Alaska Seaweed Market Assessment

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PREPARED FOR:

Alaska Fisheries Development Foundation

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Glossary

Alginate - A useful industrial material made from brown seaweeds. Alginates are valued for their hydrocolloid (gelling and thickening) properties. Gelatin and pectin are types of alginate.

Bioactive compound - A substance that has biological effects. Seaweeds contain various bioactive compounds such as fucoidan, a complex carbohydrate found in brown seaweeds which may have medical uses.

Biorefinery - A zero-waste production facility that uses a biological feedstock (such as corn, wood, or seaweed) and produces multiple products to extract the maximum value from the input. (Analogous to an oil refinery that produces gasoline and various byproducts from crude oil.)

Brown seaweed - One of the three main groups of seaweed. (The other two are red seaweed and green seaweed). Brown seaweeds with commercial potential that can be grown in Alaska include sugar kelp, bull kelp, and ribbon kelp.

Bull kelp - A brown seaweed species. Bull kelp is currently both commercially wild harvested and farmed in Alaska. Scientific name: *Nereocystis luetkeana*.

Carrageenan - A useful industrial material made from red warm-water seaweeds valued for its hydrocolloid (gelling and thickening) properties.

Dulse - A red seaweed species. Dulse has been proposed as a farmed seaweed species for Alaska and is valued for its "bacon-like" flavor profile. Scientific name: *Palmaria palmata*.

Fucoidan - A complex carbohydrate found in brown seaweeds that is used in the health supplement industry. It may also have applications for the pharmaceutical industry.

Green seaweed - One of the three main groups of seaweed. (The other two are brown seaweed and red seaweed). Globally, green seaweeds are not harvested on the same scale as brown and red seaweeds. Well known grown seaweed varieties include sea lettuce and sea grapes.

Hydrocolloid - A compound with gelling and thickening properties used in many industries including food, medicine, and textiles. Seaweeds are used to produce three main types of hydrocolloids: carrageenan, alginate, and agar.

Kelp - A subset of brown seaweed from the scientific order Laminariales. All the seaweed varieties currently farmed in Alaska are kelps.

Kombu - Common name for a type of brown seaweed popular in East Asian cuisine. Generally refers to *Saccharina japonica*, but can also refer to several other similar species including sugar kelp (*Saccharina latissima*). Kombu is often used to flavor soups.

Macroalgae - Another term for seaweed. Macroalgae are sometimes described as "aquatic plants," but are actually large algae and are taxonomically distinct from plants.

Mariculture - Water-based farming in salt water (a subset of the term aquaculture).

Microalgae - Algae that are not individually visible to the human eye. Microalgae are outside the scope of this report, which focuses on visible macroalgae (seaweed). Microalgae have been proposed for some of the same uses as macroalgae, such as biofuel and fish feed.

Nori - Common name for one of several red seaweed species in the genera *Porphyra* and *Pyropia* that are popular in East Asian cuisine. Nori is often used for sushi and as a snack product.

Red seaweed - One of the three main groups of seaweed. (The other two are brown seaweed and green seaweed). Red seaweed with commercial prospects that could potentially be grown in Alaska include dulse and nori.

Ribbon kelp - A brown seaweed species farmed in Alaska. Scientific name: *Alaria marginata*. On the Atlantic coast the common name ribbon kelp refers to a different species from the same genus: *Alaria esculenta*.

Rockweed - A brown seaweed species. Currently the most harvested wild seaweed variety in North America. Rockweed is harvested in the North Atlantic for applications including fertilizers, animal feeds, and vitamin supplements. Scientific name: *Ascophyllum nodosum*.

Sugar kelp - A brown seaweed species, sometimes sold under the names Atlantic kombu, Alaskan kombu, or sweet kombu. Sugar kelp is currently the main seaweed variety farmed in the United States. Scientific name: *Saccharina latissimi*.

Wakame - Common name for the brown seaweed *Undaria pinnatifida* popular in East Asian cuisine. Wakame is often used in seaweed soups and salads.

Executive Summary

Alaska Fisheries Development Foundation, with grant support from the Pacific States Marine Fisheries Commission, contracted with McKinley Research Group to assess current and potential markets for Alaska seaweed. Findings presented below are based on a review of available secondary research and seaweed trade, production, and market data, as well as telephone interviews with 40 seaweed market participants and experts in North America and Europe.

Alaska's seaweed industry today is modest in size, with just a handful of growers with multiple years' operating experience and a limited group of retail consumer offerings produced by a small number of companies. However, a host of new potential growers are in or recently emerged from permitting processes, and the potential for seaweed production is immense in the state. To achieve this potential, the Alaska seaweed industry and individual producers must identify markets that are a match for the species, product forms, and cost structures that Alaska can provide. This report informs this discussion, while acknowledging uncertainties associated with the nascent state of the industry, emergent technologies, and evolving consumer preferences. It includes assessments of world seaweed production and trade, domestic production, food markets for seaweed, emerging uses and opportunities for seaweed, and an assessment of Alaska's current position and future opportunities.

World Seaweed Production and Trade

- More than 97% of seaweed is produced in Asia, with nearly all of that farmed. World farmed seaweed production has grown at an average annual rate of 7% a year over the last 20 years, while the world's wild seaweed harvest plateaued in the 1960s.
- Hydrocolloid products (thickeners) are the largest category of seaweed products sold in international trade by value, followed by human food products and products not for human consumption, including fertilizers and animal feeds.
- The most frequently grown seaweeds in the world are:
    - Kombu (*Saccharina japonica*) – a brown seaweed that grows in cold and temperate waters and is used for food; 35% percent of 2018 world seaweed production was kombu. *Saccharina japonica* is similar to the sugar kelp grown in Alaska.

- *Eucheuma* (various species) – a genus of red seaweed that grows in warm climates and is used primarily to produce carrageenan; 29% of world carrageenan production is from *Eucheuma*. *Eucheuma* is not farmed in Alaska.
- *Gracilaria* (various species) – a genus of red seaweed grown in warm climates, used primarily to produce agar and also consumed as a food. *Gracilaria* is not farmed in Alaska.
- Wakame (*Undaria pinnatifida*) – a brown seaweed that grows in cold and temperate waters and is used for food. Wakame is not farmed in Alaska but another kind of kelp, *Alaria marinata*, has been marketed as "Alaskan wakame" for its similarity to *Undaria pinnatifida*.

Domestic Production

- The United States grows less than one-hundredth of one percent of the world's seaweed. Most seaweed currently produced in the U.S. is wild harvest. About 80% of the U.S. wild harvest is rockweed from Maine used for fertilizers and nutritional supplements.
- Farmed seaweed production has grown rapidly in Maine and Alaska over the last three years. Most farmed seaweed grown in the U.S. is used for human food products.
- Many species being farmed in Alaska, including sugar kelp, bull kelp, and ribbon kelp, are not widely farmed on a global scale, though sugar kelp and ribbon kelp are similar to the widely grown kombu and wakame species, respectively. No red seaweeds are currently farmed in significant amounts in the U.S., though research on two species is underway.

Food Markets

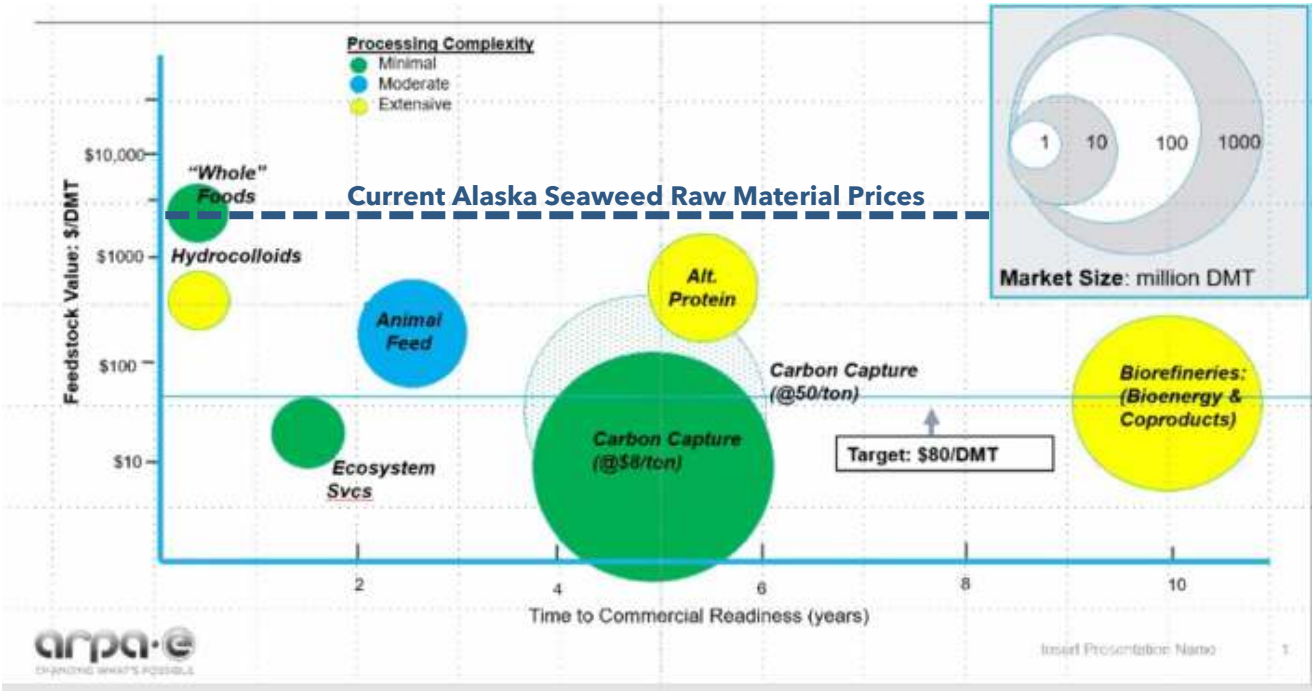
- Food markets are currently the primary users of Alaska's seaweed production.
- Companies generally have had to build their own markets for their seaweed products. Demand is limited outside traditional Asian seaweed products, which are dominated by low-cost imports.
- New markets are being built primarily through the natural foods channel and target wealthier coastal families and women concerned about sustainability and health. Online sales have grown during the pandemic but remain secondary to traditional retail sales.
- Successful development of specialty consumer products also generally requires the development of wholesale markets to reach competitive production and pricing thresholds.

Other Markets

- Existing markets that could absorb larger quantities of product (e.g., industrial ingredients such as alginates) are price sensitive and primarily use inexpensive Asian seaweeds or wild varieties not currently grown in Alaska. Alaska's current production costs are high, and market tolerance for the price structure is limited to consumer-facing specialty food products and possibly high-end cosmetics, fertilizers, and similar consumer products.

- The challenge Alaska faces is illustrated by the graphic below, produced by the Advanced Research Projects Agency-Energy (ARPA-E) at the U.S. Department of Energy. Alaska's current seaweed farming costs are roughly $4,400 per dry metric ton (depicted with a dashed line) – a price that can be supported only by the "whole" foods market, according to the ARPA-E assessment.

Figure 1. Potential Market Opportunities for U.S. Seaweed Producers, by Time to Commercial Readiness (years), Feedstock Value ($ per dry metric ton), and Potential Market Size (million dry metric tons)



Source: Advanced Research Projects Agency-Energy (ARPA-E), U.S. Department of Energy, MARINER program.

- Additional seaweed opportunities in Alaska include emerging uses that respond to global challenges, such as protein-replacement and bioplastics, as well as "blue carbon." Alaska is currently under consideration by a number of private firms and NGOs at the forefront of these emerging technologies and markets.

Key Takeaways

This research yields findings that can provide guidance to individual seaweed growers as well as private and public entities involved in mariculture development in Alaska.

- Market demand for most seaweed products is currently limited. Most industry participants are counting on considerable growth in demand for existing products as well the emergence of additional viable seaweed markets.
- The pathway to a scaled industry in Alaska will benefit from a mix of public and private investment in the near-term. Growth may hinge on investment from one or more innovative industrial manufacturers who can act as "anchor" customers or partners and help scale demand.
- Infrastructure and logistics will be a significant (and familiar) challenge for an Alaska seaweed industry. Cost structures and distance from markets limit current opportunities, but may be offset by technological innovation, coordination among growers, and other opportunities to share costs and pool resources.
- There is high interest in seaweed's role in solutions to major global challenges such as carbon sequestration, alternative proteins, and transitioning away from fossil fuels in packaging and energy.
- Regulatory structures in Alaska offer some competitive advantages and at least one disadvantage – a prohibition on strain selection. Alaska's non-U.S. competitors operate at larger scales (Asia) or with high levels of coordination and government subsidies in research and development (Europe).
- Provenance and the Alaska brand can be important in certain specialty food markets. For other uses of Alaska seaweed, logistical and price considerations are typically more important. The value of a generic Alaska seaweed "brand" may be limited at present, though it is one way to support the only major current market for Alaska seaweed (specialty foods). It could also play a role in attracting new investment to the state.
- Identifying methods to subsidize production and R&D are likely critical pathways to the continued development of current and potential markets for Alaska seaweeds. Alaska's competitive edge can be sharpened by lowering production costs, increasing regulatory flexibility and social license, and supporting sustainability messaging, among other efforts.

Introduction and Methodology

Alaska Fisheries Development Foundation (AFDF) contracted with McKinley Research Group to assess current and potential markets for Alaska seaweed products. This research is part of a larger project that includes marketing strategy development.

Alaska's seaweed industry today is quite modest, with just a handful of growers with multiple years' operating experience and a limited retail consumer offerings produced by a small number of companies. However, a host of additional potential growers are in or recently emerged from permitting processes, and the potential for seaweed production is immense in the state. To achieve its growth potential the Alaska seaweed industry and individual producers must identify markets that are a match for the species, product forms, and cost structures that Alaska can offer. This report informs this discussion, while acknowledging uncertainties associated with the nascent state of the industry, emergent technologies, and evolving consumer preferences.

Overview of Alaska's Seaweed Mariculture Industry

In their fifth year of commercial activity, Alaska's seaweed farmers are seeing exponential year-over-year production growth. The first generation of farmers have transitioned from prototype facilities to working farms with steadily increasing footprints. Permit applications have increased every year since commercial seaweed farming began in 2017, though most of this second wave of seaweed farmers have yet to produce kelp for sale. Seaweed permit applications in the 2021 application period were down, likely attributable to the COVID-19 pandemic.

Alaska's commercial seaweed crop is used almost entirely for consumer food products, much of it sold through natural foods channels and retail segments. These food markets garner a premium for Alaska's high-quality seaweed and are among the only markets able to support Alaska's current high production cost structure.

Production

Alaska's first commercial farmed seaweed harvest occurred in 2017, when two farms near Kodiak produced kelp for California-based seaweed food manufacturer Blue Evolution. As of 2021, Alaska's total seaweed mariculture harvest has grown to an estimated 440,000 pounds.

Although it has progressed rapidly, Alaska's seaweed mariculture industry is very small by global standards and needs higher volumes and lower production costs to break into many of the markets discussed in this report.

In addition to farmed seaweed, Alaska produces wild seaweed (mostly bull kelp) for commercial uses including food and fertilizer. Wild harvests grew from 18,000 pounds to about 87,000 pounds between 2017 and 2020.

Table 1. Alaska Farmed and Wild Seaweed Production Volume, 2017-2021 (thousands of wet pounds)

Year	Alaska Farmed Seaweed Production	Alaska Wild Commercial Seaweed Harvest
2017	18	18
2018	89	38
2019	112	52
2020	270*	87
2021	440*	Not Available

Source: ADF&G and McKinley Research Group interviews.
Note: *Estimate based on industry interviews.

Permitting

The growth in seaweed mariculture production has come largely from the original two kelp farms off the coast of Kodiak. As of 2021, the number of operating commercial kelp farms includes a third farm off the coast of Kodiak that produces kelp for Blue Evolution as well as Premium Aquatics, LLC. Premium Aquatics does business under the name Seagrove Kelp Co. and is based in southern Southeast Alaska with a hatchery in Ketchikan and a large farm off Prince of Wales Island.

Additional seaweed farm operations are in the permitting pipeline. Applications for seaweed aquaculture permits have grown every year since 2017 through 2020. The application window for 2021 applications closed April 30. The Alaska Department of Fish & Game permit coordinator attributed low interest in 2021 to pandemic-related uncertainty.

The following table includes applications for seaweed farms as well as combined seaweed and shellfish farms. The numbers do not include applications for shellfish-only farms.

Table 2. Number and Acreage of Proposed Alaska Aquatic Farms that Include Seaweed, 2017-2021

Application Year	# of Applications	Acreage Proposed
2017	6	436
2018	10	541
2019	11	561
2020	16	597
2021	6	199
2017-2021 total	**49**	**2,334**

Source: ADF&G and DNR.

As of July 2021, 20 seaweed and combined seaweed/shellfish farm site permits were designated as "active," meaning they are authorized to operate, although not necessarily actively farming. The map below shows the locations of active and proposed seaweed farms (including farms that plan to raise both seaweed and shellfish) as of July 2021. This map does not include three proposed farms in far southwestern Alaska: two near Sand Point, and one near Adak.

Figure 2. Locations of Operating and Proposed Seaweed Farms in Alaska

Source: McKinley Research Group. Data from Alaska Department of Natural Resources and Alaska Department of Fish & Game. Base map: © OpenStreetMap.org contributors.

Like seaweed mariculture elsewhere in the world, Alaska's seaweed farms are coastal, near-shore operations consisting of seeded lines suspended in the water column by anchors and buoys. Alaska is considered a good location for this kind of coastal farm because of its extensive, sparsely developed coastline.

Elsewhere in the U.S., research is underway on methods of growing seaweed in the offshore environment. The development of offshore farms would open large areas to seaweed farming – though such farms would likely face greater operational challenges than coastal farms.

