Name of the case study	Bering Strait – Arctic shipping – International [Resilience]		
What about this case makes it interesting? How does this case contribute to understanding of resilience and/or regime shifts in the Arctic?	This case study involves biophysical (climate change, ice-sheet coverage), ecological (high biodiversity, e.g. whales) as well as socio-economic (hunting, industry) components. There is a currently observable effect of climate change, which, although regional, also calls for international policy and agreements. Sea ice provides a habitat for microorganisms as well as marine mammals. Changes in the sea ice extent also affects the migration routes of Arctic marine mammals, such as whales. Significant ecosystem changes have been observed in the 1970s and 1990s, partly resulting from decadal climate patterns (Pacific Decadal Oscillation, Arctic Oscillation). There is also currently a transition in shipping activities from experimental to a more routine use of the Northern Sea Route (2), and vessel traffic through the Bering and Anadyr straits is expected to increase during the next ten years. The three main shipping routes (Northwest Passage, Northern Sea Route, Transpolar Sea Route) across the Arctic Ocean all pass through the Bering Strait. Experience from Alaska shows that ship strikes and whale deaths are likely to occur when whale aggregations occur in shipping lanes (3). Climate change and development of shipping technology thus currently affects this sensitive area. A possible solution is through changes in shipping policy, but requires international agreements and needs to take the local perspective into account. Furthermore, a solution needs to address multiple interacting factors of the entire system so that it can absorb disturbances and reorganize into a new equilibrium (4). There is opportunity to work with prevention, rather than acting to an eventual crisis. Namely by learning from a similar example (Alaska) and applying the knowledge and experience from there to the Bering Strait case (3).		
Template completed by: *Main contributor	Participants of the ACCESS course 2014: Elin Högström*, Vienna University of Technology Shealagh Pope, Arctic Science Policy Integration Directorate, Canada Katrin Lindbäck, Uppsala University	**Key references: Cite in the text using (1), (2), (3) etc. and provide a reference list at the bottom of the template.** (7) Humpert, M. and Raspotnik, A. 2012. The future of Arctic shipping along the Transpolar Sea Route. Pages 281-307 *in* L. Heininen, editor. *Arctic Yearbook*. The University of the Arctic. [online] URL: http://www.arcticyearbook.com/2013-10-11-09-09-56	
Reviewed by (name and affiliation)			
Category (mark with X)	**Resilience/ Adaptability**	**Loss of resilience**	**Transformation**
	X		

Case study details:	**Country**	**Place**	**Scale – space**	**Scale – time**	**Sector(s)**	**Other (e.g. disturbance)**
	International	Bering Strait		1980s-present	Shipping	Interfering with whales

Drivers (mark with X in appropriate boxes)	**Climate**	**Geopolitical**	**Mineral/ oil extraction & infrastructure**	**Tourism**	**Shipping**	**Biological invasion**	**Rapid demographic change**	**Other:** ***state here***
	x				X			

	Biophysical	**Social**
1. Basic description of coupled social-ecological system in focus **(**What are the key components and stake holders) If possible draw a systems diagram or conceptual map of the case – this can be a series of diagrams to capture different periods in the case and the drivers/ actors/ events that characterize the period.	a) What types of ecosystem(s) and other major biophysical features are present? The significance of marine (incl. mammals), avian, and coastal ecosystems in the Bering and Anadyr Straits are mentioned in the Arctic Resilience Interim Report. This part of the Arctic comprises three ecologically and biologically sensitive areas, defined by the International Union for the Conservation of Nature (IUCN). Biophysical feature: the sea ice. The sea-ice has been observed to have diminished in extent as well as thickness, noticeable through multi-year changes of ice in response to climate change (5). b) How are the case boundaries defined in terms of ecosystems or biophysical characteristics? The focal ecosystem is the Bering Strait and the Bering Sea, to the south and Chukchi sea to the north. For the purposes of the case, the ecosystem is defined as the space used by bowhead whales and walruses – both are Arctic specialist species that are the basis of subsistence hunting	c) Who are the key groups of people in this case? Indigenous communities, potentially affected by the issue of “food security”, brought up in the report. d) What kinds of livelihoods are important in the system? Hunting (eg. whaling), fishing, industry (oil, gas, affects Bering strait through shipping). e) What institutions (rules and norms) or are key to this case? If possible define what scale it addresses. f) How are the case’s boundaries socially defined, and how do these social boundaries relate to biophysical boundaries? The socially defined boundaries are defined by tradition (i.e. hunters) and by political interests (the above listed institutions), including economic ones. These boundaries

	for indigenous peoples in both Alaska and the Chukchi region of Russia. The shipping routes transit through the bowhead habitat and their migratory paths as well as between the coastal communities. It also goes through the haul out areas for walrus.	do not match with those of the ecosystem and biophysical features. There seems to be a mismatch between “local people” and the international use of this water for shipping purposes. However, a scale/boundary-integrated solution looks quite possible, when considering the scale coverage of the listed institutions.

