Navigating Coastal Decision-Making: Using shellfish aquaculture as a model for socio-ecological knowledge development

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Photo Caption: Intertidal rack-and-bag culture of oysters along Cape Shore region of New Jersey

Author's Note: This case will be used in the spring of 2017 and will be updated with notes following completion. The authors appreciate any feedback from those who use this case. Please email lindsey.c.williams@gmail.com with information on when and how the case was used, and any feedback to improve future use.

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Summary:

"He was a bold man that first ate an oyster."—John Swift, Irish essayist, novelist, satirist

The first to eat an oyster might have been bold, but they were most certainly in good company. The "lowly" oyster plays an important role in coastal ecosystems from both an ecological and social perspective. As an ecosystem engineer, oysters filter water while providing three-dimensional habitat for myriad species. Globally, the commercial impacts of oysters are noteworthy, being the third most commonly produced shellfish aquaculture species; in the US, they are an important component of coastal economies with production values growing from $89M in 2008 to over $157M in 2013 (NMFS, 2015). This case uses the challenges of selecting a location for an oyster aquaculture facility to expose students to the range of ecosystem processes and stakeholder interests at play in coastal areas, while also providing a sense of policy and management decision-making. Through concept mapping, stakeholder assessments, and mock negotiation, students will explore oyster aquaculture as a complex socio-ecological system that is indicative of many coastal systems. Students will also explore how natural and social sciences intersect with policy as we are reminded by marine ecologist and former NOAA Administrator Dr. Jane Lubchenco that "the purpose of science is to inform policy, not dictate it." This case is designed to be used over approximately six hours (in 1.5 hour classes) in an undergraduate level course. The initial design was for first-year Marine Ecology students at a community college. It can be used in policy, social or natural science focused class settings. Options are also included to modify the modules for length, content, and level.

S-E Synthesis Learning Goals:

Our case is designed to address the following S-E Synthesis Learning Goals (and sub-goals) through in-class activities and assigned work:

1. *Understand the structure and behavior of socio-environmental systems.*
   - Identify the environmental and social components of the system and their interactions.
   - Identify feedbacks and explain the dynamics of an S-E system.
3. *Co-develop research questions and conceptual models in inter- or trans-disciplinary teams.*
   - Communicate across disciplinary boundaries.
   - Understand the value of different knowledge sources and ways of knowing.
4. *Find, analyze, & synthesize existing data, ideas (e.g. frameworks or models), or methods.*
   - Identify data sources and appropriate tools, evaluate quality of data, and manage data.
   - Understand the different kinds of data and research methods used by relevant disciplines in the natural and social sciences.

Learning Objectives:

In an effort to meet the S-E Synthesis learning goals described above, the modules in this case study are designed with the following learning objectives in mind. By exposing non-science majors to marine science and/or exposing science majors to social science and stakeholder issues, students will complete the case with an:

1. Evaluate and recognize the complexity of coastal systems and their associated trans-disciplinary resource management issues by:
   a. identifying critical biologic components of estuarine ecosystems;
   b. identifying critical social components of coastal communities;

   c. analyzing connections between disciplines and data commonly considered discipline specific; and
   d. identifying the network of user groups interested in resource management decision-making, including their often hidden connections to one another, issues, and resources.
2. Define the complexities of data (limits, quality, data types) through:
   a. (further) development of critical thinking skills, and
   b. diagnosis of the appropriate use and application of varied data sources.
3. Evaluate and compare "other" perspectives; and
4. Appreciation of their personal role in complex social-ecological systems.

Please see the classroom management section for details on how the components of this case tie to the learning objectives identified here.

Introduction:[1]

PART I – Perry Raso, Oyster Farmer

Perry Raso stood in a corner of the main floor of his busy waterfront restaurant taking it all in: the noises made by happy customers as they chat, drink, eat and laugh, the rhythmic motion of servers flowing in and out of the kitchen from where complex mouthwatering aromas escape as beautiful plates of seafood are brought out, one after another. The 30-something-year-old could not help but to get emotional at the realization of his endeavors' success, the outcome of decades of hard work.

Before Perry opened this oyster bar, he was an oyster farmer. He started digging littlenecks (clams) in Point Judith Pond when he was 12 years old and grew up wild- harvesting shellfish, eel trapping, bull-raking clams and scuba diving for steamers (clams). With help from his division-2 wrestling coach, Perry managed to get into college, and while there considered becoming a medical doctor- a proven way to make enough money to buy a house. But he soon realized that medicine was not for him. He realized that if he embraced the fact that oysters were his world, then the world would be his oyster. Perry earned degrees in aquaculture and fisheries technology and then ventured into the real world to build a livelihood on the knowledge he started to acquire when he was not yet a teenager. He started his first oyster farm on a one-acre aquaculture lease and slowly expanded that to seven acres. Years later, he opened this restaurant where he now stands and most recently, bought land and started farming organic vegetables to serve with the seafood. Perry has much to be proud of, especially when considering the long journey from where he started, facing what at the time must have felt like insurmountable difficulties and opposition, to where he is now, watching the fruits of his efforts satisfy local consumers, creating numerous local jobs and promoting environmentally sustainable business practices. His story is an inspiration to many who find a life on the water their calling and want to follow in his entrepreneurial footsteps.

While we would all like to believe Perry's story could serve as a blueprint for others looking for ways to do the same, the reality is that this is more the exception than the rule. In spite of all the progress achieved in the last twenty years in the field of marine aquaculture technology and science, there are still many scientific, political, economic and social hurdles. In addition to all the items a grower must do before they begin conducting aquaculture- e.g. obtaining all necessary permits, making sure to be a good neighbor, ensuring environmentally-safe farming practices, buying all the equipment, boat, seed, etc.- is the fact that shellfish typically take between two and three years to grow to market size, sometimes longer in cooler waters. If disease and predation do not kill off the shellfish within that timeframe, the grower might just be lucky enough to potentially begin making money. Based on these challenges, it is easy to see why to this day, few folks are actually able to succeed at farming seafood in a successful and sustainable way, as Perry did. His story proves that it is doable, but certainly not as easy as it could be. This story of Perry Raso's success will be important later in this case, when you review a few issues another grower is facing with finding a good location for their aquaculture operation.

Watch Perry Raso's TEDex Providence talk: https://www.youtube.com/watch?v=oSdEQNY1mkA
Visit his website here: http://www.rhodyoysters.com/matunuck-oyster-farm/

[1] Adapted from the National Center for Case Study Teaching in Science

PART II – Case Overview

aquaculture as defined by dictionary.com

"[**ak**-w*uh*-kuhl-cher, **ah**-kw*uh*-] noun
1. the cultivation of aquatic animals and plants, especially fish, shellfish, and seaweed, in natural or controlled marine or freshwater environments; underwater agriculture."

Aquaculture is the fastest growing form of food production in the world. It is also a significant source of protein for people in many countries, including the United States. Supporters of this industry often argue that aquaculture can serve as a solution for the worldwide decline of ocean fisheries stocks, and as an answer for the inevitable increase in demand for seafood as global human population continues to expand.

Aquaculture advocates also claim that the benefits of aquaculture are not limited to those associated with growing seafood: that it can be a tool to help recover ecosystems as a whole by creating substrate for habitat recovery and to support projects aimed at preventing the extinction of endangered species. In addition, the farming of organisms that consume phytoplankton directly from the environment (i.e. filter feeders such as oysters, clams and other shellfish) alone or in combination with the farming of other species (known as polyculture) can improve water quality. Furthermore, farmed fish are generally free from environmental contaminants such as mercury and heavy metals, which is certainly a convincing human health advantage for those choosing between wild and farmed seafood.

