Deep Earth Academy
CONSORTIUM FOR OCEAN LEADERSHIP

Why study forams?

Summary

Foraminifera are single-celled protists. They are not plants or animals, yet at times they seem to take on characteristics of both. Whether a foram is 0.05 mm, 5.0 mm, or 18 cm, it only has one cell.

1. Types of Forams

There are **two main groups** of foraminifera:

- **Planktic** foraminifera float freely in the upper water column. Most planktic forams live in the sunlit surface waters with other types of plankton.
- **Benthic** foraminifera live on the bottom of the ocean, on the seafloor, and on rocks, seaweed, and other marine organisms. Some benthic forams live at or near the sediment/water interface, while others live several to many centimeters into the sediments.

2. Structure of Forams

Most foraminifera build a hard shell (test) around their cell to protect it from the environment.

There are three types of tests made by foraminifera:

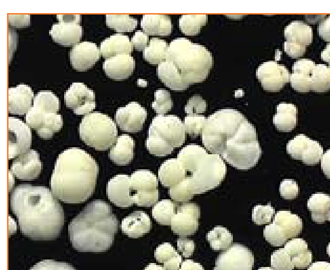
- A flexible, **organic** wall
- **Calcareous wall**: made of a secretion of calcium carbonate
- **Agglutinated wall**: made of glued grains of sand, silt, or other sedimentary particles from the surrounding area

All living foraminifera have "false feet" called pseudopods, which are sticky fibers of cytoplasm that extend out like a spider web from its test (shell) into the underwater environment. Living foraminifera send out a huge network of pseudopods, which provide forams with a wide foraging range to absorb nutrients, and to collect and transport food particles. Benthic forams also use their pseudopods to move along the substrate. Agglutinated benthic forams gather sediment grains to construct their shells.

3. What do forams eat?

Foraminifera eat a variety of foods, such as bacteria, diatoms, algae, copepods, fecal pellets, detritus, and other dead organisms. The *Astrammina rara*, an agglutinated foraminifera found in Explorers Cove, Antarctica, is capable of eating juvenile marine invertebrates many times its size.

Foraminifera lived long before the dinosaurs, and forams still flourish today in all marine and marginal marine environments. Foraminifera are like a lens on the past and present. By studying forams today, scientists can infer what past environments were like.



Dr. Mark Leckie exams forams on the JOIDES Resolution.

4. Where are they found?

Today, living foraminifera are found:

- In near-surface waters of every ocean of the world
- On the seafloor from the coasts to the deepest trenches
- In salt marshes, river estuaries, and bays
- In coral reefs and tropical lagoons
- In polar regions, such as under the Antarctic sea ice
- Near hydrothermal vents in the deepest parts of the ocean
- In both salt and fresh water
- Clinging to rocks, seaweed, and other marine organisms

We find **fossilized foraminifers** in the limestone that make up the Pyramids of Egypt, hardened into rocks, or as sand on tropical beaches; the pink sands of Bermuda are made of foraminifera. We also find fossil foraminifers in deep ocean sediment cores.

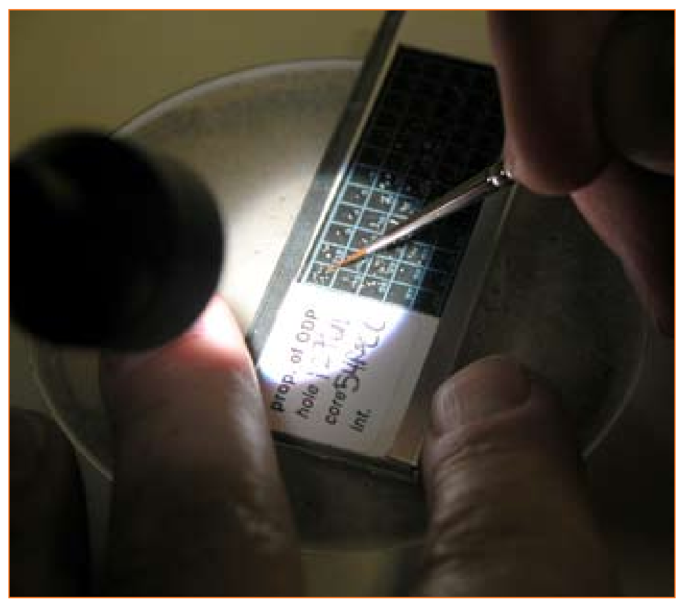
5. What do we learn from them?

