Sea Ice and Deep Sea Currents

Overview

This lesson is intended to help students make connections to polar science while discovering how and why sea ice drives deep ocean currents. Students will also learn key terminology related to sea ice and using actual salinity content charts, will graph a typical sea ice core's salinity as it relates to depth.

Objectives

- Students will be able to identify and describe layers of sea ice.
- Students will be able to explain how and why the sea ice changes in salinity and how melting and freezing of sea ice drives deep thermohaline currents.

Lesson Preparation

- Preparation time is minimal and involves printing out and photocopying various worksheets and downloading videos and pictures and becoming familiar with the information.
- The teacher should also download ice core data from the Lesson Materials for this lesson plan.
- Also included in the Lesson Materials are videos of ice coring, background information on sea ice and worksheets.
- Teachers should also print out the student guides/worksheets.
- Photos from the field are included in the Resources section

Procedure

- Students should have a basic familiarity with ocean currents prior to this lesson. Introduce students to ice coring. A video of ice coring in the field is located in

Details

Lesson
Antarctic
About 1 period
Download, Share, and Remix
High school and Up

Materials

Video of Ice Coring
Basic Background Information (in Lesson Materials)
Worksheet 1 - Ice profile with labels (in Lesson Materials)
Worksheet 2 - Ice profile no labels (in Lesson Materials)
Worksheet 3 - Student question sheet (in Lesson Materials)
Ice Core Data Set (in Lesson Materials)

Standards

Wisconsin Academic Standards for Science

ELS.C1.B.h Analyze relationships between parts of local and global natural and the resources section of this plan and can be downloaded for multiple viewings and may be a good intro.

- Discuss with students the various layers of ice one might encounter on a frozen sea. Have them draw a profile or print and photocopy the blank profile worksheet from the resources section and have them fill in the various layers.
- Have students predict what they think the salinity levels might be in a typical sea ice core and if the saline/brine content within a core is uniform from top to bottom. Students may struggle with prediction unless they understand that seawater is generally 3.5% or 35 parts per thousand (PPT), (35 grams salt per 1000 liters). Have the students write their predictions on the worksheet or on their diagram and have them justify their predictions.
- Provide students with a copy of the ice core data from the documents section. Have them graph the data. Discuss which variable would be independent and thus on the x-axis (depth of ice core) and which would be dependent and on the y-axis (saline content). Have students go back to their original predictions and determine if their predictions were accurate or not. Have them write in the correct salinity values.
- Have students complete the remaining questions on the worksheet by going on-line to the sites indicated on the worksheet. When complete, have students discuss in groups or as a class the implications of changing salinity in sea ice and how this creates movement (circulation) within the ocean.

Extension

The PIPERS project http://geotracerkitchen.org/pipers/ boasts additional information on sea ice production in the Ross Sea. Should students find interest in the topic, they may want to consider diving into the current research and in particular, the anomaly of why sea ice in the Ross Sea is growing/accumulating as opposed to melting as it seems to be elsewhere in the polar regions.

Resources

cultural systems.

ELS.EX2.A.h Identify and analyze limitations in our understanding of systems and the outcomes.

ELS.EX4.A.h Apply the laws of conservation of mass and energy to analyze cycles and flows of Earth’s systems, including: the cycling of matter and flow of energy among the biotic and abiotic components in the biosphere, atmosphere, geosphere, and hydrosphere; the transfer and loss of energy and mass at each link in an ecosystem; and the roles of photosynthesis, cellular respiration, and carbon sequestration in the global carbon cycle.

ELS.EX5.B.h Evaluate how feedback loops impact natural systems over time and predict adaptive strategies.

ELS.EN6.A.h Analyze the role of feedback loops in reinforcing the interconnectedness of parts within a system and the consequences of actions by each of those parts on the whole. Identify and analyze leverage points and cause and effect relationships within a system.

Site for the expedition to the Ross Sea, Antarctica (can be reached at: polartrec2017.com): https://www.polartrec.com/expeditions/seasonal-sea-ice-production-in-the...

