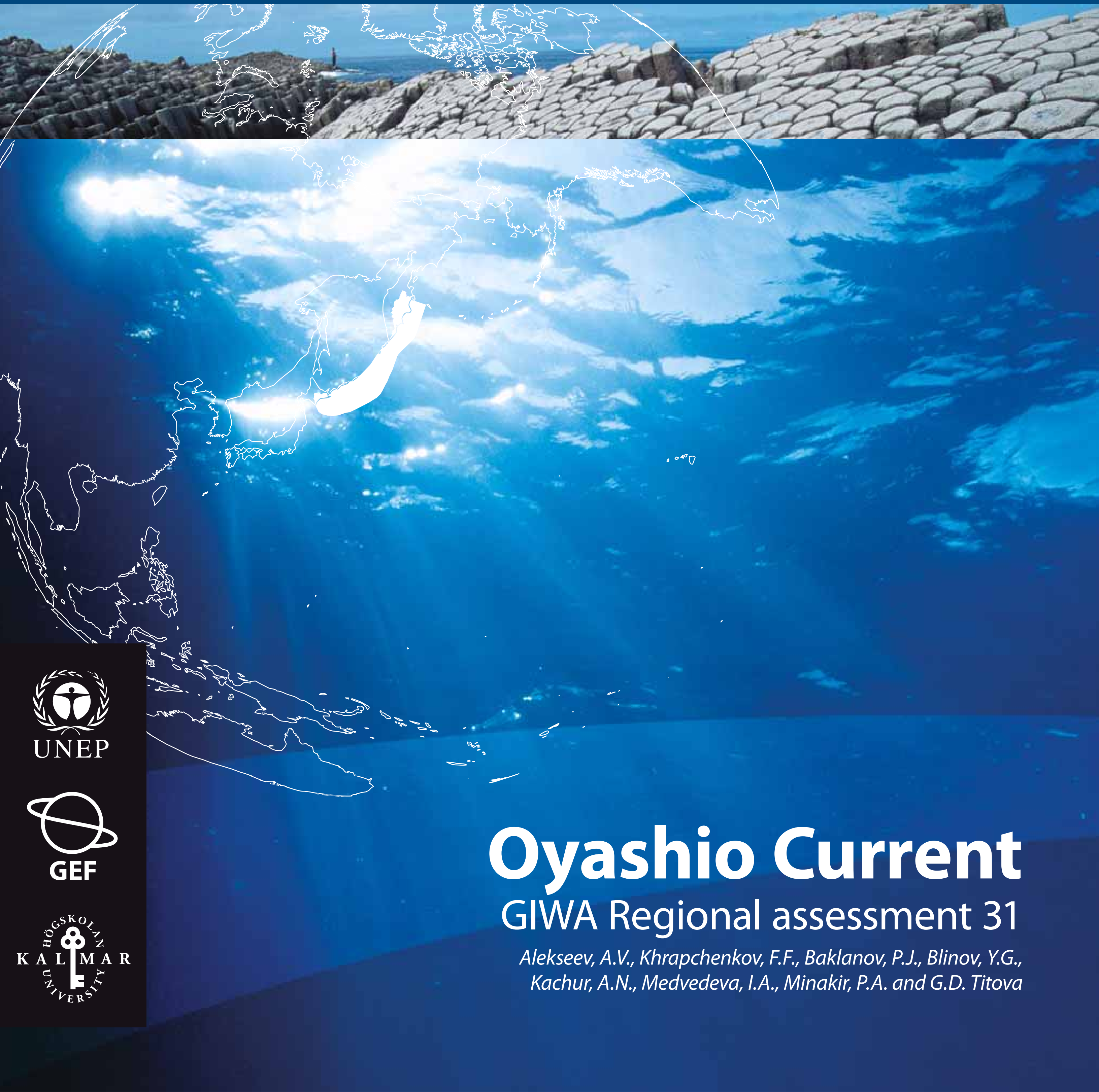
Global International
Waters Assessment



Oyashio Current

GIWA Regional assessment 31

*Alekseev, A.V., Khrapchenkov, F.F., Baklanov, P.J., Blinov, Y.G.,
Kachur, A.N., Medvedeva, I.A., Minakir, P.A. and G.D. Titova*

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Global International Waters Assessment

Regional assessment 31
Oyashio Current

GIWA report production
Series editor: Ulla Li Zweifel
Editorial assistance: Matthew Fortnam, Kristin Bertilius
Maps & GIS: Rasmus Göransson
Design & graphics: Joakim Palmqvist

Global International Waters Assessment
Oyashio Current, GIWA Regional assessment 31

Published by the University of Kalmar on behalf of
United Nations Environment Programme

ISSN 1651-940X

University of Kalmar
SE-391 82 Kalmar
Sweden

United Nations Environment Programme
PO Box 30552,
Nairobi, Kenya

CITATIONS
When citing this report, please use:
UNEP, 2006. Alekseev, A.V., Khrapchenkov, F.F., Baklanov, P.J., Blinov, Y.G., Kachur, A.N., Medvedeva, I.A., Minakir, P.A. and G.D. Titova. Oyashio Current, GIWA Regional assessment 31. University of Kalmar, Kalmar, Sweden.

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Publishing house: Kirjastusaktsiaselts MATS, Tallinn
Printed in Estonia by Tallinna Raamatutrükikoda, 2006

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Preface

This report presents the results of the United Nations Environment Programme/Global International Waters Assessment (UNEP/GIWA) of the Oyashio Current region. The report is a contribution to UNEP/GIWA by Russia and was funded by the Pacific Geographical Institute, Far East Branch of the Russian Academy of Science (FEB RAS). The assessment was conducted in collaboration with the General Northwest Pacific Region Environmental Cooperation Center (Japan), the Pacific Geographical Institute, the V.I. Il'ichev Pacific Oceanological Institute and the Pacific Institute of Fisheries and Oceanography (TINRO-Centre) (Russia).

A select number of local experts with a range of specialist backgrounds participated in three workshops hosted by the Pacific Geographical Institute in Vladivostok, Russia. A list of those consulted in the compilation of this report is presented in Annex I.

The report presents the results of the workshops, desk research, information development and policy analysis. The GIWA methodology examines five concerns: Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, and Global change. During the GIWA workshops for the Scaling and scoping (held 12-14th September 2001 and 9-11th April 2003) and the Causal chain analysis and Policy options analysis (18-20th February 2004), the transboundary issues of these concerns were assessed, the priority concerns were traced back to their root causes, and a policy analysis was executed.

Executive summary

The GIWA region Oyashio Current is a unique marine ecosystem in the Pacific Ocean, characterised by high productivity, an abundance of diverse flora and fauna, and distinct bathymetry, including a narrow oceanic shelf and the deep Kuril-Kamchatka Trench. The majority of the Oyashio Current drainage basin is located in Russia, and a minor part in Japan. The Oyashio Current region has attracted significant attention from politicians and researchers interested in its biological and hydrocarbon resources.

To date, the region has been largely unspoiled by the advances of civilization due to its remoteness, with most GIWA concerns having limited or no impact. The most severe issues are changes in the hydrological cycle and ocean circulation (Global change), and the overexploitation of the fisheries (Unsustainable exploitation of fish and other living resources). Positive temperature anomalies have changed the path of the Kuroshio Current which has consequently influenced the productivity of the fisheries. Storm activity has increased, generating greater energy in surface water layers and causing changes in the thermal flux, thus increasing the frequency of severe storms and floods. These changes are attributed to global climate change and El Niño Southern Oscillation (ENSO) events. Further, the impacts of global climate change are expected to intensify in the future. Overexploitation, particularly in the south of the Oyashio Current region, has led to the depletion of the major commercial fish stocks. This is mainly attributed to increased fishing effort and the overcapacity of the fishing fleet in the past two decades, particularly in the salmon, King crab, scallop and pollock fisheries.

Currently, the impacts of pollution from oil spills and radioactive waste remain slight. However, due to the expansion of the oil and gas industry in the region, as well as the increased shipment of oil and gas, the risk of accidental spills and leakages in the future is high. Further, there is concern that the facilities for storing radioactive waste in the Petropavlovsk-Kamchatsky area are inadequate and may lead to the contamination of the surrounding environment. Due to a lack of relevant data in the region, this issue was not prioritised for further analysis.

The Causal chain analysis identified the following root causes of the overexploitation of fish:

- *Economy:* Market reform failures; economic constraints prevent fishermen from adopting sustainable technologies; high taxes force fishermen to exceed their quotas; demand from export markets; and fluctuating market prices have changed the level of fishing pressure on each commercial species.
- *Technology:* Use of obsolete and non-selective fishing gear.
- *Governance:* Weak regulations; lack of efficient state policy; lack of alternative employment opportunities for fishermen; and conflicting regional and international fisheries policies.
- *Legal:* Inappropriate legislation regulating the fisheries sector in Russia; laws do not contain the main principles of sustainable fishing; and inadequate enforcement of laws.
- *Knowledge:* Inappropriate assessment methods; inaccurate scientific studies; gaps in fisheries statistics; and an insufficient understanding of ecosystem dynamics.
- *Political:* Political conflicts regarding fishing rights.

Because parties have expressed commitment towards international agreements for the conservation and management of the marine environment, including the Convention on Biodiversity, the UN Fish Stocks Agreement of 1995 and the World Summit on Sustainable Development in 2002, it is anticipated that the management of the fisheries in the Oyashio Current region will gradually improve.

The Causal chain analysis found that changes in the hydrological cycle and ocean circulation have been caused by global issues, such as global warming, which need to be addressed through international initiatives. It was agreed that inadequate progress had been made by the international community in mitigating this issue due to the non-implementation of relevant agreements. Despite the inability of the countries in the region to resolve this issue by themselves, it was found that insufficient effort has been made in preparation for the predicted climatic induced changes. There is an absence of an effective system in the region to monitor changes in the environment and to respond to future natural hazards. There is also a lack of knowledge on the affect of natural variability and anthropogenic activities on the ecosystems of the Oyashio Current, making it difficult to predict the impacts of future climate changes. The ability of fisheries management to react to climatic induced changes to the productivity of the fisheries is hindered by an inadequate understanding of the region's ecosystem dynamics and the lack of environmental indicators.

The GIWA Task team highlighted the necessity of scientific research. Careful implementation and enforcement of appropriate standards for the management of the fisheries is necessary to avoid disputes amongst the fishermen of South Kuril. Greater cooperation between the region's scientific and marine environmental management institutions should be encouraged in order to share data and techniques with an aim of improving the environmental quality of the entire region for the mutual benefit of all nations. A priority for the Oyashio Current region is to improve the understanding of the region's natural environment as well as to create an intergovernmental agreement between Russia and Japan.

A multilateral intergovernmental agreement should be initiated. This would aim to: (i) establish an organisation responsible for monitoring the regional environment; (ii) organise available information on the health of the environment; and (iii) establish an intergovernmental commission mandated to coordinate environmental management in the region. The GIWA Task team believes it is necessary to develop and improve the legislative basis at all levels.

Abbreviations and acronyms

APEC	The Asia Pacific Economic Cooperation
CBD	Convention on Biological Diversity
CCA	Causal Chain Analysis
EBRD	European Bank of Reconstruction and Development
EEZ	Exclusive Economic Zone
ENSO	El Niño Southern Oscillation
FAO	United Nations Food and Agricultural Organization
FEB RAS	Far East Branch of the Russian Academy of Science
GDP	Gross Domestic Product
GEF	Global Environment Facility
GOOS	Global Ocean Observing System
GIWA	Global International Waters Assessment
GRP	Gross Regional Product
GIPME	Global Investigation of Pollution in the Marine Environment
HCZ	Hidaka Collision Zone
IKIP	International Kuril Island Project
INPFC	International North Pacific Fisheries Commission
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
IWC	International Wildlife Coalition
JICA	Japan International Cooperation Agency
LDC	London Dumping Convention
LME	Large Marine Ecosystem
NGO	Non Governmental Organisation
NOA	North Atmospheric Oscillation
NOWPAP	Northwest Pacific Action Plan
PDO	Pacific Decadal Oscillation
PICES	North Pacific Marine Science Organization
PO	Policy Option
POI	Pacific Oceanological Institute
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
TINRO-Centre	Pacific Institute of Fisheries and Oceanography
WESTPAC	Working Group for the Western Pacific

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Regional definition

This section describes the boundaries and the main physical and socio-economic characteristics of the region in order to define the area considered in the regional GIWA Assessment and to provide sufficient background information to establish the context within which the assessment was conducted.

Boundaries of the Oyashio Current region

The GIWA Oyashio Current region is situated in the northwest of the Pacific Ocean and stretches for 2 000 km from north to south. The region has a total area of approximately 850 000 km^2 including the eastern part of the Kamchatka Peninsula, the Kuril Islands (east of Kamchatskaya Oblast' and Kurilskij raion of Sakhalinskaya Oblast', Russia), the east of Hokkaido (three sub-prefectures of Japan: Nemuro, Kushiro and Tokachi) and the Kuril-Kamchatka Trench. The Kuril-Kamchatka Trench extends from north to south for 1 200 km off the coasts of East Kamchatka and the Kuril Islands from the Kamchatka Strait. The region is connected to the Okhotsk Sea and the Bering Sea (Figure 1). The Oyashio Current Large Marine Ecosystem (LME) is based on the distinctive cold Kuril-Kamchatka Current which flows southwards to the east of Kamchatka and Kuril Islands. After mixing with waters flowing from the Sea of Okhotsk through the Bussol Strait, the Oyashio Current branches off along the northern Japanese coast where it meets the warmer Kuroshio Current off the coast of northern Honshu.

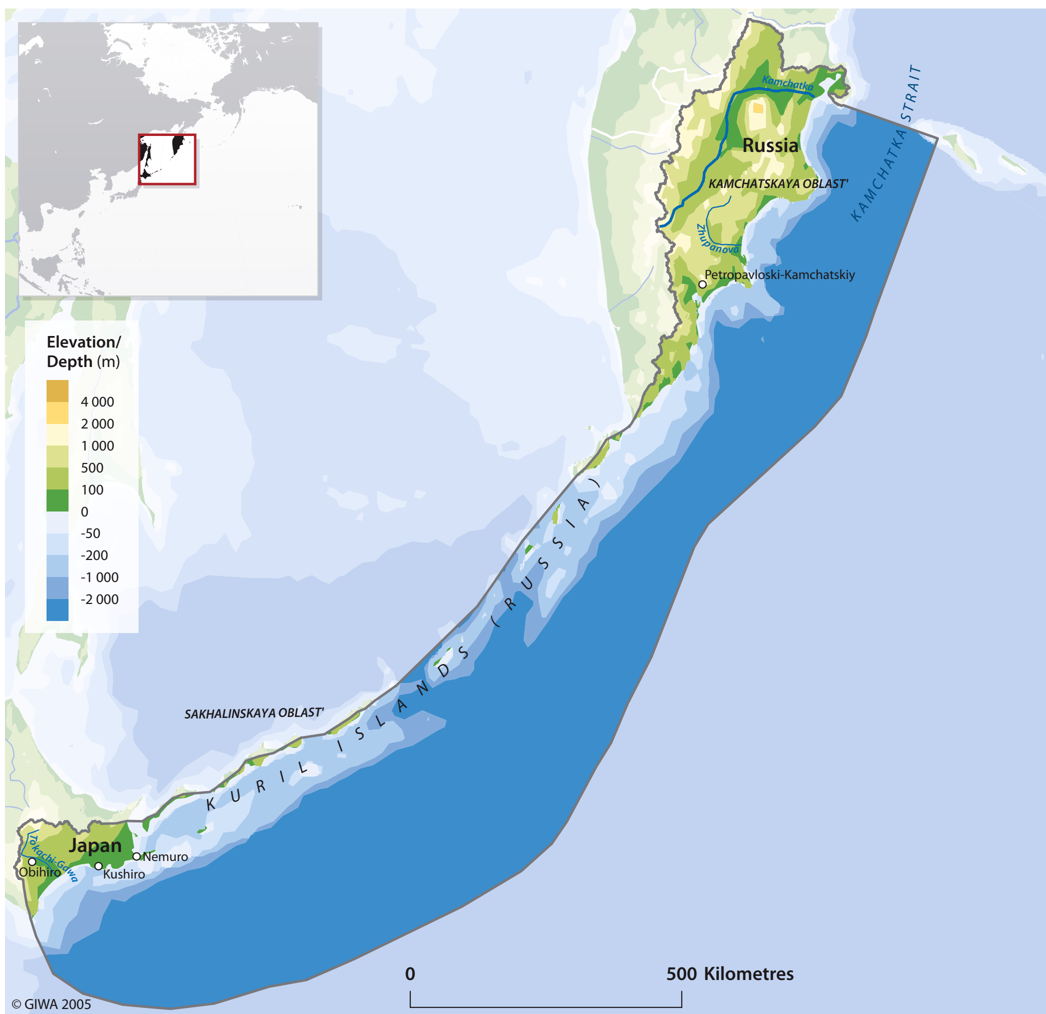

Figure 1 The boundaries of the Oyashio Current region.

A chain of islands stretches from Kamchatka to Japan, dividing the Okhotsk Sea from the Pacific Ocean. These can be divided into two groups of islands, namely the Small and the Big Kuril Island Chains. The Small Kuril Chain comprises the southern end of the chain near Japan, while the Big Chain stretches north to Kamchatka.

The entire basin lies within Russian territory, except for a small area in the southwest which is Japanese territory.

Physical characteristics

The eastern part of the Kamchatka Peninsula is located in northeast Russia, extending from about 51 to 58° N and from 157 to 164° E. The Peninsula constitutes the northern link in the 2 000 km Kuril-Kamchatka island arc. This region contains 28 active volcanoes – over 10% of the Earth's total number of active volcanoes – and is part of the "Ring of Fire" – the chain of volcanoes encircling the Pacific Ocean (Fedotov & Mansurenkov 1991). Kamchatka's volcanic spine includes the Kluchevskoi Volcano; the largest active volcano in Eurasia and one of the largest in the world (Figure 2) (Logan 2001). It is nearly 5 000 m in height and 35 times the average productivity of a land volcanoes. Eurasia's only geyser valley is found in central Kamchatka. This 8 km long valley comprises over 40 geysers, hot springs, boiling mud pots, steam vents and warm rivers (Logan 2001).

The Kuril Islands extend from Hokkaido to the Kamchatka Peninsula and are surrounded by the Sea of Okhotsk and the Pacific Ocean. They are named after an indigenous population, the Ainu people, who were originally known as the "Kur" people. There are 30 large islands and more than 20 small islands of the Kuril archipelago that are of volcanic origin, with a combined total area of nearly 10 500 km^2 (Figure 3) (IKIP 1994-1999). The Kuril Islands include approximately 39 active volcanoes (Stephan 1974, IKIP 1994-1999). The highest peaks are Alaid (2 339 m) on Atlasov Island, Tyatya (1 819 m) on Kunashir Island, and Chikurachky (1 816 m) on Paramushir Island. Vegetation on the northern and middle islands includes alder thickets (*Alnus sp.*) and Dwarf Siberian pine (*Pinus pumila*). Spruce, fir, broad leaf forests of Yew (*Taxus baccata*), Mulberry (*Morus sp.*) and oak, as well as bamboo thickets, are very common in the southern islands. Bear, fox and mink are representative of the Kuril fauna (Agafonova 2000, Barkalov 2002).

Hokkaido is located in the northernmost part of Japan; extending from about 41 to 46° N and surrounded by the Sea of Okhotsk, the Japan Sea and the Pacific Ocean (Figure 1). The majority of eastern Hokkaido

Figure 2 Kluchevskoi volcano.
(Photo: CORBIS)

comprises marshes and hilly areas with peaty soil. Large areas are covered in volcanic ash where soil fertility is low. Peat soil is present in the lower reaches of the main rivers, such as the Tokachi River, and in the wetlands (Hokkaido Government 1998b).

Climate

The climate of the various parts of the Oyashio region varies considerably. East Kamchatka and the northernmost islands of the Kuril arc (e.g. Shumshu and Paramushir) have almost arctic climatic conditions, while the southern islands (Kunashir and Iturup) contain pockets that are practically sub-tropical.