Foraminifera allow scientists to look at the past and compare it to today's world to see how the Earth has changed over time.

Scientists gain a better understanding of the Earth by looking at the distribution of foraminifera. Living forams are like mirrors on present-day conditions, while fossil foraminifers provide clues to past environments and how the surface of the Earth has changed over time. There are over 4000 extant (living) foram species today, and more than 60,000 extinct foraminifer species. Foraminifera are significant because they are some of the most abundant marine organisms on Earth. By collecting data on factors that control how living forams are distributed in the sea, scientists note whether these factors, such as **water temperature, depth, habitat, salinity, food availability, and latitude** affect, or control which species thrive in certain areas and why.

Foraminifera are useful indicators of local and global changes in the environment.

- Foraminifera are like "watch dogs" on the environment because they are so abundant, widespread, and sensitive to changes in the environment.
- Certain foraminifer species prefer different ecological conditions and habitats. Foraminifera, both now and in the past, have been sensitive to changes in climate, sea level, salinity, depth, temperature, available foods, and pollution. They are climate change detectors, and are like CSI investigators because they provide important evidence on environmental changes and conditions.



Lab work on board the ship

After washing foraminifers (**forams**) from the sediment, the **sand-size microfossils** are sprinkled on a metal picking tray and specimens are picked off the tray using a fine **brush** moistened with water. The foram specimens are mounted on a **cardboard slide** where they can be sorted and counted.

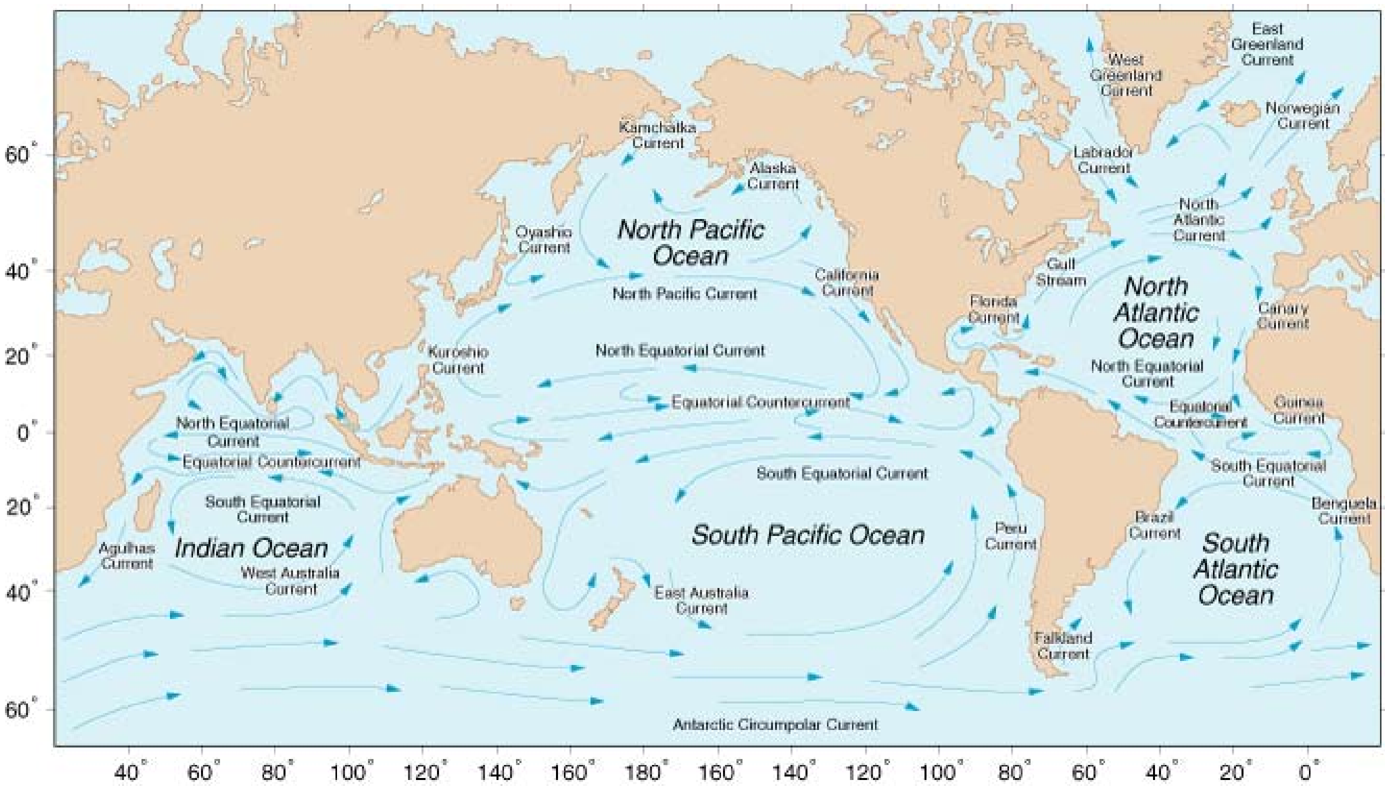
Site 806 B: Six Important Intervals or Events during this Time Frame

