



INSTITUTE OF MARINE RESEARCH
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Økosystemmodellering

Morten D. Skogen

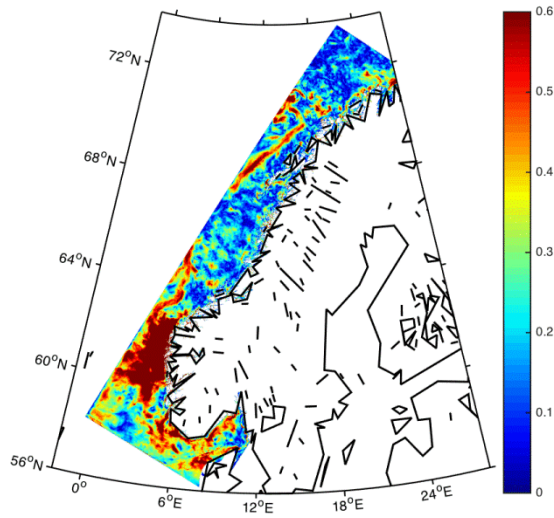


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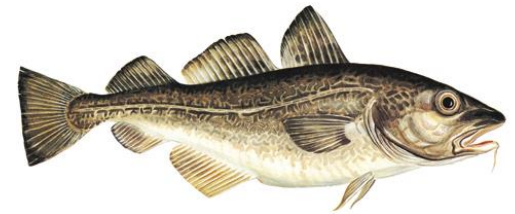
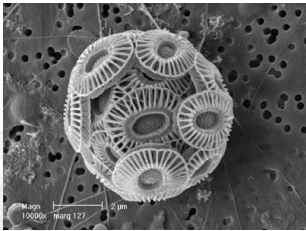
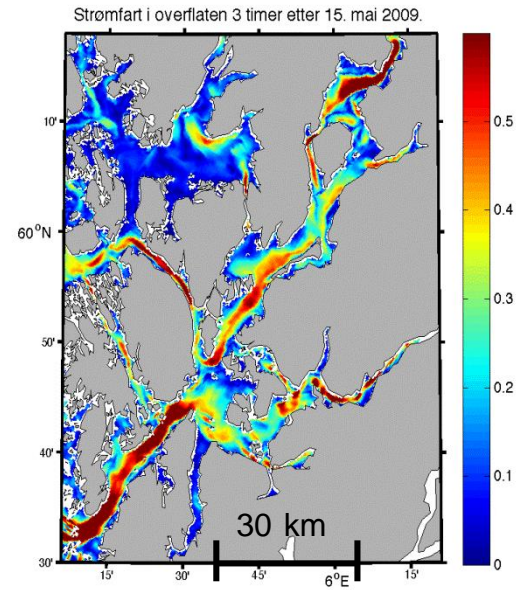
Fjord i Nord, Tromsø, 3-4. april-2019

A large school of fish, possibly mackerels, swimming in deep blue water. The fish are silhouetted against a bright light source at the top, creating a strong contrast. The water is a deep, dark blue, and the fish are densely packed in some areas, moving in various directions.

Hva er en (økosystem)modell ?



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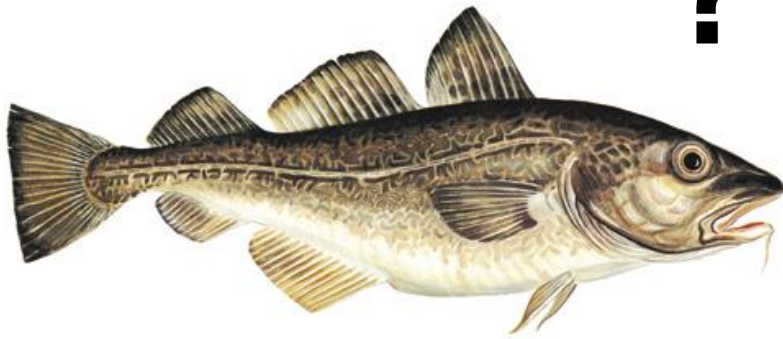


ØKOSYSTEMMODELL



Hovedutfordring:

?



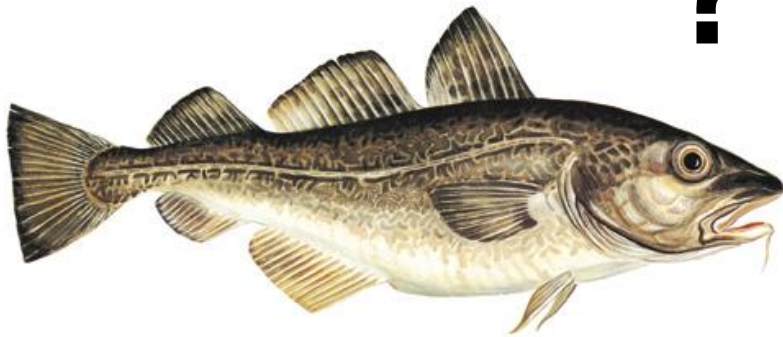
?



$$F(x,y,z,t,\dots) = ???$$

Hovedfordeler:

?



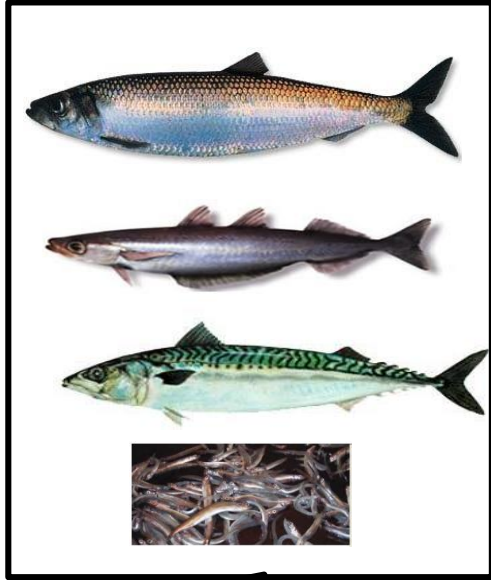
?



