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Strategic and operational risk management for wintertime maritime transportation system "STORMWINDS"

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Aalto University, Finland

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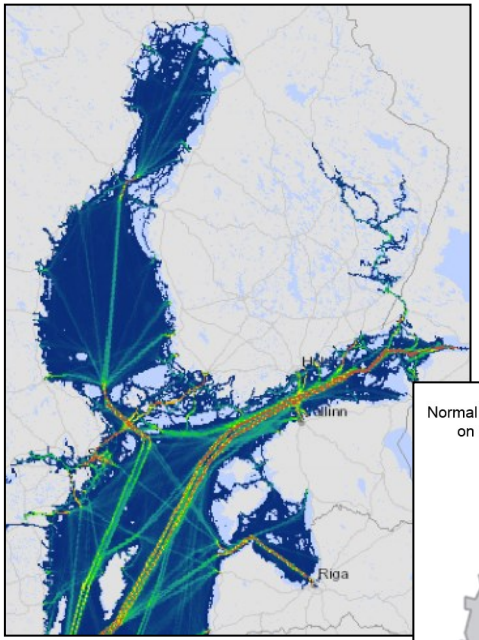
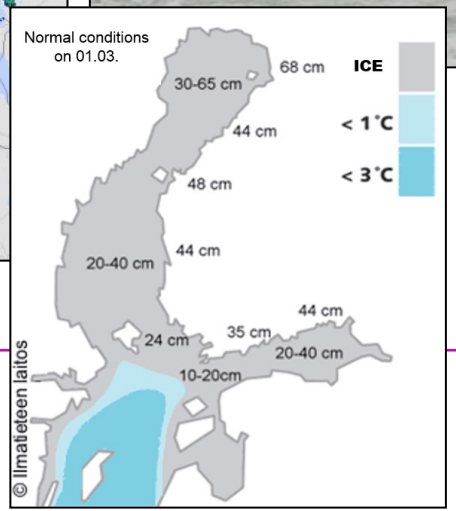
National Geospatial Research Institute, Finland
Gdynia Maritime University, Poland

17th Meeting of the International Steering Committee for the Policy Area on Maritime Safety and Security of the EU Strategy for the Baltic Sea Region (EUSBSR)
Gdynia, Poland, 09.11.2017

Background and STORMWINDS focus

Intensive shipping traffic in the ecologically sensitive Northern Baltic Sea





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BONUS
SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

Wintertime maritime transportation risks in the Northern Baltic Sea – oil spills

Wintertime operations

Oil spill in ice

The BONUS STORMWINDS contribution to implementing EU maritime policy

EUSBSR
EU STRATEGY FOR THE BALTIC SEA REGION

- Reducing environmental impact of shipping: accidental discharge of oil
- Reinforcing preparedness and response capacity

Policy	Operational
Risk analysis, preparedness and response for oil spills in ice	Decision support tools for oil spill combating in ice

Policy support for strategic risk management

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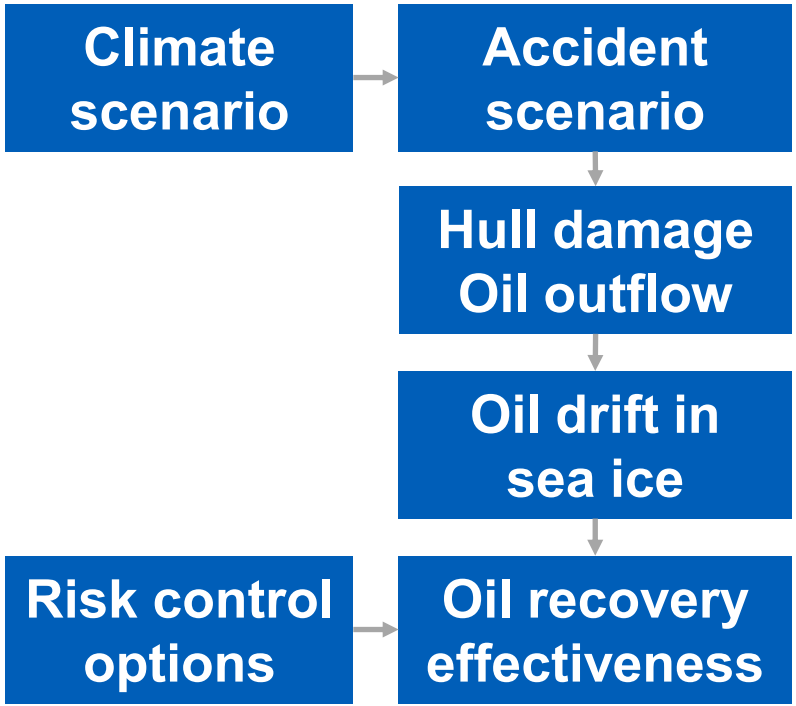
Policy support: strategic risk management

Policy questions		BONUS STORMWINDS Approach
Q1	Oil spill risk	Industry recommendations
Q2	Response effectiveness	Stakeholder participation
Q3	Improvements	Scientific research

Bayesian Network model for scenario-based oil spill risk management



Q1	What is the risk of accidental accidental oil outflow from shipping accidents in the NBS?
Q2	How effective is the response effectiveness to oil spills in wintertime?
Q3	What can be done to improve it?
Q4	How does climate change affect the need for strategic response with ice capability?

