

SEA Maine Global Opportunities Assessment



For:
Anne Schlitt
aschlittt@mdf.org
Maine Development Foundation

By:
Gregor MacAskill
gregmacaskill@gardnerpinfold.ca
Gardner Pinfold Consultants

December, 2023

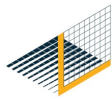
Gardner Pinfold
Consultants



ABOUT THIS REPORT

This report was commissioned by the Seafood Economic Accelerator for Maine (SEA Maine) to examine key opportunities across the marine living resource sector. The report was prepared independently therefore any errors or omissions are the responsibility of the authors. This report should not be used as the sole basis for making particular investment decisions. The report contains forward-looking statements and projections that must be read with caution recognizing inherent risks and uncertainties.

Gardner Pinfold
Consultants



www.gardnerpinfold.ca
(902) 297-6000

Cover Photo credit: SEA Maine (www.seamaine.org)

Copyright © 2023 Gardner Pinfold Consultants Inc.

TABLE OF CONTENTS

I	Background	- 1 -
1.1	Introduction.....	- 1 -
1.2	Goal and objectives	- 1 -
1.3	Approach.....	- 2 -
II	Results Overview.....	- 4 -
III	Opportunity Profiles.....	6
3.1	People – Maine Seafood Council.....	6
3.2	People – Talent and workforce development.....	8
3.3	People – Market growth and diversification.....	11
3.4	Place – Fleet de-carbonization	15
3.5	Place – Transportation & logistics.....	18
3.6	Place – Ice production and cold storage.....	20
3.7	Place – Aquaculture site access	22
3.8	Product – Land-RAS finfish aquaculture.....	24
3.9	Product – Atlantic Menhaden and Alternative bait	27
3.10	Product – On-demand Fishing Gear.....	30
3.11	Product – Biodigestion system	33
3.12	Product – American eel (market sized).....	35
3.13	Product – Green crab	37
3.14	Product – Marine seaplants.....	40
3.15	Product – Non-biological residuals	42
IV	Making Choices	44
	Appendix A – Workshop Opportunity Choices	45
A.1	Morning sessions	45
A.2	Afternoon session	45
A.3	Key results	46

I Background

1.1 Introduction

The SEA Maine New Opportunities and Emerging Technologies Subcommittee required a comprehensive assessment of opportunities that supports the long-term sustainability of Maine's marine living resource sector. This assessment profiles the essence of each major opportunity including the resources needed, benefits of implementation, timelines, and key information sources that will help galvanize partners to move these opportunities forward.

This opportunities assessment parallels the SEA Maine Roadmap development. The best opportunities are featured among the Roadmap actions that help grow the marine resource sector. The combined opportunities profiled in this report could create nearly 5,500 construction and development jobs, and nearly 2,300 permanent jobs for the sector. Similarly, the construction and development would add \$718 million in gross domestic product (GDP) for Maine, and operations would add about \$237 million to the State.

Those involved in Maine's marine resource sector will each see opportunities that they are most connected to, and there are inter-connections between opportunities so putting them all together in one document supports collaboration and coherent approaches. This will support healthy discussions around priorities, the order in which priorities should be pursued, and how to move forward in the most coordinated and efficient way. Each opportunity builds on Maine's competitive advantages and strengths, and in many cases will help position Maine as a national and international leader in marine resource products.

1.2 Goal and objectives

The goal of this report is to comprehensively assess marine living resource sector opportunities and specifically to meet the following objectives:

- **Examine all types of opportunities** – including opportunities to: develop existing markets, create new markets, grow or harvest new species, develop new (added-value) products, develop technologies to improve existing industry practices, technologies that lead to new products and practices, improve and leverage Maine's competitive advantages.
- **Profile each opportunity** – including the size and growth of local, national, and international markets, the key market players, distribution channels, trade flows, capital requirements,

- value-added and revenue analysis, regulatory requirements, and skills/training gaps;
- **Assess the market environment** – the supply and demand environment that each opportunity faces and how Maine leaders will be competitive; and
- **Evaluate time horizons** – for each opportunity considering the key requirements of each one.

1.3 Approach

A series of three workshops in 2022 and 2023 hosted by SEA Maine identified a number of opportunities across the marine resource sector. Even some sector challenges were framed as opportunities where a combination of good timing and converging interests signaled that these could be addressed. Some of the major opportunities were taken up by the SEA Maine sub-committees and there are now foundation reports examining feasibility and implementation options. This report brings together the best opportunities by building on the SEA Maine body of work to date, and the following outlines the approach that underpins the findings in this report:

- **Literature review** – Reviewing the body of work by SEA Maine to date as well as other key resources in the public domain;
- **Interviews** – Engaging key informants through workshops and interviews to better understand the opportunities and key elements needed to advance these;
- **Scale of opportunities** – Analysis of each opportunity examines the magnitude of resources (e.g. capital and operational requirements) needed, and the potential scale of economic impacts expected from implementation (e.g. jobs, added-value to the Maine economy); and
- **Business contacts** – Identifying business to business connections that will be useful for each opportunity to leverage expertise, technology providers, and sector experience.

Each opportunity profile identifies sources for transparency and to support further investigation. There are a few concepts below that appear throughout the report that deserve a brief explanation.

- **Roadmap themes** – The opportunities analysis was undertaken in support of the Roadmap so the three themes of “people”, “place”, and “product” are also used in this report. These are not rigid and distinct themes since they are inter-connected, and many opportunities can be linked to all three themes.
- **Capital** – Most opportunities involve an initial investment to complete planning (e.g. feasibility, design, approvals) and purchase of assets (e.g. land, buildings, equipment, vehicles) in order to get started. In most cases, this will be led by private sector interests but there are catalytic roles for public support,

- especially where public interests are involved such as waste and pollution reduction, de-carbonization, and economic development to create jobs for areas and populations that will benefit greatly.
- **Operations** – All opportunities have an operational phase that generates annual activity for the foreseeable future, but in a couple cases there may be an evaluation phase after which the operational model is finalized and a transition may take place.
 - **Job impacts** – The SEA Maine economic impact analysis report is referenced in relation to estimated numbers of jobs created by an opportunity. The estimates include full-time, part-time, and seasonal jobs as well as direct, indirect, and induced jobs. The direct jobs are associated with the opportunity itself, while indirect jobs are created in the supply-chain for the opportunity, and induced jobs result from the household spending by those employed in the direct and indirect activities. The SEA Maine economic impact report provides more detail. In some cases, specific economic impact estimates are available or developed for an opportunity and alternative sources of information are noted. The economic impacts are expenditure-based rather than revenue-based, so profits may not be fully reflected.
 - **Added-value impacts** – As for job impacts, the same sources of economic impacts information are used for estimating added-value impacts. This refers to gross domestic product (GDP) and again includes direct, indirect, and induced impacts.
 - **Investment** – Capital and operational costs discussed in this report are often viewed as investments, while the revenues or benefits may be viewed as the “returns” on investment. However, readers are cautioned that this report is only intended to provide a sense of scale for each opportunity and there is not necessarily a direct linkage between the two. First, the jobs and value-added (economic impacts) are not directly comparable to capital or operations spending. Spending must be compared to revenues for a sense of return on investment. Also, portions of the “investment” and “benefits” may be linked to the private sector and other portions are linked to the public sector. It is the responsibility of each stakeholder to examine opportunities from their own perspective to determine potential “return on investment”.
 - **Baseline** – Some aspects of the opportunities are already in motion where permits and approvals, land acquisition, and construction are already underway. Other opportunities are about to launch or could be in the coming months. The financial and economic analysis in this report adopts two key perspectives, namely: 1) all opportunities are assessed as if they have not yet been implemented, and 2) the year 2022 is considered the baseline for all financial and economic valuations. This means that a future evaluation (e.g. in 2025) can compare the future marine resource sector state to the baseline year. Commercial fishery landings, aquaculture production, residuals processing, jobs, added-value, and other statistics can be tracked to evaluate progress.

II Results Overview

The following table shows the key attributes of each opportunity and further explanation is provided following the table.

Report Order	Opportunity	Roadmap Theme	Capital expenditure	Jobs	Value-added	Operations expenditure	Jobs	Value-added	Time (yrs)	Risk	Locations rating 1-10
1	Maine Seafood Council	People	0	0	0	750,000	5	875,000	3	Low	1
2	Talent and workforce	People	15,000	0	0	165,000	150	9,000,000	2	Med	10
3	Market growth & diversification	People	0	0	0	200,000	431	25,840,000	2	Med	10
4	Fleet de-carbonization	Place	4,000,000	39	3,700,000	0	0	0	10	Med	5
5	Transport and logistics	Place	0	0	0	185,000	na	na	2	Low	10
6	Ice production and cold storage	Place	306,000	na	na	0	na	na	2	Low	3
7	Aquaculture access	Place	0	0	0	300,000	57	3,000,000	3	Low	10
8	Land RAS finfish	Product	1,000,000,000	5,200	686,000,000	250,000,000	1,117	167,000,000	4	Low	3
9	Alternative bait	Product	0	0	0	200,000	400	20,000,000	3	Med	6
10	On-demand gear	Product	500,000	48	3,900,000	0	41	4,000,000	5	Med	2
11	Biodigestion of residuals	Product	8,000,000	61	5,500,000	2,500,000	24	2,200,000	3	Low	2
12	American eel	Product	10,000,000	52	7,200,000	1,500,000	14	1,300,000	3	Low	1
13	Green crabs	Product	200,000	2	150,000	150,000	4	125,000	2	Low	1
14	Marine seaplants	Product	6,000,000	46	4,125,000	1,875,000	18	1,650,000	3	Low	2
15	Non-biological residuals	Product	10,000,000	45	7,000,000	2,000,000	20	1,600,000	3	Low	1

Notes:

- Capital expenditure refers to a one-time investment in property, equipment, licenses, or other assets.
- Operations are annual and on-going investments and benefits in terms of labor, materials, supplies, services, and other consumables. For some opportunities this occurs for a short-period outlined in “Next Steps” within the opportunity profiles, and for other cases it may continue for the long-term.
- Jobs and value-added are the estimated economic impacts that result from the capital and operations investments.
- Investments may involve public and private sector, therefore economic impacts (benefits) may not be simply attributable to the investments shown.
- “Locations” is a rating from 1-10 where 1= a single entity/location, and 10=many/state-wide.

The results table above is designed to support planning and prioritizing opportunity initiatives. The results provide a sense of: scale in terms of capital and operations investments required, level of returns in terms of jobs and added-value to the economy, and time horizons for realizing each opportunity. In general, these opportunities are all feasible and substantially beneficial for Maine reflecting the essential criteria for inclusion in the list of priority opportunities. Some opportunities may stand-alone (e.g. American eel), while others should move forward in parallel (e.g. Maine Seafood Council, and Talent and workforce). The key results for three opportunities are interpreted briefly below to highlight important distinctions to be aware of:

- **Maine Seafood Council** – is an opportunity that requires public support, but should be industry-driven. It is a foundational piece that supports a number of the other opportunities and, to some extent, supports all sector opportunities in the long-run. It is not the kind of opportunity that provides a “return on investment” per se, it creates organizational capital (capacity) for the sector to move initiatives forward, keep sector members connected, and address challenges in a coordinated fashion.
- **Talent and Workforce** – is a prime example of public and private sectors contributing to the same goal. Here it is important to recognize the “returns” in the form of jobs filled and added-value created are not just the result of the capital and operations investment shown in the table. Realizing the projected workforce growth will also rely on private sector businesses continuing to succeed and support more jobs, posting job openings, conducting hiring processes, training and maintaining those workers. The public sector role described in this report as an opportunity is the role of catalyst where sector promotion, linking businesses to pools of potential recruits, and other online resources to help coordination are things that private businesses cannot (easily) do on their own.
- **Land RAS finfish** – is an opportunity that is already in motion and is almost entirely driven by private investment. Maine can be supportive in some ways, but the conditions for success are largely shaped by market forces, and the strengths of the businesses to execute their project plans. It is easily the largest development cluster in the sector so this is a key opportunity for the overall sector growth and benefits to the State.

Each opportunity is unique so care should be taken in ranking or prioritizing these. Some have benefits beyond economic impacts such as climate mitigation with fleet electrification, addressing invasive species with green crab harvest, reducing landfill waste with new residuals processing, or protection of species at risk with on-demand ropeless gear. Some of these other benefits may even be primary drivers for certain opportunities. To a large extent all opportunities deserve to go forward, but some should be pursued before others, while others may unfold at their own pace. The next section provides more detailed profiles of each opportunity to help consider these factors more closely.

III Opportunity Profiles

Each opportunity profile in this section includes a: concise overview statement, opportunity description, market environment, estimates for opportunity finances and economic impacts (benefits), timeline for next steps, and key information sources.

3.1 People – Maine Seafood Council

Overview

There is an opportunity to create a Maine Seafood Council that expands on the recommendations in A Seafood Promotional Council for Maine. In addition to the “promotional” core of the Council, there is a need to continue other SEA Maine initiatives that go beyond promotion. The Council will become the “voice” of the seafood sector in numerous ways and will need to develop relations with governments, the public, and many private sector actors. The Council will serve as a vehicle for continuing the cross-cutting supports for people, place, and products in the seafood sector. Since lobster is well-served by the existing Maine Lobster Marketing Collaborative (MLMC) and its’ partners, the new Maine Seafood Council would work closely with those lobster partners, but remain focused on all other species. A \$750,000–\$1 million budget is a realistic goal to support 3–4 staff and the required costs of marketing and promotion, office, professional services, and travel.

Opportunity description

The Maine Seafood Council would meet the most pressing need for promotion and marketing of Maine Seafood products. This requires at least two (2) dedicated staff to represent all seafood products other than lobster, with a sufficient budget for trade shows, travel, marketing and promotion activities, and a mandate from a board of directors representing the seafood sector. Two (2) more staff are ideally needed to build the hub and voice of the seafood sector (aside from lobster). This entails communication, coordination of resources within and outside the State, supporting sector members with challenges, media and government relations, and continuing many of the initiatives that SEA Maine has moved forward. It makes sense to combine these functions in a financially stable organization dedicated to these objectives, and capitalize on the opportunities that might otherwise lose momentum without persistent staff holding responsibility. This should build on the foundation of assets and capacity already developed by DMR for a branding and promotion program.

