Name of the case study	Hammerfest-From a local marine fisheries community to energy production-Norway [Loss of Resilience]	
What about this case makes it interesting? How does this case contribute to understanding of resilience and/or regime shifts in the Arctic?	Hammerfest has experienced a social-ecological transformation. Fishing was the area's main activity, providing food and income and improving the community's adaptive capacity. The introduction of oil and gas industry, climate change, and fishing policies have decreased the traditional activity, affecting the coastal community's culture, tradition, and identities. The oil and gas industry development led to a shift in traditional livelihoods and has promoted an increase in the area's population. Hammerfest municipality now has a better economic base with considerable growth in tax revenues through increased property taxes. The town has modernized its public infrastructure through municipality investment and developed different projects to improve adaptive capacity to deal with climate change. However, the development of the petroleum industry led to an increase in CO2. This contribution increases the global natural vulnerability and the local environment. In addition, the warming temperature of the ocean has brought new species to the area, developing new opportunities for fishers. However, fisheries policies have not been able to adapt simultaneously as the changes in the ecosystem, constraining the fisher's adaptive capacity.	
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) Hovelsrud, G., H. Dannevig, J. West, and H. Amundsen. 2010. Adaptation in Fisheries and Municipalities: Three Communities in Northern Norway. Pages 23–62. (2) Angell, E., & Stokke, K. B. (2014). Vulnerability and adaptive capacity in hammerfest, norway. Ocean and Coastal Management, 94, 56-65. (3) Bets, L. K. J., J. P. M. van Tatenhove, and A. P. J. Mol. 2016. Liquefied natural gas production at Hammerfest: A transforming marine community. *Marine Policy* 69:52–61.

		(4) Larsen, I., and G. Hovelsrud. 2017. Activating Adaptive Capacities: Fishing Communities in Northern Norway. Pages 123–134. **(*) 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)**	
	Norway	Hammerfest			2010-2017	Fisheries	Socio-economical changes in the community	
Drivers (mark with X in appropriate boxes)	**Climate**	**Geopolitical**	**Mineral/ oil extraction & infrastructure**	**Tourism**	**Shipping**	**Biological invasion**	**Rapid demographic change**	**Other: Socio-economic**
	x	x	x					X

	Biophysical:	**Social**
1. **Basic description of coupled social-ecological system in focus** (What are the key components and stake holders)	a) What types of ecosystem(s) and other major biophysical features are present? Seascape Coastline Fish stocks Snow	c) Who are the key groups of people in this case? Hammerfest has around 9.500 inhabitants. 75% of the population live in the city. Fishermen from Hammerfest

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.	b) How are the case boundaries defined in terms of ecosystems or biophysical characteristics? Given that the system boundaries are defined by the move of fish stocks.	Liquefied natural Gas plan (LNG): Provides jobs and migration of foreigners to the community Hammerfest Municipality: Source of jobs and governance in the territory. The last few years have implemented different projects with the Scientific sector to improve the adaptive capacity of the community (2). d) What kinds of livelihoods are important in the system? Reindeer husbandry, energy production (industry), forestry. Fisheries is still one of the most important livelihoods in the area. Is a source of employment, and knowledge, culture, and local identity. Energy production from the LNG plant Administrative jobs. Municipality is an important source of jobs in the area. e) What institutions are key to this case? Fishing management regulation at national level. Municipality and fisher's community at local level. Coalition between LNG and Norwegian State f) How are the case's boundaries socially defined, and how do these social boundaries relate to biophysical boundaries?

		The social boundaries are defined by the geo-political jurisdiction.

