

# Modeling risks of marine traffic in the Gulf of Finland

Final Seminar of the MS GOF project  
20.11.2007

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# Contents

- Marine traffic risks in the Gulf of Finland based on accident statistics vs. modeling
- Risk assessments from around the world vs. the Gulf of Finland

# Literature review

- Hänninen, M. & Kujala, P. Modeling Collision and Grounding Risks in Marine Traffic, Literature Review (in Finnish). Helsinki University of Technology, Ship Laboratory, Espoo 2007. M-299. 65 p.
- Aims of the review:
  - What kind of models exists and have been used in previous marine traffic risk assessments?
  - What kind of risk assessments have been implemented in other waters of the world?

# Modelling marine traffic risks: Accident probability calculation

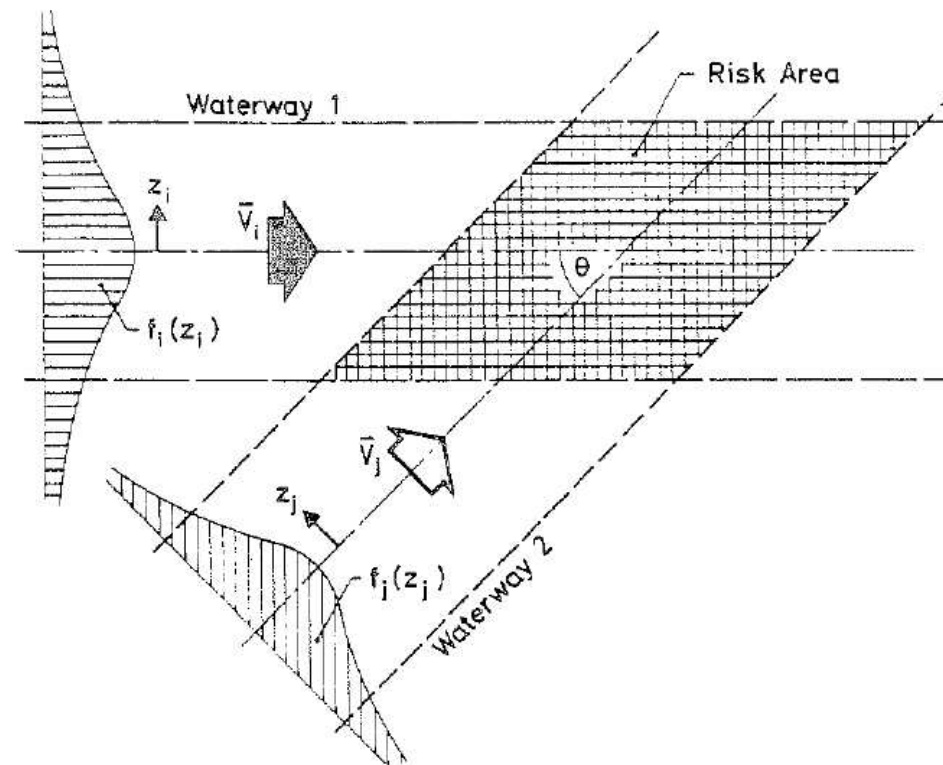
risk = probability · consequences

$$P = P_G \cdot P_C$$

- Geometrical probability: the probability of being on a collision/grounding course
- Causation probability: the probability of failing to avoid the accident while being on a collision/grounding course
- Fujii (1971, 1974), Macduff (1974), Larsen (1993), Pedersen (1995)

# Pedersen's model for collision

$$N_a = \sum_i \sum_j \iint_{\Omega(z_i, z_j)} \frac{Q_{1i} \cdot Q_{2j}}{V_i^{(1)} \cdot V_j^{(2)}} \cdot f_i^{(1)}(z_i) f_j^{(2)}(z_j) V_{ij} D_{ij} dA \Delta t$$



Source: Pedersen, P. T. (1995) Collision and Grounding Mechanics. Proceedings of WEMT'95, p.131

