We welcome additions, clarifications and response on the information in the case. If you wish to make your response directly in the template clearly mark your additions in a Word document using "track changes" or highlight your additions in the template. If you provide a references or other details please make clear how/where this compliments/completes the template.

Please send to Juan Rocha juan.rocha@stockholmresilience.su.se and ARR@sei-international.org.

Name of the case study	Community relocation due to coastal erosion, Newtok, Alaska					
What about this case makes it interesting? How does this case contribute to understanding of resilience and/or regime shifts in the Arctic?	Rising temperatures and changed precipitation patterns are causing changes in biophysical systems all over the Arctic. Along parts of the Alaskan coastline, increased wave action due to melting sea ice combined with thawing permafrost is causing increased coastal erosion (1). This increases the vulnerability of Alaskan coastal communities, and the U.S. Army Corps of Engineers has identified at least twelve communities in Alaska that need to be relocated due to climate change (2). However, the relocation of these communities is complicated by cultural, financial and jurisdictional factors, and it is still unclear how to best implement the relocation plans while still avoiding the pitfalls of past forced relocations of indigenous communities in Alaska (2). Newtok is one of the indigenous communities that have come furthest in their relocation plans, which means that it can serve as an informative example for how these relocations due to climate change could come about.					
Main Contributors	Katja Malmborg		**Key references:** Atkinson (in North by 2020) Bronen 2011 Bronen and Chapin 2013 Cochran et al. 2013			
Other Contributors						
Reviewed by (Name and affiliation)						
Category	**Resilience/ Adaptability**		**Loss of resilience/ Collapse**		**Transformation**	
					X (or increased adaptation)	
Case study details:	**Country**	**Place**	**Scale – space**	**Scale – time**	**Sector(s)**	**Other (e.g. disturbance)**
	USA	Newtok, Alaska	Newtok village 2km2; western	1984-present (village could be	Community relocation	Coastal erosion, climate change,

			Alaska coastline	underwater by 2017)		institutional misfits, financial limits		
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 coastal zone of western Alaska River delta Sea Permafrost **b) How are the case boundaries defined in terms of ecosystems or biophysical characteristics?** The coastal zone in western Alaska, Newtok village located between the Ninglick and Newtok Rivers in the Yukon-Kuskokwin Delta (2)	**c) Who are the key groups of people in this case?** Local indigenous Yup'ik Eskimo community in Newtok – have lived on the Bering Sea coast for at least 2000 years. Approximately 320 people live in the village, which means that its inhabitants have tripled since 1950 (2). Newtok Traditional Council – governing authority that collaborates with state and federal government agencies Newtok Native Corporation – village corporation that owns the land at the relocation site Mertarvik on Nelson Island (2) Newtok Planning Group – a boundary organization/voluntary collaboration between approximately 25 state, federal and tribal governmental and non-governmental agencies working toward facilitating Newtok's relocation (2, 3). State of Alaska – post-disaster response limited by fact that state laws do not include gradual ecological changes as part of definition of a disaster. Funding can also only be given to rebuilding of structures in the same place as where they were before. Therefore, special funding cannot be given to communities where coastal erosion has caused a need to relocate (2). Federal Emergency Management Agency (FEMA) – federal agency responsible for hazard mitigation and disaster relief. Limited ability to respond to gradual

		changes in ecological systems due to federal laws (2). U.S. Army Corps of Engineers – federal agency involved in evaluating the situation and involved in construction at the relocation site in Mertarvik (2). **d) What kinds of livelihoods are important in the system?** Subsistence hunting and gathering of e.g. moose, salmon, musk ox, seal and berries (2). **e) What institutions are key to this case? If possible define what scale it addresses.** State and federal laws regarding natural disasters and emergencies describe what kind of hazard mitigation and post-disaster relief that can be performed. These do not cover ecological changes that are occurring gradually, as with coastal erosion, which greatly impedes the government from responding in an effective way to communities' such as Newtok needs to relocate (2). No institutional framework exists within the U.S. that can be applied when relocating an entire community, which means that no national, state, local or tribal government agency has the legal authority to relocate communities and this has greatly impeded the relocation process (2, 3). **f) How are the case's boundaries socially defined, and how do these social boundaries relate to biophysical boundaries?**

		Newtok is a small, isolated village consisting of approximately 63 houses, inhabited by Yup'ik Eskimo (2). The system consists of the village's inhabitants and the surrounding land.

