Name of the case study	Alaska- Transforming knowledge system to adapt to climate change- USA. (Transformation)		
What about this case makes it interesting? How does this case contribute to understanding of resilience and/or regime shifts in the Arctic?	Iñupiaq, Yup'ik, and Cup'ik hunters in 14 Alaska Native communities described a rapidly changing marine environment. The changes in sea ice conditions have affected the access and availability of marine mammals impacting indigenous communities who rely on hunting this species. The thinner ice increases the risk of travel, and the rapid break-up of ice in spring reduces the time that seals and walrus are available. Despite the change, marine mammal populations remain abundant. In addition, social modifications related to industrial expansion have affected the distribution of marine mammals and reduce hunting opportunities. To face these challenges, hunters have adapted combining new knowledge with traditional knowledge changing some hunting practices but maintaining the main culture practices as cooperation and food sharing system**.** This case is an example of how the transformation of traditional knowledge increases a community's resilience.		
Templated completed by: *Main contributor	Carla Lanyon, Stockholm Resilience Centre Juan Rocha*, Stockholm Resilience Centre	**Key references: Cite in the text using (1), (2), (3) etc. and provide a reference list at the bottom of the template.** (1) Huntington, H., L. Quakenbush, and M. Nelson. 2017. Evaluating the Effects of Climate Change on Indigenous Marine Mammal Hunting in Northern and Western Alaska Using Traditional Knowledge. *Frontiers in Marine Science* 4:319. (2)Malek, J.C., and V.R. Cornish. 2019. Co-management of marine mammals in Alaska: A case study-based review. Final report, Marine Mammal Commission. Bethesda, MD.. **(*) Mainly all the information comes from (1). Otherwise is explicit cited**	
Reviewed by (name and affiliation)			
Category	**Resilience/ Adaptability**	**Loss of resilience**	**Transformation**

					x	
Case study details:	**Country**	**Place**	**Scale – space**	**Scale – time**	**Sector(s)**	**Other (e.g. disturbance)**
	USA-	Alaska (16 communities: Katktovik, Utqiagvik, Wainwright, Point Lay, Hope, Elim Sta Michael and stebins, Kivalina, Kotzebue, Sishmaref, Hooper bay, Scammon bay, Mekoryuk.)	Artic Alaska	2007-2017	Hunting	

Drivers (mark with X in appropriate boxes)	**Climate**	**Geopolitical**	**Mineral/ oil extraction & infrastructure**	**Tourism**	**Shipping**	**Biological invasion**	**Rapid demographic change**	**Other:**
	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	a) What types of ecosystem(s) and other major biophysical features are present? The Arctic marine ecosystem, coastlines, sea ice, weather, and climate event as strong winds and storms b) How are the case boundaries defined in terms of ecosystems or biophysical characteristics? The distribution and migratory path of marine mammals define the boundaries of the system.	c) Who are the key groups of people in this case? The case considers 16 communities from north western Alaska: Katktovik, Utqiagvik, Wainwright, Point Lay, Hope, Elim Sta Michael and stebins, Kivalina, Kotzebue, Sishmaref, Hooper bay, Scammon bay, Mekoryuk. d) What kinds of livelihoods are important in the system?

of diagrams to capture different periods in the case and the drivers/ actors/ events that characterize the period.		The main livelihood from the area study is hunting. Some villages rely on other activities as a second income, such as wage labour. However, hunting is still the primary source of food, revenue, and cultural practice. e) What institutions are key to this case? Hunter has their organization depending on the community. They have their internal arraignment that establishes the limit to their hunt area. They share information and discuss the travel conditions to organize the hunt's travels. International Whaling Commission (IWC) set the quotas on whale stocks. Alaska Eskimo Whaling Commission is part of IWC Eskimo Walrus Commissions in Alaska are the two Alaska Native Led organizations that co-manage marine mammals. National Marine Service (NMFS) and Ice Seal Committee (which represent the native communities' interest) co-manage with Native organizations the marine mammal's hunt. f) How are the case's boundaries socially defined, and how do these social boundaries relate to biophysical boundaries? Hunting areas define the social boundaries.

