Intro to Paleoceanography Notes

*Note to the instructor:

The "Intro to Paleoceanography" presentation includes a general introduction to Paleoceanography and includes a basic introduction to the last 25 thousand years of climate change. Most slides are self-explanatory; however, more details for select slides are below.

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Slide 9:
This is a map of worlds oceans showing the change in temperature from the Last Glacial Maximum (LGM) compared to the average temperatures in august today.

As you can see, not all the oceans were colder during the LGM and some regions so much larger temperature changes that others.

Discussion Questions:

- Where was the largest temperature change seen? (Large cooling in the North Atlantic).
- In what locations do we see no change? Warming?

Slide 10:
The last deglaciation was from about 21-10 thousand years ago. This is an air temperature record for the last 25 thousand years that was constructed using a Greenland Ice Core.

As you can see, temperature did not slowly increase from the Glacial period to the Interglacial. Instead, we see large changes in temperature over very short time periods (Geologically speaking, events like the Bolling-Allerod and the Younger Dryas which were only a few thousand years long are very short events).

- What caused the rapid warming in the Bolling-Allerod and cooling during the Younger Dryas? Scientists are actively trying to figure this out!!!

Slide 11:
Today, scientists are still trying to understand how cold events like the Younger Dryas were manifested in other regions besides Greenland. As we already know, during the LGM, some regions of the world changed a lot, while other regions showed little to know change.

Discussion Questions:

- What about the Gulf of Mexico?
- How do you think Gulf of Mexico climate changed during the Younger Dryas?

Slide 12:
Paleoceanographers can use ocean sediments to reconstruct past climate change. Large research vessels like the R/V Marion Dufresne collect deep-sea sediment cores that provide a record of ocean conditions back through time.

Sediment cores are plugs of sediment from the sea floor. Imagine sticking a PVC pipe into the mud that accumulates at the bottom of the ocean. The mud at the bottom is old and the mud at the top was recently deposited. We can slice the sediment cores in sections (often 1 cm thick) so that each slice represents a certain period of time. Using different types of dating techniques, like 14C, we can construct an age model and assign a specific age to each layer of sediment.

Discussion Questions:

- How does mud at the bottom of the ocean help us understand climate?
- Where does this mud come from?

Depending on location, it often includes continent-derived (terrigenous) materials and oceanic materials. If there are large changes in climate, sediments can reflect that. Ex. Increase in precipitation vs. droughts would yield changes in the amount of terrigenous run off to a specific area.

- What is in the mud?
  Terrigenous materials (ex. Pollen, plant materials, minerals, etc.)
  Marine materials (ex. Animal waste, fossils, plant materials).

****Everything from the entire water column is deposited in the sediments.****

Slide 13:
Many paleoceanographers use fossilized foraminifera to reconstruct climate. Foraminifera or "forams" for short are a type of zooplankton that have a calcium carbonate shell (similar to the material corals are made of). Paleoceanographers like to use forams because they preserve very well in the sediment record and we also understand a lot about their life processes and what kind of environments they live in. For example, we know what species like to live at the surface of the ocean. So, if we want to understand more about sea surface conditons we look at those species.

Forams are single celled amoeboid protists with reticulating pseudopods, which are temporary projections of the eukaryotic cell. When the forams are alive they have large spines that stick out of their shell that the pseudopods can stick out of for feeding. Openings in their shells allow cytoplasm to flow between chambers and are called apertures. Forams vary in size, but most planktonic species (living in the water column near the surface) are about the size of a grain of sand.

The specific species in these photos is *G. ruber*. There are 2 varieties*:* *G. ruber* (white) and *G. ruber* (pink). The only physical difference is that one has a pink pigment in its shell. Scientists think that there are some differences in the depth and season that these organisms live in, but unfortunately there is not much data on this.

Slide 14:
In tropical and subtropical climates, the foraminiferal species *G. ruber* is very abundant and often used to reconstruct past sea surface temperature (SSTs). Although the shell is made of calcium carbonate ($CaCO_3$), Magnesium (Mg) is similar enough to Calcium (Ca), that forams will incorporate it into their shell without even noticing. Lucky for paleoceanographers, they do this at a rate that is temperature dependent! Therefore, the Mg/Ca ratio of foraminifera can be used to calculate SST. While the specific equation looks complicated, it is just the mathematical expression of the relationship between the SST and Mg/Ca ratio of the foram shell. This relationship has been derived by scientists who study different species of forams in controlled laboratory experiments. Each foram species incorporates Mg at a different rate and therefore requires a different equation to calculate SST.

Slide 16:
A recap slide (same as #9). We have an idea of what Gulf of Mexico conditions were like during the LGM…but what about the Younger Dryas??

Slide 17:
This is brand new data from the Gulf of Mexico! As you can see, we are looking at changes in SST for the last 20-10 thousand years ago.

Discussion Questions:

- How did we get this data?

All of this data was generated from Mg/Ca ratios of the planktonic foraminifera G. ruber (white), using the equation from the previous slide.

- What trends do you see?
- What was climate like during the Glacial period? Bolling-Allerod? Younger Dryas?

Slide 18:

Glacial: SSTs were cool. We see an approx 5°C increase from the glacial to the interglacial period. This is a big change!

Bolling-Allerod: Just like in Greenland, SSTs increased during the Bolling-Allerod (but not as much, remember: ocean temperature changes are much smaller than air temperature changes)

Younger Dryas: We see a 2.4°C decrease in SST in the Gulf of Mexico during the Younger Dryas. This is a large temperature change for such a short period of time! This is the first record to show a Younger Dryas cooling in the Gulf of Mexico.

What caused the Younger Dryas???

- This is a big question and we didn't really go into it for this presentation. There are a couple theories as to what caused the Younger Dryas and most of them have to do with large changes in global ocean circulation and the distribution and transport of heat from the low-latitudes to the high-latitudes. Possibly another presentation to come on this!

Other good sources:
www.realclimate.org
http://news.discovery.com/earth/why-the-younger-dryas-matters.html
www.realclimate.org