MAINE DEPARTMENT OF MARINE RESOURCES

COASTAL FISHERY RESEARCH PRIORITIES

ROCKWEED (*Ascophyllum nodosum*)

I. Background

In 2009, about 38 harvesters reported harvesting 11,090,274 lb (5,545 st) of rockweed (*Ascophyllum nodosum*) with and estimated value of $221,800. Rockweed comprised 98 % of total seaweed (11,350,227 lb) landed. The combined value of Maine seaweed landings was $339,276 in 2009. A total of 106 licenses were issued for seaweed harvesting in 2009.

Rockweed is harvested by hand raking and with mechanical cutters. Harvest regulations include leaving the lowest lateral branches undisturbed and attached to the main stalk of the rockweed that is attached to the substratum; and leaving a minimum 16 inches of the rockweed above the holdfast (http://www.maine.gov/sos/cec/rules/13/188/188c029.doc). Seaweed harvesters must be licensed and are required to report harvesting activity monthly (http://www.maine.gov/sos/cec/rules/13/188/188c008.doc).

Interest in rockweed harvesting has increased in recent years, particularly in eastern Maine. Concerns about rockweed harvesting in Cobscook Bay resulted in legislation passed in 2009 that established the Cobscook Bay Rockweed Management Area, including designation of areas closed to harvesting, harvest management sectors, annual harvest plans, and a biomass harvest limit (http://www.mainelegislature.org/legis/statutes/12/title12sec6803-C.html).

As a result of the increased interest in rockweed harvest, the Joint Standing Committee on Marine Resources directed the Department of Marine Resources (DMR) to develop research priorities for rockweed.

II. Rockweed Research Priority Meeting

The DMR, the Maine Seaweed Council (MSC), and University of Maine Sea Grant Program teamed up to organize a seaweed research symposium, February 10, 2010, at the University of Maine in Orono. The purpose of the symposium was to:

- Summarize what we know about the rockweed resource, its ecology and habitat, the effects of harvesting on the marine environment and other species, and the economic and social benefits and costs of this industry; and

- Identify and prioritize research needs that will expand our knowledge and help to ensure a sustainable resource.

While much is known about rockweed, there are gaps in knowledge about this species, its ecological function, and the effects of harvesting. Furthermore, remarkably little has been documented about the social and economic characteristics of this coastal fishery. By identifying

key research questions, the MSC and DMR hope to encourage the research community to seek funding to address some of these questions.

The format of the meeting followed a research agenda setting effort conducted in 2000 for five of Maine's major commercial species (soft-shell clams, lobsters, scallops, sea urchins, and shrimp) (http://www.maine.gov/dmr/research/table_of_contents.htm). Four topics were chosen for rockweed: biomass assessment, ecology and habitat, effects of harvesting, and economics of the fishery. Experts in these topic areas were invited to give short presentations on the topic along with their ideas of major research questions. Following each presentation, invited participants that included scientists, managers, industry members, and interested members of the public (Appendix 1), engaged in a facilitated discussion of the topic and the presentation, generating a list of questions that were summarized for later ranking. At the end of the day, an informal ranking process was held with each participant selecting five topics they believed to be most important.

The meeting concluded with a discussion of how to work together to follow up on the results of our discussion on research priorities**.** DMR's Seaweed Research Fund has very limited funding derived from seaweed buyer's licenses that is dedicated to research and management of the State's seaweed resources. Other sources of funding are needed to address the numerous priority questions identified at this symposium. There is a need to see what questions are priorities for the interested scientific community. Also, members for the industry and stakeholders may be able to address some of these questions. Bob Morse offered a matching grant to refine the biomass assessment. It was noted that a lot of research has already been conducted, so we really need to focus the unanswered questions. First steps should involve an extensive literature search. Also, we have lots of other species, such as kelp, that are just as important as rockweed. Finally, some participants expressed a desire to continue the dialogue begun at this meeting, perhaps at future Fishermen Forums.

