DEFINING CAPACITY:
COMMUNITY-BASED WATERSHED MANAGEMENT AND CLIMATE CHANGE ADAPTATION

A thesis
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Abstract

This study draws on five case studies conducted of coastal community-based watershed organizations in the Northeastern, United States to determine their capacity to incorporate climate change adaptation into their education and outreach, advocacy, and ecosystem monitoring efforts. The Intergovernmental Panel on Climate Change has determined that coastal areas are particularly vulnerable to climate change impacts, including sea level rise, changes in precipitation, and increases in air and sea surface temperature, among others. It will be essential to develop capacity to address these physical and resulting socioeconomic impacts. This is particularly important at the local level where land use, development, and natural resource management decisions are made. This study identifies the current extent to which climate change impacts and adaptation strategies are being discussed and/or addressed in watershed planning; considers the extent to which collaboration enables or inhibits integration of climate change adaptation into watershed planning; identifies additional resource needs for adaptation; and determines current and future capacity of community-based watershed organizations to incorporate climate adaptation. It was found that community-based watershed organizations have very strong adaptive capacity in regard to collaboration with critical institutions, building human and social capital, increasing the public's perceived understanding of an issue, and assisting in the risk spreading process. However, they are very limited in their access to technical resources for adaptation, their ability to manage information specific to climate change, and the availability of resources to support their efforts. The research concludes that there is an identified need for support in these areas.

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Thesis Summary

Climate change is "unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level (IPCC, 2007)." These impacts are evident in the Northeastern United States, which has experienced increases in air temperatures at a rate of 0.5 degrees Fahrenheit (°F) since 1970. Additionally, average air temperature across the Northeast is projected to rise 2.5 to 4°F in the winter and 1.5°F to 3.5°F in the summer in the coming decades (NECIA, 2007). Precipitation trends have been gradually increasing at a rate of 5-10% since 1900 and it is projected that the region will experience an increase of 4 inches of precipitation by 2100, with more snow falling as rain and more intense precipitation (NECIA, 2007). Sea surface temperatures have risen 1°F since 1900 and are expected to continue this upward trend at a slightly slower rate than regional air temperatures, with an increase of 4°F -8°F by the end of the century (NECIA, 2007). Finally, with the continuation of historic sea level rise trends a resulting six inch increase in sea levels is expected over 2005 levels, as early as 2050 (NECIA, 2007).

Coastal areas are particularly vulnerable to these impacts, as they are dynamic, fragile systems, constantly adjusting to geomorphic and oceanographic shifts. Secondary impacts of climate change on coastal areas include increases in eutrophication, acidification, and changes water chemistry from rising sea surface temperatures; elevated nutrient loading as wetland buffers are inundated and eroded from sea level rise; and increased stormwater runoff from more frequent

intense storms, among others. Additionally, climate change will impact hydrologic cycles, contribute to habitat and species migration, and increase the potential for infrastructure damages (U.S. Climate Change Science Program, 2008). The need for adaptation to climate change is becoming more apparent as human activity also puts additional pressure on coastal ecosystems, as development and socio-economic activity continues to expand (Nicholls, et al., 2007).

The purpose of this research is to gain a better understanding of the capacity for community-based watershed organizations to incorporate climate change adaptation into their education and outreach, advocacy, and ecosystem monitoring efforts. More specifically, this research:

- Identifies the extent to which climate change impacts and adaptation strategies are being discussed and/or addressed by community-based watershed organizations
- Considers the extent to which collaboration enables or inhibits integration of climate change adaptation into watershed planning
- Identifies additional resource needs for adaptation
- Determines current and future capacity of community-based watershed organizations to incorporate climate adaptation into program efforts.

To determine the adaptive capacity of community-based watershed organizations, five case studies were selected from the Northeastern United States: Friends of Taunton Bay, Friends of Casco Bay, the Lamprey River Watershed Association, Salem Sound Coastwatch, and Friends of

Sengekontacket. Through interviews with Program Managers and website and document review, the education and outreach, advocacy, and ecosystem monitoring activities of these organizations were analyzed against the determinate of adaptive capacity, as identified by the Intergovernmental Panel on Climate Change (2001).

Results of the case studies showed that climate change impacts are of concern to Program Managers. All organizations were able to identify observed or expected impacts, ranging from 100-year floods in two consecutive years, droughts, changes in sea level, changes in eelgrass habitats, and the inability of wetlands to migrate, among others. However, with regard to adaptation, the most advanced of the five organizations (Salem Sound Coastwatch) is only in the beginning stages of developing vulnerability assessments and determining appropriate outreach approaches.

Collaboration plays a significant role in current watershed programs and activities. Case study organizations partner with federal, state and regional government agencies, academic institutions, area non-profits, local governments, and stakeholders. These partnerships enable community-based watershed organizations to have access to additional technical resources and gain broader reach within their watershed. Community-based watershed organizations also play an important role in connecting multiple watershed organizations and disseminating information among them. This is an area that provides ample opportunity to address climate change impacts, as a successful adaptation strategy requires the education and participation of multiple stakeholders.

The case studies also identified additional needs for climate change adaptation. These included additional funding resources for baseline monitoring, case studies and locally scaled scenarios for multiple impacts, a national central database with the current climate science available to the public, information developed for multiple audiences, predictive data particularly for sea level rise and precipitation, and LIDAR maps.[1]

In determining a community-based watershed organization's current and future adaptive capacity, it was found that they have very strong adaptive capacity in the areas of collaboration with critical institutions, building human and social capital, increasing the public's perceived understanding of an issue, and assisting in the risk spreading process. However, they are very limited in their access to technical resources for adaptation, their ability to manage information specific to climate change, and the availability of resources to support their efforts. There is an identified need for support in these areas.

The watershed scale provides ample opportunity to address a variety of important environmental, social, and economic issues. Since climate change adaptation requires changes on the local scale, stakeholders, government agencies, and nonprofits should view community-based watershed organizations as the key actors and collaborative partners.

[1] LIDAR (Light Detection And Ranging) is a remote sensing technology used to produce highly detailed topographic maps. The data are accurate both vertically (< 15 cm) and horizontally (< 1 meter), meaning that the data accurately represent the position and height of the ground. Common LIDAR products are digital elevation models, contours, raw point data, and intensity imaging. Please visit: http://www.csc.noaa.gov/crs/rs_apps/sensors/LIDAR.htm

Chapter 1: Introduction

Coastal areas are some of the most ecologically productive and economically important ecosystems, supporting a variety of natural resources, including diverse species, habitat types, and nutrients, as well as employment, recreation and tourism opportunities, waterborne commerce, and energy and mineral production. As a result of these opportunities, coastal areas are highly developed. Seventeen of the 20 fastest growing counties in the United States are located along the coast, as well as 23 of the 25 most densely populated counties (Kleppel, 2006). These trends continue in the Northeast (identified by Kleppel as Virginia to Maine), which is the most populous coastal region in the U.S. containing 34% of the coastal population. The population density of coastal communities in the Northeast is over 11 times that of non-coastal communities in the U.S. (Kleppel, 2006).

Due to the important ecosystem, economic and cultural services coastal areas provide, it is essential to incorporate climate change impacts into management strategies and formal planning of coastal areas, particularly considering the important ecosystem, economic and cultural services they provide. Estuaries are facing increased risk from the direct impacts of climate change and indirect consequences of human responses to climate change, as they exist in the nexus where the ocean meets the coast. Climate change impacts that are particularly relevant to coastal areas include increases in air and water temperature, changes in precipitation and storm climatology, and sea level rise. These, in turn, will impact hydrologic cycles of the watershed, habitat and species

migration, alter timing of seasonal changes, increase stormwater runoff, and potentially damage infrastructure (U.S. Climate Change Science Program, 2008). As these impacts occur, it will be essential for coastal ecosystem managers to take actions to "reduce impacts or exploit beneficial opportunities resulting from climate change (US EPA, 2008, p. 1)." These steps are referred to as climate change adaptation.

Adaptation measures can be proactive, developed to "preserve and protect resources in anticipation of climate change impacts (US EPA, 2008, p. 5)," or can be reactive, implemented after impacts have been observed. Reactive measures can be further divided into those that are developed in advance but not implemented until climate change impacts have been observed or those that are ad hoc, unplanned responses. Different approaches will be appropriate in different locations, with varying resources, risk, and certainty in the data (US EPA, 2008).

Although not all adaptation strategies will require direct shifts in day-to-day management of estuarine ecosystems, many of them will require a shift in management strategies, resource needs and decision making processes (US EPA, 2008). Additionally, management responses have the potential to alleviate or exacerbate a system's vulnerabilities as "natural resource mismanagement contributes to the vulnerability of human systems to these hazards, and enhanced management can provide a tool for vulnerability reduction (Abramovitz, ND, p.6)." It will become increasingly important to ensure that coastal ecosystem managers and decision makers have the appropriate resources to address these issues.

Community-based watershed organizations play an important role in the management of coastal watersheds and ecosystems. Often involved in education and outreach, advocacy, and ecosystem monitoring, these initiatives effectively work with multiple stakeholders to forward their missions and improve ecosystem health. As climate change increasingly alters the natural systems these initiatives monitor and protect, it will be essential that they have the capacity to incorporate climate change impacts into all aspects of education and outreach, advocacy, and ecosystem monitoring. Additionally, "early recognition and assessment of potential climate impacts at a local level give communities time to develop the capacity to adapt to climate impacts, potentially reducing disruptive effects (Binder, 2007)."

The ability of these initiatives to address climate change adaptation in their programs and management plans is referred to as 'adaptive capacity.' A system's adaptive capacity can been determined by the availability of and access to technological options for adaptation; the availability of capital resources; the structure of critical institutions; human and social capital; the system's risk-spreading process; the ability of decision makers to manage information; and the public's perceived understanding of the risk (Yohe, 2002; IPCC, 2001).

The purpose of this research is to gain a better understanding of the capacity for community-based watershed organizations to incorporate climate change adaptation into their education and outreach, advocacy, and ecosystem monitoring efforts. More specifically, the research will identify the current extent to which climate change impacts and adaptation strategies are being discussed

and/or addressed; consider the extent to which collaboration enables or inhibits integration of climate change adaptation into watershed planning; identify additional resource needs for adaptation; and determine current and future capacity of community-based watershed organizations to incorporate climate adaptation.

Chapter 2: Background

Climate Change Impacts on Coastal Ecosystems

According to the Fourth Assessment Report (A4), published by the Intergovernmental Panel on Climate Change (IPCC), climate change is "unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level (IPCC, 2007)." Coastal areas are particularly vulnerable to these impacts, as they are dynamic systems, constantly adjusting to geomorphic and oceanographic shifts. Human activity also puts additional pressure on coastal ecosystems, as development pressures continue to expand (Nicholls, et al., 2007). In 2003, it was estimated that 23% of the world's population lived within 100 km of the coast and less than 100 m above sea level. Additionally, population densities in coastal areas are approximately three times higher than the global average (Nicholls, et al., 2007). Nearly 53 million people live in coastal counties in the Northeast[2] and this number continues to grow, especially around urban centers like Boston. The Northeast has also experienced significant increases in coastal housing and resort development, with the value of insured coastal property exceeding $3.7 trillion dollars (NECIA, 2007).

[2] The Northeast, as defined by the Northeast Climate Impacts Assessment (2007) includes Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

Air Temperature

The Northeast is also experiencing trends consistent with global climate change forecasts, with rising temperatures, decreasing snow cover, and spring arriving earlier. The Northeast Climate Impacts Assessment (NECIA) used IPCC's high and low emission scenarios and three different climate models to predict climate impacts for the Northeast. According to this assessment, temperatures in the Northeast have been rising at a rate of 0.5 degrees Fahrenheit (°F) since 1970. In this same time period, winter temperatures have increased even more rapidly, at a rate of 1.3°F per decade. Average air temperature across the Northeast is projected to rise 2.5 to 4°F in the winter and 1.5°F to 3.5°F in the summer in the coming decades (NECIA, 2007).

Additionally, a recent study by Environment Canada, Clear Air Cool Planet, and the Gulf of Maine Council on the Marine Environment found similar trends. Temperature trends for the Northeastern United States and Canadian Maritime Region were analyzed using data from over 100 monitoring stations (Wake, et al., 2006).[3] Wake, et al. (2006) found that there is a clear warming trend of 1.4°F since 1900, with the 1990s being the warmest decade on record. Additionally, over the last 33 years (1970-2002), annual average temperature increased at a rate three times higher than for the entire century (0.54°F per decade). Seasonal temperature trends were also analyzed and showed similar results. Over the past 100 years, the winter season has shown significant warming,

[3] The Northeast, as defined by Wake, et al. (2006) includes Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New York, New Jersey and Pennsylvania and the Canadian Maritime Region of New Brunswick, Nova Scotia, and Prince Edward Island

with average December through February temperatures increasing by 2.5°F. However, the average temperature increase over the last 33 years has been even more startling, increasing 4.3°F (1970-2002) (Wake, et al., 2006).

Changes in temperature have been linked to other changes in the region. These include more frequent days with temperatures above 90°F, longer growing seasons, earlier first-leaf and first-bloom dates for plants, less precipitation falling as snow and more as rain, reduced snowpack and increased snow density, earlier breakup of winter ice on lakes and rivers, earlier spring snowmelt, resulting in earlier peak spring stream flows, earlier migration of Atlantic salmon and mating frogs, and raising sea-surface temperatures (NECIA, 2007). Due to these correlations, temperature is one of the most frequently used indicators of climate change (Wake, et al., 2006).

Precipitation

Precipitation trends vary greatly between seasons and trends tend to be local. However, as a region precipitation has been gradually increasing at a rate of 5-10% since 1900 (NECIA, 2007). NECIA (2007) projects that under either high or low emission scenarios, the region will experience an increase of four inches of precipitation by 2100. Winter precipitation, in particular, is projected to increase an average of 20-30% under higher emission scenarios, with a greater proportion of this precipitation falling as rain, rather than snow. However, little change in summer precipitation is projected (NECIA, 2007). Wake et al. (2006) found that since 1960, annual precipitation (rain and snow) has become increasingly

variable. The region as a whole has seen a slight decrease in annual precipitation. However, monitoring stations in coastal areas have witnessed a 20%-30% increase (7.8 – 11.8 inches) in precipitation (Wake et al., 2006).

Extreme precipitation events, defined as more than two inches of rainfall in a 48 hour period, are expected to increase by 8% by mid-century and by 12-13% by 2100 (NECIA, 2007). Extreme precipitation events averaged 2.6 events per year for the region from 1950-2002. Several coastal sites in Massachusetts and Rhode Island experienced more than four extreme precipitation events per year. Stations in the northern part of the region saw a decrease in annual extreme precipitation events, whereas those in the southern part of the region showed a significant increase in extreme events (Wake et al., 2006). Finally, snow cover in the Northern Hemisphere has decreased over the past three decades. This decrease is strongly linked to increases in temperature (Wake et al., 2006).

Ocean Temperature and Sea Level Rise

Sea surface temperatures have risen 1°F since 1900 and are expected to continue this upward trend at a slightly slower rate than regional air temperatures (NECIA, 2007). Under higher emission scenarios, sea surface temperatures are expected to rise 6°F -8°F (4°F-5°F under lower emission scenarios) by the end of the century (NECIA, 2007). According to Wake et al., (2006) sea surface temperatures throughout the region have warmed on average from 0.9°F – 1.18°F over the past 100 years. This represents large amounts of excess energy that is

being taken up by the ocean's surface waters. This can have significant impacts on extreme weather events and water chemistry (Wake et al., 2006).

Continuation of historic sea level rise trends would result in six inches of sea level rise over 2005 levels, as early as 2050. Under lower emissions levels, sea level is projected to rise 7-14 inches (10-23 inches under high emission scenarios). Certain localities may experience further increases in sea level rise due to local land movement and geography. 'Relative sea level rise,' the local net increase, is predicted to be rising faster than the global average because the land in the Northeast is gradually subsiding (NECIA, 2007).

NECIA (2007) also determined the impact of sea level rise on 100-year storm[4] frequency on five coastal cities: Atlantic City, NJ; New London, CT; New York City, NY; Woods Hole, MA; and Boston, MA. By 2050 it is predicted that the maximum elevation and frequency of major coastal floods will increase. Boston is particularly vulnerable, with present 100-year floods predicted every two to three years.

Additional Impacts

These identified impacts of climate change have ramifications for coastal communities and ecosystems. The U.S. Climate Change Science Program (2008) identified a number of secondary impacts of climate change on estuarine ecosystems including, among others, increases in eutrophication and changes

[4] An 100-year flood is the maximum flood elevation likely to be equaled or exceeded on average once every century in a given location. There is a 1% chance of a 100-year flood occurring in any given year. From the Northeast Climate Impacts Assessment (2007).

water chemistry from rising sea surface temperatures; elevated nutrient loading as wetland buffers are inundated and eroded from sea level rise; and increased stormwater runoff from more frequent intense storms. Additionally, climate change will impact hydrologic cycles and contribute to habitat and species migration, and increase the potential for infrastructure damages.

