Maine Scallop Aquaculture Report

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Gulf of Maine Research Institute
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EXECUTIVE SUMMARY

The Gulf of Maine Research Institute, the University of Maine, and Coastal Enterprises, Inc. came together in January 2021 to form the Scallop Aquaculture Initiative (SAI), whose goal it was to take a holistic look at the current state of Atlantic Sea Scallop aquaculture in Maine. Backed by generous private funding, the SAI was directed to create an open-source document that addressed the current state of the industry and identified both its challenges and its opportunities for growth. Des FitzGerald, a longtime Maine aquaculture industry veteran, was hired to serve as Project Manager for this five-month effort, and in this capacity, he conducted all the research, interviews, and site visits noted in this report. The SAI provided oversight, guidance, and support to Des throughout the project, and has reviewed and accepted his written project report which we find to be comprehensive and accurate.

GLOBAL BEST PRACTICES

A number of aquaculture enhancement best practices from around the world were examined. They revealed certain characteristics that need to be in place to help insure the successful growth of an aquaculture industry.

- Federal and state support manifested in a planning process and resulting management plan is essential to codify the economic role for marine aquaculture.
- The existence of waterfront infrastructure resources, a marine trained workforce, access to market, sound profit margins for the farmed products and, in many cases, a threat to or collapse of a dominant commercial fishery, are the central features of most successful aquaculture industries globally.

Maine possesses many of these attributes, and with its 3 million acres of state coastal waters, it has a unique potential to develop marine aquaculture. Key findings of this report are as follows:

OPPORTUNITIES

Favorable Growing Conditions

The farming of sea scallops holds real promise for Maine. The ocean conditions supporting the natural wild populations span a large portion of our near-shore coast that appears to also be suitable for farming this species.

Operations Improvements for Improved Profitability

Sea scallop farmers can improve their prospects for profitability through increased mechanization, better understanding of important farm siting characteristics, and overall husbandry technique improvements.

A Brandable Story and Product to Market

The commercial fishery for sea scallops in the northeast U.S. has established a very high commodity value for the scallop meats. Scallop farmers should be able to capitalize on this with branded high value products through fresh year-round availability, a lighter environmental impact story, and improved product quality.

Hatchery Potential

Many of the world's successful aquaculture industries are supported by a commercial hatchery system that can advantage farmers of specific species for increased growth rates, improved finished product, disease resistance, and a steady supply of seed throughout more of the year. Sea scallops offer a particular challenge to overcome in a hatchery system; however, as surviving their protracted larval period has proved difficult/impossible to date. Every effort should be made to overcome this hurdle as the benefits of seed from a hatchery system are significant and can complement the collection of wild spat.

Alternate Product Forms

A number of sea scallop products are available for farmers to sell, including: whole live, roe on, meats on the half shell, and the meats alone. All of these products, other than the meats, are relatively new to the U.S. market and offer unique potential to maximize their value proposition in the marketplace.

CHALLENGES

Biotoxin Risk

The one caution and ongoing challenge for both whole live and roe on products are a short shelf life and the need for strict and costly biotoxin testing. In the rapidly changing ocean environment of the Gulf of Maine, managing for biotoxin blooms and the resulting toxicity to these products is particularly challenging. This is a pressing need for current growers and the State.

Co-existence with Other Marine Users

Co-location of aquaculture lease sites with other economic uses, in particular commercial fishing interests, marine traffic, and conservation, put negative pressure on selection and permitting of larger scale lease sites. In addition, the Gulf of Maine, Maine's coastal waters, shorefront, and working waterfront infrastructure are in high demand for competing and complimentary uses. Real estate development also puts pressure on working waterfront properties and access to the shore.

Sea scallop aquaculture is currently a mix of small individual businesses. It has the potential to be a larger contributor to Maine's economy, as demonstrated in other countries, and could significantly contribute to the diversification and resiliency of communities with deliberate alignment between Maine's economic goals and aquaculture policy and regulation.

Maine's current seafood economy, and many of its rural communities, are very dependent on a single species, lobster, and diversification is critical to protect against decreases there, whether from climate change or shifting economic demand.

State of Maine Leasing Process

Maine NGOs, membership organizations, and educational institutions have invested a good deal of time and money into growing the aquaculture sector, but, as of this writing, the potential economic growth and expansion of Maine's marine aquaculture has not yet been realized. Growth over the last dozen years has been modest, averaging just over 30 acres per year of approved aquaculture standard leases through the Department of Marine Resources (DMR). The Maine leasing process can be lengthy, and individual lease by lease timeline can vary based on the specific locations.

The State of Maine has identified aquaculture as a statutorily defined technology sector since 1996. State programs including state agencies (DMR and the Department of Environmental Protection), the University of Maine System, the Maine Technology Institute, the Maine Community College System, and the Maine Aquaculture Innovation Center all have resources and programs supporting aquaculture research and development, incubation, and workforce development. In addition, many Maine non-profit research and community/economic development groups, such as the Gulf of Maine Research Institute, Bigelow Laboratory for Ocean Sciences, University of New England, Coastal Enterprises Inc., the Island Institute, and FocusMaine, as well as others, all have aquaculture programs and initiatives. Maine's 2019 10-year economic strategic plan and the 2020 Climate Action Plan recognize aquaculture as part of Maine's economic growth and climate friendly sectors as well.

However, the State of Maine has not established a strategic growth plan for aquaculture that sufficiently recognizes marine aquaculture as an essential contributor to long term economic growth and vital diversification strategy in the face of a changing world. This lack of policy in aquaculture industry growth is related to a siloed view of various fisheries, the attention to the dominant single species (lobster) fishery, along with a protective coastal community that can be averse to change. State leadership's vision is needed to define and advocate for aquaculture's place in Maine's coastal economy. As part of this, the lease administration process needs to be more robustly funded to support adequate management of a prosperous aquaculture industry.

For sea scallop aquaculture to become a growing source of marine related jobs, Maine policy makers and communities will need to decide if the coast can be more of a shared common resource and the degree to which aquaculture can grow to play the role this Maine's economic future.

MAIN REPORT

Phase 1:

INTRODUCTION

The Gulf of Maine Research Institute, University of Maine, Coastal Enterprises, Inc. (CEI), and the Maine Aquaculture Innovation Center collaborated to form the Scallop Aquaculture Initiative (SAI), whose goal was to take a holistic look at the current state of scallop aquaculture in Maine. Backed by generous private funding, the SAI was directed to create an open-source document that addressed the current state of the industry and identified both its challenges and its opportunities for growth.

The first scoping phase herein describes both historic and current experiences of the scallop farming industry in Maine and elsewhere, recent and ongoing research, and development activities, current and anticipated product forms, market trends and distribution channels, as well as addressing the many issues that offer both hope and headwinds to this as yet nascent industry in Maine.

The results of the first scoping phase will also be recommendations for a Phase 2 project plan that may include pilot study activities intended to fill the knowledge and operational gaps identified in Phase 1 and that could be implemented beginning in the FY 21 & FY 22 farming seasons. Working with Maine's existing farmers, supporting and learning from their experience, and plans for their growth and expansion is an important component going forward.

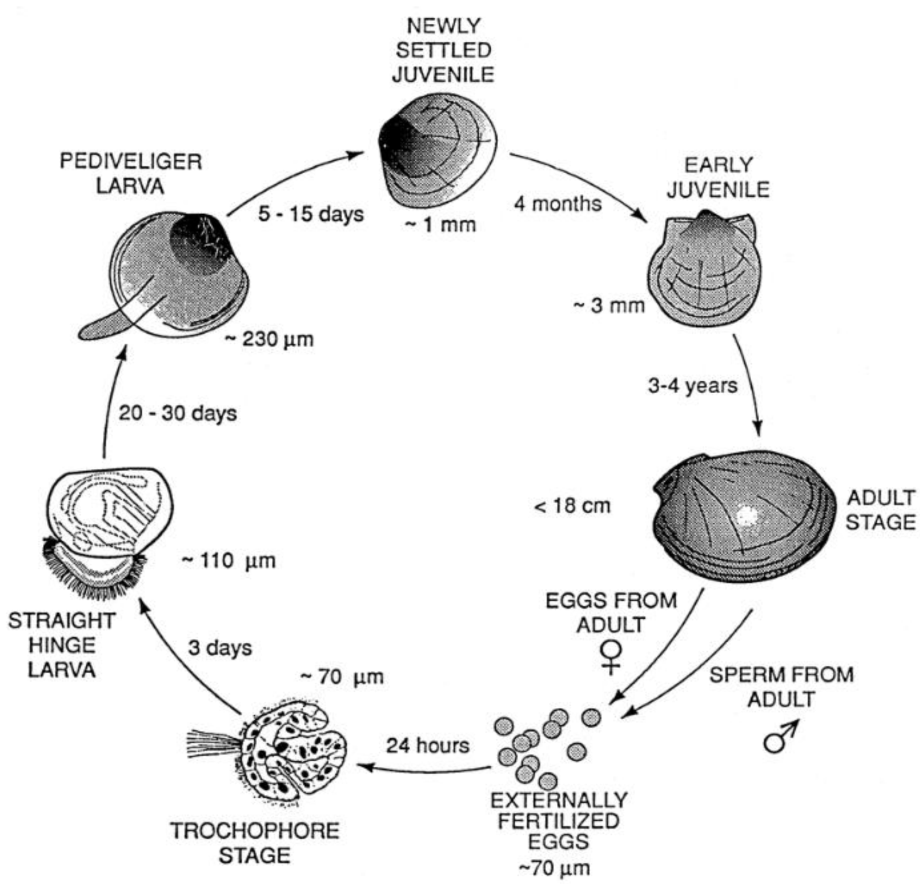
For the sake of this exercise, which was initially intended to include an examination of other species of scallops to be considered for growing, the leadership team has determined that it will focus on sea scallops (*Placopecten magellanicus*) as the best scallop species candidate for aquaculture in Maine at this time. SAI did research the potential for growing Cape Cod Bay scallops (*Argopecten irradians*) in Maine. It was determined that, although legal to grow in State waters, the species has proven to be very challenging to raise consistently, and it is even more difficult in the shorter, colder water growing season that Maine has compared to bay scallops' native habitat further to the south. (Gary Wikfors interview)

CURRENT STATE

Sea Scallops

Of the 400 +/- species of scallops worldwide only about 10% are currently farmed, but the farmed volume worldwide, as of 2017, was 4.5 times larger than the total worldwide wild harvest of all species of scallops (Shumway, 2020). The commercial harvest of sea scallops from the northeast U.S. represents the largest landings and highest value of any scallop fishery throughout the world. China, Japan, Peru and France are among the leading countries that have developed robust farmed scallop industries.

The sea scallop is a long-lived, up to 29 years, cold water species whose range extends from the Gulf of Saint Lawrence south to Cape Hatteras, N.C.. It prefers to live in deep water, especially in its more southern range. Sea scallops can reproduce in their second year of life, and a mature 10-year-old female is capable of spawning upwards of 90 million eggs in a year (MacDonald, 1986). Certain populations of sea scallops can have two annual spawning cycles. Like a number of other scallop species, sea scallops can swim short distances to escape predators or to migrate to more favorable locations.



The Life Stages of the Sea Scallop

It's worth noting that the unusually long larval stage of up to 45 days has presented a challenge to the successful growing of sea scallop hatchery seed to the settled juvenile stage when they are more hardy and transportable.

Sea Scallop Farming in Maine

The culture of sea scallops in Maine has been the source of some interest and efforts over the past 15 plus years, but has yet to grow to a point where sufficient economies of scale or accurate costing models are available. Through the efforts of a number of Maine NGOs and State organizations, early investigations have looked into the thriving scallop aquaculture industry growing the Japanese scallop (*Patinopecten yessoensis*) centered in Mutsu Bay and around Aomori, Japan. Japan began its scallop farming in the 1930's in an effort to help re-seed and bolster its wild scallop fishery. By the mid-1960's, the industry began to grow out their scallops to market size. Today scallops are being farmed on some 1,900 farms, and their output represents 70% of Japan's total scallop harvest. Several trips to the Aomori region (1999-2016) by interested parties involved in the Maine scallop growing effort helped to first bring equipment and culturing techniques to Maine.

Today there are seven to nine active sea scallop farmers in Maine waters, but only a few have had product to sell so far, primarily in the form of small "Princess" or medium size whole live scallops. These farms are located from Schoodic Peninsula to the Casco Bay area in water 40 feet or deeper. Seed is collected from the wild in spat bags. It is then cleaned and sorted, and the spat is placed in lantern nets for the initial grow out period of nine to twelve months. Both scallops and lantern nets must be periodically cleaned of biofouling during this first year of growth. Scallops are then graded and put into any of four types of equipment for the final grow out to market. Pearl nets, ear hanging, bottom cages, and pocket nets have all been used and tested for this final grow out to market period of an additional nine to twelve months. The choices for growing techniques are largely dependent on the site characteristics and the final product type that a grower would want to produce.