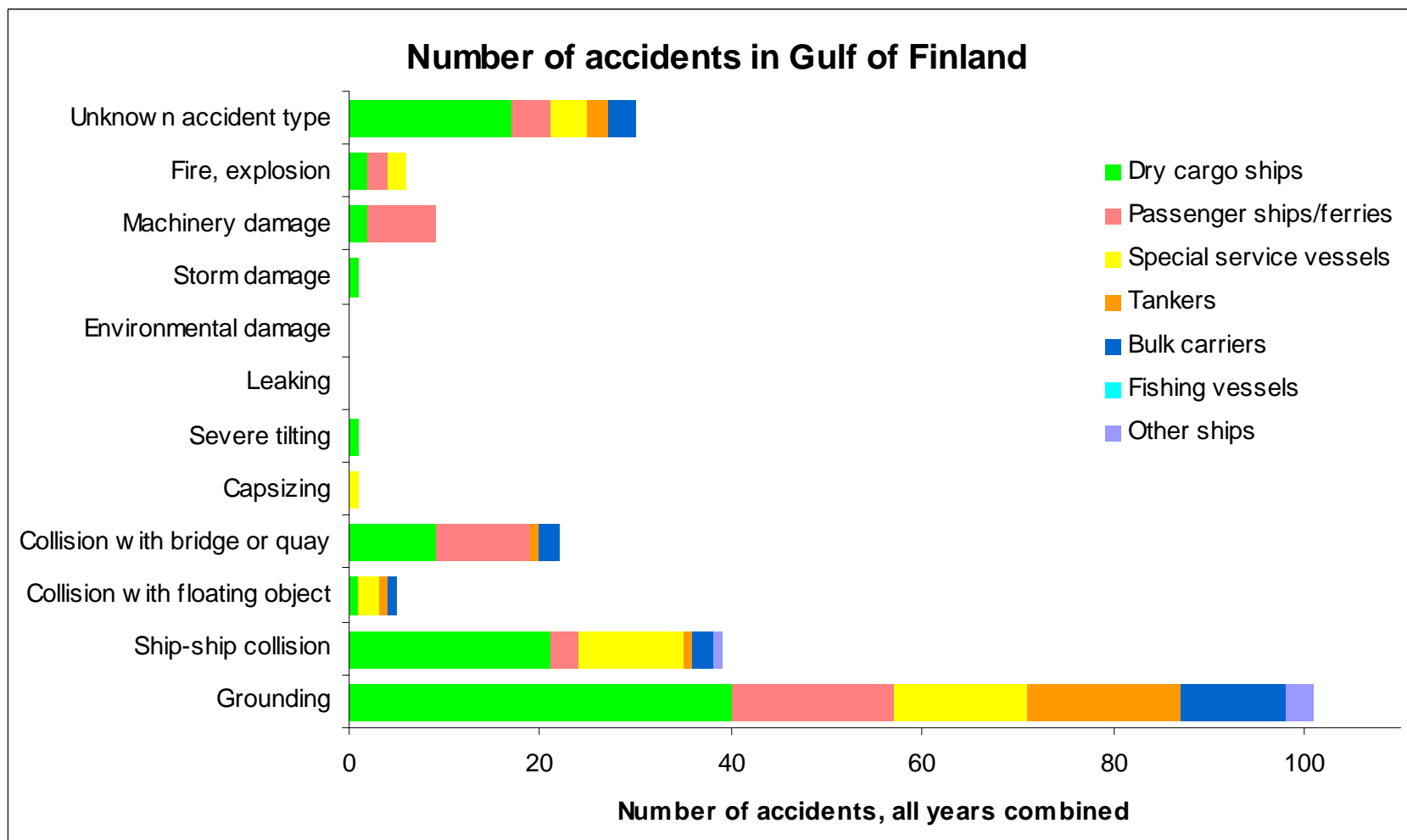
# Analysis of accident statistics (1)

- Calibration of frequency models
- Estimation of models' input parameters
- Accidents in the Gulf of Finland 1997-1999, 2001-2006
- DAMA-database: accidents in Finnish territorial waters and Finnish vessels outside the territorial waters
- Data from HELCOM: accidents in the GoF
- Total 220 accident registrations

# Analysis of accident statistics (2)

- Number of accidents
- Accident types
- Ship types
- Conditions
- Causes
- Locations, water areas
- Damages
- Nationality
- Cluster analysis?

