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ASSESSMENT OF COASTAL WATER RESOURCES AND WATERSHED CONDITIONS AT CUMBERLAND ISLAND NATIONAL SEASHORE, GEORGIA

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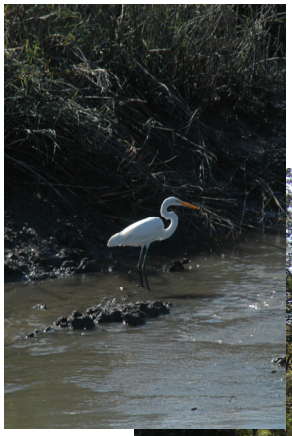

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Assessment of Coastal Water Resources and Watershed Conditions at Cumberland Island National Seashore

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Commonly used abbreviations

CRD – Coastal Resources Division (of the Georgia Department of Natural Resources)
CUIS – Cumberland Island National Seashore (National Park Service designation)
DNR – Department of Natural Resources
EIS – Environmental Impact Statement EPA – U.S. Environmental Protection Agency
EMAP – Environmental Monitoring and Assessment Program (of the EPA)
EPA – U.S. Environmental Protection Agency
EPD – Environmental Protection Division (of the Georgia Department of Natural Resources)
HUC – Hydrologic Unit Code area (geographical region defined by USGS)
GA – Georgia
GIS – Geographic information system
NCA – National Coastal Assessment (of the EPA)
NPDES – National Pollutant Discharge Elimination System (of the EPA)
NPS – National Park Service (in the U.S. Department of the Interior)
NOAA – National Oceanic and Atmospheric Administration (in the U.S. Department of Commerce)
UGA – University of Georgia
USGS – U.S. Geological Survey (in the U.S. Department of the Interior)

Executive Summary

Cumberland Island is a barrier island located in the Atlantic Ocean off the coast of Georgia just north of the Florida border. The east coast of the island is an almost continuous strip of beaches that face the ocean, whereas the remaining shore is a network of tidal creeks that flow through salt marshes and eventually open out into coastal water. Habitats associated with the island include marine areas (offshore water and associated bottom areas, tidal creeks, saltwater ponds) and associated structures (i.e. jetties, docks); intertidal areas (beaches, salt marshes, tide pools); upland areas (dunes, maritime forest, remnant agricultural areas); and inland ponds (both brackish and fresh water). Although Cumberland Island is considered relatively pristine in comparison to more highly developed barrier islands, both point and nonpoint sources of pollutants can be found nearby that have the potential to affect the island. In addition to the numerous industrial and municipal waste facilities in the area, the submarine base at Kings Bay is of concern in terms of the potential effects of dredging and other activity. There are also a significant number of Superfund sites nearby, most of which are located in Brunswick, GA, a port city located approximately 16 miles from Cumberland in Glynn County. (Cumberland itself is in Camden County, GA.) Continuing development in the region could also adversely affect park resources and is an issue of increasing concern.

There were relatively few measurements of water or sediment quality in or around Cumberland Island before 2000. The National Park Service (NPS) Horizon report retrieved all data that had been entered into the U.S. Environmental Protection Agency (EPA) StoRet database for the park and the surrounding area (all lands and waters within at least three miles upstream and one mile downstream) as of November 1993 (National Park Service 1997). The query yielded 48 stations in and around the park, 22 of which contained no data (including all of the stations located within the park itself). Most of the stations represented either one-time or single-year sampling efforts. The report did point to some potential water quality problems in the region: 17% of the dissolved oxygen measurements were less than the EPA criteria of 4 mg L^{-1} for the protection of freshwater aquatic life and 20% of total coliform measurements (19% of fecal coliform) exceeded the criteria for bathing water. The report concluded that there was some evidence that surface waters were affected by human activities, most likely from municipal and industrial effluent.

More recent water quality information comes largely from the monitoring efforts of the Coastal Resources Division (CRD) of the Georgia Department of Natural Resources (DNR), which has 20 monitoring stations located in and around Cumberland Sound. These sites have been sampled on a monthly basis since the summer of 2001 for numerous parameters including concentrations of dissolved nutrients (nitrogen, phosphorus, silica), fecal coliform, and dissolved oxygen. When compared with the criteria established by the EPA as part of the National Coastal Assessment (NCA) program, 56% of the dissolved inorganic nitrogen observations in Cumberland Sound were Good and 44% were Fair (none were Poor). In terms of PO_4, 85% of the observations were considered Fair; 11% are Good, and 5% were Poor. These conditions warrant continued observation. It would also be useful to obtain measurements of dissolved organic nitrogen for the region. Bacterial concentrations were generally low, although state sampling of the beaches in the park has been quite limited (and was recently discontinued).

One of the findings of particular concern in the CRD data set was the frequent observation of low dissolved oxygen concentrations in surface waters in and around Cumberland Sound. Low concentrations (less than or equal to the Georgia DNR - Environmental Protection Division criterion of 4 mg L^{-1}) occurred 16% of the time (182 out of 1136 observations taken between March 2000 and December 2004). Exceedances (values $\leq$ 4 mg L^{-1}) were most common during summer months, with 83% of the low observations occurring between May and September. These low observations indicate a potential problem, as dissolved oxygen concentrations lower than 2.0 mg L^{-1} are considered hypoxic and can negatively affect many estuarine and marine organisms.

Information on metals and other contaminants was compiled from various sources. The EPA Environmental Monitoring and Assessment Program (EMAP) station in Cumberland Sound did not show elevated metal concentrations. Seventeen stations analyzed for a total of 28 analytes were categorized as "Good" in the 2000-2001 National Coastal Condition Report II (U.S. Environmental Protection Agency 2004d) although there were single measurements of lead, arsenic and copper above the program's screening criteria. Historic data collected as part of the Kings Bay Naval Base Environmental Impact Statement (EIS) as well as the information collected by the state to generate fish consumption advisories suggest a potential problem with mercury. Although mercury can come from atmospheric or natural sources, there are also high concentrations of mercury associated with several Superfund sites in the Brunswick region that could be contributing to the problem. In terms of contaminants, the EMAP station in Cumberland Sound (CP95169) showed evidence of elevated pesticide levels in the sediment (dieldrin, lindane, 4,4'-DDD, and 4,4'-DDT, total DDT and 4,4'-DDE), which were again reminiscent of elevated pollutant concentrations observed as part of the EIS (aldrin-dieldrin, DDT, heptachlor, lindane, and heptachlor epoxide). More recent analyses (for the 2000-2001 NCA) suggest that mercury, dieldrin, lindane, DDT, aldrin, and heptachlor are present at very low levels in some sediment samples, and some fish had elevated levels of arsenic, PCB, and dieldrin. However, benthic survival rates for locations in the study area averaged 92%, giving all 17 stations a perfect 5 for a sediment toxicity score. It would be useful to continue sampling sediment and biota in the area.

There are no real sources of pollution on Cumberland Island itself, as the island is largely undeveloped forest and wetlands. However, the large feral horse population represents a source of organic material to the water resources of the island, particularly to inland ponds, tidal creeks, and marshes. In the larger region, both point and nonpoint sources of pollution can be introduced via either the Satilla or the St. Marys rivers, both of which empty into Cumberland Sound to the west of the island. The Crooked River, which has a much smaller watershed, also drains from the mainland into the Sound. There are a total of 29 federally regulated National Pollutant Discharge Elimination System (NPDES) permittees in the study area: 16 in Glynn County (almost all of which are industrial facilities located in and around Brunswick); nine in Camden County itself (the largest of which, Durango-Georgia Paper, is no longer active) and four in Nassau County, Florida. Although there are no current areas in Camden County listed on the Georgia 303(d) list, there are seven regions not meeting designated uses (99 mi^2) in Glynn County, all of which are attributed (at least in part) to industrial sources. Valuable information on point source pollution comes from River Basin Management Plans for both the Satilla and St. Marys rivers prepared by the Georgia EPD (Georgia EPD 2002a;Georgia EPD 2002b). They

report impairments due to low dissolved oxygen, fecal coliform exceedances, and failure to meet fish consumption guidelines issued for high mercury concentrations for different reaches of each river. Information from the Florida 1998 Section 303(d) list includes three segments of the St Marys River in Nassau County not too far from Cumberland Island. The parameters of concern in these reaches include nutrients, mercury, suspended solids, dissolved oxygen, and coliform bacteria.

Nonpoint pollutants are difficult to assess, but the Georgia EPD pointed to nonpoint sources of pollution as having the most significant effects on water quality in both the Satilla and the St Mary's river basins (Georgia EPD 2002b; Georgia EPD 2002a). In a study of nutrient inputs to seven southeastern rivers for the period 1986 to 1990, Asbury and Oaksford (1997) concluded that animal waste was the largest source of both nitrogen and phosphorus in the Satilla River basin, with fertilizer (from both urban and agricultural settings) second. Although the study concluded that most of the nutrients generated in the headwaters appear not to reach the lower coastal plain, the high number of animals in the state is cause for concern.

All of these pollutants affect water quality, which in turn can affect the organisms that live in and around Cumberland Island. The organisms and their habitats can also be affected by physical alterations such as dredging, shoreline changes, and the construction of impoundments, dikes and ditches. The very high rate of growth in the area (the population of Camden County tripled during the 1990s) suggests that pressure on the resources will only increase. There are currently several developments being proposed or expanded in the Cumberland Island area, which will likely result in increased sources of pollution as well as increased boat traffic. The closest, a development called Cumberland Harbour, is located on Point Peter Creek (which is less than two miles from the southern tip of the island). It is slated to have approximately 1200 homes with facilities for as many as 900 boats.

Although it is challenging to draw direct connections between these various influences and specific organisms or habitats, this report describes the organisms that are associated with each habitat on the island, as well as what is known in terms of protected and managed species. There are a number of protected species that inhabit Cumberland Island or its surrounding waters, including shore birds (least terns, oystercatchers, piping plovers, wood storks), sea turtles (loggerhead turtles, *Caretta caretta,* use the beaches for nesting), and marine mammals (manatees, whales). There are also reports of two newly introduced marine species, the green mussel, *Perna viridis*, and the green porcelain crab, *Petrolisthes armatus*, both of which are likely present near the island (Knott and King; Center for Aquatic Resource Studies [USGS] 2002; Bishop and Hurley 2003). The ecological effects of these organisms are still under investigation.

The potential for impairment to the various water resources associated with the park are summarized in **Table i**. Indicators considered include contaminants and other indicators of poor water quality; population effects in terms of fish harvest and invasive species; and habitat disruption. The largest potential water quality problem identified was low dissolved oxygen in Cumberland Sound, but there are also potential problems associated with nutrients and contaminants. Fecal bacteria are a potential problem in areas accessed by feral horses. In terms of population effects, potential problems exist as the result of the introduction of exotic species

in the area. In addition, fish and shellfish (particularly crab) landings have decreased considerably in recent years. Habitat disruption on the island occurs from the activities of feral horses, particularly in tidal creeks and inland ponds. Erosion from boat traffic is also a potential problem in this regard. There are several categories in **Table i** for which there were not enough data to make a judgment, the largest of which is the lack of available information regarding water quality in the tidal creeks.

Table i. Potential for impairment of Cumberland Island water resources

Indicator	Ocean beach	Sound shore	Tidal creeks	FW ponds	Ground water
Water Quality					
Nutrients	LP	PP	ND	LP	LP
Fecal bacteria	LP	PP	ND/PP	ND/PP	ND
Dissolved oxygen	LP	HP	ND	PP	NA
Metal contamination	ND	PP	ND	LP	LP
Toxic compounds	ND	PP	ND	ND	ND
Population Effects					
Fish/shellfish harvest	ND	PP	ND	LP	NA
Invasive species	ND	ND/PP	ND/PP	LP	NA
Habitat Disruption	ND	PP	ND/HP	ND/HP	LP

Definitions:

ND – no data to make judgment, NA – not applicable, LP – low or no problem,
HP – high problem, PP – potential problem

There are a number of additional and/or continuing observations that would be useful to have to better evaluate coastal water resources in the region, and these are summarized in **Table ii**. This includes improved access to existing data; continued monitoring of water conditions (particularly in light of impending development in the area); and selection and monitoring of sentinel organisms in different habitat types that could act as indicators of degrading water quality. In addition, it is important to clarify the hydrology in the area so that the watershed can be better-defined and the links between upstream pollutant and delivery to the area are better-established. In this regard, it would also be useful to determine the residence time of the different sub-water bodies (i.e. tidal creeks; Cumberland Sound) so that there is a means to quantify exposure and the potential vulnerability of different areas to water-borne pollutants.

Table ii. Recommendations

Data access/management

1. Baseline information from CUIS ecological survey
2. Delineation of jurisdictional boundaries

3. Integration of information into a single GIS
4. Improved access to state and federal water quality data and improved metadata

Water quality

1. Continuing and improved measurements of water quality in Cumberland Sound
2. Information on water quality in tidal creeks
3. Targeted monitoring of development projects

Biological resources and habitats

1. Species inventories linked to habitat type
2. Information on habitat disruption
3. Identification of sentinel organisms
4. Population-level information specific to Cumberland Island

Hydrology

1. Reassessment of coastal watershed boundaries
2. Determination of residence times for near-park water bodies
3. Characterization of the potential for erosion

Assessing the effects of watershed conditions on coastal resources requires information not just on the relationship between land use and pollutant loading but also on water transport processes and residence times. These are issues that are not unique to Cumberland, and it would be productive for the National Park Service to work with other agencies on the coast that are actively supporting research on the linkages between land use, water quality, and coastal resources.

A. Park Description

A1. Background

A1a. Setting

Cumberland Island, one of Georgia's coastal barrier islands, is located near the Georgia/Florida border in Camden County, Georgia (**Figure 1**). Jekyll Island lies to the north of Cumberland Island (across St Andrews Sound), Kings Bay (and a U.S. Naval Submarine Base) lies to the west, and Amelia Island, Florida is to the south (across the St Marys River entrance to Cumberland Sound). The Cumberland Island National Seashore (CUIS) is comprised of the majority of Cumberland Island proper and the surrounding marshes and islands, (with the exception of Little Cumberland Island, all of which is privately owned, and several private in-holdings on the island itself). The island is approximately 17.5 miles long, the width varies from one-half mile to three miles (Hillestad et al. 1975), and the total area (including intertidal area) is 36,402 acres (14,731 hectares).[1] The NPS manages the National Seashore (7,096 acres) as well as the portion of Cumberland Island designated as Wilderness (8,674 acres) (Kramer et al. 2003). Note that the NPS only has jurisdiction over those portions of the island that are above the mean high tide line. Intertidal areas (i.e. salt marshes and beaches) and subtidal areas (i.e. tidal creeks and estuarine waters) are held in public trust by the state of Georgia and are managed by the Coastal Resources Division of the Georgia Department of Natural Resources (CRD). **Figure 2** shows the extent of the park boundaries and jurisdiction of the managing authorities.[2]

The majority of Cumberland Island formed during the Pleistocene Epoch (35,000 to 40,000 years ago), whereas the marshes and the seaward portions of Cumberland and Little Cumberland Islands formed mainly during the Holocene Epoch (4,000 to 5,000 years ago). Soil types present on the island include Capers soil, Chipley sand, Duckston sand, Fripp-Leon sand, Johnston loam, Lakeland sand, and Olustee sand (Hillestad et al. 1975) The overall profile of Cumberland Island is typical of a large barrier island. The ocean side is characterized by wide sandy beaches, beyond which lie primary and secondary dunes with lower interdunal areas. Upland of the dunes is a shrub zone which gives way to maritime forest. In addition to forested uplands, the interior of the island also contains low-lying wetlands. On the back side (west) of the island is a broad expanse of salt marshes and tidal creeks. These marshes, which eventually feed into Cumberland Sound, serve to separate the island from the mainland. More detail on land cover and various habitat types are presented in **sections A1b** and **A3**.

Although Cumberland Island is considered relatively pristine in comparison to more highly developed barrier islands, both point and nonpoint sources of pollutants can be found nearby that have the potential to affect the water resources of the island. In addition to the numerous industrial and municipal waste facilities in the area, the submarine base at Kings Bay

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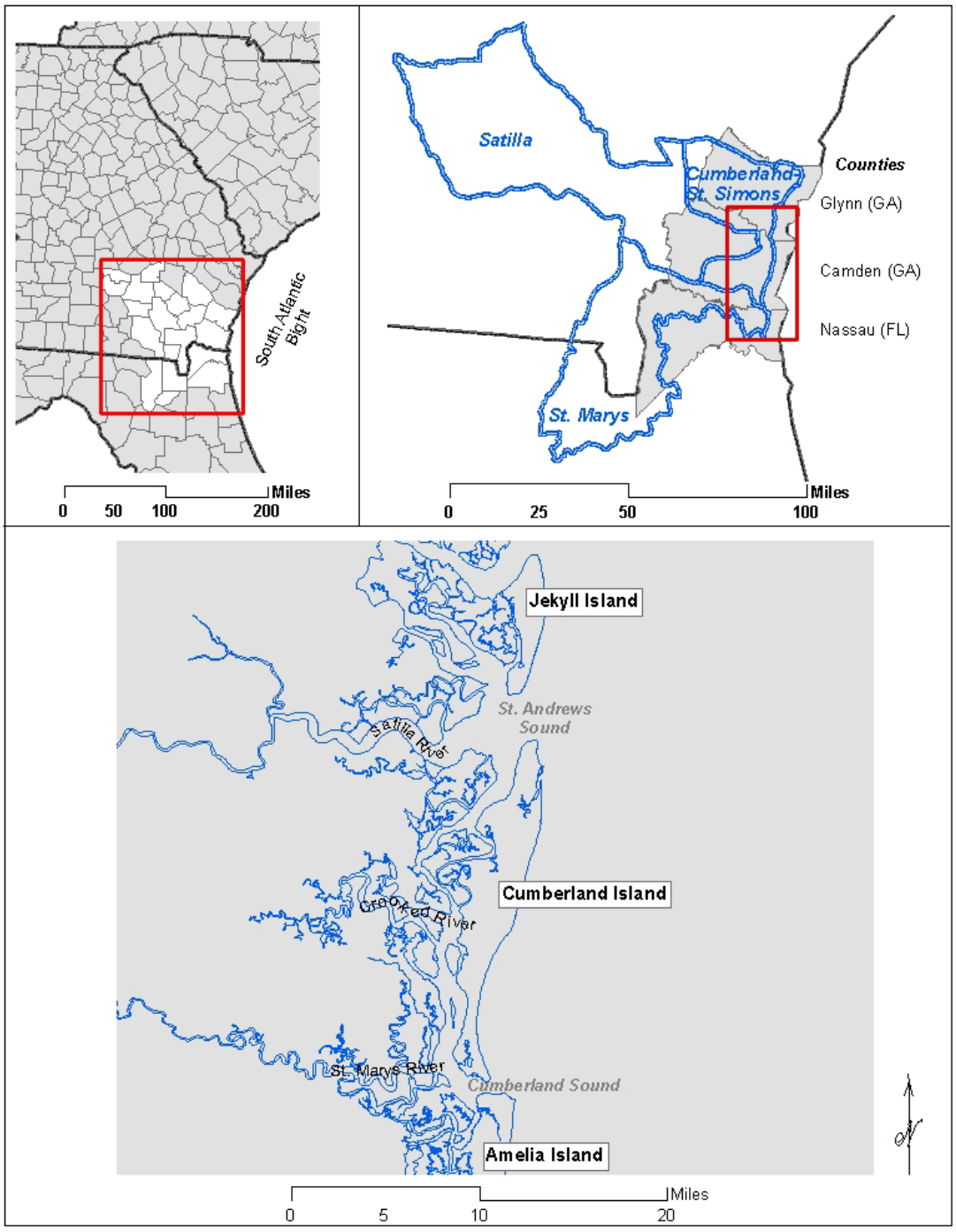
[1]The GIS analysis contained in this report utilizes the park polygon from the U.S. National Park Service web page (http://www.nps.gov/gis/metadata/water_resources/cuis.html) as the National Seashore boundary. This includes Little Cumberland Island as well as the intertidal areas of Cumberland Island.

[2] Figure 2 does not indicate Drum Point Island, which is owned by the Navy, and a portion of Raccoon Keys, which is owned by the U.S. Army Corps of Engineers. To our knowledge, publicly available spatial databases delineating the extent of these managed areas do not exist.

is of concern in terms of the potential effects of dredging and other activity, and there are a significant number of "Superfund" sites in the watershed. Moreover, continuing development in the region could significantly affect the park.

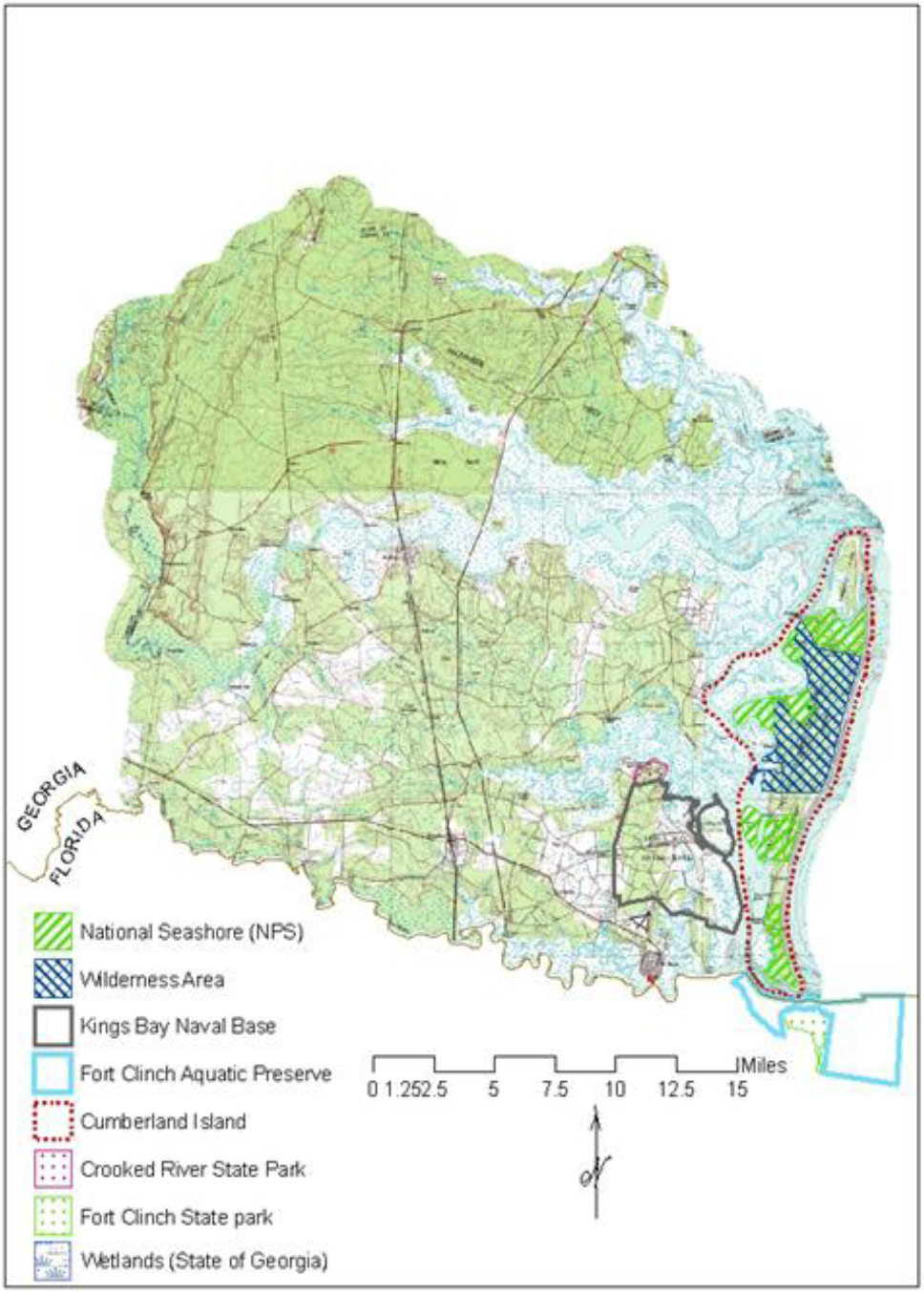
Figure 1. Location map of Cumberland Island in the southeastern United States



Various levels of geographic analysis were undertaken for this report. Cumberland Island is in the watershed of the Satilla River, Georgia. The USGS divides the Satilla into three 8-digit hydrologic unit code areas (HUCs 03070201-3) and Cumberland falls within the most

Figure 2. Location of Cumberland Island in Camden County, Georgia along with jurisdictional boundaries

Background image 1:100,000 digital raster graph (Musser 1997).



downstream one (03070203), which is called Cumberland-St. Simons. The island is also influenced by the outflow of the St. Marys River (HUC 03070204), which empties into Cumberland Sound just to the south. The Cumberland Island-St. Simons HUC is split between Camden County (which is where CUIS is located) and Glynn County. The St. Marys HUC is split between Camden County and Nassau County, Florida. Depending on the level at which information was available and/or judged relevant, data are either presented by HUC, by county, for the island itself, or for the Cumberland-St. Simons portion of Camden County.

A1b. Land cover

Regional analysis

Payne et al. (2003b) used 1996 to 1998 *Landsat* 5 TM data as baseline imagery to develop land cover maps of the state of Georgia. Land cover classifications for both the Cumberland-St. Simons HUC and Camden County are shown in **Figure 3**. The most common land cover classifications in the Cumberland-St. Simons watershed are managed pine (120,239 acres) and salt marsh (109,393 acres), which together cover 46.1% of the total area. Other important classifications are forested wetlands (evergreen forested wetland, deciduous forested wetland, mixed forested wetland, and cypress gum), which together account for an additional 14.9 % of the area, and roads and clearcut/sparse areas, which account for 12.3 %. These proportions are similar to those observed in Camden County as a whole, although the county does not have as much area classified as salt marsh (78,792 acres, which accounts for 17.6 % of the total area). The amount of land classified as either commercial/industrial or low density residential was comparatively small when considered either in terms of the county (8,200 acres) or the watershed (11,897 acres). The highest population density in Camden County is found in the St. Marys-Kingsland corridor. A total of 164 acres in the county and 155 acres in the Cumberland-St. Simon's watershed were classified as high density residential.

We compared the current information on land use (which is from 1998) with an analysis done in 1992 (Vogelmann et al. 1998) as well as one based on information from 1988 to 1990 (GADNR 1995). All three maps were analyzed to determine the distribution of land use types in terms of both the Cumberland-St. Simon's watershed and Camden County (**Table 1**). (Note that in order to do this comparison, all land cover groups from the three datasets were "cross-walked" or reclassified to the common set shown.) The most obvious change in both data sets is the decrease in mixed forest after 1990, with a concurrent increase in coniferous forest. It is not clear if this reflects an actual land use change or a change in classification. A change that is more relevant is the increase in the high intensity urban category from 1988 to 1998, which increased from 1 to 8% in the watershed and from 1 to 7% in the county.

Figure 3. 1998 land cover map of Camden County, Georgia and the Cumberland-St. Simon's watershed

(Payne et al. 2003)

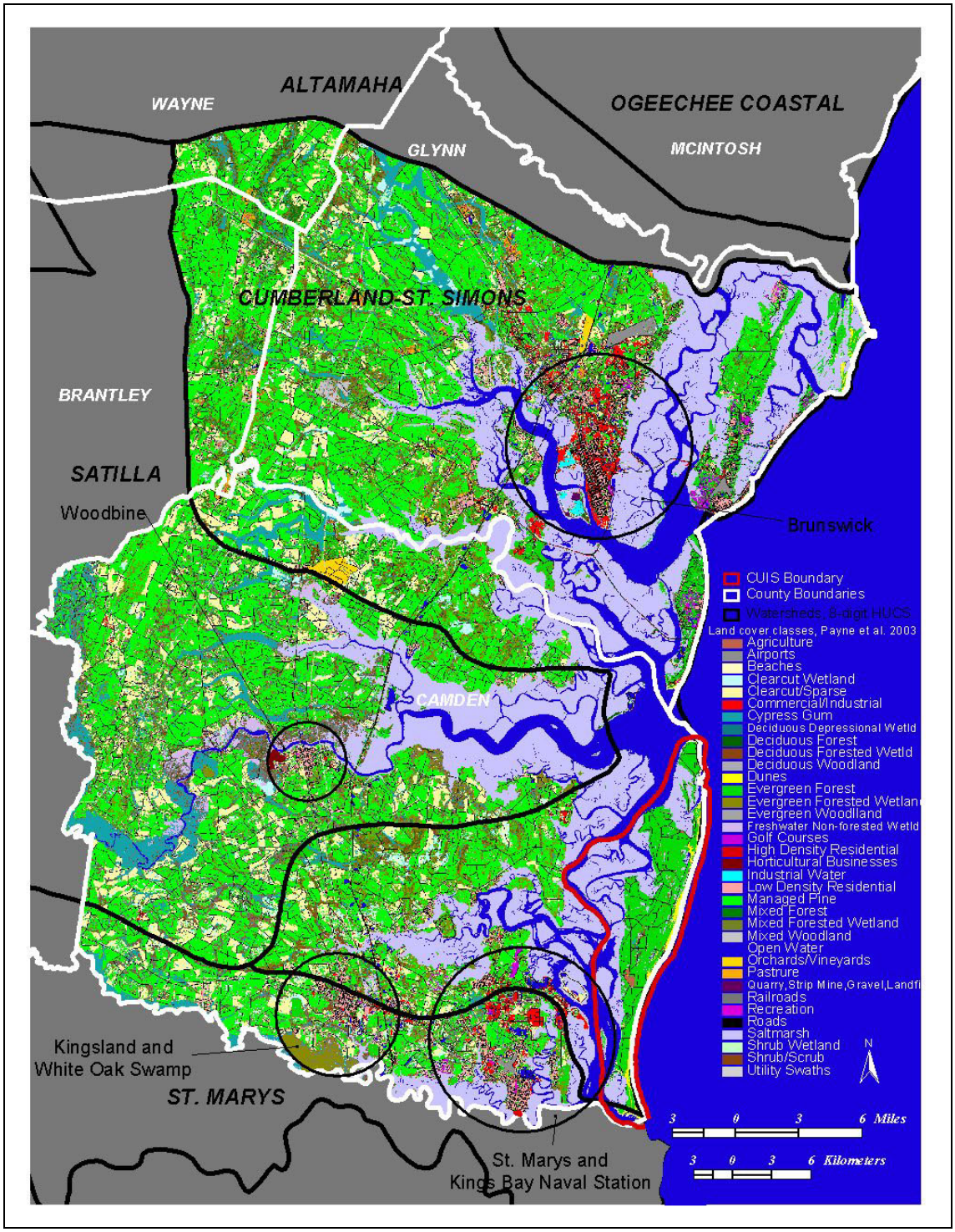


Table 1. Land cover percentage comparisons for Cumberland-St. Simons HUC and Camden County, Georgia

Land Cover Type	Cumberland – St Simon's			Camden County		
	1988 to 1990	1992	1998	1988 to 1990	1992	1998
Open Water	12%	14%	11%	9%	11%	9%
Clearcut/Young Pine	7%	4%	8%	7%	5%	11%
Pasture	1%	1%	1%	0%	1%	0%
Cultivated/Exposed Earth	2%	2%	1%	1%	1%	1%
Low Intensity Urban	2%	2%	1%	1%	1%	1%
High Intensity Urban	1%	2%	8%	1%	1%	7%
Emergent Wetland (salt and fresh)	21%	19%	22%	18%	17%	19%
Shrubland and Woody Wetlands	20%	16%	15%	22%	21%	21%
Coniferous Forest	18%	35%	30%	22%	38%	30%
Mixed Forest	13%	3%	1%	15%	2%	1%
Hardwood Forest	3%	2%	1%	3%	1%	1%

Cumberland Island

Land cover classifications for Cumberland Island itself are shown in **Figure 4** and summarized in **Table 2**. Out of a total of 36,384 acres included in the analysis, salt marsh was again a dominant classification, accounting for almost 30% of the area (10,717 acres), with another 30% classified as evergreen forest (10,924 acres). The evergreen forest category is comprised of longleaf pine, loblolly-slash pine, and live oak. Although live oak is technically a hardwood, it rarely sheds its leaves in southern Georgia and so was included with evergreen forest in this analysis. In contrast to the land use breakdown observed in the larger watershed or the county (**Figure 3**), very little of the island is in managed pine (only 11 acres).[3] Open water accounted for an additional 9,651 acres; dunes and beaches totaled 2,416 acres; and forested or shrub wetlands comprised 946 acres. Developed area (low density residential and commercial/industrial) was only 10 acres. The Georgia GAP project did a similar analysis of land cover for Cumberland Island, based on the same imagery as that presented here, with fairly comparable results. (*For a detailed comparison of the two analyses, see* **Appendix A**.)

[3] This is an unrestored remnant of the Carnegie pine plantation and is not actively managed.

Figure 4. Land cover -- Cumberland and Little Cumberland Islands

(Payne et al. 2003)

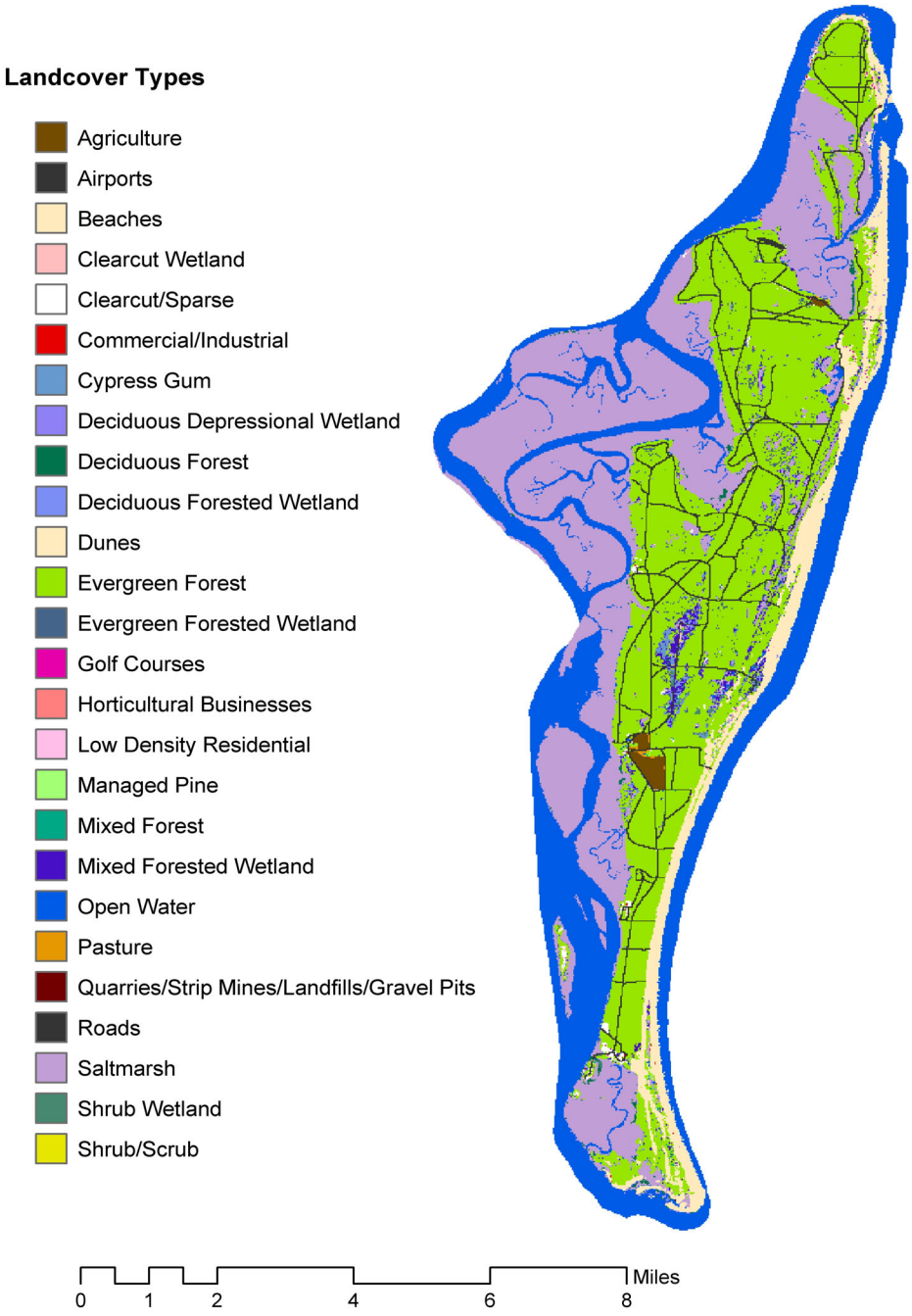


Table 2. Summary of land use classifications on Cumberland Island

(Payne et al. 2003a)

Land use classification	Acres	% of total
Beaches	1,169.1	3.2
Dunes	1,246.7	3.4
Open water	9,651.4	26.5
Airports	14.5	< 0.1
Roads (*overestimate*)[4]	1,190.6	3.3
Low density residential	2.7	< 0.1
Clearcut/sparse	95.4	0.3
Clearcut wetland	57.4	0.2
Shrub/scrub	2.0	< 0.1
Pasture	13.3	< 0.1
Agriculture	147.8	0.4
Salt marsh	10,721.7	29.5
Shrub wetland	38.0	0.1
Evergreen forested wetland	300.1	0.8
Deciduous forest	151.8	0.4
Evergreen forest	10,924.0	30.0
Managed pine	11.3	< 0.1
Mixed forest	12.7	< 0.1
Cypress gum	80.7	0.2
Mixed forested wetland	346.8	1.0
Deciduous forested wetland	157.6	0.4
Deciduous depressional wetland	22.9	0.1
Other	30.2	< 0.1
Total	36,388.7	100

A total of 11,725 acres were classified as wetland[5] in the present analysis, of which 10,722 is salt marsh. We compared this with several other estimates, which range from 11,349 to 15,347 acres (**Table 3**). [The NPS website estimates that Cumberland Island has 16,850 acres of marsh, mud flats, and tidal creeks (http://www.nps.gov/cuis/)]. The reason for the discrepancies among these estimates may be due to differences in the spatial resolution of the source data used in different studies and/or differences in the treatment of open water areas such as tidal creeks. The National Wetlands Inventory identified 65 different types of wetlands on Cumberland Island. Estuarine intertidal wetlands were the most common, but in their analysis freshwater wetlands accounted for approximately 2,500 acres. These include upland ponds and

[4] The source for both the USGS and the Payne landcover dataset is *Landsat* V, which has 30-meter resolution. During image processing, any pixel (30 m by 30 m) with a road passing through it was classified as a road, even if the road was only 5 or 6 m wide. Otherwise, roads would fall entirely below the 30-m resolution of the imagery. Therefore, roads are overestimated to a large degree, and landcover of this type should be ground-truthed.

[5] The wetland classes are: clearcut wetland, salt marsh, shrub wetland, evergreen forested wetland, cypress gum, mixed forested wetland, deciduous foreseted wetland and deciduous depressional wetland.

seasonal wetlands that can be found in interdunal swales and low-lying areas in the island interior (Frick et al. 2002). It would be useful to groundtruth some of the other categories, particularly those areas classified as agriculture, as these are not readily identifiable on the island.

Table 3. Databases for estimating wetland extent within Cumberland Island

Source	Database[6]	Scale	Wetland Area (Acres)
Payne et al. (2003b)[a]	1998 Land cover	1:24,000	11,725
U.S. Fish & Wildlife Service (varies, 1981 to present)[b]	National Wetlands Inventory	1:20,000 to 1:132,000; most 1:24,000	15,347
U.S. Geol. Survey (2000b) [a]	1998 Land cover	1:24,000	12,085
GA Dept. of Transportation (1997)[c]	Polygonal Hydrography	1:24,000	11,503
GA Dept. of Transportation (unpubl. data)[d]	Camden Wetlands	unknown	11,349

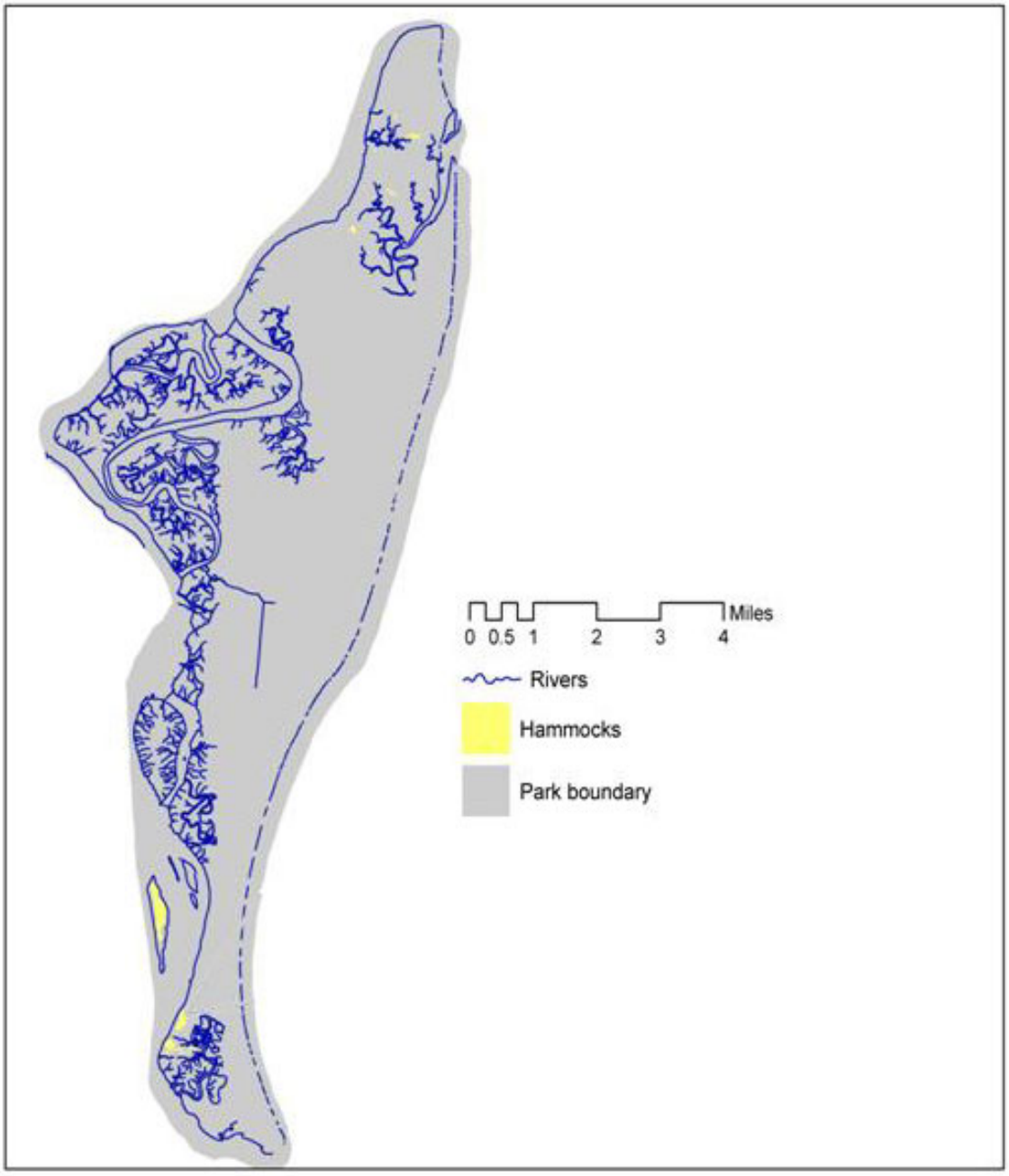
[a] derived from *Landsat* TM data (30-meter resolution)
[b] primarily derived from aerial photo interpretation
[c] determined by capturing information from topographic sheets
[d] unknown methodology

Marsh hammocks

One of the common features of the salt marshes of Georgia is the presence of small islands surrounded by marshlands or tidal creeks. These upland areas are nested between the mainland and larger barrier islands, and are called back barrier islands or marsh hammocks. The state of Georgia has identified 20 marsh hammocks covering a total of 112 acres within the National Seashore Boundary. Many of these are located on Little Cumberland Island, but several also occur on the southern tip of Cumberland Island (**Figure 5**). The hammocks range from 0.1 to 65 acres in size, with an average size of 5.6 acres. Seven (35.3 acres) are federally owned and 13 (76.5 acres) are privately owned. The potential development of hammocks on the Georgia coast is an active and contentious issue. The state is currently considering permitting developments based on the size of the hammock. The state's database indicates that one of the hammocks at Cumberland (Dungeness hammock at Raccoon Keys) has a causeway connecting it to other upland areas. This site is a former dredge spoil area now used as a source for road fill. As described earlier, Raccoon Keys is an area of the island managed outside of the NPS (it is U.S. Army Corps of Engineers property). More information on the location of hammocks in the region can be found in **Appendix B**.

[6] The 1997 land cover data from the National Oceanic and Atmospheric Administration Coastal Change Analysis Program covers only the northern third of Cumberland Island and is not included in this list.

Figure 5. Hammocks within the CUIS park boundary



A1c. History and human utilization

Cumberland Island was likely first populated by the Timucuan people around 4000 years ago. The Timucuan name of the island was "Misso" or "Wisso", which means sassafras. Sassafras was valued by Europeans as a medicinal plant and it is speculated that early traders

engaged with the Timucuan for this resource. Spaniards settled on Cumberland in the mid 16th century for its good port and strategic location. They used the island for more than 100 years and established an important mission there, San Pedro Mocama.

English General James Oglethorpe, considered to be Georgia's founder, came to the island in 1736.[7] Two British forts were built on Cumberland Island: Fort St. Andrew (~ 1736, a large fort on the north end of the island) and Fort Prince William (~ 1740, on South Point). Between 1765 and 1769 a number of British land grants were issued on Cumberland Island, forming the basis for the dozen or so plantations and small farms cultivated by slave labor during the next century. Sea Island cotton, a desirable long-fibered cotton (imported from the Caribbean in 1786) was the most plentiful and perhaps profitable crop although many others were grown including rice, indigo, corn, sweet potatoes, and sugar cane. Oranges, lemons, pomegranates, figs, and olives were cultivated at various times in plantation orchards (Griffin 1991). Timber extraction was also a successful, albeit unsustainable, industry: century-old pine and live oak trees were harvested for ship-building in the 18th and early 19th century. Horses were first brought to Cumberland by the Spaniards and cattle were likely introduced in the early 18th century (they were already known on nearby Jekyll Island by 1737, (Georgia Humanities Council 2004)). Hogs, too, were brought to the island and along with the cattle and horses eventually became feral inhabitants. Cattle were fully removed by the 1980's and the remaining pigs are being eliminated by the NPS (*see* **section C2**).

After the social and economic changes brought about by the Civil War, the pattern of land ownership on Cumberland changed significantly. After the war, newly freed slaves established a settlement on the North End.[8] Lands were then purchased by outsiders attracted to the isolated nature of the landscape. Thomas Carnegie purchased two defunct plantations for entertaining and hunting (one in 1881 and one in 1882), and by the early 1900's the Carnegie family owned more than 90% of the island. It was during this time that T. Morrison Carnegie attempted to establish a tung tree plantation to produce tung oil, the valuable nut oil used in wood finish, paints, and inks.[9] Population again dwindled as land-holders and their descendents died off, and parcels were bought by prospective developers, including Charles Fraser, known for the development of Hilton Head. After Fraser began to construct a 5,000-ft airport runway on the north end of the island in 1969, protection efforts began in earnest. Results of an earlier study by the NPS had rated Cumberland as one of the top sites of national significance along the Atlantic and Gulf coast. With this information in hand, Congressmen Bill Stuckey and Bo Ginn introduced a bill which established Cumberland Island as a national seashore and President Nixon signed the bill in 1972 – just two years after electricity came to the island (Hillestad et al. 1975; Koransky 1999; National Park Service 2004a).

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[7] Per the suggestion of an Indian companion named Toonahowie, Oglethorpe named the island after the Duke of Cumberland, William Augustus, whom Toonahowie had met while in England.

[8] The descendents of this community of African Americans and others like it along the Georgia-Carolina coasts is known for their language and culture, called Gullah.

[9] Some members of the Carnegie family also sought to profit from the natural mineral resources on the island (ilmenite, leucoxene, rutile, zirconium, and rare earth minerals). However, a $9 million mineral rights bid from the Glidden Company of Cleveland was invalidated in the late 1950's by the state Supreme Court because the life of the mineral lease would have extended beyond the life of the Carnegie family's trust in the land.

Today, recreational visits to the national seashore represent the most common usage of the island. NPS records show that 41,612 visitors came to CUIS in 2003 (down slightly from previous years) (National Park Service 2004a). This is an average of 114 visitors a day, well below the legislated daily maximum capacity of 300 visitors (National Park Service - Southeast Coast Network 2004 – appendix 5 of the Issues document). Visitors come primarily by ferry from St. Marys, although some come by private boat. Popular activities on the island include fishing, boating, hiking, camping, and swimming. Activities within CUIS are fairly restricted: camping is only allowed at Sea Camp Beach Campground and several backcountry sites; no campfires are allowed, except for those in designated fireplaces at Sea Camp Beach Campground; all supplies are "pack in" and all trash must be packed off the island; and potable water is only available at the visitor center, the ranger station, the Ice House Museum[10], and the campgrounds (National Park Service 2004a).

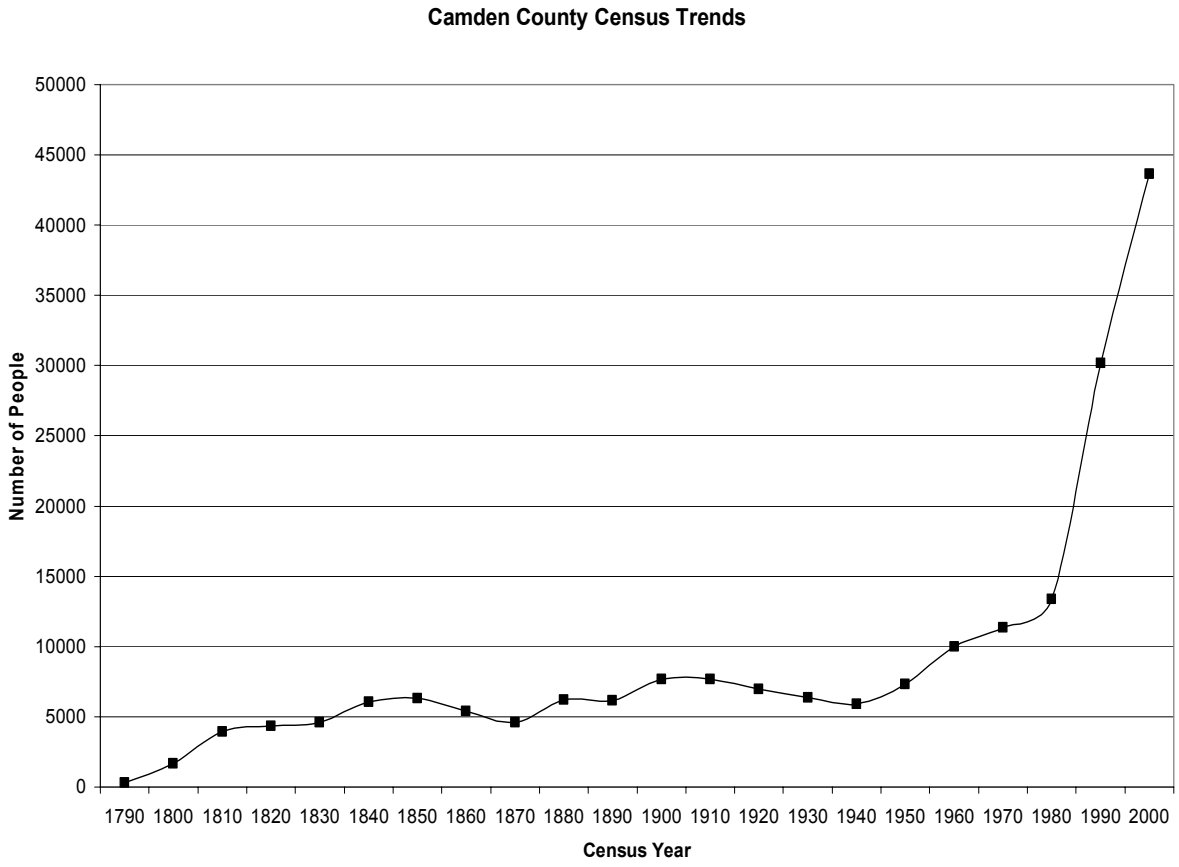
Additional activity on the island results from residents and visitors to privately owned in-holdings, which do not fall under the National Park Service's jurisdiction. There are two types of in-holdings on the island: retained rights and private. In areas of retained rights, the property has been sold to the National Park Service but the individual or family has rights to continue using the property until a given date or specified circumstance. While the National Park Service has jurisdiction over these properties there are certain rights and responsibilities to which both parties must adhere. Private land owners own property outright and the National Park Service has no jurisdiction or ownership. Private holdings on Cumberland Island total between 650 and 700 acres and include, among others, Greyfield Inn and the Rockefeller tract. According to the 2000 census, Cumberland Island currently has 13 households with 17 residents and Little Cumberland has 15 households and 25 residents.[11] However, Little Cumberland Island may have as many as 80 homes (National Park Service - Southeast Coast Network 2004). This difference likely reflects the seasonal occupation of the region. Private residents of Cumberland Island are permitted to travel on the island with personal vehicles, and may additionally venture on and off the island with private boats. The only public accommodations on the island are at the Greyfield Inn, which has 11 rooms.

Although Cumberland and Little Cumberland Island have a very small residential population, population in Camden County has increased, with more than a three-fold increase between 1990 and 2000 (**Figure 6**). This trend is in keeping with the increase in high intensity urban development noted in **Table 1**. A comparison of census tract data from 1990 with that from 2000 reveals that most of the growth occurred in the southern portion of the county (**Figure 7**). Between 1990 and 2000 the southern portions of Camden County experienced so much population growth that an additional census tract was created from what had been a single tract. Much of this increased population occurred in the area of St. Marys, following expansion of the Kings Bay Naval Station (1978-1989). There are currently several proposed developments in the area that would serve to increase growth further in the area. [*These are discussed in* **section C1**].

[10] The National Park Service operates the Ice House Museum, located at the Dungeness Dock on Cumberland Island, as well as a mainland Visitor Center and Museum, located in St. Marys. The Cumberland Island Museum, which is a private entity, is also located on Cumberland Island.

[11] Cumberland Island population based on Tract 106, block group 3, blocks 3001, 3002, 3003, 3004, 3005, 3995, 3996, 3997, and 3998; Little Cumberland Island based on Tract 106, block group 3, blocks 3000 and 3006 (US Census Bureau 2000).

Figure 6. Trends in Camden County population: change in total population

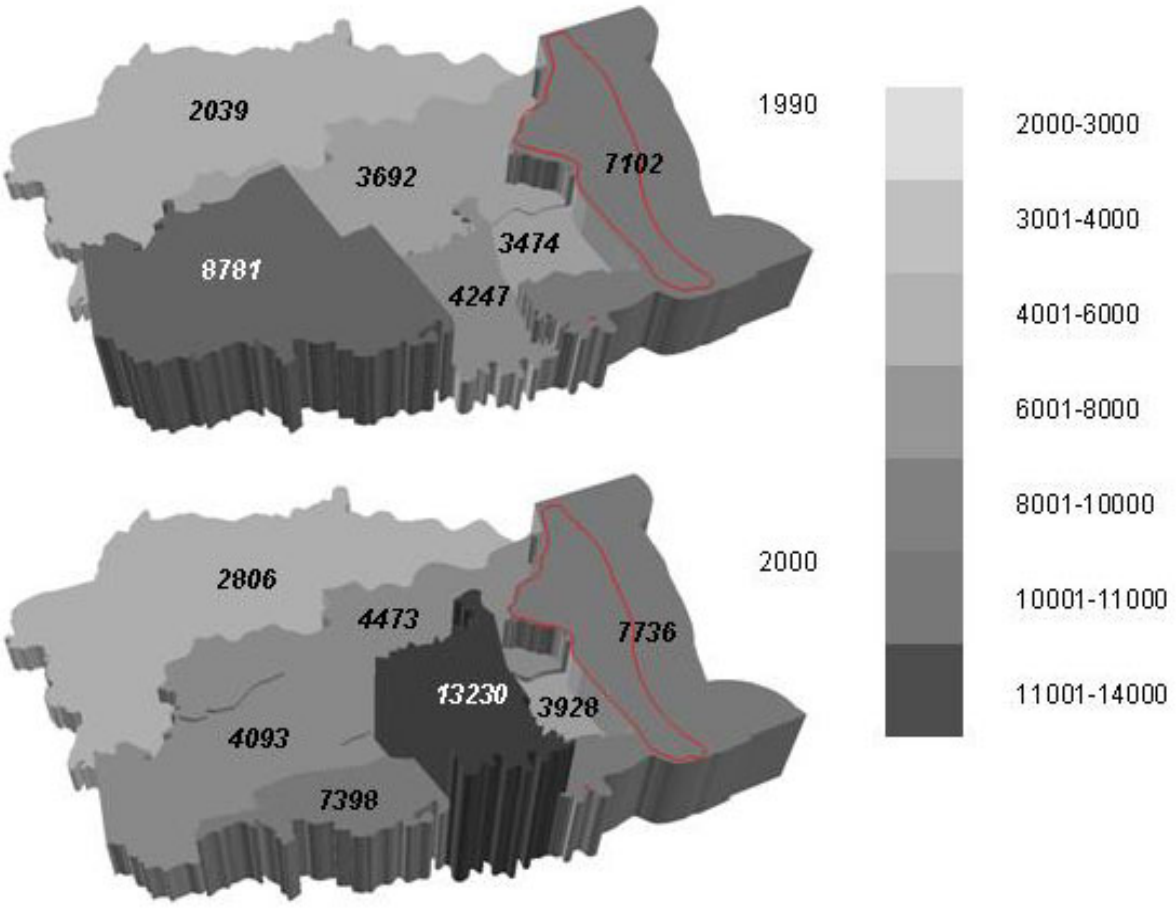


A2. Hydrologic information

A2a. Oceanographic and climatic setting

The South Atlantic Bight extends from Cape Hatteras, NC to West Palm Beach, FL. Cumberland Island is in the middle of the Bight at the location where the Atlantic Ocean reaches its westernmost point on the continental U.S. The broad expanse of the Continental Shelf in this area helps to protect the island from wave and storm activity but it also serves to funnel the tides. Tides, which are semi-diurnal, range approximately 6 ft (1.8 m) at neap tide and can exceed 8 ft (2.4 m) during spring tide. The Gulf Stream has a pronounced influence on the outer shelf, but closer to shore (up to 66 ft [20 m] depth), wind, tide, and freshwater inflow are the main forces affecting circulation. Salinity of the outer shelf waters are typically 35 practical salinity units, but with increased river flows in the late spring, nearshore waters may fall below 30 and may remain somewhat stratified through the summer. Freshwater runoff has a greater influence on the west side of Cumberland Island: salinity in the Sound varies from around 16 at winter low tide to 29 at autumn high tide (Naval Facilities Engineering Command 1975). The spring tidal prism (the difference between the high and low tide volume during spring tide) is estimated to be from 6 to 10^9 ft^3 in Cumberland Sound (Fisackerly et al. 1991).

Figure 7. 1990 (top) and 2000 (bottom) U.S. census tract data for Camden County, Georgia, showing the total number of people per tract



Five wind patterns have been identified in the region. Winter (Nov – Feb) brings southward winds with cold fronts passing each 2 to 10 days (during a front, winds may be in a more offshore direction). Spring (Mar – May) is characterized by eastward and northeastward winds with great variability in flow over the region. In summer (Jun – Jul), more northward winds blow across coastal Georgia. The Fall Transition (Aug) is a period of inconsistent wind patterns, while during the Mariners Fall (Sept – Oct) winds are strong and more south- or southwestward (Menzel 1993). The climate in the area is characterized by hot summers, mild winters, and a mean annual temperature of about 68^{o}F (20^{o}C) (Georgia EPD 2002a; Georgia EPD 2002b). Water temperatures may fall below 50^{o}F (10^{o}C) in February or March and will reach 83^{o}F (28^{o}C) or higher in the later summer. Average annual rainfall in the area is 50 inches (127 cm); summer is the wettest period of the year and autumn is the driest (Georgia EPD 2002a; Georgia EPD 2002b).

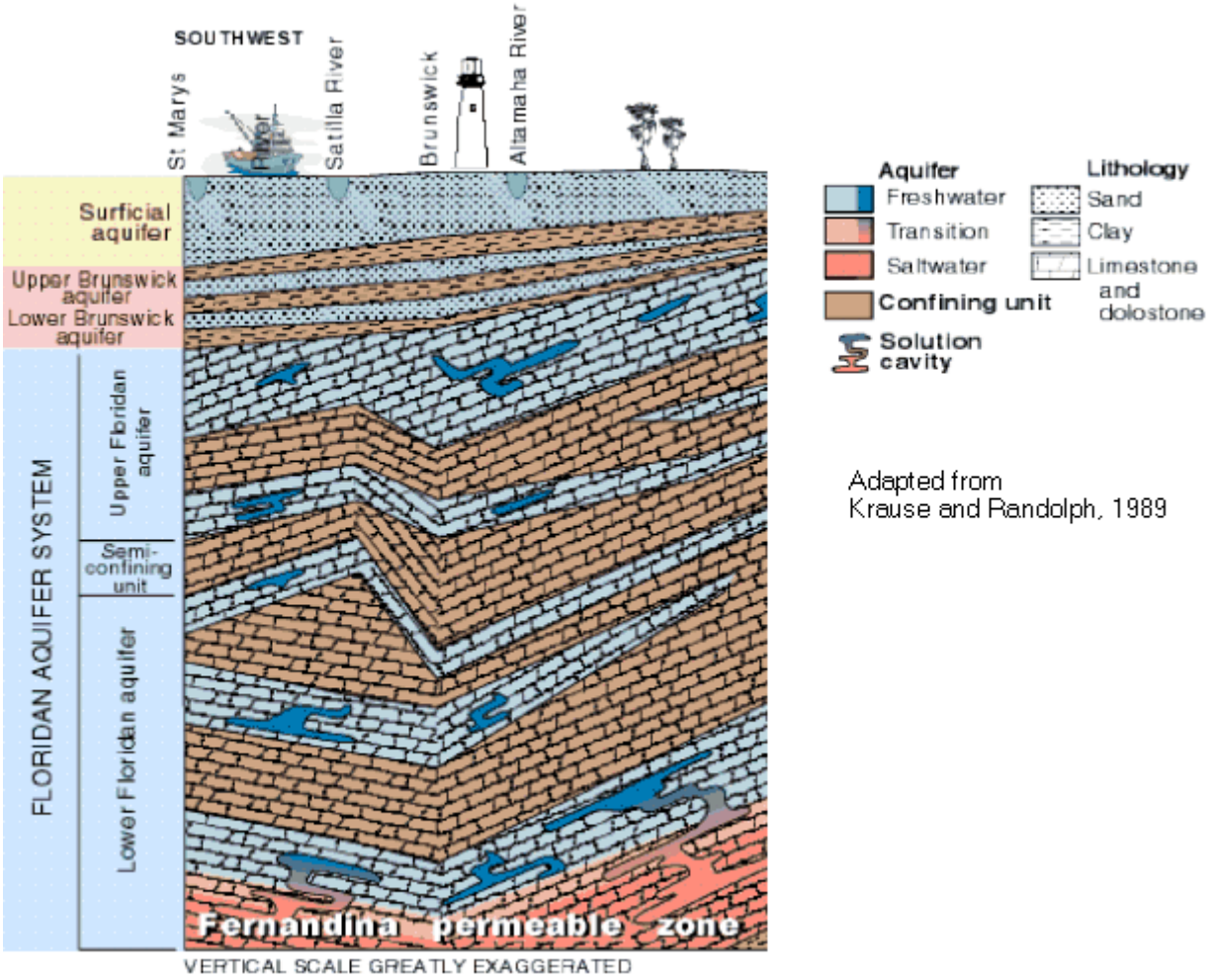
A2b. Hydrology

Three rivers enter the area west of Cumberland Island, bringing fresh water and materials to the Sounds that surround the island: The Satilla River enters St. Andrew Sound between Jekyll and Cumberland Islands; the Crooked River enters Cumberland Sound near the island's mid-point; the St. Marys River flows into Cumberland Sound at the southern tip of the island. The Satilla contributes the most fresh water of the three rivers and drains the largest amount of upland area. The basin covers 3,940 mi^2 and the river itself is approximately 250 miles long. Median discharge is 34 m^3s^{-1} (Alber and Sheldon 1999). The watershed of the St. Marys River is approximately 1,300 mi^2 (of which 59% is in Georgia and 41% is in Florida) and median discharge is 15 m^3s^{-1}. The Crooked River is comparatively small, draining only 68 mi^2. Because the Satilla is the largest river in the area, and because the littoral current runs generally southward, materials from the Satilla River may have a greater influence on the water quality of Cumberland Island than those that enter from the other rivers. However, discharge from the St. Marys is certain to affect Cumberland Island: drogue studies show that the direction of current flow in the Cumberland Sound region is affected by freshwater flow (and wind). During ebb tide, water flows southward through the Sound, but during flood tide, water flows north along Cumberland Sound from the St. Marys channel (Naval Facilities Engineering Command 1975).

Another hydrologic factor that must be considered is the influence of groundwater. The surficial aquifer can interact with surface water and affect water quality conditions, particularly in freshwater wetlands. The surficial aquifer on Cumberland consists of an unconfined or surficial aquifer of Pliocene-Miocene sediment interspersed with younger clay, sand, and limestone, and can be up to 280 ft thick. Below the surficial aquifer are first the Brunswick and then the Floridan aquifers, both of which are confined aquifers with no direct connection to surface water. The Brunswick aquifers (375 to 500 ft deep) are predominantly Miocene sand sequestered into an upper and lower aquifer, each about 50 ft thick. The Upper and Lower Floridan aquifers are composed of limestone and other Eocene or Oligocene carbonates and are 700 ft to more than 2,500 ft thick (**Figure 8**).

The Upper Floridan aquifer is the primary source of fresh water for all of coastal Georgia including Cumberland Island (the Lower Floridan aquifer is saline). Groundwater withdrawals from this aquifer have resulted in saltwater contamination in several locations on the Georgia coast, and a cone of depression developed near St. Marys as the result of industrial pumping. More information on groundwater use can be found in **section C3d** (*artesian wells*, p. 86). A significant effort is now underway to understand coastal groundwater supplies through a USGS / Georgia DNR-EPD cooperative study, the Sound Science Initiative (http://ga2.er.usgs.gov/coastal/).

Figure 8. Geologic framework for coastal groundwater in southern Georgia



The studies being performed as a part of this initiative will provide better information regarding the movement of water through the aquifer and the ways in which groundwater utilization might be reduced so that the saltwater does not spread. Although saltwater has been found in Cumberland Island's surficial aquifer (on the south end of the island), intrusion into the Upper Floridan has not been observed: a recent analysis shows the potentiometric surface of the Upper Floridan on Cumberland Island measures 18 to 40 feet above sea level (Frick et al. 2002). (*See also* **Appendix G**, USGS water resources site inventory). This issue is important in terms of the drinking water supply to Cumberland Island, but it should not have any direct effects on surface water resources.[12] Of more immediate concern is that there are a number of abandoned artesian wells on the island that were not properly capped (National Park Service, 2004). These are now

[12] There has been some concern that groundwater pumping from the Floridan aquifer on the mainland could adversely affect the wetlands of Cumberland Island. However, in a report that directly evaluated this issue, Martin (2001) could find no corroborating evidence for this claim.

releasing significant amounts of water and are likely affecting local drainage patterns and habitat characteristics (*see* **section C3d**).

