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Using Seafood Traceability to Teach the Complexities of Natural Resource Management and Sustainability

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CourseSource

Lesson

Using Seafood Traceability to Teach the Complexities of Natural Resource Management and Sustainability

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Abstract

This lesson plan addresses the challenge of conveying to students the globalized nature and complexity of natural resource management. Specifically, it uses seafood traceability, or the ability to track seafood as it moves through the global seafood supply chain, as a theme for understanding the potential for science and technological innovations to enable traceability as well as the different roles that various stakeholders play in ensuring fisheries sustainability. The lesson plan conveys several themes related to environmental sustainability including: the role of consumer empowerment, the importance of data and information sharing, the need to coordinate multiple stakeholders, and the intersection of science, technology, and policy-making. In one classroom activity, students are guided through a small-group, active-learning exercise that challenges them to make sustainable seafood choices from a restaurant menu. In another activity, students are asked to role-play and consider the information needs of various stakeholders in the seafood supply chain. Overall, the lesson plan is designed to demonstrate that there is no one single solution to realize seafood traceability and ensure fisheries sustainability. Instead, fisheries and natural resource management require multifaceted solutions and the involvement of multiple sectors of society.

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Supporting Materials: S1. Seafood Traceability – Day 1 Presentation Slides; S2. Seafood Traceability – Seafood Menu; S3. Seafood Traceability – Restaurant Server Q&A; S4. Seafood Traceability – Day 2 Presentation Slides; S5. Seafood Traceability – Post-Class Reflection; S6. Seafood Traceability – Restaurant Activity Discussion; and S7. Seafood Traceability – Stakeholder Analysis Sheet.

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Learning Goal(s)

Students will:

- Understand the impacts humans have on ecosystems.
- Understand what humans can do to mitigate the negative impacts they have on ecosystems.
- Recognize the potential for science and technological innovations to improve natural resource management.
- Recognize the importance of stakeholder engagement and coordination in relation to natural resource policy-making.

Learning Objective(s)

Students will be able to:

- Describe challenges of tracing seafood through the supply chain.
- Provide different definitions for the term "sustainable".
- Describe the limitations of consumer-driven natural resource management incentives.
- Provide examples of science and technological innovations relevant to fisheries management.
- Identify different stakeholders in the seafood supply chain.
- Explain the characteristics of data collection and research that can strengthen the effectiveness of using science to guide policy.

INTRODUCTION

The life sciences are uniquely positioned to address many complex societal problems related to human health, the environment, and food systems (1). Solving many of these problems will require that students be given interdisciplinary training as well as a broader appreciation of the connections between science, technology, and policy (2). The challenge of preparing students to address society's environmental issues lies in conveying the full complexity of required solutions for achieving sustainability. This includes: government regulation, consumer-based approaches, reliable information for appropriate decision-making, and technological innovations (3). Furthermore, the concept of sustainability can be broadly defined, ranging from a more traditional view focused solely on environmentalism to a more all-encompassing view including societies, cultures, and economies (4). Despite these challenges, colleges and universities have the potential to be leaders in the field of sustainability education and environmental literacy (5) and in preparing students for the future by emphasizing the interdependence between people and nature (4). Teaching sustainability and environmental literacy at the university level has been shown to increase students' care about the future, belief that they can make a difference, and willingness to participate in solving societal problems (6).

Rather than avoid the full complexity of environmental issues, we embrace it in this lesson plan. Here, we use seafood traceability, or the ability to trace seafood through multiple players, from the point-of-catch, through the point-of-purchase, as a cross-cutting theme that can be used to illustrate the complexity of environmental issues. Fisheries provide an excellent case study example of a current and pressing issue in natural resource management. The Food and Agricultural Organization of the United Nations estimates that a third of all fisheries are overfished (i.e., currently at biologically unsustainable levels), which they define as fisheries stocks with abundance levels below that needed to produce maximum sustainable yield (7). Managing fisheries is further complicated by the fact that the seafood supply chain is global; the previously mentioned report estimates that about 80% of seafood in the US is imported (7). Yet by some estimates, 20-30% of seafood imported into the US is illegal or unreported (8). One of the challenges in managing fisheries is the complexity of tracing seafood throughout the supply chain. Seafood traceability requires the deployment and coordination of technologies and stakeholders across multiple sectors of society and therefore serves as an excellent example of the intersection of science and policy as well as the complexity of managing renewable natural resources (9).

