HUMAN ACTIVITIES IN NORTHEASTERN ASIA AND THEIR IMPACT TO THE BIOLOGICAL PRODUCTIVITY IN NORTH PACIFIC OCEAN

NARITA[a] H., SHIRAIWA[b] T. AND NAKATSUKA[b] T.

a) Research Institute for Humanity and Nature

b) Institute of Low Temperature Science, Hokkaido University

OUTLINE OF RESEARCH PROJECT

1. RESEARCH OBJECTIVES

This is a project assessing the human impacts in the Amur River basin on the marine ecology in the Sea of Okhotsk and the northern North Pacific. The key element supporting the biomass production in the Sea of Okhotsk is considered to be “dissolved iron” from the Amur River. Primary goal of the project is, therefore, to elucidate the mechanism how the dissolved iron and fulvic acids are formed and transported to the ocean both by the Amur River and through the atmosphere, and how the flux changes will affect the phytoplankton production in the Sea of Okhotsk and the northern North Pacific. We will then clarify the anthropogenic impacts on the flux changes to the ocean.

2. METHODOLOGY

1) Distribution and transportation of the dissolved iron in the Sea of Okhotsk and the northern North Pacific will be studied together with the monitoring of phytoplankton production in the same area; 2) we will clarify the balance and flux of dissolved iron through the course of the Amur River by spatial and temporal samplings of the river water; 3) we will conduct biogeochemical investigations in different small drainages in the Amur River basin. The experimental drainage basins include those affected by forest fire, deforestation, agricultural and industrial activities. The above-mentioned basins are compared with control basins which are not suffered by anthropogenic impacts; 4) we will evaluate the spatial and temporal fluctuations in air-borne iron by continuous monitoring of aerosol in the circum Okhotsk coast and by analyses of ice cores from Kamchatka and Alaska; 5) we will reconstruct historical records of land-surface changes in the Amur River basin and analyze the background of the changes by economical, social, and political perspectives; and 6) we will develop a numerical model to simulate the effect of changing fluxes of dissolved iron and fulvic acids on the biomass production in the Sea of Okhotsk.

3. TIME SCHEDULE

2004 (PR): Assessment of the experimental drainages in the Amur river basin; ice core drillings.

2005 (1st): Continuous geochemical monitoring in the experimental sites; research cruise in the Amur River and its estuary region; land-use analyses in the Amur River basin.

2006 (2nd): Research cruise in the Sea of Okhotsk and the northern North Pacific.

2007 (3rd): Research cruise in the Sea of Okhotsk and the northern North Pacific.

2008 (4th): Continuous geochemical monitoring in the experimental sites; research cruise in the Amur River and its estuary region.

2009 (5th): Socio, economical, and political analyses on land-surface changes in Russia and China; development of the marine ecosystem model in the Sea of Okhotsk and its simulations.

4. EXPECTED RESULTS

A guideline of sustainable land-use in the Amur River basin to maintain the present ecosystem in the Sea of Okhotsk will be presented. This will allow us to promote an ideal management of the land-uses in the Amur River basin.

RESEARCH PROJECT PLAN

1. RESEARCH OBJECTIVES

This is a project assessing the role of Amur River on biomass production and the prediction of human impacts in the Amur River basin on the marine ecology in the Sea of Okhotsk and the northern North Pacific. Primary goal of the project is to elucidate the mechanism how the dissolved iron are to be formed and transported to the ocean both by the Amur River and through the atmosphere, and how the flux change of dissolved iron will affect the phytoplankton production in the Sea of Okhotsk and the northern North Pacific. Secondly, we will clarify the anthropogenic impacts on flux changes of dissolved iron to the ocean. Finally, we will present a guideline of sustainable land-use in the Amur River basin to maintain the present ecosystem in the Sea of Okhotsk and the northern North Pacific. More specifically, we will propose so-called “sustainable threshold” on the flux of dissolved iron, which can maintain the biomass production in the Sea of Okhotsk and the northern North Pacific. This will give us an ideal management of the land-use in the Amur-River basin.

2. BACKGROUND

Land-ocean linkage by material transport through rivers is now believed to play a key role for the growth of fish populations in the coastal area. People concerned with fishery and/or environmental conservation begin to plant trees on the areas around the upstream of rivers in order to create the forest so-called as “Uotsuki-Rin” and improve the condition for fish growth in the coastal areas. However, it has not yet been well understood to what extent the material discharged from rivers affect the marine ecosystem, how much and what kinds of materials are exported under various conditions of land surfaces and how far the terrestrial materials affect the off-shore marine ecosystem. Therefore, it is very important to clarify the real relationship between land conditions and marine ecosystem and to predict the changes in land-use by human beings for precise assessments of future changes in marine biological productivities in the ocean. This information will be helpful not only for the people concerned with the “Uotsuki-Rin” but also for most of the people consuming the sea product. In this context, the Amur River basin and the Sea of Okhotsk are the most typical and biggest examples in the world.

