Indicator: Harmful Algal Bloom Outbreaks Occurring in the Near Shore Waters of the Western Florida Coastline (327R)

Harmful Algal Blooms (HABs) are “blooms” of large numbers of microscopic algae (phytoplankton) that occur in aquatic environments, especially in nearshore coastal waters and estuaries, that may harm humans and/or the environment. HABs can be caused by a number of species of phytoplankton. One type of HAB common in the Gulf of Mexico is “red tide,” which is caused by the phytoplankton organism *Karenia brevis* (a dinoflagellate). *K. brevis* can cause massive fish kills, marine mammal mortality, and in humans, neurotoxic shellfish poisoning (NSP) and respiratory irritation (NRC 2000). In the Gulf of Mexico, red tide occurs almost every year, generally in the late summer or early fall (Haverkamp, 2004). The blooms are most common off the central and southwest coasts of Florida, but they may occur anywhere in the Gulf. Most red tide blooms last three to six months and may affect hundreds of square miles (Haverkamp, 2004). However, occasionally, blooms continue sporadically for up to eighteen months and may affect thousands of square miles (Haverkamp, 2004). The Gulf of Mexico has experienced intense blooms of *K. brevis* in 22 of the last 23 years (HABSOS, 2004).

At least 40 species of toxic, or potentially toxic, marine microalgae, including 11 ichthyotoxic species, have been identified from Gulf of Mexico waters (Landsberg, 2000). All of these have potential impacts on natural resources and public health. Blooms of the toxic dinoflagellate, *K. brevis* have been responsible for most documented HAB events along the Gulf coast. For at least the last 50 years, *K. brevis* ‘red tides’ have been mostly concentrated along the west coast of Florida and, to a lesser extent, along the Texas coast (HABSOS, 2004). In 1996, red tides occurred in the coastal waters of all five Gulf States for the first time in recorded history, resulting in Gulf wide fish mortalities and numerous beach and shellfish bed closures (Prospectus, 2002). In addition, red tide persisted for over a year along the coast of Florida, killing over 150 endangered manatees (Prospectus, 2002).

K. brevis bloom events occur most frequently from August through February but have been documented in every month of the year. Offshore surveys have shown that Florida red tides generally begin 10 to 40 miles from the coast in the Gulf of Mexico on the mid-continental shelf. Winds and currents may push the patches of red tide onshore or along the shore to other areas. If conditions are right a bloom may remain in an area for several weeks or may move up and down along the coast for months at a time.

K. brevis may be found year-round throughout the Gulf of Mexico at background concentrations of approximately 1,000 cells per liter (Geesy and Tester, 1993). When *K.brevis* concentrations reach approximately 5,000 cells per liter, monitoring efforts intensify and the harvesting of shellfish is prohibited if these concentrations are detected in a shellfish harvesting area (ISSC, 1999). Monitoring for *K. brevis* requires resource managers to collect water samples for microscopic examination with supplemental data provided by animal mortalities, satellite imagery, and shellfish bed closures as blooms intensify (NOAA).

This indicator presents data on the frequency and duration of *K. brevis* blooms off the Gulf coast of Florida from 1996-2001. Data are from the Florida Fish and Wildlife Conservation Commission’s red tide monitoring program and historical database of *K. brevis* cell concentrations and associated data. The monitoring program and dataset are used for prediction and management of HAB events, for addressing hypotheses concerning the ecophysiology of blooms, and for providing information to the public on current bloom status and locations.

What the Data Show

Red tide bloom events in 1997 and 2001 persisted along the Florida coastline for over 120 consecutive days (Figure 237R). In 1996, four separate red tide bloom events occurred along the western Florida coastline, and for the first time in recorded history, blooms of red tide were documented in all five of the Gulf States.

Indicator Limitations

- HAB data are biased toward surface and inshore sampling.

Data Sources

Florida Fish and Wildlife Conservation Commission, FWRC:
http://ocean.floridamarine.org/mrgis/viewer.htm

References

Geesy. M and P.A. Tester. 1993. Gymnodinium breve: Ubiquitous in the Gulf of Mexico waters? In: Smayda, T.J. and Shimizu, Y. (eds)., Toxic Phytoplankton Blooms in the Sea, Elsevier, N.Y., 251-255.

HABSOS, An Integrated Case Study for the Gulf of Mexico. Final Report July 2004

Haverkamp, Darlene, Steidinger, K.A., and Heil, C.A. 2004. HAB Monitoring and Datbases: The Florida *Karenia Brevis* Example. Harmful Algae Management and Mitigation, 102-109.

ISSC Model Ordinance 1999.

