Assessment and management of invasive crab stocks in the Barents Sea

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Spatial Issues in Arctic Marine Resource Governance

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Two commercial and invasive species of crabs

Red king crab

Scientific classification	
Kingdom:	Animalia
Phylum:	Arthropoda
Subphylum:	Crustacea
Class:	Malacostraca
Order:	Decapoda
Infraorder:	Anomura
Family:	Lithodidae
Genus:	*Paralithodes*
Species:	**P. camtschaticus**
Binomial name	
Paralithodes camtschaticus	
(Tilesius, 1815) [1]	

Snow crab

| Scientific classification	
Kingdom:	Animalia
Phylum:	Arthropoda
Subphylum:	Crustacea
Class:	Malacostraca
Order:	Decapoda
Infraorder:	Brachyura
Family:	Oregoniidae
Genus:	*Chionoecetes*
Species:	**C. opilio**
Binomial name	
Chionoecetes opilio	
(O. Fabricius, 1788)	

No crabs before 1965

Red king crab was introduced deliberately from the Pacific Region in the 1960s.

The origin of snow crab are still unclear and may be associated either with an incidental transport of larvae in the ballast water or with the natural migration.
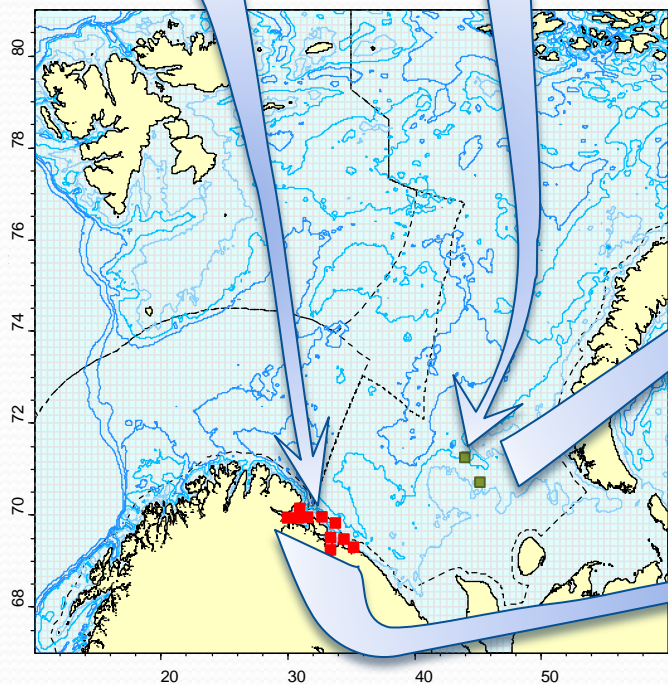
Data 1992 - 1996
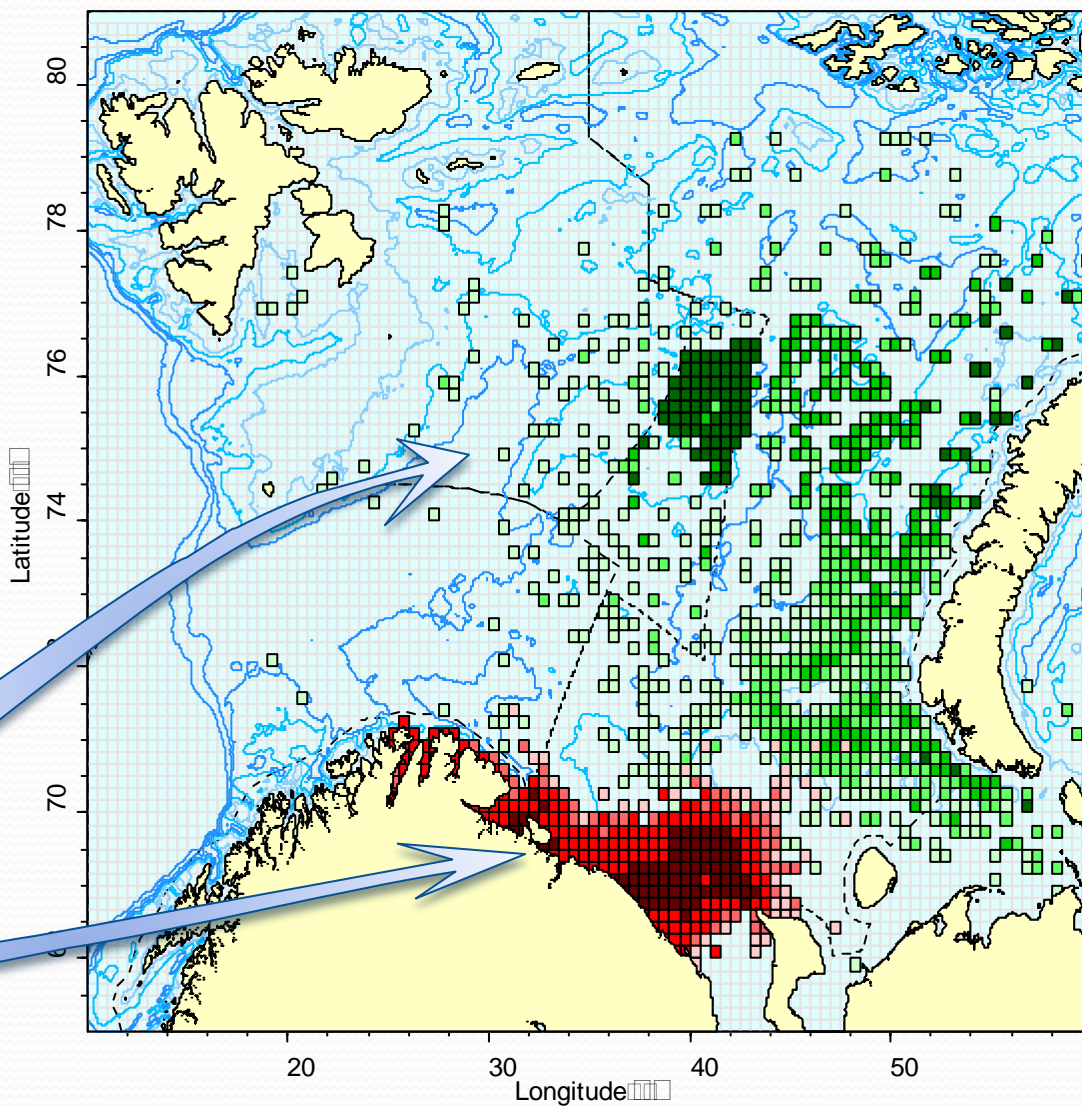
Data 2005 - 2014