The climate and wildlife of Kamchatka are equally diverse. There is a moderate maritime zone on the coasts, a continental zone with four distinct seasons in the central valley and an arctic zone in the northern parts of the peninsula. Maximum and minimum temperatures on the islands reach 34°C and -26°C, respectively, but temperatures of -49 to -60°C are observed in the central and northern parts of the peninsula. In the coastal areas, between 1 and 6 days per year have temperatures over 20°C in the summer, whereas the Kamchatka River valley has 35 to 55 days (Tersiev 1998, Newell 2004). Maximum precipitation approaches 2 600 mm/year on the southeastern coasts. Maximum wind speeds in winter reach 40 m/s on the coast (Logan 2001).

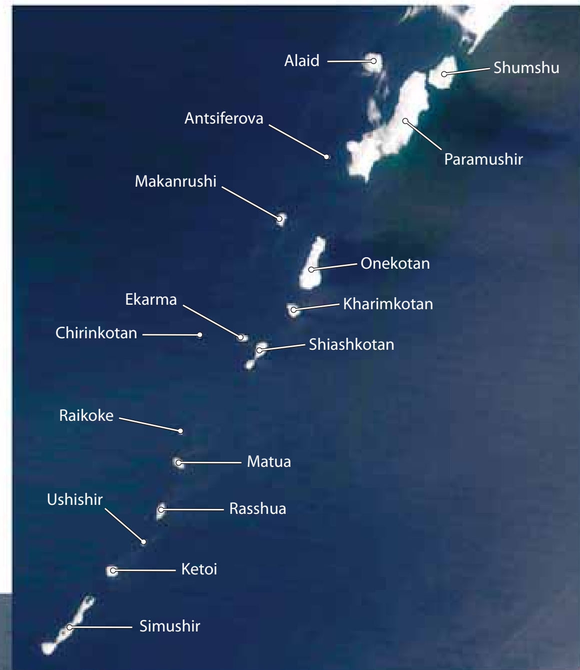

Figure 3 The Kuril Islands.
(Source: NASA, IKIP)

The Kuril Islands have a predominantly maritime climate, with no severe frosts or excessive summer heat. Rain and fog are relatively frequent in the summer with total annual precipitation ranging from 1 000 to 1 400 mm. Winds often reach hurricane strength, i.e. more than 40 m/s (Tersiev 1998). The Okhotsk Sea is icebound from November to June and frequently has heavy fogs. The Kuril Islands have a complex climate, including regular passages of deep cyclones with strong winds, heavy precipitation and storms (Tersiev 1998).

Hokkaido is located in a temperate and sub-arctic climatic zone. Prefectures located in the temperate zone are subject to monsoons and typhoons which result in higher temperatures and humidity, as well as greater precipitation, making the climate suitable for rice production. The dry and moderate summer climate is suitable for crop production and animal breeding but sub-freezing temperatures and snow do not favour such agricultural activities from October to March (Figure 4) (Hokkaido Government 1998a). Although climatic conditions in Hokkaido differ from region to region, generally large diurnal temperature fluctuations and cool nights during the summer favour the production of high quality crops.

Rivers

The Tokachi is the only large river in the Oyashio Current region and enters the ocean from eastern Hokkaido. Consequently, there are no international rivers in the region. The eastern part of the Kamchatka

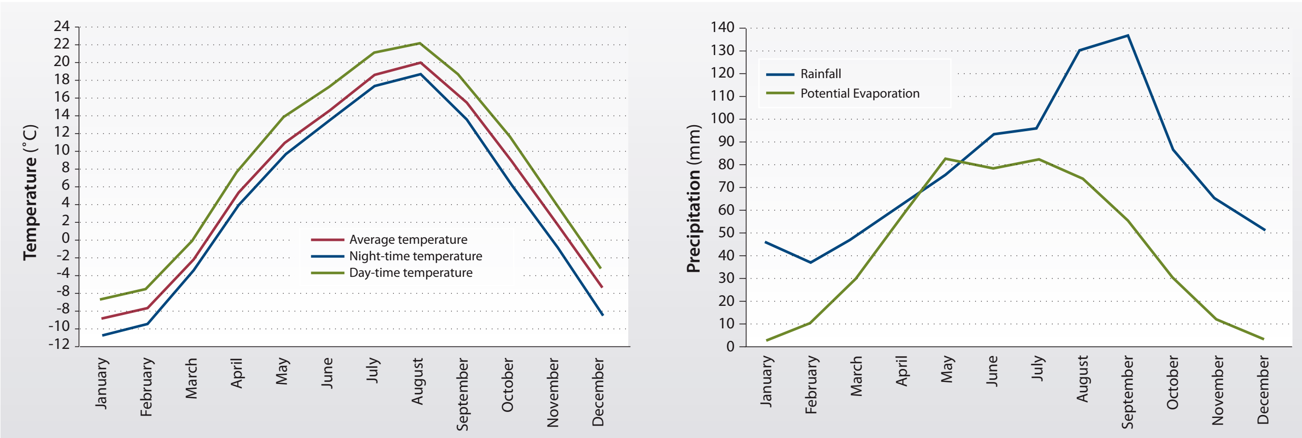

Figure 4 Temperature and precipitation distribution in Hokkaido.
(Source: FAO/AGROMET 2005)

Peninsula is characterised by a network of over 110 smaller rivers which flow into the Pacific Ocean. These rivers contribute cool and less saline water to the East Kamchatka Current. The largest is the Kamchatka River, which flows 758 km from the head river, the Ozernaya Kamchatka, to the Pacific Ocean, draining a river basin area of 55 900 km^2. There are also numerous lakes, the largest being the Nerpichye in the northeast of Kamchatka which has an area of 552 km^2 (Bortin et al. 1999, Chernjaev 2001). Kamchatka rivers generally have very wide floodplains which cause them to flow over large areas (Logan 2001). They are renowned for large catches of Red salmon (*Oncorhynchus nerka*).

Rivers and streams number nearly 4 000 on the Kuril Islands and there are numerous lakes, including those of crater origin (Figure 5). The highest waterfall in Russia, Ilija Muromets (141 m high), is located on Iturup Island. There are many small isolated lakes that dot the majority of the islands; at least 19 lakes on Shumshu, 5 on Onekotan, 7 on Simushir, 14 on Iturup, 10 on Kunashir, and 8 on Shikotan.

Figure 5 The Kraternaya Bight, Ushishir, Kuril Archipelago.
(Photo: CORBIS)

Oceanography

In the Oyashio Current region, the western boundary current merges with the East Kamchatka Current – a southwestwardly flowing western boundary current – in the north and the Oyashio Current in the south (Figure 6). The cold Oyashio Current, known also as the Kuril Current, is formed by the mixing of two sub-arctic waters: the Okhotsk Sea and the East Kamchatka Current. The Oyashio Current meets waters from the East Kamchatka Current and flows southwestwards towards Hokkaido where it branches off along northern Japan and meets the warmer Kuroshio Current off the coast of northern Honshu (Talley & Nagata 1995, Zalogin & Kosarev 1999).

The Oyashio Current is strongest in spring and surface temperatures vary seasonally from 0°C in early spring to 20°C in the summer. Sub-surface minimum and maximum temperatures occur at depths of approximately 100 m and 300 m, respectively, and the halocline at depths of 200 to 300 m in summer and autumn. A developed seasonal thermocline is found below 50 m (Kono & Kawasaki 1997). The topography of the Oyashio Current is characterised by the Kuril-Kamchatka Trench and Rise, and a continental shelf of limited width (Tersiev 1998).

The East Kamchatka Current originates in the Bering Sea and from the northern sub-polar gyre. It transports approximately 15-25 Sv* in the upper 1 000 m (Talley & Nagata 1995), whereas the Oyashio Current transports about 10-15 Sv in the upper 1 000 m east of Hokkaido. Therefore, 5-10 Sv remain in the sub-arctic gyre while 4-5 Sv enters the sub-tropical gyre. The Kuril Straits are affected by strong tidal mixing and tsunamis (Bogdanov et al. 1991, Talley & Nagata 1995, Nakamura et al. 2000). The Oyashio Current generally flows southwestwards from the Kuril Islands but the flow pattern varies annually. Large eddies propagate against the current and carry warm waters of sub-tropical origin northwards. Off the Kuril Islands, the southern flow bifurcates around these eddies to create the Oyashio coastal and

*1 Sv= 1 million m^3/s

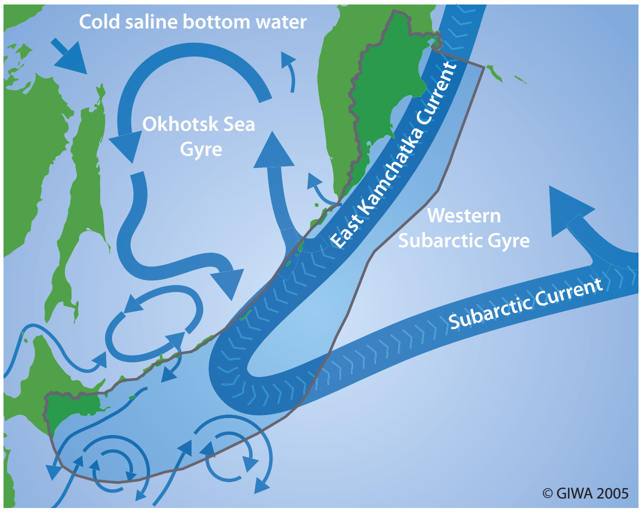

Figure 6 Sub-arctic gyre in the North Pacific.
(Source: Redrawn from PICES 1993)

Oyashio offshore branches. During the 1990s, a major thermohaline transition occurred within this current system, linked to the relative fluxes of two major water masses entering the Sea of Okhotsk; warm salty waters through the Soya Strait and cold fresh waters through the Kuril Island straits. This thermohaline transition was manifest in changes in the temperature and salinity structure of the boundary current regime, an alteration of the path of the Oyashio Current and a strengthening and restratification of the coastal Oyashio branch. These changes were reflected in the structure of mesopelagic fish communities (Yasuda et al. 1996, Nakamura et al. 2000).

According to observation data, the general pattern of water circulation within the active sea layer is subject to considerable seasonal variations. In autumn, the current speed increases slightly, whereas during the winter the currents flow in southerly and southwesterly directions in the ice-free areas. The aperiodic currents reach greatest speed in the surface layer of the southern and peripheral areas of the sea, i.e. the coastal belt, bays, straits and narrow waters. In typical synoptic conditions, they reach 10 to 20 cm/s over the Kuril hollow, 15 to 40 cm/s near the Kuril Islands and 10-15 cm/s in the Kamchatka Current. However, in the deep-water straits of Bussol and Kruzenstern, the speeds of aperiodic currents at depths of 1 000-2 000 m can exceed 30-45 cm/s (Bogdanov et al. 1991, Tersiev 1998, Khrapchenkov & Dmitrieva 2002). Against this background of general water circulation, quasi-stationary eddies and currents can be traced on the surface. Consequently, 2 to 4 anticyclonic eddies with diameters of 160 to 240 km can be observed off the Kamchatka Peninsula and Kuril hollow every year (Khrapchenkov 1989, Ohtani 1991).

Tectonic setting and tsunamis in the Oyashio Current region

The Kuril Trench was formed by the subduction of the Pacific plate under the North American plate and extends from the central area of Kamchatka to Hokkaido (Figure 7). The plate tectonics of the South Kuril Islands and northern Hokkaido region are quite complex and very different to those located along the southern part of the Japanese Trench. The South Kuril Islands are part of the Kuril arc on the boundary of the Okhotsk plate which has been colliding westwards against the Northeast Japan arc along the Hidaka Collision Zone (HCZ) where new continental crust is created by active arc-arc collision (Ito et al. 2001).

The complex, seismo-tectonic kinematic processes operating in the region have been named the "Delamination-wedge-subduction system" which may apply also to other areas where active arc-arc collision and concurrent subduction take place (Pararas-Carayannis 2000). The entire area appears to be highly fractured by complex tectonic interactions with crust displacements found along the boundaries of broken subplates. The Kuril Backarc Basin is a deep basin in the southern Okhotsk Sea, northwest of the Kuril arc. These fractured smaller plates, which are in close proximity to the tectonically active arc collision area, limit the extent of crust displacements. Consequently, large earthquakes have generated tsunamis that are only locally destructive tsunamis in this region.

Many of the large earthquakes and tsunamis on the Pacific side of northern Japan and the South Kuril Island area are attributed to subduction along the Japanese Trench. The tsunamis of October 1963 and October 1994 occurred on the Pacific boundary of a smaller tectonic subplate, which includes the Sea of Okhotsk and a northern part of the Sea of Japan (Pararas-Carayannis 2000). The grinding motion of the North Pacific Plate against this subplate has resulted in large earthquakes (like those

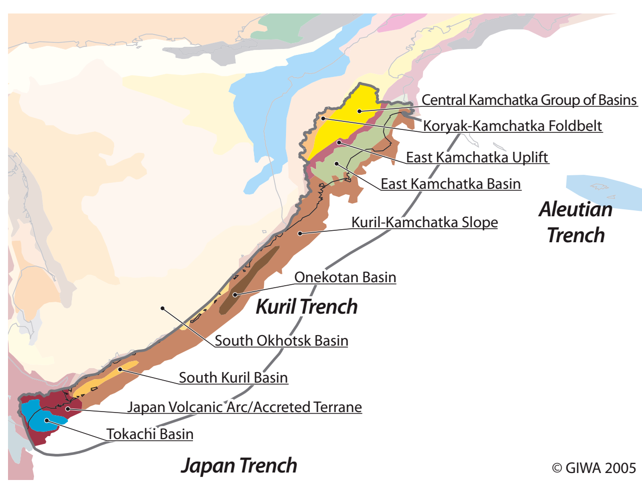

Figure 7 Tectonic provinces of the Oyashio Current region.
(Source: Geoscience Interactive Databases 2001)

of 1963 and 1994) but with less vertical subduction and more rotational movement. Therefore, despite its large magnitude, the earthquake of 1994 resulted in only 0.5 m of land subsidence but caused extensive lateral movement on Shikotan Island (Pararas-Carayannis 2000).

Biological resources

The southern Kuril coastal waters have some of the richest biological resources in the world due to the convergence of cold and warm sea currents. Economically valuable fish from cold water climates include Walleye pollock (*Theragra chalcogramma*), Atlantic cod (*Gadus morhua*) (Figure 8), Atlantic mackerel (*Scomber scomber*), flounder (*Platychthys* spp.), Atlantic halibut (*Hippoglossus hippoglossus*) and salmon (Salmonidae). Other species of fish, such as Pacific saury (*Cololabis saira*), tuna (*Thunnus* spp.) and sardine (*Sardina* spp.), migrate to the coastal waters of Kunashir from sub-tropical waters. Hundreds of thousands of Pink and Chum salmon (*Oncorhynchus gorbuscha, O. keta*) (Figure 8) migrate through the southern Kuril Islands via the rivers and streams of Kunashir. Various types of invertebrates live off Kunashir Island, although only a small number have been analysed. Many of these species, such as crab, shrimp, sea urchin, squid, sea slug, and scallop, are of economic value (Agafonova 2000, Gritsenko 2000, Shuntov 2001, Baklanov et al. 2003). Pacific saury, squid and Walleye pollock accounted for 19.5%, 19.6% and 10.1%, respectively, of the total fishery catch in the Russian EEZ in 2003.

The waters around Kamchatka are inhabited by the rare Blue whale (*Balaenoptera musculus*), Fin whale (*B. physalus*), Sperm whale (*Physeter macrocephalus*) and Killer whale (*Orcinus orca*) (Shuntov et al. 1993, Shuntov 2001). According to various sources there are between 10 000 and 14 000 Northern sea lions (*Eumetopias jubatus*) on the Kamchatka rockeries and 6 000 on the Kuril Islands (Burkanov & Semenov 1991, Maminov et al. 1991), up to 17 000 sea otters on the southern Kamchatka and northern Kurils, and between 3 000 and 5 000 Killer whales in the adjacent southwestern Bering Sea (Sobolevsky & Mathisen 1996). Between 125 000 to 253 000 dolphins migrate to the Russian Exclusive Economic Zone (EEZ), especially during the summer (Shuntov 2001).

Freshwater and terrestrial molluscs

Little is known of the molluscan fauna in the Kurils. Among the freshwater species are nine bivalves (one endemic) and eight gastropods (two endemic). There are 12 known species of terrestrial gastropods and another seven listed as possible inhabitants of the islands (Arzamastzev et al. 2001). In the southern Kurils, numerous endemic populations of bivalves are said to inhabit the small isolated lakes that dot the islands. Furthermore, an estimated 50 species of terrestrial gastropods that inhabit the more heavily vegetated southern islands are yet to be identified (Bogatov & Zatravkin 1990, Bogatov pers. comm.).

Figure 8 Atlantic cod (*Gadus morhua*) and Pink salmon (*Oncorhynchus gorbuscha*).
(Photo: W. Savary, Regulatory Fish Encyclopedia)

Freshwater fish

At least 48 species of freshwater fish (including anadromous forms) are found in freshwater habitats in Kamchatka, Hokkaido and Sakhalin Island but only 18 species are known to inhabit the Kuril archipelago (Arzamastzev et al. 2001, Agafonova 2000, Gritsenko 2000). Nine of these are found throughout the Kurils (anadromous salmonids and osmerids, and euryhaline gasterosteids) and, in addition to these, one species is reported to inhabit the northern Kurils (an osmerid, *Hypomesus olidus*) and three species the southern Kurils (the osmerids, *Hypomesus nipponensis* and *H. japonicus*, and a gasterosteid, *Pungitius sinensis*). Three other species have been reported in Iturup (a cyprinid, *Tribolodon brandti*, and two gobiids, *Tridentiger obscurus* and *Chaenogobius urotaenia*), three in Shikotan (the gobiids, *Luciogobius guttatus*, *Chaenogobius mororanus* and *C. castaneus*) and two in Kunashir (the gobiids, *Luciogobius guttatus* and *Chaenogobius urotaenia*). In eastern Hokkaido, volcanic activities have influenced the character of the regional hydrology and its biological resources.

Distribution of biological resources

The Bussol strait in the central area of the Kuril Arc where there is strong tidal mixing contains phytoplankton concentrations of over 5 000 mg/m^3, and the front where the cold Oyashio Current meets the warm Kuroshio Current off northern Japan has some of the most productive waters in East Asia (Lapshina 1996, Shiomoto 2000).

The Oyashio Current region is a Large Marine Ecosystem (LME) which is considered a Class I, highly productive ecosystem with more than 300 g C/m^2/year (Sea Around Us Project 2004). The Oyashio LME is known for its high biological productivity and diversity of fauna and flora. Phytoplankton in this LME has traditional spring bloom dynamics leading to a typical phytoplankton, macrozooplankton and fish food web. Odate (1991, 1994) estimates the zooplankton biomass at 1.1 to 3.7 million tonnes. It is believed that a high zooplankton biomass depends on the cold waters of the Oyashio Current below the thermocline (Sea Around Us Project 2004).

Socio-economic characteristics

Population

The population dynamics correspond to the region's socio-economic development and to the level of State support for the Russian Far East. One of the most significant declines in population among the Pacific coastal regions during the period 1991-2000 was observed in Kamchatskaya Oblast', which saw 20% decline (Russian Statistical Yearbook 2001, Russian Regions 2001). The age structure of the population in the Russian Far East is shown in Table 1.

The population of Kamchatka was 389 100 in 2000, with a population density of 0.8 persons/km^2. A large proportion of the population lives in the eastern part of the peninsula around Avacha Bay. In 2000, half of the population lived in the cities of Petropavlovsk-Kamchatsky (197 100) and Elizovo (37 900). Kamchatka is located far from large industrialised cities and transportation routes. Untouched by the advances of civilisation, the majority of the peninsula is uninhabited. In the north of the peninsula, the indigenous people of Kamchatka – the Koryaks, the Itelmen, the Chukchies and the Evens – have maintained their traditional ways of life (Logan 2001).

The total population of the three administrative districts of the Kuril Islands is slightly below 19 000 (Table 2). The Islands are very sparsely populated, with fewer than 2 people/km^2. The most populated cities and villages in the Kuril Islands are Severo-Kuril'sk, Kuril'sk and Yuzhno-Kuril'sk (Eremina et al. 2000).

In 1995, the population in the eastern part of Hokkaido (the three prefectures: Nemuro, Kushiro, and Tokachi) was approximately 740 000. The population density was 68 persons/km^2. The largest city in Hokkaido is Kushiro, which had a population of 205 640 in 1990 (Hokkaido Government 1998a).