Market environment

Supply – The Maine Seafood Council will represent Maine seafood suppliers in a highly competitive domestic market versus other leading seafood states. The majority of U.S. East Coast states have similar organizations including MA, RI, MD, VA, NC, SC, and FL. The Alaska Seafood Marketing Initiative (AMSI) is also widely recognized for its impact. The international competition is also intense both in U.S. markets where other countries compete for sales, and in overseas markets. Differentiating Maine products and making evidence-based claims about superior products and quality from Maine will require a concerted and sustained effort.

Demand – There is strong domestic and international demand for the advantages Maine offers to seafood markets. Maine’s story of traditional and sustainable production from clean northern waters resonates with consumers and major buyers. Building on Maine’s national recognition for lobster, it

will be critical to promote Maine's key species, modern capture and culture production methods both in marine waters and on land, and elevate Maine products in the marketplace. Maine will be well-positioned with a brand committed to trusted regulatory oversight and product traceability, superior quality, sustainability, and innovation for a future focused on low-carbon foods.

Finances and economics

Finances – Maine DMR supported some of these functions during and after the pandemic with a larger budget, so the following is a conservative estimate. Supporting at least four (4) staff and operational budgets for office, travel, promotion, media and government relations, and industry support will require \$750,000 to \$1 million. This could be all or mostly grant funding at first (2 years) for establishment and proof of concept, then industry would need to contribute.

Economics – Many of the economic benefits are attached to the marketing and promotion that opens markets and improves prices for Maine suppliers, workforce development, supporting small businesses to scale up, working with the public and local governments on working waterfront challenges, and coordinating resources (grants, programs) that will help the sector. The economic impacts will be cross-cutting and substantial, though difficult to estimate.

Next steps

Year 1 – Use Phase II funding opportunity to establish the Council with staff, office, funding and reporting arrangements to continue initiatives flowing from SEA Maine and partners. Review DMR promotion assets and approaches to transfer key components. Work closely with the MLMC for consistency and alignment. Work with one organization, such as Coastal Enterprise Inc., for organizational support during establishment.

Year 2 – Deploy full programs based on a communications and marketing plan, with performance metrics that help track efficient and effective use of resources to support Maine seafood sales, jobs, and market success.

Year 3 – Evaluate Council performance to determine where improvements or changes are possible. Explore potential mechanisms for industry funding contribution.

Key sources

- Pentallact and Merritt Carey, 2022. A Seafood Promotional Council For Maine Report (online: <https://www.seamaine.org/reports-presentations/>)
- Coastal Enterprises Inc. (CEI), 2021. Maine Seafood Marketing Initiative (available upon request).

3.2 People – Talent and workforce development

Overview

There is an opportunity to address sector workforce challenges such as: fluctuating fish stocks, seasonality, changing regulations, market demand, and environmental factors. There can be labor shortages during peak seasons, as the sector requires skilled and experienced workers. Like many other sectors, the Maine seafood sector is also grappling with an aging workforce. Many experienced fishermen and seafood processors are reaching retirement age, leading to a potential loss of knowledge and expertise. This opportunity is critical to achieving at least 25% of the projected core workforce growth over the next ten years. The annual average salaries over ten years is \$9 million for an annual average of 150 jobs, which represent a cumulative 1,500 person-years of employment.

There is a need for a MLR human resource (HR) office to implement a number of programs and initiatives including: developing vocational training and apprenticeship programs, increasing promotion of careers in the seafood sector, workforce housing initiatives, collaboration with educational institutions, and streamlining regulatory processes. The sector businesses can also help attract and retain workers by modernizing facilities, automating basic tasks in order for workers to focus on more interesting work, and presenting the sector in an attractive way.

Opportunity description

Addressing workforce challenges in the Maine seafood industry requires a targeted strategy. One approach would be to establish a Maine marine living resource (MLR) human resource office linked to the proposed Maine Seafood Council to facilitate coordinated efforts among industry stakeholders, educational institutions, community representatives, and government bodies. By strategically aligning resources and expertise, the office would aim to enhance the industry's adaptive capacity to market fluctuations and further the economic resilience, sustainability, and competitiveness of the sector.

A MLR human resource office could be designed simply with one full-time human resource professional (i.e. Executive Director), a full- or part-time (shared) administrative support person, and a small or shared office space. Core funding is required for staff salaries and overhead, but projects could be funded through state and federal grants. The council would take on previously identified initiatives, including:

1. Establishing connections with groups representing traditionally marginalized populations (e.g. justice-involved, Native American populations).
2. Developing high school and college outreach programs to increase awareness of and interest in the sector.
3. Connecting with other organizations and government bodies actively engaged in workforce development.
4. Creating a central database for labor force data and current job openings in the sector.

Market environment

Supply – According to the Bureau of Labor Statistics, the Maine labor force currently totals approximately 717,000 individuals, 80% of whom are considered working age (between 25 and 64). The labor force participation rate has been on a downward trend since 2017, which is a concern for employers in the state and reflects both the ongoing exit of older workers and relatively low rates of workforce participation by the younger demographic. Most recent estimates made for SEA Maine identified a total Marine Living Resource (MLR) workforce (employed and self-employed) of 34,125 with 12,052 in central industries (solely dependent on seafood and seafood products) and 22,073 in peripheral industries (partially dependent on seafood and seafood products).

Demand – The number of jobs in MLR core sectors is expected to grow by 9%, adding 1,091 positions by the year 2033, and the number of jobs in MLR periphery sectors is expected to grow by 10.5%, adding another 2,313 over the same period (Thomas P. Miller & Associates, 2023). Reflecting strong demand for labor, workers in the MLR economy typically earn higher hourly wages than their counterparts in other sectors of Maine. Those in the MLR economy earn an average hourly wage of \$28.85, while the state average for all workers stands at \$26.21. Core occupation workers earn even more, with an average wage of \$32.96 per hour, as opposed to the \$28.27 hourly wage for those in supporting roles. Notably, most jobs in supporting roles earn below the statewide average.

Finances and economics

Finances – Developing a MLR human resource office requires about \$15,000 for initial setup and \$165,000 for ongoing operations with additional grants varying from year to year for certain projects and initiatives. The annual \$165,000 in core funding covers a director and administrative support, office rental, utilities, and office supplies.

Economics – Securing the growth of 1,091 core sector positions by 2033 (above) beyond the regular HR challenges of maintaining the current workforce will only materialize by undertaking this strategic initiative. A conservative assessment is that a MLR HR office will be critical to achieving at least one-quarter (25%) of the growth target, representing 273 jobs or about 27 jobs per year. The minimum value of the 27 jobs is expressed by the core salaries worth \$1.6 million in the first year, then accumulating (27+27 in the second year etc.), and by 2033 there are 273 jobs with \$90 million in salaries. The annual average salaries over ten years is \$9 million for an annual average of 150 jobs, which represent a cumulative 1,500 person-years of employment. This does not include the spinoff jobs and value-added associated with indirect (supply-chain) and induced (spending of salaries by employees). The total economic value to the State is even greater including the spinoff jobs and value-added that is generated.

Next steps

Year 1 – Establish terms of reference for the council; form a steering committee; develop job description / hire executive director; locate and set up office; hire admin support; conduct needs assessment, establish strategic priorities, and begin stakeholder outreach.

Year 2 – Identify funding sources and develop terms of reference for projects; apply for funding and deliver projects; continue stakeholder outreach.

Year 3 – Continue delivering projects and outreach initiatives; implement system to monitor progress of projects and the impact on the MLR workforce; collect feedback from stakeholders for continuous improvement.

Key sources

- Thomas P. Miller & Associates, 2023. Workforce Needs Assessment for SEA Maine (online: www.seamaine.org/reports-presentations/).
- Maine Aquaculture Association, 2023. Maine Aquaculture Apprenticeship Program (online : <https://maineaqua.org/apprenticeship/>).
- Educate Maine, 2021. Maine Career Catalyst Program – Aquaculture Pioneers (online: <https://mainecareercatalyst.org/aquaculture-pioneers/>).
- University of Maine, 2023. Aquaculture Research Institute (Externship Program online: <https://umaine.edu/aquaculture/education/externships-11-01-2022/> and Experiential Opportunities online: <https://umaine.edu/aquaculture/education/4701-2/>).
- Maine Department of Marine Resources, 2023. Maine Lobster Limited Entry and Apprentice Program (online: <https://www.maine.gov/dmr/fisheries/commercial/fisheries-by-species/lobsters/maine-lobster-limited-entry-and-apprentice-program>).
- The Maine Aquaculturist, 2023. Aquaculture Job Board (online: <https://www.themaineaquaculturist.org/aquaculture-job-board/>).

3.3 People – Market growth and diversification

Overview

There is an opportunity to support the seafood sector more broadly in growth and diversification of markets. This opportunity combines two commonly raised issues in the sector, and we focus on Maine lobster, crab, and oysters as key examples for two reasons. The scale of lobster landings and recent downward trend underscore the need to maximize prices and manage market risks. On the other hand, crab and oysters are examples of increasing Maine landings in recent years with opportunities for domestic and international market growth. There are other species with similar opportunities, but salmon, marine plants, American eels and others are captured within other opportunities in this report.

First, there is a need for better risk management related to: 1) anticipated climate change impacts on stock abundance for key species the sector is highly dependent upon, 2) trade tensions that could result in border closures or high tariffs, and 3) market interruptions like the pandemic that cause major shifts in marketing channels from foodservice to retail for example.

Second, there is a desire to better maximize prices and market growth by being more responsive to market signals. There can be a lag between the time negative or positive market developments are recognized by Maine suppliers. In addition, it takes time to pivot, especially if there is little or no foundation laid in alternative markets. Finally, this involves some coordination between harvesters, processors, and distributors as it may mean holding off some volume to better time markets and achieve higher prices.

In total, \$30.4 million may be captured with timely market intelligence achieving 5% higher prices for lobster, crab, and oysters. This will result in \$26 million in added-value for Maine and about 500 jobs.

Opportunity description

The industry is composed of large and small companies, many with limited resources to conduct basic market research or engage in market development. For these companies, access to basic market intelligence could prove invaluable to support their efforts to identify opportunities as well as potential obstacles to market access. This opportunity involves a first step of working with smaller businesses involved in inter-state and international exports to identify the most needed market information and analytical tools, the markets and scope of information should be captured, and how best to make this available to support decision-making. The opportunity and resulting online data portal or dashboard must address both international and domestic markets since there are some important differences.

International – U.S. economic and trade services provide market reports for important export destinations. Ideally, these reports would be modified where necessary to follow a standard format

that includes: details on seafood imports quantity and value by species and exporting nation; trend data (quantity, price, format) by species; factors affecting demand (e.g., price, freshness, place or origin, food safety); market channels and contacts; competitors; currency used for trade; exchange rate trends; tariff regime as it affects Maine; upcoming trade shows. Providing up-to-date information on implementation of trade agreements is essential.

Domestic – Similar market information, as mentioned for international markets, is needed for domestic opportunities. Greater attention to food service versus retail is needed for the U.S. market since international markets tend to focus more on commodity trade since further processing can occur in country. Import substitution should be the easiest goal for Maine seafood companies, where “buy American” compared to imported seafoods means better: quality, food safety, sustainability, fair trade, supply-chain security, avoiding international trade requirements, and “local” economic development. Market data on seafood imports is readily available to identify the scale of import substitution potential, trends, and where key importers are located. Developing contacts and maintaining market awareness should be straight-forward and simpler compared to international markets.

Market environment

Supply – Maine plays a leadership role in supplying lobster, crab, and oysters to domestic and global markets. In the last decade, Maine lobster landings peaked in 2016 at 60,149 metric tonnes (mt), but dropped 26% to 44,432 mt in 2022. Landed value of lobster per license in 2022 (\$68,862) was the lowest since 2014. The 2022 crab landings (1,341 mt) were 23% above the decade average and just 16% off the 2018 peak. The 2022 oyster landings (1,535 mt) were 21% above the decade average and just 4% off the 2020 value (2021 was the peak, but it was anomalous due to the pandemic).

Demand –

- **Lobster** – There is a minimum \$74 million per year lobster market growth opportunity in the U.S. domestic market based on the ten-year trend in state imports. The top five states with the largest growth in demand are Massachusetts (\$45 million per year), followed by Florida (\$9.2 million), New Jersey (\$33.5 million), Illinois (\$30.5 million), and Georgia (\$19.6 million). There is another \$20.3 million annual international market opportunity representing just 10% of growth in major import countries like Canada, China, Hong Kong, Italy, and South Korea. This represents about 24% of the 2022 landings value, which are declining, so there will be tension in the market pushing prices higher.
- **Oysters** – There is a minimum \$4.7 million per year oyster market growth opportunity in the U.S. domestic market based on the ten-year trend in state imports. The top five states with the largest growth in demand are California (\$1.8 million per year), followed by Massachusetts (\$1.3 million), New Jersey (\$0.4 million), Washington (\$0.3 million), and New York (\$0.1 million). There is another \$1.4 million annual international market opportunity representing just 10% of

growth in Canada, Hong Kong, and Singapore. This is about 60% more than Maine currently produces therefore it is achievable to pursue, but there will be strong competition for market share.

- **Crab** – There is a \$216 million per year crab market growth opportunity in the U.S. domestic market based on the ten-year trend in state imports across species. The top five states with the largest growth in demand are Alaska (\$67 million per year), followed by Alabama (\$60 million), Arizona (\$16 million), Arkansas (\$14 million), and California (\$11 million). Alaska is not a target opportunity for Maine producers, however the next 15 states with market growth represent a combined \$46 million per year opportunity. There is another \$11 million annual international market opportunity representing just 10% of growth mainly in Canada, China, South Korea and Singapore. This is about 100 times more than Maine currently produces, making it easier to win market share but important to seek out the highest-value markets.

Finances and Economics

Finances – The first phase involves a consultation process to develop the service involving a cross-section of key stakeholders to define the scope and approach. The second phase would be web portal/dashboard development, beta testing, and then launching the service. The two phases would require \$175,000 for setup to cover fees, travel to meet stakeholders, and expenses for website hosting and possible subscription fees. One additional year of maintenance (\$25,000) should be grant-funded until a fee for dashboard access can be devised to sustain the service based on cost and uptake.

