NOAA Teacher at Sea Program

Lesson Plan on Hydrography

Activity Title: Ping It! An exploration of how sonar data can be used to determine the landscape of the ocean floor.

Subject (Focus/Topic): Hydrographic Surveys

Grade Level: 4th-12th

Average Learning Time: 1 class period (block schedule) - approximately 90 minutes

Lesson Summary (Overview/Purpose): Students will simulate the collection and analysis of sonar data used to map the ocean floor.

Overall Concept (Big Idea/Essential Question):

1. Why is it important to map the ocean floor?

2. How is the ocean floor mapped?

3. What factors must be accounted for to complete a good nautical chart?

Specific Concepts (Key Concepts):

1. Creating quality nautical charts is important for the safety of humans and marine life.

2. Sonar works by sending sound pulses to the ocean floor and recording the time and angle at which they return.

3. Many factors must be considered when creating a nautical chart including tides, rocking of the boat, and changes in sound speed depending on the composition of the water.

4. NOAA must consider multiple factors when determining where to chart next including amount of traffic in the area, when the area was charted last, and how dynamic the ocean floor is in a particular area.

Focus Questions (Specific Questions):

1. What does the ocean provide for us?

2. What resources provided by the ocean must be obtained using a boat or ship?

3. What can happen if nautical charts aren't up to date?

4. How does sonar detect objects?

5. Why should tides be considered when mapping the ocean floor?

6. How can we correct for tides in our data?

7. How is multibeam sonar different than single beam sonar?

8. How does sound speed change depending on temperature, salinity, and pressure?

9. What should be considered when determining where to chart next?

10. What is longitude and latitude?

Objectives/Learning Goals: Students will complete a model chart of the ocean floor given tidal data and sonar data with an average of 80% accuracy .

Background Information: Students need to know what lines of longitude and latitude are. If they don't, this can easily be added to the lesson.   Students need to be able to do simple arithmetic (multiplication and subtraction) and should be able to read a basic graph. (NOTE: To make the math easier, you can have the students round their data to the nearest whole number. Just be sure to explain that this wouldn't occur in the real collection of data)

Common Misconceptions/Preconceptions: Students probably have few misconceptions, because they know little about the topic. They may think that computers do all of the work in the mapping of the ocean floor and not understand the importance of human data analysis. Also, students could possibly have misconceptions about tides. Further, students may have misconceptions about what is involved with safe navigation. If they have been on a smaller boat, they make think visual clues are the main data used for safe navigation.

Materials: Stopwatch, Student Assignment Cards, Handout for recording data, Calculators (if desired)

Technical Requirements: Computer, Projector, PowerPoint (ALL ARE NOT NECESSARY, BUT ARE HELPFUL)

Teacher Preparation: Print handouts, Cut out Student Cards

Keywords: Sonar, Hydrography, Tides, Fathom, NOAA

Pre-assessment Strategy/Anticipatory Set:

1. Students will answer questions upon arriving in class. First, they will individually brainstorm and list what the ocean provides for us? Once they have answered that question, they will be asked to circle their answers from above that require a boat or ship to obtain?

2. Once students have completed the two questions, the teacher will ask for students to share what the ocean provides. Once students have shared all of their ideas, the teacher will show the students everything she has listed. To make this more exciting and interactive, the teacher will present it as if it is family feud. She will basically see how many answers the students got out of the ones she listed and say "Ding, ding, ding!" when they get one right.

3. Now, as a class, they will circle the ones that require a ship or a boat.

Lesson Procedure:

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4. NOTES/DISCUSSION - The previous step will lead into a quick explanation/discussion that includes students taking notes of the importance of safe navigation and NOAA's role in safe navigation. Particularly, teacher will discuss that

mapping the ocean floor is crucial so ships don't wreck. Specifically, an oil covered otter from the Exxon Valdez spill will be shown and briefly discussed. Teacher will show a picture of a nautical chart and explain that NOAA makes them. This includes an explanation of what NOAA is. Teacher with briefly explain how sonar data collection has changed over time. Also, teacher will directly teach the following vocabulary: Sonar, Tides, Hydrography, and Mean Low or Low Water (MLLW). Teacher will also ask where in nature we see sonar being used and briefly compare animal sonar in dolphins and bats to sonar used to collect hydrographic data.

