Estimating Ecosystem Services From Harvested and Unharvested Ascophyllum Nodosum on the Maine Coast

Ashley E. Sarra

University of Maine

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ESTIMATING ECOSYSTEM SERVICES FROM HARVESTED AND
UNHARVESTED *ASCOPHYLLUM NODOSUM* ON THE MAINE COAST

by

Ashley E. Sarra

A Thesis Submitted in Partial Fulfillment
of the Requirements for a Degree with Honors
(Marine Sciences)

The Honors College
University of Maine
May 2018

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**ABSTRACT**

*Ascophyllum nodosum*, better known as rockweed, is a commercially important, harvested intertidal brown alga species common in coastal Maine. Rockweed sea vegetable harvesting is a lucrative wild harvest fishery, that has also proved to be socially contentious and whose future management is uncertain.  

*Ascophyllum nodosum* is an intertidal macroalgal species that may also be impacted by sea level rise. Through a combination of biomass estimation, newspaper analysis, and interview data collection, this project seeks to (a) develop a typology of ecological services of *A. nodosum* in harvested and unharvested areas in the state of Maine; and (b) assess the stakeholder perspectives amidst the *Ross v. Acadian Sea Plants Ltd.* court case.

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DEDICATION

To my family: thank you for supporting me through all of my youth science projects, state competitions, and other academic adventures. This final school project was for you just as much as it was for my love of learning.

To Maine: thank you for being the first home I got to choose to live in. You’re no Honolulu, but I’ll never forget the rocky intertidal and all your secluded treasures. Thank you for teaching me love the ocean again.
ACKNOWLEDGEMENTS

I would like to thank my entire Honors Committee, Dr. Aaron L. Strong, Dr. Bridie McGreavy, Dr. Brian Olsen, Dr. Joshua Stoll, and Chris Mares for their support and academic guidance. The Price Laboratory at Bigelow Laboratory was a big help when first beginning my project and helped me incorporate standing stock and biomass into my report. I would also like to thank Parker Gassett for his mentorship while I attended my first scientific conference with the Strong Laboratory and throughout the rest of my senior year. Classmates such as Daniel Berry also deserve gratitude, as they helped me stick to deadlines and provided emotional support.
PREFACE

One of the most striking parts of the state of Maine is its working waterfront. Like many people who come to Maine from out of state, watching the lobster boats come into Bar Harbor after a day exploring Acadia National Park held a certain romantic wonder for me. After pursuing my Marine Sciences degree at the University of Maine, I learned even more about how people have come to depend on Maine’s ocean and rocky intertidal as a part of their culture and livelihood. I am incredibly blessed to have had the opportunity to study and learn from incredible professors and Mainers alike.

Many of Maine’s coastal towns are heavily reliant on their coastal fisheries. At the same time, much of Maine has experienced significant declines in smaller fisheries while the lobster industry continues to be Maine’s most valuable (and abundant) marine resource (Steneck et al., 2011). This is not a recent problem. Many people who have lived near Maine’s coasts remember other fisheries which have been almost completely depleted, such as the green sea urchin. The sea urchin industry had boomed in the 1990s, with its high international demand and unregulated fisheries growth leading to the state’s population of urchins to drastically decline (Lauer, 2009).

Today, many people are conflicted about Maine’s smaller fisheries. In an age of fertilizers and pesticides, many people question whether the harvest of rockweed is economically and ecologically viable, or if it could be properly regulated. With a 20 million dollar industry (including value added products) and rockweed being the most
abundant in areas with low economic opportunity, rockweed harvesting has grown contentious as stakeholders discuss what it means to properly conserve and protect this species (Feeny et al., 2009; DMR, 2014).

The ongoing court case, *Ross v. Acadian Sea Plants Ltd.*, continues to show social perspectives on the rockweed industry, as private landowners, fishermen, and other stakeholders all have different opinions on private and state-run conservation. Let this report be a preliminary guide on not only the rockweed industry, but also stakeholder relations during a difficult legal battle for the intertidal.
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Figures

Figures will be kept within the manuscript and appendix, due to the nature of my Honors Thesis. For convenience, each figure is listed below with corresponding page numbers.

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Tables

The table below shows insight on what data was collected to calculate a back of the envelope standing stock assessment for *Ascophyllum nodosum*. Otherwise, no other tables were produced.

Table 1: Raw data from *Ascophyllum nodosum* collection at Bigelow Laboratories for biomass estimates.

<table>
<thead>
<tr>
<th>Quadrate</th>
<th>Rockweed #</th>
<th>Max Cov (cm)</th>
<th>Max Length (cm)</th>
<th>Lateral Lr (cm)</th>
<th>Harvested Density</th>
<th>Rockweed Age</th>
<th>% Cover</th>
<th>Wet weight (kg)</th>
<th>dry weight (g)</th>
<th>Quadrat size</th>
<th>Site</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>20</td>
<td>8</td>
<td>6</td>
<td>95%</td>
<td>7.5</td>
<td>1000</td>
<td>258.1</td>
<td>258.1</td>
<td>25x25m²</td>
<td>Bigelow Hand Harvest Area</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>7</td>
<td>8</td>
<td>6.9</td>
<td>61%</td>
<td>8.6</td>
<td>1000</td>
<td>261.5</td>
<td>261.5</td>
<td>25x25m²</td>
<td>Bigelow Hand Harvest Area</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>10</td>
<td>0.94</td>
<td>6</td>
<td>100%</td>
<td>0.1066</td>
<td>38.1</td>
<td>25x25m²</td>
<td>25x25m²</td>
<td>Bigelow Hand Harvest Area</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>10.2</td>
<td>1.11</td>
<td>9</td>
<td>61%</td>
<td>0.174</td>
<td>48.4</td>
<td>25x25m²</td>
<td>25x25m²</td>
<td>Bigelow Hand Harvest Area</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>7.3</td>
<td>1.1</td>
<td>6</td>
<td>61%</td>
<td>0.2</td>
<td>54.2</td>
<td>25x25m²</td>
<td>25x25m²</td>
<td>Bigelow Hand Harvest Area</td>
<td></td>
</tr>
</tbody>
</table>

Due to the range of different harvesting techniques, years, measurement strategies, and research projects, rockweed biomass data for the state of Maine was compiled on a Google Documents sheet, rather than an organized table. The raw data specifically containing biomass measurements can be found in the Appendix C, along with notes on locations and harvesting details.
Definitions

Ecosystem services

- Additional benefits a resource provides with special consideration to benefits for humans. Examples range from providing products for consumption, nutrient cycling, and more.

Stakeholders

- Any person who is involved or has a claim to a particular issue, company, or industry.

Ross v. Acadian Sea Plants Ltd.

- A Maine Supreme Judicial Court case between two Maine brothers and a Canadian based company which argues over intertidal property rights claiming *Ascophyllum nodosum* may not fall into the colonial ordinance that allows “fishing, fowling, or navigation” in the intertidal despite private ownership.