Markets

The original market for Alaska farmed seaweed when production began in 2017 was a single value-added consumer food company: California-based Blue Evolution. The number of seaweed buyers expanded in 2020 with the first commercial harvest by Seagrove Kelp Co., which sells seaweed to several small companies and also recently began selling seaweed under its own label. Blue Evolution remains the largest buyer of farmed seaweed in Alaska.

Blue Evolution uses Kodiak-grown sugar kelp and ribbon kelp to produce products such as kelp puree pouches and whole leaf kelp in various dried and frozen forms. The company operates a hatchery, provides seed, and pays farmers for farming services. The puree product is frozen in Kodiak and transported to California for secondary processing, while the frozen and dried products undergo final processing in Kodiak.

In Southeast Alaska, Seagrove sells to several buyers, including Juneau-based Barnacle Foods (which also harvests its own wild seaweed) and California-based fertilizer company Pacific Northwest Organics. Seagrove also recently began offering kelp under its own label.

In other parts of the world, seaweed product markets include alginates, animal feeds, and cosmetics. Seaweed product markets that do not yet exist on a commercial scale – but that could become important uses for Alaska seaweed – include carbon and nutrient sequestration credits, bioplastics, and biofuel.

Methodology

Executive Interviews

Forty interviews were conducted with stakeholders and experts in the North America and European seaweed industries, listed in Appendix A. More than half of those interviewed (25) represented companies producing products made with seaweeds grown or harvested from North American or European waters. Another ten interviews were conducted with industry experts and consultants. Five interviews were conducted with distributors supplying a wide range of grocery stores throughout the United States.

Interview questions covered seaweed sourcing, product manufacturing, marketing, and consumer education, among other topics. While few companies are currently marking products made with Alaska seaweed, interviews were structured to glean insights that may be transferable and/or help inform an understanding of Alaska's competitiveness as a source of various wholesale and retail seaweed products. The interview protocol used with seaweed product manufacturers is included as Appendix B.

Market Research Reports

A variety of secondary literature and research was consulted for this report, as documented in footnotes throughout the report. A selection of the most useful and informative sources is provided below.

- Alaska Mariculture Initiative, 2017. *Economic Analysis to Inform a Comprehensive Plan: Phase II.*
- Bord Iascaigh Mhara (Irish Sea Fisheries Board), 2014. *The European Market for Sea Vegetables.*
- Bord Iascaigh Mhara (Irish Sea Fisheries Board), 2020. *Scoping a Seaweed Biorefinery Concept for Ireland*.
- United Nations Food and Agriculture Organization (FAO), 2018. *The Global Status of Seaweed Production, Trade and Utilization.* Globefish Research Programme Volume 123.
- Island Institute, 2020. *Edible Seaweed Market Analysis.*
- Kim, JangKyun et al. *Opportunities, challenges and future directions of open-water seaweed aquaculture in the United States.* Phycologia.
- U.S. Department of Energy, 2021. *Kelp Energy Products and Marine Renewable Energy for Coastal Alaska Communities.*

Data Sources

Sources of data used in this report include the following:

- Fisheries and aquaculture statistics – United Nations Food and Agriculture Organization (FishStatJ)
- Global trade data – Trade Data Monitor and United States International Trade Commission
- U.S. seaweed harvest and production data – Alaska Department of Fish & Game, Alaska Department of Natural Resources, and government agencies in Maine and other coastal states
- Retail scanner data on sales of seaweed products in U.S. grocery stores – purchased from IRI, Inc.
- Data excerpts provided by market research firms Technomic and SPINS.

Seaweed Production and Trade Overview

Seaweed is a $6 billion global industry that produces more than 70 billion pounds of wet-weight harvest per year.[1] For context, that harvest weight is more than four times the weight of the world's salmon harvest, including farmed and wild. The United States is a small seaweed producer and a moderate seaweed consumer on the global scale. The U.S. imports more than 95% of the edible seaweed it consumes.[2]

This section provides an overview of global and domestic seaweed production, including quantities and trends by uses and species.

Global Seaweed Harvest and Production

Most of the world's seaweed production comes from farms in a handful of East Asian countries. Among the three broad categories of seaweed, red seaweeds are the most cultivated in the world, followed by brown seaweeds. Green seaweeds are a distant third. Red seaweeds are used for food and to produce carrageenan and agar which are hydrocolloids (thickening and gelling agents with dozens of commercial applications from toothpaste to paper manufacturing). Brown seaweeds, which include all kelp species, are used largely for food although they are also used to make alginates, another type of seaweed-derived hydrocolloid.

Seaweed Production by Country

Seaweed is a mature industry in Asia and an embryonic industry in the rest of the world. As of 2019, more than 97% of the world's seaweed production came from Asia, where seaweed is an important regional commodity and a major export. Seaweed is a food staple in East Asia. There is a tradition of eating seaweed in scattered other parts of the world, as well, but mostly as specialty products rather than staples.

The regional disparity in seaweed production is driven by farmed seaweed. In 2019, 99.5% of the world's farmed seaweed came from Asia. The largest producers of wild seaweed are outside Asia, including Chile (890 million pounds harvested in 2019), Norway (360 million pounds), and France (113 million pounds).

[1] FAO, 2018. *The Global Status of Seaweed Production, Trade and Utilization*. Globefish Research Programme Volume 123. fao.org/in-action/globefish/publications/details-publication/en/c/1154074/.
[2] Island Institute, 2020. *Edible Seaweed Market Analysis*.

The satellite image seen here provides a sense of the magnitude of seaweed mariculture in East Asia. The image shows mariculture off the southern coast of South Korea around the town of Hoejin-myeon. Large floating farms off the coast have similar dimensions to the terrestrial farm fields. For scale, the bay near the center of the frame is more than a mile long. Thousands of acres of aquaculture are visible in a larger version of the image shared by NASA.[3]

Mariculture Farms in Coastal South Korea, Viewed from Space

Source: NASA Earth Observatory.

More than three-quarters of world seaweed production is clustered in China and Indonesia. China grows more than half the world's seaweed, producing 44.4 billion pounds of seaweed (wet weight) in 2019. In general, 10 pounds of wet seaweed produces about one pound of dried seaweed, although the conversion factor varies for different types of seaweeds.

Table 3. Top Seaweed Producing Nations in 2019, Farmed and Wild Production Combined

Country	Rank	Volume (billion lbs.)	% of Total
China	1	44.4	56.6%
Indonesia	2	22.0	28.0%
South Korea	3	4.0	5.1%
Philippines	4	3.3	4.2%
North Korea	5	1.3	1.7%
Chile	6	0.9	1.2%
Japan	7	0.8	1.1%
Malaysia	8	0.4	0.5%
Norway	9	0.4	0.5%
Zanzibar (Tanzania)	10	0.2	0.3%
All other	-	0.6	0.8%
Total World Production	**-**	**78.4**	**100%**

Source: FAO.
Note: Figures may not sum to total due to rounding. Volume reflects wet weight.

[3] NASA Earth Observatory, 2015. http://earthobservatory.nasa.gov/images/85747/seaweed-farms-in-south-korea

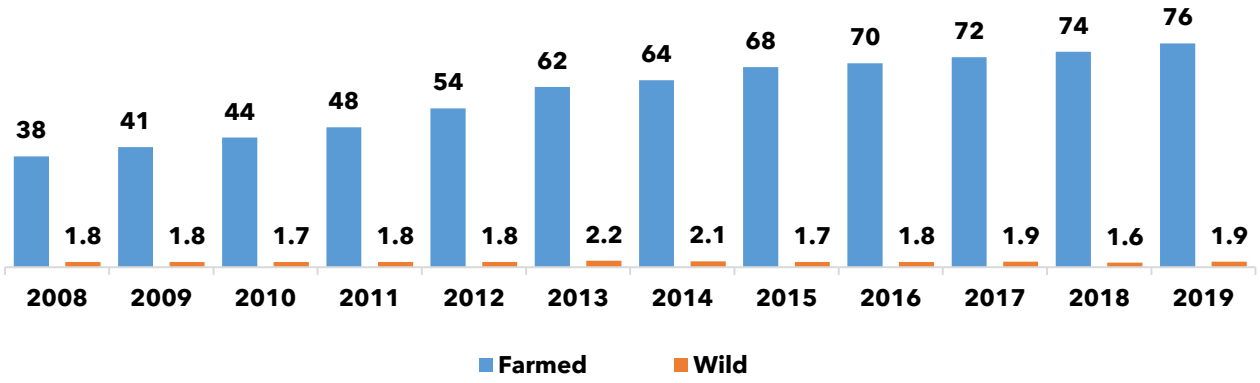
The United States ranked 22nd in seaweed production in 2019 with production of about 19 million pounds.[4] Most U.S. production is from wild rockweed harvested off the coast of Maine, as discussed later in this report.

The Growth of Farmed Seaweed

Aquaculture overtook wild harvest as the main source of seaweed supply in the world in the 1960s. Over the past six decades the world's seaweed farms have continued to grow, while the wild harvest has been relatively constant at about 2 billion wet pounds per year.

World aquaculture seaweed production has grown at an average rate of 7% annually over the past 20 years, with the fastest growth in 2012 and 2013. Growth slowed to an annual average of 4% over the past five years.

Figure 3. World Seaweed Production (billions of wet pounds)



Source: FAO.

Global Seaweed Production by Seaweed Type

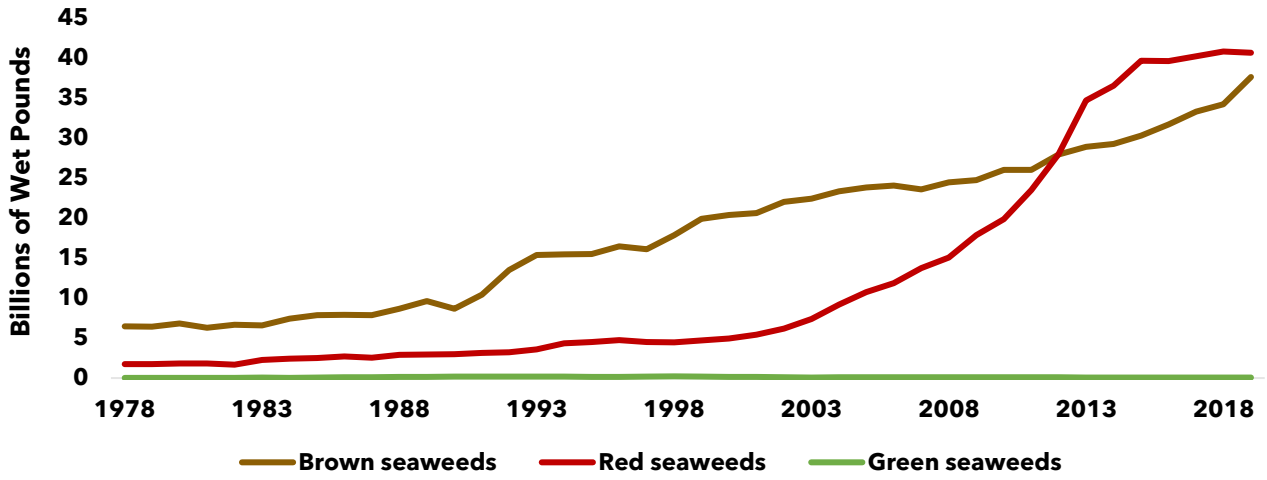
The growth of seaweed production has varied across the three main seaweed categories: brown, red, and green. World red seaweed production started to grow rapidly around the year 2000, overtaking brown algae in 2012, but slowing down in last five years of available data. Red seaweed varieties include nori and dulse, both widely cultivated for human food. In addition to their use as food, red seaweeds are often used globally for producing carrageenan and agar.

Green algae, the third major category of seaweed, is not cultivated at a globally significant scale. Types of green seaweed with commercial value include sea lettuce and sea grapes.

[4] McKinley Research Group estimate based on production totals from main seaweed producing states.

Most of the Alaska commercial seaweed harvest to date has been in the brown seaweed category, which includes all kelp species.

Figure 4. Global Farmed Seaweed Production Volume, by Type, 1978-2019



Source: FAO.

Seaweed Production by Genus and Species

Both brown and red seaweed farming have grown over the past two decades, but red seaweed production has grown at a faster rate. The most dramatic change over the two-decade period has been the rapid expansion of two red seaweed genera that grow best in warm waters and are used predominantly to make hydrocolloids. *Eucheuma* is used largely to make carrageenan, which has numerous applications including as a food additive in products such as soy milk and deli meats. *Gracilaria* is used largely to make agar, which is used among other things as a bacterial growth medium and as a clarifying agent in wine and beer brewing.

There are more than 10,000 species of seaweed and more than 500 with known human food or medicinal uses. However, only 20 species are prominent enough to be tracked by the United Nations database of seaweed production, and 96.8% of world mariculture production comes from eight seaweed genera, according to a recent academic review.[5] These eight genera have become more prominent over the last two decades: in the year 2000, they accounted for 72.3% of seaweed mariculture production.

[5] Chopin et al., 2020. *Importance of Seaweeds and Extractive Species in Global Aquaculture Production.* Reviews in Fisheries Science & Aquaculture. https://doi.org/10.1080/23308249.2020.1810626

Table 4. Highest-Volume Farmed Seaweed Genera, 2000 and 2018 (billions of wet pounds)

	Main Use	2000		2018	
		Production Volume	% of Total	Production Volume	% of Total
Red seaweeds		**4.3**	**19%**	**38.2**	**54%**
Eucheuma (various species)	Carrageenan	0.7	3%	20.8	29%
Kappaphycus (various species)	Carrageenan	1.4	6%	3.5	5%
Gracilaria (various species)	Agar	0.1	1%	7.6	11%
Nori (various species *Porphyra, Pyropia*)	Food	2.1	9%	6.3	9%
Brown seaweeds		**18.9**	**81%**	**32.9**	**46%**
Saccharina japonica (kombu)	Food	11.9	51%	25.2	35%
Undaria pinnatifida (wakame)	Food	0.7	3%	5.1	7%
Sargassum (various species)	Varied	0.0	0%	0.6	1%
Other brown seaweeds (various species)	Varied	6.3	27%	2.0	3%
Other seaweeds	**Varied**	**0.2**	**1%**	**0.3**	**0%**
Total seaweed production		**23.4**	**100%**	**71.4**	**100%**

Source: Chopin et al., 2020 (based on FAO 2018 statistics).

The list of genera currently grown or proposed in seaweed farms in Alaska looks substantially different than the list of genera most frequently grown in the rest of the world. These differences create both challenges and opportunities for Alaska producers.

Nori (which can refer to genus *Porphyra* or *Pyropia*) is the only seaweed variety grown or proposed for the Alaska mariculture industry that is on this list of most frequently grown seaweeds in the world. Species grown or proposed for Alaska that are not among the most produced in the world include bull kelp, three-ribbed kelp, ribbon kelp, and dragon kelp.

However, it should be noted that sugar kelp (*Saccharina latissima*) in the same genus as *Saccharina japonica* (kombu), which is the most produced brown seaweed in the world. Because of its similarity to kombu, sugar kelp is sometimes marketed as "Alaskan kombu," or as "Atlantic kombu" when it is harvested on the East Coast. Similarly, Alaska's ribbon kelp (*Alaria marginata*) has been marketed as "Alaskan wakame" for its similarity to *Undaria pinnatifida*.

Within the United States, sugar kelp is the most widely produced species currently farmed. Still, sugar kelp is not grown on a large scale by international standards.

Global Seaweed Product Types

Hydrocolloid extracts (carrageenan, alginate, and agar) make up the bulk of seaweed's value in international trade. As seen in the table below, these hydrocolloid products made up more than 65% of the value of all world seaweed exports between 2016 and 2020. An additional 27% came from seaweed products for human consumption, with the remaining 11% coming from seaweed products not for human consumption such as fertilizers and cosmetics.

Table 5. Global Seaweed Export Value, by Category, 2016-2020 Average

Seaweed Product Category	Export Value ($millions)	Percent of Total
Carrageenan*	1,041	51%
Seaweed for human consumption	548	27%
Seaweed not for human consumption	233	11%
Agar	224	11%
Alginate	160	8%
Total	**2,046**	**100%**

Source: Trade Data Monitor.
*Note: This number is slightly overstated because carrageenan's customs category code contains small amounts of thickener products that are not seaweed derived.

When considered by weight instead of by value, hydrocolloids represent a smaller part of the market because these highly processed extracts are more valuable by weight than foods and other seaweed products.

International Seaweed Exports

The largest seaweed exporters by value include major seaweed-growing nations as well as places such as the European Union and the United States that are major importers and exporters but not growers.

China is the world's largest seaweed exporter by value, in addition to being the world's largest seaweed producer. Most of China's seaweed exports are in the form of carrageenan, which is exported primarily to the European Union and the United States.[6]

By weight, Indonesia is the world's largest seaweed exporter. The archipelago shipped out 34% of the seaweed volume sold in international trade in 2020. But as primarily an exporter of seaweed for human

[6] FAO, 2018. The Global Status of Seaweed Production, Trade and Utilization. Globefish Research Programme Volume 123.

consumption, which is much less valuable by weight than seaweed extracts, Indonesia captures a comparatively small share of the world market by value.

The United States produces 4% of the world's seaweed products despite growing less than 1% of the world's seaweed. Seventy-eight percent of the value of U.S. seaweed exports are carrageenan or agar products.[7]

Table 6. Seaweed Export Volume and Value, by Country/Trade Block, 2016-2020 Average

	Rank by Value	Export Value ($millions)	% World Value	Export Volume (million lbs.)	% World Volume
China	1	$552	25%	171	13%
South Korea	2	$290	13%	72	6%
Indonesia	3	$255	12%	441	34%
European Union*	4	$242	11%	153	12%
Chile	5	$221	10%	168	13%
Philippines	6	$193	9%	75	6%
United Kingdom	7	$115	5%	31	2%
United States	8	$90	4%	15	1%
All other		$248	11%	152	12%
Global exports		**$2,206**	**100%**	**1,278**	**100%**

Source: Trade Data Monitor.
Notes: Seaweed exports include edible and nonedible seaweeds, agar, carrageenan, and alginate.
*Not including the United Kingdom.

