Duration (dates) of entire project, including extensions:
From: [12/1/11] to [12/31/14].

Project Title: **A Pilot Project to Stimulate Seaweed Production on Mussel Farms in Maine**

Project Coordinator
Dana L. Morse
Maine Sea Grant, and Univ. of Maine Cooperative Extension, Darling Marine Center, 193 Clark's Cove Road, Walpole, ME 04573; 207.563.8186, fax: 207.563.3119, dana.morse@maine.edu

Principal Investigators and key personnel
Sarah Redmond
33 Salmon Farm Rd, Franklin, ME, 04634; 207.841.3221; sarah.redmond@maine.edu
Carter Newell
Pemaquid Mussel Company; 7 Creek Lane, Damariscotta, Maine 04543, 207.563.8440; musselsandoysters@gmail.com
Evan Young
Blue Hill Bay Mussels, 460 US Highway 1, Hancock, ME 04640, 207.479.4600, bluehillbaymussels@yahoo.com
Nick Brown
Formerly: Center for Cooperative Aquaculture Research, 33 Salmon Farm Rd, Franklin, ME 04634. 207.422.9096. Fax 207.422.8920. Email. npbrown@maine.edu
Matt Moretti
Wild Ocean Aquaculture, LLC. 165 Edwards Street, Portland, ME 04102 207.458.6288 mattmoretti@gmail.com

COLLABORATORS AND PARTNERS:
Ocean Approved, LLC; Tollef Olson (CEO), Paul Dobbins (President), Portland, ME
Peter Fischer - Pemaquid Mussel Co.
Tim Levesque - Pemaquid Mussel Co.
Joe Larrabee - Pemaquid Mussel Co.
Virginia and Blaine Olson - Oceanville Seafood, Stonington, Maine

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Executive Summary

Maine is in a unique position to become the leader in integrated aquaculture and new aquaculture crop development. The clean, cold waters and expansive coastline are ideal for the culture of many economically important species and we have long been investing in the development of our aquaculture industry. There are already shellfish, fish, and seaweed aquaculture operations in the state, and there is a strong community of cooperation among industry, outreach, and research groups. The seafood industry is an important source of income and livelihood for all of our coastal communities, and it is estimated that for every job created in fisheries and aquaculture production, about three jobs are created in related secondary activities, so a sustainable aquaculture industry could play a very important role in supporting and reviving our traditional fishing communities.

Saccharina latissima, ("sugar kelp") is a cold temperate brown algal kelp species native to Maine. While similar kelp species have been cultivated for decades in Asia, the sea vegetable aquaculture industry had been nonexistent in the US until recently. Maine was home to the first commercial kelp farm in the US in 2010 with the development of native kelp culture technologies. In an effort to share and encourage the expansion this new crop, kelp lines were integrated onto shellfish farms along the coast of Maine over three years. This project created important linkages within the State and region, allowed for experimental kelp culture, and helped launch the growth of a new sea vegetable aquaculture industry in Maine.

An integrated, multi-trophic aquaculture pilot project was conducted to encourage production of the edible marine alga *Saccharina latissima* on shellfish farms in Maine. Existing and new sea farmers were given lines seeded with *S. latissima* as well as technical training and permitting assistance. Grow out trials occurred on several sites along the Maine coast, and growth was evaluated in light of such measured characteristics as temperature, turbidity, ammonia and nitrate, and the distance of the algal lines from the main shellfish production structure. Opportunities to foster knowledge and new relationships between algal producers and buyers were created.

PROJECT GOALS AND OBJECTIVES:

Overall, our **goal** was to encourage the expertise needed to make algal production a profitable and sustainable enterprise for Maine producers and buyers.

We proposed to accomplish this goal through three principal **objectives**, as follows:

1) To conduct pilot scale integrated growth trials of sugar kelp on existing shellfish farms in Maine
2) To develop expertise and culture technologies for seaweeds in Maine
3) To develop relationships between sea vegetable growers and buyers

Objective 1

To conduct pilot scale integrated growth trials of the sugar kelp on existing shellfish farms in Maine.

Two production seasons were completed under the present grant, and are reported accordingly.

Activities

1. Produce lines seeded with *S. latissima*, for distribution to participating growers
2. Deploy seeded lines on mussel farm sites state-wide including assistance in any permitting changes necessary
3. Monitor growth and yield, via direct sampling at each farm, including tissue analysis at the conclusion of the project.
4. Monitor environmental data at each site: temperature, salinity, ammonia, nitrate, turbidity.
5. Record operational and husbandry issues and suggestions as observed by each cooperating grower

<u>Year 1: 2011-2012</u>

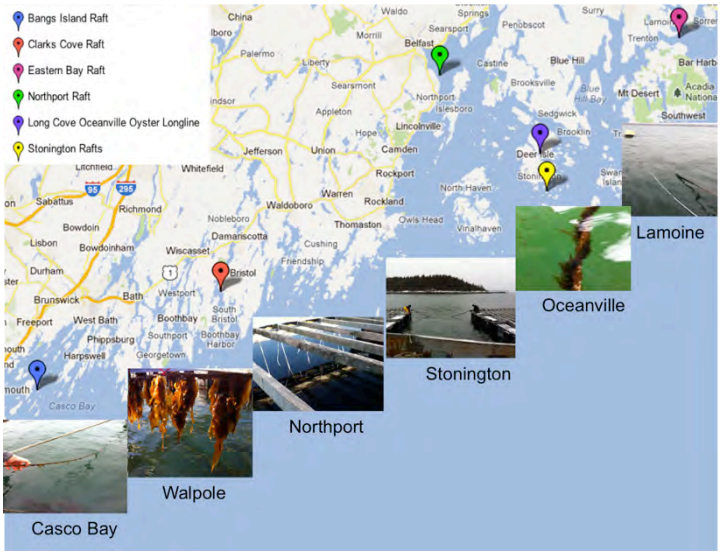
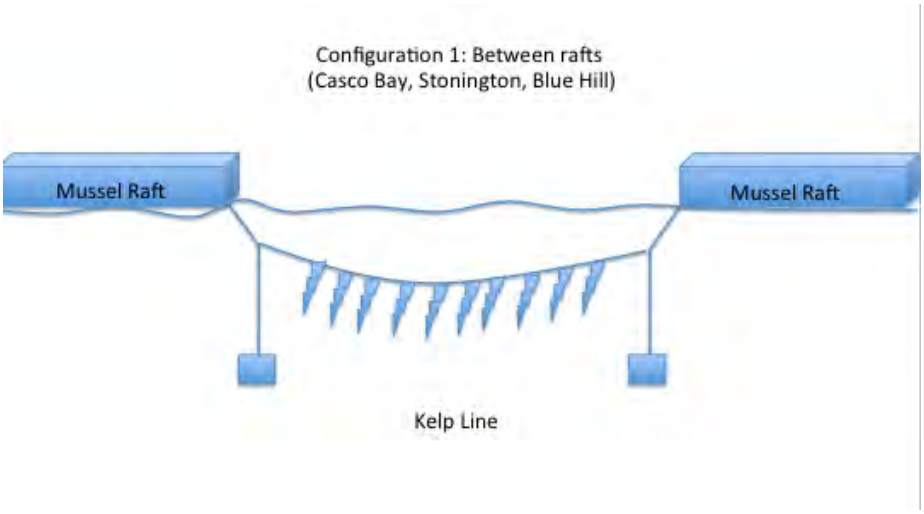
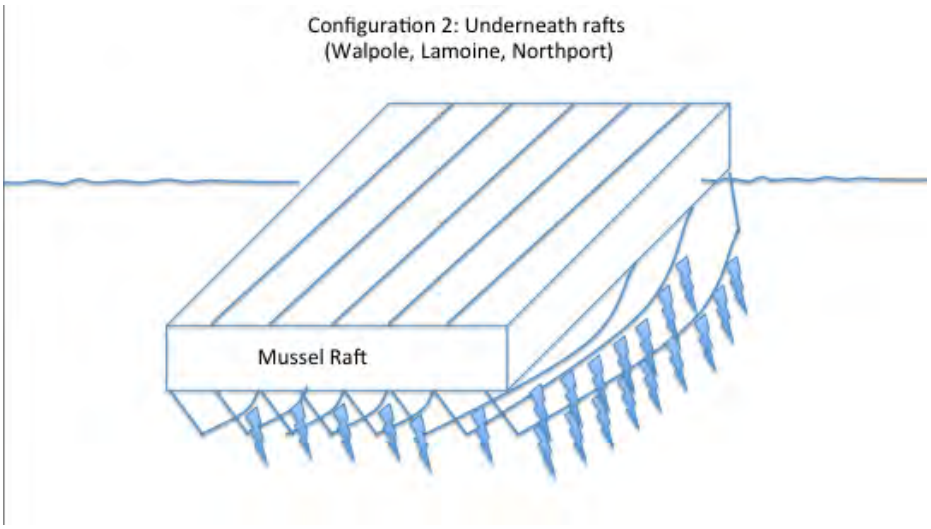


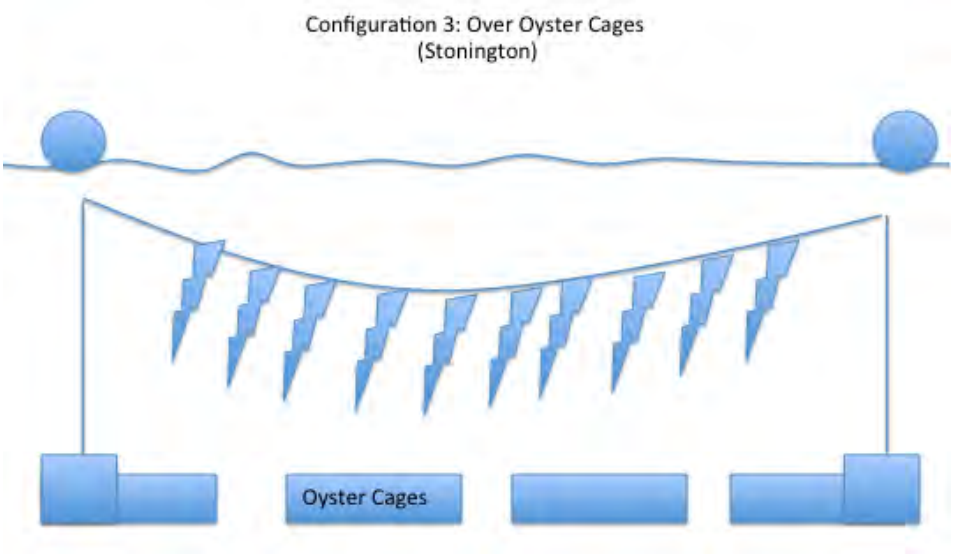
Figure 1. Map of participating sea farms in year 1.

Seven different shellfish aquaculture farms - six mussel farms and one oyster farm - were seeded in the winter of 2011 for the 2011/2012 kelp-growing season (Figure 1, Table 1), using seeded lines produced by Ocean Approved in their nursery facility in Portland, ME. There were six mussel farms and one oyster farm involved in this project, and each site incorporated kelp lines in different configurations Figure 2), according to the site. Each site received approximately 200 linear feet of seeded line, wound over 9/16" Hy-Liner sink rope, purchased through Brooks Trap Mill. For sites seeded under rafts, sections of seeded line were approximately 35" long, with steel sash weights at the end of each seeded section, to keep the lines negatively buoyant. The ends of each seeded line were tied to the raft platform.

Figure 2. Integrated Kelp/Shellfish Configurations







Sites were seeded according to their most convenient configuration. Sites with two adjacent seeded mussel rafts (Casco Bay, Stonington, Blue Hill) strung kelp lines between the two rafts, at depths of 4-7 feet. Unseeded mussel rafts strung kelp lines underneath the rafts. Kelp lines were approximately 4-7 feet. At the oyster farm in Stonington, the kelp line was seeded over the sunken oyster cages.

Sites were visited several times throughout the season to collect environmental and growth data. Kelp samples were collected throughout the season to measure total length, width, and weights to determine growth, density, and yield. Results are summarized below.

Table 1. Summary of the 2011-2012 season.

