HELMHOLTZ ASSOCIATION

ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Environmental and Ecological Challenges

Session 2: Technological Requirements and Developments

Conference “Developing clean and cost efficient Arctic Trade Routes”
Oslo, 20 November 2014

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Head Technology Transfer

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Bremerhaven, Germany

Outline

- Brief introduction to AWI
- Main Arctic changes under the forcing of global warming
- Challenges for Arctic Activities
- Exemplary innovative approaches (technologies, services,…)
- Specific recommendations of the AMSA Report

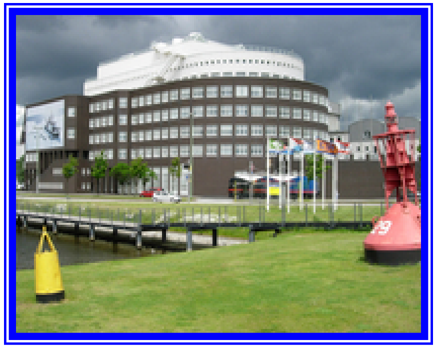
AWI Overview

- 1980: AWI established as foundation under public law
- AWI member of the Helmholtz Association
- AWI Budget >110 m€ p.a.

  90% German Fed. Gov. (BMBF via HGF)
  10% Local States Bremen, Brandenburg & Schleswig-Holstein

  \+ 10-30 m€ third party funding
- \> 1000 Employees
- Research sites in Bremerhaven, Potsdam, Helgoland and List / Sylt

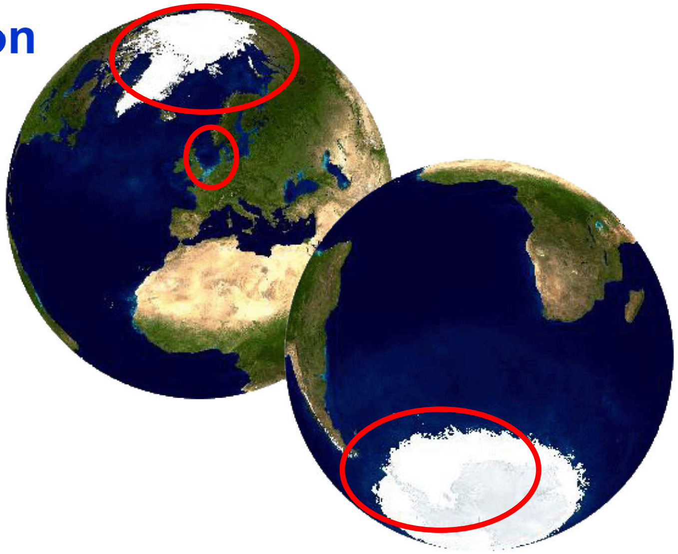
Alfred Wegener
(1880 – 1930)



AWI Primary Task: Basic Research

Climate: Development, Reconstruction, Prediction

- Reconstruction from climate archives (ice shields, marine sediments)
- Comprehension of climate variability
- Models ➔trends, prediction
- Contribution to IPCC Reports



Polar and marine ecosystems / matter cycles, Coastal Environments

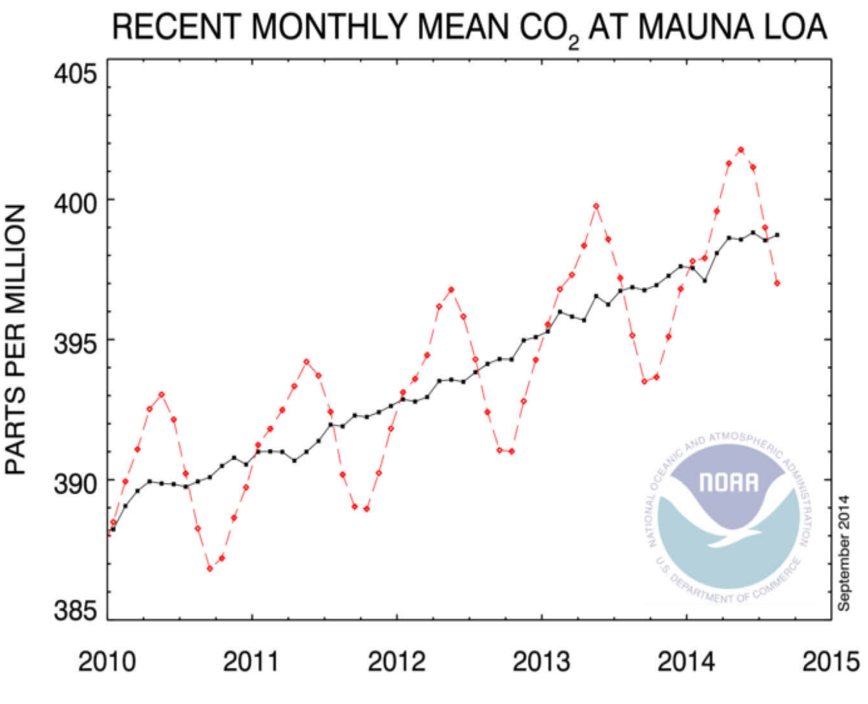
- Function, importance, changes, anthropogenic impact of CO_2 and CH_4 emissions
- Ecosystem functioning, biodiversity
- Ecological accompanying research
- Arctic coastal erosion
- Permafrost research