U.S. Domestic Seaweed Harvest and Production

The current seaweed industry in the United States contrasts in many ways to the global industry. Domestic seaweed production is predominantly from wild seaweed, not farms. Most U.S.-grown seaweed is used to produce fertilizers and vitamin supplements, while the main international trade seaweed categories are hydrocolloids and human food.

The domestic mariculture industry remains very small compared to both domestic wild harvest and to the global industry. However, the U.S. farmed seaweed industry, centered in Maine and Alaska, has grown quickly over the past three years, and has largely focused on developing human food products for the domestic market. The major farmed seaweed species in Maine and Alaska are sugar kelp, ribbon kelp, and bull kelp.

[7] *Ibid.*

Table 7. Maine, California, and Alaska Seaweed Production, 2018-2020, (thousands of wet pounds)

	Key Species Harvested	2018	2019	2020P	2021F
Maine					
Wild Harvest	Rockweed, dulse, laver	23,323	15,197	16,224	n/a
Farmed	Sugar kelp/skinny kelp, alaria/winged kelp	54	281	482	800+
California					
Wild Harvest	Giant kelp, Bull kelp	4,974	3,376	2,044	n/a
Farmed	Ogo, dulse, kombu, sea lettuce	<1	<1	<1	<1
Alaska					
Wild Harvest	Bull kelp, detached beach detritus	38	52	78	n/a
Farmed	Sugar kelp, alaria, bull kelp	89	112	275	400

Source: Maine Department of Marine Resources, California Department of Fish and Wildlife, Alaska Department of Fish & Game, McKinley Research Group interviews.
Notes: 2020 and 2021 are preliminary (P) and projected (F) volumes, respectively.

Maine Wild Harvest

As of 2020, Maine has the most significant wild kelp harvest in the United States. About 90% of Maine's wild harvest is rockweed, *Ascophyllum nodosum*, a species harvested by hand, by rake, and by mechanical harvesting boat. Rockweed is used predominantly for fertilizers, animal feed, and nutritional supplements.[8]

Maine wild seaweed harvesters landed 16.2 million pounds in 2020, worth approximately $1.1 million and representing more than 80% of U.S. wild and farmed seaweed production volume that year.

Initial harvest prices for Maine's wild seaweed harvest have been between $0.04 and $0.07 per pound over the last decade, and mostly reflect rockweed prices due to that rockweed's overwhelming share of harvest volume. These prices are an order of magnitude below farmed seaweed prices in both Maine and Alaska.

The regulatory environment for Maine wild seaweed harvest changed in 2019 with a Maine Supreme Court ruling in a lawsuit against Canadian company Acadian Seaplants Limited. The ruling prohibited commercial seaweed harvesters from cutting seaweeds in the intertidal zone without permission from the owner of the shoreline.[9] This ruling has so far not affected harvest volumes, which over the last two years have remained in line with the 10-year average.

In addition to rockweed, Maine has a smaller commercial harvest of several seaweeds used mainly for human consumption, including dulse *(Palmaria palmata*), Irish moss (*Chondrus crispus*), and bladderwrack (*Fucus*

[8] Maine Department of Marine Resources & Rockweed Plan Development Team, 2014. *Fishery Management Plan for Rockweed*.
[9] Maine Supreme Judicial Court, 2018. Ross et al. v. Acadian Sea Plants Limited.

vesiculosus). Maine Sea Coast Vegetables, the principal company marketing edible wild seaweeds harvested in the U.S., in the last decade ventured into purchasing and growing farmed seaweed to supplement purchases of wild seaweed, citing demand for some species that exceeds what can be sustainably harvested in the wild. In an interview the company noted that prices for farmed seaweed are significantly higher than for wild harvest, and that farmed seaweed is not a replacement for the wild product because wild seaweeds have a different taste, texture, and potentially different nutritional profile than farmed seaweeds of the same species.

California Wild Harvest

In California, wild kelp (largely giant kelp with some bull kelp) is harvested for abalone feed. Last year's harvest was about 2 million wet pounds. California also has a small harvest of edible seaweeds including sea palm (*Postelsia palmaeformis)*, *Alaria*, *Laminaria*, and nori (*Porphyra, Pyropia*). Small amounts of giant kelp and bull kelp are harvested under edible seaweed regulations, in addition to the larger not-for-human-consumption harvest.

Historically, California had a far larger commercial harvest of wild giant kelp for the alginate industry. This harvest totaled more than 300 million pounds annually in the 1970s and was 145 million pounds in 2005, the year alginate producer ISP Alginate (formerly Kelco, a Merck & Company subsidiary) closed its plant in San Diego.

Growth of Mariculture in Maine and Alaska

Prior to the current generation of farms established in the last 10 years, efforts to establish a farmed seaweed industry in the U.S. failed to achieve commercial production.[10] Past efforts include unsuccessful seaweed biomass projects in California and New York in the 1970s and 1980s, and a movement to grow nori in Washington State in the 1980s that succumbed to opposition from coastal landowners. The failure of subsequent nori mariculture efforts in Maine and Alaska in the 1990s has been attributed to biological and technological challenges.

Commercial seaweed mariculture in the U.S. started in 2010 with the first harvest and sale of kelp by Ocean Approved (today known as Atlantic Sea Farms) in Maine. Larger-scale production began in 2018. Maine remains the leader in farmed seaweed, followed by Alaska which started to scale seaweed farming a few years later.

[10] Kim, JangKyun et al. *Opportunities, challenges and future directions of open-water seaweed aquaculture in the United States*. Phycologia. https://doi.org/10.1080/00318884.2019.1625611

Although U.S. seaweed mariculture has grown rapidly since 2018, the scale of the domestic industry compared to the global industry is important context. Domestic farmed seaweed production would have to double every year for 14 years to reach China's current level of production.

Seaweed Mariculture in Other States

Numerous projects are in the works along the Northern Atlantic and Pacific coasts to test the viability of commercial seaweed mariculture. Among other states (besides Maine and Alaska) venturing into the seaweed mariculture industry, Rhode Island and Connecticut are the farthest along in transitioning from research to commercial production.

Efforts on the East Coast have largely followed the model of existing commercial seaweed farms in Maine. Several of the Pacific projects are researching tank-grown seaweeds rather than open-water operations. The following table is based on research compiled by Sea Grant for the 2020 National Seaweed Symposium and should be considered a conservative estimate for the number of seaweed mariculture facilities in each state.

Table 8. Seaweed Infrastructure in U.S. States Other than Maine, California, and Alaska

State	Seaweed Farming Facilities	Key Species
New Hampshire	3 research farms	Sugar kelp
Massachusetts	3 commercial farms, 1 research farm	Sugar kelp
Rhode Island	10 permitted farms (3 operating in 2019)	Sugar kelp
Connecticut	15 permitted farms	Sugar kelp, *Gracilaria tikvahaie*
New York	2 research farms	Sugar kelp, *Gracilaria tikvahaie*
Washington	1 farm, 1 tank research operation	*Chondracanthus*, sugar kelp, bull kelp
Oregon	3 land-based farms	Dulse

Source: National Seaweed Symposium 2020 "State of the States" presentation.

U.S. Seaweed Farm Gate Prices

Farm gate prices (the price paid for a crop at harvest) have generally trended down in the first few years of commercial sales in Maine and Alaska. In Maine, average prices for the entire farmed seaweed harvest dropped from $0.71 a pound to $0.60 a pound between 2018 and 2020. In Alaska, average prices dropped from $0.70 a pound to $0.54 a pound from 2018 to 2019.

These price drops likely reflect improvements in farming efficiency and movement toward a price point sustainable for both harvesters and buyers. Species composition also influences average prices for farmed seaweed. Among the two main species grown, *Alaria* generally sells at higher prices than sugar kelp, though species-specific data are not currently available.

It is important to note that further reductions in U.S. seaweed farming costs are needed for competitiveness in many of the markets discussed in this report.

Table 9. Maine and Alaska Farmed Seaweed Farm Gate Value and Average Price, 2018-2020

	Farmed Seaweed Production (USD)			Average Farm Gate Price ($/pound)		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**
Maine	$37,897	$176,132	$288,490	$0.71	$0.63	$0.60
Alaska	$58,167	$60,540	not available	$0.65	$0.54	not available

Source: Maine Department of Marine Resources, Alaska Department of Fish & Game, McKinley Research Group interviews.

U.S. Seaweed Imports

Over the last five years, the U.S. has imported an average of $229 million worth of seaweed and seaweed products. The bulk of seaweed imports to the U.S. are hydrocolloid extracts, led by carrageenan and followed by agar and alginate. Seaweeds for human consumption make up about a quarter of seaweed imports by value over the last five years, and seaweed not for human consumption averaged 17%. By weight, low-priced seaweeds not for human consumption account for more than 50% of U.S. imports.

Table 10. Seaweed Imports to the U.S. by Product Type (2016-2020 average)

Product Type	Value ($ millions)	% of Import Value	Volume (million lbs.)	% of Import Volume	Top Trading Partner
Carrageenan	$79	34%	20	23%	Philippines
Seaweed for human consumption	$52	23%	15	18%	South Korea
Seaweed not for human consumption	$39	17%	46	52%	South Korea
Agar	$34	15%	4	4%	Spain
Alginates	$25	11%	2	3%	Norway
Total Seaweed Product Imports	**$229**	**100%**	**87**	**100%**	**Philippines**

Source: U.S. International Trade Commission.

Competitive Landscape for Emerging Seaweed Production

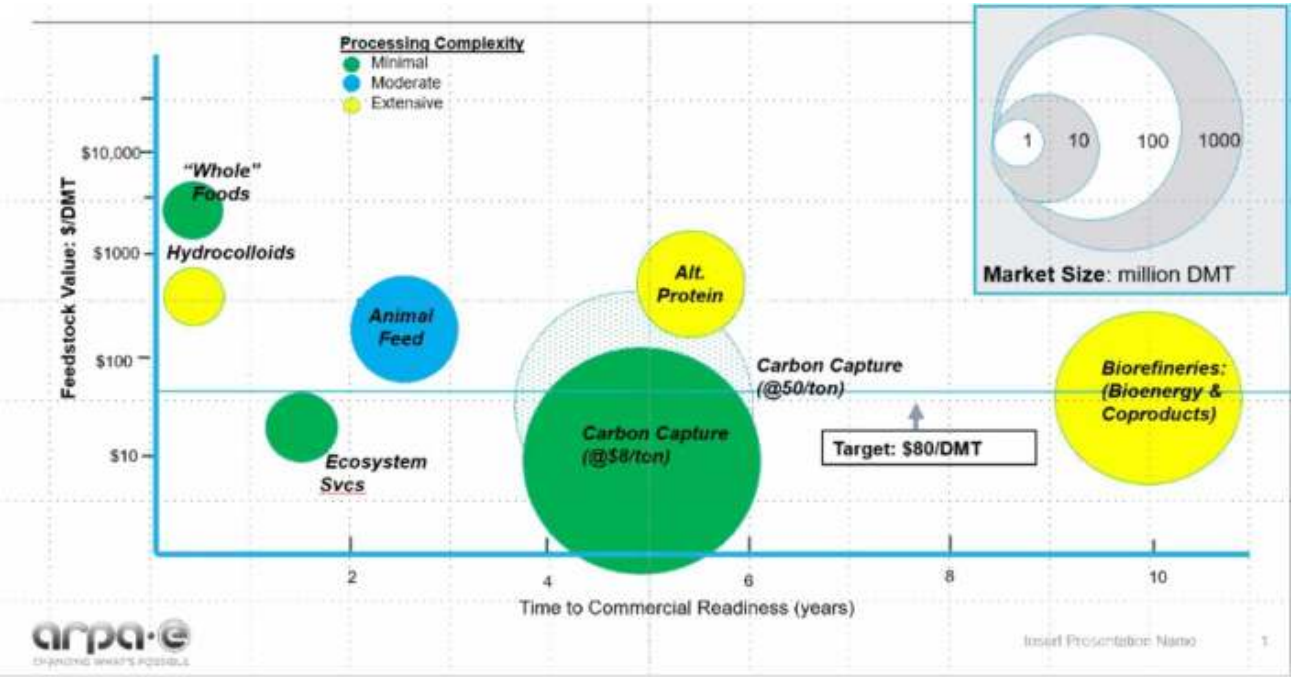
In addition to the seaweed products already in trade streams globally, there is significant interest and investment in scaling seaweed production around the globe. Initiatives exist in Europe, other U.S. states,

Canada, Chile, and numerous Asian countries, among others. Growing interest is in large part due to seaweed's potential as a tool in carbon mitigation and as a protein replacement for plant-based meats and other foods.

While it is beyond the scope of this report to detail these initiatives, it is important to recognize that the opportunities presented by seaweed are globally recognized and subject to a global competitive landscape. Research and development investments happening around the world may also be of benefit to Alaska's industry, to the extent that the information developed is available in the public domain.

The graphic below, produced by the Advanced Research Projects Agency-Energy (ARPA-E) at the U.S. Department of Energy, illustrates the potential market opportunities for seaweed. Though the assessment focused on opportunities for U.S. seaweed producers, the market segments examined are equally valid for non-U.S. production. For each potential market, the figure compares estimated time to commercial readiness (horizontal axis), maximum raw material cost structure that can be supported (vertical axis), and the potential market size (size of circle). Additionally, the coloring of the circles indicates the seaweed processing complexity needed for the final product in each market segment.

Figure 5. Potential Market Opportunities for U.S. Seaweed Producers



Source: Advanced Research Projects Agency-Energy (ARPA-E), U.S. Department of Energy, MARINER program.
Note: Y-axis is on a logarithmic scale.

A Sampling of Global Initiatives

While not an exhaustive list, the following initiatives provide a window into the nature and sophistication of global efforts to scale seaweed production and improve scientific understand of its potential utility. Alaska's efforts to develop its seaweed industry are situated within this larger global context.

- The U.S. Department of Energy's ARPA-E MARINER project has funded several innovative seaweed projects in recent years including one that explored farm site design with collaborators in Alaska. A target of the MARINER program is to bring American seaweed production costs down to $80 per dry metric ton (depicted as a horizontal line in the figure above). The agency funds innovative research that would dramatically improve farming efficiency, such as selective breeding, use of autonomous vehicles for transportation, and other technologies.

- In 2020, the United Nations Global Compact and Lloyd's Register Foundation published the "Seaweed Manifesto," an assessment of opportunities, barriers, success factors, and a proposed set of milestones for "a fully and responsibly developed seaweed industry." The editorial board of the manifesto drew from numerous European seaweed industry specialists and NGO and private sector partners such as Cargill, the World Wildlife Fund, and the World Bank.[11] In March 2021, the United Nations Global Compact and Lloyd's Register Foundation, in partnership with the French National Centre for Scientific Research (CNRS), launched a global coalition intended to "unlock the full potential" of seaweed to contribute to the United Nations Sustainable Development Goals.[12]

- Seaweed for Europe is a coalition of seaweed producers, ocean- and carbon-focused venture capital firms, investment funds, NGOs, think tanks, technology firms, and other European interests allied to support the development of a European seaweed industry.[13]

- The GENIALG Project is a consortium of European biorefineries with experts in seaweed cultivation, genetics, and metabolomics (the study of metabolites produced by a cell, tissue, or organism). With more than €12 million in funds, including nearly €11 million from the European Commission, the initiative aims to accelerate seaweed biomass production in Europe by solving issues related to cost, quality, and scales of production. The group aims to support scaling of seaweed production through a set of research projects, intended to result in high-yielding seaweed cultivation systems.[14] Work at

[11] http://www.seaweedmanifesto.com/about/

[12] UN Global Compact, *The UN Global Compact, Lloyd's Register Foundation and CNRS launch Safe Seaweed Coalition to drive a sustainable industry*, March 16, 2021. https://www.unglobalcompact.org/news/4692-03-16-2021

[13] https://www.seaweedeurope.com/

[14] https://genialgproject.eu/about/project-overview/

GENIALG has already resulted in publication of 25 journal articles on subjects that will support seaweed cultivation and commercialization.[15]

- Oceans 2050's Seaweed Project is attempting to design a methodology to quantify seaweed carbon sequestration. The market for "blue carbon" has potential to expand rapidly as governments and businesses race to reduce carbon in Earth's atmosphere. A carbon methodology is a critical step in monetizing and incentivizing seaweed's contribution to carbon reduction.

[15] https://genialgproject.eu/results/publications/

Potential Markets for Alaska Seaweed

Alaska's seaweed industry is emerging amidst an evolving global market for seaweed products. An assessment of potential markets for Alaska seaweed must consider current opportunities as well as nascent opportunities that may come to fruition in the medium- to long-term. While the bulk of current Alaska production is bound for consumer "whole" foods markets, growth in this market is likely to be limited in the near term, particularly relative to the potential volumes of production that Alaska could support. This chapter examines market opportunities and strategic considerations that can impact the scale, speed, and trajectory of the industry's development in Alaska.

This report groups the myriad current and prospective seaweed markets into four categories (based in part on the ARPA-E graphic discussed in the previous chapter):

1) **Whole foods**: These are human foods, the primary current market for Alaska seaweed. This category does not include food additives extracted from seaweeds (see category 3).

2) **Fertilizer and animal feeds**: Besides food, these are the only other major existing markets for seaweed that have relatively low-tech processing requirements.

