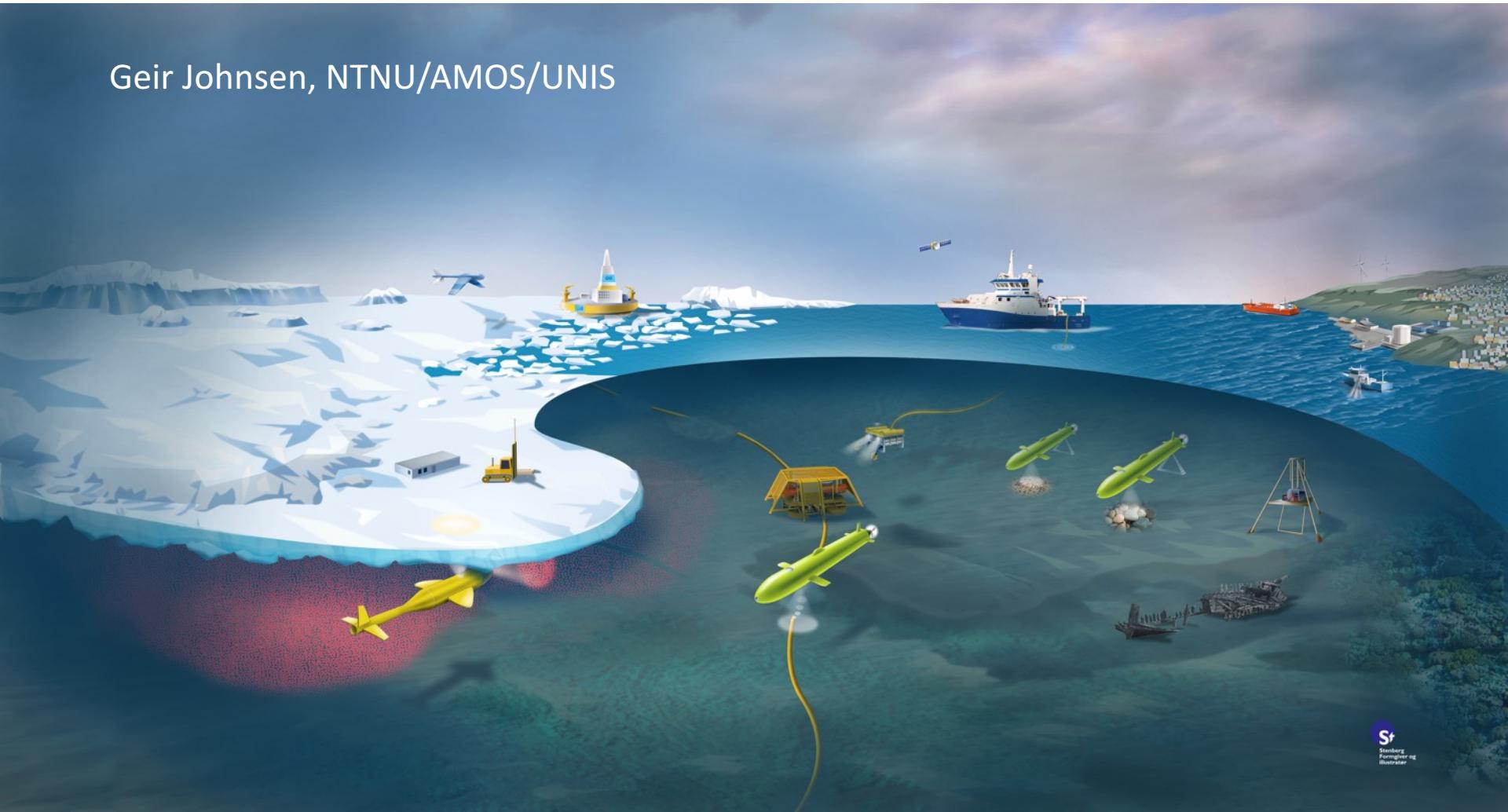


Kunnskapsgenerering, karlegging og overvåking i nordområdene med autonome systemer

Geir Johnsen, NTNU/AMOS/UNIS





Overview:

- Sensor platforms (instrument carriers): Landers, ROV, AUV, USV, Gliders, drones)
- Data collection: Space (spatial resolution) and time (temporal resolution)
- Examples of mapping from sea surface, water column and sea bed.

Key words:

Enabling technology and marine science

Provide new knowledge for nature management and decision making.

