



USDA SRGP FINAL REPORT:

Assessment of regional U.S. consumer attitudes and preferences about domestic farm-raised seaweed

ABSTRACT

This final report was prepared by Maine Aquaculture Innovation Center (MAIC) and supported by the intramural research program of the U.S. Department of Agriculture, National Institute of Food and Agriculture, Special Research Grant Program Aquaculture Research (USDA SRGP), award number 2020-70007-32414. The findings and conclusions in this report entitled, “Assessment of regional U.S. consumer attitudes and preferences about domestic farm-raised seafood” have not been formally disseminated by the U.S. Department of Agriculture and should not be construed to represent any agency determination or policy.

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ABOUT MAIC

The Maine Aquaculture Innovation Center (MAIC), located in Walpole, Maine, was established in 1988 by the Maine Legislature with a mission to assist in developing economically and environmentally sustainable aquaculture opportunities in Maine. MAIC sponsors and facilitates innovative research and development projects involving food, pharmaceuticals, and other products from sustainable aquatic systems; invests in the enhancement of aquaculture capacity in Maine; serves as a source of educational information to enhance public visibility and acceptance of aquaculture; and encourages strategic alliances tasked with promoting research, technology transfer, and the commercialization of aquaculture research.

An underwater photograph showing sunlight filtering through a dense forest of seaweed. The light creates a bright, hazy atmosphere with rays of light and a color palette of blues, greens, and yellows. The seaweed appears as dark, branching structures against the lighter background.

Table of Contents

Introduction	4
Task 1. Survey Design and Vetting	5
Task 2. Survey Programming and Implementation	5
Task 3. Data Analysis and Descriptive Statistics	6
Task 4. Economic Modeling and Inferential Statistics	6
Task 5. Findings Report	7
Task 6. Interactive Data Dashboard Development	7
Task 7. Launch, Outreach, and Extension	8
Task 8. Outreach and Extension Impact Assessment	9
Conclusion	10
Appendix A. Survey	12
Appendix B. Findings Report	20

Introduction



Producing seaweed is a viable and sustainable source of income for new and established aquaculture operators and as an off-season occupation for fishermen currently struggling in the declining wild-catch industry. However, little consumer research has been done on the product, leaving stakeholders in need of consumer preference data on which to base market-driven decisions to increase revenues and profitability for everyone along the seaweed supply chain, from aquaculture operators to value-added producers.

The Maine Aquaculture Innovation Center (MAIC) conducted a comprehensive nationwide consumer insights survey on fresh and value-added seaweed products to develop an easy-to-use market assessment and business planning data dashboard for seaweed farmers, processors, distributors, researchers, and Extension professionals. The primary objective of this project, funded by the United States Department of Agriculture Special Research Grants Program Aquaculture Research (USDA SRGP), was to measure U.S. regional consumer attitudes and preferences for farmed seaweed and value-added products to identify and estimate the size of seaweed market opportunities for new and established aquaculture operators. Specific objectives included:

- 1** *Develop and implement a robust, consumer preference survey on domestic farmed seaweed and value-added products across a nationally representative sample from the nine U.S. census regions, further balanced by age and gender.*
- 2** *Analyze the results to determine consumption habits, awareness of edible seaweed and its various species, purchasing behavior, preferences, perceived benefits, perceived quality, and willingness to pay for seaweed stratified by region and by product.*
- 3** *Complete a findings report detailing all methodologies and findings of the study.*
- 4** *Create an interactive data dashboard displaying findings by product and by region that can be filtered by key demographic characteristics such as age, gender, income level, education status, and household size.*
- 5** *Engage in outreach efforts to disseminate study results and tools to seaweed farmers and other aquaculture operators, seaweed and aquaculture associations and organizations, local food organizations, extension offices, and other key stakeholders.*

To accomplish these objectives, MAIC completed the activities listed below between September 2020 and May 2023. These tasks are described in greater detail in the following sections of this report.

- ✓ *Survey design and vetting.*
- ✓ *Survey programming and implementation.*
- ✓ *Data analysis and descriptive statistics.*
- ✓ *Economic modeling and inferential statistics.*
- ✓ *Findings report preparation.*
- ✓ *Interactive data dashboard development.*
- ✓ *Conduct launch, outreach, and extension activities.*
- ✓ *Outreach and extension impact assessment.*

Task 1. Survey Design and Vetting

MAIC designed an online survey in collaboration with agricultural economist, Dr. Karina Gallardo of Washington State University. The survey assessed the following themes related to preferences for seaweed and value-added products:

- **Consumption habits:** consumer consumption frequency and expenditures on seaweed and value-added products such as seaweed salad, kelp chips/dried seaweed, kelp noodles, etc.
- **Knowledge:** consumer knowledge and awareness of edible seaweed, including knowledge of different farmed species such as the following: skinny kelp, sugar kelp, horsetail kelp, winged kelp, dulse, bull kelp, giant kelp, nori, and sea lettuce.
- **Perceived importance:** consumer perception of importance of the following attributes of seaweed including origin (domestic vs. imported), source (farmed vs. wild), and on local, niche, and value-added products.
- **Perceived accessibility:** consumer perception on their accessibility to seaweed products and willingness to overcome challenges to access.
- **Perceived availability:** consumer perceived availability of seaweed products in terms of seasonality and region.
- **Willingness to pay premiums:** consumer likelihood to pay more for seaweed and value-added products.
- **Social demographics:** consumer social and demographic characteristics including age, marital status, income level, education, race, ethnicity, number of household members, number of children, location type (urban, suburban, rural, coastal), and region and state.

MAIC also engaged Atlantic Corporation (Atlantic) to assess the draft survey and made recommended modifications to assure the greatest value. Dynata conducted a final pre-survey programming review with Dr. Gallardo, including questions and sampling methodology. We then engaged Solutions IRB, LLC, a fully accredited Institutional Review Board, to review the survey and study protocol. The final survey language can be found in **Appendix A**.

Task 2. Survey Programming and Implementation

MAIC engaged Dynata to program, host, execute, and provide data tabulation and utilized Dynata’s nationally representative survey panels for implementation. We targeted 600 respondents from each of the nine U.S. census regions (**Table 1**) for a total sample size of 5,400 and balanced the sample for age group and gender. This sample size is sufficient to generate point estimates and associated confidence intervals that are significant at the 95% level. Survey implementation followed a pre-designed and proven project lifecycle that included soft launch, full launch, monitoring and quota management, and data cleansing. Dynata used a multi-sourcing panel recruitment model, which maximized reach and capacity, improved consistency, and minimized bias. Dynata’s online sample is made up of a number of different brands across the globe and almost all participants are re-contactable. All Dynata survey participants go through rigorous quality controls prior to inclusion. The survey was fielded by Dynata through their online U.S. consumer panel between December 15 and December 28, 2020.

Table 1. U.S. Census Regions

Region	States
New England	CT; MA; ME; NH; RI; VT
Mid-Atlantic	DC; DE; MD; NJ; NY; PA; VA; WV
South Atlantic	FL; GA; NC; SC
East North Central	IL; IN; MI; OH; WI
East South Central	AL; KY; MS; TN;
West North Central	IA; KS; MN; MO; ND; NE; SD
West South Central	AR; LA; OK; TX
Mountain	AZ; CO; ID; MT; NM; NV; UT; WY
Pacific	AK; CA; HI; OR; WA

Specific to themes on willingness to pay a premium, MAIC used contingent valuation method to design double-bounded dichotomous choice questions to elicit consumer willingness to pay for seaweed and certain value-added products (seaweed salad, kelp chips/dried seaweed, seaweed seasoning, seaweed pasta/noodles, etc.). We then conducted an in-depth market price investigation and consulted seaweed farmers and suppliers to determine the price variations (in percentage) we were to use in the choice questions.

Task 3. Data Analysis and Descriptive Statistics

After the successful implementation of the survey, the team analyzed the survey data and presented descriptive statistics to summarize consumer perceptions, preferences, purchase intentions for seaweed products, consumers characteristics, and segmentation. The data and resulting descriptive statistics will equip seaweed farmers and producers with potential business strategies for producing and promoting seaweed products to meet U.S. consumer needs. The descriptive statistics included the following categories and subcategories:



Socio-demographic characteristics:

- *Geographic distribution*
- *Age, Gender, Race, and ethnicity*
- *Shopper Status*
- *Education and income*
- *Food Expenditure demographics*
- *Seaweed purchasing frequency*



Key findings:

- *Consumer consumption habits and perceptions of seaweed*
- *Consumer preferences and willingness to pay for various seaweed attributes*
- *Consumer perception and knowledge of aquaculture*
- *Consumer consumption habits, preferences, and attitudes toward value-added seaweed products*

Results of the descriptive statistics were included in a findings report (**Appendix B**). This work was completed between January 2021 and February 2021, but shared with stakeholders between March 2021 to December 2021.

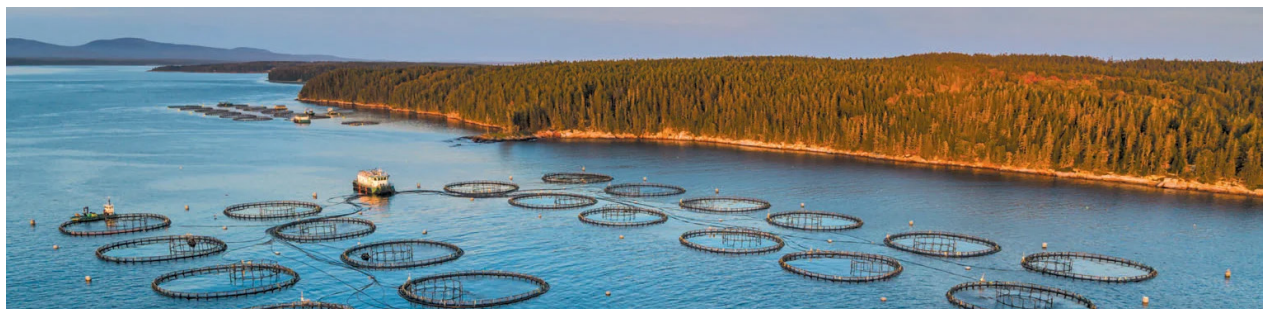
Task 4. Economic Modeling and Inferential Statistics

Dr. Zheng built discrete choice models using statistical software that links the influencing factors to variables on consumer consumption habits, perception, and attitudes toward farm-raised seaweed to understand the effects of consumer characteristics. Logistic regression models were used to analyze the contingent valuation choice questions and estimate consumer willingness to pay premiums for each food category. Given our major objective was to estimate respondent's marginal willingness to pay for the farm-raised and domestic attributes, we designed a choice experiment with three attributes including production method (farm-raised vs. wild-caught), country of origin (domestic vs. imported), and price (the levels will be determined based on observation of market prices). Results were analyzed so they can be presented at aggregate and disaggregate levels by state. Based on the findings, drew implications on marketing strategies that potentially benefit small to mid-size fisheries in terms of entering or expanding business in a specific category to meet consumer needs. This work started on December 15, 2022 and was completed by January 31, 2023.



Task 5. Findings Report

Atlantic prepared a findings report describing the methodology and findings of the descriptive statistics (**Appendix B**). The report, titled “Consumer perceptions, preferences, and attitudes about domestic farm-raised seaweed products,” was circulated to the review committee prior to outreach and extension activities. The report was modified for submissions to *Aquaculture in America* and *Agribusiness* for publication. The report is available online and has been shared with key U.S. aquaculture stakeholders (See Task 7).



Task 6. Interactive Data Dashboard Development

MAIC consulted with Business Intelligence Developer James Lucht and Atlantic to create a series of public, web-based interactive dashboards where users can explore all aspects of project data using the Microsoft Power BI Pro® platform (**Figure 1, Microsoft Power BI Data Dashboard**).



Figure 1. Data dashboard, Average seaweed consumer

This interactive data dashboard displays visualizations by product and by region that can be filtered by key demographic characteristics such as age, gender, income level, education status, and household size (**Figure 2**). The data dashboard was beta tested extensively by the project team prior to launch.

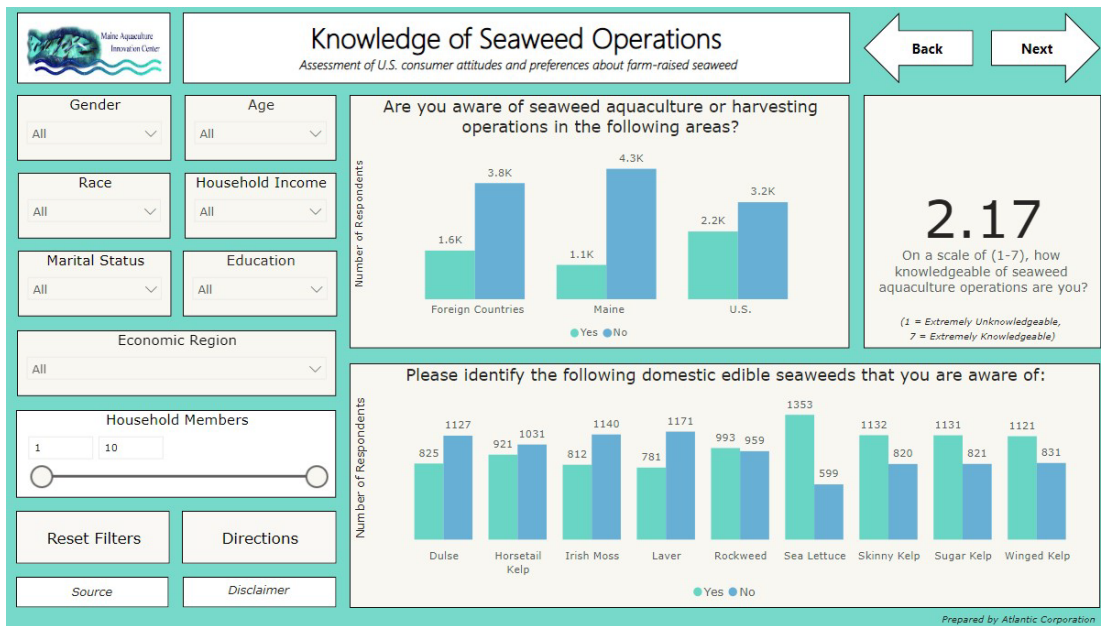


Figure 2. Data dashboard, Knowledge of Seaweed Operations

Task 7. Launch, Outreach, and Extension

MAIC and Atlantic disseminated the findings of the market research survey to a broad audience and raised awareness of the data dashboard as a resource for informing aquaculture business marketing strategies and business plans. The findings have reached over 5,000 people across the key seaweed producing regions of the U.S., including sea vegetable farmers, extension agents, small business development professionals, academics, and aquaculture educators.

Table 1 summarizes the outreach and dissemination activities of the project:

Table 1. Outreach and Dissemination Activities

Delivery Method	Date	Total Audience	Notes
Scientific Paper submission to <i>Agribusiness</i>	August 1 2022; 2nd revision submitted April 1, 2023	Impact Factor = 2.841	In press; North US Consumer Preferences and Attitudes towards seaweed and value added products.
Scientific Paper submission to <i>Aquaculture America</i>	July 31, 2022; 2nd revision submitted September 27, 2022	Impact Factor = 2.841	In press: U.S. consumer preferences and attitudes towards seaweed and value-added products
Poster Presentation	April 2022	550	Northeast Aquaculture Conference & Exposition/ Milford Aquaculture Seminar
Poster Presentation	September 2022	250	Seagriculture USA 2022
Poster Presentation	September 2023	250	Seagriculture USA 2023
Dashboard Demonstration	September 2022	250	Seagriculture USA 2022
Dashboard Demonstration	September 2023	250	Seagriculture USA 2023
Oral Presentation/ Dashboard Demonstration	April 2023	225	National Seaweed Symposium

Delivery Method	Date	Total Audience	Notes
Oral Presentation/ Dashboard Demonstration	January 2023	200	Maine Aquaculture Research, Development, & Education Summit
Oral Presentation	February 2023	50 in session	Aquaculture America
Oral Presentation	April 2023	200	National Seaweed Symposium
Oral Presentation	February 2023	300	Alaska Mariculture Conference
Webinar	February 2023	50	Maine Aquaculture Innovation Center (MAIC) webinar series
Webinar recording	March 2023	100	Holdfast Seaweed Community Web Portal
Webinar recording	June 2023	>100	MAIC YouTube Channel
Webinar recording	May 2023	>100	MAIC Social Media (Facebook/Instagram)
Infographic	May 2023	100	Holdfast Seaweed Community Web Portal
Infographic	May 2023	>100	MAIC Social Media (Facebook/Instagram)
Electronic Dissemination of Report	May 2023	>1500	MAIC email distribution list & website
Training for New Farmers	March 2023	107	Integration into Aquaculture in Shared Waters Program
Data Dashboard Visitors	February 2022 to May 2023	500	The total # of visitors may not be unique visitors.

We expect the findings to reach additional stakeholders once the submissions to Aquaculture in America and Agribusiness are cited and used by researchers to support future studies. The dashboard will also remain open and shared with our findings report informally at each of MAIC’s annual events and conferences. The cumulative forecasted reach of the project is expected to be 7,500 (2024), 9,000 (2025), and 10,000 (2026). These numbers surpass the Outcome 4 goal of 1,000 stakeholders identified in our application.

Task 8. Outreach and Extension Impact Assessment

As outlined in Task 7, the outreach and extension efforts surpassed the project goal of 1,000 stakeholders, reaching over 5,000 people. The total reach tracked is likely to be a duplicative sample, as attendees at various conferences and presentations may have been counted more than once. To account for this in our impact assessment we are assuming a unique stakeholder factor of 0.8—meaning that roughly 4,000 unique stakeholders ($0.8 * 5,000 = 4,000$) were reached during the outreach and extension phase of the project.

Concurrent to this project, MAIC was funded by the Maine Department of Agriculture through an Agricultural Development Grant (#20210818*0389) to create a suite of market research services resulting in a secondary market research report and modules for twelve participating aquaculture businesses. 70% of participants indicated the research they were provided had a value of “high”, while 92% indicated the value was “above average” or “high”. In addition, all of the participants were provided the findings report from this USDA SRGP project and 100% indicated the report would meet or exceed their expectations of in-depth consumer research. When provided the cumulative research, 40% of respondents indicated they would use the research to expand existing market/product, while an additional 40% said they would use it to update business or marketing strategies/plans.

If we extrapolate those data points across the total number of unique stakeholders reached, we discover that roughly 1,600 project beneficiaries will likely use the findings to expand existing markets or products of their own business or for a business they know or are working with. Of the 1,600, we estimate 73% of the benefiting businesses would increase their revenues using our research that supports product and market expansion. This is based on the findings from a publication in **American Aquaculture (2019)**, that indicated 73% of aquaculture businesses report a forecasted increase in sales, with the support of expanded markets and products.

Table 3. Outreach and Extension Impact Assessment

	# of Aquaculture Businesses	Calculation
Total Unique Reach	4,000	$5,000 * 0.8 = 4,000$
Total # of Businesses Likely to Expand Products/Markets	1,600	$4,000 * 40\% = 1,600$
Total # of Businesses Likely to Increase Revenue Using Research that Supports Market and Product Expansion	1,170	$1,600 * 73\% = 1,170$

The project team is pleased with the results of the outreach impact assessment given we quintupled the target goal of n=1000 (n=5,000) and estimated a total number of businesses who are likely to increase their revenue based on our market research (n=1,170), which also exceeds the initial reach goal. MAIC will continue to track outreach metrics post-project as part of our mission to assist in developing economically and environmentally sustainable aquaculture opportunities in Maine and beyond.

