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Content of presentation, 2) The Shtokman development

- Further to the north, a development solution for the Shtokman gas and condensate field in 300 m depth is being detailed.
- The ice drift is of concern as ridges, multiyear ice and icebergs are possible. A ship shaped floater is being selected as processing center.
- The design considerations for a floater versus a fixed platform in these conditions will be discussed and it is concluded that ice management, ultimately with disconnection of the floater will be needed.
- Some words about the planned LNG harbor in Teriberka will also be given.

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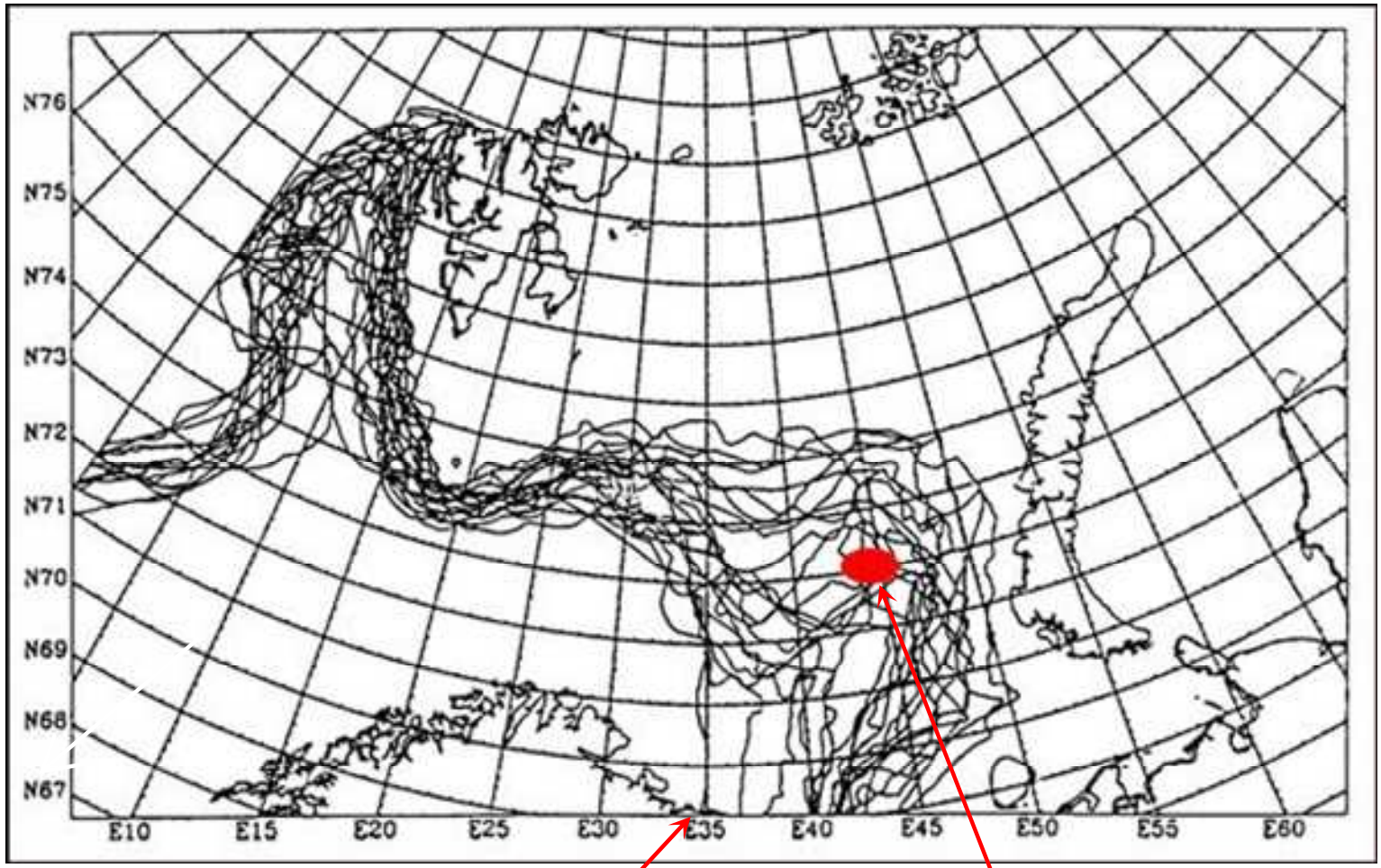
Shtokman map



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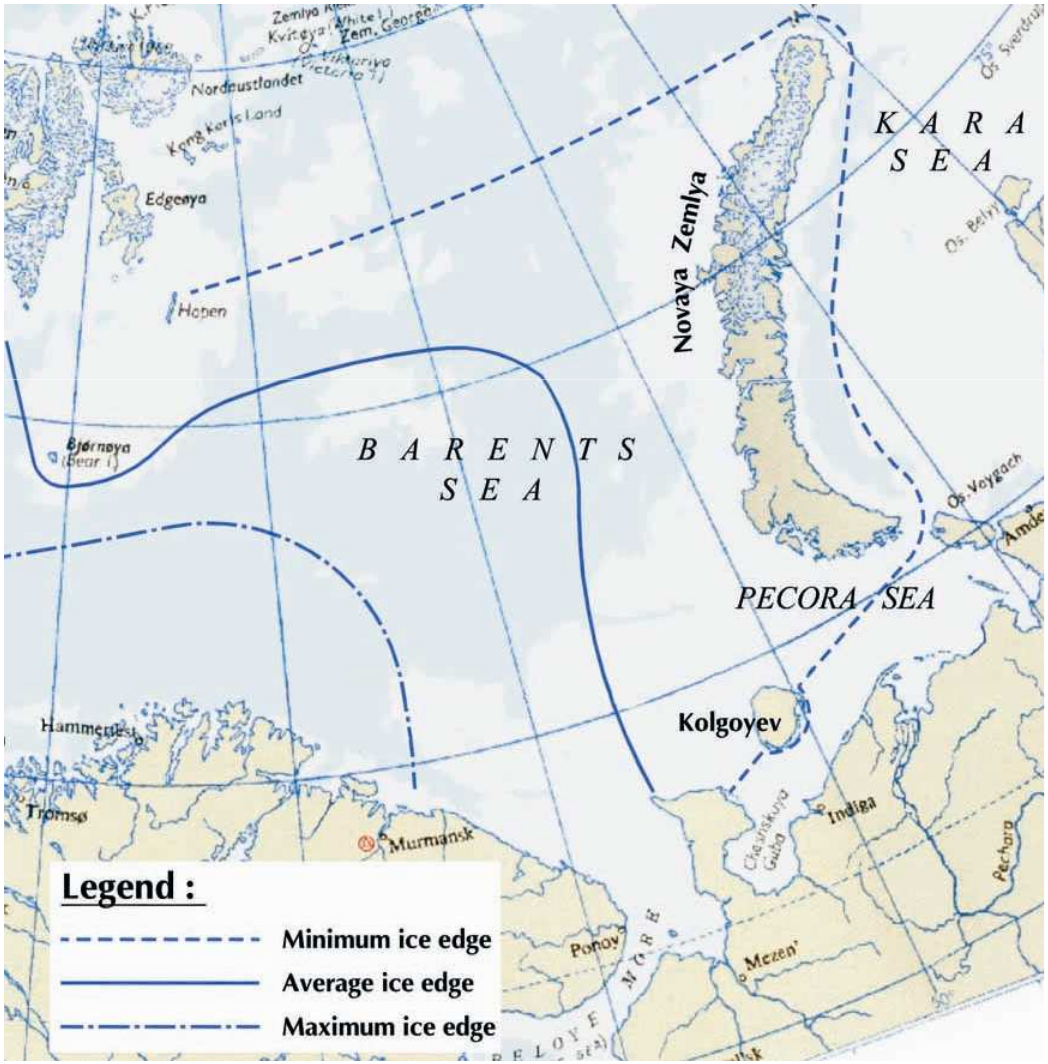
Eastern Barents Sea ice

