Respecting the Ice

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September 2010

Are you over 50 with a good driving record?

But it couldn't happen today

Presentation outline

- **What is ice?**
- **Why do we care?**
- **Safe operation in ice**
  - Design
  - Equipment
  - Crewing
  - Navigation

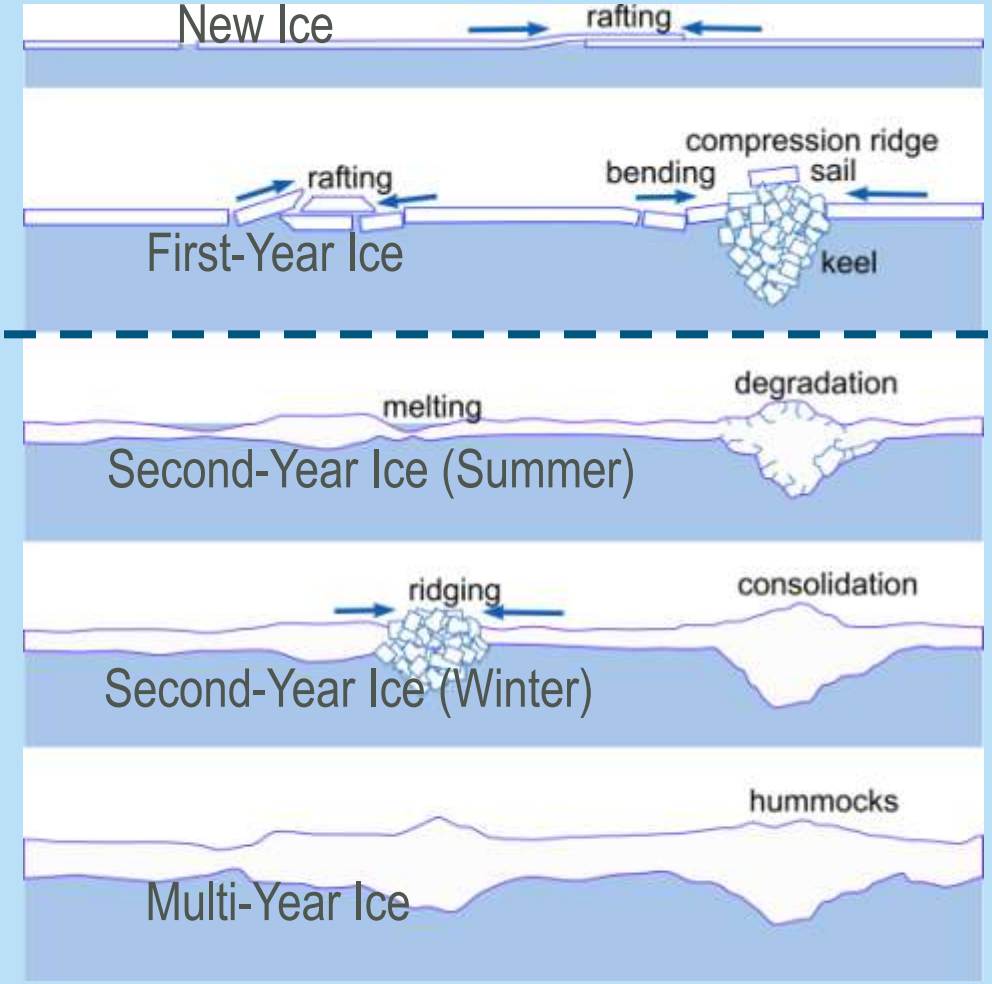
Ice

n 1: water frozen in the solid state; "Americans like ice in their drinks"
2: the frozen part of a body of water
3: (informal) diamonds; "look at the ice on that dame!"
4: a flavored sugar topping used to coat and decorate cakes
5: a frozen dessert with fruit flavoring (especially one containing no milk)
6: a heat engine in which combustion occurs inside the engine rather than in a separate furnace; heat expands a gas that either moves a piston or turns a gas turbine [syn: internal-combustion engine, ICE]
7: a rink with a floor of ice for ice hockey or ice skating; "the crowd applauded when she skated out onto the ice"
(source: dictionary.die.net

Development of Sea Ice

First season of freezing, rafting and ridge formation

Seasons of melting and Refreezing (Polar regions)



Second-Year and Multi-Year Ice Compared to First-Year Ice

Thicker ice features

Greater contact areas

Higher total forces

Higher average and peak pressures

Multi-year ice inclusion in first-year ice

(Source: BP Petroleum Development)

Icebergs

Are found at sea, but are not really ‘sea ice’. They are very old, and present a risk similar to other types of old ice

Eastern Canadian and Antarctic waters are especially prone to icebergs

Large berg s are not usually a risk, as they are (relatively) easy to see. The larger risk comes from bergy bits and growlers