Conclusion

In this USDA SRGP project, MAIC conducted a comprehensive nationwide consumer insights survey on fresh and value-added seaweed products to develop an easy-to-use market assessment and business planning data dashboard for use by seaweed farmers, distributors, researchers, and Extension professionals. The primary objective of this project was to measure U.S. consumer attitudes and preferences for farmed seaweed and value-added products by region to identify and estimate the size of seaweed market opportunities for new and established aquaculture operators.

The specific tasks in this project were completed by MAIC with assistance from Atlantic and an extended network of industry experts. The MAIC team designed the survey, which gathered data related to consumer consumption habits, knowledge and awareness of edible seaweed, perceived importance of various attributes (i.e., origin, source, value-added products), perceived accessibility and availability, willingness-to-pay premiums, and social and demographic characteristics. MAIC engaged Dynata to host and implement the survey to a total sample size of 5,400 respondents through their online U.S. consumer panel between December 15 and December 28, 2020.

After the successful implementation of the survey, Dr. Zheng conducted descriptive statistics, economic modeling, and inferential statistics to analyze the survey data thoroughly and determine the main variables effecting consumer habits, perceptions, and attitudes including their willingness to pay premiums on various seaweeds and value-added products. The resulting descriptive statistics were included in a findings report by Atlantic for circulation and use in the seaweed industry. Our insights will help seaweed farmers and producers with potential business strategies for producing and promoting seaweed products to meet U.S. consumers' needs, expanding the seaweed consumer pool, and penetrating the seaweed market. Notably, the survey determined that seaweed consumers live near or closer to the coast, are younger, have more education and household income, and have larger household sizes and more children in the household. We also gathered seaweed consumers' knowledge of seaweeds and perceptions of its quality, price, and availability. Our results suggest that expanding seaweed product availability, providing information to consumers to help them learn seaweed products, and educating consumers about how to prepare seaweeds at home may be effective marketing strategies.

We also gathered insights on specific seaweed attributes and product certifications. The most important seaweed attribute to consumers is whether the products are safe for consumption. Most consumers also desire to know the origin of a seaweed product at the country level. Consumers believe seaweed products from the U.S. have the highest quality and indicated in our survey that a U.S.-sourced certification is most important to increase their willingness to purchase while an internationally sourced certification is least important. These results indicate the potential for expanding domestic seaweed aquaculture production and U.S. seaweed market. Seaweed consumers also believe farmed seaweeds are safer and more sustainable than wild-harvested seaweeds, but wild-harvested seaweeds are higher quality. These results further emphasize the importance of educating consumers and improving their knowledge about the differences between farmed and wild-harvested seaweeds in relation to safety, sustainability, and quality in order to promote seaweed aquaculture and farmed seaweed products.

Finally, our survey also provides valuable insights into non-seaweed consumers. Consumers do not eat seaweeds primarily because of a lack of awareness, uncertainty on how to prepare them, and their taste. Our results indicate that seaweed products are relatively new to some markets and that there is a necessity to expand marketing efforts to educate consumers. Seaweed farmers and producers may consider attractive names/brands for their products and avoid using “weeds”.

After thorough analysis of the survey results and the creation of the findings report, MAIC engaged Atlantic to create a series of online interactive data dashboards that allow users to explore all aspects of the data generated through this project. This tool displays visualizations by product and by region that can be filtered by key demographic characteristics such as age, gender, income level, education status, and household size and was the major deliverable of this project.

The data dashboard, in conjunction with the findings report, are available for free on MAIC’s website. Through the outreach and extension included in this project, MAIC and Atlantic have shared the findings of the survey and the launch of the data dashboard to a large audience through multiple channels. Through the final task of the outreach and extension impact assessment, the findings of this project have reached an estimated 4,000 unique aquaculture businesses so far. MAIC will continue to track the reach and impact of this research as they continue their mission to support aquaculture businesses in Maine



Appendix A. Survey

Survey of regional U.S. consumer attitudes and preferences about domestic farm-raised seaweed

INTRODUCTION

You are invited to take part in a research project conducted by the Maine Aquaculture Innovation Center. The purpose of the research is to better understand consumer attitudes and preferences about seaweed products for human consumption. We hope to understand consumer attitudes and preferences about farm-raised edible seaweeds, and domestic and international supplies. This information will help farmers and producers make seaweed products that have a wide consumer appeal, as well as help them to better understand who buys seaweed products, and how and where to sell them.

This research is being completed under a contract with the United States Department of Agriculture's Special Research Grants Program Aquaculture Research grant.

What Will You Be Asked to Do?

If you decide to participate, you will be asked to take an anonymous survey. It should take you about 15 minutes to complete.



Risks:

Confidentiality of survey data is of utmost importance and every effort is made to ensure that no personal information is disclosed. All survey responses are collected anonymously and there will be no records linking you to your survey responses. If you have any discomfort in answering any of the questions, you have no obligation to respond.



Benefits:

This study will have no direct benefit to you. This research will help us learn more about what consumers want in seaweed products and will help farmers and processors be more successful.



Compensation:

Dynata offers a diverse range of incentives for participating in this study according to the choices you have already made.



Confidentiality:

This study is anonymous. There will be no records linking you to your survey answers. Survey data will be kept on a password-protected computer for two years. Information provided for receiving the compensation is not connected to survey responses.



Voluntary:

Participation is voluntary.

If you choose to start this survey, you may stop at any time and answers will only be saved if you finish. Answers may be changed at any time before completing the survey.

You may skip any questions you do not wish to answer but answering all the questions will improve the information we collect. This will help us obtain a better idea of consumer attitudes and preferences.

The submission of the survey implies consent to participate and once your responses have been submitted, it is not possible to withdraw the data.

This survey is only being administered to English speaking participants. If you are not conversant in the English language, do not proceed with this survey.

Contact Information

If you have any questions about this study, please contact Dr. Chris Davis at cdavis@midcoast.com or 207-832-1075 or Dr. Anne Langston Noll at annelangston72@gmail.com or 207-217-2734.

If you have any questions regarding your rights as a participant in the study, you may contact Solutions IRB (the body that oversees our protection of study participants) at (855) 226-4472 or participants@solutionsirb.com

It is suggested that you print a copy of this introduction and consent form for your personal records.

If you would like to take part in this survey, please check yes to continue.

- Yes, I'd like to take part in this survey
- No TERMINATE

If you would like to take part in this survey, please click this button to continue.

Please tell us about yourself

1. **State** – Pulldown

[PN: CREATE h_REGION]

- Northeast
- Midwest
- South
- West

2. **Zip code** (5 digits) – Write in _____

3. **Ethnicity** Hispanic or Latino Not Hispanic or Latino

4. **Race** — [Dropdown: American Indian or Alaska Native alone/Asian alone/Black or African American alone/ Native Hawaiian or Other Pacific Islander alone/ White alone/Two or more races/Prefer not to answer]

5. **Birth year** – [Drop down list 1934-2005 Prefer not to answer

[PN: TERMINATE IF “Prefer not to answer”]

[PN: CREATE h_AGE]

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65+

6. **Gender** – Male Female Other Prefer Not to answer

7. **Currently, what is your marital status**— Never married Married Widowed Divorced Separated

8. **Education** - Up to High School or GED Some college, no degree Associate degree Bachelor's degree Graduate or professional degree

9. **Currently, what is your annual household income:** [Drop down list; Less than \$15k/\$15k-\$24.99k/\$25k-\$34.99k/\$35k-49.99k/\$50-74.99k/\$75k-99.99k/\$100k-149.99k/\$150k-199.99k/over \$200k]

10. **Currently, are you the primary food shopper for your household?** Yes No Shared equally

If no is selected, please terminate.

11. **Currently, how many household members do you or the primary shopper generally buy groceries/meals for, including yourself?** [Radio buttons 1 member to 10+ members]

12. **Of your household members, how many are UNDER the age of 18?** [Radio buttons; 0 members to 8 members]

13. **This year (within the past 12 months), what is your household's average monthly expenditure on food at:**

- Food stores (e.g., big box stores, convenience stores, farmer's markets, gourmet markets, local organic markets, meat markets, seafood markets/trucks/stands, and supermarkets)? [Numeric fill in – max \$5000]
- Mail order and other home delivery services? [Numeric fill in – max \$5000]
- Restaurants and prepared takeout? [Numeric fill in – max \$5000]

Key Terms and Definitions

Seaweeds – all species of edible saltwater macroalgae/seaweed (e.g., sugar kelp, dulse, nori, etc.).

Aquaculture – the farming/cultivation of macroalgae/seaweed under controlled conditions.

Farm-raised seaweeds - seaweeds sourced from aquaculture operations.

Wild harvested seaweeds - macroalgae and seaweeds gathered directly from coastal habitats.

Domestically sourced - farmed or harvested in the US.

North American sourced - farmed or harvested in the US or Canada

Small and medium sized farms/processors – operations that appear to be smaller in nature than large, national, or international brands.

Note: ALL references in this survey are to saltwater, not freshwater, macroalgae.

Knowledge of Aquaculture

14. **Are you aware of seaweed aquaculture or wild harvesting operations in:**

- Maine? Yes No
- The US? Yes No
- Foreign countries? Yes No

15. **Please rate your knowledge of seaweed aquaculture or wild harvesting operations:** Slider (1 = no knowledge of seaweed operations to 5 = working knowledge of seaweed operations)

Shopping Habits

16. **Do you (or others in your household) purchase or consume seaweeds?** Yes No

If “Yes,” route to next question (17).

If “No” route to 16a. and 16b.

- 16b. Why do you not consume seaweeds?

- Availability
- Cost
- Allergy

- Dietary restrictions
- Taste
- Unaware of them
- Not sure how to prepare them
- Uncertain about possible environmental contamination
- Other (Please specify)

“Not sure how to prepare them” and “Uncertain about possible environmental...” are not allowing for multiple selections (all other options are)

16c. Which of the following would encourage you to try seaweeds? (click all that apply)

- Increased availability
- Recipes
- Easy-to-use products
- Fresh product easily available from grocery store
- Fresh seaweed dishes at restaurants
- Seaweed dishes at fast-food chains
- Other (Please specify)

16d. How likely are you to try a new product (e.g., bread, pasta, smoothy, seasonings) if it were flavored with or contains seaweeds? [Radio buttons, Scale 1-7, 1 = Extremely unlikely to 7 = Extremely likely, remove No preference option]

Route to question 34

17. **How many members of your household consume seaweed?** [Radio buttons 1 member to 10+ members]

18. **How old are your household’s seaweed consumers?** Please select all that apply. [Multiple selections accepted, dropdown menu; under 5 years, 5-14 years, 15-24 years, 25-44 years, 45-64 years, 65 and higher]



19. **This year, how much have you spent on all seaweed products at:** [Numeric fill in – max \$500]








- Food stores? Slider: \$0-\$500+
- Mail order and other home delivery services? Slider: \$0 to \$500+
- Restaurants? Slider: \$0-\$500+

20. **This year, approximately what portion of your annual seaweed budget do you spend at the following types of stores?** (Auto-sum must add up to 100)

- Big box stores/ Supermarkets Drop down: 0 to 100% (5% inc.)
- Convenience store Drop down: 0 to 100% (5% inc.)
- Specialty/Gourmet market Drop down: 0 to 100% (5% inc.)
- Local/Farmer’s market Drop down: 0 to 100% (5% inc.)
- Online (excluding direct from farm/producer) Drop down: 0 to 100% (5% inc.)
- Directly from producer (online or store) Drop down: 0 to 100% (5% inc.)
- Gift shop Drop down: 0 to 100% (5% inc.)
- Other Drop down: 0 to 100% (5% inc.)

21. **Please identify the following domestic edible seaweeds that you are aware of:** (Check all that apply):

Sugar Kelp, Atlantic Kombu <i>Saccharina latissima</i>		Yes <input type="checkbox"/> No <input type="checkbox"/>
Rockweed, Bladder wrack <i>Fucus vesiculosus</i>		Yes <input type="checkbox"/> No <input type="checkbox"/>

<p>Skinny Kelp, another type of Atlantic Kombu <i>Saccharina latissima</i> forma <i>angustissima</i></p>		<p>Yes <input type="checkbox"/> No <input type="checkbox"/></p>
<p>Horsetail Kelp <i>Laminaria digitata</i></p>		<p>Yes <input type="checkbox"/> No <input type="checkbox"/></p>
<p>Winged Kelp <i>Alaria esculenta</i></p>		<p>Yes <input type="checkbox"/> No <input type="checkbox"/></p>
<p>Dulse <i>Palmaria palmata</i></p>		<p>Yes <input type="checkbox"/> No <input type="checkbox"/></p>
<p>Laver, Atlantic Nori <i>Porphyra</i> spp.</p>		<p>Yes <input type="checkbox"/> No <input type="checkbox"/></p>
<p>Sea Lettuce <i>Ulva lactuca</i></p>		<p>Yes <input type="checkbox"/> No <input type="checkbox"/></p>
<p>Irish Moss <i>Chondrus crispus</i></p>		<p>Yes <input type="checkbox"/> No <input type="checkbox"/></p>

22. Which of the following seaweed products are currently available to you?

Type	Total Value
Dried (whole leaf, flakes, granules, sprinkles, seasoning, flavor enhancer, nutritional supplement, sushi sheets, snacks, etc.)	[Numeric fill in – max \$1000]
Fresh (salad, whole leaf, etc.)	[Numeric fill in – max \$1000]
Frozen (cubes, noodles, whole leaf, etc.)	[Numeric fill in – max \$1000]
Canned/preserved (chutney, puree, etc.)	[Numeric fill in – max \$1000]

23. How much did you spend on the following seaweed products this year? If none, enter 0.

Type	Total Value
Dried (whole leaf, flakes, granules, sprinkles, seasoning, flavor enhancer, nutritional supplement, sushi sheets, snacks, etc.)	[Numeric fill in – max \$1000]
Fresh (salad, whole leaf, etc.)	[Numeric fill in – max \$1000]
Frozen (cubes, noodles, whole leaf, etc.)	[Numeric fill in – max \$1000]
Canned/preserved (chutney, puree, etc.)	[Numeric fill in – max \$1000]

24. How would you rate the following factors of seaweed products available to you: Price; Quality; Availability; Radio buttons (1 = Poor to 7 = Excellent)?

25. This year, assuming everything is equal, including price, which of the following would you prefer to purchase?

- a) Farm-raised seaweeds
- b) Wild harvested seaweeds
- c) No preference
- d) Not applicable

26. Currently, how would you rate farmed and wild harvested seaweed products among the following categories? (1 = Poor to 7 = Excellent)

Category	Farmed	Wild harvested
Safe to consume	<input type="checkbox"/> <input type="checkbox"/> 1 to 7	<input type="checkbox"/> <input type="checkbox"/> 1 to 7
Sustainable	<input type="checkbox"/> <input type="checkbox"/> 1 to 7	<input type="checkbox"/> <input type="checkbox"/> 1 to 7
Product quality	<input type="checkbox"/> <input type="checkbox"/> 1 to 7	<input type="checkbox"/> <input type="checkbox"/> 1 to 7
Product price	<input type="checkbox"/> <input type="checkbox"/> 1 to 7	<input type="checkbox"/> <input type="checkbox"/> 1 to 7

27. How likely are you to try a new product this year (e.g., bread, pasta, seasonings) if it were flavored with seaweed? [Radio buttons, Scale 1-7, 1 = Extremely unlikely to 7 = Extremely likely, Do not include No preference]

28. This year, how often have you consumed/used seaweeds during the following seasons?: (Select one per season) [Drop down or Radio buttons: Once a week or more; 2 to 3 times per month; Once per month or less; Not used]

- a) Summer
- b) Fall
- c) Winter
- d) Spring

29. This year, how often have you consumed/used seaweeds during the following meals?: (Select one per meal) [Drop down or Radio buttons: Once a week or more; 2 to 3 times per month; Once per month; Not used]

- a) Breakfast
- b) Lunch
- c) Dinner
- d) Snack
- e) Holidays and special occasions

30. Currently, if you buy seaweed, what do you use it for? [Multiple selections allowed]

- a) Topping for salads, soups, etc.
- b) Baking and/or cooking ingredient
- c) Sushi
- d) Snacks
- e) Nutritional supplement

- f) Give as a gift
- g) Skincare
- h) Animal feed
- i) Fertilizer
- j) Other
- k) Not applicable

31. How much detail do you currently desire to know about the geographic origin of your seaweed products? (choose one) No Detail Country State/Province County City/town Farm
32. How important to your current purchasing decisions is knowing the geographic origination of seaweed products? (1 = Not important, 7 = Extremely important) Radio buttons 1-7
33. Is your motivation to purchase seaweed due to any member(s) of your household whom currently adhere to the following diets?
- a) Do not adhere to a particular diet
 - b) Vegan
 - c) Vegetarian
 - d) Pescatarian
 - e) Keto
 - f) Paleo
 - g) Other (Please specify)
34. In your opinion, how would you rate quality of seaweed products from the following regions: (1 = Poor , 7 = Excellent) [RANDOMIZE SELECTIONS]

Region	Rating	Not applicable
Europe	1 to 7	<input type="checkbox"/>
North America	1 to 7	<input type="checkbox"/>
Africa	1 to 7	<input type="checkbox"/>
Asia	1 to 7	<input type="checkbox"/>
Australia	1 to 7	<input type="checkbox"/>
South America	1 to 7	<input type="checkbox"/>

Please ensure the top row says “1 = Poor” and “7 = Excellent” and not Poor1 and Excellent7.

35. How do the following attributes affect your current willingness to purchase seaweed products? Select Not sure if not important. (1 = Extremely decreases, 7 = Extremely increases). Radio buttons

Quality	1= Extremely decreases to 7 = Extremely increases	Not sure
Taste	1 to 7	<input type="checkbox"/>
Salt substitute	1 to 7	<input type="checkbox"/>
Impact on water quality	1 to 7	<input type="checkbox"/>
Impact on marine environment	1 to 7	<input type="checkbox"/>
Impact on coastal economies	1 to 7	<input type="checkbox"/>
Carbon capturing	1 to 7	<input type="checkbox"/>
Safe for consumption	1 to 7	<input type="checkbox"/>
Gluten free	1 to 7	<input type="checkbox"/>
Cholesterol-free	1 to 7	<input type="checkbox"/>
Low-fat	1 to 7	<input type="checkbox"/>
Low-calorie	1 to 7	<input type="checkbox"/>

Quality	1= Extremely decreases to 7 = Extremely increases	Not sure
Good source of fiber	1 to 7	<input type="checkbox"/>
Good source of vitamins and minerals	1 to 7	<input type="checkbox"/>

Please ensure the top row says ‘1 = Extremely decreases’, ‘7 = Extremely increases’ and not Extremely decreases 1 and Extremely increases 7.