5. Next, select a student or ask for a volunteer to act as the ship's sonar. Explain to the student that they will send out pings by saying the word "ping" with their back turned to the class. This same student is given a stopwatch and is asked to record the time it takes for the ping sound to return, so the whole class will be able to calculate the depth of the ocean floor at that point. Then, the student will move over and repeat the procedure until all data has been collected (6 points). Once this student understands his/her role, send them out of the room, so you can give further instructions to the class.

6. Pick 6 students at varying distances from the front of the room and give them a longitude/latitude card. The card will tell them how many seconds to wait before saying ping back to the sonar. These students represent the ocean floor. If a card has a shorter amount of time (ex. 1 second) they should be closer to the front of the room then a student whose cards says to wait a longer amount of time (ex. 3 seconds). Tell all of the students that the student will card 4 is at the deepest point. In fact, when sonar data is collected and scientists move to a deeper area the scientists have to turn up the power so the sonar produces a louder noise and the echo will be detected. To simulate this, tell student 4 to return the ping sound after 6 seconds but whisper it, so that the sonar student cannot hear it. Once the sonar person is informed he must increase the power and turns an imaginary knob then student four can send the ping sound back after a six seconds. The sonar student will inevitably forget to turn the power knob back down, so the next student (student 5) is going to scream ping back after just four seconds to show that the power was now too high for this depth. This is how students get an idea of how sonar tuning works. Finally, the sonar student will collect the last data point.

7. Bring the sonar student back in to the classroom and run the simulation.

8. Have the students calculate the distance between the sonar student and the ocean floor for each data point by giving them a fake speed of sound (2 fathoms/second). Explain to students that sound actually travels much faster, but a fake speed of sound is being used to make the simulation easier to understand.

9. Ask students if they can now chart this data on a map. Guide them to realize that tides still need to be taken into account, because charts are made to show Mean Low or Low Water.

10. Show students a real tidal graph from NOAA (http://tidesandcurrents.noaa.gov/noaatidepredictions/NOAATidesFacade.jsp?Stationid=9457292) and help them use the data to determine the depth of the ocean at each point at Mean Low or Low Water. This will just involves subtracting the tide height at the time of the day the data was collected from the number previously calculated as the distance between the sonar and the ocean floor.

11. Finally, have students chart data on a map by adding each data point to the appropriate longitude and latitude.

12. Explain the limitations (with PowerPoint) of this simulation including a discussion about how the speed of sound underwater varies depending on temperature, pressure, and salinity of the water. Explain that a CTD (Conductivity, Temperature, and Depth Probe) is deployed by scientists that takes this factor into account. Also, explain that over 200 pings are sent continuously as opposed to our one ping that we sent at discrete intervals. Also, explain that the sophisticated sonar technology can take into account the angle at which the sound ping is returning. Further, explain that a piece of equipment called the POS/MV can correct for the rocking of the boat.

13. Have students answer the questions on the handout where they have been collecting their data.

14. To conclude the lesson, have the students think, pair, share the following question. "Considering that only 10% of the seafloor has been mapped and the ocean accounts for 71% of the surface of our planet, what should NOAA consider when deciding where they should map next?"

Extension: Students could be given more data to analyze independently now that they have stepped through the process with teacher guidance.

Assessment and Evaluation:

Students will be assessed both informally and formally. Students participation, discussion and questions in steps 1-4 will serve as an informal assessment of their understanding. Formally, they will be assessed based on their ability to correctly calculate ocean depth, chart data, and answer discussion questions on their handout. If students make an 80% average score on their handout, the lesson will be deemed a success. If they score lower than 80% average, major lessons will need to be reviewed.

