RED TIDE

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2. WHAT IS RED TIDE?

Red tide is a common name for a phenomenon known as algal bloom (large concentrations of aquatic microorganisms), that occurs when toxic, microscopic algae in sea water proliferate to higher-than-normal concentration often discoloring the water red, brown, green, or yellow. These microscopic forms of algae produce toxins that can sicken humans and be fatal for marine animals.

3. DISTRIBUTION OF RED TIDE GLOBALLY

World distribution: Mexico, Texas, Florida, California, Japan, Caribbean, and South Pacific area.

4. CAUSES OF RED TIDE

Natural causes:

- Coastal upwelling

- Coastal upwelling is the process by which strong winds blow down the coasts of continents and, in conjunction with the earth's rotation, cause the surface waters to be pushed offshore. Water from the ocean depths is then pulled up - or upwelled - to the surface to take its place. Coastal upwelling is closely tied to the climate and economy of California; it is the cause of the region's foggy weather, robust fisheries

- Systematic increase in seawater temperature
  - Due to global warming
- Iron-rich dust influx from large desert areas
  - The advection of such dust was found to be a fundamental cause of red tide formation regardless of the location. The advection of iron-rich dust can enhance the formation of red tide even in open oceans.
- El Niño events
  - During a normal year the currents produce equatorial upwelling and give rise to beds of algae. When El Niño hits, warm water prevents this upwelling, as it does in many other parts of the ocean, and the algae die off. At the end of the cycle the algal bloom should re-establish itself at the equator.
  - Changes in conditions and patterns in marine ecosystems such as slower water circulation, with increase in nutrients such as nitrogen and phosphorous due to a variety of point and non-point sources of pollution can cause intense algae blooms.

Human activities

- Ballast water
  - Ballast water discharge typically contains a variety of biological materials, including plants, animals, viruses, and bacteria. There are hundreds of organisms carried in ballast water that cause ecological effects outside their natural environment.
- Sewage
  - Chemicals from farming, factories, sewage treatment plants and other sources can become dissolved in water on the land. This water, called runoff, eventually flows into the ocean, and can cause algae to grow faster, leading to red tides
- More incidents were highlighted to be possible causes of red tide, but these are the most important ones to cover.

5. EFFECTS OF RED TIDE

To the environment and marine life

- Dolphins and manatees die off (in Florida)

- Marine animals are not necessarily going to die off, but they might transport these toxins to humans when they eat them.

To human health

- Asthma issues
  - Small microscopic harmful algal bloom produces a potent neurotoxin which therefore triggers asthma

Impacts to the economy

- Fisheries production
- Tourism

6. RESEARCH / RED TIDE: A NEW THREAT TO WATER RESOURCES IN THE ARABIAN GULF REGION BY DR. MUTHANNA A. AL-OMAR

Highlights

- Arabian Gulf is an enclosed area of water with a relatively high evaporation rate, which exceeds the fresh water input through Shatt AlArab or through precipitation.
- Two clockwise-rotating water masses; one in the central gulf area and the other in Abu Dhabi-Qatar basin.
- Arabian Gulf is surrounded by rapidly developing countries. Therefore, there are numerous sources of pollution that gets dumped in the gulf, such as:
  1- Sewage outfalls
  2- Industrial outfalls
  3- Oil pollution
  4- Discharge of ballast water
- Early in 2009 and throughout the year, there were many incidents of algal bloom in the Arabian Gulf
- These phytoplankton are always present in seawater, but only when their population density reaches a certain critical mass (about 1,000,000 cells/l) the HAB is said to occur.
- Some types of phytoplankton are non-toxic to fishes, but they may be killed because of oxygen depletion which is known to occur simultaneously with HAB. This phenomenon consequently may seriously threaten water resources and aquatic life in the region.
- Some studies have found that around 337 species of phytoplankton are living in the Gulf's waters.

7. RED TIDE IN OMAN

- According to the Director-General of Fisheries Research, Oman has been maintaining a record of red tide outbreaks since 1988. In some years tens of tones of dead fish have washed up on Omani shores. At Muscat and the Batinah region of Oman, the scores of dead fish that have collected on the beach have all accumulated toxins, making them unsafe

- The highest massive fish kills were reported from 2001 to 2002 when 27 tonnes of dead fish came ashore along Batinah, Sur, and south of Oman

- The Director of the Marine Conservation Department at the Ministry of Fisheries reported that the red tide is occurring usually between July and September due to monsoon winds and currents

- During 2008 the red tides were first reported sometime in July, with a second outbreak recorded in August

- Monitoring red tide using satellite imageries.
    - Identifying the locations where red tide is present. In addition, monitoring the ocean currents flow and the concentrations of the chlorophyl to predict the possibility for red tide to occur.
- Field Observations:
    - During the event of red tide, a specialized team makes protocol guided visits to take samples and test it biologically, chemically, and physically. All to the purpose of identifying the exact type of microorganism that is present.