- **Kvantitativ**
- **Høy oppløsning i tid og rom**
- **Kan beregne ting som ikke kan måles**
- **Hypotesetesting**
- **Projeksjoner i tid**
- **What-if scenarier**



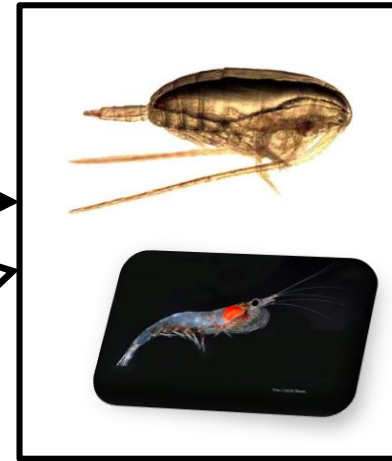
Pelagic fish – capelin, mackerel, herring, blue whiting



Fish boats, minke whale,



Zooplankton – cal.fin., cal.hyp, krill



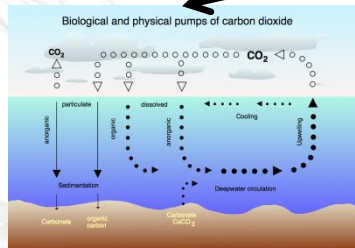
Mesopelagic fish



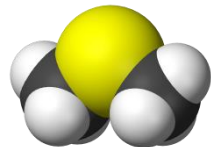
Individual based modules (IBMs)

NORWECOM.E2E

Other modules



Ocean acidification



DMS/DMSP



Plankton production/eutrophication

NPZD



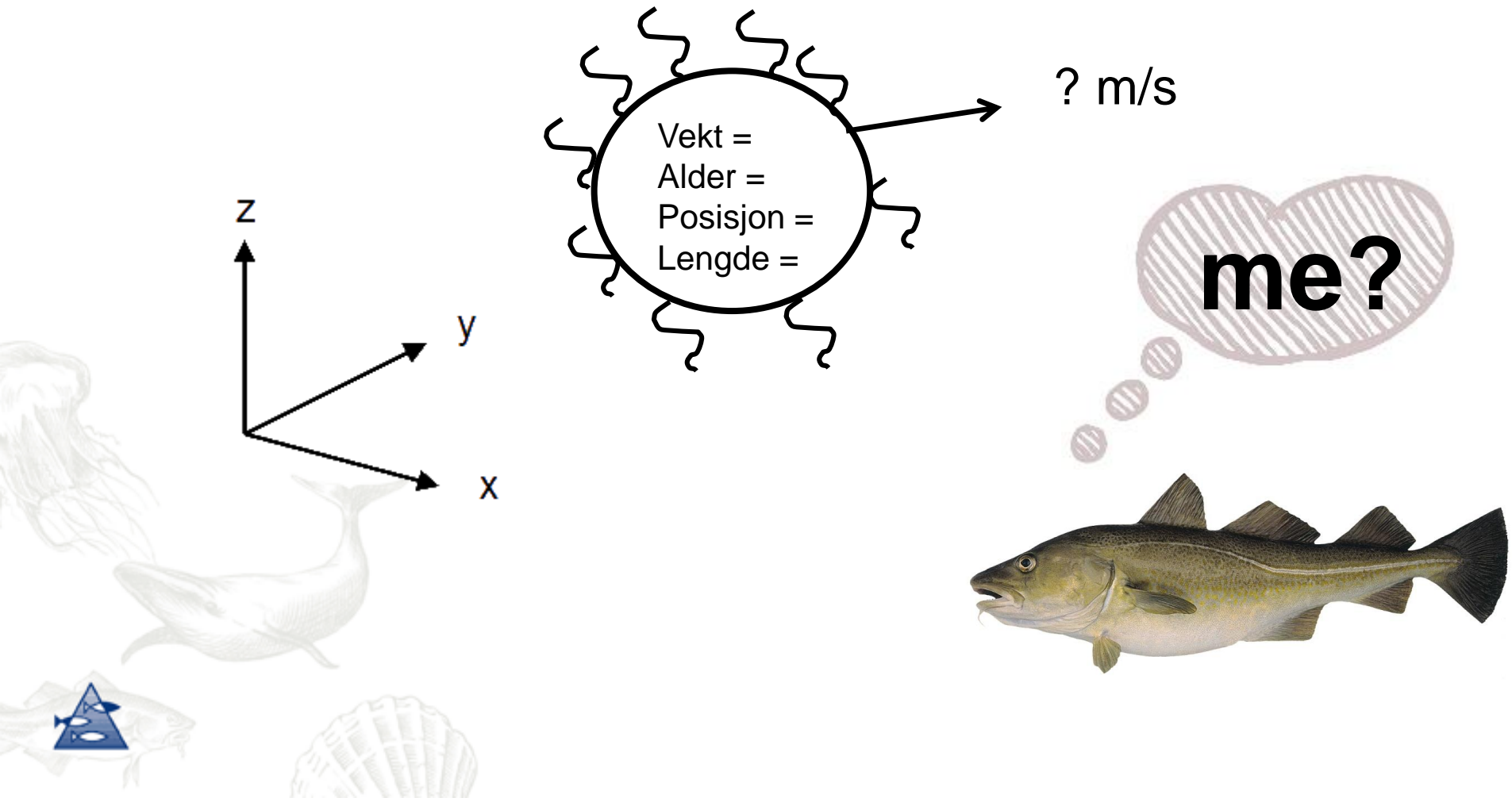
Contaminants



Individ baserte modeller (IBM)

