WATER QUALITY CONDITIONS NEAR CUMBERLAND ISLAND, GEORGIA

Merryl Alber[1], Janice Flory[2], and Karen Payne[3]

AUTHORS: [1]Assistant Professor and [2]Project Coordinator, Dept. of Marine Sciences, University of Georgia, Athens, GA 30602 [3]Director, University of Georgia Marine Extension Service - Spatial Technology Center, Athens GA 30602
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Abstract. This paper describes water quality information compiled as part of a report to the National Park Service on the water resources and habitat conditions of Cumberland Island National Seashore. Observations of nutrients, bacteria, dissolved oxygen, and contaminants in Cumberland Sound were obtained from state and federal agencies (particularly data collected by the Coastal Resources Division (CRD) of the Georgia Dept. of Natural Resources) and from the literature. Dissolved nutrient concentrations (orthophosphate, total dissolved phosphorus, nitrate plus nitrite) were considered fair to good according to the U. S. Environmental Protection Agency (EPA) National Coastal Condition Report II criteria. Bacterial concentrations (fecal coliform) did not show evidence of problems. Dissolved oxygen levels were sometimes critically low, particularly during summer: measurements made by CRD at 20 stations between 2000 and 2004 were less than 4 mg/L 18% of the time. Although it is not clear the extent to which this is a natural phenomenon, these low values warrant continued observation. This review also suggests potential problems in terms of mercury and several pesticides (i.e. dieldrin, lindane, 4,4′-DDD), which may be due to legacy contamination of the sediment or to continued input from both point and non-point sources. Continued monitoring of water conditions (particularly dissolved oxygen) and forthcoming observations of contaminant concentrations in organisms and sediment taken as part of the EPA National Coastal Assessment Program will enable better evaluation of coastal water resources in the region.

INTRODUCTION

Cumberland Island is a barrier island located in the Atlantic Ocean near the Georgia-Florida border. Although it is considered relatively pristine in comparison to more highly developed barrier islands, both point and non-point sources of pollutants can be found nearby that have the potential to affect water-dependent resources on the Island. In addition to the presence of 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 in the area, most of which are located in Brunswick, about 16 miles from Cumberland Island.

The National Park Service is currently developing watershed-level assessments of several southeastern coastal parks, one of which is the Cumberland Island National Seashore. The purpose of these reports is to evaluate water quality in and around the park, compile information on pollutant sources in the watershed of the park, and identify potential threats to water-dependent resources and habitats. A draft assessment of the coastal water resources and watershed conditions of Cumberland Island is now completed (Alber et al., 2004). This paper summarizes the information on water quality that was compiled as part of the National Park Service report and provides recommendations for further work.

METHODS

The most complete source of water quality data for the area is the Coastal Resources Division (CRD) of Georgia Dept. of Natural Resources. CRD has 20 stations located in and around Cumberland Sound that are sampled on a monthly basis as a part of several different programs (Fig. 1). This paper summarizes measurements of dissolved inorganic nutrients (nitrate + nitrite (NO_3 + NO_2); dissolved inorganic nitrogen (DIN); orthophosphate (PO_4); total dissolved phosphorus (TDP)) from summer 2001 through either May 2003 (11 stations) or October 2003 (8 stations), plus one station sampled from August 2001 to August 2002. Instantaneous measurements of surface water dissolved oxygen (DO) concentration were obtained for 3 stations from March 2000 through April 2004 and for 17 stations through December 2004. Fecal coliform samples were taken as part of the shellfish sanitation program at 17 stations sampled monthly between 1991 and 2004; counts are reported as most probable number (MPN) per 100 ml.

