Summary Report: Sea Level Rise and Coastal Ecology: Science, Policy, and Practice course at the University of Florida

4-12-17

Travis M. Thomas

Introduction

The Big Bend region is one of the least developed and sparsely populated areas in Florida. This region is considered a "sediment starved" coastline and lacks sandy beaches (Wood and Hine, 2007). This, combined with the dark tea-stained water from the Suwannee River, may have contributed to the low levels of coastal development in this region. Today, massive amounts of land are protected from development due to state and federal land holdings. The Suwannee River Basin (30 people/mile^2) is minimally populated relative to the rest of Florida (239 people/mile^2). The economy of the Big Bend is heavily dependent on the relatively intact natural resources of the region, such as forestry, fisheries, and tourism. The island of Cedar Key has a long history stemming back ~2,500 years where several Native American tribes relied on the estuaries for food and resources. In more modern times, the area has seen a timber industry, a fiber industry, a commercial fishing industry, and now, an aquaculture industry. Often referred to as a "working waterfront", the Suwannee estuary consists of ~300 aquaculture operations with over 900 acres of submerged leases designated for clam and oyster farming. The impending impacts of climate change on this region must be addressed using creative solutions and will require an interdisciplinary approach to be successful.

While the effects of climate change are global, a few are particularly relevant for Florida's Big Bend region. Rising sea levels, more frequent/intense storms, shifts in annual weather patterns, and increasing air temperatures all present significant concerns for this region. The Big Bend region is a low elevation, low energy shoreline, which makes it extremely vulnerable to sea-level rise (Morton et al., 2004). Furthermore, this region has a long history of impacts from hurricanes. The town of Cedar Key was historically located on a barrier island, and was subsequently destroyed during a hurricane in the 1800's. Climate change is expected to cause more frequent and intense storm events, which have the potential to negatively impact the region. In 2016, hurricane Hermine cause widespread damage to the area, despite being barely a category 1 storm. Finally, shifts in rainfall patterns could exacerbate issues related to reductions in freshwater inputs to the Big Bend coast, such as increased salinities [citation]. Given these challenges, communities in the Big Bend will need to implement creative solutions developed through careful consideration of the many facets of each individual issue, while also considering the global scale of the problems facing Florida's coast.

In order to be prepared to address complex problems such as those posed by climate change, early career scientists, policymakers, and legal professionals must be allowed to work across disciplines and gain experience with the ecological, biological, geological, legal, and social factors relevant to climate change issues. A new course, *Sea Level Rise and Coastal Ecology: Science, Policy, and Practice* course at the University of Florida, was formed in order to provide opportunities for graduate students to practice collaborating across disciplines to solve complex natural resource problems. In the March 2017 course, there were five interdisciplinary groups that consisted of three students from distinct programs of study: one student from the Levin College of Law, one student from the College of Agriculture and Life Sciences, and one student from the College of Liberal Arts and Sciences. Each group was assigned a case study of local relevance to natural resources in the Big Bend region. Each natural resource case study was associated with problems presented by sea-level rise and climate change in the region. The following sections summarize the results and recommendations of the five case studies examined during the March 2017 course.

Case study 1: *Long-term planning for coastal wetland habitat restoration along the Gulf Coast region*

Overview

Currently, two coastal wetland plants dominate in the Big Bend region: *Spartina* saltmarsh and mangroves. Generally, these species are separated by a temperature threshold (Osland, et al 2013), with mangroves being limited by cold temperatures; however, due to climate change, the number of mangroves has increased in the region. This area is experiencing sea-level rise with increasing temperatures, which could lead to mangrove forest overtaking traditional saltmarsh. Once established, mangroves outcompete *Spartina* by growing rapidly and shading out low growing grasses. Rising sea-levels and more intense/frequent storms are expected to cause significant erosion of natural habitat. Although different, both *Spartina* and mangroves provide many ecological benefits and provide habitat for numerous marine and estuarine species; however, as far as habitat restoration, both the short and long term goal should be considered. For instance, *Spartina* is thought to provide rapid sediment stabilization due to its fast growth rate, unlike mangroves which take considerably more time to take root. Nevertheless, once fully grown, mangroves are thought to withstand the effects from intense storms due to their larger size and robust root structure (Clark, pers comm). Mangroves come with several caveats. First, they are protected by the Mangrove Trimming and Preservation Act of 1996, which prohibits the cutting or removal of mangrove trees without a permit from the state. This can become problematic for residents as there are few legal options available (other than limited trimming) for managing these species. Planting mangroves is far more expensive then planting *Spartina*. Also, this region is still vulnerable to hard freezes, which could rapidly kill mangroves and leave shorelines bare and unprotected.

Findings/Recommendations

- Outreach and education aimed at increasing knowledge of mangrove benefits and management
- Modify mangrove laws to accommodate more flexibility for management
- Recommend *Spartina* spp. for short-term sediment stabilization
- More research needed for long-term mangrove viability.