III. Rockweed Report Format

Brief summaries of each presentation along with highest ranking priority research questions are presented in Section V. A detailed, categorized listing of questions, observations, and opinions articulated during the discussion sessions is presented in Section VI. The list of all prioritized research questions is presented in Appendix 2.

IV. Overview of Rockweed Harvesting and Economics in Maine

Robert Morse, member of the Maine Seaweed Council, presented a short history of seaweed harvesting in Maine. Evidence from archeological digs indicates that early people used fish waste and seaweed for farming, perhaps dating back to 15,000 years ago. During the 1880's, Luther Maddox ran a successful business drying rockweed with a wood fired kiln in Boothbay Harbor, and shipping it south to be sold as a fertilizer for tobacco fields. It was a combination of the liquid seaweed and fish waste that turned out to have the optimal combination of nutrients for commercial farming. Sea moss was harvested and dried on Cape Cod during the 1960's, and sold to Marine Colloids in Rockland. This spurred an enormous sea moss harvest in coastal Maine. There were dehydration processers along coast from Stonington to Rockland, extracting carrageenin**.** Kraft Foods had a plant in Portland around time that also processed sea moss for

carrageenin. In the 1970's Bob and Shep Erhart went into rockweed harvesting business, first using rakes and knives and now a mechanical harvester that uses suction pumps and cutters. The products include horticultural, home and garden liquid seaweed fertilizer that will increase the yield and quality of crops in pasture lands. The history of the colonial ordinance regarding ownership in the intertidal zone dates back to 1647. There is a white paper that was reviewed by an attorney with regards to trust right access and harvesting seaweed on the Maine Seaweed Council's website.

V. Priority Research Questions

Rockweed Priority 1: Biomass Assessment

Dr. Raul Ugarte addressed the following questions in his presentation that can be found at: http://www.maine.gov/dmr/rm/rockweed/symposium2010/ugarte.pdf.

- Why is this biomass assessment important?
- What does past and current research tell us about the location, quantity and quality of rockweed along Maine's coast?
- What do we need to know more about?

We need to know how much biomass is there and what we can harvest because both people and fish rely on this resource. Satellite images and both black & white and color aerial photography have both been used to identify the resource and surface coverage. The advantage of satellite imagery is that one image can cover the entire target area. Disadvantages include low resolution (although resolution down to 0.5 m is now available) and high cost. The angle of incident light also affects satellite imagery. Aerial imagery provides good resolution; images can be digitized and quantified to calculate the size of the resource. The disadvantage to this process is that it requires a lot of pictures and every flight line the plane takes is different due to the angle of the sun. Both methods require ground truth calibration for confirmation of beds, species composition, and slope calibration.

There are a number of techniques that exist to assess rockweed, both destructive and non-destructive. We chose to use a combination of these. We used a random stratified sampling approach running sampling transects along the shore. In general, most of the bed is quite homogenous in terms of species; however, near the top and the bottom parts of the bed, other species tend to make up a portion of the biomass. More complex shoreline areas, such as Cobscook Bay, require a higher level of sampling effort in order to accurately characterize the resource. When transects were undertaken for Cobscook Bay, 110 sampling stations were required, with certain areas of the shoreline only accessible by a kayak. Quadrat size can have implications on how the data gets extrapolated and have been evaluated. We found that the smaller quadrats tend to overestimate the biomass, and find that the 0.25 m^2 quadrate is optimal.

There are seasonal variations in the rockweed wet biomass, so timing must be taken into consideration as there are natural peaks and troughs. Surveys are conducted in the summer during the harvest season. This is also when the biomass is naturally at it lowest as it is when the rockweed is starting to grow vesicles resulting in higher weights. The storms in fall and winter can detach rockweed, therefore reducing the biomass, while the biomass will peak in spring

around reproduction time when there are a high number of sperm and eggs, holding a lot of water thus contributing to the higher weight. Annual mortality could vary between 10 and 35%, and in high hurricane years could be higher. Overall, the biomass estimates for Cobscook Bay range from 46,000 MT to 105,000 MT, depending on the techniques that are employed. We need to determine which one is most accurate.

