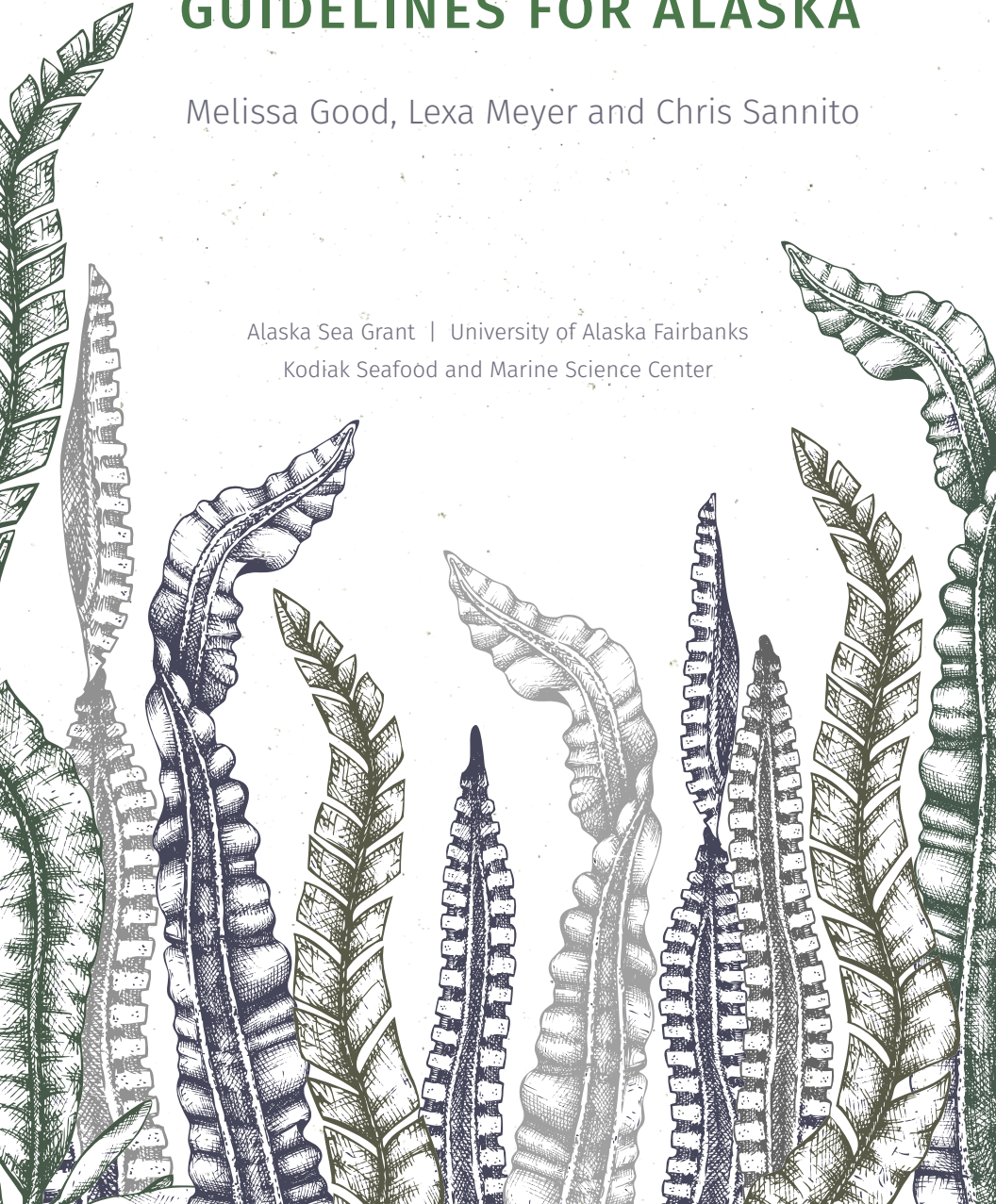


# Seaweed Handling and Processing GUIDELINES FOR ALASKA

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Alaska Sea Grant | University of Alaska Fairbanks  
Kodiak Seafood and Marine Science Center



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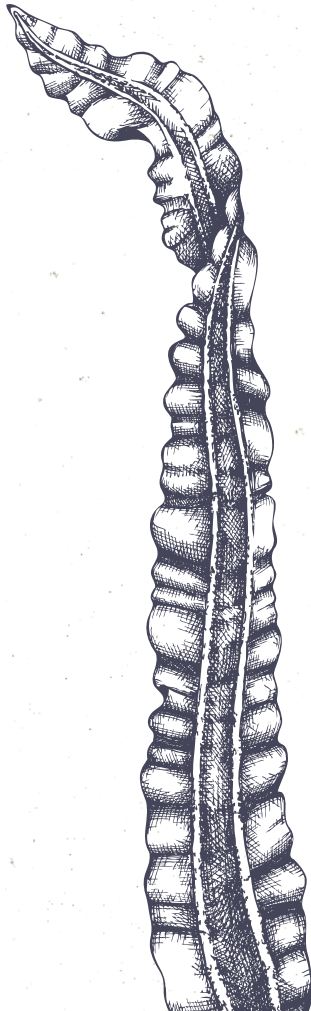
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# TABLE OF CONTENTS

|   |    |
|---|----|
| Introduction to seaweed and the industry . . . . .                      | 5  |
| Considerations for entering the seaweed<br>processing industry. . . . . | 11 |
| Rules and regulations. . . . .  | 15 |
| Processing facilities. . . . .  | 21 |
| Labeling packaged food . . . . .  | 27 |
| Hazards . . . . .   | 29 |
| Harvest to dock handling . . . . .                                      | 41 |
| Primary processing . . . . .  | 49 |
| Business planning . . . . .   | 69 |
| Appendices . . . . .  | 71 |
| References . . . . .  | 72 |
| Agency contacts. . . . .  | 75 |



# INTRODUCTION TO SEAWEED AND THE INDUSTRY

Seaweed farming is a significant and growing industry worldwide, driven by demand for seaweeds, especially kelp, for food, medicinal products, additives, and bioremediation. In 2018, global aquaculture production of seaweed was 28 million metric tons per year, worth \$11.7 billion, and produced in 35 countries. Of that production, over 90% came from three countries, China, Indonesia, and the Philippines (Piconi et al., 2020).

While seaweeds are highly nutritious and gaining traction in the domestic market, the United States imports more than 95% (19 million tons) of edible seaweeds (FAO, 2018). In 2016, the United States imported 8,560 metric tons of edible seaweed at a value of \$55,882,000, with over half of that coming from China and South Korea (Piconi et al., 2020).

Alaska has more than 30,000 miles of pristine, nutrient-rich coastline, which produces over half of all seafood in the United States. It has an ideal environment for mariculture—the enhancement, aquatic farming, or restoration of shellfish and seaweed—to meet more of the domestic and international demand.

According to the Alaska Department of Natural Resources (ADNR), as of May 2021, there are 402.38 authorized and leased acres for seaweed production, and 1,579.49 acres under review in Alaska waters (ADNR Report, 2021). The authorized space alone has the potential to grow over 5,100 metric tons of sugar kelp. If all of the leases under

review were approved and farms were growing at maximum capacity, there could be as much as 20,000 metric tons of sugar kelp grown in Alaska, not including the potential to add vastly more lease sites. Despite this potential, only 104 metric tons were sold in 2020 (ADFG, 2021).

There is state and federal support for developing Alaska mariculture industries, which could help increase sales of Alaska seaweed, and increase the capacity and capability of new and existing companies involved in purchasing and processing. This guide was developed to help individuals and companies better understand what's involved as they decide whether to enter the seaweed processing industry, and to provide some industry standards in the manufacturing or processing of kelp.

Collectively, the large brown seaweeds are called kelp. While there are many types of kelp, in this guide we are referring to the primary species of interest for cultivation in Alaska, sugar kelp (*Saccharina latissima*), ribbon kelp (*Alaria marginata*), and bull kelp (*Nereocystis luetkeana*). All three species are a brown alga (phylum Ochrophyta, order Laminariales) widely distributed around the state's lower intertidal zones (Lindeberg and Lindstrom, 2010).



Sugar kelp

**Sugar kelp** (*Saccharina latisima*) is light to medium brown with a finely branched holdfast, a cylindrical stipe up to 50 cm (20 in) long, and a blade up to 4.6 m (15 ft) long. The blade is moderately thin and frequently has rows of ripples or indentations near the base. This kelp is generally considered an annual, though some blades can persist longer, with the blade dying back in the fall/winter and re-growing in the spring. It can be found attached to rocks in the low intertidal to subtidal zones, and prefers protected or semi-protected habitat. Its distribution ranges from Santa Catalina, California to the Arctic, and west to Japan.



Ribbon kelp

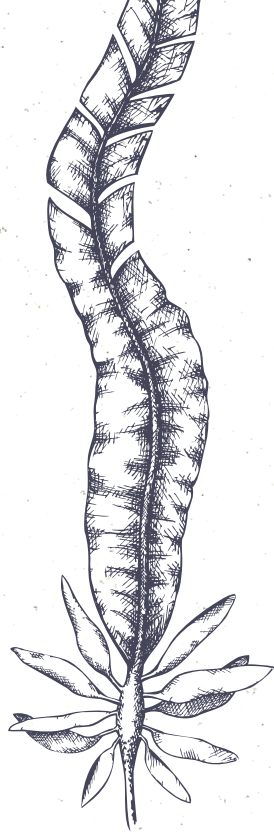
**Ribbon kelp** (*Alaria marginata*) is a common intertidal species with a branched holdfast, a stipe that is cylindrical near the base but flattened near the blade. The blade is thin and of a narrow, oval shape, and can be up to 3 m (10 ft) long with a solid mid-rib. Twenty to forty elliptical sporophylls form in spring on the upper portion of the stipe and grow up to 25 cm (10 in) long, thickening with maturity. This is an annual kelp that is found on rocks in the mid to low intertidal zones from semi-protected to exposed habitats. Its distribution ranges from Point Conception, California through the Aleutian Islands in Alaska.



