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Simulating oil spill impacts on plankton populations

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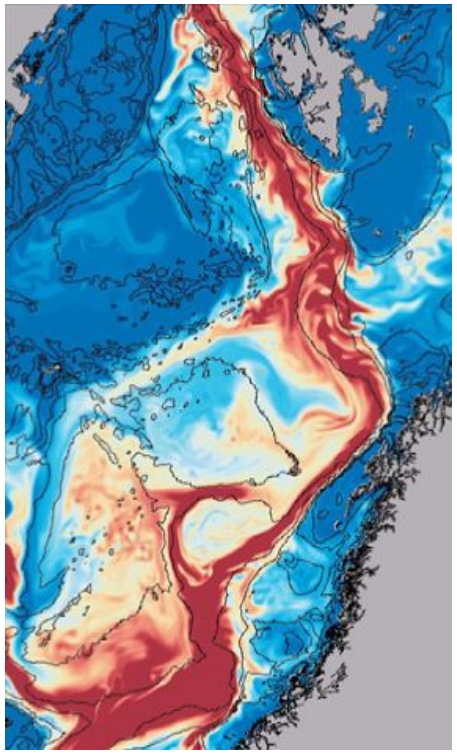

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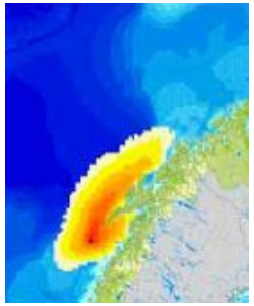
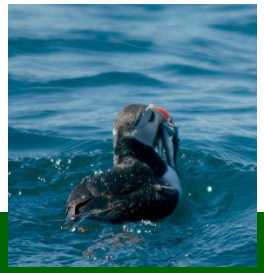
Overview

- A look at three important components of the SYMBIOSES model system
  - oil dispersal (including physics)
  - zooplankton dynamics
  - bioaccumulation model
- A look at some of the output from these model components
- Discussion of how this is relevant to
  - effects on cod larvae (and "higher trophic levels")
  - ecosystem-based management in general

