Aalto-yliopisto
Insinööritieteiden
korkeakoulu

Perspectives and risks of oil transportation in the Gulf of Finland

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Marine Technology

Maritime Safety Group

Leverage from the EU 2007–2013

Tekes

European Union
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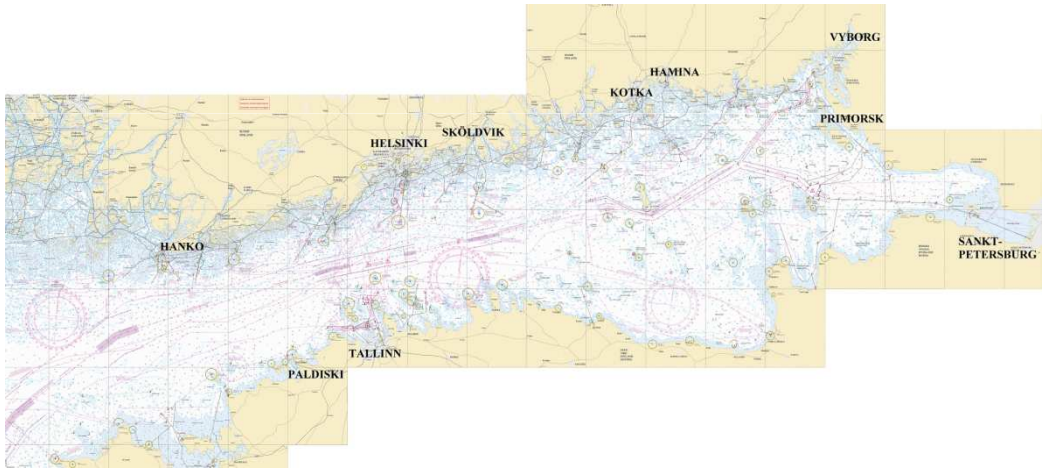
Content

- Situation in the GoF
- Traffic
- Accidents
- Collision risk analysis
- Risk control options

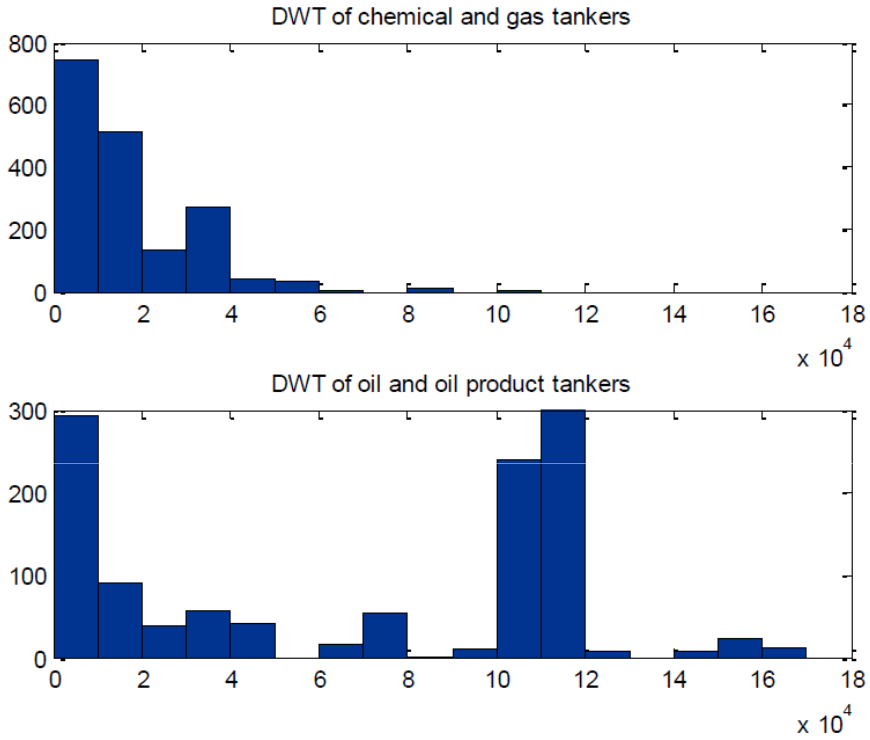


Ships entering and exiting GoF				Composition:				
Year	Total	Change	N_passenger	N_cargo	N_tanker	N_other	N_unknown	Ice
2011	43112	18,0 %	5613	23338	7416	3956	2789	Harsh
2010	36541	-4,8 %	4607	19398	6574	3346	2483	Average
2009	38396	-19,3 %	5349	19749	7031	4115	2152	Mild
2008	47584	19,4 %	4585	23237	6053	10986	2723	Very mild
2007	39866	7,6 %	5507	23323	6796	3472	767	Mild
2006	37036	-	5098	23107	6850	1981		Average