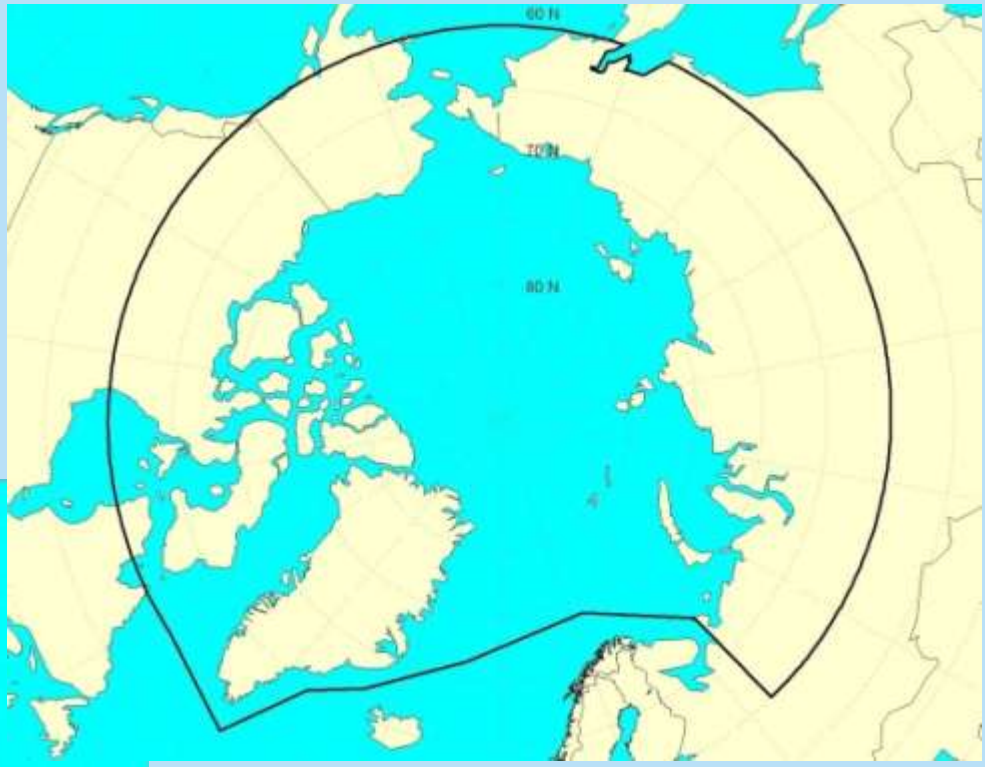
These smaller pieces have typically calved from larger icebergs. A typical ‘undetectable’ size can be 10,000+ tonnes

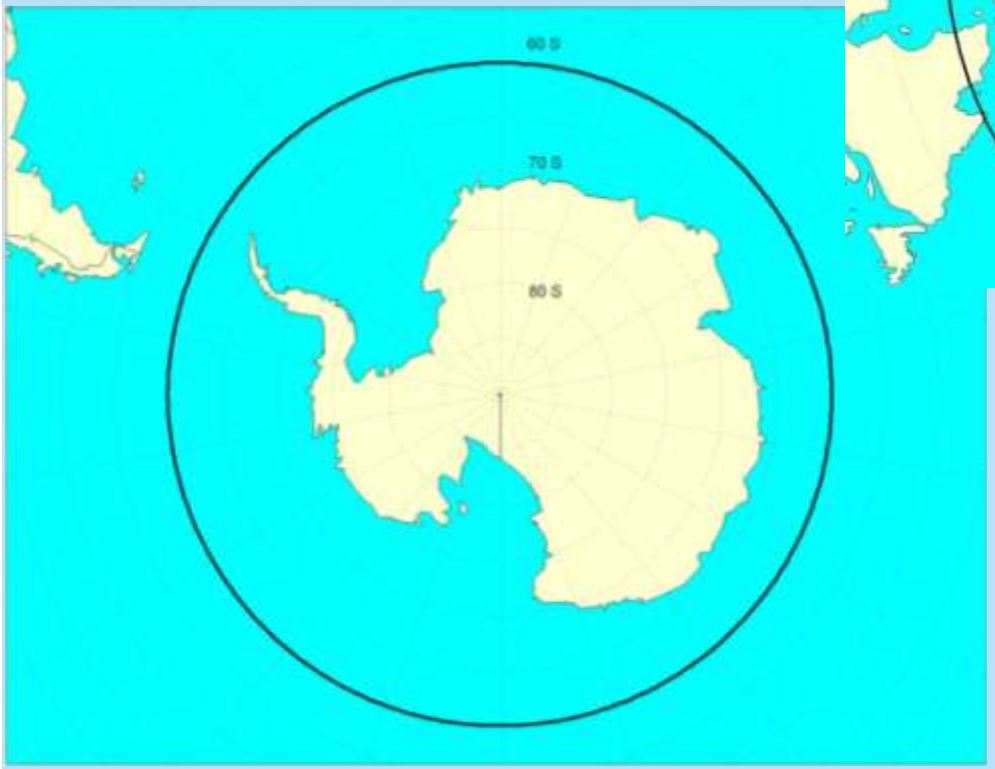
Why do we care?

- Shipping in ice-infested waters is going to increase in the coming years
- New types of operation will be undertaken
- Effective risk management needs knowledge, and an appreciation of the “known unknowns”

Situation Today

Polar Waters





Shipping Activity

Traffic is predominantly during the polar summers

The Arctic Marine Shipping Assessment program derived traffic statistics for 2004 base year. The main types of shipping included:

- Community re-supply
- Bulk cargo transport
- Tourism (24 cruise ships, with 195 ‘port’ calls)
- Fishing

Some categories are increasing rapidly; e.g. in 2008 39 cruise ships made 375 port calls

Antarctic shipping activity remains relatively modest, but also with upward trends