We envision this lesson plan, although originally developed for an introductory fisheries and aquaculture course, to also be appropriate for a general or applied ecology course as well as a natural resource economics or environmental policy course. General biology concepts or skills that are taught in this lesson plan include the concept of sustainability and the intersection of science, markets, and policy. The lesson plan also overlaps with the Ecological Society of America's framework of essential ecological concepts and skills for undergraduates, including: human dependence on the environment; human-accelerated environmental change; how humans can shape and manage natural resources; and critical thinking about the values underlying environmental problems, challenges, and opportunities (10). The lesson plan presented here centers on two in-class activities. The first simulates the challenges of making sustainable seafood purchasing decisions from a restaurant menu with the aid of a smartphone app, Seafood Watch. The second activity divides the class into various seafood stakeholder groups (fishers, scientists, enforcers/managers, businesses/restaurants) to illustrate the multiple perspectives involved in fisheries management and seafood traceability. In particular, this activity asks students to consider how information needs (e.g., fishing location, catch biomass, species ID, seafood processing methods, storage conditions, etc.) differ between stakeholder groups, and what these differences mean for tracking data through the entire supply-chain.

Other lesson plans have been developed to convey the complexity of environmental issues. For example, Larson and Wong (11) developed a lesson that asks students to role-play and consider the environmental issues surrounding hydroelectric development in the Amazon. In their lesson plan, students are guided through a structured decision-making activity to illustrate the importance of engaging with multiple stakeholders before making policy decisions. Most students, however, will likely be geographically and culturally removed from the case study presented by this lesson plan. While there are certainly benefits to having students draw from their personal experiences in order to consider another's point of view (12,13), there are also benefits to having students be able to relate more directly to the curriculum (e.g., place-based learning; 13). The lesson plan presented here presents an issue - seafood consumption - to which many students should be able to relate.

The California Academy of Sciences has also developed a lesson plan that asks students to explore information in the Seafood Watch guides (15). Their activity, however, is more loosely structured, having students select their favorite seafood before learning about the consequences of their choices. The activity presented in our lesson plan attempts to simulate a more real-life situation, requiring students to ask for additional information about their seafood beyond what is presented on a restaurant menu. In addition, our activity is more structured, and specifically designed to guide students to the conclusion that making responsible seafood purchasing decisions is not a clear-cut choice, and that deciding on the most sustainable choice on a menu may not be possible due to missing or incomplete information.

Intended Audience

This lesson plan was developed for an undergraduate-level introductory fisheries and aquaculture course, taught separately to both majors and non-majors at a large, public research university. While the topic is specific to fisheries, it could be easily presented as a case study within a more general ecology course as well as a natural resource economics or environmental policy course.

Required Learning Time

This lesson plan is taught over the course of two class sessions, each lasting 75 minutes.

Prerequisite Student Knowledge

This lesson plan was originally designed for an introductory fisheries and aquaculture course, but is being presented here as part of an ecology course. In a fisheries course, the required background knowledge in fisheries management is likely introduced in earlier classes and developed throughout the semester. For a general ecology course, it is recommended that students first familiarize themselves with the concept of "sustainability," including the variety of ways in which it is defined. Some useful resources for this include: the United Nations Sustainable Development Goals (https://www.un.org/sustainabledevelopment/), which are a collection of broad-based, global-scale objectives adopted by the United Nations General Assembly; FishWatch (https://www.fishwatch.gov/), an informational database created by the U.S. National Oceanic and Atmospheric Administration of popular wild and farmed seafood; and the Marine Stewardship Council (https://www.msc.org/), a sustainable seafood certification program.

As a broad overview on the status of global fisheries and potential solutions that will ensure their continued availability, students can be directed to a video produced by the Food and Agriculture Organization of the United Nations: The State of World Fisheries and Aquaculture (https://youtu.be/EiBlbpJk3kE). Another video produced by the U.S. National Oceanic and Atmospheric Administration, "The ABCs of Stock Assessments," explains the importance of stock assessments

- studies conducted by scientists for different fisheries and used by regulators in setting catch limits or other fishery regulations (https://youtu.be/3UbWMdpavUE). The video also touches on the need to balance both the socio-economic and ecological tradeoffs of fisheries. Finally, as an introduction to the concept of seafood traceability, students should watch this video produced by the international ocean conservation organization, Oceana "Fish Stories: Success and Value in Seafood Traceability" (https://youtu.be/DY7dfB1Jjh8).

