FINAL REPORT TEMPLATE
2024/2025 Joint Innovation Project

Novel Compound Discovery in Newly Domesticated Alaskan Kelp

Lead Entity: Marine Biologics
Project Location: Kodiak, San Francisco, Roscoff (France), Vancouver (Canada)
Project Start Date: August, 2024
Project End Date: April, 2026
Award Amount: $99,875

Project Team & Partners:

Project Lead: Marine Biologics

Project Support: Alaska Ocean Farms (AOF), Alaska Sea Greens (ASG), Spruce Island Farms (SIF), Kodiak Seafood and Marine Science Center (KSMSC)

PROJECT OVERVIEW

a. Problem Statement

Novel kelp species are being explored for cultivation across Alaska – Dragon (*Eualaria fistulosa*), Split (*Hedophyllum nigripes*), and Bull (Nereocystis luetkeana) – but little is known about their chemical components and potential markets. More information is required, such as seasonal availability and chemistry, to better identify specific uses that maximize (or differentiate) this biomass on the global stage.

b. Background/Context

Macroalgae cultivation at sea holds immense potential for alleviating pressure on terrestrial biomass systems by providing a sustainable alternative devoid of reliance on agrochemical inputs. However, the market development for macroalgal products in the US is still in its early stages, requiring a broader range of applications and enhanced processing capacity to become economically feasible. Additionally, the absence of markets near farm operations creates challenges for farmers in bringing their products to market efficiently. In this project, Marine Biologics collaborated with AOF, SIF, ASG, and KSMSC to collect and dry seaweed samples. The MB research team performed detailed chemical analysis of the seaweed samples. This work is in support of MB's new clean label stabilizer product (SeaTex).

c. Proposed Solution

Sample Collection - Method Development - Analysis - Data Interpretation - Reporting

Over this project, MB was provided with samples of multiple kelp species for sequential extraction and chemical characterization. MB developed new methods for sample stabilization and chemical analysis. The KSMSC was piloted for use to prepare samples for shipping to laboratories for extraction/analysis. External and internal lab data is interpreted to identify any major differences between the kelp species that may be used to support food ingredient development. All information is compiled in a finished report.

d. *Project Objectives, Tasks and Measures of Success*

1. *Sample Collection and Preparation*
    a. Design sample collection methodology (document)
    b. Design sample generation methodology (document)
    c. Perform sample collection/preparation (KPI: # of samples generated)
2. *Laboratory Setup and Initial Analysis*
    a. Laboratory design (KSMSC)
    b. Analysis methodology
    c. Perform initial analysis (KPI: # of results generated)
3. *Compound Extraction/Quantification*
    a. Laboratory design (Roscoff)
    b. Analysis methodology
    c. Perform analysis (KPI: # of results generated))
4. *Data Interpretation*
    a. Data analysis (all laboratory data consolidated)
5. *Documentation and Reporting*
    a. Finished Report (KPI: completed report)

e. *Project Outcomes*

Sample Collection and Preparation: Over the course of the project activity a sample collection and sample generation methodology was developed to standardize the process from on-farm collection to stabilized sample. Seaweed intended for samples was immediately frozen at harvest and transferred cold to KSMSC. There, a standardized defrosting and drying protocol was used to create all project samples. Samples were collected/frozen by farmers/harvesters across Alaska April-June (Figure 1) and processed at KSMSC over June. The project was initially complicated when all planted seaweed was unviable leading to complete crop loss. Fortunately, MB was able to coordinate with the AFDF 2025 Seaweed Tissue Analysis Project (STAP) and secure representative biomass of Split and Bull Kelp. Dragon Kelp had to be omitted from the project. Partnership with STAP permitted the MB research team to explore additional kelp species beyond the initial scope.
Total number samples = 65

Laboratory Setup and Initial Analysis: A small research lab was created at KSMSC to support two staff during sample collection, processing, and handling. Simple measurements could be collected to monitor sampling consistency - moisture and water activity (see: KSMSC processing log). This initial analysis revealed that the drying conditions (70 °C, 20 hours) were well suited to generating samples that remain stable under ambient conditions. For example, averages for moisture (1.6%) and water activity (0.32) were well below typical industry standards: 10% and 0.5, respectively. The seaweed undergoes thermal treatment during drying and is expected to have a low microbial load. Total number dried (including process development) = 76. Samples were shipped to multiple labs to support STAP (SGS Laboratories Inc., Creative Proteomics, Foodmetrics, CEVA) and Roscoff.

