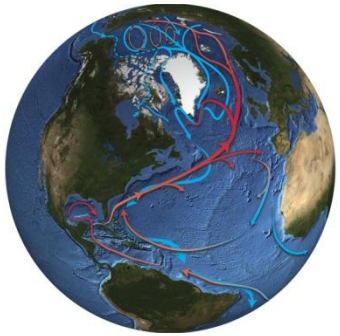
ICES
CIEM

4th EMB Forum
ARCTIC 2050
Towards ecosystem-based management in a changing Arctic Ocean
12 March 2014, Brussels
European MARINE BOARD
Advancing Seas & Oceans Science
EUROPEAN POLAR BOARD
EPB/ESF
Royal Flemish Academy of Belgium for Sciences and the Arts, Hertogsstraat 1, 1000 Brussels



Arctic Fisheries

Present and Future Perspectives

Dr. Paul L. Connolly
President - International Council for the Exploration of the Sea (ICES)

Content

1. **Context**
   The fisheries of the Arctic ocean and adjacent seas;
2. **Concerns**
   Fisheries Ecosystem Impacts; Focus on fish by catch;
3. **Socio Economic**
   Consequences of a shift in fish stocks;
4. **Arctic Fisheries Management**
   Needs and Opportunities.

The views expressed in this presentation are intended to prime discussion at this forum. They are not necessarily the views of ICES.

ICES CIEM

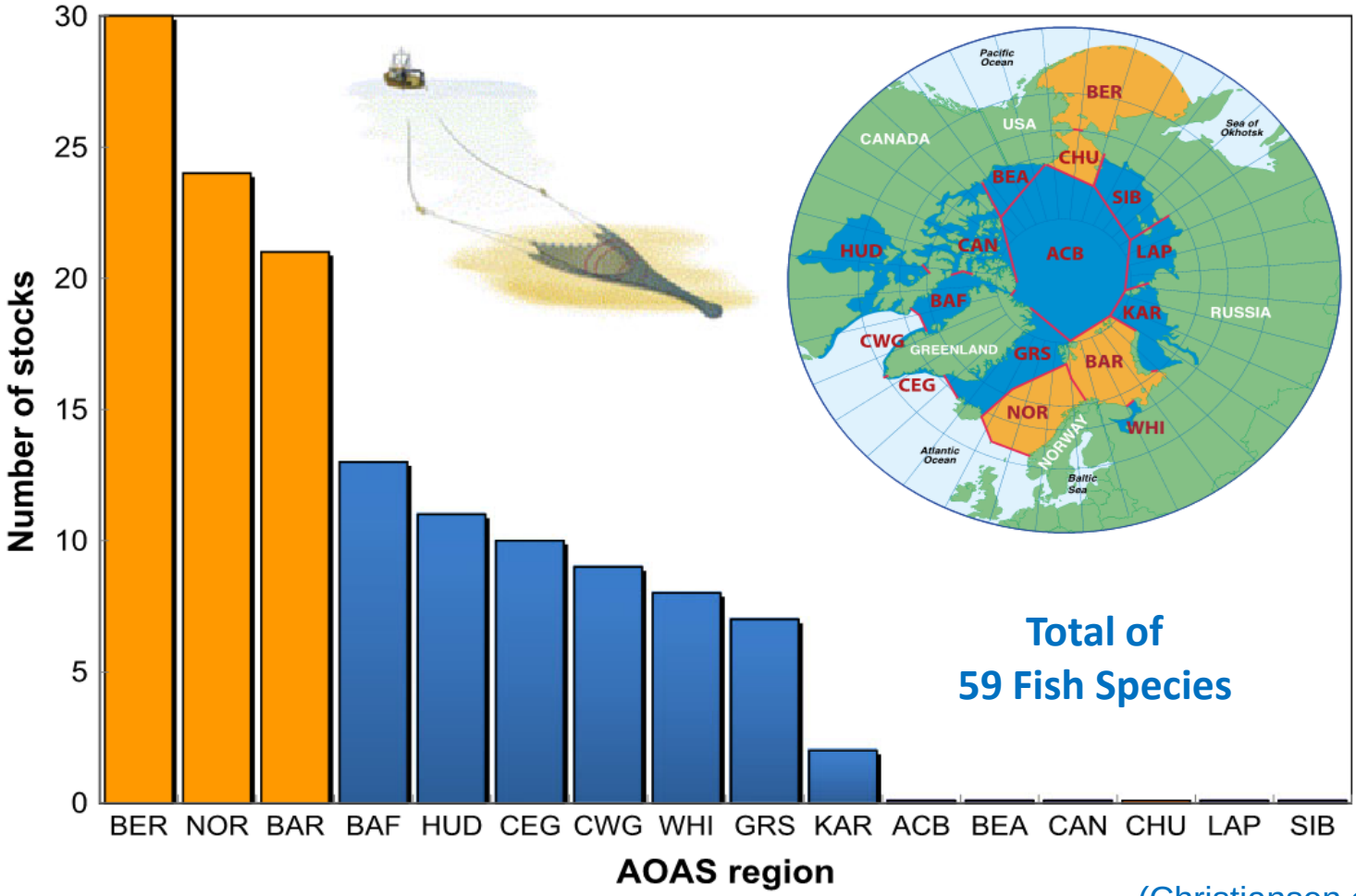
4th EMB Forum
ARCTIC 2050
Towards ecosystem-based management in a changing Arctic Ocean
12 March 2014, Brussels