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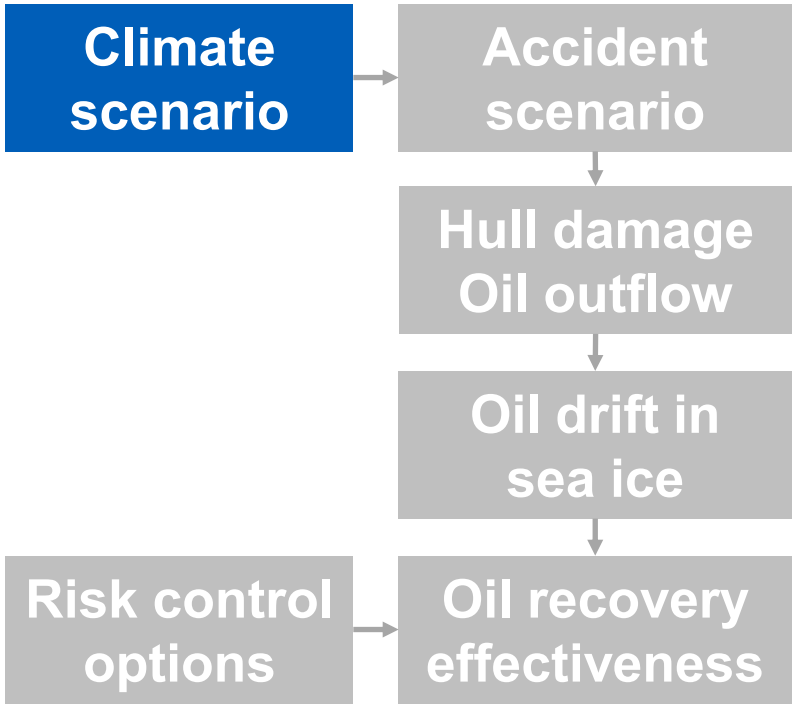
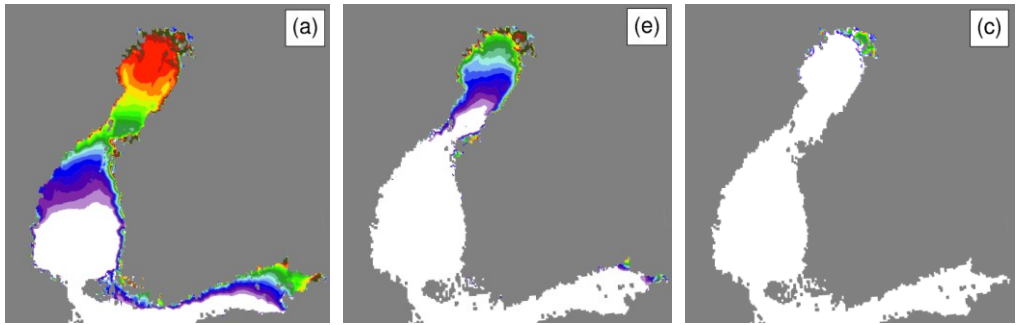
Goerlandt F., Lu L., Valdez Banda O.A., Rytkönen J. 2017.
An approach for an integrated assessment of maritime accidental oil spill risk and response effectiveness for the Northern Baltic Sea
Proceedings of IMAM2017 Conference, Lisbon, Portugal.

