Frequently Asked Questions about the 2005 Offshore Benthic Mortality Event and Red Tide

Answers to some of the commonly asked questions about the 2005 offshore benthic mortality event and red tide.

What happened to the reefs off Pinellas County?
Was this event related to the current red tide?
What happened to the bottom communities?
What is hypoxia?
What is anoxia?
Why, when we have red tides every year, was anoxia associated with this red tide only?
Why did the jewelry that divers wore tarnish?
Has a bottom mortality event like this happened before?
How does the benthic mortality event of August 2005 off west central Florida differ from the anoxia and dead zone which occurs every year at the mouth of the Mississippi River?
Could the same bottom mortalities happen within Tampa Bay since the red tide is there also?
Why doesn’t red tide occur within Tampa Bay every year?
How soon will the reefs recover?
What can be done to speed the recovery of the benthic organisms?
How long will this red tide last?
Is our current red tide and the bottom mortality event related to the Piney Point wastewater discharge?
Did pollution cause this red tide?
Why is it so hard to determine the sources of nutrients for a Florida red tide?
Why do most scientists argue against a direct link between Florida red tides and coastal nutrient pollution?
Why are the fish kills so bad this year?
Are these the worst fish kills in history?
Why are more turtles dying during this red tide?
Is this red tide affecting turtle hatchlings?
Is this red tide affecting manatees?
What can we do to kill the red tide?
Why haven’t scientists solved the red tide problem in Florida?

What happened to the reefs off Pinellas County?
Both divers and scientists began documenting patch reefs with bottom mortalities in the area offshore from Tarpon Springs to Sarasota during the first week of August. Initial volunteer and Florida Fish and Wildlife Conservation Commission’s (FWC) Fish and Wildlife Research Institute
FWRI diver inspections have shown that some reefs have been heavily impacted, with no live animals observed. Other reefs have been impacted but still have living organisms. Reefs with no impacts have also been observed.

**Was this event related to the current red tide?**
Yes. The impacted region lies within the central region of the large red tide that was located both nearshore and offshore at the time. Soft bottom habitats were also impacted, not just reefs.

**What happened to the bottom communities?**
Scientists hypothesize that several factors may have contributed to the widespread animal mortality observed. In mid-July, the red tide appeared in a large coastal region to the west of central Florida. During the summer, intense heating of the coastal nearshore surface waters by the sun resulted in a ‘layering’ of warmer, less dense seawater over a cooler, denser layer near the bottom. The red tide dinoflagellate cell (known as *Karenia brevis*, or *K. brevis* for short) is motile, and can swim through the water at a rate of one foot per hour. It is also phototactic, which means it can sense light, and swims up toward sunlight. Most red tides thus have cells most concentrated near the surface, but they can be distributed down to 150 feet. An abrupt change in water temperature of three to five degrees Fahrenheit over a small depth change can act as a physical barrier to red tide cells (which cannot swim up through the area of temperature change), trapping the cells at depth in the cooler bottom layer. Bottom-dwelling animals which come into contact with red tide cells and their toxins trapped at depth may be killed. Bacterial decomposition of dead animals and *K. brevis* cells decreases oxygen concentrations, which may further stress other animals, eventually
resulting in mass mortalities and low oxygen (called hypoxia) to no oxygen (called anoxia) at depth. The large temperature difference between the two water layers further restricts the diffusion of dissolved oxygen from surface layers to depth, aggravating the oxygen depletion.

Fish killed on the surface by red tide toxin may also sink to the bottom during the decay process and contribute to a decrease in dissolved oxygen. The large quantity of red tide toxin sinking to the bottom also exacerbates mortalities of bottom-dwelling animals.

**What is hypoxia?**
Hypoxia is the scientific word which refers to extremely low (<2.0 mg per liter) concentrations of dissolved oxygen (DO) in seawater. These are the concentrations at which animals become stressed.

**What is anoxia?**
Anoxia is the scientific word for zero concentrations of dissolved oxygen (DO) in seawater. Most sea life cannot live under anoxic conditions.

**Why, when we have red tides every year, was anoxia associated with this red tide only?**
Although red tides can start throughout the year, the normal 'season' when most red tides start is from late August through November. Surface heating of seawater, which may trap red tide cells at depth, is not characteristic of fall red tides.