The northern North Pacific is known as the ocean of high-nitrate and low-chlorophyll (HNLC) where dissolved macro nutrients (nitrate, phosphate and silicate) in the surface water cannot fully be utilized by phytoplankton because of low availability of iron. Iron is usually supplied to ocean from land surface and is difficult to be transported onto the remote central area of northern North Pacific. The idea was proposed by Martin *et al*. (1989) and is called “the iron limitation hypothesis”. The idea is now being confirmed by a mesoscale *in situ* iron enrichment experiment in the North Pacific (Tsuda *et al*., 2003).

The neighboring Sea of Okhotsk is also characterized by sufficient nutrients supplied by winter convective mixing of surface and deep water. The Sea of Okhotsk is, however, not HNLC region. This is probably because sufficient dissolved iron can be mainly transported from the Amur River. Amur River, including major tributaries like Shilka, Argun, Zeya, Bureya, Songhua Jyang (Sungari) and Ussuri, is 4440 km long and has a drainage area of 1,885,000 km^2. The major part of the drainage area is underlain by boreal forest, mixture-forest and swamps. Lower parts of the drainage is spotted by cultivated land and major cities such as Blagoveshchensk, Harbin, Khabarovsk and Komsomolsk-na-Amure. The relatively less civilized situation of Amur River basin enables the river to transport various kinds of terrestrial materials to the Sea of Okhotsk. Of particular importance is the dissolved iron, which is considered to be originated in an anoxic environment such as swamps.

The dissolved iron is mainly formed as a complex of iron and fulvic acids originating from forest and swamps in the basin. The processes how the dissolved iron is formed, how it is transported to the river, and how it is transported to the ocean, are still uncertainly understood. It is, nevertheless, clear that changes in the land-surface and the river discharge affect the flux of the dissolved iron significantly, because the land surface and the river constitute the source and the way of dissolved iron inputs. This change in the dissolved iron flux affects the biomass production in the Sea of Okhotsk and the northern North Pacific.

The Amur River drainage was historically developed after the end of 19^{th} century in the

Russian part. In Chinese part, *i.e.*, Songhua Jyang basin, intensive human activities dates back to several hundreds years. Accelerated human impacts became more obvious after the middle of 20th century in both side of the Amur River. The area is being disturbed currently by various anthropogenic and natural impacts such as forest fire, deforestation, agricultural and industrial activities, flooding and drought. Land-use changes in the Amur River drainage, therefore, might have caused or may cause significant changes in the flux of dissolved iron, which might or may result in the biomass production changes in the ocean.

The Sea of Okhotsk and the northern North Pacific are known to be one of the most productive ocean in the world. Certain amount of the sea product in Japan owes to this sea, and, more importantly, significant amount of the sea product is imported to Japan from Russia. The ecosystem and environment of the Sea of Okhotsk and the northern North Pacific are important not only with respect to the environment but also the economics in Japan.

3. CONTENTS AND METHODOLOGY

In order to achieve the research objectives mentioned above in five years, we set nine sub-themes. By combining the results obtained from the nine sub-themes, we will be able to propose an ideal management of the land-use in the Amur River basin to maintain the present ecosystem in the Sea of Okhotsk and the northern North Pacific. Followings are the nine sub-themes and their methodologies;

3.1.Physical oceanographic conditions in the Sea of Okhotsk and the northern North Pacific (Group 1: Chief scientist: Masaaki Wakatsuchi)

This theme is to clarify the physical oceanographic conditions in the Sea of Okhotsk and the northern North Pacific which transport the terrestrial materials and supply them for marine organisms. It has been found that two mechanisms transport the water and materials off the river mouth of Amur-River to the northern North Pacific. One is the East Sakhalin Current, which is a western boundary current along the east Sakhalin coast. A part of this current flows eastward as far as Bussol Strait to enter the northern North Pacific. The volume transport of this current is estimated to be in the range 3-10 Sv with the increase from summer to winter (Ohshima et al., 2002; Mizuta et al., 2003). The other mechanism which transport the water and material from the coastal area near Amur River to the Sea of Okhotsk and further to the northern North Pacific is what we call "tidal and brine pump" (Nakatsuka et al., 2002). On the bottom of northwestern continental shelf of the Sea of Okhotsk, very cold dense water due to brine rejection is formed in winter. This water is characterized by enormously high turbidity due to tidal mixing and is transported into the intermediate depth by East Sakhalin Current. By these two mechanisms, the water and the material off the coast of the Amur River is effectively transported to the southern part of the Sea of Okhotsk and further to the northern North Pacific.

