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Paper L:09

Modeling secondary production in the Norwegian Sea with a fully coupled model system

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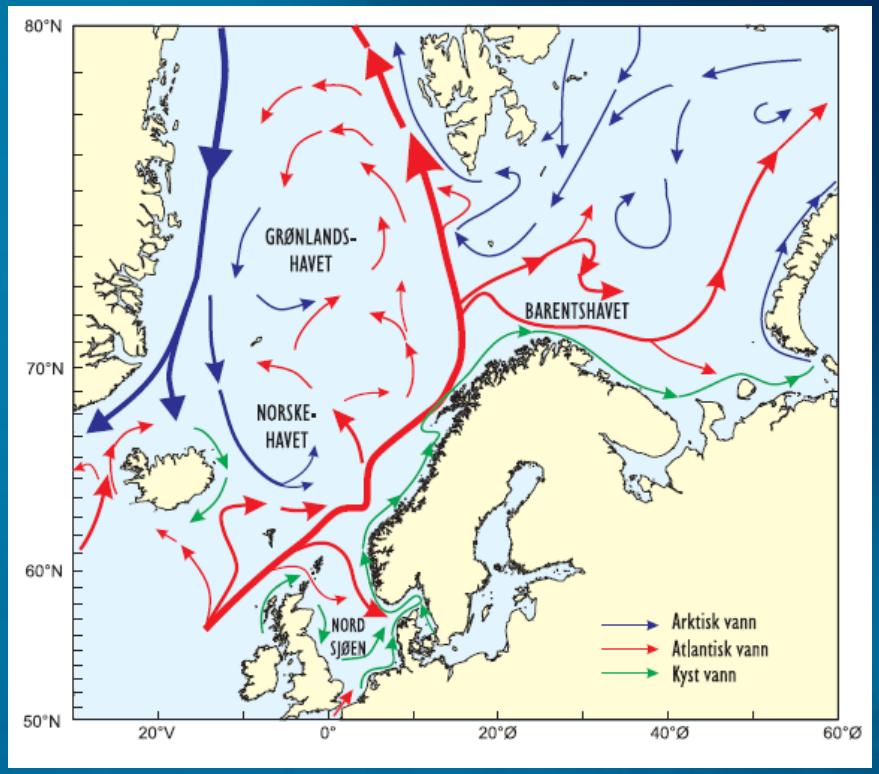
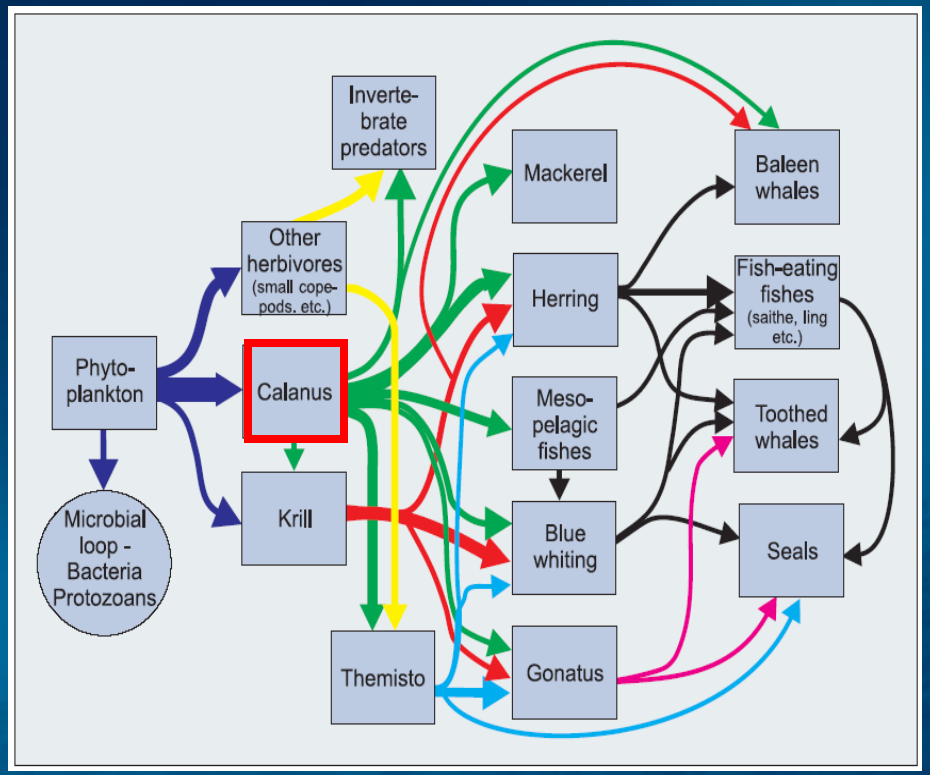
- Background and motivation
- Coupled model system
  - Model upset and parameterizations
  - Trophic coupling and impacts of various drivers
- Summary and future plans –towards NORWECOM.E2E