Information sites:
https://nsidc.org/cryosphere/seaice/index.html
http://www.pik-potsdam.de/~stefan/thc_fact_sheet.html
https://oceanservice.noaa.gov/education/tutorial_currents/05conveyor1.html

Ice Core from the Ross Sea

Removing the snow portion of the freeboard on the Ross Sea in preparation for ice coring

Ice core drilling on the Ross Sea, Antarctica

Sawing ice cores in the field

Assessment

- Students will be assessed on their completed worksheets and graph.
- Aspects of this lesson could be incorporated into summative assessments on ocean circulation.

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Ross Sea Ice Data

Site #4 Core #1

Depth (cm)	Salinity (ppt)
Top	6.8
10	6.2
20	6.9
30	7.4
40	6.9
50	5.3
60	5.5
70	5.3
80	4.7
90	4.9
100	4.9
110	5.6
120	5.6
130	5.5
140	5.3
150	4.8
160	4.7
170	4.7
180	4.1
190	4.6
200	4.8
210	4.9
220	4.6
230	4.9
Bottom	6.8

Site #4 Core #2

Depth (cm)	Salinity (ppt)
30	7.5
60	7.5
90	5.9
120	5.4
150	5.4
180	4.9
210	5.1
Bottom	7.3

Site #7 Core #1

Depth (cm)	Salinity (ppt)
10	7.0
20	6.1
30	6.3
40	5.8
50	5.0
60	5.4
70	5.0
80	5.5
90	5.2
100	5.6
110	5.4
120	5.1
130	5.7
140	5.0
150	5.2
160	4.9
170	4.9
180	5.0
190	6.8

Site #2 Core #1

Depth (cm)	Salinity (ppt)
10	4.2
20	4.9
30	5.8
40	5.1
50	5.1
60	4.6
70	4.2
80	3.8
90	4.1
100	4.0
110	3.9
120	4.2
130	3.9
140	4.0
150	3.6
160	3.2
170	3.5
180	3.5
190	3.8
200	6.3

Site #23 Core #3

Depth (cm)	Salinity (ppt)
10	9.7
20	7.8
30	6.5
40	5.8
50	5.4
60	4.9
70	5.4
80	4.7
90	4.8
100	5.6
110	5.5
120	4.5
130	5.1
140	4.2
150	4.6
160	4.5
170	4.1
180	4.3
190	4.5
200	4.5
210	3.9
220	5.7

Site #23 Core #1

Depth (cm)	Salinity (ppt)
10	6.4
20	5.8
30	6.2
40	4.5
50	3.9
60	3.7
70	4.0
80	3.3
90	4.5
100	4.0
110	3.8
120	3.7
130	4.3
140	3.0
150	4.1
160	3.8
170	4.6
180	3.7
190	4.3
200	3.9
210	5.2

Site #22 Core #1

Depth (cm)	Salinity (ppt)
10	6.5
20	6.0
30	6.3
40	6.7
50	5.5
60	5.1
70	5.0
80	5.2
90	5.5
100	5.4
110	5.5
120	5.3
130	5.5
140	6.0
150	5.5
160	4.6
170	4.7
180	5.3
190	6.5
200	4.7
210	4.9
220	4.8
230	4.8
Bottom	6.7

Temperature of Cores

SITE 2 3/11/17

Depth (cm)	Temp (C°)
10	-10.3
20	-9.7
30	-9.4
40	-9.1
50	-8.8
60	-8.6
70	-8
80	CUT
90	-7.5/BREAK
100	-7.5
110	BREAK
120	-5.2
130	-5
140	-4.6
150	-4.3
160	-3.9
170	BREAK
180	-3.3
190	-2.7 and -2.8
200	-2.2

SITE 5 11/11/17

Length (cm)	Temp (C°)
10	-10.5
20	-10.2
30	-9.8
40	-9.3
50	-9.1
60	-8.6
70	-8.3
80	-8.1
90	-7.9
100	No measurement
110	-7.1
120	-6.7
130	No measurement
140	-6.4
150	-5.6
160	-5.1
170	-5.0
180	-4.3
190	-3.6
200	-3
210	-2.6
220	LONG

