The background of the slide is a deep blue underwater scene. Numerous small, dark bubbles are scattered throughout the water. A bright, ethereal light source from the upper left creates a strong beam of light that filters through the water, illuminating the bubbles and creating a shimmering effect. The overall atmosphere is mysterious and scientific.

Advanced modelling of potential impacts on Norwegian NEA cod from petroleum discharges

Geir Morten Skeie and
JoLynn Carroll

Marine areas – economic opportunities and environmental risks



Tourism and nature

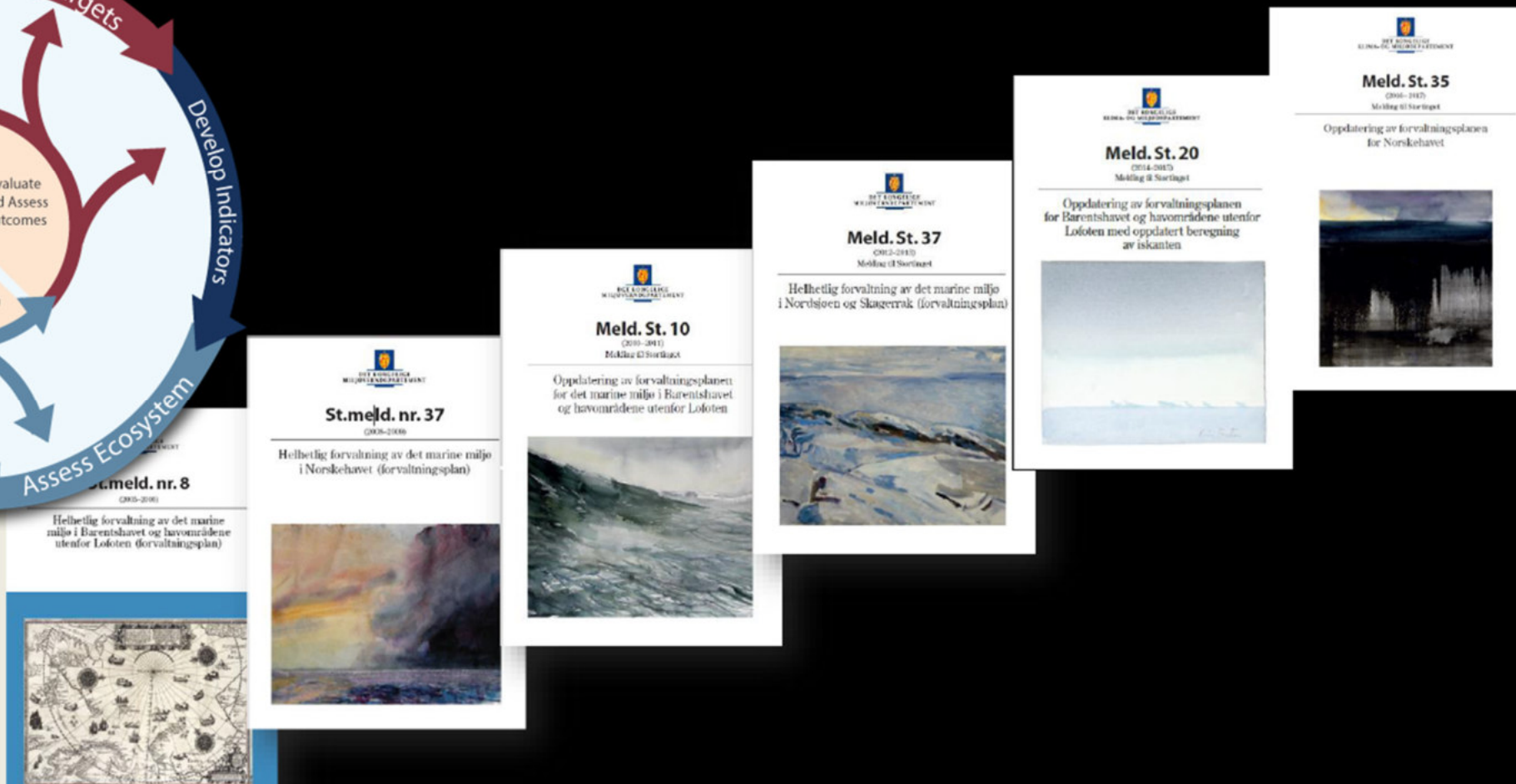
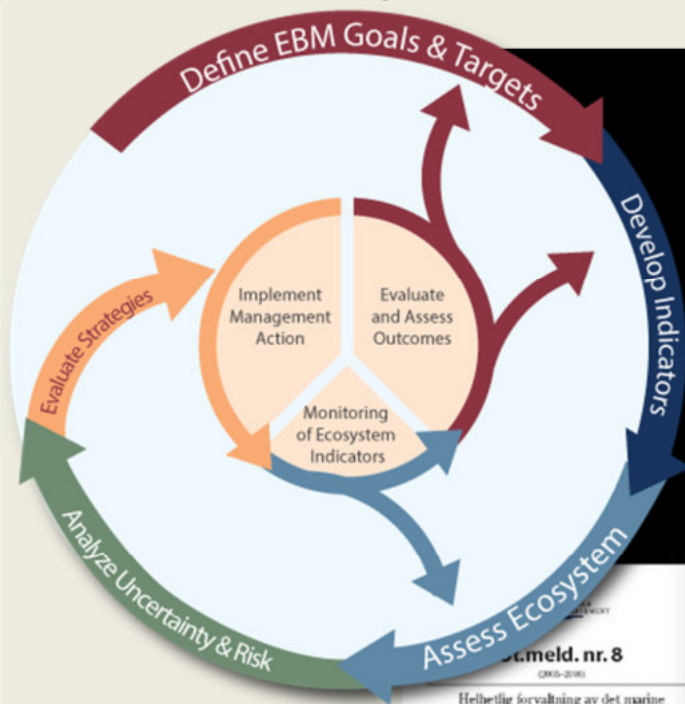