Bayesian Network model for scenario-based oil spill risk management



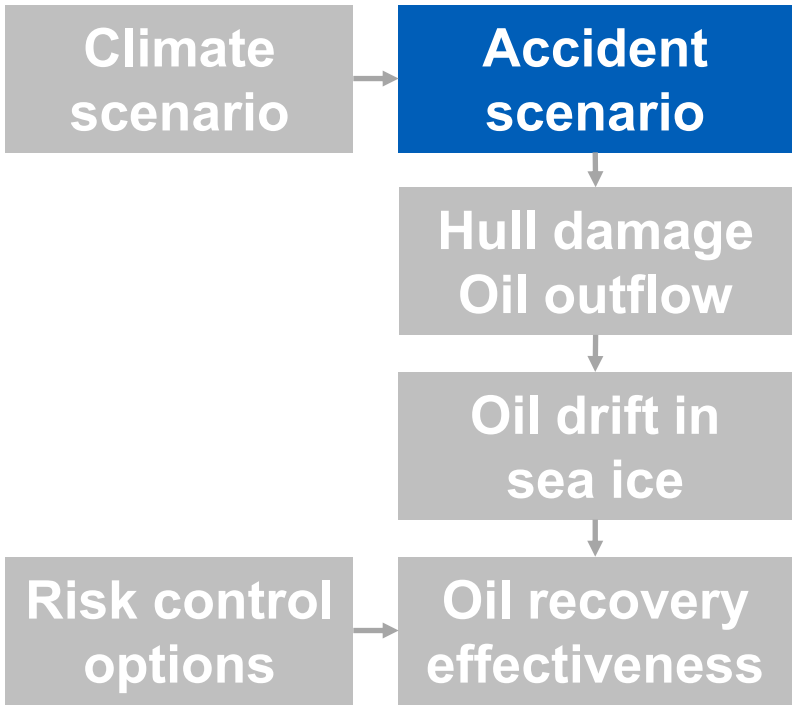
Mean ice thickness in March-April

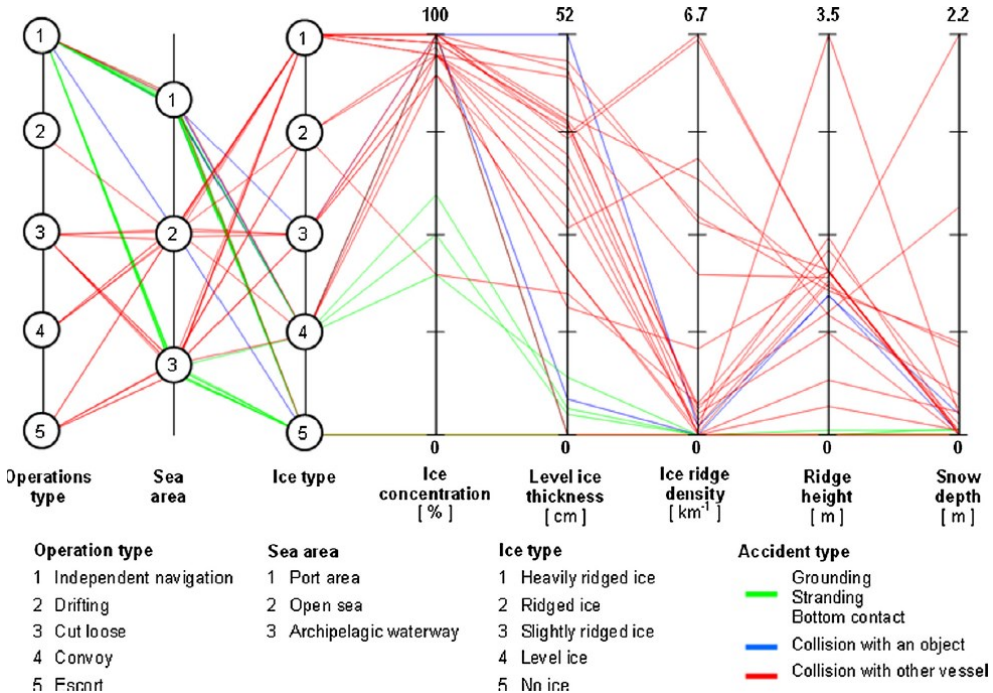


1970-1999	2070-2099 RCP4.5 (ca. +2°C)	2070-2099 RCP8.5 (ca. +4°C)

Höglund A., Pemberton P., Hordoir R., Schimanke S. 2017.
Ice conditions for maritime traffic in the Baltic Sea in future climate.
Boreal Environment Research 22:245-265.

Bayesian Network model for scenario-based oil spill risk management





Goerlandt F, Habtamnesh G, Valdez Banda OA, Höglund A, Ahonen-Rainio P, Lensu M. 2017. An analysis of wintertime navigational accidents in the Northern Baltic Sea. *Safety Science 92:66-84*

Bayesian Network model for scenario-based oil spill risk management

Climate scenario → Accident scenario

↓

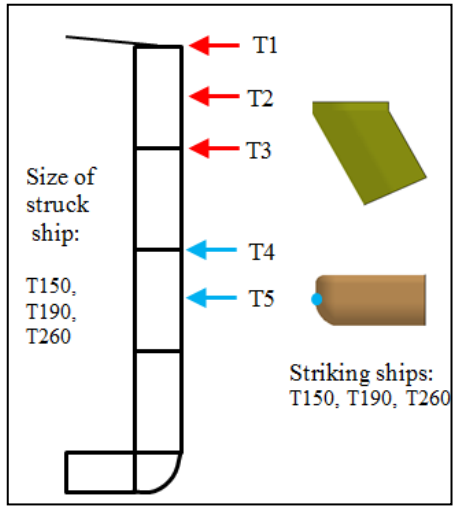
Hull damage Oil outflow

↓

Oil drift in sea ice

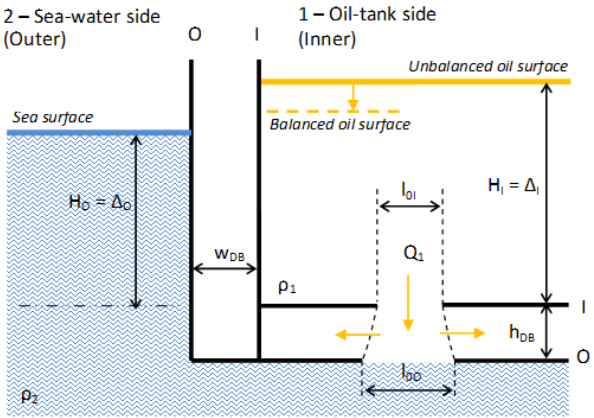
↓

Risk control options → Oil recovery effectiveness



Accidental hull damage in ice

Oil outflow in ice



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Heinvee M. 2016. The Rapid Prediction of Grounding Behavior of Double Bottom Tankers. Doctoral dissertation. Tallinn University of Technology.
Kollo M, Laanearu J, Tabri K. 2017. Hydraulic modellling of oil spill through submerged orifices in damaged ship hulls. *Ocean Engineering 130:385-397*.

Bayesian Network model for scenario-based oil spill risk management

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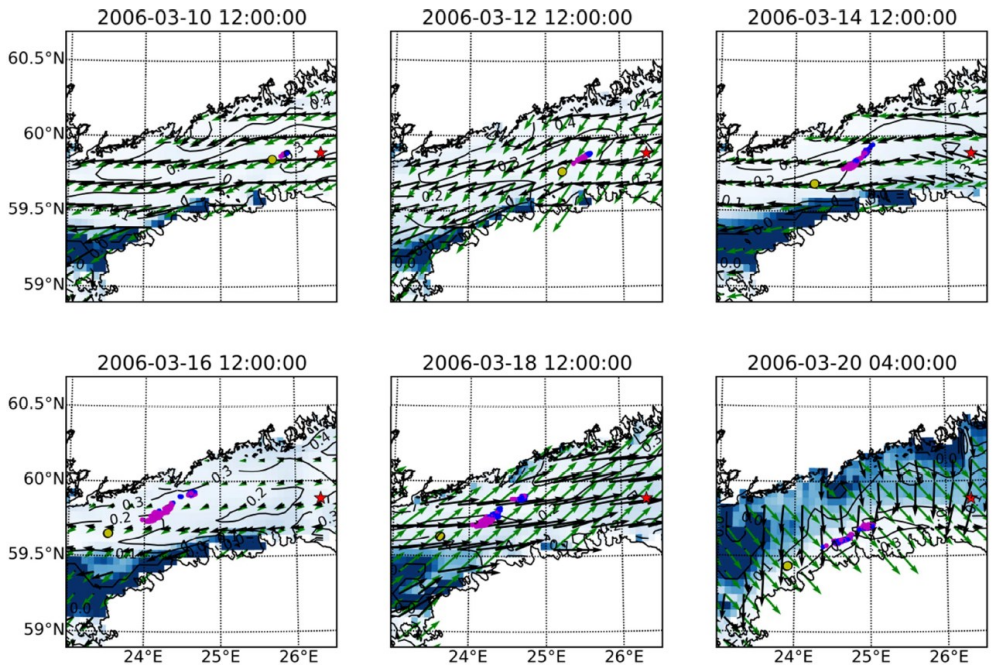

Arneborg L, Höglund A, Axell L, Lensu M, Liungman O, Mattsson J. 2017
Oil drift modeling in pack ice – sensitivity to oil-in-ice parameters.
Ocean Engineering, accepted.

