Krylov State Research Centre

R & D SUPPORT OF ARCTIC PROJECTS AIMED AT HYDROCARBON OFFSHORE PRODUCTION AND TRANSPORTATION

Vladimir Dyukov

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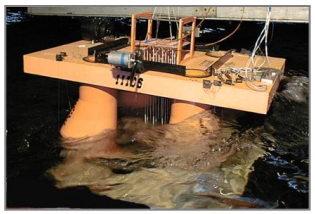
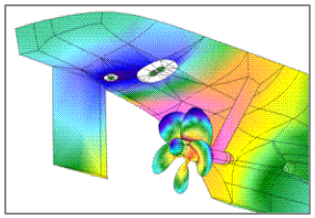
Krylov Centre - Profile





- Advanced engineering center
- Key vector – Arctic projects.
- Follows key requirements and development trends of oil & gas sector.
- Develops and implements advanced comprehensive R&Ds.
- High expertise in engineering and manufacturing know-hows.
- Unique experimental facilities.
- Satisfies international and Russian standards

R&D and Engineering:

- General design, integrated developments
- Hydro- & aero-dynamics
- Strength and structures
- Acoustics and physical fields
- Ship power engineering
- Propulsion systems
- Electric installations
- Standardization and communication systems

Globally acknowledged research center founded in 1894. Since that time:

- ✓ More than 1200 designs developed for ships and other offshore structures
- ✓ Tests of more than 12 thousand of models of ships and other engineering structures
- ✓ Designs for more than 10 thousand of propellers and other propulsors
- ✓ Tests of more than 20 thousand of half-sized and full-scale hull structures
- ✓ Expertise of more than 2000 designs of ships and other offshore structures

Specific conditions of Arctic shelf

Major requirements to arctic offshore facilities are attributable to natural environment and climate

- ice conditions,
- Arctic ecological features,
- onshore infrastructure
- presence of drowned objects with radioactive materials play the key role.

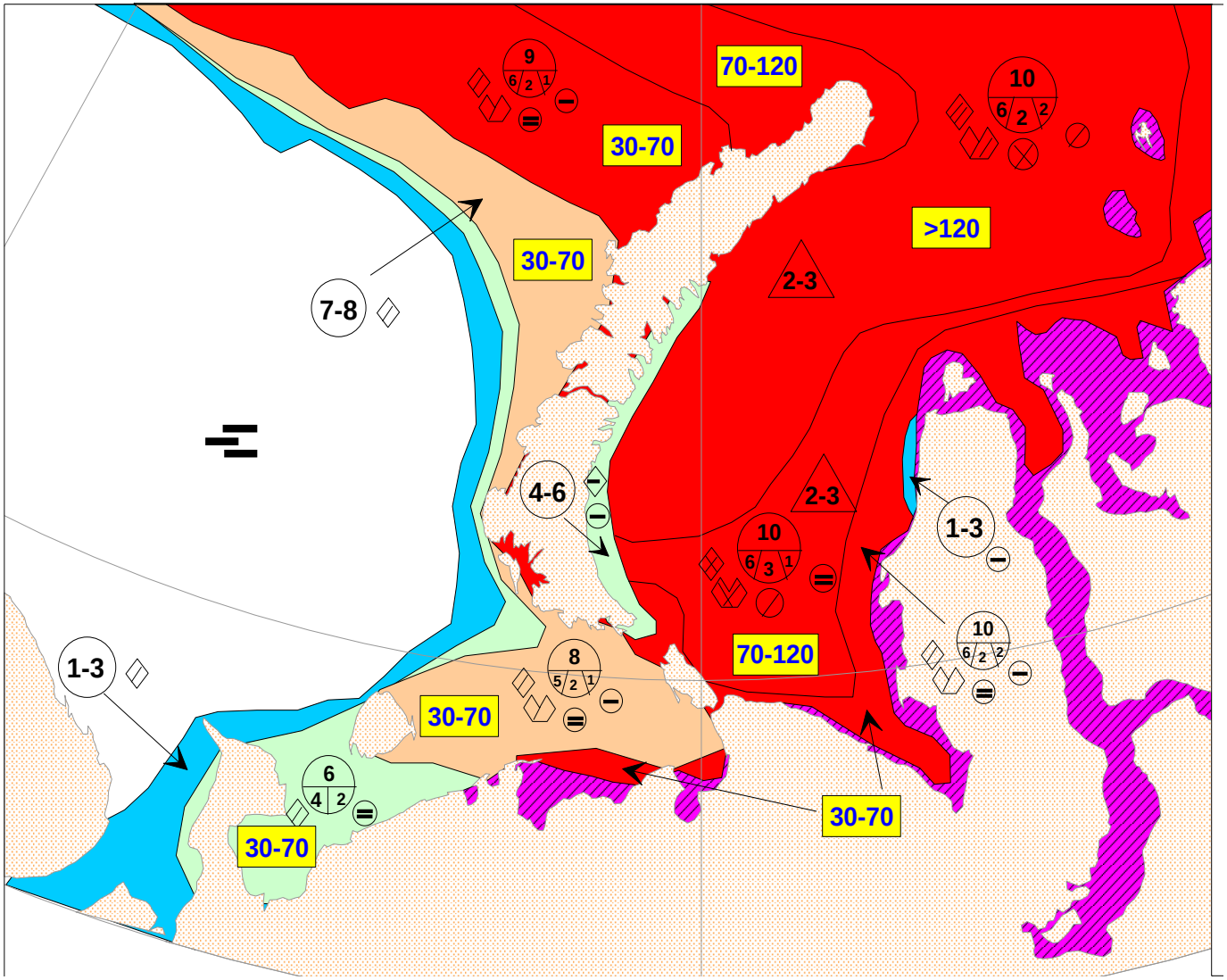
Non-uniformity of ice parameters

● The main body of ice cover is the first-year saline ice. Its strength is lower as compared to multi-year fresh pack ice in the Greenland region.