On the other hand, many in opposition to aquaculture have reservations regarding possible negative impacts of the industry. Farming carnivorous species requires large inputs of wild fish for feed, a practice that wastes energy and protein in the process. Fish like salmon, for instance, depend on fishmeal and oil in feed made from wild caught forage fish like herring and anchovies, which are often captured from overexploited wild fisheries. Other possible negative ecological impacts from unsustainable aquaculture practices include the reduction of wild fish supplies through habitat modification, wild seedstock collection, accidental introductions of non-native invasive species, and effluent/ nutrient buildup, which can lead to eutrophication and harmful algal blooms, disease and parasite outbreaks. These are unquestionably valid concerns that if not prevented and addressed render aquaculture farming unsustainable.

In addition to ensuring their activities are in fact sustainable, proponents of sustainable aquaculture expansion- and specifically of marine aquaculture in the United States- face a number of hurdles related to regulatory policies and social acceptance of aquaculture as a valid farming practice. Studies rank the United States as one of the top countries in terms of marine aquaculture potential; however, the US produces relatively little seafood from aquaculture. Although a small industry compared with its potential, U.S. marine aquaculture is an economically important sector regionally. In many fishing and coastal communities, aquaculture creates significant jobs and supports other sectors such as seafood processing, feed and equipment manufacturing, and food service.

Experts say that in much of the country, opposition to marine aquaculture by local and national interest groups and restrictive local, state, tribal, or national policies have limited marine aquaculture to a scale far below its potential. Experts note several reason for this: (1) marine aquaculture is relatively small, diverse, and (with some notable exceptions) unproven; (2) marine waters are public resources; (3) some Americans perceive potential negative effects of marine aquaculture as not sufficiently offsetting positive effects; (4) aquaculture faces significant social opposition; and (5) the governance system for leasing and regulation hinders the development of U.S. marine aquaculture.

Decisions regarding proper use of coastal resources are rarely simple and straightforward. Over half of all Americans live in coastal states, which creates great pressure for more development, and greater need for scrutiny in the decision making processes that authorize new projects that can place pressure on the environment, potentially diminishing the ecological, aesthetic and economic values of coastal areas. Balancing the use of resources in coastal areas with their protection requires good tools, information and the participation of multiple stakeholders, which often represent divergent opinions if not competing interests. Governmental organizations from various levels are expected to play significant roles as moderators, stewards of public resources and interests and regulatory bodies. However, lacking federal, state and regional leasing, permitting and regulatory policies that apply for different aspects of aquaculture practices may be in disharmony with local interests, creating further difficulties for those involved in this complex decision-making process.

Introductory Videos:

- NOAA National Ocean Service Ocean Facts: Aquaculture - http://oceanservice.noaa.gov/facts/aquaculture.html
- NOAA Fisheries - https://www.youtube.com/watch?v=3Oi9GARr-Xc
- Chesapeake Bay Program, Bay 101: Oysters (optional) - http://www.chesapeakebay.net/videos/clip/bay_101_oysters

Classroom Management:[2]

In this case, students will seek to explore estuaries as a complex social-ecological system while focusing specifically on oyster aquaculture as a way to understand the data, interests, and decision processes around coastal issues. Students will simulate the decision-making process that coastal managers and other relevant stakeholders go through when deciding on approving leases and/or issuing permits for the development of marine aquaculture operations.

This case is designed to encompass four 1.5 hour classes, with accompanying work outside of class. Class activities and assignments within the case can be used independently or modified to fit within a different course context. For shorter class blocks, activities may need to be modified based on the time available. Class handouts and draft assignment sheets are included as attachments to this case to accompany the detailed notes here. Suggested modifications are noted along with each class as are recommended assessments.

The basic outline of the case is arranged according to class as follows, with three homework assignments required of students (one between each class) as well as two final memos (final papers) after completion of the case.

Class 1: Introduction to case and beginning data assessment (4 activities)
- A. Warm-up discussion
- B. Introduction to Theme and Concepts
- C. Critical Analysis
- D. Conclusion and Homework Review

Class 2: Concept Mapping, Stakeholder Assessment, Negotiation prep (4 activities)
- A. Data Review
- B. Concept Mapping and Stakeholder Identification- groups
- C. Concept Map and Stakeholder ID Review- groups/whole class
- D. Stakeholder Assessment and Negotiation Preparation

Class 3: Negotiation (1 Activity)

Class 4: Debrief and Final Assignment Preparation (3 Activities)
- A. Debrief- review negotiation from last class
- B. Real World Examples Discussion
- C. Review final Assignments

Class 1:

Overview: This class is meant to introduce students to the case's general topic (i.e. estuaries as a social-ecological system and using a collective approach to the decision-making process) as well as to the goals, structure and expectations associated with each proposed activity and learning tool. This class has four components, with modifications possible for length.

SE Synthesis Goals/subgoals for Class 1:

1. Understand the structure and behavior of socio-environmental systems.

• Identify the environmental and social components of the system and their interactions.

[2] Adapted from the National Center for Case Study Teaching in Science

3. Co-develop research questions and conceptual models in inter- or trans-disciplinary teams.
- Communicate across disciplinary boundaries.
- Understand the value of different knowledge sources and ways of knowing.

4. Find, analyze, & synthesize existing data, ideas (e.g. frameworks or models), or methods.
- Identify data sources and appropriate tools, evaluate quality of data, and manage data.
- Understand the different kinds of data and research methods used by relevant disciplines in the natural and social sciences.

Materials:
- Multi-media equipment to watch online videos (w/ audio) as a class
- Hard copies/handouts of this case's Introduction section (Parts I and II)
- Highlighters, markers, pencils, paper

Homework due: n/a

Total class time: 1.5 hrs

1.1) WARM-UP ACTIVITY (15 minutes)
Activity Objectives:
- Assess student knowledge about marine aquaculture;
- Engage students in a meaningful but general discussion that helps them understand how the topic of this case (i.e. marine aquaculture) relates to their own everyday lives;
- Set up the stage for the in-depth discussion that will follow

1) The instructor should initiate the class by asking the students: "Have you ever heard of aquaculture before? What is it? Can someone please define it?". Orally elicit answers from two to three volunteers, build on their answers and rearticulate back a general definition of aquaculture, making sure to also define marine aquaculture.

2) If time permits, engage students in an informal conversation about the topic by asking more general questions about aquaculture. For example:
A. Have you ever visited an aquaculture farm or facility? Where? What was it like?
B. Have you ever eaten seafood that you know was produced in an aquaculture facility? Did it taste different? Was it more or less expensive? Were you surprised by its quality?
C. Have you ever heard of anyone who works in an aquaculture farm or lives near an aquaculture farm? What do they think of aquaculture farms?

***Assessment**:* No graded items with this task; participation grading at instructor's discretion.

1.2) INTRODUCTION TO THEME AND CONCEPTS (30 min)
Activity Objective:
- To give students enough background information about the case's topic and associated concepts so that they can begin to develop a critical analysis of all the factors, interests,

actors, variables and systems involved in the decision-making process of permitting aquaculture activities in coastal areas.

1) Ask the class to break into groups of 3-4 students and tell them they will watch a couple of videos about this case's topic. They will also read the Introduction and after that they will have two 10-minute sessions to discuss and answer the following questions within their groups:

A. Why should we care about marine aquaculture, specifically in the US?
B. What are some of the pros and cons of allowing marine aquaculture facilities to be installed and operated in coastal areas? (ask students to organize their pros and cons into two columns)

2) Watch the first Introductory Video together
National Oceanic and Atmospheric Administration, National Ocean Service - What is Aquaculture? 0:35 seconds - http://oceanservice.noaa.gov/facts/aquaculture.html

3) Give groups 10 minutes to conduct their preliminary discussion. The instructor should walk around the room to identify groups that may need help and, if necessary, facilitate their discussion to ensure all students participate and attempt to answer the questions proposed.