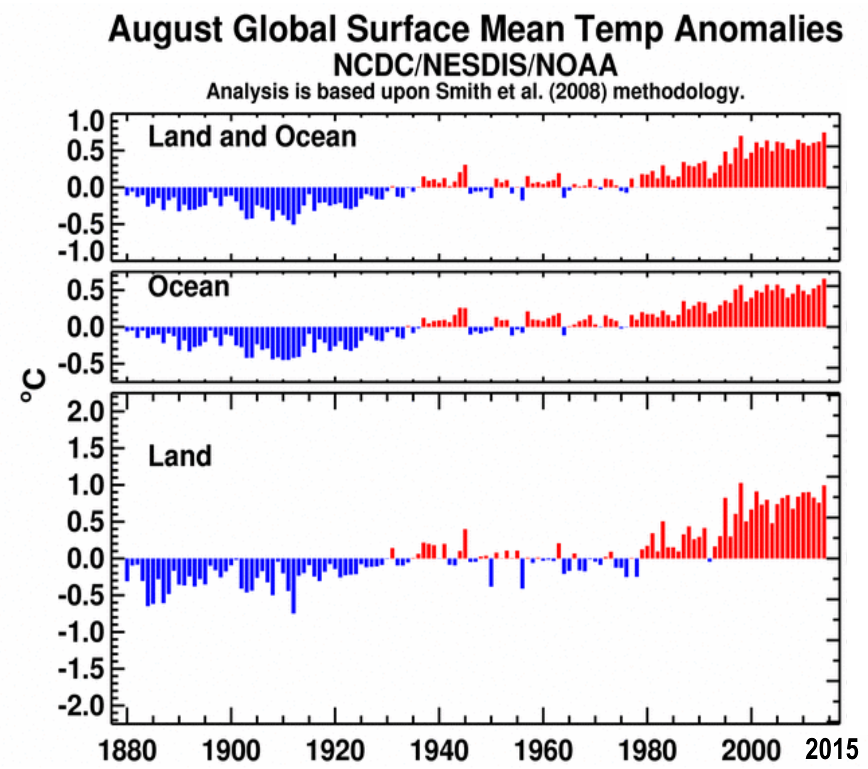
Operation of research infrastructures

Research icebreaker, ships, airplanes, polar field stations

Knowledge and technology transfer into the society

CO_2 ↗





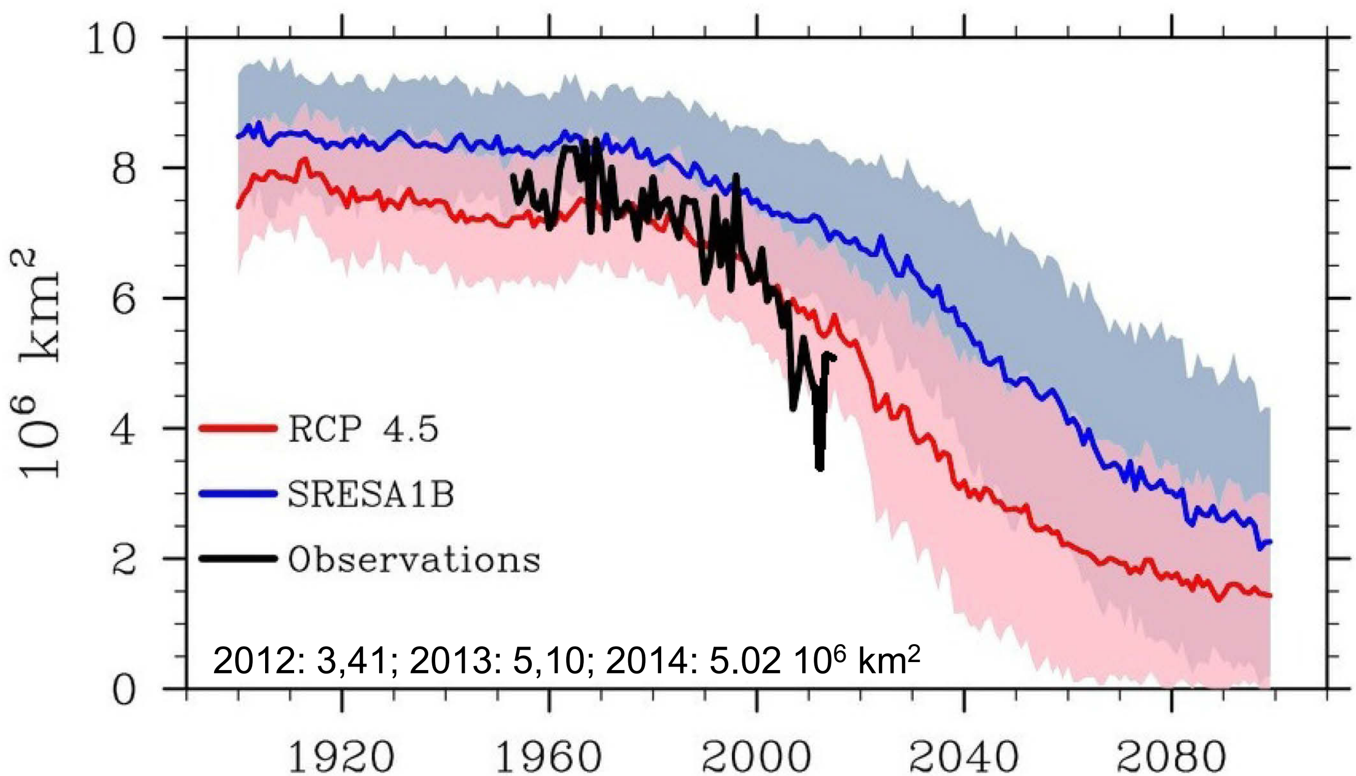
Monthly atmospheric CO_2 concentration measured at Mauna Loa Observatory, Hawaii

Red: monthly mean walues
Black: monthly means less average seasonal variation

Main heat uptake by the ocean!

