Bjerknes Centre for Climate Research

Operational oceanography and the ecosystem approach

Einar Svendsen

with input from many others

PICES ASC, Victoria BC 02 November, 2007

HAVFORSKNINGSINSTITUTTET
INSTITUTE OF MARINE RESEARCH

Operational Vision

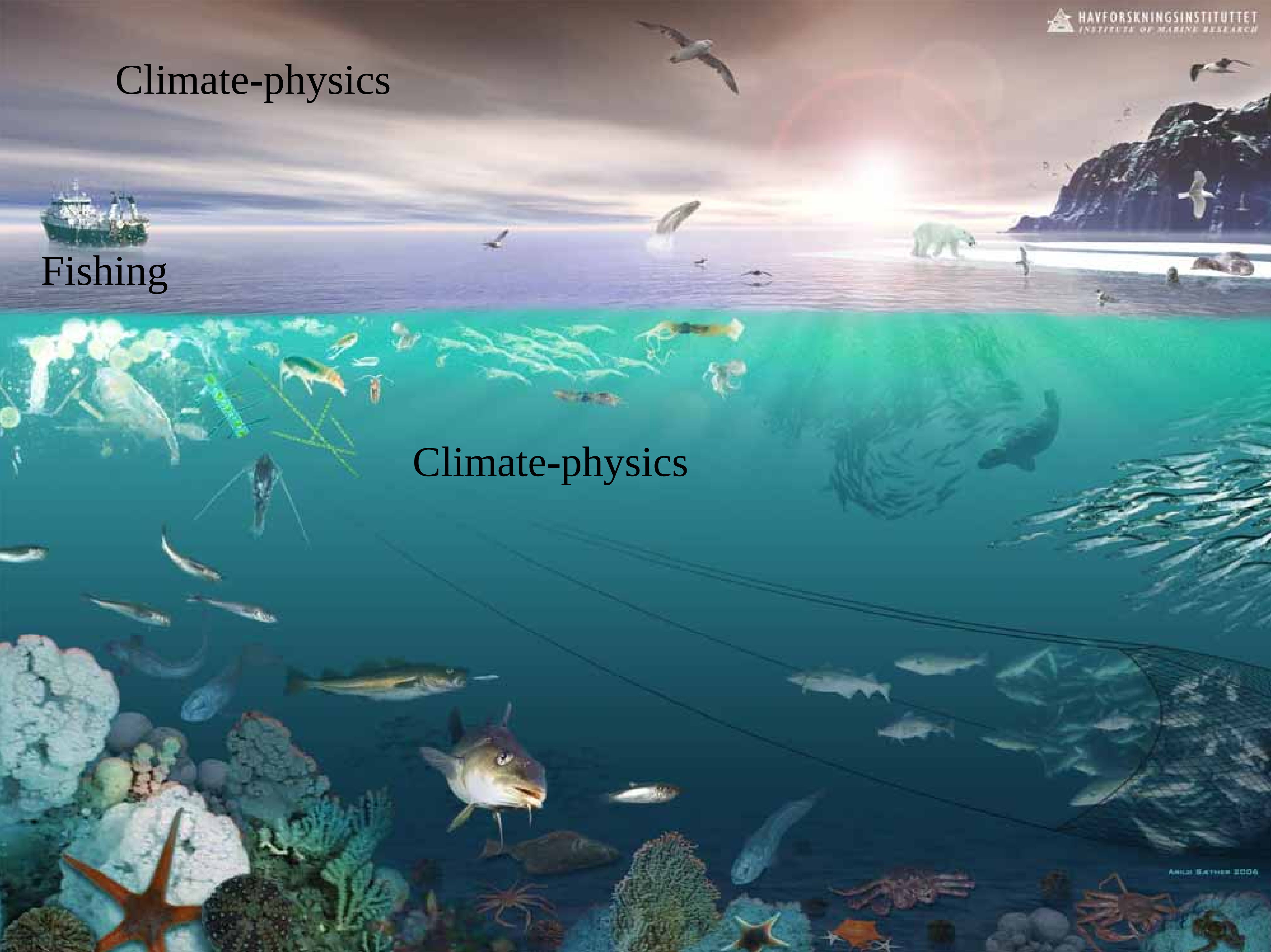
Deliver operational information of the marine environment to support and improve marine research and knowledge-based ecosystem assessment, prediction and management for wealth creation and sustainable use

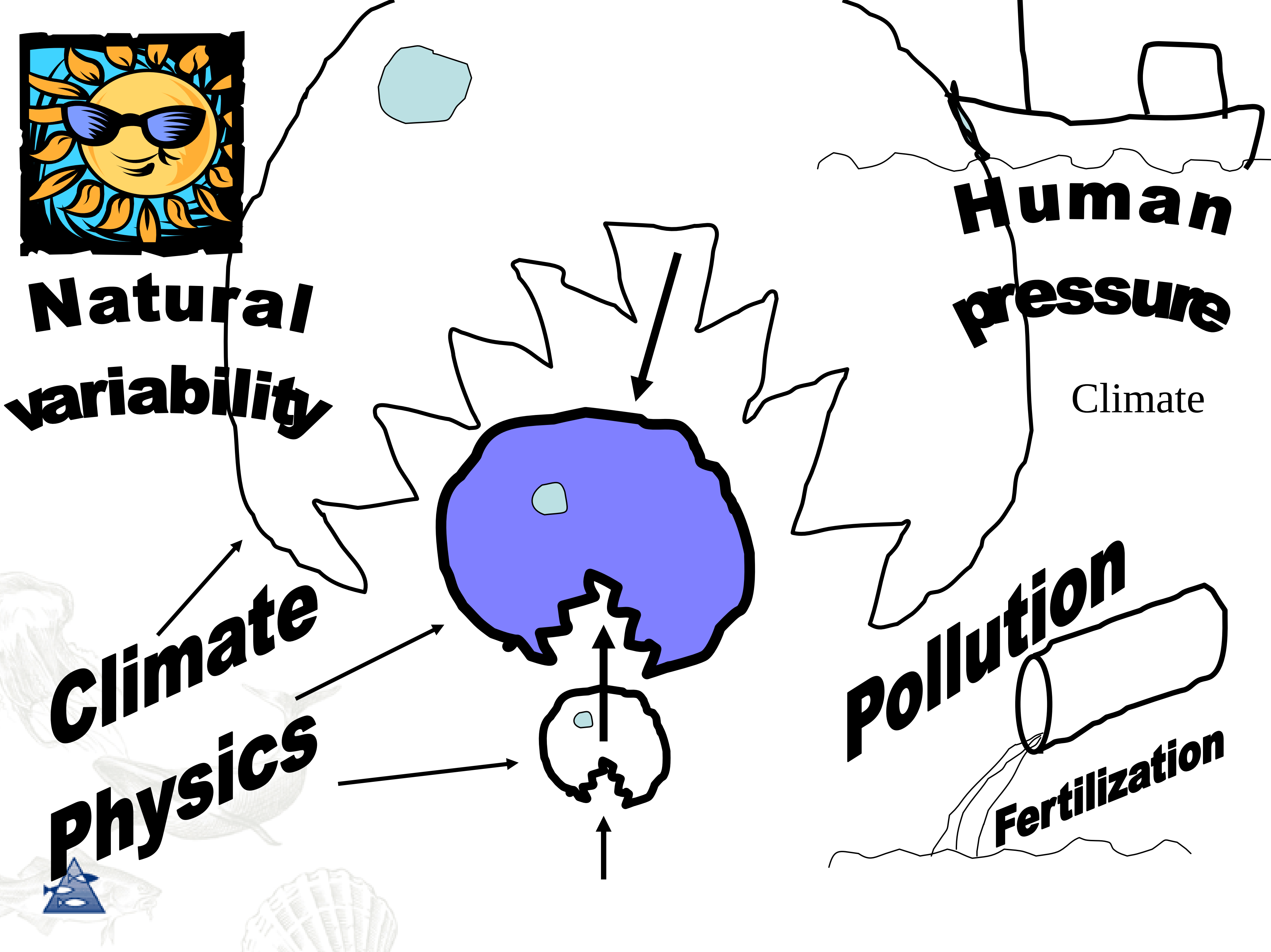
Content

- Some definitions of operationality and the ecosystem approach
- What are we aiming for
- Demonstration of examples
- What’s the near future looking like (in Europe) with respect to operational oceanography

Operationality to us means to deliver timely information about the marine ecosystems in useful formats

- Hindcast (long time series)
- Nowcast (today’s or recent status)
- Forecast (days to several years)
- Scenaria (what if, climate change)


HAVFORSKNINGSINSTITUTTET
Climate-physics
Fishing
Climate-physics


Natural
variability
Human
pressure
Climate
Climate
Physics
Pollution
Fertilization

Why modeling?

Due to the **dynamics and complexity**

of the marine ecosystems, and the challenge to determine the interaction between

large natural variability and

the impact from man,

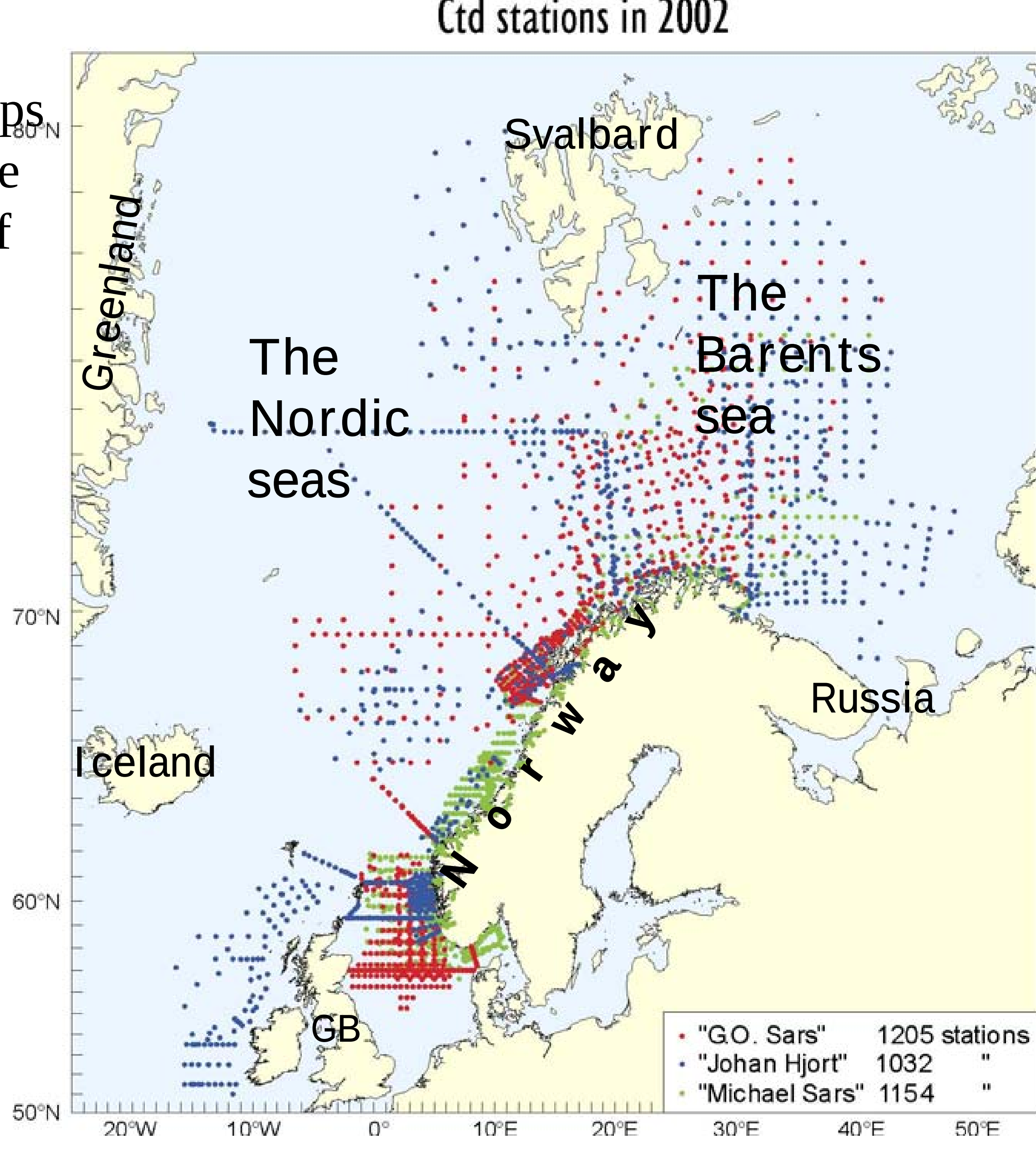
this is only possible by

extensive use of mathematical models

in combination with

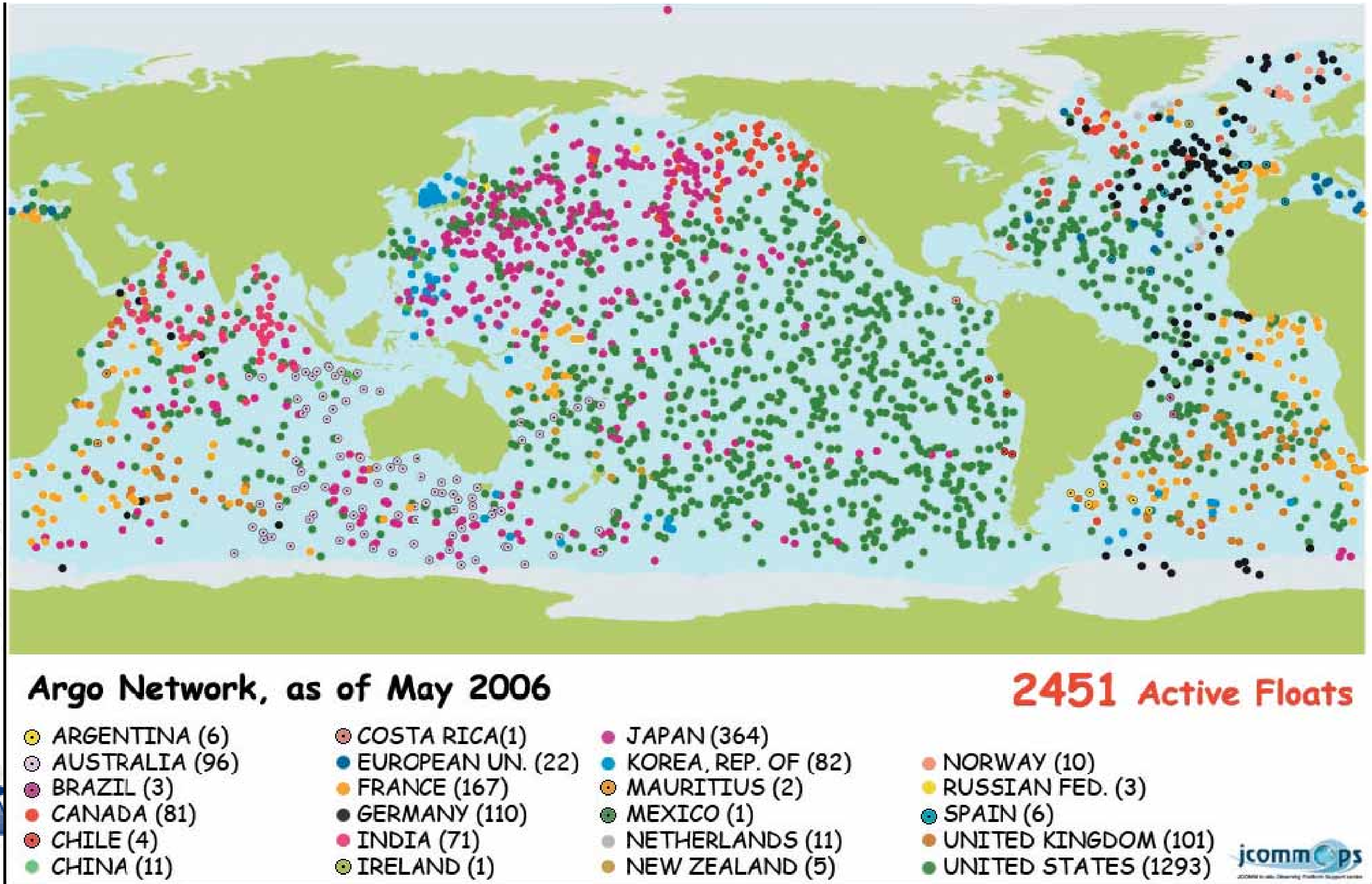
observations.

