An Economic Assessment of Harvesting, Processing, And Primary Stabilization Methods For Commercially Grown Kelp

Chugach Regional Resources Commission

Harvesting Kelp in Latouche Passage

Executive Summary

The Chugach Regional Resources Commission received funding for a kelp processing feasibility study from the Alaska Mariculture Cluster for a project titled "*An Economic Assessment of Harvesting, Processing, and Primary Stabilization Methods for Commercially Grown Kelp*." The goal

of the project is to develop powdered kelp from the Prince William Sound and determine its value for potential end users.

The project was initiated in May of 2024 with the harvest of test sites funded by Exxon Valdez Oil Spill Kelp mariculture Project. CRRC has been evaluating sites throughout the Prince William Sound for potential locations for kelp farms. These sites are seeded with lines of bull, sugar and ribbon kelp produced at the Alutiiq Pride Marine Institute which cannot be used for commercial purposes but are well suited for harvest feasibility and product development purposes.
Harvesting kelp, especially at remote sites, can be expensive and time consuming. This study evaluated the possibility of holding kelp in refrigerated seawater system and sought to determine the time frame required to get kelp to port before quality was affected. A commercial fishing vessel and large salmon tender were used for these purposes. While the logistics of holding kelp "on deck" in totes or in brailer bags in fish holds were different, they yielded similar results. Circulating sea water through the kelp was helpful in limiting deterioration based on bacterial counts and sucrose degradations but quality of kelp post-harvest was still limited to 2-3 days.
The ultimate disposition of kelp grown in Alaska is the largest issue facing the industry's development. One of the possibilities is developing a powdered product that can be used in a variety of industries such as food additives, textiles, pharmaceuticals, nutraceuticals, cosmetics, or bioplastics. At issue is the cost of producing this product in state with capital costs, energy, and a skilled workforce to utilize specialized equipment versus the high cost of shipping a product with over 90% water weight to be processed out of state. Ultimately the comparison can be held when the value of the product is determined.

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Summary: Costs, freight, product, reception pricing.

Tender Delivery
The Chugach Regional Resources Commission chartered the F/V Rough Rider, a 42-foot commercial fishing vessel with a holding capacity of 20,000 pounds in fish holds plumbed into a Recirculating Seawater System (RSW), and additional capacity aboveboard on the back deck, to harvest kelp site arrays at three test farm sites at Boulder Bay near Tatitlek, Foxfarm at the southern end of Elrington Island, and Latouche Passage near Chenega. The test sites are funded by the Exxon Valdez Oil Spill Trustee Council (EVOSTC). This project consists of 10 kelp sites scattered throughout Prince William Sound (and recently Lower Cook Inlet) to evaluate site suitability and monitor environmental conditions. A detailed report of this project can be found on the EVOSTC website, located here.
On May 15, 2024, the F/V Rough Rider arrived at Tatitlek and harvested two test sites comprised of ribbon, sugar, and bull kelp. To further test the hypothesis that kelp could be held for up to a week if handled properly, two of the fish holds were flooded and loaded as full as possible with sugar and ribbon kelps. The kelp was placed in brailer bags for ease of handling and removal from the hold. Each bag held approximately 500 pounds. The temperature and salinity were sampled using a Yellow Springs Instrument (YSI) and were recorded every four hours and bacteria agar plates were swabbed to look for vibrio and pseudomonas. Vibrio in high concentrations can be pathogenic but the few colonies grown on the TCBS were yellow in color and nonpathogenic. Pseudomonas is ubiquitous in saltwater environments and is associated with biofouling. The plates had a low count and did not show many colonies until day 4. The bacterial plating showed no significant color or coverage for high bacterial counts.
On May 16th, the Rough Rider went back across the Prince William Sound where it harvested a dropper line at Sawmill Bay and test arrays at Latouche and Foxfarm. Bull kelp from Latouche was placed in brailer bags in two fish holds and sugar kelp from Foxfarm was also placed in brailer bags in fish holds. YSI readings were recorded every six hours.
On May 19th, the Rough Rider was offloaded at the Resurrection Seafoods Dock in Seward. The kelp was examined for biodegrading, smell, and texture, using grading standards derived from USDA

Grades and Standards Inspection Instructions. No noticeable changes in decay or damage caused by dirt, debris, mechanical influences, or foreign matter were observable. Kelp held on board in fish holds was beginning to get slimy and the texture definitely softened.

The harvest crew and RBS had little experience with numeric rating of kelp and relied on consensus from the team evaluating the material.

