INSTITUTE OF MARINE RESEARCH

Offshore wind energy – effect on maritime resources and environment

Solfrid Sætre Hjøllo

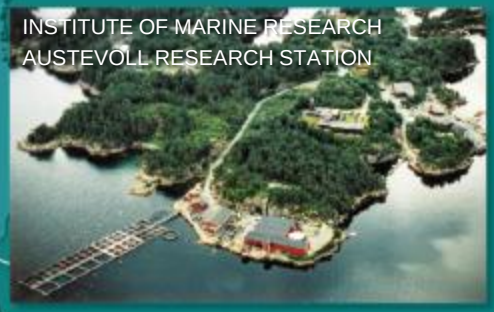
NORCOWE DAYS 2010

Content

- IMR field activities
- Wind power and the marine environment - interactions and possible conflicts
- North Sea/Norwegian Sea marine resources

▸ Institute of Marine Research

Bergen: the IMR headquarters. Offices and laboratories in several buildings at Nordnes



The research vessels

Our most important tools for collecting data on the ecosystem

CRUISE ACTIVITY 2008

Vessel	Days at Sea
G.O. Sars	276
Johan Hjort	253
Håkon Mosby	255
G.M. Dannevig	180
Dr. Fridtjof Nansen	319
Hans Brattström	216
Fangst	200
Jan Mayen	75
Chartered vessels	947
Total	**2 723**

G.O. SARS
BUILT: 2003
4067 GRT.
L.o.a: 77,5 M

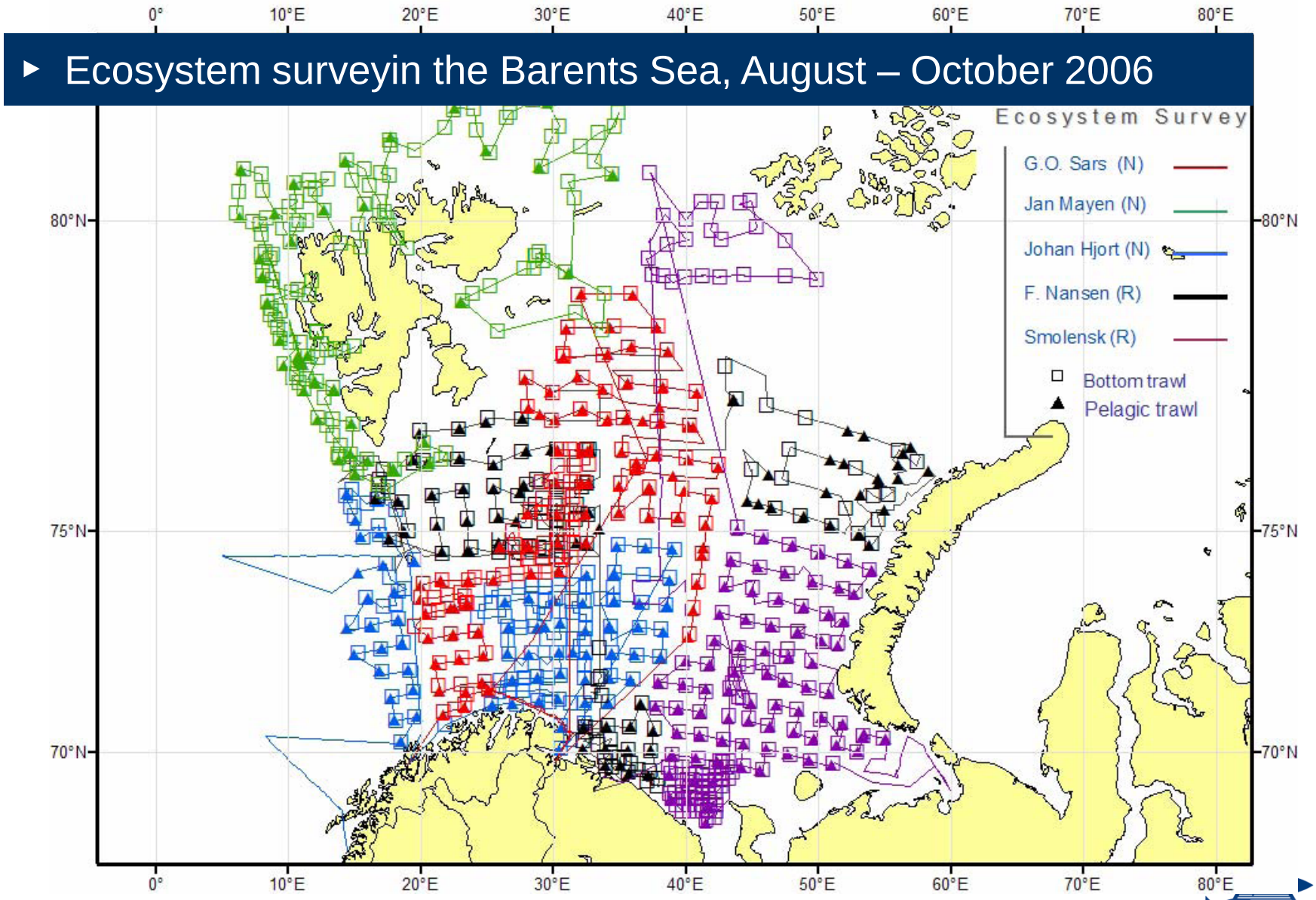
JOHAN HJORT
BUILT: 1990
1828 GRT.
L.o.a: 64,4 M

G.M. DANNEVIG
BUILT: 1979
171 BGRT.
L.o.a: 27,9 M

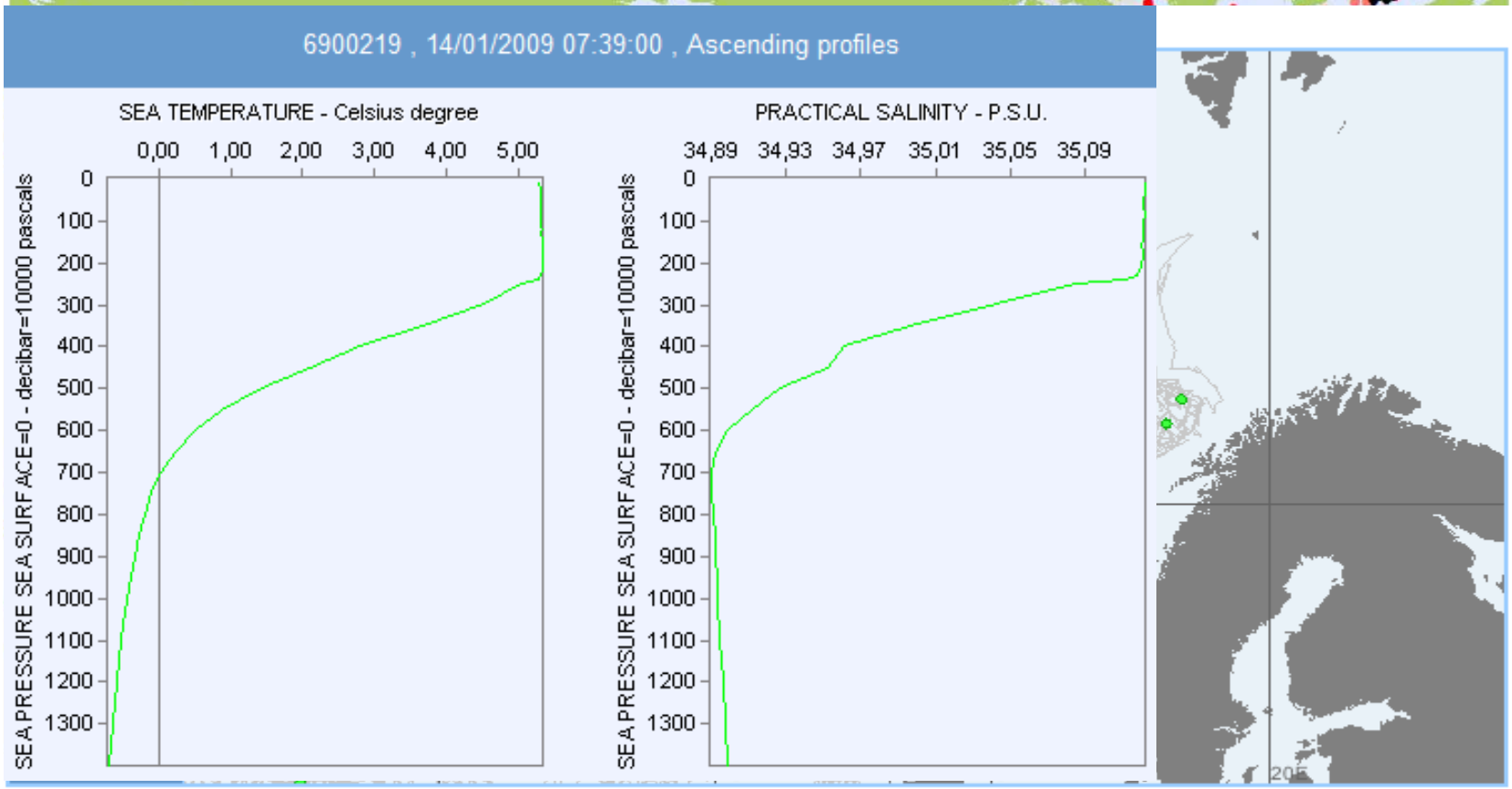
HÅKON MOSBY
BUILT: 1980
701 GRT., L.o.a: 47,2 M
OWNER: UNIVERSITY OF BERGEN

