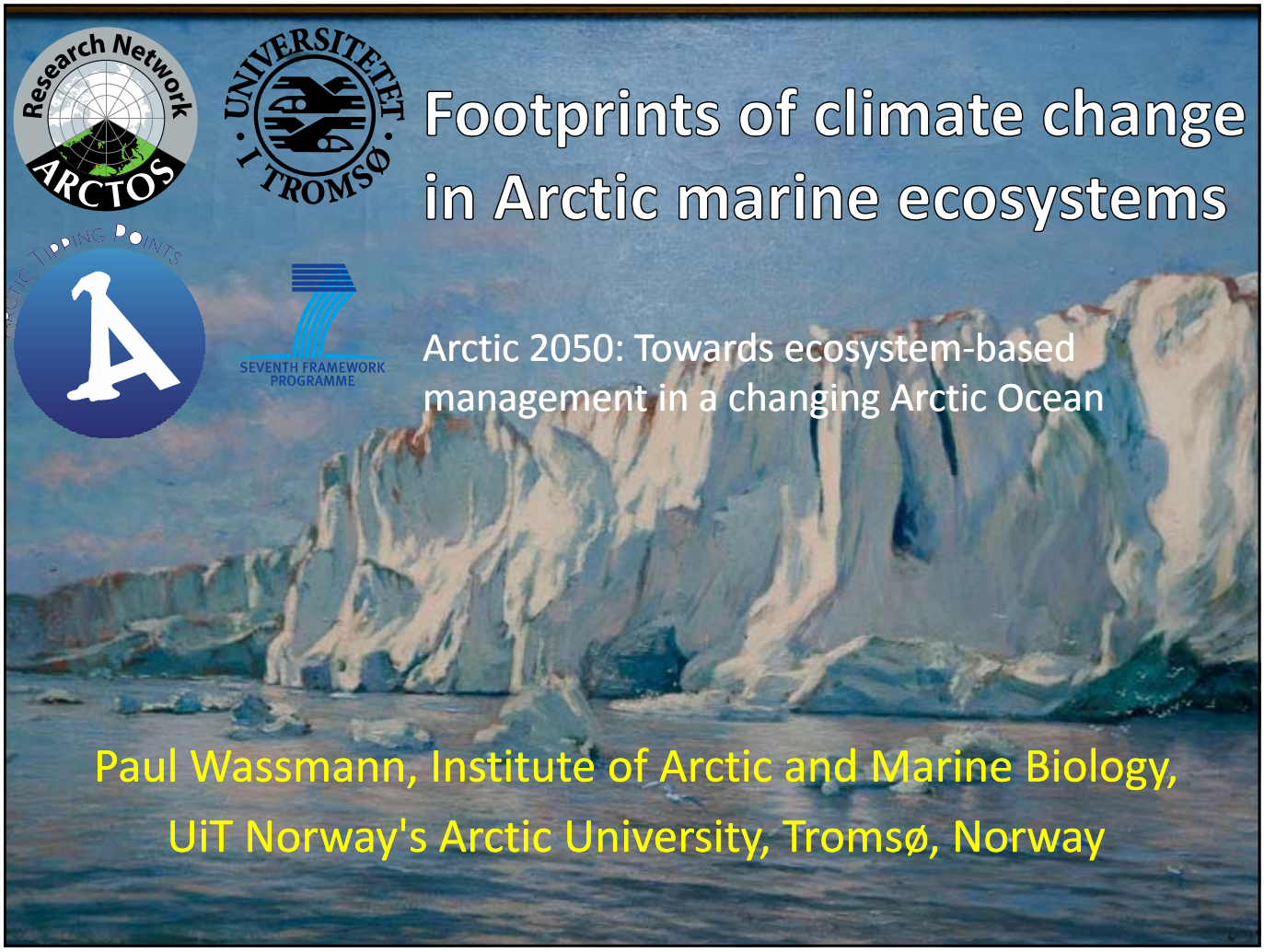


Footprints of climate change in Arctic marine ecosystems

Arctic 2050: Towards ecosystem-based management in a changing Arctic Ocean

Paul Wassmann, Institute of Arctic and Marine Biology,
UiT Norway's Arctic University, Tromsø, Norway

For some the Arctic Ocean is

Drill for oil and gass

Transport cargo, oil and gass

Build up new industries

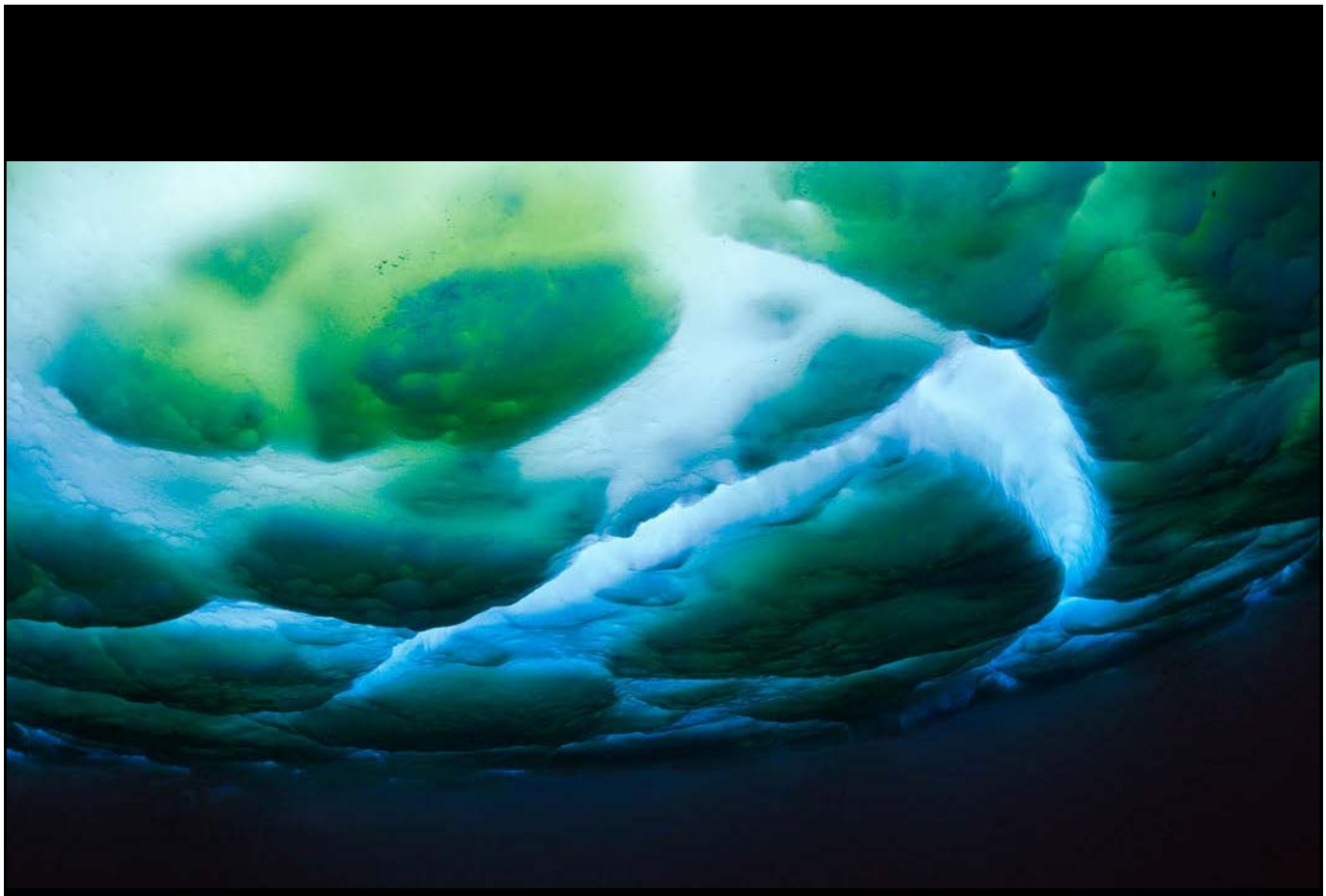
Barents Sea delivers 15 million fish servings per day