Economy

In 1991, the dissolution of the Soviet Union became a key factor in the decline of production and the regional economy faced collapse. Since then, the Russian Far East economy has experienced a severe and long recession. Only since 2000 has the Russian economy had stable annual growth. Table 3 shows the economic growth rates in the Russian Far East and Figure 9 shows the structure of industrial output in 1995 and 2001 in Kamchatskaya Oblast'.

The economy in Kamchatka is predominantly based on fishing (accounting for 80% of the economy) its associated industries (e.g. ship maintenance) and, more recently, tourism. The economy expanded following the development of the electric power generation and nonferrous metallurgy industries. Economic activities are concentrated in the largest city, Petropavlovsk-Kamchatsky (Alekseev & Baklanov 2002,

Table 1 Age structure of the population in Russia 1991 and 2001.

	Age structure					
	1991			2001		
	Below working age (%)	Working age (%)	Above working age (%)	Below working age (%)	Working age (%)	Above working age (%)
Russia	24.3	56.7	19.0	19.3	60.1	20.6
Far East	27.6	61.4	11.0	20.6	64.7	14.7
Kamchatskaya Oblast'	27.2	66.8	6.0	19.0	69.7	11.3
Sakhalinskaya Oblast'	26.5	62.8	10.7	19.4	66.5	14.1

(Source: Russian Statistical Yearbook 1992, 2001)

Table 2 Population of the Kuril Islands 1995-1999.

	1995	1996	1997	1998	1999
Central Kuril Islands	9 102	8 463	8 300	8 110	7 992
North Kuril Islands	4 501	4 239	4 100	4 100	4 079
South Kuril Islands	8 302	6 246	6 630	6 396	6 675
Kuril Islands (Total)	21 905	18 948	19 030	18 606	18 746

(Source: Eremina et al. 2000)

Table 3 Economic growth rates.

		Economic growth rate (% of preceding period)						
		1991	1995	1997	1998	1999	2000	2001
Investment projects	Kamchatskaya Oblast'	97.6	ND	92.0	93.0	104.3	ND	ND
	Sakhalinskaya Oblast'	ND	ND	99.1	95.9	119.1	ND	ND
Industrial production	Kamchatskaya Oblast'	92	108	ND	95	ND	107	99
	Sakhalinskaya Oblast'	103	109	ND	104	ND	113	109.5
Agricultural output	Kamchatskaya Oblast'	ND	81	ND	102	ND	113	91.4
	Sakhalinskaya Oblast'	ND	82	ND	112	ND	92	130.5

Note: ND = No Data.

(Source: Russian Regions 2001)

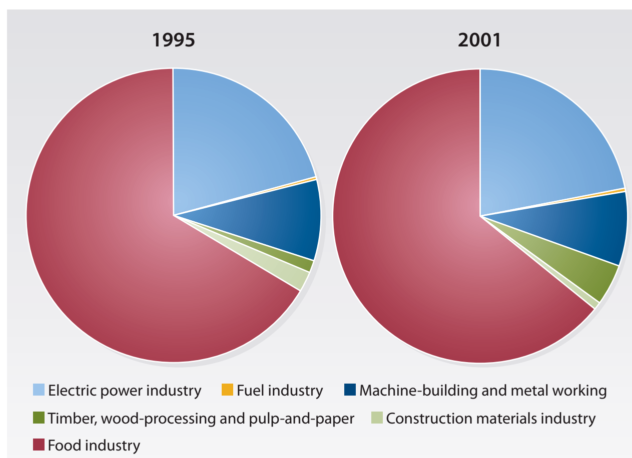

Figure 9 Industrial output in Kamchatskaya Oblast' in 1995 and 2001.

(Source: Russian statistic yearbook 1996, Russian Regions 2001)

Baklanov et al. 2003). After the fisheries industry, the timber, light and food industries are secondary in importance. The region's energy industry relies on imported fuel. Recently, geothermal power stations, geothermal heat supply systems, wind-driven power plants and hydroelectric power plants have been developed.

The abundance of marine biological resources surrounding the Kuril Islands has made the fisheries industry its primary economic activity (Table 4). The Kuril Islands are known also for their geothermal resources. On Kunashir Island, geothermal heat resources have been used for the provision of electricity and heating. Surrounding Iturup Island, studies on the ocean geothermal reservoir have been undertaken and reserves of two-phase geothermal fluids have been discovered. Specialists estimate the capacity of these reserves at 30 MW which is enough to meet the island's electricity and heat requirements for the next 100 years. Geothermal reserves on Paramushir Island have been less researched, although there are known to be considerable reserves of geothermal water with temperatures between 700 and 950°C (Eremina et al. 2000). Furthermore, the Kuril Islands have substantial reserves of titanium and sulphur, and gold has also been discovered.

Table 4 Export deliveries of fish and other seafood 1995-1999.

	1995	1996	1997	1998	1999
Export (USD)	12 586 200	8 665 000	4 067 300	6 252 800	16 938 600
Export (tonnes)	2 493	1 811	1 861	4 247	9 131

(Source: Eremina et al. 2000)

Agriculture is comparatively well developed in East Kamchatka and poorly developed in the south Kuril Island of Kunashir. A large proportion of food products is imported from other Russian Far East regions and other countries. Agriculture generates 44.2 million USD, of which vegetables produce 29.1 million USD and animal production, 15.1 million USD (Russian Regions 2001, Eremina et al. 2000).

Hokkaido's rich forests and its proximity to the sea make the island the national base for food supply in Japan; its gross agricultural product is nearly 10 000 million USD. Traditional food processing industries thrive and many technologically orientated companies have recently located in Hokkaido. Regarding industry in Hokkaido, 3.3% (1.3% of the national total) of GRP is from primary industries, 21% (28.1%) from secondary industries and 77.5% (74.8%) from tertiary industries. Compared with the rest of Japan, the manufacturing industry is less significant in Hokkaido – contributing 10.4% to GRP (half the national GRP) – and consisting largely of food, pulp/paper, ceramics, stone and clay industries rather than processing and assembly industries (Annual Economic Calculation Report for Hokkaido Citizens for FY 2001 in Hokkaido Government 2004).

Fisheries

The fishing industry dominates the Kamchatka economy due to the high concentration of biological resources and the large spawning grounds of Pacific salmon in the region. The fisheries industry in the Russian Far East comprises fishing, processing, specialised facilities and services, and fish stock management organisations. In many regions this industry is closely linked with other sectors of the economy. It is serviced by a large number of specialised industries such as shipbuilding and repair, ports, transport and reefer fleet, and manufacturers of fishing gear and packing materials. Auxiliary services (including procurement, sales, communication and construction) provide support to both the fishing industry and the specialised services involved.

Concerning pollock activities in the western Bering Sea, Kamchatskaya Oblast' is second in importance after Primorye. Conover (1997) lists eleven fishing organisations that are associated with pollock fishing in the Bering Sea. In 1996 and 1997, Kamchatka fishermen caught 23% of the region's pollock quota (516 000 tonnes) and 22% of the western Bering Sea quota (96 000 tonnes). The main fishing port is Petropavlovsk-Kamchatskiy (Wespestad 1996, Ozolin'sh & Spiridonov 2001).

The Pacific coast surrounding the Kuril Islands is among the most productive areas of ocean in the world and constitutes Russia's largest fishing ground. Approximately 40 fishing companies in Sakhalinskaya Oblast' are involved in pollock fishing in the region, though none are specifically associated with western Bering Sea pollock (Conover 1997). The majority of the companies are located in the cities of Nevelsk, Yuzhno-Sakhalinsk and Kholmsk on the southernmost point of the island. The Kuril Islands shelf is favourable for the harvesting of King crab (*Paralithodes camtschaticus*), shrimp, mussels and other bivalves. There has been concern over the depletion of certain species, particularly King crab, however there is generally minimal overexploitation of other species in the region (Arzamastzev et al. 2001, Sea Around Us Project 2004). The total annual fish quota for the islands is 1.4 million tonnes and for sea invertebrates (squid, shrimps, oysters, etc.), 345 000 tonnes (Eremina et al. 2000, Ozolin'sh & Spiridonov 2001).

Hokkaido has excellent offshore fishing grounds, including the continental shelf which stretches northwards. In 2001, marine fishery and aquaculture production was 1.58 million tonnes (26.3% of the nation's total) and generated 2.7 billion USD. Many valuable fish species thrive in these waters, including salmon, pallas, herring, flounder, mackerel, cod and halibut which account for 90% of the total annual catch (Noto & Yasuda 1999). The major species which are artificially cultivated and propagated in Hokkaido are restricted in numbers due to the environmental conditions of the region. Almost all are northern forms which have their major distribution range in Hokkaido. Recently, the cultivation of fish and other marine organisms has become commercially significant for Hokkaido, and seed production systems have been established for some of the most important northern species.

International cooperation

Water management in the Oyashio Current region is affected by several international programmes:

- The Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP UNEP). Originally, Japan supported the idea of NOWPAP but felt that a lack of consensus on the issue would prevent diplomatic relations between some of the countries.
- International Maritime Organisation (IMO). Russia and Japan have signed 10 and 8 of the pollution treaties, respectively. However, only Russia has joined the 1973 Intervention Convention. They have both acceded to the International Convention for the Prevention of Pollution from Ships (1973), as modified by the Protocol of 1978 (MARPOL 73/78).
- London Dumping Convention (LDC). Both Japan and Russia are parties to the 1972 LDC. LDC members have an obligation to report ocean-dumping permit activity so that all concerned countries are aware of the kind and quantity of wastes that enter their shared waters. The signatories approved permanent total bans on toxic industrial waste disposal at sea, beginning in 1996.
- The Asia Pacific Economic Cooperation Forum (APEC). The APEC environment ministers met in Vancouver in March 1994 to discuss a regional environmental strategy. Marine pollution was among the topics discussed.
- Working Group for the Western Pacific (WESTPAC). WESTPAC has focused on intercalibration exercises, with the collaboration of the Global Investigation of Pollution in the Marine Environment (GIPME) and the International Oceanographic Commission (IOC) Group of Experts on Methods, Standards and Intercalibration (GEMSI).

Both countries have also signed the UNESCO World Heritage Convention, United Nations Convention on Biological Diversity (CBD) and Ramsar Convention on wetlands, and are members of the North Pacific Marine Science Organization (PICES).

There is an agreement between the Japanese and Russian Federation governments permitting Japanese fishing in the Russian Federation territorial waters near Kunashir, Iturup Islands and Habomai. Several further agreements are currently under development. The validity period of the agreement allowing Laminaria extraction by Japan in the area of Signalny Island was extended in 1999.

Three North Pacific Ocean rim countries (Canada, Japan and the United States) organised the International North Pacific Fisheries Commission (INPFC) to regulate catches in the Oyashio LME. INPFC was dissolved and the Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean was established in February 1993.

The International Kuril Island Project (IKIP 1994-1999) is an international collaboration of American, Russian and Japanese scientists to survey the plants, insects, spiders, freshwater and terrestrial molluscs, freshwater fishes, amphibians and reptiles of the Kuril Archipelago. Participating institutions include the University of Washington (United States), the Far East Branch of Russian Academy of Sciences (Russia) and Hokkaido University (Japan).

Between 1994 and 2005, the basic purposes and tasks of the Federal programme of socio-economic development of the Kurils in the Sakhalin area were:

- Constant geo-strategic development of the Kurils in the interests of the Russian Federation.
- The creation of infrastructure and the stimulation of investment for the development of major branches of the economy and the realisation of programmes and projects of international cooperation in the Kurils.
- Stable socio-economic development in the Kurils (Russian Federation Government 2001).

Russia and Japan signed in 2000 a programme of economic joint development of South Kuril. The programme promotes joint Russian-Japanese investigations.

Academic institutes include the Far East Branch of the Russian Academy of Science and TINRO-Centre. Data is collected during marine expeditions, which can be classed into three groups:

- Complex expeditions on the research ships of the TINRO-Centre;
- Scientific research expeditions on ships of different organisations; and
- Fishing trips with observers.

Assessment

Table 5 Scoring table for the Oyashio Current region.

Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter)

- IMPACT 0 – No known impacts
- IMPACT 1 – Slight impacts
- IMPACT 2 – Moderate impacts
- IMPACT 3 – Severe impacts

The arrow indicates the likely direction of future changes.

- ↗ Increased impact
- → No changes
- ↘ Decreased impact

Oyashio Current	Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***
Freshwater shortage	0* →	0 →	0 →	0 →	0	5
Modification of stream flow	0					
Pollution of existing supplies	0					
Changes in the water table	0					
Pollution	0* →	0 →	0 →	0 →	0	4
Microbiological pollution	0					
Eutrophication	0					
Chemical	0					
Suspended solids	0					
Solid wastes	1					
Thermal	0					
Radionuclides	0					
Spills	1					
Habitat and community modification	0* →	0 →	0 →	0 →	0	3
Loss of ecosystems	0					
Modification of ecosystems	1					
Unsustainable exploitation of fish	1* →	0 →	0 →	1 →	0.5	2
Overexploitation	1					
Excessive by-catch and discards	0					
Destructive fishing practices	1					
Decreased viability of stock	0					
Impact on biological and genetic diversity	0					
Global change	1* →	1 →	0 →	0 →	0.5	1
Changes in hydrological cycle	2					
Sea level change	0					
Increased UV-B radiation	0					
Changes in ocean CO_2 source/sink function	1					

* This value represents an average weighted score of the environmental issues associated to the concern.

** This value represents the overall score including environmental, socio-economic and likely future impacts.

*** Priority refers to the ranking of GIWA concerns.

This section presents the results of the assessment of the impacts of each of the five predefined GIWA concerns i.e. Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, Global change, and their constituent issues and the priorities identified during this process. The evaluation of severity of each issue adheres to a set of predefined criteria as provided in the chapter describing the GIWA methodology. In this section, the scoring of GIWA concerns and issues is presented in Table 5.

Freshwater shortage

The GIWA Oyashio Current region has abundant water resources. Within the boundaries of the drainage basin, total annual precipitation rates increase from south to north: from 1 000 to 1 400 mm in the Kuril Islands to 2 600 mm in the southeast of Kamchatka. However, humidity varies comparatively little over the same area as evaporation increases at nearly the same rate (from 100 to 250 mm annually) (Tersiev 1998, Logan 2001). This results in an extensive river and lake network. There are more than 110 rivers and thousands of streams which flow into the Pacific Ocean on the east coasts of the Kamchatka Peninsula and Kuril Archipelago, the largest being the Kamchatka River. There are also many lakes, the largest being the Nerpichye in the northeast of Kamchatka (Bortin 1999, Chernjaev 2001). As a result of these hydrological features, there is an abundant freshwater supply in the region, with more than 150 000 m^3 per person annually (Bortin et al. 1999).

Freshwater shortage is therefore not a significant concern for the region. Correspondingly, the GIWA issues of modification of stream flow, changes in the water table, and pollution of existing supplies were assessed as having no known impact. However, it should be noted that there is evidence of localised pollution of surface waters in the regions of Kamchatka and on some of the Kuril Islands (Tkalin 1991a,b), although the impact of this contamination on the region's international waters is negligible as the Oyashio Current has a vast dispersion capacity. Industrial infrastructure that could result in the modification of stream flow, pollution, or aquifer draw-down is largely non-existent.

Conclusion and future outlook

Freshwater shortage is not a major concern for the Oyashio Current region neither at present, nor in the foreseeable future. Kamchatka, the Kuril Islands and Hokkaido have extensive supplies of high quality freshwater in their lakes and rivers.

IMPACT Pollution

The GIWA assessment concluded that presently only the issues of solid wastes and spills have a slight impact for the Oyashio Current region. The issues of microbiological pollution, eutrophication, chemical pollution, suspended solids, thermal pollution and radionuclide pollution were considered to have no known impacts and are therefore not further discussed.

Environmental impacts

Avacha Bay, on the Kamchatka Peninsula, has increasingly become a source of chemical and radioactive pollution for the Pacific coastal water. However, there is currently no comprehensive assessment of the ecological health of the region's coastal zone.

Solid wastes

The impacts of solid wastes were assessed as slight due to the prevalence of such wastes near human settlements, including seasonal camps. These are predominantly timber and ligneous wastes, which are found along the entire coastline, and municipal waste of various origins and descriptions which accumulates in bays that are in close proximity to coastal settlements and ports. There is no quantitative information on solid wastes.

Radionuclides

This issue was considered to have no known impacts in the region. In the coastal waters of the Kamchatka Peninsula, however, there is some evidence of radionuclide contamination and there remains a potential for future incidents originating from disused nuclear submarines. Due to a changing political climate and deficiencies in the Russian economy, it has become no longer viable to maintain the submarine fleet. Consequently, many submarines remain inoperative at the dockside, resulting in the degradation of their nuclear reactors. As a result, accidents are becoming more common. In 1997 a decommissioned Charlie-class nuclear submarine sank at Rybachy after corrosion allowed water to seep into its hull (Ikeuchi et al. 1999, Petterson et al 1999, Newell 2004, Larin 2004)

The main potential sources of radioactive pollution in the region are: (i) nuclear submarine bases; (ii) ship-repair yards for nuclear submarines; (iii) civil enterprises, where civil vessels with nuclear energy installations are based, repaired and maintained; and (iv) sites used for the temporary storage of radioactive waste and spent nuclear fuel.

Spills

The issue of spills was considered to have slight impacts in the region. At present, crude oil spills in the Oyashio region are rare. Isolated and relatively minor oil spills have been recorded in the Kuril Straits and off the East Kamchatka coast. According to the GIWA Task team, oil slicks have been observed in the oil extraction areas of Sakhalin. Currents flowing from the Okhotsk Sea and the Soya Current transport this oil contamination to the southern Kuril Straits.

The region has a dense network of navigation routes traversing its waters. Many large vessels, including fishing and merchant vessels and tankers, sail through the waters of the Kuril Islands discharging oil hydrocarbons both deliberately and accidentally .

Further exploitation of hydrocarbons in the Sakhalin region and the subsequent increase in oil transport is likely to increase the quantities of contaminants in the Oyashio Current region. According to the GIWA Task team, there is currently a maximum of five spills per year originating from vessels carrying oil products from the southern ports of Far East Russia, particularly Kamchatka. All oil vessels from these ports travel through the Kuril Straits in close proximity to the islands. Furthermore, fishing vessels travel through the straits en-route to the Sea of Okhotsk, the Bering Sea and the northwest Pacific Ocean. However, there is a dearth of information on the adverse environmental effects of spills in the region.

Socio-economic impacts

The GIWA Task team concluded that there is no known economic, health or other social and community impacts as a result of pollution in the Oyashio Current region. If pollution intensifies in the future, however, there will be possible costs from the disruption of shipping, marine reserves and marine scientific activities during the assessment and clean-up of spills.

Conclusions and future outlook

Overall, the impact of Pollution under present conditions was assessed as slight. The most relevant GIWA issues for the Oyashio Current were identified as solid wastes and spills. At present the region's ecosystems, excluding Avacha Bay, are in a relatively satisfactory condition. However, due to the rapid development of oil and gas deposits on the Kamchatka and Sakhalin shelves and the increased volume of oil and gas transported through the Oyashio Current region, oil spills are considered to be a significant future threat to the region. Radionuclides have little effect on the regional environment at present, but their impact may increase with the further corrosion of Russian submarines.

Habitat and community modification

There is no record of serious loss of habitat in the region and there are consequently no known impacts from this issue. There is evidence, however, of some minor habitat modification as a result of the construction of ports, tourism activities and the construction of dams. This issue was considered to have slight environmental impacts.

Since the region has a relatively small economy and is sparsely populated, habitat modification in the region has had no known socio-economic impacts.

Conclusions and future outlook

Habitat and community modification is assessed as having no known impacts. The majority of the regional ecosystems are located far from the developed coastal regions of Japan and Russia, and consequently are not affected by economic development. Wetlands and rivers were considered by the GIWA Task team to have experienced slight environmental impacts but these are localised with no transboundary consequences.

Unsustainable exploitation of fish and other living resources

The fisheries of the Pacific coast of the Kuril Islands are among the most productive in the world. The Oyashio Current LME constitutes Russia's and Japan's largest fishing grounds. The majority of this productive area is situated in Russia's 200 nautical mile Exclusive Economic Zone (EEZ). Many commercially valuable fish species thrive in these waters. Russia's annual income from the regional marine bioresources is estimated to be between 2.5 to 5 billion USD (according to experts from the Russian State Committee for Environmental Protection and the Federal Border Guard Service). More than 4 million tonnes of bioresources are harvested annually in the Russian Far East EEZ. The most sought after species in this region are salmon, Walleye pollock, crab, shrimp, sea urchin and sea cucumber (Greenpeace 2000, Ozolin'sh & Spiridonov 2001, Baklanov et al. 2003).