-når organismen har "fri vilje"

Individ som partikkel som beveger seg i rommet:

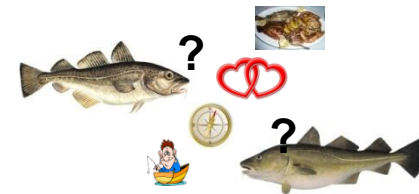


Definerer oss en partikkel/organisme/individ med ulike egenskaper/attributer

Individ egenskaper (eksempel) :

- alder
- vekt
- lengde
- posisjon
- stadie (egg, larve, juvenile, voksen)
- kjønn
- fettinnhold
- svømmehastighet
- eggproduksjon
- moult fraction
- homing posisjon
- ulike gener som styrer bevegelse og oppførsel
-

- I en IBM følger vi (tids)utviklingen av alle disse egenskapene for en organisme
- (men hva styrer tidsutviklingen??)



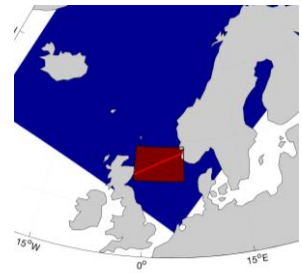
$$F(x,y,z,t,\dots) = ???$$

A large school of fish, likely mackerels, swimming in deep blue water. The fish are silhouetted against a bright light source from above, creating a dramatic, high-contrast scene. The fish are densely packed and appear to be moving in a coordinated pattern.

Noen eksempler

(fra det åpne hav)