Frozen ecosystems

Majestic landscapes

Spectacular wild life

Whales means food and birds



Ice algae from below


Krill

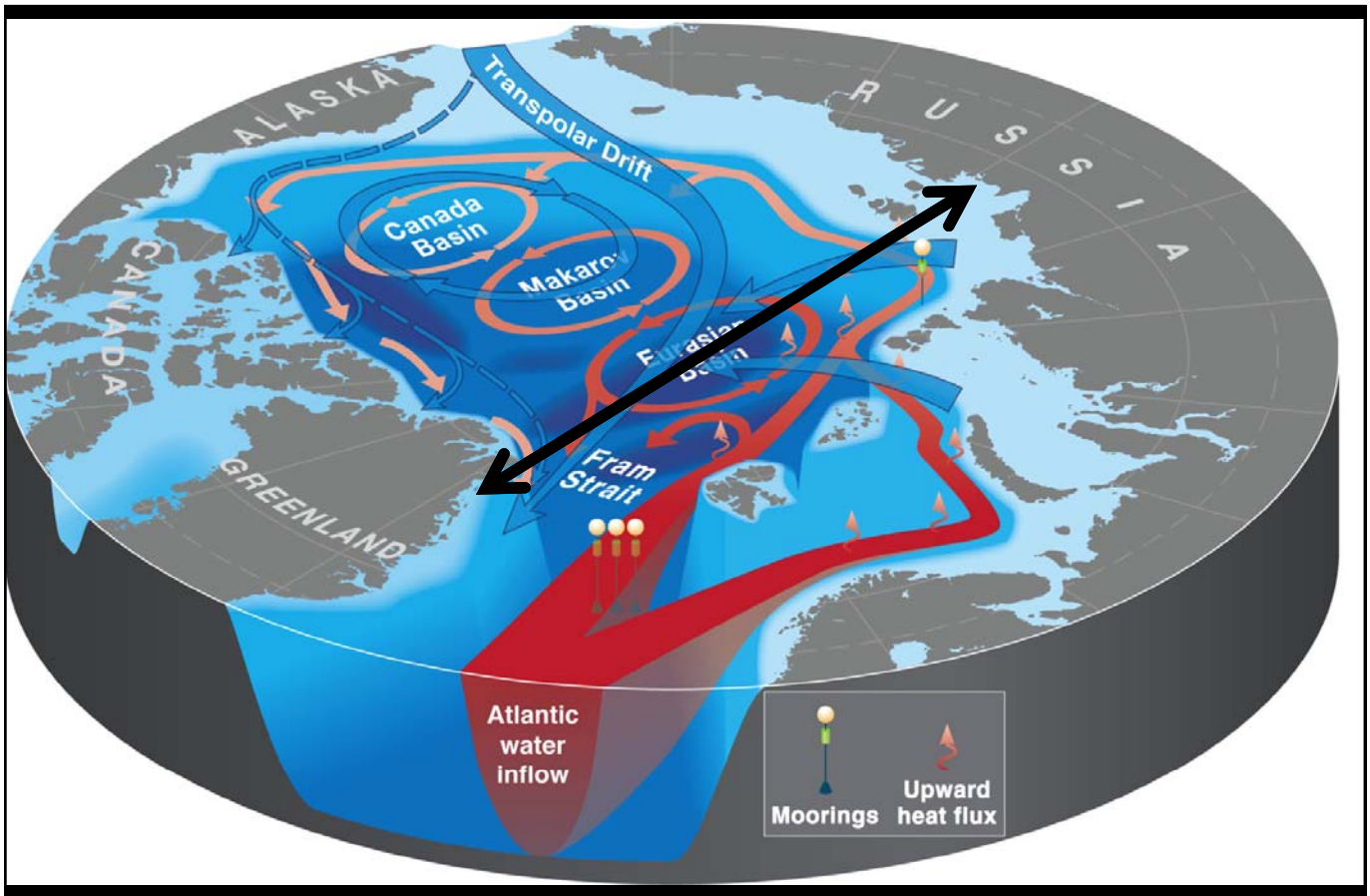

A
Some arctic amphi unev
Ice fauna

Ecosystem-based management in a changing Arctic Ocean?

- For the most we are unable to afford such a management now
- And in 2050?
- If Europe prepares for it now we can achieve this goal in the European Arctic Corridor

European Arctic Corridor controls much of the Arctic marine climate

- 90 % of water exchange takes place here
- 60 % of the primary production takes place here
- Probably the best managed fish stocks, etc
- Geographically in the periphery; with regard to climate, transport and resources it is THE determining in the north



The Atlantic Ocean drives much of the Arctic Ocean

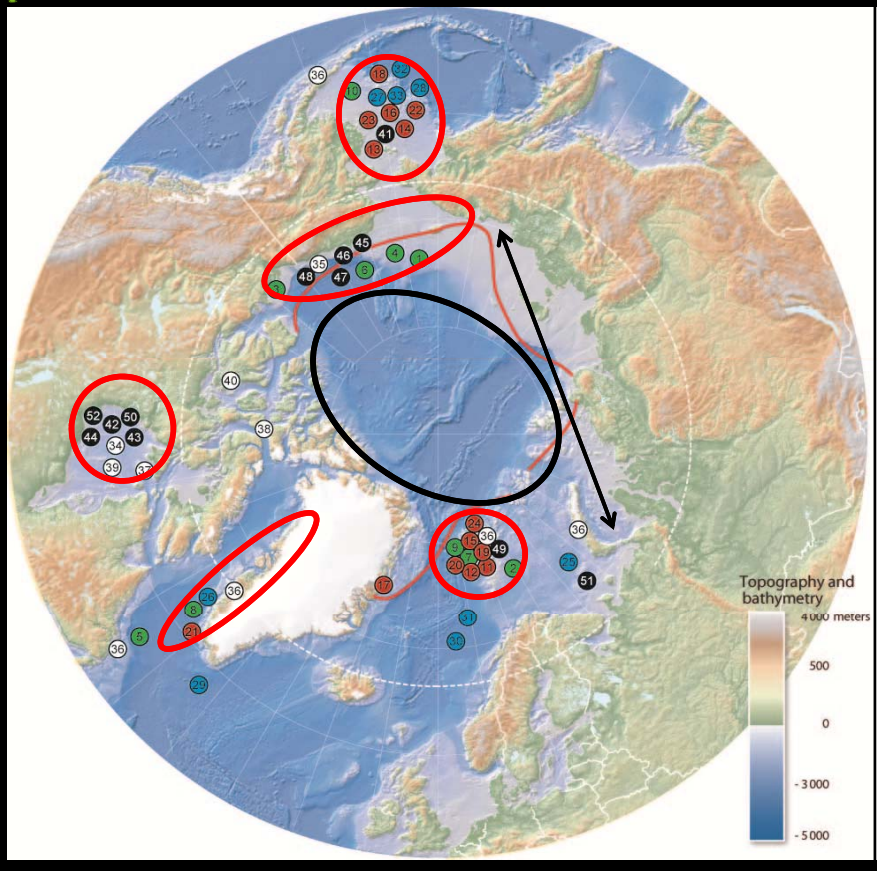
Content

- Footprints of climate change
- Tipping points
- Changes in production during this century

- The challenge of predicting the footprints when climate change is extreme
- The golden standard of managing rapidly changing ecosystems

No footprints without an undisturbed substrate

Only 51 examples of marine arctic footprints of climate change by 2010



Will we determine more examples by 2014 and in years to come?

- Probably not
- Lack of investigations prior to rapid climate change prevent determination
- We did not do our home work when the Arctic yet was relatively stable (Cold War)

An inconvenient truth……

- A large number European nations carry out few or no oceanographic studies in the Arctic Ocean
- Consequently, the Artic Ocean with the Worlds greatest climate change is also **the least investigated ocean**.
- With great recent progress……

Little things can make a big difference: Tipping points

Do we have artic tipping points?