Sea Ice Retreat

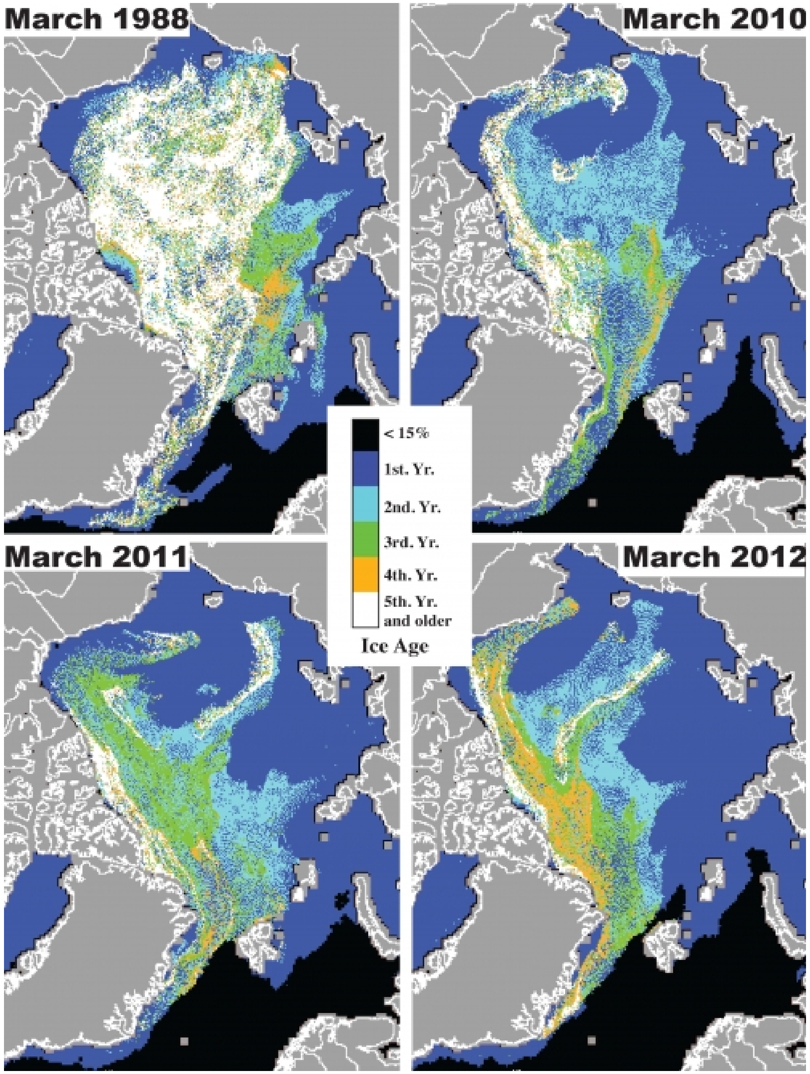
- After the minima in Sept. 2007 and 2012 larger the sea ice extend was observed in 2013 and 2014
- Regional differences in sea ice distribution (less ice in European sector (ice edge at 85°N), more off Canada)

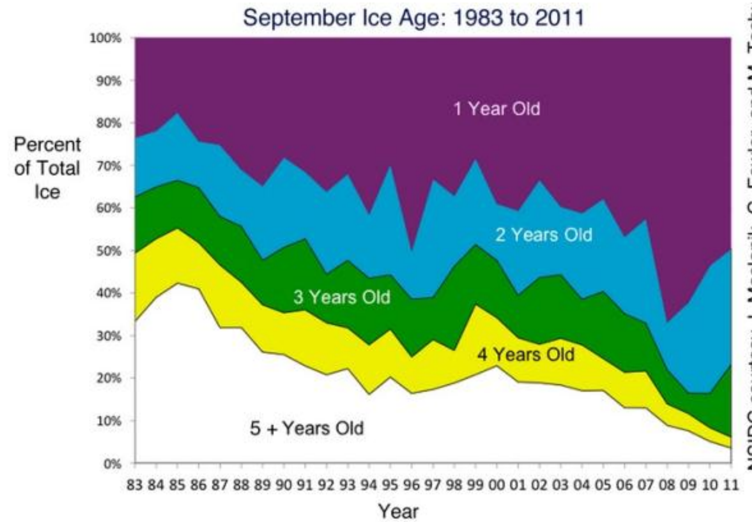


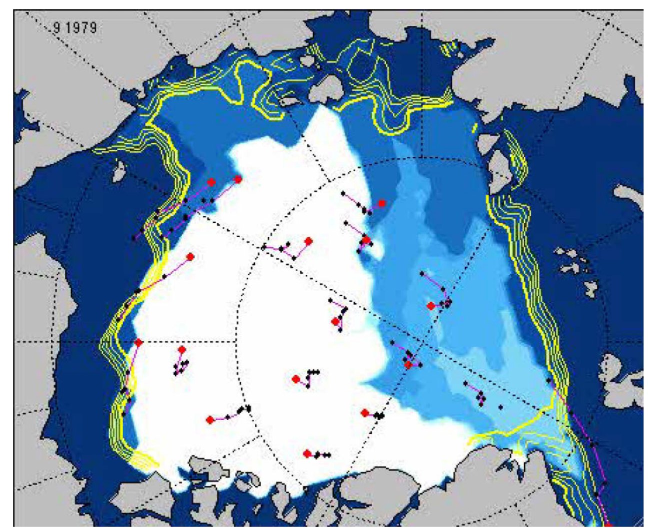
Modified from Stroeve et al. 2012 (National Snow and Ice Data Center)