As of today, there is no consensus within Maine in regard to the optimal size of individual scallop farms or for farms of other species being grown in Maine. In trying to answer this question, the authors of this report would suggest that a scallop aquaculture industry and its role in the Maine economy is far more robust and resilient if it is made up of large-, medium-, and small-sized companies.

Throughout Maine, the local/host community has great influence on the acceptance of new aquaculture businesses. Communities often reflect on the size of the business including lease size and land-based assets in their evaluation. Maine has recent examples of community resistance to larger ocean lease-based businesses that are considered by some to be less beneficial to the community and may impede the ability of smaller or start-up companies to co-exist and prosper.

The virtues of variable farm/business size, where best practices win out and the ability of the single entrepreneur is enabled by a larger company's ability to do research and development (R&D) bring stability to a market, act as buyer and distributors for smaller farms, or offer the single operator a potential financial exit or partnership, should they choose. If the aquaculture sector is to grow and support Maine's coastal rural economy, Maine policy makers should facilitate aspects of Maine's 10-Year Economic Strategic Plan and support a blend of private and public investments in a continuum of company size and locations and the support of R&D, workforce development, market development, and efficient and pragmatic regulatory processes. Innovation can come from both large and small companies. Start-up farmers need the option and ability to build a business to a scale, to attract investment, and/or grow business assets to sell or pass to the next generation. Maine's policymakers must proactively align the State's historical support for aquaculture R&D/innovation, the goals of 10-Year Economic Strategic Plan, new resources at the Department of Marine Resources (DMR) aquaculture programs, and revisions to legislation/rulemaking on leasing. As will be discussed in the aquaculture enhancement best practices section of this report, there are examples of state governments that thoughtfully support the growth of an aquaculture sector through any number of leasing policies that allow for growth, while at the same time protecting and enhancing local communities.

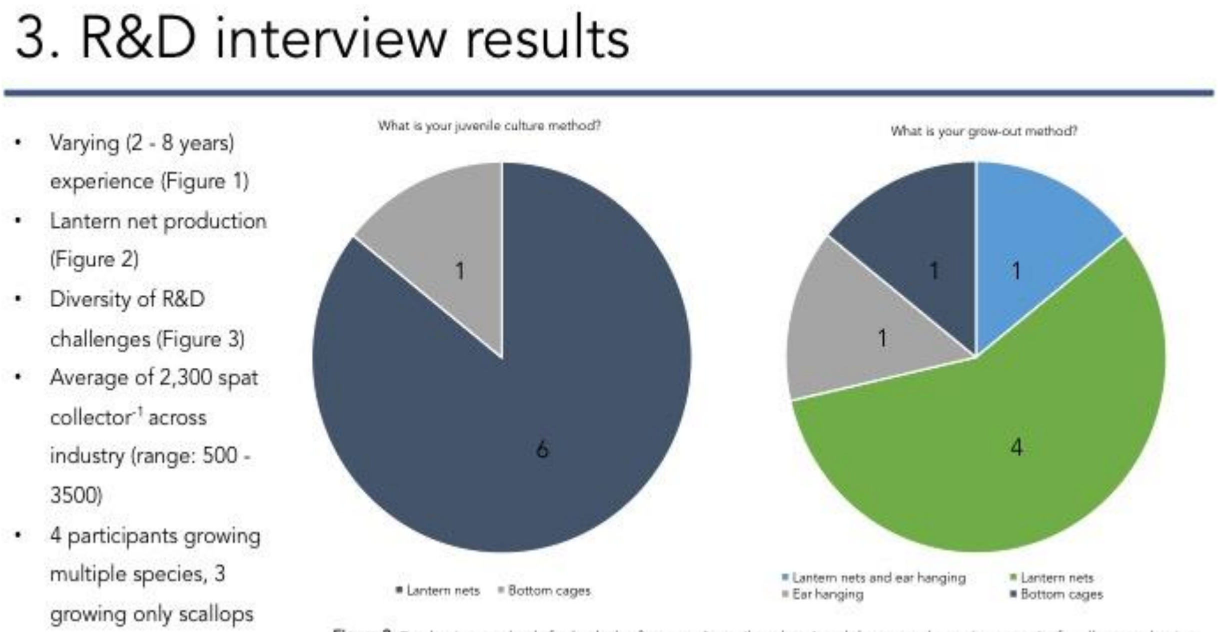


Figure 2. Production methods for both the first year (juvenile culture) and the second year (grow-out) of scallop production used by interview participants (n=7)

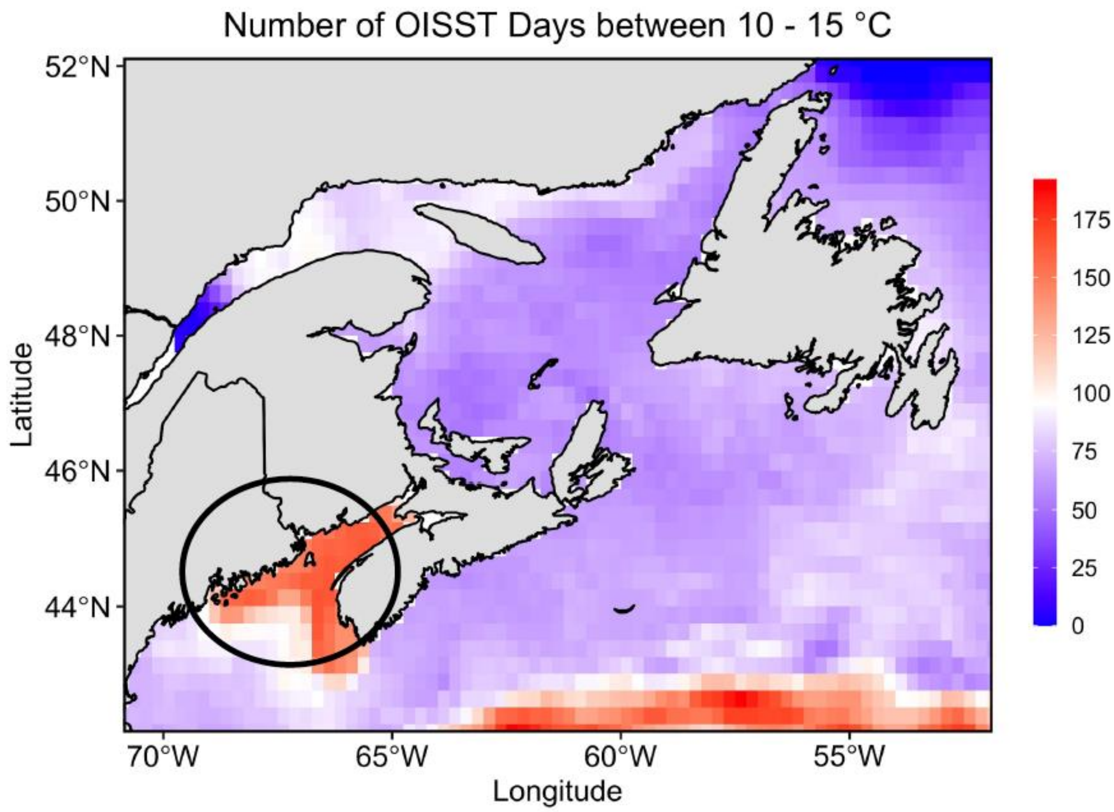
Courtesy of Struan Coleman

Site Selection

Site selection is key to beginning to actualize a successful aquaculture operation. Sea scallops require a farm site with cold and deep water (greater than 40 feet) with enough tidal exchange to deliver feed to the filter feeding scallops, but not enough wave and weather action to stress the animals and slow growth. Other considerations are the amount of biotoxin activity that has been historically measured in the prospective lease area. Sites with a low or no evidence of Paralytic Shellfish Poisoning (PSP) or Amnesic Shellfish Poisoning (ASP) organisms are the most preferable. Sites with historically high nutritional loads of edible organisms are another factor to consider, as is the amount of biofouling organisms experienced on the site.

Water temperature is also a key component. It has been determined by a number of growth studies for sea scallops that optimal ocean temperatures are between 10 to 15 degrees C. Recent work by

University of Maine graduate students Struan Coleman and Thomas Kiffney looked at average ocean temperatures from the north shore of Newfoundland to Midcoast Maine and found that the highest number of ideal temperature days for growing sea scallops fell along Maine's Down East coast. Given that there are currently no active sea scallop farm lease sites Down East beyond Frenchman's Bay, this region may hold particular promise.

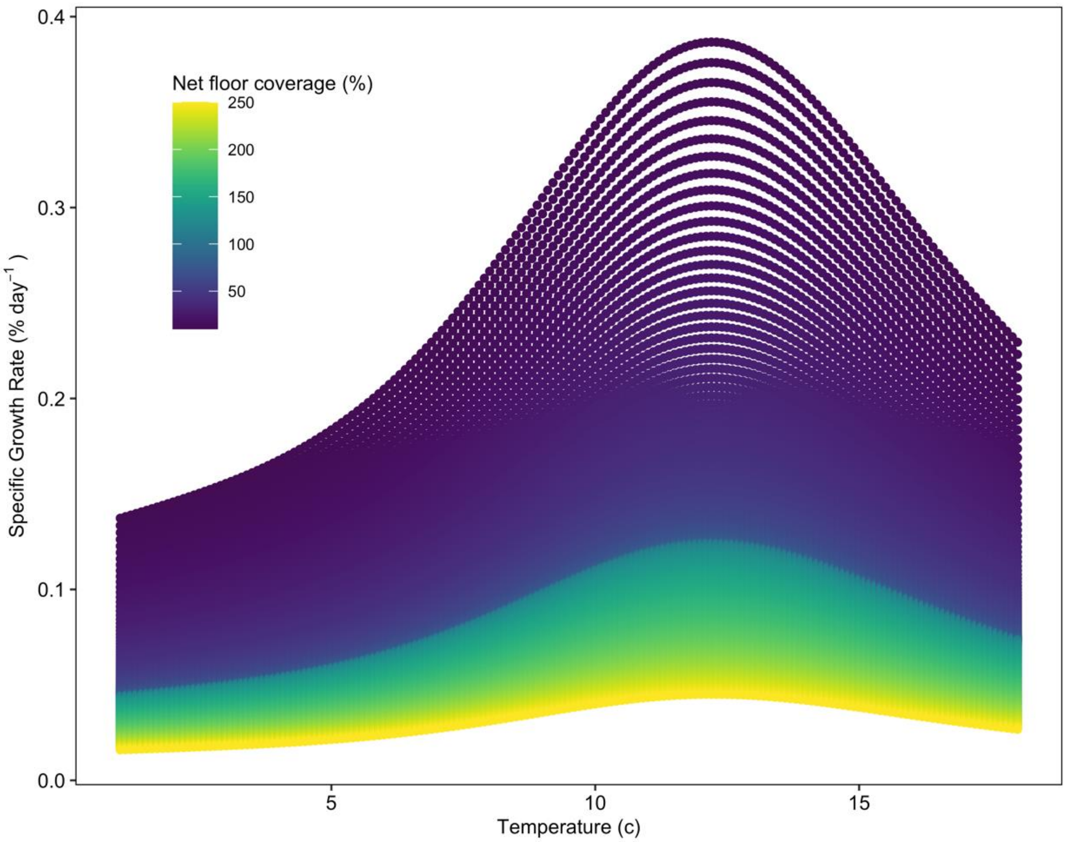


Optimum Interpolation Sea Surface Temperature (or daily OISST) for Sea Scallops, Courtesy Tom Kiffney and Struan Coleman

Husbandry: Stocking Density, Handling, Biofouling and Mechanization

Three key elements to successfully farming sea scallops are a result of the fragile nature of these animals. Unlike other bivalves that live in the intertidal zone and are exposed to the air at low tide and can hermetically seal their shells to prevent desiccation (like mussels, clams, and oysters), sea scallops live under water all of the time and cannot seal their shell shut as well or as long as their intertidal cousins. That natural "gaping" makes sea scallops susceptible to stress when out of the water or, when crowded together, can cause open scallops to cut each other as one inserts its sharp-edged shell inside another.

A result of the natural characteristic of gaping and the fragile nature of the sea scallop then initially impacts the number of scallops a farmer can stock in their growing equipment. This stocking density configuration should be low enough to allow the scallops to grow within the equipment they are stocked in for as long as possible without grading or moving them to another system. What may feel like an economic burden of a low volume of animals in a single net or tray system pays for itself in higher growth rates and lower mortality over time. Reduced stocking density can also speed the growth of each scallop as it is able to compete better for filtered nutrients.