Compound Extraction/Quantification: Alginic acid was identified as a desirable bioactive target as it allowed the development of custom extraction and analysis methodologies: gravimetric analysis, viscosity, size-exclusion chromatography (SEC).

Gravimetric Analysis. MB developed a gravimetric analysis protocol that converts alginic acid into sodium alginate, a common food ingredient and more soluble chemical, followed by isolation and weighing. Sodium alginate yield was collected for all samples (Figure 2). The average extraction yield was 18.7 ± 4.3 %, with no significant difference based on species or harvest months.

Viscosity. Sodium alginate isolated during gravimetric analysis were dispersed in water and the resulting viscosity measured using a viscometer equipped with a MS-ULV spindle. Three groups of samples were identified and are significantly different (below). In total, 1 sample showed low viscosity, 10 samples had medium viscosity, and 47 samples had high viscosity (Figure 3).

Low viscosity ➜ < 200 mPas
Medium viscosity ➜ 200-1200 mPas
High viscosity ➜ > 1200mPas

Fucus vesiculosus (~50 mPas) and Alaria marginata (500 mPas) showed the lowest viscosities and Hedophyllum nigripes exhibited the highest viscosity (9000 mPas). F. vesiculosus is not expected to contain alginate at the same level as kelps and the low viscosity of the extract is not surprising. Some species were shown to exhibit seasonal variations: viscosity values for gravimetric extracts of Nereocystis luetkeana appear to decrease from April to June (Figure 4) but the limited sample size for this analysis is noted.[1]

Size-Exclusion Chromatography. SEC analysis revealed a range of values for weight average molecular weights (M_w) of the sodium alginate isolated from the seaweed samples of 2000-8500 kDa. These values did appear to correlate with the observed viscosity (Figure 5) but followed a logarithmic trend. A linear correlation is observed when the viscosity was plotted against the natural logarithm of molecular weight [i.e., $\ln(M_w)$] (Figure 6). Polydispersity index, PDI, was not significantly different between species, with an average PDI of 6.14 for the extracts. Commercial alginates have been reported with lower PDI (1.5 - 3.5) and M_w (100-1,000 kDa) (Milkova, 2023; Turquois et al., 2000). This may indicate that polymers from this rapid gravimetric extraction are more dispersed than commercial samples, resulting in a large mass distribution. However, commercial samples we analyzed with the same SEC method and exhibited PDI from 5.22 to 8.38.

A common formula for relating viscosity to molecular weight is the Mark-Houwink formula (below). Using this equation, the viscosity of a polymer can be determined from M_w (or vice versa). This requires knowledge of the Mark-Houwink constant (K) and scalar quantity (ɑ), which have been reported for sodium alginate in literature (Belalia et al., 2014; Ramsackal et al., 2019). However, the constants K and ɑ may need to be adapted to specific analysis conditions and need to be determined experimentally.

[1] Based on 1 sample available in April and 2 in May

$$[\eta] = KM^a$$	$[\eta]$: Intrinsic viscosity K: Mark-Houwink constant for a given polymer type (chemistry and architecture) at a given solvent and temperature. a: A scalar quantity which relates to the conformation of a polymer.

A test was done using α = 1.67 and K = 0.000169 (Ramsackal et al., 2019). From this, a linear relation was obtained between viscosity and calculated viscosity (Figure 7). This highlights the fact that viscosity could be predicted from Mw, but more data analyses (and lab validation) are required to determine the optimal constants.

