Status of the Arctic Marine Environment

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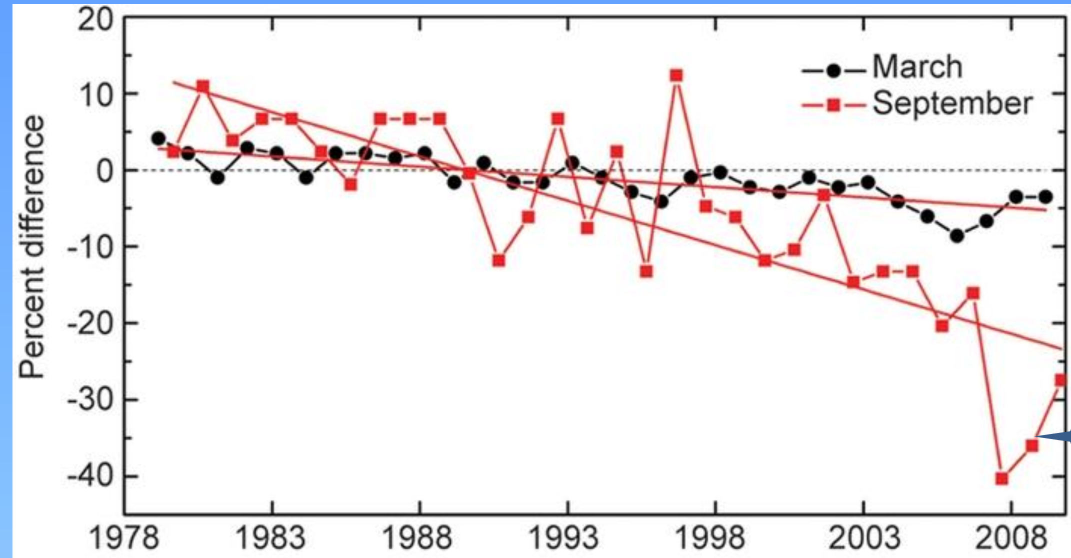
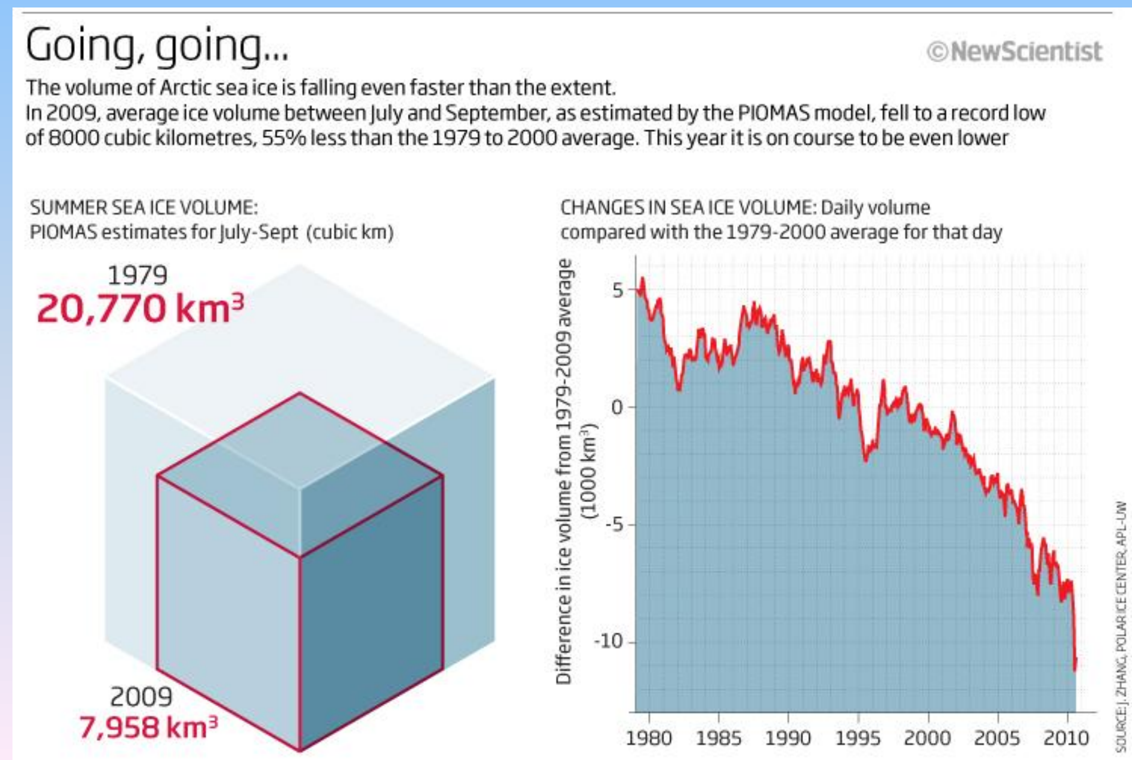
Loss of Arctic Sea Ice

- Multi-decadal trend in extent of sea ice cover at March maximum and September minimum
- Area of multi-year ice much reduced – as is total ice volume
- Likelihood is low for a return to mid-80's conditions, but high for continued losses





