This powerpoint lecture with annotated slides is aimed at healthcare providers interested in learning more about the exposures and possible health effects for humans and other animals from the harmful algal bloom, Florida red tide.
This is an overall Outline of the Presentation.
This is a photograph of a Harmful Algal Bloom or “HAB.”
Florida red tide is actually part of a larger phenomena, harmful algal blooms or HABs.
These are photographs of harmful algal blooms – note that they can be a) many different colors, and b) on the surface of the water or as in the lower right hand corner, on coral reefs.
Harmful Algal Blooms (HABs)

Definition:
- “Red/Brown/Yellow/etc. Tides”
- Proliferation of microscopic organisms
- Marine, fresh & estuarine waters

⚠️ Potential danger to:
- Environment
- Wildlife
- Humans

Harmful algal blooms (HABs) are caused by microscopic organisms (such as dinoflagellates, diatoms, and the blue green algae or cyanobacteria) at the base of the food chain. A HAB is caused by an exuberant growth of these organisms resulting in harm to the environment, wildlife and/or humans. These HABs can occur in marine, fresh and estuarine waters, ie. in any aquatic environment.
This is a photograph of a classic Florida red tide; note that the color is brown not red!
What causes Florida Red Tide?
Many people are convinced that HABs or red tides are caused by human and other pollution.
There are many factors involved in the occurrence of a HAB, both environmental and biological. One possible cause of current scientific interest is the increasing range of human interactions. Humans have increasing contact with the marine, freshwater and estuarine environments. Directly, humans are eating more seafood worldwide, as well as interacting with these environments through recreational and occupational behavior. In addition, through international trade and tourism, humans are exposed to new types of seafood and marine environments with their attendant risks. Some of these marine organisms may respond with exuberant growth and HABs due to exposure to the inadvertent enrichment of marine, freshwater and estuarine waters due to the runoff of fertilizers and other chemicals from human activities. In addition, there are even some HABs which may be affected by global climate change.
The organisms causing the HABs are microscopic, at the base of the food chain. These organisms are very ancient and include dinoflagellates, diatoms and the blue green organisms (also known as cyanobacteria). A small number of these organisms are able to produce natural and highly potent toxins. Many of these toxins are neurotoxins, although some are hepatotoxins and even carcinogens. The organisms involved in HABs can produce these toxins, nevertheless an HAB can also be harmful purely by causing a lack of oxygen in the water and death to other organisms.
This is a picture of the harmful algal bloom dinoflagellate that causes Florida red tide, known as *Karenia brevis*. Of note, this is a relatively fragile organism. Thus, *Karenia brevis* (or *K. brevis*) will release its toxins into the water when it is broken up as under surf conditions.
The HAB toxins are exceedingly potent. For example, ciguatoxin, the natural toxin associated with Ciguatera fish poisoning, is toxic to humans in picogram doses. Therefore, it is often very difficult to detect these toxins, especially since they are odorless and tasteless. Furthermore, these toxins are heat and acid stable. Therefore, normal methods of cleaning, cooking and storage of toxin contaminated food will not remove the toxins.
The natural toxins associated with *Karenia brevis* or Florida red tides are the brevetoxins. There are at least 10 different brevetoxins identified to date.
Brevetoxins are potent neurotoxins. Neurophysiologic research has shown that (similar to Ciguatoxins which cause Ciguatera Fish Poisoning), the brevetoxins can intercalate into the sodium channels of nerve cells, causing them to remain open. This disrupts the basic electrochemistry of the nerve cell.
How are people exposed to Florida Red Tides?
Florida has had reports of Florida red tide since recorded history, at least since the 1850s. The Florida Fish and Wildlife Commission has been collecting data on the location of the Karenia brevis organism and Florida red tides since the 1950s. As demonstrated in this map, although Florida red tides seem to concentrate on the west coast of Florida, they can also occur on the East Coast. These red tides have been reported as far north as North Carolina, and they have been reported throughout the Gulf of Mexico including in Mexico.
Historically, the major route of exposure to Florida red tide for humans has been through the consumption of shellfish contaminated with the *Karenia brevis* organisms and their brevetoxins. The illness in humans is known as Neurotoxic Shellfish Poisoning or NSP.
More recently, researchers have become aware that people and other animals can be exposed to Florida red tides and the brevetoxins through the air with aerosols and through the skin with direct water contact. The illnesses in humans include respiratory irritation (with increased impact on asthmatics and others with underlying pulmonary disease), possibly increased risk for pneumonia and bronchitis, and possibly skin rashes.
New research has also revealed that although traditionally the brevetoxins in the water immediately kill fish, in some cases fish are able to consume the *Karenia brevis* organisms and absorb the brevetoxins into their tissues without dying. These fish can then be consumed by larger fish and marine mammals, resulting in documented deaths of dolphins from “Brevetoxin Fish Poisoning.” Of note, this is a new area of research, but it appears that the major concentration of the brevetoxins is in the fish organs rather than the fish muscle.