The crew at Resurrection Bay Seafoods (RBS) is used to handling many types of fish and were extremely efficient in handling the kelp. Each species was loaded into a hopper which was dumped on a sorting table where workers removed any remaining kelp string, holdfasts parts or other debris and fouling organisms. The kelp was rinsed with saltwater and then placed into a chute that directed the kelp to a grinder typically used to grind fish waste and viscera for disposal. The ground kelp was collected and wheeled to the boxing/packaging station where it was weighed, boxed, strapped, and labelled before going into a flash freezer. A total of 3,000 pounds were processed. The processed kelp was tracked for freezing rate which took between 10 and 12 hours to be frozen completely. RBS charged $.40/lb. for its services.
Agar plates of BTBS which selected for vibrio bacteria and Pseudomonas agar plates were held for 4 days. No vibrio was found.

Disposition
The original proposal was to purchase 20,000 pounds of kelp from a commercial farm site in Resurrection Bay operated by Mothers of Millions and take stabilized kelp to markets in Oregon and to a tolling company Advanced Powder Dynamics (APD) in Payson Arizona. Unfortunately, Mothers of Millions farm site could not withstand the winter storms and did not produce any kelp. In addition, the bull kelp market in Oregon they had secured fell through eliminating the economics of shipping a container of kelp overland to the “lower 48”.
Samples of the kelp were sent to two companies interested in working with APMI. Samples were sent to APD in Payson Arizona and to Valentine Chemical in Louisiana. Both companies tested the kelp in their systems and sent dried samples back to APMI, with cost estimates and shipping and handling instructions.
With limited kelp on hand, it was decided to work exclusively with APD to produce the powdered kelp. Samples of shredded kelp processed at RBS were sent to the production plant and it was determined that the kelp needed additional processing to be able to easily flow through their high-pressure nozzles. APD did a Liquid Specification and Dry-Ability Evaluation (LSDE) Test on the kelp to see what agents they would need to add to the kelp to make it go through their machinery. The LSDE report has been attached to this report and indicated that some kind of additive (gum acacia, tapioca malto, nu-flow rice, and pea protein were all tested) would be necessary to maintain the necessary texture and viscosity for the material to pass through APD’s commercial drying system. The kelp needed to be 3000 centipoise, or able to go through a 10-mesh screen (2000-micron screens.)
APMI looked extensively for food service equipment capable of making a slurry suitable for APD including Boston Shearing and ADMix.
Processing
The Food Technology Center located at the Kodiak Seafood and Marine Science Center (KSMSC) in Kodiak has an Urschel 40 that is used to grind the pulp into the slurry of the pulp.
On August 7th 40 boxes of kelp were sent to Kodiak on the FV Kruzof and received by Chris Sannito and placed in freezers at the center.

On October 29, 2024, staff from APMI loaded a truck full of buckets and took the state ferry from Homer to Kodiak. When staff arrived, they discovered the kelp had been transferred to a refrigeration unit from a freezer and wasn't completely thawed. The staff quickly opened as many boxes as they could and spread the kelp around the processing plant to facilitate thawing. Due to time restrictions of the ferry schedule, not all of the kelp sent over to Kodiak had thawed to the point where it could run throughout the machine and therefore not all of the product was processed through the Urschel machine.

The Urschel machine Control Process Model 2100 FF 425 was outfitted with .08 blades that easily reduced the kelp to a slurry. Kelp, which was still partially frozen and contained some portions of ice crystals, wasn't as easy to process as other portions that were completely thawed, and didn't pass through the machine as easily or quickly. The kelp gelled in the delivery chute and would not easily come out of the bottom. The machine needed to be stopped often and the kelp had to be physically extricated from the chute pushed into the buckets.

The machine could process the kelp as fast as you could load it into the hopper, but a larger hopper and taller stand would improve the efficiency of the processing operation and the ergonomics of getting the kelp from the machine to the final packaging, easing labor costs in the future. Without a larger hopper the shredded kelp splattered when it hit the blades and had to be shielded.

A total of 40 5-gallon buckets were filled. APMI staff weren't sure that the slurry would meet APD requirements, so some of the buckets were run through the processing machine twice, though APD staff ultimately confirmed that one pass through the machine was more than adequate to reduce kelp to the required liquified state.

The buckets of kelp were brought back to Seward, sampled, and then refrozen. The kelp needed to be below 3000 microns to be able to pass through the high-pressure nozzles. One, five-gallon bucket of each species (ribbon kelp, sugar kelp, bull kelp, and three-ribbed kelp) was shipped through UPS to APD, which did the preliminary trials.

