Adaptation to climate change effects on fisheries in the Shiretoko World Natural Heritage area, Japan

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In the Shiretoko World Natural Heritage area, many factors have been observed that imply the effects of climate change on the ecosystems, such as decreases in seasonal sea ice, changes of fishing grounds, appearance of non local species, etc. This study summarizes the observed and anticipated effects of such climate change on the fisheries in the heritage area, and discusses policy and research needs for adaptation to these changes. International research and monitoring, at the large marine ecosystem (LME) scale, is the basis of all policy measures for adaptation to climate change. A variety of measures should be combined, taking into account various socioecological aspects of fisheries, and various scales of ecosystems. Such measures of adaptation should be incorporated into the cross sector coordination system, and the Integrated Management Plan, which were newly established for the management of the World Heritage area. Also, we point out that culture is an important part of society, and the World Heritage Program may offer clues for creating a new peaceful culture based on the LME.

Keywords: UNESCO World Natural Heritage, fisheries, climate change, adaptation.

Introduction

The Shiretoko Peninsula and its adjacent marine areas (that is, the Shiretoko World Natural Heritage (WNH) area (Figure 1)) were inscribed in the UNESCO (UN Educational, Scientific and Cultural Organization) World Natural Heritage List in 2005. The Shiretoko ecosystem is characterized by rich low trophic level activity created by algal blooms following the melting sea ice. The area's high primary production supports a wide range of species, including marine mammals, seabirds, and commercially important species for local fisheries.

Many factors emerging in recent years indicate changes in the Shiretoko ecosystem, such as decreases in the amount of seasonal sea ice, changes in the location of fishing grounds, appearance of non local species, etc. In February 2008, UNESCO and IUCN (International Union for the Conservation of Nature) suggested that the Japanese government would develope a Climate Change Strategy that includes (a) development of a monitoring program that identifies both long and short term impacts of climate change, and (b) adaptive management strategies that could be applied to minimize any impacts of climate change on the value of the WNH site (UNESCO and IUCN, 2008). In order to address this suggestion, this study summarizes the observed and anticipated effects of climate change on the Shiretoko WNH ecosystems and fisheries, and then discusses policy and research needs for adapting to these changes. The objective of the study is to provide the baseline information for developing a Climate Change Strategy for the fisheries in the Shiretoko WNH area.

Shiretoko World Natural Heritage Site

Its ecosystems and fisheries The Shiretoko WNH area is the southernmost limit of seasonal sea ice in the Northern Hemisphere, and is affected by both the East Sakhalin cold current and the Soya warm current (Ohishima *et al.*, 2001). The area is also influenced by the Okhotsk Sea Mode Water, derived from the formation of dense shelf water in the Sea of Okhotsk (Yasuda, 2004), creating a complex and rich marine ecosystem with both migrating and resident species (Ministry of the Environment and Hokkaido Prefectural Government, 2007). In early spring, the Shiretoko ecosystem is characterized by rich low trophic level activity created by algal blooms following the melting sea ice. The area's high primary production supports a wide range of species, including marine mammals, seabirds, and commercially important species (Sakurai, 2007).

A distinguishing characteristic of the site is the interrelationship between its marine and terrestrial ecosystems. Large numbers of anadromous salmonids, such as chum salmon (*Oncorhynchus keta*), pink salmon (*O. gorbuscha*), masu salmon (*O. masou masou*), and dolly varden (*Salvelinus malma*), migrate up the rivers to spawn. They serve as an important source of food for terrestrial species such as brown bears (*Ursus arctos*), Blakiston's fish owls (*Ketupa blakistoni blakistoni*), Steller's sea eagles (*Haliaeetus pelagicus*), and white tailed eagles (*H. albicilla*). The peninsula is also internationally important as a stopover point for migratory birds (IUCN, 2005). Steller's sea eagles and white tailed eagles migrate from Russia to this area in winter, although some white tailed eagles live permanently on the peninsula.

Commercial fisheries in Shiretoko began in 1790 with the establishment of a fishery market by the rulers of mainland Japan, with the main products at that time being dried or salt cured salmon, trout, and herring (Shari Fisheries History Editing Committee, 1979). Today, marine areas around the peninsula are among the most productive fisheries in Japan. In 2008, Shiretoko fishers caught about 64,000tonnes of fish, worth about 24 billion yen (US$313 million) (MAFF, 2010). Their main target species and gear types are salmonids, using large scale coastal set nets; Japanese common squid (*Todarodes pacificus*), by jigging and/or using large scale coastal set nets; and walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), and Atka mackerel (*Pleurogrammus azonus*), using gill nets and/or longlines. Fish processing industries are also very active on the peninsula, and the dried Oni-Kombu kelp (*Laminaria diabolica*) produced in this area is highly prized, fetching the highest prices on the Japanese market.

