Teaching Notes

Conflict in paradise: Managing watersheds on a crowded island

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1. Summary

Hawai'i is known for its abundant, beautiful natural resources, from waterfalls cascading through verdant rainforest to colorful coral reefs. These attract more tourists and new residents each year. Ironically, the resources are being loved to death: coastal development, land use change, water extraction, waste disposal, fishing, and habitat destruction to accommodate expanding human uses stress these valued fragile and finite environments, and often diminish the very ecosystem services people want to experience. This case study focuses on Maunalua Bay, which encompasses seven watersheds on O'ahu, the most populated island in HI, USA. Students explore an active and contentious watershed management process, applying knowledge from multiple sources to characterize the social-environmental system and evaluate the trade-offs associated with economic development, biodiversity, social and indigenous cultural values, and different management approaches.

2. What course(s) might this case be appropriate for?

Environmental science, Environmental studies, Geography, Natural resource management, Sustainability

3. What level is this case appropriate for?

Advanced UG and graduate students who want an introduction to interdisciplinary analysis of social-environmental systems, including their governance.

4. Social Environmental Synthesis Learning Goals, Objectives, and Activities

- Goal: Understand the structure and behavior of a SES, including environmental and social components and their interactions

Objectives:

- Students can identify management-relevant environmental and social components of the watershed from ridge to sea that affect human use of resources, including the history, cultural significance, and interactions
- Students can identify and describe the key feedbacks between land and sea systems, natural resources, users of those resources, and managers and decision makers that govern them
- Students will explain biophysical dynamics of the watershed and the social and cultural dimensions of watershed management through individual and group conceptual models and discussions
- Goal: Ability to consider the importance of context and scale in addressing socio-environmental problems
- Students will develop greater insight into the scientific and socio-cultural complexities of socio-environmental problems across contexts
- Students will identify how governance institutions can match SES scales (spatial, temporal, process), and develop insight into problems related to institutional mismatch
- Goal: Ability to co-develop research questions and conceptual models in inter-or trans-disciplinary teams
- Students will identify, seek out, translate, and synthesize information from relevant disciplines and perspectives (e.g., natural science, social science, economics, culture, political) and identify good questions and hypotheses based on what they learn
- Students will reflect on their own normative understanding of this SE case study and how that perspective may influence their science and communication, and conflict with various stakeholders' livelihoods and beliefs
- Students will understand the need for multiple perspectives and ways of knowing in order to identify trade-offs associated with viable solutions in this and other SE challenges
- Students will identify potential users of and applications for research findings
- Goal: Ability to find, analyze, and synthesize data, ideas, and methods
- Students will identify quantitative and qualitative data sources needed to answer research questions/test hypotheses, understand research methods used by different disciplines, evaluate quality of data
- Students will gather, read, and interpret information from various credible sources and evaluate how those sources of knowledge can be used
- Students will use geospatial and data visualization tools to map social-ecological systems conceptually and locate key features geographically
- Students will engage in open dialog with peers and experts around the challenges and opportunities of interdisciplinary collaboration and data integration

Table 1. How learning objectives connect to modules and activities

	Learning Objectives	Module					Activity
1.1	scientific and socio-cultural complexities						- Driver-Pressure-State-Impact-Response (DPSIR) Conceptual Ecosystem Model (CEM) - videos
1.2	feedbacks						- DPSIR CEM
1.3	biophysical dynamics and social and cultural dimensions						- DPSIR CEM - discussions
2.1	complexities across contexts						- DPSIR CEM - discussions - end case wrap-up
2.2	governance institutions						- videos, web search - stakeholder analysis - institutional mapping
3.1	synthesize information						- knowledge domain homework and discussions - DPSIR CEM - hypothesis generation - stakeholder analysis, public forum - end of case reflection
3.2	normative perspective						- stakeholder analysis, public forum - end of case reflection
3.3	value of multiple perspectives						- stakeholder analysis, public forum - end of case reflections
3.4	potential users						- stakeholder analysis, public forum - institutional analysis - discussion - case study wrap-up discussion and reflection
4.1	data sources, research methods						- knowledge domain homework and discussions - data discussion
4.2	gather, read, and interpret information						- knowledge domain homework and discussions
4.3	use geospatial and data visualization tools						- Google Earth mapping - CMAP
4.4	engage in open dialog						- classroom discussions