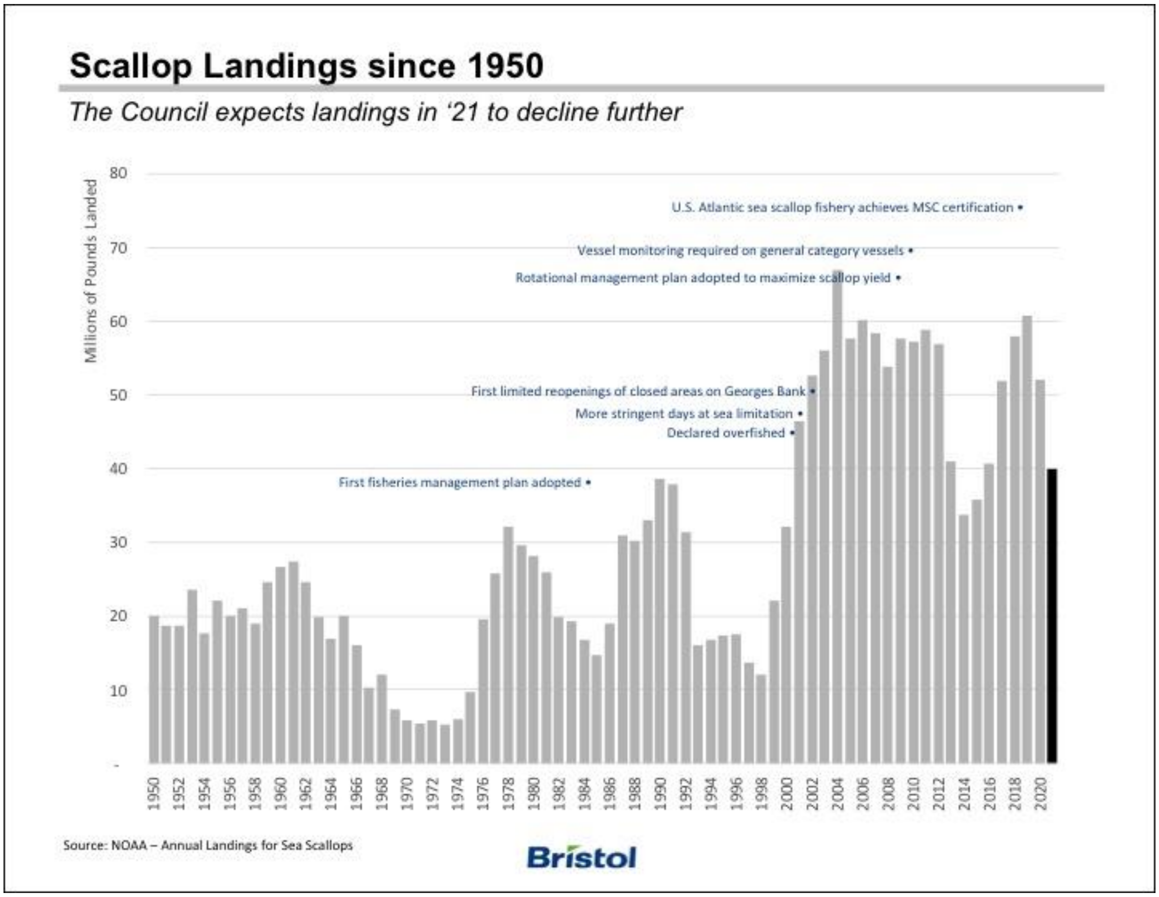


Courtesy Tom Kiffney & Struan Coleman, 2021

Sea scallop farmers should try to limit time out of the water for the life of the scallop on the farm. Biofouling growth on the grow out gear and the scallops themselves can cause serious issues for a farmer by way of higher mortality, lower growth rates, and strain on mooring gear. The depth of the water the scallops are in and the seasonality and site location all impact biofouling volumes. The less the farmer needs to incur the labor expense to clean, and in turn stress the scallops, the better.

Wild Sea Scallop Fishery

Commercial fishing for scallops in the U.S. in 2020 represented the fourth most valuable seafood species landed at $541 million with sea scallops being the largest portion of that value bringing in $400 million of that total. Imports of all species of scallops from countries like China, Japan, Peru, and Canada (sea scallops) generally represent about 50% of the total U.S. landings. In most years, the higher the U.S. landings in volume, the lower the import volume, and the converse is also true. This trend suggests there is some limit on at least the scallop segment demand in total, but this may not correlate as closely to the market cap for sea scallops.



Scallop Market Factbook 2021, Bristol Seafood

The sea scallop commercial fishery comes in three basic forms: diver scallops harvested by hand, day boat scallops with strict daily catch limits, and drag boat sea scallops caught more often in deeper water. Diver and day boat scallops command the highest pricing in part because they can be landed more fresh with little or no absorption of water weight. The season within Maine State waters opens in December and closes in April. In federal waters, the season is open throughout the year with rolling closures of certain areas. Maine's total landings of sea scallops represent a small portion of the overall U.S. sea scallop landings running at between 1-2% each year. Day boat and diver fishermen are limited to 10 to 15 gallons per day of harvested meats.

The New England Fishery Management Council predicts a 23% reduction in the landed volume of sea scallop meats for 2021, which could well mean a continuing trend of elevated prices for this high-value commodity into the future. Wild harvest sea scallop meats are sized and sold as U-10s (10 scallops per pound) 10-20, 20-30 and 30-40 count. Generally, the highest value is attached to the largest scallops. Interestingly, the other New England scallop is the Cape Cod Bay scallop (*Argopecten irradians*), which runs generally at a 60-80 count and is priced often at $5.00/lb above the auction price for a U-10 sea scallop. This begs the question of the ideal product size and selling price for sea scallop farmers to sell their products. This issue will be discussed further in the marketing section of this report.

Among experts who study Atlantic sea scallop populations, there is a general consensus that stocks in the ocean are likely to decline slowly over time due to the impacts of climate change and the fact that there are not enough closures to allow populations to rebound throughout their range. There has not been a significant increase in year class populations since 2013 and, on top of that, commercial fishermen are tending to now target the larger spawning aggregations of sea scallops. This will conspire to put downward pressure on stock assessments and the resulting management into the near future.

For the Maine scallop farmer, the important fact is that Maine sourced wild sea scallops usually command a higher value in the marketplace than sea scallops from other New England waters. At the same time, the stability of the sea scallop adductor market in total has created a “commodity” price that has both elevated historically with no clear sign that the resource will grow and weakened the demand and price into the foreseeable future. Maine scallop farmers should be able to use the base line average U-10 auction price of about $10.00/lb. as the departure point price from which to market and sell a superior, fresher, drier and more year around supply of adductor meats.

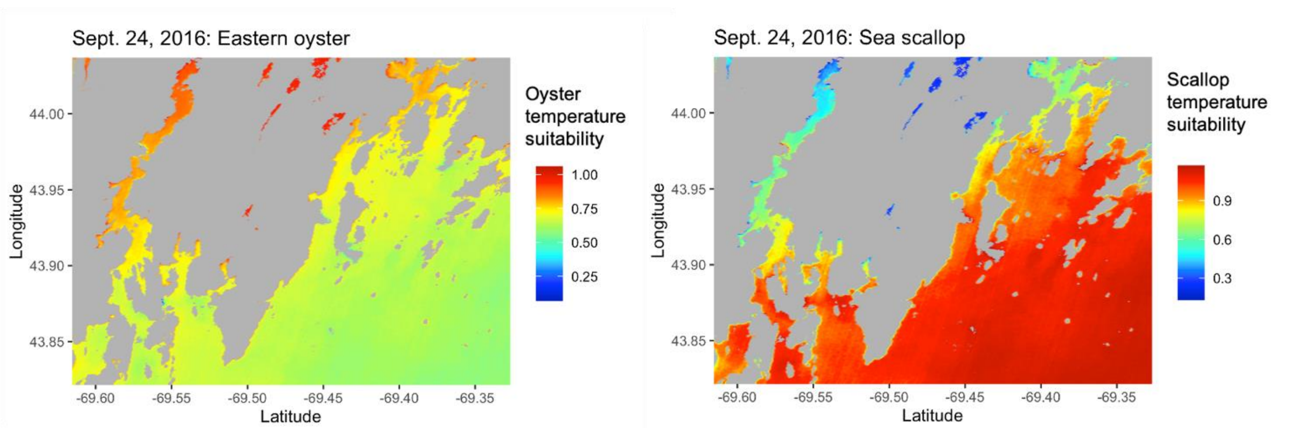
It is reasonable to assume that if Maine scallop farmers can optimize the value of their scallops grown in Maine waters that this could lift the value of Maine diver and day boat scallops as well. Maine has seen this happen in other aquaculture species like salmon and mussels, where farmed product caused the market to view a wild catch product as higher value than it had been historically and at the same time farmed product has raised the bar on the quality of fishing and processing of wild caught. This is true for salmon in Alaska, blue mussels in the Northeast or oysters throughout the U.S. There is no reason why Maine-based wild catch and farmed sea scallop groups cannot benefit each other and together promote the value proposition that is Maine sea scallops.

OPPORTUNITIES

The Future of Sea Scallop Farming for Maine

It is difficult to estimate the potential growth of sea scallop farming in Maine. There are reasons to believe that it could at least reach the current modest level of oyster farming in Maine, which today stands at approximately four commercial hatcheries, 450 Limited Purpose Aquaculture (LPA) licenses and another 53 Standard and Experimental leases. The Maine oyster farming segment employs a total of close to 250 full-time employees. In 2020, the commercial value of oysters sold from Maine's farms represented Maine's sixth largest landed species by value, but this $5.9 million represented only slightly more than 1% of Maine's total landed seafood value. In 2020, total seafood landings in Maine were just over $516 million dollars. The top five landed values by species were: Lobsters at $406 million, soft shell clams at $15.6 million, wild harvested sea scallops at $6.7 million, bloodworms (used for fishing bait) at $6.6 million and Menhaden (used for lobster bait) at $6.4 million.

Because of the potential for more widespread scallops grow out sites in Maine, as compared to oysters, it is fair to assume a higher potential growth horizon for this species as a farmed product. This greater abundance of scallops farming sites is due to the temperatures and water depths required to successfully grow sea scallops. The image below shows the amount of ocean area that is suitable for oysters as compared to sea scallops. It is important to note that this is the area with the highest concentrations of oyster farms in Maine. Farther Down East, where the water is generally colder the differences become even more pronounced.



Map of Damariscotta River/Muscongus Bay Showing Comparison of Temperature Suitability Potential for Oysters and Sea Scallops: Courtesy of Tom Kiffney

Additionally, the U.S. market for sea scallop meat is robust and well established. New Bedford, Massachusetts has had the highest value seafood landings in the U.S. for the last 19 years resting on the strength of their sea scallop fishery, which usually makes up 85% of the landings and is valued at some $350 million annually for New Bedford alone. This foundation of an established high value commodity is an asset to Maine scallop farmers, because it sets the value proposition for scallop meats or other scallop products at a very high level.

The factors that both inhibit and enable this growth will be discussed in the body of this report. For anyone looking at the economic sustainability of Maine's coastal working waterfront, having three quarters of the seafood landings in 2020 come from the lobster fishery and given the precarious and unpredictable nature of oceanographic dynamics and climate change, diversity of commercial marine species harvested and farmed is a recognized goal by many State, trade and community-based organizations for Maine and its working waterfronts.

There have been some promising efforts towards diversifying Maine's coastal economy. A collaboration with CEI, Maine Aquaculture Association, Maine Sea Grant, and the Maine Aquaculture Innovation Center led to the Shared Waters program that has, since its inception, recruited over 250 participants from commercial fishing and start-up business backgrounds. This 12-week aquaculture training program is free of charge.

Mechanization

Mechanization of the scallop farming/handling tasks is used world-wide to improve efficiency and productivity and reduce manual labor costs. Maine's active scallop farmers have identified the need for mechanization as a priority. Beginning in the fall of 2017, several farms in Maine experimented with specialized equipment from Japan. After several years of relationship building CEI purchased sea scallop farming equipment from Mutsu Kaden Tokki Co. for experimentation on multiple farms. An ear hanging drilling machine, scallop grader, and a scallop washer and supporting washer power pack were delivered to Maine, and to date the equipment has been used on 5 Maine scallop farms. Maine Scallop Company has also purchased an ear hanging drilling machine from Mutsu Kaden Tokki Co. for use on their farm in Casco Bay. The University of Maine followed up by purchasing a scallop washer from Mutsu Kaden Tokki Co., but designed a generator, sump pump, and hydraulic system to power the unit. An older semi-automated drilling machine was also given to the University for use on Maine farms. The Maine Aquaculture Co-op purchased a scallop grader from Mutsu Kaden Tokki Co. and constructed a star wheel system that could move from one vessel to another. The Co-op is currently in the process of purchasing a lantern net washer from Jin Fishing Net Company (but it has not arrived in state as of this writing). Hollander and de Koning Mussel Farms purchased a HAMADE all-in-one drilling and pinning machine for ear hanging. This equipment is now in use on their farm in Frenchmen's Bay.

