CFANS Init'l 3500/5500
Integrated tropical water quality management: Jamaica
Class Outline

Introduction
This class is an intensive, inquiry-based field experience. This class involves field work in several areas in Jamaica, with a focus on a single community (Robin's Bay, St Mary's Parish). Students experience a range of habitats and environmental impacts in which to address land-use and water quality issues. They use a range of tools to investigate water-quality on a working farm. They also connect closely with members of the community surrounding the farm, working with them as stakeholders in water quality decisions. The farm offers a ridge-to-reef opportunity where we analyze freshwater and marine water quality. We use inquiry-based techniques to learn about the tools and designs needed to understand water quality impacts, how those tools and designs are used in a tropical setting and how students from two different academic and social cultures approach the same questions. Throughout the class, we integrate discussion about land-use practices and water quality in this tropical island setting.

The farm (Green Castle Estate) is on the north coast of Jamaica. Many small rivers and streams flow through the watershed. These rivers and streams are affected by the upstream communities and the land uses on the farm; at their terminus, the empty into the bay. Land uses in this setting affect fresh water and marine systems. The Calabash Bottom is a small stream that flows through the Estate. The Calabash and similar rivers join the Haughton River in a larger watershed. Each of those fresh waters has a community of plants and animals, structured by the physical and chemical habitat of the system. Along the coast, the land edge is beach, a combination of material deposited by the sea and from the land. Offshore are marine communities like coral reefs and associated fish and invertebrates. Changes in the landscape alter sediment load, hydrology and other attributes of the rivers and streams, which then change waters of the coastal zone. Other areas along the north coast, like Discovery Bay and Montego Bay are impacted differently than the area near Green Castle; we experience those areas as well to maximize the students' ability to compare habitats and environmental impacts in Jamaica, and to understand cross-cultural issues between US and Jamaican perspectives.

Goals
This class has four, related goals. Students:

- engage in an inquiry-based, hands-on approach to education in a field setting,
- engage in a cross-cultural setting, including working with students from another social and academic culture as well as presenting the results of their assessment to community leaders (people outside the academic setting),
- use a range of water-quality assessment tools in a field setting, and
- use those tools to comment on land-use impacts in a range of tropical aquatic ecosystems.

We focus on student-driven questions and discovery. We begin on the south coast in Kingston, where we explore the coral-reef zone, become familiar with the near-shore marine organisms, and begin to understand how organisms can indicate water quality. We travel to Green Castle, on the north coast where we begin our exploration by walking the landscape of the Calabash Bottom. We then sample the Calabash, the Albany Bottom and a wetland. We then sample the beach and the reef in coastal zone. Through the 2½-week experience, students lead and participate in discussions and presentations. Twice, those sessions include the farm

management team, as well as business and community leaders from Robin's Bay. The second of those sessions is a final, celebratory dinner at the beach at which students present their analysis of the degree to which the class has succeeded in meeting the four course goals.

Learning objectives
Successful students will be able to demonstrate inquiry-based questioning and adaptive data collection, be able to demonstrate an understanding of the uses and limitations of various water-quality field techniques, and will increase their cross-cultural understanding (demonstrated by their contributions to discussions and other interactions). Grading is based on the quality of participation, presentations and discussions, and is influenced by peer review.

Adaptive Teaching
One of the cornerstone concepts in water quality is called adaptive management; the practice of framing objectives, taking management actions, collecting performance data and then revising the actions. During this class, we have three formative evaluations. Two of those look inward and ask *What is going well and what could change to make this a better experience*? The third asks *What would make this a better experience as a future offering*? During the 2008 class, students offered ideas for a future offering. The following summarizes the changes made in the 2009 class based on their ideas:

- In 2009, our opening session will include personal backgrounds of each person involved, an overview of land use-water quality relationships and their assessment, and a structured introduction to Inquiry Based learning
- We will spend four days in Kingston including introduction to marine ecology work at the Kingston Marine Lab, tours of the UWI campus, New Year's Eve celebrations and Kingston restaurants.
- We will stress understanding of the ridge-to-reef concept, including sampling 3D habitat complexity of the reef, submarine groundwater discharge, and land use relationships in the riparian zone of the streams.
- There is more attention to analysis of data. The Estate House has a dedicated computer available for this class. That computer is pre-loaded with Excel spreadsheets for this class. Those spreadsheets facilitate data storage and analysis. They contain data from the 2008 class, as well as exemplary statistical and graphical analyses of those data to empower interpretation.