5. Introduction

Site description

Maunalua Bay, on the southern shore of the island of O'ahu, is one of the largest bays in the Hawaiian archipelago. The bay has ~13km of shoreline between Black Rock point at the bottom of Diamond Head's volcanic cone (21° 15' 17.55"N 157° 47' 30.84") and Koko Head peak (21° 15' 34.70" N 157° 42' 37.33"W). It encompasses and 16.8 km^2 of ocean with nearly eight miles of fringing coral reefs and seagrass beds, which provide habitat for fish as well as protected and endangered species (sea turtles, dolphins, monk seals, humpback whales).[1] Seven watersheds drain into the bay via four perennial streams and at least 50 drainages.[2] Groundwater aquifers store freshwater in the volcanic soils, and discharge into the nearshore environment. Much of the land was developed in the past 50 years, although the steep slopes of the Ko'olau mountains are protected by geography and law, to ensure groundwater recharge and protect endangered birds (O'ahu 'Elepaio (flycatcher). The watersheds also host endangered seabirds, the Ae'o (Hawaiian stilt) and Alai'ua (Hawaiian moorhen).

Figure 1. Map of Maunalua Bay. Diamond Head's crater is on the left, and Koko Head peak on the right.

History

[1] http://malamamaunalua.org/wp-content/themes/mm_theme_dark/pdf/09%20CAP_final.pdf
[2] http://hawaiihumpbackwhale.noaa.gov/management/pdfs/05_maunalua_bay.pdf

Ancient Hawaiians settled in Maunalua Bay, establishing productive farms and fishponds that fed the local communities. Traditional Hawaiian resource management typically divided islands along watershed boundaries in divisions called ahupua'a, such that management units spanned forests, farmland, and reefs. The chief of the ahupua'a (the konohiki) managed resources integrally and sustainably, trading with nearby ahupua'a, but generally sustaining local residents from the local resources.

This productive and sustainable landscape, including the ancient inland fishpond and wetlands, was transformed to suburban housing developments in the 1950s. Over 60,000 people now call this affluent neighborhood home. Impermeable surfaces now cover much of the area, streams have been channelized, wetlands filled and dredged, corals dredged, and native forests invaded by invasive species. Channelized streams efficiently deliver freshwater to the nearshore environment, causing major fluctuations in salinity. Runoff also carries nutrients from residential fertilizers, detergents, sewage, and pet waste, as well as toxins, such as chlorine, hydrocarbons, heavy metals, and pesticides, to the nearshore environment. As a result, reefs can become smothered by sediment and algae. Invasive marine algae outcompete native species and smother reefs. Finally, over fishing has depleted once abundant fish stocks to critical levels.[3]

Implications of environmental declines

These environmental declines have direct implications for residents and visitors alike. The Bay is heavily used by jet skiers, kayaks, stand-up paddlers, surfers, swimmers, divers, fishers, and other recreationalists, and a large local business community supports these activities. The water quality in the marina has direct implications for nearby property values. The upper watersheds are popular with hikers and birders, and important recharge areas for O'ahu's domestic water supply.

Management of the Bay

Maunalua Bay has been the focus on extensive restoration action over the past decade. A local group is working to restore the ancient Hawaiian coastal fishponds. A community group called Mālama Maunalua (to care for Maunalua) has stewarded conservation action in the area since 2005. A 2006 conservation action plan focused on improving conditions in the marine environment was updated in 2009, diagnosing the problem, setting management targets, and outlining actions and monitoring. Actions focused on curtailing polluted runoff and sediment, culling invasive marine algae, and halting unsustainable extraction of resources.

