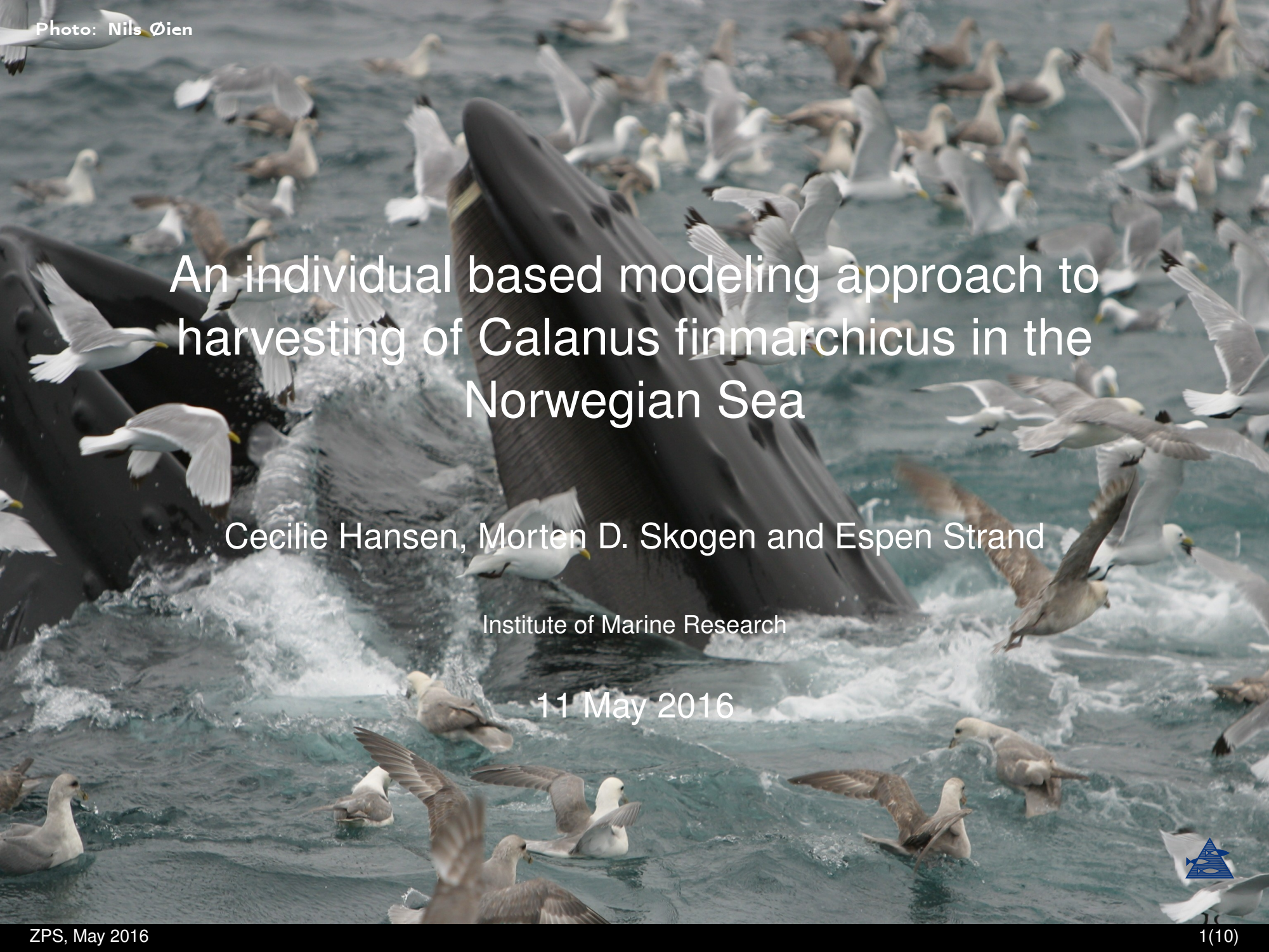

An individual based modeling approach to harvesting of Calanus finmarchicus in the Norwegian Sea