Priority research needs are:

a) Improved method of biomass assessment that is less variable and uses non-destructive techniques
b) What is natural mortality versus harvest mortality?
c) Assessment of natural rockweed export from beds to ocean
d) Evaluation of long term effects of harvesting techniques on defined areas

Rockweed Priority 2: Ecology and Habitat

Dr. Thomas Trott addressed the following questions in his presentation that can be found at: http://www.maine.gov/dmr/rm/rockweed/symposium2010/trott.pdf.

- Why is knowledge about ecology and habitat important?
- What do we know about the ecology of places where rockweed grows, including ways in which rockweed serves as habitat for other species?
- What do we need to know more about?

Rockweed is important in nutrient cycling/budgets in terms of turnover, carbon, energy. It is a habitat for other species, providing an attachment site for epiphytes and epifauna, a nursery function, and refuge for a number of species of invertebrates and fish. It also provides a foraging habitat, supporting a lot of trophic levels of invertebrate predators, fish and birds. Little has been published on these services.

Rockweed is a species growing on exposed and sheltered shores in the northern hemisphere. Near shore physical affects on rockweed include natural erosion, currents, storms, and run off. A lot of anthropogenic input can negatively affect rockweed, i.e. fish waste from aquaculture, unnatural man made inputs from a system.

The architecture of rockweed habitat changes from two dimensional at low tide to three dimensional at high tide. At high tide rockweed can be thought of as a bed and the structure can be measured by the number of branches, lateral and dichotomous on each shoot, length, thickness of shoot, etc. The density of clumps is a structural component at scale of bed. At the base, we have the holdfast, and this area is sheltered from light and wave action with the primary shoots widely spaced. In the middle is the most complex part of the bed, with lateral and dichotomous branches with and without epiphytes. It is least complex at the ends.

The invertebrate community can vary greatly, from very small copepods (0.06 mm) to snails (>1cm). The abundance of certain species can be very high (22,000 m^2 juvenile mussels), and can vary greatly with geographic locations, as well as seasonal changes. There is also a change in the community composition through the year as some groups occur year round while others are

only there seasonally. The canopy invertebrates are the most motile, as they move within and between the beds. Their movement is influenced by physical factors such as temperature and the amount moisture available at low water. The turnover is high with short life spans for these invertebrates.

Rockweed also provides a habitat for fish , including residents such as rock gunnels and visitors such as pollock. The visitors often have juvenile stages that use rocky intertidal as nursery ground, moving in and out with the tide. There are foraging fish lured into this habitat by the great diversity of potential prey, primarily invertebrates. Rockweed can also provide a refuge from predators as small fish comprised the diet of at least six species out of a potential 16 of piscivorous fish in Passamaquoddy Bay. Rockweed is a main foraging habitat for eiders and black ducks feeding on invertebrates; buffleheads, scoters, and sandpipers all forage in rockweed, although it is not their primary feeding area. Piscivorous birds such as cormorants foraged during the day and night at all tidal stages. Birds such as eagles fed on other birds.

Priority research needs are:

a) *A definition of sustainability*
b) *An understanding of nutrient budgets and trophic links*
c) *How does structural change from harvest benefit/detract from habitat?*
d) *How does architecture of rockweed affect species?*
e) *How much loss/change is too much?*

Rockweed Priority 3: Effects of Harvesting

Dr. Jill Fegley addressed the following questions in her presentation that can be found at http://www.maine.gov/dmr/rm/rockweed/symposium2010/fegley.pdf.

- Why is knowledge about effects of rockweed harvesting important?
- What do we know about how harvesting affects the marine environment and other species?
- What do we need to know more about?