GoF traffic

		2010 cargo Mt	2010 oil Mt	2010 cargo total Mt
Finnish ports				
	Sköldvik	4.647	15.898	20.545
	Kotka	11.284	0.018	11.302
	Helsinki	10.540	0.340	10.880
	Hamina	4.268	0.242	4.510
	Hanko	3.489	0.090	3.579
	Other Finnish ports (GoF)	4.731	0.045	4.776
	Sum	**38.959**	**16.633**	**55.592**
Russian ports				
	Primorsk	0.000	77.640	77.640
	St Petersburg	41.931	16.117	58.048
	Vysotsk+Vyborg	3.931	12.012	15.943
	Ust-Luga	11.776	0.000	11.776
	Sum	**57.638**	**105.769**	**163.407**
Estonian ports				
	Muuga (Port of Tallinn)*	6.243	23.505	29.748
	Paldiski (Port of Tallinn)*	1.838	2.065	3.903
	Sillamäe	1.304	2.196	3.501
	Vanasadam	2.61	0	2.61
	Kunda	1.657	0	1.657
	Vene-Balti	0.241	0.374	0.615
	Bekker	0.6	0	0.6
	Miiduranna	0.001	0.34	0.341
	Paljassaare (Port of Tallinn)*	0.241	0.095	0.336
	Sum	**14.735**	**28.575**	**43.311**
	Total	**111.332**	**150.977**	**262.31**

GoF tanker DWT



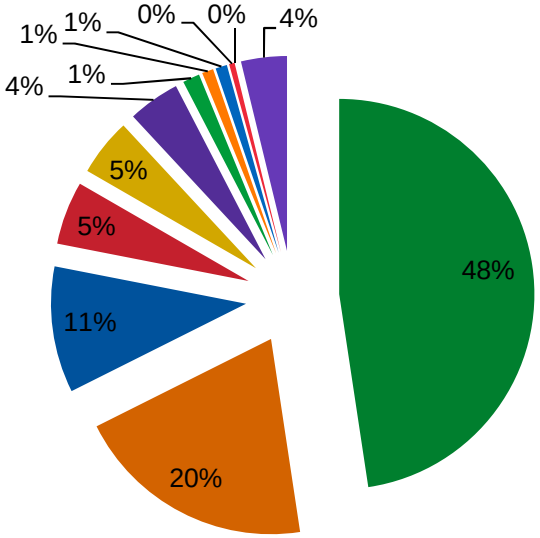
Lähde: Sormunen O. 2011. Mitigating environmental risks of chemical tanker collisions with recovery vessels in the Gulf of Finland. Diplomityö. Hanken School of Economics. 128 s.

Figure 19 Histograms of chemical & liquid propane gas tankers and oil & oil product tankers in 2007

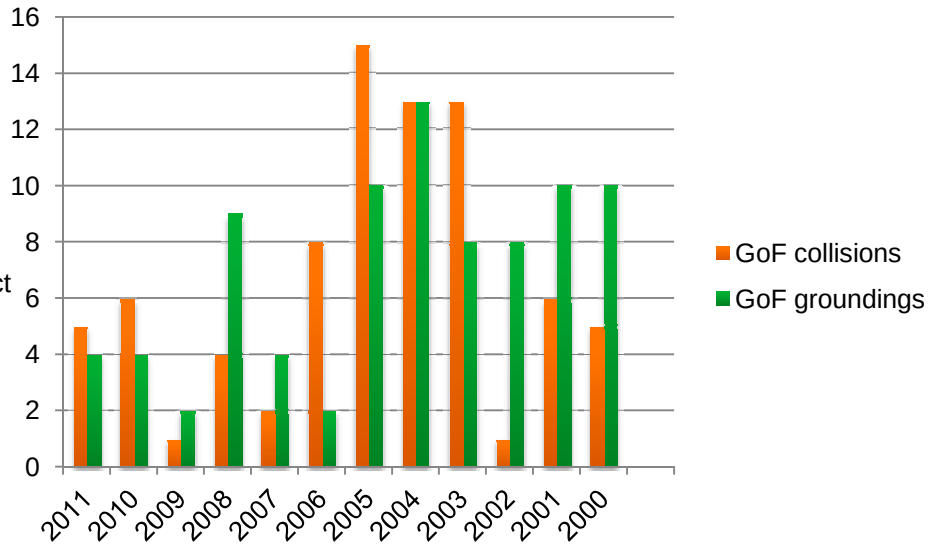
With permission of P.Kujala

Accidents

- Gulf of Finland 1997-2006 (DAMA-database)



HELCOM 2000-2011



Causes

- HELCOM (Baltic Sea)

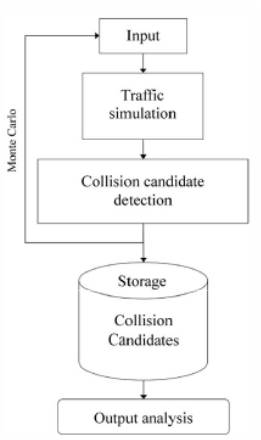
	Human factor	Technical	External	Other	No information
2011	50 %	22 %	17 %	5 %	6 %
2010	30 %	20 %	9 %	5 %	36 %
2009	52 %	20 %	15 %	8 %	5 %
2008	47 %	13 %	18 %	7 %	15 %
2007	32 %	20 %	12 %	4 %	32 %
2006	36 %	15 %	9 %	5 %	35 %
2005	42 %	23 %	5 %	23%*	7 %
2004	45 %	21 %	5 %	10 %	19 %
	* includes cases where multiple factors were the cause				

