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Addressing sea level rise in the People's Republic of China and the United States: a comparative review of administrative and policy frameworks

Mo Chen
Louisiana State University and Agricultural and Mechanical College

ADDRESSING SEA LEVEL RISE IN THE PEOPLE'S REPUBLIC OF CHINA AND THE UNITED STATES: A COMPARATIVE REVIEW OF ADMINISTRATIVE AND POLICY FRAMEWORKS

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ABSTRACT

Sea level rise (SLR) is directly influenced by climate change through the processes of temperature affecting the growth and decay of continental ice (Barron and Thompson 1990). It is a significant environmental challenge that threatens coastal areas of many nations throughout the world. The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report issued in 2007 states that SLR poses a serious challenge to sustainable development along many coastal areas. The objectives of this thesis are to examine the SLR management issue both in the P.R.C. and the U.S, identify the government agencies that are concerned with SLR issues in the two countries and the specific programs that have been conducted by these agencies, analyze the key obstacles to managing risks associated with SLR, and recommend actions to address some of these challenges. The research methods include reviewing the monitoring efforts, laws, and administrative systems dealing with SLR in the U.S. and the P.R.C., surveying a panel of experts consisting of government agency administrators and researchers in the two countries, and performing vulnerability analysis through case studies of two significant coastal areas in the U.S. and the P.R.C. The research findings indicate that the SLR monitoring efforts of the two countries are very similar, both in terms of technology used and the density of monitoring stations along the coastlines. However, different stages of policy development related to SLR were evident, with the U.S. having established a more integrated federal and state-level policy framework for incorporating SLR issues into coastal planning through the Coastal Zone Management Act of 1972. Currently, risk assessments and some planning activities similar to those conducted in the U.S. are being implemented or are under development by policy makers in the P.R.C.. The main obstacles reported by the experts in both countries to systematically incorporating SLR risks into coastal zone planning were limited budgets, public apathy and the

presence of other pressing coastal management issues. Public education efforts designed to convey the potential risk of SLR to stakeholders of specific coastal communities, including possible socioeconomic and environmental consequences, would appear to be a logical strategy to address key reported obstacles to integration of SLR risks into long-term coastal planning.

CHAPTER 1 INTRODUCTION

Sea level rise (SLR) is directly influenced by climate change through the processes of temperature affecting the growth and decay of continental ice (Barron and Thompson 1990). It is one of the greatest environmental challenges and threatens coastal areas of many nations throughout the world. The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report issued in 2007 states that SLR poses a serious challenge to sustainable development of many coastal areas.

Coastal areas have enormous economic and aesthetic value for human activities. In a very real sense, we have built our cultures and our economies on our shores. It has been estimated that 23% of the world's population lives both within 100 km distance of the coast and less than 100 m above sea level and that population densities in coastal regions are about three times higher than the global average (Small and Nicholls, 2003). As a result, many of the coastal communities threatened by rising sea levels are large population centers. The IPCC Fourth Assessment Report indicated that the average rate of SLR for the 20^{th} century as 1.7 ± 0.5 mm per year (Bindoff et al., 2007). Additionally, under four different scenarios the estimate of the average rate of SLR is between 0.18 to 0.59 m in the 21^{st} century which means that future rates of rise would be more rapid than the last century (Meehl et al., 2007).

1.1 Causes and Impacts of SLR

The major force associated with SLR is climate change. Increasing temperatures affect sea level by leading to greater water mass in the oceans from ice melting on land, and an increase in ocean volume as a result of thermal expansion of the ocean water (Meier and Wahr, 2002) The main climate drivers for coastal systems are inter-related and their main physical and ecosystem effects are summarized in the following table released by IPCC, 2007:

Table 1 Main climate drivers for coastal systems, their trends due to climate change, and their main physical and ecosystem effects (Trend: "↑" increase; "?" uncertain; "R" regional variability). (IPCC, 2007)

Climate driver (trends)	Main physical and ecosystem effects on coastal systems
CO_2 concentration (↑)	Increased CO_2 fertilization; decreased seawater pH (or 'ocean acidification') negatively impacting coral reefs and other pH sensitive organisms.
Sea surface temperature (↑, R)	Increased stratification/changed circulation; reduced incidence of sea ice at higher latitudes; increased coral bleaching and mortality; pole ward species migration; increased algal blooms.
Sea level (↑, R)	Inundation, flood and storm damage; erosion; saltwater intrusion; rising water tables/impeded drainage; wetland loss (and change)
Storm intensity (↑, R)	Increased extreme water levels and wave heights; increased episodic erosion, storm damage, risk of flooding and defence failure
Storm frequency (?, R) Storm track (?, R)	Altered surges and storm waves and hence risk of storm damage and flooding
Wave climate (?, R)	Altered wave conditions, including swell; altered patterns of erosion and accretion; re-orientation of beach plan form.
Run-off (R)	Altered flood risk in coastal lowlands; altered water quality/salinity; altered fluvial sediment supply; altered circulation and nutrient supply.

Table 1 lists the significant impacts to coastal eco-systems due to increases of variability of sea level. SLR might be an underestimated natural threat because of the slow process of its incremental increase; however, the accumulated impacts of SLR are large and are expected to influence various factors in the coastal ecosystem. SLR can be expected to affect water temperature; raise river levels, increase red tides and storm tides, reduce the protection provided by levees and other flood control structures, and cause other damaging consequences including the following:

- About 25,200 to 43,000 residential buildings would be at risk of inundation as a result of SLR of 1.1 meters by 2100 in South Australia (DCC 2009);
- SLR would impact salt marshes, mangroves and coastal wetland ecosystems since they are generally within a few feet of sea level (IPCC 2007).

- SLR increases the vulnerability of coastal areas to flooding during storms seasons. A given storm surge from a hurricane would lead to more damages as a result of a higher level of water. A Report to Congress by FEMA (1991) estimated that a 1-foot rise in sea level would increase by 36-58 percent the annual damages to the U.S. coastal zone. Further, the damages would be doubled or tripled for a 3-foot rise (FEMA 1991); and
- The EPA stated that the water quality of New York City, Philadelphia, and other large coastal cities may be affected by salinity increases of both surface water and ground water due to associated salt water intrusions. Salt water intrusions are consequences because rising sea levels would push salty water upstream during dry periods of the year. Salinity increases in estuaries also can harm aquatic plants and animals that do not tolerate high salinity (EPA n.d.).

Monitoring SLR as accurately as possible is a key component in adaptive planning and policy development to further long-term safety and sustainable development in coastal communities. Currently, there are several technologies related to sea level change monitoring, including satellite, tide gauge, biological, and numerical modeling. Additional challenges lie in how to design land-use plans for sea-level rise and coordinate the activities of different levels of government and national agencies in this process. An examination of the key government agencies and laws addressing SLR in the U.S. and the P.R.C. sheds light on how these two large nations with long coastlines approach the issue and yields insight into administrative and policy options that may be relevant to other countries facing similar risks.

To reduce potential losses, coastal zone managers need to contemplate what are the most efficient and effective programs and policies to mitigate the impacts of SLR. Options may include activities to discourage future development in flood-prone areas, requiring more stringent

building codes, constructing larger flood control structures, and making sure that all community stakeholders understand the long-term risks associated with SLR through public education programs.

1.2 Background

SLR does not pose an equal threat to all countries with coastlines. According to the observing data, we can see that in some regions sea level is actually decreasing (Figure 1), so the issue of sea level may not be a major concern to stakeholders in all coastal areas. However, coastal areas of the United States (U.S), one of the most influential developed country, and the People's Republic of China (P.R.C), the largest developing country, both are vulnerable. So this thesis will examine the efforts of the U.S. and the P.R.C. as two case studies to review the sea level monitoring systems and policy frameworks designed to support planning for the long-term safety and sustainability of coastal communities.