Also of interest, it appears that the *Karenia brevis* organisms can also be concentrated on sea grass which may be important to marine mammals such as the endangered Florida manatee as well as to the marine food chain.
Who are the exposed populations?

- **Animals**
  - Fish
  - Marine Mammals
  - Birds
  - Pets

- **Humans**
  - Coastal Residents
  - Workers
  - Snowbirds (elderly)
  - Tourists

The routes of exposure suggest that there are certain populations at increased risk for exposure to Florida red tides and their brevetoxins. Among animals, due to their extensive and obligatory marine water exposure, fish and marine mammals are vulnerable, but also sea birds. Coastal residents throughout the Gulf of Mexico, weather temporary (tourists and snowbirds) or permanent are also potentially exposed, as well as their pets. And occupational as well as recreational exposures must be considered, particularly for jobs (such as life guard) which result in extended beach exposures.
This is a montage of some of the animals who have been exposed and affected by Florida red tides and their toxins, including large mortalities of both fish and the endangered Florida manatee.
Florida red tide has been associated with massive fish kills along the Gulf Coast. Brevetoxin is a nerve toxin, which paralyzes the fish’s gills when fish swim into an active Florida red tide bloom with brevetoxins in the water. Slow-moving or bottom-dwelling fish are usually the first to die in a red tide. However, nearly all fishes are susceptible, depending on the density of the bloom, length of exposure time, and other factors.
The Florida manatee is highly exposed to Florida red tides and the brevetoxins from the water itself, from their food source (primarily sea grasses), and from their obligatory breathing at the air-sea interface where the brevetoxins may concentrate during an active Florida red tide bloom.
Pets

- Dogs
  - At increased risk
    - Contaminated seatoam exposure
- Birds
  - Seabirds susceptible
    - Contaminated seafood & aerosol exposures

Dogs may be at increased risk due to their lower stature which makes them physically closer to the sea foam and air-sea interface where the brevetoxins may concentrate during an active Florida red tide bloom. Furthermore, they may lick their fur after water contact during an active Florida red tide bloom. Sea birds have been reported to die during Florida red tides, possibly from “Brevetoxin Fish Poisoning” and/or susceptibility to contaminated aerosols.
Humans can be exposed while playing or exercising in coastal areas, particularly non-residents who may not know about the Florida red tides.
Many people also work in coastal areas and are thus exposed occupationally to Florida red tides, with little recourse with regards to that exposure.
Based on current research, several different human populations should be considered to be possibly more susceptible to the health effects of exposure to Florida red tides and the brevetoxins. Elderly and immunosuppressed people may be at increased risk because there is some evidence in animal model research that the brevetoxins may cause immunosuppression. Current research has demonstrated that asthmatics and possibly others with underlying lung disease may have a more severe and prolonged response to aerosolized brevetoxins. Animal model research has demonstrated that inhaled brevetoxin aerosols can cross the placenta and concentrate in the fetus, although at doses higher than experienced on beaches by humans. Finally, children may be at increased risk because they are closer to the air-sea interface, and because their smaller size means that a smaller dose may cause harm compared to adults.
Currently there are 4 major illnesses identified in humans associated with exposure to the Florida red tides and their toxins.