2. Timeline

Draw a timeline of *key* events/ developments to the case. Points to include:

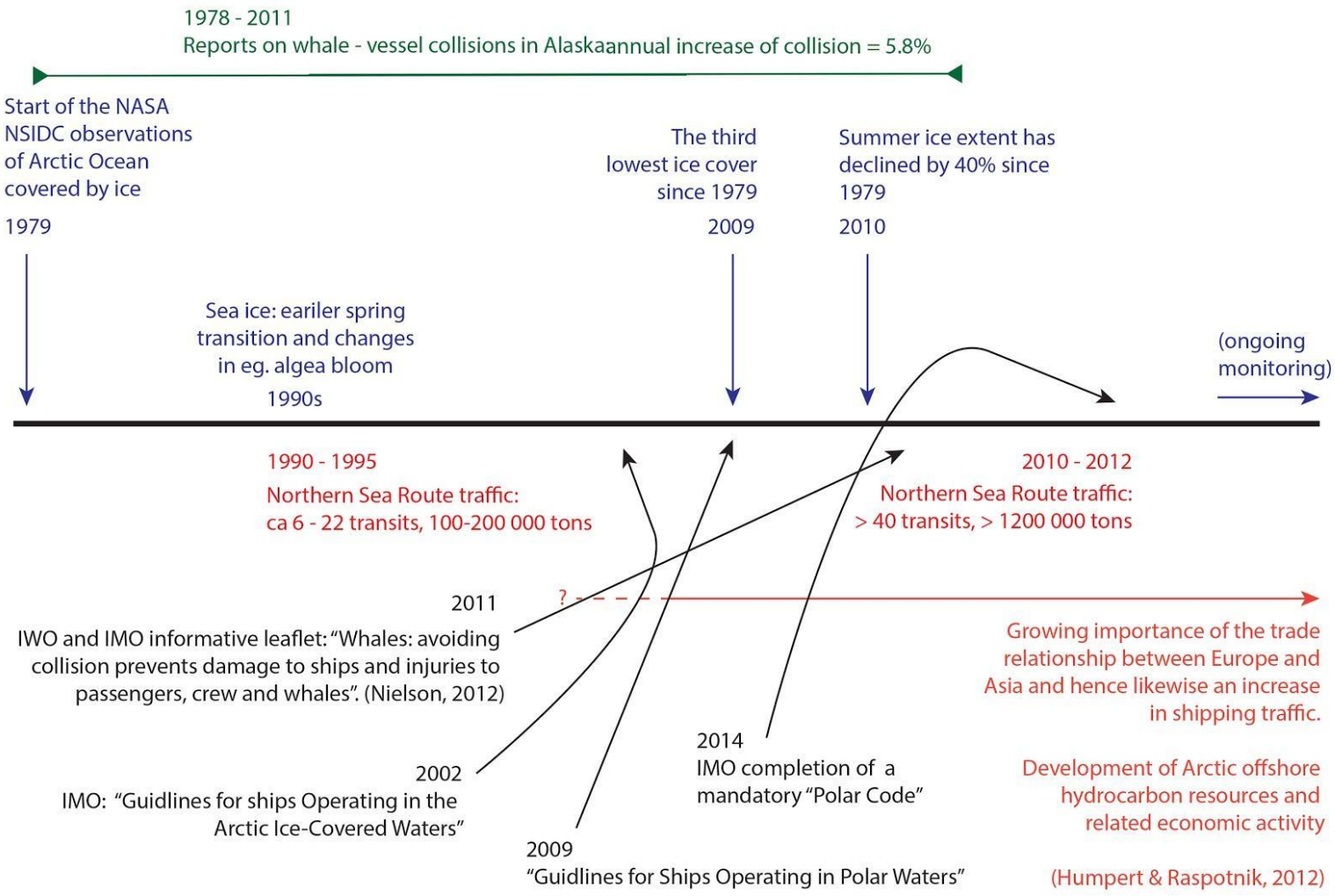
Make clear the period of time over which the change is being considered.

Provide a brief description of event/ actors, and ecological impacts. Mark particularly significant events with *.

Consider both biophysical and social dimensions.

Additional points that can be considered:

Is it possible to identify periods of change from one type of system to another, transformations?