● Winds, currents, seabed slopes due to tides result in significant displacement of ice cover, ice cracks, hummocking, stamukhas (grounded ice).

● At the influxes of Siberian rivers strong and thick fresh ice is formed.

Kara sea / May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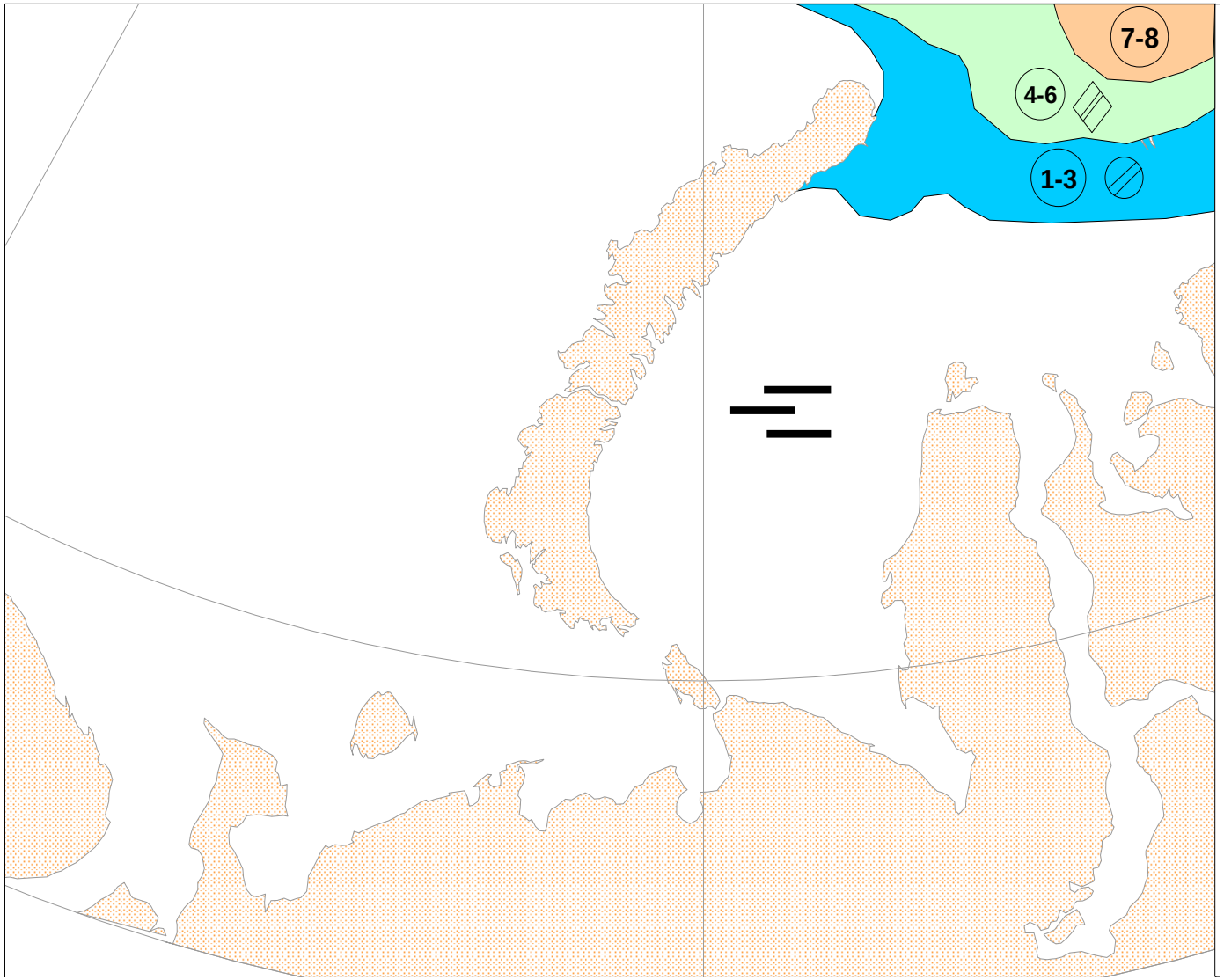
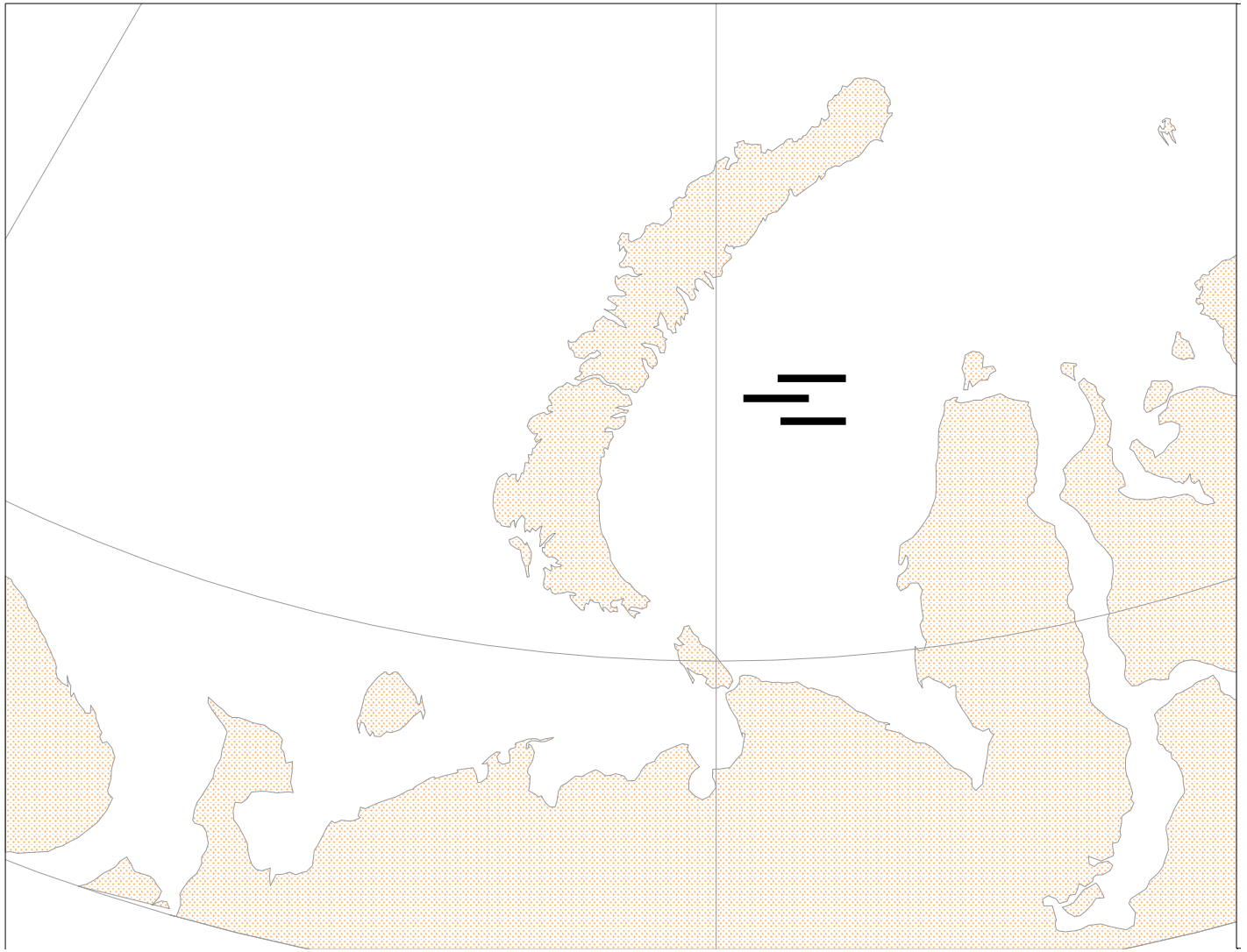
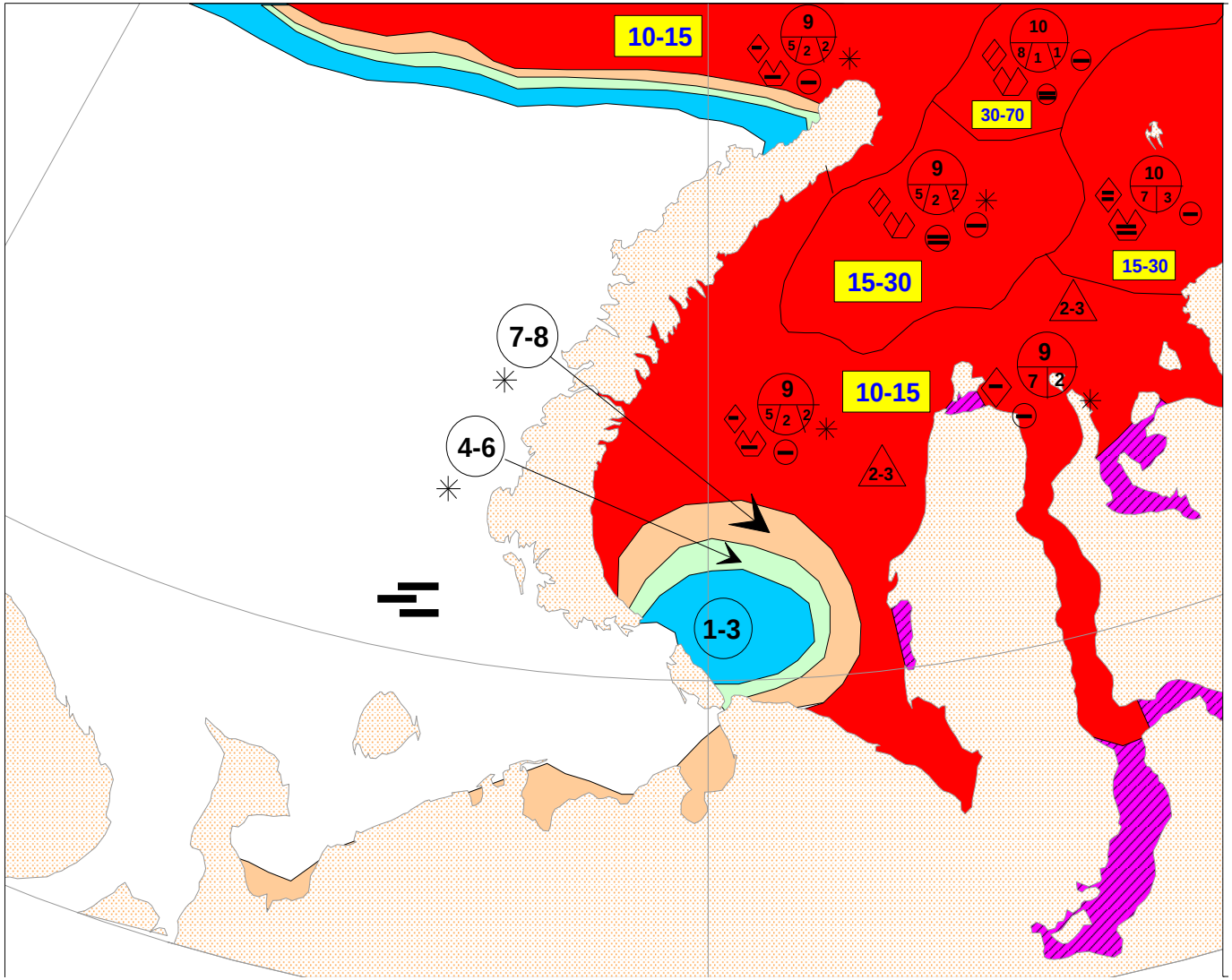
Kara sea / August