Decrease of Multi Year Ice

Source: NOAA / Richter-Menge and Farrell, GRL, 2013

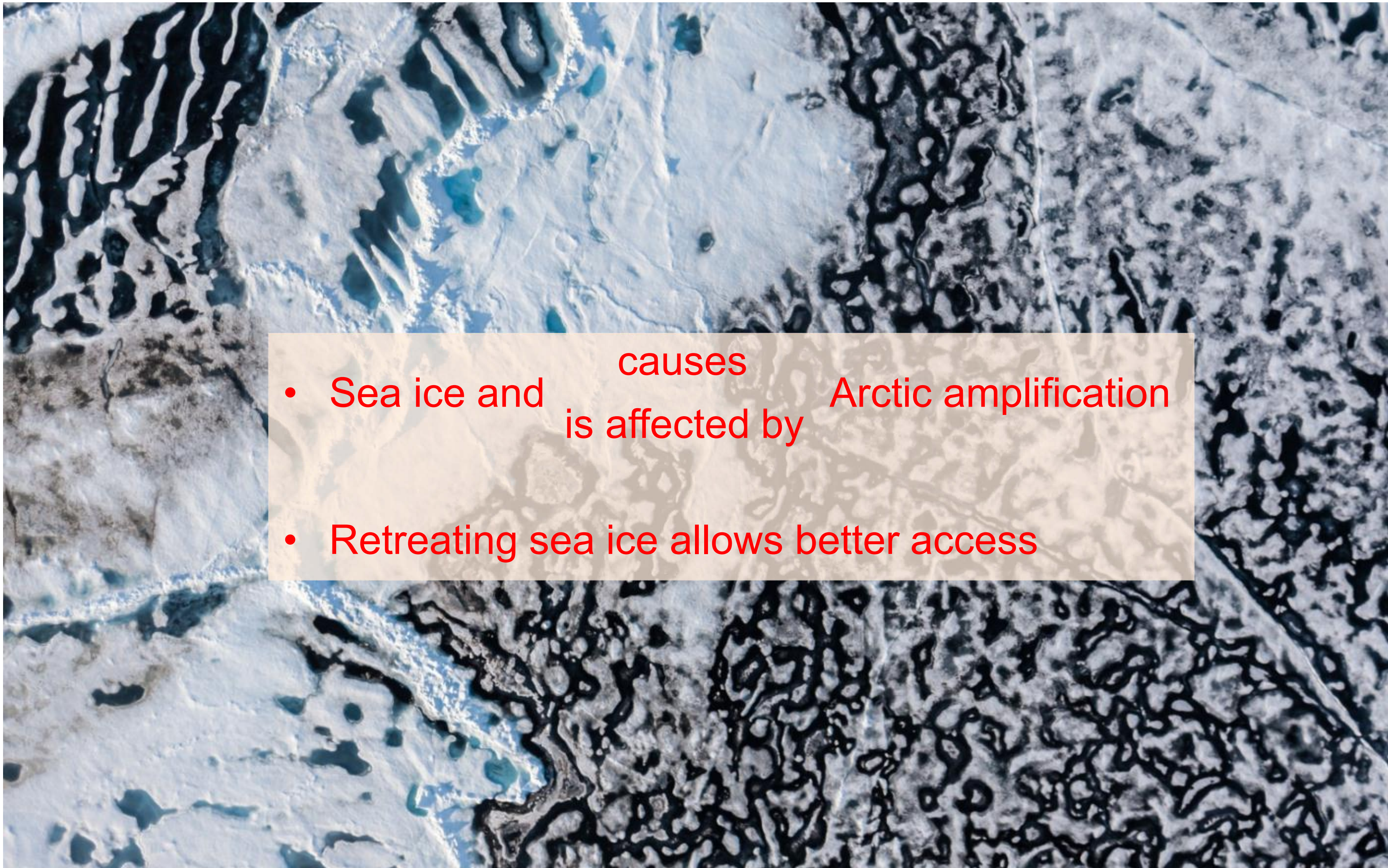






Rigor and Wallace, GRL, 2004

Why is Sea Ice Important?

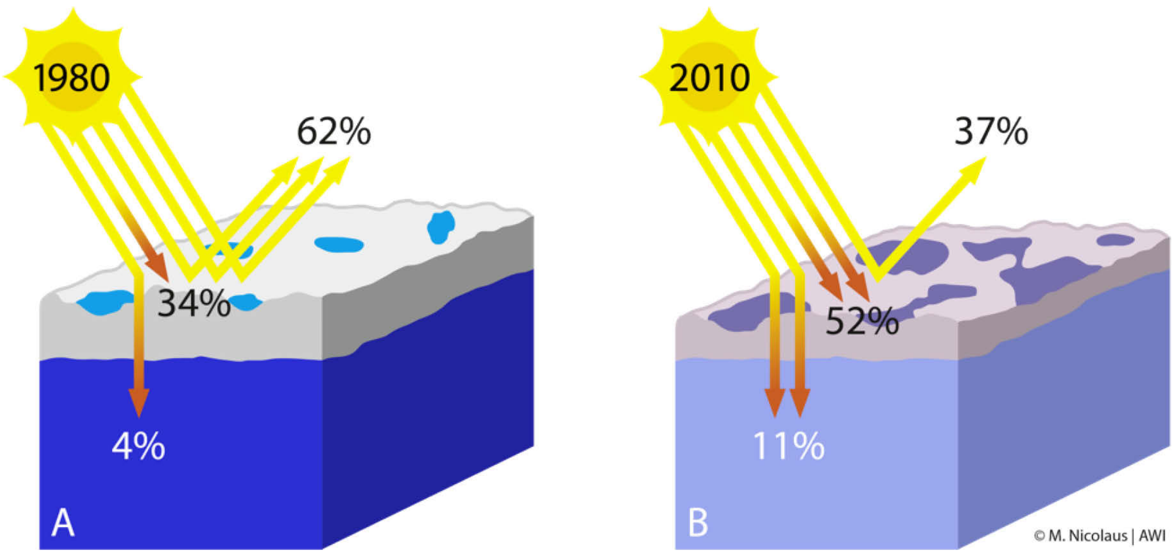


- Sea ice and causes / is affected by Arctic amplification
- Retreating sea ice allows better access

Energy Budget and Feedback

Effects of (changes in) surface properties (e.g. melt ponds)

- 2–3 times more light transmission
- 50% more absorption / reduced albedo
- Thin, first-year ice has increased by 50% ➔ positive feedback

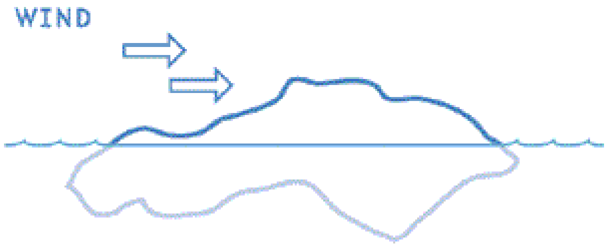


Fractions of solar radiation: Reflected, absorbed, transmitted (Nicolaus *et al.*, 2012, modified)

Sea Ice Dynamics

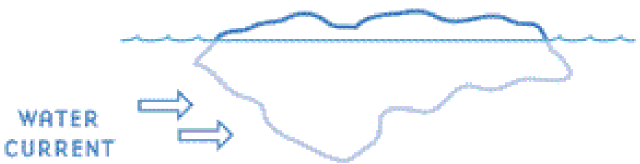
Although the Arctic sea ice cover opens up during summer, navigation through pack ice and drift ice is still risky since pack ice fields may be in motion forced by wind stress and currents.