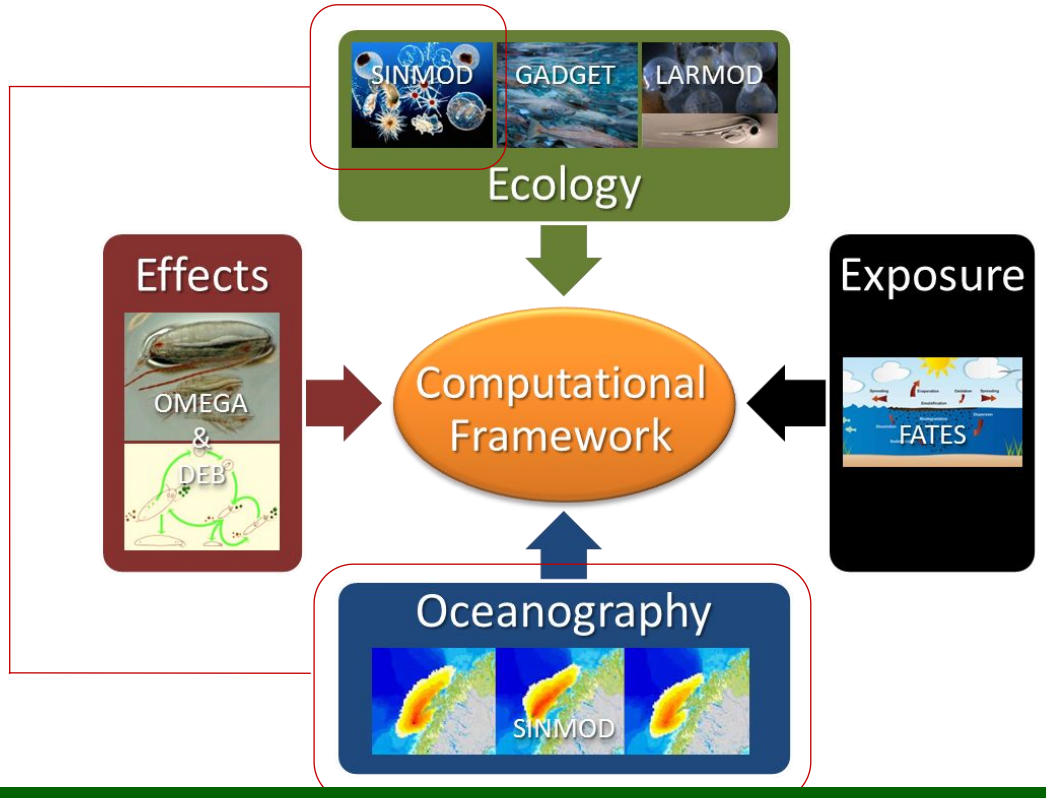
SYMBIOSE

An integrated modelling framework for decision S

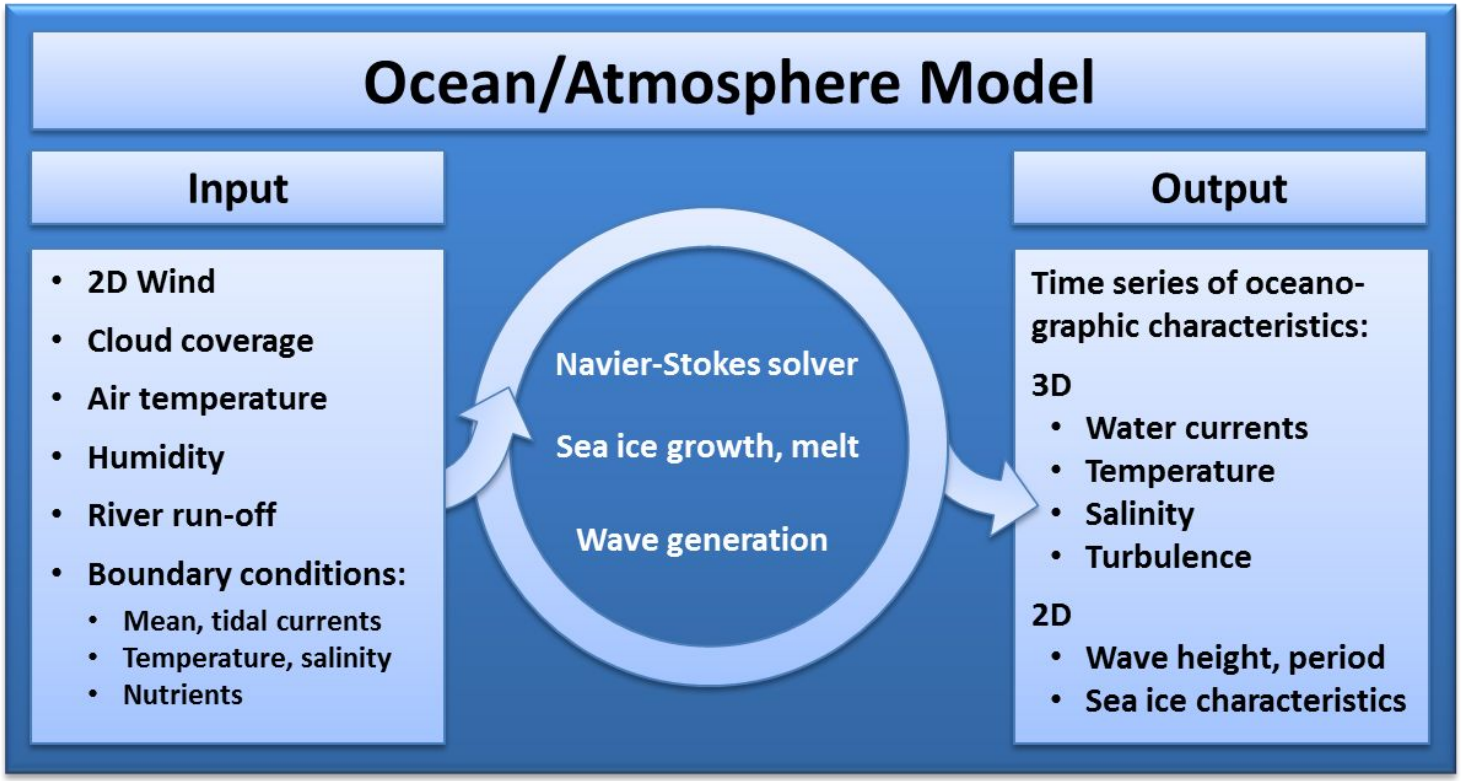




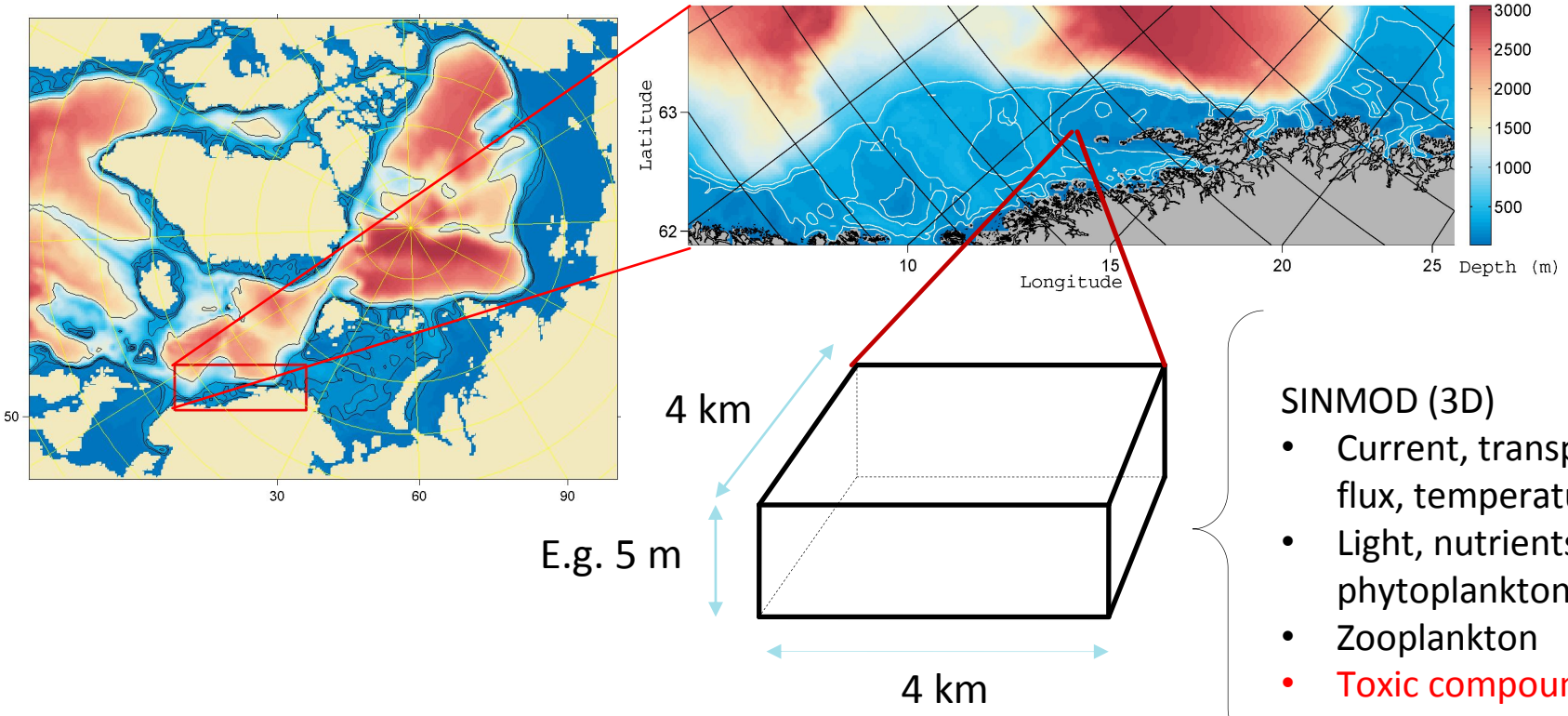
Simulating the ocean environment & plankton



SINMOD: 3D hydrodynamic-biogeochemical model



SINMOD: 3D hydrodynamic-biogeochemical model

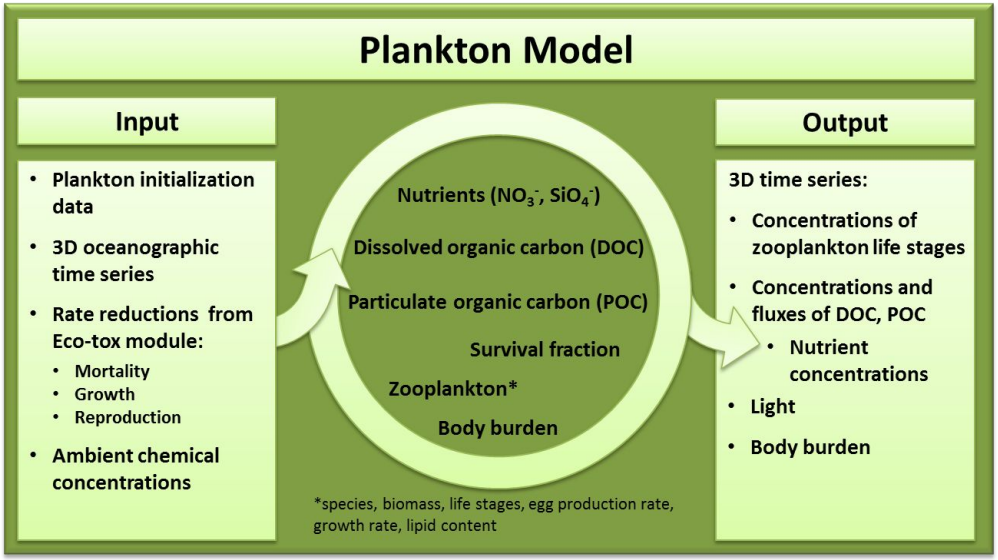


SINMOD (3D)