Observations (from ships satellites and buoys) are crucial for validation of and assimilation into the models



The ARGO program

Can we add some "simple" acoustics to also measure plankton in the upper 2000 m??



Hindcast (50 year), nowcast and forecast (week (or 100 years)) of:

Relevant physics

- Circulation, temperature, salinity, turbulence

Phytoplankton

- Concentration of functional groups (or specific (harmful) species), nutrients, detritus, oxygen, sedimentation, light

Zooplankton

- Individual species (or functional group(s)? (IBM or Eulerian)

Fish larvae

- growth and distribution (and mortality?) (IBM)

Fish migration

- growth and distribution (overlap between species)

The operational needs

From the above variables, only **physics** is operationally available in hindcast, nowcast and forecast (and still the quality can be questioned, partly due to lack of resolution due to lack of computer resources.

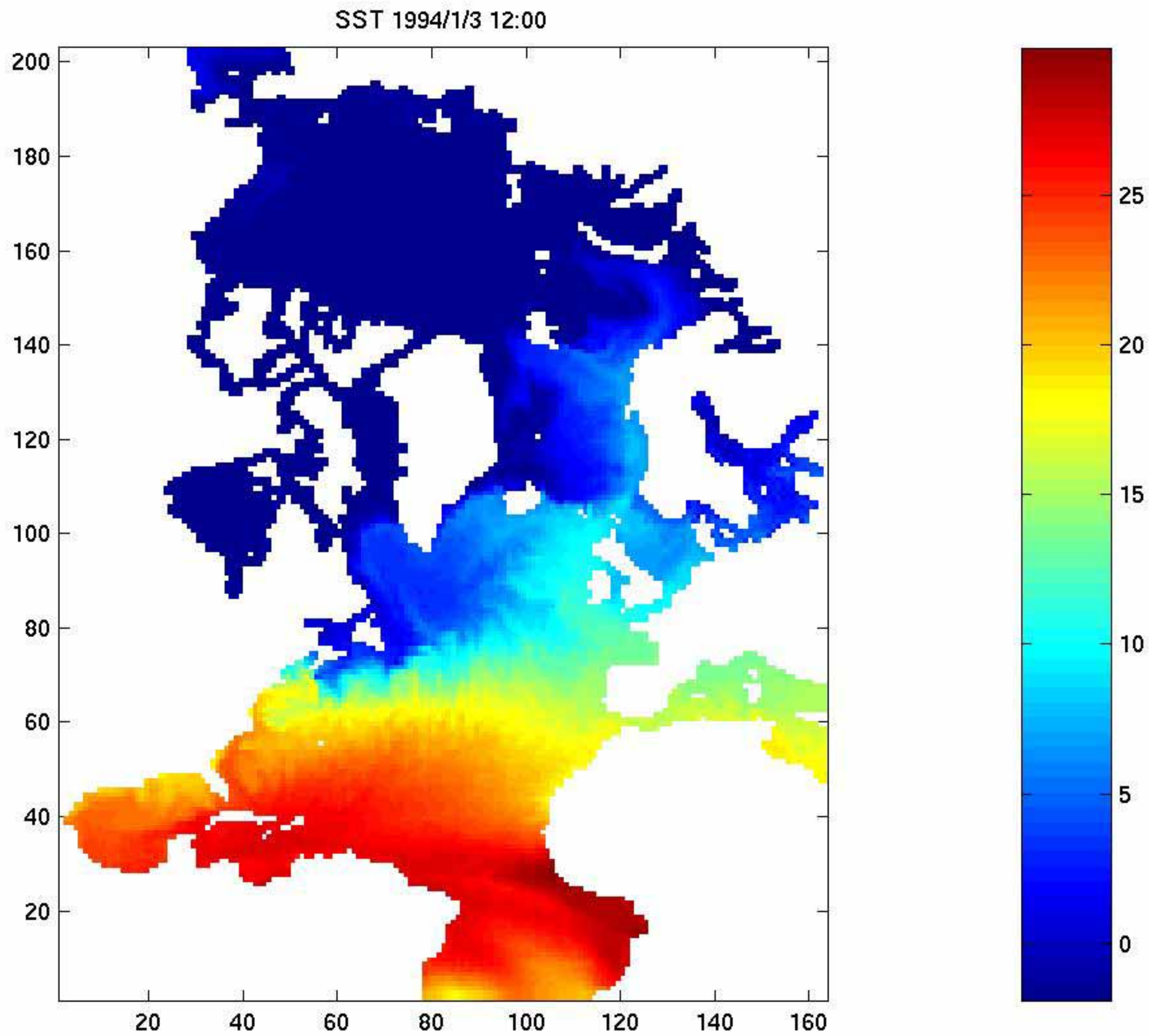
Phytoplankton is starting to be operational (eg. MONCOZE, Liverpool Bay….)

We need **zooplankton** to realistically model larval growth and planktivour fish migration, because this we need to more realistically address the key challenges for the fisheries research, namely quantifying and predicting:

Recruitment, growth, mortality and distribution

Since we (mathematically) do not know all the processes leading up to these states/processes, we need to make statistically shortcuts between smart **INDICATORS** (derived from our modelled state variables) and recruitment, growth, mortality and distribution, **including observations** where necessary.

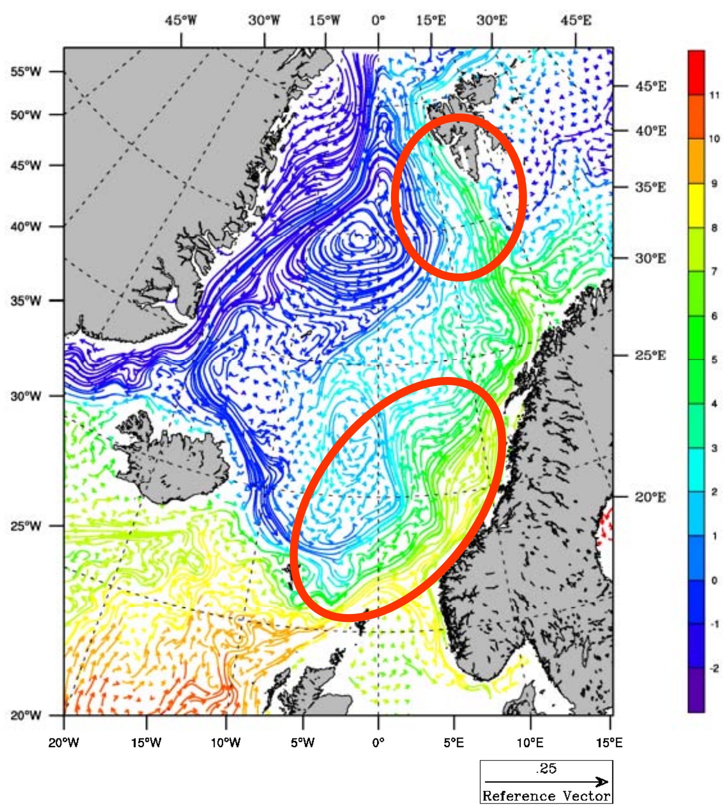
NB! Overlap between pray and predators determines **natural mortality**



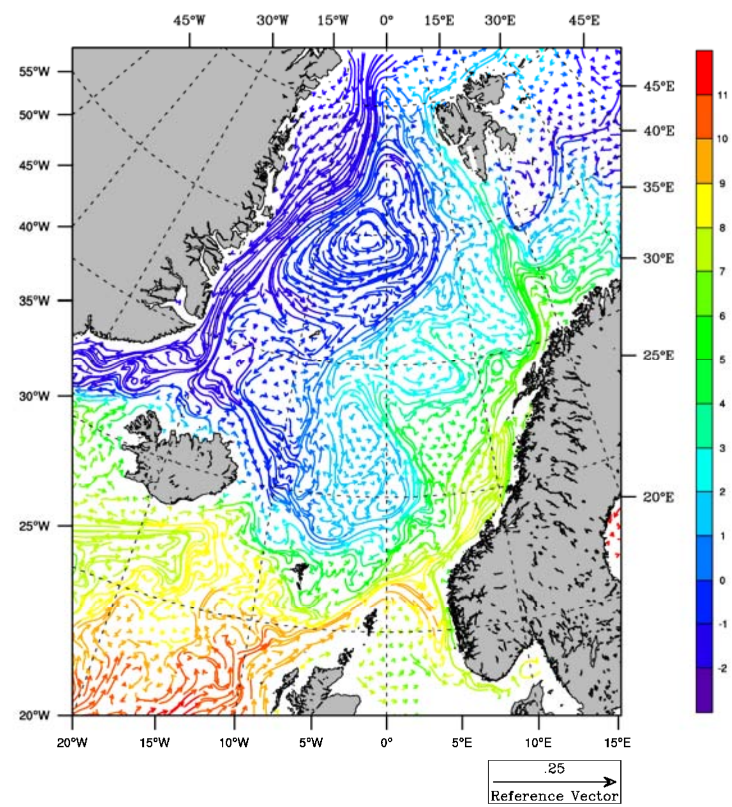
Paul Budgell & ROMS

Circulation and temperature at 50 m depth (50 year global simulations)

Winter 1995 average, high NAO

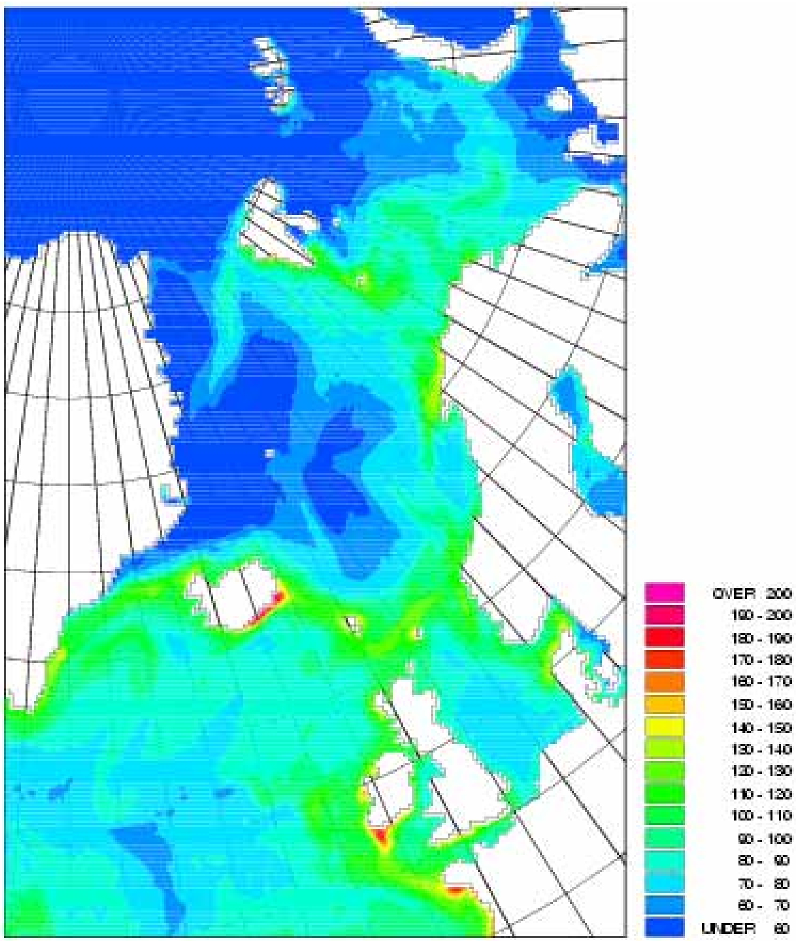


Winter 1996 average, low NAO



Paul Budgell, Bjørn Ådlandsvik, Vidar Lien

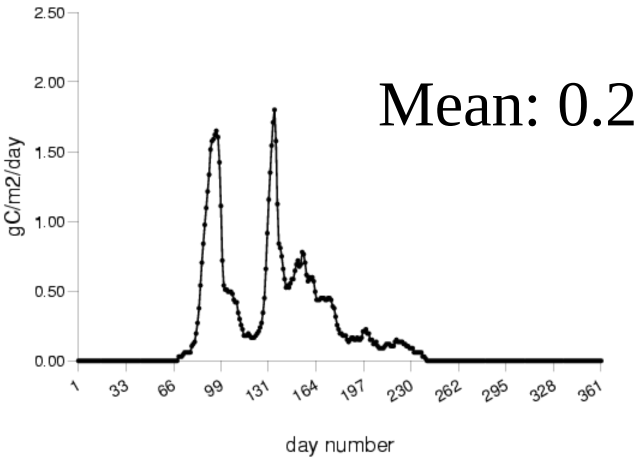
Primary production

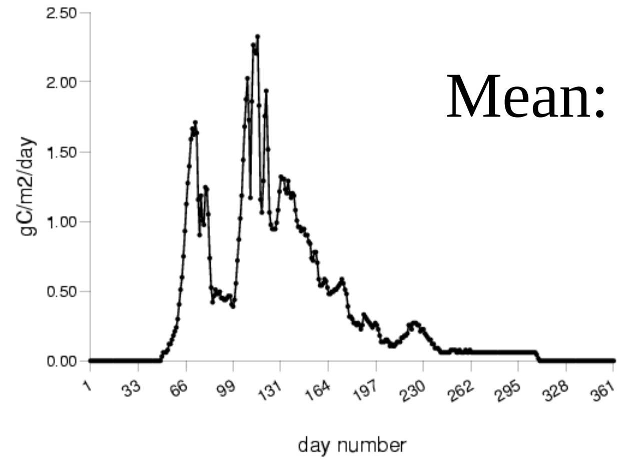


Yearly average primary production, 1981-2004.