Bayesian Network model for scenario-based oil spill risk management

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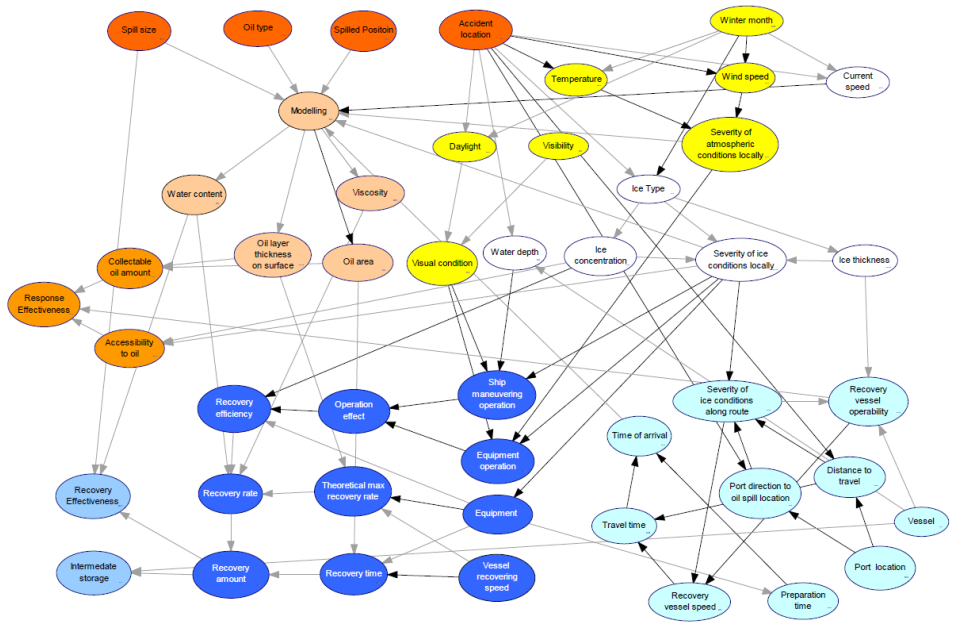

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Lu L., Goerlandt F., Valdez Banda O.A. 2017.
A Bayesian Network model for mechanical oil spill recovery effectiveness in ice conditions. *In preparation*.

Operational decision support tools

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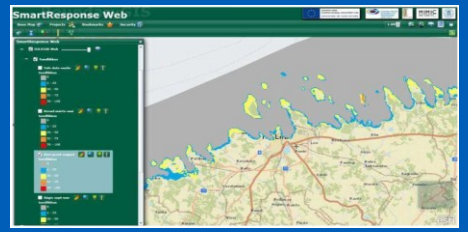
Key issues in managing risk in operational oil spill response

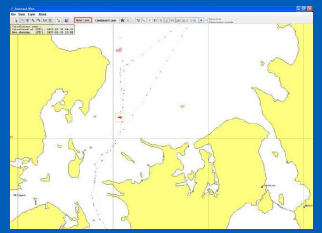
- How much oil is expected to flow out from the damaged ship?
- In what time frame does the oil flow out?
- How will the oil drift at sea?
- Which coastal and sea areas to give priority for protection against oil pollution?

Operational support: decision support tools

Existing tools



SmartResponse Web



SeaTrack Web

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Scientific research

- Oil dispersion in ice
- Sea ice dynamics models and tests
- Oil ouflow models
- …

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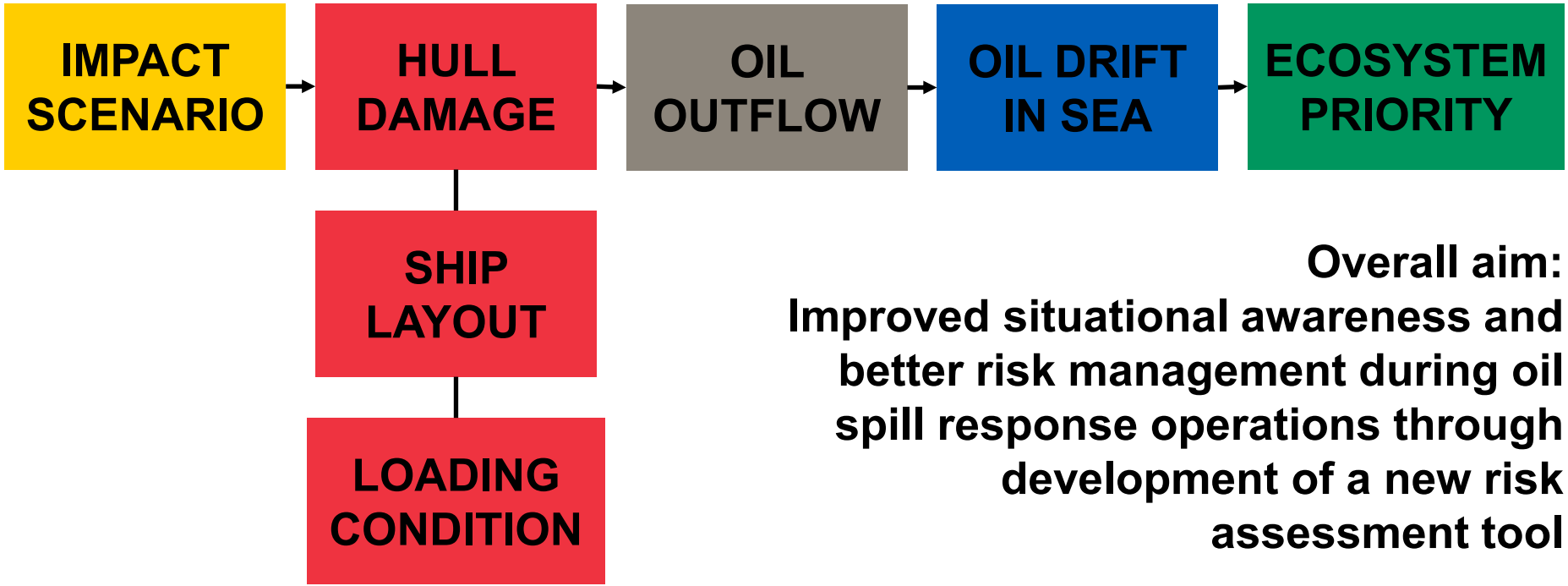
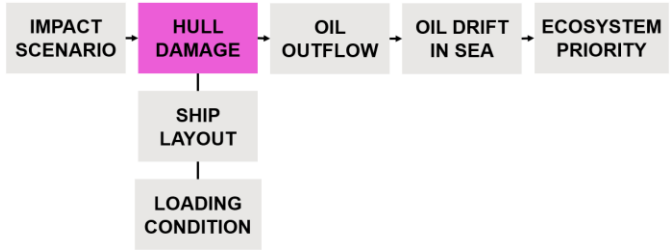
Improved situational awareness tools during oil spill operations in ice conditions