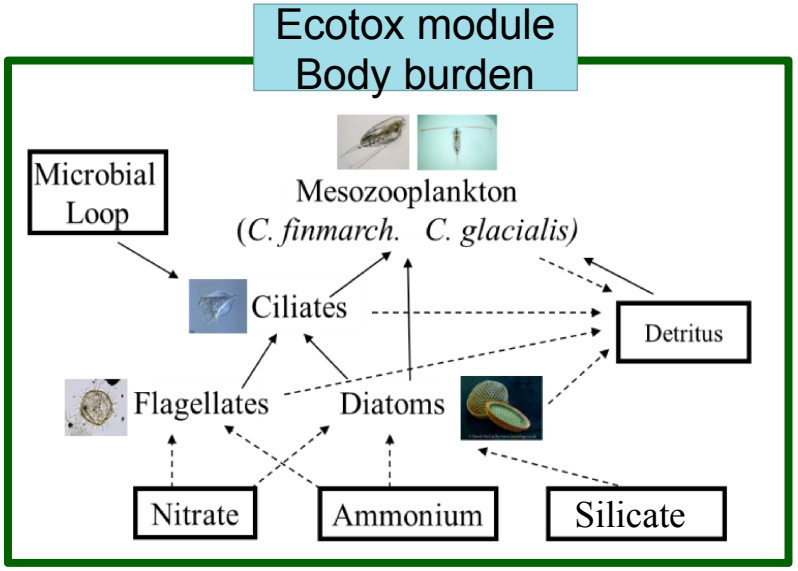
- Current, transport, flux, temperature
- Light, nutrients, phytoplankton ++
- Zooplankton
- Toxic compounds