Increased mechanization among existing and new scallop farms can reduce labor costs in a number of the husbandry steps. Grading and sorting of wild spat, efficient and low impact equipment to clean biofouling from grow out systems and of the scallops themselves, and grading systems for the growth stages and final sizing for market, all would benefit the farmer and their need to reduce costs while improving survival, growth rates and the final product. Additionally, a number of farms are beginning to do trials using one or more drilling and ear hanging machines. This form of scallop growing has potential to maximize growth rates for the adductor meat market and needs further examination.

For smaller farms, the cost of certain equipment can be prohibitive. There are instances where a co-operative model of equipment sharing can be employed or where two or more farms might band together to purchase a piece of equipment for their shared use.

Sea Scallop Hatchery

There are few examples of successful cultured species of shellfish or finfish throughout the world where the industry is not supported by an active and innovative hatchery program. Until recently, mussels grown in Prince Edward Island relied on natural seed from the wild. Equally, New Zealand's green lipped mussel farming industry collected its seed from the shoreline windrows of spat that farmers could easily harvest. Today, both industries are moving to build hatcheries to support their farmers and to provide stability of supply and product quality. These industries have also begun to see that the vagaries of wild seed (spat) collection are difficult to plan around and manage.

The Japanese scallop farming industry is one of the very few aquaculture verticals in the world that has built successful commercial enterprises without the benefit of a hatchery system to supply it. This is due to the huge number of farms in the relatively closed system of the Mutsu Bay area and the resulting ample biomass of seed naturally produced in that embayment. In other parts of the world where different scallop species are farmed, such as France, Chile, and Peru, hatcheries are an important part of the industry.

Maine scallop farmers today rely on the collection of wild seed (spat using collection bags deployed in the water column during the late summer months of the year. Some scallop farmers purchase their spat from others who collect in volume and may have access to better collection sites. Considerable effort is spent sorting scallop spat from the other organisms (e.g., jingle shells, mussels, rock-boring clams) that come with this open water collection process. Spat is usually then graded by size and taken to the grow out site where it's loaded into lantern or pearl nets for the start of the growth period.

Wild spat collection has been a very successful way for the small number of Maine scallop farmers to secure seed, but the uncertainties of present-day ocean bio-dynamics puts into question how fragile this reliance on wild seed collection may be. To build an industry based on the spatial and temporal variability of wild seed has its risks. As noted Maine shellfish biologist Brian Beal put it, "Wild spat collection cannot sustain an industry. An industry based on the whim of zooplankton can't survive." Maine's oyster industry has relied on hatchery reared seed since its inception. The grow out time for farm-reared oysters has gone from averaging 26 months on a farm to 14 months largely due to selective breeding and the use of sterile triploid seed stock in hatcheries. One prominent oyster hatchery in Maine today sells 80% of its oyster seed as triploid. Certainly, a warming ocean and improving farming husbandry are a part of this growth rate success for Maine oysters, but hatchery practices must assume the major role in this beneficial outcome.

The challenge for sea scallops is that no hatchery, either in the U.S. or Canada, has been able to raise scallops consistently from the larval (pediveliger) stage to the post larval settlement stage. Because it is a boreal species, the prolonged larval period for sea scallops of up to 45 days has made it especially difficult to reach the settlement and metamorphosis phase compared to other shellfish. Those who work in this field and have tried to rear sea scallops in a hatchery setting, feel that it is a "code that can be cracked", but it will take a coordinated effort on the part of industry, educational institutions, and the private sector working together to solve this riddle. Once solved, the benefits of a robust hatchery system for sea scallop farmers are varied with significant potential impact on reducing Cost of Goods Sold (COGS) and improving the marketability of the finished product.

The many benefits of a hatchery-backed production system include, most importantly, a shortened grow out time to market for the farmer. While it is difficult to project what this could be for sea scallops, it is certainly within reason to think that it could at least match, over time, the significant improvements seen in the Maine oyster industry and other aquaculture verticals. Selective breeding for a number of traits is a key driver, and the first and most primary would be to identify and spawn the fastest growing animals that survive to market size that then can be used for brood stock. Given the physiology of sea scallops and the high ratio of gonad-to-viscera and meat, it might be especially relevant for sea scallop hatcheries to pursue the strategy of triploidy. Evidence exists from the use of triploids in farming bay scallops (*Argopecten irradians*) and the Pacific calico scallop (*Argopecten ventricosus)* that the energy stored in the adductor muscle is the reservoir for gonad development and, without that reproductive demand in a triploid scallop, the adductor weight increases dramatically over the normal diploid animal. For farmers, the adductor meat and its size at harvest, no matter the final product type, impacts the value to the market and accordingly the price and ultimately the farm's profitability.

Hatcheries might also select for sea scallops that are resistant to disease, which could become a more important issue should the industry experience substantial growth with more biomass in proximity from farm to farm. In addition, some work has shown that the variability of uptake of biotoxins (e.g., saxitoxin, domoic acid, okadaic acid and other dinophysistoxins) among scallop populations could have genetic implications. Researching this within a hatchery system is the only way to understand and try to resolve this issue. Hatchery systems can also select for more marketable characteristics of the final product types like meat texture, color, shell conformity, shape, etc.

Most obviously, a hatchery-based sea scallop farming industry gives Maine scallop farmers a far more secure supply of seed stock for them to grow out. In addition, by controlling the timing of the spawning cycle and spreading it out throughout the year, farmers can plan on more secure market-sized product throughout the sales year and thereby command better market penetration and pricing. A sea scallop hatchery system would not preclude farmers from continuing to harvest spat themselves and having both wild and hatchery stock to work from could be ideal.

Product Types, Pricing & Sales

At present there are four product forms available for Maine sea scallop farmers to grow and sell. All four products can have various size adductor meats, from the largest U-10 down to an 80-100 count size meat. Whole live scallops are sold as the smallest meats, called "Petites", then mediums and large sizes. Roe-on product, which is sold on the half shell, can also be sold at various size meats as with whole live. Meats on the half shell, sold with the adductor meat left attached to the shell, can be sold alone or with the opposing cleaned shell banded over the half shell. Shucked meats can be sold conforming to the exiting size ranges that are established by the wild fishery. This report will discuss the pros and cons of all four product types and examine the potential market for each. It is worth noting that price forecasting is an inexact science. This is especially true with sea scallops pricing that is impacted by the results of the domestic wild fishery landings, imports of other species of scallops, demand, and the ability of farmers to create a value proposition for their products.

Some sea scallop farmers in Maine have made early and important steps in beginning to market the whole live product. This product type is insulated from competition from the wild fishery in which fishermen are not allowed by regulation to land or sell whole live scallops out of Georges Banks or elsewhere along the Maine coast. The amount of biotoxin testing any farmer has to do is dependent on their location along the coast, that location's historical biotoxin activity, and the time of year which will reveal biotoxin levels according to sentinel tests on mussels and other shellfish. For the State to allow farmers to sell this product, however, there is the burden of testing for both PSP and ASP biotoxins that is a considerable negative impact to the cost of goods. Current testing costs require 15 live scallops to be delivered to a certified testing lab and tested as a part of a lot. Each test costs about $70@, but could ultimately run as high as twice this cost. Depending on the time of year and location of the farm, the State could require that any time a farmer wants to harvest and sell a new lot of product they are required to pass a new biotoxin lot test for both PSP and ASP.

This HPLC test technology is expensive and it additionally includes the cost of farmers getting their live samples to a qualified lab. By way of example, if a farm harvests 1,000 whole live scallops, the test costs alone would be as high as adding an additional $.30 per scallop to the cost to the farmer. Work is underway to create a less expensive antibody-based ELISA test that could reduce the cost to farmers for testing in the future. For a farm harvesting an average of two times per week, to complete PSP and ASP testing is a cost burden of approximately $7,200/yr. No small amount when considering selling either whole live or roe-on product.

Pricing for whole live scallops is difficult to predict as there has been so little volume to date from Maine farms. As with all sea scallop products, the size of the meats is directly correlated to the perceived value to the market. Petite whole live scallops, which are generally an 80-100 count scallop meat, can and have been sold to wholesalers (farm gate price) anywhere from $.50 to $1.00 each. Because this product is sold by the piece, there is the opportunity for the framer to get a higher per unit price than if they were just selling the meats alone.

Most chefs will serve the meat only on the shell or alone, and some smaller percentage get cooked whole and served in a number of Mediterranean- and Asian-inspired recipes. Medium size whole live scallops run a 50-60 count meat and currently sell for about $1.00-$1.25@ farm gate price, while large 30-40 count meat whole live scallops sell at $1.75 to $2.00@. The largest "jumbo" size have a 20 count meat and generally sell for $2.25 to $2.50@.

One wholesaler in the Chicago area expressed real interest in a 20-30 and 30-40 count whole live product, and a wholesaler out of Portland, Maine today pays about $2.75 for jumbo (U-10) whole live product that are being sold into some of this country's finest restaurants. Those restaurants, according to the wholesaler, usually shuck the product themselves before cooking and serving it and may use the shell in the presentation. Chefs view the whole live scallops as a way to guarantee the freshness of the scallop and the fact that it cannot have gained any water weight.

The four-day shelf life for whole live sea scallops is a limiting factor in its distribution and scalability. For home use, one should figure to eat the product the day you buy it or, at most, the next day. For distributors selling into retail or food service markets, speed to market is the key, and a constant supply becomes that much more essential. It's difficult to see where there is enough time for the farm to sell to a distributor who then sells to a retail market. However, there is probably just enough shelf life for a farm to sell to a distributor who then sells directly into food service with the understanding of the immediacy of use requirement.

Photo courtesy of Marnie Reed Crowell, Recipe Ideas for Farmed Sea Scallops

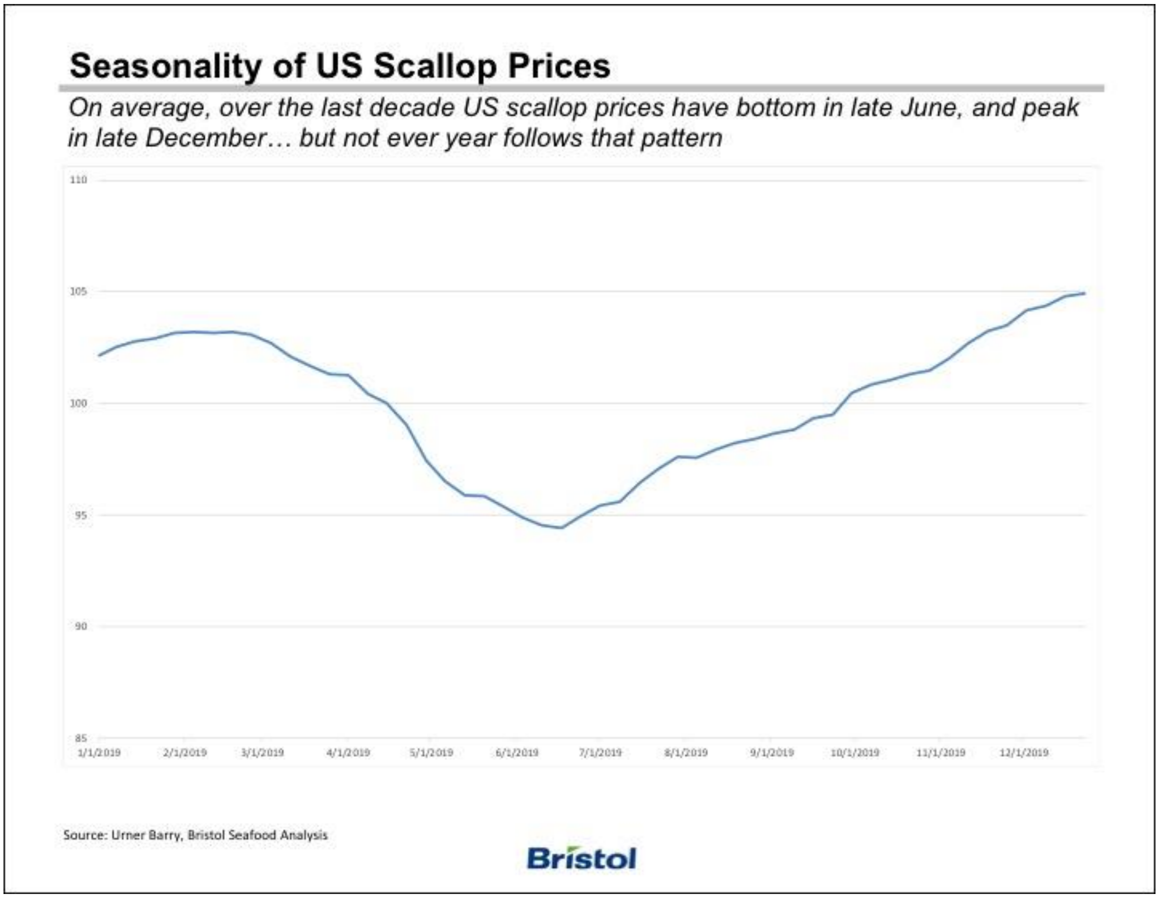
The roe-on sea scallop product offers many of the same marketing challenges, opportunities, and pricing potential as the whole live product. Both the white male roe and salmon colored female roe are edible and interchangeable. This product is usually sold by the piece as with the whole live and can be sold attached to the shell or shucked. The roe-on product offers a reduced risk from biotoxins, because all viscera, organs, and the mantle, which tend to concentrate higher biotoxins levels, are removed, leaving just the attached adductor meat and the roe. The regulatory requirements for testing and Memorandum of Understandings (MOU) are the same as with whole live scallops, and so is the additional burden on COGS. There is so little experience with Maine scallop farmers selling this product that pricing is difficult to predict, but one should assume a higher selling price per unit than for whole live, but by how much is still to be determined.