**Why was there a sulfur smell associated with this event?**
The sulfur and rotten egg smell is related to changes which occur in the chemistry of seawater when anoxia is present. It is not a product of a chemical spill offshore. When normal dissolved oxygen concentrations are present in seawater, bacteria responsible for the decomposition process use dissolved oxygen to produce carbon dioxide, ammonia, and phosphate in predictable amounts. When oxygen concentrations are low or zero, bacteria are forced to use other chemical compounds containing oxygen to produce carbon dioxide, including manganese dioxide (MnO$_2$), nitrate (NO$_3$), iron (FeO$_3$), and sulfate (SO$_4$). Natural sulfate processes associated with anoxia produce the sulfur responsible for the smells associated with this event.

**Why did the jewelry that divers wore tarnish?**

The tarnishing of silver jewelry worn by divers who were documenting the event is probably the result of contact with sulfur underwater.

**Has a bottom mortality event like this happened before?**

Yes, similar mortalities of bottom-dwelling animals occurred during a summer red tide bloom in 1971. A large area of anoxia occurred offshore of Sarasota County in approximately the same area as the current event when a red tide was trapped below a thermocline (an abrupt change in temperature with depth). An area of over 580 square miles was affected with mortalities of bottom-dwelling animals (e.g. sponges, corals, mollusks, crabs, echinoderms, and fish) observed on the patch reefs.

**How does the benthic mortality event of August 2005 off west central Florida differ from the anoxia and dead zone which occurs**
every year at the mouth of the Mississippi River?
The ‘dead zone’ located off the Louisiana coast each summer is directly associated with Mississippi River discharge. Inorganic nutrients (NO₃, NH₄, PO₄) delivered to the coast from the river cause large blooms of fast growing, non-toxic diatoms. These blooms die and sink to the bottom along with fecal material from small animals feeding on the diatoms. Warmer surface waters act as a barrier, trapping this decomposing material in deeper, cooler waters where it decomposes and uses up oxygen. Lower concentrations of oxygen stress animals and cause many to leave the area. Other non-motile animals which cannot escape die, leading to more decomposition and oxygen reduction, ultimately leading to anoxia. The Florida red tide is not associated with the Louisiana dead zone. Red tide only rarely occurs off the Louisiana coast. Scientists have found that no single nutrient source, such as the Mississippi River in Louisiana, provides enough nutrients to support a red tide.

The area of anoxia off west central Florida resulted from an unusual summer toxic algal bloom. Red tides usually start in fall in Florida, when waters are well-mixed and oxygenated, and last for several months. This red tide lasted through summer, when surface coastal waters have been heated by the summer sun and are much warmer than bottom waters.

Could the same bottom mortalities happen within Tampa Bay since the red tide is there also?
No, probably not. It did not happen in 1971 when red tide penetrated the upper reaches of Tampa Bay and an anoxic red tide event occurred offshore. Tampa Bay is shallower and the water tends to be well-mixed from surface to bottom by winds and tides. Red tide cells tend to be more concentrated in surface waters within the Bay because the temperature stratification (= layering) observed offshore does not occur.
Why doesn’t red tide occur within Tampa Bay every year?
Red tide cells prefer higher, more oceanic salinities (24–36.6 parts per thousand) and cannot grow in freshwater or at salinities much below 24 parts per thousand in nature. This salinity restriction generally keeps red tide out of the rivers and upper bays characterized by lower salinities. Usually red tide only is able to penetrate into Tampa Bay as far as the Skyway Bridge unless it is a drought year and salinity is higher than normal (e.g., 1971). Currently, red tide populations within Tampa Bay are existing at their salinity minimum of 23–24 parts per thousand.

How soon will the reefs recover?
The amount of time required for recovery of both the reef and the animals on the reef will vary with the specific animals involved. Dr. Gregory Smith studied reefs affected by the 1971 red tide off Sarasota for more than 5 years and documented recovery of diversity of fish populations within 12–18 months of the end of the event. Recovery of slower growing animals, such as coral and sponges, is estimated to take from two to five years.

What can be done to speed the recovery of the benthic organisms?
There is very little that can be done to speed the recovery of benthic organisms and reef communities affected by this event. These communities do eventually recover to prior population and diversity levels as part of natural recolonization and growth processes.