NTNU in Nansen Legacy (AeN, 2017-21, 750 mNOK)- National team

Enabling technology for marine science

Key environmental variables

Ecology & physiology of phyto- and zooplankton

Photo-biology of phyto-zooplankton

Nutrient dynamics

Marine chemistry

Ice and current dynamics

Autonomous platforms and sensors

Communication

Management

Environment

Security

Innovation

Outreach



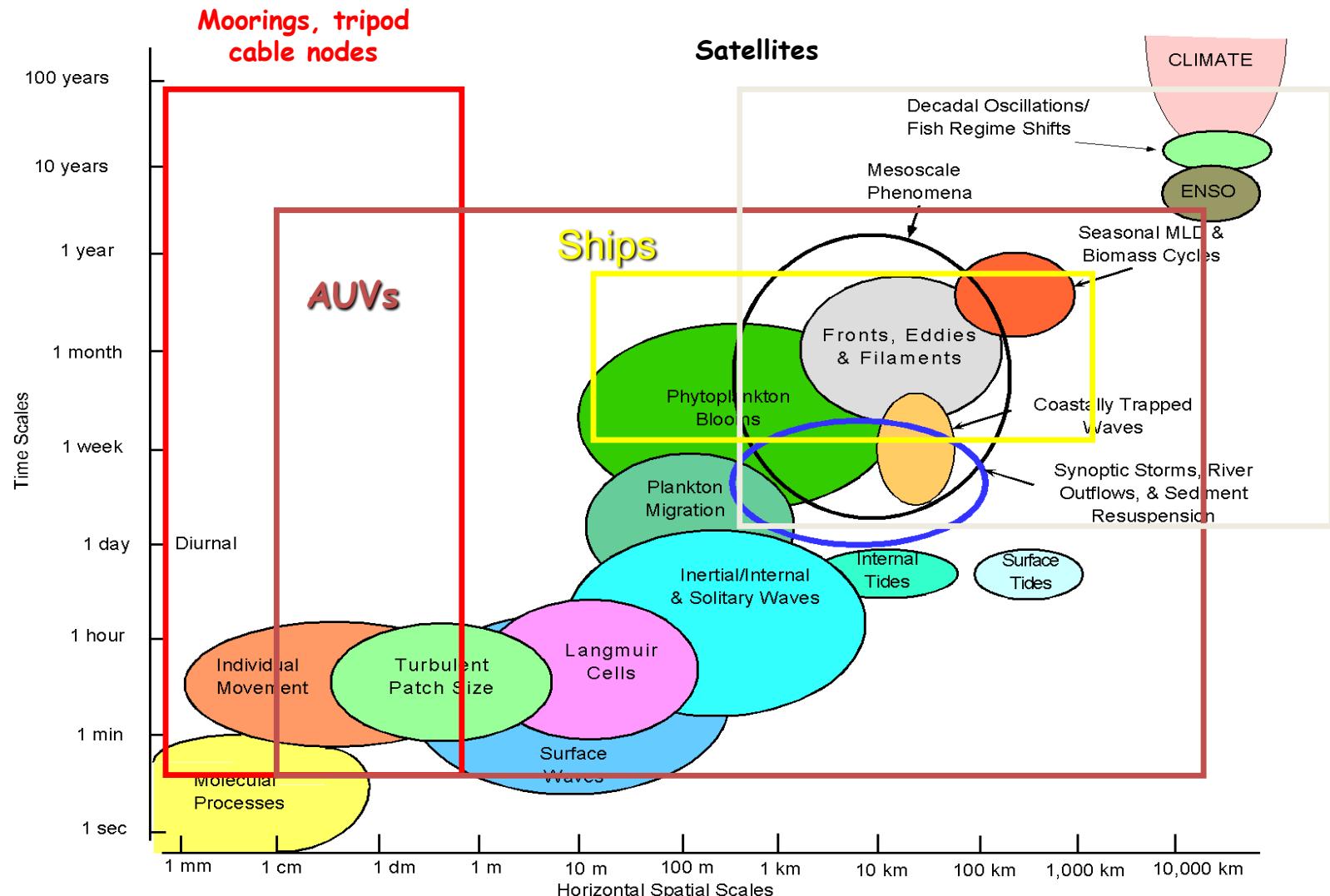
Coordinate these activities with on-going activities in:

NTNU Applied Underwater Robotics laboratory

CeO AMOS (Autonomous Marine Operations and Systems)

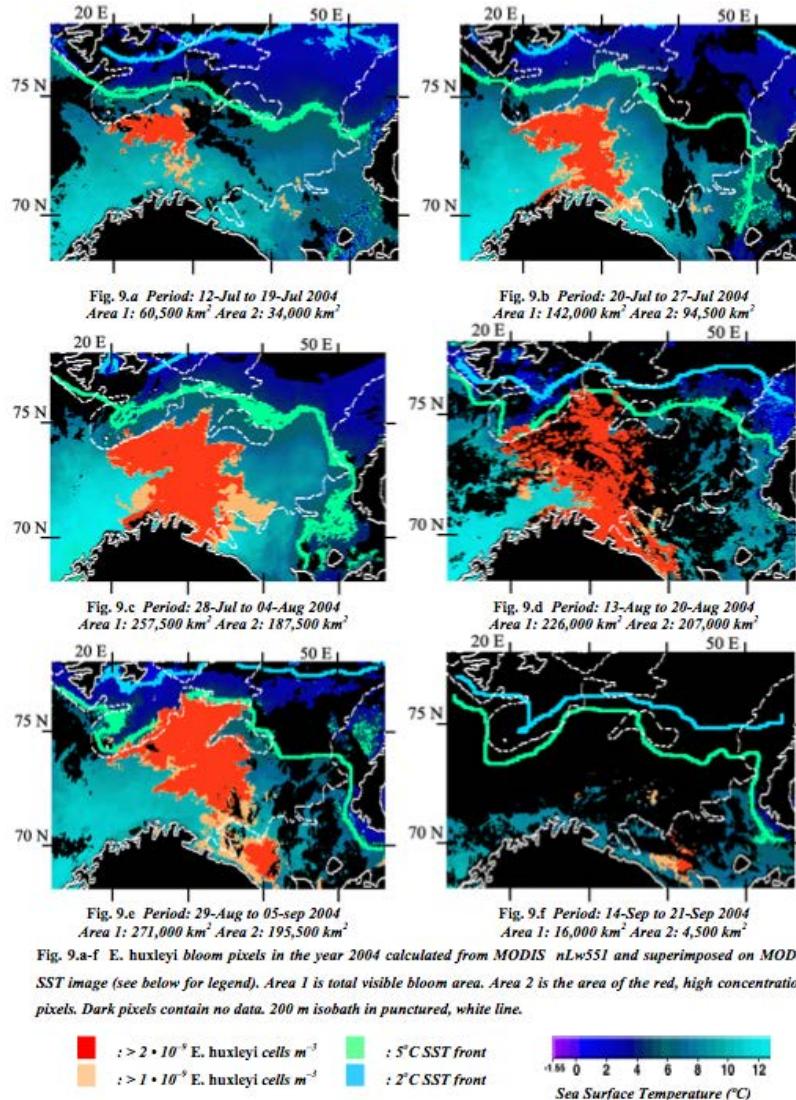
NRC projects Arctic ABC (science) & Arctic ABC-Development (Infrastructure)

Major challenge in marine science & ecosystem management: Sample across appropriate scale (time and space).