Day	Time	Activity
In country		
Dec 28 Fri		**Travel** Arrive Kingston in the evening
	6:30 PM Dinner at *Some wonderful place* in Kingston	
Dec 29 Sat	7:30-8:30 AM Self serve breakfast	
	9:00 AM	Personal introductions; introduction to freshwater and marine water-quality assessment and decision making Tour of the Mona campus
	11:30 AM-12:30 PM Lunch on campus	
	Class is structured as two groups, each addressing the same questions. This simulates a consulting experience. People are assigned to groups in advance. When we move from freshwater to marine (i.e., Jan 7), group assignments are adjusted.	
	1:00-5:00 PM	Introduction to, and tour of Kingston marine lab

		During this 1½-day session in Kingston, students are exposed to the coral-reef zone, the taxonomy and ecology of the most common organisms in that zone, and sampling techniques for assessing near-shore marine water quality.
	6:30 PM Dinner at *Some other wonderful place* in Kingston	
Dec 30 Sun	6:30-7:30 AM Self serve breakfast	
	8:00 AM -5:00 PM	Kingston marine lab Taxonomy and ecology of the coral-reef zone as above Lunch at the lab
	6:30 PM Dinner at *Some other wonderful place* in Kingston	
Dec 31 Mon	Open	New Year's eve available for Kingston
Jan 1 Tues	Open	New Year's day available for Kingston
Jan 2 Wed	8:30-9:30 AM Self serve breakfast	
	10:30 AM	Drive to Green Castle
	1:30 PM Lunch at the Estate House	
	Afternoon	Relax, settle in (**Question**: Is this too loose? Should we start activities this afternoon?)
	6:00-7:00 PM **Estate House Patio Hosted**	▪ Facilitated formative evaluation: Discussion of how things are going, structure and expectations, what I think is going well or not, and what you think is going well and not ▪ Appetizers and beverages provided
	7:00-9:00 PM Dinner at the Estate House	
Jan 3 Thurs	6:30-8:00 AM Self serve breakfast	
	8:00-11:30 AM **Field**	Green Castle Beach *Bring cover-ups to go over your swimwear; we go to Highgate for lunch and will not be back the Estate House before leaving* Structured swim • Group 1: to the Blue Hole • Group 2: to Jack's Bay ▪ 8:00-9:00 Snorkel and explore, any distance from shore. At least twice, stop and float in place for a count of 100. During this hour, consider the following questions: *What spatial pattern do you see?* and *If there were land-use impacts in this near-shore zone, what do you think would provide evidence of them (i.e., how would you be able to tell)*? ▪ 9:00-10:00 Everyone to the beach. Discuss what each person saw and what questions they have about what they saw. Discuss land uses in the watershed, which lead to changes in the river, which lead to changes in the marine system. Lead to a discussion of *What would you want to know if you were asked to assess those impacts*? ▪ 10:00-11:30 All return to the water; Group 1 to Jack's Bay and Group 2 to the Blue Hole. Each group address

		the question *What experimental design (i.e., what samples taken where and how often) would you use to assess land use impacts in this near-shore zone*?
	Alternative	A long walk If the marine water is too rough, we walk from the Estate House to the mouth of the Haughton River In that case, we discuss current and historical land use of the valley, water quality as a function of land use, the significance of various qualities of water for human society, and how water quality can be assessed
	11:30 AM-1:00 PM Lunch at Christine's, Highgate. Visit supermarket, ATM, local market	
	1:30-5:00 PM **Field**	Green Castle and the landscape of the Calabash Bottom • 1:30-2:30 Begin with a walk through the landscape and the riparian zone. Pay special attention to land-use practices, the riparian zone and the stream channel. Throughout that walk, ask the same two questions (i.e., *What spatial pattern do you see*? and *If there are land-use impacts on the water quality of this river, how could you tell?*) • 2:30-3:30 Everyone back to the road. Discuss what each person saw and what questions they have about what they saw. Discuss land uses in the watershed, which lead to changes in the river, which lead to changes in the marine system. Lead to a discussion of *What would you want to know if you were asked to assess those impacts?* • 3:30-5:00 All return to the stream. Each person ask *What experimental design (i.e., what samples taken where and how often) would you use to assess land use impacts in this portion of the river*?
	6:00 PM-9:30 PM **Estate House Patio**	Appetizers and drinks, then dinner with community leaders • I introduce the four goals of the class and class structure, including plans for the final dinner and student presentation • Discussion of logistics (rules, safety, food, drink, social and cultural expectations, acceptable academic and social behavior)
Jan 4 Fri	6:30-8:00 AM Self serve breakfast	
	8:00-10:30 AM **Field**	Calabash Bottom-Exploration • *What do you think is happening with land-use impacts in this reach of the river and what would you need to know to tell if that was correct and/or to quantify it?* • Distribute habitat data collection forms as reference • Each group explore the 500m of from the flagging up to the dam • Walk the channel; observe, think, talk among yourselves • Discuss local and regional geology at the dam spillway