In total, 65 samples were analyzed for gravimetric extraction yield, viscosity and molecular weight.

Quantification: All data was collected and compared across species
Documentation and Reporting: This report

f. Successes, Challenges, Lessons learned

There were challenges in securing biomass from Kodiak in 2025. The exact reason is unknown but it is likely related to poor seed quality and not growing conditions - other kelp species were successful for the farm partners and in some cases the target species (split and dragon kelp) were observed on adjacent guidelines. A great success was the support of the farmers from across Alaska and AFDF/SEC to get seaweed samples to KSMSC to permit this work to be continued. Unfortunately, no dragon kelp could be sourced for this work

The samples provided a large quantity of data regarding sodium alginate, viscosity, and Mw that has not been explored in this detail before. In general, limited variations were highlighted between samples that could be due to (1) limiting number of samples, and/or (2) extraction process that may not be able to differentiate samples (i.e. extraction of polysaccharides, without differentiation in composition and structures of alginate, fucoidan, or laminarins).

Lessons Learned:

- New protocols developed: Farm Sampling Plan, Sample drying (KSMSC), Sodium Alginate Extraction, Viscosity Measurement, Size-Exclusion Chromatography
- Consistent sodium alginate extraction yield: ~20% across all species
- High viscosity (>1200 mPas) for many of the extracts: confirming a composition rich in alginate
- Viscosity variations between species: Split Kelp was shown to have the highest extract viscosity, while Bull Kelp was comparatively lower (Figure 6). Unfortunately, specific trends according to time or location could not be identified, due to the limited number of samples by species.
- A relation between Mw and viscosity: Data collected in this study showed a correlation of viscosity to M_w. Size-exclusion chromatography requires more specialized equipment than viscosity. Based on this, viscosity measurements can be used to verify alginate molecular weight in seaweed.

Changes:

- Seaweed pigments/biorefining was not explored for this project - marine bioactives are not a focus of the current Marine Biologics products, which are clean-label (whole plant) texturizers for food and not individual extracts (fucoidan, laminarin, pigments) targeting human health. This was the focus at the time of the project proposal, but has shifted over last year. Alginate and viscosity differences in seaweed species is more directly related to current Marine Biologics initiatives and were prioritized for this work.
- The seaweed species used in the study were adjusted (no Dragon Kelp, addition of several other Kelps) and samples were collected from outside Kodiak (Homer, Cordova, and Southeast). Initially, only 9-12 samples were expected (3 species, 3 locations). By simplifying the analysis protocol, a larger sample size was able to be explored (65 samples).
- Future planning and collaboration: Direct strategic planning has been delayed while Marine Biologics focuses on the current product launch and identification of key product specifications. Once that work is complete, a more detailed collaboration plan can be developed with Alaskan seaweed farmers.

g. Continuation + Dissemination of Results

Marine Biologics launched the new stabilizer, thickener product SeaTex in March, 2026 (Global Newswire). The methodologies developed and seaweed data collected in this project will contribute to new product lines built off Alaskan seaweed. This work will begin in May, 2026. Results will be disseminated in the AFDF Seaweed Tissue Dashboard over the next 3 months.

DATA & PROJECT OUTCOMES

All methods and raw data can be found in the appendix:
Standard Operating Procedures: Farm Sampling Plan, KSMSC Drying, Sodium Alginate Extraction, Viscosity Measurement, Size-Exclusion Chromatography
Datasets: KSMSC Processing Log, KSMSC Sample Log

Project Outcomes

- New protocols developed for farmers, researchers, and industry to standardize sample collection, sample preparation, data collection, and alginate evaluation.
- Results indicate consistency in total alginate extracted from the kelps of Alaska - suggesting species alone does not play a role in total alginate yield (Figure 2).
- Results indicate key differences in the alginate properties of different seaweed species. Split Kelp extracts are shown to have higher viscosity than other Kelps (Figure 3). Bull Kelp had medium viscosity, Alaria marginata had lowest viscosity of kelps tested. This information may be used to tailor new products and applications to particular functional or chemical requirements.