The process of creating knowledge, maps of OOI for monitoring purposes

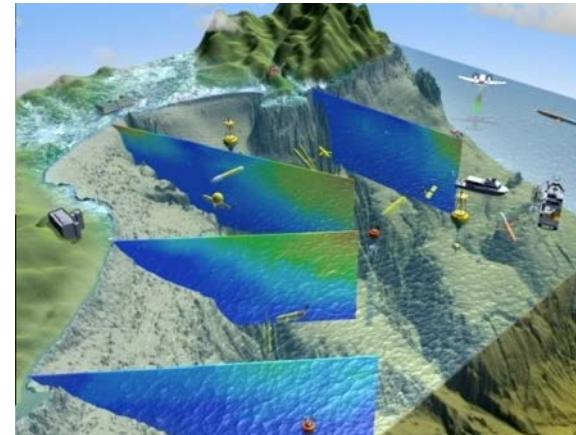
E. huxleyi bloom in the Barents Sea - 2004



Verification of remotely sensed data:
What about the "unseen" below the surface:

AUV and gliders can provide 3D data
of chl a, coccoliths, TSM, cDOM at

Surface and water column



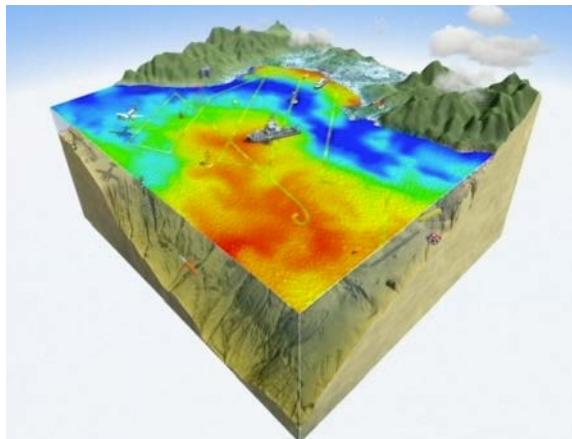
From PhD thesis, EK Hovland (NTNU) Bio-optics and ecology in *Emiliania huxleyi* blooms: Field and remote sensing studies in Norwegian waters".

Examples of underwater robot platforms:

Surface:

Satellites & airplanes

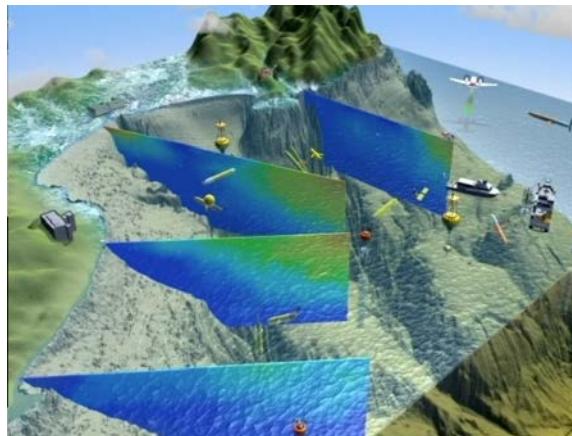
Multi- & hyperspectral imagers



Water column:

AUV and gliders

Acoustic, chemical & optical sensors



Sea floor:

ROV, AUV, crawler & lander

Acoustic & optical sensors



3 D coverage:
Bio-geo-chemical OOI:

Physics (eg. T, S, D, E)