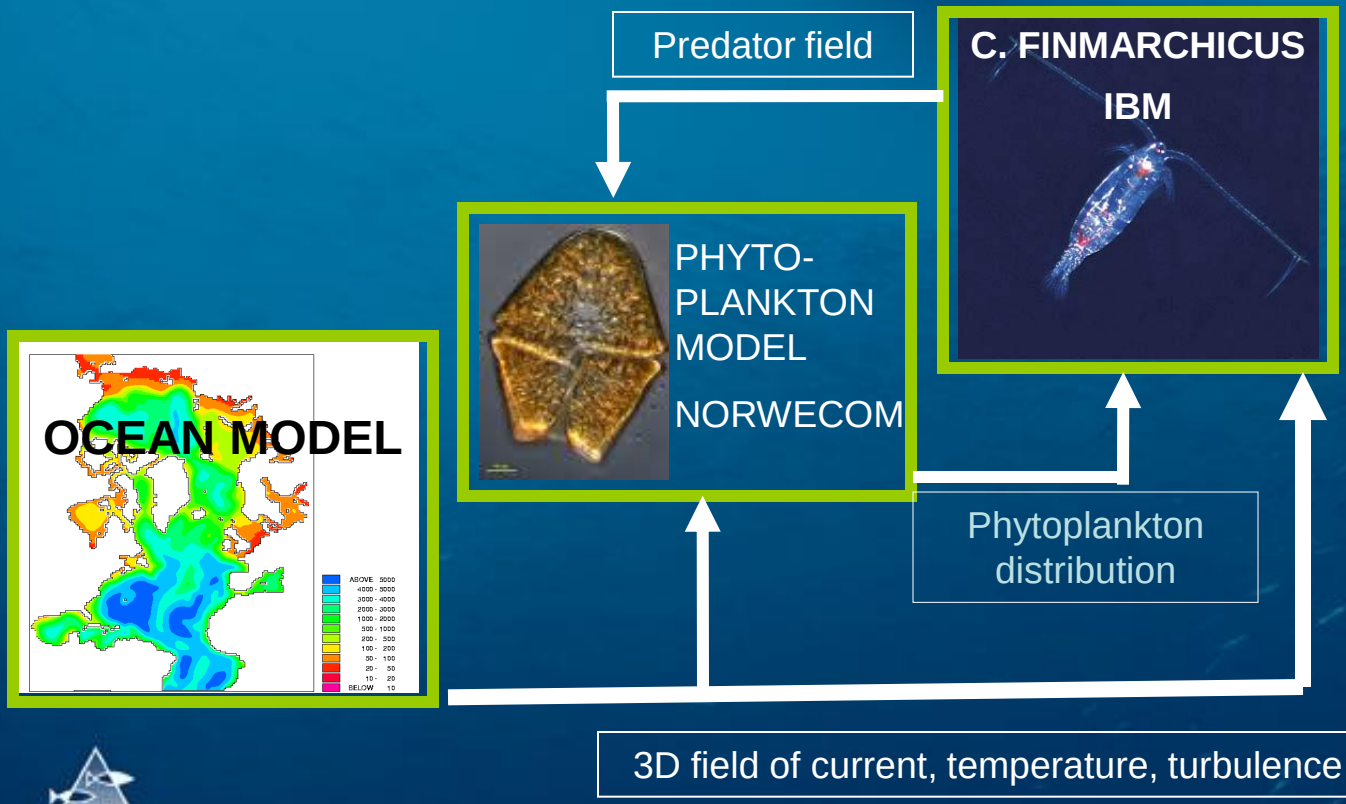




From Skjoldal et al. 2004

Need: an integrated system of models that describe the ecosystem function with focus on processes of importance to harvestable stocks

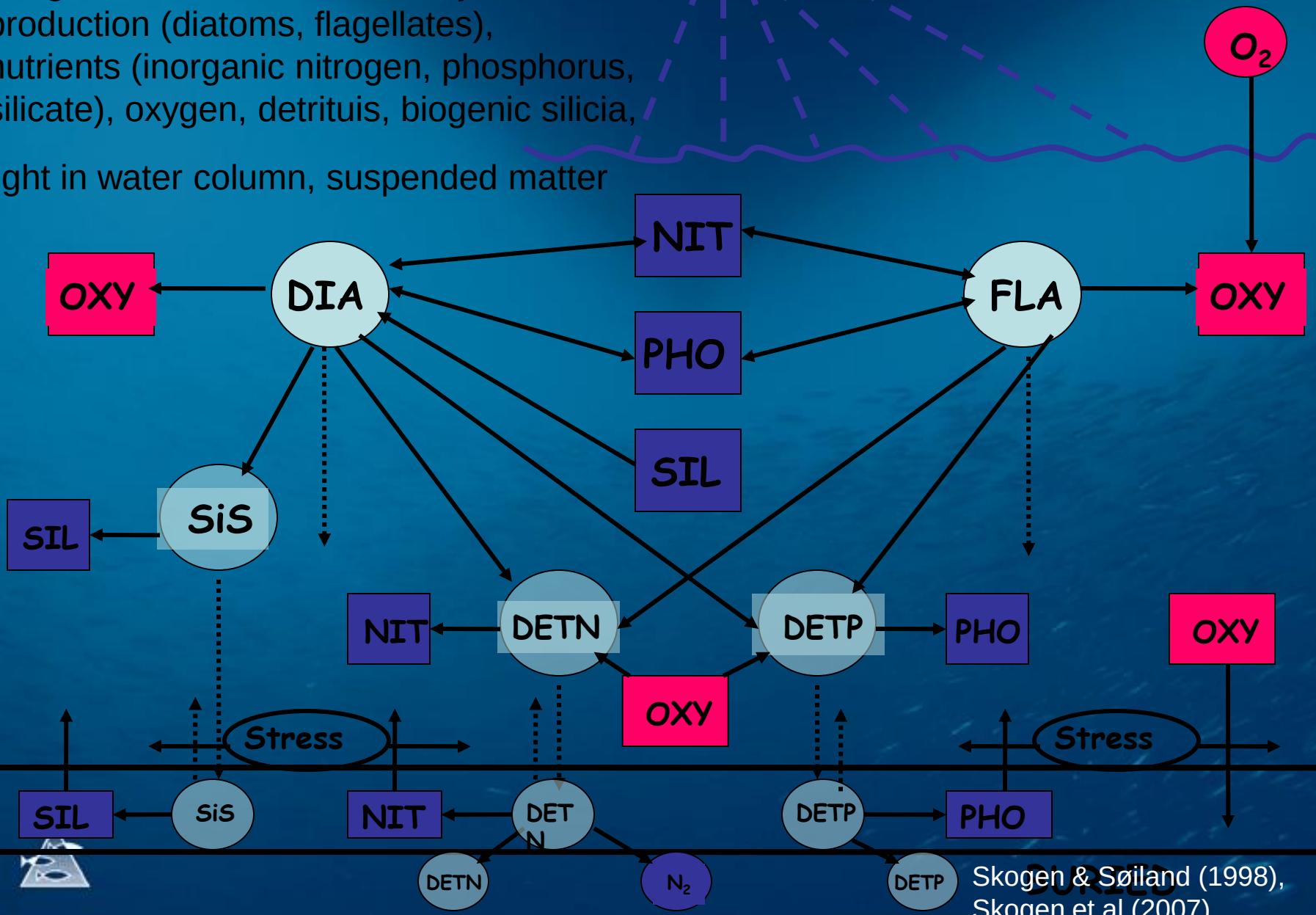
Coupled model system



NORWECOM

Prognostic variables: Primary production (diatoms, flagellates), nutrients (inorganic nitrogen, phosphorus, silicate), oxygen, detrituis, biogenic silicia,