**What are the Symptoms & Illnesses associated with Florida Red Tides?**

- Neurotoxic Shellfish Poisoning (NSP)
- Aerosolized Respiratory Irritation
- Brevetoxin Fish Poisoning
- Skin
Until recently there has been very little research into the human health effects of the harmful algal blooms and their toxins, including for Florida red tide and the brevetoxins. What little is known is expressed in terms of clinical epidemiology, including the attack rate which is the prevalence of persons who got sick among those who were exposed.
Neurotoxic Shellfish Poisoning (NSP) has a rapid onset within minutes to hours, but definitely less than 24 hours, from consumption of the contaminated shellfish. Of note, the contaminated shellfish are reported to taste delicious. Although never formally studied, the attack rate is considered to be close to 100% since the toxic dose is low. The symptoms are predominantly gastrointestinal, however neurologic symptoms and signs (including paresthesias and even respiratory depression) are also reported. Although fatalities have not been reported with NSP, some victims end up in intensive care units (ICU) and require ventilatory support for 24-48 hours. There have been no formal follow up studies to evaluate for chronic disease after acute NSP poisonings. Of note, the clinical presentation can be confused with Ciguatera Fish Poisoning as well as other food poisonings including other HAB illnesses (such as paralytic shellfish poisoning or PSP).
Recent research has demonstrated that all persons exposed to an active Florida red tide with strong onshore winds and brevetoxins aerosols experience upper respiratory irritation. Among asthmatics and possibly others with underlying lung disease, there can be the onset or worsening of lower respiratory symptoms with documented respiratory physiologic change. To date there have been no fatalities reported although this is a poorly documented phenomena. Research looking at emergency room admissions in an area with frequent Florida red tide blooms demonstrated a significant increase in respiratory admissions (particularly, pneumonia and bronchitis as well as asthma) during active Florida red tides compared to similar time periods without red tides, and particularly among coastal residents.
The research into the possibility of Brevetoxin Fish Poisoning is currently in its infancy, and has been documented only in Marine Mammals to date. However, based on the similar structure of their toxins (ie. brevetoxins and ciguatoxins), it would be expected to be similar to Ciguatera Fish Poisoning as well as Neurotoxic Shellfish Poisoning (NSP). Of note, the dolphin cases of Brevetoxin Fish Poisoning resulted in deaths.
There are anecdotal reports of skin signs and symptoms among persons who have entered marine waters during an active Florida red tide. The signs and symptoms have ranged from itching to hives and rashes. There is documentation in an asthmatic sheep model that brevetoxins can cause an histamine-like reaction in skin leading to a rapid skin reaction.
How can these Symptoms & Illnesses be treated and prevented?
At the present time, assuming that the illness is appropriately diagnosed, the primary treatment of neurotoxic shellfish poisoning (and presumably brevetoxin fish poisoning) is supportive. This includes intravenous fluids and anti-emetics, but may have to include respiratory support and admission to the ICU for careful monitoring of respiratory and circulatory function.

Intravenous mannitol (1g/kg in 30 minutes) has been demonstrated to rapidly decrease symptoms and prevent chronic illness in Ciguatera Fish Poisoning. The structure of the ciguatoxins and the brevetoxins are very similar with a similar site of neurologic action, therefore IV mannitol may be effective in NSP (and possibly brevetoxin fish poisoning). Of note in ciguatera, the IV Mannitol is most effective if given within 2-3 days from consumption, and multiple treatments may be required.

Researchers have discovered both a natural and synthetic antagonist of brevetoxins. The former is known as brevenal and it has been patented for use in brevetoxin related diseases as well as possibly for the treatment of cystic fibrosis.

Regardless, for diagnostic and surveillance purposes, it is very important to attempt to obtain a piece of the contaminated shellfish (and fish) for toxin testing which is performed by the Food and Drug Administration (FDA) after contacting the state and local Dept of Health.
Anecdotally, residents of coastal areas with annual Florida red tide blooms report that if they leave the beach and seek an air conditioned enclosed area, the symptoms of respiratory irritation resolve quickly, particularly if there is no asthma or underlying lung disease.

Research using an asthmatic sheep model has demonstrated that a number of commonly used asthma medications may be able to prevent the respiratory effects of aerosolized Florida red tide toxins. These medications include: cromolyn, albuterol and steroids, as well as dipheniramine. Brevenal, the natural antagonist of brevetoxins made by the *Karenia brevis* organism, has also been shown to block the subsequent effects of exposure. Albuterol can be used to treat the respiratory effects of aerosolized Florida red tide toxins.

It should be noted that these medications have not been evaluated in humans, and thus these data should be treated with caution, particularly since medications such as albuterol can be dangerous if over-used. Persons with asthma and underlying lung diseases should be urged to practice primary prevention rather than using medications to prevent or treat the effects of exposure to the aerosolized Florida red tide toxins.
As with all harmful algal bloom illnesses, the best way to deal with Florida red tide illnesses is to avoid exposure whenever possible, and thus practice primary prevention.

Thus, during active Florida red tide blooms, do not harvest shellfish yourself and only consume shellfish harvested from legally open and monitored shellfish beds. Shellfish and other seafood served in restaurants during an active Florida red tide should be safe to eat since it will have been obtained from non-exposed areas.

Although there are very little data available, it appears that brevetoxin fish poisoning can be avoided if only the muscle or fillet of the fish is eaten, not the organs (where the brevetoxins concentrate). Dead fish found during a Florida red tide should be avoided more from the possibility of bacterial overgrowth than from brevetoxin contamination.