Commercial fisheries



Petroleum resources

Management Plans for Norwegian Marine areas



Protect ecosystem health & provide ecosystem services

Routine events

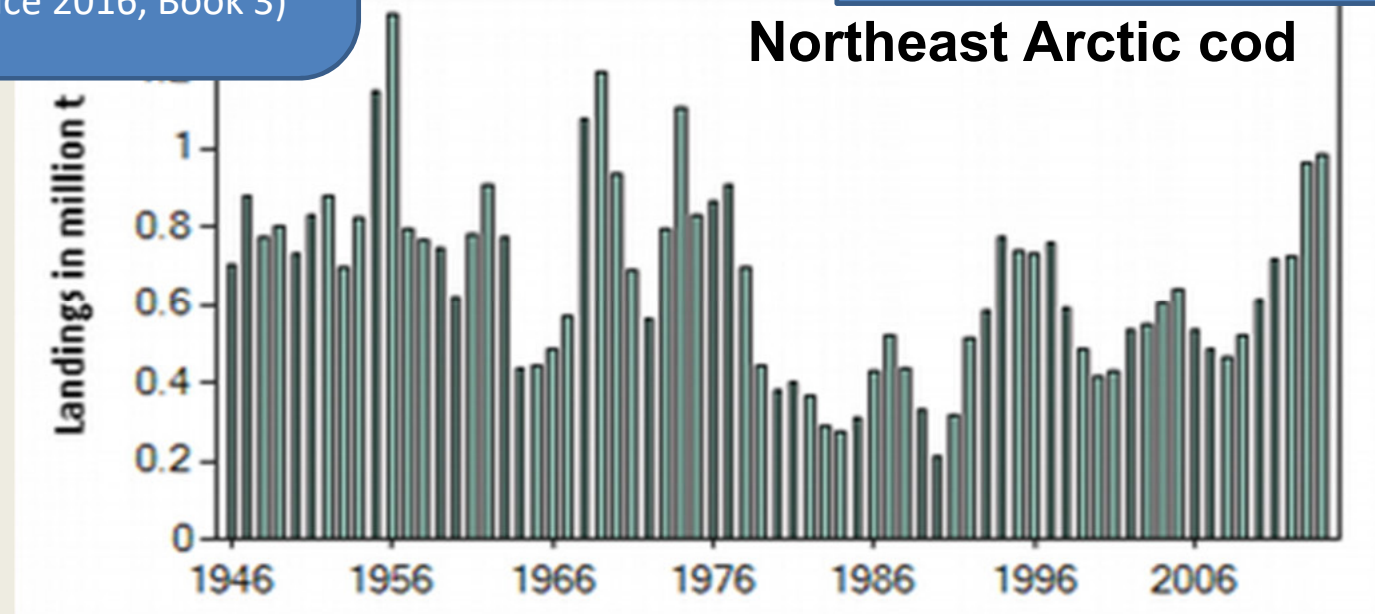
Quota system
Total stock biomass =
2-4 million tons since 2000

