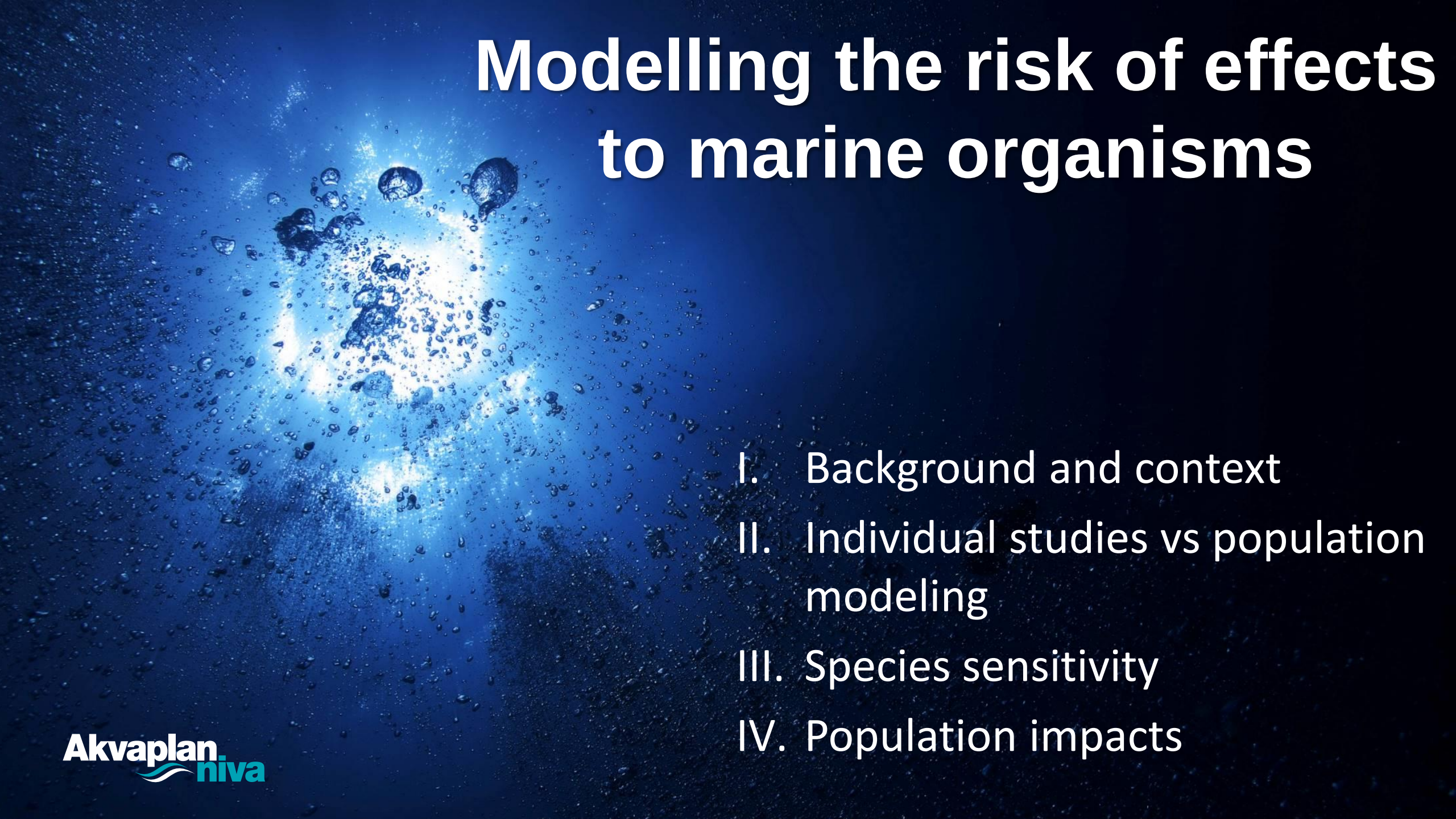
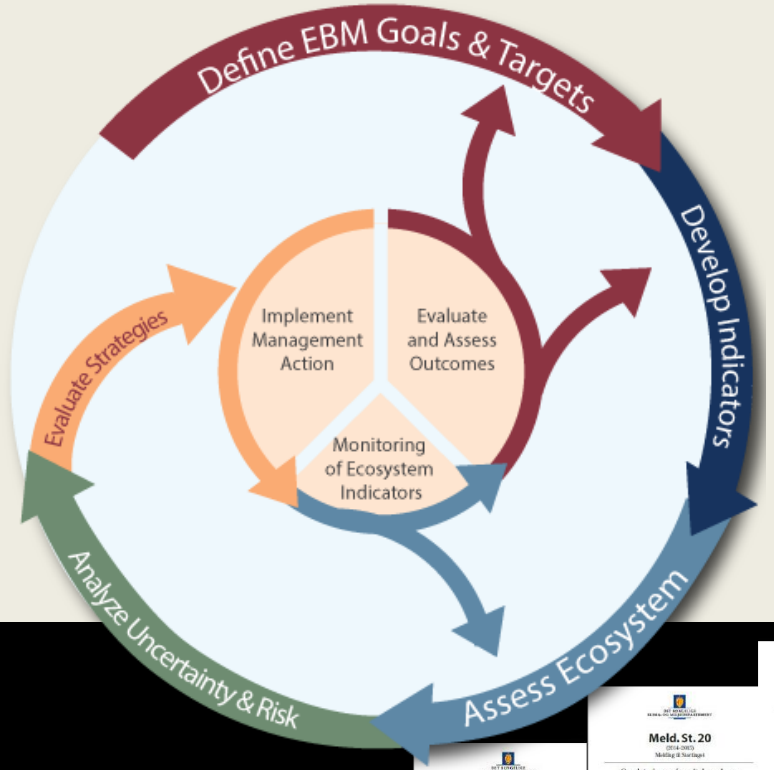
Modelling the risk of effects to marine organisms