Prerequisite Teacher Knowledge

Instructors should refer to the websites listed in the "prerequisite student knowledge" section above to familiarize themselves with concepts important to this lesson plan. If additional resources are desired, the United Nations Educational, Scientific and Cultural Organization has several publications on education for sustainable development (https://en.unesco.org/themes/education-sustainable-development/clearinghouse/publications). For additional information on seafood traceability, instructors can look to the article from Gorospe et al (9) which describes how science and technological innovations could potentially be implemented on an international scale.

For this lesson plan we provide presentation slides for in-class lectures. The first day is primarily about generating interest and conveying the complexity of the global seafood supply chain. The first day's lecture (Supporting File S1. Seafood Traceability – Day 1 Presentation Slides) introduces: the concept of seafood traceability; its importance; some of the challenges associated with it; and the different stakeholders. These concepts serve as motivational factors leading into the main learning objective for the day - namely, why we as consumers would be interested in seafood traceability. This culminates in a class activity asking students to make sustainable seafood purchasing decisions using information provided in the Seafood Watch app. For this activity, we provide a menu, based on a seafood restaurant in Rhode Island (Supporting File S2. Seafood Traceability – Seafood Menu). Instructors are welcome to use the provided menu, but they are highly encouraged to familiarize themselves with a menu from an establishment that would be relevant to their students (e.g., local restaurant, campus dining hall, or by combining seafood options from various fast food chains). If instructors use their own menu for their classrooms, they will also need to create a Q&A bank (Supporting File S3. Seafood Traceability – Restaurant Server Q&A) about the origins and methods of catch for the various menu items.

The Seafood Watch app summarizes seafood into three categories based on their definition of sustainability. These three categories are: "best choice", "good alternative", and "avoid." Instructors with no background in fisheries science should not be intimidated by creating their own Q&A bank. Once the instructor has chosen a menu (e.g., from a local seafood restaurant), they will then need to examine what the Seafood Watch app has to say about the different menu options. Based on the information provided on the Seafood Watch app, the instructor should assign different options (e.g., location and fishing gears) to the various menu items such that students are led down a path of "no easy answers." In other words, the Q&A bank should be designed such that no matter how many questions a student asks, they are unable to narrow down a single "best choice" for choosing a menu item based on Seafood Watch's recommendations. Instead students are led to multiple options that are considered "good alternatives." This provides students with a more credible simulation of what they would encounter in their daily lives, leading to a more stimulating discussion about the challenges of making sustainable seafood purchasing choices as well as the limitations of relying solely on consumer empowerment for managing natural resources.

The second day of the lesson plan delves deeper into the intersection of science, technology and policy as it relates to seafood traceability and natural resource management. The multi-disciplinary nature of the second day's topics will likely require more preparation on the instructor's part. The lesson begins with a sequential tour of the seafood supply chain (i.e., pre-catch, point-of-catch, point-of-processing, point-of-purchase) and highlights specific seafood traceability challenges and potential solutions at each point (Supporting File S4. Seafood Traceability – Day 2 Presentation Slides). Next, students are asked to role-play different stakeholder groups and conduct a more in-depth analysis of the needs of different stakeholders in the seafood supply chain. By illustrating the disjointed needs of different stakeholders, this analysis is meant to illustrate the characteristics of effective science-based policy. This second day may be seen as a more optional component in the lesson plan - possibly more suited to a fisheries class or for an upper level ecology or natural resource management class. Overall, however, Day 2 of the lesson plan adds a level of depth not found in other published lesson plans on natural resource management. Instructors should not be intimidated by the diversity of advanced technologies presented in Day 2 (Supporting File S4. Seafood Traceability – Day 2 Presentation Slides); a superficial understanding is all that is needed. The main learning objective here is not to overwhelm students with science and technology concepts, but rather to demonstrate the various ways in which science and technology intersect with natural resource management and policy.