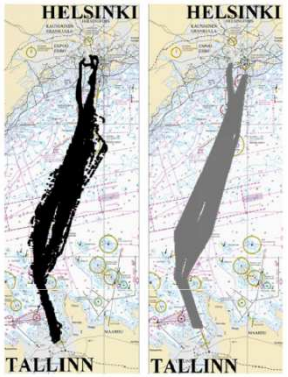
Baltic sea HELCOM	Groundings			
	Pilot =1	Pilot = 0	Pilot = n.i.	Pilot = exemption certificate
2011	23 %	64 %	9 %	4 %
2010	19 %	70 %	8 %	3 %
2009	27 %	63 %	5 %	5 %
2008	18 %	65 %	10 %	7 %
2007	26 %	67 %	4 %	4 %
2006	7 %	43 %	50 %	0 %
2005	24 %	57 %	17 %	2 %
2004	20 %	41 %	36 %	3 %

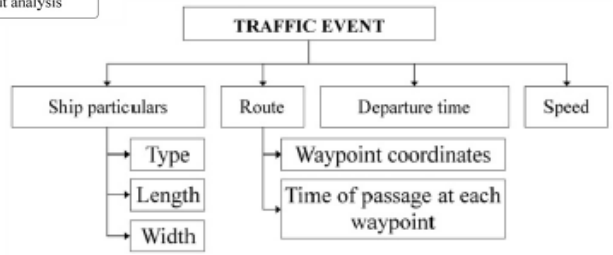
GoF traffic simulation

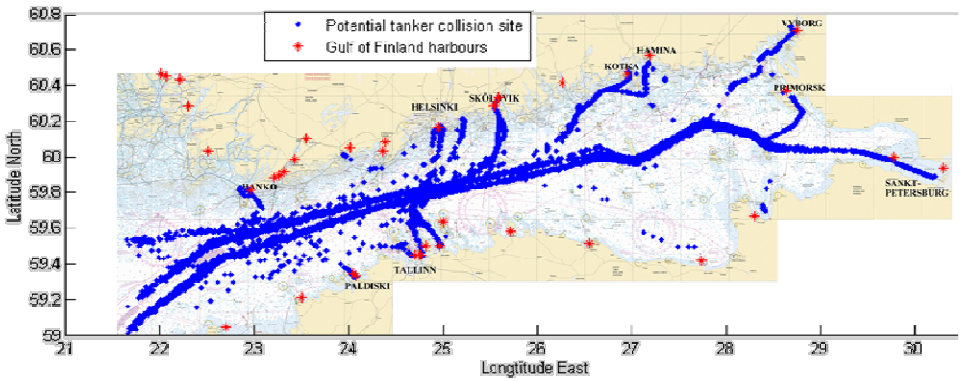
- Goerlandt & Kujala (2011)

Marine Traffic Simulation Model

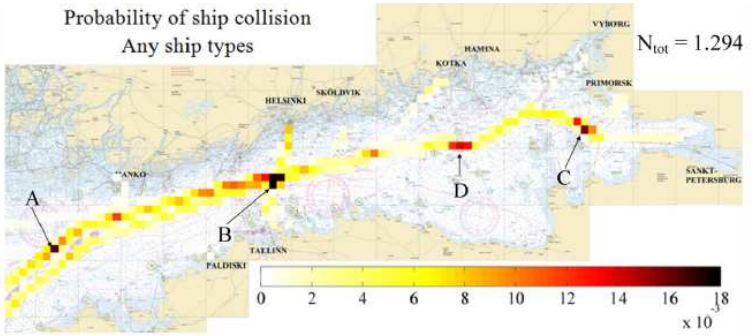






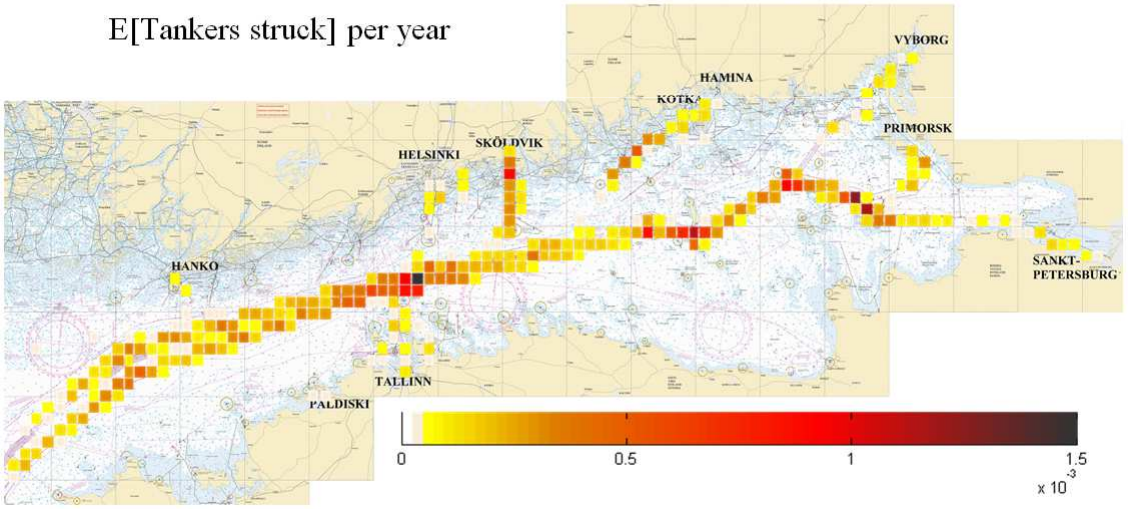


Causation factors: Hänninen & Kujala (2012)
Range: $1.01 \cdot 10^{-5}$ to ~$7.7 \cdot 10^{-5}$