Economics – It is difficult to estimate the value of missed opportunities to maximize the price for lobster or be caught facing a sudden market interruption without an option to pivot. Each of the following considers the value of gaining 5% on prices with better market intelligence. Gaining 5% on the landed value of lobster in 2022 is worth \$19 million and the export value per pound of landed lobster is about 1.5 times higher yielding \$29 million in total. Gaining 5% on the landed value of oysters in 2022 is worth \$420,000 and the export value per pound of landed oysters is about 2.65 times higher yielding \$1.1 million in total. The market growth for crab far exceeds Maine supply growth, so this is an ideal opportunity to seek the highest prices for all crab. Gaining 5% on the landed value of crab in 2022 is worth \$134,000 and the export value per pound of landed crab is about 1.4 times higher yielding \$188,000 in total. In total, \$30.4 million may be captured with timely market intelligence achieving 5% higher prices for lobster, crab, and oysters. This will result in \$26 million in added-value for Maine and about 500 jobs.

Next steps

Year 1 – Confirm the scope and approach with a representative cross-section of potential users of market intelligence, and get an online dashboard ready for launch.

Year 2 & 3 – Maintain the portal, gather feedback for improvement and additions, then consider a small subscription fee to sustain the service.

Key sources

- Sea Maine, 2022. Maine's Seafood Baseline Report (online: <https://www.seamaine.org/reports-presentations/>).
- SEA Maine, 2023. The Economic Impacts of the Maine Seafood Sector. (online: <https://www.seamaine.org/reports-presentations/>).
- Maine Centre for Entrepreneurs – Market Share Program (<https://mced.biz/marketshare-accel/>)
- International Trade Centre, Trade and Market Intelligence Section – Export Potential Map (<https://exportpotential.intracen.org/en/>)
- U.S. Department of Commerce, International Trade Administration – Market Diversification Tool (<https://beta.trade.gov/marketdiversification>)
- United Nations Commercial Trade Database – Global Trade Data (<https://comtradeplus.un.org/>)
- U.S. Census Bureau – U.S.A Trade Online (<https://usatrade.census.gov/index.php>)

3.4 Place – Fleet de-carbonization

Overview

There is an opportunity to support adoption of hybrid electric systems for fishing vessels that are becoming available for commercial application. The Maine Climate Action Plan combined with the U.S. Inflation Reduction Act provides a significant funding opportunity for de-carbonization initiatives. The primary focus is the medium-sized vessels (16–45 ft). The involvement of Maine boat-builders, charging station installers, and energy suppliers all contribute to local economic development as imported diesel is displaced. The environmental benefits and progressive initiative will also be viewed favourably by seafood consumers, coastal residents, and potential recruits the sector aims to attract and retain. An on-going conversion of 100 vessels per year will annually generate \$3.7 million in added-value and 39 jobs in Maine.

Opportunity description

This involves retrofits or new replacements of fishing vessels with engines that include battery-electric motors. Initially, these will be hybrid models that include a diesel-powered combustion engine. Diesel will power longer return trips to fishing grounds. Electric engines are more efficient when setting traps and moving short distances between sites. Incorporating hybrid or all-electric engines in new vessels is more effective than retrofits, mainly because efficient hull designs, LED lighting, efficient cooling systems, and hydraulic lifts can be optimized for the power system. Alternative fuels for combustion engines such as bio-diesel, hydrogen, or liquid natural gas may also play a role, especially in larger vessels and those that travel greater distances. However, hybrid systems can be still effective in larger boats up to 80 ft in length that spend more time operating diesel engines below 10% of their capacity when the diesel engines are very inefficient.¹

Charging stations on shore must also be installed to support these vessels. This will be more cost-effective where sufficient power infrastructure is already onsite or nearby. Level 3 charging stations for marine applications can restore 80% of the charge for a 275 kWh battery in 33 minutes (lobster boat scale). Next generation chargers will reduce the time to 15 minutes. Individual charging stations can be as little as \$30,000, but several may be needed at a site, and in some cases additional site work is needed to bring a grid connection to the appropriate charging location. The opportunity is more attractive with bi-directional charging, where hybrid fishing vessels can generate income when their energy storage helps balance the electrical grid².

¹ Kemp, C. and S. Atshan. 2021. Electric Power Systems for Fishing Vessels: Feasibility, Fuel Savings, and costs. Kempy Energetics.

² Rimot, 2023. BlueGrid turns marine vessels into virtual power plants for utility grade energy storage (online: <https://rimot.io/>).

With today's technology, hybrid systems will not be suitable for the entire fleet of about 7,605 vessels (see table below). A study of the lobster fleet in Nova Scotia, Canada found that a 275 kWh hybrid systems on average would work for fishing trips under 12.5 miles from shore, which account for 70% of all fishing trips³. In Maine, an on-going initiative to convert 100 vessels per year starting at several ports most suitable for charging infrastructure will demonstrate capabilities along the coast.

Maine fishing vessel counts by length of vessel (2022 license holders)

Boat Length (ft)	Count
Up to 15 ft	793
16 – 30 ft	3,353
31 – 45 ft	3,245
Over 45 ft	214
Total	7,605

Source: Maine DMR 2023 custom tabulation.

Finances and Economics

Finances – Lobster boats taking trips within 12.5 miles of shore converting to a 275 kWh battery hybrid system will involve capital costs of about \$125,000 per vessel compared to a diesel system that costs about \$75,000 (\$50,000 difference). The operational savings in energy use at \$0.17 per kWh electricity rates and diesel prices of about \$4.74/gal are about \$3,500 per year. The payback will take about 20 years, therefore an incentive of about \$30,000 per vessel is required, and vessel owners should participate in data sharing and research. Finally, the charging stations should be installed with partnerships between energy utilities and government so there are no additional costs to harvesters. Altogether about \$4 million in grants through the U.S. Inflation Reduction Act sources will be required. These estimates do not incorporate rising prices of diesel or anticipated cost reductions for hybrid systems over time, both of which will improve the outlook.

Economics – Although this technology is being developed around the world, the retrofitting and construction of hybrid boats will require Maine's boatbuilding industry to complete most of the work. There are about \$9 million in new boat sales in Maine each year so adding \$5 million will bring over 50% more boat-building sales. Adding about 20 charging stations to 10 ports for a total of \$1 million will also benefit local installation companies. The operational savings will accrue to vessel owners, and the replacement of imported diesel with locally produced electricity (import substitution) will also generate local economic impacts. Capital spending to convert 100 vessels will support \$3.7 million in added-value and 39 jobs in Maine each year. Economic impacts of operations will be minor since there are operational savings, but jobs and added-value in the diesel supply chain will shift to the electricity

³ Oceans North, 2023. Nova Scotia Lobster Fleet Electrification Assessment (online: <https://www.oceansnorth.org/en/resources/>).

sector. This will achieve annual reductions in greenhouse gas (GHG) emissions of about 1,400 metric tons, or the equivalent of removing 609 cars from the road.

Next steps

Year 1 – Work with boat builders to determine a selection process for candidate new or retrofit boats to participate in programs. Work with utilities and local authorities to identify best ports for installation of charging stations and ensure all requirements are met.

Year 2 – Convert 100 vessels and begin data sharing and research program to document key aspects of conversion and operations.

Years 3 – Continue vessel conversions recognizing the incentive for conversions could decline as hybrid prices drop and operational savings increase, however the cost to install charging stations may increase for the less suitable ports along the coast. Overall, a ten-year plan based on U.S. Inflation Reduction Act funding should maintain the same annual budget, but the target of funds should adjust to circumstances each year.

Key sources

- Oceans North, 2023. Nova Scotia Lobster Fleet Electrification Assessment (online: <https://www.oceansnorth.org/en/resources/>).
- Kemp, C. and S. Atshan. (2021). Electric Power Systems for Fishing Vessels: Feasibility, Fuel Savings, and Costs. Kempy Energetics. 46 pp. <https://kempyenergetics.com/wp-content/uploads/2021/01/Kemp- ElectricPowerSystemsForFishingVessels-2021.pdf>
- Rimot, 2023. BlueGrid turns marine vessels into virtual power plants for utility grade energy storage (online: <https://rimot.io/>).

3.5 Place – Transportation & logistics

Overview

There is an opportunity to address the current and growing gap in transportation and logistics by developing a real-time central database of transport and storage asset availability. This opportunity links to the next one regarding ice and cold storage capacity. Maine relies on efficient systems to transport its seafood products from the fishing grounds to processing facilities and markets. The system includes fishing vessels, landing ports, processing facilities, transportation (trucking, air freight, marine transport), infrastructure (road network, airports, seaports), and cold chain logistics and storage. Maintaining the quality and freshness of seafood is crucial. However, the long distances involved and the limited availability of temperature-controlled transportation options can pose challenges, particularly during summer months. There is interest in exploring opportunities around developing specialized cold storage and warehousing facilities near landing ports and processing centers. A real-time database of supply and demand for transport and storage assets will maximize available resources and lay the foundation for efficient use of new assets as they are developed in Maine. It is difficult to estimate the amount of added-value, jobs, and incomes that would be gained, but the financial cost is small enough that benefits are expected to exceed this by several multiples.

Sector description

Maine has numerous landing ports along its extensive coastline. These ports serve as critical hubs where fishing vessels offload their catch. The landing ports provide facilities for unloading, sorting, and initial processing of the catch. Seafood processing facilities then handle tasks such as cleaning, sorting, filleting, shucking, freezing, and packaging the seafood products. The processed seafood is finally prepared and packaged for further transportation to domestic and international markets. Many dealers utilize airfreight through UPS and FedEx. After harvesting, seafood products must either be stored on ice or flash-frozen. This is driven, in large part, by consumer demand for high-quality, lightly processed products with minimal changes in nutritional and sensory properties. It is critical to keep seafood cool and moist while in transit which requires a cold location below 45°F, which adds additional challenges and cost to trucking logistics.

Market environment

Supply – Maine's coastline is long and jagged, with numerous islands and peninsulas, making it difficult to establish efficient transportation routes. The seafood sector operates in remote and dispersed locations, posing challenges in accessing fishing grounds and transporting seafood to processing plants and markets. Many coastal areas in Maine lack robust transportation infrastructure, including adequate road networks, ports, and cold storage facilities. Insufficient infrastructure makes it challenging to transport seafood quickly and efficiently, particularly to distant markets or processing facilities.

There were 5,300 trucking companies located in Maine in 2020. While many large seafood operations rely on their own refrigerated trucking services, commercial transport options are still restricted. For smaller operators, the scale of shipments often poses challenges in finding a cost-effective and logistically feasible method to deliver their goods to the market. In 2021, the U.S. Department of Transportation reported that truck transportation services saw the largest price increase of 12.8%. Trucking costs are likely to remain high due to several factors including the high cost of diesel,

increasing emission and fuel economy standards, and a lack of new drivers entering the trucking business.

Demand – 84.4% of Maine communities depend exclusively on trucks to move their goods, with 98.7% of total manufactured tonnage transported by trucks in the state. According to the US Department of Labor Statistics, there were 29 establishments operating in the Seafood Product Preparation and Packaging sector in Maine in 2020. There are also more than 50 ports along the coast where fish are landed and require some form of cold storage and/or transportation to market. Maine seafood products, like lobster and various fish species, have peak harvesting seasons. During these times, the demand for transportation services spikes due to the increased volume of catch. In recent years, there has been a growth in value-added seafood products, such as pre-cooked or processed seafood items. These products often require different transportation and handling compared to live or fresh seafood.

Finances and economics

Finances – The following estimated costs are for developing a central database with real-time inventories of available and idle trucking and storage assets. The top priorities are to develop the inventory of real-time transport assets (\$100,000), create a central database (\$60,000), promote the existing online dashboard (\$10,000), complete outreach to connect seafood sector and transport sector (\$15,000). The total \$185,000 is considered a one-time cost to establish the platform and process for data sharing, then participants maintain the data flow and communications for the database to serve on-going needs.

Economics – Establishing additional transportation capacity across the Maine seafood sector is essential to its growth and sustainability. Current transportation options for most operators / producers are inconsistent, inefficient, and costly, therefore cost-savings, operational efficiencies, and economies of scale could be achieved through improved coordination of transportation. It is difficult to estimate the amount of added-value, jobs, and incomes that would be gained, but the financial cost is small enough that benefits are expected to exceed this by several multiples.

Next steps

Year 1 – Promote SEA Maine’s Seafood Transportation Dashboard; develop terms of reference for projects; identify industry / grant funding; plan outreach to transportation and logistics sector.

Year 2 – Develop asset map of existing transportation and storage infrastructure; develop real-time database of idle capacity; initiate outreach to enhance connections between the seafood and logistics industries.

Year 3 – Launch and promote asset map, real-time database.

Key sources

- SEA Maine, 2023. Marine Living Resource Needs and Opportunities in Transportation and Logistics
- Aquaculture Research Institute, University of Maine (2017). Maine Aquaculture Economic Impact Report.
- Maine Motor Transport Association, 2020. Trucking statistics in Maine and beyond. (online: <https://www.mmta.com/truckingfacts/>)

3.6 Place – Ice production and cold storage

Overview

There is an opportunity to improve freshness of seafood landings and ease transport and logistics challenges by increasing ice making and cold storage capacity. This opportunity links to the previous one regarding transport and logistics. Capacity is especially limited outside of major centres closer to the remote ports. Greater access to cost-effective ice making capacity will reduce costs and improve the quality of catch brought in by harvesters. The seafood sector relies on cold storage and cold chain logistics to preserve product freshness from harvest to consumption. The ability to store seafood allows suppliers to adjust to transport schedules and market demands. During periods of lower demand, seafood can be stored for future sales, helping to stabilize prices and ensure consistent supply. Small volumes can also be held or combined between suppliers in order to fill larger volume orders. A total of \$306,000 for purchase and installation of six (6) cold storage units would benefit from public support for a portion of the costs. It is difficult to estimate the amount of added-value, jobs, and incomes that would be gained, but the financial cost is small enough that benefits are expected to exceed this by several multiples.

Opportunity description

This opportunity involves at least three ice machines and three cold storage facilities being established at strategic locations along the coast. In consultation with harvesters and processors, the most suitable sites will meet demand where there is the greatest shortfall in capacity. Additional capacity and sites could be considered in the future. Cold storage in the Maine seafood sector involves using refrigerated trucks, containers, and storage facilities to control temperature and ensure that seafood remains in optimal condition during storage and transportation. There is significant interest among sector participants to increase cold storage capacity through several initiatives, including developing cold storage aggregation sites, employing mobile cold storage, especially in remote and frequently used transportation routes. The first three ice making machines and cold storage units can be established immediately. Over the next few years, the Maine MLR sector could focus on developing an asset map of existing capacity and implementing a pilot project involving more advanced systems including mobile systems.