Multi-year Sea Ice

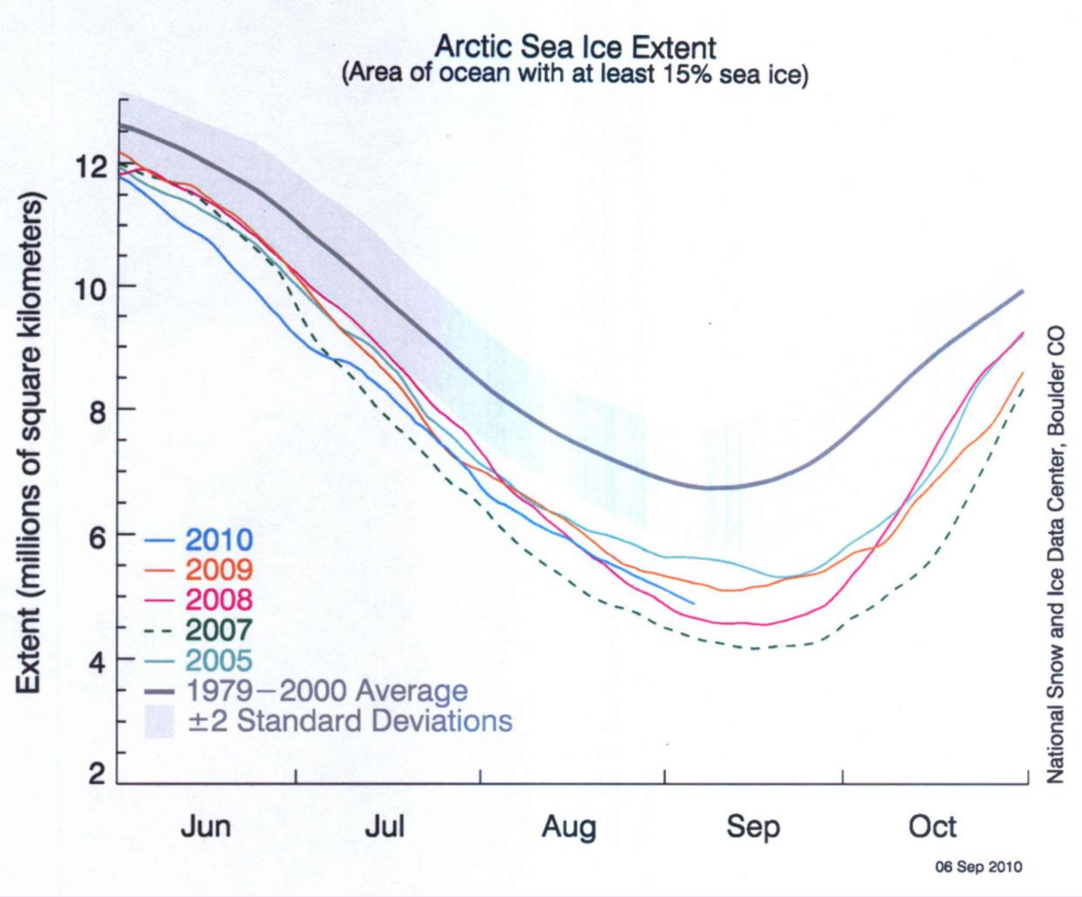
Severe loss of sea ice in summer 2007 reduced area of thicker multi-year sea ice.

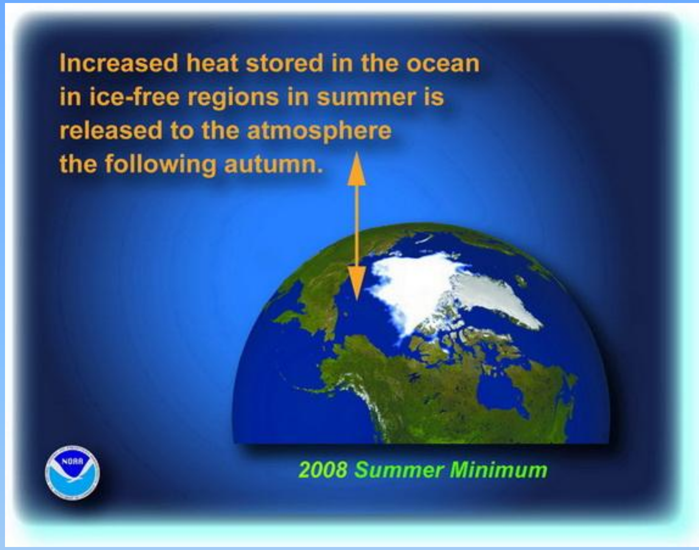
Even though sea ice extent minimums trended higher in summer 2008 and 2009, multi-year ice in March continued to decline.

Figure from S. Ngheim, JPL

Latest Sea Ice Extent Data

September 2010 may have minimum extent of less than 5 million km^2





Ice-free ocean absorbs solar heat that must be released to the atmosphere before new ice can form in the fall

Impacts

National Oceanic and Atmospheric Administration

Home | Sea Ice | Heat | Impacts

Future of *Arctic Sea Ice* and *Global Impacts*

The Arctic is losing sea ice, impacting climate & weather farther South

Satellites show the Arctic losing summer sea ice for the past 30 years

Models predict this loss will continue

Click for NEXT

Heat absorbed by open Arctic waters changes Arctic heat and atmospheric pressure patterns