Fisheries regulations in the region stipulate that all by-catch should be landed, although it is generally believed that some discards occur. However, it is difficult to assess to what degree this is practiced due to an absence of control and monitoring programmes. The GIWA issues of decreased viability of stock, excessive by-catch and discards, and impact on biological and genetic diversity were assessed as having no known impacts and are therefore not discussed further.

Environmental impacts

Overexploitation

The commercial fisheries of the Oyashio Current, such as some stocks of Pacific salmon, King crab, scallop and Pacific sardine, are exploited above biologically safe limits (Ozolin'sh & Spiridonov 2001, Baklanov et al. 2003, Titova 2003). The issue of overexploitation was considered to be moderate only in the southern Kuril area and slight in the remaining part of the region.

Russia licenses foreign fishermen to operate inside the Russian economic zone. Catch quotas are allocated for the various fish species. Up to 150 Russian fishing vessels, as well as Japanese, Taiwanese and Chinese vessels, and flag of convenience ships are believed to practice illegal salmon and calamari fishing in the region during the summer. Records of illegal fishing activities in Russian territorial waters have not been disclosed. Figure 10 demonstrates how the marine catches of the main commercial species of the Oyashio Current LME have declined since the 1990s.

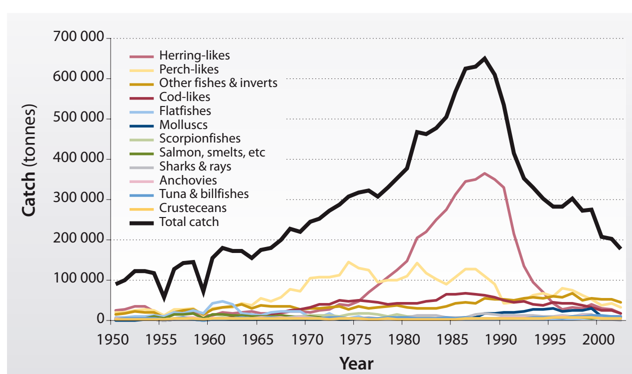

Figure 10 Marine catches in the Oyashio Current.
(Source: Sea Around Us Project 2004)

Figure 11 A team of fishermen pull in a net filled with fish on Kuril Islands, Russia.
(Photo: CORBIS)

Between 1990 and 1996, fisheries production in the Russian Far East declined by 35% (Baklanov et al. 2003, Titova 2003). Catches for each individual species have varied from this overall trend: salmon catches have not changed; catches of flounder have increased by about 15%; and crab and King crab catches have declined by almost 70%. The shelf of the Kuril Islands favours the harvesting of crabs, shrimp, bivalve and mussels (Arzamastzev et al. 2001). The populations of these species have been severely depleted, particularly the King crab, although this has not been attributed to any single factor, such as overfishing (Baklanov et al. 2003). Catches of Walleye Pollock have declined from over 55 000 tonnes in the mid 1980s to less than 15 000 tonnes in the last five years (Sea around us project 2004) (see figure 12).

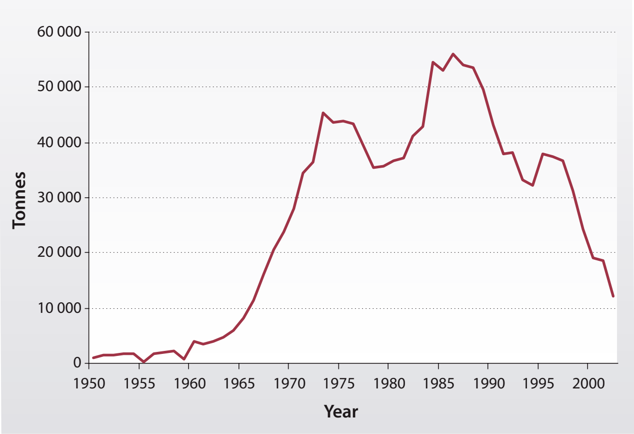

Figure 12 Catch of Walleye pollock (*Theragra chalcogramma*) in the Oyashio Current.
(Source: Sea around us project 2004)

Destructive fishing practices

The GIWA assessment considered the impacts of destructive fishing practices as slight. In Russia, driftnets – a destructive pelagic fishing method – are widely used. In 2000, 74 Japanese vessels using driftnets were licensed to exploit 16 500 tonnes of salmon in the Russian EEZ (Greenpeace 2000). The Russian fishing fleet began to employ driftnet fishing methods only in 1997. Today, approximately five Russian driftnet vessels are in operation, the majority of which are used for scientific studies of species stocks. For salmon fishing, ships tend to use standard 50x8 m driftnets that when interconnected with one another make up a 4 km long set of nets. According to regulations the total length of sets installed by one ship cannot exceed 32 km and the distance between the sets should be at least 4 km. The ends of each set are marked with buoys and radio beacons. Meshes with less than 110 mm diagonal are prohibited. Commercial ships commonly use nets with a mesh of 124 to 132 mm (Greenpeace 2000).

The fisheries quota system is also applicable to all vessels using driftnets, which are liable for inspection by Russian officials (Ozolin'sh & Spiridonov 2001). However, only five inspectors are employed for the entire Kuril Islands region, which covers an area of 840 000 km^2 (Ozolin'sh & Spiridonov 2001, Sea Around Us Project 2004).

Socio-economic impacts

The fisheries and its associated industries are the primary economic activities for the coastal communities of eastern Hokkaido (Japan) and the Russian coast of Kamchatka and the Kuril Islands. However, the overexploitation of certain commercial species and reduced catches has not significantly affected the economy of these communities in terms of employment, income, and investment activity. Economic impacts from the Unsustainable exploitation of fish and other living resources were considered to be negligible.

There is no evidence of a direct link between the level of exploitation of the Oyashio Current fish stocks and the health of the population. Therefore, this concern was not considered to have any known health impacts on the region.

Illegal foreign fishermen are operating in fishing grounds that have been traditionally fished by the coastal communities. There is concern amongst these communities over the depletion and possible exhaustion of the fish stocks which are fundamental to their livelihoods (Figure 11). Therefore, this concern was assessed as having slight social and community impacts.

Conclusions and future outlook

According to the GIWA Task team, the Unsustainable exploitation of fish and other living resources has a slight impact on the Oyashio Current region. The issues of overexploitation and destructive fishing practices around the Kuril Islands were also assessed as having a slight impact. The overexploitation and discarding of fish in the Oyashio Current region is likely to remain a problem in the foreseeable future. However, the intensity of overfishing is generally not too severe, allowing stocks to restore themselves periodically . As a result of the development of other marine sectors in northeastern Russia and Japan, it is likely that regional dependency on the fishing industry will be reduced in the forthcoming decades, which in turn will reduce the socio-economic impacts of a downturn in the fisheries sector. The realisation of the Federal Program for the socio-economic development of the Kuril of the Sakhalin area (1994-2005) and cooperation between Russia and Japan will result in the creation of necessary infrastructure and a favourable investment climate for the development of the Kuril Islands and the waters of the Oyashio Current.

Global change

Environmental impacts

Changes in the hydrological cycle and ocean circulation

This issue was assessed as having moderate impacts due to the following environmental changes: (i) positive sea temperature anomalies and changes in the meandering path of the Kuroshio Current, which has influenced the productivity of the Longfin codling (*Laemonema longipes*) and mackerel; and (ii) changes in the energy active zone causing changes in the thermal flux, as well as an increased frequency of heavy storms and floods (Noto & Yasuda 1999, Yoshinari & Yasuda 1999).

The sub-arctic Kuril Current flows into Japanese coastal waters, providing a rich habitat for a variety of fish and making the region one of the most productive fishing areas in the world. The most significant effect of global warming on the region is predicted to be changes in epipelagic fish resources. Japan's future fishery production will mostly depend upon changes in the course and flow of the Japanese Current caused by global warming (Yasuda & Watanabe 1994, IPPC 2001).

Concerning long-term changes, some researchers believe that global warming will lead to reductions in the flows of both the Kuril and the Japanese currents, and that the thickness of the mixed layer will be reduced if marine winds also weaken (Noto & Yasuda 1999, IPPC 2001). Based on the primary production volume offshore of Kushiro in Hokkaido during years when the waters are relatively warm compared to those when it is relatively cold, it appears that global warming in this region will lead to a reduction in primary production. Additionally, the southern limit of salmon habitats is expected to move northwards as a result of global warming (IPPC 2001).

Research has identified a relationship between higher global temperatures and an increase in sardine numbers (Omori & Kawasaki 1995). This field however requires further study, including an examination of the influence of shifting climates on the ecosystems of the region.

In coastal areas, the primary production volume of phytoplankton will increase as a result of rising water temperatures, resulting in a greater food supply for fish. The quantity of coldwater seaweed may diminish which, in turn, could lead to a reduction in the populations of abalone, turbos, sea urchins and other sessile organisms, including macrophytic algae, corals, sponges, bryozoans and ascidians (Global Warming Impacts Assessment Working Group 2001). In coastal areas with breakwaters or other coastal protection structures where the shoreline cannot move further inland, productivity may fall when sea levels rise because of the loss of tidal flats and seaweed beds.

The average water temperature of streams and rivers is estimated to rise by between 1 and 4°C as a result of global warming. Consequently, the habitat of Dolly varden (*Salvelinus malma*) will decline by 25 to 74% and that of Whitespotted charr (*S. leucomaenis*) by 4 to 46% (Global Warming Impacts Assessment Working Group 2001).

Despite abundant precipitation, it is difficult for Japan to fully utilise its water resources due to physical constraints. Precipitation varies greatly throughout Japan and the nation's rivers are short and steep, with relatively small catchment basins. According to hydro-meteorological models, global warming may lead to lower precipitation rates in Hokkaido, higher evaporation from the land surface and a consequential reduction in water resources.

According to Global Warming Impacts Assessment Working Group (2001) the following conclusions have been drawn from the hydrological research conducted so far:

- The effects on flow from a 10% change in precipitation are greater than those from a 3°C temperature rise.
- If a 3°C temperature rise is accompanied by a 10% increase in precipitation, the average flow will not decline significantly in low-flow conditions but will increase by about 15% in high-flow conditions.
- A rise in temperature will mean that what was once snowfall will change to rainfall and winter snows will melt earlier. As a result, the flow will increase from January through to March and decrease between April and June.

The regional climate fluctuates as a result of variations in mean global characteristics and climatic phenomena such as the North Atmospheric Oscillation (NOA), the Pacific Decadal Oscillation (PDO) and the El Niño-Southern Oscillation (ENSO). To date, most studies considering the impacts of climate variability on the regional marine ecosystem have used correlation statistics of a given population and physical climate indices.

The effects of a shift in the climate regime on ENSO activities, winter monsoon patterns, western boundary currents and upper ocean stratification, as well as the resultant biological impacts are summarised as (Noto & Yasuda 1999, Omori & Kawasaki 1995, Global Warming Impacts Assessment Working Group 2001):

- Variations in atmospheric conditions influence the intensity of the winter monsoon, the depth of the upper mixed layer and the path of the Kuroshio and Oyashio currents.
- In the western sub-arctic Pacific, phytoplankton biomass was higher from the mid 1960s to mid 1970s than in the preceding and succeeding decades, corresponding to a transition of the westerly currents from a meandering to a straighter path.
- Plankton biomass in the Oyashio Current region has decreased since the early 1970s.
- In the northwestern sub-tropical Pacific a reduction in winter cooling and vertical mixing associated with the calm and warm winter of the early 1970s increased surface chlorophyll concentrations, which might have caused higher zooplankton production and better feeding conditions for sardine larvae.
- A considerable weakening of the southward intrusion of the Oyashio Current off the east coast of Japan from 1988 to 1991 led to a reduction in plankton biomass in the transition zone between the Kuroshio and Oyashio currents in late spring and early summer, and caused a series of recruitment failures of Japanese sardine.

Sea level change and Increased UV-B radiation as a result of ozone depletion

According to the GIWA Task team, this issue has no known impacts. There may be possible sea level rise on the coast of Japan, although only a limited stretch of the coastline, mainly in eastern Hokkaido, will be affected.

Changes in the ocean CO_2 source/sink function

Despite incomplete research, the GIWA Task team considered this issue to have a slight impact on the region as they had "reasonable suspicions" that current global change is impacting the aquatic system enough to alter its source/sink function for CO_2. However, there have been no measurable changes. The Oyashio region is a CO_2 source during the winter due to deepwater upwelling and also a CO_2 sink during the summer as a result of biological activities. In fact, the region has the highest biological CO_2 drawdown in the global ocean. Global change may influence both physical and biological processes in this region and change the function of the carbon cycle (DeGrandpre et al. 2002, PICES 2003). The influence of global change is observed not only in surface currents but also in deep water circulation, with subsequent impacts on biological production in the region.

Socio-economic impacts

The economic impacts for the whole region are assessed as slight. Global change has influenced the living conditions of fishermen and their communities. Because the economy of the area is based on fishing, depleted fish stocks as a result of global changes have had economic consequences. The following impacts have been identified that may be associated, to some extent, with global changes:

- Human migration from the Kuril Islands and Kamchatka. This has been attributed to severe climatic conditions and 90 years of weak economic growth in Russia (Russian Statistical Yearbook 1996, 2001, Eremina et al. 2000).
- Emergency response costs for severe environmental conditions e.g. flooding caused by increasingly frequent storm surges (Tersiev 1998, PICES-GLOBEC 2003).
- Increased cost of coastal protection.

- Loss of income and foreign exchange from a downturn in the fisheries sector.

There is concern about the possible effects of rising sea levels and increasingly frequent storm surges on Japan's socio-economic system. The existing social infrastructure and socio-economic system has been optimised for the present climate conditions. Concerning global warming, the effects of higher sea levels, higher temperatures and from changing precipitation and typhoon patterns would be serious and wide-ranging (Global Warming Impacts Assessment Working Group 2001, IPCC 2001).

There are no known health or other social and community impacts from global changes in the region.

Conclusion and future outlook

Overall, global change is considered to have slight impacts on the region. The following changes have been observed in recent years: positive temperature anomalies; changes in the meandering path of the Kuroshio Current, which has influenced the productivity of the fisheries; changes in the energy active zone; changes in the thermal flux; and increasing frequency of severe storms and floods. The economy of the region is predominantly dependent on fishing. Climatic changes have led to reduced catches, thus having economic consequences. Global climate trends are expected to exacerbate the environmental and economic impact of this concern in the future. Health and other community impacts will most likely not change.

There is currently a lack of research on the influence of global changes on the productivity of the fisheries. However, specialists from academic institutes, including the Far East Branch of the Russian Academy of Science, TINRO-Centre and Japanese universities and institutions, are presently investigating this concern. According to the GIWA Task team, the influence of global changes on depleted fish stocks have increased unemployment rates and reduced income and investment activity.

Furthermore, the analysis suggests that overfishing in the Oyashio Current region could become less severe due to the implementation of regulatory and control measures. Overexploitation of fish resources was considered to be moderate only in the southern Kuril area where illegal fishing is prevalent.

The GIWA Task team identified a strong linkage between Global change and Unsustainable exploitation of fish and other living resources in the Oyashio Current region (Figure 13) due to changes in pelagic fish abundance caused by changes in water temperature and a reduction in the flow of currents. There are weaker linkages between Global change and Freshwater shortage as well as Habitat modification. The GIWA Task team also recognised a weak linkage between Habitat modification and the Unsustainable exploitation of fish and other living resources.

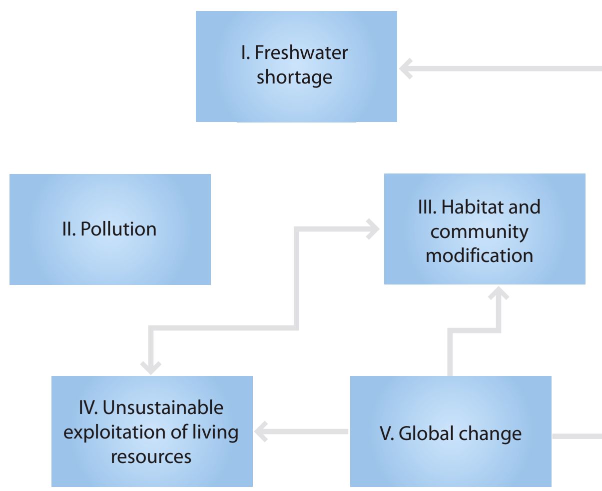

Figure 13 Linkages between the GIWA concerns.

Priority concerns

At present, the concerns with the highest severity for the region are Global change, in particular the issue of changes in the hydrological cycle, and Unsustainable exploitation of fish and other living resources, specifically the issue of overexploitation. The concerns were ranked as follows:

1. Global change
2. Unsustainable exploitation of fish and other living resources
3. Habitat and community modification
4. Pollution
5. Freshwater shortage

Causal chain analysis

This section aims to identify the root causes of the environmental and socio-economic impacts resulting from those issues and concerns that were prioritised during the assessment, so that appropriate policy interventions can be developed and focused where they will yield the greatest benefits for the region. In order to achieve this aim, the analysis involves a step-by-step process that identifies the most important causal links between the environmental and socio-economic impacts, their immediate causes, the human activities and economic sectors responsible and, finally, the root causes that determine the behaviour of those sectors. The GIWA recognises that, within each region, there is often enormous variation in capacity and great social, cultural, political and environmental diversity. The Causal chain analysis uses a relatively simple and practical analytical model. For further details on the methodology, please refer to the GIWA methodology chapter.

The concerns of Unsustainable exploitation of fish and other living resources and Global change were considered as the GIWA Oyashio Current region's priority concerns. Concerning Unsustainable exploitation of fish and other living resources, the issue of overexploitation was selected, and for Global change the issue of changes in the hydrological cycle and ocean circulation. These issues have transboundary impacts as both the Russian and Japanese territories are highly dependent on the fisheries and have experienced climate changes. The focus of the Causal chain analysis is to determine the drivers of these two prioritised issues, so that they can be addressed by policy makers rather than the more visible causes.

Overexploitation

Figure 14 shows the causal chain diagram of overexploitation in the Oyashio Current region.

Immediate causes

Overexploitation in the Oyashio Current region has primarily been a result of increased fishing effort and the overcapacity of the fishing fleet in the past 10 to 15 years, particularly in the salmon, King crab, scallop and pollock fisheries. Although overfishing has caused only slight impacts overall, catches of some commercial fish species now exceed biologically safe limits. A large proportion of catches go unreported which means fishermen exceed their allocated fishing quotas, thus leading to overfishing (Greenpeace 2000, Ozolin'sh & Spiridonov 2001, Titova 2003).

Root causes

Economy

Foreign trade liberalisation has led to a sharp growth of interest rates and prices for fuel and materials in Russia. Vessel owners lack the financial resources to invest in the modernisation of the fleet and their fishing equipment in order to meet the requirements of sustainable fishing.

A decline in the profitability of fishing has led to increased poaching and unregistered landings in order to avoid taxation. High taxes in the fisheries sector in Russia and the non-conformity of the tax system to the specific character of the fishery have also led to catches exceeding quotas. The introduction of fishing auctions with prices for quota-rights has only served to increase overfishing (Titova 2001).