Market environment

Supply – There is no known current estimate of total cold storage capacity specific to the Maine seafood sector. As of 2022, the USDA reported that Maine has two public and eight private refrigerated warehouses with a total of 7.2 million ft³ of gross refrigerated space, 5.6 million ft³ of which is useable⁴. Flash freezing at sea is a possible solution, however a recent SEA Maine report noted that flash freezing is predominantly an industrial-level practice, but it may not be broadly applicable considering the limited number of very large boats in Maine.

Treadwell Franklin Infrastructure, Emskip, and Amber Infrastructure formed a consortium to build a 107,000-square-foot, temperature-controlled building on state-owned land at the International Marine Terminal in Portland, ME. The facility is expected to begin operations in early 2024.

⁴ <https://downloads.usda.library.cornell.edu/usda-esmis/files/x059c7329/kd17dw989/9p291c96d/rfwh0122.pdf>

Demand – A large number and variety of businesses in the Maine seafood sector drive the demand for cold storage to ensure the preservation, quality, and safety of seafood products. Firstly, harvesters who are often at sea for prolonged durations handling substantial catch volumes require immediate access to cold for preserving their catch's freshness and quality. Equally reliant on cold storage are the processing plants that transform the catch into consumer-ready products or value-added items. Wholesalers and distributors, positioned between the harvesters and the market, purchase seafood in bulk and also depend on cold-chain logistics.

Finances and economics

Finances – Industrial flake ice making machines are more efficient and cost less as they increase in size. Starting at 500 lbs of ice per 24hrs, the purchase price is about \$10,500 (\$23.33 per lb of capacity), then about 900 lbs per 24 hrs costs \$15,500 (\$17.22 per lb of capacity), and 2,000 lbs per 24 hrs costs \$26,300 (\$13.15 per lb of capacity). Larger systems will achieve lower costs per lb of capacity and also lower electricity consumption per lb of capacity.

Based on work done in 2006 by the Alaska Sea Grant College Program (adjusted for inflation), a small 8' by 10' cold storage unit capable of holding 5,000 lbs of product could be installed for approximately \$23,000 and operated at a cost of approximately \$4,500 per year. A larger 14' by 20' unit holding 20,000 lbs could be installed for approximately \$69,000 and operated at a cost of approximately \$12,400 per year. Asset mapping to determine additional capacity gaps could be completed for \$50,000 with funding through infrastructure grants. A total of \$306,000 for purchase and installation of six (6) units, 3 of each size according to needs of different locations in Maine, would benefit from public support for a portion of the costs.

Economics – It is difficult to estimate the resulting value of improved seafood fetching higher prices, the benefit of consolidating small volumes to fill larger orders, and easing transport and logistics challenges. However, there is strong interest from the sector to improve the situation. The current high cost of getting ice from less efficient and more distant sources could also be avoided. Overall, increasing ice to land fresh catch and developing better access to cold storage could result in: better access to markets, higher market prices due to efficient supply and higher quality product, lower costs to get product to market, and greater economic returns for seafood producers. It is difficult to estimate the amount of added-value, jobs, and incomes that would be gained, but the financial cost is small enough that benefits are expected to exceed this by several multiples.

Next steps

Year 1 – Investigate private, NGO, municipal, state, and federal funding sources for infrastructure development; create a central database for idle / underutilized cold storage in the seafood and other agriculture sectors (e.g. Barber Foods, Good Shepherd, other producers); develop a map of all cold storage assets in the seafood sector.

Year 2 – Develop cold storage pilot site(s) in area(s) where access to cold storage is limited.

Year 3 – Evaluate site; develop additional sites if business case is positive.

Key sources

- USDA, National Agricultural Statistics Service, 2022. Capacity of Refrigerated Warehouses 2021
- Kolbe, Kramer, & Junker, 2006. Planning Seafood Cold Storage (Alaska Sea Grant College)

3.7 Place – Aquaculture site access

Overview

This opportunity mirrors the top goal in the Maine Aquaculture Roadmap (2022-2032), but helps quantify the economic impacts in more detail. There is an opportunity to streamline the licensing and permitting process in a way that balances the interests of applicants and the public. There are 127 total pending aquaculture lease applications listed on the DMR website including: 54 standard lease applications, 15 renewal, transfer, amendment or expansion proposals, and 58 experimental lease applications. The description here is brief since further details can be obtained from the Maine Aquaculture Roadmap. The annual added-value of operations for the state will be about \$3.0 million and there would be an estimated 57 jobs generated from operations alone (not including capital impacts) until the application backlog is addressed.

Opportunity description

The DMR website indicates 21 new aquaculture leases were approved in 2021, down from a peak of 32 in 2019, but up from the decade average of 14 per year. At current rates of incoming applications and average processing times, a backlog will remain for at least the next five (5) years. In order to maintain process integrity and diligence in reviews while reducing processing time, DMR needs more resources and staff to address the backlog. The Aquaculture roadmap contains four (4) action items to support this goal including: 1) increasing DMR capacity, 2) increasing support for applicants within the process, 3) expanding input from the broader aquaculture sector and others in policy development, and 4) improving municipal awareness of permits and fluency of permits moving through the process. Some actions are already being led by DMR with support from Maine Sea Grant, Maine Aquaculture Association, and the Aquaculture Research Institute. The Maine Aquaculture Innovation Center is also developing a guide to the application process that will be helpful for multiple audiences.

Finances and Economics

Finances – The estimated cost to implement this opportunity will ramp up from about \$250,000 in the first two years to about \$365,000 in years 5 and 6. Similarly the number of additional staff (relative to 2019 baseline) needed at DMR will ramp up from about 2.5 full-time equivalents (FTE) to about 3.5 FTE. Some of the funding and staff are already in place and the opportunity is already in year 1-2.

Economics – Examining a sample of pending applications indicates the average size of proposed aquaculture leases is about 7.5 acres. Considering different species and the circumstances of new entrants along with established growers across all applications, the average capital costs range from about \$11,500 to \$23,400 per acre, and average operations costs range from about \$14,200 to \$28,846 per acre. Addressing the backlog in a timely manner will require about 20 more applications representing about 150 more acres to be processed above the 2022 level (41 instead of 21 applications). Using mid-range capital and operations costs per acre, this means about \$2.6 million in capital is

deployed, and operations worth \$3.3 million will begin earlier. The annual added-value of operations for the state will be about \$3.0 million and there would be an estimated 57 jobs generated from operations alone (not including capital impacts) until the application backlog is addressed. This is a conservative estimate first because this assumes applications will only be approved one year earlier, however achieving approvals two years earlier will double the economic benefits for those applicants while the backlog is being cleared. This is also conservative because it does not include capital impacts or the impacts of value-added processing for aquaculture products harvested such as kelp, seaweed, scallops, clams, mussels, and oysters, all of which generate further revenues and incomes elsewhere in the seafood sector.

Next steps

Years 1 & 2 – Increasing DMR capacity and involving the broader aquaculture sector and others in policy development is already underway.

Years 3 & 4 – Increasing support for applicants within the licensing and permitting process.

Years 5 & 6 – Increasing municipal awareness of permits moving through the process and the fluency of the process.

Key sources

- Sadusky, H., C. Brayden, G. Zydlewski, and S. Belle, 2022. Maine Aquaculture Roadmap 2022-2032. (online: <https://seagrant.umaine.edu/maine-aquaculture-hub/>)
- DMR Pending Aquaculture Lease Applications (online: <https://www.maine.gov/dmr/aquaculture/maine-aquaculture-leases-and-lpas/pending-lease-applications>)

3.8 Product – Land-RAS finfish aquaculture

Overview

There is an opportunity to realize three major land-based re-circulating aquaculture systems (RAS) for finfish production in Maine. Kingfish Maine aims to annually produce up to 8,000 metric tonnes (mt) of Dutch yellowtail kingfish in Jonesport. Whole Oceans Maine has a phased plan for at least 10,000 mt of Atlantic salmon per year in Bucksport. Nordic Aquafarms in Maine also aims to build a 33,000 mt annual capacity Atlantic salmon facility in stages at their Belfast site. Constructing these three projects will cost over \$1 billion and bring significant capital investment to Maine⁵. During construction a total of 2,600 jobs and \$685 million in added-value will be generated in Maine, then operations will ramp up to a total of over 1,100 jobs and \$167 million in added-value for on-going peak production.

Opportunity description

Land-based RAS facilities have gained attention in the last decade as they resolved technical challenges for key species such as Atlantic salmon. The systems consist of multiple large fish tanks linked by pipes and pumps to various filters that allow the water to be re-used. The system filters remove waste (solids, ammonia and carbon dioxide), while adding oxygen to maintain water quality at an optimum level for fish health and faster growing cycles. Advanced systems recirculate upwards of 99% of water, while capturing nearly all waste materials to produce other value-added products. Hatcheries for egg to smolt production can be integrated, and built-in processing including smoke houses can offer more value-added processing.

U.S. RAS projects have attracted major investments as they address many challenges with marine finfish aquaculture production. Maine offers highly suitable locations given the temperate climate, access to clean water resources, and proximity to major seafood markets in the U.S. As prices for salmon and yellowtail products have remained strong, the economic case for RAS facilities underpins the developments in Maine.

Market environment

Supply - Like all other U.S. land-based RAS projects, the primary focus of Maine companies will be the U.S. seafood market. Import-substitution is the main strategy, where about 94% of salmon, and all yellowtail consumed in the U.S. are imported from Chile, Norway, Canada and other EU countries. The highest value fresh product requires air-freight at high-cost and carbon intensity, so U.S. RAS facilities located near major markets (e.g. Boston and New York) can be competitive on price and quality despite their higher capital costs.

⁵ Hill, S. 2020. Maine's 10-year economic development plan spotlights aquaculture, In: SeafoodSource (online: <https://www.seafoodsource.com/news/aquaculture/maine-10-year-economic-development-plan-spotlights-aquaculture>)

Demand – As reported in the SEA Maine Benchmarking report, salmon fillet imports to the U.S. have been growing over the last decade (up at least 53%). Some fresh and chilled product imports have declined (down at least 31%) over the last decade. Overall, the top five states with the largest growth in demand for salmon are Florida (\$136 million per year), followed by California (\$34 million), Massachusetts (\$17 million), New York (\$16 million), and Texas (\$10 million).

Import data specific to Kingfish are not available, but Kingfish Maine indicated the United States and Canada are its primary markets, fulfilling demand that has so far been met through imports. Their products have already found their way into various U.S. states, including California, Maine, Boston, and Washington DC, which demonstrates market acceptance and potential for growth.

Finances and economics

Finances – Based on public reports on the planned scale and capacity, the capital costs for these three land-based RAS facilities will total over \$1 billion. This is most likely a lower-bound estimate as costs of construction rise before the facilities are complete, and the long-term goal of the operators is to add capacity in future phases. Once the facilities are built, the operational expenditures for the combined three projects will increase steadily over the first three or four years to reach full production capacity with steady growing cycles.

Economics – The full- and part-time capital construction jobs on-site for all three projects will total over 1,500 each year for an estimated two-year construction period. Not all three projects will proceed simultaneously, this is an aggregate estimate. Over 1,100 more jobs will be generated in the supply-chains to the construction projects and in businesses where employees spend their earnings on household goods and services. The full- and part-time operations jobs for all three projects will total over 500 on-site once peak production capacity is reached for the initial scale of each project. Over 600 more jobs will be generated in the supply-chains to the three operations and in businesses where employees spend their earnings on household goods and services. During construction a total of 2,600 jobs and \$685 million in added-value will be generated in Maine, then operations will ramp up to a total of over 1,100 jobs and \$167 million in added-value for on-going peak production.

Next steps

Year 1 – The Kingfish facility is operating initially at about 10-20% of planned capacity. Both of the salmon sites have obtained their permits and are in phases of design, site preparation, and construction.

Year 2-3 – All three facilities could be built and ramping up production.

Year 4 – All three facilities could reach peak production for the initial scales of operations they are planning.

Key sources

- Whole Oceans, 2023. Whole Oceans Maine Sustainable Salmon (online: <https://wholeoceans.com/#contact>)
- Nordic Aquafarms, 2023. Nordic Aquafarms Sustainable Salmon: U.S. Newsdesk (online: <https://nordicaquafarms.us>)
- The Kingfish Company, 2023.
- Bailey, M., and S. Green, 2020. Economic and fiscal impacts of a proposed recirculating aquaculture facility in Jonesport, Maine.

3.9 Product – Atlantic Menhaden and Alternative bait

Overview

There is an opportunity to develop a long-term alternative bait strategy as other common bait species such as herring and mackerel have declined steeply. Atlantic menhaden (pogie) catches have climbed to partially meet the challenge and become a leading replacement. Other bait solutions include imported bait, a mix of other fish species, and other food residuals used in manufactured bait products⁶. There are other potential commercial opportunities for processing Menhaden into fishmeal and fish oil products, Omega-3 supplements and other nutraceuticals, industrial products (e.g. lubricants, adhesives, paints), and agricultural fertilizers. NOAA's climate vulnerability assessment indicates the "effect of climate change on Atlantic Menhaden on the Northeast U.S. Shelf is very likely to be positive". The Menhaden situation is part of an opportunity that combines emerging species and other resources with the need to address the decline of traditional bait such as herring and mackerel. The benefits of a Maine-based solution are likely to be worth at least \$20 million in added-value and over 400 jobs.

Opportunity description

There is a need for researchers and harvesters to jointly develop a Maine-based solution that is effective and sustainable. This involves a three-year concerted effort to examine the most efficient, effective, and sustainable bait solutions with all options for consideration including: reducing bait-to-catch ratios, avoiding species that are in decline or low abundance, and making use of residuals, bycatch, and underutilized species.

There were no Maine landings of Atlantic menhaden a decade ago, but landings climbed rapidly to over 10,000 metric tons in recent years with a landed value of \$12 million in 2022⁷. Menhaden will be part of the solution, but it does not fully replace the traditional bait sources that have disappeared. Other bait species under investigation include alewives, redfish, monkfish and other underutilized species. This is particularly important as climate change may drive historically more southern species into Maine waters. There could also be a role for fish processing residuals or groundfish bycatch to be part of the solution.

There is already funding for academic and research institute efforts to investigate and develop alternative bait solutions primarily for the lobster fishery. The gap this opportunity addresses is in helping the fishery navigate the multiple options for alternative bait that are emerging, and to find the ones that are less vulnerable to cyclical stock abundance or have risks associated with dependency on international sources.

⁶ Stoll, J.S., E.J. Oldach, T. Witkin, K. Reardon, D. Love, P. Pinto da Silva, 2022. Rapid adaptation to crisis events: Insights from the bait crisis in the Maine lobster fishery, *Ambio* 2022, 51:926–942 (online: <https://doi.org/10.1007/s13280-021-01617-8>).