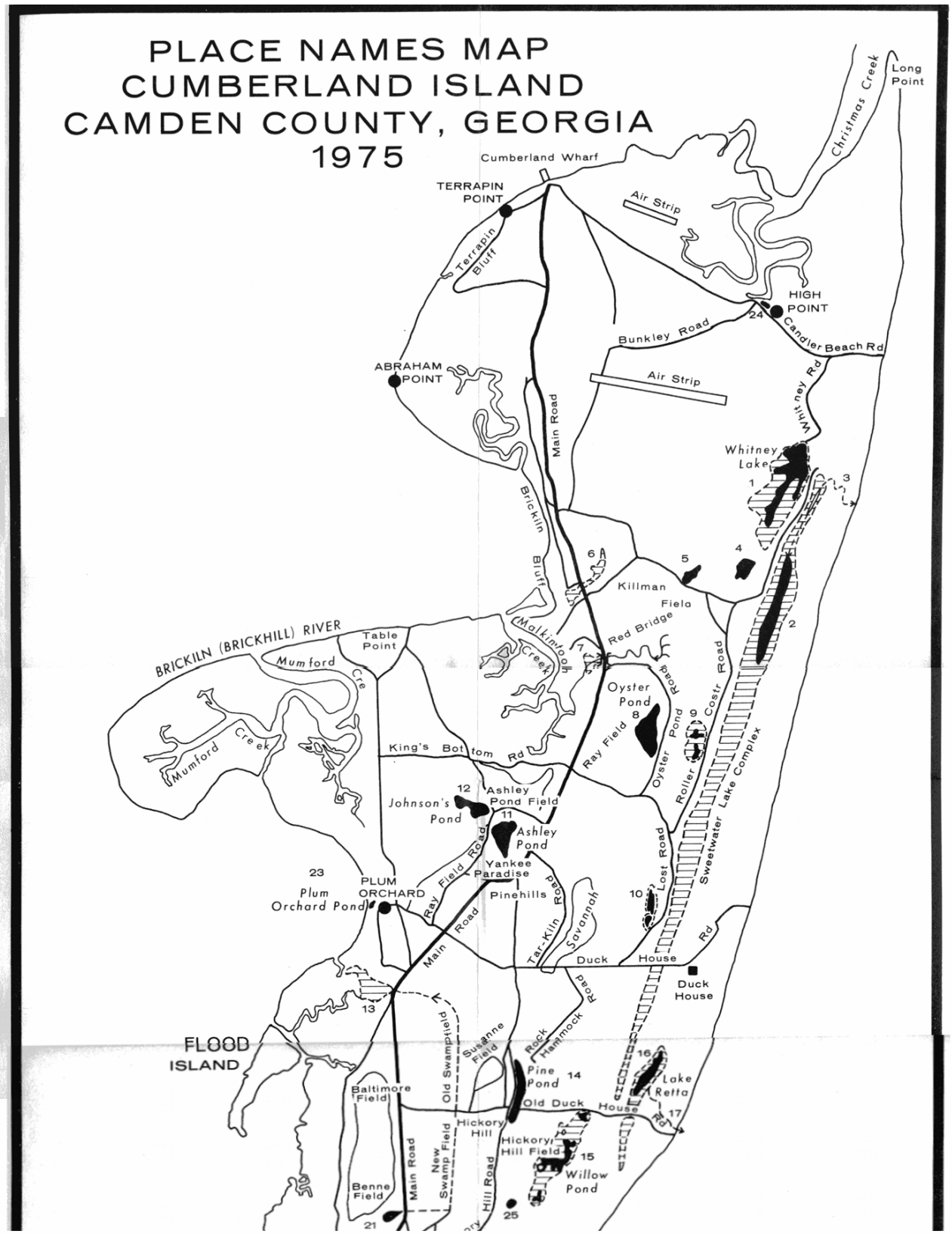
A2c. Water resources

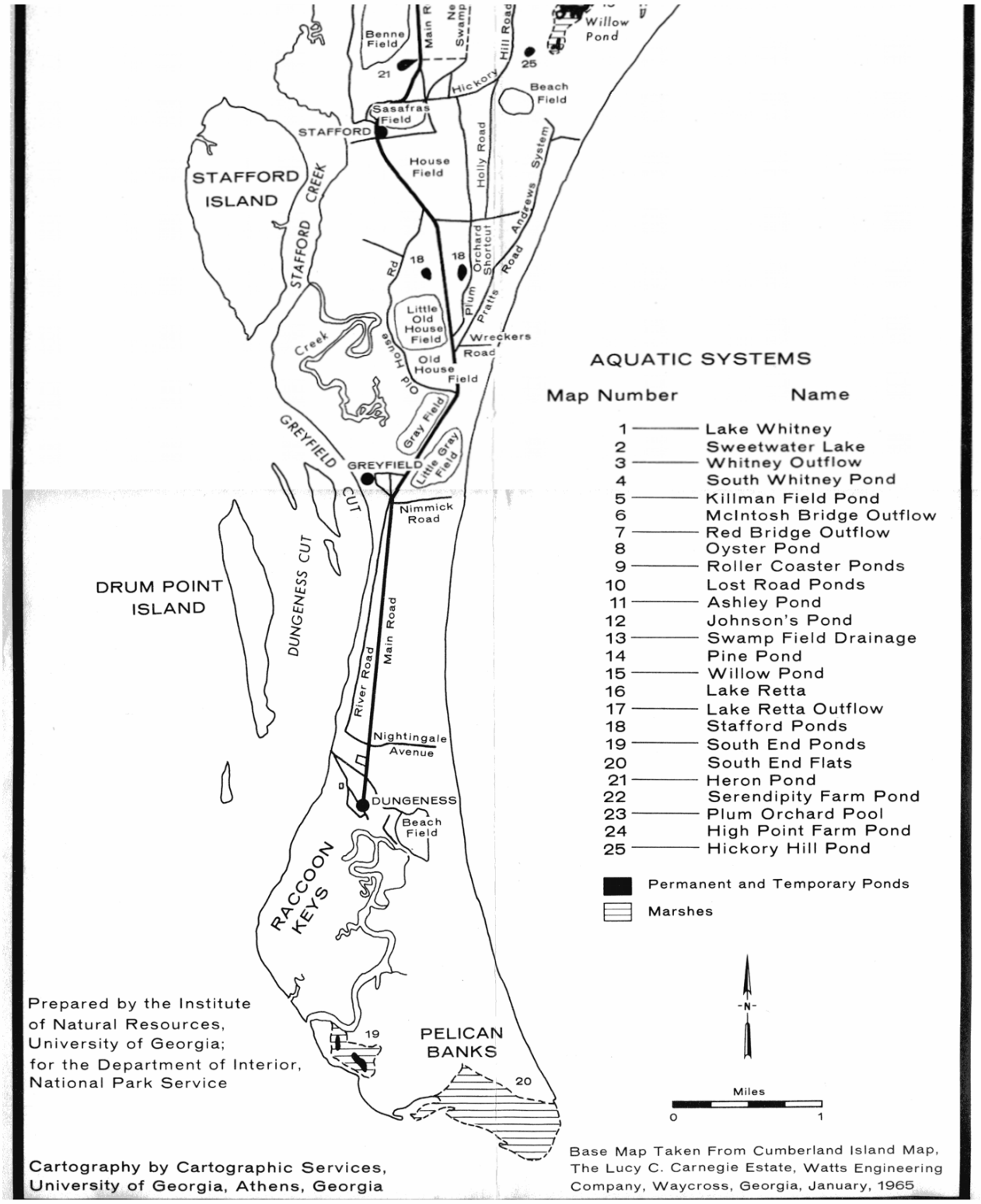
Cumberland Island is surrounded by saltwater resources, including 16.6 miles of beaches that lie in an almost continuous strip along the Atlantic Ocean. The remaining shores of the island are a network of salt marshes, tidal creeks, and tidal rivers that eventually open out into the Sounds (St. Andrews Sound to the north and Cumberland Sound to the west and south). Where the Crooked River meets Cumberland Sound is another region in this system called Kings Bay. A total of 10 named creeks and two "rivers" (which actually carry saline water) can be found on the map of the Cumberland Island National Seashore (**Figure 9**).[13] Note, however, that there are numerous smaller creeks on the island that are not named.

Cumberland Island also has a number of inland water bodies, which are listed in **Table 4** (many of these can be seen in **Figure 9**). Lake Retta and South End Pond 3 each have an outlet to the ocean and are inundated regularly enough to remain brackish, but most are freshwater ponds and lakes. The outflow to these areas is also listed. These are places where the water flows out and eventually connects with the ocean. For example, the Whitney Outflow will drain to the Sweetwater complex when heavy rains cause an overflow. Note also that some of the water bodies listed are seasonal and some are artificial.

[13] Named creeks on Cumberland Island are: Hawkins Creek, Malkintooh Creek, Mud Creek, Mumford Creek, Delarouche Creek, Old House Creek, and Beach Creek. Brockington Creek and Christmas Creek run between Cumberland and Little Cumberland Islands. Named rivers are the Cumberland River and Brickkiln (or Brickhill) River.

Figure 9. Place names on Cumberland Island





(from Hillestad et al., 1975)

Table 4. Freshwater lakes, ponds, and drainages on Cumberland Island

System type	Open water area (acres)	Total area (acres)
Freshwater bodies - permanent		
Lake Whitney	40	83
Roller Coaster Ponds	4	14
Ashley Pond	-	15
Willow Pond or "Lake"	13	70
Heron Pond	1	5.5
Serendipity Farm Pond (artificial)	1	1
Plum Orchard Pool (artificial)	1	1
High Point Farm Pond (artificial)	0.5	0.5
North Cut Ponds*	N/A	N/A
McCall Pond*	N/A	N/A
Freshwater bodies - temporary		
Sweetwater Lake	-	300
South Whitney Pond	-	16
Killman Field Pond	-	4
Oyster Pond	-	21
Lost Road Ponds	-	-
Johnson's Pond	-	11
Pine Pond	-	16
Stafford Ponds	-	3
Hickory Hill Pond	-	5
Saline water bodies - permanent		
Lake Retta	15	34
South End Ponds	4.5	24
Saline water bodies - temporary		
South End Flats	-	100
Outflows		
Whitney Outflow	-	-
McIntosh Bridge Outflow	-	-
Red bridge Outflow	-	-
Lake Retta Outflow (or Big Slough Overflow)	-	-

Adapted from Hillestad et al. 1975 (p.53 Table 3)
*Not listed in Hillestad

A3. Biological resources

There have been several excellent reviews of the flora and fauna of Cumberland Island. In a study undertaken shortly after CUIS was designated a National Seashore, Hillestad et al. (1975) presented a thorough accounting of vegetation, mammals, birds, amphibians, reptiles, and insects, although these are not always matched to habitat type. The CUIS draft natural resources management plan did a careful review of Hillestad et al. (1975) as well as several other studies and provided species lists along with quality assurance information (i.e. "assumed present", "identification questionable", "specimen voucher") (National Park Service 2001a). Naturalists working through the private Cumberland Island Museum[14] have also inventoried the island fauna and made this information available on the Internet (Cumberland Island Museum 2000; Cumberland Island Museum 2001). Included in the museum fauna checklists is the relative occurrence of each species along with notes on appearance, habit, call, or preferred terrain. In the most recent overview, 36 species of mammals and 59 species of amphibians and reptiles were noted. Unfortunately, fish and marine invertebrates were not included in these efforts. Up to date information on Cumberland Island's fish, reptiles, amphibians, birds, small mammals, and vascular plants will available soon through the NPS – Southeast Coast Network's Inventory and Monitoring Program (National Park Service (Southeast Coast Network) 2005).

Below we provide an overview of the species known to be associated with the various habitats of Cumberland Island. For the species lists provided here, we used Hillestad et al. (1975), Kings Bay Coastal and Estuarine Physical Monitoring and Evaluation Program: Coastal Studies (1994), the Cumberland Island Museum inventories, Guide to a Barrier Island (Schoettle 1996), and the Kings Bay Environmental Impact Statements (Naval Facilities Engineering Command 1975; Department of the Navy 1977).

A3a. Marine habitats and species

Nearshore waters

Specific catch information for Cumberland Sound is unavailable[15], but the open waters of the Atlantic Ocean and the surrounding sounds provide habitat for numerous fish[16], turtles, and marine mammals (dolphins, manatees, whales) and a livelihood and/or recreation for many coastal residents. Penaid shrimp and hard blue crab (*Callinectes sapidus*) are the leading

[14] A non-profit entity incorporated by Carol Ruckdeschel and the late C. Robert Shoop, not to be confused with the museums of the National Park Service.

[15] Commercial fishing statistics cannot be broken into sub-state regions because the State is required to protect confidentiality. Recreational finfish catch data are derived primarily from a creel survey (the Marine Recreational Fisheries Statistics Survey) performed by GA DNR in conjunction with NOAA fisheries. Here too, sub-state information is not available since sample size would have to be increased considerably to provide sub-state data with an acceptable statistical confidence.

[16] According to the GA-DNR CRD, the top ten finfish species harvested in 2003 from Georgia's marine areas were: Southern kingfish / whiting (*Menticirrhus americanus*), spotted seatrout (*Cynoscion nebulosus*), Atlantic croaker (*Micropogonias undulatus*), sheepshead (*Archosargus probatocephalus*), red drum (*Sciaenops ocellatus*), black sea bass (*Centropristis striata*), Southern flounder (*Paralichthys lethostigma*), black drum (*Pogonias cromis*), king mackerel (*Scomberomorus cavalla*) and vermilion snapper (*Rhomboplites aurorubens*) (Knowlton 2004).

products of the Georgia commercial fisheries: average annual value (1994-2003) of the shrimp and crab industries was in excess of $20 million compared to $872,000 for finfish (Georgia DNR 2005). In recent years there has been a dramatic decrease in crab harvest: by weight, the estimated 2004 Georgia crab harvest is only 53% of the 10-yr average and 30% of the 45-yr average (Lee and Frischer 2004; Georgia DNR 2005). Possible factors leading to catch reductions include drought, habitat degradation (diminishing freshwater inflow, increasing polluted runoff), stock depletion, and disease.[17] Again, information on these factors as they pertain specifically to the Cumberland Sound region is unavailable.

EPA's Environmental Monitoring and Assessment Program (EMAP) did otter trawls in St. Andrew's Sound in August 1994 and in the Cumberland River in September 1995. A total of 18 different species were caught[18], the most abundant of which were white shrimp (*Penaeus setiferus*), hardhead catfish (*Arius felis*), Atlantic croaker (*Micropogonias undulatus*), spot (*Leiostomus xanthurus*), and star drum (*Stellifer lanceolatus*). Complete information on organisms sampled in the EMAP program can be found in Table C-1 (**Appendix C**). The EPA National Coastal Assessment program (NCA) did similar trawls at 17 stations in or near Cumberland Sound (July or August 2000 and 2001) and these results are provided in Table C-2 (**Appendix C**). Fish populations sampled in spring 1977 at the proposed offshore disposal site for Kings Bay project dredge material (approximately seven miles from Cumberland Island[19], (Department of the Navy 1977) yielded a similar list of species as those reported in the EMAP sampling. The most abundant fish species in this effort were: bighead sea robin (*Prionotus scitulus*) - 29.8 %, tonguefish (*Symphurus plagiusa*) - 23.0 %, bay anchovy (*Anchoa mitchilli*) - 21.8 %, and spotted hake (*Urophycis regius*) - 10.3 %. The fish diversity index was 2.70, species richness was 1,946, evenness was 0.45, and the average biomass was 0.61 g m^{-2}. Sport fishermen in the area are reported to have also caught Crevalle jacks (*Caranx hippos*), sharks, tarpon (*Megalops atlanticus*), mackerel (*Scomberomorus* spp.), bonito (*Sarda sarda*), bluefish (*Pomatomus saltatrix*), and cobia (*Rachycentron canadum*)(Kumiski 2000).

Subtidal benthos

The subtidal habitat around Cumberland Island is soft-bottom and has no submerged aquatic vegetation: high turbidity in the South Atlantic Bight prevents enough light from penetrating to the bottom to support seagrasses along the Georgia coast, and macroalgae are only found ephemerally in very shallow areas. Benthic macroinvertebrates at the proposed King's Bay dredge disposal site (sampled in spring 1977) yielded 25 macroinvertebrate species, with a diversity index of 3.82 and an average biomass of 0.13 g m^{-2} (Department of the Navy 1977). The most abundant invertebrate groups were: Echinodermata - 24.3 %, Amphipoda/Isopoda - 22.3 %, Polychaeta - 20.4 %, Gastropoda - 9.1 %, and Pelecypoda - 7.6 %. The most abundant species found during benthic grab sampling at the two EMAP stations (the same sites where fish were sampled) were *Sphenia antillensis* (a bivalve), *Sabellaria vulgaris* (an annelid worm),

[17] Georgia blue crabs are susceptible to a fatal parasitic infection with the dinoflagellate *Hematodinium perezi*, which is associated with high salinity water (Lee and Frischer 2004).

[18] EMAP also had a station in the St. Marys River that was sampled in August 1994. A total of five species of nekton were caught, none of which were the same as those observed in the sounds. These results are included in **Appendix C** (Table C-1).

[19] The site was located at 30°41'– 30°42' N, 81°17'55"– 81°19'05" W (Naval Facilities Engineering Command 1975).

brittle stars (Unid. Ophiuroidea), and oligochaete worms (*see* Tables C-3, C-4, and C-5, **Appendix C**).

Jetty

The Cumberland Jetty extends 2.4 nautical miles east into the Atlantic Ocean from the south tip of the island. This is a popular fishing area, and sheepshead (*Archosargus probatocephalus*), black drum (*Pogonias cromis*), red drum (*Sciaenops ocellatus*), spotted sea trout (*Cynoscion nebulosus*), Crevalle jacks (*Caranx hippos*), tarpon (*Megalops atlanticus*), Spanish mackerel (*Scomberomorus maculatus*), bonito (*Sarda sarda*), bluefish (*Pomatomus saltatrix*), southern kingfish (*Menticirrhus americanus*), and cobia (*Rachycentron canadum*) have all been caught by anglers at this location (CRD angler survey; (Kumiski 2000); (OutdoorPlaces.com website; Ingram and Holt 1982). In addition, dolphins have been observed in the area. The jetty ecosystem was surveyed monthly between April 1988 and May 1990 as part of the Kings Bay Environmental Monitoring Program (Richardson and Gilligan 1991). Macroalgae were seen to vary seasonally and annually and were found in distinct zones along portions of the jetty. Of particular note is the fact that two of the 42 macroalgal species observed over the course of the study (*Codium decorticatum* and *Spyridia filmentosa*) had not previously been reported in Georgia. These were reported to be "large, distinctive, and common" on the jetty in the summer of 1989, but had not been seen the previous year. An additional 16 species represent those seen at Cumberland Island previously and during this study, but not found elsewhere in Georgia waters.[20] Specimens were deposited at CUIS and the Savannah State University Marine Algal Herbarium.

Intertidal zone - The highest portions of the jetty itself are approximately 0.5 m above high tide and present a mostly clear rock surface. During the Kings Bay Environmental Monitoring Program, a star barnacle, *Chthamalus stellatus* and the striped false limpet, *Siphonari pectinata* were identified in some number, along with a few of the fragile barnacle, *Chthamalus fragilis* and some red algae, *Porphyra rosengurttii*. The mid intertidal zone was well-colonized by the eastern oyster, *Crassostrea virginica*. Other species found with the oysters were the Atlantic ribbed mussel (*Geukensia demissa*), limpets, barnacles (*Balanus* spp.), sea lettuce (*Ulva* spp.), and a seasonal accumulation of *Bryopsis plumosa.* The low intertidal zone had more seasonal variability than the mid zone and was dominated by barnacles rather than oysters (although both were present). Small fan worms (*Hydroides dianthus*), oyster drills (*Urosalpinx cenerea*), and tinted canthrus (*Pisania tincta*) were the commonly seen gastropods here. The bryozoan *Bugula neritina* became more prevalent in late winter through early spring.

Subtidal zone - In addition to invertebrate taxa from a number of phyla (Porifera, Cnidaria, Bryozoa, Mollusca, Annelida, Arthropoda, Echinodermata, and Hemichordata), numerous fish taxa were also observed during the Kings Bay Environmental Monitoring Program either on or in close proximity to the jetty[21], as were Atlantic bottlenose dolphin, *Tursiops truncates.*

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[20] These were: Division Chlorophyceaea (*Chaetomorpha linum*); Division Phaeophyceae (*Padina gymnospora*); Division Rhodophyceae (*Antithamnion cruciatum, Bryocladia cuspidate, Ceramium nitens, Ceramium rubrum, Gelidium pusillum, Gracilariopsis lemanaeformis, Grateloupia filicina, Grateloupia gibbesii, Gymnogongrus griffithsiae, Hypnea musciformis, Hypoglossum hypoglossoides, Lomentaria bailyeana, Polysiphonia flaccidissima,* and *Rhodymenia pseudopalmata*).

[21] Fish sampled on the jetty included: anchovy, *Anchoa* spp.; black sea bass, *Centropristis striata*; blennies, Blenniiae; bluefish, *Pomatomus saltatrix*; bumper, *Chloroscombrus chrysurus*; gobies, Gobiidae; gray snapper, *Lutjanus griseus*; herrings, Clupeidae; lookdown, *Selene vomer*; mullet, *Mugil cephalus*; mummichog, *Fundulus*

Tidepools – The fish community present in the jetty's tidepools and rock reefs was assessed over six sampling trips (Richardson and Gilligan 1991). Fish were classified as sandy shore or resident reef species, and were listed as unique, uncommon, common, or ubiquitous/abundant. Thirty-six species were identified including three that had not been previously reported in Georgia: the molly miller (*Scartella cristata*), the hairy blenny (*Labrisomus nuchipinnis*), and the frillfin goby (*Bathygobius sporoator*). The ranges for these fish do not generally extend so far north (although the hairy blenny and the frillfin goby are known in Bermuda). The sandy shore fish identified as seasonally common or abundant were: spot (*Leiostomus xanthurus*), anchovy (*Anchoa* spp.), Atlantic bumper (*Chloroscombrus chrysurus*), striped mullet (*Mugil cephalus*), pinfish (*Lagodon rhomboides*), mummichog (*Fundulus heteroclitus*), spotfin mojarra (*Eucinostomus argenteus*), and striped killifish (*Fundulus majalis*). The common and resident reef fish were: crested blenny (*Hypleurochilus geminatus*), oyster toadfish (*Opsanus tau*), tomtate (*Haemulon aurolineatum*), sergeant major (*Abudefduf saxatilis*), feather blenny (*Hypsoblennius hentzi*), seaboard goby (*Gobiosoma ginsburghi*), and skilletfish (*Gobiesox strumosus*). Tidepools are typically very rich in invertebrates and it would be interesting to examine these areas for invertebrate fauna.

Docks

Two NPS docks on Cumberland Island (at Dungeness and Sea Camp Beach) were also part of the Kings Bay Monitoring Program (Richardson and Gilligan 1991). Macroalgal observations (including species identification and primary production studies) were accompanied by measurement of air temperature, surface water temperature, salinity, and Secchi-disk depth (turbidity). The floating docks had a total of 15 macroalgal species (nine Rhodophyceae, four Chlorophyceae, and two Phaeophyceae) – with only small variations between the populations on the two docks. Manatees (*Trichechus manatus*) have been observed feeding on the algae attached to the floating docks in late spring [Zoodsma, pers comm. In (Richardson and Gilligan 1991)]. There is also a dock at Plum Orchard with an extensive fouling community (i.e. barnacles, oysters, etc.).

Tidal creeks

Tidal creeks serve as the interface between salt marshes and estuaries. The channel network provides a source of sediment, oxygenated waters, and nutrients to the marsh, and also helps to flush the system. In addition, creeks and channels provide accessibility to the marsh surface by free-swimming nekton. Some species like killifish (*Fundulus heteroclitus*) and grass shrimp (*Palaemonetes pugio*) are common permanent residents, whereas others such as spot (*Leostomus xanthurus*) and silver perch (*Bairdella chrysura*) are likely abundant during their juvenile or larval stages (DeVoe and Baughman 1986). The benthic organisms found subtidally in the creeks provide a rich food resource for aquatic species such as crabs and fish. As part of a study on stream biology for the Georgia DNR – Environmental Protection Division, researchers

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heteroclitus; oyster toadfish, *Opsanus tau*; pinfish, *Lagodon rhomboides*; sea robin, *Prionotus* spp.; sergeant major, *Abudefduf saxatilis*; sheepshead, *Archosragus probatocephalus*; silversides, Atherinidae; southern flounder, *Paralichthys lethostigma*; spadefish, *Chaetodipterus faber*; spot, *Leistomus xanthurus*; stingray, *Dasyatis* spp.; striped killifish, *Fundulus majalis;* and tomtate, *Haemulon aurolineatum.* Fish identified in close proximity to the jetty included: black drum, *Pogonias cromis;* blacktip shark, *Carcharhinus limbatus;* Crevalle jack, *Caranx hippos;* Florida pompano, *Trachinotus carolinus;* kingfish, *Menticirrhus* spp.*;* ladyfish, *Elops saurus;* menhaden, *Brevoortia tyrannus;* northern needlefish, *Strongylura marina;* red drum, *Sciaenops ocellata;* spadefish, *Caetodipterus faber;* spotted seatrout, *Cynoscion nebulosus;* spotted snake eel, *Ophichthus ocellatus;* and tarpon, *Megalops atlantica.*

from Columbus State University surveyed the macroinvertebrates at three tidal stream locations on Cumberland Island (Gore et al. 2005). Their results are summarized in **Appendix C** (Table C-6).

Saltwater ponds

There are two inland ponds on Cumberland Island that are occasionally inundated by the ocean, Lake Retta and the South End Pond 3 (although lower salinities and groundwater influence was found in Lake Retta by Frick et al. [2002], and cattails there are also indicative of fresh water). In both cases, the ocean may serve to supply the lake with fish when tides are particularly high. Fish observed in these water bodies include sheepshead minnow (*Cyprinodon variegates*), sailfin molly (*Poecilia latipinna*), striped mullet (*Mugil cephalus*), American eel (*Anguilla rostrata*) and mosquitofish (*Gambusia affinis*) (Frick et al. 2002). These areas also attract abundant diving or wading birds, including herons, egrets, ibis (and others of the order Ciconiiformes), wood storks (*Mycteria americana*), anhinga (*Anhinga anhinga*) and ducks (family Anatidae). Some unusual bird sightings at the South End Ponds include: peregrine falcon (*Falco peregrinus*), buff-breasted sandpiper (*Tryngites subruficollis*), stilt sandpiper (*Calidris himantopus*), upland plover (*Bartramia longicauda*), and golden plover (*Pluvialis dominica*). Turtles and alligators are also present.

The South End Flats are saltwater marshes at the southeastern extreme of the island. These are vegetated primarily by salt meadow cordgrass (*Spartina patens*). As water levels increase in this area, so do populations of insects and crayfish. This increase supports a large number of frogs (e.g. southern leopard [*Rana sphenocephala*] and southern cricket [*Acris gryllus*]) as there are few (if any) fish present. When water levels fall, the temporary ponds in the flats become more bog-like with the appearance of sphagnum moss species and yellow-eyed grass (*Xyris* spp.).

A3b. Intertidal habitats and species

Beaches

In comparison to beaches that are further east (i.e. North Carolina or Florida), the beaches of Cumberland Island are relatively wide, with fine sand and low wave energy. Animals inhabiting the intertidal area of the beach include: ghost shrimp (*Callianassa* spp.), polychaete worms, sand dollars (*Mellita isometra*), moon snails (*Polinices duplicatus*), lettered olives (*Oliva sayana*), coquina clams (*Donax* spp.), surf crabs (*Albunea* spp.), mole crabs (*Emerita talpoida*), and ghost crabs (*Ocypode quadrata*) (Schoettle 1996; Kumiski 2000). Shore birds such as sandpipers (family Scolopacidae), plovers (family Charadriidae), skimmers /gulls / terns (family Laridae), and shearwaters (family Procellariidae) feed extensively on or in view of the beach, and loggerhead sea turtles (*Caretta caretta*) may be spotted making their way to and from their nesting sites during nesting season. No other sea turtles commonly use Cumberland Island for nesting, but in a given year the island usually supports more than 50 and occasionally upwards of 300 loggerhead nests. Staff of the private Cumberland Island Museum keep records of nesting activity and the number of dead turtles washed up on shore. A few pioneer plants can be found in the upper reaches of the beach area. Such plants might include: orach (*Atriplex arenaria*), beach croton (*Croton punctatus*), flat-beaked sea rocket (*Cakile harperi*), beach morning glory (*Ipomoea stolonifera*), railroad vine (*Ipomoea pes-caprea*), and Russian thistle (*Salsola kali*).

Salt marshes

It is estimated that between 60 and 80 % of the commercially important fish and shellfish species in the southeast have some life stage associated with salt marsh habitats (DeVoe and Baughman 1986; Crowder 1999), and much has been written about the importance of the salt marsh ecosystem (i.e. Weinstein and Kreeger 2000). The extensive salt marshes on the west side of Cumberland Island are dominated by *Spartina alterniflora*, although other plants such as glasswort (*Salicornia virginica*), saltwort (*Batis maritima*), black needlerush (*Juncus roemerianus*), spike grass (*Uniola sessiliflora*), and sea ox-eye (*Borrichia frutescens*) can also be found. Among the birds frequenting the marsh are egrets and herons (family Ardeidae). Small mammals such as mink (*Mustela vison*), raccoons (*Procyon lotor*), and marsh rice rats (*Oryzomys palustris*) are also present at low tide. Common invertebrates include fiddler crabs (*Uca* spp.), wharf crabs (*Sesarma cinereum*), mud crabs (*Panopeus* spp.), stone crabs (*Menippe mercenaria*), blue crabs (*Callinectes sapidus*), Eastern oysters (*Crassostrea virginica*), ribbed mussels (*Geukensia desmissus*), periwinkle snails (*Littoraria irrorata*), marsh snails (*Ilyanassa obsoleta*), and mud snails (*Melampus bidentatus*). More complete information on salt marsh organisms in the southeast can be found in Wiegert and Freeman (1990). There is also a species list for Sapelo Island and its environs on the website of the Georgia Coastal Ecosystems LTER project (http://gce-lter.marsci.uga.edu/lter/asp/db/species_list.asp).

In 2001, portions of the salt marshes of coastal Georgia began experiencing dieback. Dieback areas were characterized by loss of vegetation, resulting in large expanses of bare mud that are susceptible to erosion. The problem affected salt marshes in all six Georgia coastal counties, and was extensive, with the largest site covering more than 600 acres. None of these areas were located on Cumberland Island, but other Georgia barrier islands were affected (including Ossabaw and Sapelo Islands) and there was also a site reported in the City of St. Marys). As of fall 2004, limited re-growth had been observed, but the cause of the dieback was never determined. Given these observations, it would be appropriate to do some baseline sampling of the Cumberland Island marshes and to maintain a continued awareness of their status.

Mud flats

Mud flats are found in the lower intertidal areas of salt marshes. Salt marsh grass cannot survive inundation for more than 6 hours per day and mud flats are found below the edge of the vegetation. These protected areas are rich in benthic infauna, including polychaete worms and bivalves, which serve as food sources for pelagic organisms as well as terrestrial species such as birds that can be found feeding in these areas when they are exposed at low tide. Oxygen does not penetrate these sediments very deeply and these areas often have a characteristic "rotten egg" smell due to the presence of hydrogen sulfide. The fauna of the mud flats on Cumberland Island have not been specifically studied, but they are again expected to be similar to that reported for the southeast (Wiegert and Freeman 1990, *see also* Fox and Ruppert 1985).

A3c. Upland habitats and species

Dunes

The Cumberland dune fields form a prominent ridge from north to south in a nearly continuous strip on the ocean side of the island. Dune sands here are quartz and finer than that

on the beach. Dunes on Cumberland Island may reach 30 feet, whereas the highest permanent elevation in the region is 12 m (39.4 ft) above mean sea level (Frick et al. 2002; Gustafson 2003). The vegetation in the dunes and swales is well-characterized and can be subdivided into a number of habitats: dune-grass forb habitat, grass-sedge meadows, high meadow, dune or interdune shrub thicket, dune shrub thicket, interdune pine-mixed hardwood forest, and dune oak-buckthorn scrub forest. The specific vegetation associated with each of these communities is described in **Appendix D**. It should be noted that animals such as horses and deer have destabilized some dune areas by grazing on the sea oats (*Uniola paniculata*).

Maritime forests

Maritime forests are the dominant upland habitat on Cumberland Island and constitute approximately 30% of the land cover. The overstory in these areas is dominated by live oak (*Quercus virginiana*) with an understory of cabbage palm (*Sabal palmetto*) and shrubs. The diverse landscapes in maritime forests provides habitat for numerous bird species, including threatened and endangered species like brown pelicans (*Pelecanus occidentalis*), woods storks (*Mycteria americana*), bald eagles (*Haliaeetus leucocephalus*), and painted buntings (*Passerina ciris*), and several common species of shorebirds, wading birds, and hawks. Commonly sighted mammal species include white-tailed deer (*Odocoileus virginianus*), raccoons (*Procyon lotor*), opossums (*Didelphis virginiana*), and armadillo (*Dasypus novemcintus*). The maritime forest can be subdivided into various specific habitats, as the vegetation found in an area depends on the specific characteristics of the site (i.e. soil type, elevation, degree of wetness) as well as its history (i.e. fires, hurricanes, historical land use). Each of the communities identified by Hillestad et al. (1975) (oak-juniper palm forest, oak-palmetto, pine-oak scrub, oak scrub, mixed oak-pine-hardwood, lowland mixed hardwood) is described in **Appendix D**.

Marsh hammocks

Marsh hammocks have only recently begun receiving attention in Georgia and have not been explicitly inventoried in the Cumberland Island area. In a survey of the flora and fauna of 23 marsh hammocks along the Georgia coast, Fabrizio and Calvi (2003) found 113 species of birds, 15 of which are rated as "high" or "highest" conservation priority for the region or are federally listed as threatened or endangered (including wood stork [*Mycteria Americana*] and painted bunting [*Passerina ciris*]). They also found that hammock biota varied greatly depending on island size, location, and origin. In a study that described the vegetation of undeveloped marsh hammocks near Sapelo Island, Albers (2004) observed communities that were comparable to subxeric maritime forest and shrub lands. She found a strong association between live oak (*Quercus virginiana*) and yaupon holly (*Ilex vomitoria*), and subdominants like cabbage palm (*Sabal palmetto*) and red cedar (*Juniperous virginiana*), which are indicative of upland evergreen forests unique to intact areas of the southeastern coastal plain. This survey also found three plants that, because of their relative rarity, are considered species of concern by the state of Georgia: buckthorn (*Sageretia minutiflora*), Florida privet (*Forestiera segregata*) and silver buckthorn (*Bamelia anomala*). All of this suggests that it would be useful to characterize the vegetative community on the marsh hammocks associated with Cumberland Island.

Agricultural areas

Recent land cover analyses show that the current total of pasture and agricultural lands is less than half of what was recorded in 1974 (Hillestad et al. 1975). Some of the meadows are

maintained in perpetuity as National Historic Register cultural landscapes. Undisturbed meadows and pastures would likely follow the succession of abandoned fields described by Griffin (1991), in which weedy annuals colonize the area during the first year; perennials such as broomstraw dominate starting in the second year; pines dominate the overstory with palmettos below after 50 to 100 years, and deciduous trees (mainly oaks) are found after 150+ years. Fire will likely play an increasingly important role in the vegetative succession of these areas.[22]

A3d. Freshwater bodies

Freshwater bodies - permanent

As listed in **Table 4**, Cumberland Island has a series of permanent freshwater ponds and lakes, the largest and best-studied of which is Lake Whitney. The Lake is approximately half open water and appears to demonstrate several natural successional vegetation stages (Hillestad et al. 1975). On the northeastern shore where drifting sands meet the deepest water (> 3 feet), rooted floating vegetation is found (waterlilies [*Nymphaea odorata*], floating hearts [*Nymphoides aquatica*]). There are also floating mats of bladderwort (*Utricularia* spp.) and frog's bit (*Limnobium spongia*) and some emergents such as duck potato (*Sagittaria latifolia*) and pickerel weed (*Pontederia cordata*). The stabilizing emergents (saw grass [*Cladium mariscus*], sand cordgrass [*Spartina bakeri*], water willow [*Decodon verticillatus*], and marsh mallow [*Hibiscus grandiflorus*]) are also found among some trees (red maple [*Acer rubrum*], willow [*Salix caroliniana*], blackgum [*Nyssa sylvatica*], and dahoon [*Ilex cassine*]) (Hillestad et al. 1975). The introduction of predatory fish (bluegill [*Lepomis macrochirus*], warmouth [*Lepomis gulosus*], and largemouth bass [*Micropterus salmoides*]) for recreational fishing many years ago may be continuing to affect the amount of prey available for wading birds: egrets, ibis and heron (order Ciconiiformes) are not as common here as one might expect, although there are several types of ducks on the lake (scaup [*Aythya affinis*], ringneck [*Aythya collaris*], and mallards [*Anas platyrhynchos*]). A comparison of fish population studies at Lake Whitney and Whitney Outflow in 1973 (Hillestad et al. 1975) versus 1999 (Frick et al. 2002) shows similar species in both areas, with six out of seven species found in both years.[23] Otter (*Lutra canadensis*) and mink (*Mustela vison*) are fairly common, as are Florida cottonmouth snakes (*Agkistrodon piscivorus conanti*).

Roller Coaster Ponds, Ashley Pond, and Heron Pond are all less than three feet deep and have less than one-quarter open water surface. These ponds are typical freshwater environments, with floating and emergent vegetation and good numbers of mosquito fish (*Gambusia affinis*). Willow Pond is similar to the ponds above except that it is quite a bit larger than the others and has a population of warmouth (*Lepomis gulosus*), believed to have been introduced. Vegetation at Willow Pond includes sand cordgrass (*Spartina bakeri*) and a few red maples (*Acer rubrum*). Hillestad et al. also noted the presence of a small, unique, floating bog, but did not give details on the species present (Hillestad et al. 1975).

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[22] Park managers have recently developed a fire management plan for Cumberland Island National Seashore.

[23] *Eucinostomus lefroyi, Gambusia affinis, Lepomis gulosus, Lepomis macrochirus, Mugil cephalus* and *Poecilia latipinna* were all collected in either Whitney Lake or the Whitney Outflow in both 1973 and 1999. Sheepshead minnows (*Cyprinodon variegatus*) were only observed in 1999 (Hillestad et al. 1975, Frick et al. 2002).

The three artificial ponds on Cumberland Island tend to attract waterfowl, such as night herons, ibis and egrets. When described in 1974, the previously ornamental Plum Orchard Pond had a good number of largemouth bass (*Micropterus salmoides*) and bluegills (*Lepomis macrochirus*) and was frequented by alligators (*Alligator mississippiensis*) (Hillestad et al. 1975).

Freshwater bodies – temporary

The temporary freshwater areas on Cumberland Island are primarily vegetated with sand cordgrass (*Spartina bakeri*) and saw grass (*Cladium mariscus*), with a few small trees (blackgum [*Nyssa sylvatica*], red maple [*Acer rubrum*], dahoon [*Ilex cassine*]). The Sweetwater Lake complex is a four-mile long, narrow, 300-acre natural impoundment found between the rear dune ridges. It stretches roughly from Lake Retta north to the Whitney Outflow. Approximately half of Sweetwater is vegetated sloughs and channels and the other half is forested with live oaks (*Quercus virginiana*), ferns, and orchids. Wildlife makes excellent use of this habitat. Fish include mosquitofish (*Gambusia affinis*), sailfin mollies (*Poecilia latipinna*), warmouth (*Lepomis gulosus*), and largemouth bass (*Micropterus salmoides*). Mink (*Mustela vison*), otter (*Lutra canadensis*), and alligators (*Alligator mississippiensis*) enjoy the prey.

Pond sloughs

Most of the freshwater areas on Cumberland are likely undergoing natural vegetative succession from open water habitat with submerged vegetation (through floating vegetation, emergent vegetation, then shrubs) to a lowland mixed hardwood forest community. Typical submerged vegetation found associated with pond sloughs include water milfoil (*Myriophyllum pinnatum*), pondweed (*Potamogeton* spp.), spike-rush (*Eleocharis* spp.), and bladderwort (*Pinguicula pumila* and *Utricularia* spp.); floating vegetation might include waterlily (*Nymphaea odorata*), lotus (*Nuphar luteum*), floating hearts (*Nymphoides aquatica*), water shield (*Brasenia schreberi*), pondweed (*Potamogeton* spp.), big duckweed (*Lemna valdiviana*), frog's bit (*Limnobium spongia*), mosquito fern (*Azolla caroliniana*), American lotus (*Nelumbo lutea*); emergent vegetation might include arrow head (*Sagittaria* spp.), duck potato (*Sagittaria latifolia*), pickerel weed (*Pontederia cordata*), common and narrow-leaved cattail (*Typha latifolia, T. angustifolia*), lizard's tail (*Saururus cernuus*), knotweed (*Polygonum glaucum*), water primrose (*Ludwigia* spp.) (Hillestad et al. 1975). As these areas continue to fill in, one might expect to see emergent grass, sedge, and rush species (maiden cane [*Panicum hemitomon*], *Paspalum* spp., sand cordgrass [*Spartina bakeri*], saw grass [*Cladium jamaicense*], nutgrass [*Cyperus* spp.], umbrella grass [*Fuirena squarrosa*], bull rushes [*Scirpus* spp.], spikerushes [*Eleocharis* spp.], beak rushes [*Rhynchospora* spp.], sedges [Family Cyperaceae], rushes [*Juncus* spp.]) followed by shrubs and juvenile trees (water willow [*Decodon verticillatus*], button-bush [*Cephalanthus occidentalis*], persimmon [*Diospyros virginiana*], dahoon [*Ilex cassine*], bayberry [*Myrica cerifera*], willow [*Salix caroliniana*], blackgum [*Nyssa sylvatica*], sweet bay [*Magnolia virginiana*], swamp red bay [*Persea palustris*]) (Hillestad et al. 1975).

B. Water Resources Assessment

B1. Water quality

The water quality observations compiled for this report were compared to state and federal standards, as appropriate. In some cases, such as for dissolved nutrients, there are no EPA standards, so these observations were compared to the guidance developed for classifying coastal water as part of the National Coastal Condition Report II (U.S. Environmental Protection Agency 2004d). Georgia standards for water quality can be found in **Appendix E**. Note that, where available, information on ecosystem effects and human health issues are also included below.

B1a. Data sources

There are relatively few historic observations of water or sediment quality in or around Cumberland Island. The Horizon report retrieved all data that had been entered into the U.S. Environmental Protection Agency's online **STO**rage and **RET**rieval (StoRet) repository for biological, water quality and physical data for the park and the surrounding area (all lands and waters within at least 3 miles upstream and 1 mile downstream) as of November 1993 (National Park Service 1997). The query yielded 48 stations in and around the park, 22 of which contained no data (including all of the stations located within the park itself). Most of the stations represented either one-time or single-year sampling efforts. The vast majority of the observations retrieved (96%) were collected from the Amelia and St. Mary's rivers in the Florida portion of the study area. These limited observations did point to some potential water quality problems in the region: 17% of the dissolved oxygen measurements were less than or equal to the EPA criteria of 4 mg L^{-1} for the protection of freshwater aquatic life and 20% of total coliform measurements (19% of fecal coliform) exceeded criteria for bathing water (200 colony forming units/100 mls). The report concluded that there was some evidence that surface waters were affected by human activities, most likely from municipal and industrial effluent. Some useful historic data were included in the Draft Environmental Impact Statement for the Kings Bay Naval Base (Naval Facilities Engineering Command 1975). Sites in Cumberland Sound (n = 9 stations), Kings Bay (5), St. Marys River (2), North River (2), Amelia River (2), and offshore (5) were sampled four times between June 1976 and April 1977 for a variety of water and sediment characteristics. The report also summarized previous observations in the area.

Most of the water quality data that are discussed in this report come from the Coastal Resources Division (CRD) of the Georgia Department of Natural Resources. CRD has 20 monitoring stations located in and around Cumberland Sound, which have been sampled regularly over the past several years, during random stages of the tide (**Figure 10**). These stations are part of several different programs and so the parameters measured and the period of record varies, but they include measurements of fecal coliform, temperature, pH, dissolved oxygen, salinity, and dissolved nutrients. Samples collected as part of the Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) also provided some relevant information. EMAP is a national program that was designed to assess the conditions of estuarine resources through in-depth sampling at a few locations each year, and

includes information on water quality (dissolved oxygen, salinity, temperature, depth, pH, nutrients, chlorophyll), sediment quality (grain size, total organic carbon, sediment chemistry, sediment toxicity), and biota (community structure, external pathology, tissue analyses) (U.S. Environmental Protection Agency 2004c). Three of the EMAP sites were in the vicinity of Cumberland Island. Additional sites have been sampled since 2000 as part of the National Coastal Assessment (NCA), which represents a continuation and revision of the EMAP sampling. Some of the Georgia data are unavailable (as they are still undergoing quality assurance), but we were able to obtain some information from samples collected during the summers of 2000 and 2001 for this report.

Figure 10. Location of GA DNR – Coastal Resources Division monitoring stations near CUIS

Water quality information for the habitats of Cumberland Island itself comes primarily from a study conducted for the National Park Service by the U.S. Geological Survey (Frick et al. 2002). This study focused on freshwater wetlands but also included more limited observations of water quality in groundwater and on bathing beaches.

One of the authors (Dr. Karen Payne) is currently involved in a large-scale effort to compile all of the water quality observations that are available for the Georgia coast and place them into a single geographic information system (GIS). The project will incorporate all of the data sets that are discussed in this report as well as data for the entire state. When the project is complete it will be available to the NPS. Information regarding the data sets that have been identified to-date in the watersheds surrounding Cumberland Island can be found in **Appendix F**.

B1b. Water quality in Cumberland Sound and surrounding estuarine areas

Dissolved nutrients

We obtained CRD data on dissolved nutrient concentrations (nitrate, nitrite, ammonium, orthophosphate, total dissolved phosphorus, and dissolved silica) at 20 stations in Cumberland Sound. Monthly sampling began in summer 2001 and is ongoing. This paper summarizes measurements from summer 2001 through either May 2003 (11 stations) or October 2003 (8 stations), plus one station sampled from August 2001 to August 2002. Once additional data are released, they will be incorporated into the coast-wide GIS data inventory described above.

Average dissolved inorganic nutrient concentrations for all CRD stations are summarized in **Table 5**. These concentrations are similar to the limited nutrient measurements made in Cumberland Sound in 1976 and 1977 for the Kings Bay Environmental Impact Statement (EIS): $NO_3 + NO_2$ averaged 0.045 ± 0.36 mg N L^{-1}; NH_4 averaged 0.088 ± 0.043 mg N L^{-1}; PO_4 averaged 0.025 ± 0.008 mg P L^{-1}. **Table 5** also presents nutrient concentrations reported for South Carolina open waters (n = 30) and tidal creeks (n = 30) in summer 2000 (Van Dolah et al., 2002). Average nutrient concentrations in Cumberland Sound are comparable to those reported for South Carolina; although the maximum concentrations in Cumberland Sound are always lower (Van Dolah et al. 2002). Note that eight observations of nitrogen were omitted from the compilation because of suspected sample contamination. When included; the average NH_4 concentration becomes 0.082 ± 0.274 mg N L^{-1} (max = 3.367 mg N L^{-1}), $NO_3 + NO_2$ average concentration becomes 0.044 ± 0.048 mg N L^{-1} (max= 0.673), and average dissolved inorganic nitrogen (DIN) concentration becomes 0.129 ± 0.308 mg N L^{-1} (max = 4.04 mg N L^{-1}).

Table 5. Dissolved inorganic nutrient concentrations in Cumberland Sound, Georgia and South Carolina coastal water

	Cumberland Sound, Ga.	South Carolina*
	NH_4 (mg N L^{-1})	
mean ± s.d.	0.049 ± 0.029	0.051 ± 0.064
min - max	0.004 – 0.131	0 - 0.28
no. obs.	488	53
	$NO_3 + NO_2$ (mg N L^{-1})	
mean ± s.d.	0.042 ± 0.036	0.035 ± 0.049
min - max	0.004 - 0.162	0 – 0.305
no. obs.	473	57
	DIN (mg N L^{-1})	
mean ± s.d.	0.091 ± 0.066	0.094 ± 0.087
min - max	0.011 – 0.230	0.006 – 0.380
no. obs.	473	50
	PO_4 (mg P L^{-1})	
mean ± s.d.	0.028 ± 0.015	0.023 ± 0.034
min - max	0 – 0.129	0 – 0.209
no. obs.	526	60
	TDP (mg P L^{-1})	
mean ± s.d.	0.036 ± 0.020	0.039 ± 0.035
min - max	0 - 0.170	0.006 – 0.255
no. obs.	488	60

* Reported in Van Dolah et al., 2002

In the National Coastal Condition Report, DIN concentrations less than 0.1 mg N L^{-1} were considered "Good"; those between 0.1 and 0.5 were considered "Fair"; and those above 0.5 were considered "Poor" for the southeast (U.S. Environmental Protection Agency 2004d). Dissolved inorganic phosphorus concentrations less than 0.01 mg P L^{-1} were considered "Good"; those between 0.01 and 0.05 were considered "Fair"; and those above 0.05 were considered "Poor". By these criteria, 56% of the DIN observations in Cumberland Sound are Good and 44% are Fair (none are Poor). In terms of PO_4, 85% of the observations are considered Fair; 11% are Good, and 5% are Poor.

It is unclear whether the dissolved nutrients in Cumberland Sound are indicative of a water quality problem. Nutrient concentrations represent a balance between inputs (which would include loading from upstream, recycled input from the sediment, and mixing with other water masses) and outputs (which would include uptake by phytoplankton and bacteria, sinking to the bottom, and transport to other areas), so the concentration in the water at any given time is not necessarily a good indication of the potential for eutrophication. In addition, these observations are similar to the limited reports from the 1970s and are also similar to nutrient concentrations in South Carolina. However, the fact that a substantial proportion of both DIN and PO_4

measurements fall in the "Fair" category suggest that they warrant continued observation. It would also be useful to obtain measurements of dissolved organic nitrogen (DON) for the region. DON comprises approximately 80% of total dissolved nitrogen, and Verity found that DON concentrations have been increasing at a faster rate than inorganic nitrogen in the Skidaway River (Verity 2002a; Verity 2002b). If this is the case for Cumberland Sound as well, it may be related to the low dissolved oxygen concentrations observed in the area (*see below*).

Dissolved oxygen

Measurements of dissolved oxygen (DO) concentration were obtained for 3 stations from March 2000 through April 2004 and for 17 stations through December 2004. These are instantaneous measurements taken in surface water using an oxygen probe. Dissolved oxygen concentrations at all 20 stations sampled over the four-year period between March 2000 and December 2004 averaged 5.6 ± 1.5 mg L^{-1}. Low concentrations (less than or equal to the Georgia Environmental Protection Division (EPD) criterion of 4 mg L^{-1}) occurred 16% of the time (182 out of 1136 observations). Examination of the period of record reveals similar cycles at different sites (the records at the 3 stations closest to Cumberland Sound are shown in **Figure 11**). Not surprisingly, there was a distinct seasonal cycle in these observations with summertime minima and wintertime maxima. The seasonal cycle for all stations is shown in **Figure 12**. In the entire data set, exceedances (values < 4 mg L^{-1}) were most common during summer months, with 83% of the low observations occurring between May and September. Concentrations were below 3 mg L^{-1} 40 times and below 2 mg L^{-1} five times; the minimum observation was 1.77 mg L^{-1}.

These observations of low DO concentrations are surprising. It is not unusual for bottom water oxygen to be depleted, particularly in deeper areas where the bottom is cut off from surface mixing, but low concentrations in surface water is rare in nearshore marine water because the water mixes readily with the atmosphere. Moreover, the CRD measurements were generally taken at mid-day. They therefore do not necessarily reflect the average concentration at a given site, and are almost certainly higher than the daily minimum (which generally occurs just before dawn). When DO levels get too low, it can negatively affect many estuarine and marine organisms. In the National Coastal Condition Report II, EPA applied a range of 2 to 5 mg L^{-1} as "Fair" and less than 2 mg L^{-1} as "Poor" water quality. Concentrations below 2.0 mg L^{-1} are considered hypoxic, and organisms such as crabs, shrimp, and finfish become physiologically stressed in hypoxic waters and are forced to migrate to areas with higher oxygen concentrations (Diaz and Rosenberg 1995). For non-motile organisms such as oysters or attached epifauna, DO concentrations below their metabolic or reproductive threshold can be lethal (Diaz and Rosenberg 1995).

It is not clear whether the low oxygen concentrations reported here represent a new phenomenon. The St. Marys and Satilla Rivers, both of which empty into Cumberland Sound, are blackwater rivers that are naturally high in organic matter. Comparable historic data at sites in Cumberland Sound were not found, but a former EPD station near the mouth of the St. Marys River (monitored through 1990) exhibited low concentrations at a similar frequency to that observed here: 22 out of 131 observations were less than 4 mg L^{-1} (National Park Service, 1997). It is, however, also possible that some of the oxygen deficit is the result of the increased concentrations of dissolved nutrients (both organic and inorganic), particulate material, and

chlorophyll that have been observed in Georgia coastal water over the past decade (Verity 2002a; Verity 2002b). It is therefore extremely important to continue monitoring DO in the region, particularly during summer. It would also be useful to perform vertical profiles and diel measurements at selected sites in order to better characterize the DO field, and to re-visit some of the historic sampling sites to be able to make direct comparisons.

Figure 11. Dissolved oxygen concentrations over time at selected stations in Cumberland Sound

(data from GA DNR-Coastal Resources Division, see **Figure 10** for station locations)

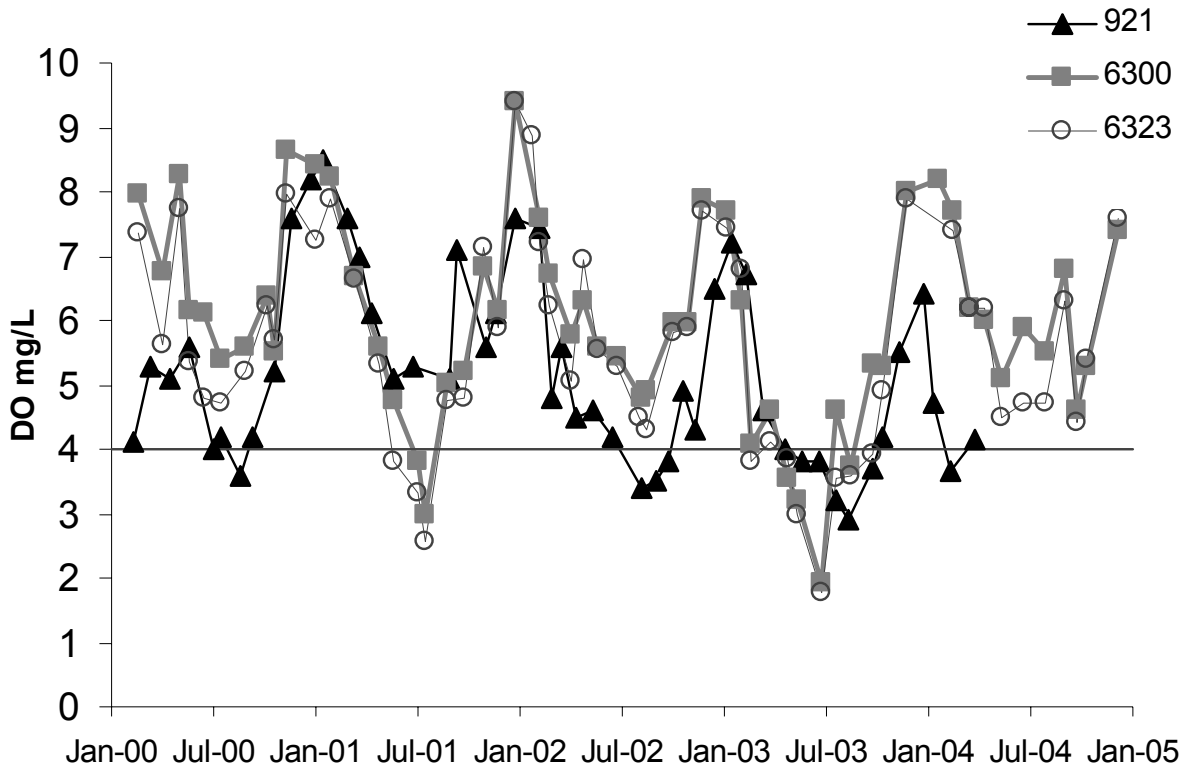
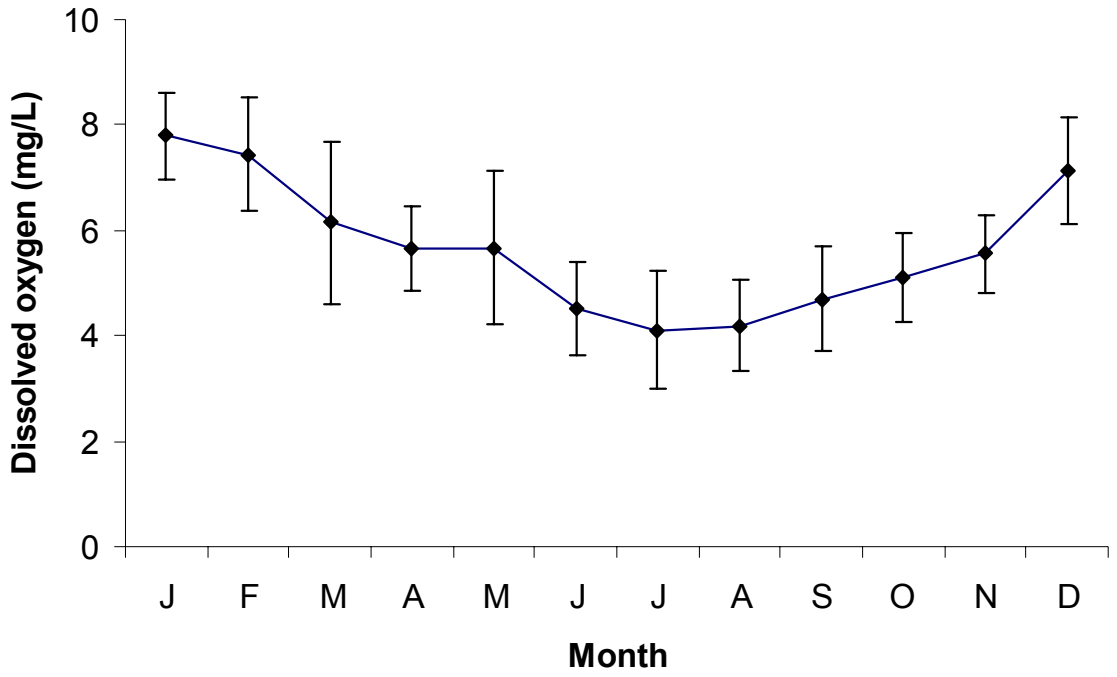


Figure 12. Seasonal cycle of dissolved oxygen concentrations in Cumberland Sound (data from Georgia DNR-Coastal Resources Division)

Points represent average monthly concentration ± standard deviation.



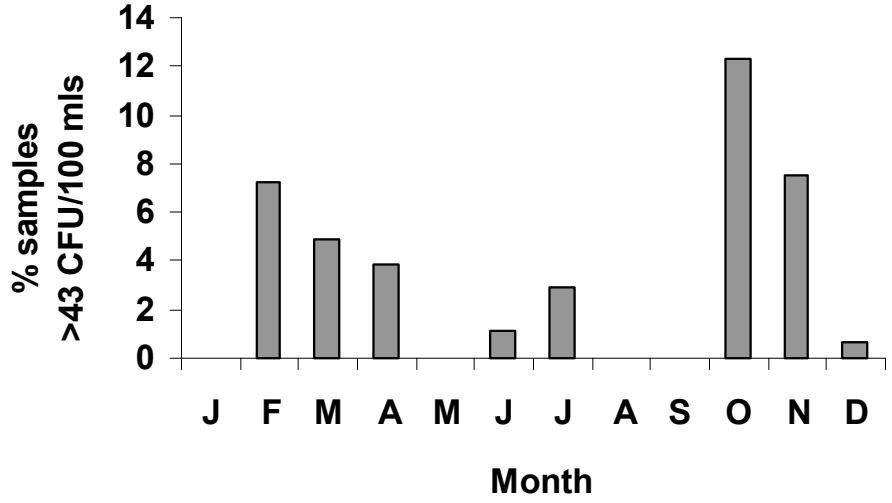
Bacterial contamination

As part of the shellfish sanitation program, Georgia CRD takes samples for measurements of fecal coliform concentration based on most probable number (MPN). Of the 2092 observations taken at 17 stations in Cumberland Sound between 1991 and 2004, only one station (6215) was ever above the standard for shellfishing (geometric mean value > 14 colony forming units (CFU) per 100 ml over the course of 30 observations [which is 2.5 y]). Station 6215 was above 14 CFU per 100 ml June through November of 1992, July through November of 1993 and in October 1994. This station is located well up the Crooked River (*see* **Figure 10**) and so is likely more susceptible to local runoff. Another area, between Terrapin Point and Cumberland Wharf (near station 6300) has been closed to shellfishing as a precaution. Although not above the state standard (since high measurements were not sustained for 30 observations), coliform levels at this station are often elevated (the station average is more than twice the combined average of all other Cumberland Sound stations) and feral horses have been observed grazing in this area.

In terms of coastal recreational water, only 19 observations were above the Georgia criterion of 100 CFU per 100 ml (13 of which were greater than 200). Given that these are single observations and state standards are written to reflect geometric mean concentrations sampled over a 30-d period, they cannot be used for regulatory purposes. In order to evaluate similar one-

time observations, the South Carolina Estuarine Coastal Assessment Program (SCECAP) considered 43 CFU per 100 ml as representative of marginal conditions. In the CRD data set, 76 observations (3.6%) were above this threshold. The distribution of these observations showed a strong seasonality (**Figure 13**), with peaks in fall (October/November) and early spring (February/March). Fecal coliform bacteria may arise from point and nonpoint sources, such as wastewater treatment plants, agricultural nonpoint sources, leaking septic systems, and storm water runoff. However, these observations suggest that bacterial contamination is not a large concern, particularly given the fact that there were so few observations of elevated concentrations during summer months when people are more likely to be swimming.

Figure 13. Monthly observations of elevated fecal coliform bacteria in Cumberland Sound



All of the above analysis pertains to samples collected at shellfish sampling sites. In 2004, CRD initiated seasonal monitoring of two Camden County beaches: the northern tip of Little Cumberland and Sea Camp Beach on Cumberland Island. The program began by measuring fecal coliform, but switched to *Enterococcus* in September 2004 in response to a U.S. EPA ruling that designated *Enterococcus* as the new standard bacterial indicator for marine waters (U.S. Environmental Protection Agency 2004e). Samples are taken monthly from April to November. Only limited data are available to-date, but they will be included in the StoRet database.[24] The only published observations of bacterial abundance at bathing beaches on the island come from a study conducted by USGS (Frick et al. 2002). They measured *Enterococcus* concentrations at five Cumberland Island beaches (North Cut Road, South Cut Trail, Stafford, Sea Camp, and Dungeness) daily from April 26 to 30, 1999. All samples fell below the U.S. EPA standards for Enterococci. This study also found undetectable levels of fecal coliform in samples collected from two domestic water-supply wells on the island.

[24] Note added in proof: In spring 2005 CRD re-classified both Sea Camp Beach and the one at Little Cumberland Island from Tier 2 to Tier 3 beaches, meaning that they will no longer be monitored regularly for bacterial abundance.

Contaminants

Historic information on contaminant concentrations in Cumberland Sound comes from the final Kings Bay EIS, which sampled water, sediment, and organisms for concentrations of metals, pesticides and other pollutants in 1976 and 1977 (Department of the Navy 1977). In terms of metals, the EIS uncovered evidence for a potential problem with mercury. Mercury concentrations in Cumberland Sound ranged from 0.6 to 4.1 mg L^{-1} and average concentrations in most of the study area were well above the acute criteria of 1.4 µg L^{-1} in marine waters. In contrast, most offshore samples were less than the limit of detection of the analytical technique (0.2 mg L^{-1}), as were samples from the freshwater portions of the St. Marys and Satilla rivers. However, extremely high concentrations were observed in some of the surface freshwater samples from the Kings Bay site. In the EIS it was suggested that a potential source of the problem was mercury-based fungicides that had been previously applied to pine plantations. High mercury concentrations were also found in the biota: flounder, crab and oyster tissue collected in the lower Cumberland Sound exceeded the FDA recommended limit of 0.5 µg g^{-1}. The level of mercury found in organisms collected at the two other sites approached but did not exceed this limit. Zinc levels were also elevated in oysters (ranging from 2770 to 4190 ppm as compared to the stated typical range of 6 to 1500 ppm). Copper and manganese were found also at higher levels in oysters than in the other organisms tested, but these metals were not considered problematic (Department of the Navy 1977).

The EIS also found indications of elevated pollutant concentrations in the area. Water column samples exceeded 1976 federal criteria at one or more locations for five compounds[25]: aldrin-dieldrin, DDT, heptachlor, lindane, and heptachlor epoxide. Bottom sediments from the same locations were also analyzed, with similar results. When estuarine biota were tested, aldrin-dieldrin, heptachlor, and lindane were detected at 11 to 36% of the 1976 EPA limit for edible fish tissue; chlordane, DDT, endrin, toxaphene[26], α-BHC, and heptachlor epoxide were present at 16 to 264 ppb (with no listed FDA standard); and mirex and PCB's showed undetectable levels. The distribution of pesticides in 14 different animals from the Cumberland Sound was also recorded: Heptachlor epoxide was ubiquitous, and five others (aldrin-dieldrin, toxaphene, lindane, α-BHC and heptachlor) were quite common. Endrin, DDT, and chlordane were also found in several species.

More recent data on contaminants comes from the EMAP program. Although limited in terms of the number and frequency of observations, the program sampled at one station in the St. Marys River (site CP94019) and one in St. Andrew's Sound (CP94020) in 1994, and in 1995 they sampled at a station in the Cumberland River (CP95169). The results from these sampling efforts are summarized in two reports (Hyland et al. 1997; 1998), which compared EMAP data on sediment contaminants (hydrocarbons, PCBs, pesticides, and metals) to bioeffect guidelines to identify potentially degraded areas within the Carolinian Province (which stretches from NC to FL).

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[25] Water, sediment and biota were tested for 11 compounds in all: aldrin-dieldrin, DDT, heptachlor, lindane, and heptachlor epoxide, chlordane, endrin, mirex, toxaphene, α-BHC, and PCB's.

[26] Toxaphene, a mixture of chlorinated camphenes, is not particularly water soluble, but may accumulate in soils and in aquatic tissues (http://www.epa.gov/safewater/contaminants/dw_contamfs/toxaphen.html).

The EMAP stations in St. Marys and St. Andrews Sounds did not have any evidence of water or sediment quality degradation. Dissolved oxygen concentrations and pH were within normal ranges and there were no exceedances of bioeffect guidelines in terms of sediment concentrations of hydrocarbons, PCBs, pesticides or metals.[27] In contrast, the EMAP station in Cumberland Sound proper (CP95169) showed evidence of elevated pesticide levels in the sediment. Concentrations of dieldrin, lindane, 4,4'-DDD, and 4,4'-DDT were all in excess of Effects Range-Median (ER-M) guidelines and concentrations of total DDT and 4,4'-DDE were above Probable Effects Level (PEL) guidelines. Although sediment contamination often corresponds to effects on benthic or demersal fauna (and this was the case for many of the stations in the southeastern region), all of the sediment toxicity tests at the Cumberland Sound site were normal, and species richness, diversity, and abundance of both benthic and demersal organisms showed no indication of degradation. Moreover, the concentrations of contaminants in tissue samples of commercial biota were well below FDA guidelines for all samples (although the tissue samples from Cumberland Sound tended to have higher concentrations than those from the other two stations considered here).

Both the older and more recent observations raise concerns regarding contaminants, particularly mercury and the pesticides dieldrin, lindane and DDT. Although dieldrin and DDT are now banned and the use of lindane is quite restricted, contaminants can persist for many years in sediment. The fact that sediment toxicity tests and benthic invertebrate indices were normal for the area is positive, but it is difficult to draw any real conclusions with so few observations. Additional contaminant samples were collected at 17 stations in Cumberland Sound during the summers of 2000 and 2001 as part of the National Coastal Assessment (NCA) program. These results show very little evidence for elevated sediment contaminant levels (only two stations out of 17 had any observations that exceeded the sediment contaminant criteria[28] for a total of 28 analytes), and were all categorized as "Good" in the National Coastal Condition Report II (U.S. Environmental Protection Agency 2004d). Sediment toxicity tests were also negative; benthic survival rates were all above 92%.