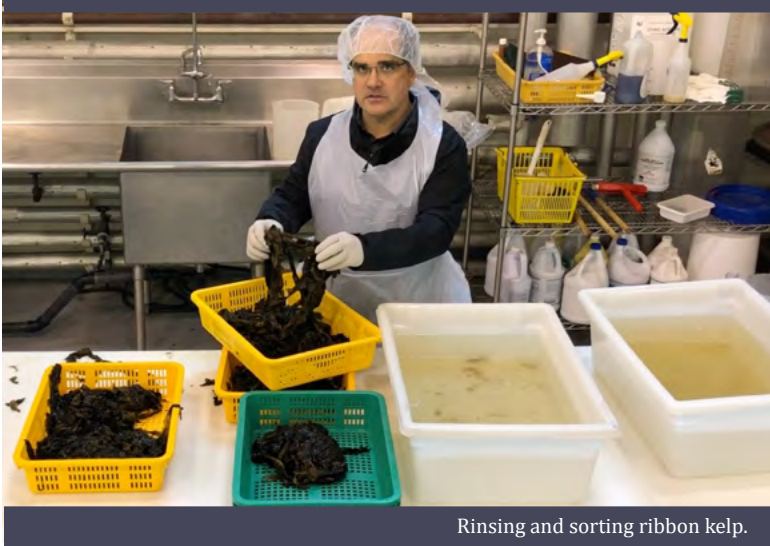


Bull kelp

**Bull kelp** (*Nereocystis luetkeana*) is a brown canopy-forming kelp found in the low intertidal to subtidal zone. It is characterized by a single gas-filled pneumatocyst from which many blades grow that float at the surface, a long cylindrical stipe, and a richly branched holdfast. This annual kelp can grow a stipe up to 36 m (118 ft) with 10 m (33 ft) blades. Its distribution ranges from San Luis Obispo County, California to the Umnak Islands in the Eastern Aleutian Island chain in Alaska.



# CONSIDERATIONS FOR ENTERING THE SEAWEED PROCESSING INDUSTRY



Rinsing and sorting ribbon kelp.

Starting a seaweed processing operation can be expensive and entail a lot of work. The seaweed industry in Alaska is nascent and there is still a lot to learn. While kelp farming has become a significant and growing industry in the U.S., several barriers still hinder its development and expansion, including limited primary processing capacity or stabilization. There are several questions to consider when thinking about whether seaweed processing is for you.

## ***Is there enough seaweed being produced to sustain processing?***

Consider whether there is enough seaweed being grown, or if there are applications with the state of Alaska for additional seaweed farms, to supply your operation and make it profitable. You will need to talk with local active and

prospective growers about their plans for selling their crop. If someone purchases their seed from a certain company, they may already be committed to selling their crop back to that company. You can check the Alaska Department of Fish and Game [Operations Map](#) to view approved farm sites.

### ***Can you produce consistent quality?***

High quality is essential in developing new markets. If a customer receives poor quality seaweed products, they may be discouraged from buying seaweed from you and other producers, hurting the local industry.

### ***Are there local resources that you can utilize?***

The seaweed processing season in Alaska is short, usually running for four to eight weeks between April and June depending on where you are located. Seaweed needs to be harvested during peak growth in the spring, prior to biofouling, deterioration or bleaching. This is a convenient time, coming after many of the winter groundfish and shellfish fisheries and before the salmon harvesting season. It may be possible to lease processing space inside of an established seafood processing plant or custom processing operation, utilize excess freezer capacity, have access to labor that is in between seasons, and access other resources that are otherwise not being employed (e.g., tenders, insulated totes, dock space, etc.).

### ***Can you reliably transport your product?***

Your processing operation will not succeed if you cannot get your product to your customers reliably and for a reasonable cost. Producing a frozen or dried product will restrict shipping options. Due to temperature and weight, frozen products can be expensive to ship. Make sure to research shipping and handling requirements and options available to you.

### ***Can you find markets?***

You will need customers for your products. Some options include selling family size portions direct to consumers or wholesalers, bulk units to wholesalers, or bulk units to food manufacturers for inclusion in other products. Each business should have a marketing plan and means to promote its brand and products.

### ***Can you get good workers?***

Processing seaweed can be very labor intensive. To ensure a safe, high-quality product, seaweed needs to be sorted at multiple stages and handled gently. Seaweed processing is a short season, four to eight weeks long. You will need to find people that are willing to work long hours for a short season. You will need people with expertise to train workers, maintain and fix equipment, and provide quality control and assurance.

### ***How much money will you earn or lose?***

Think carefully about what your sales revenues and costs are likely to be. Do the research to make realistic estimates of your costs, processing yield, and what prices you're likely to get for your products. Remember to allow for unexpected expenses when things go wrong. How much you process and your processing yield can make a big difference in how much money you earn or lose. You will also need to consider the quantity and quality of the seaweed you need for a particular product, which will determine how much you can expect to pay farmers. This can range widely, from 45 cents per pound for food-grade kelp, to cents on the ton for non-food grade kelp. Even if your main objective is not profit, you will still need sufficient income to pay workers, operate and maintain a plant, purchase seaweed, and administer a business.



# RULES AND REGULATIONS

Depending on how a food product is handled, processed, and distributed, different regulatory agencies may require permits, registration, or authorization to operate.

## Raw seaweed in whole form

The Alaska Department of Environmental Conservation (ADEC), US Food and Drug Administration (FDA), and the US Department of Agriculture (USDA) do not regulate the processing and sale of raw seaweed in its whole form. At the time of this publication, there are no specific federal or State of Alaska references to raw seaweed in regulation or guidance.

## Processing and packaging seaweed for human food

Regulatory authorities that are involved with the processing of seaweed include FDA and ADEC.

ADEC regulates Alaskan food processors that make and distribute food to other businesses for resale, commonly referred to as “wholesale distribution.” If an operator wishes to process products in Alaska and distribute them outside of Alaska, both ADEC and FDA regulate the processor’s activities. Depending on the size of operation that you would like to establish, there are two pathways to consider, a cottage food operation or a food processing facility.

### Cottage foods

ADEC exempts “cottage food operations” from permitting. A cottage food operation is a small

business that processes foods that do not require temperature control for safety, sells the foods directly to consumers in Alaska, and has sales below a certain annual threshold. Dried or pickled kelp are examples of foods that do not require temperature control for safety and would fall under the cottage food exemption if produced on a small scale and sold in state.

## Food processor

A [Food Establishment Permit](#) from ADEC is required for operations that process kelp beyond harvest and trimming and require temperature control for product safety, or that meet certain sales thresholds, or that distribute product wholesale or outside the state. This permit allows for processes such as freezing, drying, and packaging seaweed products, unlimited sales, and wholesale or interstate distribution.

FDA is responsible for human food and animal feed products that cross state lines prior to consumption, or products composed of ingredients that have crossed state lines. Facilities need to register with the FDA if they process or manufacture raw agricultural commodities, including seaweed, for use as food or components of food need. The registration includes general information about the facility, contact information, and the category of food being produced (Id. § 350d).

## Seaweed as animal feed or food

FDA oversees operations that produce animal feed from seaweed. More information on [animal feed regulations](#) are available on the FDA website.



## Organic certification

USDA regulates seaweed under an organic certification only when it is used as an ingredient in livestock feed, fertilizer, or food for human consumption.

USDA regulates federal organic standards, including those for kelp and seaweed, though not for seaweed in its whole form. “Kelp” is listed in [7 CFR 205.606](#) of the USDA organic regulations, allowing for its use in non-organic form when certified organic forms are not commercially available, such as extracts used in organic crop production as plant or soil amendments.

The USDA National Organic Program (NOP) has produced at least one applicable rule and guidance document ([7 C.F.R. § 205.237](#)).

- ▶ NOP 5027 provides for the use of kelp in organic livestock feed, and establishes that kelp must be certified organic if used as an ingredient (U.S. Department of Agriculture National Organic Program, NOP 5027, The Use of Kelp in Organic Livestock Feed, 2013).
- ▶ The only existing route for organic certification is through USDA’s wild harvest provisions:
  - > Marine algae must be harvested in a manner that ensures the harvesting or gathering will not be destructive to the environment and will sustain the growth and production of the wild crop ([7 C.F.R. § 205.207](#)).
  - > Harvest must be from designated areas that have had no prohibited substances applied for a period of three years immediately preceding the harvest. Prohibited substances consist of seven

listed categories including such things as ionizing radiation and sewage sludge ([7 C.F.R. § 205.105](#)).

- ▶ While USDA does not currently certify any type of commercial aquaculture production as organic in its whole form, NOP has stated it is in the process of developing related practice standards, though these may focus on aquatic animal production.

## Seaweed added to foods as a flavor enhancer

In addition to rules for the processing of food crossing state lines, FDA regulations address the addition of certain species of seaweed, including sugar kelp, to other foods as a flavor enhancer.

Currently, seaweed may be added to other foods as a flavor enhancer because it is “generally recognized as safe” (GRAS) and its use is outlined in [21 CFR Part 184](#). These regulations provide guidance for the addition of seaweed as a flavor enhancer as GRAS, but the regulations are limited to certain marine algae species and do not encompass the sale of seaweed in its full form. Not every GRAS food is mentioned in the CFR, but FDA may be contacted if there is a question about whether a food or substance is GRAS.

- ▶ FDA’s GRAS determination and regulations apply to certain species of dehydrated, ground kelp, including giant kelp, sugar kelp, and several others only as a flavor enhancer. The FDA also has specific regulations for both brown and red algae ([21 C.F.R. §§ 184.1120, 1121](#)).
- ▶ Listed brown and red algae species may be considered GRAS, whether or not they are meant to impart any of their own taste to the food to which they are added.

- ▶ GRAS determinations do not apply to singular products, such as kelp or seaweed in its whole raw, cooked, or dried forms.
- ▶ FDA has set maximum daily amounts of seaweed additives, including red and brown algae, certain subsets of people should be able to ingest without consuming too much iodine ([21 C.F.R. § 172.365](#)).

Substances added to food that are determined GRAS by qualified experts are not food additives and do not need to be reviewed and approved by FDA before being marketed. However, a GRAS notification must be sent to FDA if a substance and specific use have not already been determined GRAS. For more information on GRAS, see [Generally Recognized as Safe \(GRAS\)](#) on the FDA website.



# PROCESSING FACILITIES

ADEC and the Municipality of Anchorage oversee preparation, service, and sale of food in food services restaurants and retail markets. Regulations require that food prepared, held, served or sold in these venues come from an approved source, which means that if a permit is required to process or package a food, the processor has obtained the proper permit and meets applicable requirements.