Wind stress



- In the absence of other forces, open pack ice will typically move at a speed equivalent to 2% of the wind speed.
- Wind stress dependent on ridges and hummocky areas

Currents



- Permanent currents (large oceanographic features)
- Periodic currents (e.g. tides)
- Temporary currents (e.g. wind induced)

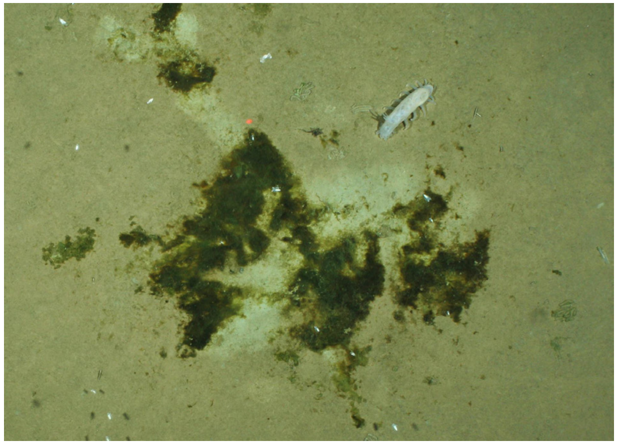
Source: Environment Canada

Algal Growth under Sea Ice

- Increased irradiance under sea ice increases algal growth
- Melting of sea ice releases under-ice algae (Melosira arctica) which rapidly sink to the sea floor
- Deep-sea bacteria and benthic organisms consume the increased flux of organic material to the deep Arctic Ocean

➔ The warming climate influences the entire ecosystem from the sea ice to the deep Arctic Ocean.

Melosira mats under sea ice



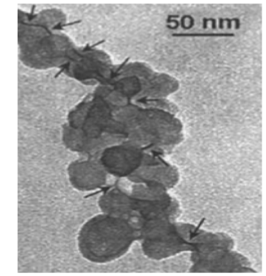
Algal patch in >4000 m depth

Boetius et al. (2013) Science 339: 1430-1432.

Black Carbon (BC) Emissions

- BC originates from incomplete combustion of fossil fuels and biomass burning (particle size: 20-800 nm)
- BC is a strong absorber for visible light ➔ deposits on sea ice
  - ➔ increase heat absorption
  - ➔ decrease surface albedo

  } positive feedback

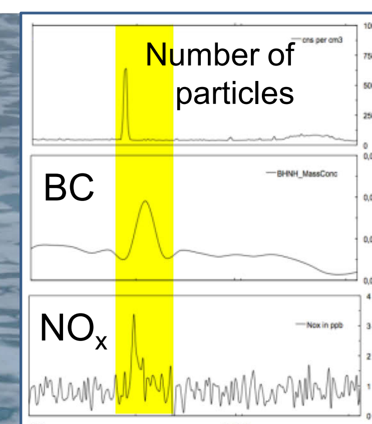


BC particle
[Posfai et al., 1999]

Very limited data available for the Arctic
➔ more observations and modelling needed

AWI Polar 6 meets CCGS Amundsen on July 2014 during NETCARE
(Network on Climate and Aerosols: Addressing Key uncertainties in Remote Canadian Environments)

photo: M. Levasseur, NAVAL



(1) Challenges – Arctic Research

- Changes in the Arctic are caused by and affect global climate change. A comprehension of the complex sub-processes needs **regional and global investigations**.
- These challenges require **internationally coordinated research** in the Arctic.
- **Joint use of large infrastructures** and the development of coordinated strategies is essential.
- **Trans-disciplinary** research is needed including natural, social and economic sciences
- There is a need for **year round observations,** and for integrated **environmental monitoring** and **modelling** systems
- What is the **role of science** amongst other stakeholders (governments, private sector, NGOs)?

Example: Observatory FRAM / SIOS

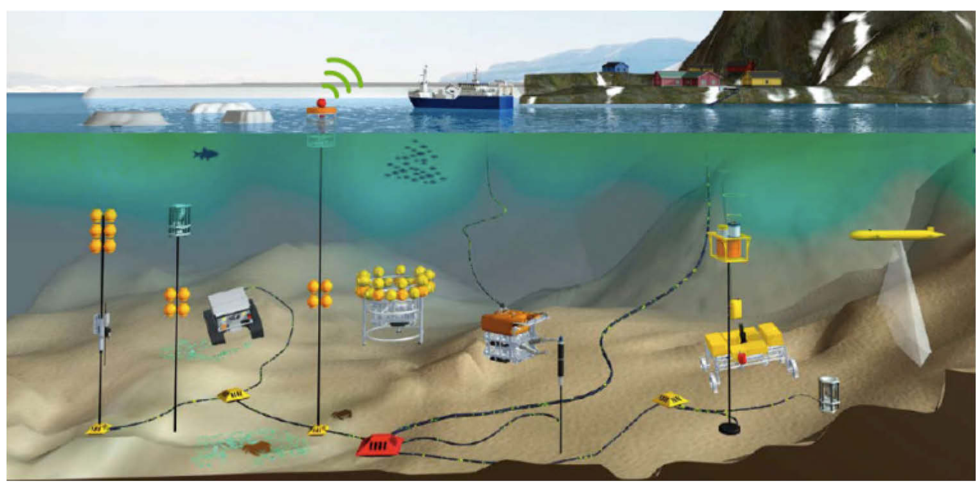
FRAM: FRontiers in Arctic marine Monitoring

SIOS: Svalbard Integrated Earth Observing System

- continuous, near real-time observation and data (no more "hit and miss“)
- better possibility to record short-term events
- better understanding of cause/effect relationships

This growing observatory links numerous European and international research projects and programs (EMSO, SIOS, SAON)

However, continuous sampling / real time observation is still limited



Example: Arctic Research Icebreaker Consortium for Europe ARICE

AWI

Development of a European / international network for joint operation of research icebreakers in the Arctic Ocean.

➔ Better coordination and more efficient use of available ice breaker capacities and ice-strengthened research vessels in Europe

➔ 20 partners from EU, US and Canada are interested.