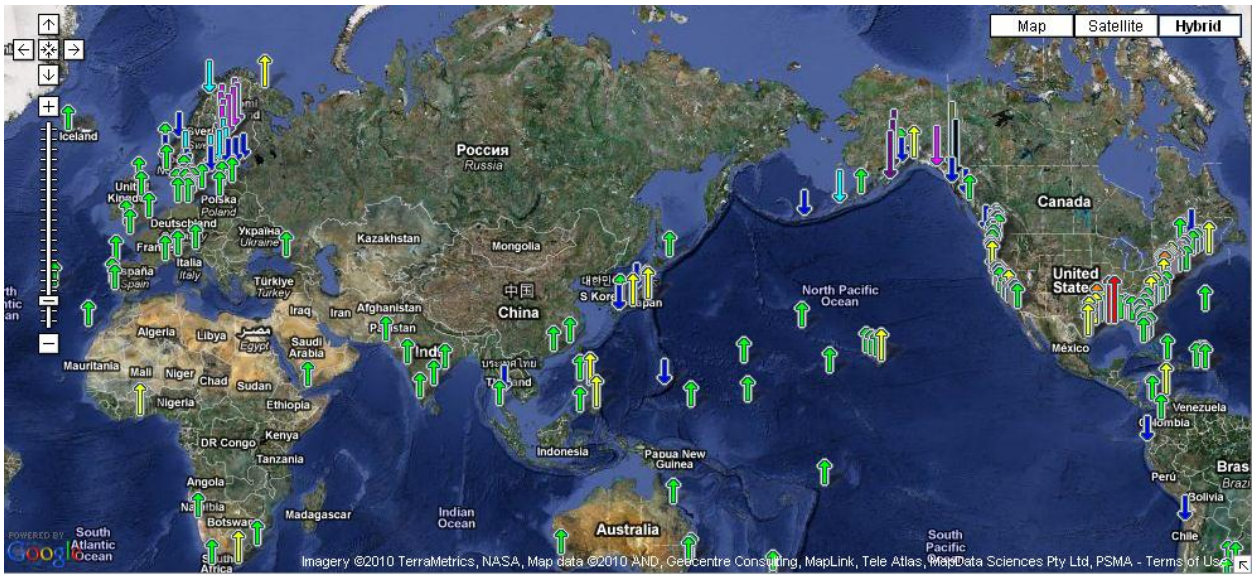

Figure 1 Global sea level trend from Sea Level Online of NOAA, http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml; last viewed 12/12/2010

SLR monitoring efforts in both the U.S. and the P.R.C. sea level are based on the tide gauge observing system. The U.S. has been measuring sea level for over 150 years by many methods. The National Oceanic and Atmospheric Administration (NOAA) of the United States Department of Commerce operates an almost completed monitoring system including tide gauge and satellite altimetry, two major methods for monitoring sea level change. NOAA maintains 200 stations throughout the United States and about 18 of them are used for calculating mean sea level changes on the California coast (CZMA 1972).

In recent years, NOAA has worked with the National Aeronautics and Space Administration (NASA) to monitor sea level change by satellite. The Goddard Institute for Space Studies (GISS) of NASA uses historical geological records and the TOPEX/POSEIDON satellite to analyze the sea level trends (Gornitz 2007).

In addition, some researchers and universities are using various biological process methods to research the relationship between biological communities and SLR. In 2003, the Coastal Elevations and Sea Level Rise Advisory Committee (CESLAC) was established to develop a ten-year strategic plan as a part of the U.S. Climate Change Science Program (CCSP). (Fitzgerald 2008)

The P.R.C. established the first tide gauge station in the 1950's and has at least 60 years of data with which to measure sea level. The State Oceanic Administration (SOA) of the P.R.C. uses at least 20 years of data from tidal stations to calculate and analyze sea level trends. However, despite the interest in collecting monthly sea level measures, the State Council of the P.R.C. began to focus keen attention on climate change issues only in the last decade. The SOA released the first report of sea level change to the public in 2001 and began to release annual reports in 2006.

Program activities and policies related to SLR over the last 5 years include establishing the National Leading Committee on Climate Change (NLCCC), publishing "China's National Climate Change Programme" and establishing four levels within the SLR monitoring and assessment administration system. The Government of the P.R.C. appears to be working toward establishing a more integrated administration system to enhance the efficiency of monitoring and measurement.

1.3 Research Objectives

Given the technical complexities involved in assessing and planning for potential risks associated with SLR, it is useful to examine current administrative frameworks and policy approaches adopted by the U.S. and the P.R.C. for monitoring sea levels, estimating the risks, and encouraging overall sustainable develop in coastal zones.

Therefore, the objectives of this thesis are to:

- Identify the government agencies that are concerned with SLR issues in the P.R.C. and the U.S, and to examine the specific programs or activities that have been conducted by these agencies;
- Survey a panel of experts consisting of government agency administrators and researchers in the P.R.C. and the U.S. to help identify key obstacles to managing risks associated with SLR, and;
- Recommend some possible solutions to address key obstacles and develop more effective policies (or government efforts) to address the SLR issue in the two countries.

This first chapter of the thesis has described the problems of SLR, the primary impact of SLR in the world, the U.S. and the P.R.C.. Chapter 2 describes the current observing or

monitoring systems and related policies regarding SLR in the P.R.C. and the U.S., and compares the monitoring and policy administration systems at the national level in the U.S. and the P.R.C.. Chapter 2 also includes two brief case studies of two significant areas, one from the U.S. and the other from the P.R.C. that are particularly vulnerable to SLR.

In Chapter 3, we describe a SLR survey completed by experts and officials in the P.R.C. and the U.S. to gain insight into the challenges facing planners and policy makers. Chapter 4 presents the results of the panel-of-experts survey and focuses on the obstacles and challenges for different agencies attempting to integrate SLR into their coastal planning programs and activities. The final chapter presents a summary of the comparisons between P.R.C and the U.S. monitoring and planning programs, along with several general recommendations for better integration of sea-level considerations into future coastal zone management efforts.

CHAPTER 2 OVERVIEW OF THE COASTAL AREAS IN TWO NATIONS

Chapter 2 provides an overview of coastal policies and laws in both the U.S. and the P.R.C. This chapter begins with a brief introduction of geographic and demographic attributes of the coastal areas and the important economic roles these areas have played. Following will be a detailed description of the two nations' coastal administration and monitoring systems and relevant national coastal policies and laws.

2.1. Brief Introduction of the Coastal Areas

2.1.1. China Coastal Areas

China's coastline is approximately18,400 kilometer long (Le 1993). It stretches along 9 provinces, 2 municipalities and 2 districts and covers the area of 1,286,160 square kilometers. According to the census data from provinces and cities' census bureau, the population of China's coast areas has reached to at least 535,680,000 by the end of 2009, which accounts for about 40% of the country's population. And the coastal economy contributes to 40% of the nation's GDP in 2009.

2.1.2. U.S. Coastal Areas

The United States coastline is approximately 19,924 kilometers long (CIA 2010) that stretches along 23 coastal states. It covers an area of 4,693,721 square kilometers and the U.S. Census Bureau estimated that the population in the coastal states had reached 180,093,062 (CB 2009) by the end of 2009.

Table 2 Geological information for the P.R.C. and the U.S. coastal areas

Country	Length of coastline	Costal Administrative Divisions	Area	Population (By 2009)
U. S.	19,924 km	23 states	4,693,721 km ²	180,093,062
P.R. C.	18,400 km	9 provinces, 2 municipalities and 2 districts	1,286,160 km ²	535,680,000

Industries are developed based on the resources and competitive advantages of certain areas. Because of the convenient transportation and agreeable climates, many coastal areas were occupied by human beings at the very beginning of human history and became centers of commerce and cultural development. Accordingly, often people are well-educated in the coastal areas and the human capitals are utilized to develop the financial and high-tech industries, which are the drivers for social and economic development.

Examples of this type of social and economic development include the Pearl River Delta area, located on the southern coast of the P.R.C. Here diverse industries including banking and finance, conventions and tourism, information technology, and other hi-tech businesses are highly developed and growing. Another example is the Yangtze River Delta. Because of the abundant natural resources located on the east coast of China, this area is focusing on the development of petroleum and chemical manufacturing, steel production, automobile manufacturing, communication equipment production, and bio-medical research and related technological support industries (CSHRI 2006).

2.2. Administration System Relevant to SLR

The top level of the administration of China's monitoring system for SLR is the State Council of the P.R.C. The Ministry of Land and Resources of the P.R.C. (MLR) is responsible for the planning, administration, protection and rational utilization of natural resources such as land, mineral and marine resources in P.R.C. (MLR 2007) The State Oceanic Administration (SOA) is an administrative agency under the MLR for the supervision and management of all sea area issues (GOV 2009), and all the monitoring centers and stations are maintained by SOA. There are three regional branches under the supervision of the SOA and they are responsible for

different coastal regions. All the monitoring centers and stations along the coastal areas are maintained by these regional branches. This administrative structure is summarized below in Figure 2.