The U.S. EPA Environmental Monitoring and Assessment Program (EMAP) also provided some relevant information. EMAP was specifically designed to assess the conditions of estuarine resources through in-depth sampling at a few locations each year. Additional data came from a recent report done by the USGS for the Park Service (Frick et al., 2002), which was mainly

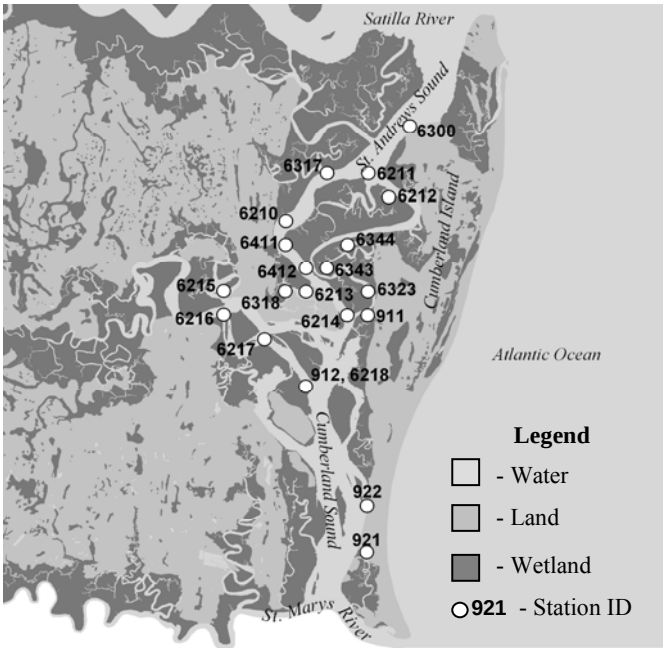

Fig. 1. Location of stations near Cumberland Island sampled by the Ga. DNR-Coastal Resources Division. The figure boundary is 31.01°, -81.26° to 30.68°, -81.71° (Note that station designations 912 and 6218 represent the same location.)

focused on freshwater wetlands. Some useful historic data were in the Draft Environmental Impact Statement (EIS) for the Kings Bay Naval Base (U.S. Navy, 1975).

RESULTS

Dissolved nutrients. Average dissolved inorganic nutrient concentrations for all 20 CRD stations near Cumberland Island are summarized in Table 1. These are presented in comparison to nutrient concentrations reported for South Carolina open waters and tidal creeks 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.

There are no EPA standards for dissolved nutrients, but in the National Coastal Condition Report II (U.S. EPA, 2004) they developed ranges for classifying coastal water in the southeast region in terms of both Dissolved Inorganic Nitrogen (DIN) and Dissolved Inorganic Phosphorus (DIP) concentrations. DIN concentrations less than 0.1 mg N/L are considered "Good;" those between 0.1 and 0.5 are considered "Fair;" and those above 0.5 are considered "Poor." DIP concentrations less than 0.01 mg P/L are considered "Good;" those between 0.01 and 0.05 are considered "Fair;" and those above 0.05 are considered "Poor." By these criteria, 56% of the DIN observations in Cumberland Sound are Good and 44% are Fair (none are Poor). The majority of Cumberland Sound PO_4 measurements (85%) are Fair; 11% are Good, and 5% are Poor.

Bacterial contamination. Of the 2092 observations of fecal coliform bacteria at 17 stations in Cumberland Sound between 1991 and 2004, only 1 station (6215, located well up the Crooked River) was ever above the standard for shellfishing (geometric mean value >14 MPN over 30 observations), and only 22 observations were above the Georgia criterion for coastal recreational water (100 colony forming units (CFU)/100 ml). These are single observations so they cannot be used for regulatory purposes. In order to evaluate similar one-time observations, the South Carolina report (Van Dolah et al., 2002) considered 43 CFU/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 (Fig. 2), with peaks in fall (October/November) and early spring (February/March).