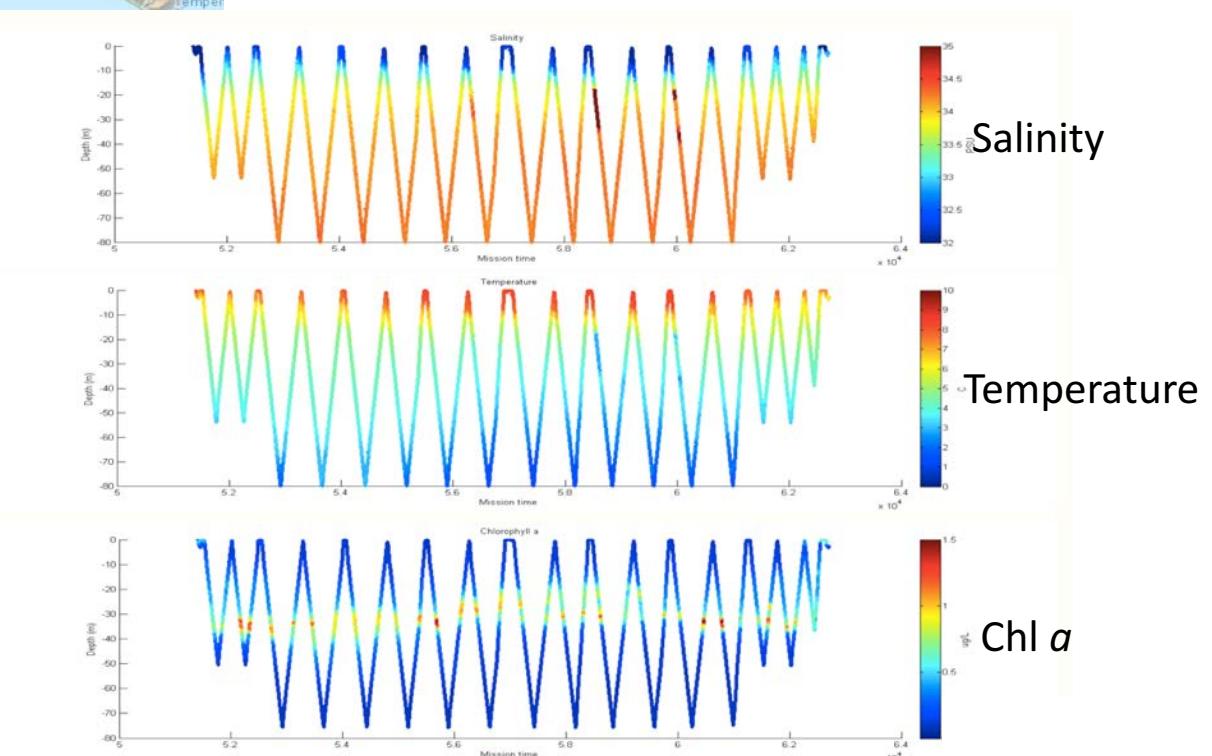
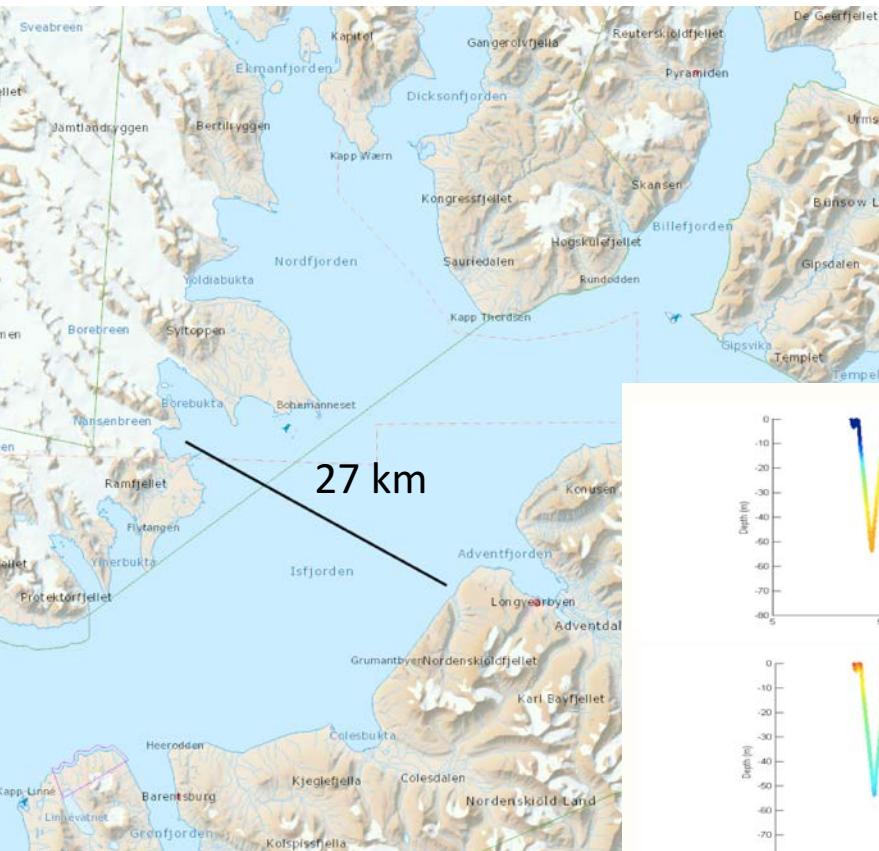
Chemistry (O_2 , CO_2)

Biology (plankton & benthos)

Geology (habitat, substrate & minerals)

Images: By permission of MBARI

AUV data of S, T & Chl *a* during a transect across Isfjorden, Svalbard



Applied Underwater Robotics Lab – NTNU (2011-)

A child of the strategic programme Marine Coastal Development (2000-12) and NORUS (2009-11)