Resource Development

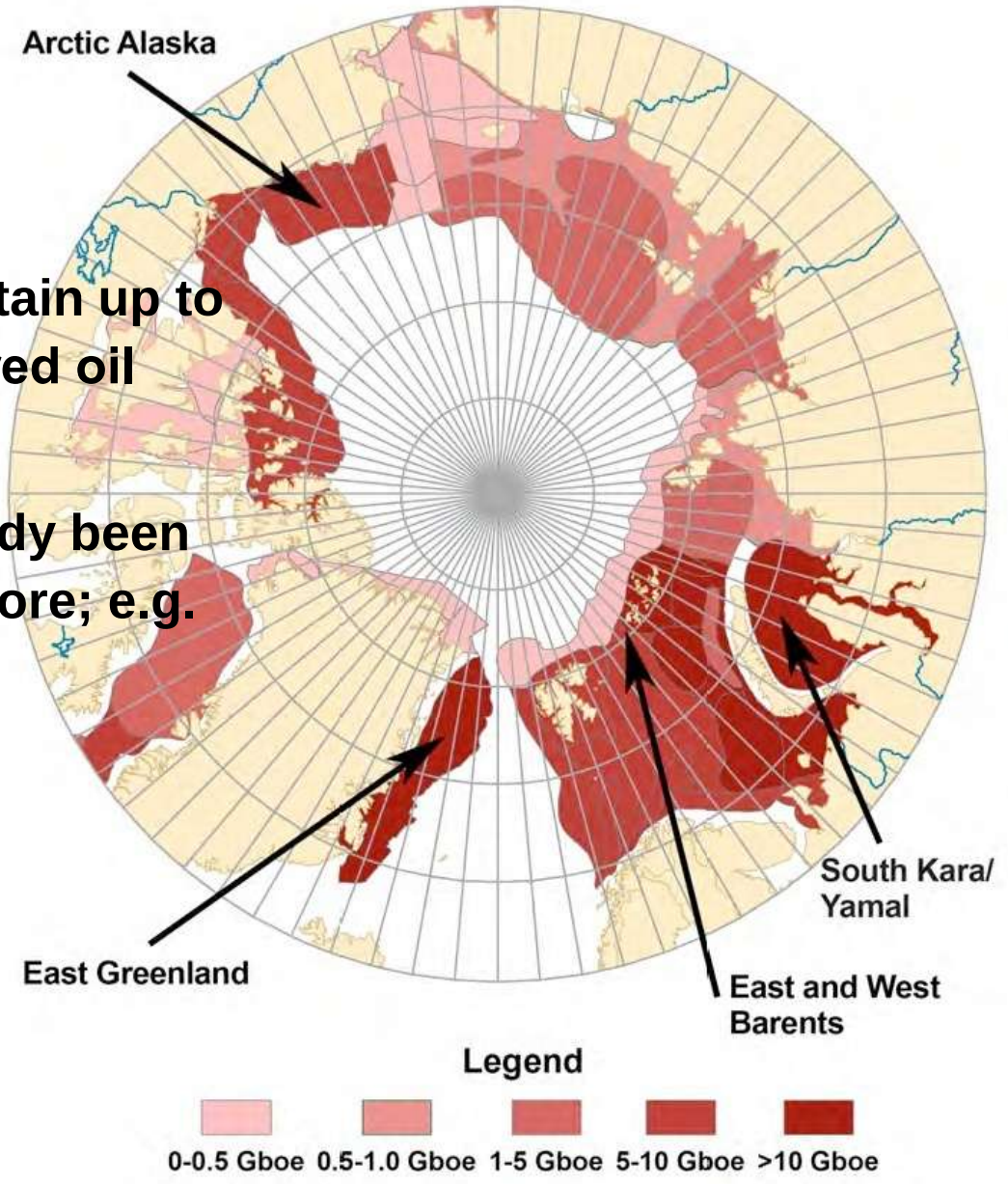
- **Oil and Gas**
  - Offshore
  - Onshore
- **Bulk Minerals**
- **Precious metals, etc**

Oil and Gas

The Arctic is estimated to contain up to 25% of the world's undiscovered oil and gas reserves (USGS).

Several giant fields have already been discovered offshore and onshore; e.g.

- Shtokman
- Yamal
- North Slope Alaska
- Mackenzie Delta
- Arctic Islands

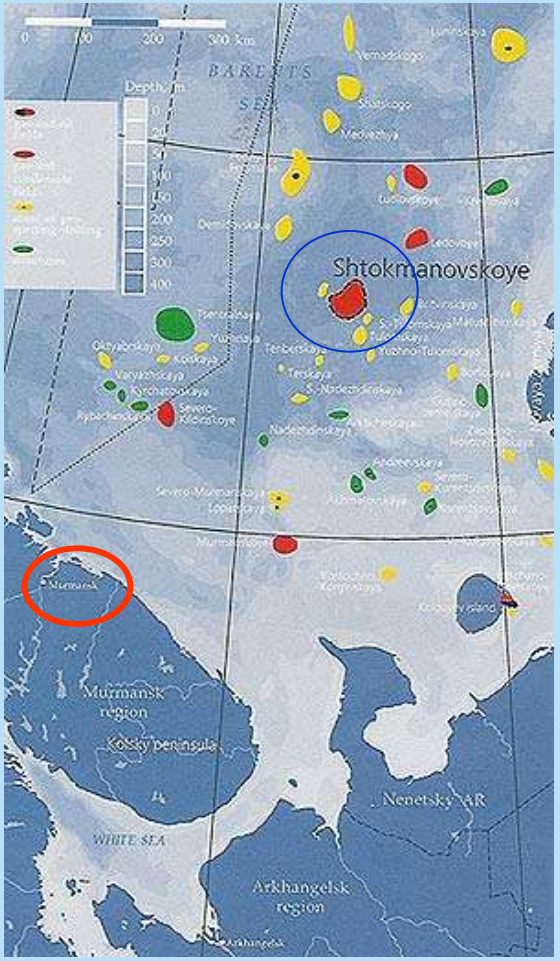


Oil and Gas Development

Offshore fields will have marine components for exploration, drilling, and production.

Onshore fields may have large marine components for development due to lack of infrastructure. Heavy lift by ship and barge is envisaged for many projects.

Transportation of oil and gas (LNG, etc) from both offshore and onshore projects may be by sea for many reasons.



