TEACHERS AND RESEARCHERS EXPLORING AND COLLABORATING

PolarTREC Lesson Resource

What's Your Proof?

Denise Hardoy

Antarctic Fish Development Under Future Ocean Conditions

PolarTREC Expedition Page
https://www.polartrec.com/expeditions/antarctic-fish-development-under-future-ocean-conditions

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Overview

Antarctic ecosystems are undergoing change at unprecedented levels. In this lesson, students will use real data to evaluate the effect of climate change on Antarctic fish. Denise Hardoy created this lesson plan after joining Dr. Anne Todgham's team studying Antarctic Fish Development Under Future Ocean Conditions in October/November of 2019.

Objectives

- Given data sets, graphs, videos, and articles, students will develop a claim, support it with evidence, and explain their reasoning in a well-developed paragraph.
- Students will evaluate climate change impacts on the fish of Antarctica.

Lesson Preparation

- Prior to the start of this lesson, students should have a basic understanding of climate change.
- Teacher should provide a digital or printed copy of the graphic organizer.
- Students should be sent a copy or given access to the slide presentation.
- Students should have access to the internet.
- This lesson could be conducted in person, or during an online video class.

Procedure

Engage

- Display the CO2 graph for students. Fill in the I Notice/I wonder/This reminds me of… graphic organizer. This can be done for the whole class, in partners, or in a think-pair-share system.
- Guide students to develop one driving question for the class - Can animals adapt to our changing climate?

Explore

- Using the slide presentation, students build background knowledge by reading about the Ross Sea ecosystem of Antarctica, temperature and carbon dioxide, energy budgets and fish species of McMurdo Sound, Antarctica.
- Students will watch a video of a polar scientist explain her research.

Resource Details

Date

26 April 2021

Region

Arctic

Antarctic

Completion Time

About a week

Grade

Middle School and Up

Permission

Download, Share, and Remix

Location

McMurdo Station, Antarctica

Expeditions

Antarctic Fish Development Under Future Ocean Conditions

Author(s)

Denise Hardoy

Related Members

Denise Hardoy

Anne Todgham

Materials

Printouts of Lesson Materials

Video attached to lesson

Topic

- Then students analyze a graph of fish survival rates under future ocean conditions.
- Lastly, they will collect their own data by watching videos of fish under different conditions. This could also be done as a carousel activity with each group of students assigned to become an expert on that piece of evidence, then share their expertise.

Tools and Methods

Organisms and Their Environments

Oceanography

Regulation and Behavior

Climate Change

Formative assessment opportunity
* Students document evidence on notes - use included graphic organizer (in Materials).
* Set up a gallery walk displaying notes. Students can add sticky notes to offer ideas and suggestions. Students should be given time to incorporate ideas. This could also be done digitally using any online collaboration board, such as Jamboard or Padlet.
* The teacher should check for understanding of each piece of information.

Explain

- Rubric is handed out and reviewed whole class.
- Students develop a claim (or choose one if they need scaffolding)
- Students list their evidence that supports their claim and explain how that evidence supports the claim using the graphic organizer.
- Final paragraphs could be typed as well.

Elaborate

Students could be given time to conduct additional online research if time allows. Online articles and websites can be referenced to narrow their search. This would also be an opportunity to review how to cite sources.

Evaluate

Students first evaluate their own work using the given rubric. They then trade paragraphs and give each other feedback. Students are given time to incorporate peer suggestions before the final product is turned in.

Transferability

Developing the ability to think critically and communicate effectively is an essential skill for all learners. Students can use Claim/Evidence/Reasoning in all subjects when asked to provide evidence to support their answers.

Author/Credits

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Name__________________

Date___________

Period__________

Prove it!

1. After observing the Carbon Dioxide graph…
   I notice ____
   ____
   ____
   I wonder ____
   ____
   ____
   ____
   This reminds me of ____
   ____
   ____
   ____
2. Driving Question:
   ____
   ____
   ____
3. Now open the slide deck. Take notes on each piece of evidence that you evaluate.
   a. Antarctica facts
      ____
      ____
      ____
      ____
   b. Underwater Environment in Antarctica
      ____
      ____

c. CO2 Graph

d. Carbon Dioxide and temperature website

e. Meet the Fish

f. Energy budgets explained

g. Dr. Todgham research set up:

h. Graph or survival rates:
What do you notice?
Patterns and trends?

i.

Trial(video) Number	Condition-	Heart Rate (Beats per minute)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

j.

