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

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137Cs 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 2.94 %, averaging 4.53 %. Clay size particles present in Mar Negro located in JBNERR ranged between 0.101 % and 0.68 % 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 137Cs present at the VNWR Kiani Lagoon sampling site ranged from below detection limits to 0.021 (Bq/kg). At the JBNERR Mar Negro site 137Cs activities range from below detection limits to 0.00798 (Bq/kg). The majority of 137Cs activity at Mar Negro was identified in the upper 20 cm of the sediment core. Significant 137Cs 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 easternmost point 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 activities on Vieques ceased in 2005.
- Significant baseline data, including detailed contamination reports (ATWTF, 2002; US Navy, 2002 US EPA, 2003).
- Region of ATWF are now the Vieques National Wildlife Refuge (VNWR), under the US Fish and Wildlife Service jurisdiction.

Jobs Bay National Estuarine Research Reserve
- The Jobs 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 north coast of Puerto Rico (Fig. 2).
- The JBNERR includes a strip of 75 contiguous islands, known as Culebra Cays, and the Blue Negro area located west of Jobs 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 officially developed a management plan in 1996 and included 5 major target areas as part of its management efforts.

OBJECTIVES
The main objectives include:
- determining the 137Cs activity levels and sediment grain size baseline of the study sites,
- determining that 137Cs levels are significant enough for management,
- recommending management initiatives for VNWR that should be implemented for the long-term monitoring and restoration, and
- recommending a JBNERR management program that can be applied to VNWR.

METHODS
• With the purpose of providing sediment quality baseline data that can support management efforts being undertaken at the study sites.
• Sediment cores were taken from mangrove areas at two study areas. Sediment cores were extended, sectioned into 0.5 and 1 cm portions, weighed, frozen, and freeze-dried. Sediment samples were prepared for radionuclide analysis by selecting in silification vials for a period of 28 days in order to allow for secular equilibrium to be achieved.
• Particle size distribution data were obtained using a Micromeritics Satoris Digisizer® 5200 equipped with Satoris Software 5200. Prior to analysis, samples were weighed and fiberglass removed the <63 μm particle fractions. The < 63 μm size fractions were air dried and weighed, while the ≥63 μm size fractions were analyzed in the Micromeritics Satoris Digisizer 5200. Size fractions are separated at 45 μm to 63 μm, 63 μm to 125 μm, 125 μm to 250 μm, 250 μm to 500 μm, >500 μm.
• Sediment samples were analyzed for gamma activity using low-background Canberra gamma well detectors and a computer software. Activities determined for radionuclide-specific energy peaks located at 662 keV for 137Cs (half-life 30 years).

RESULTS
Sediment Grain Size
- Clay size particles in Kiani Lagoon and Mosquito Bay averaged 4.53 % and 2.12 %, respectively. Mosquito Bay displayed different clay size particles with slight variations in the upper (0-10 cm) and deeper (24-30 cm) sediments, the mid portion (11-24 cm) were fairly constant.
- Clay size particles present in Mar Negro and Cayo Caribe averaged 11.18 % and 5.74 %, respectively. Cayo Caribe exhibited a minor even distribution of clay size particles when compared to Mar Negro. At Mar Negro sediment deeper than 20 cm exhibit a slightly higher concentration of clay size particles than the shallower sediments.

137Cs Distributions
- 137Cs present at the VNWR Kiani Lagoon and Mosquito Bay sampling sites ranged from below detection limits to 0.021 and 0.00798 (Bq/kg), 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. Clay size particles present in Mar Negro and Cayo Caribe averaged 11.18 % and 5.74 %, respectively. Cayo Caribe exhibited a minor even distribution of clay size particles when compared to Mar Negro. At Mar Negro sediment deeper than 20 cm exhibit a slightly higher concentration of clay size particles than the shallower sediments.

CONCLUSIONS AND RECOMMENDATIONS
- For future activities at the former US Navy Atlantic Fleet Weapons Training Facility, research and monitoring have resulted in several forms of contamination, including radioactive isotopes.
- Significant 137Cs activities were detected at greater depths and through the entire core at the Kiani Lagoon site, with the highest levels found at 3 cm of depth.
- Habitat restoration for 137Cs is a priority. Currently, efforts are underway to plan for site clean-up at selected FNOC (Damal 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 major goals, due to the post military activities at VNWR it is recommended that additional attention and research efforts be directed toward understanding short and long-term contamination cycling in the local ecosystems.
- Baseline data of the regions should be preserved, including sediment characterization, grain size analysis, nutrient, and organic content, as well as water quality monitoring.
- The mangrove community should be studied, as well as its faunal assemblage. This data can help inform the initial monitoring design, which will ultimately help guide the restoration of the impacted sites.

SELECTED LITERATURE

ACKNOWLEDGEMENTS