(ICES Advice 2016, Book 3)



Annual removal of ~25% total biomass of
cod from the Barents Sea

Northeast Arctic cod



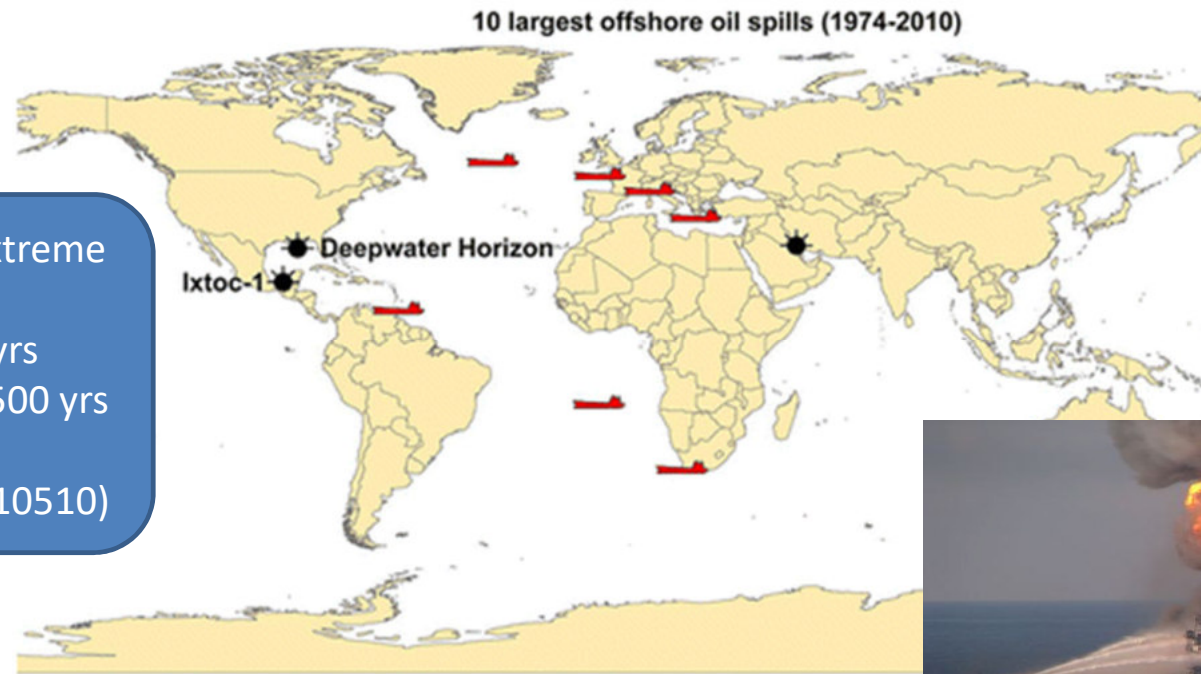
Rare events

Statistical analysis of extreme events (US OCS):

Return time = 165 yrs

Conf. interval = 41 to >500 yrs

(ES&T 2014:48, 10505-10510)



DWH = 4.9 MMbbl

Modelling is an essential decision-support tool

- ✓ Examine multiple what if scenarios
- ✓ Link impacts to outcomes
- ✓ Identify and quantify uncertainties
- ✓ Examine different response options



Models provide the required quantitative capacity to examine processes on relevant spatial and temporal scales and to conduct numerical experiments when real experimentation is infeasible.