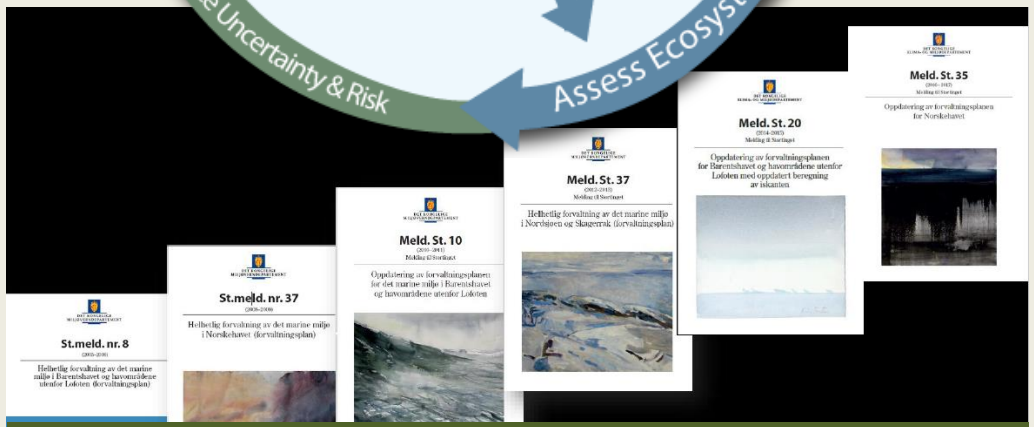


I. Background and context
II. Individual studies vs population modeling
III. Species sensitivity
IV. Population impacts

Akvaplan niva

I. Background and context





Protect ecosystem health
Provide ecosystem services

- Involvement of a wide range of professionals
- Synthesis of information across sectors
- Mechanisms and models for projecting change
- Peer review mechanisms to validate analyses

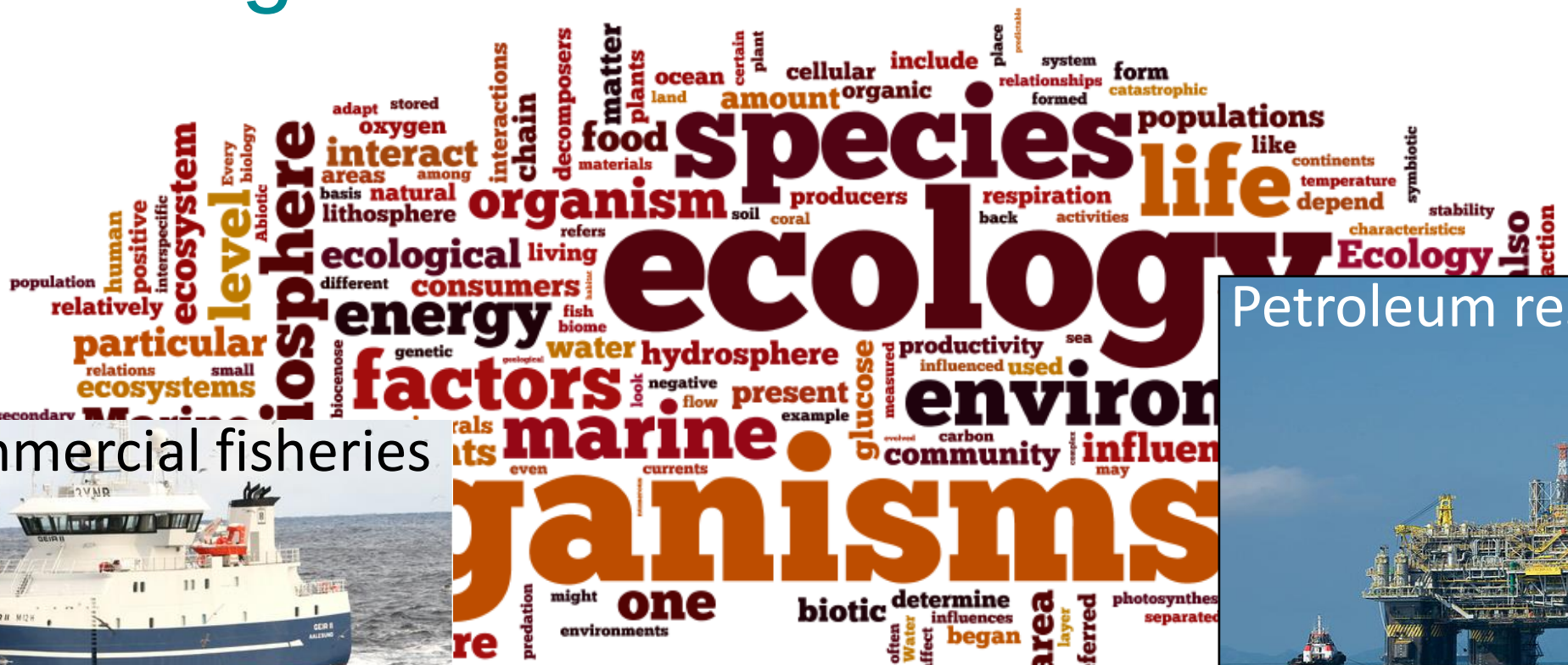
Rosenberg, A.A. and Sandifer, P. A., 2009

adaptive and flexible, responsive to monitoring and research results

Ecological interactions

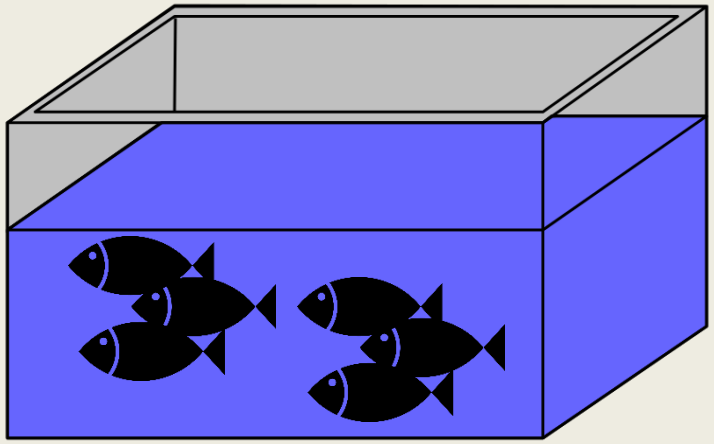
adaptive and flexible, responsive to monitoring and research results

Ecological interactions



II. Individual studies versus population modeling

Studies at the individual level determine species sensitivity to oil



Individual effects (exposure experiments)

Understand oil toxicity:

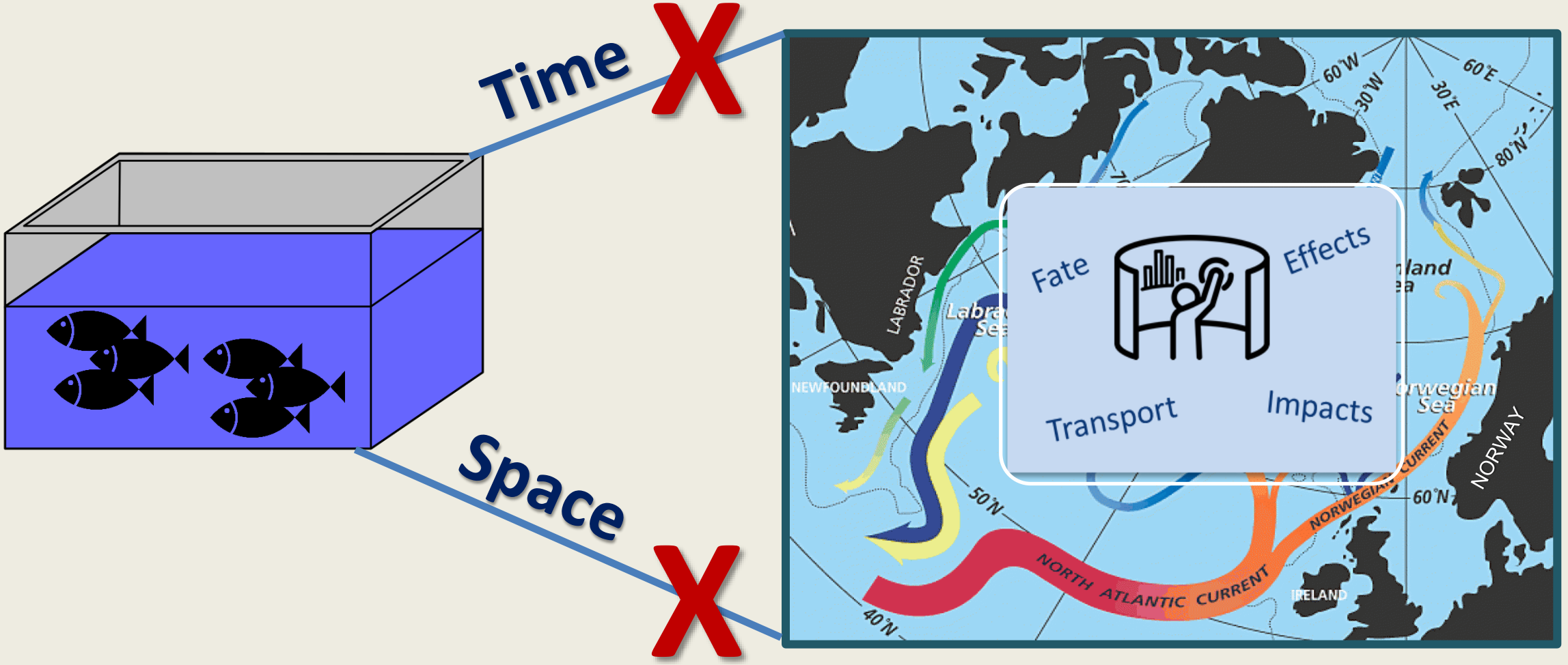
- Characterise sensitivities to oil
- Observe effects
- Identify dose–response relationships

Support for models:

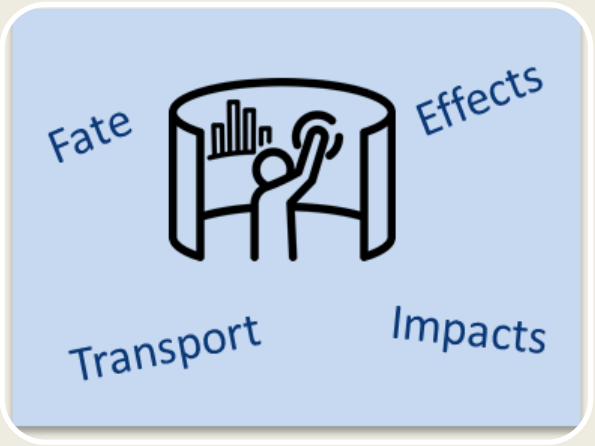
- Assign values of metrics used by risk assessment models (e.g. NEC, HC_5)
- Support development of algorithms for impact assessment modeling

Studies at the **individual** level determine species sensitivity to oil

Models assess **population** impacts over relevant scales of space and time



Models support decision – making



- Examine multiple what if scenarios
- Extrapolate from individual to population level impacts
- Link impacts to biological/ecological responses
- Identify key sources of uncertainty
- Quantify uncertainties
- Examine different response options

REVIEW

SCIENCE VOL 302 19 DECEMBER 2003

Long-Term Ecosystem Response to the Exxon Valdez Oil Spill

Charles H. Peterson,[1*] Stanley D. Rice,[2] Jeffrey W. Short,[2] Daniel Esler,[3]
James L. Bodkin,[4] Brenda E. Ballachey,[4] David B. Irons[5]

'the growing role played by risk assessment modeling in a priori environmental decision making and a posteriori estimation of natural resource injury needs reconsideration.

Much incentive exists for advancing the predictive capacity of ecology to allow more confident modeling of chronic, indirect, and delayed effects of stressors through ecosystem-based frameworks.

Take home #1

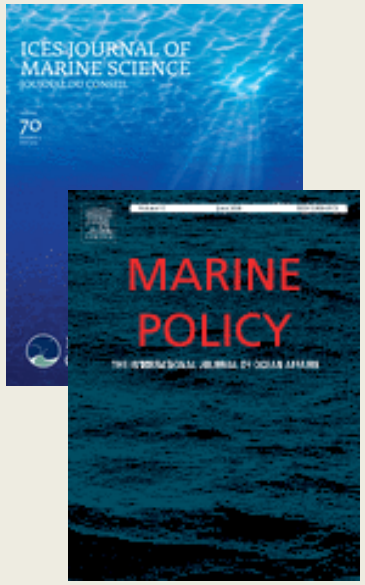
Individual effects versus population impacts

- Decision-making for EBM involves the integrated assessment of human activities and ecological processes
- Models aid decision-making for the assessment of natural and human related influences on the marine ecosystem
- Individual level studies provide key insight into the sensitivity of organisms exposed to oil