3) **Seaweed extracts and biofuels (biorefinery model)**: This category includes biorefineries, alternative protein, and hydrocolloids. This category includes production of high-value nutritional supplement products such as fucoidan. As will be explained in this section, much of the research into these markets is built around the concept of a cascading biorefinery – a processing facility that would turn seaweed biomass into multiple product streams. Concepts for seaweed biorefineries are still in the modeling phase but working commercial biorefineries exist for other feedstocks including wood.

4) **Nonconsumptive market opportunities**: This category includes carbon capture and ecosystem services – markets that produce environmental benefits rather than tangible products.

Seaweed as a Whole Food

Currently, the most market-ready and valuable use for seaweed is as a whole food.[16] This market category includes seaweeds – fresh, frozen, or dried – sold as-is to consumers or used as ingredients in other food products. The category does not include seaweed extracts or components such as carrageenan and other food additives.

Nineteen U.S. and European companies that produce seaweed products in the "whole food" market were interviewed for this report. Appendix C includes overviews of the companies interviewed, including photos and descriptions of each company's seaweed products.

North America Market Overview

Seaweed consumption outside the context of sushi and Asian seaweed snacks is not common in the United States, though there is a history of eating seaweeds in some Native American and other communities.

The following table, excerpted from a report by the Island Institute of Maine, describes the main channels by which edible seaweeds reach end consumers in the U.S.[17]

[16]One industry participant in Alaska estimates that best efforts in the state have resulted in product costs as low as $4,400 per dry metric ton, corresponding to about $0.20 per wet pound. Such farm gate prices can only be supported by the "whole" foods market, according to ARPA-E's assessment.

[17] Island Institute, 2020. *Edible Seaweed Market Analysis*.

Table 11. Leading U.S. Channels for Edible Seaweed Products

Channel	Number of Locations	Primary Product Source: Imported	Primary Product Source: Domestic	Estimated Market Share
Foodservice				
Asian Restaurants	64,000	✓		25%
Independent Fine Dining Restaurants	17,800	✓	✓	5%
Colleges/Universities	4,500	✓	✓	3%
Independent Seafood Restaurants	6,800	✓		<2%
All Other Foodservice	670,000+	✓		
Retail				
Health/Natural Foods	3,500	✓	✓	15%
Asian Markets	8,000+	✓		30%
Grocery–Sushi Franchises	7,000	✓		10%
All Other Retail Grocery	30,000+	✓		10%

Source: Pentallect Inc. research included in Island Institute, 2020. *Edible Seaweed Market Analysis*.

Retail outlets make up an estimated 65% of the U.S. edible seaweed market, with health and natural food stores the only segment regularly selling domestic seaweed products. Food service outlets make up the remaining market, with only independent fine dining restaurants and colleges/universities listed as regularly using domestic seaweeds. In all, three market channels totaling 23% of the U.S. edible seaweed market regularly sell at least some seaweed products of domestic origin.

SOURCING

Wild harvest is the main source of seaweed food products produced in North America, although seaweed aquaculture is growing rapidly. The current generation of wild seaweed food businesses in North America began in 1971 with the opening of Maine Coast Sea Vegetables. On the Pacific coast, Canadian Kelp was founded in 1982 on Vancouver Island, British Columbia. Wild seaweed food product processors largely sell seaweed in dried whole leaf and dried flake form. A wider variety of species is available in wild form compared to farmed. A handful of value-added wild products exist, such as the Kelp Krunch snacks from Maine Coast Sea Vegetables.

Seaweed farming is a new industry in North America, only producing seaweed at a significant commercial scale in the last three years. Farmed seaweed in the U.S. is nearly all used for food products. The largest farmed seaweed business by volume of product sold is Maine-based Atlantic Sea Farms. Founded in 2009,

the company was reorganized in 2017 to focus on seaweed food production and marketing instead of farming. Atlantic Sea Farms buys seaweed from a network of farmers and produces value-added refrigerated seaweed salads and frozen kelp puree cubes, among other products.

Over the last few years, producers have developed other value-added products that use farmed North American kelp in varying quantities. Examples include jerkies, chips, popcorn, and a kelp burger.

Europe Market Overview

Seaweeds have been part of historical cuisines in Iceland (dulse), Wales (laver), Ireland (dulse), and Scotland (dulse). In France, particularly in the Brittany region, wild seaweed harvesting is a decades-old industry. As in the U.S., farmed seaweed is a relatively new prospect in Europe.

A variety of value-added products is available in different European markets, reflecting local tastes and culinary history. In France, seaweed butters and tartares (a type of spread that accompanies a meal) have been sold in fine grocery stores for more than 20 years. Seaweeds are used in many complex ready-to-eat products like burgers, "meatballs", vegan sausages, and nuggets. The Dutch Weed Burger, created in Amsterdam, has been on the market since 2012 and is sold in 200 restaurants in the Netherlands and beyond.

Retail Seaweed Food Products

The whole food products produced in Europe and North America from seaweed grown and harvested in those regions are a very small component of a market dominated by Asian seaweed products.

For instance, the project team reviewed the 688 products in U.S. conventional retail stores that included the words "kelp" or "seaweed" in their product name, as tracked by retail scanner data company IRI. Of these, fewer than 20 products (3%) are made with domestic seaweeds. Scanner data, including sales prices and volumes, was purchased for the top 120 of these products. Together the top 120 products grossed more than $43 million in sales at outlets tracked by IRI's multi-outlet market channel, which notably does not include natural foods stores among other limitations. No domestic-origin seaweed product made this list. A breakdown of the top 120 U.S. retail seaweed products by category indicates the dominance of dried seaweed snacks, along with seaweed salads, sushi wrappers, and miscellaneous other products.

Table 12. Top 120 Seaweed Products at Mainstream U.S. Retail Outlets, by Category

Product Category	Number of Products	Total Dollar Sales	% of Total Sales	Example Product Description
Salty Snacks	76	$33,153,400	77%	Stacks of mini nori sheets, produced by companies like Ocean's Halo
Refrigerated Side Dishes	19	$3,361,300	8%	Prepared seaweed salad, typically available in the sushi section

Asian Food	9	$3,244,700	8%	Sushi wrappers
Spices/Seasonings	4	$1,049,200	2%	Seaweed spice mixes and salts
Crackers	4	$1,004,900	2%	Crackers covered in or incorporating seaweed flakes
Soup Mixes	4	$866,300	2%	Dried soup mixes containing seaweed
Rice/ Popcorn Cakes	1	$367,200	1%	Rice cakes with seaweed flakes
Pasta	1	$41,900	<1%	Blue Evolution's seaweed pasta made with sea lettuce grown in Mexico
Total	**120**	**$43,126,800**	**100%**	

Source: Retail scanner data purchased from IRI, Inc.
Note: Reflects products in IRI's Total U.S. Multi-Outlet (MULO) market, which does not include natural foods stores among other limitations. Sales data reflect the 52-week period ending 11/29/2020. Includes only the top-grossing 120 UPC codes with seaweed or kelp in the product description field. Categories were not available for two products.

Dried Products Made with U.S. and European Seaweeds

Many farmers and harvesters interviewed sell dried whole-leaf and milled products to consumers. The dried form depends on species characteristics. Kelps, including kombu (*Saccharina spp.*), tend to be sold as whole leaves due to their tougher texture, or milled to a powder. More tender species of seaweed, like dulse (*Palmaria palmata*) and sea lettuces (*Ulva*) are often sold as flakes.

Other dried products made with seaweeds include:

- Seasoning blends
- Seaweed salts
- Dried soup mixes
- Tea blends
- Chocolates
- Seaweed pastas
- Chips and crisps
- Jerky
- Crackers
- Wraps/tortillas

Of these dried products, seasoning blends and salts are especially common, presumably because they require less processing and product development. Some producers making sea salt/seaweed blends have partnered with local sea salt producers, creating opportunities that support both enterprises; for example, the Cornish Sea Salt Company and the Cornish Seaweed Company both sell seaweed salt blends using each other's product, and Pembrokeshire Beach Food in Wales use local Halen Mon sea salt for their seaweed salt blends. Daybreak Seaweed Co. uses farmed Alaska Wakame in their seaweed salt blend.

Healthy snack foods and crisps are a growing market in the U.S. and Europe. Current snack foods featuring seaweed include chips, clusters, crackers, puffs, jerky, and kelp chews. Seaweed fits neatly into emerging trends toward healthy, sustainable, and plant-based foods.[18]

Shelf-Stable Wet Products Made with U.S. and European Seaweeds

Shelf-stable sauces, relishes and spreads are common products featuring seaweed. In Europe, tartares, mustards, pestos, and tapenades are popular uses for seaweed, and companies have been making some of these products for well over 20 years.

Other shelf-stable products made from dried and fresh U.S. and European seaweeds include:

- Mustard
- Tartare
- Seaweed purees
- Infused oils and vinegars
- Canned soup
- Pesto
- Relish
- Pickles
- Tapenade
- Salsa
- Hot Sauce
- Alcoholic beverages
- Prepared canned seaweed
- Chutney

Fresh, Chilled, and Frozen Products Made with U.S. and European Seaweeds

Typically, seaweed is dried before further processing, though some value-added products use fresh or frozen seaweed. European producers have been successful in selling fresh and chilled products, including fresh salted seaweed, fresh sauces and condiments, butters, and plant-based meat alternatives. In the U.S., fresh products are less common but include regular and fermented seaweed salads (similar to sauerkraut). Fresh chilled products on the market today in the U.S. and Europe include:

- Seaweed salad

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[18] Food Ingredients Europe, 2020. *Snacking the Modern Way: An Overview of US and EU Trends.* https://www.figlobal.com/content/dam/Informa/figlobal/fieurope/en/2020/documents/HLN20FIE-ES-Snacking-the-modern-way.pdf

- Tartares
- Salted, fresh seaweed
- Ready-cut kelps
- Seaweed infused butters
- Plant-based meat products
- Krauts and fermented seaweed salads

There is also a limited range of frozen seaweed products, including:

- Kelp cubes
- Plant-based meat products
- Chopped leaf, ready-to-eat seaweeds

Wholesale and Food Service

Most U.S. and European seaweed producers and harvesters, including those who produce consumer-facing specialty food products, also sell raw or minimally processed seaweed to wholesale markets. This was confirmed across many interviews and appeared to be critical to supporting operations at significant scale.

Markets for wholesale seaweed include food service operations, restaurants, meal kit companies, and consumer packaged goods manufacturers. Some growers and harvesters sell to companies that source seaweed from their own production as well as from other sources.

Interviewees reported selling seaweed products in bulk or catering sizes for food service use. Whole leaf and fresh/salted fresh are reported to be popular items in the food service industry as they provide chefs creative leeway. Custom seaweed blends are popular as well for food service as they can be adapted for specific flavor and texture profiles.

Data provided by the market research firm Technomic indicates that roughly 10% of U.S. food service operators tracked by the company include menu items with seaweed. As in the retail market, nearly all of these seaweed ingredients are likely of Asian origin, though sourcing data was not available to evaluate directly.

Co-Products of Seaweed Food Production

Interviewees noted that waste from processing seaweed was negligible, with only 1-2% of harvested seaweed not of high enough quality for human consumption. Interviewees shared that the small amount of waste generated was generally sold or given away for use in composting, soil enrichment, or animal feed supplements. It is important to note that more considerable waste can occur at the farm site, depending on biofouling and other issues, but selective harvesting addresses this issue for those down the supply chain.

Fertilizers and Animal Feeds

Fertilizers and animal feeds together make up the most substantial North American seaweed industry. The industry has a decades-long history, an established supply chain, and well-developed markets. Acadian Sea Plants, the market leader, is based in Nova Scotia, Canada, and has 300 employees that generate an estimated annual revenue of $133 million.[19]

The animal and plant nutrition market, like the human food market, functions with existing technology and requires minimal processing compared to products that will be described in the next section of this chapter.

The fertilizer and animal feed industries generally rely on wild harvested seaweeds that are available at costs below current Alaska farmed seaweed production costs. There are exceptions: Pacific Northwest Organics, a small fertilizer manufacturer in Northern California, recently purchased farmed Alaska bull kelp. This sale points to potential in this market, though it may be limited to consumer-facing products like home and garden fertilizers and pet nutrition.

Fishy Peat, a soil amendment produced by Anchor Point Greenhouse on the Kenai Peninsula in Alaska, has been popular with gardeners in Alaska for decades. The product uses a particularly low-cost seaweed input: washed up detritus seaweed collected by truck from nearby beaches.

Sourcing

In North America, wild rockweed is currently the main seaweed used to produce fertilizers and animal nutrition supplements. Rockweed is harvested in the North Atlantic on both sides of the U.S.-Canada border, with larger harvests in Canada. Acadia Sea Plants through its subsidiaries also harvests rockweed and other seaweeds from Ireland and the United Kingdom. Globally, other wild wrack species in the same family as rockweed are often used for fertilizers.

Estimated prices paid to Maine rockweed harvesters range between $0.02 and $0.05 per wet pound.

Product Forms

Seaweed fertilizer product forms include a ground meal used as a soil amendment, a crystalized powder, and a liquid fertilizer made from the powder. Seaweed fertilizer is used in both commercial agriculture and for home and garden applications. The product has advantages over conventional petroleum-based fertilizers including that it is better for soil microorganisms and can be used on organic farms.

[19] Dun & Bradstreet.

When used as a nutritional supplement for livestock, kelp meal provides nutrients including iodine, amino acids, and vitamins.

In addition to the relatively low-value agricultural markets, Acadian Sea Plants also sells seaweed ingredients into the high-value nutrition supplement, food-additive, and cosmetics industries under the Acadian Seaplus brand. These markets are described in more detail in the next section.

Cattle Methane Reduction Potential

Recent research has shown that supplementing cattle diets with the seaweed *Asparagopsis taxiformis* can dramatically reduce belching of methane – a substantial contributor to global greenhouse gas emissions. *Asparagopsis taxiformis* is a red seaweed grown in warm water regions of Asia, so these findings are not currently relevant to the Alaska seaweed industry. Cold water and U.S. native seaweed species are being evaluated for their ability to similarly reduce methane emissions. No matter the species, any growth in this market will require overcoming a variety of hurdles, including palatability and food safety concerns, animal safety and performance issues, and the need for policy changes, among others.[20]

Seaweed Extracts and Biofuels: The Biorefinery Model

Seaweed biorefineries are a manufacturing model in which seaweeds are broken down to extract a variety of higher-value products. Significant interest in this model exists globally and numerous private firms and regional initiatives are moving to develop the potential for advanced seaweed processing and use. Multiple private firms are currently exploring the potential for Alaska investment.

Current methods for extracting high-value substances such as alginate from seaweed do not make use of the entire biomass. Significant research and startup activity is focused on designs of zero-waste seaweed biorefineries.[21]

Like petroleum refineries that extract multiple valuable products from crude oil (such as propane, gasoline, lubricants, and waxes), the concept for a seaweed biorefinery is a factory capable of extracting numerous products, including alginates, protein concentrates, bio-active compounds like fucoidan, and potentially biofuels.

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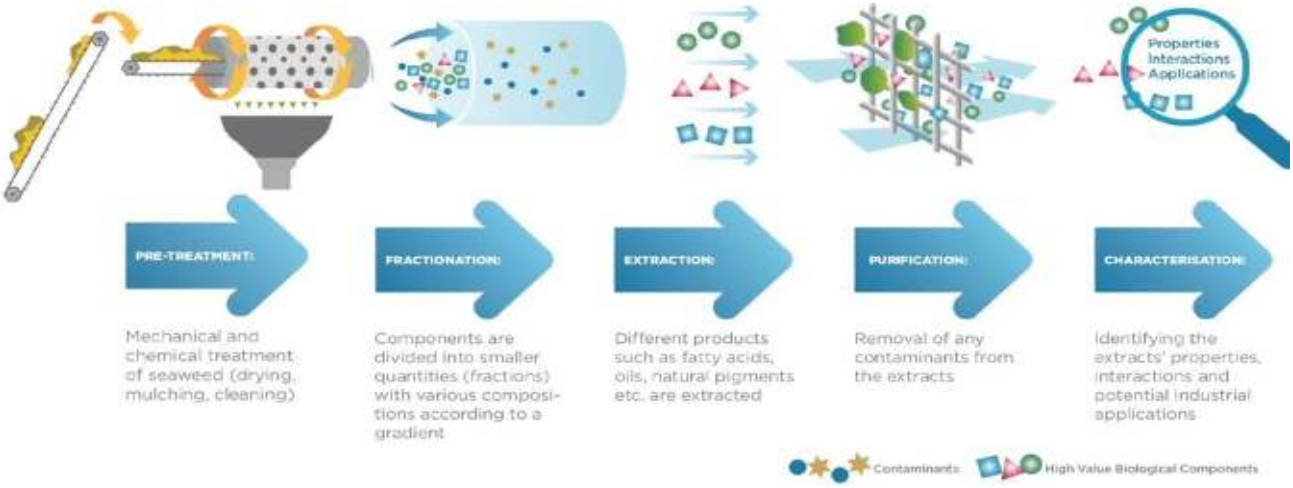
[20] Vijn S et al., 2020. *Key Considerations for the Use of Seaweed to Reduce Enteric Methane Emissions from Cattle,* Front. Vet. Sci. 7:597430. https://www.frontiersin.org/articles/10.3389/fvets.2020.597430/full

[21] For example, the GENIALG Project is a consortium of European biorefineries with experts in seaweed cultivation, genetics, and metabolomics. With more than €12 million, including nearly €11 million from the European Commission, the initiative aims to accelerate seaweed biomass production in Europe by solving issues related to cost, quality, and scales of production.

Figure 6. Schematic of the Cascading Biorefinery Process



Source: GENIALG Project.