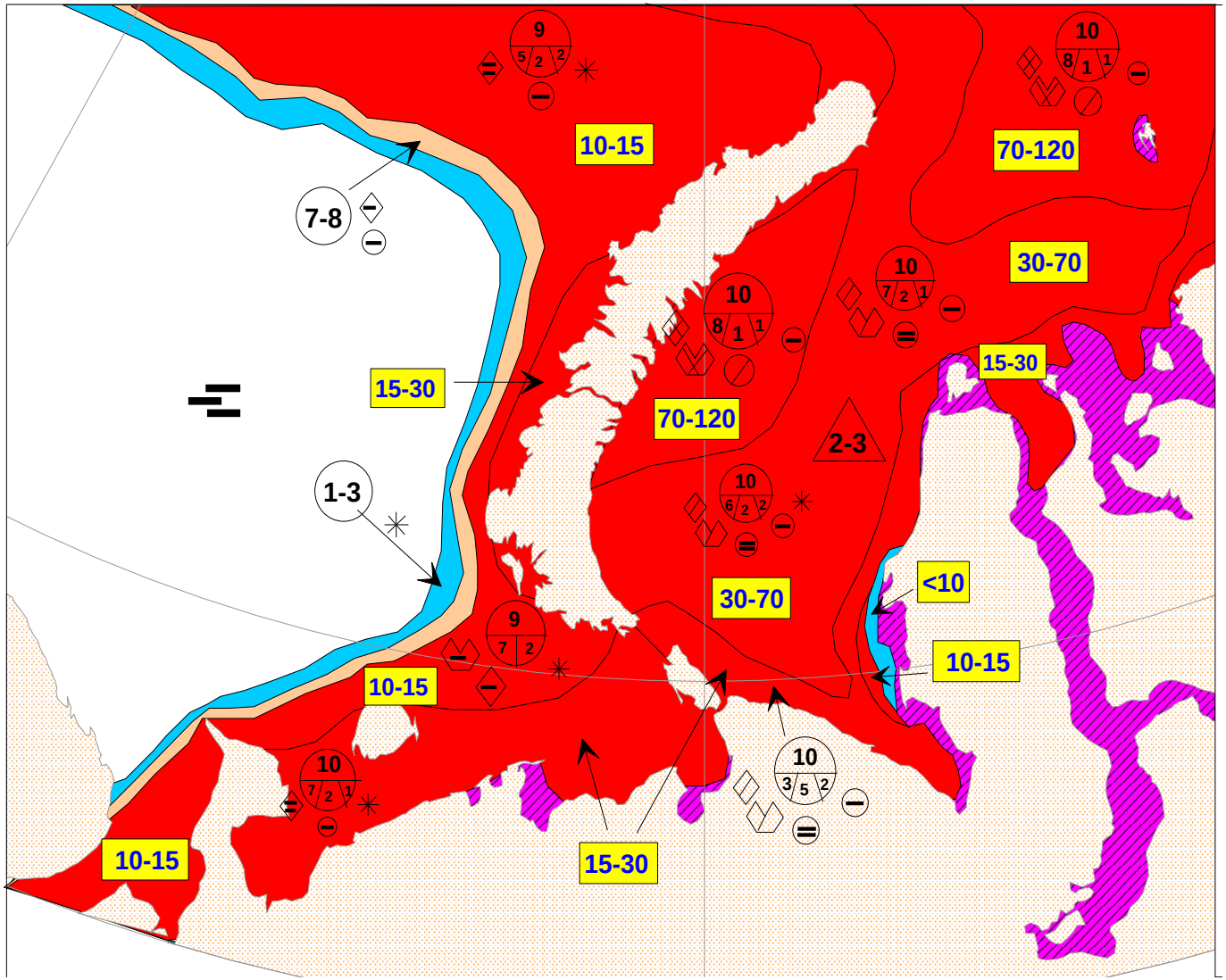
Kara sea / September



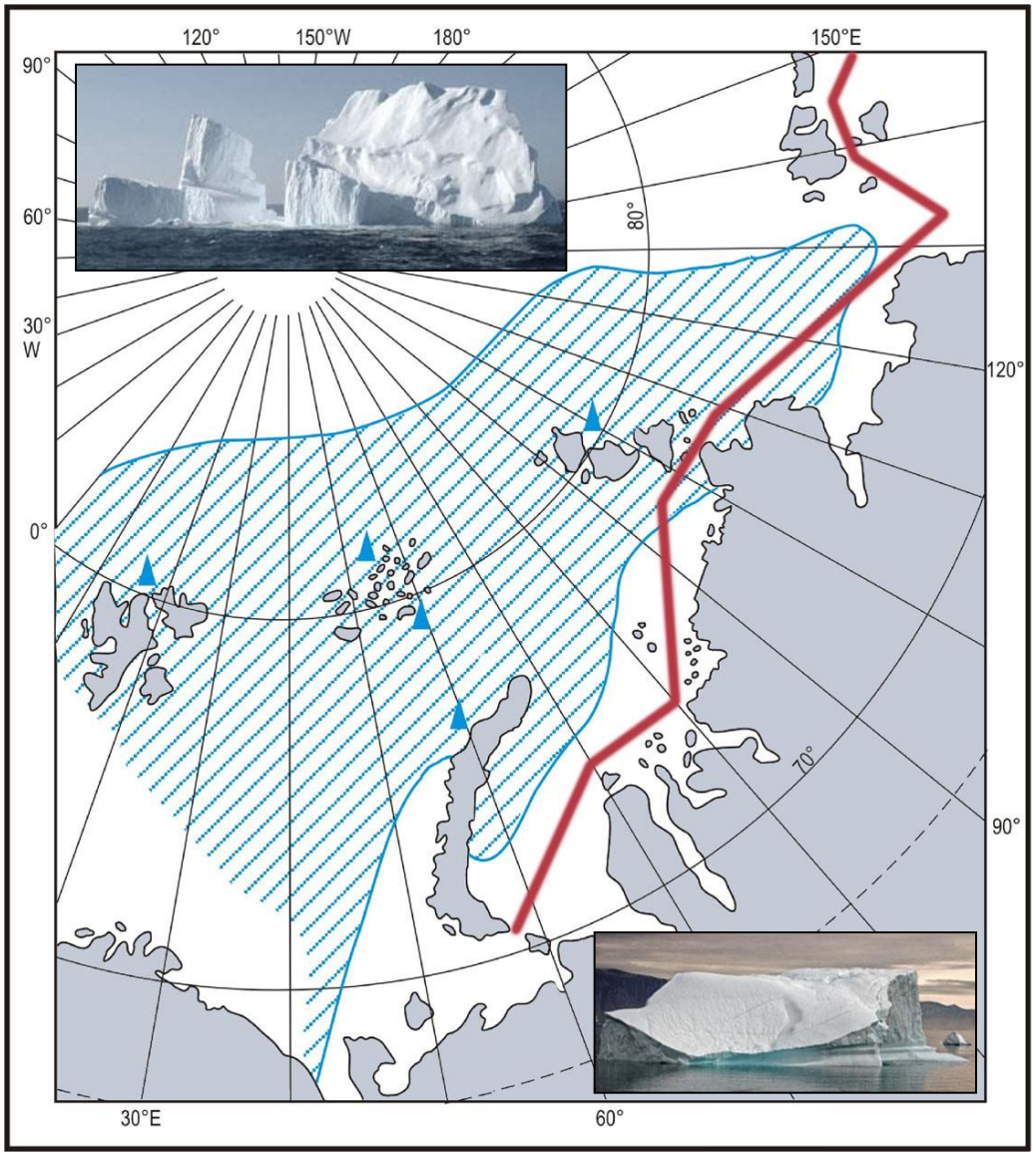
Kara sea / November



Kara sea / February