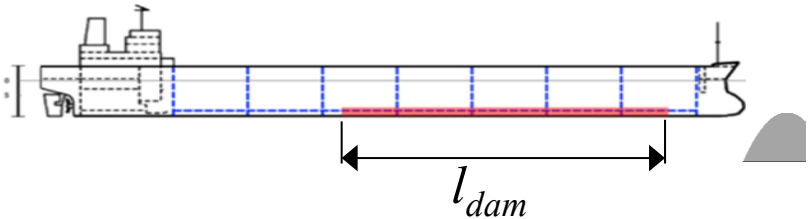
Outline of the oil spill response tool



Overall aim:
Improved situational awareness and better risk management during oil spill response operations through development of a new risk assessment tool

Hull damage: grounding

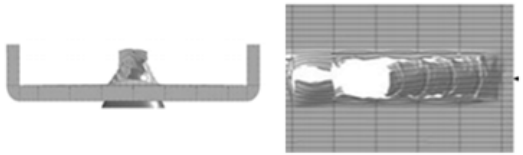




Scenario definition

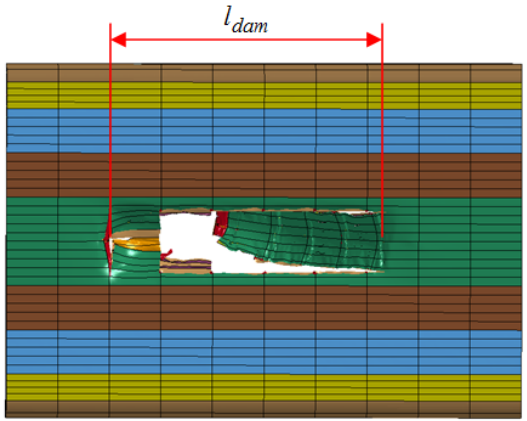
- Opening width in outer bottom $D_{out}(a,\delta) = B_a(a,\delta)$
- Opening width in inner bottom $D_{in}(a,\delta,h_{db}) = B_a(a,\delta,h_{db})$

Single range for rock size

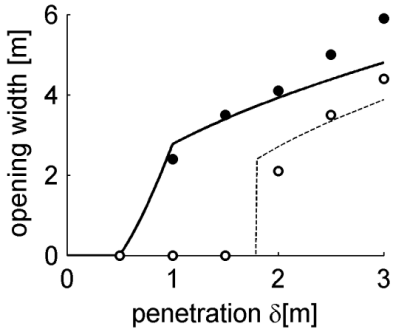


wide opening

Simple criterion for damage extent

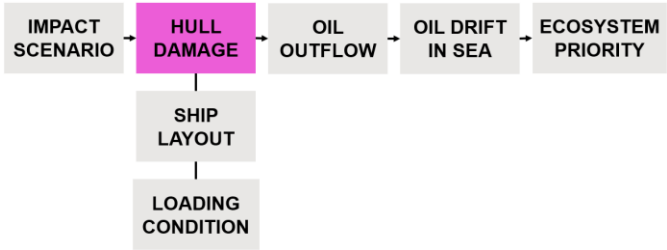


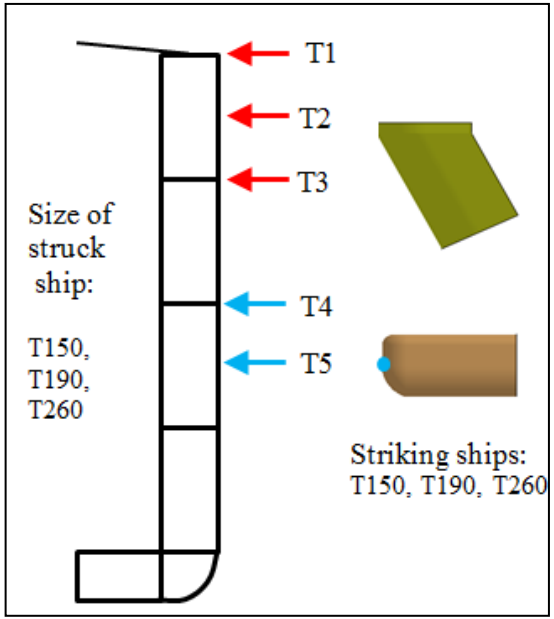
Finite Element calculations



Heinvee M. 2016. The rapid prediction of grounding behavior of double bottom tankers. *PhD thesis, Tallinn University of Technology*