Levels in Core	Paleoceanographic Events and Intervals	Time Frame
~ 3 to present	**Interval: Modern Pacific Circulation**	late Pliocene to present
~ 3	**Event: Northern Hemisphere Glaciation** (Big Ice Sheets)	late Pliocene
~ 4 to 3	**Event: Closing of Panamanian Seaway**	early to late Pliocene
~ 10 to 3	**Interval: New Circulation in Pacific** (Pre-Northern Hemisphere ice)	late Miocene to late Pliocene
~ 10	**Event: Indo Pacific Seaway Closing** This was not completely closed. It is still open today, but this event changed the environment and the biota. The closing of the seaway and the shoaling of the thermocline caused many species changes. Dominant taxa: More equitable distribution of surface, thermocline, and deep sea dwellers.	middle to late Miocene
24 to 10	**Interval: Indo Pacific Seaway was open** between the Pacific and Indian Oceans. Dominant taxa: surface dwellers	early to middle Miocene

Notes and Background Information

Events cause changes and define the intervals of time, or new environmental conditions. (Modern day analogy: Hurricane Katrina was an event that defined the interval of time prior to Katrina and the interval of time that followed Katrina as noted by the effect that this event had on the people, biota, and environmental living conditions.)

The ***Closing of the Indo Pacific Seaway*** was an event that made this region in the tropics tighter and more constricted to ocean circulation, which led to the interval: New Circulation in the Pacific. When the Indo Pacific Seaway got narrower and tighter, more waters went north and south instead of westward into the Indian Ocean from the Pacific. Not only did the movement of waters north and south become stronger, but a strong eastward flow also developed. The Pacific currents and waters circulated in a different way, which intensified tropical circulation and upwelling. This caused nutrients to change in the Pacific. This "New Circulation" may have been the first step to modern day circulation in the Pacific. When the "New Circulation" increased the Pacific circulation, productivity increased and conditions became favorable for a mix of thermocline and surface water dwellers. *Note: Changes going on in the ocean will change and affect foram assemblages and distribution.*



Present-day circulation in the Pacific: faster current and more nutrients.
Image: http://oceanmotion.org/images/surface_current_map.jpg