There are no current fish consumption guidelines that apply specifically to Cumberland Sound, although there have been problems in the past. There is a regional advisory pertaining to the consumption of King Mackerel due to mercury in the entire southeast.[29] (King mackerel are predatory fish that accumulate mercury from other fish tissues as they attain a larger size.) There are however, concerns about mercury in other portions of the watershed. The EPD fish tissue analysis database used to generate the annual fish consumption advisories for Georgia shows that the detection frequency of mercury in fish tissue from the St. Marys River basin is 100% over 15 composites of 65 fish, with a mean concentration of 0.402 μg of mercury per g fish tissue. For

[27] Although there was reduced survival of the amphipod *Ampelisca abdita* in solid phase toxicity tests at one site (CP94019) and significant Microtox toxicity at another (CP94020), both of these were likely false positives caused by high concentrations (> 100 $\mu g\ L^{-1}$) of unionized ammonia nitrogen.

[28] Criteria were based on *Effects Range-Low* values, determined for each chemical as the 10th percentile in a database of ascending concentrations associated with adverse biological effects (U.S. EPA 2004d).

[29] NC, SC, FL, GA have issued a joint statement for King Mackerel consumption: 1 meal /week recommended limit for fish with fork length of 33-39 inches (1 meal /month for pregnant women, nursing mothers and children aged 12 and younger). Fish over 39 inches should not be eaten. Fish with a fork length of 24-32 inches have no consumption restrictions.

the Satilla River basin, the detection frequency is 90% over 31 composites of 154 fish, with a mean concentration of 0.587 µg of mercury per g fish tissue (DNR-EPD 2004).[30] Although mercury can come from atmospheric or natural sources, there are also high concentrations of mercury associated with several Superfund sites in the Brunswick region that could also be contributing to the problem. NCA samples of fish found elevated concentrations of arsenic, dieldrin, and PCB's in some specimens, but these observations might not reflect current levels of contamination in Cumberland Sound. It will be useful to have additional samples of both sediment and biota in the area, both of which will be available from the NCA program.[31]

B1c. Water quality on Cumberland Island

Freshwater and estuarine wetlands

Information on the water quality of the freshwater resources of Cumberland Island is described in a recent report prepared by the USGS for the National Park Service (Frick et al. 2002). The report summarizes previous water quality observations in freshwater areas of the park and provides the results of a yearlong sampling program (1999-2000) conducted in five freshwater and two outflow areas where these ponds drain to the ocean.[32] Surface water samples were collected from a total of nine sites for analysis of water quality (major ions, nutrients, trace elements, field parameters). Water quality observations were quite variable among the sites sampled in this study, in part because the various wetlands had differing amounts of saltwater influence and ground-water inflow, and in part because sampling was done after differing antecedent rainfall conditions (including Hurricane Floyd, which passed through the area during the study). High variability was particularly evident in the two outflow sites, which is likely due to the effects of tidal influence and/or overwash events.

Dissolved nitrogen concentrations (NH_4, NO_3) in the study were low and often fell below the limit of detection. Dissolved phosphorus (PO_4) tended to be higher, averaging 0.30 ± 0.46 mg P L^{-1} at all sites with the exception of one very high concentration (32.6 mg P L^{-1}). This observation was made in South End Pond in October 1999, two weeks after Hurricane Floyd, and it is speculated that manure may have been washed into the Pond. The report also notes that a previous investigation of water quality (Kozel 1991) had documented eutrophic conditions in South End Pond between 1988 and 1990, and so this observation is worth following up. When water quality data were compared to drinking water standards, nitrate concentrations were all below the primary drinking water standard (10 mg L^{-1}). Exceedances of secondary standards were noted for several other factors (pH, Cl, SO_4, total dissolved solids, Fe, F, and Mn). Some of these exceedances are likely due to the episodic inflow of saltwater (Cl, SO_4). Others (total

[30] The Georgia EPD program issues fish consumption guidelines annually, but they only take samples in a given area periodically, when asked, or when problems are suspected. The database was searched for: 4'4 DDT, a-BHC, aldrin, chlordane (technical), a-chlordane, g-chlordane, dieldrin, endrin, lindane, heptachlor, lead, mercury, PCB (total), and toxaphene. Satilla River samples were taken in 1994, 1996, and 1998 at Jamestown (near highway 84) and in 1998 at Burnt Fort and GA highway 252. St Marys samples were taken in 1997 and 2001 near the US highway 17 bridge and in 2001 at St. George (Charlton County).

[31] Georgia data from NCA are available for 2000 and 2001. EPA quality assurance/quality controls are being applied to the data from the summers of 2002-4, and they will be made available to the public.

[32] Freshwater wetlands were North Cut Pond 2A, Whitney Lake, Willow Pond, Lake Retta, and South End Pond 3; the outflows were Lake Retta and Whitney outflows.

dissolved solids, F, Fe, Mn) did not exceed standards often so there was not enough information to draw a conclusion. The pH standard is 6.5 and exceedances occurred consistently in North Cut Pond (range 4.3 to 4.5) and Whitney Lake (range 5.3 to 5.8). These low pH readings may be the result of in situ decomposition of plant material, or they could be the result of low pH in rainwater. Dissolved oxygen concentrations in the ponds ranged from <0.5 to 9.3 mg L^{-1} over the course of the study, and averaged 4.5 ± 3.0 mg L^{-1}.

Single measurements of stream condition (temperature, specific conductance, dissolved oxygen, pH, turbidity) were included in a study of stream health at three locations on Cumberland Island (Gore et al. 2004), but no other water quality information in the tidal streams could be located for this assessment. This represents a significant data gap in the assessment of park water quality conditions.

Groundwater

Groundwater samples were also collected from both the Upper Floridan and the surficial aquifer as part of the USGS study (Frick et al. 2002). EPA Maximum Contaminant Levels were not exceeded in any of the samples collected from the surficial aquifer, or in samples collected from shallow monitoring wells on the southern end of the island. However, samples from the surficial aquifer commonly exceeded secondary standards for drinking water (Cl, SO_4, total dissolved solids, Mn), and this was attributed to saltwater intrusion into the surficial aquifer. A study done for Kings Bay concluded that the source of saltwater to the surficial aquifer is a natural submarine outcrop off the southern end of the island that predated the deepening for the ship channel (Mack 1994).

The Upper Floridan aquifer is highly confined where it underlies Cumberland Island, and, based on chloride concentrations, Frick et al. (2002) concluded that saltwater intrusion is not currently a problem on the island. They also point out that one should not expect to see changes in major ion concentrations unless there is surface contamination from faulty well construction or large drawdowns in the potentiometric surface that change the source areas for a well or cause saltwater intrusion. However, they did recommend periodic monitoring of Cumberland Island as a way to provide early warning of potential future saltwater intrusion. More information on the USGS sampling program to monitor groundwater in the Upper Floridan aquifer can be found in **Appendix G**.

B2. Water quality impairments

The Environmental Protection Division (EPD) of the Georgia Department of Natural Resources prepares River Basin Management Plans for the major river basins in the state. These plans provide information on the major sources of both point and nonpoint pollutants within a river basin, as well as information on point source pollution control efforts that have been undertaken in the region. Management plans for both the Satilla and St. Marys River basins are based on observations from 1998 to 1999 (Georgia EPD 2002a, b). In addition, the Clean Water Act requires states to prepare and submit a list of those waters that do not attain the standards and conditions outlined by the designated use for that water body. This 303(d) list (named for the section of code outlining the mandate) is prepared biennially by the state EPD. This report is based on information from the 2000, 2002 and draft 2004 lists.

B2a. Nearfield impairments in Cumberland Island and surrounding estuarine areas

HUC 03070203 is that portion of the Satilla River watershed that contains Cumberland Island. The Satilla River basin management plan reports observations made in 11 estuarine areas within the HUC (150 square miles). These can be seen in **Figure 14**, which shows impaired waters based on the 2002 303(d) listing broken down by the specific violations for each evaluated segment. This information is from assessments conducted in 2000 and 2001 and represents the most recent listing for which spatial information is available. (Water bodies not mapped in **Figure 14** were not evaluated for violations and may or may not be supporting their designated use.[33] In addition, some estuarine areas under a shellfish ban receive this designation because the area has not been tested.) All 11 estuarine areas failed to support their designated uses: Four were cited for shellfishing bans, three for shellfishing bans plus fish consumption guidelines, two for shellfishing bans plus low dissolved oxygen, and two for shellfishing bans plus fish consumption guideline with the presence of PCB's and mercury (one also had cadmium).

Two of the impaired water segments listed on the 2002 303(d) list occurred in the southern portion of the HUC, which is the portion of the HUC closest to Cumberland Island. Both of these areas (Cumberland Estuary and St. Andrews Sound) were listed for a shellfishing ban covering a total of 39 square miles. However, neither the Georgia 303(d) list for 2002 nor the draft 2004 list have any estuarine impairments in Camden County for the Satilla River basin. It is not clear whether this represents an improvement in water quality in these areas, or whether a shellfish ban alone is not enough to trigger a listing. As noted above, in some cases a shellfishing ban is considered an administrative issue (i.e. where the site has not been monitored) and not one of water quality.

The remaining failures for HUC 03070203 all occur in and around Brunswick, which is a significant port city located approximately 16 miles from Cumberland in the Glynn County portion of the HUC (**Figure 3**). There are currently seven listed regions (99 mi^2) on the Georgia 303(d) list (**Table 6**). The causes are all attributed (at least in part) to industrial sources. It should be noted that several of these are near Superfund sites (*see* **section B3a**, below).

[33] The database records the extent of the stream, river or lake which is impaired, but fails to provide a unit of measure for the attribute, either in the database itself or its accompanying metadata. Recommendations for ways to make this database more useful are provided in **section D**.

Figure 14. 303(d) and 305(b) impaired waters for Georgia

(based on 2000-2001 assessment)

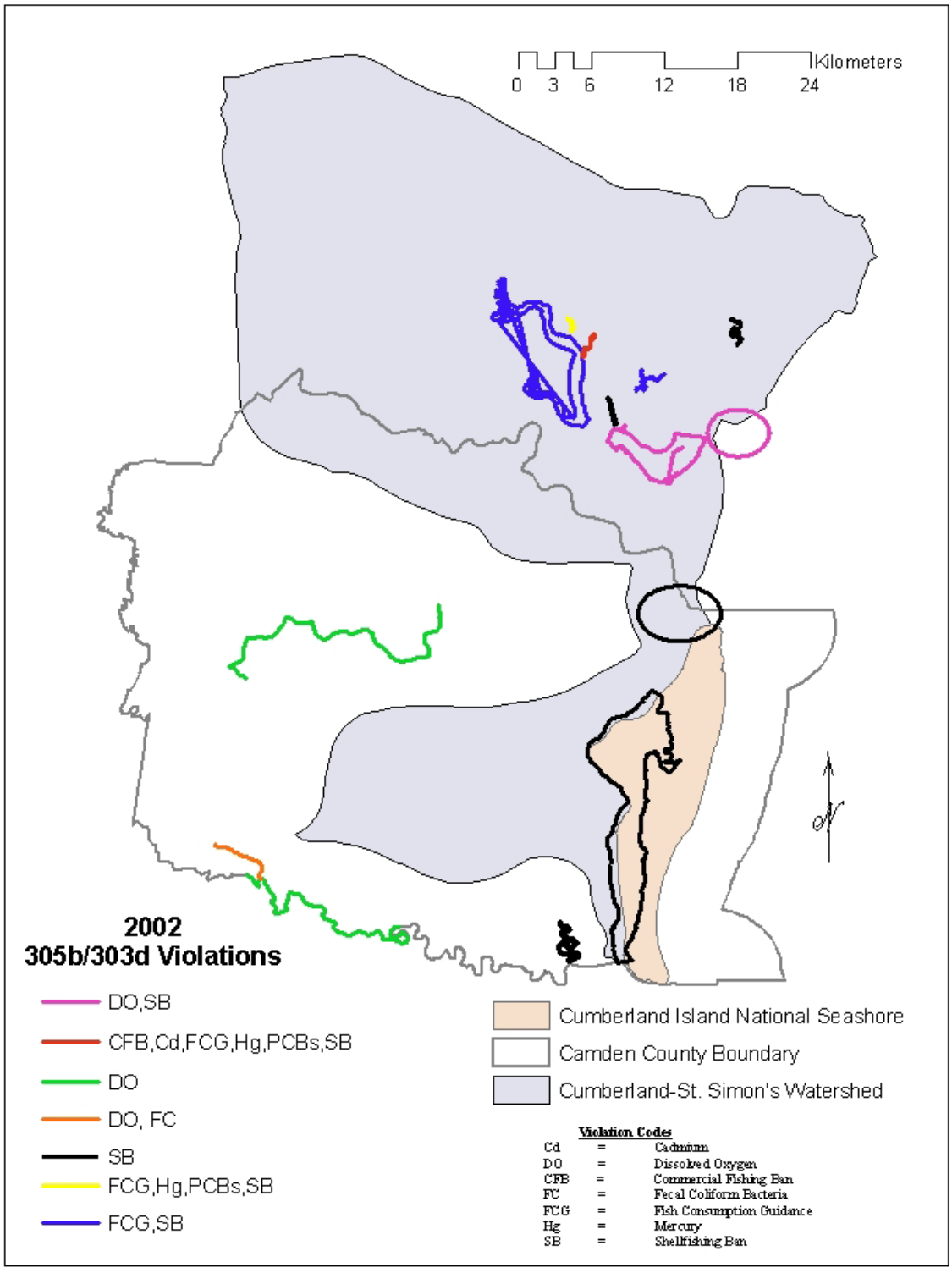

Table 6. Estuarine regions in St. Simons-Cumberland Sound on the Georgia 303(d) list that are *not fully supporting* designated use classification (fishing).
(Source: EPD, 2004 draft list).

- Back River, one mile above confluence with Terry Creek to Torras Causeway (Brunswick). 1 square mile, shellfishing ban and fish consumption guidance (for the presence of toxaphene-like compounds), potential causes listed as industrial facility/ residual from industrial source.
- Gibson Creek (Brunswick). 1 square mile, shellfishing ban and fish consumption guidance (for the presence of PCB's and mercury), potential cause listed as residual from industrial source. A TMDL has been developed.
- Purvis Creek (Brunswick). 1 square mile, commercial fishing ban, shellfishing ban, and fish consumption guidance (for the presence of PCB's, cadmium, and mercury), potential causes listed as industrial facility/ residual from industrial source. A TMDL has been developed.
- St Simons Sound (Brunswick). 66 square miles, dissolved oxygen limit exceeded, potential causes listed as industrial facility, municipal facility, urban runoff/effects, nonpoint/unknown sources. A TMDL has been developed.
- Terry and Dupree Creeks, north of Torras causeway to confluence with Back River (Brunswick). 1 square mile, shellfishing ban and fish consumption guidance (for the presence of toxaphene-like compounds), potential causes listed as industrial facility/ residual from industrial source. A TMDL has been developed.
- Terry Creek, south of Torras Causeway to Lanier Basin (Brunswick). 1 square mile, shellfishing ban and fish consumption guidance (for the presence of PCB's), potential causes listed as industrial facility/ residual from industrial source. A TMDL has been developed. In 2002, this location was also listed for mercury and toxaphene-like compounds.
- Turtle River System; Turtle River, Buffalo River, S. Brunswick River. 18 square miles, shellfishing ban and fish consumption guidance (for the presence of PCB's and mercury), low dissolved oxygen (not listed for this in 2002). Potential causes listed as industrial or municipal facility. TMDL's have been developed.

B2b. Farfield impairments in Cumberland Island and surrounding estuarine areas

Satilla River watershed

The river basin management plan for the Satilla River also considers water quality in stream segments in the two HUCs within the basin located upstream of Cumberland Island. In the most upstream HUC (03070201), observations were made at 24 stations. Four river or stream segments (56 miles) were found to be in support of designated uses, eight segments (165 miles) partially supported designated uses, and 12 segments (122 miles) did not support their

designated usage. Of those not supporting or only partially supporting designated use: nine segments failed because of both low dissolved oxygen concentrations and fecal coliform exceedances, seven for low DO alone, two for fecal coliform, and two for fish consumption guidelines issued for high mercury concentrations. In the intermediate HUC (03070202), observations were made at nine stations. Two segments (8 miles) that were evaluated were acceptable but the remaining seven segments (90 miles) did not support their designated usage. These areas again failed either because of high fecal coliform counts (six segments) or low DO (one segment). The report notes that in both of these upper HUCs there was a potential threat from erosion and sedimentation, but at that time, all reaches supported use based on this criterion.

St. Marys River watershed

Further to the south, information on impairments in the St. Marys River (HUC 03070204) comes from both Georgia and Florida. The St Marys River basin management plan prepared by the Georgia EPD contains 1998 and 1999 information regarding water quality in the basin. This report describes nine river or stream segments and one estuarine area, none of which fully supported designated uses. Five segments (102 river or stream miles) partially supported uses, but were listed for low dissolved oxygen and/or fish consumption guidelines (one of them was also listed in 2002 for fecal coliform). The remaining four stream segments (20 miles) all failed for low dissolved oxygen (one of them was also listed for fecal coliform). Nonpoint or unknown sources were given as the reason for all nine river segment impairments. The three-square-mile estuarine area did not support usage because of a shellfishing ban (industrial sources were cited as the cause). Similar information is present in the 2002 and draft 2004 Section 303(d) lists, but one new stream segment has been added (for low dissolved oxygen) and one stream segment previously listed for low dissolved oxygen in 2002, is also listed in 2004 for fecal coliform contamination. The impaired estuarine area described in the River Basin Management Report did not appear on either the 2002 or draft 2004 Section 303(d) lists. This is similar to what occurred in the estuarine areas in Camden County, and may be due to the fact that untested waters are prohibited for shellfishing (or perhaps the water quality has improved).

Finally, information from the Florida 1998 Section 303(d) list includes three segments of the St Marys River in Nassau County, not too far from Cumberland Island. The parameters of concern in these reaches include nutrients, mercury, suspended solids, dissolved oxygen, and coliform. There is also a listed segment in the Amelia River, which identifies nutrients as a parameter of concern and places a high priority on the development of a TMDL for the reach. As of 2002, however, there were no impairments listed in Nassau County for the St Marys watershed.[34]

[34] However, in the Nassau - St. Marys Basin Planning documents, Amelia Island area is described (by a color-coded map) as having insufficient or no data with regard to bacteria, dissolved oxygen, chlorophyll, and "biology" (Florida Department of Environmental Protection, http://www.dep.state.fl.us/water/basin411/nassau/maps.htm).

B3. Sources of pollutants

B3a. Point sources of pollutants

There are no federally regulated point sources of pollution within the boundary of Cumberland Island. The only evidence for point source pollutants on the island were a leaking underground storage tank at CUIS and one oil spill, both of which were reported to the Georgia EPD.[35] These appear to be isolated and rare events. More significant potential point sources of pollution exist in the surrounding watershed, particularly in the Brunswick area. Note that the following discussion is primarily focused on those portions of Camden and Glynn Counties that fall within the Cumberland Island-St. Simons portion of the Satilla River watershed (although Nassau County, FL and the portion of Camden County that falls in the St. Marys watershed were also considered). The Camden County sites are probably the most relevant to Cumberland Island.

Superfund and the National Priorities List

Congress enacted the Superfund program in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). There are two Superfund sites in Camden County, and 12 in Glynn County[36] (**Table 7**). This is relevant in terms of the potential effects of dredging activity as well as pollutants. All of the Glynn County sites are in Brunswick. The high concentration of sites in Brunswick is of concern, particularly in light of the fact that three of them are presently on the National Priorities List (NPL), and a fourth is proposed. NPL sites are those areas given high priority for federal evaluation and remediation on the basis of potential human health and environmental risks (there are a total of 14 NPL sites in the state of Georgia.) Although the EPA database does not provide information on the identity of contaminants at each Superfund site, it does provide that information for NPL sites.

The contaminants at the three final (and one proposed) NPL sites in Brunswick include metals (mercury, lead, chromium, copper, and arsenic), PCBs, and other organic compounds (toxaphene, pentachlorophenol, and creosote). One Brunswick location of particular concern is the LCP site. This has been at various times an oil refinery, a paint and varnish manufacturing plant, a power plant, and a chlor-alkali plant. The 550-acre area was designated a Superfund site by the EPA in 1996, due to large amounts of mercury and PCB contamination of the nearby creeks and marshes. Other metals (including lead) and volatile organic compounds have also been found in about 500 acres of marsh, a one-mile portion of the Turtle River, and the entirety of Purvis Creek. Since 1996, 253 thousand tons of hazardous waste and contaminated soils and sediments have been removed from the site, and an additional 13 acres of marsh have been excavated. Through mandated cleanup activities and additional pilot projects (including phyto-remediation to remove mercury from the soil), the LCP Superfund site has been improved to the point that fish consumption advisories have been lifted or lessened for Purvis Creek (U.S. Environmental Protection Agency).

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[35] The EPD data on spills and leaking underground storage tanks does not include information on cleanup or restoration activities.

[36] There are no Superfund sites in Nassau County, FL

Table 7. CERCLA sites in Camden and Glynn County, Georgia

(NPL: National Priorities List; N.A.: information not available).
Data source: (http://cfpub.epa.gov/supercpad/cursites/srchsites.cfm)

Location	Site Name	EPA ID	NPL	Contaminants	Additional Reference
Camden Co.					
Woodbine	Union Carbide Agric. Products Co. (a.k.a. Rhone-Poulenc)	GAD030035356		N.A.	
Kings Bay	U.S. Naval Submarine Base	GA4170090001		N.A.	
Glynn Co.					
Brunswick	4th Street Landfill	GAD980556898		N.A.	
Brunswick	Brunswick Light & Water Co.	GA0000360594		N.A.	
Brunswick	Brunswick Wood Preserving	GAD981024466	+	pentachlorophenol, creosote, chromium, copper, and arsenic	(U.S. EPA, Escambia)
Brunswick	Cate Road Landfill	GAD980556914		N.A.	
Brunswick	Chemresol, Inc.	GAD047964291		N.A.	
Brunswick	GA Creosoting Co.	GA0001098029		N.A.	
Brunswick	Hercules, Inc.	GAD004065520		N.A.	
Brunswick	Hercules Landfill	GAD980556906	+	toxaphene	(U.S. EPA, Hercules)
Brunswick	LCP Site (and GA Power – proposed substation)	GAD099303182 (and GA0001401967)	+	mercury, PCB's, lead, volatile organic compounds	(U.S. EPA, LCP Chem.)
Brunswick	T Street Dump	GAD980556880		N.A.	
Brunswick	Terry Creek dredge spoil, Hercules outfall	GAD982112658	Pro-posed	toxaphene	(U.S. EPA, Hercules - Bruns-wick)
Brunswick	O'Brien Corp.	GAD004067534		N.A.	

National Pollution Discharge Elimination System

The National Pollutant Discharge Elimination System (NPDES) was established under the Clean Water Act as a regulatory mechanism to monitor point-source discharges from industrial and municipal facilities. Information on NPDES permit-holders can be obtained through the U.S. EPA. In addition, EPA maintains the Enforcement and Compliance History Online (ECHO) program, which provide many details to the public on water, air, and hazardous waste facilities regulated by federal statutes (U.S. Environmental Protection Agency 2004b). Georgia EPD also has a wealth of information on point sources on their website: the *Georgia's Environment* page includes links to a hazardous site inventory[37], radiation monitoring reports, and information on environmental releases (which includes toxics release inventory reports as well as data on industrial spills[38]). The *Enforcement Order* search page allows one to access a list of the proposed and executed EPD enforcement orders[39], and the *Regulated Community* pages include listings of Leaking Underground Storage Tanks and Industrial Stormwater Permittees.[40]

There are a total of 30 federally regulated NPDES permittees in the HUCs of the St. Marys River (03070204) and Cumberland-St. Simons (03070203). These are listed in **Table 8** along with EPA- or EPD-listed events (violations, toxic releases, known hazards, enforcement orders, spills and leaking underground storage tanks). (*For more specific information regarding many of these facilities, see* **Appendix H**.) There are nine current permittees in Camden County, most of which are municipal wastewater treatment plants. Until recently, the Durango-Georgia Paper facility was one of the largest discharges in the area and the source of spills and leaking tanks. However, this permit expired in May 2003 and the plant has been in shutdown since October 2002 (Harris and Georgia EPD 2004b). The only active industrial permit is Bayer (Aventis) Cropscience, which is a chemical manufacturing facility. However, the Kings Bay Naval Base has a permitted discharge in Camden County. Information on activities at the base is not readily available to the public, but the facility has been cited for leaking storage tanks, numerous spills (as well as ECHO violations and toxic releases), and the site is on the Georgia Hazardous site inventory.

There are a total of 16 NPDES permittees in Glynn County. These are almost all industrial facilities located in and around Brunswick, although there are also several municipal

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[37] The hazardous site inventory includes name, location, property owner, regulated substances released, threats to human health and environment posed by the release, status of cleanup activities, cleanup priority, and the EPD Director's "determination regarding corrective action".

[38] A table of these events (including the date, spill number, facility/incident name, location, material spilled, waterway impacted, type of action, and to which agency the incident was referred) can be downloaded from the website.

[39] EPD enforcement orders resulting from action under the Water Quality Control Act (including Surface Water Allocation), Air Quality Act, Comprehensive Solid Waste Management Act, Erosion and Sedimentation Act, Safe Drinking Water Act, Surface Mining Act, or Underground Storage Tank Act (Georgia DNR 2002) can all be found. A recent search turned up 46 executed enforcement orders in Camden County and 78 in Glynn County.

[40] Other sources of information include the Brunswick office of Georgia DNR - EPD, which has paper copies of some of the monthly monitoring reports for NPDES permitted facilities. Mr. Jim Harris has begun to create a database of such information. Some of the Florida NPDES facility monitoring information is also publicly available on the FL Department of Environmental Protection website (http://www.dep.state.fl.us/).

wastewater facilities and a marina. Various facilities in the county have been sited at different times under the Water Quality Control Act (WQCA), Air Quality Control Act (AQCA), Safe Drinking Water Act (SDWA), Hazardous Site Response Act (HSRA), and the Hazardous Waste Management Act (HWMA). Finally, there are four facilities in Nassau County included in **Table 8**: two municipal facilities and two pulp paper mills. Although these areas are downstream of Cumberland Island, they are all listed in HUC 03070304.[41] These were considered close enough that wind / storm events, dredging, shipping, and movement of contaminants via organisms could still have impacts on the nearshore areas of Cumberland, especially along the southern reach.

[41] There are likely others in this HUC, but location information is not consistent throughout the Envirofacts database.

Table 8. List of NPDES permit-holders and summary of violations

Operator or Facility Name	County, *River basin* / Location	Type	Flow (mgd)	NPDES Permit Number	Available Monitoring Information	ECHO Violation[a]	Toxic Release	Georgia Hazard-ous Site	Enforcement Orders[b]	Spills[c]	Leaking Tanks[d]
Bayer (Aventis) Cropscience	Camden, *Satilla*	Industrial chemical manufacturing	N/A	GA0003468	(Harris and Georgia EPD 2004a)	Yes	Yes				
Durango-Georgia Paper	Camden, *St. Marys*	Industrial pulp and paper products	30	GA0001953 expired	(Georgia EPD 1986) (Harris and Georgia EPD 2004b)	Yes	Yes		4 – WQCA, AQCA	>40	1 S, 1 C
Kingsland Water Pollution Control Plant	Camden, *St. Marys,* Kingsland	Municipal	2.2	GA0037800		Yes			1 - WQCA		
River Oaks Mobile Home Park	Camden, *St. Marys*	Other	N/A	GA0035599, (formerly GAG550126)	(Harris and Georgia EPD 2004c)						
State Route 110 MSW Landfill	Camden, *St. Marys*	Municipal	0.015	GAU050153							
St. Marys Water Pollution Control Plant	Camden, *St. Marys*	Municipal	0.7	GA0026255	(Harris and Georgia EPD 2004d)				2 – WQCA, 1 -- SDWA	8	2 C
St. Marys Scrubby Bluff	Camden, *St. Marys*	Municipal	0.5	GA0037931							
St. Marys, LAS	Camden, *St. Marys*	Municipal	0.8	GAU020068							
U.S.N Base Kings Bay	Camden, *Satilla*	Federal submarine homeport	0.5	GA0027707		Yes	Yes	Yes		~176	28 C
Woodbine Water Pollution Control Plant	Camden, *Satilla*	Municipal	0.368	GA0023701	(Harris and Georgia EPD 2004f)						1 C
Academy Creek WPCP	Glynn, *Satilla*, Brunswick	Municipal	13.5	GA0025313		Yes			2- WQCA	NS	NS

Operator or Facility Name	County, *River basin* / Location	Type	Flow (mgd)	NPDES Permit Number	Available Monitoring Information	ECHO Violation[a]	Toxic Release	Georgia Hazard-ous Site	Enforcement Orders[b]	Spills[c]	Leaking Tanks[d]
Driftwood #1 Mobile Home Park	Glynn, *Satilla*, Brunswick	Industrial	0.015	GA0033901						NS	NS
Driftwood #2 Mobile Home Park	Glynn, *Satilla*, Brunswick	Industrial	0.015	GA0033910						NS	NS
Georgia Pacific (Brunswick Cellulose, Inc)	Glynn, *Satilla*, Brunswick	Industrial, pulp mill	32.2	GA0003654			Yes	Yes	3-HSRA	NS	NS
Georgia Ports Authority	Glynn, *Satilla*	Industrial	N/A	GA0047937				Yes	1-HSRA	NS	NS
Georgia Power	Glynn, *Satilla*, McManus	Industrial electric utility	N/A	GA0003794			Yes	Yes	1-HSRA	NS	NS
Glynn County Board of Commissioners	Glynn, *Satilla*, Brunswick	Municipal, wastewater land application system	0.3	GAU020059						NS	NS
Golden Isles Marina	Glynn, St Simons Island	Other	N/A	GAG550111						NS	NS
Hercules	Glynn, Brunswick	Industrial, gum and wood chemicals	8.7	GA0003735		Yes	Yes	Yes	3- AQCA, 2- HWMA 1- WQCA	NS	NS
Jekyll Island WPCP	Glynn	Municipal	1.0	GA0020508		Yes				NS	NS
Lewis Crab Factory	Glynn, *Satilla* Brunswick	Industrial, fresh and frozen seafood	N/A	GA0003701						NS	NS
Millennium Specialty Chemicals	Glynn, *Satilla,* Brunswick	Industrial, organic chemicals	N/A	GA0050016		Yes	Yes		1- HWMA	NS	NS
Millennium Specialty Chemicals	Glynn, *Satilla,* Brunswick	Other	N/A	GAU010519		Yes					

Operator or Facility Name	County, *River basin* / Location	Type	Flow (mgd)	NPDES Permit Number	Available Monitoring Information	ECHO Violation[a]	Toxic Release	Georgia Hazard-ous Site	Enforcement Orders[b]	Spills[c]	Leaking Tanks[d]
New Hope Mobile Home Park	Glynn, *Satilla*, Brunswick	Industrial	0.034	GA0048895					1- SDWA	NS	NS
Sea Harvest Packing Company	Glynn, *Satilla*, Brunswick	Industrial, fresh and frozen seafood	N/A	GA0002607			Yes			NS	NS
St Simons Island WPCP	Glynn	Municipal	3.0	GA0021521		Yes			2- AQCA, 1- WQCA	NS	NS
Jefferson Smurfit	Nassau, *HUC 03070204*	Industrial pulp and paper mill	37.5	FL0001104	(Florida DEP 1992; Florida DEP 1999; Florida DEP 2003a)	Yes	Yes	–	–	–	–
Marsh Cove Condominiums	Nassau, *HUC 03070204*	Municipal	0.05	FL0032654				–	–	–	–
Rayonier Inc	Nassau, *HUC 03070204*	Industrial cellulose pulp mill	26.31	FL0000701	(Florida DEP 1991; Florida DEP 2003b)		Yes	–	–	–	–
Town of Hilliard	Nassau, *HUC 03070204*	Municipal	0.32	FL0043079				–	–	–	–

[a] This plant is listed in the ECHO database as having had a violation in the last two years, but is not listed for a "current significant violation" (U.S. Environmental Protection Agency 2004b)

[b] GA EPD, Enforcement order search page: WQCA (Water Quality Control Act), AQCA (Air Quality Control Act), SDWA (Safe Drinking Water Act), HSRA (Hazardous Site Response Act), HWMA (Hazardous Waste Management Act).

[c] Camden Co (5/1990 – 9/2000) had >300 spills

[d] Leaking underground storage tanks:
S-Suspected C-Confirmed

NS – database not searched for this information

In addition to NPDES permittees, there are also numerous facilities that produce and release air pollutants, facilities that have reported toxic releases, and those that have reported hazardous waste activities. These are tallied below (**Table 9**); information regarding facilities of particular concern in each county is reported in **Appendix H**.

Table 9. Number of facilities with violations listed in the EPA Envirofacts website

No. facilities	Camden County, Ga.	Glynn County, Ga.	Nassau County, Fl.
air pollutants	21	55	10
toxic releases	3	14	3
hazardous waste activities	41	152	134

It should be noted that some point source control efforts have been undertaken in the region. In terms of waste treatment, several cities and other entities have either opened new facilities or made improvements to existing ones (i.e. the cities of Waycross, Nichols, Folkston, Kingsland and St. Marys; Golden Isles Marina; Glynn County; Kings Bay). Improvements include movement of discharge points, increased aeration, land application systems, and changes in sludge processing, all of which should serve to improve water quality (Georgia EPD 2002b).

Landfills

There are a number of landfills (and other types of waste disposal sites) listed by the GA –EPD as sources of environmental contamination. These can be considered point sources of pollution since to some extent contaminants enter the environment at these locations through deliberate introduction of waste materials. **Figure 15** shows historic and active landfills (Georgia Department of Natural Resources 2000) and recycling centers (Georgia Department of Community Affairs 2000) in the Cumberland-St. Simons watershed and surrounding counties. The landfill information reflects both landfills that are permitted and regulated as well as older landfills that closed prior to the creation of the state of Georgia's landfill regulations.

There is one landfill in Camden County listed in the GA EPD Hazardous Site Inventory. This location (Vacuna Road Landfill, #10647) was listed for the presence of vinyl chloride, cadmium, and benzene (Georgia EPD 2003b). An additional 12 sites are listed in Glynn County. These are listed in **Table 10** along with the number and type of contaminants found associated with the soil or groundwater at each site.

Figure 15. Historic and active landfills and recycling centers in the Cumberland-St. Simons watershed and surrounding counties

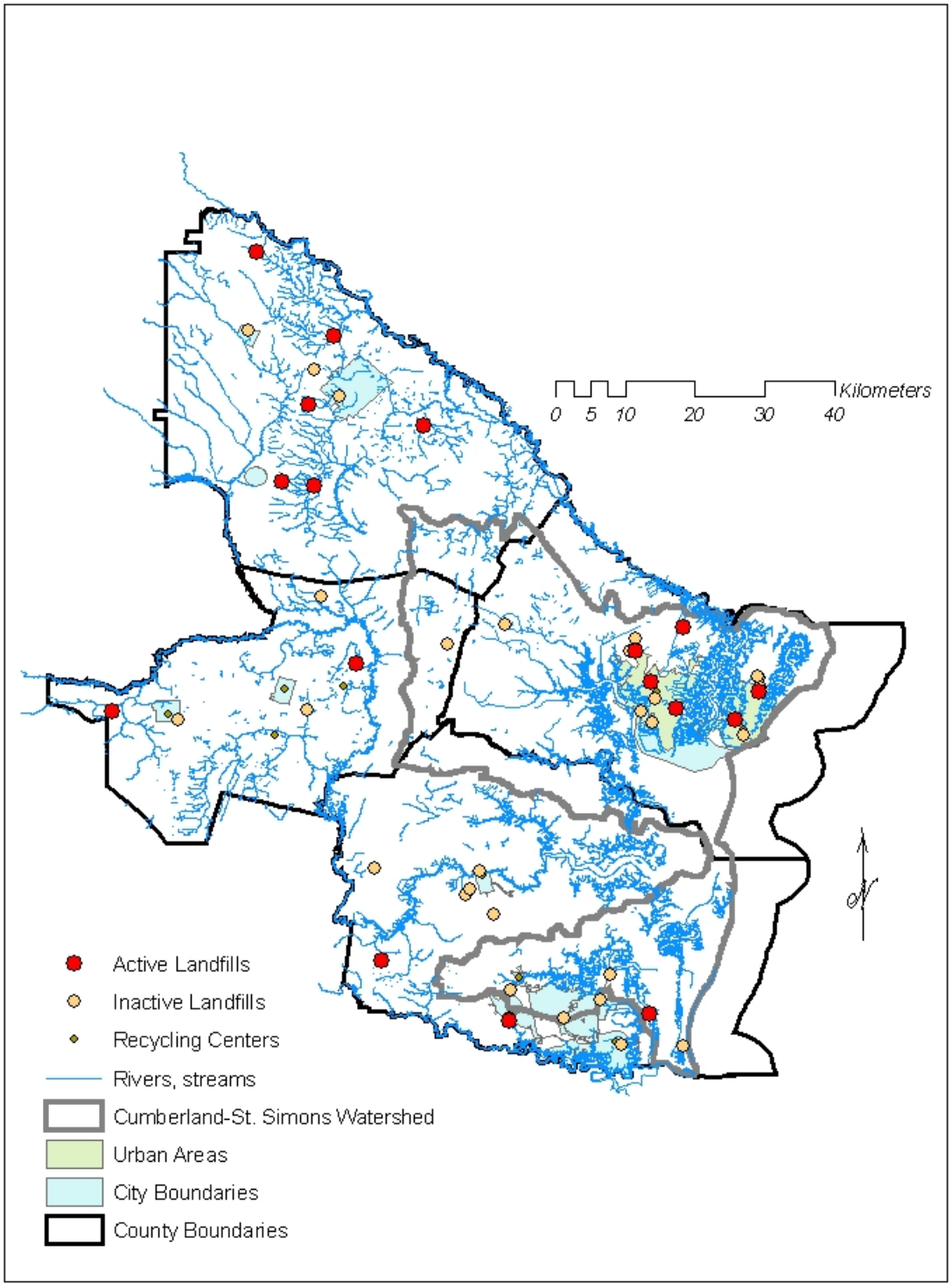


Table 10. Hazardous materials sites in Glynn County, Georgia

("Type" refers to the main contaminant found in that environment.)

[a] Site is on (or proposed for) the National Priorities List.

Location	Site ID	Groundwater contaminants		Soil contaminants		Ref.
		#	Type	#	Type	
4th Street Landfill (Brunswick Airport)	10282	1	Lead	1	Lead	(Georgia EPD 2003a)
Atlanta Gas Light Company - Brunswick MGP Site	10069	28	Benzene	40	Benzo(a)-pyrene	(Georgia EPD 2004c)
Atlantic Engineered Products (Former)	10399	4	1,1-dichloro-ethene			(Georgia EPD 2004i)
Chemresol, Crispen Blvd	10251	2	Cadmium	2	Dioxin	(Georgia EPD 2004g)
Escambia Treating Company - Brunswick	10028	17	Arsenic	19	Arsenic	(Georgia EPD 2004b)
Federal Law Enforcement Training Center	10156		Lead			(Georgia EPD 2004e)
Cate Road C&D MSWLF	10665	1	Vinyl chloride			(Georgia EPD 2004c)
LCP Chemicals [a] Ross Road	10144	1	Mercury	17	PCB's	(Georgia EPD 2004d)
Lanier Shopping Plaza	10769	4	Vinyl chloride	8	Tetrachloro-ethene	(Georgia EPD 2004k)
Southern Tri-State Electric	10587	3	Benzene			(Georgia EPD 2004j)
T Street Dump (GA Pacific)	10317	16	Lead	10	Lead	(Georgia EPD 2004h)
Terry Creek Dredge Spoil Area (Hercules) [a]	10242			1	Toxaphene	(Georgia EPD 2004f)

Airports

There are numerous public and private airfields in the region that are likely to have some effects on regional water quality through atmospheric deposition, runoff from impervious surfaces, and incidents related to fuel storage or use. Public airfields within approximately 30 nautical miles of Cumberland Island include: Jekyll Island (38 flights/week), Hilliard Airpark

(96 flights/week), St Marys Airport (34 flights/day), Fernandina Beach Municipal Airport (129 flights/day) and Jacksonville International Airport (338 flights/day) (AirNav.com 2005). There has been recent discussion of moving the small St. Marys airport further from Kings Bay (due to security concerns). This would almost certainly position the airport further from Cumberland Island. An FAA project is in place for the city of St. Marys to determine the feasibility of relocating the airport and evaluate several possible sites (City of St Marys 2004; News 4 Jacksonville April 21, 2004).

B3b. Nonpoint sources

Cumberland Island is considered to be a relatively pristine barrier island made up largely of undeveloped forest and wetlands (**Table 2**). On the island itself, atmospheric deposition is probably the largest source of nonpoint pollution, in terms of both nutrients (i.e. nitrogen) and contaminants (particularly mercury and lead). Waste from large feral animals (hogs and horses) do not represent a new source of pollution so much as a shift in the food web. However, to the extent that they add organic material to areas such as tidal creeks that would not otherwise receive it (i.e. if horses are displacing deer), then they can cause water quality degradation. Aging septic systems are also potential sources of organic material and nutrients to the water, which could be locally important. Within the larger region, nonpoint sources of pollution include human and animal waste (including animals raised for agriculture); runoff resulting from fertilizers, pesticides, and herbicides applied to agricultural crops, lawns, and golf courses; and such things as hydrocarbons from fuel spills and emissions, and atmospheric deposition. Nonpoint pollutants are very difficult to assess, but as part of the 2002 River Basin Management Plans, the Georgia EPD identified nonpoint sources of pollution as having the most significant effects on water quality in both the Satilla and the St Marys River basins (Georgia EPD 2002b). Moreover, there is evidence that concentrations of nutrients are increasing in Georgia's coastal water (Verity 2002a), likely from nonpoint sources. Below we briefly review the available information for different potential pollutants.

Nutrients

In a study of nutrient inputs to the watersheds of seven southeastern rivers for the period 1986 to 1990, Asbury and Oaksford (1997) concluded that animal waste was the largest source of nitrogen in the Satilla River basin, contributing more than 3,000 kg N km^{-2} y^{-1}. Fertilizer (from both urban and agricultural settings) was second, estimated as approximately 1,200 kg N km^{-2} y^{-1} and atmospheric sources were third (~600 kg N km^{-2} y^{-1}). In comparison, nitrogen from wastewater treatment plants and septic tanks totaled approximately 50 kg N km^{-2} y^{-1}. In terms of phosphorus, animal waste was again the most important (~ 1,000 kg N km^{-2} y^{-1}) and fertilizer second (almost 300 kg N km^{-2} y^{-1}). There is no atmospheric source for phosphorus, and wastewater treatment plants and septic tanks were again comparatively small. Although the study concluded that most of the nutrients generated in the headwaters appear not to reach the lower coastal plain, the high numbers of animals in the state is cause for concern. Note also that a recent report in Chesapeake Bay concluded that animal manure is the second biggest source of nitrogen pollution that reaches the water (point source discharges from sewage treatment plants was first) (Chesapeake Bay Foundation 2004).

According to recent figures from the Georgia Poulty Federation, Georgia currently produces more poultry products than any other state in the U.S., and production has increased steadily for several decades. This fact, coupled to the concurrent trend that shows that the amount of land allocated to farming is decreasing, means that high densities of animals end up in confined animal feeding operations (CAFOs). CAFOs are of particular concern, because of their potential to contribute high amounts of organic waste and nutrients to nearby water bodies. At the time of this report the Georgia DNR – CRD has funded two studies concerning the identification of animal feeding operations (AFOS) on the Georgia coast. The first is developing methods for documenting the spatial location of small confined animal feeding operations on the Georgia coast and the second is a survey that targets county agricultural extension agents and U.S. Department of Agriculture - Natural Resources Conservation Service employees on the coast, asking them to identify small, unpermitted AFOS.[42] As part of the first project, K. Payne has developed a preliminary map to identify the confined animal feeding operations in the watersheds of the Satilla and St. Marys rivers. This work suggests that there are no large CAFOs in the Cumberland – St. Simon's HUC.[43] However, total animal operations in the Satilla and St Marys watersheds are estimated to generate 2,900,000 and ~42,700 tons yr^{-1} of animal waste respectively (Georgia EPD 2002a; Georgia EPD 2002b). These estimates account for commercial domestic stock alone – animal waste from natural populations is a much more difficult problem that has yet to be addressed.

Organic matter

Organic matter likely enters the watershed through the same mechanisms as nutrients, described above (i.e. animal waste). There has been no estimate done of other sources of organic matter, but failing septic tanks can be locally important, particularly if they are located close to a water body. The Camden County Environmental Health Department Director Dr. Stuart Stevens is currently in the process of mapping the location of septic tanks throughout the county (but this effort does not include Cumberland or Little Cumberland Islands).

Contaminants

Nonpoint source delivery of pollutants likely occurs via stormwater runoff and atmospheric deposition. Runoff is generally a function of the amount of impervious surface in an area. The existing municipalities in the area include Kingsland, St. Marys, Woodbine, Brunswick, and Jekyll Island (in Georgia), plus Amelia Island and Fernandina Beach (in Florida). Although forest and wetlands are still the dominant land cover classification (**Table 1**), the increasing rate of residential development in the area, as determined through our analysis discussed above (*see* **section A1c**), certainly presents the possibility of increased water- or air-borne pollutants reaching Cumberland Island in the future.

[42] This first project is being conducted by Mark Rissee, Tommy Bass and Karen Payne at UGA and should be completed by October 2005; the second is being conducted by Nick Ogden of the U.S. Department of Agriculture Natural Resources Conservation Service.

[43] This database is preliminary and is not intended to be comprehensive. CAFOS were identified by digitizing what appear to be large barns or animal pens that are visible on 1993 black and white aerial photos that have a 1-meter resolution.

One source of contaminants comes from the application of materials like pesticides and herbicides to the land. These can be used in field agriculture[44] as well as on golf courses and suburban lawns.[45] Pesticides, herbicides and fungicides are also used in silviculture[46] but these are considered less important because chemical use is relatively low in mature stands of trees. It is higher in commercial nurseries, but there are none in the St Marys basin and only five in the Satilla River basin (Georgia EPD 2002a; Georgia EPD 2002b).

The atmosphere can also be an important source of pollutants to coastal waters: the U.S. EPA identifies nitrogen compounds, mercury, other metals, pesticides, and combustion emissions as the five types of pollutants "most likely to degrade water quality through atmospheric deposition" (U.S. Environmental Protection Agency 2004a). The inter-agency National Atmospheric Deposition Program collects data on a suite of constituents (calcium, magnesium, potassium, sodium, ammonium, nitrate, inorganic nitrogen [from ammonium and nitrate], chloride, sulfate, and hydrogen). The monitoring stations closest to Cumberland Island are GA23 (Fort Frederica National Monument), GA09 (Okefenokee National Wildlife Refuge) and FL03 (Bradford Forest). There is also a new station at Sapelo Island (GA33) which has been operational since 11/2002 (**Figure 16**). As part of the dedicated Mercury Deposition Network, station GA09 has also collected weekly mercury deposition since 1997. The average rate of deposition at this site (0.25 ± 0.38 μg m^{-2}) is well below the national average of 4 to 20 μg m^{-2} (National Atmospheric Deposition Program 2004b; National Atmospheric Deposition Program 2004a) perhaps because it is quite a distance from any large roads or municipalities.

[44] Pesticides and herbicides used on area farms might include: 2,4-d, Prowl, Blazer/ Basagran/ Trifluralin/ Treflan/ Trilin, Gramoxone, Classic, Lexone/ Sencor, and Lasso (alachlor) (compiled from the Georgia Herbicide Use Survey summary, as presented in the River Basin Management Plans for the Satilla and St. Marys Rivers. (Georgia EPD 2002a,b).

[45] These include: chlorpyrifos, diazinon, malathion, acephate, carbaryl, lindane, dimethoate, chlorothalonil, dicamba, glyphosage, 2, 4-D, methyl sulfometuron, mecoprop, benefin, and numerous others (Georgia EPD 2002a,b).

[46] The major herbicides, pesticides, and fungicides in silviculture use include: glyphosate (Accord), sulfometuron methyl (Oust), hexazinone (Velpar), imazapyr (Arsenal), metsulfuron methyl (Escort) chlorpyrifos, diazinon, malathion, acephate, carbaryl, lindane, dimethoate, chlorothalonil, dichloropropene, and mancozeb (Georgia EPD 2002a,b).

Figure 16. National Atmospheric Deposition Program station locations closest to Cumberland Island

C. Other Water Resource Issues of Concern

C1. Coastal development

C1a. Population and land use

Between 1994 and 2015, the coastal population in the southeastern U.S. is expected to increase by more than 35% (Culliton 1998). The area around Cumberland Island is no exception to these trends. As described above, the population of Camden County tripled during the 1990s (*see* **section A1c**; **Figures 6** and **7**, **Table 1**). Moreover, the types of developments that accompany this population increase tend to be ones that increase sprawl, which has consequences for water quality in terms of increased overland runoff from impervious surfaces (roads, driveways, parking areas) in conjunction with increased acreage of pesticide or herbicide-treated land (parks, golf courses, lawns). A recent study of water quality in tidal creeks in coastal South Carolina found that when the percentage of impervious land cover in the watershed exceeded 20 to 30% there were negative effects on living resources in the creek (Holland et al. 2004).

There are currently several developments being proposed or expanded in the Cumberland Island area. These types of projects are of particular concern when they involve building docks and marinas. Docks and similar structures have the potential to contribute directly and indirectly to water quality problems in several ways, including leaching of preservatives from dock pilings and release of long-chain polyaromatic hydrocarbon pollutants from boat traffic (through combustion and fuel spills)(Sanger and Holland 2002). Physical disturbances caused by construction or boat activity can also contribute to erosion and sedimentation (Sanger and Holland 2002). In addition, docks can reduce the density of marsh vegetation by shading (which affects overall marsh productivity) (Alexander and Robinson 2004).

A number of developers have recently filed applications with the GA DNR - CRD for coastal development permits. Such projects are of concern to park managers. Four of these involve marinas or docks directly upstream from CUIS (**Figure 17**)[47]:

Cumberland Harbour

A 1,014-acre residential community known as Cumberland Harbour is currently being constructed on a peninsular property in Camden County largely surrounded by public marshlands. The community is adjacent to U.S. Navy's Kings Bay Nuclear Submarine Base to the north and lies immediately across Cumberland Sound from the Cumberland Island National Seashore. This substantial development[48] is also referred to as the Point Peter project. The developers have requested permission under the Coastal Marshlands Protection Act to build two marinas (on the St Marys and the North River) and three community docks on Point Peter Creek. It is anticipated that another 92 private docks might be built on the Creek. The two proposed commercial floating-dock marinas are intended to be full-service marinas able to accommodate approximately 296 boats in wet slips including some large vessels (30 - 40 feet) and provide dry

[47] As of this writing, public notice for additional development permit applications in nearby Glynn county has been given. These developments are the St Andrews Plantation/Yankee Landing and Tuscon Landing.

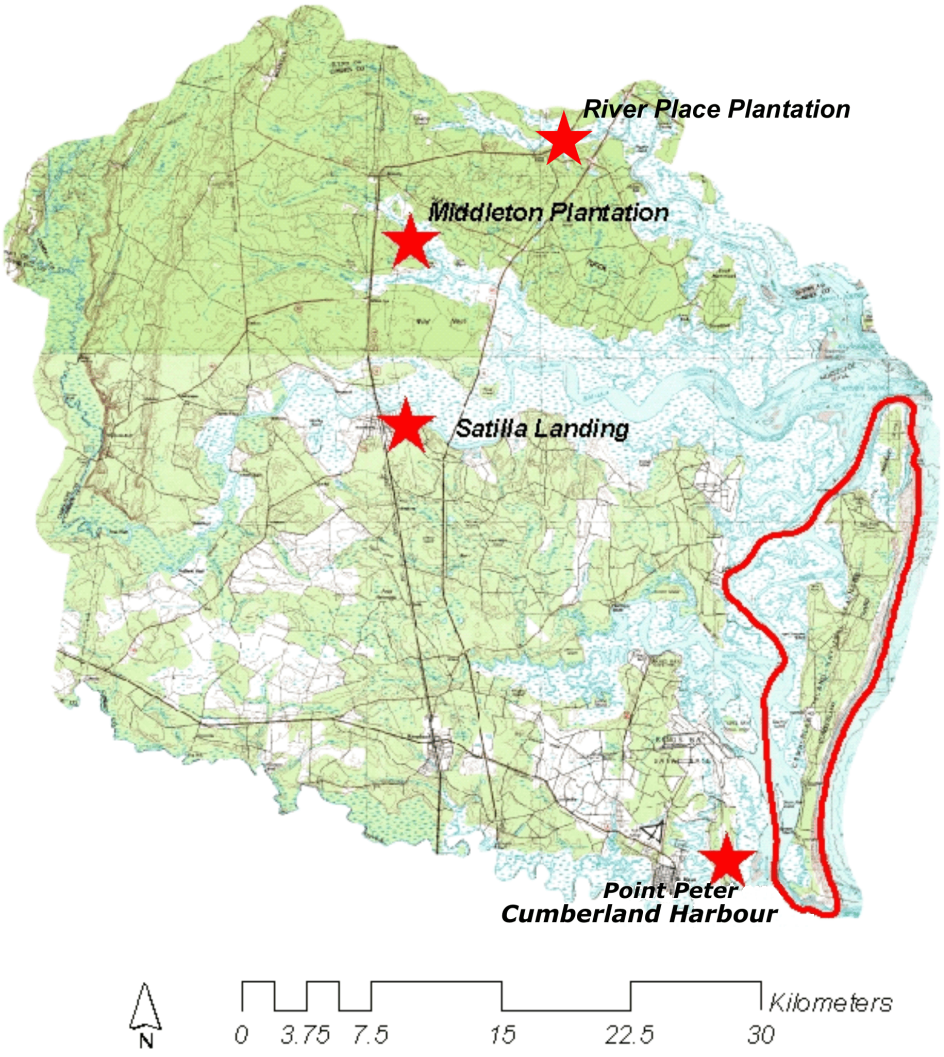
[48] At least 900 (and as many as 1200) residential units are slated for construction at the site.

rack boat storage for 400 boats. Construction and use of these facilities would also require the applicant to obtain a lease of public waterbottoms and marshlands. The permit was reviewed, amended, and then granted (March 4, 2005), but is currently being appealed by the Southern Environmental Law Center based on a number of environmental and administrative concerns. (*For more information on this proposed activity, see* **Appendix I**.)

Satilla River Landing

The Satilla River Landing is an approximately 160-acre residential development located on the Satilla River less than one mile east of U.S. Highway 17 and approximately 1.5 miles west of Interstate 95 (near Woodbine) in Camden County, GA. In March 2004, a request to construct an 86-slip marina at this development was posted for public comment on the GA DNR-CRD website (**Appendix J**). At present, the community has access of approximately 1000 linear feet

Figure 17. Proposed residential developments in Camden County, Georgia



to the Satilla River and several hundred linear feet of access to Dunn Creek (that connects to the Satilla). The application has been amended to request a modified 64-slip facility. The redesigned marina would provide more than 2,200 linear feet of docking space; 4-5 slips to be available for day-use, the majority to be sold to the residents. The proposed marina would cover 0.31 acres of public marshlands and waterbottoms and the applicant has applied for a lease to these areas (J. Butler, pers. comm.). In addition, 11 private docks in the 165-lot development would be expected to cover an additional 0.4 acres of public marshlands and waterbottoms. This permit was granted (November 2004) but is currently (as of December 8th 2004) under appeal by the Southern Environmental Law Center.

Middleton Plantation

Permission has recently been given to construct a community dock along Waverly Creek (J. Butler, pers. comm.). This dock will serve an approximately 188-acre residential development (Middleton Plantation) located less than 1.5 miles east of Highway 17 and approximately 4 miles west of Interstate 95 on Waverly Creek in the City of Waverly, Camden County, GA. The proposed community dock will provide less than 500 linear feet of dock space, so no lease of public marshlands and waterbottoms is required. It is anticipated that an additional 21 private recreational docks might be constructed along Waverly Creek and six along Uncus Branch. (*For more information, see* **Appendix K**.)

The River Place Plantation

At the November 8th 2004 meeting of the Coastal Marshlands Protection Committee, an application for a community dock at The River Place Plantation (Little Satilla River, highway 17, Camden County) was considered. When complete, the subdivision will have approximately 295 homes on 210 acres. The dock will have no permanent mooring or fuel facility. Note that the application is also planning to apply for two bridge permits at this location. (*Details are in* **Appendix L**.)

These permit applications have all been filed under The Georgia Coastal Marshland Protection Act (CMPA), which identifies the state's marshlands as "a vital natural resource system that affords habitat for species of marine life and wildlife, food for their survival, nursery areas for commercial and recreational fisheries, and for the control of flood, erosion, and pollution" (OCGA § 12-5-281). Although the CMPA does not prohibit construction in the marshes, it does require that any proposed activities meet specific criteria stated in the legislation in order to be permitted (OCGA § 12-5-286). Note, however, that private-use recreational docks are exempt under the CMPA. In these cases, a Revocable License from the state and a dock permit from the U.S. Army Corps of Engineers, who administers a general permit for the state, are required. Assessing the cumulative impact of docks and marinas are issues that need to be addressed.

C1b. Water withdrawals

Reductions in the amount of fresh water that reaches the coast can have numerous downstream effects, including increasing salinity, changing mixing patterns, and altering the distribution of both dissolved and particulate materials. All of these changes can in turn affect marine resources, particularly in estuarine environments where the life histories of many organisms

are linked to salinity (Alber 2002; Alber and Flory 2002). Fresh water can reach Cumberland Island via rivers (primarily the Satilla and St. Marys rivers); via overland runoff that results from local precipitation; and via surficial groundwater. Note that groundwater in the deeper, Floridan aquifer is not thought to have a direct influence on Cumberland Island (*see* **section A2b**).

Freshwater withdrawal and use information for 1995 is summarized in **Table 11**.[49] Almost all of the water that is withdrawn in the region is from groundwater as opposed to surface water sources. The reliance on groundwater actually results in a net gain in surface water because some of the groundwater withdrawn from the Floridan aquifer is returned via surficial groundwater flow or overland runoff. In the Cumberland Sound/St. Simons area, a total of 69 million gallons per day (mgd) of water was withdrawn (of which only 0.1 mgd was surface water), and an estimated 56.6 mgd was returned. Note that these values are relatively small compared with the amount of water withdrawn in other parts of the coast (Alber and Smith 2001). Salt and brackish water is also sometimes withdrawn from surface water. This is primarily used as industrial coolant water and is again returned, although it is arguably of different quality than the water that was withdrawn. The two permitted industrial users of surface water in the Cumberland Sound/St. Simons area are Georgia Power and Brunswick Cellulose, both of which are in Glynn County and discharge to the Turtle River.[50] Large industrial users of groundwater include Georgia Pacific Brunswick pulp plant (49 mgd), Hercules (14 mgd), Kings Bay Naval Submarine Base (2.9 mgd), and Bayer/ Aventis CropScience (1.7 mgd). More information on both surface and groundwater permit holders in the area can be found in **Appendix M**.

Table 11. Freshwater usage in the watersheds of coastal Georgia in 1995.

HUC is USGS Hydrologic Unit Code; export is net exchange with other HUCs; returned is the difference between total withdrawals and total usage (and is assumed to be surface water). Data are from the Georgia Water Use Program and are expressed in millions of gallons per day (mgd).

Hydrologic Unit	HUC	Water Withdrawn (mgd)			Water Used (mgd)			**Returned (mgd)**
		Surface	Ground	Total	Consumed	Export	Total	
Satilla								
Upper Satilla	03070201	**9.0**	27.2	36.2	21.1	3.9	25	**11.2**
Lower Satilla	03070202	**1.9**	4.8	6.7	4.9	-2.0	2.9	**3.8**
Cumberland/St. Simons	03070203	**0.1**	68.9	69.0	9.8	2.6	12.4	**56.6**
St. Marys	03070204	**0.9**	80.4	81.4	8.5	2.6	11.0	**70.3**

[49] The Georgia Water Use Program regularly surveys both water sources (groundwater and surface water) and water uses (domestic, commercial, industrial, mining, irrigation, livestock, thermoelectric, and hydroelectric) as part of the USGS National Water Use Synthesis. Water use data are generally collected every five years and are readily available (http://water.usgs.gov/watuse/). In Georgia the information is compiled by the Georgia Water Use Program, a cooperative effort between USGS and the Georgia Geologic Survey.

[50] The Durango Paper Company closed its Camden County plant in 2002. Prior to that, it was permitted for withdrawal of both surface water (12 mgd) and groundwater (44.5 mgd).

C2. Species of concern

Most of the information on the biological resources of Cumberland Island is provided in **section A3**. In this section we focus on those species that present management challenges to park staff. These species are not necessarily directly associated with water resources (although some of them are), but it can be argued that any organisms present in an ecosystem will respond to perturbations in the environment.

C2a. Rare and protected species

A number of protected species are included among the many animal and plant species believed to inhabit Cumberland Island or its surrounding waters.

C2ai. Animals

Rare and protected animals present or assumed present on Cumberland Island are listed in **Table 12**. This list includes amphibians, birds, mammals, and reptiles. Note that no fish or invertebrate species were identified as being present and protected. Relevant facts regarding life history, habitat requirements, and population information of each species is reviewed below.

Amphibians

Flat woods salamander (*Ambystoma cingulatum*) – Considered a mole salamander because it lives under leaf cover or in burrows on the forest floor, this salamander requires shallow ponds for breeding (often from winter rains). The Georgia range is the lower coastal plain, where it is found in pine and cypress forests. The population has declined significantly as a result of diminishing habitat: much of the native slash and longleaf pinelands and wiregrass habitats utilized by this species have been cleared of vegetation or drained (Georgia Museum of Natural History and Georgia Department of Natural Resources 2000).

Striped newt (*Notophthalmus perstriatus*) – Requires a wet habitat: Carolina Bays and other types of sinkholes offer a combination of vegetation and unpolluted water that is apparently ideal. This species is only found in the coastal plain of Georgia and Northern Florida (Georgia Museum of Natural History and Georgia Department of Natural Resources 2000).

Birds

The information reported below is drawn from the Georgia Wildlife Web (Georgia Museum of Natural History and Georgia Department of Natural Resources 2000) and the Audubon Watchlist (National Audubon Society 2002), unless otherwise noted. The draft NPS Vital Signs report stresses that the many over-wintering and breeding shorebirds on Cumberland are vulnerable to a number of different threats including "…human activities on the island; habitat changes; depredation from raccoons, feral hogs, and bobcats; and nest trampling from horses" (National Park Service - Southeast Coast Network 2004). A 1989 report on the effects of disturbance on wading birds on Cumberland Island concluded that although natural disturbances (thunder, predators, prey) were approximately twice as frequent during the study, unnatural disturbances (boats, foot travelers, aircraft, land vehicles) caused wading birds to flush more often (5-36% and 60-70% respectively) (Bratton 1989).

Table 12. Rare and protected animal species likely to occur in the vicinity of CUIS.

Status codes: C - Candidate for protection; R - Rare; T - Threatened, E - Endangered
Sources: (Hillestad et al. 1975, National Park Service 2001a, U.S. Fish & Wildlife Service 2004, Georgia DNR - Wildlife Resources Division 2004b)

Scientific name	Common name	Federal status	Georgia status
	Amphibians		
Ambystoma cingulatum	Flatwoods salamander	T	T
Notophthalmus perstriatus	Striped newt	-	R
	Birds		
Aimophila aestivalis	Bachman's sparrow	-	R
Charadrius melodus	Piping plover	T	T
Charadrius wilsonia	Wilson's plover	-	R
Dendroica kirtlandii	Kirtland's warbler	E	E
Elanoides forficatus	Swallow-tailed kite	-	R
Falco peregrinus	Peregrine falcon	-	E
Haematopus palliatus	American oystercatcher	-	R
Haliaeetus leucocephalus	Bald eagle	T	E
Mycteria americana	Wood stork	E	E
Picoides borealis	Red-cockaded woodpecker	E	E
Sterna antillarum	Least tern	E	R
Sterna nilotica	Gull-billed tern	-	T
Thryomanes bewickii	Bewick's wren	-	R
Vermivora bachmanii	Bachman's warbler	E	E
	Mammals		
Balaena glacialis	Northern right whale	E	E
Megaptera novaeangliae	Humpback whale	E	E
Neofilber alleni	Round-tailed muskrat	-	T
Trichechus manatus	West Indian manatee	E	E
	Reptiles		
Caretta caretta	Loggerhead sea turtle	T	T
Chelonia mydas	Green sea turtle	T	T
Dermochelys coriacea	Leatherback sea turtle	E	E
Drymarchon corais couperi	Eastern indigo snake	T	T
Eretmochelys imbricata	Hawksbill sea turtle	E	E
Gopherus polyphemus	Gopher tortoise	T	T
Lepidochelys kempii	Kemp's Ridley sea turtle	E	E
Pituophis melanoleucus mugitus	Florida pine snake	C	-

Birds

Bachman's sparrow (*Aimophila aestivalis*) – A ground feeder, utilizing pine woods with a dry understory, this species is endemic to the U.S. and can be found throughout the southeast, but the population has been declining at a rate of 2.8% per year (between 1966 and 2001). They are known to feed in areas cleared after fire, so fire suppression and its negative effects on feeding habitat has been implicated in the decline of this species. The current population is not known.

Piping plover (*Charadrius melodus*) – These animals live and breed on coastal beaches, feeding on mollusks, crustaceans, and insects. The global population is estimated at 6000 individuals. Predators include mink, foxes, skunks, and raccoons. Other threats result from disturbance in nest areas and habitat loss (i.e. from coastal development or changing land use).

Wilson's plover (*Charadrius wilsonia*) – This species feeds at waters edge on invertebrates (insects, crustaceans, mollusks, and marine worms). It breeds in coastal Georgia, but is a migratory species. The population is estimated at 6000. They are not as well studied as the piping plover but are likely to be vulnerable to the same pressures.

Kirtland's warbler (*Dendroica kirtlandii*) – An insectivore, this bird may be seen in Georgia during migration between its breeding ground in Michigan and wintering habitat in the Bahamas. There are only ~1800 estimated individuals.

Swallow-tailed kite (*Elanoides forficatu*) – Breeding habitat is the coastal plain of Georgia. These birds nest near water in large trees in forested wetlands or swamps. They feed by catching insects on the wing and by taking reptiles, amphibians, or insects from the ground.

Peregrine falcon (*Falco peregrinus*) – These birds have a typical (non urban) habitat of fields and fresh or tidal marshes. They prey on other birds (including shorebirds, waterfowl, doves, and passerines), often striking in mid-air. Falcons are in recovery from very low populations resulting from DDT effects on eggs and prey, and were removed from the federal endangered species list on August 25, 1999 (U.S. FWS 2004).

American oystercatcher (*Haematopus palliates*) – The total population is estimated at 7500, but this migratory bird is felt to be vulnerable to coastal development. It may still be found breeding on Georgia's beaches, dunes, or salt marshes. They have a typical wading-bird diet of invertebrates and some fish.

Bald eagle (*Haliaeetus leucocephalus*) – These are year-round residents of coastal Georgia. They feed predominantly on fish, but will also prey on other birds or small mammals such as rabbits. Nesting sites include tall trees or poles. As with other predator birds, this species was highly affected by the toxic effects of DDT.

Wood stork (*Mycteria americana*) – Found on the Georgia coast during breeding season (mid-Dec to late April); distributed sparsely through the coastal plain during the rest of the year. The wood stork population of Cumberland Island has been the subject of a number of studies (Bratton 1988; Bratton 1989; Bratton et al. 1989; Walsh 1991; Miscellaneous 1993; U.S. Fish and Wildlife Service 1996). They are known to roost (often at high tide) at the South End Ponds, in trees at Lake Whitney, Heron Pond (also a nesting site), or along the St Marys River (Bratton 1988). They prefer cypress trees (or other tall wetland forest species) for nest sites, and it has been noted that the presence of alligators might be beneficial to the species as they help prevent nest predation by raccoons and other small mammals. In addition to the Heron Pond mixed rookery on Cumberland Island, wood stork nests are found (in even higher numbers) at Brailey Swamp, Black Hammock, and St. Simons Island. Wood storks feed by wading in calm shallow water of fresh or salt-water swamps, streams, and other wetlands, preying on fish (mummichogs,

mullet, sunfish) and occasional invertebrates or amphibians (U.S. Fish and Wildlife Service 1996). Feeding has been observed at the roosting areas as well as Beach Creek, Table Point marsh, Brickhill River, and Lake Whitney. Predation and habitat alterations affecting their feeding grounds (loss of wetlands and changes in hydroperiod) are among the threats they face. They are also vulnerable to certain pesticides and the U.S. EPA has made efforts to protect wood storks by placing limitations on pesticide use in portions of Camden and Glynn counties (U.S. Environmental Protection Agency 2003).