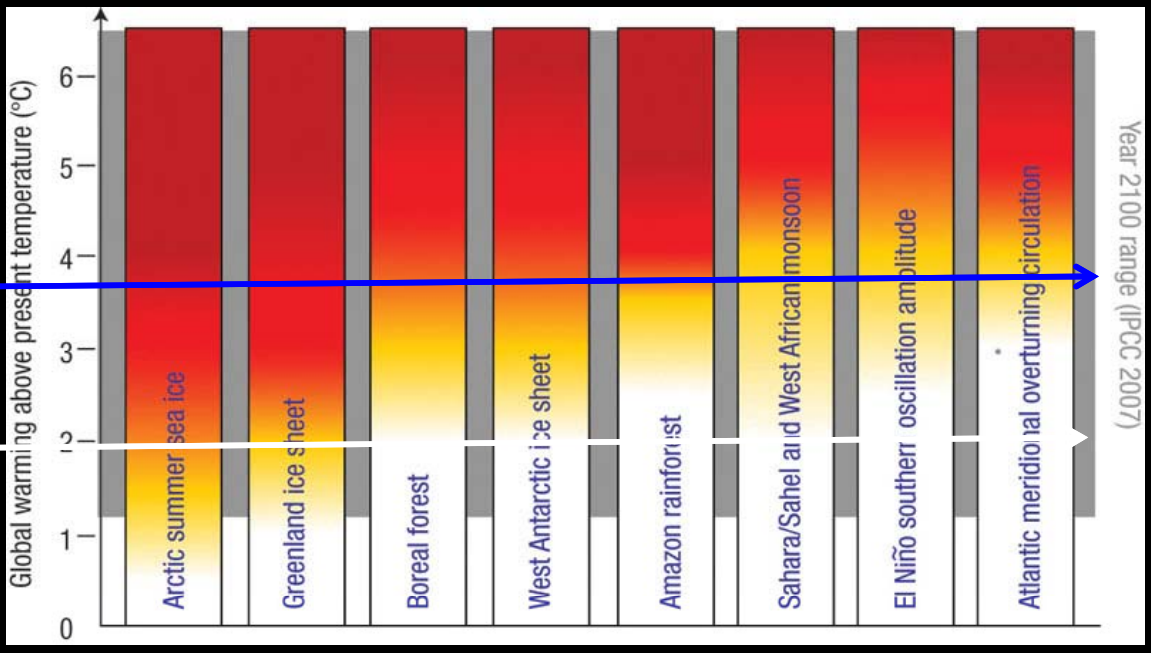
Tipping point

- The critical point at which the future state of the system is qualitatively altered (but no regime shift)

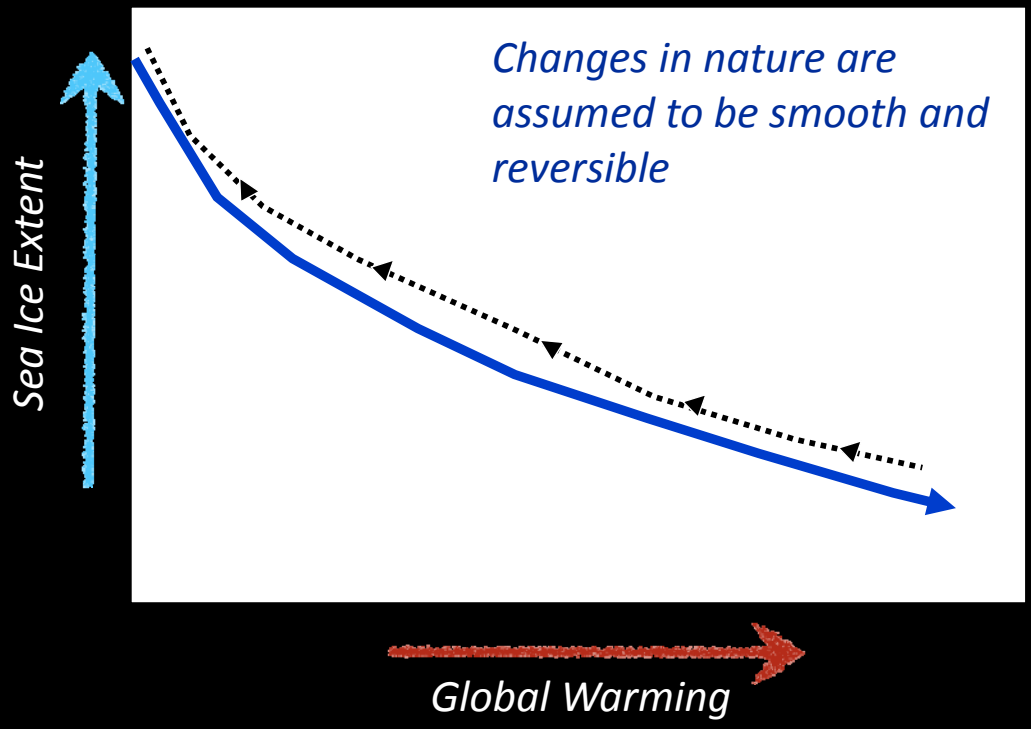
Point of no return

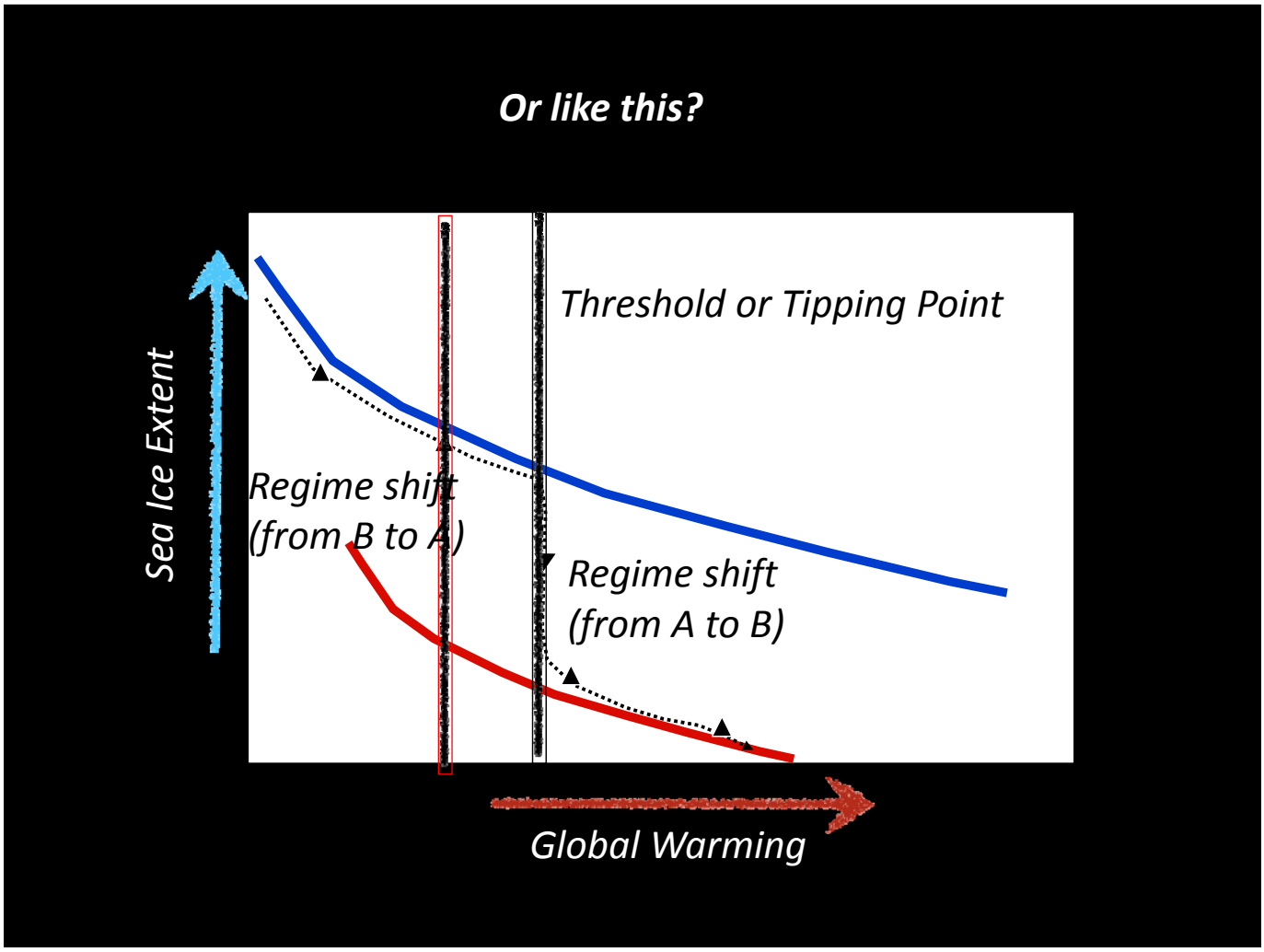
- The critical point where a regime shift takes place