4) Ask students to read Perry Raso's story (first part of the *Introduction handout*) individually and to let you know when they are done. Then watch the Perry Raso's TEDex Talk (The Importance of Sustainable Aquaculture in Our Future, 11:36 minutes).

5) Give students another 10 minutes to discuss what they have learned from Perry Raso's story and presentation and to refine their answers for questions A and B above.

6) At the end of the 10 minutes, the instructor should ask groups to orally report their answers to the rest of the class. Depending on the size of the class, the instructor may choose to randomly select 2-3 groups to report back on each individual answer; if teaching a smaller class, the instructor can ask all groups to report back on each of the answers. The instructor should summarize the answers on the board, by helping students identify which parts of their answers coincide with the answers offered by previous groups, and also add, correct or supplement each of the answers, so that at the end of the 20 minutes, all students have a solid understanding of the case before them. Explain to students that these answers are not definitive and that they will be asked to revisit and edit their answers as they progress.

Assessment: Formative assessment of progress towards learning the objectives of the case, grasping the topics at-hand, and connecting critical ideas from resource materials. No graded items with this task; participation grading according to instructor's discretion.

SLO-Learning Goal Connection:

- S-E Synthesis Learning Goal 1: Understanding structure and behavior of socio-environmental systems
- SLO 1- evaluate and recognize complexity of coastal systems
- SLO 4- appreciation of personal role within complex systems

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MODIFICATIONS

1) This case and its activities can be condensed by either reducing the time used for each section and/or assigning sections as individual or group homework assignments.

2) For those looking to add resources, or who have students interested in multispecies aquaculture, consider: Bren Smith Vertical (3D)Ocean Farming - https://www.youtube.com/watch?v=j8ViaskDSeI

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1.3) CRITICAL ANALYSIS (30 min)

Activity Objectives:

Assist students so that they can:

- Identify interests and arguments for and against expanding aquaculture in coastal areas
- Recognize potential environmental impacts from marine aquaculture activities
- List common scientific, political, economic and social hurdles that proponents of marine aquaculture often face
- Identify which of the points and opinions presented in the *Introduction Handout* and video presentations are ambiguous and should be backed up by data, facts and statistics in order to be taken into consideration.

1) Tell students that they will continue working in groups and that they will be given 20 minutes to:

A) Read the second part of the *Introduction Handout* (i.e. Case Overview);

B) Examine each section of the Case Overview and identify which statements are unclear and require specific data, facts and statistics in order to be trusted. Are there any logical fallacies, generalizations, simplifications that undermine the integrity of the information provided? Do any conclusions or arguments rely on inappropriate or potentially unrepresentative statistics?

C) Revise the list of pro and cons they made earlier, by adding, removing or changing items to each column

2) Before allowing groups to begin working on the three tasks above, the instructor should make sure the class understands what they are supposed to do and have a plan of action to complete the tasks. Specifically, make sure all groups know how to perform the critical analysis of the information presented in the Case Overview. Below is an example of a technique, the Critical Analysis Matrix, that can be used by students during this activity. This is a common tool used by educators to assist students develop critical thinking, evaluate the quality and completeness of arguments and data presented to support specific positions, identify fallacies and eventually develop their own conclusions about the validity of statements. If you have already used one in class, or have other examples you prefer, please feel free to modify to your preferences.

3) Remind students that they don't need to analyze every single statement made in the text but instead they should identify the most important arguments in favor and against the expansion of marine aquaculture and then scrutinize that statement's reliability and need for additional data to support or rebuff such argument.

Critical Analysis Matrix

Statement	Is this a statement that requires more or better data/ information in order to be trusted?	What types of data, facts or statistics are needed to validate this statement?
Aquaculture is the fastest growing form of food production in the world.	Yes; authors did not offer any data to back this statement up	Rate of growth of aquaculture activities in the world (i.e. change in global production in weight or revenue per time)
Aquaculture is a significant source of protein for people in many countries, including the United States.	Yes; authors did not offer any data to back this statement up	What percentage of the total protein consumption in the US and world comes from seafood produced by aquaculture?

Assessment: Formative assessment of progress towards learning the objectives of the case, grasping the topics at-hand, and connecting critical ideas from resource materials. No graded items with this task; participation grading according to instructor's discretion.

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MODIFICATION

Use this as a springboard to talk about critical reading of online sources in a social media age. See for example: http://www.wsj.com/articles/most-students-dont-know-when-news-is-fake-stanford-study-finds-1479752576 and https://sheg.stanford.edu/upload/V3LessonPlans/Executive%20Summary%2011.21.16.pdf.

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1.4) CONCLUSION and HOMEWORK EXPLANATION (15 min)

1) At the end of the time allotted for the Critical Analysis activity, ask students to orally report on the status of their group's analysis. The focus here should be not so much on the outcomes of the analysis but on the process itself. Ask if the group found this activity too easy, feasible or too difficult? Keep in mind that the students will need to carry out similar critical analysis individually in order to complete their homework assignments and prepare for the Class 2. Thus, make sure that all students feel comfortable with the logical steps one must follow in order to analyze claims, text and context.

2) Explain that in order to prepare for the discussion and activities they will be doing in Class 2, students will have to read a number of peer-reviewed papers and reports and use the information and data presented in these sources to either accept, refuse or correct the claims and statements they identified as incomplete during today's Critical Analysis activities. Convey to students the

importance of completing the readings and the homework assignment in light of the goals for the next meeting.

3) Explain the Homework Assignment in detail (see below) and answer any questions the students may have about it.

Class 1 Assignments:
Text below can be used or modified to provide to students as the assignment.

Overview and critical analysis – Due before Class 2:
Read the following peer-reviewed papers and technical reports (1-3) and then answer the following questions (A-D).

1) Naylor, R. L.; Goldburg, R. J.; Primavera, J. H.; Kautsky, N.; Beveridge, M. C. M.; Clay, J. Folke, C.; Lubchenco, J.; Mooney,H. ; Troell,M., 2000. Effect of aquaculture on world fish supplies. *Nature*, 405: 1017-1024. Available: http://www.nature.com/nature/journal/v405/n6790/pdf/4051017a0.pdf

2) Gunnar K. and M.C. Rubino (2016) The Political Economics of Marine Aquaculture in the United States, *Reviews in Fisheries Science & Aquaculture*, 24:3, 213-229, Available: http://dx.doi.org/10.1080/23308249.2015.1121202.

3) Marine Aquaculture Strategic Plan FY 2016-2020 by NOAA Fisheries. Available: http://www.nmfs.noaa.gov/aquaculture/docs/aquaculture_docs/noaa_fisheries_marine_aquaculture_strategic_plan_fy_2016-2020.pdf

Homework Assignment Questions:

A. Using the information provided in the reading assignments, in addition to any reliable sources you may be able to access, find the data that can be used to support or reject each statement that you identified as arbitrary during the Critical Analysis that you conducted during Class 1 of Module 1. This should include at a minimum 5 items requiring support to validate a claim; the same resource may be used to support multiple claims.
   Assessment: 10 points total; 5 points for the 5 items requiring data, and 5 points for noting appropriate data and sources to support the claims

B. Now that you have read and learned a lot more about this issue, revise the list of Pros and Cons associated with marine aquaculture that you created during Class 1. Add any new items to each column and rank each of those items according to their relative importance. Finally, classify those items into the following categories: Environmental/ Ecologic Impacts (may be positive in the case of the pros or negative in the case of the cons); Economic Gain or Loss; Social and/or Cultural Impacts; Other Effects. Note that some items may fall into more than one category.
   Assessment: 10 points total; Students must show a minimum of 3 items within the pro and 3 items within the con listing, as well as show they placed the pro and con items into one of the 4 categories listed (4 points for each category showing a pro/con).