DR. FRIDTJOF NANSEN
BUILT: 1993
1444 GRT.
L.o.a: 56,8 M
OWNER: NORAD

Ecosystem surveyin the Barents Sea, August – October 2006



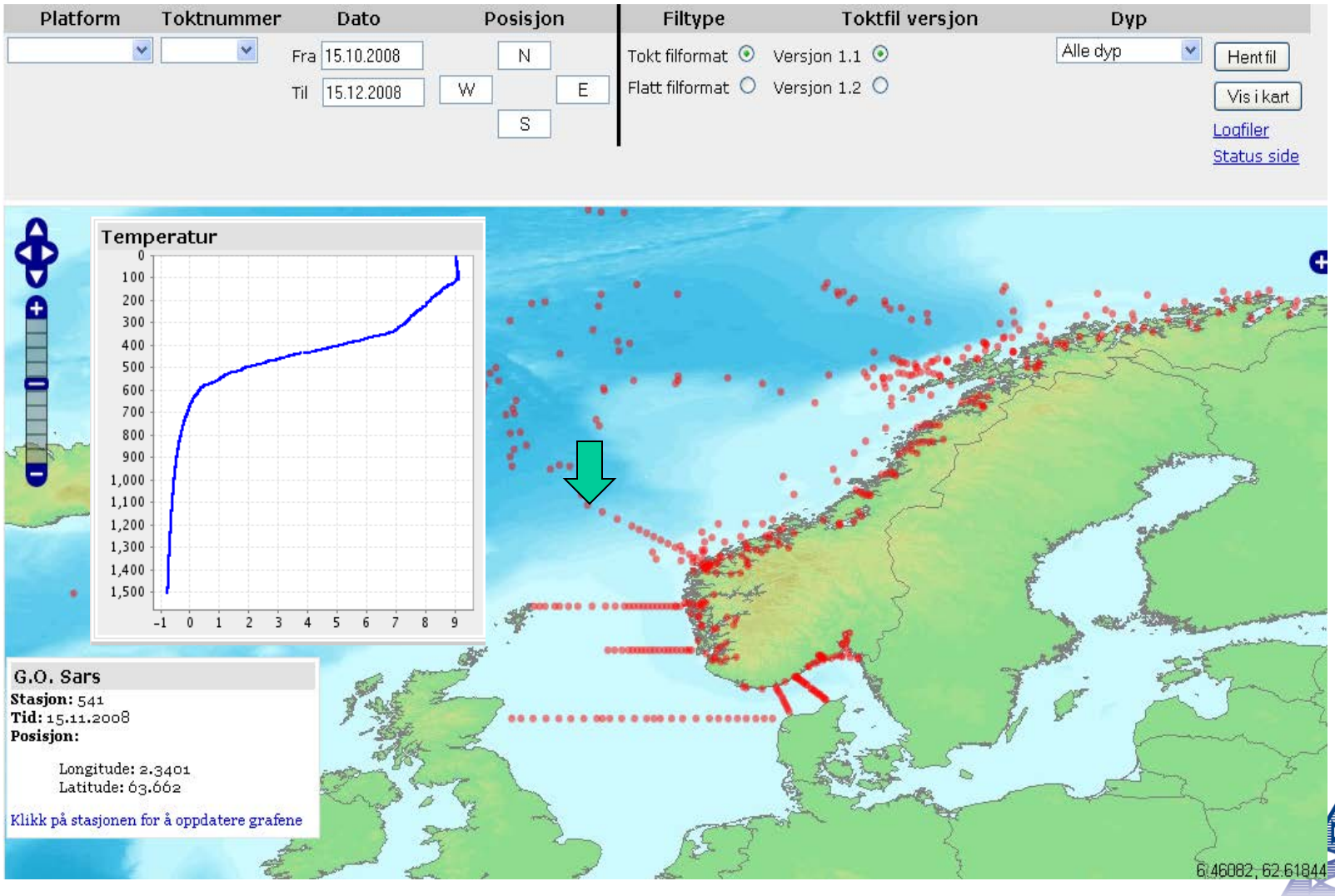
▸ 3000 ARGO floats



• : temperature and salinity profiles

• : temperature only profiles

▸ Operational data handling- (daily)– vessels, buoys, floats



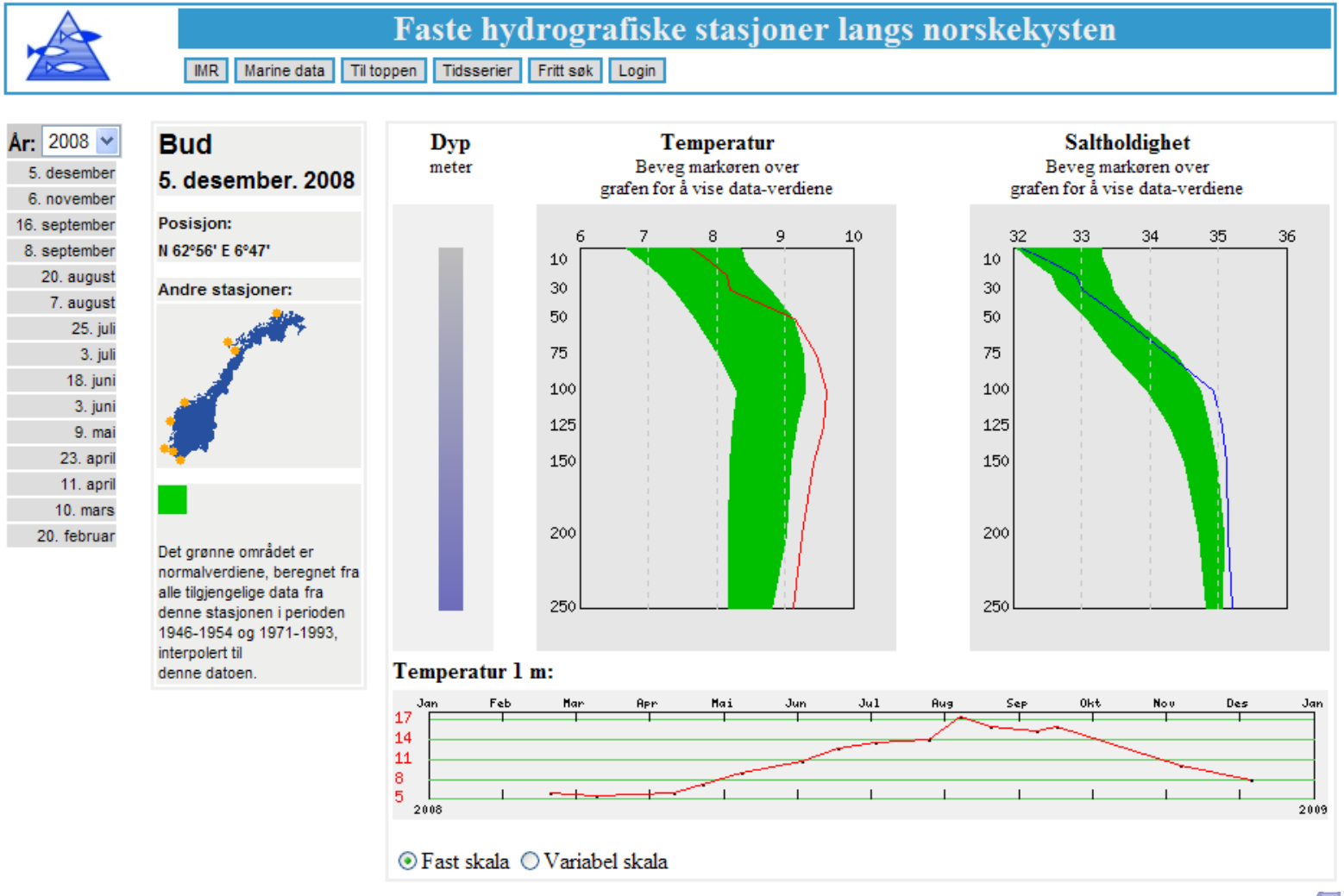
▸ Coastal monitoring – every 10-15 days

Between 1935 and 1947 Institute of marine Research established8 fixed oceanographic stations from Lista in South to Ingøy in North.