In this sub-theme, we will carry out physical oceanographic observations together with the geochemical and biological observations as mentioned below aiming at quantifying the flux of East Sakhalin Current and water exchange across Bussol Strait, all of which are essential to estimate the iron flux in the Sea of Okhotsk and the northern North Pacific. To achieve these objects, we will collaborate with Russian institutes which research vessels are essential in this project.

In the research cruises, we will carry out not only the hydrographical investigations using normal CTD but also the long-term monitoring of water current and material transport using mooring systems equipped with current profilers and sediment traps.

3.2.Geochemical and biological conditions in the Sea of Okhotsk and the northern North Pacific (Group 2: Chief scientist: Takeshi Nakatsuka)

During the previous research expeditions in the Sea of Okhotsk, we have demonstrated that the Sea of Okhotsk is actually not the HNLC region (Nakatsuka et al., 2004) and there are much larger amounts of dissolved iron even in the southern area of the Sea of Okhotsk, which is distant from land, than in North Pacific (Nishioka, unpublished data). However, the following subjects have not been understood at all; what is the source of iron in the Sea of Okhotsk (riverine or atmospheric?), how far the iron is transported from the Sea of Okhotsk to the Pacific Ocean and to what extent the irons actually affect the primary production there.

In this sub-theme, we will conduct research cruises in the Sea of Okhostk and the northern North Pacific Ocean. We will mainly focus on the spatial distributions of chemical and biological properties at the continental shelf areas near Amur River mouth and areas off East Sakhalin coast in the Sea of Okhotsk, and also in the Oyashio region around the Kuril Islands, in order to investigate the source and transport of dissolved iron from the Sea of Okhotsk to the Pacific Ocean precisely. Research cruises are planed to be carried out twice in spring 2007 and fall 2006 in order to investigate the effect of iron for the primary productivity especially in both spring and fall blooming periods of phytoplankton.

Parameters observed during the cruises will contain follows at least. Dissolved and suspended iron, including the size distribution of iron-containing molecules, and their stable isotope ratios which show their origins, riverine or atmosphere. For collecting water samples without any small contamination of iron, we will install the special sampling devises of water for iron measurement. Dissolved organic matter, especially their chemical structures combining the dissolved iron as ligand and their stable and radioactive isotope ratios showing their sources. Major nutrients (nitrate, nitrite, ammonium, phosphate, silicate), dissolved oxygen, chlorophyll-a, which are all essential for the assessment of biogeochemical conditions for phytoplankton growth. Phytoplankton and zooplankton specimen and their population densities collected by plankton nets. Physiological conditions of phytoplankton, such as limiting factors (nitrate or iron) for their growth, monitored by the *in-situ* incubation experiment and the optical analyses of water samples. Temperature, salinity, turbidity and oxygen isotope ratios of water, for investigation of the origins of water masses and materials contained there. Solid and pore water chemistry in the continental shelf sediment, especially to estimate the flux of iron from the sediment to water.

One of the main goals of this sub-theme is the quantitative estimate of the source and transport of dissolved iron in this area. We will prepare two methods for this purpose. One is the detailed analysis of hydrographical properties of water collected for the measurements of iron in order to evaluate the source of the measured water mass, especially to assess the contents of Amur River water and/or Okhotsk Sea water in it. This subject will be achieved together with physical oceanographers in the sub-theme 1. The other is the measurement of iron isotope ratio. Iron isotope ratio has become available very recently by the development of a new analytical instrument (MC-ICPMS) and has potential to distinguish the riverine iron from the atmospheric iron. Because it is very important to estimate the relative contribution of iron from the Amur River for the dissolved iron in the Sea of Okhotsk and northwestern North Pacific, we will challenge to apply this new method in our study.

3.3. Transport of biogeochemical materials from the Amur River to the Sea of Okhotsk (Group 3: Chief scientist: Seiya Nagao)

In our preliminary research, we estimated the flux of dissolved iron from the Amur River to the Sea of Okhotsk as about 2.0×10^{10} g yr^{-1} on the basis of the reported values in other Siberian rivers. This value is very similar to another estimate of dissolved iron flux from the Amur River reported by Russian scientists, who suggest that the Amur River water also has mobile form of suspended iron which is more than ten times as high as dissolved iron flux. These values are obviously higher than the estimated flux of aerosol iron (solid and dissolved) from atmosphere (Uematsu et al., 2003), and seem to exceed the biological demand for the new production in the Sea of Okhotsk. However, because these estimates are based on tentative observation of water chemistry in the estuarine area and do not cover the seasonal and/or inter-annual variation of the flux, we cannot estimate future changes in the iron flux based on the present knowledge. We must clarify the variability of iron flux and its mechanism in this research project.

