Methods

The 40 coastal parks analyzed and the corresponding NPS unit code designations can be seen in Table 1. These four letter codes will be used throughout the rest of this document. NPS regions will also be abbreviated to their appropriate three letter code (see Glossary).

Analyses for exposure to long-term SLR within the 40 coastal units included a variety of methods ranging from field observations of specific assets to blanket categorization of entire NPS units. The following section will describe the methods used for the exposure analyses; a combination of these methods was used in most cases. The methods utilized for each unit are described in detail in Appendices B-F.

Broad Categorization of Extremely Low Elevation Units

During discussions with NPS staff, it was determined that a number of units, primarily barrier island, south Atlantic and Gulf coast parks, are already extremely exposed to coastal hazards such as storms and SLR. Even if there are areas above 1 m in elevation, it was determined that a 1 m rise in sea level would reduce the integrity and the continuity of the park lands to a degree that all assets would be vulnerable or lost. Therefore, all assets within a number of these units were placed into the high exposure category.

Table 1. NPS unit codes and regions for the 40 coastal parks analyzed, with date visited.

Region	Unit	Unit Description	Date of Visit by WCU
NER	ACAD	Acadia National Park	
	ASIS	Assateague Island National Seashore	Oct 2012
	BOHA	Boston Harbor Islands National Recreation Area	Oct 2012
	BOST	Boston National Historical Park	
	CACL	Castle Clinton National Monument	
	CACO	Cape Cod National Seashore	Oct 2012
	FIIS	Fire Island National Seashore	Oct 2012
	FOMC	Fort McHenry National Monument and Historic Shrine	
	GATE	Gateway National Recreation Area	July 2012
	GEWA	George Washington Birthplace National Monument	
	GOIS	Governors Island National Monument	
	NEBE	New Bedford Whaling National Historical Park	
	SAHI	Sagamore Hill National Historic Site	
	SAMA	Salem Maritime National Historic Site	
	STLI	Statue of Liberty National Monument	
SER	BICY	Big Cypress National Preserve	
	BISC	Biscayne National Park	
	CAHA	Cape Hatteras National Seashore	
	CALO	Cape Lookout National Seashore	
	CANA	Canaveral National Seashore	
	CASA	Castillo de San Marcos National Monument	
	CUIS	Cumberland Island National Seashore	April 2012
	DESO	De Soto National Memorial	
	EVER	Everglades National Park	
	FOPU	Fort Pulaski National Monument	
	FOSU	Fort Sumter National Monument	June 2012
	GUIS	Gulf Islands National Seashore	
	TIMU	Timucuan Ecological and Historic Preserve	
PWR	CABR	Cabrillo National Monument	
	CHIS	Channel Islands National Park	
	FOPO	Fort Point National Historic Site	
	GOGA	Golden Gate National Recreation Area	April 2012
	LEWI	Lewis and Clark National Historical Park	
	OLYM	Olympic National Park	July 2012
	PORE	Point Reyes National Seashore	April 2012
	REDW	Redwood National Park	
	SAFR	San Francisco Maritime National Historical Park	
	SAMO	Santa Monica Mountains National Recreation Area	
IMR	PAAL	Palo Alto Battlefield National Historical Park	
	PAIS	Padre Island National Seashore	March 2012

Eight units were initially included in this broad categorization: FOSU, CALO, CAHA, CANA, BISC, DESO, EVER, and FOPU. One unit, GUIS, was initially included in this broad categorization, but upon further discussion it was determined that the mainland assets for this unit should be excluded from the high exposure designation and further review was necessary. Three other units, BICY, CASA and TIMU were also initially included in this designation, but park review noted assets within these parks at higher elevations that we estimate could sustain a 1 m rise of sea level.