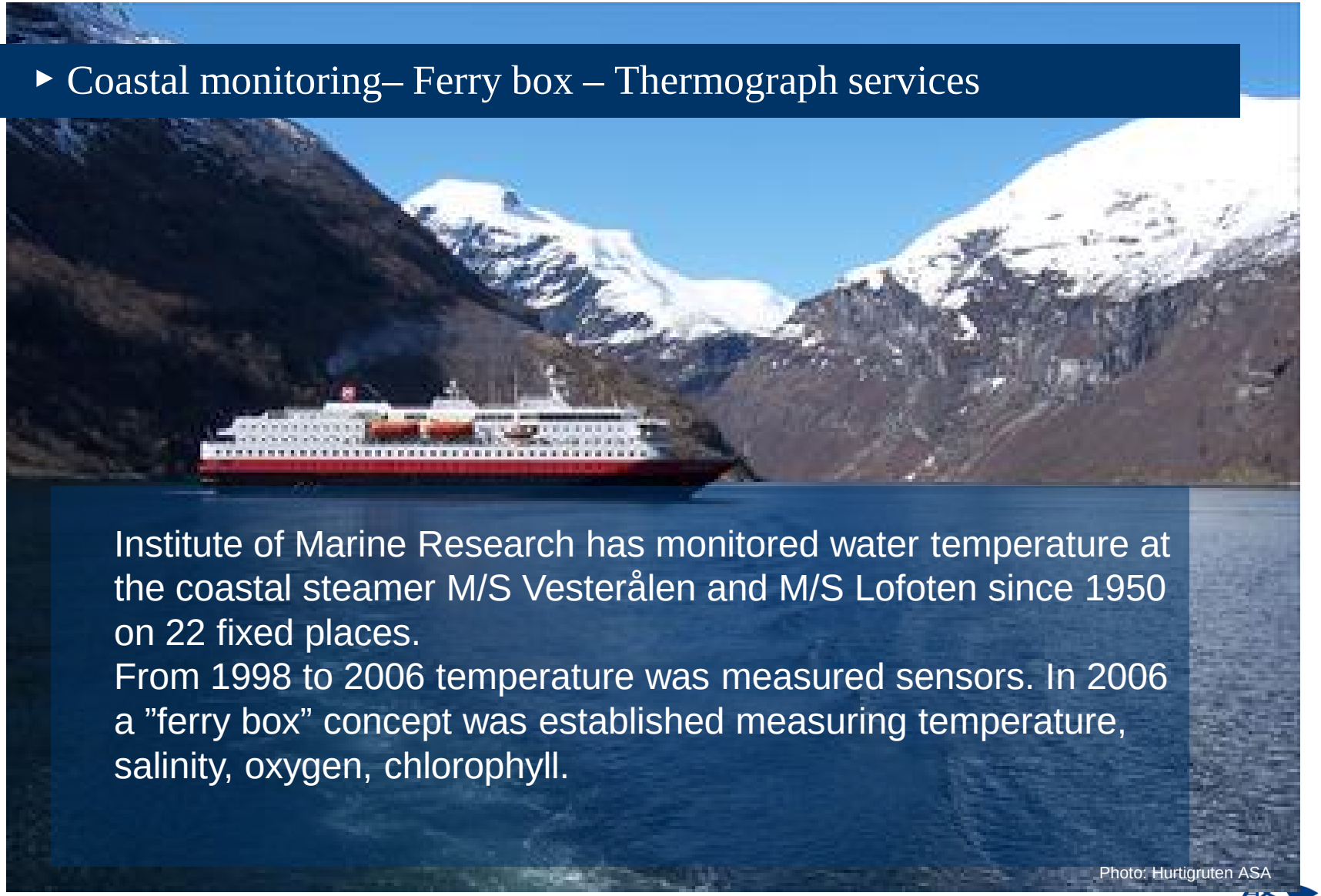
The main purpose was to establish long time series on monitoring the coast and ocean climate in general.

Photo: Institute of Marine Research, Johan Kristiansen

▸ Coastal monitoring – every 10-15 days



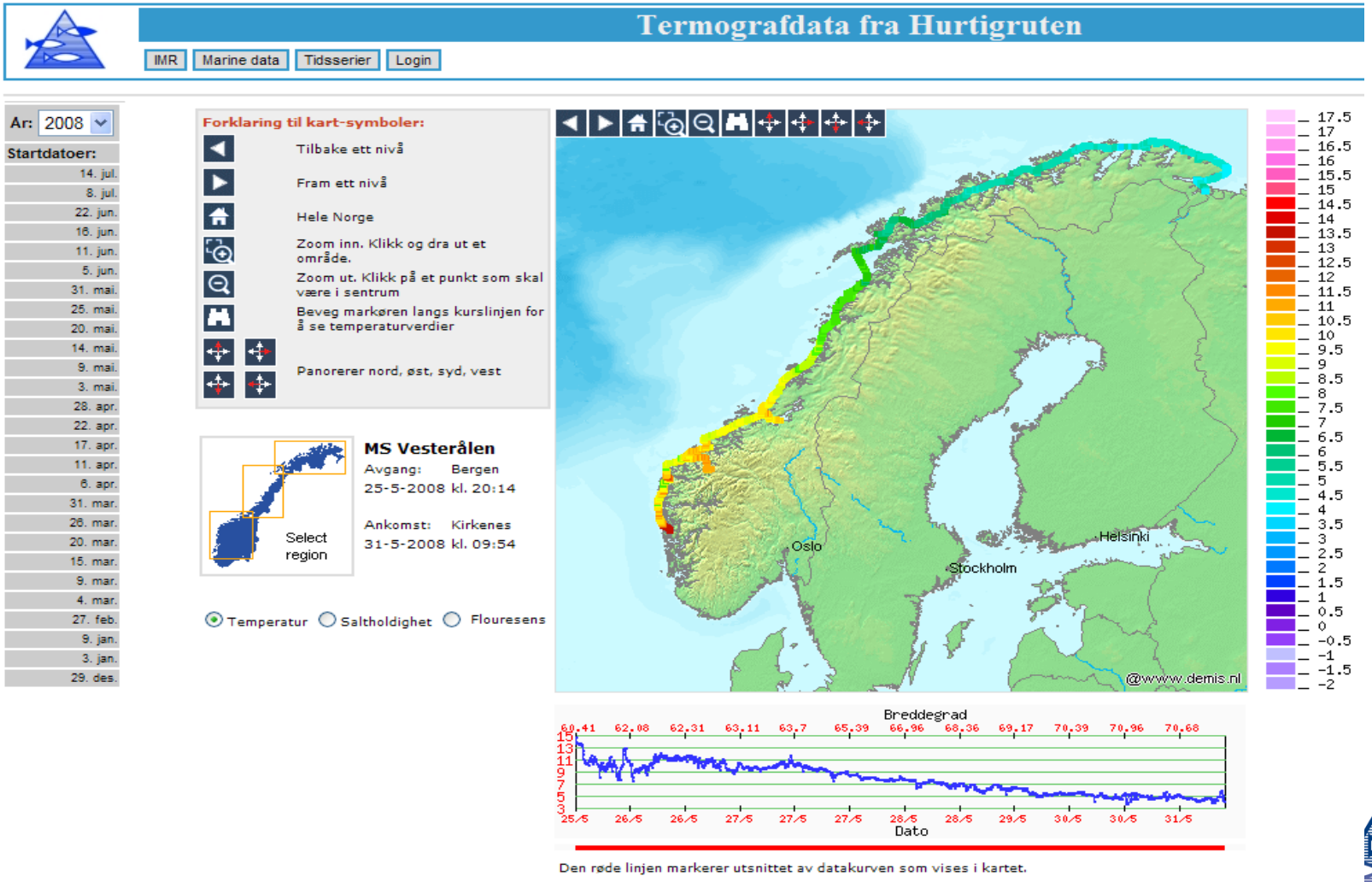
▸ Coastal monitoring– Ferry box – Thermograph services



Institute of Marine Research has monitored water temperature at the coastal steamer M/S Vesterålen and M/S Lofoten since 1950 on 22 fixed places.
From 1998 to 2006 temperature was measured sensors. In 2006 a ”ferry box” concept was established measuring temperature, salinity, oxygen, chlorophyll.

Photo: Hurtigruten ASA

▸ Coastal monitoring– Ferry box – Thermograph services



Regular transects – climatologically transects

Hydrografisk snitt - Windows Internet Explorer

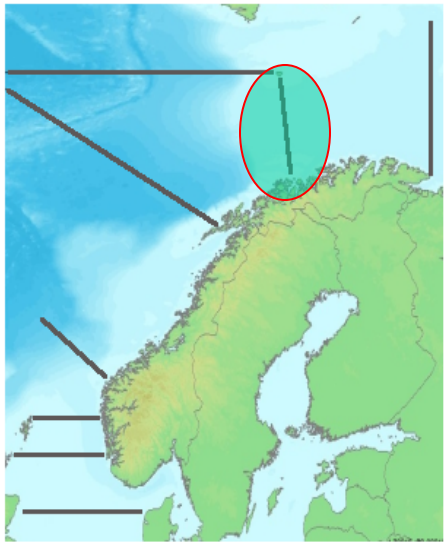
http://poseidon:8080/snittbilde/index.jsp?snitt=2