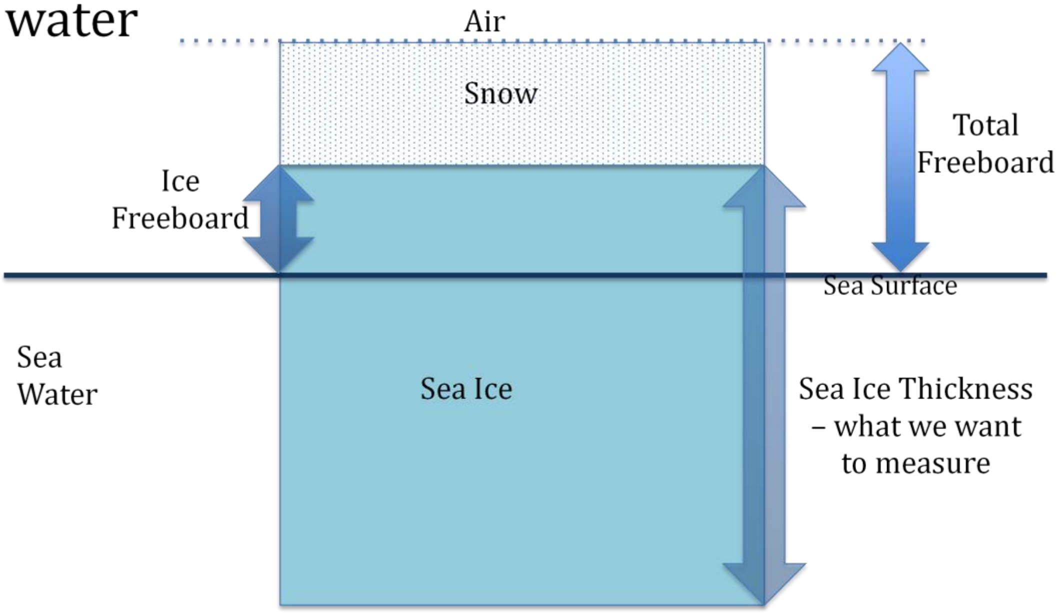
Background Information

Salt plays a vital role in ocean circulation (thermohaline). In polar areas, salinity differences affect ocean density more than changes in temperature. As sea ice forms, salt is pushed out or ejected and enters the surrounding water. This increases the salinity of the surrounding water. Salt water is more dense (heavier) and sinks towards the bottom of the ocean. This in turn causes upwelling as cold, dense water sinks and drives warmer, less dense water upward carrying with it nutrients.