- Ice bergs observed
- Dynamic ice edge
  - Marginal ice zone
  - Ice every second/third year at Shtokman
  - Teriberka at the Maximum observed ice edge
  - Level Ice
  - Ridged ice
- Simulation of drift characteristics is a key issue



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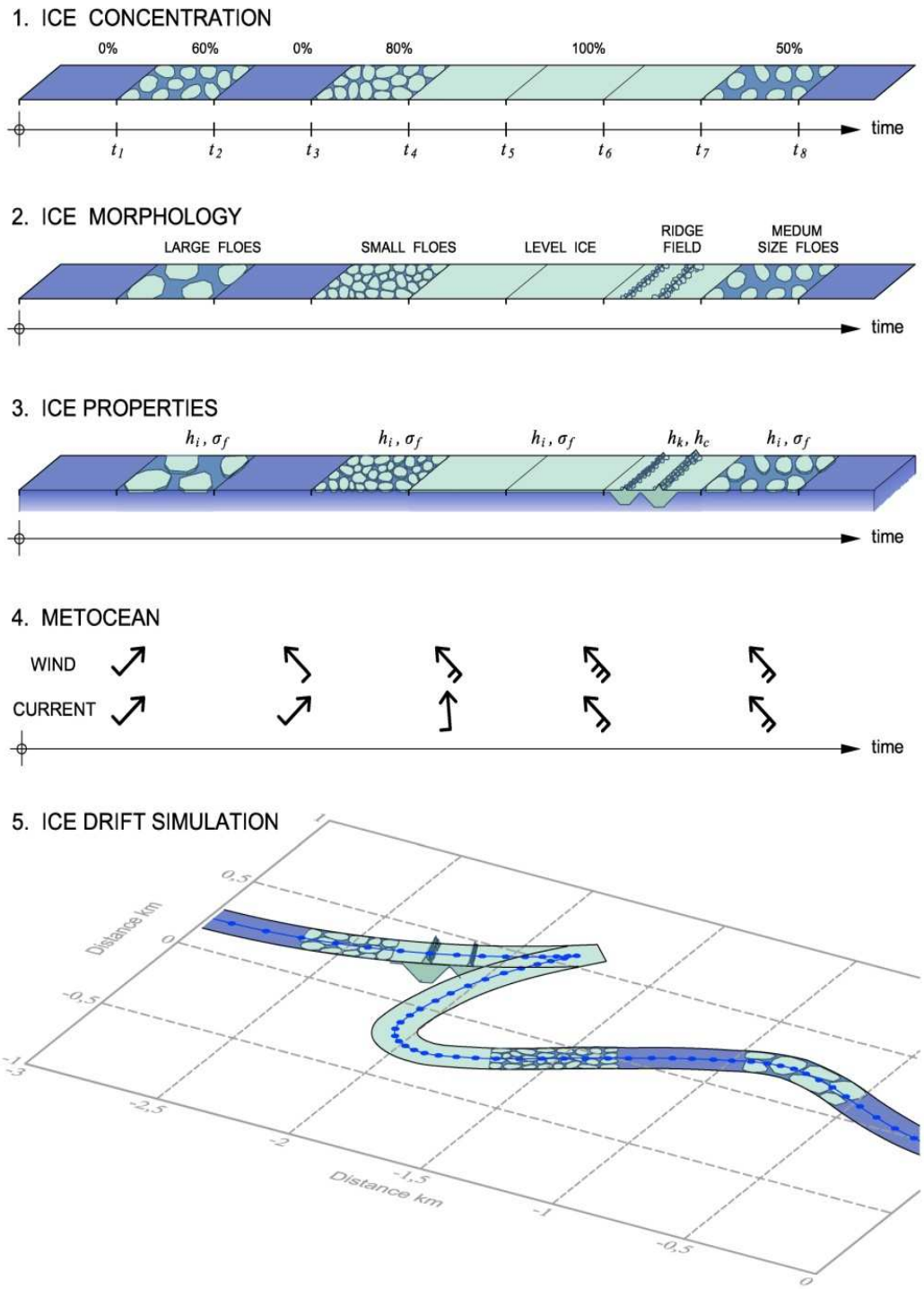
Ice simulation procedure