Methods and materials
BASIC INPUT DATA during Russian investigations

DATA	Red King crab	Snow crab	Institute
1) **Monitoring of area distribution :**	Annual monitoring	Annual monitoring	PINRO
- bycatch information;	1977-2006 demersal fishery observer data	1977-2006 demersal fishery observer data	PINRO
- surveys.	1994-2009 trawl survey	2005 -2014 ecosystem survey	PINRO
2) **Stock assessment and TAC evaluation:**	Annually	Annually	PINRO+VNIRO
- surveys;	1994-2009 trawl survey	2005 -2014 ecosystem survey	PINRO
- fishery monitoring;	VMS+ observer data	VMS+ observer data	PINRO+VNIRO
3) **Ecological impact monitoring:**	Sporadically	No special investigation	PINRO, MMBI
- benthos surveys;	Partly covered of area		PINRO
- archive data.	Benthos survey (1930)	Benthos survey (1930)	
4) **Biological and environmental data:**			PINRO, VNIRO, MMBI
- survey and laboratory data;	Growth, mortality and recruitment parameters	Growth, mortality and recruitment parameters	
- hydrological survey;	temperature	temperature	PINRO
- climate data (open-source data).	Ice covering, temperature	Ice covering, temperature	NOAA
5) **Socio-economic data:**	No special investigation	No special investigation	

PINRO – Polar Research Institute of Marine Fisheries and Oceanography (Murmansk)
VNIRO – Russian Federal Research Institute of Fisheries and Oceanography (Moscow);
MMBI – Murmansk Marine Biological Institute (Murmansk)
NOAA – National Oceanic and Atmospheric Administration (USA)

Three major points:
- Crustacean
- Invasive species
- New species for region

- **Crustacean species points:**

 a) inability to age individuals prevents to use standard finfish assessment methods;

b) length-structured model based on stochastic growth by molt increases uncertainty;

c) spatial distribution should be take into account for sedentary and semi-sedentary species.

- **Invasive species points:**

 a) no initial (virgin) biomass stock and unknown carrying capacity (K);

b) no any equilibrium assumptions for stock parameters under exponential population growth;

c) large observation errors as for low-abundance populations (during acclimatization stage).

- **New species points:**
 a) no or short exploitation history;
 b) short observation history;
 c) data poor -> data rich population (simple -> complex model)

Stock assessment

1990's

Data-poor population

Data-poor population

Time vector

Data availability

No survey

Data availability

Data poor approach

Surplus production model (Bayesian & Robin Hood Approach):
Abundance index (Number of bycatch observation, Survey Index),
Catch or no catch, Hypothetical value of Carrying Capacity (K) and
Growth rate (r). The "Robin Hood" approach (in which assessments
from data-rich species or population are used to inform assessments
of data-poor species).
Depletion Models (Leslie and DeLury):
Catch and Catch-per-unit efforts. Good VMS data from 2008.

Data medium approach

Catch-Survey Analysis (CSA):
Male 2-4 cohorts (Prerecruits I & II, Recruits and Postrecruits);
Total catch;
Stochastic growth; catchability, natural mortality. Several parameters
in AD Model Builder or
OpenBUGS (Bayesian approach)

Data rich approach

Length-Based Analysis (LBA):
Male and female 10-20 cohorts; Catch composition;
Stochastic growth; handling mortality;
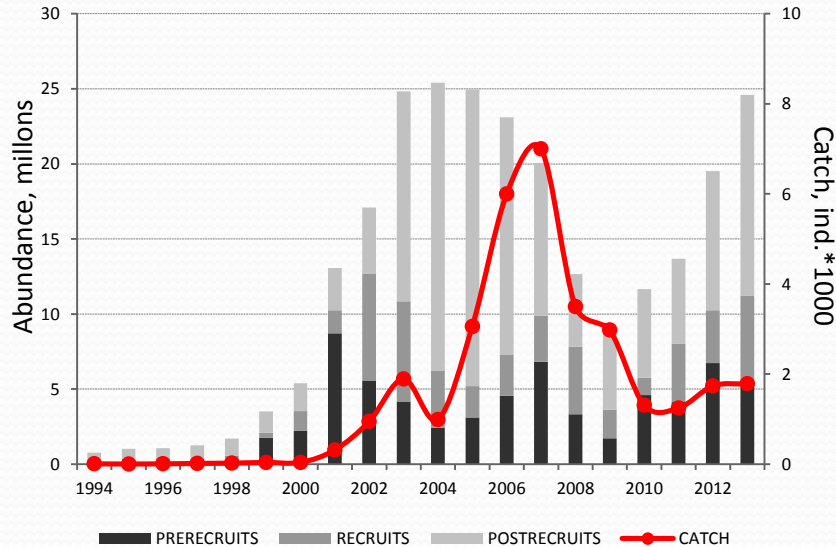Over 200 parameters in AD Model Builder.
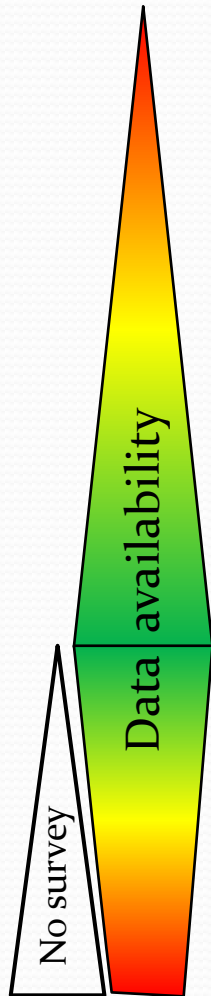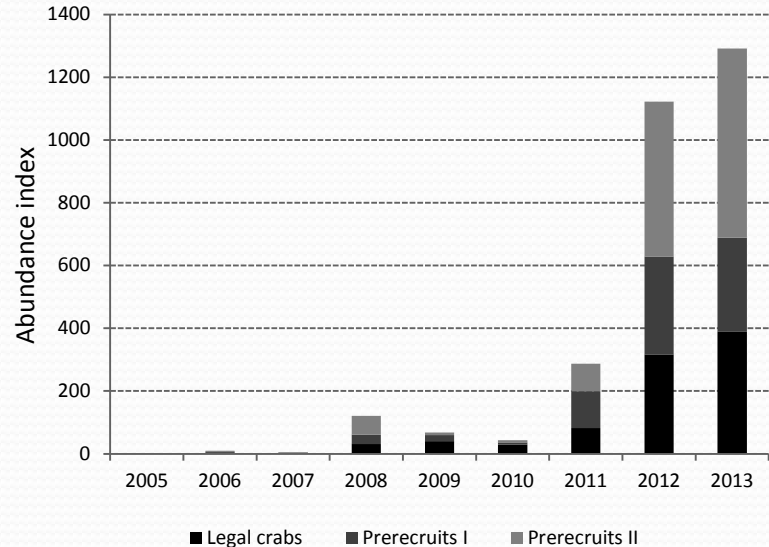
2010's