In this sub-theme, we will conduct three kinds of observation. The first is the continuous water sampling at several fixed station along the Amur River, which will cover the seasonal and inter-annual variations for chemical components including dissolved and suspended iron and dissolved organic matter. Water sampling will be carried out by Russian counterparts (Far Eastern Administration of Hydrometeorology and Environmental Monitoring, Russia) at following sites. Khabarovsk, Komsomolsk-na-Amure, Bogorodskoy and Nikolaevsk-na-Amure. Bogorodskoy is the most important site for assessment of iron flux from the Amur River to the Sea of Okhotsk, because it is the lowest site in the Amur River except for Nikolaevsk-na-Amure, which site is located near the river mouth and usually affected by seawater, not reflecting the riverine iron flux precisely.

The second is the research cruise throughout the Amur River using a Russian research vessel (IWEP) in the Amur River. In order to investigate the source area of any chemical components including iron dissolved in Amur River water, the one-dimensional distributions of the chemical components across the many tributaries like Zeya, Songhua Jyang and Ussuri are very useful. Because the dissolved iron is not only supplied from surrounding land surface but also removed out of the water by deposition onto the river sediment, the budget of dissolved iron is important to clarify the fate of iron in the lower reach of Amur River too.

The third is the research cruise at the Amur Estuary (Amur Liman) using a Russian vessel specialized for the river and estuarine research. Because most of the dissolved iron in river water flocculate and sink down at the estuary due to the increase of ion intensity by mixing with saline water, the real flux of dissolved iron from Amur River to the Sea of Okhotsk cannot be estimated solely by the observation of Amur River itself. Although the estuarine process is tightly connected with the subjects in the sub-theme 2, the oceanic research vessel cannot enter the Amur Estuary due to its very shallow water depths. Therefore, we will conduct the cruise for the estuary separately. In this observation, most of the parameters measured in the sub-theme 2 will be analyzed. Especially, we will focus on the relationship between salinity and iron concentrations in dissolved and suspended forms, emphasizing changes in the molecular and mineralogical characteristics of iron-containing matter and its relationship to the dissolved organic molecules (humic substances) in the course of the increase of salinity. Because the pure dissolved iron, which can not be removed at estuary, must be combined with organic ligands effectively, it is essentially important to quantify the iron-combining organic molecules and determine their sources for understanding of the mechanism controlling the dissolved iron flux from the Amur River to the Sea of Okhotsk.

3.4.Biogeochemical transport from terrestrial ecosystem to the Amur River (Group 4: Chief scientist: Hideaki Shibata)

In order to understand past and future changes in iron flux from the Amur River to the Sea of Okhotsk, the function of the land surface discharging the dissolved iron and the organic matter (humic substances etc.) combining iron as ligand must be understood quantitatively. There are several kinds of land surface in the Amur River Basin, which affect the discharge of iron and humic substances, such as forest, swamp, cultivated area and so on. As for the forest, recent human activities have disturbed the surface condition largely by cutting and/or firing of forest vegetations. In China, huge areas of swamp have been converted to rice paddy recently. In order to estimate the effect of such land-use changes for the material discharge to the Amur River, it is very useful to compare the functions of different kinds of land surfaces. Because there are very large areas of flood plains exchanging not only the water but also materials including iron with river itself around the lower reach of Amur River, it is necessary to investigate the biogeochemical processes occurring in the flood plains and lakes.