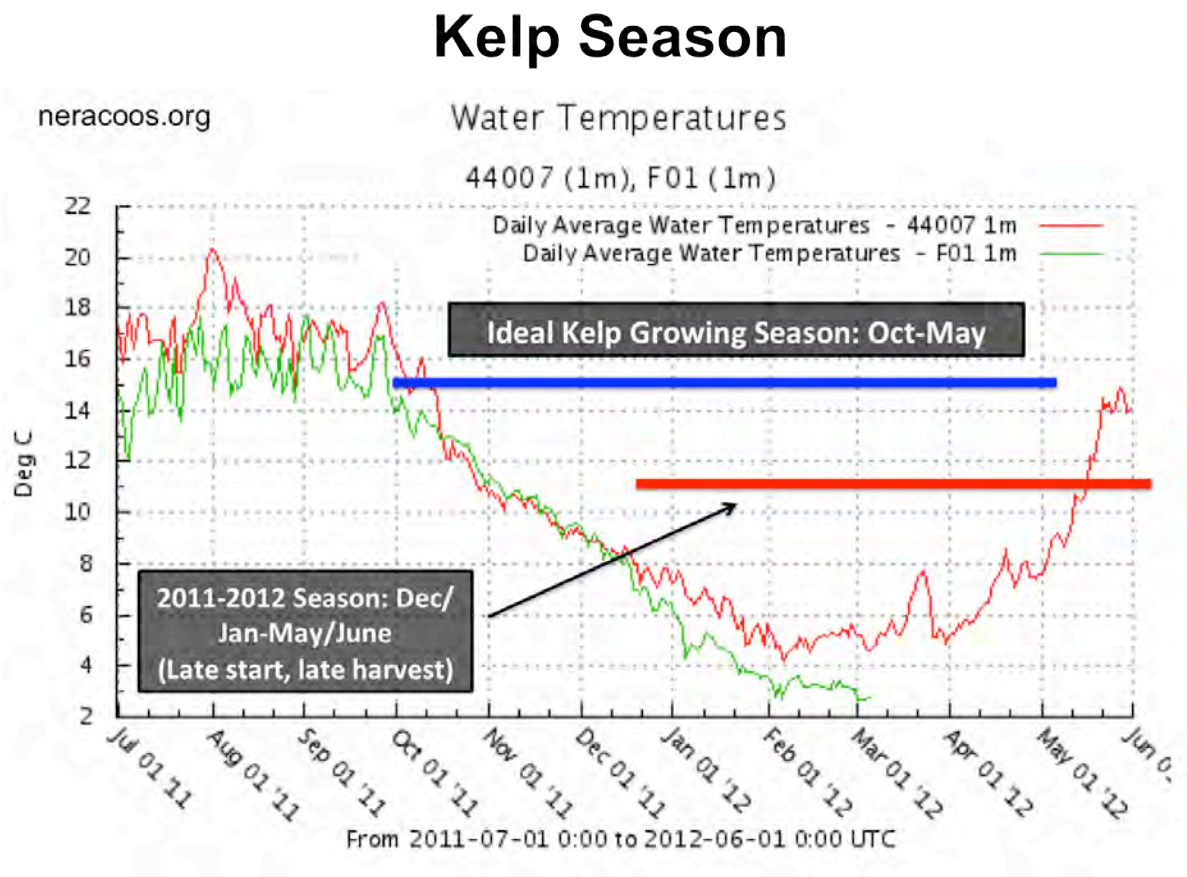
2011-2012 Farm Season

Farm Location/Name	Seeding Date	Species	Harvest Date	Notes
Blue Hill, Blue Hill Bay Mussels	12/15/11	Sugar Kelp	na	No reported yield
Casco Bay, Bangs Island Mussels	12/23/11	Sugar Kelp	6/11/12	5 lbs/ft, seeded between rafts
Lamoine, Pemaquid Mussel Co.	12/31/11	Sugar Kelp	6/19/12	2 lbs/ft, seeded under raft
Northport, Pemaquid Mussel Co.	12/14/11	Sugar Kelp	5/1/12	5 lbs/ft , seeded under raft
Stonington, Oeanville Seafood	12/1/11	Sugar Kelp	7/10/12	4.8 lbs/ft , seeded on longline
Stonington, Pemaquid Mussel Co	1/26/12	Sugar Kelp	na	No reported yield
Walpole, Pemaquid Mussel Co	12/14/11	Sugar Kelp	6/7/12	6 lbs/ft, seeded under raft

Timing

The importance of timing was one of the greatest lessons learned during this project (Figure 3). Due to the late start of the project in 2011-2012, the farms were seeded much later in the growing season than they should have been. Ideally, the growing season is from fall (September-October) to spring (May), but the farms did not get seeded until December-January. For this reason, plants and yields were much smaller than expected. Harvest timing is also incredibly important. If the crop is left too long in the water in the spring, fouling of blades becomes a problem. Heavy fouling of diatoms, skeleton shrimp, mussel seed, and hydrozoans can ruin the crop.

Figure 3. Ideal and actual kelp growing season as related to seawater temperature.



Density

The seeding density, or amount of plants on the line, is difficult to control in the nursery. The seeded lines in this project were very dense, leading to crowding. Either control of density should be developed in the nursery stage, or farmers need to thin lines during the growing season

to optimize growth of plants. In general, the density of plants decreased through the growing season (Figure 4).

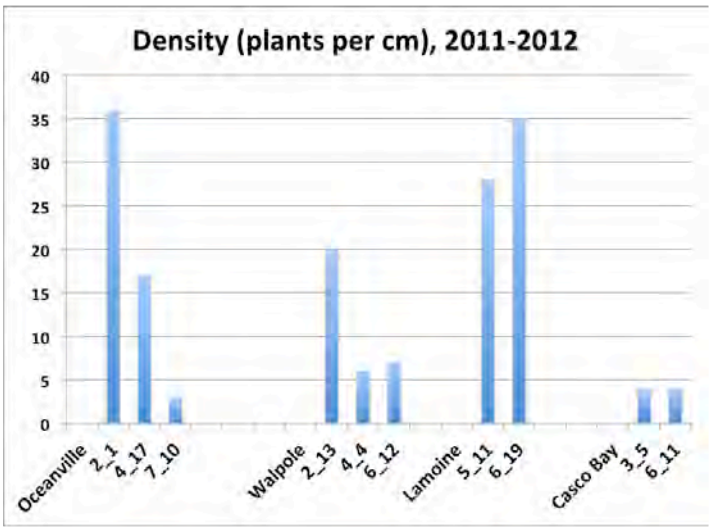


Figure 4. Summary of density of kelp lines, 2011-2012.

Planting Depth

Depth of lines should be adjusted to maximize growth. In the winter, water clarity is usually very good, and lines can be deeper, but as turbidity increases with increased productivity in the water column, this light availability is reduced, and lines should be adjusted to shallower depths. Culture depth is typically 4-7 feet, depending on the site and season. All of the farms, save one, had kelp lines that were suspended from surface lines, maintaining a constant depth with the rise and fall of the tide. In Oceanville, lines were stationary on the bottom, so experienced changing light levels with tides. The farm was in a very productive area, so there were times in the spring that the plants were light limited, which is believed to have stunted growth (Figures 5 and 6).

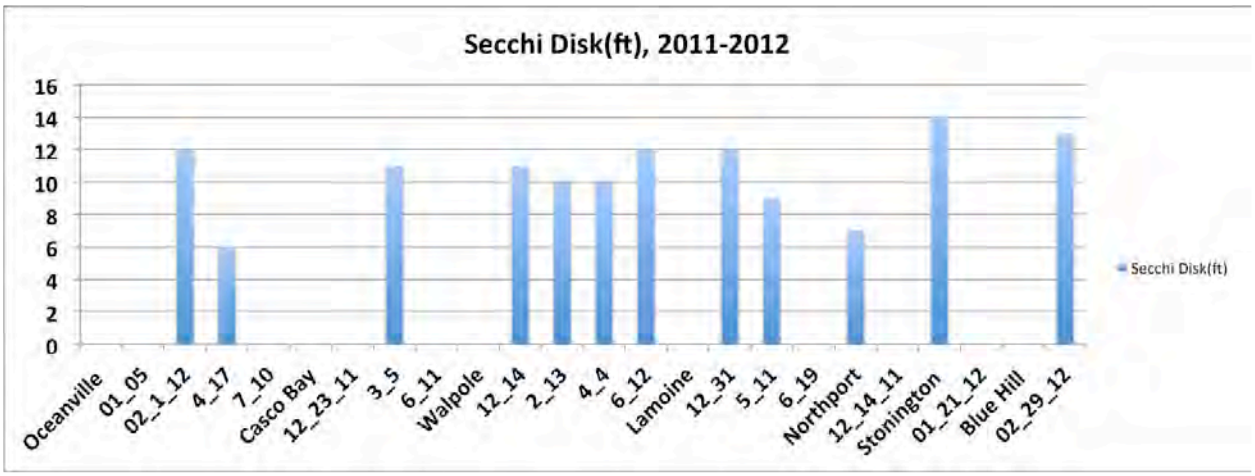


Figure 5. Secchi disc measurements, 2011-2012

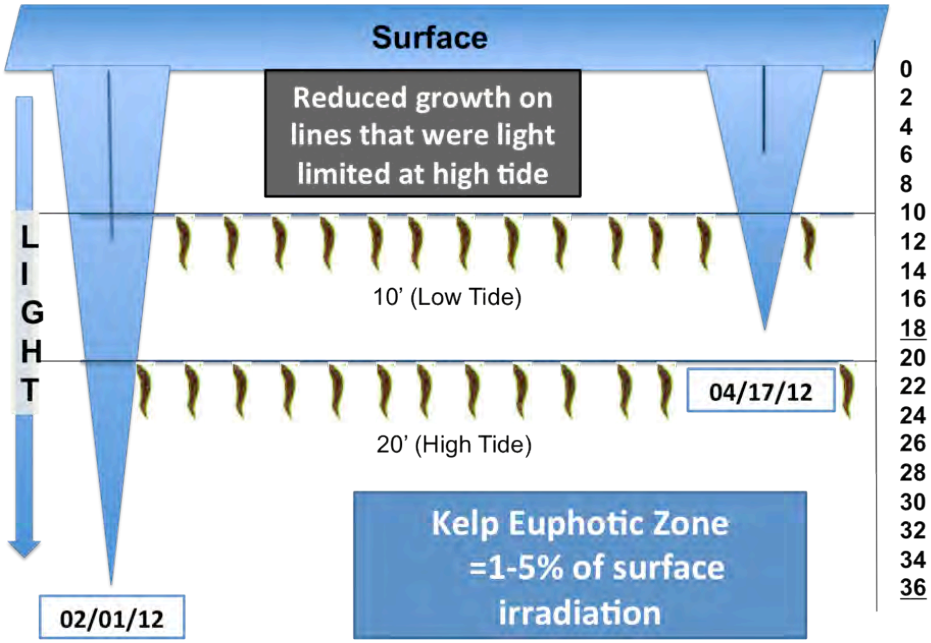


Figure 6. Light availability for static kelp lines at Oceanville, 2011-2012.

At two of the farms, Walpole and Lamoine, kelp lines were strung underneath an empty mussel raft at 3 (shallow) and at 7 feet (deep) (Figure 7). Blade length was slightly better on the shallow line than the deep line, probably reflecting a greater availability of light. Decreases in blade length in June could have been from increased stress to plants from higher temperatures and biofouling.