"First-Cut" of Assets in High Elevation Units

A number of the 40 coastal units have assets located within high elevation areas or a considerable distance from the shoreline. In these cases, a "first-cut" of assets was performed prior to the park visit or detailed analysis. The NPS FMSS location hierarchy report was the primary tool used to apply this cut to each unit. These unit specific reports group assets based on general location. For example, Table 2 is a portion of the location hierarchy report for OLYM. The field labeled "Level" is the hierarchy system for the assets. "Level 1" is a general area of the park (Area Hurricane Ridge) and all of the assets below this top level (Levels 2, 3, 4, etc.) are within the Hurricane Ridge area of the park. OLYM has 19 "areas" in the location hierarchy report and only three of these areas are near the coast (Lake Ozette, Mora and Kalaloch, Figure 2). In fact, a number of the assets, including those in the Hurricane Ridge area, have elevations over 5,000 feet (above MSL). Therefore, over 80% of the assets in OLYM, including all those in non-coastal areas, were placed into the limited exposure category using only the hierarchy reports and park maps (Figure 2). This initial reduction of assets (primarily units along the west coast) significantly reduced the number of assets that need to be analyzed in the field.

This "first cut" method was utilized on numerous units, including many within the PWR, including CHIS, REDW, OLYM, CABR, GOGA, PORE, and a few from other regions, such as ACAD in the NER. Using the geographic location of these areas within the reports, in combination with other tools such as geographic information systems (GIS, ArcGIS software), light detection and ranging digital elevation maps (LiDAR DEMs), contour maps and NPS input, a large percentage of assets were cut from the analysis and designated as having a limited exposure to SLR.

Table 2. Example of FMSS location hierarchy report for Olympic National Park

Level	Asset Location Code	Description
1	20152	Area Hurricane Ridge
2	20846	4100 Hurricane Ridge – Area Buildings
3	111269	Bldg Hurricane Ridge Hydrant Building #1
3	111271	Bldg Hurricane Ridge Hydrant Building # 2
3	114554	Bldg Hurricane Ridge Ski Shed
3	21569	Bldg 711 Hurricane Ridge Visitor Center
3	21570	Bldg 961 Hurricane Ridge Picnic Area A Comfort Station
3	21571	Bldg 962 Hurricane Ridge Picnic Area B Comfort Station
3	21572	Bldg 1248 Hurricane Ridge Water Pumphouse
3	21573	Bldg 874 Hurricane Ridge Generator/Radio
3	95823	Bldg Hurricane Ridge Obstruction Point Trail head CXT Vault Toilet