4. State your claim(Your answer to the driving question)

5. Organize your evidence-
    a. ____
    b. ____
    c. ____
    d. ____
    e. ____

6. Combine your Claim, Evidence and add your reasoning(explanation) in one organized paragraph.

Claim, Evidence, Reasoning Paragraph Rubric

		0	1	2
Conclusion *Scientific Explanation*	**Claim** *Statement or conclusion that answers the original question/problem*	Does not make a claim, or makes an inaccurate claim	Makes an accurate but vague or incomplete claim	Makes an accurate and complete claim
		0	**1**	**2**
	Evidence *Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.*	Does not provide evidence, or only provides inappropriate evidence (evidence that does not support the claim)	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence.	Provides appropriate and sufficient evidence to support claim.
		0	**2**	**4**
	Reasoning *Justification that links the claim and evidence and includes appropriate and sufficient scientific principles to defend the claim and evidence*	Does not provide reasoning, or only provides reasoning that does not link evidence to claim.	Repeats evidence and links it to some scientific principles, but not sufficient.	Provides accurate and complete reasoning that links evidence to claim. Includes appropriate and sufficient scientific principles.

From ChemEd XChange: https://www.chemedx.org/article/implementing-claim-evidence-reasoning-framework-chemistry-classroom

What's Your Proof?