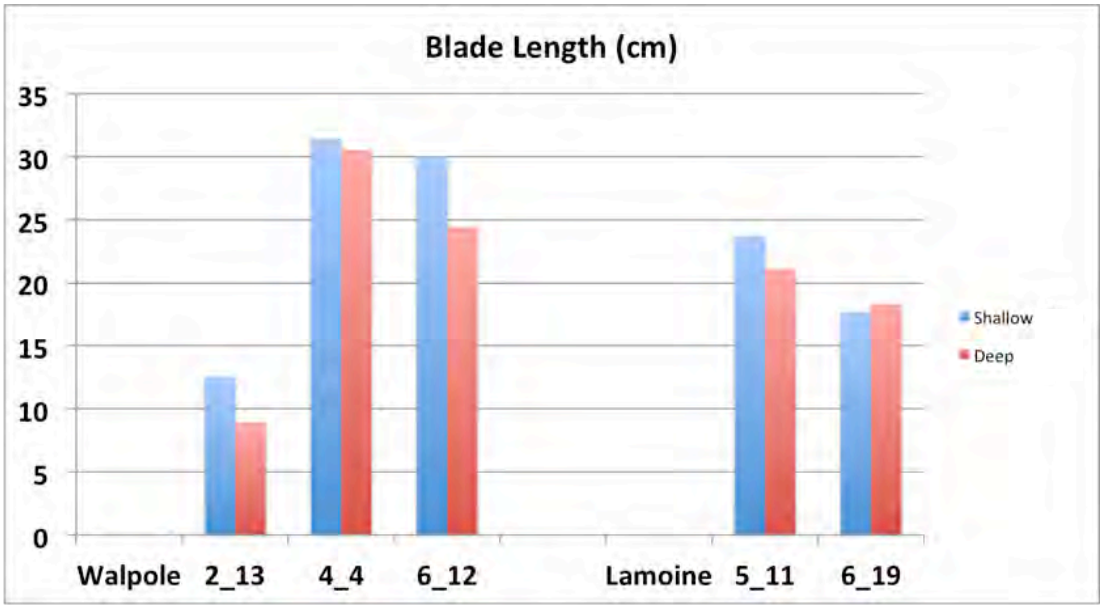
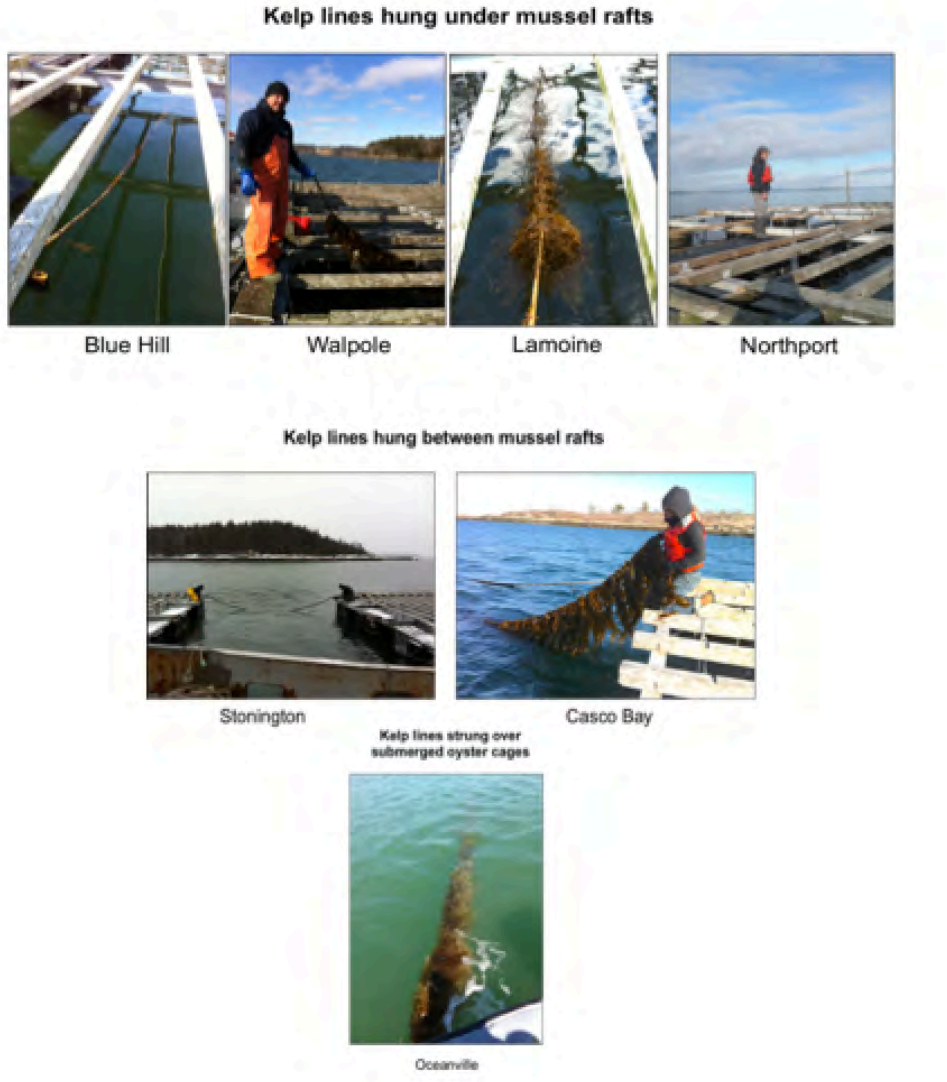


Figure 7. Differences in blade length from lines at 3 and 7 meters.

Integrated Systems

Many of the mussel farms utilized existing empty rafts to grow kelp lines by running lines underneath the rafts (Figure 8). This system had the benefit of utilizing an existing structure and offered a solid working platform for seeding, checking in on the lines, and harvesting. However, this is not an ideal place to culture kelp. While the plants will grow here, the lines do not receive optimal water flow or light levels. It is recommended that kelp lines be placed outside of the rafts on their own suspended long line systems. The plants that grew on lines between two rafts in Casco Bay had better overall growth rates than the lines that were strung underneath a raft in Walpole (Figure 9).

Figure 8. Various integrated configurations on shellfish farms.



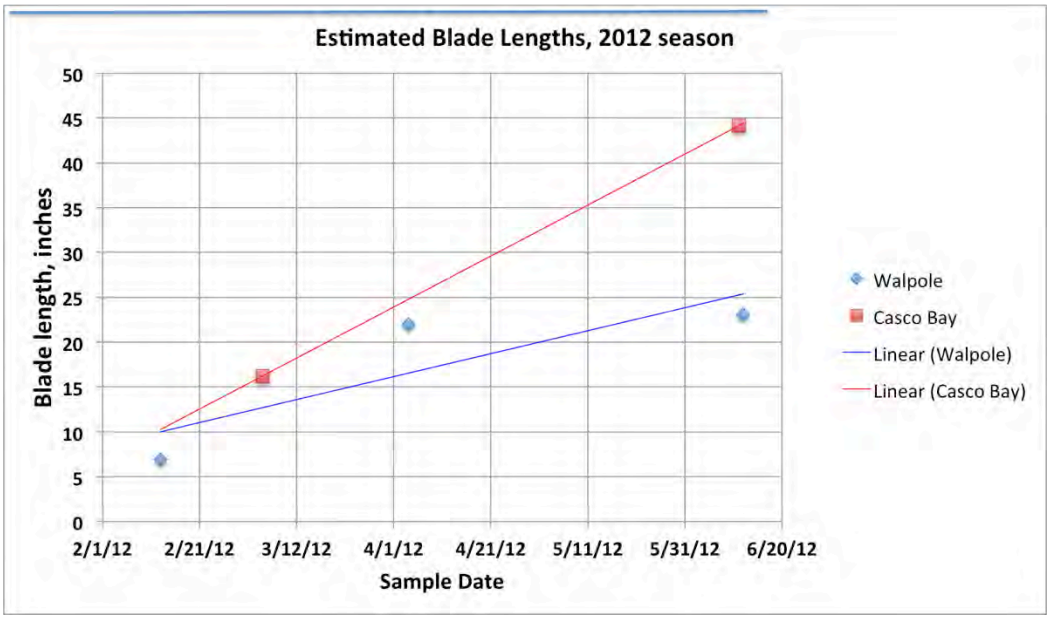
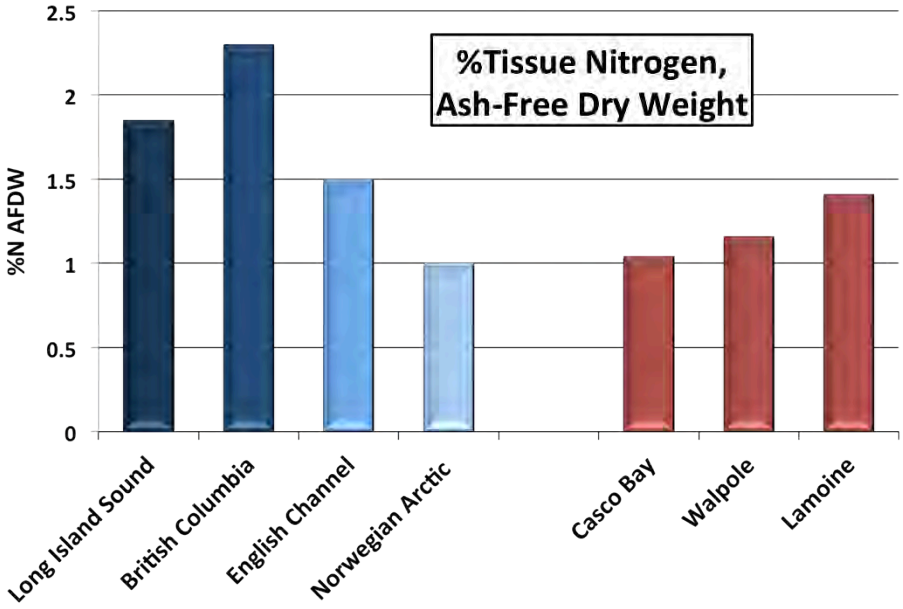


Figure 9. Blade lengths from a line under a raft (Walpole) vs. a line between rafts (Casco Bay)

Nitrogen

CHN (Carbon:Hydrogen:Nitrogen) analysis was performed on dried 2011-2012 samples on a Perkin Elmer 2400 CHN analyzer at the UCONN Stamford Seaweed Biotechnology Laboratory (Stamford, CT). Nitrogen data can be useful when considering the nitrogen removal potential, also known as bioextraction, of cultivated kelp. Samples were taken in June, at the end of the season. Results are comparable to other studies, though levels are somewhat lower (Fig. 10). This could be a result of the short growing season that produced younger, smaller plants. The overall average % dry weight nitrogen value was 1.2. The overall average Carbon:Nitrogen ratio was 26.25.

Figure 10. % Tissue Nitrogen, Ash-Free dry weight from three sites in Maine, 2011-2012 (right), compared to other reported values (left).



Yields

Yield values were obtained at the end of the season by weighing 1-meter samples of total biomass, then averaging values. Yields of kelp per unit were calculated as kilogram per meter, and total yields calculated in kg. Yields per meter were much lower than other reported values (see below), due to the shortened season. Maximum values of yield were around 8kg/m (5lbs/ft). It is expected that this number would be greater given a longer growing season. Each farm had different amounts of seeded line planted, so total estimated yields are not comparable (Figs. 11 and 12).

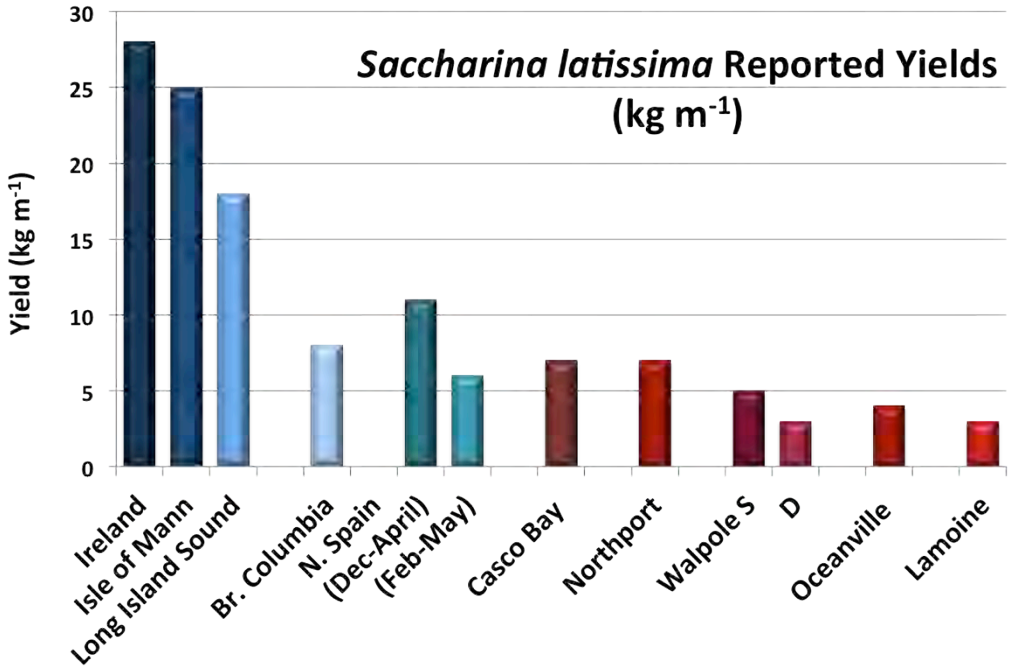


Figure 2. Project yields (right) compared to other reported values (left).

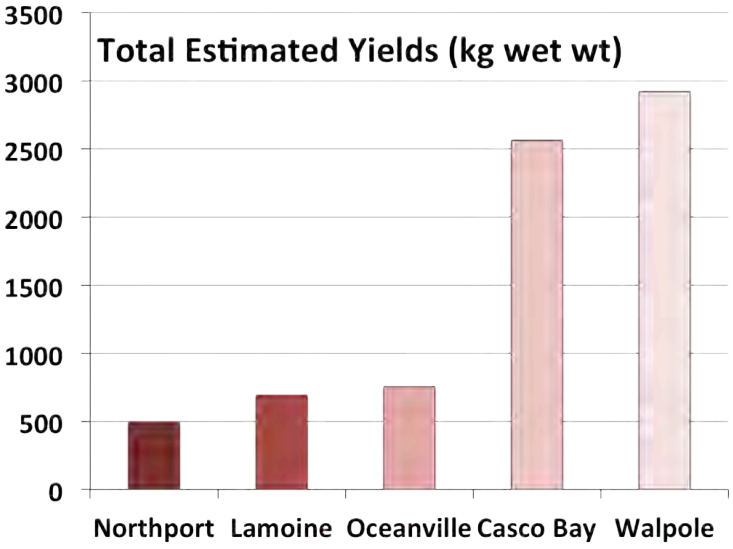


Figure 12. Total estimated yields for five farms, 2011-2012.

Growth Rates

Growth rates were calculated as cm increase per day, determined by measuring total length of samples taken throughout the growing season (Fig. 13). This is an estimate based on changes of blade length from samples over time. These values were lower than other reported values, which could be because of the shortened growing season, shading under rafts and at depths, or high densities on the lines. This is only a rough estimate of growth rate, and could be improved using the hole-punch technique, where individual plants are followed through the growing season to track blade growth. Growth rates will change over the season, with more rapid growth taking place in early spring, when nitrogen supplies are still abundant and the amount of daily light increases.