Red-cockaded woodpecker (*Picoides borealis*) – A year-round resident in the coastal plain of Georgia. Their nesting habitat is open (fire-managed) forests, with a strong preference for mature (>80 year-old) longleaf pine stands. As with most other woodpeckers, they forage for insects, specializing in the adult, larva and eggs of termites and ants. The current population estimate is around 11,000 individuals, and although they have previously been identified on Cumberland Island, none are currently known to be present (National Park Service - Southeast Coast Network 2004). Their overall decline is believed to result mostly from habitat destruction (logging, fragmentation, fire suppression). Managers feel that Cumberland Island may still provide areas of appropriate habitat for this species (National Park Service - Southeast Coast Network 2004).

Least tern (*Sterna antillarum*) – This is a migratory bird that breeds on coastal Georgia beaches, including Cumberland Island. It feeds on fish and marine invertebrates by diving into the water. A 1988 ground survey of these birds yielded three active nesting areas on Cumberland Island comprised of some 30 birds (Bratton 1989). There are four locations currently used for nesting along the island's Atlantic beach (in the primary dunes): on the South End, south of the Dungeness Crossing, north of North Cut Road entrance, and Long Point (J. Fry, pers. comm.). It was noted that the nests are very hard to see unless the parents are on them, so they are quite vulnerable to trampling. In addition, human activity can cause nesting birds to take flight, which leaves their young or eggs exposed to the hot sun (Bratton 1989).

Gull-billed tern (*Sterna nilotica*) – Breeds on coastal Georgia beaches but will also use dunes or grasslands. These birds feed over land by catching insects on the wing or preying on small mammals, frogs, crustaceans, and sometimes bird eggs, bird young, and fish.

Bewick's wren (*Thryomanes bewickii*) – According to the draft Natural Resources Management document for CUIS (National Park Service 2001a), this species is present on Cumberland Island and a voucher specimen is available. However, the distribution map for Bewick's wren on the Georgia Wildlife Web suggests that there is no coastal range for this bird in Georgia, even during migration (Georgia Museum of Natural History and Georgia Department of Natural Resources 2000). The presence of this species on the island should be reevaluated.

Bachman's warbler (*Vermivora bachmanii*) – This species is believed to be extinct, but at one time is thought to have bred in the coastal plains of Georgia. Its preferred habitat was hardwood forests and scrub wetlands. Prey included larva and other insect forms. The management document for CUIS indicates that a voucher specimen is available and suggests that at one time this species was present on Cumberland Island (National Park Service 2001a).

Osprey (*Pandion haliaetus*) – Ospreys are not a federally protected species, but they may be considered rare. They are known to nest on Cumberland Island and there has been some interesting research on nest site location at the nearby Kings Bay Naval Base: Riddleberger (1991) concluded that prominence (height and visibility with respect to the surroundings) and location (away from disturbance and less than 50 meters from feeding areas) were the important factors for platform success.

Terrestrial reptiles

Eastern indigo snake (*Drymarchon corais couperi*) – Indigo snakes can be quite large and feed on most terrestrial vertebrates (birds, mammals, amphibians, or other reptiles). They prefer pine - scrub oak woodlands, pine and forested ridges but may also be found around wetland areas such as swamps, streams, and canals. They are also known to retreat into tortoise burrows[51] and habitat loss is believed to be responsible for declining populations of both of these threatened terrestrial reptiles (Georgia Museum of Natural History and Georgia Department of Natural Resources 2000). Cumberland Island is not known to be home to any such snakes at present, but the habitat is appropriate and Eastern indigo snakes were listed as "assumed present" in the draft Natural Resources plan (National Park Service 2001b).

Gopher tortoise (*Gopherus polyphemus*) – Gopher tortoises are predominantly herbivorous (mainly eating grasses, some fruits or fungi), but may eat carrion. Their eggs and young are susceptible to many predators including indigo and kingsnakes, raccoons, skunks, armadillos, foxes, opossums, hawks, and fire ants. The gopher tortoise is also affected by a mycoplasma (bacterial) infection that causes a sometimes fatal respiratory disease (about which little information is available in Georgia) (Gopher Tortoise Council 2002). They have overlapping ranges and habitat requirements with indigo snakes in Georgia, as described above.

Florida pine snake (*Pituophis melanoleucus mugitus*) – This is another resident of the long-leaf pine ecosystem being impacted by habitat reduction. Unlike the indigo snake, pine snakes prefer dry environs, but they share the occasional use of tortoise burrows and other similar refuges. The female pine snake will also create large egg burrows. They feed on pocket gophers and other small mammals along with some reptiles, birds, or eggs.

Sea turtles

Sea turtles are dramatically affected by offshore activities (especially fishing and shrimping), but the NPS does not have jurisdiction below the mean high tide line. However, approximately 65 dead loggerheads (*Caretta caretta*), a dozen Kemps Ridley (*Lepidochelys kempii*), and occasional green sea turtles (*Chelonia mydas*) and leatherback turtles (*Dermochelys coriacea*) are identified on Cumberland Island each year (Cumberland Island Museum 2003). As noted in **section A3b** under "Beaches," loggerhead sea turtles (*Caretta caretta*) commonly use Cumberland Island beaches for nesting and this does fall within the purview of CUIS management. Each summer there may be as many as two or three hundred loggerhead nests on the island (Cumberland Island Museum 2000). Females come ashore sometime between mid-May and the end of August. For one night, each turtle returns to a specific beach to dig a nest and lay a clutch of eggs. She might lay one to three clutches in a summer, each with 50 or more eggs. Hatchlings emerge after approximately two months, and wend their way in the dark to the ocean. Although they are long-lived (estimated age at mortality in the wild is 47 to 62 years) and have fairly large clutches, females do not breed every year and predation of eggs and hatchlings is significant (Georgia Museum of Natural History and Georgia Department of Natural Resources 2000). In the early 1990's, it was estimated that 80% of Ossabaw Island sea turtle nests were preyed upon by feral hogs (Miller 1993) and the recent draft NPS Vital Signs Report cites "depredation by hogs, raccoons, fire ants, and ghost crabs" on sea turtle eggs at CUIS (National Park Service - Southeast Coast Network 2004). Nests are also vulnerable to

[51] Unfortunately, rattlesnakes also use tortoise burrows, and it has been suggested that rattlesnake hunters may have impacted several reptile populations by dousing these burrows with gasoline.

disturbance by trampling (swine, horse, human), and so nesting areas are fenced off wherever feasible.

Marine mammals

As is the case with sea turtles, management of the marine mammals that inhabit or visit Cumberland Island's offshore reaches is an area to be considered by the National Park Service, but it is beyond the scope of this report. However, the West Indian manatee (*Trichechus manatus*) is known to feed on salt marsh cord grass (*Spartina alterniflora*) in southeastern Georgia (Baugh et al. 1989). In early 1988, about ten animals were observed distributing themselves between two warm-water outfalls, approximately 10 km apart: the Gilman Paper Corporation plant on the North River near St. Marys and the Container Corporation of America plant on the Amelia River in Nassau County, Florida. The animals moved along shore (usually at high tide) to feed on the top one- to two-thirds of the plants. The authors postulate that *S. alterniflora* might be a "significant food item for manatees overwintering in northeastern Florida and southeastern Georgia"[52] (Baugh et al. 1989).

Bycatch

Turtles, marine mammals, and seabirds are vulnerable to snagging and drowning in the large nets used by commercial fishers. Several federally managed fish species (red snapper [*Lutjanus campechanus*], king mackerel [*Scomberomorus cavalla*], Spanish mackerel [*Scomberomorous maculatus*], and sharks) are also susceptible as bycatch (J. M. Nance (Editor) et al. 1998). Vulnerability of a species to this phenomenon is dependent on the fishery and the particular equipment used. National Marine Fisheries Service-approved bycatch reduction devices and turtle excluders are now required[53] and well-used on Georgia shrimp trawlers. These can significantly reduce bycatch (J. M. Nance (Editor) et al. 1998).

C2aii. Plants

Rare and protected plant species are listed in **Table 13**, and discussed below. The information presented here (unless otherwise noted) is drawn from Protected Plants of Georgia (Patrick et al. 1995), the USDA/NRSC Plants Database (Natural Resources Conservation Service 2004), the Center for Plant Conservation Website (Missouri Botanical Garden 2004), and the GA DNR-Wildlife Resources Division list of special concern plants (Georgia DNR - Wildlife Resources Division).

[52] Manatees are regularly reported in and around Cumberland Island, on a seasonal basis (according to CUIS personnel).

[53] Requirements vary by headrope length of the trawl.

Table 13. Threatened or unusual plant species likely to occur in the vicinity of CUIS

GA Status codes: U - Unusual; T – Threatened. None of these plants are federally listed.
Sources: (Hillestad et al. 1975; Georgia DNR - Wildlife Resources Division 2004b; U.S. Fish & Wildlife Service 2004)

Scientific name	Common name	Georgia status
Asplenium heteroresiliens	Wagner's or blackstem spleenwort	T
Carex dasycarpa	Velvet sedge	T
Epidendrum conopseum	Green-fly orchid	U
Hartwrightia floridana	Hartwrightia	T
Pityopsis pinifolia, (*Chrysopsis pinifolia; Heterotheca pinifolia*)	Sandhill -, Taylor County -, or pine-leaved golden-aster	T
Sageretia minutiflora	Tiny-leaf buckthorn	T
Tillandsia recurvata (*Diaphoranthema recurvata*)	Small ball-moss	T

Wagner's or blackstem spleenwort (*Asplenium heteroresiliens*) – A perennial fern with a very limited Georgia native range, this plant is assumed present on Cumberland Island (NPS 2001 appendix 4b-A). The Center for Plant Conservation describes the plant habitat as "vertical or high angle faces of marl outcrops and soft limestone rock", which is unlikely on Cumberland Island. However Patrick et al. add "…and on masonry composed of tabby (a mixture of sand, lime, and oyster shells)". If indeed this very rare species is present on Cumberland, a management strategy should be pursued.

Velvet or sandywoods sedge (*Carex dasycarpa*) – Identified by Georgia DNR in Camden County, this plant is know to inhabit hammock pine forests and other sandy acid soil regions. Habitat loss is the main reason for its decline.

Green-fly orchid (*Epidendrum conopseum*) – An epiphyte of evergreen hardwoods such as the southern magnolia (*Magnolia grandiflora*) or live oak (*Quercus virginiana*), the green-fly orchid is often found in association with the resurrection fern (*Pleopeltis or Polypodium polypodioide*). Threats include removal by plant collectors and habitat loss.

Hartwrightia (*Hartwrightia floridana*) – A rare aster found at a half dozen sites in Georgia. It prefers a very wet habitat, such as that in a pine bottoms or seeps, sedge meadows, and poorly drained sloughs.

Sandhill golden-aster also known as Taylor County golden-aster or pine-leaved golden-aster (*Pityopsis pinifolia* [synonyms: *Chrysopsis pinifolia; Heterotheca pinifolia*]) – This plant has been seen in naturalized populations in only four Georgia counties, all of which are located along the fall line and not along the coast. However, the draft Natural Resources Management document for CUIS indicates that this species is present on Cumberland Island and a voucher specimen is available (National Park Service 2001a). According to Patrick et al. (1995), this aster prefers "open, scrub oak-longleaf pine… cleared and cut over areas, and …old fields, maintained rights-of-way, and pine plantations," so one might expect it to be found in certain coastal locations.

Tiny-leaf or climbing buckthorn (*Sageretia minutiflora*) – A lanky shrub found in maritime forests (especially near shell mounds or along hammock stream banks), this plant's population is believed to be in decline due to habitat loss.

Small ball-moss or bunch-moss (*Tillandsia recurvata* [synonym: *Diaphoranthema recurvata*]) – This is an epiphyte of live oak that may be suffering reduced numbers because of over-zealous plant collectors. There are known populations in Glynn and Camden counties.

C2b. Invasive and introduced species

A number of non-indigenous invasive plants and animals are present on or near Cumberland Island. There are also introduced species, which are indigenous to the southeast but have been introduced to Cumberland. Humans may have brought in species intentionally (through ornamental garden plantings, for example) or unintentionally (e.g. ballast water releases). Some species may have reached the area through natural expansion of their native range.

C2bi. Animals

Terrestrial animals

Two common terrestrial animals are considered invaders in the southeast: fire ants and armadillos. Others, such as the opossum and fox squirrel are native species that were introduced to the island. The bobcat represents an example of a native species that was re-introduced to the island.

South American fire ants (*Solenopsis invicta*) – There are two native fire ant species in Georgia: *S. geminata* and *S. exloni*, but in the 1950's an aggressive South American fire ant (*S. invicta*) was first reported in the state. Since then, this invader has made its way throughout the southern U.S. They are successful in reproduction, form large colonies, compete with our native fire ants, and give a rather painful sting (often en masse) to those who disturb a nest. Their diet consists mainly of other insects, but they are known to attack small animals, especially newly hatched birds or newly born rabbits, etc. (Canerday 1988). The NPS is concerned about the effects of fire ants on sea turtle eggs and hatchlings (National Park Service - Southeast Coast Network 2004) and recent studies suggest this is a potential problem (Parris et al. 2002).

Nine-banded armadillos (*Dasypus novemcinctus*) – These animals have been present on both Cumberland and Little Cumberland Islands since the early 1970's, but Hillestad reported they were not numerous at that time (Hillestad et al. 1975). It might be that armadillos are expanding their natural range and challenging their northern limit: In a study that followed 16 adult armadillos on Cumberland Island for 10 months, 5 of the 11 animals located in the winter had died of cold. There were no mortalities in the other seasons, and no additional causes (starvation, parasitism, or collision) were implicated (Bond et al. 2002). It remains to be seen if armadillos will present a problem to other Cumberland Island natural resources.

Black rat (*Rattus rattus*) – This is a non-native species that has been removed from Cumberland, but according to staff of the Cumberland Island Museum black rats were numerous in the 1970's (Cumberland Island Museum 2001).

Common opossum (*Didelphis virginiana*) – Opossums are uncommon on Georgia barrier islands, but they were introduced on Cumberland in 1993 (Cumberland Island Museum 2001).

They are vectors for a number of parasitic diseases and are known predators of ground-nesting birds. Opossums represent a native species that may need to be managed as an invader. Information on its effects should be investigated.

Fox squirrel (*Sciurus niger*) – This rodent, which is native to Georgia, was brought to Cumberland Island through human actions. It is believed to have since died out on Cumberland.

Bobcat (*Lynx rufus*) – The NPS restored bobcats to Cumberland Island beginning in 1988, in part to restore predator/prey balance and reduce browsing by deer. This has been moderately successful: an investigation of the ecological effects of bobcat reintroduction showed that white-tailed deer numbers decreased, deer size increased (perhaps due to decreased competition within the herd), and vegetative growth increased in the eight years post-reintroduction (Nelms 1999). Bobcats will feed on marsh rabbits (*Sylvilagus palustris*), feral hogs (*Sus scrofa*), raccoons (*Procyon lotor*), grey squirrels (*Sciurus carolinenesis*), cotton rats (*Sigmodon hispidus*), cotton mice (*Peromyscus gossypinus*), and various bird species (Georgia Museum of Natural History and Georgia Department of Natural Resources 2000). There is some concern that they are having a negative effect on ground-nesting birds.

Aquatic animals

Table 14 lists many of the aquatic nonindigenous species identified in the watersheds upstream of Cumberland Island. The species of greatest concern is likely *Petrolisthes armatus*, the green porcelain crab. No confirmed reports of this species in the St. Marys or Satilla watersheds were found, although it is likely to occur all along the Georgia coast. This species is an exotic one that was unknown north of Cape Canaveral, FL before 1994. It lives in areas of oyster rubble and is now established at high density in both Sapelo and Doboy Sounds. The ecological effects of this invader are still under investigation (Knott and King; Bishop and Hurley 2003). Another invertebrate of concern is *Perna viridis*, the green mussel. This bivalve is considered a threat to native mollusk species due to its ability to compete for resources and act as a vector for parasitic diseases. It can also clog intakes and foul marine equipment (Center for Aquatic Resource Studies [USGS] 2002). The green mussel has apparently not been seen living in the waters of or adjacent to Cumberland Island. However, shells are readily found on the beach, and in the summer of 2004 green mussels were spotted on a buoy that had come ashore on the north end of the island (J. Fry, pers. comm.). Recent reports suggest that because water temperatures in Georgia are cooler than in their native range (the tropics of Indo-Asia), this species does not generally survive the winter (A. Power, pers. comm.).

C2bii. Plants

The NPS has concerns about some non-native or invasive ornamental species on Cumberland Island (National Park Service - Southeast Coast Network 2004). These and some other candidate plants of concern are listed in **Table 15**. Note that information on many of these plants may be found in the "Weeds Gone Wild" website (Plant Conservation Alliance 2004) or Miller's *Nonnative Invasive Plants of Southern Forests: A field guide for identification and control* (Miller 2003). No aquatic plant species were listed.

Table 14. Nonindigenous aquatic species list for St Marys and Satilla watersheds.

Species listed as Native are outside of their range.
Source: (Center for Aquatic Resource Studies [USGS] 2002)

Scientific Name	Common Name	Exotic / Native	Location closest to Cumberland Island	Notes
Craspedacusta sowerbyi	freshwater jellyfish	Exotic	Pond near Brunswick	1 coastal Georgia occurrence
Ctenopharyngodon idella	grass carp	Exotic	Sea Island	Significant habitat effects
Dorosoma petenense	threadfin shad	Native	Estuarine waters near Brunswick	Established since at least 1953
Oreochromis aureus	blue tilapia	Exotic	St. Simon's Island	Possibly extirpated from Glynn Co., but established at Skidaway Island (Chatham Co.)
Pylodictis olivaris	flathead catfish	Native	Satilla River	1 occurrence in Satilla watershed, problematic elsewhere in Georgia
Perna viridis	green mussel	Exotic	Brunswick and St. Simon's Island	Five reported occurrences in coastal Georgia in 2003
Petrolisthes armatus	green porcelain crab	Exotic	Sapelo Island and N. Florida	Likely, but not confirmed in St Marys or Satilla

Table 15. Invasive plant species on Cumberland Island.

(Alternative names listed in parentheses.)

Scientific Name	Common Name	Location on Cumberland	Notes or additional references
Ailanthus altissima	Tree-of-heaven (Chinese sumac)	Dungeness cottage garden (Zeichner 1988)	Large, rapidly growing tree with several negative effects on native species: shading impacts other plants and native vegetation; toxins in the plant may have deleterious effects on other plants and wildlife; roots / suckers are very aggressive.
Aleurites (*Vernicia fordii*)	Tung oil tree	Near Stafford Field & orchard by Dungeness Dock (Zeichner 1988)	A toxic member of the spurge family. Considered only moderately invasive (Bratton 1984; Bratton and NPS Basic Vegetation Management Course 1986).
Cynodon dactylon	Bermuda grass	Dungeness, Stafford, Plum Orchard lawns & remnant pastures (J. Fry, pers. comm.)	Rapidly growing, water-loving stoloniferous grass.
Phyllostachys and *Bambusa* spp.	Bamboo	By Duck Pond & the southwest edge of Beach Field (Zeichner 1988),	Spreads through vigorous and tough rhizomes. Also found at: Sea Camp, Stafford, Plum Orchard, Serendipity (J. Fry, pers. comm.)
Tamarix spp.	Tamarisk (salt cedar)	Marsh edge s. of Dungeness, interdune s. of Willow Pond Trail	Efficient water-loving tree that competes with native plants for moisture. Location ref: (Bratton 1984)
Triadica sebifera (*Sapium sebiferum*)	Chinese tallow (small tallow tree)	North of Sea Camp – the Rockefeller Tract [54] (J. Fry, pers. comm.)	Fast growing tree, toxic to many native fauna, difficult to control. Species is actively being eradicated from Sapelo Island (D. Bishop, pers. comm.). *See also* (U.S. Geological Survey 2000a).
Verbascum thapsus	Common mullein	Island-wide (J. Fry, pers. comm.)	A vigorous herb producing copious seeds that remain viable for many years.

C2c. Feral and game species

Feral animals

A number of different kinds of animals have returned to free-ranging status at one time or another on Cumberland Island. In the 1980's, feral cattle (*Bos taurus*) were captured and

[54] Not within the National Seashore

removed from the island or confined on private property. According to the staff of the Cumberland Island Museum, there has been a solitary burro (*Equus asinus*) seen with feral horses or on the beach: it was likely released by one-time residents (Cumberland Island Museum 2001). The two feral animals of most concern, however, are horses (*Equus caballus*) and wild hogs (*Sus scrofa*).

Horses (*Equus caballus*) – The presence of feral horses is controversial on Cumberland Island: they represent a scenic attraction to tourists and a destructive nuisance to managers. Although horses have been on the island since the time of the Spanish missions, the herd on the island now is believed by some to stem from Arizona stock introduced in the 1920's (Cumberland Island Museum 2001). There has been a significant amount of research on these animals (Ambrose et al. 1983; Lenarz 1983; Simon et al. 1984; Finley 1985; Finley 1986; Hall 1991; Noon and Martin 2004). Hillestad estimated the 1974 horse population at 60 and noted that they were often found grazing the high salt marsh (Hillestad et al. 1975). A 1985 study showed that foal survivorship in seven of the estimated 55 bands on the island was 37%, below the 50 to 86% range for other free-roaming horse populations, and it was suggested that the sustainable capacity of Cumberland had been exceeded (Finley 1986). Encephalitis has been reported to periodically reduce horse numbers in the herds (Cumberland Island Museum 2001). The island's total horse population was estimated to be 181 in May 1985, 250 in March of 2003, and between 150 and 175 in 2005 (Finley 1985; Noon and Martin 2004; J. Fry pers. comm.).

The effects of this large feral population are becoming increasingly difficult to manage. A recent National Park Service document outlines the many ways that horses negatively impact wetlands and other natural resources (Noon and Martin 2004). As mentioned above, waste material may be a source of organic material to creeks and ponds that would otherwise be recycled in upland areas. In addition, trampling/grazing on native vegetation leads to erosion; horses spread and fertilize non-native species (by carrying burrs on coat, seeds in manure); and soil and sediment disturbances from hooves have numerous direct and indirect negative effects. Noon and Martin's (2004) suggestions for managing horses range from eliminating them; confining a reduced number of them to one area; or excluding them from dunes, beaches, and wetlands. It should be noted that these recommendations are reminiscent of those put forth by Hillestad et al. (1975).

Swine (*Sus scrofa*) – Feral pigs are also a serious concern to CUIS managers. These animals, sometimes called wild hogs, are descended from European stock and differ somewhat from the usual domestic swine bred in the U.S. They have an indiscriminate appetite including all sorts of vegetative matter (especially acorns), invertebrates, and small animals (even newborn fawns). Pig rooting and wallowing activities are detrimental to a range of forest and wetland habitats (Georgia Museum of Natural History and Georgia Department of Natural Resources 2000; Cumberland Island Museum 2001). Park management plans call for the complete elimination of these free-ranging animals because their effects on native ecosystems are so wide-ranging and destructive. Roughly three-quarters of the estimated 1000 feral hogs on Cumberland Island have been culled since the hog elimination plan was initiated (Fry 2004).

Game species

White-tailed deer (*Odocoileus virginianus*) – Deer management is desirable to prevent over-browsing of island vegetation and to keep the population healthy and disease-free (Nelson et al. 1986; Ford 1987). The estimated deer population of Cumberland Island exceeded 2000 in the 1980's, then stabilized to between 500 and 800 animals for the period 1991 to 1998 (Nelms

1999). Size of the deer herd on Cumberland is controlled in part through public deer hunts (Nelms 1999; Cumberland Island Museum 2001). Deer and feral swine hunting for 2004-2005 on Cumberland Island are open to the public by advance permit. Hunting access is only at one location (Plum Orchard). There will be four deer/hog hunts and two hog only hunts. The quota for male or female deer or swine taken by archery is 125 animals for the bow season, November 15 -17. Otherwise, the quota is 100 animals (for hunting periods December 6-8, December 20-22, and January 10-12). No other species are legally hunted on Cumberland Island (Georgia DNR - Wildlife Resources Division 2004a).

C3. Physical impacts

This section reviews the potential effects that physical changes to the environment could have on the water resources of Cumberland Island. These include the effects of natural processes such as storms or sea-level rise, as well as human perturbations such as channel dredging or boating. We begin by considering the types of physical changes that occur in subtidal areas and then move inshore.

C3a. Dredging

Significant man-made alterations to Cumberland Sound and adjacent waterways began in 1876 as improvements to the route between Brunswick and Fernandina Harbors (Tinkler 1976; Foyle et al. 2004). The seven-foot deep Atlantic Intracoastal Waterway (ICW) was constructed and maintained by the U.S. Army Corps of Engineers to provide safe and adequate transport of goods. By 1943, the entire coast of Georgia from Savannah to Fernandina Beach was connected by a channel at least 12-feet deep at mean low water (Tinkler 1976). One section of the ICW runs between Cumberland Island and the Camden County mainland. The original cut between Drum Point Island and Cumberland Island is no longer maintained and the main ICW channel now passes west of Drum Point Island. Another significant alteration in the last few decades involved dredging to allow access to Kings Bay. This facility had been a relatively small Army base before it was converted to the homeport for fleet ballistic missile submarines in the late 1970's (U.S. Department of the Navy). This required that the channel be widened, deepened, and lengthened to safely accommodate the Poseidon submarines and other vessels. The base was subsequently expanded and the channel dredged to 15.5 m (50 feet) for support of Trident class submarines (1987-1988). The Environmental Impact Statements prepared for the Kings Bay projects contain information about the effects of channel alterations on bathymetry and current velocity in the Cumberland Sound region (Naval Facilities Engineering Command 1975; Department of the Navy 1977).

Dredging can have direct effects by altering the bathymetry and depth of an area, thereby changing the subtidal habitat. Dredging also affects hydrographic characteristics. Near Cumberland, a USGS study found that current velocity in the lower portion of Kings Bay decreased when the channel was altered to accommodate submarine traffic (McConnell et al. 1983). During this study, changes in natural depositional patterns were observed in four cross sections of the Kings Bay area; the west shore of Crab Island to the mainland (upper Kings Bay),

the east shore of Crab Island to the mainland (lower Kings Bay), Raccoon Keys (Cumberland Island) west to the larger unnamed island (Cumberland Sound), and north to south across the St Marys Channel. The authors concluded that dredging apparently resulted in a decrease in current velocity and an increase in sediment deposition in Kings Bay. The average suspended sediment concentration was highest at Cumberland Sound (48 mg L^{-1}) compared to 17 mg L^{-1}, 30 mg L^{-1}, and 18 mg L^{-1} for upper Kings Bay, lower Kings Bay, and the St Marys Channel entrance.

Disposal of dredged material creates further disturbance.[55] Over the period 1966 to 1976, maintenance dredging of the ICW in Georgia created roughly 9.35 million cubic yards of spoil material in projects financed by the U.S. Army Corps alone (Tinkler 1976). Easements for salt marsh sites along both sides of the channel were used for disposal of this dredge spoil. It is interesting to note that the deposited material in the Lower Kings Bay site had elevated concentrations of metals[56], which represents another water quality impact (McConnell et al. 1983).

In addition to routine dredging for channel maintenance, there was also a proposal put forth by engineering consultants of the state of Florida to dredge a portion of Cumberland Shoals (the shallow region at the far end of the jetty). Nearby Amelia Island (and Fort Clinch State Park) are experiencing a sediment deficit, and the proposed activity would provide source material for beach renourishment. If this were to occur, it would result in significant changes to the southern shores of Cumberland Island (Florida Department of Environmental Protection 1998).

In terms of the effects of dredging on water-dependent resources (such as those on Cumberland Island), the Kings Bay Environmental Research Program (a joint venture of the U.S. Department of the Interior and Department of the Navy) was initiated in 1986. The most comprehensive summary of this five-year program is the 1991 Coastal Zone volume by Cofer-Shabica (1991), (*see the* **Annotated Bibliography** (Appendix N) *for details of specific studies*).

C3b. Boat traffic

Boat traffic around Cumberland Island can potentially affect natural resources through the physical effects of grounding, anchoring and wake damage. Vessels using the waters near Cumberland Island include traffic to / from Kings Bay Naval Submarine Base (predominantly military craft) as well as boats using the ICW (commercial shipping lines and recreational craft [sailboats and motorboats]). Statistics on these different uses are not currently available[57], but a decline in commercial shipping via the ICW was cited as the reason that the U.S. government has ceased funding maintenance of the section between Port Royal Sound, SC and Cumberland

[55] The State of Florida is working with the US Army Corps of Engineers to use dredge material from Kings Bay channel maintenance to provide sands for the preservation of north Florida beaches that have had their natural sediment transport interrupted by the deepened channel and the two long jetties that bracket the St. Marys Inlet (on Cumberland Island and on Amelia Island at Fort Clinch) (US ACE and FL DEP, 2000).

[56] Metals at elevated levels included chromium, copper, iron, lead, manganese, nickel, and zinc.

[57] Neither the U.S. Army Corps of Engineers, the Navy, nor the Coast Guard have been able to provide information on boat traffic in the area, and the NPS does not presently keep track of the number of boats that visit Cumberland.

Sound, GA (U.S. Coast Guard 7th District 2004). A decrease in the number of vessels passing near the island decreases the effects of wake-related erosion, but without channel management there is some increased likelihood that incidents may occur from grounding on shoals, etc. Boat traffic can also result in fuel discharge and other types of spills: the majority (80%) of the spills reported by the Naval Submarine Base involved fuel oil, gasoline/diesel, or hydraulic fluid (*see* **section B3a** [**Table 8**] and **Appendix H**). There are rare reports of accidental groundings.[58]

There are also boats traveling specifically to / from Cumberland Island (visitors, NPS employees, and residents). The ferry from St. Marys to Cumberland Island makes 16 trips per week March through November and 10 trips per week December through February. Although there is no marina on Cumberland Island and to the extent that Cumberland Island represents a destination for boaters, increased docking facilities and marinas in the area (*see* **section C1a**) will likely increase visitation to the island. It would be useful for the NPS to keep track of the number of boats that visit the island. As a pilot program, park management plans to have interns from the turtle monitoring program do weekend boat counts (J. Fry, pers. comm.).

C3c. Shoreline change

Sediment transport

Barrier islands continuously experience a cycle of eroding, shifting, and accretion of sands and sediments. One might envision Cumberland Island as shifting seaward and slightly southward over time (McBride et al. 1995). The large rock jetty at the entrance to the St. Marys channel has added perhaps 2 km^2 around the very southern tip of Cumberland through shoaling of nearby sands (National Park Service 2001a). There are also are sections of the Atlantic side that are in retreat. The 1977 draft EIS for the Kings Bay Naval Base identified active erosion on the east shore of Cumberland, south of the Willow Pond Trail, beyond Sea Camp Beach, to about the point the where the road from Dungeness meets the shore (Naval Facilities Engineering Command 1975). Historical information on the position of Cumberland Island's shoreline can be used to extrapolate the rates and direction of changes (Foyle et al. 2004). In comparison to the shoreline as it appeared in 1857 to 1871, the island's eastern shore has advanced at an average rate of 1.5 m yr^{-1}, while the western side of the island has eroded at an estimated 0.15 to 0.5 m yr^{-1} (Dougherty and Fry 2003). The Kings Bay Coastal and Estuarine Physical Monitoring and Evaluation Program also generated a wealth of information about shoreline change and bathymetry in this region (Kraus et al. 1994). Preliminary studies of historic shoreline images suggest that the western (marsh) shoreline is also experiencing a mix of erosion (0.1 to 1.0 m) and accretion.[59]

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[58] There have been several reports of Coast Guard rescue helicopters used to evacuate stranded boaters after their boats had gone aground on the North end of Cumberland Island, one in March 1983 and another in September 2003 (U.S. Coast Guard Savannah air station search and rescue [media reports]): http://www.uscg.mil/d7/units/as%2Dsavannah/pao/sarucn265%2D03.doc

http://www.uscg.mil/d7/units/as%2Dsavannah/pao/03%2D83.htm.

[59] A "Geologist in the Park" stipend from the NPS has been granted to Chester Jackson (a graduate student of Prof. Clark Alexander, Skidaway Inst. of Oceanography) to do a GIS analysis of toposheets and aerial photographs (dating from 1857 to 2002) to measure the rate of erosion on the back barrier side of Cumberland Island.

Park managers have been concerned about erosion for their potential effects on natural, cultural, and historic resources. In particular, some archaeological sites chronicling some 4000 years of human use of the island are at risk from erosion (Dougherty and Fry 2003). After a 1988 inspection highlighted the vulnerability of Dungeness Wharf and Brickhill Bluff to erosion, an experiment utilizing bags of oyster shells as a stabilization measure was begun at the latter location. Results were promising: the rakes accumulated considerable sediment and were colonized by marsh vegetation (Ehrenhard and Thorne 1991; Ehrenhard and Thorne 1993). As it is on most barrier islands, dune migration is also a significant process. During a study of historic Lake Whitney vegetation cover, it was calculated that 7% of the lake filled with sand over a 43-year period (Lambert 1992).

Sea-level rise

Changes in sea level can also affect the shoreline, particularly in terms of the extent of tidal inundation of low-lying areas. Sea-level rise rates at Cumberland are expected to be similar to those for nearby Fernandina Beach, FL (2.04 ± 0.12 mm yr^{-1}) (Pendleton et al. 2004). Coastal vulnerability indices were predicted for 18 contiguous sections of Cumberland Island's Atlantic coastline by compiling effects from six interrelated conditions/processes; geomorphology, historic shoreline change, coastal slope, relative sea-level rise, wave height, and tidal range. Nearly 30 km (18.5 miles) of shoreline was evaluated: 22% was classified as being very highly vulnerable to future sea-level rise; 28% as highly vulnerable; 28% as moderately vulnerable and 22% as being of low vulnerability (Pendleton et al. 2004). The spatial information compiled in this study should be useful to Cumberland Island managers as they consider long-range protection measures for park resources.

Storms

Over a 117-year period (1886 to 2002), 164 recorded tropical storms and hurricanes passed within 180 nautical miles of Kings Bay. All but one of these storms occurred between May and November. At the closest point of approach, most of the storms (75%) had wind speeds below hurricane threshold (64 knots) (Handlers and Brand 2004). The impact of numerous storms striking any barrier island will include erosion, flooding, and damage to vegetation. Some breaching of the primary dune system occurred during the active hurricane/ tropical storm season of 2004 (J. Fry, pers. comm.). Park management will benefit from the recent installation of a NOAA "climate reference network" weather station near Stafford. The solar-powered setup yields real-time data on radiation, temperature, rainfall, and windspeed.

C3d. Island alterations

Impoundments

Reservoirs, dams, basins, and levees can have significant negative effects on natural resources (Cowie et al. 2002). Aside from the small ponds at High Point Farm, Plum Orchard, and Serendipity Farm, there are few existing impoundments on Cumberland Island. These artificial ponds were created for aesthetic and recreational purposes (Hillestad et al. 1975). Hillestad et al. (1975) also describe an 1802 map that shows a dike at the current location of Kings Bottom Road. They speculate that the dike may have been a water control structure to

"increase bottomland or to increase the amount of salt marsh hay" for cattle and horses needing forage.

Dikes and ditches

Rice was cultivated on Cumberland Island at the Stafford Plantation and elsewhere (Bullard 2003). The extent of the practice is unknown, but fields were drained and diked to flood at the appropriate time in the growing season. Zeichner's drawing of the Dungeness landscape shows a ditched area near the kitchen gardens (Zeichner 1988) and drainage on Swamp Field has been altered from its natural state since the plantation era (Hillestad et al. 1975). The areas adjacent to White Branch creek were also ditched for agriculture and the remnants of a flow device may still be seen along the creek. Restoration of ditched areas can be a very slow, long-term process. Cotton (2004) used GIS and aerial photography to study the drainage patterns of an abandoned rice plantation in the Ogeechee River, Georgia, that had been ditched during the 1800s. After approximately 100 years of passive restoration, drainage channels retained the characteristics of a man-made system. Whereas channels in a natural, reference marsh followed logical patterns associated with bi-directional flow, those in the restored marsh were predominantly straight without obvious circulation patterns. These observations suggest that restoring a more natural flow regime to ditched areas may require active restoration. In addition, there may have been ditches constructed on the island for mosquito control, although no information about these types of structures was located.

Abandoned artesian wells

Ten of the fifteen artesian wells that tap into the deep Floridian Aquifer under Cumberland Island are currently abandoned and no longer maintained. Most of these wells, which predate the establishment of the National Seashore, were likely not properly plugged or capped upon abandonment. These wells began to flow uncontrollably after the Durango paper plant in St. Marys ceased operations (and its significant groundwater withdrawals). NPS personnel estimate the output of these wells could be as much as hundreds of thousands of gallons per day (National Park Service 2004c). The impact of this flow has yet to be determined, but it is problematic and CUIS is seeking funding to assist in the proper disposition of the abandoned wells (National Park Service 2004c).

Roads and airstrips

A number of roads were constructed on Cumberland Island during the Carnegie era of the 1880's: Andrews System and Pratts Road appear to have been for riding, but Duck House Road, Willow Pond Trail (shown as Old Duck House Road in **Figure 9**), Roller Coaster Road, and Yankee Paradise Road could well have been built for access to prime waterfowl habitat for hunting. These latter four routes pass through some of the island's wetlands and do not incorporate many culverts, thus altering drainage patterns (Hillestad et al. 1975). Roads of this type constructed during a more recent era (1965-1975) include South Cut Trail and North Cut Road. Some of the causeways are very large (100 meters long, 3 to 5 meters high, 10 meters wide at the base), and again, they do not incorporate many culverts. There are two operational airstrips on the island: one at Stafford Field and one just north of the Settlement on the North End, as well as an abandoned airstrip south of North Cut Road. The amount of paved surface on Cumberland Island is relatively small and there is little automobile or air traffic, so these areas likely represent a very small source of pollutants in terms of runoff. The legal status of specific

roads on the island has been the subject of much current debate (National Park Service 2004b; Shelton 2004). The Cumberland Wilderness Boundary Act (originally put forth in U.S. Congress as HR 4818, but ultimately passed as a rider on the 2005 Appropriations Bill) removes the High Point (Half-Moon Bluff) Historic District from the Potential Wilderness. It also removes the Main Road, Plum Orchard Road, and North Cut Road from the Wilderness area, which will affect how these roads are used in the future.

D. Summary and Recommendations

D1. Condition overview

Table 16. Potential for impairment of Cumberland Island water resources

Indicator	Ocean beach	Sound shore	Tidal creeks	FW ponds	Ground water
Water Quality					
Nutrients	LP	PP	ND	LP	LP
Fecal bacteria	LP	PP	ND/PP	ND/PP	ND
Dissolved oxygen	LP	HP	ND	PP	NA
Metal contamination	ND	PP	ND	LP	LP
Toxic compounds	ND	PP	ND	ND	ND
Population Effects					
Fish/shellfish harvest	ND	PP	ND	LP	NA
Invasive species	ND	ND/PP	ND/PP	LP	NA
Habitat Disruption	ND	PP	ND/HP	ND/HP	LP

Definitions:

ND – no data to make judgment, NA – not applicable, LP – low or no problem,
HP – high problem, PP – potential problem

The table above summarizes our best professional judgment regarding the potential for impairment of the water resources in and around Cumberland Island as evidenced by the various listed indicators. Below we briefly describe the rationale for making these assignments:

Ocean beach – There has not been very much sampling on the ocean side of the island, but we expect that water quality there will be relatively good as it is further from the mainland and less exposed to land-derived contaminants. There are no specific data on fish harvest on the ocean side of Cumberland Island.

Sound shore – The data summarized in this report identified low dissolved oxygen as a high problem in Cumberland Sound, based on recurring observations of surface water oxygen concentrations less than 4 mg L^{-1}. We have listed metals (particularly mercury) and pesticides as a potential problem, but this inference is based on limited observations of sediment and fauna. Nutrients are also listed as a potential problem, as a substantial proportion of both DIN and PO_4 measurements fall in the "Fair" category in the National Coastal Assessment. Fecal bacteria are a potential problem in areas accessed by feral horses. In terms of stressors that affect populations, the coast-wide reduction in commercial fish and shellfish harvest potentially impacts the area. There have been no observations of introduced species, but both the green mussel (*Perna viridis*) and green porcelain crab (*Petrolisthes armatus*) are likely in the area.

Finally, there is the potential for habitat destruction due to the erosional effects of boat traffic and dredging in the area.

Tidal creeks – Sampling in the tidal creeks of Cumberland Island is extremely limited and has not included an assessment of bacterial population, dissolved nutrients, or contaminants. However, it is likely that grazing by feral horses in the marshes leads to habitat destruction and also contributes fecal bacteria. Both the green mussel (*Perna viridis*) and green porcelain crab (*Petrolisthes armatus*) are likely to be present.

Freshwater ponds – Problems in the freshwater ponds are primarily the potential for habitat disruption from feral horses, which could again be associated with input of organic nutrients and fecal bacteria. The few observations of dissolved oxygen suggest potential water quality problems in these environments.

Groundwater – There are no identified water quality problems that affect the groundwater, and there is no current evidence for saltwater intrusion into the Floridan aquifer in the area underlying the island. The USGS continues to monitor established wells on a semi-annual basis. However, uncapped artesian wells are presently flowing on the island, with potential effects on nearby resources.

D2. Recommendations

In writing this report we have encountered numerous data gaps as well as identified situations where additional and/or continuing observations would be useful to have to better evaluate the water resources of Cumberland Island. These are summarized in **Table 17** and then expanded upon in some detail below. We recognize that many of these are beyond the jurisdiction of the National Park Service, but they are listed below in order to provide a complete record of the types of information that would be helpful for future evaluations.

Table 17. List of Recommendations

Data access/management
1. Baseline information from CUIS ecological survey
2. Delineation of jurisdictional boundaries
3. Integration of information into a single GIS
4. Improved access to state and federal water quality data and improved metadata

Water quality
1. Continuing and improved measurements of water quality in Cumberland Sound
2. Information on water quality in tidal creeks
3. Targeted monitoring of development projects

Biological resources and habitats
1. Species inventories linked to habitat type
2. Information on habitat disruption

3. Identification of sentinel organisms
4. Population-level information specific to Cumberland Island

Hydrology
1. Reassessment of coastal watershed boundaries
2. Determination of residence times for near-park water bodies
3. Characterization of the potential for erosion

D2a. Data access/management

Baseline information from CUIS ecological survey

A team of investigators led by H. Hillestad at the University of Georgia conducted an ecological survey of Cumberland Island for the National Park Service in 1975 (Hillestad et al. 1975). The resulting book remains an important reference and contains valuable baseline information on habitats and biological resources on the Island. It would be extremely useful to convert the report to a digital format for text searching. Converting it to such a format will also allow it to be more widely available.

Delineation of jurisdictional boundaries

The boundary of the Cumberland Island National Seashore, as delineated in **Figure 2**, shows the area within which the Federal Government has the authority to acquire land. However, the National Park Service does not own all of the land within this boundary, as there are private in-holdings as well as areas managed or owned by other federal agencies (i.e. the Navy owns Drum Point Island and the Army Corps of Engineers owns land in the Raccoon Keys area). Note also that intertidal and subtidal areas are managed by the state of Georgia. The current administrative boundaries of the park are delineated on federal map "CUIS 40,000E" from November 1983. It would be useful to have an accurate map with a clear identification of the National Park Service's management authority.

Integration of information into a single GIS

In preparing this report we were able to identify numerous sources of both current and historic water quality data for Cumberland Island and the surrounding water. Dr. Karen Payne is currently involved in a large-scale effort to compile all of the water quality observations that are available for the Georgia coast and place them into a single GIS. When complete, it will incorporate all of the data sets that were identified in this report and will be available to the NPS.

It would also be useful to have all of the different types of spatial information described in this report located within a single GIS so that different information could be compared to habitat and land use information. An effort of this type might include information on sources of pollution (superfund sites, NPDES permits, confined animal feeding operations, septic tanks[60]); environmental sampling stations (air quality monitoring sites, groundwater sampling wells, CRD

[60] Dr. Stuart Stevens, the Camden County Environmental Health Department Director, is currently in the process of mapping the location of septic tanks throughout the county. However, this effort does not include those on Cumberland Island.

sampling sites, EMAP stations, etc.); physical characteristics (bathymetry, location of docks and jetties, areas of shoaling and active erosion); habitat utilization (commercial and recreational fishing grounds; essential fish habitat; manatee use areas; shark pupping grounds). In addition, the Hillestad report contains four maps that could be digitized (soils, geology, vegetation, and water bodies) (*see also recommendation with regard to Biological Resources,* above). It would also be useful to locate additional spatial information. For example, the Army Corps of Engineers may have information about ditching, dredging, dams and other development projects within and near the park boundary that they are willing to share with this project.

Improved access to state and federal water quality data and improved metadata

In compiling this report, we found that compiling existing data was often difficult, either because the information was not readily available or because there was not enough documentation provided. Both federal and state information on pollutants and impairments have inaccuracies and omissions with regard to location, making it difficult to construct a complete picture of either point source discharges or impaired waters. Below we provide specific information on the different data sources we utilized. However, it would also be useful to have the various programs cross-referenced, as there is overlap in the types of information covered by each.

StoRet - To the extent possible, all water quality data should be submitted to EPA StoRet. At present, beach water quality and NCA are the only two programs currently submitting coastal Georgia data, and information from these programs is not yet accessible in the database.

National Pollutant Discharge Elimination System (NPDES) - It was not possible to determine the locations of all of the NPDES discharge point sources because some permits listed in the database have no facility location information associated with them and some contain errors about the county in which they are located.

Impaired waters - The 303(d) and 305(b) lists of impaired streams required under the Clean Water Act would be more useful if the database were modified. At present, the data maps to an entire water body because the different stream segments have not been separated out. For example, "Hurricane Creek" is listed as an impaired water body but impairments were observed in the section "Whitehead Creek to downstream of Little Creek" and it is really only this section that should be flagged. In addition, all of the violations within a given stream segment are listed as a single attribute (in this case, "DO, SB", making it difficult to query the database to find all of the segments with violations based on a particular violation [i.e. shellfish ban]). There are also no units associated with the "extent" attribute and this should be included in the name (e.g.: "Extent_miles"). Finally, we were unable to distinguish between shellfish closures that are administrative closures (i.e. had not been sampled) and those that were closed due to poor water quality, and this information would be extremely useful.

Georgia EPD Envirofacts - Location information is not consistent throughout the Envirofacts database: sometimes the location refers to the parent company (rather than the point source) and sometimes it is missing. HUCs are not consistently listed and spatial information is sometimes lacking entirely. Information should be searchable by county names and relevant municipalities should also be listed.

Georgia River Basin Management Plan - It is not always clear how many segments were evaluated. The extent (and identification) of evaluated segments should accompany the list of segments not fully supporting designated uses. This recommendation also applies to the 303(d) listing by the state for the EPA.

Kings Bay Naval Base - The fact that the Kings Bay Naval Base is a military facility means that some of their activities are classified, and not fully covered by the above-mentioned inventories. Although there is a lot of information available regarding the environmental conditions in Kings Bay (particularly through the EIS), information with regard to NPDES permits is not readily available to the public. However, they have been cited for leaking storage tanks, numerous spills, some toxic releases and other environmental compliance violations, and the site is on the Georgia Hazardous Site Inventory. It would be useful to have better information on the types of activities that are going on at the facility that have the potential to influence water quality in the area. Initial contacts with the public affairs officer at the Naval Base have been very useful, and further interactions should be pursued.

D2b. Water quality

Continuing and improved measurements of water quality in Cumberland Sound

Dissolved oxygen - The low dissolved oxygen concentrations observed near Cumberland Island is potentially the largest water quality problem identified in this report (*see* **section B1b**). It is a high priority to continue monitoring dissolved oxygen, particularly during summer when concentrations generally reach their minima. In their sampling program, CRD records oxygen concentrations in surface water at mid-day. It would be very useful to do some diel measurements of oxygen as well, and to take measurements in both surface and bottom water. If there were an indication of a real problem, it would be important to tie this information to observations of the distribution of organisms: are nekton leaving the area? are low oxygen concentrations affecting benthic organisms?

Nutrients - Dissolved inorganic nutrients (nitrate, nitrite, ammonium, orthophosphate, total dissolved phosphorus, dissolved silica) are currently measured by Georgia CRD. Although the observed concentrations near Cumberland are not high, there is evidence that nutrients are increasing in Georgia's coastal water (Verity 2002a), and hence it would be useful to have continuing measurements of nutrients in the area. It would also be useful to add measurements of total nitrogen and dissolved organic nitrogen (DON) to these observations. DON (which can be calculated as total Kjeldahl nitrogen minus ammonium) generally comprises 80% or more of total dissolved nitrogen, so the nitrogen constituents currently being measured are a very small part of the total. Moreover, Verity found that DON concentrations have been increasing at a faster rate than inorganic nitrogen in the Skidaway River (Verity 2002a, b). If this is the case for Cumberland Sound as well, it may be related to the low DO concentrations.

Metals and pollutants - There are two Superfund sites in Camden County, and 12 in Glynn County. The sites in Brunswick have high concentrations of metals (mercury, lead, chromium, copper, and arsenic), PCBs, and other organic compounds (toxaphene, pentachlorophenol, and

creosote). The limited observations of contaminant concentrations that we located for this report present an equivocal picture, so it is unclear whether there are persistent problems in the region. It would therefore be useful to have additional observations of contaminant concentrations in organisms and sediment in order to address this issue. In particular, samples should be tested for mercury and pesticides. It might also be useful to test for emerging pollutants such as pharmaceuticals and hormones.

Information on water quality in tidal creeks

There is very little information available that could be used to evaluate water quality in the tidal creeks of the island. It would be useful to have some observations from these areas, in particular with regard to the potential water quality effects of feral horses on the island.

Targeted monitoring of development projects

It is important to recognize that ongoing development in the watershed will increase the potential for problems in and around Cumberland Island. Population growth on the mainland will result in additional visitors to the island itself as well as increased boat traffic in the area. Increases in the amount of impervious surface will result in increased overland runoff of nonpoint pollutants, and other types of land use changes also have the potential to increase the input of pollutants to the watershed. It would be useful for the NPS to be in a position to keep track of these activities and understand their effects. One way to do this would be to keep records of the number of boats that visit the island, in order to be able to document any large changes in activity. Ideally, these observations would be coupled to water and sediment quality measurements. Another possibility is to take advantage of the frequent ferry trips back and forth to the island (and/or other NPS boats) to obtain basic water quality information. An automatic recorder could be utilized for things such as temperature and salinity, with the potential for an autosampler for obtaining discrete samples of water quality. This type of approach has been used with success in the Neuse River, NC (Paerl and Ramus 2005).[61]

D2c. Biological resources and habitats

Species inventories linked to habitat type

Although species lists are available for much of Cumberland Island, it would be useful to match these organisms to habitat type (this has been done in some cases but not in others). It would also be useful to characterize both the flora and fauna associated with the marsh hammocks associated with Cumberland Island. These are areas receiving increased attention as potential areas for development along the Georgia coast and there is a need to have information on their function in an undeveloped landscape. There is also a need to do some additional sampling in marine areas, which have not been well-covered by past inventories. Inventories of marine habitats might also involve systematic sampling for invasive species, such as the green mussel and the green porcelain crab, both of which are likely in the area. It would also be appropriate to do some baseline sampling of the Cumberland Island marshes and to maintain a continued awareness of their status in light of the recent marsh dieback that has affected coastal

[61] Monitoring ferries are equipped with sondes to collect temperature, salinity, pH, turbidity and chlorophyll fluorescence every 3 minutes.

Georgia.[62] Currently, the NPS – Southeast Coast Network is working to prepare a number of biotic inventories for Cumberland Island: reptiles, amphibians, and bird inventories have been completed and are awaiting certification while those for fish, small mammals, bats, and vascular plants are ongoing (National Park Service (Southeast Coast Network) 2005).

Information on habitat disruption

This report did not specifically focus on the potential for habitat disruption on Cumberland. However, there is concern that the large feral horse population on the island may well be causing damage to specific habitats. In addition, groundwater flow from uncapped artesian wells may also be affecting local habitats. These and other issues would be useful to evaluate.

Identification of sentinel organisms

It is sometimes difficult to connect water quality observations with resource effects. One possibility is to select sentinel organisms in different habitat types that could act as indicators of degrading water quality. For example, studies in tidal creeks in South Carolina have shown that the abundance of penaid shrimp in tidal creeks decreases as the amount of impervious surface in the surrounding watershed increases (Sanger and Holland 2002).

Population-level information specific to Cumberland Island

There is very little population-level information available for the island, particularly for aquatic species. Several reviewers asked for information on the types and effects of introduced fresh or saltwater fish, which we were not able to provide. Although the NCA does trawl surveys to get an indication of species composition, there is also no specific information on fish catch in the area, nor is there information on the effects of introduced species.

D2d. Hydrology

Reassessment of coastal watershed boundaries

The watershed of Cumberland Island is not well delineated. The 8-digit USGS HUC for Cumberland Island (#03070203) also includes St. Simons and Jekyll Islands. The water that surrounds these barrier islands may transport materials between them via water flow and tidal mixing, but predominant watershed affects are likely to be more localized. This HUC is also considered part of the Satilla River watershed in state river basin planning, but it is unlikely that any runoff from the land that surrounds the estuary actually directly affects the island (although again material may be transported to the island with the prevailing currents). An accurately delineated watershed would require a better understanding of both runoff patterns on land and water movement and mixing patterns on the coast, but without good information on the appropriate area to consider it is difficult to evaluate whether different far-field sources of pollutants actually reach the island. This is particularly important when assessing the potential influence of industrial pollutant sources from Brunswick and/or continued development on the mainland.

[62] Dr. Karen Payne spearheaded a project to create spatial databases of marsh die-off areas on the coast of Georgia.

Determine residence times for near-park water bodies

Without information on how long the water stays in a particular area it is difficult to understand how vulnerable it might be to changes: areas that are flushed quickly are less susceptible to pollutants than those where the water stays longer. It would therefore be useful to determine the residence times of the different sub-water bodies associated with Cumberland Island (i.e. tidal creeks; Cumberland Sound) so that there is a means to quantify exposure and the potential vulnerability of different areas to water-borne pollutants. There is no easy way to do this without additional hydrologic information regarding water flow in the area (i.e. through dye studies). However, it would be possible to perform targeted studies to estimate turnover times in specific areas of concern.

Characterization of the potential for erosion

There is concern that physical activities such as dredging for the Kings Bay Naval Base and boat traffic in the area are having a negative effect on the island shore. We were unsuccessful at getting either dredging or boating records for this report.[63] There is research currently in progress that will provide information on erosion rates on the island's shore (Foyle et al. 2004; Jackson and Alexander 2005), which will be useful in this regard. However, it would also be worthwhile for the National Park Service to track boat traffic to and from the island, particularly in light of concerns that this might increase in the future.

[63] We inquired at the Public Affairs Office at the Naval Base, the US Army Corps of Engineers, and the US Coast Guard, none of whom could provide records.

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(*See* **Appendix N** *for an* Annotated Bibliography)

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Appendices

Appendix A – Comparison of two contemporary data sets that detail land use classification of Cumberland Island

Appendix B – Inventory of marsh hammocks in the Cumberland Island region

Appendix C – Inventories of nektonic and benthic organisms collected by EPA EMAP program

Appendix D – Dune and maritime forest habitat vegetation

Dune habitats

Maritime forest habitats

Appendix E – Georgia water quality standards

Appendix F – Data identified for coastwide water quality database

Appendix G – U.S. Geological Survey water resources site inventory, Cumberland Island

Appendix H – Point-source pollutant discharges in the Cumberland Island area

Facilities of particular concern in Camden County, Georgia

Facilities of particular concern in Glynn County, Georgia

Facilities of particular concern in Nassau County, Florida

Appendix I – Cumberland Harbour subdivision, Camden County, Georgia

Appendix J – Satilla River Landing, Camden County, Georgia

Appendix K – Middleton Plantation, Camden County, Georgia

Appendix L – River Place Plantation, Camden County, Georgia

Appendix M – Permitted water withdrawals

Appendix N – Annotated Bibliography

Appendix A - Comparison of two contemporary data sets that detail land use classification of Cumberland Island

Figure A-1 shows a land cover map for Cumberland Island developed by the Georgia GAP project. This is comparable to the analysis presented here (*see* **Figure 4**), because they both used 1996-1998 *Landsat* 5 TM data as baseline imagery. **Table A-1** provides acreage values associated with each of the land cover types for these two datasets. Because the land cover classes are not the same between the two datasets, the classes were "crosswalked" or aggregated to common classes for acreage comparisons.

The largest discrepancy in the two datasets is derived from the cross-walking of "Live Oak," which, while a hardwood, rarely sheds its' leaves in southern Georgia. Moreover, live oak (*Quercus virginiana*) is often short of stature and is a component of shrub habitat, making it difficult to classify clearly as either part of a forest stand or a short stature, shrub/scrub habitat. Not surprisingly, the vast majority of the land cover is marsh and open water. This differs from the remainder of Camden County, and the Cumberland-St. Simons watershed, both shown in **Figure 3**.

Figure A-1. 1998 Land cover of Cumberland and Little Cumberland Islands (USGS 2003).

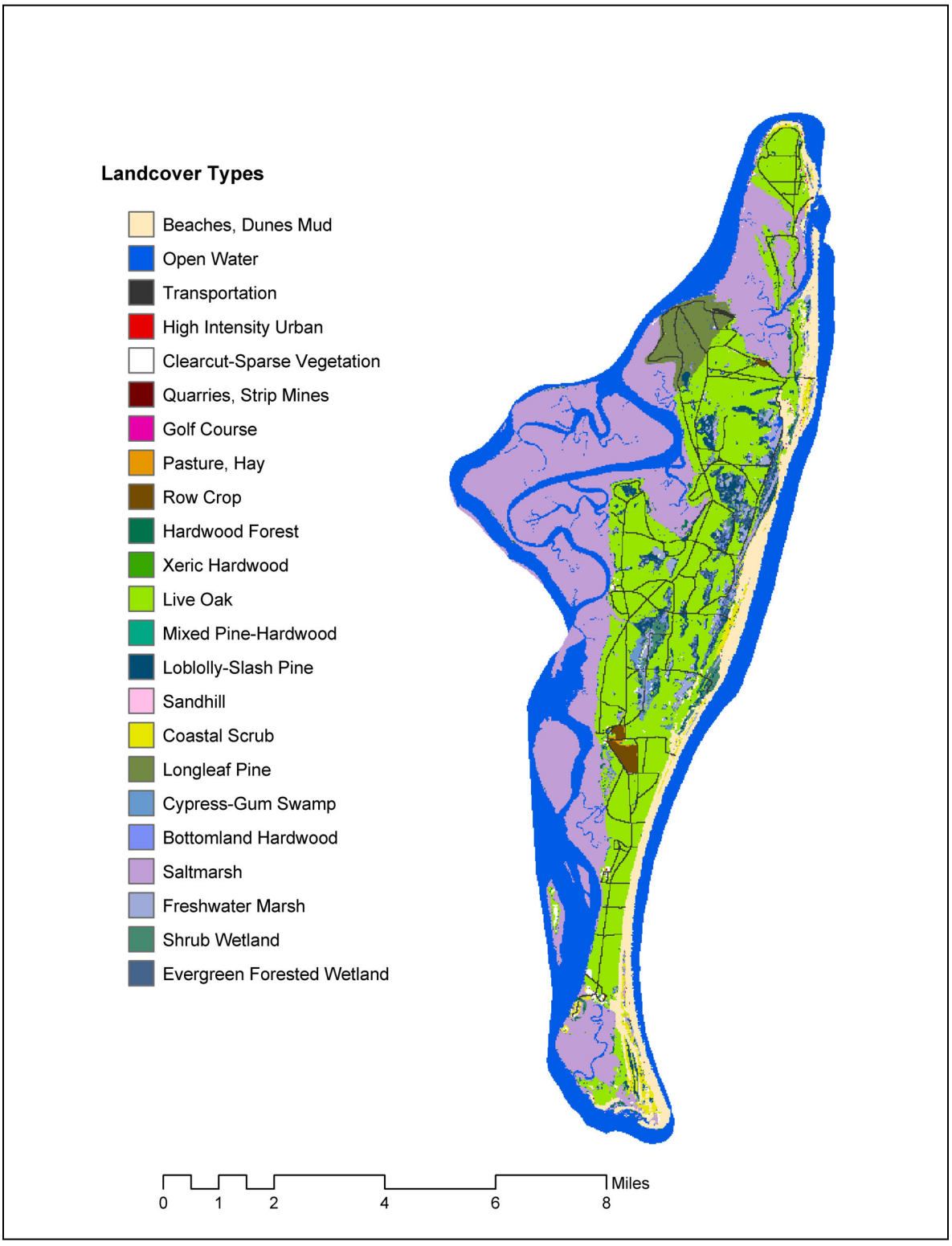


Table A-1. Comparison of land cover maps. The "Payne" map is shown as **Figure 4** (main text) and the "GAP" map is shown as **Figure A-1**.

Payne, Original Class, Acreage		GAP, Original Class, Acreage		Crosswalked Classes
Beaches	1169.08	Beaches, Dunes, Mud	2299.69	
Dunes	1246.66			**Beaches, Dunes**
Total	**2415.73**		**2299.69**	
Open Water	**9651.38**	Open Water	**9634.26**	**Open Water**
Airports	14.45	Transportation	1205.09	
Roads	1190.64			**Transportation**
Total	**1205.09**		**1205.09**	
Low Density Residential	2.67	High Intensity Urban	7.56	
Commercial/Industrial	7.56			**Urban/suburban**
Total	**10.23**		**7.56**	
Clearcut/Sparse	95.37	Sparse Vegetation	201.40	
Clearcut Wetland	57.35			**Clearcut/Sparse**
Total	**152.72**		**201.40**	
Quarries, Strip Mines, Landfills, Gravel Pits	**0.22**	Quarries, Strip Mines	**0.22**	**Quarries, Strip Mines, Landfills, Gravel Pits**
Golf Courses	**15.12**	Golf Course	**15.12**	**Golf Courses**
Shrub/Scrub	2.00	Coastal Scrub	377.47	
		Sandhill	2.00	**Shrub/Scrub**
Total	**2.00**		**379.47**	
Pasture	**13.34**	Pasture, Hay	**22.90**	**Pasture**
Agriculture	147.83	Row Crop	153.39	
Horticultural Businesses	7.34			**Agriculture**
Total	**155.17**		**153.39**	
Salt marsh	**10717.08**	Salt marsh	**10467.88**	**Salt marsh**
Shrub Wetland	**38.01**	Shrub Wetland	**232.53**	**Shrub Wetland**
Evergreen Forested Wetland	**300.11**	Evergreen Forested Wetland	**556.86**	**Evergreen Forested Wetland**
Deciduous Forest	151.83	Hardwood Forest	138.49	
		Xeric Hardwood	0.89	**Deciduous Forest**
		Live Oak	8675.48	
Total	**151.83**		**8814.86**	
Evergreen Forest	10924.04	Longleaf Pine	741.15	
Managed Pine	11.34	Loblolly-Slash Pine	828.51	**Evergreen Forest**
Total	**10935.38**		**1569.66**	
Mixed Forest	**12.67**	Mixed Pine-Hardwood	**1.33**	**Mixed Forest**
Cypress Gum	**80.69**	Cypress-Gum Swamp	**124.04**	**Cypress Gum**
Mixed Forested Wetland	346.79	Freshwater Marsh	428.37	
Deciduous Forested Wetland	157.61	Bottomland Hardwood	269.21	**Freshwater Wetland**
Deciduous Depressional Wetland	22.90			
Total	**527.30**		**697.58**	

Appendix B - Inventory of marsh hammocks in the Cumberland Island region

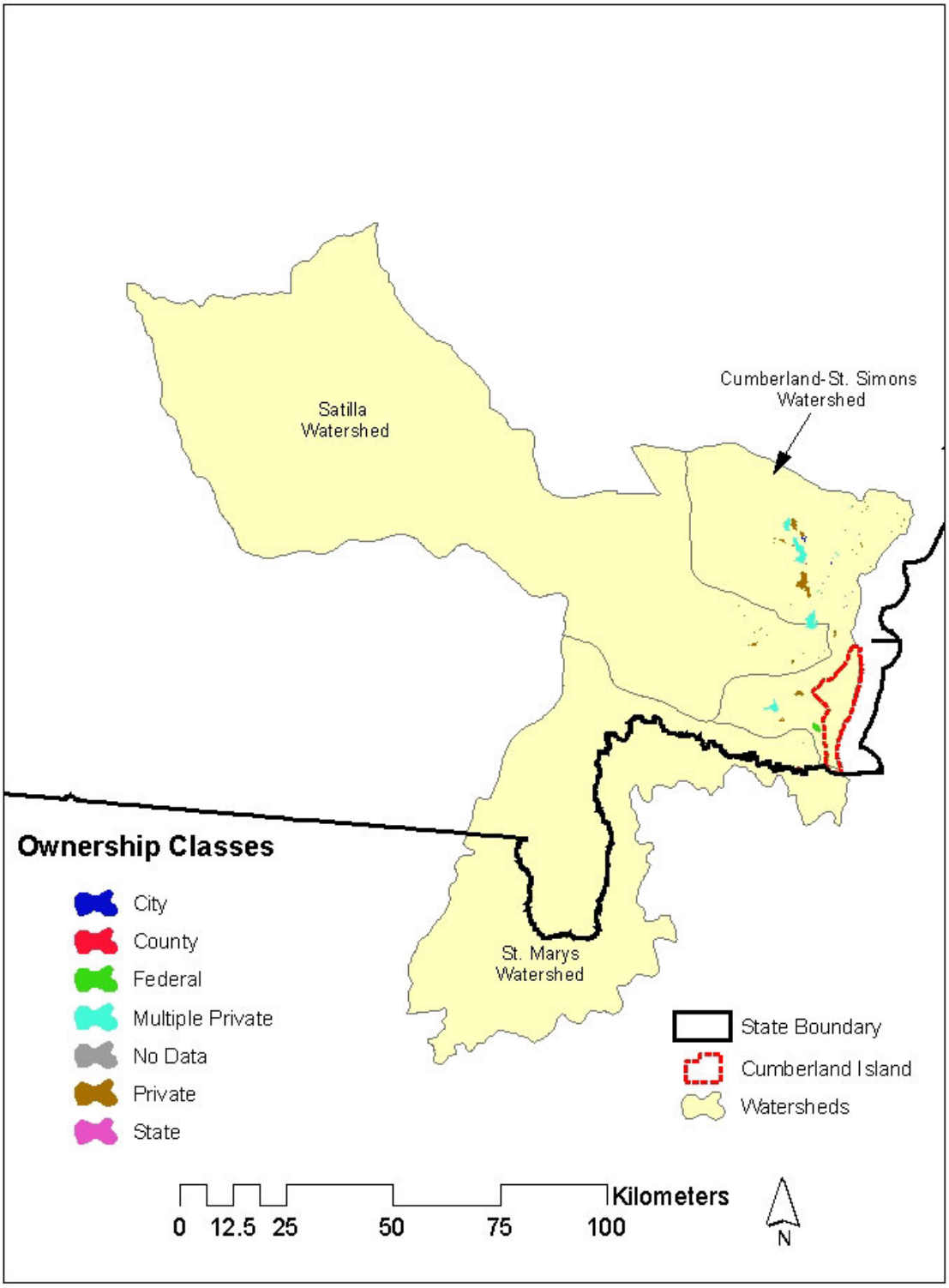
The locations of the marsh hammocks in the Satilla and St. Marys watersheds are shown in **Figure B-1**. Note that the Cumberland-St. Simons watershed (which is actually part of the Satilla River) is separate from the two HUCS in the upper portion of the basin. These data are an under representation of hammocks in the area due to the fact that the St. Marys watershed extends into the state of Florida and we have no spatial databases delineating hammocks from that area. We identified a total of 529 hammocks (which cover 12,713 acres) in the region. Most are privately owned (either by individuals or by multiple entities). The number and total acreage of hammocks in each ownership category is listed in **Table B-1**. Many of these hammocks have already been developed in some manner and this is also reflected in **Figure B-1.**

Table B-1. Tally of marsh hammocks located in the Satilla and St. Marys watersheds.

Ownership Category	Number	Size (acres)
Federal	12	710.0
State	58	155.5
County	16	18.3
City	23	212.6
Private	373	5,493.2
Multiple Private	13	6,037.1
No Data	34	86.2
Total	529	12,713

There are a total of 38 hammocks covering 176.3 acres located within the 1994 boundary of the Coastal Barrier Resources Act. This is of interest because developments in this area would not be eligible for federal flood insurance. Thirty of these hammocks are privately owned and cover 120.1 acres; seven are federally owned (35.3 acres) and one has no ownership data (20.9 acres).