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 5 Cumberland Island

Table 1. Dissolved Inorganic Nutrient Concentrations in Cumberland Sound, Ga. (measured by Ga. DNR-CRD). in Comparison to South Carolina Coastal Waters (reported in Van Dolah et al., 2002)

	Cumberland Sound, Ga.	South Carolina
	$NO_3 + NO_2$ (mg N/L)	
mean ± s.d.	0.042 ± 0.036	0.035 ± 0.049
min - max	0.004 - 0.162	0 – 0.305
no. obs.	474	57
	DIN (mg N/L)	
mean ± s.d.	0.091 ± 0.049	0.094 ± 0.087
min - max	0.011 – 0.230	0.006 – 0.380
no. obs.	474	50
	PO_4 (mg P/L)	
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)	
mean ± s.d.	0.036 ± 0.020	0.039 ± 0.035
min - max	0 - 0.170	0.006 – 0.255
no. obs.	488	60

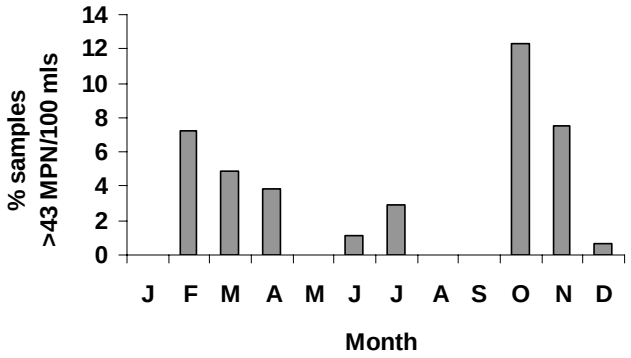

Fig. 2. Seasonal pattern of fecal coliform observations greater than 43 colony forming units per 100 ml, 1991-2004. Data from Ga. DNR – CRD.

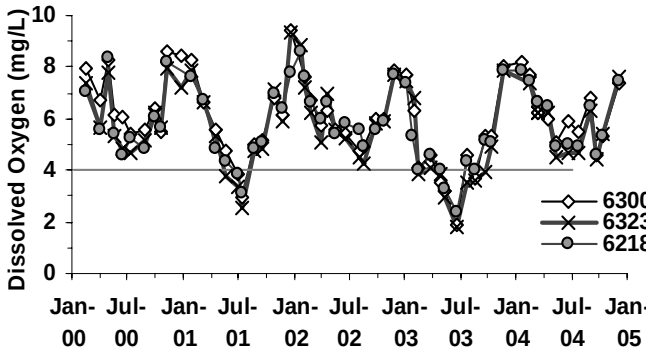

Fig. 3. Dissolved oxygen at 3 stations near Cumberland Island (locations in Fig. 1). Reference line denotes 4 mg/L, the EPD criterion. Data from Ga. DNR - CRD.

beaches daily from April 26-30, 1999, and all samples fell below EPA standards. More information on bacterial levels will soon be available; CRD began monitoring Little Cumberland and Sea Camp Beach on Cumberland Island for *Enterococcus* in September 2004.

Dissolved oxygen. DO concentrations at all 20 stations sampled between March 2000 and December 2004 averaged 5.6 ± 1.6 mg/L. Concentrations less than the Georgia Environmental Protection Division (EPD) criterion of 4 mg/L occurred 18% of the time (180 out of 992 observations). Concentrations were below 3 mg/L 40 times and below 2 mg/L 5 times; the minimum observation was 1.77 mg/L. Examination of the period of record shows similar trends at different stations (Fig. 3). The distinct seasonal cycle in these observations (summertime minima and winter maxima) were reflected in the data set as a whole: 86% of the exceedances (values < 4 mg/L) occurred between May and September.

Contaminants. Water, sediment, and organisms in Cumberland Sound were sampled for metals, pesticides and other pollutants in 1976-1977 as part of the Kings Bay Draft EIS (U.S. Navy, 1975). The EIS uncovered evidence for a potential problem with mercury in Cumberland Sound. Most offshore samples were less than the limit of detection of the analytical technique (0.2 mg/L), 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 Kings Bay. High mercury concentrations were also found in flounder, crab and oyster tissue collected in lower Cumberland Sound. The EIS also found indications of elevated pollutant concentrations in both water and bottom sediments (including aldrin-dieldrin, DDT, heptachlor, lindane, and heptachlor epoxide). When estuarine biota were tested, aldrin-dieldrin, heptachlor, and lindane were detected at 11-36% of the 1976 U.S. EPA limit for edible fish tissue. The distribution of pesticides in 14 different animals from Cumberland Sound was also recorded: Heptachlor epoxide was ubiquitous, and 5 other contaminants (aldrin-dieldrin, toxaphene, lindane, α-BHC and heptachlor) were quite common. Endrin, DDT, and chlordane were also detected in several species.