Case study 2: *Implications of Altered Freshwater Flows on Estuarine Fish and Shellfish: A Case Study Of The Lower Suwannee River*

Overview

Estuaries are coastal zones where freshwater rivers meet the saline waters of the sea. Freshwater flows deliver nutrients and organic matter to the coast, which creates a high rate of primary productivity. In fact, estuaries are some of the most productive ecosystems on Earth and hold a very high socioeconomic and ecological value (SRWMD). In fact, estuaries provide millions of dollars per year from jobs, products, and ecosystem services. However, due to sea level rise and freshwater consumption, estuaries are under threat. The Suwannee River Basin is in decline due to excessive pumping from within and outside of the basin. Lower freshwater flow and sea-level rise could cause estuaries to move inland from the coast. This has the potential to devastate local natural resource based economies, especially the commercial and recreational fisheries. Many species of fish are dependent on estuaries during some part of their lifecycle. Moreover, entire fisheries are based around estuarine depend species (e.g. spotted seatrout, redfish). Additionally, the shellfish fishery (hard clams and oysters) are vulnerable to changes in freshwater flow. The Eastern oyster requires a salinity 14-28 ppt. Although this species can tolerate salinities outside of this range, growth, survival, and disease rates are effected outside of the optimal range. The hard-shell clam thrives at salinities from 20-30 ppt; however, when salinity levels persist below 20ppt or above 30 ppt for long periods of time the begin to stress. Both species require freshwater flows to regulate optimal salinity, but they also require these flows to transport nutrients from upstream to the estuary. In Florida, the Florida Department of Environmental Protection overseas water issues at the state level and five water management districts implement regulatory framework. The WMD attempted to address concerns of low flow by establishing Minimum Flow Levels, which may help maintain water levels through a legal framework.

Findings/Recommendations

- Support water quality monitoring
- Prioritize imperiled water bodies
- All research on methods, flows and levels should be peer-reviewed and incorporate sea level rise models
- Hold workshops for public input, include stakeholders
- Recovery plan for water bodies that do not meet the MFL
- Update MFLs by accounting for cross-boundary water withdraws

Case study 3: *Coastal Erosion Control on Airport Road in Cedar Key, Florida Integration of Ecologically Sustainable Mitigation Strategies*

Overview

Cedar Key is a small community on Florida's Gulf Coast within the Suwannee River estuary. This area is considered "sediment starved" and lacks siliclastic sands and in turn has low wave energy (Hine et al. 1988). Most of this region is vegetated with marsh that is buffered by natural oyster bars as opposed to sandy barrier islands (Hine et al. 1988, Hine 2009). Typically, communities have used "Hard armored" structures, which are usually seawalls or break waters that provide some protection. In many areas of high wave energy this may be the only option (NOAA 2015). However, these hard (often concrete) structures have many negative associations such as: wall failure, scouring, low biodiversity, and erosion (Davis et al. 2006, NOAA 2015). A low energy coastline, such as Cedar Key, has the ability to use a "living shoreline" as protection. Living shorelines combine natural process and materials to build and protect infrastructure. Living shorelines utilize mainly living oyster bars, sand, marsh grasses, and mangroves (NOAA 2015). Significant erosion has taken place in Cedar Key, and residents have been involved in a preliminary discussion and decision making process to address this problem in two areas: airport road and G street. Based on recent workshops with stakeholders, a living shoreline may meet the needs of the community at a lower cost with less maintenance needs. However, many stakeholders are concerned with losing access with mangrove trees. Mangroves are protected from removal by state law, which makes management difficult.

Findings/Recommendations

- Continue stakeholder meetings and involve residents in decision process
- Establish pre/during/post project monitoring
- Work with partners in legal permitting
- Work with experts to determine if conditions and elevation are sufficient for living shoreline
- Use existing partnerships with local community, universities, NGOs, and others to decrease cost

Case study 4: *Effects of Changing Distributions on Fisheries in the Big Bend Region*

Overview

Climate change is thought to cause temperatures to rise, which in turn have caused species distributions to shift. There is no better example of this then the increase in northward distribution of the Common Snook (*Centropomus undemecialis*) in the Big Bend. The Common Snook is a popular recreational sport fish in the region prized for its fighting ability and flavor. Snook were historically found in Florida between Tarpon Springs in the Gulf and Cape Canaveral in the Atlantic (Gilmore et al. 1983). However, the FWC Fisheries independent monitoring program in Cedar Key has noted an exponential increase in local density since 2007 (FWC, pers. Comm.) ; however, this species is intolerant to cold weather, which has resulted in mass die offs in the past. However, as freezing events become more and more uncommon, Snook populations will thrive. In fact, an increase in Snook abundance within the Big Bend may lead to a regional increase in recreational fishing and thus additional revenue. However, changes in species distribution could potentially cause changes in the trophic dynamics and ecological communities. Within the Big Bend, the most commonly fished species are Spotted Seatrout (*Cynoscion nebulosus*) and the Red Drum (*Sciaenops ocellatus*). These species all feed on Pinfish and Pink Shrimp; therefore, it remains possible that increase abundance in Snook could cause increased competition for resources. Other fish have been known to interrupt trophic dynamics. The red lionfish (*Pterois volitans*), which eat a wide variety of fish and have few native predators, have caused havoc in some parts of the Gulf. Red Lionfish (Hackerott et al. 2013). In general, climate change, along with increasing global temperatures, have the potential to cause species distributions to shift. This could lead to a tropicalization of the Big Bend Region and force new community dynamics to play out. Bring in stakeholders can be used to help inform resource managers