# Number of accidents in the Gulf of Finland, years 1997-1999 and 2001-2005



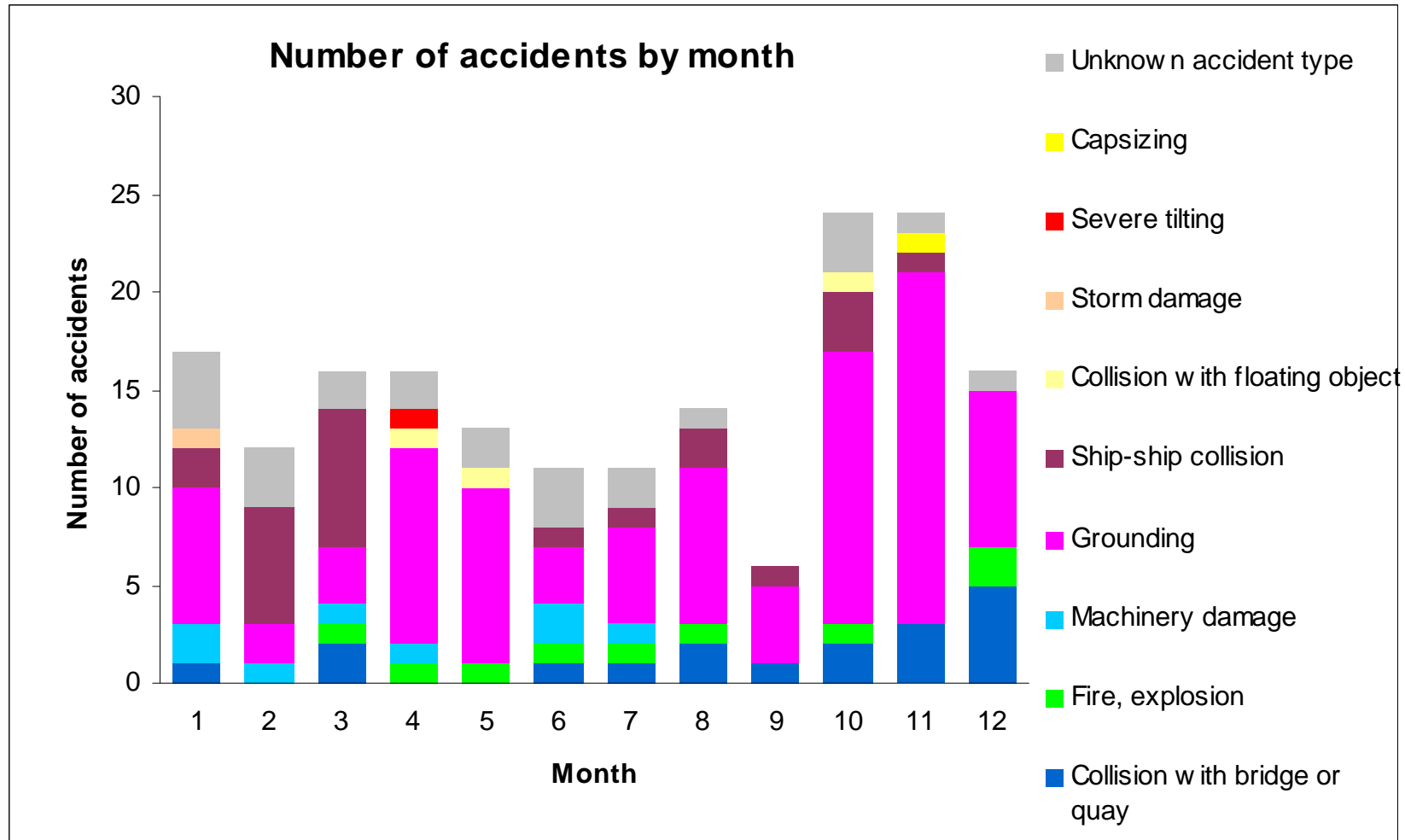
# Number of accidents per 1000 ship arrivals