## Physical requirements

ADEC requires operations to submit plans and other information concerning its physical facilities as part of the application process. Some common ADEC requirements for opening a food service facility include:

- ▶ Water and plumbing—Water source approval and appropriate plumbing requirements and preparation areas.
- ▶ Restrooms—Restrooms in accordance with the Alaska State Plumbing Code.
- ▶ Physical structure—Building requirements for the walls, wall coverings, floors, and floor coverings of food preparation areas, equipment-washing and utensil-washing areas, toilet rooms and vestibules must be smooth, non-absorbent, and easily cleanable both inside and outside.
- ▶ Wastes—Waste management system in place.

For up-to-date detailed information see the ADEC [Food Establishment Requirements](#).

## Good Manufacturing Practices

All human food processors under the oversight of ADEC or FDA must be compliant with the current Good Manufacturing Practices found in [Title 21 CFR 117 Subpart B of the Code of Federal Regulations](#).

This includes minimum requirements for a facility to safely produce food for human consumption.

- ▶ 117.10 Personnel—the management of the establishment must take reasonable measures and precautions to ensure: disease control, cleanliness, wearing of suitable garments, maintaining adequate personal cleanliness, hand washing, removing possible physical contaminants, wearing gloves, wearing appropriate hair coverings in an appropriate manner, providing areas for personal belongings and for personal consumption of items, and other contamination control measures.
- ▶ 117.20 Plants and Grounds—Ensure that the plant and grounds are kept in a condition that prevents contamination of the food. The plant is constructed in a manner to facilitate maintenance and sanitary conditions.
- ▶ 117.35 Sanitary Operations—Sanitary operations covers general maintenance, substances used in cleaning and sanitizing and storage of toxic substances, pest control, and sanitation of food contact surfaces.
- ▶ 117.37 Sanitary Facilities and Control—Each plant must be equipped with adequate sanitary facilities and accommodations.
- ▶ 117.40 Equipment and Controls—Plant equipment used in manufacturing, processing, packing, or holding must be designed and of a material and workmanship to allow for adequate cleaning

- and must be maintained to protect against contamination and cross-contact allergens.
- ▶ 117.80 General Processes and Controls—All operations in the manufacturing, processing, packing, and holding of food must be conducted in accordance with adequate sanitation principles. Raw materials and other ingredients must be cleaned and handled properly. Equipment, utensils, and other manufacturing equipment must be cleaned and sanitized appropriately.
  - ▶ 117.93 Warehousing and Distribution—Storage and transportation of food must be under conditions that will protect against allergen cross-contact and against biological, chemical (including radiological), and physical contamination of food, as well as against deterioration of the food and the container.
  - ▶ 117.95 Holding and Distribution of Human Food By-Products for Use as Animal Food—Human food by-products with the intended use as animal food must be handled appropriately with equipment and storage containers that are clean, labeled and have been inspected.
  - ▶ 117.110 Action Defect Levels—Quality control operations that reduce natural or unavoidable defects to the lowest level currently feasible is required at all times. Food may not be mixed with food containing defects.

For more details, read the [Code of Federal Regulations Title 21 - Food and Drugs, Chapter 1 - Food and Drug Administration Department of Health and Human Services, Subchapter D - Food for Human Consumption.](#)

## Food Safety Modernization Act and preventive controls

Businesses that average sales less than \$1M per year of human food plus market value of human food manufactured, processed, packed, or held without sale are exempt from the preventive controls requirements to perform a hazard analysis and implement risk-based preventive controls.

Preventive controls rules require that the facility have a written plan that includes preventive controls for identified potential hazards. Preventive controls need to be implemented to reduce the risk of such hazards with records kept.

Under preventive controls rules, food processing facilities must develop food safety plans.

Requirements of a food safety plan include:

- ▶ Hazard analysis that identifies known or reasonably foreseeable biological, chemical, and physical hazards that occur naturally, could be unintentionally introduced, or be intentionally introduced for economic gain. Hazard evaluation that considers the severity of illness/injury and probability of occurrence in absence of preventive controls.
- ▶ Preventive controls are measures or actions required to ensure that hazards are significantly minimized or prevented, including: process controls, food allergen controls, sanitation controls, supply-chain controls, and recall plans.
- ▶ Preventive controls should be identified for critical control points for food safety.
- ▶ Preventive control plans should include monitoring, corrective actions, and verifications of compliance to the plan.



- ▶ Appropriate steps of verification include: validation of preventive controls, verification of monitoring and corrective actions, calibration of process monitoring and verification instruments, product testing, environmental monitoring, and records review.
- ▶ Supply-chain program for raw materials and other ingredients.
- ▶ Preventive controls trained employees.



# LABELING PACKAGED FOOD



MELISSA GOOD

It is important to include adequate and accurate labeling on food products to minimize risks to consumers. Many consumers are allergic or sensitive to certain ingredients and need this information to make safe decisions.

Federal law, state law, and state and federal regulations outline specific labeling requirements for food that is packaged into bottles, cans, cartons, or secure wraps and bags. The location of consumption of the food does not affect labeling requirements. Packaged food labels should provide information about the product such as:

- ▶ Name—common or standard name of the food
- ▶ Ingredients—in descending order of predominance by weight including sub-ingredients
- ▶ Allergens—common allergens found in the ingredients or processed in the same facility (nine major food

allergens: milk, eggs, fish, crustacean shellfish, tree nuts, peanuts, wheat, soy, and sesame)

- ▶ Weight—net content or quantity in both metric and U.S. customary systems. Example: 1 lb (450g).
- ▶ Name and address of manufacturer, packer, or distributor
- ▶ Nutritional label (exemptions for small firms exist)

If a product is animal feed, labeling requirements may be found in the [Animal Feed Labeling Guide](#) from the Association of American Feed Control Officials.

[Food labeling information](#) is available from FDA.

# HAZARDS

Despite the lack of federally identified hazards and controls, it is important to make every effort to produce a sound and safe product. Following the steps laid out by the ADEC Food Safety and Sanitation program is required, but getting a safe standard product onto the market can also increase an individual's business and bolster the industry as a whole. At time of this publication, there are no water quality standards or food safety analyses required by the state of Alaska for seaweed production, although these do exist for shellfish production. As a processor and consumer, you want to ensure a product is safe for human consumption. To protect public health, processors need to know what the potential hazards are associated with fresh and processed seaweed and what the appropriate controls are for those hazards. Below are some hazards that have been identified within the industry. This is not a comprehensive list, and we encourage you to seek additional resources for the latest information on identified hazards, preventative controls, and best practices.

Currently, there is uncertainty about what hazards exist for seaweed, and thus there is little federal guidance. With the absence of federal regulations in the sale of seaweed in its whole form, states can fill in these gaps.

The following outlines some basics of analyzing hazards, gleaned from fish and fishery products, in the absence of seaweed-specific data. It is recommended that processors contact the appropriate state and federal agencies for the most recent requirements and guidance when developing a food safety plan. When discerning likely-to-occur safety hazards, processors should consider natural toxins,

microbiological contamination, chemical contamination, pesticides, drug residues, decomposition (in certain species), parasites, physical hazards, and unapproved use of additives.

Lists of critical control points should include those designed to control hazards potentially introduced both inside and outside the processing plant environment, before, during and after harvest.

For this guide, as with state and federal regulation, processing kelp includes handling, storing, preparing, drying, freezing, manufacturing, preserving, packaging, labeling, or holding kelp beyond harvest and trimming. There are potential hazards associated with these practices including pathogens, and chemical and physical contaminants that could pose risk when the product is consumed, and should be taken seriously.

## Environmental contaminants from harvest area

Seaweeds accumulate essential minerals from the surrounding environment, and can also accumulate certain heavy metals at levels harmful to people. Certain species of seaweed show an affinity for environmental contaminants such as heavy metals, PCBs, petroleum residue, and pesticides. Their tissues can accumulate unsafe levels when those contaminants are present in the water where the seaweed is growing. High levels of environmental contaminants have been associated with health risks ([Chapter 9 FDA Hazards Guide](#)).

Trace heavy metals are naturally found in seawater and are therefore not necessarily contaminants.

Metals are naturally occurring elements that enter into our food supply from the air, water, and land. Some metals are a necessary part of a healthy diet, while some have been shown to be detrimental to health at certain levels. Common naturally occurring heavy metals associated with seaweed include arsenic, lead, cadmium, mercury, and iodine. There is little federal guidance on consumption for most heavy metals, with the exception of iodine.

Iodine is a trace element naturally present in some foods, added to some types of salt, and available as a dietary supplement. Iodine is an essential component of thyroid function and is required for proper skeletal and central nervous system development in fetuses and infants. There can be adverse impacts from consuming too much iodine. The National Institutes of Health (NIH) does recommend a serving size of nori (a red seaweed from either the genera *Pyropia* or *Porphyra*) of 10 g, which provides 232 mcg iodine per serving. NIH has developed recommended daily allowances for iodine (Table 1).

Table 1. Recommended Dietary Allowances (RDAs) for Iodine (Office of Dietary Supplements, 2021)

| AGE               | MALE     | FEMALE   | PREGNANCY | LACTATION |
|-------------------|----------|----------|-----------|-----------|
| Birth to 6 months | 110mcg*  | 110mcg*  |           |           |
| 7-12 months       | 130 mcg* | 130 mcg* |           |           |
| 1-3 years         | 90 mcg   | 90 mcg   |           |           |
| 4-8 years         | 90 mcg   | 90 mcg   |           |           |
| 9-13 years        | 120 mcg  | 120 mcg  |           |           |
| 14-18 years       | 150 mcg  | 150 mcg  | 220 mcg   | 290 mcg   |
| 19+ years         | 150 mcg  | 150 mcg  | 220 mcg   | 290 mcg   |

\*Adequate Intake

Without federal guidance for consumption limits from FDA, states such as Connecticut have adapted limits established by the France Food Code (Table 2; Anses, 2018). California maintains a comprehensive list of chemicals known to cause cancer or reproductive toxicity and has very restrictive levels for chemical concentrations in drinking water. This is known as Proposition 65, or the Safe Drinking Water and Toxic Enforcement Act of 1986.