35. How do the following quality certifications/indicators affect your current willingness to purchase seaweed products? Select Not sure if not important. (1 = Extremely decreases, 7 = Extremely increases).
Radio buttons

Quality	Change in my willingness to purchase 1= Extremely decrease to 7 = Extremely increase	Not sure
3rd party certified sustainable	1 to 7	<input type="checkbox"/>
Non-GMO	1 to 7	<input type="checkbox"/>
Certified organic	1 to 7	<input type="checkbox"/>
Small to medium sized producers	1 to 7	<input type="checkbox"/>
Directly marketed from farm/harvester	1 to 7	<input type="checkbox"/>
Internationally sourced	1 to 7	<input type="checkbox"/>
US-sourced	1 to 7	<input type="checkbox"/>
Farm-raised	1 to 7	<input type="checkbox"/>
Wild harvest	1 to 7	<input type="checkbox"/>
US Pacific coast-sourced	1 to 7	<input type="checkbox"/>
US Atlantic coast-sourced	1 to 7	<input type="checkbox"/>
Fair trade	1 to 7	<input type="checkbox"/>

27. How much have you spent in the past year on the following non-food seaweed-based products?
 a) Skincare
 b) Fertilizer
 c) Animal feed supplement

Thank you for completing this survey. We appreciate your participation and look forward to sharing our results with you.

Appendix B. Findings Report

Consumer perceptions, preferences, and attitudes about domestic farm-raised seaweed products

1. INTRODUCTION

This report provides statistical analysis and econometric model results from a consumer survey titled “Survey of regional U.S. consumer attitudes and preferences about domestic farm-raised seaweed.” The Maine Aquaculture Innovation Center (MAIC) and Atlantic Corporation (Atlantic) conducted the survey under contract with the United States Department of Agriculture’s (USDA) Special Research Grants Program - Aquaculture Research grant. The survey was designed by MAIC and Atlantic and fielded by Dynata through their online U.S. consumer panel between December 15th and December 28th, 2020. This report analyzes the survey results and provides meaningful insights into consumer perceptions, preferences, and purchase intentions for seaweed products that will equip seaweed farmers and producers with potential business strategies for producing and promoting seaweed products to meet U.S. consumers’ needs.

We begin this report with a description of the survey data and then use descriptive statistics and data visualization to explore consumers’ knowledge of seaweed aquaculture and products, seaweed consumption habits, and perceptions and preferences for seaweed attributes. Our analysis for non-seaweed consumers is focused on their reasons for not consuming the products and possible motivating factors for encouraging them to try. Next, we build several econometric models to investigate the relationship between consumers’ intentions to try new products flavored with and/or containing seaweeds and the factors that influence their intentions, and the relationship between consumers’ preferences for farm-raised seaweeds and the factors that influence their preferences. Finally, we conclude the report and provide suggestions for seaweed industry stakeholders about potential marketing strategies to expand the seaweed market to meet consumers’ needs.

2. DATA DESCRIPTION




Socio-demographic characteristics:

Geographic distribution

Northeast	Midwest	South	West
19%	22%	38%	21%

Age and Gender

Average Age			
47	 49%	 51%	

The survey dataset contains 5401 responses from participants across the U.S., including all 50 states and Washington, D.C. We asked survey participants, “Do you (or others in your household) purchase or consume seaweeds?” to divide the participants into two groups: seaweed consumers (n=1952) and non-seaweed consumers (n=3449). The survey included questions for both groups and specific questions for seaweed consumers and non-seaweed consumers to answer.

Table 1 presents the summary statistics of the socio-demographic data in the full survey sample as well as the subsamples of seaweed consumers and non-seaweed consumers. The survey participants were spread across the country with 19% based in the Northeast region, 22% in the Midwest, 38% in the South, and 21% in the West. More seaweed consumers



Socio-demographic characteristics:

Education

high school or GED

23%

some college

23%

associate degree

13%

bachelor's degree

26%

graduate or professional degree

15%

Average Annual Household Income

\$64,270

Shopper Status

primary food shopper

23%

shared food shopping equally

23%

average household

13%

33% had children in the household

were based in the Northeast or West than in the full survey participant sample while a smaller portion were located in the Midwest or South . In contrast, non-seaweed consumers were predominantly in the Midwest or South with a smaller portion in the Northeast or West.

About 12% of the survey participants were between 18 and 24 years old, 17% between 25 and 34, 18% between 35 and 44, 17% between 45 and 54, 16% between 55 and 64, and 20% were 65 or older; the average age was about 47 years old. Seaweed consumers were younger on average than the full group of survey participants while the non-seaweed consumers were older. The average age of seaweed consumers was about 39 years old, and the average age of non-seaweed consumers was about 51 years old. In the full sample, about 51% of participants were male, 49% were female, and 0.2% chose "Other" or "Prefer not to answer." The seaweed consumer group was comprised of more men (56%), while the non-seaweed consumer group was composed of more women (52%).

In the full sample, about 23% of the participants had up to high school or GED, 23% had some college, 13% had an associate degree, 26% had a bachelor's degree, and 15% had a graduate or professional degree. The seaweed consumer group had higher education levels on average than the full survey sample and the non-seaweed consumer group had less education. In the full

sample, about 13% of the participants earned an annual household income of less than \$15k, 12% between \$15k-\$24.99k, 12% between \$25k-\$34.99k, 14% between \$35k-\$49.99k, 18% between \$50k-\$74.99k, 12% between \$75k-99.99k, 12% between \$100k-\$149.99k, 5% between \$150k-\$199.99k, and 3% over \$200k. The average annual household income was \$64,270. Seaweed consumers had a higher average annual household income (\$78,960), while the non-seaweed consumer group had a lower average household income (\$55,950).

In the full sample, about 81% of participants stated that they were the primary food shopper for the household and 19% stated that they shared food shopping equally in the household. The average household had 2.62 people and 33% had children in the household. The seaweed consumer group had a larger household size and more children in the household on average, while the non-seaweed consumer group had a smaller household size and fewer children. Seaweed consumers had about two members in their household consuming seaweed on average.

The survey asked several questions about expenditures, including household average monthly expenditure on food (\$5,000 max), household expenditure on seaweed products in 2020 (\$500 max), and household expenditure on non-food seaweed-based products in 2020 (\$1000 max). Our expenditure data shows substantial variation as there are large outliers for each expenditure variable, equal or close to the maximum allowable entry value, which substantially inflate the mean. Additionally, the magnitude of expenditures reported by some households is not consistent with their household income. We believe the expenditure data we collected is not accurate for some consumers because of the reported inconsistencies between household expenditures and household incomes and the difficulty for some consumers in remembering how much they spent. The mean and standard deviation are not reliable measures to indicate the central tendency and variation of consumer spending.



We present the summary statistics in **Table 1** to provide readers with an overview of these expenditures. We also include histograms of the expenditure variables in Appendix A, B, and C. We suggest readers use the median values to understand the overall trend of the consumers' expenditures on food, seaweed products, and non-food seaweed-based products and the histograms to understand their distributions. Our survey results indicate consumers' expenditures on seaweed products and non-food seaweed-based products account for a small portion of their overall spending on food.

Table 1. Summary statistics of socio-demographic variables in the survey dataset

Variable	Full Sample (n=5401)		Seaweed Consumers (n=1952)		Non-Seaweed Consumers (n=3449)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Region						
Northeast	0.19	0.39	0.20	0.40	0.18	0.38
Midwest	0.22	0.41	0.17	0.38	0.25	0.43
South	0.38	0.49	0.35	0.48	0.40	0.49
West	0.21	0.41	0.28	0.45	0.18	0.38
Age						
18-24	0.12	0.33	0.17	0.37	0.10	0.29
25-34	0.17	0.38	0.26	0.44	0.12	0.33
35-44	0.18	0.39	0.24	0.43	0.15	0.35
45-54	0.17	0.37	0.16	0.37	0.17	0.38
55-64	0.16	0.37	0.10	0.30	0.19	0.40
65+	0.20	0.40	0.07	0.26	0.27	0.44
Age variable, in years	46.57	17.15	39.47	14.56	50.59	17.21
West	0.21	0.41	0.28	0.45	0.18	0.38
Gender						
Male	0.51	0.50	0.56	0.50	0.48	0.50
Female	0.49	0.50	0.44	0.50	0.52	0.50
Chose 'other' or 'prefer not to answer'	0.002	0.04	0.003	0.05	0.001	0.04
Education						
Up to High School or GED	0.23	0.42	0.16	0.36	0.27	0.45
Some college, no degree	0.23	0.42	0.21	0.40	0.24	0.43
Associate degree	0.13	0.34	0.13	0.33	0.13	0.34
Bachelor's degree	0.26	0.44	0.32	0.47	0.22	0.42
Graduate or professional degree	0.15	0.36	0.20	0.40	0.13	0.33

Variable	Full Sample (n=5401)		Seaweed Consumers (n=1952)		Non-Seaweed Consumers (n=3449)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Annual household income						
Less than \$15k	0.13	0.34	0.08	0.28	0.16	0.36
\$15k-\$24.99K	0.12	0.32	0.08	0.27	0.14	0.34
\$25k-\$34.99k	0.12	0.32	0.10	0.30	0.13	0.33
\$35k-49.99k	0.14	0.35	0.12	0.33	0.15	0.36
\$50-74.99k	0.18	0.38	0.17	0.38	0.18	0.39
\$75k-99.99k	0.12	0.32	0.16	0.36	0.10	0.30
\$100k-149.99k	0.12	0.32	0.16	0.37	0.10	0.29
\$150k-199.99k	0.05	0.21	0.07	0.26	0.03	0.17
Over \$200k	0.03	0.17	0.05	0.22	0.02	0.14
Annual household income variable, in continuous values (\$1,000)	64.27	51.96	78.96	56.80	55.95	47.03
If primary food shopper						
Primary food shopper for the household	0.81	0.39	0.87	0.33	0.77	0.42
Shared food shopping equally	0.19	0.39	0.13	0.33	0.23	0.42
Household						
Number of household members	2.62	1.43	3.01	1.52	2.40	1.33
If there is (are) child(ren) in the household	0.33	0.47	0.49	0.50	0.24	0.43
Household average monthly expenditure (\$) on food at						
Food stores	597.50	933.65	650.43	1015.07	567.54	883.01
Mail order and other home delivery services	116.32	424.88	199.23	571.87	69.39	302.62
Restaurants and prepared takeout	198.67	479.68	272.91	627.39	156.65	364.34
Seaweed consumer						
If the household consumes seaweeds	0.36	0.48	1	0	0	0
Number of seaweed consumers in the household	2.03	1.14	2.03	1.14	.	.
Household expenditure (\$) on seaweed products (in 2020) at						
Food stores	82.13	107.82	82.13	107.82	.	.
Mail order and other home delivery services	40.35	83.80	40.35	83.80	.	.
Restaurants and prepared takeout	50.80	94.96	50.80	94.96	.	.
Household expenditure (\$) on non-food seaweed-based products (in 2020)						
Skincare	49.55	108.91	60.22	115.98	43.51	104.23
Fertilizer	21.58	65.73	35.26	84.58	13.85	50.52
Animal feed supplement	23.16	83.19	37.48	103.76	15.06	67.56

3. DESCRIPTIVE STATISTICS

3.1 Consumers' knowledge of seaweed aquaculture and products

The survey asked participants about their awareness of seaweed aquaculture or wild harvesting operations, to self-rate their knowledge of seaweed aquaculture or wild harvesting operations, and to take a brief quiz to test if they recognize the major domestic edible seaweeds by providing names and pictures of nine types of seaweeds. Both seaweed consumers and non-seaweed consumers answered these questions.

Figure 1 shows consumers' awareness of seaweed aquaculture or wild harvesting operations across different geographic scales. About 41.1% of the consumers were aware of seaweed aquaculture or wild harvesting operations in the U.S., 29.5% were aware of it in foreign countries, and 20.8% were aware of it in Maine.

Are you aware of seaweed aquaculture or wild harvesting operations in: (n=5401)?

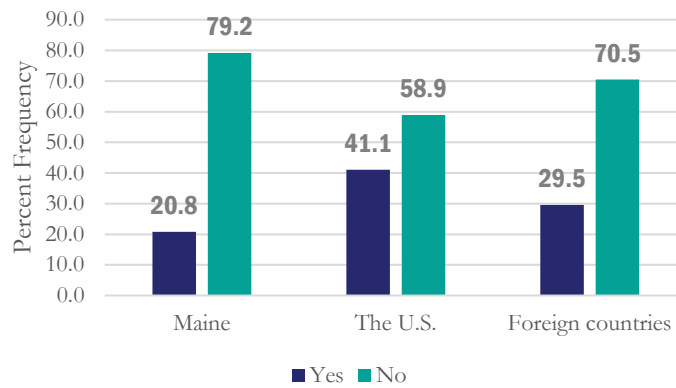


Figure 1. Consumers' awareness of seaweed aquaculture or wild harvesting operations across different geographic scales

Figure 2 depicts consumers' self-rating of their knowledge of seaweed aquaculture or wild harvesting operations. Slightly less than half of the participants (43.2%) reported that they had no knowledge of seaweed aquaculture or wild harvesting operations and about half said they had some knowledge. Only 6.6% of consumers reported having a working knowledge of seaweed aquaculture or wild harvesting operations. Consumers' self-rated knowledge level was 2.17 on average. We term this variable as subjective knowledge in the following models because the survey participants self-reported their knowledge.

Please rate your knowledge of seaweed aquaculture or wild harvesting operations

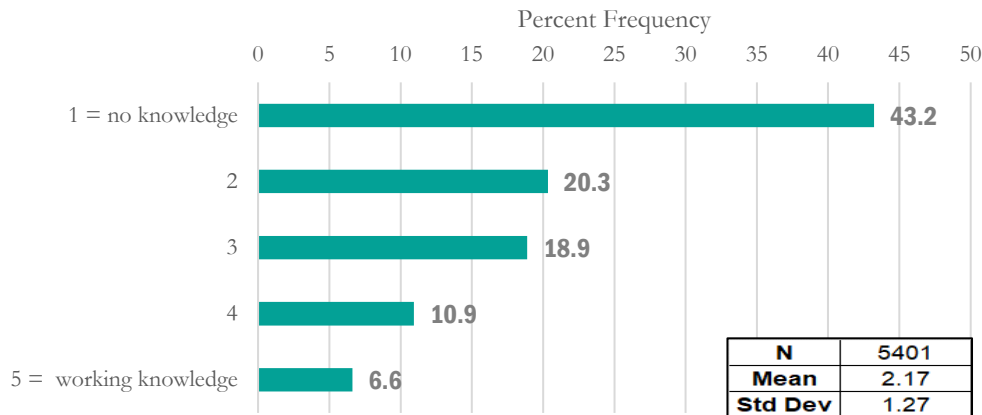


Figure 2. Consumers' self-rating of their knowledge of seaweed aquaculture or wild harvesting operations

Figure 3 illustrates consumers' knowledge of major domestic edible seaweeds. The survey gave participants the names (both common and scientific) and images of nine major domestic edible seaweeds and asked if they could identify any of the seaweeds. Only seaweed consumers (n=1,952) answered this question. Laver, Atlantic Nori was recognized by most consumers (60%), followed by Irish Moss (58.4%), Dulse (57.7%), Horsetail Kelp (52.8%), Rockweed, Bladder wrack (49.1%), Winged Kelp (42.6%), Sugar Kelp, Atlantic Kombu (42.1%), and Skinny Kelp, another type of Atlantic kombu (42%). Sea lettuce was recognized by the fewest consumers (30.7%). We term this variable as objective knowledge in the following models because it was measured by a quiz.

Please identify the following domestic edible seaweeds that you are aware of: (n=1952)

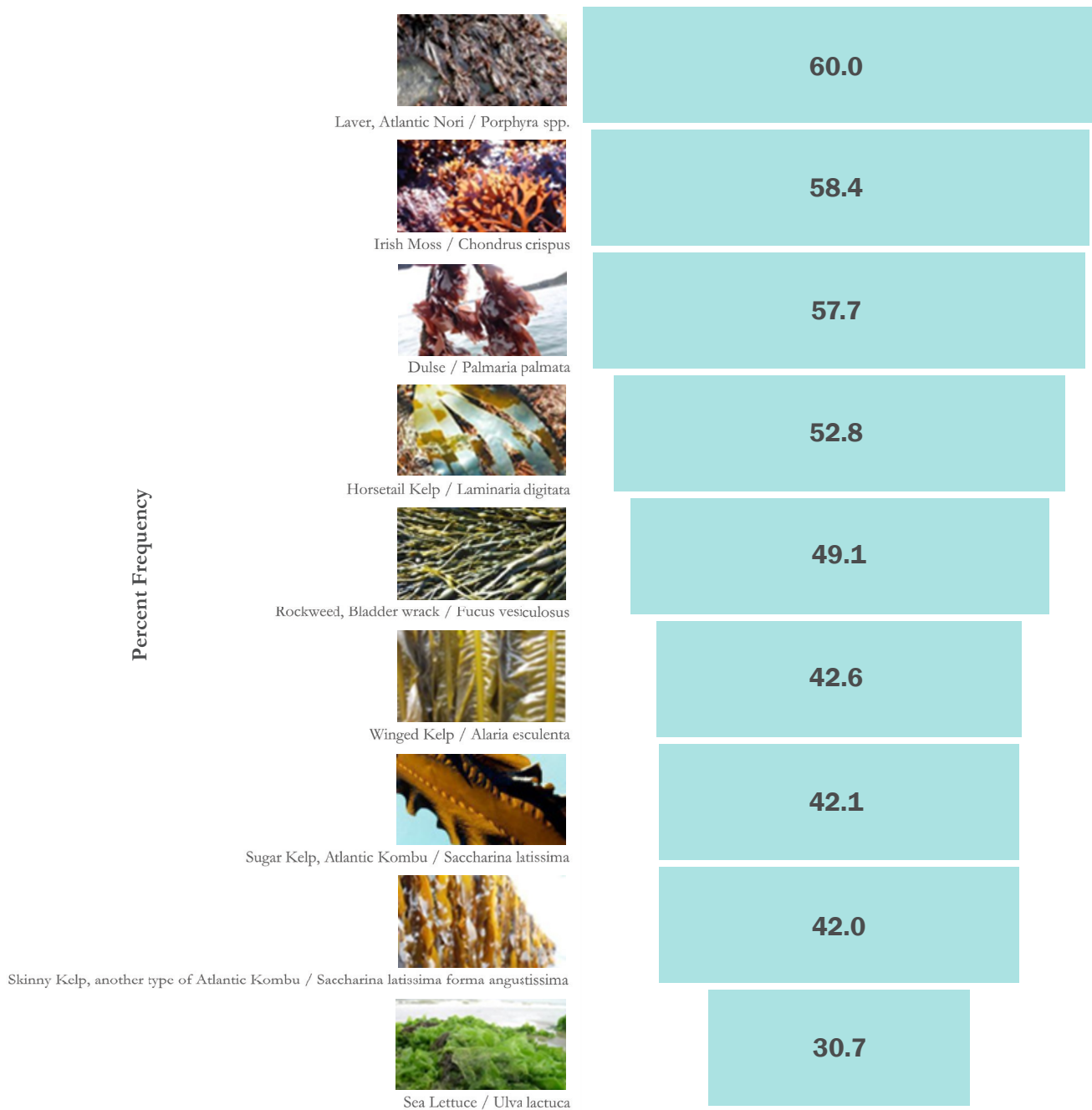


Figure 3. Consumers' knowledge of major domestic edible seaweeds

3.2 Consumers' seaweed consumption habits

3.2.1 Types of stores

Figure 4 shows the distribution of consumers' annual seaweed budget in different stores. About 60% of consumers spend their annual seaweed budget in big box stores/supermarkets (36.3%), specialty/gourmet market (15.9%), and online (excluding direct from farm/producer) (9.9%). Consumers spent about 7-8% of their annual seaweed budget locally/in the farmer's market, directly from producer (online or store), or at the convenience store. Consumers spent about 4.5% of their seaweed budget in gift shops and 9.3% of their budget at outlets other than those listed in the survey question, indicated by the "Other" category.