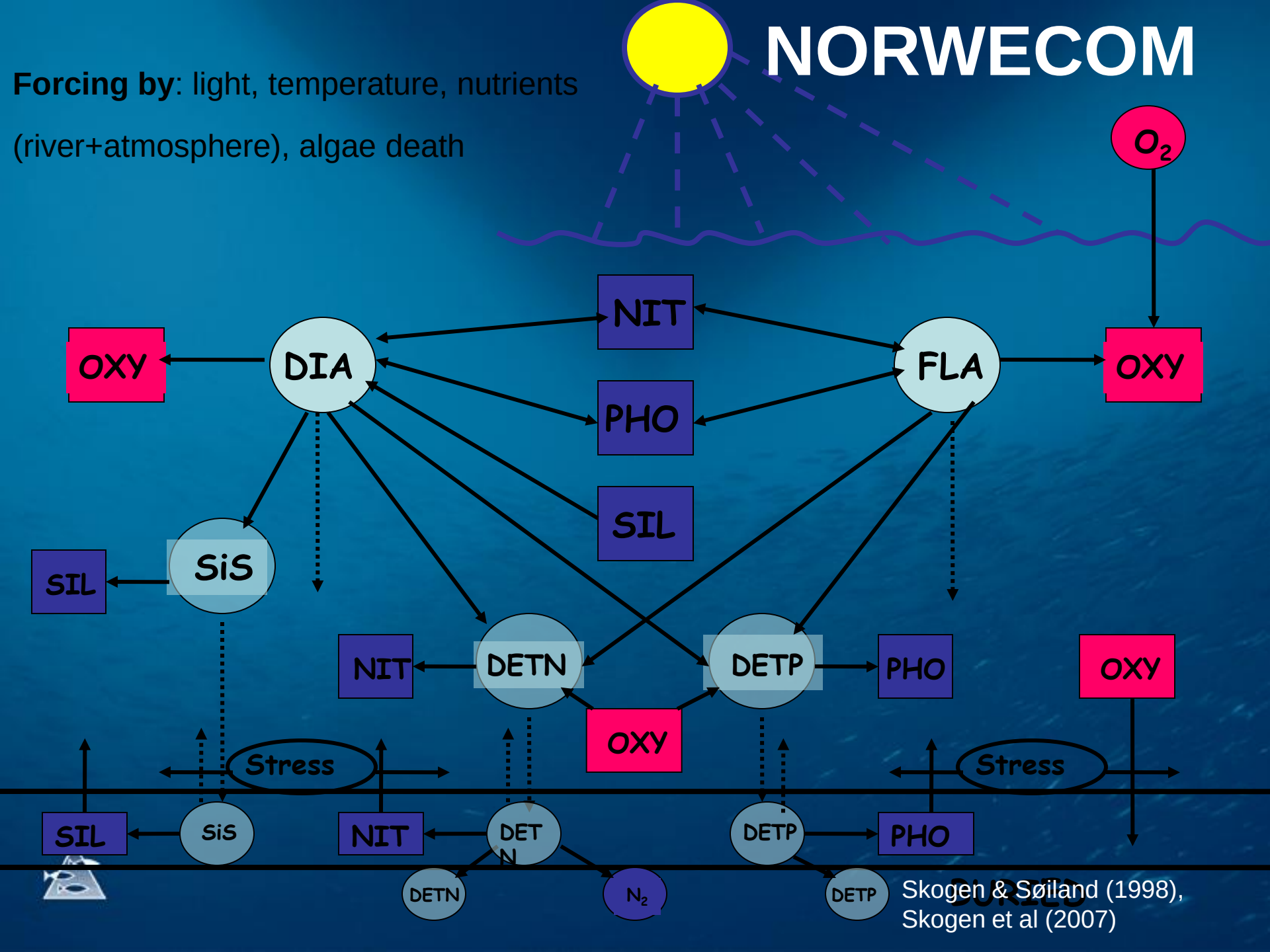
light in water column, suspended matter



Skogen & Søiland (1998), Skogen et al (2007)

NORWECOM

Forcing by: light, temperature, nutrients (river+atmosphere), algae death

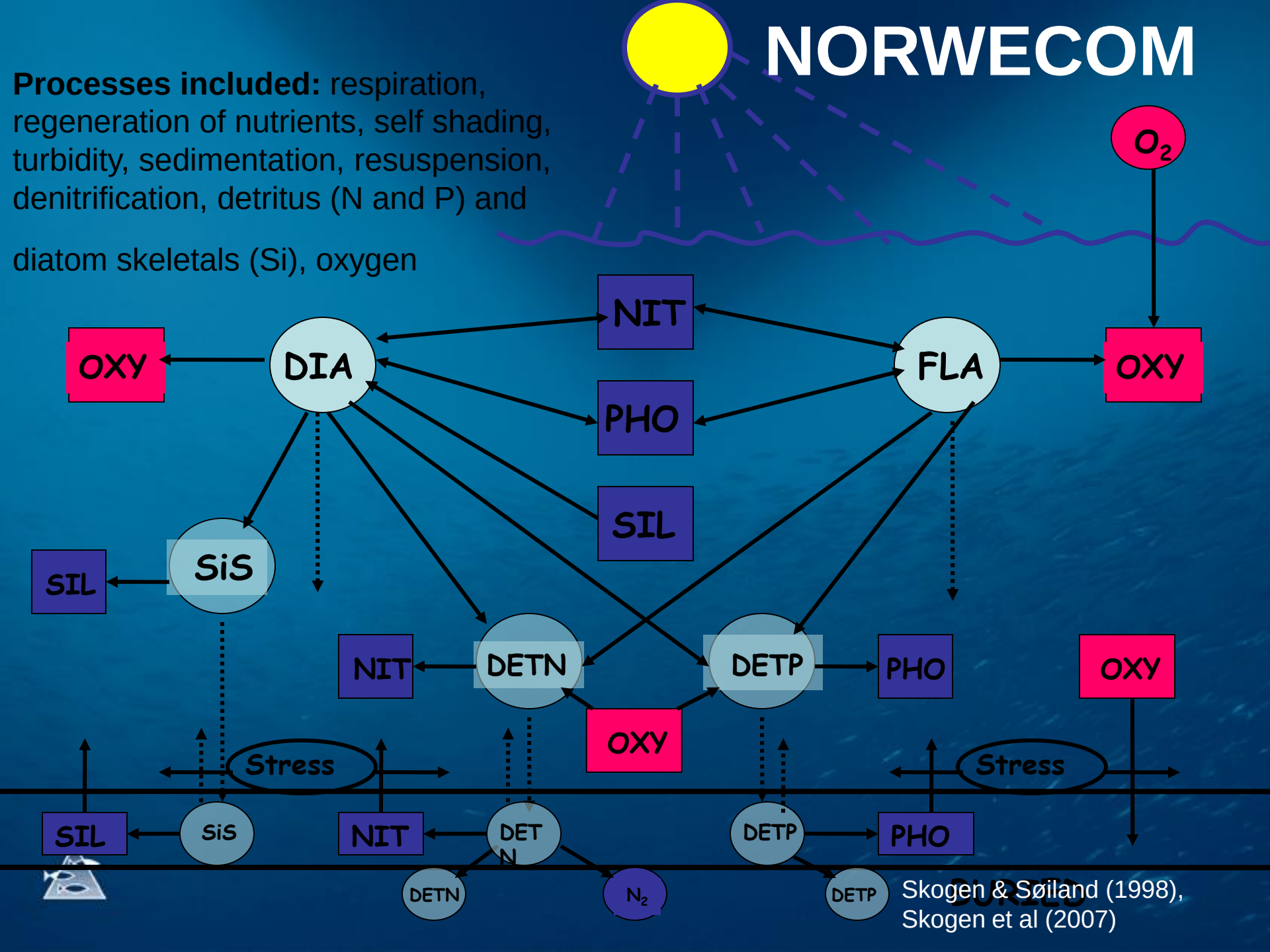


Skogen & Søiland (1998), Skogen et al (2007)