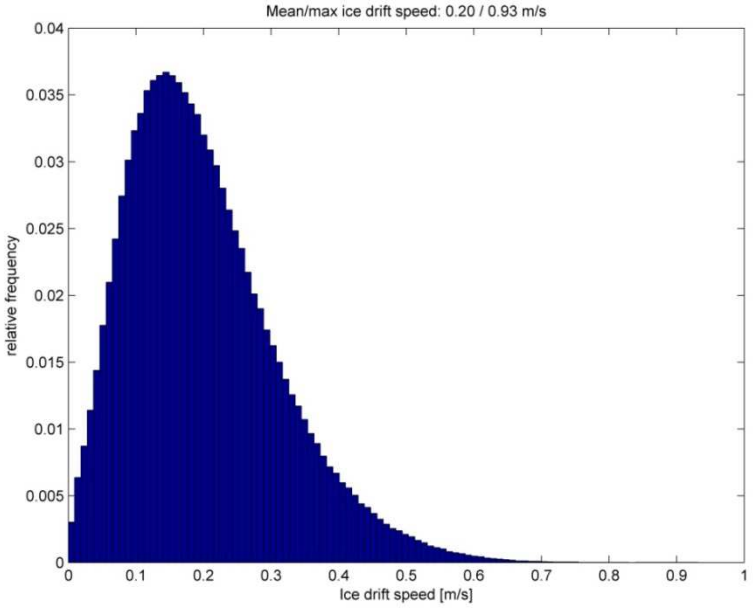
- Ice presence
- Ice concentration
- Morphological properties
  - Flow size
  - Thickness
  - Ice ridges
- Metocean properties
- Free drift ice model



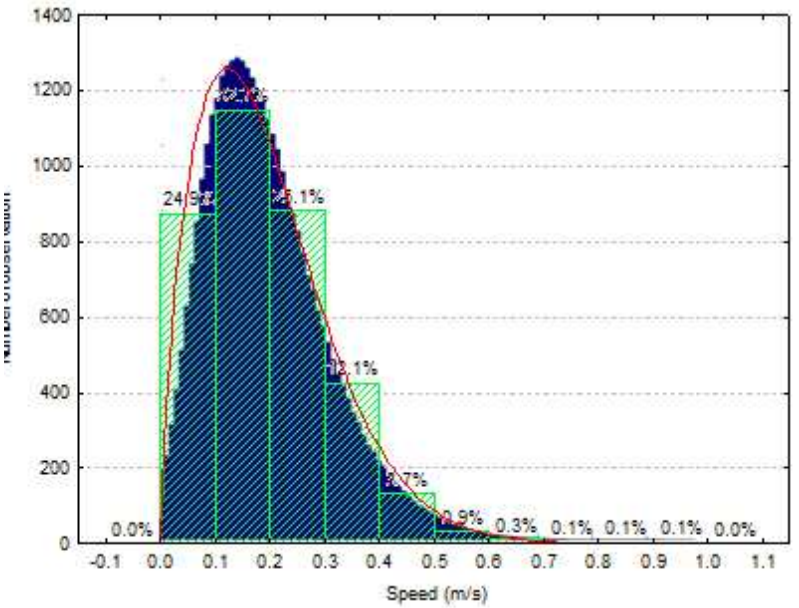
Ice simulation – velocities

- Simulated ice drift speeds (1000 years):
  - Average: 20 cm/s
  - 1-year: 60 cm/s
  - 100-year: 80 cm/s
  - Max observed: 93 cm/s

Simulations



Observations



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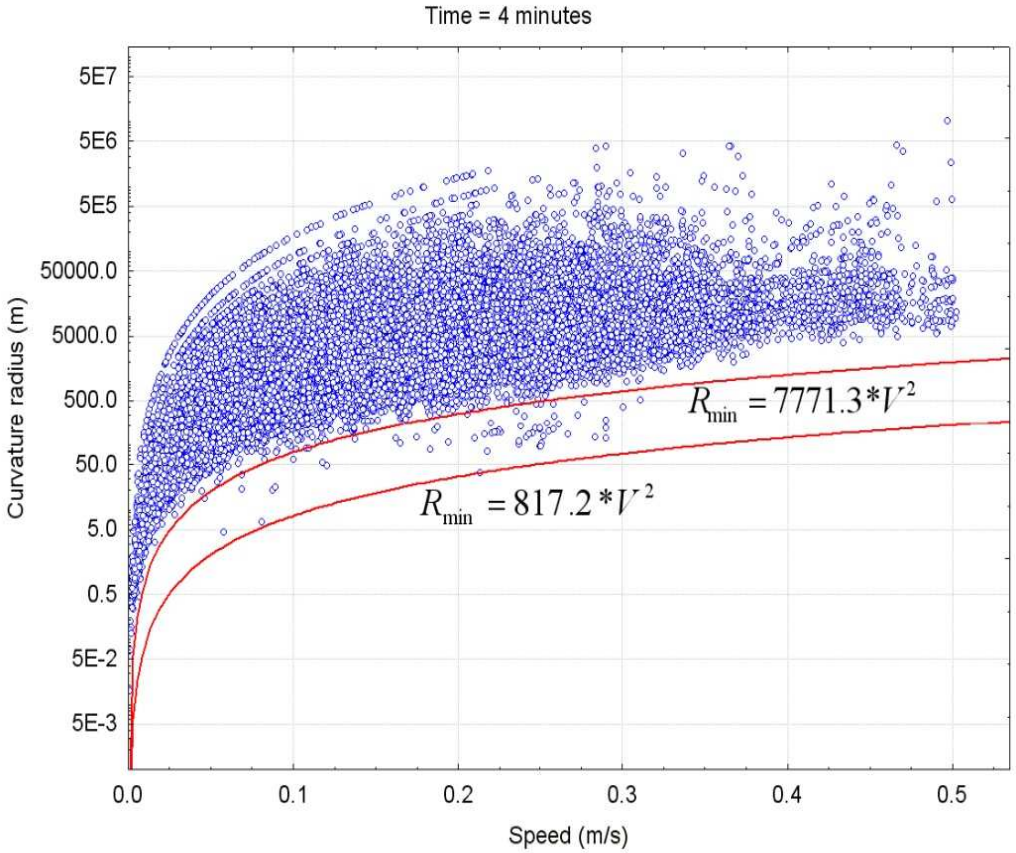
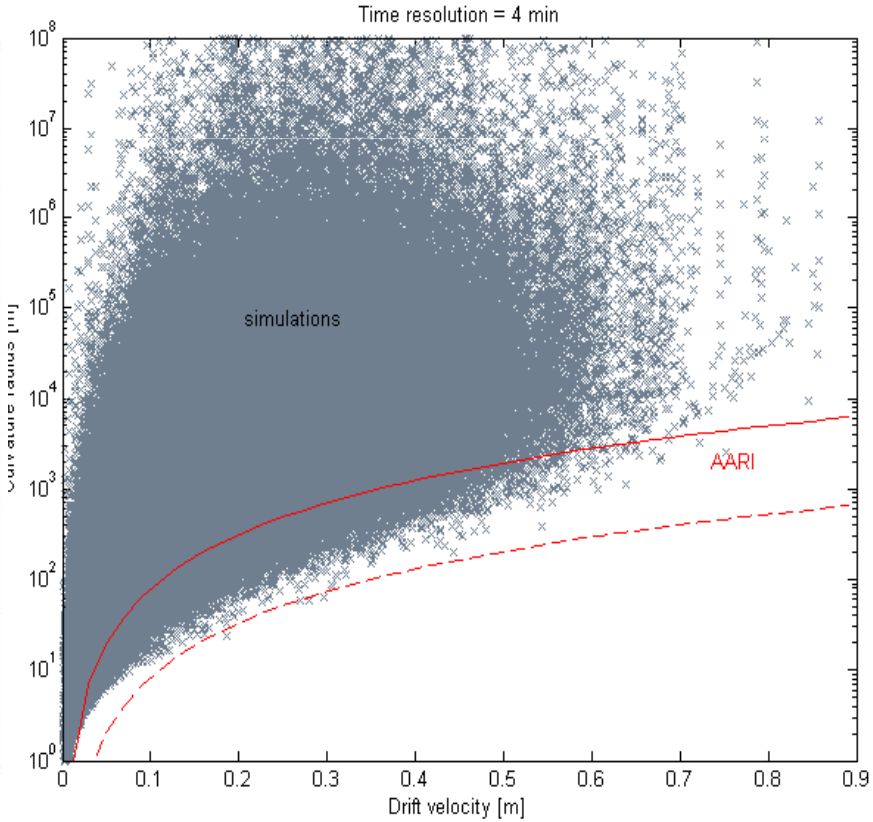
Ice simulation – curvature radius