It is also essential to consider the degree to which each impact interacts with others. For example, when looking specifically at the effects of climate change on eutrophication, impacts on physical changes in fresh water discharge, temperature, water depth, and wind must be considered. Changes in forest, land uses, and agricultural practices as a result of climate change will also impact the extent to which coastal ecosystems are susceptible to eutrophication (Ebi, et al., 2007). "Multiple stressors exacerbate climate change impacts on natural systems (Ebi, et al., 2007, p.4)" and must be considered in successfully identifying adaptation and management goals.

Climate Change Adaptation Options for Coastal Ecosystems

Climate change adaptation is a series of actions or techniques developed to "reduce impacts or exploit beneficial opportunities resulting from climate change (US EPA, 2008, p.4)." Not all adaptation strategies will require direct shifts in day-to-day management of estuarine and coastal ecosystems, as some options fulfill current management goals. However, many will require a shift in management strategies and decision making processes (US EPA, 2008). Adaptation strategies should "aim to increase the flexibility in management of

vulnerable ecosystems, enhance the inherent adaptability of the species and ecosystem processes within vulnerable natural systems, and reduce trends in environmental and social pressures that increase vulnerability to climate variability (Hulme, 2005, p.785)." As adaptation options are being developed it is important to consider that management responses can alleviate or exacerbate a system's vulnerabilities. As a result, it is increasingly important to ensure that coastal managers have the appropriate resources to address these issues.

Adaptation strategies can be *proactive*, developed to "preserve and protect resources in anticipation of climate change impacts (US EPA, 2008, p. 4)," or can be *reactive*, implemented after impacts have been observed. Reactive measures can be further divided into those that are developed in advance but not implemented until climate change impacts have been observed or those that are ad hoc, unplanned responses. Different approaches will be appropriate in different locations, with varying management goals, resources, risk, and certainty in the data (US EPA, 2008; U.S. Climate Change Science Program, 2008a). Additionally, "no-regrets" strategies are measures that have non climate related benefits that exceed the cost of implementation. Similarly, "co-benefit" strategies are those which have ancillary benefits not related to climate change (Abramovitz, ND).

The U.S. Environmental Protection Agency recognizes that "planning for adaptation, without immediate implementation, may represent the most prudent response to uncertainty over timing and or intensity of negative consequences… provided that advance actions are not required to avoid irreversible damage (U.S.

Climate Change Science Program, 2008a, p 7-41).” Political feasibility and cost of implementation strategies should also be considered during planning. The magnitude of predicted consequences, confidence associated with predictions, and the timing of the effects should be taken into account when considering costly actions to take proactive steps. To help promote low-cost strategies that can be immediately initiated, coastal communities should support planning and natural resource management that prohibit actions that will exacerbate the negative consequences of climate change, allow actions that are climate-change neutral, and actively promote actions that provide enhanced ecosystem resilience to climate change (U.S. Climate Change Science Program, 2008a).

Maintaining and Restoring Wetlands

Wetlands and tidal marshes provide essential functions within estuarine ecosystems, acting as buffers to treat non-point source stormwater runoff before entering the open waters of the estuary. Intertidal marsh plants and subtidal seagrass vegetation are among the most important estuarine species that dictate overall ecosystem health and composition. They are threatened by sea level rise and increasingly intense storms interacting with the hardening for shorelines (U.S. Climate Change Science Program, 2008a). Strategies for maintaining and restoring wetlands primarily focus on facilitating wetland migration through changes in regulations and prohibiting shoreline hardening, including the installation of bulkheads, dikes, and other engineered structures (US EPA, 2008). Regulations often include setbacks, density restrictions, land purchases, or rolling

easements, accompanied by removal of hard protection and other barriers to tidal and riverine flow. It is also important to incorporate wetland protection into infrastructure planning, specifically transportation planning and sewer utilities. Additionally, wetland restoration often incorporates efforts to restore biodiversity in tidal marshes and sea grass beds and to protect ecologically significant areas, such as spawning grounds (US EPA, 2008).

Preserve Coastal Land and Development

It is essential to integrate coastal management into land use planning. Strategies to preserve coastal land and development focus on land use planning and management, land exchange and acquisition programs, and modification of infrastructure. Options for land use planning include land exchange programs, where owners exchange property in a floodplain for county/city owned land outside of the floodplain, and land acquisition programs, though which a land trust or other entity purchases coastal land that is damaged or prone to flooding. Strategies to modifying existing and future infrastructure include permitting rules that limit locations of landfills, hazardous waste dumps, and other potentially dangerous facilities to areas outside floodplains and storm surge zones. Additionally, adjusting engineered structures affecting estuaries and coastlines, such as culverts, to properly handle increased intensity of storms and potential storm surges is another option (US EPA, 2008). Reactive coastal management and land use planning, such as dismantling or moving buildings and infrastructure, would be costly, politically challenging and increasingly unfeasible as coastal

land becomes increasingly developed. Additionally, any policy that would lead to private property loss challenging with current private property laws. Therefore it is increasingly important to proactively manage land to incorporate natural resources planning. Strategies that involve rolling easements to preserve public tidal lands will become increasingly essential (U.S. Climate Change Science Program, 2008a).

In a national study, conducted by the U.S. EPA (2008), Rhode Island and parts of Massachusetts were the only coastal areas to have regulations in place that recognize the need to allow for wetland migration as sea level rises.

Prevention of Shoreline Loss

Additional strategies seek to prevent shoreline loss from sea level rise. 'Soft' measures seek to develop living shorelines through beach nourishment, planting dune grass, marsh creation, and planting submerged aquatic vegetation. 'Hard' measures focus on techniques such as constructing bulkheads, seawalls, and breakwaters, or reinforcing dikes and headlands. It is most likely that some combination of 'hard' and 'soft' measures will be appropriate depending on shore protection costs, property values, existing infrastructure and development, and the environmental importance of habitat. It should be noted that many 'hard' measures may provide immediate remediation and protection of infrastructure, but are not sustainable in protecting coastal land in the long term. They also have potential negative impacts on ecosystems, such as preventing sediment transport and blocking species migration (US EPA, 2008).

Invasive Species Management

Invasive species management is another critical strategy for adaptation of coastal ecosystems. As habitats shift poleward due to warming ocean temperatures, it will become increasingly important to manage current ecosystems for invasive species. Removing non-native species allows for native species to repopulate and ecosystems to be restored. Rules and regulations to prevent invasive species would also be important. As habitats shift, however, it will be necessary to adapt to changing species and ecosystems. These impacts should be considered when making investments in management strategies based on currently existing species and populations. In line with this concern, preserving habitat extent is another strategy for adaptation. Actions to increase ecosystem boundaries include purchasing upland development or property rights, and expanding the horizons for land use planning to incorporate long term climate predictions (US EPA, 2008).

Habitat Preservation

Preserving habitat extent of current species is also an important management goal. Estuarine habitats have high levels of primary production and provide structural protection for numerous species, which are important prey for larger commercially important fish. Fisheries are likely to suffer from loss of tidal marshes as a result of rising sea level, increased storm intensity, and their interaction with hardened shorelines. They will also be impacted by increased

frequency, scope, and duration of bottom-water hypoxia. These impacts are expected to translate directly into lost production of fish and wildlife. Successfully managing habitat extent will likely incorporate many of the strategies identified under other management goals (US EPA, 2008). Additionally, sustainable management of fisheries will become increasingly important as commercial species are impacted by the productivity of estuaries (U.S. Climate Change Science Program, 2008a, p 7-50).

Maintain Water Quality and Quantity

Finally, strategies to maintaining water quality and quantity should be considered. Water quality is threatened by increased water surface temperatures, extended warming seasons, increased stormwater runoff, and increased nutrient inputs. These have the potential to increase risk for hypoxic (low oxygen) and anoxic (essentially no oxygen) conditions (U.S. Climate Change Science Program, 2008a). There are a variety of options to assist in maintaining water quality and quantity depending upon the specific threats a coastal area is facing. Generally, options consist of developing adaptive stormwater management practices to handle increased levels of runoff, incorporating sea level rise into planning for new infrastructure, sewage systems and culverts, and designing new coastal drainage systems (US EPA, 2008).

Many of these adaptation options meet multiple management goals and are even more effective when used in conjunction with others. It is essential for coastal managers to consider the specific conditions of their watershed before

adapting any strategy, as there can be external effects of some options, depending upon other variables.

Resource Needs for Climate Change Adaptation

There is limited literature identifying the barriers to and additional resource needs for incorporating climate change adaptation into watershed management. In a recent study of Washington State's Watershed Planning Program, Binder (2006) identified additional types of support needed to facilitate the inclusion of climate change impacts in watershed planning. Recognizing that technical and financial resources are often limited, particularly at the local level, additional resource needs include:

- Information developed for a variety of audiences is essential: Non-technical, clear information is needed for lay people, while technical and complex scientific information is needed for consultants and technical planners.
- More detailed, locally scaled scenarios: Watershed planners in Washington State are particularly concerned with impacts on snowpack and stream flow.
- Credible reports and case studies: Technical reports from credible sources, such as peer reviewed journals, research groups, or nongovernmental organizations, and case studies providing examples would aid in further integrating climate impacts into the planning process.

- Technical support: Having access to scientific expertise for modeling and climate projects would increase the ability of climate change to be integrated into watershed planning.

This study also suggests that watershed planning at the local level provides a unique opportunity to address climate change as this is where "the physical and socioeconomic impacts… may be most acutely realized (Binder, 2006, p.925)."

In 2005, the Puget Sound Action Team commissioned a study by the University of Washington's Climate Impacts Group to gain understanding of the implications of climate change for Puget Sound, Washington (Mote, 2005). In addition to identifying climate impacts on snowpack, water quality, and marine ecosystems and functions, this study also identified additional resource and monitoring needs. It is essential that monitoring of key biological populations and biologically relevant environmental variables be continued in order to compare present conditions with historical records to determine the extent of changes. Additionally, modeling studies should be conducted to determine the impact of changes in multiple variables on the health of the ecosystem.

Finally, The Northeast Climate Impact Assessment (2007) developed a series of recommendations for prioritizing adaptation strategies in the Northeast region. These do not specifically address incorporating climate change adaptation into watershed management planning, but provide a broader view to climate change adaptation. Their recommendations include:

- Monitor the changing environment: improved monitoring of the climate and its impacts on natural systems can provide decision makers with clearer signals about the need for action.
- Track indicators of vulnerability and adaptation: monitoring the progress of adaptation strategies and social factors that limit a community's ability to adapt can provide essential information needed to modify strategies to be more effective.
- Take the long view: when considering investments in infrastructure and land-use choices, future climate change impacts must be considered.
- Consider the most vulnerable first: high-priority in policy and management decisions should be given to climate-sensitive species, ecosystems, economic sectors, communities, and populations.
- Build on and strengthen social networks: pre-established, trusted relationships between individuals and organizations are an asset for adaptation at the community level.
- Put regional assets to work: the Northeast region has a wealth of scientific and technical expertise in universities and businesses.
- Improve public communication: effective communication and engagement with the public on climate change helps build capacity to adapt.
- Act swiftly to reduce emissions: immediate reduction of emissions is essential to limit impacts of climate change and give communities and ecosystems a chance to successfully adapt.

In addition to recommendations specifically for incorporating adaptation strategies into watershed planning, these broader strategies for prioritizing strategies are important, as a successful adaptation strategy requires commitment from all levels of a community and across multiple sectors.

Watershed Management

Traditional ecosystem management has focused largely on top-down, government mandated efforts, which seek input from various stakeholders through such mechanisms as public hearings and comment periods (Bentrup, 2001), working to create a one way flow of information from the public to the agency decision makers (Yaffee, 2003). The focus has been largely on establishing minimal standards and enforcement strategies and has been marginally successful in this respect (Clark, 2005). Agency driven efforts are most appropriate in circumstances where the issue is complex and there is not a lot of community interest or involvement in the issue at hand, whereas community-based efforts are more successful when the issues are boarder in scope and there is a need for community support (Moore, 2003).

Top-down traditional approaches have been criticized for regulatory inflexibility, one-size fits all policies, and high transaction costs (Clark, 2005). Additionally, numerous studies have shown that these methods restrict information sharing, reinforce stereotypes, limit public involvement in plan development, and promote win-lose situations, often resulting in limited public

support of plans (Bentrup, 2001; Koontz, 2004). They also tend to discount hydrological boundaries and ecological interconnectedness (Clark, 2005).

Over time, the watershed has come to be viewed as a "place based ecological entity, as well as a socioeconomic and political unit to be utilized for management planning, conservation strategies, and implementation purposes (Clark, 2005, p. 297)." As a result, natural resource management at the watershed scale has become increasingly common. In a recent study conducted by Clark (2005), 211 watershed management organizations throughout the United States were surveyed to determine organizational characteristics and dynamics. It was found that during the early 1990s, there was a trend in developing management strategies around the watershed. The mean year of formation of these organizations was 1991. Similarly, the emergent paradigm of ecosystem management was developing in the early 1990s, so it is not surprising to see this holistic, ecology-driven management strategy translate to watershed management decisions. Additional findings included a strong emphasis on grassroots participation and democratic process. 73.3% of organizations surveyed confirmed that their organization was based on the principles of collaboration, stakeholder participation, and inclusiveness.

In recognition of the challenges of the top-down approach, efforts have been made to decrease costs, promote flexibility and efficiency in implementation, focus on pollution prevention, and move toward a watershed approach (Clark, 2005). These emerging efforts also focus on promoting cooperation and collaboration (Leach, 2001) through which regulatory agencies

and non-governmental organizations share responsibility for protecting public health, environmental quality, and improving the use of natural resources (Sexton, 1999).

Collaboration

Natural resource planning in the United States has seen a drastic shift toward collaboration in the past 30 years (Yaffee, 2003). Collaborative approaches can produce "holistic, equitable solutions that have the support necessary to be implemented (Bentrup, 2001, p. 739)." These planning efforts tend to have an interdisciplinary approach. Stakeholders educate each other, often through face to face dialogue, are involved throughout the planning process to create a holistic plan, and decisions are usually made through consensus (Bentrup, 2001). Additionally, collaborative-based planning promotes the adaptive capacity of organizations, the creation of public-private partnerships (Clark, 2005) and provides the opportunity for stakeholders to communicate prior to problem definition (Leach, 2001). Broad community participation has been linked to improvements in cooperation among stakeholders, community organizing capacity, data dissemination, legitimacy of actions, and personal transformations in developing and understanding interpersonal relationships (Koontz, 2004).

However, it should be noted that the division of authority for natural resource and environmental management between multiple federal, state, and local agencies often inhibits the effective implementation of ecosystem-based management even if it is recognized that planning for changing conditions is the

optimal strategy. This is a particular concern regarding coastal ecosystems, as successful implementation of a holistic plan requires the cooperation and collaboration of federal, state, and local agencies, and non profits as well as other stakeholders representing coastal interests and land users throughout the watershed and airshed (U.S. Climate Change Science Program, 2008a, p 7-41).

The scientific literature also shows that "many of the factors causing ecosystem decline such as rapid urban development, urban run-off, and habitat fragmentation occur at the local level and are generated by local land use decisions (Noss and Scott, 1997)." The coordination of local plans and policies is essential when single ecological units cross multiple jurisdictional boundaries, i.e the watershed (Brody, 2004). As a result, the shift to watershed management, or more broadly ecosystem management, increasingly depends on collaboration among private landowners, local and regional government agencies, non-profits, and academic institutions. Decisions must be made collectively because multiple entities have control of various elements of the ecosystem (Brody, 2004, Weber, 2003). This is particularly relevant to communities facing changing conditions, as social capital is linked to the resilience or ability of communities to cope with change (Hartley, 2008).

Adaptive Management

Adaptive management consists of a series of linked, iterative steps involving problem identification, collaborative brainstorming, model development, hypothesis testing, planning, experimentation, monitoring,

evaluation, and behavioral change (Habron, 2003). Historically, resource dependent communities have used these strategies to act collectively to manage "weather-dependant, fluctuating, and seasonal resources" such as fish, livestock, and water resources (Adger, 2003). Adaptive management can supplement the efforts of community-based institutions in natural resource management as the iterative process provides an avenue for addressing uncertainty in data and moving forward toward management goals. Additionally, adaptive management allows for other community-based conservation concepts, such as social capital and community capacity, to be incorporated (Habron, 2003).

Adaptive Capacity

The ability to manage resources through an adaptive management approach depends in the adaptive capacity of the community or management institution. Adaptive capacity is the "potential of a system, region, or community to cope with the effects or impacts of climate change (IPCC, 2001, p. 879)." Or the ability to act collectively (Adger, 2003). This includes the ability to prepare for climate impacts and opportunities in advance, as well as the ability to respond to its effects (IPCC, 2001).