SINMOD: lower trophic levels

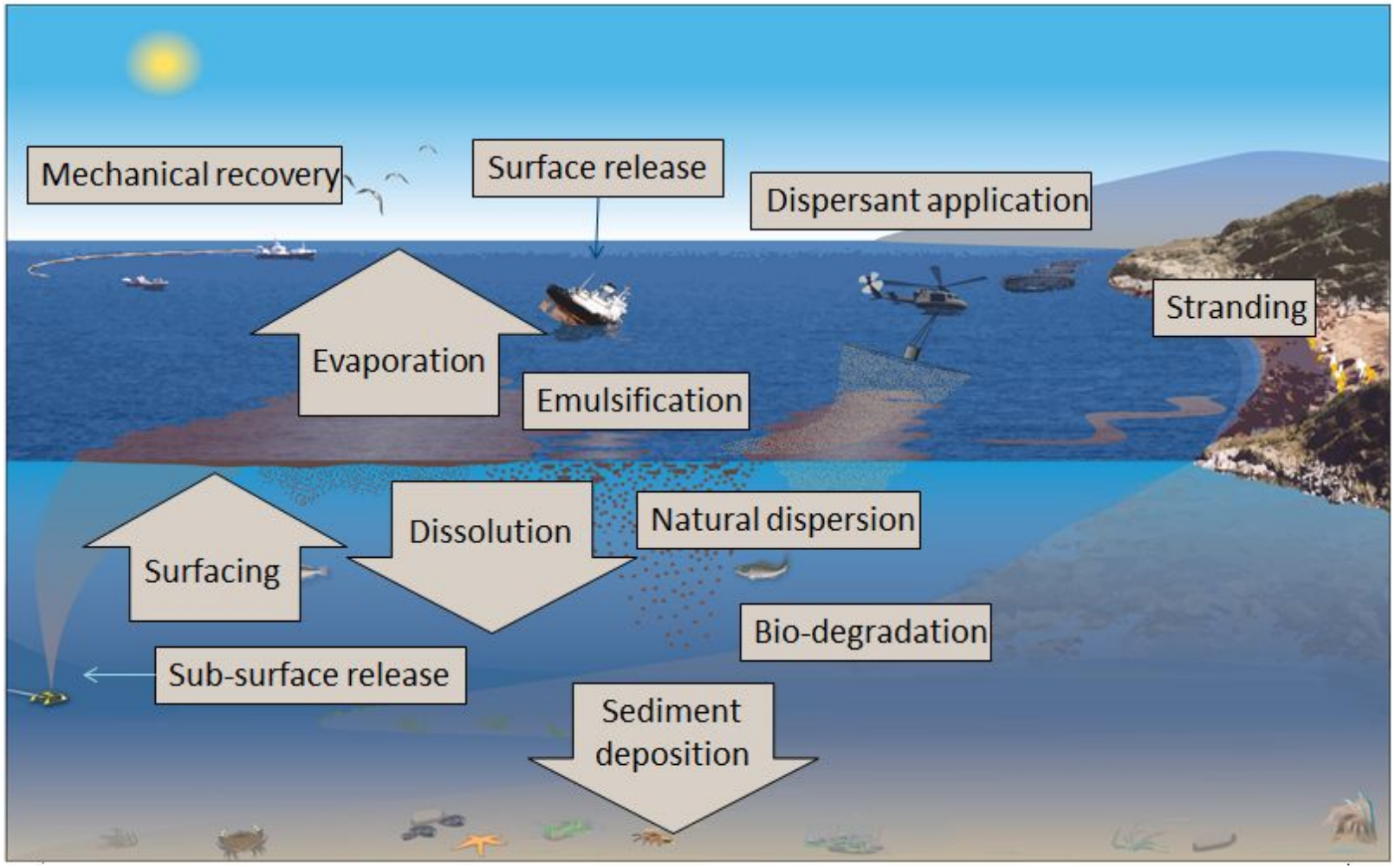
Model inputs & outputs



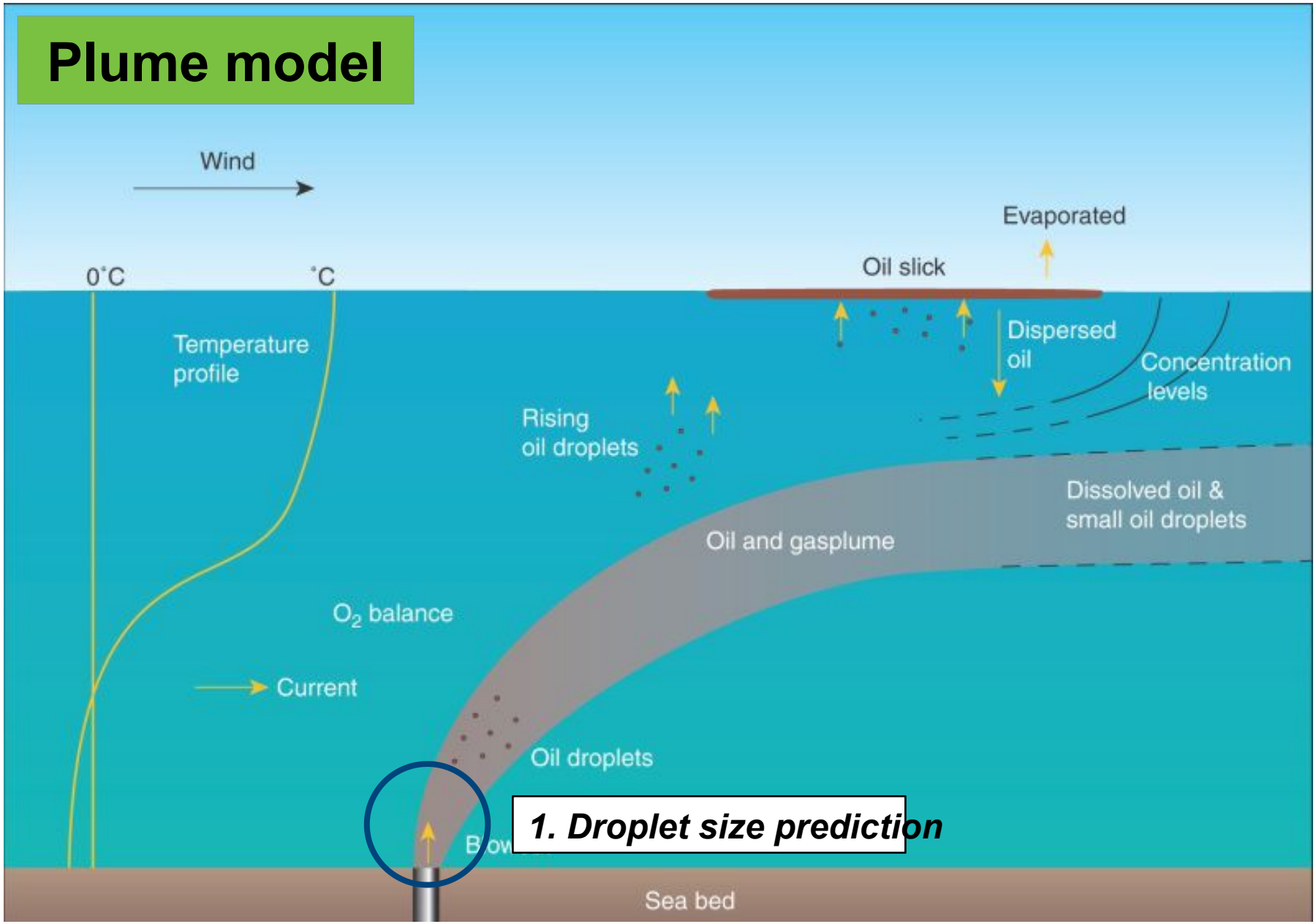
Food web relationships



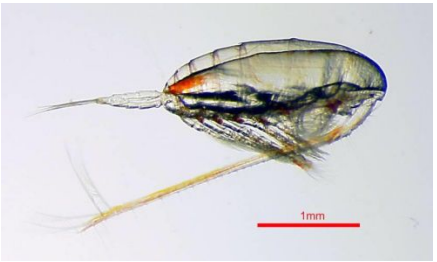
Oil dispersal modelling – OSCAR



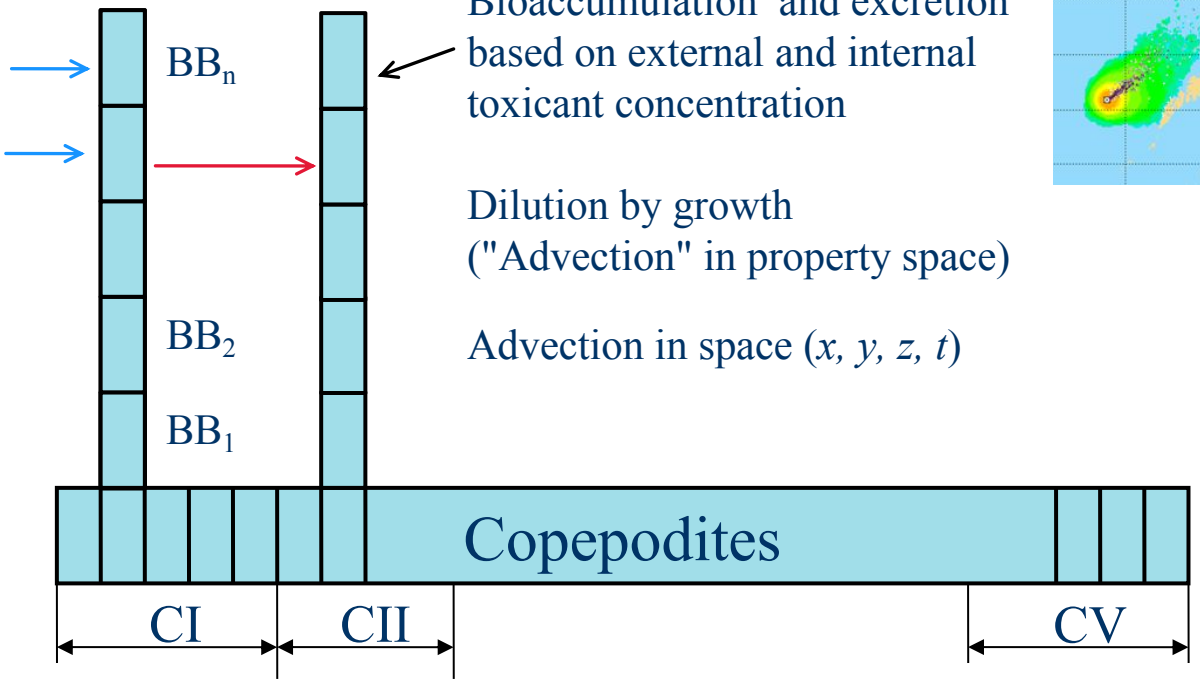
Plume model

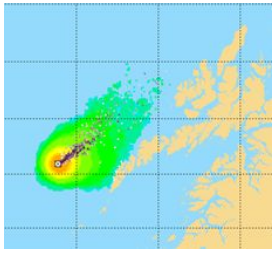

Wind
Evaporated
Oil slick
0°C
°C
Temperature profile
Dispersed oil
Concentration levels
Rising oil droplets
Dissolved oil & small oil droplets
Oil and gasplume
O_2 balance
Current
Oil droplets
1. Droplet size prediction
Sea bed