In this sub-theme, we will compare the biogeochemical dynamics of iron and related solutes among several sub-catchments which have different types of vegetation and land-use. Since Amur watershed mainly distributed in China and Russia, respectively, the comparative studies in sub-catchments will be conducted in each country under the tight collaboration with researchers in each country. In China, we will focus on the Songhua Jyang River especially to understand the effect of the forest fire and the development of the agriculture and urbanization on dissolved iron and the related solutes. Some monitoring stations in the sub-catchments are already established for the national long-term observation by Chinese researchers (Heilongjyang Hydrological Agency and Northeast Forestry University). We will use these monitoring stations to carry out the seasonal collection of the water sample in this sub-theme. Some Chinese scientists who have studied ecology of forest fire will collaborate with us in this sub-theme to understand the spatial distribution and temporal fluctuation of the fire regime in these monitoring catchments. We will also direct our attention to understand of the effect of the recent land-use change at the "Sanjyang" plain (near the meeting point of the Songhua Jyang, Amur and Ussuri Rivers) on the iron transport from Chinese catchment to the Amur River. The Sanjyang plain has been intensively converted from wet land to paddy field to increase food production during this decade. In Russian side, we will focus on the understanding of the role of the wet land containing peat soil on the iron movement to the Amur River. Stream chemistry (including the legacy data which have been collected by Russian scientists) in the main and sub stream in Amur basin will be compared to analyze the spatial and temporal distribution of the iron and organic solutes under the collaboration with Russian researchers. Soil water and groundwater will be collected to determine the source of iron from the peat soil near the stream using some well, piezometer and lysimeters. We also focus on the effect of fire on the iron dynamics from terrestrial and aquatic ecosystem using the comparative approach of the catchments, including the burned and unburned ecosystems (peat and forest soil). Using some data of vertical distribution of the soil and bedrock chemistry in the geographical maps, spatial distribution of the iron source from the surface and/or deep ground will be analyzed in this sub-theme.

The expected outcomes of this sub-theme will be (i) current concentration and fluxes of iron from terrestrial ecosystem to the Amur River, (ii) to detect the possible source of the iron in terrestrial ground to the River, and (iii) understandings of the effect of the fire, timber production and development of agriculture and urbanization on the iron dynamics in the terrestrial and aquatic continuums in the Amur River.

3.5. Background of the anthropogenic impacts in the Amur River basin (Group 5: Chief scientist: Hiroaki Kakizawa)

We are considering forest fire, forest management, agricultural activity, industrialization, artificial dam construction, and irrigation-induced drought as possible impacts on land surface by human.

The Amur River basin is shared by Russian Federation and the People's Republic of China, and the historical changes of the two countries should have impacted on the land-use policies.

Russian Federation, for example, invested tremendous money to the Far Eastern part of Russia and developed cities like Komsomolsk-na-Amure as a complex city of military and industry during the Soviet Union times. After the change of political regime in the late 1980s, less money has been invested to this region, which drastically changed the economical situation of the Far East. Forestry has been the major industry in this area and logging and forest management activities has deteriorated forest ecosystems. Forest fire caused by human activities also has great impact on forest. Farmland is second dominant category of land use, and farming and drainage activities has greatly impacted on watershed conservation.

In contrast, Chinese territory in the Songhua basin showed remarkable development in economy and population. Rice fields in the Sanjyang plain increased drastically during the last decades by drying the swamps in this region. Chinese economical development has increased import of wood from Siberia, which will in turn change the structure of Russian forest industry.

In this sub-theme we will examine social, political, and economical underlying causes for the changes in the land-uses and degradation of terrestrial ecosystem in the Amur River basin.

Firstly, we will examine underlying causes for deterioration of forest resources. The major causes of deterioration in this area are considered as logging operation and forest fire caused by human activities based on our previous research results. Analysis should be conducted on institutional, economic and social sphere. Concerning institutional study, we will analyze how political situation has impacted on forest policy framework and its organization, which influence forest fire protection and distribution of concession for forest use. As, local community plays crucial role for both causes and protection of forest fire, we will also analyze relationship between forest and local community. Concerning economic study, as current Russian timber market is dominated by export to Japan and China, economic analysis will be focused on impact of both of these markets, especially Chinese market, on logging and its related activities. We will also analyze relationship between economic growth and timber demand in China.

Secondly, we will examine underlying causes for agriculture land development and change of use in agriculture land. Concerning China, we will analyze underlying causes for development of agriculture land. For Russia, we will analyze impact of transitional economy on farm management and use of farm land.

These serious themes are, however, nervous issue for outsiders like Japanese. By inviting experts both from Russia and China, we will tackle with this issue to search for the background of driving forces of land-use policies.

3.6.Spatial and historical monitoring of land-use changes in the Amur River basin (Chief scientist: Shigeko Haruyama)

We need information of geographical distribution of land surface in the whole Amur River basin, in order to quantify the flux of dissolved iron in the basin. High-resolution geomorphologic land condition map of the alluvial plain will be important for this theme. Firstly, we have to make the geomorphologic land classification map in order to show the morphologic structure of the whole watershed area by means of satellite data and aerial photos interpretations. Secondly, based on the geomorphologic condition, Holocene alluvial sediment transport, river bed morphology and historical changes of the river courses of the Amur River and its branches should be clarified. Third, land use and land use changes are described on the alluvial geomorphologic structure. The land use has been rapidly changed in the Sang Jyang plain in China for developing rice field and we have to carefully monitor flood plain history in China.