The IPCC (2001) Third Assessment Report identified factors that determine the capacity of social, ecological, or economic systems to adapt to climate change impacts. There is a complex mix of conditions that determine a society or community's ability to adapt to climate change and impacts. The IPCC notes that there is limited literature on adaptive capacity in respect to climate

change. However, there is considerable understanding of the adaptability of communities in the fields of hazard mitigation, resource management and sustainable development. Drawing on this literature, the IPCC identified the following determinates of adaptive capacity:

- The availability of and access to technological options for adaptation;
- The availability of capital resources;
- The structure of critical institutions;
- Human and social capital;
- The system's risk-spreading process;
- The ability of decision makers to manage information; and
- The public's perceived understanding of the risk (Yohe, 2002; IPCC, 2001).

Social resilience is also used to describe adaptive capacity, or the capacity for positive adaptation in the face of resilience (Tompkins, 2004). Specifically with regard to climate change, social resilience is the ability of groups or communities to adapt in the face of external social, political, or environmental stresses and disturbances, showing the ability to successfully buffer disturbances, self-organize, and learn to adapt (Adger, 2000). The level of social resilience or social capital is particularly important in the face of climate change as adaptation occurs through collective action to mediate collective risk (Tompkins, 2004).

In particular, social capital developed through bonding and networking of groups and individuals is essential in geographically and socially defining vulnerability and risk of a community or resource. Additionally, social capital

developed through relationships with state and local government assists in planning for adaptation and providing appropriate technologies and resources (Adger, 2003). Ager (2003, p. 388) also explains that "the effectiveness of strategies for adapting to climate change depend on the social acceptability of options for adaptation, the institutional constraints on adaptation, and the place of adaptation in the wider landscape of economic development…" This suggests that some level of collaboration is essential in improving a community-based organization's adaptive capacity.

Chapter 3: Methodology

The capacity of community-based watershed initiatives to integrate climate change impacts into their management programs will be determined through a series of case studies. Cases were selected from the Northeastern United States due to the regional impacts of climate change. Community-based watershed initiatives have been defined by having a watershed focus, integrating science into the decision making process through monitoring programs, collaborative problem solving, and involving the public in the decision making process (US EPA, 2005). All initiatives in the Gulf of Maine Council on the Marine Environment's NGO Directory[5] and the Environmental Protection Agency's 'Adopt Your Watershed Directory[6] were reviewed for the above criteria. Over 30 initiatives within the Gulf of Maine fit these criteria. Cases were further refined to include initiatives that are specifically focused on estuarine management, or have a significant estuarine/coastal focus. Cases were selected based on willingness to participate, availability of data and information, and geographic representativeness. The following initiatives fit these criteria and were targeted for participation in this study: Friends of Sengekontacket, Salem Sound Coast Watch, Lamprey River Watershed Association, Friends of Casco Bay and Friends of Taunton Bay.

Reviewing a limited number of initiatives allowed for in-depth, detailed review of each initiatives capacity. This approach is preferred to a broad survey of all potential initiatives within the watershed because it will allow for specific

[5] Accessed from: http://www.gulfofmaine.org/ngo_directory/
[6] Accessed from: http://www.US EPA.gov/adopt/

programs and management items to be identified that increase capacity as well as allow for identification of data gaps, needed information and resources. Standard case study protocol was followed (Yin, 2004), by collecting and analyzing a range of qualitative data sources for each initiative. In addition to interviews with Program Managers, a review of relevant documents, brochures, programs, and management plans was conducted. Data from several sources allows for a triangulation process, through which identified results and findings from each source can be verified.

Interviews with Program Managers were conducted over a two week period, between January 30, 2009 and February 13, 2009. Interviews were conducted by phone due to program's geographic location and lasted between 40-75 minutes. The goal of the interview was to determine the extent to which climate information was being integrated into watershed planning and the extent to which watershed planning can serve as a pathway for adapting to climate change (Binder, 2006). See Appendix I for Interview Questions.

The case study analyses were based on standard qualitative data analysis methods (Weiss, 1994). Each was coded for major themes: member composition, level of collaboration, funding sources, watershed management goals, monitoring activities, climate change threats, direct climate change actions, indirect climate change actions, current collaborative partnerships, partnerships specific to climate change, additional resource needs, and identified challenges and benefits of collaboration. Each theme was developed into an excerpt file and entered into an Excel matrix (see Appendix II).

Each case study was also coded for the determinants of adaptive capacity discussed in detail in the earlier Background section, which included technical options for adaptation, availability of resources, critical institutions, human and social capital, risk spreading process, ability to manage information, and public's perceived understanding.

Results of this research will help determine the capacity for community-based watershed organizations to incorporate climate change adaptation into their education and outreach, advocacy, and ecosystem monitoring efforts. More specifically, the research will identify the current extent to which climate change impacts and adaptation strategies are being discussed and/or addressed; consider the extent to which collaboration enables or inhibits integration of climate change adaptation into watershed planning; identify additional resource needs for adaptation; and determine current and future capacity of community-based watershed organizations to incorporate climate adaptation.

Chapter 4: Results

Case Studies

Each case study is detailed in Appendix III, providing a full description of their organizational structure, collaborative partnerships, observed climate change impacts, direct or indirect activities related to climate change, current climate change adaptation measures, and additional resource needs. Below is a map and summary of each case study followed by an integrated discussion of the characteristics listed above. Detailed maps can also be viewed in Appendix IV

Friends of Taunton Bay

Taunton Bay links three rural towns, Hancock, Sullivan, and Franklin, in an increasingly commercial sector of Maine's coast (See Figure 1). Taunton Bay is a shallow estuary home to numerous wildlife of national significance: 2 nesting pairs of Bald Eagles, Blue Herons, Osprey, Loons, and harbor Seals, among others. Additionally, the Bay supports a number of fisheries, including clams, mussels, scallops, crabs, and lobsters (FTB, ND). Friends of Taunton Bay (FTB) was established with the goal of enhancing the biological integrity of the

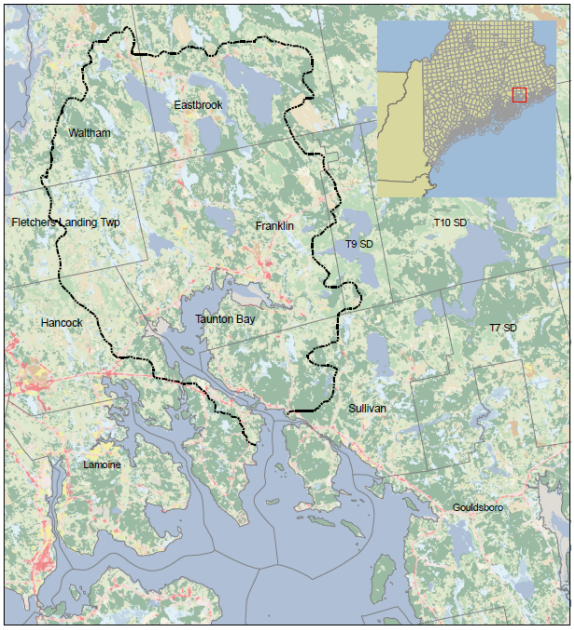

Figure 1: Taunton Bay, ME
Data Source: Maine GIS 2004; USGS National Land Cover Data 2001Projection: Transverse Mercator, NAD 1983 UTM Zone 19N
Cartographer: Holly Elwell, Tufts University, Spring 2009

Bay and to serve as an educational resource of the local community. In priority order, FTB focuses on fisheries management (clams, worms, scallops, mussels, kelp, and sea urchin), monitoring eelgrass habitat, erosion, and migratory birds (Dorsey, 2009).

In these efforts, FTB played a leading role in developing a fisheries management plan for Taunton Bay by partnering with the Maine State Planning Office to conduct a pilot study on local bay management practices and options. Additionally, FTB has collected significant data on eelgrass habitat through historical photo series data going back to 1980; has time series photos for specific sites affected by erosion; has collected time series data for salinity in the Bay; and has been conducting a tag and release study of horseshoe crabs since 2001 (Dorsey, 2009).

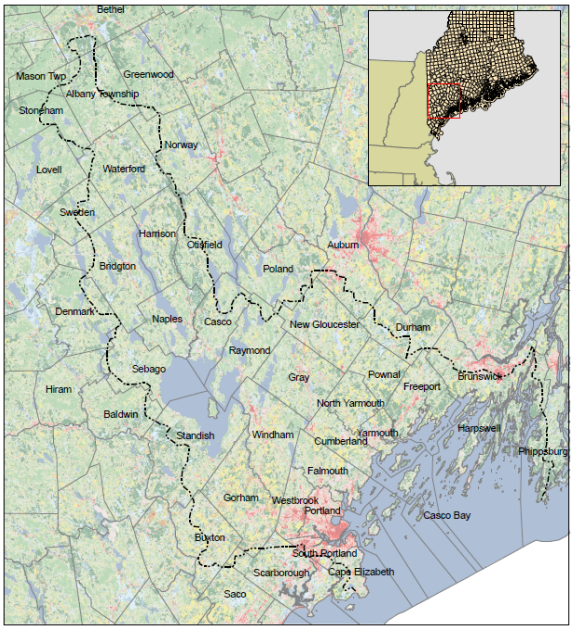

Figure 2: Casco Bay, ME
Data Source: Maine GIS 2006; USGS National Land Cover Data 200; Projection: GCS North American 1983
Cartographer: Holly Elwell, Tufts University, Spring 2009

Friends of Casco Bay

The Casco Bay watershed, in southern coastal Maine, covers 41 towns and 958 square miles, providing habitat for over 850 species of marine life and 150 species of coastal birds (FCB, 2008) (See Figure 2). Friends of Casco Bay (FCB) was established in 1989 by a group of concerned

citizens, looking to preserve and protect the health of the Bay. Over the last 20 years, they have grown to be one of the most active, well-respected organizations in the region (FCB, 2008). All program and management decisions FCB makes are based on the scientific data their organization collects. They have 17 years of water quality monitoring data for pH, salinity, temperature, nutrients, dissolved oxygen, water clarity, as well as a lobster inventory (Ramsdell and Cerullo, 2009). In effort to achieve their mission, FCB has five primary programs in public education and outreach, water quality monitoring, BayKeeping (advocacy), Bayscaping, and the Pumpout program (FCB, 2008). FCB's work is focused solely on the Bay, so collaboration and partnerships are required to ensure the entire watershed is covered and regional management goals are being met (Ramsdell and Cerullo, 2009).

Lamprey River Watershed Association

The Lamprey River is the largest tributary to Great Bay, New Hampshire, running 60 miles though 6 towns before becoming tidal and emptying into the Bay (See Figure 3). The

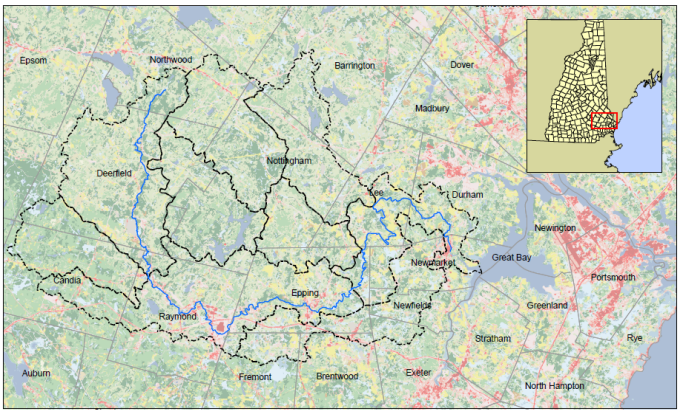

Figure 3: Lamprey River Watershed, NH
Data Source: NH GRANIT 2006;
USGS National Land Cover Data 2001
Projection: New Hampshire State Plane; 1983
Cartographer: Holly Elwell, Tufts University, Spring 2009

Lamprey River Watershed Association (LRWA) was formed in 1980 to promote the restoration, conservation, and wise development and use of the watershed. Their key goals are to conserve fish and wildlife, forests, soil, and water resources, as well as pollution abatement (LRWA, 2008). In partnership with NH Department of Environmental Services, LRWA has 14 water quality monitoring stations from which they have collected data for 11 years. LWRA also recently conducted a 'Stream Walk,' which aimed to locate and document potential threats to environmental health along the river. Sixty volunteers assessed 47 miles of the river, taking note of invasive species, culverts, stormwater outfalls, erosion, trash, and the general health of the reach of the river. This data will be used to inform future management decisions (Genes, 2009).

Salem Sound Coastwatch

The Salem Sound watershed is located on the north shore of Massachusetts Bay, in Manchester, Beverly, Danvers, Peabody, Salem, and Marblehead, Massachusetts (See Figure 4). Salem Sound Coastwatch (SSCW) was established in 1990 by a number of citizens, local government officials, and businesses committed to

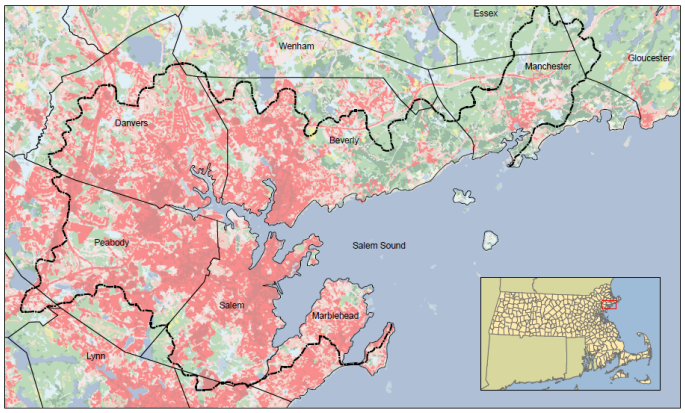

Figure 4: Salem Sound Watershed, MA
Data Source: Mass GIS 2009; USGS National Land Cover Data 2001
Projection: Massachusetts State Plane, 1983
Cartographer: Holly Elwell, Tufts University, Spring 2009

improving and protecting the environmental quality of the Sound and its watershed. Top priorities include the protection of coastal habitat, commercial and recreational marine resources, and water quality (SSCW, 2009). SSCW also focuses on non-point source pollution, which includes stormwater, flooding, and greenscapes; and habitat restoration, focusing on salt marsh monitoring and restoration, river restoration, habitat protection and improvement marine invasive species monitoring (Warren, 2009). Since 1995, SSCW has acted as a regional coordinator for the Massachusetts Bays Estuary Program, partnering closely with MA Coastal Zone Management Office, U.S. EPA, and other regional organizations to implement the Estuary Program's management plan. In this role, SSCW plays an important monitoring, advocacy, and education role for the communities in Salem Sound (Warren, 2009).

Friends of Sengekontacket

Sengekontacket Pond is a 745 acre tidal pond on Martha's Vineyard in the towns of Oak Bluffs and Edgartown, Massachusetts (See Figure 5). The pond is located on the landward side of a barrier beach and provides commercial fishing and recreational opportunities. Friends of Sengekontacket (FOS) was established in 1988 by a group of concerned citizens when the shellfish beds were closed due to high bacteria counts (FOS, 2008). FOS focuses on water quality monitoring and habitat protection around the pond and has extensive monitoring data for nitrogen, bacteria, and eelgrass habitat. In their effort to improve the health of the pond, FOS recognized the importance of having Oak Bluffs and Edgartown

working cooperatively to restore the pond and requested the formation of a joint committee. The Joint Committee on Sengekontacket Pond was established and has been proactive and successful in a number of regards. FOS continues to work closely with this committee and other local and regional organizations to raise awareness and protect the health of the pond (Appenzeller, 2009).

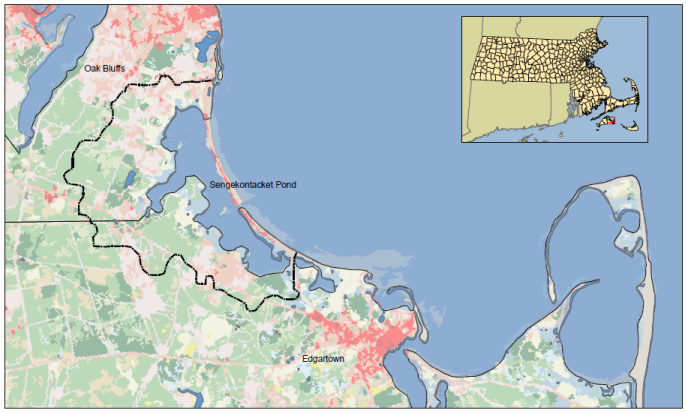

Figure 5: Sengekontacket Pond, Martha's Vineyard, MA
Data Source: Mass GIS 2009; USGS National Land Cover Data 2001
Projection: Massachusetts State Plane, 1983
Cartographer: Holly Elwell, Tufts University, Spring 2009

Results

Organizational Structure

Organizational structure for the selected case studies ranged in member composition from all volunteer staffs and Boards (Friends of Taunton Bay and Friends of Sengekontacket) to eight full-time staff members (Friends of Casco Bay). The Lamprey River Watershed Association and Salem Sound Coastwatch have 1 part-time and 2 full-time staff, respectively. All organizations rely on the consensus of the Board when making decisions (see Table 1). Friends of Casco Bay and the Lamprey River Watershed Association also use a management plan and a strategic planning process to inform decisions and determine direction.

