Indicator: Coastal Benthic Index (048)

Benthic communities are largely composed of macroinvertebrates, such as annelids, mollusks, and crustaceans, that inhabit the bottom substrates of estuaries and play a vital role in maintaining sediment and water quality. They also are an important food source for bottom-feeding fish, invertebrates, ducks, and birds. Communities of benthic organisms are sensitive to pollutant exposure (Holland, et al., 1987) and as a result are important indicators of environmental stress. Sediments can accumulate environmental contaminants over time, and because benthic organisms are relatively immobile, they receive prolonged exposure to any such contaminants (Sanders et. al., 1980; Nixon et al., 1986)

This benthic index for each site is based on a multi-metric benthic diversity index that reflects overall species diversity (adjusted for salinity, if necessary) and, for some regions, the presence of pollution-tolerant and pollution-sensitive species (e.g., Weisberg et al, 1997; Engle and Summers 1999, EPA 2004). The benthic community at each site is given a high score if the index exceeds a particular threshold (e.g., a community with high diversity, many pollution-sensitive species, and few pollution tolerant species), a low score if it falls below a certain threshold, and a medium score if it falls in between. The exact structure of the index and the threshold values vary from one region to another, but comparisons between predicted and observed scores based on expert judgment are used to insure that the classifications of sites from one region to another are consistent (see EPA 2004, p. 15). Data for the estuaries were collected using probability samples, so the results from the sampling sites produce representative samples of the entire region. No data are available for the Great Lakes.

The sediment quality index for the each region was rated high (1) if less than 10% of the sediments had a low index score and more than 50% had a high score; moderate (3) if 10-15% of the sediments had a low index score, or fewer than 50% had a high index score; and low (5) if more than 20% of sites had a low index score. These values are based on the professional judgment of water quality managers in each region.

What the Data Show

Benthic condition in the nation's estuaries overall were observed to be in moderate to low condition (Rank Score = 2.0), with 17 percent of the estuarine area rated as low (Figure 048-1). Of that 17%, 71% also exhibited degraded sediment quality and 42% exhibited degraded water quality (see indicators xxx and yyy).

EPA Regions 9 and 10 had high benthic index scores, and Region 6 was high-moderate (Figure 048-1). Region 3 had a low benthic score, and Regions 1 and 2 and the Great Lakes were rated as low-moderate. More than 75% of the estuarine bottom had high benthic index scores in Regions 1, 9, and 10. Only one Region (3) had a low benthic diversity score for more than 25% of the bottom area.

Indicator Limitations

- The coastal areas of Alaska and Hawaii have been sampled, but not yet assessed.
- Benthic indices for the Northeast, West, and Puerto Rico do not yet include measures of pollution-tolerant or pollution-sensitive species; although species diversity has the largest impact on index scores in the other regions, index values could change in the future as these components are added to the index values for these regions.
- Samples are collected during an index period from July-September, and the indicator is only representative of this time period.

Data Sources

The data source for this indicator is the National Coastal Condition Report II, U.S. Environmental Protection Agency, 2004. http://www.epa.gov/owow/oceans/nccr/2005/downloads.html

References

Engle, V.D., and J.K. Summers. 1999. Refinement, validation, and application of a benthic condition index for northern Gulf of Mexico estuaries. *Estuaries 22*(3A):624–635.

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Holland, A.F., A. Shaughnessey, and M.H. Heigel. 1987. Long-term variation in mesohaline Chesapeake Bay benthos: spatial and temporal patterns. *Estuaries* 10: 227-245 (