APD used the P-5 machine to run their preliminary trials.

APMI staff have been reaching out to companies who had expressed interest during the initial phase of the project, including the Crop Project, Keel Labs, and Daybreak Seaweed to receive feedback from organizations using kelp for both food and materials purposes. APMI will be sending samples to these customers with the nutrient panel to assess the final value of the product and gain an understanding of how the powdered kelp can fit into existing supply chains.

P-5 trial reports for bull kelp, sugar kelp, ribbon kelp, and three-ribbed kelp have been attached to this report for reference; APMI staff met over Zoom with APD staff to analyze data provided by the P-5 trials for each species. Reports provided by APD have also been useful for APMI staff to share with end-users.

Ultimately, reports indicated that kelp powder is much denser with the addition of gum acacia, which is a water-soluble additive that is odorless and tasteless, serving as an effective tool for thickening and improving texture, without affecting the smell or taste of the product. Without the gum acacia additive, there was higher moisture content and less conveyance in all kelp species.

The P-5 trial revealed at 86% recovery of bull kelp, and only a 50-60% recovery with sugar kelp, with one five-gallon bucket of bull kelp slurry yielding 0.91 pounds of powdered, dried kelp and one five-gallon bucket of sugar kelp slurry yielding 0.645 pounds of powdered, dried kelp. The recovery of three-ribbed and ribbon kelp were almost identical, with one five-gallon bucket of slurry yielding 0.94 and 0.93 pounds of powdered, dried kelp, respectively.

For processing purposes, the most important information end users were interested in obtaining about the dried kelp concerned moisture content and specific gravity, which is important when kelp is considered for more industrial uses, such as in biomaterials applications.

Moisture content was determined using an Ohaus MB27 Moisture Analyzer. An Ohaus moisture balance, also called a moisture analyzer, works by using a heating element (like a halogen lamp) to dry a sample, while simultaneously measuring the weight loss of the sample on a precision balance, thus determining the moisture content based on the principle of thermogravimetric analysis; essentially, the more weight lost during heating, the higher the moisture content in the original sample was.
The machine assumes the powder is 0.0% moisture then performs this test generating a percentage relevant to the remaining moisture in the powder sample. The moisture content varied slightly between the samples analyzed even within the same species; however, the moisture content mostly stayed within the same small range, hovering between 3-5%, except when looking at bull kelp samples, which saw drastic variation between samples analyzed, from 2-15%.

Specific gravity throughout all samples among all different species did not vary greatly.
Following the P-5 trial, APMI sent five additional 5-gallon buckets of sugar kelp to undergo the next trial, a "P-50" which is more targeted at drying on a commercial scale. The report for the P-50 trial has been attached.

Advance Powder Dynamics initiated the P-50 scale drying trial by first inspecting the containers of kelp samples provided by APMI. Two of the containers contained relatively dense kelp material, while the remaining two exhibited high moisture content with a more aqueous consistency. All material was combined and subjected to high-shear mixing in a processing tank.

Gum acacia was incrementally introduced, one scoop at a time, into the mixing vessel. The mixture was allowed to homogenize for approximately 45 minutes before a liquid sample was extracted for laboratory analysis.

During the drying phase, the material exhibited immediate accumulation within the spray dryer, with multiple spray pattern configurations trialed but demonstrating negligible improvement. In response, high airflow settings were employed in an effort to enhance material conveyance through the drying chamber, but this approach was also ineffective.

Cyclone recovery during the run was limited, necessitating continuous manual blowdowns using compressed air while the dryer remained in operation. This process yielded an 11.9% recovery via cyclone and an additional 63.3% through blowdown—a method used to extract residual material that would not otherwise convey through the system. Baghouse recovery accounted for 1.6% of the total, consisting primarily of gum acacia, which was subsequently discarded. The combined material recovery for the trial totaled 76.8%.

Based on these outcomes, additional formulation development was recommended to the team at APMI. The challenges encountered primarily stem from the solubility and physical structure of the kelp, which consists of small, leaf-like components. The team suggests further investigation into alternative feed mechanisms, including the potential use of screw feeding for dry ingredient incorporation, to improve process efficiency in future trials.

To date APMI has identified three possible customers who are interested in the product and want samples and panel results. Feedback from end users regarding the utility of powdered kelp and their ability to integrate powdered kelp into existing supply chains can be communicated as needed

to APD to further refine the drying process and yield of powdered kelp. Additional slurry material has been retained by APMI in the event that further drying trials are needed to provide additional powdered kelp samples to end users.