Shtokman Fields

New Generation Arctic Tankers

Bulk Minerals

Major bulk/concentrate operations currently are nickel (Norilsk, Raglan, etc) and lead/zinc (Red Dog)

Future developments may include iron ore (Baffinland), copper, nickel, zinc, lead and other metals

For oil and gas, pipelines are an option but with almost no Arctic infrastructure bulk mineral shipments will almost certainly use marine transportation

New Generation Bulk Cargo Carriers

Umiak

Norilskiy Nickel

Other Arctic Resources

Both the North American and Russia Arctic have significant deposits of high-value mineral resources:

- Gold
- Uranium
- Diamonds
- Platinum

Depending on location, development and resupply may have marine transportation requirements

Polar cruising

- **Larger, generally low ice class ships**

- **Smaller, higher ice class**
- Customized
- Icebreakers

Safety in Ice

- Design
- Equipment
- Crewing
- Operations

Design

- **Define the operational requirement**
  - Where?
  - When?
  - How fast?
  - How reliably?
- **Select the right Ice Class**
  - Baltic Class?
  - Polar Class?
  - Other?
- **Understand that Ice Class is only the starting point**
  - Most services will have special characteristics
  - Put strength where you need it

Operational Requirement

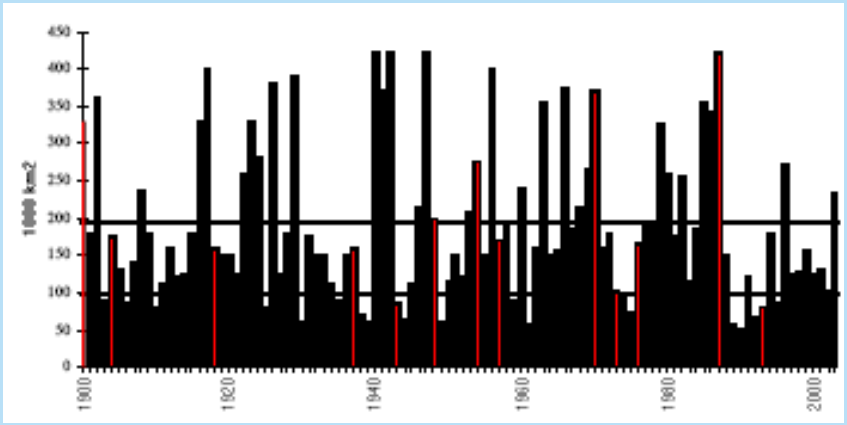
Ice conditions are highly variable season-to season and year-to-year

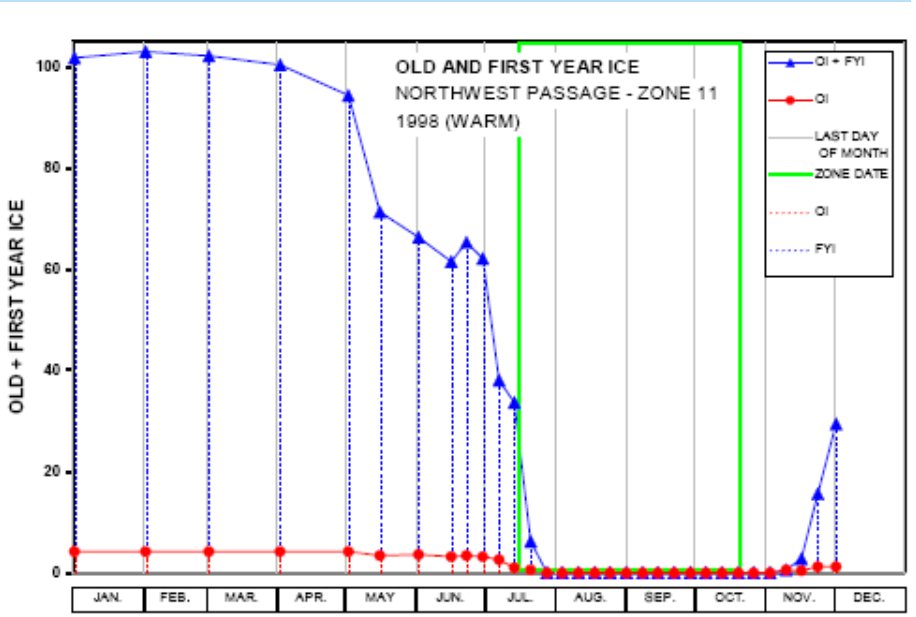
Design for extremes? – very expensive

Design for averages?

– is delay/failure an acceptable option?

- can you develop a back-up plan?





Ice Class options

Baltic (Finnish-Swedish)

- Well established and relatively familiar (though significantly amended in recent years)
- Must be understood as part of the overall Baltic navigation system
- May of may not be well suited to other applications

Polar (IMO/IACS)

- Developed specifically for polar waters
- Explicitly physics based – facilitates use in other scenarios

Other

- Russian – mandated for Northern Se Route and other Russian waters
- Class – being subsumed into Polar/Baltic