2. **Timeline** Draw a timeline of *key* events/ developments to the case. Define the time 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 *.	1970s: Norway has moved towards a performance-based approach to supervise oil and gas activities, in which the state defines the performance that needs to be achieved, while the industry is free to decide how this will be done (3). 1972: Statoil was created as state-owned company in 1972 (1) 1980: Collapse of cod stock (1). 1981-1984: Gas reserves were discovered (1). 1980-1990: Fisheries resource and market crises. Local fishers felt threatened by globalization of fisheries, as a result Hammerfest population declined. Especially youth due to the lack of opportunities as a fisher. 1996: The Petroleum Act governs petroleum activities, under jurisdiction of the Ministry of Petroleum and Energy and its Petroleum Directorate (3). 2000: Semi privatization of Statoil, owners of LNG plant. Private owners create a strong coalition with Norwegian state (3). 2002: LNG construction was approved by the Norwegian government (3). Until this time Hammerfest was a coastal communities with local subsistence-economy composed by fishermen and Sámi indigenous people and municipality 2007: LNG plan is operational. The plant is situated 140 km from Hammerfest (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? - Change in fish distribution, abundance, and species composition. - Arrival of new species in the area such us Alaskan snow crab and pipefish - Increase in greenhouse emission. Hammerfest is one of the municipalities with highest emissions (2).	b) Have there been major social disturbances that are relevant for the case? Earlier out migration due to globalization of fisheries, especially young community (3) Emigration of younger population to the are after the industry development (2) Increase in industry jobs positions, shifting the productive activities in the area. Increase in the economic resource of municipality due to the taxes from industry
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 ocean and the changes in the seascape disrupt the ecosystem changing fish distribution, abundance, and species composition.	b) What are the key social drivers of change? Fisheries policy and legislation at local and regional level. Industry develops Globalization of fisheries: Fishermen are threatened by the industrial fisheries in the southern Norway and Russia, with a lack of business opportunities
5. **Sources of**	a) Within the ecosystem?	b) Within society (e.g. people, social capital,

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 affecting adaptive capacity)	(+) Appearing of new species in the area such as Alaskan snow crab and pipefish. (+) The increase of abundance of other species in the area, such as mackerel. (-) The change in the distribution of species commercially relevant due to the increase of oceans temperature, such as cod, ferring and capellin.	management, institutions, infrastructure): (+) Fisheries policies that establish quotas systems decrease the pressure in species. (-) Fisheries policies did not include quotas for new species with high commercial value. (-) Fisheries policies restrict the diversification of livelihoods in fishermen. (-) Selling fishing quotas of species that nowadays are more common to vessels from other countries. (+) Municipality support to diversify the source of jobs in the area (-) Access to loans to invest in gear and technology have increased the debts in the fishermen (+) Municipality invest in adaptive strategies for fishers and coastline infrastructure with the revenue collected by the industry taxes (2). (-) Power asymmetries between LNG and community: Industry has power in the decision-making process that concerns the use of Hammerfest landscape. (3) (-) Legal factors such as income tax, insurance requirements for fishing vessel had decrease the flexibility of fishermen to deal with climate change and social, economic, and biological disturbance (+) Past Fishers survived diversifying their portfolio and fishing further out at sea and working long days. Other fishers combine tourism with fishing to diversify their

		productive activity.
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: The increase of ocean temperature has affected the distribution of marine biomass. Especially the distribution and abundance of important fish stocks such as cod, herring and capelin and increasing the influx of southern species. Shorter and warmer winters reduce the snow depth and cover. Resilience is found in: The arrived of different species diversify the portfolio of fishermen and provide new opportunities	b) Within society: Change: Hammerfest was a small-scale community dedicated to fisheries. Change in productive activities has decreased in fishing activities. However, this traditional practice is still an element of cultural identity. Fishing has been impacted by the globalization of fisheries. The narrow range of economic and income opportunities, higher level of education in the younger generation has decreased the interest of youth to enter the fishing industry. Among this the Industry demand attract the interest of young generations. The family dynamics had changed over the years and young families are less willing to accept being at the sea and sacrifice family time. There is an aging process for fishermen and no connection with the younger generation. This disconnection has affected the transmission of traditional knowledge in new generations and could be lost over time. Resilience: The increase of wealth in the Municipality has allowed them to invest in adaptive strategies. Some of these projects are related to improving the coastline infrastructure, creating access to fishers to technology and promoting the transfer of knowledge.

II.2. What are the system's key components?	a) Key Ecological components (e.g. lakes, coastal zones, caribou) Coastal zones, fish stocks.	b) Actors in society (e.g. individuals, groups, public or private organizations)? How are people organised – by geography, livelihood, family, etc.? Before 2002 the LGN plant started operating, Hammerfest's marine community was highly dependent on fisheries for their livelihood and economy. Community of fishermen, local inhabitants, Sami indigenous people and municipality were the key actors of the territory. Despite the decrease in fishers, this livelihood remains as an important activity that maintains the identity of the community. Municipality and LGN plant are important source of work.
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) - Fishing - Oil gas production
II.4. What are key interactions?	a) What are the key ecological interactions within the case?	c) What collaborations, conflicts, or other key linkages exist between actors?