Data-rich population

Data-rich population

Red king crab

Snow crab

Red king crab:
1) A significant increase in the total stock in the period of acclimatization;
2) Considerable decreasing of commercial stock in period of fishery development;
3) High abundance of new generations and recovery commercial stock are recorded;
4) Projection of stock status is limited by lack of data recently
5) No stock-recruitment relationship in our data yet.

Snow crab:
1) A significant increase in the total stock in the period of acclimatization;
2) High abundance of new generations are recorded;
3) Increasing of commercial stock during next 5-6 years is projected;
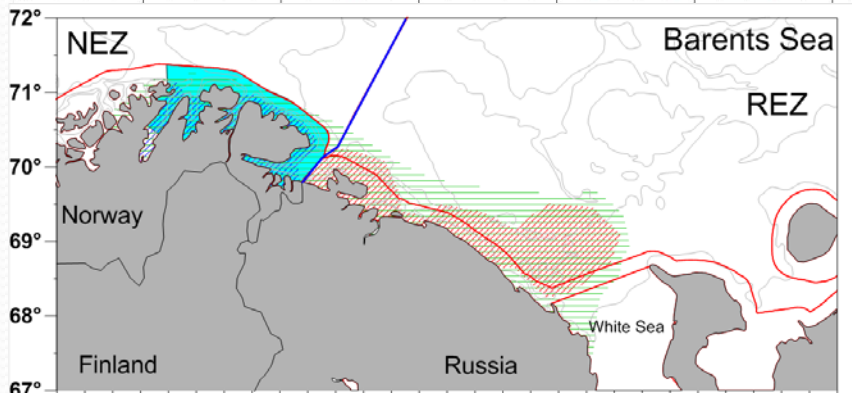4) High probability of further increasing of total stock is expected.
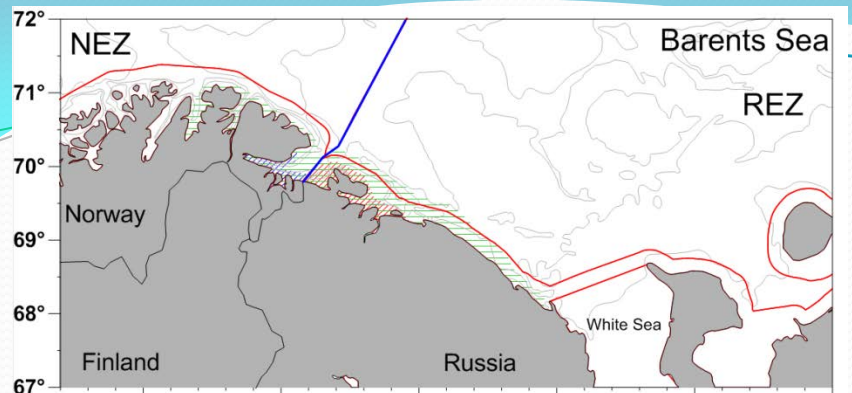
Beginning of investigation and fishery (1993-2001)

Stock status: coastal distribution within 12-miles zone, stock increasing, area expanding, prevalence of large males.
Management: trial fishery, "joint" TAC regulation (25% of assessing legal stock), sex-size-season limitation.
Russian fishery: trawl fishery mostly, 2-9 vessels less than 55 m, non-crabbers. Annual catch 9-300 t.
Norwegian fishery: traps, up to 24 vessels less than 20 m. Annual catch 40-350 t.
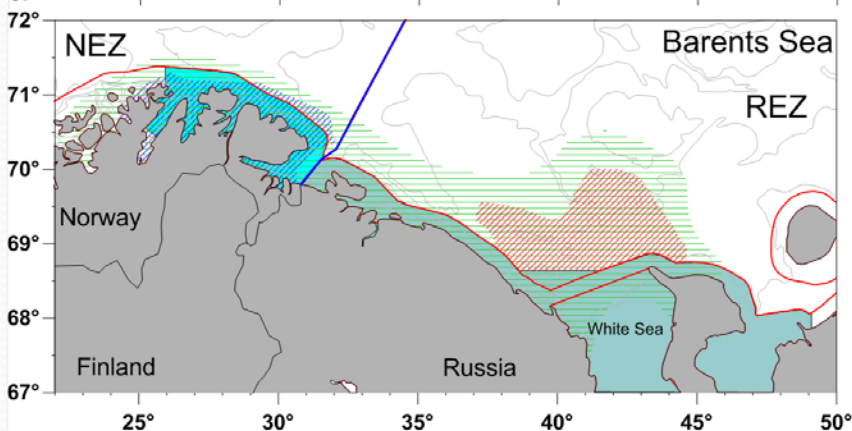
Developing management and fishery (2002-2006)