Commercial biorefineries exist using feedstocks like wood but have not yet been developed on an industrial scale for seaweed feedstock, with one notable exception. A small factory in sub-Arctic northwestern Russia, the Arkhangelsk Experimental Industrial Seaweed Factory, was founded in 1918 and still operates today. The facility produces a stream of seaweed products including pharmaceutical extracts, hydrocolloids, cosmetics, and fertilizers.[22]

Composition of Alaska Seaweeds

The yield of high-value substances in seaweed varies widely by seaweed species, growing site, time of harvest, and other factors. Pacific Northwest National Laboratory recently analyzed the composition of several commercial North American seaweeds including samples from two Alaska kelp farms.[23]

In general, average concentrations were in line with other research, although several Alaska samples had particularly low alginate levels for reasons researchers were unable to explain.

Fresh seaweed is predominantly comprised of water. Compositional analyses typically study the percentages of various components after water has been removed.

Table 13. Concentrations of Alginate and Fucoidan in Kelp from Alaska, Canada, Maine, and China

Kelp Species	Scientific Name	# of Samples Analyzed	Alginate Dry Weight %	Fucoidan Dry Weight %

[22] Bord Iascaigh Mhara (Irish Sea Fisheries Board), 2020. *Scoping a Seaweed Biorefinery Concept for Ireland.*
[23] U.S Department of Energy, 2021. *Kelp Energy Products and Marine Renewable Energy for Coastal Alaska Communities.*

Sugar kelp	*Saccharina latissima*	8	3%-21%	2%-5%
Alaria (ribbon kelp)	*Alaria marginata*	4	5%-22%	3%-6%
Kombu	*Saccharina japonica*	2	20%-21%	2%
Bull kelp	*Nereocystis luetkeana*	1	17%	n/a
Giant kelp	*Macrocystis pyrifera*	1	22%	4%

Source: U.S. Dept. of Energy.
Note: Commercial kelp samples came from Alaska, British Columbia, Maine. One kombu sample from China was analyzed.

A notable finding of the Alaska seaweed analysis was that among Alaska samples, alginate concentrations increased over the course of the spring and early summer, with the highest percentages taken from samples harvested in June. If a summer harvest is necessary to maximize alginate content in Alaska, this may conflict with the ability to use idle fishing boats and seafood processing equipment in parts of Alaska. In most areas of the state Alaska's summer fishing season is dominated by salmon and peaks in July.

Alginates

Alginates are hydrocolloids (gels and thickeners) made from brown seaweeds. Alginates have a well-developed global market with applications as a food additive, textile dye thickener, and dental impression material, among many others. World alginate sales total more than $345 million annually.[24] Globally, alginates are one of the main uses for brown seaweeds. Brown seaweeds that grow in Alaska appear to be a good source of the material used to produce alginate based on their similarity to global alginate-rich seaweeds and early Alaska seaweed composition research.

However, to grow seaweed for the alginate market, Alaska would need to produce seaweed at a much lower price and a much larger volume than it currently does. Producing alginate is also a complex process. Building a production plant in Alaska would require significant capital investment.

One possibility for an Alaska biorefinery could be to produce a less-purified substance that has hydrocolloid properties but is less expensive to extract than the alginic acids used to make alginate. Hydrocolloid consultant CyberColloids recently suggested this approach as a possible way extract value from seaweeds in the Republic of Ireland, a country that lacks the seaweed production scale needed to enter the traditional alginate market.[25] This raw style of alginate product is not now commercially produced, but a similar product is produced in the carrageenan market.

[24] Porse, Hans et al., 2016. *The seaweed hydrocolloid industry: 2016 updates, requirements, and outlook*. Journal of Applied Phycology.
[25] Bord Iascaigh Mhara (Irish Sea Fisheries Board), 2020. *Scoping a Seaweed Biorefinery Concept for Ireland.*

ALGINATE MARKET OVERVIEW

Alginic acid was first extracted from seaweed in 1893 and was first produced on a large scale in Europe in World War II (chromium alginate was spun into yarn used for camouflage netting). In the second half of the 20th Century alginate production for textiles, food and other uses scaled up in Scotland, France, Norway, California, and Chile.

Over the past 20 years, China has emerged as the world's largest alginate producer as production decreased in other places. China's alginate industry relies partially on domestic farmed seaweeds but also wild seaweed imports from Chile and Peru. The Norwegian alginate industry uses wild-harvest tangle seaweed (*Laminaria hyperborea*) and produces mainly high-grade alginate for the medical industry.

Bioactive Extracts

Seaweeds contain several substances that are bioactive, which means they affect biological processes. Bioactive compounds can sell for high prices in the pharmaceutical and health supplement markets, making them relevant to the seaweed industry even when they are present at relatively low concentrations. Bioactive extracts from brown seaweeds that have existing markets include fucoidan and fucoxanthin.

FUCOIDAN

Fucoidan supplements are made and consumed largely in Asia, but interest has grown in Europe and the U.S.[26] In the U.S., fucoidan supplement maker Fucoidan Force markets its product mainly as an immune-system booster. The company uses the origin of its seaweed (Atlantic Ocean wakame) to differentiate the products as "one of the few fucoidan supplements that is 100% guaranteed free from the radiation caused by the Fukushima disaster in 2011." Fucoidan has been the subject of medical research, including into whether it may have cancer-fighting properties.

FUCOXANTHIN

Fucoxanthin is a pigment found in brown seaweeds at much lower concentrations than other extracts discussed in this report (on the order of a tenth of one percent of dry weight). However, it has an existing market as a weight-loss supplement in products like FucoThin (from Nestlé-subsidiary Garden of Life). A study on the global market found world production of fucoxanthin in 2014 was 500 metric tons.[27]

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[26] *Ibid*.

[27] Shannon, Emer and Nissreen Abu-Ghannam, 2016. *Optimisation of fucoxanthin extraction from Irish seaweeds by response surface methodology*. Journal of Applied Phycology. https://bit.ly/3uXOgl7

Cosmetics products

Seaweeds, including several Alaska-grown species, have an established role in the cosmetics industry, particularly in the organic and natural subsector. Various market reports describe the organic and natural cosmetics subsector as having a current global market value between $10 and $35 billion and an anticipated compound annual growth rate of 5% to 7% over the next five years.[28]

Within the cosmetics industry, seaweed is valued for bioactive ingredients including fucoidan, and numerous vitamins and minerals. Seaweeds are often marketed as an ingredient with moisturizing, anti-aging, and anti-inflammatory properties. Seaweed is also used in cosmetics for its hydrocolloid properties.

Among current seaweed products, cosmetics are likely second only to food and beverages in their value per seaweed volume input. Some boutique products that feature seaweed as a main ingredient are more valuable than most food products. However, as a cosmetics product ingredient, seaweed generally requires more processing than it does for food products.

Some cosmetics use whole seaweed as a featured ingredient. The Seaweed Bath Co. has developed hair and skin product lines around extracts from Maine wild-harvested bladderwrack (*Fucus vesiculosus*). The Colorado-based company also sells a whole-leaf bladderwrack as a bath soak product.

Another prominent seaweed bath company, VOYA Seaweed Baths in Ireland, combines seaweed soaks with tourism, a model that might be applicable to Alaska. The company website says it attracts more than 40,000 visitors per year to its bathhouse in County Sligo, a remote corner of northwestern Ireland.

Proteins

Protein extracts are a promising future product for seaweed. A commercial process to extract seaweed protein is not known to exist.[29] However, there is a ready market for a seaweed-derived protein if the technology can be developed. Demand for proteins from products such as peas and potatoes have surged in recent years with the success of plant-based meat alternative products such as the Impossible Burger. Demand for plant- and algae-based proteins is also strong in the agriculture and aquaculture sectors as businesses look for alternatives to feeds made from corn, soybeans, and fish meal.

Marketing the protein content of seaweed as a food additive may be possible before a commercial process is developed to fully isolate the protein. Trophic, a California-based start-up, has created a process for

[28] For example: 360 ResearchReports, 2020. *Natural and Organic Cosmetics - Global Market Trajectory & Analytics*; Grand View Research, 2019. *Natural Cosmetics Market Size, Share, Trends Analysis*.

[29] Bord Iascaigh Mhara (Irish Sea Fisheries Board), 2020. *Scoping a Seaweed Biorefinery Concept for Ireland*.

extracting a 65% protein concentrate from red seaweed. As described in trade press, the company says the non-protein substances can be useful in the context of meat substitute products by contributing color, flavor, and vitamins.[30] Trophic has focused on red seaweeds because of their high protein content and is particularly interested in dulse because of its "bacon-like" flavor profile. The company is currently working to scale its extraction process.

Seaweeds make a favorable feedstock for protein extraction because they contain a large amount of protein by weight and are composed of a good mix of the nine essential amino acids. However, brown seaweeds like the ones most cultivated in Alaska tend to have significantly lower protein concentrations than red and green seaweeds. Among commonly farmed seaweed varieties, the red seaweed nori has a particularly high protein content.

Bioplastics

The global plastics industry is so enormous that even with a 1% market share, the bioplastics sector is itself a large industry. World bioplastic production in 2020 was 4.8 billion pounds.[31]

While several seaweed-based bioplastics have entered the market in the last three years, seaweed-based plastics are still rare. Most bioplastic is made from the starches and sugars of food crops including corn and sugar cane. These food crops are known as first-generation feedstocks in the bioplastic industry (as well as the biofuel industry), while wood and agricultural waste products such as straw are considered second generation. Seaweed and microalgae are third generation. Each succeeding generation has fewer environmental costs, but later generations are also less technologically mature.[32]

The most common application for bioplastics today is packaging (47% of bioplastics). Bioplastics are also used in more durable products such as consumer goods and textiles.[33]

Notpla, a UK-based start-up that makes compostable brown-seaweed derived food and beverage packaging – including edible drink sachets from sodium alginate – differentiates itself from other bioplastics by being fully home compostable. Many bioplastics require the heat of industrial composting to break down or are not biodegradable at all.

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[30] Watson, Elaine, 2020. *Trophic explores potential of red seaweed protein concentrate as multi-functional ingredient in plant-based meat, seafood.* FoodNavigator.com.

[31] European Bioplastics/nova-Institute, 2020. Bioplastics Market Data. https://www.european-bioplastics.org/market/

[32] Hamburg Institute of International Economics, 2020. *Innovative feedstocks in biodegradable bio-based plastics: a literature review.*

[33] *Ibid.*

Biofuels

Cost-effective biofuel is the goal of a great deal of seaweed research, including the U.S. Department of Energy's ARPA-E MARINER project. A seaweed-based fuel that could compete with fossil fuels would have nearly insatiable global demand and could help reduce global carbon-dioxide emissions. (Note that like fossil fuels, biofuels produce greenhouse gases when combusted, but the impact is lower because biofuels release carbon that was recently absorbed from the atmosphere instead of tapping into long-buried carbon stores.)

But while seaweed-based biofuel is an important potential market for Alaska seaweed, from a technical and economic feasibility standpoint it is also likely the farthest from operational.

Several processes have been shown to convert wet seaweeds – including the species grown in Alaska – into useful fuels such as biodiesel and biogas. However, commercial-scale seaweed biofuel production has not yet been achieved. Current theoretical models for commercial-scale biofuel plants require seaweed volumes and feedstock prices that are orders of magnitude from what is currently available in Alaska.

Factors that could substantially change the economic viability of seaweed biofuel production in Alaska include government subsidies, climate change regulation, and the production of other materials at biofuel plants.

Southwest Alaska Biofuels Techno-economic Analysis

A recent feasibility analysis looked at a specific use case that could be especially favorable for biofuel production: building a plant in remote southwest Alaska, where seaweed biofuel would be viable sooner than in other parts of the world because of the high cost of diesel fuel and the availability of seafood waste.[34]

Commissioned by the U.S. Department of Energy, the report concluded that under the most favorable circumstances, a plant fueled by fish and kelp waste could be potentially economically viable compared to diesel at $3.18 per gallon. A kelp-only plant could be viable with diesel at $4.16 per gallon, according to the study.

The report made several key conclusions and assumptions about the operation of this type of plant.

- The analysis focused on three methods for creating biofuel from wet seaweed, dismissing technologies based on dry input material as too costly because of seaweed's water content and the

[34] U.S. Department of Energy, March 2021. *Kelp Energy Products and Marine Renewable Energy for Coastal Alaska Communities.*

high cost of drying. Feasibility assessments were based on the most applicable of these three methods, a technology known as hydrothermal liquefaction (HTL).

- The hypothetical plant would produce 1.5 million gallons of fuel per year, supplying about 18% of Southwest Alaska's fuel needs.
- The kelp-only scenario would require 25 million pounds of seaweed waste per year. A scenario based on 60% seafood waste and 40% seaweed waste would require 10 million pounds of seaweed waste.
- The analysis did not include potential plant revenue from byproducts like alginates and nutraceuticals because of uncertainties about extraction costs of these materials. Under the biorefinery model, revenue from these extracts could be substantial and significantly improve the economics of a biofuel plant.

Non-Consumption Market Opportunities

In addition to physical products, Alaska seaweed production can offer environmental benefits, with these benefits fitting into two general categories:

- **Carbon sequestration** refers to seaweed's capacity to help mitigate climate change and ocean acidification by pulling carbon dioxide from the air and water.
- **Ecosystem services** refers to more localized environmental benefits, including seaweed's ability to pull excess nutrients from water and provide habitat for marine animals.

Carbon Sequestration

The rapid growth rates of marine algae and the fact that it does not require land or fertilizer to grow make it a promising tool for sequestering large amounts of carbon dioxide from the atmosphere. Once carbon sequestration by seaweed farms is better quantified, it may be possible to sell farmed seaweed projects in the $277 billion[35] carbon credit market. Seaweed's climate attributes may also increase its value as an ingredient in other products.

Carbon impacts of seaweed mariculture projects are not currently verified through conventional offset methodologies like the Verified Carbon Standard. More scientific research is needed to better quantify

[35] Refinitiv, 2020. *Review of Carbon Markets: 2020*.

sequestration potential before these projects can be verified and sold on carbon credit exchanges.[36] Precise accounting for how a project would reduce greenhouse gas concentrations in the atmosphere is central to the functioning of carbon offset markets.

If seaweed mariculture offsets were to be developed, producing them would not be economically viable at current carbon credit prices and Alaska seaweed production costs. The growth of one dry metric ton of seaweed displaces approximately one metric ton of carbon dioxide (based on the concentration of elemental carbon present in seaweed[37]), which is sold as one offset credit. In the voluntary offset market, the average cost of one carbon credit is about $8, although this number can vary substantially based on project type and location. Producing this quantity of seaweed in Alaska currently costs more than $4,000, although the cost would likely be substantially less if the seaweed were sequestered in the deep ocean instead of harvested to produce food as is currently done. Expansions of government greenhouse gas regulations could significantly increase the price of carbon credits, as could an increase in demand from corporations making voluntary commitments to offset their greenhouse gas emissions.

To make a viable offset project, the production method must reliably sequester carbon on timescales that are relevant for climate change mitigation. A large mass of seaweed left on a dock would not be a good carbon sink, for example, because it would quickly decompose, releasing methane gas into the air. A pilot project in Maine that received research funding from Shopify in 2020 aims to test another method: growing seaweed in the open ocean and then sinking it to store the carbon deep in the ocean. Such a project could theoretically remove large quantities of carbon from the atmosphere at low costs and keep the carbon dioxide out of the atmosphere for thousands of years. However, many unknowns remain, including the impact decomposing seaweed could have on carbon concentrations in the deep ocean. Other models for long-term storage of seaweed carbon have been proposed, such as using it to produce biological charcoal that could help store carbon in soils.

Even if carbon credit markets are not viable for seaweed farmers, seaweed's small carbon footprint compared to alternative materials may increase its perceived value as an ingredient in food or cosmetics products. For example, a noodle made from seaweed has a reasonable claim to having a lower carbon footprint than a comparable noodle made entirely from grain. This attribute could potentially increase the value of the seaweed noodle in the eyes of a climate-conscious shopper or a food company working toward sustainability goals.

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[36] One such initiative currently underway is the Oceans 2050 Seaweed Project, which aims to produce a methodology to quantify seaweed carbon sequestration.

[37] Olsson, Joakim, et al., 2020. *Biochemical composition of red, green and brown seaweeds on the Swedish west coast*. Journal of Applied Phycology.

Ecosystem Services

In addition to sequestering carbon, seaweeds have potentially beneficial local environmental effects. Two key qualities are seaweed's ability to provide fish habitat and to absorb high levels of nutrients such as nitrogen and phosphorus that cause fish-killing algal blooms.

As with carbon sequestration, the ecosystem service properties of seaweed may have market value on their own or may contribute to the market value of other seaweed product types.

Nutrient Trading Credits

Some jurisdictions have created market-based systems to regulate water pollution with exchanges, similar to the carbon marketplaces used for climate change. In these marketplaces, stakeholders such as oyster farms (whose product helps filter water) can sell nitrogen and phosphorus credits to polluters.

Unlike global greenhouse gas emissions, water quality is a local issue. This is a key difference between carbon credits and water quality credits. To be effective at absorbing nutrients produced by agricultural runoff, sewage, or other human sources, seaweed needs to be near the source of the pollution. This fact likely limits the usefulness of seaweed farming for nutrient absorption in Alaska, a state with little agriculture and few cities.

Marine Habitat

Seaweed provides important habitat for many marine fish, including commercially significant species like herring. Parts of the world with damaged kelp forest ecosystems have worked to restore these ecosystems by removing sea urchins. Sea urchins can overgraze kelp, creating areas of seafloor with little life called sea urchin barrens.

Farmed seaweed could be used for marine habitat, but the seaweed would likely need to stay in the water and would not be available for harvest for other purposes. Government or conservation organizations could potentially fund kelp habitat development, but historically this has been done through wild kelp restoration and sea urchin removal, not the construction of floating kelp farms.