This task can only be realized by compilation of historical thematic maps, statistical data, satellite images, and intensive ground truth observations. This sub-theme try to compile spatial variabilities of land-surface and land-uses in the Amur River basin with a help of Geographical Information System (GIS). A series of topographic maps with various scales, and thematic maps including information on forest, agriculture farm lands with different crops, land-uses for urbanization areas and villages, and natural landforms are essential materials for this compilation. Satellite images such as MSS, TM and ETM of LANDSAT, AVHRR of NOAA and MODIS of Terra are available for this vast region for the recent decades. AVHRR of NOAA is especially informative because the data is obtained everyday in Japan and shows various changes of the land surface such as forest fire. We will present the current surface condition in the Amur River basin mainly by the satellite images and compares it with the information obtained from historical archives both in Russia and China. The historical data and materials are generally difficult for Japanese to use, therefore, we have to collaborate with experts both from Russia and China. All the information obtained in this project will be presented by GIS for the easy access to the data base.

3.7.Estimation of atmospheric transports of terrestrial material (Group 7: Chief scientist: Takayuki Shiraiwa)

Beside the transportation of dissolved iron through the Amur River, certain amount of iron is believed to be transported to the Sea of Okhotsk and the northern North Pacific through atmosphere. The air-borne iron, associated with other inorganic constituents, is considered to be the only one source of input in the central part of the northern North Pacific. In fact, it was found that a near doubling of biomass production was observed in the mixed layer in the North Pacific over a 2-week period after the passage of a cloud of Gobi desert dust (Bishop et al., 2002). It is, therefore, necessary to estimate the contribution of atmospheric transport of iron to the biomass production in the Sea of Okhotsk and the northern North Pacific. There are two ways to quantify the flux of air-borne iron and other constituents. One is real-time monitoring of the aerosol by using network of automatic aerosol samplers distributed along the coast of the Sea of Okhotsk. Uematsu et al. (2003) quantified the flux of aerosol from the Eurasian continent to the North Pacific by this way. The other way is to reconstruct aerosol flux by means of ice core analyses. Glaciers developing in the high mountains of Kamchatka and Alaska record continuous time-series of dry and wet deposition of aerosol over several hundreds years (Shiraiwa et al., 2002; 2003; 2004). We identified a peak of iron associated with the April 2001 dust event in the ice core from Mount Logan, Canada. Those glaciers are cold enough to prevent vertical migration of the deposited matters so that the high resolution records of iron deposition can be reconstructed with year to year resolution.

In this project, we will monitor the spatial distribution of the iron and inorganic fluxes by the network of automatic aerosol samplers extended to the coast of the Sea of Okhotsk for at least three years. The samplers will be maintained by local staffs of the Far Eastern Administration of Hydrometeorology and Environmental Monitoring. Japanese members visit each site at least once a year and collect the samples. The collected samples will be analyzed in Japan. Beside the automatic monitoring, three ice cores will be drilled and analyzed for the reconstruction of iron flux history for the last several hundreds years. The ice cores will be drilled at Mount Wrangell, Alaska (fiscal year 2004), Mount Ichinsky, Kamchatka (fiscal year 2005) and Mount McKinley, Alaska (fiscal year 2008). Those three mountains are located behind the Sea of Okhotsk and the northern North Pacific, and are suitable to catch the dust record supplied from Asian continents. The drilled ice cores will be transported to Japan for the analyses of various constituents including iron. The time-series of iron fluxes to the Sea of Okhotsk and the northern North Pacific for the last several hundreds years will be provided as outcome.

3.8.Natural variability of the hydro-meteorological and hydro-chemical conditions in the Amur River basin (Group 8: Chief scientist: Yoshihiro Tachibana)

The knowledge of the natural variability of the Amur River discharge provides us the basis of understanding the interaction between the anthropogenic and natural influences. However, we are yet at far even from the starting points. The discharge of the Amur River is quite important not only for understanding variation of the chemical components to the Sea of Okhotsk but also for understanding the physical oceanographic condition of the Sea of Okhotsk. Highly stratified ocean surface layer, for example, is brought by the fresh water flux from the Amur River as well as the precipitation over the Sea of Okhotsk. This highly stratified condition may influence the surface ocean currents, whose role on the horizontal transport of dissolved minerals is quite important. In addition, the highly stratified ocean surface layer is favorable for the formation of the sea ice, which may important for the climate around the Sea of Okhotsk.

In this sub-theme, we will investigate different two time-scales of natural variability. One is the decadal scale change, which interacts the human activity and must be estimated quantitatively for assessment the anthropogenic effect separately. The other is the millennium scale change covering the whole Holocene period, in which both of the Amur River Basin and the Sea of Okhotsk actually experienced large changes of natural environments, possibly providing us of the insight on the effect of large scale land-use change in the Amur River Basin to the biological productivity in the Sea of Okhotsk.