Figures

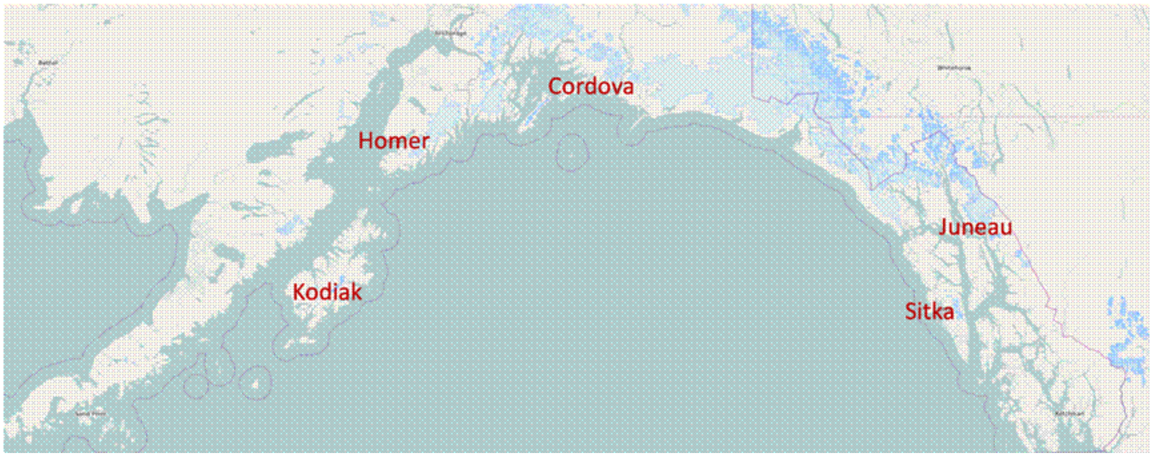


Figure 1. Zones of collections of seaweed samples

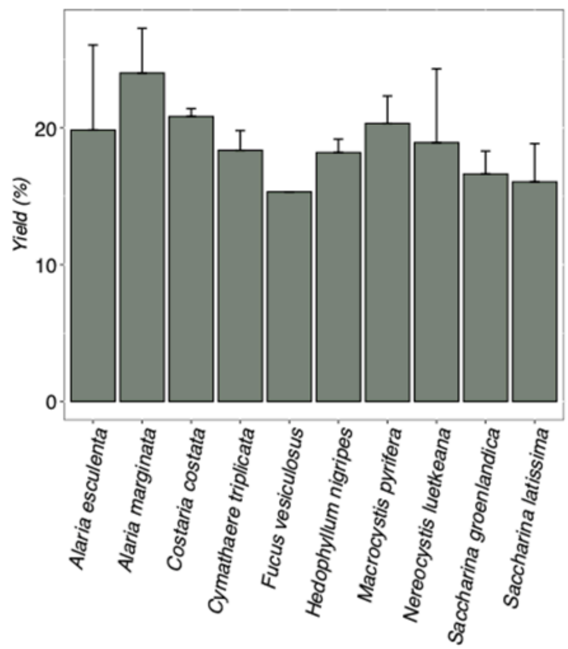


Figure 2. Extraction yield (%) from gravimetric extractions according to different macroalgal species

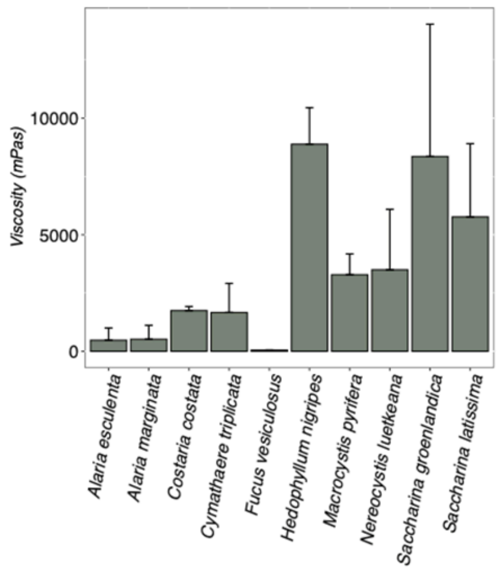


Figure 3. Viscosity (mPas) from gravimetric extracts according to different macroalgal species.