Estimates of proximity of tipping points in climate sensitive regions

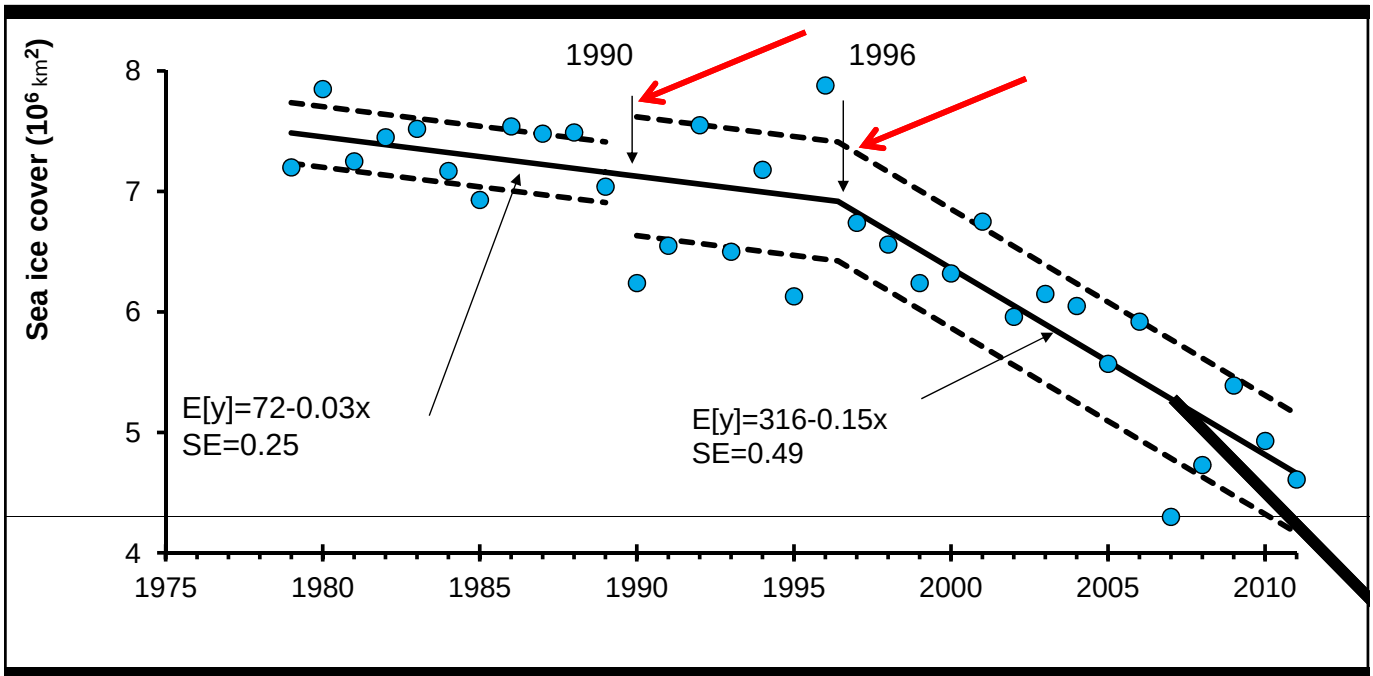


Will the combined future of global warming versus sea ice extent be like this?



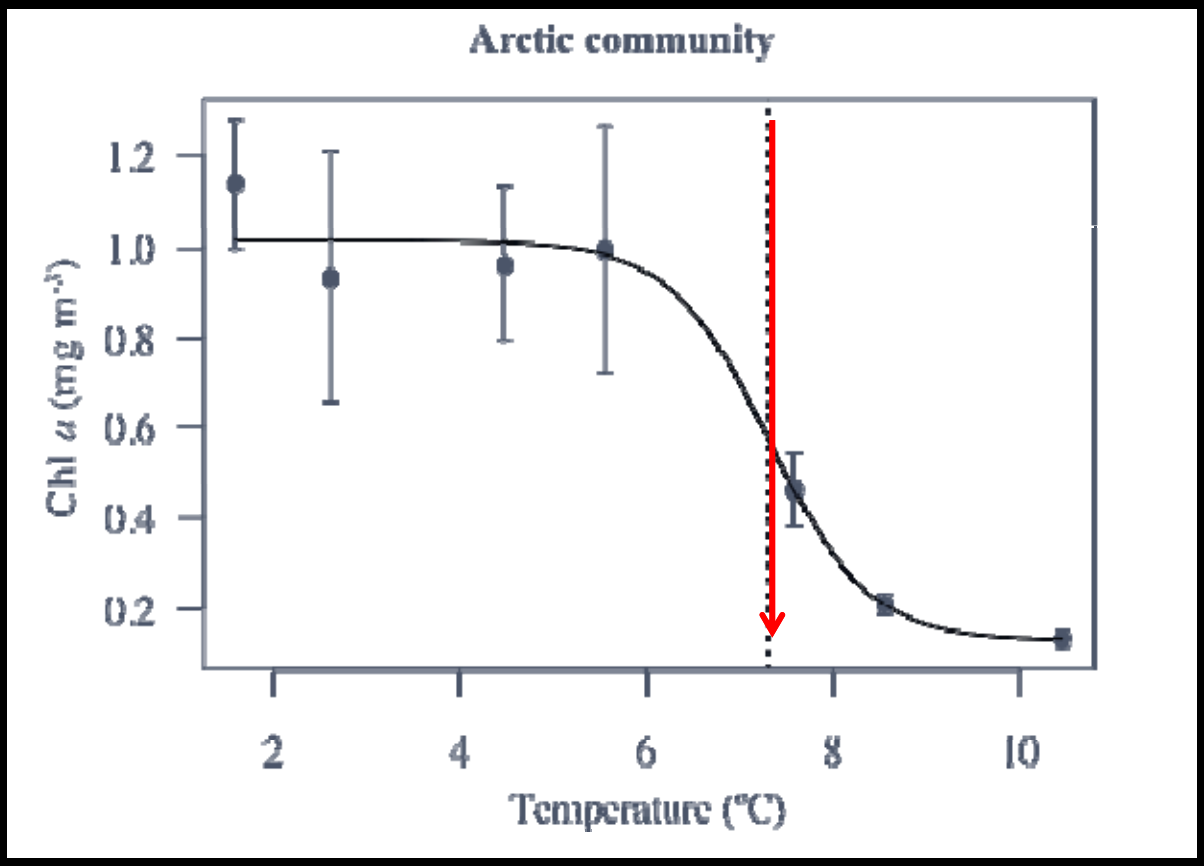

Or like this?
Sea Ice Extent
Threshold or Tipping Point
Regime shift
(from B to A)
Regime shift
(from A to B)
Global Warming

Good time series needed to determine tipping points

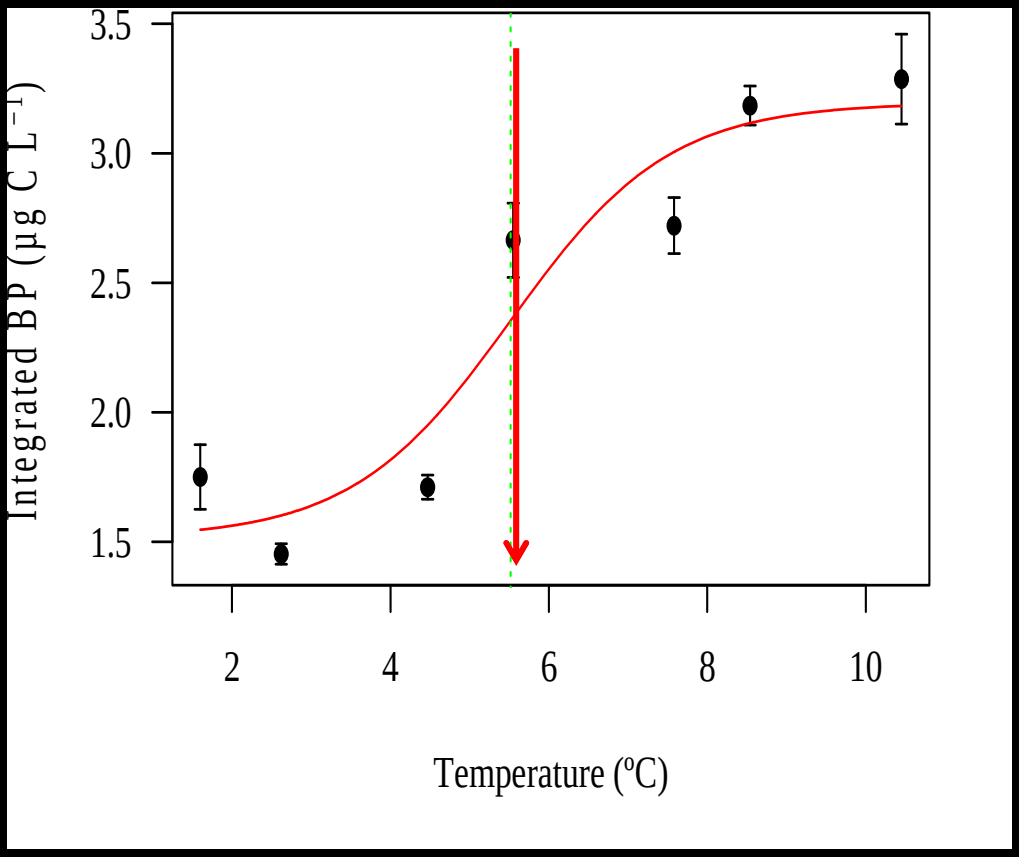


Arctic Ocean ice cover. Tipping point in 1996, prior to minima in 2007 and 2012. Approaching tipping point indicated by increased variability already in 1990. New tipping point around 2007? Increased variability?