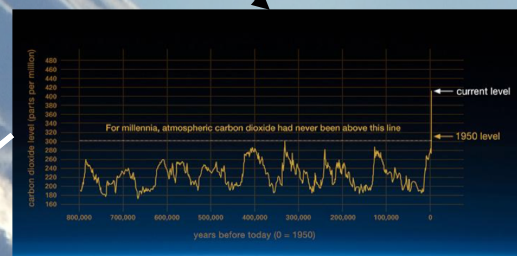
The Fate of Antarctic Fishes

Click on each link to learn more

Antarctica Fun Facts

The Underwater Environment in the Ross Sea

You count: Collect your own data



Your Work: Claim Evidence Reasoning

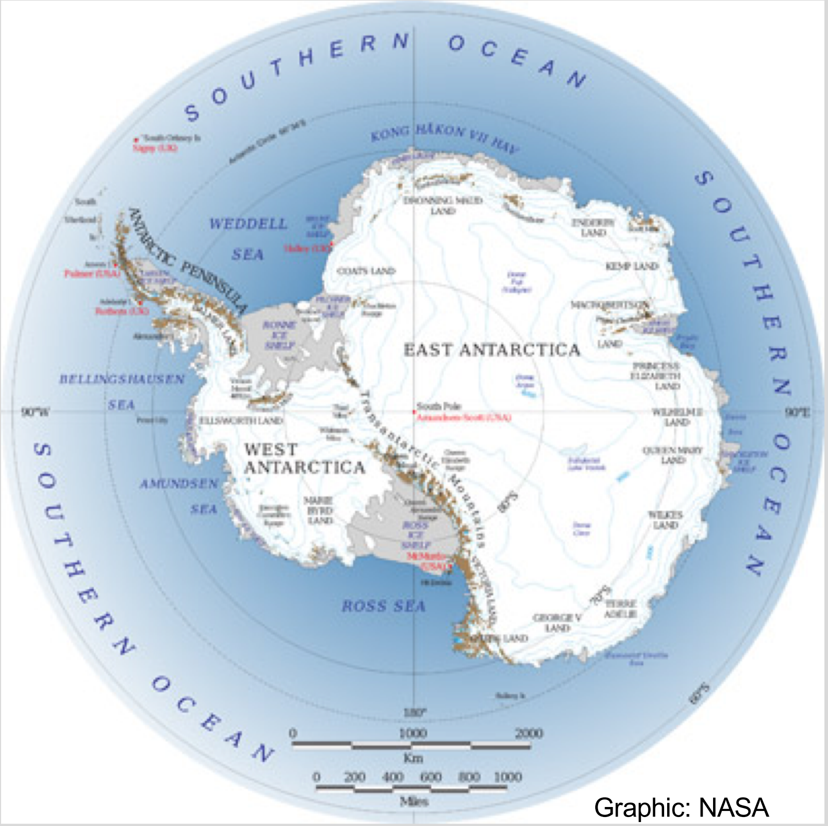
Link to Graphic organizer

Results: Respiration under stress

Results: Survival Data

Article on relationship of CO2 to Temperature

Learn about energy budgets



Graphic: NASA

Antarctica Fun Facts

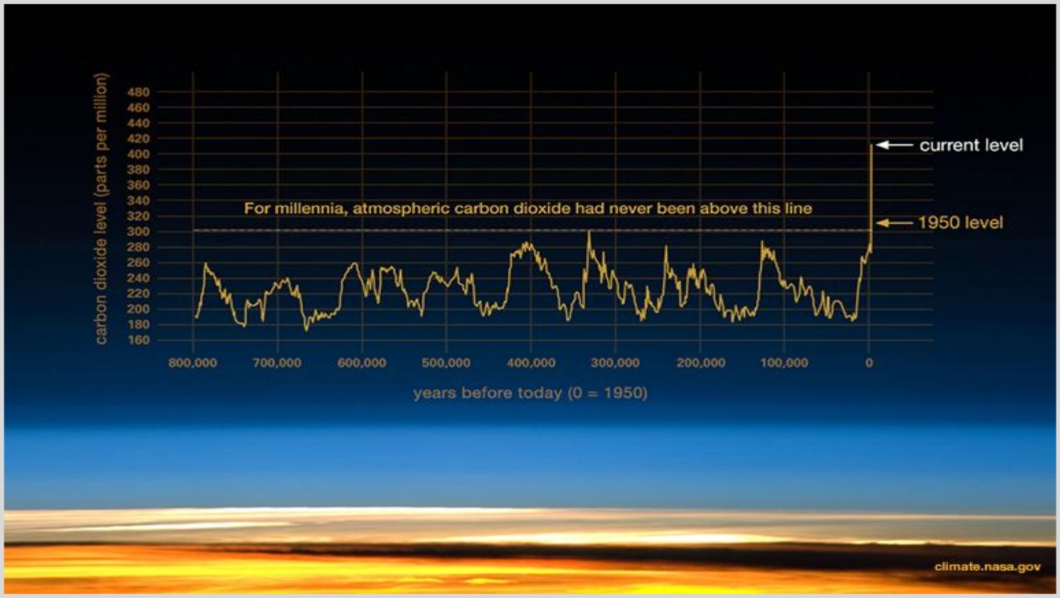
- Antarctica is located at the bottom of the Earth.
- It s a frozen continent surrounded by the Southern Ocean
- It is 1 ½ times the size of the United States
- It is the coldest(-128.6F), driest, emptiest, highest place on Earth
- If all of Antarctica's ice melted, global sea levels would rise by 230 feet.
- A treaty protects it from being claimed by any nation. It is to be used only for science.

Mt Erebus
Photo Credit: Amy Osborne

The Ross Sea's Underwater Habitat

While above the surface, Antarctica is one of the harshest climates on Earth. Only a handful or organisms call this continent at the bottom of the world home. However, under the frozen sea ice, the ocean creatures thrive in both abundance and diversity. Remarkably, their cold, undersea environment with an average water temperature of 28.65 Degrees F has not changed in millions of years. Until now. Climate change is reaching into selective areas around the continent. Changes observed include both an increase in temperature and a decrease in pH(Acidification). These changes are predicted to only accelerate in the coming years.

Carbon Dioxide levels from 600,000 years ago to the present



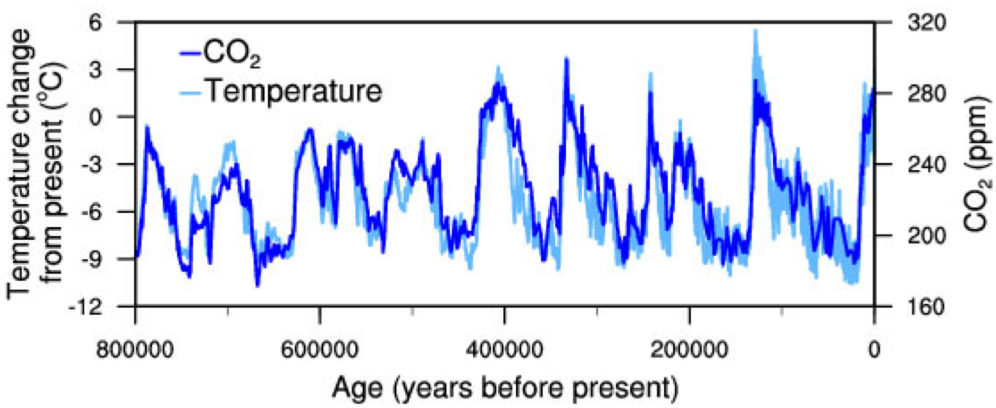
Data from the Vostok Ice Core Petit, J. R. et al. (1999) Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica. Nature 399, 429-436.