Year	Groundings	Ship-ship collisions	Others	Total
1997	0,53326	0,06666	0,00000	0,59992
1998	0,71000	0,12909	0,00000	0,83909
1999	0,29652	0,05930	0,35583	0,71166
2001	0,40039	0,00000	0,11440	0,51479
2002	0,21434	0,05358	0,21434	0,48226
2003	0,26203	0,31443	0,20962	0,78608
2004	0,14085	0,04695	0,28170	0,46951
2005	0,09731	0,00000	0,00000	0,09731

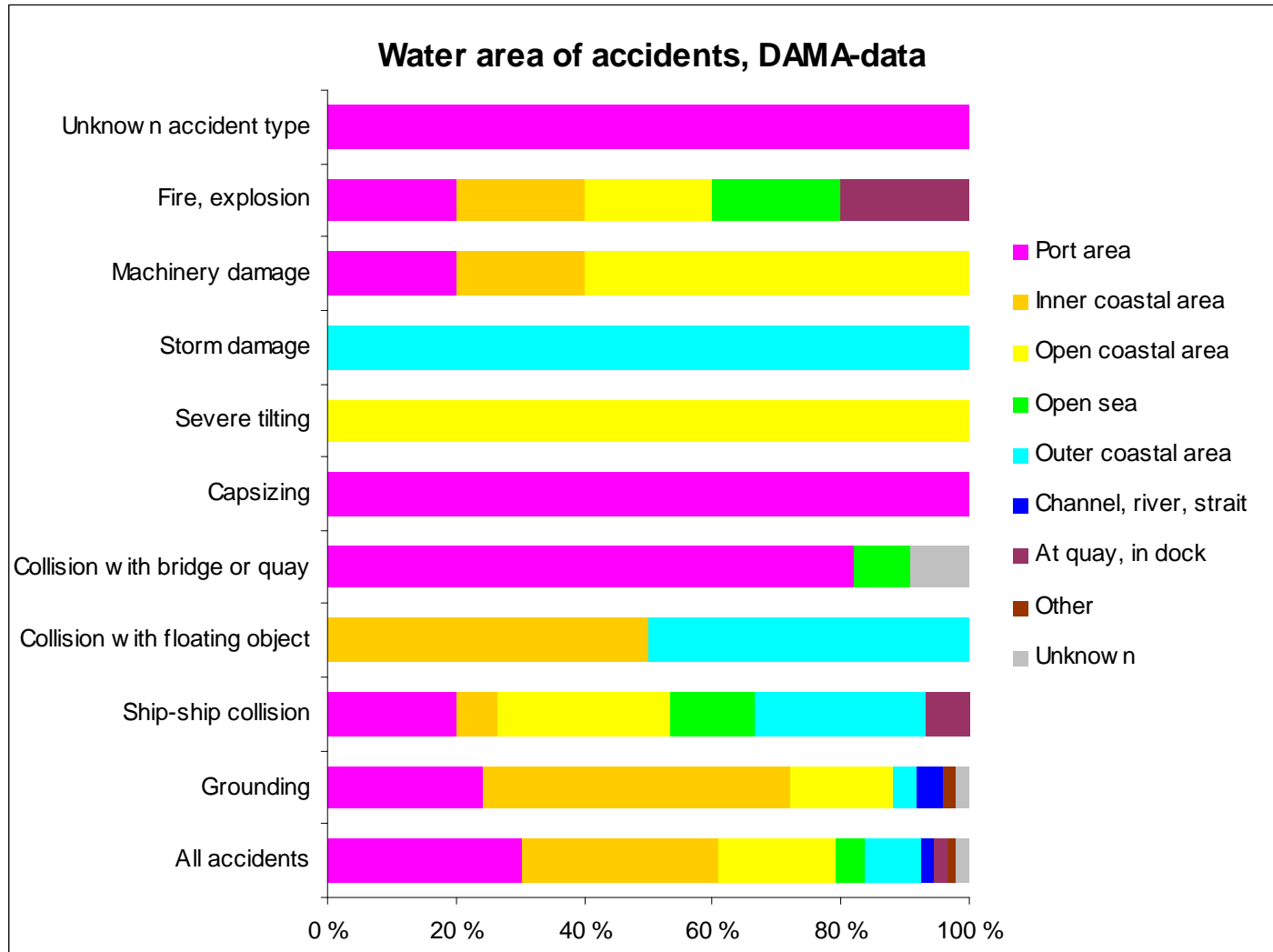
Note 1: Calculated based on accident registrations in Finnish territorial waters and arrivals to Finnish ports