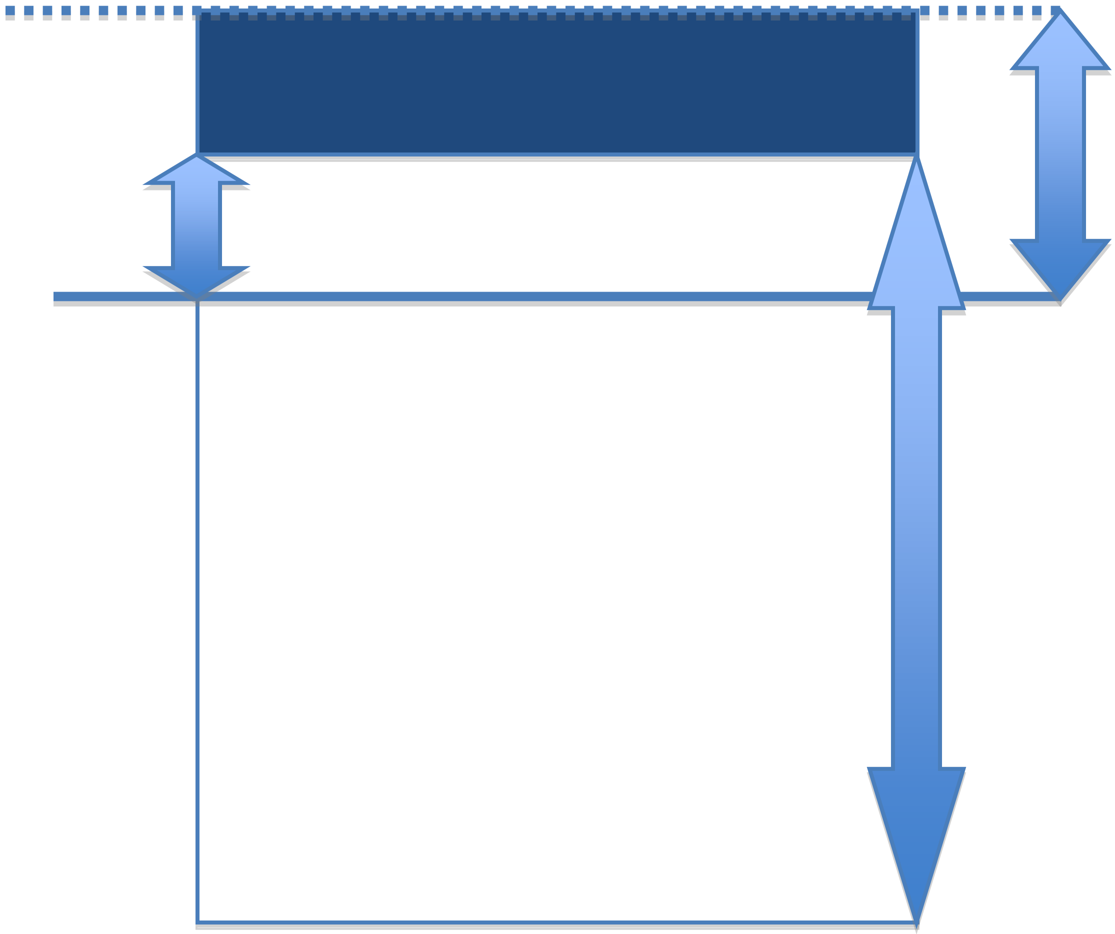
Salinity is measured in parts per thousand (ppt) or in practical salinity units (psu). Values reported in ppt or psu are nearly identical. Average ocean salinity is measured around 35 ppt. For every 5 ppt increase in salinity, the freezing point of water decreases by 0.28 C˚. So, in the ocean, when salinity is 35ppt, the freezing point drops to -1.8 C˚.

Measuring the Ice

Freeboard – section of ice and snow above water



Measuring Sea Ice



Sea Ice and Thermohaline Circulation

Visit the following websites and answer the questions that follow:

https://oceanservice.noaa.gov/education/tutorial_currents/05conveyor1.html

http://www.pik-potsdam.de/~stefan/thc_fact_sheet.html

https://nsidc.org/cryosphere/seaice/index.html

Questions:

1. What is the general salinity of the ocean water in parts per thousand (ppt)?
   a. 35ppt b. 3.5 ppt c. 350 ppt d. 0.35ppt

2. Does sea ice contain more or less salt than the water surrounding it?
   More Less

3. At what temperature does sea water freeze?
   a. 0°C b. 32° C c. 0.28° C d. -1.8° C

4. Which has a more substantial effect in driving ocean circulations in polar regions?
   a. changing salinity
   b. changing temperature
   c. changing seasons
   d. sea life

5. Define thermohaline circulation:
   ____
   ____
   ____
   ____

6. What is upwelling?
   ____
   ____
   ____
   ____

7. How does the freezing of ocean water in polar regions contribute to deep ocean circulation?

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____
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8. How does melting of polar sea ice disturb ocean currents?

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9. What effect might a warming climate have on polar regions and consequently on ocean circulation? How might this affect humans?

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____
____
____

10. When salt accumulates into droplets of meltwater, it is most commonly referred to as

    a. ocean water   b. brine   c. saline solution   d. frazil

What questions do you have about sea ice or the effects of melting of sea ice in ecosystems?

Where might you find answers to these questions?