Salem Sound Coastwatch mentioned that the availability of funding sources also drives the direction of their programs. They depend heavily on state and federal grant sources, which are often tied to specific initiatives and management goals. Friends of Casco Bay and the Lamprey River Watershed Association also identified specific state and federal grant sources that are significant in supporting their organization's activities. Friends of Casco Bay receives part of the Targeted Watershed Grant through the Casco Bay Estuary Partnership, while the Lamprey River Watershed Association receives a $25,000 grant from the National Park Service to fund a part-time Executive Director. All organizations rely on a combination of individual or membership contributions and grants.

Table 1: Organizational Structure

Organization	Member Composition	Decision Making	Funding Sources
Friends of Taunton Bay	All volunteer	Consensus of Board members	Membership and grants
Friends of Casco Bay	8 full-time staff; 17 member Board	Consensus of Board members ; Management decisions are based on Casco Bay Plan (NEP)	Membership, grants (ex. Target Watershed Initiative Grant from Casco Bay Estuary Partnership)
Lamprey River Watershed Association	1 part-time Executive Director; volunteer Board	Consensus of Board members, with input from Executive Director; Strategic Planning process	Grants, membership (~$2,000), $25,000 grant from National Park Service Wild and Scenic River Management Protection Program for part-time director
Salem Sound Coastwatch	2 full-time staff; 7 member Board	Consensus of Board members, with input from Executive Director; priorities also set by funding sources	Grants (state and federal), memberships and community donations (~80%)
Friends of Sengekontacket	13-15 member Board, not a membership organization	Consensus of Board members	individual contributions (~80%), grants, large challenge grant for addressing bacterial problem

Collaboration

All organizations expressed a firm belief in collaboration and a commitment to the "collaborative spirit (Ramsdell, 2009)." Dawn Genes (2009), Executive Director at the Lamprey River Watershed Association, explained that collaboration is essential especially when looking for funding sources, as "the worst thing you can do is appear to be operating independently and not interested in working with others." The Lamprey River Watershed Association collaborates with Federal, State, and local governments, regional non-profits, and academic institutions. One of the key roles, LRWA plays in these partnerships is that of education and outreach. There is a great deal of valuable research on the Lamprey River watershed being conducted by UNH and other organizations. LRWA works to translate this information into usable formats for local decision makers and the public. LRWA will host a technology transfer conference in June 2009 to share this research with local government officials (LRWA, 2008a).

Friends of Sengekontacket (FOS) heavily relies on collaboration with State and local governments, the Martha's Vineyard Commission, and local non-profits to advance their mission. Terry Appenzeller (2009), Vice-President and Treasurer for FOS, FOS has limited authority as the legal jurisdiction to make decisions regarding the health of the pond is in the hands of the two towns, Edgartown and Oak Bluffs, and therefore, it is "critical we serve the role we do, which is awareness and raising issues, and then help to implement."

Similarly, collaboration has been essential in the Friends of Taunton Bay's (FTB) successes. In the development of a bay area management plan, FTB

worked closely with State and local governments and a variety of stakeholders including kelp, sea urchin, mussel, and scallop harvesters. Frank Dorsey (2009), Vice-President and Secretary of FTB, further explained that there are "a lot of interlocking directorates;" being involved in a number of organizations and on the boards of multiple organizations.

Friends of Casco Bay (FCB) and the Salem Sound Coastwatch (SSCW) echoed the importance of collaboration in their organizations' accomplishments, but they also identified some challenges that arise. In specific regards to activities around climate change adaptation, Barbara Warren (2009), Executive Director of SSCW, identified the challenge of coordinating everyone involved, explaining, "so many people are working on it. How do we not step all over each other, work cooperatively, and get the best use of all our time…" Massachusetts Bays National Estuary Program has also recognized this challenge and is working to coordinate resources and stakeholders in the region (Warren, 2009).

FCB acknowledges that "working with a collaborative spirit is really a lot of how we've been able to get as many laws passed, as much improvement in the water quality here, and get as many people involved as we have (Ramsdell, 2009)." However, Cathy Ramsdell (2009), Executive Director of FCB, explains that it can be very frustrating at time, because everyone comes to the table with different levels of expertise, slightly different foci, and ways of conducting business. In the end, FCB is committed to collaborative partnerships, "...we are devoted to it. We are admittedly frustrated by it at times, but it is the right way to be trying to work (Ramsdell, 2009)."

Table 2: Collaboration

Organization	Level of Collaboration	Current Collaborative Partnerships	Collaborative Partnerships Specific to Climate Change
Friends of Taunton Bay	State, regional NGOs, academic institutions	Taunton Bay Advisory Group, sponsored by Maine DMR; Frenchman Bay Conservancy; UMaine Machias; College of the Atlantic; Audubon Society	None at this time
Friends of Casco Bay	Federal, State, local governments, regional NGOs, academic institutions, local elementary/middle/high school	Casco Bay Estuary Partnership, Natural resource Council on Maine, Lobster Conservancy, ME DEP Pumpout Program, ME DMR, WaterKeeper Alliance, University of Southern Maine	WaterKeeper Alliance conference; Eelgrass conference
Lamprey River Watershed Association	Federal, State, local government, regional NGOs, academic institutions	NH DES, 14 watershed town Conservation Commissions, Advisory committee of Wild and Scenic River, Piscataqua Region Estuaries Partnership, Strafford Regional Planning Commission, Bear Paw Regional Greenway, UNH	Not directly, but underlies/considered in many activities
Salem Sound Coastwatch	Federal, State, local governments, regional planning agency, local NGOs, academic intuitions	Massachusetts Bay NEP (Climate Ready Estuaries pilot), ICLEI, TNC, Mass Audubon, Manimont Fish and Wildlife, MAPC, MA CZM StormSmart Coasts, watershed town governments, Tufts University, MA DEP	Massachusetts Bays NEP (and all of their stakeholders)
Friends of Sengekontacket	State, local governments, regional planning agency, local NGOs	Advisory Committee, Joint Committee on Sengekontacket, MVC, Vineyard Conservation Society; Massachusetts Estuaries Partnership	MVC Island Plan, Great Ponds; "not as forthright as it could be, but it is being considered"

In addition to the identifying the benefits and challenges of collaboration, organizations were also asked to explain any partnerships they have established specific to climate change impacts or adaptation strategies (see Table 2). SSCW partnered with Tufts University's Urban and Environmental Policy and Planning program to develop a preliminary vulnerability and risk assessment of the six towns in the watershed. Additionally, SSCW is a regional coordinator for the Massachusetts Bays Estuary Program, which was recently selected by the US EPA to be a Climate Ready Estuary pilot. Through this project, an in-depth vulnerability assessment of Salem Sound will be conducted and the management

plan will be adapted to reflect recommended adaptation strategies (Warren, 2009). FCB is co-hosting two conferences, the WaterKeeper Alliance conference and the Eelgrass conference, which will both focus on climate change impacts (Ramsdell, 2009). FOS is working with the Martha's Vineyard Commission in the development of an Island Plan to ensure that Great Ponds on the island are properly protected. Climate change is not being directly addressed, but is being considered (Appenzeller, 2009). Similarly, LRWA does not have any partnerships specific to climate change, but it underlies much of their work and efforts (Genes, 2009).

Climate Change

All organizations acknowledged climate change and its potential impacts on coastal ecosystems and communities, some having experienced or documented these changes (see Table 3). The Lamprey River watershed experienced 100 year floods in both 2006 and 2007, with many communities experiencing severe flooding. This has raised awareness within communities and brought stormwater runoff to the forefront of LWRA's priorities. The Town of Epping has requested flood plain management assistance from the Conservation Commission and residents of Raymond are concerned with sub-division proposals in flood plains they recently witnessed under water. On the other extreme, this watershed experienced droughts on 2000 and 2001 (Genes, 2009). LWRA does not have any programs or activities specific to climate change at this time. However, through

their water quality monitoring program and 'Stream Walk' inventory, they have substantial data to determine baseline conditions and monitor changes.

Table 3: Climate Change Impacts

Organization	Observed Climate Change Threats/Concerns	Direct Climate Change Actions	Indirect Climate Change Actions
Friends of Taunton Bay	eel grass loss, erosion, migratory bird changes	Panel: Rising Water and Erosion, Summer 2008	All monitoring activities; Fisheries Management Plan
Friends of Casco Bay	storm surges, frequency of storms, increase intensity of storms, sea level rise, changes in pH, atmospheric deposition of nitrogen	Casco Bay curriculum-module on climate change; WaterKeeper Alliance conference; co-sponsor of Eelgrass conference	Bayscaping program
Lamprey River Watershed Association	100 year floods in both 2006 and 2007; droughts in 2000, 2001; stormwater runoff	None at this time	Water quality monitoring; all aspects of 'Stream Walk'
Salem Sound Coastwatch	sea level rise, flooding, storm surges, increased precipitation, droughts, erosion, ability of salt marshes to migrate	Salt Marsh restoration project	Greenscapes Program, focus on LID
Friends of Sengekontacket	Sea level rise, major storms	Beach Management Plan; Strategic Plan	Water quality monitoring, Eelgrass restoration

Friends of Taunton Bay (FTB) has also been working to establish baseline data on eelgrass habitat, erosion, and changes in migratory bird patterns. Since 1980, FTB has tacked eelgrass habitat through a series of aerial photographs, documenting existing and migrating habitats. There have been minimal losses to dragging and drought conditions, but otherwise eelgrass beds have been stable. Similarly, FTB has time series photos of specific sites that are vulnerable to erosion. During the last full-moon tide, Dorsey witnessed higher tides than usual and the time series photos are showing additional erosion (Dorsey, 2009). FTB has started to raise awareness about erosion issues in their newsletter, and held a panel discussion entitled "Rising Water and Erosion" in the summer of 2008 (FTB, 2008).

Friends of Sengekontacket is particularly concerned with sea level rise and increased intensity of storms, as the pond is located behind a barrier beach on the Atlantic Ocean side of the island. The beach management plan, developed in partnership with Dukes County, addresses emergency preparedness and hazard mitigation. These goals indirectly address climate change impacts, but the plan has yet to be implemented due to other priorities and inadequate funding (Appenzeller, 2009). FOS also has substantial baseline water quality data and is working on an eelgrass restoration project. Appenzeller (2009) acknowledged that the uncertainty of impacts and not having clear causal relationships defined inhibits effective action.

Salem Sound Coastwatch is actively working to ensure salt marsh habitat is preserved in light of sea level rise and habitat migration. They are currently working to restore a three-acre area of salt marsh and a stream adjacent to two acres of tennis courts that were originally wetlands in Beverly, MA. This will allow a fringe salt marsh along a barrier beach to migrate inland as sea levels rise. Sea level rise and flooding also threatens many communities in the Salem Sound watershed, as they were developed on low lying land, which are densely developed. Warren (2009) is equally concerned with droughts as the watershed has a number of rural towns without extensive fire hydrant systems. They have expressed concern that they will not have the water resources to put out wildfires once they start (Warren, 2009).

Finally, Friends of Casco Bay expressed specific concern regarding water quality and atmospheric nitrogen deposition as a result of climate change.

Ramsdell and Cerullo (2009) explained that nitrogen, as a greenhouse gas, has greater implications for marine environments than carbon. Their monitoring records show that the background level of nitrogen has gone up and small additions of fertilizer can trigger algal and jellyfish blooms. They see this as the biggest threat to the Bay and are continuing to monitor nitrogen and get nitrogen limits in place along the coast. FCB is also closely monitoring pH levels and are on 'internal alert' as they are concerned that pH problems may quickly follow the nitrogen problem (Ramsdell and Cerullo, 2009). FCB also has extensive baseline data for salinity, dissolved oxygen, water clarity, and lobster populations.

With or without monitoring data that reflects climate change impacts, FCB has moved forward in working to raise awareness among communities. FCB developed a climate change module as part of their larger curriculum program on Casco Bay. They offer free workshops to teachers in the Casco Bay watershed, training them in 37 classroom activities for grades 4-6 (FCB, 2008). These activities expose students to FCB's monitoring data, teach them age appropriate facts about climate change, and, perhaps most importantly, provides reassurance that it is not all bad (Ramsdell and Cerullo, 2009).

Climate Change Adaptation

Friends of Taunton Bay, Friends of Casco Bay, the Lamprey River Watershed Association, and Friends of Sengekontacket have not been involved in assessing their watersheds for climate change vulnerability, nor are they aware of other organizations working on that task. Through the recent partnership with

Tufts University and the ongoing support from the Massachusetts Bays Estuary Program, Salem Sound Coast Watch has a good understanding of vulnerability and risks related to climate change impacts. Warren (2009) acknowledges that SSCW is just beginning to address the adaptation side of climate change and that it appears to be a daunting task. They are "trying to figure out what we can do and what knowledge we need to have."

Table 4: Climate Change Adaptation

Organization	Additional Resource Needs	Assessed for Vulnerability
Friends of Taunton Bay	Funding for baseline data; otherwise unsure of available resources	No
Friends of Casco Bay	Continued funding from State for N monitoring; additional resources for monitoring acidification, eel grass, nitrogen; locally scaled scenarios for impacts; central database with most recent climate data (national level)	No
Lamprey River Watershed Association	Information developed for multiple audiences; case studies of other communities of similar size; technical assistance in comprehensive planning	No
Salem Sound Coastwatch	LIDAR[7], infrastructure inventory, local scenarios particularly for sea level rise and increased flood plains	Yes- in partnership with Tufts University UEP, preliminary study was conducted; Massachusetts Bays NEP- Climate Ready Estuaries pilot project
Friends of Sengekontacket	Additional funding for Beach Management Plan implementation; detailed SLR maps showing scenarios w probability; predictive data- rainfall, temperature, invasives	No

All five organizations identified adaptive management as an important approach in making management decisions. Although none were using this approach to specifically address climate change, this implies that Program

[7] See Footnote 1 for details.

Managers are comfortable working with uncertain data, changing conditions, and altering management approaches to correlate with observed changes.

Organizations were also asked to identify resource needs that would assist them in moving forward on climate change adaptation programming. Needs ranged from continued funding for baseline data to locally scaled scenarios and case studies of similarly sized communities to more predictive data for precipitation, temperature trends and invasive species habitat. For additional resource needs, see Table 4.

Chapter 5: Analysis

Determinates of Adaptive Capacity: Lessons Learned

The results of the case studies demonstrate that climate change is on the radar of these organizations and that they are very aware of potential impacts. However, they are in the beginning stages of addressing climate change adaptation, although all organizations use an adaptive management framework for current program and management decisions. By analyzing the cases through the lens of the determinates of adaptive capacity, it is possible to determine in what areas community-based watershed organizations have strong capacity and where they need assistance in strengthening their capacity to address climate change adaptation .

Technical Options for Adaptation

The lack of knowledge of or access to technical options for adaptation appears to be one of the biggest challenges for community-based watershed organizations in attempting to address climate change impacts. Dorsey (2009), with FTB, explained that "I just don't know what's out there," and that it appears to be a daunting task to determine the appropriate resources and strategies for addressing climate change.

SSCW is the only organization currently involved in assessing climate change vulnerability and directly looking at climate change adaptation. Their partnerships with academic institutions and state level agencies are critical in this effort. They collaborated with Tufts University's Urban and Environmental Policy

and Planning Program to develop a preliminary study of climate change vulnerability, risk, and adaptation strategies for the communities within Salem Sound. And through their partnership with the Massachusetts Bays Estuary Program, a vulnerability assessment will be conducted for all of Massachusetts Bay. From this report adaptation strategies will be prioritized.

Although not directed specifically toward climate change, organizations in this study rely on collaborative partnerships to gain access to technical resources in addressing other management concerns. For example, FOS is working with the Massachusetts Estuary Project (MEP) to develop data and determine TMDL (total maximum daily loads) for a variety of pollutants to Sengekontacket Pond. Appenzeller (2009) explained that this is an essential first step in determining limitations on development and other human activities and can inadvertently address the anticipated impacts from climate change. FOS collected all of the baseline data for the study, while MEP will conduct the critical analysis to develop TMDLs, which FOS does not have the capacity to do. This suggests that collaboration will be critical in gaining access to technical resources for adaption.

Case studies also identified that baseline and historical data are essential in tracking changes over time and determining the impacts of climate change. All organizations conduct extensive water quality monitoring and maintain a handle on the ecosystem health of their perspective watershed though various monitoring activities (See Table 5).

