EMAP/NS&T PILOT STUDIES IN THE CAROLINIAN PROVINCE: INDICATOR TESTING AND EVALUATION IN SOUTHEASTERN ESTUARIES

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SUMMARY

Indicator development studies were conducted during a pilot year program designed to evaluate existing EMAP indicators as well as to identify and develop new indicators of environmental quality for southeastern Atlantic estuaries. EMAP sampling activities were conducted at 24 stations throughout the Carolinian Province. Hydrolab Datasonde 3s were deployed in situ for $\geq$ 23 hr for water quality data (temperature, salinity, pH, dissolved oxygen, and depth). Sediment grabs were collected for infaunal community analyses. The top 2 cm of sediments from multiple grabs were composited and used for a variety of analyses (sediment contaminants, toxicity, sediment characterization). A limited suite of metals and PAHs were determined from sediment samples. Trawls were conducted for fish and shellfish community analyses.

The 24 stations were grouped into three categories on the basis of dissolved oxygen (DO) and sediment contaminant criteria. Nine "Reference" stations had little to no evidence of elevated sediment contaminants or DO stress. Nine "Degraded" stations were identified that were characterized by elevated sediment contaminants or low DO conditions. The remaining six stations were categorized as "Unknown" or "Uncertain" because they were clearly metal enriched so could not really be considered reference sites, but did not quite fit more stringent criteria for classification as degraded. These sites may represent potentially degraded sites that are experiencing early or low levels of stress. A three tiered classification scheme may aide in the development of bioindicator strategies that facilitate discrimination between areas experiencing early or chronic stress as well as those acutely impacted. Therefore, based on this scheme the efficacy of indicators for assessing habitat condition was evaluated.

Some indicators, such as dissolved oxygen, sediment contaminants, and benthic index have functioned as valuable core indicators in the Virginian and Louisianian Provinces. Studies in the Carolinian Province support their continued use. Many estuarine environments experience fluctuations in habitat parameters such as dissolved oxygen and pH as well as salinity. Dissolved oxygen cycles, driven in part by tidal and diurnal processes, were frequently observed at reference as well as degraded sites. However degraded sites were characterized by greater magnitudes of fluctuations and increased frequency of the cycles. These conditions present a high potential for oxygen reperfusion damage. Although water quality parameters based on minima or mean values may help to identify some stressful conditions, they may underestimate the potential impacts of cyclical patterns. Relative criteria (based on range or rate functions) that rely less on absolute values were developed for DO and pH that may be more biologically relevant for cyclical systems.

Sediments are the primary sink for contaminants that are introduced into estuarine ecosystems, and are an important indicator of potential pollutant exposure. Exceedances of Long and Morgan ER-M values were observed at only three of the degraded sites, but all degraded sites (and some of the uncertain sites) had one or more exceedances of ER-L concentrations. When the sediment metals data were evaluated based on Al- normalization procedures, enrichment of multiple metals were observed at degraded and uncertain sites. Sediment criteria are established for each contaminant, but there are presently no provisions for classifying stations with lower but enriched concentrations of multiple contaminants. Two approaches for making assessments based

on multiple contaminants were described. Sites with 3 contaminants that exceeded ER-L values or 6 metal contaminants that were enriched based on Al normalization were classified as degraded. Sediment criteria based on the summed proportional metal concentrations (i.e. metal concentration divided by ER-L or ER-M concentration) were also presented.

Laboratory toxicity tests have been used in EMAP and other monitoring programs as indicators of potential impacts on the biota and as indirect indicators of contaminant bioavailability. The amphipod *(Ampelisca abdita)* assay was the primary test of potential toxicity for the Virginian and Louisianian Provinces. Amphipod toxicity, mysid toxicity, and Microtox assays were evaluated in this study. A new candidate indicator was also developed. In this assay, the effects of sediments on growth of juvenile seed clams *(Mercenaria mercenaria)* were evaluated. Although efforts are made during pilot year programs to sample in some of the most degraded sites (validated by high contaminant levels), amphipod and mysid toxicity assays did not discriminate these sites from reference sites. Microtox was more successful at discriminating between reference sites and degraded sites with an error rate of less than 10%. Although the seed clam assay was conducted at a limited number of sites, it also demonstrated a high potential for discriminating between reference and degraded conditions.

The abundances of fish and shellfish in the trawls did not provide an acceptable approach for discriminating reference from degraded sites. In fact, the results suggest that abundances and diversity are often high in even the most degraded sites. It is difficult to correlate the conditions at a site with mobile populations. Trawls are best conducted to collect specimens for contaminant analysis or disease status. The incidence of diseases in organisms caught in trawls is relatively rare, but still appeared to be a valuable indicator. It is recommended that the disease status of shrimps and crabs should be tallied as well as fish. In the southeast, the invertebrate species are common components of trawls, and both diseases (shell disease in blue crabs and cotton disease in shrimp) are relatively easy to identify by field crews. Moreover they are important commercial species.

Studies were also conducted in which organisms were deployed *in situ* at some of the sites. Hatchery-reared oysters *(Crassostrea virginica)* were deployed at sites in the Charleston Harbor area, and the effects on growth, bioaccumulation of contaminants,

and disease status were evaluated. Oysters deployed at degraded sites had significantly slower growth rates, greater bioaccumulation of metal contaminants, and increased incidence of Den-no (a bivalve disease caused by a protistan parasite). Although this approach may not always be feasible for large scale monitoring programs, it is certainly amenable for regional studies. Furthermore, it is particularly valuable as a means of validating how well laboratory toxicity assays represent field conditions, i.e. whether the effects observed in laboratory assays are likely to reflect reduced fitness of field populations.

The assemblages of organisms associated with the benthos were described. Simple parameters, abundance and species richness, demonstrated some capacity for discriminating between reference and degraded sites. These data will be combined with 1994 data to develop a benthic index based on functionality that is expected to have greater powers of discrimination.

Mummichog *(Fundulus heteroclitus)* eggs were also deployed at various sites in SC and GA in order to evaluate the effects on reproductive success. No significant differences were observed in the response variables (embryo survival, hatching rates, length and weight of hatchlings).

The pilot year studies served to identify indicators that can discriminate reference from degraded sites in southeastern estuaries. Many of the methods and approaches used in the Virginian and Louisianian Provinces were used successfully in the Carolinian Province. The utility of some indicators (DO and pH) was extended by considering range criteria as well as absolute minima. The amphipod sediment toxicity assay was found to be the weakest component. It is uncertain if the failure of the *Ampelisca abdita* assays was due to the perceived less toxic nature of southeastern sediments or low sensitivity of this species. No single assay is likely to ever be ideal, so at least two types should be employed to eliminate potential errors due to false positives and false negatives. An effort was made to use some criteria for the identification of sites that suffer from chronic stress as well as acute conditions. Microtox, seed clam assays, multiple metals, and range/rate criteria were discussed toward this aim, and there are certainly others that warrant development. Some means of incorporating the significance of multiple stressors into assessments of habitat condition must be developed.