Name of the case study	Savoonga – Maintaining traditional Yupik whaling practices – Alaska, USA [Resilience]							
What about this case makes it interesting? How does this case contribute to understanding of resilience and/or regime shifts in the Arctic?	The St. Lawrence Island Yupik whalers in Savoonga, Alaska created a new whaling season, independently, in response to changing weather and ice conditions. The case shows the potential for innovation and adaptation to help offset some impacts from a changing climate. This was achieved through local knowledge, observation and organization, and, sufficient flexibility in existing legislation (international) allowing for this local innovation to arise.							
Templated completed by:	Henry P. Huntington, Huntington Consulting George Noongwook, Savoonga Whaling Captains Association				**Key references: Cite in the text using (1), (2), (3) etc. and provide a reference list at the bottom of the template.** (1) Noongwook, G., the Native Village of Savoonga, the Native Village of Gambell, H. P. Huntington, and J. C. George. 2007. Traditional knowledge of the bowhead whale (*Balaena mysticetus*) around St. Lawrence Island, Alaska. *Arctic* 60(1):47-54.			
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	Savoonga, St. Lawrence Island, Alaska	City: 15 km^2; Island: 4,600 km^2; Fishing/ hunting grounds: ca 10,000 km^2	1970-2005	Whaling	Changes in sea ice and weather conditions		
Drivers (mark with X in	**Climate**	**Geopolitical**	**Mineral/ oil extraction &**	**Tourism**	**Shipping**	**Biological invasion**	**Rapid demographi**	**Other: *state here***

appropriate boxes)			**infrastructure**				**c change**	
	X	X - international						

	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?** Arctic/subarctic marine ecosystem, affected by sea ice, and home to Arctic marine mammals (1). **b) How are the case boundaries defined in terms of ecosystems or biophysical characteristics?** Bowhead whale migration route around St. Lawrence Island and the northern Bering Sea, which is influenced by sea ice seasons (1).	**c) Who are the key groups of people in this case?** *St. Lawrence Island Yupik* – indigenous, traditional whaling communities. In 2000, Savoonga had a population of 643 and St Lawrence Island had a population of 1292. *Regulating bodies* – Local whaling captains' association, Alaska Eskimo Whaling Commission, National Ocean and Atmospheric Association, International Whaling Commission. **d) What kinds of livelihoods are important in the system?** Traditional hunting/fishing Traditional knowledge of hunting practices **e) What institutions are key to this case? If possible define what scale it addresses.** *National* National Oceanic and Atmospheric Administration (NOAA, a U.S. Federal agency) – conducts research (genetic, aerial photo ID, traditional knowledge assessments, satellite telemetry, stable carbon analysis of baleen)

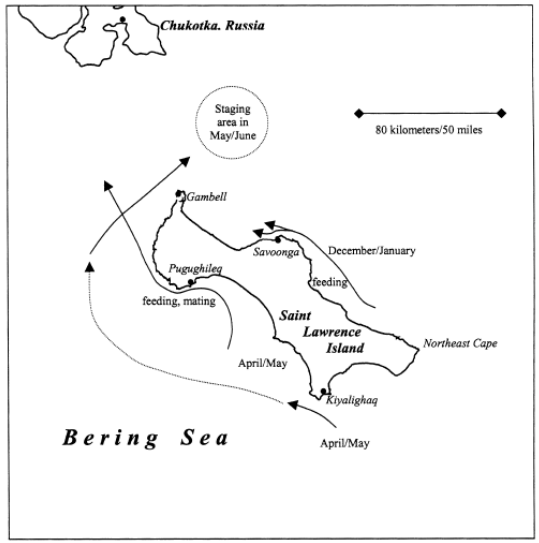

FIG. 3. The movements of whales near St. Lawrence Island. Savoonga whalers hunt near Pugughileq in spring and near Savoonga in fall/winter. Gambell whalers hunt near Gambell in both seasons. In winter, bowhead whales are generally southwest of the island, though some may remain near the coast of Chukotka or north of Gambell.

International
International Whaling Commission (IWC) – decides whaling quotas, makes recommendations

f) How are the case's boundaries socially defined, and how do these social boundaries relate to biophysical boundaries?

Local community plus the wider association of Alaska whaling communities (defined by the bowhead whale migration). The Yupik whalers and their communities define the social boundaries. The social and biophysical boundaries are connected based on whale migration, which is defined by when the sea ice breaks up each year.

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	1970: Savoonga resumes spring whaling from Pughughileq, on the south side of the island (the village is on the north side), after an interval of nearly a century 1972: Savoonga takes its first whale since resuming whaling 1977: The International Whaling Commission (IWC) bans bowhead whale hunting by Alaskan native whalers, and later changes the ban to a quota system, applied to the Bering Sea stock of bowhead whales The Alaska Eskimo Whaling Commission is formed, by the Iñupiat and Yupik whalers in Alaska, to fight the ban and then to administer the quota through a co-management agreement with NOAA 1980s-1990s: new population estimates for the whale stock and an analysis of cultural need of the Alaska whaling villages lead to increased quotas 1990s: Climate change leads to later formation of sea ice in fall, so that the bowheads migrate south while there is still open water, allowing Savoonga whalers to hunt in November and December, from the north side of the island (i.e. straight from the village rather than having to cross the island by snowmobile first) 1995-2005: 40% of Savoonga's whales are taken in fall, helping make up for deteriorating spring weather conditions in many years

