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EXPERIMENTS

Marine Reserve Design: Simulating stakeholder options

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The small marine reserve on Anacapa Island, Channel Islands National Park, has been closed to fishing since 1978. Image by author (Bonnie J. Becker), used by TIEE with permission.

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ABSTRACT

In this simulation, students work in groups to design a marine reserve in a hypothetical island state called “Udubia.” After learning about marine reserve design, students will choose characters that represent a variety of stakeholders, be placed in like-minded groups, create a reserve design based on provided data sources, and defend it in a presentation and debate. An optional individual assignment allows them to develop and defend their positions separately by writing a letter to the “governor.” At least two weeks will be needed to complete this exercise, including 1-3 class periods, although it can be modified for shorter use.

KEYWORD DESCRIPTORS

Ecological Topic Keywords: Biodiversity, community ecology, conservation biology, dispersal, endangered species, fisheries management, marine ecology, oceans, overfishing, Shannon Diversity Index, Marine reserves, marine protected areas (MPA)

Science Methodological Skills Keywords: Data analysis, graphing data, library research, oral presentation, use of primary literature, use of spreadsheets, Collaboration, conflict resolution, use of geographical data

Pedagogical Methods Keywords: Citizen's argument, cooperative learning, formal group work, role playing

CLASS TIME

- 1 hour lecture to introduce topic
- 1-2 hour class period for presentations and debate
- Optional in-class time (up to 3 hours) for group work, if needed.

OUTSIDE OF CLASS TIME

It is suggested that at least two weeks are provided between submission of characters and the debate to allow for adequate preparation time. However, this exercise has been modified to be completed within one class period with no outside work.

Total outside class time:

- With optional individual exercise: 10 hours
- Without optional individual exercise: 6 hours

STUDENT PRODUCTS

- Reserve Design: groups will develop a geographically-based reserve design based on a provided map with a standardized grid.

- Presentation and Debate: groups will present and defend their plans in class, including a references list

- Individual Position Paper (optional): students will write an essay, from the perspective of their stakeholder character, defending their position. This is in the format of a letter written to the governor of Udubia.

SETTING

This simulation can be done in class, with no need for laboratory equipment or field work.

COURSE CONTEXT

This simulation was designed for a lower division Conservation Biology lecture course (majors and non-majors combined) with approximately 40 students, and has also been used (in modified form) in an Oceanography lecture course and an Introductory Biology class with approximately 40 and 60 students respectively. The activity could be used in an introductory environmental studies/science course or an ecology or marine ecology course with an applied focus.

INSTITUTION

The simulation was designed with a small, public, 4-year undergraduate university in mind, but was also used in a condensed format at a community college.

TRANSFERABILITY

The activity is easily transferable to a variety of student audiences, including majors and non-majors, in lower division and pre-college environments. It is best to use in a larger (greater than 20 student) class and would need further modification for use in upper division courses. A disabled student (sight-impaired) has participated in the simulation with little need for special accommodation, and it is anticipated that few issues will affect students with other disabilities. Suggestions for modifying the existing exercise into a more abridged format are given below.

ACKNOWLEDGEMENTS

This simulation was created by the authors at the University of Washington Tacoma. We would like to thank Dr. Tonya Huff for her feedback on her use of the exercise in her

classes, Dr. Rachel May for the framework of creating a debate assignment and confidential peer assessment, Dr. Anne Beaufort for her inspiration on the paper rubric, and the students of TESC 232 for serving as a model class.

SYNOPSIS OF THE EXPERIMENT

Principal Ecological Question Addressed

Given limited resources and the divergent goals of multiple stakeholders, how to design a marine reserve to best preserve marine resources?

What Happens

Students are provided with information about a hypothetical island state, named Udubia, including a detailed map with infrastructure, bathymetry, currents, and a standardized grid. Data on fisheries, biodiversity, and marine mammal and endangered species populations are also provided, and are referenced to the map's grid. A table that summarizes the natural history of the species is also provided and can either be provided to the students or kept for instructor reference. Each student will choose a character representing a stakeholder in the placement and design of the marine reserve. Groups of stakeholders propose marine reserves and debate the proposals.

Experiment Objectives

By the end of this exercise, students should be able to:

1. Place the principles of conservation biology and marine ecology into an interdisciplinary context

2. Defend a conservation position using data and research

3. Interpret geographic data and information

4. Demonstrate the compromises needed to create a conservation plan given conflicting motivations of different stakeholders

5. Orally communicate their ideas in front of an audience

Equipment/ Logistics Required

Little equipment is required for this simulation, beyond paper and a printer. Ideally, a plotter will be available to produce larger maps, especially for students with disabilities.