This year, approximately what percentage of your annual seaweed budget do you spend at the following types of stores? [0 to 100%] (n=1952)

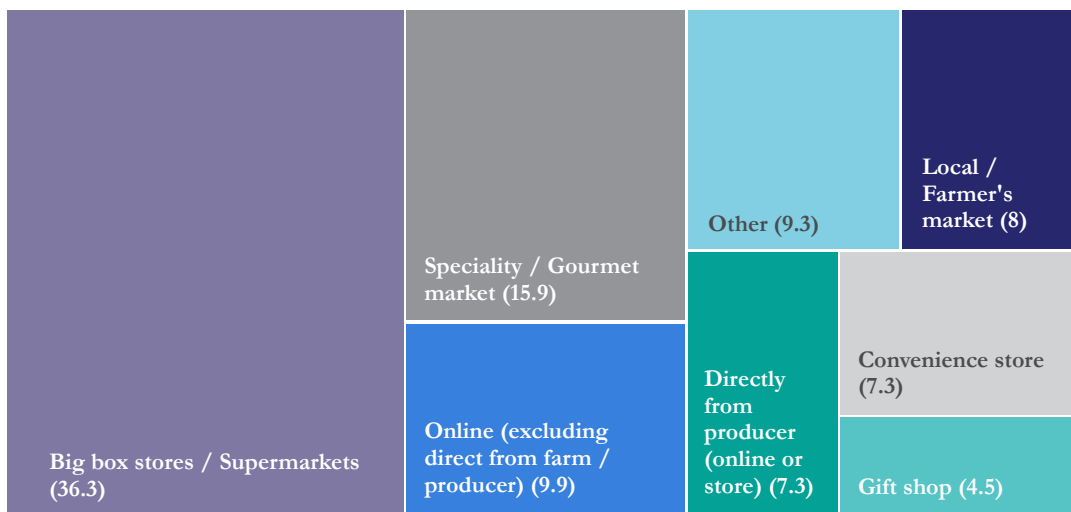


Figure 4. Distribution of consumers' annual seaweed budget in different stores

3.2.2 Product forms

Figure 5 highlights the availability of seaweed products in different forms. Dried seaweed products are the most available; about 84.9% of the consumers reported they were available to them. About 60% of the consumers said fresh seaweed products were available to them and 30.7% said frozen seaweed products were available. Canned/preserved seaweed products were the least available to consumers as only about 17.5% marked them as available.

Which of the following seaweed products are currently available to you? (n=1952)

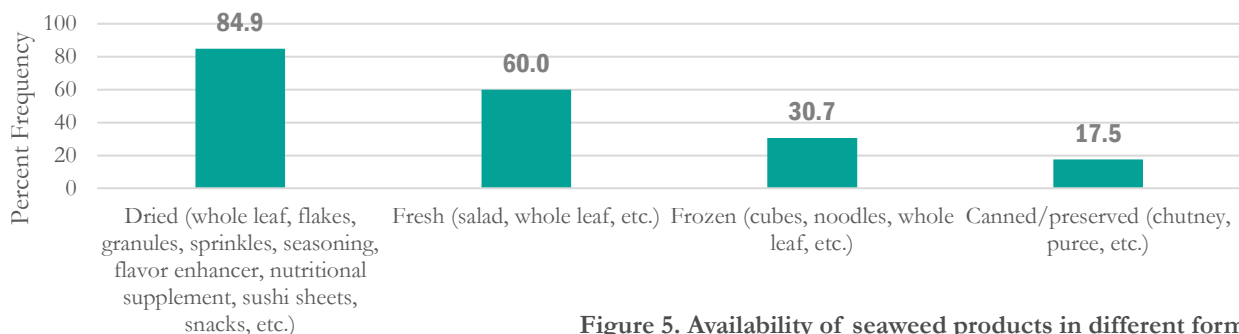


Figure 5. Availability of seaweed products in different forms

Table 2 shows summary statistics of the consumers' expenditure on seaweed products in alternative product forms. We have concerns about the accuracy of the expenditure data as we described in the Data Description section of this report. We report the summary statistics in Table 2 and the histograms of consumers' expenditures on each product form in Appendix D. We suggest readers use the median to gain a general understanding of the central tendency of consumers' spending and use the histogram to understand the variation. Consumers reported spending the most on dried seaweed products on average, followed by fresh, frozen, and canned/preserved seaweed products. These results align with the availability of different seaweed products that consumers reported in the previous question.

Table 2. How much did you spend on the following seaweed products this year? If none, enter 0. (n=1952)

Product Form	Mean	Median	Std Dev	Minimum	Maximum
Dried (whole leaf, flakes, granules, sprinkles, seasoning, flavor enhancer, nutritional supplement, sushi sheets, snacks, etc.)	62.28	30	92.29	0	1000
Fresh (salad, whole leaf, etc.)	44.55	20	87.94	0	1000
Frozen (cubes, noodles, whole leaf, etc.)	29.02	0	74.29	0	1000
Canned/preserved (chutney, puree, etc.)	25.65	0	73.14	0	900

3.2.3 Seasonal differences

Figure 6 shows the frequency of the consumers' seaweed consumption in each season. Consumers consume seaweed most frequently in summer as about 34.7% of the participants consumed it once a week or more, 39.1% consumed it 2 to 3 times per month, 21.2% consumed it once per month or less, and 5.0% did not use it. Spring and fall were the next most popular seasons for consumption. Survey participants consumed seaweed least frequently in the winter.

This year, how often have you consumed/used seaweeds during the following seasons? (n=1952)

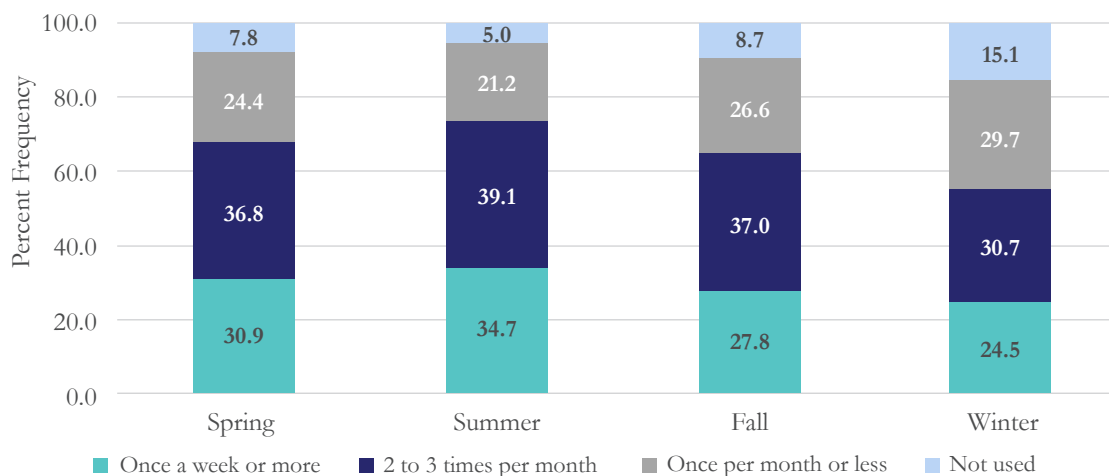


Figure 6. Frequency of seaweed consumption in each season

3.2.4 Consumption over different meals

Figure 7 shows the frequency of seaweed consumption during different meals. Consumers eat seaweed most frequently during dinner and lunch. About 87% of the consumers ate seaweed at least once per month for dinner and 83% consumed it at least once per month for lunch. Consumers did not eat seaweed often over breakfast. About 47.3% of the consumers had used seaweeds for breakfast and 52.7% did not. About 74% of the consumers had used seaweeds for snacks, and about 60% of them had used seaweeds for holidays and special occasions.

This year, how often have you consumed/used seaweeds during the following meals?
(n=1952)

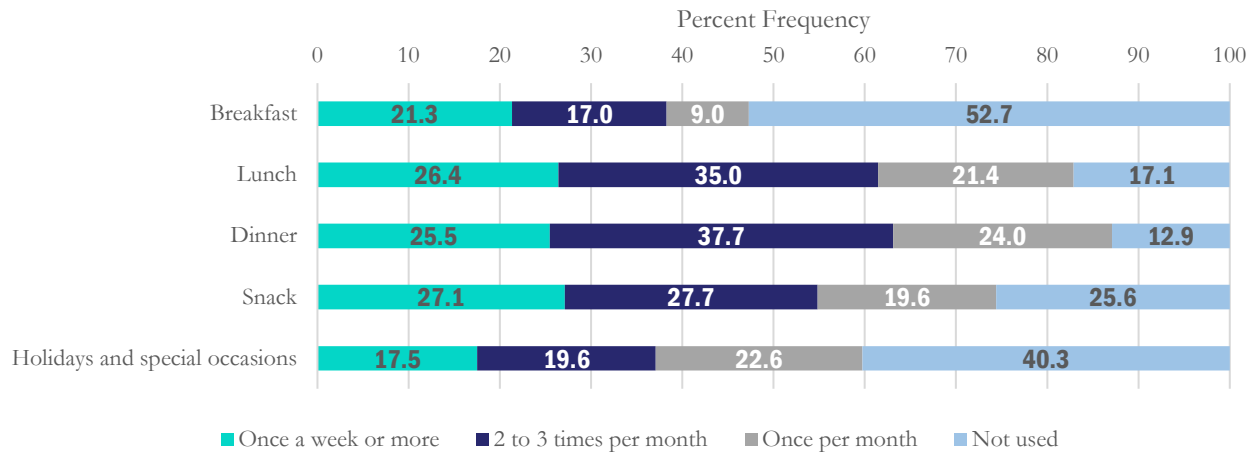


Figure 7. Frequency of seaweed consumption during different meals

3.2.5 Purpose of seaweed consumption

Figure 8 shows consumers' use of seaweeds. Topping for salads and soups, Sushi, and snacks are the most popular uses of seaweeds. More than half of the consumers had used seaweeds as a topping for salads, soups, etc. (55.3%), Sushi (55.2%), and snacks (54.8%). About one third of the consumers had used seaweed as a nutritional supplement (33.3%) or baking and/or cooking ingredient (30.3%). A small portion of the consumers had used seaweeds for skincare (15.4%), gifts (13.9%), animal feed (10%), and fertilizer (9%).

Currently, if you buy seaweed, what do you use it for? (n=1952)

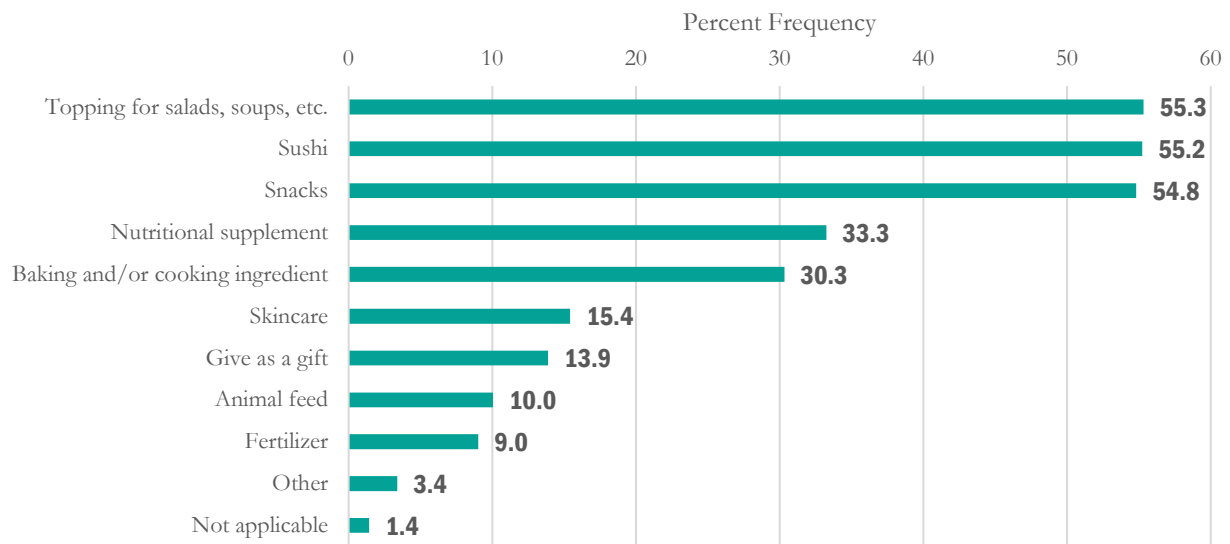


Figure 8. Consumers' use of seaweeds

3.2.6 Diet motivations

Figure 9 shows whether consumers purchased seaweeds due to their household members' diets. Most of the consumers stated that they do not consume seaweeds because of a family member's particular diet (59.7%). A small portion of the consumers indicated they purchase seaweeds because their family member(s) adhere to a particular diet of vegetarian (21.5%), vegan (16.8%), keto (11.9%), pescatarian (9.1%), paleo (4%), and other diets (1.3%).

Is your motivation to purchase seaweed due to any member(s) of your household whom currently adhere to the following diets? (n=1952)

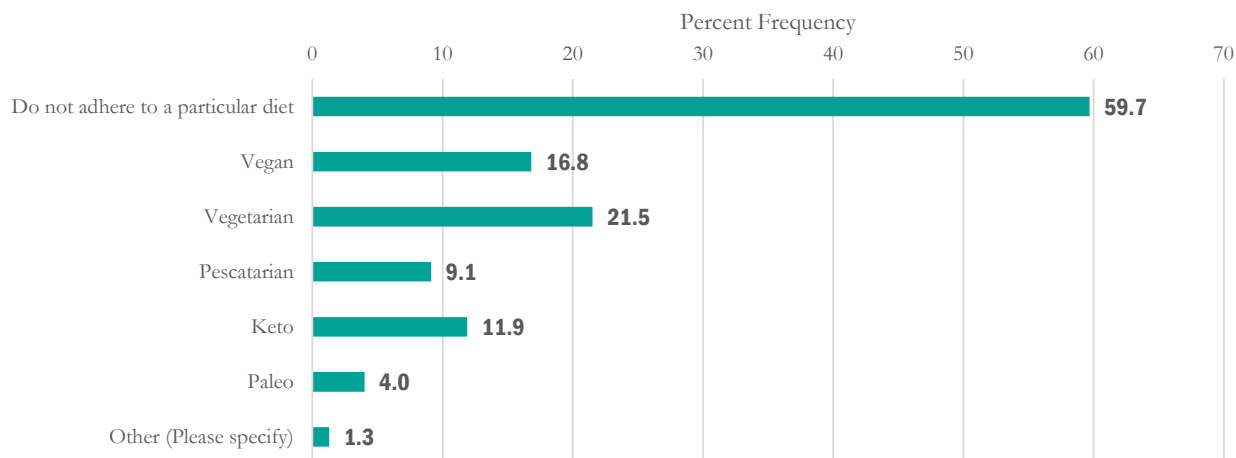


Figure 9. Motivations to purchase seaweeds due to diets

3.3 Consumers' perceptions and preferences for seaweed attributes

3.3.1 Perceptions of price, quality, and availability

Figure 10 shows the consumers' perceptions of price, quality, and availability of seaweed products available to them. Consumers rated the quality of seaweed products the highest on average, at 5.59 out of 7, followed by price (5.15 rating) and availability (5.01 rating). Our results suggest that consumers generally perceive seaweeds as high-quality products.

How would you rate the following factors of seaweed products available to you: (1 = Poor to 7 = Excellent) (n=1952)

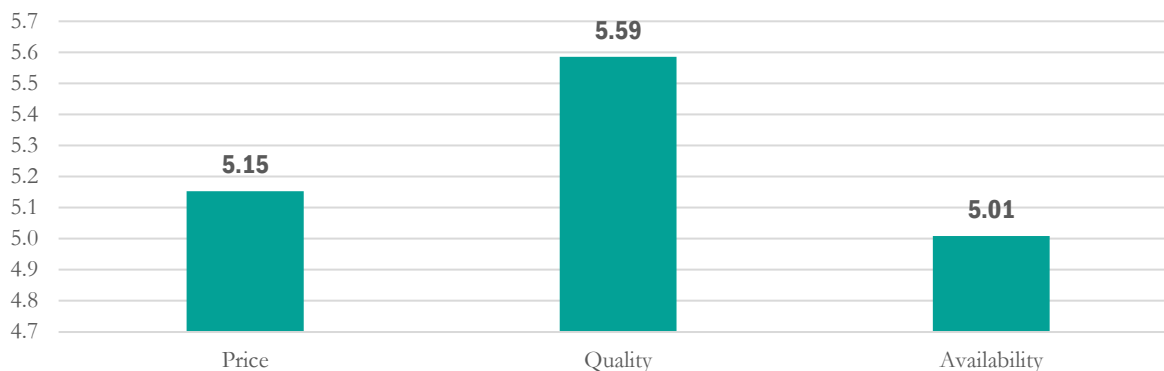


Figure 10. Consumers' perceptions of price, quality, and availability of seaweed products available to them

3.3.2 Preferences for farm-raised vs. wild-harvested seaweeds

Figure 11 shows consumers’ preferences for farm-raised and wild-harvested seaweeds. More than half of the consumers (57.6%) had no preference between farm-raised and wild-harvested seaweeds. About 18% of the consumers preferred farm-raised seaweeds, while 22.4% preferred wild-harvested seaweeds.

This year, assuming everything is equal, including price, which of the following would you prefer to purchase? (n=1952)

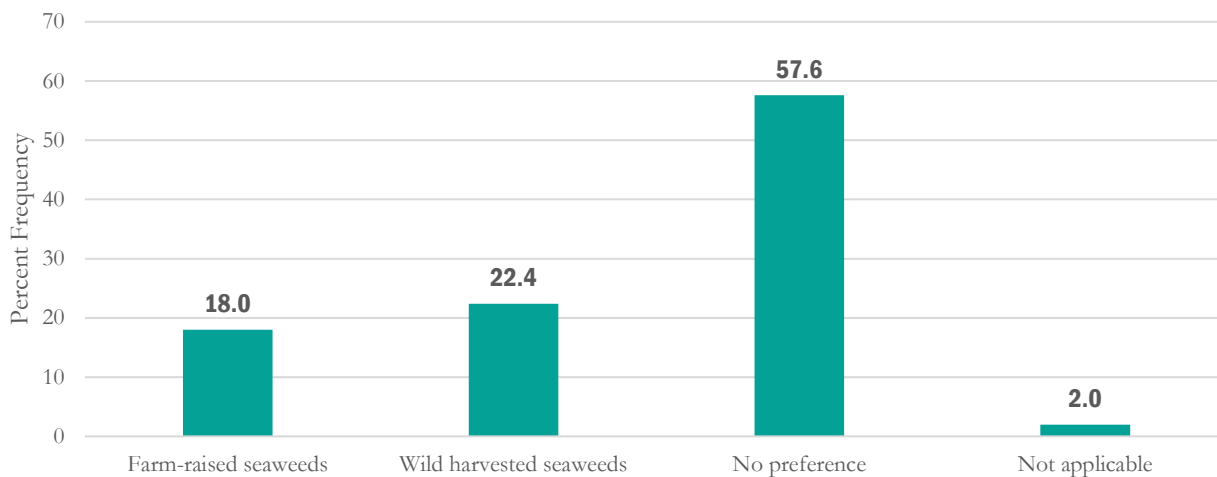


Figure 11. Consumers’ preferences for farm-raised and wild-harvested seaweeds

The survey also asked consumers about their perceptions of farmed versus wild-harvested seaweeds from four different perspectives, using a rating scale from 1 to 7, where 1 indicates poor and 7 indicates excellent. Table 3 shows the consumers’ mean ratings for farmed and wild-harvested seaweeds in each perspective and the results of two-sample t-tests for equal mean rating. Consumers believe farmed seaweeds are safer to consume and more sustainable than wild-harvested seaweeds but wild-harvested seaweeds are higher quality than farmed seaweeds. The differences between the three perspectives are statistically significant (p-values < 0.01). The difference between consumers’ perception of whether farmed or wild-harvested seaweeds have a better price (i.e., less expensive) is not statistically significant using a t-test.