In the Spring of 2015, working with Malama Maunalua, the Hawaii Island National Marine Sanctuary proposed a special management area for Maunalua Bay as part of their effort to move from single-species (focused on humpback whales) towards ecosystem-based management.[4] This proposal was met with enormous community resistance[5], and remains imperiled. The proposed special

[3] http://malamamaunalua.org/wp-content/themes/mm_theme_dark/pdf/09%20CAP_final.pdf
[4] http://hawaiihumpbackwhale.noaa.gov/management/pdfs/05_maunalua_bay.pdf
[5] e.g., http://khon2.com/2015/06/13/noaa-responds-to-maunalua-bay-concerns-in-light-of-protests/

management area aims to "enhance community stewardship and increase overall protection of the Bay[4]." The action plan would support community activities to mitigate runoff, organize community groups, and fund education. Regulations would also prohibit certain actions in the Bay, including discharges; taking of certain marine species; altering submerged lands; explosives; and introducing non-native species.

Broad strokes of the case study

In this case study, students will explore the complex social-ecological system of Maunalua Bay by seeking out and synthesizing knowledge about physical, ecological, social, and cultural processes. They conceptually map the system, explore the problem from the perspective of multiple stakeholders, and examine trade-offs across diverse objectives from alternative management approaches. They evaluate current and potential management solutions from an institutional match perspective, which encourages consideration of scales (temporal, spatial, and functional/process).

Required background and motivation

No specific background is required, although students should have a keen interest in diving in to the case because it covers a lot of material, and demands dedication to reading, homework, and in-class engagement!

6. Classroom Management

MODULE 1 – THE SOCIO-ENVIRONMENTAL CONTEXT OF MAUNALUA BAY, OAHU (60 minutes)

Homework (to be done prior to class):

- **Find and explore** Maunalua Bay and its upstream watersheds in Google Earth
- **Look** at pictures of Hawaii Kai on: http://www.huffingtonpost.com/2015/01/15/honolulu-history-change-bishop_n_6433372.html
- **Read** main text of the 33-page 2009 Conservation Action Plan http://www.malamamaunalua.org/wp-content/uploads/09-CAP_finalSM.pdf
- **Work through** EPA Module 1: http://archive.epa.gov/ged/tutorial/web/html/slide0001.html
- **Review** theory of concept mapping and how to use CMAP software: http://cmap.ihmc.us/docs/theory-of-concept-maps
- **Respond**:
    - **List** 10 observations about the site
    - **Identify, briefly describe, and use CMAP to draw** three linkages where the social system affects the ecological system and three linkages where the ecological system affects the social system.
    - Use CMAP to **draw** an interaction and a feedback

Classroom activities:

1. Defining the system (5 minutes)
    - Activity: Instructor projects Maunalua Bay and watersheds using Google Earth, every student one-by-one raises and locates observations
2. Concept mapping (25 minutes)
    - Instructor lectures on systems thinking and the DPSIR framework: http://archive.epa.gov/ged/tutorial/web/html/slide0001-2.html and http://archive.epa.gov/ged/tutorial/web/html/slide0001-3.html
    - Run DPSIR for Maunalua Bay:
        - On whiteboard, define D, P, S, I, R
        - Project blank CMAP on screen, have student volunteer draw map based on input from class
        - ***Prompts:*** *What are the main drivers of change in Maunalua? What are the main pressures, i.e., the direct vectors of environmental impacts? How do these pressures affect the state of the environment? How do changed environmental conditions affect human uses? What responses are possible?*
    - Discuss what information we need to know to understand SES
        - ***Prompts****: What types of knowledge do you currently have? What is missing?*
3. Introduction to case (30 minutes)
    - **Hand out and read** 2-page NOAA summary of Special Management Area for Maunalua Bay, Oahu: http://hawaiihumpbackwhale.noaa.gov/management/pdfs/05_maunalua_bay.pdf
    - **Watch** 3-minute video from KHON TV (6/13/2015): http://khon2.com/2015/06/13/noaa-responds-to-maunalua-bay-concerns-in-light-of-protests/
    - **Watch** 3 minute news report from Hawaii News Now (6/17/2015): http://www.hawaiinewsnow.com/story/29348456/controversy-grows-over-noaas-plans-for-maunalua-bay
    - **Pair up,** define the problem (5 minutes in pairs), report out definitions to class (10 minutes)
        - ***[Note: instructor should roam group to group and observe (see assessment section)]***
        - ***Prompts:***
        - *What is the management problem?*
        - *What are common pool resources? Why might these type of resources be prone to over-exploitation and degradation?*
        - *What are the ecosystem services that Maunalua Bay provides? For whom?*
        - *What seem to be the key challenges for managing the Bay?*
    - **Read** case study hand-out
        - Knowledge domains (10 minutes)
    - **Hand out** knowledge domain instruction sheet. Each student will be responsible for digging in to a "knowledge domain". The knowledge domain should represent a series of nodes from the conceptual map that the student wants to pursue in-depth. Instructor should ensure that most, if not all, of the class conceptual map is covered by student choices.
5. Intro to next class (1 minute)
    - Next up: digging in to the SES