Identify disturbances or events that challenged, built, or reduced resilience or adaptive capacity in the system.	

3. Disturbances What are the key disturbances in the system (present and past)	a) Have there been major biophysical disturbances that are relevant for the case? 1) Substantial decrease in sea-ice, notably between 1979 and 2010 (5). 2) The long-lived bowhead (up to 100 years) is slowly rebuilding, but is listed as a species of concern in Canada and US (unknown if also in Russia).	b) Have there been major social disturbances that are relevant for the case? 1) A major social disturbance is increased vessel traffic. This has negative implications for maritime mammals (and for the ships themselves) through strikes and the death of whales, and so for food security. 2) Commercial whaling in the 19th and first half of the 20th century decimated the western bowhead population. There is a moratorium on commercial hunting of this species; however, a small subsistence take is allowed under the International Whaling Commission (IWC) for indigenous subsistence purposes.
4. Drivers of change Clarify what impacts these drivers have on the SES and if these are direct or indirect	a) What are the key biophysical drivers of change? The observed decrease in sea ice is driven by climate change, which in turn partly results from decadal climate patterns (8). Reduction in summer **sea ice** extent affects the geographic distribution of food important to both walruses and whales. For walruses in particular, this has implications for individual and	b) What are the key social drivers of change? The social drivers for increased vessel traffic and ships striking whales are technological development, industrial interests, efficiency and economy (shorter and less congested route) and globalization. The shift in economic and political spheres of influence (geostrategy, political power shift towards Asia) (7).

	population survival as travelling to the floe edge for feeding from the haul out sites is becoming energetically costly. **Acidification** associated with CO_2 uptake by the oceans, as well as warming and freshening of the Arctic ocean, may cause shifts in primary and secondary producers – particularly zooplankton - that could have cascading negative effects on animals further up the food chain. With warming of the Arctic Ocean and the retreat of the summer sea ice, more **southerly species** are being observed in the Bering Sea. This could cause competition for resources with obligate Arctic species (such as the bowhead and walrus). It could provide different resources to indigenous people if they could make the shift.	
5. Sources of adaptive capacity: What factors allow(ed) the system to adapt to disturbances in the past and present? Give a brief assessment of recent or on-going changes (+/-/0 = increasing/	a) Within the ecosystem? (-) The cumulative effects of sea ice retreat, food chain changes due to acidification and warming, and competition from more southerly species could all negatively affect the adaptive capacity of top predators in the Arctic such as the bowhead, walrus, and humans.	b) Within society (e.g. people, social capital, management, institutions, infrastructure): Possibilities to adapt to disturbances but not yet in place: To learn from previous experience elsewhere, and thus follow recommendations for protective measures, such as vessel speed limits and alternate routes (3). This can be implemented through international and national policies. There is potential of Arctic Council to contribute to strengthening the international governance system for shipping, based on the IMO. The council may facilitate regulatory advances in the IMO, through knowledge building (research) and diplomacy.

reducing/ not affecting adaptive capacity)		
	The next two sections break down the information in Section I. While it is not necessary to fill these sections, if you have additional information pertinent to specific rows below feel free to enter the material.	
II.1-8 SES, resilience and adaptive capacity	**Biophysical**	**Social**
II.1. Where do we find changes and resilience in the face of change?	a) Within Nature	b) Within society Economic interest in the Arctic, technology.
II.2. What are the system's key components?	a) Key Ecological components (e.g. lakes, coastal zones, caribou) Sea Ice, fish, whales, walrus and associated food webs	b) Actors in society (e.g. individuals, groups, public or private organizations)? How are people organised – by geography, livelihood, family, etc.? Indigenous groups, IMO, Russian Federation, Alaska/U.S., shipping companies, Offshore companies (oil and gas).
II.3. What are the key	Changes in water temperature and sea ice affect migration of	a) From society to nature – modifying nature, extracting resources (e.g. hunting, mining, water pollution)

linkages? E.g. ecosystem services, resource extraction. These linkages should exist. If there are not mutual links between social and ecological components the case is not a social-ecological system.	indigenous and non-indigenous species.	hunting of whales extraction of oil and gas noise pollution from ships risk of pollution (oil spills etc.)
II.4. What are key interactions?		a) What collaborations, conflicts, or other key linkages exist between actors? Nations - IMO collaborations Indigenous groups hunting disturbed by shipping/offshore companies b) Between local actors and distant actors? International shipping/offshore projects - Local communities
II.5. Culture		a) What are key cultural features of relevance for the case? Traditional hunting culture b) What are key cultural practices and beliefs related to nature?