More recent data on contaminants comes from the EMAP program, which sampled one station in the St. Marys River and one in St. Andrew's Sound in 1994 and a station in Cumberland River in 1995 (summarized by Hyland et al., 1996; 1998). The St. Marys River and St. Andrew's Sound stations did not have any evidence of water or sediment quality degradation. In contrast, the station in the Cumberland River showed evidence of elevated dieldrin, lindane, 4,4′-DDD, and 4,4′-DDT, total DDT and 4,4′-DDE in the sediment. Although sediment contamination often corresponds to effects on fauna, sediment toxicity tests at the site were normal, and species richness, diversity, and abundance of both benthic and demersal organisms showed no indication of degradation.

EPD does not currently have any fish consumption guidelines that apply specifically to Cumberland Sound, and the concentrations of contaminants in commercial biota sampled by the EMAP program were all well below FDA guidelines. There are, however, concerns about mercury in some portions of the watershed: according to the Georgia Environmental Protection Division database, detection frequency of mercury in fish tissue is 100% in the St. Marys River basin and 90% in the Satilla River basin (EPD, 2004).

DISCUSSION

The observations of low DO concentrations in surface waters in and around Cumberland Sound compiled for this

project indicate a potential problem. 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 are rare in nearshore marine water. Moreover, the CRD measurements were generally taken at mid-day and so are likely higher than the daily minimum (which generally occurs just before dawn). Low observations are a cause for concern, as DO levels below 2.0 mg/L are considered hypoxic and can negatively affect estuarine and marine organisms.

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 (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, b). 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.

Another area of concern in Cumberland Sound is the potential for high concentrations of contaminants. Historic data collected as part of the Kings Bay EIS as well as the information collected by EPD 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 associated with several Superfund sites in the Brunswick region. It was also suggested in the EIS that another potential source is mercury-based fungicides that had been previously applied to nearby pine plantations. The EMAP station in Cumberland Sound showed evidence of elevated pesticide levels in the sediment (dieldrin, lindane, DDT-related compounds), many of which had been observed earlier in the EIS. Although dieldrin, lindane and DDT are now banned or 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 (Hyland et al., 1996; 1998), but it would be useful to evaluate additional samples of both sediment and biota in the area. Additional data on sediment contaminants and toxicity on the Georgia coast was collected by CRD as part of the EPA National Coastal Assessment Program. A total of 21 stations in Cumberland Sound were sampled during the summers of 2001 and 2002. These data are not yet available, but will be extremely useful in determining whether elevated contaminant levels are a continuing problem in the area.

The fact that the majority of PO_4 observations and almost half the DIN observations reported here were considered "Fair" according to the EPA National Coastal Condition Report II criteria (U.S. EPA, 2004) suggests that they also bear 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, 2000a, b). If this is the case for Cumberland Sound as well, it may be related to the low DO concentrations.

Bacterial contamination is probably not a large concern in the area, particularly since there were so few observations of elevated concentrations during summer months when people are more likely to be swimming. Note, however, that the Georgia CRD beach monitoring program has not traditionally included Cumberland Island.

In conclusion, it is important to point out how critical the ongoing CRD water quality monitoring program was to this effort. It would have been impossible to develop a water quality assessment for Cumberland Sound without the CRD data set, as the only other available observations were limited in scope and were often dated. Continued and improved monitoring of DO, nutrients, and contaminants in the coastal region will be essential for any future water quality assessments and for tracking trends over time.

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