Table 5. Monitoring Activities

Organization	Monitoring Activities/Programs
Friends of Taunton Bay	Eel grass- historical photo series going back to 1980; Erosion- time series photos; salinity- time series data; Horseshoe crabs- tag and release study since 2001; 25 ecological indicators for bay management
Friends of Casco Bay	water quality monitoring: 17 years of data - pH, salinity, temperature, nutrients, dissolved oxygen, water clarity; lobster inventory
Lamprey River Watershed Association	Water quality monitoring- 11 years of data, 14 monitoring stations, in partnership with NH DES; 'Stream Walk'- 41 volunteers surveyed 47 miles of the river for stormwater outfalls, erosion, invasive species, trash, land use (data in process as of February 2009)
Salem Sound Coastwatch	invasive species- current location, abundance, characteristics; 'Clean Beaches and Streams'- volunteer, every 2 weeks, bacteria; wetland health- birds, fish, plants, water chemistry, land use, tidal hydrology, benthic macro-invertebrates; Salt marsh monitoring- 12 years of data
Friends of Sengekontacket	Nitrogen, bacteria, eel grass

Finally, all organizations easily identified additional resource needs for addressing climate change adaptation, suggesting that their current needs are not being met. These included funding for baseline data and monitoring activities, locally scaled scenarios for a variety of impacts, information developed for multiple audiences, case studies of other communities of similar size, technical assistance in comprehensive planning, LIDAR[8], infrastructure inventory, and predictive data, among others. Ramsdel and Cerullo (2009), with FCB, also suggested there be a central place at the national level where the most recent climate change data can be made available to the public in useable formats.

Availability of Resources

All organizations depend heavily on grants and membership donations to support programs and activities. Addressing climate change adaptation requires

[8] See Footnote 1 for details.

acknowledgement and support from donors and granting institutions. SSCW is the only organization interviewed that has a direct funding partnership for climate change adaptation. As part of the Massachusetts Bays Estuary Program (MBEP), Climate Ready Estuaries pilot project, MBEP is working to complete a vulnerability assessment and prioritize adaptation strategies. Warren (2009), with SSCW, also mentioned that their activities and programs are subject to 'hot topic' grants from state and federal agencies. Without their recognition of climate change as an important topic to be addressed, it will be difficult to get funding directly for adaption strategies.

To increase monetary resources for climate change adaptation programs, it may be necessary to persue other, non-traditional avenues for funding. Although not directed toward climate adaptation, FOS received a challenge grant from an anonymous donor to help address the bacteria problem the pond is currently facing. It was matched by a local neighborhood organization (Appenzeller, 2009). If awareness is raised among the community, additional financial support may become available.

Critical Institutions

All organizations appear to have good working relationships with critical institutions in their watersheds and a good understanding of the decision making processes within their networks. For example, FOS works very closely with the towns of Oak Bluffs and Edgartown, as both towns have jurisdiction over Sengekontacket Pond. FOS realized that they have very little authority when it

comes to making decisions about the pond and therefore coordination and communication between the two towns would be essential in protecting the health of the pond. With this in mind, they helped establish a Joint Committee on Sengekontacket with members from both Oak Bluffs and Edgartown. FOS feels this was an essential step in moving their agenda forward (Appenzeller, 2009). Additionally, FTB developed extensive relationships with the Maine Department of Marine Resources, land owners, harvesters, scientists, local businesses, regulators, academic intuitions, and state and local governments to cooperatively develop a bottom-up approach to mussel, sea urchin, kelp, and scallop harvests (Dorsey, 2009; Arter, 2007). Dorsey (2009) specifically mentioned the challenge of getting local harvesters to the table, but that FOS was successful in getting their input and ultimately having them decide on the management scheme.

SSCW identified the Massachusetts Bays Estuary Program as an essential organization in coordinating efforts within the watershed. Specifically in regards to climate change adaptation, it is critical because there are so many players who are beginning to think about these issues and are all at the same point of realizing how big the problem is (Warren, 2009). Finally, LRWA and FCB work closely with all watershed towns. LWRA focuses efforts on disseminating critical information in useful formats to decision makers and residents and works closely with researchers at the University of New Hampshire to gain access to their research and studies and share this with the public (Genes, 2009). On the other hand, FCB's work stops at the high tide line, so it is critical for them to work with

other watershed organizations and the watershed towns to reach regional management goals identified by the Casco Bay Estuary Partnership (CBEP).

These relationships with critical institutions are essential as community-based watershed organizations do not have jurisdiction over decisions being made within the watershed. It is essential that they work with state, regional, and local governments to establish and advocate for appropriate policies and planning programs.

Human and Social Capital/Public's Perceived Understanding

Community-based watershed organizations currently play a large role in increasing human and social capital around watershed issues. In specific regards to climate change adaptation, this is an area where community-based watershed organizations have the potential to have considerable impact.

FCB has taken direct action to improve students' and teachers' understanding of climate change science and impacts by developing a climate change module as part of their Casco Bay curriculum (FCB, 2008).

Providing information in usable formats to decision makers and local citizens is essential in raising people's awareness. Dawn Genes (2009), with the LWRA, explained that a lot of her work is focused on translating information for these audiences. LRWA will host a technology transfer conference in June 2009 to share technical research from the University of New Hampshire with local government officials (LRWA, 2008a). Although they do not have a specific

climate change program, it is a concern that underlies their current programming (Genes, 2009).

Additionally, SSCW is just beginning outreach programs specific to climate change. Warren (2009) feels that it is critical to identify what the issues are and begin doing outreach to watershed communities while the vulnerability assessment is still being completed. SSCW has clearly been successful in raising awareness and gaining public involvement in other arenas, such as the Peabody Street Park project. Similarly, FOS has acknowledged that there are a lot of players involved in working to improve the health of the Pond and they have made it their goal to document the changes in water quality, habitat loss or migration, and beach erosion and then move toward raising awareness with the public and working with the two towns to move toward a resolution (Appenzeller, 2009).

Finally, FTB worked with land owners, harvesters, scientists, local businesses, regulators, academic intuitions, and state and local governments to cooperatively develop a bottom-up approach to mussel, sea urchin, kelp, and scallop harvests (Dorsey, 2009; Arter, 2007). Although not directly targeted toward climate change impacts, this suggest that there are good social networks within the watershed.

There is a lot of activity around education and outreach and gaining public involvement in existing projects. This suggests that there are good networks and systems currently in place to help educate the public and decision makers about climate change, when information is developed and/or becomes available.

Risk Spreading Process

Community-based watershed organizations use a variety of outlets to disseminate information to decision makers and local residents. For example, SSCW uses a variety of media outlets to raise awareness about watershed issues. These include newspapers, their newsletter, and local television (Warren, 2009). These could become critical methods through which to spread information regarding climate change risks and opportunities. Additionally, LRWA serves as a clearing house for information and activities for the 24 conservation organizations in their watershed (LRWA, 2008a). This provides easy access to information and helps coordinate efforts.

FCB works closely with the Casco Bay Estuary Partnership to disseminate information to stakeholders through regular meetings throughout the watershed. Similarly, SSCW works closely with the Massachusetts Bays Estuary Program to stay connected to watershed stakeholders and share information (Warren, 2009).

Another critical component of the risk-spreading process is making monitoring and baseline data available to larger audiences. Watershed organizations make management decisions based on this data and it should also be considered by decision makers at multiple levels. Since FCB's focus is on the Bay and their organization's work stops at the high tide line, they work hard to distribute their data to organizations and decision makers throughout the watershed. This ensures others know the results of their monitoring efforts. However, Ramsdell and Cerullo (2009) mentioned that 17 years of data has not

shown any strong trends clearly reflecting climate change impacts. This makes it challenging to take the data to decision makers in support of climate adaptation measures.

Ability to Manage Information

Managing the breadth and depth of climate change information is a challenge for community-based watershed initiatives. Of the five case studies, two were all volunteer, one had a part-time Executive Director, one had two full-time staff, and one had eight full-time staff. Particularly with the volunteer organizations, the ability to manage information heavily depends on the personal background and experience of the individuals involved. Additionally, in their efforts to focus on disseminating information in useable formats to decision makers and residents, LRWA recognizes that it is very difficult to translate an issue of global concern into actions at the town or individual level.

It is also hard to manage information for an issue that is so complex. Appenzeller (2009), with FOS, explained that one of the major issues is causality; "we don't know what all the drivers are." In the case of Sengekontacket Pond, it is difficult to pin point what is causing the recent increase in bacteria when there are different driving factors. In the Salem Sound watershed, there are a number of organizations looking at climate change adaptation strategies. Warren (2009) explained that everyone is beginning to realize how big the problem is and it is hard to know exactly where to get started.

FCB has developed an approach that begins to address complexity. FCB's approach to managing information and results of their monitoring efforts is to work on potential solutions for problems as they are emerging. By identifying emerging problems, they are able to get a head start on education and outreach and build partnerships specific to those issues.

Chapter 6: Recommendations and Conclusions

From these case studies, it has been determined that community-based watershed organizations have very strong adaptive capacity in collaborating with critical institutions, building human and social capital, increasing the public's perceived understanding of the issue, and assisting in the risk spreading process. However, they are very limited in their access to technical resources for adaptation, their ability to manage information specific to climate change and the availability of resources to support their efforts.

There is consensus in the literature that addressing climate change adaption at the local scale is essential in the adaptation planning process. Community-based watershed organizations are just beginning to gain access and develop the capacity to address climate change impacts and adaptation in this way. Of the five initiatives in this study, they ranged from not addressing climate change to beginning to develop vulnerability assessments and taking first steps in addressing climate change adaptation. All initiatives thought climate change was important and could identify expected and observed impacts related to climate change.

Community-based watershed initiatives play an essential role as they act as an intermediary organization in the watershed planning process. They provide a link between stakeholders in the watershed and funnel information and monetary resources from federal and state agencies and granting organizations to address issues on the local scale. As intermediaries, these organizations are important advocates to local governments and to the general public. They have the ability to

bring important issues to the forefront and build community consensus and support. However, there is a missed opportunity when it comes to climate change. Community-based watershed organizations are heavily dependent on collaborative partnerships to accomplish their missions, broaden their reach, and disseminate information. In regards to climate change, the initiatives in this study identified specific resource needs that would allow them to further integrate climate impacts into their education and outreach, advocacy, and ecosystem monitoring efforts. Federal and state agencies, academic institutions, and regional non-profits could play a significant role in providing these technical resources.

There is consensus in the literature that management at the watershed scale was initiated as an alternative to the top-down, bureaucratic approach of larger federal and state agencies. However, these larger institutions often have the resources to provide needed grants, technical assistance, and resources. In the cases of Salem Sound Coastwatch and the Friends of Casco Bay, both organizations have significant partnerships with their respective National Estuary Programs. Additionally, the Massachusetts Bays Estuary Program was selected as part of the US EPA's Climate Ready Estuaries Pilot project and has provided a climate focus to SSCW. This has provided these community-based efforts great resources and partnership opportunities, allowing them to broaden their impact. This demonstrates that more formal partnerships between community-based watershed organizations and state or federal agencies can be very beneficial.

Additional research is needed to determine other organizations that have capacity in access to technical resources for adaptation, their ability to manage

information specific to climate change, and to provide resources to support adaptation efforts. It would be ideal to identify organizations within each watershed that could be potential collaborators with community-based watershed organizations.

In establishing collaborative partnerships for climate change adaptation, larger institutions should depend on community-based watershed organizations for the extensive social networks they have established. The watershed scale provides ample opportunity to address a variety of important environmental, social, and economic issues. Since climate change adaptation requires changes on the local scale, agencies and organization should partner with existing watershed organizations. Due to the nature of their work, community-based watershed organizations have already established relationships with key stakeholder groups, local town governments, and regional planning agencies. These groups could play a pivotal role in moving the climate change adaptation agenda forward and formalizing the process through adoption of local bylaws, ordinances and regulations.

In order for community-based watershed organizations to be successful in incorporating climate change into their education and outreach, advocacy, and ecosystem monitoring, it will be essential to provide them with accurate and appropriate information. Case studies in this report identified a variety of additional resource needs including predictive data, information developed for multiple audiences, and case studies and locally scaled scenarios. Additionally, developing locally scaled vulnerability assessments and having access to current,

credible climate science would assist in prioritizing adaptation measures. This would provide community-based watershed organizations with the tools to confidently advocate for specific measures and conduct education and outreach to build community support and consensus.

Ultimately, climate change adaptation is going to become an essential piece of the watershed planning process, especially in coastal areas where climate change impacts have the potential to greatly disrupt concentrated areas of development and socio-economic activity. As more local stakeholders, government agencies, and nonprofits become more involved in the adaptation field, community-based watershed organizations should be viewed as the key actors and collaborative partners. Their ability to collaborate with critical institutions, build human and social capital, increase the public's perceived understanding of the issue, and assist in the risk spreading process are essential components of developing a successful and implementable adaptation strategy.

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Appendix I: Interview Questions

Research Hypothesis

Coastal watershed communities and ecosystems will be significantly impacted by climate change. Community-based watershed management has been successful in addressing a number of watershed issues over the past ~50 years. This success has been attributed to their level of local knowledge, community support, and collaboration with other non-profits, academic institutions, and government agencies. Due to the uncertainty of climate change impacts and limited resources it is essential for community-based watershed initiatives to develop the capacity to address these impacts at the local watershed level. Their current capacity will depend on the extent to which climate change adaptation is directly or indirectly addressed in their education and outreach, advocacy, or ecosystem monitoring and the level of collaboration with other organizations, agencies, and academic institutions.

Organizational Structure

- What are the most significant watershed management challenges your organization is currently working to address? How are they prioritized?
- How are decisions made in your organization?
- How is your organization funded?

Climate Change Adaptation

- What are the biggest challenges your watershed is facing, or expects to face, as a result of climate change? Through current programming, is your organization working to address any of these challenges?

- Are you familiar with the term 'adaptive management'?[9] Is this concept included in your current planning efforts? If so, how?
- Has your watershed been assessed for climate change vulnerability?[10]
- In your opinion, does climate change uncertainty inhibit integration of climate change impacts into management plans? If so, how?
- Are there any specific opportunities or obstacles provided to address climate change adaptation by other expected changes in the watershed? (development, transportation, sector development)[11]
- In an ideal world, without regard to technical or monetary resources, what would you like to see happen in regards to climate change adaptation in your watershed?

Collaboration and Increasing Capacity

- Do you collaborate with other organizations? If so, in what ways?
- How important is collaboration in your organization's programs and accomplishments?

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[9] Adaptive management focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders who learn together how to create and maintain sustainable ecosystems. Adaptive management helps science manager maintain flexibility in their decisions, knowing that uncertainties exist and provides mangers the latitude to change direction; will improve understanding of ecological systems to achieve management objective; and is about taking action to improve progress towards desired outcomes. (http://www.doi.gov/initiatives/AdaptiveManagement/whatis.html)

[10] Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. (IPCC, 2007)

[11] Adapted from Kirshen, P. Tufts/MIT, Somerville Water Drainage Project, 2008.

- Has collaboration helped you address climate change adaptation? If so, how? If not, are you interested in developing partnerships to help address climate change adaptation?
- Are you aware of other organizations' efforts to address climate change impacts within your watershed?
- Are you aware of state, regional, or federal programs that assist watershed organizations in climate change adaptation? If so, which ones?
- What additional type of information/resources do you need to increase your capacity to address climate change impacts?
- If state or federal agencies, academic institutions, or other organizations were to provide assistance for climate change adaptation what type of assistance would be most useful? (i.e. funding; grants; technical assistance; technical information on prioritizing adaptation options)

Appendix II: Case Study Matrix

Organization	Member Composition	Level of Collaboration	Decision Making	Funding Sources	Watershed Management Focus
Friends of Taunton Bay	All volunteer	State, regional NGOs, academic institutions	Consensus of Board members	membership and grants	Fisheries management, eel grass loss, erosion, migratory birds (in priority order)
Friends of Casco Bay	9 full-time staff; 17 member Board	Federal, State, local governments, regional NGOs, academic institutions, local elementary/middle/high school	Management decisions are based on Casco Bay Plan (NEP)	Membership, grants (ex. Target Watershed Initiative Grant from Casco Bay Estuary Partnership)	Focus on water quality
Lamprey River Watershed Association	1 part-time Executive Director; volunteer Board	Federal, State, local government, regional NGOs, academic institutions	Consensus of Board members, with input from Executive Director; Strategic Planning process	Grants, membership (~$2,000), $25,000 grant from National Park Service Wild and Scenic River Management Protection Program for part-time director	Focus on water quality, conservation, and more broadly river health
Salem Sound Coastwatch	2 full-time staff; 7 member Board	Federal, Sate, local governments, regional planning agency, local NGOs, academic institutions	Consensus of Board members, with input from Executive Director; priorities also set by funding sources	Grants (state and federal), memberships and community donations (~80%)	non-point source pollution- stormwater, flooding, greenscapes; habitat restoration- salt marsh, river restoration, habitat protection and improvement; marine invasives
Friends of Sengekontacket	13-15 member Board, not a membership organization	State, local governments, regional planning agency, local NGOs	Consensus of Board	individual contributions (~80%), grants, large challenge grant for addressing bacterial problem	water quality, habitat preservation,