SCIENTIFIC TEACHING THEMES

Active Learning

This lesson plan incorporates active learning strategies that simulate real-world situations related to seafood traceability in order to illustrate the complexity of natural resource management issues. The seafood restaurant simulation from Day 1 uses small-group learning. The stakeholder analysis from Day 2 uses role-play and is run using the think-pair-share technique.

Assessment

In our introductory fisheries and aquaculture course, students were assessed using both formative (think-pair-share, small-group student participation, and classroom discussions) and summative (post-class reflection; Supporting File S5. Seafood Traceability – Post-Class Reflection) methodologies. In both cases, the emphasis was on students' ability to explain their opinions, rather than their ability to recall details from the lectures.

The formative assessments consist of two classroom-based activities (i.e., the Seafood Watch activity on Day 1 and the stakeholder analysis on Day 2). For both, students are given a

participation grade related to these activities. For the Seafood Watch activity, instructors should be prepared to lead a class discussion on each group's choice of seafood. While each group should be prepared to report and explain their particular choice, the discussion and assessment should focus on overall observations about the activity (Supporting File S6. Seafood Traceability – Restaurant Activity Discussion). What information did the students observe to be missing from the menu that would otherwise have aided them in making their choice? Was there any additional information they would like to see included in the Seafood Watch app? Did they have any hesitations about the process of making responsible consumer decisions? Similarly, for the Day 2 stakeholder analysis, less emphasis should be placed on the expected answers of each stakeholder group's needs (Supporting File S4. Seafood Traceability – Day 2 Presentation Slides: slide 44), and more on students' reasoning for their answers.

The summative post-class reflection (Supporting File S5. Seafood Traceability – Post-Class Reflection) asks students to provide and explain their opinions on natural resource management. For example, how has the issue of seafood traceability changed your opinions about who should be responsible for natural resource management? Should environmental stewardship mainly be the responsibility of individual consumers, businesses, or governments? How important is scientist input to environmental management and policy-making? Instructors who wish to place more emphasis on factual recall in their assessments can refer to the presentation slides (Supporting Files S1 and S4. Seafood Traceability – Day 1 and Day 2 Presentation Slides) for content. For example, they could ask students to provide a definition for sustainability that goes beyond the traditional biological or ecological considerations. Instructors can also draw from Day 2's presentation on science and technological innovations as a source of assessment questions. Depending on the instructors' preferred style, these can be short-answer (e.g., Explain how integrated ecosystem research, which has emerged as the new gold standard for conducting fisheries studies, is different from traditional methods) or multiple-choice (e.g., Which of the following technologies, made famous by Bitcoin and other cryptocurrencies, are being pioneered as a decentralized and secure method for tracing seafood? Answer: blockchain electronic reporting). For a more policy-focused assessment, instructors could have students elaborate on the three principles for ensuring that science and technology guides policy and decision-making effectively (Supporting Files S4. Seafood Traceability – Day 2 Presentation Slides: slide 50).

Inclusive Teaching

The incorporation of classroom activities on both days of this two-day lesson plan is meant to engage undergraduate students in meaningful ways that will increase student learning (16). The goal of these classroom activities is to stimulate critical thinking on issues related to natural resource management and environmental sustainability. Specifically, the Seafood Watch activity on Day 1 uses small-group learning and the stakeholder analysis activity on Day 2 uses role-play and think-pair-share. Our use of the think-pair-share technique in the stakeholder assessment allows us to be inclusive of students who prefer individual work as well as students who prefer group work. Importantly, this allows students who are intimidated by group work to have a moment to work on their own (i.e., think) and build up confidence (i.e., pair) before reporting to the larger group (i.e., share).

We also use place-based examples to illustrate some of the seafood traceability issues. Overall, the issue of seafood sustainability is already economically relevant to the state of Rhode Island where marine-based industries form a large sector of the economy. Using images of local restaurants and other stakeholders in the presentation slides increased the place-based nature of the lesson plan. Similarly, basing the Seafood Watch activity off a menu from a local seafood restaurant enhanced the authenticity of the activity. Accordingly, we encourage instructors to locate a menu from a local seafood restaurant for their own classes. Some student populations may be significantly less connected to seafood for cultural and/or geographic reasons. In this case, the best approach for connecting to these students may be through the use of fast food examples. Many popular fast food chains have seafood items on the menu, with varying levels of disclosure regarding from where they are sourced (e.g., imported shrimp vs. Alaskan Pollock vs. North Pacific cod). Instructors could modify the Seafood Watch Activity such that students are asked to compare seafood options from multiple fast food chains.