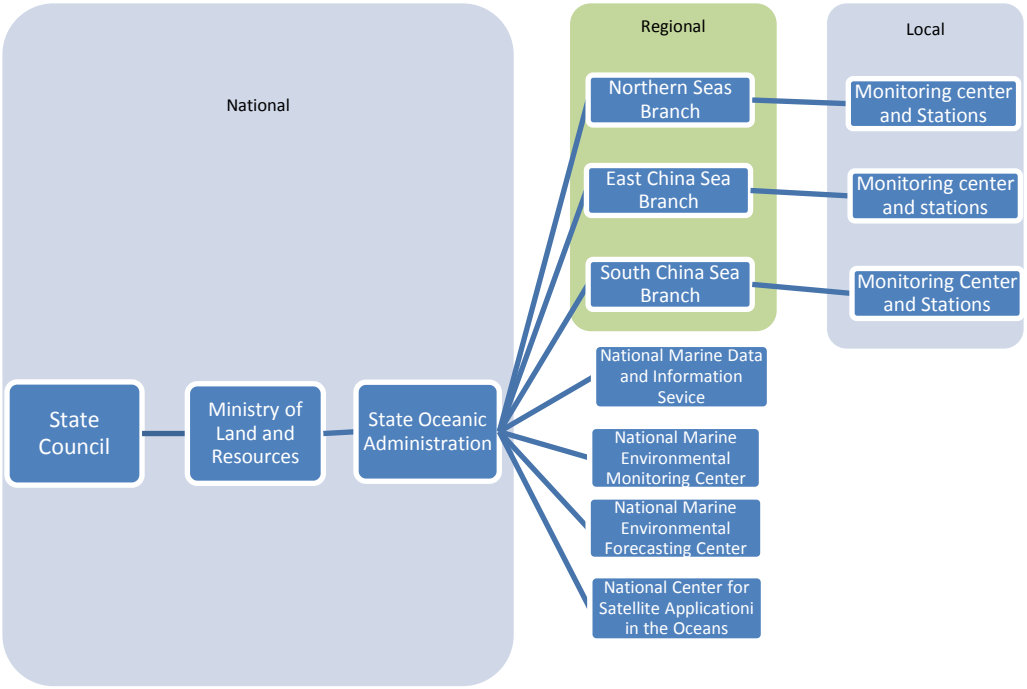

Figure 2 China's administration system relevant to SLR

Similar to the P.R.C.'s administration system, in the U.S. the National Oceanic and Atmospheric Administration (NOAA) administers all sections including the Center for Operational Oceanographic Products and Services (COOPS). The COOPS operates observing stations, Satellite and Information Services, National Weather Service Marine Forecasts and office of Coastal Zone Management. The U.S. administrative system is summarized below in Figure 3.

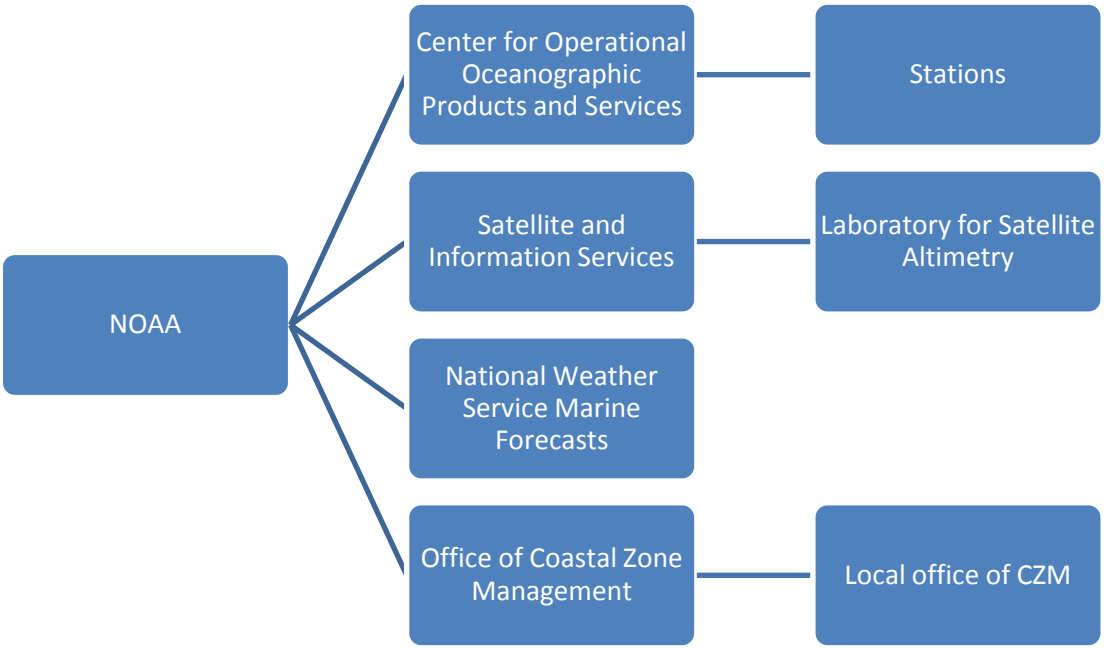

Figure 3 United States' administration system relevant to SLR

2.3. Sea Level Observation

2.3.1. China's Observation

China's tide gauge observing stations were initially installed in the 1950's when the technology was absorbed from the former Soviet Union. However, the current technologies applied to monitor China's sea level are following the methods adopted by the U.S.

Figure 4 and Figure 5 present the public tide gauge stations in the southern coast area and the East China Sea area. One of the issues concerning the monitoring system in China is the confidentiality of data and tide gauge stations. Since some information is not available to the public, there might be potential stations that exist but are not shown on the figures below. Based on the information we have, there are 40 stations on the southern coast of P.R.C. (Huang 2000), and on the eastern coast, 39 out of 81 total sea tide gauge stations are located in China. The other stations are in North Korea, South Korean and other coastal countries (Zhang and Zhu 2005).

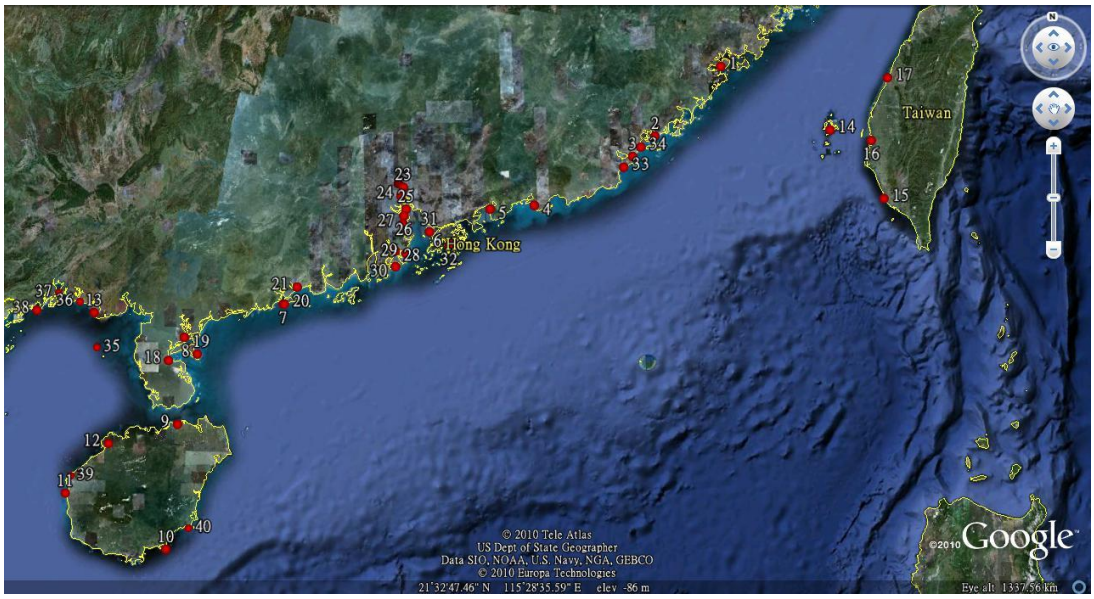

Figure 4 Tide gauge Stations on the South Coast of China, Data from Huang, zhenguo's "Sea-level Changes and its impacts and strategies of Guangdong"

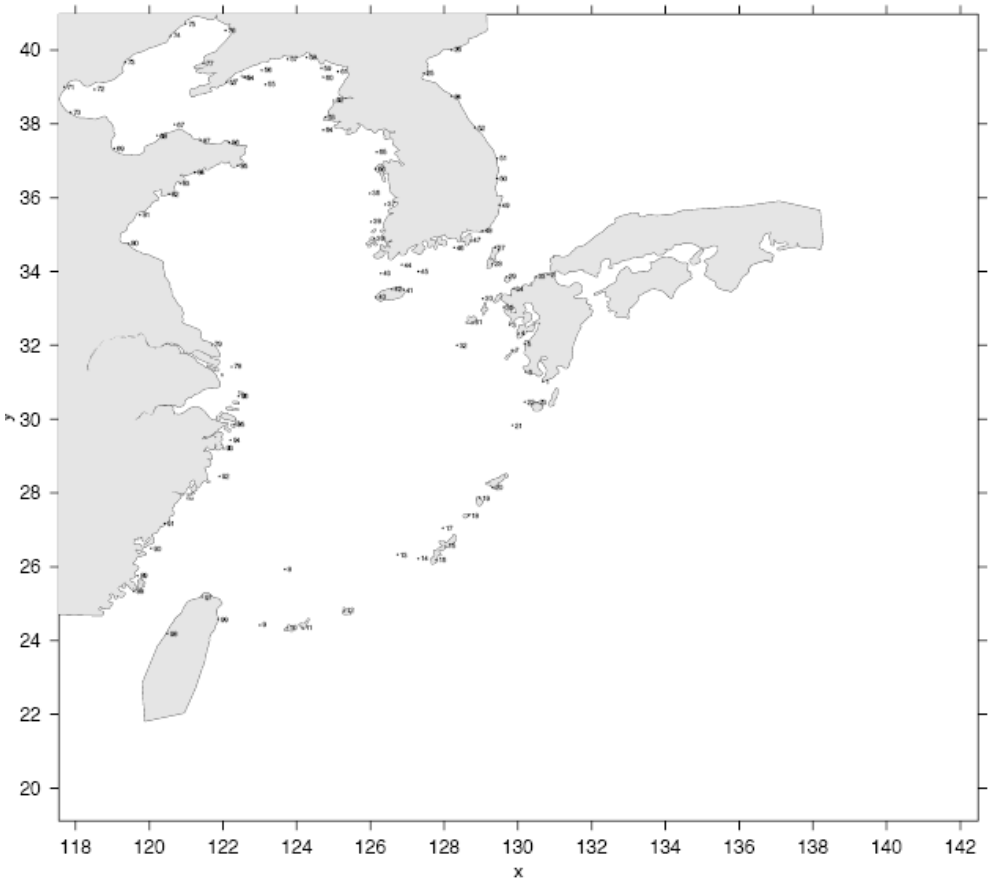

Figure 5 Tide gauge Stations on Eastern coast of the P.R.C. (Zhang and Zhu 2005)

