Operational oceanography and the ecosystem approach

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with input from many others

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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)
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**
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


Skogen et al. submitted ICES JMS
Station M (66°N, 2°E)

Mean: 0.20

Mean: 0.37

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/m²/year)
Annual total mean North Sea primary production

- Y-axis: gC/m²
- X-axis: Years (1985 to 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, 1200 UTC
Current, Salinity
Today’s prediction
02. Nov, 1200 UTC
Current, Phytoplankton
Attributes

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

Strategies

• OWD, WUD, AFD, FSR, VM1, VM2

From http://pulse.unh.edu/
Environment

• Environmental features:
  • Temperature
  • Currents
  • Light
  • Food
  • Predators

• Model grid 181x154 20x20 km squares
• 1 m vertical resolution

Bathymetric

Diatoms & flagellates

Mesopelagic fish and herring

Invertebrate predators
Distribution of copepodites after 100 years of spin up time
Population dynamics
Stock-recruit relations

![Graph showing stock-recruit relations with Calanus production and biomass over time. The graph includes a scatter plot with a trend line and a note indicating $R^2 = 0.33^*$.](image)

Results
Ocean Climate Parameters

- Transport
- Temperature
- Light conditions
- Turbulence

Spawning and nursery grounds

- Predators
- Cod larvae and early juveniles
- Copepods
- Phytoplankton

Trophic transfer

OCEAN CLIMATE PARAMETERS

Russia
Vikebø et al. (2004)
Modelled volume transport at the entrance to the Barents Sea

![Graph showing modelled volume transport from 1980 to 2006.](image)

- Y-axis: Transport (Sv)

The graph indicates fluctuations in transport over the years, with peaks and troughs occurring at various points.
Inflow to the Barents Sea in autumn vs. cod (3y) recruitment 3 years later

\[ R^2 = 0.5 \]
Correlation map between primary production in April and cod recruitment 3 years later
Primary production in April vs. cod recruitment 3 years later

![Graph showing the relationship between primary production and cod recruitment. The graph includes a linear trend line with an $R^2$ value of 0.35.](image.png)
Statistical model of 3-year old cod recruits

\[ R^2 = 0.7 \]

\[ P < 0.01 \]
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.
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

Now looks frightening
Total ice cover in the Arctic

Ice Area, mod−0.7×10^6 km²

Area (10^6 km²)

Observations
Model
ROMS

Year
To eat or to be eaten, that's the question.