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?** Delayed freezing of sea ice in fall (primary) and worse spring weather (secondary). This changes the migration patterns, and therefore hunting season.	**b) Have there been major social disturbances that are relevant for the case?** Not a "disturbance" per se, but the increases in the bowhead whale hunting quota created more opportunity. In 1970s/1980s, the early harvest quota stressed whalers and their communities, created tensions in the community, and distrust to the government.
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?** *Climate change*, which contributes to: (i) Sea ice retreat (ii) Weather pattern changes	**b) What are the key social drivers of change?** *Innovation* - Savoonga whalers recognize and seize the opportunity to hunt bowheads in fall (1).
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/ reducing/ not	**a) Within the ecosystem?** (+) Multiple hunting opportunities (spring/fall for bowheads and walrus, summer for sea lions, spring/fall/winter for seals and polar bears, etc.), providing many alternatives if one season was poor for any reason. (+) Bowhead whale populations are increasing according to both research estimates and Yupik knowledge.	**b) Within society (e.g. people, social capital, management, institutions, infrastructure):** (+/-) The lack of rules, apart from the overall quota itself, allowed Savoonga to go whaling in fall solely on their own initiative, without having to get any regulations changed (e.g., applying for a change in hunting season, etc.). (+) The innovative flexibility of Savoonga hunters to take an opportunity when it came rather than to be stuck in the usual pattern of activity. (+) Traditional knowledge has proven to be detailed and

affecting adaptive capacity)		successful in transmitting knowledge across generations, even generations that did not participate in whaling activities due to a whaling ban. (+) *Yaayasitkegpenaan* concept – Yupik word for taking care of the surroundings and animals (ie. Harvesting only enough that one needs, keeping the environment clean, etc.). (-) However, strict regulations have been thought to degrade the Yupik concept of *Yaayasitkegpenaan*.

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** The bowhead whale population around St. Lawrence Island appears to be increasing based on both local reports and scientific surveys.	**b) Within society** The strong connection to the environment and transmission of traditional whaling knowledge suggest a resilient Yupik whaling society.
II.2. What are the system's key components?	**a) Key Ecological components (e.g. lakes, coastal zones, caribou)** Bering Sea and surrounding areas along the shoreline of St. Lawrence Island.	**b) Actors in society (e.g. individuals, groups, public or private organizations)? How are people organised – by geography, livelihood, family, etc.?** Yupik whaling boats – captains and whalers Yupik communities

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)** The hunting of whales provides a provisioning service to the Yupik communities.	**b) From society to nature – modifying nature, extracting resources (e.g. hunting, mining, water pollution)**
II.4. What are key interactions?	**a) What are the key ecological interactions within the case?** The seasonal changes have contributed to changes in the Yupik's whaling seasons. **b) What are the most important biophysical tele-connections to distant systems?** Few to none. The whales do not migrate far.	**c) What collaborations, conflicts, or other key linkages exist between actors?** Conflict – External regulations on whaling quotas in the late 1970's and early 1980's created stress and distrust towards the government. **d) Between local actors and distant actors?** Few to none. The meat is for local consumption.
II.5. Culture	**a) How is the relationship between society and nature viewed?** The concept of *Yaayasitkegpenaan* indicates strong social links to the environment. Additionally, the strong sense of traditional knowledge, and enriched vocabulary surrounding whaling activities, suggests there is a strong society-nature relationship.	**c) What are key cultural features of relevance for the case?** **d) What are key cultural practices and beliefs related to nature?**

	b) What meanings are attributed to nature and to interactions with nature?	
II.6. Disturbance What are important types of stress & shock	**a) Describe important biophysical or ecological shocks and stresses (e.g. floods, storms, etc).** Changes in sea ice formation and storms.	**b) Describe important social shock and stresses (e.g. austerity policies, changes in government policy, introduction of new technologies, etc)** Prior to 1972, there was a century long gap in whaling activities. Although traditional knowledge was passed down to new generations, arguably some knowledge may have been lost through lack of active participation in whaling activities.
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?** *Climate change* – contributes to the change in seasonal periods and weather conditions, such as earlier springs, warmer winters, and increasingly frequent sea ice break up events.	**b) What types of slow social processes (e.g. aging, population growth, loss of language) are driving important changes in social institutions and behaviours?**
II.8. Relationships with ecological regime shifts	**a) Are ecological regime shifts driving further ecological change or pressure?** There's not enough evidence to suggest that a regime shift is occurring. However, increasingly extreme changes due to climate change have the potential to create a regime shift. **b) Are external or internal ecological dynamics**	**c) Can social stresses or major changes be attributed to ecological regime shifts?** **d) Are there specific social practices that might be contributing to ecological regime shifts**

	potentially or actually producing ecological regime shift(s)?	
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 regime shift	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)? How do the properties and behaviours of regimes differ? e.g. collapse of subsistence food sources, fundamental change in types of livelihoods, change in governance institutions, new actors with significant political power who transform decision making)	
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**

REFERENCES/ SOURCES CITED:

(1) Noongwook, G., the Native Village of Savoonga, the Native Village of Gambell, H. P. Huntington, and J. C. George. 2007. Traditional knowledge of the bowhead whale (*Balaena mysticetus*) around St. Lawrence Island, Alaska. *Arctic* 60(1): 47-54.

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.