⁷ Maine DMR, 2023. Historical Maine Fisheries Landings Data. (online: <https://www.maine.gov/dmr/fisheries/commercial/landings-program>).

Market environment

Supply – By 2019 herring quotas dropped by 77 million lbs over the previous decade, tightening bait supply. This was partially offset by increasing landings of menhaden from 90,000 pounds in 2018 to 715,000 pounds in 2022 (+694%), followed by a decline in 2021. Menhaden now account for over 30% of bait use, while herring has fallen to about 20%. Imported bait has climbed to about 20%, and manufactured bait from food processing residuals remains low at about 5%⁷. The balance of bait comes from a mix of other species. All bait prices have risen significantly, but there is also less fresh bait available so more expensive frozen bait is required (prices 50% higher than fresh).

Demand – Harvesters traditionally use about 1.2 lbs of bait per trap and may operate up to 800 traps per vessel. The Maine lobster fishery spends about \$95 million on bait annually⁸ indicating upwards of 160 million lbs of bait is used each year.

Although menhaden catches have climbed and the outlook is good, there are competing demands for menhaden oil as manufacturers have tapped growth in global aquaculture, animal feed, pet food, and human supplements with omega-3 oil content. Market prices for menhaden as reflected in landed value remained relatively stable from 2018 to 2021 with an average landed value of \$0.27 per pound. Landed value then jumped to \$0.59 per pound in 2022 reflecting the sharp competition for this resource. Overall, the tightening supply and healthy demand puts pressure on the search for alternative bait.

Finances and economics

Finances – A three-year annual budget of up to \$200,000 is needed for dedicated staff and operational capacity to better engage researchers evaluating alternative bait solutions with lobster and crab harvesters. While providing new bait to harvesters, there would be sharing of information between these stakeholders, but also with harvesters broadly regarding best practices and sharing results. Online resources and information sharing in-person and on-site will both be helpful.

Economics – The cost of traditional bait will continue to rise due to supply and demand tension, and importing other fish species for bait will undermine the Maine economy. A local solution will be a critical economic development. There will be some economic contribution from rising landings of suitable bait species such as menhaden, but development of novel solutions and successful adoption will keep bait costs at an affordable level for harvesters. There are three main ways to characterize the economic significance of developing a successful bait alternative, namely: import substitution, keeping bait prices affordable, and avoiding reduced lobster catches. Replacing current bait imports of \$20 million is worth at least \$26 million in added-value and about 1,060 jobs to Maine. Reducing bait costs by just 10% is worth \$9.5 million, which would be applied to other capital and operations in Maine. This would be worth about \$20 million in added-value and over 400 jobs. A 10% shortfall in lobster catches is worth about \$64 million in added-value and 650 jobs¹⁰. These three types of benefits are not additive, but show the total is likely to be worth at least \$20 million in added-value and over 400 jobs.

⁸ Gardner Pinfold estimate based on average bait spending by vessel size (Oppenheim et al., 2023) applied to DMR reported number of vessels by length in the Maine lobster fishery.

Next steps

Year 1 – Establish alternative bait for harvester coordination team and initially supply bait options to some harvesters for implementation and data sharing.

Years 2 & 3 – Expand program to include more harvesters and new bait options as they become available.

Key sources

- Sea Maine, 2022. Maine's Seafood Baseline Report (online: <https://www.seamaine.org/reports-presentations/>).
- SEA Maine, 2023. The Economic Impacts of the Maine Seafood Sector. (online: <https://www.seamaine.org/reports-presentations/>).
- The Atlantic States Marine Fisheries Commission (ASMFC), 2022. Atlantic Menhaden Stock Assessment Update.
- Whitehead, John C.; Harrison, Jane; Adams, Brendan; Meley, Andreanne; Naumenko, Alexandra, 2017. Socioeconomic analysis of the Atlantic menhaden commercial bait and reduction fisher.
- Atlantic States Marine Fisheries Commission (ASMFC), (n.d.). Atlantic Menhaden (online: <https://www.asmfc.org/species/atlantic-menhaden>).

3.10 Product – On-demand Fishing Gear

Overview

There is an opportunity to use on-demand gear (ODG) to continue lobster and crab fishing where whale protection measures are implemented. This will maintain landings and revenues while gaining recognition from concerned consumers, sustainability certification bodies, international trade partners, and the general public. The U.S. Congress has appropriated tens of millions of dollars for the development and implementation of ODG in New England states. Directing support towards purchase and lease options will enhance use of ODG. A five-year program that adds 100 ropeless gear systems each year to Maine lobster fleet capacity each year, will generate a total of \$7.9 million in added-value and 89 jobs. This may also avoid losses in lobster catch from closed areas, maintain open markets for trade, and maintain high prices for Maine lobster where this is viewed as a positive development for whale protection.

Opportunity description

On-demand gear (ODG), also known as “ropeless” fishing gear avoids whale entanglements with fishing lines that extend from gear on the seafloor to the water surface. A line of up to 40 lobster traps (a trawl line) is deployed on the ocean floor with rope coiled up inside one cage or bag at one or both ends of the trawl. An acoustic signal is sent to the ODG on the seafloor when it needs to be retrieved for harvest. This releases a buoy that floats to the surface, bringing up the coiled rope, and then the trawl of 40 traps is hauled in. The location and direction of trap trawls is recorded by a global positioning system (GPS) in order to find the traps later and to avoid gear conflicts with other harvesters.

This opportunity is for a portion of vessels rather than the entire lobster fleet. Lobster harvesters have a range of financial circumstances and likelihood of being subject to whale protection measures. Some typically prefer to purchase and own gear, but the purchase cost and operational challenges associated with ODG suggest that incentives are needed for uptake in the sector⁹. An organization could offer lease options as a way to make gear available only when needed, and provide guidance, maintenance, and storage for harvesters in the early stages of use¹⁰.

Working with ODG manufacturers, harvesters, and non-profit organizations, the inventory of ODG gear should increase by 100 units annually for at least a couple years, and incentives should be made available for gear purchase where there is interest. As gear technology improves and investment costs decline with more units produced, the program should adapt to changing circumstances.

⁹ Oppenheim, N.G., Griffin, R.M., and Goode, A.G. (2023). Estimating the Costs of Using On-demand Gear in Massachusetts Lobster Fisheries. Homarus Strategies LLC, Brunswick, Maine, USA.

¹⁰ Canadian Wildlife Federation, 2023. CanFish Gear Lending Program. (online: <https://canfishgear.ca/>)

Market Environment

Supply – NOAA is documenting performance of ODG systems from at least 40 manufacturers in order to understand operational aspects and support improvements. A small annual inventory buildup for the fishing fleet will help manufacturing capacity ramp up gradually rather than get overwhelmed by sudden increases in demand. Although there may be multiple manufacturers at the moment, only two or three are currently producing units that meet requirements efficiently and effectively. There are multiple U.S. based manufacturers so there should not be supply-chain challenges.

Demand – Current uptake by harvesters is very limited as there are concerns about additional time requirements for harvest, how to mark locations of deployed gear to avoid gear conflicts, costs, and possible operational failures with the technology. Using the gear where whale protection measures are in effect requires an experimental fishing permit. In addition to the administrative requirements for a permit, the ODG users must collect data and report to administrative organizations such as NOAA. These factors limit demand, but there are 500-600 systems linked to over 20,000 traps being used in the United States and Canada.

Finances and economics

Finances – ODG systems vary in price, but the most promising products cost about \$4,000 per unit. For a trawl, each system can be connected to approximately 40 lobster traps, fewer for crabs. Given the number of traps fished on a vessel in Maine, they will typically need from 4-20 ODG systems and other related equipment at a capital cost of between \$24,000 to \$90,000. Although estimates of net revenues from ODG have been compared to fishing with traditional gear¹³, this opportunity only applies where traditional gear cannot be used in closed areas. The relevant comparison is therefore with either no fishing, or having to travel further to open fishing areas. In this case, the net benefits of ODG could be net positive with incentives to purchase, or with lease options so it is only used when needed.

Economics – Manufacturing, maintenance, and services for ODG systems will generate economic activity in Maine. Adding 100 systems annually for five years generates \$2.5 million in spending on ODG manufacturing. The number of units deployed rises from 100 to 500 by the fifth year. This will support 3.2 jobs per 100 ODG units deployed for a total of 48 job-years across the five years, and \$260,000 in added-value per 100 ODG units deployed for a total of \$3.9 million across the five years.

The net revenues in the fishery compared to no fishing in closed areas or having to transit farther to open areas is about \$20,000 per vessel. The operational impacts will vary by vessel size and trawl length, but with ten (10) ODG systems per vessel, this will equip 10 vessels per year. The net revenues gained across 10 vessels is about \$210,000 per year, which generates about 2.7 jobs per year or 41 job years over five years, and \$265,000 in added-value per 100 ODG units deployed for a total of \$4.0 million across the five years. The combined capital and operational impacts over 5 years is about 89 jobs and \$7.9 million in added-value. This does not include declining costs for ODG systems,

technology improvements, variable lobster prices, evolving whale protection measures, or positive lobster price responses to whale conservation efforts.

Next steps

Year 1 – Continue working with NOAA on regulatory for improved use of ODG, increase inventory of gear, and build on the \$2 million Maine Lobster Innovation Fund created in 2023 to expand commercial testing of equipment.

Year 2 – Have sufficient gear in use to test protocols to avoid gear conflicts for many users as well as mobile fishing vessels.

Key sources

- Oppenheim, N.G., Griffin, R.M., and Goode, A.G. (2023). Estimating the Costs of Using On-demand Gear in Massachusetts Lobster Fisheries. Homarus Strategies LLC, Brunswick, Maine, USA.
- Canadian Wildlife Federation, 2023. CanFish Gear Lending Program. (online: <https://canfishgear.ca/>)
- SEA Maine, 2023. The Economic Impacts of the Maine Seafood Sector. (online: <https://www.seamaine.org/reports-presentations/>).

3.11 Product – Biodigestion system

Overview

There is an opportunity to process marine resource sector residuals (waste) into value-added products. Bio-digestion systems use fermentation to process residuals and then separate the outputs into key ingredients for a variety of products. Lobster and crab shells, and finfish processing waste are particularly good inputs. There is an estimated 22 – 28 million lbs of these residuals generated in Maine each year. Marine seaplant residuals imported to Maine from other U.S. sources are addressed separately in the marine seaplant opportunity. Two or more biodigestion systems strategically placed according to the main sources of residuals requires an \$8 million capital investment. The systems can accept any seafood or other food residuals as inputs, so there is flexibility for expansion over time. The capital construction will support 61 jobs and \$5.5 million in added-value, then on-going operations will generate 24 jobs, and \$2.2 million in value-added (GDP) each year.

Opportunity description

Bio-digestion can be accomplished in a variety of ways and the following brief description starts with the high-value example of chitosan extraction from the hard outer shells of lobster, crab, and shrimp. One bio-digestion company explains that shells are washed, dried, and ground before going through three main processes: demineralization, deproteinization, and deacetylation. The chitosan produced is a sugar that can be used in medicine and in drug manufacturing. Among other things, chitosan can reduce the amount of fat and cholesterol the human body absorbs from foods, and it helps blood clot when applied to wounds. This is just one product, while all of the following can be produced from bio-digestion systems:

- **Finfish residuals** – ingredients for: livestock feed, aquaculture feed, and pet food;
- **Finfish residuals** – functional peptide formulations for animal and human consumption that provide antioxidants and anti-inflammatory products; and
- **Shellfish residuals** – chitosan for: medicines, drug manufacturing, plant and animal growth and disease applications, water purification, recyclable plastics, battery cell electrodes, luxury leather goods, calcium lactate food ingredients and specialty formulations, functional ingredients with anti-oxidants for human and animal feeds.

Market environment

Supply – One company with facilities in the U.S. is producing chitosan (from shellfish), and another company produces marine oil and protein products (from finfish). The chitosan product quality may not be optimal and there are concerns with the use of a chemical processing system. The marine oil and protein production company has no capacity to purify functional ingredients that represent higher-value opportunities. Maine would move into a leadership position within the U.S. regarding sustainable

processing and high-value product delivery. The current demand for chitosan far exceeds supply, especially with import substitution strategies (displacing Asian chitosan-based products).

Demand – The Maine bio-digestion system would yield sustainable, nature-based products that are in high demand, especially where these can replace synthetic products. A zero-waste biodigestion system that does not use harsh chemical processing to deliver novel ingredients from Maine’s clean oceans will be well-received in the U.S. market-place. The final products do not necessarily have to undercut prices from other suppliers where it is considered a superior, and trusted U.S.-based product. The market for food ingredients, animal and pet feed, medicine and pharmaceuticals far exceeds the production capacity from Maine.

Finances and Economics

Finances – Biodigestion systems can be scaled to the volume of residuals inputs, however there are economies of scale at larger sizes. Two facilities handling shellfish residuals and one handling finfish residuals (land and/or marine based aquaculture) could make sense. The combined capital cost would be about \$10 million. The on-going annual operating costs would be about \$2 million, with gross profits of about \$1 million per year depending on the mix of feedstock and product volumes.

Economics – The capital construction will support 61 jobs and \$5.5 million in added-value, then on-going operations will generate 24 jobs, and \$2.2 million in value-added (GDP) each year. A \$2 million public investment would be a catalyst for private sector investment to move forward, as this would advance the detailed analysis, site selection, facility design, and show strong support to lending institutions as needed for financing.

Next steps

Year 1 – The major producers of residuals in Maine should build on a recent meeting with Maine and Co., where a candidate technology provider delivered a presentation to support detailed discussions. The details of ownership structure, supply agreements, designs, site selection, permits and approvals would be pursued.

Years 2-3 – Construction and operation would proceed with first sales after two or three years.

Key sources

- Sea Maine, 2022. Marine Resource Residuals in Maine. (online: <https://www.seamaine.org/reports-presentations/>).

3.12 Product – American eel (market sized)

Overview

There is an opportunity to expand land-based production of market-sized eels from elvers (juvenile eels) that are wild caught in Maine. The American eel (*Anguilla rostrata*) elver fishery is a unique and economically significant fishery that primarily targets juvenile eels, known as elvers or glass eels. Elvers are in high demand from Asian and European countries where they are grown to market-sized eels, then sold as a delicacy to East Asian countries such as China, Japan, South Korea, and the U.S. Land-based production of eels would keep the growing operations in the U.S. rather than importing market eels from Asia that may have originated as elvers from the U.S. The Maine-based company, American Unagi, has already demonstrated successful commercial-scale operations, and additional capacity could be developed through partnerships. The construction will generate 52 jobs and \$7.2 million in added-value, then operations will generate 14 jobs and \$1.3 million in added value each year.

