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ENY-851

UF UNIVERSITY of FLORIDA
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Red Tides[1]

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What are Red Tides?

Red tides are caused by abnormal increases (known as blooms) in the concentration in the water column of certain microscopic algae and algae-like organisms that can cause changes in the color of the water due to the pigments present in the microorganisms (Figure 1). Some of these organisms, particularly dinoflagellates (see below), produce toxins that can be harmful to man, either directly, or through the consumption of contaminated mollusks, crustaceans, and fish.

Figure 1. Red tide off the California Coast. Credits: Alejandro Diaz

The term "harmful algal bloom" (HAB) is preferred over "red tide" because the blooms are not always red and are not directly associated with tides, and because the term "red tide" applies to many harmless blooms that discolor the water but may exclude many toxic blooms that do not cause water discoloration (for example some highly toxic species may cause problems at concentrations low enough to not cause perceptible change in the coloration of the water).

HABs occur throughout the world and are affected by a large number of poorly understood factors that make it difficult to predict their occurrence or mitigate their effects. No one knows the exact combination of factors that causes HABs but some experts believe that high temperatures combined with a lack of wind and rainfall are usually at the root of some red tide blooms. Some HABs have been blamed on over-enrichment of coastal water by nutrient-ladden runoff from lawns, roads, and agricultural lands; modification of the ratios of different nutrients in the water column; or reduction of natural grazer populations by toxic chemicals such as pesticides and herbicides, but there is no scientific evidence to indicate that that any of the above factors are, or are not directly responsible for HABs. There may also be a link between HABs and some extreme weather events including hurricanes, floods and drought.

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Dinoflagellates

The dinoflagellates form a large and diverse group of microscopic, usually unicellular organisms that are classified as protists (cellular organisms that cannot be classified as fungi, animals, or plants). They generally have two whip-like body projections (the flagellae) of unequal size that are used for locomotion and which result in a characteristic spiral swimming motion. Some dinoflagellates are photosynthetic and free-living, others are autotrophic and symbiotic with marine animals and protozoa, some are predators on protozoa, and a few forms are parasitic. Some species produce neurotoxins which can kill fish and accumulate in organisms that can then be eaten by humans and other animals. The "Florida red tide" is usually caused by the dinoflagellate *Karenia brevis,* whereas in the northern East Coast of North America the major culprit is another dinoflagellate known as *Alexandrium tamarense.*

Biotoxicity

Biotoxins produced by HAB organisms are often preferentially concentrated via filtration or bioaccumulation (when an organism absorbs a substance at a rate greater than the rate at which it is eliminated from the body) by many marine organisms including fish and invertebrates. Often the animals themselves do not exhibit any visible sign of contamination so it is impossible to distinguish them from uncontaminated animals by sight. Bivalve mollusks such as scallops, clams, oysters, and mussels are particularly prone to accumulation of toxic quantities of these products because they feed by filtering large volumes of water, which allows them to obtain and concentrate appreciable quantities of the red tide organisms including those producing toxic substances. As a result of the continuous filtration of toxic plankton, large quantities of the poisons bind to the animals tissues or are concentrated in their digestive glands.

Fish can also acquire the toxins through direct uptake (planktivorous fish), or by bioaccumulation through the food chain. These toxic fish can in turn poison larger predatory fish, birds, marine mammals and humans. The toxins are often further concentrated in fish internal organs, which makes their consumptions particularly risky.

Several types of toxic syndromes are associated with HABs. Among the most common are:

Amnesic shellfish poisoning (ASP) is caused by domoic acid produced by several diatom species (*Pseudo-nitzschia* spp. - Figure 2) ASP toxins have been detected in shellfish in Canada, California, Washington, Oregon, Maine and Massachusetts, and toxic diatoms have been found in Florida coastal waters. Poisoning is potentially fatal within 24 hours of consumption. Symptoms include nausea, vomiting and cramps. More severe neurological symptoms can include dizziness, headache, seizures, disorientation, short-term memory loss, respiratory difficulty and coma.

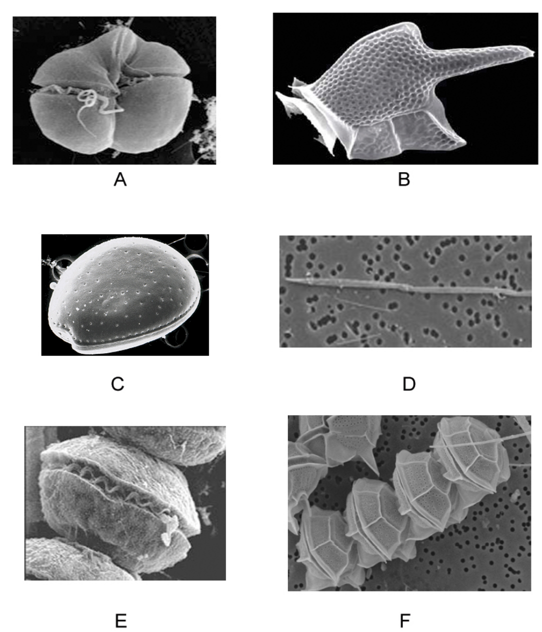

Figure 2. Some toxic marine plankton. (A) *Karenia brevis,* (B) *Dinophysis caudata,* (C) *Prorocentrum lima,* (D) *Pseudo-nitzschia pseudodelicatissima,* (E) *Alexandrium monilatum,* (F) *Pyrodinium bahamense.* Credits: Individual images - Florida Fish and Wildlife Conservation Commission.