2.3.2. U.S. Observation

The United States has been monitoring SLR for almost 150 years. Similar to the P.R.C. and other countries, the sea level monitoring in the U.S. is a part of tidal monitoring.

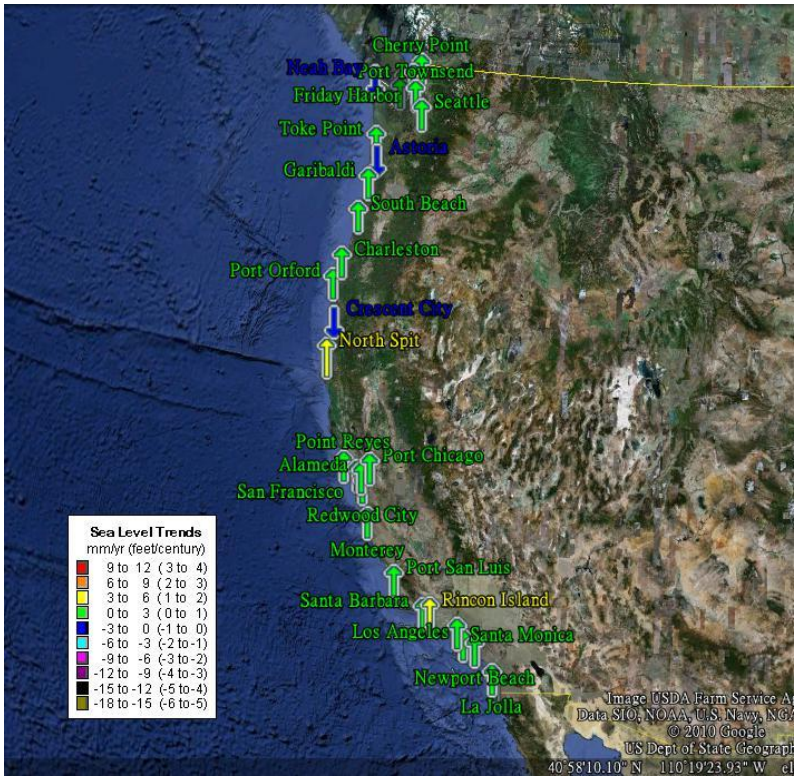

Figure 6 U.S. SLR measuring stations on the western coast, source from NOAA Sea-level Trend, http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml; last viewed 12/12/2010

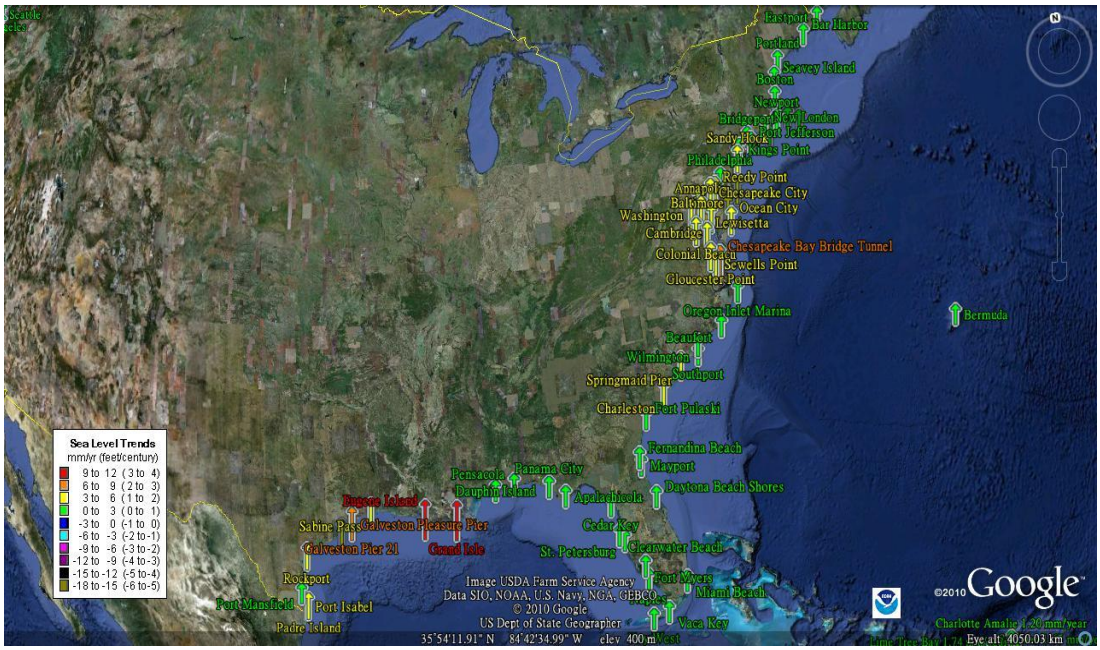

Figure 7 U.S. SLR measuring stations on the eastern coast and Gulf coast, http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml; last viewed 12/12/2010

2.4. Comparison between P.R.C. and U.S.

Table 3 Major SLR observing methods: Tide gauge and Satellite facilities in the P.R.C. and the U.S.

Country	Length of Coastline (km)	Tide gauge Stations	Density of Stations (m/station)	Satellite
P.R.C.	18,400	79	232.9	TOPEX/Poseidon Jason-1, Jason-2, ERS-2, GFO, Envisat
U.S.	19,924	90	221.4	

The table 3 above shows that the distribution of the tide gauge stations in both the U.S. and the P.R.C. are almost the same, which indicates a very similar level of data gathering regarding tides in both the U.S. and the P.R.C.. Although the tidal gauge measurements have been used for sea level monitoring for quite a long time, there are two major disadvantages.

The first one is that the distribution of tidal gauge stations is limited to only the coastline areas and the second one is the effectiveness of tidal gauge survey is impacted by the vertical land movement (Pugh 2004).

So a new, more accurate method using satellite altimetry to measure sea level changes has been introduced. NOAA's Laboratory for Satellite Altimetry is the leading laboratory in the world, having used satellite altimetry to measure global and regional sea level changes since 1992 and using this data to predict long-term sea-level change trends.

China launched its first satellite HY-1A for ocean monitoring in May 2002 and HY-1B in April, 2007, which are used to measure the sea optical characteristics, surface temperature, concentration of chlorophyll, content of suspended sediment, oceanic ice regime, dissolved organic matters, and ocean pollution. However, they were not used for monitoring sea level. Chinese researchers were using old TOPEX/Poseidon data to research the changes of sea level in China's coastal areas during the period from 1992 to 2004. Now the old satellite has been phased

out and the replacing satellite Jason-1 shall be used to generate the data for the research on current sea level changes. (Qiao and Chen 2008)

Besides the tide gauge survey and satellite altimetry, scientists are conducting research related to SLR that includes examining the historical sea level changes through research on Holocene SLR using geological methods. Also, since animals often appear to be the first to sense changes in tides and other water movements, biological research on the changes of coastal animals' behaviors has been conducted and could yield additional indicators of SLR. .

2.5. Overview of Policy and Law

2.5.1. U.S. Coastal Zone Management Act (1972)

By 1972, Congress had enacted the Coastal Zone Management Act to strongly encourage and guide states with coastal areas to develop programs to manage and balance competing land and natural resource uses within the coastal areas. The Coastal Zone Management Act is administered by NOAA's Office of Ocean and Coastal Resource Management (Titus and Richman 2001). The Coastal Zone Management Act (CZMA) helps states to develop individual coastal programs, allowing for flexibility and discretion in how they formulating and implement their programs (Kalo, et al. 2007).