Modeling spills

- Collision frequency – all tankers
  - Return period
  - GoF
    - 1 every 16,75 y
    - Spill every 40 y
  - Most risky location:
    - Collision 1 every 666 y



Map: © TraFi

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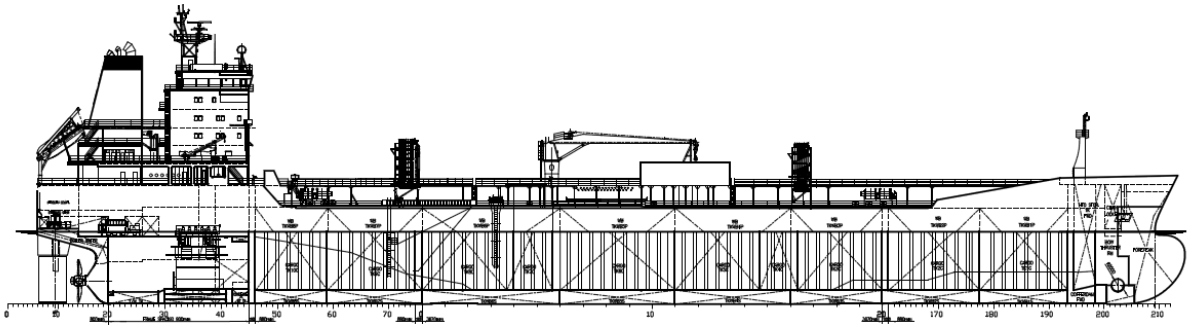
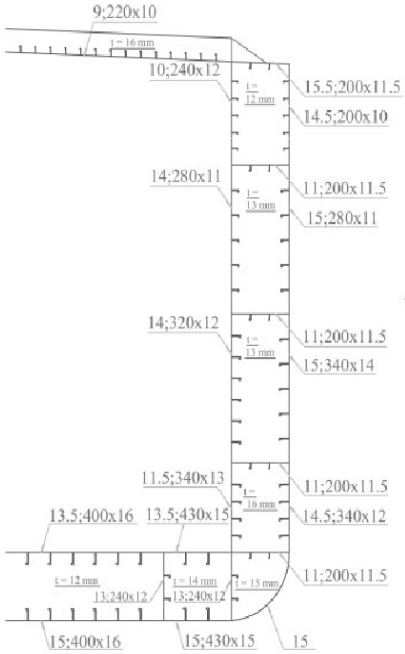
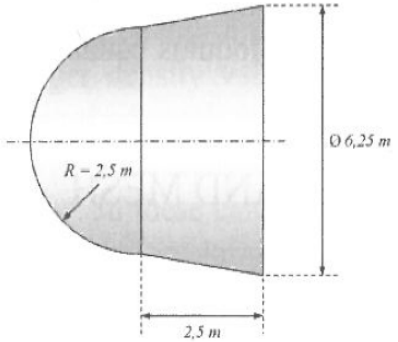
Spill model



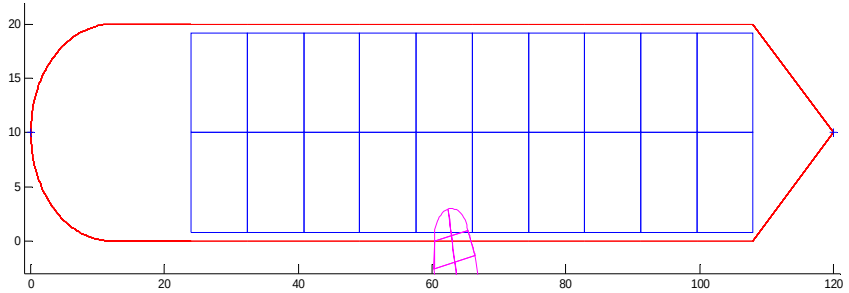
- New FEM/MATLAB-based model built upon Ehlers (2010)