Technology

There are often significant by-catch and discards associated with the cod fisheries. This is due to the employment of outmoded and non-selective fishing gear and the use of inappropriate or illegal fishing

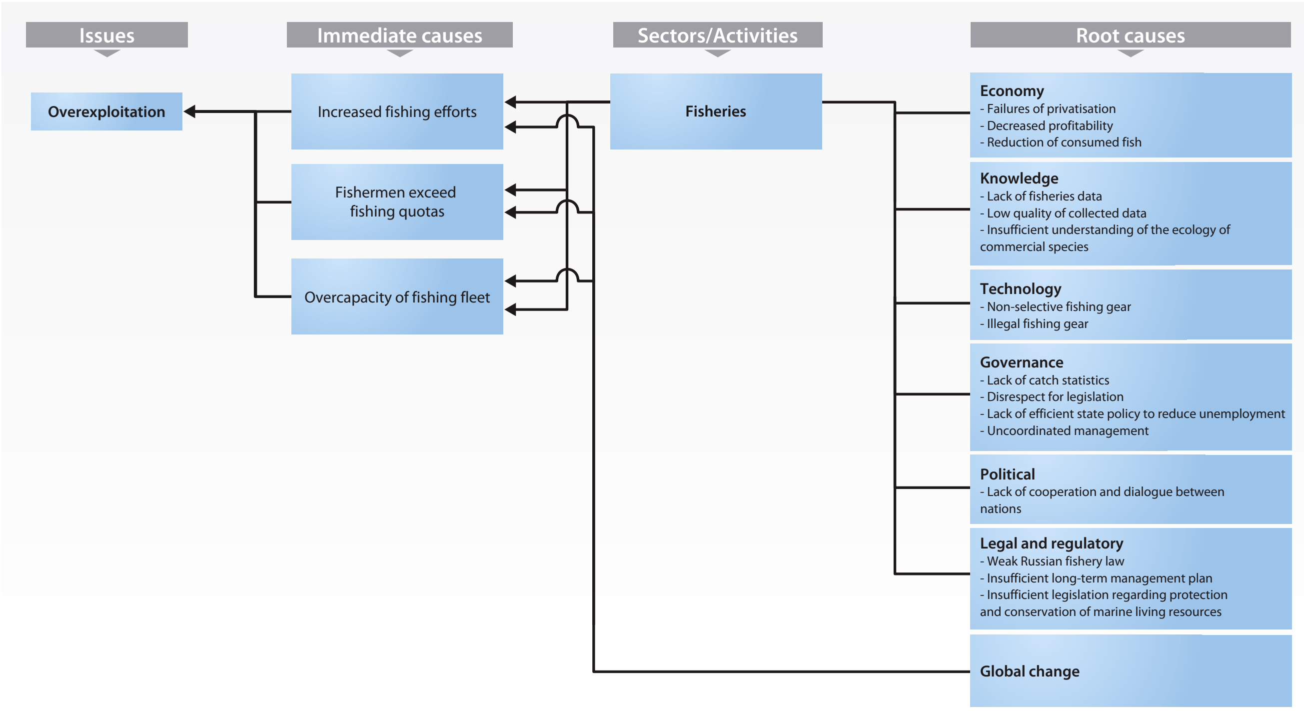

Figure 14 Causal chain diagram illustrating the causal links for overexploitation of fish.

practices. Bottom trawling for cod, perch, Black halibut and American plaice destroys benthic habitats.

Governance

There is a lack of efficient state policy aimed at reducing unemployment among fishermen, supporting the coastal fishery and improving living standards in coastal settlements. The fisheries industry is the economic backbone of these communities; in order to reduce overexploitation, alternative livelihood strategies and greater governmental support are required.

Uncoordinated management has led to conflicting regional and international policies regarding the use of biological resources (Kotenev & Zaytseva 2003, Titova 2003). This has, for example, led to the concentration of King crab exploitation around East Kamchatka and the Kuril Islands.

The rapid transition from the centralised planned economy to the free market system in Russia did not allow for the creation of market structures and an adequate system of auctions in the fisheries sector. There was a lack of state support for the national fishery sector during the period of market reforms (Ozolin'sh & Spiridonov 2001, Titova 2001, 2003).

The reduction in state control over fisheries export activities and the increasingly export-oriented fishery has increased fishing pressure on the most commercially attractive species on the world market (for example salmon, King crab, scallop and pollock). Additionally, a variable market price for fish products has led to fluctuations in the level of fishing pressure on different fish species.

Legal and regulatory

Russian Fishery Law is particularly weak as it does not reflect the current market situation nor contain the main principles of sustainable fishing. Weak legislation and a lack of enforcement enable fishermen to exceed their quotas. The state regulatory system for the long-term management of marine living resources lacks an effective mechanism to control illegal fishing. Although the level of illegal fishing in Russian territorial waters is never declared, it is known that many pirate fishing vessels of Russian, Japanese, Chinese (mainly calamari and non-salmon species) and Taiwanese origin, as well as flag of convenience ships, operate in these waters. Fishermen often violate fisheries legislation. It has been argued that fishing quotas are too meagre, so fishermen have no choice but to catch illegal quantities of fish in order for their business to survive.

There is an absence of Federal Law regarding the fishery and the protection and conservation of marine living resources in order to meet the requirements of sustainable fishing and to reduce poaching and corruption. Without such laws many provisions of the "Conception of the development of the fishery sector of the Russian Federation until the year 2020" cannot be fulfilled.

The Federal Border Service is now responsible for the enforcement of fisheries laws. Fishery inspectors only control coastal and inland fisheries while the Marine Guard of the Federal Border Service patrols the EEZ with the use of marine boats and planes. According to media reports and newsletters of the North Pacific Anadromous Fish Commission, the seizure of illegally operating fishing boats is common (Greenpeace 2000).

Knowledge

The credibility of scientific recommendations and predictions is diluted by a high level of scientific uncertainty and a lack of fisheries data. While researchers are aware of the inaccuracies of their recommendations, politicians and industry officials do not take this into account when formulating policies (Ozolin'sh & Spiridonov 2001).

Knowledge of the fisheries is lacking due to gaps in fisheries statistics; the low quality of collected data on which the science is based; and an insufficient understanding of the ecology of some commercial species and of the region's ecosystems.

Political

The region is governed by Japan and Russia. Fishing rights in the region, sovereignty over the South Kuril Islands, and a weak Russian economy at the beginning of the 1990s appear connected. The question of sovereignty over the islands, a legacy from World War II, is a nationalist issue as well an economic question for the two nations. Japan refers to the four southern Kuril Islands as its 'northern territories' and has offered to buy them from Russia. Regarding fishing rights, Russia currently allocates Japan only a small proportion of fish in the region and has also issued fishing licenses to countries such as South Korea, North Korea and Ukraine whose fishermen all operate near the Kuril Islands. Japan is seeking to prevent the implementation of a Russian-South Korean agreement on the fishing of Pacific saury off the southern Kuril shores.

Changes in the hydrological cycle

Climate changes in the region are predominantly a result of global issues, in particular global warming. It is not within the scope of the GIWA Assessment to analyse the root causes of global climate change as these are issues that need to be addressed at the global level rather than within the region. It was agreed, however, that inadequate progress had been made by the international community in mitigating this issue due to the non-implementation of relevant agreements.

The GIWA Task team analysed the region's precautionary responses to the predicted global changes and found that the region is inadequately prepared to react to the anticipated changes in the environmental conditions. Climate change greatly influences the distribution and abundance of biological resources, including the fisheries. There is an absence of an effective system in the region to monitor changes in the environment and to respond to future natural hazards. Knowledge is lacking regarding the impacts of climatic variability on the ecosystems of the Oyashio Current region, making it difficult to predict the impacts of future climate changes. The ability of fisheries management institutions to react to climatically induced changes to the productivity of the fisheries is hindered by an inadequate understanding of the ecosystem dynamics of the region and the lack of environmental indicators.

Policy recommendations

This section aims to identify feasible policy recommendations that target key components identified in the Causal chain analysis in order to minimise future impacts on the transboundary aquatic environment. Recommended findings were identified through a pragmatic process that evaluated a wide range of potential findings proposed by regional experts and key political actors according to a number of criteria that were appropriate for the institutional context, such as political and social acceptability, costs and benefits, and capacity for implementation.

In the GIWA Oyashio Current region, Global change and Unsustainable exploitation of fish and other living resources were identified as the priority concerns and, specifically, their respective constituent issues of changes in the hydrological cycle and overexploitation, respectively. This section provides alternative courses of action that may be taken by regional policy makers. The causes of Global change need to be addressed at a global forum rather than within the region.

Feasible policy relevant findings that target key components identified in the Causal chain analysis will be outlined in order to minimise future impacts on the transboundary aquatic environment. Recommended policy options were identified by regional experts and key political representatives. The policy relevant findings presented in this report require additional detailed analysis beyond the scope of GIWA and, as a consequence, they are not formal recommendations to governments but rather contributions to broader policy processes in the region.

Political framework

Politicians and administrative authorities in Russia and Japan are aware of the threat that the priority concerns pose to socio-economic development. Accordingly, a large number of policy initiatives, both national and international, have been instigated. The issue of changes in the hydrological cycle and its influence on the issue of overexploitation in the Oyashio Current region is under consideration by several international programmes. The Northwest Pacific Action Plan and the Northeast Asian Regional Global Ocean Observing System (GOOS) promote intergovernmental mechanisms to facilitate regional cooperation and coordination. Further details of relevant regional organisations and programmes are presented in the Regional definition section under International cooperation.

Policy recommendations

A priority for the Oyashio Current region is to improve the knowledge and understanding of the region's natural environment and to create an intergovernmental agreement between Russia and Japan.

The conclusion of the multilateral (including Russian Federation and Japan) intergovernmental agreement is needed for the:

- Organisation of an international environmental monitoring system in the region.
- Organisation of available information on the health of the environment in the region.
- Creation of an intergovernmental commission with a mandate to coordinate environmental management in the region.
- Comprehensive study of the impacts of future changes in the hydrological cycle and ocean circulation on the fisheries of the Oyashio Current region.

- Promotion of cooperation and integration between the region's national scientific and environmental management institutions in order to share data and techniques with an aim to improve the environmental quality of the entire region for the mutual benefit of both nations.

To address the lack of knowledge, further studies and actions are required, including:

- A comprehensive oceanographic survey of the currents.
- A survey of fish stocks and other bio-resources.
- The development of a model of hydrological and ecological processes in the region which is able to simulate the impacts from anthropogenic activities, such as oil spills.
- The creation of a monitoring network and information management system to regularly assess the ecological quality of the region.
- The development and improvement of the legislative basis at all levels.

Many of the root causes of changes in the hydrological cycle and ocean circulation are global issues that can not be resolved by Russia and Japan alone. These countries can, however, stress the severity of climate change on the natural resource dynamics and human population of Kamchatka and the Kuril Islands in the global forum. The potential future impacts from climate change on the region need to be identified and presented based on scientific studies to enable the formulation of precautionary measures. Climate change needs to be addressed through international cooperation and the implementation of international agreements, such as the Kyoto Protocol.

International organisations, such as the Northwest Pacific Action Plan (NOWPAP), United Nations Environment Programme (UNEP) and the North Pacific Marine Science Organization (PICES) are aware of the ecological and socio-economic threats from climate change and the overexploitation of fish. They should continue to actively participate in international discussions aimed at mitigating the impacts of global environmental changes on marine ecosystems.

Conclusions

The GIWA Assessment of the Oyashio Current region identified priorities that should be addressed by policy makers in order to improve the environmental health of the region's transboundary waters. Because the region is located far from the developed coastal regions of Japan and Russia, it is largely not affected by economic development. The most significant threats to the region are posed by Global changes and the Unsustainable exploitation of fish and other living resources, and, more specifically, the issues of changes in the hydrological cycle and overexploitation.

Positive temperature anomalies have changed the path of the Kuroshio Current which has consequently influenced the productivity of the fisheries. Storm activity has increased, thus generating greater energy in surface water layers and causing changes in the thermal flux. These changes are attributed to climate changes caused by global warming and ENSO events. Overexploitation in the Oyashio Current region has been caused mainly by increased fishing effort and the overcapacity of the fishing fleet in the past two decades, particularly in the salmon, King crab, scallop and pollock fisheries. The growing export market has encouraged the industry to concentrate fishing effort on these commercially attractive species. A large proportion of catches go unreported which means fishermen exceed their allocated fishing quotas, leading to overfishing. However, the intensity of overfishing is generally not too severe, allowing stocks to restore themselves periodically.

The principal root causes for changes in the hydrological cycle and ocean circulation can not be resolved solely by Russia and Japan. However, climate change is significantly impacting the natural resource dynamics, and social and economic integrity of Kamchatka and the Kuril Islands. Climate change is a global issue that needs to be addressed through international cooperation. It is important for regional policy makers to inform the international community of the impacts experienced within the Oyashio Current region as a result of climate change and to take active participation in discussing and formulating solutions to the root causes of the Global change concern. The region is currently ill prepared to respond to future changes in the hydrological cycle that are likely to affect fish stocks. This is alarming given the importance of the fisheries to the regional economy. There is an absence of a regional system capable of monitoring climatic changes and a lack of knowledge regarding its influence on the future abundance and distribution of biological resources.

Fishermen employ outmoded and non-selective fishing equipment and due to economic difficulties they lack the necessary capital to invest in modern fishing gear essential for sustainable fishing. Fishermen argue that due to the inappropriate taxation system they are forced to exceed their quotas in order to make a profit. The fisheries in the region are poorly regulated with weak legislation that has not been formulated based on the principles of sustainable fishing. Enforcement is ineffective and illegal fishing is known to occur in the region. The governments of the region have not provided alternative employment opportunities in coastal settlements in order to reduce the fleet capacity. In addition, a lack of knowledge regarding commercial species and their ecosystems does not allow fisheries managers to make informed decisions.

A priority for the Oyashio Current region is to improve the understanding of the region's natural environment. Studies that are currently needed include: (i) a comprehensive oceanographic survey of the currents; (ii) full estimate of marine living resources; (iii) a model of basic hydrological and ecological processes in the region which could simulate the impacts from anthropogenic activities; (iv) the creation of a monitoring network and information management system to regularly assess the ecological quality of the region; and (v) a comprehensive study of the impact of future changes in the hydrological cycle and ocean circulation on the issues of overexploitation and habitat modification in the Oyashio

Current region. Cooperation and integration between the region's national scientific and environmental management institutions should be promoted in order to share data and techniques with an aim to improve the environmental quality of the entire region for the mutual benefit of both nations.

A multilateral (including Russian Federation and Japan) intergovernmental agreement should be created. This would aim to: (i) establish an organisation responsible for monitoring the environment in the region; (ii) organise available information on the health of the environment in the region; and (iii) establish an intergovernmental commission mandated to coordinate environmental management in the region. The GIWA Task team believes it is necessary to develop and improve the legislative basis at all levels.

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Personal communication

Bogatov, V.V. (Institute of Biology and Soil Sciences, Far East Branch, Russian Academy of Sciences, Vladivostok)

Annexes

Annex I
List of contributing authors and organisations

Name	Institutional affiliation	Country	Field of work
Authors			
Arkady V. Alekseev	Presidium of Far East Branch of the Russian Academy of Science	Russia	Environmental protection
Fedor F. Khrapchenkov	Pacific Oceanological Institute, Far East Branch of the Russian Academy of Science	Russia	Physical oceanography
Peter J. Baklanov	Pacific Geographical Institute, Far East Branch of the Russian Academy of Science	Russia	Nature management
Ivan S. Arzamastsev	Pacific Geographical Institute, Far East Branch of the Russian Academy of Science	Russia	Natural science
Yury G. Blinov	The Pacific Institute of Fisheries and Oceanography	Russia	Fish ecology
Alexander V. Tkalin	Far Eastern Regional Hydrometeorological Research Institute of Russian Federal Service for Hydrometeorology and Environmental Monitoring, FERHRI-Rosgidromet	Russia	Oceanographer
D.L. Pitruk	Institute of Marine Biology, Far East Branch of the Russian Academy of Science	Russia	Marine biology
Anatoly N. Kachur	Pacific Geografical Institute, Far East Branch of the Russian Academy of Science	Russia	Nature management
Irina A. Medvedeva	Pacific Geographical Institute, Far East Branch of the Russian Academy of Science	Russia	Natural science
P.A. Minakir	Institute of Economic Forecasting, Far East Branch of the Russian Academy of Science	Russia	Economy
Galina D.Titova	Laboratory of Natural Resources Management Economics, Research Center of Environmental Safety, Russian Academy of Science	Russia	Environmental economy
Aleksandr Fedorovsky	Far Eastern National University	Russia	Economy
Hiroyuki Ishitobi	Special Monitoring & Coastal Environmental Assessment Regional Activity Centre, Northwest Pacific Action Plan	Japan	Natural science
Regional GIWA Task team			
Arkady V. Alekseev	Presidium of Far East Branch of the Russian Academy of Science	Russia	Environmental protection
Fedor F. Khrapchenkov	Pacific Oceanological Institute, Far East Branch of the Russian Academy of Science	Russia	Physical oceanography
Hiroyuki Ishitobi	Special Monitoring & Coastal Environmental Assessment Regional Activity Centre, Northwest Pacific Action Plan	Japan	Natural science
Peter Ya. Baklanov	Pacific Geographical Institute, Far East Branch of the Russian Academy of Science	Russia	Nature management
Anatoly N. Kachur	Pacific Geographical Institute, Far East Branch of the Russian Academy of Science	Russia	Nature management
Boris A. Voronov	Water and Ecology Problems Institute, Far East Branch of the Russian Academy of Science	Russia	Biology
Yury G. Blinov	Pacific Institute of Fisheries and Oceanography	Russia	Fish ecology
Aleksandr Fedorovsky	Far East State University	Russia	Economy
Ivan S. Arzamastsev	Pacific Geographical Institute, Far East Branch of the Russian Academy of Science	Russia	Natural science
Vladimir M. Shulkin	Pacific Geographical Institute, Far East Branch of the Russian Academy of Science	Russia	Marine chemistry
Anatoly V. Moshkov	Pacific Geographical Institute,Far East Branch of the Russian Academy of Science	Russia	Natural science
Gennady P. Skrilnik	Pacific Geographical Institute, Far East Branch of the Russian Academy of Science	Russia	Natural science
Evgeniya V. Terekhova	Cathedra of foreign languages, Far East Branch of the Russian Academy of Science	Russia	Interpreter
Svetlana Savintsteva	Cathedra of foreign languages, Far East Branch of the Russian Academy of Science	Russia	Interpreter
Irina A. Medvedeva	Pacific Geographical Institute, Far East Branch of the Russian Academy of Science	Russia	Biology
Galina D. Dimova	Pacific Geographical Institute, Far East Branch of the Russian Academy of Science	Russia	Interpreter
Galina D. Titova	Laboratory of Natural Resources Management Economics, Research Center of Environmental Safety, Russian Academy of Science	Russia	Environmental economy
Ki-Suk Lee	Department of Geography Education Seoul National University	South Korea	Urban development
Tatiana A. Belan	Far Eastern Regional Hydrometeorological Research Institute	Russia	Pollution monitoring

Annex II
Detailed scoring tables

I: Freshwater shortage

Environmental issues	Score	Weight	Environmental concern	Weight averaged score
1. Modification of stream flow	0	N/a	Freshwater shortage	0
2. Pollution of existing supplies	0	N/a		
3. Changes in the water table	0	N/a		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	0	N/a
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	0	N/a
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	N/a
Weight average score for Economic impacts		**0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	0	N/a
Degree of severity	Minimum – Severe 0 1 2 3	0	N/a
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	N/a
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	0	N/a
Degree of severity	Minimum – Severe 0 1 2 3	0	N/a
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	N/a
Weight average score for Other social and community impacts		**0**	

N/a = Not applied

II: Pollution

Environmental issues	Score	Weight	Environmental concern	Weight averaged score
4. Microbiological	0	N/a	Pollution	0
5. Eutrophication	0	N/a		
6. Chemical	0	N/a		
7. Suspended solids	0	N/a		
8. Solid wastes	1	N/a		
9. Thermal	0	N/a		
10. Radionuclides	0	N/a		
11. Spills	1	N/a		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	0	N/a
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	0	N/a
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	N/a
Weight average score for Economic impacts		**0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	0	N/a
Degree of severity	Minimum – Severe 0 1 2 3	0	N/a
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	N/a
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	0	N/a
Degree of severity	Minimum – Severe 0 1 2 3	0	N/a
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	N/a
Weight average score for Other social and community impacts		**0**	

N/a = Not applied

III: Habitat and community modification

Environmental issues	Score	Weight	Environmental concern	Weight averaged score
12. Loss of ecosystems	0	N/a	Habitat and community modification	0
13. Modification of ecosystems or ecotones, including community structure and/or species composition	1	N/a		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	0	N/a
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	0	N/a
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	N/a
Weight average score for Economic impacts		**0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	0	N/a
Degree of severity	Minimum – Severe 0 1 2 3	0	N/a
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	N/a
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	0	N/a
Degree of severity	Minimum – Severe 0 1 2 3	0	N/a
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	N/a
Weight average score for Other social and community impacts		**0**	

N/a = Not applied

IV: Unsustainable exploitation of fish and other living resources

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
14. Overexploitation	1	N/a	Unsustainable exploitation of fish	1
15. Excessive by-catch and discards	0	N/a		
16. Destructive fishing practices	1	N/a		
17. Decreased viability of stock through pollution and disease	0	N/a		
18. Impact on biological and genetic diversity	0	N/a		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	0	N/a
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	0	N/a
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	N/a
Weight average score for Economic impacts		**0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	0	N/a
Degree of severity	Minimum – Severe 0 1 2 3	0	N/a
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	N/a
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	1	N/a
Degree of severity	Minimum – Severe 0 1 2 3	1	N/a
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/a
Weight average score for Other social and community impacts		**1**	

N/a = Not applied

V: Global change

Environmental issues	Score	Weight	Environmental concern	Weight averaged score
19. Changes in the hydrological cycle	2	N/a	Global change	1
20. Sea level change	0	N/a		
21. Increased UV-B radiation as a result of ozone depletion	0	N/a		
22. Changes in ocean CO_2 source/sink function	1	N/a		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large (0 1 2 3)	1	N/a
Degree of impact (cost, output changes etc.)	Minimum – Severe (0 1 2 3)	1	N/a
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	1	N/a
Weight average score for Economic impacts		**1**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large (0 1 2 3)	0	N/a
Degree of severity	Minimum – Severe (0 1 2 3)	0	N/a
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	0	N/a
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large (0 1 2 3)	0	N/a
Degree of severity	Minimum – Severe (0 1 2 3)	0	N/a
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	0	N/a
Weight average score for Other social and community impacts		**0**	

N/a = Not applied

Comparative environmental and socio-economic impacts of each GIWA concern

Concern	Types of impacts								Overall score	Rank
	Environmental score		Economic score		Human health score		Social and community score			
	Present (a)	Future (b)	Present (a)	Future (b)	Present (a)	Future (b)	Present (a)	Future (b)		
Freshwater shortage	0	0	0	0	0	0	0	0	0	5
Pollution	0	0	0	0	0	0	0	0	0	4
Habitat and community modification	0	0	0	0	0	0	0	0	0	3
Unsustainable exploitation of fish and other living resources	1	1	0	0	0	0	1	1	0.5	2
Global change	1	1	1	1	0	0	0	0	0.5	1

The Global International Waters Assessment

This report presents the results of the Global International Waters Assessment (GIWA) of the transboundary waters of the Oyashio Current region. This and the subsequent chapter offer a background that describes the impetus behind the establishment of GIWA, its objectives and how the GIWA was implemented.