Governance of the Heritage area Marine ecosystem conservation is typically composed of a suite of activities across a wide range of related sectors such as fisheries, transport, tourism, etc. However, there is no domestic law specific to World Heritage programs, and conservation measures have been implemented by more than one authority based on separate laws (for details see Makino *et al*., 2009). Therefore, a new system for cross sector coordination was established for the integrated management of the Shiretoko WNH area (Figure. 2).

In October 2003, the Shiretoko WNH Site Regional Liaison Committee was established, with officers from different ministries and departments in national and local government. They discuss the proper management of the site, exchange information, and coordinate various interests among related sectors.

The Shiretoko WNH Site Scientific Council was established in July 2004. It provides scientific advice regarding both the establishment of an Integrated Management Plan (explained below) and support for research and monitoring activities.

The Council has two working groups and two committees (Figure 2). In April 2010, the Shiretoko WNH Site Committee on the Proper Use of Nature and Ecotourism was founded. It conducts research and discussions on proper use rules for tourists.

Through these organizations and their interrelationships, stakeholder participation is ensured, information and opinions are exchanged, and consensus between the wide-ranging interests of multiple users of ecosystem services is achieved, thus increasing the legitimacy of Integrated Management Plans and related rules. This is the core institutional framework for integrated management in the Shiretoko WNH area (Makino *et al.*, 2009).

Integrated Management Plan The Integrated Management Plan was developed by the Marine Working Group of the Scientific Council. The Plan defines measures to conserve the marine ecosystem, strategies for maintaining major species, monitoring methods, and policies for marine recreational activities. The objective of the Plan is "to satisfy both conservation of the marine ecosystem and stable fisheries through sustainable use of living marine resources in the marine area of the heritage site."

Under the Plan, local fishers are identified as an integral part of the ecosystem, and the data they provide are used to cost effectively monitor the ecosystem. The Local Fisheries Cooperative Associations (FCAs), organizations of local fishers, have been collecting and compiling catch data for more than 60 years. This data covers many of the indicator species and other major marine species (Matsuda *et al.*, 2009).

Climate effects and research needs for adaptation

Framework for the discussion

Fisheries management has various objectives. For example, conservation of marine ecosystems and fisheries resources are essential to all fisheries activities. In addition, as an industry, improvement of economic efficiency is an important aspect of fisheries management. Fisheries products are one of the major sources of animal protein for the Japanese nation, so the national importance of a stable seafood supply, as well as related food safety, cannot be overemphasized. Taking all of this into account, the Fisheries Research Agency of Japan summarized five principal aspects of the policy objectives of fisheries management (FRA, 2009)—A: the resource and environmental aspect, B: the food provision aspect, C: the industrial and economic aspect, D: the local and community aspect, and E: the cultural and science aspect. We apply this framework to discuss the climate effects and measures of adaptation for fisheries in the Shiretoko WNH area.

Resource and environment

Vertical mixing owing to melting sea ice and seasonal upwelling provides nutrients that support the rich and diverse marine ecosystem (Sakurai, 2007). Figure 3 shows 65 years of changes in the number of days of sea ice cover at the Abashiri Local Meteorological Observatory (LMO), which is located about 50 km west of the Shiretoko Peninsula (Figure 1). Although there are frequent short term (1-3 year) oscillations, and several medium term (10-20 year) regime shifts, the changes show clear evidence of a long term (30-50 year) decreasing trend. Over this period, the 10 year average decreased by 22%, from 95.8 days through 1946-1955 to 74.6 days through 2001-2010. It is thought that the current amount of nutrients supplied by the Okhotsk Sea Mode Water and Oyashio Current is sufficient, and the observed decrease in sea ice will not immediately limit primary production (Ono *et al.*, 2001). If this decreasing trend continues, however, the long term impact on the Shiretoko ecosystems could be substantial.

There are several studies on the effects of long term climate change on the main fisheries resources for the Shiretoko fisheries. Chum salmon has been identified as a decreasing species (Kaeriyama, 2008, Kishi *et al.*, 2010), and ocean acidification could produce negative effects on invertebrates (Kurihara, 2008) such as short spined sea urchin (*Strongylocentrotus intermedius*). In addition, local fishers report that the size and shape of Oni Kombu kelp are gradually changing, and now more resemble those of temperate water kelp.