Diarrhetic shellfish poisoning (DSP) has a worldwide distribution and is caused by okadaic acid and its analogs produced by *Dinophysis* spp. and *Prorocentrum lima* (Figure 2). Symptoms include diarrhea, nausea, vomiting, abdominal cramps and chills. Patients usually recover within 72 hours. Several *Dinophysis* species are found in Florida.

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Paralytic shellfish poisoning (PSP) is worldwide in distribution and can affect humans, birds, fish, and marine mammals. It produces gastrointestinal and neurological symptoms and is a result of saxitoxins produced by dinoflagellates, particularly *Alexandrium* spp., *Gymnodinium catenatum*, and *Pyrodinium bahamense* (Figure 2). Onset of symptoms is rapid (within 30 minutes to 12 hours) and include a tingling sensation around the mouth, face and neck. Symptoms may progress to numbness and burning sensations, ataxia, drowsiness, giddiness, fever and rash. In severe cases difficulty swallowing, tightness of the throat, slurred speech or complete loss of speech, respiratory failure and death can occur within 2-12 hours. Other symptoms include headache, dizziness, nausea, vomiting, and anuria. PSP is a significant problem on both the east and west coasts of the U.S., including Florida.

Neurotoxic Shellfish Poisoning (NSP) produces symptoms similar to ciguatera poisoning (diarrhea, vomiting abdominal pain, hypersensitivity to cold, inversion of cold and hot sensations, numbness or "pins and needles" feeling in the limbs and lips, dizziness, ataxia, tremors, muscular stiffness, hypersensitivity of the nipples, depression, itching, and general muscle pain – Rey 2007) but usually less severe. It is caused by brevetoxins produced by *Karenia brevis*, a dinoflagellate that occurs principally in the Gulf of Mexico, in the east and west coasts of Florida, and in the Carolinas (Figure 2). Blooms of *K. brevis* can kill millions of fish and birds in a few days, and blooms can last for weeks. In addition to transmission through contaminated fish and shellfish, the poison can be disseminated in aerosol form by breaking waves and can cause respiratory distress and asthma-like symptoms.

Impacts of HABs

HABs can have consequences on human health, the environment, local and regional economies, and can impact natural ecological communities directly, or indirectly through the production of excessive biomass. Some can cause massive mortalities to natural populations of fish, birds, and marine mammals including endangered and protected species, and can also damage coral reefs, shade submerged vegetation, and decrease water quality. They can also cause a variety of other less obvious effects including decreased reproduction, increased susceptibility to predation and others.

HABs can have economic impacts by affecting seafood industries and businesses, tourism, and aquaculture operations. They can impact the quality of life, sometimes for extended periods of time, of people living in and around affected areas and they can result in disruption of social relationships and cultural practices tied to coastal resources (Jewett *et al.* 2007).

Mitigation and Control

Most present efforts at mitigation and control of HABs focus on diminishing their effects on fisheries and aquaculture rather than on human health (Kim 2006). Strategies for mitigation of HAB effects can be divided into into *precautionary strategies*, and *bloom control.*

Precautionary strategies:

Monitoring. Involves species identification and abundance monitoring, toxicity assays, and gathering of physical oceanography and meterology data to provide advance warning and to build, test, and validate predictive models.

Prediction. There are some experimental predictive models of HAB pathways and population dynamics that would allow affected parties to take emergency actions (e.g. Allen 2004). However, thus

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far, truly operational predictive models of population and transport dynamics of important species have not yet been developed.

Emergency Actions. These include early harvesting, reducing feed, transporting fish to "safe" mitigation facilities, and use of clay-pump/aspirator systems to reduce the effects of the HABs on cultured species. For humans, these actions may include staying indoors during HABs for people with respiratory conditions and avoiding eating seafood from the affected area.

Bloom control:

Biological control organisms include species that feed, infect, or decompose HAB species. Included among these are copepods and ciliates that graze on algae and dinoflagellates, and some viruses, parasites, and bacteria that hold promise as control agents because they are abundant in marine systems and have high reproductive ouptut. Lack of effective mass rearing facilities and logistic problems related to storage, and deployment of these agents are the major obstacles to their widespread use.

Chemical control is the use of chemicals to kill or reduce the density of HAB cells. A variety of chemicals such as copper sulfate, sterol surfactants, sodium hypochlorite, magnesium hydroxide, and others have been tried for control of HAB organisms. In general, most chemicals tried have been too expensive and too non-specific (causing damage to non-target components of the marine ecosystem) for effective use against HABs.

Physical control involves removing the harmful algal cells via filtration, skimming, ultrasound, electrolysis or similar methods. For various reasons, most techniques tried so far have not proven to be useful for HAB control in actual situations. One promising non-chemical strategy involves the treatment of blooms with flocculant clays which scavenge particles, including algal cells, from seawater and carry them to bottom sediments. However, environmental consequences of this technique have not been fully evaluated yet.

Precautions

Some precautions that can be taken to avoid disease and/or discomfort due to HABs include:

- Stay away from the water where HAB conditions have been identified or if water is foamy or discolored or contains dead fish.
- Do not eat, use or collect any fish, crabs, other life or items from those waters.
- Do not let pets swim in or eat fish from those waters.
- If contact is made with the water, rinse as soon as possible with fresh water.
- If you suffer respiratory discomfort when near the water, moving a short distance away from the shore may alleviate the symptoms. In more severe cases or when moving away from the HAB is not possible, staying indoors in air-conditioned rooms as much as possible is indicated until the HAB passes.
- Avoid eating fish and shellfish from HAB areas or during times when a red tide is prevalent.
- Avoid eating the internal organs of fish.

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