Summary of What is Due

- A brief description of a stakeholder character and position (can be ungraded)
- Spatially-specific reserve design developed by a group, using data and research
- Reserve design presented to class and defended in a structured debate format
- Individual position essays based on unique stakeholder motivations, provided data, and research
- A reference list submitted prior to the debate to provide an opportunity for feedback

DESCRIPTION OF THE EXPERIMENT

Introduction

Udubia is a state located off of the coast of Washington. It consists of 3 islands surrounded by kelp forests, sandy bottoms, rocky and shell reefs, and deep canyons. Three of the islands are inhabited: Tacominone, Bothellia, and Sea Lattle. The main industries of Udubia are tourism, fishing, shipping, kelp harvesting, aquaculture (oysters), a little bit of industrial manufacturing, and film making (there is a small movie studio in Odegaard on Sea Lattle). Most tourists come for hiking, diving, recreational fishing, kayaking, and surfing. There is a Cruise Ship Terminal on Sea Lattle where ships come into port. These tourists usually stay near the terminal for their short port stay on the way to Alaska, sometimes touring the movie studio. There is an upscale marina, called Pratt Yacht Harbor, on the north coast of Tacominone. This area is known for expensive real estate. The major port for the state is located in Woodruff on Tacominone. The Husky Tribe has important tribal lands on Bothellia. They currently have exclusive and unlimited rights of harvest in their area.

Due to its location, Udubia is an important breeding location for the northeastern Pacific population of northern fur seals (*Callorhinus ursinus*). Seals are protected under the national Marine Mammal Protection Act. There is an endangered snail, the Chihuly glass-shelled snail (note: not a real species), within the waters of Udubia, that tends to be found in muddy habitats at 100-200 meters depth. This snail was aggressively collected for decades for its beautiful shell, but collection has been banned for the past 13 years. It is protected under the Endangered Species Act.

A map of Udubia[1] is attached including: towns, ports, tribal lands, sewage pipes, bottom types, kelp forests, prevailing currents, distribution of endangered species, and seal rookeries. The whole area has been divided into a grid for management and study. All data is provided as referenced to this grid with 1-20 down the vertical axis and A-NN across the horizontal. Each square measures 5 km by 5 km. In addition, Udubia's progressive government has invested heavily in inventory and monitoring. Existing data is provided about the following:

- Fisheries landings
  - Spiny lobsters (*Panulirus interruptus*)
  - Pacific ocean perch (POP, *Sebastes alutus*)
  - Rockfish (excluding POP, *Sebastes* spp.)
  - Kelp (*Nereocystis luetkeana, Macrocystis pyrifera, M. integrifolia, Porphyra* spp., and a variety of other brown and red seaweeds)
  - Pacific halibut (*Hippoglossus stenolepis*)
  - Albacore tuna (*Thunnus alalunga*)
  - Walleye pollock (*Theragra chalcogramma*)
- Shannon Diversity Index of indicator taxa
- Northern fur seal (*Callorhinus ursinus*) census data

After the monitoring program detected a few bad fishing years in a row, Udubia decided to take action. During the next few weeks, the legislature of the state of Udubia will debate and pass State Bill TESC232, the Udubia Marine Ecosystem Protection Act (UMEPA). The purpose of this law is to establish a place-based conservation approach for the coastal areas of this island state. A network of marine reserves will be established under UMEPA. In this exercise, you will participate in the public process to form this network.

Under UMEPA, a network is to be established that protects somewhere between 20-50% of the submerged lands within the coastal zone of the state in marine protected areas (MPAs). The reserves will be set up using the existing grid—so a 25 square kilometer square is managed as a complete unit. These MPAs can be zoned for different levels of protection including[2]:

State Marine Reserve

Restrictions: it is unlawful to injure, damage, take or possess any living, geological or cultural marine resource, except under a permit or specific authorization from the managing agency for research, restoration or monitoring purposes. While, to the extent feasible, the area shall be open to the public for managed enjoyment and study, the area shall be maintained to the extent practicable in an undisturbed and unpolluted state. Therefore, access and use (such as walking, swimming, boating and diving) may be restricted to protect marine resources.

Allowable uses: research, restoration and monitoring may be permitted by the managing agency. Educational activities and other forms of non-consumptive human use may be permitted by the designating entity or managing agency in a manner consistent with the protection of all marine resources.

