Modelling the risk of effects to marine organisms

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

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

adaptive and flexible, responsive to monitoring and research results

Ecological interactions
adaptive and flexible, responsive to monitoring and research results

Ecological interactions

Petroleum resources

Commercial fisheries

Routine

Rare
II. Individual studies versus population modeling
Studies at the individual level determine species sensitivity to oil

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<sub>5</sub>)
- 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
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

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

- 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

- 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 similarly to oil-related compounds?

- Can toxicity data generated for temperate species be used to assess sensitivity of Arctic species?
2. Threshold levels of effects

18 species from Arctic and non-Arctic regions
2. Threshold levels of effects

- 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

Ocean dynamics

Oil transport and behavior

Ecosystem compartments

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

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

- Location: Nordland 6/2
- Discharge: Subsea @ 4500 m$^3$/day
- Duration: 90 days
- Start date: 19 March 1995
- Oil type: Balder
- Fishing: unchanged
- Grid resolution: 4 km

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