Figure B-1. Hammocks within the three watersheds surrounding CUIS



Appendix C - Inventories of nektonic and benthic organisms

Table C-1. Inventory of nektonic organisms collected by EPA Environmental Monitoring and Assessment Program.

(Organisms were caught in 4.9-m otter trawls with 2.5 cm mesh wings.) Station CP94019 was located in the St. Marys River and was sampled August 11th 1994; CP94020 was in St. Andrews Sound and was sampled August 3rd 1994; CP95169 was located in the Cumberland River and was sampled September 7th 1995. Data source: http://www.epa.gov/emap/

Station	Latin Name	Common Name	Abundance
CP94019	*Chaetodipterus faber*	Atlantic spadefish	3
	Dasyatis say	Bluntnose stingray	1
	Gobiosoma robustum	Code goby	1
	Menippe mercenaria	Stone crab	1
	Monacanthus hispidus	Planehead filefish	1
CP94020	*Arius felis*	Hardhead catfish	8
	Brevoortia tyrannus	Atlantic menhaden	1
	Cynoscion regalis	Weakfish	1
	Leiostomus xanthurus	Spot	22
	Lolliguncula brevis	Brief squid	1
	Menticirrhus americanus	Southern kingfish	1
	Micropogonias undulatus	Atlantic croaker	34
	Pogonias cromis	Black drum	15
	Rhizoprionodon terraenovae	Atlantic sharpnose shark	1
	Sphyrna tiburo	Bonnethead	2
CP95169	*Arius felis*	Hardhead catfish	30
	Bairdiella chrysura	Silver perch	2
	Callinectes similis	Crab	1
	Cynoscion regalis	Weakfish	1
	Dasyatis sabina	Atlantic stingray	2
	Etropus crossotus	Fringed flounder	2
	Leiostomus xanthurus	Spot	2
	Menticirrhus americanus	Southern kingfish	1
	Micropogonias undulatus	Atlantic croaker	5
	Penaeus setiferus	White shrimp	62
	Stellifer lanceolatus	Star drum	25
	Symphurus plagiusa	Blackcheek tonguefish	16
	Trinectes maculatus	Hogchoker	12

Table C-2. Inventory of nektonic organisms sampled during EPA National Coastal Assessment (summer 2000, 2001).

Data source: http://www.epa.gov/emap/nca/index.html

Latin Name	Common Name
Chloroscombrus chrysurus	Atlantic bumper
Micropogonias undulatus	Atlantic croaker
Selene setapinnis	Atlantic moonfish
Chaetodipterus faber	Atlantic spadefish
Larimus fasciatus	Banded drum
Anchoa mitchilli	Bay anchovy
Symphurus plagiusa	Blackcheek tonguefish
Lolliguncula brevis	Brief squid
Penaeus aztecus	Brown shrimp
Etropus crossotus	Fringed flounder
Bagre marinus	Gafftopsail catfish
Arius felis	Hardhead catfish
Trinectes maculatus	Harvestfish
Limulus polyphemus	Hogchoker
Synodus foetens	Inshore lizardfish
Lutjanus synagris	Lane snapper
Callinectes similis	Lesser blue crab
Selene vomer	Lookdown
Stomatopoda	Mantis shrimp
Opsanus tau	Oyster toadfish
Orthopristis chrysoptera	Pigfish
Lagodon rhomboides	Pinfish
Penaeus duorarum	Pink shrimp
Monacanthus hispidus	Planehead filefish
Centropristis philadelphica	Rock seabass
Bairdiella chrysoura	Silver perch
Paralichthys lethostigma	Southern flounder
Menticirrhus americanus	Southern kingfish
Leiostomus xanthurus	Spot
Eucinostomus argenteus	Spotfin mojarra
Cynoscion nebulosus	Spotted seatrout
Stellifer lanceolatus	Star drum
Anchoa hepsetus	Striped anchovy
Chilomycterus schoepfi	Striped burrfish
Paralichthys dentatus	Summer flounder
Cynoscion regalis	Weakfish
Penaeus setiferus	White shrimp

Table C-3. Inventory of benthic organisms collected at EMAP station CP94019 (St. Marys River)

The station was located at 30.711° latitude / -81.47° longitude and sampled on August 11th 1994. Organisms were caught using a 0.04 m^2 Young grab sampler. Abundance is mean abundance per 440 cm^2. (Source: http://www.epa.gov/emap/)

Latin Name	Abundance	Latin Name	Abundance
Alpheus sp (juv)	1	*Loimia medusa*	1
Ampelisca vadorum	3	*Mediomastus californiensis*	1
Anadara transversa	1	*Membranipora arborescens*	1
Anthozoa	20	*Membranipora tuberculata*	1
Apseudes sp	1	*Modiolus modiolus squamosus*	3
Armandia maculata	1	*Neanthes spp.*	4
Autolytus spp.	1	*Neanthes succinea*	2
Axiognathus squamata	1	*Nematoda*	1
Balanus spp.	139.5	*Nereis micromma*	11.5
Balanus venustus	2	*Noetia ponderosa*	1
Batea catharinensis	7	*Nucula proxima*	15
Boccardiella hamata	1	*Ophiophragmus filograneus*	1
Boguea enigmatica	1	*Ostrea equestris*	2
Brania wellfleetensis	7	*Pagurus annulipes*	1
Bugula neritina	1	*Pagurus pollicaris*	1
Carinomidae	1	*Panopeus herbstii*	2
Caulleriella sp1	2.5	*Phyllodocidae*	1
Caulleriella sp2	2.5	*Pinnotheridae*	1
Caulleriella sp3	7	*Podarke spp.*	1.5
Cheilostomata	1	*Polycirrus spp.*	14
Cheilostomata	1	*Polydora cornuta*	1
Cirratulidae	2	*Polydora spp.*	4
Conopeum tenuissimum	1	*Polygordius spp.*	1
Corbula swiftiana	2	*Porifera sp2*	1
Crassinella lunulata	1.5	*Porifera sp6*	1
Crepidula spp.	1	*Prionospio cristata*	8
Ctenostomata	1	*Prionospio perkinsi*	1
Diopatra cuprea	1	*Pseudopotamilla tortuosa*	2
Dipolydora barbilla	2	*Sabellaria floridensis*	1
Dipolydora socialis	1	*Sabellaria sp1*	1
Elasmopus laevis	3	*Sabellaria spp. (juv)*	2
Emplectonematidae	1	*Sabellaria vulgaris*	4
Entoprocta	1	*Schizoporella unicornis*	1
Eobrolgus spinosus	2	*Seila adamsi*	1
Euceramus praelongus	1	*Sphenia antillensis*	4
Eumida sanguinea	4	*Spiophanes bombyx*	2.5
Exogone dispar	9	*Sthenelais boa*	1
Grubeosyllis clavata	7	*Streblosoma verrilli*	3
Haplosyllis sp	1	*Streptosyllis pettiboneae*	3
Hemipholis elongata	2	*Syllides floridanus*	1
Hydrozoa	1	*Syllis gracilis*	1
Kupellonura sp1	1	*Tectidrilus sp*	1
Lembos smithi	2	*Tellina versicolor*	1
Leptochela serratorbita	1	*Tubificidae*	2
Lineidae sp6	1	*Tubulanidae sp1*	4.5
Linopherus paucibracnchiata	1	*Unciola sp*	2
Lioberus castaneus	1		

Table C-4. Inventory of benthic organisms collected at EMAP station CP94020 (St. Andrews Sound)

The station was located at 30.982° latitude / -81.428° longitude and sampled on August 3rd 1994. Organisms were caught using a 0.04 m^2 Young grab sampler. Abundance is mean abundance per 440 cm^2. (Source: http://www.epa.gov/emap/)

Latin Name	Abundance	Latin Name	Abundance
Abra aequalis	4	*Monticellina dorsobranchialis*	10
Amastigos	4	*Nassarius acutus*	2.25
Ampelisca spp.	3	*Nassarius trivittatus*	1
Ampharetidae	1	*Natica pusilla*	1
Ancistrosyllis carolinensis	1	*Neanthes succinea*	10.25
Anthozoa	2	*Nemertea*	6
Aphelochaeta marioni	1	*Nereis micromma*	1.5
Arabella iricolor	1	*Nucula proxima*	6
Aricidea fragilis	1	*Odostomia laevigata*	1
Batea catharinensis	11	*Oligochaeta*	1
Bivalvia	2	*Ostracoda*	1
Bugula neritina	1	*Oxyurostylis smithi*	1.5
Callianassa biformis	1	*Pagurus sp*	1
Callianassidae	1.5	*Paraprionospio pinnata*	1.33
Clymenella torquata	3.67	*Parvanachis obesa*	1.5
Corbula contracta	1	*Pectinaria gouldi*	1
Corophium spp.	1	*Petricola pholadiformis*	1
Crassostrea virginica	1	*Phoronis architecta*	4.33
Doridella obscura	1	*Phyllodoce arenae*	2.5
Edotea triloba	1	*Pinnixa sayana*	3.67
Galeommatoidea	2.75	*Podarkeopsis*	1
Glycera spp.	1.5	*Polychaeta*	3
Glycinde sp	2	*Polydora spp.*	1
Hemipholis elongata	3.5	*Prionospio perkinsi*	2
Leitoscoloplos fragilis	2	*Sabellaria vulgaris*	40.25
Lepidonotus sublevis	1.5	*Saccoglossus kowalevskii*	1
Leptochela serratorbita	1	*Scoletoma tenuis*	4
Leptosynapta tenuis	1	*Sigambra tentaculata*	1.5
Leucon americanus	1	*Spiochaetopterus oculatus*	1
Listriella barnardi	1	*Spionidae*	1
Listriella clymenellae	7	*Spiophanes bombyx*	1
Loimia viridis	2	*Spiophanes missionensis*	1.5
Magelona phyllisae	2	*Sthenelais limicola*	1
Maldanidae	2.75	*Tellina texana*	3.5
Malmgreniella sp	3.25	*Terebra concava*	1
Mediomastus spp.	1.33	*Turbellaria*	3.33
Micropholis gracillima	24.5		

Table C-5. Inventory of benthic organisms collected at EMAP station CP95169 (Cumberland River)

The station was located at 30.927° latitude / -81.462° longitude and sampled on September 7th 1995. Organisms were caught using a 0.04 m^2 Young grab sampler. Abundance is mean abundance per 440 cm^2. (Source: http://www.epa.gov/emap/)

Latin Name	Abundance	Latin Name	Abundance
Abra aequalis	*1*	*Nemertea*	1.5
Ampelisca spp.	2	*Nereiphylla castanea*	1
Anadara transversa	8	*Odontosyllis spp.*	8
Arabella iricolor	2	*Odostomiidae*	1
Aricidea fragilis	1.5	*Oligochaeta*	17
Astyris lunata	5	*Ostracoda*	1
Autolytus cornutus	1	*Paguridae*	1
Barbatia sp	23	*Parapionosyllis longicirrata*	3
Batea catharinensis	7	*Paraprionospio pinnata*	1
Bivalvia	2	*Pinnixa spp.*	2
Bryozoa	1	*Podarkeopsis*	2
Callianassidae	3	*Polydora spp.*	1
Caprellidae	6	*Pycnogonida*	2
Carinomidae	2.5	*Sabellaria vulgaris*	1
Cerapus tubularis	1	*Sclerodactyla briareus*	1
Chiridotea sp	5	*Scoletoma tenuis*	7
Costoanachis avara	6	*Sigambra tentaculata*	3
Diopatra cuprea	2	*Sphenia antillensis*	42
Dorvillea	1	*Spiochaetopterus oculatus*	1
Exogone dispar	27	*Spionidae*	1
Glycera americana	2	*Streblospio benedicti*	4
Glycinde solitaria	1	*Tellina spp.*	6
Mediomastus ambiseta	2	*Tharyx spp.*	3
Mediomastus californiensis	12	*Unid. ophiuroidea*	20
Mediomastus spp.	21	*Unid. thalassinidea*	1
Neanthes succinea	3	*Unid. turridae*	1
Nematoda	8	*Xanthidae*	1

Table C-6. Tidal Creek Macroinvertebrates

Source: Gore et al. 2004

Type or species	White Branch Creek – site 1	White Branch Creek – site 2	Tributary to Brickhill River
Bezzia complex	X		X
Caecidotea spp.		X	
Cassidinidea lunifrons	X	X	
Chironomus spp.		X	X
Crangonyx spp.			X
Corophium spp.	X		
Corynoneura spp.		X	X
Cyathura spp.		X	
Gammarus spp.	X	X	
Goeldichironomus devineyae	X	X	
Hyalella azteca			X
Labrundinia spp.			X
Larsia spp.			X
Limnophyes spp.	X	X	
Oligochaeta	X		X
Pachydiplax longipennis			X
Palaemonetes spp.	X	X	
Polypedilum spp.	X	X	X
Zavrelimyia spp.			X

White Branch Creek, site 1 (30° 50m 44.434s x 81° 27m 36.258s)
White Branch Creek "QC", site 2 (30° 50m 43.215s x 81° 27m 36.258s)
Tributary to Brickhill River (30° 52m 44.851s x 81° 26m 07.012s)

Appendix D – Upland habitats

Vegetation information in this section is taken primarily from Hillestad et al. (1975) and Schoettle (1996) as well as the plant list maintained by CUIS (National Park Service 2001 – their Appendix 4b).

Dune Habitats

Dune-grass forb habitat – Some of the island's foredunes can be classified as a dune grass-forb community. Dominant plant species include: seashore paspalum (*Paspalum distichum*), pennywort (*Hydrocotle* spp.), seashore dropseed (*Sporobolus virginicus*), railroad vine (*Ipomoea pes-caprea*), Russian thistle (*Salsola kali*), seaside spurge (*Euphorbia polygonifolia*), and sea oats (*Uniola paniculata*).

Grass-sedge meadows – Meadow plants populate low interdunes that infrequently have standing water. The shrubs and vines typical of the grass-sedge interdune are: seaside evening primrose (*Oenothera humifusa*), sea-coast marsh elder (*Iva imbricata*), moundlily yucca / Spanish bayonet (*Yucca gloriosa*), and bayberry (*Myrica cerifera*). Herbaceous plants include: pennywort (*Hydrocotle* spp.), cape weed (*Lippia nodiflora*), seashore paspalum (*Paspalum distichum*), salt marsh fimbristylis (*Fimbristylis castanea*), nutgrass / purple flatsedge (*Cyperus rotundus*), toad rush (*Juncus bufonius*), marsh gentian (*Sabatia stellaris*), love grass (*Eragrostis* spp.), and star rush (*Cyperacea* spp.).

High meadow – The high meadow is an interdune habitat of grasses and sedges very similar to the grass-sedge meadow described above. The significant difference is that the high meadow is found outside the influence of the tides, so the plant species populating the area are slightly different. Shrubs here include: sea-coast marsh elder (*Iva frutescens*), moundlily yucca / Spanish bayonet (*Yucca gloriosa*), and bayberry (*Myrica cerifera*). The prevalent vines and herbs are: seaside evening primrose (*Oenothera humifusa*), cape-weed (*Lippia nodiflora*), pennywort (*Hydrocotle* spp.), seashore paspalum (*Paspalum distichum*), horseweed (*Conyza canadensis*), centipede grass (*Eremochloa ophiuroides*), ground cherry (*Physalis viscose*), muhly grass (*Muhlenbergia* spp.), salt marsh fimbristylis (*Fimbristylis castanea*), nutgrass / purple flatsedge (*Cyperus rotundus*), toad rush (*Juncus bufonius*), marsh gentian (*Sabatia stellaris*), love grass (*Eragrostis* spp.), and star-rush (*Cyperacea* spp.).

Interdune shrub thicket – Protected interdunes and margins by intermittent ponds and sloughs may develop into a shrub thicket of vines (pepper vine [*Ampelopsis arborea*], muscadine grape [*Vitis rotundifolia*], Virginia creeper [*Parthenocissus quinquefolia*], and bamboo brier [*Aralia nudicaulis*]), juvenile trees and dense shrubs (bayberry [*Myrica cerifera*], cabbage palm [*Sabal palmetto*], live oak [*Quercus virginiana*], hackberry [*Celtis laevigata*], slash pine [*Pinus elliottii*], dahoon [*Ilex cassine*], willow [*Salix caroliniana*], elderberry [*Sambucus* spp.], Hercules' club [*Zanthoxylum clava-herculis*], saw palmetto [*Serenoa repens*]). Herbaceous plants are also found here, including: nutgrass / purple flatsedge (*Cyperus rotundus*), dog fennel (*Eupatorium capillifolium*), cape weed (*Lippia nodiflora*), salt meadow cordgrass (*Spartina patens*), marsh fleabane (*Conyza canadensis var. pusilla*), pennywort (*Hydrocotle* spp.), climbing hempweed (Mikania scandens), salt marsh fimbristylis (*Fimbristylis castanea*), *Paspalum* species, rush (*Eleocharis* spp.), broom sedge (*Andropogon virginicus*), and false nettle (*Boehmeria cylindrical*).

Dune shrub thicket – The tops of rear-dune foreslopes sometimes take on a different type of shrub thicket. Here the vegetation is predominantly juvenile trees, small woody plants and vines (bayberry [*Myrica cerifera*], saw palmetto [*Serenoa repens*], Spanish bayonet [*Yucca*

gloriosa], tough buckthorn [*Sideroxylon tenax*], yaupon [*Ilex vomitoria*], red bay [*Persea borbonia*], live oak [*Quercus virginiana*], bamboo-brier [*Smilax auriculata*], pepper-vine [*Ampelopsis arborea*], and cross vine [*Bignonia capreolata*]).

Interdune pine-mixed hardwood forest – The pine-mixed hardwood forest habitat is similar to the interdune shrub thicket, but is more protected and has a more advanced ecological succession. The canopy (lacking in the thicket) is composed of: slash pine (*Pinus elliottii*), loblolly pine (*Pinus taeda*), cabbage palm (*Sabal palmetto*), hackberry (*Celtis laevigata*), live oak (*Quercus virginiana*), southern red cedar (*Juniperus virginiana*), sweet bay (*Magnolia virginiana*), and blackgum (*Nyssa sylvatica*). Bayberry (*Myrica cerifera*) and saw palmetto (*Serenoa repens*) form a shrub story. Vines (muscadine grape [*Vitis rotundifolia*], laurel greenbrier [*Smilax laurifolia*], pepper vine [*Ampelopsis arborea*]) and herbs (false nettle [*Boehmeria cylindrica*], spike grass [*Uniola sessiliflora*], lizard's tail [*Saururus cernuus*], beak rush [*Rhynchospora* sp], water pimpernel [*Samolus parviflorus*], and pennywort [*Centella asiatica*]) make up the ground vegetation.

Dune oak-buckthorn scrub forest – The oak-buckthorn scrub forest is sometimes found at the tops and rear slopes of rear dunes. There is a canopy dominated by live oak (*Quercus virginiana*) and containing: tough buckthorn (*Bumelia tenax*), red bay (*Persea borbonia*), slash pine (*Pinus elliottii*), and loblolly pine (*Pinus taeda*). Interstory vegetation is a mixture of shrubs, vines, and juvenile trees (saw palmetto [*Serenoa repens*], tough buckthorn [*Sideroxylon tenax*], Hercules' club [*Zanthoxylum clava-herculis*], bayberry [*Myrica cerifera*], yaupon [*Ilex vomitoria*], rusty lyonia [*Lyonia ferruginea*], muscadine grape [Vitis rotundifolia], bamboo-brier [*Smilax auriculata*], pepper vine [*Ampelopsis arborea*], and live oak [*Quercus virginiana*]). Ground perennials are not common, but may include: bedstraw (*Galium hispidulum*), nut rush (*Scleria* spp.), panic grass (*Panicum portoricense*), nutgrass / purple flatsedge (*Cyperus rotundus*), sandspur (*Cenchrus tribuloides*), poor-Joe (*Diodia teres*), and broom-sedge (*Andropogon virginicus*).

Maritime Forest Habitats

Oak-juniper palm forest – Forming the boundary between the salt marsh shrub thicket and the upland forests is a zone that Hillestad characterized as the oak-juniper-palm forest. The canopy is composed of live oak (*Quercus virginiana*), southern red cedar (*Juniperus virginiana*), and cabbage palms (*Sabal palmetto*). Other vegetation includes bayberry (*Myrica cerifera*), yaupon (*Ilex vomitoria*), Florida privet (*Forestiera porulosa*), and saw palmetto (*Serenoa repens*).

Oak-palmetto – Mixed oak-palmetto forest communities are common throughout the Leon sand soil areas of Cumberland, including the northern area surrounding the old airstrip. Cultivation and fire have had relatively little effect on the largest parcels of this forest type. The dominant species are saw palmetto (*Serenoa repens*) and live oak (*Quercus virginiana*), but red bay (*Persea borbonia*), rusty lyonia (*Lyonia ferruginea*), saw brier (*Smilax glauca*), bamboo brier (*Smilax auriculata*), bayberry (*Myrica cerifera*), fetter bush (*Lyonia lucida*), and sparkleberry (*Vaccinium arboreum*) are also present. Vines include muscadine grape (*Vitis rotundifolia*); herbs are scattered but may include panic grass (*Panicum portoricense*), spike grass (*Uniola sessiliflora*), nut rush (*Scleria* spp.), and resurrection fern (*Polypodium polypodioides*).

Pine-oak scrub – Mixed pine-oak scrub communities are found on the north end of Cumberland where timber harvesting and fire may have played a significant role in the last 200 years. The dominant species are live oak (*Quercus virginiana*), pond pine (*Pinus serotina*), and slash pine (*Pinus elliottii*), but rusty lyonia (*Lyonia ferruginea*) and red bay (*Persea borbonia*) are also present. Shrubs are huckleberry (*Gaylussacia frondosa* var. *tomentosa*), dwarf blueberry (*Vaccinium myrsinites*), fetterbush (*Lyonia lucida*), gallberry (*Ilex glabra*), tar-flower (*Befaria racemosa*); herbs are milk pea (*Galactia* spp.), bracken fern (*Pteridium aquilinum*), beak rush (*Rhynchospora* spp.), broom sedge *Andropogon virginicus* and other grasses, sedges, forbs in disturbed areas.

Oak scrub – These scrub forests are quite similar to the pine-oak scrub forests in that they occur in moderately drained areas previously used for timber or pasture. Evidence of fire is also noted. The dominant species is again live oak (*Quercus virginiana*), although slash pine (*Pinus elliottii*), myrtle oak (*Quercus myrtifolia*), American olive (*Osmanthus americanus*), and Chapman's oak (*Quercus chapmanii*) are also present. Shrubs are gallberry (*Ilex glabra*), huckleberry (*Gaylussacia frondosa* var. *tomentosa*), dwarf blueberry (*Vaccinium myrsinites*); herbs are milk-pea (*Galactia* spp.) and bracken fern (*Pteridium aquilinum*), plus additional grasses, sedges, and forbs in disturbed areas.

Mixed oak-pine-hardwood – This forest community is found along Terrapin Point, and at several interior regions of the island where Lakeland soils were cultivated some 100 years ago. Hillestad suggests that these are areas representing secondary growth after first generation pines were logged from agricultural land. The dominant species is live oak (*Quercus virginiana*), with laurel oak (*Quercus laurifolia*), loblolly pine (*Pinus taeda*), longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), American holly (*Ilex opaca*), southern magnolia (*Magnolia grandiflora*), red bay (*Persea borbonia*), rusty lyonia (*Lyonia ferruginea*), and southern red cedar (*Juniperus silicicola*) also present. Shrubs are bamboo brier (*Smilax auriculata*), bayberry (*Myrica cerifera*), sparkleberry (*Vaccinium arboreum*), pawpaw (*Asimina* spp.), squaw huckleberry (*Vaccinium stamineum*); vines are muscadine grape (*Vitis rotundifolia*), summer grape (*Vitis aestivalis*), Virginia creeper (*Partenocissus quinquefolia*); herbs are panic grass (*Panicum portoricense*), spike grass (*Uniola sessiliflora*), thoroughwort (*Euphatorium aromaticum*), nutgrass / purple flatsedge (*Cyperus rotundus*), frost weed (*Helianthemum* spp.), broom sedge (*Andropogon virginicus*), nut rush (*Scleria* spp.), centipede grass (*Eremochloa ophiuroides*), and stinging nettle (*Cnidoscolus stimulosus*).

Lowland mixed hardwood – These maritime forest communities are found in topographical depressions with access to fresh water. The dominant trees are live oak (*Quercus virginiana*) and swamp red bay (*Persea palustris*), with several other species again present (loblolly pine [*Pinus taeda*], bayberry [*Myrica cerifera*], loblolly bay [*Gordonia lasianthus*], sweet bay [*Magnolia virginiana*], water oak [*Quercus nigra*], red maple [*Acer rubrum*]). Shrubs are fetterbush (*Lyonia lucida*), bayberry (*Myrica cerifera*), saw palmetto (*Serenoa repens*), and buttonbush (*Cephalanthus occidentalis*); vines are muscadine grape (*Vitis rotundifolia*), pepper vine (*Ampelopsis arborea*), and laurel greenbrier (*Smilax laurifolia*); herbs are lizard's tail (*Saururus cernuus*), beak rush (*Rhynchospora* sp), cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis* var. *spectabilis*), water pimpernel (*Samolus parviflorus*), chain fern (*Woodwardia virginica*), and switch cane (*Arundinaria gigantea*).

Appendix E - Georgia water quality standards

Surface water quality standards for dissolved oxygen, fecal coliform concentration, pH, and temperature are listed in **Table E-1**. These apply to all Georgia waters, although the standard for fecal coliform is different from coastal as compared to fresh water (GA DNR – EPD).

Table E-1. Georgia surface water quality standards

	Bacteria (fecal coliform)		**Dissolved Oxygen[1]**		**pH**	**Temperature[1]**	
Use Classification	*30-day geometric mean (no./ 100 ml)*	*maximum (no./ 100 ml)*	*daily average (mg L^{-1})*	*minimum (mg L^{-1})*	*std. units*	*max. rise (^oF)*	*max. (^oF)*
Drinking Water (requiring treatment)	1,000 (Nov-April) 200 (May-Oct)	4,000 (Nov-April)	5.0	4.0	6.0-8.5	5	90
Recreation	200 (fresh) 100 (coastal)	--	5.0	4.0	6.0-8.5	5	90
Fishing[2]			5.0	4.0	6.0-8.5	5	90
Wild River	No alteration of natural water quality						
Scenic River	No alteration of natural water quality						

[1] In trout streams, different standards apply: dissolved oxygen (average 6.0 mg/l, minimum 5.0 mg/l), temperature (no alteration in primary trout streams, 2^{o}F change allowed in secondary trout streams).

[2] For coastal fishing areas, different dissolved oxygen standards apply (site specific).

Standards for toxic substances in coastal waters are summarized below. This covers chemical constituents that are considered to be other toxic pollutants of concern in the state of Georgia and those listed by the U.S. Environmental Protection Agency as toxic priority pollutants (excerpted from Georgia Rules and Regulation for Water Quality Control, Ch 391-3-6.03 *Water Use Classifications and Water Quality Standards*). **Table E-2** lists criteria not to be exceeded under 7-day, 10-year minimum flow or higher stream flow conditions except within established mixing zones, and **Table E-3** lists criteria not to be exceeded under annual average or higher stream flow conditions.[64] The law also specifies that asbestos criteria will be developed on an as-needed basis through toxic pollutant monitoring efforts at new or existing discharges that are suspected to be a source of the pollutant at levels sufficient to interfere with designated uses, and that applicable state and federal requirements and regulations for the discharge of radioactive substances shall be met at all times.

[64] In addition, there is an upper concentration of 0.0012 ng/l 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) that is not to be exceeded under long-term average stream flow conditions.

Table E-2. Criteria not to be exceeded under 7-day, 10-year minimum flow or higher stream flow conditions except within established mixing zones:

Constituent	Coastal and Marine Standard ($\mu g\ L^{-1}$)	Standard differs from that for Freshwater
Arsenic	36	X
Cadmium	9.3	X
Chlordane*	0.004	X
Chromium VI	50	X
Total Chromium (at hardness >200mg/l)	370	
Copper	2.9	X
Cyanide*	1.0	X
Dieldrin	0.0019	
2,4-Dichlorophenoxyacetic acid (2,4-D)	70	
4,4'-DDT*	0.001	
a-Endosulfan*	0.0087	X
Endrin*	0.002	
Heptachlor*	0.0036	X
Lead*	5.6	X
Lindane (hexachlorocyclohexane [g-BHC-gamma])	0.8	
Mercury*	0.025	X
Methoxychlor*	0.03	
Nickel, C	8.3	X
Pentachlorophenol*	7.9	X
PCB-1016	0.014	
PCB-1221	0.014	
PCB-1232	0.014	
PCB-1242	0.014	
PCB-1248	0.014	
PCB-1254	0.014	
PCB-1260	0.014	
Phenol	300	
Selenium	71	X
Silver	**	
Toxaphene	0.0002	
2,4,5-Trichlorophenoxy propionic acid (TP Silvex)	50	
Zinc	86	X

* Instream criterion is lower than the EPD laboratory detection limits.
** Numeric limit not specified (toxin is covered in more detail in the Rules).

Table E-3. Criteria not to be exceeded under annual average or higher stream flow conditions:

Constituent	Standard ($\mu g\ L^{-1}$)
Acenaphthene	**
Acenaphthylene	**
Acrolein	780
Acrylonitrile	0.665
Aldrin	0.000136
Anthracene	110000
Antimony	4308
Arsenic	0.14
Benzidine	0.000535
Benzo(a)Anthracene	0.0311
Benzo(a)Pyrene	0.0311
3,4-Benzofluoranthene	0.0311
Benzene	71.28
Benzo(ghi)Perylene	**
Benzo(k)Fluoranthene	0.0311
Beryllium	**
a-BHC-Alpha	0.0131
b-BHC-Beta	0.046
Bis(2-Chloroethyl)Ether	1.42
Bis(2-Chloroisopropyl)Ether	170000
Bis(2-Ethylhexyl)Phthalate	5.92
Bromoform (Tribromomethane)	360
Carbon Tetrachloride	4.42
Chlorobenzene	21000
Chlorodibromomethane	34
2-Chloroethylvinyl Ether	**
Chlordane	0.000588
Chloroform (Trichloromethane)	470.8
2-Chlorophenol	**
Chrysene	0.0311
Dibenzo(a,h)Anthracene	0.0311
Dichlorobromomethane	22
1,2-Dichloroethane	98.6
1,1-Dichloroethylene	3.2
1,3-Dichloropropylene (Cis)	1700
1,3-Dichloropropylene (Trans)	1700
2,4-Dichlorophenol	790
1,2-Dichlorobenzene	17000
1,3-Dichlorobenzene	2600
1,4-Dichlorobenzene	2600
3,3'-Dichlorobenzidine	0.077

Constituent	Standard ($\mu g\ L^{-1}$)
4,4'-DDT	0.00059
4,4'-DDD	0.00084
4,4'-DDE	0.00059
Dieldrin	0.000144
Diethyl Phthalate	120000
Dimethyl Phthalate	2900000
2,4-Dimethylphenol	**
2,4-Dinitrophenol	14264
Di-n-Butyl Phthalate	12100
2,4-Dinitrotoluene	9.1
1,2-Diphenylhydrazine	0.54
Endrin Aldehyde	0.81
Endosulfan Sulfate	2.0
Ethylbenzene	28718
Fluoranthene	370
Fluorene	14000
Heptachlor	0.000214
Heptachlor Epoxide	0.00011
Hexachlorobenzene	0.00077
Hexachlorobutadiene	49.7
Hexachlorocyclopentadiene	17000
Hexachloroethane	8.85
Indeno(1,2,3-cd)Pyrene	0.0311
Isophorone	600
Lindane [Hexachlorocyclohexane g-BHC-Gamma)]	0.0625
Methyl Bromide (Bromomethane)	4000
Methyl Chloride (Chloromethane)	**
Methylene Chloride	†
2-Methyl-4,6-Dinitrophenol	765
3-Methyl-4-Chlorophenol	**
Nitrobenzene	1900
N-Nitrosodimethylamine	8.12
N-Nitrosodi-n-Propylamine	**
N-Nitrosodiphenylamine	16.2
PCB-1016	0.00045
PCB-1221	0.00045
PCB-1232	0.00045
PCB-1242	0.00045
PCB-1248	0.00045
PCB-1254	0.00045
PCB-1260	0.00045
Phenanthrene	**
Phenol	4,600,000

Constituent	Standard ($\mu g\ L^{-1}$)
Pyrene	11,000
1,1,2,2-Tetrachloroethane	10.8
Tetrachloroethylene	8.85
Thallium	48 (6.3) ‡
Toluene	200000
1,2-Trans-Dichloroethylene	**
1,1,2-Trichloroethane	41.99
Trichloroethylene	80.7
2,4,6-Trichlorophenol	6.5
1,2,4-Trichlorobenzene	**
Vinyl Chloride	525

** Numeric limit not specified (toxin is covered in more detail in the Rules).

† EPD has proposed to the Board of Natural Resources changing numeric limits for methylene chloride from unspecified to 1600 $\mu g\ L^{-1}$ consistent with EPA's National Toxics Rule.

‡ EPD has proposed to the Board of Natural Resources changing numeric limits for thallium from 48 to 6.3 $\mu g\ L^{-1}$ consistent with EPA's National Toxics Rule.

Appendix F - Data identified for coastwide water quality database

At the outset of this project we assessed existing, potential and available water quality data in the watersheds surrounding CUIS. This Appendix provides information about:

1. Datasets that have been identified in the watersheds surrounding Cumberland Island that are potentially relevant to the coastwide assessment (**Figure F-1**).
2. Datasets currently residing with other agencies that were identified as being relevant to the assessment (**Figure F-2**). We contacted these agencies and they agreed to make these datasets available to us.
3. Water quality data located in the watersheds surrounding Cumberland Island that are being compiled (from researcher contributed data, online datasets, or recovered from published reports) into a single GIS database (**Figure F-3**).

The current report is based on many of these datasets. At the time of this writing Dr. Payne is in the process of integrating all of this information into a single GIS of historic and contemporary water quality data as part of a coastwide effort that will be available to the NPS upon its completion. A detailed listing of the data sources is given below.

Figure F-1. Datasets that have been identified in the watersheds surrounding Cumberland Island

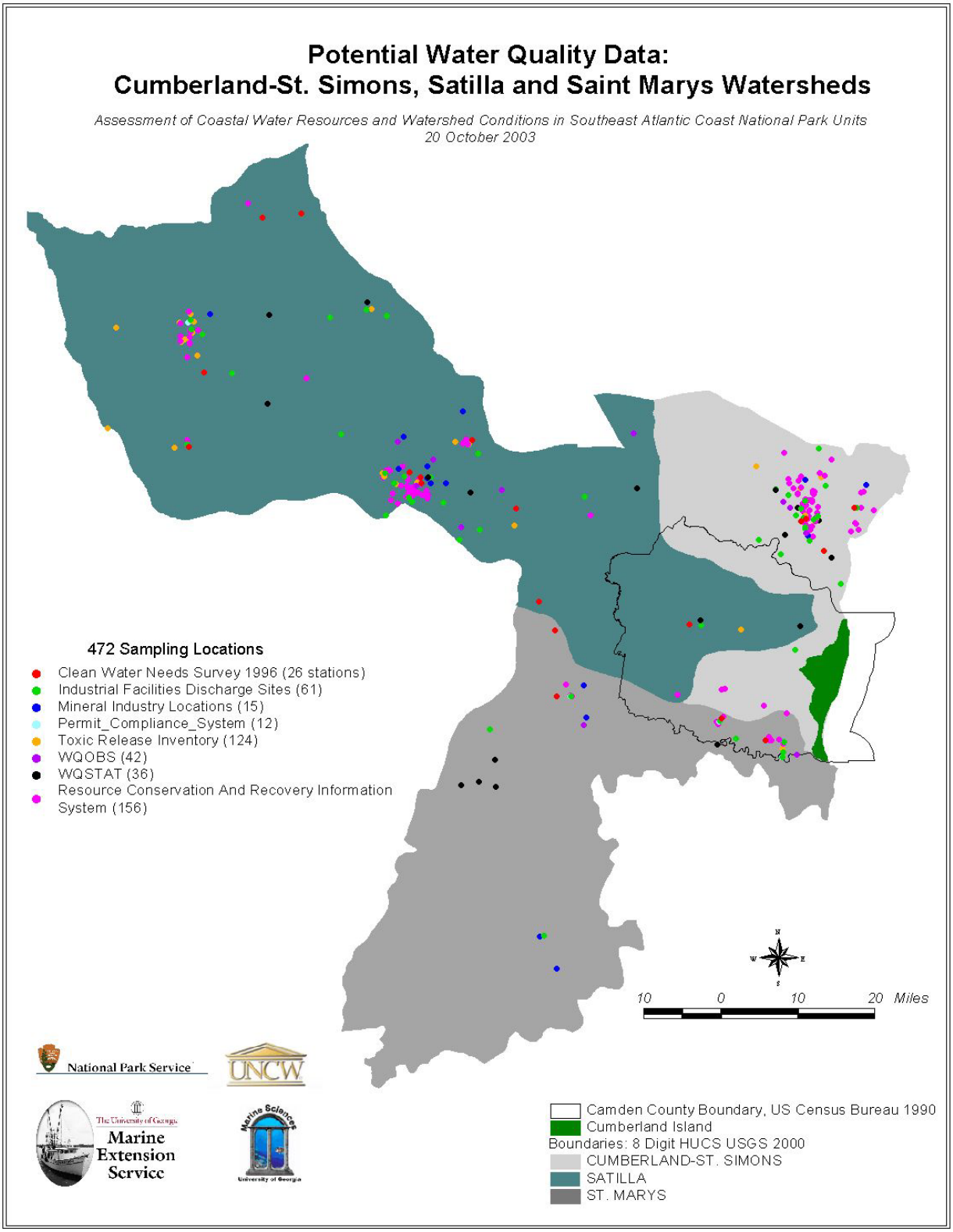


Figure F-2. Water quality data located in the watersheds surrounding Cumberland Island that have been requested from the collecting agency

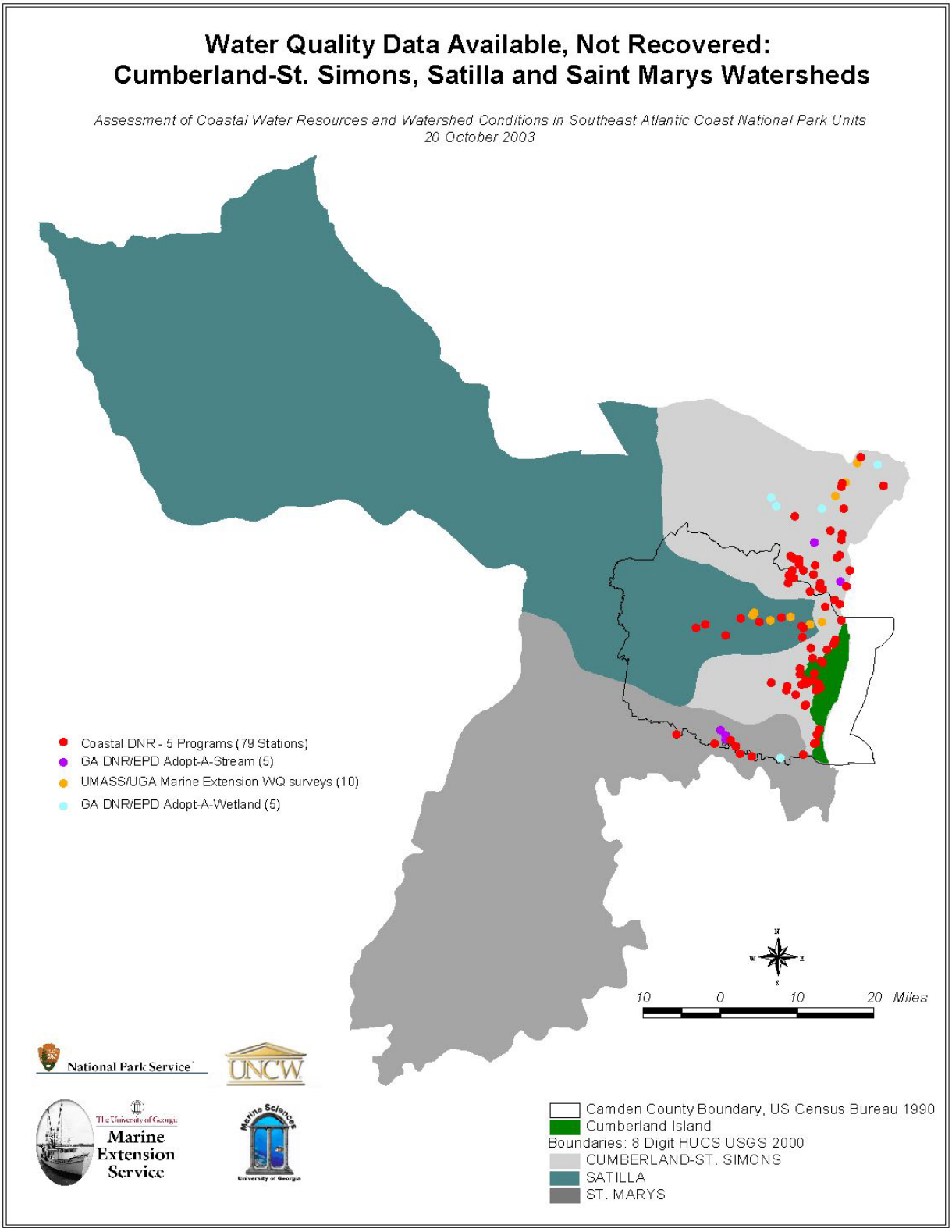
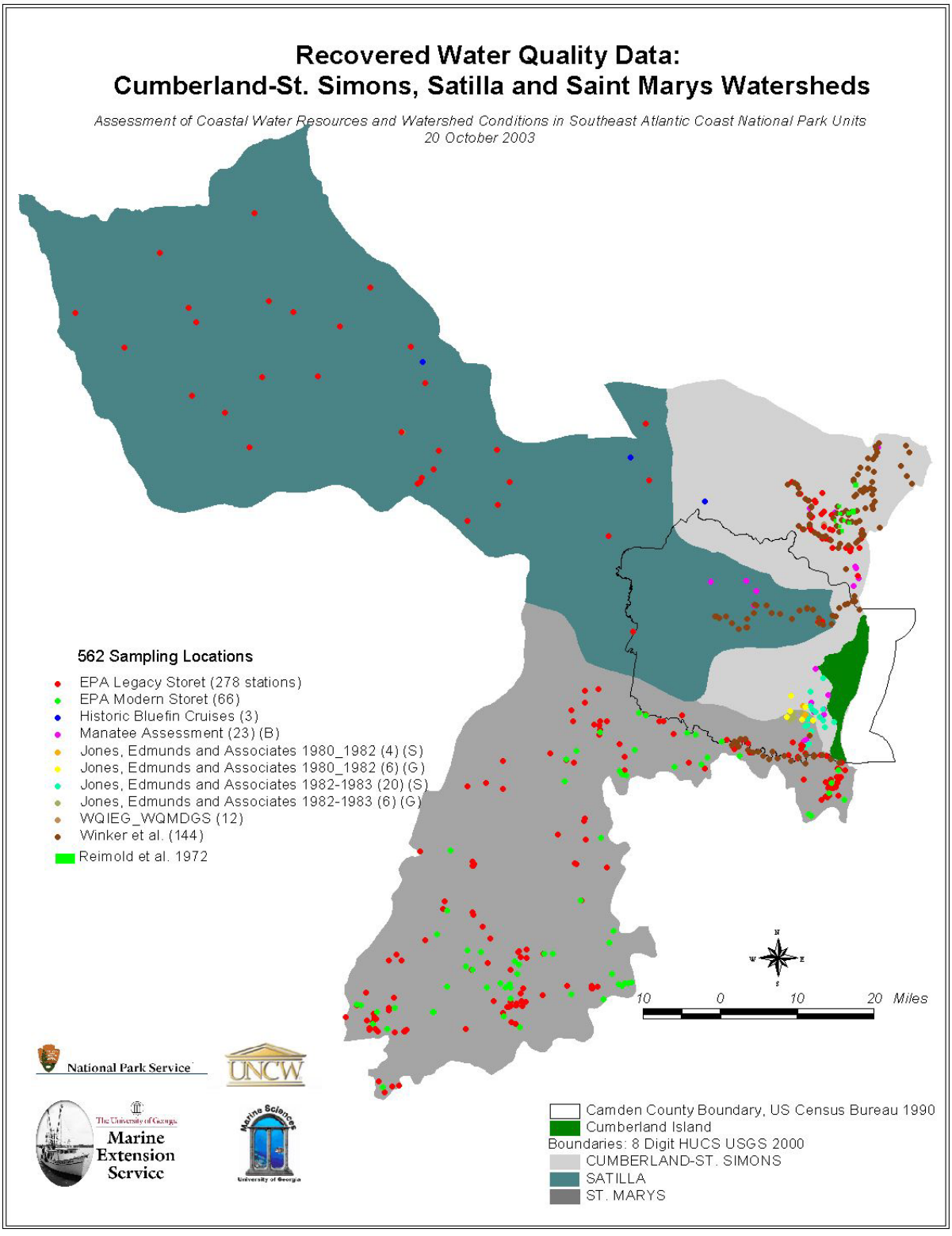


Figure F-3. Water quality data located in the watersheds surrounding Cumberland Island that are being compiled (from online datasets, contributions from researchers or recovered from published reports) into a GIS database



1. Potential Water Quality Data:

Clean Water Needs Survey 1996 –
Scale: 1:100,000
Originator: U.S. Environmental Protection Agency
Published: 1998
Abstract: The 1996 CWNS presents the results of the EPA's detailed estimates of capital costs eligible for funding under the State Revolving Fund provisions of the Clean Water Act. The CWNS covers publicly owned, municipal wastewater collection and treatment facilities, facilities for the control of combined sewer overflows, activities designed to control storm water runoff and nonpoint source pollution. The heart of the CWNS is the cost and technical information on approximately 16,000 publicly owned wastewater treatment facilities.

Industrial Facilities Discharge Sites –
Scale: 1:100,000
Originator: U.S. Environmental Protection Agency
Published: 1998
Abstract: This data set provides a locational point file of selected Industrial Facilities Discharge Sites. These sites are industrial or municipal point sources discharging to surface waters. The facilities are extracted from the U.S. EPA's Industrial Facilities Discharge (IFD) database that is contributed to by a number of organizations including federal, state, and interstate agencies. The IFD File is an automated database of industrial point source dischargers to surface waters in the United States. The IFD was created specifically to provide the Office of Wetlands, Oceans and Watersheds with a comprehensive database of industrial point source dischargers.

Mineral Industry Locations –
Scale: 1:100,000
Originator: U.S. Geological Survey
Published: 1998
Abstract: This dataset lists known mining operations, mineral deposits/occurrences and processing plants, and identifies more than 221,000 mineral locations and processing plants. This dataset was derived from the Mineral Availability System (MAS)/Mineral Industry Location System CD-Rom. The MAS is an activity of the Bureau of Mines that systematically measures and classifies identified domestic and foreign mineral resources according to their respective extraction technologies, economics, and availability. The MAS program provides a procedure for continuous monitoring of the present and potential availability of minerals to the United States within the context of many parameters that can impinge upon this availability. Examples of such technical parameters are methods and costs of: mining, beneficiation, smelting, refining, transportation, infrastructure, labor, and capital investment.

Permit Compliance System -
Scale: 1:100,000
Originator: U.S. Environmental Protection Agency

Published: 1998
Abstract: PCS is a national computerized management information system that automates entry, updating, and retrieval of National Pollutant Discharge Elimination System (NPDES) data and tracks permit issuance, permit limits and monitoring data, and other data pertaining to facilities regulated under NPDES. PCS records water-discharge permit data on more than 75,000 facilities nationwide. The NPDES permit program regulates direct discharges from municipal and industrial wastewater treatment facilities that discharge into the navigable waters of the United States. Wastewater treatment facilities (also called "point sources") are issued NPDES permits regulating their discharge. The PCS database was developed for tracking permit, compliance and enforcement status, to meet the informational needs of the NPDES program under the Clean Water Act. It is a dynamic system that supports the NPDES program at the state, regional and national levels.

Toxic Release Inventory -
Scale: 1:100,000
Originator: U.S. Environmental Protection Agency:
Published: 1998
Abstract: This database contains data on annual estimated releases of over 300 toxic chemicals to air, water, and land by the manufacturing industry. Industrial facilities provide the information, which includes: the location of the facility where chemicals are manufactured, processed, or otherwise used; amounts of chemicals stored on-site; estimated quantities of chemicals released; on-site source reduction and recycling practices; and estimated amounts of chemicals transferred to treatment, recycling, or waste facilities.

WQOBS -
Scale: 1:100,000
Originator: U.S. Environmental Protection Agency
Published: 1998
Abstract: This data set provides a limited set of raw water quality observation data for the conterminous United States. The data are extracted from the U.S. EPA Storage and Retrieval of U.S. Waters Parametric Data (StoRet) that is contributed by a number of organizations including federal, state, interstate agencies, universities, contractors, individuals and water laboratories. Data updates are performed weekly. (*WQOBS and WQSTAT are from StoRet – see the following section*)

WQSTAT -
Scale: 1:100,000
Originator: U.S. Environmental Protection Agency
Published: 1998
Abstract: This data set provides statistical summaries of water quality monitoring for 47 physical and chemical-related parameters. The parameter specific statistics were computed by station for 5-year intervals from 1970 to 1994 and a three-year interval from 1995 to 1997. The data are extracted from the U.S. EPA Storage and Retrieval of

U.S. Waters Parametric Data (StoRet). (*WQOBS and WQSTAT are from StoRet – see the following section)*

Resource Conservation and Recovery Information System -
Scale: 1:100,000
Originator: U.S. Environmental Protection Agency
Published: 1998
Abstract: RCRIS is a national computerized management information system in support of the Resource Conservation and Recovery Act (RCRA). RCRA requires that generators, transporters, treaters, storers, and disposers of hazardous waste provide information concerning their activities to state environmental agencies. The system is used primarily used to track handler permit or closure status, compliant with federal and state regulations, and cleanup activities.

2. Water Quality Data Available and Requested from Agencies

DNR (Coastal Resources Division):
National Coastal Assessment Program
Beach Water Quality
Nutrient Monitoring In Georgia's Coastal Rivers, Sounds, and Estuaries
Shellfish Water Quality

UMASS/UGA MAREX - The University of Georgia Marine Extension Service (MAREX) recently completed a one year water quality study of the Satilla River in Cooperation with the Skidaway Institute of Oceanography and Dr. Changsheng Chen of the University of Massachusetts – Dartmouth. This project was funded by the Georgia Department of Natural Resources and the Georgia Sea Grant College Program.

Adopt-A-Stream Program

Adopt-A-Wetland Program

3. Water Quality Data in Process

EPA Legacy StoRet - http://www.epa.gov/storpubl/legacy/gateway.htm

EPA Modernized StoRet - http://www.epa.gov/storpubl/legacy/gateway.htm

Historic Bluefin Cruises - R/V Blue Fin continental shelf cruises 1988-1993 http://coastgis.marsci.uga.edu/ctd/home.html

Manatee Assessment - Valade, James A., 1990, Coastal Georgia Manatee Assessment Final Report.

Jones, Edmunds and Associates – surface and ground water data from three reports:

Jones Edmunds and Associates, Inc., 1981, Environmental Monitoring Naval Base King's Bay 1980-1981

Jones Edmunds and Associates Inc., 1982, Environmental Monitoring Naval Base King's Bay 1981-1982

Jones Edmunds and Associates, Inc., 1984, Environmental Monitoring Naval Base King's Bay 1982-1983

WQIEG_WQMDGS – is a series of technical reports:

Brunswick Junior College, 1975, Water Quality Investigation of Estuaries of GA

Brunswick Junior College, 1976, Water Quality Investigation of Estuaries of GA

Brunswick Junior College, 1977, Water Quality Investigation of Estuaries of GA, 1976

Brunswick Junior College, 1978, Water Quality Investigation of Estuaries of GA, 1977

Brunswick Junior College, 1979, Water Quality Investigation of Estuaries of GA, 1978

Brunswick Junior College, 1980, Water Quality Investigation of Estuaries of GA, 1979

Brunswick Junior College, 1982, Water Quality Investigation of Estuaries of GA, 1980 and 1981

Brunswick Junior College, 1983, Water Quality Investigation of Estuaries of GA, 1982

Georgia Department of Natural Resources, EPD, Water Quality Monitoring Data for Georgia Streams, 1974

Georgia Department of Natural Resources, EPD, 1976, Water Quality Monitoring Data for Georgia Streams 1975

Georgia Department of Natural Resources, EPD, 1978, Water Quality Monitoring Data for Georgia Streams 1977

Georgia Department of Natural Resources, EPD, 1984, Water Quality Monitoring Data for Georgia Streams 1983

Winker et al. - Winker, C.D., Jaffe, L.C., Howard, J.D.,1985, Georgia Estuarine Data 1961-1977, Technical report number 85-7.

Reimold et al. 1972 - Reimold, Robert J. & Durant, Charles J., 1972, Survey of Toxaphene Levels in Georgia Estuaries, Technical report number 72-2.

Appendix G - U.S. Geological Survey water resources groundwater site inventory, Cumberland Island

Table G-1. USGS groundwater site inventory

Station Code	Location	Well ID	WQ	Data Range		GW level	Data Range	
304310081272601	Charlton Formation	34D010	2	1989	1989	6	1990	1992
304310081272600	Holocene Series	34D011	2	1989	2000	6	1990	1992
304310081272603	Charlton Formation	34D012	3	1989	2000	6	1990	1992
304311081281301	Charlton Formation	34D007	1	1989	1989	6	1990	1992
304311081281302	Holocene Series	34D008	3	1989	2000	20	1990	2000
304311081281303	Charlton Formation	34D009	2	1989	2000	6	1990	1992
304448081280401	?	34D003	NA			NA		
304450081280001	Charlton Formation	34D013	2	1989	1989	6	1990	1992
304450081280002	Holocene Series	34D014	2	1989	2000	1	1990	1990
304450081280003	Duplin Marl	34D015	1	1989	1989	1	1990	1990
304450081280004	Charlton Formation	34D016	2	1989	2000	1	1990	1990
304451081280101	Miocene Series	34D006	1	1989	1989	1	1990	1990
304522081281301	Upper Floridan Aquifer System	34E001	12	1990	2000	28	1984	2003
304610081280901	Upper Floridan Aquifer System	34E010	5	1984	1999	27	1984	2003
304619081280500	Upper Floridan Aquifer System	34E015	2	1989	1990	13	1989	1998
304646081280901	Upper Floridan Aquifer System	34E003	4	1984	1999	26	1984	2003
304814081304201	Surficial Aquifer	33E131	2	1999	1999			
304851081274001	Upper Floridan Aquifer System	34E014	3	1989	1993	24	1984	2003
304940081261101	Surficial Aquifer	34E017	1	2000	2000			
304953081261001	Surficial Aquifer	34E016	1	2000	2000			
305029081265101	Upper Floridan Aquifer System	34E013	2	1989	1990	29	1984	2003
305032081280101	Upper Floridan Aquifer System	34E012	4	1989	1999	29	1984	2003
305122081275602	Upper Floridan Aquifer System	34E011	2	1989	1990	16	1980	2003
305122081275601	Upper Floridan Aquifer System	34E002	5	1984	1999	26	1984	2003
305242081263401	Upper Floridan Aquifer System	34F014	1	1990	1990	11	1984	2003
305314081250301	Surficial Aquifer	34F018	1	2000	2000			
305320081244601	Surficial Aquifer	34F017	1	2000	2000			
305438081244101	?	34F013	NA			NA		

Station Code	Location	Well ID	WQ	Data Range		GW level	Data Range	
305452081252301	Upper Floridan Aquifer System	34F015	2	1990	1999	18	1999	2003
305452081251901	Upper Floridan Aquifer System	34F016	1	1990	1990	11	1990	2000
305610081302901	Upper Floridan Aquifer System	33F004				2	1966	1985
305314081244501	Upper Floridan Aquifer System	34F002				5	1967	1995
305619081244601	Upper Floridan Aquifer System	34F003				6	1967	1995
305630081244401	Upper Floridan Aquifer System	34F004*				8	1966	2003
305658081251601	Upper Floridan Aquifer System	34F010				5	1967	1995
305709081244101	Upper Floridan Aquifer System	34F005				6	1967	1995
305717081244701	Upper Floridan Aquifer System	34F006				4	1967	1995
305737081243601	Upper Floridan Aquifer System	34F007				5	1967	1995
305742081252501	Upper Floridan Aquifer System	34F008				5	1967	1995
305803081243601	Upper Floridan Aquifer System	34F009				4	1967	1995
305813081250501	Floridan Aquifer System	34F011				4	1968	1995
305824081243501	Upper Floridan Aquifer System	34F012				4	1968	1995
		42	70	1984	2000	376	1966	2003
		40 w/data						

Shading identifies wells still being measured semi-annually by the U.S. Geological Survey (Stayton 2004).

*This well may be measured less frequently due to access issues -- it is on Little Cumberland Island.

Appendix H – Point-source pollutant discharges in the Cumberland Island area

Facilities of particular concern in Camden County include:

GA0003468 Aventis, formerly Bayer CropScience. Industrial discharge from this site is permitted to Floyd Creek. The Georgia DNR – EPD Toxics Release Inventory Report cites one or more release(s) of "fugitive air" or "stack air" from this location (Georgia EPD 2004a).

GA0001953 Durango-Georgia Paper, formerly Gilman Paper. The permit for this facility expired in May 2003 and the plant has been in shutdown since October 2002 (Harris and Georgia EPD 2004b). The permitted industrial discharge to the North River was >30 mgd. This site was monitored and modeled by Georgia EPD in the mid-1980's in consideration of a successful effort to reclassify the North River from *industrial* to *fishing* uses (Georgia EPD 1986). The toxic releases cited in the inventory include: "stack air" and "fugitive air" (dioxin-like compounds [including chlorine dioxide], lead/lead compounds, mercury /mercury compounds, and polycyclic aromatic compounds) (Georgia EPD 2004a). The spill incidents reported to EPD included chlorine gas as well as petrochemicals (oil, gasoline, and diesel).

GA0037800 Kingsland Water Pollution Control Plant. The facility is a major wastewater discharge permittee, with monthly average flows allowed up to 2.2 mgd. The EPA listing for violation and Georgia EPD issuance of an enforcement order under the Water Quality Control Act along with the large flow permitted makes this a significant *potential* point source.

GA0026255 St. Marys Water Pollution Control Plant. The incidents reported to the DNR Emergency Response Team involved sewage. In addition to the report at the water pollution control plant, the St. Marys Public Works at Point Peter also had one confirmed and one suspected report of a leaking underground storage tank. A land application system permit (GA02-068) for flow of 0.8 mgd was issued to St. Marys as well.

GA0027707 U.S. Naval Submarine Base, Kings Bay. Georgia DNR - EPD issued the industrial discharge permit to the Naval Base for discharges to Kings Bay. A land application system permit was also issued: this carries a permitted flow of 1.5 mgd (GA03-751). The Georgia DNR – EPD Toxics Release Inventory Report cites one or more release(s) of "fugitive air" or "stack air" from this location (Georgia EPD 2004a). In Georgia DNR- EPD's Hazardous Site Inventory, this location (#10093) was listed for the presence of ethylbenzene, toluene, xylenes, p-dichlorobenzene, chloroethane, methyl chloride, trichloroethene, tetrachloro-ethene, chloroform, chlorobenzene, and acetone (Georgia EPD 2003a). Approximately 80% of the spill incidents associated with the Naval Base involved fuel oil, gasoline/diesel, or hydraulic fluid. Fortunately, no inordinately high dosimetry readings in the Kings Bay area have been noted, although several of the environmental radiation monitoring stations on or near Cumberland Island have been abandoned due to access or security issues (Georgia EPD 2004a).

Facilities of particular concern in Glynn County include:

GA0025313 Academy Creek WPCP. This facility has a fairly large permitted discharge (13.5 mgd) and has recently been cited for EPA violations (ECHO).

GA0003654 Georgia Pacific Brunswick. Permitted discharge is to the Turtle River. This facility had the most toxic releases in the county for 2002 and was listed for release of: dioxin and dioxin-like compounds, lead, and polycyclic aromatics. The plant is listed as a hazardous site (#10619) for chromium in groundwater above the limit. The T-street landfill received material from Georgia Pacific and is listed for the presence of lead (site #10317).

GA0047937 Georgia Ports Authority. The Ports Authority manages the former Interstate Paint Company site, which has a hazardous site (#10558) listed for lead contamination.

GA0003794 Georgia Power, McManus. Toxic releases of stack air were noted by the EPD.

GA0003735 Hercules, Brunswick. This plant was in the state list for top ten fugitive air releases: more than 400,000 lbs of methyl isobutyl ketone were released. Dioxins were also listed on the toxic releases report. Hazardous site #10058 had / has soil and groundwater contamination with chromium in excess of reportable quantities as well as the presence of other metals and compounds (including solvents). The Hercules Landfill on Benedict Road (#10006) was cited for toxaphene contamination of groundwater.

GA0050016 Millenium Specialty Chemicals, organic chemical manufacturing. Unspecified toxics were released from this plant and an enforcement order was placed against it under the Hazardous Waste Management Act.

GA0020508 St. Simons Water Pollution Control Plant. This facility has a large flow (3 mgd), is listed in the ECHO database for NPDES permit violations, and was served with three enforcement orders; two under the Air Quality Control Act, and one under the Water Quality Control Act.

Facilities of particular concern in Nassau County include:

FL0001104 Jefferson Smurfit (formerly Container Corporation of America) pulp and paper mill, Amelia River basin. This plant has a very large discharge (37.5 mgd) and is listed in the ECHO database as having had a EPA violation (U.S. Environmental Protection Agency 2004b)

FL0000701 Rayonier Inc, chemical cellulose pulp mill, Amelia River basin. (Florida DEP 1991; Florida DEP 2003b). This site has been listed for release of toxins and has a very large discharge, 26.31 mgd.

*Petroferm, Fernandina Beach, Amelia Island, Industrial. This plant has nine stacks and is listed by the EPA for air releases (Envirofacts website).

*Topper Hermanson Boat Building, Fernandina Beach.

*Williams Used Auto Parts, Fernandina Beach.

* These are *non-NPDES* sites. They are listed in the ECHO database as having had a violation in the last two years, but are not listed for a "current significant violation" (U.S. Environmental Protection Agency 2004b).

Appendix I - Cumberland Harbour subdivision, Camden County, Georgia

Additional details regarding the Cumberland Harbour Subdivision are provided below. This includes information about their permit application, as well as the text of a newspaper article that describes the potential effects of this development on blue crabs in Georgia.

Permit information - The following information was obtained from the website of the Coastal Resources Division of the Georgia Dept. of Natural Resources (http://crd.dnr.state.ga.us). It provides details regarding the permit applications for proposed docks and marinas at the Cumberland Harbour subdivision in Camden County, GA. (Information posted prior to 4/16/2004 public comment deadline, http://crd.dnr.state.ga.us/content/displaycontent.asp?txtDocument=526&txtPage=1) Updated information on this permit application may be obtained by contacting Karl Burgess (GA DNR – CRD).

Developer: Point Peter, LLLP d/b/a Land Resources Company, LLC

Request: 2 Full-Service Marinas & 3 Community Docks, St. Marys River, North River, Point Peter Creek

This serves as notification from the Georgia Department of Natural Resources' Coastal Resources Division of a request from Point Peter, LLLP d/b/a Land Resources Company, LLC for a Coastal Marshlands Protection Act Permit under O.C.G.A. 12-5-280 et. seq. to construct and maintain 2 full-service marina facilities on the St. Mary's River and North River and 3 community docks located on Point Peter Creek in the subdivision known as Cumberland Harbour, Camden County, Georgia. Current plans for the subdivision also depict 90+ private single-family recreational docks that may be constructed along Point Peter Creek. Private single-family recreational docks are generally exempted from the permitting and public notice requirements of the Coastal Marshlands Protection Act.

The applicant is developing a 1,014-acre residential community known as Cumberland Harbour in Camden County on a peninsular property largely surrounded by public marshlands. The community is adjacent to U.S. Navys King's Bay Nuclear Submarine Base to the north and lies immediately across Cumberland Sound from the Cumberland Island National Seashore. Installation of the commercial marinas is considered by the applicant to be an integral part of the development, as the community is intended largely for boat owners and marine recreation. The applicant is also applying for a lease of public waterbottoms and marshlands occupied by the structures.

The two proposed commercial floating dock marinas include South Point Marina Village to be located on the St. Mary's River and the Cumberland Harbour Yacht Club to be located on the North River. These are both large full-service marinas intended for docking of larger vessels (30+ feet), providing approximately 296 wet slips for long-term storage, plus additional space for transient vessels. Dry rack boat storage for 400 boats and launching capabilities by travel hoist will be offered for boats up to 32' in length on the upland of the Cumberland Harbour Yacht Club. Commercial sales locations will also be available on the upland of the marinas, possibly in

the form of gift shops or restaurants. The three proposed community docks will be used by Cumberland Harbour residents for single day recreation and are designed to allow fishing from the fixed piers. The uplands of the community docks will be developed as parks, containing event lawns, picnic pavilions, open green space, and/or playgrounds. These sites will also be community gathering areas in the form of marsh or water overlooks.

At all locations, the proposed docks will be polystyrene-encased concrete floating docks with steel through-rods, anchored by concrete anchor piles, manufacturer and installation contractor not yet determined. Timber walers and aluminum gangways (4' or 6' wide, as specified) will be used. Where specified, canoe/kayak launching floats will be made up of many individual high density polyethylene units, approximately 20" x 20", fastened together to form a single dock (arrangement to be determined on construction). Pedestrian piers shall be fixed concrete piers with concrete piling and timber decking and handrails.

Cumberland Harbour Landing Community Dock & Fishing Pier: Site layout proposes a 255'-long by 6'-wide concrete fixed pier with timber decking extending from the upland to a 20' x 10' fixed deck for fishing on Point Peter Creek. A 4-wide aluminum gangway is to extend from the fixed pier to a 76' x 6' row of concrete floating docks. Along the landward side of the floating docks will be attached 40 linear feet of low freeboard polyethylene encased floats which will allow quick and easy docking of small watercraft.

Club Village Park Community Dock & Fishing Pier: Site layout proposes a 286'-long by 6'-wide concrete fixed pier with timber decking extending from the upland to a 20 x 15 covered fixed deck for fishing on Point Peter Creek. A 4'-wide aluminum gangway is to extend from the fixed pier to a 60' x 6' row of concrete floating docks. Along the landward side of the floating docks will be attached 45 linear feet of low freeboard polyethylene encased floats which will allow quick and easy docking of small watercraft.

3rd Proposed Community Dock: Site layout proposes a 800'-long by 6'-wide concrete fixed pier with timber decking extending from the upland to a 20' x 10' fixed deck for fishing on Point Peter Creek. A 4'-wide aluminum gangway is to extend from the fixed pier to a 62 x 6 row of concrete floating docks. Along the landward side of the floating docks will be attached 30 linear feet of low freeboard polyethylene encased floats which will allow quick and easy docking of small watercraft.

South Point Village Marina: Site layout is proposed to provide dockspace for permanent and transient boats on the St. Mary's River. A 550'-long by 12'-wide concrete fixed pier with timber decking will extend from the upland to a 32' x 30' fixed deck over the river. A 6'-wide aluminum gangway is to extend from the fixed deck to a marina of concrete floating docks of varying widths. A concrete floating wave attenuator 16'-wide and approximately 2170 linear feet long will protect the marina from wake and provide additional dock space for large vessels. Within the attenuator will be eight trees of floating fingers, sized to accommodate boats of approximately 40' length. The eight dock trees will accommodate 192 to 200 boats, and additional side-tie docking will be used for transient boaters and substantially large long-term boats. The marina will be open to permanent and transient boaters. A boat ramp or hoist will not be located on site, so landing and launching will not be available. A commercial center located on the upland will provide space for the marina administration offices, and for possible shops and/or restaurants. Parking will be provided on the upland based on the requirements and approval of Camden County and the Saint Marys Planning and Building Department. No food

service or preparation will be allowed on the pier or fixed deck. No permanent residences will be allowed on boats docked in the marina.

