Gray's Reef National Marine Sanctuary: Sediment Quality and Condition of Benthic Fauna

Cynthia Cooksey, Jeffrey Hyland, Leonard Balthis, Geoffrey Scott, and Daniel Bearden
NOAA/National Ocean Service/National Centers for Coastal Ocean Science/Center for Coastal Environmental Health and Biomolecular Research, Charleston, South Carolina

Contact Information
Phone: 843-762-8511
E-Mail: Jeff.Hyland@noaa.gov
Cynthia.Cooksey@noaa.gov

Abstract

A multi-year study is being conducted to assess the condition of benthic macroinfauna and contaminant levels in sediments and biota of the Gray's Reef National Marine Sanctuary and nearby inner-shelf water off the coast of Georgia. This information is of direct importance to the development of management plans for the sanctuary, as a contribution to our understanding of the overall ecology of this system, and as a baseline for monitoring any future changes due to either natural or anthropogenic influences. Results from the first year of sampling, April 2000, indicate that chemical contaminants throughout the sanctuary are generally at background levels, below probable bioeffect guidelines. Contaminants in tissues of target benthic species are below human-health guidelines (where available). However, trace concentrations of man-made pesticides, PCBs and PAHs were detected in both sediments and biota. The large stretches of sandy substrate throughout the sanctuary support a highly diverse and abundant macroinfaunal community.

Introduction

This multi-year study is being conducted to assess the condition of benthic macroinfauna and contaminant levels in sediments and biota of the Gray's Reef National Marine Sanctuary (GRNMS) and nearby inner-shelf waters off the coast of Georgia. Benthic research in the sanctuary by previous investigators has focused largely on live-bottom assemblages associated with rocky outcrops. In contrast, there has been limited work on the ecology of unconsolidated sandy substrates which surround the rocky-reef structures and characterize much of the inner-shelf area in the general vicinity of Gray's Reef. The present study is providing a first-ever quantitative baseline on levels of potential environmental contaminants and condition of the infaunal organisms living within these substrates. The soft-bottom benthos is a key component of coastal ecosystems, playing vital roles in detrital decomposition, nutrient cycling, and energy flow to higher trophic levels. Moreover, because of their relatively stationary existence within the sediments, benthic infauna (Fig. 1) can serve as reliable indicators of potential environmental disturbances to the seafloor. Such information is of direct importance to the development of management plans for the Sanctuary, as a contribution to our understanding of the overall ecology of this system and as a baseline for monitoring any future changes due to either natural or anthropogenic influences. The present benthic survey is a component of a larger, ongoing coordinated site characterization of the sanctuary by the GRNMS Office and three NCCOS Centers (CCMA, CCFHR, and CCEHBR).

Figure 1. Examples of benthic macroinfauna at GRNMS. From left to right: *Aspidosiphon muelleri*, *Kurtziella rubella*, *Chloeia viridis*, and *Nephtys picta*.

Objectives

Year One: (1) Assess baseline condition of macroinfauna (> 0.5 mm), concentrations of chemical contaminants in sediments, and contaminant body burdens in target benthic species within the sanctuary boundaries; and (2) provide a quantitative basis for tracking potential changes in these properties with time due to either natural or human events.
Year Two: (1) Examine spatial patterns in benthic communities and sediment contaminant levels in relation to both natural factors (e.g., depth) and potential anthropogenic factors (e.g., proximity to land-based sources of contaminants); and (2) Assess between-year temporal variability of measured parameters within the sanctuary boundaries.

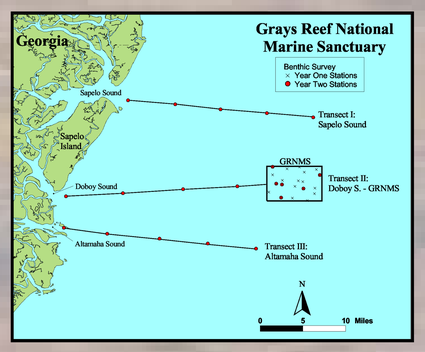


Figure 2. Sampling design for the benthic survey of GRNMS.

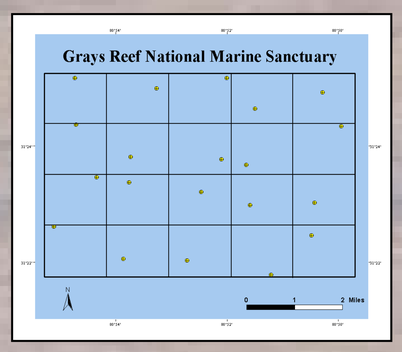


Figure 3. Site locations within GRNMS. Each cell = 2.9 km².

Methods

To address year-one objectives, 20 stations were sampled in April 2000 within the GRNMS boundaries. A random sampling design was used to support probability-based estimates of the percentage of area with degraded versus non-degraded condition relative to various measured environmental indicators. At each year-one station samples were collected for characterization of general habitat conditions, concentration of sediment contaminants, diversity and abundance of macroinfauna, and aesthetic quality. Target benthic species (the turkey wing arc shell *Arca zebra*, and the black sea bass *Centropristis striata*) were collected in selected areas and analyzed for contaminant levels in tissues.

To address year-two objectives, 20 stations were sampled in May 2001: three cross-shelf transects of five stations each, including one station in GRNMS serving as the seaward end of the middle transect, and an additional five stations within the sanctuary boundaries. At each year-two station samples were collected for characterization of general habitat conditions, concentration of sediment contaminants, diversity and abundance of macroinfauna, and aesthetic quality. Samples collected during May 2001 are currently being analyzed.