Because of weekly monitoring of oxygen and red tide levels in the region of the bottom mortalities, scientists know that the passage of Hurricane
Katrina offshore caused enough mixing of seawater to disrupt and mix the low oxygen region and return oxygen levels to normal. This reoxygenation of the seawater is the first step in the recovery of bottom communities.

**How long will this red tide last?**
Scientists cannot predict this. Most red tides last 4 to 5 months, although red tides as long as 21 months have occurred.

**Is our current red tide and the bottom mortality event related to the Piney Point wastewater discharge?**

No. Scientists know this because 1) offshore discharge of Piney Point wastewater in 2003 was monitored for nutrients, red tide, and dispersal patterns, 2) nearshore discharge at Bishop Harbor was monitored for red tide for two years, and 3) laboratory experiments were conducted in which Piney Point wastewater was added to red tide and the effect on red tide cells measured.

The Piney Point wastewater discharge occurred offshore over the fall of 2003. During the discharge, scientists at FWRI, the Florida Department of Environmental Protection (FDEP) and the University of South Florida’s (USF) College of Marine Science sampled the offshore discharge area each month after...
discharge. Of 271 water samples from the discharge area examined by microscopic analysis, red tide cells were found in only 2, both at the extremely low concentrations normally found offshore. Analysis of dissolved nutrients in the seawater after the passage of the discharge barge offshore showed that they were either dispersed, or rapidly taken up by microbes in the area and was not detectable after several days. Drogue studies (drogues are floats which track surface currents and relay their positions via satellite) used to track the movement of surface water at the offshore discharge site showed that the water was carried south and west, away from the coast of Florida.

Discharge of Piney Point wastewater at Bishop Harbor, adjacent to the Piney Point facility in southern Tampa Bay, also occurred. Weekly water samples were collected by FDEP at four sites within Bishop Harbor during the discharge to monitor the water for possible harmful algae, including red tide. Although tides carried a red tide in lower Tampa Bay into Bishop Harbor during discharges in February of 2004 and 2005, microscopic analyses of water samples by FWRI showed that red tide cells became abnormally shaped and did not survive within the harbor. During the initial nearshore discharge, a bloom of the macroalgae *Ulva* (= sea lettuce) occurred. This bloom was physically removed by FDEP and disposed of. Several species of harmful or nuisance microalgae (e.g. the dinoflagellate *Prorocentrum minimum* and the raphidophyte *Heterosigma*) known to be linked to nutrient pollution did briefly bloom at the discharge site over a one to two week period; however the red tide organism did not. During our current red tide, Bishop Harbor is one of the few areas within lower Tampa Bay where the red tide has not occurred.

Laboratory experiments were conducted at FWRI in which scientists added Piney Point wastewater to red tide cultures at concentrations from 2% to 20%. All additions depressed red tide growth and final cell yield
(total amount of red tide produced) were the same as control cultures with no wastewater additions. Results were similar when the experiments were repeated.

**Did pollution cause this red tide?**

No, we know from angler reports and water samples they collected and provided to FWRI in early January 2005, as well as from satellite imagery of high chlorophyll areas offshore that was ground-truthed with live water samples, that the current red tide started approximately 20 miles offshore of Pinellas County, in a region beyond the influence of coastal nutrients.

There is no evidence of a direct link between Florida red tides and nutrient pollution. Some red tides in other areas of the world, which are caused by different species of microalgae than are found in Florida, have been linked to nutrient pollution. However, red tides in Florida occurred long before settlement and severe red tides have been observed in each decade since *Karenia brevis*, the red tide dinoflagellate, was first recognized as the cause of red tides and described in scientific literature in 1948.

**Why is it so hard to determine the sources of nutrients for a Florida red tide?**

It is difficult to track the nutrients which support a red tide because nutrient concentrations within and surrounding red tides are very low, often too low to be detected. Scientists have thus used a variety of different methods to try to 'source' the nutrients supporting a bloom, including examining nutrient concentrations in a region immediately prior to a red tide, stable nitrogen isotope signatures and nutrient ‘budgets’ of
nutrients provided by coastal nutrient inputs. All methods indicate that coastal nutrient pollution does not cause the start of a red tide, and while it may contribute in part to maintaining a red tide in coastal waters, it cannot solely account for an entire larger tide. Scientists have thus concluded that many different nutrient sources contribute to a red tide, including nutrients from bottom sediments, from other microalgae able to fix N2 gas and excrete it into seawater as dissolved organic nitrogen or as ammonium, from atmospheric nutrient inputs, from rivers and runoff, from decaying dead fish, and from excretion of small crustaceans that feed upon phytoplankton. Many of these are currently being studied in individual research projects.