Roe-on is a product form seen in European and Asian markets sold both fresh and frozen. The frozen form (pictured below) is a product that whole live cannot assume for obvious reasons and may give farmers a way to hedge and manage inventory. Scallops frozen properly are very close to fresh in quality. The ability to freeze product gives the farmer the latitude to harvest if market size scallops coming off of the farm exceed demand or the price is momentarily too low to justify sales.

Some Maine sea scallop farmers have begun to focus their attention on growing product for sale into the adductor meat market. Maine scallop farming LPAs are also not able to sell whole live or roe-on products, and so are forced to only grow for the adductor market. This market is directly subject to influence from the commercial fishing sector where virtually all product is sold as a meat only. As was said earlier, this market is based on the value proposition that bigger is better and therefor more expensive. U-10s command the highest value for sea scallops throughout the year, and generally the smaller the meat the less the price. However, there is this strange phenomena attributable to Cape Cod Bay scallops, which normally run at a 60-80 count and carry a higher value than a U-10 sea scallop. Often the price for bay scallops is based on the auction price for U-10 sea scallop, and then the market adds $5.00/lb. to that number. The seafood business has always been full of contradictions, and Cape Cod Bay scallops offer a great example of this. In the early 1980's, China began growing Cape Cod Bay scallops from seed originally brought back from the NOAA Milford, Connecticut facility. Today that product is among the lowest priced scallops in the world. Cape Cod Bay scallops harvested in Cape Cod waters are today the most expensive scallops in the world. Same animal with different marketing stories and volume characteristics resulting in a wide disparity of value propositions.

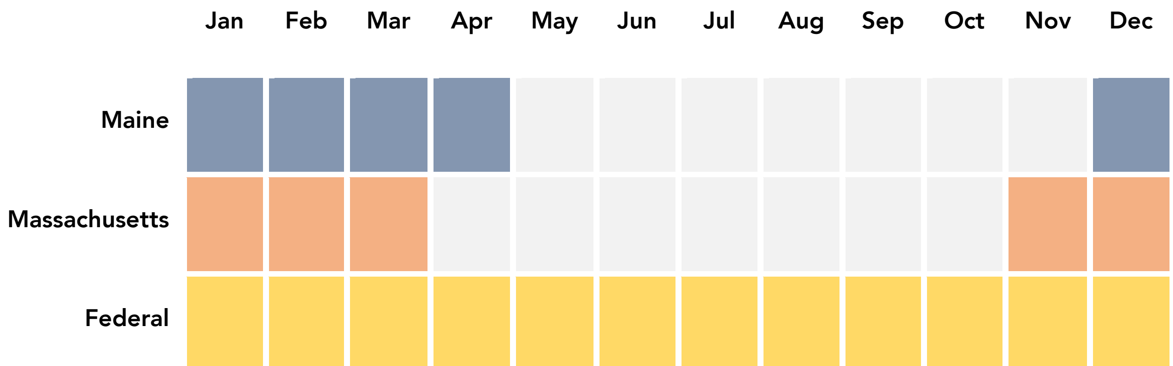
Bay scallops from Cape Cod are admittedly a far more finite and seasonal resource, but the fact that a large sea scallop sells for $5.00 lb. less than a bay scallop day in and day out should offer an opportunity to Maine farmers who would always prefer to sell a smaller scallop at a higher price. The question is, can a well marketed brand sell a fresh farm raised 20-30 sea scallop meat at $16 to $18 dollars per lb. (farm gate price) available throughout the year? The cost to shuck 20 count scallops for a proficient processor paid by the piece should be about $.50/scallop at an equivalent of about $15/hr.

Commercial landings of sea scallop meats follow traditional trends of seasonality and demand. One of the benefits of selling a farmed scallop meat product into a commodity market supplied from a wild fishery is that the cyclical pricing nature of the commodity offers the farmer the chance to sell when prices are high and retain product when prices soften. In most years, the auction price of sea scallops begins to rise in the fall and peaks in the first quarter of the year. For instance, on the second week of February in 2021 the auction price for U-10 sea scallops was $20/lb. It would behoove farmers selling meats to focus their growth and harvest strategies to take advantage of these annual changes in pricing.



Scallop Market Factbook 2021, Bristol Seafood

Sea Scallop Harvest Seasons:



The fourth product type, meats on the half-shell, offers yet another variety outside of the commercial fishery meats-only product. There has been a good deal of interest on the part of distributors and end-users to purchase meats on the half shell as a new to the U.S. product form. One can find this product in other parts of the world, but it is virtually untested in the U.S. As with whole live and roe on, this product can be sold by the piece. It can be presented fresh or frozen and sold on the half shell or with the opposing shell banded onto the shell that holds the meat. This product form needs to be explored as it offers by the piece pricing with a limited need for biotoxin testing requirements under the current standards. It is hoped that DMR would make a concerted effort to appeal to the National Shellfish Sanitation Program of the U.S. Food and Drug Administration (FDA) to amend the language to include adductor meats on the half shell into the same category as adductor meats alone to clarify the fact that there should be no biotoxin testing requirements for this product.

Marketing Farmed Sea Scallops

> *"Projections estimate that domestic supply will lag demand by roughly 50% over the planning horizon under all growth scenarios. Demand above what the U.S. can produce is being met by typically smaller, frozen scallops that are imported from Asia and South America. Current imports totaling 40-million pounds with a value of $350 MM (nearly equal to U.S.-produced volume) represent an opportunity for Maine."*
>
> (Hale Group 2016 Study: Maine Farmed Shellfish Market Analysis)

It is worth noting that scallop imports do satisfy a large segment of the U.S. demand, but no other country other than Canada has indigenous populations of sea scallops to export into the U.S. and no other scallop species, with the exception of Cape Cod Bay scallops, can offer the high-value proposition and consumer preference that sea scallops do.

Sea scallop farmers should be able to take advantage of the positive consumer food and seafood preference that Maine enjoys. Being a Maine origin product alone however guarantees no standing in the market place, rather it is only a point of entry. Assuming that farmers can produce a product that is available year around and tastes as good or better than the wild harvest scallop, there is plenty of room for Maine scallop farmers to market the advantages of farmed over wild product.

Farming sea scallops has less of a negative footprint on the marine environment compared to commercial drag boat fisheries. Farms can develop and promote their own farm "merroire" much as the wine and oyster industries have done. The farm grown scallop has no grit, mud, or sand in it, which can be a negative with wild harvest product, and Maine farmed product can and should always be free from "soaking" and chemicals to gain water weight. These attributes, coupled with appropriate branding and year-round availability, should allow Maine scallop farmers to realize some pricing advantages. How much is difficult to say, and is too often over estimated. Being competitive at all the aspects that the buyer values, is the key and the only place to begin.

CHALLENGES

Biotoxins

Sea scallops are a long-lived cold-water species that have the unfortunate characteristic of accumulating biotoxins from their environment and are unusually slow to purge the toxins from their system. Sea scallops from the George's Banks wild fishery tested positive for PSP in 1990 and caused the regulations to change such that no whole scallops could be landed in east coast ports. The regulations required that all scallops be shucked prior to the vessel arriving back to port and only the adductor muscles (meats) be sold.

For Maine, the concern over Paralytic Shellfish Poisoning (PSP) and more recently Amnesic Shellfish Poisoning (ASP) has been a major focus of both farmers, wild harvesters, and the Maine Department of Marine Resources (DMR). The toxins tend to reside in the viscera and digestive gland of the scallop and to a lesser degree in the gonads of both the male and female scallops. The adductor muscle meat itself does not hold harmful levels of biotoxins. It is not known if fast growing farmed scallops, that would rarely exceed three years of age before being harvested, would naturally retain less biotoxin than their wild counterparts that may live as long as 29 years. It is equally uncertain as to whether a younger farmed scallop is more able to depurate (purge) biotoxins compared to wild populations. This is an important area for future consideration.

The primary dinoflagellate species that cause PSP ("red tide") in the warmer months of the year and are found most commonly in Maine waters are from the genus *Alexandrium*. The National Shellfish Sanitation Program closure threshold for PSP is 80µg/100g of scallop tissue. ASP is a more recent phenomena in the northwest Atlantic having been first seen at toxic levels in Prince Edward Island in 1987 and then in Maine in 2016. ASP is caused by the microscopic algal species of the genus *Pseudo-nitzschia* which produce toxic domoic acid. The closure threshold for ASP is 20µg/g of scallop tissue. Both PSP and ASP biotoxins in shellfish can be lethal to consumers at high enough concentrations and should be treated within the strictest requirements of the regulatory authorities. (Shumway & Cembella 1993)

The Maine DMR has one of the more sophisticated and strict monitoring, testing, and precautionary closure systems found anywhere in the world. Maine sea scallop farmers are subject to similar regulations around biotoxins, but are currently able to sell whole live scallops and roe-on scallops with specific DMR testing protocols and agreed upon MOUs. There are no testing requirements for farmers selling scallop meats, and there is pending legislation to include with that the sale of adductor meats on the shell. Currently, scallop farmers who want to sell meats on the half shell need a special license, but no biotoxin MOU is required.

When considering the sale of live or roe-on sea scallops, both existing and prospective sea scallop farmers should consider the historical data for both PSP and ASP levels in the area in which they plan to grow scallops. However, the occurrences of PSP and ASP are constantly changing. Relying on historical data does not replace the need for continuing monitoring going forward. Scallop farmers need to have a reliable and not cost prohibitive way to safely monitor/test for the presence of these biotoxins. There is an area off the Maine coast between the west side of Mount Desert Island and eastern Casco Bay often referred to as "the Penobscot Bay sandwich" which has been relatively free of historical levels of biotoxins. Areas that have tested historically high for biotoxins may be subject to additional year-round testing, closures, and other requirements. The cost burden of testing for farmers of sea scallop products that fall into the “high risk” category (whole live, and roe-on) is a significant obstacle to the ongoing growth and marketability for these products. A number of studies are currently underway to reduce the cost of testing while at the same time improving efficacy. Additional funds should be made available to farmers to have this testing conducted and could be assisted by additional labs conducting the testing. Farmers should be assisted in testing product before it goes to market, for public safety.