In one recent case in a Southeast Alaska seaweed farm, herring used seaweed as a spawning surface with poor results for both the herring and the kelp farm. For the herring, many of the eggs did not hatch. For the farm, the harvest was delayed because of fishing regulations that prohibit the harvest of kelp with herring eggs outside the context of a regulated fishery. When the kelp was harvested later than usual it was of poor quality and had to be cleared of decomposing eggs before further processing could continue.

Alaska's current seaweed industry centers on food products, and most of the executive interviews conducted for this research focused on seaweed food market participants. Regardless of how other seaweed markets develop, food products are likely to remain an integral part of Alaska's seaweed industry and are clearly key to the industry's initial growth phase.

Interviews with seaweed food producers in North America and Europe yielded valuable insights unique to marketing seaweed products made with non-Asian raw materials.[38] These findings are summarized below, with the goal of increasing Alaska's understanding of how consumers perceive seaweed and how demand for Alaska seaweed products might be increased.

Food Market Overview

The United States currently imports about 15 million pounds of seaweed for human consumption per year, representing about 95% of domestic consumption. By value, most of it comes from South Korea, China, and Japan. Most is eaten in snacks and within Asian cuisine in forms such as nori sheets for sushi and wakame seaweed salad.[39]

U.S.-based seaweed producers have generally avoided selling into the Asian cuisine market because of the competitive advantage enjoyed by imported products from countries such as China with lower production costs and greater economies of scale. Instead, U.S. producers have focused on creating new seaweed products designed for the U.S. market, and where a higher price point can be tolerated.

Europe is somewhere between the U.S. and Asia in the development of a seaweed industry. Europe has a stronger tradition of eating seaweed than most of the United States, and has a greater number of seaweed businesses, including many with decades of experience. Governmental and non-governmental organization (NGO) supports also flow to the industry in Europe,[40] providing a level of focus that is not currently paralleled in the U.S.

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[38] Though outside the scope of this research, there is a potential market for North American seaweed products in Asian markets, as health and safety conscious consumers there look to food supplies that are more traceable and less likely to be exposed to environmental contaminants.

[39] Island Institute, 2020. *Edible Seaweed Market Analysis*.

[40] For example, the coalition Seaweed for Europe (www.europeseaweed.com) includes 45 members ranging from international banking conglomerate BNP Paribas to venture capital firms to natural foods ingredients manufacturers to startup accelerators, as well as kelp and seaweed growers.

Executive interviews for this report focused on both the U.S. and Europe, in order to understand the current U.S. industry and gain insights from a more mature market that, like the U.S., is largely geared towards health- and sustainability-minded consumers.

The Target Seaweed Consumer

Nearly all U.S. seaweed food producers interviewed identified the same target market, while acknowledging that additional research would be helpful. Customer segmentation is based primarily on each company's understanding of internal sales data, limited private surveys/focus groups, and educated assumptions based on the customer base for foods with similar characteristics to seaweed. A few examples of publicly available quantitative research into seaweed consumers were found.[41]

Customer Profile

In interviews, seaweed product producers in both North America and Europe generally described the core of their customer base as upper-income women, with or without children, in the 30-45-year-old range.

Additional frequently cited characteristics of current seaweed buyers included:

- Customers – especially those from coastal areas – who care about the environmental and social impacts of their food purchases.
- Health-conscious customers who are drawn to nutritional features of seaweed.
- Vegetarians and vegans looking for plant-based alternatives to meat.
- People with other specialized diets including keto, paleo, and gluten free.
- Ambitious home cooks who like to experiment with new flavors.

The "ambitious home cook" characteristic was frequently used to describe buyers of existing seaweed products on the market. However, many newer seaweed producers are marketing products that are easy and familiar in hopes of attracting a broader customer base. In North America, examples of seaweed incorporated into existing food categories include seaweed noodles, chips, jerkies, and burgers. European producers have been incorporating seaweed into already-popular regional and national foods for decades

[41] For example:
- Birch et al., 2018. *Who Eats Seaweed? An Australian Perspective*. Journal of International Food & Agribusiness Marketing.
- USDA, 2018. *Potential Supply Chains for Seaweed Produced for Food in the Northeastern United States.*
- Island Institute, 2019. *In Pursuit of Sea Vegetable Market Expansion: Consumer Preferences and Product Innovation.*

with products like seaweed tartares, mustards, mayonnaise, confits, and butters in France. In Spain, common seaweed products include tapenades, chimichurri sauces, and prepared tapas in tins.

Marketing Messages

Interviews and a review of seaweed product marketing materials revealed several themes relevant to Alaska. In the face of competition from low-cost seaweed imports, crafting a compelling message for why customers should pay more for non-Asian products is perceived as critical.

Seaweed Sourcing Brand Narratives

One effective way to compete with low-cost commodity products is to build brand loyalty. For seaweed food products, this can involve telling customers a story about the business including the people behind the business and how the business serves a broader social and environmental purpose. The existing European and North American seaweed markets already have numerous brands that differentiate themselves from generic seaweed products by telling stories about their seaweed sourcing.

Packaging on a bag of kelp chips shows two examples of seaweed brand narrative building: a message about the product's role in supporting ocean ecosystems, and the brand's role in helping small seaweed farming businesses.

Some common themes include emphasizing the brand's role in:

- **Improving ocean ecosystems and reducing ocean acidification** – Several American seaweed product producers including 12 Tides and Akua make the case on their packaging for seaweed farming's role in ocean health. European seaweed brands also use environmental narratives, although the style is typically less forceful.
- **Supporting (or resurrecting) traditional foods –** A few European and North American businesses emphasize the value of seaweed as a connection to food traditions of earlier times. Examples include Pembrokeshire Beach Food Company (Wales), Cup of Sea (Maine), and Lofoten Seaweed (Norway).

- **Making food supply chains more transparent** – Third party-certifications are used in many natural food products including seaweed in both North America and Europe to give credibility to products. Among seaweed food products, certifications advertised by various producers include USDA Organic, GMO Free, Gluten Free, B Corporation certification, and 1% For the Planet participation.

- **Supporting small businesses including farmers, wild harvesters, and artisanal processors** -. Larger businesses like Atlantic Sea Farms often highlight their ties to small-scale seaweed suppliers. Among smaller businesses, "small batch" and "hand-picked" are selling points.

- **Growing the alternative meat product movement** – Seaweed is an ingredient in emerging products marketed as more sustainable alternatives to seafood. These include New Wave Foods (a plant-based shrimp) and Good Catch.

See Appendix C for a complete description of seaweed product producers contacted for this report, including examples of seaweed product packaging and marketing materials.

Spelling Out Seaweed's Positive Features Across Brands

Several seaweed attributes were common in marketing by most or all brands. These attributes could form the basis of future coordinated industry-wide marketing efforts.

Absence of Required Inputs (land, fresh water, fertilizer)

The nexus of many of seaweed's positive attributes is the fact that it requires no land, fertilizer, or fresh water to grow. These properties are believed to give the product an edge over terrestrial plants in terms of the carbon and larger ecological footprint. Projects to quantify these aspects are underway.

Health

Ocean-grown seaweeds are rich in nutrients like omega-3 fatty acids and iodine that are harder to find among terrestrial foods.

Novel flavor

The fact that seaweed is not generally part of the current American diet is often regarded as an obstacle because it means consumers need to be educated in how to eat it. On the other hand, the variety of tastes and textures found in seaweeds can reportedly be a selling point for people looking to add something new and interesting to their diet.

Combating Negative Associations

In addition to its many positive traits, seaweed carries several negative associations, especially in the North American market, that will need to be addressed as part of any broad effort to promote the industry.

In particular, the association of seaweed with the unpleasant experience of stepping on something "slimy" at the beach came up in interviews and routinely appears in media stories about seaweed products. Other common negative associations include that seaweed is unhealthy because it comes from polluted ocean or that it tastes fishy. A natural foods distributor shared feedback that the "mouth feel" of seaweed products may be an obstacle in some consumers' preferences. Several strategies may be effective for combating these associations.

"Sea vegetable" Terminology

Some companies (such as Maine Coast Sea Vegetables) and parts of the industry use the term "sea vegetable" to position marine macroalgae alongside familiar terrestrial foods and convey the wide variety of different tastes and textures within the category. An alternative terminology for seaweed from Alaska is simply "kelp," since all the main seaweeds currently farmed in the state are kelps.

Regardless of the terminology used, any effort to rebrand seaweed will have increased effectiveness if it is a coordinated effort among Alaska, Maine, and seaweed-producing states.

In the seafood industry, rebranding of species types is a common practice and has been used for products like Chilean sea bass (technically Patagonian toothfish) and keta salmon (commonly known as chum or dog salmon among fishermen).

Product forms

The "sliminess" that can be associated with seaweed is an inherent part of the product. One source of sliminess is the hydrocolloids that are useful products in other contexts.

The sliminess is present to some degree in products like seaweed salads and soups. But products such as seaweed sheets, chips, and popcorn feature seaweed in crispy form that may appeal to a broad range of consumers.

Water Quality Concerns

Concerns about ocean water quality are a barrier to the edible seaweed industry in general but can be an important tool for differentiating domestic seaweeds from Asian imports.

Some North American seaweed brands make direct arguments against Asian competitors, for example warning consumers about industrial pollution and lack of government oversight in East Asia, calling out human rights abuses in China, or pointing to radiation from the 2011 Fukushima Daiichi disaster in Japan. Other brands highlight the clean waters at their seaweed farms, without explicitly describing Asian seaweed as potentially unsafe.

Challenges of Differentiating from Asian Imports

A challenge of differentiating U.S. grown seaweed products from imports is that producers of Asian imports are also working to create products that will sell in North America outside the confines of Asian restaurants, Asian groceries, and ethnic aisles at supermarkets.

For example, consider the marketing material seen here for gimMe, a California-based company that sells seaweed snacks made from seaweed grown in South Korea. Although mini nori sheets are an existing Asian snack product, they are being marketed here to a broader U.S. audience.

Much of the messaging used by gimMe mirrors that used by companies selling U.S. grown seaweed food products. This messaging includes the theme of seaweed as an easy to eat food, the emphasis on product certifications (USDA Organic among others), and the sustainability benefits of eating seaweed.

According to seaweed producers interviewed for this research, there are indications that some U.S. shoppers will pay a premium for products grown in the U.S. However, it may be challenging for the industry to support consumers in product differentiation, particularly as producers using imported seaweed develop products geared toward similar segments of the U.S. market.

Distribution Channels

Interview subjects frequently identified the middle of the supply chain as a challenging obstacle to getting seaweed food products to customers. Relationships with distributors are key for placing products into large

numbers of retail stores and foodservice outlets. To better understand the dynamics of seaweed distribution channels, interviews were conducted with five distributor and retail contacts.

In the U.S., the largest seaweed brands work through distributors to reach hundreds of retail and foodservice establishments. One U.S. farmed seaweed business interviewed now has its products featured in more than 1,100 U.S. stores including Whole Foods and Sprouts, the nation's largest natural food chains.

But there is room to grow. Most seaweed companies have focused their efforts on natural food stores. While there are more than 3,500 such stores, there are more than 30,000 stores in the larger grocery category.

The two main distributors for natural foods in the U.S. are UNFI and KeHE, although numerous regional and specialty distributors also exist. In the foodservice industry as a whole, major distributors include Sysco and U.S. Foods.

Distribution Challenges

Food manufacturers and distributors identified challenges to selling new seaweed products.

- **Limited industry knowledge**: Many seaweed product manufacturers are small vertically integrated businesses that grew out of interest in seaweed farming or food product design. These companies do not always have expertise in the wholesale food business.
- **Category confusion**: It is more challenging for companies that specialize in domestic seaweed products to establish brand identities given the small scale of the category. In U.S. stores, shelf-stable seaweed products traditionally go in ethnic or Asian aisles, where U.S. products would compete head-to-head against low-cost imports. Seaweed products made from Alaska seaweed may perform better in natural food sections, the seafood section, or in special displays.
- **Lack of familiarity**: Producers and distributors identified a lack of consumer familiarity with seaweed as a key obstacle to growth. Producers devote significant resources to teaching consumers what the product is and how it tastes. Before the COVID-19 pandemic, in-store tasting events were an important avenue for introducing shoppers to seaweed products.
- **Sales rate requirements**: Producers report that keeping products in stores can be a bigger obstacle than getting initial placement. Once products arrive at retail shelves, they must retain their place with minimum sales rates – which can be challenging for new products without established customers. Items that do not initially sell well are not re-ordered.
- **Limited demand**: Distributors, even those who had positive impressions of seaweed products, reported that demand for seaweed has generally been steady but limited. Compared to producers,

distributors have a more skeptical eye to the potential for the seaweed food products industry, having seen many new products try and fail.

Other Paths to the Consumer

In addition to selling through distributors, other important sales channels for seaweed food businesses include direct sales and the wholesale ingredients market.

Online and Other Direct Sales

Seaweed product producers described direct online sales as an increasingly important channel in 2020, part of economy-wide e-commerce growth that accelerated during the pandemic.

However, even with recent increases, direct sales are a relatively small channel for seaweed food products as a whole. Some smaller sellers in North America and Europe reported as much as 50% of sales came from e-commerce or other direct sales. Larger seaweed product businesses generally rely on distributors to reach large audiences and reported selling 0-20% of their products through online or direct sales.

Ingredients Wholesale Market

Although branded products are the most visible part of the seaweed food industry, branded seaweed products may not be the biggest part of the industry. An unexpected finding from interviews was that both small and large vertically integrated seaweed companies routinely sell much of their raw or minimally processed seaweed to the wholesale ingredient market, where it is used by customers like meal kit subscription companies and food manufacturers that do not have their own seaweed supply.

Considerations for Alaska's Seaweed Industry

This research provides considerable insights into the state of the seaweed industry in Europe and North America. It assesses the current markets, provides a scan of many of the key producers, and considers the current product mix, with a particular focus on consumer-facing value-added products that mirrors the current and near-term focus of Alaska's active and permitted producers.

Alaska can play an important role in the North American seaweed market and continued focus and efforts are warranted to build out the industry. At the same time some of the challenges facing Alaska's seaweed industry, which echo those experienced by many other industries in the state, mean development will likely require coordination and efforts at many scales.

Key Research Findings

This research yields findings that can provide guidance to individual seaweed growers as well as private and public entities involved in mariculture development in Alaska.

- Market demand for most seaweed products is currently limited. Most industry participants are counting on considerable growth in demand for existing products as well the emergence of additional viable seaweed markets.
- The pathway to a scaled industry in Alaska will benefit from a mix of public and private investment in the near-term. Growth may hinge on investment from one or more innovative industrial manufacturers who can act as "anchor" customers or partners and help scale demand.
- Infrastructure and logistics will be a significant (and familiar) challenge for an Alaska seaweed industry. Cost structures and distance from markets limit current opportunities, but may be offset by technological innovation, coordination among growers, and other opportunities to share costs and pool resources.
- There is high interest in seaweed's role in solutions to major global challenges such as carbon sequestration, alternative proteins, and transitioning away from fossil fuels in packaging and energy.
- Regulatory structures in Alaska offer some competitive advantages and at least one disadvantage – a prohibition on strain selection. Alaska's non-U.S. competitors operate at larger scales (Asia) or with high levels of coordination and government subsidies in research and development (Europe).

- Provenance and the Alaska brand can be important in certain specialty food markets. For other uses of Alaska seaweed, logistical and price considerations are typically more important. The value of a generic Alaska seaweed "brand" may be limited at present, though it is one way to support the only major current market for Alaska seaweed (specialty foods). It could also play a role in attracting new investment to the state.

- Identifying methods to subsidize production and R&D are likely critical pathways to the continued development of current and potential markets for Alaska seaweeds. Alaska's competitive edge can be sharpened by lowering production costs, increasing regulatory flexibility and social license, and supporting sustainability messaging, among other efforts.

Few Consumer Markets Currently Exist for Seaweed Products

Across the board, our research revealed that existing markets for domestic seaweed products are limited. Existing markets and products have been painstakingly developed by seaweed producers or rely on inexpensive Asian seaweed as an ingredient. The companies interviewed for this research (and profiled in Appendix C) generally developed both the products and the markets for their products. Interviews with food product distributors suggested that demand for seaweed products is quite limited, though interest is increasing because of environmental and nutritional benefits. Across interviewees there is broad agreement that the most promising target market for seaweed products will be higher-income younger families and consumers in coastal regions with a connection to the sea.

Alaska producers will likely need to continue pioneering markets for the seaweed they produce.

The Importance of Anchor Projects or Seafood Processor Participation

Alaska's industry is currently oriented around small volumes of seaweed processed into specialty food products, though multiple operations are presently moving toward larger scales.

Significant scaling of the industry, however, will likely require the presence of either a major buyer or a major industrial processor in the state. The state's potential seaweed wealth comes, in part, from its vast geographic scales and limited potential for conflict with other uses. These same characteristics also mean that limited transportation infrastructure, processing infrastructure, and human capital can pose challenges to development. There is some regional variation, but Alaska is a high-cost jurisdiction for processing and manufacturing activity relative to other seaweed-producing regions of the world.

Alaska is currently under consideration by a number of private and NGO entities with an interest in investing or partnering in the state. Similarly, two existing Alaska seafood companies have approved or pending seaweed farm applications with the State of Alaska. The presence of a major industrial player, whether an

anchor seaweed-focused firm or an existing Alaska seafood company with established infrastructure and distribution streams, could create efficiencies of scale that could change the economics of seaweed production.[42] Attracting this kind of business activity may be critical to the industry's growth. Coordinated and strategic effort, particularly in the case of attracting new industries or companies, is a likely important next step in the state. Participants in this kind of effort should include policy makers as well as the business development, non-profit, higher education, and private sectors.

