MANAGING RISK

Winterization of LNG Carriers

Tanker Operator Conference

Oslo, 14th June, 2007

Presented by
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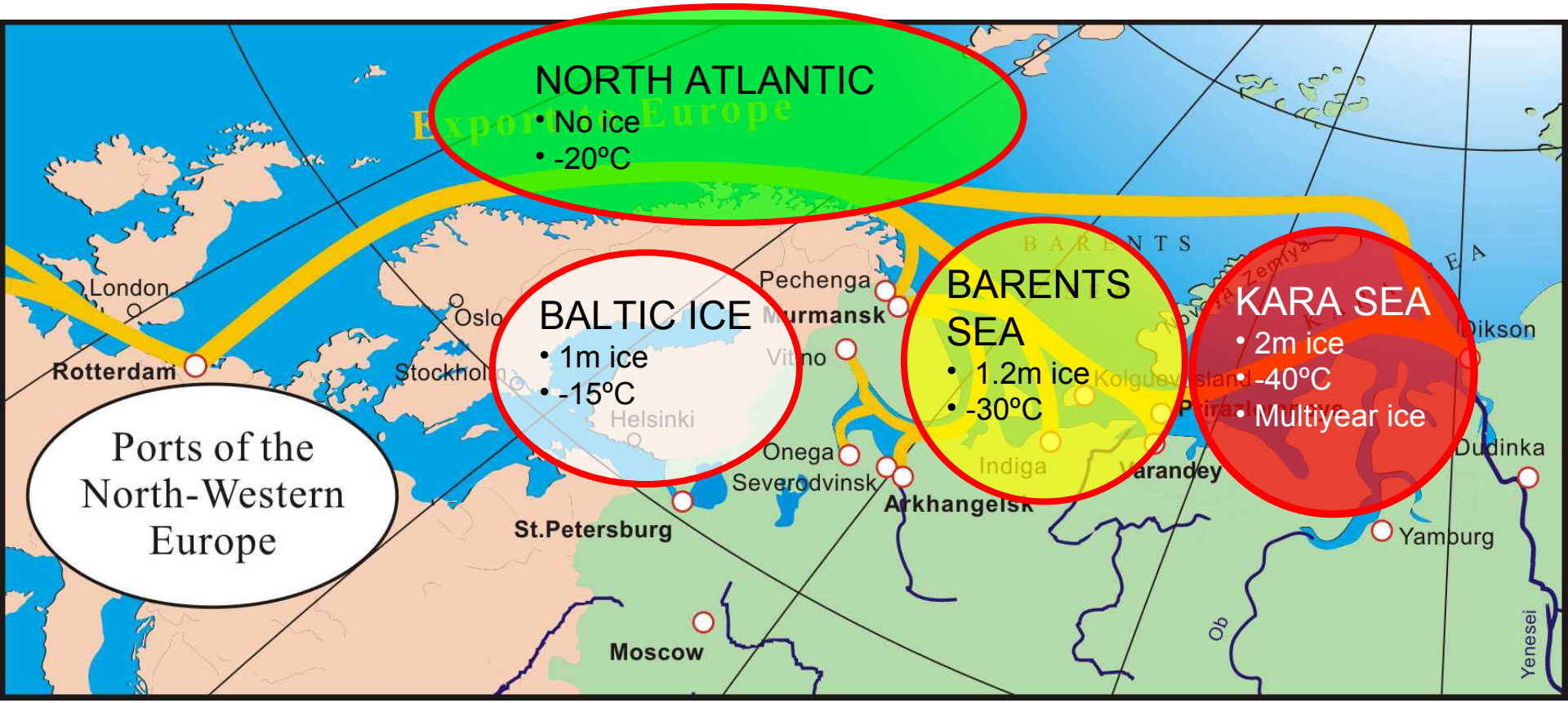
Export of oil & gas from Barents and Kara Seas.



Laboratory of Icebreaking Technology of CNIIMF

The Scene is Changing

Ice thicknesses and ambient temperatures

Area	Ice thicknesses (cm)
The Baltic (Gulf of Finland/Gulf of Bothnia)	40/80
The Caspian Sea	70
Azov Sea (Black Sea)	70
The White Sea	80
Barents Sea (Arctic)	*120*
The Sea of Okhotsk (East Siberia/Sakhalin)	*140*
The Kara Sea (Arctic)	*180*

Temperature levels in the Baltic are normally in the -15^0 C level, while -35^0 C is typical for the Arctic.

Typical hazards when operating in cold climate

Overstress of hull

Lack of good ice reports/routing

Ice restriction vs. commercial pressure on master

Propulsion failure

Stuck in ice, crushing of hull or drifting aground

Remote from rescue and spare parts

Ships use same ice channel/ convoy: risk of collision?

Extreme temperatures (- 50 C)

Icing (stability, safety functions, cargo operations)

Black-out (freezing of ship, crew, difficult restart).

Evacuation problems in ice

Malfunction of fire fighting

Experience/competence

Crew fatigue (additional work load, low temperature, noise/vibrations, 24 hrs darkness)

Ice accreation (icing)

Wind
+
Waves
+
Low airtemperature
+
Open water
=
Icing

Icing, - a serious challenge..

- **High Wind Speed**

  Usually above 18 kts or 9 m/s but sometimes low

- **Low Air Temperature**

  Below freezing (-1.7 oC)