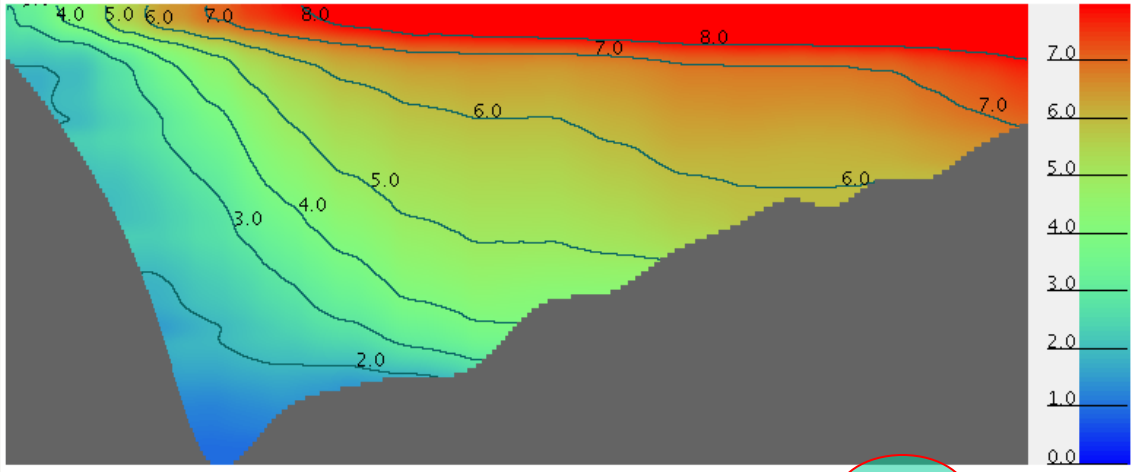
Live Search

Faste hydrografiske snitt langs norskekysten

IMR | Marine data | Til toppen | Tidsserier | Fritt søk | Login

Temperatursnitt
Middelverdier Fugløya-Bjørnøya for ukene 33-37



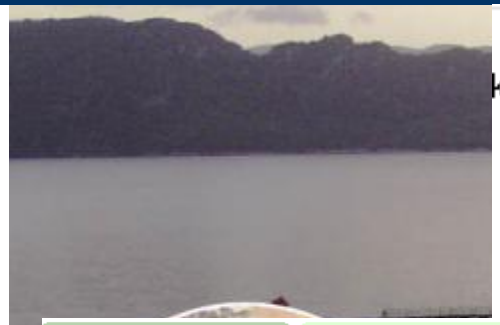


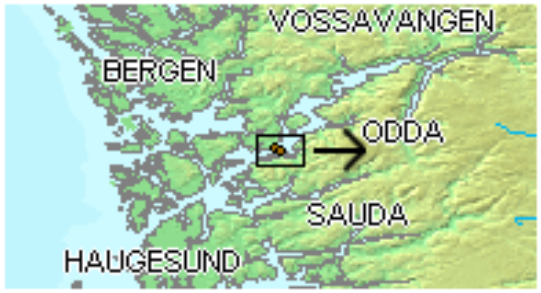
Klikk i kartet for å velge snitt

Standarder (30 års middelverdier):	Vinter Uke 1-5	Vår Uke 9-13	Vår Uke 16-20	Sommer Uke 23-27	Høst Uke 33-37	Høst Uke 39-43
Målte snitt, startdatoer (dd-mm-åååå):	23-01-2004	05-03-2004	10-04-2004	22-06-2004	14-08-2004	
	22-01-2005	12-03-2005	20-05-2005	12-08-2005	14-09-2005	22-10-2005
	27-01-2006	19-05-2006	16-06-2006	28-08-2006	21-10-2006	

Done | Local intranet | 100%

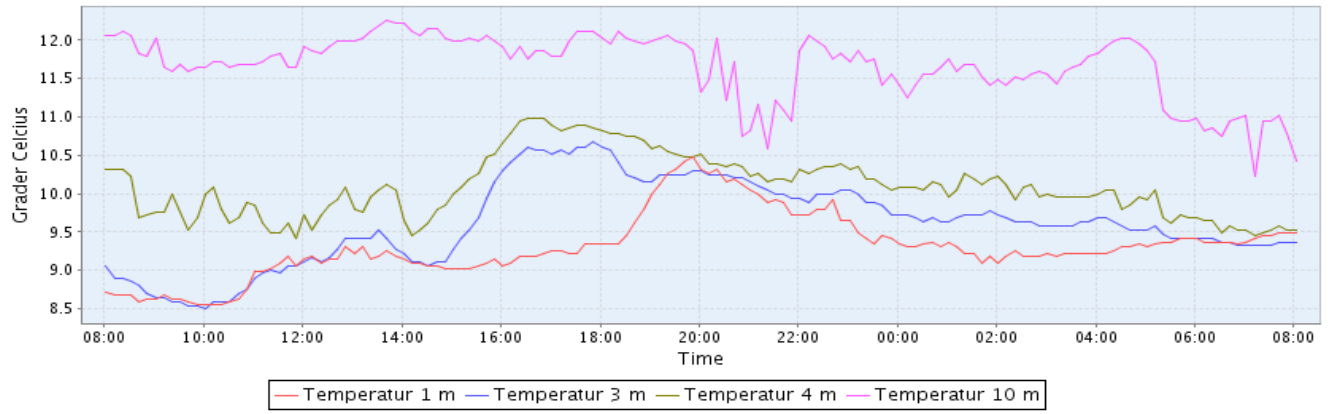
▸ Buoys – Weather station- Water (temperature, salinity, currents)





Hardangerfjorden Øst | **Hardangerfjorden Vest**

Målinger de siste 24 timer



Målingstyper
- ○ Vind
- ○ Lufttemperatur
- ◉ Vanntemperatur
- ○ Saltholdighet
- ○ Strøm

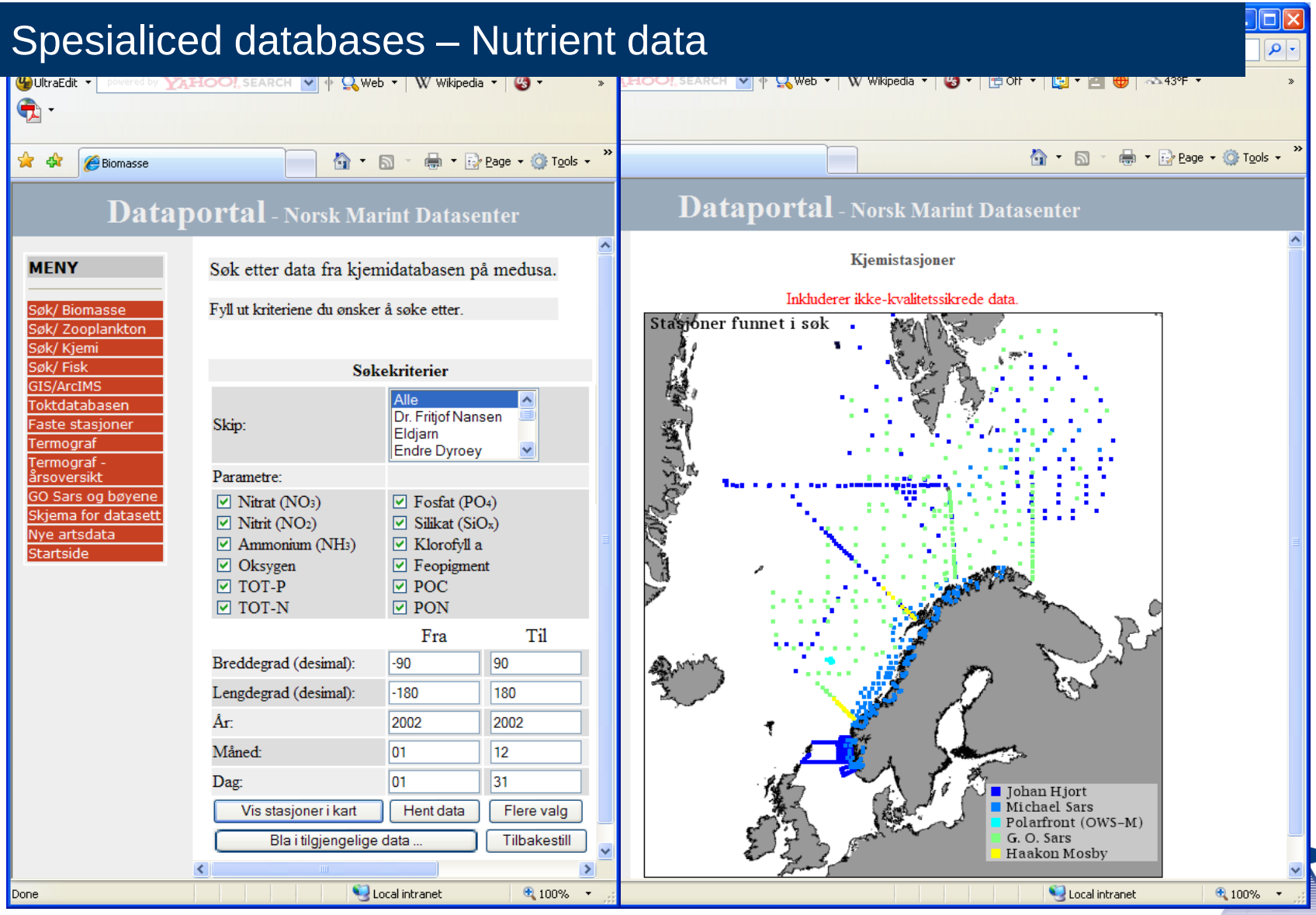
Tidsintervall
- ◉ Siste 24 timer
- ○ Siste 48 timer
- ○ Siste uke
- ○ Siste måned