Co-operation between marine technology and science

Ocean Space Research

Marine surveillance systems

Energy from the ocean

Marine ecosystems

Eco-toxicology

Marine archaeology and cultural history

Coastal zone development and infrastructure

Infrastructure

RV Gunnerus

Trondhjem Biological Station

Marine Technical Laboratory

ACE

NTNU and SINTEF Sealab



GLIDER - NORTHERN MOST DEPLOYMENT

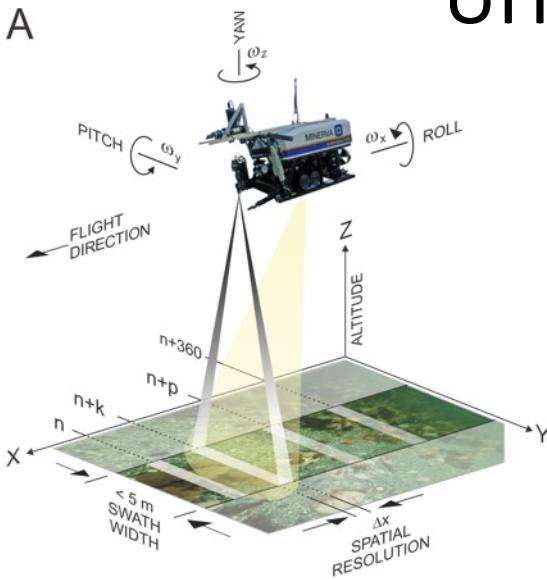


AUV - REMUS ACROSS ISFJORDEN



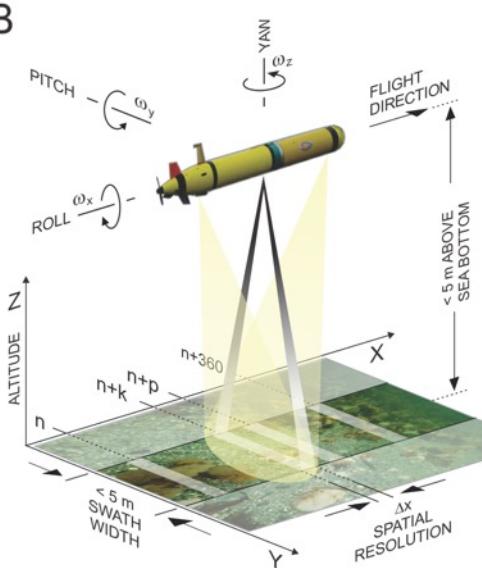
UHI underwater platforms

A



ROV – start building UHI Dec 2011 – 1 st survey April 2012

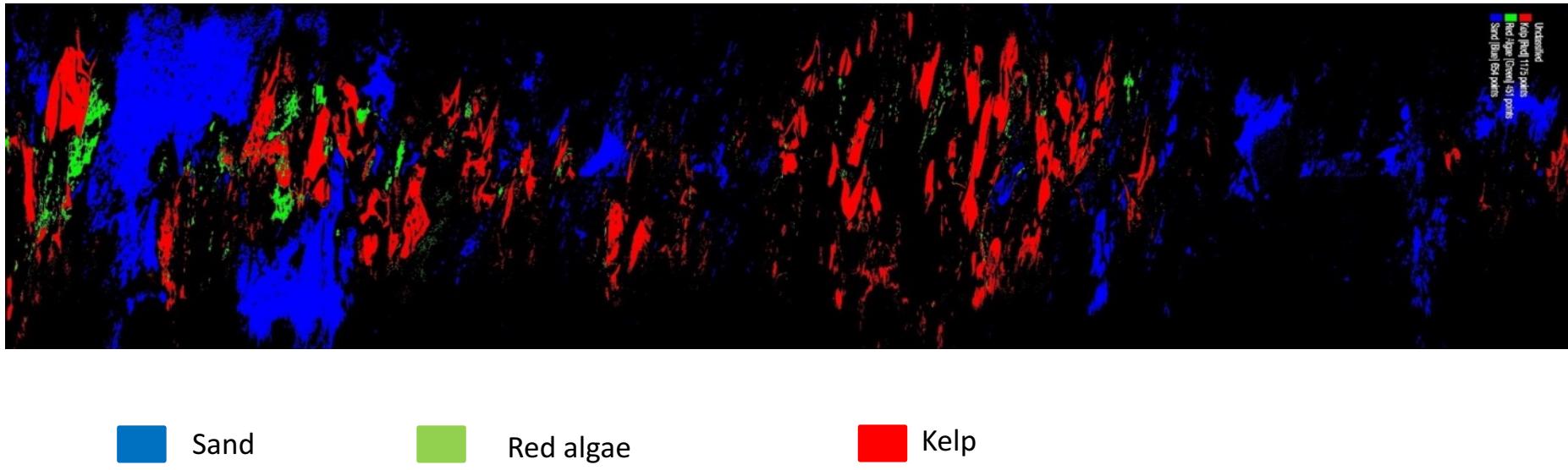
B



AUV – new UHI version in 2016 for HUGIN AUV

Johnsen, G., Volent, Z., Dierssen, H., Pettersen, R., Ardelan, M. V., Søreide, F., Fearn, P., Ludvigsen, M.A., Moline, M. (2013). Underwater hyperspectral imagery to create biogeochemical maps of seafloor properties. In "Subsea optics and imaging", [Eds] Watson, J. and Zielinski, O. Woodhead Publishing Ltd., Cambridge, UK. Pp 608.

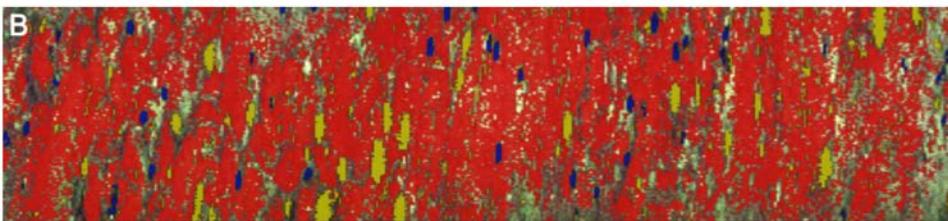
UHI mapping of kelp forest



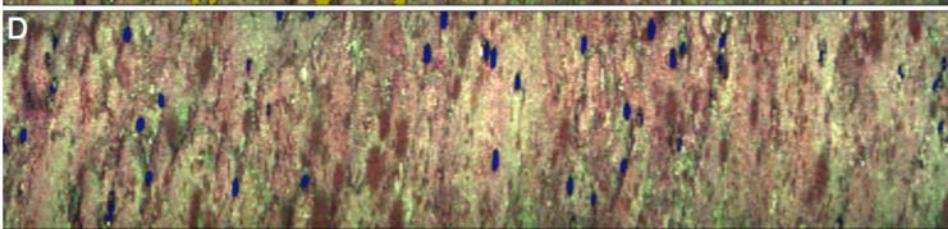
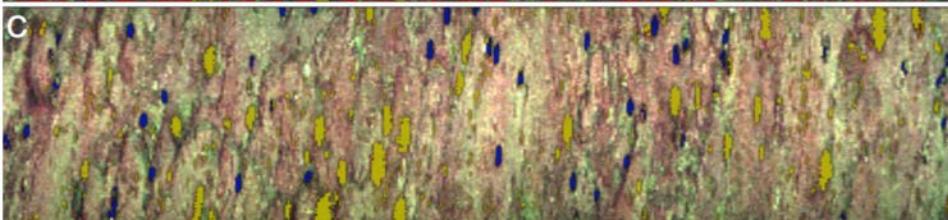
UHI map only looking at new tissue of kelp (the orange part), not the brown (old part). This exemplifies estimation of new growth, in addition to identify taxa.