NORWECOM

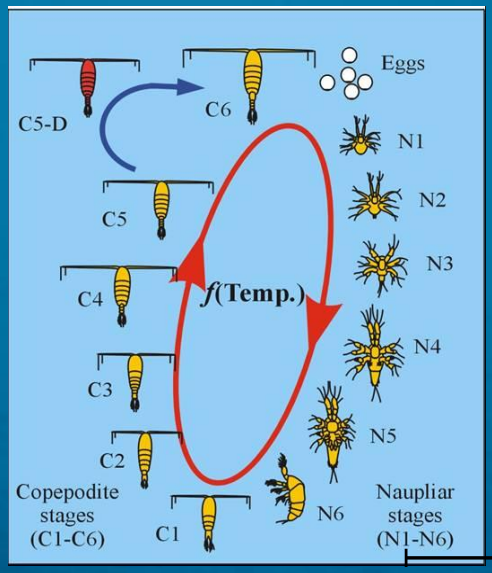
Processes included: respiration, regeneration of nutrients, self shading, turbidity, sedimentation, resuspension, denitrification, detritus (N and P) and

diatom skeletals (Si), oxygen



Skogen & Søiland (1998), Skogen et al (2007)

Individual-based model (IBM)
Calanus-model



From http://pulse.unh.edu/

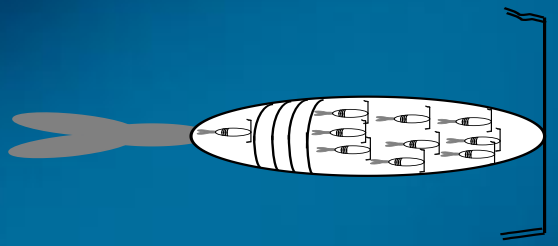
Structural weight

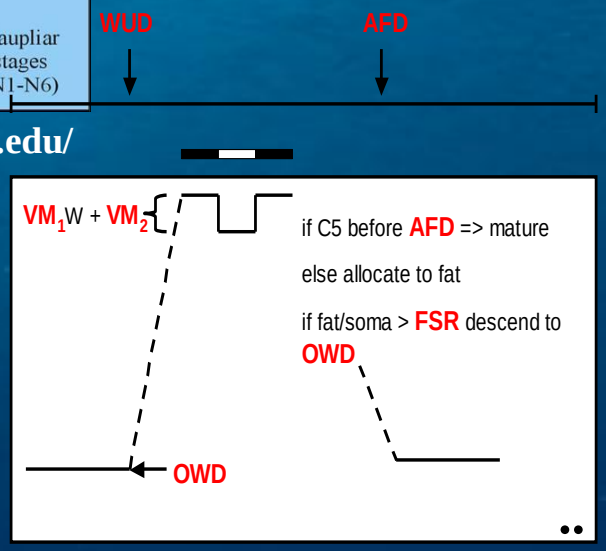
Fat content

3D Position

Stage

Individual number





Huse et al (in prep)

Feeding: functional response, type 2 (Campbell 2001)

Growth: bioenergetics (Carlotti & Wolf 1998)

Reproduction: mature adults above weight and fat thresholds, in mixed layer

Vertical movement: dvm, annual cycle

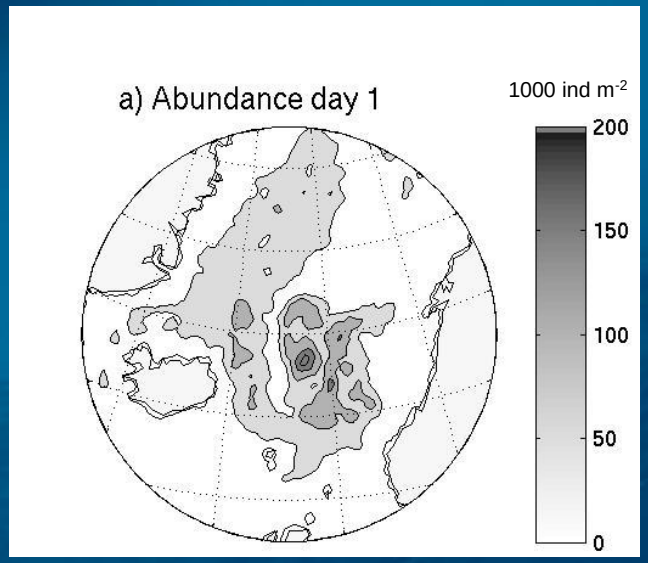
Horizontal movement: by currents

Calanus mortality

1. Geographical limitations (Nordic Seas)
2. Stage specific weight limitations (i.e.starvation)
3. Age and spawning stress limitations (< 400 days and <800 eggs)
4. Invertebrate predation parameterized (not year specific)
    1. day/night dependent
    2. geographically uniform & exponentially decying in upper 1000m
5. Predation from pelagic fish parameterized (not year specific)
    1. preysize and daylight dependent
    2. geographically uniform & restricted to upper 600m

Model upset

- Physical forcing for year 1997
- NORWECOM initialization
  - Typical winter values of Atlantic water for nutrients (12.0,5,5 and 0.8 uM inorganic nitrogen,silicate and phosphoros)
  - Small amounts of algae (0.10mgNm^{-3})
  - 200 mgN/m^2/year added from the atmosphere
- CALANUS initialization
  - 50.000 super individuals with influence ratio of 4 gridcells
  - ”Standard” initial *C. Finmarchicus* distribution
  - ~10^{11} C5 individuals distributed on 50.000 super individuals
  - Strctural weight 80µg, fat level 40µg; total mass: 17 mill tonn C
  - Overwintering depth 300-1100m
  - Diapause termination : Feb 10 –April 9