Skogen et al. submitted ICES JMS

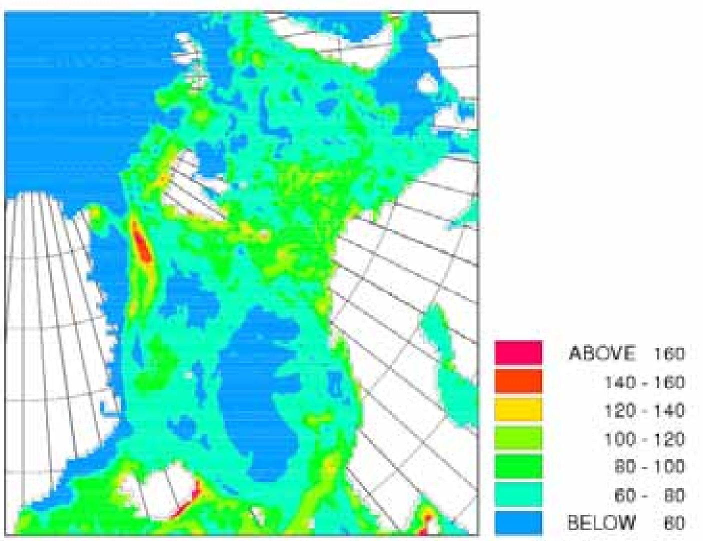
Station M (66ºN, 2ºE)



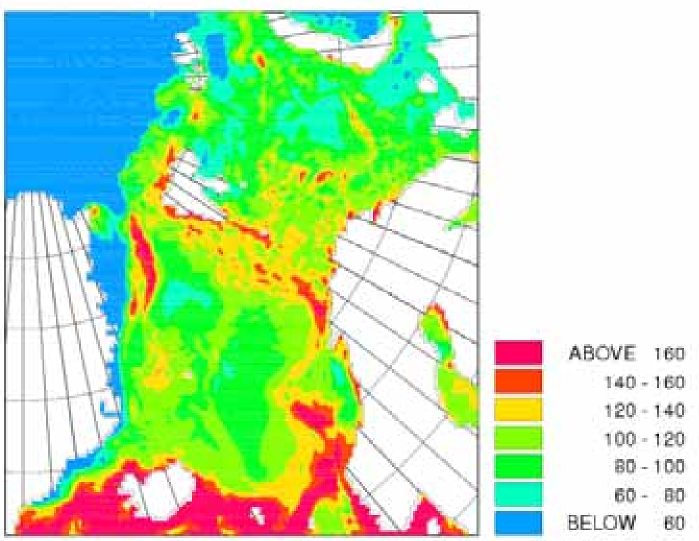


2006

mean 61 gC/m2/year



mean 91 gC/m2/year



Biophysical (NORWECOM)

processes

- Primary production
- Respiration
- Algae death
- Regeneration
- Self shading
- Turbidity
- Sedimentation
- Resuspension
- Denitrification

state variables

- Diatoms, flagellates (chatonella)
- Detritus (N and P) and diatom skeletals (Si)
- Inorganic nitrogen, phosphorus, silicate
- Oxygen
- Light model

North Sea primary production

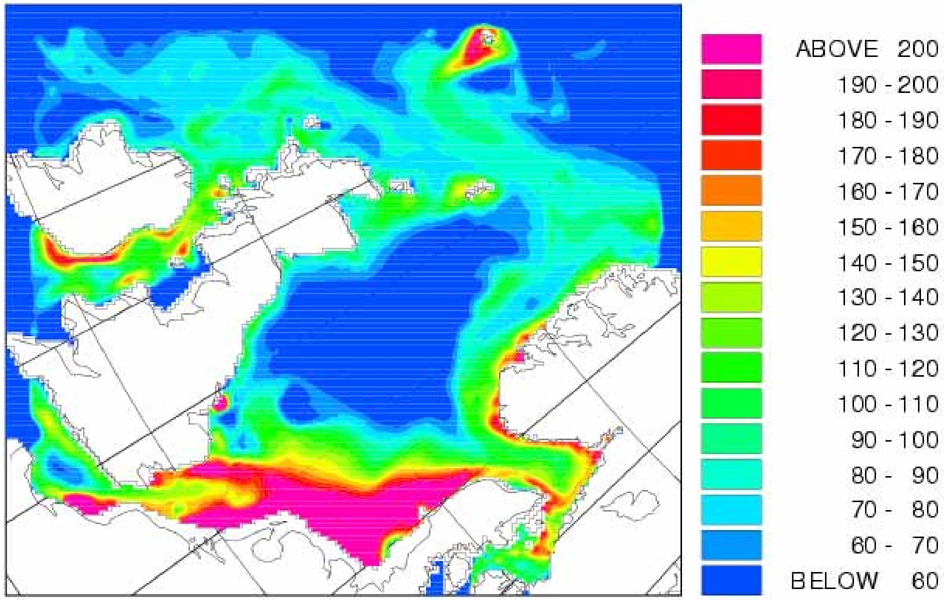
Run: North Sea+POM 1981-2006, 10km res

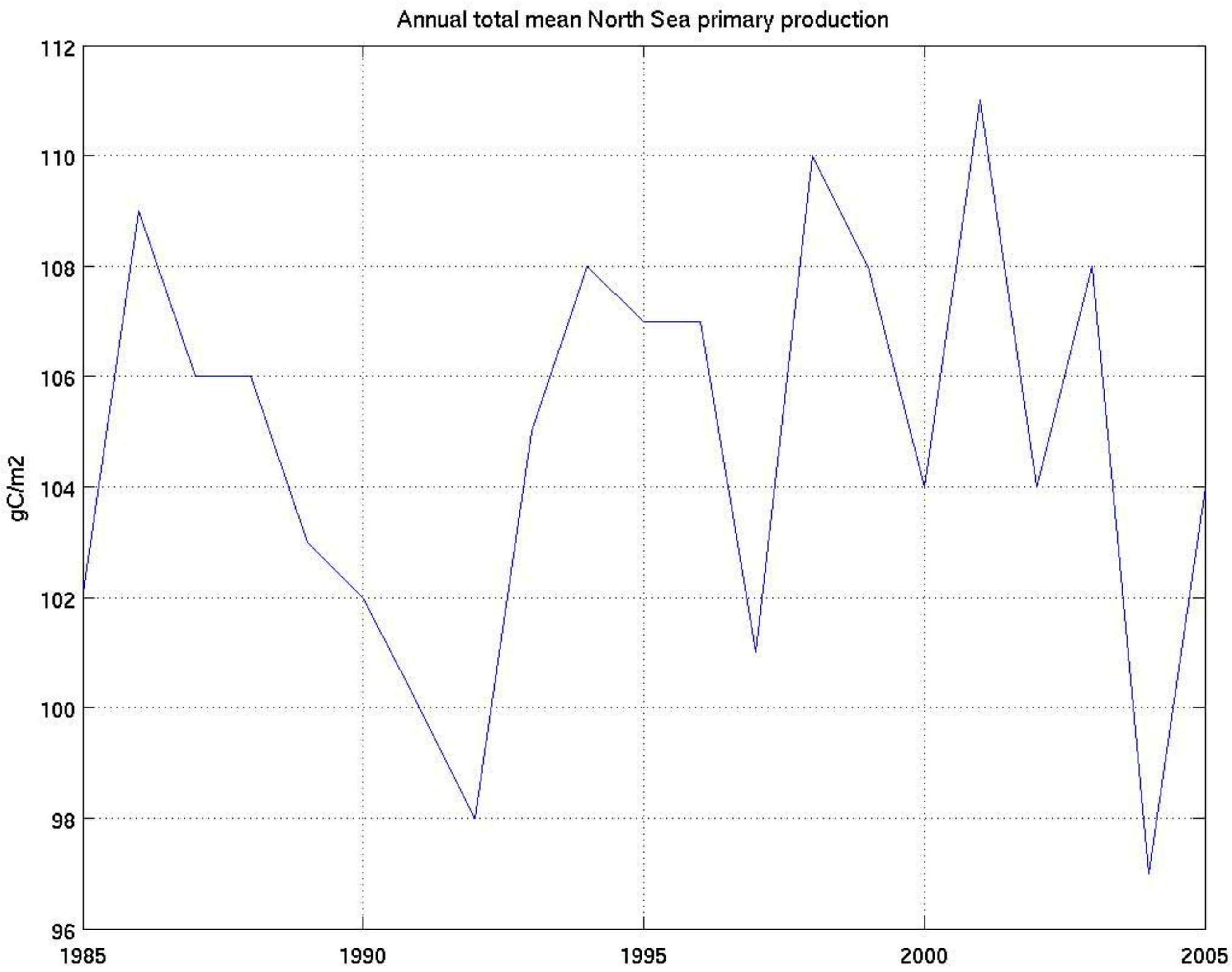
Morten Skogen, Solfrid Hjøllo, Einar Svendsen

Prim.production, nutrients, sedimentation, oxygen, current, hydrography…..

Monthly means, daily/2.daily values field+ sections

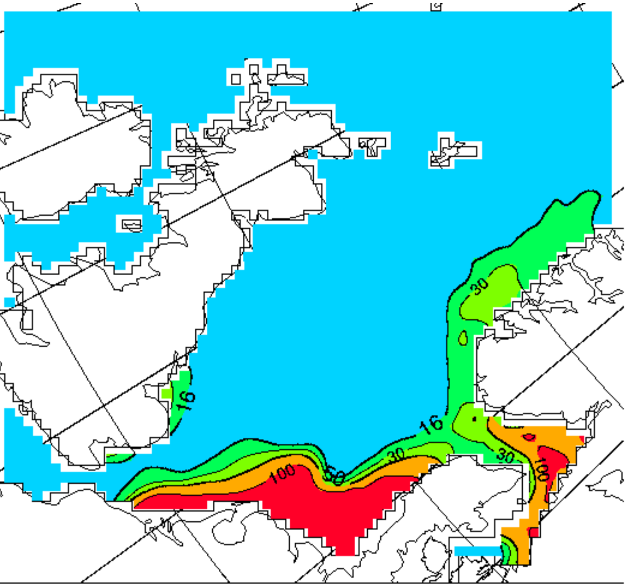
Mean modelled annual NorthSea primary production (1981-2006) (gC/m^2/year)



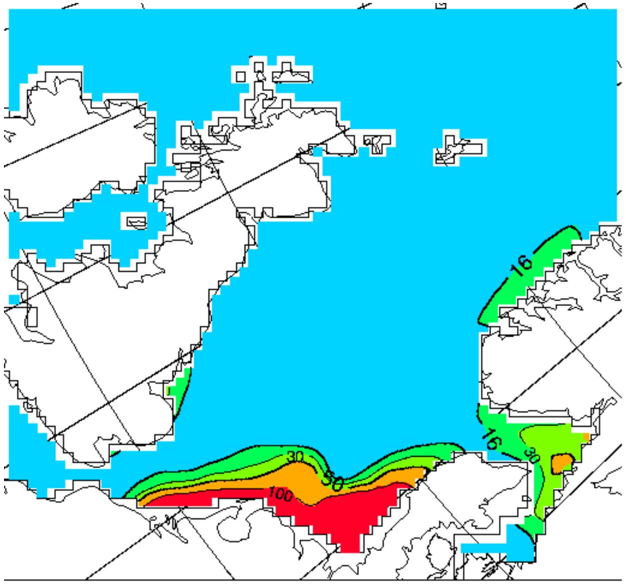


Annual total mean North Sea primary production
gC/m2
112
110
108
106
104
102
100
98
96
1985
1990
1995
2000
2005

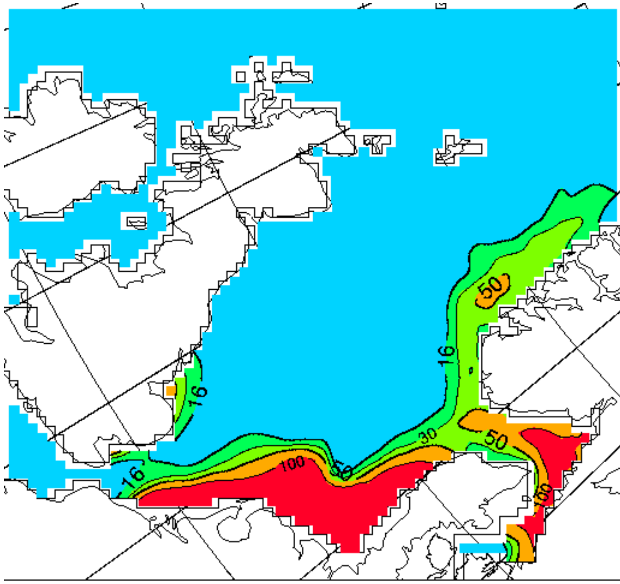
N/P eutrophication assessment (2)



Run1 (reference)

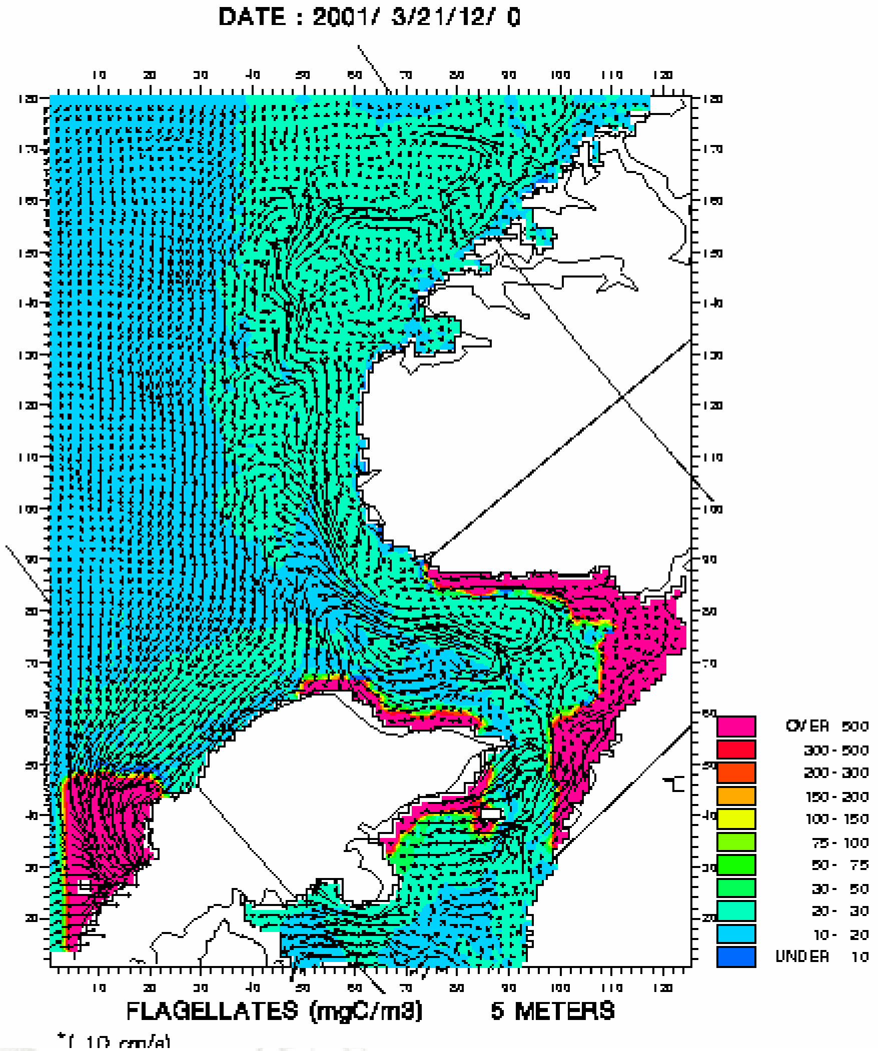


Run2 (N+P reduction)