SINMOD – *Calanus finmarchicus* population model



Structure of *Calanus* model with body burdens

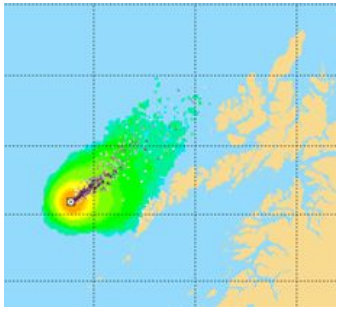


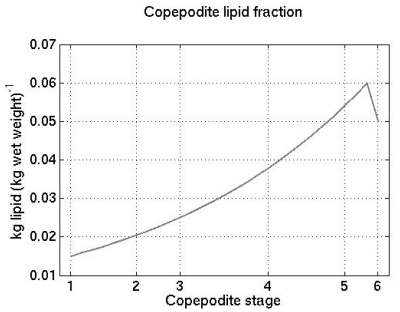


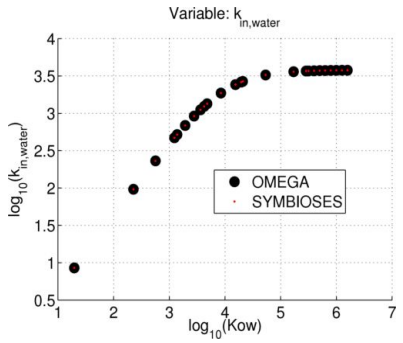
The SYMBIOSES model framework uses 25 body burdens, corresponding to 25 OSCAR *pseudo components*

Bioaccumulation model (OMEGA; Hendriks et al. 2001, 2014)

- Depends on
  - External toxicant concentration + KOW
  - Internal toxicant concentration (Body Burden)
  - Organism weight (size matters)
  - Lipid content
- Body burdens may be several orders of mangitude greater than that of the external concentration
- Lethal and sublethal effects
  - Increased mortality
  - Reduced reproduction

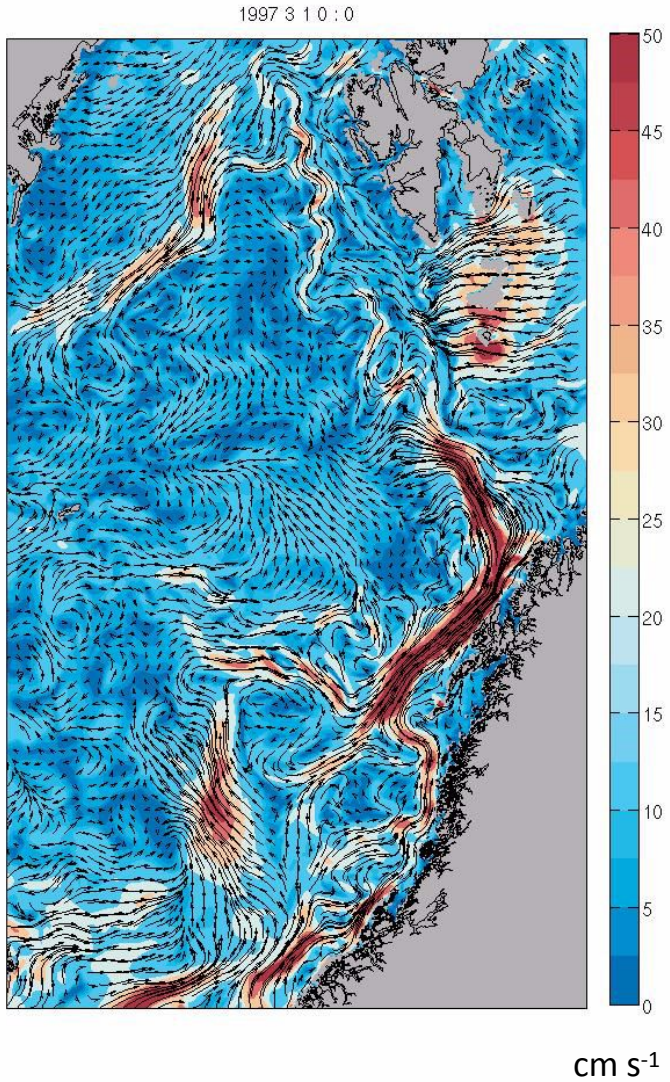






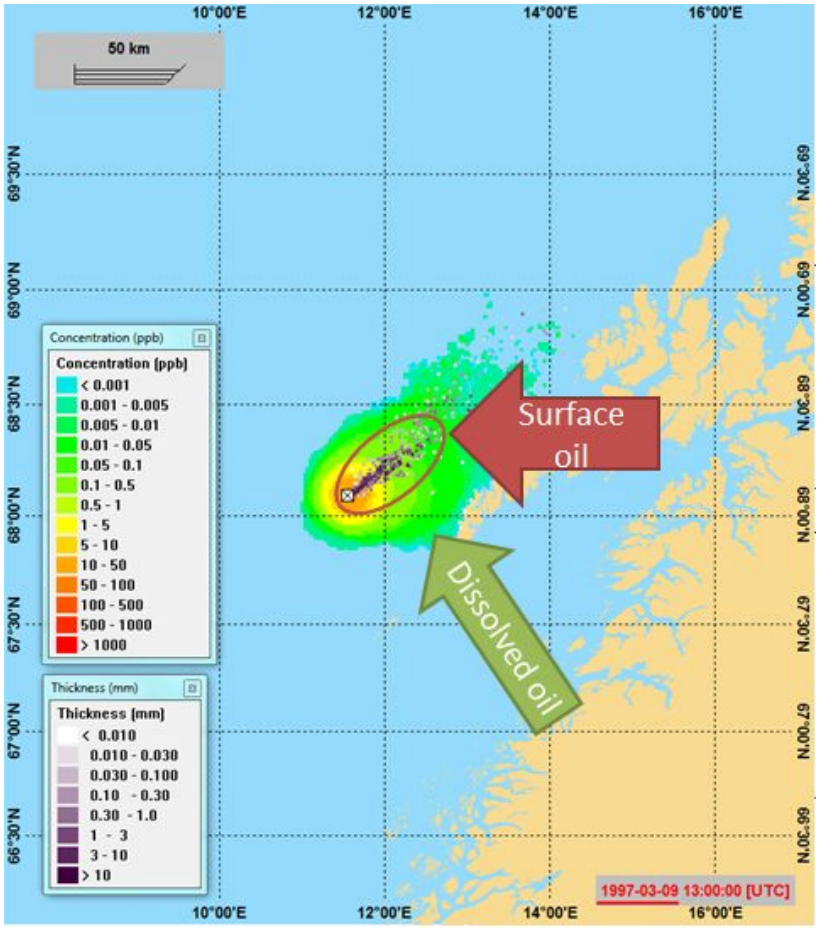
Ocean dynamics

- Ocean circulation pattern
- 50 m depth
- A lot of structure and dynamics even at 4 km horizontal resolution