MODULE 2 – DATA-DRIVEN SES CHARACTERIZATION (60 minutes)

Homework (to be done prior to class):

- **[Note: Instructor and students see knowledge domain handout]**
- **Find** information related to your knowledge domain
- **Document** the process you used to find information and **summarize** your key take-aways
- **Develop** an individual Conceptual Ecosystem Model specifically for your knowledge domain
- **Prepare** any visuals you need to help teach your knowledge domain to your peers
- **Suggest** revisions to the Conceptual Ecosystem Model done in class yesterday

Classroom activities:

1. Peer-to-peer learning of knowledge domains (30 minutes)
    - **Reporting**. Using a jig-saw approach, students act as "experts" in their chosen domain. Experts share insights with each other, and present their individual CEMs, to reconsider the class CEM.
        - Large class option: Students first **group up** according to knowledge domain, discuss information they found, summarize it, and collectively adapt the DPSIR CEM accordingly.
        - ***[Note: instructor should observe (see assessment section)]***
    - **Project** CEM from last class, and discuss amendments. Student volunteer can map in real time.
    - **Discuss as a class**
        - ***Prompts****: How did new knowledge enlighten your CEM? What new connections did you discover between the social and ecological components? How confident are you with the information you gathered? With information presented by others?*
        - *What types of knowledge do you trust and why? How is that related to the type of data, its scale, source, your background, worldview, etc.? In revising the CEM, what information do you feel was weighted more? Why? Were certain types of data given precedence?*
2. Generating good hypotheses (29 minutes)
    - **Fill out** worksheet individually[6] using the CEM as guidance (i.e., each relationship represents a hypothesis): http://participatoryscience.org/sites/default/files/CuUnit3Activity1_Stu-BrainstormingWksht.pdf
    - **Group up** into 2-3 student teams, discuss individual brainstorming, and **fill out** as a group for one of the claims: http://participatoryscience.org/sites/default/files/CuUnit3Activity1_Stu-ScientificClaimwksht.pdf

[6] Materials from http://participatoryscience.org/curriculum-activity/developing-research-questions-and-hypotheses

- **Discuss** as a class: Report out hypotheses, data needed, and what you predict you'd see.
- ***[Note: instructor should collect individual and group sheets for grading (see assessment section)]***

3. Introduction to next class (1 minute)
   - Stakeholder analysis and engagement (see below - Module 3 classroom activities)

MODULE 3: STAKEHOLDERS (60 minutes)

Homework (to be done prior to class):

- **Read** 11-page HIHWNMS management plan revision summary http://hawaiihumpbackwhale.noaa.gov/management/pdfs/mp2015_dmp_deis_summary.pdf
- **Read** "myth buster" http://www.friendsofmaunaluabay.org/
- **Read** first 4 pages of "What is a stakeholder analysis" (World Bank): http://www1.worldbank.org/publicsector/anticorrupt/PoliticalEconomy/PDFVersion.pdf
- (Optional) Watch 28 minute video about the history of the area and the effort to restore the traditional Hawaiian fishpond in Maunalua Bay: https://www.facebook.com/MaunaluaFishpond/videos/vb.102012409868829/821020754634654/?type=2&theater
- (Optional) Read: K. Schmeer "Guidelines for conducting a stakeholder analysis" http://www.who.int/management/partnerships/overall/GuidelinesConductingStakeholderAnalysis.pdf

Classroom activities:

1. **Conduct** a stakeholder analysis (25 minutes)
   - **Individually list** stakeholder groups
   - In group session, **write each stakeholder group** at the top of a large piece of paper stuck to the wall or whiteboards (may need to group some)
   - **Round robin**: everyone walk around to each identified stakeholder, write down a unique interest for each stakeholder group (do not repeat an earlier one!)
   - Students spread out across each stakeholder group and **map out** a power/interest grid for each using https://www.mindtools.com/pages/article/newPPM_07.htm
2. **Writing exercise** on stakeholders, equity implications (5 minutes)
   - ***Prompts:*** *Whose voice is most likely to be heard? Least likely? Why? What conflicts and common ground do you see? Are there outcomes that different stakeholder groups can agree upon? Who do you identify with most? Why?*
   - ***[Note: instructor should collect these for grading (see assessment section)]***
3. **Conduct** mock public forum: (15 minutes)
   - Instructions: Instructor adopts moderator role. Two to three students group up, adopt role of NOAA, and in 2 minutes present basics of Special Management Area proposal to Maunalua Bay community/stakeholders. Everyone else adopts a stakeholder persona (see

sheets prepared earlier). After NOAA has made its presentation, stakeholders and NOAA scientists discuss merits and challenges of the Special Management Area for Maunalua Bay.
    - ***Prompts:*** *How do you feel about the SMA? Why? What is the problem, from your perspective? What are the trade-offs that you are worried about? Are there alternatives to the SMA that you think are better? Whose interests are being protected by the SMA? Whose aren't? Does the proposed SMA align with local values? Are there alternatives that aren't being considered?*
- **Debrief** (5 minutes)

4. **Revisit** problem definition and CEM as a class (10 minutes)
    - ***Prompts:*** *Are there any changes to the CEM you'd like to make based on this discussion?*

MODULE 4: GOVERNANCE INSTITUTIONS (60 minutes)

Homework (to be done prior to class):

- **Investigate** mission and jurisdiction of regulatory agencies: *Federal* (NOAA Fisheries, HIHWNMS), US Army Corps of Engineers, USEPA: http://www2.epa.gov/aboutepa/epa-hawaii, USFWS); *State* (Office of Planning: http://planning.hawaii.gov/, Coastal zone management program, Ocean Resources Management Plan; Department of Land and Natural Resources: http://dlnr.hawaii.gov/ including Division of Aquatic Resources, Division of Forestry and Wildlife, Commission on Water Resource Management, and Hawaii Association of Watershed Partnerships; State Department of Health).
- **Read** local rep's comments at http://www.hawaiifreepress.com/ArticlesMain/tabid/56/ID/15629/Ward-NOAA-should-not-be-given-cart-blanche-over-Hawaii-Waters.aspx
- **Read** two articles about institutions and institutional match
    - Ostrom, E. 2008. "Institutions and the Environment." *Economic Affairs*. http://beyondostrom.blog.rosalux.de/files/2013/10/Governance-Ostrom-Adaptive-MLG.pdf
    - Epstein, Graham, et al. "Institutional fit and the sustainability of social–ecological systems." *Current Opinion in Environmental Sustainability* 14 (2015): 34-40.
- **Briefly summarize** jurisdictions and formal and informal rules in place for one resource of your choice (e.g., fish, reefs, coastal water, streams, watersheds, forests, native species, etc.) or one agency of your choice (e.g., NOAA fisheries, DAR, etc.).
- **Write 1-2 pages discussing** how and why this may or may not fit the resource or social environmental system.

Classroom activities:

1. **Identify jurisdictions and rules** in place (15 minutes)
    - **Draw** a watershed from ridge to reef, every student indicate the jurisdiction and rules they identified
    - **Reflect** on drawing (jurisdictional overlap, etc.)
        - ***Prompts:*** *What are the boundaries of the jurisdiction (i.e., conservation zone; pelagic marine, etc.)? What is being managed? What are "institutions"? What rules are in*

place? Are these formal (legal) or informal (social norms, custom, etc.)? Centralized or decentralized?