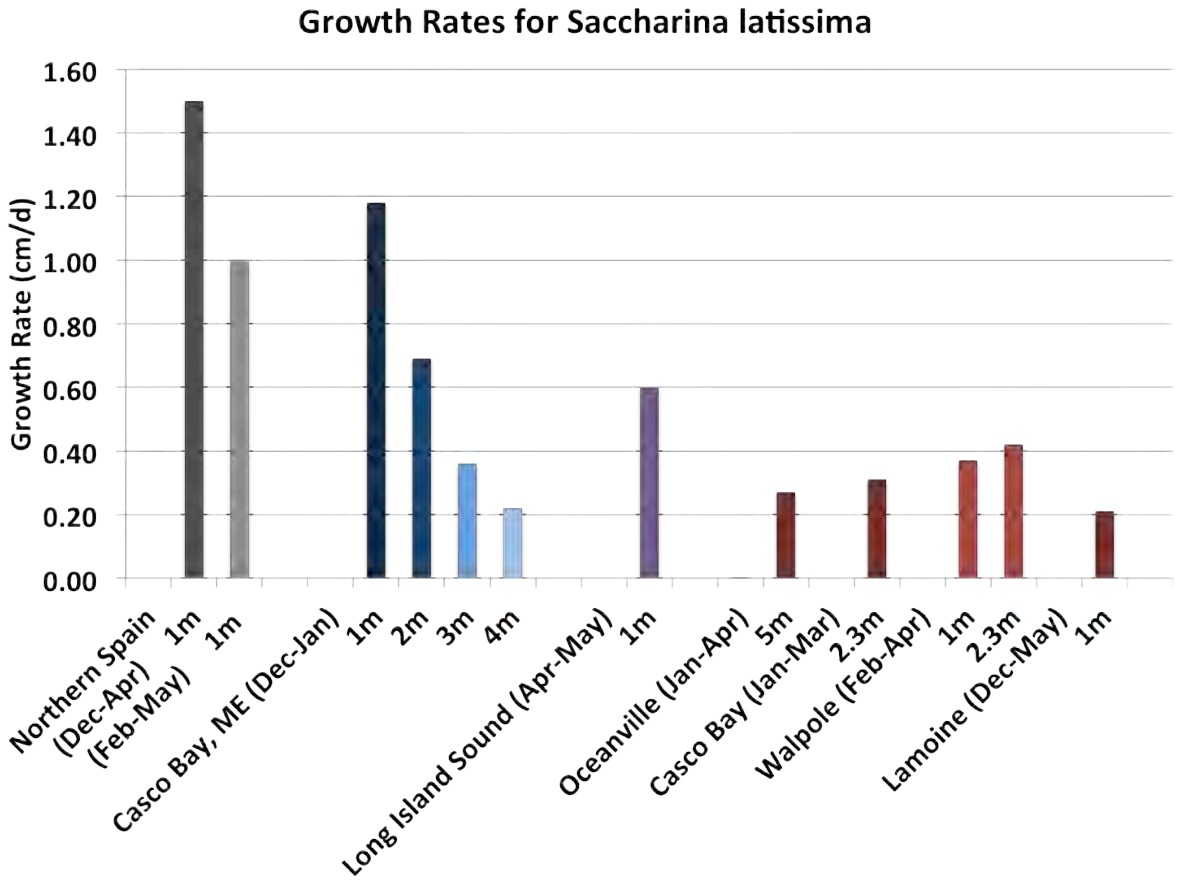


Figure 3. Estimated growth rates for 2011-2012 (right), compared to other reported values.

Blade and Stipe Lengths

Samples were taken throughout the growing season for blade (width and length) and stipe (length) measurements. Samples of 10cm along the line were taken and all plants were measured. The data was somewhat complicated by the large numbers of small plants that were present underneath the larger blades. The process of useful data collection from kelp lines is ongoing, as we develop best practices for sampling. Stipe length increased dramatically in the spring, and represented a significant portion of overall length (Fig. 14). This could have been a result of crowding and poor light conditions, or it might be an inherited morphological trait.

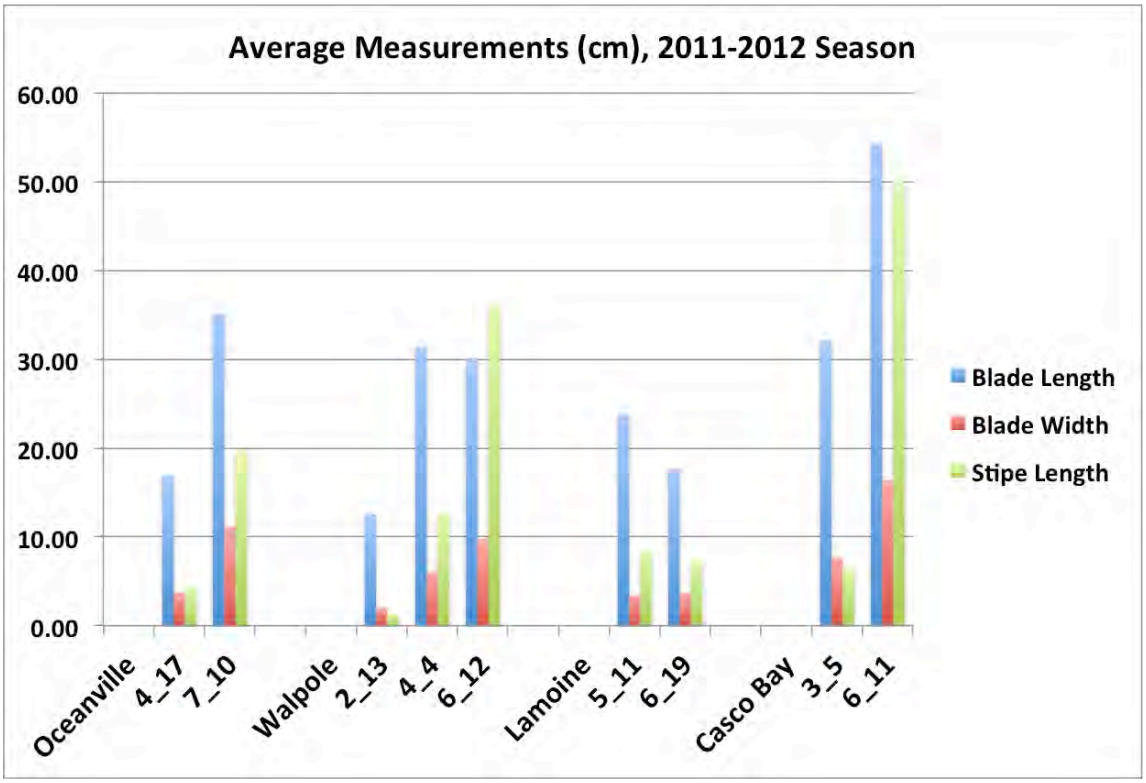


Figure 4. Averages for blade length, blade width, and stipe length

Salinity
Salinity was measured periodically throughout the project using a refractometer (Fig. 15).

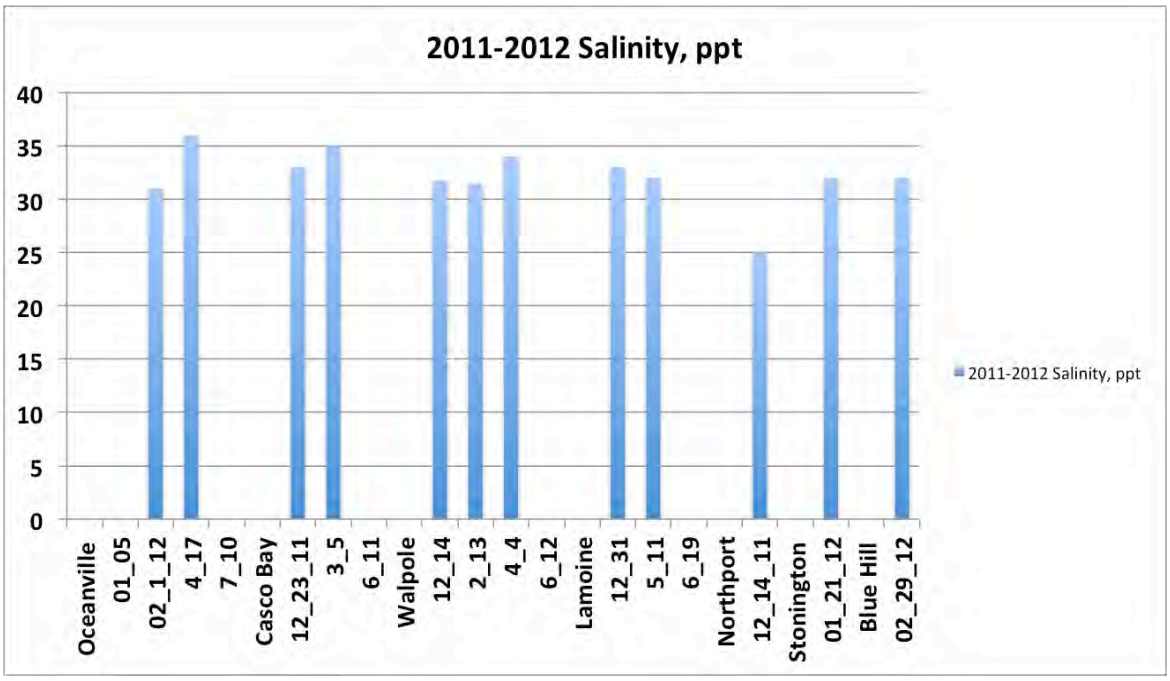


Figure 5. Salinity measurements, 2011-2012.

Temperature
Temperature data loggers (AlphaMach IBCod-Z) were placed at each site to record temperatures over the growing season (Fig. 16).

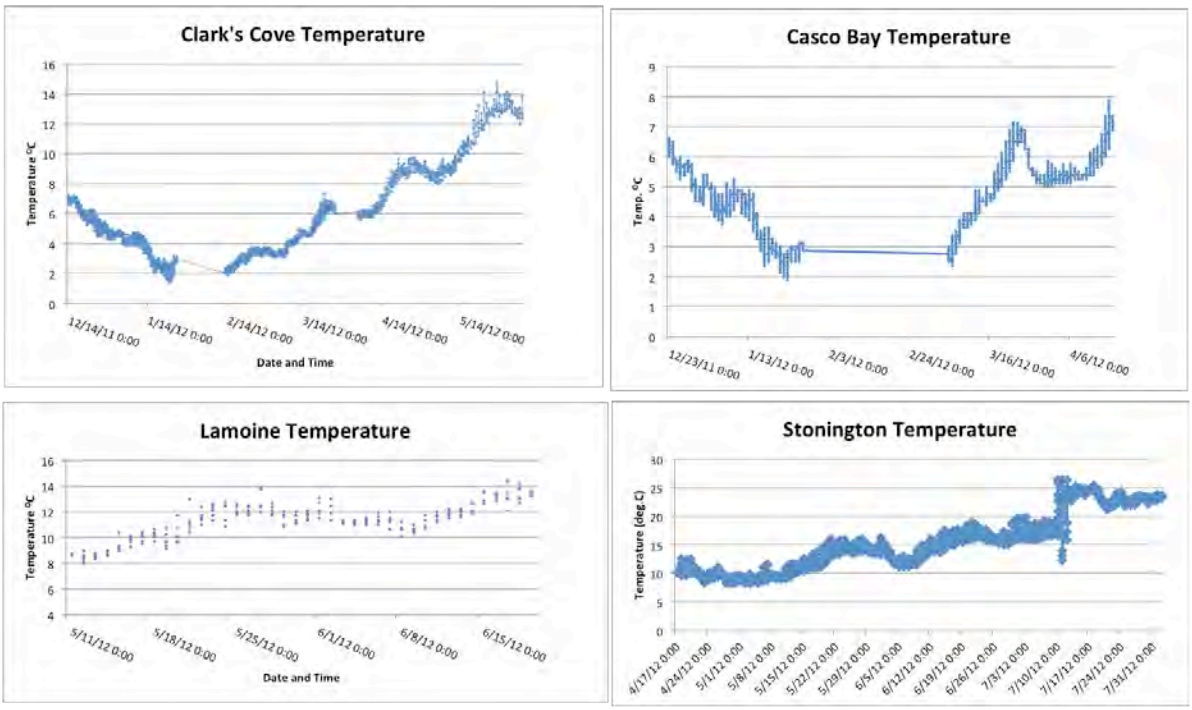


Fig. 16: Temperature measurements, 2011-2012.

Marketing

Samples of the kelp crop were taken to Ocean Approved, Llc and Maine Coast Sea Vegetables for analysis in May and June. The short growing season produced plants that were too small and thin to be utilized, and late harvest resulted in fouling organisms on the blades. Maine Coast Sea Vegetables also requires that the crop be organically certified, which had not yet been developed for farmed kelp. Work for certification has been ongoing, with expected certification to occur by the spring of 2015.

Overall Observations

Seeding should be done well before December in order to take advantage of the full growing season, and harvest should take place in spring before fouling sets in. Separate kelp longlines near the rafts will allow for more space, water movement, and light than placing lines underneath rafts. Heavy seeding densities on the seed string can result in crowding, smaller plants, and slowed growth.