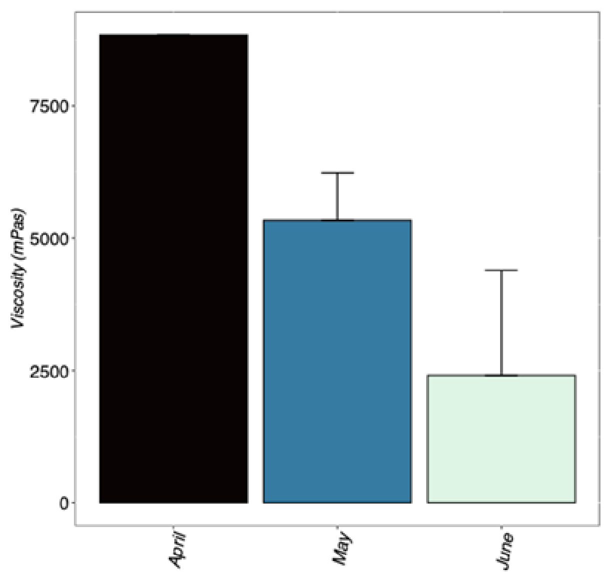


Figure 4. Viscosity (mPas) from gravimetric extracts from *Nereocystis luetkeana* collected April-June.

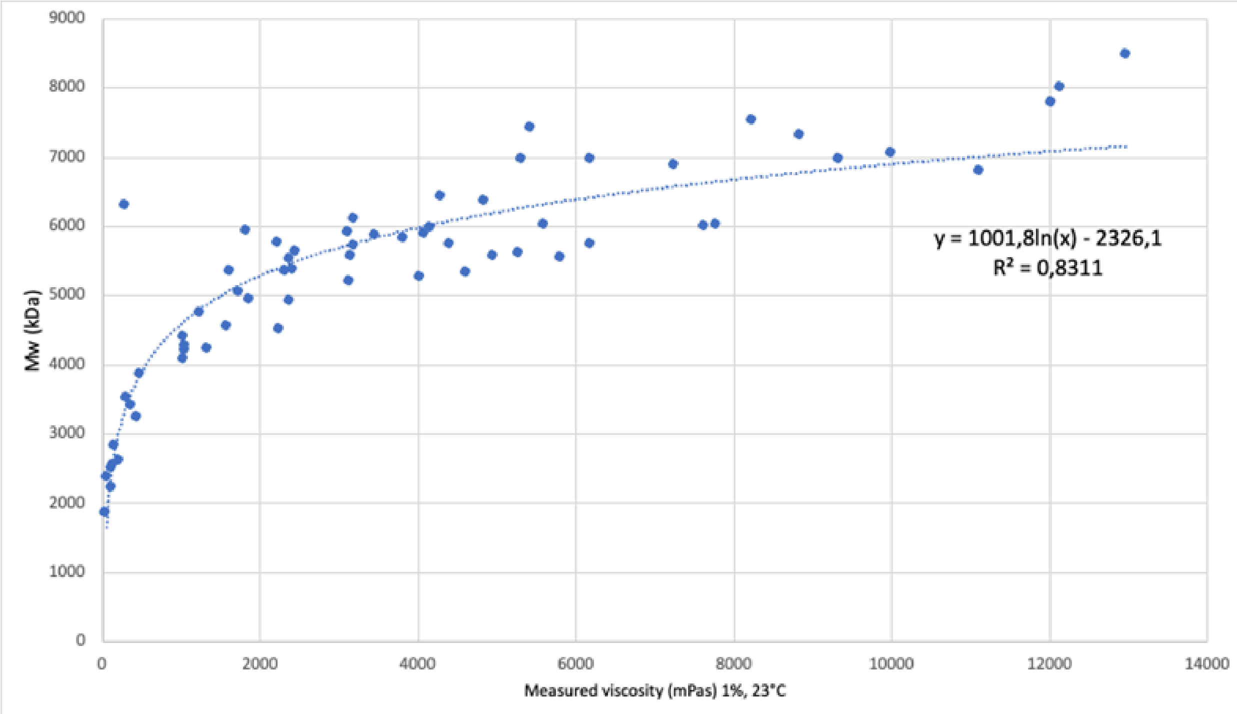


Figure 5. Viscosity (mPas, 1%, 23°C) versus