Public/Private Investment Will Be Key to Industry Growth

Identifying methods to subsidize research, development, and production will be key to the industry's continued development. With active interest in seaweed from across a host of businesses and global entities, opportunities exist to expand connections with investors and research that can advance Alaska's industry.

Ongoing and future investments in R&D may play an important role in the feasibility of future development. Efforts to improve growing and harvesting yields, improve quality and processes for product stabilization, and measure the carbon and other environmental benefits of seaweed, and other R&D needs are likely best supported by public or philanthropic dollars in partnership with seaweed industry participants.

In these early stages of Alaska seaweed industry development, the diverse challenges and needs exceed those that can be borne on the back of the small businesses pioneering the space.

Cost Structures and Distance from Markets Are Real Constraints

Existing markets that could absorb larger quantities of product (e.g., industrial ingredients such as alginates) are price sensitive and primarily use inexpensive Asian seaweeds or wild varieties not currently grown in Alaska. Alaska's current production costs are high, and market tolerance for the current price structure is limited to consumer-facing specialty food products and possibly high-end cosmetics and similar consumer products. In general, developing consumer-facing value-added products at a distance from the end user presents challenges. (Some evidence for this is the limited scale of consumer-ready value-added seafood processing that occurs within Alaska.)

Interviewees said successful development of specialty consumer products also generally requires development of markets for larger wholesale volumes to achieve competitive production and pricing thresholds. Examples of wholesale buyers include food service, fertilizer, or processed/refined product

[42] Because of Alaska's large scale those efficiencies are likely to be regionalized and there may intraregional competition for any such investor or opportunity.

buyers. The lack of an ecosystem of potential wholesale users in Alaska, or at regional scales in the state, means that access to wholesale markets will be via shipping routes, adding cost to Alaska's product.

Efficiencies in production and competitive pricing will be an important challenge for Alaskans, and may be offset by technological innovation, coordination between growers, anchor users who provide economies, and other opportunities to share costs and pool resources.

As is true for many Alaska industries, the triple challenge of infrastructure, logistics, and distances within the state and to out-of-state markets are likely to be constraining factors for the industry's near-term development. Potential synergies with existing seafood processing infrastructure and coastal transport and logistics may prove important to the industry's development. There are well established logistics and distribution systems in place for Alaska's seafood products.

Seaweed's Role in Addressing Global-Scale Issues Attracts Significant Attention

Global attention to seaweed's potential contribution to major environmental and food security challenges is significant and growing. Interest is building in seaweed as a bioplastic (to replace petroleum-based plastics), biofuel, protein replacement, resource for blue carbon/carbon sequestration, and as a contributor to habitat and biodiversity.

With this interest comes both resources and competition for those resources. In the European context, coalitions focused on seaweed industry development include venture capital firms, investment funds, NGOs, think tanks, and technology firms, among others. Climate change is driving initiatives that will be able to mobilize capital to industries and technologies that support the global push toward net-zero carbon.[43] Venture capital is backing private-sector efforts to develop bioplastics from seaweed.[44] Research to quantify (and maximize) the carbon contribution of various seaweeds and growing locations is underway.[45]

While some of these technologies currently exist only in prototype, scalable models are in development and first-to-market solutions are expected in the near to medium term depending on the technology. To the extent that Alaska can position itself for early investment, resources can flow to the nascent industry in a way that supports its development and captures benefits of being an early entrant.

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[43] See, for example, the April 2021 announcement of the Glasgow Financial Alliance for Net Zero (GFANZ), which brings together 160 firms in the financial sector with a combined $70 trillion in management in support of the UN Race to Zero campaign. Member firms commit to net-zero emissions within their portfolios by 2050 or sooner. https://unfccc.int/news/new-financial-alliance-for-net-zero-emissions-launches

[44] Oceanium Raises £2M to Turn Seaweed into Food and Packaging, https://thespoon.tech/oceanium-raises-2m-to-turn-seaweed-into-food-and-packaging/

[45] https://www.oceans2050.com/seaweed

Current Regulatory Structures Have Positive and Negative Attributes

Key informant interviews suggest that Alaska's regulatory structure and available coastline and ocean are broadly seen as advantageous. This is particularly true when compared to competing regions in North America such as California, British Columbia, or the Northeast, where restrictive regulatory structures and competing coastal uses are barriers to development.

Permitting timelines in many jurisdictions can be two years or more – a key consideration (or barrier) mentioned by interviewees. Alaska's average lease application processing times have been halved over the last couple years and are below those in other coastal U.S. states.[46] To the extent that Alaska can develop and maintain an advantageous permitting environment, it may be well positioned to compete with other jurisdictions. However, length of permitting process is not likely to be the determining factor relative to other elements such as energy costs, logistics, and proximity to markets.

One important negative attribute of Alaska's current permitting regime is the prohibition on strain selection and breeding of seaweed stocks. Unlike in agriculture, where plant breeding has been essential to meeting global food demands, Alaska growers are required to use wild seed that mimics the biodiversity surrounding each farm site. Numerous interviewees cited this as a significant barrier to investment in Alaska and a barrier not present in most competing regions.

Sophistication in the Competitive Landscape

The drive behind seaweed development is significant in many regions of the world. As noted earlier in this report, coordinated efforts by European producers and boosters (such as the Seaweed for Europe coalition and the GENIALG Project) marshal significant, coordinated resources to develop sophisticated seaweed industries.

Resources supporting Alaska's seaweed industry development are more modest, though efforts through SeaGrant, the U.S. Department of Energy, World Wildlife Fund, and the Pacific Northwest National Laboratory have all touched down in Alaska. No North American coalition of a scale that parallels European efforts exists for seaweed at present.

Furthermore, East Asian countries, such as China and South Korea, remain the world leaders in seaweed production and a logical location for future seaweed innovations. Outside Asia, Chile is a major wild seaweed exporter, and an emerging competitor in seaweed farming.

[46] https://www.afdf.org/wp-content/uploads/Mariculture-Task-Force-Report-to-Gov-Final-compressed.pdf

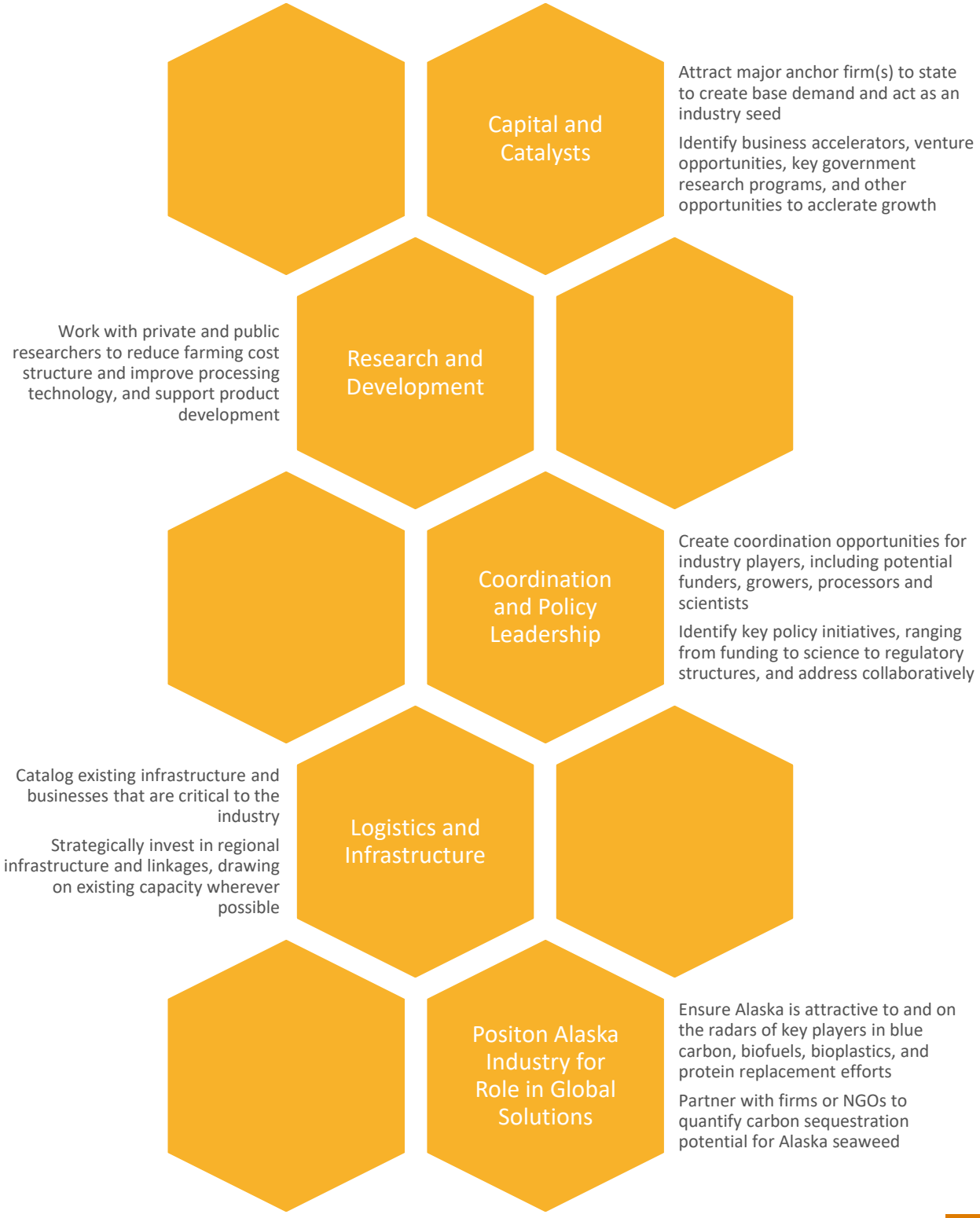
Seaweed investment in Alaska will be competing for capital on a global scale, particularly with respect to biorefinery technology and blue carbon initiatives. It will be important for Alaska's industry to consider the competitive landscape and envision policy and collaboration approaches, perhaps in coordination with other North American partners.

Alaska Seaweed Brand May be Premature

While provenance and the "Alaska" brand can be important in certain food markets, the number of these seaweed products from Alaska is currently limited. Interviewees, including distributors, reported that consumer interest in seaweed products largely resulted from in-store demonstrations and other consumer outreach. The extent to which an Alaska seaweed brand, if created, would help drive sales is unknown. While it is unlikely that differentiation through an Alaska brand will overcome other limiting factors, brand development is one of the ways to support the only significant current market for Alaska seaweed (specialty foods). A useful brand, however, requires significant and ongoing investment to build meaning and resonance with consumers.

A near-term challenge for Alaska will be attracting partnerships or investment sufficient to develop the necessary infrastructure in regions pursuing this industry. An Alaska seaweed brand may have value in supporting visibility of Alaska's potential as a seaweed region to investors interested in new markets for Alaska seaweed. For many of these markets – such as bioplastics, biofuels, or alternative proteins – logistical and cost considerations are most important in selection of Alaska seaweed as a potential ingredient.

Figure 7. Building Blocks for Development of the Alaska Seaweed Industry



Appendix A: List of Key Informant Interviews

- Adrian Hoffman, Four Star Seafood
- Al Poindexter, Anchor Point Greenhouse
- Anna Soler, Irish Seaweed Consultancy
- Associated Buyers
- Beth Zotter, Trophic
- Laurence Cabioch, Bord-a-Bord
- Courtney Boyd Meyers, AKUA
- Craig Cayton, Crown Pacific Fine Foods
- Desiree Antczak, Wulf's Fish
- Elisa Capuzzo, CEFAS
- Elisa Ravagnan, ASTRAL
- Erin Bremner-Mitchell, Cascadia Seaweeds
- Evan Talty, Wild Irish Seaweed
- Hugh Coulson, Shore
- James Crimp and Jesse Baines, Atlantic Sea Farms
- Jess Slater, Whitby Gin
- Jonathan Williams, Pembrokeshire Beach Food
- Justin Mauz, Dorsia Provisions
- Karen Scofield Seal and John Seal, Oceanium
- Krishna Doraiswamy, ARPA-E
- Laurence Cabioch, Bord à Bord
- Lexa Meyer, Blue Evolution
- Lia Heifetz, Barnacle Foods
- Louis Druehl, Canadian Kelp
- Mark Jones, Retail Contractor
- Markos Scheer, Premium Aquatics, LLC (d/b/a Seagrove Kelp Co.)
- Monterey Bay Seaweeds
- Pat Schnettler, 12 Tides
- Paul Cobb, Roaring Waters Sea Vegetables
- Quentin Fong, Alaska Sea Grant
- Robert Jones, The Nature Conservancy
- Ross Campbell, CyberColloids
- Sandy Parco, Neptune's Harvest
- Seraphina Erhart and Shep Erhart, Maine Coast Sea Vegetables

- Shannon Carrol, Trident Seafoods
- Tamara Singer, Lofoten
- Thomas Mumford, Marine Agronomics, LLC
- VitaminSea
- Wave Crookes, Sea Grown

Appendix B: Seaweed Producer Interview Protocol

Hi this is ___ with McKinley Research Group. We are conducting a market research study to inform Alaska's small but growing seaweed industry. I'd like to ask you a few questions about your experience manufacturing and/or selling seaweed products. Our study is publicly funded, and the end report will be freely available. Any information shared confidentially will be kept strictly within McKinley Research Group.

Background and Sourcing

1. Could you provide a brief overview of the history of your company?
    a. What makes your company unique?
2. Where do you source your seaweed?
    a. Location?
    b. How important is provenance in your marketing?
    c. Farm/wild?
    d. Price and form of what you buy?
    e. What are the major species you use?

Production Questions

3. Do you mostly sell into wholesale markets or end consumer markets?
    a. For wholesale product, what form and price?
    b. Chilled, frozen, or shelf-stable products?
4. What is the relative importance of retail versus foodservice markets for you?
5. Do you outsource manufacturing or do it in house?
6. What are the biggest production challenges you face?
    a. Limited by seaweed supply? Consumer demand? Other limits more important?

Retail Markets

7. Do you sell your products directly to consumers or through distributors/retailers/etc.?
8. Do you sell in grocery stores?
    a. How difficult has it been to get into stores? What has been required?
    b. In what regions are your products sold?
9. Do you sell online? Has that grown during the pandemic?
10. Which of your products are the most popular with consumers?

Foodservice Markets

11. Do you sell to chefs and foodservice outlets? What portion of your sales are through this channel roughly?
12. Do you produce products specifically for the foodservice market?

Customers and Marketing

13. What type of consumers buy your products? Who is your target market?
14. What type of marketing do you engage in?
15. How important are each of the following marketing elements for your company?
    a. Origin/region
    b. Sustainability
    c. Nutrients/health benefits
    d. Any others?
16. Do you find customers need education on how to eat seaweed products?
    a. What has been the most effective method of education, if so?
17. What do you see as your main competition?
    a. Other seaweed products? Other "local" foods?

Last Questions

18. What information do you consider publicly available about the scale of your company?
    a. What volume of seaweed do you use in your products each year?
        i. What percentage is waste?
    b. Number of units by product type?
19. If willing to share, what are your annual sales in a typical year from products containing seaweed?
20. Where do you see your company going in the future (areas for future growth, goals)?
21. Where do you see the domestic seaweed industry going in the future?
22. What other companies or people do you recommend we talk to that have insight into seaweed markets?

Appendix C: Profiles of Seaweed Product Manufacturers Interviewed

This appendix highlights the product manufacturers and growers interviewed for this report and includes background information on the companies and their product range. Product photos are from the companies and their websites, shared to highlight marketing approaches and product presentation.

12 Tides: San Francisco, California, 12tides.com

- Year founded: 2019
- Sourcing: Purchases farmed sugar kelp from a single grower in Maine
- Retail products: Puffed kelp chips in three flavors: Sea Salt, Everything, and Chili Pepper

12 Tides is a certified B Corporation producing crispy kelp chips made with seaweed as a key ingredient. The company purchases seaweed from sustainable seaweed farmers in Maine. As a B Corporation, 12 Tides partners with an organization working to restore kelp forests along California's coastline.

AKUA: New York, New York, akua.co

- Year founded: 2016
- Sourcing: Purchase primary-processed sugar kelp, both frozen and whole leaf blanched from farmers in Maine (will shift to whole-leaf dried)
- Retail products: Kelp jerky in four flavors, kelp "pasta," kelp and lemon pepper seasoning, and recently launched kelp burgers
- Manufacturing: works with a co-manufacturer in Portland, Maine
- Volume: 15,000 wet pounds of sugar kelp in 2020 to produce and sell 50,000 units of kelp jerky and 100,000 units of kelp burgers, with sales around $500,000 annually
- Employees: three full-time, five interns

AKUA is a seaweed food product company working to develop products mainly for the alternative meat market, including kelp jerky and their new kelp burger. AKUA's existing products use kelp, mushrooms, and legumes. The company sells primarily direct-to-consumer and has a presence in the foodservice markets and more than 40 retail stores. In early 2021, AKUA raised about $800,000 through an equity crowdfunding platform to launch their kelp burger to a broader market.

Anchor Point Greenhouse: Anchor Point, Alaska, anchorpointgreenhousellc.com

- Year founded: 1976
- Sourcing: beach-combed seaweed
- Volume: 40,000 bags a year (ranging from 1 to 1.5 cubic feet each)
- Retail products: Fishy Peat, a soil additive made from seaweed and fish meal, and Alaska Earth, potting soil with Fishy Peat already added
- Anchor Point makes soil additive and potting soil from Alaskan fish meal and wild, washed-up seaweed. The company's products are sold in and around Anchorage, Alaska, at locally owned greenhouses and garden supply stores.