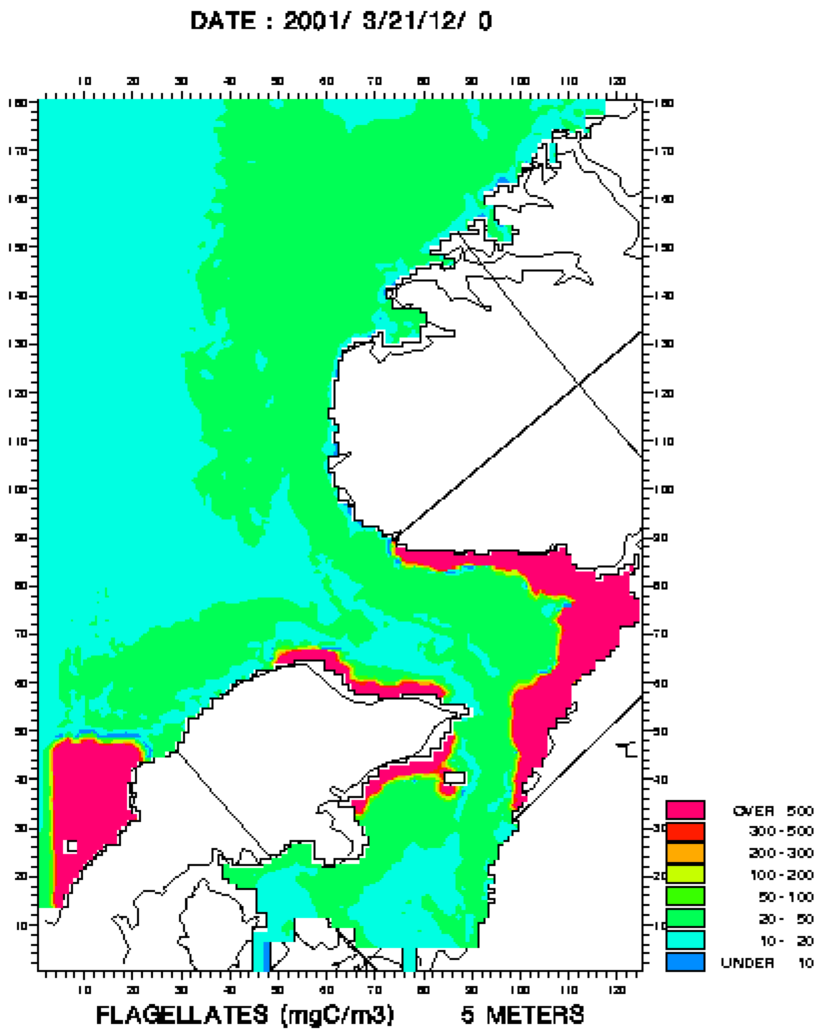


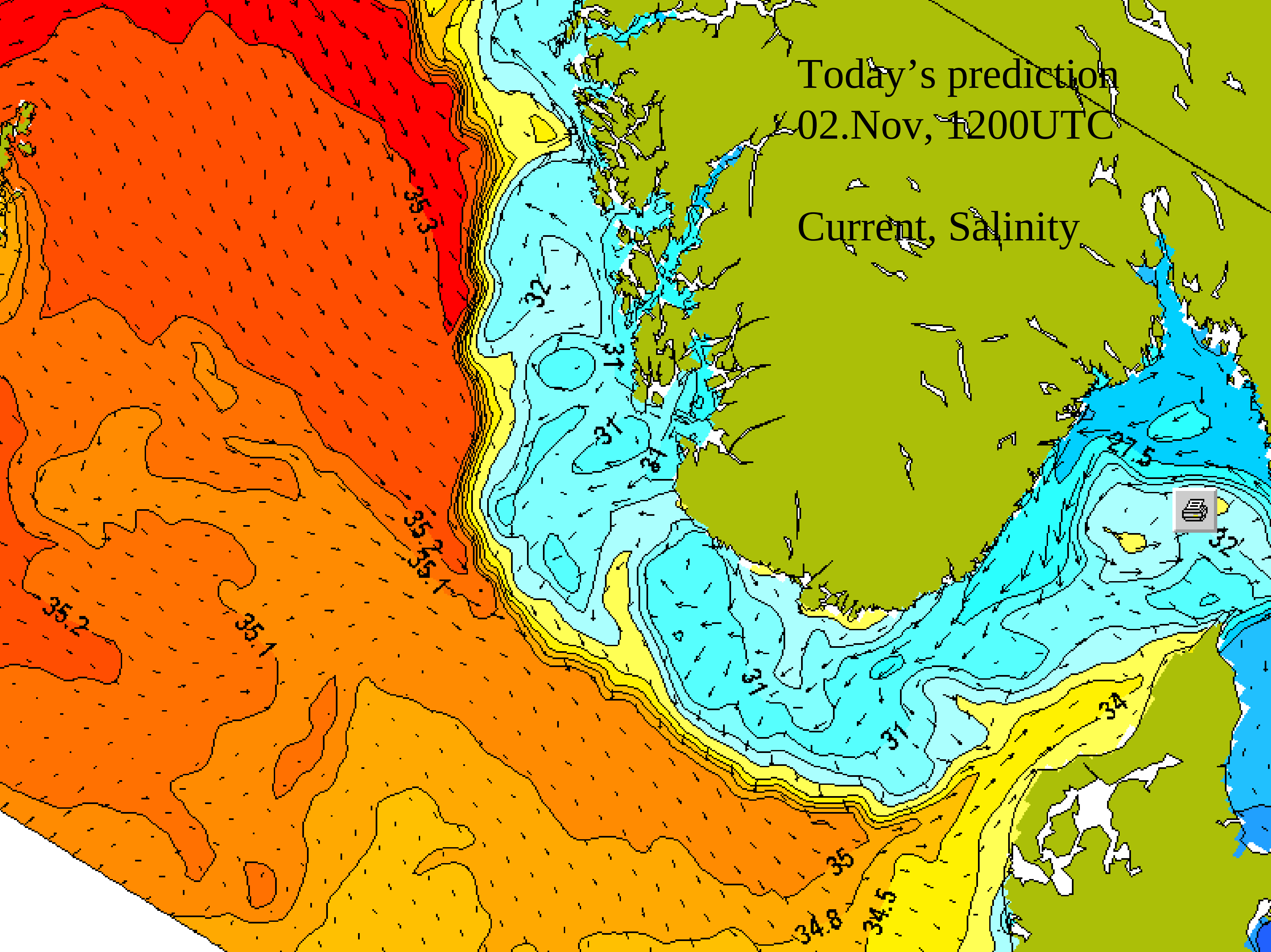
Run3 (P reduction)

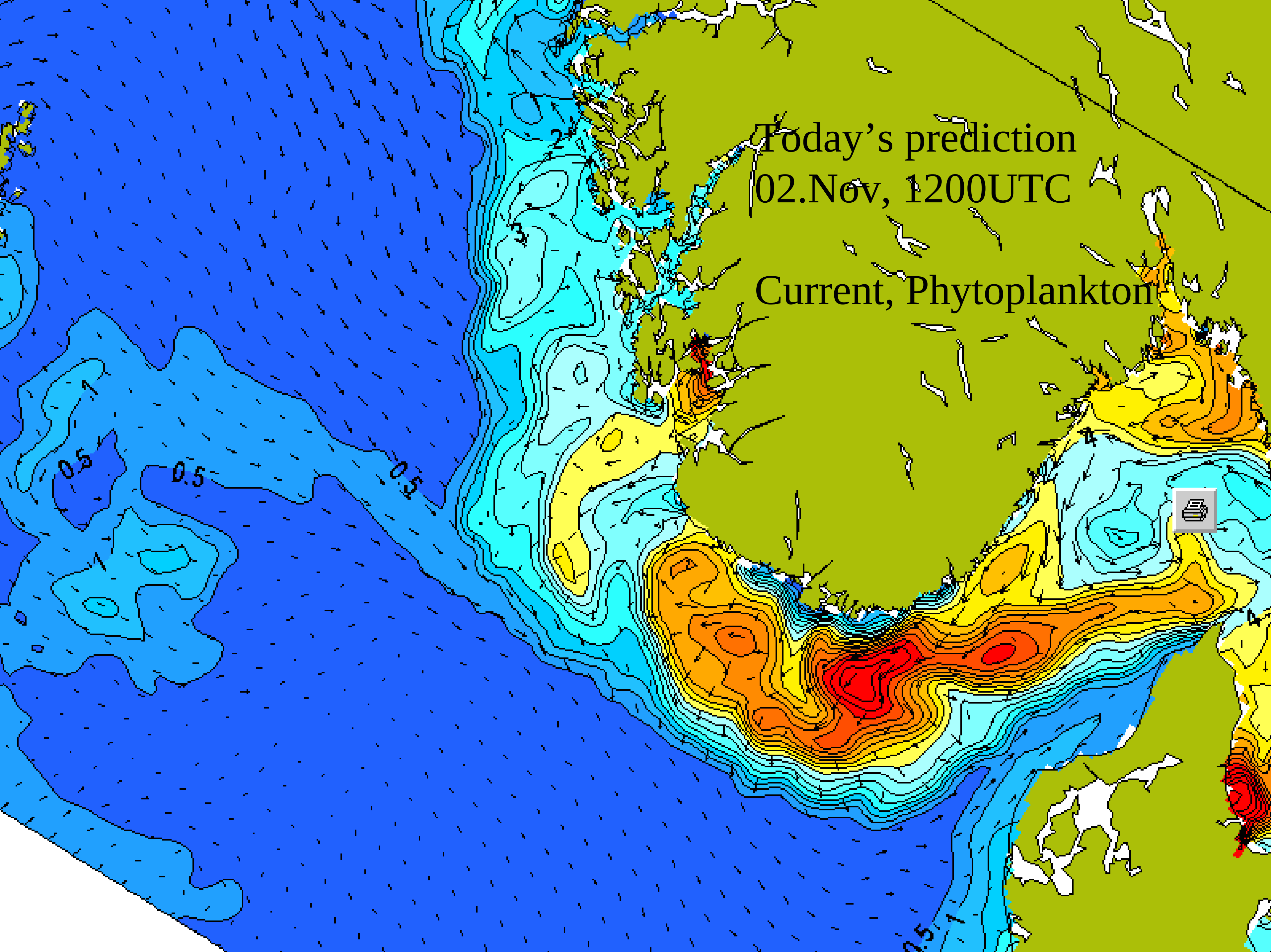
Harmful algae blooming 2001



Harmful algae blooming, 2001



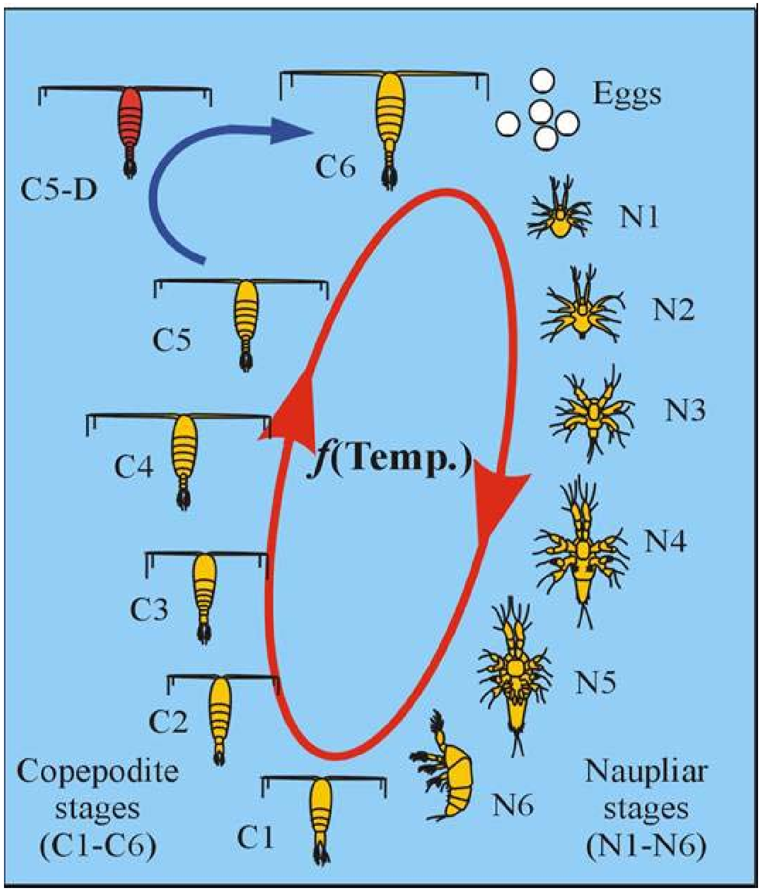

Today's prediction
02.Nov, 1200UTC
Current, Salinity
35.3
35.25
35.1
35.2
35.1
35
34.8
34.5
34
32
31
31
31
31
31
32
27.5


Today's prediction
02.Nov, 1200UTC
Current, Phytoplankton
0.5
0.5
0.5
1
2
3
4
4
0.5
1

Individuals

Attributes

- Stage
- Structural weight
- Fat content
- Internal number
- Position
- Depth



From http://pulse.unh.edu/

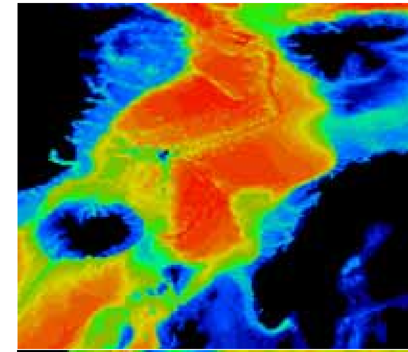
Strategies

- OWD, WUD, AFD, FSR, VM1,VM2

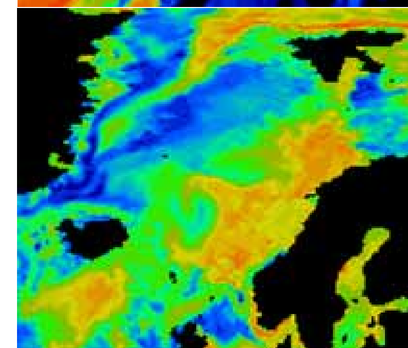
Environment

- Model grid 181x154 20x20 km squares
- 1 m vertical resolution
- Environmental features:
  - Temperature
  - Currents
  - Light
  - Food
  - Predators