Note 2: When comparing with the results given by risk model(s), these numbers are for the whole Gulf of Finland (Finnish terr. waters)

# Influence of the time of year



# Water area



Note: Based only on DAMA-data, 92 accidents

# Main cause

<b>Cause</b>	<b>Groundings</b>	<b>Ship-ship collisions</b>	<b>All accidents</b>
Human factors	64,0 %	13,3 %	45,7 %
Conditions outside the ship	24,0 %	66,7 %	29,3 %
Technical condition of ship equipment	10,0 %	0,0 %	16,3 %
Routines, communication, organization	2,0 %	13,3 %	4,3 %
Load conditions, protection of load and fuel	0,0 %	0,0 %	2,2 %
Unknown	0,0 %	6,7 %	2,2 %
			100,0 %

# Causation probability (1)

- = Fraction of the accident candidates which result in an accident
- Contributes substantially to accident probability  
-> modeling must be done very carefully
- Factors influencing  $P_c$ 
  - Human factors
  - Weather
  - Currents
  - Ship characteristics
  - Technical failures

# Causation probability (2)

- Ways to estimate  $P_c$ 
  - Accident statistics
  - Adjusting previous  $P_c$  to local conditions
  - Fault trees
  - Bayes nets
  - Expert opinions

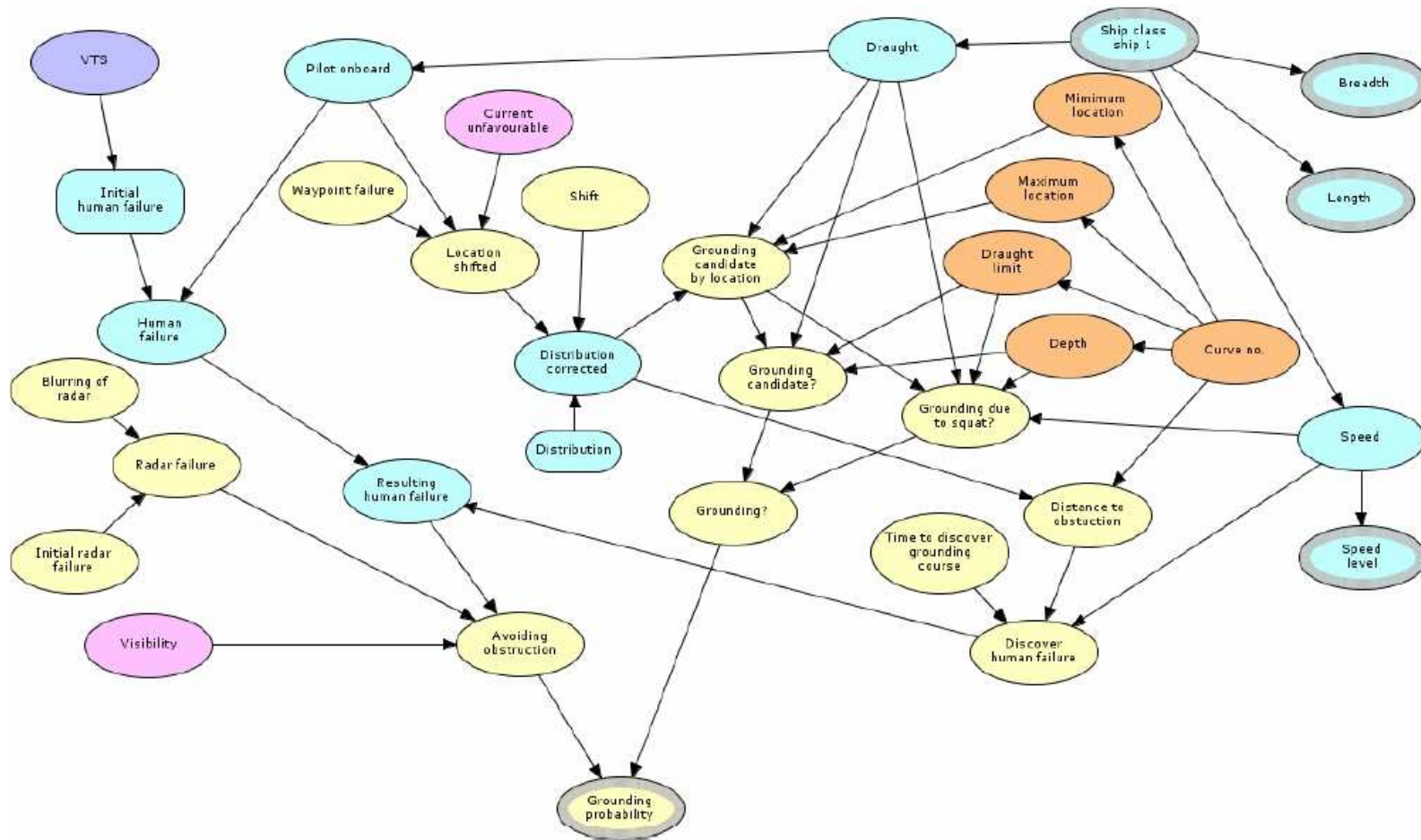
# Causation probability (3)

- $P_c$  values used for groundings