Polar Class – Links IMO and IACS requirements

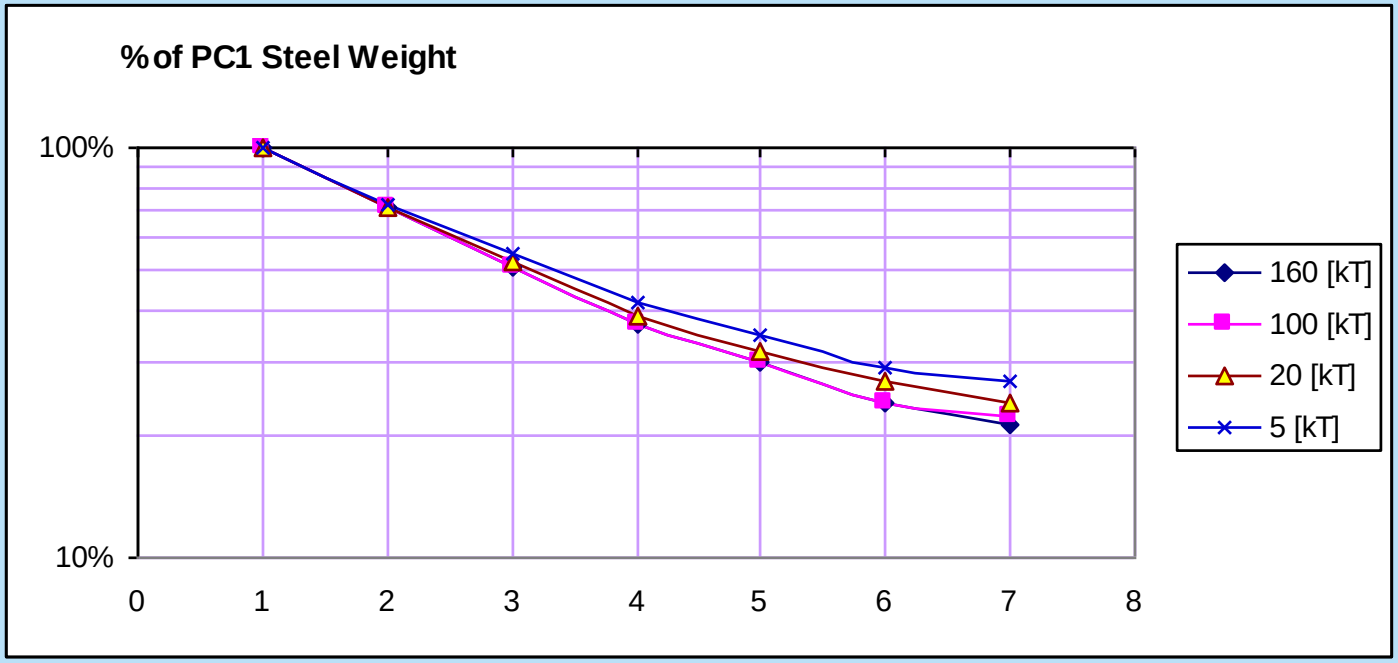
Polar Class	Ice Description (based on WMO Sea Ice Nomenclature)
PC 1	Year-round operation in all Polar waters
PC 2	Year-round operation in moderate multi-year ice conditions
PC 3	Year-round operation in second-year ice which may include multi-year ice inclusions.
PC 4	Year-round operation in thick first-year ice which may include old ice inclusions
PC 5	Year-round operation in medium first-year ice which may include old ice inclusions
PC 6	Summer/autumn operation in medium first-year ice which may include old ice inclusions
PC 7	Summer/autumn operation in thin first-year ice which may include old ice inclusions

Ice Class implications

Structural weight increases rapidly with ice class

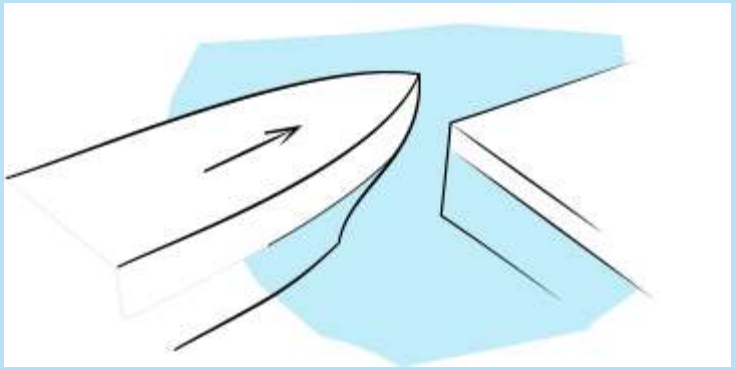
Strength buys the potential for extending safe operations

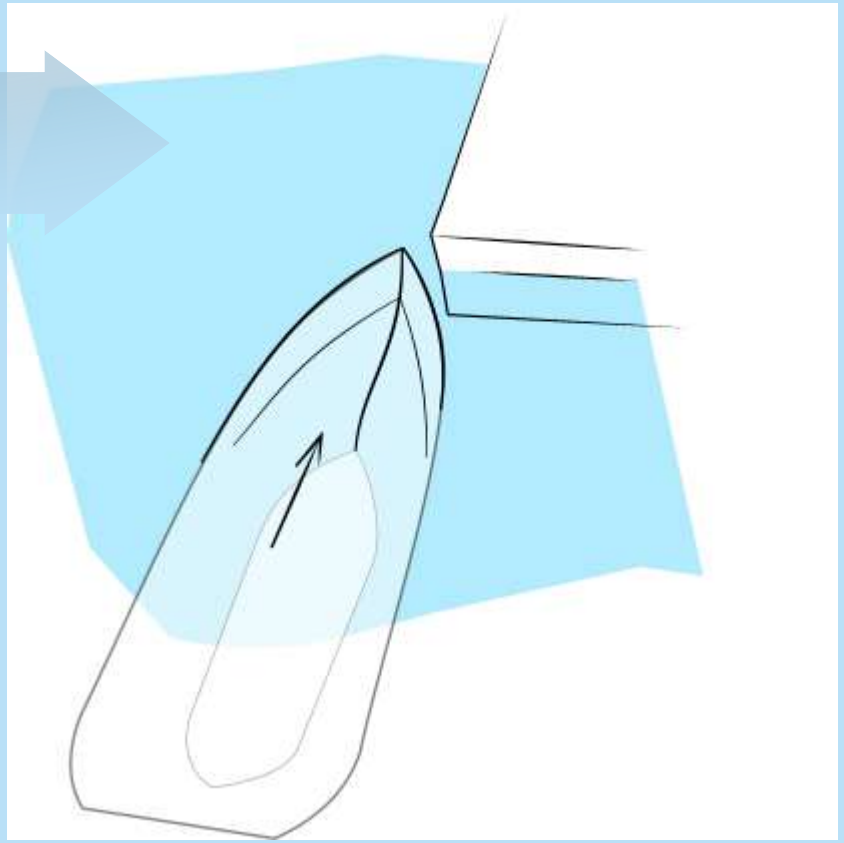
Operators, designers need a full understanding of operational requirements before selecting base ice class, and any supplementary features



Polar Class Design Point

Scenario: ship striking an ice edge.