***Cumberland Harbour Yacht Club*:** Site layout proposes a 611'-long by 21'-wide concrete fixed launch pier and pedestrian walkway extending from the upland to a 50' x 50' (45' x 40' covered) fixed deck and hydraulic boat hoist on the North River. The sheltered deck will serve as a pavilion and gathering area for boat owners and residents in the community. The boat hoist will allow launching and retrieving of boats up to 32' in length for dry storage in enclosed rack buildings on the upland. Current plans propose dry storage for up to 400 boats. Also on the upland will be an administration office for marina management, a location for commercial opportunity or restaurant, and adequate parking for the marina and dry storage. A 6'-wide aluminum gangway is to extend from the fixed pier to a 12'-wide concrete floating main dock extending channelward. Dockspace will be provided by two 8'-wide concrete floating dock fingers extending west from the main dock. Space for approximately 96 boats (side-tie) will be available, varying depending on boat lengths. Floating docks to the east of the main pier will serve as a staging area for the boat hoist. The marina will be open to the public for permanent and transient boaters. Parking will be provided on the upland based on the requirements and approval of Camden County and the St. Marys Planning and Building Department. No food service or preparation will be allowed on the pier or fixed deck. No permanent residences will be allowed on boats docked in the marina.

It is the responsibility of the applicant to demonstrate that the project is not contrary to the public interest and that no feasible alternative sites exist. In passing upon the application for permit, the Coastal Marshlands Protection Committee shall consider the public interest: (1) Whether or not unreasonably harmful obstruction to or alteration of the natural flow of navigational water within the affected area will arise as a result of the proposal; (2) Whether or not unreasonably harmful or increased erosion, shoaling of channels, or stagnant areas of water will be created; and (3) Whether or not the granting of a permit and the completion of the applicant´s proposal will unreasonably interfere with the conservation of fish, shrimp, oysters, crabs, clams, or other marine life, wildlife, or other resources, including but not limited to water and oxygen supply. Applicant is taking steps to address these public interest concerns, and the marina facility on the North River has been reduced to limit navigation impacts. The applicant has stated that all activities will be performed in a manner to minimize turbidity in the stream, that there will be no oils or other pollutants released from the proposed activities which will reach the stream and, that all work performed during construction will be done in a manner to prevent interference with any legitimate water uses. The project is proposed in proximity of habitat for federally threatened loggerhead sea turtles, and federally Endangered West Indian manatees, and adjacent to the calving grounds of endangered Northern Right Whales. A community education program and a Biological Assessment to address threatened and endangered species concerns is being prepared by the applicant. Upland development methods are also being proposed which may reduce impacts of nonpoint source pollution, such as increasing greenspace and limiting impervious cover to 50% of each residential lot adjacent to coastal marshlands.

Article from *Creative Loafing*, **1/15/2004 (Atlanta)**
Emphasis added to highlight text concerning Cumberland Harbour.

COVER | NEWS FEATURE 01.15.04

In a pinch

Where have Georgia's blue crabs gone?

BY MICHAEL WALL

James Holland patrols the waters where the Altamaha River meets the Atlantic Ocean.
(Jim Stawniak)

The U.S. Army Corps of Engineers declared this wetland at Brantley County titanium mine "isolated" and not subject to the Corps' protection. A pipe connects it to a wetland that the Corps will protect.
(Michael Wall)

For 25 years, James Holland made a fine living catching and selling blue crabs along Georgia's coast. During the glory days, he owned three boats and more than 100 traps. He harvested 1,400 pounds of crabs a day, which he sold from a shack he built in his back yard out of two-by-fours and sheet metal.

Crabbing gave Holland something few other jobs offer. He was his own boss, his office was the Georgia coast, and the clock he punched was set by Mother Nature.

"I loved the freedom of it, being able to work on my own. I loved the outdoors, and I loved fishing," Holland says. "But it was hard work. No one will ever tell you crabbing is easy."

Holland smiles when he talks about the years he toiled, pulling up traps from the deep waters where the Altamaha River meets the Atlantic Ocean. The Altamaha's current moves fast, so he had to rig his traps with 11-pound weights to keep them in place. The weights were attached to floats so Holland would know which ones were his.

The few crabbers who are left today use motorized winches to pull up their traps. But Holland always pulled his up by hand, fighting against the current, the weight of the traps and, he hoped, the added weight of the crabs inside.

He'd dump his catch into a box, then restock the trap with fresh-cut pogeys and lower it back into the swirling water. If there were no crabs, he'd just replace the bait, lower the trap again and aim his boat toward the next float.

That's what crabbers do. Or what they used to do. Four years ago, like hundreds of other Georgians who used to catch crabs or process their meat, Holland quit. He simply wasn't catching enough of them to make a living.

"When I had a very small retail store for crab, for me to operate that store without having to work seven days a week, I needed to catch about five, six boxes [of crab] a day," he says. "Well, when you're getting down to where you're catching two boxes a day, working seven days a week -- I couldn't keep it up. Then it was time, I knew right then, for a change."

Holland's decision wasn't made in haste. He'd watched the crab population slowly and steadily dwindle.

"We started seeing declines, visually, back in the early '90s," he says. "Then it kept getting worse and kept getting worse."

In 1994, crabbers banded together to figure out why the catches continued to shrink. State biologists figured the crabs simply were being over-harvested.

So Holland and the other crabbers asked lawmakers for legislation that would limit the number of crabs that could be caught. The bill passed, and the Blue Crab Management Program was enacted. Since then, only 159 people at a time have been allowed to catch crab commercially. But Holland's traps still came up empty.

Then the state forced crabbers to use traps that had holes of a certain size so that juveniles could escape -- and hopefully grow old enough to mate. But the measly harvests persisted.

Meanwhile, Holland began noticing strange things in the water. Hermit crabs, spadefish and angelfish -- primarily saltwater creatures -- were surviving well upstream from the point where the Altamaha traditionally was freshwater.

One day on the nearby Satilla River, he saw a sponge crab -- a female crab bearing eggs -- near the I-95 bridge, more than 10 miles from the open sea. Usually, crab eggs are born in pure ocean water.

"I crabbed that area 20 years, so it was obvious that something was going on," Holland says. Saltwater was seeping inland because the rivers weren't pushing enough freshwater downstream into the coastal marshes. That spelled trouble for blue crabs.

While they spend their adult lives in the ocean and are hatched there, larval blue crabs move attached to their mothers into the mixed water of marshes and estuaries, where they spend their juvenile and sub-adult phases before crawling back out to sea.

Holland could see something was upsetting the natural equilibrium that normally would keep too much saltwater from seeping into freshwater areas. He figured others would be trying to find out what the problem was, too. After all, crabbing wasn't the only thing at stake. Entire coastal ecosystems were shifting. Lots of saltwater animals -- from shrimp to Red Drum fish -- spend phases of their life cycles in the rich estuaries where freshwater and saltwater mix.

The state Department of Natural Resources has something of an official explanation for the crab decline.

"The prolonged drought during the period from 1998 to 2002 created unfavorable conditions for blue crabs in Georgia's coastal waters," according to the department's website devoted to the "Blue Crab Fishery Crisis." "Catches of blue crabs in the commercial trap fishery and in Department monitoring surveys have declined greatly since 2000, and the 2002 blue crab harvest was the lowest on record."

Last May, the National Marine Fisheries Service even declared Georgia's blue crab fishery a "failure" and a "disaster."

Crabbers aren't the only ones losing their livelihoods because of the crab shortage. Fifteen years ago, six plants processed crabmeat around Brunswick. Those plants employed more than 1,000 people during the summer crabbing season.

The last one to hold out, the Lewis Crab Factory in Brunswick, closed in 1997. Nowadays, crabs are trucked to North Carolina for processing.

A drought would account for why freshwater wasn't able to push saltwater out of estuaries, marshes and rivers -- for four years. But the crab decline that drove Holland out of business began long before the drought started. It appears to be continuing now that the drought is over.

Between 1980 and 2000, Georgia's crab harvest declined from 10.1 million to 3.2 million pounds, according to DNR's Coastal Resources Division. Since then, harvests have kept dropping. And, through October, 2003 yields were tracking another 23 percent below the record-low 2002 numbers.

"Sure [the drought] hurt. There's documented evidence out there that if you go into a drought period, 18 months after the drought starts you will have a drop in blue crab," Holland says. "But the state is in denial. People want you to believe that this all of sudden happened because of a drought we had the late 2000, 2001. That's a lie. That's a myth."

You don't have to be the captain of a trawler to see that four years of drought cannot account for two decades of serious crab decline, or that Georgia's crabbing industry is on the brink of extinction.

Holland found a job that still lets him get out on the water. He's the Altamaha river keeper, the leader of an environmental group dedicated to protecting Georgia's largest river system.

Sometimes Holland's work requires him to be more of a detective than an activist, and the case of the disappearing blue crabs has frustrated and puzzled him more than any other. On a late fall day, he and Chris DeScherer, an attorney with the Southern Environmental Law Center, are following leads inland. They drive 40 miles into the middle of a pine plantation that's set to be cut and dredged by a mining company.

You wouldn't think anything so far inland could have an impact on blue crabs. It looks like nothing but flat land covered in pine trees and underbrush with scattered swampy areas.

But Holland and DeScherer believe the health of those wetlands is directly tied to the health of the blue crab.

Wetlands flush freshwater into coastal estuaries while the ocean pushes back with saltwater. "What's important to the crabs and the shrimp is maintaining the right salinity balance," says Ron Carroll, co-director of the River Basin Science and Policy Center in the University of Georgia's Institute of Ecology. "What the wetlands do is essentially buffer the flow of freshwater. They act like a hydrological control valve on the rivers, and that's mainly where I see the connection to the estuarine critters."

Too much saltwater hurts young fish and shellfish in a variety of ways. It's linked, for example, to an outbreak of a disease that's killing off crabs.

The parasite -- a dinoflaggelate called Hematodinium, if you really want to know -- prevents the crab's blood cells from holding oxygen.

"The crab ends up starving to death for oxygen," Holland says. "I've seen mudflats covered with 20 to 25 of them. I've pulled up crab traps and every one of them in there was dead. And the problem with that is, these animals are cannibalistic. Well now, if one crab dies form this Hematodinium parasite, it's passed along to the next one."

The state says the "outbreak reached epidemic levels during the drought," which contributed to the failure of the crab fishery.

Without enough freshwater flowing to the coast, the parasite thrived, according to Dorset Hurley, a

researcher for the Georgia Department of Natural Resources and the National Oceanic and Atmospheric Administration's Sapelo Island research site.

"The crabs are more susceptible to catching [the disease] in higher salinity regimes in their home ranges, which are estuarine waters," Hurley says. In other words, without a regular flow of freshwater, estuaries and marshes aren't as hospitable to crabs as nature intended them to be. Wetlands, Hurley stresses, supply that regular flow by "weeping on a continuum into the salt marsh areas."

Now, just guess what resource is vanishing at about the same pace as crabs. That's right: wetlands.

The Altamaha River's watershed runs from north of Stone Mountain through the heart of the state to the Georgia coast. The river forms when Middle Georgia's Ocmulgee and Oconee rivers join 20 miles south of Vidalia, and it filters through the coast's rich marshlands before emptying into the Atlantic Ocean at Darien. Between 1985 and 2001, 30,400 acres of wetlands in the lower part of the Altamaha basin were converted to pine plantations. And there were similar patterns along other coastal rivers.

But sometimes science takes awhile to catch up with the obvious. Unfortunately for the blue crab, researchers can't conclusively state that a decline in wetlands is to blame for crabbing declines -- not because they don't believe it, but because they don't feel they've studied it enough. There are, everyone admits, other factors, particularly overfishing.

"The problem is people haven't done enough long-term studies to know for sure," says UGA's Carroll. Then he asks, "But have you talked to James Holland? He has a long history with crabbing, and I tend to trust those people."

Unlike the scientists, Holland is certain about the connection and blunt about what he thinks should be done.

"It's clear in my mind that we just can't stand any more loss of wetlands," he says.

With DeScherer, he's followed the clues of the crab debacle inland. They're in the middle of the pine plantation that's about to become a mine.

An Australian company called Iluka Resources Limited plans to dredge at the Brantley County site for titanium and zircon. Zircon is a gemstone and the main component of the metal zirconium. The titanium will be processed in Florida and used in paints, coatings and plastics.

The mine is split down the middle by an unpaved county road, which means DeScherer and Holland can scope out the project as long as they don't leave the road. DeScherer parks his car as far to the side of the road as he can, just past a small swampy area. He gets out carrying a digital camera and takes pictures of the wetlands on both sides of the road.

Holland steps across a drainage ditch and gently takes a black gum stalk into his hand. Black gums are found only in wetlands. Every winter, the tree supplies the black bear with its last meal before the bear goes into hibernation. Holland tries to remember the last time he saw a bear in coastal Georgia, but he can't.

Until recently, many people viewed wetlands as mosquito-ridden swamps best logged, drained and paved over. They were that sorry swatch of land sandwiched between the BP and the Hardee's at the highway exit on the way to the beach.

But wetlands are incredibly valuable. They stifle flood surges, minimize droughts, offer refuge to wild and

rare animals, harbor diverse plant species, filter out pollution, and pump a steady flow of water downstream to cities, farms and coastal marshes. And they are rapidly disappearing: In all, about a quarter of Georgia's wetlands have been drained, paved over, developed or destroyed in some other fashion.

Under the Clean Water Act, the U.S. Army Corps of Engineers is charged with wetlands protection. When the state of Georgia wants to dam a river or build a reservoir, it has to get a permit from the Corps. When a developer wants to fill in a wetland to build a subdivision, when a timber company wants to fill in a wetland to grow pine trees, or when a mining company wants to dredge a wetland for titanium, they all must seek permission from the Corps.

Still, protecting wetlands has been among the most contentious battlegrounds in the effort to clean up the nation's waterways. While scientists have found more and more value in wetlands, industry groups have carved away at the regulations meant to protect them.

Iluka's titanium mine is one tiny front in that contest between public good and private gain. And it's a skirmish that hinges on yet another push by industry to make it easier to develop wetlands.

The Clean Water Act says the Corps doesn't have any authority over wetlands that are "isolated" -- that is, not connected to other wetlands, lakes or streams. Before a 2001 Supreme Court ruling, however, the Corps could exert control over isolated wetlands under a separate federal law if it found those wetlands to be home to migratory birds. But the Supreme Court said the Corps didn't have authority over wetlands just because migratory birds were found there. Now, if a wetland is deemed isolated, the Corps doesn't have jurisdiction.

In some parts of the country, that ruling hasn't had much of an impact because state and local laws help protect wetlands. But in Georgia, there are no state or local laws to protect wetlands. That means isolated wetlands can now be filled in, dredged, mined, or destroyed any kind of way without any kind of acknowledgment [See story, above].

"Before the court case, people at least had to go through the permit process with the Corps of Engineers," says Kathy Chapman, a biologist with the U.S. Fish and Wildlife Service. "But now, with the court case, it's up to the Corps districts to interpret the wetlands on a particular site as to whether they are isolated or connected."

And the Corps doesn't even have standards to separate isolated wetlands from wetlands that fall under the Corps' jurisdiction. That's a crucial shortcoming because it creates a gray area between protected and unprotected wetlands. Corps biologists say they are as frustrated about the lack of clarity as anybody else.

"There is no real guidance on how to implement [the Supreme Court ruling]. In other words, there's no guidance on what really is an isolated wetland," says David Crosby, a biologist with the Corps' Savannah District. "What we're trying to do is see if there is any connection. If you go on a site and there's no ditch and no evidence that water flows out of that [wetland] system and goes somewhere else, then we pretty much are calling those isolated wetlands."

The problem with Crosby's practice is that any hydrologist can tell you coastal wetlands are almost always interconnected. They often form the tip of vast aquifers that lie under the state's coastal region. In many cases, they even flow above ground through culverts to other bodies of water.

"What concerns us the most is some of the calls they [Corps biologists] have been making is calling these areas isolated," DeScherer says. "But in our view, they are clearly adjacent and clearly connected

to navigable waters. That's our primary concern: [The Corps'] view of an isolated wetland is way broader than we think it should be."

For instance, the Corps found a big chunk of isolated wetlands -- 302 acres -- right where Iluka is planning its titanium mine. On one side of a sandy county road that splits the property is a wetland that the Corps says is connected to other wetlands; that land is protected by the agency's permitting rules.

The wetland on the other side of the road is an isolated wetland, according to the Corps. The road is all that splits the two wetlands, and a pipe that runs underneath the road actually does connect them -- but the Corps still claims the wetland on the north side is "isolated."

Elliott Mallard, operations manager for the mining operation, says his company's policy is to restore wetlands. "We proposed all along that we were not going to destroy any wetlands that we impacted, whether they are isolated or not," Mallard says.

The mining operation will work like this: The company will scoop up the topsoil on a 15-acre area, process it, and then put most of it back. Mallard says the company will keep an average of two out of every 100 grains of sand because that's roughly the proportion of the land that's commercially valuable.

"We put the 98 [grains of sand] back and then we can contour the landscape as it was and plant the same species there," Mallard says. Then, they'll move on to the next 15-acre area.

But such restorations are a bit like repairing your car after it has been totaled: The "restored" wetland might clunk along, but it doesn't operate nearly as well. And DeScherer notes that nobody will be looking over the company's shoulder to ensure the planned restoration will take place.

"Once the Corps makes a decision [that wetlands are isolated], it prevents other agencies from weighing in, so the whole project goes on without any sort of oversight," DeScherer says.

That means Fish and Wildlife biologists won't be brought in to make sure Iluka doesn't vacuum up the habitat of an endangered species, and it means state inspectors won't check to make sure Iluka is following water quality laws.

In October, DeScherer sent Iluka an e-mail threatening to sue if the company proceeded with its plans. A month later, Iluka asked the Corps to re-examine the wetlands, and to make sure they're isolated after all.

DeScherer considers that good news. It would take only one ruling or settlement to establish a more concrete, scientific way of determining what falls within the Corps' jurisdiction in coastal Georgia.

"This," he says, "gives us and our clients an opportunity to weigh in to the Corps and EPA [Environmental Protection Agency] with a letter articulating the reasons why we believe all of these wetlands are still protected under the Clean Water Act."DeScherer also is investigating three residential developments where the Corps has declared more than 200 acres of wetlands isolated. Four environmental groups hired DeScherer to exert the same kind of pressure on private developers that he's placed on Iluka.

The groups -- the Altamaha Riverkeeper, Save Our Satilla, the National Wildlife Federation and the Center for a Sustainable Coast -- grew suspicious of the Savannah District for repeatedly finding isolated wetlands where swank developments were planned. The developments -- one near Savannah and another two on the southern end of Georgia's coast -- are each more than 1,000 acres and have their own golf courses. Two have their own yacht clubs and marinas.

The most controversial, Cumberland Harbour, will be a gated, waterfront community of 1,200 homes with at least three marinas and a yacht club. It's under construction on a peninsula directly across the sound from Cumberland Island National Seashore.

Even the Fish and Wildlife Service, in an Aug. 25 letter, questioned a Corps decision to let Cumberland Harbour's developers fill in an indeterminate amount of wetlands.

"A concern was the large ditching/de-watering system, and the lack of visible erosion control measures," Fish and Wildlife biologists wrote. "The amount of water that was flowing through the ditches/trenches and the water pooling associated with this process caused us to question the 'isolated' nature of the wetlands. The Corps maintains that the extensive amount of water accumulation was due to rainfall events."

Fish and Wildlife employees also noted that the peninsula, now a construction site, is home to threatened and endangered animals. "Of the federally protected species within the action area, we are particularly concerned about the potential adverse impacts to the West Indian manatee ... the wood stork, Eastern indigo snake, and bald eagle."

Cumberland Harbour's developer claims the property didn't have any habitats for endangered species until the company started changing the landscape. "We've really tried to protect what we've got out there," says Paul Veivel, a vice president for Land Resources Inc. "But we are in a business where we have to have a return on our investment for our investors, and we've gone to large steps to balance that."

Veivel also says he got a second opinion from state officials to make sure the wetlands were isolated. "We always [get a second opinion]," he says, "because we use the environment as part of our sales tool."

And Cumberland Harbour's plots surely will sell. Like the other two developments -- the Heritage and Sanctuary Cove -- Cumberland Harbour's name evokes the romantic serenity of Georgia's coast. Soon cable subscribers will get to see the development, or at least the very first home built there. Home and Garden Television selected Cumberland Harbour to build its $1.2 million 2004 "Dream Home." The house has its own deep-water dock, screened in, of course, and a four-story tower.

Other million-dollar homes will go up in a month. And the project's marinas will fill up with 50-foot yachts. It's a far cry from Jim Holland's modest house. His back yard is a crabber's graveyard. The wood shack he built for his crab store is now just a mess of two-by-fours and sheet metal.

The 20-foot-by-50-foot cinder block building that housed Holland's soft shell crab tanks still stands. Now, it's a storage shed for his lawnmower and duck decoys. Ten feet away is a shiny industrial freezer. It was used to hold Holland's harvests. After sitting idle for four years, it still works, and Holland is proud he found a buyer for it.

The traps, the ones with the 11-pound attachment to keep them from floating away, were gathered up for some college study or a recycling program -- Holland forgets which.

In all -- three boats, trailers, traps, buildings, insulation for the soft shell business, tanks, pumps -- Holland figures he put close to $150,000 into his crabbing business.

It was a good living while it lasted. He says he made back every dime he sunk into his business, and then some.

Holland's boats don't sit idle now. He uses them to give students, activists and reporters tours of the rivers and the coastal waters, and to investigate complaints he gets about polluters from neighbors who worry about the declining water quality along the coast.

"Let me tell you something," he says. "What happens here on dry land affects what happens 500 miles offshore, believe you me. Because each little ecosystem thrives and lives off the others, beginning in Stone Mountain, Ga. What goes on up there hits every ecosystem along the way, all the way down here because it's all tied together.

"Hell, the Indians had more sense then we all do put together, and they didn't' have a microscope."

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01.15.04

Appendix J - Satilla River Landing, Camden County, Georgia

Permit Information - The following information was obtained from the website of the Coastal Resources Division of the Georgia Dept. of Natural Resources (http://crd.dnr.state.ga.us). It provides details regarding the permit applications for the proposed marina at the Satilla Landing subdivision in Camden County, GA. (Information dated March 29, 2004)
http://crd.dnr.state.ga.us/content/displaycontent.asp?txtDocument=526&txtPage=1
Updated information on this permit application may be obtained by contacting Karl Burgess (GA DNR – CRD).

Developer: Land Resources Companies, LLC

Request: 86 Slip Marina, Satilla River Landing Subdivision, Satilla River, City of Woodbine, Camden County, Georgia

This serves as notification from the Georgia Department of Natural Resources of a request from Land Resources Companies, LLC for a Coastal Marshlands Protection Act Permit under O.C.G.A. 12-5-280 et. seq. to construct and maintain an 86-slip private marina on public marshlands and waterbottoms, in the new community of Satilla River Landing, located approximately 1.5 miles west of I-95 on the Satilla River, Woodbine, GA. The marina will provide approximately 2,650 linear feet of docking space; 80 slips will be sold to residents and 6 will remain available for day-use by residents. The community has approximately 1000 linear feet of shoreline on the Satilla River and the marina structures will impact 0.38 acres of public marshlands and waterbottoms. Applicant expects the dock facilities to augment the value and marketability of the subdivision and has also identified 11 private docks that may be constructed immediately adjacent to the marina.

Land Resource Companies, LLC is planning the marina in conjunction with the development of the Satilla River Landing subdivision, a residential development located on a 159.97 acre tract, less than one mile east of U.S. Highway 17 and approximately 1.5 miles west of Interstate 95 on the Satilla River in the City of Woodbine, Camden County, Georgia. The community has approximately 1000' linear feet of shoreline on the Satilla River and several hundred more feet of natural tidal shoreline on the connecting Dunn Creek. The property is partially bounded on the west by a flood control ditch (Dunn Branch) constructed from upland by the U.S. Army Corps of Engineers to provide drainage for the City of Woodbine. Applicant is willing to preclude private dock construction to the manmade flood control ditch. The applicant is also applying for a lease of public waterbottoms and marshlands for marina. The proposed structure is ADA compliant, including the fixed walkway and platform, until reaching the aluminum ramp and docks. Parking will be provided on the upland portion of the lot where the amenity center is located. None of the proposed structures will support any fueling or pump-out facilities.

The proposed marina amenity site will be located between lots 24 and 25 and will be limited in use to Satilla River Landing residents and their guests. The proposed marina will include the construction of a 30' x 18' gazebo, which will serve as an amenity center on the upland portion of the marina lot. From the gazebo, a 200' x 10' ADA fixed walkway with an elevation of 12 will extend to a 20' x 20' covered fixed deck, adjoined by a 6' x 24' landing with a fish cleaning sink

and table. An aluminum 5' x 30' gangway will lead from the fixed platform to the floating docks. The proposed marina complex will extend approximately 147.6' channelward into the waterway at the mean low water (MLW) where the Satilla River is approximately 500' from MLW to MLW. The proposed floating docks will consist of 4 fingers running north from a 20' x 45' floating dock, connecting to a 10' x 80' floating dock. The most channelward floating dock will measure approximately 12.25' x 600'. Moving away from the channel, the second proposed northern floating dock is 56' x 30'. The third proposed northern floating dock measures 10' x 550'. The fourth and most landward floating dock is 56' x 30'. Additionally, there will be 2 southern floating docks, 50' x 9.25'. The construction materials will consist of wood for the decking on the docks and platform, aluminum for the gangway, and concrete or wood for the piles to support the fixed structures. The distance to the nearest docks on either side of the proposed marina is approximately 4,500' to the northwest and approximately 1,800' to the southeast. The total area of coastal marshlands and waterbottoms that will be covered with structure is approximately 0.38-acres.

Assuming a maximum boat length of 30', the private marina on the Satilla River will allow for approximately 86 slips, which will accommodate slightly more than half of Satilla River Landing lot purchasers. The applicant has informed the Department that 80 of the marina slips will be permanently transferred (sold) to Satilla River residents for a fee; 6 slips will be for day use at no charge to the residents. The applicant, Land Resources, have engaged in similar transactions at their other coastal development, Misty Harbor, Camden County, Georgia.

Applicant also states that 0.006-acres of marsh will be impacted via the placement of a small water discharge location between lots 16 and 17. The Division has not received any drawings of this discharge pipe impact to coastal marshlands.

It is the responsibility of the applicant to demonstrate that the project is not contrary to the public interest and that no feasible alternative sites exist. Impacts to coastal marshlands must be mimimal in size. In passing upon the application for permit, the Coastal Marshlands Protection Committee shall consider the public interest: (1) Whether or not unreasonably harmful obstruction to or alteration of the natural flow of navigational water within the affected area will arise as a result of the proposal; (2) Whether or not unreasonably harmful or increased erosion, shoaling of channels, or stagnant areas of water will be created; and (3) Whether or not the granting of a permit and the completion of the applicant´s proposal will unreasonably interfere with the conservation of fish, shrimp, oysters, crabs, clams, or other marine life, wildlife, or other resources, including but not limited to water and oxygen supply. The applicant is proposing upland development methods which may reduce impacts from nonpoint source runoff to coastal marshlands. Approximately twenty percent of the land is apportioned to roads and infrastructure. This will result in a net $\pm$ 128-acres for residential development. Land Resource Companies, LLC has subdivided the parcel into 155 lots, which is a 60% reduction from permitted land development codes in Woodbine. Jurisdictional freshwater wetlands will remain largely intact. Architectural guidelines for development will limit impervious cover to approximately 50-55% on each residential parcel. The Department does not currently have information from the applicant on wildlife and marine species which may be impacted by the project and associated upland development. Applicant is developing a community awareness program for threatened and endangered species for the Cumberland Harbor Subdivision (St.

Marys) and associated marinas and community docks which may be applicable for the Satilla River Landing Subdivision.

Application modified: (October, 2004) Citing information on the GA DNR – CRD website, "The facility design has been reduced in scope and impact from 86 slips under the original proposal noticed by the Department in March 2004. The marina as now designed will provide approximately 2,260 linear feet of docking space; 59-60 slips will be sold to residents of Satilla River Landing and 4-5 slips will remain available for day-use by residents. The community has approximately 1000 linear feet of shoreline on the Satilla River and the marina structures will impact 0.31 acres of public marshlands and waterbottoms. Applicant expects the dock facilities to augment the value and marketability of the subdivision and has also identified 11 private docks that may be constructed immediately adjacent to the marina."

Appendix K - Middleton Plantation, Camden County, Georgia

Permit Information - The following information was obtained from the website of the Coastal Resources Division of the Georgia Dept. of Natural Resources (http://crd.dnr.state.ga.us). It provides details regarding the permit applications for the proposed Middleton Plantation subdivision in Camden County, GA. (Information posted prior to 7/25/04 public comment deadline, http://crd.dnr.state.ga.us/content/displaycontent.asp?txtDocument=526&txtPage=1). Updated information on this permit application may be obtained by contacting Karl Burgess (GA DNR – CRD).

Developer: Waterfront Group Georgia, LLC (Middleton Plantation Subdivision)-

PUBLIC NOTICE
June 25, 2004
Waterfront Group Georgia, LLC
Middleton Plantation Subdivision
Community Dock
Waverly Creek, Camden County

Project Application
Project Description
Project Drawings
Project Aerial GIS Photo
Lot Layout

This serves as notification from the Georgia Department of Natural Resources of a request from Waterfront Group Georgia, LLC for a Coastal Marshlands Protection Act Permit under O.C.G.A. 12-5-280 et. seq. to construct and maintain a community dock facility located on a + 188-acre residential development known as Middleton Plantation located less than 1.5 miles east of Highway 17 and approximately 4 miles west of Interstate 95 on Waverly Creek in the City of Waverly, Camden County, Georgia. Current plans for the subdivision also depict as many as 27 private single-family recreational docks that may be constructed, 21 along Waverly Creek and 6 along Uncus Branch in addition to the proposed community dock. Private single-family recreational docks are generally exempted from the permitting and public notice requirements of the Coastal Marshlands Protection Act. The applicant proposes less than 500 linear feet of dock space at the community dock, so no lease of public marshlands will be required.

The proposed activities include the construction of a fixed walkway, measuring approximately 6' x 625' at a maximum elevation of 12'. This stationary structure will connect to a fixed platform, measuring approximately 16' x 12', and descend to a 6' x 6' deck landing. A 4' x 24' aluminum ramp will lead from the fixed platform and deck landing to a ramp-landing float, measuring approximately 8' x 10'. From the ramp-landing, residents will be able to access the 8.25' x 80' floating dock. The proposed floating complex will be at an approximate distance of 52' northeast into the creek from the approximate mean low water line (MLW). This distance is less that one-third (58') of the narrowest width of the channel, which measures between 175' and 200', varying by the location within the dock corridor of Tract A from MLW to MLW.

The construction materials will consist of wood for the decking on the walkway, docks and platform, aluminum for the gangway, and concrete or wood for the piles to support the fixed structures. The total area of marsh and water bottom that will be covered is approximately 4,220 square feet (approximately 0.097 of an acre). The proposed project is under a 1/10 of an acre, and therefore, is considered a minor alteration of coastal marshlands.

Access to the proposed community dock will be permitted to property owners and their guests in the development. A boat storage facility will be provided on Tract C with a 15-boat capacity to accommodate residents since overnight docking will be discouraged. None of the proposed structures will support any fueling or pump-out facilities. The walkway will include safety lighting and 2 electrical pedestals with 4 one hundred and twenty volt convenience outlets in each. The structure is ADA compliant, including the fixed walkway and platform, until reaching the aluminum ramp and docks. No motorized vehicles will be allowed on the walkway or dock. It is the responsibility of the applicant to demonstrate that the project is not contrary to the public interest and that no feasible alternative sites exist. Impacts to coastal marshlands must be minimal in size. In passing upon the application for permit, the Coastal Marshlands Protection Committee shall consider the public interest: (1) Whether or not unreasonably harmful obstruction to or alteration of the natural flow of navigational water within the affected area will arise as a result of the proposal; (2) Whether or not unreasonably harmful or increased erosion, shoaling of channels, or stagnant areas of water will be created; and (3) Whether or not the granting of a permit and the completion of the applicants proposal will unreasonably interfere with the conservation of fish, shrimp, oysters, crabs, clams, or other marine life, wildlife, or other resources, including but not limited to water and oxygen supply.

A detailed public notice with drawings has been distributed and further information is available by visiting the Divisions website: http://crd.dnr.state.ga.us/ under Permits and Public Notices or by calling Karl Burgess at (912) 262-3133.

Please provide this office with substantive, site-specific comments as to why the proposed work should or should not proceed. Comments and questions concerning this proposed project should be submitted in writing and postmarked by July 25, 2004 to Karl Burgess, Department of Natural Resources, One Conservation Way, Brunswick, Georgia 31520.

Appendix L - River Place Plantation, Camden County, Georgia

This permit application information is from the Tentative Agenda of the November 8th meeting of the Coastal Marshlands Protection Committee, posted on the GA DNR- CRD website: http://crd.dnr.state.ga.us/content/displaycontent.asp?txtDocument=689. Updated information on this permit application may be obtained by contacting Karl Burgess (GA DNR – CRD).

"Coastal Marshlands Act Permit Request from Spring Bluff, LLC to construct and maintain a community dock facility providing approximately 490' of docking space on public marshlands and waterbottoms located in Phase I of a 210-acre residential development known as The River Place Plantation at Little Satilla located on Highway 17, Camden County, Georgia. The subdivision encompasses approximately 210 acres of upland and is projected to have about 295 homes (139 single-family homes and 156 townhouses) when all phases have been developed. The subdivision plat depicting Phase 1 was not originally available at the time of the public notice; this plat has now been submitted to the Department. The property owners in the first phase will be using the proposed community dock for private recreational use. There will be no fuel located at the proposed facility. There will be no permanent mooring or assignment of dock space. The use of the facility will be for the inland property owners to have access to the water. Applicant has defined an area of approximately 16 docks that will not be eligible for a private single-family recreational dock in the future. The applicant has also identified 29 private docks that may be constructed by future individual lot owners. The proposed community dock consists of a 6' x 692' walkway with handrails. The walkway will terminate at a covered 16' x 24' main fixed dock. A 4' x 30' aluminum all-weld ramp will connect to a 10' x 235' floating dock. (This is down-sized from 240'.) The structure will extend no more than 50' beyond mean low water (MLW) where the waterway is 195' from MLW to MLW. Applicant will be proposing two bridge crossings at this development under separate Coastal Marshlands Protection application."

Appendix M - Permitted water withdrawals

The Georgia Environmental Protection Division requires permits for municipal and industrial users in excess of 1 million gallons per day (mgd) on a monthly average. Below we list permitted water withdrawals (both fresh and saline) in the Cumberland Island-St. Simons area.

Surface water withdrawals

There are currently no municipal surface water withdrawals in Camden or Glynn Counties, but there are three permits for withdrawals to meet industrial needs (**Table M-1**).

Table M- 1. Industrial surface water withdrawals

Facility	County	River Basin	Source Water	Permit No.	Max daily withdrawal (mgd)	Monthly average (mgd)
Durango Paper	Camden	St. Marys	North R.	020-0803-02	12	12
Brunswick Cellulose	Glynn	Satilla	Turtle R.	063-0712-02	58	56
Georgia Power (Plant McManus)	Glynn	Satilla	Turtle R.	063-0712-01	155	188

Source: EPD, Regulated Community – updated August 2004

Ground water withdrawals

Ground water withdrawals in Camden County come primarily from the Floridan aquifer, and represent the major source of drinking water for Georgia coastal communities. Municipal permits include those issues to the City of Brunswick (7 mgd), St. Simons (5.7 mgd), City of Kingsland (3 mgd), City of St. Marys (3 mgd), Jekyll Island (2.2 mgd), Sea Island Cloister Complex (2.2 mgd), and Glynn County Golden Isles (2 mgd). Large industrial users include Georgia Pacific Brunswick pulp plant (49 mgd), Durango Paper Company (44.5 mgd, although this plant is not currently operating), Hercules (14 mgd), Kings Bay Naval Submarine Base (2.9 mgd), and Bayer/ Aventis CropScience (1.7 mgd). (EPD, Regulated Community, updated April 2004). A complete list of permitted withdrawals is in **Table M-2**.

Table M-2. Permitted ground water withdrawals

Source: GA DNR - EPD, Regulated Community

GEORGIA COUNTY	PERMIT NUMBER	Groundwater Withdrawal Permit - User Name	PERMIT EXPIRATION DATE	PERMITTED MONTHLY AVG W/D (Million gal per day)	PERMITTED YEARLY AVG W/D (Million gal per day)	PERMITTED DAILY MAXIMUM (Million gal per day)	# OF WELLS	PERMITTED AQUIFER	RIVER BASIN
Camden	020-0001	Kingsland, City of	31-Dec-05	3.000	2.500		4	Floridan	St Marys
Camden	020-0002	St. Marys, City of	31-Dec-07	3.000	2.500		5	Floridan	St Marys
Camden	020-0003	Durango Paper Co – Kraft Division	31-Dec-05	44.500	40		8	Floridan	St Marys
Camden	020-0004	Durango Paper Co – Kraft Bag Division	31-Dec-05	0.169	0.169		2	Floridan, Miocene-Pliocene	St Marys
Camden	020-0005	Thiokol Corp – Union Carbide, Merged into 0007	OUT 1986-07			0.600	3	Floridan	Satilla
Camden	020-0006	Woodbine, City of	31-Dec-05	0.325	0.250		2	Floridan	Satilla
Camden	020-0007	Bayer CropScience USA LP	31-Dec-05	1.700	1.700		4	Floridan	Satilla
Camden	020-0008	Kings Bay Naval Sub Base – Wharf Area	REVOKED OUT, 1985-12			0.300	2	Floridan	St Marys
Camden	020-0009	Southeast Energy Group, LTD	EXPIRED OUT, 1991-12			0.720	2	Floridan	Satilla
Camden	020-0010	Kings Bay Naval Sub Base	31-Dec-05	2.900	2.900		3	Floridan	St Marys
Camden	020-0011	Watkins Engineers & Constructors	EXPIRED OUT, 1987-12			0.600	1	Floridan	St Marys
Camden	020-0012	Kings Bay Naval Sub Base - Irrigation	31-Dec-05	1.000	1.000		16	Miocene	St Marys

GEORGIA COUNTY	PERMIT NUMBER	Groundwater Withdrawal Permit - User Name	PERMIT EXPIRATION DATE	PERMITTED MONTHLY AVG W/D (Million gal per day)	PERMITTED YEARLY AVG W/D (Million gal per day)	PERMITTED DAILY MAXIMUM (Million gal per day)	# OF WELLS	PERMITTED AQUIFER	RIVER BASIN
Camden	020-0013	Coastal Water & Sewerage Co	31-Mar-13	1.000	1.000		2	Miocene	St Marys
Glynn	063-0001	King & Prince Seafood Corp	08-Aug-04	0.325	0.270		1	Floridan	Satilla
Glynn	063-0002	Jekyll Island Authority – Public Water System	31-Dec-05	2.150	1.850		5	Floridan	Satilla
Glynn	063-0003	Georgia-Pacific Corp (Brunswick Pulp Operation)	31-Dec-05	49.000	45.000		8	Floridan	Satilla
Glynn	063-0004	LCP Chemicals – Georgia Inc	REVOKED OUT, 1995-03	2.000	2.000		6	Floridan	Satilla
Glynn	063-0005	Golden Shore Division - King & Prince Seafood	EXPIRED OUT, 1995-01	0.560	0.560		2	Floridan	Satilla
Glynn	063-0006	Georgia Power Company – Plant McManus	31-Dec-05	0.150	0.150		1	Floridan	Satilla
Glynn	063-0007	Scientific Agricultural Fish Farms	EXPIRED OUT, 1985-02			2.200	1	Floridan	Satilla
Glynn	063-0008	Hercules, Incorporated	31-Dec-05	14.000	12.000		12	Floridan	Satilla
Glynn	063-0009	Sea Island Company – Cloister Complex	31-Dec-05	2.200	1.600		4	Floridan, Miocene	Satilla
Glynn	063-0010	St. Simons Water & Sewer District	31-Dec-05	5.670	4.350		4	Floridan	Satilla
Glynn	063-0011	Brunswick, City of	31-Dec-05	7.000	6.440		10	Floridan	Satilla

GEORGIA COUNTY	PERMIT NUMBER	Groundwater Withdrawal Permit - User Name	PERMIT EXPIRATION DATE	PERMITTED MONTHLY AVG W/D (Million gal per day)	PERMITTED YEARLY AVG W/D (Million gal per day)	PERMITTED DAILY MAXIMUM (Million gal per day)	# OF WELLS	PERMITTED AQUIFER	RIVER BASIN
Glynn	063-0012	Glynco Golf Course	31-Dec-05	0.250	0.100		1	Floridan	Satilla
Glynn	063-0013	Lewis Crab Factory	31-Dec-05	0.310	0.300		2	Floridan	Satilla
Glynn	063-0014	Millennium Specialty Chemicals	31-Dec-05	0.860	0.760		3	Floridan, Miocene	Satilla
Glynn	063-0015	Rich-SeaPak Corporation	31-Dec-05	0.350	0.350		2	Floridan	Satilla
Glynn	063-0016	DuPont	EXPIRED OUT, 1989-12			1.000	1	Floridan	Satilla
Glynn	063-0017	Brunswick, City of Glynco System	REVOKED OUT, 1987-07			0.300	2	Floridan	Satilla
Glynn	063-0018	Brunswick, City of – I95 & 341 Interchange	MERGED OUT, 2001-09	0.600	0.540		2	Floridan	Satilla
Glynn	063-0019	Georgia Ports Authority – Colonels Island	31-Dec-05	0.150	0.150		1	Floridan	Satilla
Glynn	063-0020	Sea Island Co – Sea Island Golf Course	31-Dec-05	0.850	0.420		5	Miocene, Floridan	Satilla
Glynn	063-0021	Sea Island Co – Island Club Golf Course	31-Dec-05	0.500	0.200		5	Miocene, Floridan	Satilla
Glynn	063-0022	Jekyll Island Authority – Golf Course	31-Dec-05	1.000	0.550		7	Miocene, Floridan	Satilla
Glynn	063-0023	Glynn County W & S – North Mainland	10-Aug-02	0.450	0.350		4	Floridan	Satilla
Glynn	063-0024	Sea Palms Development Corp	31-Dec-05	0.688	0.400		8	Floridan	Satilla

GEORGIA COUNTY	PERMIT NUMBER	Groundwater Withdrawal Permit - User Name	PERMIT EXPIRATION DATE	PERMITTED MONTHLY AVG W/D (Million gal per day)	PERMITTED YEARLY AVG W/D (Million gal per day)	PERMITTED DAILY MAXIMUM (Million gal per day)	# OF WELLS	PERMITTED AQUIFER	RIVER BASIN
Glynn	063-0025	Glynn County – I95 & US17 Interchange System	31-Dec-05	0.300	0.300		2	Floridan	Satilla
Glynn	063-0026	Georgia Ports Authority	31-Dec-05	0.200	0.200		1	Miocene (Basal)	Satilla
Glynn	063-0027	Hampton Group	10-Mar-09	0.800	0.500		2	Miocene	Satilla
Glynn	063-0028	Glynn Brunswick Memorial Hospital	OUT, 2000-03	0.134	0.134		1	Floridan	Satilla
Glynn	063-0029	Georgia-Pacific, Gypsum Corporation	31-Dec-05	0.225	0.225		1	Floridan	Satilla
Glynn	063-0030	Oak Grove Island Plantation Water Co	REVOKED OUT, 2004-01	0.065	0.065		1	Floridan	Satilla
Glynn	063-0031	Glynn County – Hampton Plantation	31-Dec-05	0.280	0.170		2	Floridan	Satilla
Glynn	063-0032	Oak Grove Island Golf Investors	12-Mar-02	0.550	0.550		1	Miocene	Satilla
Glynn	063-0033	Sea Island Co – Ocean Forest Golf Course	08-Apr-14	0.500	0.500		2	Miocene	Satilla
Glynn	063-0030	Oak Grove Island Plantation Water Co	REVOKED OUT, 2004-01	0.065	0.065		1	Floridan	Satilla
Glynn	063-0031	Glynn County – Hampton Plantation	31-Dec-05	0.280	0.170		2	Floridan	Satilla

GEORGIA COUNTY	PERMIT NUMBER	Groundwater Withdrawal Permit - User Name	PERMIT EXPIRATION DATE	PERMITTED MONTHLY AVG W/D (Million gal per day)	PERMITTED YEARLY AVG W/D (Million gal per day)	PERMITTED DAILY MAXIMUM (Million gal per day)	# OF WELLS	PERMITTED AQUIFER	RIVER BASIN
Glynn	063-0034	Jekyll Island Authority – Golf Course	REVOKED OUT, 1996-09	0.400	0.360		1	Miocene	Satilla
Glynn	063-0035	Jekyll Island Authority – Summer Waves	REVOKED OUT, 1996-09	0.400	0.360		1	Miocene	Satilla
Glynn	063-0036	Jekyll Island Authority – Indian Mounds Golf Course	30-Sep-06	0.400	0.360		1	Miocene	Satilla
Glynn	063-0037	Jekyll Island Authority – Oleander Golf Course	30-Sep-06	0.500	0.450		1	Miocene	Satilla
Glynn	063-0038	Glynn County – Golden Isles	02-Oct-08	2.000	2.000		2	Miocene	Satilla
Glynn	063-0039	Georgia-Pacific – Thalmann Woodyard	01-Jun-09	0.350	0.350		3	Floridan, Miocene	Satilla
Glynn	063-0040	Wade & Claire – Coastal Pines Golf Club	31-Dec-05	0.300	0.250		1	Miocene	Satilla
Glynn	063-0041	Jekyll Island Authority – Pine Lakes Golf Course	20-Aug-12	0.400	0.360		1	Miocene	Satilla
Glynn	063-0042	Glynn County North Recreation Complex	10-Oct-13	0.630	0.630		2	Miocene	Satilla
Glynn	063-0043	Live Oak Power Co, LLC	03-Feb-14	0.975	0.550		4	Miocene	Satilla
Glynn	063-0044	Sea Island Company – North Golf Course	07-Nov-13	1.000	0.550		2	Miocene	Satilla

Appendix N – Annotated bibliography

Alber, M. 2002. A conceptual model of estuarine freshwater inflow management. Estuaries 25(6B): 1246-1261.

Keywords: model; estuary; freshwater; inflow; management; salinity; policy; Texas; Florida; California

Summary: (from source) "As humans continue to influence the quantity, timing, and quality of freshwater input to estuaries, it is becoming increasingly common for policies to be enacted that mandate the establishment of freshwater inflow criteria that will serve to preserve and protect estuarine ecosystems. This paper reviews the scientific literature describing how changes in freshwater inflow affect estuaries, proposes a conceptual model that explores the roles of scientists, citizens, politicians, and managers in the management of freshwater inflow to estuaries, and uses the model to explore the ways in which freshwater inflow is managed in a variety of estuaries. The scientific review is organized to provide an overview of the connections between freshwater inflow (in terms of the quantity, quality, and timing of water delivery), estuarine conditions (such as salinity and concentrations of dissolved and particulate material), and estuarine resources (such as the distribution and abundance of organisms), and to highlight our understanding of the causative mechanisms that underlie the relationships among these variables. The premise of the conceptual model is that the goal of estuarine freshwater inflow policy is to protect those resources and functions that we as a society value in estuaries, and that management measures use scientific information about the relationships among inflow, conditions, and resources to establish inflow standards that can meet this goal. The management approach can be inflow-based (flow is kept within some prescribed bounds under the assumption that taking too much away is bad for the resources), condition-based (inflow standards are set in order to maintain specified conditions in the estuary), or resource-based (inflow standards are set based on the requirements of specific resources), but each of these is carried out by regulating inflow. This model is used as a framework to describe the development of freshwater inflow criteria for estuaries in Texas, Florida, and California."

Alber, M. and J. Flory. 2002. The effects of changing freshwater inflow to estuaries: a Georgia perspective. Georgia Coastal Research Council, Athens, GA.

Keywords: freshwater, inflow, management, estuary

Summary: (excerpted from preface) "Part One provides an overview of the scientific information available regarding the connections between freshwater inflow, estuarine conditions, and resources. Part Two presents a conceptual model for inflow management in terms of the types of regulation available and the societal values that must be considered. In this section we categorize management as inflow-based, condition-based, or resource-based, and use this structure as the basis to explore the differing approaches to estuarine inflow management that have been taken in various parts of the country. In Part Three we apply this perspective to Georgia. We describe the inflow policy currently in place in Georgia's rivers and summarize the scientific efforts being undertaken to understand the impact of changing freshwater flow to Georgia's estuaries."

Alber, M. and J. E. Sheldon. 1999. Use of a date-specific method to examine variability in the flushing times of Georgia estuaries. Estuarine, Coastal and Shelf Science 49: 469-482.

Keywords: flushing time; fraction of freshwater; transit time; model; river discharge; estuary; Savannah River; Ogeechee River; Altamaha River; Satilla River; St. Marys River; freshwater volume

Summary: Median flushing time of the Savannah River estuary over 30 years (1968-1997), calculated by a modified fraction of freshwater method, was 5.6 d. This is comparable to the flushing time of the Altamaha River estuary and much shorter than the flushing times of the Ogeechee, Satilla, and St. Marys estuaries. Flushing time is more sensitive to decreases in discharge than to increases, and the Savannah estuary flushing time is less sensitive to discharge changes than are those for the slower-flushing estuaries.

Notes: Related papers: Alber and Sheldon (in Proceedings of the 1999 Georgia Water Resources Conference)

Alber, M. and C. Smith. 2001. Water use patterns in the watersheds of the Georgia riverine estuaries, Georgia Water Resources Conference, University of Georgia, Athens, GA. Institute of Ecology.

Keywords: water, withdrawal, consumptive use

Summary: (from source document) "We examined water use patterns in the hydrologic units that comprise the watersheds of the 5 major coastal rivers in Georgia (Savannah, Ogeechee, Altamaha, Satilla, St. Marys). The data for this analysis were obtained from the Georgia Water Use Program, which regularly surveys both water sources (groundwater and surface water) and water uses (domestic, commercial, industrial, mining, irrigation, livestock, thermoelectric, and hydroelectric) as part of the USGS National Water Use Synthesis. Total water withdrawal in the study area totaled 5749 million gallons per day (mgd) in 1995, with no large changes in either water withdrawal or water use patterns for the last 3 reporting years (1985, 1990, and 1995). Surface water accounted for 91% of the water withdrawal in the region, and much of this was for thermoelectric use in the watersheds of the Savannah and Altamaha rivers. However, most of the groundwater that was withdrawn was withdrawn in the Coastal Plain. Only 10% of the water withdrawn was actually consumed, with the remainder returned to the surface water. Irrigation represented the largest consumptive use, and much of this occurred in the Coastal Plain."

Albers, G. L. 2004. Applications of island biogeography; plant diversity and soil characteristics of back-barrier islands near Sapelo Island, Georgia. M.S. thesis, University of Georgia, Athens, GA.

Keywords: hammocks, variance, vegetation, diversity

Summary: (from source) "This work reviews Georgia coastal policy with respect to the bridging of back-barrier islands (BBIs), or marsh hammocks. It characterized plant and soil composition on BBIs near Sapelo Island, Georgia. Species richness of fourteen BBIs was examined according to the theory of island biogeography. Eighty-three species were observed in 52 100 m2 plots. Quercus virginiana and Ilex vomitoria were the dominant overstory and understory plants, respectively, in these maritime forest communities. Linear regression analyses showed that biogeographic variables contributed to ~30% of the variance; island size and origin were important predictors of diversity. Soil analyses indicated fine sands with low nitrogen (less than or equal to 2%) and variable carbon values (1.7-48%). Nonmetric multidimensional scaling showed differences in species composition based on plot location and

soil C:N ratios that were not reflected in diversity analyses. Resource managers may use these findings to designate sensitive areas and develop policies that promote their sustainable use."

Alexander, C., A. Foyle, D. Bush and S. Langley. 2003. An Integrated GIS-Based Approach to Quantifying the Rates of Shoreline Change in the Georgia Bight. USGS and South Carolina Sea Grant.

Summary: (from progress report) "The South Carolina/Georgia Coastal Erosion Study is a USGS cooperative program administered through the South Carolina Sea Grant Consortium. The goals of the Georgia portion of the program are twofold: 1) to determine the historical rates of shoreline change in Georgia and southernmost South Carolina and 2) to synthesize existing knowledge to identify gaps in our understanding of coastal processes in the Georgia Bight as a guide for further research."…"Historical shoreline change was determined using aerial photographs from the late 1950s, 1979, and 2000. USGS Digital Orthophoto Quarter-quads (DOQQs) from 1993 were used both for shoreline position and for selecting ground control points for georeferencing the photographs. Ground control points were carefully identified from the base-layer DOQQs and assigned to each photograph. Each photograph was then registered into ArcView. The wet/dry line was then digitized into an ARCView polyline shapefile. Shoreline position for periods prior to aerial photography were derived from T-sheets that were scanned, digitized, georeferenced and imported into ARCView. Shoreline change rates varied from +8 m/y to -2 m/y. Typically the northern ends of Georgia barrier islands are eroding and the southern ends are accreting."

Alexander, C. R. and M. H. Robinson. 2004. GIS and field-based analysis of the impacts of recreational docks on the saltmarshes of Georgia. Georgia Department of Natural Resources - Coastal Resources Division.

Summary: (from source) "Population pressure along the Georgia coast has greatly increased the number of docks that extend across the marsh, impacting marsh ecosystems. To understand the patterns and impacts of dock proliferation, aerial photography and field data were used within a geographic information system (GIS) to quantify the number of docks and the area of docks affecting marsh. Digitizing the perimeter of docks, we created maps showing the footprint of docks from 1970 to 2000 on Wilmington Island, GA." The study assessed the number of docks, the amount of total dock area, Spartina alterniflora stem density and plant height.

Ambrose, J., S. Bratton, K. Davison, L. Fitch, M. Goigel, F. Golley, F. Lemis, J. McMurtray, W. Querin and D. Simon. 1983. An analysis of feral horse population structure on Cumberland Island. CPSU Technical Report #1. National Park Service Cooperative Unit, Institute of Ecology, University of Georgia, Athens, Georgia.

Keywords: horse, habitat, herd

Summary: (excerpts from results) "The census revealed a population of at least 154 horses arranged in 33 groups. Group size ranged from one to ten animals, with an average group of 4.7 individuals. Most herds consisted of a single adult male, several adult females and sub-adults and/or foals." This study also addressed the location of these bands.

Notes: UGA Science library

Asbury, C. E. and E. T. Oaksford. 1997. A comparison of drainage basin nutrient inputs with instream nutrient loads for seven rivers in Georgia and Florida. Water-Resources Invest. Rep. 97-4006. U.S. Geological Survey, Washington, D.C.
Summary: (excerpt) "Instream nutrient loads of the Altamaha, Suwannee, St. Johns, Satilla, Ogeechee, Withlacoochee, and Ochlockonee River basins were computed and compared with nutrient inputs for each basin for the period 1986-90. Nutrient constituents considered include nitrate, ammonia, organic nitrogen, and total phosphorus. Sources of nutrients considered in this analysis include atmospheric deposition, fertilizer, animal waste, wastewater treatment plant discharge, and septic discharge."

Baugh, T. M., J. A. Valade and B. J. Zoodsma. 1989. Manatee use of *Spartina alterniflora* in Cumberland Sound. Marine Mammal Science 5(1): 88-90.
Keywords: West Indian manatee, *Trichechus manatus latirostris*, feeding ecology, radiotagging, salt marsh cord grass, *Spartina alterniflora*
Summary: (from article) "*Spartina alterniflora* is used as browse by the West Indian manatee in the Cumberland Sound area and may be a significant food item for manatees overwintering in northeastern Florida and southeastern Georgia."

Berndt, M. P. 1994. National Water-Quality Assessment Program -- preliminary assessment of nitrate distribution in ground water in the Georgia - Florida Coastal Plain Study Unit, 1972-1990. Open-File Report 93-478. U. S. Geological Survey.
~~http://fl.water.usgs.gov/Gafl/gaflpubs.html~~
Keywords: nitrogen, land use http://fl.water.usgs.gov/Gafl/Abstracts/ofr93478/ofr93478.html
Summary: The relationship between land use and groundwater nitrogen levels was investigated. Highest levels found adjacent to agricultural land, next highest in urban areas, and the lowest levels near barren or forested areas. The study included sites in Camden County, but none on Cumberland Island.

Bishop, D. and D. Hurley. 2003. The non-indigenous porcelain crab, *Petrolisthes armatus*: population trends in the Sapelo Island National Estuarine Research Reserve. Estuarine Research Federation Meeting -- Seattle, Washington.
Summary: (from poster) "*Petrolisthes armatus*, a non-indigenous crab in Georgia, is a native of tropical regions. It has expanded its range since 1994 from Indian River Lagoon, Florida to throughout Georgia and most of South Carolina. This study was the Sapelo Island National Estuarine Research Reserve's contribution to a pilot study, initiated by the National Estuarine Research Reserve System, to monitor invasive decapod crabs nationwide. Seven oyster reef substrate samplers were deployed at Marsh Landing Reef (Sapelo Island, GA) and sampled quarterly. *P. armatus* was the most abundant crab seasonally, with densities up to 3 times those of native decapods. Density of *P. armatus* decreased in the spring, possibly in response to low salinity and low water temperatures. Percent of ovigerous females in the population was as high as 73% in September. One ovigerous female was found in December. Mean size of females and males was similar as was their densities. A low percentage of both male and female *P. armatus* were parasitized by an isopod crustacean. No ovigerous females were parasitized. Other decapods collected were *Panopeus herbstii*, *Eurypanopeus depressus*, *Menippe mercenaria*, *Palaemonetes vulgaris* and *Palaemonetes pugio*. Native decapods

contrasted with *P. armatus* in the timing of peak abundance, reproductive periods and degree of parasitism."

Bond, B. T., R. J. Warren and M. I. Nelson. 2002. Winter mortality of adult nine-banded armadillos (*Dasypus novemcinctus*) on Cumberland Island, Georgia. Georgia Journal of Science 60(4): 209-216.
Summary: (from Introduction) "…objective was to determine the seasonal survival rates of male and female nine-banded armadillos on Cumberland Island, Georgia." (from Abstract) "We suggest that poor thermoregulatory ability of armadillos may predispose them to overwinter mortality".

Bratton, S. P. 1984. The distribution of tung and tamarisk on Cumberland Island National Seashore. CPSU Technical Report #11. Institute of Ecology, University of Georgia, Athens, GA.
Keywords: tung, vegetation management, controlled burn
Summary: (from Introduction) "The purpose of this report is to describe the distribution of two exotic woody plant species, tung, *Aleurites fordii* and tamarisk, *Tamarix gallica*, on Cumberland Island National Seashore, and to discuss preliminary experiments with mechanical removal."
Notes: UGA Science Library

Bratton, S. P. 1988. Wood stork use of fresh and saltwater habitats on Cumberland Island National Seashore. CPSU Technical Report No. 50. Athens, GA.
Keywords: habitat, bird, wood stork, *Mycteria americana*
Notes: UGA Science Library, QL696.C535 B72 1988

Bratton, S. P. 1989. Responses of wading birds to natural and unnatural disturbances in Cumberland Sound. CPSU Technical Report No. 53. Athens, GA.
Keywords: wading birds, human disturbance, boat, vehicle, natural disturbance
Summary: This study was a comparison of the responses of wading birds to various disturbances. Comparisons were made between: natural disturbances (thunder, raccoon, hawk, deer, alligator, horse, hog) and unnatural disturbances (boats, foot travelers, aircraft, land vehicles); different locations (water vs. trees, creeks vs. estuaries); species; distance; and time of the tidal cycle. Among the conclusions was the finding that disturbances more than 60 meters away were not likely to elicit a major response, suggesting that traffic in the ICW may be sufficiently far away from wading bird habitat not to present a disturbance. The author also found that although natural disturbances (thunder, predators, prey) were approximately twice as frequent during the study, unnatural disturbances (boats, foot travelers, aircraft, land vehicles) caused wading birds to flush more often (5-36% and 60-70% respectively).
Notes: UGA Science Library, QL696.C5 B72 1989

Bratton, S. P., C. Canalos and A. Bergeron. 1989. 1988 surveys for wood storks and least terns, Cumberland Island National Seashore. CPSU Technical Report No. 56. Athens, GA.
Keywords: *Mycteria americana*, wood stork, *Sterna antillarum*, least tern
Notes: UGA Science Library, QL696.C535 B7175 1989

Bratton, S. P. and NPS Basic Vegetation Management Course. 1986. Experimental control of tung trees at Cumberland Island National Seashore. CPSU Technical Report #29. Institute of Ecology, University of Georgia, Athens, GA.
Keywords: tung, vegetation management, controlled burn
Summary: (from report) "Tests of methods of removing exotic tung trees, *Aleurites fordii*, on Cumberland Island National Seashore indicate hand cutting can be effective but requires multiple repeated treatments ... The most cost effective method for removing small plants was hand pulling." Other methods were tested and survivorship results are described.
Notes: UGA Science Library

Byrnes, M. R. and M. W. Hiland. 1995. Large-scale sediment transport patterns on the continental shelf and influence on shoreline response: St. Andrew Sound, Georgia to Nassau Sound, Florida, USA. Marine Geology 126: 19-43.
Keywords: sediment transport, shoreline change, Cumberland Island
Summary: (from original) "Regional sediment transport patterns on the continental shelf seaward of Cumberland Island, Georgia and Amelia Island, Florida are documented using historical shoreline position and bathymetry data. Spatial variability in the net rate of shoreline change is considerable due to jetty construction at St. Marys Entrance in the early 1900s. Net average shoreline progradation is documented for both islands (1.5 m yr^{-1} for Cumberland and 0.4 m yr^{-1} for Amelia), however, localized areas of shoreline retreat are recorded along Amelia Island, especially for the southernmost 5 km of beach where erosion has been chronic since 1871. Rapid shoreline progradation adjacent to the jetties accompanied sediment deposition by longshore sediment transport. Simultaneously, a large quantity of sediment from the natural ebb-tidal delta was reworked and transported offshore in response to jetty construction and channel dredging, creating the modern ebb-tidal delta. Patterns of sediment movement at this inlet and throughout the study area indicate a dominant direction of drift to the south-southeast. Sediment losses and gains were quantified to evaluate long-term coastal change within the framework of a sediment budget. Qualitative descriptions of net sediment transport were integrated with quantitative results to produce a model of large-scale coastal evolution for the study area. From this analysis, net sediment transport in this coastal compartment is controlled by inlet and shelf hydraulics, and littoral zone processes have minimal impact on net long-term coastal change."

Canerday, T. D. 1988. Fire ants in Georgia. University of Georgia Entomology. http://www.ent.uga.edu/docs/fire_ants_in_georgia.htm
Summary: Information about fire ants in Georgia includes sections on: identification, spread, development and site selection, agricultural importance, and control tactics.

Center for Aquatic Resource Studies [USGS]. 2002. Nonindigenous aquatic species database. http://nas.er.usgs.gov/queries
Keywords: invasive, nonnative, nonindigenous, aquatic
Summary: Lists of introduced aquatic species may be generated by location (state, 2 or 6-digit HUC), or one can access fact sheets (photo, description, native range, nonindigenous occurrences, means and impact of introduction, status, references) and collection information records (specimen ID#, state, county, locality, year, HUC, drainage name, status) for individual species.

Notes: Center for Aquatic Resource Studies is part of the Biological Resources Division of the Geological Survey (within the U. S. Department of the Interior)

Chesapeake Bay Foundation. 2004. Manure's impact on rivers, streams and the Chesapeake Bay. http://www.cbf.org/site/DocServer/0723manurereport_noembargo_.pdf?docID=2143
Keywords: nitrogen, phosphorus, manure, fertilizer, Chesapeake, water quality

City of St Marys. 2004. St. Marys Airport Feasibility & Site Selection Study. http://www.ci.st-marys.ga.us/Airport%20Study%20Website/Presentations_and_Handouts.htm
Summary: includes map of possible new sites for St Marys airport

Cofer-Shabica, S. V. 1991. Biological and physical aspects of dredging, Kings Bay, Georgia. American Society of Civil Engineers, Long Beach, California.
Keywords: manatee, clam, boat traffic, sedimentation, jetty, fish, invertebrate, macroalga, pond, saltwater intrusion, meteorology, wave data, estuarine dynamics, inlet stabilization
Notes: Chapters handled as separate documents

Cofer-Shabica, S. V., R. H. Becker and D. L. Allen. 1991. Aerial photographic analysis of boat traffic distributions in Cumberland Sound, Georgia. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.
Keywords: boat traffic, ICW
Summary: Over 16 flights, location of 737 boats was plotted. 70% of boats were found to be south of the midline of Stafford Island, 57% mapped were not on the intracoastal waterway, but 85-90% were estimated to be crafts originating in the region (and not through traffic). Additionally, the authors state "All the traffic mapped in proximity to the island would have crossed the commercial shipping lanes at least twice during a boating day".

Cofer-Shabica, S. V. and W. Hargrove. 1991. Automated remote meteorological stations for climatic water budget determination at Cumberland Island, Georgia, USA. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.
Keywords: rain, humidity, wind, radiation
Summary: 4 automated remote weather stations were installed on CUIS to monitor; rainfall, humidity, air/soil/water temperature, windspeed/direction, simulated leaf wetness, and solar radiation. The sites were: South End, Dungeness, Stafford, and Settlement.
Notes: Results of this study have not been located

Cofer-Shabica, S. V., D. Molzan and J. Pope. 1991. Biological and physical aspects of dredging, Kings Bay, Georgia. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.
Summary: The series editor, S. Cofer-Shabica, was the program manager for the Kings Bay Environmental Research Program, which was begun in 1986 by the U.S. Departments of the Interior and the Navy. The program was a 5-year study (1988-1992) looking into the effects of the submarine shipping channel (and its dredging) on local marshes and barrier islands (especially Cumberland and Amelia). The National Park Service was tasked with investigation

of the ecological aspects and the overall synthesis. The Department of the Navy was to present findings on the physical aspects of the study area.

Corson, W. D. and J. P. McKinney. 1991. Summary of directional wave data from 3 different monitoring systems deployed offshore of St. Mary's [sic] entrance, Georgia. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.
Keywords: wave direction
Summary: Three offshore wave monitoring systems were compared near the St. Marys inlet. May 1989, pressure and orbital velocity components were recorded by a U.S. Army Corps of Engineers device (through the Coastal Engineering Research Center). From April 1989 - May 1990, a slope array (also from the CERC) was employed. Under contract to CERC, data from pitch-roll buoy #41008 (NOAA, National Data Buoy Center) was also recorded. The authors determined that these methods are useful for confirming data. One interesting observation was the occurrence of long-period (15-17 sec), low amplitude wave sets from the south-east.

Cotton, A. C. 2004. Tidal Marsh Mitigation in the Ogeechee River Estuary, GA: Short and Long Term Changes. Thesis, University of Georgia, Athens, GA.
Keywords: mitigation, restoration, drainage patterns, impoundment, edge, geomorphology, diked wetlands, sinuosity, channel order, GIS, aerial photographs, estuary, Georgia, rice plantation
Summary: (from thesis) "Short and long-term changes were examined in Georgia tidal marshes to evaluate mitigation progress. Water conditions, sedimentation, and vegetation were monitored in a former rice impoundment before and after removal of hydrologic restrictions. Water conditions (water level, salinity, pH, dissolved oxygen) improved immediately, but after 2 years vegetation cover remained low and sedimentation rates were extremely high. A GIS was used to compare channel density, order, sinuosity, and edge habitat in aerial photographs of a natural marsh with those in a formerly impounded marsh 50 and 100 years after restoration. Drainage patterns in the restored marsh were highly altered and did not exhibit substantial changes over time. Channel density and edge habitat were highest in the restored marsh, but edge may not equal access to the intertidal area. Natural drainage patterns are not expected to develop in the mitigation site over the long term (100 years)."