  - Macduff (1974):  $1.4 - 1.6 \cdot 10^{-4}$
  - Fujii (1974):  $1,59 \cdot 10^{-4}$
- $P_c$  values used for collisions
  - Macduff (1974):  $1.1 - 9.5 \cdot 10^{-5}$  (crossing)
  - Fujii (1971):  $\sim 10^{-4}$  (crossing)
  - GRACAT:  $1.3 \cdot 10^{-4}$  (crossing)
  - Karlsson et al. (1998):  $2.7 \cdot 10^{-5}$  (head-on)

# Accident frequency estimation in the GoF

- When  $P_G$  is modeled based on AIS-data, it automatically includes local features
- No values for  $P_c$  found in the literature that have been estimated especially for the GoF
- Some input for modeling  $P_c$  in the GoF can be derived from accident database analyses
  - Direct comparison between values given by model and databases
  - Causes
  - Effects of weather, winter navigation etc.

# An example of a Bayesian network: Grounding frequency



Source: Rambøll. Navigational safety in the Sound between Denmark and Sweden (Øresund); Risk and cost-benefit analysis. Rambøll Danmark A/S, 2006 (online) [cited 11.7.2007]. Available in pdf-format: <URL:[http://www.dma.dk/graphics/Synkron-Library/Sofartsstyrelsen/Publikationer/2006/Navigational\\_safety\\_Oresund.pdf](http://www.dma.dk/graphics/Synkron-Library/Sofartsstyrelsen/Publikationer/2006/Navigational_safety_Oresund.pdf)>.