2. **Introducing the notion of institutional fit** (20 minutes)
   - **Discuss** concept of institutional fit and Ostrom and Epstein papers
     - ***Prompts***: *What is meant by institutional fit? Why might it be important for SES management?*
   - **Project** class CEM at the front of the classroom: students can get up, and point to processes that have rules in place
   - **Discuss** gaps, overlap
   - **Identify** potential sources of conflict, synergies for different levels of government, potential routes forward for Federal, State, and community governance to co-exist
     - ***Prompts:*** *Does the theory of institutional fit provide any insight into why there is conflict in this case? How might management be designed to better fit the system?*

MODULE 5: WRAP UP (60 minutes)

Homework (to be done prior to class):

None

Classroom activities:

1. **Synthesize CEM** and knowledge domain data (20 minutes)
   - Break into groups of 2-3 students. **Observe your early and final CEMs**. Using prompts below, list three main points. Report out to class.
     - ***Prompts****: What changed? What changes were a result of new knowledge? What types of new knowledge were used - traditional knowledge, qualitative data? Were there types of knowledge you trusted/used more than others?*
     - *What hypotheses were generated? Which are most certain/uncertain?*
2. Institutional diagnosis (20 minutes)
   - **Differing perspectives:** *Is there agreement on the "vision" for this bay? Is current management adequate to achieve this vision? Proposed management? Is the Bay the right scale to look at this problem?*
3. Case study conclusion
   - **Watch** 24-second video from khon tv (1/27/2016): http://khon2.com/2016/01/27/noaa-abandons-plan-to-expand-humpback-whale-national-marine-sanctuary/
     - Note: Alternatives to the video include http://www.huffingtonpost.com/entry/noaa-humpback-sanctuary_us_56a9194de4b0947efb6655b0 and http://www.civilbeat.com/2016/01/noaa-withdraws-proposal-to-expand-whale-sanctuary/
   - **Class discussion**
     - **Prompts:** *Are you surprised? Why are problems like this so difficult to resolve? What do you think could have been done differently? What would you suggest moving forward?*

- **Individual reflection writing:** Identify ways your analysis can be applied and by whom. If you had to bring three recommendations back to someone, who would that be, and what would you tell them?

7. Background

Here are resources (in addition to the course readings) that the instructor can use to dig in to the science and context.

Land-sea systems

- Instructor should study: EPA (n.d.) Whole Systems Model on ReefLink Database http://archive.epa.gov/ged/coralreef/web/html/wholesystem.html

Maunalua Bay

- Atkinson, A. (2007) "A natural and cultural history of Maunalua Bay and its watershed." MS Thesis submitted to SFState. http://malamamaunalua.org/wp-content/uploads/A-Natural-Cultural-History-of-Maunalua-Bay.pdf
- Wolanski, Eric, Jonathan A. Martinez, and Robert H. Richmond. "Quantifying the impact of watershed urbanization on a coral reef: Maunalua Bay, Hawaii." *Estuarine, Coastal and Shelf Science* 84.2 (2009): 259-268.

Watersheds in Hawa'i

- Hawaiian watersheds: http://hawp.org/what-is-a-watershed/ and http://www.boardofwatersupply.com/files/Watershed%20Brochure_Website3.pdf
- USGS (2000) Groundwater in Hawaii. USGS report FS 126-00. 6 pp.: http://hi.water.usgs.gov/publications/pubs/fs/fs126-00.pdf

Coral Reefs

- General coral reef ecology: http://coral.org/coral-reefs-101/coral-reef-ecology/
- Hawaii coral reef ecology: http://coralreefnetwork.com/reefs/ecology/index.htm and http://www.coralreefnetwork.com/reefs/ecology/ecology.htm

Stressors:

- Land-based source pollution: Fabricius, K E (2005). Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis. *Marine pollution bulletin 50*(2): 125-146.

Local studies:

- Nelson, C E, M J Donahue, H Dulaiova, S J Goldberg, F F La Valle, K Lubarsky, J Miyano, Christina Richardson, N J Silbiger, and F I M Thomas (2015). Fluorescent dissolved organic matter as a multivariate biogeochemical tracer of submarine groundwater discharge in coral reef ecosystems. *Marine Chemistry* 177: 232-243.

- Kelly, J L, C R Glenn, and P G Lucey (2013). High-resolution aerial infrared mapping of groundwater discharge to the coastal ocean. *Limnology and Oceanography: Methods 11*(5): 262-277.
- Impacts from algae: Wolanski, E, J A Martinez, and RH Richmond (2009). Quantifying the impact of watershed urbanization on a coral reef: Maunalua Bay, Hawaii. *Estuarine, Coastal and Shelf Science*, *84*(2), 259-268.

