored to kelp to address this bottleneck and create a more transparent and certain permitting process for applicants would simplify obtaining a permit. The federal government has already done this for aspects under the jurisdiction of the U.S. Army Corp of Engineers. With their establishment of Nationwide Permit 55, a streamlined process to authorize seaweed projects in federal and some state waters can be utilized.

California could create a similar version in which prospective kelp farms could apply for a streamlined kelp-only permit, assuming suitable site selection has already been considered.

Kelp aquaculture has been proven to have minimal environmental risks and a multitude of environmental benefits, and therefore should be given special consideration in the permitting process. The Fish and Game Commission, the lead agency involved in state aquaculture permitting, could work to establish this specialized permit and remove the current bottleneck that exists.



### Investing in marine spatial planning

To avoid conflicts with other uses of state waters, such as shipping lanes, commercial fishing areas, marine protected areas, and military exclusion zones, there needs to be special care taken to properly site areas for kelp aquaculture use. Appropriate spatial planning is necessary to ensure that a potential kelp aquaculture site will not negatively impact other industries, ecosystems, or species. NOAA is the federal agency tasked with siting federal Aquaculture Opportunity Areas (AOAs), areas which are environmentally, socially, and economically appropriate for commercial aquaculture (NOAA). In a 2021 marine spatial planning study, they found several AOAs in the Southern California Bight (Morris et al., 2021). The sites are all in within federal jurisdiction though, and therefore are not directly influenced by California policy and agencies.

Extensive spatial planning necessary for the development of kelp aquaculture in California state waters requires skilled identification of suitable sites, therefore NOAA may be utilized as a resource for this purpose. As NOAA has already conducted similar spatial planning projects previously, they would be well positioned to perform spatial analyses within state waters that would be best suited for kelp aquaculture, maximizing the benefits and minimizing any user conflicts. NOAA aided Washington State in a similar matter, in which they created a seafloor mapping tool that could then be utilized by planners, managers, and scientists to prioritize areas

which needed additional data collection ([Washington State Prioritization Tool](#)). NOAA could create a similar mapping tool for California, identifying promising regions for kelp aquaculture, which state planners could then use during the permitting process to ensure proper marine spatial considerations.



## Education

To gain the social license to operate and encourage public support around new kelp aquaculture projects, more education is needed to better inform people and decision makers. Often, opposition to kelp farms is due to misinformation or bias against aquaculture in general (Hansen). Creating a public campaign around the environmental benefits of kelp aquaculture and the relatively small risks associated with it would be beneficial to garnering public support for kelp aquaculture. Obtaining kelp aquaculture permits in California requires public notice of the application by both the Fish and Game Commission and Coastal Commission at public meetings, and that can attract supportive or oppositional public comment. Creating and implementing methods of sharing accurate information based in sound science which gives a clear picture of kelp aquaculture to those concerned is vital to the development of the industry. This could be in the form of outreach material including pamphlets, short videos, infographics, and website resources. Such information can alleviate concerns that usually arise around aquaculture projects. Depending on the format and scope, developing social license for kelp aquaculture would be relatively inexpensive but still effective, as shifting perceptions to a more accurate and positive narrative would establish the community support necessary to begin kelp aquaculture projects.



## Promotion of kelp foods and developing the market

While overcoming obstacles to establishing kelp farms in California is important, it is equally important that there is an adequate market ready to absorb what will be produced by the farms. The market for kelp domestically needs to grow and diversify, taking the form of new specialty products that can be marketed for their sustainability and climate friendly nature. GreenWave, an environmental nonprofit that helps coastal communities to launch and scale regenerative ocean farms, has been working to open new sales channels for small sized farms up and down the East Coast, ensuring long-term and rising demand for kelp. GreenWave has partnered with value-add processors to come up with products like kelp burgers, kelp jerky, fermented products, and more, which can provide demand for locally grown kelp at an economically feasible price (GreenWave). There is significant opportunity for kelp-based products to fill demand for sustainable options, as nearly 6 in 10 consumers say that its important their food is produced sustainably (International Food Information Council, 2020).

Creating opportunities for this kind of research and development for kelp products and market expansion in California is essential. This would benefit all prospective California kelp companies and farmers, ensuring that what they produce can reliably be sold. The nascent U.S. kelp industry would benefit significantly if they collectively worked on diversifying products and growing the domestic market, expanding demand from coast to coast while concurrently working to expand production. Creating a public campaign to promote kelp products and expose people who are not familiar with the food is an important step to ensuring long-term demand; think of the “Got Milk?” campaign, but for kelp.