The need for a global international waters assessment

Globally, people are becoming increasingly aware of the degradation of the world's water bodies. Disasters from floods and droughts, frequently reported in the media, are considered to be linked with ongoing global climate change (IPCC 2001), accidents involving large ships pollute public beaches and threaten marine life and almost every commercial fish stock is exploited beyond sustainable limits - it is estimated that the global stocks of large predatory fish have declined to less that 10% of pre-industrial fishing levels (Myers & Worm 2003). Further, more than 1 billion people worldwide lack access to safe drinking water and 2 billion people lack proper sanitation which causes approximately 4 billion cases of diarrhoea each year and results in the death of 2.2 million people, mostly children younger than five (WHO-UNICEF 2002). Moreover, freshwater and marine habitats are destroyed by infrastructure developments, dams, roads, ports and human settlements (Brinson & Malvárez 2002, Kennish 2002). As a consequence, there is growing public concern regarding the declining quality and quantity of the world's aquatic resources because of human activities, which has resulted in mounting pressure on governments and decision makers to institute new and innovative policies to manage those resources in a sustainable way ensuring their availability for future generations.

Adequately managing the world's aquatic resources for the benefit of all is, for a variety of reasons, a very complex task. The liquid state of the most of the world's water means that, without the construction of reservoirs, dams and canals it is free to flow wherever the laws of nature dictate. Water is, therefore, a vector transporting not only a wide variety of valuable resources but also problems from one area to another. The effluents emanating from environmentally destructive activities in upstream drainage areas are propagated downstream and can affect other areas considerable distances away. In the case of transboundary river basins, such as the Nile, Amazon and Niger, the impacts are transported across national borders and can be observed in the numerous countries situated within their catchments. In the case of large oceanic currents, the impacts can even be propagated between continents (AMAP 1998). Therefore, the inextricable linkages within and between both freshwater and marine environments dictates that management of aquatic resources ought to be implemented through a drainage basin approach.

In addition, there is growing appreciation of the incongruence between the transboundary nature of many aquatic resources and the traditional introspective nationally focused approaches to managing those resources. Water, unlike laws and management plans, does not respect national borders and, as a consequence, if future management of water and aquatic resources is to be successful, then a shift in focus towards international cooperation and intergovernmental agreements is required (UN 1972). Furthermore, the complexity of managing the world's water resources is exacerbated by the dependence of a great variety of domestic and industrial activities on those resources. As a consequence, cross-sectoral multidisciplinary approaches that integrate environmental, socio-economic and development aspects into management must be adopted. Unfortunately however, the scientific information or capacity within each discipline is often not available or is inadequately translated for use by managers, decision makers and policy developers. These inadequacies constitute a serious impediment to the implementation of urgently needed innovative policies.

Continual assessment of the prevailing and future threats to aquatic ecosystems and their implications for human populations is essential if governments and decision makers are going to be able to make strategic policy and management decisions that promote the sustainable use of those resources and respond to the growing concerns of the general public. Although many assessments of aquatic resources are being conducted by local, national, regional and international bodies, past assessments have often concentrated on specific themes, such as biodiversity or persistent toxic substances, or have focused only on marine or freshwaters. A globally coherent, drainage basin based assessment that embraces the inextricable links between transboundary freshwater and marine systems, and between environmental and societal issues, has never been conducted previously.

The Global Environment Facility (GEF)

The Global Environment Facility forges international co-operation and finances actions to address six critical threats to the global environment: biodiversity loss, climate change, degradation of international waters, ozone depletion, land degradation, and persistent organic pollutants (POPs).

The overall strategic thrust of GEF-funded international waters activities is to meet the incremental costs of: (a) assisting groups of countries to better understand the environmental concerns of their international waters and work collaboratively to address them; (b) building the capacity of existing institutions to utilise a more comprehensive approach for addressing transboundary water-related environmental concerns; and (c) implementing measures that address the priority transboundary environmental concerns. The goal is to assist countries to utilise the full range of technical, economic, financial, regulatory, and institutional measures needed to operationalise sustainable development strategies for international waters.

United Nations Environment Programme (UNEP)

United Nations Environment Programme, established in 1972, is the voice for the environment within the United Nations system. The mission of UNEP is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

UNEP work encompasses:

- Assessing global, regional and national environmental conditions and trends;
- Developing international and national environmental instruments;
- Strengthening institutions for the wise management of the environment;
- Facilitating the transfer of knowledge and technology for sustainable development;
- Encouraging new partnerships and mind-sets within civil society and the private sector.

University of Kalmar

University of Kalmar hosts the GIWA Co-ordination Office and provides scientific advice and administrative and technical assistance to GIWA. University of Kalmar is situated on the coast of the Baltic Sea. The city has a long tradition of higher education; teachers and marine officers have been educated in Kalmar since the middle of the 19th century. Today, natural science is a priority area which gives Kalmar a unique educational and research profile compared with other smaller universities in Sweden. Of particular relevance for GIWA is the established research in aquatic and environmental science. Issues linked to the concept of sustainable development are implemented by the research programme Natural Resources Management and Agenda 21 Research School.

Since its establishment GIWA has grown to become an integral part of University activities. The GIWA Co-ordination office and GIWA Core team are located at the Kalmarsund Laboratory, the university centre for water-related research. Senior scientists appointed by the University are actively involved in the GIWA peer-review and steering groups. As a result of the cooperation the University can offer courses and seminars related to GIWA objectives and international water issues.

International call for action

The need for a holistic assessment of transboundary waters in order to respond to growing public concerns and provide advice to governments and decision makers regarding the management of aquatic resources was recognised by several international bodies focusing on the global environment. In particular, the Global Environment Facility (GEF) observed that the International Waters (IW) component of the GEF suffered from the lack of a global assessment which made it difficult to prioritise international water projects, particularly considering the inadequate understanding of the nature and root causes of environmental problems. In 1996, at its fourth meeting in Nairobi, the GEF Scientific and Technical Advisory Panel (STAP), noted that: *"Lack of an International Waters Assessment comparable with that of the IPCC, the Global Biodiversity Assessment, and the Stratospheric Ozone Assessment, was a unique and serious impediment to the implementation of the International Waters Component of the GEF"*.

The urgent need for an assessment of the causes of environmental degradation was also highlighted at the UN Special Session on the Environment (UNGASS) in 1997, where commitments were made regarding the work of the UN Commission on Sustainable Development (UNCSD) on freshwater in 1998 and seas in 1999. Also in 1997, two international Declarations, the Potomac Declaration: Towards enhanced ocean security into the third millennium, and the Stockholm Statement on interaction of land activities, freshwater and enclosed seas, specifically emphasised the need for an investigation of the root causes of degradation of the transboundary aquatic environment and options for addressing them. These processes led to the development of the Global International Waters Assessment (GIWA) that would be implemented by the United Nations Environment Programme (UNEP) in conjunction with the University of Kalmar, Sweden, on behalf of the GEF. The GIWA was inaugurated in Kalmar in October 1999 by the Executive Director of UNEP, Dr. Klaus Töpfer, and the late Swedish Minister of the Environment, Kjell Larsson. On this occasion Dr. Töpfer stated: *"GIWA is the framework of UNEP´s global water assessment strategy and will enable us to record and report on critical water resources for the planet for consideration of sustainable development management practices as part of our responsibilities under Agenda 21 agreements of the Rio conference"*.

The importance of the GIWA has been further underpinned by the UN Millennium Development Goals adopted by the UN General Assembly in 2000 and the Declaration from the World Summit on Sustainable

Development in 2002. The development goals aimed to halve the proportion of people without access to safe drinking water and basic sanitation by the year 2015 (United Nations Millennium Declaration 2000). The WSSD also calls for integrated management of land, water and living resources (WSSD 2002) and, by 2010, the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem should be implemented by all countries that are party to the declaration (FAO 2001).

The conceptual framework and objectives

Considering the general decline in the condition of the world's aquatic resources and the internationally recognised need for a globally coherent assessment of transboundary waters, the primary objectives of the GIWA are:

- To provide a prioritising mechanism that allows the GEF to focus their resources so that they are used in the most cost effective manner to achieve significant environmental benefits, at national, regional and global levels; and
- To highlight areas in which governments can develop and implement strategic policies to reduce environmental degradation and improve the management of aquatic resources.

In order to meet these objectives and address some of the current inadequacies in international aquatic resources management, the GIWA has incorporated four essential elements into its design:

- A broad transboundary approach that generates a truly regional perspective through the incorporation of expertise and existing information from all nations in the region and the assessment of all factors that influence the aquatic resources of the region;
- A drainage basin approach integrating freshwater and marine systems;
- A multidisciplinary approach integrating environmental and socio-economic information and expertise; and
- A coherent assessment that enables global comparison of the results.

The GIWA builds on previous assessments implemented within the GEF International Waters portfolio but has developed and adopted a broader definition of transboundary waters to include factors that influence the quality and quantity of global aquatic resources. For example, due to globalisation and international trade, the market for penaeid shrimps has widened and the prices soared. This, in turn, has encouraged entrepreneurs in South East Asia to expand aquaculture resulting in the large-scale deforestation of mangroves for ponds (Primavera 1997). Within the GIWA, these "non-hydrological" factors constitute as large a transboundary influence as more traditionally recognised problems, such as the construction of dams that regulate the flow of water into a neighbouring country, and are considered equally important. In addition, the GIWA recognises the importance of hydrological units that would not normally be considered transboundary but exert a significant influence on transboundary waters, such as the Yangtze River in China which discharges into the East China Sea (Daoji & Daler 2004) and the Volga River in Russia which is largely responsible for the condition of the Caspian Sea (Barannik et al. 2004). Furthermore, the GIWA is a truly regional assessment that has incorporated data from a wide range of sources and included expert knowledge and information from a wide range of sectors and from each country in the region. Therefore, the transboundary concept adopted by the GIWA extends to include impacts caused by globalisation, international trade, demographic changes and technological advances and recognises the need for international cooperation to address them.

International waters and transboundary issues

The term "international waters", as used for the purposes of the GEF Operational Strategy, includes the oceans, large marine ecosystems, enclosed or semi-enclosed seas and estuaries, as well as rivers, lakes, groundwater systems, and wetlands with transboundary drainage basins or common borders. The water-related ecosystems associated with these waters are considered integral parts of the systems.

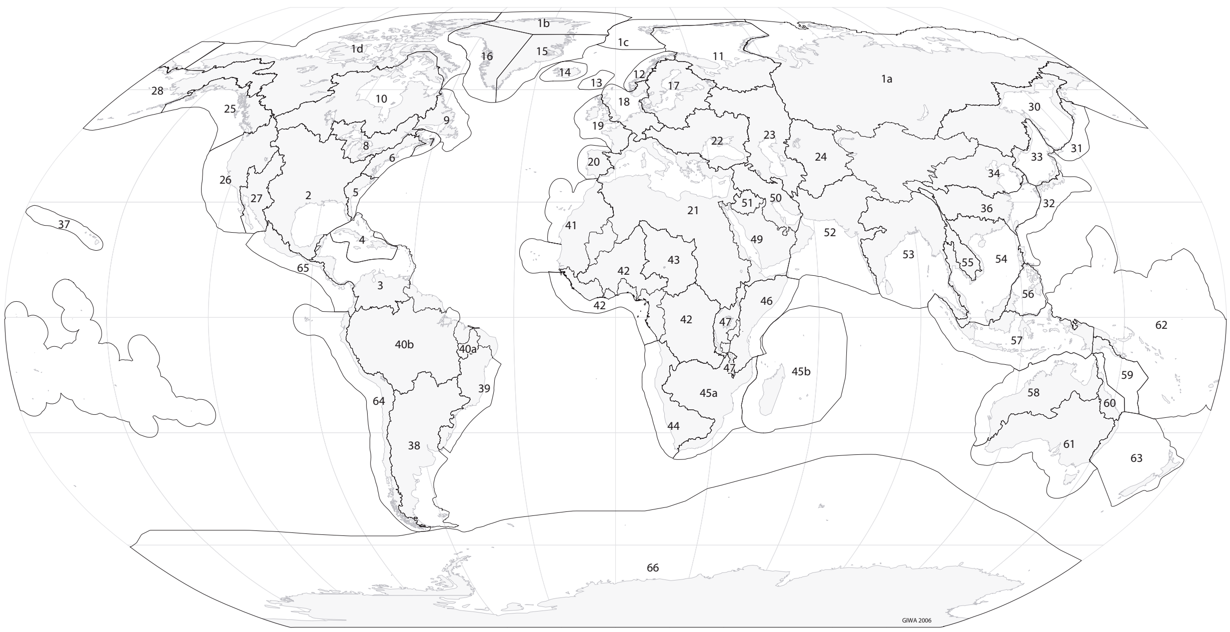
The term "transboundary issues" is used to describe the threats to the aquatic environment linked to globalisation, international trade, demographic changes and technological advancement, threats that are additional to those created through transboundary movement of water. Single country policies and actions are inadequate in order to cope with these challenges and this makes them transboundary in nature.

The international waters area includes numerous international conventions, treaties, and agreements. The architecture of marine agreements is especially complex, and a large number of bilateral and multilateral agreements exist for transboundary freshwater basins. Related conventions and agreements in other areas increase the complexity. These initiatives provide a new opportunity for cooperating nations to link many different programmes and instruments into regional comprehensive approaches to address international waters.

The organisational structure and implementation of the GIWA

The scale of the assessment

Initially, the scope of the GIWA was confined to transboundary waters in areas that included countries eligible to receive funds from the GEF. However, it was recognised that a truly global perspective would only be achieved if industrialised, GEF-ineligible regions of the world were also assessed. Financial resources to assess the GEF-eligible countries were obtained primarily from the GEF (68%), the Swedish International Development Cooperation Agency (Sida) (18%), and the Finnish Department for International Development Cooperation (FINNIDA)



1a Russian Arctic (4 LMEs)
1b Arctic Greenland (LME)
1c Arctic European/Atlantic
1d Arctic North American
2 Gulf of Mexico (LME)
3 Caribbean Sea (LME)
4 Caribbean Islands (LME)
5 Southeast Shelf (LME)
6 Northeast Shelf (LME)
7 Scotian Shelf (LME)
8 Gulf of St Lawrence
9 Newfoundland Shelf (LME)
10 Baffin Bay, Labrador Sea, Canadian Archipelago
11 Barents Sea (LME)
12 Norwegian Sea (LME)
13 Faroe plateau
14 Iceland Shelf (LME)
15 East Greenland Shelf (LME)
16 West Greenland Shelf (LME)
17 Baltic Sea (LME)
18 North Sea (LME)
19 Celtic-Biscay Shelf (LME)
20 Iberian Coastal Sea (LME)
21 North Africa and Nile River Basin (LME)
22 Black Sea (LME)
23 Caspian Sea
24 Aral Sea
25 Gulf of Alaska (LME)
26 California Current (LME)
27 Gulf of California (LME)
28 Bering Sea (LME)
30 Sea of Okhotsk (LME)
31 Oyashio Current (LME)
32 Kuroshio Current (LME)
33 Sea of Japan (LME)
34 Yellow Sea (LME)
36 East China Sea (LME)
37 Hawaiian Archipelago (LME)
38 Patagonian Shelf (LME)
39 Brazil Current (LME)
40a Northeast Brazil Shelf (2 LMEs)
40b Amazon
41 Canary Current (LME)
42 Guinea Current (LME)
43 Lake Chad
44 Benguela Current (LME)
45a Agulhas Current (LME)
45b Indian Ocean Islands
46 Somali Coastal Current (LME)
47 East African Rift Valley Lakes
49 Red Sea and Gulf of Aden (LME)
50 Euphrates and Tigris River Basin
51 Jordan
52 Arabian Sea (LME)
53 Bay of Bengal
54 South China Sea (2 LMEs)
55 Mekong River
56 Sulu-Celebes Sea (LME)
57 Indonesian Seas (LME)
58 North Australian Shelf (LME)
59 Coral Sea Basin
60 Great Barrier Reef (LME)
61 Great Australian Bight
62 Pacific Islands
63 Tasman Sea
64 Humboldt Current (LME)
65 Eastern Equatorial Pacific (LME)
66 Antarctic (LME)

Figure 1 The 66 transboundary regions assessed within the GIWA project.

(10%). Other contributions were made by Kalmar Municipality, the University of Kalmar and the Norwegian Government. The assessment of regions ineligible for GEF funds was conducted by various international and national organisations as in-kind contributions to the GIWA.

In order to be consistent with the transboundary nature of many of the world's aquatic resources and the focus of the GIWA, the geographical units being assessed have been designed according to the watersheds of discrete hydrographic systems rather than political borders (Figure 1). The geographic units of the assessment were determined during the preparatory phase of the project and resulted in the division of the world into 66 regions defined by the entire area of one or more catchments areas that drains into a single designated marine system. These marine systems often correspond to Large Marine Ecosystems (LMEs) (Sherman 1994, IOC 2002).

Considering the objectives of the GIWA and the elements incorporated into its design, a new methodology for the implementation of the assessment was developed during the initial phase of the project. The methodology focuses on five major environmental concerns which constitute the foundation of the GIWA assessment; Freshwater shortage, Pollution, Habitat and community modification, Overexploitation of fish and other living resources, and Global change. The GIWA methodology is outlined in the following chapter.

Large Marine Ecocsystems (LMEs)

Large Marine Ecosystems (LMEs) are regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundaries of continental shelves and the outer margin of the major current systems. They are relatively large regions on the order of 200 000 km^2 or greater, characterised by distinct: (1) bathymetry, (2) hydrography, (3) productivity, and (4) trophically dependent populations.

The Large Marine Ecosystems strategy is a global effort for the assessment and management of international coastal waters. It developed in direct response to a declaration at the 1992 Rio Summit. As part of the strategy, the World Conservation Union (IUCN) and National Oceanic and Atmospheric Administration (NOAA) have joined in an action program to assist developing countries in planning and implementing an ecosystem-based strategy that is focused on LMEs as the principal assessment and management units for coastal ocean resources. The LME concept is also adopted by GEF that recommends the use of LMEs and their contributing freshwater basins as the geographic area for integrating changes in sectoral economic activities.