**Why do most scientists argue against a direct link between Florida red tides and coastal nutrient pollution?**

There are a variety of reasons:

1. What is known about the nutrient preferences of *Karenia brevis* and how it uses different forms on nutrients in comparison with other species of phytoplankton found in the same coastal and bay environments. *Karenia* blooms depend upon forms of nutrients that are not a common component of ‘typical’ nutrient pollution, i.e. organic nitrogen and organic phosphorus. It is easily out-competed by other types of phytoplankton when common forms of nutrients present in coastal pollution, such as inorganic nitrogen (nitrate (NO$_3^-$), ammonium (NH$_4^+$) and inorganic phosphorus (PO$_4^{3-}$)), are present, as it is a slow grower and a physiologically poor competitor for these nutrients. Its ‘niche,’ or ecological specialization, seems to be the use of organic nutrients and very low concentrations of inorganic nutrients.

2. Experimental work: It has been known since the early 1950s that
Karenia will grow well in the laboratory on organic nutrients. Experiments with Piney Point discharge water and red tide cultures showed a suppression of red tide growth and total amount of cells produced with all concentrations of wastewater additions.

3. Field research:

   a. A long-term federally- and state-funded research project (ECOHAB: Florida) conducted by USF with FWRI assistance between 1998 and 2002 included four-day long research cruises monthly in the region from Tampa Bay to Ft. Myers. These cruises sampled 70 sites for red tide as well as all forms of dissolved nutrients. Four different red tides were documented over these four years in this region. In the month prior to the start of each bloom there was no evidence of an increase in inorganic nutrients in the area where the blooms were first detected. This project also tracked nutrient sources for red tides using stable isotopes (Havens, 2004; Havens et al., 2004) as well as nutrient budgets (Vargo et al., in review) and did not find a link with coastal nutrient inputs.

   b. Measurements of the uptake of many different forms of nitrogen by a large 2001 red tide off St. Petersburg showed that the bloom was using organic nitrogen forms to a greater extent than inorganic nitrogen forms (Bronk et al., 2004).

4. There was no increase in red tides coincident with the greatest period of increase in fertilizer application (i.e. an increase in sugarcane area in the Everglades Agricultural Area) from 1959–1979, when the largest increase in nutrient inputs to Florida coastal waters probably occurred.
Why are the fish kills so bad this year?
The large number of fish mortalities are related to the extent and widespread area covered by the red tide. Fish are exposed to red tide toxins (called brevetoxins) in a number of ways: through directly feeding on *Karenia brevis* cells containing brevetoxin, by absorbing dissolved toxin across the gills (released from red tide cells dying in seawater or trapped on the gills), or potentially by consuming accumulated toxin contained within their prey. Fish die from respiratory arrest when they are exposed to red tide toxins dissolved in seawater, which passes over the fish gills as they swim. Early in red tides, these toxins are contained within the red tide cells and the amount of toxin dissolved in the seawater is relatively low. At this stage fish, such as thread herring and mullet, feeding on microscopic algae like *K. brevis* can ingest toxin, but are at first relatively unaffected. In later stages of red tides, there are usually high concentrations of toxins dissolved in seawater, or trapped on fish gills, resulting in more fish kills. Initially, fish that swim in the upper surface areas of the red tide are affected, but the longer the bloom persists, the more the toxin is present in the water, and then the toxin starts to sink. Bottom-dwelling fish, such as grouper, snapper, and other reef fish, can also be affected as the toxin, absorbed to particles or present in dead animals, sinks to the bottom. The combination of low dissolved oxygen, bacterial decomposition from dead animals, and red tide cells, as well as high concentrations of toxin and hydrogen sulfide, provides suboptimal conditions for bottom-dwelling fish. This combination of factors, and widespread distribution of toxin in the water column, contributes to large scale fish kills involving a wide variety of fish species occupying different habitats.
Are these the worst fish kills in history?
No. Large fish kills have been reported in southwest Florida coastal waters for hundreds of years. However, it is difficult to determine the total number of fish killed, because fish both float and sink (they sink first, and then float when the airbladder fills) during the decomposition process and floating fish may be carried by wind and tides to other places. Determining the number of fish killed would involve a massive costly effort involving many simultaneous observations on the beach and water, as well as on the sea bottom for hundreds to thousands of square kilometers. Most observations of fish kills are thus descriptive and difficult to compare directly. However, the longer the red tide, the more the numbers of fish likely to be killed.