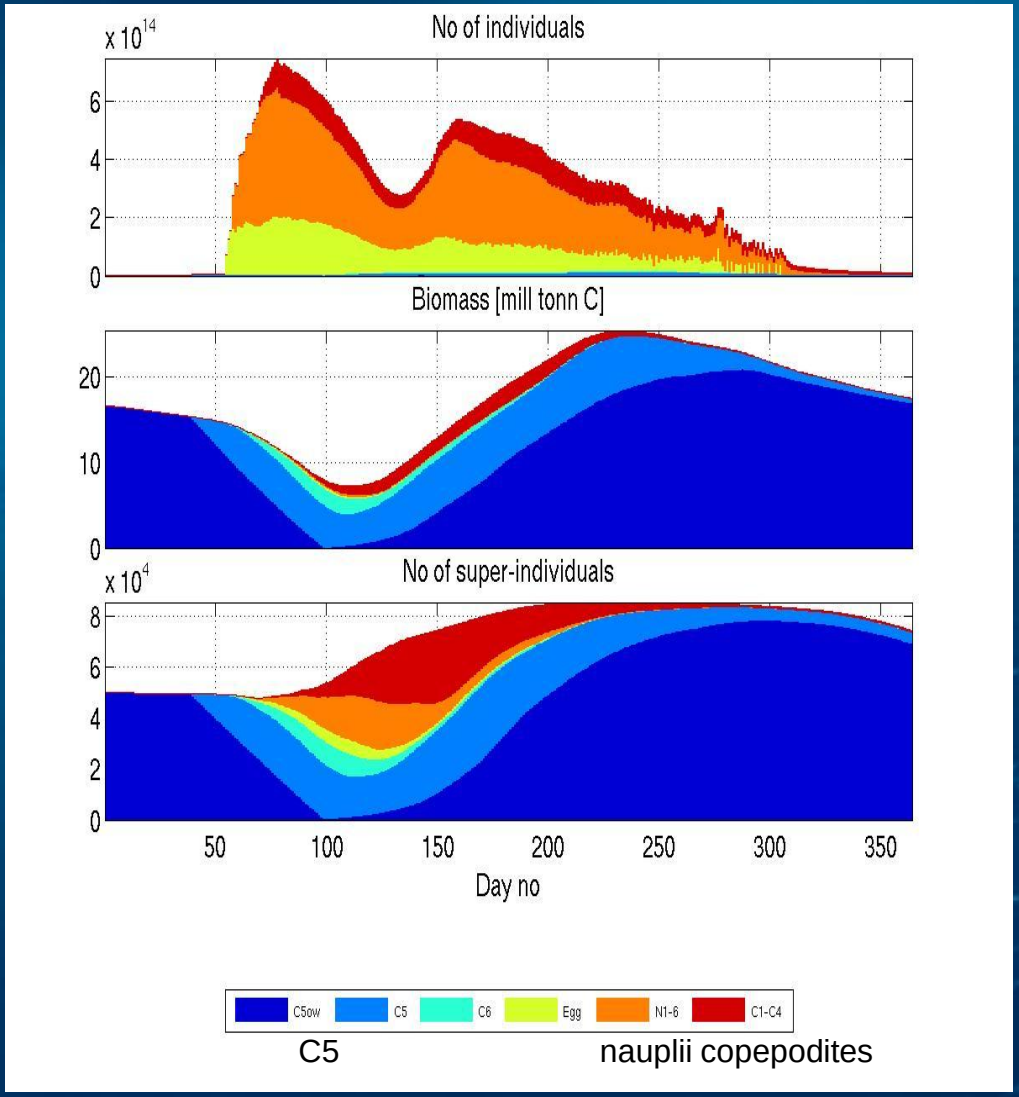
”Standard” initial C5 distribution from test run

Model performance

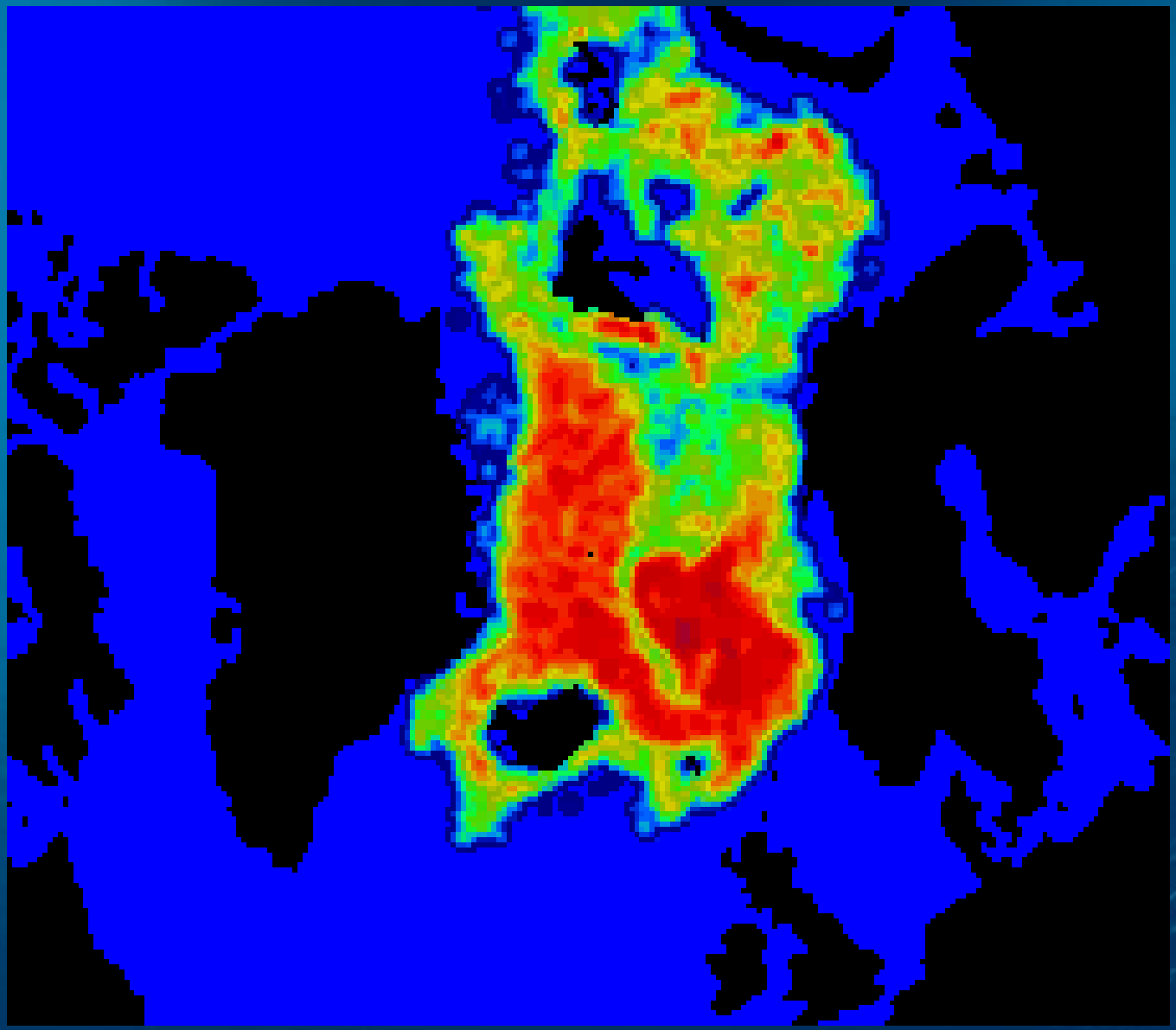
Initial no of calanus (overwintering C5) 100*fold increased, slightly elevated at end of simulation