Project lead:



Main partners & subcontractors:



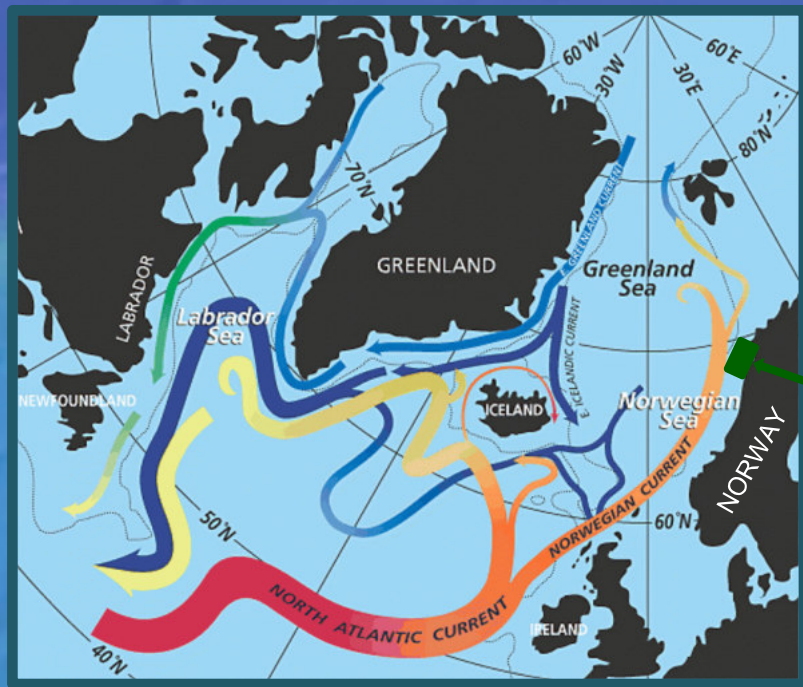
Partners & subcontractors:



Support provided by:



Modeling framework includes both petroleum and fisheries



Lofoten Islands

- Aid in decision-making
- Estimate resource injury

Created by linking state of the art models



Ocean dynamics

Oil transport and behavior

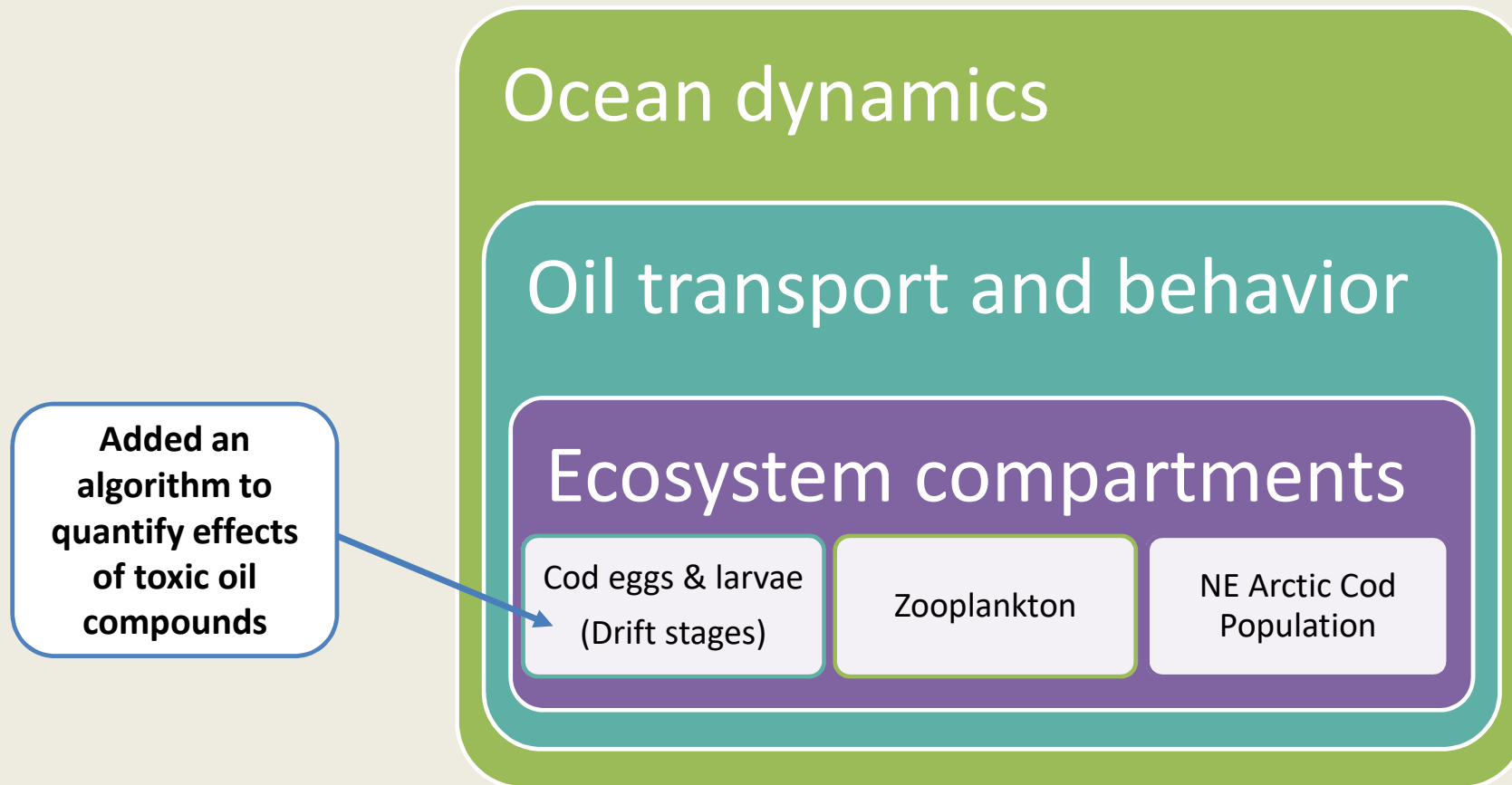
Ecosystem compartments

Cod eggs & larvae
(Drift stages)