C. Formulate 3-5 questions that you think need to be answered before we can move on to the next phase of this Case (concept maps focused on the connections between the various factors, elements and stakeholders involved in this case).
Assessment: 10 points total; minimum 3 questions, with information related to the topic at hand.

Assessment of Homework Assignment 1: 30 points total; 10 points per question (noted above with the questions and summarized here). This is a summative assessment of student's critical thinking ability. A= 5 points for the 5 items requiring data, and 5 points for noting appropriate data and sources to support the claims. B= Students must show a minimum of 3 items within the pro and 3 items within the con listing, as well as show they placed the pro and con items into one of the 4 categories listed (4 points for each category showing a pro/con). C= 10 points for the minimum 3 questions, with information related to the topic at hand.

SLO-Learning Goal Connection (applies to formative assessment during class, and summative assessment in the assignment between Class 1 and Class 2):

- SE Synthesis Learning Goal 4: Find, analyze, & synthesize existing data
- SLO 2- define the complexities of data

Instructor prep work note: Prior to class 2, the instructor should determine how best to break up the class for the negotiation in class 3 as the materials need to be handed out in class 2. When assigning roles, be cognizant of your class composition. Be sensitive to diversity in your classroom; avoid negotiation groups with only one member of an underrepresented group if at all possible. There are five roles in the negotiation. Students can be divided into multiple groups of five, teams, or a mix depending on the size of your class. See modification options in the following section for options to create additional roles to accommodate various class sizes.

Class 2:

Overview: This class has four components: a beginning discussion on data (10 mins), group concept mapping (30 min), whole class mapping review (25 min), stakeholder assessment and negotiation (25 min). Possible modifications on each section can be used to shorten the class, adjust for class size or level (e.g. upper level or graduate student modifications).

SE Synthesis Goals/subgoals for Class 2:

1. Understand the structure and behavior of socio-environmental systems.
• Identify the environmental and social components of the system and their interactions.
• Identify feedbacks and explain the dynamics of an S-E system.
3. Co-develop research questions and conceptual models in inter- or trans-disciplinary teams.
• Communicate across disciplinary boundaries.
• Understand the value of different knowledge sources and ways of knowing.
4. Find, analyze, & synthesize existing data, ideas (e.g. frameworks or models), or methods.
• Identify data sources and appropriate tools, evaluate quality of data, and manage data.

Materials:

- Paper
- Post-it notes
- Dry erase or chalk board
- Pens, markers, etc.
- Negotiation Background and Bio handouts (see attachment)

Homework due: Assignment 1 (overview and question responses)

Total class time: 1.5 hrs

2.1) DATA REVIEW (10 mins)
Activity Objectives:

- Ensure students have clear understanding of supporting data, and
- What data is appropriate to support claims or statements of fact.

1) Begin by reviewing some of the responses provided in the assignment regarding data appropriate to support the claims made in the Case Overview. Address the whole class with some of the more prominent sources that should be noted, including:

a. National Oceanic and Atmospheric Administration (NOAA)
b. US Department of Agriculture
c. Science
d. Nature
e. Any other peer reviewed journals.

2) Query the class to see why they selected the references, and how they went about selecting those citations. Ask generally to the entire class, *can anyone tell me why they selected a certain citation, how they went about finding the reference, and why it seemed appropriate for this purpose?*

3) Once 3-5 students have provided their feedback, address the class on appropriate data for the sciences (peer review) versus public consumption (general media sources). Depending upon previous class discussions, this discussion may be relatively short (e.g. if data and sources have been addressed already in this class or a pre-requisite). The authors of this case study intend to provide the class with a general overview of appropriate sources. This will include a discussion on how the class uses popular and public sources such as YouTube, but for a scientific paper peer reviewed journal articles, technical reports, and scholarly books are required. Popular and public knowledge is critical to understanding an issue; however, for science, peer review is the one and only standard.

Assessment: Formative assessment of progress towards learning the objectives of the case, grasping the topics at-hand, and connecting critical ideas from resource materials. No graded items with this task; participation grading according to instructor's discretion.

SLO-Learning Goal Connection:

- SE Synthesis Learning Goal 4: Find, analyze, & synthesize existing data
- SLO 2- define the complexities of data

2.2) ESTUARY CONCEPT MAP AND STAKEHOLDER BRAINSTORMING (30mins)

Activity Objectives:

Assist students so that they can:

- Identify the critical socio-ecological components of an estuary
- Appreciate the breadth of stakeholders and societal concerns involved in environmental situations
- Begin to build the connections between the estuary components that are typically reserved for ecology or biology class and those of social sciences

1) After the introductory discussion outlining the activities for the day, the class should begin the process of brainstorming the critical components of an estuary. The brainstorming sessions should also include a basic mapping of the connections between ideas to begin the process of understanding how all the items are interrelated. Break the class into groups of no more than 4-6 students (for larger classes) or conduct this activity with the entire class if using in a seminar of no more than 20 students.

2) The following dialog and prompts should be stated to the entire class, or handed out to the groups for them to use as task instructions. For this task, it is recommended that easel paper or dry erase boards be provided to each group, as well as a stack of post-it notes. The students will place members of the concept maps into post it notes, and then draw connections on the easel paper or dry erase board. A chalkboard or notepaper, computer, etc. will all work fine for this task and is at the discretion of the instructor and students.

Now that you have a basic understanding of shellfish aquaculture and some of the issues the industry faces, your task is to develop a concept map. A concept map is a way to visually identify critical topics, issues, or items related to an overarching theme, with clear connections between the topics, issues, or items noted. In simplest terms, this outlines relationships, such as a family tree, but with many more connections between the family members, or items of the diagram. For today's topic, however, you may find that some diagram items do not have as clear of a relationship as they would in a family tree because coastal issues are not always neat and easy.

The first item I want you to develop, as a group, is a concept map of all items you can think of when we discuss an estuary. This should include the biological and ecological aspects as well as any societal or community items that come to mind. Think back to your homework reading and our discussions over the semester to help brainstorm these ideas. Once you have most of the members of your concept map on paper, you should next connect the ideas. For instance, oysters filter phytoplankton, so a line between these two members of the map should be drawn. You will have 20 minutes for this task, so I suggest you allot 10 minutes to develop ideas and 10 minutes to determine all potential connections between members.

Please provide as many items as your group can think up in the 20 minutes provided; more information on this diagram is better than less. This mapping will help you to better understand the complex systems of estuaries. We will review the key items as a class after all groups are finished.

As the students are developing their group concept maps, the instructor should walk around to assist groups who seem to be unable to think of ideas, are off onto tangents, or simply stop brainstorming after a period of time.

3) After allowing 20 minutes for development of group concept maps (or less time if groups seem to be done earlier), circle back with the entire class and have them focus now on the stakeholder brainstorming. Some of the items in this task may have been noted in the concept mapping (e.g. oyster grower). For this task, the students remain in their groups and are provided the following (or instructor states):

Now that you have critically considered the multitude of components within an estuary, I want you to identify all the stakeholders you think might be associated with an estuary. A stakeholder is someone that has an interest (or a stake) in the topic being discussed. For this mapping, please be as broad as possible with your listing of stakeholders. If you include too many people or roles, we can work to reduce the number later, but it is better at this time to try to include everyone you think is interested in activities within an estuary.

Assessment: Formative assessment of progress towards learning the objectives of the case, grasping the topics at-hand, and connecting critical ideas from resource materials. No graded items with this task; participation grading according to instructor's discretion.

SLO-Learning Goal Connection:

- SE Synthesis Learning Goal 1- Identify environmental and social components and their connections
- SE Synthesis Learning Goal 3- Co-develop concept models
- SLO 1- evaluate and recognize the complexity of coastal systems
- SLO 3- evaluate and compare "other" perspectives
- SLO 4- appreciation of personal role in complex systems

2.3) CONCEPT MAP AND STAKEHOLDER BRAINSTORM REVIEW (25 mins)
Activity Objectives:

- Ensure critical concepts are addressed
- Review concepts previously noted throughout the class
- Explore processes for data (e.g. student knowledge) application and synthesis

This case is using shellfish aquaculture as a lens through which to view the complexity of estuarine ecosystems, combining the many concepts and topics addressed throughout the semester. The instructor must ensure key topics are addressed by the students.