This graph shows carbon dioxide levels taken from ice core samples. The samples were part of a project called the Vostok Ice Core. A core of ice was drilled out of Antarctic ice pack. The layers of the sample were dated using gas bubbles that were trapped in the ice. They were analysed for carbon dioxide content. The results of this project are displayed above. This graph clearly illustrates the unprecedented increase in carbon dioxide levels that began in the 1900's. It is projected that this increase will continue, or even worsen, if humans take no action.

Increased levels of carbon dioxide in our atmosphere and oceans cause multiple problems. The most obvious is its role as a greenhouse gas causing a rise in average global temperature.. Another problem happens when the carbon dioxide dissolves in the ocean water. It combines with the water to form carbonic acid. This chemical reaction results in a decrease in pH of the water- making it more acidic. This causes problems with organisms with some types of shells- causing them to dissolve. However, the decrease in pH is also a stress factor for all species, including fish.

NOAA: Temperature Change and Carbon Dioxide Change

One of the most remarkable aspects of the paleoclimate record is the strong correspondence between temperature and the concentration of carbon dioxide in the atmosphere observed during the glacial cycles of the past several hundred thousand years. When the carbon dioxide concentration goes up, temperature goes up. When the carbon dioxide concentration goes down, temperature goes down. A small part of the correspondence is due to the relationship between temperature and the solubility of carbon dioxide in the surface ocean, but the majority of the correspondence is consistent with a feedback between carbon dioxide and climate. These changes are expected if Earth is in radiative balance, and they are consistent with the role of greenhouse gases in climate change. While it might seem simple to determine cause and effect between carbon dioxide and climate from which change occurs first, or from some other means, the determination of cause and effect remains exceedingly difficult. Furthermore, other changes are involved in the glacial climate, including altered vegetation, land surface characteristics, and ice sheet extent



Graph of temperature change and carbon dioxide change measured from the EPICA Dome C ice core in Antarctica Temperature change (light blue) and carbon dioxide change (dark blue) measured from the EPICA Dome C ice core in Antarctica (Jouzel et al. 2007; Lüthi et al. 2008).

Other paleoclimate proxies help us understand the role of the oceans in past and future climate change. The ocean contains 60 times more carbon than the atmosphere, and as expected, the changes in carbon dioxide in the atmosphere were paralleled by changes in carbon in the ocean over the past several hundred thousand years. While the ocean changes much more slowly than the atmosphere, the ocean played an essential role in past variations in carbon dioxide, and it will play a role in the future over thousands of years. Finally, paleoclimate data reveal that climate change is not just about temperature. As carbon dioxide has changed in the past, many other aspects of climate changed too. During glacial times, snow lines were lower, continents were drier, and the tropical monsoons were weaker. Some of these changes may be independent; others tightly coupled to the changing level of carbon dioxide. Understanding which of these changes might occur in the future, and how large those changes might be, remains a topic of vigorous research. NOAA's Paleoclimatology Program helps scientists document the changes that have occurred in the past as one approach to understanding future climate change

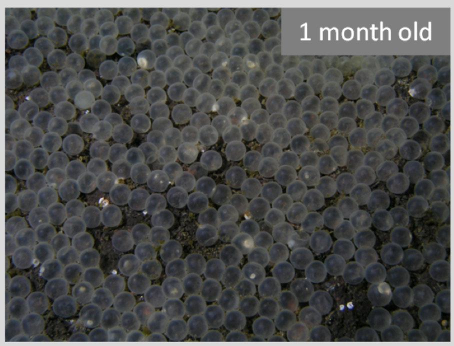
.https://www.ncdc.noaa.gov/global-warming/temperature-change#:~:text=When%20the%20carbon%20dioxide%20concentration,goes%20down%2C%20temperature%20goes%20down.

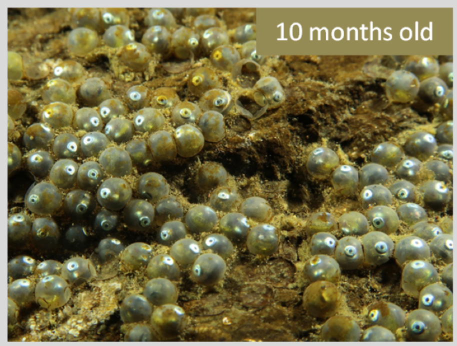
Meet the Fishes!