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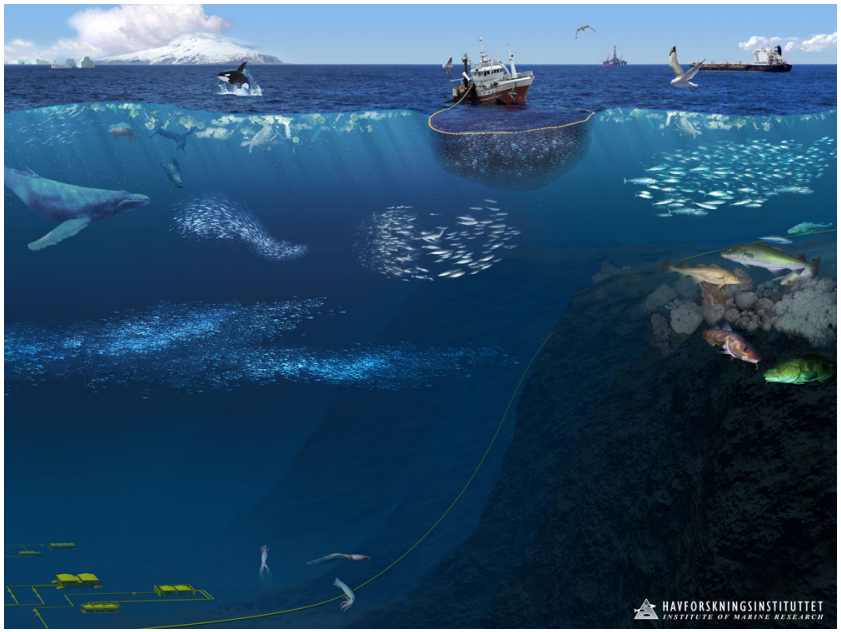
Objective

Will harvesting *Calanus finmarchicus* have an impact on the zooplankton biomass and inflow to the Barents Sea?