Outreach

In August of 2012, a meeting called 'The Seaweed Scene' was held at the University of Maine's Hutchinson Center. The purpose of the meeting was to highlight results from this project and other similar work, and to build networks for those interested in seaweed aquaculture, from any perspective. The meeting attracted nearly 100 individuals, and was view as a great success. An agenda from the meeting is in Appendix II, and the web page from the meeting can be found at: http://www.seagrant.umaine.edu/seaweed/seaweed-scene-2012.

Year 2: 2012-2013

A small kelp nursery was set up at UMaine's Center for Cooperative Aquaculture Research (CCAR) for the production of seeded kelp line for new and experimental growers (Fig. 17). This new nursery was the beginning of a new research and development seaweed nursery for Maine, where seeded lines of sugar kelp (*Saccharina latissima*), alaria (*Alaria esculenta*), laver (*Porphyra umbilicalis*), and dulse (*Palmaria palmata*) have been produced and given to growers. In 2012, the CCAR nursery provided over 3,150 feet of seeded kelp line to sea farmers to trial on their leases, which supported the development of at least 4 new growers (Walpole (two growers), Casco Bay) that are committed to developing sea vegetable crops on their farms for additional income.

Figure 17. First small kelp nursery at CCAR.

One new seaweed farm - Maine Fresh Sea Farms - in Walpole was created from our prior efforts in Year 1. This farm added new independent long lines next to the mussel raft, and cultivated sugar kelp, dulse, and porphyra in 2012-2013 (Fig. 18). This was the first farm ever to sell crop in 2013. They sold kelp stipes to Ocean Approved and kelp blades to CCAR for a sea urchin aquaculture bulking research project.

Kelp **Laver** **Dulse**

Figure 18. Species diversification on the Walpole farm.

Table 2. 2012-2013 Season summary.

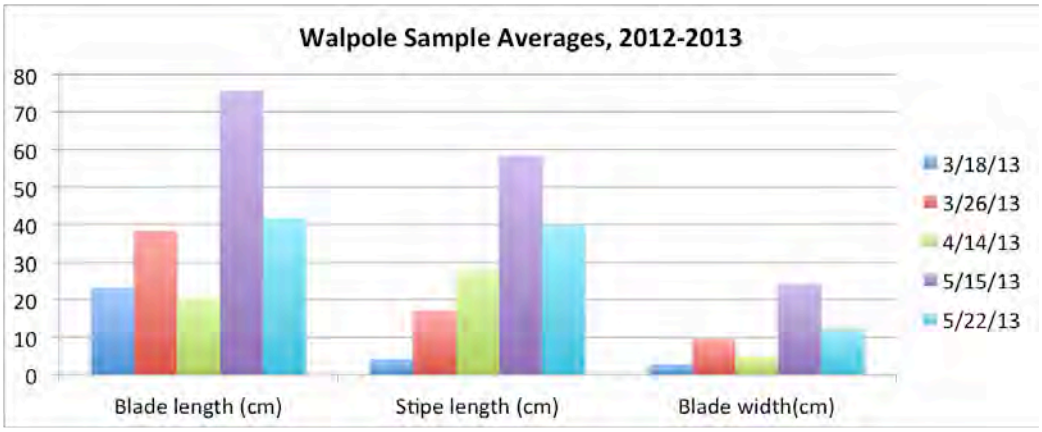
2012-2013 Farm Season

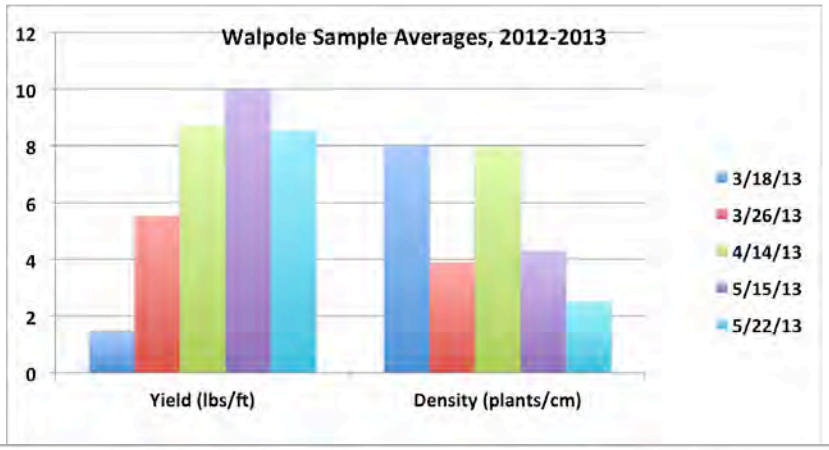
Farm Location	Seeding Date	Species	Harvest Date	Notes
Casco Bay (Bangs Island)	12/7/12	Sugar Kelp	nd	
New Hampshire	1/15/13	Sugar Kelp	5/6/13	Small plants
Walpole (Newell)	11/20/12	Sugar Kelp	nd	Dried for sale locally
Walpole (Fischer)	11/20/12	Sugar Kelp (early planting)	4/5; 5/16; 6/12; 7/7	6lbs/ft; Harvest May-June, Fouling June-July- snails, hydrozoans, skeleton shrimp
Walpole (Fischer)	1/5/13	Sugar Kelp (late planting)	4/5; 5/16; 6/12; 7/7	
Walpole (Fischer)	11/20/12	Laver net	23-Jun	April: very little growth, net under wharf; May-June, blades bleached out
Walpole (Fischer)	11/20/12	Dulse (attached, avg length 7.8cm)	15-May	March 8th: Dulse harvestable, deep red, 33cm length, 162g/plant; May 15th: Dulse reproductive, color loss
Walpole (Fischer)	4/10/13	Dulse (attached, avg length 4.83cm)	nd	
Walpole (Fischer)	11/1/12	Digitata	5/17/13	Few plants, long and thin, non digitate
Port Clyde (Herring Gut)	11/28/12	Sugar Kelp	May	Line in Lobster Pound

Farm Samples

20 cm samples were taken from kelp lines on the Walpole farm throughout the season (Fig. 19). Measurements of blade width and length, and stipe length were taken, along with weights of samples and density estimates. These values were averaged, though most of the samples contained a large percentage of smaller size classes (approximately 56% plants under 20cm per sample) compared to the larger, harvestable, plants. Meaningful sampling along the line still

needs to be developed in order to obtain data of harvestable plants throughout the growing season.





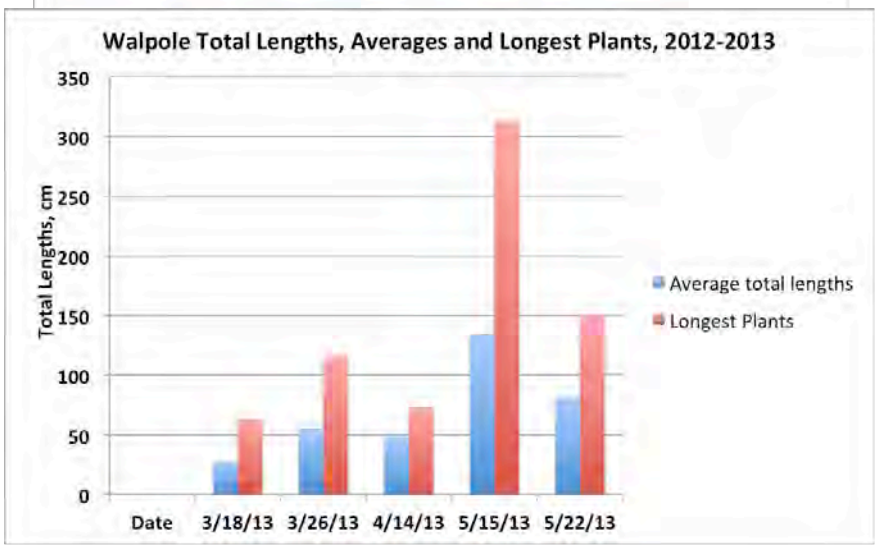


Figure 19. Walpole measurements, 2012-2013.

Thinning

Selective harvesting of lines took place throughout the spring in Walpole (Table 3). This thinning activity allowed for multiple harvests, and was an attempt to reduce density on the lines in order to optimize growing conditions for the remaining plants.

Table 3. Summary of thinning activity, Walpole.

Selective Harvesting of line (thinning)	
Date	Pounds harvested
03/29/13	58
04/05/13	52
04/14/13	36
05/02/13	90

New Growers

Ocean Approved and Sarah Redmond (ME Sea Grant) traveled to New Hampshire in early 2013 to deliver kelp seed to Michael Chambers at UNH. This kelp was planted alongside rainbow trout for an integrated multi-trophic aquaculture project.

Ocean Approved and Sarah Redmond (ME Sea Grant) assisted Herring Gut Learning Center in building a small kelp nursery in their oyster hatchery facility in Port Clyde. They also provided seed for Herring Gut to plant and grow out in their lobster pond.

This allowed an entire new curriculum about marine algae to be offered at Herring Gut (Fig. 20).

Figure 20. Students at Herring Gut learning center hold up the kelp line. Image from http://www.herringgut.org/newsarchive.html?id=85

Outreach

Due to the popularity and success of the first "Seaweed Scene" meeting, we held another "Seaweed Scene 2013". This meeting had over 100 participants, and was expanded into a full all-day facilitated meeting at the Hutchinson Center in Belfast. The meeting included an overview of the growing season and current projects as well as breakout sessions to discuss needs, opportunities, and challenges for the seaweed industry. A "Kelp Aquaculture" workshop followed the meeting in the evening. This workshop showed participants how to grow kelp, from nursery to harvest. Information about this meeting can be viewed at http://www.seagrant.umaine.edu/seaweed/seaweed-scene-2013, and the agenda is given in Appendix IV.

Year 3: 2013-2014

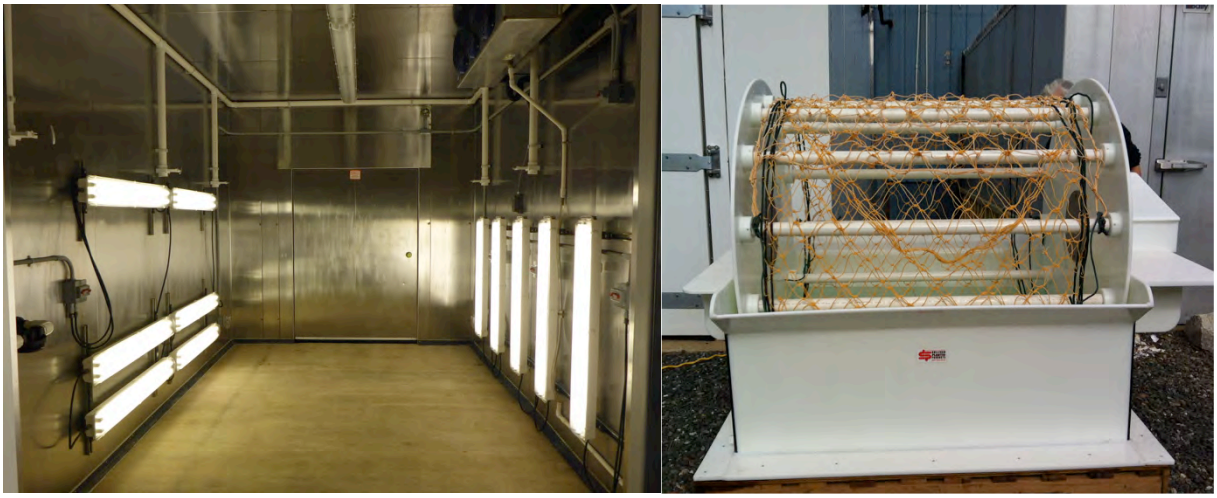


Figure 21. New nursery room (left) and laver seeding wheel (right) added to CCAR.

In year 3, the small CCAR kelp nursery was expanded with investments from Maine Technology Institute and Maine Coast Sea Vegetables, to include two large walk-in incubation chambers, new lighting and aeration infrastructure, and a Porphyra net seeding wheel (Fig. 21). An additional MAIC award supplied a new refrigerator, a Percival environmental chamber, and a supply of Kuralon kelp seed string for the nursery.

The Walpole farm continued to trial new species and lines, with Alaria, dulse, and sugar kelp all planted out in the fall. The Casco Bay farm was planted with Sugar Kelp again in December, and harvested in May and June. Small, fresh plants were sold in early spring, and the remainder of the crop was dried and sold to local restaurants. Late planting dates and spring/early summer fouling continued to be a problem.

Three major milestones occurred in 2013-2014; sugar kelp was planted out at the earliest date yet, in late August and early September, and *Alaria esculenta* was cultivated for the first time. A new farm in Sorrento was created in this year, where Alaria and sugar kelp was grown for the first time. 2014 was also the first year for the Maine Seaweed Festival, which grew out of the "Seaweed Scene" meetings held in the two years previous.

Table 4. 2013-2014 Farm season summary.