	The increase of water temperature among the human activities in the coastline affects the migration path of key species. The imbalance of the marine ecosystem had also brought new species such as Alska snow crab and pipefish to the area. b) What are the most important biophysical tele-connections to distant systems? Emission from Industry contributes to global emissions and climate change. Hammerfest has become in one of the cities with highest levels of emissions	Municipality has invested resources in adaptive strategy for fishers, risk assessments and coastline infrastructure to deal with climate events (2). Potential conflicts between new populations in the area due to the industry jobs opportunity and local community (3). The potential increase of development and infrastructure of LGN may overlap Sami´s Land currently used for reindeer herding (3). The positive effect of Industry in the area such as the increase of jobs and revenue of the municipality has delivered power to industry in the decision-making process, concerning the community (3). d) Between local actors and distant actors? National institutions who set the fishing legislation and fishers Scientific municipality partnership and industry overlapping the use of the coastline (2). Potential conflicts could arrive between industry, government, and fisheries. Although fishermen dialogue with the industry to protect their fishing areas. They argue that power asymmetries were present during the conversation and the company only pursued their economic success (3).
II.5. Culture	a) How is the relationship between society and nature viewed?	c) What are key cultural features of relevance for the case?

	Coastal line, seascape and fish are fundamental parts of coastal communities' livelihoods and identity. Fishers describe themselves as stewards of their coastal culture (4). b) What meanings are attributed to nature and to interactions with nature? Coastal fishers rely on fish and seascape. Fisheries play a role as a secondary source of income, but more important as part of their cultural heritage.	Coastal fishers rely on their own experience-based and locally transferred knowledge about weather, ocean, and fish interactions. They plan their sail according to their observations, discussions with pairs and local forecasts. Knowledge is a key element to travel safely in the sea and to success in catching fish. d) What are key cultural practices and beliefs related to nature? Fishermen claim as a community that "faces whatever comes". Due to their knowledge about the weather, fishing stocks and sea landscapes they consider themselves as a highly resilient group (4). They have historically adapted to change in the ecosystem. Climate change is not perceived as a risk from them; therefore, they don't create adaptive response to the current change in the ecosystem (2)
II.6. Disturbance What are important types of stress & shock	a) Describe important biophysical or ecological shocks and stresses (e.g. floods, storms, etc). Climate changes increase the occurrence of extreme weather events such as storms and polar lows create unfavourable conditions to fish activities. Hammerfest have historically had strong storms depending on the strength and direction of the wind. Some areas are exposed to floods, avalanches, and landslides (2).	b) Describe important social shock and stresses (e.g. austerity policies, changes in government policy, introduction of new technologies, etc) -Fishing regulations: Coastal fisheries are exposed to global market fluctuations. In the past, fishermen coped with the uncertainty of prices by having a second part-time job. The new regulation, tax and quotas, restrict fishers to diversify their livelihoods and encourage specialization to state a primary livelihood.
II.7. What are key slow variables	a) What types of ecological processes (e.g. loss of permafrost, shifts in species composition) are driving	b) What types of slow social processes (e.g. aging, population growth, loss of language) are driving important

Changes that occur over decadal or longer time scales	important long-term changes in ecological structures and processes? Change in the fish stock, distribution, and composition. Pollution of sea due to the Oil Gas Industry.	changes in social institutions and behaviours? - Aging of fishers who carry the traditional knowledge - Shift in interest and values of younger community
II.8. Relationships with ecological regime shifts	a) Are ecological regime shifts driving further ecological change or pressure? No, there have been ecological crises since the function of the industry. However, the change in ocean temperature that may be reinforced with the Energy industry, could lead to a future regime shift. b) Are external or internal ecological dynamics potentially or actually producing ecological regime shift(s)? External, due to the increase of water temperature.	c) Can social stresses or major changes be attributed to ecological regime shifts? Yes, climate change represents an additional stress to the current resource management regime, which may increase the local vulnerability. Regulations are not flexible enough to deal with the changes in the system such as change in seasons, arrival of new species among others. d) Are there specific social practices that might be contributing to ecological regime shifts Yes. The increase in energy demand and the expansion of the oil gas industry in the region. In addition, the production of energy had increased abruptly the emission of the area.
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	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)? Small scale fisher communities rely on natural resources and second jobs such as tourism. Mainly a local economy where the Municipality had the main role in the decision-making process. Due to the globalization of fisheries, policies restrictions and shift in value in younger communities there has been a decrease in the activity.	