Table 2. France Food Code heavy metal limits.

| HEAVY METAL             | MAXIMUM LEVEL (MG/KG) |
|-------------------------|-----------------------|
| Arsenic (as, inorganic) | <3.0                  |
| Cadmium (Cd)            | <0.5                  |
| Iodine (I)              | <2000.0               |
| Lead (Pb)               | <5.0                  |
| Mercury (Hg)            | <0.1                  |

In order to understand your product and to generate a recommended serving size for labeling, it is recommended that you test kelp for nutrient levels. Keep in mind that nutrient levels of fresh, blanched, and dried products can vary. For example, it is believed that blanching can reduce the amount of iodine, though more information is needed.

Polychlorinated biphenyls (PCBs) are a complex group of compounds found in older industrial products and chemicals that were banned in 1979 due to their impacts on human and wildlife health and environmental persistence. Although banned, they can still be found in the environment at toxic levels, especially in areas that have accumulated levels due to long-range atmospheric



transport and formerly used defense sites. These toxins are associated with lipids however, and since seaweeds such as ribbon kelp, sugar kelp, and bull kelp do not contain lipids, there is little risk of PCB contamination.

Pesticide and herbicide contamination is a concern in many parts of the country and levels allowed in food commodities is set by the Code of Federal Regulations, [Title 40: Protection of Environment PART 180–TOLERANCES AND EXEMPTIONS FOR PESTICIDE CHEMICAL RESIDUES IN FOOD Subpart C–Specific Tolerances](#). While chemical contamination needs to be taken under consideration, these may be of less concern in Alaska where their use is minimal.

As mandated by the Clean Water Act, the state of Alaska has developed a program to monitor and report on the quality of its waters and prepare a report describing the status of its water quality. Waterbodies that persistently exceed state water quality standards ([18 AAC 70](#)) for two or more years of water quality monitoring may be declared as impaired by ADEC or the U.S. Environmental Protection Agency (EPA). ADEC provides [a list of impaired waters in Alaska](#).

Testing for heavy metals, PCBs, or other chemical contaminants is not required by state or federal regulations, but can be done through labs using analytical methods validated by the FDA and EPA.

To maintain a high quality product, it is recommended that kelp be sourced from clean growing areas with minimal exposure to contaminants.

## Natural toxins from harvest area

Harvest areas of seaweed can have various levels of natural toxins including toxins from species of phytoplankton (single-celled marine algae) which produce the toxins that are known to bioaccumulate in fish and shellfish and some species of toxin producing bacteria such as *Vibrio* spp (Chapter 6, [FDA Hazards Guide](#)). Although shellfish cultivated in Alaska must be grown in approved waters and undergo rigorous biotoxin testing, these requirements do not exist for seaweed. Seaweeds do not absorb toxins, although toxin producing phytoplankton and bacteria can be present on the surface of the blades.

## Pathogens

Microorganisms are found everywhere, including on the food that we eat. Raw foods eventually spoil and break down. The breaking down of organic matter by microorganisms is a natural process that turns it into a form that is available as food for plants, which in turn is available to animals.

Some microorganisms that break down organic matter can cause diseases and are called pathogens. Pathogens are normally present in the environment, and at low levels do not cause illness. However, they can be difficult to control in a food processing facility. In a processing facility, pathogens can be found on processing equipment, tables, utensils, humans, in water, and in the air. Pathogens have varying tolerance to different types of treatment, such as heating or sanitizing, making it important to properly clean all surfaces in contact with food products and perform proper stabilization practices. This next section will cover some basic pathogens to be aware of when processing seaweed.

## Bacteria

Pathogenic bacterial growth and toxin formation can occur when products are in a warm environment for an extended period of time. This is a known concern with seafood products, and is something to consider with kelp. Managing time and temperature of exposure can ensure a safe product (FDA, 2021). Only a few bacterial cells need to be present to lead to rapid growth. In optimal environmental conditions, the number of bacteria cells can double every 20–30 minutes. To control bacterial growth, refrigeration, freezing, and hot holding can be used, with heat treatments killing many bacteria. Temperatures for holding should be below 40°F or above 140°F (USDA, 2012). Harvested, transported, and stored seaweed should be maintained at or below 40°F to prevent the growth of pathogens and to maintain food safety (Concepcion et al., 2018). The kelp should be adequately chilled, and if ice is used, it should not be in direct contact with the kelp to maintain quality. Keep in mind that kelp is a living organism. Kelp dies once it is frozen or cooked. If ice is used and you see some areas of the kelp turn green, those green portions should be discarded, as the tissue has died and may cause texture and quality loss.

Food processes should ensure that food products spend as little time as possible inside of the temperature “danger zone,” 40°F to 140°F (4°C to 60°C), to avoid optimal growth conditions for bacteria. Temperatures above the danger zone begin to destroy most microorganisms, although the time needed for cell destruction is longer at lower temperatures. Temperatures below the danger zone greatly slow the growth of spoilage bacteria and some pathogens. There is no significant bacterial growth below freezing (USDA, 2012).

## Pathogenic bacterial growth as a result of inadequate drying

Dried products are generally considered shelf-stable and safe. However, inadequately drying a product for stabilization can lead to pathogenic bacterial growth and toxin formation, which can cause illness when consumed. It is critical that shelf-stable products have a *water activity*—the measurement of the amount of water in a food that is available for the growth of microorganisms—at or below 0.85 to prevent growth of pathogenic bacteria. Pathogens of primary concern include *Staphylococcus aureus* and *Clostridium botulinum* (FDA, 2021). Processing procedures and packaging type will determine if a dried product is shelf-stable or needs refrigeration. Once safe processing procedures are developed for your product, water activity does not need to be measured for every batch, though the procedure should have standardized drying times, input/output air temperatures, humidity, velocity, and thickness of the seaweed critical limits that demonstrate that the dried product achieves a water activity below 0.85.

While achieving the appropriate water activity level will prevent bacterial growth, it is important to also implement a “kill” step to destroy the bacteria present on the kelp. Bacteria can persist at low levels on dried products, ready to multiply when conditions change.

## Pathogenic bacteria survival through heat treatment

Some pathogenic bacteria can survive cooking or pasteurization. Primary pathogens of concern for seafood include *Clostridium botulinum*, *Listeria monocytogenes*,

*Campylobacter jejuni*, pathogenic strains of *E. coli*, *Salmonella spp.*, *Shigella spp.*, *Yersinia enterocolitica*, *Staphylococcus aureus*, *Vibrio cholera*, *Vibrio vulnificus*, and *Vibrio parahaemolyticus*.

Cooking is a type of heat treatment, with the final product either refrigerated or frozen for distribution. Pasteurization is generally a heating process below 212°F (100°C) used to eliminate pathogenic bacteria of public health concern. Both processes destroy pathogenic bacteria and greatly reduce the amount of spoilage bacteria present (FDA, 2021).

Viral pathogens, as opposed to bacterial pathogens, are heat tolerant and need to be controlled through the sanitation process.

## Molds, yeast, and viruses

Molds are found throughout nature and are commonly observed on household foods that are old or have been inadequately refrigerated. Molds can grow on many different surfaces and proliferate under favorable conditions of moisture and temperature on almost any food, which can cause spoilage and lead to allergic reactions and respiratory problems. Most molds cannot survive heat treatments, though they can grow on products with reduced water activity if oxygen is present.

Yeasts are another single-celled microorganism found widely in nature, and are often associated with liquids containing sugars and acids. The presence and growth of yeast can cause spoilage. Yeast shows very little heat resistance and is easily destroyed with heat treatments. Yeast generally does not present public health concerns.

Viruses are microscopic protein-encased sections of either ribonucleic acid (RNA) or deoxyribonucleic acid (DNA) and require living hosts for multiplication. While viruses

produced within hosts cannot multiply on food, they can be transmitted by food. Viruses can get into food through contaminated water and by the presence of humans and other animals. In processing facilities, it is best to use potable water from a trusted and tested source, and for employees to practice good hygiene (Piconi et al., 2020).

Food processing comes with inherent risks of proliferation of pathogenic microorganisms and contamination of products. Working in a clean environment, following sanitization protocols, and preparing and packaging seaweed in a safe manner can reduce the risk of contamination and hazards and ensure a high-quality product. Prior to products going to market, we recommend that final product processes are reviewed and products tested for pathogens prior to being sold to consumers. Alaska Sea Grant at the [Kodiak Seafood and Marine Science Center](#) is the designated processing authority for the state of Alaska and can provide this service.

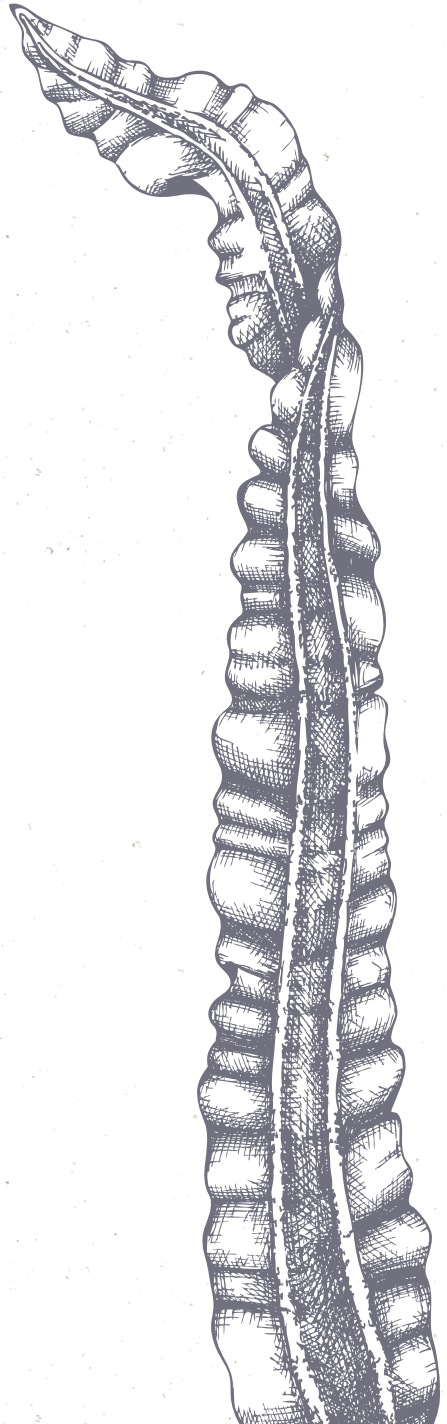
## Metal and glass

Under the Federal Food, Drug, and Cosmetic Act, a food containing foreign objects is considered adulterated ([21 U.S.C. 342](#)). Metal and glass fragments in food products may cause injuries and are prohibited by this act, which prohibits interstate commerce of adulterated foods ([21 U.S.C. 331](#)). All efforts should be made to prevent inclusion of non-food products, or adulterated food products, into your product. Metal is most often found in food products processed on manual and mechanical processing equipment. Equipment should be regularly maintained and inspected for any alterations. Glass is often used for storage and distribution of products. All glass containers should visually be inspected (FDA, 2021). X-ray equipment

designed to examine food packages post production are readily available through food equipment manufacturers.