- **Low Water Temperature**

  Usually below +7 oC

Icing …

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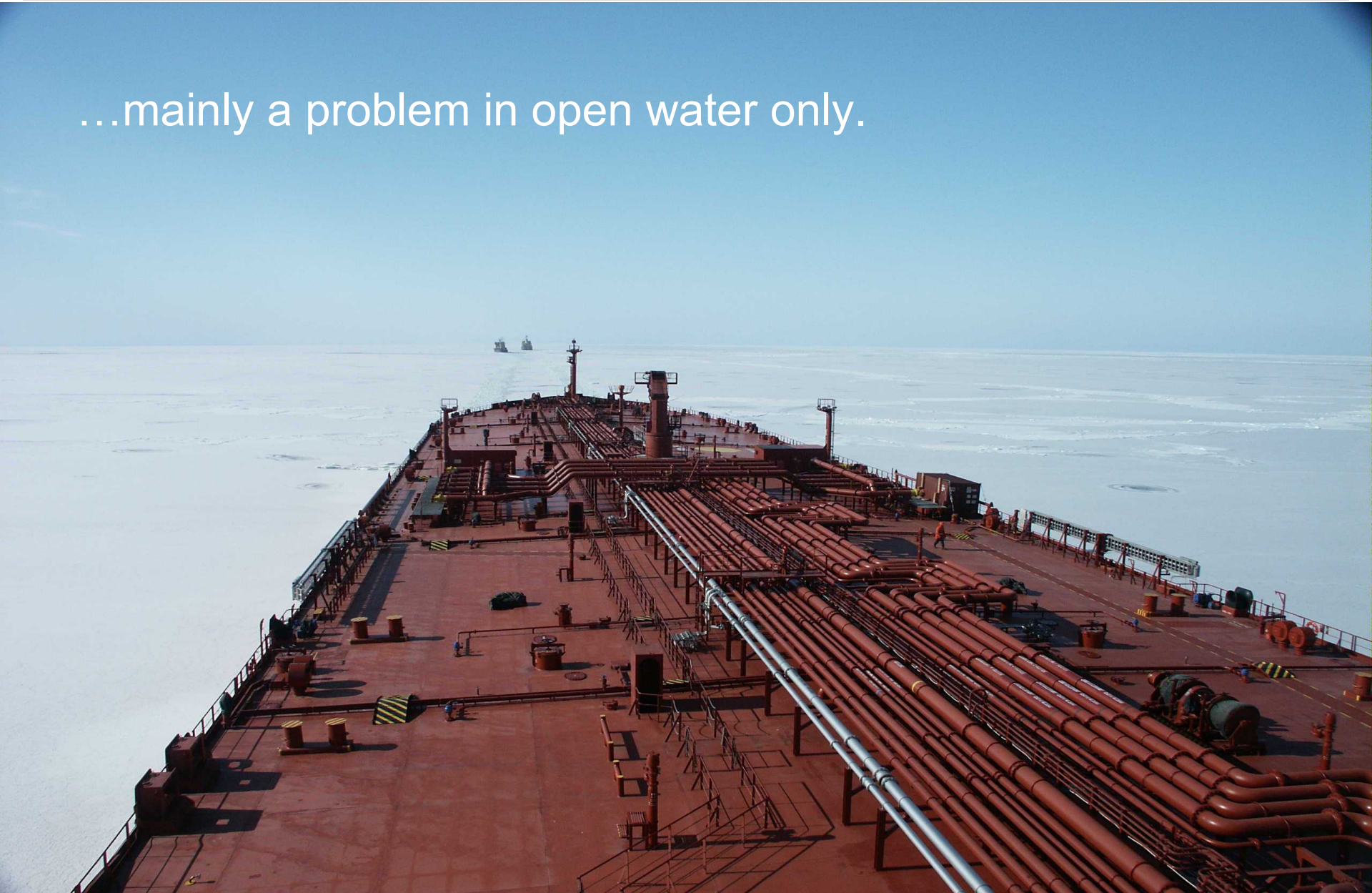

Icing

Need for de-icing arrangements to maintain safety of ship and

Source:

Access to forecastle and forward liferaft severely hampered by presence of ice

Ice strengthening is not new….

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"In all vessels that may have to steam through ice, the frames at the extreme forepart are to be closer than here directed, or some other sufficient additional strengthening of the vessel's forepart must be adopted."

DNV's leading market position…

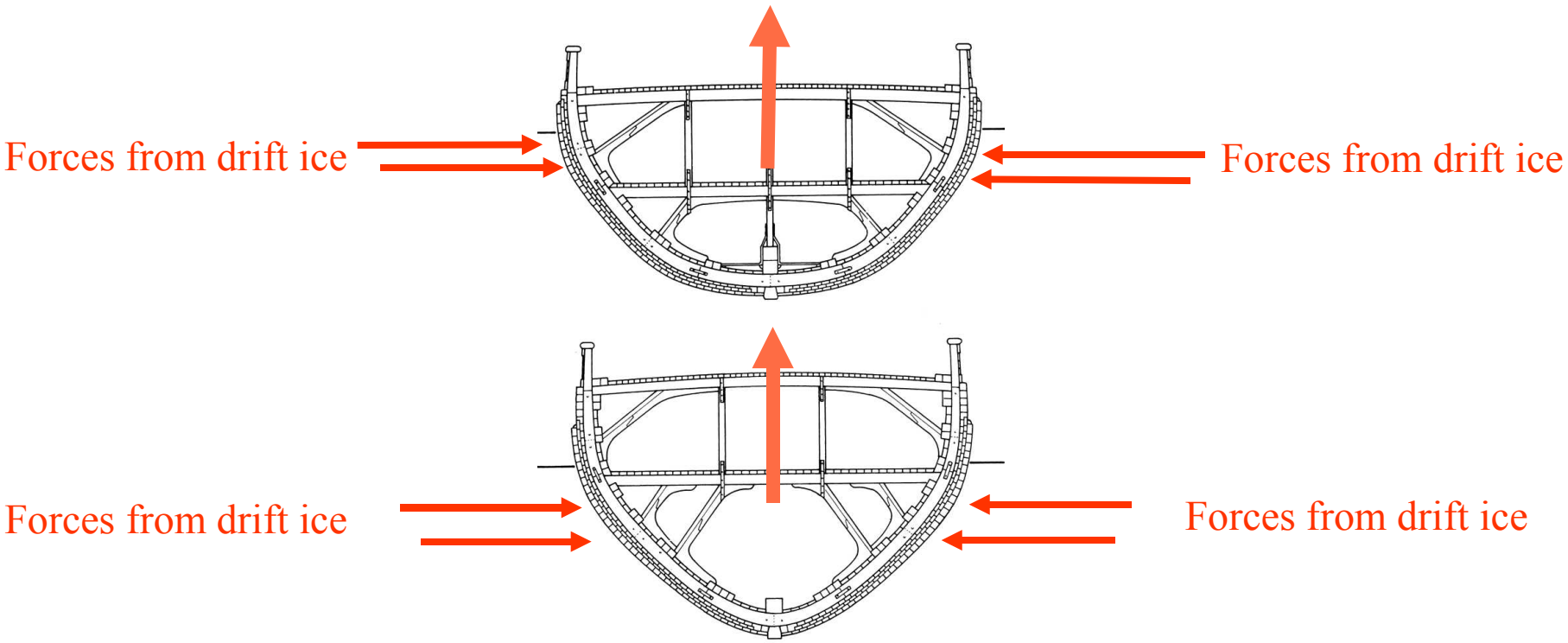
"Fram" in the Arctic, 1893

--- is based on long Norwegian history of cold climate ship operations

- *"Fram"* was built to survive in severe Arctic drift ice, by the Norwegian explorer and Nobel Peace Price Laurate, Fridtjof Nansen. He used *"Fram"* for his expedition to reach the North Pole in 1893 as the first man.
- *"Fram"* was later used by the Norwegian explorer Roald Amundsen to the Antarctic when he was the first man to reach the South Pole in 1911.