State Marine Park

Restrictions: it is unlawful to injure, damage, take or possess any living or nonliving marine resources for commercial exploitation purposes. Any human use that would compromise protection of the species of interest, natural community or habitat, or geological, cultural or recreational features, may be restricted by the designating entity or managing agency.

Allowable uses: all other uses are allowed, including scientific collection with a permit, research, monitoring and public recreation (including recreational harvest, unless otherwise restricted). Public use, enjoyment and education are encouraged, in a manner consistent with protecting resource values.

State Marine Conservation Area

> **Restrictions**: it is unlawful to injure, damage, take or posses any specified living, geological or cultural marine resources for certain commercial, recreational, or a combination of commercial and recreational purposes. In general, any commercial and/or recreational uses that would compromise protection of the species of interest, natural community, habitat or geological features may be restricted by the designating entity or managing agency.
>
> **Allowable uses**: research, education and recreational activities, and certain commercial and recreational harvest of marine resources may be permitted.

UMEPA will be passed and signed by the governor. The Udubia Board of Fisheries Commissioners will hold a pubic hearing to hear public proposals for a network of MPAs under UMEPA from stakeholders. The stakeholders must present their plans as a group and answer questions from the Commissioners and other stakeholders.

1-- The background data (including the island shapes, the bathymetry, the bottom types, and the currents) is based on the real California Channel Islands. Everything else is unique to Udubia.
2-- Definitions are a restatement of existing California law, http://www.dfg.ca.gov/Mrd/mlpa/defs.html#system

Materials and Methods

Overview of Data Collection and Analysis Methods

Task 1: Choose your role

Choose your stakeholder role. You can be anyone who might be affected by these reserves. You should be someone specific, and you do not have to be someone with an opinion that you actually agree with. Feel free to be creative with your choice. The most important thing is that you are someone who would have an opinion about the marine reserve! Some *examples* of roles you could choose include:

- A third generation halibut fisherman with no debt left on his boat.
- A tribal leader who is progressive and interested in this issue but concerned about the loss of tribal rights.
- A conservation activist from out of state.
- A local kayaker who has watched the state of the ocean decline over the past two decades.
- A scientist who is passionate about this issue but concerned that getting involved will compromise her "objectivity."
- A business person who runs ecotourism tours (including diving, sport fishing, kayaking). His business is just taking off but there is still a lot of debt.
- Etc. Use your creativity!

Places to get some ideas:

- To see actual public comments of a wide variety of real-life stakeholders to the U.S. Commission on Ocean Policy go to: http://www.oceancommission.gov/publicomment/

- Your readings and research

- http://www.jasonproject.org/digital_labs/CINMS/mrlab.html

Bring your written character description to class. All that is required is a couple of sentences stating who you will be and what your general position regarding marine reserves will be.

Task 2: Your individual activism

Note that you can begin working on Task 3 while working on this assignment. This assignment should be done individually.

Write a position paper from the perspective of your character to the governor of Udubia that addresses State Bill TESC232. The paper should be written in first person (in your character's voice). Your paper should be your reaction to the passage of this bill and your attempt to take action or convince someone about how (or if) it should be enacted. Your paper must contain *at least* 3 pages (or about 800 words) of writing and should be based on both your character's perspective and factual information (provided data and outside research).

You should spend a section of your paper developing your character and the rest devoted to the issues. This paper requires research. Therefore, you must include a bibliography. Citations, however, are not needed unless your character would normally use them in the format you are using. Direct quotes, data, and facts must be attributed to their original sources, however (for example, you could state, "According to the Fisheries Commission of Udubia, 24% of lobster fishers are female").

You will be assessed on the strength of your argument, including your use of provided and outside research to make your case. Factor in the ecology of the relevant species and what you have learned about how reserves are designed.

Task 3: State Commission Public Hearing

You will be divided into groups of like-minded characters for the in-class debate, and you will be given time in class to prepare for the hearing, but you should plan to also meet outside of class to prepare well. You will need to conduct outside research to build your case, including consideration of the ecology of the species in the area and the science of marine reserves. A reference list is due prior to the debate.