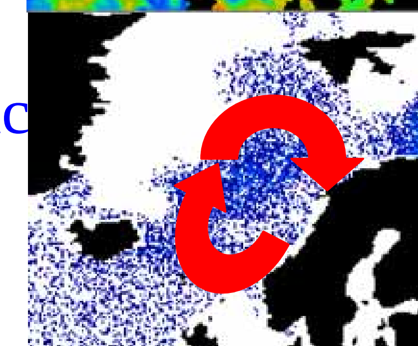
Bathymetri



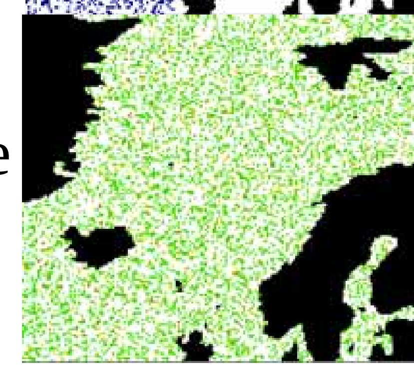
Diatoms & flagellates



Mesopelagic fish and herring

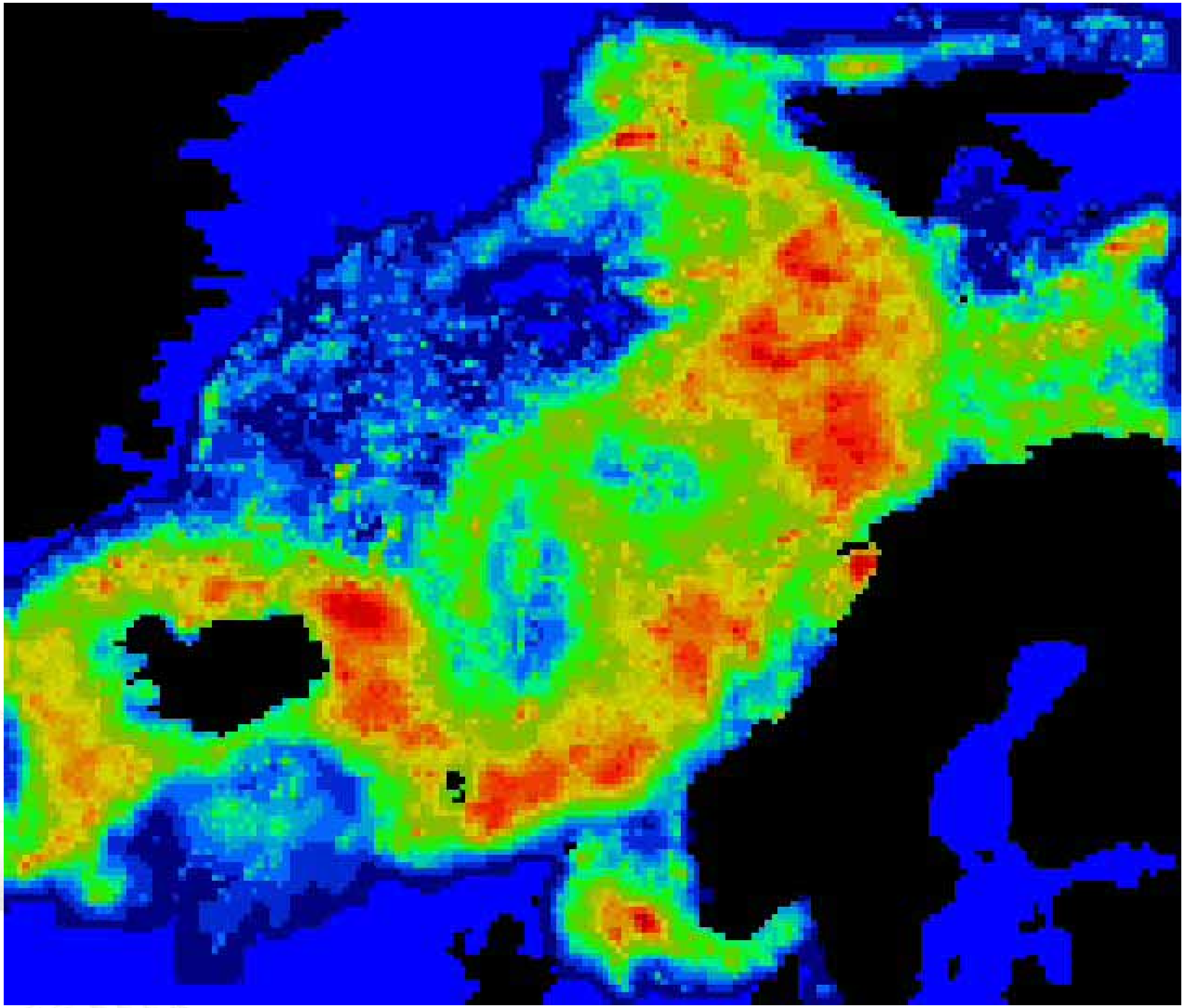


Invertebrate predators



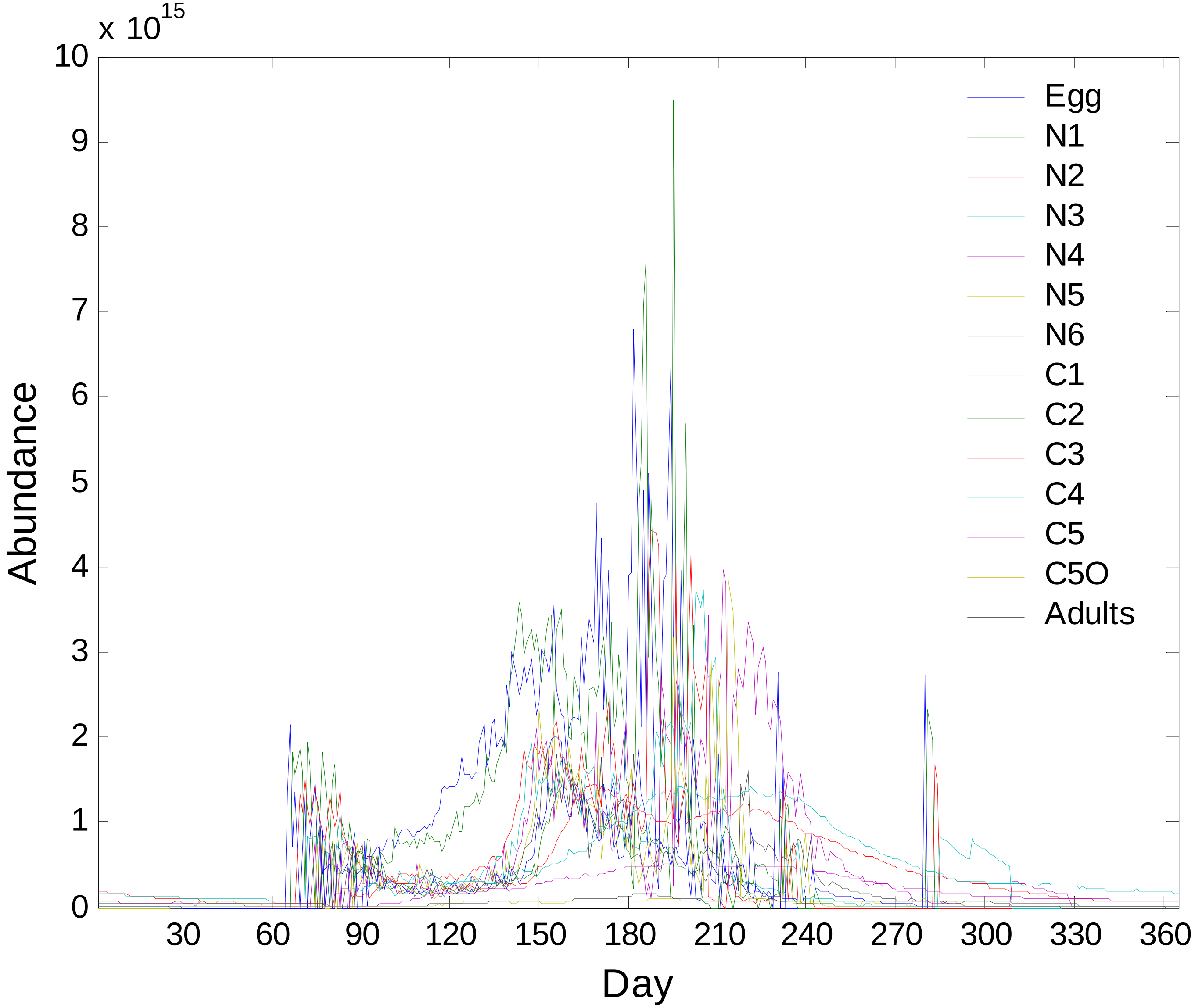
Results

Distribution of copepodites after 100 years of spin up time



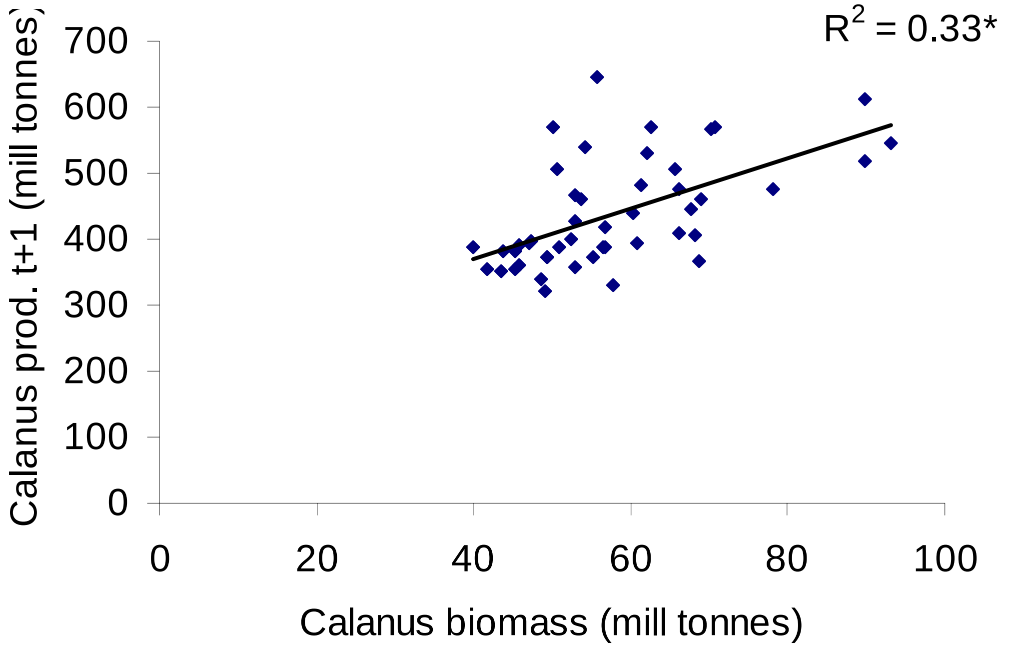
Results

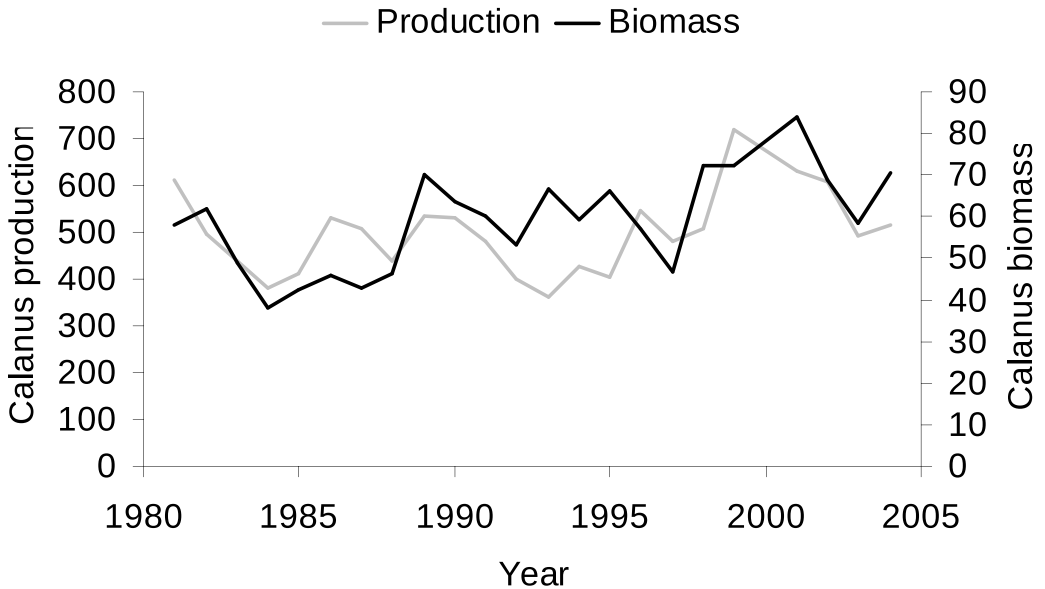