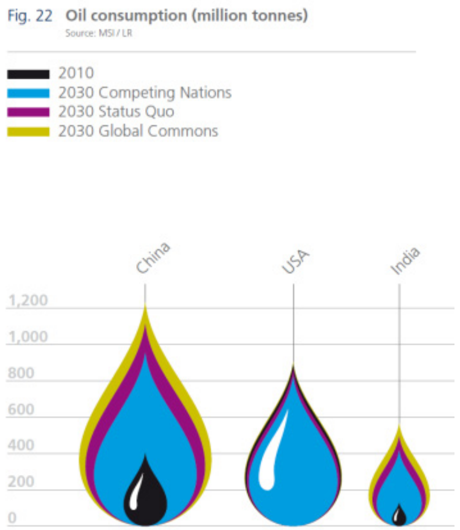
➔ More winter expeditions

Additional capacities are offered within the Polar Call of **EUROFLEETS II**

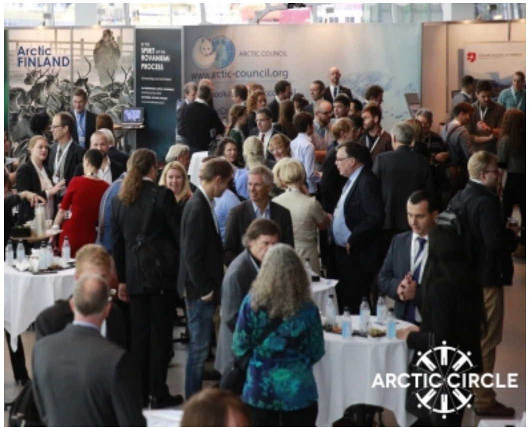
(2) Challenges beyond Arctic Research

- Most **changes** taking place **in the Arctic** are **caused** by demands and processes **outside the Arctic**.
- Vice versa, **changes in the Arctic** will **affect areas outside the Arctic** – climatically, economically, politically.
- **Economic activities will increase in the Arctic**, resources will be exploited – the questions are: how, and when will it happen, who will benefit, will it be **sustainable and environmentally compatible?**
- All relevant **stakeholders have to be involved** to design appropriate boundary conditions for a sustainable development of the Arctic
- **Decision makers need reliability** in respect to physical and legal **boundary conditions**

➔ For this reason **the trans-sectoral dialog** between science, industry and politics needs to be intensified

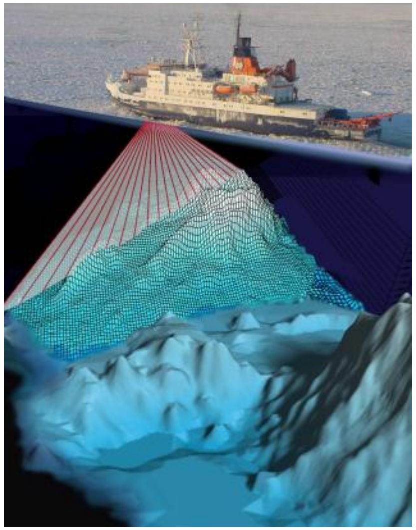


Source: Global Marine Trends 2030 by Lloyd's Register, QinetiQ and University of Strathclyde.



(3) Technological Challenges

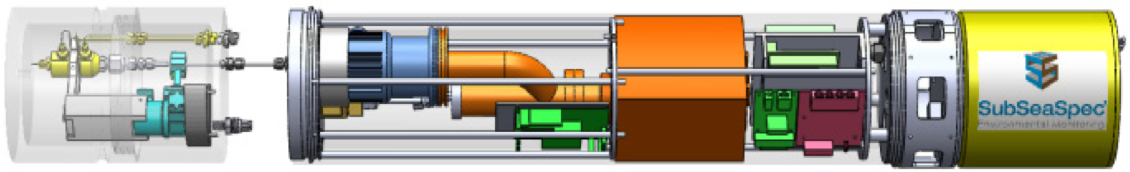
- **Knowledge** and **technological innovations** have to be transferred / exchanged multi-directionally between sectors / stakeholders
- Relevant **data** have to be accessible / shared in a reasonable / fair mode
- Best knowledge and available technology (in terms of sustainability) has to be considered in the context of **standardization**
- Also **small & medium enterprises** are to be involved appropriately in the **value chains** since they mostly are flexible and innovative.
- Fair IP sharing / exchange models have to be applied / developed



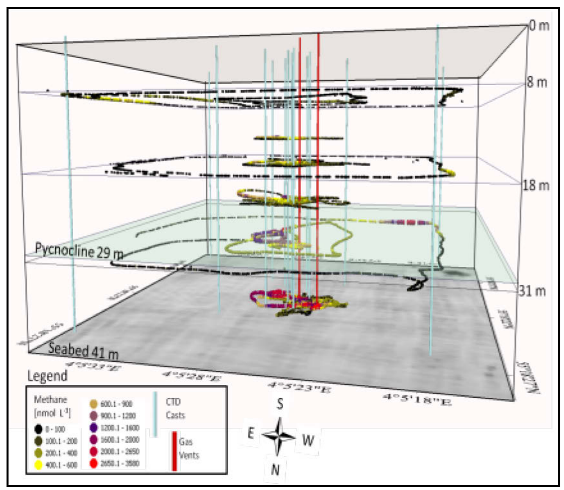
Example: Innovation for Environmental Monitoring

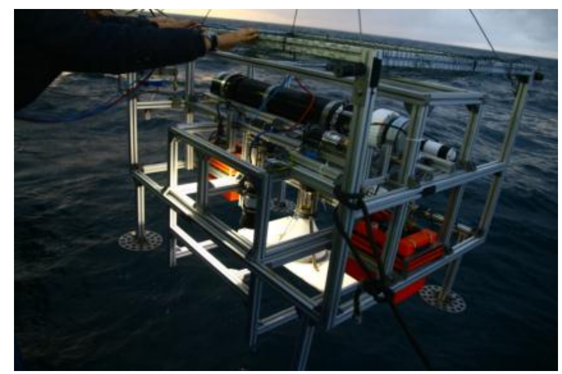
Underwater mass spectrometer for multiple near real-time analysis of dissolved matter ➔ AWI spin-off company in preparation

SubSeaSpec®
Environmental Monitoring



Either used in UUVs …





… or stationary

For environmental monitoring or exploration.