European MARINE BOARD
Advancing Seas & Oceans Science

Royal Flemish Academy of Belgium for Sciences and the Arts, Hertogsstraat 1, 1000 Brussels

1. Context - *The fisheries of the Arctic ocean and adjacent seas*

Number of fish stocks currently harvested by industrial Fisheries in the Arctic Oceans and adjacent seas



(Christiansen *et al.* 2014)

Arctic Fisheries Snapshot

Table 3.1. Marine fishery in the Arctic. 2002. Million tonnes

Species	North-east Atlantic	Eastern Bering Sea	Western Bering Sea	Central North Atlantic (Iceland, Greenland and Faroe Islands)	North-eastern Canada (Newfoundland and Labrador Sea)	Total
Capelin	0.64			1.12	0.02	1.78
Herring	0.83		0.05	0.27	0.01	1.16
Cod fish						3.58
North-east Atlantic cod	0.49[1]			0.25		
Saithe north of 62°N	0.15					
Haddock, saithe				0.42[2]	0.01	
Pollack		1.50	0.40			
North-east Arctic haddock	0.08					
Blue whiting				0.28		
Greenland halibut	0.01			0.04	0.04	0.09
Pacific salmon		0.04	0.02			0.06
Other groundfish		0.20				0.20
Flatfish		0.06	0.01			0.07
Others	0.01	0.04	0.04	0.23		0.32
Total wild fish	**2.21**	**1.84**	**0.52**	**2.61**	**0.08**	**7.26**
Shrimps	0.06			0.13	0.10	0.29
Snow crab		0.01[3]		0.01	0.05	0.07
Total crustaceans	**0.06**	**0.01**		**0.14**	**0.15**	**0.36**
Aquaculture (salmon, trout)	0.09			0.01		0.10

[1] Includes coastal cod.
[2] See endnote 19.
[3] Includes king crab and Tanner crab.