Zooplankton

NE Arctic Cod
Population

With addition of a toxic effects subroutine



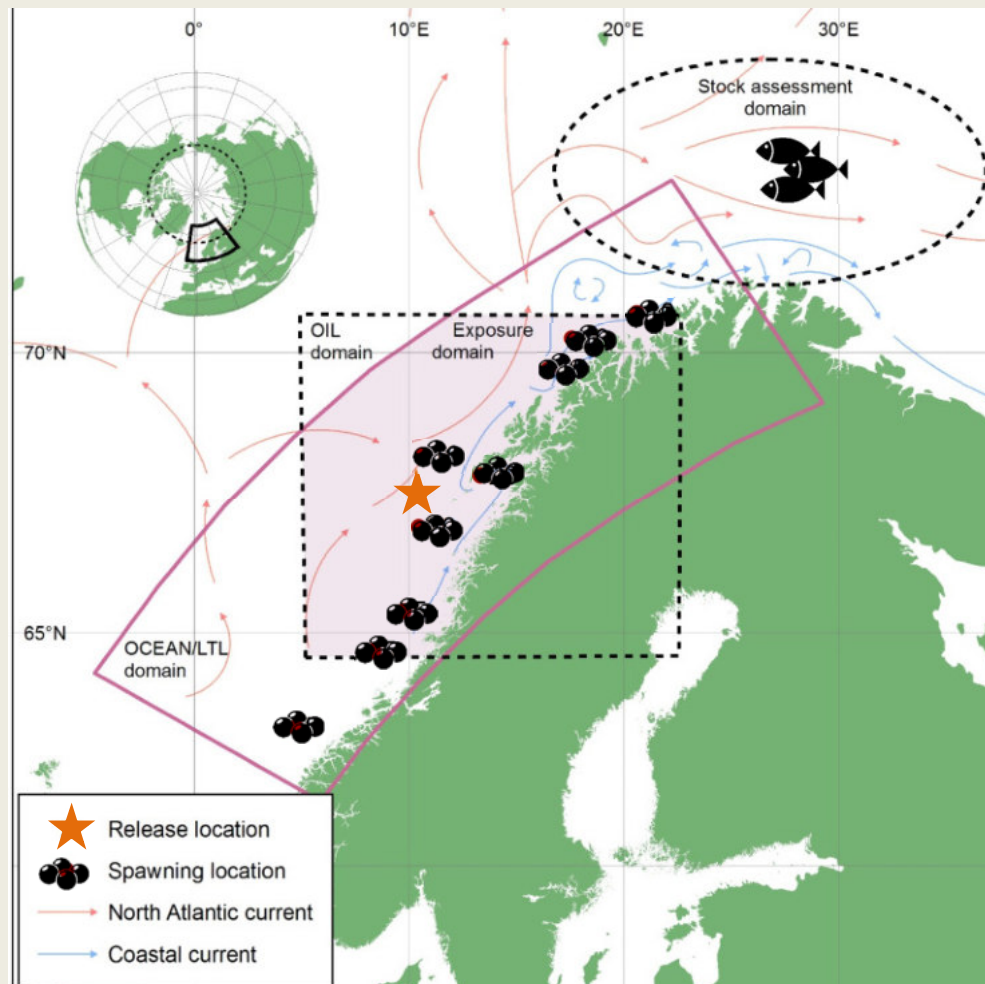


What is the potential loss of cod larvae from an oil spill near the nursery grounds off the Lofoten islands?

What is the potential impact on the population of Northeast Arctic cod?