Over the course of this project, APMI has observed significant volatility in the markets for commercially cultivated kelp in Alaska. Since the initial planning stages, several prospective buyers and end users who had previously expressed strong interest in kelp-based inputs have exited the market or significantly reduced their engagement. This instability reflects broader uncertainties in the early-stage U.S. kelp industry, including inconsistent supply volumes, lack of standardized processing infrastructure, and unclear regulatory or commercial pathways for scale. As a result, many of the original market opportunities identified during project inception are no longer viable, underscoring the need for more resilient, diversified, and regionally anchored supply chains to stabilize demand and build investor and buyer confidence.

Next steps

At the start of this project, there were not any opportunities to mechanically dry kelp in Southcentral Alaska. Recently, a Kenai Peninsula-based operation, Alaska Fish Nutrition, led by Nick Zorich and Tim Dillon, purchased a warehouse with food processing equipment and capabilities located in Kasilof on the western side of the Kenai Peninsula. Alaska Fish Nutrition have improved on an infrared drying prototype and are prepared to dry some of the buckets of kelp slurry we retained, as well as boxes of the kelp pulp. We are cautiously optimistic that the infrared dryer will be an adequate means of stabilizing and removing water weight from harvested kelp to reduce shipping costs and eliminate the need for costly, constant freezer storage. This represents a promising development in reducing the need for long-distance, costly shipments to out-of-state toll processors. Infrared drying offers a rapid, energy-efficient method of moisture removal that may allow for in-state stabilization of harvested kelp, significantly reducing both freight costs and the need for freezer storage. APMI hopes to work with Alaska Fish Nutrition to test retained slurry and pulp material to evaluate cost-effectiveness, drying quality, and compatibility with market specifications. If successful, this partnership could represent a scalable, Alaska-based model for value-added kelp processing.

The operators have quoted a price of $6.00 per pound (wet weight) to dry kelp delivered to their facility, which can be compared against drying costs from APD with freight costs factored in. The APD quote is forthcoming and can be integrated to this report at the project's termination.

Summary of findings to date:

Ultimately, based on poor growth and lack of available commercial kelp from the Mothers of Millions commercial kelp site as originally proposed in the submitted proposal, final reports, and assessments of the economics of processing, stabilizing, and marketing dried, powdered kelp are still in the process of being developed. APMI staff are in the process of sharing powdered kelp samples with interested end-users who will be able to provide reports on the potential, and the price point, for dried kelp to be integrated into their supply chains. Dried kelp samples from four different commercial species have been obtained and are available for limited product testing; staff have prioritized spreading dried kelp samples among food-grade and industrial users to get a sense of varying price points and criteria throughout different industries.

Samples produced from the P-50 drying trials at APD will be shared with end-users who received samples from the P-5 trial. APD will provide a final product analysis and development recommendation and will be able to provide APMI with consultation regarding the necessary drying equipment to continue drying and powdering kelp.

Kelp dried using the infrared dryer on the Kenai Peninsula will also be shared with end-users for comparative analysis as to how dried kelp samples fit into existing supply chains. A full cost-analysis of converting wet, harvested kelp, to stabilized powder, including shipping and freight costs, will be conducted for kelp sent to APD, Valentine Chemical in Louisiana, and at infrared dryer in Kasilof.

Marketing

Dried kelp samples have been distributed to potential buyers, including Daybreak Seaweed and the Crop Project, with the goal of assessing product-market fit and gathering feedback on product performance and integration potential. However, despite these outreach efforts, APMI has received limited response from recipients. This lack of engagement is symptomatic of the broader volatility currently facing the commercial kelp sector in Alaska. Other markets that APMI has identified, including Keel Labs, who originally provided a Letter of Support for this project, have been so constrained by the economies of scale of processing kelp, that they are unwilling to receive samples without farmers providing a clear commitment to supply a large volume of kelp.
Since the start of this project, several companies and buyers who once showed strong interest have left the industry or paused their involvement. This trend has made it difficult to secure consistent feedback, let alone commercial commitments. These changes reflect the uncertainty that still surrounds the young U.S. kelp sector—issues like inconsistent harvest volumes, limited processing options, and unclear business models are still being worked out. Because of this, many of the early opportunities APMI planned to pursue are no longer active. It's become clear that in order to move forward, the industry needs more stable, local systems for processing and distributing kelp—ones that can help build trust and long-term interest from both growers and buyers.