RGB (false colours)



UHI classification of all OOI



A) UHI-2 on ROV photomosaic.

B) dominated by red calcareous algae (red area, 68.5% of total area).

C) Anemones (dominated by *Urticina*, yellow, 65 specimens, 4.7% of total area area in

D) Sea urchins (*Strongylocentrotus* spp., blue, 45 specimens, 1.9% of total area in D).

From Polar night campaign at 15 m depth Kvadehuken, 79°N, Kongsfjord, Svalbard 21 Jan 2016. Length of transect 10 m.

Polar night: Dark, cold and with sea-ice

Polar night = no biological activity?

Answer: High biological activity, biomass and bio-diversity in:

Water surface (eg. 6 species of seabirds feeding)

Water column (eg. Zooplankton DVM, fish)

Sea-floor (eg. mating, spawning, kelp growth)

What about: High human activity in the Arctic during the polar night:

Ship transport

Oil, gas & mineral extraction

Fisheries



Picture: Ny Ålesund, Kongsfjorden at 79°N 15 Jan 2013 at noon
Polar night cruise with RV Helmer Hansen (UiTø, UNIS, NTNU AUR-Lab)

Polarnattsstudier- overflaten

Black guillemot - a visual predator



Alkekonge (Little auk)
Teiste (Black guillemot)
Polarlomvi (Brünnichs guillemot)
Havhest (Atlantic fulmar)
Krykkje (Black legged kittiwake)
Polarmåse (Glaucous gull)

Hvordan kan sjøfuglene se sitt bytte?

Polarnattsstudier - vannmassene



GJ

Krill – positiv fototaksisk

Hoppekreps (åte) – negativ fototaksisk

Døgnlige vertikal migrering (DVM) studier – stor biomassebevegelse per døgn

Polarnattstudier - havbunn

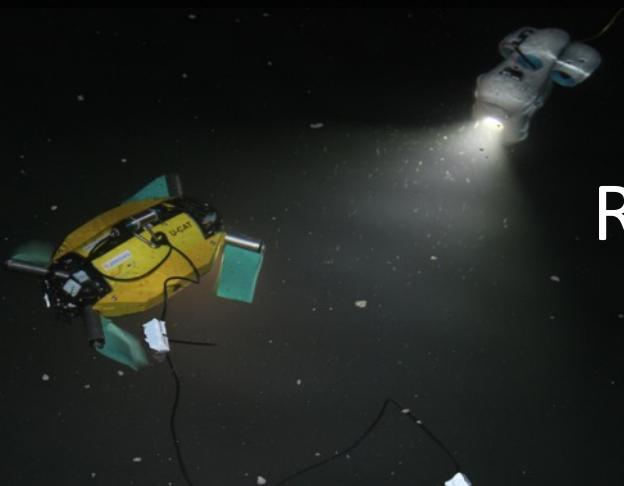
Masseforekonst av spøkelseskrepss.
Hvorfor?

Polar Night Studies

-usually affected by light from humans-



Robots in action



Photos: Ole M Rapp, Aftenposten

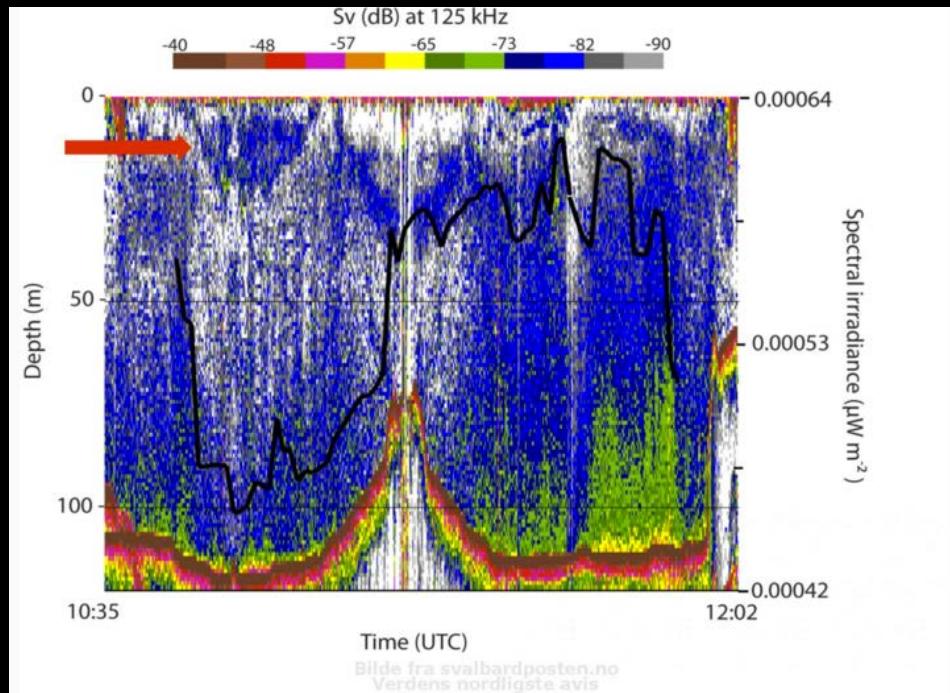
Autonomt overflatefartøy (JetYak) for måling av lysintensitet og DVM av plankton