molecular weight (M_w, kDa) for seaweed alginate extracts.

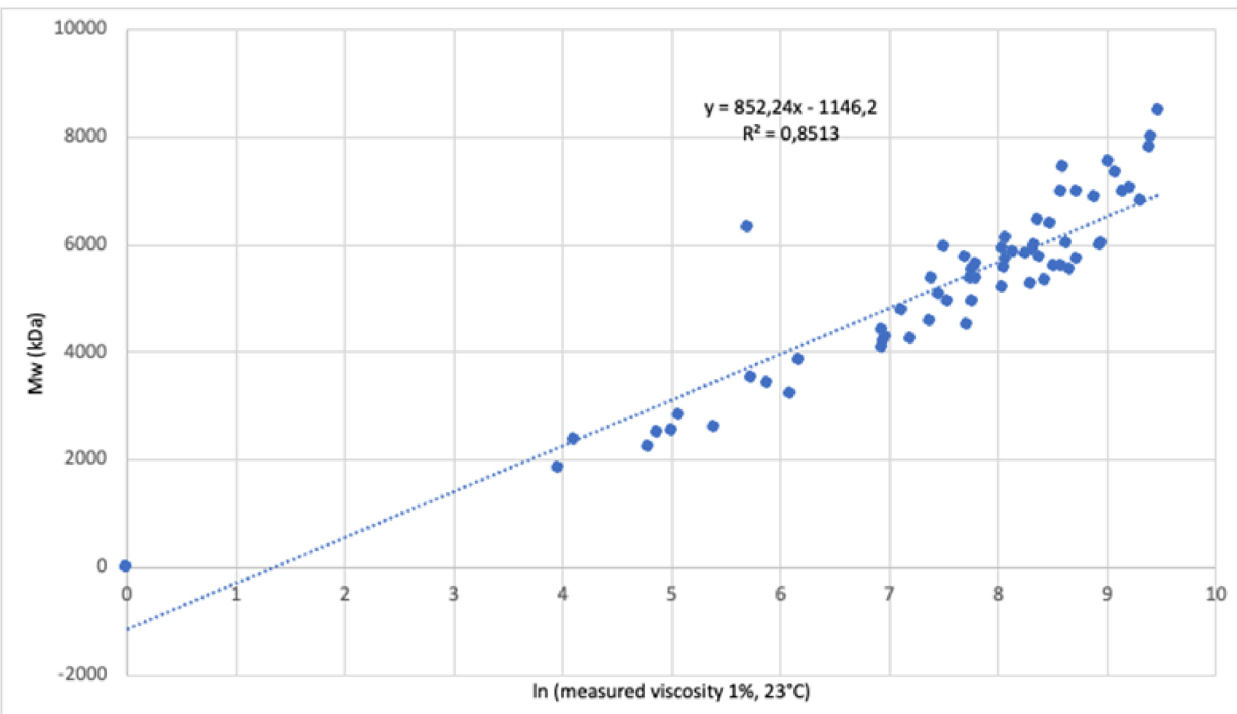


Figure 6. Viscosity (mPas, 1%, 23°C) versus natural log (ln) of molecular weight (M_w, kDa) for seaweed alginate extracts.