Opportunity description

Harvesting – The American eel is found along the Atlantic coast of North America, from the Gulf of Mexico to Canada. During their migration, elvers enter coastal rivers and estuaries including those in the state of Maine. American eels have a catadromous life cycle, meaning they spawn in the ocean, but spend most of their lives in freshwater habitats. The elver fishery typically occurs during the spring months when the elvers migrate up streams from the ocean. They are predominantly harvested using specialized nets, often referred to as dip nets or fyke nets. Harvesters typically work at night when the elvers are more active and easier to catch. The Maine fishery is managed with allocations to harvesters each year. The elvers supplied to the existing Maine system are currently acquired through an agreement with the holders of an annual allocation from the elver fishery.

Processing – Aquaculture offers a sustainable approach to meet domestic demand and support economic development. Land-based recirculating aquaculture systems (RAS) contain indoor tanks linked to biofilters and water treatment processes. The system maintains optimal conditions for eel growth and feeding until they reach markets sizes. They are graded by size and harvested to meet customer orders. More advanced American eel aquaculture could eventually involve captive reproduction, thereby reducing the reliance on wild populations and providing further growth opportunities.

Market environment

Supply – US Atlantic coast elver landings were relatively consistent from 2018 to 2022, averaging 9,400 pounds per year, with a low of 9,200 pounds (2018) and a high of 9,700 pounds (2020). US imports of processed eel products have been increasing by about 7% per year over the last decade and this highlights the import-substitution opportunity.

American Unagi operates a 27,000 ft³ facility with the capacity to produce more than 500,000 pounds a year (or about 2 million eels). This is currently the largest U.S. facility producing market-sized eels. Compared to imported eel products in the U.S., Maine production offers trusted and safe U.S.-based, traceable, more sustainable and low-carbon eel products to American consumers. American Unagi's elver supply is only a small portion of all elvers caught in Maine, while there is additional catch in other

States and in Canada. There is significant potential for expansion with Maine taking a leadership role in developing other facilities.

Demand – American eel is considered a specialty food item in the United States, primarily consumed in high-end restaurants, sushi bars, and seafood-focused establishments that cater to customers looking for novel and exotic seafood options. In 2021, about \$3.1 million worth of fresh and frozen eels was imported to the U.S. with about two-thirds going to New York State. Additional eel content goes into prepared sushi products not included in these statistics. Imports have risen by about 7% every year for the last decade as the U.S. sushi restaurant market grew to \$22.6 billion in 2021. The American domestic market for American eel food products is very small compared to the demand in Asian markets, where U.S. exports could compete on quality and food safety rather than on price.

Finances and economics

Finances – There is an interest in Maine to build on American Unagi’s success by establishing more grow-out operations. An approximate \$10 million investment is required to establish additional 27,000 ft³ production facilities capable of producing 500,000 pounds of eel per year. Economies of scale and logistical efficiencies could be achieved across multiple sites through shared transportation, cold storage, IT infrastructure, marketing, and personnel.

Economics – Millions of dollars’ worth of processed eel products enter the US market every year. Replacing these imports with US-made products and gaining access to the multi-billion-dollar sushi market is a realistic goal where Maine could take a leadership role. The capital construction will generate 52 jobs and \$7.2 million in added-value, then operations will generate 14 jobs and \$1.3 million in added value each year.

Next steps

Year 1 – Confirm new locations / partners for additional production facilities in Maine.

Years 2 & 3 – Build the next facility and secure sales agreements with domestic buyers.

Key sources

- The Atlantic States Marine Fisheries Commission (ASMFC), 2017. American Eel Stock Assessment Update (online: <https://asmfc.org/species/american-eel>)
- Sea Maine, 2022. Maine’s Seafood Baseline Report (online: <https://www.seamaine.org/reports-presentations/>).

3.13 Product – Green crab

Overview

Green crabs have been a delicacy in Europe (e.g. Italy) and Asia (e.g. Cambodia, and Vietnam) for centuries and there is an opportunity to develop domestic U.S. cultural markets and potential exports. Green crabs have been examined closely in Maine as an invasive species¹¹ costing millions of dollars in damage to marine ecosystems (e.g. eelgrass beds) and other commercial fisheries (e.g. American eel, crab, and lobster) on the Eastern U.S. coastline¹². Although catching and processing green crabs is more challenging than for other crabs, the shell-off product commands high prices as chefs and consumers are able to consume the whole body. Shell-on products can also be turned into seafood sauces, pet foods, aquaculture feed, bait, and fertilizers. Green crabs are caught in other fisheries as by-catch, but a small targeted fishery in areas of high green crab density can be developed along with processing capacity. A \$200,000 investment in feasibility assessment and capital support is needed considering the coordination required between harvesters and processors, facility design, siting, and equipment purchase. In addition to the economic benefits of local capital construction, the on-going operations for every ten (10) tons of green crab harvest will represent an estimated annual 4 jobs, and \$125,000 in annual value-added (GDP).

Opportunity description

The aim is to catch green crabs within three (3) weeks of moulting and store them in a holding facility. They are checked daily for moulting and harvested when the shell has been off for less than 24 hours (even 12 hours) since any longer will lead to new shell hardening and they are not suitable for the highest-value markets. The crab grows as much as 40% following moulting, which is also ideal for harvest. This is much like the larger U.S. blue crab industry established since the 1970s, therefore water quality parameters and holding facility design will be similar. Holding facilities should maximize separation of crabs to avoid cannibalism and make it easier to identify moulting, therefore stacking trays as used for salmon eggs in hatcheries are an ideal setup for containing as few as one crab per tray.¹³ It is also possible to simply separate crabs into three groups according to the anticipated number of weeks to moulting by noting biological indicators.

Market environment

Supply - U.S. landings of green crab have increased from 141,000 lbs in 2016 to over 250,000 lbs in 2022 (110 metric tons), while landed prices over this period improved slightly from \$0.45/lb to \$0.49 per lb.¹⁴

¹¹ Governor's Task Force on the Invasive European Green Crab, 2014. Report to Maine Governor Paul R. LePage, September, 2014.

¹² Lovell, S., E. Besedin, and B. Grosholtz. 2007. Modeling Economic Impacts of the European Green Crab, Presentation at the American Agricultural Economics Association Annual Meeting.

¹³ St. Hilaire, S. 2016. Assessing the potential for a soft-shell green crab industry in PEI, UPEI Masters Thesis.

¹⁴ Atlantic Coastal Cooperative Statistics Program. 2023. (online: <https://www.accsp.org>)

The most successful option is an American eel fyke net by-catch fishery, however this may not yield sufficient volumes. A doubling of prices (about \$0.90/lb) is needed to motivate targeted effort to catch green crabs with dedicated fyke nets and baited traps. This would support supply volumes necessary for viable processing and market development, especially since this is a short-duration fishing season. Male green crabs are the primary focus in a 3-4 week window, however product development for females that lead to a higher percentage of shell-on product would help extend the season. Most product will ship fresh, however some “fresh frozen” product will avoid flooding nearby markets and offer opportunities for long-range shipment including the more lucrative markets in Europe and Asia.

Demand – The greater Boston area alone is home to over 53,000 Vietnamese that eat about 92 pounds of seafood per person, which is almost six times the average American seafood consumption rate (16lbs/year). Markets also exist in New York and beyond as well as other cultural markets in the U.S.. Restaurants serving green crab in the U.S. will pay upwards of \$25/lb in order to offer high-end dishes to their customers.¹⁵ To the extent that exports are possible, the harvest season in Maine (July-August) will not compete with the harvest season in Italy (April-May), making this a good opportunity to maintain high prices. Price in Italy can reach \$136/lb³, which easily offsets export costs.

Finances and Economics

Finances – The first step will be to determine the potential scale of harvest so the following represents a ten (10) ton fishery that is scalable. Since the fishery is small, economies of scale will not differ substantially in the 5-20 ton range, and additional catch is likely to occur in different locations along the Maine coast so the setup can be replicated.

The first component involves the harvesting requirements where either fyke nets (akin to eel fisheries) or baited traps (i.e. crab traps) are purchased for a dedicated fishery. A three (3) week ten (10) ton fishery is assumed to take place just before moulting time. About \$15,000 in capital costs are needed for a combination of 60 traps and 20 fyke nets along with minor modifications to fishing vessels. Annual operational costs are about \$22,000 for bait, fuel, labor, and other supplies. About 2 full-time equivalent (FTE) jobs are created through harvesting activities.

The second component is the holding and processing with 10-ton capacity, which is estimated to cost about \$200,000. The operational costs are about \$95,000 including purchase of the crabs from harvesters, water, power, packaging, freezing, transport, and marketing. Five (5) to ten (10) workers are needed to process the crabs each day for 21 days and some additional labor is required for sales, marketing, and distribution (1-2 FTE per year).

¹⁵ Poppick, L. 2019. Harm to Table: Turning an Invasive Crab into a Delicacy, Scientific American (online: <https://www.scientificamerican.com/article/harm-to-table-turning-an-invasive-crab-into-a-delicacy/>)

Economics – In addition to the economic benefits of local capital construction, the on-going operations for every ten (10) tons of green crab harvest will represent an estimated annual 4 jobs, and \$125,000 in annual value-added (GDP).

Next steps

Year 1 – Determine the best location(s) and work with harvesters to confirm participation. Harvesters or a separate interest could own and manage the processing facility. Administrative arrangements, crab pricing, and logistics must be established.

Year 2 – Purchase and set-up the harvesting and processing infrastructure to begin targeted fishing by end of the second year.

Key sources

- Multicultural Market Analysis: Cambodian, Vietnamese Seafood (Tae Chong – Maine State Chamber of Commerce)
- St-Hilaire, S., Krause, J., Wight, K., Poirier, L., & Singh, K. (2016). Break-even analysis for a green crab fishery in PEI, Canada. *Management of Biological Invasions*, 7(3), 297303. <https://doi.org/10.3391/mbi.2016.7.3.09>
- Hungria, D.B., dos Santos Tavares, C.P., Pereira, L.Â. et al. Global status of production and commercialization of soft-shell crabs. *Aquacult Int* 25, 2213–2226 (2017). <https://doi.org/10.1007/s10499-017-0183-5>
- Governor's Task Force on the Invasive European Green Crab, 2014. Report to Maine Governor Paul R. LePage, September, 2014.
- Lovell, S., E. Besedin, and B. Grosholtz. 2007. Modeling Economic Impacts of the European Green Crab, Presentation at the American Agricultural Economics Association Annual Meeting.
- Atlantic Coastal Cooperative Statistics Program. 2023. (online: <https://www.accsp.org>)
- Poppick, L. 2019. Harm to Table: Turning an Invasive Crab into a Delicacy, *Scientific American* (online: <https://www.scientificamerican.com/article/harm-to-table-turning-an-invasive-crab-into-a-delicacy/>)

3.14 Product – Marine seaplants

Overview

There are multiple opportunities related to marine seaplants including: sugar kelp (food) product expansion, rockweed (non-food) product expansion, imported seaweed processing, and seaweed cultivation for carbon capture. This opportunity is linked, in part, to the aquaculture lease access opportunity since there are numerous applications for marine plant production caught in the backlog. There is also a potentially large value-added opportunity for seaweed being imported to Maine and sold for agricultural applications. Two to three processing facilities are needed to keep value-added processing from leaving Maine (for Canada), accommodate increasing Maine cultivation (aquaculture lease application trend), and add value to some portion of the 30,000 tons of processing waste containing imported seaweed from foreign sources. The capital construction will support 46 jobs and \$4.2 million in added-value, then on-going operations will generate 18 jobs, and \$1.6 million in value-added (GDP) each year.

Opportunity description

Marine seaplants are broadly divided in two according to their consumer end-uses as either food (e.g. sugar kelp) or non-food (rockweed) products. Rockweed is primarily collected in the intertidal zone so shoreline access to the resource is critical, whereas sugar kelp may be grown on lines away from shore. Land-based tanks are also now being used to grow a small portion of seaweed for food products. There is also about 30,000 tons of mixed composition material containing seaweed imported from foreign sources, with potential for value-added processing to create products for agriculture and landscaping¹⁶. While cultivation capacity is addressed by the aquaculture access opportunity, there is still a need to greatly increase processing capacity for Maine-grown and imported seaplant materials.

Market Environment

Supply – Globally, most marine plant supply and demand is focused on Asian markets, while the U.S. market is currently small by comparison. The estimated U.S. market size in 2015 was \$1.3 billion¹⁷ and now likely over \$2 billion, about 90% of which is food product, and the balance is seaweed products for agriculture and soil amendments. Large volumes of seaweed are currently imported to the U.S. from major global producers, but there are concerns about quality and food safety, therefore Maine producers offer distinct advantages. Cultured production in Maine grew ten-fold in just two years from 54,000 wet lbs in 2018 to 497,000 lbs in 2020, and growth is poised to continue. Most of this Maine production is focused on U.S. markets and there are some volumes of rockweed shipped to Canada for processing. Developing processing capacity in Maine and expanding production to meet domestic and international market demands should be the focus over the next decade.

¹⁶ Due to the mixed composition, this material is also mentioned in the non-biological residuals opportunity in this report.

¹⁷ Maine Biz, 2018. Ocean Bounty Tolef Olson has a knack for turning seaweed into products that are in demand (www.mainebiz.biz/article/ocean-bounty-tollef-olson-has-a-knack-for-turning-seaweed-into-products-that-are-in-demand)

Demand – Because marine plants are so versatile and support a wide array of products that are not necessarily identified as seaplant-based, it is difficult to determine total market demand beyond the raw material. There are many seaweed products and inputs to other products (animal feeds, cosmetics, processed foods, soil amendments, etc.) that market data is not available for so the following clearly underestimates the potential. In the past decade, U.S. imports of raw seaweed has grown by \$5 million per year, where the top five states with the most growth in demand are Florida (\$0.7 million per year), followed by Massachusetts (\$0.6 million), Missouri (\$0.5 million), New York (\$0.3 million), and Delaware (\$0.3 million). Since this is raw material rather than value-added product demand, the total value is at least ten (10) times higher, so there is about \$50 million per year in domestic market opportunity. Singapore, Italy, and Canada represent the best international export opportunities where there is a combined \$20 million growth per year. Maine could target a portion of this domestic and international growth in demand.