*Ascophyllum nodosum*

- The scientific name for rockweed.
- A long lived, relatively slow growing brown macroalgal species which is prevalent in thick mats along North Atlantic rocky intertidal shorelines.
TEXT OF MANUSCRIPT

BACKGROUND

*Ascophyllum nodosum*, also known as knotted wrack or rockweed, is a long-lived and slow-growing brown alga species with a large distribution spreading across the Atlantic Ocean (Lubchenco, 1980; Seely and Schlesinger, 2012). *A. nodosum* grows small bladders alongside long fronds that hang off of rocky substrates in the rocky intertidal zones (Guiry, 2016). *A. nodosum* are important for life residing in the rocky intertidal zone, as their thick mats are able to keep in moisture in what would otherwise be exposed areas, which dramatically reduces desiccation rates (Bertness, et al., 1999). *Ascophyllum nodosum* has a variety of human uses, but some of the most notable and historical uses including biofertilizer and animal feed (Feeny, 2001). As the demand for agricultural products – especially those which are organically produced – steadily rises, *A. nodosum* is seen as a potential aid for agriculture. The use of *A. nodosum* can increase seed germination rates, seedling growth, and nutrient uptake when used as an agricultural amendment (Liu et al., 2014). Demand for *A. nodosum* has steadily increased over time, leading to the creation of a highly lucrative $20 million industry for *A. nodosum* in Maine (Hoey, 2017).

*The harvesting of A. nodosum in Maine has also become increasingly controversial as it has expanded.* Coastal property owners have become concerned about loud mechanical harvesters in the intertidal and about the potential for overharvest. On
March 16, 2017, a superior court judge declared that intertidal zones as privately-owned land in Maine, and that intertidal macroalgae were not a fishery (access to which is preserved in the intertidal under the public trust), but rather the property of coastal property owners (Hoey, 2017). This leaves the *A. nodosum* industry with uncertain future management, despite a fishery plan from Maine’s Department of Marine Resources already established.

Mechanical harvesting tools have the capacity to take more than twenty thousand pounds of seaweed in one day, selling each wet ton for up to $30 (Feeny, 2001). Determining how to manage rockweed harvest sustainably is a major question facing this growing industry along coastal Maine, especially throughout Washington county. Additionally, the coast of Maine is threatened by rising sea levels due to anthropogenic climate change (Strauss et al. 2012). Assessing the vulnerability of coastal economies to sea level rise is a key question facing state and local planners, and little is known about the potential impacts of rising sea levels on rockweed distribution and abundance due to a lack of comprehensive mapping of *Ascophyllum* distribution.

The key to addressing all these questions and understanding the current and future potential development of *Ascophyllum nodosum* harvest in Maine is an understanding of the full suite of ecosystem services benefits which *Ascophyllum* populations provide. Ecosystem services include both the market (economic) and the non-market benefits that ecosystems provide, like aesthetic and recreational values, habitat support, carbon and nutrient cycling (Nelson et al., 2009; Crain & Bertness, 2006). The full accounting of
ecosystem services is important to guiding trade-off decisions for management (Lester et al. 2013). The ecosystem services of *Ascophyllum nodosum* – and the relative difference in services between harvested and unharvested areas – have yet to be calculated for the state of Maine, nor has the vulnerability of this sea vegetable fishery to changing sea levels been assessed.

The objectives of this research are: (1) Compare the stakeholder and media impressions about the quality of the *Ascophyllum nodosum* fishery management given the recent court case and (2) further assess the ecosystem services in which *Ascophyllum nodosum* provides. In addition, a presentation given at the Coastal Estuarine Research Federation Conference detailed the standing carbon stocks and carbon storage potential for *Ascophyllum nodosum*, which will also be discussed using biomass data and back of the envelope calculations.
MATERIALS AND METHODS

Biomass Assessments

In order to assess biomass variations across the state of Maine, a series of data management plans and unpublished literature, biomass extraction techniques were recorded. After all available data was compiled, a location near Bigelow Laboratories was assessed with permission. This was to get an estimate on standing carbon stocks. Rockweed was removed from a 0.25m x 0.25m transect square. Six individuals were taken that were representative of the coastline. After the individuals were brought to the lab, their longest frond length was recorded, along with each air bladder counted along the given frond. Wet weight was also measured using a scale available on site.

Individuals air dried for the first day but were brought back to the lab room due to slow drying rates. Each individual was labeled and placed in tin 21 x 11 x 6 cm cooking tins. After drying out individuals in a drying oven, a dry weight was recorded. A backof the envelope calculation was made to estimate the biomass found in the area the rockweed was taken from.

Interview Data Collection

After obtaining IRB approval, a preliminary list of stakeholders was made and requests for interviews were sent out. The first batch of interview requests was chosen based on proximity and warm past experiences with similar research studies. After this point, interview requests were done via a snowball approach. The kinds of stakeholders commonly contacted were defined as researchers, fishermen, and those directly involved
in the industry. Others interviewed involved conservation agencies and artists, however it proved hard to contact landowners. Confidentiality of the stakeholders was always kept.

Interviews were semi-structured including pre-set questions discussing how each stakeholder was connected to *A. nodosum*, the roles it played for the environment, the importance it held culturally, as well as questions detailing each stakeholder’s beliefs on management and conservation efforts. Each interview was slated to be anywhere from one to two hours long but was usually around forty-five minutes to an hour long in practice. Interviews were recorded via electronically. Depending on stakeholder preference and accessibility, interviews were either done in person or remotely via Skype or standard phone call. Notes during each interview were taken down in a personal notebook as well.

**Semi-structured Interview Analysis**

Semi-structured data allows for a great range and diversity quality information into a given industry or fishery. The approach used in this study used grounded theory with inductive coding, much like the technique referenced by Strauss and Corbin (1990). Information was coded for important themes regarding the current affairs of the *Ascophyllum nodosum* fishery, given its relevance in the justice system and Maine coastline. The coding guidelines used in this study were inspired from Dr. Kent Lofgren, a Swedish professor in social sciences (Lofgren, 2013). Details on the coding for this study specifically is detailed below.
After reading the data, several categories were noted. These themes were ultimately bundled into larger themes: Lawsuit Opinions, Wariness Level of Others, Uncertainties of Definitions and Decisions, “Solutions” for Maine, and a final Cultural Expectations category. These themes were established through the frequency that these topics were mentioned.

Amount of mentions within a category was done per unique idea. Great care was taken to ensure “double-dipping” did not occur, but multiple “types” of ideas were recorded. This means that a piece of testimony could be anecdotal (Lawsuit Opinions) but also show distrust of the state (Wariness Level of Others). The goal of quantifying the testimony was to make qualitative data easier to interpret. Quotes were added to give an example of the types of phrases and quotes shown to help add context to longer but singular ideas, so that the nature of the qualitative data would still have context to the researcher and potential readers.

“Lawsuit Opinions” Methods and Justification

Lawsuit Opinions contained categories: anecdotal experiences, previous court and law rulings, research cited, as well as establishing “pro Acadian Seaplants” and “pro Ross brothers” sentiments. For those sentiments that were not necessarily about Acadian Seaplants, but about concerns about the intertidal beyond Ascophyllum nodosum, a “pro intertidal rights” category was also defined.

The Lawsuit Opinions theme attests to the Ross v. Acadian Sea Plants Ltd. legal case has become integrally intertwined with my project. Through semi-structured
interviews, most information was said within the framed by a prevailing legal
“viewpoint,” no matter the interviewees actual involvement within the case itself. This
category helps to digest legal concerns apparent within the current *Ascophyllum nodosum*
(rockweed) fishery.

**“Wariness Level of Others” Methods and Justification**

The Wariness Level of Others contained categories: distrust in others, distrust in
state, as well as trust in state. No trust in “x company” or “x person” was included in
order to avoid making contrived categories of lists. The point of the “distrust in others”
category was to mark discontentment with other factor at play rather than merely
enforcement strategies.