Danger of icebergs



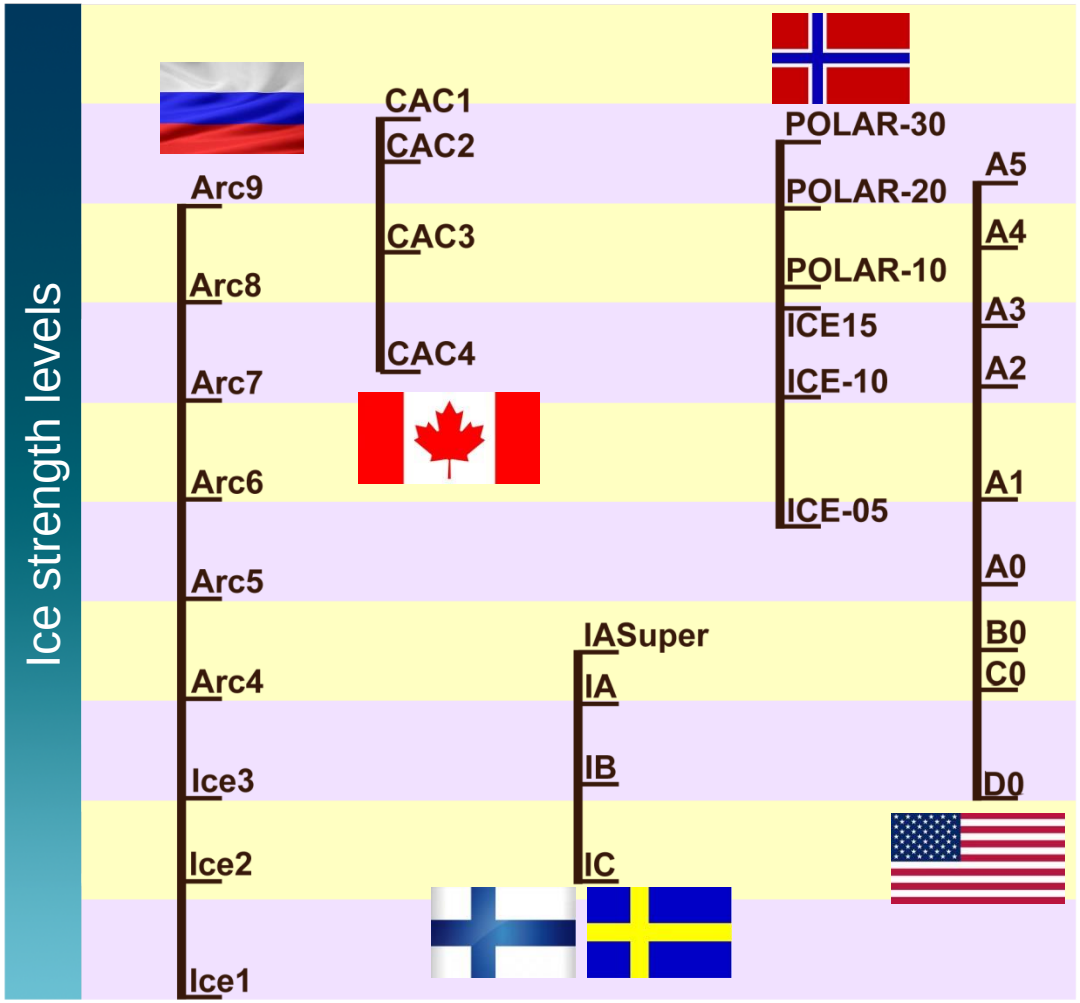
- Northern Sea Route

- Icebergs spreading out area

- Areas of iceberg emerging