III. Species sensitivity
IV. Population impacts

Findings of data-driven research results published in peer-reviewed, reputable scientific journals

Peer-reviewed, data-driven research results

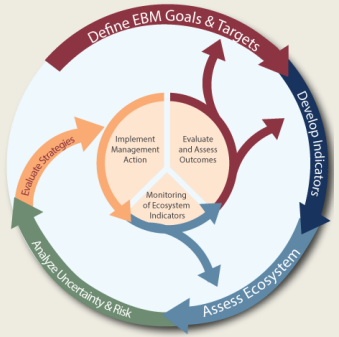


Expert opinion articles

Fake journals

III. Species sensitivity:

Studies at the individual level



Laboratory Exposure studies

Mesocosm Exposure studies

1. Toxic effects of oil
2. Threshold levels
3. Exposure dynamics

1. Toxic effects of oil

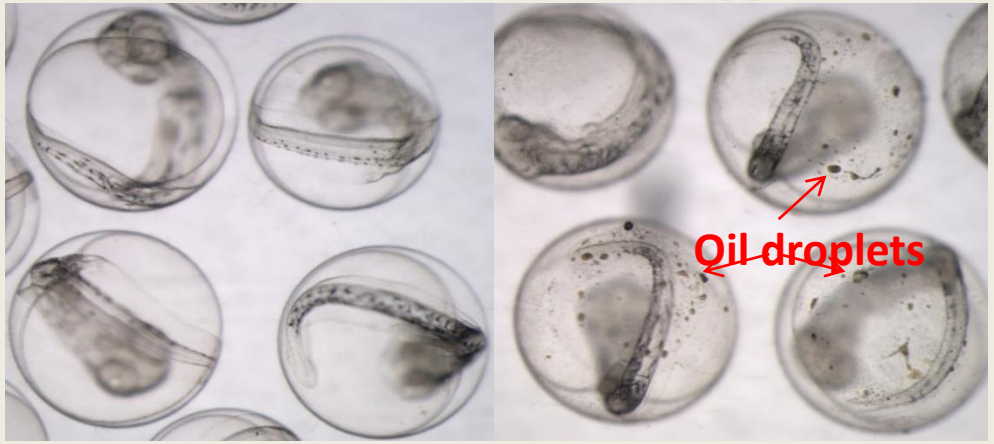
Laboratory
Exposure studies

Mesocosm
Exposure studies

- Sensitivity to compounds are organism- and life stage-specific
- Effects can be induced after concentrations exceed a certain concentration in an organism, or threshold level

1. Toxic effects of oil

Northeast Arctic cod eggs



Elin Sørhus, Institute of Marine Research


Juvenile lumpsucker


Mature polar cod

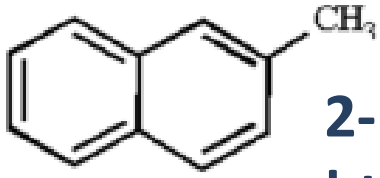
- Early life stages are more sensitive to oil exposure compared to later life stages
- No long-term effects documented on later life stages after acute and chronic exposure to oil

2. Threshold levels of effects

Risk assessment for Arctic areas usually relies on data from temperate areas

- Do Arctic and temperate species respond similarily to oil-related compounds?
- Can toxicity data generated for temperate species be used to assess sensitivity of Arctic species?

2. Threshold levels of effects

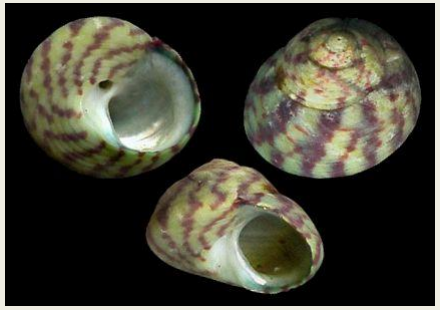


2-methyl naphthalene

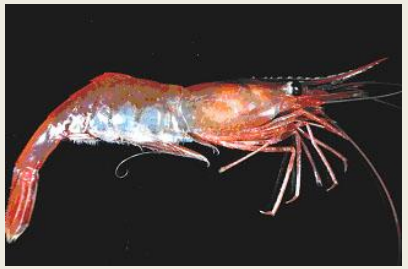


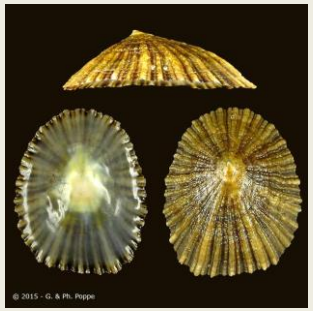






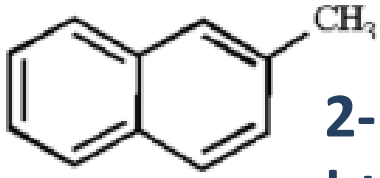


18 species from Arctic and non-Arctic regions

2. Threshold levels of effects



2-methyl naphthalene

- Range of threshold levels obtained for Arctic and non-Arctic species are comparable
- For regulatory purposes, non-Arctic toxicity data may be used to derive threshold levels for Arctic regions