Siste observasjoner 2008-11-10, 08:02:00 UTC

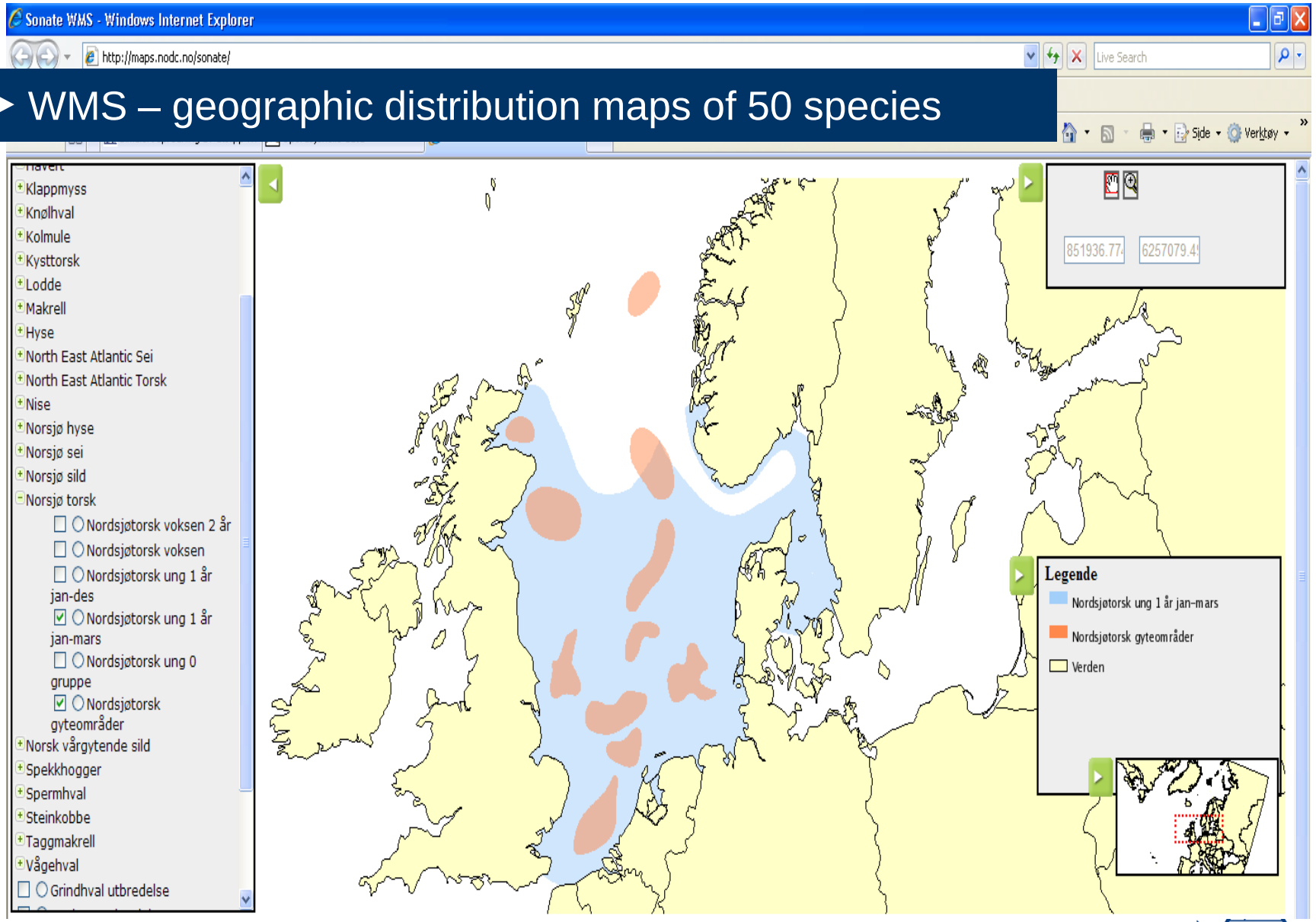
Luftmålinger		
Lufttemperatur [°C]	Vindretning [°]	Vindstyrke [m/s]
6.7	109.0	13.05

Sjømålinger				
Dybde [m]	Temperatur [°C]	Saltholdighet	Strømstyrke [cm/s]	Strømretning [°]
1.0	9.49	24.18		
3.0	9.37		2.35	295.66
4.0	9.53	23.96		
10.0	10.43	25.4		

Spesialiced databases – Nutrient data



- WMS – geographic distribution maps of 50 species



Model results – netCDF files presented in WMS

- Institute of Marine Research
  - Year Files
    - Current velocity, U-component
    - Current velocity, V-component
    - Salinity
    - Temperature
    - Nitrate
    - Phosphate
    - Silicate
    - Diatoms
    - Flagellates
    - Oxygen
    - Surface elevation
    - Bottom topography

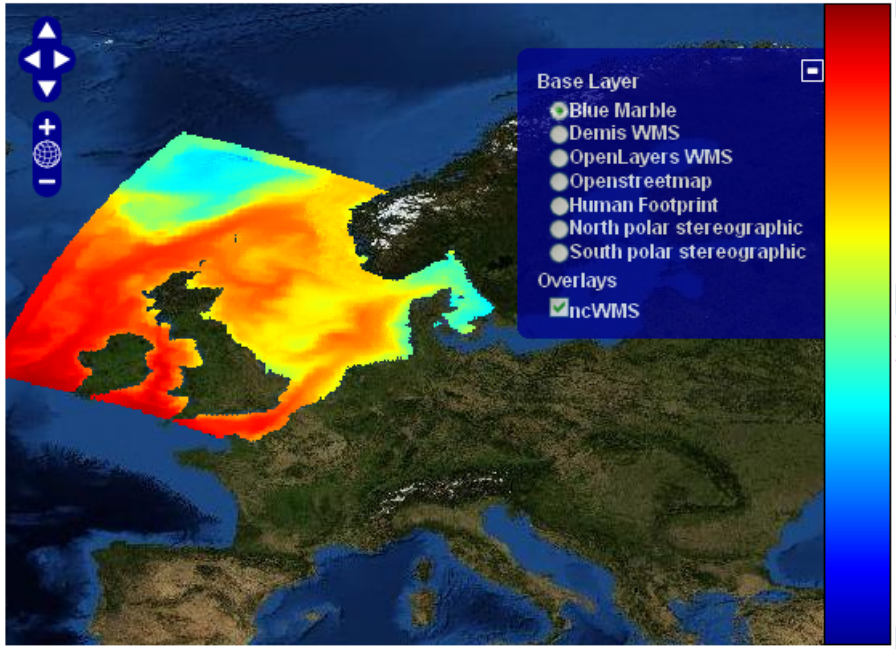
Layer: Institute of Marine Research > Year Files > Temperature
Units: deg C
Depth (meters): 0.0009999999310821295
Date/time: 31 Dec 2005 00:00:00 UTC first frame last frame

December, 2005

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Today | Select date

Fit layer to window



User guide

Reading e-Science Centre

link to test image Open in Google Earth

Overlay opacity: 100%

Powered by OpenLayers and OGC standards

Permalink | email

- Yearly environmental status based on observations and research
- Fishery catches/quotas
- Reports & Consequense analysis
  - ”Direktoratgruppen for arealvurderinger havvind” v/ Fiskeridirektoratet: *ringvirkninger eventuelle vindparkutbygginger til havs vil påføre det marinøkologiske miljøet i norsk eksklusiv økonomisk sone (NEØS) med hovedvekt på Nordsjøen.*

    To ministry of Fisheries on effect of offshore windfarms on marine ecology

Environmental impacts of offshore wind farms

- Construction phase: building work (digging, blasting, building of foundations, erection, laying cables, etc.) and traffic. Short period ~ months
- Operation phase: physical, acoustic, visual and electromagnetic disturbances from wind turbine towers, substations&cables, risk of pollution (contaminants etc.), change in habitat, artificial reef effect, space occupation/habitat conflicts. Period ~ 25 years
- Decommissioning phase – back to normal (?)

Construction phase and effects on marine mammals

Most vulnerable time for the seals are the pupping and weaning season, which for harbour seals is June-July and for grey seals September-December

Less vulnerable during the moulting season (August for harbour seals and February–March for grey seals) because they are more flexible in terms of finding places to haul out

Electromagnetic fields

- Electromagnetic fields near turbines, cables and substations 5-22 μT, i.e.low
  - fish, and particularly cartilaginous fish that possess electro-receptive sensory organs are capable of navigating using the geomagnetic field, and that this ability might be affected by the magnetic fields near wind turbine installations
  - Little research done

Changes in habitats

- During the construction phase: non-mobile organisms killed in small area
- Operation phase: mobile organisms re-establish, structures overgrown (material dependent) by typical solitary hard bottom organisms and/or new groups of fauna

Figur 4. Påslag av grønnalger (til venstre) og blåskjell (til høyre) på vindturbinfundamenter ved Horns Rev vindpark, utenfor Danmarks vestkyst, omtrent ett år etter at turbinfundamentene ble utplassert. *Green algae (left) and mussels (right) on wind turbine foundations at Horns Rev wind farm, off the west coast of Denmark, around one year after the foundations were installed.* Kilde/source: Leonhard & Pedersen 2004. (http://www.hornsrev.dk/Miljoeforhold/miljoerapporter/POST-CONSTRUCTION-Annual%20Report-2003-Hardbottom.pdf).

Artificial reef-effect ("fish aggregating device")

- Significant knowledge of designs, materials, the effects
- General experience: reefs get colonised relatively quickly, but that there are constant changes in terms of which species dominate the reef at any given time
- Example Horns Rev, Denmark (sandy bottom): biomass 8 times higher (shellfish species and fish)
- May change currents and the type of sea bottom, leading to a change in the composition of species =>must assess the environmental impacts on each individual location that is being considered for an offshore wind farm.