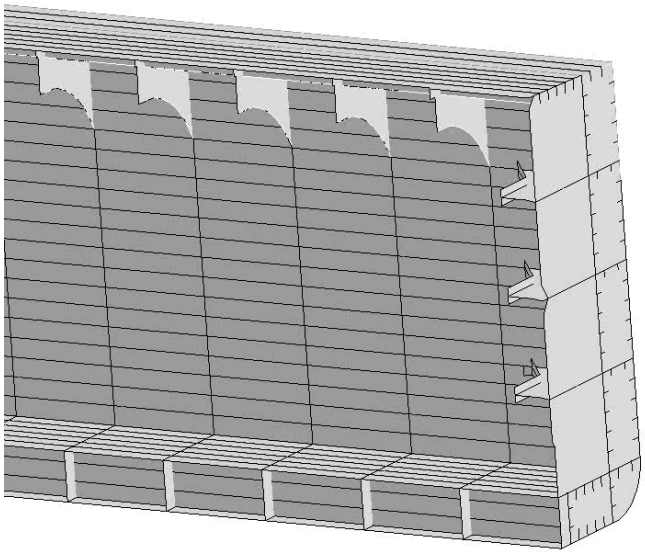
Hull damage: collision



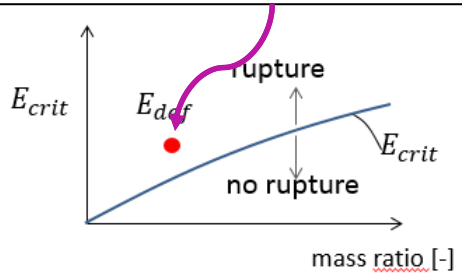


Scenario definition

Finite Element calculations

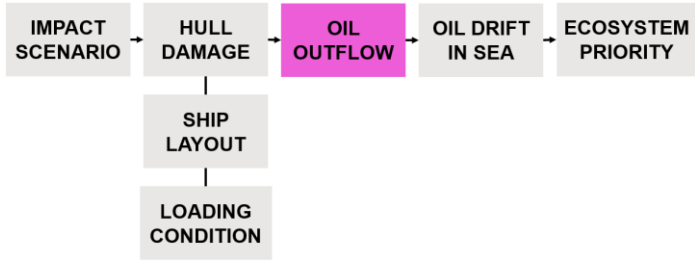


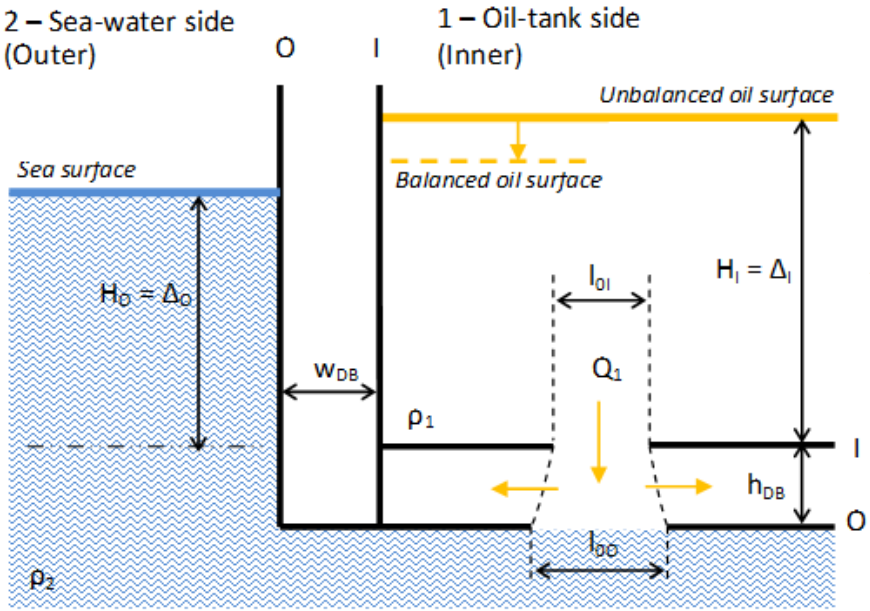
E_{def} - Energy available for structural deformations (obtained from collision Dynamics analysis)



Simple criterion for damage extent

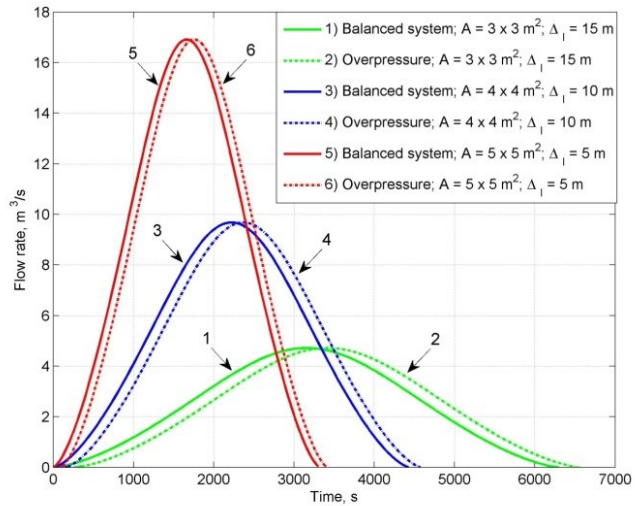
Oil outflow from ship





$$T_{oil} = \frac{2S}{A\sqrt{2g}} \frac{1}{C_d} \sqrt{V_{oil}^{*}/S} \quad \&$$

$$V_{oil}^{*} = \left(\Delta_I^{*} - \frac{\rho_2}{\rho_1} \Delta_O \right) S .$$

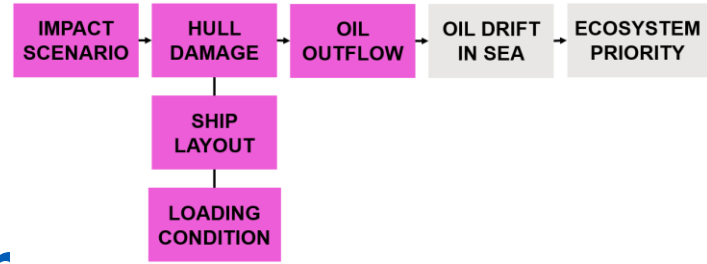


Scenario definition

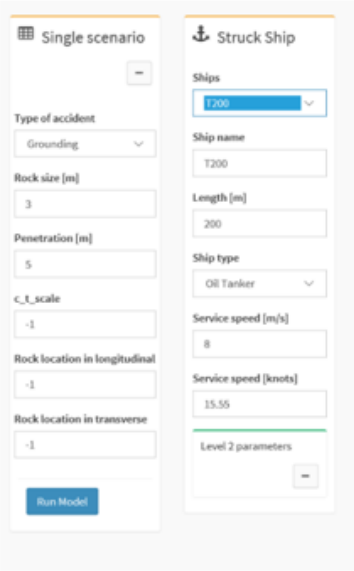
Oil outflow as function of time based on hydrostatic balance

Kollo M., Laanearu J., Tabri K. 2017. Hydraulic modelling of oil spill through submerged orifices in damaged ship hulls. *Ocean Engineering 130:385-397*.