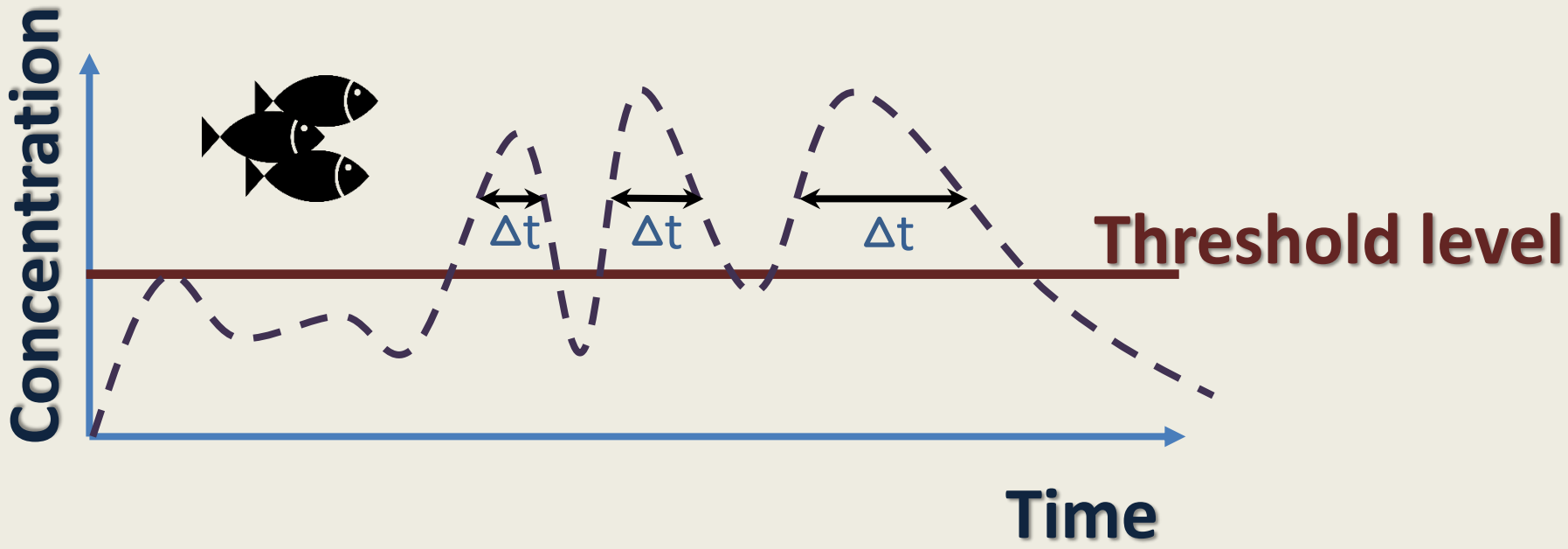
3. Exposure dynamics

CHEMICAL EXPOSURE →

- **Threshold** (of an effect) concentration
- **Intensity** (toxicity of the compound)
- **Speed** (time to an effect)

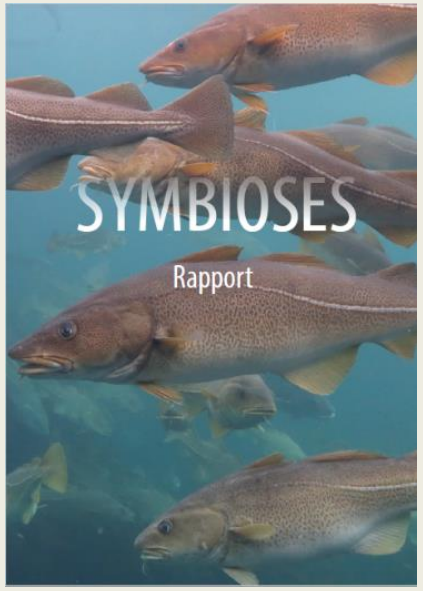
3. Exposure dynamics

An effect only occurs when an organism is exposed to chemical concentrations above a threshold level for a sufficient amount of time.



3. Exposure dynamics

SURVIVAL OF THE POPULATION



'time to an effect' → Reduced survival ✗

No 'time to an effect' (effect is instantaneous) → Reduced survival

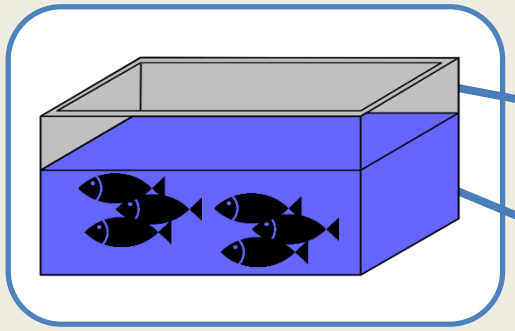
Take home #2

Species sensitivity

- Exposure dynamics (**threshold levels, intensity, speed**) control the occurrence of toxic effects in real world situations
- The similarity in threshold levels for Arctic and non-Arctic organisms supports that effects are the result of the same mode of action
- When data are unavailable for Arctic species, toxicity parameters for other species can be substituted.

IV. Modeling impacts on populations

Exposure dynamics included:
Data from individual effects studies are used to assign parameter values