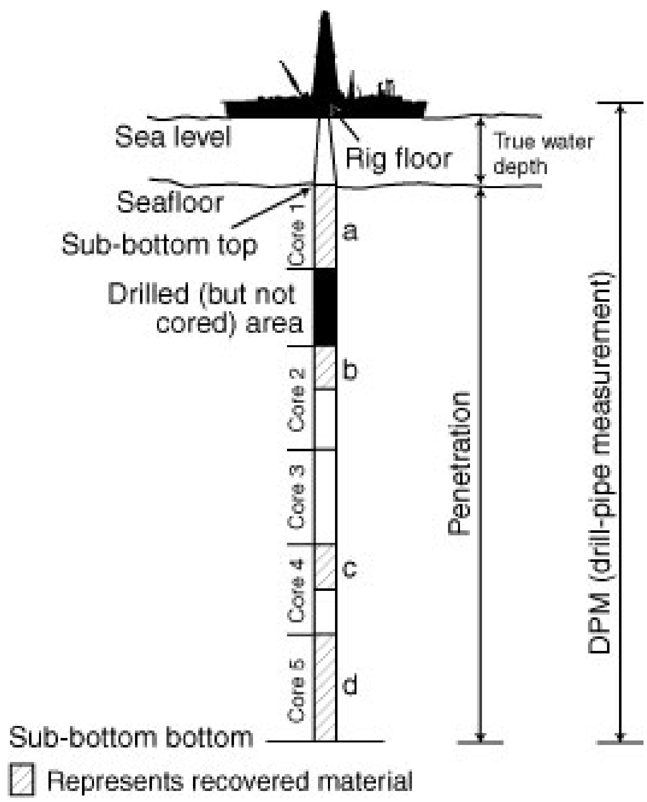
New Circulation

These currents were much like the circulation around Japan (Kuroshio Current) and Australia that Nemo, the little fish in the animated movie, *Finding Nemo,* experienced when it was caught up in the East Australian Current. Nemo was taken from his home on the Great Barrier Reef and ended up much further south in Sydney, Australia.

Today's Circulation

The Western Pacific Warm Pool keeps the thermocline from shoaling in the Western Pacific, which makes the thermocline very deep. This indicates low productivity in the west. Strong trade winds cause tropical waters to pile up in the west. Although, the Indo Pacific Seaway is not closed, it is tight, and this pushes the thermocline down deep in the western Pacific. Today's foraminifer thermocline dwellers are a special group because they have adapted to a deep thermocline. The east Pacific, on the other hand, has shoaling of the thermocline, which makes productivity high in the east.

Figure 1



Bottom felt: distance from rig floor to seafloor

Total depth: distance from rig floor to bottom of hole (sub-bottom bottom)

Penetration: distance from seafloor to bottom of hole (sub-bottom bottom)

Number of cores: total of all cores recorded, including cores with no recovery

Total length of cored section: distance from sub-bottom top to sub-bottom bottom minus drilled (but not cored) areas in between

Total core recovered: total from adding a, b, c, and d in diagram

Core recovery (%): equals total core recovered divided by total length of cored section times 100

Figure 1. Coring and depth intervals.

Volume 130. Initial Reports

Ontong Java Plateau

Explanatory Notes: Fig. 1 (Slide 2, pg. 16)

http://www-odp.tamu.edu/publications/130_IR/130TOC.HTM

ODP Leg 130, Hole 806 B

Drilling Vessel: *JOIDES Resolution*

February 18, 1990 – February 22, 1990

(Time at Drill Site: 4 days, 4 hours, 30 min.)

- Distance between rig floor and sea level (m): 11.14 m
- Water Depth: (from sea level) 2519.9 m
- Total Depth: (rig floor) 3274.10 m
- Penetration through seafloor: 743.10 m (mbsf = meters below sea floor)
- Number of Cores: 78
- Total Length of Core Section: 743.10 m
- Core Recovery: 89%
- 230 samples examined *(110 planktonic foraminifer species identified)*

Coring and Depth Intervals

After the drilling vessel, *JOIDES Resolution*, arrived at the site, it positioned itself over one acoustic beacon before drilling three holes at Site 806. The Ocean Drilling Program (ODP) numbered the drilling sites consecutively (Site 803-806). Site 806 had three holes drilled: 806 A, 806 B, and 806 C. This activity is focused on Site 806 B. The first hole drilled represents 806 A. Site 806 B was the second hole drilled at Site 806. When drilling multiple holes at a site, the ship will pull the pipe out, move over a short distance within the site and begin drilling the next hole. The core is drilled in intervals about 9.5 m long (the length of a core barrel), so the maximum full recovery for a core is 9.5 m. The core is measured in meters below the seafloor (mbsf). The cores from each hole are numbered in a series from the top of the hole downward (e.g., Core 1, Core 2, Core 3….).