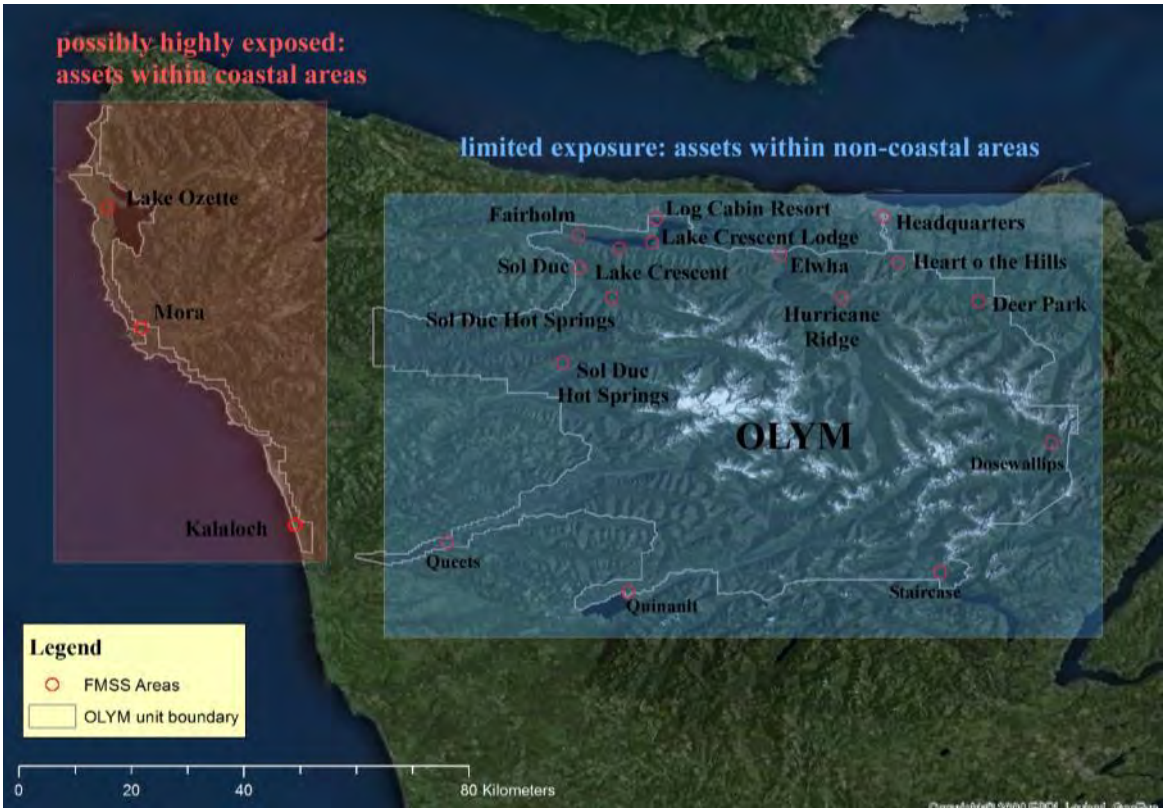

Figure 2. Location of FMSS location hierarchy areas and park boundary for OLYM. Only three areas from the hierarchy report are near the coast (in red shading). All other areas and corresponding assets were automatically considered as having a limited exposure to sea-level rise due to elevation and distance from the shoreline.

Park Visits

Eleven NPS units were visited for field analysis of the assets listed in FMSS. Most commonly, these parks were partially analyzed prior to the scheduled visit, using a combination of tools and methods. This included eliminating assets based on the location hierarchy report, or other data collected and compiled for this study, including LiDAR DEMs, contour data (including topographic maps), or geographic location data. These data were commonly retrieved from the NPS Integrated Resource Management Applications (IRMA) data download portal. This integrated approach reduced the assets that needed to be located in the field during each park visit.

During each park visit, WCU staff met with appropriate NPS personnel to discuss the exposure of assets to SLR. These NPS discussions included a variety of participants, including superintendents, natural resources, cultural resources, and facilities personnel as well as GIS analysts and FMSS coordinators. Additional GIS data, such as recent LiDAR or other elevation data, were often obtained from NPS staff during these meetings.

Field analysis for each unit consisted of visiting the "areas" from the location hierarchy report and as many specific assets as possible. GPS (geographic positioning system) coordinates were taken for the

assets visited and an initial estimate of exposure was also assigned to assets based on discussion with NPS staff and field observations.

GIS Analysis of Assets

For each applicable unit, GIS analysis (using ArcMap 10.1) was performed on data obtained from one or more of the methods previously discussed. Geospatial data (GPS data obtained during the field visits or location data obtained from each unit) were used to map each asset (when possible) and elevation data (commonly LiDAR DEMs or contour shapefiles) were used to determine approximate elevation of each asset (Figure 3).

Final WCU Categorization of Assets: High or Limited Exposure to SLR

The final step in the exposure analysis for each of the 40 coastal units was to place each asset into one of two categories based on relative exposure to long-term SLR: 1) high exposure or 2) limited exposure. These two simple categories were recommended by personnel in the Climate Change Response Program in order to reach the ultimate goal of the study: describing the degree to which NPS is exposed to the hazard of long-term SLR. The final decision on the exposure of a particular asset or group of assets was dependent on multiple factors and a wide variety of data sources. Table 3 illustrates the general data types available for each unit, and Table 4 summarizes the sources for each data type. The specific GIS data sources used for each unit are listed in Appendix B. Results for each of the 40 coastal units, including a detailed breakdown of the method, data sources and assets determined to be high exposure, can be found in Appendices C-F. Characterization of some assets was obvious; for example, any assets located below 1 m or on the active oceanfront were classified as high exposure. Other assets were put into the high exposure category because a 1 m rise in sea level would make them storm vulnerable or because of geomorphological changes that would follow the SLR. Some of this was based on the opinion and expertise of the authors. Even so, we have a high level of confidence in the fact that those assets listed in the high exposure category are at risk. To some degree, we have used our extensive experience as coastal hazards specialists to make the final exposure determination, given the fact that we were limited by the resources available for analysis.