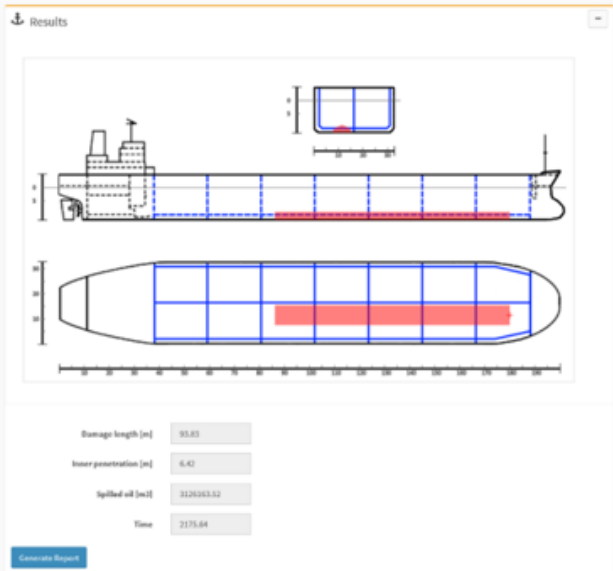
Web-based application for scenario-based accidental oil spill assessment



a) Input parameters



b) Visual representation of bottom damage



c) Grounding scenario report

Ship parameters			
Name	T200	Block coefficient	0,77
Type	Oil Tanker	Mass [kg]	61615,32
Length [m]	200,00	Tanks (longitudinal)	7
Service speed [m/s]	8,00	Tanks (transverse)	2
Service speed [knots]	15,60	Tanks total	14
Breadth [m]	32,93	Double bottom height [m]	2,00
Draft (fully loaded) [m]	12,15	Breadth of double hull [m]	2,00
Depth [m]	17,40	Cargo type	Crude oil
Deadweight [t]	51807,96	Cargo density	865,00

Scenario			
Rock size [m]	4,00	Rock location (longitudinal)	-1,00
Penetration [m]	3,00	Rock location (transverse)	-1,00
c_t_scale	-1,00		

Damage		Oil spill	
Length [m]	93,83	Volume (m^3)	3126163,52
Inner width [m]	6,42	Duration	2175,64
Outer width [m]	8,02		

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Available online:
www.sea.ee/adsam

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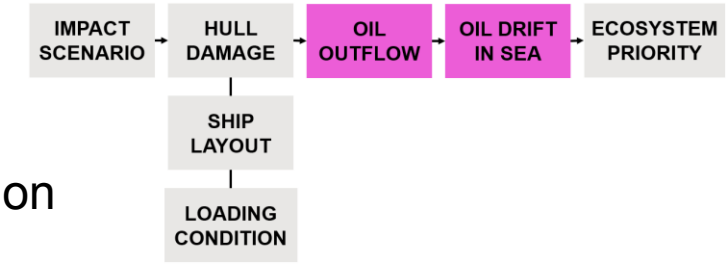
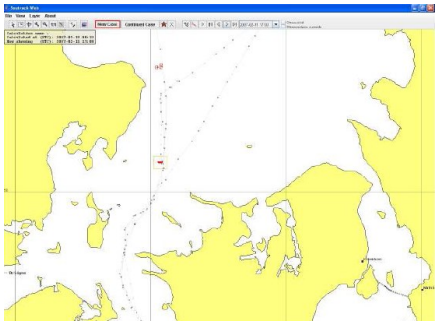
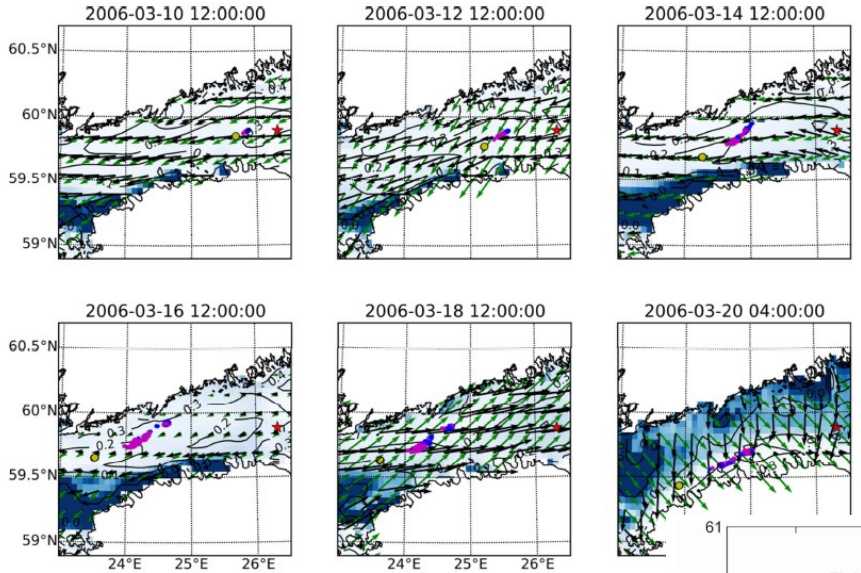
Oil drift in the sea