Figure 2

Ontong Java Plateau

Western Equatorial Pacific

The Ontong Java Plateau is a broad, shallow, mid-ocean highland close to the equator in the western equatorial Pacific. Site 806, (Position of Hole 806B: latitude 0°19.11'N, longitude 159°21.69' E) is located in the northeastern margin of the Ontong Java Plateau, near the top of the plateau in a water depth of 2520 m (8266 ft.).

Figure 2 is from the Shipboard Scientific Party Site Report: *ODP (Ocean Drilling Program) Leg 130 Preliminary Report: Site 806*, Fig.2, pg. 294. (*http://www-odp.tamu.edu/publications/130_IR/130TOC.HTM*)

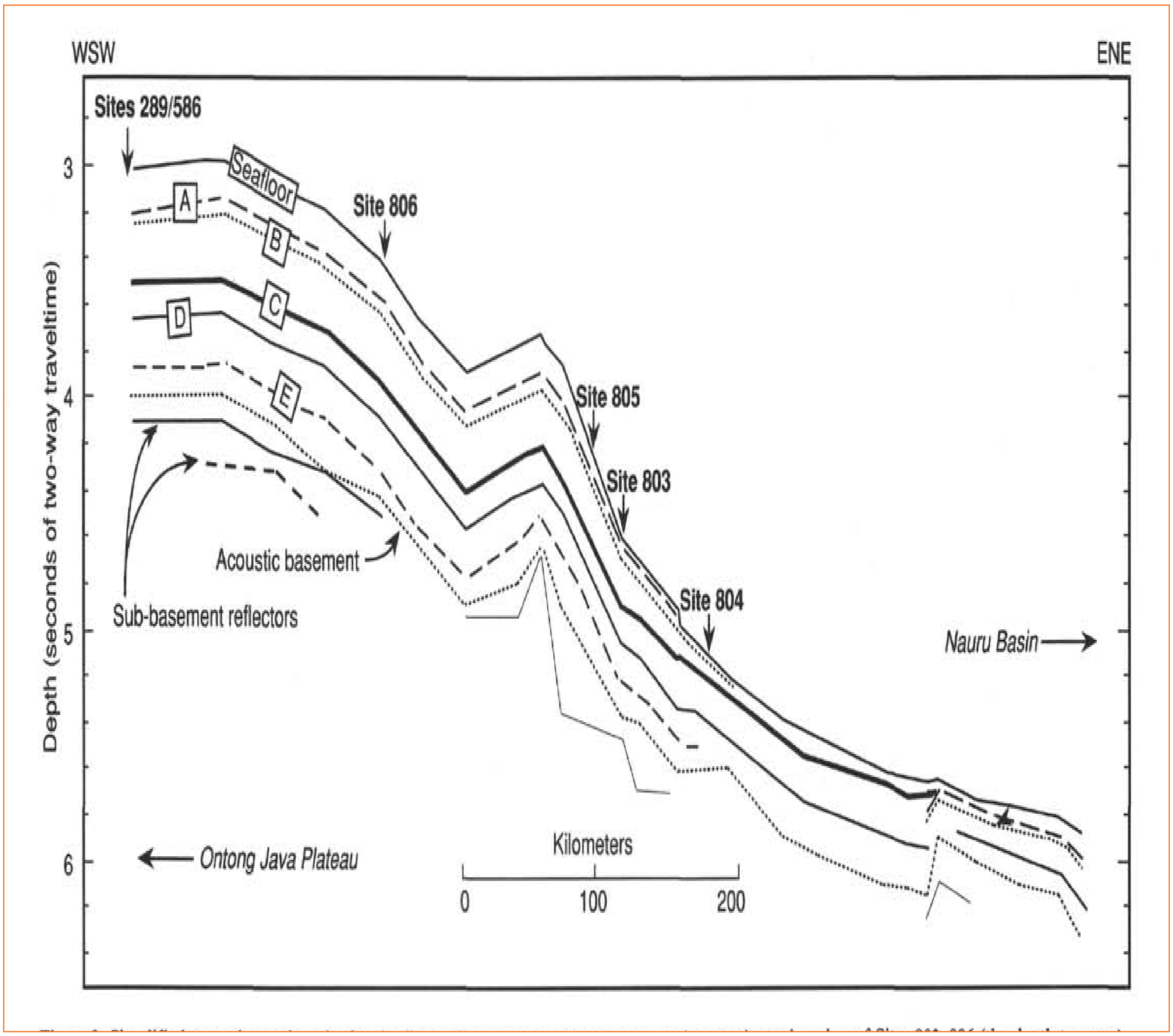
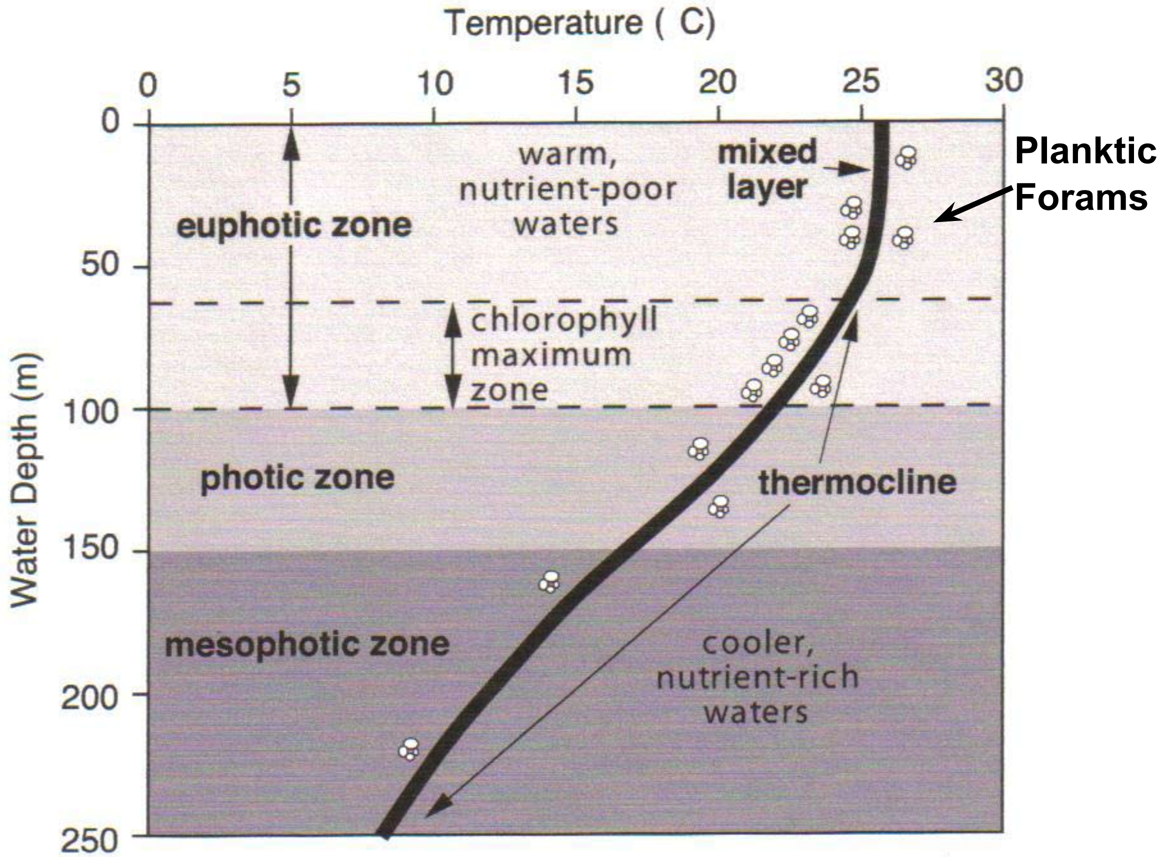


Figure 2. Simplified acoustic stratigraphy for the flank of the Ontong Java Plateau, and approximate location of Sites 803-806 (the depth transect).

"Mohawk Guy" Activity Vocabulary Page



This cartoon depicts a generalized thermocline in the tropics, the general distribution of light for photosynthesis, and a representation of how planktic forams may be distributed along the mixed layer and thermocline. Some species are best adapted to the warm, less dense waters of the mixed layer, or surface layer (above the thermocline), while others are distributed at various density, light, and food levels of the cooler, denser waters of the thermocline.