FEM => MATLAB





=>

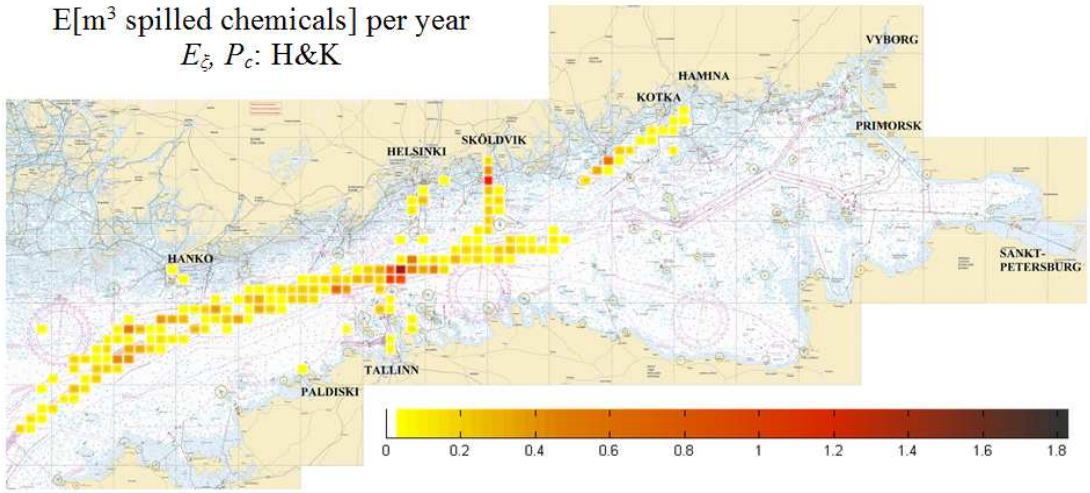


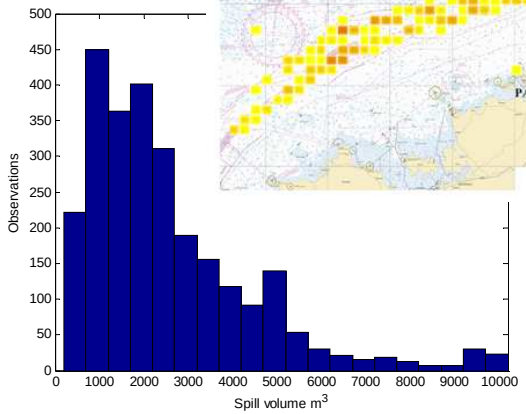
Chemical spill model

- $E[chemical\ spill\ volume]_{ij} = R_{ij} = \frac{1}{N_{sim}} \sum_{t=1}^{T} P_{c\,t} \cdot Pr(tanker\ t\ \ is\ chemical) \cdot \frac{N_{t\ tanks\ breached}}{N_{total}} \cdot 1.11\ DWT_t$

- Total: 2700 simulated spills
  - Collision every 77 y
  - Spill every 154 y
  - Median: 2100 m3

Range:
119 - 28 388 m^3





Risk control options

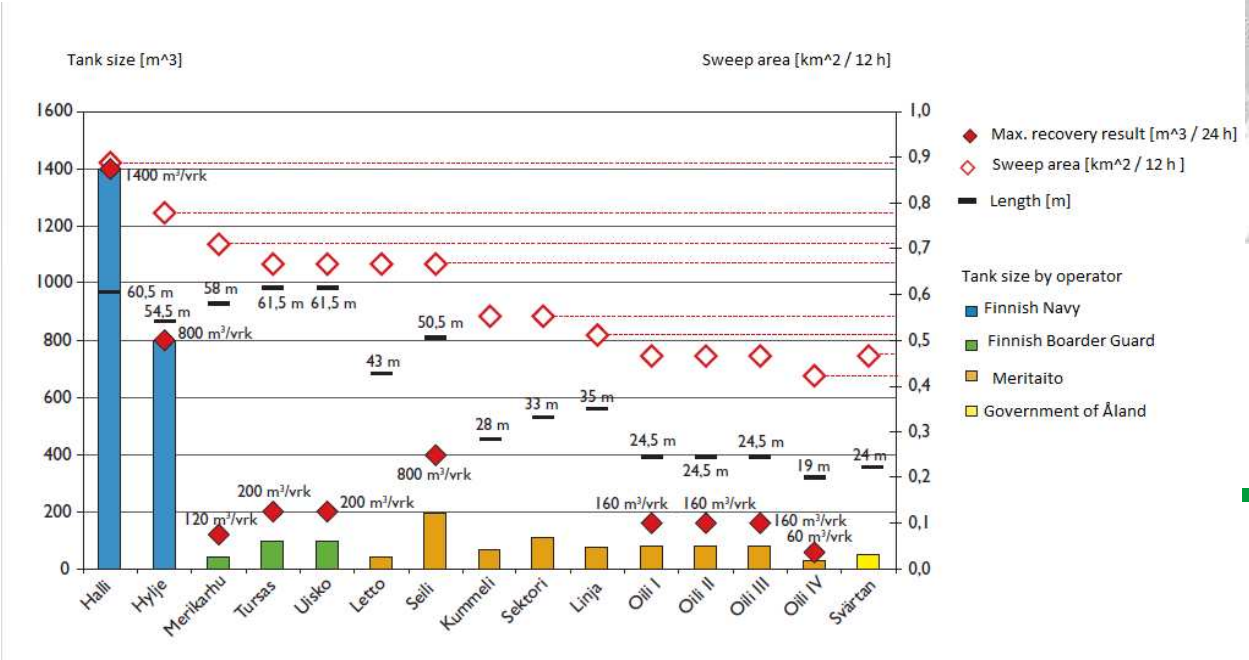
- Re-routing
- Velocity reduction
- Recovery
- Training
- Wider double hulls / stronger hull structure