As for the former time-scale, time-series of the discharge are available at the lowermost part of the Amur River, which shows large variations with multi-years frequency. The variation is considered to have been controlled by large scale changes in atmosphere-land-ocean interactions (Ogi et al., 2001). We will clarify the interactions by analyzing synoptic scale atmospheric data such as NCEP and ECMWF re-analysis data and satellite data. Main goals are to clarify what kinds of the large-scale atmospheric patterns are in association with the interannual variation of the Amur River, to clarify the existence of the inter-decadal and century time scale trends associated with natural global climatic variations, and to assess whether these large-scale atmospheric patterns are related to the global warming. Another important processes influencing on the surface physical conditions of the Sea of Okhotsk is the thermodynamic and hydorological air-sea interactions over the Sea of Okhotsk. The air-sea interaction processes are mainly composed of two processes; one is the precipitation/evaporation over the Sea of Okhotsk along with the Amur River Basin, and another is the surface heat flux in these regions. An unsolved important air-sea interaction process is the existence of the marine fog covering the Sea of Okhotsk during summer. The dense marine fog, for example, intercepts the solar insolation, which may influence the primary production of the ocean and may influence the ocean temperature. To uncover the vertical structure of the marine fog, we plan an atmospheric upper air observational study using the radiosonde over the Sea of Okhotsk.

Another impact that changed the discharge of Amur River was anthropogenic disturbances. Extension of rice fields in the San Jyang plain, for example, might have changed local hydrological condition of Songhua Jyang River. Because the discharge from Songhua Jyang River constitutes 25 % of that of Amur River, the hydrological changes in the Songhua Jyang River should be seriously studied.

We will collect hydrological and hydrochemical data obtained by Russian and Chinese institutions so far. According to our preliminary survey, Russia has been measuring the water discharge and the chemical properties, including dissolved iron and organic matter, of Amur River at least at 7 stations. China has several stations for Songhua Jyang River, too. By analyzing these hydrological and hydrochemical data based on a large scale of hydrological model with chemical components, we will quantify contribution as well as its historical changes of each tributary to the total water discharge and material flux of the Amur River.

On the latter time-scale, we have demonstrated in our previous studies that the Sea of Okhotsk has experienced a large change of phytoplankton productivity throughout the Holocene period (Narita et al., 2002; Seki et al., 2004; Koizumi et al., 2003). In the early half of Holocene, the phytoplankton community in the Sea of Okhotsk had been dominated by coccolithophorid, but from 6,000yrs ago, the contribution of diatom increased rapidly and it has occupied most of phytoplankton production, supporting the large biological productivity in the present Sea of Okhotsk. In general, the diatom requires larger amounts of iron than coccolithoporid. Land surface conditions in the Amur River Basin must have gradually changed throughout the period after last glacial maximum such as enlargement of forest areas and formation of peat and soil. Therefore, if the millennium scale of changes in land surfaces had made conditions preferable to increase the iron discharge from the Amur River to the Sea of Okhotsk, it may explain the increase of diatom in the latter half of Holocene in the Sea of Okhotsk.

In this sub-theme, we will collect not only the ocean sediment cores for assessment of past changes in marine productivity but also the peat cores ranging over last 10,000 years at sites around the lower reach of the Amur River to investigate the past changes in vegetation and their relationship to the marine productivity.

3.9.Modeling of biomass production in the Sea of Okhotsk and northern North Pacific (Group 9: Chief scientist: Hiroyuki Matsuda)

The final goal of our project is the quantitative estimate of the influence of land-use changes in the Amur River Basin to the marine biological productivity in the Sea of Okhotsk and the northwestern North Pacific Ocean. We are now assuming that the influence occurs as a result of change in the rate of iron discharge from the Amur River. However, it is not a simple task to evaluate quantitatively the effect of change in iron discharge rate to the marine productivity. There are also other important limiting factors for the primary productivity in the

Sea of Okhotsk, such as the winter convective mixing supplying major nutrients to surface water from deep layers, the duration of sea-ice in spring suppressing the occurring of spring phytoplankton bloom, the fresh water contents in surface water intensifying the water stratification and improving the light conditions for phytoplankton, and so on. The overall effect of changes in iron supply to marine primary productivity must be evaluated on the basis of the concept considering other all important limiting factors.