On debate day, the Udubia Fisheries Commission will have a public meeting to solicit plans for the newly-passed UMEPA. The ultimate goal is to create a marine reserve (or reserve network) that protects between 20-50% of the submerged lands of Udubia. Use the grid to create your reserve—each square is considered one unit that will be managed together. You need to choose 20-50% of the grid squares that are not land (there are approximately 75 squares of land out of 800). In order to do this, you should first agree on a set of goals for your reserve—is it meant to protect fisheries? Is it meant to maximize species diversity? Protect marine mammals? Maximize the number of habitats protected? Provide for the most larval spillover? You should use outside research to get some ideas about how and why marine reserves are designed, then design your reserve on the map. Choose which grid squares you want to protect and what kind of protection (Reserve, Park, Conservation Area) you want them to have.

You will have 8 minutes to make your case to the Commission. Make sure you practice your talk to make sure it will fit in the time allotted. Your group should be coordinated so that you appear to be practiced. The Commissioners and the rest of the stakeholders will then ask you a few questions about your plan. This should take approximately 5 minutes. Note that your group will get a higher grade if you ask more questions of other groups.

Some of the questions you should be prepared to answer include:

1. How will your reserve affect the economy of Udubia?
2. How will your reserve improve fisheries outside of the reserve? What life history stages did you focus on?
3. How does your reserve impact existing protection (the Husky Reserve, the Marine Mammal Protection Act, the Endangered Species Act) in Udubia?
4. What would happen if a catastrophic event destroys your reserve?
5. What will your reserve do to protect biodiversity of Udubia?
6. How are the costs of setting up this reserve distributed among the stakeholders of Udubia? How are the benefits distributed?
7. How will this reserve be enforced?

There might be some questions specific to your plan as well. Other groups can ask you questions specific to their own biases and perspectives. If there is time after each group presents, we will ask these questions in a round robin.

Costumes and props are encouraged for the debate.

Questions for Further Thought and Discussion:

1. What are the predicted effects of creating a no-take marine reserve for each of the goals listed below, both inside and outside of the reserve?

    - Biodiversity and Habitat
    - Fisheries
    - Human Experience

2. What are some disturbances that marine reserves cannot protect against?

3. How are marine parks different from terrestrial parks in terms of the way they are managed or designed?

4. Compare the Udubia process to that used in the California Channel Islands (Airamé *et al.* 2003). What is different about the constraints in the two situations? How are the two processes different or similar? Note that although the two island sites look similar in terms of coastline, the real and hypothetical places are very different in terms of scale and human influence.

5. Find an example of a conservation biology compromise similar to what you simulated in UMEPA. Identify the pros and cons of the compromise form different stakeholder points of view.

References and Links

References

- Airamé, S., Dugan, J.E., Lafferty, K.D., Leslie, H., McArdle, D.A., and R.R. Warner. 2003. Applying ecological criteria to marine reserve design: a case study from the California Channel Islands. *Ecological Applications* 13: S170-S184.

- Alcala, A.C. and G.R. Russ. 2006. No-take marine reserves and reef fisheries management in the Philippines: A new people power revolution. *Ambio* 35: 245-254.

- Bartholomew, A., Bohnsack, J.A., Smith, S.G., Ault, J.S., Harper, D.E., and McClellan, D.B. 2008. Influence of marine reserve size and boundary length on the initial response of exploited reef fishes in the Florida Keys National Marine Sanctuary, USA. *Landscape Ecology* 23(Suppl. 1):55-65.

- Bohnsack, J.A. 2000. A comparison of the short-term impacts of no-take marine reserves and minimum size limits. *Bulletin of Marine Science* 66:635-650.

- Botsford, L.W., Micheli, F., and A. Hastings. 2003. Principles for the design of marine reserves. *Ecological Applications* 13: S25-S31.

- Carr, M.H. and D.C. Reed. 1993. Conceptual issues in the design of marine refuges. *Canadian Journal of Fisheries and Aquatic Sciences* 50: 2019-2028.

- Drew, J.A. 2005. Use of traditional ecological knowledge in marine conservation. *Conservation Biology* 19: 1286-1293.

- Gaylord, B., Gaines, S.D., Siegel, D.A., and M.H. Carr. 2005. Marine reserves exploit population structure and life history in potentially improving fisheries yields. *Ecological Applications,* 15: 2180–2191.

- Halpern, B.S. 2003. The impact of marine reserves: do reserves work and does reserve size matter? *Ecological Applications* 13: S117–S137.

- Halpern, B.S. and Warner, R.R. 2003. Matching marine reserve design to reserve objectives. *Proceedings of the Royal Society of London B* 270: 1871–1878.

  Jones, P.J.S. 2002. Marine protected area strategies: issues, divergences and the search for middle ground. *Reviews in Fish Biology and Fisheries* 11: 197–216.