April 2000 Results

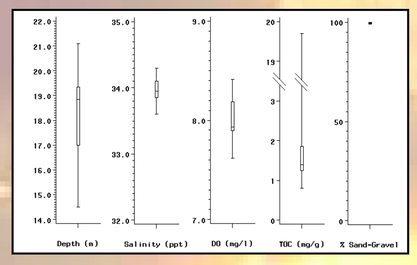


Figure 4. Key Habitat characteristics at GRNMS in April 2000 (n=20). Boxes are interquartile ranges, horizontal lines within boxes are medians and whisker endpoints are high/low extremes. Note in the last plot that values of % sand-gravel fall within a very narrow range of 99-100%.

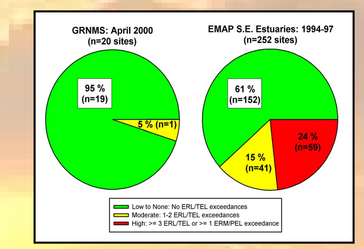
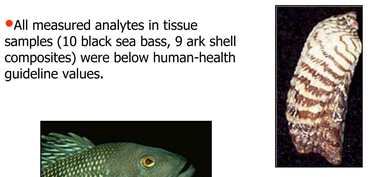


Figure 5. Comparison of sediment contamination (% area) at GRNMS (April 2000) vs. southeastern estuaries sampled during EMAP (unpublished data from Jeffrey Hyland). ERL and TEL values are both lower-threshold bioeffect limits, below which adverse effects of contaminants on sediment-dwelling organisms are not expected to occur. In contrast, ERM and PEL values both represent midrange concentrations of chemicals above which adverse effects are more likely to occur.

- All measured analytes in tissue samples (10 black sea bass, 9 ark shell composites) were below human-health guideline values.



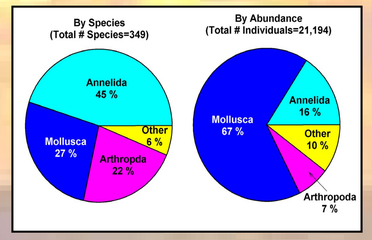


Figure 6. Relative composition of major taxonomic groups of macroinfauna at GRNMS. Data based on 3 replicate grabs (0.04 m²) at each of 20 stations, April 2000.

Table 1. Dominant macroinfaunal species at GRNMS contributing to >= 1% of total species abundance individually and to 75% of cumulative % abundance collectively.

Taxon	Group	Average Density (#/m²)	% of Total Abundance	Cum % Abundance	% Station Occurrence
Ervilia sp. A*	Bivalve	4938	55.9	55.9	75
Caecum johnsoni	Gastropod	301	3.4	59.3	95
Crassinella lunulata	Bivalve	268	3.0	62.4	100
Branchiostoma spp.	Chordate	251	2.8	65.2	95
Aspidosiphon muelleri	Sipunculid	218	2.5	67.7	95
Spiophanes bombyx	Polychaete	164	1.9	69.5	100
Spio pettiboneae	Polychaete	158	1.8	71.3	100
Oxyurostylis smithi	Cumacean	155	1.7	73.0	100
Ophiuroidea	Ophiuroid	125	1.4	74.5	90
Actiniaria	Anthozoan	102	1.2	75.6	80

* Possible new subspecies of *Ervilia concentrica*.

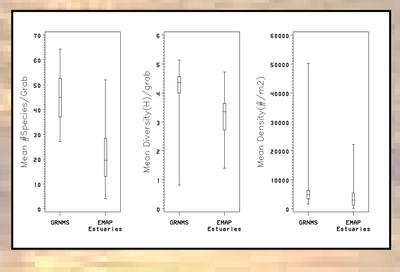


Figure 7. Comparison of benthic species richness, diversity and abundance at GRNMS sites (n=20) vs. estuarine sites of similar salinity (>30 ppt) in EMAP Carolinian Province (n=38). Boxes are interquartile ranges, horizontal lines within boxes are medians and whisker endpoints are high/low extremes. Base 2 logarithms were used to calculate H´.

Conclusions

- In general, chemical contaminants in sediments are at background levels, below probable bioeffect thresholds, throughout sanctuary.
- Contaminants in tissues of target benthic species are below human-health guidelines (based on limited sample population of n = 19).
- Trace concentrations of man-made pesticides, PCBs, and PAHs were detected in both sediments and biota.
- Sandy substrates throughout sanctuary support a highly diverse and abundant infaunal community (comprised mostly of annelids, molluscs & arthropods).

Implications for Coastal Management

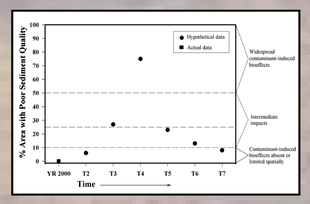


Figure 8. Example of how probability-based sampling data could be used to monitor potential changes in sediment quality with time at GRNMS. Y-axis is % area exhibiting poor sediment quality, as indicated by combined evidence of low benthic species (e.g., <30 species/grab) accompanied by high sediment contamination (e.g., 1 ERM or ≥3 ERL exceedances).

Probabilistic sampling design provides a powerful quantitative tool for assessing current status in conditions of sanctuary and for using this information as a baseline for tracking any future changes due to natural or anthropogenic influences.

Future Directions

- Long-term monitoring of potential environmental impacts.
- Studies to evaluate functional role of benthos as prey for higher trophic levels.
- Understanding relationships between conditions in sanctuary and surrounding SAB shelf environment.
- Educational and public outreach.