Stock status: coastal distribution in NEZ and expanding offshore area in REZ, increasing total stock to 2005, but overfishing area in REZ since 2006.
Management: Opening of a commercial fishery, the fishery only by traps is permitted, "joint" TAC regulation (25% of assessing legal stock), sex-size-season limitation. REZ:The minimal depth of fishery (100 m); NEZ: Free fishery to the west from 26° E.
Russian fishery: coastal mosquito fleet, big crabbers in open water, unreported fishery in open waters and coastal area, up to 34 vessels, annual official catch 900-12600 t, annual unofficial catch was up to 25500 t.
Norwegian fishery: mosquito fleet and crabbers (up to 272 vessels), annual catch was up to 2000 t.
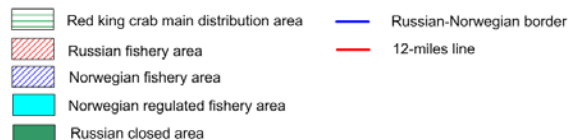
Separate management and current fishery (since 2007)

Stock status: legal stock recovery in REZ due to good recruitment, sustainable good concentration of total stock in the east of distribution offshore area.
Management: Separate (national) management of a stock. REZ: Closing of 12-miles zone because of by-catch of females and young crabs; NEZ: Free fishery to the west from 26° E, using any gears, females fishery
Russian fishery: no coastal mosquito fleet only crabbers out of 12-miles zone, one stakeholder in 2012-2013. annual catch 3700-9300 t.
Norwegian fishery: mosquito fleet and crabbers (up to 282 vessels), annual catch 1150-6000 t.
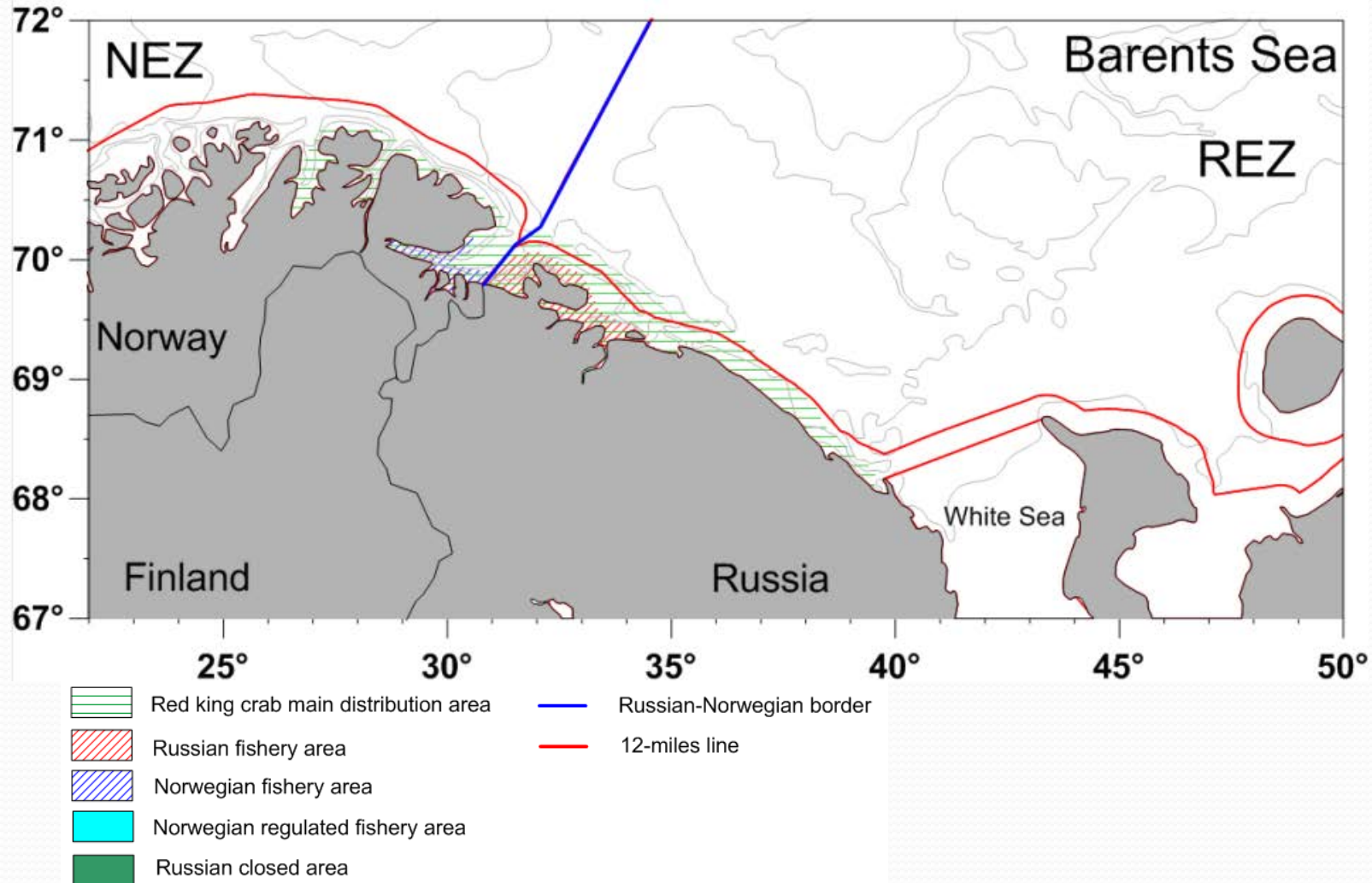
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Legend:
- Red king crab main distribution area
- Russian fishery area
- Norwegian fishery area
- Norwegian regulated fishery area
- Russian closed area
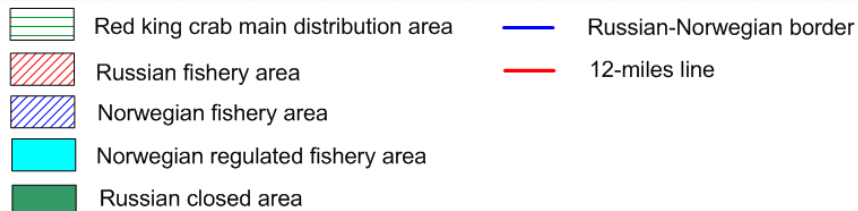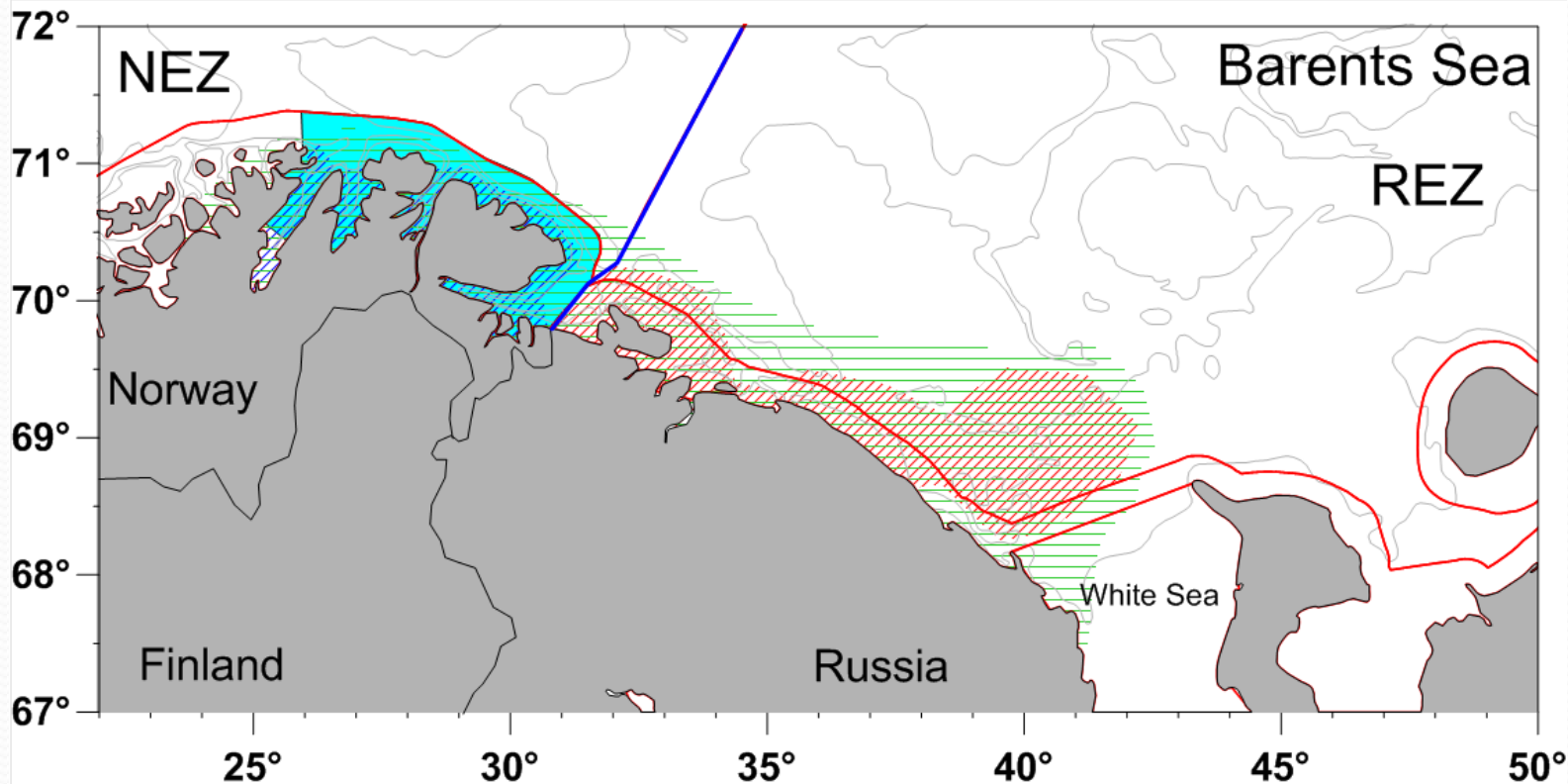- Russian-Norwegian border
- 12-miles line