Walleye pollock (Sakurai, 2009) and Pacific saury (*Cololabis saira*) (Ito *et al.*, 2010) in the Shiretoko area are considered to be resilient to such long term climate changes, while Kichiji rock fish (*Sebastolobus macrochir*), owing to their habitat being typically located at depths below 100 ms, are little influenced by such changes (Kuwahara *et al.*, 2006).

Japanese common squid (Sakurai, 2006; Rosa *et al.*, 2011), and Pacific herring (*Clupea pallasii*) (Megrey *et al.*, 2007) are expected to increase in abundance over the long term. In addition, according to fisheries statistics, increasing numbers of Japanese amberjack (*Seriola quinqueradiata*) are being caught using large scale coastal set nets off Hokkaido Island. Because the total number of large scale coastal set nets in use, and therefore the fishing pressure from them, is relatively stable (Fisheries Agency and Fisheries Research Agency, 2010), the increase in catch implies a northward expansion of the Japanese amberjack fishing ground. Fishers in the Shiretoko area expect Japanese common squid and amberjack to be substitutes for the species decreasing in abundance.

Because the Shiretoko marine ecosystem forms part of the LME of the Okhotsk Sea, similar phenomena have been reported on the Russian side (Radchenko *et al.*, 2010). Therefore, joint monitoring and co-operative research programs regarding the LME should be established. Because Japan and Russia have territorial disputes over parts of this LME, scientific collaboration should take the lead. At the same time, more fine scale analysis of the effects of climate change on major fisheries resources should be facilitated. In addition, local fishers are required to monitor and report local scale (fishing ground scale) changes. Based on these results, strict and cautious resource management should be implemented for species increasing in abundance, such as Japanese common squid and Pacific herring. These species should not be seen as a temporary 'bonus', but rather as forming the main components of the future fisheries in Shiretoko. On the other hand, with regard to species decreasing in abundance, mitigating measures should be introduced. For example, the majority of chum salmon harvested in Japan are from artificially hatched stocks. They have lower genetic diversity and a narrower spawning period compared to the wild stocks (Nagata, 2011). In order to enhance the genetic diversity, environmental restoration of the natural spawning rivers is important as a medium term measure of adaptation.

Food provision

The Japanese are avid consumers of fish. The annual per capita supply of seafood in Japan was 61.5 kg in 2008, and this figure is the second largest in the world after Iceland. Fisheries products are the second largest source of total protein intake for the Japanese population, and the largest source of animal protein intake (MAFF, 2009).

The global demand for food is expected to increase for at least another 40 years, and the effects of climate change present a further threat to global food security (Godfray *et al.*, 2010). Moreover, the Japanese food self-sufficiency ratio is less than 40%. Thus, Japan is a vulnerable country in terms of food security, and increasing this ratio is one of its most important policy concerns. Hokkaido prefecture, in which Shiretoko is located, is the largest fisheries production site in Japan. About 30% of the total Japanese catch is landed in Hokkaido, and is expected to continue to play a vital role in the nation's seafood supply in the long term.

If species such as Japanese common squid and Pacific herring are to increase in abundance, efforts aimed at efficient utilization should be made; for example, new processing technologies, new transportation logistics, new markets and recipes, etc. From the standpoint of increasing the self-sufficiency ratio, these efforts are especially important for highly fluctuating species such as herring, if they are to be available for human consumption and not merely used as fertilizer or animal feed. Also, because Shiretoko is oceanographically vulnerable to accidents such as oil spills or chemical discharge occurring in the Russian Far East (Ohsima and Shimizu, 2008), tight communication between the two countries and the establishment of international contingency plans for seafood safety are required.

Industry and economy

The majority of fishers in Shiretoko are small scale fishers whose financial base is weak. In light of this vulnerability, catch composition is of particular importance in this area. For example, Figure 4 shows the composition of fisheries production (values) in two towns in the Shiretoko WNH area over the last five years. In Shari town, located on the western side of the Shiretoko Peninsula, more than 90% of fisheries income derives from salmonids, the majority of which are chum salmon, a decreasing species under the long term climate change. In Rausu town, the average value of fish production during 2004-2008 is higher than that in Shari town, and it is not dominated to the same extent by the contribution of salmonids. Note that, for the last ten years, the climate-related marine conditions in the western North Pacific Ocean have been favorable for chum salmon (Irvine and Fukuwaka, 2011), presumably as the result of the medium-term oceanographic regime-shift toward the cold phase.