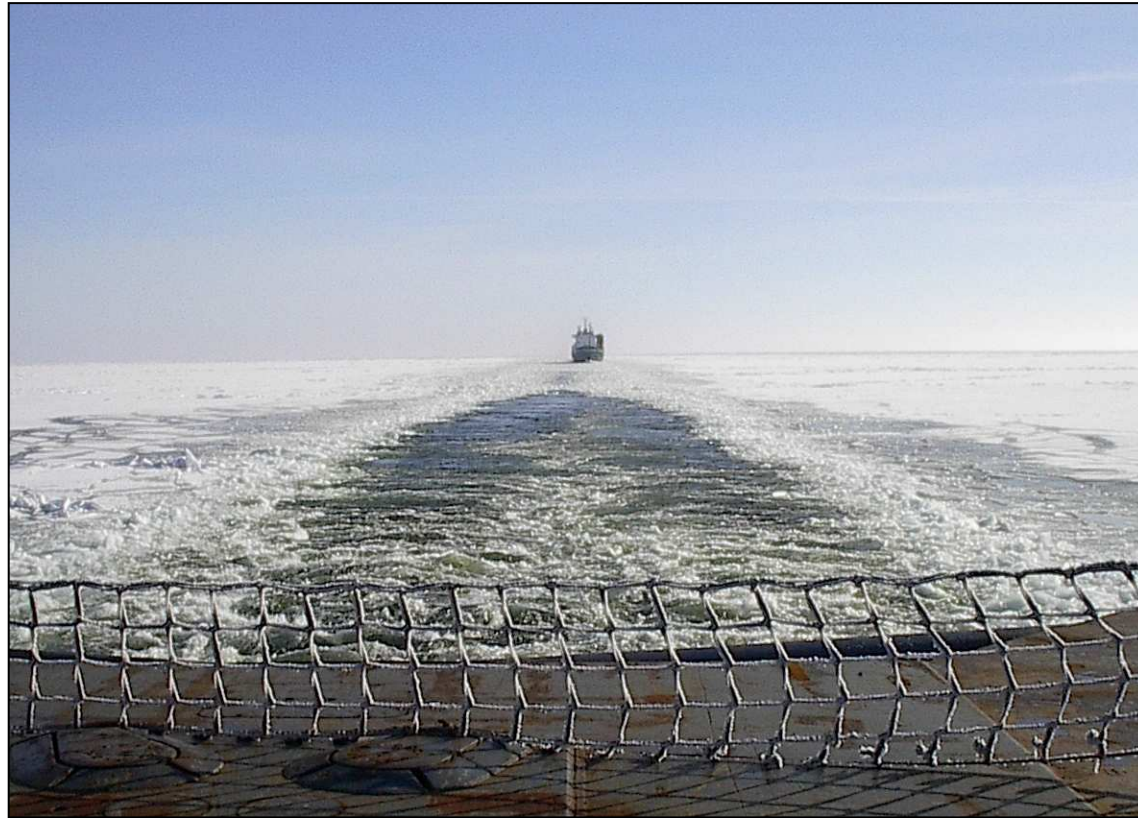
# Marine traffic risk assessments: examples of accident frequencies

- Øresund, Drogden (2006):
  - 1.30 groundings/year
  - 0.58 ship-ship collisions/year
- Ro-ro passenger ferries, Cadiz – the Canary Islands Traffic (2002):
  - $5,78 \cdot 10^{-3}$  groundings/year
  - $4,29 \cdot 10^{-2}$  ship-ship collisions/year
- Annual frequencies in the Gulf of Finland based on accident registrations (1997-1999, 2001-2005):
  - 12.63 groundings/year
  - 4.5 ship-ship collisions/year
  - 27.5 accidents/year

# Summary

- Statistical analysis of registered accidents can give rough estimates for critical events and accident frequencies but they do not give information on near miss cases or on the future  
-> risk modeling is essential
- Causation probability (mostly human factor) has significant role on accident probability  
-> modeling  $P_c$  for the GoF must be done carefully
- No risk model found in the literature considers the different nature of winter navigation

# Thank you!



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