2013-2014 Farm Season				
Farm Location	**Seeding Date**	**Species**	**Harvest Date**	**Notes**
Casco Bay (Ocean Approved)	8/22/13;9/9/13	Sugar Kelp, Alaria	4/13 (Alaria)	
Casco Bay (Bangs Island)	12/7/2013; 1/6/14	Sugar Kelp	6/14; 7/11	June and July, snail damage, fouling. Dried for sale locally
New Hampshire	12/24/13	Sugar Kelp	nd	nd
Walpole (Newell)	12/20/13	Sugar Kelp	nd	dried and sold locally
Walpole (Fischer)	9/6/13	Sugar Kelp	April-May	Oct: fouling, 10/30: blades 1.5 ft, Dec blades 3ft; April: Sorus tissue, blades 10ft
Walpole (Fischer)	9/6/13	Alaria	5/8/14	Feb: 3 feet; Apr: 6ft, May: Reproductive Sporophylls
Walpole (Fischer)	10/4/13	Sugar Kelp	May-June	Sugar kelp dried and sold for kelp beer
Walpole (Fischer)	12/4/2013; 12/30/13	Sugar Kelp	May-June	Some fresh sales to local restaurants
Walpole (Fischer)	9/21/13	Dulse (attached)	April	October: fouling on blades;Dec: Clear red blades, April: Reproductive mottling
Walpole (Fischer)	9/21/13	Dulse (seeded, 1cm)	nd	10/30: plants 3cm, hydroids on line
Port Clyde (Herring Gut)	1/6/14	Sugar Kelp, Dulse	May-June	Lobster pound. Sugar kelp harvest, no dulse
Sorrento	12/27/13	Sugar Kelp	June	1/15: plants 2'', 4/2: plants 2', June heavy fouling
Sorrento	12/27/13	Alaria	June	1/15: plants 2'', 4/2: plants 5', clean, harvestable. June: hydrozoan fouling
Sorrento	2/7/14	Dulse (attached)	June	Plants smothered by fouling
Scarborough (Perry)	11/15/13	Sugar kelp, dulse	June	nd

Outreach

The "Seaweed Scene" meetings, previously held in Belfast at the end of August, evolved into the first ever Maine Seaweed Festival, an all day educational festival that celebrated and highlighted all things Maine seaweed. The same type of presentation-style meeting was held in the morning to review experiences, challenges, and successes of the 2013-2014 sea vegetable growing season, then the afternoon opened up to a festival-style event with various presentations, demonstrations, art, music, and food vendors. The turnout was estimated to be around 1500 people, and the event was well received in the press. More information about the festival can be found here: http://www.seaweedfest.com. This is event is expected to become an annual festival, with a mission of "raising awareness and educating the public about the positive impact that Maine macroalgae is having in our local food culture, agriculture and aquaculture industries, and its growing role in the academic arts and sciences".

Objectives 2 and 3

These objectives were equally accomplished through several complimentary activities, and are reported on together.

Objective 2: To develop expertise and culture technologies for seaweeds in Maine.
Objective 3: To develop relationships between sea vegetable growers and buyers.

Activities

1. Create a catalog of video and photographic images, for use by future producers, and in outreach activities/products
2. Provide opportunities to share information and transfer technology, both among project participants and to other interested parties

Below, we list a series of activities relative to Objectives 2 and 3; they form a cohesive and broad attempt to create and improve networking/tech transfer opportunities, and to develop materials that will help existing and future producers to begin new enterprises, or to improve those already in business.

In December of 2011, we held an 'Orientation/Start-of-Project Meeting' at the Taste of Maine restaurant, in Wiscasset. We met with the various industry partners, and heard from Paul Dobbins and Tollef Olson of Ocean Approved, to learn about their experiences in growout and hatchery/nursery technology.

Images, Videos, Web resources

A series of videos were created to share the details of the project and to summarize each growing season. These videos were presented at the "Seaweed Scene" meetings (described below), and are currently available on you tube.

1) Integrating Kelp onto Shellfish Farms in Maine, 2011-2012 (51 views as of 2/11/15) https://www.youtube.com/watch?v=6uQpObhbRwg
2) "The Kelp Farm", 2012-2013 (4,917 views as of 2/11/15) https://www.youtube.com/watch?v=VgkBZq0CDqI

3) Seaweed Farms of Maine 2013-2014 (176 views as of 2/11/15)
https://www.youtube.com/watch?v=me3RjoGzy5E

A student from the Salt Institute for Documentary Studies in Portland, ME, also created a short video about seaweed in Maine, available here: http://vimeo.com/98634209.

Seaweed Production on Mussel Farms in Maine Press release, project info
http://www.seagrant.umaine.edu/extension/kelp-mussels

Redmond, S. Maine Seaweed Social Facebook Page.
https://www.facebook.com/MaineSeaweedSocial.

Redmond, S., D. Morse and J. Peters. Seaweed Scene 2012. Maine Sea Grant Website.
http://www.seagrant.umaine.edu/seaweed/seaweed-scene-2012.

Redmond, S., D. Morse and J. Peters. Seaweed Scene 2013. Maine Sea Grant Website.
http://www.seagrant.umaine.edu/seaweed/seaweed-scene-2013

Redmond, S., D. Morse and J. Peters. Seaweed Scene 2014. Maine Sea Grant Website.
http://www.seagrant.umaine.edu/seaweed/seaweed-scene-2014

Seaweed Scene 2012, 2013 and the Maine Seaweed Festival

Conference Papers and Presentations (Chronological Order):
2012

Redmond, S, D Morse, S Brawley, N Brown, P Dobbins, S Eddy, S Erhart, P Fischer, J Larrabee, T Levesque, M Moretti, C Newell, B Olsen, V Olsen, T Olson, E Young. 2012. "Development of Seaweed Culture Technologies in Maine" Poster presented at the 2012 Maine Sea Grant Research Symposium, April 7, Orono, ME.

Redmond, S, Morse D, Brawley S, Brown N, Dobbins P, Eddy S, Erhart S, Fishcr P, Larrabee J, Levesque T, Moretti M, Newell C, Olsen B, Olsen B, Olson T, Young E. 2012."Development of Sea Vegetable Technologies in Maine" Poster Presented at: 51rst Annual Northeast Algal Society Symposium: 2012 April 20-22; Schoodic Point, ME.

Anderson, P., D. Morse, S. Redmond, T. Olson, & M. Moretti. "Seaweed Aquaculture" Talk of the towns radio show, WERU 89.9, 6/8/12. Online at http://archives.weru.org/talk-of-the-towns/talk-of-the-towns-6812

Redmond, S. & D Morse. 2012. A Pilot Project to Stimulate Seaweed Aquaculture on Mussel Farms in Maine. Presentation at the Maine Seaweed Scene 2012, Aug 8, Belfast, ME.

Redmond, S, D. Morse, C Yarish, J Kim, P Dobbins, T Olson, S Brawley. 2012. The Cooperative Culture of Seaweed in New England—How Research, Industry and Extension are Cultivating a New Field in Aquaculture. Presentation at the 40th United States-Japan Natural Resources Panel on Aquaculture Scientific Symposium, "Hatchery Technology for High Quality Juvenile Production". October 22-23, University of Hawaii, Honolulu, HI.

Redmond, S, D Morse, S Brawley, N Brown, P Dobbins, S Eddy, S Erhart, P Fischer, J Larrabee, T Levesque, M Moretti, C Newell, B Olsen, V Olsen, T Olson, E Young. 2012. Development of Sea Vegetable Culture Technologies in Maine. Presentation at the Northeast Aquaculture Conference and Exposition, December 13. Groton, CT.

2013

Redmond, S., et al. 2013. A Pilot Project To Stimulate Seaweed Production On Mussel Farms In Maine. World Aquaculture Society Meeting. 22 February 2013, Nashville, TN. (50)

Redmond, S., D. Morse, C. Yarish, J. Kim, P. Dobbins and T. Olson. The Cooperative Culture of Seaweed in New England—How Research, Industry, and Extension are Cultivating a New Field in Aquaculture. World Aquaculture Society Meeting. 24 February 2013, Nashville, TN. (20)

Redmond, S. Opportunities for Fisherman: Seaweed Aquaculture. Maine Fisherman's Forum. 2 March 2013, Rockland, ME. (20)

Redmond, S. et al. Integrating Seaweed aquaculture into Shellfish farms – the role of extension in bringing together research and industry to develop a new field of aquaculture in the US" (Invited speaker). Gangwon Sea Grant International Symposium: Development of Integrated Multi-Trophic Aquaculture. 26 March 2013, Gangneung-Wonju National University, Gangneung, Korea. (60)

Redmond, S. et al. Integrating Seaweed aquaculture into Shellfish farms – the role of extension in bringing together research and industry to develop a new field of aquaculture in the US" (Invited speaker). NFRDI 1rst International IMTA Symposium. 28 March 2013, Busan, Korea. (75)

Redmond, S. et al. Opportunities and Challenges for the Developing Seaweed Culture Industry in New England. Northeast Algal Society Meeting. 20 April 2013, Mystic, CT. (Poster) (20)

Redmond, S. Seeing Seaweed—how seaweed aquaculture is changing the way we look at both. University of New Hampshire Marine Docent Meeting. 4 June 2013, Durham, NH. (60)

Redmond, S. Seaweed Aquaculture in Maine. White Head Community Center, White Head Island, Grand Manan, NB. Aug 7 2013 (17)

Redmond, S. and S. Barker. Seaweed on Shellfish Farms: Another Step Forward. The Seaweed Scene 2013. 29 August 2013, Belfast, ME. (120)

Redmond, S. Advances in Seaweed Aquaculture. Maine Sea Grant Policy Advisory Council Meeting. 1 October 2013, Belfast, ME. (13)

Redmond, S. Techniques in Sea Vegetable Aquaculture. University of New England, 31 October 2013, Biddeford, ME. (10)

Other Products (including popular articles):

2012

Morse, D & Schmitt, C. "A Pilot Project to Stimulate Seaweed Production on Mussel Farms in Maine" (2012) ARI News, Aquaculture Research Institute, University of Maine. Vol 1, Issue 2.

Haskell, Meg. Sea Fare: Marine biologists help ocean vegetables go gourmet. UMaine Today Magazine, Summer 2012. Online at http://umainetoday.umaine.edu/past-issues/summer-2012/sea-fare/.

Hendrix, Muriel, "Pilot IMTA project in Maine pairs mussels and kelp" (Jul/Aug 2012). *Aquaculture North America.* Article. Vol 3 Issue 4.

Redmond, S. "Roadmap to a Seaweed Farm". Factsheet, available at the Seaweed Scene, August 2012, Belfast, ME.

Hendrix, Muriel. "Seaweed: The versatile vegetable" Aquaculture North America (Nov/Dec 2012) Vol 3 Iss 6.

Morse, D & Schmitt, C. "Mussel farms in Maine participating in unique pilot project to stimulate seaweed production" (2012) Fish Farming News Vol 19 Iss 2.

2014

Alana Fichman. Ocean Harvest. Video from 2014 Salt Institute. Feb. 4 2014. Online at http://vimeo.com/98634209.

Field, Jay. Craft Beer Reaches New Depths as Mainers Brew a Batch from Seaweed. Maine Public Broadcasting Network and National Public Radio. 7 July 2014. Online at http://www.npr.org/blogs/thesalt/2014/07/16/331423345/craft-beer-reaches-new-depths-as-mainers-brew-a-batch-from-seaweed.

Spiegel, Alison. Is Seaweed Beer the Next Big Thing? Article, Huffington Post. 24 July 2014. Online at http://www.huffingtonpost.com/2014/07/24/seaweed-beer_n_5614794.html.

Associated Projects Emerging from the Current Project
1. "Pilot production of native *Porphyra* for land and sea-based IMTA", $17,500, Maine Aquaculture Innovation Center, 1/1/2012-12/31/2012.

2. “A Pilot project to Stimulate Seaweed Production on Mussel Farms in Maine”, $19,999, Maine Aquaculture Innovation Center (MAIC) 1/01/12-/12/13.

3. “From Capture to Culture: Adding Value to the Sea Urchin Fishery in Maine”, $216,625, NOAA Sea Grant Aquaculture Research Program 2012 (associate), 9/1/12-9/01/14, 2 mo.

4. “Aquaculture in Shared Waters”, $281,000, NOAA Sea Grant Aquaculture Research Program 2012, 9/1/12-09/01/14.

5. “Seeding Technologies for Sea Vegetables”, $19842, Maine Technology Institute Seed Grant, 7/1/13-12/1/13

6. “Supporting Sea Vegetable Aquaculture in Maine”, $149884, University of Maine Sea Grant Program, 2/1/14-1/31/2016.

7. “The development of sustainable, multi-seasonal, multi-species, marine algal aquaculture in coastal Maine”, NOAA SBIR Phase I, 6/15/14-12/15/14.

8. “Supplying Reliable Seed for Maine’s Developing Sea Vegetable Aquaculture Industry”, Maine Aquaculture Innovation Center, $24341, 9/1/14-8/31/14.

9. “Development of a Cultivation Program for a Morphologically Distinct Strain of the Sugar Kelp, *Saccharina latissima forma angustissima* from Southern Maine”, Maine Aquaculture Innovation Center, $25000, 9/1/14-8/31/14.