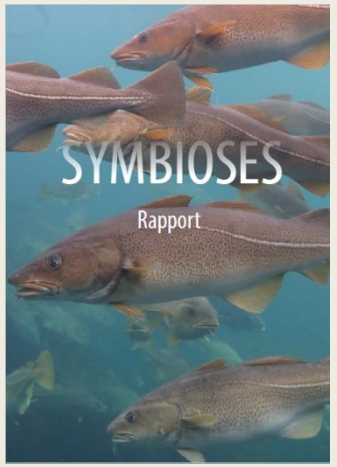


Ocean dynamics

Oil transport and behavior

Ecosystem compartments

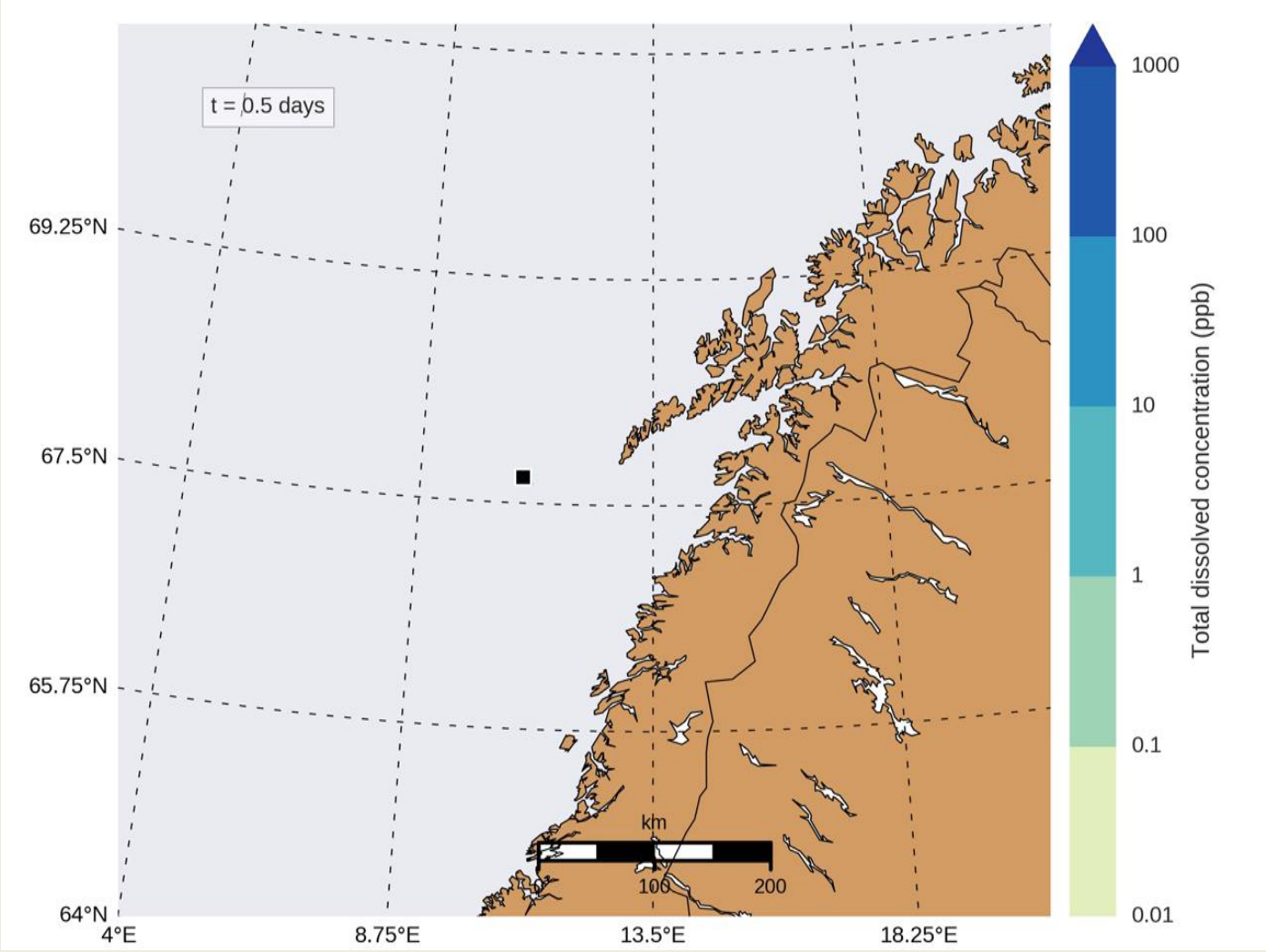
- Cod eggs & larvae (Drift stages)
- Zooplankton
- NE Arctic Cod (Mature)



Oil spill simulations

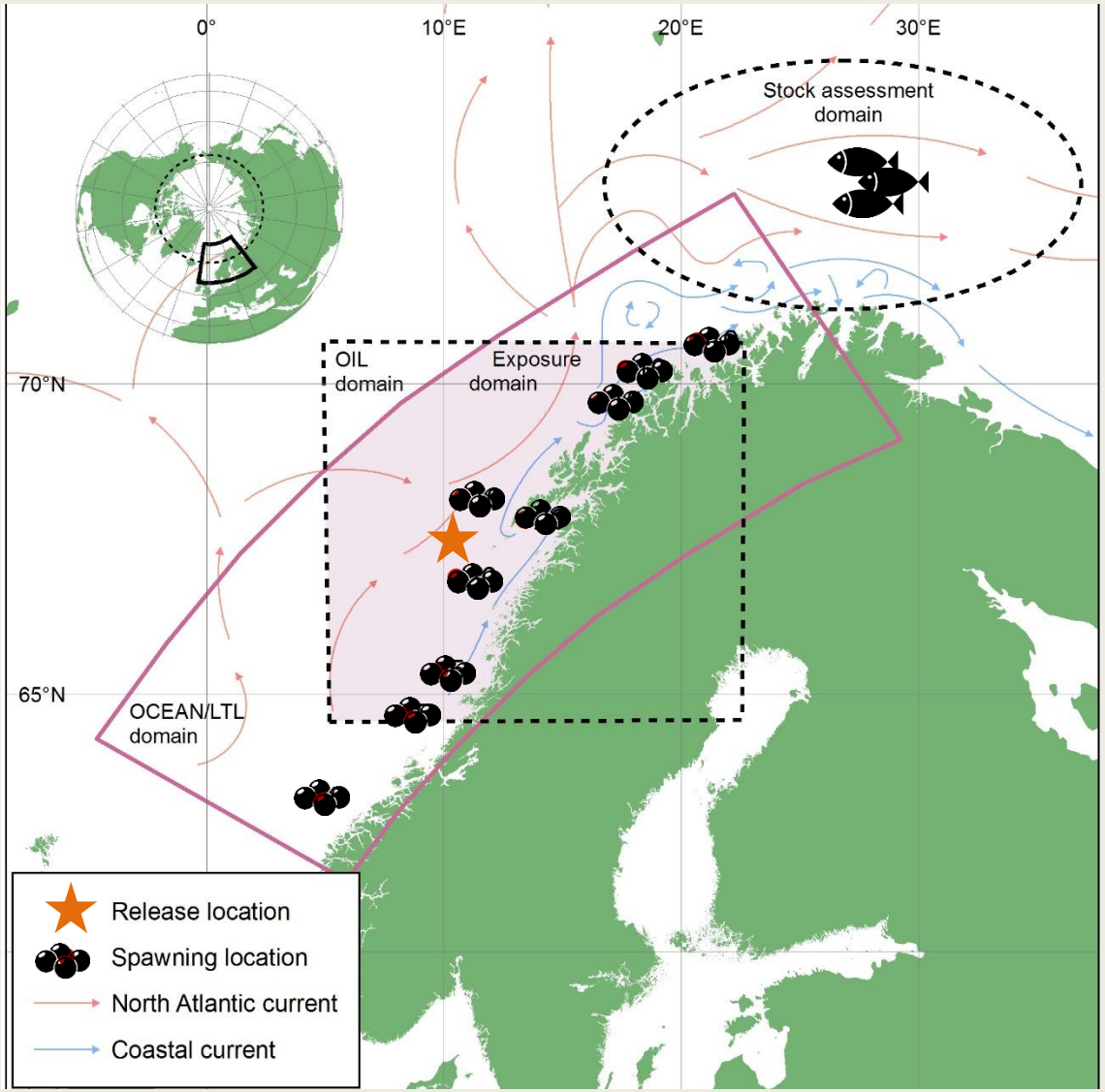
Durations: 14, 45, 90 days
Rates: 1500 m^3/d, 4500 m^3/d
Years: 1995 (H),2000,2001 (L)