Biomass ~stable

No of super-individuals elevated; increased computer time ☹

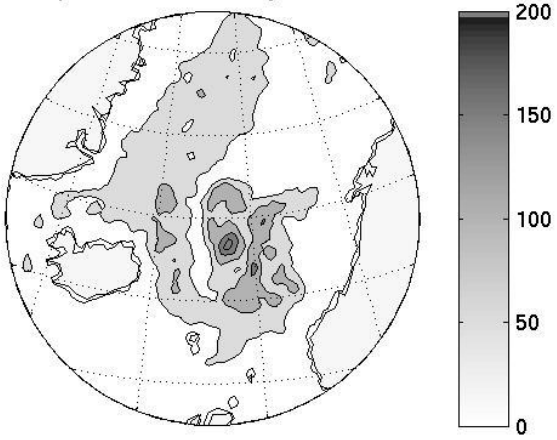


Calanus Finmarchicus copepodite abundance

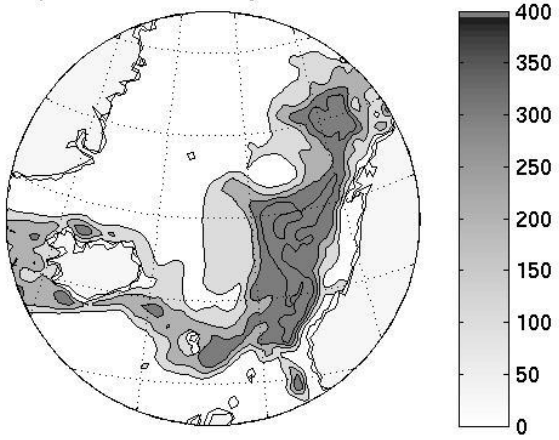


Mid April - Mid-July

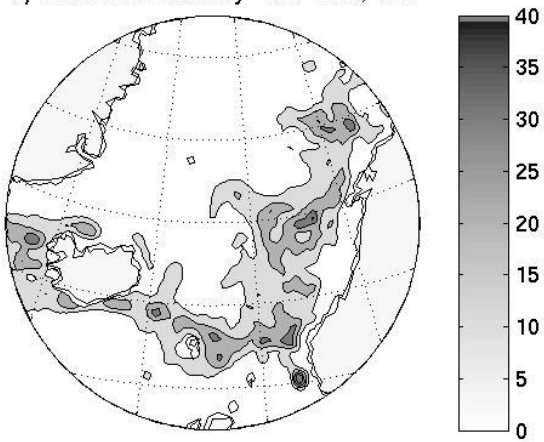
a) Abundance day 1



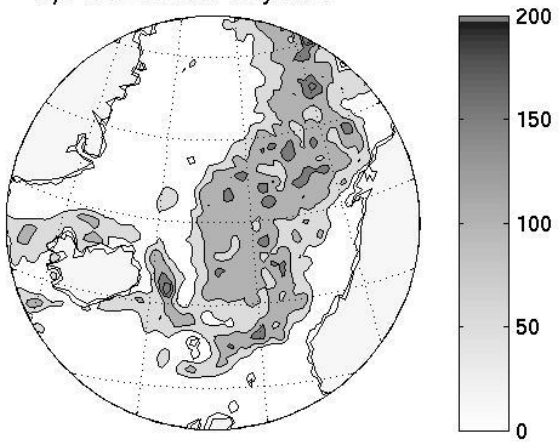
b) Abundance day 100-200



c) Abundance day 100-200, C6



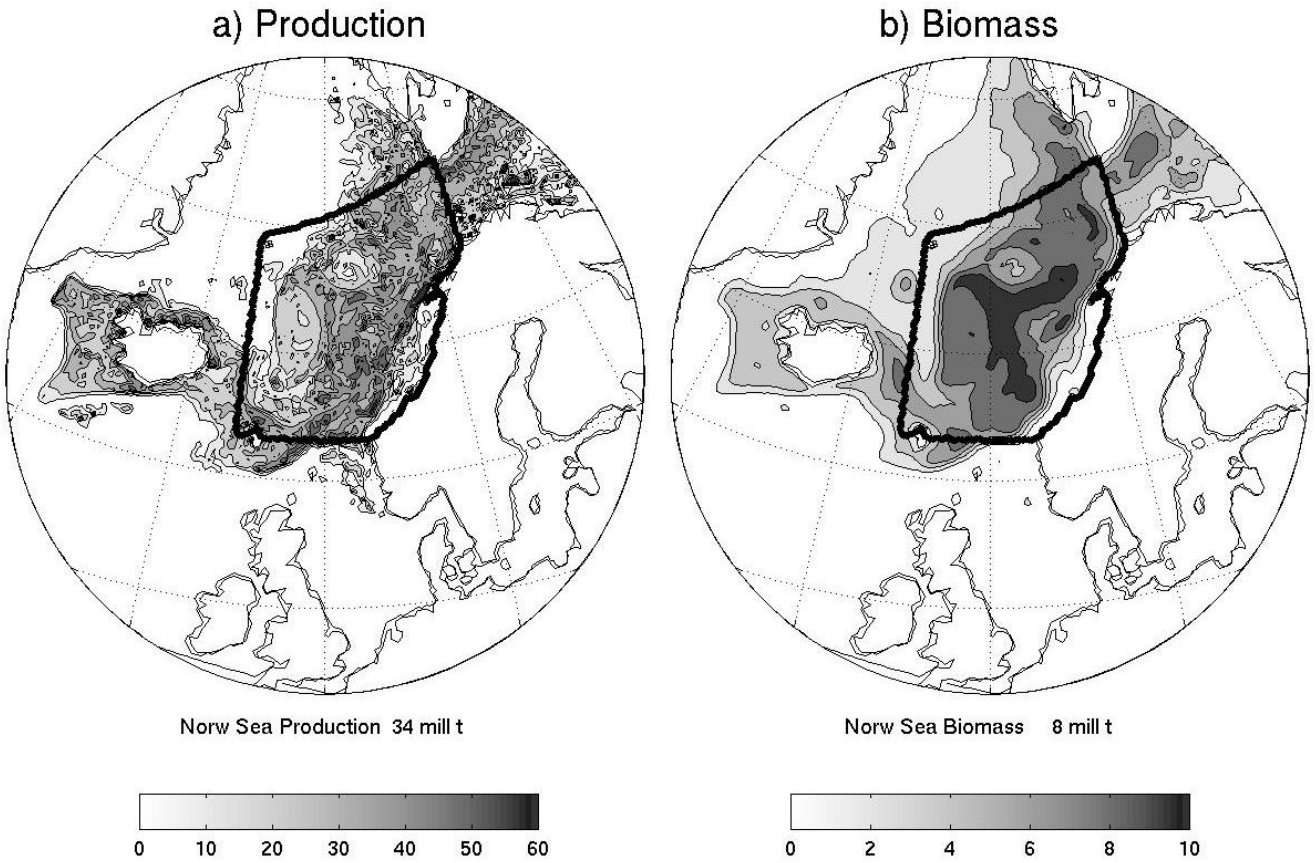
d) Abundance day 364



Initial: 0-100.000 ind/m2

Apr-July: peak values of 400.000 ind m-2, 40.000 ind m-2 C6

Overwintering population: 0-100.000 ind m-2, in Atlantic Water zone



Geographical distribution of a) annual production and b) mean of daily top to bottom biomass. Unit is [gC/m2]. Below panels the same quantities integrated within the Norwegian Sea.