Table 3. Consumers’ perceptions of farmed vs. harvested seaweeds (n=1952)

	Sample mean		Two sample t-test p-value
	Farmed	Wild harvested	
Safe to consume	5.16	5.03	0.0005
Sustainable	5.11	4.92	<.0001
Product quality	5.19	5.29	0.005
Product price	4.98	4.92	0.0593

3.3.3 Preferences for the geographic origin of seaweeds

The survey asked questions about consumers’ preferences for the geographic origin of seaweeds, including the detail they desire to know about the origin, the importance of the origin as a factor in their purchasing decisions, and their rating of seaweed product quality from various regions. Seaweed consumers answered the first two questions, and all survey participants answered the third question.

Figure 12 shows the level of detail consumers desire to know about the geographic origin of seaweed products. About 22.9% of the consumers did not desire to know the detail of the origin of their seaweed products. About 32.1% of the consumers desired to know the country of origin of their seaweed products and about 19.6% desired to know the state/province. Only about 5.6% of consumers desired to know the county. About 10% of the consumers desired to know the origin of the farm (10.2%) or the city/town (9.6%).

How much detail do you currently desire to know about the geographic origin of your seaweed products? (n=1952)

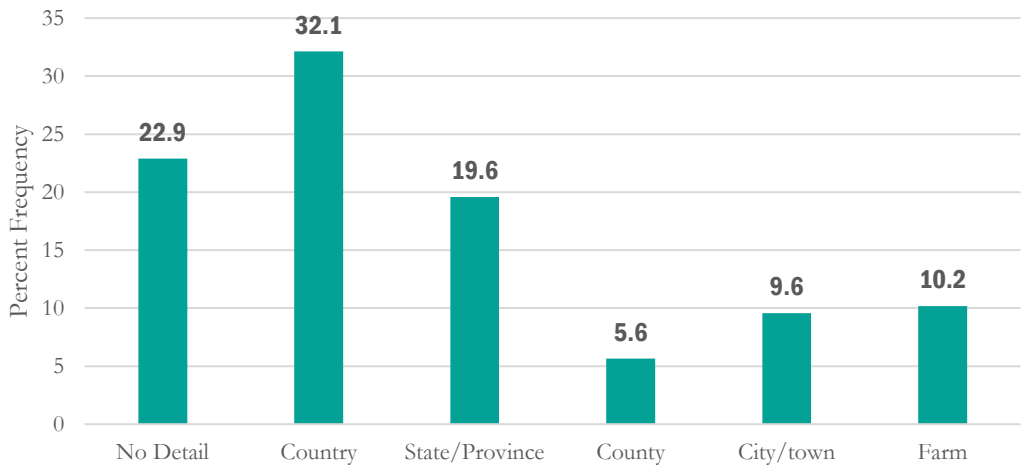


Figure 12. The detail consumers desire to know about the geographic origin of seaweed products

Figure 13 shows the importance consumers place on knowing the geographic origin of a product in their purchasing decisions. Participants rated the importance on a scale from 1 to 7 and the average rating was 4.81. About 60% of the consumers report that knowing the geographic origin is very important (scale=5-7), about 29% of the consumers see it as moderately important (scale=3-4), and about 11% feel it is not important (scale=1-2).

How much detail do you currently desire to know about the geographic origin of your seaweed products? (n=1952)

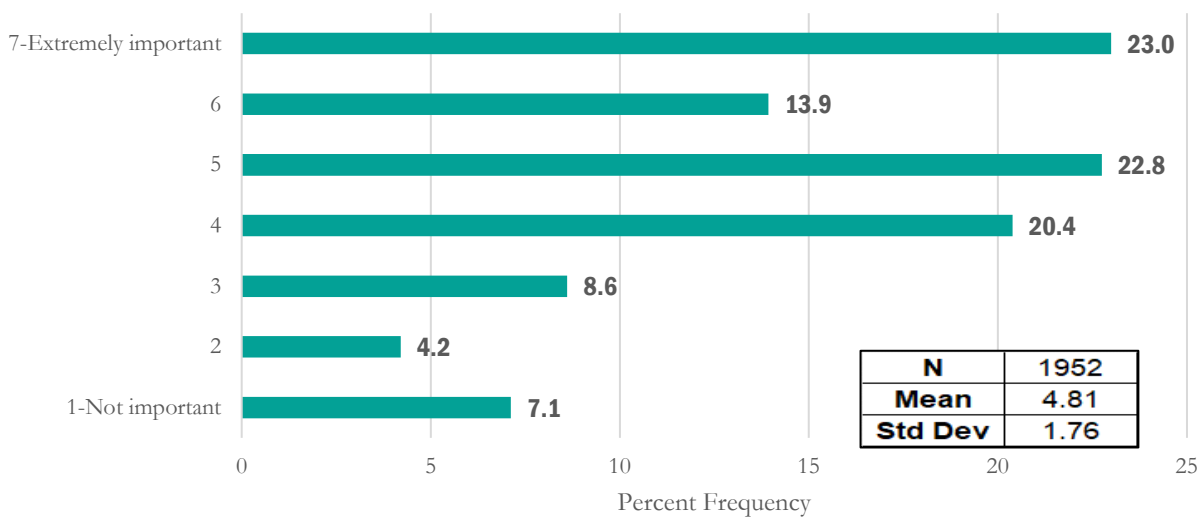


Figure 13. The importance of knowing the geographic origin in consumers' purchasing decisions

Figure 14 shows consumers' rating of quality of seaweed products from different regions. All survey participants answered this question. Consumers rated the seaweed products from North America as having the highest quality on average, followed by products from Asia, Australia, Europe, South America, and Africa.

In your opinion, how would you rate quality of seaweed products from the following regions: [1=Poor, 7=Excellent] (n=5401)

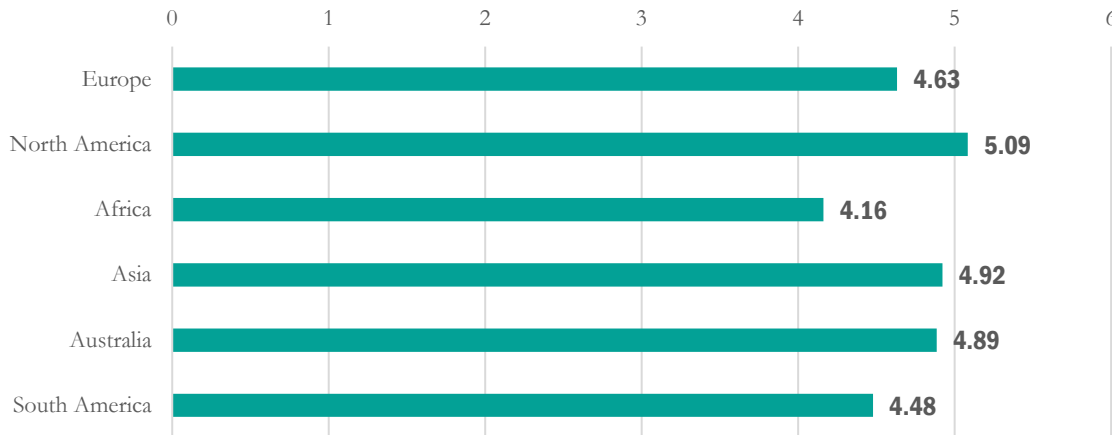


Figure 14. Consumers' rating of quality of seaweed products from different regions



3.3.4 Product attributes that may affect consumers' willingness to purchase seaweed products

The survey provided a list of seaweed product attributes and asked consumers to rate how the different attributes affect their current willingness to purchase seaweed products on a scale from 1 to 7, where 1 indicates “extremely decreases” and 7 indicates “extremely increases”. Table 4 shows consumers' average ratings of the attributes from the highest to the lowest. All the attributes have average ratings above 4, meaning that consumers believed all the listed attributes potentially increase their willingness to purchase seaweed products. The top five attributes that increased consumers' willingness to purchase seaweed products include safe for consumption, good source of vitamins and minerals, good source of fiber, taste, and low-calorie. Consumers believed these are the most important attributes that motivate them to consume seaweeds. Seaweeds that are safe for consumption is the most important attribute to the consumers. Extrinsic attributes such as impact on coastal economies, impact on marine environment, impact on water quality, and carbon capturing are also important to consumers. The gluten-free attribute was the least important attribute to consumers.

Participants were allowed to choose a “Not sure” option for this question. The survey question instructed “Select Not sure if not important.” This could have caused confusion since some consumers may have chosen “Not sure” because they did not know some listed attributes, such as “impact on coastal economies,” “impact on marine environment,” and “impact on water quality.” Consumers may also have chosen the “Not sure” option or provided a rating of 4 if they believed the attribute was not important. As a result, the “Not sure” responses may include consumers who were not sure about the attribute or believed the attribute was not important. The mean in Table 4 was calculated using the consumer responses with 1 through 7 ratings and excluded the “Not sure” answers. The response rate shows the proportion of consumer responses with a 1 through 7 ratings. The mean may not be accurate due to this issue.

Table 4. Consumers' rating of attributes that may affect their willingness to purchase seaweed products (n=5401)

Attribute	Mean	Response Rate
Safe for consumption	5.52	85.93%
Good source of vitamins and minerals	5.52	86.65%
Good source of fiber	5.39	85.30%
Taste	5.25	86.08%
Low-calorie	5.06	83.76%
Low-fat	4.99	83.13%
Impact on coastal economies	4.96	80.91%
Impact on marine environment	4.92	80.93%
Cholesterol-free	4.92	81.32%
Impact on water quality	4.89	79.00%
Carbon capturing	4.77	75.08%
Salt substitute	4.74	81.37%
Gluten free	4.53	78.62%

3.3.5 Product certifications/ indicators that may affect consumers' willingness to purchase seaweed products.

The survey also provided a list of quality certifications/ indicators and asked consumers to rate how those affect their current willingness to purchase seaweed products. Table 5 shows consumers' average ratings of the certifications/indicators from the highest to the lowest. All the certifications/indicators have average ratings above 4, meaning that consumers believed all the listed certifications/indicators potentially increase their willingness to purchase seaweed products. The U.S.-sourced certification/indicator was rated the highest, while the international sourced was lowest. This is consistent with results in Figure 14, indicating that consumers perceive the seaweed products from the U.S. are higher quality and are willing to purchase them. The certifications/indicators "Directly marketed from farm/harvester," were rated the second highest. The others were rated similarly, including certified organic, farm-raised, U.S. Atlantic coast-sourced, U.S. Pacific coast-sourced, fair-trade, small to medium-sized producers, non-GMO, wild harvest, and 3rd party certified sustainable. In this question (answered by both seaweed and non-seaweed consumers), consumers rated farmed-raised higher than wild harvest, which is inconsistent with the results in **Figure 11** that show a higher percentage of consumers prefer to buy wild-harvested seaweeds (answered by seaweed consumers only).

This question also included a "Not sure" option and the survey instructed that "Select Not sure if not important." Due to concerns described above, we followed similar steps for calculation and provided **Table 5** in a similar format as **Table 4**.

Table 5. Consumers' rating of quality certifications/indicators that may affect their willingness to purchase seaweed products (n=5401)

Certifications/indicators	Mean	Response Rate
US-sourced	5.34	83.19%
Directly marketed from farm/harvester	5.17	82.02%
Certified organic	5.09	83.34%
Farm-raised	5.08	81.28%
US Atlantic coast-sourced	5.08	78.54%
US Pacific coast-sourced	5.07	78.74%
Fair trade	5.03	78.99%
Small to medium sized producers	4.98	80.34%
Non-GMO	4.97	80.89%
Wild harvest	4.97	79.95%
3rd party certified sustainable	4.75	75.45%
Internationally sourced	4.47	77.93%

3.4 Reasons that consumers do not consume seaweeds and motivating factors that may encourage consumers to try seaweeds

As mentioned in the Data Description section, 3449 survey participants stated that they do not consume seaweeds. These consumers answered specific questions, including why they do not consume seaweeds and possible motivating factors that may encourage them to try them, among others.

3.4.1 Reasons that consumers do not consumer seaweeds

Figure 15 shows the reasons that consumers do not consume seaweeds. The top reasons include being unaware of them (38.2%), not sure how to prepare them (23.7%), and taste (20.2%). Our results indicate that educating consumers, such as disseminating general information about seaweed food products and providing recipes showing possible ways to prepare seaweed at home, might be helpful marketing strategies for the seaweed products to penetrate the market. Consumers also indicated that taste is a major reason that they do not consume seaweeds. About 12% of consumers chose availability as the primary reason, which suggests seaweed products may still be relatively new for some markets. About 7.5% of the consumers were uncertain about possible environmental contamination, which further suggests the importance of providing information to consumers and educating consumers.

This question allowed participants to select multiple items in the survey design. Participants that chose “Not sure how to prepare them” or “Uncertain about possible environmental contamination” were not allowed to select other options. The volume of consumers that chose other options might be underestimated due to this restriction.

We also note that about 4% of the consumers chose the “Other (Please specify)” category. Consumers who selected this option provided a text specification. Figure 16 shows a word cloud of consumers’ text specifications. The word cloud shows that “sound” frequently occurs, representing consumer text specifications such as “It just sounds gross,” “it just sounds nasty!” “It sounds yucky,” “doesn’t sound good,” “doesn’t sound tasty at all,” “they don’t even sound good,” etc. This finding indicates that the “seaweed” name may have negatively affected this food product. “Heard” is another word that frequently occurs in the word cloud. In the text specifications, consumers wrote “Never even heard u can eat seaweed.”, “Never heard of it”, “Never heard of eating it”, etc. These show that some consumers do not know seaweeds or do not know seaweeds as food products, indicating needs to expand marketing efforts and educate consumers.

Why do you not consume seaweeds? (n=3449)

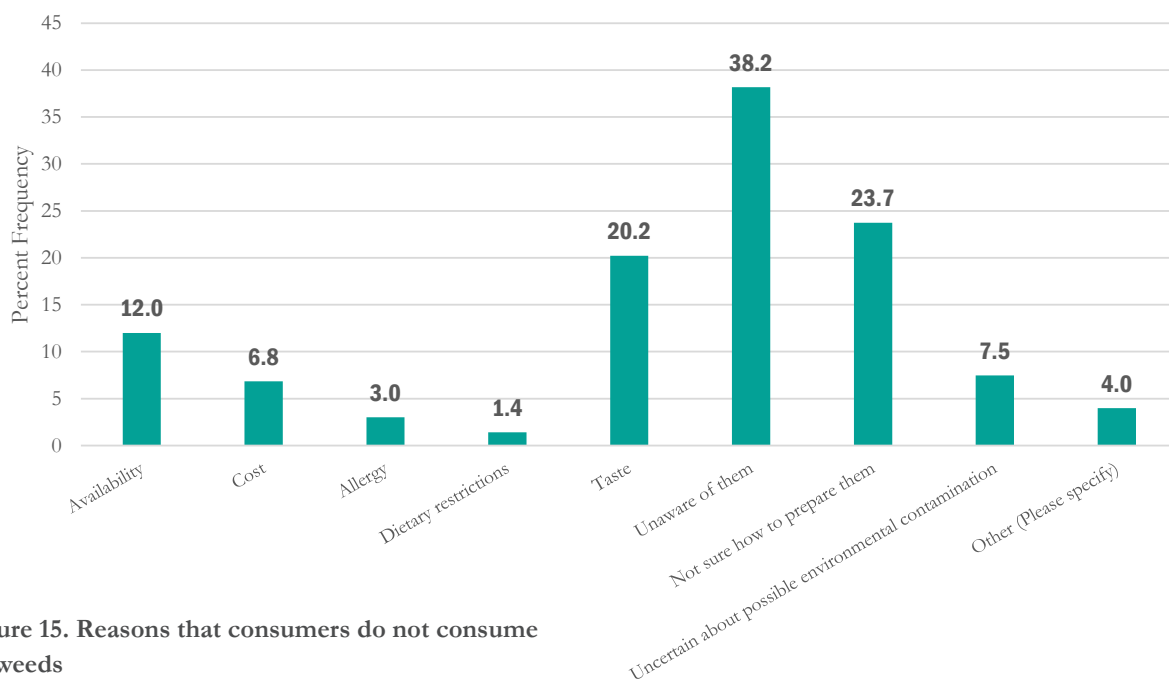


Figure 15. Reasons that consumers do not consume seaweeds

Which of the following would encourage you to try seaweeds? (n=3449)

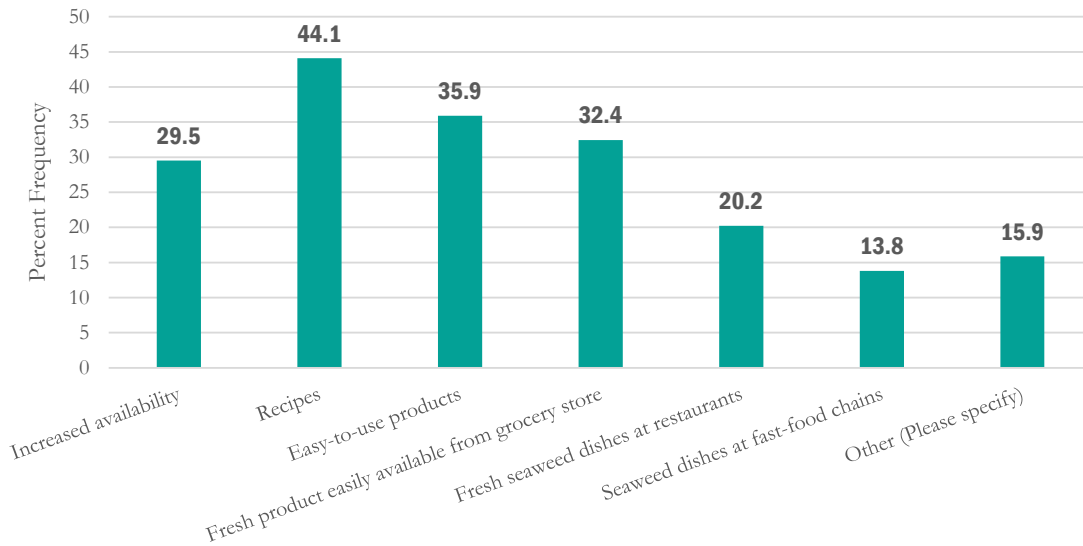


Figure 17. Methods that may encourage consumers to try seaweeds



Figure 18. Word cloud of consumers' text specification about the methods that may encourage consumers to try seaweeds

4. ECONOMETRIC MODELS

We built econometric models to investigate the relationship between a number of factors (including consumers' knowledge, perceptions, and socio-demographic information) and consumers' intentions to try new products flavored with and/or containing seaweeds and preferences for farm-raised and wild-harvested seaweeds.