Light

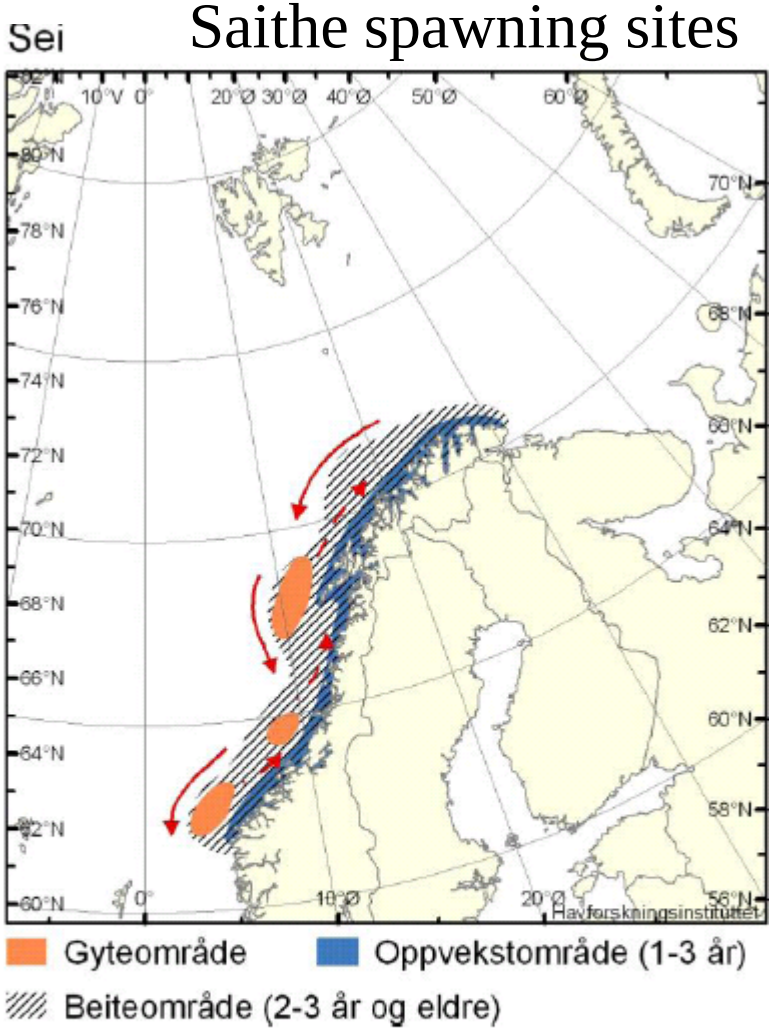
- Shadows and flashing reflections off the towers and rotor blades. Wind strength, hub height, rotor blade diameter, angle of the incoming light and reflective dependent

- Many fish species react strongly to visual stimuli (fleeing);little research done

Sound & noise

- The rotors and turbines of wind turbines produce mechanical energy as vibrations that are released into the ground and water
- Effects on fish
  - flight reaction and fish leave the area. Fish can detect sounds produced by wind turbines at distances of up to 25 km, but fish are only scared away from the wind turbines at distances of less than 4 m, and at wind speeds of more than 13 m/s
  - Increased background noise level and problems communicating with other fish of the same species (particularly important for individual interaction during spawning)
  - Changes to background noise patterns: Low-frequency sound (< 50Hz) may play an important role in how fish navigate and their sense of direction. Changes to background noise patterns may make it more difficult for them to navigate f exp to spawning grounds herring, haddock, saithe and cod that migrating to the spawning grounds

Saithe spawning sites



Figur 2.30. Utbredelse og gytefelt for sei langs Norskekysten, i Norskehavet og Barentshavet.

Effects on marine mammals

- During constructing phase: hearing damages can occur if marine mammals are exposed to loud, short-term sounds (pulses of sound) or less intense sound pressure levels that last over an extended period of time

- Noise during the operation phase: not harmful; change in behaviour &ability to utilize their habitat or get accustomed to sound unknown

Current patterns & oceanic mixing

- Mixed layer important for lower trophic levels and pelagic fish

- Structure diameter ~m and >100m apart : no effect
- Structure diameter ~m but closer: water whirl downward => greater mixing
- massive structures may entirely block the current, creating eddies downstream

Convergence/divergence zones

Up/downwelling due to Brostrøm (2008): wind farm at open ocean,
Depth of upper layers change by 1-2m/day in wind wake

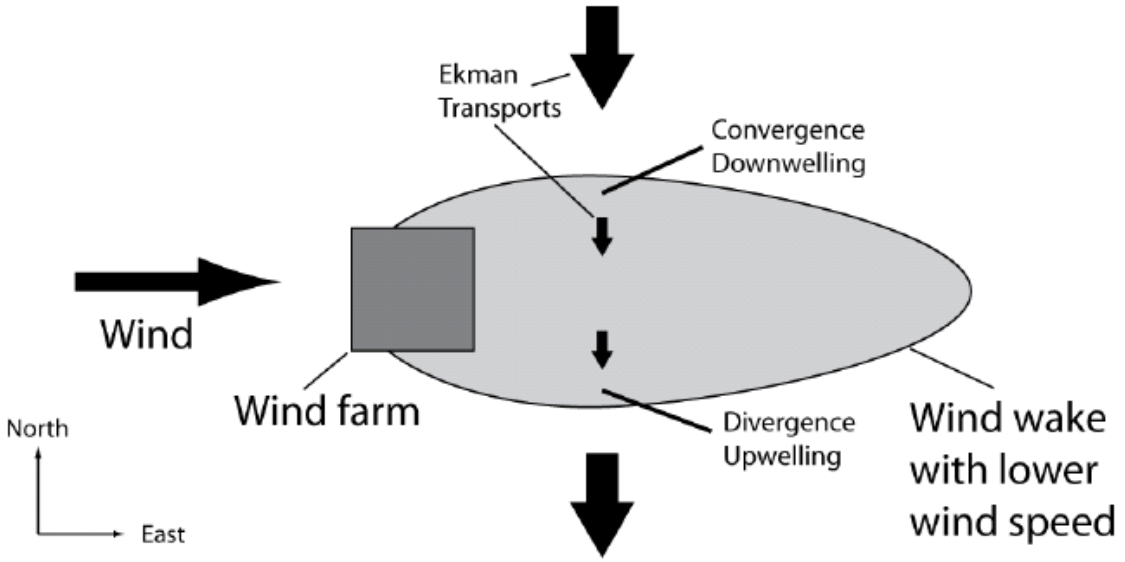


Fig. 3.1. Skjematisk tegning av innvirkning fra en vindpark på sirkulasjonen i havet og tilknyttede konvergens- og divergenssoner.

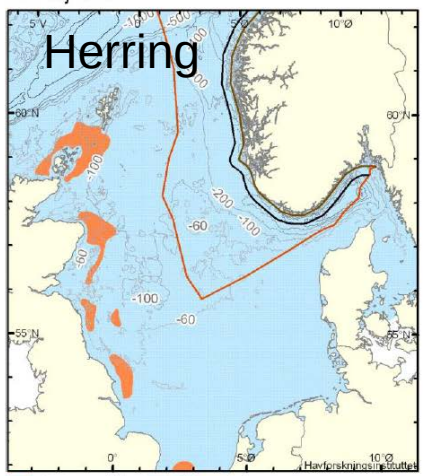
Area conflicts

- Offshore wind farms are generally built in shallow coastal waters, which are highly productive, speciesrich habitats, and vulnerable to environmental disturbances.
- Reduce general access to fishing of commercially important species
- Area conflict with fish farming industry
- At depths 2-20m: towers & networks of cables (with safety corridors) represent a potential barrier to kelp trawling

North Sea resources

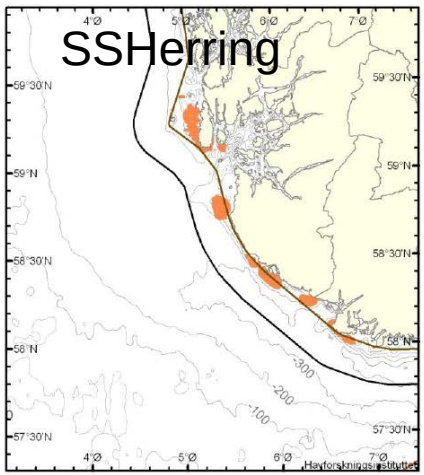
Pelagic and demarsals

Nordsjøsild



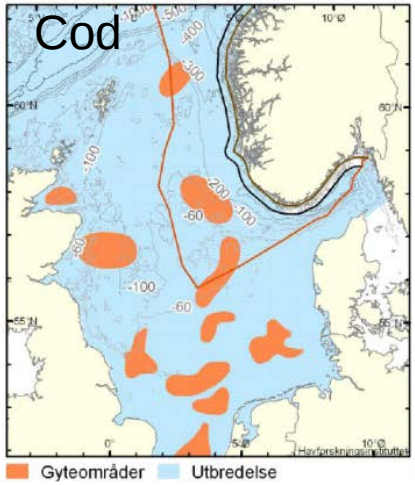
Figur 2.2. Utbredelse og gytefelt for nordsjøsild i Nordsjøen.