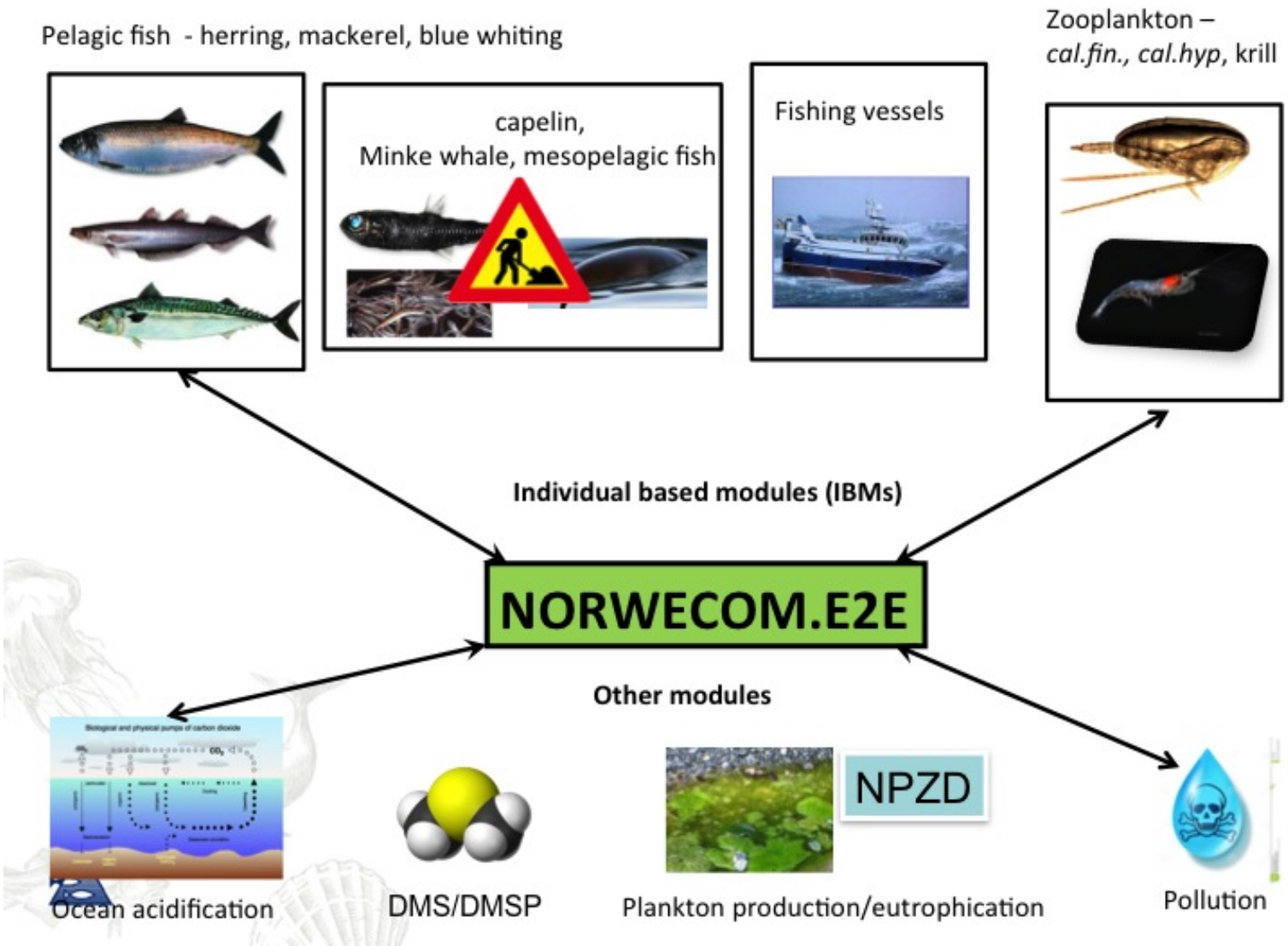


Calanus finmarchicus

- Key species in the Norwegian Sea ecosystem, important food source for mackerel, herring and blue whiting
- 13 life stages; eggs + 6 nauplia stages + 5 copepodite stages + adult stage
- Overwinter at depth, before ascending to the surface for spawning in the spring
- Large production, roughly 290 million tonnes, and a biomass around 24 million tonnes
- Valuable source for oil, ongoing trial fishery with a 1000 tonnes quota