The CZMA addresses SLR in Section 302, which states that, "(l)Because global warming may result in a substantial sea level rise with serious adverse effects in the coastal zone, coastal states must anticipate and plan for such an occurrence." (16 U.S.C. §1451). In Section 303, the Act outlines broad policy objectives concerning planning for SLR. In Section (2)(B) the rationale for comprehensive coastal zone management is stated as "the management of coastal development to minimize the loss of life and property caused by improper development in flood-

prone, storm surge, geological hazard, and erosion-prone areas and in areas likely to be affected by or vulnerable to SLR, land subsidence, and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands." Further, Section(2)(K) states that there will be study and development, in any case in which the Secretary considers it to be appropriate, of plans for addressing the adverse effects upon the coastal zone of land subsidence and of SLR;" (16 U.S.C. §1452). Sections 303(3), 304(1) and 309(2) also contain guidelines and requirements relevant to SLR.

2.5.2. Coastal Zone Management in the P.R.C.

After The Coastal Zone Management Act of United States was enacted in 1972, other countries in the world began to develop their own coastal zone management programs. In 1979, the P.R.C. completed several technical evaluations and reports including the "Comprehensive Survey of Estuary and Beach Resources", "Annals of Chinese Bay", "Comprehensive Survey of National Island Resources", "Marine Function Divisions of Whole Country", and "National Ocean Development Programming" to document and better understand the coastal natural environment and status of development of natural resources (Tong and Zhang 2010). China's researchers from various disciplines are conducting research on SLR, coastal disasters, coastal erosion, coastal environmental protection options and coastal biology. These preparations have built a solid foundation for the coastal zone management efforts.

In the last two decades, China's SOA divisions have developed local coastal zone management programs. However, the policies and regulations for guiding coastal zone planning and management are not well established yet. For local coastal zone management, Jiangsu Province enacted its "Temporary Coastal Zone Management Regulation" in 1986 and the

"Jiangsu Coastal Zone Management Regulation" in 1991, which was last amended in 1997 (He 2010). Qingdao City which is located in Shandong Province enacted the "Qingdao Coastal Zone Management Act" in 1995, with amendments added in 1999 (QDSC 1995). These local regulations and guidelines played a critical role in coastal zone management and provide a basis for future policy development in the P.R.C..

2.6. Overview of Current Research Activities

As introduced earlier in this thesis, two of the most important methods for monitoring sea levels are tide gauges and satellite altimetry. Scientists from both the U.S. and the P.R.C. are using these two methods to measure long-term and short-term sea-level changes. Otherwise, different countries have their specific SLR strategies and activities. Scientific research includes examining the direct physical effects of coastal erosion, shoreline inundation during storms and saltwater intrusion into estuaries and groundwater (Sorensen, Wisman and Lennon 1984).These observations and observations of direct physical effects are relevant to future land-use plans for coastal areas. Determining these effects is a fundamental step for estimating the impacts of SLR on coastal areas and considerations about how to prepare for them.

2.6.1. Current Research Activities in the U.S.

Michael J. Gibbs has examined potential economic impacts of SLR since 1980s (Gibbs 1984). James G. Titus, an EPA project manager for SLR, has worked on climate change and especially on SLR issues over the last 30 years. He has examined potential relationships between SLR and coastal disasters in the 1980s. His 1984 work examined changing coastal activities, preparations before coastal disasters and emergency responses after the disturbances, and offered recommendations to government officials (J. G. Titus 1984). In recent years, Titus wrote a report issued by the U.S. EPA called *Coastal Sensitivity to Sea Level Rise: A Focus on the Mid-Atlantic*

Region. This report focused on eight eastern coastal states to examine what governments have done and what needs to be done to address SLR issues. It indicated that the decision makers need to understand the vulnerabilities and risks of SLR impacts better and to develop tools, databases and other coastal management information repositories to support wise coastal planning. Additionally, the agencies need to improve their ability to conduct long-term projections since there are multiple and interacting factors that contribute sea level changes (CCSP 2009).

2.6.2. Current Research Activities in the P.R.C.

In the P.R.C., Guangdong Province was the first province to examine the impacts of SLR. The Province supported research and released a book called *Sea Level Changes and Its Impacts and Strategies of Guangdong Province* in 2000. The study included the identification of potential impact areas, damages to the built environment of coastal communities, the relationship between SLR and storms, saltwater intrusion, and gave five recommendations to the governments and agencies. These recommendations are:

1. Strengthen the levee systems to improve the ability to defend against SLR.
2. Increase the number of pumps available as a strategy to improve the adaptive capacities of coastal communities.
3. Increase investment in and size of tidal flat reclamation areas.
4. Incorporate the latest sea level estimates in plans for all coastal constructions.
5. Construct a serious of hydraulic projects to control potential flood waters and storm surges in the Pearl River Delta (Huang 2000).

In 2007 the SOA conducted a study and issued a report called *China's Climate, Sea Level Change and Their Trend and Impact* (NDRC 2007). The study included four key sub-projects

including the following: the research of China's historical climate; China's sea level change and its impacts; the trace gases, radiation cloud and climate numerical models; and research and impacts of climate change for China's northern and northeastern water resources. The National Development and Reform Commission (NDRC) added SLR and its impacts as an important part in *China's National Climate Change Program* (NDRC 2007). This program now requires the oceanic agencies and research institutes to improve the ability of monitoring of sea level changes and coastal management via performing following activities: encouraging more sustainable land-use planning efforts, integrating multiple protection methods to mitigate impacts associated with flooding, improving emergency response after coastal disasters, estimating the potential risk of saltwater intrusion, coastal erosion and other impacts of SLR, constructing or reconstructing coastal levees and planting protective forest in the coastal areas.

CHAPTER 3 METHODS AND DATA

3.1. Methods

To better understand the types of SLR programs in both the U.S and the P.R.C and potential obstacles to integrating SLR into coastal planning efforts, a series of questions were posed to a panel of experts in both countries. The recipients of the survey included officials of several local government agencies and university research institutes in the PRC and officials from state and local agencies and one university –based researcher in the U.S.. Three questions were posed to help gain insight into the extent to which SLR considerations are included in coastal zone planning, what specific activities are conducted, and the key obstacles to more effective integration of SLR considerations into coastal planning efforts in the U.S. and the P.R.C..

The first question posed to the experts is whether the agencies take into account SLR in coastal management programs. From this question, we may gain understanding of the status of SLR planning within these agencies, including intentions to implement future SLR measuring or other related activities.

The second question offers five options for the respondent to describe specific program activities they may be conducting. These include: monitoring SLR; keeping current with data gathered by others showing trends for sea level; adding sea- level rise risk to public education efforts; adding sea-level rise risk to hazards planning; and forging partnerships with other jurisdictions or agencies.

The last question concerns potential obstacles to integrating SLR considerations into the daily agency work. There are six factors we think could affect SLR integration: monitoring data availability budget constraints; presence of other pressing coastal management issues; public

apathy; lack of technical staff, and; difficulty in communicating with other agencies or organizations.

The responses of the experts were recorded and tallied in a table format to determine frequencies of responses.

The list of the agencies and universities with whom the experts are affiliated are presented below in Table 4. The survey questions are shown below in Table 5.

Table 4 Agencies participated in this survey

United States
Ocean and Coastal Resource Management at NOAA
Maryland Department of Natural Resources
Massachusetts Office of Coastal Zone Management
San Francisco Bay Conservation and Development Commission
Louisiana Department of Natural Resources
School of Marine Affairs, University of Washington
People's Republic of China
Shanghai Ocean University
Guangxi-ASEAN Marine Research Center
South China Sea Branch, State Oceanic Administration
The Second Institute of Oceanography, SOA
Guangdong Maritime Safety Administration

Table 5 Original Survey Questions

Have you formulated a SLR Program
☐ No Effort
☐ Planning for some SLR program component
☐ Formulated Activities but not implemented
☐ Formulated and implemented 1 or more activities
Are you conducting any of these activities
☐ Monitoring SLR
☐ Keeping current with data gathered by others showing trends for SL
☐ Adding SLR risk to Public Education Efforts
☐ Adding SLR risk to hazards planning
☐ Partnerships with other jurisdictions or agencies
Are any of following obstacles to integrating SLR into your agency's work?
Monitoring data availability ☐1☐2☐3☐4☐5
Budget Constraints ☐1☐2☐3☐4☐5
other pressing coastal management issues ☐1☐2☐3☐4☐5
Public apathy ☐1☐2☐3☐4☐5
Lack of technical staff ☐1☐2☐3☐4☐5
Hard to communicate with other agencies or organizations ☐1☐2☐3☐4☐5
Please **rank obstacles** by relative importance from the least (1) to the greatest (5)

3.2. Data

Geographic and socioeconomic data of the P.R.C. was obtained from the National Bureau of Statistics, an agency that provides statistical information to the public including population, annual marine disasters, and aspects of the economy. The total population of coastal areas within the P.R. C. is calculated by the sum of population of all coastal provinces. The geographic data of the United States was obtained from the Central Intelligence Agency (CIA) and the U.S. Census Bureau (CB). The total population of coastal areas within the U.S. is the estimated population of the coastal states.