Population dynamics

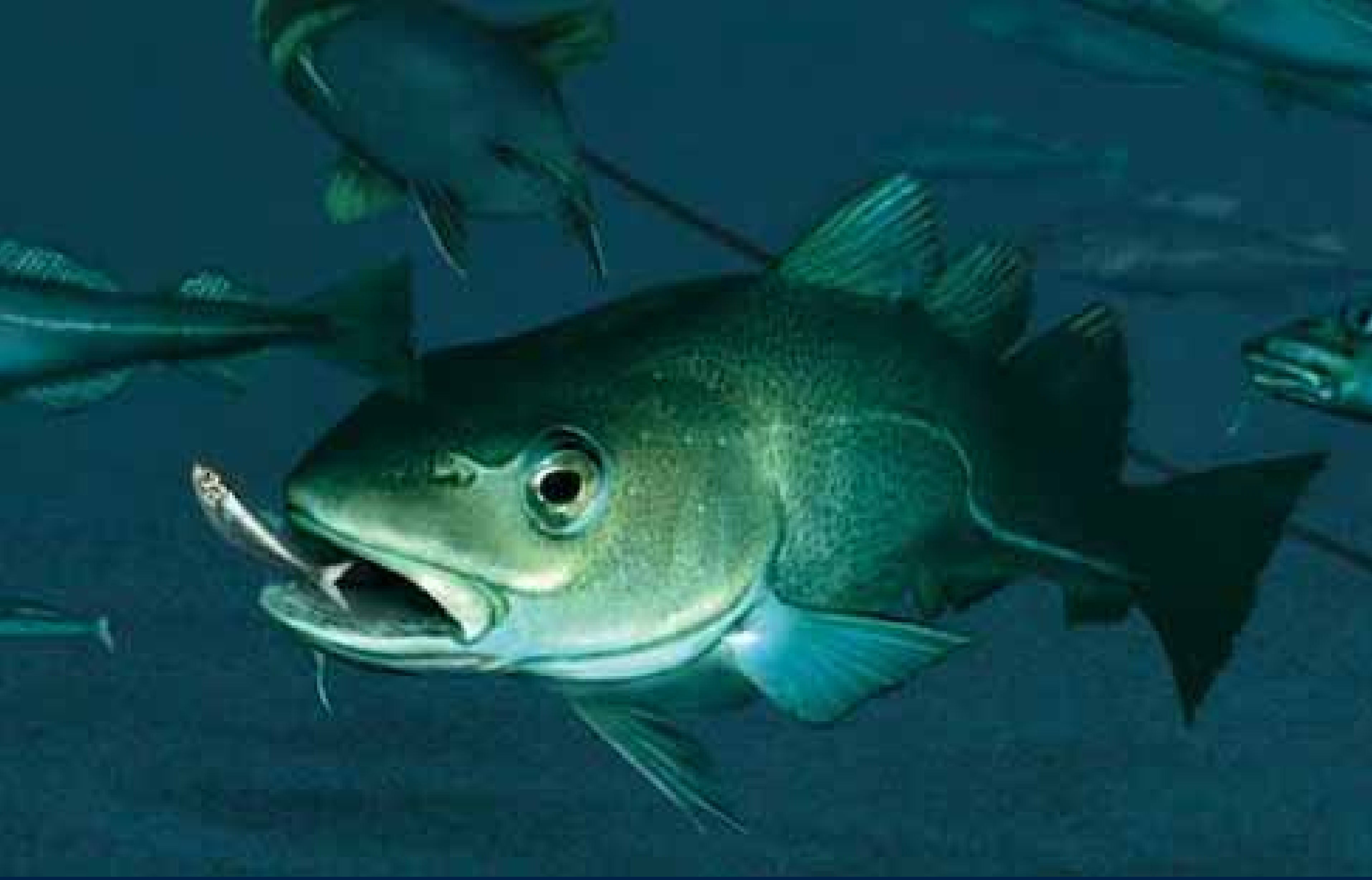


Results

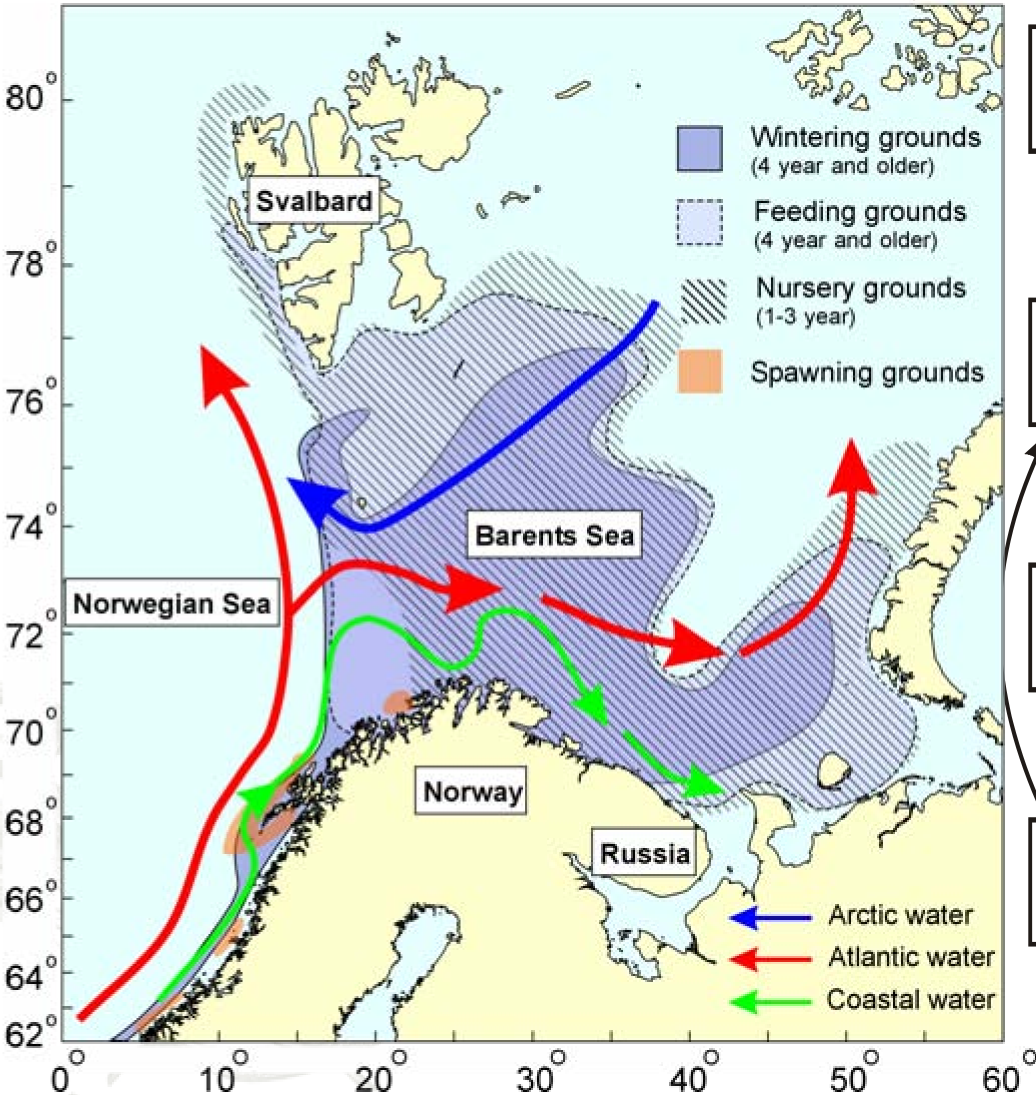
Stock-recruit relations

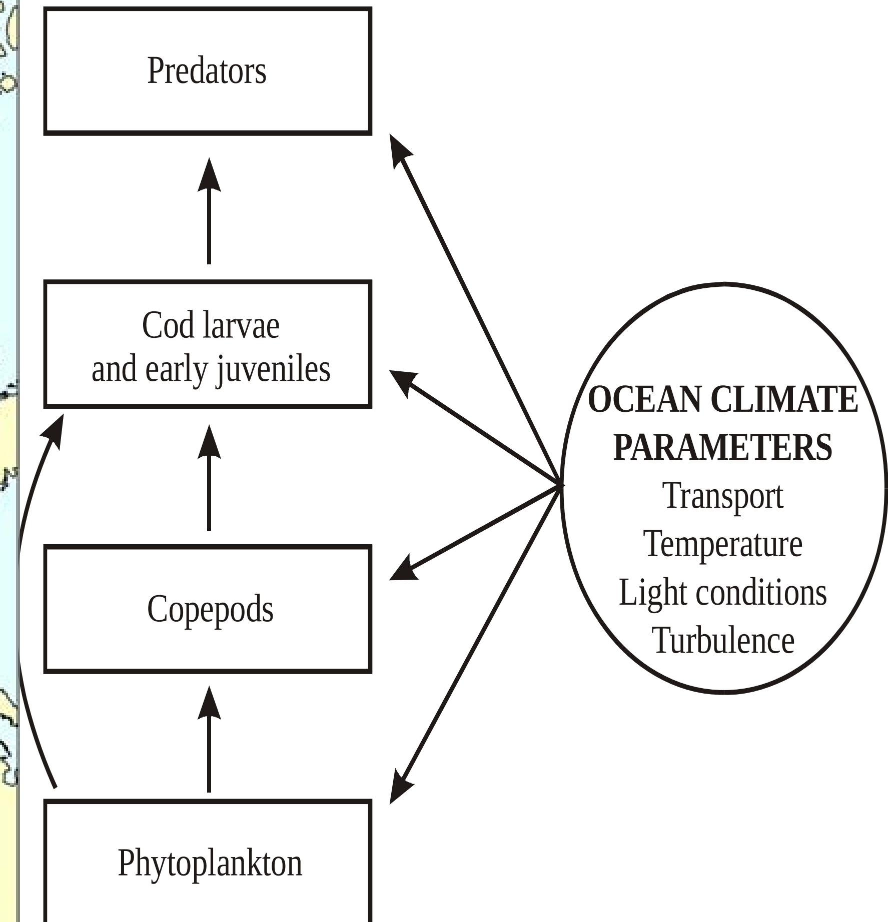




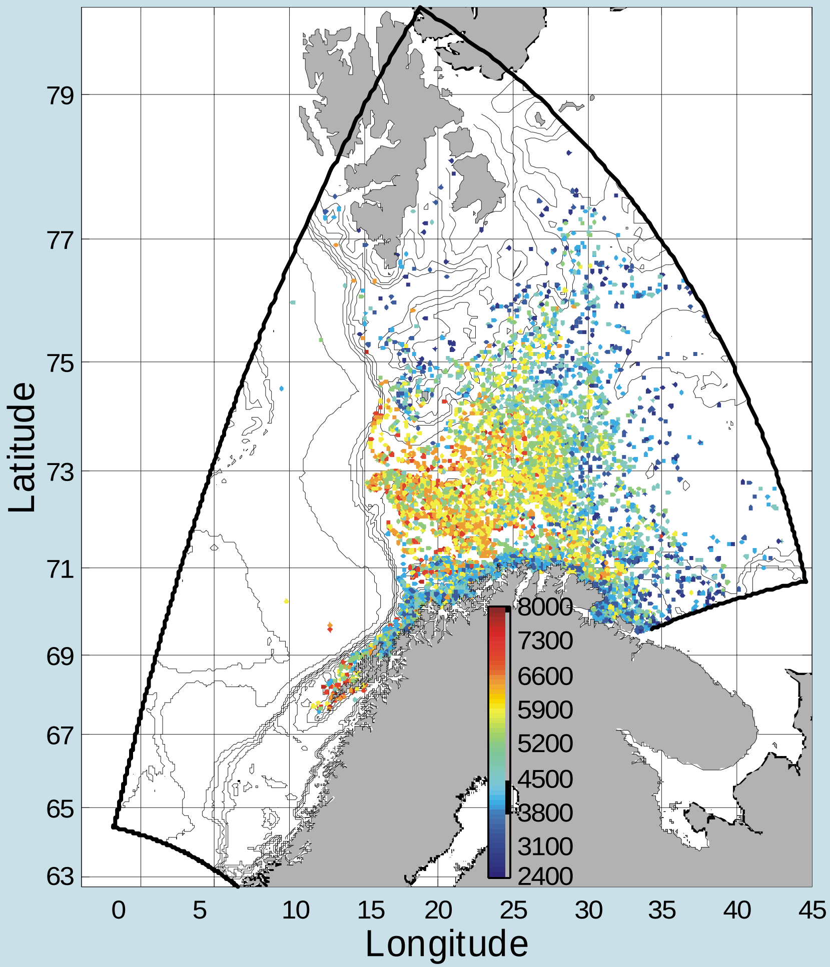


Spawning and nursery grounds

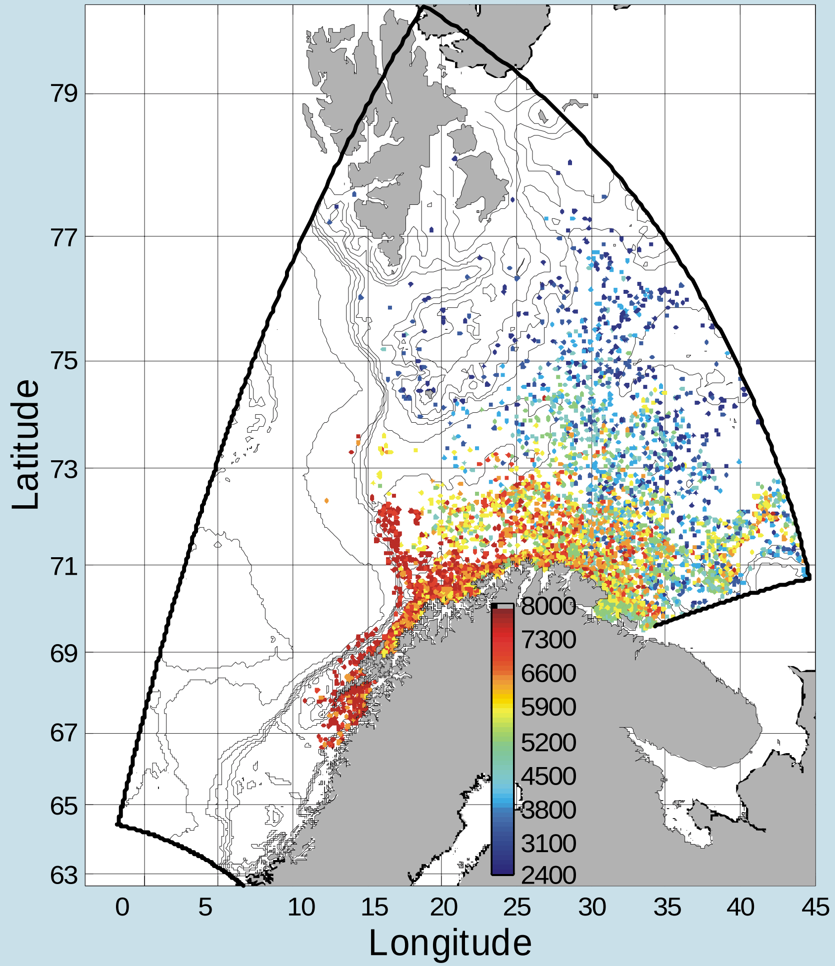




Trophic transfer



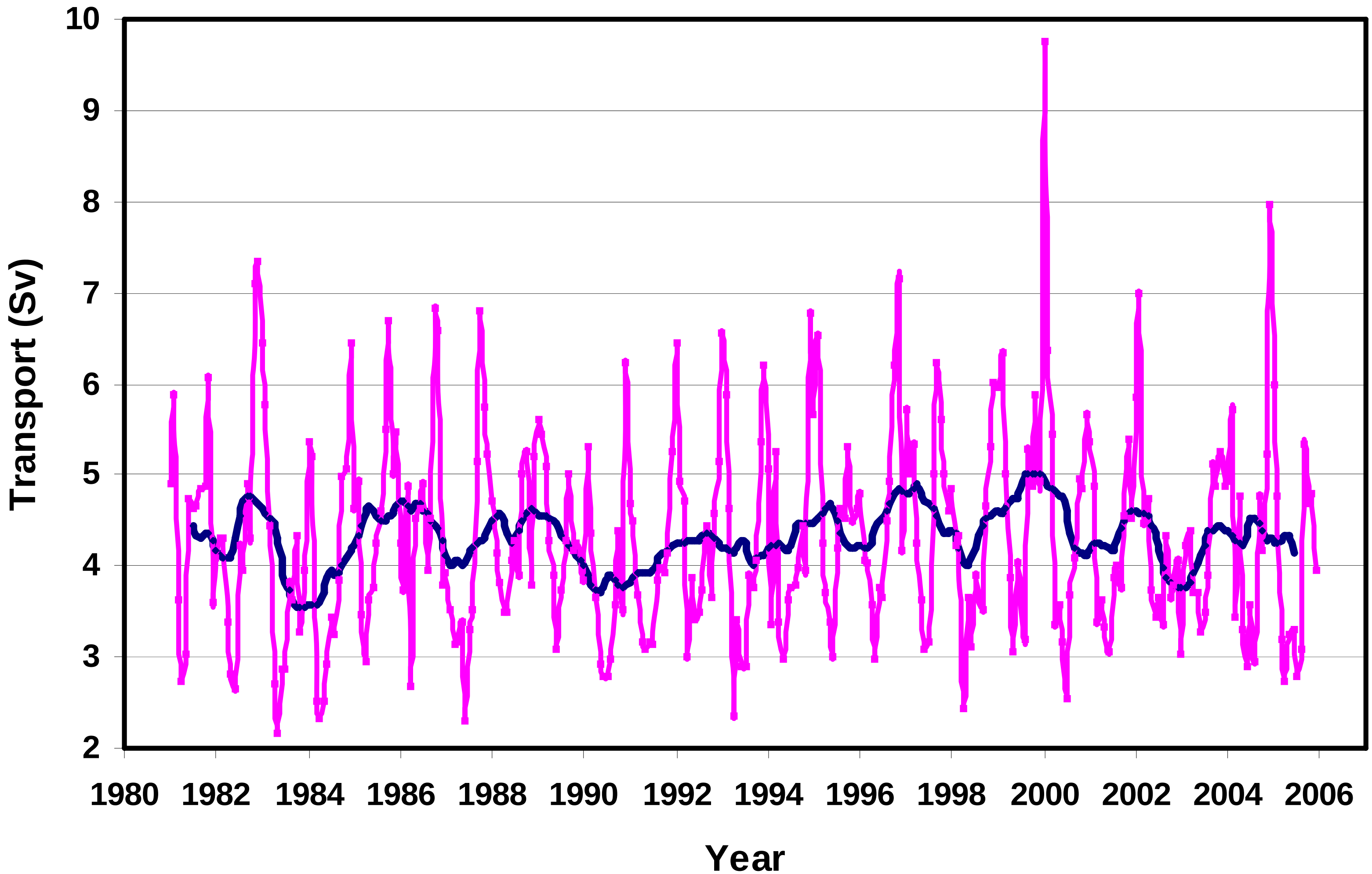
1985



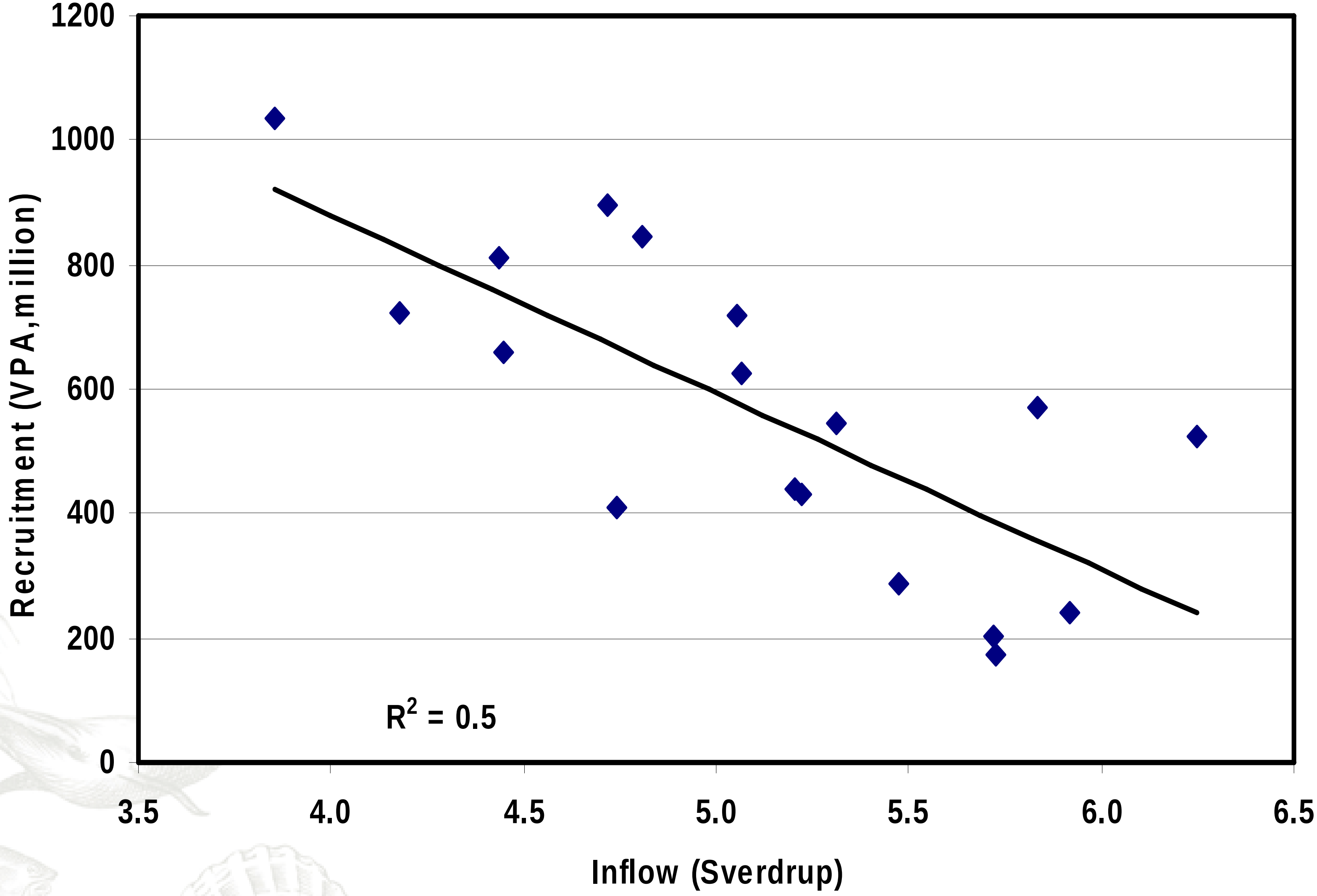
1986

Vikebø et al. (2004)