Managing Cold Climate Risks

Cross sections of *"Fram"*, built 1892,

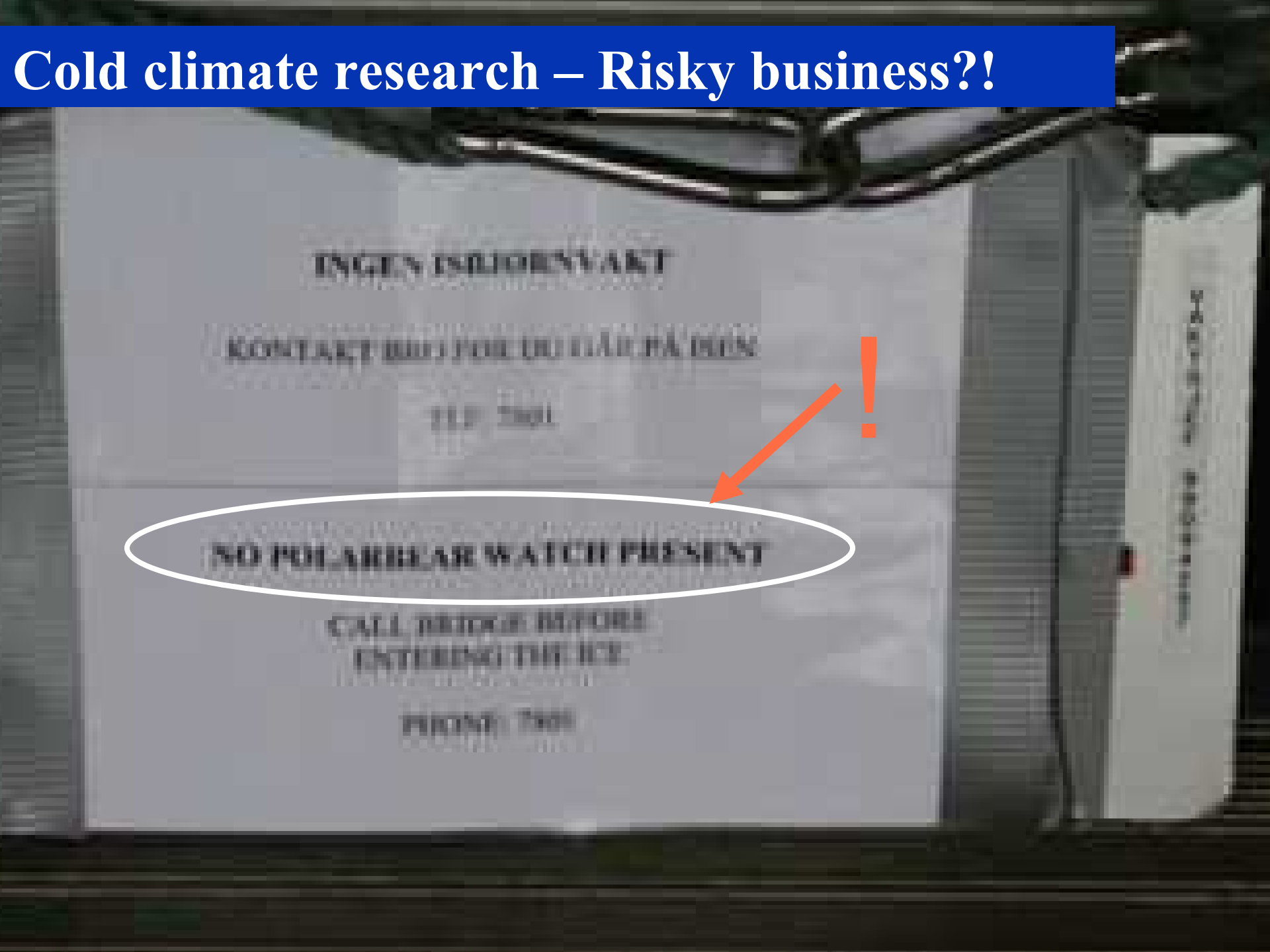


Ice forces would lift the vessels out of the ice, and save her.

A brilliant example of practical risk management.

COLD CLIMATE RESEARCH BY DNV

Cold climate research – Risky business?!



DNV Rules and other requirements - Hull

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DNV Class Notations	Equivalent Baltic Ice class	Vessel Type	Ice Conditions	Impact Limits
ICE-C		- All ship types	Very light ice condition	No ramming
ICE-1C	**1C**		- First year ice and **broken channel** 0.4 m ice thickness	
ICE-1B	**1B**		0.6 m ice thickness	
ICE-1A	**1A**		0.8 m ice thickness	
ICE-1A*	**1A Super**		1.0 m ice thickness	
ICE-1A*F			1.0 m ice thickness	
ICE-05 **ICE-10** **ICE-15**		- Vessels intended for ice breaking - Built for another main purpose	First year ice with pressure ridges	
POLAR-10 **POLAR-20** **POLAR-30**			Multi year ice with glacial inclusions	Accidental ramming
ICEBREAKER		Icebreaking is main purpose		Repeated ramming

Availability of ice breakers?

Are they wide enough?

Items covered by Ice-Class Notation (Baltic, Arctic and Polar)

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The following areas are subject to requirements depending on the ice class selected.

- **BALTIC ICE CLASSES**
  - Hull – ice belt
  - Machinery output
  - Shaft – system
  - Propeller
  - Mooring
  - Heating ballast tanks
  - Sea chest
  - Air capacity for starting compressor (1A*)
  - Rudder and steering gear
  - Corrosion protection
- **ARCTIC ICE NOTATION (ADDITIONAL SCOPE)**
  - Hull girder transverse strength, line loads due to vessel being trapped between moving ice flows.
- **ARCTIC POLAR AND ICEBREAKER NOTATION (ADDITIONAL SCOPE)**
  - Hull materials exposed to low temperatures (DAT-notation)
  - Subdivision, intact and damage stability (additional requirements)
  - Hull girder longitudinal strength due to beaching and ramming
  - General information