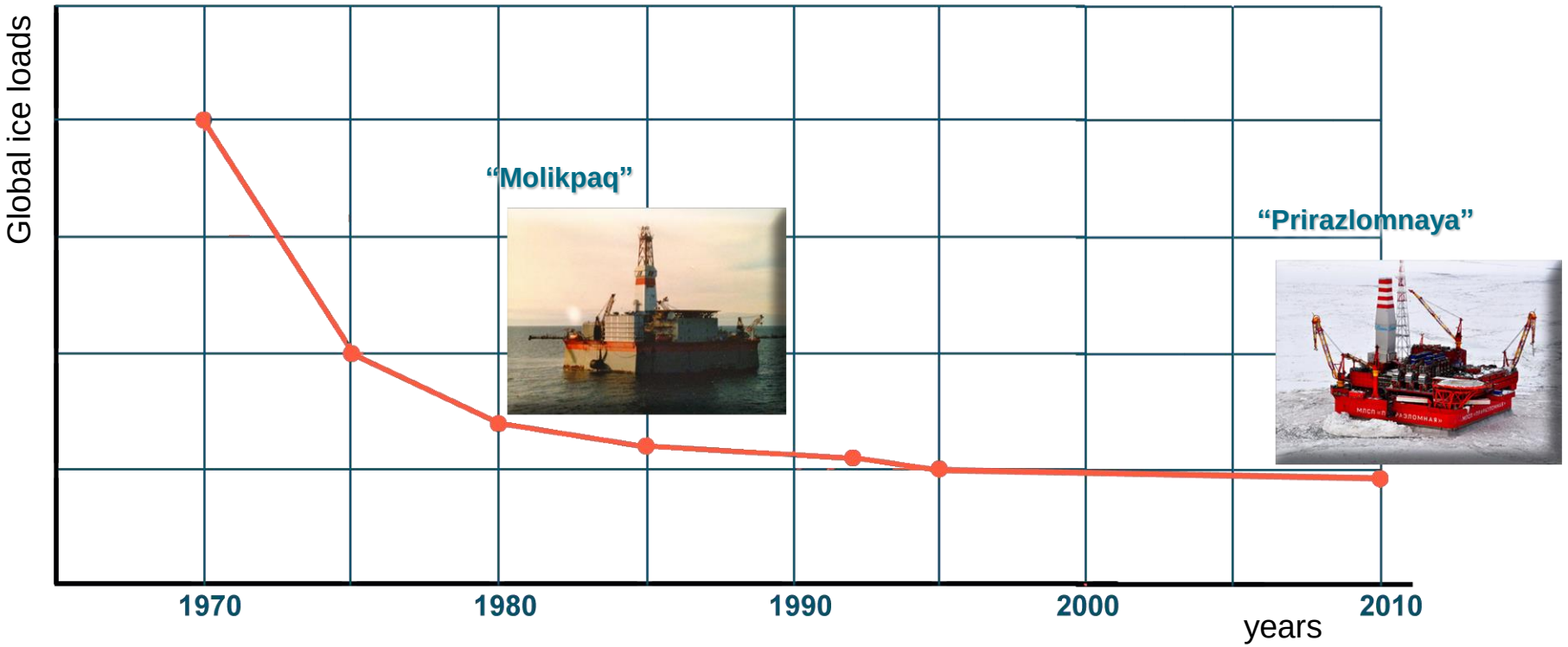
Icebergs of Russian Arctic are much smaller than the ones from Greenland. They disintegrate much faster and have limited spreading out.