- Comparison with estimated radii from observations (which include measurement errors, AARI 2008)





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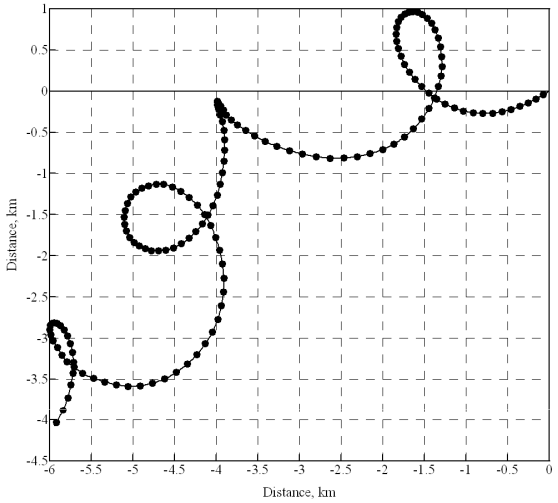
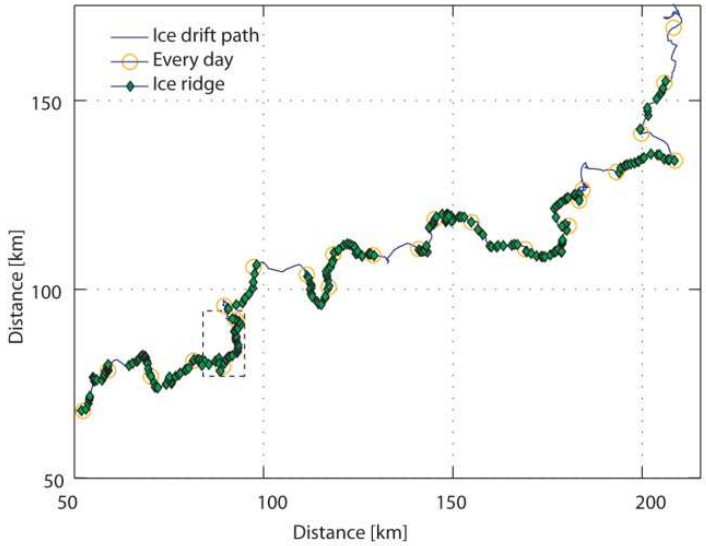
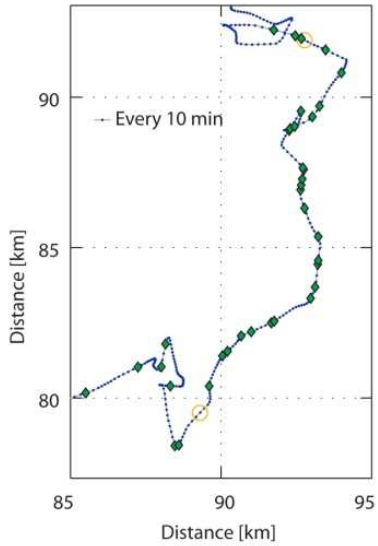
Ice simulation – results