Total Arctic Fish 7.26 million tonnes (10% global catch)
Total Arctic Crustaceans 0.36 million tonnes (5.3% global catch)
Total Arctic Aquaculture 0.2 million tonnes (7.7% global salmon trout)

(Lindholt, 2005)

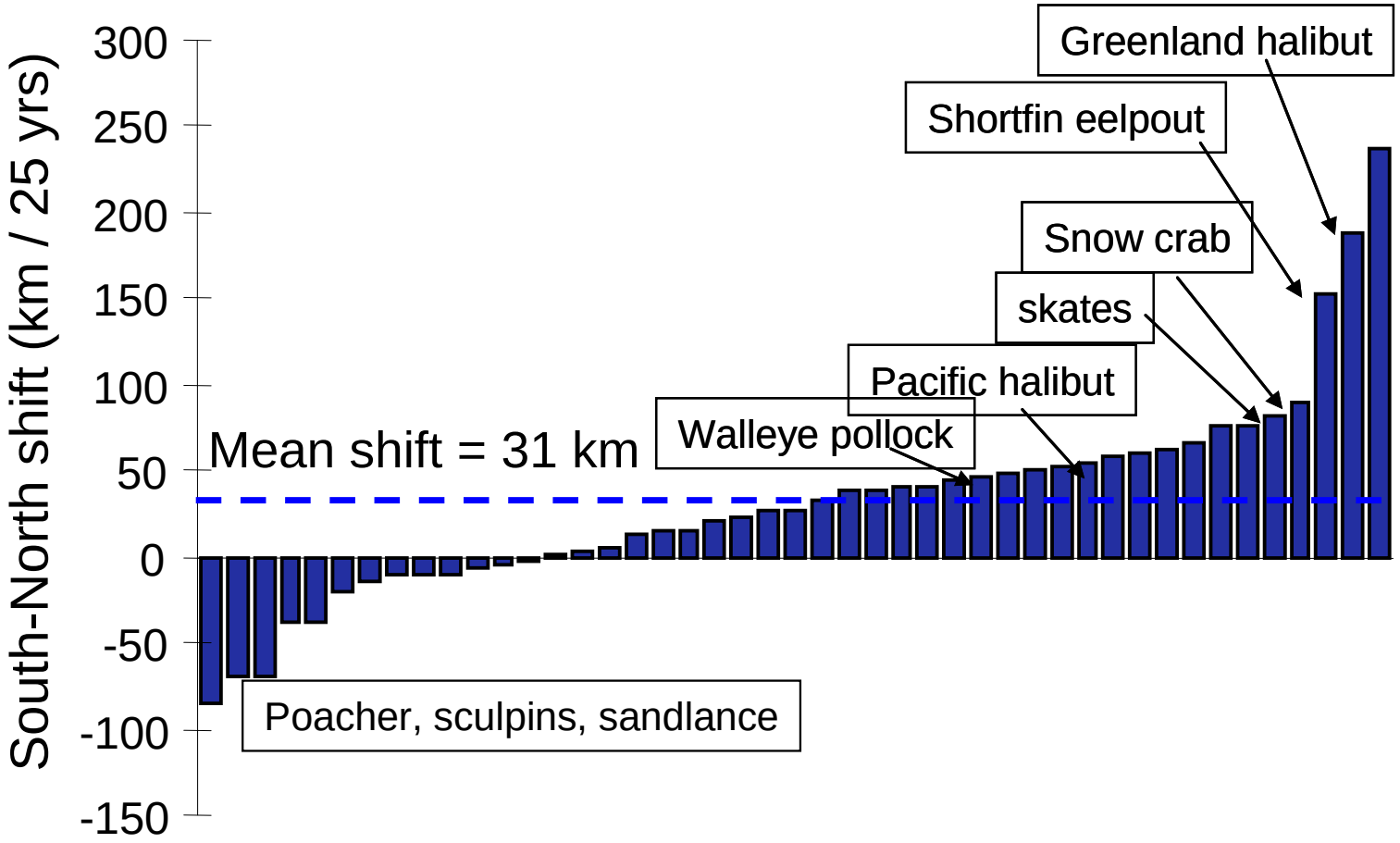
Fishing Intensity

Arctic commercial fishing is regionally Concentrated

Days at Sea per LME

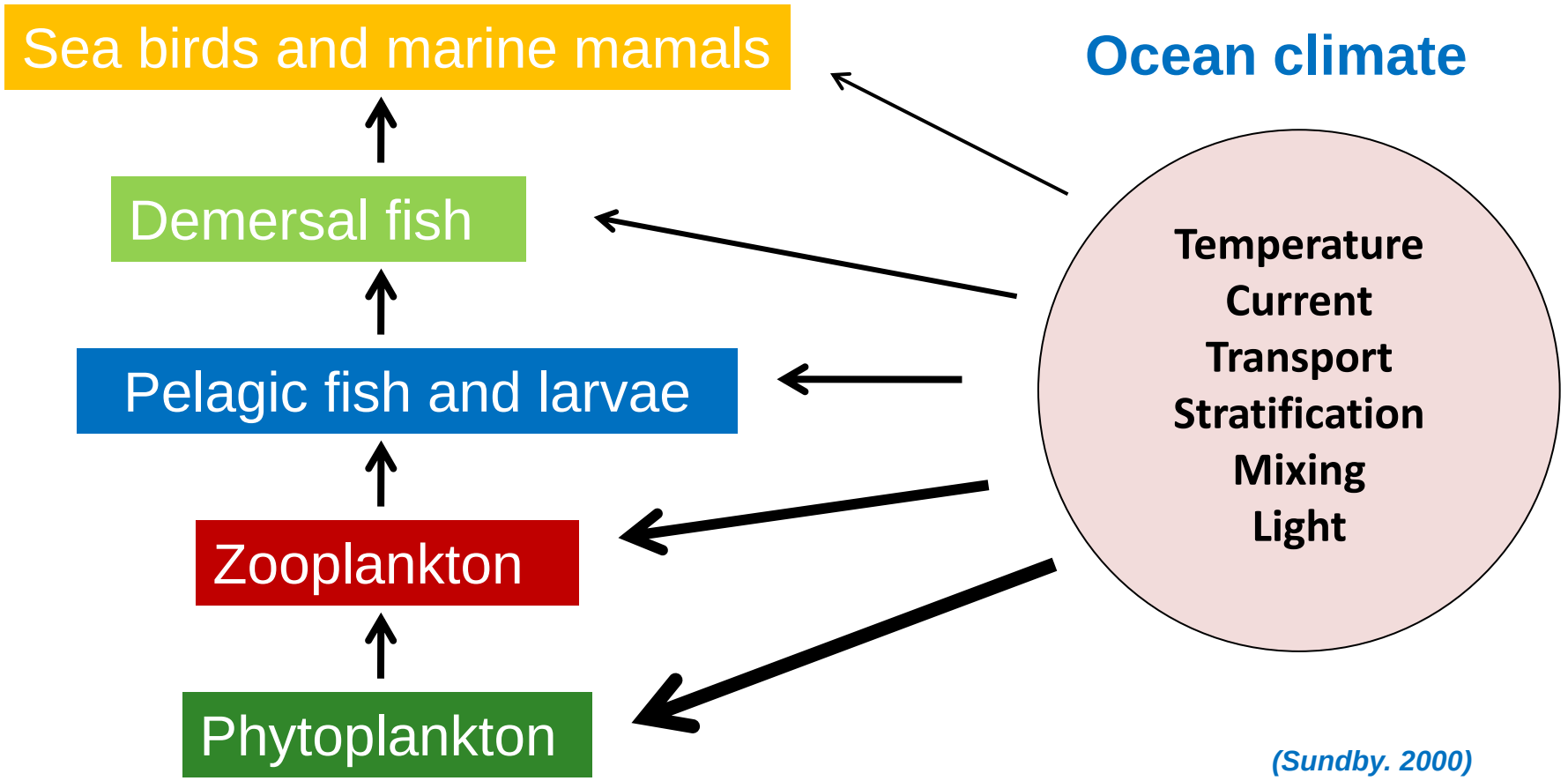
(Arctic Marine Shipping Assessment Report, 2009)