4.1 Consumers' intentions to try new products flavored with/containing seaweeds and its influencing factors

An ordered logit model is built to model consumers' intentions to try new products flavored with seaweeds. In the survey, the intention question was answered by consumers (seaweed consumers and non-seaweed consumers, respectively) on a scale from 1 to 7, where 1 is extremely unlikely and 7 is extremely likely. Figure 19 shows the frequency distribution of seaweed consumers' intentions to try a new product flavored with seaweed. Figure 20 shows the frequency distribution for non-seaweed consumers.

How likely are you to try a new product this year (e.g., bread, pasta, seasonings) if it were flavored with seaweed? [1=Extremely unlikely to 7=Extremely likely] (n=1952)

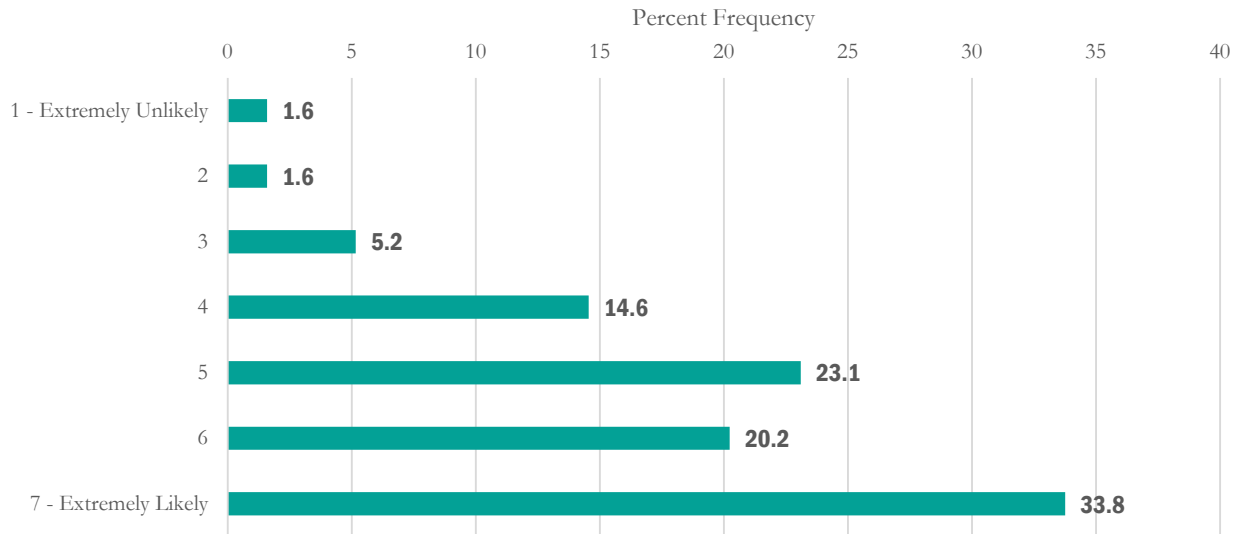


Figure 19. Frequency distribution of seaweed consumers' intentions to try a new product flavored with seaweed

How likely are you to try a new product (e.g., bread, pasta, smoothy, seasonings) if it were flavored with or contains seaweeds? [1 = Extremely unlikely to 7 = Extremely likely] (n=3449)

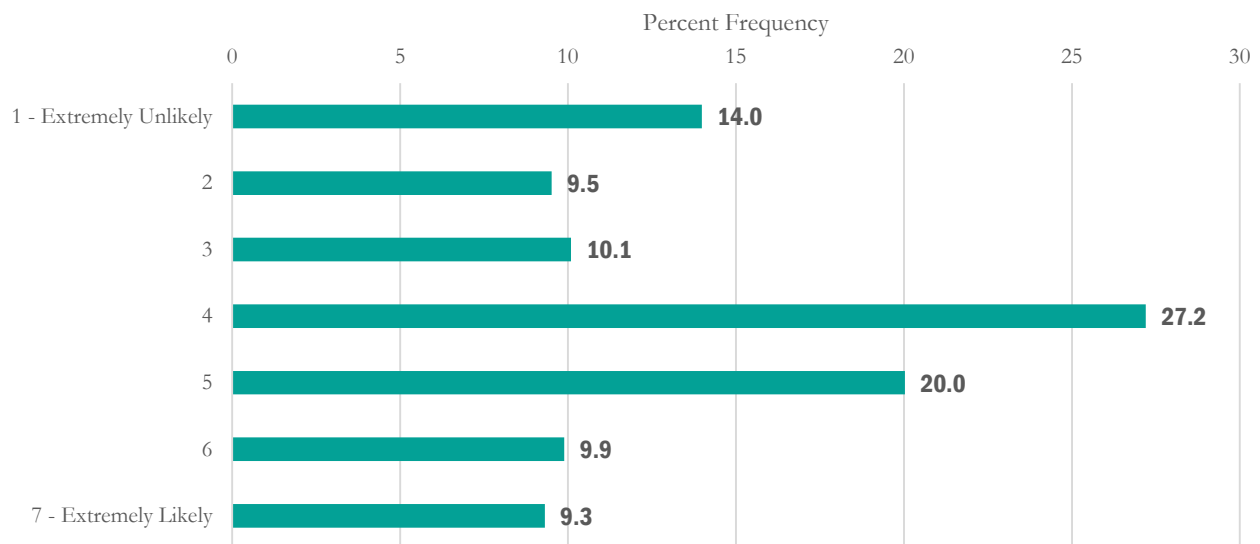


Figure 20. Frequency distribution of non-seaweed consumers' intentions to try a new product flavored with seaweed

In this analysis, we assume consumers' utility can be represented by the common random utility function with linear specifications. The utility of individual i , U_i^* , can be represented as:

$$U_i^* = x_i'\beta + \varepsilon_i \quad (1)$$

where x_i represents a vector of factors affecting the utility from purchasing the seaweed product, β are the corresponding coefficients, and ε_i represents the unobserved random component that is assumed to be logistically distributed.

We use variable Y_i to represent the consumers' responses to the purchase intention question and assumes values from 1 to 7, where 1 is extremely unlikely and 7 is extremely likely. The ordered responses represent a censored version of the consumer's true underlying utility, U_i^* . Higher levels of U_i^* indicate the consumer has a higher intention to purchase the product and lower levels mean the consumer has a lower intention to purchase it. A consumer's decision is represented by the underlying utility as:

$$Y_i = k, \text{ if } \mu_{(j-1)} < U_i^* < \mu_j \quad (2)$$

where μ_j ($j = 1, 2, \dots, 7$) indicates the utility threshold level corresponding to each purchase intention category. Particularly, $\mu_0 = -\infty$ and $\mu_7 = +\infty$.

The probability of observing a respondent choosing a particular purchase intention category is equal to the probability that their utility is within the range of the threshold levels of that category. The probability of observing a specific response $Y_i = j$, $j = 1, 2, \dots, 7$ for individual i is:

$$\begin{aligned} P(Y_i = j) &= P(\mu_{(j-1)} < U_i^* \leq \mu_j) \\ &= P(\mu_{(j-1)} < x_i'\beta + \varepsilon_i \leq \mu_j) \\ &= P(\mu_{(j-1)} - x_i'\beta < \varepsilon_i \leq \mu_j - x_i'\beta) \\ &= \frac{e^{u_j - x_i'\beta}}{1 + e^{u_j - x_i'\beta}} - \frac{e^{u_{(j-1)} - x_i'\beta}}{1 + e^{u_{(j-1)} - x_i'\beta}}, \text{ for } j = 1, 2, \dots, 7 \end{aligned} \quad (3)$$

The likelihood function is obtained by multiplying the probabilities across all respondents. Maximizing the log likelihood function provides the estimates of coefficients and the threshold levels for the ordered logit model. The exponential value of the estimated coefficient is the odds ratio, which is the ratio of the cumulative odds of the dependent variable belonging to a certain category or higher versus its belonging to the lower categories, i.e., $P(Y_i \geq j)/P(Y_i < j)$ where $j = 1, \dots, 7$. In the ordered logit model, these odds are assumed constant for any category j .

Table 6 shows the results of the ordered logit model for seaweed consumers' intentions to purchase a new product flavored with seaweeds. The summary statistics of the independent variables used in the model are presented in Table E1 in **Appendix E**. Seaweed consumers' purchase intentions are positively and significantly affected by age, gender, and education level. The odds of having a greater intention to purchase a new product flavored with seaweeds are 1.02 times higher when the consumer ages one year. Female consumers have greater purchase intentions than male consumers. The odds of female consumers having a greater purchase intention are 1.2 times the odds of male consumers. Consumers having a graduate or professional degree have greater purchase intentions than consumers having up to high school or GED. The odds of consumers having a graduate or professional degree are 1.44 times the odds of consumers having up to high school or GED.

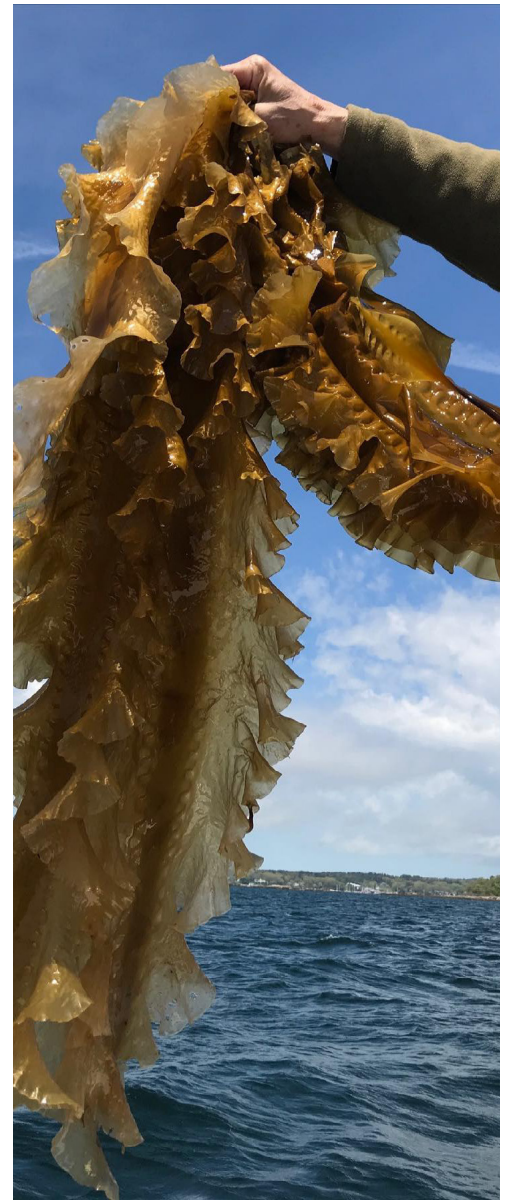
Consumers' knowledge of seaweed and perceptions of seaweed attributes, including price, quality, and availability, have a positive effect on consumers' purchase intentions. The odds of having a greater purchase intention are 1.25 times higher when the consumer's self-rated seaweed knowledge (i.e., subjective knowledge) score is one point higher. The odds of having a greater purchase intention are 1.11 times higher when the consumer's objective seaweed knowledge (i.e., the quiz) score is one point higher. The odds of having a greater purchase intention are 1.49, 1.58, and 1.10 times higher when the consumer's perception of the price, quality, and availability of seaweed products available is one point higher, respectively. These results indicate that it could be critical for seaweed farmers and producers to find channels to help consumers improve their seaweed-related knowledge and build positive perceptions of seaweed products.

Table 6. Results of ordered logit model for seaweed consumers' intentions to purchase a new product flavored with seaweeds

Variable	Coefficients	Std. Err.	Odds Ratio
<i>northeast</i>	-0.217	0.1397	0.80
<i>south</i>	-0.075	0.1245	0.93
<i>west</i>	-0.179	0.1307	0.84
<i>age</i>	0.018***	0.0033	1.02
<i>female</i>	0.184**	0.0911	1.20
<i>other</i>	1.291	0.7992	3.64
<i>edu_col</i>	-0.078	0.1428	0.92
<i>edu_asso</i>	0.020	0.1601	1.02
<i>edu_ba</i>	0.162	0.1386	1.18
<i>edu_grad</i>	0.363**	0.1660	1.44
<i>inc</i>	0.000	0.0009	1.00
<i>primary</i>	0.122	0.1317	1.13
<i>n_hbsize</i>	0.027	0.0370	1.03
<i>d_child</i>	0.008	0.1141	1.01
<i>knowledge_sub</i>	0.224***	0.0455	1.25
<i>knowledge_obj</i>	0.103***	0.0203	1.11
<i>per_price</i>	0.397***	0.0431	1.49
<i>per_quality</i>	0.458***	0.0477	1.58
<i>per_availability</i>	0.093**	0.0384	1.10
μ_1	2.175	0.3564	
μ_2	2.929	0.3342	
μ_3	4.079	0.3238	
μ_4	5.546	0.3292	
μ_5	7.006	0.3433	
μ_6	8.199	0.3565	
Number of obs	1952		
Log likelihood	-2662.035		

Note: ***p<0.01, **p<0.01, *p<0.1.

Table 7 shows the results of the ordered logit model for non-seaweed consumers' intentions to purchase a new product flavored with seaweeds. The summary statistics of the independent variables used in the model are presented in Table F1 in Appendix F. Consumers' purchase intentions are positively affected by geographic location, household income, primary food shoppers, and children in the household. The purchase intentions for non-seaweed consumers in the West are significantly different from those in the Midwest. The odds of non-seaweed consumers in the West having a greater purchase intention are 1.21 times the odds of non-seaweed consumers in the Midwest. The coefficient on income is positive and statistically significant at the 5% level, but the magnitude is small, indicating trivial economic meaning. Primary food shoppers for the household have a higher purchase intention. The odds of primary food shoppers having a higher purchase intention is 1.4 times the odds of consumers sharing food shopping equally with other household members. Households with children have a higher purchase intention. The odds of households with children having a greater purchase intention are 1.22 times the odds of households without children.



Consumers' seaweed knowledge affects their purchase intentions positively. The odds of having a greater purchase intention are 1.64 times higher when the consumer's self-rated seaweed knowledge (i.e., subjective knowledge) score is one point higher. The distinct reasons why consumers do not consume seaweeds impact purchase intentions. Consumers who do not consume seaweeds due to availability, are unaware of seaweed products, and are not sure how to prepare seaweeds have higher purchase intentions to try a new product flavored with seaweeds, which indicates that making seaweed products available to consumers and helping them gain related knowledge may be effective strategies to expand the seaweed consumer pool. The odds ratios for these three variables are 2.34, 1.29, and 1.54, respectively. The consumers who do not consume seaweeds due to allergy, taste, and uncertainty about possible environmental contamination have lower intentions to try a new seaweed flavored product. The odds ratios for these variables are 0.67, 0.48, and 0.57, respectively. The odds ratio for taste is the lowest, meaning the odds of consumers who do not consume seaweeds due to taste having a higher purchase intention is 0.48 times the odds of consumers for whom taste is not the reason why they do not consume seaweeds. It is likely challenging for seaweed businesses to gain consumers who do not like the taste of seaweed.



Table 7. Results of ordered logit model for non-seaweed consumers' intentions to purchase a new product flavored with seaweeds

Variable	Coefficients	Std. Err.	Odds Ratio
<i>northeast</i>	0.162*	0.094	1.18
<i>south</i>	0.130*	0.078	1.14
<i>west</i>	0.194**	0.095	1.21
<i>age</i>	-0.003	0.002	1.00
<i>female</i>	-0.082	0.063	0.92
<i>other</i>	0.535	0.818	1.71
<i>edu_col</i>	0.150*	0.086	1.16
<i>edu_asso</i>	-0.005	0.104	0.99
<i>edu_ba</i>	0.081	0.093	1.08
<i>edu_grad</i>	0.015	0.116	1.02
<i>inc</i>	0.002**	0.001	1.00
<i>primary</i>	0.334***	0.075	1.40
<i>n_hhsize</i>	0.023	0.032	1.02
<i>d_child</i>	0.196**	0.098	1.22
<i>knowledge_sub</i>	0.493***	0.036	1.64
<i>rea_availability</i>	0.849***	0.108	2.34
<i>rea_cost</i>	0.043	0.131	1.04
<i>rea_allergy</i>	-0.403**	0.195	0.67
<i>rea_diet</i>	-0.225	0.269	0.80
<i>rea_taste</i>	-0.726***	0.104	0.48
<i>rea_unaware</i>	0.252**	0.106	1.29
<i>rea_prepare</i>	0.430***	0.122	1.54
<i>rea_environment</i>	-0.562***	0.154	0.57
<i>rea_other</i>	-0.810***	0.190	0.44
μ_1	-0.657	0.208	
μ_2	0.047	0.207	
μ_3	0.608	0.207	
μ_4	1.870	0.209	
μ_5	2.974	0.213	
μ_6	3.866	0.217	
Number of obs	3449		
Log likelihood	-6254.1334		

Note: ***p<0.01, **p<0.01, *p<0.1.

4.2 Consumers' preferences for farm-raised and wild-harvested seaweeds and its influencing factors

We built a multinomial logit model built to connect consumers' preferences for farm-raise and wild-harvested seaweeds with several selected influencing factors. Under the random utility model mentioned earlier, the utility of choice j for the i th individual facing J choices (i.e., farm-raised seaweeds, wild-harvested seaweeds, or no preference) is

$$U_{ij} = \mathbf{z}_i' \theta_j + \varepsilon_{ij} \quad (4)$$

where \mathbf{z}_i denotes the vector of individual-specific characteristics, θ_j is the vector of coefficients, and ε_{ij} is the error term following Gumbel (type 1 extreme value) distribution. The individual chooses choice j that provides him or her the maximum utility U_{ij} . Thus, the model can be represented by the probability of the individual i choosing j , which is

$$Prob(Y_i = j | z_i) = P_{ij} = \frac{\exp(z_i' \theta_j)}{\sum_{j=1}^J \exp(z_i' \theta_j)} \quad (5)$$

The log-odds of individual i choosing option j versus k is

$$\ln \left[\frac{P_{ij}}{P_{ik}} \right] = z_i' (\theta_j - \theta_k) = z_i' \theta_j \quad \text{if } k = 0 \quad (6)$$

Given that the probabilities of choices add up to 1, only $J-1$ parameters are needed for estimation. We normalize the parameter $\theta_0 = 0$ and name the corresponding choice as a base category. Therefore, the coefficient θ_j can be interpreted as the marginal change of the log-odds for a unit change in variable \mathbf{z}_i . Accordingly, $\exp(\theta_j)$ is the marginal change of odds ratio for a unit change in variable \mathbf{z}_i .