Vocabulary

Foraminifer (Foraminifera or forams)

Sand-sized, single-celled protists with a shell of calcite (calcium carbonate) or agglutinated particles; some forams live in the upper water column (planktic forams); some live on the seafloor (benthic forams).

Mixed Layer

The uppermost part of the ocean is warmed by the sun and mixed by winds to create a layer of water that is all the same temperature (much like the warm surface layer you feel when swimming in a lake)

Thermocline

Cold/warm barrier; water layer between warm surface waters and cool deep waters (as "felt" by your feet below the warm surface layer when you swim in a lake).

Chlorophyll maximum

Where the maximum abundance of phytoplankton (base of the food chain) is concentrated. It is the right balance between filtered sunlight from above and nutrients from below. Forams and other organisms (e.g., bigger animal plankton, fish, and whales) feed on these phytoplankton.

Photic Zone and Euphotic Zone

Layer of water that has enough sunlight coming through for phytoplankton to perform the process of photosynthesis and make organic matter (carbohydrates, proteins, and fats); the food for consumer organisms.

Planktic or Planktonic

Referring to organisms that float with or are carried by ocean currents (these are organisms that cannot swim like fish, dolphins, or sea turtles). Some forams are planktonic.

Benthic

Referring to organisms that live on the seafloor. Some forams are benthic.

Niche

An environment; a place where organisms live (e.g., tropical fish of a reef only live where the water is warm, clear, and free of mud from rivers; these conditions define the niche of tropical fish… where it can live and the role it plays there).

Surface dweller

Organisms whose niche is in the upper water column, within the photic zone.

Shoaling of the thermocline

Thermocline moves upward, and the warm water layer becomes thinner as cooler water and nutrients rise toward the surface.