Stakeholder analysis

- From health sector: Schmeer, K. (1999). Guidelines for conducting a stakeholder analysis. Partnerships for Health Reform, Abt Associates Inc. Bethesda, MD. 42pp. http://www.who.int/management/partnerships/overall/GuidelinesConductingStakeholderAnalysis.pdf
- To get another perspective from the private sector: http://www.forumstrategies.com/content/pdf/stakeholder_engagement.pdf

Management Institutions

- Hawaiian ahupua'a: http://www.hawaiihistory.org/index.cfm?fuseaction=ig.page&CategoryID=299
- Watershed management: http://health.hawaii.gov/cwb/files/2013/05/Hawaiis-Watershed-Guidance.pdf
- The website of NOAA's Hawaiian Islands Humpback Whale National Marine Sanctuary management plan review: http://hawaiihumpbackwhale.noaa.gov/management/management_plan_review.html
- Institutions for governing the commons: McCay, Bonnie J. "Emergence of institutions for the commons: Contexts, situations, and events." *The drama of the commons* (2002): 361-402. http://www.nap.edu/read/10287/chapter/16

8. Suggested Modifications

Logistics: Modules can be split into two days of 30-45 minutes each. Module 4 – Governance Institutions could be skipped (as well as fit discussion in module 5). Other modifications peppered throughout teaching notes.

9. References

Atkinson, A (2007) "A natural and cultural history of Maunalua Bay and its watershed." MS Thesis submitted to SF State. 151pp. http://malamamaunalua.org/wp-content/uploads/A-Natural-Cultural-History-of-Maunalua-Bay.pdf

Carpi, A, A E Egger. Uncertainty, error, and confidence. Visionlearning online material. http://www.visionlearning.com/en/library/Process-of-Science/49/Uncertainty-Error-and-Confidence/157

Chevalier, J (2001) Stakeholder analysis and natural resources management. 14 pp. http://www1.worldbank.org/publicsector/politicaleconomy/November3Seminar/Stakehlder%20Readings/SA-Chevalier.pdf

Developing research questions and hypotheses. Acadia learning for participatory science. http://participatoryscience.org/curriculum-activity/developing-research-questions-and-hypotheses

Epstein, G, J Pittman, S Alexander, S Berdej, T Dyck, U Kreitmair, K J Rathwell, S Villamayor-Tomas, J Voigt, and D Armitage (2015). Institutional Fit and the Sustainability of Social–Ecological Systems. *Current Opinion in Environmental Sustainability* 14: 34–40.

Fabricius, K E (2005). Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis. *Marine pollution bulletin 50*(2): 125-146.

Kelly, J L, C R Glenn, and P G Lucey (2013). High-resolution aerial infrared mapping of groundwater discharge to the coastal ocean. *Limnology and Oceanography: Methods 11*(5): 262-277.

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Mease, L, and R Martone (2013). To fish or not to fish: Challenges of managing culturally and ecologically important species. SESYNC Social Environmental Synthesis Case Study. http://www.sesync.org/to-fish-or-not-to-fish-challenges-of-managing-culturally-and-ecologically-important-species-2014-3

Nelson, C E, M J Donahue, H Dulaiova, S J Goldberg, F F La Valle, K Lubarsky, J Miyano, Christina Richardson, N J Silbiger, and F I M Thomas (2015). Fluorescent dissolved organic matter as a multivariate biogeochemical tracer of submarine groundwater discharge in coral reef ecosystems. *Marine Chemistry* 177: 232-243.

NOAA (2015). Summary of the draft management plan and draft environmental impact statement. 11 pp. http://hawaiihumpbackwhale.noaa.gov/management/pdfs/mp2015_dmp_deis_summary.pdf

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10. Assessment

In addition to the notes below, which focus on in-class activities and some small homework assignments, see the individual rubrics in the student hand-outs for each larger homework assignment.