Anytime you harvesting a marine plant, you need to think about the vulnerability of the species you are harvesting, the techniques you are using, the level of exploitation, and the timing of harvest. After harvest, we need to consider re-growth and the length of time it takes to recovery. This recovery needs to be defined in terms of biomass, percent cover, or original length. Also we need to think about the changes to the plant morphology after harvest.

The results of studies on re-growth after harvest to pre-harvest levels vary, depending on what method is used for measuring (percent cover or original length), the age structure of the population, the pattern of branching, and existence of grazers. Changes in plant morphology were revealed in several studies, with the plants becoming bushier. Declining biomasses resulted in a study of repeated annual harvesting which provided the basis for not allowing an annual harvest.

There have been many studies looking at short term effects on the community, but there have not been a lot of studies looking at the long term affects that could include impacts to the understory

algae, epiphytic algae, understory invertebrates, fish and birds. In some studies both the target species and the associated community were resilient to a single perturbation at a moderate experimental harvesting intensity. Other short-term studies showed an increase in ephemeral green algae and fucus increase significantly after harvest as it can resettle faster; decreased densities of mussels, cryptic and emergent fauna; and higher densities of limpets. Long-term impacts are not known. Only a few studies have been made on the impacts of harvesting rockweed on fish and birds (eider ducks).

Research priority needs are:

a) *Assess long-term effects of harvesting on a large spatial scale*
b) *What is the difference between the 17% harvest rate and natural mortality in a given year?*
c) *What is the difference between uniform and patchy harvesting (include scale)?*
d) *Will cumulative effects of successive harvest restructure habitat and/or ecosystems?*

Rockweed Priority 4: Economic and Social Benefits and Costs of Rockweed Harvesting

Although unable to find a scientist with expertise in economic and social issues of rockweed harvesting, we were interest in addressing these questions:

- Why is knowledge about economic and social benefits and costs important?
- What do we know already?
- What research is needed and how would we frame the questions?

Bernardita Silva, a graduate student in Resource Economics at the University of Maine, attended the symposium. Lee Hudson, president of the Maine Seaweed Council, gave an overview of a 1999 survey conducted by Coastal Enterprises. At that time there were 197 license holders that paid $10 each for a license. The theory was that people just paid extra for the license and didn't use it, but wanted to have it just in case they decided to use it later on. When the fee was raised to $50, the number of license holders dropped to about 100. The survey pertained to all seaweeds, not just rockweed and the accuracy of data is questionable, as landings reports were not required at the time of the survey. Results of the survey indicated ~1 million lb being landed annually at a value of $0.10/lb. Uses were described as being for home and garden, sports turf, etc. University of Maine professor Jim Wilson calculated the industry to be valued at about $10 million, using a multiplier of 2.39. This multiplier accounted for the spin off jobs, value added and other income generated in the coastal community from harvesting seaweeds. An updated economic multiplier is needed to estimate the value of this fishery. Other research questions are what portion of annual income comes from harvesting rockweed compared to other commercial harvesters; who benefits from the harvest, the individual or public at large; the ownership of the resource.

Research priority needs are:

a) *Need to know how rockweed harvest balances with other commercial fisheries.*
b) *What is the value of rockweed as a medicinal?*

c) Is rockweed a public or private resource?

VI. Rockweed Observations and Questions from Discussion

Biomass Assessment Comments and Questions:

A comment for comparing satellite to aerial photos: Every flight line the plane takes is different due to the angle of the sun. Satellites are improving with better images being produced. Before it used to be 4 m pixel sizes, where now we have attained .5 m pixel size. This could give good estimates.

We need some assessment of where in Cobscook Bay there is weak substrate and holdfast attachment and if those areas can be identified and be made publically available.

An assessment method is needed to resolve the high variation in the different biomass estimates.

We need to increase the sampling intensity to get at this, to decrease the high variability.

We need to look at cultures that have used rockweed for a long time.

We need a definition of a rockweed bed.