Historically, Shiretoko fishers have experienced considerable instability in fisheries resources as a result of medium term regime shift. For example, herring was one of the main target species for coastal fishers in Shari town before the Second World War. In the late 1960s Japanese common squid landings in Shari town amounted to more than 4,000 tons per year. In Rausu town, too, common squid made up more than half of total landed values in that period. According to the legal system aimed at adapting to such resource fluctuations, fishing rights and licenses are revised every 5 to 10 years. The revision process is based on the plans drafted by the local fishers (Makino, 2011). In order to enhance adaptive capability in the face of climate change, in this revision process, government and scientists should provide the results of ecosystem monitoring and future prospects in a form easily understood by the Shiretoko fishers. A combination of fishing rights/licenses both for species increasing and decreasing in abundance will stabilize the fishers' total income and increase their economic resilience.

Hitherto, research on the economic implications of climate change on fisheries has been fragmentary (Hannesson *et al.*, 2006), and information and knowledge regarding adaptation to climate change is very limited (Brander, 2010). More economic analysis, in concert with the work of natural scientists, is required.

Local and community support

In the Shiretoko WNH area, the fisheries sector is the most important source of job creation along with the tourism sector. For example, more than 40% of the workers in Rausu town are engaged in fisheries activity (Rausu Town, 2010). Therefore, establishing a fisheries system resilient against climate change, by introducing measures of adaptation such as those mentioned above, will lead to a corresponding increase in the resilience of such local communities.

Geographically speaking, Shiretoko Peninsula is very mountainous, and almost all the fishers and their families live along the coast or the rivers. In addition, climate change is expected to increase the amount of rainfall. The latest future projections of western North Pacific typhoons indicates that the frequency of typhoon generation will decrease, while the average instantaneous maximum wind velocity will increase (Murakami *et al.*, 2011). Thus, the risk of floods in the residential area of the Shiretoko fishers will increase. However, the need to conserve salmonid pathways limits the opportunities for new dam construction on the rivers in the Shiretoko Peninsula (Nakamura and Komiyama, 2010). Also, the rise in sea level increases the risk of high tides and tsunamis (IPCC, 2007).

Hazard maps and evacuation plans have been drawn up by the town governments[1], and these are highly important for protecting the lives of local residents. However, at the moment, they do not incorporate the effects of climate change. Therefore, in the medium term, these maps and plans should be revised according to the climate change scenarios. In the long term, land use planning should be investigated and revised, to adapt to the climate change.

Culture

In Hokkaido, indigenous people such as the Ainu have developed a local culture based on local ecosystem services. For the Ainu, salmon is 'the fish of god' and important for their traditional ceremonies, arts, and food culture. However, as mentioned earlier, salmon numbers are expected to decrease with the climate change.

Once having vanished, culture will never return. Moreover, and importantly, indigenous culture is of great value in terms of cultural diversity, and should thus be protected by government policy. However, local culture has, by its nature, been closely

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[1] For examples of hazard maps or evacuation plans in Shari town, see (http://www.town.shari.hokkaido.jp/02life/20bousai_yobou/20bousaimap/kouzui.html).

linked to the local ecosystem services. In other words, local culture is changing with the changing environment. In that sense, we should not prevent the transformation of culture, or the creation of a new culture, as forms of adaptation to the changing ecosystems.

Historically, in the Shiretoko Peninsula, there was a hunter-gatherer culture called "Okhotsk culture" in the 5th to 9th centuries. In the 14th to 15th centuries, Ainu culture, which is the direct inheritor of Okhotsk culture, developed in the area covering the Amur River basin, Sakhalin, and the northern Hokkaido area (Segawa, 2011). Thus, one long term adaptation option would be not only to conserve the existing Ainu culture, but to promote the development of an extended culture based on the LME, a so called "Neo-Okhotsk" culture. Taking the territorial disputes over this LME into account, the UNESCO Heritage Program could be a tool for such peaceful innovation (Crosby, 2007).

Discussion and conclusion

Co-operative research and monitoring at the LME scale (Russia and Japan) is the basis for all policy measures for adaptation. International scientific programs can play a vital role in this respect. Local fishers are also required to monitor and report local scale changes in the ecosystems. Based on these results, a variety of measures should be combined, taking into account various socioecological aspects of fisheries (resource and ecosystem conservation, food provision, economic development, community support, and culture promotion).