		Whale hunting from umiaks (skinboats)
II.6. Disturbance What are important types of stress & shock		a) Describe important social shock and stresses (e.g. austerity policies, changes in government policy, introduction of new technologies, etc.) Risk of hunters getting killed (overrun by ships) Whales disappear (move to remote regions too far away from community) Offshore techniques preventing traditional hunting (spatially) Weather (storms)
II.7. What are key slow variables Changes that occur over decadal or longer time scales		a) What types of slow social processes (e.g. aging, population growth, loss of language) are driving important changes in social institutions and behaviours? Habitat changes (whales decrease, change behavior) Climate change (loss of sea ice, warmer ocean waters)
II.8. Relationships with ecological regime shifts		a) Can social stresses or major changes be attributed to ecological regime shifts? Climate change (loss of sea ice) b) Are there specific social practices that might be contributing to ecological regime shifts
II.8 Regime shifts		

II.8.a. Detailed description of alternate regime shifts A case study can contain more than one type of regime shift		Traditional hunting communities change to other types of livelihoods, or the communities get abandoned. The hunting communities change their hunting techniques (modernize).
II.8.b. Feedback mechanisms within the system that maintain each regime		
II.8.c. What key changes drive regime shifts? Describe how these changes alter the state of the system or feedback processes.		a) Drivers of social regime shifts (either social or ecological): Climate/Sea ice decrease Changes in whale (marine mammals) populations and habitats Industrial interest Offshore development Technological development Economy Price of oil Globalization “Surprises” b) How do these changes alter the social feedback processes?
II.8.e. What is (+/-) impacted by		a) Impacts from regime shift on social actors

changes in ecosystem services directly or indirectly		
II.8.g. Where do actors intervene to alter regime shift dynamics and who can do the intervening?		Socially oriented interventions

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GLOSSARY OF TERMS IN THE TEMPLATE

Actor	We use this term generally to look for individuals, groups, organisations, and so on that structure actions and/ or are stakeholders.
Adaptive capacity	Is the capacity of actors in the system to manage resilience in order to stay within a desired state during periods of change. This is related to the diversity in the system behind the provision of a function.
Disturbance	This refers to any disturbance to the system, regardless of scale, duration, intensity and frequency. See shock and stress.
Driver	Actor or process that directly or indirectly affects change in a social-ecological system. External means that the system in question (the scale being looked at) is unable to affect the driver in question – there is no feedback from the system to the driver.
Ecosystem services	The goods and services humans derive from ecosystems. These include: provisioning, regulating, cultural ecosystem services respectively.
Feedbacks	A change within a system that occurs in response to a driver, and that loops back to control the system. A feedback can help to maintain stability in a system (negative or balancing feedback), or it can speed up processes and change within the system (positive or enhancing feedback). Feedback processes play a very important role in determining system thresholds and in maintaining system resilience.
Institution	Here we refer to the humanly devised constraints that shape human interactions, such as rules, norms and laws. These can be formal or informal. Note that we are not referring here to institutions as organisations.
Regime shift	For complex systems, a substantial and enduring reorganization of the system, where the internal dynamics and the extent of feedbacks undergo change.
Resilience	This is a property, in this context of social-ecological systems. It relates to the capacity of a system to cope with disturbances and recover in such a way that they maintain their core function and identity. It also relates to the capacity to learn from and adapt to changing conditions, and when necessary, transform.
Shock	A sudden, unexpected disturbance. This kind of disturbance is often punctual, and has important impacts on large parts of the system.
Slow variable	When analysing complex system is often useful separating “fast” and “slow” variables. Fast variables often represent the primary concern of ecosystem users, for instance game or crop production. Slow variables shape the behaviour of fast ones but change slowly with respect to the overall dynamics of the system. Examples of slow variables might include permafrost thawing for a social-ecological system of Arctic hunters where the fast variable is game, or soil organic matter for an agricultural system where the fast variable is crop production.
Stress	This is a disturbance that has long persistence and often low intensity in impact.
Social-ecological	This is an interwoven system of human societies and ecosystems. This concept emphasises that humans are part of nature and

system	that these components function in interdependent ways. In the template identifying these interactions between the components aims to identify the processes and actors/ components that interact and particularly the feedbacks between the human-related components and the ecosystems/ biophysical components.
Stakeholder	See “actor”
Systems Diagram	This is using a diagram to illustrate the configuration of a system. This is done by defining its structure, function, and feedbacks. For a case there may be more than one diagram if the system changes in character (actors, processes, drivers, disturbances, feedbacks etc.) over time.
Timeline	The goal with the timeline is to capture important events – both punctual and over longer periods of time, identifying the causes of these events and the actors/ processes involved. This should be done chronologically and distinguishing events.