The most recent rockweed assessment that shows a lower biomass may just be showing that we are at a historical low.

Is there a feature of quality that is not being captured in terms of weight? We need to identify quality as it is harvested.

Once the rockweed is harvested it branches out more. Is this taken into account when assessments are made?

We need estimates of rockweed export, the natural export once it breaks off and float away.

We need to take into account offshore beds as well.

We need to have demonstration farms for the public to explain the different harvesting techniques and see results.

How do you establish conservation areas for research?

There need to be long term testing/demonstration areas.

We would need to be careful with the definition. It should include active harvest areas.

There is no way to reconstruct species or habitat when generalizing. We haven't taken into consideration the aspect of the shore and shading by trees vs sunlit areas.

For the non-destructive method of assessment, there are problems as they are time consuming and they do not hold post harvest, so that relationship won't hold. I suggest we should find another non-destructive method of assessment.

We should look at the rockweed growth rate variation along coast of Maine and how does it impact the biomass.

Biomass assessments should include holdfast removal estimates. When the harvest is reported, the total amount of holdfast should be reported. And how do we quantify this, should it be the number of holdfasts or total weight?

Mortality caused by harvest and mortality caused naturally should be monitored.

Need to harvest in a way that minimizes the destruction of holdfasts.

Ecology and Habitat Questions:

Things to think about are how much habitat change is too much and when do we start to lose things?

How might the role of rockweed habitat change with different levels of harvest?

What are the roles of low trophic level species in affecting rates if recovery from commercially important species?

What are the feeding preferences of invertebrates, fish and birds, and how is it affected by changes in structure and /or invertebrate abundance resulting from harvesting?

Can you accurately assess the nutrient cycling of rockweeds? This is difficult and requires an interdisciplinary approach.

We also need to look at the role of dead rockweed. Land-based birds feed on dead rockweed.

What about lobster and rockweed? Lobsters are foraging during high tide in this habitat.

If rockweed is essential fish habitat for juvenile pollock, are we breaking the law by harvesting it? (*Note: rockweed has not been designated as EFH for Pollock*)

How does structure change caused by harvesting benefit or detract from habitat?

We need to understand if there is a correlation between changing structural complexity as a result of harvesting and increasing species diversity.

We need to understand trophic links in rockweed habitat.

Now that eelgrass beds are gone, rockweed habitat becomes more essential habitat to juvenile species like mussel seed). We need to understand the relationship between the two.

We should put the entire life cycle of rockweed together, including the rockweed that ends up on the shore as detritus. We need to quantify the entire life and death cycle.

We need a biological assessment and characterization of rockweed beds and where they occur along the coast. There seems to be a higher level of productivity in heads of the bays. As a land manager, I need to know the impacts to biological communities that harvest will have in different areas.

Rockweed is actually two organisms. In every rockweed, there is a fungus that lives inside and we know nothing about its role and how much it contributes to biology, survivability and success of rockweed.

Different types of harvesting impacts different organisms. Are mobile animals impacted differently by different harvesting methods? Is rockweed essential habitat for any animal?

Are there are any benefits to harvesting?

We need to look at the species on a functional level. How does the architecture of the rockweed itself affect the species? How does the size scale of the bed affect species?

What do we know about the function of rockweed covered ledges that are detached from the mainland?

Do post larval lobsters use rockweed to assist them in settlement? Post larval lobsters respond to the scent of rockweed.

We need to know more about how other species and communities use rockweed habitat when the tide is in.

How does structural change affect rockweed? Land grasses increase productivity after being cut. Is harvesting beneficial?

What are the seasonal and daylight affects on harvest?

Can research in one area be extrapolated to other parts of the coast (i.e. from Cobscook Bay to Casco Bay)?

Is there a variation between boulder fields and ledges?

How do natural and man made factors affect rockweed biomass and health?

Cobscook Bay fisheries assessments want to know about scallop spat in rockweed

What happens to periwinkles in winter when there is no rockweed due to overharvest?