This study has concentrated mostly on fisheries, but there are many ecosystem services, other than fisheries resources, which have been enjoyed by the Shiretoko local people, as well as the national population. Similar discussions are required regarding other sectors such as tourism. The effects on endangered species in the Shiretoko WNH area, such as the Steller sea lion or white tailed eagle, are also important issues to be addressed. Therefore, the adaptation strategy for climate change must be an integrated strategy covering all the related sectors and ecosystem services in the Shiretoko WNH area. Currently, in the Shiretoko WNH area, we have a cross sector coordination system (Figure 2) and the Integrated Management Plan. In order to ensure widespread stakeholder participation, and to increase the legitimacy of the measures of adaptation, it is both logical and reasonable to draft an *integrated* Climate Change Strategy under this existing management regime. However, the social resources for adaptation (e.g., human, financial, and organizational) are limited. We thus need to set priorities among the measures of adaptation; and in order to do that in a manner based on sound science, more assessment research on social vulnerability is required (Perry *et al.*, 2010), particularly involving social indicators, social thresholds, non-market values, and governance flexibility.

We outlined five principal aspects of Japanese fisheries management policy objectives, as a framework for the discussion. However, the objectives of fisheries management differ from country to country. For example, fish exporting countries without a large domestic market might have considerably different objectives than those of a nation like Japan. Comparison of adaptation strategies among high latitude communities (McGoodwin, 2011) which have different management objectives would be a useful next step. Furthermore, other ecosystems would present other issues requiring other measures of adaptation. Thus, comparison of various types of ecosystems would also be an important logical step toward a holistic understanding of humanity's adaptation to climate change.

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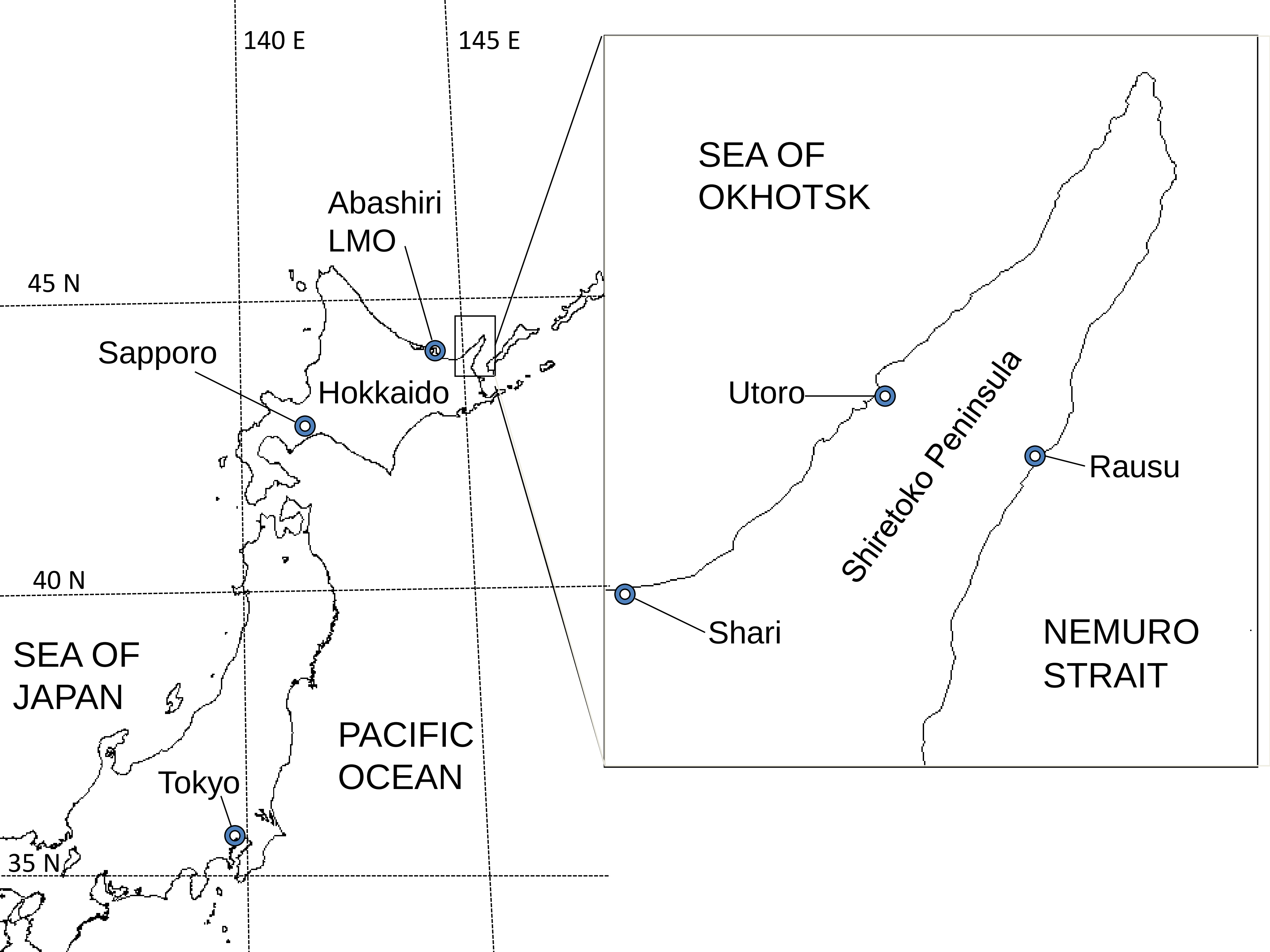
Figure 1. The location of the Shiretoko Peninsula in Hokkaido, Japan