1) First, have all groups post their maps and stakeholder assessments on a wall or desktop. Then have each group move around the room (clockwise, counterclockwise, etc - in an orderly fashion) to see the other maps and brainstorming ideas. As they do this, note to the students that you want them to consider two items:

a. *Do you find any other maps interesting, revealing, helpful, etc.?*
b. *Reviewing other maps, think about how you went about creating your map.*

2) Bring the class back as one group to ensure that critical concepts are addressed.

c. Ask each group to report out on their process of building the concept map and stakeholder diagram, as well as to provide one item that they found useful from the other maps. This may include the lay-out, colors, another member of the maps they did not consider.
d. **Modification:** For larger classes, or when time is limited, it may be best to simply ask 1-2 groups to report on their process, and to provide 1-2 key items they noted from another group's map.

As the groups are going around reviewing the other maps, review to see if any critical items are absent. Consider that at a minimum, the maps should include:

1. Bivalve filter feeders as ecosystem engineers- they filter the water to reduce turbidity and eat plankton- phytoplankton and zooplankton, positively affect nitrogen cycling; and serve as habitat builder (typically via reef formation, but the gear is serving that role in aquaculture).
2. Aquaculture provides a local industry- local economy- local community resiliency.
3. State and Federal regulatory agencies regulate the siting and operation of farms via leases, permits and licenses.
4. User conflicts are bound to occur within the densely populated coastal zone, including conflicts with recreational uses- boaters, fishers, jet skiers; birders; and potential issues with other commercial fishing industries such as crabbers or other fisheries (e.g. oyster fishery).

Instructor Note: An example of the estuary concept map and stakeholder brainstorming are provided in the attachments to this case [see *Instructor Slides*], along with two examples of actual concept maps- one created by the authors and one by an undergraduate class. Page 8 in that file is an example of modification #2 listed below.

Additionally, more information on estuaries may be found at: https://www.epa.gov/nep/basic-information-about-estuaries.

Assessment: Formative assessment of progress towards learning the objectives of the case, grasping the topics at-hand, and connecting critical ideas from resource materials. No graded items with this task; participation grading according to instructor's discretion.

SLO-Learning Goal Connection:

- SE Synthesis Learning Goal 1- Identify environmental and social components and their connections
- SE Synthesis Learning Goal 3- Co-develop concept models
- SLO 1- evaluate and recognize the complexity of coastal systems

- SLO 3- evaluate and compare "other" perspectives
- SLO 4- appreciation of personal role in complex systems

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MODIFICATIONS

1) To shorten the exercise, students can focus on brainstorming the components of the system and not worry about the connection arrows.

2) A single concept map merging the social-ecological components can be created to adjust the time spent on this activity or if your course goals include underscoring the connections across systems more than connections within the social or ecological system. For this modification, ask students to think about an estuary as a coupled human-natural system and create a concept map including all elements and connections. An example of a map created under this direction is included in the Concept Map Example slides.

3) If taught at a higher level or within a seminar, we recommend the students be grouped in pairs for this discussion, with the majority of the mapping conducted with the entire class.

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2.4) STAKEHOLDER ASSESSMENT, NEGOTIATION BASICS, AND PREP FOR CLASS 3 (25 minutes)

For this task, students should remain as a whole class and develop a notional "stakeholder assessment" guided by the instructor.

1) The instructor should note to the students that a stakeholder assessment is a tool used in several different settings to explore the parties in a dispute or conflict and seek to understand their interests (represented in the cells of the table). The instructor should also spend some time discussing the concept of "interests" versus "positions" in framing views and needs of stakeholders (see Fisher et al 2012). *Sample slides that can be used by the instructor to outline basic topics related to negotiation are provided as an attachment [see Instructor Slides, beginning on page 10].* The instructor might also consider assigning Chapter 1 of Fisher et al 2012 (*Getting to Yes*) as a reading. These concepts are key to understand as they are included in the assessment activity (reflective memo) for this portion of the case.

2) Students are asked to brainstorm ideas to fill in the blank table. This can be done on a chalk board or white board, easel paper, or electronically using the blank template in the slides. While there are no right answers to this exercise, the instructor may wish to steer the discussion towards the ideas presented in the negotiation bios and in the data exercise.

After completing the table, the instructor should note that the class has gone through this exercise as preparation for the upcoming mock negotiation. The instructor may use this time to reiterate several negotiation concepts from the sample slides.

Sample completed stakeholder assessment (also provided in slides):

Stakeholder/ Issue	Compliance	Endangered species	Economy	Outdoor Recreation	Water Quality
Grower/ Aquaculturist	follow rules from agency	Avoid impact	Maintain job	Time on water at work	Clean water for oysters
Coastal Property Owner	Not concerned	Want to see species thrive	Want property value to inc.	Views and access to boat	Clean water to swim
Conservation /Env. NGO Rep	Comply with ESA	Want to see species thrive	Want people to donate	Access to birdwatch	Clean water for birds
Local Chef	Comply with health standards	Avoid impact (PR angle)	want people to eat out	Not concerned	Clean water for oysters
Gov't Decision maker	Comply with fed and state laws and regs	Protect as required under ESA	Strong tax base to fund work	Maintain access	Clean water per CWA

3) Close class by handing out the role bios and negotiation overview (see attachment). Underscore that this is not a "game" – mock negotiations are a tool used in professional trainings, community workshops, etc. Underscore that students should be careful to think about whether they are falling into stereotypes in playing their "character." Remind students not to discuss their role bios with each other before class.

Assessment: Formative assessment of progress towards learning the objectives of the case, grasping the topics at-hand, and connecting critical ideas from resource materials. No graded items with this task; participation grading according to instructor's discretion.

SLO-Learning Goal Connection:

- SE Synthesis Learning Goal 1- Identify social components and connections
- SE Synthesis Learning Goal 4- understanding different methods
- SLO 1 - identify critical social components of estuary
- SLO 3- evaluate and compare "other" perspectives
- SLO 4- appreciation of personal role in complex systems

Module 2 Assignments:

The text below can be used or modified to provide to students as the assignment along with the overview and bios. The negotiation overview and role bios for this assignment and the following class may be found in the attached file titled *Navigating Coastal Decision Making…Student Handouts*. Class 1 material is contained within pages 1-3 of this attachment; the handouts for the

negotiation begin on page 4. To prepare the students for the assignment, besides handing out bios, the following text (or modified version for class needs) should be provided in hard copy/electronic copy format to the students.

Negotiation Prep – Due before Class 3 (negotiation day):
Read the negotiation overview document and the bio for the role you were assigned. DO NOT SHARE YOUR BIO WITH OTHER STUDENTS BEFORE THE NEGOTIATION. Explore the links provided and think about the data already discussed so far in class. Consider how the data might be useful in the negotiation either to support your interests or create creative solutions with others.

At the beginning of class, submit a list of 5-10 short bullets on the following topics -

- Thoughts about the interests of your role and the interests of other roles,
- what type of data you would like to have access to,
- possible creative solutions to offer in the negotiation, etc.

These should help you frame your thoughts for the negotiation (you should also bring a copy for your own use in the negotiation).

Assessment: 10points. This is a formative assessment used to prepare students for the Class 3 negotiation. If students provide a listing with a minimum of 5 bullets (2 points per bullet), they receive full credit. Scores will be reduced by 2 points for each bulleted item below 5, or where the information does not pertain to the topic/roles.