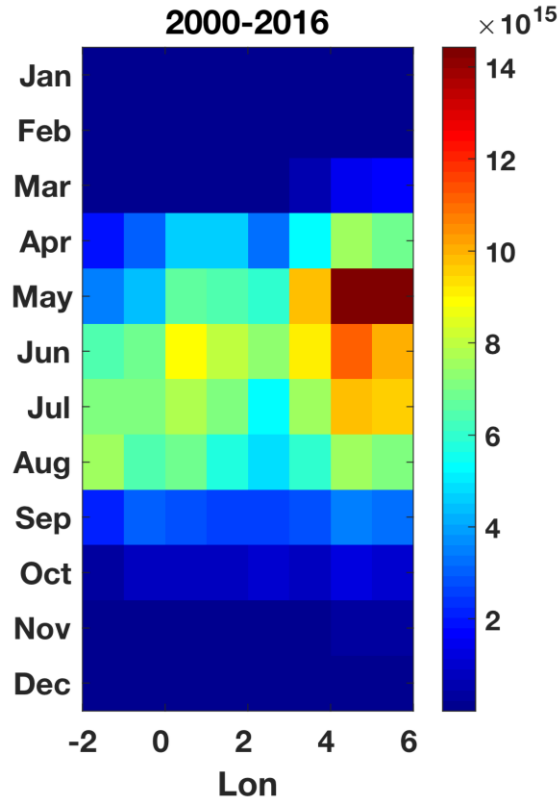
Model vs. CPR data - *Calfin*



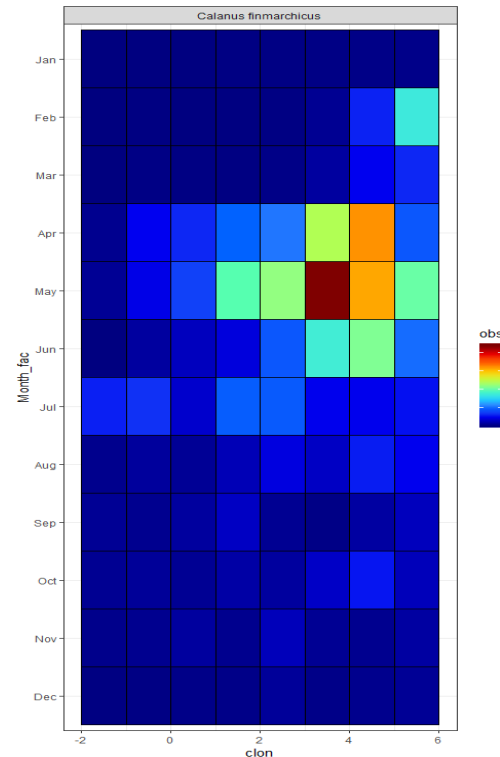
Model

CPR

Cf abundance per m^2 , $\leq 30m$, C5C6
2000-2016

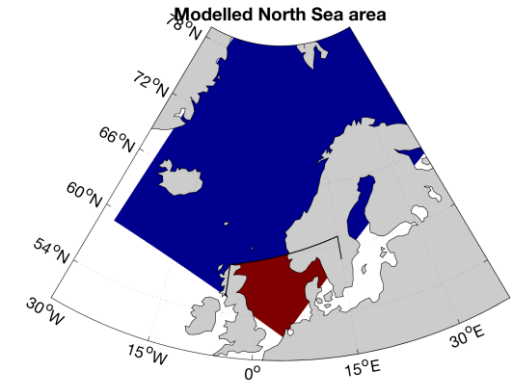


number of individuals per $3 m^{-3}$

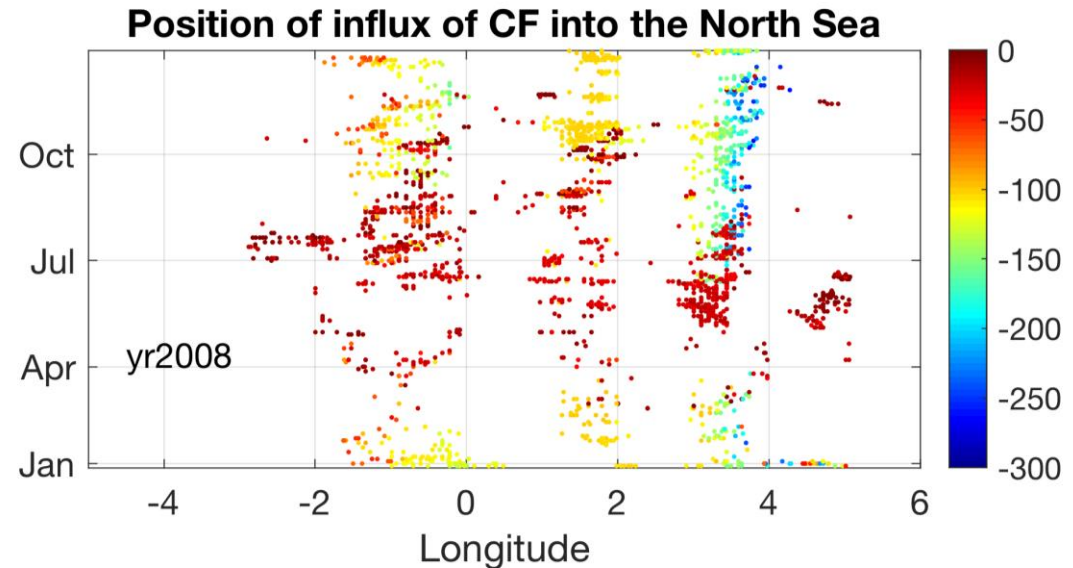
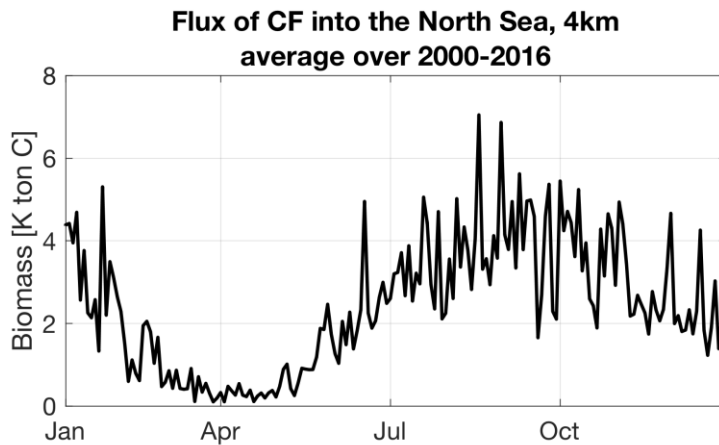


Monthly averaged over the years 2000-2016

Influx of *C. finmarchicus* to the North Sea

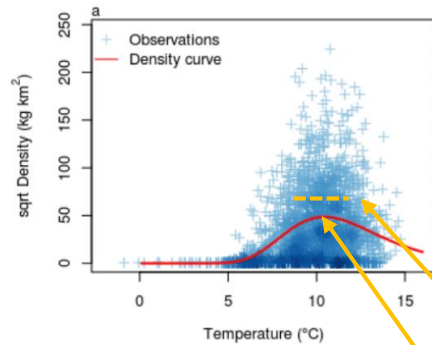


- Depth, time and position



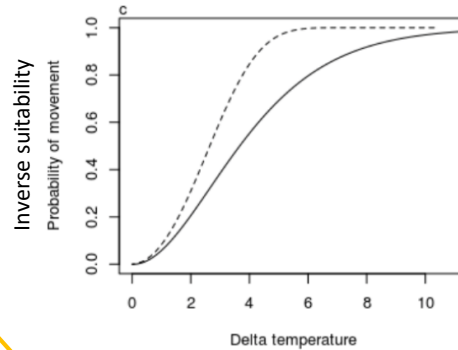
Fiskevandring: Parameterizing temperature and food preference niche (mackerel)

Temperature

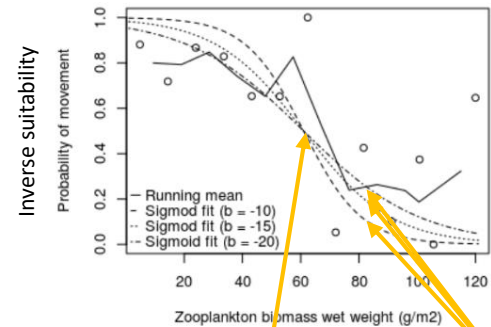


$$P^{temp} = 1 \div (\sqrt{(2 \times \pi)} \times s \times x) * \exp(-((\log(x) - \bar{x})^2 \div (2 * s^2)))$$