		• Group 1 Choose a 50m reach that you think is the ***least*** impacted of the overall 500m. Mark that with flagging • Group 2 Choose a 50m reach that you think is the ***most*** impacted of the overall 500m. Mark that with flagging
	11:00-11:30 AM Lunch at the Packing house	
	11:30 AM-6:00 PM **Field**	Calabash Groundwater • Inquiry-based analysis of groundwater quantity and quality (led by Paul if possible, otherwise led by Jim) • *What evidence would you want to determine that there is or is not hydraulic connectivity between the deep and shallow groundwaters? How would we tell if the deep groundwater, shallow groundwater and stream are chemically similar? What would we pose as next steps if we believe the shallow and deep groundwaters are or are not connected or chemically altered?*
	7:00-9:00 PM Dinner at Sanchez's, Robin's Bay	
	9:00 PM Evening open, but arrange your own transportation home	
Jan 5 Sat	7:30-9:00 AM Traditional Jamaican breakfast-salt fish, ackee and more	
	9:00 AM-1:30 PM **Field**	Calabash Bottom • Each Group will sample the reach they marked yesterday. The day addresses the questions *What are the effects of land use on this reach of the river* and *how certain are you in your answer to that question?* • 9:00-10:30 Group 1 samples fish and Group 2 samples physical habitat • 10:30-12:00 Group 1 samples macroinvertebrates and Group 2 samples fish • 12:00-1:30 Group 1 samples physical habitat and Group 2 samples macroinvertebrates • **Sampling protocol** • Physical: assess habitat, stream gradient and channel morphology, transects. Later we will calculate water quality based on physical variables • Macroinvertebrates: collect with kick nets, process animals into morpho-species. Later we will assign tolerance values and calculate water quality based on benthic invertebrates • Fish: electrofish your reach, identify fish as appropriate, measure length of all or at least 20 per species. Later we will ask about fish ecology and calculate water quality based on fish
	1:30-2:30 PM Lunch at the Estate House	
	2:30-5:30 PM **Estate House Patio**	Analysis: what have we done? • 2:30-3:30 Each group prep for the afternoon discussion • 3:30-4:00 Group 1 present analysis of the least impacted reach, the patterns it found, explanations for those patterns.

		▪ 4:00-4:30 Group 2 present analysis of the most impacted reach, the patterns it found, explanations for those patterns. ▪ 4:30-5:00 Everyone discuss those results, asking *What land-use impacts do we think we see here, what do we think the impact of those land uses will (would) be on a larger river* and *how would we tell if we were right?*
	6:30-7:30 **PM** **Estate House** **Patio Hosted**	Facilitated formative evaluation • Discussion of how things are going, structure and expectations, what I think is going well or not, and what you think is going well and not • Appetizers and beverages provided
	7:30-10:00 PM Traditional Jamaican jerk dinner prepared by members of the local community	
Jan 6 **Sun**	7:30-8:00 AM Self serve breakfast	
	9:30-11:30 AM	Albany Bottom-Exploration and sampling ▪ *What do you think is happening with land use impacts in this reach,* and *what would you need to know to tell if that was correct and/or to quantify it?* ▪ 8:30-9:00 Walk the channel; observe, think, talk among yourselves ▪ 9:00-11:30 sampling ▪ Fish: People assigned ▪ Habitat: People assigned ▪ Macroinvertebrates: People assigned ▪ Chemistry: People assigned
	12:30-1:30 PM Lunch at Highgate: Patties, visit supermarket, local K-12 school	
	2:30-4:30 PM **Field**	Wetland Exploration and sampling ▪ *What do you think is happening with land-use impacts in this water body?,* and *what would you need to know to tell if that was correct and/or to quantify it?* ▪ 2:00-2:30 Walk around but disrupt the wetland as little as possible; observe, think, talk among yourselves ▪ Fish-sample with seine: People assigned ▪ Macroinvertebrates: People assigned ▪ Chemistry: People assigned ▪ Substrate-core samples: People assigned
	6:00-8:00 PM Dinner at Green Castle Beach	
	Eve **Open**	Evening available for Robin's Bay
Jan 7 **Monday**	6:30-8:00 AM Self serve breakfast	
	Pretend this is Sunday … full day open; sleep late, no agenda **Optional walking and swimming excursions arranged as desired** *Change group assignments so there are three groups for marine work*	
	1:00-1:30 PM Lunch at the Estate House	
	7:00 PM Dinner at the Estate House	
	Eve **Open**	Transport to Robin's Bay can be arranged at your cost
Jan 8	6:30-8:00 AM Self serve breakfast	