type of regime shift	Multi marine communities share the production of energy by the exploitation of oil and gas in the Barents Sea, becoming the "Arctic Energy capital". Increase in population in the area and Municipality revenue enable us to invest in infrastructure and adaptive strategies to deal with climate disturbance. The arrival of industry has captured the interest of the young community reinforcing the decrease in traditional fish activities (3).	
II.8.b. Feedback mechanisms within the system that maintain each regime	Ecological feedback mechanisms - Increases in temperature have changed the distribution of key species in the area (cod, herring and capelin) and the arrival of southern species such as Alaska snow crab and pipefish. - Change in seasons have affected fishing practices - Increase of emission in the area could reinforced the increase of temperature and can generate a pollution of water in the area	Social feedback mechanisms - Shift in interest of young community - Loss in traditional knowledge - Increase in the municipality investment capacity
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). - Climate change due to increased greenhouse gases lead to a change of ocean temperatures and circulation pattern - Fishing quota, especially in cod allows to overcome the past over exploitation of the species. - b) How do these changes alter biophysical feedback processes? The increase of ocean temperature has affected the distribution of marine biomass. Especially the distribution	c) Drivers of social regime shifts (either social or ecological). - Fishing policies - Industry development - Globalization of fisheries - Aging of fishermen who carry the knowledge d) How do these changes alter the social feedback processes? Fishing policies constrains the adaptive capacity of fishers to catch new species with commercial value in the area, making the activity less attractive for younger generations. Industry demands offer opportunities for younger

	and abundance of important fish stocks such as cod, herring and capelin and increasing the influx of southern species. Shorter and warmer winters reduce the snow depth and cover.	generations, attracting them to shift from fishing activity to wage labour (3). On the other hand, taxes from industry have increased municipalities revenues, reinvesting in adaptive strategies for fishers facilitating technologies and restoring traditional knowledge (2). Globalization of fisheries has threatened small fisheries that are more vulnerable to market fluctuation, motivating the young generation to practice fishing (3). Aging of elder fishers and the disconnection with new generations have put on risk the transmission and reproduction of traditional knowledge
II.8.d. Ecosystem services substantially impacted by regime shift	a) Changes in ecological processes that produce ecosystem services The marine ecosystem is still providing fish stock, new or traditional species (2).	b) Changes in demand for ecosystem services (market and non-market) - Decrease in fish stock demanding - Increase in oil and gas exploitation - Decreases in cultural ecosystem services. Fishing has a main role in cultural identity.
II.8.e. What is (+/-) impacted by changes in ecosystem services directly or indirectly	a) Impacts from regime shift on ecological components Future pollution of water due to operation of oil and gas industry	b) Impacts from regime shift on social actors Continued decreasing fishing livelihood in the area losing traditional knowledge and changing the human nature relation.
II.8.f. Potential cascading effects	Describe, if any, the likelihood of potential ecological cascading effects to other SES Increase of emission by Oil and gas industries will contribute to global climate change.	Describe, if any, the likelihood of potential social cascading effects to other SES The expansion of industry can affect Sami communities' livelihoods competing with reindeer-herding grazing areas

		(3)
II.8.g. Where do actors intervene to alter regime shift dynamics and who can do the intervening? This can be listed here or marked with (*) in the table above	Ecological oriented interventions Industry has power in the decision-making process due to the contribution to Hammerfest and the coalition with Norwegian government. Having a strong voice in the management of natural resources in the area (3).	Socially oriented interventions Municipalities have implemented different projects to contribute to the adaptive capacity of the community. working among fishers to improve their livelihoods, investment in risk assessment, collaborating with science and in infrastructure to cope with climate events (2).

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(4)	Bay-Larsen, I., and G. Hovelsrud. 2017. Activating Adaptive Capacities: Fishing Communities in Northern Norway. Pages 123–134.
(5)	Jensen, J.L.A., Christensen, G.N., Hawley, K.H. et al. 2016. Arctic charr exploit restricted urbanized coastal areas during marine migration: Could they be in harm's way?. *Hydrobiologia* 783, 335–34.

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.