The Russian requirements

MANAGING RISK DNV

Ship category	Operation modality	Winter-spring sea navigation					Summer-autumn sea navigation				
		Barents Sea	Kara Sea	Laptev Sea	East Siberian Sea	Chukchi Sea	Barents Sea	Kara Sea	Laptev Sea	East Siberian Sea	Chukchi Sea
		EHML	EHML	EHML	EHML	EHML	EHML	EHML	EHML	EHML	EHML
LU4	IO	---+	----	----	----	----	++++	--++	---+	---+	--++
	IA	-*++	---+	----	----	---*	++++	*+++	--++	-*++	-*++
LU5	IO	--++	---+	----	----	----	++++	-+++	--++	--++	--++
	IA	*+++	--*+	---+	---+	--*+	++++	*+++	*+++	*+++	*+++
LU6	IO	*+++	---+	---+	---+	---+	++++	++++	-+++	-+++	-+++
	IA	++++	**++	-**+	-**+	-*++	++++	++++	++++	++++	++++
LU7	IO	++++	--++	---+	---+	--++	++++	++++	++++	++++	++++
	IA	++++	++++	*+++	*+++	*+++	++++	++++	++++	++++	++++
LU8	IO	++++	++++	-*++	*+++	*+++	++++	++++	++++	++++	++++
	IA	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++

IO: Independent operation

IA: Icebreaker-assisted operation

\+ Operation permissible

\- Operation impermissible

* Operation associated with an increased risk of damage

E Extreme navigation conditions (average recurrence once every 10 years)

H, M, L : Heavy, medium, light navigation conditions (average recurrence once every 3 years)

DNV classification Rules for Cold Climate

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Mandatory

Class/Statutory (basic)

- Hull strength/fatigue
- Corrosion
- Coating
- Machinery
- SOLAS/MARPOL/LL

- Additional class notations
  - **PLUS**
  - **CSA-2**
  - **F-AMC**
  - **NAUT**

Normally required

Ice Class Baltic/Arctic

- Ice strengthening
  - Rudder/ stock
  - Hull
  - Propeller/ shaft
- ME output
- Sea chest arr.
- Ballast water anti freezing

WINTERIZED ARCTIC (material °C, extreme °C)

- Built to ARCTIC or ICEBREAKER class
- Requirements to CP propeller, or diesel/electric
- Propeller material (austenitic stainless steel or equiv.)
- Two engine rooms for Power, AUX, and heating
- **OPP-F** and Oil outflow index less than 0.01 (ref. MARPOL)
- Helicopter landing facilities
- Life saving and navigation equip certified for low temperatures

WINTERIZED (material °C, extreme °C)

- Built to BALTIC or ARCTIC ice class
- Requirements to location of safety equipment
- Requirements to steel grades, DAT(-xx) notation
  - Low temp. materials hull
  - Low temp. material equipment
  - Propeller material

WINTERIZED BASIC

- Arrangements for anti-icing and de-icing
- Heating of spaces with important equipment
- Arrangements and location of generator capacity

Human factors

- Comfort class
  - Noise
  - Vibrations
  - Indoor climate

From the Arctic to the world market: Crossing the World's most hostile Wave Environment

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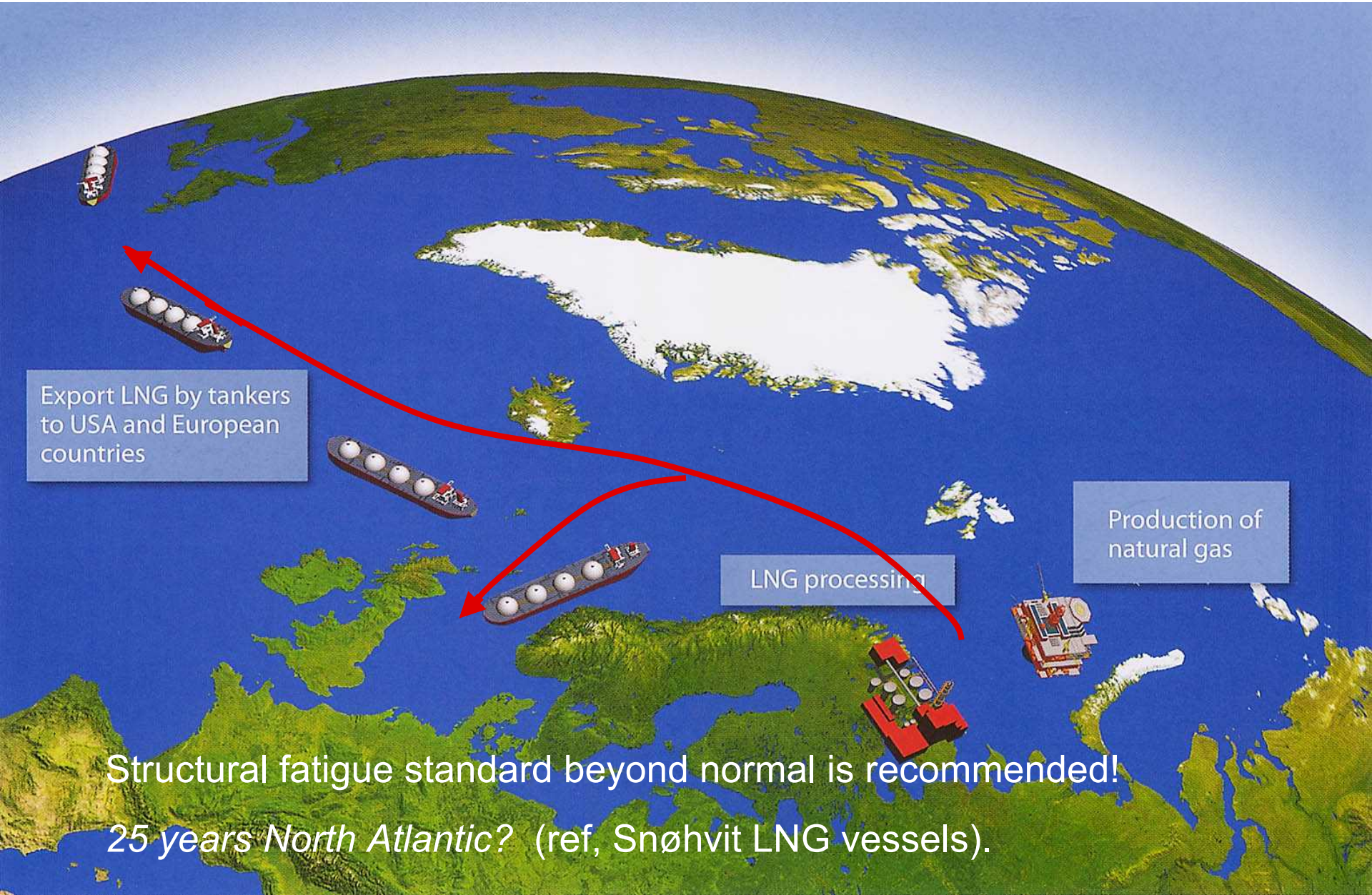

Structural fatigue standard beyond normal is recommended!