Findings/Recommendations

- Conduct research on trophic dynamics, spatial use, and resource partitioning on important game fish
- Harsher penalties and more enforcement regarding importation, possession, and release of invasive species
- Adaptive management strategies concerning bag limits, slot sizes, and harvest windows
- Implementing a region-specific ecosystem based fishery management plan
- Incorporating spatial management or “trophy” zones in the Big Bend for catch and release Snook fishing

Case study 5: *Climate Change and Oyster Restoration Policy in the Big Bend*

Overview

Oyster reefs play an important ecological role and provide valuable ecosystem and cultural services for local communities. For example, oyster reefs provide habitat for many commercially viable marine species. Additionally, they provide a breakwater from wave energy hitting the shore; therefore, oyster reefs are important in maintaining property values in coastal areas. Oyster reefs provide improved water quality by removing excess nutrients from the water column and decrease harmful algal blooms and fish kills (Kroeger, 2012). Oysters also taste delicious (Thomas pers. comm.) Despite providing the above-mentioned services in the Big Bend, oyster reefs are one of the most endangered marine ecosystems in the region. Oysters declines have been linked to overharvest, pollution, freshwater input, development, and erosion to name a few (Buzan et al., 2009). Reduced freshwater flow has been theorized as the major reason for oyster reef declines in the Big Bend region. The Eastern Oyster (*Crassostrea virginica*), thrives in a optimum salinity range from 15-20 ppt (Barnes et al., 2007). Increases in salinity from decreased freshwater inputs and accelerated sea-level rise stresses oyster reefs through predation and disease, ultimately leading to increased mortality (Bergquist et al., 2006; Peters et al., 2012). Since healthy oyster reefs provide several ecological and economic functions, there has been an increased interest in restoring rapidly declining oyster reefs. In Levy County, a pilot study was conducted on a small section of Lone Cabbage Reef. This project used derelict clam bags, a byproduct of the aquaculture industry, as material, which was very successful but limited by the availability of appropriate materials. Overall, the Lone Cabbage Project has proven that oyster reefs can be restored in this region.

Findings/Recommendations

- Simplify general permitting.
- Modify harvest zones are determined.
- Create a new shellfish management plan that incorporates environmental factors like climate change and sea level rise.
- Create wild oyster harvesting leases that use the legal framework in place.

- Create a monitoring program for restored oyster reefs to assess their environmental and economic impact.
- Consider diverse stakeholder perspectives and include stakeholders in management and decision-making.

Conclusions

There are several common themes that emerged among the five case studies. For instance, each case study, and the pertinent issues therein, were, in some way, influenced by the Suwannee River. Not surprisingly, freshwater discharge from the Suwannee River plays a vital role in the region, as it accounts for much of the freshwater input into the Big Bend region (SRWMD; Ceryak et al., 1983). The Suwannee River is the second largest river by drainage in Florida, and is one of the last unaltered major rivers left in the country (SRWMD). Oyster reefs, fisheries, saltmarsh, regional geology, and local freshwater input are all influenced, to some degree, on factors that influence the Suwannee River watershed and fresh water discharge. Similarly, social factors play an incredibly important role when addressing local issues. Cedar Key has a unique diverse culture made up of local "water-men", business owners, tourist, and part-time residents from all around the country. These groups all have different attitudes, perceptions, and motives regarding environmental issues. Due to the complexity of these issues, several conclusions are listed below:

1. It will be critical to engage stakeholders when formulating solutions/adaptation plans. For example, including fisherman and other groups in discussions about fisheries management is essential. Not only do fisherman represent an important sector of the coastal economy, they also have expertise that may be of use to resource managers and stand to be highly affected by impacts from climate change.

2. Collaboration among local, state, and federal partners is very important. In order to restore a marsh or create a living shoreline, one would need to work with multiple levels of government just to receive a permit. Partnerships and collaboration can be important for funding, permitting, expertise, and monitoring/research.

3. Additional applied research is required to execute effective solutions to important issues. For instance, to restore an oyster reef, detailed information on the biology of oysters and how it may be affected by climate change is essential. Also, an understanding of the unique regional geology and the mechanisms that drive abiotic conditions in the estuary is required before large-scale restoration projects can be planned and successfully executed.

4. Inflexible, "one-size-fits-all" policies hamper the ability of practitioners to apply locally tailored and creative solutions. The existing policies are not flexible enough to accommodate a changing environment. This issue is prominent when dealing with restoration of habitat, especially mangroves, living shorelines, and oyster reefs. Policy should be developed region specific and able to change rapidly as the climate changes.

In conclusion, sea-level rise will continue to impact the Big Bend region, which will produce many challenges to local communities. Often, these issues are complex, and there is a great need to examine problems across an interdisciplinary framework. In the future, more interdisciplinary teams may be able to provide more effective strategies in dealing with climate related issues.

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