The Wariness Level of Others theme shows potential hurdles in stakeholder
engagement, decision making, and proper enforcement processes, as well as poses an
indicator for hopefulness for the established industry.

**“Uncertainties of Definitions and Decisions” Methods and Justification**

The Uncertainties of Definitions and Decisions shows information gaps and
colloquial terminology that may differ from person to person which may impact the
ability for stakeholders to find a firm, well informed vocabulary to find common ground.
Also included in this category is the idea of “worth” for rockweed harvesting, which can
be affected by factors including location, current employment, and other differences in
perspective.
The categories within this theme are “sustainability,” “conservation,” and “worth harvesting”/“not worth harvesting”.

“Solutions” for Maine Methods and Justification

The Solutions for Maine theme showcases a range of ideas meant for the future of Maine’s rockweed fishery in how it interacts with science, management, and the economy. While it may seem at first that “economy/industry” and “aquaculture” belong in separate categories on their own, it is imperative to mention that keeping the fishery and the Department of Marine Resources Fishery Management Plan is indeed in itself a solution for both the economy and the management of the resource itself. To exclude industry from this fishery would be impossible, due to the processing needs of the resource. Furthermore, the economy of Maine (especially Downeast, where smaller fisheries may be more important locally) is intrinsically tied to its coastal fisheries. 

*Ascophyllum nodosum*’s placement within that label is still under review as of March 15, 2017, so for the purposes of this study, it will be called a fishery until the Maine Supreme Court of Law states otherwise. Within the Solutions for Maine theme are the following categories: call for science, call for education, stakeholder engagement, economy/industry focused, aquaculture, and sectoring practices.

These categories are called “solutions” since each category is ultimately rooted in better understanding, perspectives, and management for *Ascophyllum nodosum*, regardless of court case leaning.
Cultural Expectations Methods and Justification

This theme suggests actions that are expected of the Maine rocky intertidal ecosystem, as well as how people personally view *Ascophyllum nodosum*’s place in their daily lives and coastlines. This is an almost “catch all” category. To reduce speculation, only personal testimony was included, rather than the other categories, which included thoughts and feelings that others may have. This is because Maine’s anthropogenic culture is often personal and varies from individual. Other thoughts, such as feelings on those who may have an opposing opinion, can still provide information on interviewees views on issues of trust, stakeholder engagement, and lawsuit opinions, which all are impacted in previous themes. The categories within this theme are “resilience” and “part of coast”.

Newspaper Analysis

Unlike the earlier semi-structured interview data, the newspaper data was published openly on Maine newspaper websites. This data is crucial as it operates as a way to verify feelings recorded via interview process as well as provides new insight to groups that may be more underrepresented in my collected research data. Newspaper articles analyzed must have been published between the years 2016 to 2018 and must have been written in regard to either the *Ross v. Acadian Sea Plants Ltd.* case and/or the *Ascophyllum nodosum* fishery within Maine’s intertidal waters.

After reading the data, several categories were noted. These themes were ultimately bundled into larger themes: Lawsuit Opinions, Wariness Level of Others, Uncertainties of Definitions and Decisions, “Solutions” for Maine, and a final Cultural
Expectations category. These categories remained the same as to stay comparable to the interview data, but some adjustments were made from category to category. The overall justification for each theme remains the same.

“Lawsuit Opinions” Methods and Justification

This theme remains the same as the semi-structured interview, with special attention paid to both how represented each “side” of the lawsuit in each article as well as how each article was worded by the reporter. The same categories are included as in the semi-structured interview methods and justification.

“Wariness Level of Others” Methods and Justification

This theme remains the same as the semi-structured interview, except special attention was paid attention to “othering,” as well as trust in the state, distrust in state, and distrust in others. Distrust in others and “Othering” differ, as newspaper articles may choose to resonate or exclude various groups without necessarily outright distrusting the information the subject in question may or may not involve.

“Uncertainties of Definitions and Decisions” Methods and Justification

This theme remains the same as the semi-structured interview, except special attention is put in place to locate inaccuracies within media reporting. This is important to note, as the media is often the first step in educating the general public, and misinformation can be used to either explain or otherwise confirm previous stakeholder testimonies. This means the categories for this theme includes “conservation,” “sustainability,” “worth harvesting,” “not worth harvesting,” and “inaccurate media
reporting”. This includes testimony from others that are incorrect if the media source does not correct it with fact later in the article.

“Solutions” for Maine Methods and Justification

This theme remains the same as the semi-structured interview.

Cultural Expectations Methods and Justification

This theme remains the same as the semi-structured interview, except the addition of “disruptive mechanical noise” is also included for the newspaper analysis. The reason this category is excluded from the semi-structured interview analysis is due to the lack of overlap between interviews, and the conflicting information recorded when interviewees brought the harvesting noises up. However, this was included in newspaper analysis due to its occurrence in different newspaper presses.

The categories within this theme are “part of the coast”, “resilience,” and “disruptive mechanical noise.”

Visual Map of Data Presented

Alongside quantitative data, a visual will be produced to show frequency of a topic. This is to give a visual into how smaller categories and themes play into the perception of the future of *Ascophyllum nodosum*. Below is a proposed set up for the final draft.
Figure 1: Example of conceptual graphic to portray summary of results.
Figure 2: Finalized graphic showcases a simplified structure but shows topics percentage on the proposed outcomes.
RESULTS

Biomass assessment estimation data showed that the ages of rockweed sampled ranged from 3 to 10 years old. In the Freeport area, standing carbon stocks were found to range between 37.2 to 599.8 tons of carbon. From literature, biomass ranged greatly across 3 to 6 kg m$^2$ to 32 kg m$^2$ and depended greatly on geography. The highest biomass was found in Cobscook Bay, whereas the lowest was found round the Pemaquid/Damariscotta area.

Newspapers often focused on the court case and brought up “sides” as if the issue was black and white. Take the quotes from *Ellsworth American* and *Bangor Daily News*. *Ellsworth American* stated that “According to Smith, the issue confronting the court is a fairly straightforward matter of property law controlled by a Maine Supreme Court case decided in 1861, *Hill v. Lord*” (Rappaport, 2017). Other newspapers, such as *Bangor Daily News* mentioned that “Supporters of seaweed harvesting have said that since colonial times, fishing, fowling and navigation have been allowed in Maine’s intertidal zone, regardless of ownership, and that seaweed should fall into the same category as other harvested marine organisms,” (Trotter, 2017). The *Ellsworth American* also stated that “In addition to DMR, supporting Acadian were the Downeast Lobstermen’s Association, the Maine Coast Fishermen’s Association, the Maine Clammers Association, the Independent Maine Marine Wormers Association, an individual fisherman and a corporation that harvests Maine rockweed. Supporting the landowners were, among others, six Jonesport-Beals Island fishermen, the Cobscook Bay
Fishermen’s Association and several local and national conservation organizations, including the Maine Coast Heritage Trust, the Downeast Coastal Conservancy, the Pleasant River Wildlife Foundation and the Conservation Law Foundation” (Rappaport, 2017).

Meanwhile, stakeholder testimony often brought up the improving the *Ascophyllum nodosum* fishery before discussing the court case, and only mentioned lawsuit opinions about 57 times, less than half as often as the newspapers. Stakeholder testimony discussing wariness of management strategies and cultural significance were also mentioned more frequently than the newspaper articles. Stakeholders showed wary behavior 56 times, which was 25 more mentions than the newspaper and media. Stakeholders also had 43 mentions about *A. nodosum*’s significance to the state of Maine, while newspapers only discussed the issue 21 times. Interestingly, uncertainties throughout stakeholder testimony and newspaper articles stayed similar with 29 and 32 mentions specifically.