25 years North Atlantic? (ref, Snøhvit LNG vessels).

DNV's DEICE notation – Rule fundamentals

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- Maintenance of the main functions of the ship
- Manoeuvrability
- Stability related to icing
- Crew safety

DEICE - Rule Definitions

Ice accretion on the various equipment/areas has unequal importance on the vessel safety.

- **Category I** : to be kept completely ice free

- **Category II** : shall have de-icing arrangements removing ice within a reasonable period of time (4-6 hours)

LNG/C “Arctic Discoverer” (Snøhvit)

LNG/C “Arctic Discoverer”

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- Winterized for operation in the Barents Sea

Enlosed bridge wings


NO SMOKING

Avoiding icing problems, - methods

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- Protected location. Also with heating (i.e. adjacent to heated spaces or hot air ventilation).
- Protective covers
- Electric tracing (Note ex-requirements)
- Heating coils (steam/hot water)
- Ice-repellant coating
- Self-draining piping/operating procedures
- Circulation of liquids (e.g. hydr.oil)

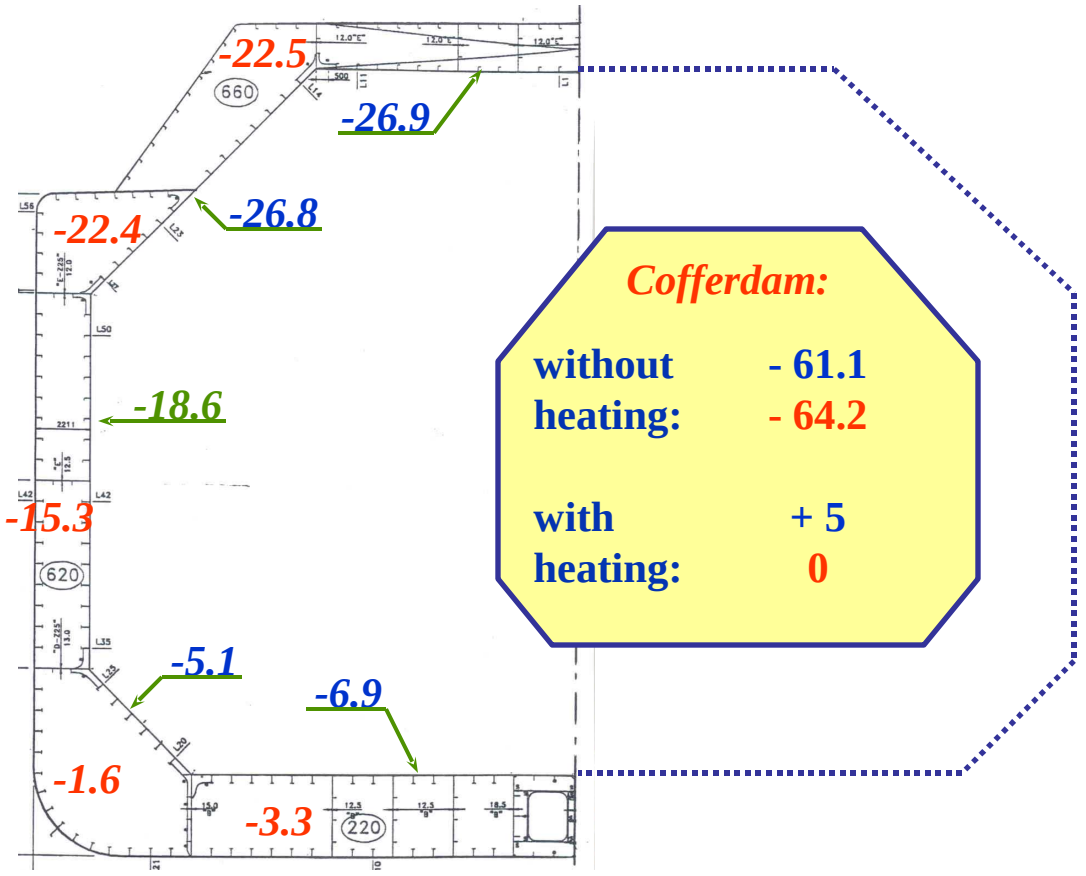
Selection of Steel Grades

Assumptions:

- LNG on secondary membrane
- Air temp.: - 18°C
- Sea temp.: 0 °C
- LNG temp.: - 163 °C

Insulation thickness:

Primary : 230 mm
Secondary : 300 mm



Blue: Inner hull steel temperature
Red: Compartment temperature

Resistance through ice-HSVA

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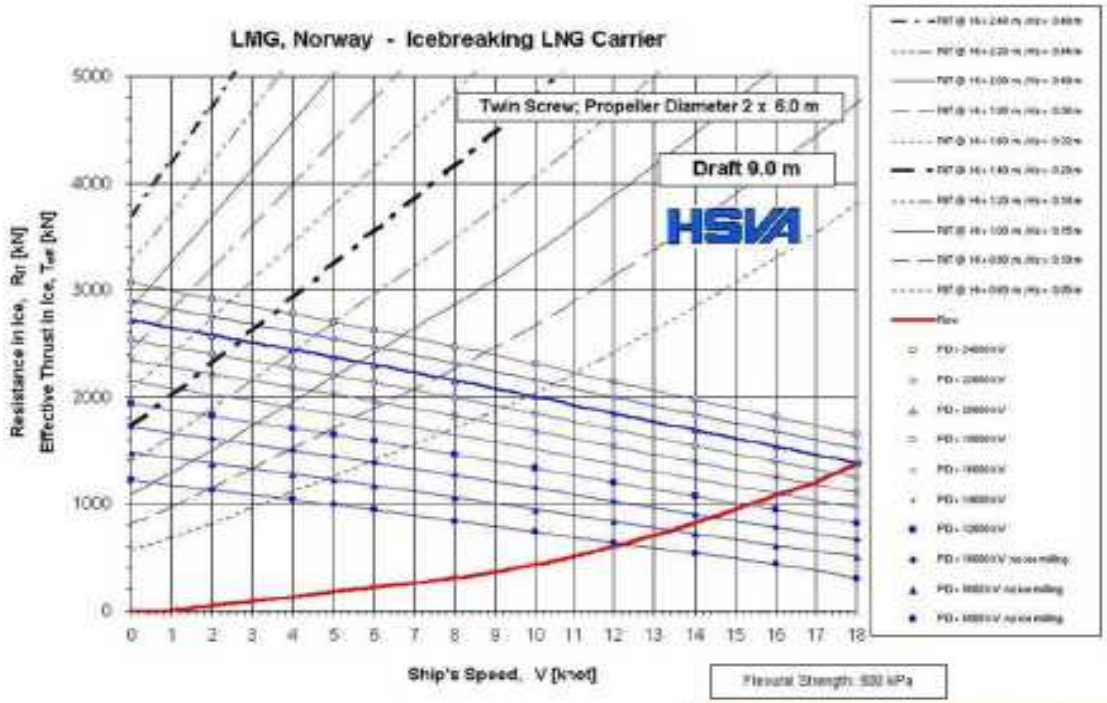
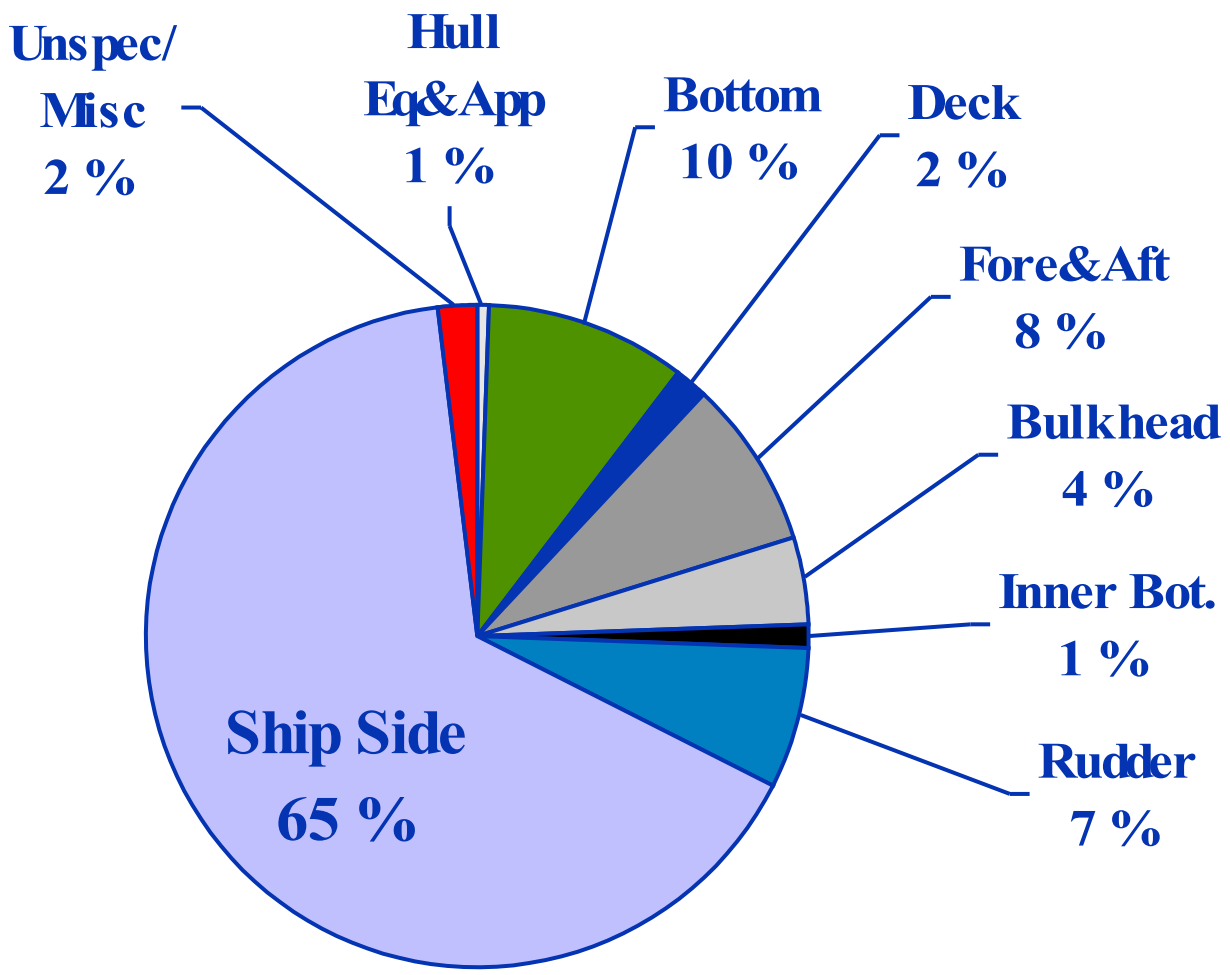
Resistance through ice



Example of speed through ice predictions from HSVA

- Determination of resistance through ice and ice loads
- Parametric exercise where size/capacity, speed and ice conditions are variables