Many species of fish call the Southern Ocean home. Among the species in the shallower waters of McMurdo Sound are members of several genuses- including Dragonfish and Cod icefish. They occupy different niches that make up this amazing ecosystem. Some are cryo pelagic and prefer to hide and forage under the sea ice. Others are more benthic, choosing to spend their time mostly on the seafloor. They are all well adapted to the very cold, stable environment where they live. Most have a special protein in their tissues that prevents ice crystals from forming- so they don't freeze.The average water temperature is 28.65 degrees F and does not change much throughout the year. These small fish species are generally slow growing and long lived. They play an important role in the marine Antarctic food web. They eat almost anything smaller than themselves, including other fish, krill, all types of larva, and even algae. Bigger fish, penguins and Weddell seals are their predators. Some of the more abundant species around Ross Island, Antarctica that have been studied are:

Naked Dragonfish- Gymnodraco acuticeps

Learn more at: https://animalia-life.com/fishes/naked-dragonfish.html

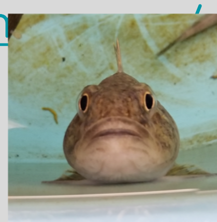


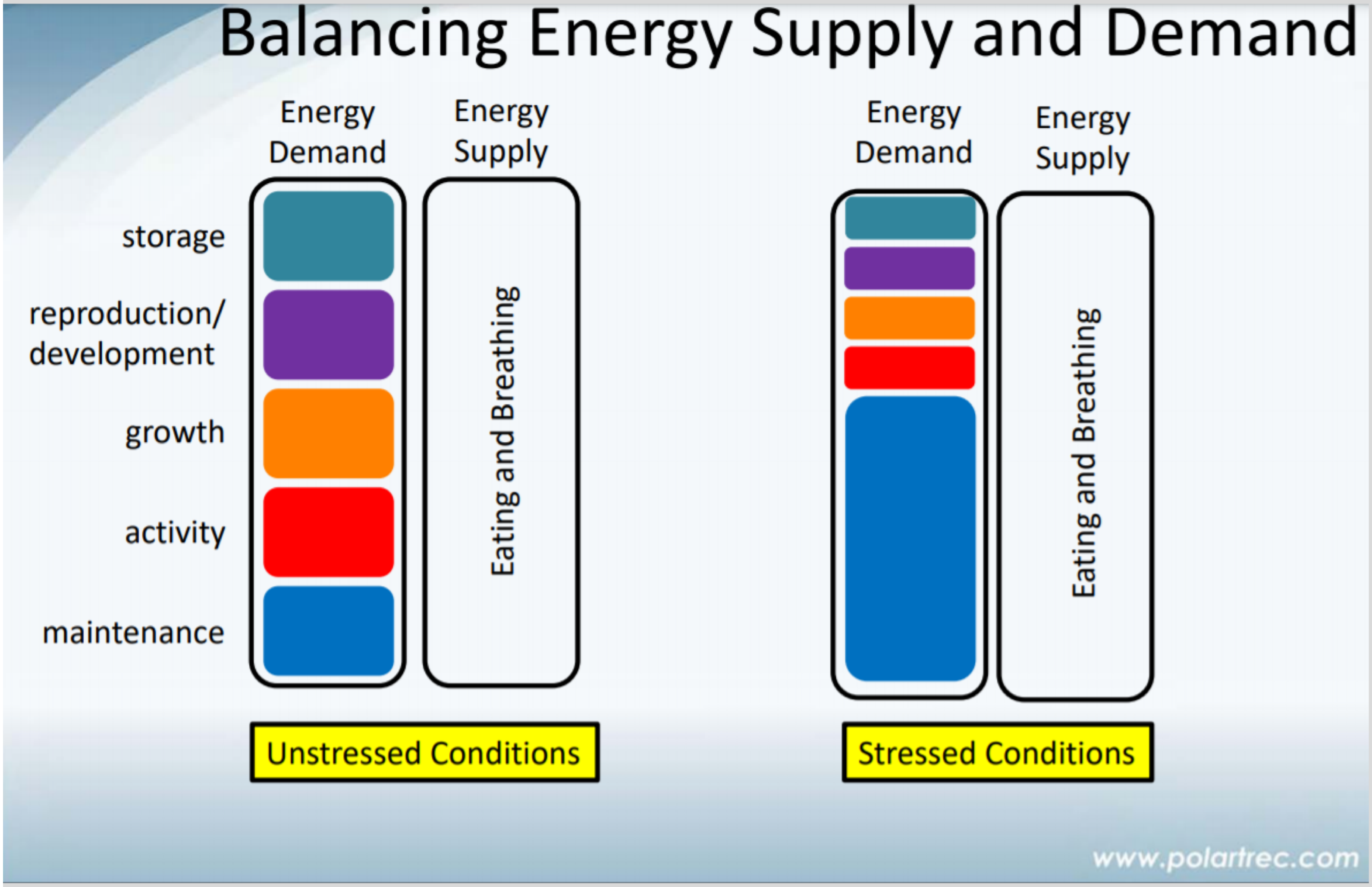


Cod Icefish- genus Trematomus

Species studied include: borchgrevinki, pennellii, nicolai, newnesi, bernacchi

Learn more at:
https://ww gen /nsf/fguide/chordata--fish.pdf



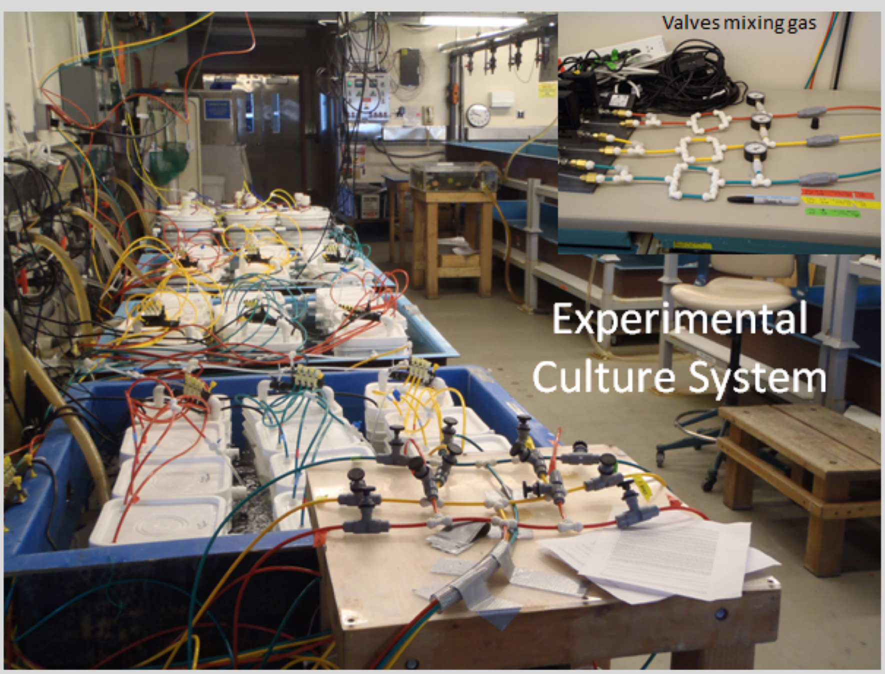


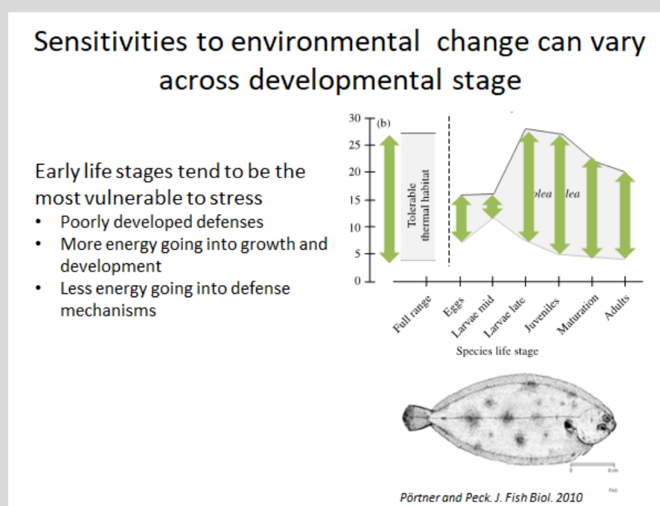
The amount of energy organisms have available is limited by the amount of food they can eat, as well as the amount of oxygen they take in. They divide up this energy in order to meet all of their requirements. This is called their energy budget. This graphic shows energy use both under normal and stressed conditions. As you can see, when organisms are under stress, they require more energy for maintenance. This leaves less energy available to perform other life functions, such as growing and reproducing. How they use this limited remaining energy could mean the difference between successful adaptation to changing environmental conditions, or extinction of their species.