What happens to clams flats after rockweed harvest?

What happens when you remove all these nutrients from the system itself?

We need to look at tide stage and pH.

We need to look at the synergistic effect of any one activity.

Effects of Harvesting Questions:

What is the scientific basis for the 17% harvest rate. It is based on both science and politics and is a third of 50%. If you harvest 17% each year for each of three years, you will remove 50% of the biomass, as it takes three years for the biomass to recover.

We need to define recovery after harvesting.

The taller plants will dominate and keep other plants from growing until those larger plants are harvested.

We need to know the relationship between experimental cuts and harvesting cuts. How do these cuts impact the biomass and the translation of the scientific results and their applicability to commercial harvest.

What about patchiness and scale?

What is the relationship on a geographical level of 17% removal as you are taking the biomass where it is easiest to cut?

There are areas that are more easily accessible than others and we discount those hard to access areas. The 17% exploitation rate is an average over 3 years. The plants that are cut the first year will not be floating at the surface the following year, as there will be other plants that have grown up to replace those that you cut. The following year, those plants cut the two years prior are not available, so you cut a third group that is at the surface. So essentially, you cut 17% each year and after 3 years you have removed 50% of biomass.

Is there a natural breaking point on plants? If the plants is locked in ice and pulled, it will break.

The plants will be hardier in places along the coast that are exposed to wave action. You cannot break those plants, as opposed to areas that are protected as these plants are weaker since they don’t naturally have to withstand the same physical forces.

Do short-term algae, e.g., sea lettuce, come into a rockweed bed after harvest? To what extent does it displace rockweed settlement?

It will have an effect for the first season, but as soon as the canopy starts to regenerate, the rockweed will out compete the opportunistic settlers.

What are the long term effects and spatial scale of harvesting?

What are the effects of the 17% cut and natural mortality in a given year?

Is harvesting older plants with more biomass at the top beneficial to the bed as a whole?

We need to look at natural mortality vs. fishing mortality, see what the effects are of removing the plants, and look at shoot mortality vs. plant mortality.

Does productivity differ along coast of Maine? In the United Kingdom study (Boaden & Drin 1980) bed still has not recovered to previous levels after being scraped down.

What about bycatch in terms of other algal species? Will the cumulative effects of successive harvest restructure the habitat and/or ecosystems?

The Russians conducted a study over 50 years ago and found that the bigger plants were never replaced.

What about a regional question? Perhaps we look at the effects of flow, etc. on different sites across the state.

The focus that I harvest as bycatch can be used for thyroid treatment. It is also useful.

We know there is bycatch, but we just don't know what the impacts are in terms of species.

We need to determine what rockweed can sustain in terms of the natural mortality and harvesting in combination? What is level of sustainability for a healthy ecosystem?

The tidal range should be included in any future studies.

If we are going to monitor bycatch in terms of impact, we need to know what the density is in terms of bycatch. Baseline work on bycatch species is needed.

One of the priorities of this meeting is looking at the remediation of zygotes. How do we remediate areas that have been scrapped clean and devastated?

Social and Economic Questions

What portion of annual income comes from harvesting rockweed compared to other commercial harvesters?

A broad literature search should be done conducted.

Who benefits from the harvest? Is it the individual or the public at large?

Is rockweed owned by the upland owner or is it a public resource as it is in the intertidal?

Where is the local and traditional knowledge?

Should rockweed be categorized as a medicinal product?

We need to know today's value of rockweed at the dock, and then value added.

Where do dollars generated by rockweed end up? Who benefits from the harvest - is it local economy?

What is economic resilience of communities that harvest rockweed?

Compare communities where rockweed has been harvested long term (NS) and recently (Grand Manan) to see what can be learned.

At what levels should it be managed? Should rockweed management be done on a bay basis by the communities that are affected?

With the high potential for commercialization for nutriceuticals, we need to look at sustainability, seasonality and functional properties.