Table 8 shows the results of the multinomial logit model for seaweed consumers' preferences for farm-raised seaweeds. The summary statistics of the independent variables used in the model are presented in Table G1 in Appendix G. We use the "No preference" category as the base of the model. For the "prefer to purchase farm-raised seaweeds" category, consumers' knowledge positively affects their preference for farmed seaweeds, while consumers' ratings on the safety, sustainability, and quality of wild-harvested seaweeds negatively affect their preference. The coefficient on the subjective knowledge is significant at the 5% level. This indicates that consumers' seaweed knowledge increase by one point, the odds of them preferring farm-raised (over having no preference between farmed and wild-harvested) increase by 1.2 ($=e^{0.184}$). The coefficient on consumers' perceptions of the safety of farmed seaweeds is positive and significant at the 5% level, indicating that consumers' perceptions of farmed seaweeds' safety increase by one point, the odds of them preferring farmed seaweeds increase by 1.15 ($=e^{0.137}$). The coefficients on consumers' perceptions of the safety, sustainability, and quality of the wild-harvested seaweeds are all negative and significant at the 1% or 5% levels. These indicate that for one-point increase in consumers' corresponding perception scores, the odds of them preferring farmed seaweeds decrease by 0.82 ($=e^{-0.202}$), 0.88 ($=e^{-0.124}$), 0.83 ($=e^{-0.187}$), respectively. In summary, if consumers perceive farmed seaweeds safer and wild-harvested ones less safe, less sustainable, and having lower quality, they are more likely to prefer farmed seaweeds.

For the "prefer to purchase wild-harvested seaweeds" category, consumers' rating on wild-harvested seaweed safety positively affects their preference for wild-harvested seaweeds, while their ratings on farmed seaweed safety, quality and price negatively affect their preference. The coefficient on consumers' perceptions of wild-harvested seaweed safety indicates that for one point-increase in consumers' perception score, the odds of them preferring wild-harvested increase by 1.32 ($=e^{0.273}$). The coefficients on consumers' perceptions of the safety, quality, and price of farmed seaweeds are negative and significant at the 1% level, indicating for each one-point increase in the corresponding perception score, the odds of preferring wild-harvested decrease by 0.72 ($=e^{-0.335}$), 0.81 ($=e^{-0.205}$), 0.87 ($=e^{-0.141}$), respectively. In summary, if consumers perceive farmed seaweeds less safe, having lower quality, and more expensive and wild-harvested ones safer, they are more likely to prefer wild-harvested seaweeds.

Since only 2% of the consumers chose the "Not applicable" category, the information from this category is limited, and we do not explain the results for this category.

Table 8. Results of multinomial logit model for seaweed consumers' preferences for farm-raised and wild-harvested seaweeds

Variable	Prefer to purchase farm-raised seaweeds		Prefer to purchase wild-harvested seaweeds		Not applicable	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
<i>northeast</i>	0.178	0.214	-0.080	0.196	1.679**	0.784
<i>south</i>	0.297	0.192	-0.147	0.175	0.881	0.787
<i>west</i>	0.159	0.204	-0.060	0.181	1.147	0.781
<i>age</i>	-0.007	0.005	0.008*	0.005	-0.006	0.012
<i>female</i>	0.019	0.139	0.230*	0.128	0.660*	0.372
<i>other</i>	-0.164	1.164	-12.821	528.405	-12.787	1499.917
<i>edu_col</i>	-0.051	0.217	0.086	0.203	-0.731	0.482
<i>edu_asso</i>	0.087	0.245	0.235	0.229	-0.963	0.637
<i>edu_ba</i>	-0.318	0.214	0.059	0.200	-1.309**	0.540
<i>edu_grad</i>	0.058	0.243	-0.123	0.242	-0.329	0.578
<i>inc</i>	0.002	0.001	-0.003*	0.001	-0.001	0.003
<i>primary</i>	-0.225	0.206	-0.074	0.189	0.018	0.451
<i>n_hbsize</i>	-0.015	0.054	0.054	0.050	0.169	0.140
<i>d_child</i>	0.172	0.171	0.095	0.161	-0.878*	0.476
<i>knowledge_sub</i>	0.184***	0.068	0.112*	0.064	-0.263	0.182
<i>knowledge_obj</i>	0.048	0.031	-0.003	0.029	-0.274***	0.089
<i>safe_farmed</i>	0.137**	0.061	-0.335***	0.055	-0.308*	0.163
<i>safe_wild</i>	-0.202***	0.056	0.273***	0.058	0.151	0.156
<i>sustainable_farmed</i>	0.054	0.058	-0.093*	0.054	-0.141	0.158
<i>sustainable_wild</i>	-0.124**	0.054	0.066	0.052	-0.110	0.142
<i>quality_farmed</i>	0.012	0.064	-0.205***	0.059	-0.296	0.184
<i>quality_wild</i>	-0.187***	0.058	0.146**	0.059	-0.081	0.161
<i>price_farmed</i>	0.062	0.057	-0.141***	0.054	0.118	0.152
<i>price_wild</i>	-0.059	0.052	-0.043	0.049	0.210	0.153
<i>_cons</i>	-0.380	0.467	-0.057	0.445	-0.193	1.308

Note: ***p<0.01, **p<0.01, *p<0.1.



5. CONCLUSIONS AND SUGGESTIONS

We analyzed the consumer survey data using descriptive statistics, data visualization, and econometric models to reveal meaningful insights into consumer perceptions, preferences, and purchase intentions for seaweed products in this report. Our insights will help seaweed farmers and producers with potential business strategies for producing and promoting seaweed products to meet U.S. consumers' needs, expanding the seaweed consumer pool, and penetrating the seaweed market. We summarize major findings and provide several suggestions below.

Our survey categorized consumers into two groups: seaweed consumers and non-seaweed consumers. The two groups have different socio-demographic characteristics. Seaweed consumers live near or closer to the coast, are younger, have more education and household income, and have larger household sizes and more children in the household.

Seaweed consumers knowledge of seaweeds and perceptions of seaweed quality, price, and availability positively affect their intentions to try a new product flavored with seaweeds. Seaweed farmers and producers that can find channels to help these consumers improve their seaweed-related knowledge and build positive perceptions of seaweed products may expand their customer base. Knowledge is also an influencing factor for whether non-seaweed consumers try a new product flavored with seaweeds. Non-seaweed consumers have unique reasons for not consuming seaweeds, several of which are associated with their intentions to try a new seaweed product. The consumers who do not consume seaweeds due to availability, are unaware of seaweed products, and are not sure how to prepare them have higher purchase intentions to try a new product flavored with seaweeds. On the other hand, the consumers who do not consume seaweeds due to allergy, taste, or were uncertain about the possibility of environmental contamination have lower intentions to try a new seaweed flavored product. Our results suggest that expanding seaweed product availability, providing information to consumers to help them learn seaweed products, and educating consumers about how to prepare seaweeds at home may be effective marketing strategies.

Consumers indicated that specific seaweed attributes and product certifications are important for their purchase decisions. The most important seaweed attribute to consumers is whether the products are safe for consumption. Most consumers desire to know the origin of a seaweed product at the country level. Consumers believe seaweed products from the U.S. have the highest quality and indicated in our survey that a U.S.-sourced certification is most important to increase their willingness to purchase while an internationally sourced certification is least important. These results indicate the potential for expanding domestic seaweed aquaculture production and U.S. seaweed market. Consumers indicated that products directly marketed from the farm/harvester is an important factor to increase their willingness to purchase, which suggests an possible effective marketing channel.

Seaweed consumers believe farmed seaweeds are safer and more sustainable than wild-harvested seaweeds, but wild-harvested seaweeds are higher quality. Consumers do not perceive the price of farmed and wild-harvested seaweeds to be significantly different. Most of the seaweed consumers stated they had no preference between farm-raised and wild-harvested seaweeds. More seaweed consumers stated they prefer wild-harvested seaweeds than consumers that prefer farmed seaweeds. Having more knowledge of seaweed products help consumers build their preference for farmed seaweeds. Consumers are more likely to prefer farmed seaweeds if they believe wild-harvested seaweeds are comparatively less safe, less sustainable, and have a lower quality. These results further emphasize the importance of educating consumers and improving their knowledge about the differences between farmed and wild-harvested seaweeds in relation to safety, sustainability, and quality in order to promote seaweed aquaculture and farmed seaweed products.

Our survey also provides valuable insights into non-seaweed consumers. Consumers do not eat seaweeds primarily because of a lack of awareness, uncertainty on how to prepare them, and their taste. Some consumers find the "seaweed" name to sound unappealing, which is the reason that they do not want to try them. Consumers believe that recipes, easy-to-use products, and fresh products easily available from grocery stores will motivate them to try seaweeds. Consumers that are particularly deterred by the taste of seaweed report that an improvement of the taste will motivate them to try seaweeds. Our results indicate that seaweed products are relatively new to some markets and that there is a necessity to expand marketing efforts to educate consumers. Seaweed farmers and producers may consider attractive names/brands for their products and avoid using "weeds". Seaweed farmers could also explore alternative recipes to improve the taste of their products and make those recipes available to seaweed consumers.

Appendix A. Histograms of household's average monthly expenditure on food

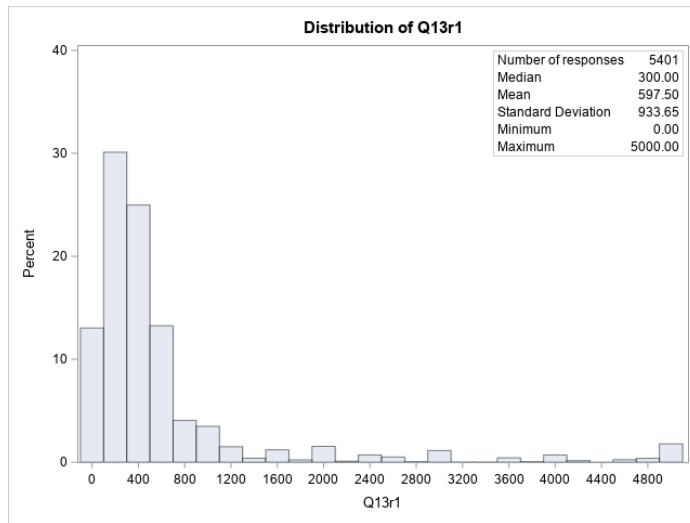


Figure A1. Household's average monthly expenditure on food at food stores (e.g., big box stores, convenience stores, farmer's markets, gourmet markets, local organic markets, meat markets, seafood markets/trucks/stands, and supermarkets) [Numeric fill in – max \$5000]

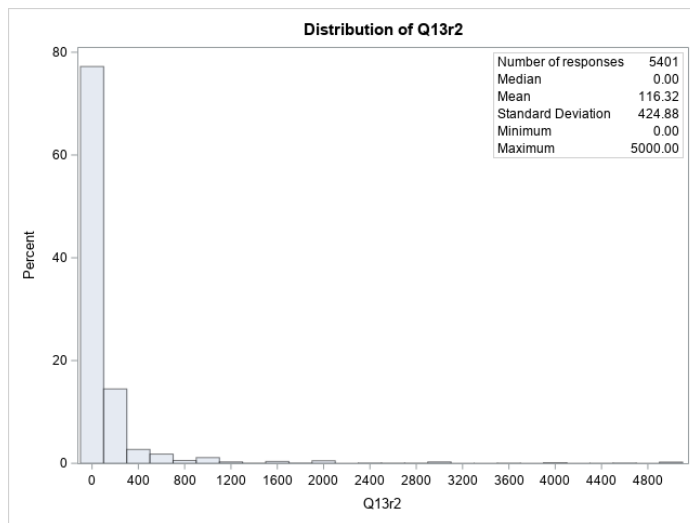


Figure A2. Household's average monthly expenditure on food at mail order and other home delivery services [Numeric fill in – max \$5000]

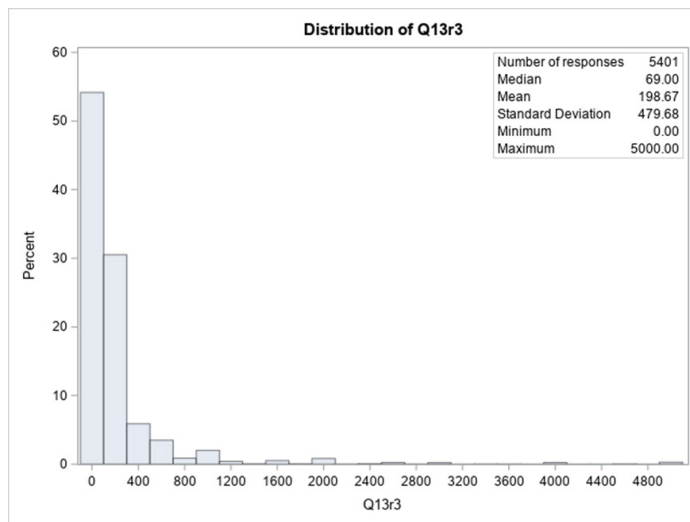


Figure A3. Household's average monthly expenditure on food at restaurants and prepared takeout [Numeric fill in – max \$5000]

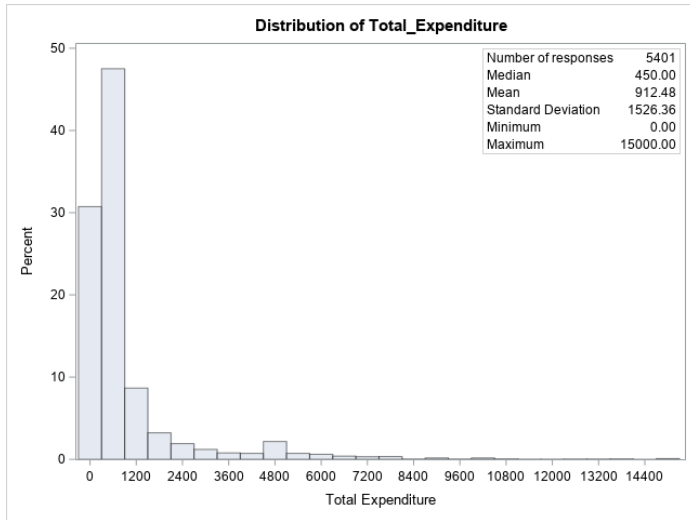


Figure A4. Household's average monthly total expenditure on food

Appendix B. Histograms of household's expenditure in 2020 on all seaweed products

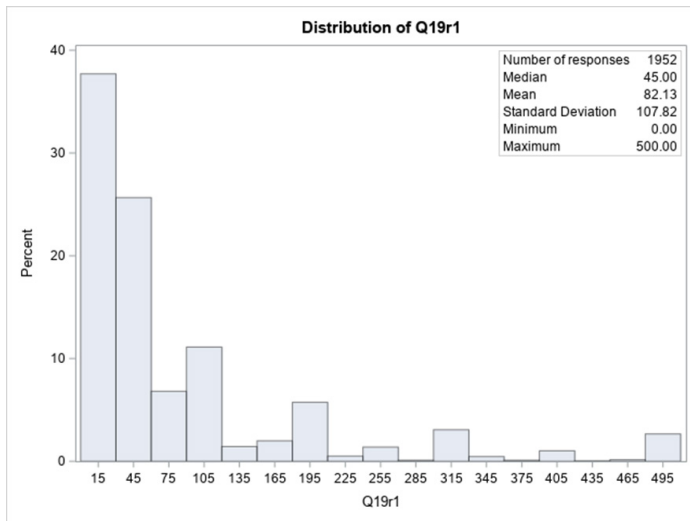


Figure B1. Household's expenditure in 2020 on all seaweed products at food stores [\$0-\$500+]

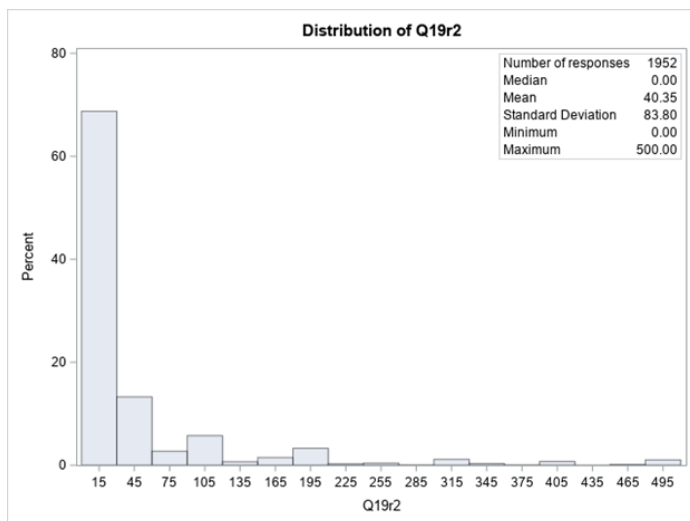


Figure B2. Household's expenditure in 2020 on all seaweed products at mail order and other home delivery services [\$0-\$500+]

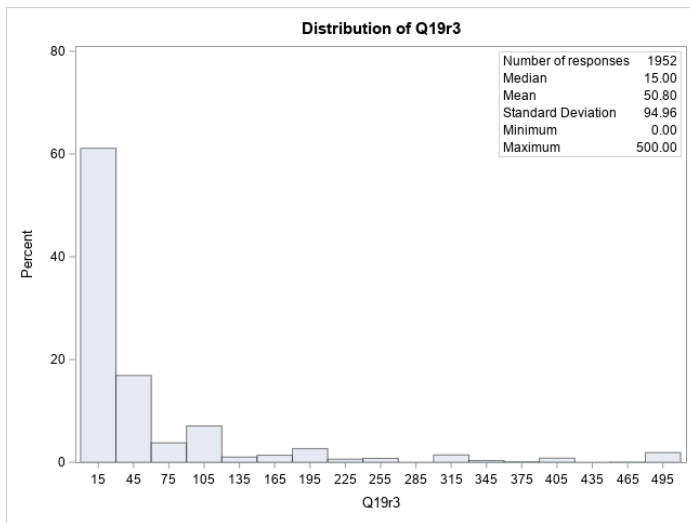


Figure B3. Household's expenditure in 2020 on all seaweed products at restaurants [\$0-\$500+]

Appendix C. Histograms of household's expenditure in 2020 on non-food seaweed-based products

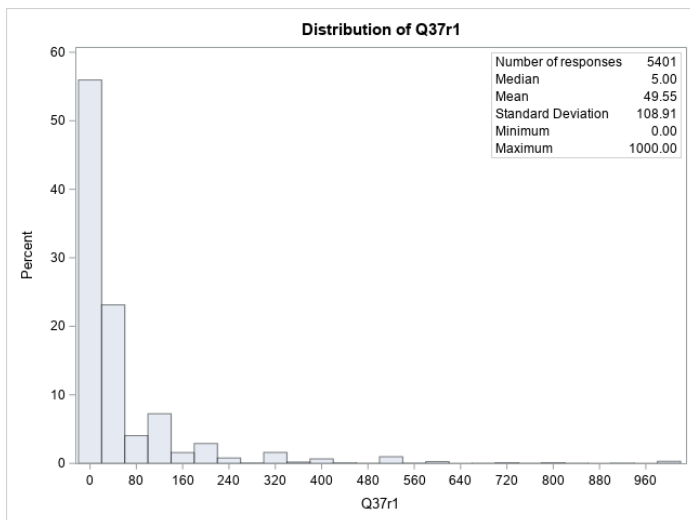


Figure C1. Household's expenditure in 2020 on seaweed-based skincare products [\$0-\$1000]