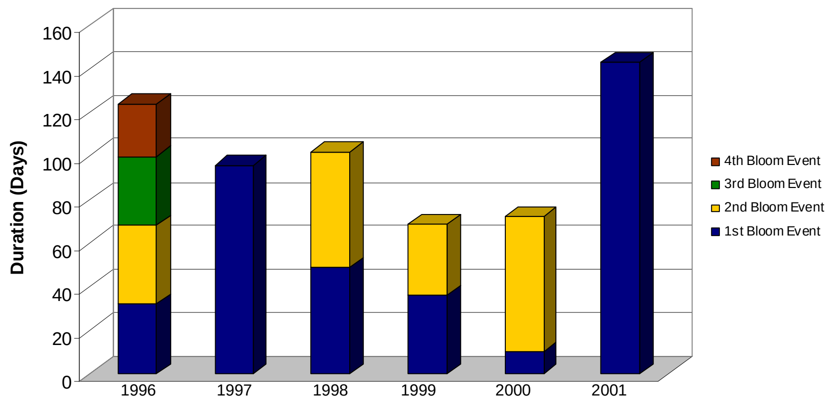
Jan H. Landsberg, Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute. The Effects of Harmful Algal Blooms on the Health of Florida's Fish. Abstract submitted to the Florida Chapter, American Fisheries Society. (see: http://www.sdafs.org/flafs/doc/abs-2000.html)

National Research Council (NRC). 2000. Clean Coastal Waters: understanding and reducing the effects of nutrient pollution. National Academy Press, Washington, DC, 405 pp.

Prospectus, The Gulf of Mexico Pilot Project for a Harmful Algal Blooms Observing System (HABSOS) May 29, 2002.

Graphics

Figure 237R: The Frequency and Duration of Karenia brevis Blooms in Florida from 1996-2001



R.O.E. Indicator QA/QC

Data Set Name: HARMFUL ALGAL BLOOM OUTBREAKS OCCURRING IN THE NEAR SHORE WATERS OF THE WESTERN FLORIDA COASTLINE
Indicator Number: 237R (89158)
Data Set Source: FMRI, DISL, ADPH, USM-GCRL, LUMCON, UTMSI, TPWD
Data Collection Date: 1996-2000 (and as needed)
Data Collection Frequency: As outbreak conditions occur
Data Set Description: Harmful Algal Bloom Outbreaks Occurring in the Near Shore Waters of the Western Florida Coastline
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?

Yes. Florida has had an on-going database project at the Florida Fish and Wildlife Research Institute for Harmful Algal Bloom (HAB) monitoring and event response. This database includes data collected by citizens, commercial fishermen, private and public institutions throughout the state since 1953. This historical data was recently rescued and almost 50 years of data digitized. HAB monitoring cruises in the Gulf of Mexico have been conducted with some regularity since 1954, particularly since 1997 with the advent of the Ecology and Oceanography of Harmful Algal Blooms (ECOHAB): Florida program. In May 2000, the Red Tide Offshore Monitoring Program (a citizen volunteer network) was begun, enhancing the spatial and temporal sampling efforts of federal and state funded HAB monitoring.

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

Yes. Additional details are provided in: HABSOS Case Study Report; Fisher, William S., Thomas C. Malone and James D. Giattina. 2003. Pilot Project to Detect and Forecast HABs in the N. Gulf of Mexico. Environ. Monit. Assess. 81 (1-3): 373-381. (ERL, GB 1141). Development of the Volunteer Offshore Red Tide Monitoring Program for the Gulf Coast of Florida. Steidinger, Karen A., Jay Paul Abbott and Earnest W. Truby. Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute. Available online at: http://research.myfwc.com/engine/download_redirection_process.asp?file=volunteer_posterforweb_1949.pdf&objid=24851&dltype=article

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?

Yes. The data presented in the bar chart illustrates the K. brevis bloom events for the western shelf of Florida from 1996-2001. According to NOAA, monitoring HAB events requires resource managers to use data collected from animal mortalities, cell counts, satellite imagery, and shellfish bed closures. Satellite imagery alone does not detect the early stages of HAB bloom events and cannot differentiate between the different HAB species (or any other phytoplankton species) unless direct cell counts are available for validation. The State of Florida closes shellfish beds based on direct cell count data and will open the shellfish beds based on mouse assays. The underlying dataset for this indicator is based upon the State of Florida's HAB database that is developed from direct counts of water samples provided by a year round monitoring program. As a component of the Florida HAB dataset, a Volunteer Offshore Monitoring Program was established to provide regular sampling in offshore areas where red tides have traditionally come onshore. The Volunteer Offshore Monitoring Program was designed for charter captains to sample twice per month at distances of 1,5,10, 20 and 30 miles offshore at established targeted sampling sites. Available online at: http://research.myfwc.com/engine/download_redirection_process.asp?file=volunteer_posterforweb_1949.pdf&objid=24851&dltype=article

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

The HAB indicator serves as a measure of the number of events and duration of K. brevis blooms in the western Florida shelf. Although K. brevis may be found year round in the Gulf of Mexico at background concentrations (<1,000 cells/L), the harvesting of bivalve (filter-feeding) shellfish is prohibited in an approved or conditionally approved shellfish harvesting area when concentrations in the area reach 5,000 cells/L. Based upon this, the States will monitor and sample in response to a bloom event to protect public health and the environment from HAB effects. The indicator is also based upon an issue of national concern. The Harmful Algal Bloom and Hypoxia Research and Control Act was enacted in 1998 (PL 105-383) in response to concerns that HABs and related environmental events are increasingly a threat to human and coastal ecosystem health.