Strength standards for ice-class ships



Equivalence of ice classes defined by different classification societies.

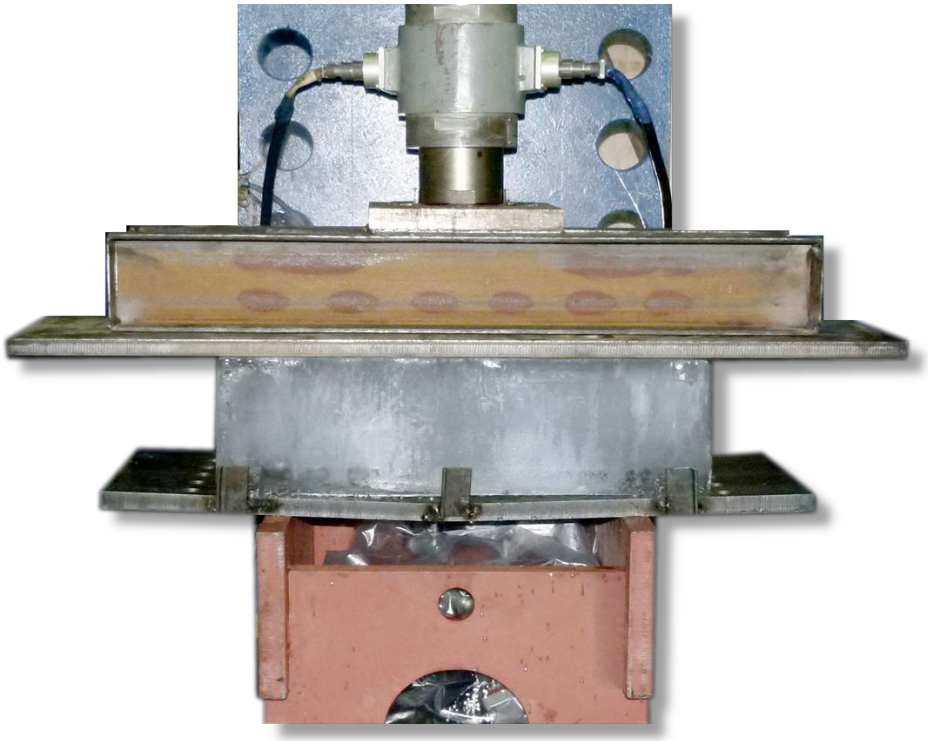
Global ice loads on ice-resistant platforms



Grounds:

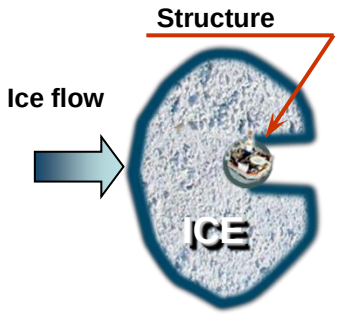
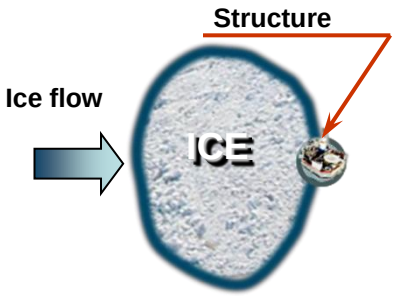
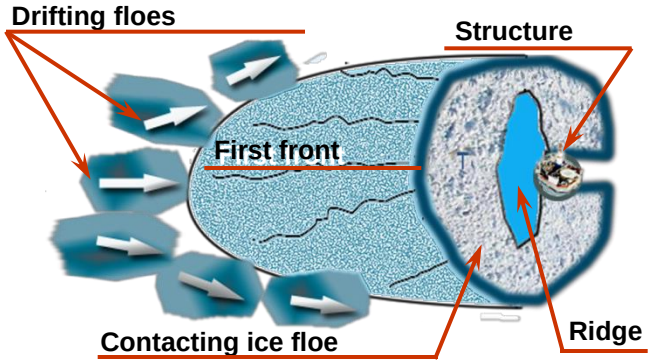
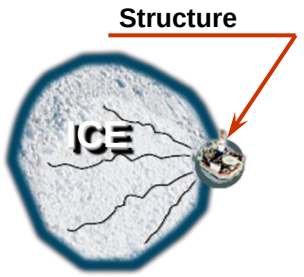
- Investigation of ice cover actual condition.
- Insight into physics of ice/platform supports interaction.
- Implementation of design solutions to reduce global ice load.