When looking at semi-structured interview results, stakeholders focused largely on proposing new solutions and increasing science rather than announcing a definite side. Between the ten stakeholders, there were 83 separate solution suggestions mentioned for the rockweed industry. The focus of the newspaper articles and media analyzed was noticeably on the *Ross v. Acadian Sea Plants Ltd.* lawsuit, with 117 different mentions of the court case between 15 different articles. Despite more articles than stakeholder
testimony, there were only 68 different suggestions for solutions released via newspapers and media.

![Bar graph](image)

Figure 3: The following graph compares the total mentions between each coded category for each of the five respective categories. Stakeholder testimony was compiled from 10 stakeholders from various backgrounds, whereas the 15 newspapers were taken from local sources within the past 2 years.

The “Lawsuit Opinion” category, also known as “Lawsuit Opinion Breakdown” in Figure 4, showed that while newspapers focused heavily on previous court case results and research testimony, stakeholder testimony held more anecdotal information. Newspaper articles collectively mentioned previous court case data 36 times, far larger than stakeholder testimony, which only included court case data 9 times. Stakeholders cited research 5 times, whereas newspapers did so 23 times. Anecdotal testimony was mentioned 11 times from stakeholders, and 9 times from media sources. Stakeholders tended to resonate the least with “pro-Ross” sentiments and the most with sentiments that protected intertidal rights. This trend is shared by newspaper articles but is much less pronounced. While only there were only four “pro-Ross” mentions from all ten
stakeholders’ testimony, there was 14 mentions from newspaper articles. Stakeholder testimony mentioned Acadian Sea Plants Ltd. in a sympathetic light 13 times, and newspapers mentioned such opinions 16 times. Stakeholders also expressed the need for intertidal rights nearly 15 times, while newspapers showed the same sentiment 21 times.

Figure 4: 

Figure 4: Ross v. Acadian Sea Plants Ltd. muddles the issue of *A. nodosum* management, but many stakeholders and newspapers show viewpoints protecting the idea of a working waterfront. Newspapers relied heavily on previous court cases in their papers, while stakeholders were relatively balanced between anecdotal and previous court testimony.

The “Wariness of Others” category gave insight in how well stakeholders and newspapers viewed trust in current and future management. Trust in the state of Maine management was lowest in both stakeholder and newspaper data, with only 11 and 2 mentions respectfully discussing contentment in the state’s ability to properly handle fisheries. Distrust in state for stakeholder and newspaper articles were seen in 18 and 6 different mentions respectfully. Most importantly, the largest amount of distrust was seen in other people, with stakeholders and newspapers mentioning these concerns 27 and 12
times. For newspaper analysis only, the “othering” category was included, which had 11 different mentions--nearly as much as distrust in others, the most popular category for newspaper data.

![Bar chart showing mentions of wariness of others compared between stakeholder testimony and newspaper analysis.]

Figure 5: Othering was not considered in stakeholder testimony, as it was determined on specifically coded wording within the expectation that reporting should be neutral. Again, trends between the 10 stakeholders and 15 newspapers mostly mirrored each other.

The next category, “Solutions Proposed,” was the most diverse group of result data, and unlike other trends, newspaper and stakeholder data did not match each other as well as previous data categories. The most popularly discussed solution amongst stakeholder testimony was the call for more scientific research, at 22 mentions, notably higher than newspaper articles mentioning the need for scientific research only 13 times. Interestingly, stakeholders also called for considerably higher rates of educational programs, with 12 mentions compared to the newspaper articles only mentioning education once total. Meanwhile, newspapers most popularly discussed how the economy could be positively impacted by the rockweed industry, with 35 mentions compared to
stakeholder testimony of only 18 mentions. The need for more stakeholder engagement was mentioned 15 times by stakeholders and 11 times by newspaper articles. Expanding aquaculture was discussed 12 times by stakeholders and 7 times by newspaper media. The suggestion of sectoring harvest areas was also brought up more by stakeholders, with four mentions compared to newspapers only bringing up the topic once.

Figure 6: Newspaper articles put heavy emphasis on industry and less on education, whereas stakeholders solidly brought up a range of solutions focused on better scientific understanding and fishery involvement.

Quotes from stakeholders were often emotionally charged and cautious towards unchecked management, especially if the industry was outside the United States. Stakeholders often had opinions that were directly correlated to their main source of employment and experiences. Examples are seen below.
Stakeholder quote:

“I’ve said it about clams and clam harvesting, the local economy isn’t just about the dollars. It’s about saving lives...And you know I think, would [name of person] have picked up a rake and started harvesting rockweed? I don’t know. Maybe he was destined to kill himself. But to me, it seems like a pretty big cause and effect sort of thing.”

This quote is a particularly emotional one, as it intrinsically ties use of the intertidal with the people working on Maine waterfront. Instead of talking of property owners and company battles, this stakeholder narrows down specifically on the fishermen living in poor areas, specifically in Washington county. Rockweed, according to this stakeholder, gave people opportunities through harvesting and industry. Without it, the stakeholder was worried that the economy and the health of small communities would continue to worsen.

Stakeholder quote:

“The right to harvest it as a citizen of the state of Maine is crucial to anybody who is in the business from who will benefit from it. It’s a little self-evident.”

Although the intertidal can be owned by one person in the state of Maine and Massachusetts, the intertidal zone remains open for “fishing, fouling, and navigation,” which has allowed the working waterfront to be a charismatic symbol of the Maine economy. This stakeholder mentions that rockweed has a place in a person’s right to harvest along the intertidal. If fishing rights are restricted, the stakeholder warns that this could have an impact on Maine economies through its businesses reliant on the Maine working waterfront.
Stakeholder quote:

“...if the court decides more broadly that property rights go to the mean low tide watermark regardless of what kind of activity will be carried out on them that changes the whole way of life on the Maine coast and that would be people couldn’t dig clams without permission or a number of activities would be denied to harvesters…”

This stakeholder also brings up the implications of restricted rockweed harvesting and how the court case could impact the Maine fisherman’s right to harvest. This stakeholder mentioned specifically the other species which are not “fish-like” and are harvested almost completely within intertidal areas as a comparison for the rockweed industry. The concern that rockweed harvesting restrictions could be the first of many other small fishery restrictions, should the first Ross v Acadian Sea Plants Ltd. decision remain, was very real within the stakeholder community.

Stakeholder quote:

“I know there’s fishing towns and not fishing towns, I don’t know if Downeast Maine, where things are a little tighter and people are looking for jobs, if harvesting periwinkles and things like that become a good job for people but it needs to be looked at. There are some places where it could be needed but where I live in Maine and where I’ve been in Maine [rockweed harvesting] doesn’t seem necessary and such.”

This stakeholder discusses the economic differences between Downeast Maine and the wealthier areas where more common fisheries are more productive. Despite the stakeholder’s view that rockweed harvesting is not needed for the state of Maine, they mention smaller fisheries do have an impact on Maine’s poorer regions.
Stakeholder quote:

“[Stakeholders] depend on landowners where a very large number are absentee and don’t live in the area or may live in the area but only two weeks in the summer and they would have no reason to allow harvesters allowed on their beach if it is their beach.”