Impacting Arctic winds

Click for NEXT

Changes in the Arctic atmosphere increase variability in global winds

With potential outbreaks of cold Arctic air and winter storms in US and Eurasia

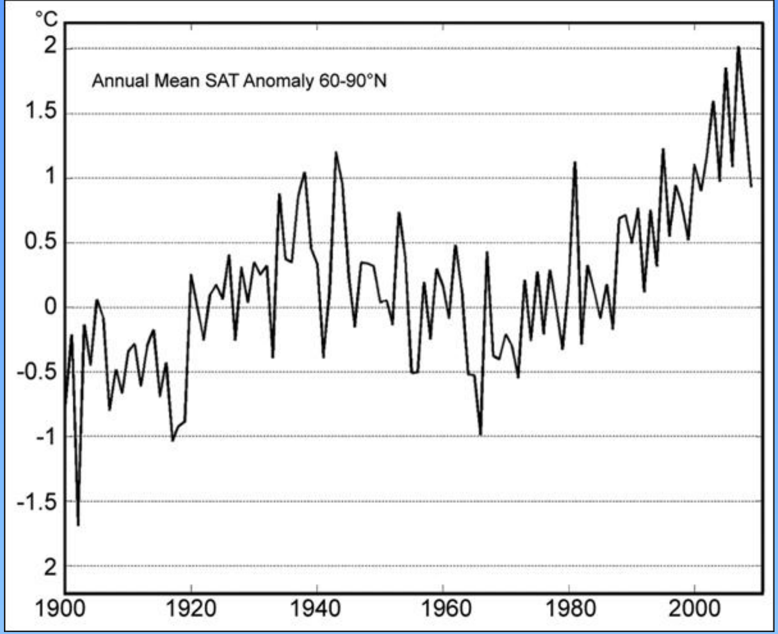
Tell me more.... How changes in the Arctic impact weather and climate in Europe, Asia and the US

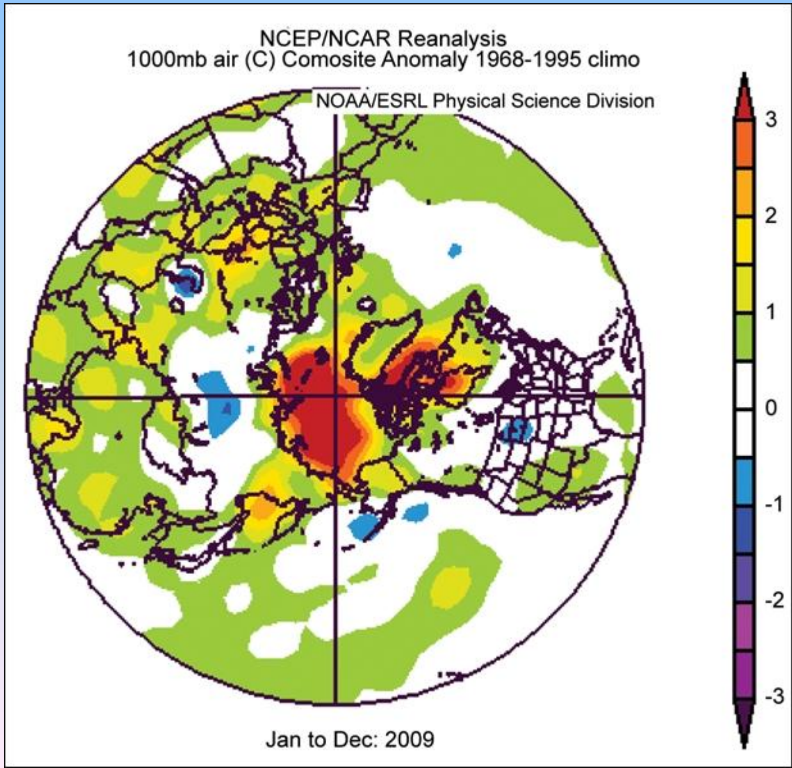
Warm Air Over the Arctic

Surface air temperatures north of 60 deg. N, for the last decade are the warmest of the last century.

Variability in time and space is high. During winter 2009, Eurasian Arctic was very cold, while other Arctic areas were warm.

For the entire 2009, the central Arctic had warming amplified by at least a factor of two compared to lower latitudes.





Arctic Ocean Warming

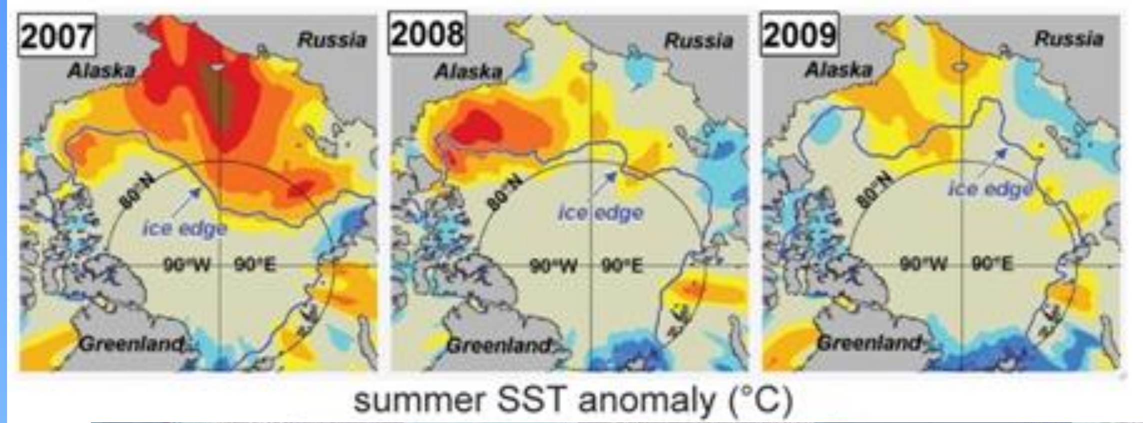
Recent in situ data show warming of the Atlantic layer of water entering the Arctic Ocean from 2003, with a peak around 2007 and cooling thereafter. (Polyakov)