Organization	Observed Climate Change Threats/Concerns	Monitoring Activities/Programs	Direct Climate Change Actions	Indirect Climate Change Actions
Friends of Taunton Bay	eel grass loss, erosion, migratory bird changes	Eel grass- historical photo series going back to 1980; Erosion- time series photos; salinity- time series data; Horseshoe crabs- tag and release study since 2001; 25 ecological indicators for bay management	Panel- Rising Water and Erosion, Summer 2008	All monitoring activities; Fisheries Management Plan
Friends of Casco Bay	storm surges, frequency of storms, increase intensity of storms, sea level rise, changes in pH, atmospheric deposition of nitrogen	water quality monitoring: 17 years of data - pH, salinity, temperature, nutrients, dissolved oxygen, water clarity; lobster inventory	Casco Bay curriculum-module on climate change; WaterKeeper Alliance conference; co-sponsor of Eel Grass conference	Bayscaping program
Lamprey River Watershed Association	100 year floods in both 2006 and 2007; droughts in 2000, 2001; stormwater runoff	Water quality monitoring- 11 years of data, 14 monitoring stations, in partnership with NH DES; 'Stream Walk'- 41 volunteers surveyed 47 miles of the river for stormwater outfalls, erosion, invasive species, trash, land use (data in process as of February 2009)	None at this time	Water quality monitoring; all aspects of 'Stream Walk'
Salem Sound Coastwatch	sea level rise, flooding, storm surges, increased precipitation, droughts, erosion, ability of salt marshes to migrate	invasive species- current location, abundance, characteristics; 'Clean Beaches and Streams'- volunteer, every 2 weeks, bacteria; wetland health- birds, fish, plants, water chemistry, land use, tidal hydrology, benthic macro invertebrates; Salt marsh monitoring- 12 years of data	Salt Marsh restoration project	Greenscapes Program, focus on LID
Friends of Sengekontacket	Sea level rise, major storms	Nitrogen, bacteria, eel grass	Beach management Plan; Strategic Plan	Water quality monitoring; Eelgrass restoration

Organization	Current Collaborative Partnerships	Collaborative Partnerships Specific to Climate Change	Additional Resources Needed	Climate Change Vulnerability
Friends of Taunton Bay	Taunton Bay Advisory Group, sponsored by Maine DMR; Frenchman Bay Conservancy; Maine Machias; College of the Atlantic; Audubon Society	None at this time	Funding for baseline data; otherwise unsure of available resources	No
Friends of Casco Bay	Casco Bay Estuary Partnership, Natural resource Council on Maine, Lobster Conservancy, ME DEP Pumpout Program, ME DMR, WaterKeeper Alliance, University of Southern Maine	WaterKeeper Alliance conference; Eel Grass conference	Continued funding from State for N monitoring; additional resources for monitoring acidification, eel grass, nitrogen; locally scaled scenarios for impacts; central database with most recent climate data (national level)	No
Lamprey River Watershed Association	NH DES, 14 watershed town Conservation Commissions, Advisory committee of Wild and Scenic River, Piscataqua Region Estuaries Partnership, Strafford Regional Planning Commission, Bear Paw Regional Greenway, UNH	Not directly, but underlies/considered in many activities	Information developed for multiple audiences; case studies of other communities of similar size; technical assistance in comprehensive planning	No; aware of Oyster River Watershed- being assessed for vulnerability- culvert- NEP
Salem Sound Coastwatch	Massachusetts Bay NEP (Climate Ready Estuaries pilot), ICLEI, TNC, Mass Audubon, Manimont Fish and Wildlife, MAPC, MA CZM StormSmart Coasts, watershed town governments, Tufts University, MA DEP	Massachusetts Bays NEP (and all of their stakeholders)	LiDAR, infrastructure inventory, local scenarios particularly for sea level rise and increased flood plains	Yes- in partnership with Tufts University UEP, preliminary study was conducted; Massachusetts Bays NEP- Climate Ready Estuaries pilot project
Friends of Sengekontacket	Advisory Committee, Joint Committee on Sengekontacket, MVC, Vineyard Conservation Society; Massachusetts Estuaries Partnership	MVC Island Plan, Great Ponds; "not as forthright as it could be, but it is being considered"	Additional funding for Beach Management Plan implementation; detailed SLR maps showing scenarios w probability; predictive data- rainfall, temperature, invasives	No

Appendix III: Case Studies

Friends of Taunton Bay

Interview: Frank Dorsey, Vice President and Secretary of Friends of Taunton Bay. Phone interview conducted February 12, 2009

Taunton Bay, located east of Mount Desert Island in Maine, has received a lot of attention over the past 3 years for their progressive research and management of fisheries in small estuaries. Friends of Taunton Bay (FTB), a volunteer membership organization, played a crucial role in the development of one of the first fisheries management plans for an intertidal estuary (Dorsey, 2009). In 2005, FTB received a grant from the Maine State Planning Office to conduct a pilot project in local bay management. After thorough research on bay management practices, collaboration with key stakeholders, and input from community members, FTB produced an extensive report, the Taunton Bay Study: A Pilot Project in Collaborative Bay Management, with environmental indicators data, GIS maps, an economic assessment of bay fisheries, policy recommendations, and outreach materials for the public (Arter, 2007). This pilot study laid the foundation for the development for the Taunton Bay Mudflat Management Plan and the Comprehensive Management Plan for Taunton Bay (Arter, 2007).

Organizational Structure

Friends of Taunton Bay is a volunteer, membership organization with a four member Executive Board, 2 committee chair people and 4 members at large. Decisions are made by consensus of the Executive Board and funding for activities is obtained though membership donations and grants. In addition to focusing on sustainable fisheries management, FTB also focuses on eel grass loss, erosion, and migratory birds. Their mission, as stated on their website is "to enhance the biological integrity, healthful functioning, capacity for self-renewal and scenic beauty of Taunton Bay; to study and take action on issues affecting the Bay; to promote understanding, appreciation, and protection of the bay by the general public and by government; and serve as an educational resource for the public (FTB, ND)."

Collaboration

One of the best examples of collaboration in which FTB has been involved is the development of the Comprehensive Management Plan for Taunton Bay. With the establishment of the Taunton Bay Advisory Group, sponsored by the Maine Department of Marine Resources, this process brought together land owners, harvesters, scientists, local businesses, regulators, academic intuitions, and state and local governments to cooperatively develop a bottom-up approach to mussel, sea urchin, kelp, and scallop harvests (Dorsey, 2009; Arter, 2007). Dorsey (2009) also identified the Frenchman's Bay Conservancy, a local land trust, the University of Maine at Machias, the College of the Atlantic, and the Audubon Society as current collaborative partners.

Climate Change

Although FTB does not have specific programs to address climate change at this time, there have been observed impacts that are starting to raise concern. FTB has been tracking eel grass health through historical photos series since 1980, documenting eel grass habitat and migration. They are particularly interested in eel grass beds because they are critical to the health of the bay, providing a nursery for many species and improving water quality by filtering out silt and other contaminants. In 2002, Taunton Bay witnessed a die back in eel grass as a result of drought conditions. Trace areas of eel grass are lost to dragging and 'eel grass dieback disease,' but FTB witnessed more extreme dieback in high salinity (i.e. drought) conditions. Changing precipitation patterns and increases in temperature could increase drought conditions and change water chemistry, negatively impacting this essential habitat. FTB is currently working with a researcher from the University of Maine at Machias on an eel grass restoration project to try to replant some of the lost habitat (Dorsey, 2009).

FTB is also concerned about climate change impacts on erosion. They have time series photos of specific sites that are prone to erosion and are concerned that sea level rise is causing further incursion in the banks. During the last full-moon tide, Dorsey witnessed higher tides than usual and the time series photos are showing additional erosion (Dorsey, 2009). FTB has started to raise awareness about erosion issues in their newsletter, and held a panel discussion titled "Rising Water and Erosion" in the summer of 2008 (FTB, 2008).

Another climate change concern is that of sea surface temperature increases and habitat migration. Taunton Bay provides critical habitat and breeding ground for horseshoe crabs. Through FTB's tag and release study, which they have conducted since 2001, they found that there are two distinct populations of horseshoe crabs in Egypt and Hogs Bay (Dorsey, 2009; Arter, 2007). FTB is concerned that these populations will change if their habitat is affected by climate change. However, from the tag and release study they do have the baseline data to track any changes in the populations that might occur (Dorsey, 2009)

Climate Change Adaptation

FTB's current efforts in addressing climate change focus on developing baseline data and raising awareness within the Bay communities (Dorsey, 2009). For the 'Taunton Bay Study: A Pilot Project in Collaborative Bay Management,' FTB gathered publicly available data and original data for 25 ecological indicators. According to its health or current state, each indicator was given a green, yellow, red, or unknown score. Oyster sets, harbor seals, salinity, phytoplankton, invasive species, and horseshoes crabs in Egypt and Hog Bays were all determined to be healthy and given a green score. Indicators that could use improvement, receiving a yellow score, included benthic invertebrates, buffer strips, septic systems, water transparency, surface temperature, bottom temperature, eagle reproduction, and weather. Coliform bacteria, eelgrass, shorebirds, and erosion were all found to be in poor condition, receiving a score of red. There was not enough information to determine the current status of

dissolved oxygen, nitrogen, blue mussel assay, commercial landings, and clam pots (FTB, 2006). Knowing the current state of these indicators will allow FTB and their partners to track trends over time and identify changes in the indicators while observing changes in the climate.

In effort to further address climate change impacts and adaptation strategies, Dorsey (2009) identified resources that would be most useful to FTB in their efforts. Most importantly was funding for baseline data collection and monetary assistance in data analysis.

Friends of Casco Bay

Interview: Cathy Ramsdell, Executive Director, and Mary Cerullo, Associate Director. A phone interview was conducted on February 11, 2009.

In 2006, Friends of Casco Bay (FCB) played an integral role in getting the Bay designated as the first 'No Discharge Area' in Maine by the U.S. Environmental Protection Agency (EPA). With indication of increased cruise ship and private boat traffic, FCB worked with harbor masters, local citizens, and members of federal, state, and local governments to prevent boat sewage from being dumped in the Bay (Ramsdell and Cerullo, 2009). To qualify as a 'No Discharge Area,' there has to be adequate pumpout facilities for over 4,500 boaters to pumpout their holding tanks. Boat sewage has increasingly lead to degraded water quality, health problems for swimmers, and closed shellfish beds (US EPA, 2006). FCB plays a crucial role in the success of this program. Since

1995, they have had a boat that can pumpout holding tanks of recreational boats at their mooring or dock, keeping over 100,000 gallons of sewage out of the Bay. Now with the designation of a 'No Discharge Area,' they also assist boat owners with locating and operating shoreside facilities and will continue to protect the health of the Bay (FCB, 2008).

Organizational Structure

The Casco Bay watershed covers 41 towns and 958 square miles, providing habitat for over 850 species of marine life and 150 species of coastal birds. FCB established in 1989 by a group of concerned citizens and is a science-based organization focused on protecting and improving the health of Casco Bay. Over the last 20 years, they have grown to be one of the most active, well-respected organizations in the region. Over that time period, they have grown from one to eight full-time staff members and a 17 member board representing citizens and public and private interests throughout the watershed (FCB, 2008). Funds are acquired by membership donations and grants (Ramsdell and Cerullo, 2009). In an effort to preserve and protect the bay and its watershed, FCB has five areas of focus:

- Public education and outreach: One of FCB's major efforts is their Casco Bay Curriculum, which is designed for 4^{th}-6^{th} graders, incorporating locally focused environmental education and scientific data into their science curriculum. FCB also produces newsletters and an annual report,

and coordinates public events, such as the Casco Bay forum, and an Annual Meeting, to help educate the public (FCB, 2008).

- Water quality monitoring and stormwater management program: Since 1992, FCB has been monitoring the bay for salinity, dissolved oxygen, temperature, pH, water clarity, and nutrients. They have collected over 250,000 water quality measurements and it is considered one of the most comprehensive in the region. FCB also monitors stormwater and is developing a first-in-the-nation volunteer stormwater monitoring pilot project (FCB, 2008).
- Baykeeping program: FCB work to ensure existing environmental laws and policies are enforced throughout the bay, advocate for new protections, and respond to citizen concerns. This program is part of the international WATERKEEPER Alliance (FCB, 2008).
- Bayscaping program: FCB works in partnerships with the Maine Board of Pesticides Control to encourage homeowners, businesses, and municipalities to reduce their pesticide and fertilizer use (FCB, 2008).
- Pumpout program: In cooperation with Maine's Department of Environmental Protection, FCB provides shoreside facilities for private vessels to pumpout raw sewage. Since the program was launched in 1995 they have prevented more than 100,000 gallons of raw sewage from entering the Bay (FCB, 2008).

Collaboration

Since FCB's work is solely focused on "improving and protecting the environmental health of the Bay (FCB, 2008)," and does not go above the high tide mark, they find it essential to collaborate with other organizations to attain larger, regional management goals for the Bay (Ramsdell and Cerullo, 2009). One of the key actors in coordinating collaborative efforts is the Casco Bay Estuary Partnership (CBEP).[12] Through the CBEP, FCB is part of a Targeted Watershed Grant. This grant was provided to promote collaborative, community based efforts in the clean-up of the Presumpscot River, one of the major tributaries to Casco Bay. FCB works with the Presumpscot River Watershed Coalition, Cumberland County Soil and Water Conservation District, Presumpscot River Watch, the Maine Board of Pesticides Control, and the Maine Department of Environmental Protection in these efforts (US EPA, 2005).

In addition to numerous direct partnerships and collaboration, FCB relies heavily on other informal partnerships and networks to share data, volunteers, and resources. FCB is very concerned about the impacts of air quality on the marine environment, particularly nitrogen deposition though snow and rain fall (Ramsdell and Cerullo, 2009). They rely on The Natural Resources Council on Maine for data regarding air quality and pollution. NRCM has a well established monitoring and policy programs and can provide information to FCB. Additionally, FCB provides staff and volunteers to The Lobster Conservancy for juvenile lobster monitoring and provides space on their boat, often free of charge, during monthly

[12] Casco Bay is one of 28 estuaries in EPA's National Estuary Program. For more information: http://www.epa.gov/nep/

monitoring transects for researchers, volunteers, and interns. FCB is committed to sharing their expertise and resources: "[We] depend on a lot of other groups and have a lot of groups that are depending on us (Ramsdell and Cerullo, 2009)."

In addition to the partnerships described above, FCB also works closely with Waterkeeper Alliance, Southern Maine Community College, Department of Marine Education and the Gulf of Maine Ocean Observing System (Ramsdell and Cerullo, 2009).

Climate Change

FCB is very "excited and concerned (Ramsdell and Cerullo, 2009)" about climate change impacts on Casco Bay and surrounding communities, particularly regarding sea level rise, storms, changes in water chemistry (pH), increasing atmospheric deposition of nitrogen, and increased stormwater runoff (Ramsdell and Cerullo, 2009). Through their water quality monitoring work, FCB has been working to develop baselines for pH, salinity, nitrogen, dissolved oxygen, and water clarity. Overall, 17 years of data have not shown any strong trends to reflect climate change impacts. Ramsdell and Cerullo (2009) explained that nitrogen, as a greenhouse gas, has greater implications for marine environments than carbon. Their monitoring records show that the background level of nitrogen has gone up and small additions of fertilizer can trigger algal and jellyfish blooms. They see this as the biggest threat to the Bay and are continuing to monitor nitrogen and working to get nitrogen limits in place along the coast. FCB is also closely

monitoring pH levels and are on 'internal alert' as they are concerned that pH problems may quickly follow the nitrogen problem (Ramsdell and Cerullo, 2009).

With or without monitoring data that reflects climate change impacts, FCB has moved forward in working to raise awareness among communities. FCB developed a climate change module as part of their larger curriculum program on Casco Bay. They offer free workshops to teachers in the Casco Bay watershed, training them in 37 classroom activities for grades 4-6 (FCB, 2008). These activities expose students to FCB's monitoring data, teach them age appropriate facts about climate change, and, perhaps most importantly, provides reassurance that it is not all bad (Ramsdell and Cerullo, 2009). FCB's BayScaping program also provides another avenue through which to connect individual's actions to the health of the Bay and reducing climate change impacts. The BayScaping model focuses on natural ecological lawn care, encouraging reduced pesticide and fertilizer use, limiting lawn space, increasing native vegetation, and allowing appropriate buffers around waterways (Ramsdell and Cerullo, 2009; FCB, 2008). This indirectly addresses climate change as these factors will be important with increased potential for droughts, floods, and precipitation events.

Climate Change Adaptation

Ramsdell and Cerullo (2009) acknowledged the challenge of developing adaptation strategies in light of climate change impacts that occur on different temporal and spatial scales, as it is hard to find a balance between addressing long term, chronic impacts such as sea level rise, and providing appropriate protection

to communities in the face of acute, dramatic impacts, such as storm surges. One of FCB's major strengths as an organization is making science understandable and accessible for people in the community. Their focus has been to "train people to help do scientific research and to communicate what is valuable about that to the community, which builds better stewardship, decision making, collaboration, and a sense of ownership as a community and organization (Ramsdell and Cerullo, 2009)." This role will be important as climate change impacts become more apparent, as the focus on communities and local decision makers is essential. FCB also expects that the Casco Bay Estuary Partnership will play a critical role in identifying adaptive strategies and providing avenues for outreach throughout the watershed (Ramsdell and Cerullo, 2009).