2. Timeline Draw a timeline of *key* events/ developments to the case. Define the period (decades – centuries) over which change is considered, Provide a brief description of event/ actors, and ecological impacts 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. Consider both biophysical and social dimensions. Mark particularly significant events with *.	1946: Creation of International Whaling Commission (IWC), which establish harvesting quotas 1985: Alaska Eskimo Whaling Commissions (AEWC) start function. Their main goal is balancing development with subsistence resources and livelihood. 1972: All marine mammals are protected by the US Marine Mammal Protection Act (MMPA) 1994: MMPA gives National Marine Service (NMFS) and Fish Wildlife Service the authority to cooperate with Alaska Native Organizations (NGOs) to conserve marine mammals and provide co-management of subsistence used by Alaska Natives. 1997: Alaska AEWC documented their subsistence needs and demand the need for bowhead whale for subsistence. IWC set a quota for AEWC 2006: National Marine Service (NMFS) and Ice Seal Committee (which represent the native community's interest) co-manage the marine mammals 2008: Increase in oil and gas exploration. Indigenous communities demand to review the impact of these activities on marine mammals. 2010: Bloom of red algae occur for the first time. 2016: MMC session with communities to evaluate the change on the environment in Utqiagvik 2016: Bearded seal listed as threatened species 2017: Walrus on the listing under ESA

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? The change in distribution, behaviour, and health of marine mammals is the main disturbance. In addition, habitat change modified the migratory routes of the species by moving them away or bringing them closer to the coast, affecting the feeding of the species. Animal diseases have increased, indicating ecosystems state. In addition, hunters have recognized change in the quality of meat.	b) Have there been major social disturbances that are relevant for the case? Changes in Hunting is the major disturbance in the case. These changes are mainly produced by the changes in the physical environment, especially in sea ice. They have a shorter period of good hunting; therefore, hunters make efforts to adapt and make it efficient. This change may change the relation that hunters have with the ecosystem.
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? Loss of sea ice has generated cascade effects in the arctic marine ecosystem, increasing temperature water, stratification, and changing the population of fishes, sea birds, and marine mammals behaviour.	b) What are the key social drivers of change? The literature does not present information regard to social drivers. Offshore oil, gas activity, and motors' noise close to the shore, pushing away the animals from the shore.
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 =	a) Within the ecosystem? (+) Despite the change in the marine habitat marine mammal population stay stable. They have adapted to the environmental changes. (+) Species change their migration path adapting to the new sea-ice conditions. (+/-) New species have arrived at the area due to the lack of	b) Within society (e.g. people, social capital, management, institutions, infrastructure): (+) Hunters need to incorporate new knowledge into the traditional knowledge to adjust rapidly changing environment (+) Communities follow basic principles of cooperation, patience, and sharing the harvest.

increasing/ reducing/ not affecting adaptive capacity)	sea ice. New species can bring new food sources for marine mammals or become a competition. (-) New red algae boom, due to the change in the ecosystem, affecting mollusc, shrimp and krill, and the rest of food web. (-) Decrease in the health of marine mammals. Disease in seals and walrus populations is more common.	(+) Traditional knowledge contributes to monitoring marine mammals helping to detect behaviour changes, migration patterns, health, and other parameters essential to adjust local livelihoods. (-) Due to the increase of risk and difficulty to hunt, hunters invest in technology. This adaptation can only be developed by the hunter who has more income or access to financial resources. (-) Changes in traditional practices, preparing in advance hunt decreasing the risk.
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 change and resilience in the face of change?	a) Within nature: Change: Sea ice dynamics have changed: Sea ice forms later in fall, is thinner and less reliable during the winter, breaks up earlier in spring, and is scarce or absent throughout the summer. The weather is unpredictable. This biophysical change has led to a modification in the marine mammal's distribution, behaviour, and health. Shift in the abundance of some species is changing. For instance, there is declining in walleye pollock but an increase in Jellyfish, pacific cod. New bird species have arrived, and other animals such as killer whales and stellar sea lions are more common. Resilience is found in: The change in the migration path of species allowed them to adapt to environmental changes.	b) Within society: Change: Change in season make much shorter the period of hunting. The instability of shore fast ice makes travel and hunting more hazardous in winter and spring. As a result, hunters have changed traditional practices related to safe travel and hunting practices. Resilience: Although some practice has changed, the main cultural practices that support the community's social structure is still intact. The cooperation in hunting, the share of knowledge, and food are vital variables that allow them to sustain their social networks, playing a key role in the resilience of the communities.
II.2. What are the	a) Key Ecological components (e.g. lakes, coastal zones,	b) Actors in society (e.g. individuals, groups, public or

system's key components?	caribou) Coastal zones, sea ice, bowhead whales, Walrus, ice seal, beluga whales.	private organizations)? How are people organised – by geography, livelihood, family, etc.? Hunter between 20-60 years old organized according to their villages. At the community level, hunters have a key role in the community providing food for those who are more vulnerable and cannot hunt.
II.3. What are the key 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.	a) From nature to society (e.g. ecosystem services) - Primary production - Knowledge and educational values - traditional livelihoods.	b) From society to nature – modifying nature, extracting resources (e.g. hunting, mining, water pollution) - Hunting - Gas and oil industry pollution
II.4. What are key interactions?	a) What are the key ecological interactions within the case? b) What are the most important biophysical tele-connections to distant systems?	c) What collaborations, conflicts, or other key linkages exist between actors? Potential conflicts include overlapping interests between hunters and Oil and gas industries. d) Between local actors and distant actors? People from the community are worried about the increase of ships in the area and possible environmental accidents. This concern and the increase in traffic can become a conflict in the future. Potential conflicts between with hunter association and