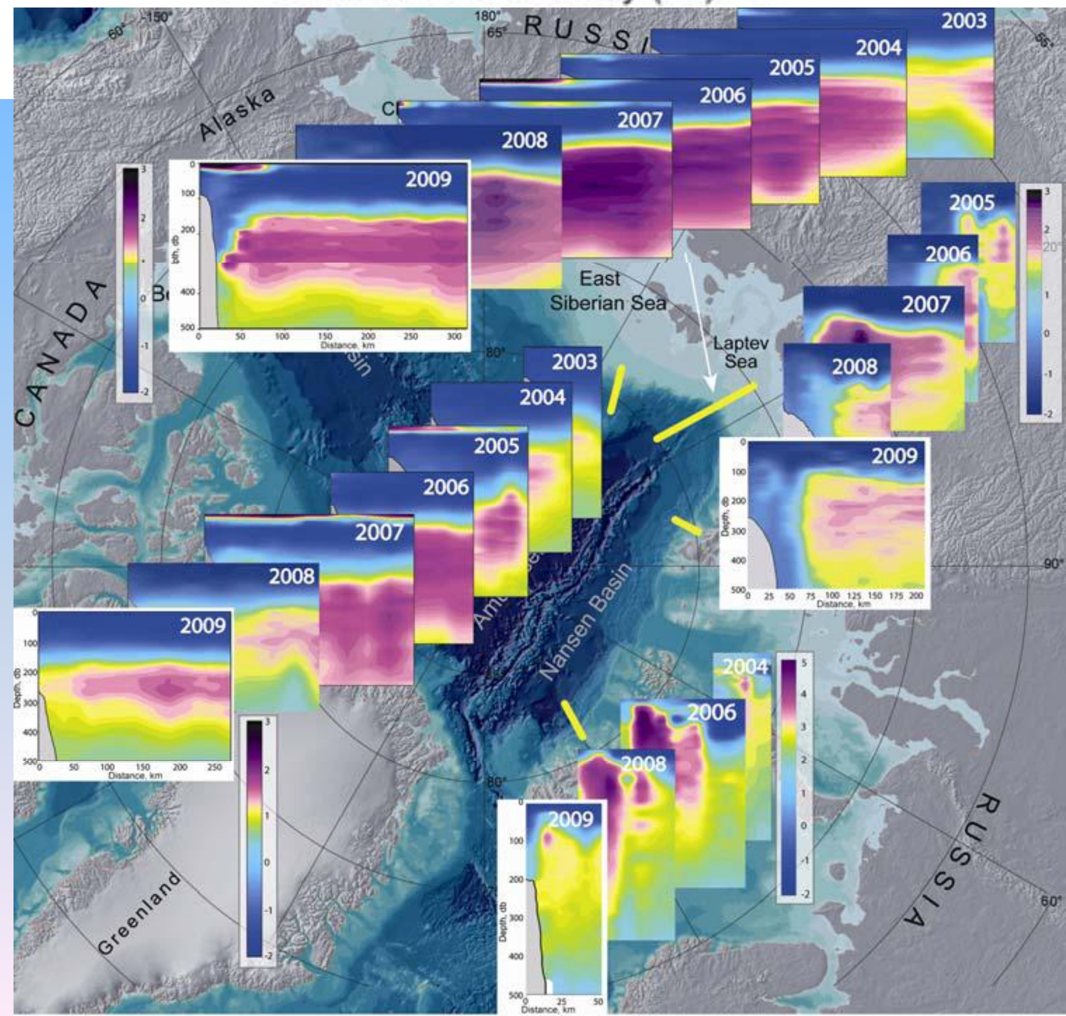
Pacific water inflow was also unusually warm in summer 2007 and less thereafter. (Woodgate)

Satellite data show very warm surface water on the Pacific side of the Arctic in summer 2007, with cooling thereafter. (Reynolds)

Other data show sub-surface warming at about 30 meters in the Canada Basin. (Jackson)

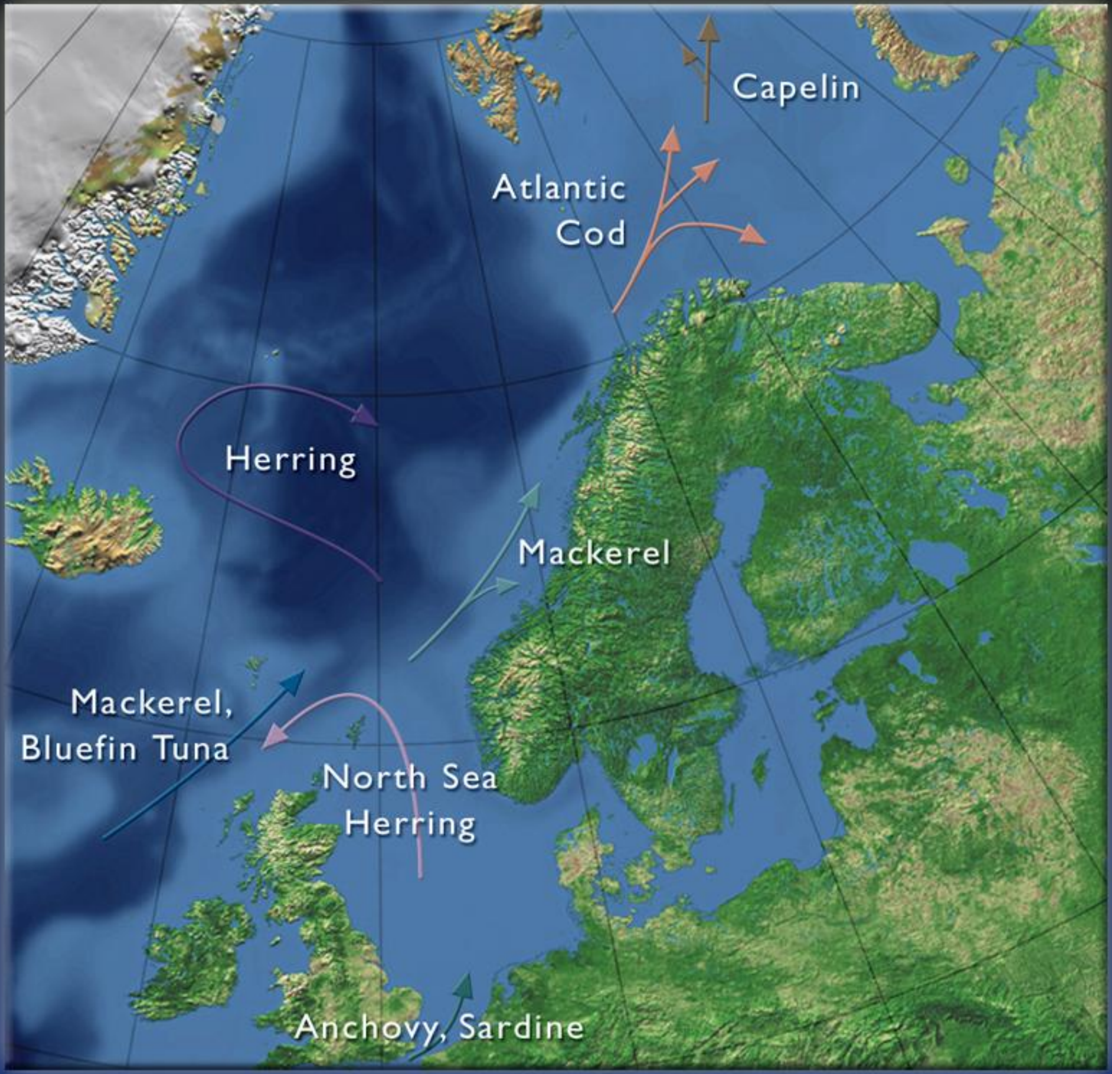
Is the long term trend toward a warmer Arctic Ocean?