Shift in species distribution in the Bearing Sea 1982 - 2006



(Mueter and Litzow, 2008)

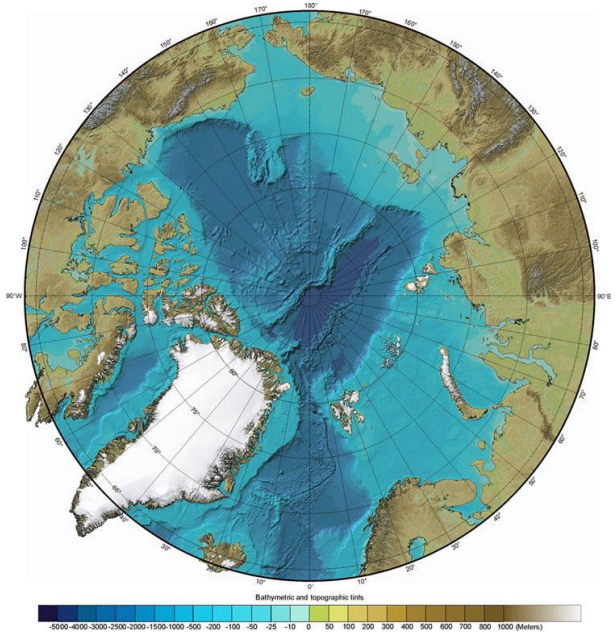
How climate affect species: directly and indirectly



(Sundby. 2000)

Key external criteria for establishing fish stocks in the Arctic Ocean

- Bottom topography
  - *Depth of migration corridors*
- Climatic conditions
  - *Temperature and salinity*
  - *Sea ice distribution*
- Food conditions
  - *Phytoplankton and zooplankton*
- Distance to spawning grounds



(Hollowed et al. 2013)

What criteria need to be fulfilled in order to get commercial fishing in the Arctic Ocean and the surrounding shelf seas?

- Rapid growth to survive during short growing season;
- Capability of avoiding unfavourable conditions (seasonal movement, feeding migration)
- Broad spawning range, with low site fidelity;
- Species has a diverse prey base

(Hollowed et al. 2013)

Those who have knowledge, don't predict;
Those who predict, don't have knowledge.

Lao Tzu, 6th Century BC Chinese Poet

Forecasting is the art of saying what will happen, and then explaining why it didn't!

Anonymous

(Adapted from Loeng, 2013)

Evaluation of potential for species to move into Arctic

Exposure (E)

The nature and degree to which a species is exposed to variations in the environment that results from climate change

Sensitivity (S)

Is the degree to which a species responds to variation in an aspect of the marine environment that will be affected by climate change

Potential for Impact (PI)

Is the outcome of the combination of E and S on species.

Adaptive Capacity (AC)

The ability or capacity of the species to mitigate the projected impact.

The potential for a species for moving into the Arctic is the result of the Potential Impact mitigated by the Adaptive Capacity.

(Hollowed, et. al. 2013)

Evaluation of potential for species to move into Arctic

Species/Stock	Current Main Areas	High	Potential	Low
Pacific ocean perch	Bering Sea			
Beaked redfish	Atlantic + Barent Sea			
Greenland halibut	Northern Atlantic + Pacific			
Greenland shark	Arctic Ocean + Adjacent Areas			
Arctic skate	Arctic Ocean + Adjacent Areas			
Other Elasmobranchs	Barent Sea			
Atlantic cod	Barent Sea			
Atlanto-scandic herring	Norwegian and Barent Seas			
Capelin	Bering + Barent +Kara Seas + Arctic			
Northern rock sole	Bering Sea			
Pacific cod	Bering Sea			
Polar cod	Barent Sea			
Walleye pollock	Bering Sea			
Yellowfin sole	Bering Sea			
Alaska plaice	Bering Sea			
Bering flounder	Bering Sea			
Snow crab	Bering Sea			
TOTALS		**6**	**6**	**5**

(Hollowed, et. al. 2013)

2. Concerns - *Fisheries ecosystems impacts – fish bycatch*

Fisheries Ecosystem Impacts

Focus on fish bycatch

" The increasing dominance of harvestable groundfish in Arctic waters, followed by intensified bottom trawling, will inevitably have direct and instant effects on the sea bed and non targeted species as they turn up as unwanted and unprecedented bycatch."