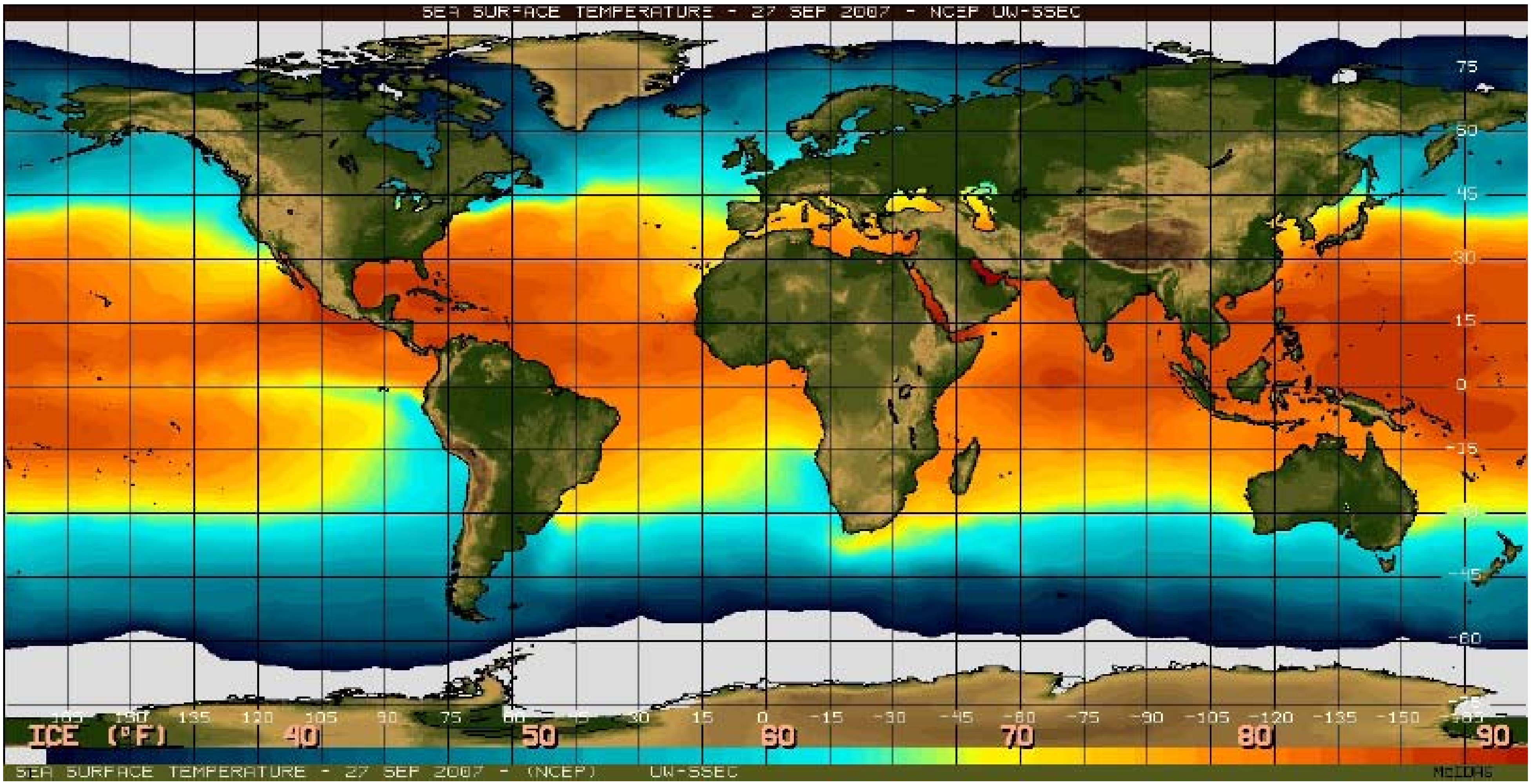
Micron

One millionth of a meter (= 0.000001 m, or 0.001 mm); you cannot see something the size of one micron with your naked eye. Forams are sand-sized microfossils; you can see them with your naked eye, but they are best studied using a microscope. Forams range in size from 60 to 2000 microns (= 0.06 mm to 2.0 mm).

FYI

- Most of the ocean is icy cold and deep. The upper 100 – 200 meters of the ocean are warmed by the sun. Below this, the ocean is dark and cold (see diagram above). Sunlight + nutrients = high productivity
- The ocean surface has different characteristics. Organisms live where they can thrive and survive the changes. Small changes can make a difference to what organism thrives and is dominant in specific regions (e.g., coral is affected by slight changes in pH, water clarity, or even by a 1° C change in water temperature). Planktic forams are affected by temperature, salinity, seasonality, and productivity of the surface ocean.
- Organisms are most concentrated where nutrients and phytoplankton are abundant = food "hot spots," (an abundance of phytoplankton at the base of the food chain) as seen during seasonal changes.
- Nutrients and plankton are not distributed evenly in the ocean, which also affects the organisms (patchiness of ocean). Some places have an abundance of nutrients, which allows for an abundance of phytoplankton (provided there is enough sunlight), which in turn supports greater abundances of plankton and animals that depend on phytoplankton.
- Why is the thermocline so important? The thermocline forms a density barrier (bench) where some forams hang out on the bench. Less dense warm surface water (warmed by the sun) floating on more dense cold water creates this bench where many planktic foraminifers feed and reproduce at the thermocline.
- Why are planktonic forams so small? They have to be small in order to beat the force of gravity, which will cause objects denser than seawater to sink. They are successful at staying in the surface ocean because they are so tiny. They have calcareous shells, which tend to be heavy (like a small stone!) compared with the seawater that they live in. They build their tests (shells) of stone (calcium carbonate), so they must devise ways to make them light and buoyant. They need to hang out in or near the warm, sunlit waters of the upper ocean. All organisms have a hardship, and gravity is one of their hardships. They build their tests to overcome this hardship. Their morphology keeps them from sinking. Some planktic forams have big pores, long thin spines, large apertures (openings), keels, or different shapes, (like parachutes) for this reason. They are not like the fossil ammonites that fill their chambers with gas. Instead, their chambers are filled with protoplasm. Some forams have lipids (fat) in their protoplasm, which is less dense than water. This counteracts the denser calcite.

Sea Surface Temperature Map



This sea surface temperature map (http://www.ssec.wisc.edu/data/sst/latest_sst.gif) is a world map that depicts the temperature gradient between climate zones from the equator to both poles. Organisms follow the climate zone. These belts, based on temperature, go around the planet.