Atlantic Sea Farms: Saco, Maine, atlanticseafarms.com

- Year founded: 2009
- Sourcing: Farmed sugar kelp and skinny kelp.
- Volume: Expected 2021 harvest of 850,000 to 1 million wet pounds from 24 partner farmers
- Retail products: Kelp cubes (frozen); fermented seaweed salads - Sea Beat Kraut, Seaweed Salad, and Sea-Chi (refrigerated); Ready-cut kelp (frozen)

Atlantic Sea Farms is the oldest commercial seaweed farm in the U.S. The business transitioned from farming to purchasing, processing, and product development in 2018. The business has a retail presence that grew to more than 1,000 stores in 2021.

Atlantic Sea Farms products are now sold in major national retailers, including Sprouts and Whole Foods. The company has focused mainly on fresh and frozen products, including fresh seaweed salad (in retail jars and gallon buckets for foodservice), fermented seaweed, and frozen seaweed cubes. Despite its visible retail presence, its primary revenue comes not from its own branded products but sales to the ingredient market, including food subscription company Daily Harvest and a chain of pizza restaurants.

Barnacle Foods: Juneau, Alaska, barnaclefoods.com

- Year founded: 2016
- Sourcing: wild harvest and farmed bull kelp
- Retail products: kelp hot sauce; kelp relish; kelp salsa in Bonfire, Campfire, Salsa Verde, and Original; kelp pickles in Dill, Sweet & Tangy, and Extra Sour Dill; kelp seasonings in Kelp Pinch, Kelp Pow, Everything, Ocean Gold, and Furikake; they also sell other food brands incorporating their kelp, like chocolate bars
- Volume: 20,000 wet pounds farmed and 50,000 wet pounds wild harvest

Barnacle foods creates shelf-stable products that highlight Alaskan kelp; the company's goal is to make accessible products like pickles, hot sauce, and salsa that people use every day. Barnacle offers subscriptions for its most popular item, Bullwhip Hot Sauce, through the company's online store. Barnacle products are sold in 400 grocery stores up and down the west coast of the U.S. through several distributors.

Blue Evolution, Los Altos, California, blueevolution.com

- Year founded: 2009
- Sourcing: Tank-farmed sea lettuce (from Mexico), ocean-farmed wakame and kombu (farmed near Kodiak, AK)
- Retail products: Alaskan Kombu Kelp Puree, popcorn with organic sea lettuce (from Mexico) in four flavors, penne and rotini pasta with seaweed, dried wakame and dried kombu (whole leaf)
- Volume: about 400,000 wet pounds of kombu and wakame (200,000 lbs. each) from Alaska
- Employees: 12 (not including farmers)

Blue Evolution operates a seaweed seed hatchery in Kodiak and sells seed to Kodiak-based kelp farmers.

Farmers are paid for their farming services instead of quantity, and Blue Evolution has right of first refusal for their products. Products are sold direct-to-consumer online, through distributors, and via Amazon. Farmers in Kodiak for Blue Evolution repurpose old fishing gear for their kelp lines and farm sites.

Bord à Bord: Roscoff, France, bord-a-bord.fr

- Year founded: 1996
- Sourcing: Wild harvest Royal Kombu and sea spaghetti; wild harvest and farm-supplemented (as needed) sea lettuce, nori, wakame, and dulse
- Retail products: Fresh seaweed tartare in four flavors; fresh mustards, and fresh vegan mayo; fresh salted seaweeds (all species); Onion Confit and Tsukudani with and without yuzu; crackers, wafers, and lentil puffs; cooking ingredients including a 3-species blend, seaweed salt, court-bouillon blend, and agar-agar; three kinds of pasta with seaweed; dried seaweed leaves and flakes (all species); pesto with sea lettuce and basil or dulse and tomato; pickled sea spaghetti

Bord à Bord originated fresh seaweed tartare in 1997, and it continues to be the company's most popular product (only one other company produces fresh seaweed tartare in France). Bord à Bord says it is the only company in France producing fresh mustard with seaweed and fresh vegan mayonnaise made from seaweed.

Canadian Kelp: British Columbia, canadiankelp.com

- Year founded: 1982
- Sourcing: Farmed macro kelp (giant kelp), bull kelp, Alaria (winged kelp), sugar kelp, and kombu
- Retail Products: Kelp flakes, dried kelp, and Bull Kelp Twists

Canadian Kelp is the oldest kelp farm in North America. In addition to harvesting kelp, the company operates a demonstration farm to teach kelp farming basics and kelp breeding. The consulting side of the business offers services including kelp farm design and construction, kelp seed supply, product development and testing, and environmental remediation.

Cascadia Seaweed: Sydney, British Columbia, koveocean.com

- Year founded: 2019, first harvest in 2020
- Sourcing: Ocean-farmed sugar kelp and alaria, and land-based farmed dulse
- Retail Products: Five projects were announced under the Kove Ocean Foods brand in spring 2021: seaweed jerky, a protein chip, a roasted seaweed snack, a shelf-stable seaweed salad, and an "everything" seaweed spice.
- Volume: 881,000 wet pounds anticipated 2021 harvest, plus 1,760 pounds from land-based facility
- Employees: 16 full-time and two part-time year-round employees, ten seasonal contractors

Cascadia expanded rapidly from an initial harvest in 2020 to an expected 2021 harvest of more than 800,000 pounds. The company has plans to become one of the largest seaweed growers in North America, with 1,235 acres under cultivation by 2025. Cascadia launched the Kove Ocean Foods brand in May. Of its five planned products, a seaweed spice blend is expected to be the first to market. In addition to food products, Cascadia is participating in research into other seaweed uses including bioplastics, methane reduction, and carbon sequestration. The company is one of two North American test sites in the Oceans 2050 effort to quantify seaweed carbon sequestration. Cascadia Seaweed was formed through a partnership with First Nations communities to farm seaweed in their waters. The partnership provides useful local knowledge for Cascadia and helps with the permitting process while creating jobs for First Nations communities.

Lofoten Seaweed: Lofoten, Norway, lofotenseaweed.no

- Year founded: 2016
- Sourcing: Wild harvested from around Lofoten, purchased from local seaweed farm to supplement as needed: Alaria, sugar kelp, Laminaria digitata, nori, truffle seaweed (Vertebrata lanosa), dulse
- Retail products: Simply Seaweed flake blend, seaweed salt in Truffle or Arctic, furikake, pasta with seaweed, dark chocolate and white chocolate with seaweeds, Seaweed for Bread, whole-leaf winged kelp, seaweed soap
- Volume: About 400kg dried seaweed (4 metric tons wet), with 80% of that alaria
- Sales: About 3,000 units of Truffle Seaweed Salt, plus over 6,000 units of their other products in a typical year, resulting in about €200,000 (about $244,000) in sales.

Lofoten, Norway, is home to one of the strongest tidal currents in the world and is known for its fishing industry. Lofoten Seaweed is capitalizing on the recognition of fresh, clean water present in the archipelago to harvest its seaweed and sell across Europe and the world, including Norway, the U.S., Austria, Malaysia, the Netherlands (the company's 2nd biggest market), and Germany. About 10% of Lofoten sales are online, 10% in its storefront shop, 20% to restaurants (fresh, frozen, and other forms), and 60% is sold wholesale (some unprocessed to manufacturers, and some finished products).

Maine Coast Sea Vegetables: Ellsworth, Maine, seaveg.com

- Year founded: 1971
- Sourcing: Purchases from a network of wild harvesters in Maine, Canada, and Iceland; has experimented with limited purchase of farmed seaweed.
- Retail products: Eight species of dried whole-leaf seaweeds, and whole-leaf Smoked Dulse; five species of flakes and one blended flake variety; six species in powdered form; five seasoning blends, including sea salt with sea vegetables; Kelp Krunch Seaweed Bars in original and ginger; Nori sheets (for sushi); and two kinds of kelp-based nutrition capsules.

Maine Coast Sea Vegetables is one of the largest and oldest producers of wild seaweed products for human consumption in the U.S. The company's products are certified organic, and are sold to retail distributors and widely available at natural food stores in the U.S. The company also sells seaweed to other food producers as an ingredient and has a significant e-commerce presence. Maine coast is employee owned and devotes considerable resources to seaweed education and research. The company website also sells seaweed products from other companies, including shampoo bars from Dulse & Rugosa and seaweed teas from Cup of Sea.

Monterey Bay Seaweeds: Moss Landing, California, montereybayseaweeds.com

- Year Founded: 2009
- Sourcing: Shore-based farmed seaweed
- Retail products: Live seaweed, direct to customers and via distributors.

Monterey Bay Seaweeds operates a land-based closed aquaculture system with artificial seawater. Seven species of seaweed are cultivated for white-tablecloth restaurant markets. The company is located at the San Jose State University aquaculture research facility at Moss Landing Marine Laboratories. It is a public/private partnership that includes SJSU as an equity investor. Monterey Bay Seaweeds produces a particularly high-cost product for very high-value uses, primarily garnish.

Neptune's Harvest: Gloucester, Massachusetts, neptunesharvest.com

- Year founded: 1986
- Sourcing: purchase powdered kelp extract and ground kelp meal from two companies that harvest wild rockweed Ascophyllum *nodosum* from Maine, Iceland, and Northern Ireland
- Products: Fish-seaweed blend fertilizer, seaweed plant food, kelp meal, and other fertilizer and garden products that contain kelp

Neptune's Harvest is part of Ocean Crest Seafoods, a Massachusetts seafood wholesaler that sells fishmeal fertilizer made from the seafood business. The company sells fertilizers made from kelp, fish, and a mix of both. The fertilizers sell mainly to agricultural customers but also home and garden customers. A key selling point of Neptune's Harvest products is that they are Organic Materials Review Institute listed, meaning they can be used for growing USDA Certified Organic plants.

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Pembrokeshire Beach Food Company: Pembroke, Wales, beachfood.co.uk

- Year founded: 2010
- Sourcing: wild harvested laver, dulse (including pepper dulse), sugar kelp and other kelps, sea spaghetti, other farmed supplement testing in the works
- Retail Products: Barti Spiced Rum, Captain Cat's Môr Seasoning (a seafood seasoning blend), Kelpchup (similar to HP sauce), prepared laverbread, seaweed flakes, seaweed salt blends, Sea Truffle butter made with pepper dulse, Seaweed Pesto, Welsh Sea Black Butter made with laverbread
- Volume: 10 to 15 metric tons wet seaweed per year (mostly laver) with £50,000-60,000 net profit in recent years

- Units: 10,000-15,000 catering tubs of Kelpchup and pickles a year, 20,000 units of Captain Cat's seasonings, 5,000-10,000 units of Welshman's Caviar (dried laver), the biggest sellers through the food cart, delis, and online sales

The Pembrokeshire Beach Food Company was founded to highlight and celebrate traditional Welsh foods, specifically laverbread (laver seaweed), and to use local seaweeds and seafood. The company has a seasonal food cart at a popular beach in the Pembrokeshire Coast National Park that features its retail products and other local food. The company also operates an outlet to sell their retail products and sells its products in local delis and markets and through a wholesaler. Beach Food also partners with a Welsh brewery to provide seaweed for the brewery's beers. Plans in the works include farming more seaweed and opening a seaweed and seafood pub.

Roaring Water Sea Vegetables: Ireland, roaringwaterseavegetable.ie

- Year founded: 2010
- Sourcing: Wild harvest nori, sea spaghetti, dulse, and carrageenan; farmed brown seaweeds and red seaweeds
- Retail products: chilled and frozen vegan sausages, chorizo, burgers, and black pudding; dried whole leaf and flakes of all species
- Volume: 200kg (dried, wholesale to Japan and the UK), 2,000-3,000 units of vegan chilled products (about €10,000-15,000 in sales)

Roaring Water Sea Vegetables developed and produced its own vegan meat products, made with at least 24% seaweed; the company enrolled in an artisan food "academy" through a major grocery chain in Ireland and learned what was needed to scale up and get into the retail market. The company plans to open a café featuring vegan seaweed products and other local foods.

SHORE: Wick, Scotland, shoreseaweed.com

- Year founded: 2015
- Sourcing: Farmed Atlantic wakame and Saccharina latissimi; wild harvest wracks, dulse, sugar kelp, sea spaghetti, and some other kelps
- Retail products: seaweed clusters; seaweed chips in Lightly Salted, Asian Peking, and Sweet Sriracha; seaweed pesto in Black Kale, Italian Basil, and Red Pepper, Dulse & Chilli, and Green Olive & Seaweed Tapenade and Black Olive & Dulse Tapenade

SHORE has been harvesting wild and farmed seaweed for wholesale and foodservice since 2015 and added retail food products in 2020. Wholesale is primarily focused on powdered and milled product for food manufacturers. The company moved up its production of value-added products in part due to a decline in foodservice sales during the COVID pandemic. SHORE hired a chef to help develop its product range. The company's snacks and spreads are sold in most major grocery chains and Whole Foods in the U.K. and on Amazon; they are not sold directly to consumers online.

Seagrove Kelp Co.: Ketchikan, Alaska, seagrovekelp.com

- Sourcing: Farms in and around Ketchikan
- Products: Alaria (ribbon kelp), bull kelp, sugar kelp, frozen ribbon kelp

Premium Aquatics, LLC (d/b/a Seagrove Kelp Co.) sells kelp products to producers in Alaska, California, and elsewhere for use in food products and fertilizers. The company is working on adding more farm sites and planning to co-locate oysters with their kelp. Seagrove also maintains its own nursery and conducts research for companies and scientific organizations.

SeaGrown: Scarborough, England, seagrown.co.uk

- Year founded: 2019
- Sourcing: wild harvest: sugar kelp, sea lettuce, dulse, and nori; they currently have a hatchery and have begun farming kelps including brown kelp, *Laminaria digitata*, *Saccharina latissimi,* and alaria
- Retail products: seaweed bath soak, seaweed seasonings in four flavors: Everyday Seaweed, Salt & Sichuan Pepper, Smokey Piri, and Kombu Seaweed Salt Alternative
- Sales makeup: 90% of sales are currently retail products, including online sales and high-end specialty markets, with 10% sold to other companies.
- Volume: 2-3 metric tons (wet weight) currently harvested; sells 300-400 units of each seasoning blend and the combination set annually

SeaGrown was started by a marine biologist and professional seafarer who did extensive research into seaweed as a versatile crop with potential use as a food crop, biomass source, and carbon sink. SeaGrown developed artisanal food products and plans to expand into industrial use in the future. The company has participated in Integrated Multi-Trophic Aquaculture (IMTA) trials for U.K.'s Centre for Environment, Fisheries and Aquaculture Science, and will incorporate shellfish into its farming plan. SeaGrown purchased a boat in the Scarborough harbor that has been turned into a seaweed café, shop, and education center to encourage people to eat and use more seaweed.

Vitamin Sea: Scarborough, Maine, vitaminseaseaweed.com

- Year founded: 2004
- Sourcing: Wild kelp with some farm-supplemented alaria
- Retail products: Whole leaf, flakes, granular, and powdered wakame, bladderwrack, dulse, applewood smoked dulse, Irish Moss (carrageen), digitata kelp, Atlantic nori, sea lettuce, kombu,

and blends; Dulse & Sea Salt seasoning and Dulse, Kelp & Sea Salt seasoning; fresh rockweed for clam/lobster bakes

- Animal supplements: kelp chips; SeaNutrients for Horses for Overall Health and Bone and Joint Health; VitaminSea Pet for Bone and Joint Health, Overall Health, and Skin and Coat
- Fertilizers: kelp meal and kelp powder

VitaminSea relies on wild kelp as yields tend to be higher after drying. The company uses 40-50 harvesters along 300 miles of the Maine coast to source the majority of its kelp, depending on lease availability. VitaminSea sells to wholesalers and some direct-to-consumer.

Whitby Gin: Whitby, England, whitbydistillery.com

- Year founded: 2018
- Sourcing: Harvest wild sugar kelp from the Yorkshire coast, purchase pepper dulse and sugar kelp from SeaGrown in the off-season and when own harvest is insufficient
- Products: Whitby Original (London Dry) Gin with sugar kelp botanical, Demeter Edition made with pepper dulse, other gin editions

The provenance of botanicals and ingredients is the most important product feature for Whitby Gin. All botanicals are locally sourced and sustainably harvested. The company is currently limited by distillery capacity but is expanding.

Wild Irish Seaweed: County Clare, Ireland, wildirishseaweeds.com

- Year founded: 2009
- Sourcing: wild harvest 14 species of seaweeds including dulse, carrageenan (Irish Moss), kelps (including kombu/sugar kelp), bladderwrack, sea lettuce, sea spaghetti, spirulina, alaria, and wakame
- Wholesale products: custom milled dried seaweeds and custom blends of food-grade, cosmetic grade, or pharmaceutical grade including the following species: carrageen (Irish Moss), dillisk, bladderwrack, kombu, spirulina, serrated wrack, sea lettuce, egg wrack, wakame, nori, and sugar kelp
- Retail food products: seaweed sprinkles: sugar kelp, dillisk, sea salad, nori, kombu, carrageen moss, bladderwrack, Atlantic wakame; whole-leaf dried: soft dulse (dillisk plastic), sugar kelp, sea spaghetti, sea salad, kombu, dillisk, Atlantic wakame, and carrageen; and powdered smoothie blends: bladderwrack, Irish moss, Detox blend, and Alkaline blend
- Non-food products made with seaweed: body scrub, moisturizing mask, face oil, kelp body wrap, seaweed bath, clay mask, exfoliator
- Volume: 80,000 metric wet tons with sales of about €900,000 in 2019
- Employees: 10 full-time, more seasonal workers

Wild Irish Seaweed sells primarily to wholesale customers in the food and nutraceutical industry, with retail sales mainly coming from health food stores. The company does its own drying, manufacturing, and milling. The provenance of its wild harvest seaweed is essential, as is sustainable wild harvesting.