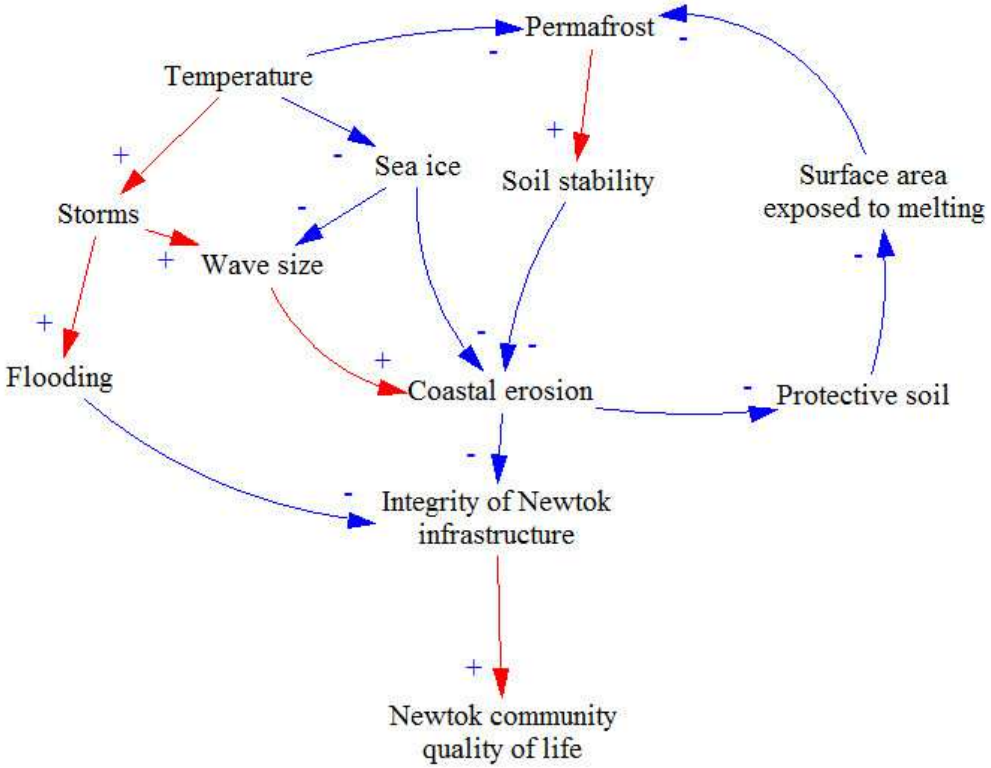

Figure 1: Systems diagram (The variables *Protective soil* and *Surface area exposed to melting* are not based on literature particular for this case, and might not be relevant here.)

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?	1950 – Community was moved to current location between Ninglick and Newtok Rivers, because the Bureau of Indian Affairs (BIA) decided they needed a school 1958 – BIA built the school in Newtok 1984 – First erosion assessment commissioned by the Newtok Traditional Council 1994 – Newtok Traditional Council starts evaluating potential relocation sites and identifies Nelson Island as suitable 1996 – Newtok community votes on relocation, overwhelming support for Nelson Island 2001 - Newtok community votes on relocation again, overwhelming support for Nelson Island 2002 – U.S. Army Corps of Engineers publishes a report evaluating the suitability of Mertarvik as a relocation site, and concludes that it is suitable 2003 – U.S. Government Accountability Office issues report stating that flooding and erosion affect 184 indigenous villages in Alaska, of which 4 are imminently threatened (Kivalina, Koyukuk, Newtok and Shishmaref). Newtok community votes on relocation again, overwhelming support for Nelson Island. Land on relocation site on Nelson Island purchased by Newtok Native Corporation. 2004 – 2nd erosion assessment commissioned by the Newtok Traditional Council (Newtok Background for Relocation Report) Powerful fall storm, declared as a FEMA disaster by U.S. President. 2005 – Primary barge landing erodes into the Ninglick River. Sea storm caused severe flooding, declared as a FEMA disaster by U.S. President. 2006 – Severe storm caused flooding, declared as a FEMA disaster by U.S. President. Newtok Planning Group created. Construction of 3 houses in Mertarvik by Newtok community members, funded by Newtok Traditional Council.