Park Review

After the categorization of SLR exposure for the assets in each park, the lists were distributed to the regions, and in some cases to each unit for review. The parks that were visited, as well as several parks that WCU was in direct communication with, were sent the preliminary results and given the opportunity to comment. A few of the parks returned revised exposure lists based on internal analysis and discussion (e.g., ACAD). Further review (by the units and regions) of the assets determined to be high exposure was planned as part of this document, and as of June 2014 final review from all regions was completed. The comments and recommendations from the units have been addressed and changes were made when appropriate and feasible within the scope of this project.

FMSS Limitations and Asset Exclusions

Certain types of assets were not included in the analysis of any of the 40 parks. Examples include: 1) assets that location or elevation could not be assigned easily, such as some large general areas (e.g., landscapes, grounds, beaches or dunes) or assets that represent systems likely distributed park wide (IT, radio, water, wastewater, etc.) and 2) assets with a FMSS status of "planned" or "removed." Any of these assets can be placed onto the high exposure or limited exposure lists if so desired by NPS. During review some parks requested these type of assets (like a waterfront system) be included in the high exposure category. Also, some of these exclusions did not apply to all units. If a decision could be made about that particular asset (e.g., a landscape that is clearly at risk), that asset was included in the analysis.

There are also a number of park assets that may not be included in this version of FMSS but are likely to be at risk to SLR. This includes numerous archaeological assets and maintained cultural landscapes that are not currently part of the FMSS database, but are extremely valuable and preserving these resources is part of the mission of NPS. Also, during the review of this document it was noted that numerous assets have been added and updated in FMSS that are not part of this document, and could increase the number of assets listed as high exposure to SLR.

In addition, many of the assets listed in this report may have changed in location, condition, or status (some may have been relocated, removed, salvaged, some may have been rebuilt, etc.) and therefore, all the quantitative values (FCI, CRV, API, etc.) and assets presented in this document represent a snapshot of a particular time. Many of the reviewers suggested that FMSS has been updated recently and the quality of the data has increased significantly. However, the data utilized for analysis in this study is from spring of 2012, when NPS provided the FMSS data to WCU. Some edits to the FMSS were made to specific assets if the unit or region provided these changes during the review process (i.e., a few reviewers actually changed the Optimizer Band values in the asset list provided).