Ramsdell and Cerullo (2009) also identified additional resources that would be most beneficial for moving forward an agenda of climate change adaptation within Casco Bay. It will be essential to get continued funding from the State for nitrogen monitoring as nitrogen pollution will affect multiple sectors of the community, including resource harvesting, tourism, and recreational uses. Resources for acidification monitoring and eelgrass and locally scaled scenarios for climate change impacts would also be important. Finally, it would be useful to have a place at the national level where the public can access the most up-to-date information on climate change science, projected impacts, and adaptation strategies.

Lamprey River Watershed Association

Interview: Dawn Genes, Executive Director. Phone interview was conducted February 6, 2009.

The Lamprey River is the largest tributary to Great Bay, New Hampshire, running 47 miles though 12 watershed towns before becoming tidal and emptying into the Bay (WRA, 2008). The Lamprey River Watershed Association (LRWA) has played a critical role in assessing the latest state of the river and watershed. Through a grant from the New Hampshire Department of Environmental Services, LWRA conducted a 'Stream Walk,' which aimed to locate and document potential threats to environmental health along the river. Volunteers took note of invasive species, culverts, stormwater outfalls, erosion, trash, and the general health of the river. Fourty-one volunteers assessed the river and found that

> "a large amount of stormwater runoff from parking lots, roads and buildings is entering the river without any type of filter or vegetative buffer to minimize the oils, road salt and trash that accompany it; Japanese knotweed, and invasive shrub, is being found mainly in disturbed areas like road crossings or areas of new construction, but is also being found in heavily wooded areas downstream of these sites; many of the culverts near roadways are being clogged with trash and woody debris from upstream. This can make even adequately sized culverts too small, leading to an increased risk of flooding; erosion is not occurring along large portions of the river, and most of the documented areas where likely caused by the major floods in recent years; and most of the Lamprey River has very good vegetated buffers to help filter pollution, slow down flood waters and make canoeing down the river more pleasant (LRWA, 2008)."

LRWA is currently developing additional projects based on the results of the Stream Walk, such as invasive species removal and stormwater runoff mapping (LRWA, 2008; Genes, 2009).

Organizational Structure

The Lamprey River Watershed Association (LRWA) was formed in 1980 to promote the restoration, conservation, and wise development and use of the watershed. With the designation of the Lamprey River as a Wild and Scenic River by the National Park Service, who provides funding to a local advisory committee, LRWA received funding ($25,000) in 2004 to initiate a part-time Executive Director who would seek grant funding from other sources to continue. A volunteer LRWA Board provides direction and leadership, making all decision by consensus with input from the Executive Director. The Board has members from almost all of the towns within the watershed, usually appointed from the local Conservation Commission.

LRWA's key goals are to conserve fish and wildlife, forests, soil, and water resources, as well as pollution abatement. In partnership with the NH Department of Environmental Services (NH DES), LRWA has been conducting water quality monitoring at 14 sites along the river in Newmarket, Durham, Lee, Epping, Nottingham, Raymond and Deerfield. Volunteers conduct the monitoring after receiving training in May. Generally the water quality of the river is healthy. However, during low flow months areas are vulnerable to low pH, bacteria, and low dissolved oxygen levels (LRWA, 2008a).

LRWA also serves as a clearing house for information and activities and a link for the 24 conservation organizations in the watershed (LRWA, 2008a).

Collaboration

Collaboration is essential in LRWA's program and education and outreach efforts, particularly in acquiring grants. Genes (2009) explained that "it makes grant proposals more successful, to show that you are working with others. The worst thing you can do is to appear you are operating independently… We don't have the capacity not to work with others." LRWA collaborates with NH DES in their water quality monitoring program. NH DES provides two staff members to manage the program statewide, helping to develop the program, provide water quality kits to volunteers, and producing initial reports. LRWA is currently building a partnership with Bear Paw Regional Greenway to share their 'Stream Walk' data and hopefully have Bear Paw Regional Greenway involved in raising awareness about wildlife corridors in riparian zones that were recently surveyed.

LRWA has also been involved in a collaborative effort to disseminate critical information to local decision makers and citizens. The University of New Hampshire (UNH) has used the Lamprey River and its watershed as a study area and model and recently gathered research scientists to share the research and studies. It was very well attended, but Genes (2009) recognized that the information is not getting to the Planning Boards and Conservation Commissions in an understandable and useable format. With this in mind, LRWA will host a

technology transfer conference in June 2009 to share this research with local government officials (LRWA, 2008a).

In addition to the partnerships mentioned above, LRWA also works with the 12 watershed town's Conservation Commissions, the Wild and Scenic River Advisory Committee (LRAC), the Piscataqua Region Estuaries Partnership, Strafford Regional Planning Commission, and Save our Groundwater.

Climate Change

The Lamprey River watershed experienced 100 year floods in 2006 and 2007, bringing flooding to the forefront of many people's minds. Citizens in Raymond are concerned because subdivisions have been proposed in flood plains they recently witnessed underwater and the Conservation Commission in Epping has requested assistance in flood plain management, since they have a lot of development near the river. The Lamprey River also experienced droughts in 2000 and 2001, suggesting changes in precipitation patterns. Stormwater runoff is also a concern with the recent floods and heavy precipitation. LWRA is working to use the 'Stream Walk' data to determine where there are stormwater outfalls and what land uses contribute to the runoff upstream from the culvert (Genes, 2009).

Climate Change Adaptation

Although, LRWA does not have programs directly related to climate change impacts and adaptation, it is considered in many of their efforts and

underlies their programs (Genes, 2009). From Genes' (2009) perspective, it is essential to bring climate change issues down to the personal level. For example, through LRWA's focus on stormwater, they work to help individual citizens make the connection between limiting impervious surfaces and controlling runoff on their own property and the more general health of the river.

Genes (2009) identified additional resources that would be helpful in addressing climate change in the Lamprey River watershed. These include developing information for multiple audiences, case studies of other communities of similar size, and technical assistance in comprehensive planning.

Salem Sound Coastwatch

Interview: Barbara Warren, Executive Director. Phone Interview conducted on February 12, 2009.

The Salem Sound watershed, located on the North Shore of Massachusetts, covers the six towns of Manchester, Beverly, Danvers, Peabody, Salem, and Marblehead. Salem Sound Coastwatch (SSCW) plays a critical role in maintaining the health of the Sound. Through partnering with local municipalities, scientific monitoring, education, and stewardship, SSCW works toward this goal. Recently, SSCW played a key role in making plans come to fruition at the Peabody Street Park. The City of Salem Harbor Plan included plans to have a park in this location, but no one had moved forward on it. In partnership with Tufts University's Urban and Environmental Policy and Planning program,

SSCW took a pro-active role to coordinate public meetings and get community input on the design and use of the park. Community supported plans were presented to the local government and were very positively received. Having the strong community support and vision motivated the city to apply for the Urban Self Help (P.A.R.C.) grant. They were successful in obtaining the grant and park construction is underway. SSCW is an important member of the community and played a critical role in raising awareness, educating the community, and getting their input and involvement (Warren, 2009).

Organizational Structure

SSCW was established in 1990 as an informal working group of citizens, local officials, and businesses concerned with the degradation of the local waters, Salem Sound. SSCW was originally started to identify water pollution and in 1993 brought together over 100 volunteers to survey the 47-mile shoreline of Salem Sound to identify outfall pipes and streams that could be pollution sources. This led to one of its flagship programsthe 'Clean Beaches and Streams' program, which trains volunteers to conduct water quality monitoring at prioritized shoreline sites. Over their 19 years of existence, they have substantially grown and are a well recognized organization throughout the watershed. SSCW has two full-time staff members, an Executive Director and an Outreach Coordinator, and a seven member Board. Decisions are ultimately made by the Board, with input from the Executive Director (SSCW, 2009; Warren, 2009). However, availability of funding and commitments to certain programming also drives the direction of

SSCW. For example, they continue their 'Clean Beaches and Streams' program even though it is difficult to secure funding for it. Also, in the late 1990s they took on salt marsh monitoring by request and it has grown into an important program over the last 12 years (Warren, 2009).

SSCW receives about 20% of its funding from membership and donations and the rest from grants. They rely most heavily on state and federal grant programs. One of their most significant grants is that from the Massachusetts Bays National Estuary Program (MBP). Since 1996 SSCW has been a regional coordinator for MBP, which requires re-application every 3 years and provides substantial grants to carry out programming. SSCW's reliance on state and federal grants for funding can be challenging however, as it leaves them vulnerable to restricted funding. For example, it is currently difficult to secure funding for the 'Clean Beaches and Streams' program, as there is not a lot of grant money at the state level available for monitoring programs. MA Department of Environmental Protection uses the data from this program, so it is a challenge to get other funders to see the value in paying for the monitoring program. It leaves SSCW's activities vulnerable to 'hot topic' driven grants (Warren, 2009).

Collaboration

SSCW works closely with a number of other organizations in carrying out its mission. As mentioned above, SSCW is a regional coordinator for MBP. MBP was recently selected for an EPA 'Climate Ready Estuaries' pilot project, which will consist of conducting an extensive vulnerability assessment of the entire

Massachusetts Bay coast. This partnership has increased SSCW's access to technical resources and allowed them to more easily partner with other area organizations, as MBP plays a critical role in coordination and facilitation of efforts (Warren, 2009).

Other important partnerships include Mass Audubon, MA Division of Marine Fisheries , Massachusetts Area Planning Commission, MA Coastal Zone Management, watershed town governments, Tufts University, and MA Department of the Environment (Warren, 2009).

Climate Change

Salem Sound watershed is vulnerable to a number of climate change impacts. Warren (2009) explained that sea level rise is a major threat as there are a number of low lying areas, many of which are highly developed. SSCW is also concerned with flooding, increased storm surges, and erosion. The Salem Sound watershed has experienced two devastating floods during the springs of 2006 and 2007. These led to erosion and flooding, impacting homes and infrastructure. This watershed is particularly vulnerable as there is a long history (over 300 years) of building on filled lands along the coast and in floodplains.(Warren, 2009).

Droughts are also of concern, as there are also some rural, wooded areas within the watershed. Since it is rural, there is not an extensive fire hydrant system. With a potential for increased wildfires, there is concern the towns will not have the water resources to put out the fires. SSCW is also concerned about the ability of salt marshes to migrate inland as sea levels rise. The Beverly/Manchester shore has the second largest eelgrass bed in Massachusetts.

They are dependent on shallow, clear water in near shore areas. It will be important to determine if these habitats have space to migrate as sea level rises and other conditions change (Warren, 2009).

SSCW recently partnered with Tufts University, Urban and Environmental Policy and Planning program to conduct a climate change risk assessment and vulnerability analysis of the communities in the watershed. Recommendations for climate change adaptation strategies were developed and presented to the communities (Hamann et al., 2008).

Climate Change Adaptation

SSCW acknowledges the importance addressing climate change and it has become a priority in recent years. Through the recent partnership with Tufts University and the ongoing support from the MBP, SSCW is developing a better understanding of climate change impacts and vulnerability. Additionally, through their monitoring efforts, SSCW has developed baseline information for invasive species, general water quality parameters, wetland and salt marsh health (SSCW, 2009; Warren, 2009).

Warren (2009) acknowledges that SSCW is just beginning to address the adaptation side of climate change and that it appears to be a daunting task. They are "trying to figure out what we can do and what knowledge we need to have (Warren, 2009)." They are currently working on a salt marsh restoration project at Endicott College in Beverly. There is a three-acre area of salt marsh and a stream adjacent to two acres of tennis courts that were originally wetlands. SSCW is

working to restore the salt marsh habitat by removing the tennis courts, to increase the ability for the salt marsh to migrate as sea level rises (Warren, 2009).

Among other groups in the watershed, there is a lot of activity around climate change adaptation, "everyone is at the same point of realizing how big the problem is (Warren, 2009)." MBP is playing a key role organizing and coordinating multiple organizations efforts. Particularly with MBP's new focus on 'Climate Ready Estuaries,' they are a great resource and collaborative partner for SSCW. Warren (2009) feels that it is essential to hear from communities regarding what they think their needs are and how other organizations can be most helpful in addressing climate change impacts. Additionally, there are a number of resources that would be important in moving forward on adaptation. These include LIDAR remote sensing technology to be able to make better local predications of sea level rise, more accurate flood maps, and an inventory of coastal infrastructure to identify location, current conditions, and level of risk to climate change impacts (Warren, 2009).

Friends of Sengekontacket

Interview: Terry Appenzeller, Vice-President and Treasurer. Phone interview conducted on February 13, 2009.

Sengekontacket Pond is located in Edgartown and Oak Bluffs on Martha's Vineyard, Massachusetts. The Pond is 745 acres and about 2.5 miles long, on the landward side of the Joseph Sylvia State/Edgartown barrier beach. Friends of

Sengekontacket (FOS) was established in 1988 when the shellfish flats in the pond were closed due to high bacteria counts. Since then, they have played an important role in monitoring the health of the pond and raising awareness within the community (FOS, 2008). Through their strategic planning process, it was recognized that much of what needed to be done had to be coordinated between Oak Bluffs and Edgartown. FOS asked the two towns to form a Joint Committee on Sengekontacket, which has been "pretty proactive and pretty effective (Appenzeller, 2009)" in addressing some of the essential issues of the pond. The Joint Committee worked to raise awareness across the island to inform residents and visitors about the risks the pond faces. They have installed "dog poop" stations, which was an essential step in controlling bacteria levels in the pond, raised funds, applied for dredging permits, conducted physical land surveys, and planned summer water quality testing. The establishment of the committee has been one of FOS public policy achievements and they believe that the collaboration and coordination of efforts in both towns is essential to protecting the pond (Appenzeller, 2009).

Organizational Structure

Friends of Sengekontacket's (FOS) is a non-membership, volunteer organization with a 13-15 member Board. Decisions are made by the Board while following an agenda and discussion. FOS focuses on the health of Sengekontacket Pond through water quality monitoring and natural habitat preservation. In the last 3-5 years, FOS has found increasing levels of nitrogen in the pond, which is

negatively affecting the eelgrass beds, and in turn, the shellfish beds. Additionally, bacteria levels have been elevated in the past two years. Funding for monitoring, habitat conservation, and education and outreach efforts is obtained through individual donations (approximately 80%-90%). They also receive small grants from local foundations, including the Eady Foundation and the Farm Next Foundation. FOS also received a challenge grant from an anonymous donor targeted for monitoring and evaluating the bacteria problems. The grant was matched by a local neighborhood organization (Appenzeller, 2009).

Collaboration

As mentioned above, FOS works closely with the Joint Committee for Sengekontacket and the municipal governments of Oak Bluffs and Edgartown. An Advisory Committee has also been established, which includes Shellfish Constables from the two towns, a water resources planner from the Martha's Vineyard Commission, and harbor managers. FOS is also on committees for activities involving the pond and stay plugged into to other's activities (Appenzeller, 2009). Appenzeller (2009) explained that collaboration "is critical, because… we have the authority to do very little. We can raise issues, communicate and educate, some amount of independent research, but the actual authority to make changes is pretty much in the hands of the two towns, the state or the county. I think it is critical we serve the role we do, which is awareness and raising issues and then helping to move to implementation."

The Martha's Vineyard Commission (MVC) is also an important partner for FOS, as they play an essential role in island wide planning, particularly around development, transportation and human impacts on the environment. FOS hasn't played a specific role in MVC's planning, but Appenzeller is on the Board and feels well heard. The bridge and roadway between the barrier beach and the pond will be repaired. They are considering what has to be done to protect the beach and the pond while it is under construction and determining an appropriate physical structure, as not to disable dunes and cause more damage to the pond. Development around the pond is also a critical issues that MVC is working to address (Appenzeller, 2009).

Climate Change

FOS is particularly concerned about sea level rise and increased intensity of storms. Located behind a barrier beach, Sengekontacket Pond is very vulnerable to these impacts. FOS has focused on water quality monitoring and working to build a baseline of data that can track changes over time (Appenzeller, 2009).