"Arctic bycatch fish play a fundamental role in the transfer of bioenergy from the lower trophic levels to seabirds and marine mammals – i.e. wildlife that forms the livelihood of indigenous peoples."

Arctic Marine Fish – Three key shortfalls

1. Unsettled and controversial taxonomy.	2. Poor Knowledge on temporal and spatial distribution.	3. Lack of quantitative data on growth and life history traits.

(Christiansen, et al. 2014)

Table 1 Marine fishes in the Arctic Ocean and adjacent seas (AOAS). 'TARGETED' denotes the number of species ('stocks') currently harvested by industrial fisheries in the AOAS, and their zoogeographic affiliation. 'BYCATCH' denotes the number of prospective Arctic bycatch species as industrial fisheries move poleward. 'IUCN' is the International Union for Conservation of Nature (http://www.iucn.org, accessed 10 July 2013). 'Other scientific bodies' embrace national and international marine fisheries services such as FAO and ICES. 'Biological knowledge' includes e.g. analyses on demographic structuring, abundance and trends

Category	TARGETED (n = 59)			BYCATCH (n = 60)
Zoogeography	Arctic	Arctic-boreal	Boreal	Arctic
Number of species	3	6	50	60
Evaluated by IUCN	1	0	7	4
Evaluated by other scientific bodies	3	6	50	0
Biological knowledge	Poor to moderate	Moderate	High	Negligible

633 marine fish species in AOAS (CAFF)
63 (10%) considered Arctic species

(Christiansen et al. 2014)

ICES CIEM

4th EMB Forum
ARCTIC 2050
Towards ecosystem-based management in a changing Arctic Ocean
12 March 2014, Brussels
Royal Flemish Academy of Belgium for Sciences and the Arts, Hertogsstraat 1, 1000 Brussels

European MARINE BOARD
Advancing Seas & Ocean Science

3. Socio economics *Consequences of shifts in fish stocks*

Some Socio Economic Considerations

Area	Key Fisheries	Social	Economic
NE Atlantic Norwegian and Barent Seas	Capelin, Polar Cod, Greenland Halibut, Northern Shrimp, Herring. NE Atlantic Cod	Coastal communities experiencing population reduction. Pressure towards urbanisation Lack of employment opportunities Trend for sale of fishing vessels out of communities Regional diversification programmes Russia cities rather than fishing communities	Considerable economic significance to Norway - 14% of total exports. Most northern coastal communities dependent on fishing Russian fleet concentrated in large cities Total Yield 2.1 million tonnes Total annual value $ 2 billion
Central Norh Atlantic, Iceland and Greenland	Atlantic Cod, Northern Shrimp, Herring, Greenland Halibut, Capelin, Polar Cod, Blue Whiting	Accounts for 40% local employment in 24 municipalities in Iceland Communities on eastern and western fjords depend on fishing	Iceland - economy driven by fishing. ITQ - allow stability in profits. Contributesd 11% to GDP Greenland - fishing very important- scale. Iceland $ 1.2 billion Greenland $ 285million
Newfoundland and Labrador Seas Northeastern Canada	Atlantic Cod, Greenland Halibut, Capelin, Herring, Polar Cod, Northern Shrimp Snow Crab	From economy based on fisheries, newfoundland has moved to a service economy. Dominates rural economy and culture Collapse of cod Newfoundland experience a template for what mat happen with climate change? Dramatic drop in family size. Exodus	Collapse of cod Diversification - Tourism and IT Shellfish replace groundfish.
North Pacific Bearing Sea	Capelin, Greenland Halibut, Shrimp, Polar Cod, Pollock, Crab, Pacific Cod, Flatfish Salmon	Community development quotas (CDQ) 10% of Bering Sea TAC to 65 coastal communities Large distant water fleet Component	6 CDQ corporations $40million annually Russian far east - $ 3 billion ? Pollock TAC 2011 2012 1.2 million tonnes