Cowie, G., M. Davis, S. Holmbeck-Pelham, B. Freeman, M. Freeman, K. Hatcher, R. Jackson, A. M. Keyes, M. Merrill, J. Meyer, E. Sutherland and S. Wenger. 2002. Reservoirs in Georgia: meeting water supply needs while minimizing impacts. River Basin Science and Policy Center, Athens, Georgia. http://outreach.ecology.uga.edu/publications/pdf/reservoir.pdf
Summary: (from Executive Summary) "With a growing population and increasing demand for water supply exacerbated by a multiyear drought, Georgia residents are being challenged to meet water needs for now and for the future. To date, meeting water demands in North Georgia has often meant construction of reservoirs. The state's free-flowing rivers and streams, however, provide an array of services, and construction of reservoirs has consequences that extend throughout river ecosystems. The process by which water supply decisions are made must address increasing and often conflicting demands for water while maintaining the health and integrity of the state's rivers and streams." This paper is directed at Georgia's water supply decision makers and the stakeholders in that process. Part I provides an overview of the number of reservoirs in Georgia and their impacts. Dams and reservoirs differ

markedly in size, purpose, and operations, and their effects vary accordingly. Part I presents a generalized outline of impacts; for details on how these impacts vary with different types of reservoirs, beyond the scope of this discussion, readers are referred to the references listed in the notes. Part II describes water supply planning that considers a variety of water supply options in order to meet Georgia's future water needs while minimizing impacts on the services that free-flowing streams and rivers provide.

Crowder, L. 1999. Estuaries Vital To the Productivity Of Southeastern U.S. Fisheries. Presentation at AAAS annual meeting, Anaheim CA (Feb 1999).
Summary: (excerpt) "About 80% of commercially important seafood species along the Southeastern US spend parts of their lives in estuaries, brackish coastal nursery areas that show signs of being degraded by human activities. When salt marsh habitat and production is lost, when estuarine creeks and rivers are anoxic (oxygen depleted), when seagrass beds disappear, those things tell us that the habitat on which these organisms depend is being degraded."

Culliton, T. J. 1998. Population: distribution, density and growth. National Oceanic and Atmospheric Administration. http://state_of_coast.noaa.gov/bulletins/html/pop_01/pop.html
Summary: (from source) "Coastal areas are the most developed in the nation. This narrow fringe–comprising 17% of the contiguous U.S. land area–is home to more than 53% of the nation's population. Further, this coastal population is increasing by 3,600 people per day, giving a projected total increase of 27 million people between now and 2015."

Cumberland Island Museum. 2000. Amphibians & reptiles of Cumberland Island. http://www.cimuseum.org/checklists/amp_rep_order_list.html
Keywords: amphibians, reptiles
Summary: Checklist of amphibians and reptiles found on Cumberland Island includes common and scientific name, and notes on habitat, behavior and relative abundance of the species.
(From the website) About the museum -- "The Cumberland Island Museum was incorporated in 1985 to assure the protection and maintenance of the library, archival materials, and natural history collections of Carol Ruckdeschel and C. Robert Shoop after their lives, as well as items donated by other individuals. These materials and collections serve as resources both now and in the future for scholars, who will find most of the information and material available on Cumberland Island and much of the Southeast Coast ... Theses, doctoral dissertations, government publications and reports, maps and aerial photographs, letters and notes of biologists and collectors of the past, in addition to the specimens, provide a comprehensive basis for all types of historical and biological studies of the island." The museum operates as a private, non-profit entity distinct from the operations of the National Park Service.

Cumberland Island Museum. 2001. Mammals of Cumberland Island. http://www.cimuseum.org/checklists/mammals_order_list.html
Keywords: mammals, feral, introduced, extirpated
Summary: The checklist of mammals found on Cumberland Island includes common and scientific name, and notes on habitat, behavior, and relative abundance of the species.

Cumberland Island Museum. 2003. Turtle strandings on Cumberland Island. http://www.cimuseum.org/Strandings.html

Keywords: turtles
Summary: 2003 saw 106 turtle strandings on Cumberland, the highest number in two decades. Of these, 83 were loggerheads.

Department of the Navy. 1977. Final Environmental Impact Statement for preferred alternative location for a fleet ballistic missile submarine support base, Kings Bay, Georgia. OPNAVINST 6240.3. Washington, D.C.
Keywords: EIS, environmental impact statement, Kings Bay, submarine, Trident, naval base
Summary: Contents include: background and project justification, site selection process, master planning and project description, evaluation of alternatives, probable environmental impacts and mitigating actions, public and agency comments with Navy responses. This report is much less detailed than the draft EIS prepared in 1975.
Notes: UGA science library,(two volumes)

DeVoe, M. R. and D. S. Baughman. 1986. South Carolina coastal wetland impoundments: ecological characterization, management, status, and use. III. Technical appendix. SC-SG-TR-86-2. South Carolina Sea Grant Consortium.
Summary: (from Sea Grant Library summary): "The Coastal Wetland Impoundment Project (CWIP) was designed to generate the first comprehensive characterization of a coastal impoundment system in South Carolina. The purpose of this investigation was to develop an information base which could be used by policy-makers and regulatory agencies to address the complex questions surrounding this valuable state resource. Volume I provides a concise statement of the research findings, along with a summary of research, management, and policy recommendations. Volume II contains the detailed results of the CWIP and has been organized into nine sections. This publication, Volume III, provides supplemental technical data and information which support the results presented in Volume II."

Diaz, R. J. and R. Rosenberg. 1995. Marine benthic hypoxia: a review of its ecological effects and the behavioral responses of benthic macrofauna. Oceanography and Marine Biology: an Annual Review 33: 245-303.

Donahue, J. C. 1998. Ground-water quality in Georgia for 1996-1997. Circular 12M. Georgia Department of Natural Resources, Environmental Protection Division, Georgia Geologic Survey, Atlanta, GA.
Summary: (From Introduction) "Analyses of water samples collected for the Georgia Ground-Water Monitoring Network during calendar years 1996 and 1997 and from previous years form the database for this summary. The Georgia Ground-Water Monitoring Network comprises 128 wells and springs. Beginning in 1996, most stations in the network were changed from an annual sampling frequency to a biennial sampling frequency. Certain stations, typically recent additions to the network or stations with past evidence of pollution or contamination, remain on an annual sampling frequency. Stations showing recent pollution or contamination may be subject to confirmatory sampling on a basis more frequent than annual. During the 1996-1997 period, EPD personnel collected 160 samples from 115 wells and 6 springs. A review of the 1996-1997 data and comparison of these data with those for samples collected as early as 1984 indicate that ground-water quality at most of the 128 sampling sites generally has changed little and remains excellent." Note that graphs and figures were not available in the on-line version.

Donahue, J. C. 1999. Ground-water quality in Georgia for 1998. Circular 12N. Georgia Department of Natural Resources, Environmental Protection Division, Georgia Geologic Survey, Atlanta, GA.

Summary: (From Summary) "EPD personnel collected 79 raw water samples from 73 wells and five springs on the Ground-Water Monitoring Network during calendar year 1998 for inorganic and organic analysis. These wells and springs monitor the water quality of nine aquifer systems in Georgia. Comparisons of analyses of water samples collected during calendar year 1998 were made with analyses for the Ground-Water Monitoring Network dating back to 1984, permitting the recognition of temporal trends. Table 4-l lists the major contaminants and pollutants detected at the stations of the Ground-Water Monitoring Network during 1998. Although isolated water quality problems existed at specific localities, the quality of water from most of the Ground-Water Monitoring Network stations remains excellent."

Notes: no sampling noted in Camden County

Donahue, J. C. 2000. Ground-water quality in Georgia for 1999. Circular 12O. Georgia Department of Natural Resources, Environmental Protection Division, Georgia Geologic Survey, Atlanta, GA.

Summary: (From Summary) "EPD personnel collected 123 raw water samples from 114 wells and seven springs on the Ground-Water Monitoring Network during calendar year 1999 for inorganic and organic analysis. These wells and springs monitor the water quality of nine aquifer systems in Georgia. Comparisons of analyses of water samples collected during calendar year 1999 were made with analyses for the Ground-Water Monitoring Network dating back to 1984, permitting the recognition of temporal trends. Table 4-l lists the contaminants and pollutants detected at the stations of the Ground-Water Monitoring Network during 1999. Although isolated water quality problems existed at specific localities, the quality of water from most of the Ground-Water Monitoring Network stations remains excellent."

Notes: Two Camden County stations were monitored: GWN-PA10B (Gilman Paper #11) and GWN-PA11 (St Marys #2). Conductivity and pH are given. Nitrate, nitrite, and several organics were not detected, but tentative identification of sulfur dioxide compounds was listed (in the ppb range).

Donahue, J. C. 2001. Ground-water quality in Georgia for 2000. Circular 12P. Georgia Department of Natural Resources, Environmental Protection Division, Georgia Geologic Survey, Atlanta, GA.

Summary: (From Summary) "EPD personnel collected 125 raw water samples from 114 wells and seven springs on the Ground-Water Monitoring Network during calendar year 2000 for volatile organic and limited inorganic analysis. These wells and springs monitor the water quality of nine aquifer systems in Georgia. Comparisons of analyses of water samples collected during calendar year 2000 were made with analyses for the Ground-Water Monitoring Network dating back to 1984, permitting the recognition of temporal trends. Table 4-1 lists the contaminants and pollutants detected at the stations of the Ground-Water Monitoring Network during 2000. Although isolated water quality problems existed at specific localities, the quality of water from most of the Ground-Water Monitoring Network stations remains excellent."

Notes: Two Camden County stations were monitored: GWN-PA10B (Gilman Paper #11) and GWN-PA11 (St Marys #2). Conductivity and pH are given. Nitrate, nitrite, and several organics were not detected.

Donahue, J. C. 2002. Ground-water quality in Georgia for 2001. Circular 12Q. Georgia Department of Natural Resources, Environmental Protection Division, Georgia Geologic Survey, Atlanta, GA.

Summary: (From Summary) "EPD personnel collected 122 raw water samples from 114 wells and seven springs on the Ground-Water Monitoring Network during calendar year 2001 for volatile organic and limited inorganic analysis. These wells and springs monitor the water quality of nine aquifer systems in Georgia. Comparisons of analyses of water samples collected during calendar year 2001 were made with analyses for the Ground-Water Monitoring Network dating back to 1984, permitting the recognition of temporal trends. Table 4-1 lists the contaminants and pollutants detected at stations of the Ground-Water Monitoring Network during 2001. Although isolated water quality problems existed at specific localities, the quality of water from most of the Ground-Water Monitoring Network stations remains excellent."

Notes: Two Camden County stations were monitored: GWN-PA10B (Gilman Paper #11) and GWN-PA11 (St Marys #2). Conductivity and pH are given. Nitrate, nitrite, and several organics were not detected.

Donahue, J. C. 2003. Ground-water quality in Georgia for 2002. Circular 12R. Georgia Department of Natural Resources, Environmental Protection Division, Georgia Geologic Survey, Atlanta, GA.

Summary: (From Summary) "EPD personnel collected 124 water samples from 113 wells and nine springs on the Ground-Water Monitoring Network during calendar year 2002 for volatile organic and limited inorganic analysis. These wells and springs monitor the water quality of nine aquifer systems in Georgia. Comparisons of analyses of water samples collected during calendar year 2002 were made with analyses for the Ground-Water Monitoring Network dating back to 1984, permitting the recognition of temporal trends. Table 4-1 lists the contaminants and pollutants detected at stations of the Ground-Water Monitoring Network during 2002. Although isolated water quality problems existed at specific localities, the quality of water from most of the Ground-Water Monitoring Network stations remains excellent."

Notes: Two Camden County stations were monitored: GWN-PA10B (Gilman Paper #11) and GWN-PA11 (St Marys #2). Conductivity and pH are given. Nitrate, nitrite, and several organics were not detected.

Dougherty, A. J. and J. F. Fry. 2003. Back-barrier erosion threatens archeological sites on Cumberland Island National Seashore, Georgia. Annual Meeting of the Geological Society of America, Seattle.

Keywords: Cumberland Island, erosion, geomorphology

Summary: (from document) "A joint project by the Geological Society of America and the National Park Service is looking into the contributing factors and erosion rates along the western shore of Cumberland Island. Preliminary shoreline change studies using air photo analysis, and limited geomorphic profile comparison, have generated approximate rates of erosion between 15-50 cm/y. To augment this remote sensing data and ground-truth these

erosion rates, geomorphic profile stations have been established and a monitoring program implemented."

Ehrenhard, J. E. and R. M. Thorne. 1991. Archeological site stabilization on Cumberland Island National Seashore, Georgia: an experiment. Coastal Resource Management 14(2): 13-16, 19. http://www.cr.nps.gov/seac/CRM-14-2-cuis.pdf
Keywords: oyster shell, erosion, stabilization
Summary: (from document) "Changes in the natural and cultural environment on and around Cumberland Island National Seashore are accelerating shoreline erosion; the rate of loss of unprotected cultural deposits has increased accordingly. Surprisingly, along the northwest shore between Terrapin Point and Cumberland Wharf, the tidal marsh zones are stabilizing thanks to an increase of naturally deposited oyster shell rakes (dikes). Construction of an experimental, artificial rake emulating this natural phenomenon was undertaken to expedite the revegetation of a static marsh zone, and thus help stabilize the bankline and its cultural deposits."

Ehrenhard, J. E. and R. M. Thorne. 1993. An experiment in archeological site stabilization -- part II: Cumberland Island National Seashore. Coastal Resource Management 16(2): 3-4, 16. http://crm.cr.nps.gov/archive/16-5/16-5-1B.pdf
Keywords: oyster shell, erosion, stabilization
Summary: (from document) "Numerous significant archeological sites and cultural resources are being severely degraded through cutbank shoreline erosion on the western side of Cumberland Island National Seashore, GA. Wind- and boat-generated waves, daily tidal fluctuations, and the deepening of the inland waterway are taking their toll. While some portions of the shoreline are eroding, others are rebuilding and developing stable tidal marsh zones. This rebuilding process is attributed to the formation and expansion of an interlacing network of naturally deposited oyster shell rakes." This is a follow up to a previous report on experimental construction of rakes to stabilize the shoreline (Ehrenhard and Thorne 1991).

Fabrizio, L. and M. S. Calvi. 2003. Georgia's marsh hammocks: A biological survey. Southern Environmental Law Center. http://www.selcga.org/Cases/marsh_hammocks/Bioblast_report.pdf
Summary: (from source) "Between October 2001 and September 2002, the Southern Environmental Law Center, in conjunction with the Georgia Conservancy and the Altamaha Riverkeeper, conducted a series of biological inventories of marshland hammocks in the coastal region of Georgia. The surveys represent the first comprehensive investigation of these unique and threatened coastal resources. Marsh hammocks support maritime forests, a disappearing natural community. Many hammocks provide roosting and nesting areas for wading birds (including the endangered Wood Stork), as well as habitat for Diamondback Terrapin and other wildlife. Hammocks are facing increasing development pressure, and lack of information about these resources is hampering conservation efforts of state agencies and private conservation organizations. Preliminary data analyses have revealed that small hammocks (5-10 acres in size), support a significant diversity of plant and bird species. Yet because of their differing locations, sizes, and origins, marsh hammocks exhibit widely varied characteristics. Only through additional investigation can we gain a sound understanding of marsh hammocks and the dynamic role they play in our marshland ecosystem."

Finley, M. 1985. Structure of the feral horse population, 1985: Cumberland Island National Seashore, Camden County, Georgia. CPSU Technical Report #17. National Park Service, St. Marys, Georgia.
Keywords: horse, habitat
Summary: (from results) "The total horse population on Cumberland Island National Seashore on May 14, 1985 was at least 181, in 55 herds. Herd size ranged from 1-9 individuals. The mean group size was 3.29. Most herds consisted of a single adult male, several mares, and occasional subadults and/or foals." Herd locations were also given.
Notes: UGA Science library

Finley, M. 1986. 1985 foal survivorship in feral horses on Cumberland Island National Seashore, Georgia. CPSU Technical Report #26. National Park Service, St. Marys, Georgia.
Keywords: horse, reproduction
Summary: (from report) "From March through December 1985, observers monitored foal birth and mortality for seven feral horse herds on Cumberland Island National Seashore. Eight foals were born, but only three survived. The survivorship rate of 37% is lower than estimated rates of 50 to 86% reported for free ranging horses in the western US and suggests the Cumberland herd may be exceeding the carrying capacity of the island."
Notes: UGA Science library

Fisackerly, G. M., T. L. Fagerburg and S. C. Knowles. 1991. Estuarine dynamics at Cumberland Sound, Georgia, USA. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.
Keywords: current speed, direction, salinity
Summary: May 1990, an intensive study of estuarine dynamics was made in the St. Marys entrance to the Cumberland Sound. Hourly measurements were made at seven multi-station ranges in the Sound, recording: variable depth current speed, direction, salinity, and suspended sediment. Among the authors observations was that the spring tidal prism was estimated to be between 6 and 10 (x 10exp9) cubic feet.
Notes: Abstract contains useful data summary.

Florida DEP. 1991. Bioassays of Ranonier Incorporated, Fernandina Beach, Nassau County, Florida NPDES #FL0000701. Florida Department of Environmental Protection.
Keywords: wastewater sampling
Summary: Sampled 25 July, 1991.
Notes: http://www.dep.state.fl.us/labs/cgi-bin/reports/search.asp

Florida DEP. 1992. Bioassays of Container Corporation of America, Nassau County, Florida NPDES #FL0001104. Florida Department of Environmental Protection.
Keywords: wastewater sampling
Summary: Sampled July, 1991.
Notes: http://www.dep.state.fl.us/labs/cgi-bin/reports/search.asp

Florida DEP. 1995. Bioassays of Fernandina Beach Wastewater Treatment Plant, Nassau County, Florida NPDES #FL0027260. Florida Department of Environmental Protection.

Keywords: wastewater sampling
Summary: Sampled 4/10/95.
Notes: http://www.dep.state.fl.us/labs/cgi-bin/reports/search.asp

Florida DEP. 1999. Bioassays of Container Corporation of America, Nassau County, Florida NPDES #FL0001104. Florida Department of Environmental Protection.
Keywords: wastewater sampling
Summary: Sampled April 1998.
Notes: http://www.dep.state.fl.us/labs/cgi-bin/reports/search.asp

Florida DEP. 2002. Bioassays of Fernandina Beach Wastewater Treatment Plant, Nassau County, Florida NPDES #FL0027260. Florida Department of Environmental Protection.
Keywords: *Ceriodaphnia dubia*, *Cyprinella leedsi*, *Americamysis bahia*, *Menidia beryllina*, wastewater sampling
Summary: Sampled 4/10/95. Bioassays for toxicity to *Ceriodaphnia dubia, Cyprinella leedsi, Americamysis bahia, Menidia beryllina* were performed. Chemical analysis of the wastewater showed the presence of: calcium, copper, iron, magnesium, silver, zinc, and atrazine (pesticide).
Notes: http://www.dep.state.fl.us/labs/cgi-bin/reports/search.asp

Florida DEP. 2003. Bioassays of Ranonier Incorporated, Fernandina Beach, Nassau County, Florida NPDES #FL0000701. Florida Department of Environmental Protection.
Keywords: *Americamysis bahia, Menidia beryllina*, wastewater testing
Summary: Sampled 6/3/02. Toxicity tests for *Americamysis bahia* and *Menidia beryllina* were performed. The following were also detected in wastewater samples by chemical means: aluminum, cadmium, calcium, chromium, copper, iron, lead, magnesium, nickel, silver, zinc, ammonia, nitrate/nitrite, phosphate, phenol, and 2,4,6-trichlorophenol.
Notes: http://www.dep.state.fl.us/labs/cgi-bin/reports/search.asp

Florida DEP. 2003. Bioassays of Jefferson Smurfit Corporation, Fernandina Beach, Nassau County, Florida NPDES #FL0001104. Florida Department of Environmental Protection.
Keywords: *Ceriodaphnia dubia, Cyprinella leedsi*, wastewater testing
Summary: Sampled 11/4//02. Toxicity tests for *Ceriodaphnia dubia* and *Cyprinella leedsi*, were performed. The following were also detected in wastewater samples by chemical means: aluminum, arsenic, cadmium, calcium, chromium, copper, iron, lead, magnesium, nickel, zinc, ammonia, nitrate, nitrite, phosphate, ethyl methanesulfonate, and metalaxyl (pesticide).
Notes: http://www.dep.state.fl.us/labs/cgi-bin/reports/search.asp

Florida DEP. 2004. Watershed monitoring ground water quality data downloads. http://www.floridadep.org/water/monitoring/download.htm
Keywords: groundwater, metals, organics
Summary: (From source) "Background Network. The purpose of the Background Network is to help define background water quality through a network of approximately 2000 wells that tap all major potable aquifers within the state. The Background Network was created primarily to determine the regional ground water quality in areas relatively unaffected by human activities, to provide a context with which to interpret other water quality data. To avoid the expense of

drilling, the Background Network was created from a set of existing wells located throughout the state. Chief criteria for well selection include: availability of well construction data, ability to gain access to the well, and location away from obvious sources of contamination." One of the 7 stations in the Nassau County baseline dataset (nasbdata.dbf) is fairly close to CUIS: station N-0018 (ID 304144081270201) maps to Amelia Island. Many parameters have been recorded, but this program is only a baseline program, with water quality data from existing wells. This site has data only from 1987, 1989, 1992, and 1995. Parameters measured over this time period include: temperature, turbidity, total and fecal coliform, level, depth to water, conductance, pH, alkalinity (as CaCO3), hardness, ammonia, nitrate and nitrite, dissolved P, orthophosphate, organic C (and detection of ~28 specific organics including benzenes, etc), total and dissolved calcium, magnesium, sodium, potassium, chloride, sulfate, aluminum, selenium, mercury, manganese, nickel, silver, strontium, zinc, copper, chromium, barium, arsenic, fluoride; dissolved silica; and total / dissolved / suspended iron and lead.

Florida DEP. 2004. Florida StoRet. http://storet.dep.state.fl.us
Keywords: water data
Summary: Florida's storage and retrieval system for water data (the same data entered into the EPA system of the same name). One can access databases on geography (with an interactive map), or by date, by parameter, station ID, organization, etc.

Florida Department of Environmental Protection. 1998. St Marys River Entrance Inlet Management Study Implementation Plan. http://bcs.dep.state.fl.us/bchmngmt/st-marys.pdf
Summary: Included in the St Marys River inlet management plan adopted by the state of Florida is a recommendation to "Initiate discussions with the State of Georgia and National Park Service to pursue removal of the interior north jetty shoal. This action is intended as a means of reducing erosional stress to Amelia Island and Fort Clinch resulting from the southerly migration of the entrance channel."

Ford, C. R. 1987. Spotlight survey for white-tailed deer population trends on Cumberland Island National Seashore. CPSU Technical Report #42. School of Forest Resources, University of Georgia, Athens, GA.
Keywords: deer
Summary: (from report) "A population survey technique for white-tailed deer population trends on Cumberland Island National Seashore is developed utilizing night time counts by spotlight. A protocol is described and results given from two trial applications."
Notes: UGA Science Library

Fox, R. S. and E. P. Ruppert. 1985. Shallow-water marine benthic macroinvertebrates of South Carolina: species identification, community composition and symbiotic associations. University of South Carolina Press, Columbia, SC.
Summary: species lists broken down by habitat

Foyle, A. M., V. J. Henry and C. R. Alexander. 2004. Georgia-South Carolina coastal erosion study: phase 2 southern study region. State of knowledge report and semi-annotated bibliography. S.C. Sea Grant, U.S. Geological Survey, Penn State Erie, Georgia Southern

University, Skidaway Institute of Oceanography. http://www.skio.peachnet.edu/publications/pdfs/gasc_coastalerosion_sok.pdf
Keywords: sediment, stratigraphy, coastal and shelf geomorphology, shoreline change, sea-level change, geology, inlet processes and morphology, beach management, dredging, hydrogeology
Summary: (from Executive Summary) "The coastal zone at the apex of the Georgia Bight between St. Helena Sound, South Carolina and Cumberland Sound, Georgia consists of twenty-three barrier islands and their associated ebb-tidal delta, nearshore sand shoal, inlet, estuary, and salt-marsh environments. ...The objectives of this State of Knowledge Report are to: (1) document basic and applied coastal research and coastal-engineering-related work that has been or is currently being conducted at the apex of the Georgia Bight, (2) identify information gaps and significant deficiencies pertaining to coastal geomorphology, shallow stratigraphic frameworks, physical coastal processes, and non-living resources, and (3) identify and prioritize areas where opportunities exist for future geologic research to further our understanding of coastal hazards and the evolution of trailing-edge continental margins. This report is intended to provide guidance to research scientists, practicing coastal geologists and engineers, coastal managers, environmental groups interested in the coastal environment, and educators. (The literature search yielded approximately 1330 documents.)"

Frick, E. A., M. B. Gregory, D. L. Calhoun and E. H. Hopkins. 2002. Water quality and aquatic communities of upland wetlands, Cumberland Island National Seashore, Georgia, April 1999 to July 2000. U.S. Geological Survey Water-Resources Investigations Report 02-4082. U.S. Geological Survey in cooperation with the U.S. Department of the Interior, National Park Service, Atlanta, Georgia. http://ga.water.usgs.gov/pubs/wrir/wrir02-4082/pdf/wrir02-4082.pdf
Keywords: water quality, beach water, groundwater, wetlands, fish, invertebrates
Summary: History water quality studies were summarized (mostly those concerning groundwater). Several water quality studies were performed within CUIS. Six surface water sites were assayed quarterly (between April 1999 and March 2000) for conductance, pH, temp, dO2, alkalinity, tannin, lignin, turbidity. Two surface water sites were assayed continuously between April 1999 and July 2000) for temperature and specific conductance. Six wetlands were sampled (in April 1999 and December 1999) for fish and invertebrates (relative abundance sampling with D-nets). Five beaches near campgrounds were assayed (April 1999, 5 consecutive days) for beach water quality. Fifteen groundwater sites were assayed for major ions, nutrients, trace elements, and field water-quality constituents (conductivity, pH, temperature, dissolved oxygen, alkalinity), domestic wells also sampled for fecal coliform: ten sites from the surficial aquifer were tested (March 2000) and five sites from the Upper Floridan aquifer were tested (April 1999). The results of the study show that most water quality standards are met for waters in the park. However, one maximum contaminant level was exceeded and some secondary standards were also exceeded.

Fry, J. 2004. Feral hog eradication [article appeared in Cumberland Island Newsletter, "The Mullet Wrapper"]. National Park Service. http://data2.itc.nps.gov/parks/cuis/ppdocuments/Spring%202004.pdf

Georgia Coastal Management Program. 2003. Coastal Incentive Grant Program: Camden County water resources project.

Summary: Funds have been granted to the Camden County Board of Commissioners to survey, document and map in GIS format all drinking water wells and septic systems in Camden County. This project is still underway.

Georgia Department of Community Affairs. 2000. Georgia community facilities GIS. Athens, GA.

Georgia Department of Transportation. 1997. Georgia DOT polygonal hydrography. http://gis1.state.ga.us/discover/

Georgia DNR. 2002. Environmental Protection Division Website. Georgia Department of Natural Resources, Environmental Protection Division. http://www.dnr.state.ga.us/dnr/environ/
Summary: Website sections include:
-Geologic Resources
Ground-Water Quality in Georgia Reports are available online for calendar years 1997 through 2002. Unfortunately, the earliest online reports are not "text-searchable" and some lack the figures and tables included in the printed documents. However, they still comprise a useful backdrop of ground-water quality trends in the state.
-Hazardous Site Inventory
This directory of sites includes; name, location, property owner, regulated substances released, threats to human health and environment posed by the release, status of cleanup activities, cleanup priority, and the GA EPD Director's "determination regarding corrective action".
-Enforcement Order
A search page allows one to access a list (for a particular authority, facility, location, or time period) of the proposed and executed EPD enforcement orders resulting from action under the Water Quality Control Act (including Surface Water Allocation); Air Quality Act; Comprehensive Solid Waste Management Act; Erosion and Sedimentation Act; Safe Drinking Water Act; Surface Mining Act; or the Underground Storage Tank Act.
-Regulated Community
These pages include information on the Air Protection Branch, Geologic Survey Branch, Land Protection Branch, Water Protection Branch, and Water Resources Branch. The Land Protection Branch includes a list of leaking underground storage tanks -- there are 79 in Camden County, GA (34 of them located at the Naval Submarine Base at Kings Bay.)

Georgia DNR. 2004. Guidelines for eating fish from Georgia waters. Georgia Department of Natural Resources, Atlanta, GA. http://www.dnr.state.ga.us/dnr/environ/gaenviron_files/fishadvs_files/fcg_2004.pdf
Summary: Due to fish tissue contamination concerns, the GA DNR issues advisories on fish consumption. These advisories are habitat and species specific. 2004 guidelines:
Little Satilla River / Jekyll Sound - no advisories
Satilla River/ St Andrews Sound - no advisories
St Marys River/ Cumberland Sound - Largemouth bass consumption advisory due to mercury: 1 meal /week recommended limit.
Atlantic Ocean offshore Georgia - King Mackerel consumption advisory due to mercury: 1 meal /week recommended limit for fish with fork length of 33-39 inches (1 meal /month for

pregnant women, nursing mothers and children aged 12 and younger). Fish over 39 inches should not be eaten. Fish with a fork length of 24-32 inches have no consumption restrictions.

Georgia DNR. 2005. Coastal Resources Division Website. Georgia Department of Natural Resources, Coastal Resources Division. http://crd.dnr.state.ga.us
Summary: The website includes information on these areas: Coastal Management Program (about GCMP, Coastal Advisory Council, grant program, marsh dieback, marsh hammocks, technical assistance, water quality), Commercial Fishing (announcements, blue crab, industry newsletters, landings and licensing statistics, meetings, regulations, studies), Saltwater Recreational Fishing (artificial reefs, boating information, fisheries management , fishing education and information, fishing licenses & regulations, freshwater fishing information, research projects), Current Events (blue crab fishery crisis, career opportunities, coastal resources events, press releases, public hearings/meetings), Education and Outreach (beaches, coastal critters, CoastFest, Earth Day nature trail & pavilion, Georgia Sound newsletter, publications & TV programs), General Information (citizen advisory groups/committees, coastal links, contacts, CRD mailing list, directions to CRD, trouble shooting PDF files, website policies), Laws and Regulations (beach driving rules, Coastal Marshlands Protection Act, federal consistency regulations, Shore Protection Act), Permits and Public Notices (public notices, pending projects, beach driving, dock permits, federal consistency, marsh permits, revocable licenses & nationwide permits, shore permits, when a permit is needed).

Georgia DNR - Wildlife Resources Division. Special concern plant species in Georgia. http://www.georgiawildlife.com/content/specialconcernplants.asp
Summary: This list gives scientific and common name, global and state rank, federal and state status, and a brief description of the habitat in Georgia where these plants are found.

Georgia DNR - Wildlife Resources Division. 2004. Nongame animals and plants website. http://georgiawildlife.dnr.state.ga.us/content/displaycontent.asp?txtDocument=89
Keywords: Endangered species, threatened species, protected species, ESA
Summary: Georgia Rare Species Information was compared the list to plants and animals expected to occur at Cumberland Island (based on NPS management documents).

Georgia DNR - Wildlife Resources Division. 2004. Hunting website. http://georgiawildlife.dnr.state.ga.us/content/displaynavigation.asp?TopCategory=81
Keywords: hunting
Summary: Public hunting permit applications, license information, education, survey information and hunting regulations are available.

Georgia DNR Environmental Protection Division. 2000. Combined databases of landfills in Georgia; historic and current through 1999. Atlanta, GA.

Georgia DNR Environmental Protection Division. 2002. State of Georgia 305(b)/303(d) List for the Year 2000. Atlanta, GA.

Georgia DNR-EPD. 2004. Fish tissue contamination database.

Summary: The annual Fish Consumption Guidelines are determined (wholly or in part) by the detection of contaminants in fish tissues, as tested by the Georgia DNR Environmental Protection Division.

Georgia EPD. 1986. The North/St. Marys River Project: Recommendation and analysis of options with respect to the existing North River water quality classification. Department of Natural Resources, Atlanta.
Keywords: designated use, reclassification
Summary: Under recommendation by EPD, the classification of the North River in St Marys, Georgia was changed from "industrial" to "fishing". North River salinity, DO, and BOD were monitored in September 1985 so that computer modeling could be used to predict river conditions under several management options. The final strategy included moving the location of the Gilman plant's wastewater discharge.

Georgia EPD. 2000. Emergency response team spill report search page. Georgia Department of Natural Resources, Environmental Protection Division.
http://dnrnet.dnr.state.ga.us/pls/ert/ert.q_field
Summary: Environmental Releases, "Georgia's Environment" web page
Emergency Response Team activities may be searched by site visitors. Results include: the date, spill number, facility/incident name, location, material spilled, waterway impacted, type of action, and to which agency the incident was referred.
A Camden County search showed 318 incidents between May 1990 and September 2000.

Georgia EPD. 2002. Satilla River Basin Management Plan. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Keywords: Satilla, designated use
Summary: The document includes information on: the characteristics of the river basin (water resources, biological resources, population and land use); water quantity and water quality conditions. Water quality information covers nonpoint and point sources of pollution (municipal, industrial, and permitted storm water discharges), designated use support, key environment stressors (dissolved oxygen, fecal coliform contamination, metals, nutrients, fish tissue contamination, flow / temperature modification, sediment loading and other forms of habitat degradation. Impairments are listed (CWA 303b and 305d), and strategies for water supply and quality are discussed. The appendix also includes the River Basin Planning Act, the Georgia Instream Water Quality Standards, Point Source Control Efforts, list of NPDES permitted discharges in the basin, and the Support of Designated Uses for Rivers, Streams, Lakes (and Estuaries) in the Satilla River Basin, 1998-1999.
Quoting from Executive Summary: "This [EPD] assessment indicated that 6 out of 44 stream segments (64 miles) supported uses, and 8 out of 64 (165 miles) partially supported uses, while 19 out of 64 (212 miles) did not support designated uses. A number of estuarine areas also failed to fully support designated uses." "...urban runoff and rural nonpoint sources are now the major sources of failure to support designated uses of water bodies in the Satilla basin."
Municipal discharges were identified as a contributing factor in the 1998-1999 assessment wherein two estuarine areas (77 square miles) were found "failing to support designated uses". TMDL's were established for those areas in 2001. In addition, three major industrial point sources were cited as the possible cause for the failure to support designated uses of seven

other estuarine areas (205 square miles) - industrial discharges identified as a contributing factor. TMDL's were also established for those areas.
Notes: 11 separate files on EPD website (see Watershed Information)
http://www.dnr.state.ga.us/dnr/environ/

Georgia EPD. 2002. Saint Marys River Basin Management Plan. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Keywords: Saint Marys
Summary: (quoting from Executive Summary) "This [EPD] assessment indicated 5 out of 9 (102 miles) partially supported uses, while 4 out of 9 (20 miles) did not support designated uses." "The primary source of pollution that continues to affect waters of the St. Marys River basin results from nonpoint sources..." The document includes information on: the characteristics of the river basin (water resources, biological resources, population and land use); water quantity and water quality conditions. Water quality information covers nonpoint and point sources of pollution (municipal, industrial, and permitted storm water discharges), designated use support, key environment stressors (dissolved oxygen, fecal coliform contamination, metals, nutrients, fish tissue contamination, flow / temperature modification, sediment loading and other forms of habitat degradation. Impairments are listed (CWA 303b and 305d), and strategies for water supply and quality are discussed. The appendix also includes the River Basin Planning Act, the Georgia Instream Water Quality Standards, Point Source Control Efforts, list of NPDES permitted discharges in the basin, and the Support of Designated Uses for Rivers, Streams, Lakes (and Estuaries) in the Saint Marys River Basin, 1998-1999.
Notes: 11 separate files on EPD website (see Watershed Information)
http://www.dnr.state.ga.us/dnr/environ/

Georgia EPD. 2003. Hazardous Site Inventory -- #10647 Camden County Vacuna Road Landfill. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: This site has a known release of vinyl chloride in groundwater at levels exceeding the reportable quantity. No human exposure via drinking water is suspected from this release. The nearest drinking water well is less than 0.5 miles from the area affected by the release. Other substances in groundwater: cadmium; benzene.
Notes: http://www.dnr.state.ga.us/dnr/environ/gaenviron_files/hazwaste_files/hsi_600-699.pdf

Georgia EPD. 2003. Hazardous Site Inventory -- #10093 U.S. Naval Submarine Base, King's Bay. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: "This site has a known release of Vinyl chloride in groundwater at levels exceeding the reportable quantity. This release has resulted in suspected human exposure. Other substances in groundwater: Ethylbenzene; Toluene; Xylenes; p-Dichlorobenzene; Chloroethane; Methyl chloride; Trichloroethene; Tetrachloroethene; Chloroform; Chlorobenzene.
This site has a known release of Vinyl chloride in soil at levels exceeding the reportable quantity. This site has limited access. The nearest resident individual is less than 300 feet from the area affected by the release. Other substances on site: Xylenes; Acetone."

Notes: http://www.dnr.state.ga.us/dnr/environ/gaenviron_files/hazwaste_files/hsi_1-99.pdf

Georgia EPD. 2003. Hazardous Site Inventory -- #10282 4th Street Landfill (Brunswick Airport). Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: "This site has a known release of Lead in groundwater at levels exceeding the reportable quantity. No human exposure via drinking water is suspected from this release. The nearest drinking water well is less than 0.5 miles from the area affected by the release.
This site has a known release of Lead in soil at levels exceeding the reportable quantity. This site has limited access. The nearest resident individual is between 301 and 1000 feet from the area affected by
the release."
Notes: http://www.dnr.state.ga.us/dnr/environ/gaenviron_files/hazwaste_files/hsi_10200-10299.pdf

Georgia EPD. 2004. Georgia toxics release inventory report (for reporting year 2002). Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA. http://www.dnr.state.ga.us/dnr/environ/gaenviron_files/ertspill_files/gatri_rpt_2002.pdf
Summary: (Paraphrasing from document) "Since 1988, EPD has compiled information about the presence and release of toxic chemicals in communities within Georgia. Facilities must file for each listed chemical that is manufactured, processed or otherwise used above the threshold limits in a calendar year. The facility must report information such as: physical address of the facility, contact person for questions on the reported information, on-site uses of the chemicals documented in the report, maximum quantities on-site, estimated amounts released to the environment, accidental release quantities, or one time events not associated with production events, quantities of chemicals transferred off-site (for recycling, energy recovery, treatment, or disposal), source reduction activities, and quantities of chemicals treated or recycled on-site."

Georgia EPD. 2004. Environmental radiation monitoring report (2000-2002), Naval Submarine Base, Kings Bay. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
http://www.dnr.state.ga.us/dnr/environ/gaenviron_files/radiation_files/radrpt2002_kbs.pdf
Summary: The 2000-2002 Environmental Radiation monitoring report shows no inordinately high dosimetry readings in the area. Several of the monitoring stations on or near Cumberland Island have been abandoned due to access or security concerns

Georgia EPD. 2004. Hazardous Site Inventory -- #10069 Atlanta Gas Light Company - Brunswick MGP Site. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: "This site has a known release of Benzene in groundwater at levels exceeding the reportable quantity. No human exposure via drinking water is suspected from this release. The nearest drinking water well is between 0.5 and 1 miles from the area affected by the release. Other substances in groundwater: 2,4-Dimethylphenol; o-Cresol; p-Cresol; Acenaphthylene; Anthracene; Barium; Benzene; bis(2-Ethylhexyl) phthalate; Cadmium; Chromium; Copper;

Di-n-octyl phthalate; Dieldrin; Diethyl phthalate; Ethylbenzene; Fluoranthene; Fluorene; Heptachlor; Naphthalene; Nickel; Phenol; Pyrene; Selenium; Silver; Toluene; Acetone; Xylenes. This site has a known release of Benzo(a)pyrene in soil at levels exceeding the reportable quantity. This site has unlimited access. The nearest resident individual is less than 300 feet from the area affected by the release. Other substances on site: 2,4-Dimethylphenol; 2,6-Dinitrotoluene; o-Cresol; p-Cresol; Acenaphthylene; Anthracene; Barium; Benzene; Benzo(a)anthracene; Benzo(b)fluoranthene; Benzo(ghi)perylene; Benzo(k)fluoranthene; Cadmium; Chromium; Copper; Dichloromethane; Ethylbenzene; Fluoranthene; Fluorene; Indeno(1,2,3-cd)pyrene; Lead; Mercury; Naphthalene; Nickel; PCBs; Pentachlorophenol; Pyrene; Styrene; Toluene; Xylenes; Zinc; Arsenic; Acetone; Carbon disulfide; Antimony; Chrysene; Dibenzo(a,h)anthracene; Beryllium; Acenaphthene."
Notes: http://www.dnr.state.ga.us/dnr/environ/gaenviron_files/hazwaste_files/hsi_1-99.pdf

Georgia EPD. 2004. Hazardous Site Inventory -- #10399 Atlantic Engineered Products (Former), Sterling Industrial Park. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: "This site has a known release of 1,1-Dichloroethene in groundwater at levels exceeding the reportable quantity. No human exposure via drinking water is suspected from this release. The nearest drinking water well is less than 0.5 miles from the area affected by the release. Other substances in groundwater: Toluene; 1,1,1-Trichloroethane; 1,1-Dichloroethane."

Georgia EPD. 2004. Hazardous Site Inventory -- #10317 T Street Dump. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: "This site has a known release of Lead in groundwater at levels exceeding the reportable quantity. No human exposure via drinking water is suspected from this release. The nearest drinking water well is between 2 and 3 miles from the area affected by the release. Other substances in groundwater: Arsenic; Cadmium; Chromium; Cyanides (soluble salts and complexes) n.o.s.; m-Xylene; p-Xylene; Ethylbenzene; Mercury; Dichloromethane; Nickel; Selenium; Toluene; Trichlorofluoromethane; bis(2-Ethylhexyl) phthalate; Aroclor 1254. This site has a known release of Lead in soil at levels exceeding the reportable quantity. This site has unlimited access. The nearest resident individual is between 1001 and 3000 feet from the area affected by the release. Other substances on site: Arsenic; Cadmium; Chromium; Cyanides (soluble salts and complexes) n.o.s.; Mercury; Nickel; Selenium; Toluene; bis(2-Ethylhexyl) phthalate; Antimony."

Georgia EPD. 2004. Hazardous Site Inventory -- #10251 Chemresol. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: "This site has a known release of Cadmium in groundwater at levels exceeding the reportable quantity. No human exposure via drinking water is suspected from this release. The nearest drinking water well is less than 0.5 miles from the area affected by the release. Other substances in groundwater: Lead. This site has a known release of Dioxin in soil at levels exceeding the reportable quantity. This site has unlimited access. The nearest resident individual is between 301 and 1000 feet from the area affected by the release. Other substances on site: Zinc."

Georgia EPD. 2004. Hazardous Site Inventory -- #10242 Terry Creek Dredge Spoil Area. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: "This site has a known release of Toxaphene in soil at levels exceeding the reportable quantity. This site has unlimited access. The nearest resident individual is between 301 and 1000 feet from the area affected by the release."

Georgia EPD. 2004. Hazardous Site Inventory -- #10028 Escambia Treating Company - Brunswick. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: "This site has a known release of Arsenic in groundwater at levels exceeding the reportable quantity. No human exposure via drinking water is suspected from this release. The nearest drinking water well is less than 0.5 miles from the area affected by the release. Other substances in groundwater: Benzene; Dichlorobromomethane; Chloroform; Dibromochloromethane; Ethylbenzene; Methyl ethyl ketone; Tetrahydrofuran; Toluene; m-Xylene; o-Xylene; p-Xylene; p-Dichlorobenzene; Barium; Zinc; 2,4-Dimethylphenol; bis(2-Ethylhexyl) phthalate. This site has a known release of Arsenic in soil at levels exceeding the reportable quantity. This site has limited access. The nearest resident individual is between 301 and 1000 feet from the area affected by the release. Other substances on site: Benzene; Dichlorobromomethane; Chloroform; Dibromochloromethane; Ethylbenzene; Methyl ethyl ketone; Tetrahydrofuran; Toluene; m-Xylene; o-Xylene; p-Xylene; p-Dichlorobenzene; Barium; Zinc; 2,4-Dimethylphenol; bis(2-Ethylhexyl) phthalate; Pentachlorophenol; Creosote."
Notes: http://www.dnr.state.ga.us/dnr/environ/gaenviron_files/hazwaste_files/hsi_1-99.pdf

Georgia EPD. 2004. Hazardous Site Inventory -- #10665 Glynn Co. - Cate Road C&D MSWLF. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: "This site has a known release of Vinyl chloride in groundwater at levels exceeding the reportable quantity. No human exposure via drinking water is suspected from this release. The nearest drinking water well is less than 0.5 miles from the area affected by the release."

Georgia EPD. 2004. Hazardous Site Inventory -- #10156 Federal Law Enforcement Training Center. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: "This site has a release of Lead that exceeds a reportable quantity because it has the potential to contaminate groundwater. The nearest drinking water well is less than 0.5 miles from the area affected by the release. This site has a known release of Lead in soil at levels exceeding the reportable quantity. This site has limited access. The nearest resident individual is between 1001 and 3000 feet from the area affected by the release."

Georgia EPD. 2004. Hazardous Site Inventory -- #10144 LCP Chemicals - NPL Site. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: "This site has a known release of Mercury in groundwater at levels exceeding the reportable quantity. No human exposure via drinking water is suspected from this release. The nearest drinking water well is between 0.5 and 1 miles from the area affected by the release.

This site has a known release of PCBs in soil at levels exceeding the reportable quantity. This site has limited access. The nearest resident individual is between 1001 and 3000 feet from the area affected by the release. Other substances on site: Mercury; Pentachlorophenol; Chloroform; Trichloroethene; Tetrachloroethene; Hexachloroethane; Hexachlorobenzene; Dieldrin; Lead; Chromium; Barium; Silver; Toluene; Ethylbenzene; Xylenes; Naphthalene. Releases of Mercury and PCBs at this site have caused bioaccumulation in fish and shellfish that has resulted in the need to recommend that human consumption be limited. A cleanup and investigation have been initiated at this site, pursuant to a CERCLA 106 removal order issued by U.S.EPA. The site is listed on the National Priority List."

Georgia EPD. 2004. Hazardous Site Inventory -- #10769 Lanier Shopping Plaza. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: "This site has a known release of Vinyl chloride in groundwater at levels exceeding the reportable quantity. No human exposure via drinking water is suspected from this release. The nearest drinking water well is between 0.5 and 1 miles from the area affected by the release. Other substances in groundwater: Tetrachloroethene; Trichloroethene; Vinyl chloride; 1,2-Dichloroethane. This site has a known release of Tetrachloroethene in soil at levels exceeding the reportable quantity. This site has unlimited access. The nearest resident individual is between 301 and 1000 feet from the area affected by the release. Other substances on site: Tetrachloroethene; Benzene; 1,1-Dichloroethene; Ethylbenzene; Trichloroethene; Toluene; Xylenes; 1,2-Dichloroethane."

Georgia EPD. 2004. Hazardous Site Inventory -- #10587 Transco Railcar Facility (Former). Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA.
Summary: "This site has a known release of PCBs in soil at levels exceeding the reportable quantity. This site has unlimited access. The nearest resident individual is less than 300 feet from the area affected by the release. Other substances on site: Lead."

Georgia Humanities Council. 2004. The New Georgia Encyclopedia. University of Georgia Press. http://www.georgiaencyclopedia.org/nge/Home.jsp

Georgia Museum of Natural History and Georgia Department of Natural Resources. 2000. Georgia Wildlife Web. http://museum.nhm.uga.edu/gawildlife/gaww.html
Keywords: mammals, birds, reptiles, amphibians, Georgia, taxonomy, habitat, natural history
Summary: (from mission statement) "The purpose of this website is to provide information concerning the common species of mammals, birds, reptiles, and amphibians found in the state of Georgia. Each species has a home page which contains a description of the animal; its taxonomic relationships; information about the animal's biology, natural history, distribution, and conservation status; and a review of similar animals which might be confused with it. These pages are intended for use by the general public in the identification and study of the natural history of Georgia."

Georgia State Legislature. 1970. Coastal Marshlands Protection Act of 1970. In Official Code of Georgia Annotated (OCGA).
Summary: Code states "The General Assembly finds and declares that the coastal marshlands of Georgia comprise a vital natural resource system. It is recognized that the estuarine area of

Georgia is the habitat of many species of marine life and wildlife and, without the food supplied by the marshlands, such marine life and wildlife cannot survive. The General Assembly further finds that intensive marine research has revealed that the estuarine marshlands of coastal Georgia are among the richest providers of nutrients in the world. Such marshlands provide a nursery for commercially and recreationally important species of shellfish and other wildlife, provide a great buffer against flooding and erosion, and help control and disseminate pollutants. Also, it is found that the coastal marshlands provide a natural recreation resource which has become vitally linked to the economy of Georgia's coastal zone and to that of the entire state. The General Assembly further finds that this coastal marshlands resource system is costly, if not impossible, to reconstruct or rehabilitate once adversely affected by man related activities and is important to conserve for the present and future use and enjoyment of all citizens and visitors to this state. The General Assembly further finds that the coastal marshlands are a vital area of the state and are essential to maintain the health, safety, and welfare of all the citizens of the state. Therefore, the General Assembly declares that the management of the coastal marshlands has more than local significance, is of equal importance to all citizens of the state, is of state-wide concern, and consequently is properly a matter for regulation under the police power of the state. The General Assembly further finds and declares that activities and structures in the coastal marshlands must be regulated to ensure that the values and functions of the coastal marshlands are not impaired and to fulfill the responsibilities of each generation as public trustees of the coastal marshlands for succeeding generations."

Georgia State Legislature. 1970. Coastal Marshlands Protection Act of 1970. In Official Code of Georgia Annotated (OCGA).

Summary: Code states "No person shall remove, fill, dredge, drain, or otherwise alter any marshlands or construct or locate any structure on or over marshlands in this state within the estuarine area thereof without first obtaining a permit from the committee or, in the case of minor alteration of marshlands, the commissioner." The code further describes the procedures for permit application, review, and action.

Gopher Tortoise Council. 2002. Position statement on tortoise relocation. http://www.gophertortoisecouncil.org/reloc_position.pdf

Summary: (from source) "This position statement was prompted by recent discussions within the Gopher Tortoise Council, a group of concerned scientists and laypersons working to conserve and manage the gopher tortoise (Gopherus polyphemus). Our primary goal is to preserve resident gopher tortoise populations in intact, managed, native habitats. However, because of the widespread occurrence of upland habitat destruction and its resulting impact on gopher tortoise populations, we must address the issue of tortoise translocation. The objectives of this statement are to define translocation, as it applies to the gopher tortoise, and to outline scenarios where we should support (or not support) this endeavor."

Gore, J., U. Rai, D. Hughes, J. Mehaffey and G. Williams. 2004. Ecoregion Reference Site Project - Phase IV. Columbus State University and Georgia Dept of Natural Resources - Environmental Protection Division.

Summary: (paraphrased from April 2002 application for permit to collect samples at Cumberland Island) "The Georgia Environmental Protection Division has begun a multi-phase project to

develop biological criteria for wadable streams. The primary objective of Phase I (the Georgia Ecoregion/Subecoregion Delineation and Reference Site Selection) was to develop a useful, general-purpose, geographical framework that categorizes large sections of Georgia into logical units of similar geology, physiography, soils, vegetation, land use/land cover, and water quality. Phase II focused on (1) developing land use judgment criteria for candidate reference sites in level IV ecoregions that were delineated in Phase I, and (2) conducting an intensive sampling of the reference sites. Characterization of resident biota inhabiting those reference sites established baseline, best attainable reference conditions representative of each level IV ecoregion. The objective of Phase III was to identify trends and establish a numerical scoring system (i.e., biological criteria for macroinvertebrates) and to validate the results. The objective of Phase IV is the verification and validation of the numerical scoring system, as well as the development of a defensible system for applying the numerical scoring system to evaluate the health of other streams in Georgia."

Notes: Field datasheets for three study locations on Cumberland Sound were obtained: White Branch Creek, site 1 (30º 50m 44.434s x 81º 27m 36.258s), White Branch Creek "QC", site 2 (30º 50m 43.215s x 81º 27m 36.258s), Tributary to Brickhill River (30º 52m 44.851s x 81º 26m 07.012s). Habitat parameters characterized included: epifaunal substrate/ available cover, pool substrate, pool variability, sediment deposition, channel flow status, channel alteration, channel sinuousity, bank stability, vegetative protection, riparian vegetative zone width, stream type, stream features (depth, width, estimated reach, high water mark, canopy cover, evidence of nonpoint source pollution), water quality (temperature, specific conductance, dissolved oxygen, pH, turbidity), and macroinvertebrates present. The latter were collected with D-frames by wading.

Gorman, L. T. 1991. Assessment of the nearshore zone at St. Mary's inlet, Florida. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.

Keywords: wave height, wave period, grain size, bathymetry

Summary: Daily field measurements were made at three offshore sites in the St. Marys inlet. The 18 m site (a National Data Buoy Center site) was monitored from March 1988 to March 1992. A pressure-orbital velocity device was in place at the 8 m site during May 1989. The Amelia Island slope array at 10 m was used from April 1989 to May 1990. Sediment samples were also collected at selected locations and bathymetry profiles were made from the shoreline to the -10m contour. Wave height in the area was given as 0.27 - 1.76 m, with a period of 4.3 - 14.2 seconds. Sediment data suggested that grain size decreased between August 1988 and 1989. Analysis of the bathymetry profiles showed 3 large sediment storage areas and two embayments where sediment moved along and offshore.

Griffin, M. M. 1991. Geologic Guide to Cumberland Island National Seashore. GA DNR, Environmental Protection Division, and Georgia Geologic Survey, Geologic Guide, Atlanta, GA.

Keywords: trail guide, geology, sand, dune, soil, aquifer

Summary: This pamphlet is a geologically oriented trail guide starting from the visitors station (maritime forest), and guiding visitors through the boardwalk at Sea Camp, dune fields, the beach zone, Dungeness Beach, the jetty, Dungeness wells, Indian middens, salt marsh, dredge spoil, and the back barrier environment.

Gustafson, D. L. 2003. Environmental statistics group - hydrologic unit project: Cumberland-St. Simons -- cataloging unit 03070203. http://www.esg.montana.edu/gl/huc/03070203.html
Summary: This website includes graphical locater maps, flow connections information, a list of named places in the watershed, elevation analysis, and map line analysis.

Hall, C. 1991. Movement ecology of white-tailed deer and feral horses with observations on behavior of mares and foals on Cumberland Island, Georgia. M.S., University of Georgia, Athens, Georgia.
Keywords: feral horse, Equus caballus, white-tailed deer, Odocoileus virginianus, behavior
Summary: (from Chapter 1, Introduction) "This study was conducted to evaluate 1) mare / foal behavior (foal nursing rate, foal activity-time budget, mare-to-foal spatial relationships, mare movements in response to her recumbent foal, and maternal aggression toward foals) of feral horses on Cumberland Island; and 2) seasonal, nocturnal / diurnal, and annual movement rates and home-range sizes of feral horses and white-tailed deer on Cumberland Island; and to assess the spatial and temporal overlap of home ranges between these two species to estimate interspecific competition." Among the author's conclusions (Chapter 4) were that "...there was little or no competition for available resources between these two sympatric ungulates."
Notes: repository of UGA Science Library

Handlers, G. and S. Brand. 2004. Hurricane Haven -- Kings Bay. Science Applications International Corp. (G.H.) and Naval Research Laboratory (S.B.). https://www.cnmoc.navy.mil/nmosw/tr8203nc/kingsbay/text/frame.htm
Keywords: hurricane, port operations, Kings Bay
Summary: (from main handbook Introduction) "This Handbook provides guidance for assessing a hurricane threat's circumstances and likely impact on the given port to support decision-makers' reasonable choice between either remaining in port or evading at sea. This choice is based on informed compromise between a harbor's protective qualities, and the possibility that a sortie will prove to have been unnecessary." The Kings Bay section has useful descriptions of the site location, topography, weather history, harbor and facilities.

Harris, J. and Georgia EPD. 2004. Kingsland water pollution control plant - NPDES # GA0037800.
Keywords: NPDES, wastewater, monitoring
Summary: As per a CWA permit, Kingsland water pollution control plant has been monitored monthly. Permitted limits for the effluent are listed as: BOD, chlorine, pH, TSS, flow volume, ammonia, DO. The influent is also monitored for BOD, TSS, and fecal coliform. % removal BOD, TSS are calculated.
Notes: Monitoring reports are held at GA EPD Brunswick office.

Harris, J. and Georgia EPD. 2004. Saint Marys water pollution control plant - NPDES # GA0026255.
Keywords: NPDES, wastewater, monitoring
Summary: As per a CWA permit, St Marys water pollution control plant has been monitored monthly. Permitted limits for the effluent are listed as: BOD, chlorine, pH, TSS, flow volume,

ammonia and DO. The influent is also monitored for BOD, TSS and fecal coliform. % removal BOD and TSS are calculated.
Notes: Monitoring reports are held at GA EPD Brunswick office.

Harris, J. and Georgia EPD. 2004. Woodbine water pollution control plant - NPDES # GA0023701.
Keywords: NPDES, wastewater, monitoring
Summary: As per a CWA permit, the Woodbine water pollution control plant has been monitored monthly. Permitted limits for the effluent are listed as: BOD, chlorine, pH, TSS, flow volume and DO. The influent is also monitored for BOD, TSS and fecal coliform. % removal BOD and TSS are calculated.
Notes: Monitoring reports are held at GA EPD Brunswick office.

Harris, J. and Georgia EPD. 2004. River Oaks facility - NPDES # GA0023701.
Keywords: NPDES, wastewater, monitoring
Summary: As per a CWA permit, the River Oaks facility is monitored for BOD, TSS, pH, and flow only when there is a discharge. This is a small facility.
Notes: Monitoring reports are held at GA EPD Brunswick office.

Harris, J. and Georgia EPD. 2004. Durango Georgia Paper plant - NPDES # GA001953.
Keywords: NPDES, wastewater, monitoring
Summary: As per a CWA permit, the Durango-Georgia Paper plant final effluent was monitored daily for: BOD, TSS, pH, and flow; and weekly for color, when the plant was shut down in October 2002.
Notes: Monitoring reports are held at GA EPD Brunswick office.

Harris, J. and Georgia EPD. 2004. Bayer (Aventis) Cropscience, spray irrigation area - NPDES # GA0003468.
Keywords: NPDES, wastewater, monitoring
Summary: As per a CWA permit, the Bayer (Aventis) Cropscience spray irrigation area near Floyd Creek (Camden Co, Georgia) has been monitored. Washdown water from Bayer's aldicarb manufacturing plant is treated by alkaline hydrolysis and then sprayed in a test area. This area is then sampled for the presence of aldicarb in the soil, and in animal and plant tissue collected from the site.
Notes: Monitoring reports are held at GA EPD Brunswick office.

Herndon, J. G. 1991. The hydrogeology of southern Cumberland Island, Georgia. Research Resources Management Report SER-91/04.
Keywords: groundwater, salinity
Summary: (paraphrased from source) A hydrogeologic investigation of the Pliocene-Miocene aquifer was conducted to determine the effect of channel dredging on groundwater quality. 10 wells were drilled in two clusters of three wells (on the southern coast) and one cluster of four wells (located north and inland). Water-level measurements during high tide indicate that the horizontal gradient of the surficial aquifer was toward the SW and the Pliocene-Miocene aquifer was toward the W. Transmissivity of the P-M aquifer ranged from 235 to 650 ft squared per day, the hydraulic conductivity ranged from 34 to 94 ft per day, the storage

coefficient ranged from 1.05 x 10exp-5 to 5.6 x 10exp-5, and the diffusivity ranged from 5.9 x 10exp3 to 3.5 x 10exp7 ft squared per day. Test data showed lateral and vertical heterogeneities in the aquifer. The seepage velocity of the P-M aquifer ranged from 0.049 to 0.085 ft per day. The surficial aquifer was in a steady-state condition with constant long-term recharge, equivalent discharge, and no appreciable withdrawals due to pumping. Analysis of hydraulic data suggests that intrusion of sea water from the channel into the P-M aquifer was insignificant.
Notes: The author was a 1991 M.S. graduate, Department of Geology (Dr. Ram Arora), Georgia State University. This report is very likely her thesis.

Herndon, J. G. and S. V. Cofer-Shabica. 1991. Potential for seawater encroachment near Cumberland Island, GA. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.
Summary: June 1990, 3 wells at two sites on the south end of CUIS, and 4 wells at a third location (in Dungeness) were studied for possible saltwater contamination. The south end ponds had significant potential, but since they were not monitored prior to the channel alternation, it is unknown if this was a result of dredging or not.

Hillestad, H. O., J. R. Bozeman, A. S. Johnson, C. W. Berisford and J. I. Richardson. 1975. The Ecology of the Cumberland Island National Seashore, Camden County, Georgia. Georgia Marine Science Center Technical Report contract number 1910P21157. National Park Service contract to the Institute of Natural Resources, University of Georgia. http://nsgl.gso.uri.edu/gaus/gaust75003.pdf
Keywords: History, geology, soil, nutrients, water, vegetation, habitat, land use, fauna, mammals, birds, reptiles, amphibians, fish, invertebrates, management, erosion, fire, grazing, wildlife, feral animals, disease and parasites.
Notes: Very thorough examination of Cumberland Island ecology as it was in the early 1970's. However: 1) Animal species are listed (except for saltwater fish), but their habitats are not always given, 2) no water quality information is given.

Holland, A. F., D. M. Sanger, C. P. Gawle, S. B. Lerberg, M. S. Santiago, G. H. M. Riekerk, L. E. Zimmerman and G. I. Scott. 2004. Linkages between tidal creek ecosystems and the landscape and demographic attributes of their watersheds. Journal of Experimental Marine Biology and Ecology 298: 151-178.
Keywords: Tidal creeks; Impervious cover; Watershed development; Landscape indicators; Ecosystem responses; Nursery habitat
Summary: (from document) "Twenty-three headwater tidal creeks draining watersheds representative of forested, suburban, urban, and industrial land cover were sampled along the South Carolina coast from 1994 to 2002 to: (1) evaluate the degree to which impervious land cover is an integrative watershed-scale indicator of stress; (2) synthesize and integrate the available data on linkages between land cover and tidal creek environmental quality into a conceptual model of the responses of tidal creeks to human development; and (3) use the model to develop recommendations for conserving and restoring tidal creek ecosystems. The following parameters were evaluated: human population density, land use, impervious cover, creek physical characteristics, water quality, sediment chemical contamination and grain size

characteristics, benthic chlorophyll a levels, porewater ammonia concentration, fecal coliform concentration, and macrobenthic and nekton population and community characteristics."
Notes: available online at Science Direct

Hyland, J. L., L. Balthis, C. T. Hackney, G. McRae, A. H. Ringwood, T. R. Snoots, R. F. V. Dolah and T. L. Wade. 1998. Environmental quality of estuaries of the Carolinian Province: 1995. Annual statistical summary for the 1995 EMAP Estuaries Demonstration Project in the Carolinian Province. NOAA Technical Memorandum NOS ORCA 123. NOAA/NOS, Office of Ocean Resources Conservation and Assessment, Silver Spring, MD.
Summary: "A study was conducted to assess the environmental condition of estuaries in the EMAP Carolinian Province (Cape Henry, VA St. Lucie Inlet, FL). A total of 87 randomly located stations was sampled from July 5 September 14, 1995 in accordance with a probabilistic sampling design. Wherever possible, synoptic measures were made of: (1) general habitat condition (depth, physical properties of water, sediment grain-size, organic carbon content), (2) pollution exposure (sediment contaminant concentrations, sediment toxicity, low dissolved oxygen conditions in the water column, ammonia and sulfide in sediment porewater), (3) biotic conditions (diversity and abundance of macroinfauna and demersal biota, pathological disorders in demersal biota), and (4) aesthetic quality (presence of anthropogenic debris, visible oil, noxious sediment odor, water clarity). Percentages of degraded vs. undegraded estuarine area were estimated based on these various environmental indicators. The data also were compared to results of a related EMAP survey conducted in 1994 in this same region as part of a multi-year monitoring effort."

Hyland, J. L., T. J. Herrlinger, T. R. Snoots, A. H. Ringwood, R. F. V. Dolah, C. T. Hackney, G. A. Nelson, J. S. Rosen and S. A. Kokkinakis. 1996. Environmental quality of estuaries of the Carolinian Province: 1994. Annual statistical summary for the 1994 EMAP Estuaries Demonstration Project in the Carolinian Province. NOAA Technical Memorandum NOS ORCA 97. NOAA/NOS, Office of Ocean Resources Conservation and Assessment, Silver Spring, MD.
Summary: "A study was conducted in the Carolinian Province to identify the estuarine resources of this region and assess their condition based on a variety of synoptically measured indicators of environmental quality. The Carolinian Province, one of 12 coastal regions established under the nationwide Environmental Monitoring and Assessment Program (EMAP), extends from Cape Henry, Virginia through St. Lucie Inlet, Florida. Indicators used in this study included measures of: (1) general habitat condition (depth, physical properties of water, sediment grain-size and organic carbon content), (2) pollution exposure (sediment contaminants, sediment toxicity, low dissolved oxygen conditions), (3) biotic conditions (diversity and abundances of macroinfaunal and demersal species, pathologies in demersal biota), and (4) aesthetic quality (presence of anthropogenic debris, visible oil, noxious sediment odor, and water clarity). A stratified random sampling approach was incorporated to support probability-based estimates of the areal extent of degraded vs. undegraded resources."

Ingram, J. D. and D. V. Holt. 1982. Fishing locations and information, Camden County, Georgia. University of Georgia.
Summary: The map includes marina locations (and facilities) and a listing (by fishing location) of fish species, tidal stage, method, and season.

J. M. Nance (Editor), D. Foster, E. Martinez, T. McIlwain, J. Nance, S. Nichols, R. Raulerson, M. Schirripa, G. Scott, E. Scott-Denton, A. Shah and J. Watson. 1998. Southeastern United States Shrimp Trawl Bycatch Program. Report to Congress. National Marine Fisheries Service.
Keywords: BRD, TED, bycatch, trawling
Summary: (from Executive Summary), "NMFS, acting on behalf of the Secretary, has attempted to respond fully to the Congressional mandates to conclude and summarize the incidental harvest research program initiated in 1992 (Section 405 (a)-(d)), and to then prepare a detailed report on those activities (Section 405(e)). In doing so, it should be noted that three guiding principles have been consistently applied throughout this research program. First, priority attention has been given to ensure that the research program was scientifically sound in its design and implementation. To this end, NMFS' Southeastern Regional Office (SERO) and Fisheries Science Center (SEFSC) jointly developed and published a document entitled "Shrimp Trawl Bycatch Research Requirements." This document established scientific protocols for conducting onboard shrimp trawl bycatch characterization research, developing and testing bycatch reduction devices (BRDs), and evaluating various bycatch management options. These protocols were subjected to peer review by an industry-organized panel of researchers and statisticians and, upon approval, became the scientific foundation of the bycatch research program."

Jackson, C. and C. Alexander. 2005. Coastal Erosion Study of Cumberland Island, Georgia.
Summary: With NPS funding ("Geologist in the Park" support for C. Jackson), historical oceanfront shoreline images of Cumberland Island are being examined for the period between 1857 and 2002. A preliminary map of long-term erosion/accretion patterns along the the primary channel system on the backbarrier between 1933 and 2002 has been created. Initial results from the 1933 to 2002 analysis suggest that segments of the primary channels of the backbarrier are eroding at rates from 0.1 to 1.0 m yr^{-1}.

Knott, D. M. and R. A. King. *Petrolisthes armatus* - an introduced species in the South Atlantic Bight? Southeastern Regional Taxonomic Center.
http://www.dnr.state.sc.us/marine/sertc/P%20armatus%20SOM.pdf
Summary: A short report on natural history, habitat, and range of the porcelain crab in the Southeastern U.S.

Knowlton, M. K. 2004. Marine recreational finfish species commonly harvested in Georgia during 2003 (GA DNR- CRD).

Koransky, A. 1999. Brief Timeline of History on Cumberland Island.
http://koransky.com/Trip/History/CumberlandIslandGA/History.html

Kozel, T. R. 1991. Interdunal pond water quality and fish fauna. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.
Keywords: depth, fauna, water quality, water chemistry
Summary: Between April 1988 and May 1990, the depth, fauna and water chemistry of three South End CUIS ponds was assessed. Parameters included: temperature, DO, turbidity, color,

pH, conductivity, alkalinity, COD, TSS, ammonium, nitrate, nitrite, reactive phosphorus and salinity. The South End ponds were selected for the study because of their use for drinking water a habitat for the threatened wood stork (and other vertebrates) and their vulnerable location close to the dredging in Kings Bay.