SLO-Learning Goal Connection:

- SE Synthesis Learning Goal 1- Identify environmental and social components and their connections
- SLO 1- evaluate and recognize the complexity of coastal systems
- SLO 3- evaluate and compare "other" perspectives

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MODIFICATIONS

1) For higher level classes or those teaching management or policy course, add to the above assignment the following items.

a. All students- regardless of role assigned for the Class 3 negotiation - read through the Public Trust Document included in the attachments.
b. Students are asked to provide a 1-2 page (single spaced) *description of 1) how the Public Trust Doctrine should be applied in this case, 2) how it may influence negotiations, and 3) why it is an important component of coastal marine management decision-making*.
c. Instructor states to the students: *Outside resources are welcome but not required. The purpose of this assignment is to get you (the student) thinking about our upcoming negotiation and how legal/regulatory items may influence the process. Please provide thoughtful answers that rely on the attached document as well as your review of your role in the negotiation.*

Assessment: 30 points. This is a formative assessment used to prepare students for the Class 3 negotiation. Thoughtful responses to each item will receive 10 points; there is no partial credit as there are no right/wrong answers, only those with or without thought to the assignment.

2) If working with a seminar or graduate level class, a modification to the assignments between classes two and three is as follows. First, include all assignments listed above. Second, include an additional concept map, if you did not already have the students map socio-ecological connections found within the estuary. The following can be directly supplied to the students.

Based on the concept mapping, stakeholder brainstorming, and the work we did in the previous class, your assignment is to build a concept map of how you envision the farm described by Perry Raso in his TEDx video. This must include the biologic and ecologic components, the aquaculture structure (e.g. gear, vessel, etc.), and the stakeholders that interact with Perry and his farm. If you wish to expand the idea to his restaurant, that is acceptable so long as you adequately address the on-farm socio-ecological dynamics. You must also include a brief legend listing out those items you identify as biological, those which as social, and those which overlap the disciplines. If an item overlaps, please also note where you think it should primarily reside (e.g. is aquaculture gear more of a biologic item or more social). You can use a color scheme on your mapping as well to identify these three categories, with a legend explaining the colors.

Since it may be unfamiliar to some of you to combine the ideas we have been discussing, you will be working in pairs to complete this assignment. Only one map is required per pair, but it must include the following:

1. Biologic/Oceanographic elements
2. Social elements/roles
3. Interactions- clear connections between members
4. Connections between biological and social components

If possible, the inclusion of feedback loops is welcome but not required. This is possible for some students with a greater knowledge of marine and coastal ecosystems or coastal community dynamics.

In addition to the map, with attached legend, please also provide a 1-2-page explanation of the process your pair used to develop the map and interactions. You can use bullets or short answers to provide the requested information, so long as you completely answer the following:

1. Basic outline of the process- e.g. listed ideas, then connections, then revised
2. Was there disagreement on any items, or any roadblocks in the development of the map (if none, please note)?
3. Did you favor biological or social items when first developing the map? why?
4. What knowledge did each partner bring to the process? Please list name and general knowledge field, topics, etc.; these should be agreed to by both partners in the process.

Instructor Note: if possible pair those who have the same role in the negotiation; also aim to pair students with different majors, minors, and/or backgrounds to facilitate potential enhancement of the exercise (e.g. biology major with a government/environmental science major). Also allow for groups if class size dictates, however assessment of work will be difficult with multiple students providing a single map.

An example of what this mapping may look like is included in the attachments to this case [see page 8 of *Instructor Slides*], with a very minimal legend. Instructors choosing to use this modification should determine key concepts appropriate for the course and student level.

Assessment: 100 points. This is a summative assessment of students' knowledge of concept maps, estuarine dynamics, and the intersection of disciplines within a socio-ecological arena. There will be 10 points assigned for each of the listed concept map items, as well as 10 points for the legend. The associated write-up will be 50 points, with 10 points per question asked (two questions for #3).

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Class 3: **Mock Negotiation**

Overview: This class has one component (the negotiation) with a brief intro and closing by the instructor. It is designed to take the full 1.5-hour class. Possible modifications include shortening the time for negotiation, adjusting roles for class size, and providing locally specific information on laws/regulations and/or data.

SE Synthesis Goals/subgoals for Class 3:

1. Understand the structure and behavior of socio-environmental systems.

• Identify the environmental and social components of the system and their interactions.

3. Co-develop research questions and conceptual models in inter- or trans-disciplinary teams.

• Communicate across disciplinary boundaries.

• Understand the value of different knowledge sources and ways of knowing.

4. Find, analyze, & synthesize existing data, ideas (e.g. frameworks or models), or methods.

•Understand the different kinds of data and research methods used by relevant disciplines in the natural and social sciences.

Materials: Easels and markers or access to white board/chalk board for each group. Instructor may also consider displaying a copy of the agenda on a board or screen.

Homework due: Students hand in their list of 5-10 bullets at the beginning of class.

Total class time: 1.5 hrs

3.1) NEGOTIATION (1.5hours)

Instructor provides overview and ground rules for negotiation - max 5 min.

Turn over to students to run negotiation – state rep role is the "facilitator" for each group. The meeting agenda provided in the role bio document (and included below) is planned for approximately 1:15 minutes.

Basic Meeting Agenda

1) Introductions (2 min each, 10 total)
2) Meeting Purpose (2 min)
3) Discussion of interests (20 min)
4) Brainstorming options (20 min)
5) Discussion of concerns and final views (10 min)
6) Reaching Final agreement (10 min)

Instructor should rotate among groups to listen in and provide slight course correction if any group is getting off course or overly heated (some consternation is okay).

Five minute close out at the end of class for assignment reminder (negotiation debrief). If negotiations end early, you can begin short debriefs or let the class end early.

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MODIFICATIONS

1) Adjust or add roles in negotiation

- Additional roles can be added (ideas listed below):
  - Local Government Rep (Neighboring municipality)
  - Nearby Wastewater Treatment Plant engineer
  - Health Inspector/ Seafood safety advocate
  - University research scientist (options include geologist, fisheries biologist, political scientist, sociologist, etc.)
  - A wild oyster harvester
  - Aquaculture Association Representative
  - Commercial Fisherman
  - Recreational Fisherman
  - Boater (boat or jet ski)
  - Birder/Naturalist
  - Additional Decision-Makers (e.g. representatives from Dept. of Environmental Protection and Dept. of Agriculture, possibly USFWS, NOAA)
- Complicating factors can be added to each bio (ideas listed below)
  - Chef is best friends with a wild harvester
  - NGO rep is neighbor of chef
  - Property owner wants to sell land next year

2) Shorten times listed in mock agenda for attached role bios (DCOAST scenario) or leave out agenda and allow students to manage time and experience the challenges.

3) Instructor may add locally specific laws or regulations to the DCOAST or other bios.

4) Instructor may add locally specific data or issues to focus students on a nearby or course relevant geographic area.

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Assessment: No assessments during Class 3- these are contained within the assignments listed below; participation grading according to instructor's discretion.

SLO-Learning Goal Connection:

- SE Synthesis Learning Goal 1- Identify environmental and social components and their connections
- SE Synthesis Learning Goal 3- Understand the value of different knowledge sources
- SE Synthesis Learning Goal 4- Identify, evaluate, manage data
- SLO 1- evaluate and recognize the complexity of coastal systems
- SLO 2- define the complexity of data
- SLO 3- evaluate and compare "other" perspectives

Module 3 Assignments:
Text below should be provided to students as the assignment; modify as necessary for class needs.

Negotiation Debrief – Due before Class 4:
At the beginning of class, submit a list of 5-10 short bullets reflecting on the negotiation. This can include comparing your thinking as you prepared to how you felt during or after, further reflection on the type of data you would have liked to have access to, how other reacted to your proposed solutions, etc.