A few observations of fish kills from previous red tides are quoted below:

1880 Red Tide  “The dead fish were most numerous on the outside beaches and on the inside beaches” (Walker, 1884)

1917 Red Tide  “Fishes of a great number of species were noted dead and dying” (Taylor, 1917)

1946–1947 Red Tide  "In a preliminary note regarding the 1947 Red Tide, it was very conservatively estimated that 50,000,000 fishes were killed. "Since that time the area increased and a recheck of the area and the numbers of fishes seen floating and washed ashore leads to the corrected estimate that the fishes killed must have numbered in the neighborhood of a half billion" (Gunter et al., 1948)."Heavy masses of fish were reported 5
miles off Gulf Beaches. Fish were reported 32 miles northwest of Clearwater beach and 19 miles out. (Feinstein et al., 1955). “Practically all species of fish, including such large forms as tarpon and jewfish, were included in the victims of the red water.” (US Fish and Wildlife Service, 1961).

1953 Red Tide
“Millions of dead fish from the Dry Tortugas to Ft. Myers” and “Dead fish from red tide were stretched from Venice to Indian Rocks” (Feinstein et al., 1955)

1971 Red Tide
"Severe kill of reef fishes, 80-90 percent of offshore resident reef fish species perished." (Smith, 1975)
“St. Petersburg city officials estimated that 2,367 tons of fish were removed during cleanup, costing approx. $155,763” (Steidinger and Ingle, 1972).

1995 Red Tide
"Extensive Fish Kills in more than 5,000 km² of open water. . . between Sanibel and Tampa Bay" (Tester and Steidinger, 1997)

Why are more turtles dying during this red tide?
Sea turtles are susceptible to red tide toxins. The amount of sea turtles affected by this bloom is probably related to the large size of the bloom and to the large number of resident sea turtles in the area of the bloom. Because toxin is being distributed into the bottom areas where these sea turtle species feed, and the toxin is likely in their prey items (crabs,
sponges, mollusks), they are being exposed to brevetoxins more frequently than normal. Updated sea turtle mortality information is available in the Current Florida Sea Turtle Stranding Report.

Back to top

Is this red tide affecting turtle hatchlings?
We have witnessed many red tide events where we have documented unusually high sea turtle mortality. Several of these red tide events occurred during the summer when hatchling sea turtles were making their way from the beach to offshore water. We have never documented unusual hatchling mortality during any of these events, including the present event. FWC sea turtle researchers have observed live hatchlings offshore of the current red tide and did not find any dead hatchlings in the area of the red tide. Because hatchlings swim quickly offshore, they may not linger in areas of red tide long enough to incur any noticeable mortality.

Back to top

Is this red tide affecting manatees?
Yes. Biologists have been responding to reports of dead manatees throughout southwest Florida since early March, in areas where red tide counts have been higher than normal for several months. As animal carcasses were recovered and necropsies (non-human autopsy) were conducted, it became more obvious that these animals might be dying as a result of exposure to red tide. Staff members continue to recover carcasses and necropsy dead manatees. A table with information on manatees suspected to have died from red tide exposure during the current red tide bloom can be found in the March 5, 2005 News Announcement.

Back to top
What can we do to kill the red tide?
Control and mitigation of red tide blooms is not a simple issue. There are a variety of scientists and other interested individuals working on control methods, but before any method could be used several points need to be considered.

First, scientists are very cautious about any proposed red tide mitigation or control because much of the harmful effects of a red tide are due to toxins within the cells, rather than the cells themselves. It is actually very easy to kill red tide cells. But red tide cells themselves are not the cause of red tides’ harmful effects—it is the toxin contained within the cells that harms sealife and causes fish kills and respiratory irritation in humans. Killing red tide cells releases these toxins directly into seawater, effectively making a red tide more toxic. Any potential mitigation strategy must not only kill or remove red tide cells, but also destroy the toxins released into the water.