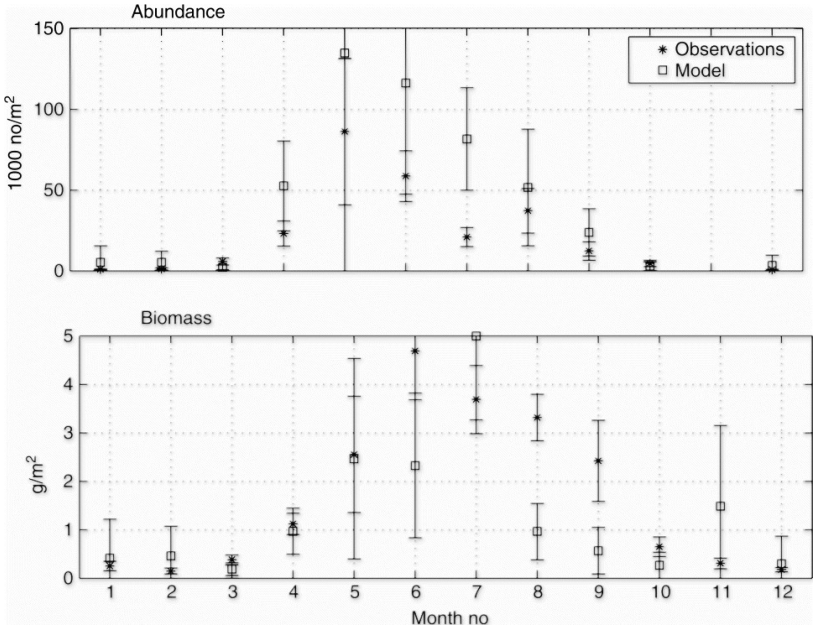
Photo: Courtesy of Terje van der Meeren

Model system: Norwecom.e2e



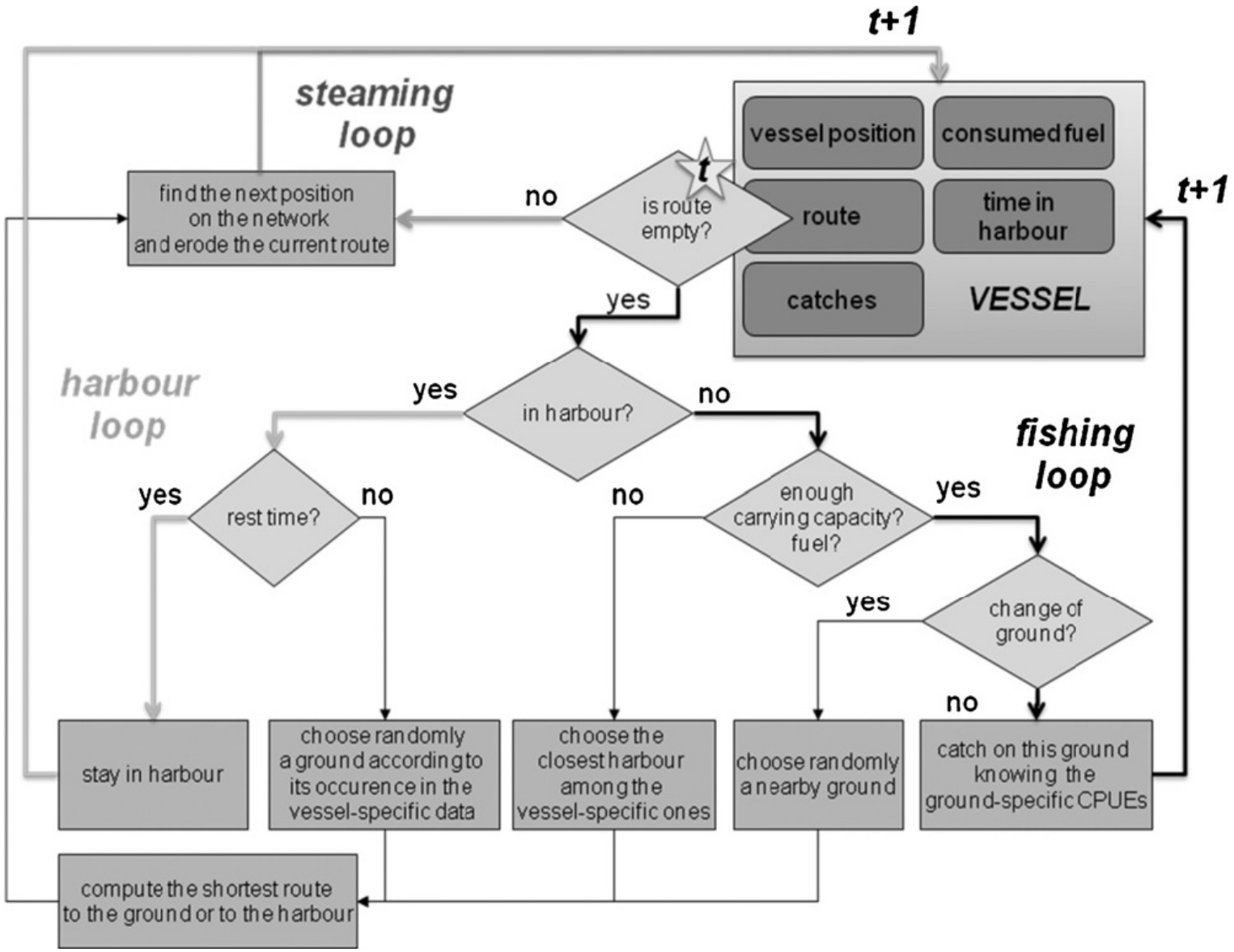
Model system: *Calanus finmarchicus*

- Individual based model, where the number of *C. finmarchicus* individuals are represented by super-individuals
- Includes all life stages of *C. finmarchicus*
- Individuals governed by growth, mortality, movement and reproduction
- Feed on phytoplankton, and includes a two-way coupling between zooplankton and phytoplankton