Example: Polar Services, Ice Information System

AWI Spin-off Drift & Noise Polar Services GmbH

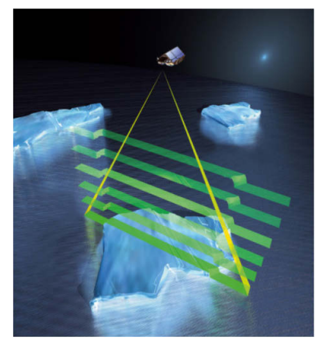
www.driftnoise.com

DRIFT & NOISE
POLAR SERVICES

Satellite Remote Sensing

- Near real-time information service optimized for high latitudes
- Minimizing requirements for operators in the Arctic (low-bandwidth data connection)
- Support for European Copernicus Services

➔ **Hazard awareness for stakeholders**

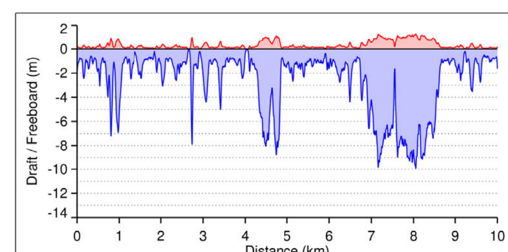


Airborne
EM measurements

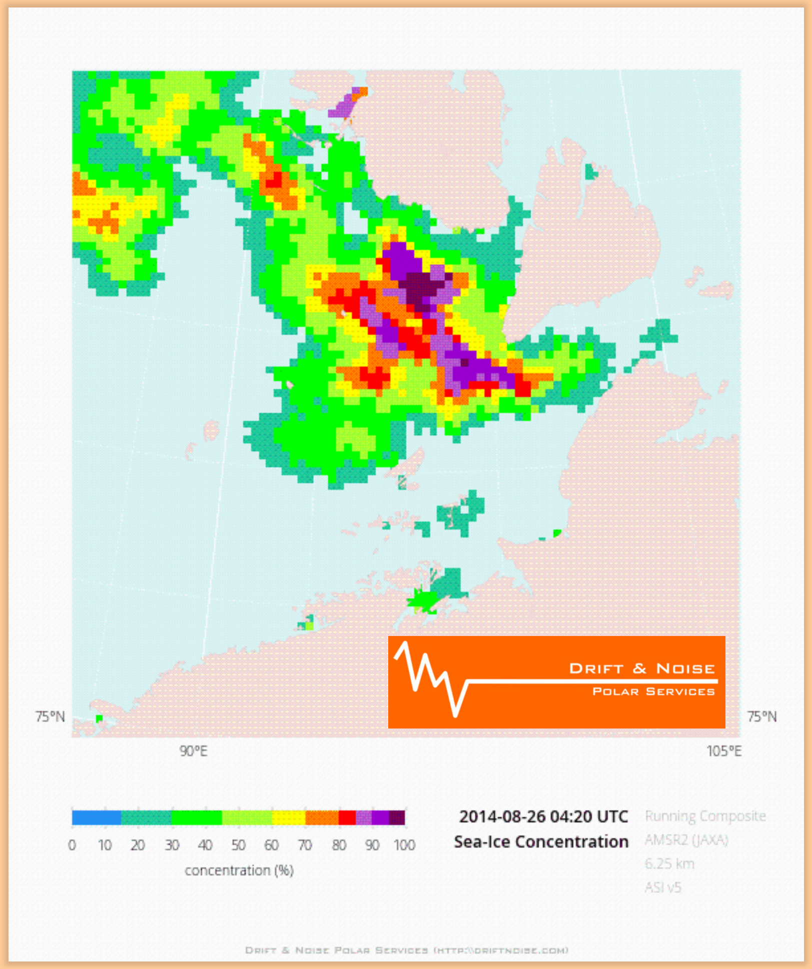
Sea Ice Geophysics

- Geophysical sea-ice thickness information
- Operationalize techniques from climate research
- Baseline information for ship designs and operation planning

➔ **Risk analysis based on best available technology**



Example: Polar Services, Ice Information System



Example: Vilkitsky Strait in North East Passage

OSSI – On Site Sea Ice Information

- Sea ice information service for **low bandwidth** data connections
- Suitable for research activities and operators (**shipping, tourism**) in high latitudes

Developed **from climate data sets** and optimized **for operational needs**

OSSI – Open Data Portal

http://www.driftnoise.com/data-delivery.html

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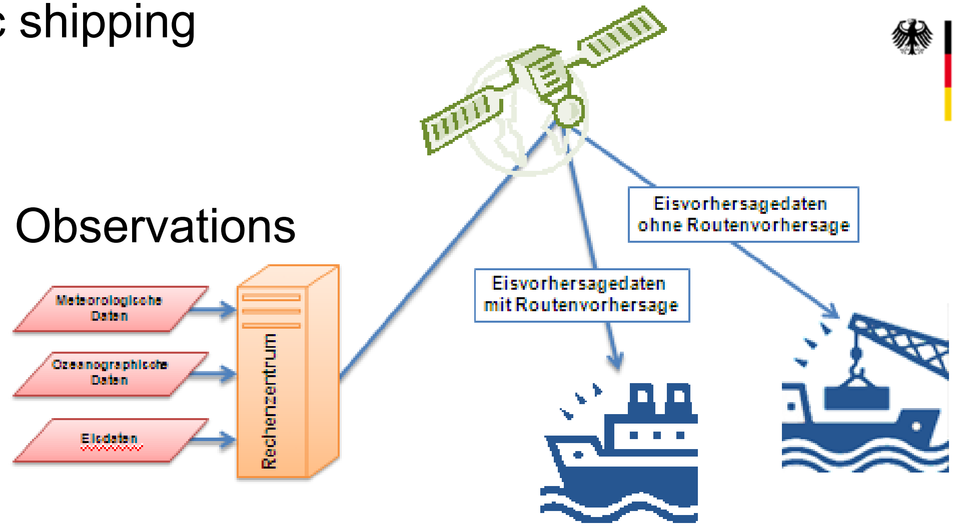
Example: Project Ice Route Optimization

Bundesministerium für Wirtschaft und Technologie

Services to support safe Arctic shipping

potential clients:

- Shipping Companies
- Offshore Production
- Offshore Exploration



IRO2 Objectives

- Large scale ice forecast for the entire Arctic
- Fine scale ice forecast for 3-5 days in advance and 6 hours actualization frequency with spatial resolution of ~2.5 x 2.5km
- Special route optimization for ships of different ice classes and different ice formations
- Display of optimal ice routes and ice conditions in ECDIS conform data format