Tuesday	8:00 AM-12:00 noon **Field**	Coral-reef zonation Green Castle Beach, Blue Hole (and possibly the Long Hole) An Inquiry-based approach to understanding coral-reef zonation - *Based on the hypotheses we developed the first day, are there apparent patterns in zonation of water quality, structure (i.e., coral, sand channels) and/or biology? Is there evidence that any apparent zonation is related to land management and/or freshwater inputs?* - Groups 1 & 2 Jack's Bay - Jack's Bay-two transects, each 75m out from the beach; half of the group assigned to each. Each person sample on square meter plot somewhere on the shallow half of their transect, and somewhere on the deeper half - (If we do involve the Long Hole, we'll have one Jack's Bay transect) - Group 3 The Blue Hole - Transects laid out in advance with 10 sampling points identified. Each person sample one location to left and one to right of entry location - **Sampling protocol** - At each sample plot, measure 1 square meter. Quantify the numbers and identities of all fish and invertebrates, including corals and sponges. Evaluate the 3-dimensional complexity of the habitat on a 1-5 scale.
	12:00-1:00 PM Lunch at Green Castle beach	
	1:00-5:00 PM **Field**	Green Castle Beach An Inquiry-based approach to understanding coastal zone management (i.e., erosion, deposition, environmental impacts) - *Are there discernible sediment erosion and deposition zones? Does sediment erosion and/or deposition appear to differ with hydraulic gradient? What is litter density on the beach what is the origin of that litter (i.e., natural vs. anthropogenic)? What is the origin of the anthropogenic litter? What are appropriate disposal strategies for the anthropogenic litter?* - Group 1 & 2 sample the Long beach; Group 1 near the mouth of the Haughton and Group 2 closer to Jack's Bay - Group 3 samples Green Castle Beach - Each Group mark 3 parallel transects up from the water. In Jack's Bay, transects are 5 m; on the Long Beach, they are 15 m - Section each transect into 5 intervals: transects start at the saturated edge of the splash zone. Points in Jack's Bay are at 0, 1.25, 2.5, 3.75 and 45 m. Points on the Long Beach are at 0, 3.75, 7.5, 11.25 and 15 m. - Along one of your three transects, measure beach profile, taking vertical observations at least every meter

		✚ At each transect point, measure sediment particle size in a 25 square cm, 10 cm deep plot. Also, measure litter in 1 m plot. For litter, identify volume, whether anthropogenic or natural, chemical composition (e.g., plastic, glass, rubber) and country of origin for anthropogenic. ✚ Measure psammic organisms and related their distribution to hydraulic gradient ✚ Discuss disposal strategies for anthropogenic litter, then dispose of it as possible. Discuss what sediment and litter distribution implies for environmental management.
	7:00 PM Dinner at the Estate House	
	Eve **Open**	Transport to Robin's Bay can be arranged at your cost
Jan 9 Wednesday	6:30-8:00 AM Self serve breakfast	
	8:00-11:30 AM **Field**	Coral-reef zonation ✚ Groups 2 & 3 The Blue Hole (and the Long Hole) ✚ Group 1 Jack's Bay ✚ Duplicate sampling of the day before
	11:30 AM-12:30 PM Lunch at the Estate House	
	1:30-6:00 PM **Estate House Patio**	Data analysis, synthesis and discussion: land-use effects from the landscape to the Calabash Bottom, Albany Bottom, the Haughton, the beach and the reef ✚ *What did we experience and learn about our water bodies and land use impacts on them?* ✚ 1:30-2:30 Prepare for the rest of the discussion ✚ 2:30-3:00 **Group 1** Summarize initial questions and hypothesis about the in-stream measurements in the Calabash, Albany Bottom and wetland, what they feel we learned about those questions and hypotheses ✚ 3:00-3:30 Response from Group 2 and discussion ✚ 3:30-4:00 **Group 2** Summarize initial questions and hypothesis about the near-water landscape (i.e., the riparian zone and the geology, the groundwater sampling), what they feel we learned about those questions and hypotheses ✚ 4:00-4:30 Response from Group 1 and discussion
	6:00-7:00 PM **Estate House Patio Hosted**	Facilitated formative evaluation-looking forward ✚ Discussion of how things have been structured, what would make this class more effective if it were offered again ✚ Appetizers and beverages provided
	7:30 PM Dinner at the Estate House	
Jan 10 Thursday	6:30-8:00 AM Self serve breakfast	
	8:30-11:30 AM **Field**	Beach transects ✚ **Group 2** samples Green Castle Beach ✚ **Groups 2 & 3** sample the Long Beach ✚ Follow sampling protocol established earlier