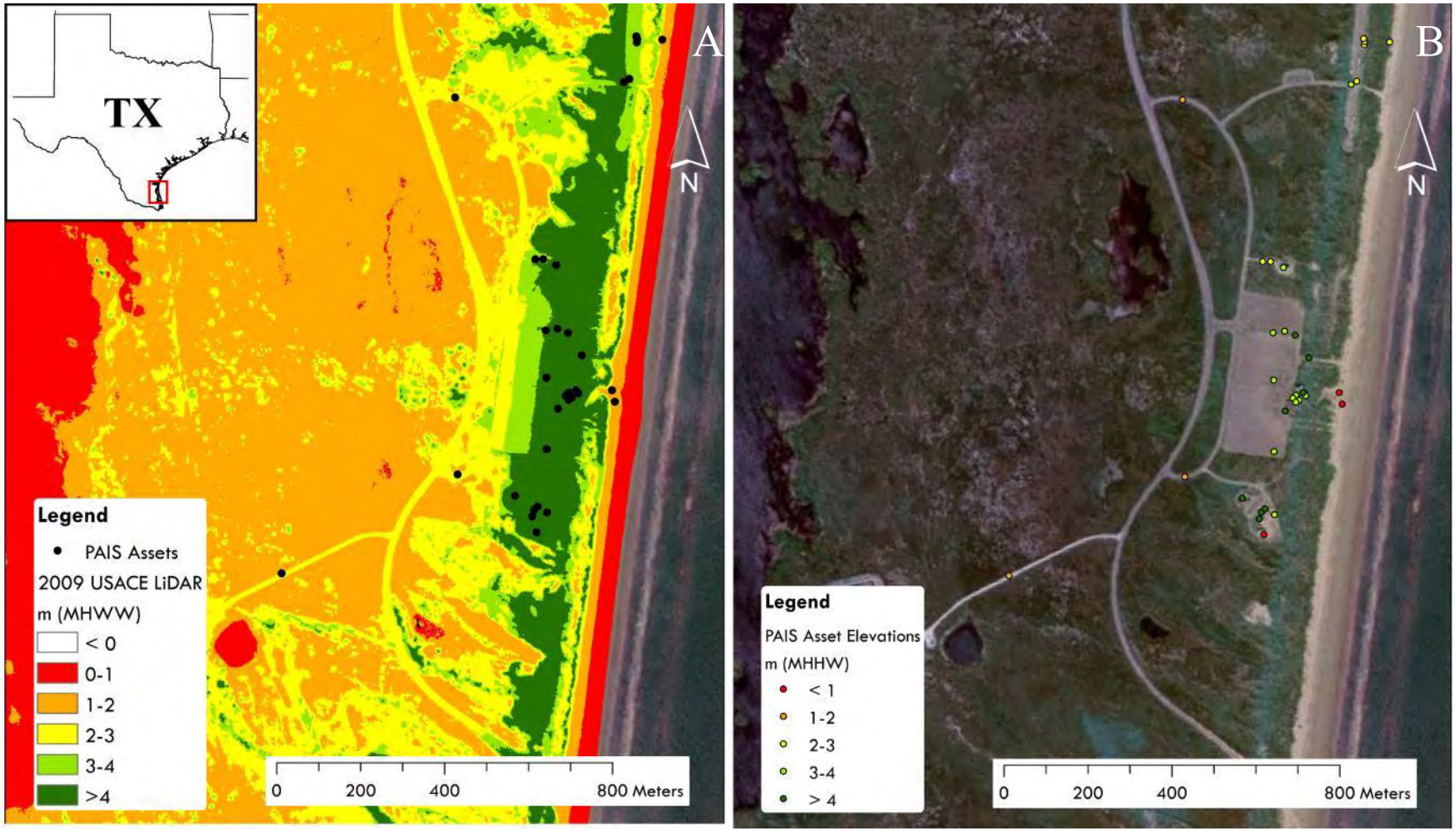

Figure 3. PAIS exposure analysis example. A) LiDAR DEM of a portion of PAIS and asset locations. B) Color coded assets for the same area based on elevations obtained from the LiDAR DEM.

Table 3. General summary of data types available for each unit. Quality and quantity of each data type varies between units. Specific data sources can be found in Appendices A-F.

Unit	Asset Geographic Data	GIS Elevation Data		Field Visit	Park Review	Broad Categorization: All Assets High Exposure
		Contour	LiDAR			
ACAD	○	○			○	
ASIS	○		○	○	○	
BOHA	○		○	○		
BOST	○		○		○	
CACL			○		○	○
CACO	○		○	○		
FIIS	○		○	○		
FOMC			○		○	
GATE	○		○	○	○	
GEWA			○			
GOIS			○		○	
NEBE			○			
SAHI	○		○		○	
SAMA			○		○	
STLI			○			○
BICY					○	
BISC	○	○	○			○
CAHA	○		○			○
CALO	○		○		○	○
CANA	○		○		○	○
CASA			○		○	○
CUIS	○		○	○		
DESO						○
EVER	○				○	○
FOPU						○
FOSU				○		○
GUIS	○		○			
TIMU	○				○	
CABR	○		○			
CHIS	○		○		○	
FOPO	○		○		○	
GOGA	○		○	○	○	
LEWI	○					
OLYM	○		○	○	○	
PORE	○				○	
REDW	○		○			
SAFR	○		○			
SAMO	○				○	
PAAL					○	
PAIS	○		○	○	○	

Table 4. Primary data types and common sources used in the SLR exposure analysis.

Data Type	Common Source(s)
LiDAR DEM	NOAA, USGS, USACE, city and county
Contour Data	NPS-IRMA
GPS data	WCU- Park visits
Asset geospatial data (e.g., roads, trails)	NPS-IRMA
Geospatial buildings data	NPS- Facilities Management GIS Data Manager
Specific asset exposure	NPS staff discussions