Assessment: 10 points. This is a formative assessment of the students' experience in the negotiation to allow them to think more critically about the negotiation process, materials required in decision-making, difficulty in managing items that cross the ecological-social disciplinary bounds, and how there may not be a clear right answer with resource management issues. There will be 2 points for each of the 5 bulleted items; scores will be reduced by 2 points for each bullet less than the minimum.

SLO-Learning Goal Connection:

- SE Synthesis Learning Goal 1- Identify environmental and social components and their connections
- SE Synthesis Learning Goal 3- Understand the value of different knowledge sources
- SE Synthesis Learning Goal 4- Identify, evaluate, manage data
- SLO 1- evaluate and recognize the complexity of coastal systems
- SLO 2- define the complexity of data
- SLO 3- evaluate and compare "other" perspectives

Class 4: Reflections and debrief
Overview: This class has three components (negotiation debrief, "real world" discussion, final assignment review) and is designed to take 1.5 hrs. The class should be split about evenly with time for the debrief and discussion of "real world" cases (approx. 35 min each with 15 min to discuss the

final assignments). Each of the three components can be shortened to fit time available. Assignments can be modified or left off to adjust for workload.

Materials: none needed

SE Synthesis Goals/subgoals for Class 4:
3. Co-develop research questions and conceptual models in inter- or trans-disciplinary teams.
• Communicate across disciplinary boundaries.
• Understand the value of different knowledge sources and ways of knowing.

Homework due: Students should hand in their bullet list of "reflections" at the beginning of class.

4.1) DEBRIEF (approx. 35 min)
1) Begin the class with a debrief of the negotiation from the class prior. Possible guiding questions to ask during debrief:

- What did you do to prepare for the negotiation? What were you thinking about when you read the bio?
- Before the negotiation, who did you think you'd align yourself with?
- Were you surprised by any of the approaches other roles took in the negotiation?
- Did you take time to think about the four elements from *Getting to Yes?*
- How did "science" come into play?
- What questions did this raise for you about decision-making? About science in policy and management settings? About how stakeholders are included (or not)?

4.2) Real World Examples (approx. 35 min)
Discussion of "what really happens," cases where decisions like this are getting made; Discuss laws, approaches to public engagement (who is "invited"), etc. Instructor is encouraged to use examples they are familiar with (especially those their students might have also heard about to drive home the connections). Prompts to gain student input and connect students back to the learning objectives (e.g. SLO4- appreciate personal role in complex issues), could include, "*Do any of you know of any examples where a situation such as this is ongoing? Have any of you experienced something like this- it does not have to be aquaculture specific? Maybe you were at a town meeting, or heard about an issue that required balancing of interests, laws, science, etc*."

In addition to aquaculture, examples could include LNG facility siting, marine spatial planning, marine protected area placement, windfarm construction, etc. When discussing the siting of aquaculture, two current examples that may be discussed include:

1. Drakes Bay Case – National Seashore, oyster farm conflict
    a. Articles on the situation: http://civileats.com/2015/08/26/the-oyster-war-what-really-happened-to-drakes-bay-farm/ and http://advocate.gaalliance.org/two-years-after-shutdown-california-oyster-farm-remains-a-community-hot-button/
    b. *Oyster Wars* (book), can be reviewed in entirety for higher level courses
2. New Jersey shellfish aquaculture in areas of red knot (migratory shorebird) use.
    a. Article: http://newfoodeconomy.com/red-knots-and-oysters-cape-may/

***Assessment**:* There is no assessment for this task; accounting for class participation at instructor's discretion.

4.3) FINAL ASSIGNMENTS DISCUSSION (approx. 15 min)
Close unit with a brief discussion about the reflective memo and final decision memo assignment.

***Final Assignments*:**
Text below should be provided to students as the assignment; modify as necessary for class needs. We recommend that this reflective memo is due two to three days after the negotiation. This gives students time to reflect, but not so much time that they forget the nuances of the activity.

Reflective Memo – Due 48 hours after negotiation is complete
For this assignment, please put your name at the end of the paper (not the top of the first page). Responses should be at least 1.5 pages (approx. 750 words) but no more than 2 pages (1000 words). All written documents should be 12pt Calibri, single spaced, with 1 inch margins.

Please reflect on the following questions. In your written response, address at least three questions. Be sure you address all subparts of the question that you chose. I recommend you create headers with the question number and/or theme so it is easy to follow.

1) What did you do to prepare for the negotiation? Was there something you did to prepare that really helped? Was there something you wish you had done?
2) Thinking back to the class discussion on negotiation and the difference between "interests" and "positions," do you think your group focused on positional bargaining or interest based negotiation or some of both? What do you think contributed to that approach?
3) Thinking back to the class discussion on negotiation and the importance of focusing at the issue at hand, were you able to separate the "people" from the "problem"? Why or why not? What does that mean for how you would approach future negotiations?
4) What steps did your group take to come up with creative solutions?
5) How much discussion was there of the data or reports you all had reviewed?
6) Did your group prepare any criteria for deciding your final agreement? How did the final agreement come about? Did you feel rushed?

Assessment: See attached rubric- [*Reflective Memo*]

SLO-Learning Goal Connection:

- SE Synthesis Learning Goal 1- Identify environmental and social components and their connections
- SE Synthesis Learning Goal 3- Understand the value of different knowledge sources
- SE Synthesis Learning Goal 4- Identify, evaluate, manage data
- SLO 1- evaluate and recognize the complexity of coastal systems
- SLO 2- define the complexity of data
- SLO 3- evaluate and compare "other" perspectives

Decision Memo – Due 2 weeks after negotiation

For this assignment, please put your name at the end of the paper (not the top of the first page). Responses should be at least 2 pages (approx. 1000 words) but no more than 3 pages (1500 words). All written documents should be 12pt Calibri, single spaced, with 1 inch margins.

You have been elected by those at the public meeting to write the final recommendation memo to the Commissioner documenting the outcome of the meeting. This memo must include references to the actual decision, roles that supported or opposed the decision, and detailed discussion of the data considered in coming to the decision (or data that the group wished it had access to). Remember to be concise and clear, the Commissioner will have about 20 minutes to read and process this to make their final decision.

Assessment: See attached rubric- [*Decision Memo*]

SLO-Learning Goal Connection:

- SE Synthesis Learning Goal 1- Identify environmental and social components and their connections
- SE Synthesis Learning Goal 3- Understand the value of different knowledge sources
- SE Synthesis Learning Goal 4- Identify, evaluate, manage data
- SLO 1- evaluate and recognize the complexity of coastal systems
- SLO 2- define the complexity of data
- SLO 3- evaluate and compare "other" perspectives

Overall Case Attachments:

A. Case Overview Handout [pages 1-3, *Student Handouts*]
B. Negotiation Preparation (Overview and bios) [pages 4-11, *Student Handouts*]
C. Public Trust Document [*Public Access Handbook*]
D. Concept Map Slides – Regular [pages 2-6 & 9, *Instructor Slides*]
E. Concept Map Slides – Modification –pages 7-9, *Instructor Slides*]
F. Negotiation Slides (include optional photos) [pages 10-22, *Instructor Slides*]
G. Grading Rubric for Reflective Memo [page 1, *Memo Rubrics*]
H. Grading Rubric for Decision Memo [page 2, *Memo Rubrics*]

Assessment:

Assessments of student learning- achievement of goals and learning objectives- is included with each task, within each class. This includes daily formative assessments of both group and whole class activities, as well as formative and summative assessments via assignments the students are assigned to do between class meetings. Connections between the tasks, assessments, and the Student Learning Objectives and Socio-Environmental Synthesis Learning Goals are noted below the assessment. Not all assessments are graded, but in the instances where a grade is not provided, instructor discretion to allot points for class participation is noted.