IMPACTS OF A WARMING ARCTIC

Possible Changes in Fish Distribution

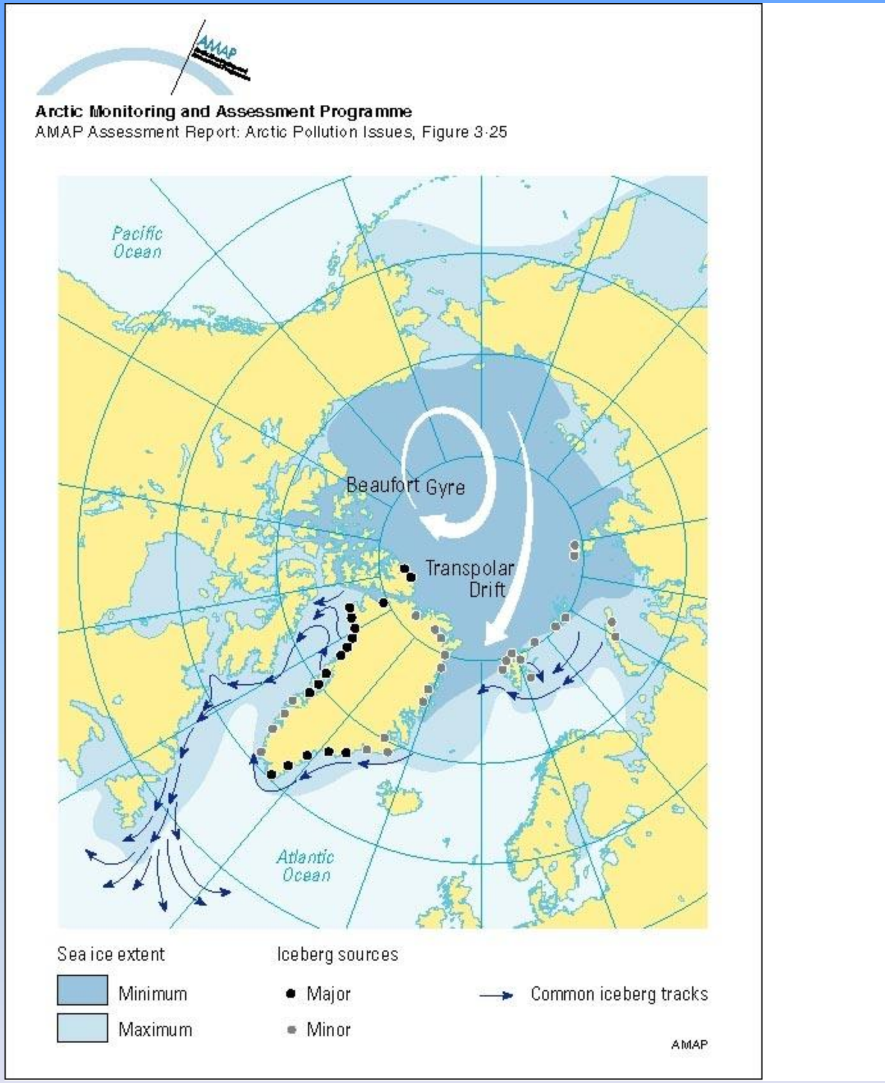


Ocean Circulation

Normally, the Beaufort Gyre, over the Canada Basin, has a strong clockwise circulation, and the trans-polar drift moves sea ice from the Russian side to Fram Strait and out of the Arctic. Both are driven by surface winds.

In 2007, both were very strong, aiding in the low summer sea ice extent. In 2009, both were drastically reduced in strength, aiding in the "recovery" of sea ice extent.