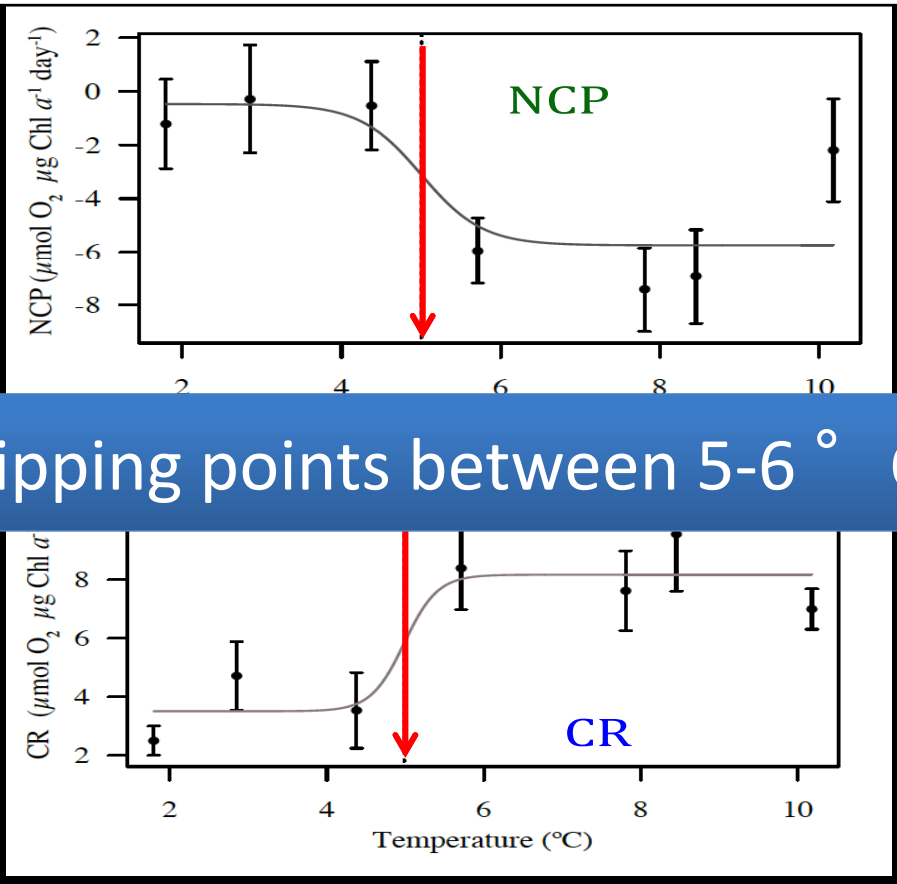
Experimental approaches



Response of phytoplankton to temperature



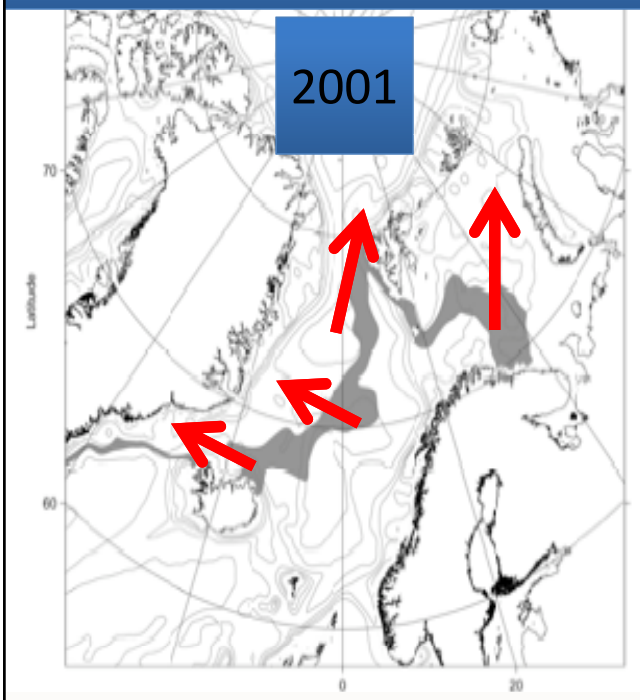
Response of bacterial production to increasing temperatures



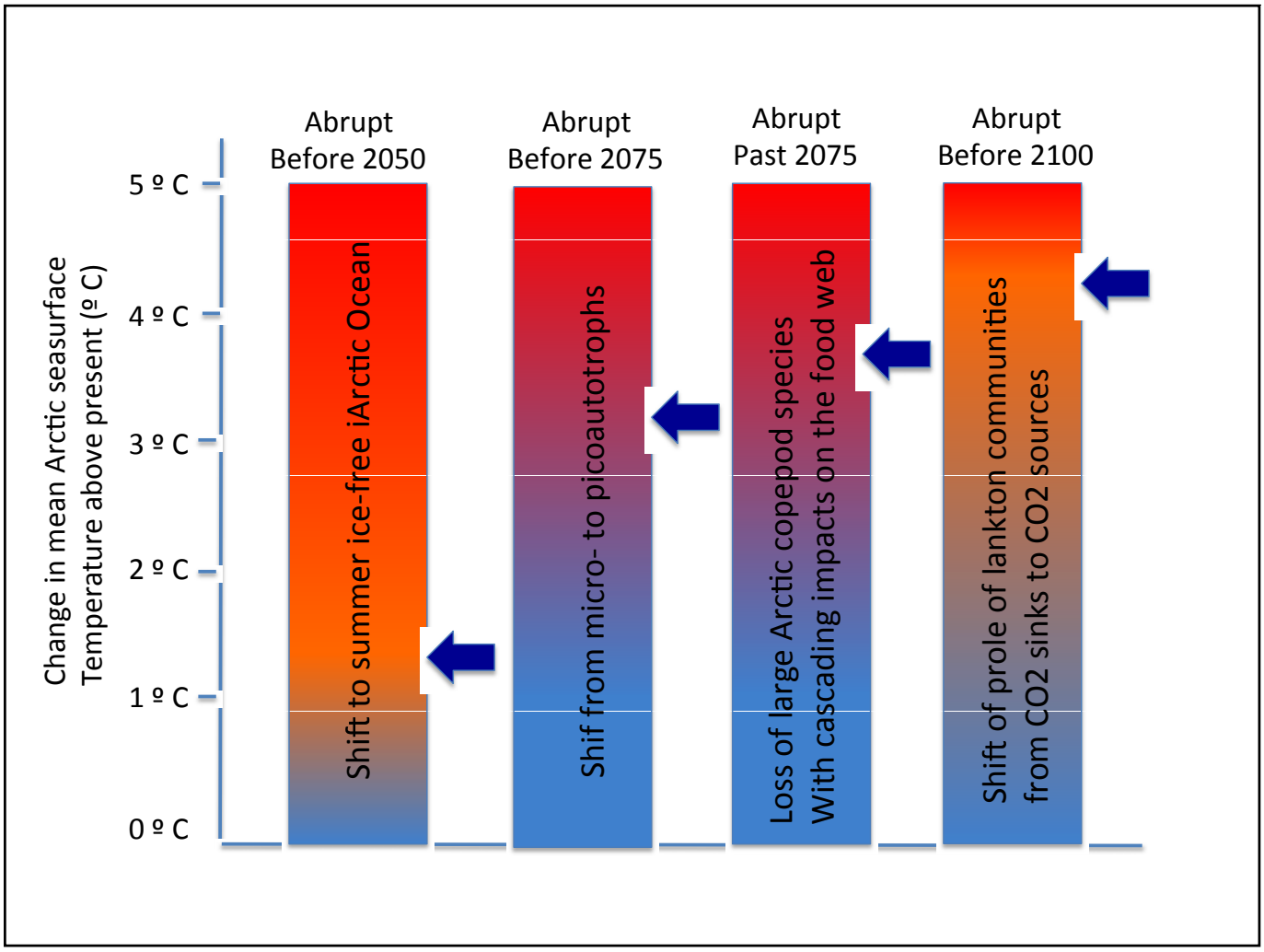
Tipping points between 5-6 ° C

Temperature dependent response of net community production (NCP) and community respiration (CR)