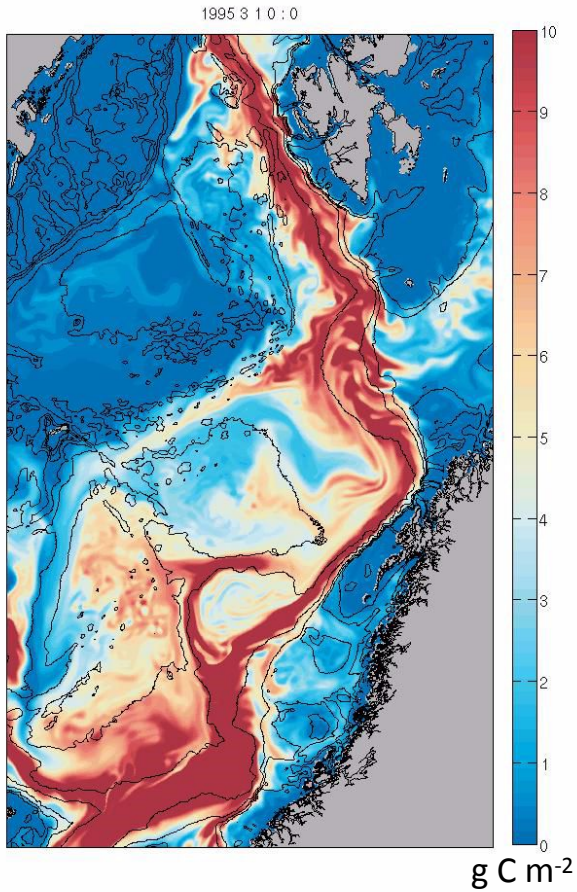
Oil dispersal

- Ocean current data from SINMOD "drives" OSCAR
- Output from OSCAR model
- 3D
- 25 pseudo components

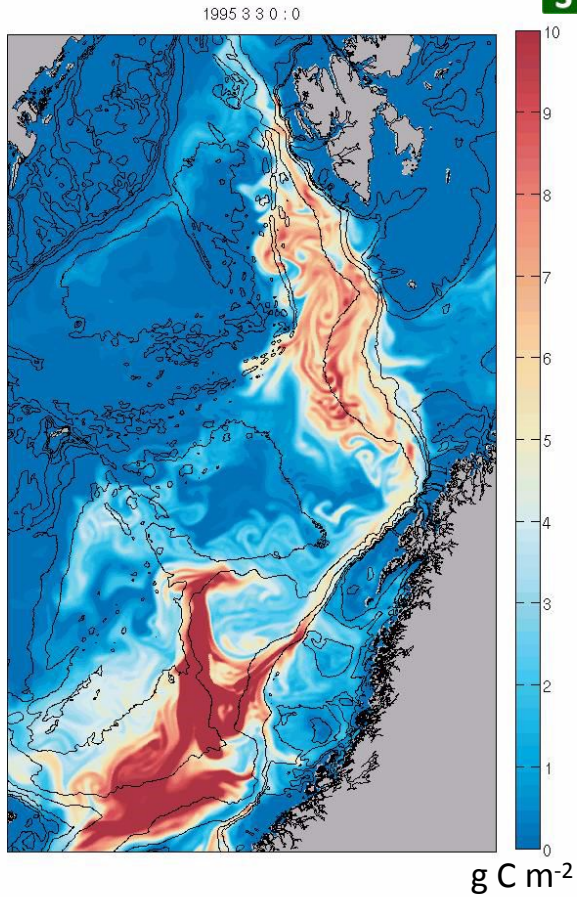


Calanus biomass in time and space

1995



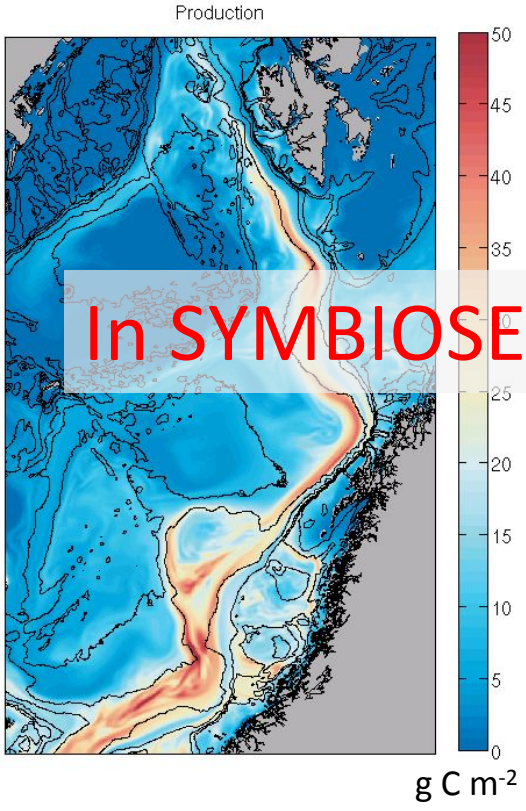
1997



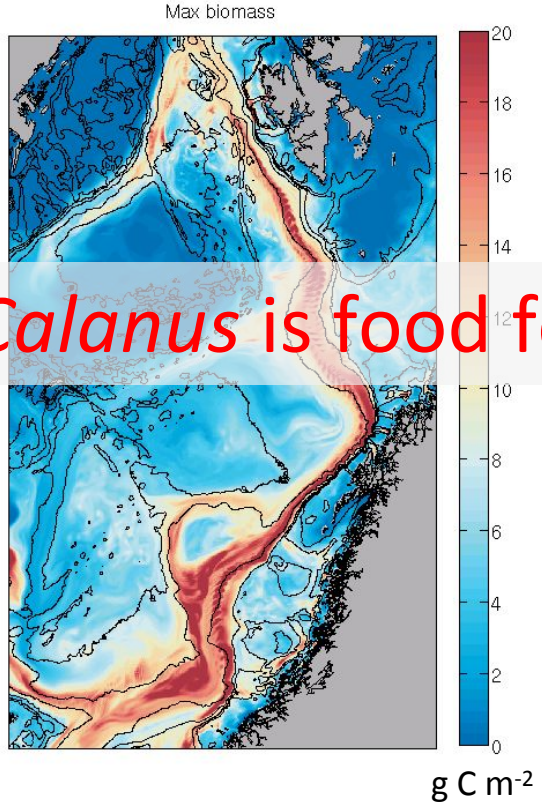
SINMOD simulation results: *Calanus* biomass for 1995