Avoidance of coastal areas when the winds are onshore and strong during an active Florida red tide is recommended, particularly for asthmatics. Initial research has demonstrated that the use of a simple surgical mask may prevent 35-45% of the exposure, although there is no information as to for how long this effective.
The harmful algal bloom (HAB) illnesses in humans and other animals, including Florida red tide, have been poorly reported and studied until recently.
Different states have different reporting requirements for the harmful algal bloom (HAB) illnesses in humans and other animals, including Florida red tide. Therefore it is important to contact your state and local Department of Health if you suspect an illness in humans or other animals related to HABs and their toxins.
The Florida Poison Information Center – Miami has established a toll free 24/7 Aquatic Toxins Hotline (1-888 232 8635) in English and Spanish. This Hotline provides automated information on a range of harmful algal bloom (HAB) illnesses in humans and other animals, including Florida red tide. In addition, the caller can speak directly with a trained Poison Information Specialist for more information; the Poison Information Specialist will also report the cases to the Florida Dept of Health and the Centers for Disease Control and Prevention (CDC).
A number of governmental agencies, researchers, and grassroots community groups have been developing outreach and educational materials on harmful algal bloom (HAB) organisms and their toxins, and their exposures and effects on humans and other animals.
The Florida Dept of Health has established an Aquatic Toxins Program (850 245 4444 x 2295) which provides information on HABs and their illnesses, as well as HAB surveillance. On their website (http://www.doh.state.fl.us/ENVIRONMENT/community/aquatic/), they have consolidated a number of outreach and education materials on HABs, including Information Handouts specifically targeted at Healthcare Providers on the known HABs and their human illnesses, including Florida red tides.
The grassroots community group, Solutions to Avoid Red Tide (START), has created a website with outreach and education materials targeted at tourists and business owners in coastal areas (http://www.start1.com/)
START Outreach and education materials targeted at tourists and business owners in coastal areas (http://www.start1.com/)
There are also a range of other materials available targeting different audiences on the exposures and health effects of Florida red tides.
The Mote Marine Laboratory has developed a Beach Conditions Reporting System that provides real-time reporting from specific beaches on the West Coast of Florida (and beyond in the future), including Florida red tide and other beach conditions (such as wind and surf). This information can be accessed via the phone (**1-941-BEACHES** or **1-941-232-2437**) or via the internet ([http://coolgate.mote.org/beachconditions/](http://coolgate.mote.org/beachconditions/)).
In 2004, NOAA unveiled the NOAA Harmful Algal Bloom (HAB) Bulletin, which is an early warning system to monitor and forecast red tide activity and effects based on combination of satellite imagery, buoy data, and sample data from Florida Fish and Wildlife Commission as well as other sources. Bulletins are posted on http://coastwatch.noaa.gov/hab/bulletins_ns.htm.
To Access These Resources:
- [state-of-coast.noaa.gov/bulletins/](http://state-of-coast.noaa.gov/bulletins/)
- [doh.state.fl.us/environment/community/aquatic/](http://doh.state.fl.us/environment/community/aquatic/)
- [Floridamarine.org/](http://Floridamarine.org/)
  - [mote.org/](http://mote.org/)
  - [start1.com/](http://start1.com/)
- [rsmas.miami.edu/groups/niehs/](http://rsmas.miami.edu/groups/niehs/)

This is a list of additional informational websites (addresses subject to change) on Harmful Algal Blooms including Florida red tides.
Acknowledgements

- Florida Dept. of Environmental Protection & Florida Dept. of Health
  - Florida Red Tide Control & Mitigation Funding
  - Aquatic Toxins Program
- CDC
- Florida Poison Information Center
- NSF NIEHS Oceans and Human Health Center
- NIEHS Florida Red Tide POI

The creation of this Presentation was made possible by multiple funding sources, including the Florida Departments of Environmental Protection (particularly the Florida red tide Control and Mitigation Program) and Public Health (particularly the Aquatic Toxins Program), the Centers for Disease Control and Prevention HAB Program, and the Florida Poison Information Centers (particularly the Miami Center). Additional funding was made possible by the National Science Foundation and National Institute of Environmental Health Sciences Oceans and Human Health Center at the University of Miami Rosenstiel School (NSF 0CE0432368; NIEHS P50 ES12736), the former National Institute of Environmental Health Sciences Marine and Freshwater Biomedical Sciences Center at the University of Miami Rosenstiel School (NIEHS P30ES05705), and the National Institute of Environmental Health Sciences Red Tide POI (P01 ES 10594).