This stakeholder mentions the difficulties of intertidal harvesting should rockweed only be taken from the intertidal with landowner permission. Since many landowners who have coastal property are only in Maine for part of the year as a vacation spot, complications can arise for harvesters. If landowners are not present, they cannot ask for permission to harvest, and even if the harvesters asked when the family was home, the family may or may not want someone so close to their homes when on vacation.

Stakeholder quote:

“...showed her and started to differentiate and I was like ‘This is Fucus, this is Ascophyllum, this is something else.’ And she went ‘Oh! Okay. I feel better now.’ She thought it was some foreign material eating at her beach.”

This story from a stakeholder discusses the lack of understanding many landowners have regarding the seaweeds that commonly grow or wash up on their beachfront property. The stakeholder mentions this story to drive home the importance of public engagement and education of macroalgae species.
Stakeholder quote:

“...[I] think the big thing right now is a lot of junk rhetoric and a lot of deliberate misinformation from certain conservation actors, and I think it's just done a disservice to a sometimes legitimate concerns of the conservation community.”

This stakeholder holds distrust in the conservation movement for rockweed, due to the spread of misinformation for the public. The stakeholder does realize that the conservation community can have concerns worth looking into, but the stakeholder’s own concerns remain.

Stakeholder quote:

“The way politics works these days, no. Once upon a time sea urchins were everywhere on the Maine Coast...I think it was ‘94. I was at the Maine’s Fishery Forum there was a panel and they were talking about sea urchin harvest and I stood behind Maine Patrol officers as they made small comments to each other and one of their comments were ‘They're never going to [properly regulate the fishery]. By the time they get around to doing it, this harvest will be long gone’. And that is in fact the case, that is what happened.”

This stakeholder shows distrust in their state government due to past experiences watching the fall of the green sea urchin fishery in the 1990s. This experience motivated the past stakeholder to speak out about their own concerns with the condition of the rockweed fishery as well as how they feel management is currently being handled. In the past, Maine has seen a loss of many small fisheries.

Stakeholder quote:

“So I think an ideal management approach would be something analogous to clam harvesting today. The challenge with that is there’s thousands of clam fishers throughout the state and I don’t think there’s that many Ascophyllum harvesters.”
This stakeholder further mentions the challenges that face state management of the rockweed fishery. While the stakeholder believes that the state should manage the resource, the stakeholder still has doubts about effective management.

Stakeholder quote:

“...the reason why I agreed to help work on the management plan was we do absolutely need to ensure---when I was younger it was the Russians actually--Russian boats in Rockport processing fish--we do have to be ever alert to large offshore business from other countries coming in and processing our rockweed.”

This stakeholder, like others, saw ineffective management of resources and wanted to ensure current fisheries are better enforced and handled. Instead of quoting stories of green sea urchins, the stakeholder brought up Russian fishing boats. This is an interesting story considering Acadian Sea Plants Ltd. is a Canadian company, not an American one. This stakeholder is concerned about foreign powers taking American resources when they could instead be used to benefit local economies and communities (through development or conservation).

Stakeholder quote:

“No, it’s unfair that people don’t learn about seaweeds and people don’t learn about algae pretty much ever in their life.”

This stakeholder, like previous quotes, discusses the lack of public understanding of seaweed and calls for more education. This is ever more relevant considering the “fish or plant” argument seen throughout state courts during the Ross v. Acadian Sea Plants Ltd. case.
Overall, these quotes suggest that there is a great level of distrust of others from relevant stakeholders, and that those involved in the industry believe there is a general lack of public understanding regarding macroalgae resources along the state of Maine. Ultimately, there is a general concern that restricting harvest of rockweed will lead to restrictions for the economy, even though mismanagement has happened with other fisheries in the past. Many of the stakeholders also expressed helping or participating in the creation of the Maine Department of Marine Resources Fishery Plan in some way, either by interacting with the board directly or just by giving public commentary.
DISCUSSION

This project was outlined to set the groundwork for future studies on ecosystem services. Through preliminary biomass assessments, engaging with stakeholders, and rifling through newspaper reports on *Ascophyllum nodosum* due to *Ross v. Acadian Sea Plants Ltd.* gathering more attention within the state of Maine, the hope was that a modern understanding of *A. nodosum* and its importance in ecosystems and working waterfront communities could be assessed.

While it is currently impossible to determine whether ecosystem services of harvested and unharvested areas of the Maine coast differed from each other, it was made very clear through stakeholder testimony discussing their location that *Ascophyllum nodosum* harvesting and its importance varies greatly throughout the state of Maine. Harvesting is more profitable in Washington Country, where there is the greatest yield. The greatest yield of rockweed also corresponds to the macroalgae’s biomass estimations. Biomass was highest Downeast and smallest in Mid-coast Maine. Understandably, in areas of higher biomass, stakeholders saw more potential for *Ascophyllum nodosum* as a fishery.

It is important not to overgeneralize, as the standing stock for *Ascophyllum nodosum* ranged greatly even on a more local scale, where Freeport ranged from 37.2 to 599.8 tons of carbon. This incredible range of biomass and spotty understanding of current standing stocks on local scales is one of the reasons stakeholder’s call for more
science and research, regardless of their own leanings on the courtcase *Ross v. Acadian Sea Plants Ltd.* Should another similar study on *A. nodosum* be reproduced, the future studies could use ground-truthing to produce a more confident number in standing stock or biomass assessments.

The value of *Ascophyllum nodosum* as a commercial product currently appears to correlate to the proximity of the harvester to Cobscook Bay, the “ground zero” for the *Ross v. Acadian Sea Plants Ltd.* lawsuit. Due to its need for product enhancement, *Ascophyllum nodosum* is only valuable where industry is available to turn resources into value added products. Therefore, stakeholders outside of Downeast took less of a stance on rockweed itself, and instead worried about the implication the *Ross v. Acadian Sea Plants Ltd.* could have on other fisheries within the intertidal. Those stakeholders located closer to Downeast Maine (such as Cobscook) often talked longer about rockweed itself and were more vocal for the potential for the fishery to grow and develop past its humble beginnings. Stakeholders with ties to Downeast were also more emotional and often spoke about *Ascophyllum nodosum* from a more personal level. For someone in Washington County, it was expressed from stakeholders from across the state that small fisheries could be the job that keeps money flowing into impoverished communities.

Some stakeholder testimony focused directly on what harvesting could mean for an economically troubled state. This stakeholder testimony was particularly emotionally charged, suggesting that while the *Ross v. Acadian Sea Plants Ltd.* case covered a small industry, it was nonetheless important for those who felt involved. An example of this
dealt with high suicide and unemployment rates near Washington County, where one stakeholder discussed the importance of rockweed harvesting. Interestingly, the anecdote began with suicide and unemployment rates involving a named young adult’s suicide the stakeholder saw in the newspaper, and then expanded to the potential the *Ascophyllum nodosum* fishery had for development some time after the original discussion on the dwindling health of small Maine communities. It is unclear if this name was legitimate, but the stakeholder was clearly focused on the state of his community first, and then how the rockweed industry could help the town.

While there were more stakeholder testimony mentions of rockweed not being valuable enough for harvest than being worth harvesting, it is important to realize this does not count how many people believe this sentiment, but rather, how often the sentiment was mentioned. This suggests further suggests that stakeholders were more concerned with the precedent that the *Ross v. Acadian Sea Plants Ltd.* case would leave, and that proponents of stricter rockweed regulations were often more likely to say its lack of worth outright. Those who were closer to Downeast saw *A. nodosum* as a more profitable fishery. Stakeholders outside of Washington County often stated that the fishery was more economically important Downeast as well. This distinction in abundance and economic need was not talked about in newspaper articles outside of the rockweed industry potentially bringing in jobs.