Mode = 10.44
 Log Mean (\hat{x}) = 2.41
 Log SD (s) = 0.253



Food density



$$P^{prey} = \exp((x - a) \div b) \div (1 + (x - a) \div b)$$

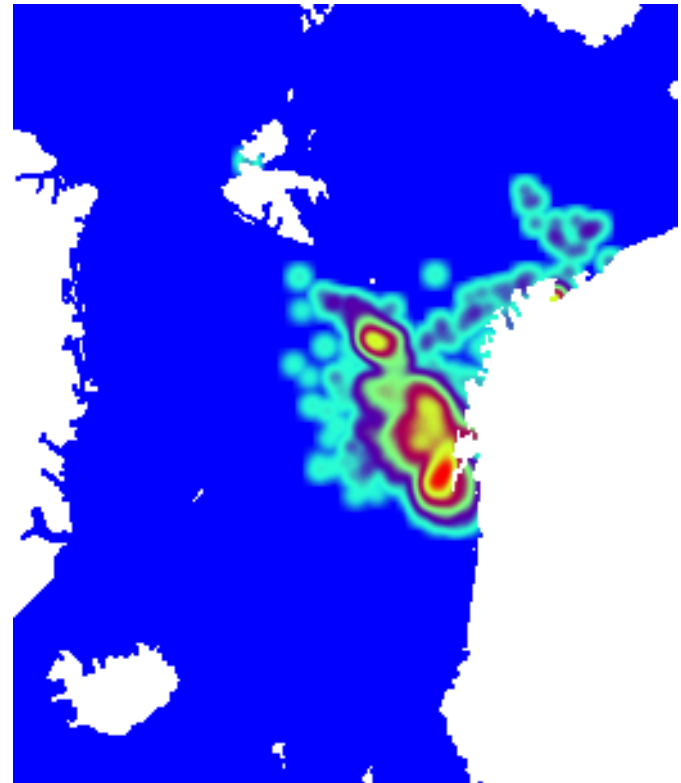
50 % cutoff (a) = 60
 Flatness (b) = -15

Fiskevandring – sild og makrell

Mackerel May-Oct 2012



NSS Herring JAN-DEC 2012

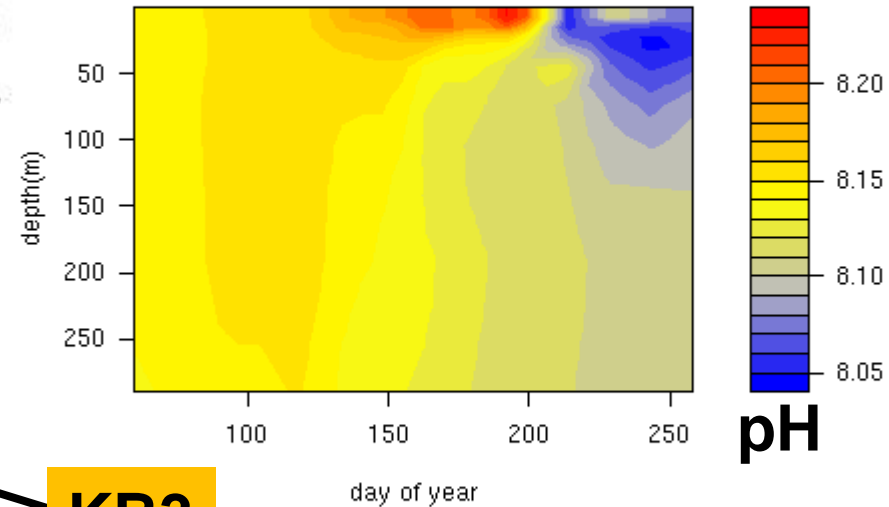
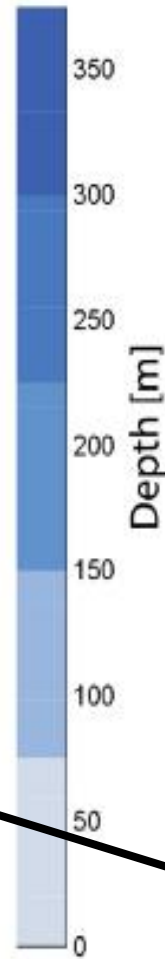
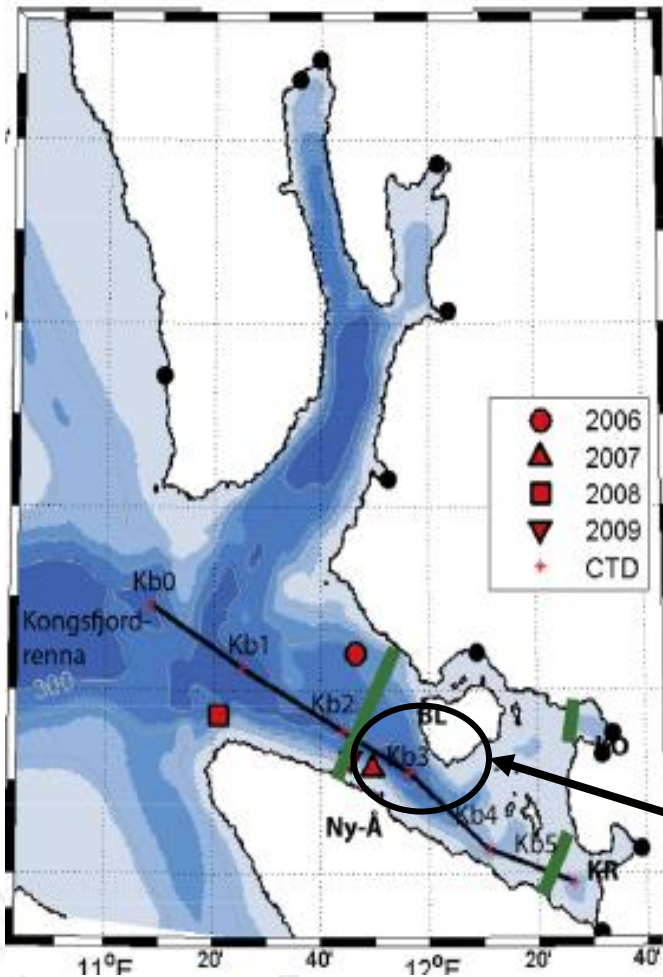


(Mousing et al., in prep)

A large school of salmon swimming in deep blue water, illuminated from above. The fish are silhouetted against the bright light, creating a shimmering effect. The text "Hva med fjordene?" is overlaid in the center in white.