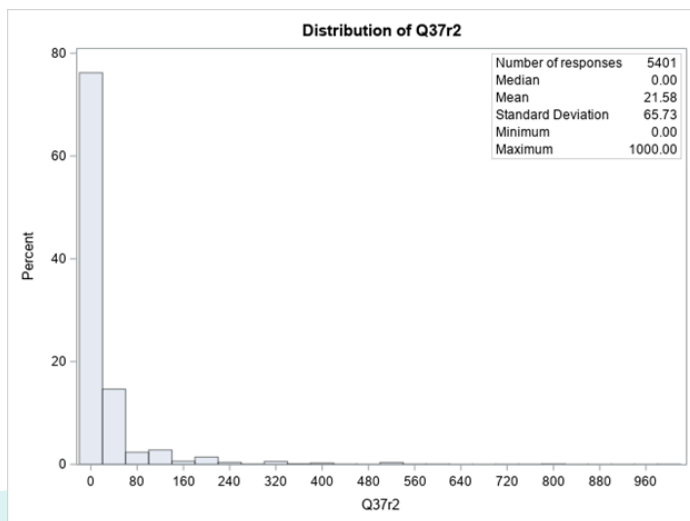


Figure C2. Household's expenditure in 2020 on seaweed-based fertilizer products [\$0-\$1000]

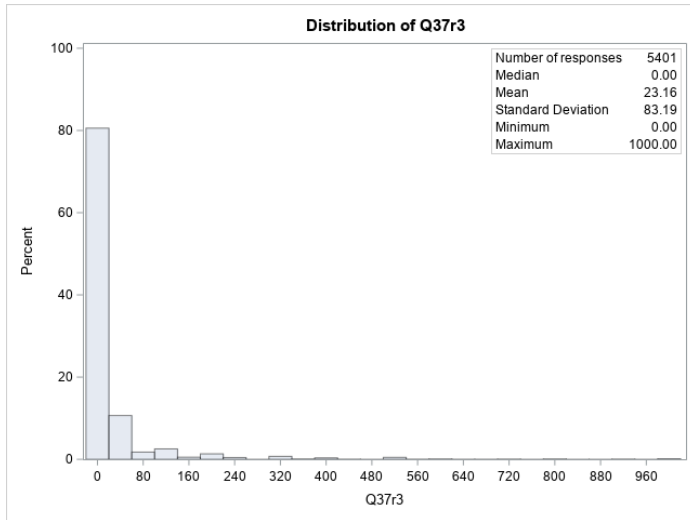


Figure C3. Household's expenditure in 2020 on seaweed-based animal feed supplement products [\$0-\$1000]

Appendix D. Histograms of household's expenditure in 2020 on seaweed products in different product forms

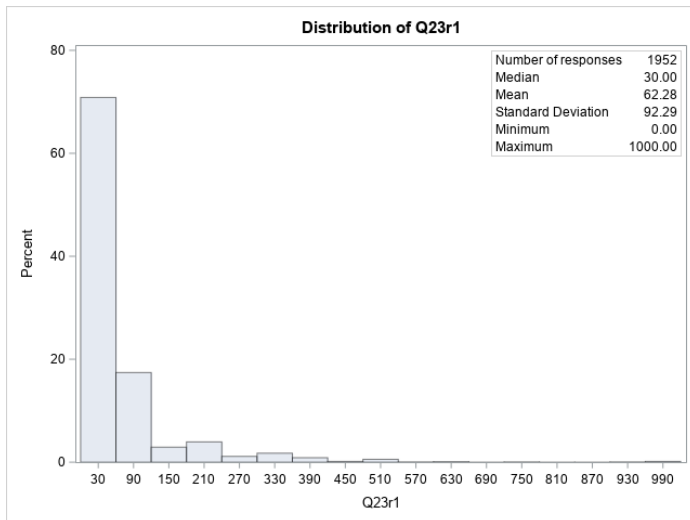


Figure D1. Household's expenditure in 2020 on dried seaweed products (whole leaf, flakes, granules, sprinkles, seasoning, flavor enhancer, nutritional supplement, sushi sheets, snacks, etc.) [Numeric fill in – max \$1000]

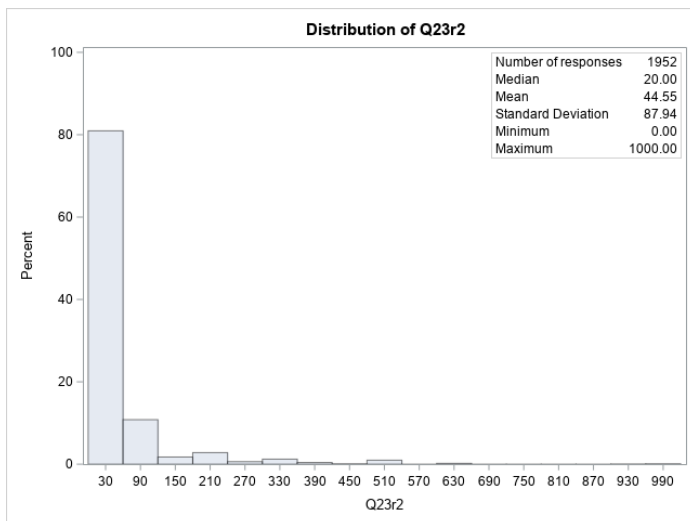


Figure D2. Household's expenditure in 2020 on fresh seaweed products (salad, whole leaf, etc.) [Numeric fill in – max \$1000]

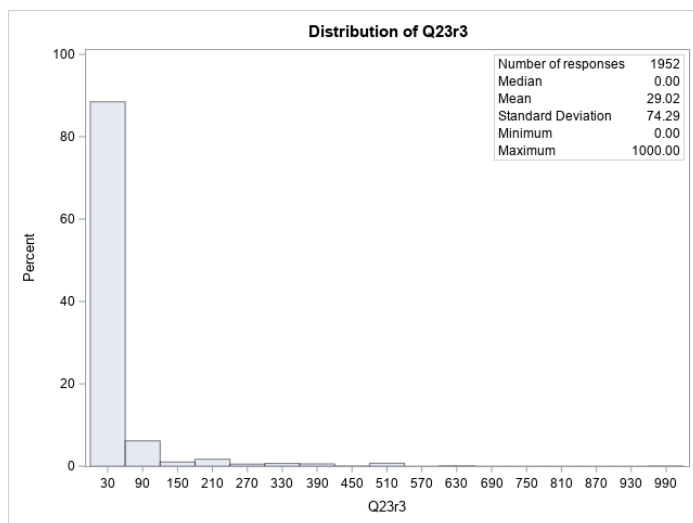


Figure D3. Household’s expenditure in 2020 on frozen seaweed products (cubes, noodles, whole leaf, etc.) [Numeric fill in – max \$1000]

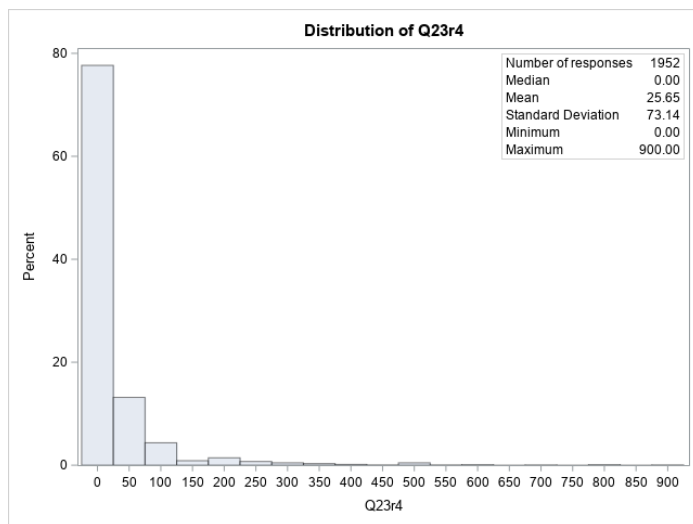
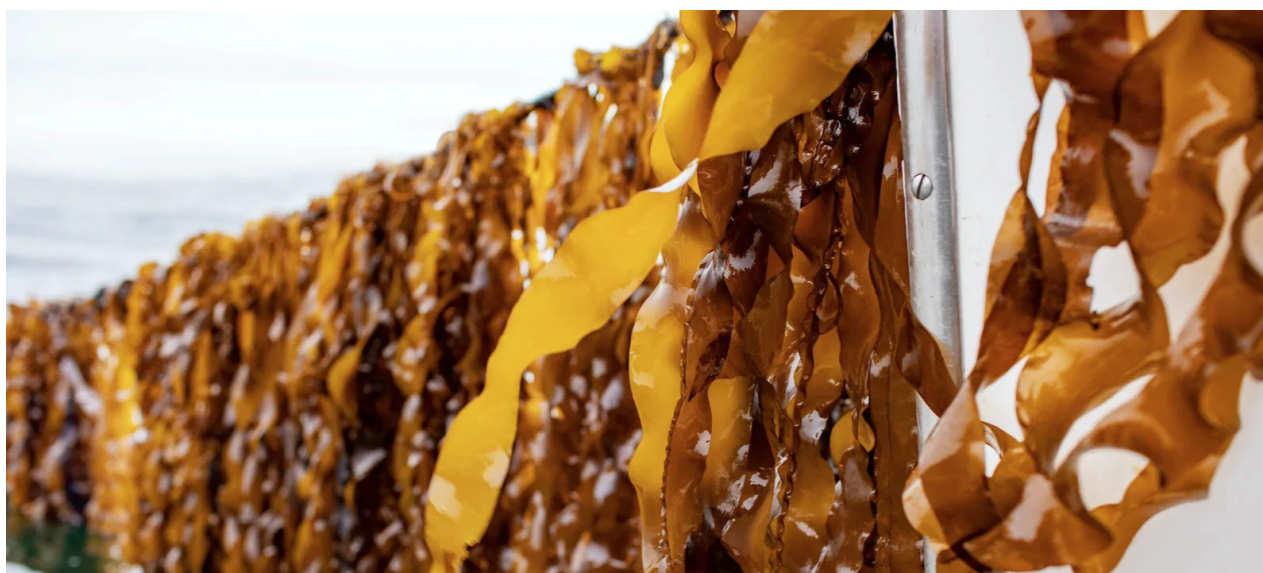


Figure D4. Household’s expenditure in 2020 on Canned/preserved seaweed products (chutney, puree, etc.) [Numeric fill in – max \$1000]



Appendix E.

Table E1. Summary statistics of variables used in the ordered logit model for seaweed consumers' intentions to purchase a new product flavored with seaweeds (n=1952)

Variable	Description	Mean	Std. Dev.	Min	Max
<i>northeast</i>	=1 if in northeast; =0 otherwise	0.2008	0.4007	0	1
<i>midwest</i>	=1 if in midwest; =0 otherwise	0.1742	0.3794	0	1
<i>south</i>	=1 if in south; =0 otherwise	0.3453	0.4756	0	1
<i>west</i>	=1 if in west; =0 otherwise	0.2797	0.4490	0	1
<i>age</i>	age in years	39.4708	14.5552	18	86
<i>female</i>	=1 if female; =0 otherwise	0.4360	0.4960	0	1
<i>male</i>	=1 if male; =0 otherwise	0.5615	0.4963	0	1
<i>other</i>	=1 if chose "Other" or "Prefer not to answer" for gender; =0 otherwise	0.0026	0.0506	0	1
<i>edu_hs</i>	=1 if high school or GED; =0 otherwise	0.1563	0.3632	0	1
<i>edu_col</i>	=1 if some college, no degree; =0 otherwise	0.2054	0.4041	0	1
<i>edu_asso</i>	=1 if associate degree; =0 otherwise	0.1255	0.3314	0	1
<i>edu_ba</i>	=1 if Bachelor's degree; =0 otherwise	0.3176	0.4657	0	1
<i>edu_grad</i>	=1 if graduate or professional degree; =0 otherwise	0.1952	0.3964	0	1
<i>inc</i>	annual household income, in \$1,000	78.9613	56.8041	7.5	225
<i>primary</i>	=1 if primary food shopper in the household; =0 otherwise	0.8745	0.3314	0	1
<i>joint</i>	=1 if share food shopping equally with members in the household; =0 otherwise	0.1255	0.3314	0	1
<i>n_hbsize</i>	number of members in the household	3.0092	1.5204	1	10
<i>d_child</i>	=1 if children present in the household; =0 otherwise	0.4928	0.5001	0	1
<i>knowledge_sub</i>	subjective knowledge of seaweed aquaculture	3.0256	1.3003	1	5
<i>knowledge_obj</i>	objective knowledge of seaweed products	4.6460	2.6575	0	9
<i>per_price</i>	perceptions of price of available seaweed products	5.1532	1.4406	1	7
<i>per_quality</i>	perceptions of quality of available seaweed products	5.5856	1.2746	1	7
<i>per_availability</i>	perceptions of availability of available seaweed products	5.0087	1.5588	1	7

Appendix F.

Table F1. Summary statistics of variables used in the ordered logit model for non-seaweed consumers' intention to purchase a new product flavored with seaweeds (n=3449)

Variable	Description	Mean	Std. Dev.	Min	Max
<i>northeast</i>	=1 if in northeast; =0 otherwise	0.1772	0.3819	0	1
<i>midwest</i>	=1 if in midwest; =0 otherwise	0.2464	0.4310	0	1
<i>south</i>	=1 if in south; =0 otherwise	0.4010	0.4902	0	1
<i>west</i>	=1 if in west; =0 otherwise	0.1754	0.3804	0	1
<i>age</i>	age in years	50.5866	17.2094	18	86
<i>female</i>	=1 if female; =0 otherwise	0.5216	0.4996	0	1
<i>male</i>	=1 if male; =0 otherwise	0.4769	0.4995	0	1
<i>other</i>	=1 if chose "Other" or "Prefer not to answer" for gender; =0 otherwise	0.0014	0.0381	0	1
<i>edu_hs</i>	=1 if high school or GED; =0 otherwise	0.2749	0.4465	0	1
<i>edu_col</i>	=1 if some college, no degree; =0 otherwise	0.2404	0.4274	0	1
<i>edu_asso</i>	=1 if associate degree; =0 otherwise	0.1316	0.3381	0	1
<i>edu_ba</i>	=1 if Bachelor's degree; =0 otherwise	0.2247	0.4174	0	1
<i>edu_grad</i>	=1 if graduate or professional degree; =0 otherwise	0.1284	0.3346	0	1
<i>inc</i>	annual household income, in \$1,000	55.9488	47.0266	7.5	225
<i>primary</i>	=1 if primary food shopper in the household; =0 otherwise	0.7686	0.4218	0	1
<i>joint</i>	=1 if share food shopping equally with members in the household; =0 otherwise	0.2314	0.4218	0	1
<i>n_hbsize</i>	number of members in the household	2.4004	1.3340	1	10
<i>d_child</i>	=1 if children present in the household; =0 otherwise	0.2427	0.4288	0	1
<i>knowledge_sub</i>	subjective knowledge of seaweed aquaculture	1.6915	0.9711	1	5
<i>rea_availability</i>	availability is the reason not consuming seaweeds	0.1200	0.3250	0	1
<i>rea_cost</i>	cost is the reason not consuming seaweeds	0.0684	0.2525	0	1
<i>rea_allergy</i>	allergy is the reason not consuming seaweeds	0.0302	0.1710	0	1
<i>rea_diet</i>	diet restrictions is the reason not consuming seaweeds	0.0142	0.1184	0	1
<i>rea_taste</i>	taste is the reason not consuming seaweeds	0.2021	0.4016	0	1
<i>rea_unaware</i>	unaware of them is the reason not consuming seaweeds	0.3818	0.4859	0	1
<i>rea_prepare</i>	not sure how to prepare them is the reason not consuming seaweeds	0.2372	0.4254	0	1
<i>rea_environment</i>	uncertain about possible environment contamination is the reason not consuming seaweeds	0.0748	0.2631	0	1
<i>rea_other</i>	having other reasons not consuming seaweeds	0.0397	0.1953	0	1

Appendix G.

Table G1. Summary statistics of variables used in the multinomial logit model for seaweed consumers' preferences for farm-raised and wild-harvested seaweeds (n=1952)

Variable	Description	Mean	Std. Dev.	Min	Max
<i>northeast</i>	=1 if in northeast; =0 otherwise	0.2008	0.4007	0	1
<i>midwest</i>	=1 if in midwest; =0 otherwise	0.1742	0.3794	0	1
<i>south</i>	=1 if in south; =0 otherwise	0.3453	0.4756	0	1
<i>west</i>	=1 if in west; =0 otherwise	0.2797	0.4490	0	1
<i>age</i>	age in years	39.4708	14.5552	18	86
<i>female</i>	=1 if female; =0 otherwise	0.4360	0.4960	0	1
<i>male</i>	=1 if male; =0 otherwise	0.5615	0.4963	0	1
<i>other</i>	=1 if chose "Other" or "Prefer not to answer" for gender; =0 otherwise	0.0026	0.0506	0	1
<i>edu_hs</i>	=1 if high school or GED; =0 otherwise	0.1563	0.3632	0	1
<i>edu_col</i>	=1 if some college, no degree; =0 otherwise	0.2054	0.4041	0	1
<i>edu_asso</i>	=1 if associate degree; =0 otherwise	0.1255	0.3314	0	1
<i>edu_ba</i>	=1 if Bachelor's degree; =0 otherwise	0.3176	0.4657	0	1
<i>edu_grad</i>	=1 if graduate or professional degree; =0 otherwise	0.1952	0.3964	0	1
<i>inc</i>	annual household income, in \$1,000	78.9613	56.8041	7.5	225
<i>primary</i>	=1 if primary food shopper in the household; =0 otherwise	0.8745	0.3314	0	1
<i>joint</i>	=1 if share food shopping equally with members in the household; =0 otherwise	0.1255	0.3314	0	1
<i>n_hbsize</i>	number of members in the household	3.0092	1.5204	1	10
<i>d_child</i>	=1 if children present in the household; =0 otherwise	0.4928	0.5001	0	1
<i>knowledge_sub</i>	subjective knowledge of seaweed aquaculture	3.0256	1.3003	1	5
<i>knowledge_obj</i>	objective knowledge of seaweed products	4.6460	2.6575	0	9
<i>safe_farmed</i>	perceptions of safety of farmed seaweed products	5.1609	1.6075	1	7
<i>safe_wild</i>	perceptions of safety of wild harvested seaweed products	5.0297	1.5673	1	7
<i>sustainable_farmed</i>	perceptions of sustainability of farmed seaweed products	5.1148	1.5761	1	7
<i>sustainable_wild</i>	perceptions of sustainability of wild harvested seaweed products	4.9221	1.6047	1	7
<i>quality_farmed</i>	perceptions of quality of farmed seaweed products	5.1865	1.4870	1	7
<i>quality_wild</i>	perceptions of quality of wild harvested seaweed products	5.2853	1.4856	1	7
<i>price_farmed</i>	perceptions of price of farmed seaweed products	4.9841	1.5076	1	7
<i>price_wild</i>	perceptions of price of wild harvested seaweed products	4.9201	1.5730	1	7