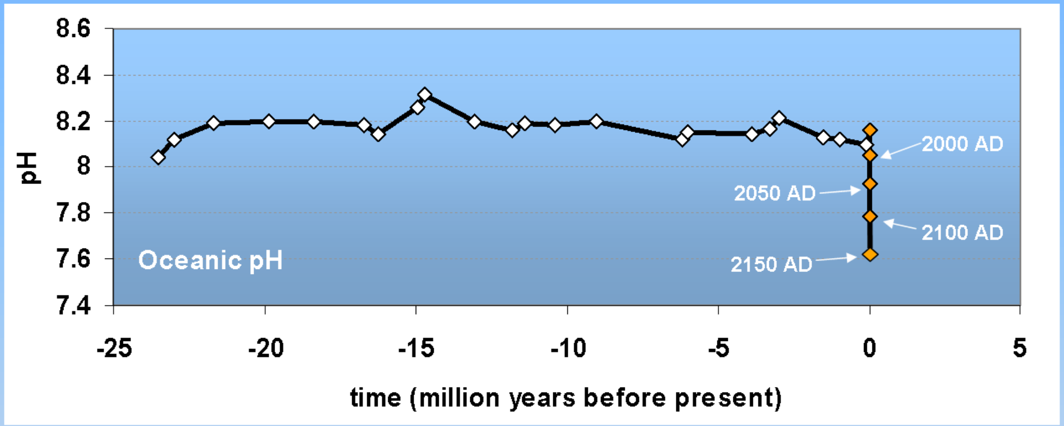
Wind patterns are a major driver of summer sea ice, along with heat content of the ocean.



Ocean Acidification

Increasing CO_2 in the atmosphere leads to increasing CO_2 in the surface ocean through equilibrium processes. The “biological pump” can further draw CO_2 from the atmosphere to the ocean by converting CO_2 to organic matter that is exported to deep water before it can be decomposed back to CO_2.

Experts believe that the ice-free Arctic could take up much CO_2 and be a significant global CO_2 sink. More direct exposure to the atmosphere and to sunlight would increase equilibrium uptake and photosynthesis. Recent data (Cai et al. 2010.Science, 329 p 556.) demonstrate the equilibrium uptake over the Canada Basin, but show limited photosynthetic uptake due to nutrient limitation. Perhaps no “sink” in the Arctic?



How will marine ecosystems respond to a pH level unknown over millenia?

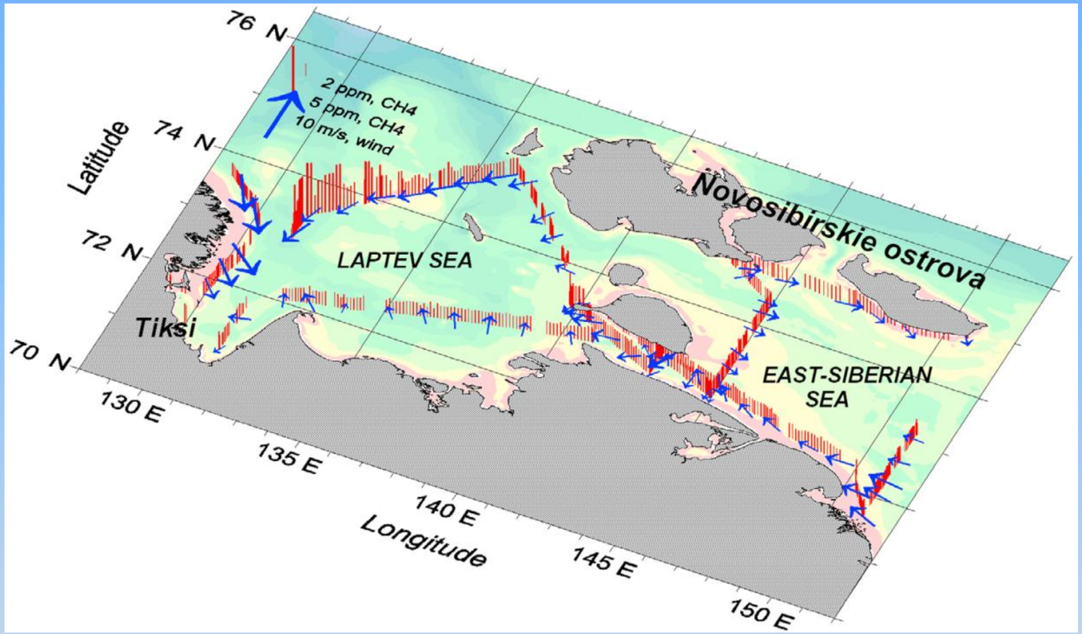
Subsea Permafrost and Methane Release

Recent studies of CH_4 in the Laptev and East Siberian Seas and overlying atmosphere show elevated levels of CH_4 in both water and air. (Shakova et al., 2010. JGR Vol. 115) Authors propose release from the seabed as a result of permafrost warming.