Climate change induced movement of tipping point front



5-6° C temperature in surface water


Change in mean Arctic seasurface Temperature above present (º C)
5 º C
4 º C
3 º C
2 º C
1 º C
0 º C
Abrupt Before 2050
Abrupt Before 2075
Abrupt Past 2075
Abrupt Before 2100
Shift to summer ice-free iArctic Ocean
Shif from micro- to picoautotrophs
Loss of large Arctic copepod species With cascading impacts on the food web
Shift of prole of lankton communities from CO2 sinks to CO2 sources

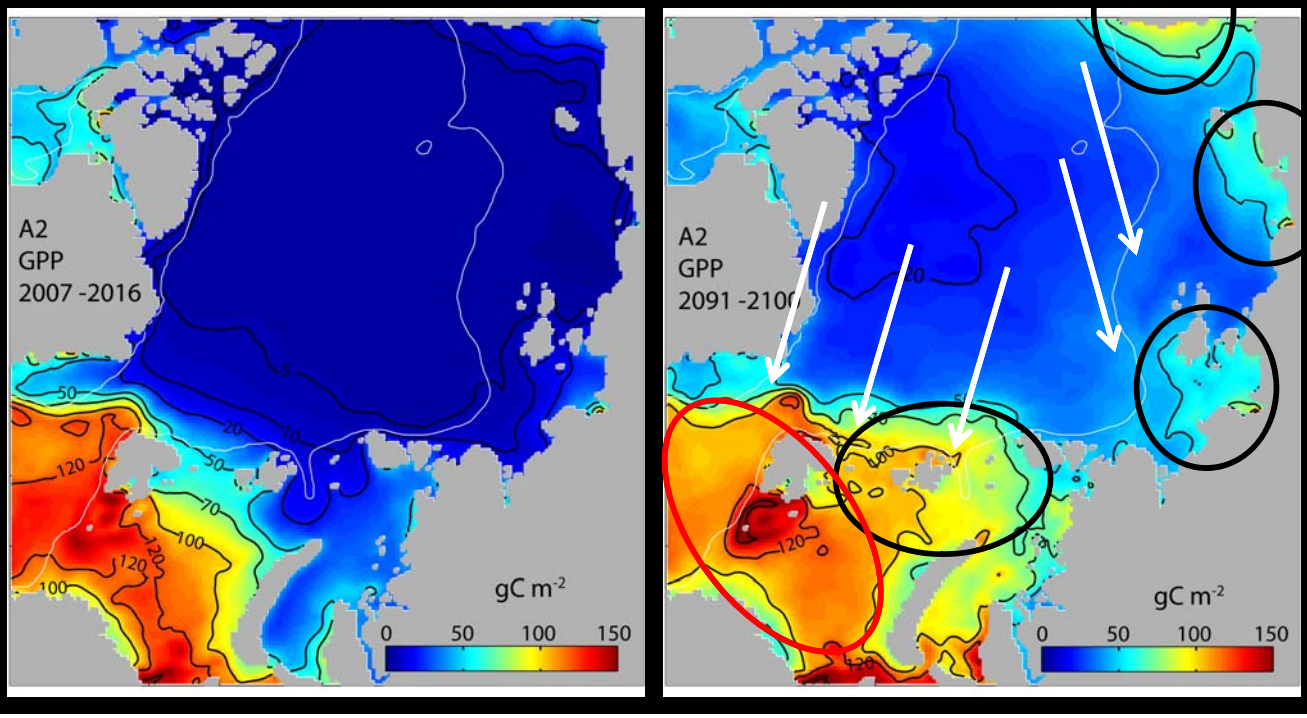
- Recent tipping points have and can be discovered when time series data exist
- Experimental research suggest tipping points at water temperatures between 5 to 6° C.
- Approaching tipping points may be thus detected ahead of time and guide managers

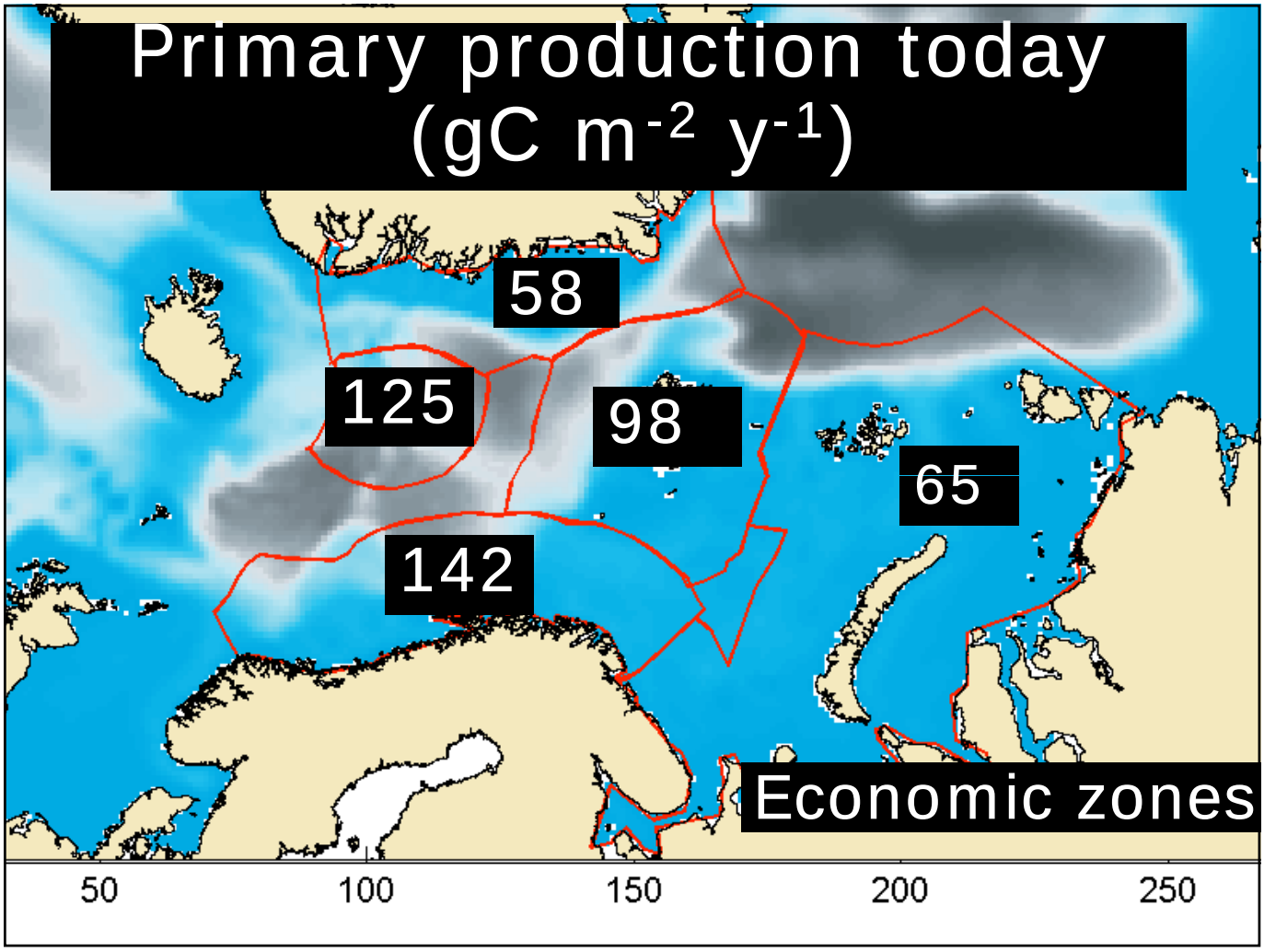
Changes in productivity: primary production

SINMOD model A1B – scenario (+3.8° C by 2100)

Change in annual gross primary production

2007-2016 2091-2099




Primary production today
(gC m-2 y-1)
58
125
98
65
142
Economic zones
50
100
150
200
250

By 2100 primary production has in/decreased (in percent of today)

- Norwegian Sea: - 20%
- Svalbard: - 8%
- Jan Mayen: - 15%
- East Greenlandic: - 8%
- Russian zone: + 55%

Demands with extreme changes

Science tries, but is not able to predict future states of extremely changing ecosystems

- Extent of changes and speed of change is outside the ”empirical window”: there are no historic analogies
- Ecosystem models: predictive power when system is close to equilibrium, not when system is outside

Demands with extreme changes

Science tries, but is not able to predict future states of extremely changing ecosystems

- New and strongly disturbed ecosystem may arise, with unknown qualities.
- Climatic changes are accompanied by new infrastructure, new industries, new pollution sources: cumulative effect are notoriously difficult to predict

Demands with extreme changes

Research of arctic ecosystems ought to change its modus

- More focus upon extensive and precise real-time observations than theoretical model projections
- More long-term and continuous than short-term campaigns and programmes.