Audio file to explain

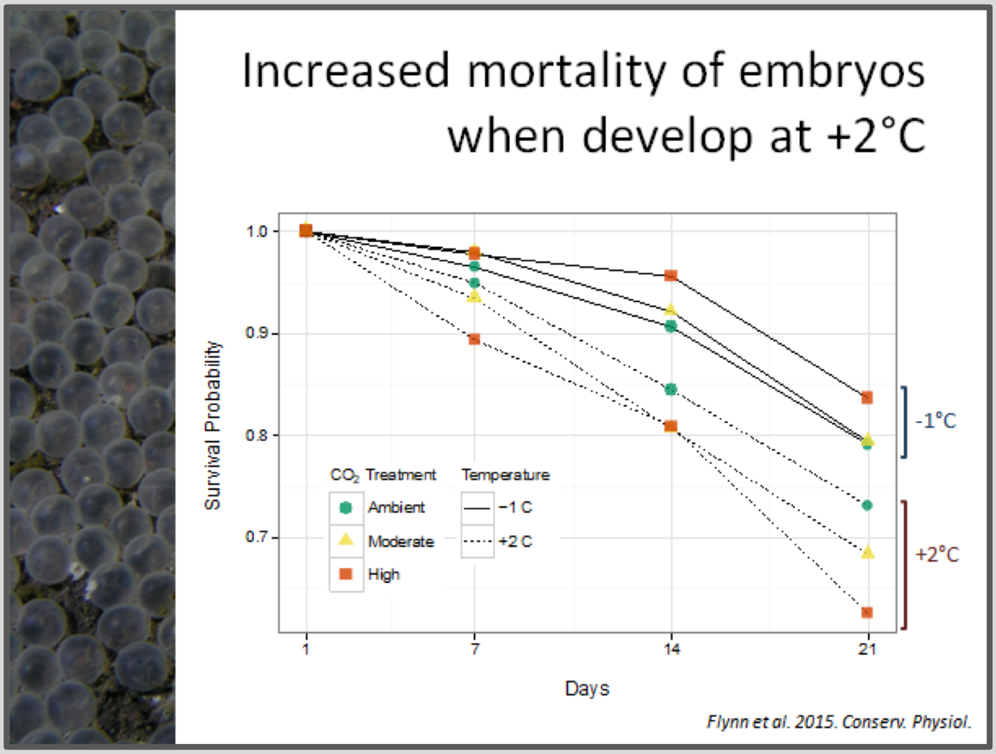
Research scientist, Dr. Anne Todgham, explains her work in Antarctica.- (See video)

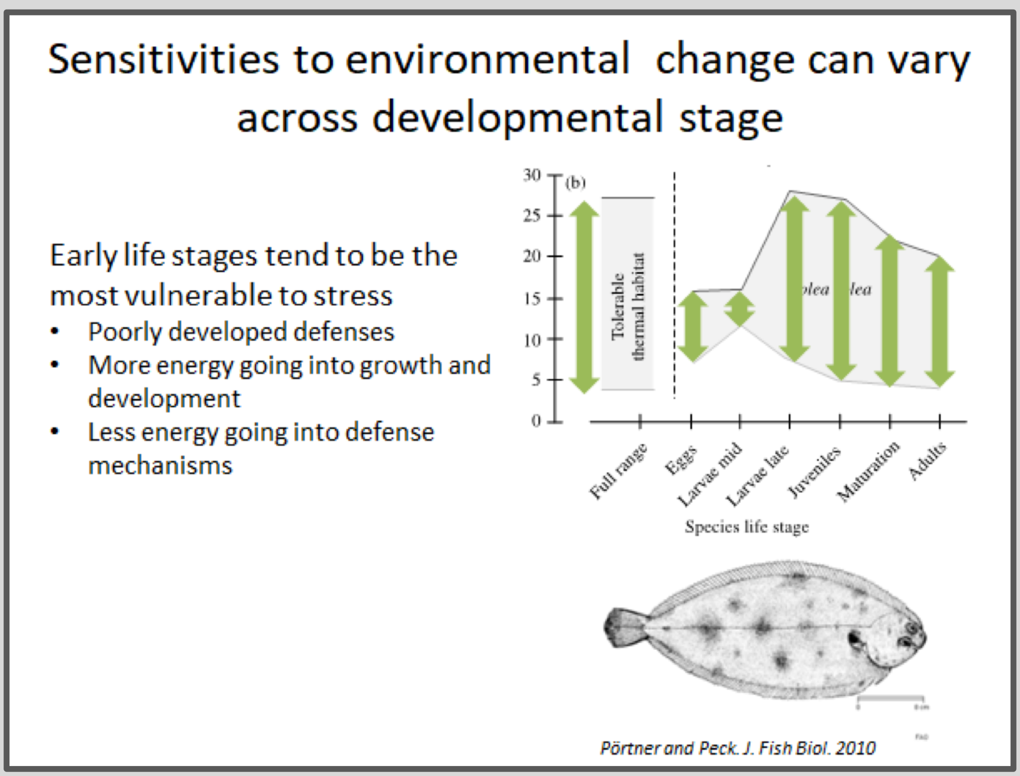
Dr. Todgham is a research scientists and instructor at UC Davis in California. She is an environmental physiologist who is interested in how animals cope with environmental change.



