Sediment Quality Baseline Data for Coastal Resource Management in Two Protected Areas in Puerto Rico

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Findings of an on-going comparative study of mangrove regions in the US NOAA Jobos Bay National Estuarine Research Reserve (JBNERR), an estuary that has been managed for more than 20 years, and the recently established US FWS Vieques National Wildlife Refuge (VNWR) are presented. For many years the JBNERR and VNWR regions, received significant amounts of anthropogenic contaminants from nearby agricultural and industrial activities. In addition to these two sources of anthropogenic contaminants, the VNWR has also been impacted by military exercises at the US Navy Atlantic Fleet Weapons Training Facility, resulting in the release of several contaminants, including heavy metals and depleted uranium. With the purpose of establishing baseline data for sediment quality, sediment cores were collected in the island of Vieques and in the JBNERR using core liners. After collection, the sediment cores where be extruded and sectioned. Sectioned samples were sealed in plastic bags, weighed, frozen, and freeze-dried in preparation for radiogeochemical analysis.

^{137}Cs retention is strongly influenced by particle grain size and clay mineralogy (Pyrtle and Scott, 2001; Livingston et al., 1982; Aarkrog et al., 1983; Dahlgaard et al., 1986; Santschi and Honeyman, 1989; Smith et al., 1990; Dahlgaard, 1994; Cochran et al., 1995). Preliminary analysis indicated that clay size particle in Kiani Lagoon in VNWR ranged between 2.68 % and 9.24 %, averaging 4.53 %. Clay size particles present in Mar Negro located in JBNERR ranged between 0.71 % and 65.88 % and averaged 11.18 %. In general, grain size particle distributions at the VNWR Kiani Lagoon site are fairly constant with depth. Both study sites, Kiani Lagoon and Mar Negro, indicate the presence of ^{137}Cs. ^{137}Cs present at the VNWR Kiani Lagoon sampling site ranged from below detection limits to 0.021 (Bq/g). At the JBNERR Mar Negro site ^{137}Cs activities range from below detection limits to 0.00798 (Bq/g). The majority of ^{137}Cs activity at Mar Negro was identified in the upper 20 cm of the sediment core. Significant ^{137}Cs activities were detected at greater depths for the Kiani Lagoon core. These preliminary findings provide useful data for the decision making process of reserve managers when deciding on monitoring and restoration strategies.

BACKGROUND

Vieques National Wildlife Refuge

- The island of Vieques is located seven miles east of the main island of Puerto Rico (Fig. 1).
- For over 50 years, Vieques served as the US Navy Eastern Maneuver Area (EMA) and the Atlantic Fleet Weapons Training Facility (ATWTF), which contained the Live Impact Area (LIA).
- Military exercises at the ATWTF introduced depleted uranium, Agent Orange and napalm into the local environment (Yarrow, 2000).
- Military activities on Vieques ceased in 2003.
- Significant amount of debris, including depleted uranium ammunitions remain (ATSDR, 2002; US Navy, 2002; US EPA, 2003).
- Regions of ATWF are now the Vieques National Wildlife Refuge (VNWR), under the US Fish and Wildlife Service jurisdiction.

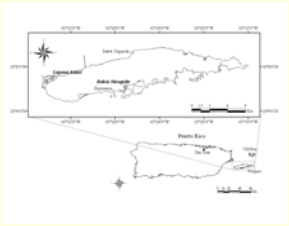

Figure 1. Sampling sites at the US FWS Vieques National Wildlife Refuge.

Jobos Bay National Estuarine Research Reserve

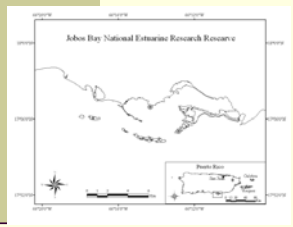

Figure 2. Sampling sites at the US NOAA Jobos Bay National Estuarine Research Reserve.

- The Jobos Bay National Estuarine Research Reserve (JBNERR), established in 1981 by agreement between the Puerto Rico Dept. of Natural and Environmental Resources and NOAA, is located on the south coast of Puerto Rico (Fig. 2).
- The JBNERR includes a chain of 15 mangrove islets, known as Cayos Caribe, and the Mar Negro area located west of Jobos Bay.
- Management efforts are being conducted by the NOAA National Estuarine Research Reserve System (NERRS).
- Because of a need to evaluate these areas and implement strategies to protect valuable resources, JBNERR officials developed a management plan that included 5 major target areas as part of its managing efforts.

METHODS

- With the purpose of providing sediment quality baseline data that can support management efforts being undertaken at the study sites, ^{137}Cs and grain size distributions were determined.
- Sediment cores were taken from mangrove areas at two study areas. Sediment cores were extruded, sectioned into 0.5 and 1 cm portions, weighed, frozen, and freeze-dried. Sediment samples were prepared for radionuclide analyses by sealing in scintillation vials for a period of 28 days in order to allow for secular equilibrium to be achieved.
- Particle size distribution data was obtained using a Micromeritics Saturn DigiSizer® 5200 equipped with Saturn Software 5200. Prior to analysis, samples were weighed and filtered to remove the > 63 µm size fractions. The > 63 µm size fractions were air dried and weighed, while the ≤ 63 µm size fractions were analyzed in the Micromeretics Saturn DigiSizer 5200. Size fractions are reported as silt (≤ 63 µm to > 4 µm), clay (≤ 4 µm) and sand (> 63 µm).
- Sediment samples were analyzed for gamma emitters using low-background Canberra gamma well detectors and APEX software. Activities were determined for radionuclide-specific energy peaks located at 661 keV for ^{137}Cs (half-life 30 years).