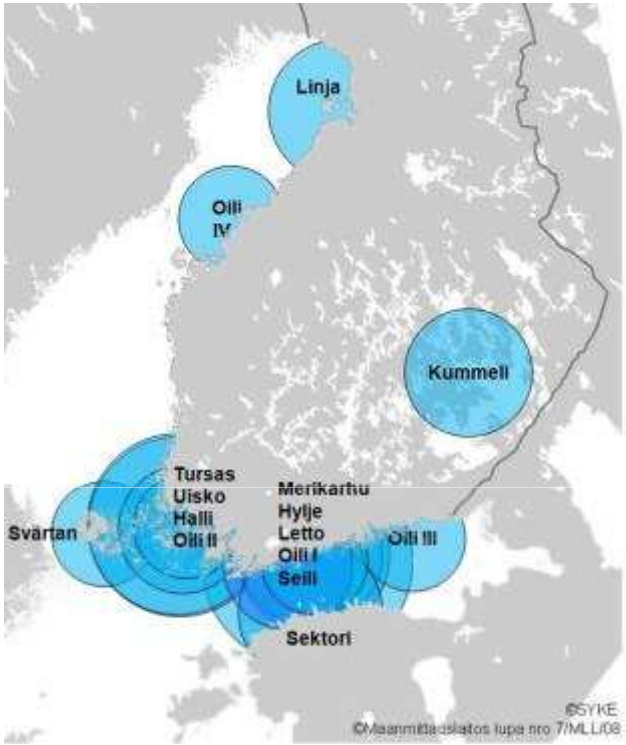
Risk control options

- Factros most affecting spill:
  - Double hull width
    - 1 m increase => Spill probability decreases by x 10
  - Colliison velocity of striking ship
    - 1 kn increase => Spill probability increases by x 1.4
- Recovery vessels
- Louhi
  - 1. ”real” chem recovery vessel
    - 1200 m3 oil
    - 200 m3 chemicals

Other recovery vessels

- HELCOM:
  - 6 h response time to any accident
  - 72 h to collect 30 000 t oil
  - No similar for chemicals





Optimal placement for collision spill response

$$\min z_1 = \operatorname{argmin}_h \sum_{t=1}^{T} E[\text{spilled chemicals}]_t * d_t$$

- 1 vessel available
- 2 vessels
- 3 vessels

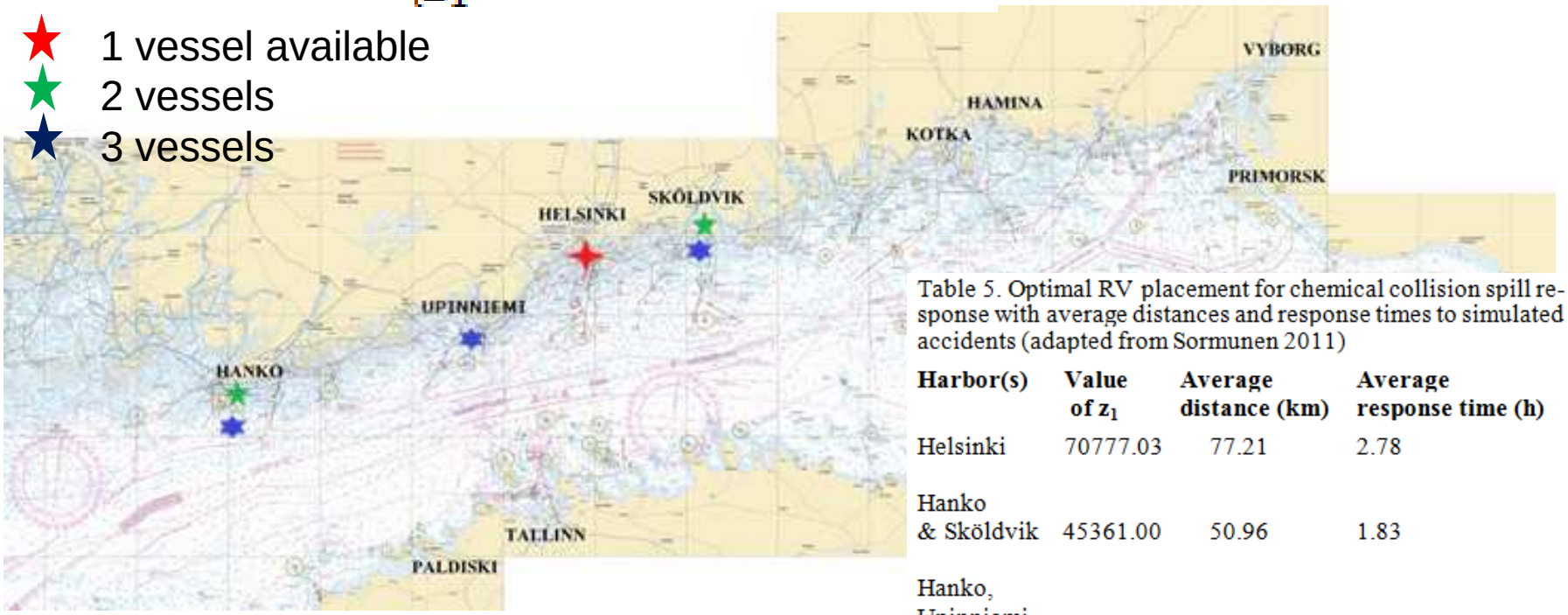


Table 5. Optimal RV placement for chemical collision spill response with average distances and response times to simulated accidents (adapted from Sormunen 2011)