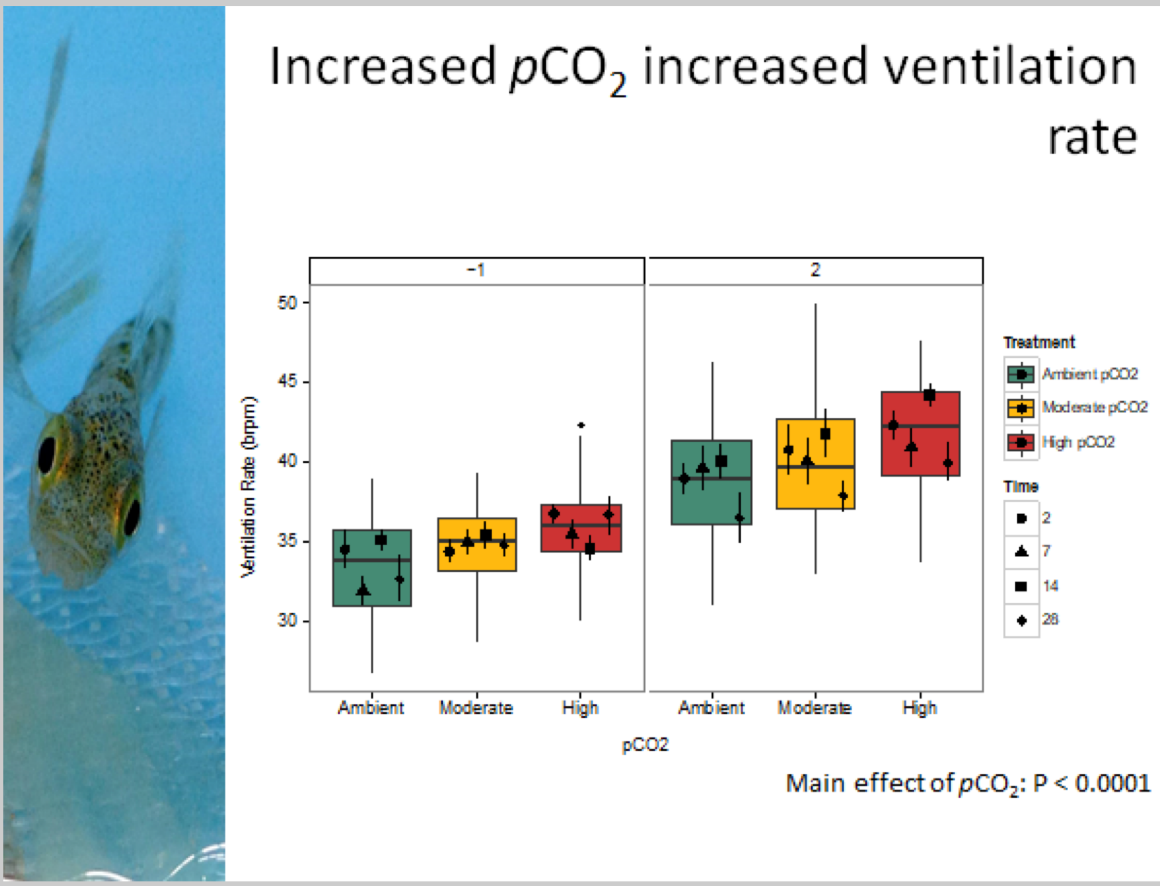


Results:
Survival probability with increased temperatures and carbon dioxide levels





Respiration Rates(ventilation) with increasing Carbon Dioxide Levels



Students Collecting data- Video Analysis

Each video runs for one minute. You can count either the heartbeats, or the respiration rates.

Option 1- count for the entire 60 seconds

Option 2- count for ten seconds, and multiply your number by 6.

Then record as beats/respirations per minute.

The first three videos are for fish held at their normal -1 celsius. In the last three videos, the fish were held at +2 celsius(an increase from their normal water temperature of 3 degrees).