Finances and Economics

Finances – Building or expanding two to three strategically located processing facilities will keep value-added processing from leaving Maine (Canada), accommodate increasing Maine cultivation (aquaculture lease application trend), and add value to some portion of the 30,000 tons of processing waste containing imported seaweed material. About \$6 million in capital divided according to 2-3 facilities is required. There will be about \$1.5 million in on-going operations for the facilities.

Economics – The capital construction will support 46 jobs and \$4.2 million in added-value, then on-going operations will generate 18 jobs, and \$1.6 million in value-added (GDP) each year. A \$1-\$2 million public investment would be a catalyst for private sector investment to move forward, as this would advance the detailed analysis, site selection, facility design, and show strong support to lending institutions as needed for financing.

Next steps

Year 1 – Work with existing Maine seaplant producers and processors to confirm the priority locations and scales of facilities required.

Year 2 & 3 – Build and begin operating new processing facilities.

Key sources

- Sea Maine, 2022. Maine's Seafood Baseline Report (online: <https://www.seamaine.org/reports-presentations/>).
- Sea Maine, 2022. Marine Resource Residuals in Maine. (online: <https://www.seamaine.org/reports-presentations/>).
- PR Newswire, 2021. Commercial seaweed market size worth \$37.8 billion by 2028 (<https://www.prnewswire.com/news-releases/commercial-seaweed-market-size-worth-37-8-billion-by-2028-grand-view-research-inc-301437675.html>)
- Maine Aquaculture Association, 2023. Maine Seaweed Benchmarking Report (online: <https://maineaqua.org/benchmarking/>).

3.15 Product – Non-biological residuals

Overview

There is an opportunity to increase recycling of non-biological residuals and create value-added products locally. These residuals from fisheries and aquaculture operations include nets, buoys, ropes, and other gear. In particular, plastics can be recycled into a wide range of products including some that are used in the marine resource sector. There are key people already involved and interested in expanding non-biological residual recycling in Maine, and a feasibility study will determine the best scale and products to develop. The economic impacts of planning and construction will support about 45 jobs and \$7 million in added-value for Maine, while operations will support added-value of about \$1.6 million and 20 jobs annually.

Opportunity description

There are two parts to this opportunity, namely: 1) establishing recycling capacity in Maine to capture the added-value processing that is currently performed outside the State, and 2) expanding the volume of recycled commercial fishing while adding aquaculture gear. One organization with four (4) staff is already collecting some gear in Maine, but this is exported to be processed into new products. There is enough potential gear collection in Maine to support a recycling facility, where much higher value is generated from manufacturing into new products. Expanding commercial fishing gear collection and including aquaculture gear, particularly marine finfish aquaculture (sea cages and buoys), makes sense because it will increase the input volume for viability of a recycling facility. There is strong interest amongst aquaculture companies to address this. One valuable application for aquaculture growers is to produce compensator buoys (CBs) and other buoys from recycled materials. For instance, multiple CBs are needed to stabilize and secure sea cages and other floating platforms for marine finfish aquaculture. Resolving this will create recycling jobs while reducing landfill waste and highlighting a marine resource sector contribution to a more sustainable circular economy. There is also over 30 million lbs of mixed composition material containing seaweed and perlite imported from other states, with potential for value-added processing to create products for agriculture and landscaping.¹⁸

Finances and Economics

Finances – There are hundreds of CBs, and thousands of other buoys deployed in Maine waters each year, with a portion needing replacement each year at a cost of \$100 to several thousand dollars depending on size and features. A \$75,000 feasibility study is required to determine the scale, location, and other specifics of a recycling facility in Maine. There is strong supply represented by the interest of marine sector companies that produce used gear and would prefer recycling over landfilling (also gear manufacturer interest), and there is strong demand for used gear since there are currently no limits on the volume accepted by recyclers. This reflects consumer market interest in products made from recycled content and recycling competitiveness compared to sourcing virgin materials. The capital

¹⁸ Due to the mixed composition, this material is also mentioned in the marine seaplants opportunity in this report.

construction for a recycling facility of about \$10 million would rely on private investment and some government support. There are several models for ensuring sustainable operations (volume and revenue) with options for incentivizing recycling including: “environmental fees” paid at the point of sale for gear to cover recovery and recycling (like many appliances), a deposit-refund system where part of the deposit is returned to the gear owner when gear is delivered for recycling (like bottle refund), or discounts on the purchase of new gear when old gear is returned to manufacturers/retailers (like some electronics). Some of these topics have already been discussed in Maine. One of the above options will generate revenues for collection of gear and possibly cleaning and sorting, while the manufacturing of new products will generate further revenues. Operational revenues are expected to be at least \$2 million per year.

Economics – The economic impacts of planning and construction will support about 45 jobs and \$7 million in added-value for Maine, while operations will support added-value of about \$1.6 million and 20 jobs annually.

Next steps

Year 1 – Bring key organizations together to scope a feasibility study and explore levels of commitment from key players. This should examine both the supply (used gear) and demand (processing and end markets) for a thorough analysis.

Year 2 – Locate and build the recycling facility keeping in mind final details may incorporate residuals from more than just the marine resource sector.

Year 3 – Begin operations of the recycling facility.

Key sources

- Net-Your-Problem (online: <https://www.netyourproblem.com/>)
- Maine Aquaculture Association (online: <https://maineaqua.org>)

IV Making Choices

As the global opportunities are considered for investment and prioritization, it is worth recalling results from the 2023 SEA Maine Workshop in Belfast, Maine. A presentation about making opportunity investment choices involved an exercise for workshop participants. At the time, the specific opportunities were not ready for evaluation so the first workshop exercise asked participants to rank the priority of six Roadmap action themes with the following results:

Priority order and average rankings on a scale from 1-6 (n=38)

- 1st Infrastructure (avg. rank 2.4)
- 2nd Business and community sustainability (avg. rank 2.9)
- 3rd Talent and workforce (avg. rank 3.4)
- 4th Markets and communication (avg. rank 3.6)
- 5th New product development (avg. rank 4.1)
- 6th Research and data (avg. rank 4.6)

A more complex exercise then asked workshop participants to make choices between opportunities, again not specific ones, but with the key attributes associated with opportunities as follows:

- **Risk** (Lower, Higher)
- **Time** to start an opportunity (1 years, 3 years)
- **Scale** / cost (\$10Ks, \$100Ks, \$Millions)
- **Return** / benefits (Avoid loss, Low return, High return)

Trade-offs between attributes is often required when making investment decisions, for instance spending more (cost) can lower risk or increase returns. Taking more time can also increase returns or reduce risk. The 36 participants each completed ten (10) choice sets involving three opportunities. In total, participants evaluated 1080 different opportunities (i.e. $36 \times 10 \times 3 = 1080$) with the following results:

- **Risk** - preference for lower risk opportunities (62% of choices vs. 38% for high risk),
- **Time** - almost equal support for shorter (52% like 1 year) vs. medium-term start-up (48% like 3 year),
- **Scale** - preference for small-scale opportunities (57% for \$10,000), medium-scale (30% for \$100k-\$1 million), and less interest in large-scale opportunities (12% for \$1 million and up), and
- **Return** - preference for a high return on investment (74%) vs. low return (12%) or potential loss (12%).

The above six (6) action themes and four (4) opportunity attributes exist across the fifteen (15) priority opportunities in this report. Although each opportunity is worthy of investment and effort, putting some ahead of others should consider the tradeoffs not just from the perspective of workshop participants, but what is needed most for the sector as a whole.

Appendix A – Workshop Opportunity Choices

A.1 Morning sessions

The 2023 SEA Maine Workshop in Belfast, Maine was guided by the six (6) Roadmap framework themes at the time including:

- Infrastructure
- Business and Community Sustainability
- Workforce Development
- Markets and Communication
- New Product Development
- Research and Data

These were flexible themes as the Roadmap developed, and these were the basis for six (6) break-out sessions in the morning. The Roadmap actions aligned very well with the opportunities analysis, and Gardner Pinfold team members were involved in all six morning break-out sessions to capture the group discussions.

A.2 Afternoon session

While the opportunities discussions in the morning cut across the six themes, the afternoon dedicated an interactive presentation to focus on all opportunities. The aim was to inform workshop participants about the approach to the opportunity analysis, and to gather input from participants as the opportunities must be short-listed and prioritized for on-going work across the marine sector. The presentation contained the following parts, and key results are highlighted below:

- Introduction
- Analysis approach and scope
- Ranking of six (6) roadmap themes
- Ranking of three (3) groups of six (6) specific opportunities
- Discussion of ranking challenges
- Investment criteria and opportunity attributes
- Making choices about opportunity attributes
- Summary of choice responses
- Next steps for opportunities analysis
- Questions and discussion

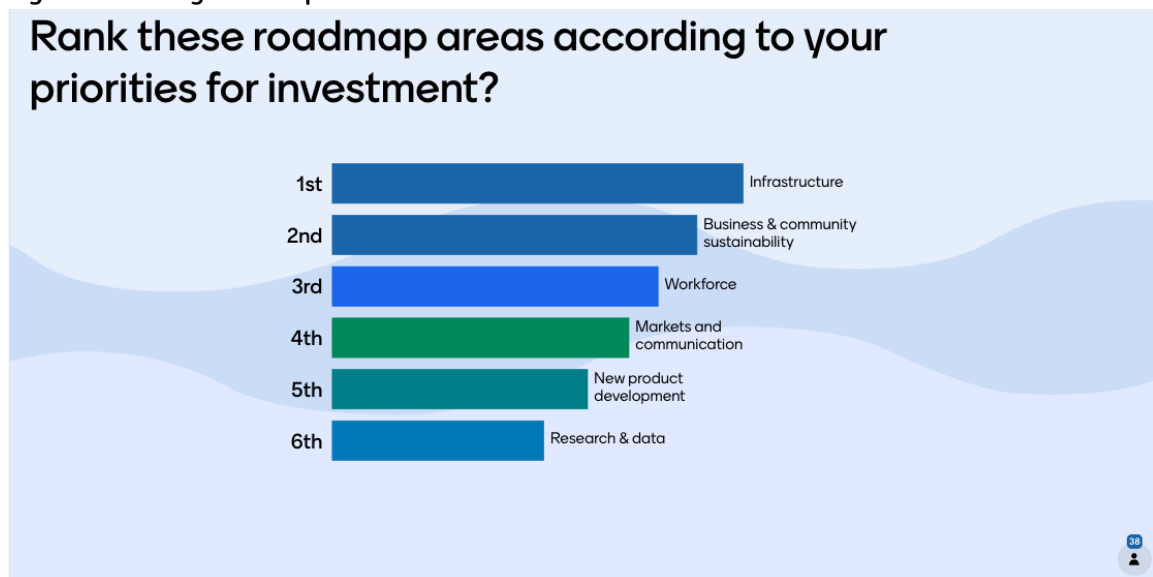
A.3 Key results

All of the following results must be interpreted while recognizing that participants in the workshop do not represent the entire marine sector, and are providing input without full information regarding opportunities. The aim was to help workshop participants understand the key considerations and provide input regarding their general views on the needs and priorities of the sector. The full Global Opportunities Assessment report includes the same rigorous and objective criteria discussed in the workshop, and can be applied to finalize and prioritize the key opportunities in Maine.

Roadmap theme rankings

Following the morning sessions, the first thing that was easiest for participants to evaluate was the relative importance (in their view) of each theme in moving the sector forward. Work will continue in all areas, but more effort could be placed in areas that are seen as higher priority. The following slide reflects the input from the group (n=38). In particular, “Infrastructure” was the first choice for 44% of participants and it was the second choice for another 15%, making it the first or second choice for almost two-thirds (59%) of participants. This theme covers a wide variety of goals and actions in the roadmap such as roads and transport, power and internet connectivity, strengthening waterfront structures, equipment and capital projects.

Figure 1: Ranking Roadmap themes



Specific opportunities

In order to provide a sense of the key opportunities being investigated as well as how to prioritize these, eighteen (18) specific opportunities were ranked in groups of six (6). The following slides indicate the ranking results by workshop participants.

Figure 2: Ranking specific opportunities (set 1)

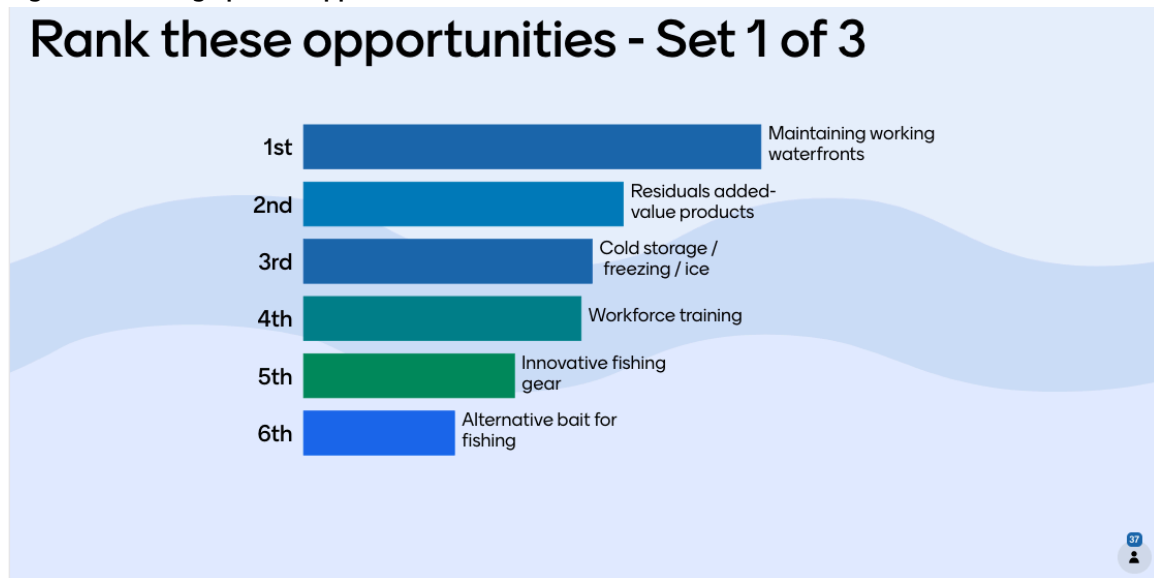


Figure 3: Ranking specific opportunities (set 2)