CLASS	TASK	ASSESSMENT	SLO	SE LEARN GOAL	MODIFICATION
1	1.2	Formative	SLO1 SLO4	Goal 1	
	1.3	Formative	SLO 2	Goal 4	
	Assignment 1	Summative	SLO 2	Goal 4	
2	2.1	Formative	SLO2	Goal 4	
	2.2	Formative	SLO1 SLO3 SLO4	Goal 1 Goal 3	YES
	2.3	Formative	SLO1 SLO3 SLO4	Goal 1 Goal 3	YES
	2.4	Formative	SLO1 SLO3 SLO4	Goal 1 Goal 4	
	Assignment 2	Formative	SLO1 SLO3	Goal 1	YES
3	3	Participation	SLO1 SLO2 SLO3	Goal 1 Goal 3 Goal 4	YES
	Assignment 3	Formative	SLO1 SLO2 SLO3	Goal 1 Goal 3 Goal 4	
FINAL ASSIGNMENTS	Reflective Memo	Summative	SLO1 SLO2 SLO3	Goal 1 Goal 3 Goal 4	
	Decision Memo	Summative	SLO1 SLO2 SLO3	Goal 1 Goal 3 Goal 4	

*Shaded rows are homework and represent the greatest assessment of student learning.

Suggested Modifications: Suggested teaching modifications are included with the relevant activity notes. For example, the introductory materials can be modified for a more science heavy or more policy heavy student group, or the negotiation simulation can be modified for additional roles to team negotiation. A modification for use with adult citizen scientists is also in development (contact Joana Flor Tavares if interested).

Answer Key[3] : The suggested assignments with this case do not require specific answer keys.

[3] Adapted from the National Center for Case Study Teaching in Science

Background:

In addition to the background included within the modules above, we recommend that instructors who do not feel well versed in these topics review some of the following readings or contact the authors to discuss this case.

D'Anna, L. M., & Murray, G. D. (2015). Perceptions of shellfish aquaculture in British Columbia and implications for well-being in marine social-ecological systems. *Ecology and Society*, 20(1). http://doi.org/http://dx.doi.org/10.5751/ES-07319-200157

Fisher, R., Ury, W. L., & Patton, B. (2012). Chapter 1: Don't Bargain Over Positions. In *Getting to Yes.* Penguin Books. Available from: http://www.williamury.com/nowithconvictionizbedathanyes2plz/wp-content/uploads/books/yes/Getting_to_Yes-sample_chapter.pdf

Fisher, R., Ury, W. L., & Patton, B. (2012). *Getting to Yes.* Penguin Books.

Kurlansky, M. (2007). *The Big Oyster: History on the Half Shell.* Random House Trade Paperbacks.

Liu, J., Dietz, T., Carpenter, S. R., Alberti, M., Folke, C., Moran, E., … Taylor, W. W. (2007). Complexity of coupled human and natural systems. *Science*, 317(5844), 1513–6. http://doi.org/10.1126/science.1144004

MacKenzie Jr., C. L. (1996). History of oystering in the United States and Canada featuring the eight greatest oyster estuaries. Marine Fisheries Review, 58(4), 1–78. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-0030318040&partnerID=40&md5=c2dc6381356dd3a8b65e4574e42dc05f

Petiet, M. B. (2013, May). Washburn Island Oysters. *Edible Cape Cod*. Retrieved from http://ediblecapecod.ediblefeast.com/shop/washburn-island-oysters

References:

Introduction and Classroom Management references are summarized here. See above background section for additional related readings.

Brennan, S. (2015). *The Oyster War: The True Story of a Small Farm, Big Politics, and the Future of Wilderness in America*. Counterpoint. Retrieved from http://theoysterwar.com/

Browdy, C.L. and J.A. Hargreaves (editors). 2009. Overcoming Technical Barriers to the Sustainable Development of Competitive Marine Aquaculture in the United States. U.S. Department of Commerce, Silver Spring, MD USA. NOAA Technical Memo NMFS F/SPO- 100. 114pp.

Cavaliere, V. (2016). Birds versus bivalves: oyster farmers and bird advocates clash on Cape May. *The New Food Economy.* Retrieved from http://newfoodeconomy.com/red-knots-and-oysters-cape-may/

Chesapeake Bay Program. (2012). Bay 101: Oysters. Available: http://www.chesapeakebay.net/videos/clip/bay_101_oysters.

Clark, L. (2015). "The Oyster War": What Really Happened to Drakes Bay Oyster Farm. *Civil Eats.* Retrieved from http://civileats.com/2015/08/26/the-oyster-war-what-really-happened-to-drakes-bay-farm/.

Dictionary.com. (2016). Aquaculture | Define Aquaculture at Dictionary.com. Retrieved from http://www.dictionary.com/browse/aquaculture

Dumbauld et al. (2009) The ecological role of bivalve shellfish aquaculture in the estuarine environment: A review with application to oyster and clam culture in West Coast (USA) estuaries. *Aquaculture*. 290:196-223. doi:10.1016/j.aquaculture.2009.02.033

Gunnar K. and M.C. Rubino (2016) The Political Economics of Marine Aquaculture in the United States, *Reviews in Fisheries Science & Aquaculture*, 24:3,213-229, Available: http://dx.doi.org/10.1080/23308249.2015.1121202

Loomis, I. (2016). Two years after shutdown, California oyster farm remains a community hot-button. Retrieved from http://advocate.gaalliance.org/two-years-after-shutdown-california-oyster-farm-remains-a-community-hot-button/.

Matunuck Oyster Bar. (n.d.). Matunuck Oyster Farm - Matunuck Oyster Bar. Retrieved from http://www.rhodyoysters.com/matunuck-oyster-farm/

National Marine Fisheries Service. (2015). Fisheries of the United States, 2014. U.S. Department of Commerce, NOAA Current Fishery Statistics No.2014. Retrieved from http://www.st.nmfs.noaa.gov/Assets/commercial/fus/fus14/documents/FUS2014.pdf

Naylor, R. L., Goldburg, R. J., Primavera, J. H., Kautsky, N., Beveridge, M. C. M., Clay, J., … Troell, M. (2000). Effect of aquaculture on world Fish supplies. Nature, 405, 1017–1024. Retrieved from http://www.nature.com/nature/journal/v405/n6790/pdf/4051017a0.pdf

NJ DEP. (2006) PUBLIC ACCESS IN NEW JERSEY: The Public Trust Doctrine and Practical Steps to Enhance Public Access

NOAA. Coastal Decision-making Tools, (n.d.) Available: http://oceanservice.noaa.gov/tools/dmtools/

NOAA Fisheries. (n.d.) Aquaculture. Available: https://www.youtube.com/watch?v=3Oi9GARr-Xc

NOAA Fisheries. (2015). Marine Aquaculture Strategic Plan FY2016-2020. Retrieved from http://www.nmfs.noaa.gov/aquaculture/docs/aquaculture_docs/noaa_fisheries_marine_aquaculture_strategic_plan_fy_2016-2020.pdf.

NOAA National Ocean Service. (n.d). Ocean Facts: Aquaculture. Available: http://oceanservice.noaa.gov/facts/aquaculture.html.

Raso, P. (2016). The Importance of Sustainable Aquaculture in Our Future. TEDxProvidence. Retrieved from https://www.youtube.com/watch?v=oSdEQNY1mkA.

US EPA. (2016). Basic Information about Estuaries. Retrieved December 1, 2016, from https://www.epa.gov/nep/basic-information-about-estuaries.

World Bank. (2013). FISH TO 2030- Prospects for Fisheries and Aquaculture. WORLD BANK REPORT NUMBER 83177-GLB . 70 pp. http://www.fao.org/docrep/019/i3640e/i3640e.pdf.

Oyster farm in NH, racks lifted for cleaning. Photo credit Lindsey C. Williams