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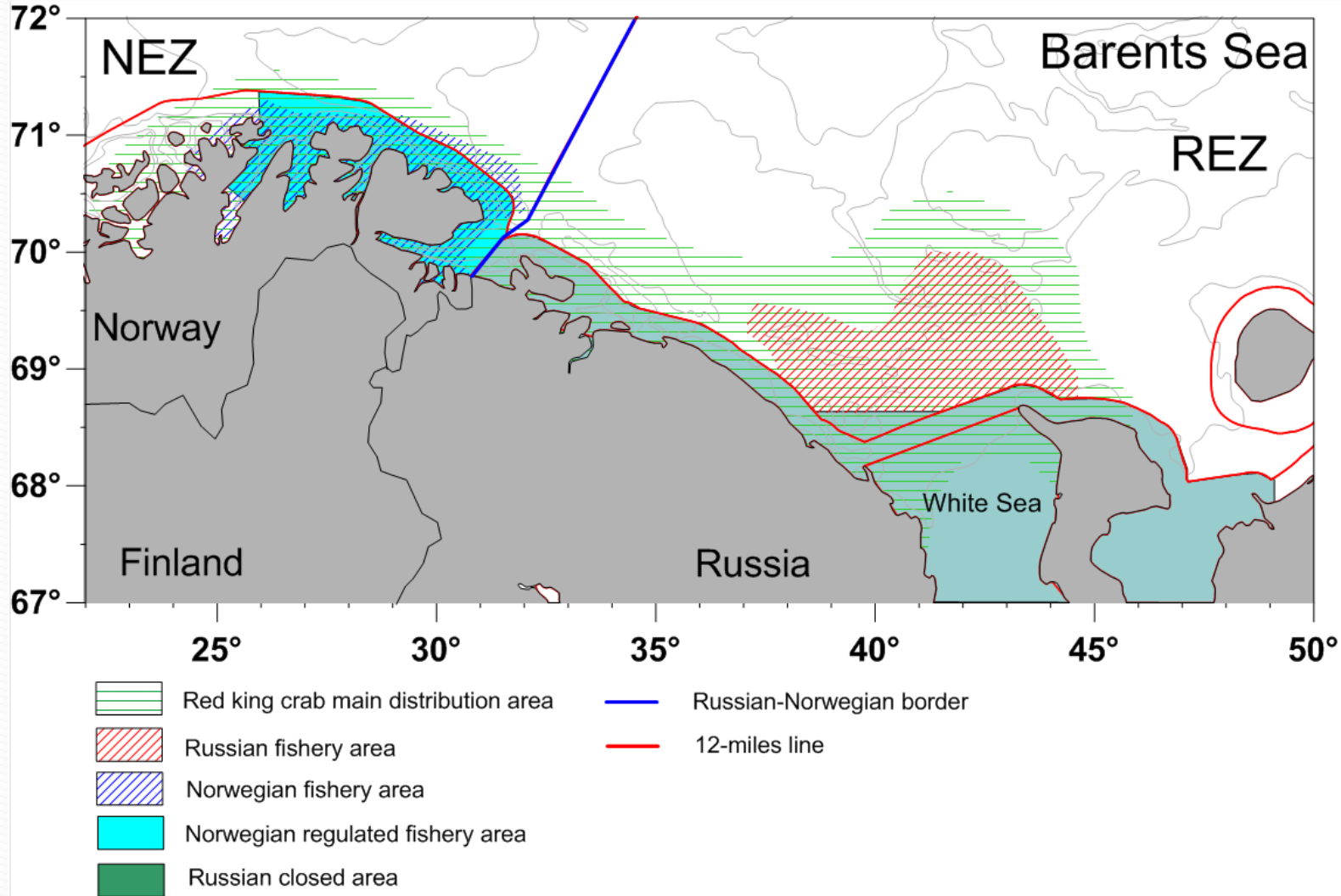
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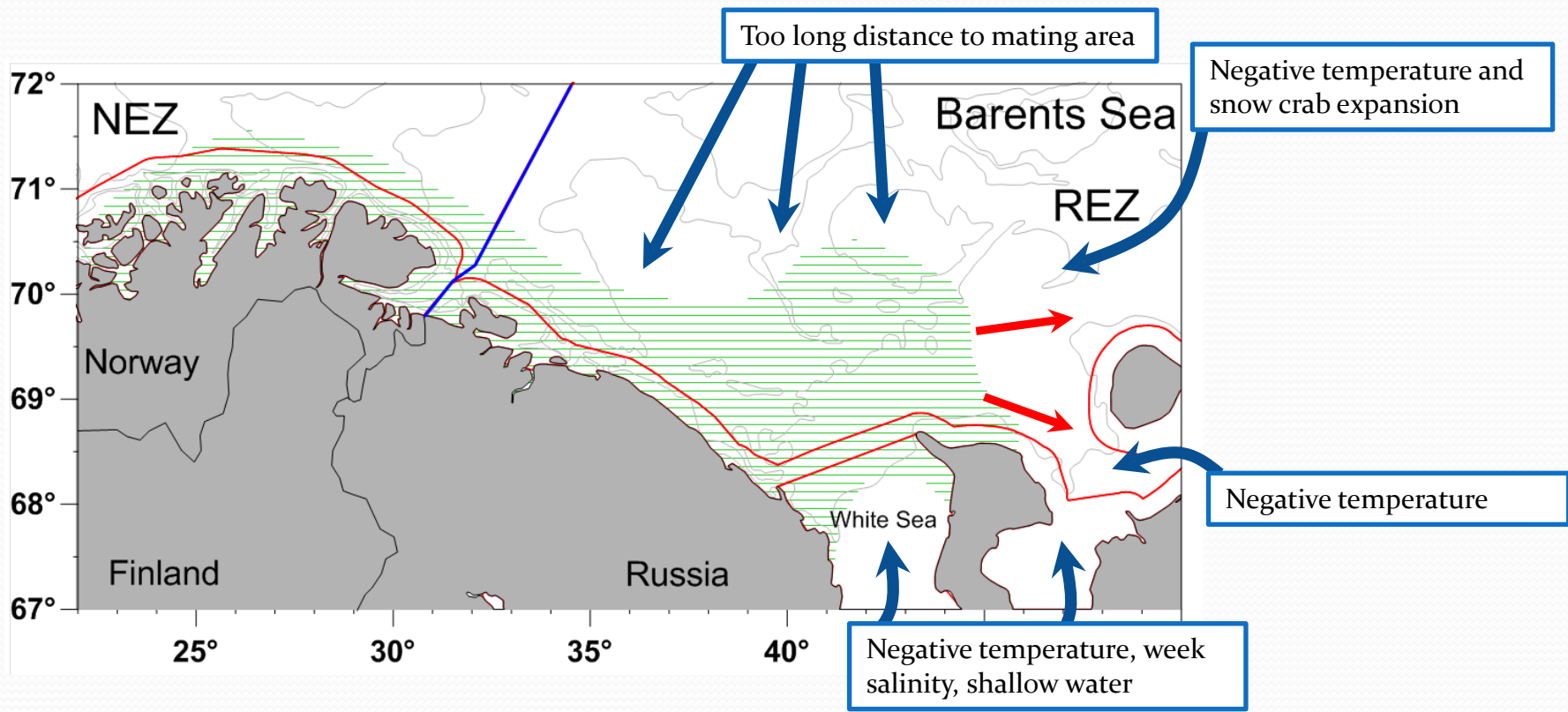