LESSON PLAN

This lesson is designed to be taught over the course of 2 classes, each lasting about 75 minutes, with the possibility of modification for shorter class times by adjusting the content of the presentation slides (Supporting Files S1 and S4. Seafood Traceability – Day 1 and Day 2 Presentation Slides). A detailed description of the timing of each day's class and activities and suggested modifications can be found in Table 1. Over the course of two days, the topic of seafood traceability is used as a cross-cutting theme to teach students about human impacts on marine ecosystems, the concept of sustainability, and the complexity of environmental management.

Pre-class

Before Day 1, instructors should ask their students to download the Seafood Watch app onto their smartphones. The Seafood Watch guide is a sustainable seafood advisory list maintained by the Monterey Bay Aquarium. For situations where phones may not be available to some students or are not wanted in the classroom, Seafood Watch's website provides downloadable files that can be printed out (https://www.seafoodwatch.org/seafood-recommendations/consumer-guides). Other good resources that could be used to supplement the information provided in Seafood Watch are the Marine Stewardship Council or NOAA's FishWatch.

Day 1: Where does your seafood come from and why would you want to know?

The lesson begins by showing students a clip from the TV series, Portlandia (https://youtu.be/G__PVLB8Nm4). The point of this video clip is to grab students' attention about why some people are so concerned about the origin of their food. Alternatively, this can be replaced by a live re-enactment of the skit between the instructors (if there are more than one) or between an instructor and one of the students, with the instructor playing the role of an information-demanding restaurant customer, and a student playing the role of a restaurant server. As the server takes the customer's order,

the customer begins with simple, benign questions about the chicken on the menu (e.g., Where is the chicken from? How was it raised? What's the name of the farm?), but quickly escalating into awkwardness and absurdity (e.g., Did the chicken have a name? Did they have any friends? What type of life did the chicken have?).

The lecture then goes on to introduce students to the challenges of tracing seafood through the supply chain by emphasizing the global reach and complexity of the seafood industry, highlighting certain challenges such as transshipment and seafood processing. Other topics include: an introduction to the various stakeholders in the seafood supply chain; how we as consumers can make sustainable seafood purchasing decisions; as well as different definitions for the term "sustainable."

Day 1: Seafood Watch Activity

At the start of the presentation (Supporting File S1. Seafood Traceability Day 1 – Presentation Slides: slide 5), students are asked to rate on a scale from 1 to 5 their comfort level in asking a server multiple questions about items on the menu and to write this on a piece of paper. Their answers to this question will be used to determine how many questions students can ask their server as part of this activity (see below). Then students are randomly placed into groups of 4-5, with the option of having them share phones if necessary. They are then asked to imagine themselves as customers at a seafood restaurant. Each group is given a copy of a restaurant menu (Supporting File S2. Seafood Traceability – Seafood Menu). The students' goal should be to choose the "best choice" based on the guidance they are given on the Seafood Watch app. The instructor(s) will then play the role of server at the restaurant. Students are allowed to ask the server (i.e., instructor) questions about menu items. The instructor should prepare ahead of time for these questions (Supporting File S3. Seafood Traceability – Restaurant Server Q&A). The number of questions each student group is allowed to ask is simply the average response in the group to the comfort level question (Supporting File S1. Seafood Traceability – Day 1 Presentation Slides: slide 5). Before students begin the activity, they are reminded that they will be required to explain their choice and what information they used to make their decision. Examples of some questions and discussion points are provided (Supporting File S6. Seafood Traceability – Restaurant Activity Discussion). The take home message gleaned from the discussion should be that the information needed to make responsible consumer decisions is often incomplete or unknown and that the information provided on Seafood Watch App is limited to environmental sustainability concerns.

Day 1: Post-Activity

Day 1 concludes with the remaining slides from Supporting File S1. Seafood Traceability – Day 1 Presentation Slides: slide 36-45). The students are presented with a host of other reasons, besides environmental sustainability, that could potentially influence their seafood purchasing decisions including the following: seafood safety, reducing wastes/costs, mislabeling, social responsibility (e.g., illegal worker conditions and modern-day slavery aboard some fishing vessels), as well as health and nutritional content.