The global network

In each of the 66 regions, the assessment is conducted by a team of local experts that is headed by a Focal Point (Figure 2). The Focal Point can be an individual, institution or organisation that has been selected on the basis of their scientific reputation and experience implementing international assessment projects. The Focal Point is responsible for assembling members of the team and ensuring that it has the necessary expertise and experience in a variety of environmental and socio-economic disciplines to successfully conduct the regional assessment. The selection of team members is one of the most critical elements for the success of GIWA and, in order to ensure that the most relevant information is incorporated into the assessment, team members were selected from a wide variety of institutions such as

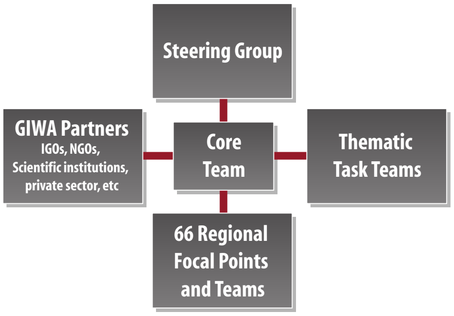


Figure 2 The organisation of the GIWA project.

universities, research institutes, government agencies, and the private sector. In addition, in order to ensure that the assessment produces a truly regional perspective, the teams should include representatives from each country that shares the region.

In total, more than 1 000 experts have contributed to the implementation of the GIWA illustrating that the GIWA is a participatory exercise that relies on regional expertise. This participatory approach is essential because it instils a sense of local ownership of the project, which ensures the credibility of the findings and moreover, it has created a global network of experts and institutions that can collaborate and exchange experiences and expertise to help mitigate the continued degradation of the world's aquatic resources.

GIWA Regional reports

The GIWA was established in response to growing concern among the general public regarding the quality of the world's aquatic resources and the recognition of governments and the international community concerning the absence of a globally coherent international waters assessment. However, because a holistic, region-by-region, assessment of the condition of the world's transboundary water resources had never been undertaken, a methodology guiding the implementation of such an assessment did not exist. Therefore, in order to implement the GIWA, a new methodology that adopted a multidisciplinary, multi-sectoral, multi-national approach was developed and is now available for the implementation of future international assessments of aquatic resources.

UNEP Water Policy and Strategy

The primary goals of the UNEP water policy and strategy are:

(a) Achieving greater global understanding of freshwater, coastal and marine environments by conducting environmental assessments in priority areas;

(b) Raising awareness of the importance and consequences of unsustainable water use;

(c) Supporting the efforts of Governments in the preparation and implementation of integrated management of freshwater systems and their related coastal and marine environments;

(d) Providing support for the preparation of integrated management plans and programmes for aquatic environmental hot spots, based on the assessment results;

(e) Promoting the application by stakeholders of precautionary, preventive and anticipatory approaches.

The GIWA is comprised of a logical sequence of four integrated components. The first stage of the GIWA is called Scaling and is a process by which the geographic area examined in the assessment is defined and all the transboundary waters within that area are identified. Once the geographic scale of the assessment has been defined, the assessment teams conduct a process known as Scoping in which the magnitude of environmental and associated socio-economic impacts of Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, and Global change is assessed in order to identify and prioritise the concerns that require the most urgent intervention. The assessment of these predefined concerns incorporates the best available information and the knowledge and experience of the multidisciplinary, multi-national assessment teams formed in each region. Once the priority concerns have been identified, the root causes of these concerns are identified during the third component of the GIWA, Causal chain analysis. The root causes are determined through a sequential process that identifies, in turn, the most significant immediate causes followed by the economic sectors that are primarily responsible for the immediate causes and finally, the societal root causes. At each stage in the Causal chain analysis, the most significant contributors are identified through an analysis of the best available information which is augmented by the expertise of the assessment team. The final component of the GIWA is the development of Policy options that focus on mitigating the impacts of the root causes identified by the Causal chain analysis.

The results of the GIWA assessment in each region are reported in regional reports that are published by UNEP. These reports are designed to provide a brief physical and socio-economic description of the most important features of the region against which the results of the assessment can be cast. The remaining sections of the report present the results of each stage of the assessment in an easily digestible form. Each regional report is reviewed by at least two independent external reviewers in order to ensure the scientific validity and applicability of each report. The 66 regional assessments of the GIWA will serve UNEP as an essential complement to the UNEP Water Policy and Strategy and UNEP's activities in the hydrosphere.

Global International Waters Assessment

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The GIWA methodology

The specific objectives of the GIWA were to conduct a holistic and globally comparable assessment of the world's transboundary aquatic resources that incorporated both environmental and socio-economic factors and recognised the inextricable links between freshwater and marine environments, in order to enable the GEF to focus their resources and to provide guidance and advice to governments and decision makers. The coalition of all these elements into a single coherent methodology that produces an assessment that achieves each of these objectives had not previously been done and posed a significant challenge.

The integration of each of these elements into the GIWA methodology was achieved through an iterative process guided by a specially convened Methods task team that was comprised of a number of international assessment and water experts. Before the final version of the methodology was adopted, preliminary versions underwent an extensive external peer review and were subjected to preliminary testing in selected regions. Advice obtained from the Methods task team and other international experts and the lessons learnt from preliminary testing were incorporated into the final version that was used to conduct each of the GIWA regional assessments.

Considering the enormous differences between regions in terms of the quality, quantity and availability of data, socio-economic setting and environmental conditions, the achievement of global comparability required an innovative approach. This was facilitated by focusing the assessment on the impacts of five pre-defined concerns namely; Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources and Global change, in transboundary waters. Considering the diverse range of elements encompassed by each concern, assessing the magnitude of the impacts caused by these concerns was facilitated by evaluating the impacts of 22 specific issues that were grouped within these concerns (see Table 1).

The assessment integrates environmental and socio-economic data from each country in the region to determine the severity of the impacts of each of the five concerns and their constituent issues on the entire region. The integration of this information was facilitated by implementing the assessment during two participatory workshops that typically involved 10 to 15 environmental and socio-economic experts from each country in the region. During these workshops, the regional teams performed preliminary analyses based on the collective knowledge and experience of these local experts. The results of these analyses were substantiated with the best available information to be presented in a regional report.

Table 1 Pre-defined GIWA concerns and their constituent issues addressed within the assessment.

Environmental issues	Major concerns
1. Modification of stream flow 2. Pollution of existing supplies 3. Changes in the water table	**I Freshwater shortage**
4. Microbiological 5. Eutrophication 6. Chemical 7. Suspended solids 8. Solid wastes 9. Thermal 10. Radionuclide 11. Spills	**II Pollution**
12. Loss of ecosystems 13. Modification of ecosystems or ecotones, including community structure and/or species composition	**III Habitat and community modification**
14. Overexploitation 15. Excessive by-catch and discards 16. Destructive fishing practices 17. Decreased viability of stock through pollution and disease 18. Impact on biological and genetic diversity	**IV Unsustainable exploitation of fish and other living resources**
19. Changes in hydrological cycle 20. Sea level change 21. Increased uv-b radiation as a result of ozone depletion 22. Changes in ocean CO2 source/sink function	**V Global change**

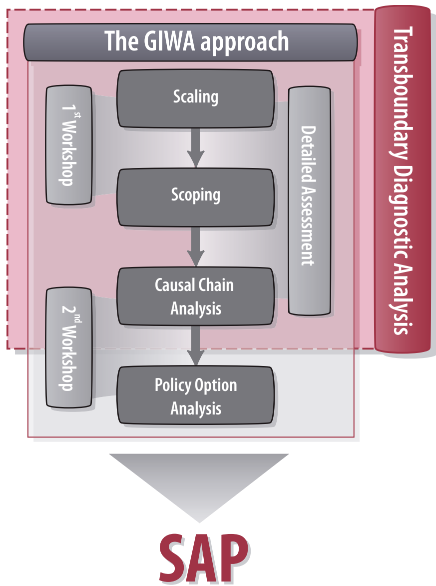

Figure 1 Illustration of the relationship between the GIWA approach and other projects implemented within the GEF International Waters (IW) portfolio.

The GIWA is a logical contiguous process that defines the geographic region to be assessed, identifies and prioritises particularly problems based on the magnitude of their impacts on the environment and human societies in the region, determines the root causes of those problems and, finally, assesses various policy options that addresses those root causes in order to reverse negative trends in the condition of the aquatic environment. These four steps, referred to as Scaling, Scoping, Causal chain analysis and Policy options analysis, are summarised below and are described in their entirety in two volumes: *GIWA Methodology Stage 1: Scaling and Scoping*; and *GIWA Methodology: Detailed Assessment, Causal Chain Analysis and Policy Options Analysis*. Generally, the components of the GIWA methodology are aligned with the framework adopted by the GEF for Transboundary Diagnostic Analyses (TDAs) and Strategic Action Programmes (SAPs) (Figure 1) and assume a broad spectrum of transboundary influences in addition to those associated with the physical movement of water across national borders.

Scaling – Defining the geographic extent of the region

Scaling is the first stage of the assessment and is the process by which the geographic scale of the assessment is defined. In order to facilitate the implementation of the GIWA, the globe was divided during the design phase of the project into 66 contiguous regions. Considering the transboundary nature of many aquatic resources and the transboundary focus of the GIWA, the boundaries of the regions did not comply with political boundaries but were instead, generally defined by a large but discrete drainage basin that also included the coastal marine waters into which the basin discharges. In many cases, the marine areas examined during the assessment coincided with the Large Marine Ecosystems (LMEs) defined by the US National Atmospheric and Oceanographic Administration (NOAA). As a consequence, scaling should be a relatively straight-forward task that involves the inspection of the boundaries that were proposed for the region during the preparatory phase of GIWA to ensure that they are appropriate and that there are no important overlaps or gaps with neighbouring regions. When the proposed boundaries were found to be inadequate, the boundaries of the region were revised according to the recommendations of experts from both within the region and from adjacent regions so as to ensure that any changes did not result in the exclusion of areas from the GIWA. Once the regional boundary was defined, regional teams identified all the transboundary elements of the aquatic environment within the region and determined if these elements could be assessed as a single coherent aquatic system or if there were two or more independent systems that should be assessed separately.

Scoping – Assessing the GIWA concerns

Scoping is an assessment of the severity of environmental and socio-economic impacts caused by each of the five pre-defined GIWA concerns and their constituent issues (Table 1). It is not designed to provide an exhaustive review of water-related problems that exist within each region, but rather it is a mechanism to identify the most urgent problems in the region and prioritise those for remedial actions. The priorities determined by Scoping are therefore one of the main outputs of the GIWA project.

Focusing the assessment on pre-defined concerns and issues ensured the comparability of the results between different regions. In addition, to ensure the long-term applicability of the options that are developed to mitigate these problems, Scoping not only assesses the current impacts of these concerns and issues but also the probable future impacts according to the "most likely scenario" which considered demographic, economic, technological and other relevant changes that will potentially influence the aquatic environment within the region by 2020.

The magnitude of the impacts caused by each issue on the environment and socio-economic indicators was assessed over the entire region using the best available information from a wide range of sources and the knowledge and experience of the each of the experts comprising the regional team. In order to enhance the comparability of the assessment between different regions and remove biases in the assessment caused by different perceptions of and ways to communicate the severity of impacts caused by particular issues, the results were distilled and reported as standardised scores according to the following four point scale:

- 0 = no known impact
- 1 = slight impact
- 2 = moderate impact
- 3 = severe impact

The attributes of each score for each issue were described by a detailed set of pre-defined criteria that were used to guide experts in reporting the results of the assessment. For example, the criterion for assigning a score of 3 to the issue Loss of ecosystems or ecotones is: *"Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades."* The full list of criteria is presented at the end of the chapter, Table 5a-e. Although the scoring inevitably includes an arbitrary component, the use of predefined criteria facilitates comparison of impacts on a global scale and also encouraged consensus of opinion among experts.

The trade-off associated with assessing the impacts of each concern and their constituent issues at the scale of the entire region is that spatial resolution was sometimes low. Although the assessment provides a score indicating the severity of impacts of a particular issue or concern on the entire region, it does not mean that the entire region suffers the impacts of that problem. For example, eutrophication could be identified as a severe problem in a region, but this does not imply that all waters in the region suffer from severe eutrophication. It simply means that when the degree of eutrophication, the size of the area affected, the socio-economic impacts and the number of people affected is considered, the magnitude of the overall impacts meets the criteria defining a severe problem and that a regional action should be initiated in order to mitigate the impacts of the problem.

When each issue has been scored, it was weighted according to the relative contribution it made to the overall environmental impacts of the concern and a weighted average score for each of the five concerns was calculated (Table 2). Of course, if each issue was deemed to make equal contributions, then the score describing the overall impacts of the concern was simply the arithmetic mean of the scores allocated to each issue within the concern. In addition, the socio-economic impacts of each of the five major concerns were assessed for the entire region. The socio-economic impacts were grouped into three categories; Economic impacts, Health impacts and Other social and community impacts (Table 3). For each category, an evaluation of the size, degree and frequency of the impact was performed and, once completed, a weighted average score describing the overall socio-economic impacts of each concern was calculated in the same manner as the overall environmental score.

Table 2 Example of environmental impact assessment of Freshwater shortage.

Environmental issues	Score	Weight %	Environmental concerns	Weight averaged score
1. Modification of stream flow	1	20	Freshwater shortage	1.50
2. Pollution of existing supplies	2	50		
3. Changes in the water table	1	30		

Table 3 Example of Health impacts assessment linked to one of the GIWA concerns.

Criteria for Health impacts	Raw score	Score	Weight %
Number of people affected	Very small – Very large 0 1 2 3	2	50
Degree of severity	Minimum – Severe 0 1 2 3	2	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	20
Weight average score for Health impacts		**2**	

After all 22 issues and associated socio-economic impacts have been scored, weighted and averaged, the magnitude of likely future changes in the environmental and socio-economic impacts of each of the five concerns on the entire region is assessed according to the most likely scenario which describes the demographic, economic, technological and other relevant changes that might influence the aquatic environment within the region by 2020.

In order to prioritise among GIWA concerns within the region and identify those that will be subjected to causal chain and policy options analysis in the subsequent stages of the GIWA, the present and future scores of the environmental and socio-economic impacts of each concern are tabulated and an overall score calculated. In the example presented in Table 4, the scoping assessment indicated that concern III, Habitat and community modification, was the priority concern in this region. The outcome of this mathematic process was reconciled against the knowledge of experts and the best available information in order to ensure the validity of the conclusion.

In some cases however, this process and the subsequent participatory discussion did not yield consensus among the regional experts regarding the ranking of priorities. As a consequence, further analysis was required. In such cases, expert teams continued by assessing the relative importance of present and potential future impacts and assign weights to each. Afterwards, the teams assign weights indicating the relative contribution made by environmental and socio-economic factors to the overall impacts of the concern. The weighted average score for each concern is then recalculated taking into account

Table 4 Example of comparative environmental and socio-economic impacts of each major concern, presently and likely in year 2020.

Concern	Environmental score		Economic score		Human health score		Social and community score		Overall score
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)	
Freshwater shortage	1.3	2.3	2.7	2.8	2.6	3.0	1.8	2.2	**2.3**
Pollution	1.5	2.0	2.0	2.3	1.8	2.3	2.0	2.3	**2.0**
Habitat and community modification	2.0	3.0	2.4	3.0	2.4	2.8	2.3	2.7	**2.6**
Unsustainable exploitation of fish and other living resources	1.8	2.2	2.0	2.1	2.0	2.1	2.4	2.5	**2.1**
Global change	0.8	1.0	1.5	1.7	1.5	1.5	1.0	1.0	**1.2**

(Types of impacts)

the relative contributions of both present and future impacts and environmental and socio-economic factors. The outcome of these additional analyses was subjected to further discussion to identify overall priorities for the region.

Finally, the assessment recognises that each of the five GIWA concerns are not discrete but often interact. For example, pollution can destroy aquatic habitats that are essential for fish reproduction which, in turn, can cause declines in fish stocks and subsequent overexploitation. Once teams have ranked each of the concerns and determined the priorities for the region, the links between the concerns are highlighted in order to identify places where strategic interventions could be applied to yield the greatest benefits for the environment and human societies in the region.

Causal chain analysis

Causal Chain Analysis (CCA) traces the cause-effect pathways from the socio-economic and environmental impacts back to their root causes. The GIWA CCA aims to identify the most important causes of each concern prioritised during the scoping assessment in order to direct policy measures at the most appropriate target in order to prevent further degradation of the regional aquatic environment.

Root causes are not always easy to identify because they are often spatially or temporally separated from the actual problems they cause. The GIWA CCA was developed to help identify and understand the root causes of environmental and socio-economic problems in international waters and is conducted by identifying the human activities that cause the problem and then the factors that determine the ways in which these activities are undertaken. However, because there is no universal theory describing how root causes interact to create natural resource management problems and due to the great variation of local circumstances under which the methodology will be applied, the GIWA CCA is not a rigidly structured assessment but should be regarded as a framework to guide the analysis, rather than as a set of detailed instructions. Secondly, in an ideal setting, a causal chain would be produced by a multidisciplinary group of specialists that would statistically examine each successive cause and study its links to the problem and to other causes. However, this approach (even if feasible) would use far more resources and time than those available to GIWA[1]. For this reason, it has been necessary to develop a relatively simple and practical analytical model for gathering information to assemble meaningful causal chains.

Conceptual model

A causal chain is a series of statements that link the causes of a problem with its effects. Recognising the great diversity of local settings and the resulting difficulty in developing broadly applicable policy strategies, the GIWA CCA focuses on a particular system and then only on those issues that were prioritised during the scoping assessment. The starting point of a particular causal chain is one of the issues selected during the Scaling and Scoping stages and its related environmental and socio-economic impacts. The next element in the GIWA chain is the immediate cause; defined as the physical, biological or chemical variable that produces the GIWA issue. For example, for the issue of eutrophication the immediate causes may be, inter alia:

- Enhanced nutrient inputs;
- Increased recycling/mobilisation;
- Trapping of nutrients (e.g. in river impoundments);
- Run-off and stormwaters

Once the relevant immediate cause(s) for the particular system has (have) been identified, the sectors of human activity that contribute most significantly to the immediate cause have to be determined. Assuming that the most important immediate cause in our example had been increased nutrient concentrations, then it is logical that the most likely sources of those nutrients would be the agricultural, urban or industrial sectors. After identifying the sectors that are primarily

[1] This does not mean that the methodology ignores statistical or quantitative studies; as has already been pointed out, the available evidence that justifies the assumption of causal links should be provided in the assessment.

responsible for the immediate causes, the root causes acting on those sectors must be determined. For example, if agriculture was found to be primarily responsible for the increased nutrient concentrations, the root causes could potentially be:

- Economic (e.g. subsidies to fertilisers and agricultural products);
- Legal (e.g. inadequate regulation);
- Failures in governance (e.g. poor enforcement); or
- Technology or knowledge related (e.g. lack of affordable substitutes for fertilisers or lack of knowledge as to their application).

Once the most relevant root causes have been identified, an explanation, which includes available data and information, of how they are responsible for the primary environmental and socio-economic problems in the region should be provided.

Policy option analysis

Despite considerable effort of many Governments and other organisations to address transboundary water problems, the evidence indicates that there is still much to be done in this endeavour. An important characteristic of GIWA's Policy Option Analysis (POA) is that its recommendations are firmly based on a better understanding of the root causes of the problems. Freshwater scarcity, water pollution, overexploitation of living resources and habitat destruction are very complex phenomena. Policy options that are grounded on a better understanding of these phenomena will contribute to create more effective societal responses to the extremely complex water related transboundary problems. The core of POA in the assessment consists of two tasks:

Construct policy options

Policy options are simply different courses of action, which are not always mutually exclusive, to solve or mitigate environmental and socio-economic problems in the region. Although a multitude of different policy options could be constructed to address each root cause identified in the CCA, only those few policy options that have the greatest likelihood of success were analysed in the GIWA.

Select and apply the criteria on which the policy options will be evaluated

Although there are many criteria that could be used to evaluate any policy option, GIWA focuses on:

- Effectiveness (certainty of result)
- Efficiency (maximisation of net benefits)
- Equity (fairness of distributional impacts)
- Practical criteria (political acceptability, implementation feasibility).