NVG-sild



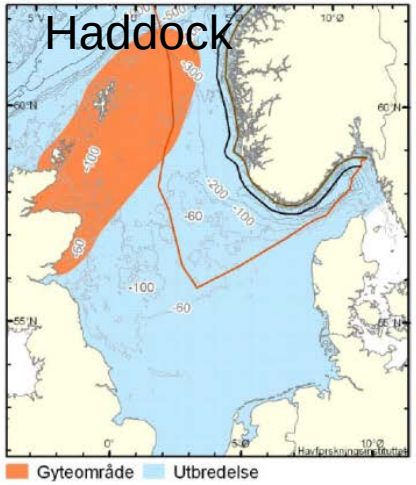
Figur 2.3. Sørlige gytefelt for NVG-sild.

Torsk



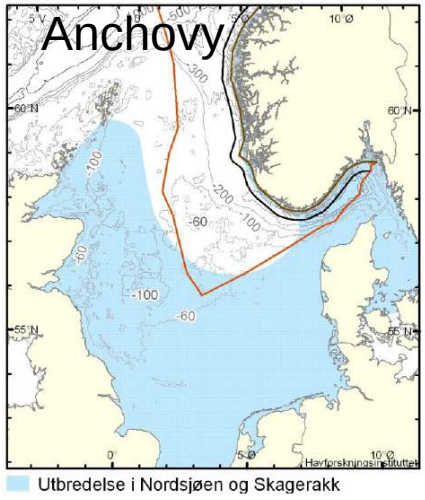
Figur 2.7. Utbredelse og gytefelt for torsk langs norskekysten og i Nordsjøen.

Hyse



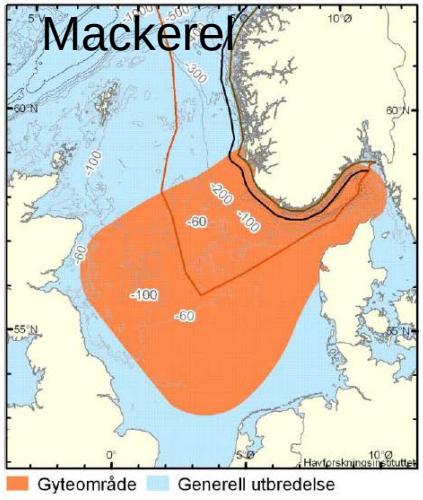
Figur 2.8. Utbredelse og gytefelt for hyse langs Norskekysten og i Nordsjøen.

Brisling



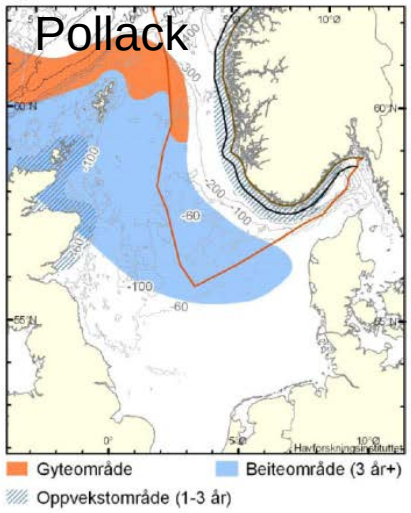
Figur 2.4. Utbredelse av brisling langs langs Norskekysten og i Nordsjøen.

Makrell



Figur 2.5. Utbredelse og gytefelt for makrell Norskekysten og i Nordsjøen.

Sei



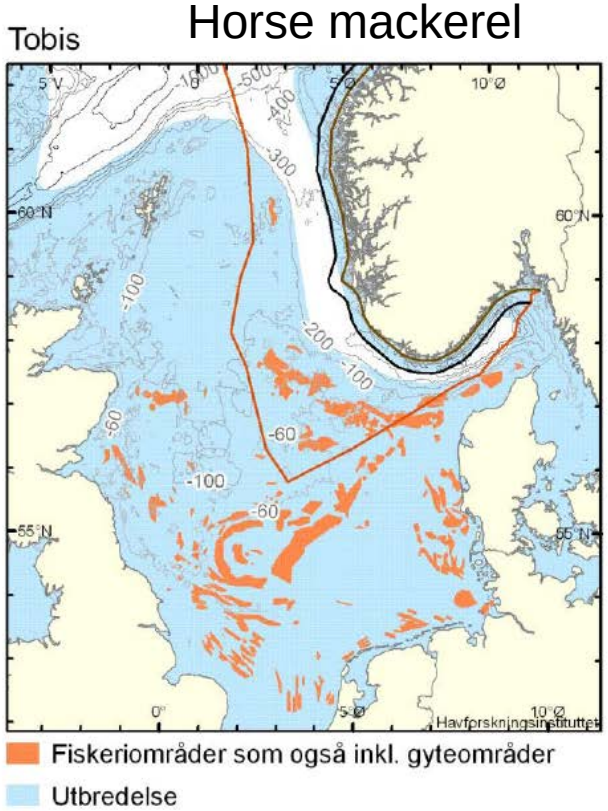
Figur 2.9. Utbredelse og gytefelt for sei langs Norskekysten og i Nordsjøen.

Kviting

Figur 2.10. Utbredelse og gytefelt av kviting langs Norskekysten og i Nordsjøen.

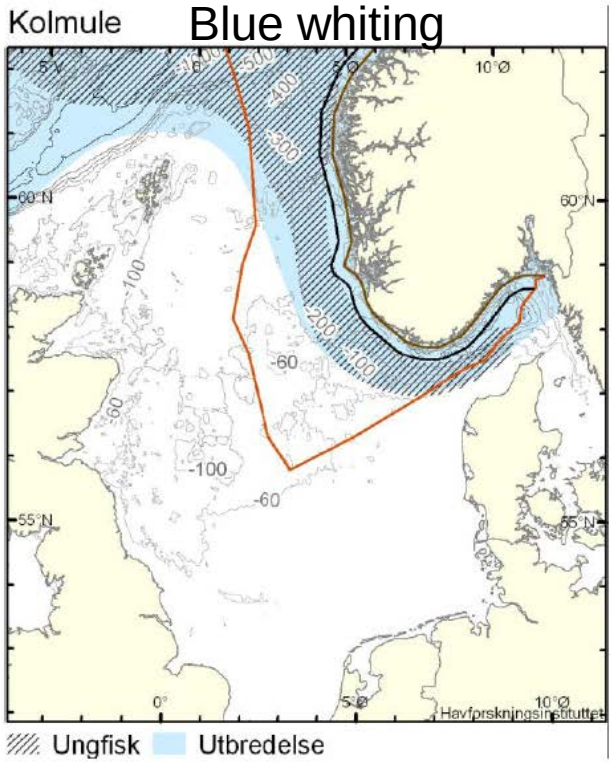
Industrial fishes

Horse mackerel



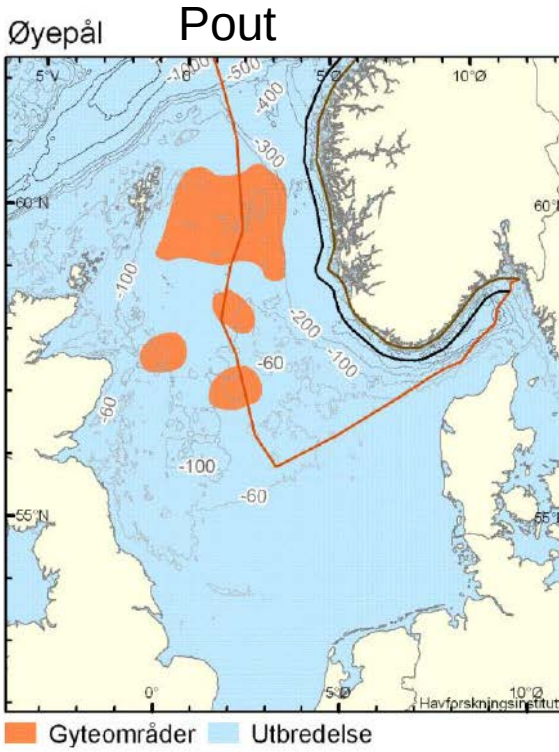
Figur 2.15. Utbredelse og gytefelt for tobis langs norskekysten, i Nordsjøen, Skagerrak og Kattegat.

Blue whiting



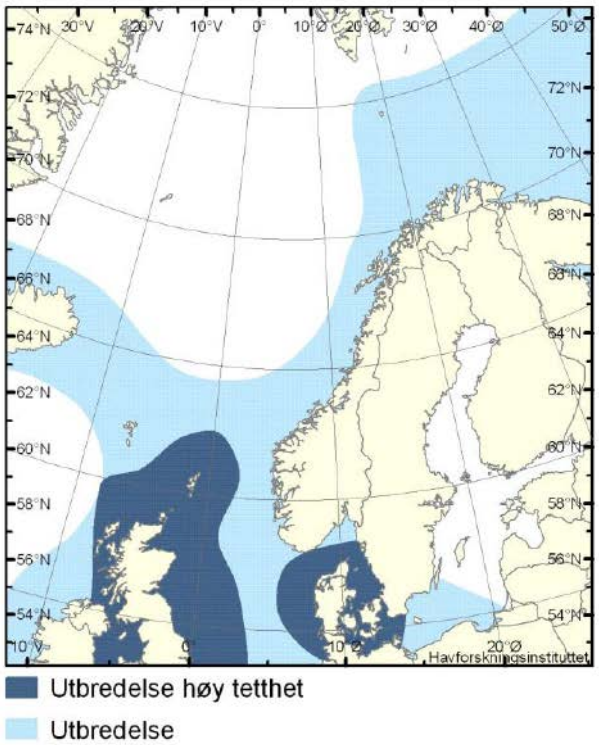
Figur 2.16. Utbredelse av kolmule i Nordsjøen og Skagerrak.