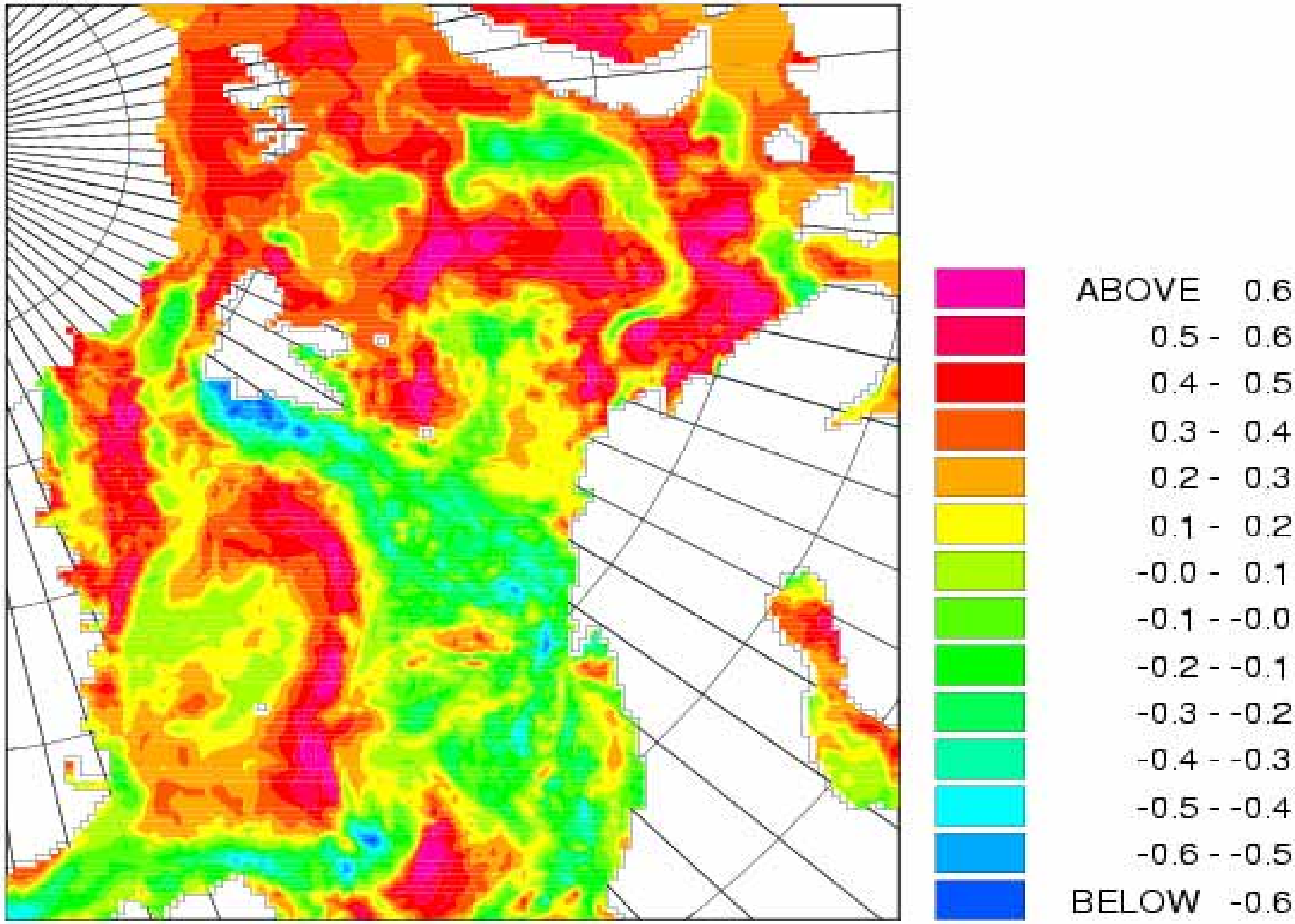
Modelled volume transport at the entrance to the Barents Sea



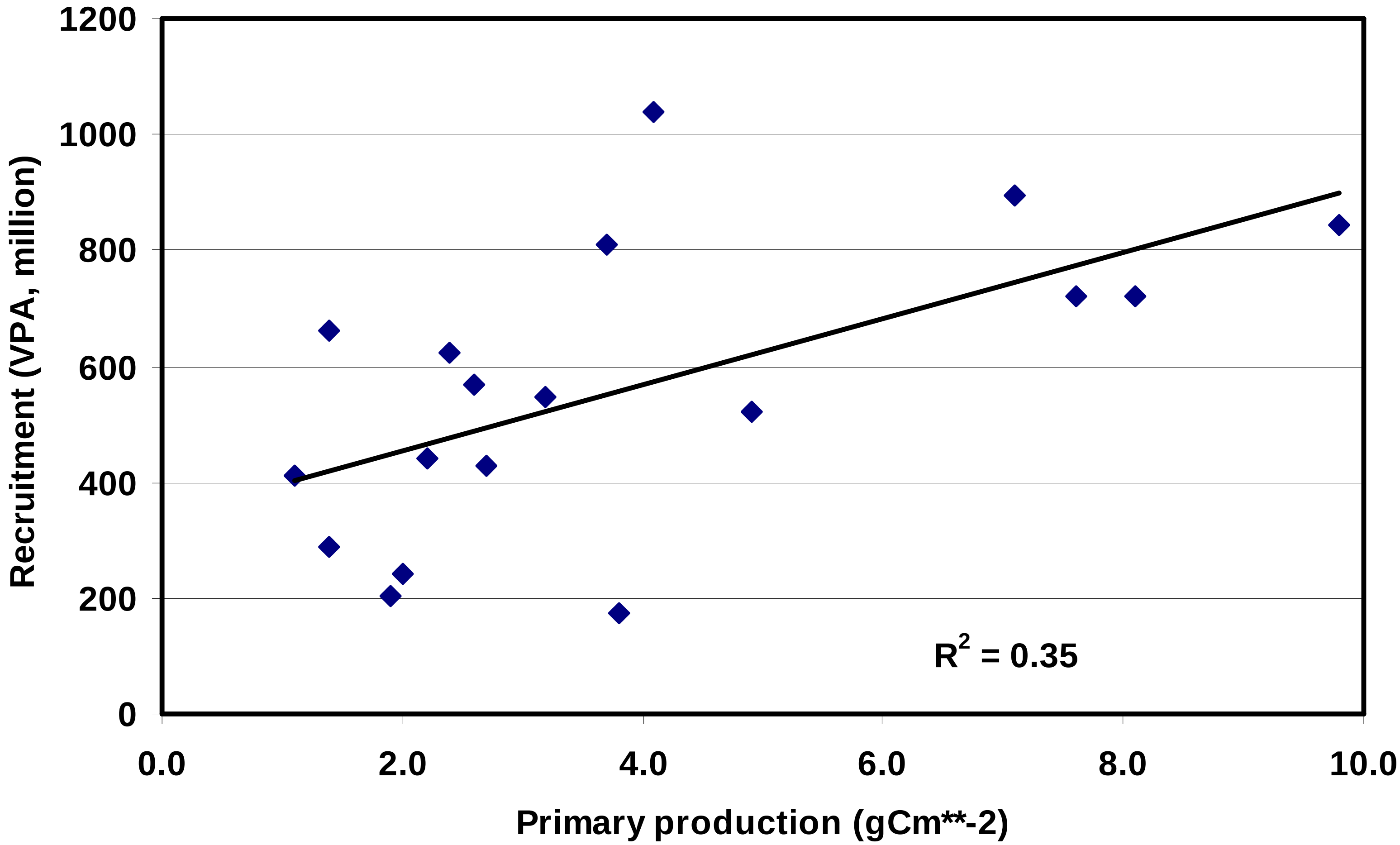
Inflow to the Barents Sea in autumn vs. cod (3y) recruitment 3 years later



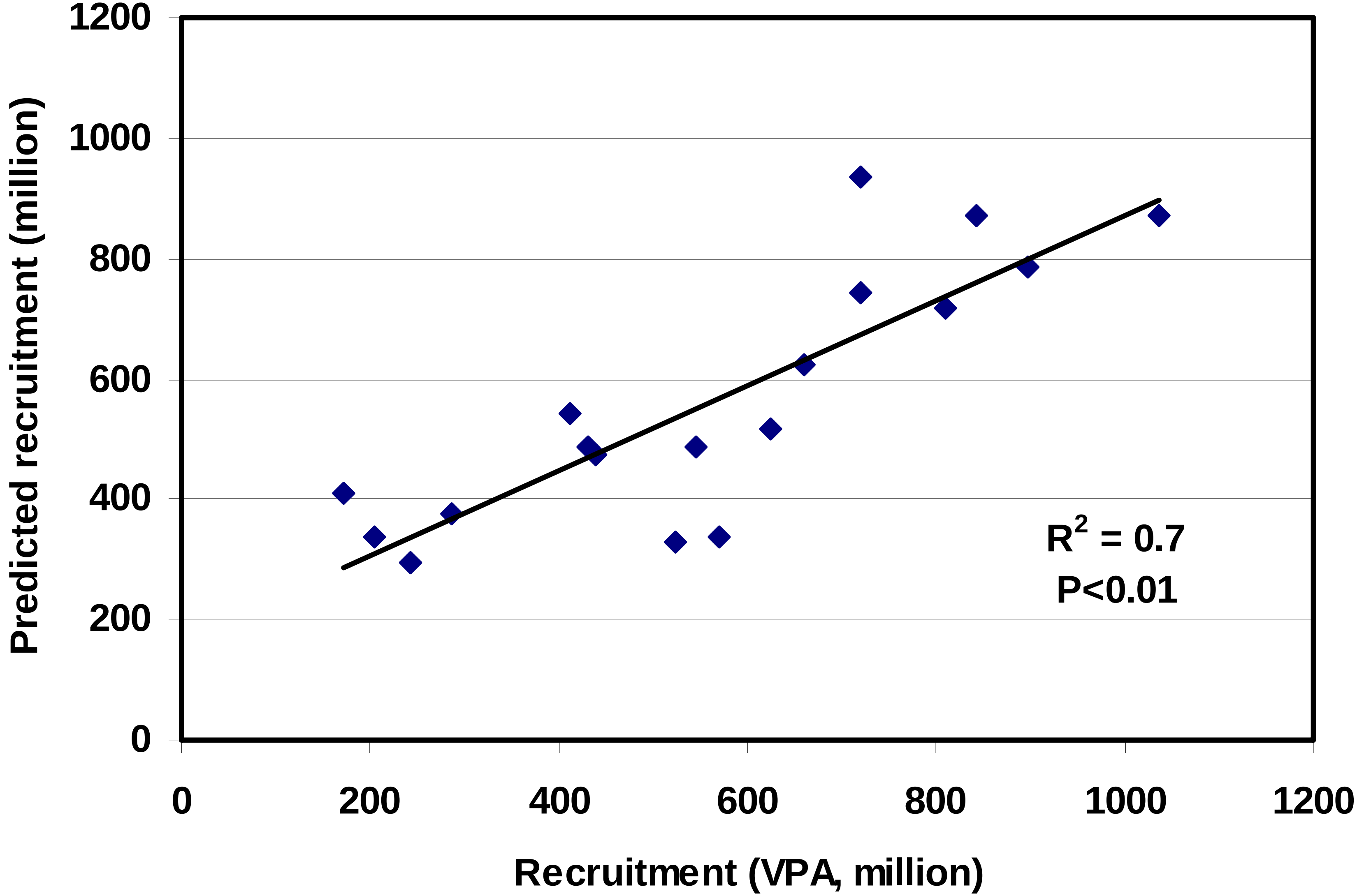
Correlation map between primary production in April and cod recruitment 3 years later

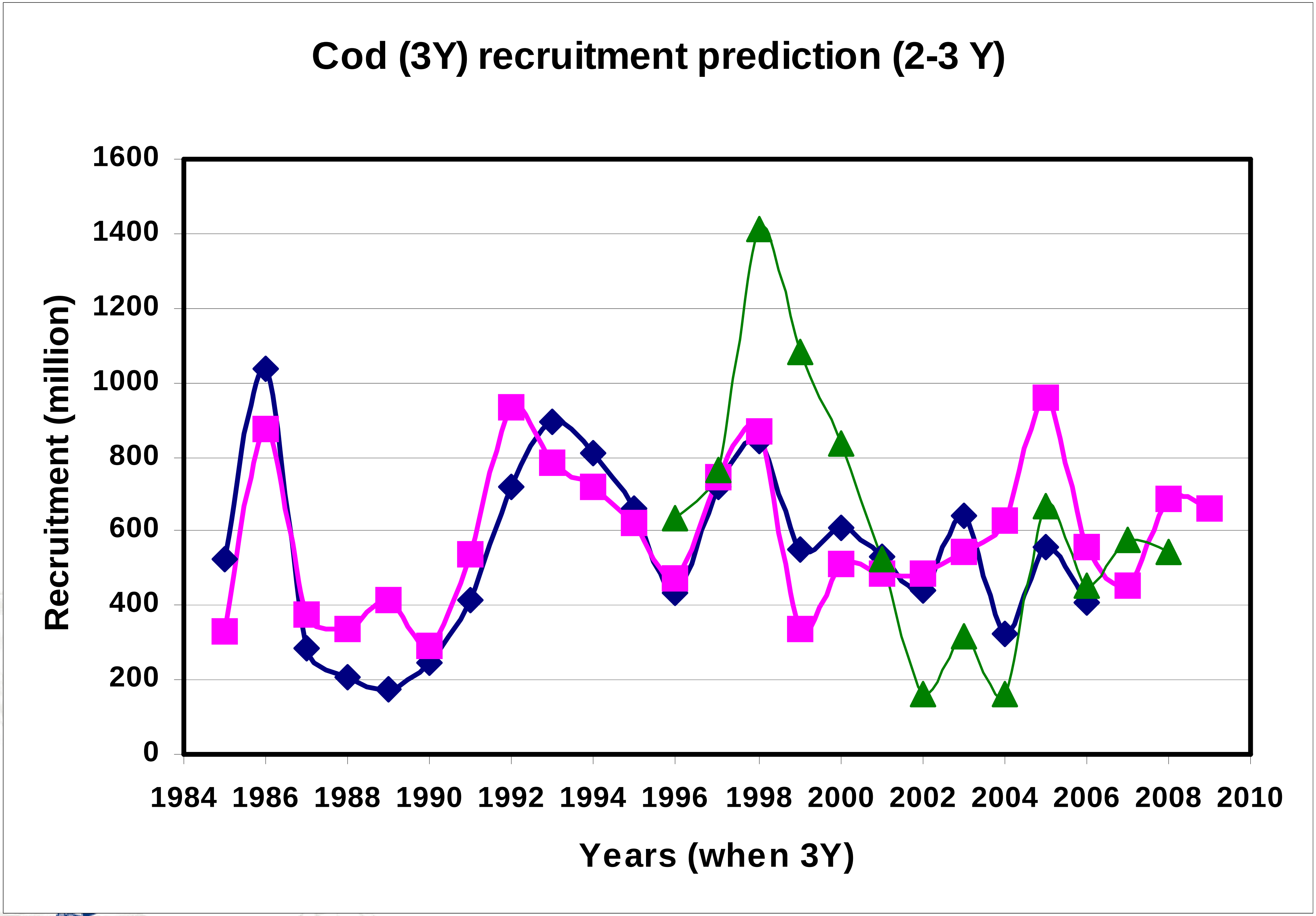


Primary production in April vs. cod recruitment 3 years later



Statistical model of 3-year old cod recruits




Cod (3Y) recruitment prediction (2-3 Y)
Recruitment (million)
1600
1400
1200
1000
800
600
400
200
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Years (when 3Y)

