assessing the impact of effluents from offshore activities by their biological effects – local and regional scales

Ketil Hylland (NIVA, Norway)
Steinar Sanni (RF-Akvamiljø, Norway)
Jarle Klungsøyr (IMR, Norway)
the issue

- major inputs of chemicals from offshore activities
  - drilling
  - production
- impacts virtually the entire North Sea to some extent
- ecological impacts not really established
- laboratory data suggest effects, but at levels higher than those generally found

- how can we assess the risk of produced water effluents?
risk assessment

- inputs from many sources need to be considered
  - adjacent production areas
  - drilling in relation to production
  - chemicals change over time

- risk assessment by way of models (DREAM)
  - exposure (3-D model using real-time data)
  - effect (PNECs derived from laboratory tests)

- assessment of biological effects in the field - validation of model or contributions to risk assessment?
effects in the water column

- complementary approaches
  - *in situ* extracts can be tested for mechanisms of toxicity
  - caging provides direct link to local exposure
  - field sampling provides ecological relevance

- which effect methods?
  - identifiable threshold or dose-response level(s)
  - methods should be used in combination
  - quality assurance of methods is essential

- which species/systems?
  - there are no "universal" species, even in a limited area such as the North Sea
  - unresolved problems for the use of fish (migration, exposure)
  - have to be able to separate zooplankton species during sampling
<table>
<thead>
<tr>
<th>approach</th>
<th>pro's</th>
<th>con's</th>
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<tbody>
<tr>
<td>field sampling</td>
<td>ecological relevance</td>
<td>difficult to assess area integrated (but large); high natural variability (needs large sample numbers)</td>
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<td>caging</td>
<td>reflects local exposure (history); can use organisms with desirable properties (e.g. blue mussel and fish)</td>
<td>&quot;semi-natural&quot; exposure situation; food availability unknown; limited to selected species (relevance in relation to local species); exposure at one point (does not integrate over larger area)</td>
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<tr>
<td><em>in situ</em> extracts/bioassays (can be extended to TIE*)</td>
<td>identify specific mechanisms and substances; sensitive and reproducible; possible to test systems not otherwise included (e.g. early lifes stages in fish)</td>
<td>not possible to extrapolate directly to ecological impact</td>
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activities

- WCM 1999-2000
  - caging (passive samplers, blue mussels)
- DREAM development
- BECPELAG
  - field-collection
  - caging
  - extracts
  - modelling
- WCM 2003
  - caging (cod, blue mussels)
  - few locations
- regional monitoring 2002-2003
  - field-collection
    - haddock, saithe, cod, pelagic species
    - a range of endpoints
activities

- WCM 1999-2000
  - caging (passive samplers, blue mussels)
- DREAM development
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  - field-collection, caging, extracts, modelling
  - many methods
- WCM 2003
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  - histopathology and biomarkers
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indications that there may be effects - BECPELAG

- gradient for PAH exposure away from platforms – predominantly 2-/3-ring
- clear responses in caged blue mussels
- histopathological changes in both caged and field-collected fish; no obvious effects for biomarkers
- more responses in caged organisms (cod, blue mussel) than in field-collected organisms
- limited responses in bioassays of SPMD extracts
the follow-up: WCM 2003

- Troll field
- caged blue mussels, cod
- blue mussels
  - PAH
  - histopathology
  - BaPH
  - lysosomal stability (on board)
- cod
  - PAH-metabolites
  - histopathology
  - vtg
  - EROD
  - GST
regional studies: what is this?

- different fish species sampled in three areas:
  - Tampen (high input)
  - Sleipner (low input)
  - Egersund banken (reference)
- haddock, saithe, cod, herring, ++
- endpoints included
  - alkylphenols and PAHs in muscle and liver
  - PAH metabolites in bile
  - a range of biomarkers including phase-I, phase-II enzymes, antioxidant enzymes and DNA adducts
  - lipid composition of muscle
- results indicated
  - differences between areas with regard to:
    - some PAH metabolites
    - phase-I enzymes, antioxidant responses
    - lipid composition
    - DNA adducts
risk assessment?

- Risk assessment models predict effects near platforms, but not in larger areas.
- Have we detected all ecologically relevant impacts?
- Which options are available?
  - Revise model with new data
  - Combined modelling and field measurements
  - Rely more heavily on field measurements (needs larger resources)
summary and the future

- risk assessment models are probably not sufficiently predictive of environmental impacts from produced water inputs
- it is difficult to separate impacts from specific activities (drilling, production) or effluents from different production areas

- a link should be established between the risk assessment models and field data ("validation")
- a large-scale "inventory" of possible effects in the North Sea from offshore activities is needed (research on ecologically relevant endpoints)
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