The government agency administration system of the P.R.C. was obtained from the website of the Central People's Government of the People's Republic of China and the website

of State Oceanic Administration of the P.R.C. (SOA). The agency administration system of the U.S. was obtained from website of National Oceanic and Atmospheric Administration (NOAA).

The location of China's observing stations was obtained from "Annual Report of Sea level of the P.R.C.", "Annual Report of Marine disaster of the P.R.C." and "Impacts and Strategy of Sea Level Changes in Guangdong Province". I uploaded these coordinates in Google Earth and saved the information as a high-resolution photograph. Data concerning sea level changes in the P.R.C. was obtained from the "Annual Report of Sea Level of the P.R.C." and the IPCC 4th report in 2007. The observing stations of the United States were obtained from the website "Sea Level Trends" which was provided by Center for Operational Oceanographic Products and Services of NOAA. The estimation of the sea level changes in the future was obtained from the IPCC 4th assessment report in 2007 for 2030. The IPCC estimation was considered conservative because it ignored the impacts of ice sheet melting. It was only the sum of global sea level change plus changes of vertical land movement such as the impact of subsidence (MDDNR n.d.).

Information concerning coastal zone management in the P.R.C. was obtained from meeting records of the SOA which includes the current status of China's major coastal zone management efforts and likely future development. The information on coastal zone management in the United States was provided by NOAA's Office of Ocean and Coastal Resource Management and the Coastal Zone Management Act of 1972.

3.3 Survey Summary

Survey questions were sent to a total of fifteen experts and complete responses were received from eleven. These responses are from officials of government agencies and researchers from university institutes in both the P.R.C. and the U.S. Six out of fifteen survey

questions were answered by the U.S. participants and one response was received from a P.R.C. participant. During the course of this research, it became evident that email is not widely used as a communication tool among P.R.C. agencies. Thus, I conducted phone interviews with four P.R.C. participants. The results of the survey and a discussion of the findings are summarized in the table below.

Table 6 Survey results

	National Level		State or local level		Research Institute	
	U.S.	***P.R.C.***	***U.S.***	***P.R.C.***	***U.S.***	***P.R.C.***
Have you formulated a SLR Program						
No Effort				I I	I	I I
Planning for some SLR program component			I	I		
Formulated Activities but not implemented						
Formulated and implemented 1 or more activities	I		I I I			
Are you conducting any of these activities						other
Monitoring SLR	I		I I	I I		
Keeping current with data gathered by others showing trends for SL	I		I I I I	I I	I	I
Adding SLR risk to Public Education Efforts	I		I I I I	I I		
Adding SLR risk to hazards planning	I		I I I I	I I I		
Partnerships with other jurisdictions or agencies	I		I I I I	I		
Are any of following obstacles to integrating SLR into your agency's work?*						
Monitoring data availability	4		3	2	2	2
Budget Constraints	5		4.75	4	3	5
other pressing coastal management issues	3		3.75	4.7	2	4
Public apathy	1		4.25	4.3	4	4

Lack of technical staff	3		2.7	2.7	1	4
Hard to communicate with other agencies or organizations	3		2.3	4	1	2

* **rank obstacles** by relative importance from the least (1) to the greatest (5), the amount in the form are the average value from all response.

CHAPTER 4 ANALYSIS OF SURVEY RESULTS

4.1. Analysis of Survey Results for the U.S.

According to the survey results, NOAA, the national agency of the United States, has already formulated SLR programs for the examination of various aspects such as potential ecological effects, satellite altimetry, and model storm surge effects in the Northern Gulf of Mexico region. NOAA's office of coastal resources management conducts the major activities related to SLR of concern to this research.

At the state or local level in the U.S., three of four respondents indicate that they have formulated and implemented one or more activities to consider SLR in their work. One is at the planning stage for some sea level program components. Although not all of those four state or local agencies have the facilities or capabilities to monitor SLR, all of them conduct other activities we are concerned about including the following:

- Keeping current with data gathered by others showing trends for SLR;
- Adding SLR risk to public education efforts;
- Adding Sea- level rise risk to hazards planning; and
- Partnering with other jurisdictions or agencies.

While it is positive to see that the works (activities) related to SLR have been conducted by these state and local agencies, there are some reported problems or barriers to integrating SLR considerations into their agency's work. According to the survey results, the main issue is that budgetary constraints hamper the integration of SLR considerations into the agencies' annual work planning. The root cause for this may be that many people think of SLR as a relatively minor change in ocean levels that may be occurring very slowly and would not lead to great impacts to human communities. This might also be the reason why "public apathy" was reported

as an obstacle to better integration of SLR risks into the agencies' work. The positive result from the "obstacles" section in this survey is that three of four agency representatives in the U.S stated that there were no barriers in communicating with other agencies and organizations. In addition, the respondent from NOAA and the expert from the university research institute also reported that communication with others was not a problem for them. Another positive response is about staffing. The experts indicated that enough researchers and scientists are available to their agencies or organizations to conduct activities related to sea-level rise.

4.2. Analysis of Survey Results for the P.R.C.

The survey and interview results suggest that few local government agencies have formulated sea-level rise program activities, which indicates that work related to SLR may not be fully developed yet. So far agency work appears to be limited somewhat to some research projects about the potential impacts of SLR. Also, some coastal provinces appear to integrate sea level rise risk assessment into hazards planning and disaster emergency programs. The respondents stated that sea-level rise in the P.R.C. is an important subject for southern coastal provinces especially Guangdong, Hainan and Guangxi Province. So far, research for SLR appears to focus on the potential impacts for land loss, economic development and coastal ecology using the data from local institutes, national tide gauge stations and IPCC 4th assessment report. None of the national or local government agencies offer abundant budgets for the research of SLR and any other related issues.

<u>Obstacles Specific for the P.R.C</u>

Different from the United States, the results regarding technical staff suggest the need for more technical staff in some regions of the P.R.C.. Personnel with strong technical skills may

prefer to stay in the major metropolitans such as Shanghai, Guangzhou and Qingdao. Some less developed areas such as Guangxi and Fujian province where salaries are lower may have trouble attracting well-trained technical staff.

Another obstacle that may be more relevant to China is a reported communication barrier between agencies, research institutes or organizations at the same administrative level. Every interviewee mentioned that the P.R.C. needs a comprehensive law or policy to guide coastal planning similar to the United State Coastal Zone Management Act 1972. The respondents thought that a more comprehensive policy framework would help to reduce potential conflicts and increase communication between different agencies, departments and stakeholders of coastal communities.

4.3 Common Obstacles for both the U.S and the P.R.C

The survey results suggest two common, fundamental obstacles to the integration of sea-level rise considerations into government agencies' works, possibly hampering efforts in both the U.S. and the P.R.C. These are budget constraints and public apathy. Since integration of SLR considerations is mostly performed as a part of coastal zone management, this discussion considers the two common obstacles in the context of coastal zone management.

1) Budget Constraints

The issue of budget constraints raises questions about funding allocations to the agencies in both countries. In the U.S., the majority of the budgets for coastal zone management are funded by NOAA's office of Ocean and Coastal Resource Management (OCRM) and the rest are provided by partnerships. The FY 2009 OCRM Budget Allocations by Program provided by NOAA's OCRM shows that there were a total of $76.4 million allocated to coastal zone

management, with $7 million allocated to CZMA administration of the National Program, and the vast majority, $69.4 million, allocated to state Coastal Management Programs (OCRM 2010). Under Section 306, 306A, 309 and 310 of the CZMA, OCRM provides funding for state administration, coastal resources improvement, state coastal zone enhancement and coastal nonpoint pollution control to protect, restore and develop coastal communities and resources (OCRM 2010). Compared with FY2006 and FY2007 that OCRM awarded $72.7 million and $66 million to state coastal zone management programs (OCRM 2007), the funding for coastal zone management remained the same.

One explanation for the reported budgetary obstacles may be that state programs and OCRM awards only a small portion of coastal planning funds to sea-level rise research. This may be due to the fact that changes in sea levels may be slow, difficult to predict accurately, and, as such, are seen by the public as a less immediate public issue when compared to other pressing concerns.

Similar to the U.S, four provincial officials from government and local oceanic agencies in the P.R.C., stated that the SOA and province governments award abundant funding for Oceanic research and management each year, but only a small portion will be allotted for SLR research and related work. Even the coastal zone management programs planned by the 10 coastal cities in the P.R.C are not funded by the SOA or the province government. They are solely financially supported by the local governments. Other than that, there are no public partnerships or loans available to provide additional funding.

2) Public Participation

The need for meaningful public participation by stakeholders of coastal communities may be an important factor in incorporating considerations of SLR into planning and management of

coastal zones. The stakeholders include property owners, interested citizens and organizations, surrounding communities, interest groups, corporation and business (DEWA 2009). Meaningful and active public participation is important for SLR planning due to the need to consider local history, the socioeconomic, geographic, natural resource, and ecosystem attributes of the area, as well as the stakeholders' long-term aspirations for their communities. Increasing local participation could help marine agencies in a variety of ways, ranging from helping to monitor changes in coastline conditions that may be early indicators of growing SLR risks, to accepting more stringent building codes, to developing more efficient evacuation plans in the event of major hurricanes and typhoons.