So, what does the future look like with respect to operational oceanography

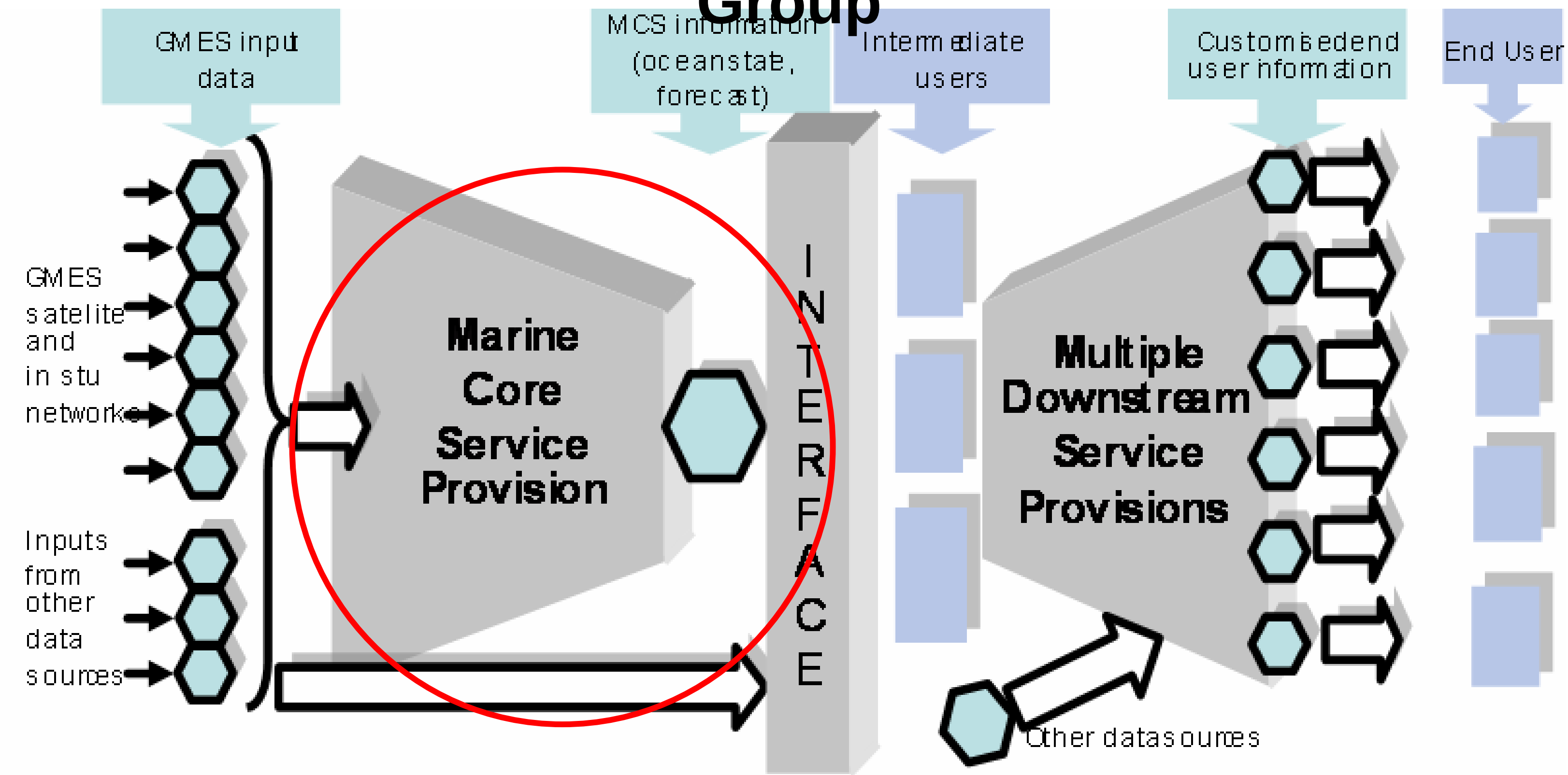
after MERSEA and ECOOP

and do the ecosystem/fisheries people manage to take advantage of this development ?

A project for the European "Marine Core Service"

A European Marine “core” service

clearly defined by the EC GMES Implementation Group



From GMES MCS Implementation Group report by P.Ryder & al

7 rules

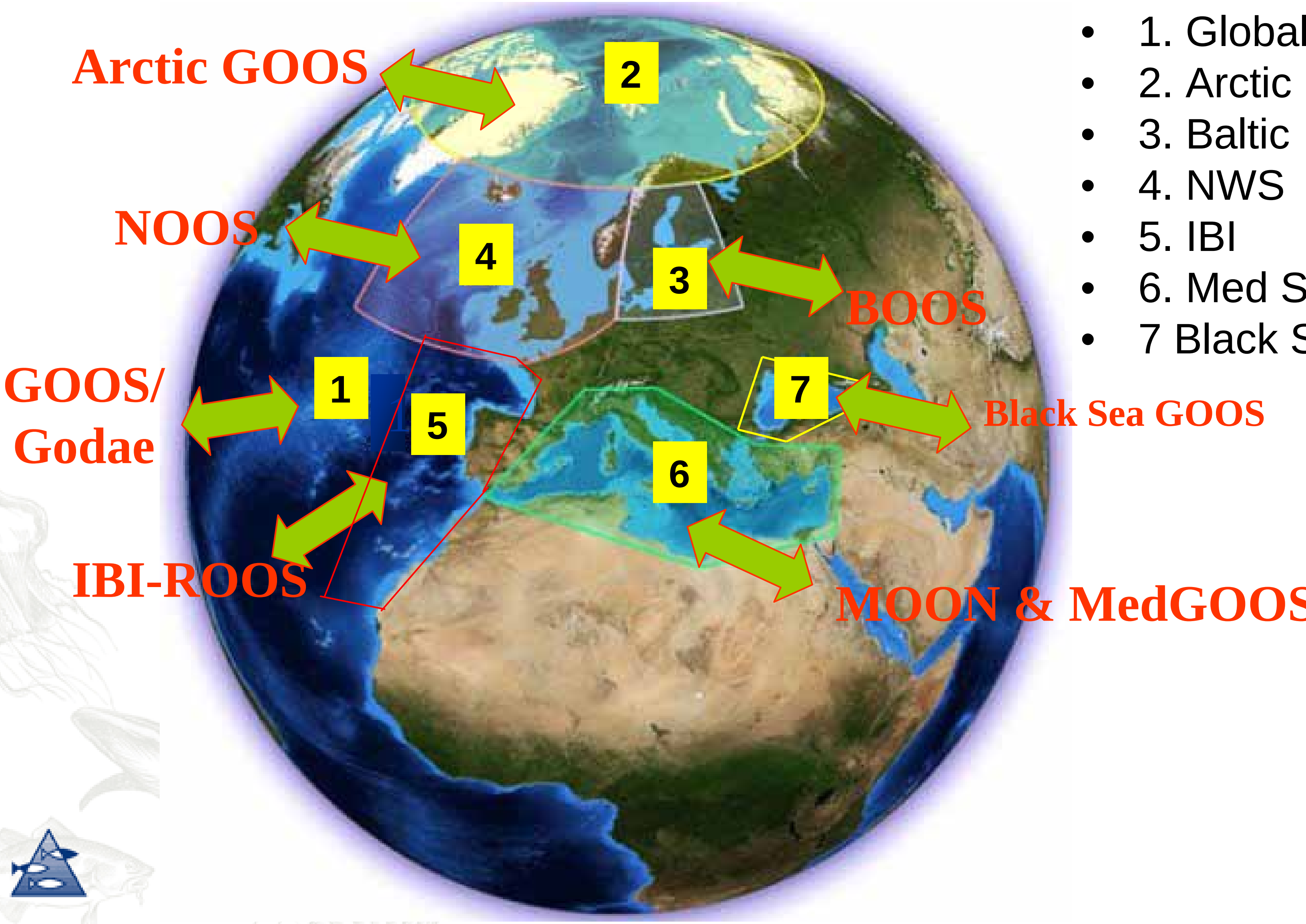
1. Look for and focus on the **European added-value** : build and set up the "**European Core**"
2. Start from **existing** core systems
3. Be **service** oriented
4. Be simple but fully **operational** !
5. Ensure full **connection** with the **EuroGOOS** networks
6. Involve **users** in the success of the MCS
7. Ensure **quality**, and make sure to link **operational & research**

Areas of Benefit

- MyOcean will *"provide the common denominator data for* ***all users in the marine sector****, in other words the information for existing & new downstream services."*

- Climate
- Marine Environment
- Seasonal and weather forecasting
- Offshore
- Maritime transport and safety
- Fisheries
- Research
- General Public

MFC and regions

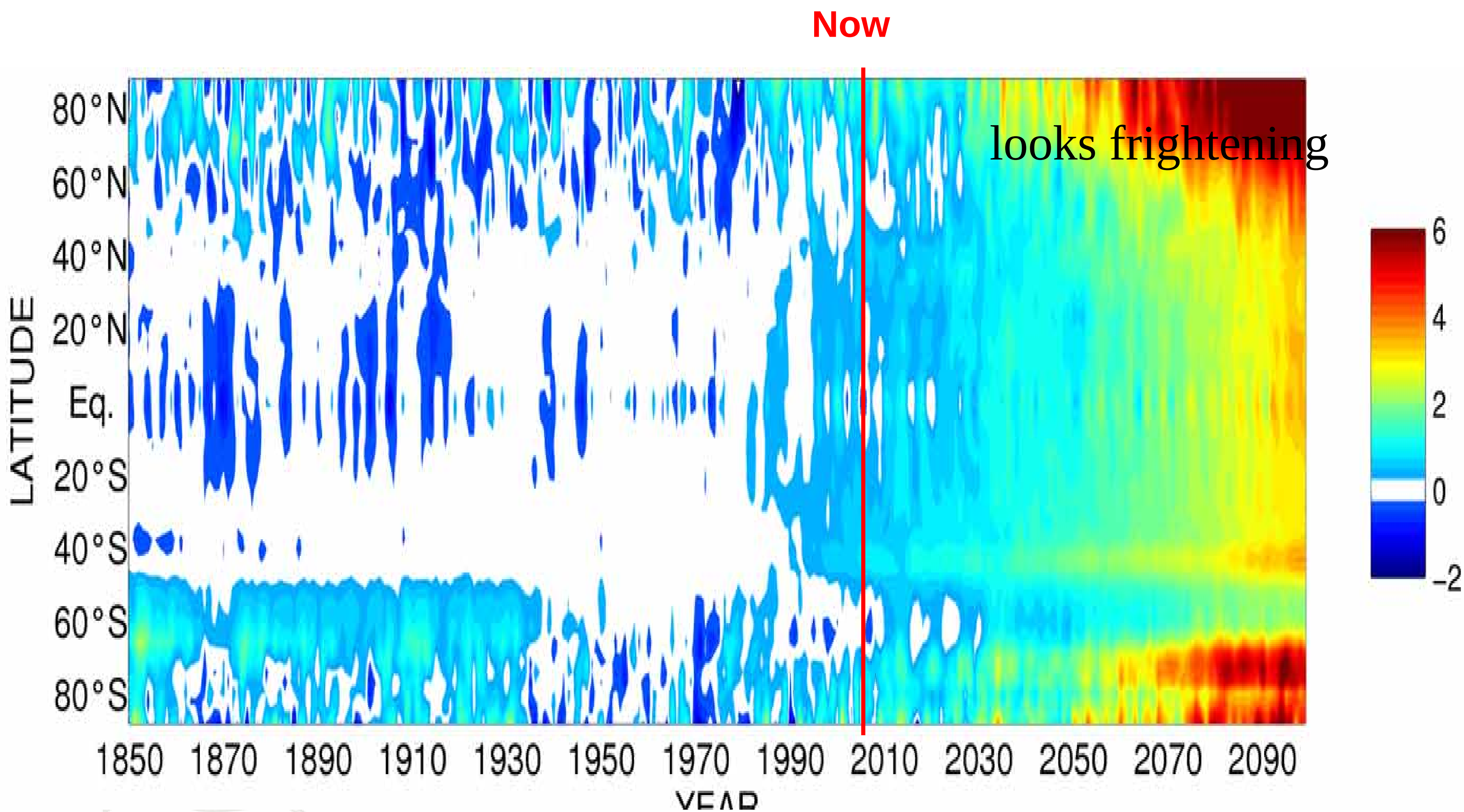


- 1. Global
- 2. Arctic
- 3. Baltic
- 4. NWS
- 5. IBI
- 6. Med Sea
- 7 Black Sea

Conclusions / actions

- The marine ecosystem research community must prepare to take advantage of the operational oceanography products. We must define our needs being more than regular “ocean weather forecasts”.
- Realistic (operational and long term) zoo-plankton fields
- Couple larvae models to zooplankton fields, operationally and long term simulations→recruitment
- Improve and run fish migration models to explain the dynamics in natural mortality and growth.
- Improve the usefulness towards improved management
- Simulate possible ecosystem effects of the future

Estimated temperature with Bergen Climate Model - deviation from 1951-1980 mean



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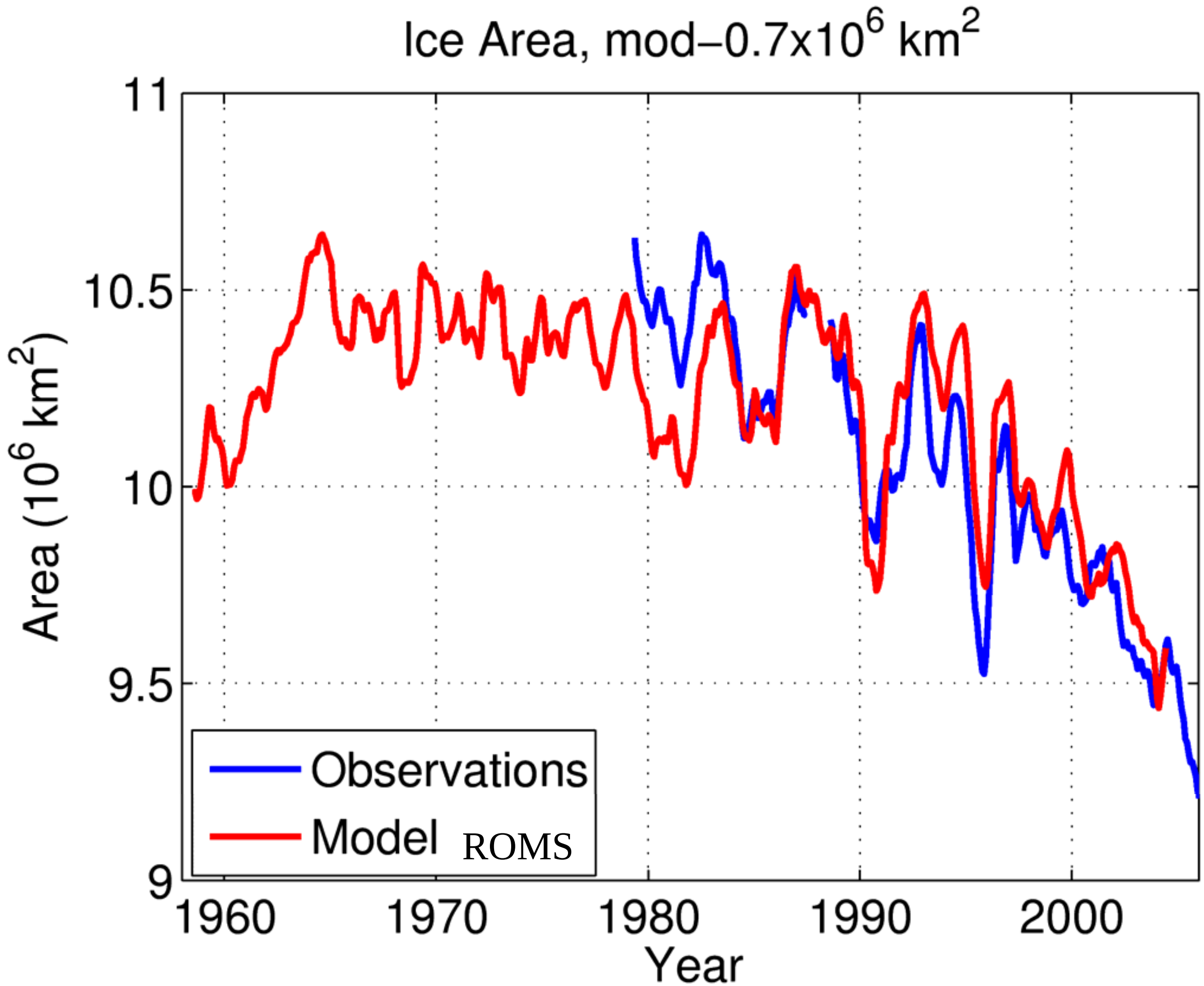
Total ice cover in the Arctic




To eat or to be eaten,
thats the question
Natural
variability
Human
pressure
Climate
Climate
Physics
Pollution
Fertilization
Thank you