- 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



Population of Northeast Arctic cod

Drifting cod (eggs & larvae) in the nursery grounds



Barents Sea Northeast Arctic cod population

1. Drifting eggs & larvae

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

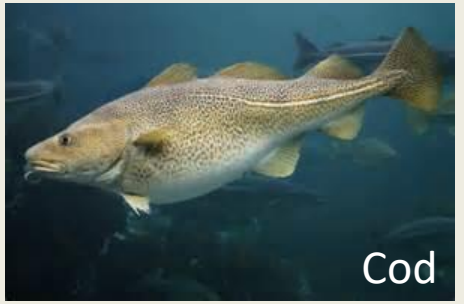
2. Adult population

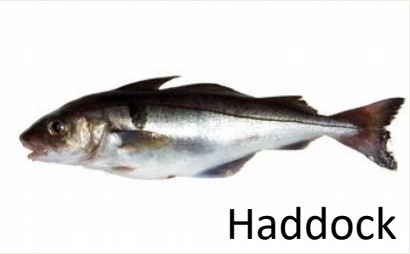
- **Small losses absorbed with little impact on stocks**
- **Reproductive health of the adult population was maintained**

The diverse age distribution of the population protects against losses

Extending the impact of SYMBIOSES (2017-2018)

- ✓ Utilise SYMBIOSES in support of planning
- ✓ Research dissemination through publications
- ✓ NFR proposal to be submitted (Fall 2018)



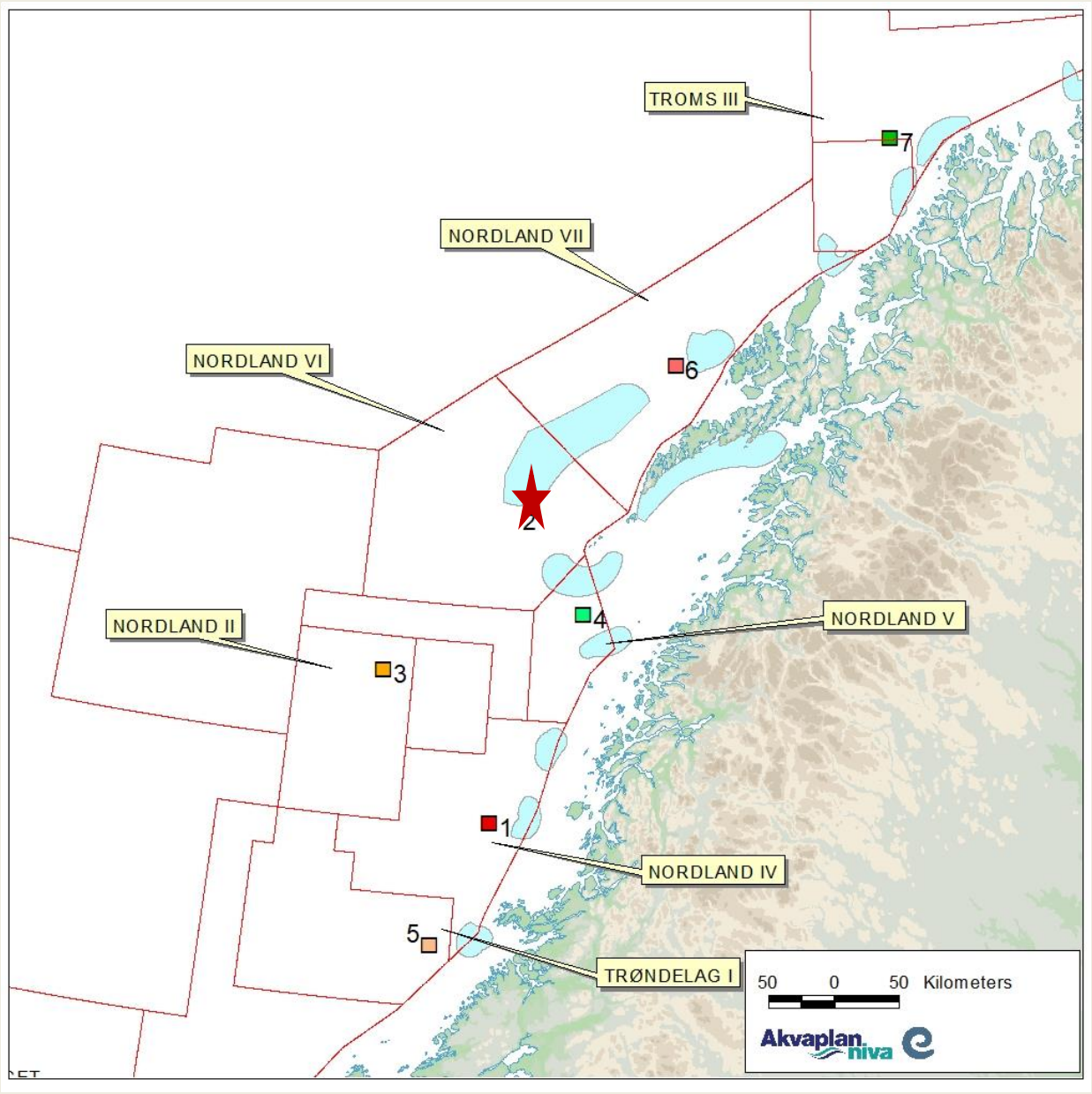


ConocoPhillips Statoil

Akvaplan niva INSTITUTE OF MARINE RESEARCH HAVFORSKNINGSINSTITUTTET SINTEF UNIVERSITETET I TROMSØ

New simulations

- New locations
- Rates based on recent NPD applications
- Durations based on recent NPD applications



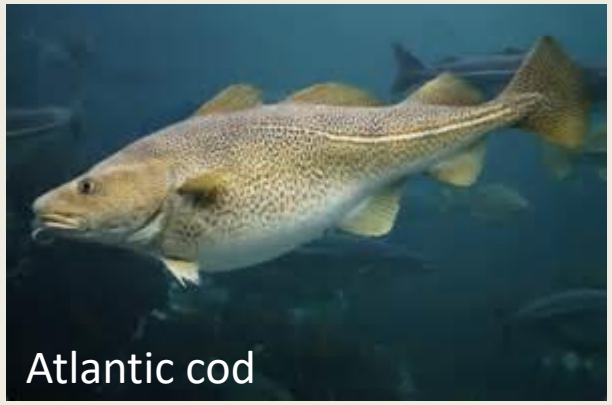
New NFR proposal to focus on other fish species