The threat of economic instability was something that weighed on many stakeholders, as Maine is widely known for its working waterfront economy. With past
fishery regulation failures set forth by the Maine state government, many stakeholders turned to their own understanding of current events and research to better understand what was going to happen to the rockweed fishery following the *Ross v. Acadian Sea Plants Ltd.* court case. While there were stakeholders who “double-downed” and refused to say there were factors threatening the rockweed itself (those of which were largely from Downeast), others worried about lack of scientific understanding on *Ascophyllum nodosum*. Those who were more scientifically inclined expressed some concerns about global climate change and the role the macroalgae may have on carbon sequestration.

Other stakeholders relied on the legal footing of the *Ross v. Acadian Sea Plants Ltd.* case, stating that *Hill v. Lord* (1861) only talked of rockweed which had already been cut from its holdfasts, or contradictions within the first few pages of the *Ross v. Acadian Sea Plants Ltd.* case itself.

Despite stakeholder’s academic and legal knowledge, some of the best information provided were from their past experiences. Those with experiences working in the intertidal discussed their concern as they watched foreign demand for American resources dwindle Maine’s smaller fisheries. This remains particularly powerful with the stakeholder testimony that talks of Maine’s own state workers being unsure of its proper management. Today, stakeholders remain skeptical of the state governments ability to defend its marine resources, even if the stakeholder believes it is the fishery’s best option for management. Others used these past experiences, such as the stakeholder who witnessed Russian boats coming close to American waters to fish, to become actively engaged in proposing future management of the *Ascophyllum nodosum* fishery. This
suggests that above all else, it was the stakeholders’ experiences that impacted their drive to help create and support new management decisions.

Unsurprisingly, stakeholders appeared to cite sources that aligned with their confirmation bias and promoted solutions best for their personal interests. Out of 10 stakeholders, there were only three times comments were considered pro-Ross sentiments. Although most expressed the importance of using and interacting with the intertidal, many were hesitant to pick a complete side on the Ross v. Acadian Sea Plants Ltd. case. Instead, stakeholders tended to “lean” towards a “side” of the Ross v. Acadian Sea Plants Ltd. case. When questioned further, stakeholders expressed repeatedly that they were on the “side” of the ability to use the intertidal.

Stakeholders mostly showed support of public intertidal rights and pro-Acadian viewpoints, as it would allow stakeholders to continue their use of the intertidal. When lawsuits and research was brought up by stakeholders, it was often used to defend the rockweed industry after their perspective was announced. One stakeholder even mentioned that the judge knew that it would be challenged and go to the state supreme court no matter what ruling he chose.

It is no surprise that these stakeholders, many of which depend on Maine’s intertidal, would bring more anecdotal evidence than what newspapers and media discussed in its reporting of the Ross v. Acadian Sea Plants Ltd. court case. There was nearly double the amount of stakeholder anecdotal testimony when compared to the
media. What is interesting, however, is the potential impact newspapers had on how stakeholders engaged and interacted with others as well as the *Ross v. Acadian Sea Plants Ltd.* case.

This brings up the question of how Maine newspapers reported on how others viewed the sides of the *Ross v. Acadian Sea Plants Ltd.* case. The media made the case seem very black and white; *The Ellsworth American* went as far as to claim entire fisheries supported either the Ross brothers or the company Acadian Sea Plants Ltd.

Despite the clean-cut narrative told by newspapers, stakeholders had messier opinions when picking “sides” in the *Ross v. Acadian Sea Plants Ltd.* court case. Stakeholders having strong opinions often focused on the right to harvest any fishery from the intertidal, not whether the Ross brothers or Acadian Sea Plants Ltd. had their complete support. Stakeholders agreed that it was Maine’s fisheries they were ultimately concerned with, along with the intertidal rights that surrounded them.

Simply put: this court case was not just about rockweed for most stakeholders. The court case on rockweed was often interpreted as the gateway to additional intertidal fisheries restrictions. While one stakeholder mentioned that they’d agree with a narrow decision focusing on just *A. nodosum*, they were nervous about a more generalized law or regulation. Many stakeholders also further talked of the difficulties that could lead to getting landowner permission. Even stakeholders that did not fully support rockweed harvesting remained somewhat sympathetic.
There was some overlap in consensus between stakeholders and newspaper findings. Compared to the stakeholder testimony, newspapers remained balanced in terms of portraying either “side” of the *Ross v. Acadian Sea Plants Ltd.* court case, but still ultimately favored the use of the intertidal rights over the Ross claim to private property. Newspaper articles focused heavily on previous court case citings, background, and decisions in their paperwork by a large margin. Stakeholders and newspapers articles alike often brought up the court document *Hill v. Lord*, which dealt with washed up *A. nodosum* which had already made its way onto shore (1861). Newspaper articles were also technically less bias than stakeholder testimony, however, subtle wording suggests that bias against Maine outsiders existed. Alongside quotes of testimony and media, this study largely uncovered that the court case increased distrust of those originating outside of Maine, while increasing trust in “Mainers” themselves.

In the era of fear of falsified information entering the media, one may wonder the impact newspapers had on stakeholders, if at all. The data suggests that newspapers may be the reason why stakeholders held a great deal of distrust, in combination with their past experiences in management.

Newspapers that discussed the Department of Marine Resources fishery plan at times used phrases that suggested distrust, such as using phrases such “apparently more extensive”. This distrust may also be seeded from United States versus Canadian feelings. Setting aside the fact newspapers referred to the Ross brothers as “Maine natives” and
mentioned Acadian Sea Plants status as a Canadian company, one newspaper discussed a heavy critic of harvesting living in New York as “an eighth generation Mainer who grew up in Freeport.” This also suggests that Mainers tend to trust those who are naturally from the area.

Many stakeholders discussed many aspects of the Department of Marine Resources fishery plan for rockweed, from the percentages of take to its call for ongoing research. While some disagreed with take limits, asking for higher or lower percentages of removal, many approved of the state regulating the resource under the developed plan. Overall, the main concern with the plan was the ability for the state to properly afford the costs of management for such as small fishery, rather than blatant distrust of the state of Maine.

The newspapers, which talked about the Ross brothers and Acadian Sea Plants perspectives equally due to journalistic standards, may have been responsible for heightened tensions and elevated distrust. Results showed that newspapers and stakeholder testimony followed the same general trend of distrust in others and the state, but stakeholder testimony mentioned distrustful comments almost twice as often as the newspapers wrote.

This distrust did not leave this research untouched. This project was constrained by the fact that stakeholders were reluctant to give out names of people they disliked or distrusted. This led to landowners, who were more private and hard to contact, left out of
the interview process. To include some aspects of landowner perspectives, a newspaper analysis was done to help balance out the data collected. Another aspect of this project was to compare stakeholder perspectives to the *Ross v. Acadian Sea Plants Ltd.* Supreme court decision, but the results are currently still pending.

Newspapers that discussed the DMR plan at times used phrases that suggested distrust, such as using phrases such “apparently more extensive”. This distrust may also be seeded from United States versus Canadian feelings. Setting aside the fact newspapers referred to the Ross brothers as “Maine natives” and mentioned Acadian Sea Plants status as a Canadian company, one newspaper discussed a heavy critic of harvesting living in New York as “an eighth generation Mainer who grew up in Freeport.” This also suggests that Mainers tend to trust those who are naturally from the area.