Figure 2. New organizations for cross-sector coordination in the Shiretoko World Natural Heritage area (modified from Makino et al. 2009)

Figure 3. Changes in the sea ice days observed at Abashiri LMO in 1946-2010
Data : Japan Meteorological Agency (1947-2011)

Figure 4. Fisheries production values in the Shiretoko Peninsula for 2004-2008
Data: MAFF (2006-2010)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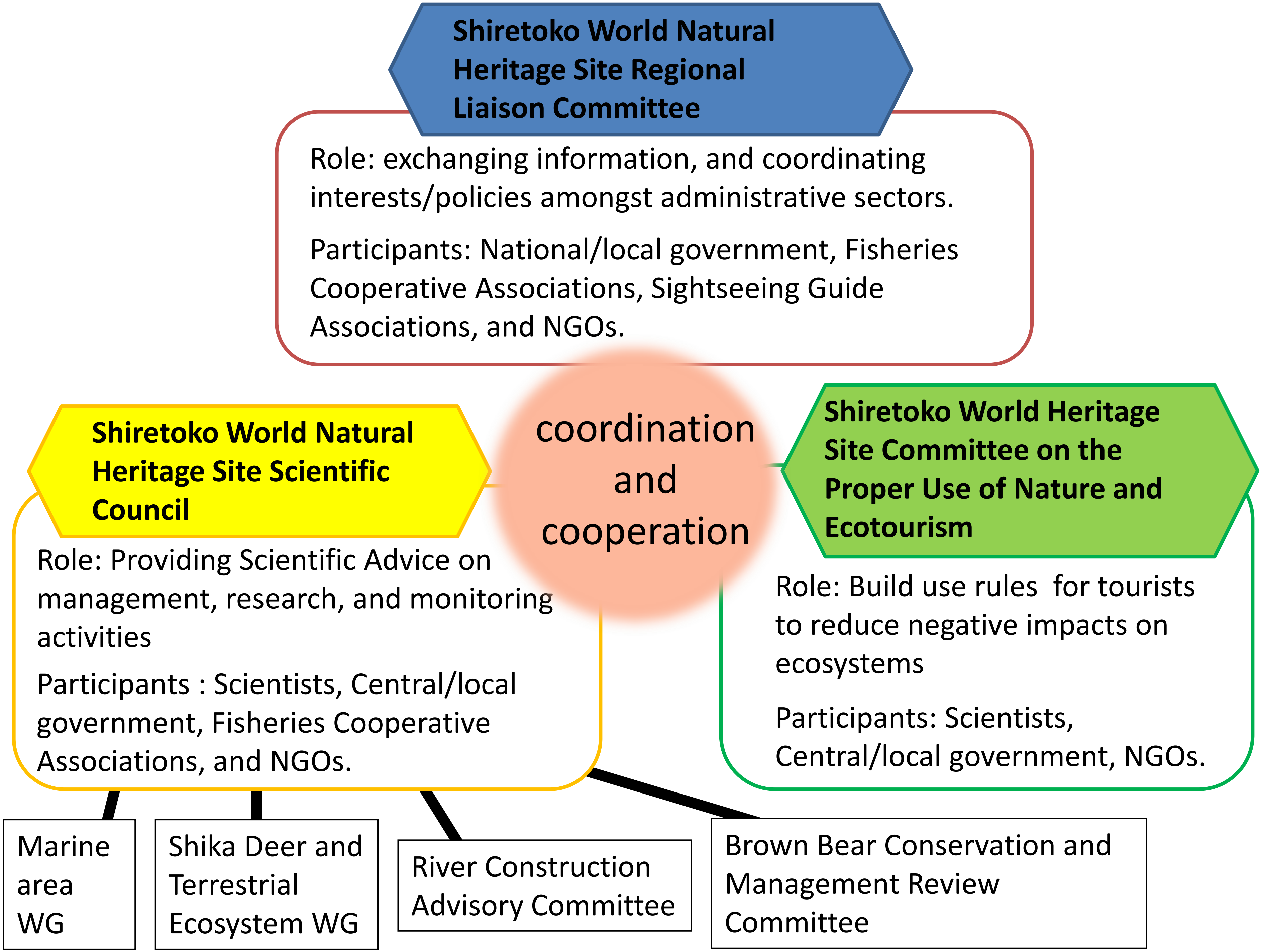
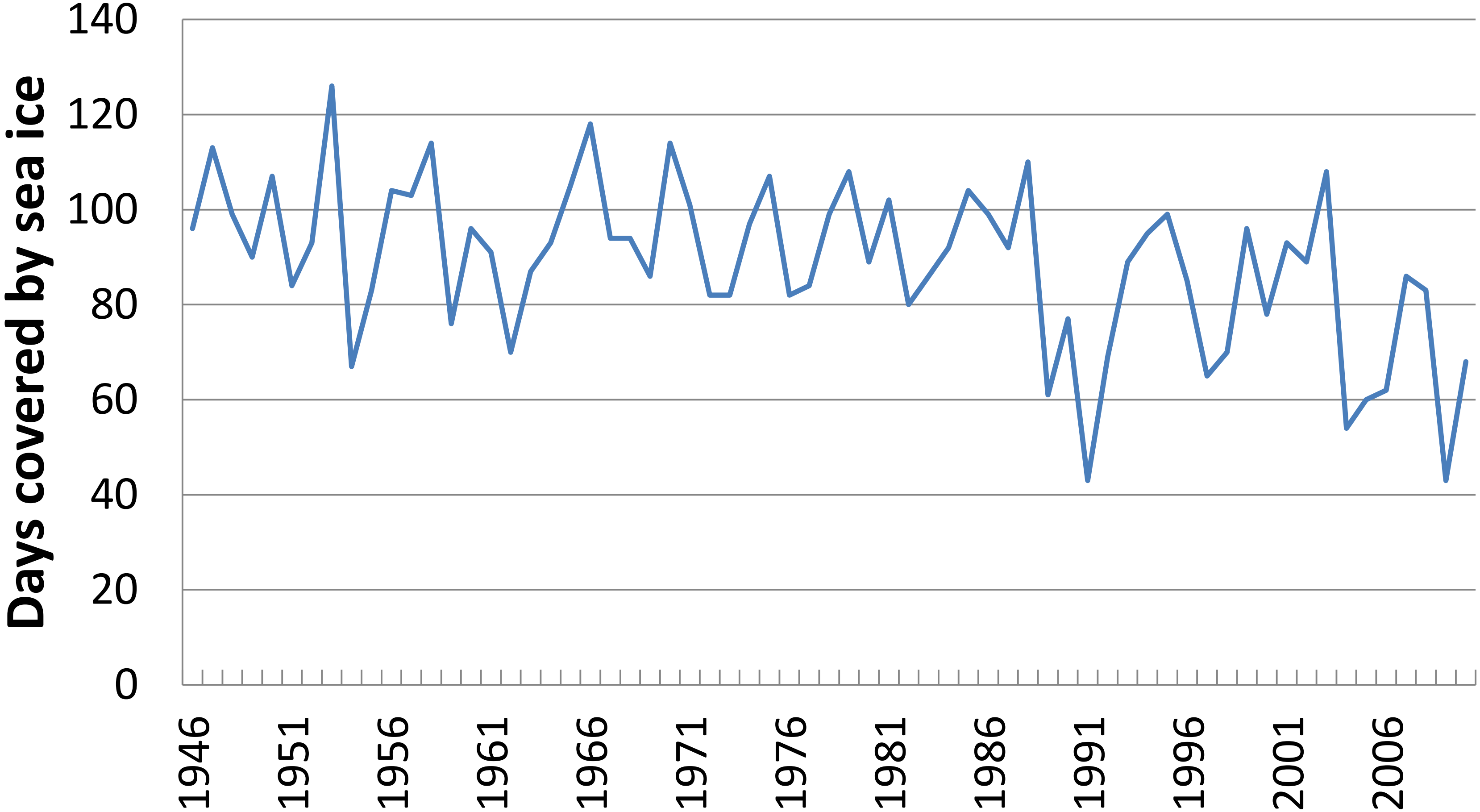
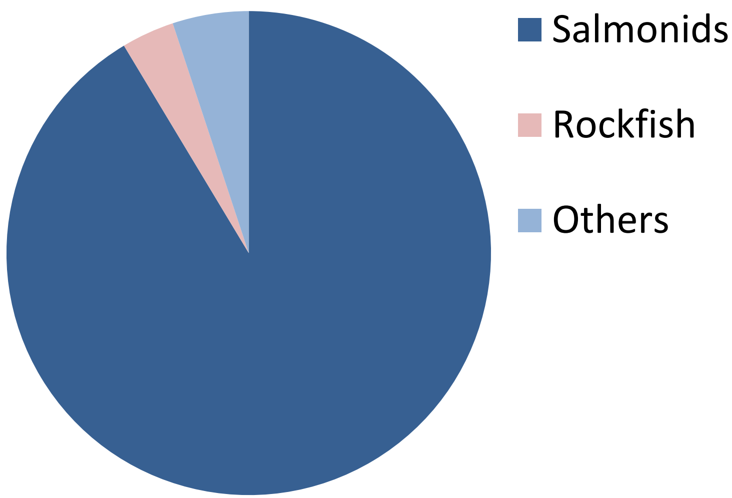
NEMURO
STRAIT