Day 2: The role of science and technology in sustainable fisheries management

Since this is a continuation of Day 1's lesson, it's recommended that a brief recap of Day 1 be presented before beginning Day 2's lesson. Day 2 starts by introducing students with several examples of emerging science and technologies that can help with tracing seafood throughout the supply chain, including integrated ecosystem models, vessel tracking systems (e.g., AIS and VMS), forensic labs, smartphone apps, and blockchain electronic reporting. Next, the question is posed, how do we decide on a particular technology? The answer is Day 2's activity: stakeholder analysis.

Day 2: Stakeholder Analysis Activity

While Day 1 focused primarily on consumers, Day 2 will look at other stakeholders in the seafood supply chain, including fishers, scientists, enforcers, and restaurants. While we won't necessarily answer what is the most appropriate technology for seafood traceability, the point of this activity is to highlight the challenges of aligning interests and motivations across stakeholder groups which in turn underscores the challenges associated with fisheries and/or environmental management and conservation. Through this role-playing activity, students are immersed in a fisheries example of how science and technology intersect with policy and society.

Students are introduced to the different stakeholders as well as their different interests (Supporting File S4. Seafood Traceability – Day 2 Presentation Slides: slides 36 to 40). Next, the class is prompted in conducting a stakeholder analysis. For this, the class is randomly divided into groups of 4-5 students. Each group is assigned one of the following stakeholder identities: fishers, scientists, enforcers, and restaurants. In each group, instructors should assign one student the role of recorder and another student the role of reporter. The recorder's role is to tally individual responses about the seafood supply chain points and key data elements that are of interest to their stakeholder group (see details below). The reporter's role is to report their group's consensus to the class. If additional groups are needed, additional stakeholder groups can be created that already align with the ones provided. For example, enforcers could be considered as part of a larger group of "fisheries managers" that could include policy-makers and food inspectors. The restaurants group could be considered as part of a larger group of "businesses" that could also include fishmongers. Fishers could also be subdivided into fishers (i.e., those who catch fish in the wild) and seafood farmers (i.e., aquaculturists).

The instructor should distribute one stakeholder analysis activity sheet to each student (Supporting File S7. Seafood Traceability – Stakeholder Analysis Sheet) as well as an additional activity sheet for each group that the group recorder will use to tally responses. Students are then asked to "think" like the stakeholder group to which they've been assigned. First, while displaying slide 41 (Supporting File S4. Seafood Traceability – Day 2 Presentation Slides), students should choose which points along the seafood supply chain (i.e., pre-catch, point-of-catch, point-of-purchase, and/or point-of-processing) they think their stakeholder group would be most interested to learn. Then after presenting slides 36 to 40 (Supporting File S4. Seafood Traceability – Day 2 Presentation Slides), students are asked to choose four types of information

(slide 42, Key Data Element column) that they believe would be useful to them based on their stakeholder group's interests. Instructors should run this small group activity in a "think-pair-share" format, whereby students are asked to do the activity individually first before discussing their answers within their small groups.

Small groups should come to a consensus regarding the points along the seafood supply chain as well as the four Key Data Elements that are of interest to their stakeholder group. Groups report their answers to the class, while the instructor records their responses in a table format (e.g., by writing them down on the board or by filling them out on a presentation slide displayed for the whole class to see; slide 43). For small classes, it may be possible to record all responses (more than four responses) reported by each stakeholder group. For larger classes, instructors may require groups to only report the consensus within their group. After all groups have reported, the instructor can then reveal the answer key (slide 44). Answers here are somewhat subjective - stakeholders, after all, may have their own individual reasons for wanting to know particular pieces of information. Rather, the "answer" or key take home messages should be: (1) Information needs are different for different stakeholders; (2) Not all stakeholders are interested in all parts of the supply chain; (3) Some pieces of information are universally desired (e.g., species ID and volume) and (4) Some pieces of information (e.g., location) could generate mistrust or conflict of interest.

Day 2: Post-Activity

The second day ends with a presentation (slides 47 to 52) on the characteristics of information or data-sharing that make it most effective for decision-making. A major challenge in natural resource management issues is the diversity of stakeholders and their information needs. Science and technology have the potential to address this, but their implementation must meet certain characteristics. These characteristics (salience, credibility, and legitimacy) are considered best practices for how science and technology can most effectively be used to guide policy (17).