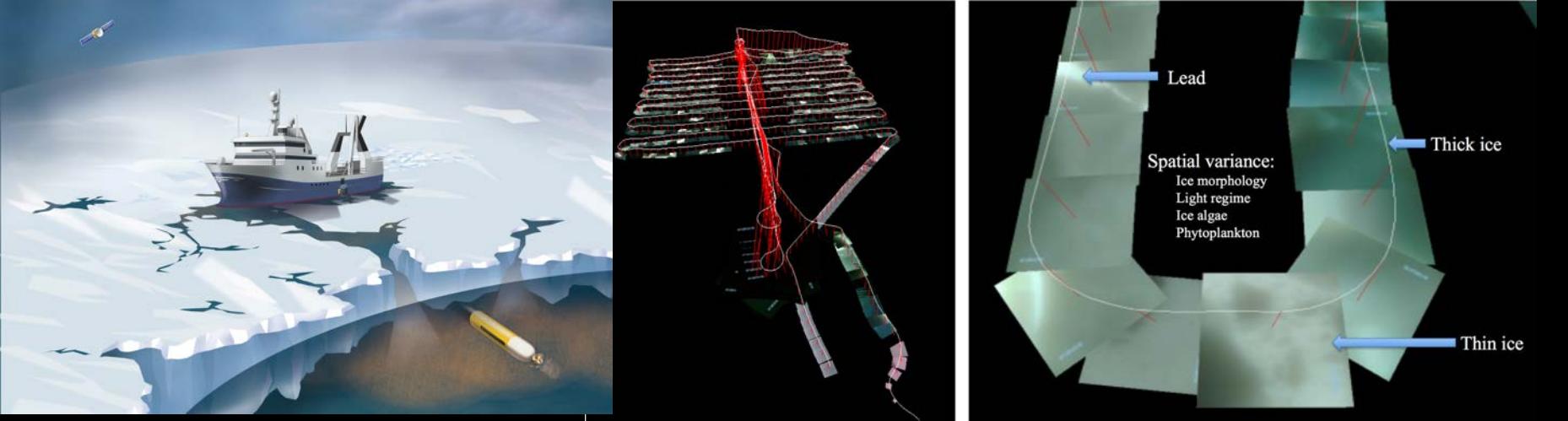
Kronikk Svalbardposten 4 Feb 2016:

Design for latskap - men med store muligheter

Lysmålinger gjort på havet er bortimot umulig å få gjort uten at de "foreureses" av kunstig lys fra skip. Inntil nå.