OBJECTIVES

The main objectives include:

- determining the ^{137}Cs activity levels and sediment grain size baseline of the study sites,
- determining if ^{137}Cs levels are significant enough for management,
- recommending management initiatives for VNWR that should be implemented for the long-term monitoring and restoration, and
- recommending JBNERR management programs that can be applied to VNWR.

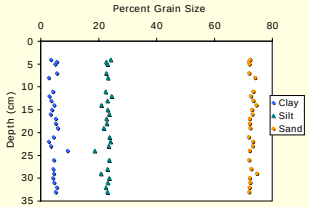

Figure 3. Percent grain size in Kiani Lagoon, VNWR, Puerto Rico.

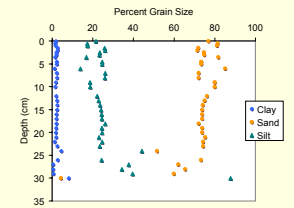

Figure 4. Percent grain size in Mosquito Bay, VNWR, Puerto Rico

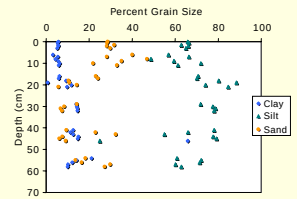

Figure 5. Percent grain size in Mar Negro, JBNERR, Puerto Rico.

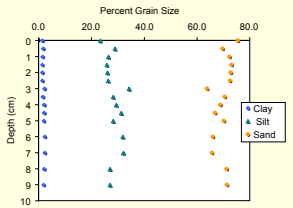

Figure 6. Percent grain size in Cayo Caribe, JBNERR, Puerto Rico.

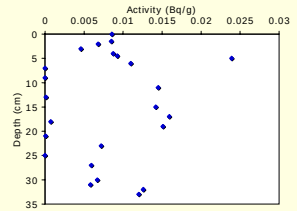

Figure 7. ^{137}Cs activity in Kiani Lagoon, VNWR, Puerto Rico. Percent errors associated with ^{137}Cs values are ≤ ± 10 %.

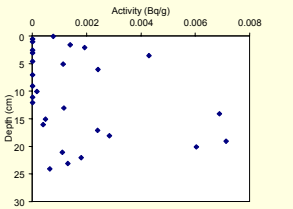

Figure 8. ^{137}Cs activity in Mosquito Bay, VNWR, Puerto Rico. Percent errors associated with ^{137}Cs values are ≤ ± 10 %.

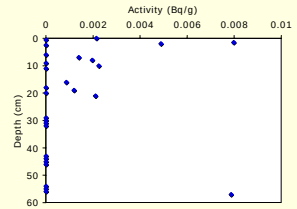

Figure 9. ^{137}Cs activity in Mar Negro, JBNERR, Puerto Rico. Percent errors associated with ^{137}Cs values are ≤ ± 10 %.

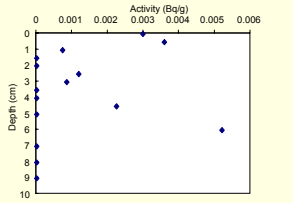

Figure 10. ^{137}Cs activity in Cayo Caribe, JBNERR, Puerto Rico. Percent errors associated with ^{137}Cs values are ≤ ± 10 %.

RESULTS

Sediment Grain Size

Clay size particles in Kiani Lagoon and Mosquito Bay averaged 4.53 % and 2.12%, respectively. Mosquito Bay displayed differences down core with slight variations in the upper 10 cm and deeper (24-30 cm) sediments, the mid portion (11-24 cm) are fairly constant (Fig. 4). Clay size particles present in Mar Negro and Cayo Caribe averaged 11.18 % and 1.74%, respectively. Cayo Caribe exhibited a more even distribution of clay size particles when compared to Mar Negro. At Mar Negro sediments deeper than 20 cm exhibit a slightly higher concentration of clay size particles than the shallower sediments (Fig. 5).

^{137}Cs Distributions

^{137}Cs present at the VNWR Kiani Lagoon and Mosquito Bay sampling sites ranged from below detection limits to 0.021 and 0.00712 (Bq/g) respectively (Fig. 7 and Fig.8). At the JBNERR Mar Negro site ^{137}Cs activities range from below detection limits to 0.00798 (Bq/g) at 1.5 cm (Fig. 9). ^{137}Cs activity levels at Cayo Caribe ranged from below detection limits to 0.00519 (Bq/g) at 6 cm (Fig. 10). The majority of ^{137}Cs activity at Mar Negro was identified in the upper 20 cm of the sediment core. At the VNWR Mosquito Bay site all sediment samples deeper than 12 cm contained ^{137}Cs. Significant ^{137}Cs activities were detected at greater depths for the Kiani Lagoon core.

CONCLUSIONS AND RECOMMENDATIONS

- Past military activities at the former US Navy Atlantic Fleet Weapons Training Facility have resulted in several forms of contamination, including radioactive isotopes.
- Significant ^{137}Cs activities were detected at greater depths and through out the entire core at the Kiani Lagoon site, with the highest levels found at 5 cm of depth.
- Habitat restoration for VNWR is a priority. Currently, efforts are underway to plan for site clean-up at selected PAOC (Potential Area of Concern) and other identified sites.
- The process of establishing management plans at JBNERR has led to the identification of specific objectives and goals for the appropriate development of the Reserve.
- VNWR should give priority to activities focusing on education and volunteering, research and monitoring, and restoration. In addition to these target areas, due to the past military activities at VNWR it is recommended that additional attention and research efforts be directed towards understanding short and long-term contaminant cycling in the local ecosystem.
- Baseline data of the region should be gathered, including sediment characterization, grain size analysis, nutrients and organic content, as water quality monitoring.
- The mangrove community should be studied, as well as its faunal associations. This data can help inform the initial monitoring design, which will ultimately help guide the restoration of the impacted sites.

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