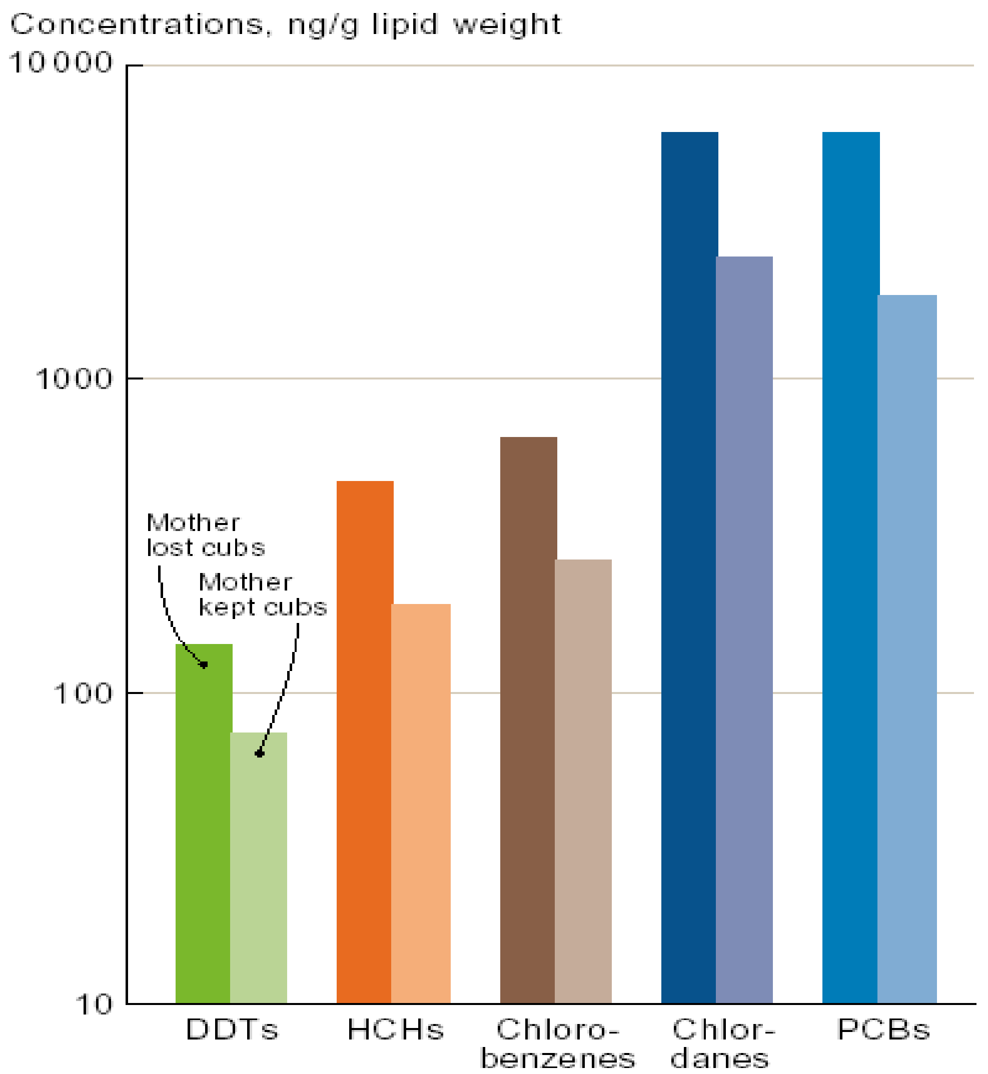
This is not the result of “global warming”, but a consequence of gradual warming of the permafrost once it was submerged thousands of years ago.

But continued destabilization of the submerged permafrost could affect the present day atmospheric warming by release of large amounts of CH_4.

Continued observations are required.



Effects of POPs on Reproduction of Polar Bears



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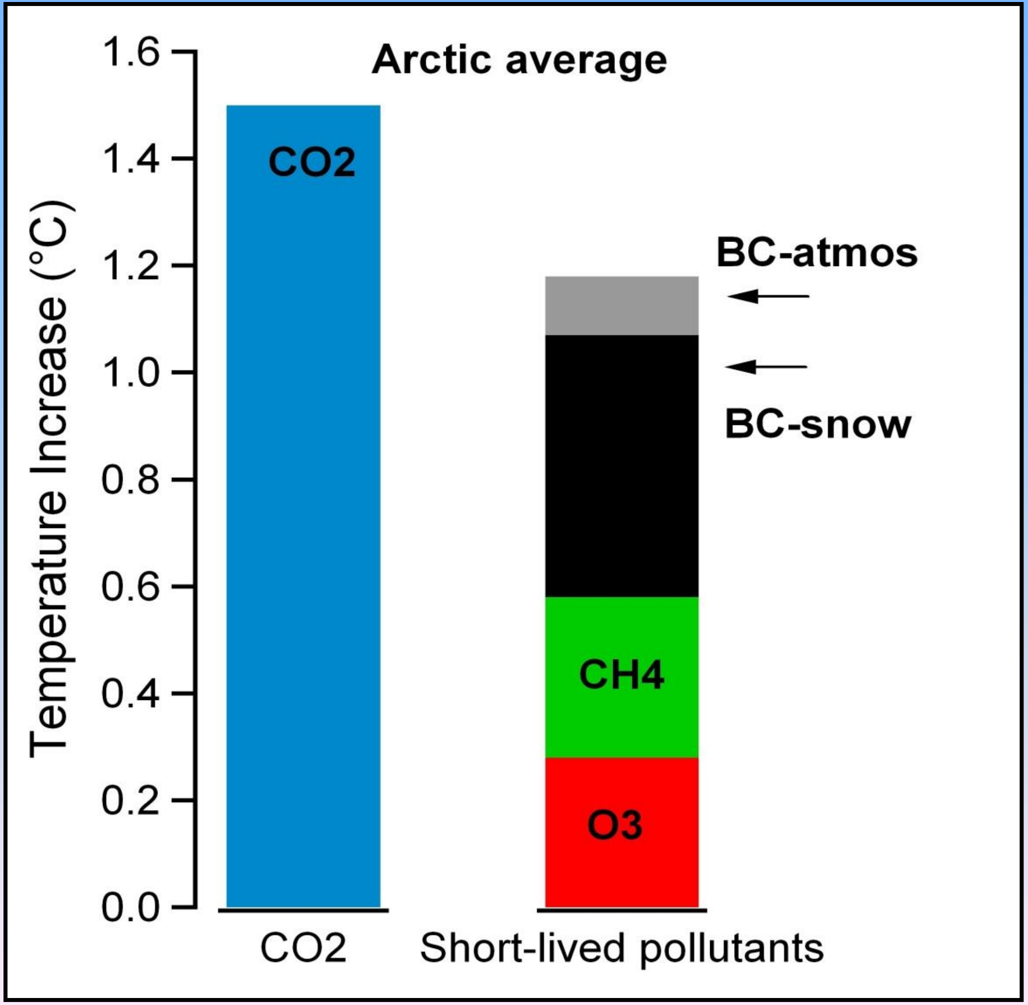
Annually Averaged Temperature Increase due to CO_2 vs. Short-Lived Pollutants (relative to pre-industrial)