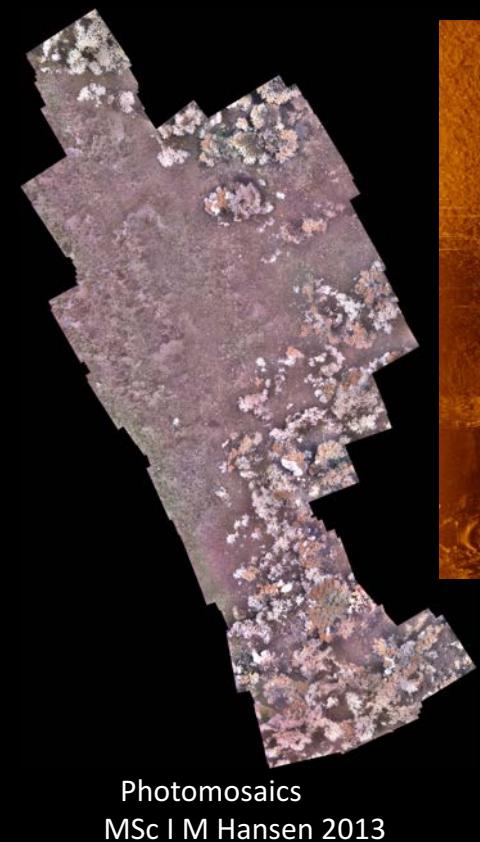


Bilde fra svalbardposten.no
Verdens nordligste avis

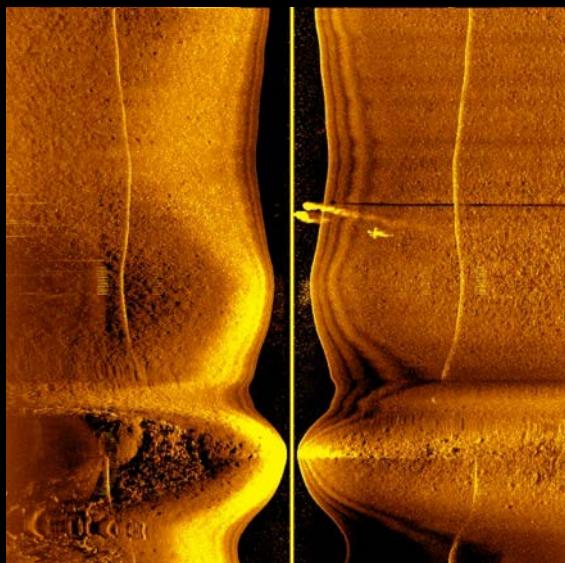


Johnsen et al, submitted Polar Biology

New imaging techniques to
Provide underwater maps



Photomosaics
MSc I M Hansen 2013

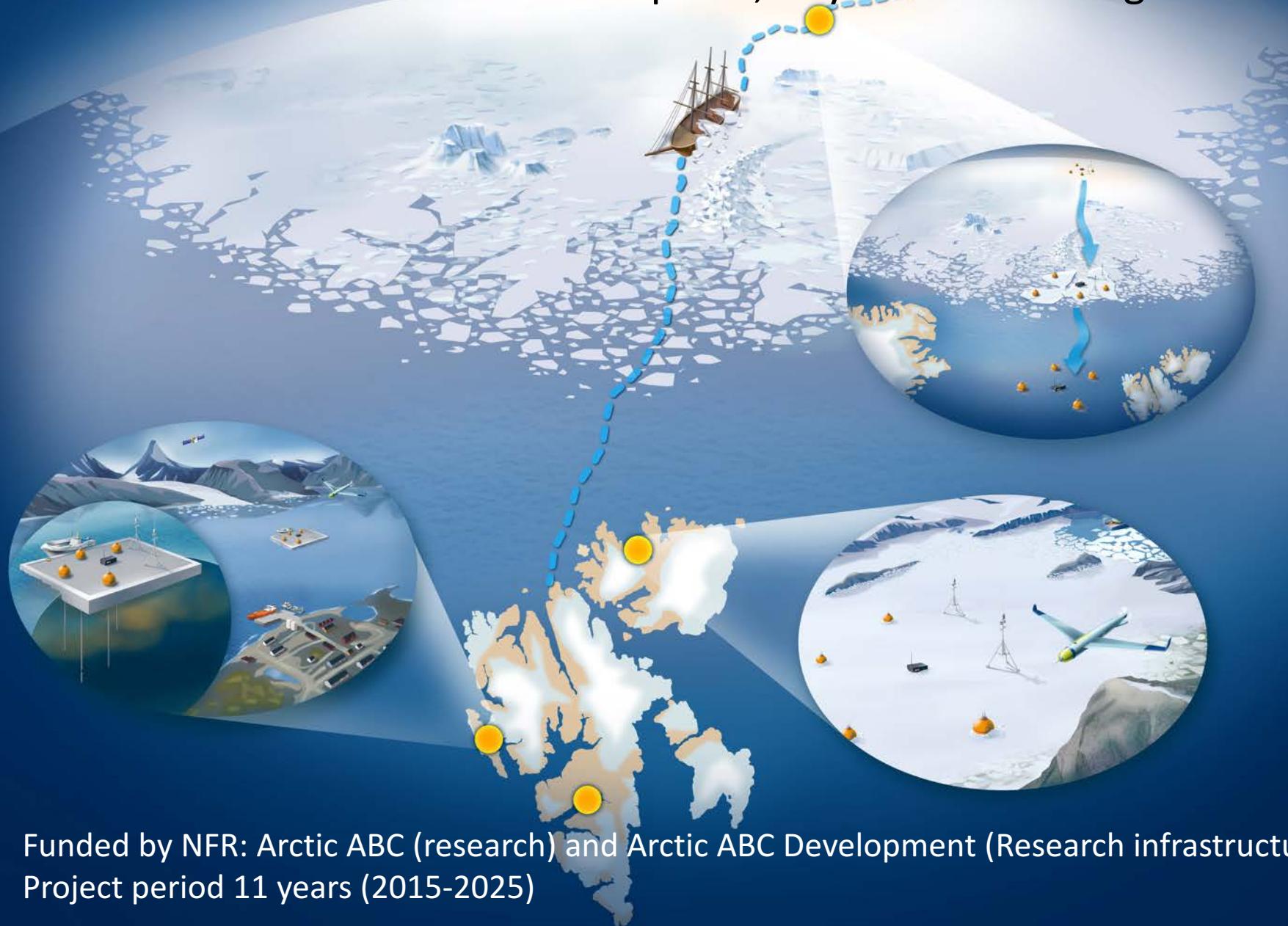


Side Scanning Sonar
MSc S Ekehaug 2013



UHI 3D map of deep water corals

Arctic ABC programme with ICE-POPEs: ICE tethered Platform-cluster for Optical, Physical and Ecological sensors



Funded by NFR: Arctic ABC (research) and Arctic ABC Development (Research infrastructure).
Project period 11 years (2015-2025)

Biological oceanography – water-plankton-fish-bird dynamics

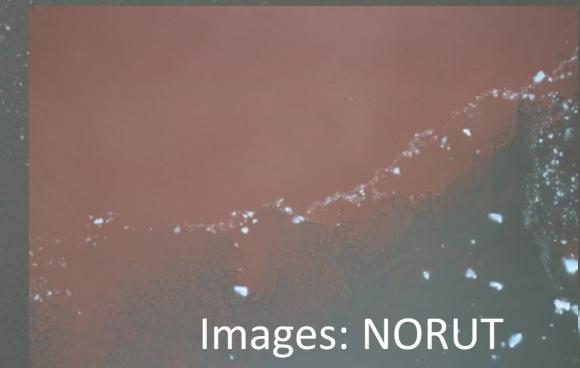
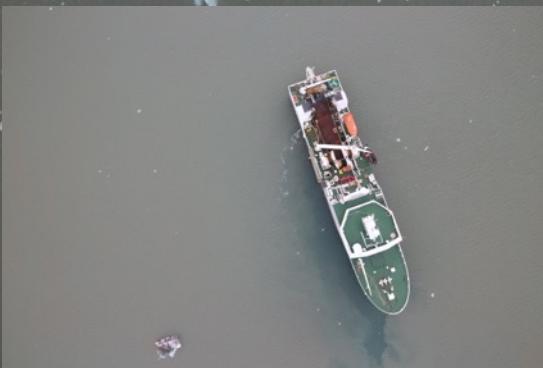


JetYak with acoustic and optical sensors:

- Autonomous surface vehicle performing a geo-localized sampling grid:
- AZFP: Acoustic zooplankton fish profiler + bottom profile
- EcoTriplet: Chl a, cDOM and TSM
- CTD with autonomous winch
- Cameras in water and air

Synchronized mission with drones, autonomous surface vehicles, research vessels and ground radars 23-25 August 2016 - Kongsfjorden

- Aerial images: Drone – NORUT.
- Ground radar time-series of ice and water movements – NORUT.
- T, S, Depth, Chl a, cDOM, zooplankton, fish & birds: JetYak (NTNU, UiTØ)
- Detailed sampling zooplankton, fish, birds: Helmer Hanssen (UiTØ, UNIS)



Images: NORUT

- Ny polarnattsutstilling til NTNU-VM sep 2016-mai 2017
- St. Johns, Canada, okt 2016-