* New or existing sea scallop farmers in Maine should consult with DMR and pay attention to their Biotoxin Monitoring Guidance Document for Bivalve Shellfish Aquaculture report:

https://www.maine.gov/dmr/shellfish-sanitation-management/forms/documents/BiotoxinGuidance2020.pdf

DMR Biotoxin Monitoring Guidance Document for Bivalve Shellfish Aquaculture

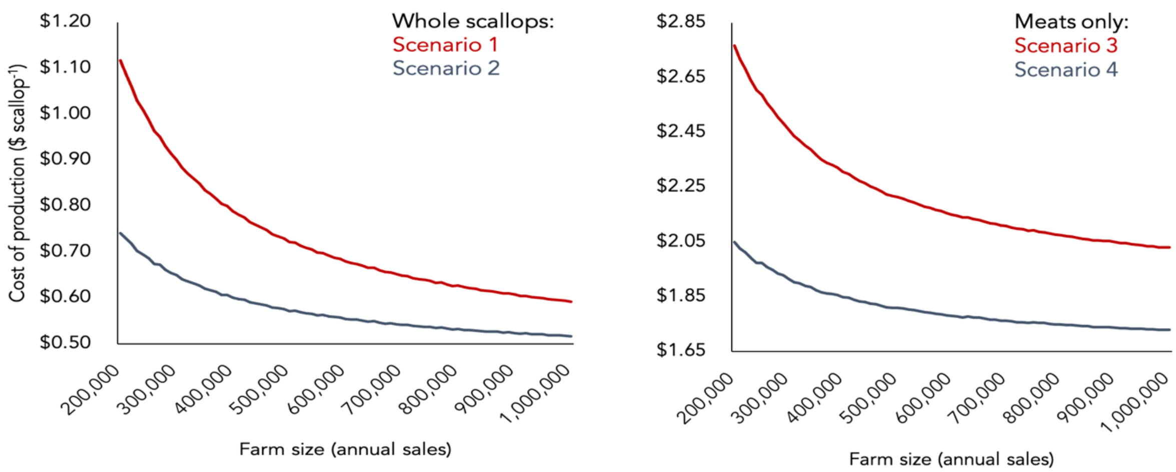
Figure 1. Maine high risk areas for PSP and ASP based on DMR historic bivalve shellfish data.

Sea Scallop Farming Financials

Because of the still start-up state of sea scallop farming in Maine, there is very little financial information that can begin to represent a mature industry. Today’s financial picture for growing any of the sea scallop products discussed earlier does not look as positive as it could and should with higher volume producers, more advanced labor-saving equipment, an evolved hatchery system, and a marketing program to enhance selling prices.

Current information is the result of interviews with scallop farmers in the business today and the result of the competent work of Professor Damian Brady and his graduate students Struan Coleman and Tom Kiffney. Part of Coleman's focus has been to try to better understand the cost of goods sold (COGS), cash flow, and cost structure that exists today for a typical scallop farmer in Maine. He looked at four scenarios: #1) Whole live scallops with fully loaded cost of boat, truck and equipment, #2) Whole live scallops with boat, truck cost removed (as it might be for an existing fisherman) and the equipment being shared through some sort of Co-op type arrangement, #3) Meats alone with fully loaded cost of boat, truck and equipment, and #4) Meats alone with boat, truck cost removed (as it might be for an existing fisherman). He further layered three size farms into this model, a 200,000, 600,000, and 1 million animals harvested each year. He assumed all other parameters, including labor cost, mortality, debt burden, depreciation, and selling price. His results, shown below, suggest a current break-even price for a million-animal farm selling whole live under scenario #1 at just over $.60@ and for scenario #2 at just over $.50@. For meats-only, a million-animal farm would need to sell a U-10 size scallop under scenario #3 at close to $21.00/lb. to break even, and for scenario #4 at about $17.00/lb.

This study assumes a grow-out time on the farm of 19 months for whole live scallops at an average selling price of $1.00@. For adductor meats the grow-out time was assumed to be 30 months with an average market price of $10.50/lb. These assumptions are appropriate and conservative and should give a scallop farmer ample target numbers to improve upon and exceed.



Courtesy of Struan Coleman

These are obviously not encouraging numbers, but they are preliminary, and they assume a current state with no improvement in husbandry or production efficiencies that should be available over time. For the growing and selling of adductor meats, this study does not yet include data from farmers using ear hanging technology, which seems to hold significant benefits over the full grow out in lantern nets given the proper depth and required site characteristics for a farm. Further study of ear hanging technology performance compared to lantern nets would be very useful to farmers.

A collaboration with Struan Coleman, the University of Maine, the Maine Aquaculture Association and Maine Sea Grant are perfecting the following tool, which will be updated and of use to any existing or would-be scallop farmer as a way to asses their business. As of this writing the tool is under construction, but it will include detailed inputs around: 1) Business and Loan Characteristics,

2) Key Biological Assumptions, 3) Other Inputs for Capital Expenses, Operating Expenses, Fixed Costs, and Models for Mooring Line Costing, Replacement Capital Schedule, and Labor Costing. Once completed, this valuable tool should be available through the Maine Aquaculture Association as well as Maine Sea Grant.

University of Maine and Maine Sea Grant: Sea Scallop Aquaculture Budget Tool

1865 THE UNIVERSITY OF MAINE

Sea Grant Maine at the University of Maine

1. Background

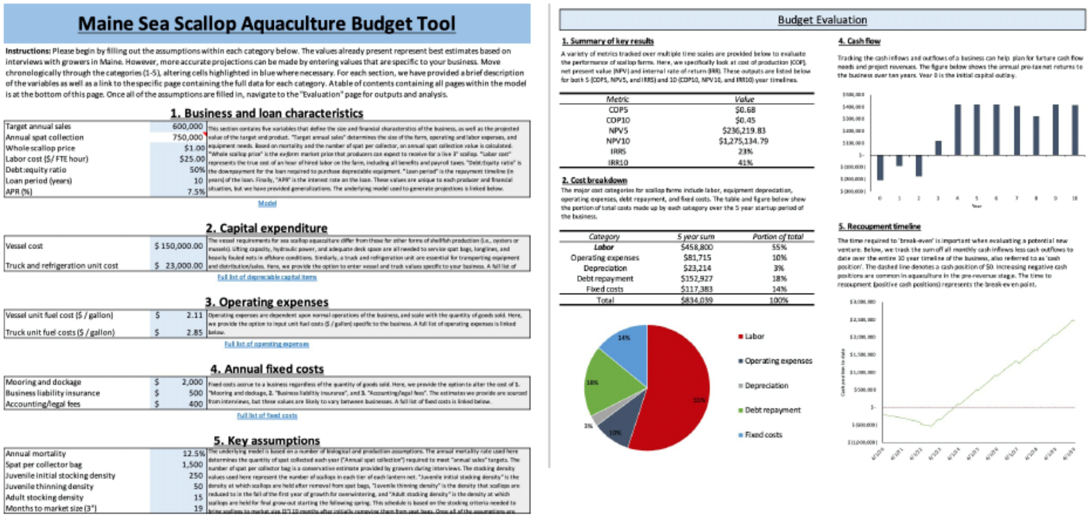
This scallop aquaculture budget tool is designed to help either new growers or established farmers better understand how specific changes to the production process, biological inputs, or whole scallop market will impact their business. The data used to build this model are based on interviews and conversations with growers in Maine. Therefore, the values used here are supposed to represent a 'typical' farm. In practice, however, all farms are different and require a unique set of parameters. Therefore, this tool has areas where you may input the specifics of your business to more accurately project future revenues and costs. A 'User Manual' accompanies this tool and should be read in full before any inputs are made or results are analyzed. This document also contains further information regarding scallop aquaculture in Maine and a more detaile description of the source of the data used here. The link to the document is below. **DISCLAIMER:** the results of this tool should be taken with the same precautions and caveats of any financial projection. It is simply one tool designed to help guide decision making and should not be used as the sole source of projected future earnings or financial success. Results may vary depending on the specifics of your farm.

Scallop aquaculture budget tool 'User Manual' *Link to manual here*

2. Instructions

Before you begin, please notice that the pages within the spreadsheet are numbered. These pages are designed to be read and altered (when necessary) chronologically. Doing so will help you move through the 'INPUTS' sections more efficiently and arrive at the 'Evaluation' page with a better understanding of the underlying assumptions within the model. The first step is to read the 'User Manual'. Once you have finished reading the User Manual, naviagate to the INPUTS page to alter (if necessary) key assumptions. Pages 2 - 4 contain specific submodels and might require additional inputs. Cells that are designed to be altered are highlighted in GREEN on all pages. You will notice that the pages that follow the 'Evaluation' page are locked. These appendix pages contain submodels that should not be altered. Once you have read the manual and are ready to start, hit the BEGIN button below.

4. Results: budget tool



Climate Change

Climate change and its impact on the Gulf of Maine marine environment, and in particular sea scallops, comes in a number of problematic forms. Lowered PH, increased water temperatures, and the introduction of new potentially competitive species into Maine's ocean waters are all concerns. Proper wild scallop population management can go a long way toward mitigating those impacts, but many estimates agree that even the most robust management practices will not totally blunt the negative impacts likely to occur to sea scallops from climate change.

Ocean Acidification

> *"Ocean acidification, the process where increased atmospheric carbon dioxide (CO_2) concentration reduces ocean pH and the calcium carbonate saturation state, has already been implicated as negative impact on the aquaculture industry on the U.S. West Coast. Marine mollusks appear to be particularly sensitive to ocean acidification due to the sensitivity of the calcification process to seawater chemistry during shell building."*
>
> (Rheuben, JE et al., 2018 Projected impacts of future climate change, ocean acidification, and management on the U.S. Atlantic sea scallop (*Placopecten magellanicus*) fishery.)

A lowering PH in the Gulf of Maine for sea scallops can begin to impact the survival rate in the very fragile larval stages as well the shell deformity and shell thickness in juvenile and/or adult stage animals making them more susceptible to predation. In addition, there are questions as to the impact an increasingly acidic marine environment would have on the food that sea scallops require to be healthy, grow, and reproduce. The very complex but increasingly alarming trends of ocean acidification make predictions perilous. The study cited above suggests that by the end of this century populations of wild sea scallops could be impacted by ocean acidification anywhere from no impact to a 50% reduction in overall populations.

Temperature

In the Gulf of Maine sea scallops are usually found in water that stays below 17°C and above 0°C but they can tolerate, for a time, temperatures as high as 20°C. However, sea scallops have been found to perform best on farms at between 10 and 15°C. Over the last 15 years the average temperature in the Gulf of Maine has risen 3° C making it one of the fastest warming oceans in the world and potentially impacting sea scallops. For the scallop farmer, warmer temperatures, if they exceed the 15°C optimal range, will stress their scallops and can lead to mortality or slower growth below what is optimal. A warmer Gulf of Maine could also create the environment for increased harmful algae blooms resulting in more closures and testing for PSP and ASP. In addition, there is the chance that increasing ocean temperatures could have unforeseen impacts on the spread of disease pathogens like Vibrio, with negative effects on scallops.

It is also worth recognizing that a warming ocean will probably shrink the southern range of sea scallops on the east coast and could push populations more into the Gulf of Maine seeking cooler waters and cause a temporary increase in local abundance. A counter to that could also be that as Maine's shallower inshore coastal waters warm faster than deeper water, Maine could see decreases in their closer to shore dive and day boat catch.

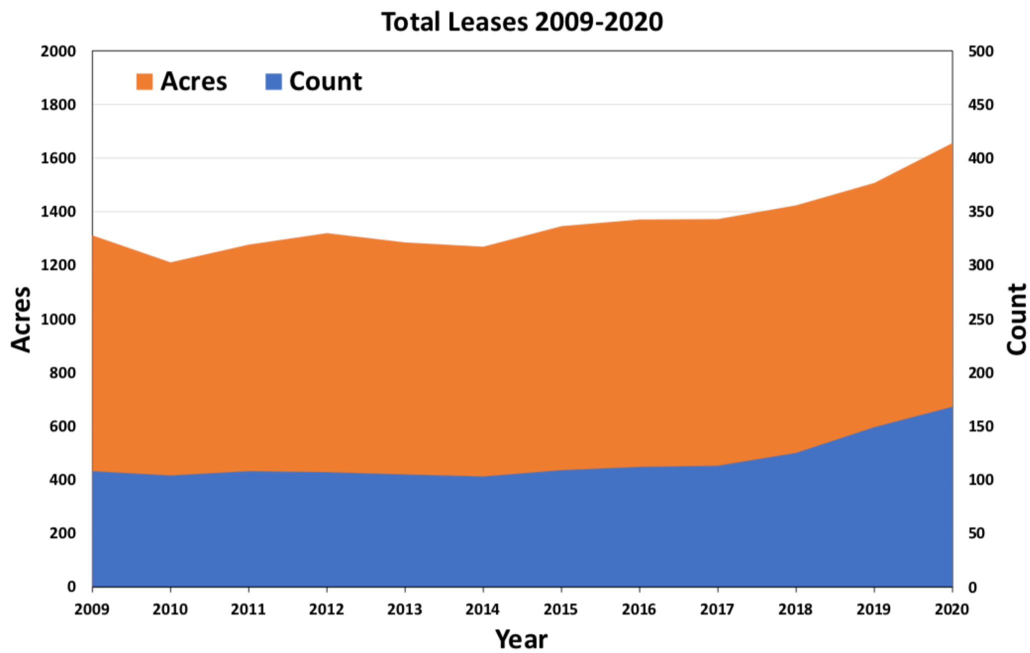
Invasive Species

The Gulf of Maine is starting to lose its subarctic characteristics as it warms, and with that comes troubling signs of decreasing populations of native species like cold water shrimp, cod, herring, and the changing dispersion of lobsters. With warming ocean waters also comes the infiltration of warmer water species both indigenous to states to our south as well as non-native and invasive species like the green crab (*Carcinus maenas*). The green crab is an example of a relatively new predator prospering due to warmer winters and that is now eating its way through many species of Maine shellfish including scallops.