PB ratio:

Annual production/mean summer biomass = 6.3

Biomass:

~10 gC m-2

Norw Sea: 8 mill tonnes C

Observed estimate Skjoldal et al (2004) :

7 mill tonnes C

Production:

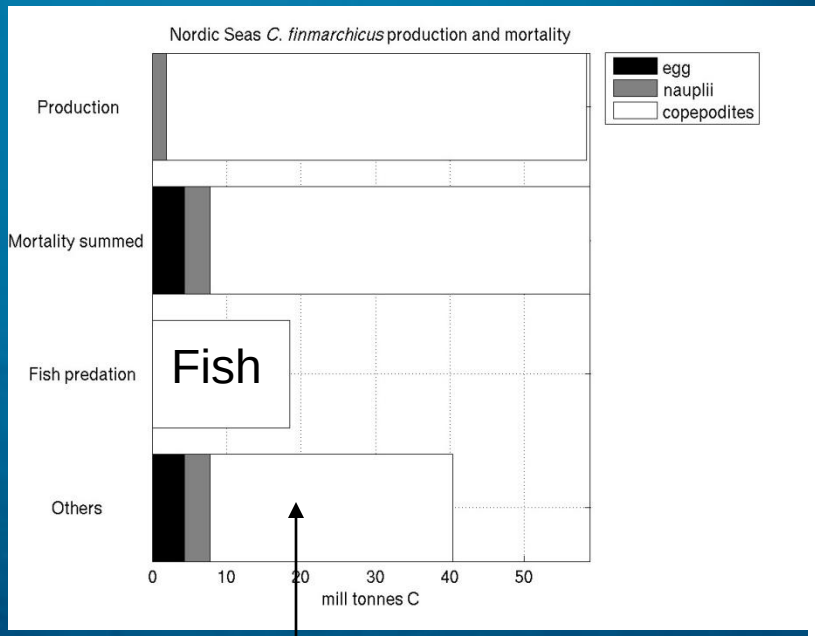
~60 gCm-2

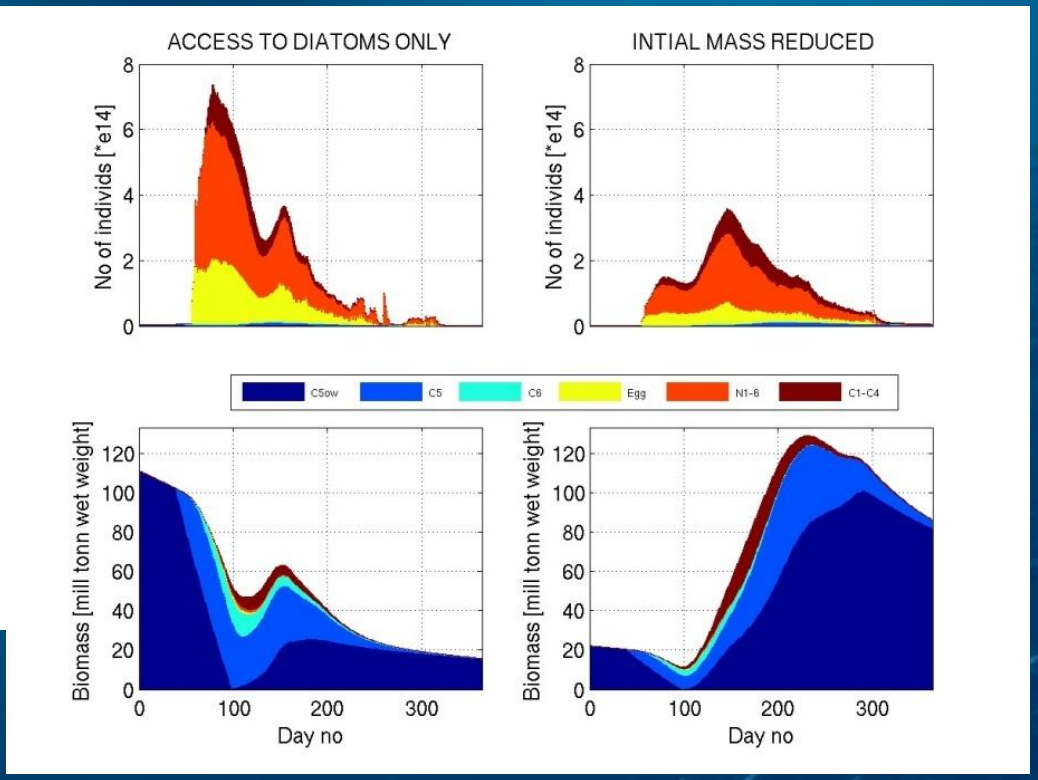
Norw Sea: 34 mill tonnes C

Observed estimate Skjoldal et al (2004) :

42 mill tonnes C, assuming PB-ratio of 6

Trophic coupling through Calanus mortality





Geographical limitations

Starvation

Age and spawning stress

Invertebrate predation

Diapause termination

WUD early:

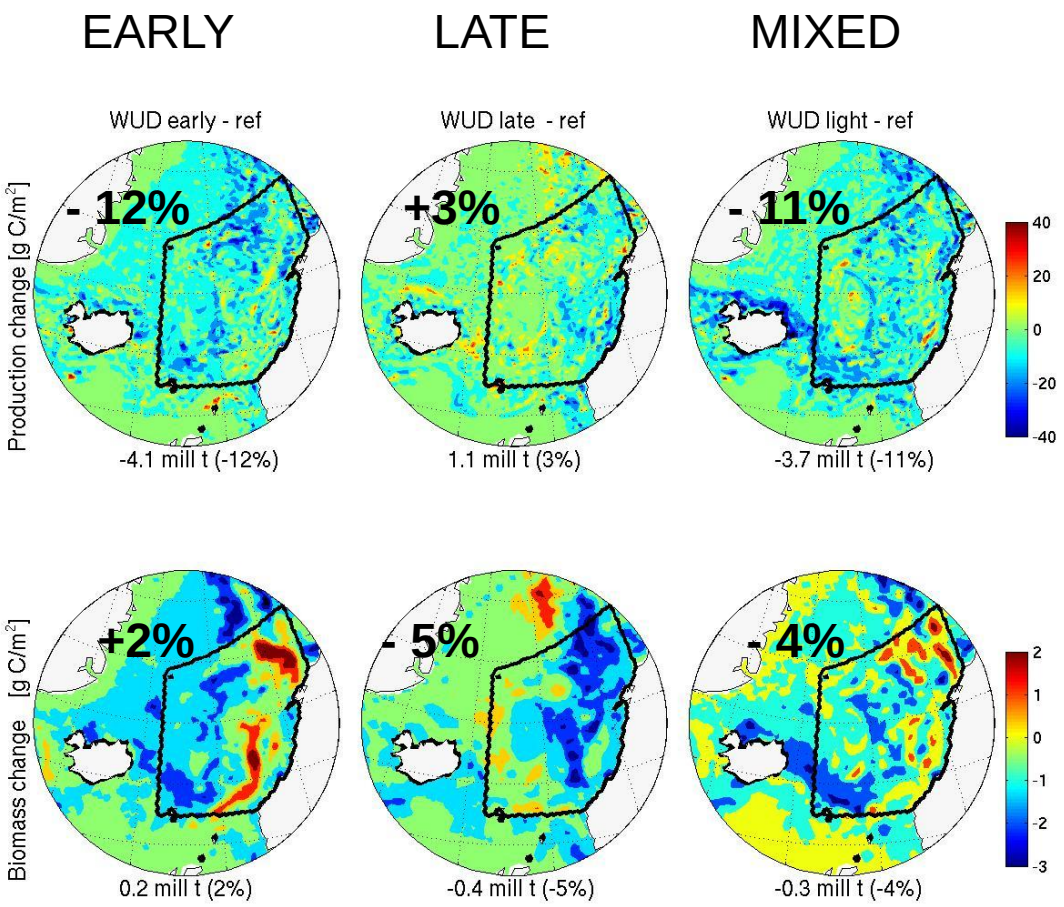
- production weakly increased in Atlantic Water zone/coastal waters; otherwise reduced.
- Biomass increase in Atlantic Water zone, reduced elsewhere.

WUD late:

- production decreased in coastal waters, increased elsewhere
- Biomass reduced in coastal/Atlantic Water zone, increased elsewhere

WUD light dependent:

- production pattern as for WUD early
- Biomass weakly increased in northern coastal/Atlantic Water zone, decreased elsewhere

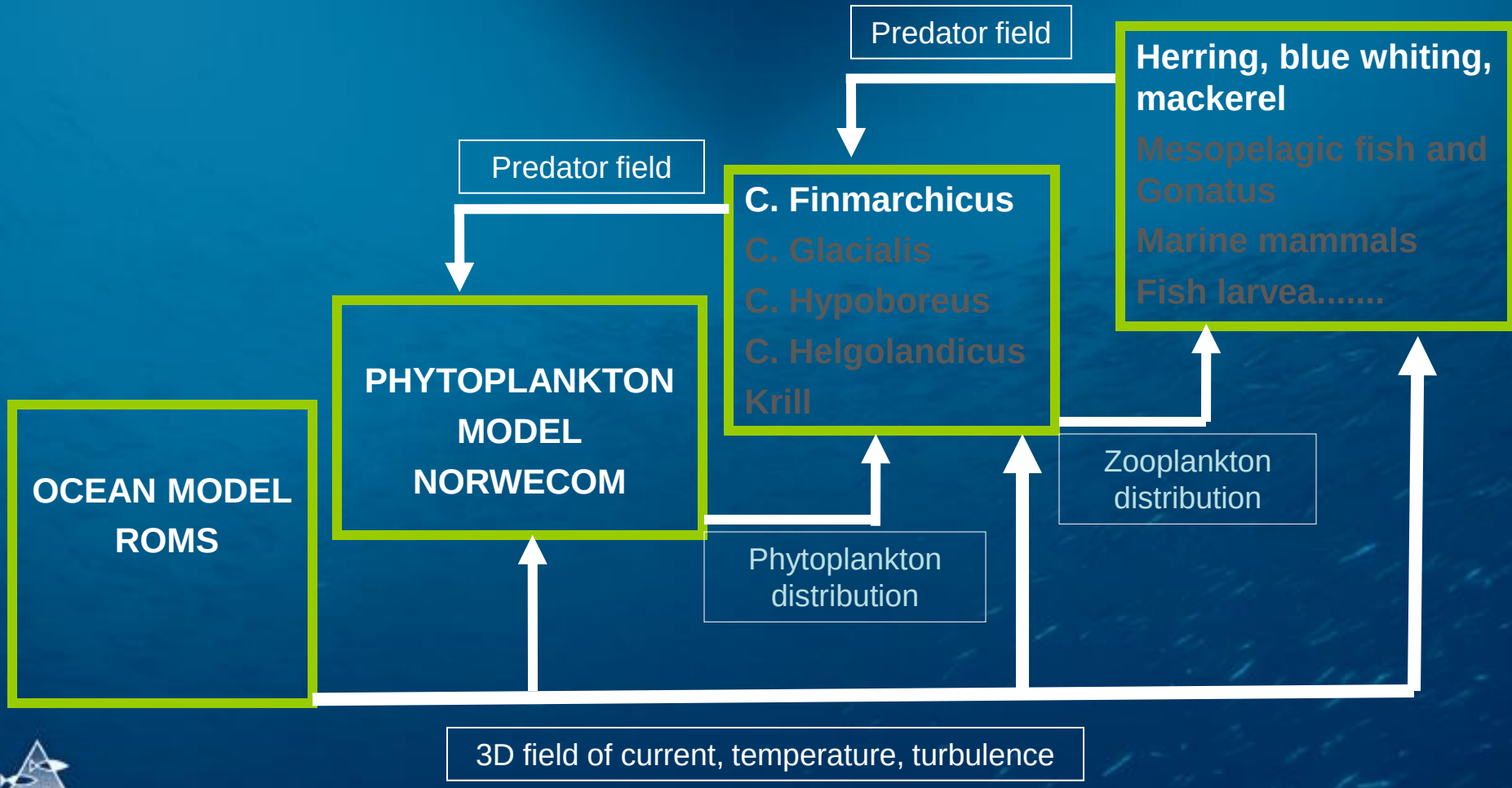


Summary

- Coupled model system for the Norwegian Sea implemented and running
- ~50.000 calanus super-individuals sufficient
- Stable biomass development; multi-year simulations possible
- Two way coupling between different trophic levels
  - Stock collapse due to food limitations within one year possible
  - Diapause termination changes production more & different than biomass
- Towards end-to-end modelling:

  NORWECOM.E2E is a suitable model tool to study ecosystem dynamics
- Flexible module system allows easy inclusion of new species

NORWECOM.E2E future plans



NORWECOM.E2E future plans