Harbor(s)	Value of z_1	Average distance (km)	Average response time (h)
Helsinki	70777.03	77.21	2.78
Hanko & Sköldvik	45361.00	50.96	1.83
Hanko, Upinniemi & Sköldvik	36821.00	41.44	1.49

Cost-Benefit Analysis

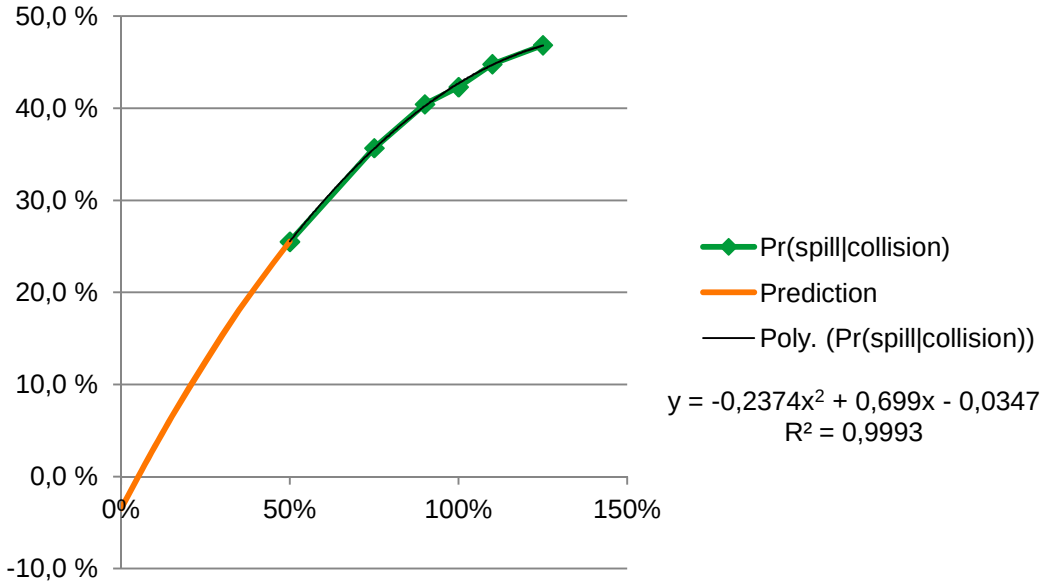
- Traditional CBA makes no sense-
- HELCOM recommendations for oil
  - 6 h to site
  - 72 h to recover total spill from 2 side tanks of the biggest size of tanker
- No corresponding one for chemicals

- Adapted to chemicals
  - More chemical than oil tankers in the GoF
  - 2 / 3 transported chemicals float
  - 1 / 2 float and are toxic

Effect on spill probability

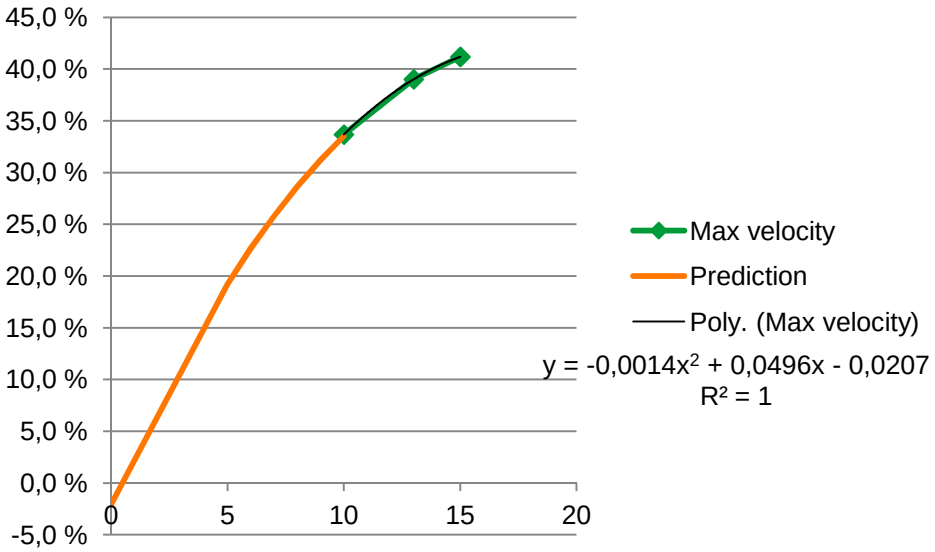
-

Init. Velocity:	Pr(spill|collision)
125 %	46,9 %
110 %	44,8 %
100 %	**42,3 %**
90 %	40,4 %
75 %	35,7 %
50 %	25,5 %