Ice Load Derivation

Normal Kinetic Energy = Ice Indentation Energy

↓

Find indentation → Find force, area, pressure.

$$\frac{1}{2}\frac{M_{ship}}{Co}\cdot\left(V_{ship}\cdot l\right)^2 = Po\cdot ka^{1+ex}\int_0^{\delta m}\delta^{2+2\cdot ex}\cdot d\delta$$

Solve for δ

-then solve for Force

Speed dependency

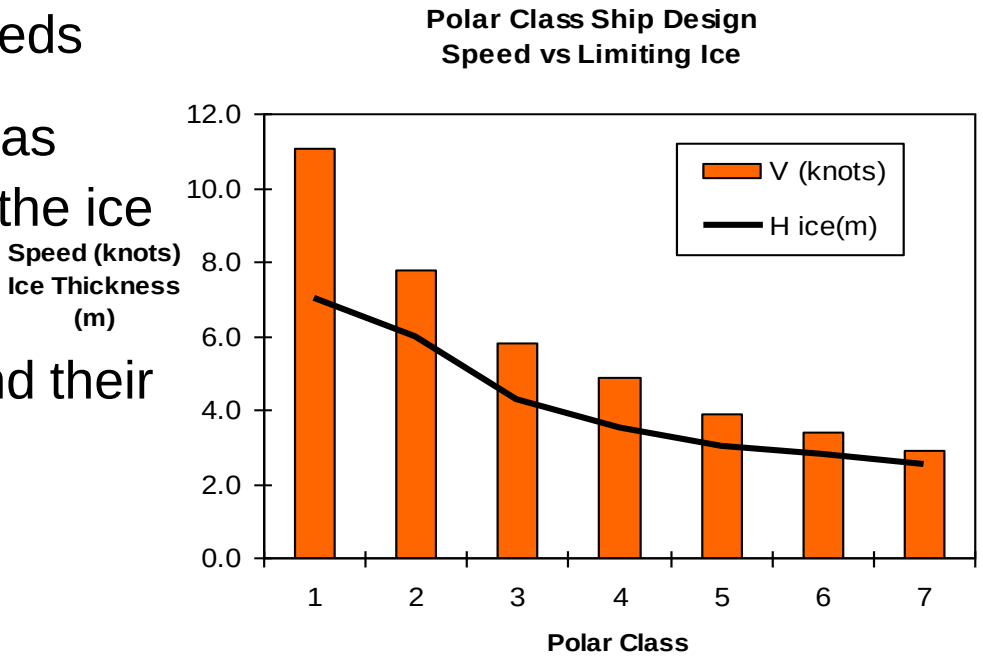
FMA Baltic Guidelines:

Recent observations on ice damages on ice strengthened vessels indicate that most of the damages on hull occur at an early stage of the winter season. These ships are probably operated at open sea at a high speed when the ice coverage is less than 10. Damages on the hull may thus occur when the vessel hits an ice floe at high speed.

Speed dependency

Impact velocity is a key parameter in the IACS Polar Rules loads, but:

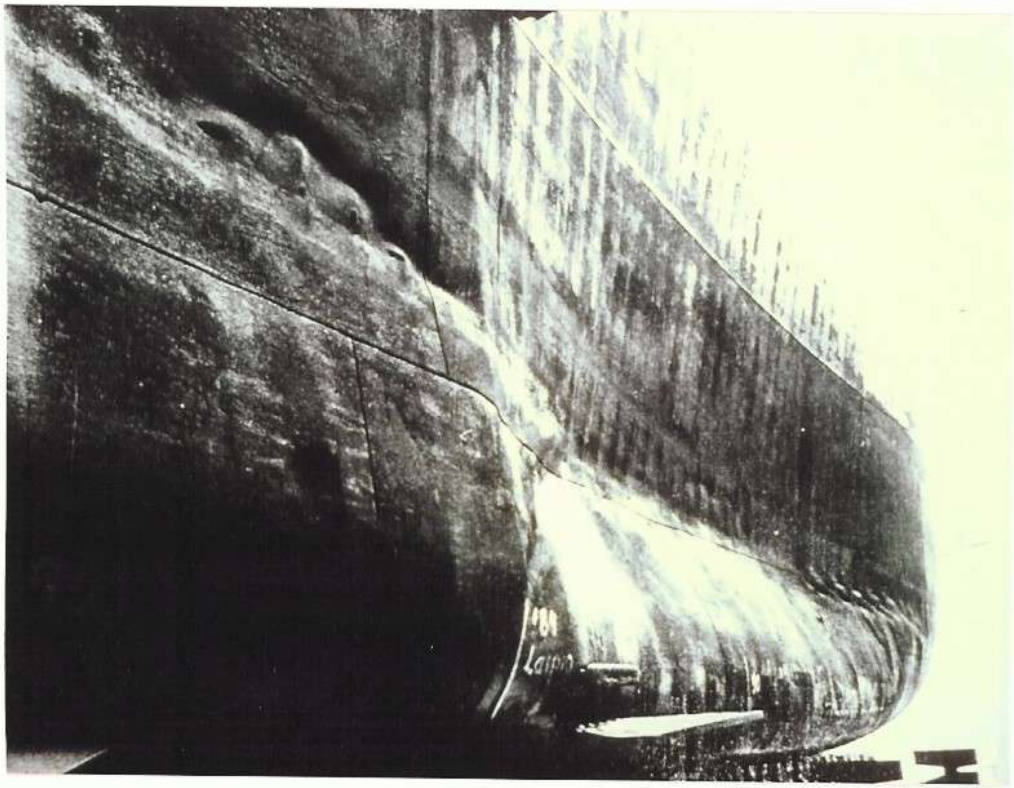
- Values in class factors are nominal
- Different vessel types may need to sustain higher (or lower) speeds
- Selection of class should be as much about speed as about the ice conditions
- Operators need to understand their vessels' limits