Module 1

- Graded response:
    - Collect and review pre-case activity and grade for quality of responses (10 observations, linkages identified, CMAP drawing of feedback and interaction)
    - Rubric:

	Basic	Analyzing	Evaluating	Creating
Observations	10 things IDed	Span social and ecological realms	Observations in a narrative with some reflection about complexity/ impact for management	Observations narrative identifies novel issues
Linkages	3 of each Feedback and interaction		See above	See above

	correctly identified			
CMAP	1 each interaction and feedback drawn in CMAP			Use of links in CMAP to justify/provide context

- Direct observation:
    - Quality, originality, and topical breadth (social and environmental) of student observations about the watershed
    - Engaged identification and proper categorization of drivers, pressures
    - Discuss complexity of the problem (feedbacks, interactions, emergent properties)
    - Identify missing knowledge
    - Report outs of problem definition: do students identify different aspects of the problem? Do they identify alternative ways of defining the problem? Do they reflect on whose perspective, and their own world view?

Module 2

- Graded response:
    - See Knowledge Domain handout for rubric
- Direct observation:
    - Observe each knowledge domain group (if in groups) or individual report-outs. What level of information is each student bringing to the table? How well is she communicating with others? How well is each student conveying the collective knowledge of the knowledge domain group to the interdisciplinary team (again, if in groups)? Is she able to recognize any confusion, try different ways to explain the concepts? Do students take the time to define jargon and make sure everyone is using terms similarly?
    - Are students able to critically assess the quality of information and reflect on what influences the quality? Are they self-aware about their own biases?
    - Were the teams able to use the new knowledge to update the CEM?
    - Do students recognize/raise issues of scale, i.e., space, time, of different processes, and the scales of information and data?
    - How accurate is the collective CEM? Are the main social and environmental components present? Feedbacks? Interactions?
- Graded response:
    - Collect worksheets: assess the quality of the hypotheses generated

Module 3

- Direct observation:
    - Are stakeholders identified and accurately analyzed? Does each student identify key interests? Are students able to define the problem via the stakeholder's lens?
    - In mock forum, do students identify trade-offs? Are they able to correctly identify interests and values? Do they have alternatives to the SMA?

  - Are students able to identify common ground (where problem definitions, values, interests, etc. might overlap)? Are they able to relate all of this back to the proposed SMA?
  - Are students able to bring all the information back to revise the CEM?
- Graded response:
  - Collect writing exercise.
  - Rubric:

	Basic	Analyzing	Evaluating	Creating
Values	Acknowledgement of differing values			Self-reflection of own worldview/values and how that affects own analysis
Interests	Each stakeholder's interest separate	Use of power/voice concepts		Equity discussion
Trade-offs			Trade-offs identified	Identification of alternatives

Module 4

- Graded response:
  - Does the student accurately depict the key jurisdictional boundaries and rules in place? Are they able to assess issues of institutional fit?
  - Rubric:

	Basic	Analyzing	Evaluating	Creating
Jurisdictions	Correctly identify jurisdiction(s)		Discuss overlap/gaps	Modifications suggested
Rules	Some formal rules identified	Both formal and informal rules identified	Discuss formal vs informal or overlap/gaps	New rules suggested
Fit	Use fit language	Discuss overlap/gaps of rules given scales from reading	Discuss implications of overlap/gaps	Modifications suggested

- Direct observation:
  - Are they able to identify jurisdictional overlap and dissonance? Conflicting rules? Levels of governance?
  - Can they map jurisdictions and rules onto the CEM and use the diagram to identify gaps, conflicts, and synergies?

- Are they able to grapple with issues of scale (temporal, spatial, processes), and identify how fit/mismatch may affect outcomes?
- Are they able to use this analysis to brainstorm creative ways forward?

Module 5

- Direct observation:
  - In final wrap-up discussion, are they able to reflect on:
    - How different types of information informed their conceptual map?
    - How different types of information can be integrated, and the quality of that information?
    - How it is important to consider different types of knowledge and perspectives?
- Graded response:
  - Rubric

	Basic	Analyzing	Evaluating	Creating
Application	Students identify direct application of what they learned	Students correctly identify user of info in Basic	Students evaluate what they are missing to be able to apply	Students suggest how to apply to other contexts
Recommendations	Recall of material from class	Identify where things fell apart and reasons why	Recommendations offered that clearly build on knowledge	Novel ideas for moving forward

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[7] http://www.sesync.org/to-fish-or-not-to-fish-challenges-of-managing-culturally-and-ecologically-important-species-2014-3