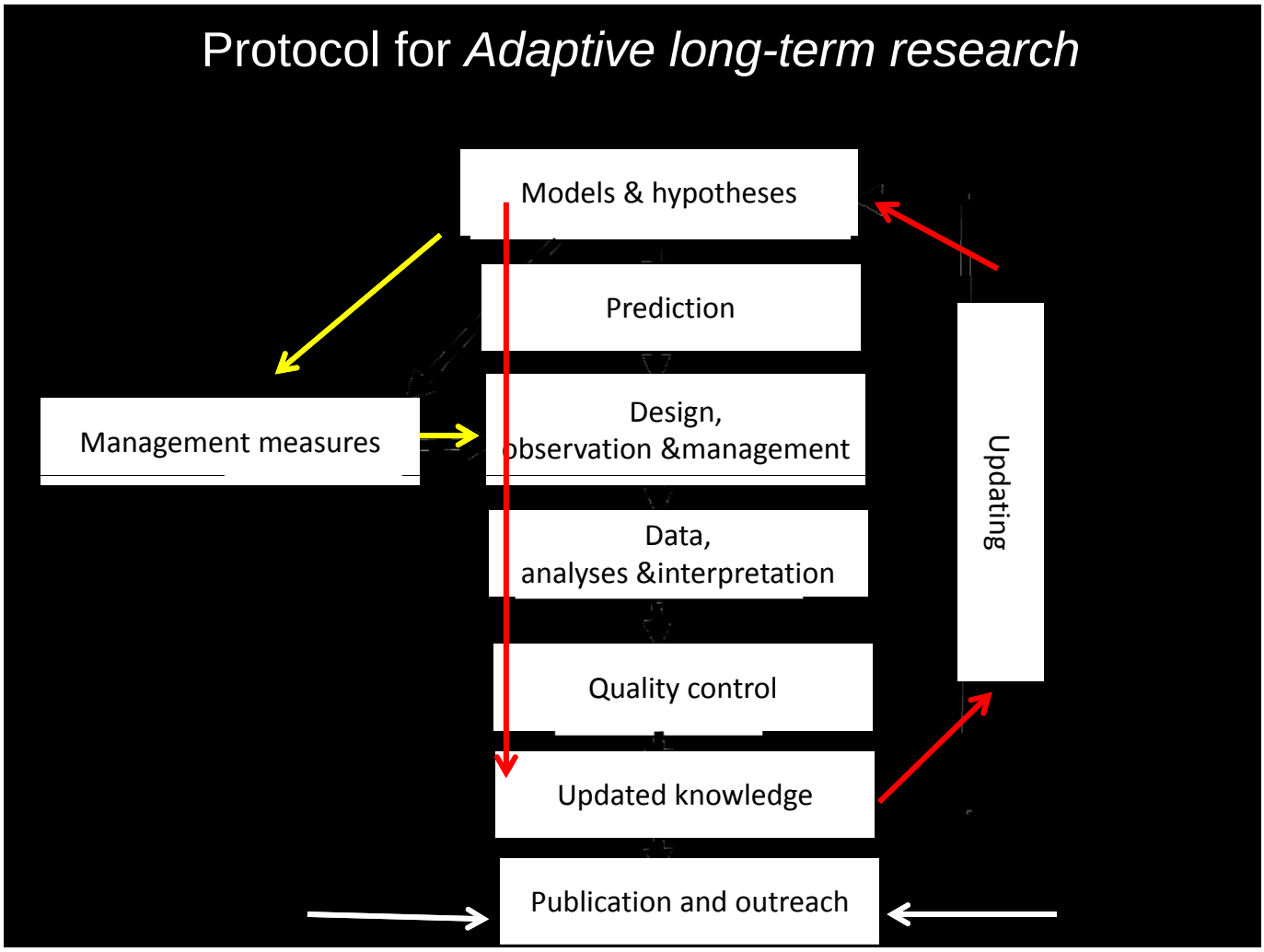
  Continuous over the extent of rapid climate change until a new equilibrium is reached