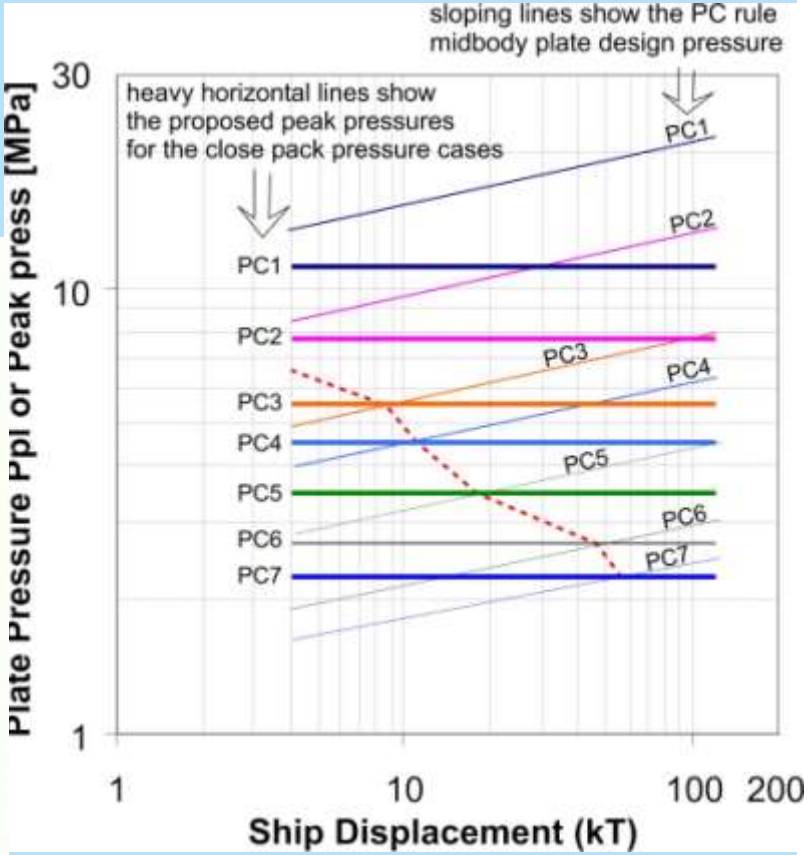


Other dangerous interaction scenarios exist

e.g. pressure, which is common in some areas.

Risk can be assessed and designed for





Equipment

Ship systems and equipment and personnel must be selected and configured for cold, ice accretion, etc

Protection of key safety systems such as firefighting apparatus, anchoring, towing and lifesaving equipment is essential

Water inlets and discharges, engine air supply arrangements must be properly designed

Winterization

Class rules and guidance notes are useful as checklists. Examples include:

- **ABS *"Guide for Building and Classing Vessels Intended for Navigation in Polar Waters"***
- **DNV Winterization Notations: WINTERIZED, WINTERIZED ARCTIC, DEICE, DAT**
- **Lloyds Winterisation Notations: Winterisation H (hull), Winterisation A, B, C (machinery)**

All of these cover similar subject matter, but there are substantive differences (e.g.) in the selection of design temperatures and in the consequent effects on materials and equipment. This can have major impacts on cost.

Crewing

“The navigation of the Polar seas, which is peculiar, requires in a particular manner, an extensive knowledge of the nature, properties and usual motions of the ice, and it can only be performed to the best advantage by those who have long experience with working a ship in icy conditions.”

- William Scoresby 1820

BMT Fleet Technology

Martech Polar Consulting ltd.

Crewing Challenges

- **Few suitably experienced and qualified personnel**
- **No standardization of national/international requirements/certification**

  IMO Definition of Ice Navigator
  "have documentary evidence of having satisfactorily completed an approved training program in ice navigation."

- **Training programs are under development by various organizations; not yet consistent**
- **Simulator training improving but limited**

Enfotec

Transas

Operations

- **Planning**
- **Navigating**
- **Emergency Response**

Voyage (Passage) Planning

Can the route be changed?

- Ice information
- Bathymetry
- Environmental impact

Can the voyage be supported?

- Escort/Ice management/Teaming

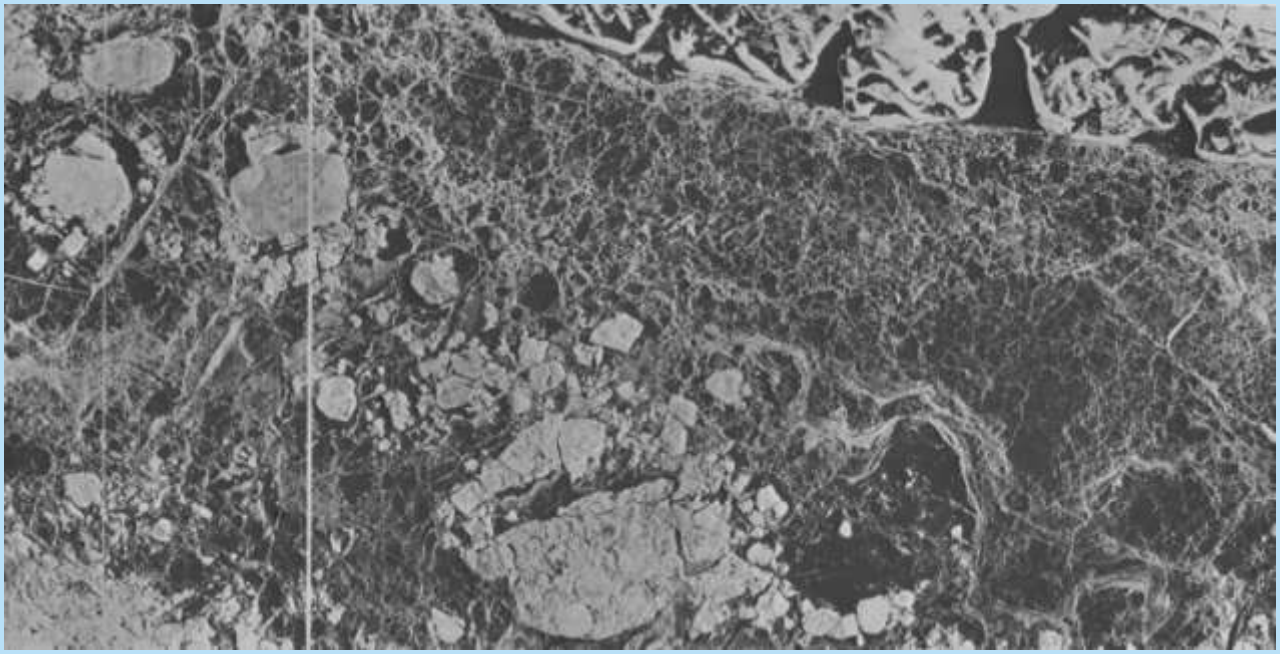
Can the voyage be delayed?