Hjøllo et al., 2012

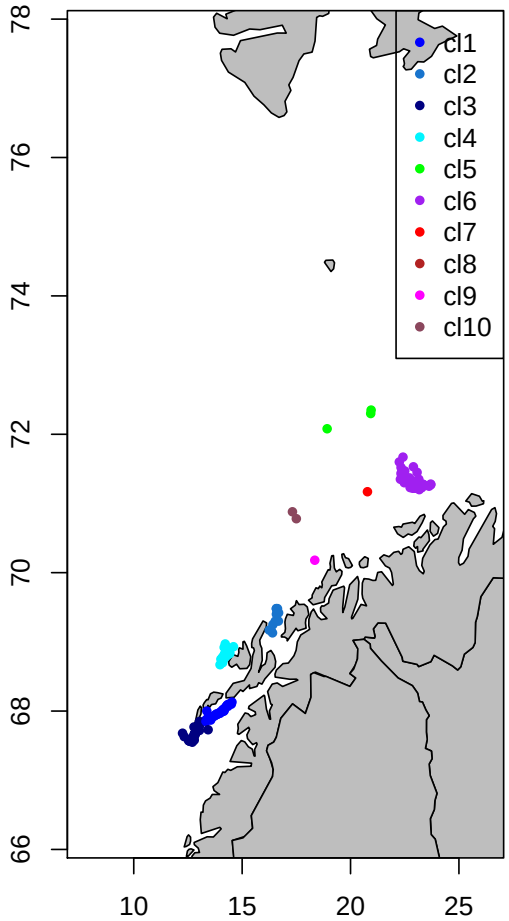
Model system: Fishing vessels



Bastardie et al., 2010

Fishing vessel module - details

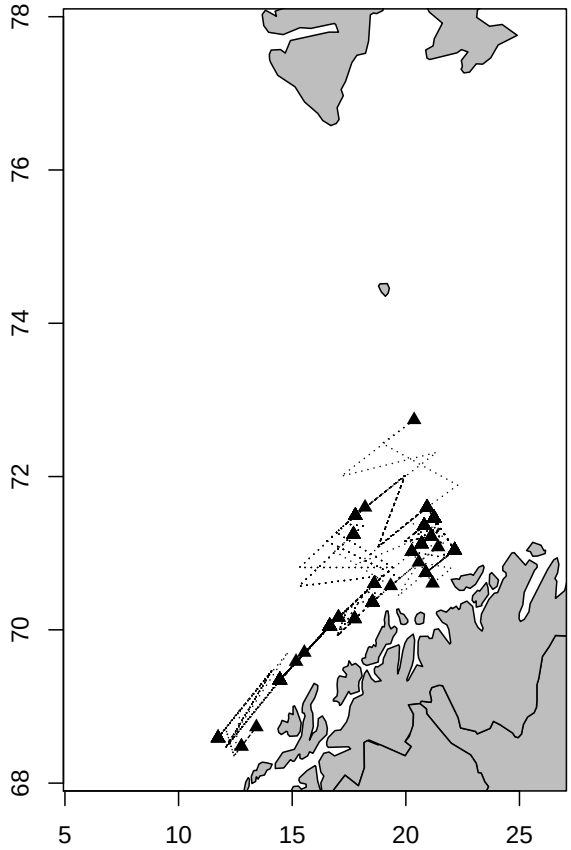
- The size, carrying capacity and fuel usage of the implemented fishing vessels are in line with the boats harvesting *C. finmarchicus* in the Norwegian Sea
- Currently two vessels included in the model
- Double trawling, gear size based on the gear in use
- Fishing grounds defined based on information from the ongoing fishery, harbours chosen as closest road connections to the fishing grounds



