Impact of sea dumped munitions on Baltic Sea environmental services

Towards cost-benefit analyses

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Lech Kotwicki

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State of art

The Baltic Sea is a severely disturbed marine ecosystem that has previously been used as a dumping ground for Chemical Warfare Agents (CWA).

The presence of unexploded underwater ordnance is an additional risk factor for offshore activities and an environmental risk for the natural resources of the sea.
Ecosystem services

- functions and processes through which ecosystems, and the species that they support, sustain and fulfil human life.

- are sometimes divided into goods, referring to items given monetary value, and services, which are valued but rarely bought and sold.
Baltic Sea region

- Total area: 415 000 km²
- Average depth: 52 m
- Deepest: 459 m (Landsort)
- PSU: 1-20
- Average PSU: 7
- Moderate Climate
- Limited water exchange
- Low biodiversity

- Site specific case studies
Ecosystem services

9 countries

- ~85 million people in the Baltic Sea drainage
- 15 mio within 10 km
- 29 mio within 50 km

Direct End Users
Non Direct End Users
### Types of service

**Categories according to SEPA 2008**

#### Supporting
- Biogeochemical cycling (O₂; C; N; P)
- Water circulation and exchange
- Primary production
- Food web dynamics
  - Diversity
  - Habitat
  - Resilience

#### Cultural
- Recreation
- Scenery
- Science & education
- Cultural heritage
- Inspiration
- Legacy of the sea

#### Provisioning
- Food
- Inedible resources
- Genetic resources
- Chemical resources
- Ornamental resources
- Energy
- Space and waterways

#### Regulating
- Climate & atmospheric regulation
- Sediment retention
- Mitigation of eutrophication
- Regulation of hazardous substances
Healthy environment
Sustainability

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NO COST
TO SUSTAIN STATUS QUO

ADDED VALUE
Baltic Sea ecosystem
Already affected: eutrophication
Annual costs of degradation

<table>
<thead>
<tr>
<th>Country</th>
<th>EUTROPHICATION</th>
<th>RECREATION</th>
<th>VEGETATION AND FISH STOCK</th>
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<tr>
<td>ESTONIA</td>
<td>21 - 31</td>
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<tr>
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<td>834 - 1 155</td>
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<td>5 - 8</td>
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<td>LITHUANIA</td>
<td>19 - 22</td>
<td>14 - 22</td>
<td>9 - 14</td>
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<td>POLAND</td>
<td>368 - 383</td>
<td>151 - 232</td>
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<td>SWEDEN</td>
<td>440 - 674</td>
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<td>RUSSIA</td>
<td>1 028 - 1 129</td>
<td>30 - 736</td>
<td>636 - 999</td>
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<tr>
<td>TOTAL (million €)</td>
<td>3 760 - 4 380</td>
<td>1 024 – 2 155</td>
<td>1 822 – 2 663</td>
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</table>

The cost assessment is based on valuation study of citizens’ willingness to pay (WTP) for achieving a good eutrophication status in the Baltic Sea.

The cost of degradation estimates for recreation are based on a *preference travel-cost* study with the data from surveys performed in all nine coastal countries in 2010 (Czajkowski et al. 2015).
Same results suggest that the value of coastal and marine recreation in the Baltic Sea could **increase by 1 - 2 billion Euro annually** if the environmental conditions improved. The results suggest that citizens’ welfare would **increase 1.8 – 2.6 billion euros annually**, if the state of the perennial vegetation and fish stocks improved.
Socio-economic indicators related to different socio-economic indicators (based on HELCOM 2017) (data for 2014)

<table>
<thead>
<tr>
<th>Types of service categories according to SEPA 2008</th>
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Cthulu vs Unicorns
DAIMON findings
CWA / Explosives toxicity
Detection of Chemical Warfare Agent-Related Phenylarsenic Compounds in Marine Biota Samples by LC-HESI/MS/MS
Hanna Niemikoski, Martin Söderström, and Paula Vanninen
VERIFIN, Finish Institute for Verification of The Chemical Weapons Convention, Department of Chemistry, University of Helsinki, P.O. Box 55, FI-00014 Helsinki, Finland.

Supporting Information

ABSTRACT: A new method has been developed to determine oxidation products of three chemical warfare agent (CWA) related phenylarsenic compounds from marine biota samples by a liquid chromatography-tandem mass spectrometry (LC-HESI/MS/MS). The target chemicals were oxidation products of Arsenite (As(III)), monoxide (As(V)), and tetrathionate (TNTO4) in mixture of marine samples collected from near Swedish coast, Malékär danishwar, and the elemental composition of oxidized form of Clark oxidized chemo.

Sea-dumped chemical warfare agent

Bioaccumulation of 2,4,6-trinitrotoluene (TNT) and its metabolites leaking from corroded munition in transplanted blue mussels (M. edulis)
Daniel Appel, Jennifer S. Strehe, Hans-Jörg Martin, Edmund Maser
Institute of Toxicology and Pharmacology for Natural Sciences, University Medical School Schloßwitz-Holzau, Brander Str. 10, 24105 Kiel, Germany.

ABSTRACT: Bioaccumulation of 2,4,6-trinitrotoluene (TNT) and its main metabolites 2-amino-4,6-dinitrotoluene (2-ADNT) and 4-amino-2,6-dinitrotoluene (4-ADNT) leaking from corroded munitions at a munitions dumping site (Kielberger Heide, Germany) was evaluated in transplanted blue mussels (Mytilus edulis). Six mussels with mussel bags were placed out and went at varying positions near the mine mound. In order to monitor any differences resulting from changing seasons, these exposures were chosen. First exposure period: April-July 2016 (136 days); second exposure period: July-December 2016 (186 days); third exposure period: December 2016-March 2017 (92 days). We found amounts of 2-ADNT in mussel tissue ranging from 2.40 ± 2.13 to 7.76 ± 1.97 mg/g mussel wet weight. Neither TNT nor 2-ADNT could be detected. Considering seasonal differences, orientation and distances of the mussels to the mine mound no correlation between levels in mussel tissue was evident.
### Types of service Categories according to SEPA 2008

- **Bornholm:** 40%
- **Kolberger Heide:** 7%

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**daimon**

Decision Aid for Marine Munitions
NO ACTION

COST:

Lost control of a problem, discontinuation of research, increasing the costs of remediation in the future, increasing environmental losses that already exist, increasing risk of loosing the monetary value of goods and services

- ca. 20 billion Euro/year

BENEFIT:

Saving funds at the very moment, avoiding negative impacts of “wrong action”
MONITORING

COST:

"no action"

BENEFIT:

Establishing scientific network, constant implementation and evolution of methods and in-situ exploration.

Alerting system formation, potentially raising public awareness, that is filling knowledge gaps and improves threats categorization and risk assessment. Possibly lowering costs of remediation in the future.
LIMITATION OF ACTIONS

COST:

BENEFIT:

Establishing administrative network, implementation of policies, controlling offices. Diminishing potential of accidents occurrence, raising public awareness that involves direct end-users.
NEUTRALIZATION AT SEA
DETONATION IN SITU
RECOVERY AND DESTRUCTION

COST:
Create new problem if performed incorrectly. Can have their specific negative impacts on ecosystem

BENEFIT:
Proper clean up and removal of a threat
CONCLUSIONS

• Baltic Sea provides multiple goods and services that need to be secured

• Sea dumped warfare poses a specific threat to each other, and any forms of action would have to be site specific

• Potential environmental costs of different management can be predicted

• Potential monetary value and benefits depend on the “market demand”, which is directly related to public awareness.