Observed ice drift path

Simulated ice drift path





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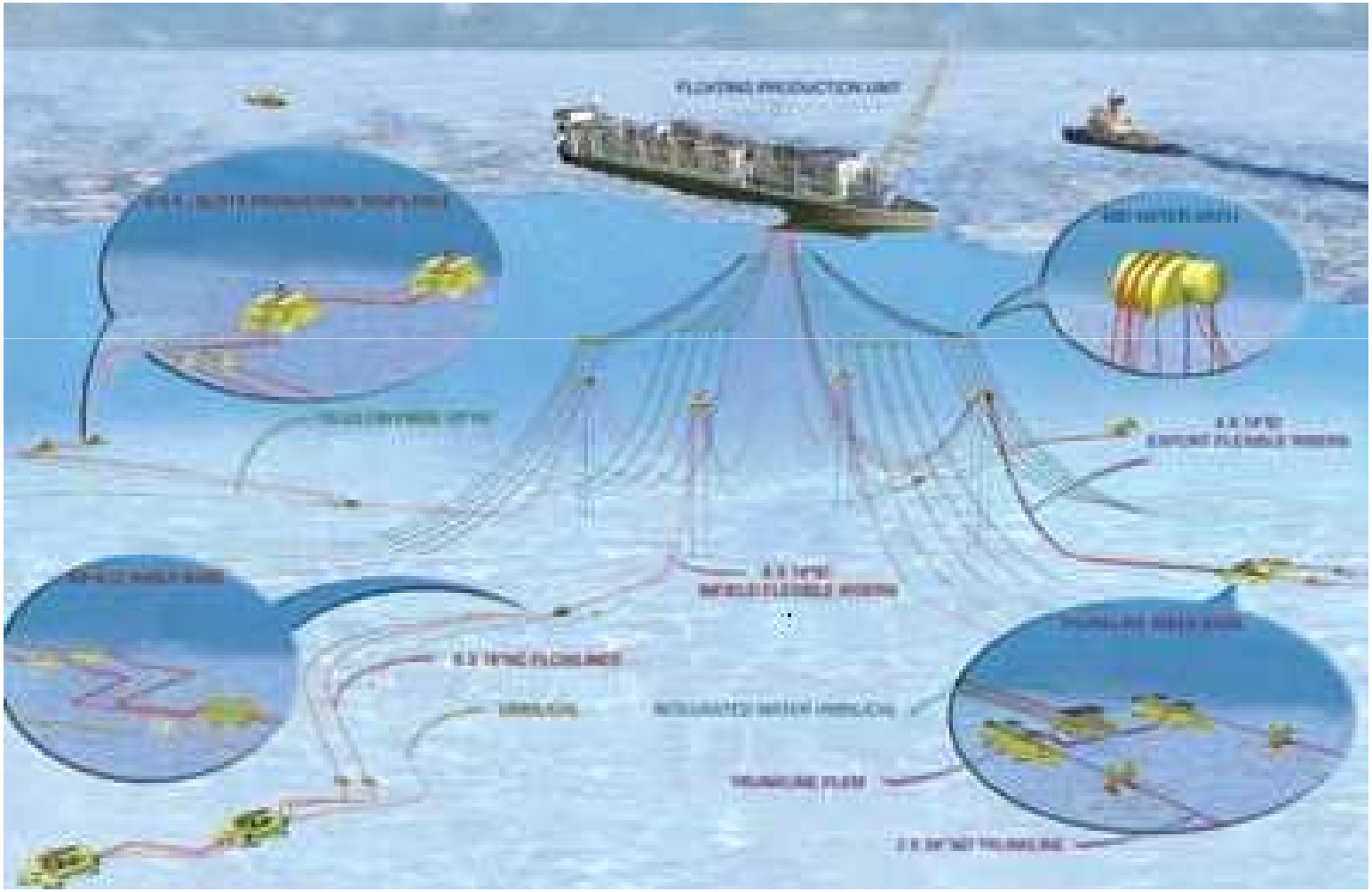
Shtokman development concept



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Arctic FPU

Moored vessels
Simulation of variable ice drift

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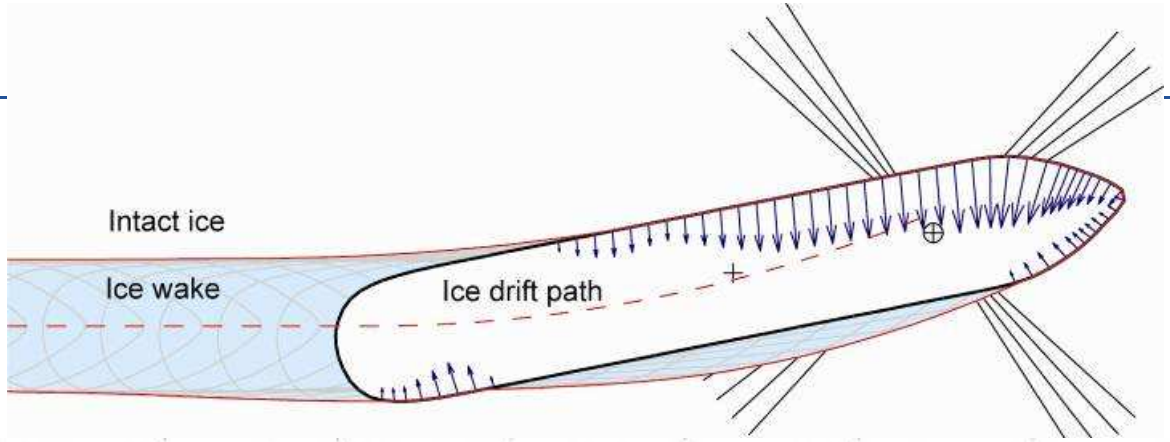