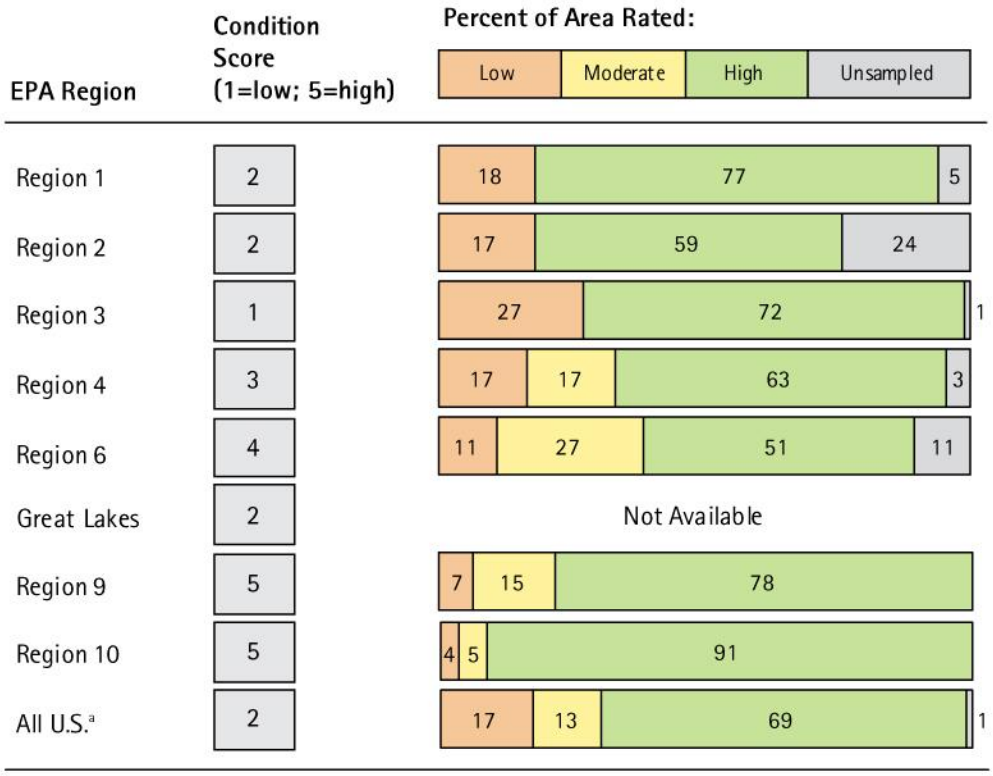
Nixon, S.W., Hunt, C.D., and Nowicki, B.L. 1986. "The retention of nutrients (C, N, P), heavy metals (Mn, Cd, Pb, Cu), and petroleum hydrocarbons by Narrangansett Bay." In P. Lasserre and J.M. Martin (eds.), *Biogeochemical Processes at the Land-Sea Boundary*, New York, NY: Elsevier 99-1122.

Sanders, H.L., J.F. Grassle, G.R. Hampson, L.S. Morse, S. Gerner-Price, and C.C. Jones. 1980. Anatomy of an oil spill: long-term effects from the grounding of the barge Florida off West Falmouth, Massachusetts. *Journal of Marine Research* 38: 265-380.

Weisberg, S.B., J.A. Ranasinghe, D.D. Dauer, L.C. Schnaffer, R.J. Diaz, and J.B. Frithsen. 1997. An estuarine benthic index of biotic integrity (B-IBI) for Chesapeake Bay. *Estuaries 20*(1):149–158.

Graphics

Figure 048 – 1. Summary of Condition Based on the Benthic Index



Source: National Coastal Condition Report II, U.S. EPA, 2004.

[a]The national score is based on an aerially weighted mean of the regional scores.

R.O.E. Indicator QA/QC

Data Set Name: COASTAL BENTHIC INDEX
Indicator Number: 048 (89177)
Data Set Source: EPA/EMAP/NCA
Data Collection Date: 1999-2000
Data Collection Frequency: annually
Data Set Description: This index reflects changes in benthic community diversity and abundance of pollution-tolerant and pollution-sensitive species. It is capable of distinguishing between degraded and undegraded benthic habitats.
Primary ROE Question: What are the trends in extent and condition of coastal waters