- Jones, P.J.S. 2007. Point-of-View: Arguments for conventional fisheries management and against no-take marine protected areas: only half of the story? *Reviews in Fish Biology and Fisheries* 17:31-42.

- Leslie, H., Rosenberg, A.A., Eagle, J. 2008. Is a new mandate needed for marine ecosystem-based management? *Frontiers in Ecology and the Environment* 6: 43-48.

- Lubchenco, J., Palumbi, S.R., Gaines, S.D., and S. Andelman. 2003. Plugging a hole in the ocean: the emerging science of marine reserves. *Ecological Applications* 13: S3–S7.

- Roberts, C.M., Andelman, S., Branch, G., Bustamante, R.H., Castilla, J.C., Dugan, J., Halpern, B.S., Lafferty, K.D., Leslie, H., Lubchenco, J., McArdle, D., Possingham, H.P., Ruckelshaus, M., and R.R. Warner. 2003. Ecological criteria for evaluating candidate sites for marine reserves. *Ecological Applications* 13: S199–S214.

- Sala, E., O. Aburto, G. Paredes, I. Parra, J.C. Barrera and P.K. Dayton. 2002. A general model for designing networks of marine reserves. *Science* 298: 1991-1993.

- Salomon, A.K., Ruesink, J.L., and R.E. DeWreed. 2006. Population viability, ecological processes and biodiversity: Valuing sites for reserve selection. *Biological Conservation* 128: 79-92.

- Sanchirico, J.N., Malvadkar, U., Hasting, A., and Wilen, J.E. 2006. When are no-take zones and economically optimal fishery management strategy? *Ecological Applications* 16: 1643–1659.

- Shafer, C.L. 1999. National park and reserve planning to protect biological diversity: some basic elements. *Landscape and Urban Planning* 44: 123-153.

- Viteri, C. and Chávez C. 2007. Legitimacy, local participation, and compliance in the Galápagos Marine Reserve. *Ocean & Coastal Management* 50: 253–274.

Useful Web Sites

California Department of Fish and Game. 2007. Marine Life Protection Act Initiative.
The UMEPA law used in this simulation is based on the MLPA of California. This page has current information about the act as well as marine reserves on a state level.
http://www.dfg.ca.gov/Mrd/mlpa/defs.html#system

Froese, R. and D. Pauly, eds. 2008. FishBase.
This webpage provides a wealth of information about the natural history of the fish species used in this exercise.
www.fishbase.org

National Marine Fisheries Service Office of Science and Technology. 2007. Commercial Fisheries Landings.
This page has links to a database (click on "Annual Landings" for example) that provides landings data by species and state. Includes some useful economic data.
http://www.st.nmfs.noaa.gov/st1/commercial/index.html

National Oceanographic and Atmospheric Administration (NOAA) Office of Coast Survey. 2001-2007. NOAA ENC Direct to GIS.
Web-based access to NOAA coastline, bathymetric, and seabed characteristic GIS data. Used to create the map of Udubia.
http://ocs-spatial.ncd.noaa.gov/encdirect/viewer.htm

Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO). 2007. The Science of Marine Reserves.
A booklet produced for multiple audiences to summarize the science behind marine reserves. A useful short reading for students of multiple backgrounds.
http://www.piscoweb.org/outreach/pubs/reserves

United States Commission on Ocean Policy. 2004. Public Comment.
Public comments from a wide variety of real-life stakeholders to the U.S. Commission on Ocean Policy go, useful for designing characters.
http://www.oceancommission.gov/publicomment/

Tools for Assessment of Student Learning Outcomes

Individual Component
The individual papers are assessed using a simple rubric that stresses the strength and consistency of the argument (especially using provided data and outside sources) used and your creativity. Points are given based on the following:

Component	Weight
Strength of Argument	4
Use of Outside Sources	4
Consistency of Argument	3
Critical thinking skills (comprehension)	4
Organization skills	1
Linguistic skills (word choice and meaning)	1
Mechanics & Correctness (grammar and proofreading)	1
Creativity	2

The “exceptional” category for each item are as follows:

- Strength of Argument: Argument is constructed persuasively and includes a strong scientific backing.
- Use of Outside Sources: Outside sources are integrated that add to the argument presented. Includes appropriate attribution and bibliography.
- Consistency of Argument: Elements of argument are consistent with character described.
- Critical Thinking Skills (comprehension): Shows understanding of concepts and ability to synthesize information. Ideas are factually correct and all main assertions are well supported with evidence, examples, or citations.
- Organization Skills: Essay is organized with a thesis and topic sentence, and paragraphs are ordered logically.
- Linguistic Skills (word choice and meaning): Wording is appropriate, clear, and concise.
- Mechanics & Correctness (grammar and proofreading): No errors in grammar or punctuation.
- Creativity: Credit is given for creating a creative character that is well developed with a unique point of view.