Hva med fjordene?

Havforsuring Kongsfjorden



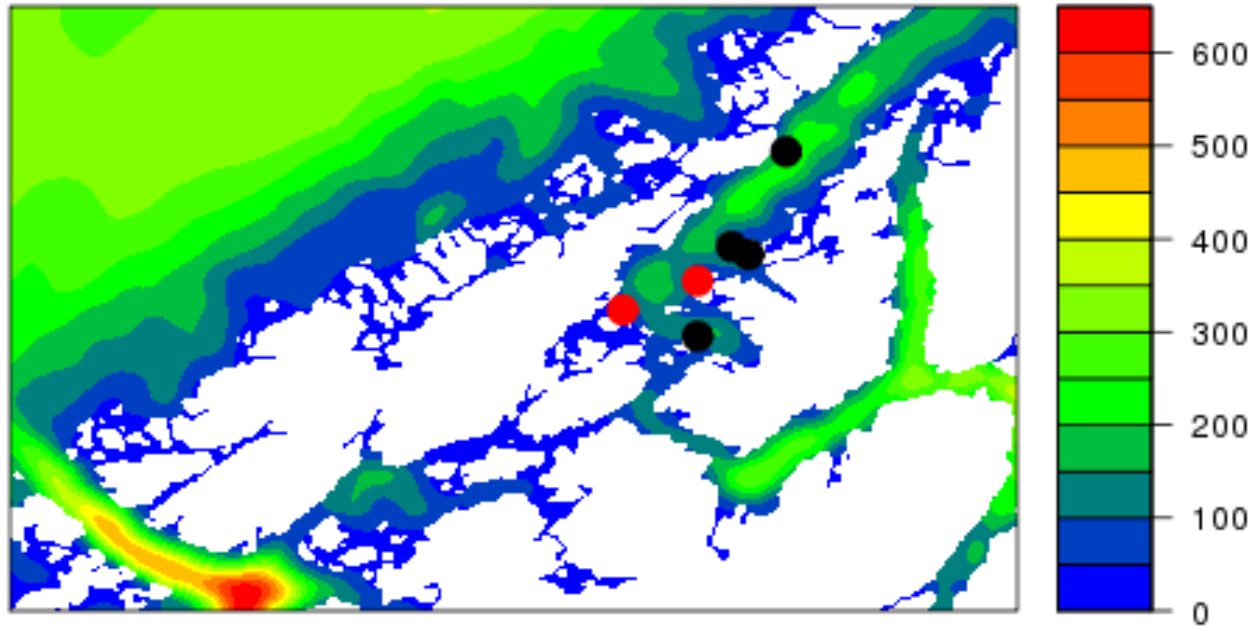
KB3

- Physics: 160m ROMS Kongsfjorden 1/3-30/9, 2009
- Initial fields of nutrients + OA from Fransson et al. (2016)



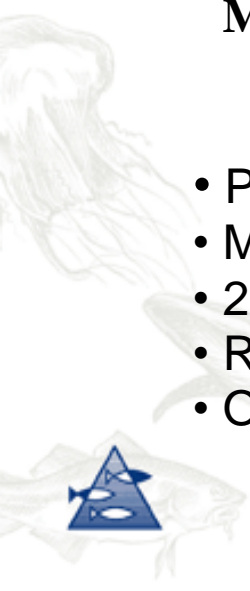
Case-study:

Hjeltefjorden with two fish farms: Kelvesteinen and Ramsøy



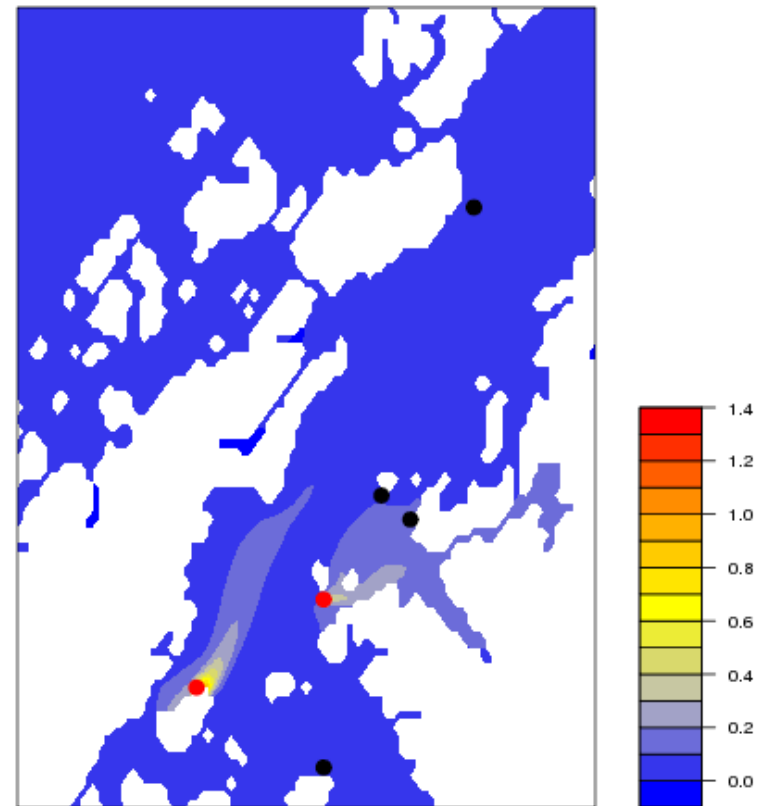
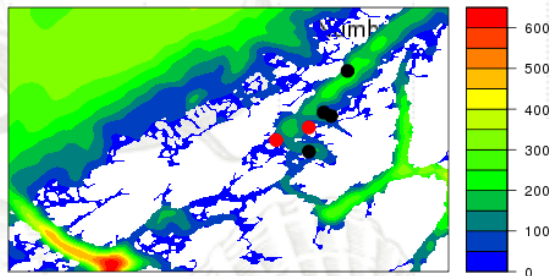
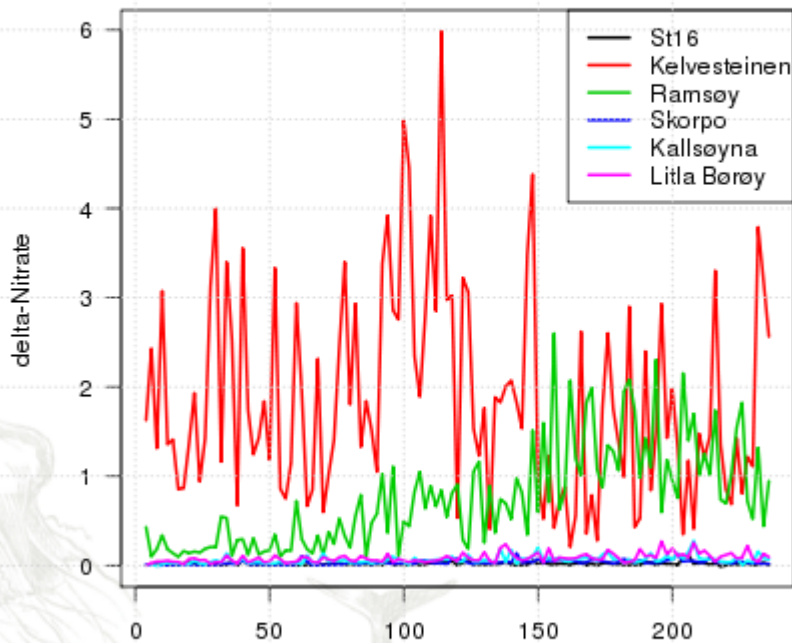
Model domain with bottom topography

- Physical fields from NorFjords (Hordaland 160m)
- Model period: January 1 – August 31, 2015
- 2 simulations – with and without fish farms
- Releases of N and P from Kelvesteinen and Ramsøy (red dots)
- Output: time series of N and P from 6 points (red+black dots (= reference))



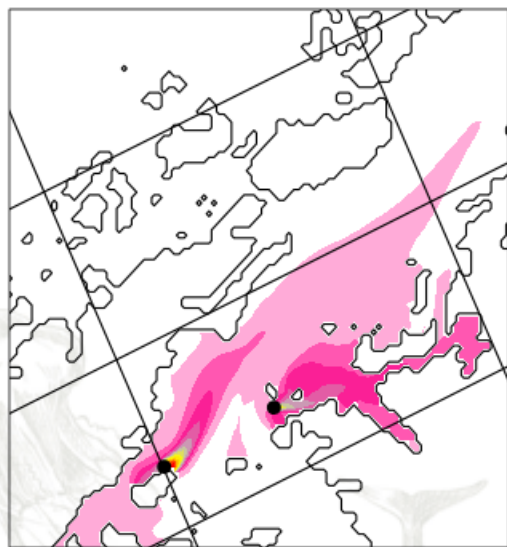
Spredning av næringssalt fra fiskeoppdrett (1)

Endring av nitrate (middel øvre 5 m):

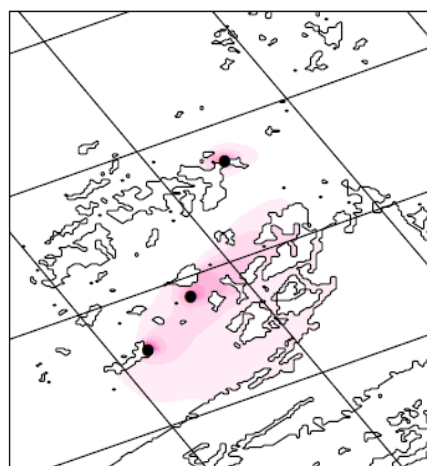


Spredning av nærings salt fra fiskeoppdrett (2)

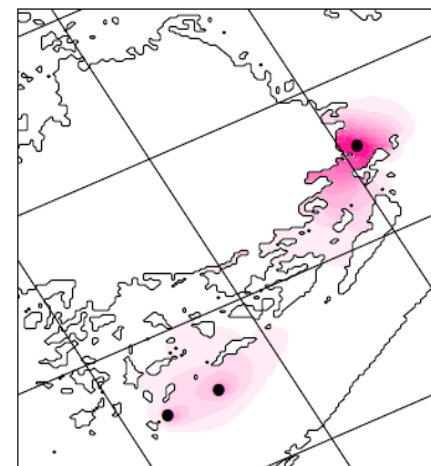
Endring av nitrate (middel øvre 5 m):