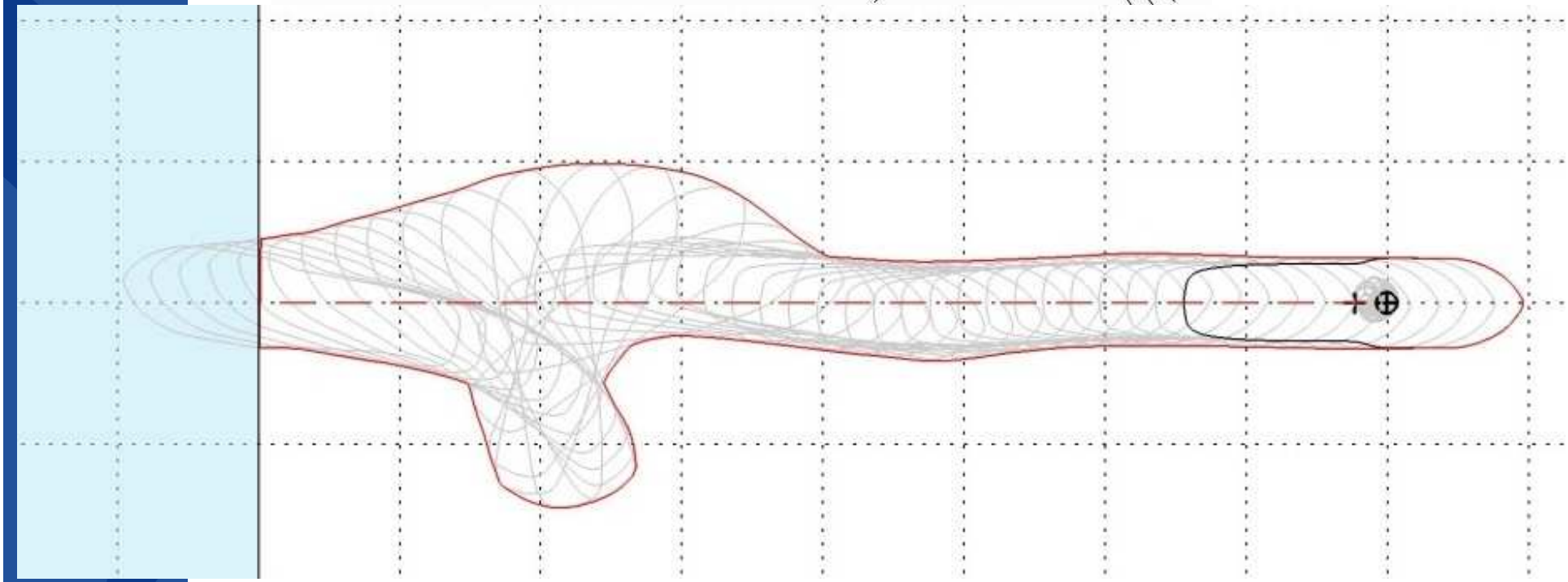

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Ice transport and accumulation in vaning

Turning 180 degrees in ice

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Onshore development

- Pipeline to Teriberka
- Pipe gas to Baltic sea
- LNG plant in Teriberka
- LNG transport from Teriberka
- No sea ice present
- Remote location
- Challenges similar to Melkøya
- Russian contents

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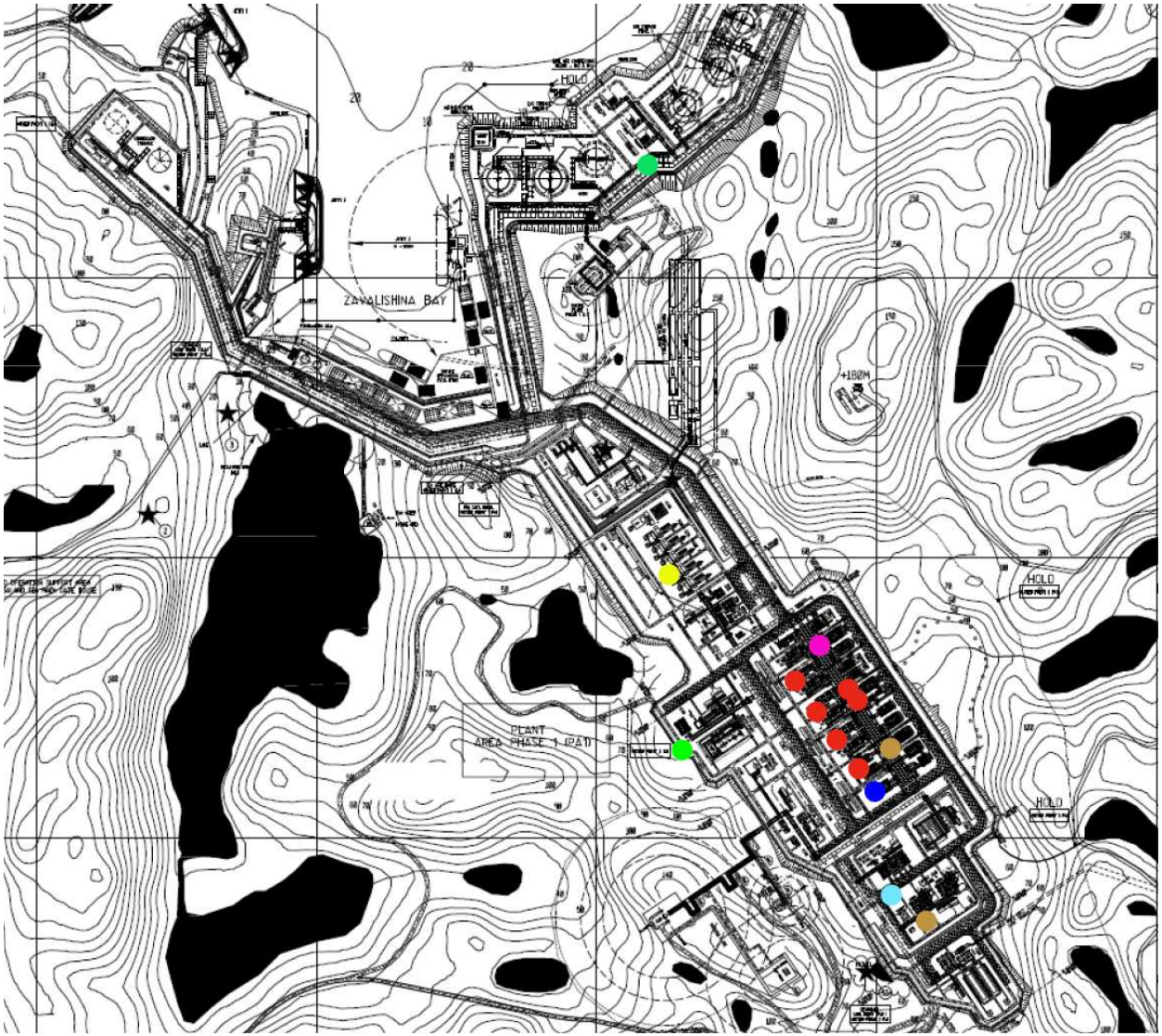
Teriberka onshore plant



Content of presentation, 3) South Eastern Barents Sea and the Prirazlomnoye development

- The development of the Prirazlomnoye field in 20 m in the Pechora Sea in the Russian sector of the Barents Sea is still ongoing after many years of delays.
- The ice conditions can be very hard with large ridges moving with the tide. A fixed caisson platform is being fabricated. Offloading will be by loading directly to vessels from the platform.
- The design basis is being reviewed with emphasis on the main challenges. Of particular concern is the ice drift.

