Marine indicators for environmental impact assessment in the Arctic

Decrease in sea ice coverage

Graph: National Snow and Ice Data Center

Photo: Scientific Visualization Studio, NASA Goddard Space Flight Center
Increase in Arctic developments

- Harbour development and shipping
- Offshore oil & gas exploration
- Tourism
- Fishery
Challenge

- Potential pressures of new activities on ecosystems

  *Example*: oil spills, emission of chemicals, air pollution

- How to develop new activities in the Arctic ...
  
  ...in reconciliation with people and planet?
Environmental Impact Assessment

Impact Assessment:
→ Assess pressures of one or more activities on ecosystems components

Indicators:
→ Tools to measure one or more pressures of one or more activities on ecosystems components

See poster: **Lagerveld et al** - Integral framework for assessing impacts on Arctic marine productivity

Karman & Jongbloed, 2008
What are indicators...

- **simple measures** that tell us what is happening in the environment
- used to communicate the state of the environment to the general public and decision makers
- **diagnostic tool** through detecting trends in the environment (related to a certain pressure)
- applied in monitoring and assess results of mitigation measures
Types of biological indicators

- Contaminant concentrations in water, sediment, species (e.g. bivalves, bird eggs, marine mammal tissue)
- Effects in species (e.g. biomarkers)
- Community indices (e.g. BEQI)
- ...

Activity: Shipping

Pressure: Emission of TBT through antifouling paints

Effect: Tissue concentration or effects of TBT in molluscs

Monitoring: Imposex rates in molluscs (OSPAR QSR2010)
## Examples of biological indicators

<table>
<thead>
<tr>
<th>Activity</th>
<th>Pressure</th>
<th>Ecosystem component</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shipping</td>
<td>TBT emissions</td>
<td>Invertebrates, especially bivalves and gastropods</td>
<td>-Imposex in gastropods (OSPAR) -[TBT] in bivalves and gastropods</td>
</tr>
<tr>
<td>Shipping</td>
<td>Introduction of non indigenous species</td>
<td>Species interactions</td>
<td>DNA profiling</td>
</tr>
<tr>
<td>Oil &amp; gas extraction</td>
<td>PAH emissions</td>
<td>Invertebrates</td>
<td>Chemical and toxicological profiling</td>
</tr>
<tr>
<td>Fishery</td>
<td>Extraction</td>
<td>Fishes</td>
<td>Large fish indicator (OSPAR)</td>
</tr>
</tbody>
</table>
Pilot indicator development Svalbard 2012

Goals:
- Benthic biota - sampling methodology
- Sediment – chemical analysis
- Benthic biota – chemical analysis
- Van Veen grab and small dredge
Pilot indicator development Svalbard 2012

- June 2012
- 2 days Teisen work boat
- Kongsfjorden, Ny-Ålesund
- Impacted and reference sites:
  1. Ny-Ålesund harbour
  2. Coal harbour Ny-Ålesund
  3. Reference site
Pilot - Benthic biota - sampling

Shell fish:
- *Astarte borealis*
- *Macoma* spp.
- *Serripes groenlandicus*
- *Hiatella arctica*

Marine worms:
- *Nephtys* spp.
- *Pectinaria* spp.
Pilot - Sediment screening by GCxGC-MS

Ny-Ålesund harbour: full scan

Ny-Ålesund harbour: PAHs/Alkylated-PAHs

Reference site: full scan

Reference site: PAHs/Alkylated-PAHs
## Pilot - TBT in sediment

<table>
<thead>
<tr>
<th>Sample location</th>
<th>Sum Butyltin</th>
<th>Sum Phenyltin</th>
</tr>
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<tbody>
<tr>
<td>Harbour Ny-Ålesund</td>
<td>2 of 3 samples</td>
<td>&lt; dl</td>
</tr>
<tr>
<td></td>
<td>Range &lt;4.2-12 ng Sn/g dw</td>
<td></td>
</tr>
<tr>
<td>Coal Harbour</td>
<td>1 of 3 samples</td>
<td>&lt; dl</td>
</tr>
<tr>
<td></td>
<td>Range &lt;3.6-14 ng Sn/g dw</td>
<td></td>
</tr>
<tr>
<td>Reference</td>
<td>&lt; dl</td>
<td>&lt; dl</td>
</tr>
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</table>

**Butyltin Degradation Index (BDI) (Diez et al., 2002):**

$$BDI = \frac{[MBT] + [DBT]}{[TBT]}$$

**BDI harbour N-A (Butyltin > dl):**

> 1 (1.2 – 5.6)

→ Degradation processes
## Pilot - TBT in biota

### Future analysis:
- Profiles of PAHs en alkylated PAHs in sediment and biota

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*Astarte borealis*
Indicator development – future work

- PhD project ARCIND
  (Development of ARCTic biological INDicators for the impact assessment of (new) human activities (2013-2016)(oil & gas)

- Project IPOP Arctic
  (mining, shipping, harbour development)(2012-2015)

Ariadna Szczybelski
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Kings Bay AS: Vidar Nilsen
Questions?