Standards:

National Science Education Standard(s) Addressed:

NSES A5. Abilities necessary to do scientific inquiry
NSES E7. Understandings about science and technology
NSES F16. Science and technology in local, national, and global challenges
NSES G5. Science as a human endeavor
NSES G6. Nature of scientific knowledge

Ocean Literacy Principles Addressed:

1A The ocean is the defining physical feature on our planet Earth
1B Ocean basins are composed of the seafloor and all of its geological features
1D Sea level is the average height of the ocean relative to the land
7A The ocean is the largest unexplored place on Earth—less than 5% of it has been explored.
7D New technologies, sensors, and tools are expanding our ability to explore the ocean.

State Science Standard(s) Addressed:

CLE 3210.Inq.1 Recognize that science is a progressive endeavor that reevaluates and extends what is already accepted.
CLE 3210.Inq.3 Use appropriate tools and technology to collect precise and accurate data.
CLE 3210.Inq.4 Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias
CLE 3210.Inq.6 Communicate and defend scientific findings.
CLE 3210.T/E.4 Describe the dynamic interplay among science, technology, and engineering within living, earth-space, and physical systems.

Additional Resources:

http://oceanservice.noaa.gov/navigation/hydro/
http://tidesandcurrents.noaa.gov/
http://www.dosits.org/science/sciencesummary/

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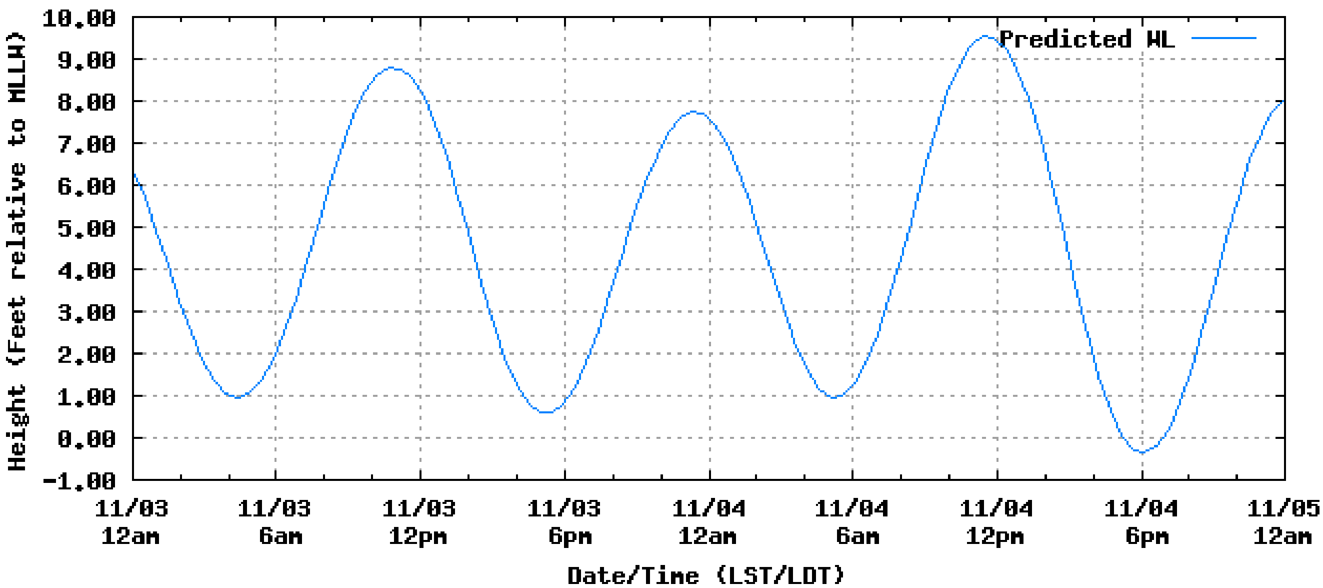
Name ___________________

Mapping the Ocean Floor

Complete the data table below. We are pretending that sound travels at a speed of 2 fathoms/sec although in reality, it travels much faster. We are also assuming the data was collected on 11/03 around 2 pm.