8. TRACKING FLORIDA'S RED TIDE USING SATELLITES AND SMARTPHONES

- Growth rates may be affected by sunlight, and shade may play an important role in the development of blooms. In addition, water temperature is also a major player in the increase of these blooms' density in the water

- Scientists who study the life cycle of red tide in Florida divide red tide blooms into four stages: initiation, growth, maintenance, and termination. Initiation is believed to occur offshore and at depth. Blooms can develop in deeper levels of the water column before portions migrate to the surface. Prevailing ocean and wind currents can transport the bloom closer to shore or move it along the coast

- Even though red tide blooms have long been a fixture of the West Florida Shelf marine ecosystem, many people believe that they are getting worse in terms of frequency, intensity, and duration.

Initial Factors	
Upwellings	Upwellings of deep, nutrient enriched water along the continental shelf are viewed as playing a potential role in the initiation of offshore blooms.
Saharan Dust	Dust clouds from the Sahara Desert contain iron. When deposited in the Gulf of Mexico the iron can boost *trichodesmium* blooms and their production of nutrients.
Rainfall	Rainfall may enhance a number of nutrient delivery mechanisms including those that involve atmospheric deposition (see *trichodesmium* discussion) and terrestrial fluxes.

Table I : Possible causes for Florida's red tide

- The release of these brevotoxins during a bloom can have substantial impacts on marine life that include massive fish kills and significant mortality events for birds and marine mammals. Large fish kills can occasionally generate hypoxic, or oxygen deficient, zones that amplify the impacts on a broader spectrum of marine life

- Marine life is exposed to brevotoxins by eating them, breathing them, or touching them. The toxins can also pass-through cell membranes, including the blood-brain barrier and skin tissue. Different forms of marine life vary in their reaction to the toxins.

- Fish kills are both an early warning sign for humans and a sad hallmark of red tide blooms. Fish are exposed to brevotoxins by swimming through blooms and ingesting forms of marine life that have become contaminated with toxins. They are thought to be killed through lack of muscle coordination and paralysis, convulsions, and respiratory failure.

- Humans can be exposed to brevotoxins through ingestion of contaminated seafood.
- Humans can also be exposed to brevotoxins through inhalation.
- One of the best ways to test for the presence of red tide is to analyze water samples collected from boats or beaches. State environmental agencies do this on a regular basis but understanding the full extent and evolution of fast-changing blooms or predicting where they will move with ground sampling alone is a challenge.

How Scientists are Tracking Florida's Red Tides with Satellites and Smartphones

Red tide monitoring systems:

1- Forecast: National Oceanic and Atmospheric Administration's (NOAA's) Harmful Algal Bloom Forecast System
2- Near real time observations: Integrated Red Tide Information System (IRIS) from the University of South Florida

Both make use of satellite data from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensors on NASA's Aqua and Terra satellites. These sensors pass over Florida's Gulf Coast twice a day, acquiring data at several wavelengths that can be useful for identifying and mapping the spatial extent of algal blooms. Other satellite sensors such as the Visible Infrared Imaging Radiometer Suite (VIIRS) on Suomi NPP and the Ocean and Land Color Instrument (OCLI) on Sentinel-3 collect information that can be used to monitor red tides as well.

Despite the utility of satellite observations, there are some significant challenges to interpreting satellite data of algal blooms in shallow, coastal waters, explained oceanographer Chuanmin Hu of the University of South Florida. Chief among them: it can be quite difficult to distinguish between algal blooms, suspended sediment, and colored dissolved organic matter (CDOM) that flows into coastal areas.

To get around this problem and make satellites better at pinpointing algal blooms, Hu and colleagues at the University of South Florida have developed a red tide monitoring system that makes use of MODIS observations of fluorescence, which algal bloom emit in response to exposure to sunlight. "If we have fluorescence data to go along with a natural-color image from MODIS, we can say with a high degree of confidence where the algal blooms are and where the sensor is just detecting sediment or CDOM," he said. When fluorescence data is available, the Florida Fish and Wildlife Commission pushes it out to the public as part of its red tide status updates (see the August 21 update below).

Likewise, NOAA has combined a fluorescence method with a long-standing technique that identifies recent increases in chlorophyll concentration, the combination improves the identification of likely K. brevis blooms — information that then gets

incorporated in NOAA's HAB Forecast System, noted Richard Stumpf, an oceanographer with NOAA.

However, that still leaves some big problems—only about ten percent of MODIS passes collect usable fluorescence data. The rest of the time images are marred by either sunglint or clouds. And the algorithm that scientists use to detect algal blooms with MODIS does not work well within one kilometer of the coast—the part that is of the greatest interest to beachgoers and boaters.

To help fill in the gaps, NASA's Applied Science program is working with several partner institutions on a smartphone app called HABscope. The app, developed by Gulf of Mexico Observing System (GCOOS) researcher Robert Currier, makes it possible for trained water samplers (typically lifeguards who participate in Mote Marine Laboratory's Beach Conditions Reporting System) to collect video of water using microscopes attached to their smartphones.

9. EXTRA NOTES

What can be done

- Observing systems that track the toxins in the air (how harmful it is to our health)
- Observations that go deep in the water and report more detailed information
- Satellite imageries that continuously monitor the sea water
- Issuing reports and bulletins to keep the public aware and updated
- Including such monitoring in the air quality systems

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