## Kelp subsidy

Starting an offshore kelp farm in the U.S. is more expensive than in other regions of the world with more established industries, and therefore issues of cost-competitiveness arise. One way to encourage the expansion of the industry and lower the barrier to entry is to offer a subsidy to kelp aquaculture operations. This would boost domestic production and create the opportunity for the industry to scale significantly. Subsidies are typically given to offset market shortcomings and externalities with the goal of achieving better economic efficiency. In the case of kelp aquaculture, farmers are not being compensated for the ecosystem services their facility provides, in the form of nitrogen and phosphate removal, ocean acidification buffering, and potentially carbon uptake. A subsidy could compensate kelp farmers for the positive externalities their kelp farms provide, and increase the public goods associated with a healthy environment.

GreenWave has created a program with similar goals. Their Kelp Climate Fund “provides farmers with direct payments for a bundle of climate impacts, including carbon, nitrogen, and reef restoration. In return, farmers provide key monitoring data on out planting, growth rates, and harvest” (GreenWave). A subsidy of \$1 per foot of kelp seed planted is used, based on the market value of the ecosystem services provided (Barrett et al., 2022). California could implement a similar subsidy program, in which a fund could be created that pays farmers a certain amount per unit of kelp produced. These direct payments would encourage growth of the industry and compensate farmers for the extra services their kelp provides. With California poised to allocate \$37 billion in climate spending over the next six years, a comparatively minuscule portion could be put towards a kelp subsidy fund. With proper cost-benefit analysis, the subsidy price should accurately reflect the value of the ecosystem services provided by the kelp grown.



## Funding research on kelp farm benefits and impacts

Kelp aquaculture still needs robust research to continue to quantify the ecosystem benefits as well as any potential negative impacts on the environment. There also needs to be more analysis done on the economic and business side of kelp, which would help inform investors and create more clarity for those wanting to start kelp farms in California. While the studies that have been published thus far are promising, to make informed decisions about expansion of the industry and management, more research is needed. Continual funding towards research projects that focus on kelp aquaculture is critical to the future of the industry. There are currently several organizations and research groups which have contributed important funds and research on the topic, such as California Sea Grant, Moss Landing Marine Lab, UC Davis, UC Santa Barbara, Scripps Institution of Oceanography, the Pacific States Marine Fisheries Commission and more.

Funding for kelp aquaculture research projects on a variety of aspects (ecosystem services, societal impacts, economic feasibility, etc.) should be a priority within the aquaculture sector and support for those groups who have already produced research should continue. A policy of continual support for this area of research could include funding from both state, federal, and private sources. A multitude of benefits can come from this, as research done in California can inform other states and regions, and ultimately help bolster the nascent industry nationally. As kelp aquaculture does pertain to climate change issues, money from climate related funds could be allocated towards the topic as well.

## CONCLUSIONS

Kelp aquaculture in California is complex and faces many barriers, some of which are shared by other states and some of which are unique to California. Progress to address these obstacles has been minimal, and as a result California lags behind other regions in the U.S. in establishing a successful kelp industry. The demand for kelp continues to grow both worldwide and domestically, yet California has so far failed to contribute any production to meet this demand. The environmental benefits of cultivating kelp are significant if proper spatial planning is considered. Kelp production may add climate resiliency to our vulnerable coasts.

Action is needed from both state and private entities to bring together the resources necessary to overcome the various roadblocks. A combination of cooperation within the industry to work collectively on market development and processing infrastructure along with funding from the state for a kelp subsidy, further research, and an improved permitting system would vastly improve the chances of industry success in the state.

There is potential for a low-carbon, locally grown, regenerative, environmentally positive food source, that provides a host of ecosystem services and coastal jobs, to be produced off the California coast. The obstacles that kelp aquaculture has faced in California all have solutions and addressing them is a matter of prioritization. With clear interest from several companies to start kelp aquaculture facilities in the state, time is of the essence to remove the roadblocks before the industry moves on to other more enabling states.

There is no silver bullet to solve climate change or environmental destruction, but kelp aquaculture does offer a viable array of solutions. Despite the kelp industry being slow to grow in California, there is hope on the horizon. Pilot projects in the San Diego Bay (Sunken Seaweeds) and Humboldt Bay (HSU) are promising signs of a budding industry, and with the

right incentives and tools there is possibility for significant growth. California is so often a leader in the environmental and climate change realm, and the kelp aquaculture industry presents an opportunity to take the lead once again and pave the way for others to follow.

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