‘SPI’-ing under the Surface: Sediment Profile Imagery (SPI)

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What is it?

Sediment Profile Imagery is a technique developed in the 1970s for taking still images of the water-sediment interface in submerged areas. The initial aim of this technology was to gain a window into animal-sediment interactions. For decades the primary means of studying benthic (bottom-dwelling) species and their habitats was to take grab samples.

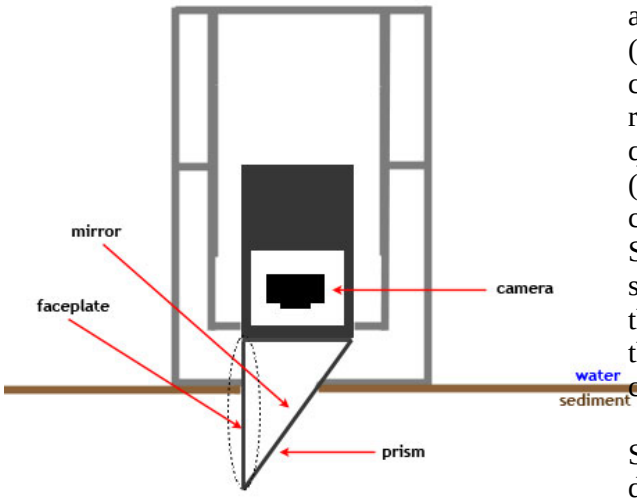
Grab sampling is just as it sounds: a sampler with a spring-loaded door is lowered to the seafloor, upon impact it closes and brings to the surface a sample of the sediment and anything living in it. The sediment is then sieved and the organisms within preserved, identified, and counted. While this technique, still widely used and valuable, provides a trove of detailed data about the species composition of the benthic community, it does no more than hint at possible organism-sediment interactions. Benthic species counts are also time-intensive, expensive, and require specialized taxonomy knowledge.

While actual survey time does not differ greatly, SPI analysis can be done in a far shorter time period. One goal of SPI is to capture some of the dynamics and structure at work in benthic communities. It can also provide clues to water column properties that can affect the benthos. These include the depth of oxidized sediment and physical properties such as grain size and evenness of the surface.

(E. Shumchenia, GSO)

How does it work?

The camera that captures the SPI images is typically a fairly standard digital camera. This camera is fixed inside an airtight housing. The lens is aligned with a window on the bottom of this housing. The housing is fixed into a water-filled prism containing a mirror and a faceplate. A trigger connected to the camera is activated by the weight of the sliding frame upon impact with the seafloor. The prism slices into the sediment and a picture is taken.



(E. Shumchenia, GSO)

How is it used in scientific studies and habitat assessments?

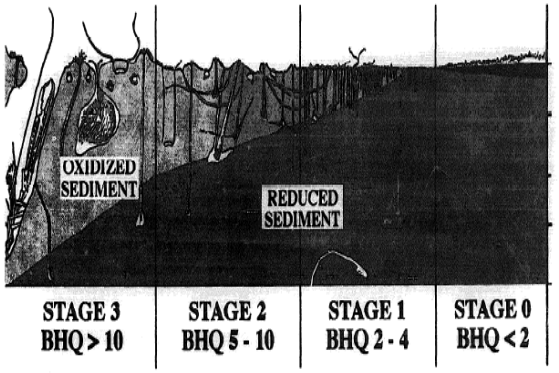
SPI surveys can be used to answer any number of ecological questions. SPI data may also lead to the formation of new hypotheses. Two scoring systems have been developed and are frequently used to quantify features seen in SPI images: the Organism-Sediment Index (OSI) and the Benthic Habitat Quality (BHQ) Index. These indices assign values to features such as fecal pellets, feeding burrows, presence of benthic organisms, etc. The value of using either one of these indices depends on the scientific questions the survey seeks to answer and the expertise of the analyst.

Additional key data gleaned from SPI includes the depth of oxidized sediment- the apparent redox potential discontinuity (aRPD). A shallow or non-existent aRPD can be a sign of hypoxia or anoxia, which results in generally poor overall habitat quality. The total Benthic Habitat Quality (BHQ) score derived from SPI data is correlated with the depth of the aRPD. Studies comparing SPI data to benthic species counts from grab samples indicate that changes in habitat quality, measured by the BHQ, are parallel to changes in faunal community succession.

SPI is frequently used to assess dredge disposal area recovery, to map disturbance gradients, such as the distance of pollution impact from a source (e.g., sewage effluent pipe, open-net fish farm), and to monitor contaminated sediment sites. SPI can also be used to combine geologic and biologic information in identifying and studying the spatial and temporal variability of habitats.

A complete SPI survey was conducted throughout Narragansett Bay in 1988 (see Valente, et. al., 1992). SPI is currently used as one of a suite of habitat mapping and assessment tools by the BayMap and MapCoast projects in the Bay and salt ponds.

There are many different ways to gain value from 'SPI-ing' on the environment!



The distribution of benthic infaunal successional stages along a gradient of increased environmental disturbance from left to right (after Pearson and Rosenberg, 1978) and the associated Benthic Habitat Quality (BHQ) index. The successional stages are similar but not identical to those described by Rhoads and Germano, 1986. (Figure from Nilsson and Rosenberg, 1997).

Ampelisca bed, Quonochontaug Pond, RI
(M. Guarinello, GSO)

Resources and Further Reading

See http://www.ci.uri.edu/projects/mapcoast/docs/MapCoast-BayMap%201-pagerCY.pdf for a brief description of the BayMap and MapCoast projects in Narragansett Bay

See http://www.remots.com/index.html for some examples of SPI projects

Grizzle, R.E. and C.A. Penniman (1991). Effects of organic enrichment on estuarine macrofaunal benthos: a comparison of sediment profile imaging and traditional methods. Marine Ecological Progess Series 74: 249-262.

Nilsson, H.C. and R. Rosenberg (1994). Hypoxic response of two marine benthic communities. Marine Ecological Progress Series 115: 209-217.

Nilsson, H.C. and R. Rosenberg (1997). Benthic habitat quality assessment of an oxygen stressed fjord by surface and sediment profile images. Journal of Marine Systems 11: 249-264.
This paper developed the BHQ

Nilsson, H.C. and R. Rosenberg (2000). Succession in marine benthic habitats and fauna in response to oxygen deficiency: analyzed by sediment profile-imaging and by grab samples. Marine Ecological Progress Series 197: 139-149.

O'Reilly, R., R. Kennedy, A. Patterson, and B.F. Keegan 2006 Ground truthing sediment profile imagery with traditional benthic survey data along an established disturbance gradient. Journal of Marine Systems 62(3-4): 189-203.

Rhoads, D.C. and J.D. Germano (1986). Interpreting long-term changes in benthic community structure: a new protocol. Hydrobiologia, 142: 291-398.
This paper developed the OSI

Rhoads, D.C. and S. Cande (1971). Sediment profile camera for in situ study of organism-sediment relations. Limnology and Oceanography 16(1): 110-114.
This paper presents the invention of SPI

Valente, R. M., D. C. Rhoads, J. D. Germano and V. J. Cabelli (1992). Mapping of benthic enrichment patterns in Narragansett Bay, RI. Estuaries 15:1-17.