Reported ice damages



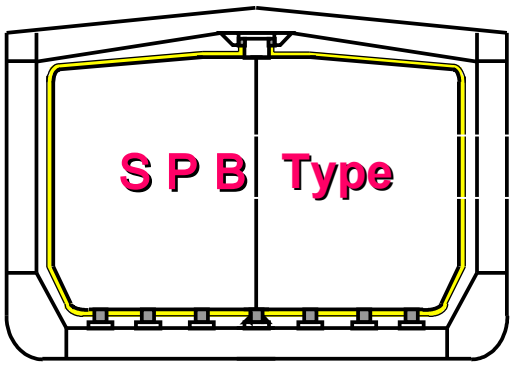
Total number of damages: 486

Source: DNV's Database

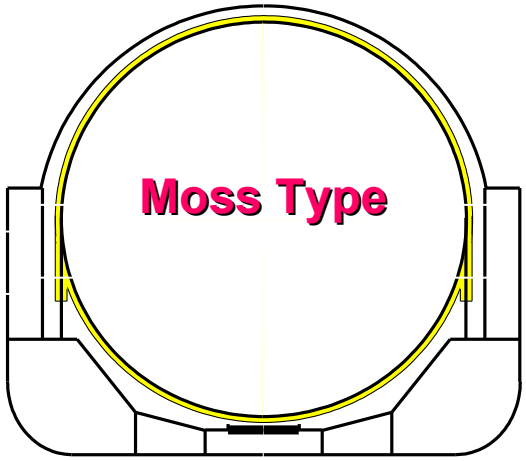
Ship getting stuck in compressive ice

Current LNG Carrier Containment Systems

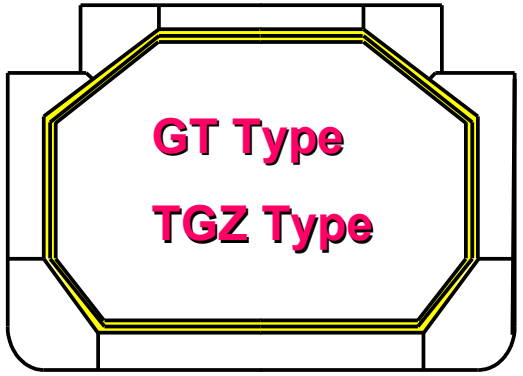
Independent prismatic tank



Spherical Tank



Membrane Tanks



Protection against Ice Pressure Damage

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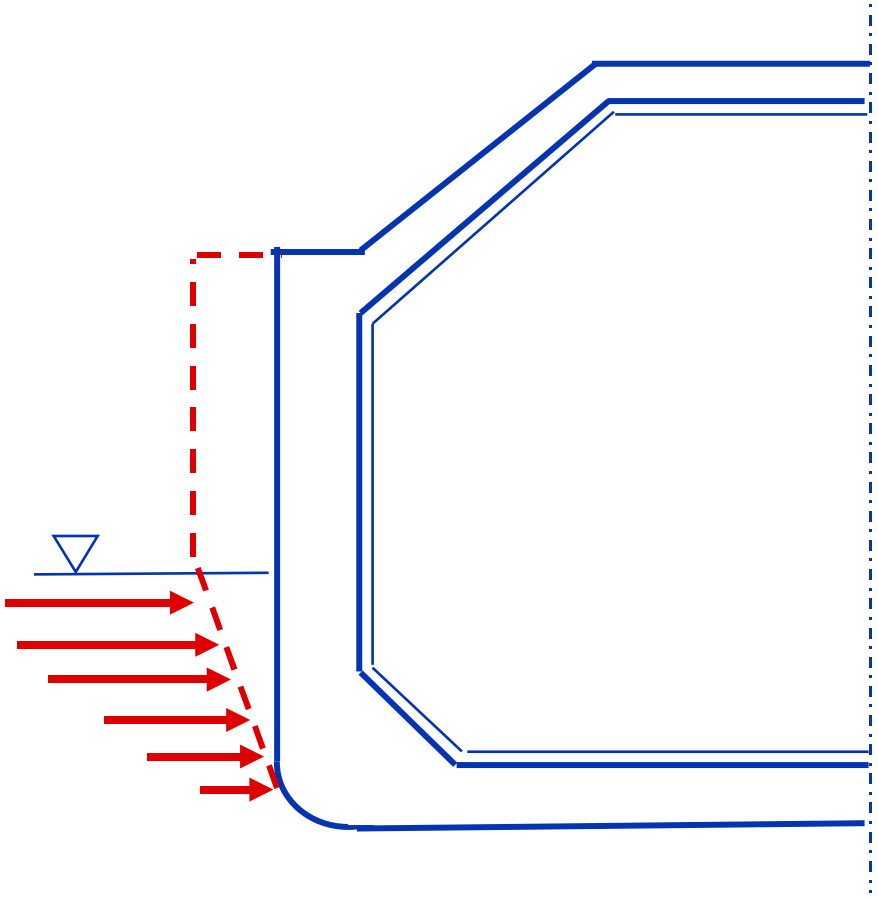
Membrane LNGC



Collision with Growlers and Bergy Bits in open waters

- Uncouple the containment system and the ship side leaving space for indentation of the side without damage/deformation of the containment system
- Increase double hull width
- Design for increased energy absorption capability of the double hull

Traversing through ice channel or the ship completely frozen in

- Design hull to lift the ship rather than pushing it down due to the ice pressure
- Increase double hull width
- Design a stronger protective outer hull, stiffer – less deformation

LNG Ice Operation – Possible Design Measures

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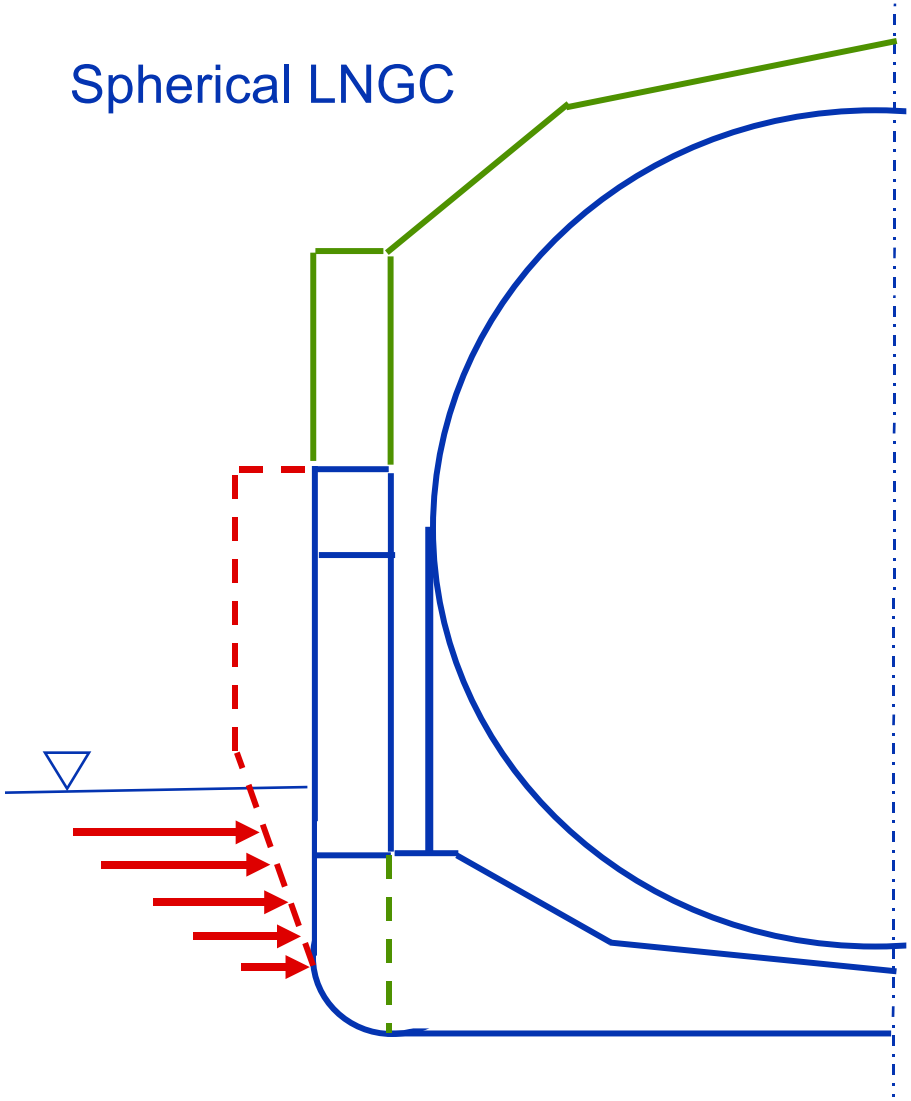