The experience gained thus far from this project has been invaluable, both for the extension agents and the farmers involved. The multiple partner collaborative model has enabled us to make great strides in realizing a profitable farm model for sea vegetables, and we continue to grow and improve together, with new species, new farms, new products, and new growers coming along every year.

An example of this is the new kelp beer, called “Sea Belt”, created by Marshall Wharf Brewing Co. in Belfast Maine, using aquacultured kelp from the Walpole farm. More info can be found about this relationship here: http://www.msnbc.com/msnbc/watch/will-your-next-beer-be-made-out-of-this-330803267511. Several new growers have also developed relationships with local restaurants in their area to find new markets, and one grower dries and sells cultured kelp at local farmer’s markets. The “Seaweed Scene” meetings and the Maine Seaweed Festival have also allowed for terrific networking opportunities within the State and Northeast region, as people come together to catch up, share ideas, and meet new people.

Future Needs/Problems Identified:

Seeding:

While there is new infrastructure at CCAR to support seeding research and development, the system has been suffering from debilitating ciliate contamination issues. This problem will need

to be solved in order for the nursery to continue to provide free seeded lines for experimental grow-out to farmers.

Timing:
Optimizing planting and harvesting timing will be very important to improve crop yield and quality. Biofouling of lines and plants has been a major issue on many of the farms.

Harvest and Processing:
Farmers need a harvest and processing plan to be able to utilize or sell crop. Much of the crop grown, especially in the first year, was not sold or utilized because of a lack of harvesting, processing, and marketing infrastructure. This infrastructure still needs to be built, though we are working to include researchers to investigate the best type of processing infrastructure to optimize efficiency and quality.

Analysis:
It is essential that the new sea vegetable crops have nutritional, heavy metal, bacteriological, and chemical analysis data to support the new industry. These tests are extraordinarily expensive, and will require a whole industry effort to obtain more useable information all along the coast of Maine.

Appendices

Appendix I.

Table. CHN Analysis data from 6/2012. BA: Bang's Island (Casco Bay); WA: Walpole (Damariscotta); LA: Lamoine.

Samples from ME

June, 2012 %Ash-Free Dry Weight

		C	N	C:N
1	BA L1	28.88	0.95	30.40
2	BA L2	32.66	0.97	33.67
3	BA L3	31.59	1.22	25.89
4	BA E1	31.93	1.14	28.01
5	BA E2	30.55	0.93	32.85
Avg		31.122	1.042	30.164
6	WA D1	33.23	1.21	27.46
7	WA D2	30.34	1.04	29.17
8	WA D3	32.93	1.20	27.44
Avg		32.16666667	1.15	28.02333333
9	WA S1	30.41	1.07	28.42
10	WA S2	30.68	1.06	28.94
11	WA S3	29.76	1.39	21.41
Avg		30.28333333	1.173333333	26.25666667
12	LA D1	28.05	2.06	13.62
13	LA D2	28.37	1.18	24.04
14	LA D3	31.25	1.17	26.71
Avg		29.22333333	1.47	21.45666667
15	LA S1	26.38	1.34	19.69
16	LA S2	28.46	1.28	22.23
Avg		27.42	1.31	20.96

Appendix II
Agenda from Seaweed Scene 2012

The Seaweed Scene 2012
A Workshop on Seaweed Aquaculture and Associated Applications
University of Maine, Hutchinson Center, Belfast, ME
30 August, 2012

With principal funding from:

Maine Aquaculture Innovation Center

In collaboration with:

Sea Grant Maine

The University of Maine Cooperative Extension

The University of Maine Aquaculture Research Institute

Goal:
To present current products, processes and research, and to discuss the potentials and obstacles for further development of the seaweed aquaculture industry in Maine and elsewhere

2:00 - 2:30
Welcome, purpose, outline of the meeting, and the 'Seaweed Speed Date'
Dana Morse and Sarah Redmond, Maine Sea Grant and University of Maine Cooperative Extension

2:30 - 3:00
Opportunities for Seaweed Mariculture in Northeast America
Dr. Charles Yarish, University of Connecticut

3:00 - 3:20
Kelp Aquaculture in Maine
Paul Dobbins and Tollef Olson, Ocean Approved LLC., Portland, Maine

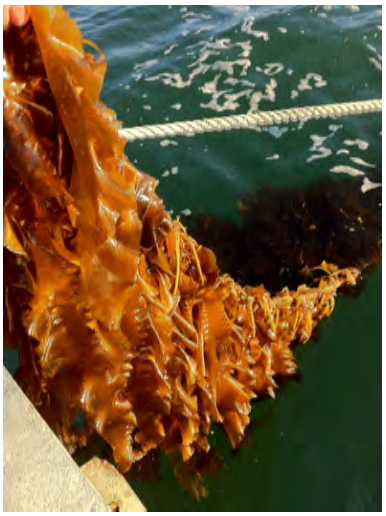
3:20 - 3:40
A Pilot Project to Stimulate Seaweed Aquaculture on Mussel Farms in Maine
Sarah Redmond and Dana Morse

3:40 - 4:00
Beyond Sushi: A Review of Current and Potential Products from Marine Macroalgae
Sarah Redmond

4:00 - 4:20
An overview of applied research on kelp aquaculture in Québec, Canada
Dr. Eric Tamigneaux, Cégep de la Gaspésie et des Îles, Quebec
Dr. Aurélie Licois, MERINOV, Quebec
Dr. Grégory Hersant - Oleotek, Thetford Mines, Province of Quebec

4:20 - 4:50
Break: Refreshments, Networking

4:50 - 6:00
Facilitated Group Discussion



This workshop is part of a project funded by the Maine Aquaculture Innovation Center. Project progress, workshop notes, outcomes, results and other project-related materials can be found on the project page at: *http://www.seagrant.umaine.edu/extension/kelp-mussels*

Appendix III
Notes from Seaweed Scene 2012

Seaweed workshop notes (C. Schmitt) 30 August 2012

Dr. Charles Yarish, UCONN

Dr. Yarish reviewed some of the global-scale details on seaweeds; about a $6 billion USD industry, for food, pharmaceuticals, animal feeds, fuels, etc. Largest producers are in Asia and Chile, with largest consumption in Asia as well. There is a variety of red, green and brown algae being cultured, and he covered the complex life cycle of marine macroalgae as well. Each species of seaweed has its own complex life cycle, but they all involve a microstage that can be manipulated in a laboratory to produce young fronds, "seeded" onto a line or net for outplanting into the sea.

He usually refers to them as sea vegetables, which many others in the industry do as well, to give consumers and the public a better sense than using 'seaweed.' For prospective growers, there are several challenges to growing sea vegetables—have to culture in a laboratory, get wild plants to reproduce and grow. Then have to get them out of the lab and into the field, which means growers will need an aquaculture lease, and that growers will need to know something about the site conditions (eg, if you are growing a seaweed that requires high nutrient levels), then have to harvest and process it. Processing can be quite a job; in some cases as simple as air drying, but otherwise can be complex - some of the same machines involved in making paper can be used to make nori sheets.

One area of great interest is remediation; marine plants can remove nitrogen, phosphorus and other pollutants quite effectively. For example, in siting a Gracillaria farm in New York City coastal waters, just off the Fulton fish market, where the East and Bronx rivers meet. There are ideal conditions—low light, high nutrients. The algae coming out of that system could not be used for food, but could be used as fuel, and we can use these techniques to take nutrients out of the water in urban areas where nitrogen is a problem. For example, a little rough math shows that 69,400 tons of seaweed at 5% nitrogen would equal about 32 million dollars in remediation value (roughly $460 per ton), since companies have to pay for their discharges.… ecosystem services is an application that represents a new opportunity.

Careful to note that he only advocates native species and using seed stock from local waters.

Question about how to respond to concerns about proliferation of seaweed in area that you are culturing.
-C. Yarish: emphasized the importance of using local seed stock for culture in an area to avoid any concerns about non native transplants in an area.
-S. Redmond: When culturing kelp, you will harvest the plants before they become reproductive, so your plants will not "seed" the area you are culturing. There are plenty of wild kelp beds in the Gulf of Maine that will be constantly sending out spores in an area naturally.

Tollef Olson
Tollef reviewed the process for producing his products; from generating the juvenile plants in the hatchery, to seeding the farm, to harvesting and product development. Field growout is a winter activity for sugar kelp, usually November through May, and plants can grow upward of an inch per day, during the mid and late winter months. 6-8 pounds of seaweed per line of growout is not unusual.

His company recognizes that one problem is competition from overseas — they have to separate themselves in the market by creating new products, especially ones that place kelp in the category of "mild green vegetable." Fortunately, many of the other products are processed and preserved, such as seaweed salad that originates from Asia, whereas his products are fresh or frozen, and minimally processed.

We also will never be able to produce on the same scale as in Asia—for example, in China, farms are so close together they actually have to add nutrients to the water to keep the plants growing. Maine farms will need to be strategically spread out in targeted areas.

Ocean Approved works hard in the education and product development area; often they go together. Working with Johnson and Wales culinary students helps them get the word out about their products, and helps them think about new items that chefs and consumers might want. Being able to harvest the whole plant - stipe and all - allows them some freedom in the product development area that wild harvesters might not have.

Question for DMR - adding seaweed to an existing shellfish lease will likely require an amendment to lease

Sarah Redmond, Dana Morse
Sarah reviewed a recent project funded by the Maine Aquaculture Innovation Center; sugar kelp was grown on 7 shellfish farms around the state. Most of the sites were mussel farms, but one oyster farm was included too. The project had to start late, with seeding in December and January, and that pushed the whole schedule back, but growth on several sites was good, with good plant densities. Plants ultimately were too small for good use in the market for dried kelp, but this was an effect of having to start the project late. Some product was dried and sold at a farmers market; roughly 50 bags of 2 ounces each were sold for $8 apiece; the remainder was used as fertilizer and food for urchin aquaculture experiments. The team will try again in 2012-2013 with a more appropriate schedule of seeding and harvesting, and part of that work will be to help growers and buyers figure out the best scheme for bringing the raw product to market. The economics of course will be critical to understand better so that growers can evaluate the profitability of this kind of work. Sarah notes that the key is to use the Maine brand—it is our source of power, and what distinguishes us from others. The other major change for the upcoming work is to avoid growing the kelp under mussel rafts; it's too shaded and with flows that are too slow. The next experiment will continue to grow kelp in between mussel rafts, or on longlines as used by Ocean Approved and Dr. Yarish's lab. Sarah put together a video on the project that will eventually be posted to the web.

Sarah Redmond - Products and Processes

Sarah's presentation covered a huge range of products that either are currently made with seaweed ingredients, to some products that don't exist yet but which might have a place in the market.

Most of the seaweed cultured globally comes from China, Korea, and Japan. Maine has a few wild harvest based seaweed companies, and the first kelp farms in the United States. The new types of kelp products possible with cultured kelp include fresh, salted, ready-to-eat, dried, frozen, and snack and convenience foods. In order to move the cultured kelp into existing markets, plants need to be comparable in size, thickness, and quality with the currently utilized wild harvested plants. There is an opportunity for the development of new types of products, however, and Maine has food science and new product development resources at the University of Maine and through USDA and FSA grants.

Other possible products include seasonings, healthy food supplementation, snacks, pet and livestock feed supplementation or treats, live and feed markets for aquaria, fertilizers, skin and beauty products, thalassotherapy (spas and seaweed baths), and health supplements.

Questions about organic certification
Questions about regulations for naming/labeling (eg, Ascophyllum labelled as kelp).
--Check your labels. Both rockweed and kelp are called "kelp". Rockweed is either Ascophyllum or Fucus species, and Kelp can be Saccharina latissima (sugar kelp or kombu), Laminaria digitata (horsetail kelp or kombu), or Alaria esculenta (winged kelp or Atlantic wakame).
Questions for Quebecois—mostly about lab and culture processes, molecular/chemical work, mannitol content, etc.

<u>Wrap-up discussion</u>
The end discussion was fairly brief, we'd gone over in some of the presentations and had started a bit late, so it was about 20 minutes of discussion at the end of the day.

One clear area of interest was the need to educate consumers and the interested public on the nutritional value of various marine plants; this would increase the demand, but currently, people outside of the health food industry don't know. There is a great story to tell here.

Related to this, we need to educate students, and should start in the schools re: food products. Seaweed can be within either the seafood or the healthy vegetable realm—need to promote overall the healthy local foods available from the sea. Many of the schools are already trying to incorporate local foods, though one person noted that in the recent 4H science fair in Bangor, there was no marine science represented - 4H might provide an excellent avenue for reaching students. UMCE, ME SG, and ARI have just started working on aq videos, and are expected to do more - these are targeted to 4H, and seaweed would fit in nicely.

Sea vegetables need a festival—or to incorporate seaweed into other summer seafood festivals; lots of good opportunities here.

The Food Science group at UM could be a good partner, both to conduct research of interest to industry and to involve students in projects; overall, we need more students involved in this whole scene. ARI pointed out the recent aquaponics workshop for teachers in inland schools.