Kramer, E., M. J. Conroy, M. J. Elliott, E. A. Anderson, W. R. Bumback and J. Epstein. 2003. A geographic approach to planning for biological diversity - the Georgia GAP analysis project. Final report Cooperative agreement no. 1434-HQ-97-RU-01551, research work order no. 44. U.S Department of the Interior, U.S. Geological Survey (Biological Resources Division), Institute of Ecology and Georgia Cooperative Fish and Wildlife Research Unit, University of Georgia. http://narsal.ecology.uga.edu/gap/pdf/georgia_report.pdf
Keywords: species richness, mapping, vertebrates, amphibians, birds, mammals, reptiles, land cover, gap analysis, management
Summary: (from Executive Summary) "Gap analysis is a scientific method for identifying the degree to which native animal species and natural communities are represented in our present-day mix of conservation lands...The purpose of the Gap Analysis Program (GAP) is to provide broad geographic information on the status of ordinary species (those not threatened with extinction or naturally rare) and their habitats in order to provide land managers, planners, scientists, and policy makers with the information they need to make better-informed decisions... The GA-GAP land cover contains forty-four classes... [and] we predicted distributions throughout Georgia for a total of 405 terrestrial vertebrate species. This included 78 amphibians, 167 breeding birds, 78 mammals, and 82 reptiles."

Kraus, N. C., L. T. Gorman and J. Pope. 1994. Kings Bay Coastal and Estuarine Physical Monitoring and Evaluation Program: Coastal Studies, vol 1. Technical Report CERC-94-9. U.S. Army Corps of Engineers, prepared for Office of the Chief of Naval Operations.
Keywords: Kings Bay, dredging, shoals, shoreline, channels, hydraulic engineering
Summary: (from source) "In the early 1980's, Kings Bay, Georgia, was selected as a U.S. Navy home port for TRIDENT submarines. In upgrading the Kings Bay base for this fleet, the navigation channels in Cumberland Sound and through St. Marys Entrance into the Atlantic Ocean had to be deepened and widened and the entrance channel lengthened... The coastal physical monitoring and evaluation study described in this report was preformed by elements of the U.S. Army Corps of Engineers for the Department of the Navy, Office of the Chief of Naval Operations, through the Naval Facilities Engineering Command. The study was conducted over the 5-year period 1 November 1987 to 30 September 1992 ...The report consists of two volumes. Volume I presents the main narrative, including study objectives, background information, procedures, and principal results ... Volume II describes the historical and field data sets and products generated and analyzed in the study."
Notes: Three Rivers Public Library System (Camden County)

Kumiski, C. J. 2000. Georgia's Coastal Gem. http://reel-time.com/feature/kumiski/cumberland
Summary: This is a feature article (with photos) on recreational fishing from the marshes or beaches of Cumberland Island. N.B. site requires user login

Lambert, C. L. 1992. Spatial vegetation dynamics of Lake Whitney: A freshwater wetland on Cumberland Island, Georgia. M. A. thesis, University of Georgia, Athens, Georgia.

Keywords: Lake Whitney, Cumberland Island, vegetation, GIS
Summary: Through vegetation maps dating from 1942, 1953, 1962, 1971, 1981 and 1988, the author compares species and type cover of Lake Whitney over time. Dune encroachment on the NE edge of this Lake is a concern: over 43 years, 7% of the lake has been filled with sand. However, it appears that some vegetative stabilization of the dunes is taking place, which will likely have the effect of slowly this process. The author also discusses the dynamics of fire on this area of the Island.
Notes: UGA Science library, LXC 15 1992.L222

Lauritsen, D. D. 1991. Dredging effects on the hard clam Mercenaria mercenaria in Cumberland Sound, Georgia. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.
Keywords: clam
Summary: Clams from south Cumberland had low growth rates during the 1987-1988 dredging period, and higher rates (faster than pre-dredging) in 1988-1989.

Lee, R. F. and M. E. Frischer. 2004. The decline of the blue crab. American Scientist 92(6): 548.
Keywords: Hematodinium, blue crab, parasite
Summary: (From publisher's website) "The blue crab, which is harvested by the millions every year, supports an important fishery along the Eastern and Gulf coasts of the United States. However, a recent crash in the blue crab population has devastated the commercial crab industry. The cause of this dramatic crash is now the subject of an intense investigation by ecologists and fishery scientists. There are hints that weather–related changes may be responsible. There is also evidence that a parasitic disease in blue crabs has become both more prevalent and more severe. Marine biologists Richard Lee and Marc Frischer have been studying these events along the coast of southeastern Georgia, a region that has been especially hard hit, to see whether the two phenomena might be related."

Leeth, D. C. and O. G. Holloway. 2000. Estuarine water-quality and sediment data, and surface-water and ground-water-quality data, Naval Submarine Base Kings Bay, Camden County, Georgia, January 1999. Open-File Report 00-75. U.S. Geological Survey (prepared in cooperation with the U.S. Department of the Navy, Southern Division Naval Facilities Engineering Command), Atlanta, Georgia.
http://wwwga.usgs.gov/pubs/ofr/ofr00-75/pdf/ofr00-75.pdf
Keywords: water quality, groundwater, sediment, metals, petrochemicals, halogens
Summary: Estuarine water and sediment data (five sites on the Crooked River, Kings Bay, and Cumberland Sound); plus surface-water (seven streams that discharge from Naval Submarine Base Kings Bay) and ground-water (six ground-water monitoring wells at Kings Bay, surficial aquifer). Samples were analyzed for nutrients, total and dissolved trace metals, total and dissolved organic carbon, oil and grease, total organic halogens, biological and chemical oxygen demand, and total and fecal coliform. Results: high levels of barium (but not exceeding EPA) and copper (exceeding GA DNR estuarine standards) were noted.

Lenarz, M. S. 1983. Population size, movements, habitat preferences, and diet of the feral horses of Cumberland Island National Seashore. CPSU Technical Report #3. National Park Service Cooperative Unit, Institute of Ecology, University of Georgia, Athens, Georgia.

Keywords: horse, habitat, vegetation
Summary: (from report) "The feral horses of Cumberland Island date back to at least the early part of this century and perhaps back to the mid-1700's. The current population included a minimum of 144 individuals and was divided into 24 family groups and 3 bachelor groups which were dispersed along the mainland side of the island. The horses were in good health and survival in most age classes was apparently high. The population was increasing at a minimum of five percent per year. Most of the horse groups were observed in one of five open habitats. Habitat use tended to be seasonal, with the salt marsh and lawn areas being most important during the spring, summer and fall. The grasslands and interdune meadows were more important during the winter months. The foredune habitats were used only sporadically. Although the remains of 32 different plant genera were found in the feces of these horses, only five of the genera [Eragrostis, Eremochloa, Spartina, Sporobolus and Unolia] were important throughout the year."
Notes: UGA Science library

Mack, J. B. 1994. Field investigation of saltwater intrusion Cumberland Island, Georgia. Technical Report. U.S. Department of the Navy (Naval Facilities Engineering Command) in cooperation with the National Park Service (U.S. Department of the Interior).
Keywords: groundwater, potentiometric surface maps
Summary: (paraphrased): A study of saltwater intrusion into the Pliocene-Miocene confined aquifer of Cumberland Island was conducted. A series of potentiometric surface maps was constructed, and analysis revealed the principal flow direction to be directly west in concert with ebb tides (with periodic cycling to the NE associated with part each of flood tidal cycle). Comparison of seismic profiles prior to dredging and Corps of Engineers coring and dredging data suggests that a naturally exposed outcrop of Miocene limestone was further exposed by dredging of the shipping channel. This exposed area is the likely origin of saltwater intrusion.

Martin, L. 1991. Potential for groundwater pumping from the Floridan aquifer on the mainland to affect wetlands on Cumberland Island. Memorandum. National Park Service, Water Resources Division.
Keywords: Floridan aquifer, well pressure, Cumberland
Summary: Paraphrasing from summary, "a letter sent to the Southeast Regional Director [of the NPS] alleges that groundwater pumping from the Floridan aquifer on the mainland in Georgia is the cause of perturbations to the hydrologic regime of wetlands on Cumberland Island. Having reviewed several reports from the USGS and Georgia Geologic Survey, I could find no corroborating evidence for this claim."
Included in this document are: well locations (with a good map), construction dates, monitoring dates, and useful well level information for 12 wells on Cumberland Island and 11 on Little Cumberland Island.

McBride, R. A., M. R. Byrnes and M. W. Hiland. 1995. Geomorphic response-type model for barrier coastlines: a regional perspective. Marine Geology 126: 143-159.
Keywords: barrier islands, shoreline change
Summary: (from document) "Based on quantitative documentation of historical changes in shoreline position between 1847 and 1991, eight geomorphic response-types were established for classifying megascale changes along barrier coastlines: (1) lateral movement, (2) advance,

(3) dynamic equilibrium, (4) retreat, (5) in-place narrowing, (6) landward rollover, (7) breakup, and (8) rotational instability. Long-term (decades to centuries) monitoring of shoreline position over a spatial scale of 10 to 100 km provides a scientific basis for documenting process-response relationships that shape regional coastal morphodynamics. Although megascale shoreline change studies often are lacking, this type of information is critical for developing realistic research and management strategies regarding form/process relationships in coastal depositional systems. The spatial distribution of geomorphic response-types is delineated along the barrier coastlines of Louisiana, Mississippi, and southern Georgia/northern Florida. At megascale, the rate of relative sea-level rise along these barrier coastlines appears to be one of the major factors controlling the occurrence of geomorphic response-types; however, sediment supply exerts significant influence on shoreline response as well." The study area included: Isle Dernieres, Bayou Lafourche, Chandeleur Islands (LA), the Mississippi Barrier Islands, Cumberland Island (GA), and Amelia Island (FL).

McConnell, J. B., D. B. Radtke, T. W. Hale and G. R. Buell. 1983. A preliminary appraisal of sediment sources and transport in Kings Bay and vicinity, Georgia and Florida. Water-resources investigations report 83-4060. U.S. Geological Survey (prepared in cooperation with the U.S. Navy), Doraville, Georgia.

Summary: (from document) "Water-quality, bottom-material, suspended-sediment, and current velocity data were collected in Kings Bay and vicinity to provide information on the sources and transport of estuarine sediments. Kings Bay and Cumberland Sound ... are experiencing high rates of sediment deposition and accumulation, which are causing serious operational and navigational problems. Data were collected between November 10-18, 1981, at cross sections in upper and lower Kings Bay, Cumberland Sound, and St. Marys Entrance. Additional water-quality data were collected at one consecutive low and high tide at 29 sites on November 15, 1981, to assess the potential suspended-sediment sources and to define salinity variation throughout the study area."

Menzel, D. W. (ed.) 1993. Ocean Processes: U.S. Southeast Continental Shelf -- A summary of research conducted in the South Atlantic Bight under the auspices of the U.S. Department of Energy from 1977 to 1991. U.S. Department of Energy, Office of Scientific and Technical Information, Savannah, GA.

Keywords: shelf, South Atlantic Bight, climatology, circulation, nutrients, environmental change, runoff, sea-level rise

Miller, J. E. 1993. A national perspective on feral swine. http://texnat.tamu.edu/symposia/feral/feral-5.htm

Summary: (from source summary) "Feral swine are well established in almost one half of the states in the United States. Considering their adaptability, reproductive capability, appeal to many hunters, and the difficulty and costs of control measures, it is likely that they will be with us for a long time. A review of the extensive research literature reveals that there have been many useful studies to help us learn more about these animals, yet we recognize the need to continue the search for better management tools and technologies. Land managers (private and public) continue to wrestle with the dilemma of management of feral swine."

Miller, J. H. 2003. Nonnative Invasive Plants of Southern Forests: A field guide for identification and control. Technical report SRS-62. U. S. Department of Agriculture, Forest Service, Southern Region, Asheville, NC. http://www.invasive.org/eastern/srs/
Summary: (excerpt) "The objective of this book is to provide information on accurate identification and effective control of the 33 plants or groups that are invading the forests of the 13 Southern States at an alarming rate, showing both growing and dormant season traits. It lists other nonnative invasive plants of growing concern and explains control recommendations and selective application procedures."

Miscellaneous. 1993. Proceedings of the Wood Stork Symposium, Savannah, Georgia. The Georgia Conservancy, 95 pp.
Notes: UGA Science Library, QL696.C535 W66 1993

Missouri Botanical Garden. 2004. Center for Plant Conservation, national collection of endangered plants website. http://www.centerforplantconservation.org/NC_Choice.html
Keywords: plants, native
Summary: Visitors to the site may search for plant profiles by species name. Profiles include information on habitat, growth, ecological relations, threats, distribution, protection, conservation, current research and references.

Monitoring, N. P. S.-I. a. 2005. Biological Inventories for the Southeast Coast Network. http://www.nature.nps.gov/im/units/secn/BiologicalInventories.htm
Summary: A number of NPS projects are underway at Cumberland Island National Seashore to create a biological inventory of the park. The status of these surveys (May 2005) was given on the NPS - Inventory and Monitoring (Southeast Coast Network) website as follows: reptiles, amphibians, and bird inventories have been completed and are awaiting certification while those for fish, small mammals, bats, and vascular plants are ongoing.

Montague, C. L., S. M. Bunker, E. B. Haines, M. L. Pace and R. L. Wetzel. 1981. Aquatic macroconsumers, p. 69-85. In Pomeroy, L. R. and R. G. Wiegert (eds.), The ecology of a salt marsh. Springer-Verlag, New York.

Musser, J. W. 1997. Digital raster graphic of Georgia, 1:100,000. http://csat.er.usgs.gov/
Summary: "The Digital Environmental Atlas of Georgia is a CD-ROM set published by the Georgia Department of Natural Resources, Environmental Protection Division, Geologic Survey Branch in cooperation with the U.S. Geological Survey. This CD-ROM set contains 38 digital map data sets covering the state of Georgia that will be useful to the general public, private industry, schools, and government agencies."

Nakashima, L. D. 1991. Marsh, mudflat and tidal creek assessment Cumberland Island National Seashore. Technical Report. U.S. Department of the Navy (Naval Facilities Engineering Command) in cooperation with the National Park Service (U.S. Department of the Interior).
Keywords: elevation, sediment
Summary: (paraphrased) Three permanent marsh study sties were selected in the southern half of Cumberland Island. The sites had comparable morphology, but differed in exposure to the Cumberland Sound, the St. Marys entrance, and the Intracoastal Waterway. Six field

techniques were employed to monitor the areal and vertical extent of erosion and accretion: field survey, sedimentation pins, clay-marker horizons, a sedimentation table, stable rare-earth tracers, and 137Cesium-dating. A marsh flume was also constructed. [*See final report*: Nakashima 1995, KBRPT 94/02.]

Nakashima, L. D. 1995. Marsh, mudflat and tidal creek assessment Cumberland Island National Seashore. Technical Report. U.S. Department of the Navy (Naval Facilities Engineering Command) in cooperation with the National Park Service (U.S. Department of the Interior).
Keywords: elevation, sediment
Summary: (paraphrased) Three permanent marsh study sties were selected in the southern half of Cumberland Island: south bank of Beach Creek (Raccoon Keys, CUIS, 3 km NW of St, Marys inlet), south bank of unnamed creek (6 km N of #1, near Greyfield dock), and south bank of unnamed creek (N of Old House Creek, 1.5 km N of #2 in lee of Stafford Island).
The sites had comparable morphology, but differed in exposure to the Cumberland Sound, the St. Marys entrance, and the Intracoastal Waterway. Six field techniques were employed to monitor the areal and vertical extent of erosion and accretion: field survey, sedimentation pins, clay-marker horizons, a sedimentation table, stable rare-earth tracers, and 137Cesium-dating. A marsh flume was also constructed. Data was collected between December 1989 and March 1994. Author's conclusions (paraphrased): The marshes and mudflats at Cumberland Island appear to be undergoing natural transgression; linear retreat of the marsh with a concomitant increase in marsh elevation combined with a eustatic rise in water level. This study suggests that the sedimentation rate of 7.5 (marsh) and 12.3 (mudflat) mm per year, exceeds the local sea-level rise of 1.6 mm per year for the area.

Nakashima, L. D., S. V. Cofer-Shabica, J. W. Day, R. Knaus, R. DeLaune, D. Reed, G. P. Kemp and E. H. Owens. 1991. Marsh/mudflat sedimentation, Cumberland Island, Georgia. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.
Keywords: sediment, field, pins, table, marker horizon, rare earth tracer, Cesium-137
Summary: Between Dec 1989 and August 1990, six methods for monitoring sedimentation were employed at 3 sites on CUIS. The methods were compared, and projections of overall rates were made.
Notes: Related document: technical report KBRPT-91/01

National Atmospheric Deposition Program. 2004. National Trends Network. http://nadp.sws.uiuc.edu/
Keywords: atmospheric deposition, nonpoint source pollution, long-term monitoring, precipitation
Summary: Atmospheric deposition data have been collected since 1978 through the inter-agency National Atmospheric Deposition Program /National Trends Network. Measured parameters include: calcium, magnesium, potassium, sodium, ammonium, nitrate, inorganic nitrogen (from ammonium and nitrate), chloride, sulfate, and hydrogen (calculated from both laboratory and field pH measurements). Data are collected daily, weekly, or monthly and are then summarized in an annual form for trend analysis.
The monitoring stations closest to CUIS are: Fort Frederica National Monument ([GA23], 31.2253 lat., -81.3922 long, 2 m elevation. National Park Service, Air Resources Division.

Operational from 9/1985 through 9/1988.), Sapelo Island ([GA33], 31.3961 lat., -81.2811 long, 3 m elevation. Georgia Department of Natural Resources. Operational since 11/2002), Okefenokee National Wildlife Refuge ([GA09], 30.7403 lat., -82.1286 long, 47 m elevation. U.S. Fish and Wildlife Service, Air Quality Branch. Operational since 6/1997), and Bradford Forest ([FL03], 29.9747 lat., -82.1981 long, 44 m elevation. St Johns River Water Management District and the University of Florida. Operational since 10/1978).

National Atmospheric Deposition Program. 2004. Mercury Deposition Network website. http://nadp.sws.uiuc.edu/mdn/
Keywords: mercury, St Marys, airshed
Summary: (from source) "The objective of the MDN is to develop a national database of weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition. The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors."

National Atmospheric Deposition Program. 2004. Mercury Deposition Network (NRSP-3) -- GA09 (Okefenokee National Wildlife Refuge). NADP Program Office, Illinois State Water Survey. http://nadp.sws.uiuc.edu/sites/siteinfo.asp?id=GA09&net=MDN
Keywords: mercury, St Marys, airshed, Okefenokee
Summary: Weekly mercury deposition data is available for download.
Okefenokee National Wildlife Refuge (GA09), Charlton County, Georgia. Dates of Operation 7/29/1997 - present. Latitude 30.7403, Longitude -82.1286, Elevation 47 meters. Operating Agency: U.S. Fish and Wildlife Service - Okefenokee National Wildlife Refuge.
Sponsoring Agency: U.S. Fish and Wildlife Service - Air Quality Branch.

National Audubon Society. 2002. Watchlist. http://www.audubon.org/bird/watchlist/index.html
Keywords: bird, conservation, population, distribution
Summary: (from website index page) "Audubon's WatchList 2002 is designed specifically to highlight those bird species that have the greatest conservation needs. Audubon and its partners work across the U.S. to identify and protect habitats that are critical to populations of WatchList species. Since many WatchList species winter south of the U.S., Audubon's Latin American and Caribbean program is helping to protect habitats throughout the hemisphere. At the same time, Audubon's BirdLife International partners are protecting threatened bird species across the hemisphere and all over the world."
The website has a search feature, allowing viewers to access species information (identification, distribution and population trends, ecology, threats, conservation activities).

National Park Service. 1997. Baseline water quality data inventory and analysis Cumberland Island National Seashore. Technical Report NPS/NRWRD/NRTR-97/104. National Park Service, Water Resources Division, Fort Collins, Colorado.
Keywords: water quality, Horizon report, StoRet
Summary: Also referred to as the "Horizon report" (after the consulting firm that created it), this is an automated gleaning of EPA's StoRet* database for the study area 3 miles upstream and 1 mile downstream of the park. Although there were 11,349 WQ observations in study area, there were no data in CUIS at any of the six StoRet stations which appeared in the database in

the period of record, Nov 1965 - Nov 1993. StoRet (the Storage and Retrieval water quality database management system) was queried Oct 1996, and the report dates from March 1997.
Databases included: River Reach File, Industrial Facilities Discharge, Drinking Water Supplies, Water Gages, and Water Impoundments information. This report also includes some useful maps of monitoring locations, discharges, gages, etc.

National Park Service. 2001. Draft Plans and Environmental Impact Statement (EIS) for Cumberland Island National Seashore. http://www.nps.gov/cuis/plan/
Keywords: wilderness, management plan, cultural resources (archaeology, history, preservation), natural resources (plants, animals, research), environmental impact statement
Summary: (from source) "The draft plans address wilderness management, commercial services, interpretation, and resource (cultural and natural) management." This report was required to address the lack of a management plan for the Cumberland Island Wilderness established in 1982. Appendix 4b includes excellent lists of the plants and animals of the island drawing heavily on Hillestad but including six other sources. The list of flora covers dicots, gymnosperms, monocots, pteridophytes (ferns and spleenworts), and one fungal species. For each species, checked columns indicate: "insufficient information", "questionable report", "identification questionable", "potentially present", "assumed present", "present", "specimen voucher", "published report/record", or "sighting report". Scientific and common names are given, as well as information source and federal and state status (threatened, endangered, etc). The list of fauna covers amphibians, reptiles, birds, mammals, spiders and insects listed by group / family. Unfortunately, fish are not included in this inventory and the tables do not identify which species might be considered non-native species at Cumberland Island (although hogs and horses are identified as feral).

National Park Service. 2004. Cumberland Island National Seashore (homepage). http://www.nps.gov/cuis/

National Park Service. 2004. Cumberland Island news on the Internet: Greyfield Inn special use permit. http://www.nps.gov/cuis/pphtml/newsdetail13476.html
Summary: Notice from Superintendent Jerre Brumbelow summarizing the actions of the NPS with respect to Greyfield Inn's interim permit authorizing specific commercial motorized tours on Cumberland Island: The owners of the Greyfield Inn have a permit to bring private tours into the Wilderness Area that is being re-examined. At present, the National Park Service has granted Greyfield a "one-year Special Use Permit authorizing commercial motorized tours only on the Main Road and Coleman Avenue (the access road to Dungeness Dock). The interim permit will not authorize commercial motorized tours on any other route in designated or Potential Wilderness at Cumberland Island National Seashore. NPS will continue to study whether it may issue a standard two-year permit that is more expansive in scope".

National Park Service. 2004. Project: Plug or Cap Abandoned Artesian Water Wells on Cumberland Island. Project Identification - PMIS 102374.
Summary: (from Project Narrative) "Cumberland Island currently has fifteen artesian wells which tap into the deep Floridan Aquifer. Ten of these wells have been abandoned and are no longer maintained. Most of them were constructed prior to park establishment and were not properly plugged or capped upon departure of the previous landowners. It is uncertain as to the

volume of water that is escaping from these abandoned, unchecked wells but, it could potentially be on the order of hundreds of thousands of gallons per day. This uncontrolled flow of groundwater has the potential to alter local habitat and morphology. In addition, valuable groundwater is being lost in a region where that resource is becoming increasingly critical. To eliminate these adverse impacts this project will plug or cap the abandoned artesian wells into the Floridan Aquifer. The methods implemented will be those prescribed by a FY2004 WASO Water Resources Division technical assessment."

National Park Service - Southeast Coast Network. 2004. Vital signs monitoring in the Southeast coast inventory & monitoring network, phase I (draft) report. http://www.nature.nps.gov/im/units/secn/reports.htm

Summary: (from source) "The Southeast Coast Network (SECN) monitoring plan is being developed over a multi-year period following specific guidance from the National Park Service, Washington Office (WASO). Networks are required to document monitoring planning progress in three distinct phases and to follow a standardized reporting outline. Each phase report requires completion of specific portions of the outline. This Phase I Report emphasizes work on Chapter 1 (Introduction and Background), Chapter 2 (Conceptual Models) and Chapter 11 (Literature Cited), but includes partial work on several other chapters (3, 6, and 8). Some chapters will remain unwritten until future Phase Reports are completed. This document presents the SECN framework and approach to vital signs monitoring planning and a summary of work accomplished to date. Specifically the Phase I Report summarizes existing information on National Park Service and related natural resource monitoring programs within the network, presents an overview of biological and physical resources of network parks, describes monitoring goals and needs, and presents a theoretical framework with conceptual models for guiding future efforts."

National Park Service Water Resources Division. 2001. Cumberland Island National Seashore small-scale base GIS data. National Park Service Water Resources Division. ~~http://www.nps.gov/gis/metadata/water_resources/cuis.html~~

Keywords: water quality, monitoring, industrial discharges, drinking water, gages, impoundments, mapping

Summary: (from source) "The data are comprised of small-scale base GIS data layers, including roads, hydrography, political boundaries, trails and other layers as available and appropriate, compiled for the purpose of displaying the locations of point-based hydrologic features (water quality monitoring stations, stream gages, industrial discharges, drinking intakes, and water impoundments) proximate to national park units. The data are intended to be used as a set to ensure spatial alignment. The accompanying Microsoft Excel file, sources.xls, lists the data sources for each data layer."

Natural Resources Conservation Service. 2004. Plants database. U.S. Department of Agriculture. http://plants.usda.gov/~~egi_bin/county.egi?state_name=Georgia&statefips=13&symbol=ASHE4~~

Summary: (from source homepage) "The PLANTS Database provides standardized information about the vascular plants, mosses, liverworts, hornworts, and lichens of the U.S. and its territories. It includes names, plant symbols, checklists, distributional data, species abstracts, characteristics, images, plant links, references, crop information, and automated tools.

PLANTS reduces costs by minimizing duplication and making information exchange possible across agencies and disciplines."

Naval Facilities Engineering Command. 1975. Environmental Impact Statement (draft), for development of the preferred alternative location for fleet ballistic missile (FMB) submarine support base, Kings Bay, Georgia. OPNAVINST 6240.3D. Department of the Navy, Washington, D.C.
Keywords: EIS, environmental impact statement, Kings Bay, submarine, Trident, naval base
Summary: Multi-volume report contains information about environmental conditions of the Kings Bay area. Kings Bay Naval Submarine base was considered for (and ultimately chosen as) the new homeport for Trident submarines moved from Spain. This proposed expansion required an EIS to present the impacts of an expanded channel and enlarged base population. This report includes: a description of proposed action, alternatives, existing environment of the proposed site, impact of the proposed action, impacts of the potential development beyond the proposed action, relationship of proposed action to land use controls. Appendix vol 1, part C, Existing Physical Environment contains more than 500 pages of data.
Notes: UGA main library

Nelms, M. G. 1999. Deer herd trends, bobcat food habits, and vegetation change on Cumberland Island, Georgia following bobcat restoration. M.S. thesis, University of Georgia, Athens, Georgia.
Summary: (paraphrased from Chapter 1 Introduction) "This study evaluates historical CINS data on deer herd trends, bobcat feeding ecology, and vegetation dynamics". The author compares these trends utilizing data collected 10 years prior to and 8 years after bobcats were reintroduced to the island. Chapter 3 contains a summary and management / research recommendations.
Notes: UGA Science Library

Nelson, M. I., C. R. Ford and T. DeSanto. 1986. The Cumberland Island deer herd: population analysis from the 1985-1986 hunting harvest. CPSU Technical Report #30. School of Forest Resources and Institute of Ecology, University of Georgia, Athens, GA.
Keywords: deer
Summary: (from Introduction) "This report presents an analysis of the white-tailed deer population on Cumberland Island National Seashore (CUIS) based on data from the 1985-1986 legal sport harvest. We compared these data to the harvest of the 2 preceding years and to data from 2 other Georgia barrier islands. Population structure, average weights, antler development, and hunter success were examined."
Notes: UGA Science Library

News 4 Jacksonville. April 21, 2004. FAA grant to allow study of moving St. Marys airport. http://www.news4jax.com/news4georgia/3026750/detail.html
Summary: "The St. Marys airport will receive a $236,538 grant from the Department of Transportation to fund a master plan of the St. Marys Airport.
Rep Jack Kingston, R-Ga., announced the grant, to be administered through the Federal Aviation Administration, will allow for a study of airport relocation and possible site selection away from the restrictions of the Naval Submarine Base Kings Bay.

'There's been a lot of focus on the St. Marys Airport since 9/11 because it is so close to Kings Bay Sub Base,' Kingston said. 'Now we can find out if it is possible and cost-efficient to move the airport.'"

Noon, K. and M. Martin. 2004. Position paper: wetland impacts from feral horses, Cumberland Island National Shoreline. Attached to memorandum L54(2380) PWR/CUIS from the authors to the Superintendent of Cumberland Island National Seashore. National Park Service, Water Resources Division.
Keywords: feral horse, CUIS, water quality
Summary: (from memorandum) "During the week of March 29, 2004, Mike Martin and Kevin Noon (Water Resource Division, NPS) visited Cumberland Island National Shoreline to provide technical assistance regarding several topics including evaluate numerous disturbed wetland areas across the island and identify and prioritize opportunities to restore altered wetlands. During our review of wetland conditions on the island, park staff requested that we evaluate the adverse impacts on the wetlands resulting from the maintenance of the 250-head herd of feral horses."
Excerpt from the position paper: "Adverse effects are particularly acute in wetlands, where horses tend to congregate most of the year, attracted by water, shade, cooler temperatures, and an abundance of high quality forage. The horses have been observed, by park staff, using the wetlands primarily in the spring, fall, and winter months and using open areas where the bugs and heat are tolerable, during the summer months. Horse grazing, trampling, and defecating cause adverse impacts in the wetlands on CUIS. We recommend that the following options in order of preference:

1. Remove the horse population from the island
2. Maintain a small number of horses in a confined area for visitor enjoyment. This would essentially be a maintained group of horses that would require health care and management, including supplemental feeding
3. Fence to exclude grazing in all of the dune areas adjacent to wetlands, and to exclude grazing from wetland areas including a surrounding 150-foot buffer area"

OutdoorPlaces.com website. Cumberland Island National Seashore. http://www.outdoorplaces.com/Destination/USNP/gacumisl/cumberland.html
Summary: This is a feature article on visiting Cumberland Island.

Paerl, H. and J. Ramus. 2005. FerryMon. http://www.ferrymon.org/images/who.htm
Keywords: water quality, monitoring
Summary: (from website) "The North Carolina Department of Environment and Natural Resources in conjunction with Duke University Marine Laboratory (DUML), the University of North Carolina at Chapel Hill Institute of Marine Science (UNC- IMS), and the NC-DOT Ferry Division commissioned the FerryMon project. FerryMon has equipped three NC ferry vessels to monitor the waters of Pamilico Sound and its tributary rivers." The sondes collect surface temperature, salinity, dissolved oxygen, pH, turbidity, chlorophyll fluorescence measurements every 3 minutes, and discrete samples for additional analyses.

Parris, L. B., M. M. Lamont and R. R. Carthy. 2002. Increased incidence of red imported fire ant (Hymenoptera: Formicidae) presence in loggerhead sea turtle (Testudines: Cheloniidae) nests

and observations of hatchling mortality. Florida Entomologist 85(3): 514-517. http://www.fcla.edu/FlaEnt/fe85p514.pdf
Summary: (from summary) "Hatching sea turtles may be at risk to fire ant predation during egg incubation, and especially at risk once pipped from the egg, prior to hatchling emergence from the nest. In addition to direct mortality, fire ants have the potential to inflict debilitating injuries that may directly affect survival of the young."

Patrick, T. S., J. R. Allison and G. A. Krakow. 1995. Protected plants of Georgia: An Information Manual on Plants Designated by the State of Georgia as Endangered, Threatened, Rare, or Unusual. Georgia Department of Natural Resources - Wildlife Resources Division, Georgia Natural Heritage Foundation.
Summary: PDF book. Following an introductory section, the book has excellent descriptions of the individual species (description, habitat, line drawing). http://www.georgiawildlife.com/content/displaycontent.asp?txtDocument=89&txtPage=7

Payne, K., K. Samples, J. Epstein, A. Ostrander, J. W. Lee, J. P. Schmidt, S. Mathes, M. Elliott, J. Nackone, S. Sand, F. Hay, M. Merrill, M. Golbali, M. Higgens, J. Howell and L. Kramer. 2003. Multisource data integration for Georgia land-cover mapping. Southeastern Geographer 43(1): 1-27.
Keywords: land-cover mapping, Georgia, Gap Analysis Program, Land use mapping, *LANDSAT*, accuracy assessment, videography
Summary: "This paper describes a multisource data integration method for creating a 28-class 1998 land-cover map of the state of Georgia. The methodology for creating the map is unique in both the number and the method of integrating data sources. An assessment of the map's accuracy in the metropolitan Atlanta region using color infrared digital ortho-quarter quads and a preliminary state-wide assessment using low altitude aerial videography is presented. We estimate the overall accuracy for the metropolitan Atlanta region to be 86.3% and the overall accuracy for the state-wide land-cover map to be 83.9%. We anticipate that this dataset will be useful in a wide range of mapping, modeling, and planning exercises across the state and in the Southeast."

Pendleton, E. A., E. R. Thieler and S. J. Williams. 2004. Coastal vulnerability assessment of Cumberland Island National Seashore (CUIS) to sea-level rise. Open-file report 2004-1196. U.S. Geological Survey. http://pubs.usgs.gov/of/2004/1196/index.html
Summary: (from document) "A coastal vulnerability index (CVI) was used to map the relative vulnerability of the coast to future sea-level rise within Cumberland Island National Seashore in Georgia. The CVI ranks the following in terms of their physical contribution to sea-level rise-related coastal change: geomorphology, regional coastal slope, rate of relative sea-level rise, historical shoreline change rates, mean tidal range and mean significant wave height. The rankings for each input variable were combined and an index value calculated for 1-minute grid cells covering the park. The CVI highlights those regions where the physical effects of sea-level rise might be the greatest. This approach combines the coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions, yielding a quantitative, although relative, measure of the park's natural vulnerability to the effects of sea-level rise. The CVI provides an objective technique for evaluation and long-term planning by scientists and park managers. Cumberland Island National Seashore consists of stable to

washover-dominated portions of barrier beach backed by wetland, marsh, mudflat and tidal creek. The areas within Cumberland that are likely to be most vulnerable to sea-level rise are those with the lowest foredune ridge and highest rates of shoreline erosion." This assessment deals primarily with the east shore of the island.

Plant Conservation Alliance. 2004. Weeds Gone Wild website: alien plant invaders of natural areas. National Park Service and the Plant Conservation Alliance (Bureau of Land Management). http://www.nps.gov/plants/alien/index.htm
Summary: (from homepage) "This site provides a compiled national list of invasive plants infesting natural areas throughout the U.S., background information on the problem of invasive species, illustrated fact sheets that include plant descriptions, native range, distribution and habitat in the U.S., management options, suggested alternative native plants, and other information, and selected links to relevant people and organizations."

Pomeroy, L. R. and R. G. Wiegert (eds.) 1981. The ecology of a salt marsh. Springer-Verlag, New York.
Summary: This work is often used as a textbook. It integrates physical, chemical and biological processes of the marsh.

Pope, J. 1991. Ebb delta and shoreline response to inlet stabilization - examples from the southeast Atlantic coast. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.

Richardson, J. P. 1991. Community description and monitoring of Cumberland Island jetty at Kings Bay - St Marys River entrance, Georgia. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.
Keywords: fish, invertebrate, macroalga, salinity
Summary: Between April 1988 - May 1990, the rock jetty south of CUIS at the St. Marys inlet was sampled monthly for fish, macro-invertebrates and macroalgae. Limited water analysis (temperature and salinity) was also done. Species and abundance were recorded. Temporal and spatial distributions were then determined.
Notes: Related document: technical report KBRPT 94/96

Richardson, J. P. and M. R. Gilligan. 1991. Tidepool fish community and structure of the jelly marine ecosystem on southern Cumberland Island, Georgia. Technical Report KBRPT 94/06. U.S. Department of the Navy (Naval Facilities Engineering Command) in cooperation with the National Park Service (U.S. Department of the Interior), Washington DC.
Keywords: fish, invertebrate, macroalga, salinity
Summary: (verbatim from source) "The rock jetty at the terminus of Cumberland Island, Georgia, provides reef and tidepool habitats for algae, invertebrates, and fishes. Sampling of this community was conducted from June 1987 through May 1990. During each sampling period, air temperature, and seawater temperature and salinity were recorded. In addition, the sessile algae on the Dungeness and Sea Camp docks were observed and recorded on a monthly basis. Forty macroalgal taxa were observed on the jetties. Newly reported species for Georgia include *Codium decorticatum, Spyridia filamentosa,* and *Grateloupia gibbesii*. Thirty-six fish

species in 29 families and 11 orders were identified. Three of them, S*cartellis cristata, Labrisomus nuchipinnis,* and *Bathygobius sporator* are unreported in Georgia. Eighteen of the species are sandy shore species that were trapped in the pools at low tide. Seventeen species are reef or rocky shore residents for which the jetty provides suitable habitat. Mortality among sandy shore species occurred regularly in upper pools due to low dissolved oxygen and high dissolved hydrogen sulfide concentrations during low tides."

Riddleberger, K. A. 1991. Platform selection by nesting ospreys at Kings Bay, Georgia. M.S. thesis, University of Georgia, Athens, GA.
Summary: (from document) "Nest site preferences of ospreys (*Pandion haliaetus*) using platforms were investigated at Kings Bay Naval Submarine Base, Georgia. The location and status of all nests and platforms were determined during aerial and ground surveys from 19 February to 24 July 1986. Ospreys occupied 8 of 19 platforms while 6 nests were located in light poles (3) and snags (3). Sixty-three variables were measured to describe the habitat and location relationship of occupied and unoccupied platforms."
Notes: Available through UGA Repository

Sanger, D. M. and A. F. Holland. 2002. Evaluation of the impacts of dock structures on South Carolina estuarine environments. Technical report number 99. South Carolina Department of Health and Environmental Control, Charleston, SC. http://mrl.cofc.edu/pdf/techreport99.pdf
Keywords: vegetation, shading, tidal creek, dock, pier, sediment, leachate
Summary: (From document introduction) "The objective of this study was to evaluate the cumulative effect of docks on tidal creek and salt marsh ecosystems. The study was composed of three parts: (1) a Spartina Shading Study which evaluated the impacts of dock shading on the dominant marsh plant; (2) a Small Tidal Creek Study which evaluated dock impacts on small tidal creek nursery habitats; and (3) a Large Tidal Creek Study which evaluated dock impacts on larger tidal creek nursery habitats. Shading impacts under individual docks were extrapolated to the tidal creek (local), county, and state-wide scales. In addition, wrack accumulation and construction damage were examined as part of the Spartina Shading Study. No new data were collected for the small and large tidal creek studies. Rather, existing research and monitoring data collected by the SCDNR were used. A bibliography of the relevant scientific literature and summarization of the science that supports the impacts of dock structures on the marine environment is also provided."

Schoettle, T. 1996. A Guide to a Georgia Barrier Island - Featuring Jekyll Island with St. Simons and Sapelo Islands. Watermarks Publishing, St. Simons, Georgia.
Keywords: field guide, ecology, beach, marsh, maritime forest, slough
Summary: (from source) "This guide is divided into four sections. The first describes the physical setting, geology and ecological environments of the barrier islands of Georgia...The ecological features that characterize the ocean beaches, salt marshes, maritime forests, and sloughs are described. Although these subjects apply to all of Georgia's barrier islands, Jekyll, St. Simons and Sapelo Islands are often referred to as examples... The second section outlines the field trip to Jekyll Island and presents the sites to be visited... The third section is the Glossary of Terms and Concepts... Appendices comprise the fourth section". Appendices include plant and animal identification, a bibliography and suggested reading, and personal safety information.

Seaber, P. R., F. P. Kapinos and G. L. Knapp. 1987. Hydrologic unit maps: U.S. Geological Survey. Water - Supply Paper 2294. U.S. Geological Survey.
Summary: The United States is divided and sub-divided into successively smaller hydrologic units which are classified into four levels: regions, sub-regions, accounting units, and cataloging units. The hydrologic units are arranged within each other, from the smallest (cataloging units) to the largest (regions). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system.

Shelton, S. 2004. Ruling ends church tours: Trips to site of JFK Jr. wedding must be on foot. In Atlanta Journal-Constitution, Atlanta, GA. www.ajc.com
Summary: In July 2004, the 11th Circuit Court of Appeals found the NPS in violation of the Wilderness Act: the National Park Service had been offering twice monthly van tours to the former African-American Settlement, which is reached by land on a dirt road passing through parts of the island federally designated as Wilderness or Potential Wilderness. The village on the island's north end is a 34-mile round trip hike from the public dock and tours there have been given by the National Park Service since 1999. Quoting from article, "Montana-based Wilderness Watch argued the trips ruined the natural experience for hikers and disturbed wildlife".

Simon, D. M., M. G. Turner, K. L. Davison and S. P. Bratton. 1984. Habitat utilization by horses, deer, and rabbits on Cumberland Island National Seashore, Georgia. CPSU Technical Report #8. National Park Service Cooperative Unit, Athens, Georgia.
Keywords: horse, rabbit, deer, habitat, vegetation
Summary: (excerpts from report) "This study compared use of the major habitat types on the island by feral horses (*Equus caballus*), white-tailed deer (*Odocoileus virginianus*), and marsh rabbits (*Sylvilagus palustris*) ... Horse use was highest in the salt marsh and salt marsh-forest edge. The oak-pine forest type had a higher percent cover of grasses and sedges than the oak-palmetto forest type and significantly more horse use. Deer use was highest in the interdune meadow. Rabbit use was highest along the dune-forest edge."
Notes: UGA Science library

Staff, G. O. N. No hogs: Cumberland plan will rid the Island of wild pigs. In Georgia Outdoor News (online excerpt, volume unknown). http://www.gon.com/cumberland502.html

Stayton, W. 2004. Ground water monitoring on Cumberland Island by the U.S. Geological Survey.
Keywords: well level measurement, upper Floridan aquifer

Tinkler, W. P. 1976. The U.S. Army Corps of Engineers Atlantic intracoastal waterway project in Georgia: a study of its history, maintenance, and present use. Georgia Dept of Natural Resources (Marshland Protection Section, Game & Fish Division), Brunswick, GA.
Keywords: ICW, intracoastal waterway, dredging, channels
Summary: Document includes four main segments plus appendices. I. A history of the U.S. Army Corps of Engineers Atlantic intracoastal waterway project in Georgia II. U.S. Army

Corps of Engineers dredging in Georgia (1884-1976) III. Historic commerce and present use of the Atlantic intracoastal waterway in Georgia IV. Conclusions and recommendations. Many of the recommendations suggest ways to reduce the impacts from excessive dredge spoil deposition by ceasing to improve areas no longer used by large commercial vessels, by coordinating dredging efforts, and by good management of spoil sites.

U.S. Army Corps of Engineers and Florida Department of Environmental Protection. 2000. Northeast Florida regional sediment management workshop. https://rsm.saj.usace.army.mil/ne/RSM%20report.doc, *see also*: http://bcs.dep.state.fl.us/env-prmt (Nassau County, issued), Public Notice 2/05/2003
Summary: A number of demonstration projects are described wherein dredge spoil from existing projects could be used to fortify beaches eroding from the interruption of sediment transport.

U.S. Census Bureau. 2000. American FactFinder web program. http://factfinder.census.gov/home/saff/main.html?_lang=en
Keywords: population, age, race, household, social and economic characteristics
Summary: The FactFinder program allows one to search for a locale (by name of city/county/state or by zip code), and present the results of the 2000 census (currently available) as compared to that for the U.S. as a whole. Numbers include: total population, and breakdown by sex, age, race, household size, housing units, educational attainment, veterans, disability, foreign born, marital status, employment, mean travel time, income, and housing value. Based on the U.S. Census geographical locator map, Cumberland Island and Little Cumberland Island fall within "block group 3 (part), census tract 106 (part), remainder of St Marys CCD, St Marys CCD, Camden County, Georgia" for the 2000 census. This region covers approximately 114 million square meters of land and 268 million square meters of water. There were 1067 individuals (438 urban, 629 rural) in 368 households and the median age was 32.4 years. Median income in the region (1999 figures) was $42, 250 per urban household and $48,264 in rural households.

U.S. Coast Guard 7th District. 2004. Local notice to mariners. U.S. Department of Homeland Security and U.S. Coast Guard, Miami, Florida. http://www.navcen.uscg.gov/lnm/d7/lnm0714.PDF
Summary: Full text of Notice on Georgia Intracoastal Waterway:
Georgia – Intracoastal Waterway - Simons Sound to Tolomato River – Cumberland Sound: Notice of Interest to Mariners.
"Due to the limited commercial use of the Atlantic Intracoastal Waterway between Port Royal Sound, South Carolina (Mile 552) and Cumberland Sound, Georgia (Mile 713), the Savannah District will not receive funds to maintain the waterway to the authorized depths. The District will monitor the conditions of the waterway and publish quarterly condition reports. Mariners are to use extreme caution when transiting the waterway until further notice."
Ref: LNM 48/03, 01, 05, and 09/04 Chart: 11489

U.S. Coast Guard. Savannah air station search and rescue (media reports). http://www.uscg.mil/d7/units/as%2Dsavannah/pao/sarucn265%2D03.doc http://www.uscg.mil/d7/units/as%2Dsavannah/pao/03%2D83.htm

U.S. Congress. 2004. Consolidated Appropriations Act, 2005.
Summary: A rider on this appropriations bill included what was originally introduced as the Cumberland Island Wilderness Boundary Adjustment Act. This legislation removes from the Wilderness Area of Cumberland Island: Main Road, Plum Orchard, and North Cut Road. Removed from the Potential Wilderness is the High Point Half-Moon Bluff Historic District. Note that CUIS boundaries are now set by map 640/20, 038i (dated September 2004).

U.S. Department of the Navy. Naval Submarine Base, Kings Bay, Georgia website. http://www.subasekb.navy.mil/kbayhist2.htm, http://www.subasekb.navy.mil/index2.htm
Summary: (from site) "The purpose is to provide information and news about the Naval Submarine Base to the general public. All information on this site is public domain and may be distributed or copied unless otherwise specified." The Base History Page gives an overview of site uses and installations since the 19th century.

U.S. Environmental Protection Agency. Land cleanup and wastes website: Escambia Brunswick Wood Preserving Site. http://www.epa.gov/region4/waste/npl/nplga/brunwpga.htm
Keywords: superfund, national priority list
Summary: (quoting from Site Background) "Brunswick Wood Preserving, located in Brunswick, Glynn County, Georgia, is an 84 acre site which treated wood from 1958 until 1991. Wood was treated using pentachlorophenol, creosote, and CCA (chromium, copper, arsenic). In March, 1991, Georgia's Environmental Protection Division (GEPD) finalized the RCRA Facility Assessment of the site. However, the company declared bankruptcy in February of that year, and the following month EPA's Emergency Response and Removal Branch (ERRB) responded to a fire at the facility. There are six municipal wells within a four mile radius, serving over 6000 people. All the municipal wells and most, if not all, the private wells draw water from the deeper aquifer. In addition, the site is adjacent to the tidally influenced Burnett Creek."

U.S. Environmental Protection Agency. Land cleanup and wastes website: Hercules 009 Landfill. http://www.epa.gov/region4/waste/npl/nplga/herculga.htm
Keywords: superfund, national priority list
Summary: (from Site Background) "The Hercules 009 Landfill site is a 16.5 acre property that is bordered by Georgia State Highway 25 (Spur 25) on the west; an automobile dealership on the north; a juvenile slash pine forest on the east; and several homes, a church, a school, and a strip shopping center to the south/southeast of the property. Hercules was issued a permit in 1975 by the GaEPD to use seven acres at the northern end of the property as a landfill to dispose of toxaphene-contaminated wastewater sludge generated during the manufacturing processes. The 009 Landfill was constructed at the northern end of the property as six cells, each approximately 100 to 200 feet wide (north-south direction) and 400 feet long (west-east direction). Toxaphene has been detected at levels exceeding 15,000 parts per million at the Hercules 009 Landfill Site."

U.S. Environmental Protection Agency. Land cleanup and wastes website: LCP Chemicals Georgia Inc. http://www.epa.gov/region4/waste/npl/nplga/lcpincga.htm
Keywords: superfund, national priority list

Summary: (from Site Background) "The LCP Chemicals Superfund Site consists of 550 acres, the majority of which is a tidal marsh. An oil refinery, a paint manufacturing company, a power plant, and a chlor-alkali plant have all operated at this site over the last 70 years. Mercury, polychlorinated biphenyls (PCBs), and semi-volatile contamination are prevalent across the plant site soils, in groundwater, and in the biota in the marsh. Since 1919 this site has been occupied by at least five major companies: Atlantic Refining Company (ARCO); Georgia Power Company; Dixie Paints and Varnish Company (currently, the O'Brien Company); Allied Chemical Inc. (currently, Allied Signal); and, the Hanlin Group subsidiary, LCP Chemicals-Georgia, Inc. The contamination of greatest concern at this Site is a large dispersion of mercury and polychlorinated biphenyls throughout the marshlands that was the result of the chemical manufacturing process undertaken by Allied Signal and LCP between 1955 and 1979; EPA estimates that more than 380,000 pounds of mercury were "lost" in the area during this period. In addition to mercury and polychlorinated biphenyls, lead, other metals, and volatile organic compounds have contaminated the 500-acre marshlands area, a 1-mile portion of the Turtle River and the entirety of Purvis Creek. Mercury and polychlorinated biphenyls have been detected in aquatic life at levels sufficient to produce a ban on commercial fishing in these areas and a seafood consumption advisory for part of the river and all of the creek."

U.S. Environmental Protection Agency. Hercules - Brunswick facility. http://www.epa.gov/region4/waste/npl/nplga/tercrkpr.htm
Keywords: superfund, national priority list
Summary: (from Site Background) "Between 1948 and 1980, Hercules, Inc. produced toxaphene, a chlorinated pesticide, at its Brunswick plant. During this period, wastewater containing toxaphene was discharged through an outfall ditch into Dupree Creek which flows into Terry Creek. Portions of Dupree and Terry Creek were periodically dredged by the U.S. Army Corps of Engineers. Dredge material was placed in several areas near the confluence of Terry and Dupree Creeks. Some material was placed south of Terry Creek and approximately 400 feet north of the Torras Causeway. Other material was placed in an area adjacent to the Riverside neighbor. Most of the dredge material was placed in the main dredge disposal area located directly north of Terry Creek and directly east of Dupree Creek. Toxaphene contamination has been found in the outfall ditch sediments, Terry and Dupree Creek sediments, and the dredge disposal areas."

U.S. Environmental Protection Agency. 1972. Federal Water Pollution Control Act (the "Clean Water Act"). http://www.epa.gov/region5/water/cwa.htm
Keywords: 303(d), 305(b)
Summary: Under section 303(d) of the Clean Water Act, states, territories, and authorized tribes are required to list those waters that do not meet their own water quality standards (even after point sources of pollution have installed the minimum required levels of pollution control technology). The law also requires that TMDLs be developed for these waters. Under section 305(b), a National Water Quality Inventory Report is also to be submitted to Congress including information on all assessed waters. Both are biennial requirements.

U.S. Environmental Protection Agency. 2003. Superfund and National Priorities List (Basic Query Form website). http://www.epa.gov/superfund/sites/query/basic.htm

a related search is at -- http://cfpub.epa.gov/supercpad/cursites/srchsites.cfm
Keywords: CERCLIS, CERCLA, Superfund, National Priorities List
Summary: One may search the database by location (street, city, county, state, zip code, EPA region), by status (currently/ deleted / not on the final NPL, proposed for the NPL), by contaminated media (e.g. air, groundwater, sediment), or by contaminants of concern (e.g. acids, metals, carcinogens, VOC's)

U.S. Environmental Protection Agency. 2003. Pesticides: Endangered Species Protection Program (Camden County, Georgia). http://www.epa.gov/oppfead1/endanger/georgia/camde.htm
Keywords: wood stork, rookery, endangered species, pesticide, Camden
Summary: Pesticide use limitations to protect wood storks are in place for portions of Camden and Glynn counties. The restrictions cover areas in a 10-miles radius from known stork rookeries and include approximately 85% of Cumberland Island. Eighteen different pesticides* are restricted within 40 yards of the water's edge for ground applications, or within 200 yards for aerial applications. An additional three pesticides** are restricted within 100 yards of the water's edge for ground applications, or within 1/4 mile for aerial applications. The website includes background information on wood storks and a map of the area under pesticide limitations.

* 4-Aminopyridine (Avitrol), Acephate (Orthene), Aldicarb (Temik), Chlorpyrifos (Lorsban), Diazinon (Diazinon), Dichlorvos (Prentox, Elastrel), Dicrotophos (Bidrin), Ethoprop (Mocap), Fenminphos (Nemacur), Fenthion (Baytex), Fonofos (Dyfoante), Isofenphos (Oftanol), Methyl Parathion (Penncap-M), Mevinphos (Phosdrin), Oxamyl (Vydate L), Paraquat (Gramoxone, Starfire), Phorate (Thimet), Temephos (Abate, Tempo)

** Azinphos-methyl (Guthion), Carbofuran (Furadan), Endosulfan (Thiodan)

U.S. Environmental Protection Agency. 2004. Enforcement and Compliance History Online (ECHO). http://www.epa.gov/echo/index.html

U.S. Environmental Protection Agency. 2004. National Pollutant Discharge Elimination System. http://cfpub.epa.gov/npdes/
Keywords: NPDES, wastewater, permitting, monitoring
Summary: (text from EPA website) Water pollution degrades surface waters making them unsafe for drinking, fishing, swimming, and other activities. As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. In most cases, the NPDES permit program is administered by authorized states. Since its introduction in 1972, the NPDES permit program is responsible for significant improvements to our Nation's water quality. There are no NPDES permitted discharges within the CUIS boundary. However, there are a number of them upstream in the Satilla and St Marys rivers and in the nearby Amelia River.

U.S. Environmental Protection Agency. 2004. Envirofacts Warehouse - Water. http://oaspub.epa.gov/enviro/ef_home2.water
Summary: Site visitors may search for: permitted wastewater discharges (by ZIP code, city or county); public water systems having reported violations (by county); water microbiology and disinfection byproduct data. There are no NPDES permitted discharges within the CUIS boundary. However, there are a number of them upstream in the Satilla and St Marys rivers and in the nearby Amelia River.

U.S. Environmental Protection Agency. 2004. Assessment and monitoring - atmospheric deposition and water quality website. http://www.epa.gov/owow/oceans/airdep/air1.html, http://www.epa.gov/owow/oceans/airdep/air2.html#mercury
Keywords: airshed, mercury, atmospheric deposition, pollutants
Summary: (from source): "Atmospheric deposition plays a major role in delivering mercury to ecosystems. Up to 83% of the mercury load to the Great Lakes comes from atmospheric deposition (see Shannon and Voldner, 1995). Approximately half of the mercury in Chesapeake Bay is deposited from the atmosphere directly to the surface of the bay (see Mason et. al., 1997). The National Atmospheric Deposition Program (NADP) estimated that mercury was deposited at the rate of 4-20 micrograms per square meter in the United States in 1998." "There are five categories of atmospheric pollutants with the greatest potential to harm water quality. The categories include: nitrogen compounds, mercury, other metals, pesticides, and combustion emissions. These categories are based on both method of emission and other characteristics of the pollutants. Mercury is in its own category since it behaves so much differently in the environment than other metals. Combustion of fossil fuels is a major source of nitrogen oxides to the atmosphere. However, nitrogen is in its own category since its effects on ecosystems is so much different than other combustion emissions. Pesticides and combustion emissions are exclusively man-made while mercury, other metals, and nitrogen compounds arise from both natural and man-made sources."

U.S. Environmental Protection Agency. 2004. Environmental Monitoring and Assessment Program website. http://www.epa.gov/emap/index.html
Summary: (from source) "The Environmental Monitoring and Assessment Program (EMAP) is a research program to develop the tools necessary to monitor and assess the status and trends of national ecological resources. EMAP's goal is to develop the scientific understanding for translating environmental monitoring data from multiple spatial and temporal scales into assessments of current ecological condition and forecasts of future risks to our natural resources. EMAP aims to advance the science of ecological monitoring and ecological risk assessment, guide national monitoring with improved scientific understanding of ecosystem integrity and dynamics, and demonstrate multi-agency monitoring through large regional projects. EMAP develops indicators to monitor the condition of ecological resources. EMAP also investigates designs that address the acquisition, aggregation, and analysis of multiscale and multitier data."

U.S. Environmental Protection Agency. 2004. Water Quality Standards for Coastal and Great Lakes Recreation Waters. In Federal Register: November 16, 2004 (Volume 69, Number 220). http://www.epa.gov/fedrgstr/EPA-WATER/2004/November/Day-16/w25303.htm

Summary: (from online document summary) "The Environmental Protection Agency (EPA) is promulgating water quality criteria for bacteria for coastal recreation waters in specific States and Territories. The States and Territories covered by this promulgation do not have water quality standards for bacteria that comply with the requirements of section 303(i)(1)(A) of the Clean Water Act. Under these circumstances, the Act requires EPA to promptly propose such standards and to promulgate such standards not later than 90 days after proposal. The criteria promulgated today apply to coastal and Great Lakes waters that specific States and Territories have designated for swimming, bathing, surfing, or similar water contact activities and for which the State or Territory does not have in place EPA-approved bacteria criteria that are as protective of human health as EPA's 1986 recommended bacteria criteria. Through this promulgation, the Federally designated water quality criteria will be added to the States' and Territories' water quality criteria applicable to coastal recreation waters. This final rule is effective December 16, 2004."

U.S. Environmental Protection Agency. 2004. National Coastal Condition Report II. EPA-620/R-03/002. Office of Water, Washington, D.C. http://www.epa.gov/owow/oceans/nccr2/
Summary: (from Executive Summary) "The NCCR II presents three main types of data: (1) coastal monitoring data, (2) offshore fisheries data, and (3) assessment and advisory data. The ratings of coastal condition in the report are based primarily on coastal monitoring data because these are the most comprehensive and nationally consistent data available related to coastal condition. One source of coastal monitoring data is obtained through EPA's National Coastal Assessment (NCA) Program, which provides information on the condition of coastal estuaries for most regions of the United States. The NCCR II relies heavily on NCA estuarine data in assessing coastal condition and uses NCA and other data to evaluate five indicators of condition—water quality, sediment quality, benthic community condition, coastal habitat loss, and fish tissue contaminants—in each region of the United States (Northeast Coast, Southeast Coast, Gulf Coast, West Coast, Great Lakes, and Puerto Rico)." "In addition to rating coastal condition based on coastal monitoring data, the NCCR II summarizes available information related to offshore fisheries and beach advisories and closures. This information, together with descriptions of individual monitoring programs, paints a picture of the overall condition of coastal resources in the United States."

U.S. Fish & Wildlife Service. National Wetlands Inventory. In, Arlington, Va. http://wetlands.fws.gov/
Summary: "The National Wetlands Inventory (NWI) of the U.S. Fish & Wildlife Service produces information on the characteristics, extent, and status of the Nation's wetlands and deepwater habitats."

U.S. Fish & Wildlife Service. 2004. The endangered species program website. http://endangered.fws.gov/, http://ecos.fws.gov/tess_public/TESSWebpage
Keywords: Endangered species, threatened species, protected species, ESA
Summary: Searched the threatened and endangered species system "TESS" by state, and compared the list to plants and animals expected to occur at Cumberland Island (based on NPS management documents).

U.S. Fish and Wildlife Service. 1996. Revised recovery plan for the U.S. breeding population of the wood stork. Atlanta, GA.
Keywords: wood stork, *Mycteria americana*
Notes: UGA Science Library, QL696.C535 R48 1997a

U.S. Geological Survey. 2000. Georgia hydrologic unit boundaries, 8-, 10-, and 12-digit. http://csat.er.usgs.gov/
Summary: (excerpted) "In 1999, the South Carolina Department of Natural Resources (SCDNR) and the South Carolina Department of Health and Environmental Control (SCDHEC) initiated a collaborative coastal monitoring program entitled the "South Carolina Estuarine and Coastal Assessment Program" (SCECAP). The goal of SCECAP is to monitor the condition of the state's estuarine habitats and associated biological resources on an annual basis. This program significantly expands ongoing monitoring efforts by each agency and draws upon the expertise of both in a cooperative effort. SCECAP integrates measures of water quality, sediment quality and biological condition at a large number of sites throughout the state's coastal zone."

U.S. Geological Survey. 2000. Chinese tallow: invading the Southeastern coastal plain. http://www.nwrc.usgs.gov/factshts/154-00.pdf
Keywords: *Triadica sebifera*, Chinese tallow, invasive species, nonnative
Summary: *Triadica sebifera*, Chinese tallow, is an aggressive invader, an ornamental tree introduced to North America from Asian more than 200 years ago. It is difficult to control, especially when present in large stands. It has negative impacts on Southeastern Coastal Plain species by shading desirable vegetation and perhaps also through the toxins present in its leaves, berries and sap. This short article describes the plants natural history in the southeastern United States, how it is controlled, how it spreads, and what research efforts are underway.

U.S. Geological Survey. 2004. National Water Information System. http://waterdata.usgs.gov/nwis/si
Summary: With the site inventory query, one can access water monitoring sites in the USGS database (by HUC or county or lat/long boundary) to see what information is available for a given region. Through links to the individual data sites, one can access the parameters tested and the actual data. A site inventory query for all data locations within the estimated CUIS boundaries: (N 30.9805o, S 30.7097o, E 81.4o, E 81.5137o) yielded 142 water quality observations. There were 72 water quality observations in CUIS surface waters between 1999 and 2000. This includes measurements in seven lakes/ponds, two outflows, and five estuarine areas. Between 1966 and 2003, there were also 70 ground water quality observations (and 376 readings of ground water level) in 40 wells on CUIS.

Van Dolah, R. F., P. C. Jutte, G. H. M. Riekerk, M. V. Levisen, L. E. Zimmerman, J. D. Jones, A. J. Lewitus, D. E. Chestnut, W. McDermott, D. Bearden, G. I. Scott and M. H. Fulton. 2002. The Condition of South Carolina's Estuarine and Coastal Habitats During 1999-2000: Technical Report. Technical Report No. 90. South Carolina Marine Resources Division, Charleston, SC.

Verity, P. G. 2002. A decade of change in the Skidaway River Estuary - I. Hydrography and Nutrients. Estuaries 25: 944-960.
Summary: (from source) "The Skidaway River estuary is a tidally-dominated subtropical estuary in the southeastern USA surrounded by extensive Spartina salt marshes. Weekly sampling at high and low tide began in 1986 for hydrography, nutrients, chlorophyll a, particulate matter, and microbial and plankton biomass and composition; hydrographic and nutrient data during 1986–1996 are reported here. Salinity varied inversely with river discharge and exhibited variability at all time scales but with no long-term trend. Water temperature typically ranged over 25oC and was without apparent long-term trend. Seasonal cycles in concentrations of NO3, NH4, PO4, Si(OH)4, and DON were observed, with annual maxima generally occurring in late summer. Superimposed on seasonal cycles, all five nutrients exhibited steady increases in minimum, mean, and maximum concentrations; mean concentrations increased c. 50–150% during the decade. Nutrient concentrations were highly correlated with water temperature over the ten-year period, but weakly related to salinity and discharge. Nutrients were strongly correlated with one another, and the relative ratios among inorganic nutrients showed little long-term trend. Correlations among temperature and nutrient concentrations exhibited considerable inter-annual variability. Major spikes in organic and inorganic nutrient concentrations coincided with significant rainfall events; concentrations increased hyperbolically with rainfall. Although pristine compared to more heavily impacted waterways primarily outside the region, residential development and population density have been increasing rapidly during the past 15–20 years. Land use is apparently altering nutrient loading over the long-term (months–years), and superimposed on this are stochastic meteorological events that accelerate these changes over the short term (days–weeks). "

Verity, P. G. 2002. A decade of change in the Skidaway River Estuary - II. Particulate organic carbon, nitrogen, and chlorophyll a. Estuaries 25: 961-975.

Walsh, J. M. 1991. Habitat use and productivity of wood storks on Cumberland Island National Seashore. Technical Report KBRPT 90/02. U.S. Department of the Navy (Naval Facilities Engineering Command) in cooperation with the National Park Service (U.S. Department of the Interior), Washington DC.
Keywords: vertebrate, bird, wood stork

Weinstein, M. P. and D. A. Kreeger (eds.) 2000. Concepts and controversies in tidal marsh ecology. Kluwer Academic Publishing, Dortrecht, The Netherlands.

Wiegert, R. G. and B. J. Freeman. 1990. Tidal salt marshes of the southeast Atlantic coast: A community profile. Biological Report 85(7.29). U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. http://cuadra.cr.usgs.gov/Techrpt/85-7-29.pdf
Summary: (from preface) "This report is part of a series of community profiles produced by the U.S. Fish and Wildlife Service on the ecology of wetland and marine communities... This profile considers those tidal salt marshes of the southeastern Atlantic coast, from northern North Carolina south to northern Florida."

Wilson, S. K. 1990. The hydrogeochemistry of southern Cumberland Island, Georgia. KBEMP 90/01. Atlanta.

Keywords: groundwater, salinity
Summary: (paraphrased) The aqueous geochemistry of three aquifers on the southern end of Cumberland Island, Georgia, was investigated. These aquifers (surficial, confined Pliocene-Miocene, and confined Miocene sand aquifer) were composed of siliceous sand, fossiliferous dolomite, and calcareous sand, respectively. The aquifers were monitored by 10 wells that were drilled in two clusters of three wells (on the southern coast) and one cluster of four wells (located north and inland). The wells were sampled in July and December 1989 for seasonal comparison. Age-dating of groundwater samples suggests that the modern sea water has mixed with 8,000-year-old fresh groundwater in the zone of dispersion (the Pliocene-Miocene aquifer). The zone of dispersion in the Pliocene-Miocene aquifer has intruded father inland than the zone of dispersion in the Miocene sand aquifer. This may be the result of higher hydraulic conductivity in the P-M aquifer, greater natural exposure of the aquifer to the ocean, exposure of the aquifer by dredging, or a combination of these three.
Notes: The author was a 1990 M.S. graduate, Department of Geology (Dr. Seth Rose), Georgia State University. This report is very likely his thesis.

Wilson, S. K., S. Rose and S. V. Cofer-Shabica. 1991. Hydrogeochemistry of southern Cumberland Island, GA. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.
Keywords: groundwater
Summary: In December 1989, 3 wells at two sites on the South End of CUIS, and 4 wells at Dungeness were sampled for: pH, DO, temperature, Ca, Mg, Na, K, bicarbonate, sulfate, sulfide, Cl, dissolved silica, total dissolved solids, calcite, and dolomite. The freshwater/saltwater interface was not encountered in the surficial aquifer. There was some intrusion of saltwater in the Pliocene-Miocene aquifer ranging from 5% - 88% SW. It is unknown if this is the result of natural exposure in the channel, the result of dredging, or both.
Notes: Related document: Wilson (1990) The Hydrogeochemistry of Southern Cumberland Island, Georgia

Winker, C. D., L. C. Jaffe and J. D. Howard. 1985. Georgia estuarine data 1961-1977. Georgia Marine Science Center technical report 85-7. Georgia Sea Grant and UGA Marine Extension Service, Skidaway Institute of Oceanography, Savannah, GA.
Summary: Estuarine data was compiled by the authors. Data may include: location (including map reference), date, time, depth, salinity, temperature, current velocity, current direction, suspended sediments, turbidity, dissolved oxygen, pH, and tidal stage. There were 6 identified sources of data in the Cumberland Island area from 1971-1975.

Zeichner, L. L. 1988. Landscape management plan for Dungeness, Cumberland Island National Seashore, Georgia. NPS - CPSU technical report #44. Institute of Ecology, University of Georgia, Athens, Georgia.
Keywords: vegetation, history
Summary: This plan was not a management plan of the NPS, but rather a thesis study submitted in partial requirement of the Masters in Landscape Architecture. The document contains interesting detail on the layout of Dungeness through description and study of the different historical eras.
Notes: UGA Main Library, Georgia Room collection

Zoodsma, B. J., L. W. Lefebvre and S. V. Cofer-Shabica. 1991. Manatee ecology and conservation in coastal Georgia. In Cofer-Shabica, S. V. (ed.) Biological and Physical Aspects of Dredging, Kings Bay, Georgia. American Society of Civil Engineers, New York, NY.

Keywords: manatee

Summary: From 1987-1989, 14 manatees were radio-tracked. The authors found that in winter, some animals apparently sought industrial warm water discharges. They also cite observations that feeding on Spartina apparently takes place at high tide, and that alga (perhaps associated with dredging equipment) is another attractive food source. Based on location of the animals and their dietary habits, it was suggested that dredging be done between November and March.