Hjeltefjorden



Frøya

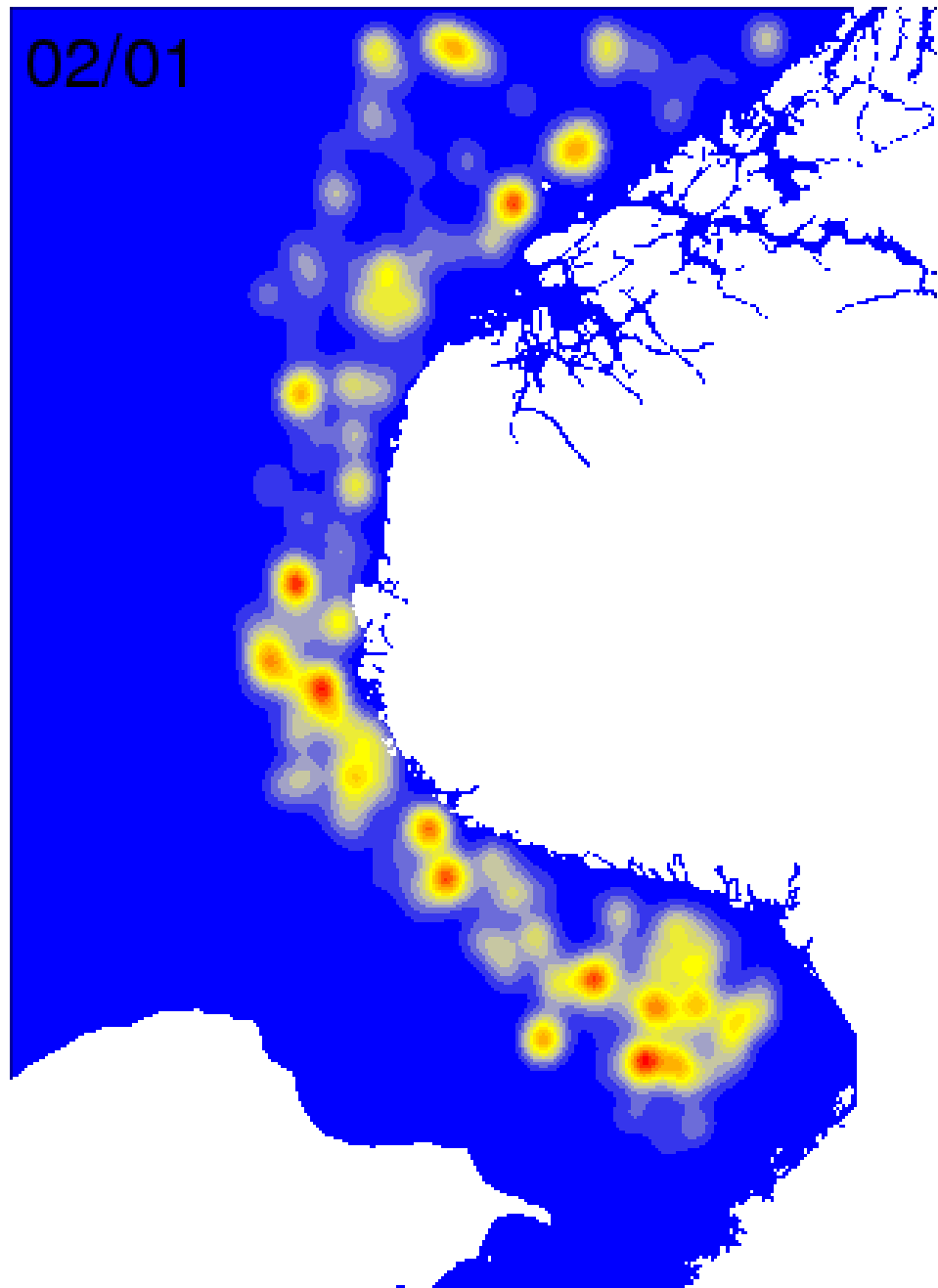
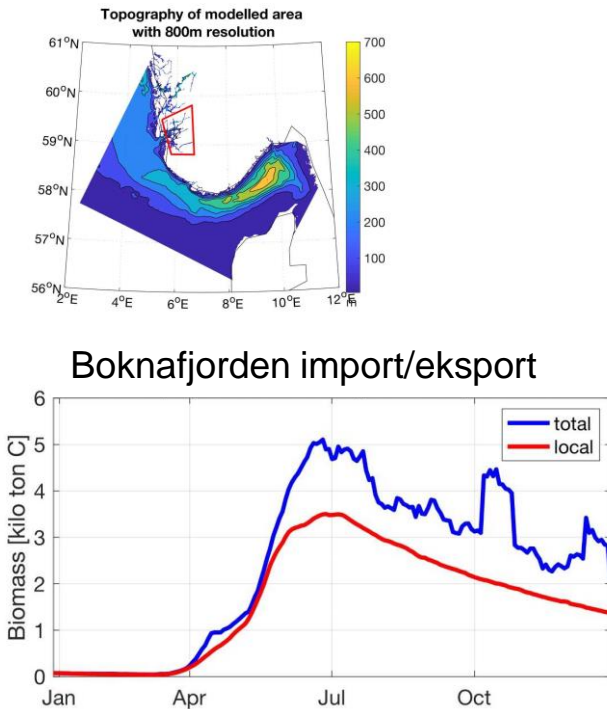


Smøla



Overflate - bunn *C.finmarchicus* biomasse 2013

Forcing: NorKyst800



Blåskjell som eutrofidedempende tiltak



Foto: HI



Foto: bellona.no



Oppsummering

- Økosystemmodeller kobler fysikk med biologi
- IBM modeller for plankton og fisk
- Mange anvendelser i havområdene
- (til nå) begrenset bruk i fjorder og langs kysten
- Havforsuring
- Nærings saltutslipp fra fiskeoppdrett
- Pågående/planlagt aktivitet kyst/fjord
 - Utveksling hav/kyst/fjord av dyreplankton
 - Blåskjell som eutrofidempende tiltak
 - IEA



Thank you for your attention!!



Bergen seen from Mt. Ulriken