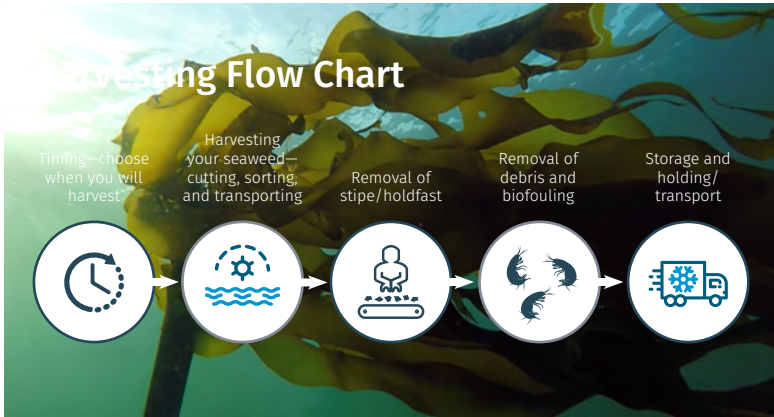
## Allergens

Seaweeds themselves are not considered allergens, but proper rinsing and cleaning of fouling organisms is important to remove any hitchhiking species that are known allergens, such as small crustaceans (e.g., amphipods, crab, or shrimp; Motoyama et al., 2007) and fish products. To avoid any cross contamination from transporting or processing surfaces, sanitization protocols should be in place. The presence of shellfish can also prevent kosher certifications.





# HARVEST TO DOCK HANDLING



## Harvesting

### Harvesting strategy

Harvesting cultivated kelp in Alaska generally occurs during a relatively short window from late spring through early summer, with the harvest season starting earliest in southeast Alaska and getting later as you move west. Timing for harvest is site-dependent, with optimal harvesting conditions occurring when increasing water temperatures decrease biomass quality and quantity. It is important for farmers to understand their site characteristics and know when fouling will start to take place.

The harvesting period for a given location ends as rapid increases in water temperature lead to development of epifauna—animals that live on and attach to the surfaces of living organisms— and they can attach to the kelp blades, known as fouling.

Common fouling organisms in Alaska include hydroids, bryozoans, snails, snail eggs, green sea urchin, skeleton shrimp, pink and side stripe shrimp, amphipods, snailfish, and blennies/pricklebacks.

The harvest period is also limited by the volume that can be harvested in a day, the capacity of the transportation vessel to the processing facility for stabilization, the distance and time necessary for transport, and daily processing capacity at the facility. Harvest strategies must therefore include the aforementioned limitations, dynamics of the site, labor requirements, possible coordination with a tender for transport of the harvested biomass, and weather. The ultimate goal is to have a harvest plan that ensures efficiency and optimizes the quality of the seaweed harvested.

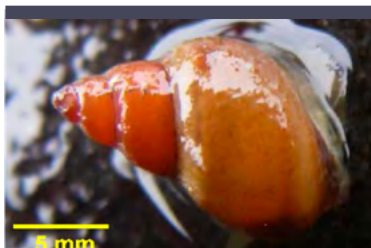


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Hydroids that were missed in the initial sorting to remove fouling organisms.

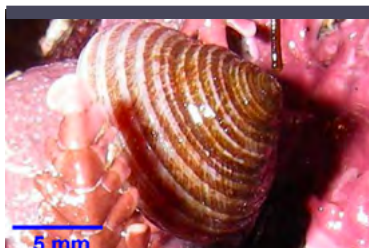


AARON BALDWIN



AARON BALDWIN

*Lacuna variegata*



AARON BALDWIN

*Margarites pupillus*



## Harvesting techniques

When it comes time to harvest, there are several things to consider: efficiency, timing, and equipment. To harvest kelp, the growlines are removed from the water onto a skiff or other floating platform. A section of one line is usually harvested at a time. These lines can be incredibly heavy and hydraulic winches may be necessary to lift the growline out of the water. Removal of the kelp from the line is done with a sharp knife or other cutting device as the vessel moves down the line. As the line comes over the vessel it should be positioned in a manner that allows for ease of cutting and getting the kelp into the holding container as efficiently as possible. The less you are handling the kelp the better. Having the line higher, even above

head height, can make cutting easier. The kelp can be cut directly from the line including the holdfast. Where you cut the kelp will depend on if your seed string is still present or not, the ability to remove it, and what it is made of, but can be done from the point where the stipe meets the holdfast, or from the point where the meristem joins the stipe. Harvesters should work with the processor to determine what should be harvested. You do not want to bring in extra kelp that you will not be compensated for, nor do you want to bring in undesirable things such as non-compostable seedstring.

As the kelp is removed from the line, it should drop or be placed into your transportation holder. The fewer steps this takes, the better. Totes, coolers, or net bags are commonly used for transportation. Once one line is harvested, the vessel moves over to the next line to start the harvesting again. This is



Harvesting sugar kelp.

CHRIS SANNITO

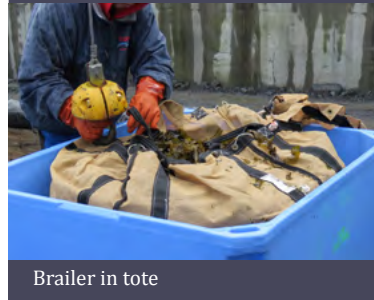
done until the skiff or tender has reached holding capacity or you've met the processing capacity.

Harvest should occur during favorable weather, as bad weather is dangerous when working in a maritime environment. Wind and waves can cause lines to cross when pulling them on board and make it difficult to slowly maneuver down the growlines. On a properly constructed growline array or catenary system, the lines are constantly under tension. Timing harvest periods around low or high water may not be important for harvest but could impact other steps of your operation such as delivery.

High-yielding growlines can have as much as 10 lbs of kelp per foot, which causes a significant amount of drag necessitating the use of hydraulic pullers. Using a knife to cut the kelp from the line is a simple method, but using equipment such as a custom built hedge trimmer can increase efficiency. Kelp cut off of the lines should fall directly into a transportation container, such as brailer bags secured to the bottom of the vessel, or fish totes. Brailer bags are convenient because once a bag is full, it can be tied shut, rolled over-board, and secured to the vessel for transport to the processing facility. Kelp within the bags or totes should not be stepped on and compacted, and should have adequate space to be light and fluffy until delivery to the processor. Kelp should not be stored in direct sunlight. The number of bags or totes filled prior to transport to a tender or processing facility depends on the capability and capacity of your vessel and the desired amount for processing.



CHRIS SANNITO



CHRIS SANNITO

Brailer in tote

Bringing kelp onboard can expose it to contamination hazards on the vessel. Use only food grade hydraulic oil and machinery grease to avoid petroleum contamination. Keep fuel and engine oil away from the harvesting area on deck. There should be a daily cleaning protocol for the harvest vessel as left over kelp on deck can start to decompose and create bacterial contamination. Use only stainless steel or plastic surfaces that can be sanitized, rather than wood or other porous material.

Care must be taken when using sharp knives and working on a moving and potentially slippery platform. Be aware of any knives that are on deck and do a count to make sure none have fallen into the bags or totes. Kelp can be especially slippery on deck. Having a clean and safe work surface is very important for everyone onboard.

A vessel should never be overloaded. The weight of the kelp along with unpredictable weather create the risk of capsizing. When planning your harvest, think about how you will move your vessel along the growlines, what you will be using to remove the kelp, where you will be storing it, and how it will be transported to the processing facility.

## Transportation

Kelp can be transported to a processing facility either by the harvesting vessel or a tender. Work with the processing facility on the species to harvest, the volume that can be received at a time or per day, and quality of the kelp appropriate for the end use (human food, feed, refinement, etc.). Kelp will degrade quickly, and quality deteriorates faster when exposed to heat, freezing temperatures, desiccation, or rough handling. Covering kelp with a clean tarp will limit dehydration from direct sunlight.

Ensure that risks of contamination are mitigated. The vessel should be constructed to prevent the kelp from coming in contact with bilge or other polluted water, fuel, animal waste, or anything unsafe for consumption.

Brailer bags filled with kelp can be transported and stored in fish totes to keep the kelp moist with sea water. A tarp can be placed over the bags or totes to cover them from direct sun, rain, or contaminants such as bird droppings. If kelp is left in standing freshwater, such as in a tote or cooler, it may blister and be unappealing to a buyer. Food grade kelp should reach the processing facility within 48 hours of being removed from the water. Ice should not be used, as freezing will cause tissue damage and degradation. Brailer bags, fishing holds, totes, and any other items coming in contact with the kelp should be cleaned and sanitized. Do not use soaps, as they can leave a residue. Remember to always clean, rinse, and sanitize, and work with the processor on their specific requirements.

For harvesting, transporting, and storing bull kelp, it is important that cut or otherwise physically impacted bulbs or stipes not be in contact with fresh or saltwater. The buoyant pneumatocyst, or bulb, and stipe of bull kelp are filled with up to 10% carbon monoxide, a byproduct of photosynthesis. The gas-filled interior is naturally insulated from contact with water, and exposure to fresh or salt water can cause blistering and other adverse effects impacting the interior quality.

## Delivery

Kelp delivered to the processing facility should be stored in a manner that does not expose the kelp to outdoor temperatures over 50° F (Flavin et al., 2013), freezing temperatures, desiccation, standing freshwater, or contaminants. Once at the processing facility, kelp can be stored in insulated fishing totes until processing. Food-grade kelp should be processed within 48 hours of harvest.