These shifts reflect deeper instability within the nascent U.S. kelp industry—characterized by fluctuating supply chains, and lack of standardized processing capacity. As a result, many of the original go-to-market pathways identified at the project's outset have proven nonviable. This underscores the urgent need for resilient, regionally grounded processing and supply networks that can anchor demand and build long-term confidence among both producers and buyers.

While initial trials with APD provided valuable insight into the technical requirements of drying and powdering kelp, toll processing with APD does not appear to be a viable long-term option for Alaska's seaweed producers. The P-50 trial demonstrated that even under ideal conditions, APD's equipment struggled to efficiently powder dry sugar kelp, and freight logistics—from Alaska to Arizona—were costly, complicated, and unsustainable at scale. These challenges limit the practicality of relying on an out-of-state tolling partner for either small- or large-scale kelp stabilization. As a result, APMI is now actively exploring other options, including testing with a second company that may be able to provide better drying performance and cost estimates. We are also prioritizing the identification of a reliable, Alaska-based drying partner—such as Alaska Fish Nutrition—to reduce transportation burdens and make kelp processing more feasible and cost-effective for local farmers.

Freight Considerations

A major component of the original proposal was the plan to truck up to 35,000 pounds frozen kelp to Oregon and Arizona. When the kelp wasn't available, alternative methods of shipping had to be

explored. For the samples that were sent to APD for the P5 and P50 trials, UPS was used. Frozen kelp stored at APMI stayed solid for up to 5 days.

Advances in stabilizing kelp through the addition of reagent may remove the need to ship frozen kelp. Kelp that has been stabilized can be kept refrigerated far less expensive and risky than keeping a product frozen. It is very clear that expedited freight such as UPS and Fed Ex are cost prohibitive. Likewise, using Alaskan Airlines or other air freight causes logistical problems with refrigerated storage and expediting services.

Kelp Harvest 2024

Deck on the Rough Rider, kelp in fish hold

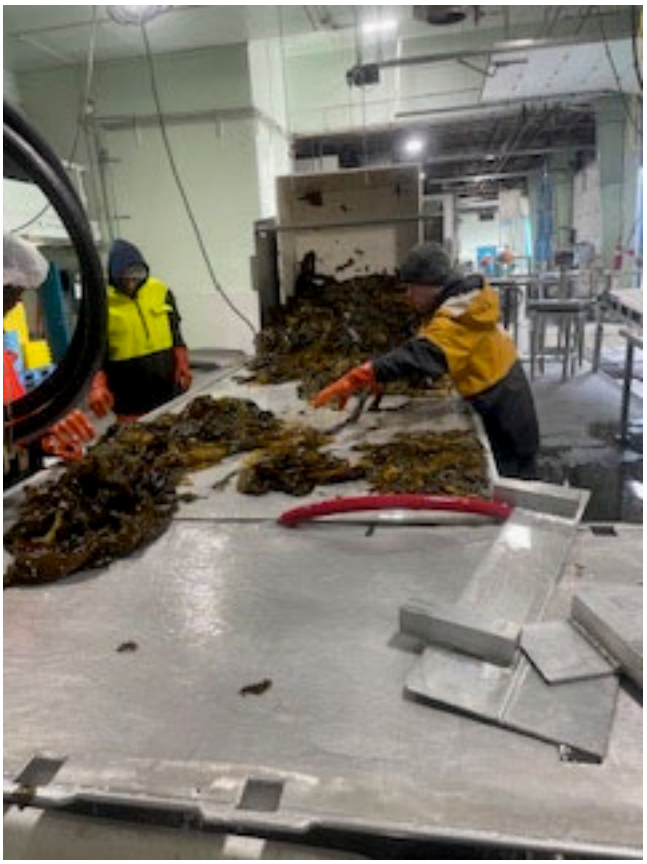
Rough Rider Deck

Kelp Unloading and Processing in Seward

Pacific Seafoods Dock Space

Trial of bringing kelp lines in whole

Feed to process line



Debris, hold fast, string removal.

Feed from sorting table

Grinder

Carted to boxing.

Boxed for freezer.

Freezer Unit

Truck getting loaded with buckets of slurry.

Prepping the kelp for processing through the Urschel 40 at KSMSC

APMI staff and Chris Sannito going over specifications of processing equipment.

1800-micron screen holding the slurry that passed through the 2400 screen

2400-screen holding some of the slurry flakes that did not impact nozzles