TEACHING DISCUSSION

Lesson's Effectiveness

After the two-day lesson plan, we administered a summative reflection (Supporting File S5. Seafood Traceability – Post-Class Reflection) that asked, "How has learning about seafood traceability changed your opinion about environmental stewardship and who should be responsible for managing natural resources?". In some cases, students specifically identified government, businesses, or consumers as needing to play a greater role in fisheries management and/or seafood traceability:

"It has taught me that mostly the government should be held responsible for maintaining fisheries and aquaculture."

"I believe businesses should play a major part in the traceability process."

"It made me realize how much responsibility the individual [consumer] can have by making an informed decision on what seafood to eat."

In most cases, however, students' responses reflected their newfound grasp of the complexity of seafood traceability and/or seafood traceability:

"[The lesson] made me realize that there are a lot of moving puzzle pieces and it falls on everyone to maintain current resources."

"Everyone needs to play a role in making sustainable decisions all the way up the supply chain."

"I [originally] thought that seafood traceability was just for the fishermen. However, all stakeholders' participation is also really important."

"I think it is important for every stakeholder to take part in traceability efforts to ensure the safety of seafood"

Furthermore, in some cases, students began to touch on the role of science in policy and decision-making, particularly the importance of data and transparency:

"I believe all parties should be aware of the issue and any information on it should be transparent to all individuals."

"I believe individuals should be more responsible in decision-making, but currently lack the proper information to do so."

Opportunities for Improvement or Modification

In terms of conveying the complexity of environmental sustainability and natural resource management, we suspect that this lesson plan will be most effective for students who have a deep personal connection to the marine environment. While we did not collect data with regards to this, we know many of our students' families are directly connected to the seafood industry either as fishers or fish market owners. This lesson was also taught at the University of Rhode Island, and with Rhode Island being the "Ocean State", our students likely benefited from the place-based themes that were presented.

Instructors should feel empowered to improve or modify the lesson plan presented here in order to better suit the needs and characteristics of their students. For example, the Day 1 Seafood Watch activity could be modified to incorporate other consumer guides, including the Marine Stewardship Council's certification label, NOAA's FishWatch, and many others. Groups of students could be assigned different consumer guides in making their seafood choices, thus revealing how these various guides may lead them to different choices. The activity would then focus on the specific "sustainability criteria" for each guide and comparing definitions of sustainability. Another activity modification, would be to run the Day 1 stakeholder analysis activity as a town hall style meeting, whereby stakeholders (i.e., groups of students) are asked to discuss and respond to each other's ideas. In contrast to the stakeholder analysis format, a town hall style meeting would allow students the opportunity to witness how different stakeholder groups interact. Ultimately, this format may require more preparation work (e.g., students may need to research background information on their stakeholder group before engaging in role-playing discussion), so we leave it to the instructor to decide which format is a better fit. In addition,

the Day 2 lesson plan could be extended to explore any of the emerging seafood traceability technologies that were covered in class. For example, as a spin-off from the forensic lab topic, instructors could incorporate a fish DNA barcoding laboratory activity using kits specifically designed for educational settings (e.g.,https://www.bio-rad.com/en-us/product/fish-dna-barcoding-kit?ID=MH1Z6S15).

For non-coastal states or classes less interested in the seafood industry, another idea would be to use the Seafood Watch activity to compare seafood choices from various fast food chains. There is also opportunity to expand this lesson plan beyond the seafood supply chain to include other topics of global food security, including examples not just from the seafood industry, but also from terrestrial and aquatic agriculture. For example, ambitious instructors could potentially rework the lesson plan to focus on traceability in other food systems, including the meat, dairy, or produce industries.

SUPPORTING MATERIALS

- S1. Seafood Traceability – Day 1 Presentation Slides
- S2. Seafood Traceability – Seafood Menu
- S3. Seafood Traceability – Restaurant Server Q&A
- S4. Seafood Traceability – Day 2 Presentation Slides
- S5. Seafood Traceability – Post-Class Reflection
- S6. Seafood Traceability – Restaurant Activity Discussion
- S7. Seafood Traceability – Stakeholder Analysis Sheet

ACKNOWLEDGMENTS

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Institutional Review Board Information: The University of Rhode Island IRB determined this research to be exempt (IRB Reference #: 1327889-2). All students were informed that the pre- and post-class questionnaires were part of a research study and that they could choose to withdraw their consent to participate at any time.