Pout



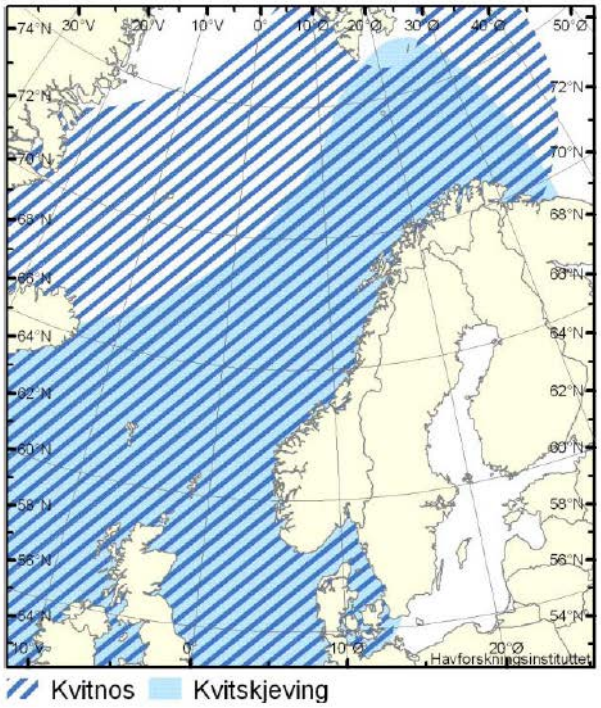
Marine mammals

Nise Porpoise

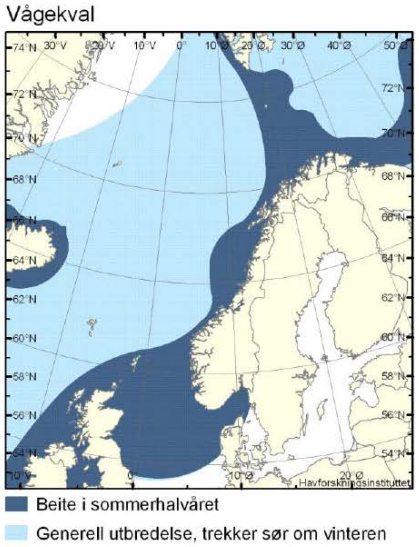


Figur 2.20. Utbredelse av nise i Nordøst-Atlanteren, Nordsjøen, Skagerrak, Kattegat, Østersjøen og Barentshavet.

Springere Dolphins

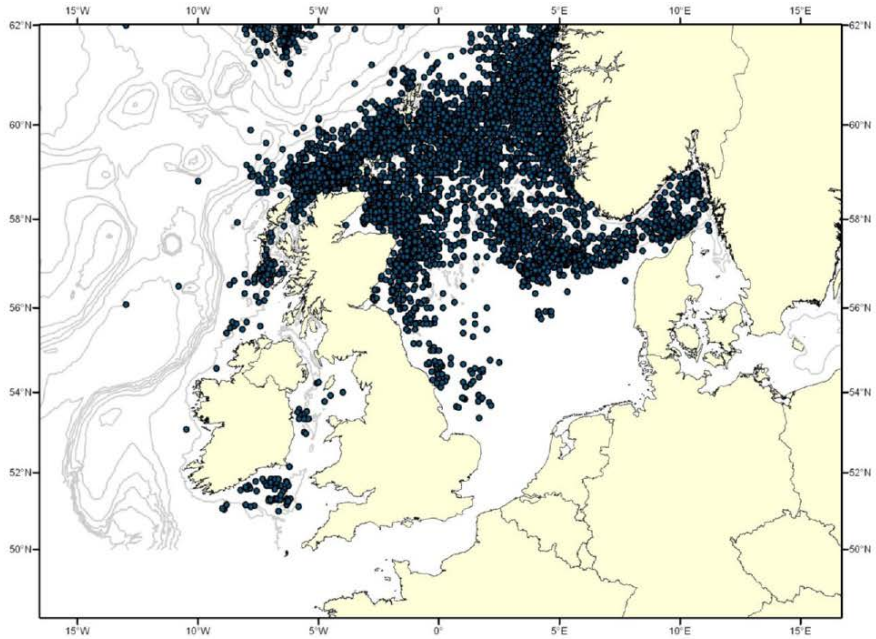


Figur 2.21. Utbredelse av springere i Nordøst-Atlanteren, Nordsjøen, Skagerrak, Kattegat og Barentshavet.



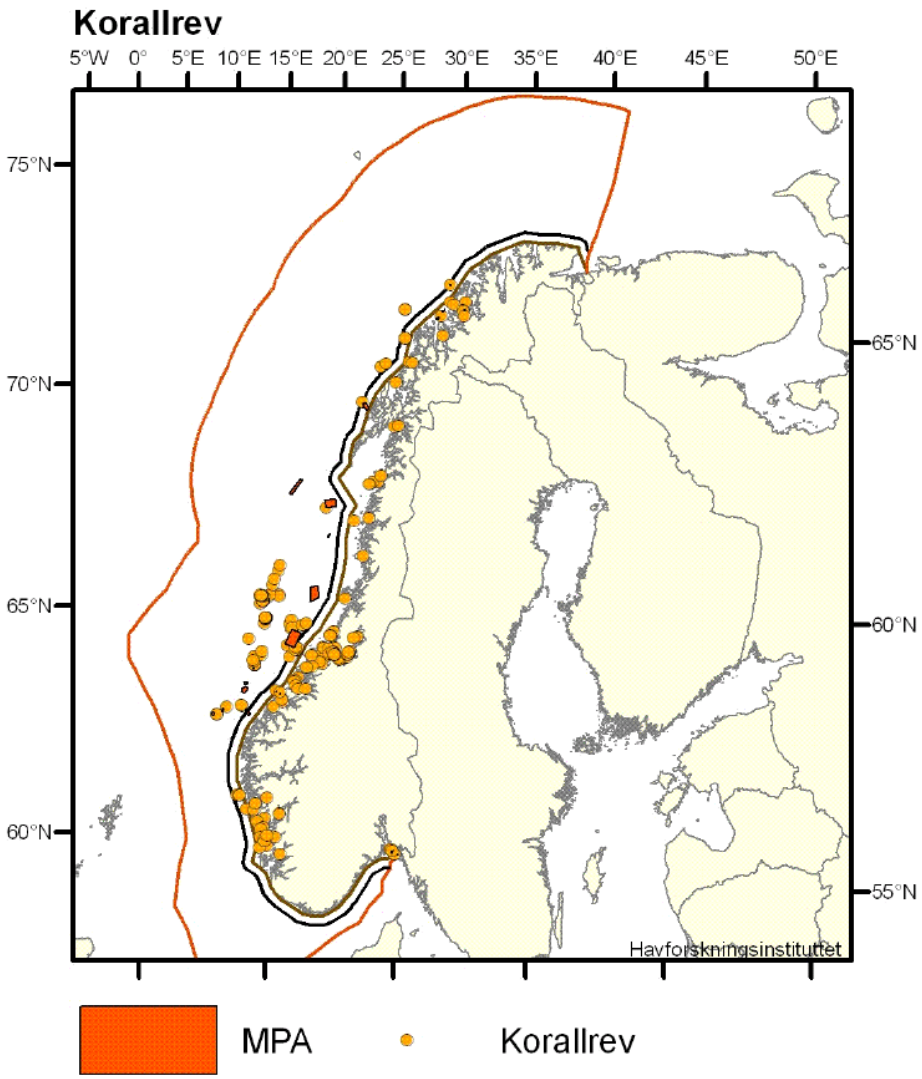
Figur 2.18. Utbredelse av vågekval i Nordøst-Atlanteren, Nordsjøen, Skagerrak og Barentshavet.

Mink whale



Figur 2.19. Fordeling av fangstposisjoner for vågekval i sørlige deler Nordøst-Atlanteren, Nordsjøen og Skagerak.

Coral reefs and Marine Protected areas



Figur 2.37. Fordeling av korallrev som også inkluderer vernede korallområder langs Norskekysten og i Norskehavet.

INSTITUTE OF MARINE RESEARCH

- IMR has extensive and updated knowledge of resources in the area and ongoing monitoring programs

- Knowledge gaps related to off shore wind farming:
  - Effect of sound and noise, other stimulus from offshore wind farm constructions on behaviour of (pelagic) fish)
  - Habitat changes before /after windfarming
  - Current pattern generated

- Fisken og Havet no 9/2008

  http://www.imr.no/filarkiv/2008/11/fh_2008-9_til_web.pdf/nb-no

- Horns Rev report

  http://www.hornsrev.dk/Engelsk/Miljoeforhold/pdf/Resume_eng.pdf

- Report to Ministry of Fisheries Oct 2010

  ”Direktoratgruppen for arealvurderinger havvind” v/ Fiskeridirektoratet