Identify disturbances or events that challenged, built, or reduced resilience or adaptive capacity in the system.	2009 – First construction of pioneer infrastructure started in Mertarvik (barge landing, evacuation centre and road), through the work of the Newtok Planning Group. Source: (2) and (3)	
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?** Melting sea ice Melting permafrost (1) Floods Salt water intrusion (2)	**b) Have there been major social disturbances that are relevant for the case?** Deteriorating public health, due to poor sanitary conditions in the village (facilities have either been damaged, or new ones cannot be built due to instability of the soil) (2).
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?** Warmer temperatures that is both causing permafrost and sea ice to melt or not form. This decreases soil stability along the coast, at the same time as the lack of sea ice causes larger waves to form. The changed weather patterns have also caused an increase of extreme weather events, like storms. All these factors combined have increased the magnitude of river and coastal erosion as well as the occurrence of floods (1, 2).	**b) What are the key social drivers of change?** The Newtok Traditional Council has been working for a relocation of the village as an adaption strategy to the changed biophysical conditions.
5. Sources of adaptive capacity: What factors allow(ed) the system to adapt to disturbances in the past and present? Give a brief	**a) Within the ecosystem?** (-) The presence of permafrost has in the past protected the soils along the coast from eroding, which means that the coastal zone in these areas has been more stable than coastlines in many other parts of the world (1)	**b) Within society (e.g. people, social capital, management, institutions, infrastructure):** (+/-) Construction of erosion protection has been done, but it is only a temporary solution. (-) Until late 19th century, indigenous communities in Alaska had a migratory lifestyle, moving seasonally between the coastal zone and inland, allowing them to adapt

assessment of recent or on-going changes (+/-/0 = increasing/ reducing/ not affecting adaptive capacity)		to the very changeable Arctic environment. However, due to the creation of a formal educational system in the late 19th-early 20th century, the communities had to become sedentary and settle where the community school was built, decreasing the community's ability to adapt to changing environmental conditions (3). (+ ?) Proposed creation of an adaptive governance framework based on the human rights doctrine for the development of adaption strategies to climate change in Alaska (2, 3).

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** Melting permafrost Less sea ice Increased damage and frequency of storms and flooding events Increasing coastal erosion	**b) Within society** Deteriorating public health in the village, due to damage to essential sanitary infrastructure caused by erosion, flooding and storms (2). The Newtok Traditional Council, together with other actors, is actively working on a relocation of the village.

II.2. What are the system's key components?	**a) Key Ecological components (e.g. lakes, coastal zones, caribou)** Coastal zone River delta Sea ice Permafrost	**b) Actors in society (e.g. individuals, groups, public or private organizations)? How are people organised – by geography, livelihood, family, etc.?** Local indigenous Yup'ik Eskimo community in Newtok – have lived on the Bering Sea coast for at least 2000 years. Approximately 320 people live in the village, which means that its inhabitants have tripled since 1950 (2). Newtok Traditional Council – governing authority that collaborates with state and federal government agencies Newtok Native Corporation – village corporation that owns the land at the relocation site Mertarvik on Nelson Island (2) Newtok Planning Group – a voluntary collaboration between approximately 25 state, federal and tribal governmental and non-governmental agencies working toward facilitating Newtok's relocation (2). State of Alaska – post-disaster response limited by fact that state laws do not include gradual ecological changes as part of definition of a disaster. Funding can also only be given to rebuilding of structures in the same place as where they were before. Therefore, special funding cannot be given to communities where coastal erosion has caused a need to relocate (2). Federal Emergency Management Agency (FEMA) – federal agency responsible for hazard mitigation and disaster relief. Limited ability to respond to gradual changes in ecological systems due to federal laws (2).

		U.S. Army Corps of Engineers – federal agency involved in evaluating the situation and involved in construction at the relocation site in Mertarvik (2).
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)** Permafrost, which stabilizes the soil and protects against extensive coastal erosion. This is essential for the integrity of both infrastructure, buildings and other structures in the coastal zone in western Alaska (1). Provisioning ecosystem services, which are part of the livelihoods of the Newtok and other indigenous communities	**b) From society to nature – modifying nature, extracting resources (e.g. hunting, mining, water pollution)** Hunting, fishing and gathering for subsistence. Construction of erosion protection – not a long-term solution.
II.4. What are key interactions?	**a) What are the key ecological interactions within the case?** When the permafrost melts, the stability of the soil decreases, making it more susceptible to wave action and coastal erosion (1). **b) What are the most important biophysical tele-connections to distant systems?** Warmer temperatures and changed seasonality is causing melting of both sea ice and permafrost, as well as increasing the occurrence of extreme weather events, like storms (1).	**c) What collaborations, conflicts, or other key linkages exist between actors?** No clear legal framework that can handle this kind of gradual environmental change and the way it affects communities. No federal or state agency has the authority to legally be responsible for e.g. relocation as an adaption strategy (2). **d) Between local actors and distant actors?** Local community – state and federal governments