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- 12-miles line

Red king crab in REZ

Possible directions and limiting factors of further expansion

Snow crab fishery in the Barents Sea in 2013-2014

Preliminary snow crab landings in the International waters of the Barents Sea in 2013-2014 (tons)

Year	Russian	Norwegian	Spanish	Lithuanian	Total
2013	62	2	1	-	
2014	1369	675	1445	345	3834

Numbers of vessels

| Year	Russian	Norwegian	Spanish	Lithuanian	Total
2013	2	2	1	-	
2014	8	4	1	2	15

Comments:
1) Due to state tax system Russian vessels still can not catch snow crab in REZ, only interntaional waters.
2) Russian fishery in 2013 were carried out during first part of December.
3) Russian fishery in 2013 started from april.
4) Russian catch in 2014 was updated in 15.07.14
5) Russian CPUE are about 3-8 tons per day.

Snow crab distribution (ecosystem survey data 2013) and Russian fishery in 2014
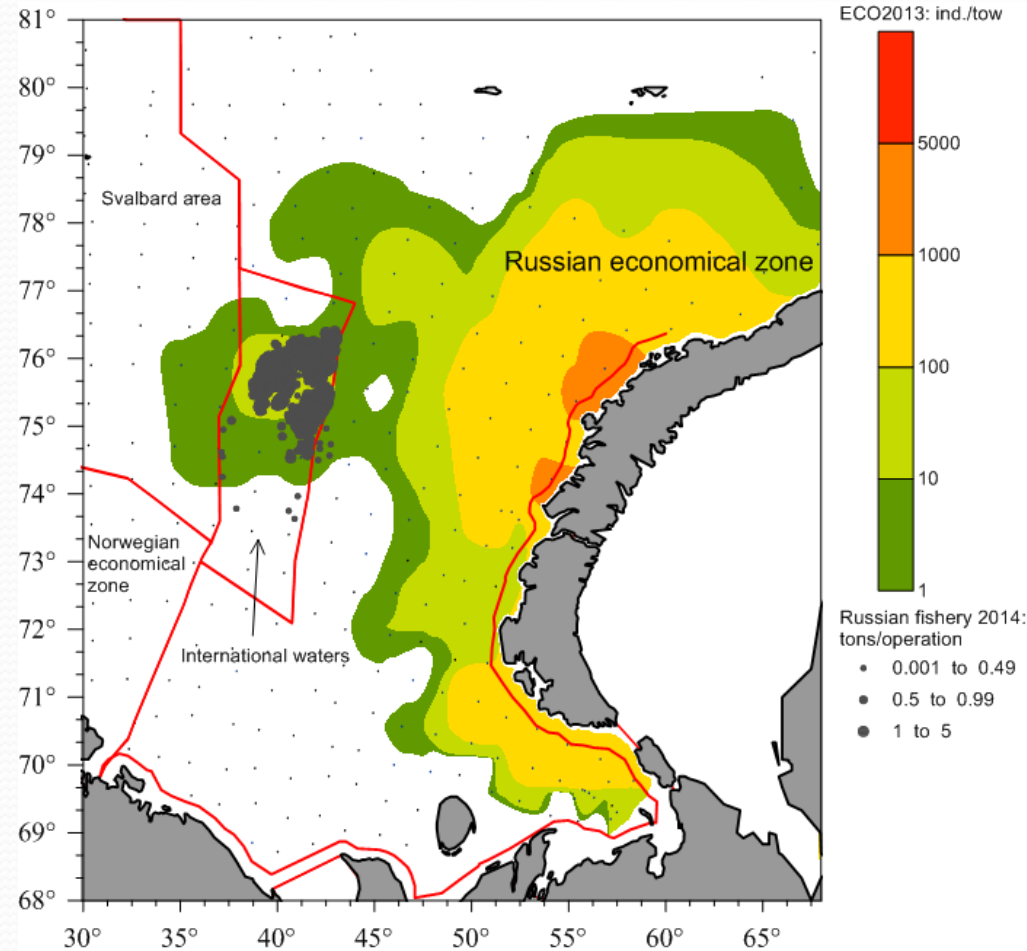
Snow crab
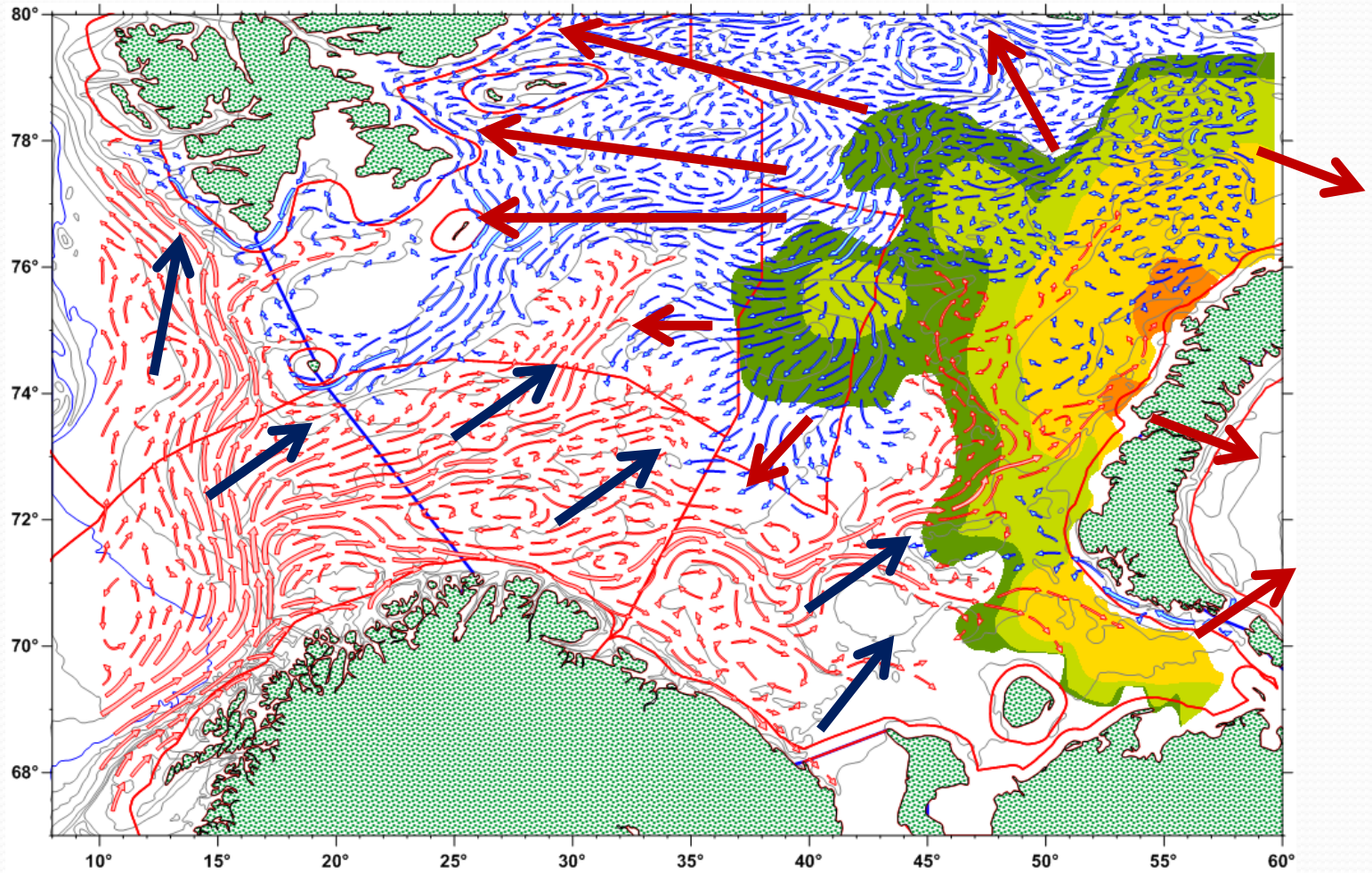
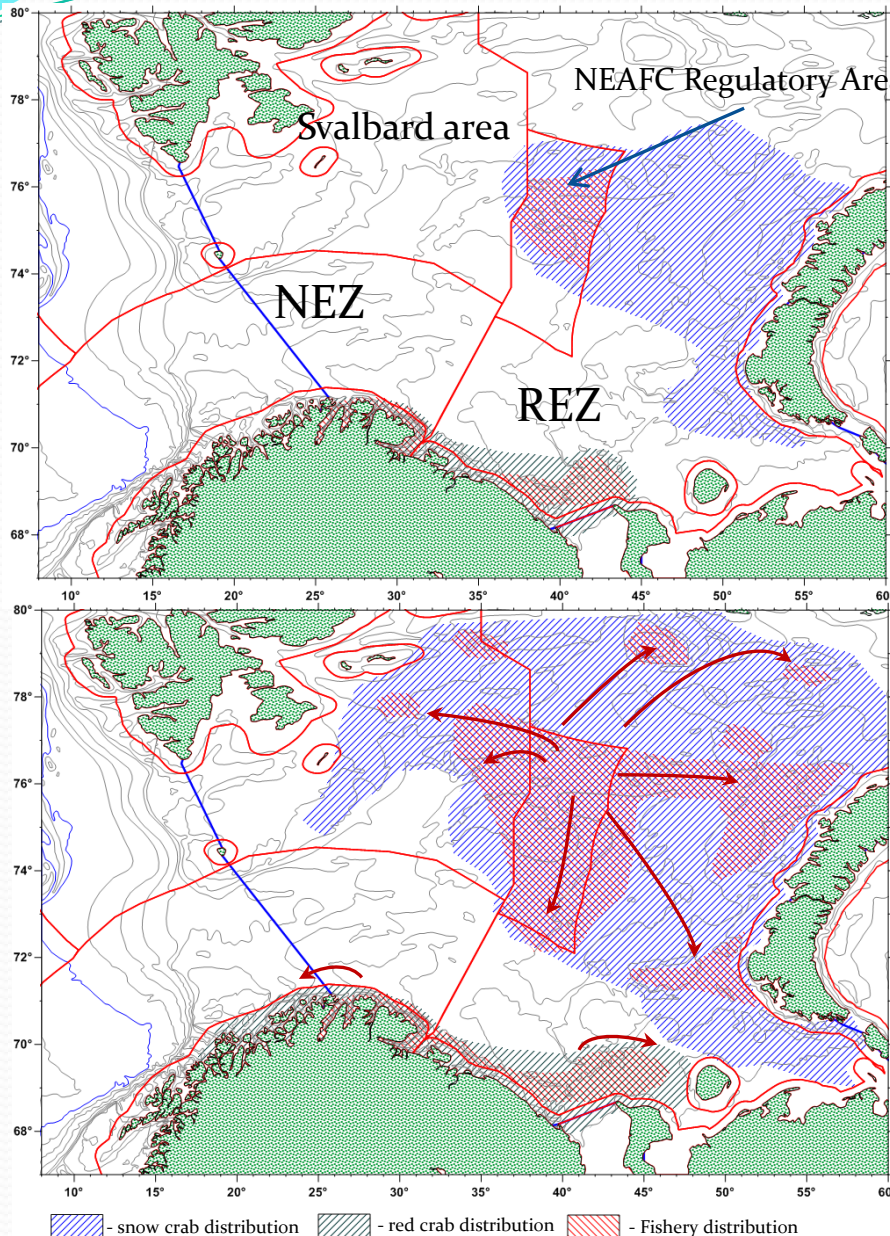Possible directions and limiting factors of further expansion