Is seaweed harvesting a sustainable activity?

What are the bionutriceutical properties of rockweed and their uses?

VII. Acknowledgements

Members of the planning team included Lee Hudson (Maine Seaweed Council), Shep Erhardt (Maine Seaweed Council), Chris Bartlett (Maine Sea Grant), Ron Beard (Maine Cooperative Extension), Pete Thayer (DMR) and Linda Mercer (DMR). Ron Beard also provided his excellent facilitation skills for the meeting. Paul Anderson (Maine Sea Grant) provided critical financial support for lunch and snacks, and assistance with meeting arrangements. Trisha DeGraaf (DMR) and Nicolas Blouin (University of Maine) provided excellent notetaking skills which greatly facilitated the preparation of this report. Dr. Raul Ugarte (Acadian Seaplants), Dr. Thomas Trott (Suffolk University), and Dr. Jill Fegley (NC Coastal Reserve & National Estuarine Research Reserve) provided excellent summaries of the research topics that set the context for discussions and development of research questions.

APPENDIX 1

Rockweed Meeting
2/10/10 - Orono

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APPENDIX 2

BROAD TOPIC	RESEARCH QUESTION	# OF VOTES	% OF VOTES CAST
Biomass Assessment	Other nondestructive methods research	10	5%
Biomass Assessment	Improved method of biomass assessment (non destruct)	21	11%
Biomass Assessment	Less variable assessment	14	7%
Biomass Assessment	What is natural mortality versus harvest mortality?	6	3%
Biomass Assessment	Assessment of natural rockweed export	3	2%
Biomass Assessment	Testing of long term effects of harvesting techniques on defined areas	2	1%
Biomass Assessment	Research into other non-destructive methods	1	1%
Biomass Assessment	Assessment of weak habitat/ holdfast attachment	0	0%
Biomass Assessment	Rectify differences between ASP Larsen, Crawford	0	0%
Biomass Assessment	Definition of a rockweed bed	0	0%
Biomass Assessment	Include quality in assessment not just biomass	0	0%
Biomass Assessment	Long term assessments (using other cultures)	0	0%
Biomass Assessment	Assessment of variable growth rates of rockweeds along the maine coast	0	0%
Biomass Assessment	Do growth rates vary along coast of Maine?	0	0%
Ecology & Habitat	**How much habitat loss/change in structure is too much? (bold from Tom's ppt)**	na	na
Ecology & Habitat	**How does rockweed as habitat change with different harvest pressure? (bold from Tom's ppt)**	na	na
Ecology & Habitat	**What is the role of low trophic levels affect commercially important ones? (bold from Tom's ppt)**	na	na
Ecology & Habitat	**What are feeding preferences of all animals and how is that affected by changes in substrate or invertebrate abundance from harvesting? (bold from Tom's ppt)**	na	na
Ecology & Habitat	Define sustainability	10	5%