Maine Marine Aquaculture Growth

Maine possesses a unique set of natural and social characteristics that satisfy many of the prerequisites that marine aquaculture requires in order to be a successful part of the coastal working waterfront. With over 3,500 miles of continuous shoreline and some 3 million acres of generally clean marine state waters, an ocean trained labor force and proximity to one of the largest seafood markets in the world, Maine would appear to be the ideal state to grow a prospering aquaculture industry. The current reality is that Maine's aquaculture industry has been slow growing or stagnant over the last 20 years and today totals just 1,650 acres in farm leases.

In 2009, there were some 1,300 aquaculture acres under cultivation. In the last 11 years aquaculture in Maine has grown by 350 acres or on average 32 acres per year. Today's total aquaculture leases, if put together side by side, would fit onto the footprint of the Bangor International Airport. It currently takes between two to three years for a Standard Lease application to be finalized through DMR, and there are over 40 Standard and Experimental leases in queue (Spring 2021). By way of comparison, one Prince Edward Island mussel farmer alone has aquaculture lease sites that total 4,300 acres. That one farm in PEI leases more than two and a half times the total farmed acreage of all aquaculture projects in the ocean in Maine. This topic is part of ongoing work that is both a challenge and an opportunity for the Maine DMR, the legislature, and other partners.



Maine Department of Marine Resources: Active Leases Per Year, Total (2009-2020)

An element that has limited the growth of the marine aquaculture industry in Maine is a lack of planning and policy making vision for the industry at the state level. This applies to all aquaculture, including finfish, shellfish, and sea vegetables whether grown on an ocean lease or in land-based facilities. However, the State of Maine has not established a strategic growth plan for aquaculture that sufficiently recognizes marine aquaculture as an essential contributor to long-term economic growth and a vital marine economy diversification strategy in the face of a changing world. This lack of policy in aquaculture industry growth is related to a siloed view of various fisheries, the attention to the dominant single species (lobster) fishery, along with protective coastal communities that can be averse to change. State leadership vision is needed to define and advocate for aquaculture's place in Maine's coastal economy. As part of this, the lease administration process needs to be more robustly funded to support adequate management of a prosperous aquaculture industry.

For sea scallop aquaculture to become a growing source of marine related jobs, Maine policy makers and communities will need to decide if the coast can be more of a shared common resource and the degree to which aquaculture can grow to play a significant role in Maine's economic future.

If there is a message to take from this report that goes beyond the support for the ocean farming of any one single species, it is that policy makers in Maine must evaluate whether a diverse working waterfront is more economically stable in the face of a changing climate and an uncertain future. Does a marine economy so dependent on the single vulnerable species (lobsters) secure a more stable economy for our coastal communities than a diverse ecosystem built on a variety of choices for work and where fishermen can become farmers or farmers can choose to become fishermen? Should Maine's lucrative lobster fishery falter, there is no volume fallback species left to fish for commercially. The risk to Maine and its geographically dispersed small coastal communities is that, without other viable ways to make a living on our coast, lobstermen likely would be forced to sell their precious ocean-side homes and docks, and Maine will potentially lose the working waterfront that has been so much a part of Maine's essential character. Marine aquaculture is not the only answer to creating a diverse and sustainable working waterfront for Maine, but it deserves a chance to prove itself farm by farm and with the full weight of support from state government.

> *"Ultimately the reason that other countries have succeeded in developing their aquaculture sectors is they view it as an Economic Development exercise, not a resource management issue or a policy or planning exercise. They identified the key factors needed to create the conditions for growth and investment and then implemented them according to a development plan with a schedule, identified resource needs, assigned responsibilities, an execution schedule and clearly identified staffing and budgets. Finally, they include a series of metrics that allowed all parties to assess progress and frankly assign accountability where necessary. It is only by doing all of that, that a government acknowledges that aquaculture is actually and really a priority."*
>
> (Sebastian Belle 6/2021)

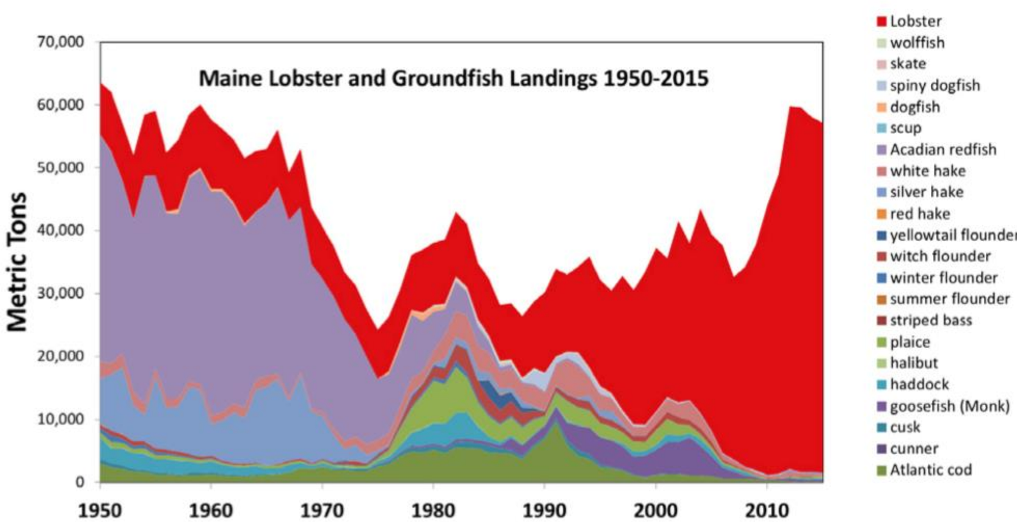
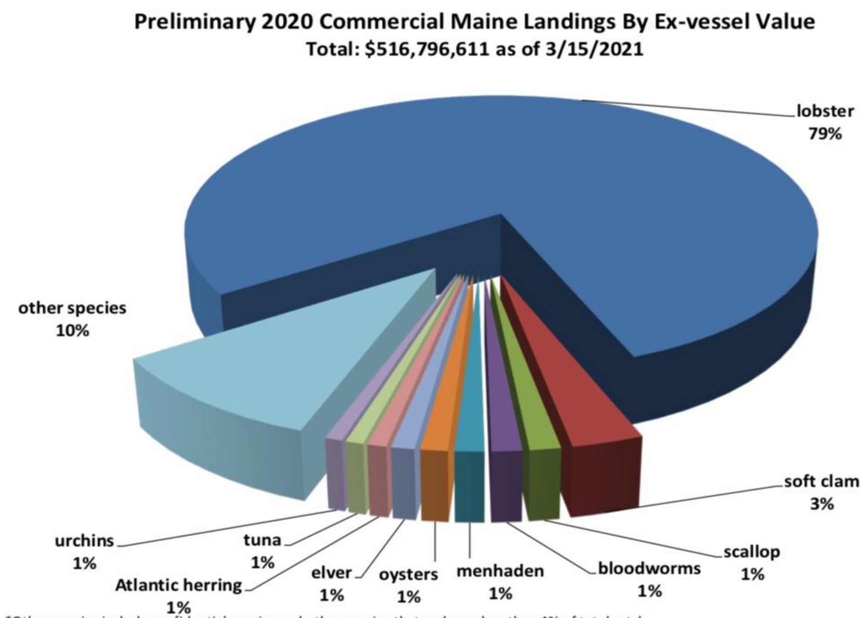


Figure 5. The growing dominance of the American lobster (red) in the wake of an increasingly depleted groundfish fishery (muted colors) in Maine, USA, from 1950 to 2015. Data from Maine Department of Marine Resources. (Figure from Wahle et al. in press).



*Other species include confidential species and other species that make up less than 1% of total catch.

AQUACULTURE ENHANCEMENT STRATEGIES, A LOOK AT BEST PRACTICES FROM AROUND THE WORLD

Maine has a unique and enviable set of natural resources that make aquaculture, both freshwater and marine, especially viable. Historically however, Maine has lacked a fully-fledged strategic plan that delineates the importance of water farming to the state, what the goal for its economic footprint is, where it should be located, and how the State and private sectors can enhance its development. This lack of an overall vision for what aquaculture means to Maine has continued to put would-be water farmers in conflict over ocean acreage with fishermen, coastal landowners and the regulators that issue leases.

Around the world there are a number of examples where states, provinces, or countries have been successful in aiding in the growth of particular aquaculture sectors. The two most important constants that one sees repeated for those programs that have been successful is an initial and then ongoing investment of federal and/or regional government support and an established federal and local coastal management plan that clearly delineates the status and locations for marine aquaculture. This report has paid particular attention to models that may mimic some of the conditions that exist in Maine. A number of these efforts share common assets, which help to establish both the need and the right conditions for success.

It is worth noting that three out of the five best practices discussed in the study below were identified and detailed by an Alaskan-launched intensive survey on what aquaculture enhancement programs throughout the world could learn from in order to responsibly promote and grow aquaculture in their state. This effort on the part of the state government in Alaska is a case in point of a state's investment in aquaculture enhancement outcomes.

The following list of conditions is gleaned from a number of successful enhancement programs and is not complete, nor are all conditions required to be in place at one time in order to secure success, but most together are a prerequisite for that success.

1) Government support. This includes:
    a) Stated aquaculture development plan (as in the case of New Zealand which adopted a research and development plan with a goal of $1 billion in sales by 2025 resulting in: Aquaculture New Zealand Research Strategy
    b) Comprehensive Coastal Zone Management Plan (CZM) which describes aquaculture leasing sites among its many characteristics
    c) Streamlined and fair leasing program with leases being transferable either at the start or after a reasonable period of time
    d) Enabling technology transfer from educational institutions and other like industries
    e) Biotoxin testing support
    f) Government supported marketing program
    g) Access to capital
2) Educational Institutions: This includes:
    a) Active research to advance key needs in the industry
    b) Educational support and training
    c) Workforce development programs
3) Access to capital through loan or grant programs from banks, credit unions and NGOs

4) Wild fishery trained work force
5) Wild fishery infrastructure: Harbors, wharves, distribution, storage, transportation, processing, etc.
6) Existing or future threat to a key wild fishery sector
7) Private/public hatchery-based system
8) Healthy margins on finished aquaculture product(s)
9) Predictable regulatory environment

Some Examples of Aquaculture Enhancement Best Practices:

Norway: Atlantic Salmon

Salmon farming began in Norway in the early 1960's when two brothers captured wild juvenile salmon and successfully raised them in the ocean. Their success at "ranching" wild stock caused another entrepreneur to try raising the fish in a hatchery. They collected eggs from 40 of Norway's salmon rivers to begin their broodstock program, and within seven generations they had managed to double the growth rate of salmon.

Early on, the Norwegian government saw salmon aquaculture as a means to provide coastal jobs. They had particular concern for the prospects of the northern regions of their country where opportunity was more limited. The government's primary controls over the growth, distribution, and health of the emerging industry were through the use of limited leases (concessions) and caps on the number of salmon that could be grown on a farm. Their theory was that limiting the initial start-up stages of salmon farming would allow pricing to grow and avoid early over investment. The government raised volume caps over the years (at least eight times between 1981 and 2009) as the industry became better established and in 1991 allowed leases to be transferable.

The Norwegian government allowed the coastal municipalities to allocate specific space in their ocean district for aquaculture. This form of a coastal zone management framework helped to pave the way for the evolution of the industry.

A close research-based cooperative relationship between industry and the government was established through the Research Council of Norway and Innovation Norway. Regional universities participated in both salmon aquaculture research and academic teaching and vocational training. Norway's Central Bank has helped to provide much needed capital for large and small farmers as the industry has grown, and salmon farms pay an annual export fee of approximately $1,800 and an export tax rate based on a percentage of the free on-board value shipped. Both payments go to the Norwegian Seafood Council that helps to promote and market Norwegian products worldwide.

Today Norway is the second largest exporter of seafood in the world, and it produces over half of all the world's farmed salmon. The salmon farming industry directly employs thousands of workers, this in a country with a population of just under 5.4 million people.