Short lived versus long lived

Semelparity (spawns once) versus iteroparity (several spawning cycles)

Aggregated versus broadcast spawning

Pelagic versus demersal eggs


Atlantic cod

- Long life span
- Iteroparous
- Several spawning year classes
- Pelagic eggs


Capelin

- Short life span
- Semelparous
- One spawning year class
- Demersal eggs


Polar cod

- Relative short life span
- Iteroparous
- More than one spawning year class
- Pelagic eggs

Take home #3

Modeling impacts on populations

- SYMBIOSES demonstrates how advanced modeling supports impact assessments of major oil spill events
- A select number of new simulations are being performed
- Future development focuses on population assessments for other fish species

V. CONCLUSIONS

Fra forskning til verdiskapning

Akvaplan niva

Forskningsinstitutt, hovedkontor, laboratorier og forskningsinfrastruktur i Tromsø

122 ansatte (46 PhD), 20 nasjonaliteter

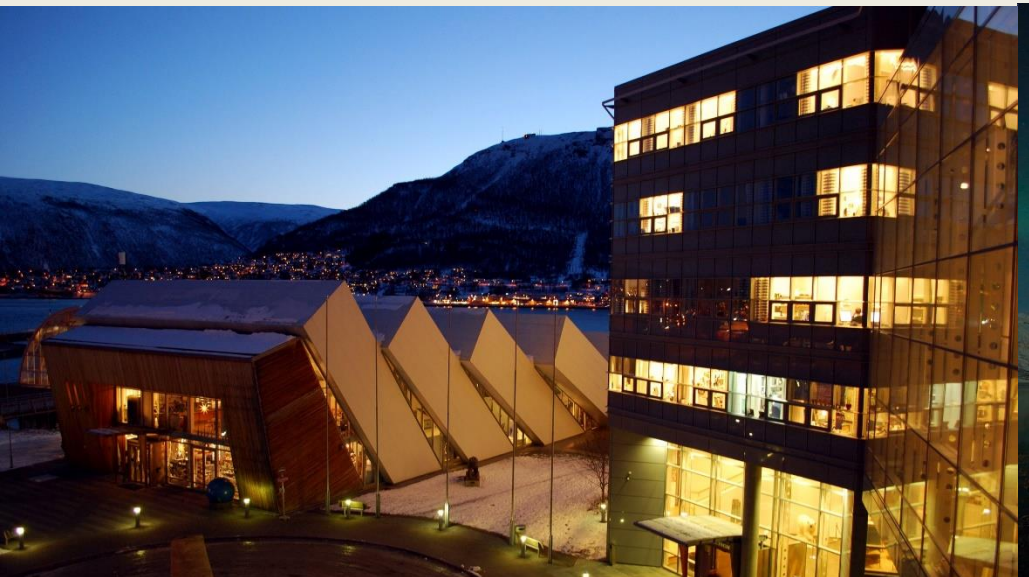
8 prof II og 20 stipendiater/Post Doc

Datterselskap i Russland

Kontorer i Oslo, Bergen, Alta, Trondheim, Bodø, Kirkenes,Svalbard, Frankrike og på Island

Sekretariatet for Arctic Frontiers

Omsetning 2016: NOK 164 mill



Bygge bro mellom forskning og rådgivning

Akvakultur

Klima og økosystem

Biodiversitet

Økotoksikologi

Miljø og petroleum

Oseanografi og & Modellering

Miljøovervåkning

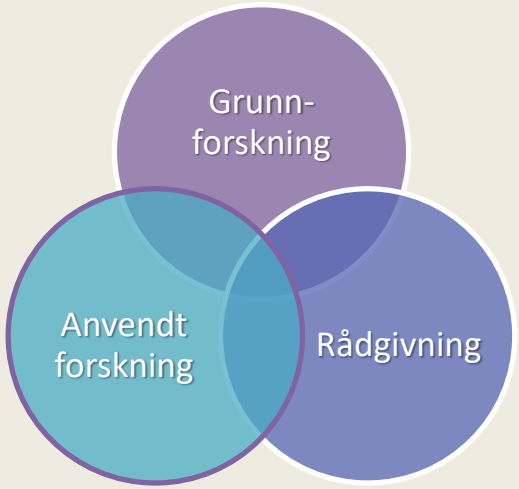
Miljørisikovurdering

Beredskap

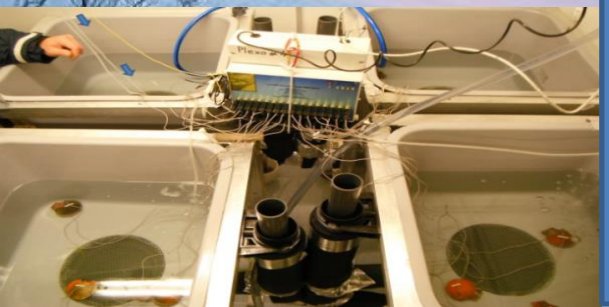
Tjenester for beslutningstakere

Akvakultur design og administrasjon

Akkrediterte tekniske tjenester



Kraknes forskningsstasjon



Våre ressurser

- Akkreditert kjemilaboratorium
- Akkreditert benthoslaboratorium
- Forskningslaboratorium
  - Godkjent forsøksdyravdeling (+30 marine arter)
  - Egen økotoks-enhet
- ROV overvåkingsteknologi

Oppdrag

- Miljøundersøkelser kystnære områder
- Miljøundersøkelser offshore
- Forskningsprosjekter

Miljørisiko og beredskap

- Sentralt arbeidsfelt - utviklingsprosjekter for modeller og verktøy basert på implementering av forskning
  - Prosjektledelsen av ERA Acute fase 1-4 og EIF akutt
  - Tilpasning og utvikling av ERA Acute-modellen til iskant og iskantressurser
  - MIRA for marginal iskantsone
  - NOFO planverk
  - MOB sjø – miljøprioritetsmodell
- Implementering av modeller i
  - Miljørisikoanalyser, beredskapsanalyser og beredskapsplanlegging,
  - Net Environmental Benefit Assessments (NEBA) og Spill Impact Mitigation Assessments (SIMA)

SENSE
Sensitive Environments Decision Support

Akvaplan niva