(Arctic Climate Impact Assessment, Chapter 13)

ICES
CIEM

4th EMB Forum
ARCTIC 2050
Towards ecosystem-based management in a changing Arctic Ocean
12 March 2014, Brussels
European
MARINE BOARD
Advancing Seas & Ocean Science

Royal Flemish Academy of Belgium for Sciences and the Arts, Hertogsstraat 1, 1000 Brussels

" Thus it is not possible to predict the effects of climate change on marine fish stocks with any degree of certainty and so the eventual socio-economic consequences of these effects for Arctic fisheries. "

"Commercial fisheries in the Arctic regions are based on a number of species belonging to physically different ecosystems. The dynamics of these ecosystems are not well understood."

" The total effects of climate change on fish stocks is probably going to be of less importance than the effects of fisheries policies and their enforcement."

(Arctic Climate Impact Assessment, Chapter 13)

ICES CIEM

4th EMB Forum
ARCTIC 2050
Towards ecosystem-based management in a changing Arctic Ocean
12 March 2014, Brussels

European MARINE BOARD
Advancing Seas & Ocean Science

Royal Flemish Academy of Belgium for Sciences and the Arts, Hertogsstraat 1, 1000 Brussels

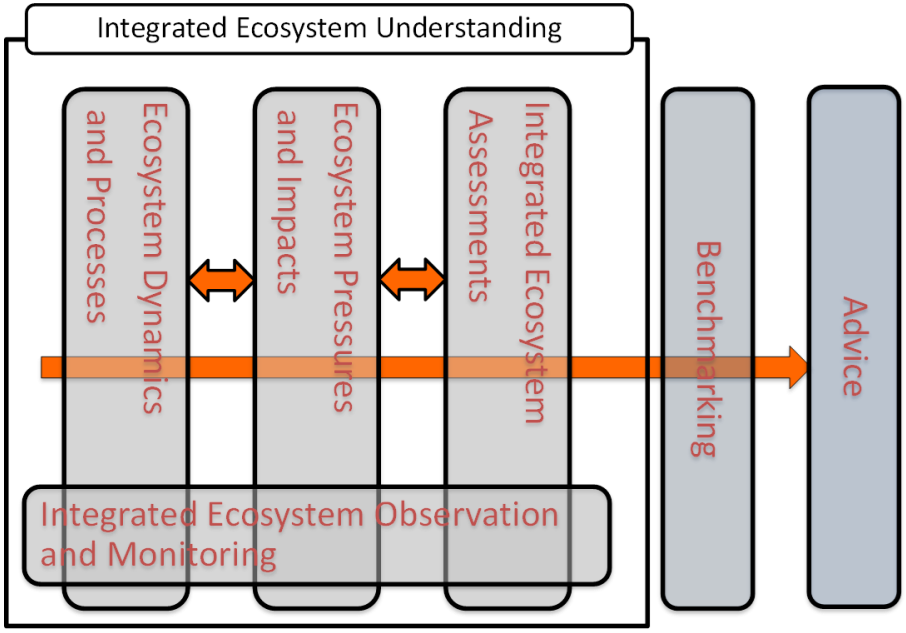
4. Arctic Fisheries Management - *Needs + Opportunities*

ICES
CIEM

4th EMB Forum
ARCTIC 2050
Towards ecosystem-based management in a changing Arctic Ocean
12 March 2014, Brussels
Royal Flemish Academy of Belgium for Sciences and the Arts, Hertogsstraat 1, 1000 Brussels