Cedar Key, Florida: Hard Clams

Cedar Key, on Florida's northwest coast, traditionally had an economy based largely on gill net fishing and the harvest of wild oysters. In 1991, the FDA closed the oyster fishery down due to salmonella from septic tank run off leaving a number of fishermen out of work. Very soon thereafter, the State identified hard clams (*Mercenaria mercenaria*), that were indigenous to Florida's east coast, as a potential species to raise in the Cedar Key ecosystem, and the Florida Department of Labor and Employment Security launched federally funded programs for training in shellfish aquaculture. The first program, called Project Ocean, continued through 1993. It funded Harbor Branch Oceanographic Institute, a marine research organization located on Florida's east coast, to oversee the program, which included a state operated working hatchery/nursery.

In 1994, the State also imposed a gill net ban in the area leaving an additional hundreds of fishermen out of work. A new initiative, Project Wave, was launched specifically to train those displaced net fishermen interested in becoming shellfish farmers. The program rewarded those fishermen who graduated from the training regimen with a lease of two to four acres and free seed and grow out bags. Discounted seed was provided to graduates of the program until the late 1990's when commercial seed became available. The leases were not transferable until the lease had been worked on for several years. 137 former oyster fishermen were rewarded with leases in the initial phase, and an additional 90 after the gill net closure. The University of Florida/Institute of Food and Agriculture Sciences invested in an extension position in 1996 to work with the new growers and address challenges in an emergent shellfish aquaculture industry.

The development of shellfish aquaculture in Cedar Key is an excellent example of a broad community effort, personal commitment, targeted training and aquatic farming assistance, and an effective government and regulatory response brought on by strong negative economic pressures. The Florida Department of Agriculture and Consumer Services (DACS) is the State's lead aquaculture agency and is responsible for coordinating and assisting in the development of aquaculture statewide. In 1999, the Florida Legislature created the Division of Aquaculture within DACS, and aquaculture was defined as an agricultural practice by the Florida Senate in 2015.

> *"The Division of Aquaculture conducts numerous activities to promote the development of aquaculture in Florida. These activities include regulatory, administrative, advisory, and technical assistance functions directed toward ensuring that aquaculture operations are compatible with the Florida Aquaculture Plan, Aquaculture Certification Program, best management practices, resource management goals, and public health protection."*
>
> (Economic Analysis to Inform Alaska Mariculture Initiative Phase 1 Case Studies).

Florida initially set the environment for success for the clam enhancement program with a Coastal Zone Management plan that recognized the promise that aquaculture held. Today there are over 150 clam growers in Cedar Key, and Cedar Key is now seeing third generation clam farmers working the family's original lease sites. The larger leases are upwards of 30 acres and no outside "large" companies have come in to consolidate the existing farms. On the marketing side, the clam farmers have tried unsuccessfully to form and sell through a Co-op, which eventually failed. Sales now are direct from the farmers to wholesalers and distributors.

Today, the Cedar Key clam aquaculture program is considered a best-case example of a government and community aquaculture response to a wild fishery crisis. 2019 sales of aquacultured hard clams in Florida reached $92 million employing more than 500 full time equivalents.

Prince Edward Island: Blue Mussels

The Prince Edward Island (PEI) mussel industry began modestly in the late 1970's when an entrepreneurial lobsterman named Russell Dockendorff harvested wild seed mussels and began growing them. He began at a time when the conditions in PEI were right for this sort of innovation:

1) There was a very supportive leasing system in place by the local government.
2) Farmers were willing to share information and best practices through an organization called the Atlantic Shellfish Exchange.
3) The government was able to provide capital through loans and grants. When serious industry-wide problems occurred as in the invasive tunicate period, money was made available for a rapid response for farmers.
4) PEI already had over 40 working fishing wharfs that aquaculture could benefit by using right away.
5) The product had very good working margins that allowed farmers to scale and weather difficult periods.
6) Technical support was provided through a veterinary college as well as a number of provincial government agencies.
7) There were no specific training programs for the industry, but the island was peopled with hardy and innovative farmers and fishermen who learned the trade through trial and error.
8) PEI is in close transportation proximity to the very large east coast U.S. market.

In Canada, the government has a supportive hand in many aspects of business. For aquaculture, it began with a federal aquaculture development strategy (FADS) in 1995 and then an updated aquaculture development strategy (National Aquaculture Strategic Plan Initiative 2010a). Within this plan, managed by the Department of Fisheries and Oceans, is a more specific east coast shellfish plan which pertained to PEI and their growing mussel farming business. In all, these plans speak to the stated commitment the Canadian government made to aquaculture and which it has followed through on. In addition, PEI has developed its own coastal zone management plan with a more granular look at the opportunities for aquaculture growth and sustainability.

Today the PEI mussel industry has leases of over 11,000 acres with one company alone holding 4,300 acres of that total. PEI grows 80% of Canada's mussels, and last year harvested over 50 million pounds of farm grown mussels. The industry has largely grown without the need for hatchery systems, but that is changing as farmers see the need for more reliable seed supply and consistent quality.

Industry growth was aided by a supportive federal leasing program, technical support from provincial, university, and federal scientists, and shellfish research and technology loans and grants, which financed early development of numerous farms around the island.

Ireland: Seaweed

Ireland's seaweed industry started with and identified export market.

> *"In 2007, the government of Ireland launched Sea Change–A Marine Knowledge, Research and Innovation Strategy 2007-2013. Sea Change aimed to transform the entire marine economy from one primarily associated with low value-added food harvesting activities to one embracing cultural traditions, but focused on high value, intensive, commercial opportunities developed in a sustainable manner. One of the marine sectors targeted in the Sea Change strategy has been aquaculture. The challenge addressed by Sea Change is to accelerate the development of the aquaculture sector by exploiting market-led opportunities and increasing the use of technological innovations."*
>
> (Economic Analysis to Inform Alaska Mariculture Initiative Phase 1 Case Studies).

Sea Change was updated in the year 2000 through a Marine Institute led report called the National Marine Foresight Exercise, part of which was input from the National Seaweed Forum, which identified a national seaweed aquaculture strategy that in turn created a 10-year industry development plan with specific production goals. An initial step in the plan was to launch a government supported project that developed both cultivation methodologies and identified seaweed species that were the highest commercial potential and those that were not. The results of this work named the species with the most potential and even projected a farm gate price that this product would need to sell at to be profitable.

This 10-year goal for Irish seaweed farming was led and overseen by the Irish Sea Fisheries Board (BIM) which also involved university and private industry support. The results of this early research built initial investment confidence in seaweed aquaculture and attracted significant funding from the European Union. These funds, along with funding from the Irish government, supported ongoing research, outright grants to farmers, investments in new technologies and new species, job training, and export marketing support. As a part of this overall 10-year vision for seaweed aquaculture, Ireland's Aquaculture & Foreshore Management Division is directed to ensures the efficient management of aquaculture leasing.

Ireland and its seaweed farmers have also had the benefit of a coastal zone management plan called Co-ordinated Local Aquaculture Management System (CLAMS), which evolved in Ireland from single bay management. It is a process that compiles relevant local oceanographic and socio-demographic characteristics for a particular water body, while convening and taking into account all interested stakeholders within those coastal waters.

As good as all of the planning and enhancement work that was done in Ireland, three key factors have to date prevented the industry from growing. First, and outside of the control of these enhancement plans, was Ireland running afoul of European Union regulations in 2007, which effectively closed the growth of new aquaculture leases for close to fourteen years. Second, and more germane to this report, the wild harvest of seaweed had enjoyed a long history of sustainable harvesting by hand. The wild stocks were well managed and not under pressure. Third, according to some, seaweed farmers in Ireland have yet to grow a product that competes with the wild harvest seaweeds in quality and price and so have taken a back seat in demand. All good lessons for conditions that must exist for aquaculture to prosper.

Atlantic Sea Farms: a Maine Model in Action

Atlantic Sea Farms (ASF) began in 2009 as Ocean Approved and was one of the first commercial scale kelp farming companies in the U.S. It began with the strategy of growing half of its annual harvest and collecting the other half from the cold ocean waters off the coast of Maine. After a few years, changes in the ecosystem in the ocean caused a bloom of Bryozoa, which effectively shut down the wild harvest resource.

The company made the decision to go all-in on farming seaweed/kelp and began to solicit interest from the fishing community to see if any fishermen would consider being contract growers for ASF if they provided them the seed for free and offered open-source suggestions for best farming practices. Most importantly they created contractual agreements with the fishermen turned part-time farmers to purchase all of their production at an agreed-on price, as long as the product performed at designated quality control qualifications. In the early days of this business model there was an expectation that a farmer could earn enough of an income from growing kelp that it would be another revenue source and put their marine skills and vessel to work in opposing months to the lobster fishery.

Today, ASF has turned its own original farm sites over to other contracted growers and gone all-in on becoming a processing and branding company. They currently have 24 part-time kelp farmers growing for them and have another 47 would-be farmer fishermen on a waiting list wanting to grow for ASF. This very successful model is completely dependent on the guarantied contractual obligations on both sides. For some fishermen growing for ASF in 2020 resulted in a significant revenue and buffer to the vagaries of commercial fishing.

In 2018, the entire state-wide kelp harvest in Maine was some 45,000 lb. In 2020 ASF purchased, processed, and sold 415,000 lb. of kelp and are projecting to do 850,000 lb. in volume in 2021. What works especially well in this particular model is the opposing seasonality of kelp growing and lobstering, but this model has significant implications for new sources of revenue for fishermen who also want to become part-time marine farmers.

Other Best Practices

Other aquaculture enhancement best practices that were identified in this initiative and are worth mentioning are: Geoduck farming in Washington State, the Alaskan salmon hatchery program and king crab farming, New Zealand green lip mussel farming, Spanish mussel farming, and the First Nation’s farming of finfish, shellfish, and seaweed in British Columbia.

SWOT FOR MAINE SEA SCALLOP AQUACULTURE

STRENGTHS

- Aquaculture products can provide year-round fresh availability
- Very high current level of support from the Univeristy of Maine and NGOs
- Maine farmed products are close to one of the largest seafood markets in the world
- New farmed product forms can be introduced: roe on and shell on, meat on shell
- Marine based workforce
- Shellfish aqaculture is seen as neutral or even positive for the environment
- Compared to wild harvest dragging of scallops, it is relatively environmentally benign
- Existing relationship with Japanese growers and OEMs
- Product is fresh, not frozen and available when the wild fishery is seasonally closed
- Maine ranks fifth in the U.S. in number of farmer's markets per capita
- High degree of interest in this sector right now
- Maine foods have positive marketing attributes
- Portland is a great test/food town
- Maine is second most locavore state in the U.S.

WEAKNESSES

- Current permitting from DMR still labored, uncertain and potentially expensive
- Short shelf life sold live and roe on (4-5 days)
- Early grow out stage gross margin challenges
- Relatively high initial CapEx
- No hatchery operating currently/heavy reliance on wild spat collection
- No critical mass yet or economies of scale
- Expensive bio-toxin testing required for whole live and roe on product
- New product form to the U.S., roe on, whole live and meat on shell
- As of yet unproven gross margin level that can lead to profitability
- Not enough volume producers yet to have firm understanding of COGS
- Low mechanization in the US industry now
- Reliance to-date on Japanese OEMs for mechanizationequipment with long relational and delivery lead times
- LPAs can only sell adductor meats

OPPORTUNITIES

- New product forms introduced in the US market
- Potential for better flavor, texture & availability
- Crack the code in a hatcheryand breeding and this could create potential improvements, such as: faster growth, disease resistance, improved taste, texture, color and year-round availability
- Farms begin to market place-based taste and value propositions as in oysters…"merroir"
- Another revenue source for fishermen if they farm as well
- Improved mechanization can lead to lower COGS
- Improved husbandry can lead to more efficiencies and shorter time to market
- Scallop meats as a wild fishery "commodity" has enjoyed high market prices
- Stable pricing from a year-round farm supply should improve market price
- State support for biotoxin testing and monitoring

THREATS

- Not enough margin in any of the product forms to be priced competitively in the marketplace
- Uncertain impact of climate change
- Risk around toxicity of whole and roe on scallops
- Bio-toxins, including shellfish closures, testing costs and consumer health
- Slow turn around time for DMR licensing may dissuade potential new incoming scallop farmers and expansions
- Resistance from wild fishery and/or coastal owners
- Competition from overseas, Canada, Peru, China, Japan, etc. could push pricing down
- 100% dependence on wild spat collection
- Maine's dominant lobster fishery could falter and Maine could quickly lose its working waterfront
- Price of commercial catch sea scallop meats collapses, putting downward pressure on farm prices
- Sea scallop diseases

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