Latitude	Longitude	Amount of Time for Sound to Return in seconds	Distance between the boat and the ocean floor in **fathoms**	Distance between the ocean floor and the water level at MLLW in **feet**



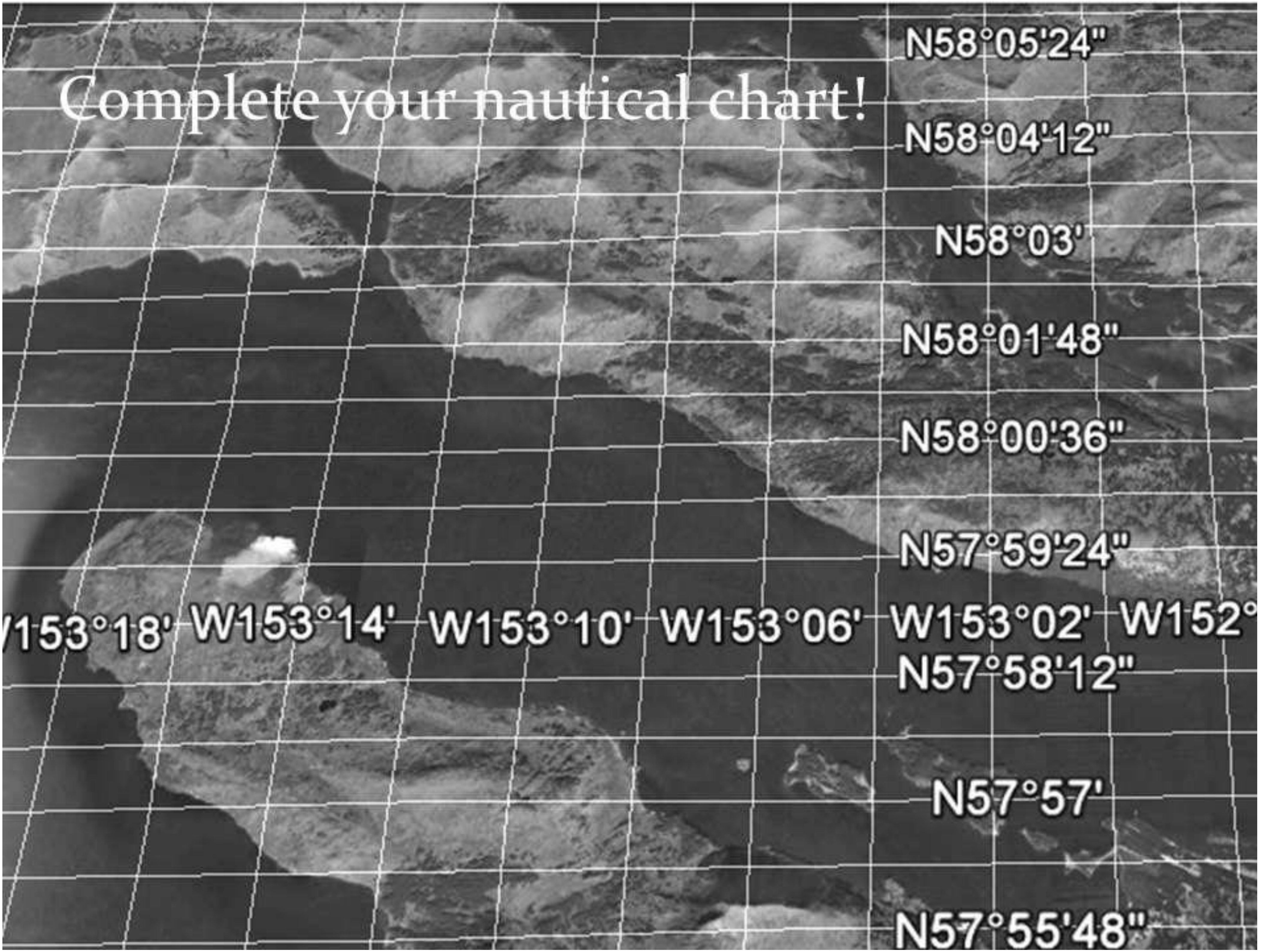
Using the data above and you background knowledge, answer the following questions:

1. Why is mapping the ocean floor important?

2. Explain at least two reasons why our simulation doesn't represent exactly how sonar data is collected in the real world?

3. Why did we have to pretend the speed of sound was much slower than it really is?

4. Mark your data in feet on the chart on the back in the correct locations.


Complete your nautical chart!
N58°05'24"
N58°04'12"
N58°03'
N58°01'48"
N58°00'36"
N57°59'24"
W153°18' W153°14' W153°10' W153°06' W153°02' W152°
N57°58'12"
N57°57'
N57°55'48"

PowerPoint Presentation

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Interphase

1. What does the ocean provide for us? (list as many things as you can)
2. Circle the resources that you would need a boat to obtain.

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- Food (200 billion lbs. a year) – 16% of worlds protein, 36% of these fish are used for food for livestock
- Transportation
- Minerals (salt, sand, gravel, manganese, copper, iron, nickel, and cobalt)
- Oil
- Recreation (Boating, Surfing, Fishing etc.)
- Climate Regulation (Major Carbon Sink, Temperature Moderation)
- Oxygen (90% of worlds oxygen come from Phytoplankton)
- Biodiversity
- Medicine (400x better chance of finding medicine in oceans)
- Water (The clouds form from evaporation of the ocean)
- Jobs

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Today's Agenda

1. Interphase
2. Quick Discussion/Notes
3. Map the Ocean Floor Activity
4. Closing

OBJECTIVE: Students will complete a model chart of the ocean floor given tidal data and sonar data with an average of 80% accuracy .

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How can you end avoid being this guy?

Or Hurting This Guy

Read one of these!

- A fathom is 6 feet!

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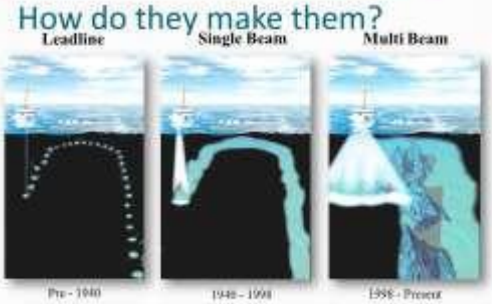
Who makes them?

How do they make them?



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Important Vocabulary

- **Sonar** – a system for the detection of objects under water and for measuring the water's depth by emitting sound pulses and detecting or measuring their return after being reflected
- **Tides** – the alternate rising and falling of the sea, usually twice in each lunar day at a particular place, due to the attraction of the moon and sun.
- **Hydrography**- the science that measures and describes the physical features of bodies of water and the land areas adjacent to those bodies of water.
- **Mean Lower Low Water (MLLW)** - The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch.

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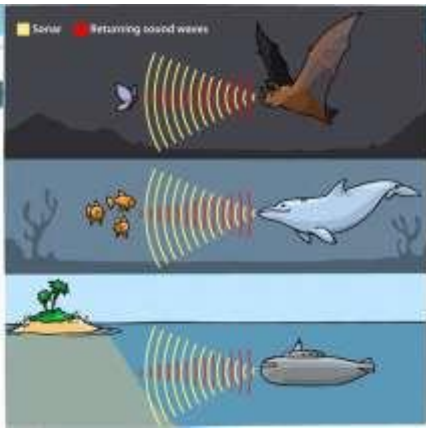

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Sonar Student – Send ping with back turned to the class. Record the time that the ping comes back to you. Continue until you complete the line.