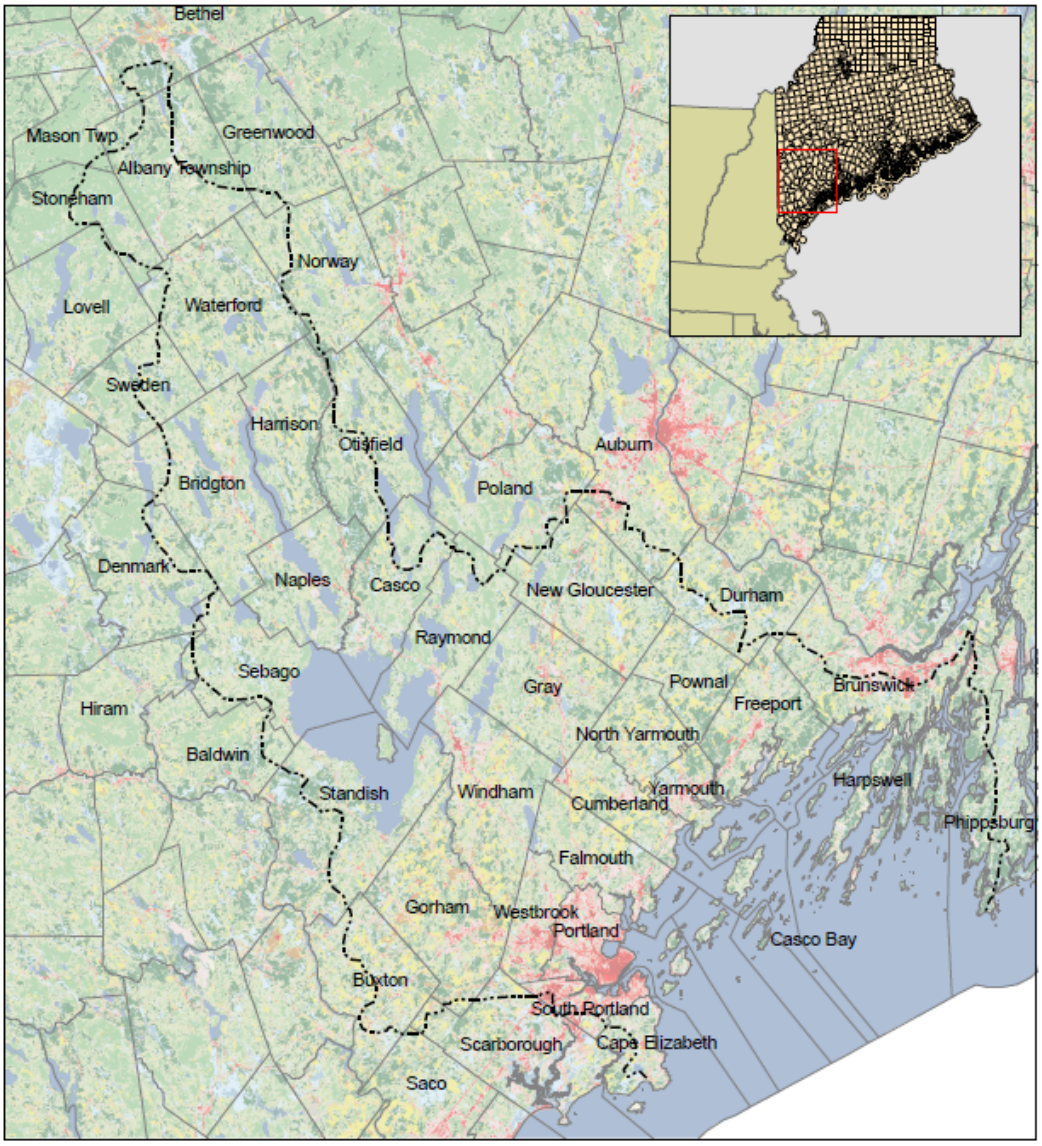
Climate Change Adaptation

Two years ago, FOS undertook a strategic planning session, which focused on resiliency of the pond. Appenzeller (2009) felt that this was important, as it focused on the recovery of the pond under different conditions and took an

adaptive management approach to setting goals and priorities. FOS has not moved forward specifically on their strategic plan goals, as they have been very focused on addressing the bacteria problem over the past two years. Another avenue through which climate change adaptation has been indirectly addressed is in the Sylvia beach management plan, on which FOS partnered with Dukes County. The plan addresses hazard mitigation for the beach and pond, but has yet to be implemented due to restricted funding (Appenzeller, 2009).

Appenzeller (2009) identified a number of additional resources that would benefit FOS in addressing climate change impacts through adaptation strategies. These included additional funding for the implementation of the Beach Management Plan, detailed sea level rise maps showing different scenarios and probabilities, and localized predictive data for rainfall, temperature, invasive, and habitat change.

Appendix IV: Maps of Case Study Areas



Casco Bay, ME

0 3 6 12 Miles

Data Source: Maine GIS 2006;
USGS National Land Cover Data 2001
Projection: GCS North American 1983

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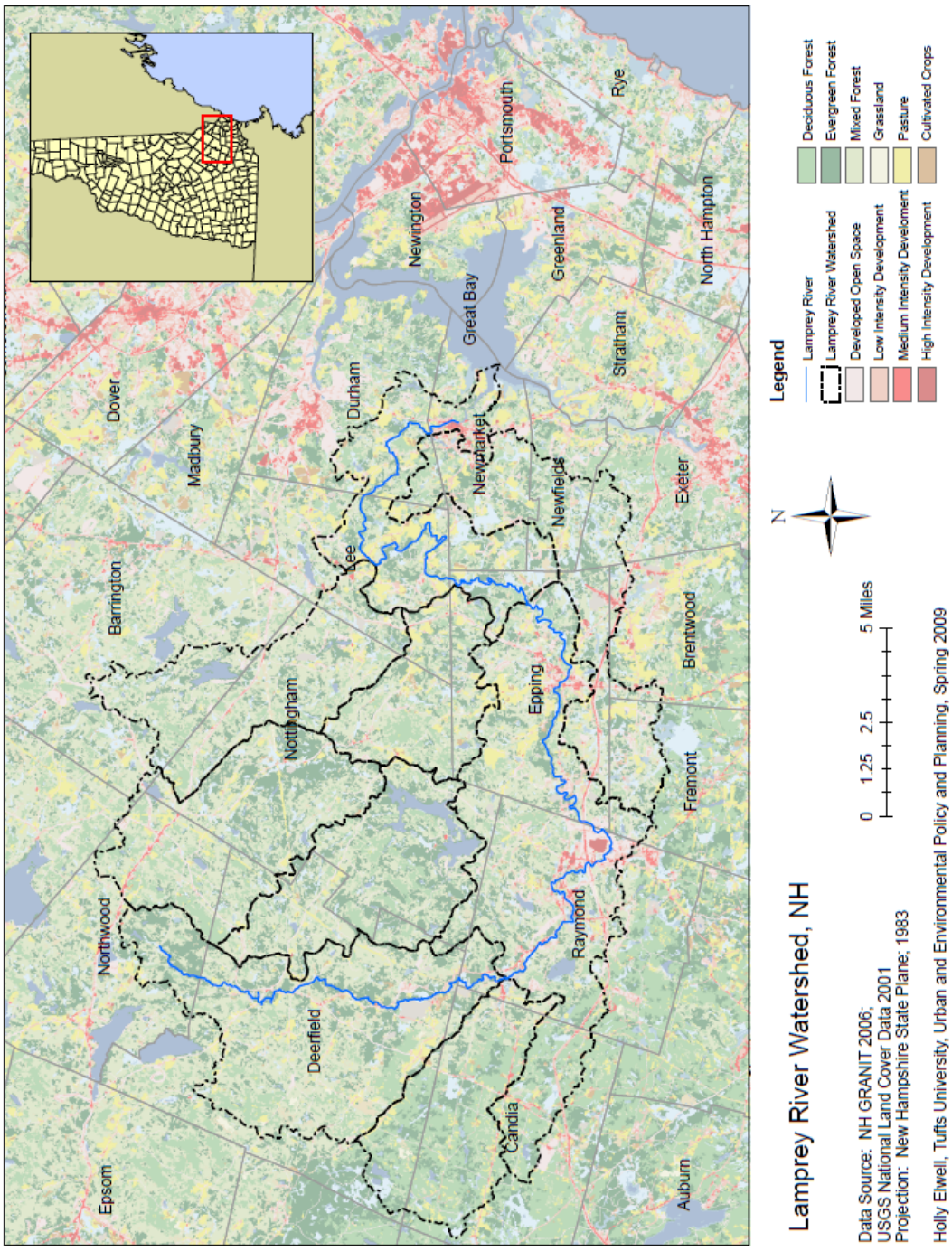
Legend

- CascoBayWatershed
- Developed Open Space
- Low Intensity Development
- Medium Intensity Develoment
- High Intensity Development
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Grassland
- Pasture
- Cultivated Crops


Lamprey River Watershed, NH
Legend
Lamprey River
Lamprey River Watershed
Developed Open Space
Low Intensity Development
Medium Intensity Development
High Intensity Development
Deciduous Forest
Evergreen Forest
Mixed Forest
Grassland
Pasture
Cultivated Crops
N
0 1.25 2.5 5 Miles
Data Source: NH GRANIT 2006;
USGS National Land Cover Data 2001
Projection: New Hampshire State Plane; 1983
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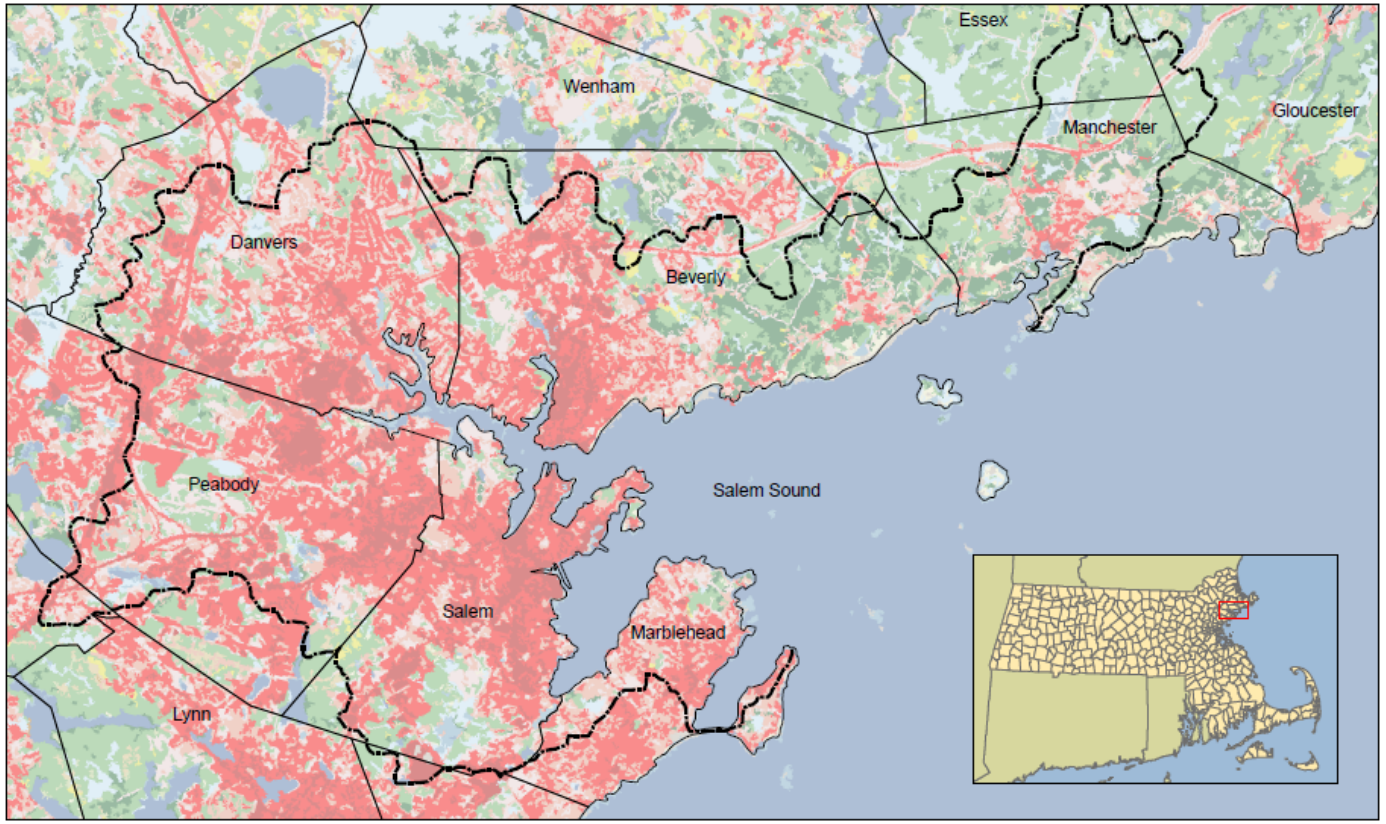
Epsom
Northwood
Deerfield
Candia
Auburn
Raymond
Epping
Nottingham
Barrington
Dover
Madbury
Durham
Lee
Newmarket
Newfields
Exeter
Fremont
Brentwood
Stratham
Greenland
Newington
Great Bay
Portsmouth
North Hampton
Rye



Salem Sound Watershed, MA

N

0 0.5 1 2 Miles

Data Source: MassGIS2009;
USGS: National Land Cover Data
Projection: Massachusetts State Plane, 1983

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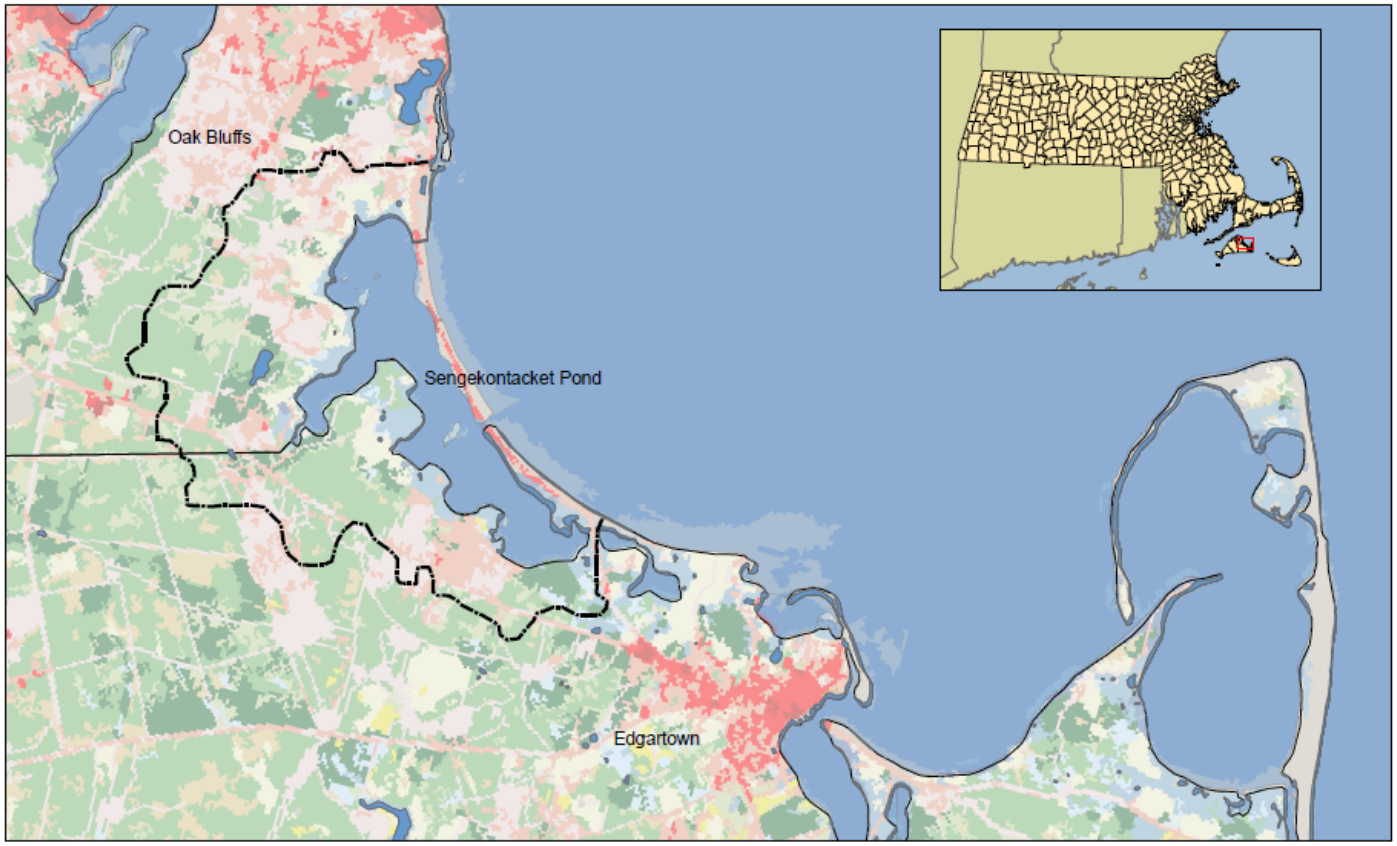
Legend

- Salem Sound Watershed
- Developed Open Space
- Low Intensity Development
- Medium Intensity Develoment
- High Intensity Development
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Grassland
- Pasture
- Cultivated Crops



Sengekontacket Pond, Martha's Vineyard, MA

Data Source: Mass GIS 2009;
USGS National Land Cover Data 2001
Projection: Massachusetts State Plane, 1983

0 0.5 1 2 Miles

N

Legend

- Sengekontacket Pond Watershed
- Developed Open Space
- Low Intensity Development
- Medium Intensity Develoment
- High Intensity Development
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Grassland
- Pasture
- Cultivated Crops

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