Young cod
(eggs & larvae)
Drifting in the
nursery
grounds

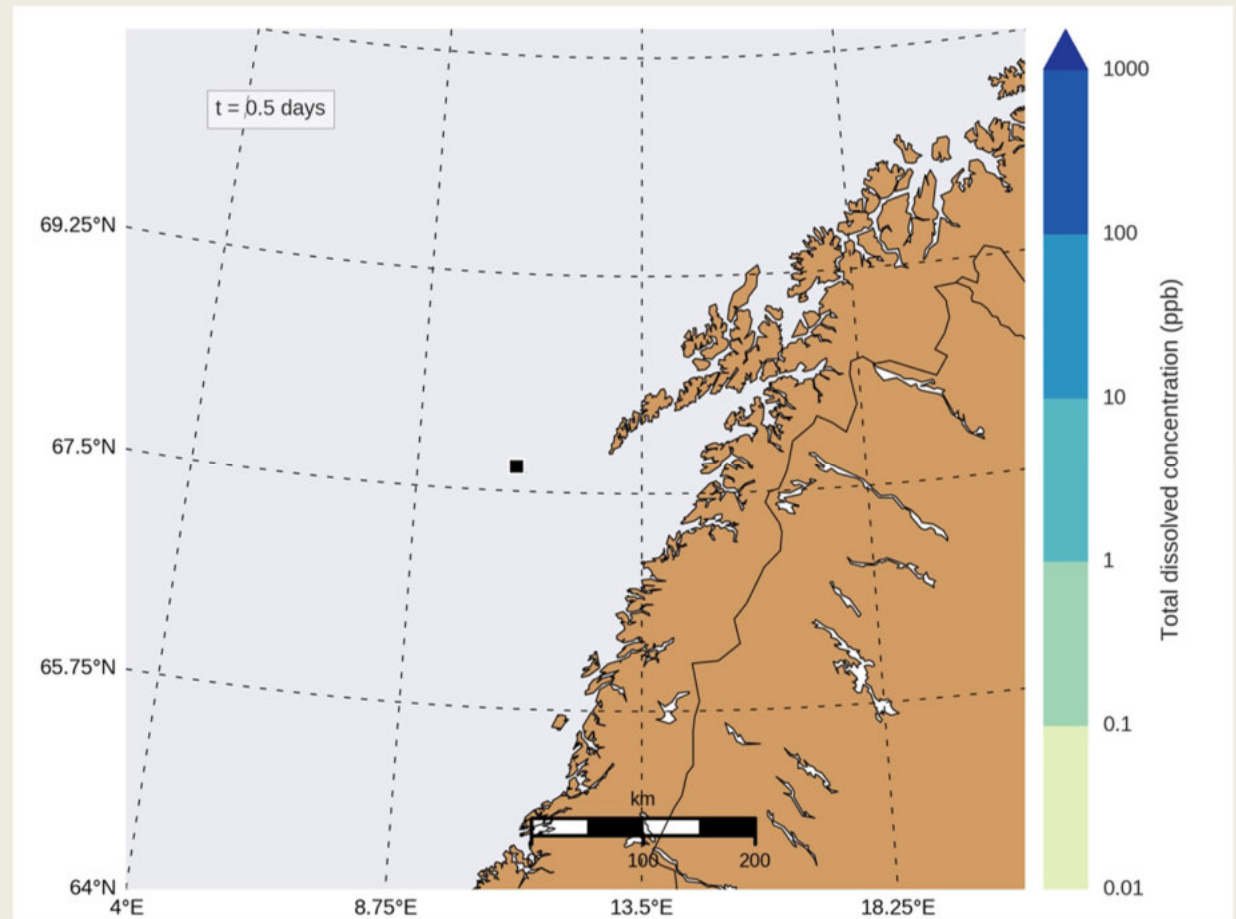


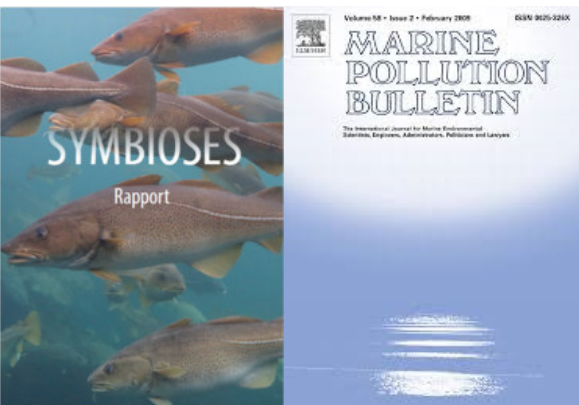
Population of
Northeast Arctic
cod in the
Barents Sea

Oil spill simulations

Oil types: Draugen and Balder
Release depth: Surface and seabed
Durations: 14, 45, 90 days
Rates: 1500 m³/d, 4500 m³/d
Years: 1995 (H), 2000 (A), 2001 (L)
Time of year: March and August

- Location: Nordland 6/2
- Discharge: Subsea @ 4500 m³/day
Duration: 90 days
- Start date: 19 March 1995
- Oil type: Balder
- Fishing: unchanged
- Grid resolution: 4 km