The policy options recommended by the GIWA are only contributions to the larger policy process and, as such, the GIWA methodology developed to test the performance of various options under the different circumstances has been kept simple and broadly applicable.

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Table 5a: Scoring criteria for environmental impacts of Freshwater shortage

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 1: Modification of stream flow "An increase or decrease in the discharge of streams and rivers as a result of human interventions on a local/ regional scale (see Issue 19 for flow alterations resulting from global change) over the last 3-4 decades."	■ No evidence of modification of stream flow.	■ There is a measurably changing trend in annual river discharge at gauging stations in a major river or tributary (basin > 40 000 km²); or ■ There is a measurable decrease in the area of wetlands (other than as a consequence of conversion or embankment construction); or ■ There is a measurable change in the interannual mean salinity of estuaries or coastal lagoons and/or change in the mean position of estuarine salt wedge or mixing zone; or ■ Change in the occurrence of exceptional discharges (e.g. due to upstream damming.	■ Significant downward or upward trend (more than 20% of the long term mean) in annual discharges in a major river or tributary draining a basin of >250 000 km²; or ■ Loss of >20% of flood plain or deltaic wetlands through causes other than conversion or artificial embankments; or ■ Significant loss of riparian vegetation (e.g. trees, flood plain vegetation); or ■ Significant saline intrusion into previously freshwater rivers or lagoons.	■ Annual discharge of a river altered by more than 50% of long term mean; or ■ Loss of >50% of riparian or deltaic wetlands over a period of not less than 40 years (through causes other than conversion or artificial embankment); or ■ Significant increased siltation or erosion due to changing in flow regime (other than normal fluctuations in flood plain rivers); or ■ Loss of one or more anadromous or catadromous fish species for reasons other than physical barriers to migration, pollution or overfishing.
Issue 2: Pollution of existing supplies "Pollution of surface and ground fresh waters supplies as a result of point or diffuse sources"	■ No evidence of pollution of surface and ground waters.	■ Any monitored water in the region does not meet WHO or national drinking water criteria, other than for natural reasons; or ■ There have been reports of one or more fish kills in the system due to pollution within the past five years.	■ Water supplies does not meet WHO or national drinking water standards in more than 30% of the region; or ■ There are one or more reports of fish kills due to pollution in any river draining a basin of >250 000 km² .	■ River draining more than 10% of the basin have suffered polysaprobic conditions, no longer support fish, or have suffered severe oxygen depletion ■ Severe pollution of other sources of freshwater (e.g. groundwater)
Issue 3: Changes in the water table "Changes in aquifers as a direct or indirect consequence of human activity"	■ No evidence that abstraction of water from aquifers exceeds natural replenishment.	■ Several wells have been deepened because of excessive aquifer draw-down; or ■ Several springs have dried up; or ■ Several wells show some salinisation.	■ Clear evidence of declining base flow in rivers in semi-arid areas; or ■ Loss of plant species in the past decade, that depend on the presence of ground water; or ■ Wells have been deepened over areas of hundreds of km²;or ■ Salinisation over significant areas of the region.	■ Aquifers are suffering salinisation over regional scale; or ■ Perennial springs have dried up over regionally significant areas; or ■ Some aquifers have become exhausted

Table 5b: Scoring criteria for environmental impacts of Pollution

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 4: Microbiological pollution "The adverse effects of microbial constituents of human sewage released to water bodies."	■ Normal incidence of bacterial related gastroenteric disorders in fisheries product consumers and no fisheries closures or advisories.	■ There is minor increase in incidence of bacterial related gastroenteric disorders in fisheries product consumers but no fisheries closures or advisories.	■ Public health authorities aware of marked increase in the incidence of bacterial related gastroenteric disorders in fisheries product consumers; or ■ There are limited area closures or advisories reducing the exploitation or marketability of fisheries products.	■ There are large closure areas or very restrictive advisories affecting the marketability of fisheries products; or ■ There exists widespread public or tourist awareness of hazards resulting in major reductions in the exploitation or marketability of fisheries products.
Issue 5: Eutrophication "Artificially enhanced primary productivity in receiving water basins related to the increased availability or supply of nutrients, including cultural eutrophication in lakes."	■ No visible effects on the abundance and distributions of natural living resource distributions in the area; and ■ No increased frequency of hypoxia[1] or fish mortality events or harmful algal blooms associated with enhanced primary production; and ■ No evidence of periodically reduced dissolved oxygen or fish and zoobenthos mortality; and ■ No evident abnormality in the frequency of algal blooms.	■ Increased abundance of epiphytic algae; or ■ A statistically significant trend in decreased water transparency associated with algal production as compared with long-term (>20 year) data sets; or ■ Measurable shallowing of the depth range of macrophytes.	■ Increased filamentous algal production resulting in algal mats; or ■ Medium frequency (up to once per year) of large-scale hypoxia and/or fish and zoobenthos mortality events and/or harmful algal blooms.	■ High frequency (>1 event per year), or intensity, or large areas of periodic hypoxic conditions, or high frequencies of fish and zoobenthos mortality events or harmful algal blooms; or ■ Significant changes in the littoral community; or ■ Presence of hydrogen sulphide in historically well oxygenated areas.

Issue 6: Chemical pollution "The adverse effects of chemical contaminants released to standing or marine water bodies as a result of human activities. Chemical contaminants are here defined as compounds that are toxic or persistent or bioaccumulating."	■ No known or historical levels of chemical contaminants except background levels of naturally occurring substances; and ■ No fisheries closures or advisories due to chemical pollution; and ■ No incidence of fisheries product tainting; and ■ No unusual fish mortality events. If there is no available data use the following criteria: ■ No use of pesticides; and ■ No sources of dioxins and furans; and ■ No regional use of PCBs; and ■ No bleached kraft pulp mills using chlorine bleaching; and ■ No use or sources of other contaminants.	■ Some chemical contaminants are detectable but below threshold limits defined for the country or region; or ■ Restricted area advisories regarding chemical contamination of fisheries products. If there is no available data use the following criteria: ■ Some use of pesticides in small areas; or ■ Presence of small sources of dioxins or furans (e.g., small incineration plants or bleached kraft/pulp mills using chlorine); or ■ Some previous and existing use of PCBs and limited amounts of PCB-containing wastes but not in amounts invoking local concerns; or ■ Presence of other contaminants.	■ Some chemical contaminants are above threshold limits defined for the country or region; or ■ Large area advisories by public health authorities concerning fisheries product contamination but without associated catch restrictions or closures; or ■ High mortalities of aquatic species near outfalls. If there is no available data use the following criteria: ■ Large-scale use of pesticides in agriculture and forestry; or ■ Presence of major sources of dioxins or furans such as large municipal or industrial incinerators or large bleached kraft pulp mills; or ■ Considerable quantities of waste PCBs in the area with inadequate regulation or has invoked some public concerns; or ■ Presence of considerable quantities of other contaminants.	■ Chemical contaminants are above threshold limits defined for the country or region; and ■ Public health and public awareness of fisheries contamination problems with associated reductions in the marketability of such products either through the imposition of limited advisories or by area closures of fisheries; or ■ Large-scale mortalities of aquatic species. If there is no available data use the following criteria: ■ Indications of health effects resulting from use of pesticides; or ■ Known emissions of dioxins or furans from incinerators or chlorine bleaching of pulp; or ■ Known contamination of the environment or foodstuffs by PCBs; or ■ Known contamination of the environment or foodstuffs by other contaminants.
Issue 7: Suspended solids "The adverse effects of modified rates of release of suspended particulate matter to water bodies resulting from human activities"	■ No visible reduction in water transparency; and ■ No evidence of turbidity plumes or increased siltation; and ■ No evidence of progressive riverbank, beach, other coastal or deltaic erosion.	■ Evidently increased or reduced turbidity in streams and/or receiving riverine and marine environments but without major changes in associated sedimentation or erosion rates, mortality or diversity of flora and fauna; or ■ Some evidence of changes in benthic or pelagic biodiversity in some areas due to sediment blanketing or increased turbidity.	■ Markedly increased or reduced turbidity in small areas of streams and/or receiving riverine and marine environments; or ■ Extensive evidence of changes in sedimentation or erosion rates; or ■ Changes in benthic or pelagic biodiversity in areas due to sediment blanketing or increased turbidity.	■ Major changes in turbidity over wide or ecologically significant areas resulting in markedly changed biodiversity or mortality in benthic species due to excessive sedimentation with or without concomitant changes in the nature of deposited sediments (i.e., grain-size composition/redox); or ■ Major change in pelagic biodiversity or mortality due to excessive turbidity.
Issue 8: Solid wastes "Adverse effects associated with the introduction of solid waste materials into water bodies or their environs."	■ No noticeable interference with trawling activities; and ■ No noticeable interference with the recreational use of beaches due to litter; and ■ No reported entanglement of aquatic organisms with debris.	■ Some evidence of marine-derived litter on beaches; or ■ Occasional recovery of solid wastes through trawling activities; but ■ Without noticeable interference with trawling and recreational activities in coastal areas.	■ Widespread litter on beaches giving rise to public concerns regarding the recreational use of beaches; or ■ High frequencies of benthic litter recovery and interference with trawling activities; or ■ Frequent reports of entanglement/ suffocation of species by litter.	■ Incidence of litter on beaches sufficient to deter the public from recreational activities; or ■ Trawling activities untenable because of benthic litter and gear entanglement; or ■ Widespread entanglement and/or suffocation of aquatic species by litter.
Issue 9: Thermal "The adverse effects of the release of aqueous effluents at temperatures exceeding ambient temperature in the receiving water body."	■ No thermal discharges or evidence of thermal effluent effects.	■ Presence of thermal discharges but without noticeable effects beyond the mixing zone and no significant interference with migration of species.	■ Presence of thermal discharges with large mixing zones having reduced productivity or altered biodiversity; or ■ Evidence of reduced migration of species due to thermal plume.	■ Presence of thermal discharges with large mixing zones with associated mortalities, substantially reduced productivity or noticeable changes in biodiversity; or ■ Marked reduction in the migration of species due to thermal plumes.
Issue 10: Radionuclide "The adverse effects of the release of radioactive contaminants and wastes into the aquatic environment from human activities."	■ No radionuclide discharges or nuclear activities in the region.	■ Minor releases or fallout of radionuclides but with well regulated or well-managed conditions complying with the Basic Safety Standards.	■ Minor releases or fallout of radionuclides under poorly regulated conditions that do not provide an adequate basis for public health assurance or the protection of aquatic organisms but without situations or levels likely to warrant large scale intervention by a national or international authority.	■ Substantial releases or fallout of radionuclides resulting in excessive exposures to humans or animals in relation to those recommended under the Basic Safety Standards; or ■ Some indication of situations or exposures warranting intervention by a national or international authority.
Issue 11: Spills "The adverse effects of accidental episodic releases of contaminants and materials to the aquatic environment as a result of human activities."	■ No evidence of present or previous spills of hazardous material; or ■ No evidence of increased aquatic or avian species mortality due to spills.	■ Some evidence of minor spills of hazardous materials in small areas with insignificant small-scale adverse effects one aquatic or avian species.	■ Evidence of widespread contamination by hazardous or aesthetically displeasing materials assumed to be from spillage (e.g. oil slicks) but with limited evidence of widespread adverse effects on resources or amenities; or ■ Some evidence of aquatic or avian species mortality through increased presence of contaminated or poisoned carcasses on beaches.	■ Widespread contamination by hazardous or aesthetically displeasing materials from frequent spills resulting in major interference with aquatic resource exploitation or coastal recreational amenities; or ■ Significant mortality of aquatic or avian species as evidenced by large numbers of contaminated carcasses on beaches.

Table 5c: Scoring criteria for environmental impacts of Habitat and community modification

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 12: Loss of ecosystems or ecotones "The complete destruction of aquatic habitats. For the purpose of GIWA methodology, recent loss will be measured as a loss of pre-defined habitats over the last 2-3 decades."	■ There is no evidence of loss of ecosystems or habitats.	■ There are indications of fragmentation of at least one of the habitats.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by up to 30 % during the last 2-3 decades.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.
Issue 13: Modification of ecosystems or ecotones, including community structure and/or species composition "Modification of pre-defined habitats in terms of extinction of native species, occurrence of introduced species and changing in ecosystem function and services over the last 2-3 decades."	■ No evidence of change in species complement due to species extinction or introduction; and ■ No changing in ecosystem function and services.	■ Evidence of change in species complement due to species extinction or introduction	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure; and ■ Evidence of change in ecosystem services[2].

[2] Constanza, R. et al. (1997). The value of the world ecosystem services and natural capital, Nature 387:253-260.

Table 5d: Scoring criteria for environmental impacts of Unsustainable exploitation of fish and other living resources

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 14: Overexploitation "The capture of fish, shellfish or marine invertebrates at a level that exceeds the maximum sustainable yield of the stock."	■ No harvesting exists catching fish (with commercial gear for sale or subsistence).	■ Commercial harvesting exists but there is no evidence of over-exploitation.	■ One stock is exploited beyond MSY (maximum sustainable yield) or is outside safe biological limits.	■ More than one stock is exploited beyond MSY or is outside safe biological limits.
Issue 15: Excessive by-catch and discards "By-catch refers to the incidental capture of fish or other animals that are not the target of the fisheries. Discards refers to dead fish or other animals that are returned to the sea."	■ Current harvesting practices show no evidence of excessive by-catch and/or discards.	■ Up to 30% of the fisheries yield (by weight) consists of by-catch and/or discards.	■ 30-60% of the fisheries yield consists of by-catch and/or discards.	■ Over 60% of the fisheries yield is by-catch and/or discards; or ■ Noticeable incidence of capture of endangered species.
Issue 16: Destructive fishing practices "Fishing practices that are deemed to produce significant harm to marine, lacustrine or coastal habitats and communities."	■ No evidence of habitat destruction due to fisheries practices.	■ Habitat destruction resulting in changes in distribution of fish or shellfish stocks; or ■ Trawling of any one area of the seabed is occurring less than once per year.	■ Habitat destruction resulting in moderate reduction of stocks or moderate changes of the environment; or ■ Trawling of any one area of the seabed is occurring 1-10 times per year; or ■ Incidental use of explosives or poisons for fishing.	■ Habitat destruction resulting in complete collapse of a stock or far reaching changes in the environment; or ■ Trawling of any one area of the seabed is occurring more than 10 times per year; or ■ Widespread use of explosives or poisons for fishing.
Issue 17: Decreased viability of stocks through contamination and disease "Contamination or diseases of feral (wild) stocks of fish or invertebrates that are a direct or indirect consequence of human action."	■ No evidence of increased incidence of fish or shellfish diseases.	■ Increased reports of diseases without major impacts on the stock.	■ Declining populations of one or more species as a result of diseases or contamination.	■ Collapse of stocks as a result of diseases or contamination.
Issue 18: Impact on biological and genetic diversity "Changes in genetic and species diversity of aquatic environments resulting from the introduction of alien or genetically modified species as an intentional or unintentional result of human activities including aquaculture and restocking."	■ No evidence of deliberate or accidental introductions of alien species; and ■ No evidence of deliberate or accidental introductions of alien stocks; and ■ No evidence of deliberate or accidental introductions of genetically modified species.	■ Alien species introduced intentionally or accidentally without major changes in the community structure; or ■ Alien stocks introduced intentionally or accidentally without major changes in the community structure; or ■ Genetically modified species introduced intentionally or accidentally without major changes in the community structure.	■ Measurable decline in the population of native species or local stocks as a result of introductions (intentional or accidental); or ■ Some changes in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).	■ Extinction of native species or local stocks as a result of introductions (intentional or accidental); or ■ Major changes (>20%) in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).

Table 5e: Scoring criteria for environmental impacts of Global change

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 19: Changes in hydrological cycle and ocean circulation "Changes in the local/regional water balance and changes in ocean and coastal circulation or current regime over the last 2-3 decades arising from the wider problem of global change including ENSO."	■ No evidence of changes in hydrological cycle and ocean/coastal current due to global change.	■ Change in hydrological cycles due to global change causing changes in the distribution and density of riparian terrestrial or aquatic plants without influencing overall levels of productivity; or ■ Some evidence of changes in ocean or coastal currents due to global change but without a strong effect on ecosystem diversity or productivity.	■ Significant trend in changing terrestrial or sea ice cover (by comparison with a long-term time series) without major downstream effects on river/ocean circulation or biological diversity; or ■ Extreme events such as flood and drought are increasing; or ■ Aquatic productivity has been altered as a result of global phenomena such as ENSO events.	■ Loss of an entire habitat through desiccation or submergence as a result of global change; or ■ Change in the tree or lichen lines; or ■ Major impacts on habitats or biodiversity as the result of increasing frequency of extreme events; or ■ Changing in ocean or coastal currents or upwelling regimes such that plant or animal populations are unable to recover to their historical or stable levels; or ■ Significant changes in thermohaline circulation.
Issue 20: Sea level change "Changes in the last 2-3 decades in the annual/seasonal mean sea level as a result of global change."	■ No evidence of sea level change.	■ Some evidences of sea level change without major loss of populations of organisms.	■ Changed pattern of coastal erosion due to sea level rise has became evident; or ■ Increase in coastal flooding events partly attributed to sea-level rise or changing prevailing atmospheric forcing such as atmospheric pressure or wind field (other than storm surges).	■ Major loss of coastal land areas due to sea-level change or sea-level induced erosion; or ■ Major loss of coastal or intertidal populations due to sea-level change or sea level induced erosion.
Issue 21: Increased UV-B radiation as a result of ozone depletion "Increased UV-B flux as a result polar ozone depletion over the last 2-3 decades."	■ No evidence of increasing effects of UV/B radiation on marine or freshwater organisms.	■ Some measurable effects of UV/B radiation on behavior or appearance of some aquatic species without affecting the viability of the population.	■ Aquatic community structure is measurably altered as a consequence of UV/B radiation; or ■ One or more aquatic populations are declining.	■ Measured/assessed effects of UV/B irradiation are leading to massive loss of aquatic communities or a significant change in biological diversity.
Issue 22: Changes in ocean CO_2 source/sink function "Changes in the capacity of aquatic systems, ocean as well as freshwater, to generate or absorb atmospheric CO_2 as a direct or indirect consequence of global change over the last 2-3 decades."	■ No measurable or assessed changes in CO_2 source/sink function of aquatic system.	■ Some reasonable suspicions that current global change is impacting the aquatic system sufficiently to alter its source/sink function for CO_2.	■ Some evidences that the impacts of global change have altered the source/sink function for CO_2 of aquatic systems in the region by at least 10%.	■ Evidences that the changes in source/sink function of the aquatic systems in the region are sufficient to cause measurable change in global CO_2 balance.

GIWA

The Global International Waters Assessment (GIWA) is a holistic, globally comparable assessment of the world's transboundary waters that recognises the inextricable links between the freshwater and the coastal marine environments and integrates environmental and socio-economic information to determine the impacts of a broad range of influences on the world's aquatic environment.

Broad Transboundary Approach

GIWA recognises that many water bodies and resources, and the human impacts on them, are not confined to a single country.

Regional Assessment – Global Perspective

GIWA provides a global perspective of the world's transboundary waters by assessing regions that encompass major drainage basins and adjacent Large Marine Ecosystems. The GIWA Assessment incorporates information and multidisciplinary expertise from all countries sharing the transboundary water resources of each region.

Global Comparability

In each region, the assessment focuses on five major concerns comprising 22 specific water-related issues.

Integration of Information and Ecosystems

GIWA recognises the inextricable links between the freshwater and the coastal marine environments and assesses them together as an integrated unit. GIWA recognises that the integration of socio-economic and environmental information and expertise is essential in order to obtain an holistic understanding of the interactions between the environmental and societal aspects of transboundary waters.

Priorities, Root Causes and Options for the Future

GIWA identifies the priority concerns of each region, determines their societal root causes and discusses options to mitigate the future impact of those concerns.

This Report

This report presents the results of the GIWA assessment of the Oyashio Current region – one of the most productive waters in East Asia. Changes in the hydrological cycle and ocean circulation have affected the productivity of the fisheries whilst overfishing has depleted commercial fish stocks. The past and present status and future prospects are assessed, and the prioritised issues traced back to their root causes. Policy recommendations are presented as contributions to broader policy processes in the region.

UNEP

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