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South Eastern Barents sea

- Prirazlomnoye development
- Present Schedule late 2011
- Varandey terminal

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РГУ нефти и газа
им. И.М. Губкина

Prirazlom platform

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Varandey oil terminal

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The world's first Fixed Offshore Ice Resistant Offloading Terminal (Varandey)

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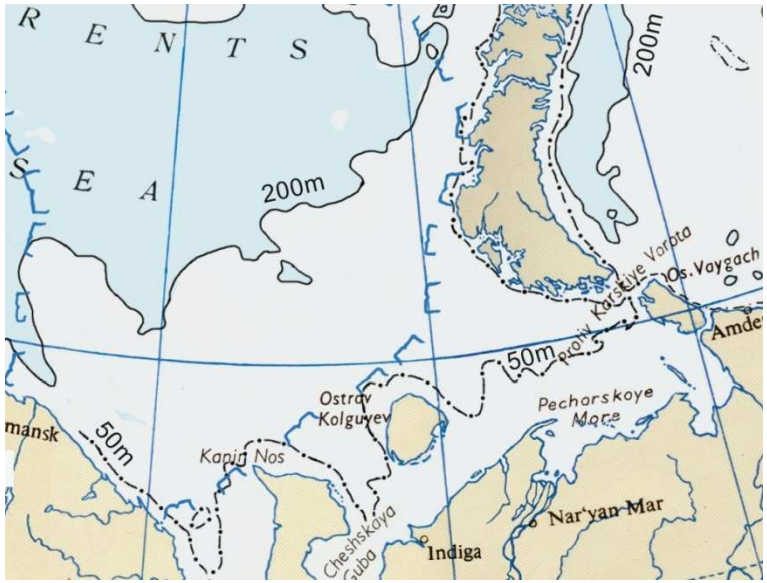
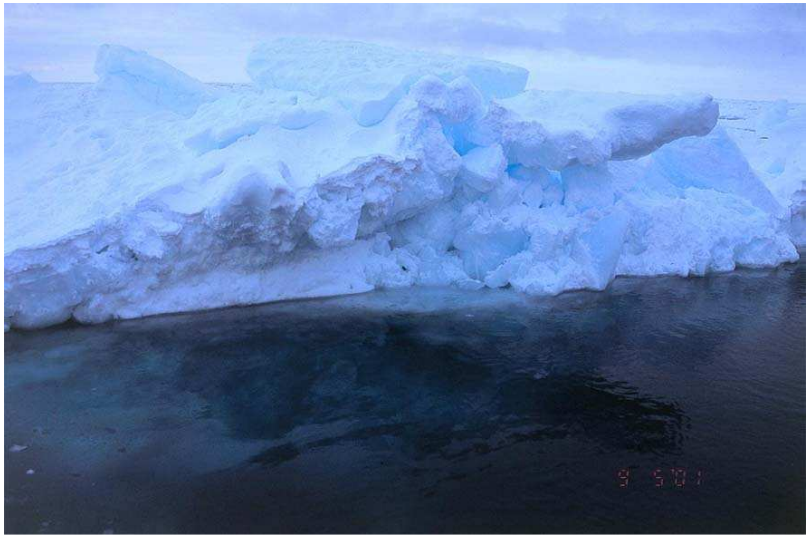
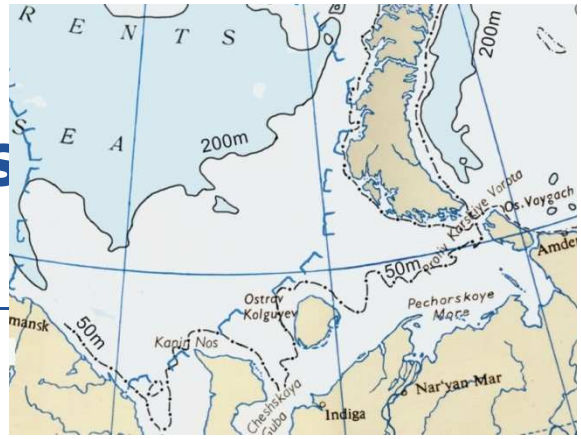
Pechora Sea



Pechora sea Ice conditions





- Shallow water, Pechora
- Land fast ice:
  - Up to 15 m water depth
  - Up to 10-15 km offshore
- Ice season
  - Forms October to mid November
  - Ends July, early August
  - Average 180 days (west) - 240 days east
  - maximum 300 days
- Level ice
  - Extreme 1.6 m
  - 2 m rafted
- Ridges
  - Extreme keel max 20 m
  - Width max 80 m
- Dynamic drift

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Content of presentation, 4) The Yamal developments

- Further to the east, the challenges represented by the ice conditions are even more severe for development of the offshore fields in the Kara Sea and for LNG facilities on the Yamal peninsula.
- These challenges relates to harbor facilities and transport across the Kara Sea and through the Kara gate.
- A comparison with challenges of crossing the Baydaratskaya Bay with pipelines will be given.