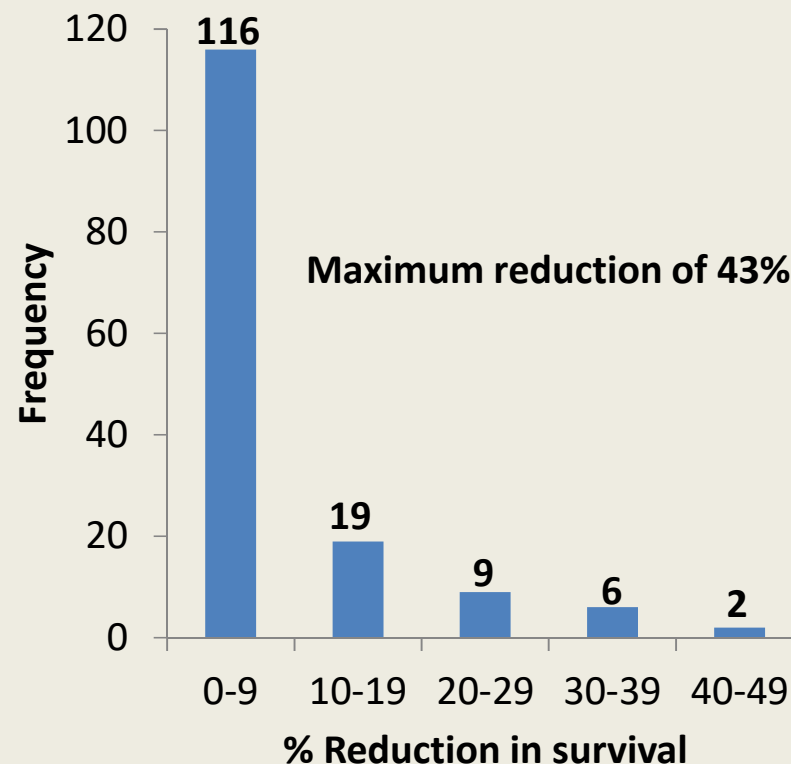


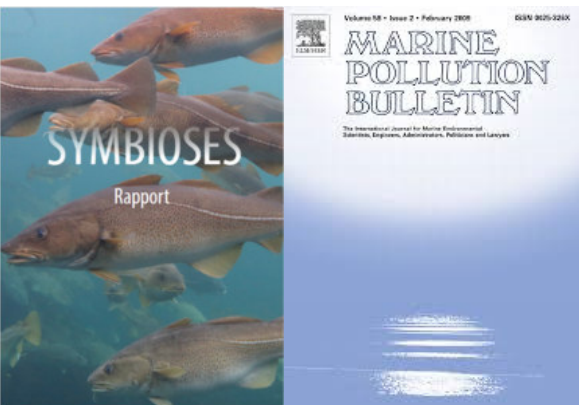


1. Drifting eggs & larvae

- **Minor reductions in survival for most scenarios**
- **Number of juveniles recruited to adult population remains sufficient in all scenarios**

Frequency histogram
Survival for drift stages

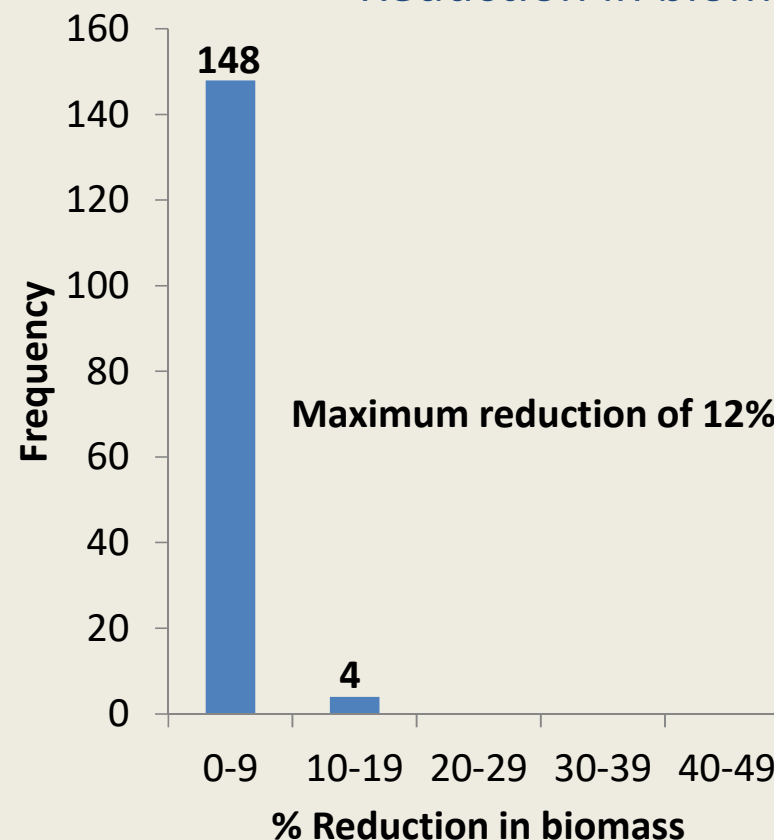




2. Cod population

- Small losses absorbed with little impact on stocks
- Reproductive health of the adult population is maintained

Frequency histogram
Reduction in biomass



SYMBIOSES combines expertise, models, and data into a simulation system for hypothesis testing



Cod



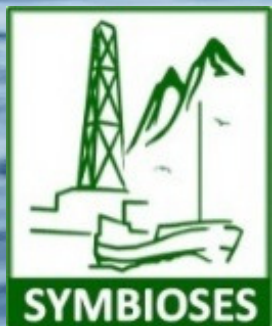
Herring



Haddock



Saithe



- New research proposal submitted to Norwegian Research Council (Sep. 2018)
 - Inclusion of additional fish species
 - Methodology to predict both lethal and sublethal effects of oil
 - Application of mitigation measures
 - New calibration methods