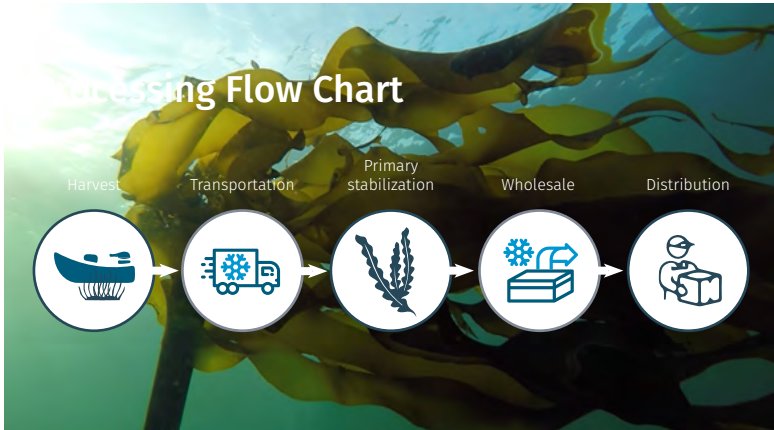


Tendering sugar kelp.

CHRIS SANNITTO



# PRIMARY PROCESSING



## Sorting

Kelp should be removed from the storage containers and placed on a sanitized sorting table that is made of smooth non-absorbent material that is easily cleaned. If the kelp has been stored in brailer bags, a hydraulic lift or crane can be used to lift the bag out of the container. If you design your own bags, having a cinch line and opening at the bottom of the bag will allow for someone to pull the line and have the kelp fall out onto the sorting table or bin. Outdoor sorting areas should be covered to prevent contaminants from above. Kelp should then go through its first round of sorting. Any fouling organisms should be removed and disposed of properly. Unhealthy looking tissue that shows discoloration, twisted or wrinkled blades, swollen stipes, twisted roughened blades, deformations, dark spots, blisters, and other impurities should be removed from food-grade kelp, but could be separated for uses such as fertilizer. Sorting is labor intensive, so streamline your steps for efficient handling of the kelp.



Kelp at the dock.

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Kelp tissue not to use.

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Sorting kelp

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Sorting kelp

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## Cleaning

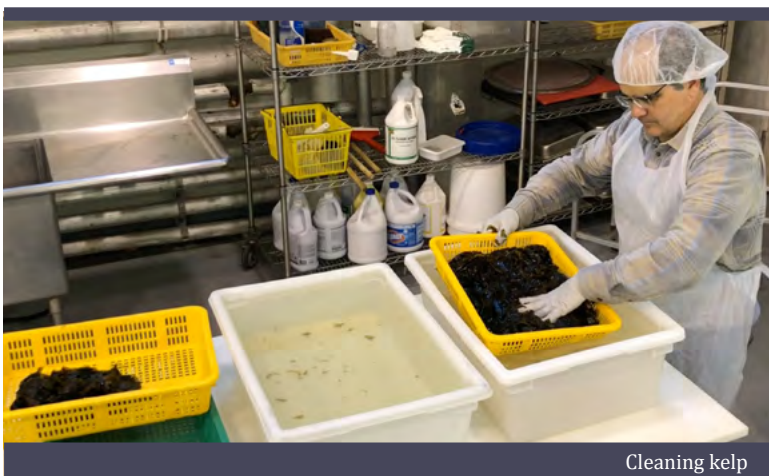
Once sorted, desirable kelp can be cut using a standard chef's knife into approximately 6-inch sections, or another length as needed, to ease handling of the kelp. Cut sections can then be submerged into a cleaning bath. Bath water should be clean potable water and include a cleaning solution, such as peracetic acid, but it is not necessary if the kelp will be blanched. Peracetic acid is a common disinfectant and cleaner used in the food industry. When applied correctly, this cleaner deactivates a large variety of pathogenic microorganisms, including bacteria, viruses and spores by oxidizing the outer cell membranes of microorganisms. This cleaner has a short half-life and quickly breaks down into safe substances (acetic acid, oxygen, and water). Cleaning and sanitizing the containers used for cleaning kelp is strongly recommended as they can have bacterial contamination, and bacterial proliferation can occur in the right conditions.

Kelp is typically clean from a microbial standpoint in its natural habitat. Taking steps to keep it this way throughout harvesting, handling, and processing greatly reduces the chances of contamination. It is easier to keep the kelp clean than to decontaminate it at a later step.

Depending on the volume of kelp, cleaning equipment can be a simple plastic tub filled with the cleaning solution, a dunk tank, or an industrial-scale vegetable washing machine.

When designing of your sanitation station, consider:

- ▶ How much does it cost?
- ▶ Can your process and equipment wash your intended volume on schedule?
- ▶ How much space does it require?
- ▶ How easy is it to clean?
  - > Are there areas that may result in harborage of water, fouling organisms, or pathogens?
  - > Can you wash all of the interior surfaces with an appropriate detergent?
- ▶ Will the unit dry completely when not in use?



Cleaning kelp

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You do not want to let the kelp sit in fresh water for more than 50–60 seconds, otherwise it may blister. During the rinsing process, you want to remove all foreign material, including fouling organisms, small fishes, amphipods, or diatoms attached to the surface.

## Washing supplies

- ▶ Peracetic acid can be purchased from online retailers for \$5–\$10 per liter from distributors such as [Lab Alley](#), [ChemWorld](#) and others.
- ▶ Plastic tubs and food pans for cleaning can range from \$8–\$55, and can be found from restaurant supply and equipment distributors such as [Daco](#), [Grainger](#), [Global Industrial](#), [WebstaurantStore](#) and Amazon. Larger, heavy items cost more but may work better for larger volumes.
- ▶ Vented plastic crates and baskets make it easy to efficiently rinse the kelp and pull it out of the cleaning solution all at once, and then allow for drainage of the excess water. Vented crates and baskets can range from \$12–\$55 from restaurant supply and equipment distributors such as Frontier Packaging, [Grainger](#), [Cambro](#), [KitchenRestock](#), [WebstaurantStore](#), [West Marine](#), [Daco](#) and Amazon.
- ▶ Dunk tanks built of hard metal or plastic with easy-to-clean surfaces can be used with a basket. Ensure that the tank can easily be filled, drained and cleaned. Trimmed and cut kelp can be placed in basket inserts for ease of washing. The removable baskets are easy to handle and make for efficient washing. They can be maintained, cleaned, sanitized and dried without difficulty. Prices vary widely depending on construction materials. Dunk tanks can be fabricated locally from stainless steel or

purchased from various suppliers including [D.H. Griffon](#), [Global Industrial](#), [Grainger](#), [Vevor](#), [Ecrecon](#), [Daco](#) and others, with prices ranging from \$300–\$3,500.

- ▶ Electric fruit and vegetable washing units that use aeration can reduce labor; however, these can be expensive, with smaller units starting about \$1,500 and larger ones up to \$9,600. Some examples include [Fresh!](#), [Food-Machine](#), [VER Machinery](#), and [Fengxiang Food Machinery](#).

Kelp needs to be completely submerged in the cleaning solution. If using a dunk basket, the kelp should be placed below the top lip of the basket and left loose and not compacted so that the cleaning fluid can touch every surface of the kelp. If washing manually, dunk the baskets of kelp into the cleaning solution and shake vigorously enough that all of the kelp surfaces are washed without any of it coming out of the basket. At this time, look for any fouling organisms or undesired tissue that may have been missed in the initial sort. Kelp should be submerged for at least 50–60 seconds, or as directed by the cleaning solution for full sanitation, and in contact with the solution at a concentration of 60–80 ppm. There are [test strips](#) available to verify concentration. Remove washed kelp from the cleaning tubs or dunk tank and allow for excess water to drain off.

Clean, drained kelp can then be staged for stabilization through heat treatment or drying. Ideally, the kelp is kept in ambient temperatures at or below 40°F to prevent microbial growth or spoilage, and staging time should be as minimal as possible. Kelp could be placed in a large walk-in cooler, making sure it is covered to keep contaminants from blowing onto it from the fans in the cooler.

# Blanching

Blanching is a mild heat treatment that improves the quality of preserved food products. It significantly reduces microbial loads, softens the products, and inactivates enzymes. Blanchers should operate at 170°F or higher, and be cleaned frequently to avoid buildup of thermophilic (heat loving) organisms. Blanching also leaves the kelp a bright green color. The heat destroys fucoxanthin, the photosynthetic pigment found in brown seaweeds, but not the heat stable chlorophyll. Kelp can be overcooked, leading to poor quality products. This guide covers two types of machinery available for blanching: electric steam kettles and conveyor belt steam blanchers.

## Water kettle blanching

One method of blanching uses an electric steam kettle. There are different types and good choices available; the illustrative description below is in part specific to the Groen EE40 Kettle 40-Gallon Steam Jacketed Floor Kettle with a metal cooking basket insert, used at the Kodiak Seafood and Marine Science Center pilot plant.

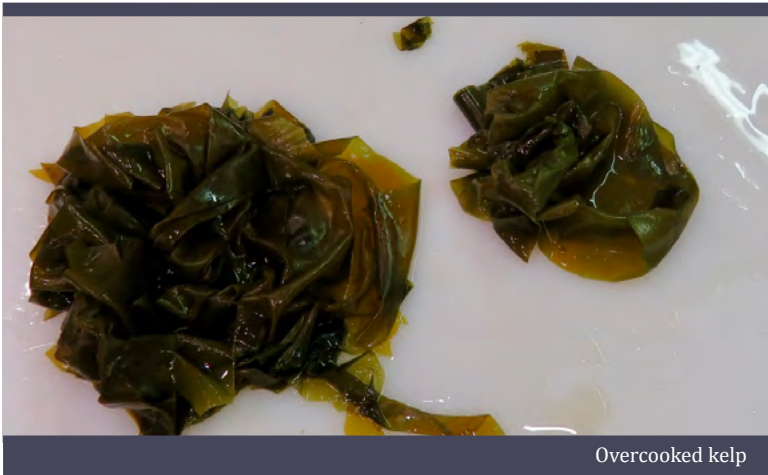
Prior to preparing the seaweed for steaming, the kettle should be filled with clean potable water to the manufacturer's specifications and set for 170°F. The kettle has a metal basket insert that fits snugly into the kettle. After the seaweed is able to drain for a couple of minutes in the cleaning baskets, add enough kelp to the metal steaming basket to make a 1:3 ratio of kelp to water. The exact amount will depend on the capacity of your kettle. The kelp should be loosely arranged inside of the kettle to allow for even cooking. Once full, the metal basket is lowered into the steamer, the lid closed, and the kelp allowed to steam

in the 170°F water for 2–3 minutes for sugar kelp, and 3–5 minutes for ribbon kelp. Due to the thickness of bull kelp, cooking times may take longer. The cool kelp will drop the temperature of the cooking water, and it is important to quickly bring the temperature back to 170°F. This will inactivate enzymes found in the kelp, destroy pathogens and fix the color. The kelp is blanched once it turns a bright green. The blanching process leaches out the accessory



photosynthetic pigments, leaving behind only the bright green of the chlorophyll. A large sanitized metal spoon can be used to stir kelp in the basket for even blanching. If the seaweed is left in the blancher for too long, it will start to break down, turn an off-green color and have a slimy texture. Overcooked kelp will appear limp, slimy, and slightly brown and should not be used for food-grade products, but could be used for other purposes such as garden fertilizer.