Collision with Growlers and Bergy Bits in open waters

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Traversing through ice channel or the ship completely frozen in

- Design hull to lift the ship rather than pushing it down due to the ice pressure

Protection against icing

- Continuous tank covers

Continuous tank cover as proposed by Aker Yards

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Arctic Shuttle LNG Carrier (~ 40 000 m3)

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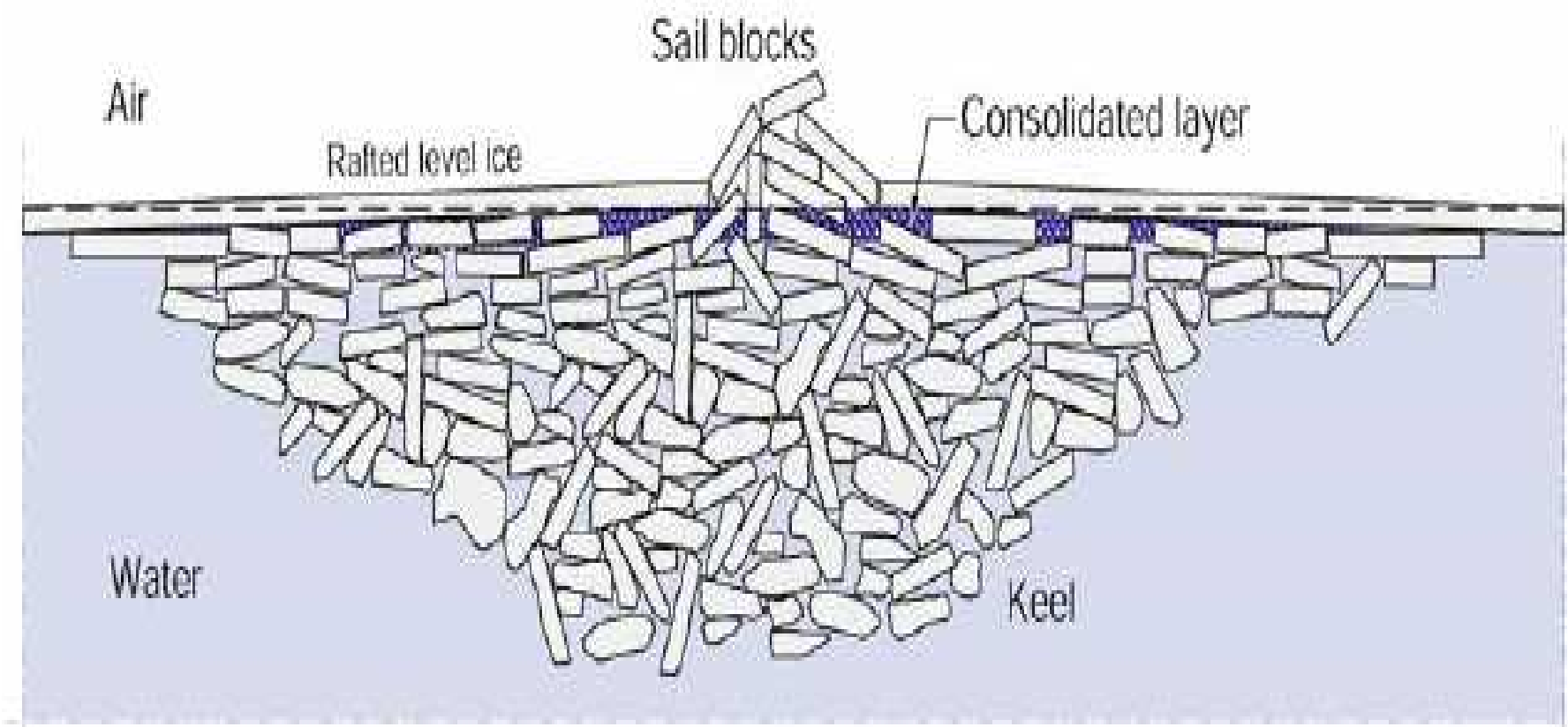
What can be seen is not the whole truth…….

Challenging ice conditions



Schematic cross-section of a first-year ice ridge (Jensen, 2002).

Competence and performance of crew is essential for safe operations

- Availability of experienced personnel?
- Training/experience!
- Increased manning?

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DNV

Source:

Challenges – human factors

- Extreme low temperatures
- 24 hours darkness
- Noise and vibrations in ice

→ Human Fatigue

Understanding the challenges?

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Comfort Class For Safety

Scope:

- Noise levels
- Vibration levels
- Indoor climate

Interior from LNG/C "Arctic Princess" (Snøhvit)

LNG/C operations in Cold Climate

Special considerations:

- Charterers must understand special challenges of cold climate operations (e.g. schedule, standards beyond minimum, manning, etc.)
- Continuity, – specialized and tailor made transportation chain. Impossible/difficult to find replacement tonnage in case of unscheduled off-hire.
- Need for redundancy beyond class requirements?
- Need for spare-parts beyond world wide trade?

Environmental issues

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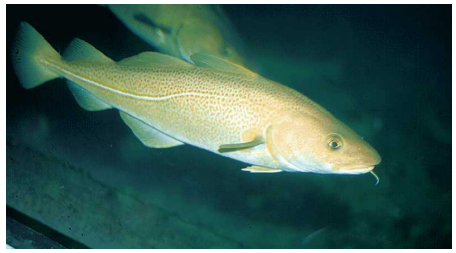
- Arctic is a sensitive ecological area:
  - "zero tolerance"
  - "zero discharge"
- Same environmental requirements as the tropics?
- Are shore based contingency plans/resources in place?

Challenge for the industry/national authorities:

- ***<u>Adequate response to the new situation</u>***
  - **Industry**: minimize risk level, apply high technical operational and emergency preparedness standards (e.g. *Oil Outflow Index* lower than Marpol ?)
  - **Authorities**: Establish contingency plans and emergency resources



Summary…..

- *Ship operations in cold climate is much more than ice strengthening of the ship alone.*

- *Compliance with basic ice class rules and regulations may be insufficient for safe and effective ship operations in cold climate*
- *Risk evaluation for specific trades and adequate "winterization" for safe and reliable operations must be carried out.*

End of Presentation…..

Thank you!