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Methods described for this survey represent a combination of standard, scientifically accepted sampling and analytical methodologies. They are described in ; US EPA 2001. National Coastal Assessment: Field Operations Manual. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA 620/R-01/003. pp72. U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. EPA/620/R-95/008.
http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is an entire portion of the EMAP website dedicated to principles and implementation of the NCA monitoring design and analysis. http://www.epa.gov/nheerl/arm/index.htm Diaz-Ramos, S., Stevens, D.L., Jr and Olsen, A.R. (1996) EMAP Statistical Methods Manual. Rep. EPA/620/R-96/002, U.S. Environmental Protection Agency, Office of Research and Development, NHEERL-WED, Corvallis, Oregon. Olsen, A.R., Stevens, D.L., Jr. and White, D. (1998) Application of global grids in environmental sampling. Computing Science and Statistics, 30, 279-84. Stevens, D.L., Jr. (1997) Variable density grid-based sampling designs for continuous spatial populations. Environmetrics, 8, 167-95. Stevens, D.L., Jr. and Olsen, A.R. (1999) Spatially restricted surveys over time for aquatic resources. Journal of Agricultural, Biological, and Environmental Statistics, 4, 415-28. Stevens, D.L., Jr. and Urquhart, N.S. (1999) Response designs and support regions in sampling continuous domains. Environmetrics, 11, 13-41. Stevens, D. L., Jr. and Olsen, A. R. Variance Estimation for Spatially Balanced Samples of Environmental Resources. Environmetrics

14:593-610. Stevens, D. L., Jr. and A. R. Olsen (2004). "Spatially-balanced sampling of natural resources." Journal of American Statistical Association 99(465): 262-278.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Benthic indices were developed utilizing a stepwise regression analysis of variables from each site with the benthic abundance and diversity data. The indices were validated against sites with known benthic quality. Benthic community diversity was used as a surrogate for areas where a benthic index has yet to be developed. Engle, V.D., J.K. Summers, and G.R. Gaston. 1994. A benthic index of environmental condition of the Gulf of Mexico Estuaries. Estuaries 17: 372-384. Engle, V.D., and J.K. Summers. 1999. Refinement, validation, and application of a benthic index for northern Gulf of Mexico estuaries. Estuaries 22(3A):624-635. Van Dolah, R.F., J.L. Hyland, A.F. Holland, J.S. Rosen, and T.T. Snoots. 1999. A benthic index of biological integrity for assessing habitat quality in estuaries of the southeastern USA. Marine Environmental Research 48:(4-5): 269-283.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Sampling for the indicator presents available information on a national scale for the conterminous 48 states and Puerto Rico. There are 50 sites sampled each year for each of the states or territory. Data collection began in 1999 and is ongoing in 2004.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Sensitive populations or ecosystems are represented to a limited extent. The monitoring design at the scale presented is to characterize condition on a regional scale, not specific areas.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Threshold values for benthic indices were established in the development of each index used. The values are different for each index, but reflect the same thresholds for condition. In the absence of an index the relationship of community diversity to natural gradients within the region were used. The application of the results from the indices was applied consistently across the geographical area.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development ,

Narragansett, RI. EPA/620/R-95/008. U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan. . U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002. U.S. EPA. 2001. National Coastal Assessment Field Operations Manual. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/003. http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

http://www.epa.gov/emap/nca/html/data/index.html Stephen Hale, U.S. EPA, Atlantic Ecology Division, (401) 782-3048

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, Using the documentation provided for the design can be reproduced by a competent statistician. All of the field sampling and analytical methods are also well documented.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan. . U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002 Hale, S., J. Rosen, D. Scott, J. Paul, and M. Hughes. 1999. EMAP Information Management Plan: 1998-2001. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

There is an entire portion of the EMAP website dedicated to principles and implementation of the NCA monitoring design and analysis. http://www.epa.gov/nheerl/arm/index.htm Diaz-Ramos, S., Stevens, D.L., Jr and Olsen, A.R. (1996). See T1Q2.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes, measurements of uncertainty are provided with each indicator.
http://www.epa.gov/nheerl/arm/index.htm

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Inconsistency in application of the design, sample collection, or sample analysis. These are controlled through standardization of methodologies, publication of operational manuals, and training of personnel involved. It is monitored through quality assurance requirements and audits.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The only data gaps would be from missing or lost samples. In this event The analyses is performed without those sites. Any error associated with the index may only increase slightly, but would be controlled by the number of sites and the survey design.