Ocean Floor Students – send ping back at appropriate time.

Collect Data for the following spots

1. N 58 00'36 W 153 18' –
2. N 58 00'36 W 153 16' –
3. N 58 00'36 W 153 14' -
4. N 58 00'36 W 153 12' –
5. N 58 00'36 W 153 10' –
6. N 58 00'36 W 153 08' –

Pretend that sound is traveling at the speed of 2 fathoms a second.

- Calculate the distance between the boat and the ocean floor.

Is it ready to be charted yet?

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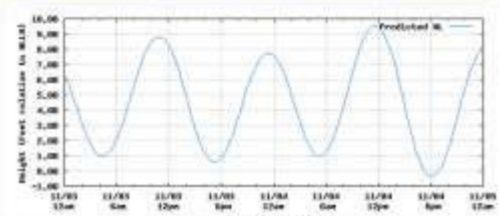
When mapping the ocean floor, you must take into account the tides!



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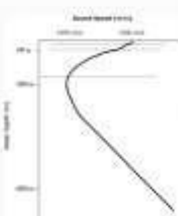
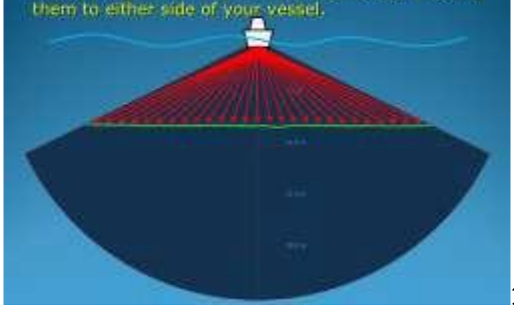
Limitations of our model

- Sound travels so fast, we had to slow it down for our activity. The speed of sounds varies according to temperature, salinity, and depth but can be in the ballpark of a whole mile in a second.
- **The speed of sound in water increases with increasing water temperature, increasing salinity and increasing pressure (depth).**



Limitations to our model continued!

- Rather than sending a single pulse of energy straight down; imagine forming multiple beams and directing them to either side of your vessel.



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Limitations of our model continued!

- Multibeam sonar sends out more 200 pings at a time and can also interpret the angle the that the ping returns and the sonar is sending out these signals continuously.

Did you know?

- The rocking of the boat can effect the data, so all of the boats have a machine POS/MV that measures the rocking and corrects for the rocking.

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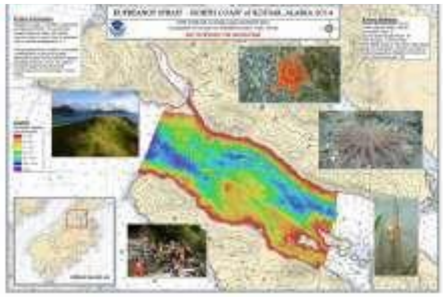

Closing
What should NOAA consider when deciding where to map next?

- *71% of the Earth surface is covered with water, yet only about 10% of the seafloor has been surveyed by echo sounders at a resolution of 1 minute or better.* –IHO, 2012

- Think, Pair, Share

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Teacher Notes

STUDENT 1 **N 58 00'36 W 153 18'** Wait three seconds after the ping to ping back	**STUDENT 2** **N 58 00'36 W 153 16'** Wait one seconds after the ping to ping back	**STUDENT 3** **N 58 00'36 W 153 14'** Wait three seconds after the ping to ping back
STUDENT 4 **N 58 00'36 W 153 12'** Wait six seconds then whisper ping After sonar power is adjusted, send ping back after 6 second at a normal volume	**STUDENT 5** **N 58 00'36 W 153 10'** Wait four seconds after the ping then YELL ping back.	**STUDENT 6** **N 58 00'36 W 153 08'** Wait two seconds after the ping to ping back.