Once kelp is thoroughly blanched, the basket should be removed from the kettle and the kelp placed into sanitized



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Overcooked kelp

plastic food bins or trays and placed where it can be cooled rapidly to stop the cooking process, such as in a sanitized refrigerator. Contaminants can be airborne, so rooms should be well ventilated while maintaining proper humidity and temperatures. Potable water from the tap can be used



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Steam kettle temperature check.



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Kelp in the steam kettle basket.



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Removing steamed kelp for cooling.



to cool the kelp. It is recommended that you do trial runs with smaller volumes with your particular equipment prior to having a large volume of kelp brought to the processing facility. You do not want a lot of valuable kelp sitting around while you test methods, processes and equipment.

## Conveyor belt steam blanching

Another method for processing high volumes of kelp is to use a conveyor belt steam blancher. These systems are designed for blanching and cooling of vegetables. The kelp is fed through a cooking zone via a continuously moving horizontal conveyor belt. The kelp is cooked in steam circulated and distributed by integrated fans, followed by multi-stage cooling which starts with evaporative cooling using ambient air and a small quantity of water, and finishes with mechanically chilled air using fans and integrated heat exchangers. The units are often described in terms of the volume of peas that they can process, which can be as much as 30 tons per hour. The unit should have controls to set your specific water temperature, belt speed, and water consumption.

If using one of these units, cleaned, sorted and sliced kelp should be evenly distributed onto the conveyor belt. These units will cook at the temperature of the steam, which is around 212–220°F. Cooking time will depend on the product thickness, initial product temperature, and distribution in the cooker. After steaming for the appropriate time, the unit will cool the kelp using evaporative and forced air cooling. The cooked and cooled kelp will come out the end of the unit. Overcooked kelp should be separated out and not be used for food-grade products, but could be used for other purposes. Cooled high quality kelp can be further processed into value-added products or packaged for distribution.

You should do trial runs with your particular units with a small volume of kelp prior to having a large volume of kelp brought to the processing facility. You do not want a lot of kelp sitting around while you test your methods, processes, and equipment. You will need a fairly large steam boiler with the conveyor belt system. Steam needs to come in contact with all sides of the kelp and the steam needs to be food grade. Steam must not be allowed to carry any chemicals or residues. When looking at conveyor belt steam blanchers, you will also need to purchase equipment for steam generators that will pair with the equipment.

## Value-added processing: pureeing

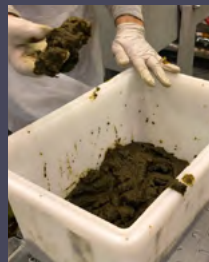
Pureeing cooked kelp is one example of value-added processing. Purees can be added into smoothies, salad dressings, dips, soups, stews, quiches, desserts and more. Alaska Sea Grant uses the Urschel Comitrol Processor Model 1700 in our processing plant to puree “blanched and dried” kelp. Pureed kelp can be frozen in food-grade containers for distribution, such as high-density polyethylene (HDPE) containers, a widely used and recyclable plastic material. When filling them, make sure to include sufficient head space to accommodate product expansion when freezing.



Urschel Food Processor



Putting kelp in the processor.



Pureed kelp

## Packing

Cooled, stabilized kelp can be stored in various ways. Two options include freezing the sliced blanched kelp into vacuum sealed packages or pureeing the kelp to be stored in food-grade plastic containers.

When vacuum packing cooked kelp, it is important to have consistent quality and quantity. After the kelp is cleaned and sorted, this final step ensures that your customers are getting a top-quality product. Vacuum packaging at room temperature or slightly warmer can suck moisture out of the package, so a water and vapor trap is needed in the vacuum line to avoid damaging the vacuum pump.

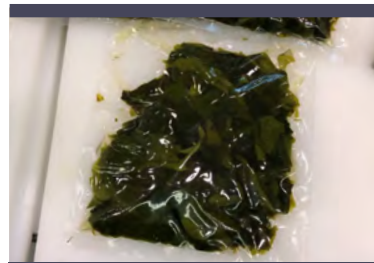
Your system should allow you to quickly and efficiently sort through the cooked and cooled kelp as it is going into the packages for sealing, again removing any kelp not food grade. Your package size will depend on your market and customers, with 1 lb and 5 lb packages being popular. Pureed kelp should be placed into food-grade sealable containers. The size and type of containers you use will depend on your customers, and can range from small ice cube size to 5-gallon food-grade buckets.

Each package should be weighed for consistency and accuracy. If you add too much, you are losing potential



Vacuum packing blanched kelp.

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Vacuum packaged blanched kelp.

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revenue, increasing shipping costs, and giving customers more product than they may be prepared to use. Adding too little shorts your customer and is also a poor business practice.

## Freezing

Kelp has up to 90% moisture content and can deteriorate before stabilizing. Freezing raw kelp is possible, but it will produce a lower-quality food-grade product, though may be used later for protein recovery after separation from non-protein components.

Because of kelp's high water content, more powerful freezers are needed to quickly freeze the product. Packages should be blast frozen for best quality. Commercial blast freezers come in different sizes. Prior to picking a blast freezer, you will need to know how much volume you can process in a day and how many days you will be processing. You may not need to hold an entire season's worth of kelp at once, but you may want to have the freezing capacity to do so. The unit you choose should meet your volume needs and shipping methods. Walk-in freezers are common in the food processing industry and could be convenient if you want to store and ship individual packages. Containerized blast freezers make a great shipping option and come in both 20 ft and 40 ft options. These are great for efficiency, but require permanently installed compressors outside, and so are as permanent as a walk-in freezer.

## Modified atmosphere packaging

Modified atmosphere packaging is another tool to slow degradation of the kelp and increase longevity by actively or passively reducing the oxygen surrounding the kelp within a package, and can be made of various

materials. More information on modified atmosphere packaging is available in the [Guide to Minimize Microbial Food Safety Hazards](#) from the FDA.

## Distribution

Your operational plan will dictate your distribution needs. With frozen products, you will want to ensure that they stay frozen until they reach your customers. If you have a storefront or sell locally, you may be able to sell straight out of your freezer. Otherwise, you will want to set up an account with a shipper in your area that ships frozen goods and provides a guarantee that contents will arrive frozen. Some areas have community cold-storage options.

## Primary processing equipment list

- ▶ *Electric water kettles* can range from \$1,300 to \$31,000 depending on the size of kettle. Common kettle sizes range from 6 to 100 gallons and can be purchased from companies including [Maltese & Co](#), [Globe](#), [Central Restaurant Products](#), and [KaTom Restaurants Supply](#). In our pilot plant, we use the Groen EE-40 Steam Kettle which costs approximately \$15,000 and can be purchased from vendors such as those listed above.
- ▶ *Steam belt blanchers* can range from \$210,000 to \$250,000 or more depending on model and size. Some units may need additional equipment, such as parts used in the blanching of spinach. It will be important to work with each manufacturer to have something built to your specifications. Companies that manufacture steam belt blancher-coolers include [Pollak](#), [Proex Food](#), and [Cabinplant](#). To save on costs, another option could be purchasing refurbished equipment from companies such as [Alard Equipment Corporation](#).

- ▶ In our puree value-added example, we discussed using an *Urschel Comitrol 1700 15 Horsepower Processor*. At the time of purchase, this unit cost \$40,000. You will want to contact the [Urschel Norwest Regional Manager](#) to find where to purchase a new unit, but may be able to find used units from companies such as [Sigma Equipment](#) or [Machinio](#).
- ▶ In our pilot plant, we use an Ultravac® 2100 Double Chamber Vacuum Packaging Machine, which was purchased for \$15,000. You may find that you can use a smaller unit, or may need something larger. Single chamber units are also available but production is slower. Chamber vacuum packing machines can range from \$200 to \$50,000, with units similar to what we use at our Pilot Plant running between \$2,000 to \$4,500, and can be purchased from companies such as [Central Restaurant Products](#), [SMAAK](#), [TechnoPack](#), [Wasserstrom](#), [Toolots](#). These costs do not include the packing bags needed.
- ▶ Blast freezers can be expensive and range from counter-top freezers as low as \$2,000, to dedicated buildings that could surpass \$100,000. Restaurant equipment and processing equipment manufacturers such as [Hotel Restaurant Supply](#), [Katom Restaurant Supply](#), and [Webstaurant Store](#) provide shelf and floor freezers, and companies such as [Conexwest](#) and [Titan Containers](#) provide blast freezer containers for rent or sale. Another option is to purchase a used blast freezer with 20 ft blast freezer containers, and purchase a 15-horsepower condenser which will cost about an additional \$35,000. Working with established seafood processing companies with freezing capabilities or using community cold-storage facilities may reduce your equipment costs.