European MARINE BOARD
Advancing Seas & Ocean Science


ICES STRATEGIC PLAN
1
Building a Foundation of Science
2
Producing the Information and Advice Decision-makers need
3
Underpinning Science and Advice through Data and Information Services
4
Supporting the Organization through the work of the Secretariat


Integrated Ecosystem Understanding
Ecosystem Dynamics and Processes
Ecosystem Pressures and Impacts
Integrated Ecosystem Assessments
Benchmarking
Advice
Integrated Ecosystem Observation and Monitoring

ICES Strategic Plan Goals (3 of 7)

1. Develop an integrated, interdisciplinary understanding of the structure, dynamics, and the resilience and response of marine ecosystems to change
2. Understand the relationship between human activities and marine ecosystems, estimate pressures and impacts, and develop science-based, sustainable pathways
3. Evaluate and advise on options for the sustainable use and protection of marine ecosystems

ICES
CIEM

4th EMB Forum
ARCTIC 2050
Towards ecosystem-based management in a changing Arctic Ocean
12 March 2014, Brussels
European MARINE BOARD
Advancing Seas & Ocean Science

Royal Flemish Academy of Belgium for Sciences and the Arts, Hertogsstraat 1, 1000 Brussels

ICES Regional Groups

WGIBAR
WGINOR
WGIAB
WGINOSE
WGEAWESS
WGNARS

Management of fish stocks

Management regimes with sufficient capacity, in terms of robust science, regulatory frameworks that contribute to reduced fishing effort and maintenance of sustainable stock levels, and enforcement capability, are more likely to respond adequately to the challenges posed by climate change than those that do not.

(Harsem and Hoel 2012)

ICES
CIEM

4th EMB Forum
ARCTIC 2050
Towards ecosystem-based management in a changing Arctic Ocean
12 March 2014, Brussels

European
MARINE BOARD
Advancing Seas & Ocean Science

Royal Flemish Academy of Belgium for Sciences and the Arts, Hertogsstraat 1, 1000 Brussels

Scientific perspectives on climate change and Arctic fisheries - Four Key Questions;

1. How will productivity of Arctic ecosystems change?
2. What species are most likely to migrate successfully to the Arctic to establish self-sustaining populations?
3. How are successful migrations likely to alter Arctic marine ecosystems?
4. What research is needed to understand these ecosystem changes and the impacts of commercial fishing on them?

Future Research Needs;

Food for thought !

1. Resolve impacts of Atlantic inflow to Arctic.
Food Webs;
Migration patterns;
Support modelling

2. Conduct periodic fish/plankton surveys.
Fish responses to variability in ocean conditions;

3. Promote novel approaches to ecosystem modelling.
Ecosystems are complex and defiant to conventional predictions;

4. Studies on zooplankton community dynamics;
Expected increase in production in ice free Arctic;

5. Studies on fish community dynamics;
Factors governing fish and shellfish movement

6. Studies on Benthic Community Dynamics;
Benthic species substantial contribution to feeding of fish;

(Hollowed et al. 2013)

The ICES Network

Partnership, Co-ordination, Cooperation

- **A scientific network committed to excellence, independence and peer review;**
- **A network for added value to national science efforts through international cooperation and coordination beyond the frontiers of Europe;**
- **A network for marine data storage, quality control and data products**
- **A network for planning, coordination, and delivery of scientific advice;**
- **Against a background of a changing policy landscape, a new ICES Strategic Plan, ICES needs new inputs from the broad marine science community as well as decision-makers.**

Concluding Comments

1. The north and eastward movement of species will depend on density distribution, temperature and food conditions
2. Only pelagic species will potentially move into the deep Arctic Ocean
3. Most likely no fishing activity in the Arctic Ocean the coming 10-15 years.
4. Great Opportunity to progress IEA and the Ecosystem Approach to Ocean Management.