Clustering positions into fishing grounds

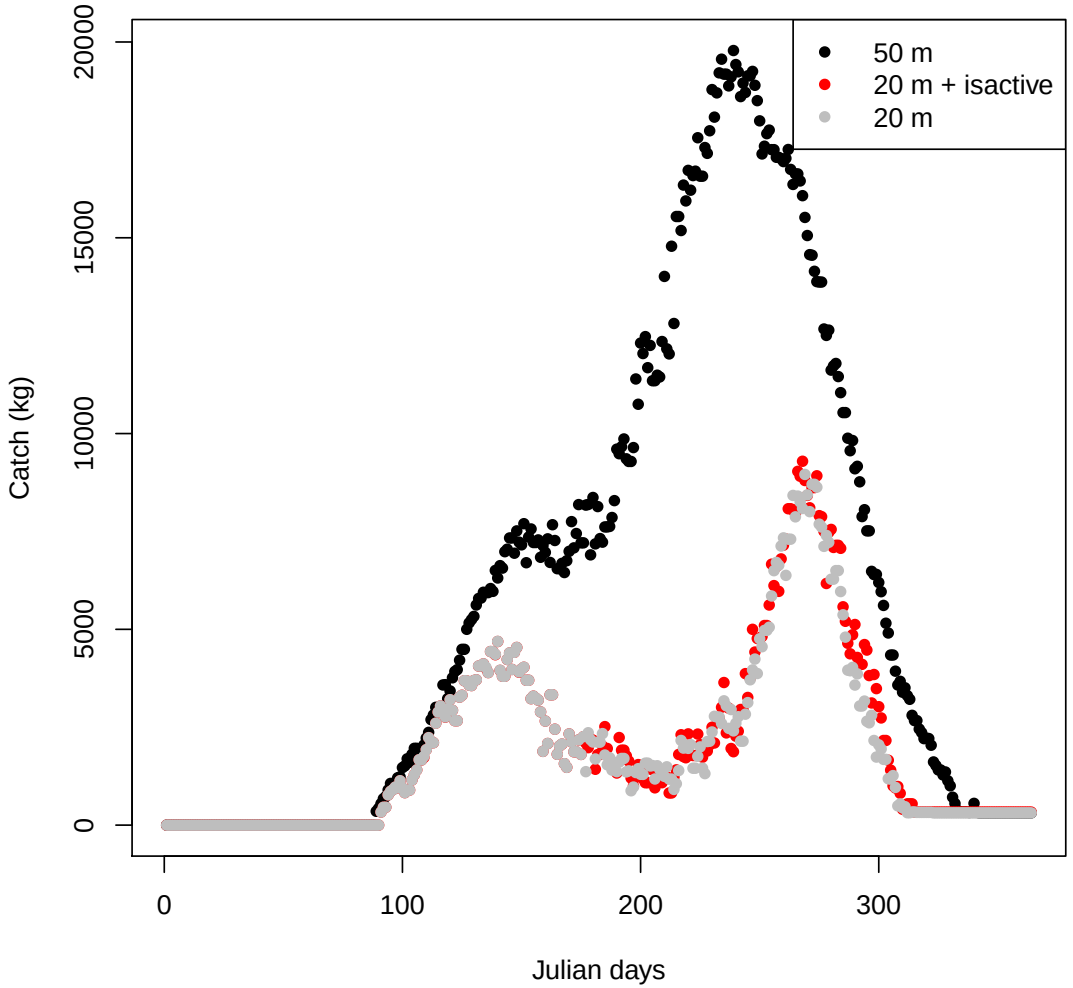
Results - position and harvesting pattern

- The start date of fishing is flexible, but includes the whole year for these simulations
- The first 3.5 months the vessel is searching between the fishing grounds for high enough levels of *C. finmarchicus*, and returns to harbour is only caused by low levels of fuel
- When the concentration of *C. finmarchicus* is high enough for fishing, the return to harbour is caused by a mix between carrying capacity and fuel levels



Route of vessel 1 for first year of simulation

Results - catches



Daily catches (kg) from the three different simulations

Conclusions and future prospects

- When keeping within the upper 20 m of the water column, starting fishing at a level of 5 g/m^2 and only including active individuals, the boat is able to fish 700-735 tonnes per year, compared to 2000 tonnes if access to the upper 50 m
- There are no significant differences between simulations which does not include fishing vessel, to those who include the fishing
- Compared to the roughly 24 million tonnes of *C. finmarchicus*, the catches represents an insignificant amount of plankton, something also seen in the comparison of the total biomass and number of eggs between the simulations including fishing to those not including fishing
- BUT: the model used does not include the fish modules, and only one vessel is fishing
- AND: How much can we fish without perturbing the total biomass, when can an ecosystem effect be seen?