Othering language found within local newspapers may be partly to blame for stakeholder’s concerns about the *Ross v. Acadian Sea Plants Ltd.* court case. Alongside their already vivid experiences of other countries’ demand for American products, newspapers now cover a story of a Canadian company moving into United States territory, and the Americans who are uneasy about new development Downeast. This was further complicated by the fact many landowners, while American, were not true Mainers. This could be the blame for why stakeholders are so distrustful of others, were also so willing to work with the Department of Marine Resources and place some trust in state regulation and management.
Despite distrust of Maine management, many stakeholders still approved of the Department of Marine Resources Management Plan. The DMR Management Plan was set up for adaptive management, invited a board of stakeholders to help draw up the regulations, and had with a period that accepted public commentary. This engagement is likely one reason for the support of Maine management.

Although stakeholders are not inherently trustful of the state government, the fact that the Department of Marine Resources fishery plan was in part created by stakeholders like themselves, allows for some hope that the state could properly manage the resource, despite well-known government limitations. A few stakeholder’s discussed the plans use of adaptive management, and others were comforted by the fact that they had a say above foreign influences. This brings up the stakeholder who participated because of their past experiences with management, such as the one which talked about Russian fishing boats. This quote simultaneously showed a cautious support of Maine management while also showing subtle distrust of Canadian based companies. While one stakeholders believed that tensions about the court case in Downeast Maine would have happened regardless, a couple other stakeholders also spoke about how a Canadian company made stakeholders distrustful, especially those who sided largely with the Ross brothers.

While newspaper evidence was able to suggest that there was built tensions between stakeholders, the topic of trust and distrust was notably highest in stakeholder testimony. Many stakeholders discussed the difficulty for harvesters and others dependent on rockweed to communicate with landowners, particularly those who were
usually out of state. One stakeholder mentioned that it would be hard to ask for permission to harvest if stakeholders were reliant on summering residents. Other stakeholders discussed that many landowners from out of state did not understand enough about rockweed to make proper management decisions. One stakeholder mentioned a story of a friend disgusted by rockweed until they discussed it at the friend’s Maine summer home, stating that it wasn’t until they taught the resident about the seaweed did they understand its importance to the ecosystem. In addition, another stakeholder discussed that information had become skewed by misinformation, suggesting that well-discussed political feelings of “fake news” could also be impacting thoughts on rockweed fisheries management.

While one stakeholder made a small mistake while describing scientific data, it was newspaper articles which showed the highest amount of scientific misunderstandings, often stating that rockweed was a plant or correcting other inaccuracies in interviewees quotes. One of the biggest court decisions in the Ross v. Acadian Sea Plants Ltd. case is whether *A. nodosum* is a plant or animal, so this observation is not surprising. Meanwhile, stakeholders would often clarify that *Ascophyllum nodosum* was not a plant when asked about Ross v. Acadian Sea Plants Ltd.. This explains why there was so much eagerness of particularly Acadian Sea Plants Ltd. side-leaning stakeholders to back up their opinions, and why they discussed local research projects, such as ones currently run by Bigelow Laboratories. Although one stakeholder did not seem to mind whether rockweed was considered a plant in the legal
sense, other stakeholders used the courts definition of rockweed as a plant to call for more education.

Most of solutions proposed from stakeholders involved more research, but was relatively well spread between education, industry, stakeholder engagement, and aquaculture expansion as well. Meanwhile, newspapers proposed boosting the economy through industry to be the most favorable solution by far. This suggests that stakeholders realize that a variety of solutions could be used together to enhance the rockweed fishery. This was seen with one stakeholder who incorporated stakeholder engagement in Cobscook and research to better understand rockweed biology. Newspaper media may be focused on the industry so squarely due to the economy being easy to understand for those not involved in fisheries management.

Overall, stakeholders were shown to be more devoted to finding solutions and expressed cultural significance in the rockweed industry when compared to the media. While newspapers focused highly the Ross v. Acadian Sea Plants Ltd. Maine Supreme Court legal case, solutions to the rockweed industry had also been discussed. It is possible that the amount of time dedicated to talking about the court case may have increased stakeholder distrust, but stakeholders largely cited past management mistakes and concern for seasonal landowners also play a role as well. Both stakeholders and the media shared a similar amount of scientific uncertainty, suggesting the need for increased scientific literacy and communication with the public. On a positive outlook, the Ross v. Acadian Sea Plants Ltd. court case has had an impact on the Maine community. With
more newspapers discussing rockweed, more of the public is becoming aware of the macroalgae. This allows a chance for the public to educate itself on Maine’s rocky intertidal, as well as give precedent for researchers to perform more relevant studies on rockweed in the future.

Even though most stakeholders struggled to come up with cultural values for *Ascophyllum nodosum* initially, every stakeholder discussed rockweed’s intrinsic value to the coast. Those stakeholders who leaned more towards the side of the Ross brothers were quick to mention rockweed as an ecosystem—serving as food or shelter for invertebrates, fish, and lobster larvae. Other stakeholders discussed briefly the history rockweed has had on the North Atlantic coastlines for both human and geological developments. Both newspapers and stakeholders discussed *A. nodosum*’s high resilience, however stakeholder testimony did discuss it more often.

With time, stakeholders talked about using rockweed on a more personal level. Many stakeholders admitted to using *A. nodosum* for their local gardens, as Mainers had been using washed up knotted wrack for centuries now. Others mentioned *A. nodosum*’s commercial use as organic fertilizer and how it affected their own lives. Although newspapers covered that *A. nodosum* talked about its role as a part of the Maine coast and agriculture much less than stakeholders, it was still present as a resource people use in their own lives.
With all this information found between biomass assessments, stakeholder testimony, and newspaper analysis, it remains resounding clear that Mainer’s hold a great deal of care for their natural marine resources. Although *Ascophyllum nodosum* is a small part of the Maine working waterfront, its potential to help fisheries and become harvested itself has created a great deal of controversy to its management.
CONCLUSION

Given the data collected, more research is needed to generate a complete list of ecosystem services of harvested and unharvested areas of the Maine coast. Data supported the idea that geographic location can alter perspectives on the *A. nodosum* industry, increasing with proximity to Washington County. Data also suggests that rockweed biomass varies greatly along the Maine rocky intertidal coast. This aside, stakeholders cared more about intertidal rights for a range of fisheries, rather than just *A. nodosum*, and were often driven by past personal experience. Those who sided more with Acadian Sea Plants Ltd. were often economically driven and wanted new industries in poorer regions in Maine. Those who sided more with the Ross brothers were concerned about potential overharvesting and its affect on already profitable Maine fisheries. Overall, stakeholders agreed more research, education, and outreach was needed for the rockweed fishery. Data supported that newspaper data had less bias compared to stakeholders on the *Ross v. Acadian Sea Plants Ltd.* court case, but still held bias when discussing those who were from Maine. This could have helped escalate tensions and lead to more stakeholder distrust for others. Due to the small sample size and difficulty gathering different types of stakeholders using the snowball approach, more data is needed to create more concrete decisions on exactly how many ecosystem services exist and how important they are to local and statewide economies. A follow-up to see stakeholder reactions after the *Ross v. Acadian Sea Plants Ltd.* case is closed would also be worth investing in the future.
WORKS CITED


Hill v. Lorde. 48 Me. 83, 96. (1861).

http://www.pressherald.com/2017/03/21/judge-rules-that-rockweed-harvesters-need-to-obtain-landowners-permission/


APPENDIX A: ADDITIONAL RESULTS

Figure 7: Stakeholder and newspaper data mirror each other with a notable exception of the “inaccuracies” category. Concerns that buzz words such as “conservation” and “sustainability” are not properly understood by the public is expressed in graph above.