IRO2 Partners:

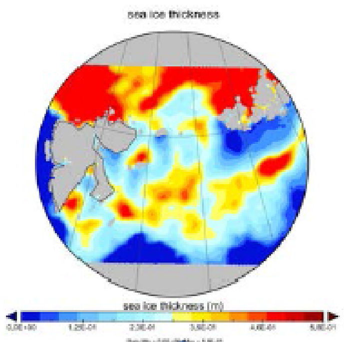
IRO2 - Safe Shipping in the Arctic

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

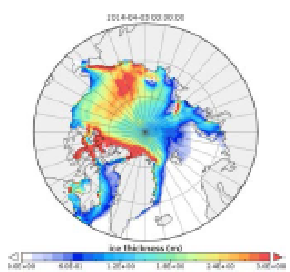
Ice Forecast HAMMER

NetCDF File
ice data
grid:
time step: 0.25h

route optimization



Data Assimilation ICEDAS



RT3 File
route data
(waypoint list,
speed)

ENC Software

2014 test cruise with Norwegian RV Lance

O.A.Sys Ocean Atmosphere Systems

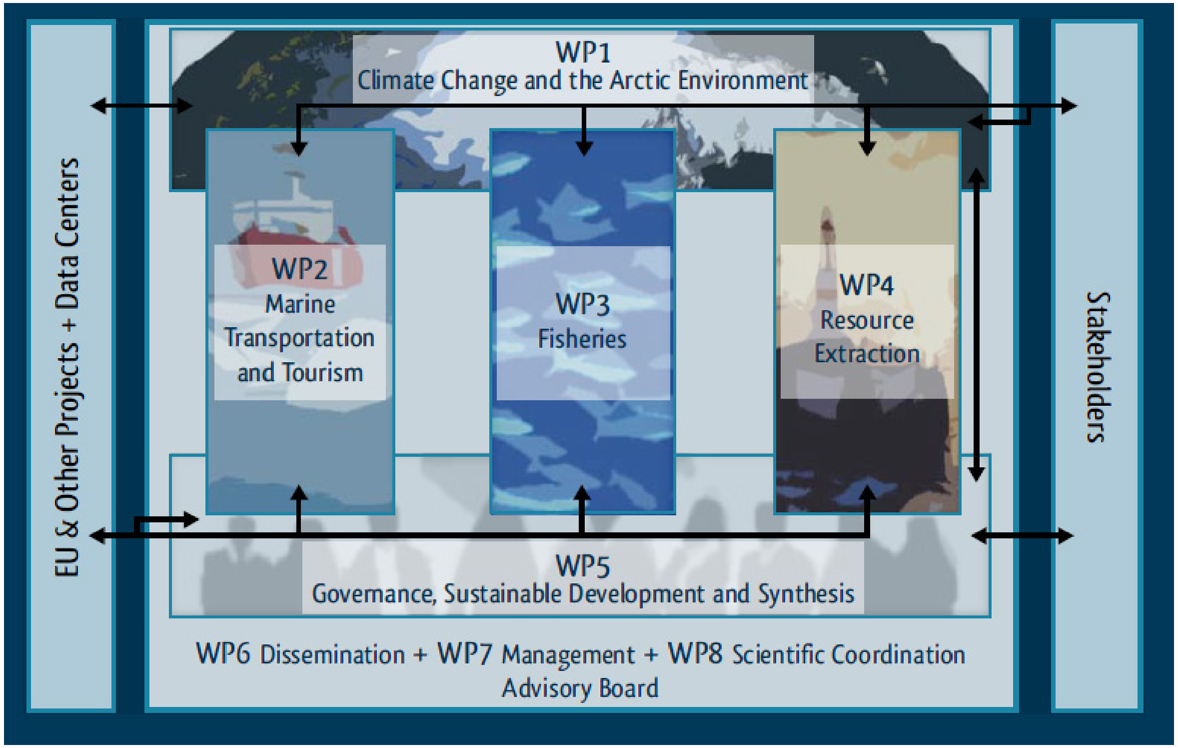
AWI

from N. Reimers, HSVA

Example: Multi Stakeholder Project ACCESS

Arctic Climate Change, Economy and Society

(➔ Presentation of J. Schwarz)



SEVENTH FRAMEWORK PROGRAMME

Ocean of Tomorrow call of the European Commission Seventh Framework Programme

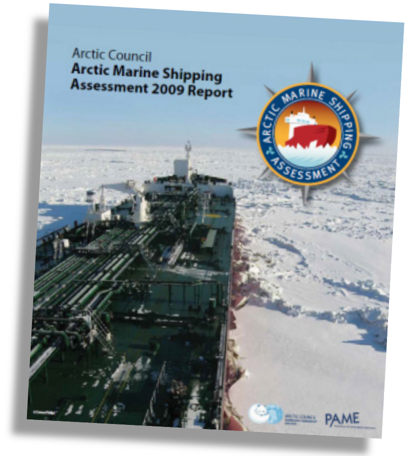
ACCESS
Arctic Climate Change Economy and Society

(4) AMSA Recommendations

AMSA: Arctic Council - Arctic Marine Shipping Assessment (Report 2009)

I. Enhancing Arctic Marine Safety

- Close linkage between IMO, IHO, WMO etc.
- Augment global standards, guidelines and governance instruments by appropriate specific issues of Arctic shipping
- Develop an Arctic SAR system including cruise ships



II. Protecting Arctic People and the Environment

- Establish appropriate instruments for the involvement of Arctic local communities (incl. indigenous peoples)
- Designate “Special Areas” or Particularly Sensitive Sea Areas (PSSA)
- Join forces to prevent oil spills, invasion of non-Arctic species and to minimize ship’s emissions and impacts on marine mammals

III. Building Arctic Marine Infrastructure

- Improve Arctic marine infrastructure
- Create pan-Arctic and national vessel traffic monitoring incl. exchange of data
- Establish appropriate forecast systems incl. hydrographic, meteorological and oceanographic information


Thank you for your attention
www.awi.de