- ▶ As you develop your blueprint and processing plans, there are software programs that can help such as [AutoCad Architecture](#), [SmartDraw](#), [CadLogic](#), and [Microsoft Visio](#). The Alaska Department of Conservation will want to see a layout of your facility. Contact them for detailed guidelines prior to drafting your plan.
- ▶ Think about items that could create efficiencies and decrease the amount of labor needed, such as wheel tray racks and carts, storage racks, smooth surface tables, sinks and cleaning supplies, and include them in your plans. Also consider future operation expansion potential in your plans and designs

## Drying

Drying is a common method for stabilizing seaweed, using a dehydrator, oven, forced air, or static air. The drying process reduces the water activity, deterring microbial growth and spoilage, and increases shelf life. In addition, the weight and volume of the seaweed is reduced, minimizing the amount of packaging and storage space needed and decreasing transportation costs. While small volumes of seaweed can be dried in a dehydrator or oven, an entire drying facility, or at least a dedicated room or container may be required for drying bulk harvest. Seaweed drying facilities in many places such as in the contiguous U.S. use greenhouse drying facilities. Keep in mind that drying at high temperatures can negatively affect the nutritional value of brown seaweeds. Kelp can be dried in a greenhouse or outside on racks, known as solar drying, but may face regulatory obstacles.

Alaska's wet weather and strong winds can interfere with outdoor or greenhouse drying. Despite the higher costs, we focus below on indoor drying techniques more suitable for Alaska's climate.

## Drying Instructions

Kelp cleaned and prepared for drying should have holdfasts, stems and stipes removed from the blades. Blades should be cut into fairly uniform sizes to ensure consistent drying. Blades then should be cleaned and sorted as outlined earlier.

Clean kelp should be placed in food-grade perforated bins that allows excess water to drain. Once most of the water is drained, the kelp can be prepped for drying in a dehydrator, oven, dedicated drying room or container, or with the use of dedicated drying technology. No matter the process, the water activity of the final product should be below 0.85 to prevent growth of microorganisms.

*Water activity* is a measure of the portion of the water content in a food that is available to foster the growth of microorganisms. It is a critical factor in determining the quality and safety of food, and can impact shelf life, safety, texture, flavor and smell. Three types of instruments for measuring water activity include resistive electrolytic hygrometers, capacitance hygrometers, and dew point hygrometers. These can be purchased from various scientific and food equipment companies. Keeping the water activity at 0.85 or less in a finished product prevents microbial growth and is then not subject to FDA regulations [21 CFR Parts 108, 113, and 114](#). See the [FDA's guide on Water Activity in Foods](#) for more details.

Seaweed prepared for drying should be cleaned and cut into uniform sizes for even dehydration, and can be spaced evenly directly onto oven racks. Kelp blades can be roasted at a low temperature, 80–100°F, for a couple of hours depending on the thickness of the blades and how much is in the oven. Because of food safety concerns related



to pathogen dormancy on the kelp, when doing lower temperature drying it is recommended that you dry the kelp at 200°F for one hour, decrease to 145°F for 1.5 hours, and then to 100°F for 10 hours, or until the blades are crisp and at or below a water activity of 0.85. You should run trial batches through your oven prior to receiving large volumes of seaweed to ensure that you have an adequate recipe that brings the water activity to 0.85 or less. Once fully dried, the kelp can be removed from the oven and placed in a sanitized, well-ventilated dry area and allowed to cool.

If using a dedicated drying room or container such as a conex shipping container, the space should be fixed with externally-draining dehumidifiers, fans and heaters. Walls of the dryer must be smooth, non-absorbent, and easily cleanable, with floors constructed of smooth, durable material such as sealed concrete, ceramic tile, durable grades of linoleum or plastic. Openings to the outside must be tight-fitting and free of breaks, and prevent the entrance of rodents or insects. Doors to the outside should be self-closing. Junctures between walls and floors must be sealed and coved or have concave molding. Lights must be shielded, coated or otherwise shatter-resistant. Adequate illumination should be provided throughout the facility.

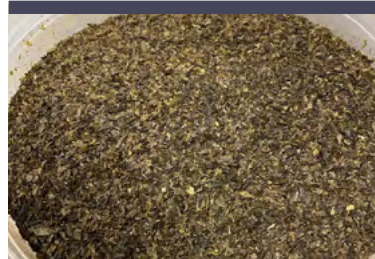
Prepped kelp can be laid out onto multiple drying trays and then placed onto tiered tray racks. Racks can either be stationary in the drying room or wheeled. Racks should be placed with enough space to ensure even and adequate drying. Several thousand pounds can be processed in a day using such methods.

- ▶ After drying and sorting, the recovery rate is between 5–10% of the raw seaweed.



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Kelp positioned on drying racks.



CHRIS SANNITO

- ▶ Dehydrators come in many sizes for different scales of operation, from small countertop dehydrators to large commercial dryers. Small units that start around \$200 can be purchased from most retail and outdoor stores, with large commercial units that can cost up to \$55,000 or more available through companies such as [Commercial Dehydrators](#), [Gryphon Environmental](#) and Amazon.
- ▶ Ovens also range in size and price. At our pilot plant, we have successfully tested an Enviro-Pak Series MP500 commercial smoke oven costing \$24,000. That model and others can be found on the [Enviro-Pak website](#).

## Packaging

Shelf-stable dried products can be packaged into clean, dry containers that seal as tightly as possible without crushing the product. All containers should seal tightly, as dry goods can spoil if moisture is reabsorbed. An array of dry foods packaging options are available, including stand-up pouches, lay-flat pouches, and other sealed plastic, metallized or compostable package options. Package sizes should be customized to meet your market niche. All packages should be properly labeled. For equipment considerations, see the primary processing equipment list above.

## Storage

Fully dried whole-leaf products, with water activity of 0.85 or less, that are packaged properly can be stored without refrigeration for up to two to three years without significant changes in quality. Finely milled or granulated material will have a shorter shelf life due to the increased surface area. Quality packaging material that provides a barrier to the elements is important for maintaining product integrity. Desiccants can be added to the resealable packaging to keep the environment dry. Avoiding direct sunlight during storage will help preserve the taste and nutrients.

## Distribution

Your operational plan needs to include distribution of your packaged products, so that they arrive in top condition to your customers when they want it. You need to understand the reliability and capabilities of shippers in your area, the volume and timing that your wholesale customers want your product, and your needs and capacity for storing product for later demand. Having sufficient environmentally controlled indoor space for storage on the premises is important, or there may be community storage options in your area.



# BUSINESS PLANNING

As you develop your business plan, you will need to consider costs associated with running your business, including upfront costs and annual operational expenses, revenue from sales and services, and cash flow—the amount and timing of the money available as it comes and goes. You should go through a couple of financial analyses before deciding if a seaweed processing plant is right for you.

Another reason to develop a business plan early on is that these are usually required in order to receive a loan or grant.

A relatively simple analysis can help reveal whether you have a reasonable chance at being profitable. The projected costs and income in these analyses can be simple at first, with reasonable estimates of your costs, revenues, and cash flow. You will need to project the startup costs of getting a processing plant operational. You will need to have money to pay farmers for kelp as well as the ongoing costs associated with processing and getting your product to market.

## Income statement

Profit and loss analysis, otherwise known as an income statement, is a financial state report that summarizes the revenues, costs, and expenses incurred during a specific time frame. This statement compares your sales to your expenses and operational costs, with the difference being your gross profit. Income statements are usually generated monthly, quarterly or yearly, though this can vary depending on your business plan. If you are only processing seaweed during one very short window, you may want to break this down weekly or lump it for the entire season.

## Balance sheet

You will want to have a balance sheet. This is a financial statement for the company that includes assets, liabilities, equity capital, and total debt. Assets include the resources that help generate revenue, as well as receivables. Liabilities represent unpaid bills or borrowing, and include long-term commitments such as loans, and short-term commitments such as amounts owed to suppliers. This is a snapshot of your company's financial position and is usually conducted on a similar timeline as your income statement.

## Cash flow statement

Cash flow is important in a processing business—you will need to spend money on raw ingredients before recouping it from sales—and complements the income statement and balance sheet as part of financial reporting. Cash flow statements report on where your business gets money and where it spends it, including cash from operating activities, investing and financing.

There are income statements, balance sheet, and cash flow statement templates available through Microsoft Office programs among others, that can provide a basic template. There are also accounting programs designed for use by small- and medium-size businesses without specialized training, including Quicken, QuickBooks, and Peachtree.

# APPENDICES

[Seaweed processing technology supply list spreadsheet](#)

[HACCP Plan, sugar kelp example](#)

[Hazard analysis worksheet, sugar kelp example](#)

[Sanitation Standard Operating Procedures Example](#)

[Product Label Example](#)

|                             |   |               |
|-----------------------------|---|---------------|
| <b>Product Name</b>         |   |               |
| <b>Product Description</b>  | <b>Species (if not include in product name)</b> |               |
| <b>Lot Code</b>             | <b>Use by Date</b>                              | <b>Weight</b> |
| <b>Allergen information</b> |   |               |



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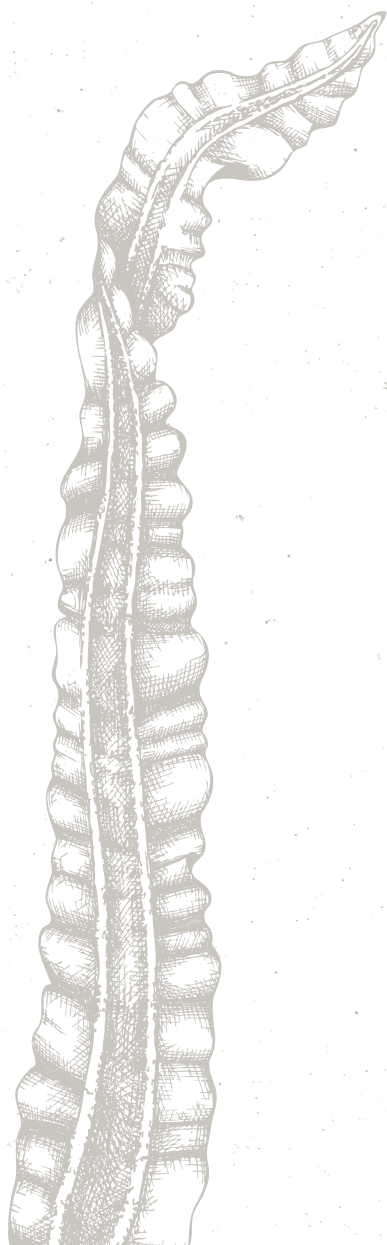
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# AGENCY CONTACTS

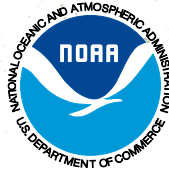
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