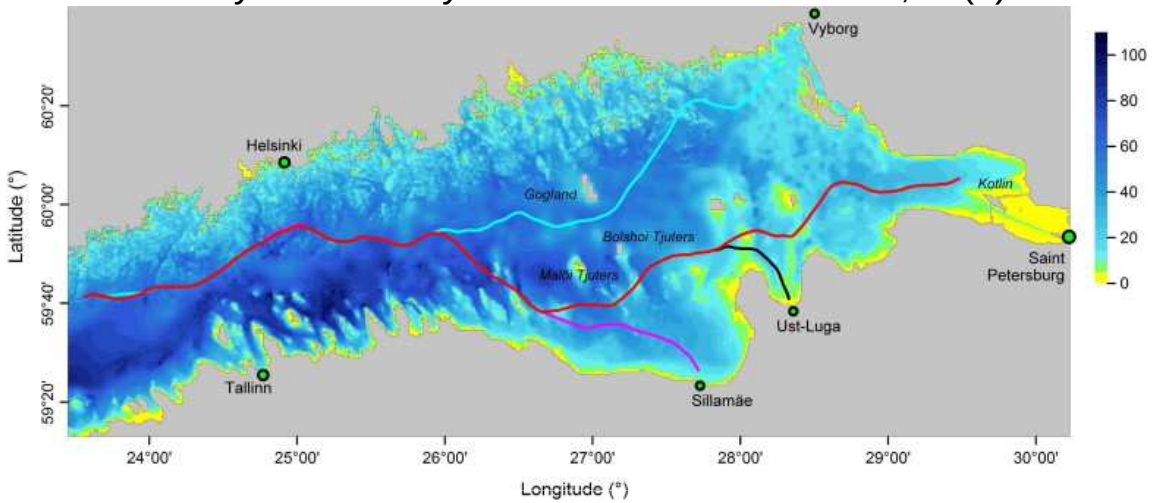
Limiting initial velocity

Max 15 kn	41,2 %
Max 13 kn	39,0 %
Max 10 kn	33,7 %

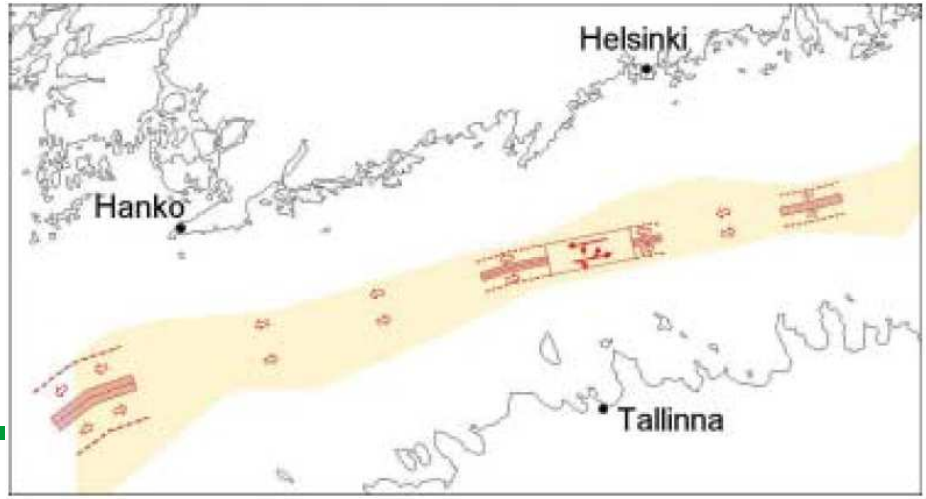


Re-routing

- Soomere T, et al. 2011. The use of Lagrangian trajectories for the identification of the environmentally safe fairways. *Marine Pollution Bulletin*; 62(7): 1410-1420.

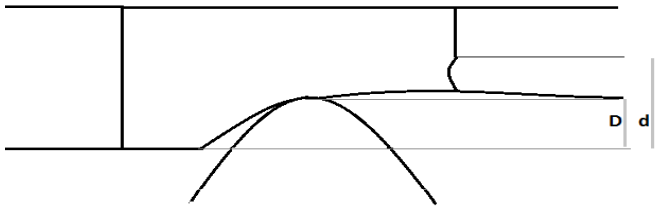


- **Gulf of Finland Traffic Separation Scheme (Rytkönen et al. 2002:82)**

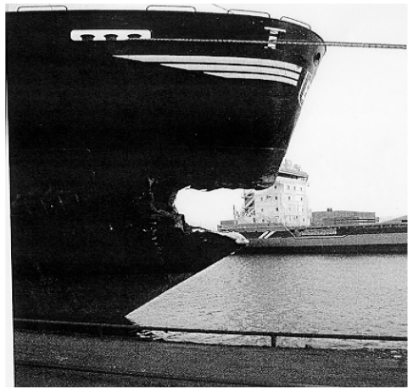


WIP

- Grounding frequency and location modelling
- Grounding damage modelling



- Ice conditions modelling



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