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Table 1. Seafood Traceability - Teaching Timeline

Activity	Description	Time	Notes
Preparation for Day 1			
Remind students in class prior to Day 1, to download the SeafoodWatch app on their smartphones.	The app is free to download.	A few minutes of the students' time.	Alternatively, if the instructor wishes to avoid the use of smartphones for this activity, they should print out paper versions of the SeafoodWatch consumer guide from their website (one for each student in class). Printable versions of the guides can be found here: https://www.seafoodwatch.org/seafood-recommendations/consumer-guides).
Print out seafood restaurant menus.	Print out one copy for each group (class should be divided into groups of 4-5 students).	Variable, depending on size of class and type of printer	An example seafood menu is provided in Supporting File S2. Alternatively, the instructor can use a menu from a local restaurant or create their own.
Day 1			
Lecture 1A: Where does your seafood come from and why would you want to know?	Topics covered include: what is traceability; what are some challenges to this; who are the stakeholders; and why we as consumers would be interested.	25 minutes	Lecture slides with notes are in Supporting File S1 (only slides 2 to 31).
SeafoodWatch Activity	The class is divided into groups of 4-5 students and asked to review the menu. As a group, they must come to a consensus on what they believe to be the most sustainable menu option. They are allowed to ask the waiter (i.e., instructor) a set amount of follow-up questions about the menu.	5 minutes to explain the activity. 15 minutes to divide class and run activity.	During the activity, the instructor walks around as the restaurant menu referring to the Q&A bank (Supporting File S3) to answer students' questions about the menu.
SeafoodWatch Discussion	Each group reports and explains the reasoning behind their menu choices. Lead class through a discussion reflecting on the activity.	15 minutes for report out. 10 minutes for discussion.	Refer to Supporting File S6 for discussion points. Discussion should segue into Lecture 1B.
Lecture 1B: Other pieces of information not covered in SeafoodWatch that we might want to know about our seafood.	Class ends with a brief presentation on the limitations of SeafoodWatch's definition of sustainability.	5 minutes	Lecture slides with notes are in Supporting File S1 (slides 37 to 46).
Preparation for Day 2			
Print out stakeholder analysis worksheet and summative assessment questionnaires.	For each document, print out one copy for each student.	Variable, depending on size of class and type of printer.	Both documents are provided (Supporting File S5 and S7). The stakeholder analysis worksheet may need to be modified to include more stakeholder groups depending on the size of the class.
Day 2			
Lecture 2A: The role of science and technology in sustainable fisheries management.	Topics covered include: emerging technologies that can help supply information about the seafood supply chain to stakeholders; a review of the different interests of each stakeholder group.	25 min	Lecture slides with notes are in Supporting File S4 (only slides 2 to 32).
Stakeholder Analysis Activity	A stakeholder analysis worksheet is given to each student. The class is divided into groups of 4-5 students, with each group representing a specific stakeholder group. The instructor should run the activity in a think-pair-share format.	5 minutes to explain the activity 10 minutes to divide class and run activity.	If desired, instructor can also display slides 37 through 40 again to remind students of the specific interests of their stakeholder group.

Activity	Description	Time	Notes
Stakeholder Analysis Discussion	Each group reports their stakeholder group's interests (both the points along the chain and the key data elements desired) while instructor records answers for all to see. After this, the instructor can display the answer key, but the focus should really be about the main take home messages.	10 minutes for report out. 5 minutes for discussion.	Use Supporting File S4 slide 43 as a blank slate for recording answers. Display slide 44 for answer key and slide 45 for take home messages.
Lecture 2B: Three principles for ensuring the success of S&T in decision-making.	Class ends with a brief lecture on how S&T can be most effectively used in policy making.	3 minutes	Lecture slides with notes are in Supporting File S4 (only slides 46 to 51).
Summative assessment questionnaires	Students are asked to explain their opinions on environmental stewardship and the role of science in natural resource management.	17 minutes, or remainder of class time.	Supporting File S5. Assure students there are no right or wrong answers, and that the focus is on their ability to defend their opinions. Optional: if additional time is needed, students can take home their questionnaires as homework.