		national policies which protect marine mammals. Potential conflicts between NMFS and FWS and the community. Hunters perceived that they implement co-management in entirely different ways (2).
II.5. Culture	a) How is the relationship between society and nature viewed? b) What meanings are attributed to nature and interactions with nature?	c) What are key cultural features of relevance for the case? Indigenous communities from this case rely on marine mammals for their livelihoods. Their traditional knowledge and the evolution of this is an essential component of their adaptive capacity. Knowledge allows them to create social networks by exchanging information about the weather o ecosystem state and sharing the harvesting with the rest of the community. d) What are key cultural practices and beliefs related to nature? The nature-human relationship is based on cooperation, therefore independently that hunters are organized at the family level, they share information and knowledge among all the community. Moreover, through their traditional knowledge, their reproduces different hunting practice, ecosystem monitoring, among others. In addition, other techniques such as handicrafts are highly connected with their landscape.
II.6. Disturbance What are important types of stress & shock	a) Describe important biophysical or ecological shocks and stresses (e.g. floods, storms, etc). Bloom algae during 2010, act as an alert of the conditions of the ecosystems.	b) Describe important social shock and stresses (e.g. austerity policies, changes in government policy, introduction of new technologies, etc) Policies introduction related to the restriction of hunting critical species in the area. Although natives have permission

	An increase in events such as storms and aggressive winds affects the dynamic of the sea ice.	to hunt, there is tension under what parameters these decisions have been made.
II.7. What are key slow variables Changes that occur over decadal or longer time scales	a) What types of ecological processes (e.g. loss of permafrost, shifts in species composition) are driving important long-term changes in ecological structures and processes? Due to the open water, it observes a slow process in the shift of species, new arrival of southern species, and the change in the migration paths of the identical species.	b) What types of slow social processes (e.g. aging, population growth, loss of language) are driving important changes in social institutions and behaviours? The change in the traditional knowledge and the integration of new knowledge.
II.8. Relationships with ecological regime shifts	a) Are ecological regime shifts driving further ecological change or pressure? b) Are external or internal ecological dynamics potentially or actually producing ecological regime shift(s)?	c) Can social stresses or major changes be attributed to ecological regime shifts? All the changes present at the social dimension, in this case, represent a response from the community to the environmental changes, where the difference in ice conditions is the primary ecological driver. d) Are there specific social practices that might be contributing to ecological regime shifts Yes. The potential overharvesting of marine mammals.
II.8 Regime shifts	**If a regime shift exists and is important to this case describe it below.** Please indicate whether the regime dynamics are well-established, contested, or speculative.	
II.8.a. Detailed description of alternate regime shifts A case study can contain more than one type of	Briefly describe the structure of each regime. What does each regime look like? What are differences in ecosystem structure and function? (e.g. permafrost loss, vegetation change)?	

regime shift		
II.8.b. Feedback mechanisms within the system that maintain each regime	Ecological feedback mechanisms	Social feedback mechanisms
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 ecological regime shifts (either social or ecological). b) How do these changes alter biophysical feedback processes?	c) Drivers of social regime shifts (either social or ecological). d) How do these changes alter the social feedback processes?
II.8.d. Ecosystem services substantially impacted by regime shift	a) Changes in ecological processes that produce ecosystem services	b) Changes in demand for ecosystem services (market and non-market) c) Changes in the institutional context of ecosystem services e.g. changes in access and changes in how ecosystem services are valued as expressed by rules and regulations.
II.8.e. What is (+/-) impacted by changes in ecosystem services directly or indirectly	a) Impacts from regime shift on ecological components	b) Impacts from regime shift on social actors
II.8.f. Potential cascading effects	Describe, if any, the likelihood of potential ecological cascading effects to other SES .	Describe, if any, the likelihood of potential social cascading effects to other SES
II.8.g. Where do actors intervene to alter regime shift dynamics and who can do the intervening?	Ecological oriented interventions	Socially oriented interventions

This can be listed here or marked with (*) in the table above		

REFERENCES/ SOURCES CITED:

(1)	Huntington, H., L. Quakenbush, and M. Nelson. 2017. Evaluating the Effects of Climate Change on Indigenous Marine Mammal Hunting in Northern and Western Alaska Using Traditional Knowledge. *Frontiers in Marine Science* 4:319.
(2)	Malek, J.C., and V.R. Cornish. 2019. Co-management of marine mammals in Alaska: A case study-based review. Final report, Marine Mammal Commission. Bethesda, MD. 58 pages.
(3)	

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 system	This is an interwoven system of human societies and ecosystems. This concept emphasises that humans are part of nature and 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.