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

K. brevis bloom events can cause massive fish kills, marine mammal mortality, and in humans, neurotoxic shellfish poisoning (NSP) and respiratory irritation. However, the purpose of this conceptual model is to serve as an ecological indicator and not a linkage to coastal eutrophication or anthropogenic stressors. The sampling design in primarily based upon locations where red tides have traditionally come onshore in the western shelf area of Florida.

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

During the 1980's, the State of Florida formalized a federally approved biotoxin control plan that regulates shellfish harvesting during K. brevis blooms, to reduce the public health risks associated with red tides. Under this plan, guidelines were established for monitoring cell concentrations and closing shellfish beds when K. brevis was detected at concentrations above background levels in bay and lagoon passes or inlets. Harvesting bivalve (filter-feeding) shellfish is prohibited in an approved or conditionally approved shellfish harvesting area when concentrations in the area reach 5 x 103 K. brevis cell L-1. When the bloom terminates and the K. brevis population drops below that level, shellfish usually purge the toxins from their systems in two to six weeks. The shellfish meats are tested for toxicity during that period and the beds are reopened when mouse bioassay results demonstrate that shellfish meats are <20 Mouse Units (MU) per 100 grams of shellfish meat. Harvesting bans do not apply to crabs, shrimp, lobsters, or fish, which are safe to eat even during red tide blooms because brevetoxins do not accumulate in the parts of those organisms that are consumed by humans. (Haverkamp 2004)

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

Haverkamp, D., K. A. Steidinger and C. A. Heil. 2004. HAB Monitoring and Databases: The Florida Karenia brevis example. In: Hall, S., S. Etherridge, D. Andereson, J. Sleindinst, M. Zhu and Y Zou (eds.), Harmful Algae Management and Mitigation, Asia-Pacific Economic Cooperation (Singapore): APEC Publication #204-MR-04.2, pp. 102-109.

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?

To protect public health and the environment from harmful bloom effects, the Florida Fish & Wildlife Conservation Commission's Fish and Wildlife Research Institute has developed a red tide monitoring program in cooperation with another state agency, which consists of both microalgal and shellfish monitoring components. As part of this monitoring program, FWRI created and maintains a historical (1953-present) database of K. brevis cell concentrations and associated data (e.g., collection time, date, location, associated water-quality parameters). It is updated daily by FWRI staff as new data are available. Currently (2004), the database includes more that 63,000 records. Public and scientific access to the database is provided by 1) a CD-ROM that includes a subset of the database, GIS tools to view the data, Java-based query tools to ask summary questions of the data, and remote sensing images for the identification and potential prediction of red tide blooms; and 2) web access to the data, which will eventually incorporate additional meteorological and physical oceanography (i.e., current) data. Available online at: http://ocean.floridamarine.org/mrgis/viewer.htm

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

The State of Florida continuously monitors for K. brevis and other potentially toxic, harmful, or nuisance microalgal bloom species in state waters and working with the

Florida Department of Agriculture and Consumer Services Division of Aquaculture, successfully manages shellfish resources to protect the public from NSP. Development of an effective red tide monitoring program for Florida has involved four major components: 1) establishment of a network of individuals associated with marine-related industries affected by red tide, who provide water samples collected from diverse regions; 2) training staff to routinely identify and enumerate toxic phytoplankton within these samples to the species level; 3) development of a database suitable to the specific program needs; and 4) identification of methods and means to provide this data to the public on a timely basis.

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

Haverkamp, D., K. A. Steidinger and C. A. Heil. 2004. HAB Monitoring and Databases: The Florida Karenia brevis example. In: Hall, S., S. Etherridge, D. Andereson, J. Sleindinst, M. Zhu and Y Zou (eds.), Harmful Algae Management and Mitigation, Asia-Pacific Economic Cooperation (Singapore): APEC Publication #204-MR-04.2, pp. 102-109.

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)?

The data has not been extrapolated beyond that actual point of measurement. The bars on the chart represent actual K. brevis blooms events during 1996-2001 for the west coast of Florida.

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

No. The indicator is a summary of the number and duration of K. brevis events in the western shelf region of Florida.

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

Not being able to complete a survey, not being able to reach shallow areas due to the draft of the boat and missed bloom events could cause the number and/or duration of blooms to be smaller than was actually the case in any particular year, but this is not believed to significantly affect the overall trend pattern represented by the indicator.

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?

There is no limitation that could lead to a fundamental error. A data gap may occur when a K. brevis bloom is present and no measurement was taken to verify.