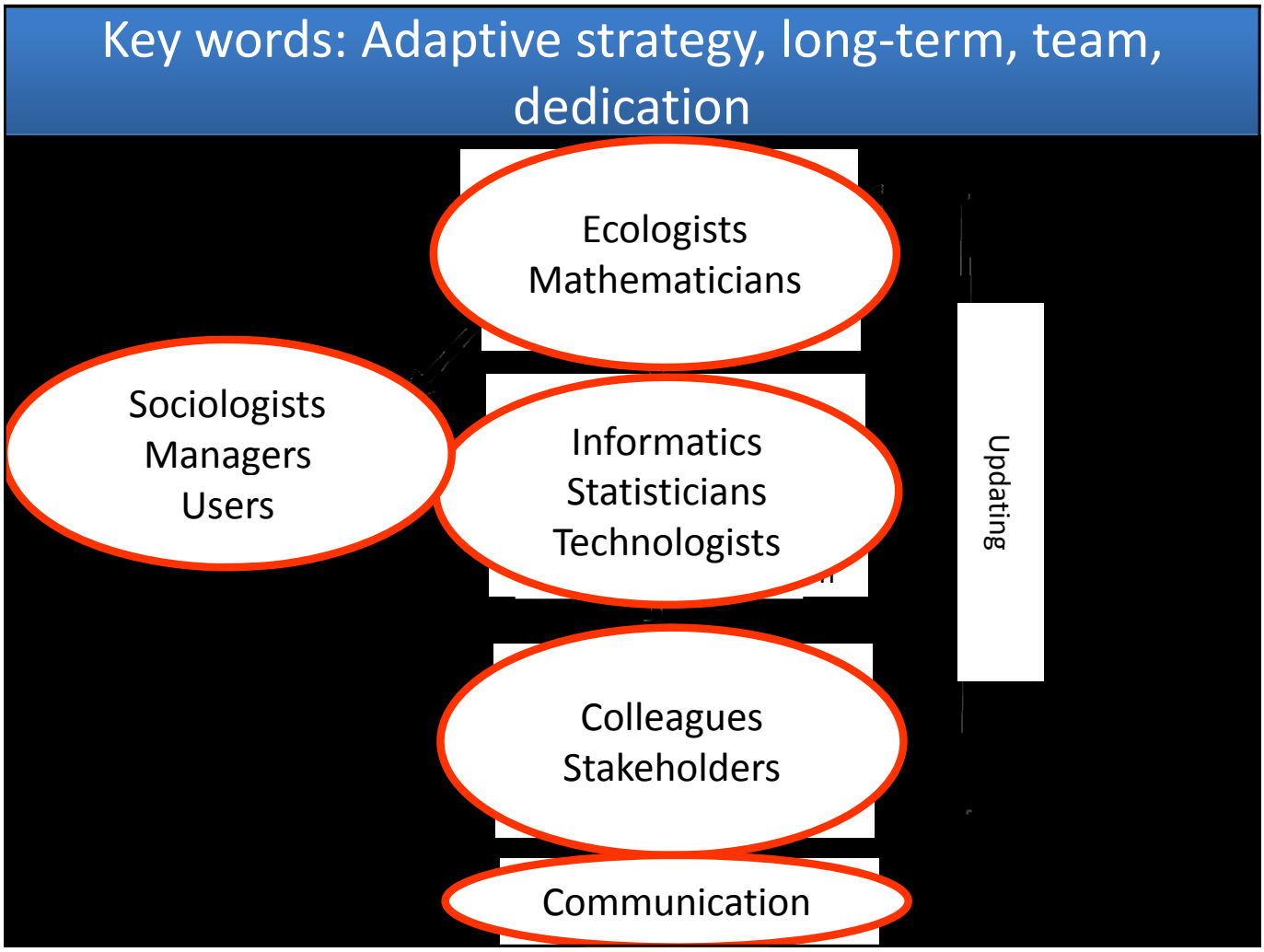
Demands with extreme changes

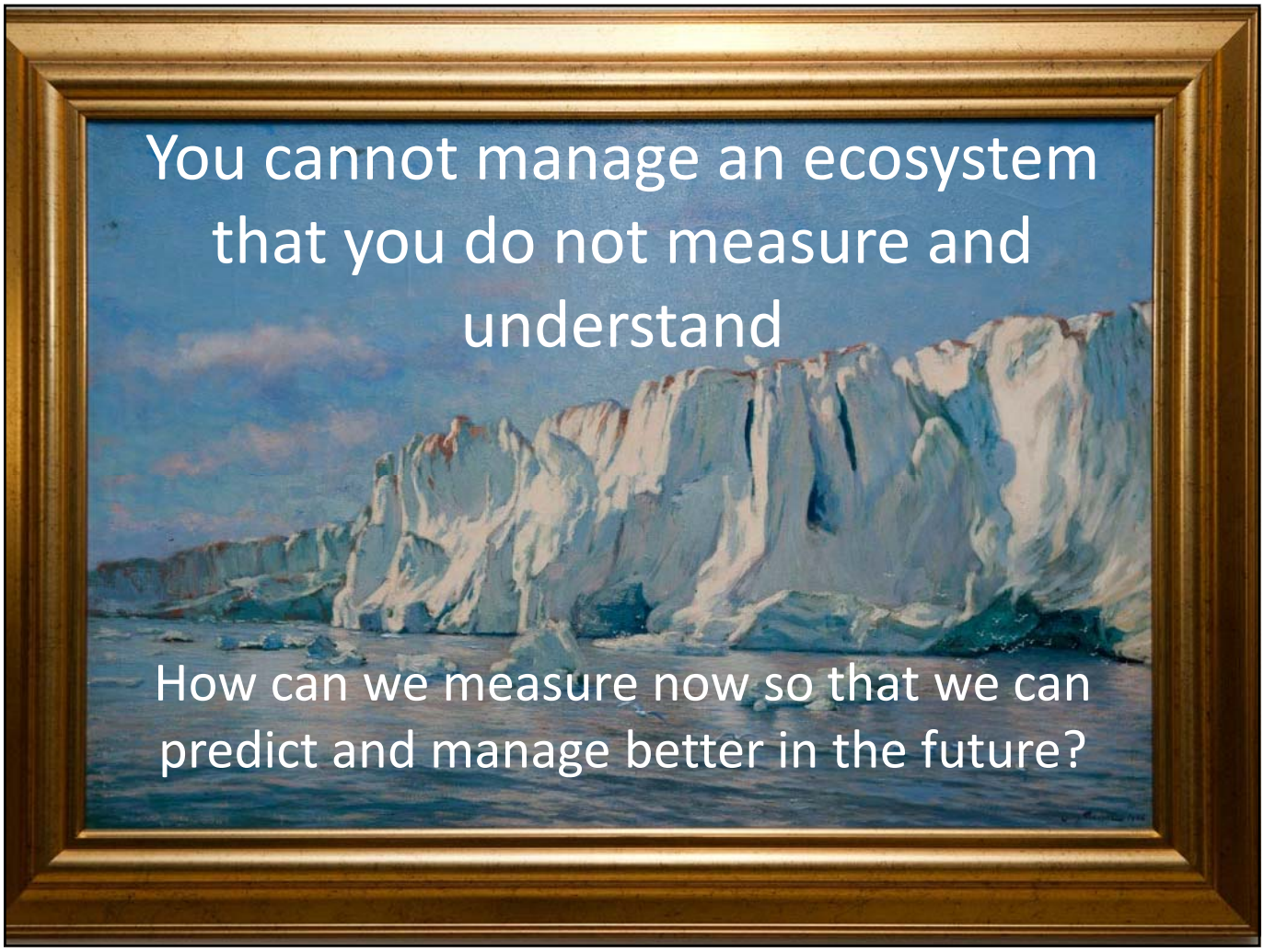
Research of arctic ecosystems ought to change its modus

- More holistic and ecosystem-based than fragmented and indicator based programmes
- Changes in biological resources and diversity happens often through ”cascade effects” along food chains

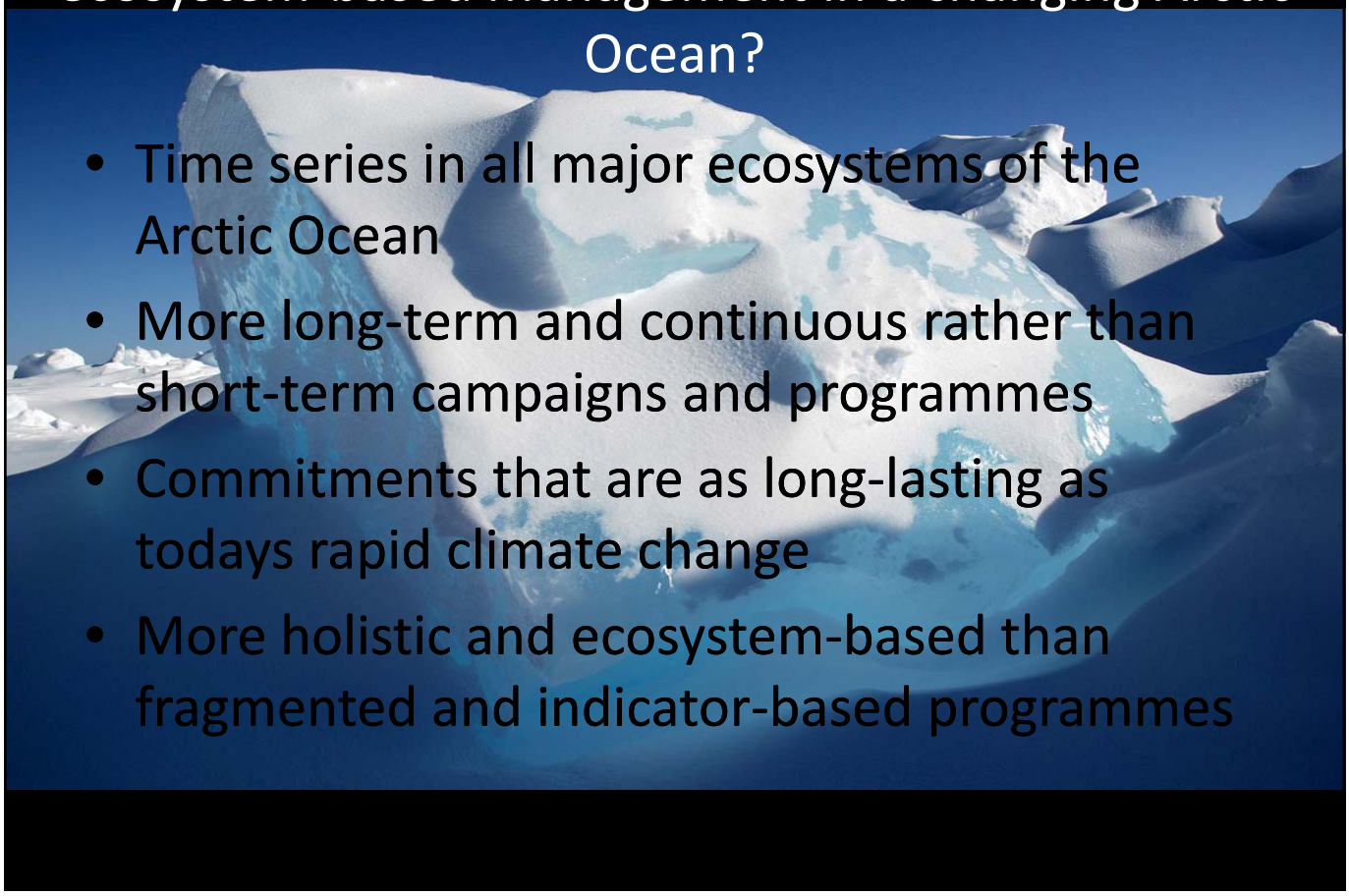
The golden standard of managing rapidly changing ecosystems


Protocol for *Adaptive long-term research*
Models & hypotheses
Prediction
Management measures
Design,
observation &management
Data,
analyses &interpretation
Quality control
Updated knowledge
Publication and outreach
Updating


Key words: Adaptive strategy, long-term, team, dedication
Ecologists
Mathematicians
Sociologists
Managers
Users
Informatics
Statisticians
Technologists
Updating
Colleagues
Stakeholders
Communication


You cannot manage an ecosystem that you do not measure and understand
How can we measure now so that we can predict and manage better in the future?

What do we need before achieving more adequate ecosystem-based management in a changing Arctic Ocean?



- Time series in all major ecosystems of the Arctic Ocean
- More long-term and continuous rather than short-term campaigns and programmes
- Commitments that are as long-lasting as todays rapid climate change
- More holistic and ecosystem-based than fragmented and indicator-based programmes


Thank you!
Photo: A. Sveen