Shiretoko World Natural Heritage Site Regional Liaison Committee
Role: exchanging information, and coordinating interests/policies amongst administrative sectors.
Participants: National/local government, Fisheries Cooperative Associations, Sightseeing Guide Associations, and NGOs.
coordination and cooperation
Shiretoko World Natural Heritage Site Scientific Council
Role: Providing Scientific Advice on management, research, and monitoring activities
Participants : Scientists, Central/local government, Fisheries Cooperative Associations, and NGOs.
Shiretoko World Heritage Site Committee on the Proper Use of Nature and Ecotourism
Role: Build use rules for tourists to reduce negative impacts on ecosystems
Participants: Scientists, Central/local government, NGOs.
Marine area WG
Shika Deer and Terrestrial Ecosystem WG
River Construction Advisory Committee
Brown Bear Conservation and Management Review Committee

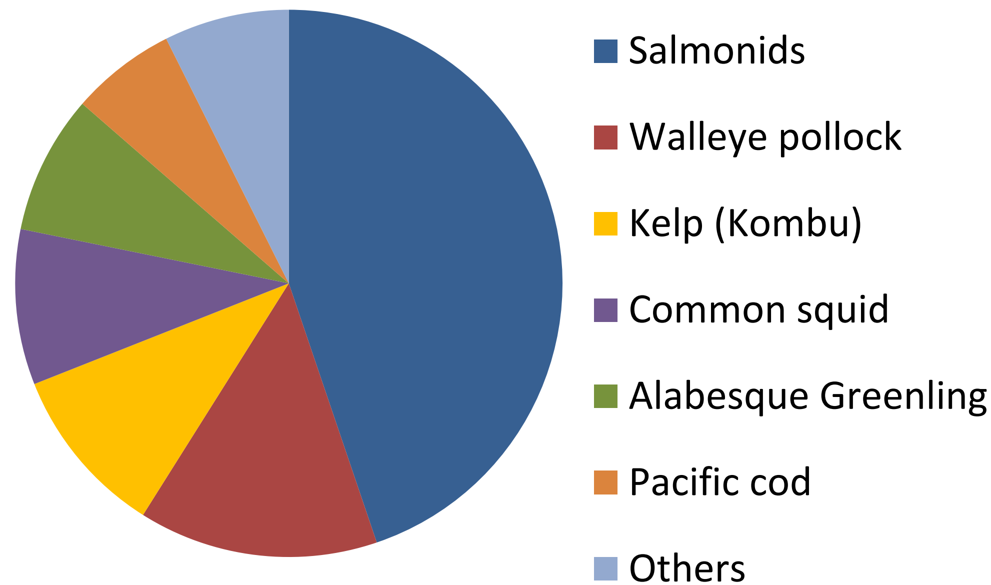


Days covered by sea ice
0
20
40
60
80
100
120
140
1946
1951
1956
1961
1966
1971
1976
1981
1986
1991
1996
2001
2006



a) Shari Town

(2004-2008: Average 9.9 billion yen)



b) Rausu Town

(2004-2008: Average 13.9 billion yen)