Ecology & Habitat	Understand nutrient budgets and trophic links	9	5%
Ecology & Habitat	How does structural change from harvest benefit/detract from habitat?	9	5%
Ecology & Habitat	How does architecture of rockweed affect species?	8	4%
Ecology & Habitat	How much loss/change is too much?	6	3%
Ecology & Habitat	How do seasonal, spatial, and diel variability affect rockweed habitat use?	4	2%
Ecology & Habitat	Variation between boulder fields and ledge	3	2%
Ecology & Habitat	What are synergistic effects of rockweed harvest	3	2%
Ecology & Habitat	Use of rockweed wrack as habitat	2	1%
Ecology & Habitat	Quantify life/death cycles-contribution	2	1%
Ecology & Habitat	Do post-larval lobsters us rockweed for settlement?	2	1%
Ecology & Habitat	Are rockweed beds where harvest occurs essential habitat for fish species?	1	1%
Ecology & Habitat	Connections between rockweed and eelgrass	1	1%
Ecology & Habitat	Biological assessment of rockweed beds	1	1%
Ecology & Habitat	Is rockweed essential habitat for any taxa?	1	1%
Ecology & Habitat	How does spatial scale of bed affect species?	1	1%
Ecology & Habitat	Is there a correlation bet structural complexity and species diversity?	1	1%
Ecology & Habitat	What are the pros and cons of habitat structure changes from harvesting?	0	0%
Ecology & Habitat	Role of endophytic fungi in rockweed	0	0%
Ecology & Habitat	Are mobile animals differentially impacted by different harvesting methods?	0	0%
Ecology & Habitat	Function of rockweed covered ledges detached from mainland.	0	0%
Ecology & Habitat	Better understanding of how other species use rockweed (e.g. clam, scallop)	0	0%
Ecology & Habitat	How does harvesting affect scallops, clam, periwinkles (commercial species)?	0	0%
Ecology & Habitat	How does architecture change affect *Ascophyllum* zygote settlement?	0	0%
Ecology & Habitat	How do natural and man effect the standing biomass?	0	0%
Effects of Harvesting	Assess long-term effects on large spatial scale	9	5%
Effects of Harvesting	What is the difference between 17% and natural mortality in a given year?	7	4%

Effects of Harvesting	What is the difference between uniform and patchy harvesting (include scale)?	5	3%
Effects of Harvesting	Will cumulative effects of successive harvest restructure habitat and/or ecosystems (Russian research)?	5	3%
Effects of Harvesting	What is the biological recovery of the system?	4	2%
Effects of Harvesting	What is the applicability of scientific methods of harvest to commercial practices?	4	2%
Effects of Harvesting	What are impacts of by-catch?	3	2%
Effects of Harvesting	By-catch & harvest(%) data outside of Cobscook Bat	2	1%
Effects of Harvesting	Are there site effects-flow rate, etc.?	2	1%
Effects of Harvesting	Densities (baseline) of by-catch species	2	1%
Effects of Harvesting	Are there regional differences in recovery rates?	1	1%
Effects of Harvesting	What is definition of recovery?	0	0%
Effects of Harvesting	What is significance of 17% harvest rate?	0	0%
Effects of Harvesting	What is the difference in regeneration response between hand and mechanical harvesting?	0	0%
Effects of Harvesting	Research into a natural breaking point of the rockweed thallus	0	0%
Effects of Harvesting	Is harvesting older plants beneficial to the plant/bed?	0	0%
Effects of Harvesting	Define mortality?	0	0%
Effects of Harvesting	Other by-catch species	0	0%
Effects of Harvesting	What is level of sustainability that includes harvest and natural mortality?	0	0%
Social & Economic Impacts	Need to know how rockweed harvest balances with other commercial fisheries?	12	6%
Social & Economic Impacts	Value of rockweed as a medicinal	10	5%
Social & Economic Impacts	Is rockweed a public or private resource?	7	4%
Social & Economic Impacts	What is today's value of rockweed at dock and also in value- added products?	4	2%
Social & Economic Impacts	Who benefits from the harvest?	2	1%
Social & Economic Impacts	How to incorporate local knowledge into future studies	2	1%

Social & Economic Impacts	What is the economic resiliency of communities where rockweed is harvested?	1	1%
Social & Economic Impacts	At what level should rockweed be managed?	1	1%
Social & Economic Impacts	Need info on all harvested rockweed	0	0%
Social & Economic Impacts	What is current economic multiplier (dollars/jobs)?	0	0%
Social & Economic Impacts	Portion of income for harvester-raker	0	0%
Social & Economic Impacts	Literature search of social and economic studies needed	0	0%
Social & Economic Impacts	How to sustain a dialogue about rockweed (many voices)?	0	0%
Social & Economic Impacts	What are the benefits of rockweed as a nutraceutical?	0	0%
	total votes cast	**204**	
	total divided by 6	**34.0**	