We can refer people to the information already on line at several industry sites; not just about their products, but about the plants, ecology, and health benefits.

Regarding networking people at the meeting together, and beginning to increase that to others in the region, there was interest in web-based material and in an on-line list serve. ME SG staff will be working on the list serve, web material and potentially a Facebook pages, although not everyone will use each of these mechanisms. The outcomes from this meeting will be posted on the ME SG website for future reference.

Overall, there was strong interest to make connections, get people working together, and to create lists of available resources (UM food science group for example, and etc.) At some point, it may make sense to have breakouts/working groups that cover the spectrum of who is here today—production, commercial fishermen, marketing and products, pharmaceuticals, etc., that way, people who have some specialization in one area can have a more focused discussion. In addition, a Seaweed Working Group came up as a possible approach, modeled after the Shellfish Working Group.

There was some great discussion about cooperatives for large machinery that might be needed for preserving, processing, etc. The capital investment is too much for one person; and all the aquaculture companies in Maine are small, but they all need the same types of equipment and machinery. The shared use center in Belfast came us as one potential resource for bringing product to market and working on new products, also Crown of Maine/Northern Girls processing (putting seaweed in empty trucks going up to pick up food, for example). Currently, some seafood folks already collaborate with dealers to get products where they need to go, so there’s a working template.

Appendix IV
Agenda From Seaweed Scene 2013

Seaweed Scene 2013
August 29th, University of Maine's Hutchinson Center
Moderator: Ron Beard, University of Maine Cooperative Extension

9:00 - 9:30 Arrivals, coffee & refreshments
9:30-10:00 Welcome & Introductions: The Seaweed Speed Date
Introduce yourself and tell us something we should know, or what you'd like to know from the group…in 15 seconds or less!
10:00-12:00 Research Update Presentations
10:00-10:15 Seaweed on Shellfish Farms: Another step forward
Sarah Redmond & Seth Barker
10:15-10:30 News from the front: The year in review from Ocean Approved
Paul Dobbins/Tollef Olson
10:30-10:45 Urchins and Seaweed – 2 potential new industries for Maine
Steve Eddy
10:45-11:00 Refreshment Break
11:00-11:15 Seaweed farming in Long Island Sound—An update from CT
Dr. Charles Yarish
11:15-11:30 New Paths Forward: Maine Algae & The ME Seaweed Institute
Willie Wilson & Liz Solet
11:30-11:45 EPSCOR / Aquaculture Research Institute & New Species R&D
Annie Langston & Carter Newell
11:45-12:00 Maine Harvest Company and CYON Solutions
Tod Yankee and Lisa Cooper
12:00 - 1:30 Lunch & Vendors / Food and Networking
Time to meet new people, chat with vendors and exhibitors, or just talk shop.
1:30 - 2:45 Seaweed Café Break-outs
Facilitated smaller groups to allow more people to discuss their interests, needs and ideas for moving the industry forward.
2:45 - 3:00 Refreshment break and re-convene
3:00 - 3:30 Reports from the break-out groups
3:30 - 4:00 Future Directions & Meeting Wrap-Up
Will include a short discussion with Hilary Krapf, regarding the development of a 'Seaweed Festival'

And don't forget:
4:30-7:30 Kelp Farming Techniques with Ocean Approved and UConn
(see below for description, dinner provided)

Sea Grant Maine
1865 THE UNIVERSITY OF MAINE Cooperative Extension
Maine Aquaculture Innovation Center

An Introduction to the Equipment, Processes, and Techniques of Kelp Farming

Interested in learning more about kelp farming?

Ocean Approved and the University of Connecticut will conduct a free workshop immediately following the Seaweed Scene 2013 meeting.

Ocean Approved, a Portland based company, has been farming native kelp on the Maine Coast for 3 years utilizing techniques developed in conjunction with the University of Connecticut. This workshop will be a hands-on opportunity to learn techniques for growing kelp from spore to harvest. Equipment, techniques, and lessons learned will be covered from leaders in this new and emerging industry.

This course is free to any interested participants, but it is requested that you sign up. Please contact Sarah Redmond (email sarah.redmond@maine.edu, (phone (207)841-3221) if you would like to attend.

Appendix V
Notes from Break out Sessions at "Seaweed Scene 2013"

Compiled Flipchart Notes from the Seaweed Scene 2013

Summary:
During the Seaweed Scene 2013, a 90-minute session was devoted to the process of dividing up into groups of 10 or 15 people, and discussing the issues they felt to be important. The general charge to the groups was to consider the question "What is needed to help the seaweed industry move forward?" and more specifically, to think of their answers in terms of Production, Policy or Processing. The notes below were taken from the points listed on flip charts during those sessions. Many of the points were raised repeatedly throughout the groups. Some came to the front of the discussions particularly strongly, including:

- Improving the capacity for drying seaweed (many mechanisms suggested)
- Improved education
- Improving product diversity
- Improved networking capacity; this concerned a variety of interests such as educators, scientists, industry, etc.

While there was no specific attempt to prioritize the items that were discussed, we hope that the bullets themselves will serve as reminders, will help to generate concrete action, and will demonstrate the breadth of activities suggested as important by the attendees at the meeting.

Market

- Will cultured product supplant wild harvests? Wild harvests are presently sustainable.
- Austin TX company selling 'Fucus' products from Maine
- W. Coast products are being viewed as somewhat risky, Maine products can fill a void
- Market analysis in the US and elsewhere would be very helpful in meeting market needs and product development
- To further develop the Maine brand, should have a good history of the Maine industry, and should have some standards for quality. Maine brand recognition should be built upon - great start and great opportunity to differentiate from competitors.
- Meal-ready microwaveable products desirable?
- Should separate wild harvest and culture production
- Can farmers collaborate to coordinate harvests to meet the market demand on a broader scale?
- We are presently missing the middle piece of distribution, to connect growers to marketers…will pay off in new product development an din other ways
- Need to diversify market away from just food products
- Local farmers' market presence and different dishes, to increase demand
- Need to create demand
- Need to develop products so that we fully utilize biomass
- Holistic pet industry an opportunity
- Kelp beer
- Grain for livestock
- Sheep in Ireland - fed on seaweed…a market differentiation there
- Product diversification needed in general

Processing

- Very strong need to develop drying capacity - mentioned in several instances
- Define Best Practices for handling fresh product, and need to improve shelf life of fresh product: perhaps better packaging or handling? Modified atmosphere?
- Are there public/private finances for product development, or public/private partnerships? (several mentions of how to support product development
- Opportunity to piggyback with existing ag facilities and businesses for processing and drying (many mentions): capture waste heat, fully utilize facilities, etc.
- Movements in bulk can be expensive for wet product; a motivator to develop process capacity close to the sites of production?
- Product development is best suited to pilot plant-scale…would be helpful to have incubator-type facilities available for this work. Links to the University? Example was Rutgers: leasing spaces and facilities, with an R+D person on staff - access to skills, libraries, etc. Multiple mentions in this vein.
- Large-scale processing and drying is needed
- Any opportunities to team up with the blueberry industry on processing and packaging?

- Cooperative methods to develop drying capacity

Education

- Licensing should demand a certain level of knowledge base from licensees….a required course prior to licensing?
- Seaweed info should be readily available to anyone, a central repository would be good to create and maintain (several references)
- Should establish industry-wide principles (best practices) to ensure environmental sustainability.
- Take educational models into high schools
- Where do centers of education innovation exist? What are the functional networks for education about seaweeds?
- Demonstration farm: people need to see it
- Seaweed Institute: lots of uses and applications, including how to access existing development programs?
- Should institute an apprenticeship program
- There was a University-based seaweed appreciation day 10 years ago, but didn't gain traction…need an event like this - maybe the Seaweed Festival?
- General need to do a lot of consumer education: nutritional benefits, ecological services, preparation, etc (several mentions)
- Seaweed Festival a great way to educate
- Farmers' Markets play an important education role: once the grass roots get into it, the larger corporations take notice
- Should get 'big food' into the education pathway
- K-12 education also a great opportunity but need to develop curriculum materials
- Education themes that help to sell product: health, taste, young (it's not yucky!), food safety, traceability, holistic health
- Networking educators together will help with consistent messages, coordinate activities
- Cooking demonstrations really help build familiarity and ability to use seaweeds

Production and Technology

- Should create a priority for the top species to focus on in the future (for example, the top 6 species?)
- What is the right scale for a farm?
- Industry should have an overall vision that can be communicated to buyers, public and others (perhaps through the Cluster Grant proposal?) Would help us to develop a strategic plan, and exploit 'big picture' issues. Other uses: what are we growing? where is it going? can we demonstrate our ecological services?
- More study of what constitutes the best production sites: need year-round data, and map existing uses of potential areas.
- Need a summer species, for full-farm utilization and product diversification (revenue streams)
- New husbandry/siting to avoid or minimize fouling
- How to maximize efficiency and productivity of culture gear
- Need an engineer with a seaweed-production focus: eg drying technology, waste heat, freezing, etc.

Regulatory/Management

- Should we be managing on a species-by-species basis?
- Should separate rules apply for farmed vs. harvested? Decisions here need solid science to support.
- Lots of opportunity to learn from other management plans: New Brunswick, Nova Scotia on oversight, Maritimes, Norway, Iceland on sustainability - Scotland and Ireland as well.
- Regulatory envt is uncertain, re: federal food security - should be clarified
- State regulatory framework is fair, but the process often takes a long time because of social issues…how to mitigate that?
- Pre-permitting areas for production?...sort of like industrial parks..
- A policy cluster to keep ME innovations in ME?
- Seaweed can be grown on fallowed sites
- Existence of a thorough lease process takes is a strength, even though leases take a while to get.
- Better spatial/environmental data would improve lease siting, and farm planning: accessible on-line maps would prospective farmers.
- Management of wild harvest should be at most local level possible
- Perhaps have local rockweed wardens, similar to clam wardens?
- Need better clarity from mgmt. on harvest from shellfish-closed areas, handling of fresh product, etc.

Social

- Would be beneficial to integrate farming with fishing industry and agriculture; lots to share there in terms of expertise, labor and infrastructure
- Networking function important to help the seaweed industry develop (several mentions)
- Need to work to reduce conflict with existing uses, both for new applications and existing farms. (multiple hits)
- Working with fishermen: need to demonstrate financial viability, using existing resources

Public Health

- No demonstrated transfer of Vibrio bacteria to seaweed.
- No knowledge if shellfish closed areas are suitable for seaweed farming

Business/Finance/Economics:

- Assistance to entrepreneurs, for access to capital and business training, technical assistance
- R+D requires public funds, such as MTI
- Private capital will enter when a profitable product is identified
- Generally, more needs for funding: Sea Grant, MTI, etc…
- Feasibility studies would be helpful, for existing and new growers - both to enter the industry and to grow, once started…linked to a Vision - and a Road Map for development.
- Economic modeling: transportation costs, value of cooperative structure
- Need to identify the existing and potential value chains in the state

- Tap into Slow Money, and DECD: for relationship-building, funding and support, visibility, legitimacy

Environmental - particularly Seaweeds as Mitigators

- It's also a public relations tool: how should we best tell this story?
- Has a genesis in IMTA.
- Need some science to determine best N profile for farm siting
- Should be permitted regionally, and not regulated at Federal level
- When citing mitigation projects, keep discussions of food out of it, it creates calls for more regulation. Shellfish growing area classifications can be used to guide farm siting.
- Mitigation and fuels production can go together
- Growers in areas used to mitigate will want to know what's in the end product.
- Should optimize use of all products in mitigation projects.
- Need lots more science about carrying capacity and macroalgal production
- Invasive species a threat
- Aerial deposition of N should be more studied and acknowledged

Tourism:

- Tourism in ME can learn from Nova Scotia company, sells tours w food, on beaches
- Maine sea kayaking companies urged to use AQ sites in their brochures and marketing docs
- Should host webinars to connect with tourism companies and agencies
- S. Korea has demonstration areas, where aquaculture promotes tourism.
- Link tourism with local food and lodging
- Integrate seaweeds with spa treatments, now dominated by French (Normandy and Brittany)
- Boothbay Botanical Gardens could be a good partner to promote sea-plant tourism

Arsenic:

- Public perception of Arsenic issue should be studied and addressed with the current science
- 3rd party verification might be useful to demonstrate product quality
- Education can play a big role here, as can good recordkeeping by producers
- What are the actual impacts of arsenic? On the flip side, what are the benefits of eating seaweed, such as importance of bioactive isotopes vs. non-bioactives?

Research:

- Genetic differences: use locally-sourced stocks for culture? Differences detectable in farmed vs. wild?
- Chemical constituents need to be defined, perhaps based on nutritional value, or time/location of harvest….relevant patterns to understand there?? Opens the door for 'bio-prospecting.' (several references)
- Central location/organization for testing and accepted methodologies…what are they?
- Need to understand uptake kinetics of heavy metals, pharmacological compounds, and other molecules: Where, when and how do you test? Where is the 'fork in the road' that determines appropriateness for human consumption vs. other uses?

- Do we need to develop new species or techniques to continue to supply the market in the face of a changing climate?