II.5. Culture	**a) How is the relationship between society and nature viewed?** Holistic view of social and ecological systems. Everything is connected, which means that these interactions need to be considered in everyday practices. Plants, animals and other parts of the biophysical environment are seen as relatives and co-owners of the land, not as resources that should be exploited (4). **b) What meanings are attributed to nature and to interactions with nature?** The culture and sense of identity is directly tied to the places where the people have lived for generations, through traditions, stories, language etc. (4).	**c) What are key cultural features of relevance for the case?** **d) What are key cultural practices and beliefs related to 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).** Increased frequency of storms causes more extensive coastal erosion (1). Increased risk of flooding of the river delta (2).	**b) Describe important social shock and stresses (e.g. austerity policies, changes in government policy, introduction of new technologies, etc)** Damage to public infrastructure (e.g. village dumpsite, barge ramp, sewage treatment facility) by floods and extreme erosion (2)
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?** Melting permafrost reduces soil stability. Less landfast ice reduces the natural erosion protection.	**b) What types of slow social processes (e.g. aging, population growth, loss of language) are driving important changes in social institutions and behaviours?** Risk of loss of community identity. Collocation of community members to other nearby villages has been considered as an adaption strategy, but this is not an option

	Less sea ice increases area of open water where high waves can form, especially during the autumn and early winter months when winds are strong. Higher waves, in turn, increase the wave activity and coastal erosion (1). Salt water intrusion, which has become possible due to melted permafrost. Reduces the community's access to potable water (2).	that is supported by the community, since they fear this would greatly harm the community identity (2).
II.8. Relationships with ecological regime shifts	**a) Are ecological regime shifts driving further ecological change or pressure?** The system is moving from a permafrost to non-permafrost state, which completely changes the erosion dynamics in the coastal zone (1). **b) Are external or internal ecological dynamics potentially or actually producing ecological regime shift(s)?** When the sea ice decreases in size and starts forming later in the season, there is no longer as good protection against the autumn storms, which increases coastal erosion and the risk of flooding (1).	**c) Can social stresses or major changes be attributed to ecological regime shifts?** The decreasing life quality, e.g. health, of the Newtok community is a direct consequence of the damaged infrastructure. **d) Are there specific social practices that might be contributing to ecological regime shifts**

<table>
<tr><td>II.8 Regime shifts</td><td colspan="2">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.</td></tr>
<tr><td>II.8.a. Detailed description of alternate regime shifts

A case study can contain more than one type of regime shift</td><td colspan="2">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)

Regime 1: Cold autumn and winter, a lot of sea ice and permafrost, which in turn protects against extensive coastal erosion.

Regime 2: Mild autumns, which decreases the period of sea ice and exposes water and land to autumn storms. Increase in wave size due to less protective sea ice, which combined with increased storm frequency increases coastal erosion. Increased risk of flooding. Permafrost melts, which decreases stability of soil and exposes it to more extensive erosion.</td></tr>
<tr><td>II.8.b. Feedback mechanisms within the system that maintain each regime</td><td>Ecological feedback mechanisms</td><td>Social feedback mechanisms</td></tr>
<tr><td>II.8.c. What key changes drive regime shifts?

Describe how these changes alter the state of the system or feedback processes.</td><td>a) Drivers of ecological regime shifts (either social or ecological).

Rising temperatures.

b) How do these changes alter biophysical feedback processes?

Decreases sea ice cover, melts permafrost, increases exposure to autumn storms and increases frequency of storm events.</td><td>c) Drivers of social regime shifts (either social or ecological).

d) How do these changes alter the social feedback processes?</td></tr>
</table>

II.8.d. Ecosystem services substantially impacted by regime shift	**a) Changes in ecological processes that produce ecosystem services** Melting permafrost decreases soil stability	**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** (-) Decreased soil stability decreases the integrity of the village infrastructure.	**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)	Atkinson, David E., 2011: 4.2 The Physical Environment of Alaska's Coasts. In: Lovecraft, Amy Lauren and Hajo Eicken (eds.), 2011: *North by 2020: Perspectives on Alaska's Changing Social-Ecological Systems*. University of Alaska Press, Fairbanks.
(2)	Bronen, Robin, 2011: Climate-induced community relocations: Creating an adaptive governance framework based in human rights doctrine. *N.Y.U. Review of Law & Social Change*, vol. 35:357-407.
(3)	Bronen, Robin and F. Stuart Chapin III, 2013: Adaptive governance and institutional strategies for climate-induced community relocations in Alaska. *PNAS*, vol. 110 no. 23:9320-9325.
(4)	Cochran, Patricia, Orville H. Huntington, Caleb Pungowiyi, Stanley Tom, F. Stuart Chapin III, Henry P. Huntington, Nancy G. Maynard and Sarah F. Trainor, 2013: Indigenous framework for observing and responding to climate change in Alaska. *Climatic Change*, vol. 120:557-567.
(5)	

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.