	12:00-1:30 Lunch at the Estate House	
	2:00-5:00 PM	Prepare for synthesis and discussion - Recombine intro original 2 groups - Each group prepares a summary that describes what we learned - Specifically, consider the questions we posed, the data we collected, the analyses and interpretations of those data and ask *Where and what are we missing? Where could we sample again to make our understanding more complete?* - **Note**: no data set is ever completely adequate; we always can improve. I do expect each Group to identify one or more places where our understanding would be improved by additional sampling.
	6:30 PM Dinner at the Estate House	
	Eve **Open**	Transport to Robin's Bay can be arranged at your cost
Jan 11 Friday	6:30-8:00 AM Self serve breakfast	
	8:30-11:30 AM **Field**	**Back in the water** - Each Group collects the data they said would be appropriate - We'll make available logistics and equipment for people to sample wherever necessary
	11:30-2:00 Lunch in Annotto Bay	
	2:00-5:00 PM **Estate House Patio**	Preparation for final presentation The final presentation to the community is equivalent to your final exam; take it seriously. By 3:00, I want to see an outline of what you plan to present. However, I do not want any preview of the content; this is your analysis of the degree to which we have met the four goals of the class. The structure should be a presentation of about ½ hour, followed by questions and answers. Everyone must be clearly engaged in the preparation for the final presentation, but not everyone need speak at the final dinner. It is your responsibility to assign speaking duties to achieve what you feel is the most effective presentation.
	5:00-10:00 PM Green Castle Beach	- 5:30 Appetizers and drinks - 6:00-7:00 I will re-introduce the four goals of the class. Each group or the overall group as a unit presents its report, as a presentation to an audience that includes Green Castle management team, community leaders from Robin's Bay, the family that manages Green Castle Beach, the TAs and selected faculty from UWI.
Jan 12 **Saturday**	6:30-8:00 AM Self serve breakfast	
	8:00-10:30 AM Travel to Discovery Bay	
	10:30 AM- 12:00 noon	Tour of Discovery Bay Marine Lab; overview of the Discovery Bay watershed and research conducted at the lab
	12:30-5:30 PM **Field**	Discovery Bay - An inquiry-based exploration leading to increased

		sensitivity to water quality and ecological patterns - Underwater exploration, led by Professor Dale Weber or by Jim, snorkel out from dock to hydrological station, estimating diversity in transect plots
	6:30 PM Dinner at the lab	
Jan 13 Sunday	6:30-8:00 AM Self serve breakfast at the lab	
	8:30-11:30 AM **Field**	Discovery Bay - An inquiry-based exploration of Submarine Groundwater Discharge - *Why does that water shimmer? What would it look like if there were groundwater inputs into the Bay? What data would you need to be able to comment on the ecological significance of groundwater inputs to the marine zone?* - Sample groundwater volume and chemistry
	12:00 Lunch at Discovery Bay Marine Lab	
	1:30-4:30 PM **Lab**	- Discussion of the Discovery Bay reef, its ecology and the influence of groundwater and the bauxite plant
	5:30-7:00 PM	- Travel to some all-inclusive resort, Montego Bay; potentially *Breezes*
	Eve **Open**	Evening available for Montego Bay
Jan 14 Monday	**Open**	Day open for exploration in Montego Bay - This is your holiday-enjoy it
Jan 15 Tuesday	**Travel**	All day-Return to Minnesota