4.4. Case Study: Examining Potential Impacts of SLR to Two Coastal Areas

The case study provides a comparison between a coastal province in the P.R.C. and a U.S. state that are highly vulnerable to sea level rise. They are Guangdong Province in the P.R.C. and the U.S. state, Louisiana.

4.4.1 Guangdong Province

Guangdong Province which is located on the south coast of the P.R.C. is one of the most developed areas in China. It has a population of 96.38 million and a GDP of 4 trillion Chinese Yuan, which is 12% of the national GDP. As an important coastal province, it has 3,368 km coastline and there are 1,431isles on the coast areas of Guangdong Province. The Guangdong Province is one of the most productive provinces in terms of ocean-based industries. It produced 661.4 billion Chinese Yuan in 2009, accounting for 20.7% of the national Ocean industry products.

Oceanic disasters including storm surges, ocean waves and coastal erosion happen every year in the Guangdong Province, with storm surges taking place on an average of 4 times each year. Although the SLR is a slow process, it would raise the water level, thus increasing the damage of storm surges, flooding, land loss and decreasing the effectiveness of levees and other flood-control structures. In 2008, the ocean disaster in Guangdong Province destroyed 805.69 km coastal constructions and 48,800 houses, affecting 11 million people and resulted in the economic losses of 15.43 billion Chinese Yuan, equal to about 2.2 billion dollars (SOA 2008).

The IPCC and China's scientists estimated that sea level will continue to rise in the next three to five decades. Lv et. al. estimated the need to move 0.99, 3.11 and 4.89 million people out of Guangdong Province if the sea level rise is 30 cm, 65 cm and 100 cm (Lv, Sun and Dong 1996).

Table 7 historical y records and future estimation of SLR for Guangdong Province, P.R.C.

Province/State	**1978-2007**	***2007**	***2008**	***2009**	**2039 estimation**	**IPCC estimation by 2050**
Guangdong Province	55mm	48mm	75mm	91mm	83-149mm	400-600mm

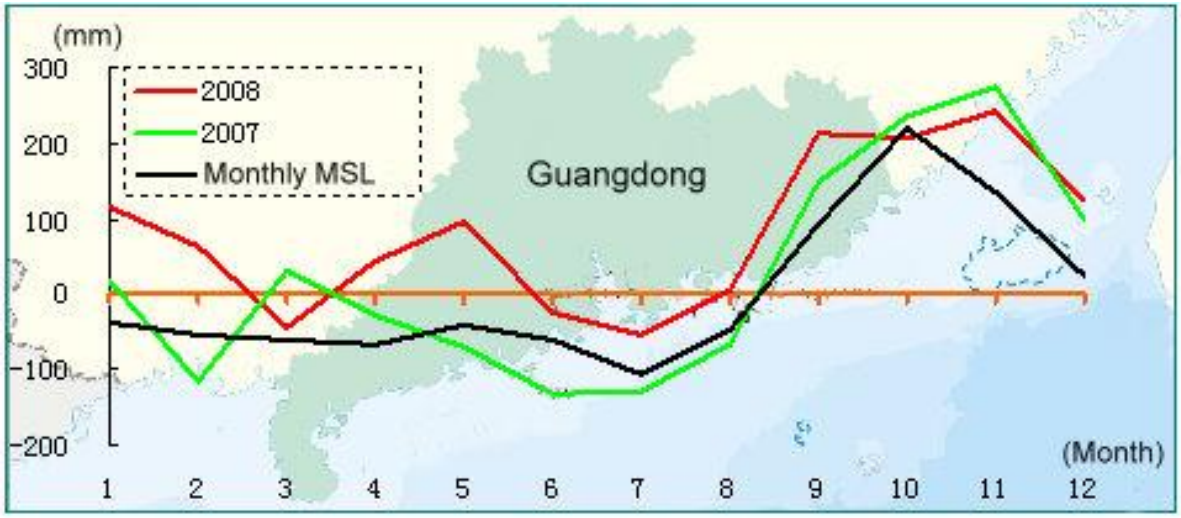

Figure 8 Comparison of sea level changes between 2007, 2008 monthly sea level change and Monthly Mean Sea Level (SOA 2008)

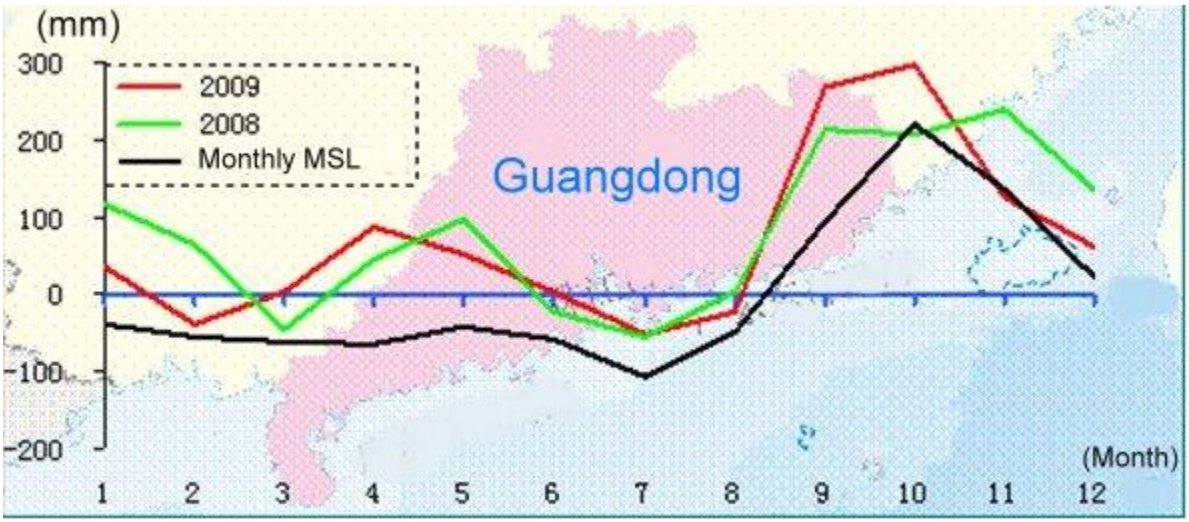

Figure 9 Comparison of sea level changes between 2008, 2009 monthly sea level change and Monthly Mean Sea Level (SOA 2009)

According to the research of the Sea Level Annual reports for the P.R.C., sea level is the highest and rises the most during the season of storm surge (September to November) compared to other periods of the year. From 2007 to 2009, there were 7 storm surges in this period and all of them were the most destructive storm for that year. In 2008, Typhoon Hagupit, the most

severe typhoon for the past 10 years landed in Guangdong on September 24th. Twenty-one tide gauge stations' storm-surge water levels increased more than 100 cm, and four of them increased more than 200 cm. It destroyed sections of 2,118 levees that stretched for about 650 km long, impacting 39 cities and counties with a total population of 7.37 million people.

What would happen if the same level of storm occurs in the future? The IPCC estimated that in the 2050 the sea level will rise at least 40cm above the current sea level. If the same level of Typhoon were to occur in 2050, 40cm higher water levels would produce a storm-surge water level of more than 100cm. This storm-surge water level would crush dikes and coastal constructions and as a result, destroy cities and farmlands. Compared with the impacts of the annual average SLR, the monthly SLR in the storm surge season would more likely bring detrimental disaster for Guangdong Province.

4.4.2. Louisiana

Louisiana, located in the southern United States, is one of the most important states on the coast of the Gulf of Mexico. Louisiana has 4.49millioin people, and about 47% of the state residents live in the coastal areas (USCB 2009). It ranks first in crude oil and second in natural gas production among the 50 states (LDNR 2008). Louisiana has about 639 km coastline (NOAA n.d.), with about 22% of the land less than 1.5m above sea level (Titus and Richman 2001). Louisiana is the largest waterborne commerce state of the 50 U.S. states. The state has five of the top fifteen largest ports in the U.S. and carried 480 million tons of waterborne commerce in 2008 (USACE 2008).

Louisiana has 40% wetlands of the continental U.S. (Williams 1995), the SLR would accelerate coastal wetland loss in Louisiana (LDNR 2010). Researchers Michael Blum and Harry

Roberts estimated that about 10,000-13,500 square kilometer wetland of the Mississippi Delta will be submerged by subsidence and SLR by the year 2100 (Blum and Roberts 2009)

Similar to the Guangdong Province of the P.R.C., Louisiana is a vulnerable area for the storm surges. The Louisiana hurricanes history showed that 18 of 28 hurricanes during 1956 to 2009 occurred during the period of September to October when the water level is always higher than in other months (Roth 2010). Jane Smith and colleagues used estimated Relative Sea Level Rise (RSLR)* of 0.5 to 1.0m in next 50-100 years to simulate the impact of SLR on hurricane storm surge from hypothetic hurricanes in southeastern Louisiana by numerical storm surge model ADCIRC and waves model STWAVE (Smith, et al. 2010). The results indicate that the storm surge would increase at least twice the RSLR especially in the more isolated areas. Wave surge increase is estimated to be as much as double to five times the RSLR over broad and isolated areas. Waves would increase significantly in shallow areas due to the combined increases in water depth due to RSLR and surge increases. Maximum increases in wave height for the modeled storms were 1–1.5 m. Surge propagation over broad, shallow, wetland areas is highly sensitive to RSLR. Wave heights also generally increased significantly for all RSLR cases. These and other estimates point to significant, increasing risks from hurricanes for residents of coastal Louisiana in the coming years.