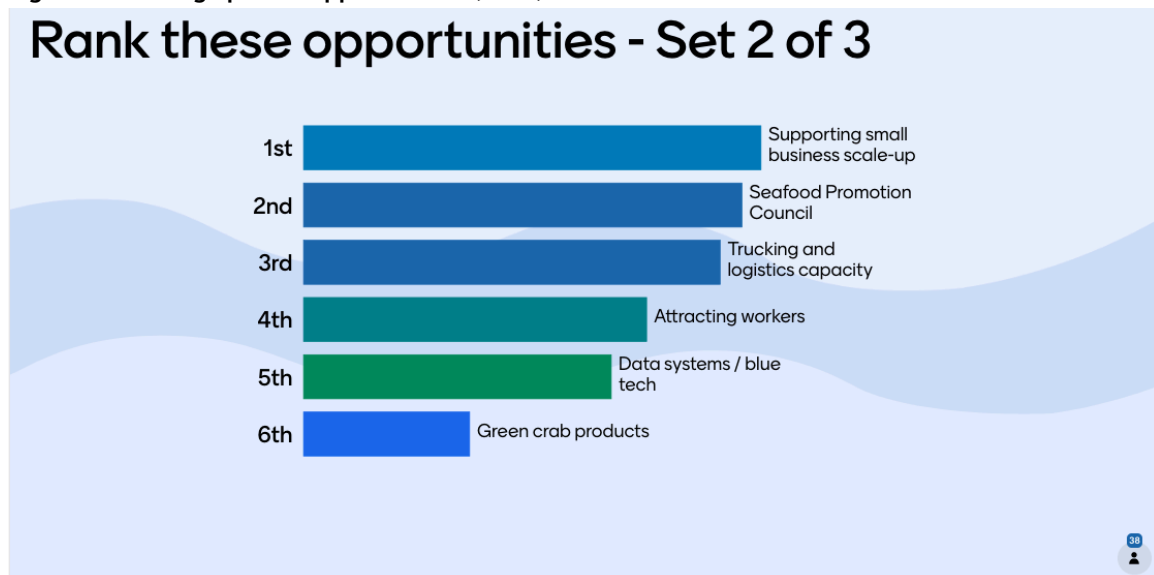
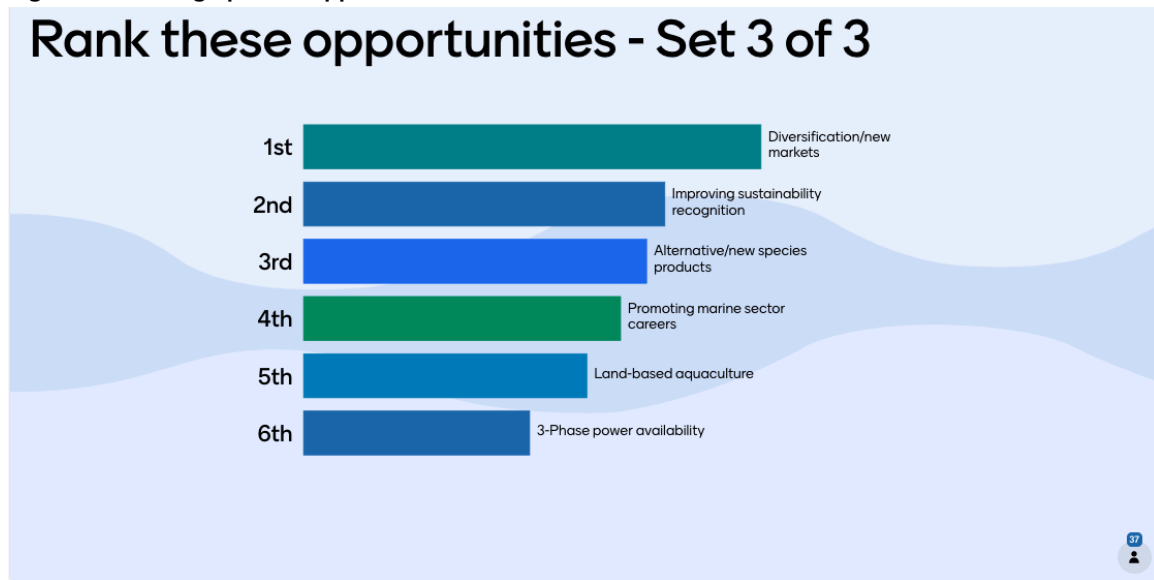


Figure 3: Ranking specific opportunities (set 3)



What participants did not realize at the time was that the specific opportunities on each slide represented each of the six (6) Roadmap themes. Although specific opportunities often cut across Roadmap themes, each opportunity has a dominant linkage to a theme. This was a chance to check for consistency in participant preferences between Roadmap theme areas and specific opportunities. For instance, would participants most interested in “Infrastructure” tend to select their top pick as the “Infrastructure” opportunity from the list on each screen? The following compares Roadmap theme results with specific opportunity results:

Table 1: Ranking consistency for Roadmap themes and specific opportunities related to each theme

Roadmap Theme Rank	Theme Item	Opportunities Rank
1	Infrastructure	3
2	Business and Community Sustainability	2
3	Workforce	4
4	Markets and Communication	1
5	New Product Development	5
6	Research and Data	6

Note: Opportunities ranks represent a composite of results for three specific opportunities.

The green highlighted items retained the same ranking, but specific infrastructure opportunities were not as attractive as the overall infrastructure theme originally, while workforce dropped slightly from 3 to 4, and markets and communication climbed to top spot.

Choices regarding opportunity attributes

Although it is very difficult to prioritize specific opportunities without having all the information, it is easier to express preferences for the key attributes or characteristics of opportunities. Participants were encouraged to think about what the marine sector in Maine needs the most and would benefit from the most as effort and resources must be applied to the most pressing and promising opportunities. The following attributes were described so participants could begin to make choices where trade-offs are often required:

Choice attributes and levels in parentheses:

- Time to start an opportunity (1 years. 3 years)
- Risk (Lower, Higher)
- Cost / Scale (\$10Ks, \$100Ks, \$Millions)
- Benefits / Return (Avoid loss, Low return, High return)

There are synergies and trade-offs between choice attributes. One can imagine a larger opportunity may take more time, risk can be reduced by taking time to complete due diligence, and there can be linkages between the scale of costs and benefits.

Participants completed a practice choice before working through a series of ten (10) choice tasks that represented a balance of choices covering possible combinations of opportunity attributes. The following summarizes the basic results for each attribute where higher percentages indicate stronger support for those types of opportunities.

Participants were not aware that the 5th choice set was repeated as the 10th choice set to check for consistency of responses. Only two (2) of the 36 participants made a different selection the second time. The 34 of 36 consistent responses (94%) is considered very strong.

Figure 4: Preference for risk

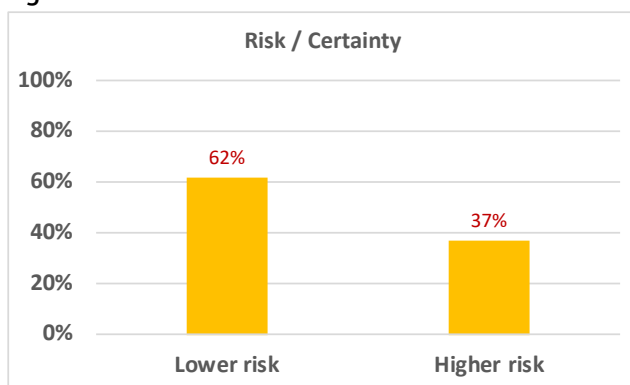
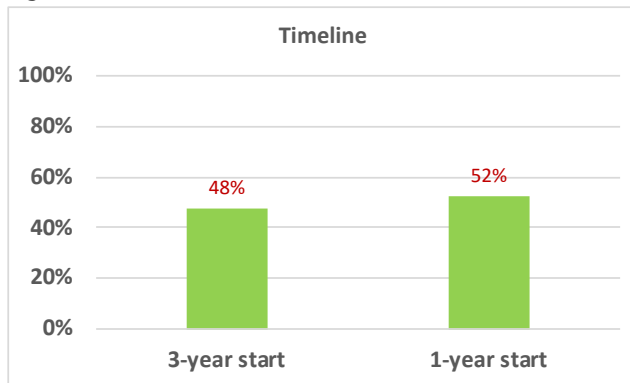
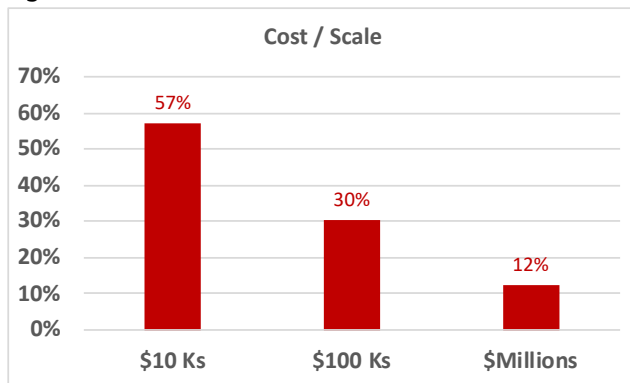
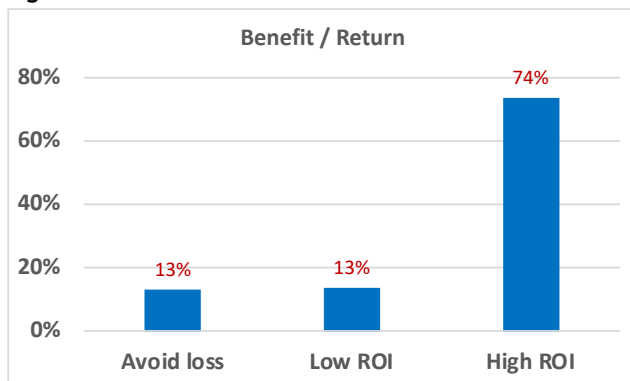


Figure 5: Preference for timelines**Figure 6: Preference for cost or scale****Figure 7: Preference for benefits or returns**

The basic results indicate a broad interest in opportunities that have lower risk (Figure 4), that have short or medium term start-up (Figure 5), that are smaller in scale such as \$10,000 – \$100,000 in cost (Figure 6), and provide a high return on investment (Figure 7).

It is possible to examine results according to sub-groups of participants at the workshop, although this is limited with a small number of people. The following slides check for differences between

participants that were most interested in infrastructure projects (44% of participants) compared to all other participants (56% of participants). There are no large differences indicating that preferences for the opportunity attributes (Figures 5-7) are broadly consistent regardless of the type of opportunity or Roadmap theme that is being assessed.

Figure 8: Preference for risk for “infrastructure” supporters vs. others

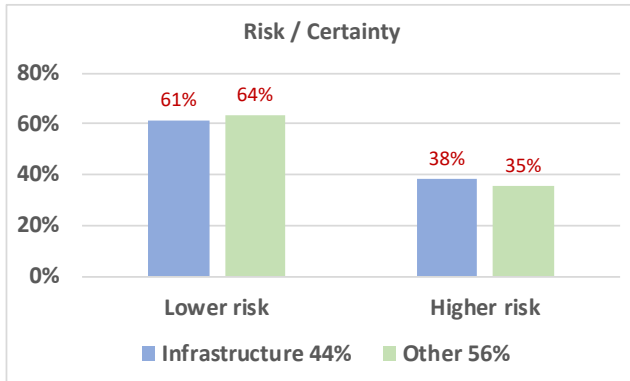


Figure 9: Preference for timeline for “infrastructure” supporters vs. others

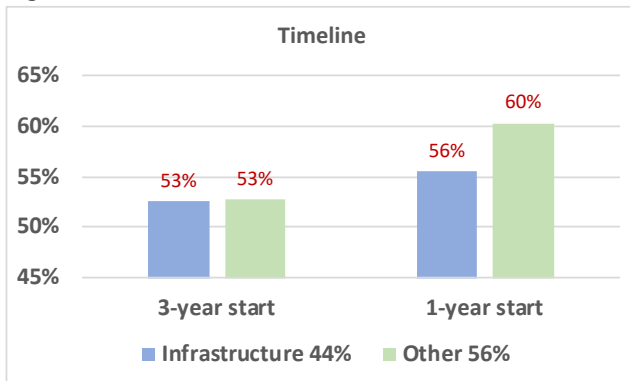


Figure 10: Preference for cost/scale for “infrastructure” supporters vs. others

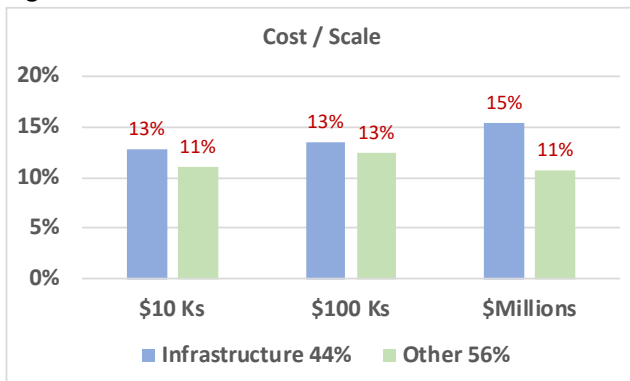
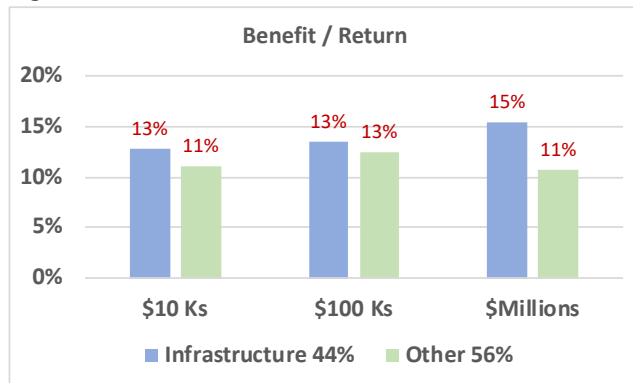


Figure 11: Preference for benefit/return for “infrastructure” supporters vs. others

Discussion

Further results will be drawn from the workshop participant input. Once the opportunity assessment is complete, some opportunities will clearly rise as priorities while others will be set aside for future consideration. Where there are a few that are more challenging to distinguish, it is important to recognize that objective, credible, and balanced criteria will be used to select and prioritize those opportunities. All information will be provided with assumptions and data sources for full transparency. SEA Maine, funding sources, and members of the marine living resource sector will ultimately select the opportunities that are best for moving the sector forward.