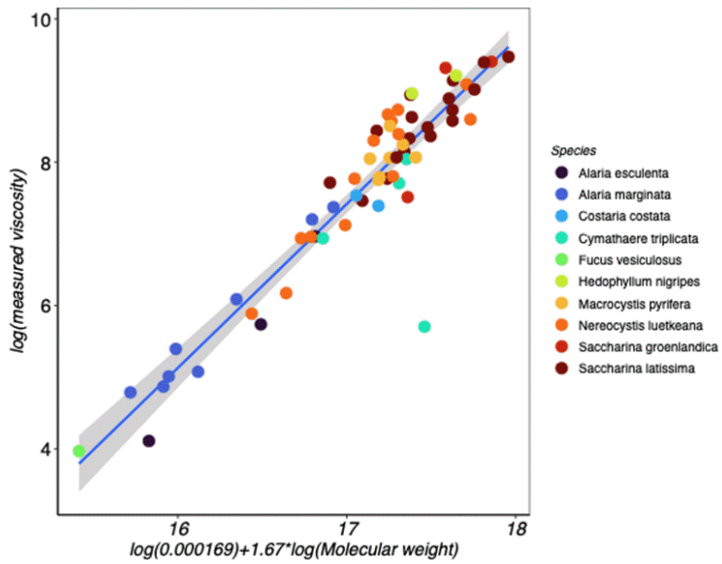


Figure 7. Relation between calculated viscosity from Mark-Houwink formula and measured viscosity.

ADDITIONAL INFORMATION

- **Project Timeline:** Did you complete the proposed scope of work in the intended timeframe? yes

- Do you have anything additional that you would like to share?

Working on this project was a great opportunity for Marine Biologics to de-risk core technology components (sampling and testing methodologies). An added secondary benefit was the chance to collaborate with farmers across Alaska. This has grown the network and created positive relationships that we hope will strengthen the core knowledge of the industry.

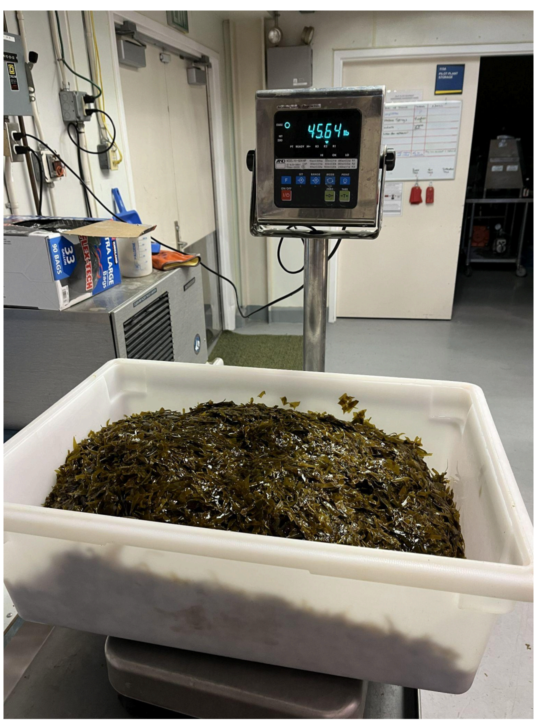
BUDGET

	Project Budget (USD)	Actual Budget (USD)
Labor	55050	54819
Travel	15178	15589
Supplies	29164	28506
Contractual	483	483
Total	**99875**	**99,397**

Budget was within 10% in all categories

PHOTOS

Research lead Emile Dantzer (Marine Biologics) receives a collection of frozen samples shipped via air freight to Kodiak for processing



Weighing seaweed immediately after grinding

Loading dryer with ground seaweed

Seaweed homogenization setup

Preparing seaweed for shipment to partner laboratories

Finished samples (70 total, 4 laboratories) are boxed and ready for shipment