Group Component

You will be evaluated as a group for your presentation and debate participation. The group presentations will be assessed using a rubric attached as an Excel file (presentation_rubric.xls). This rubric stresses comprehension and scientific evidence, as well as basic presentation skills.

In addition, you will be asked to evaluate the contributions of your group members to assure that everyone participates equally. This form is given in a Word file (evaluation_form.doc).

NOTES TO FACULTY

Challenges to Anticipate and Solve

Challenge #1: Timing of role and group assignment.

In order for students to have time to do group work, they will need to be placed into groups early. As designed, students choose their own roles that are used to break them into groups, and might have trouble developing a character earlier in the class if they have less previous knowledge of the topic.

There are a number of possible solutions to this challenge. If it is possible, students enjoy the opportunity to be creative in choosing their own roles, especially if a list of examples is provided to get them started. Students are also given a list of existing stakeholders who submitted public comments to the U.S. Commission on Ocean Policy (available at http://www.oceancommission.gov/publicomment/). In order to streamline the exercise, the instructor can pre-assign their roles or allow them to choose from an existing list of roles. Students can be given the materials in support of the exercise earlier in the course to allow them to make their decision in advance of the actual exercise

It is also likely that if students choose their own roles, the groups will become "unbalanced," with many more students in the "pro-marine reserve" groups than the more economically concerned groups. In order to balance the groups, the professor can ask for volunteers to "switch sides," and provide encouragement for students to choose a position that is different from their own.

We have found that groups as small as four have worked quite effectively. Once the groups are as large as eight, it becomes more difficult to coordinate meetings and have equal participation in the presentation.

Challenge #2: Working in groups.

As is often noted with group work, there are known difficulties that stem from different work styles and personalities. This is true of this simulation, where students will be assessed on a plan developed by their group.

A few possible solutions to this challenge is to spend some time in class discussing the importance and difficulties of group work, provide technological solutions (e.g. electronic message boards) to foster communication outside of class, and encourage students to explicitly divide tasks for different individuals. A confidential evaluation form (an example is provided in the file evaluation_form.doc) can be distributed at the end of the exercise and in cases of extreme differences in participation, different grades can be assigned. We usually do not act on a single negative peer review of a student, but rather look for a pattern within a group that indicates one student did not participate appropriately. We also look for specific comments to help determine when there is a participation inequality versus a personal disagreement among group members. This

form was adapted Exhibit B.2 from *Team-Based Learning: a Transformative Use of Small Groups* edited by Michaelsen, Knight, and Fink. Consider reviewing the ideas presented in Appendix B of this book for more discussion of the peer review issue.

We have found that the confidential peer review approach is most effective if the students see the evaluation forms at the beginning of the assignment and are aware that there are consequences of not contributing. Most students are affected by the knowledge that their individual contribution will be considered, which improves the dynamic of the group. In addition, there is an optional exercise that allows for an opportunity for individual assessment.

Challenge #3: Antagonistic Characters.

Some stakeholder groups have requested not to present a marine reserve plan since their position is that reserves are not effective or are harmful to marine conservation. We have found that it is useful to have some bounds on what we are asking of the students, so we have asked these groups to produce a reserve plan despite their reservations. However, we have worked with those groups to come up with some creative approaches to the assignment that are consistent with their characters' positions. For example, one group of fishermen designated locations that they would *not* give up, leaving the rest of the area open for negotiation. One group of fishermen designated areas they were willing to close, but stated their opposition to UMEPA in general. Both proposed more traditional methods of fisheries management, such as quotas and transferable vessel quotas.

Allowing some flexibility, with instructor guidance, has worked well to keep the arguments consistent and interesting.

Experiment Description

Introducing the Experiment to Your Students

The theories of marine reserve design are introduced in a lecture that includes examples of existing designs. This can be done at a variety of depths, depending on the goals and subject of the course. Students are assigned readings in advance that include one summary paper that all students read (PISCO reference given in the "Useful Websites" section), and a number of choices for a second reading from a variety of perspectives (the list of other citations in the References Section). This way, students come to their groups with wider individual backgrounds. In addition, the assignment is provided early to prepare students for the various steps involved.