Ice fracture mechanics



Maximum local ice pressure on side framing stiffeners has been identified by experiment. It was established that design pressure on the plating is 25% less as compared to those specified in current Rules.

Design scenarios for interaction of structures with moving ice features

Scenario 1	Scenario 2	Scenario 3	Scenario 4
Limit stress	**Limit driving force**	**Extreme force**	**Ice feature splitting**
			
● Load reaches maximum ● Maximum contact area at ice cutting	● Ice stopped prior to accumulation with maximum contact area ● Ice feature broken within contact area	● Ice feature stops at contact with structure with periodic rubbling ● High pressure of wind, waves, other floes on ice feature	● Minor penetration with radial cracking in ice floe of limited sizes
High kinetic energy of ice feature	Low kinetic energy of ice feature	Heavy ice feature in heterogeneous ice	Relatively small sizes of ice feature

Scenario realization conditions

Peculiarities of defining global ice loads acting on offshore platforms

Structures

- Configuration
- Dimensions
- Surface condition

Input data

- All characteristics are specific and single valued

Types of impact on structure :

Drifting ice (ice floes with ridges, ice cake)

- Horizontal shearing of freezing-on ice formations
- Vertical shearing of freezing-on ice
- Impact due to thermal expansion

Methods for global ice load evaluation

- **Experimental**
- **Calculation - based on mathematical description of schematised interaction of structure with design ice formations**
- **Statistical**

2÷3 times divergence of evaluations

Reasons for divergences

- Various interpretations of scenarios for ice conditions interaction
- Various methods for input data processing
- Various extrapolations

Ice

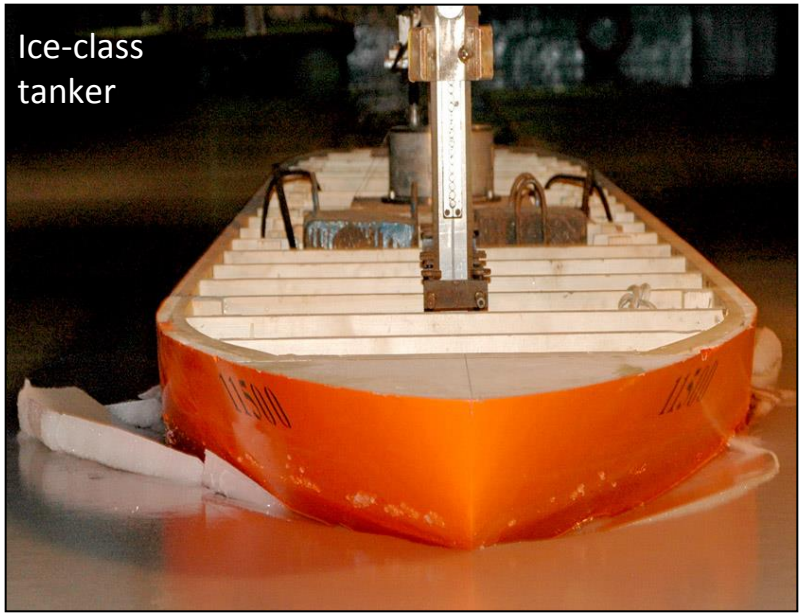
- Type of ice formations
- Dimensions
- Drift speed
- Strength
  - bending
  - compacting
- Density
- Modulus of elasticity
- Cohesion
- Friction angle, porosity of hummocks keel and ice formations

Features of input data on ice

- All characteristics are of random nature
- Design values are set by results of the analysis of available data of surveys or by recommendations, based on earlier performed researches (SNiP and VSN)

Experimental support / Simulation of ice operation conditions

Ice-resistant platform


Ice-class tanker

Simulated ice conditions:	
Continuous level ice 10 x 80 m.	Channels behind ice-breakers and offshore structures.
Broken ice of specified concentration.	Drifting ice fields and ridges.
Hummock ice with specified thickness and orientation with respect to model motion.	

Experimental support / Hull ice strength


Structures of multi-hull ice-breaker


Ice-resistant grillage

Large-size structural life and static test complex is certified by German accreditation body DAkkS validating competences as per ISO/INC.

Experimental facilities and test rigs possess vast working area and are able to develop forces up to *30.000 kN.*

No similar test complex is available in EU.

Experimental support / Strength of deep-water equipment

Complex of hydraulic pressure test tanks is certified by DAkkS validating competences as per ISO/INC requirements.

The complex is intended for strength tests of deep-water vehicles through applying direct water pressure within the range exceeding World Ocean depths.

No similar test complex is available in EU.

Thank you