Positive factors:
1) Depth range ;
2) Currents system;
3) Temperature of north and north-east parts
    (Area of Cold Water < 2°C);
4) Food availability.

Positive factors:
1) Temperature of south and west parts;
2) Red king crab distribution.

Svalbard area

NEAFC Regulatory Area 3

NEZ

REZ

- snow crab distribution
- red crab distribution
- Fishery distribution

2013-2014

Snow crab

1. Snow crab population in the Barents Sea is in active phase of acclimatization;
2. Increasing of area and abundance;
3. Increasing of fishery activity
4. Different area of management (free fishing, closed);

Red king crab

1. Positive population dynamic and moderate (reasonable) level of exploitation ;
2. Stable area of distribution and low probability of further expansion;
3. Different area of management (free fishing, TAC regulated, closed);
4. Different spatial allocation of fishing intensity;

2023-2024

Snow crab

1. Further expansion, increasing of area and abundance are expected;
2. Largest potential habitat (most expansive cold water area, even in a warm period in the Barents Sea);
3. Different area of management (REZ, NEZ, etc.);
4. International fishery. Annual catch can be around 50-100 ktons

Red king crab

1. No significant changing in area of distribution;
2. Possible expansion in east and west directions;
3. Increasing of fishery activity is not so considerable as for snow crab. Annual catch can be around 10 ktons.