Students then are asked to choose their characters and hand in a paragraph with a short description of their position. The professor uses these paragraphs to break the students into groups of like-minded characters.

Students should be encouraged to incorporate ecological concepts in their plans, including natural history of the species highlighted in the exercise and the

oceanography and community ecology involved in marine reserves. Note that all species mentioned in the exercise, with the exception of the Chihuly glass snail, are real and can be studied using outside research. A summary of the natural history of these species is provided and can either be distributed to the students, or retained by the instructor for reference if independent student research is expected. Note that this is a simulation, and therefore balances realism with a simplified system that allows students to focus on specific issues.

In order to encourage outside research, and to provide a check on the progress of the groups, a reference list can be collected before the debate. This will allow the professor to provide feedback early in the exercise and keep the students on task. It can also be used for formative evaluation to determine if the exercise is meeting the goals of teaching students about marine reserves and how to create an argument using evidence. These reference lists can also be added to the suggested reading to keep the exercise current.

Data Collection and Analysis Methods Used in the Experiment

In order to make the map somewhat realistic, actual data from the California Channel Islands were used to create the coastline, bathymetry, and bottom type map in GIS. Currents, fisheries and population data, and biodiversity information were created to spur interesting debate about the tradeoffs involved in designing marine protected areas.

Questions for Further Thought

The list of debate questions are given to the students beforehand, and are asked during the debate, as well as more specific questions that come up during the presentation. It is difficult for any one reserve plan to be strong in all seven of these questions. Students should be pressed to explicitly acknowledge the tradeoffs they needed to make, especially in the context of the goals of their characters.

1. What are the predicted effects of creating a no-take marine reserve for each of the goals listed below, both inside and outside of the reserve?

Some examples of acceptable answers include:

	Biodiversity and Habitat	Fisheries	Human Experience
Within the reserve	Protection from harmful uses leads to increased biodiversity and habitat health. Larger and more abundant individuals of many species.	No fishing allowed, so fisheries are closed—most effects outside of reserve. However, fish within the reserve are larger and more abundant, leading to more production and possible spillover.	Better habitat and increased biodiversity increases recreational and educational opportunities. No take does not mean that there is no access, just no harvesting.
Outside of the reserve	Possible spillover will improve nearby habitats/biodiversity, but otherwise, most effects within reserve.	Spillover leads to improved fishing. "Fishing the Line." More consistency in catch.	Possible improvement of recreation due to spillover (see biodiversity). Satisfaction of conservation. Economic benefits of healthy reserve. Improved tourism, seafood and employment opportunities.

2. What are some disturbances that marine reserves cannot protect against?

Some examples of acceptable answers include:

- Large-scale disturbances such as:
  - Global climate change
  - Large catastrophes such as hurricanes or tsunamis
- Sources of disturbance from outside of the reserve, such as:
  - Pollution
  - Disease
- Overfishing of migratory species such as tuna

3. How are marine parks different from terrestrial parks in terms of the way they are managed or designed?

Some examples of acceptable answers include:

- The boundaries of marine reserves are harder to mark/enforce
- Marine reserves are more connected via water, terrestrial reserves are isolated unless connected via corridors
- Marine realm is 3-dimensional, terrestrial is usually 2-dimensional
- In US, the terrestrial parks fall under the National Park Service (Dept. of Interior), while marine parks are mostly in National Marine Sanctuaries (NOAA, Dept. of Commerce). Note that there are some marine National Parks, and this is growing.
- Commercial fishing not analogous to commercial hunting

4. An example you can provide to the students for further discussion is the sanctioned harvest of marine mammals by Native Americans, such as the harvest of fur seals on the Pribilof Islands.

Assessment of Student Learning Outcomes

The rubric for the individual assignment is fairly simple and includes both content and writing. For each category, select a point value from 1-5. Multiply the points by the weight for a total possible score of 100. This can easily be scaled to any number of points as needed.

The presentation rubric was designed to streamline the process of taking notes during the debate, which can be challenging. Many of the common issues in student presentations are listed on the rubric, allowing the teacher to circle the items of concern quickly. Usually, this completed rubric is returned to the groups, along with a short paragraph with more specific comments for their consideration.

It can be challenging to check a box for each item given that there are multiple students with different levels of performance. It is possible to check multiple boxes and use the comments section to note more specific thoughts.

