Relevance of Climate Change for the Arctic Marine Biological System

Presented by: Dr. Rolf Gradinger

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Relevance of Climate Change for the Arctic Marine Biological System

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Introduction

Data and pictures from
Shelf Basin Interaction Studies 2002, 2004
NOAA Ocean Exploration 2005
Various Barrow fast ice trips
Images by Raskoff, Bluhm, Hopcroft,
Poll Question

What do you consider the top arctic issue related to global warming?
A) Loss of Polar Bear Habitat
B) Loss of ice cover
C) Influence on the arctic food web
D) All of the above are equally important
What do you consider the top arctic issue related to global warming?
A) Loss of Polar Bear Habitat
B) Loss of ice cover
C) Influence on the arctic food web
D) All of the above are equally important
Personally, how well informed do you feel you are about the different consequences of global warming?

[Place clip art on the continuum below]

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very well informed</td>
</tr>
<tr>
<td>Fairly well informed</td>
</tr>
<tr>
<td>Not very well informed</td>
</tr>
<tr>
<td>Not at all informed</td>
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</tbody>
</table>
Arctic Realms

Sea ice
Pelagic
Benthic
Nekton
The microscopic life in sea ice

Sea ice realm:
Very little biological information
Difficult to sample
Corers, divers, surface melt ponds
The microscopic life inside ice

• For the Arctic:
  • Bacteria (Archaea, Proteobacteria etc. ?? species)
  • > 200 diatoms
  • > 200 flagellates
  • > 30 metazoans
  • Allochthonous fauna
Under-ice fauna: at least 5 species

http://www.youtube.com/watch?v=CriR2B_QbPc
Arctic cod (*Boreogadus saida*): link to seals and birds
Let's Pause for Two Questions from the Audience
Life in the water column: the plankton
The Pelagic fauna

Historical Planktonic “bias”

*Calanus hyperboreus*
Diving, nets and ROV
Benthos
Imaging Tools

... combined with Box corer, and other mud collecting tools
Creepy crawlers

- Diverse infauna
- Abundant epifauna
Let's Pause for Two Questions from the Audience
The Arctic Seas: unique features
Characteristics of the Arctic

- 3 realms with >5000 invertebrate species
- **Tight coupling between ice/water/benthos**
- Huge gradients
- Open system
Coupling ice-water-benthos

- Life cycles/particle flux
Coupling ice-water-benthos

- Life cycles/ particle flux

Coupling between realms - examples

- Diving ducks
- Walrus
- Gray whale
- Bearded seal
- Demersal fish
- Zooplankton
- Phytoplankton
- Ice algae
- Sea birds
- Pelagic fish
- Minke Bowhead
Characteristics of the Arctic

- 3 realms with >5000 invertebrate species
- Tight coupling between ice/water/benthos
- **Huge gradients**
- Open system
Horizontal gradients

Phytoplankton chlorophyll
(5 day composite, August 4, 2002 NASA SeaWiFS)
provided courtesy G. F. Cota

http://www.whoi.edu/arcticedge/arctic_west02/update/020809_en3.html
Characteristics of the Arctic

• 3 realms with >5000 invertebrate species
• Tight coupling between ice/water/benthos
• Huge gradients
• **Open system**
  - Bering Strait/Chukchi Shelf
Bering Strait

Phytoplankton chlorophyll
(5 day composite, August 4, 2002 NASA SeaWiFS)
provided courtesy G. F. Cota

Ocean: Chlorophyll a Concentration (mg/m³)

http://www.whoi.edu/arcticedge/arctic_west02/update/020809_en3.html
Let's Pause for Two Questions from the Audience
Implications of Arctic Change
The number of days in which oil exploration activities on the tundra are allowed under Alaska Department of Natural Resources standards has been halved over the past 30 years due to climate warming. The standards are based on tundra hardness and snow conditions and are designed to protect the tundra from damage.
Loss of summer sea ice

Figure 1. Large panel: NRTSI-derived sea ice extent and concentration anomalies (in %, see color bar) relative to NASA Standard Team means for 1988–2000. Median ice extent over the same period is shown by the red line. Four boxes (A, B, C, and D) show MODIS validation areas (see Figure 2). Ice extent in the months leading to the September minimum are shown at left. At right, September sea ice extent and concentration anomalies for the four previous minimum extent years.
Future predictions: Precipitation, warming
These maps of current and projected vegetation in the Arctic illustrate that forests are projected to overtake tundra and tundra is projected to move into polar deserts. These changes will result in a darker land surface, amplifying warming by absorbing more of the sun’s energy and creating a self-reinforcing feedback loop.
Let's Pause for Two Questions from the Audience
Observed and suggested biological response to Arctic Change
Arctic warming: Altered ice regime, increased freshwater run-off
Light

Seeding by ice algae

Sedimentation

Ice

Water

Zooplankton

Algal bloom

Pycnocline

Sediment

Benthos

Mixing

Pycnocline

Current/Late ice retreat

Future/Early ice retreat

Bluhm and Gradinger 2008
Changes in Antarctic food web

Moline et al. 2004 (result from Antarctic LTER)
Changes in Antarctic food web

Low freshwater run off

- Large algae
- Euphausiids
- Usable by whales

Strong freshwater run off

- Small algae
- Salps
- Not usable by whales

Moline et al. 2004 (result from Antarctic LTER)
Observed Biological Changes

Increase in epifauna biomass (Norton Sound, Bering Sea) after Hamazaki et al. 2005

Northern range extensions in Chukchi Sea
Sirenko et al. 2006
Decrease in benthic infauna (Bering Sea) Grebmeier et al. 2006
Poll Question

What do you consider the top arctic issue related to global warming?
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Outlook

• Change from benthic (e.g. walrus, grey whale) to pelagic ecosystem (e.g. ringed seals)
• Loss of habitat (walrus, ringed seal, polar bear)
• Species extinction
• Change in food web structure – both quality and quantity
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