CHAPTER 5 CONCLUSION

SLR is one of the most serious challenges associated with global climate change, with some impacts already evident along some coastal areas. It is easy to see that the most vulnerable areas impacted by SLR are delta regions and also small island nations. Many people live in coastal cities and communities lower than sea level and in low-lying deltaic areas around the world (e.g. Egypt, U.S. and P.R.C.) (Douglas, Kearney and Leatherman 2001). In the face of risks associated with SLR, planners and policy makers need to employ various methods to better estimate the risks and conduct coastal zone planning to reduce the potential impacts to human communities, local and regional economies, and natural ecosystems (e.g. constructing levee or dikes and restoring wetlands).

The coastal management system was initially set up in the U.S about 40 years ago. Compared with the P.R.C., the U.S. policy for coastal zone management has a more integrated framework from the national level to state level. The experiences accumulated by all coastal states of the U.S. in these 40 years could be a good example for China to develop its overall coastal zone management program that takes SLR into account.

Based on the review of public documents and government reports and the panel of experts' survey, it is clear that most of the coastal states in U.S have formulated SLR programs and have conducted some activities including:

- Using different methods to gather data of sea level changes for monitoring and future forecasting;
- Adding the potential risk of SLR as part of public education efforts;
- Hazards planning; and
- Partnerships between different jurisdictions and agencies.

By contrast, only a few provinces in P.R.C. have added SLR to public education efforts and hazard planning as part of emergency plans for natural disasters. Now some coastal provinces and many researchers have started various SLR projects and they are starting to examine and assess potential impacts to future economic development caused by SLR. This is due to the SOA's suggestion that provinces and local governments shall consider the impacts of SLR before formulating their development plans (e.g. limiting the height and density of building to mitigate the high impact in the areas that will be more likely to be affected by SLR).

In the process of integrating SLR into agency's work, budget constraints and relatively low levels of public interest are reported as obstacles by experts in both the P.R.C. and the U.S. The limited budget issue, somewhat obviously, is a function of annual budget allocations in each country and an examination of likely changes in future funding is beyond the scope of this thesis. However, the more agency officials pay attention to SLR issues and are encouraged to identify and articulate what they need to better integrate SLR considerations into their agency's coastal planning work, it is possible that funding may increase.

Experts from the P.R.C., reported a shortage of technical staff and a lack of communication between agencies, governments or organizations as limitations for formulating and implementing either the national or local SLR programs. Since China's main focus now is economic development, more financial and staff support is provided to support those policies and agencies that are more directly involved in promoting rapid economic growth. As a result, it appears that governmental efforts concerned with the coastal planning and management of population growth and conservation of natural resources in these areas may still be in the initial stages.

Leaders in China have realized the value of education to provide a highly-trained workforce for other technology niches, and this type of investment may be applied to training coastal planners in the near future. For example, in 2009 the Ministry of Education of the P.R.C. (MOE) supported 12,769 students or scholars to study abroad, particularly to the U.S to study the most advanced technologies in the world (MOE 2010) (e.g. Energy & Resources, Environmental Science, Agriculture, Manufacturing, Information Science, Biology, etc.). The MOE also encourages students and scholars study abroad and to return to the P.R.C. to apply their expertise to a variety of challenging issues.

However, educated individuals may prefer to relocate to more wealthy areas after they complete studies and go back to China. Because of the disparity of wealth distribution, more skilled and better educated workers are found in the more developed cities and areas like Shanghai, Guangzhou, the Pearl River Delta, and the Yangtze River Delta Economic area. In the less developed areas, it may be hard to recruit the technical staff with the desired skill sets.

So I recommend that the government and agencies in these areas could adopt flexible strategies in staffing or use some short-term project to attract skilled and educated workers. For example, they could provide additional bonuses when they want to attract technical staff from more well-development areas to perform the required SLR work, including monitoring sea-level changes, developing a provincial or local coastal zone management program, estimating the potential impacts for local SLR and storms, and designing coastal flood control structures.

These technical staff then could train local technicians to conduct research and planning activities related to SLR in the long term. Since many of the specific risks and impacts associated with SLR are local and regional, it would be helpful to build the technical expertise and administrative capacity of cities and provinces within the P.R.C.. So ideally, a regional alliance

could be formed with a mixture of more and less developed cities to balance the staffing issue and provide adequate talents needed for a common research goal. Further, this regional alliance could facilitate communication between different local governments and agencies.

Another method to promote better communication is to establish a particular office to manage the coastal projects (Ma 2008). The U.S. policy model is to set up an Office of Coastal Zone Management to coordinate the SLR work, reduce the investment duplications and more importantly, minimize potential conflicts concerning communication with other agencies and organizations. Also, to better develop overall regional planning, the U.S. Coastal Zone Management Act provides a useful model. The U.S developed the National CZMA in 1972 and then established state offices of coastal zone management. In this way, the policies and procedures have been developed and all the states have basic standards or guideline to follow while creating their own programs to address issues and needs more specific to their own unique geographic and demographic situations. China adopted a different approach by developing the coastal zone management programs and regulations at the city and province level first, before drafting a national coastal zone management policy. And so far a national policy hasn't been finalized or released yet. The lack of an overall coastal zone management program may have created an additional obstacle to more effective planning and cooperation between local governments and agencies to work on regional projects.

The many technical and administrative complexities inherent in monitoring and assessing risks associated with SLR, and integrating those considerations and information into local coastal planning suggest the utility of a more integrated coastal policy framework such as that established by the U.S. Coastal Zone Management Act. Finally, the findings of this research suggest that public education efforts designed to convey the potential risk of SLR to stakeholders

of specific coastal communities, including likely socioeconomic and environmental consequences, would appear to be a logical strategy to help overcome key obstacles to the integration of SLR risks into long-term planning for coastal areas.

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APPENDIX I

AGENCIES PARTICIPATED IN THIS SURVEY

United States
Ocean and Coastal Resource Management at NOAA
Maryland Department of Natural Resources
Massachusetts Office of Coastal Zone Management
San Francisco Bay Conservation and Development Commission
Louisiana Department of Natural Resources
School of Marine Affairs, University of Washington
People's Republic of China
Shanghai Ocean University
Guangxi-ASEAN Marine Research Center
South China Sea Branch, State Oceanic Administration
The Second Institute of Oceanography, SOA
Guangdong Maritime Safety Administration

APPENDIX II

ORIGINAL SURVEY QUESTIONS

"Hello, I'm conducting research on SLR adaptations and strategies. I'm interested in learning about emerging efforts your agency's may be taking to consider SLR.

Questions

1. What kind of agency are you working for?

   ☐ National agency / National Government

   ☐ State agency / State Government

   ☐ University/Research Institute

2. Have you formulated a SLR program?

   ☐ No efforts

   ☐ Planning for some SLR program component

   ☐ Formulated activities, but not implemented yet

   ☐ Formulated and implemented at least one activity

3. Are you conducting any of these activities:

   ☐ Monitoring SLR

   ☐ Keeping current with data gathered by others showing trends for sea-level

   ☐ Adding SLR risk to Public Education efforts

   ☐ Adding SLR risk to Hazards Planning

   ☐ Partnerships with other jurisdictions or agencies

   Other _____

4. Are any of the following obstacles to integrating SLR into your agency's work?

   a. Monitoring data availability ☐1 ☐2 ☐3 ☐4 ☐5

   b. Budget constraints ☐1 ☐2 ☐3 ☐4 ☐5

   c. Other pressing coastal management issues ☐1 ☐2 ☐3 ☐4 ☐5

   d. Public apathy ☐1 ☐2 ☐3 ☐4 ☐5

   e. Lack of technical staff ☐1 ☐2 ☐3 ☐4 ☐5

   f. Hard to communicate with other agencies or organizations ☐1 ☐2 ☐3 ☐4 ☐5

   g. Other _____

   Please **rank obstacles** by relative importance from the least (1) to the greatest (5)

Others: _____

VITA

The author of the thesis is Mo Chen who comes from Nanning City, Guangxi Province, People Republic of China. I was graduated in School of Resource and Environment, Guangxi Normal University for bachelor degree. And I am a candidate of master in Department of Environmental Science, Louisiana State University. My research interests are following: environmental policy and management, coastal and ocean policy and management.