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Follow-Up to Oil and Gas Assessment (AMAP) and Oil and Gas Guidelines (PAME and EPPR)

Emerging Issues

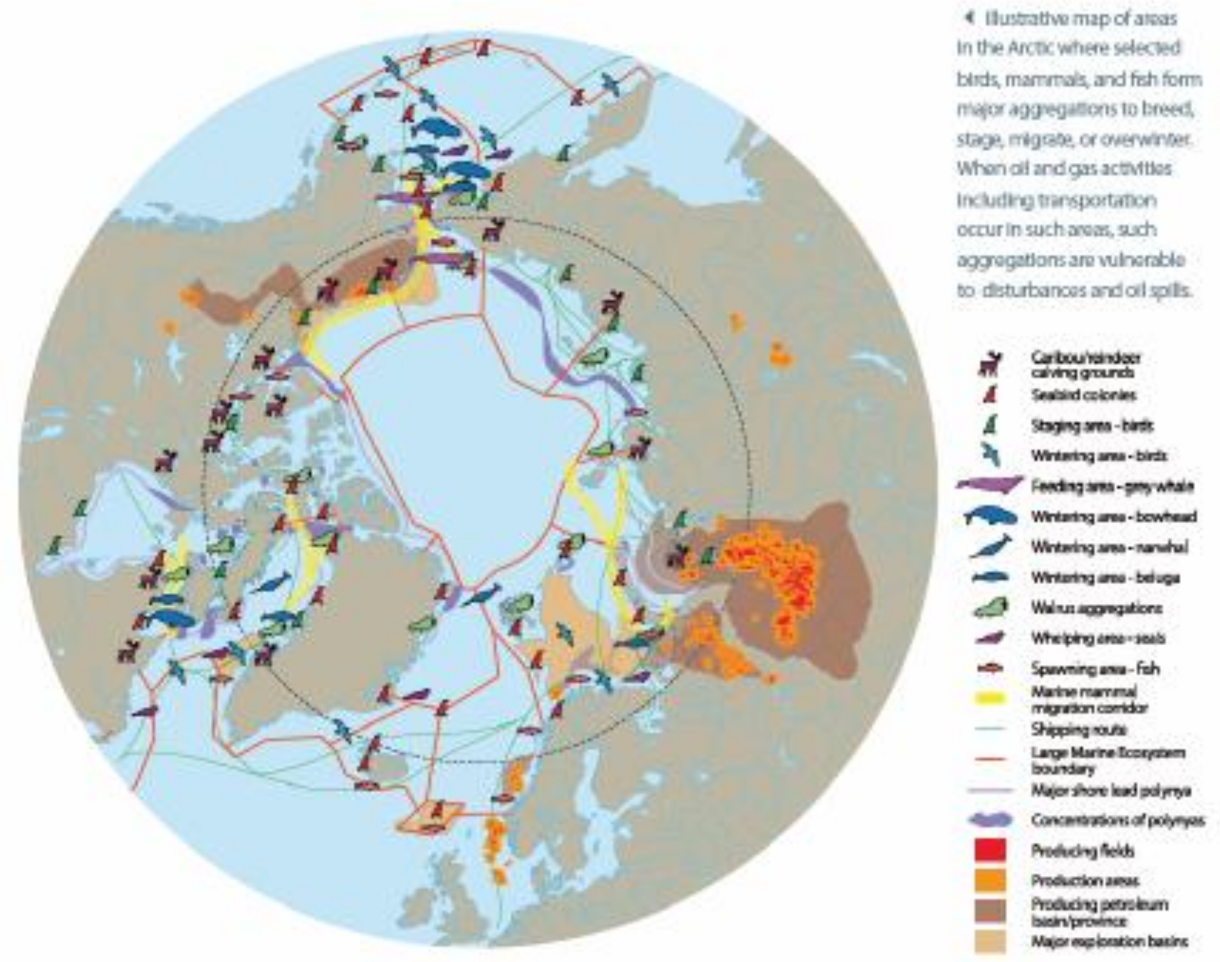
- Noise impacts
- Response capability in the Arctic in the event of a major oil spill
- Risks and vulnerabilities

AMAP

Vulnerability of the Arctic

Oil and Gas Assessment

Biodiversity Assessment



◂ Illustrative map of areas in the Arctic where selected birds, mammals, and fish form major aggregations to breed, stage, migrate, or overwinter. When oil and gas activities including transportation occur in such areas, such aggregations are vulnerable to disturbances and oil spills.

Species aggregations are vulnerable to the effects of oil and gas activities.

http://www.amap.no

Potential Future Changes

- Loss of sea ice/thinner ice leads to increased human use of the Arctic, changes to habitat and food webs for marine mammals, increased primary productivity
- Altered ocean atmosphere heat exchange leads to changes in Arctic and hemispheric weather and climate
- Surface ocean acidification leads to ecological stress and food web alteration
- Destabilization of shallow subsea permafrost with increased methane release, accelerates global warming and works against mitigation actions

Conclusions

- Physical change in the Arctic marine environment seems likely to continue along the current path
- Chemical changes are evident – ocean acidification, likely accelerated methane release, POPs, aerosols
- Ecosystem change seems inevitable as does increased human activity in the Arctic marine environment
- Indigenous and subsistence lifestyles will be transformed to an even greater degree
- Legal/regulatory/policy regimes are not evolving quickly enough, in the Arctic or globally to counteract these trends
- Research and sustained observations more important than ever in the Arctic

Thank You