Many ways to present and hence to interpret results

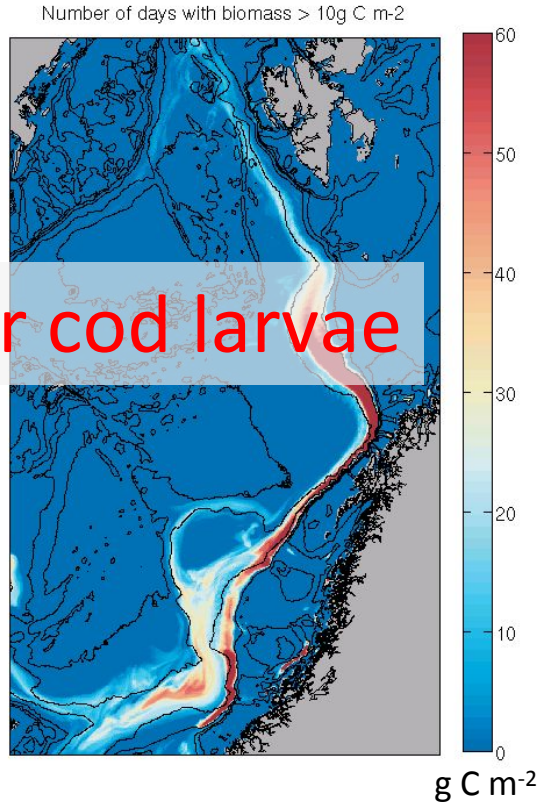
Production



Max biomass

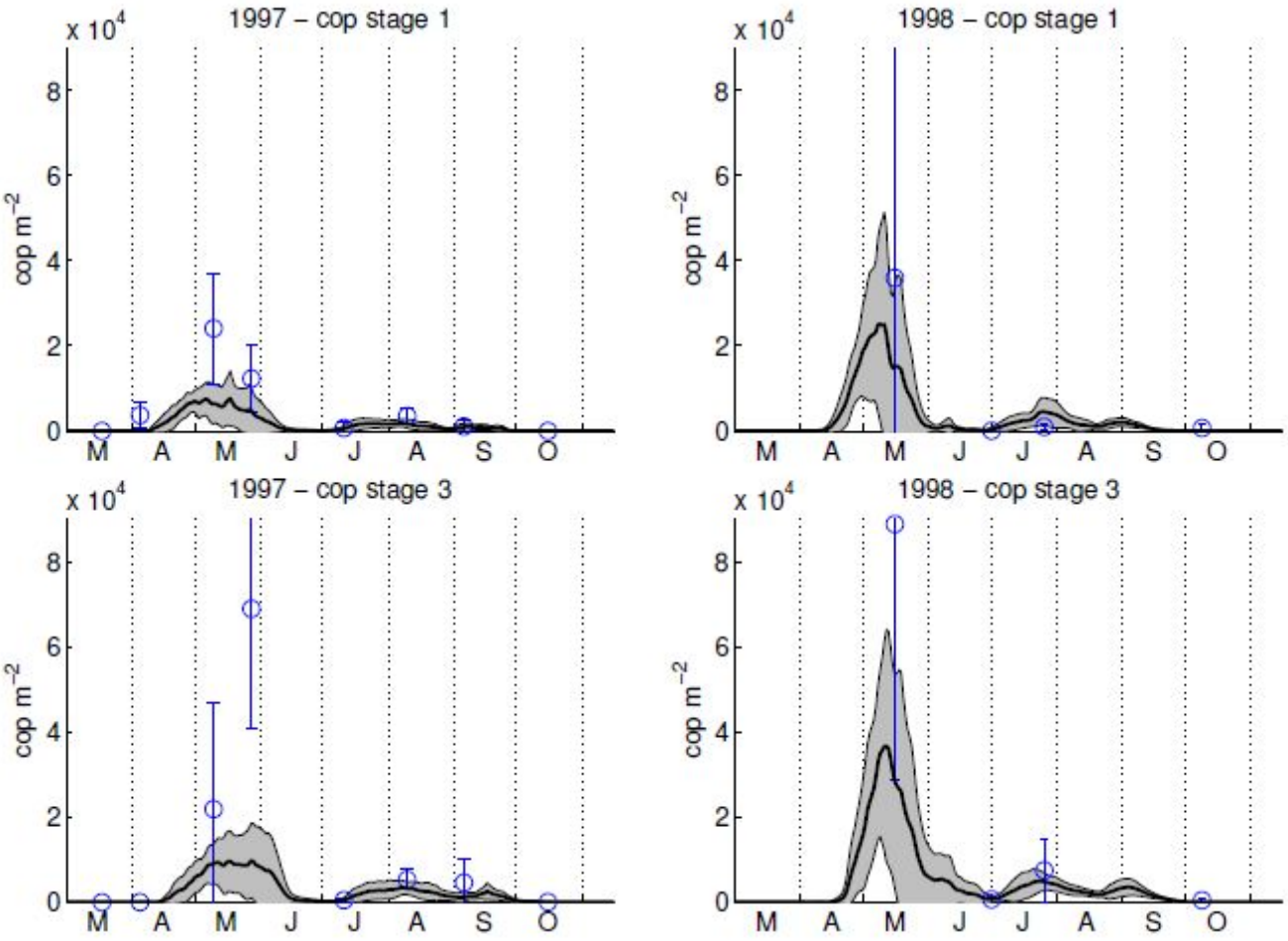


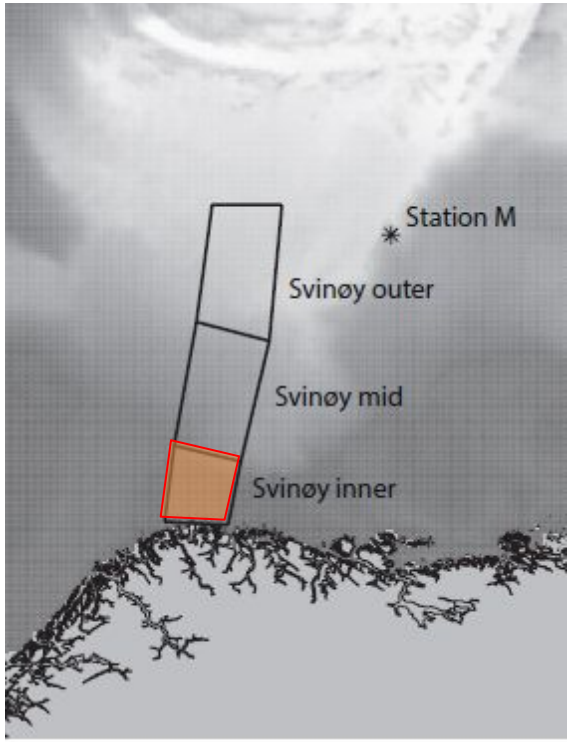
No of Days w/biomass > 10 gCm^{-2}



In SYMBIOSES *Calanus* is food for cod larvae

Is this pure speculation? No – reality and models tell the same story



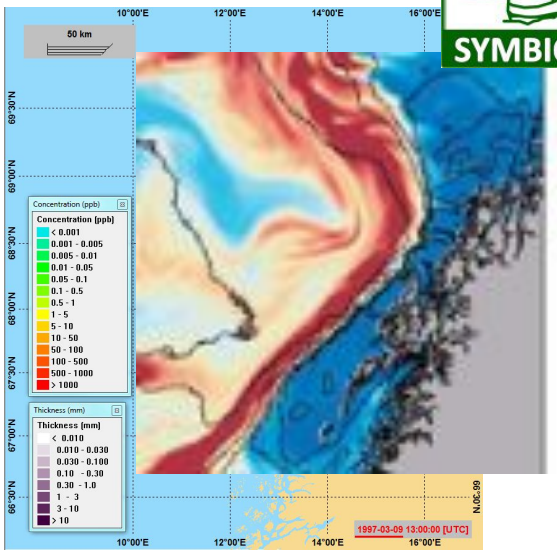


Data courtesy of
W. Melle and E. Bagøien,
Institute of Marine Research

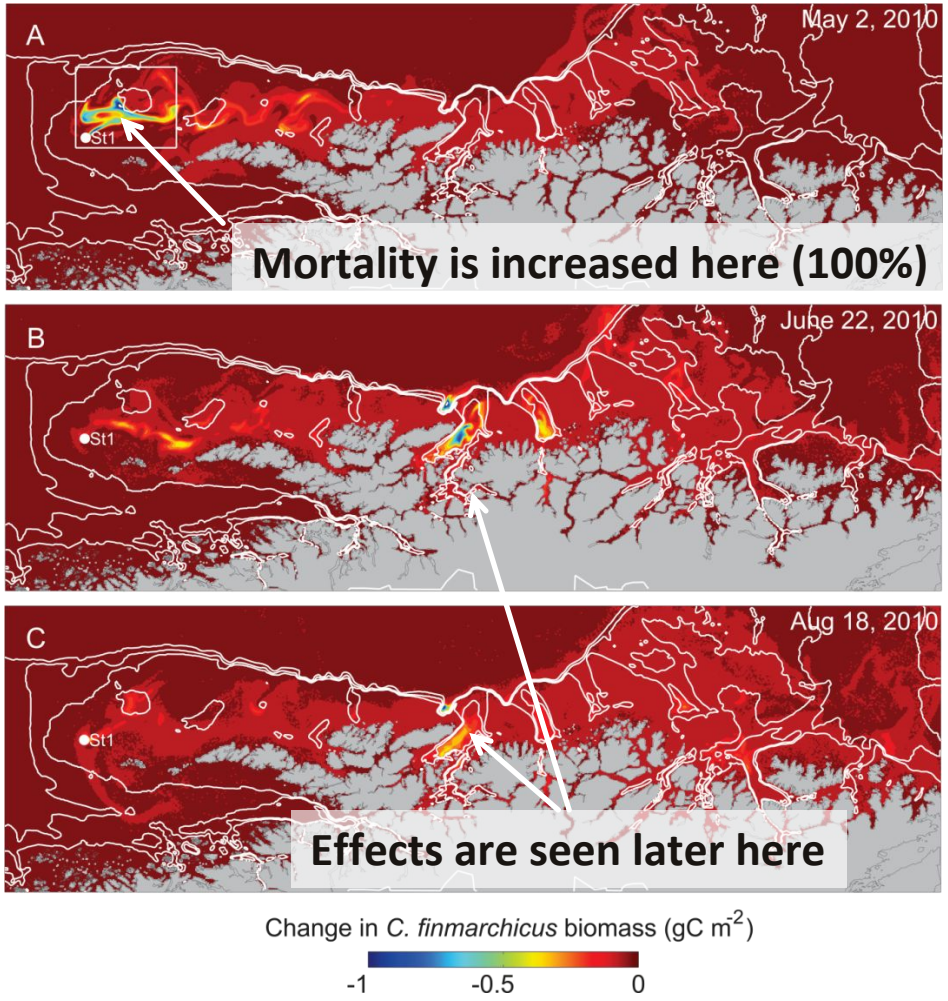
How to combine oil spill and *Calanus* data?

- First approach: overlap of oil and *Calanus*
  - *is* there an overlap at all?
  - 3D information essential: topside oil vs overwintering *Calanus* (> 500 m depth)

- More sophisticated: SYMBIOSES
  - oil, composition, *Calanus,* fish larvae in the *SAME* model system
  - OMEGA: bioaccumulation of oil components (body burdens)
  - Mortality and reproduction effect submodels (functions of BB)



WHAT IF? The difference between two scenarios

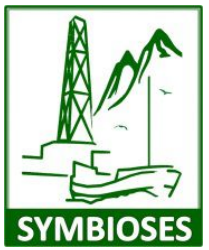


Broch et al. 2013 – Mar. Env. Res.

- One baseline scenario, the other with increased *Calanus* mortality

  $B_{\text{WITH OIL}}$ - $B_{\text{WITHOUT OIL}}$
- Scenario applicable to
  - Oil spill effect analysis
  - Effects of harvesting
- SYMBIOSES might typically produce same kind of results
- Difference represented in terms of e.g. change in number of individuals or in biomass
- Fewer animals means (e.g.) less food for cod larvae

Why is this useful for ecosystem based management?



- We get a sense of the great spatiotemporal variation, within and between years
- We are able to investigate a number of "what if"-scenarios
  - Inspiration for sampling and monitoring campaigns
  - May give an idea of the amount of data that we *need*, i.e. what is in fact missing
  - Understand our ecosystem
- Information available as "maps" (2D, 3D) and as time-series
  - GIS
  - Degree of overlap of species and compounds in time and space