Second, any control strategy or treatment to eliminate red tides must do no other harm to the environment. In the 1950s, it was discovered by federal researchers that adding copper to an aquarium of red tide killed the cells. Tons of copper sulfate were subsequently added to a large bloom in 1953 and 1955. It killed the red tide cells but did not affect the toxins within the cells, which were released directly into the water. Although the red tide cells were killed, the toxicity of the bloom was actually greater due to the direct exposure of fish to the released toxins. The copper treatment did not eliminate the bloom and the copper additions probably had a significant negative impact on organisms that were not affected by the red tide.

The application of fine clay particles to the water surface is one potential method to control red tides. Clay is applied to the surface of the ocean.
Red tide cells stick to the heavy clay particles and are carried to the bottom. Although this has been shown to remove red tide cells from the water, it just moves them and their toxins to the bottom where they either kill creatures on the bottom (e.g. crabs) or they get moved back into the water by turbulence waves. It also adds a smothering layer of clay to the bottom, resulting in less oxygen availability.

A third point about red tide mitigation is that the method must be practical. Red tides vary greatly in size and can be huge, up to 10,000 square miles, and can be present from surface to bottom. It is simply not practical to try to ‘control’ or kill something this big. It may be too costly, or just physically impossible, even if a good method existed. Although most people are aware of red tides when they impact beaches, blooms actually start in a region 18–74 km offshore with much lower concentrations. Only when blooms are in their fully developed maintenance stages with high concentrations are they apparent to coastal populations in nearshore areas. It may be possible to control these early stages of blooms offshore, but they need to be located and detected during these early stages. This is impossible at the moment because cells grow in water too deep to be detected by satellites and blooms can start offshore anywhere from north of St. Petersburg down to Naples, an area too large to cover with boats.

Another control method currently being tested is ozone application. Although ozone itself is toxic, in seawater it immediately combines with bromide to form toxic compounds and there is much research to be done to make sure that there is no harm to other marine organisms.

As well as chemical control methods, scientists have also been interested in the possibility of using biological control. Like other organisms, red tide cells can potentially be terminated by viruses or
bacteria. By understanding the potential pathogens associated with red tide cells there may be a possibility to investigate biological methods to control blooms.

Red tides are natural events, so all potential 'control' methods must be viewed with extreme caution. Both clay and ozone are merely potential tools, which would have very limited applications and are not red tide cure-alls. They are not perceived as large scale solutions to red tides, just as potential strategies for dealing with localized problem blooms. Both methods have been used successfully elsewhere in the world to manage red tides caused by other species, and it is only through controlled, very small scale scientific experiments in the lab that we can evaluate the effectiveness of each method for use in our system.

Back to top

**Why haven’t scientists solved the red tide problem in Florida?**

There is evidence that red tides have always existed in Florida’s waters. Scientists who study red tides globally consider Florida red tides to be unique because they are natural events which existed long before Florida was settled. In other areas of the world, red tides caused by different species of algae than in Florida have been linked with coastal pollution; however, not in Florida. There is often much public confusion on this issue as the term ‘red tide’ refers not only to blooms of *Karenia brevis* and other *Karenia* in Florida, but also to blooms of over 100 other types of toxic microalgae in other areas of the world, each with its own unique nutrient preferences, toxins, and ecosystem effects.

Scientists compare Florida red tides with hurricanes. Both are natural phenomena of incredible complexity with great destructive capabilities. While hurricanes are related to weather patterns, red tides are related to weather patterns and water currents, seawater chemistry, and biology.
The knowledge that we currently have of Florida red tide ecology, nutrient preferences, toxicology, and impacts has resulted from large, multi-disciplinary, multi-year studies in the past decade since 1995 which have studied all of these factors as they interact together to create red tides. Prior to this there was little funding available to scientists for extensive routine cruises or event response cruises to study red tides under sea conditions, and the research that was done generally consisted largely of diverse, laboratory studies on *Karenia brevis* biology and physiology, shellfish toxicity, and management options. Currently, research is being conducted on many aspects of red tide at both state and private institutions and universities, but ‘solving’ the natural phenomena of red tides may not be possible, even if scientists better understood their function and role in coastal ecosystems.

**Back to top**
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