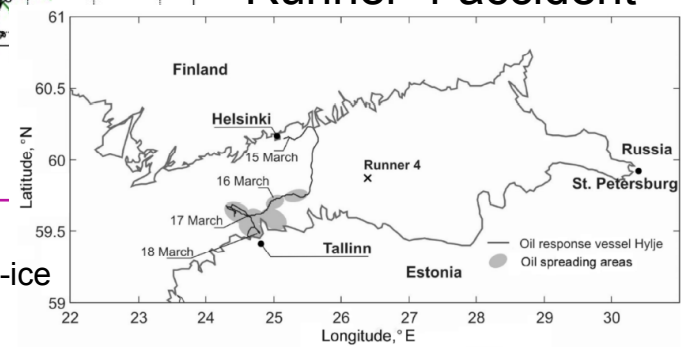


SeaTrack Web
HELCOM operational tool extensively validated for open water

Improved parameterization for winter conditions



Validation case study
Runner-4 accident



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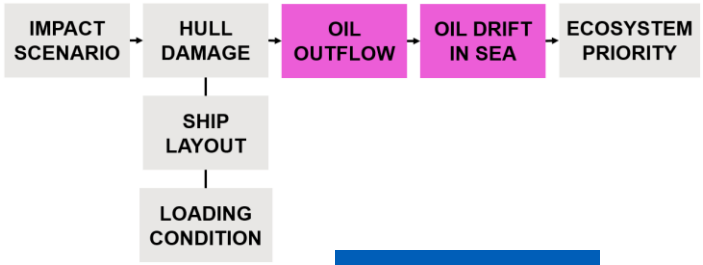
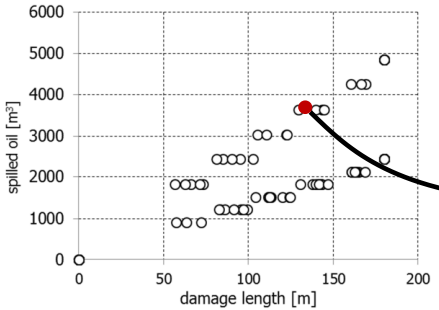
Arneborg et al. 2017.
Oil drift modeling in pack ice – sensitivity to oil-in-ice parameters. *Ocean Engineering, accepted*.

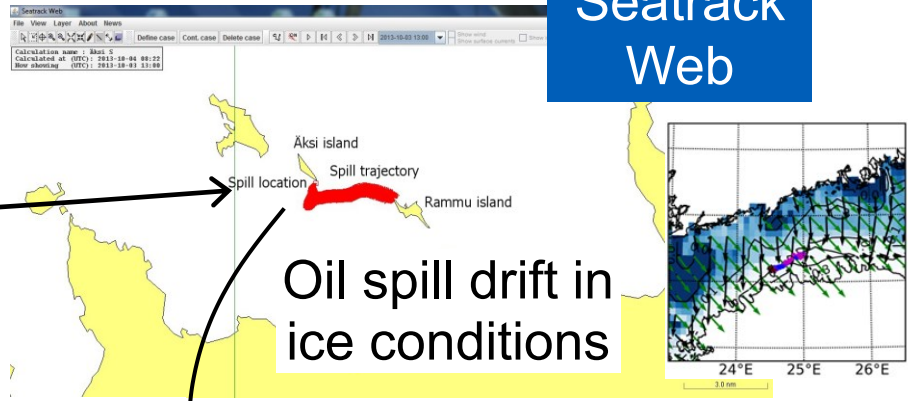
Oil outflow and spill drift assessment





spill amount

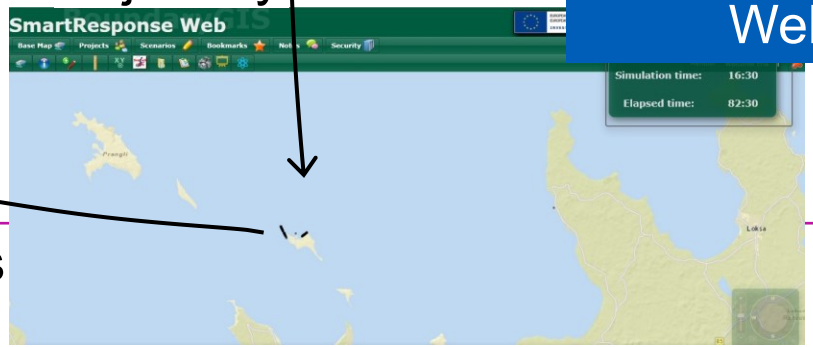
Seatrack Web



Oil spill drift in ice conditions

spill trajectory

SmartResponse Web



Spill	Oil stranding time	Impacted Natura area	Impacted Natura and Bird area
m^3	(hours)	(km^2)	(km^2)
2125	45	0.97	0.49
3642	22.5	0.49	0
4249	25	0.56	0

consequences

Impact

Impact in maritime policy and practice

- Strategic risk management has explicit links to maritime policy
- Cooperation with key stakeholders as project partner

- Synergies: HELCOM-coordinated OpenRISK project as a platform to include developed approaches and tools into guidelines for oil spill prevention and response risk management

HELCOM

OpenRisk
Methods for Maritime Risk Assessment on Accidental Spills
Co-financed by the EU – Civil Protection Financial Instrument

Impact in science

- Currently, STORMWINDS has:
  - 15 journal articles accepted, several more submitted and in preparation
  - 8 conference articles accepted
  - 2 (partially) funded doctoral theses completed
  - 3 funded master theses completed
- STORMWINDS actively contributes to the ICES Working Group on Risks of Maritime Activities in the Baltic Sea, a Committee to develop science-based tools for maritime risk management

Final Seminar
Oulu, Finland, 8-9.03.2018

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INTERNATIONAL SEMINAR

Oil Spills in Arctic Areas

Hosted by Finnish Environment Institute (SYKE)

7-8 MARCH, 2018
Scandic Hotel/Kinopalatsi
Oulu, Finland

Registration will be opened later, pls see www.syke.fi/projects/mospa2018.

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Thank you!
Questions?

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j.montewka@wn.am.gdynia.pl