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Terminals in ice

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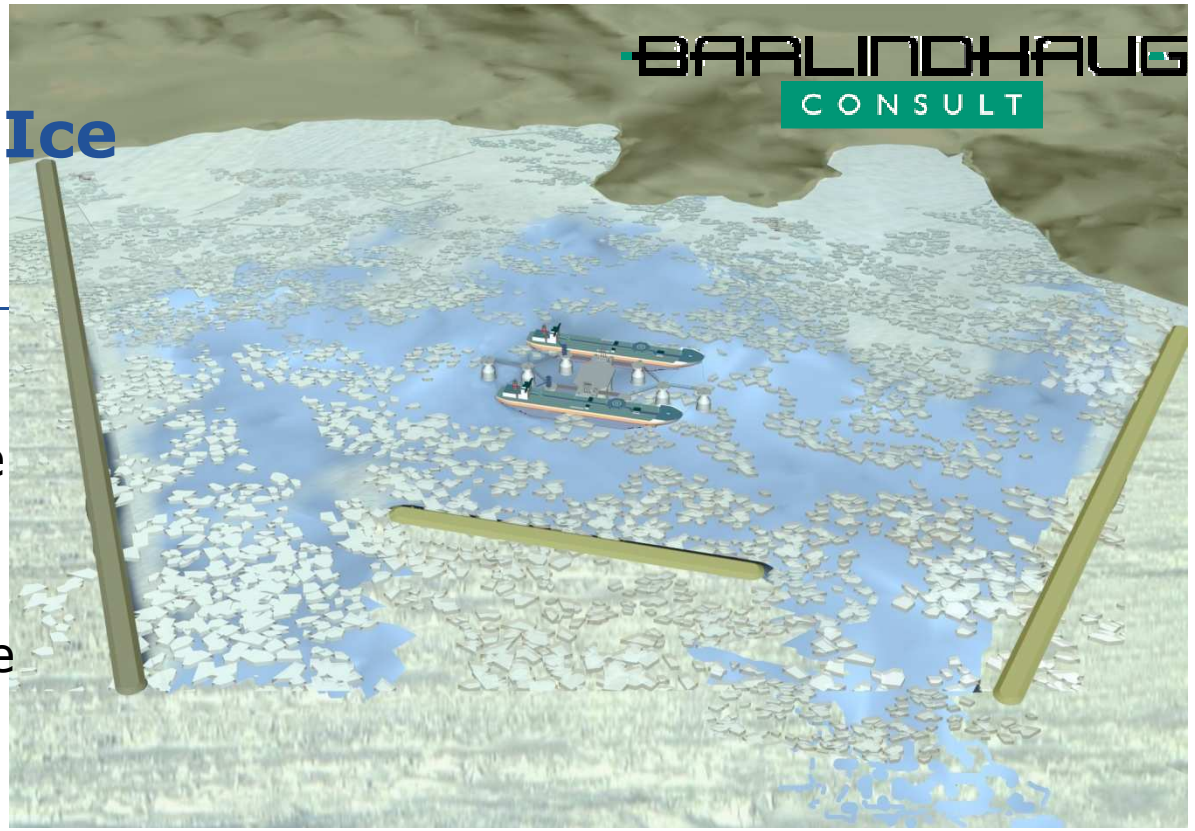
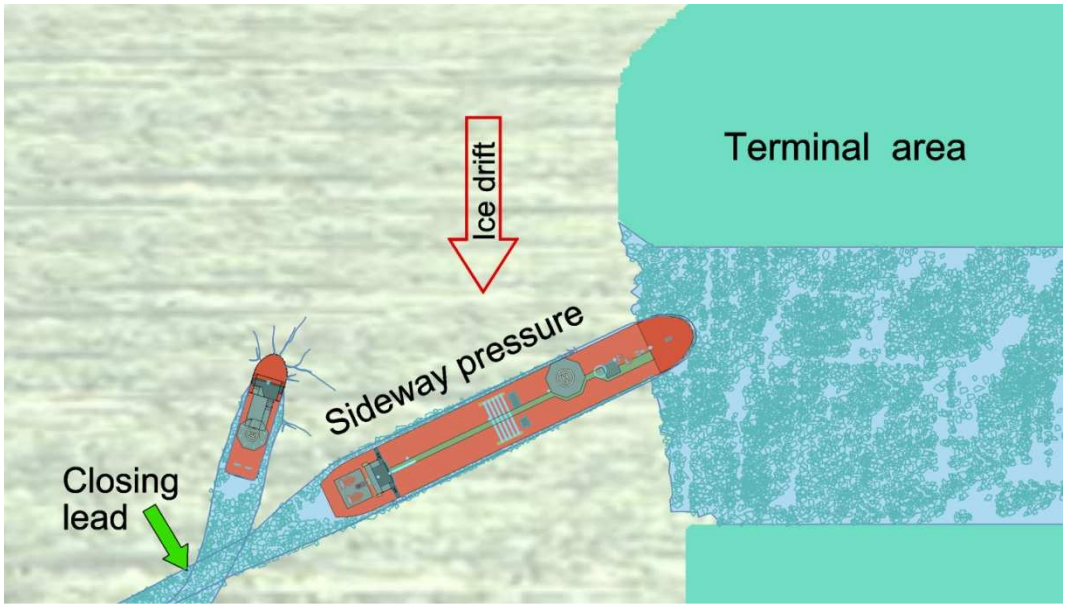
Terminals in Ice

- Location – Land fast ice – Drift ice
- Accumulation of brash ice
- Terminal entrance





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Summary

- Challenges with Arctic developments comprises remoteness and lack of infrastructure in addition to the harsh Arctic physical environment
- Physical environment will challenge all phases of a an Arctic development
- Ice operations and ice loads are the driving parameters in concept selection in ice infested areas
- Ice drift and presence of ice is a key parameter in designing ice resistant structures
- Landfast ice will pose additional challenges in year around operations of terminals

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Baydaratskaya Bay Gas Pipeline Project

Baydaratskaya Bay Gas Pipeline Project

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- Yamalgasinvest (Gazprom) decided to construct various 48" gas pipelines, crossing Baydaratskaya Bay, for the development of the Bovanenkova gas field, located on the Yamal Peninsula.
- This section of the pipeline route is part of the Yamal - Europe gas pipeline which will supply Russian gas to the European market.
- Main concern is the design conditions, in particular the gouging of the shtamoukas and the interaction with buried pipes
- The pipeline installation contract was awarded to the Russian pipe lay company Mezhregiontruboprovodstroy (MRTS) operating the pipe lay barge “Defender”.
-

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Boskalis Offshore was awarded the contract for dredging and backfilling of the pipeline trenches, which was executed with trailing suction hopper dredger "Oranje".

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The two SAR images show examples of detailed ice behavior in the freezing period in November 1993. During southwesterly winds the ice which is formed in the bay is transported to the eastern coast. On November 1 (left image) most of the bay is covered with stripes of grease ice oriented parallel to the wind direction. The new ice is accumulated along the eastern coast where it forms up to 50 cm thick layers after 1-2 weeks of freezing.

In the following two weeks the wind continued to be southwesterly and more ice is accumulated in the eastern part of the bay. On November 17 (right image) only a narrow band of open water with characteristic wind stripes is still present.

Most of the bay is covered with ice of different types organized in bands parallel to the coastline. For offshore operations it is important to monitor the ice behavior from day to day

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After Deepwater Horizon

- Improved procedures
- Improved management
  - The industry needs managers who "listen"
  - It is nice to hear report about success, it is a challenge to solve a problem
- The Operator is in charge (as in Norway)
- ISO 19906, Arctic Offshore Structures Standard in place
- All work in Cold climate takes time, delays can be expected
- Very high focus on clean environment

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Development of offshore oil and gas fields in cold climate, Conclusions

- A presentation of Challenges for development of offshore oil and gas in cold climate has been given with reference to the Barents sea
- The challenges in the ice free part relates to cold and unpredictable weather, long time waiting on weather might be expected
- Remoteness and darkness are also important factors
- The main challenges in the area with ice relate to the effect of the drifting ice
- The Arctic environment is highly guarded
- We call for respect for:
    - The local population
    - The physical environment