Both stakeholder testimony and newspaper articles discussed the topics “sustainability” and “conservation” haphazardly. Stakeholders mentioned sustainability and conservation 6 and 10 times respectfully. Newspaper media had a slightly higher rate, with 7 and 12 mentions respectfully. Unsurprisingly, stakeholders discussed whether it was biologically worth harvesting A. nodosum more often than newspaper articles. There were 5 stakeholder mentions of A. nodosum explicitly being “worth harvesting,” with 8 explicit mentions of A. nodosum not being worth harvesting overall. Newspapers also seemed to agree that there were more reasons not to harvest A. nodosum than to harvest the macroalgae, with 6 mentions against harvest and only 2 mentions for its collection. Interestingly, there was only one explicit moment where a stakeholder misunderstood scientific information, while newspapers displayed 5 different inaccuracies. Overall, trends between stakeholder and newspaper data continued to vaguely mirror each subcategory.
Figure 8: Stakeholders were more vocal about *A. nodosum*’s cultural importance than newspaper data.

Many stakeholders had trouble answering what cultural impact *A. nodosum* had when directly asked, many discussed its intrinsic value to coastlines, agriculture, and its resilient biology. Stakeholders mentioned that *A. nodosum* was a part of the coast 23 times, important for agriculture 11 times, and resilient 9 times. These numbers were much larger than newspaper data, which respectfully mentioned each category 9, 2, and 7 times. The discrepancy in agriculture data was the most jarring. While stakeholder testimony mentioned noise of harvesters occasionally, it was not included in cultural impact because they themselves did not believe the noise to be harmful. Newspaper testimony showed landowners and other stakeholders being upset by the noise 3 times, however.
APPENDIX B: HUMAN SUBJECTS

The original copy of the approved Human IRB paper was also sent to the Honors College alongside a PDF and word document of this honors thesis.
APPENDIX C: BIOMASS ASSESSMENT RAW DATA AND OBSERVATIONS

Fegley, J. C. (unpublished data). A quantitative assessment of the rockweed

(Ascophyllum nodosum) resource at selected sites along the coast of Maine:

Final Report January


- Destructive Biomass
  - Quahog Bay
    - 7.6 kg/m^2 “Head of Bay”
    - 18.1 kg/m^2 “Narrows” (Yarmouth Island)
    - Overall: 12.4 +/- .8 kg/m^2
    - Non parametric rank F test → statistically significant (P=.002)
  - Boothbay/Sheepscot River Region
    - 6.4 kg/m^2 (Sawyer Island)
    - 19.6 kg/m^2 (Spectacle Island)
    - Overall: 15.3 +/- 1.3 kg/m^2
  - Cobscook Bay
    - 8.7 kg/m^2 (Bar Island)
    - 23.2 kg/m^2 (Birch Point)
    - Overall: 14.6 +/- 1.4 kg/m^2

- Predictive Biomass
  - Dry weight (dw) against length/circumference^2 (lc^2)
    - Quahog Bay
• $\log(dw) = 0.518 \log(lc^2) - 1.207$
• $(r = 0.977, N = 701)$

- Boothbay/Sheepscot River Region
  • $\log(dw) = 0.844 \log(lc^2) - 3.821$
  • $(r = 0.956, N = 524)$


- Damariscotta-Pemaquid region of Maine
  o 3-6 kg/m² (Vadas, 1972; Vadas et al, 1976)


- Growth rates measured twice in mechanically cut plots tan uncut plots (winter growth: 4 cm/year +/- 11 cm for harvested treatment vs 1.1 cm/year mean +/- 10.8cm in Lower Woods Harbor Nova Scotia (Lazo and Chapman, 1996)

- Biomass (Estimated)
  o Cobscook Bay
    • 32 kg/m²
    • Turnover every two years (29-79% range)
  o Southwestern Nova Scotia
    • 9-26kg/.8362 m² (MacFarlane 1952)
- Cobscook Bay
  - 8.5-28.9 kg/m² (Vadas et al 2004)
  - 8.7-23.2 kg/m²; 14.6 kg/m² (Fegley and Vadas 2001)
- Frenchmans’s Bay/Taunton Bay
  - 6.3-15.4 kg/m²; 14.6 kg/m² (Fegley 2006)
- Lamoine, Blue Hill Bay, Castine
  - 7 +/- 4 kg/m² (Fegley 2001)
  - (+Rackliff Island) 17 +/- 3 kg/m² (Fegley 2001)
- Damariscotta River/Pemaquid Point
  - 5.0 +/- 3.6 kg/m²; 17.5 +/- 6.9 kg/m² (Keser et al 1981)
- Sheepscot River/Damariscotta River
  - 17 kg/m² (all fucoids) (Topinka et al 1978)
- Boothbay/Sheepscot River region
  - 6.4-19.6 kg/m²; 15.3 kg/m² (Fegley and Vadas 2001)
  - 5.8-19.3 kg/m²; 10.7 kg/m² (Fegley 2003)
- Quahog Bay
  - 7.6-18.1 kg/m²; 12.4 kg/m² (Fegley and Vadas 2001)
  - 6.7-22 kg/m²; 14.8 kg/m² (Fegley 2003)
  - 8.5-35.4 kg/m² (Fegley 2006)

• Ascophyllum nodosum had highest percentage cover in test area with 83.6% +/- 1.6 in control spots, 69.3% +/- 1.9 in 36 cm cut spots, and 47.8% +/- 2.0 in 18 cm cut. All stat. Sig. from matrix.

• In other studies mean percentage of A.nodosum were found via dry matter
  o [(dry weight/wet weight)*100)] by year and site


• Biomass Estimates
  o Bell Farm
    • 11.4 kg wet weight m^2 (spring) - 28.9 kg wet weight m^2 (fall)
  o Birch Point
    • 8.5 kg wet weight m^2
  o Mahar Pint
    • 26.7 kg wet weight m^2


• Average of 7 kg/m 2 wet weight may be appropriate (Jensen 1960)

• Study based off earlier study by Baardseth

• Biomass/Density
Their results: 1.5 ton/unit area

Baardseth: .8 ton/unit area


- Biomass
  - ~25 g dry weight in Stand 4 highest biomass
Figure 9: Individual *Ascophyllum nodosum* were left outside to airdry before ultimately placed in drying ovens available at Bigelow Laboratory.
Figure 10: *Ascophyllum nodosum* individuals were placed in deeper cooking trays to properly dry without damaging the oven itself.
AUTHOR’S BIOGRAPHY

Ashley E. Sarra was born in Honolulu, Hawaii on April 6, 1996 into a family with rich Naval history. After living in six different states in her childhood, Ashley graduated from Bedford High School in 2014. Majoring in Marine Sciences with a concentration in Marine Biology and a special focus in Marine Policy at the University of Maine, she hopes to use her connection to the ocean to further scientific education, research, or legislation. Ashley is a member of the National Society of Collegiate Scholars. She has received a Maine Sea Grant Undergraduate Scholarship for her research and spoke last November at the Coastal and Estuarine Research Conference in Providence, Rhode Island.

Upon graduation, Ashley plans to spend some time working in Moose Pass, Alaska as a Student Conservation Association Fisheries Technician Intern and AmeriCorps volunteer before further pursuing opportunities as a graduate student.