- Season
- Mission

Can the voyage be abandoned?

Navigating

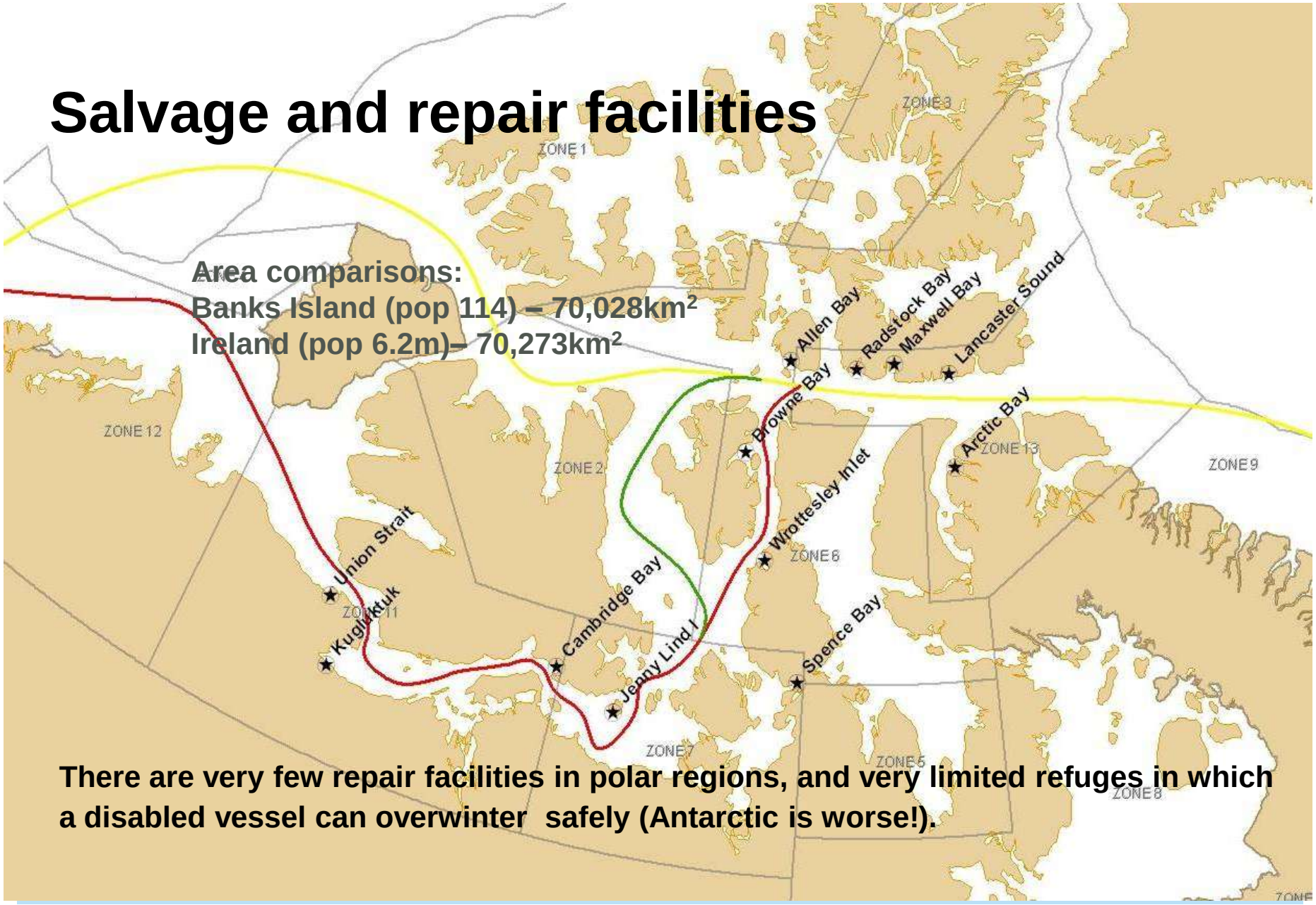
- Are key systems functioning?
- Is Environmental data available (Ice and weather?)
- Are operating procedures (e.g. escort) available and understood?



Emergency Response

- **Salvage and Repair**
- **Escape, Evacuation and Rescue**
- **Pollution Response**

Salvage and repair facilities



Area comparisons:
Banks Island (pop 114) – 70,028km²
Ireland (pop 6.2m)– 70,273km²

There are very few repair facilities in polar regions, and very limited refuges in which a disabled vessel can overwinter safely (Antarctic is worse!).

Escape, Evacuation and Rescue

If ship abandonment is needed:

- LSA nominal capacities do not account for bulky cold weather clothing or survival suits
- Liferafts have very low survivability in pack ice conditions, and other severe limitations
- Standard lifeboats have limited ice capability and little inherent winterization
- Offshore industry has been proactive in seeking better solutions; shipping (largely) has not

Rescue is likely to take a long time

Pollution Response

- **Clean-up of oil in ice-infested waters is very difficult – burning is the most effective technique**
- **Persistence of oil in cold water is much higher than in warm waters such as Gulf of Mexico**
- **Several national administrations have suggested ban on use and carriage of heavy oils in the Arctic**

Photo D. Dickins

Questions – please!