The score given for each column can be weighted according to the preference of the teacher. It is often useful to have an “exceeds standards” option for students who perform exceptionally, and to have the point difference between “exceeds standards” and “meets standards” be lower than that between “meets standards” and “approaches standards.” The weight given to each row can vary according to the goals of the teacher. The total score can vary depending on how many points are given for each row.

For both rubrics, the weight given for each component can be adjusted according to the goals of the instructor.

Formative Evaluation of this Experiment

This assignment lends itself to inviting other faculty members to participate in the debate. The "Udubia Fisheries Commission" can be a single teacher, or a panel of other faculty who are willing to participate in the exercise. This provides for a good opportunity for other faculty members to observe the exercise and provide feedback, especially for junior faculty. In addition, student reference lists can be used to determine the quality of student research and their grasp of some of the major topics in the exercise.

Translating the Activity to Other Institutional Scales or Locations

This assignment has been used in its present long format, as well as in a few shorter modified formats for different purposes. The long format has been used as a major module of a 40-person, majors and non-majors conservation biology class and is currently being adopted for a 60 student lecture oceanography course at a community college. The shorter format was used for a one-hour exercise in an oceanography class (40 students) and an introductory biology class (60 students), with no additional lecture or out of class time used.

The assignment can be given in an abridged format in a number of ways. It is possible to limit the layers of data (one or two fisheries datasets, for example) given to the students. Students can be pre-assigned into groups with known positions to streamline the beginning of the process for students with less background in the subject matter. One approach used by a professor who adapted this exercise was to provide the students with a color copy of the map and a black and white copy on an overhead transparency. Students could map out their priority reserve areas on the overheads and then stack the results for the different stakeholder groups on a projector to look for overlaps. Students can be asked to answer the seven debate questions (see "Materials and Methods") in short written minute essays or for a homework assignment.

2) Udubia is a hypothetical place, although it was designed with U.S. West Coast fisheries, habitat types (e.g., kelp) and social considerations in mind. All of the location names are based on landmarks familiar to University of Washington students, although there is little substantive information associated with these names. The content would not be significantly different in most developed countries and could be adopted directly without alterations, although teachers might prefer to give the simulation a more local flavor.

With local knowledge, the fish listed in the datasets could be converted to fish from any given area, as long as the species served similar ecological functions. For example, tuna were chosen to be a migratory species that would be transient in a given reserve (and therefore not the best candidate for protection with a marine reserve), while lobsters and rockfish were considered to be relatively sedentary and associated with the highly diverse kelp forest. The Pacific ocean perch and halibut were associated with high relief and sandy habitats, respectively. The pollock were added at the request of students whose characters were interested in protecting the food source of the northern

fur seals. The Chihuly glass snail is not a real species and its distribution was intended to create interesting conflicts. Other fish can be substituted for these, although there is no need to have specialized knowledge of these species in order to achieve the learning outcomes for this exercise.

The exercise could also be adopted for terrestrial reserve design, although this would take considerable effort.

This is an indoor activity, so seasonal considerations are not an issue. It is notable that this is a good exercise for locations with cold winters where field work becomes more difficult for a lot of the school year.

3) This exercise does not necessitate the ability to walk or move more than the normal requirements of attending class. Students with hearing disabilities might be limited in their ability to participate in a group debate. Depending on the individual situation, an accommodation can be made for replacing the presentation with written work.

The simulation has many visual components, most notably the map. A visually impaired student participated in this exercise with little need for special accommodation, although a larger version of the map was provided to her. Students who are blind might need particular help navigating the map.

4) Pre-college students would be able to participate in this simulation. Depending on the level of the class, a more abridged format as described in #2 can be utilized.

STUDENT DATA COLLECTED IN THIS EXPERIMENT

Student Collected Data from this Experiment

Check back with the TIEE site as student generated data are posted from this activity. If you have student data from this activity, please email us and share it with your colleagues!

RESOURCES

- A detailed map with coastline infrastructure, bathymetry, currents, and a standardized grid. (Udubia_Map.pdf)
- An Excel spreadsheet that includes grid-specific data on habitat, fisheries landings (lobsters, rockfish, kelp, halibut, albacore, Pacific ocean perch, and pollock), and biodiversity, as well as time series data for northern fur seal populations. (Udubia_data.xls)
- A merging of the Udubia map with the spreadsheet data for easier visualization. (Udubia_data_maps.pdf)
- Form to help students evaluate the contributions of group members. (Evaluation_form.doc).
- Life history handout. (Life_history.doc).
- Presentation rubric. (Presentation_rubric.xls)

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