In this sub-theme, we will produce a comprehensive marine ecosystem model of the Sea of Okhotsk to evaluate quantitatively the effect of change in supplies of terrestrial materials such as iron to the primary productivity in the Sea of Okhotsk. At present, the model includes the nitrogen-based ecological processes in surface water consisting of the major nutrients, phytoplankton, zooplankton and detritus in addition to the physical oceanographic processes such as water currents, water mixing and sea-ice distributions based on numerical physical simulations at fine scales of horizontal and vertical grids. In this study, the iron will be introduced as a new component as one of the limiting factor for the phytoplankton production. In order to validate the model functions, the data of zooplankton biomass and sinking particle flux observed in the study of sub-theme 2 will be compared to the model outputs after the research cruises.

4. EXPECTED RESULTS

The following results will be expected by the termination of present project in the fiscal year 2009;

1) Quantitative estimates of East Sakhalin Current and water exchange through Bussol Strait;
2) Quantitative estimates on distribution of concentration of dissolved iron in the Sea of Okhotsk and the northern North Pacific;
3) Seasonal and inter-annual variations on concentration of dissolved iron through the course of Amur River;
4) Processes how the dissolved iron is formed in different land surfaces in the basin;
5) Geochemical reaction with regard to dissolved iron during the transportation in Amur River and Amur Estuary;
6) Impact of land-use changes on the formation of dissolved iron;
7) Spatial distribution of land surface in the Amur River basin;
8) Historical changes of land surface and land-uses in the Amur River basin;
9) Sociological, economical, and political backgrounds behind the land-use changes in the Amur River basin;
10) Spatial and historical changes of aerosol and iron fluxes in the Sea of Okhotsk and the northern North Pacific;
11) Contribution of air-borne iron to phytoplankton production in the Sea of Okhotsk and the northern North Pacific;
12) Contribution of dissolved iron from Amur River to phytoplankton production in the Sea of Okhotsk and the northern North Pacific;
13) Assessment of natural variabilities in climate and hydrological conditions in the Amur

River basin

14) Assessment of anthropogenic impacts on the discharge of Amur River;

15) Simulation model on phytoplankton production in the Sea of Okhotsk and the northern North Pacific with reference to various dissolved iron fluxes.

By summarizing these results, we will propose so-called **“sustainable threshold”** on the flux of dissolved iron, which can maintain the biomass production in the Sea of Okhotsk and the northern North Pacific. We will finally propose an ideal management of the land-use in the Amur-River basin to the related institutions.

5. OUTCOME UP TO NOW

The research team has been organized. The research members were selected from the most outstanding experts from various institutions in Japan. Theme of the project was discussed through four meetings during the incubation stage (year 2002) and three meetings during the feasibility stage (year 2003). A report describing the sub-themes on this project as well as meeting summaries was published and distributed in December 2003 (Appendix 1). Two preliminary research trips were carried out in search for international collaborations and information on available data-set in the fiscal year 2003: one to Vladivostok/Khabarovsk by T. Shiraiwa, T. Nakatsuka and Y. Tachibana, and the other to Changchun / Harbin / Khabarovsk by T. Shiraiwa, T. Nakatsuka, H. Shibata, M. Yoh and S. Haruyama. Reports on the two preliminary research trips were prepared and distributed (Appendix 2). The implementation plan of the project was made according to the discussions and results obtained by January 2004 (This report). A Web site introducing the present project was started (http://glacier.lowtem.hokudai.ac.jp/~shiraiwa/amur/index.htm). An international workshop is to be planned in March 3-4, 2004 in Kyoto to confirm the implementation plan among the project members and the international collaborators. Six Russian and one Chinese collaborators will be invited to Kyoto to discuss the plan more in detail.

5.1. Meetings held during the feasibility stage (fiscal year 2003)

April 19-20 (Sapporo)

Outline of the Amur-Okhotsk Project	T. Shiraiwa
Characteristics of the physical properties of the Sea of Okhotsk	M. Wakatsuchi
Minor metals supporting the marine biomass production	K. Kuma
Supply of terrestrial materials to ocean	S. Nagao
Mechanism of fluctuations in fish resources	H. Matsuda
Forest and its management in the Amur River Basin	H. Kakizawa
Discussion on time-schedule on oceanographic observation	T. Nakatsuka
Discussion on human impacts on the Amur River Basin	S. Haruyama
Discussion on background of land-use changes in the Amur River Basin	A. Iwashita
Discussion on realization of feasibility study	H. Narita

August 26-27 (Sapporo)

Report on advancement of feasibility study — T. Shiraiwa
Report of PICE international symposium at Vladivostok — Y. Tachibana
Biogeochemical study on river and soil — M. Yoh
Numerical model on biomass production in the Sea of Okhotsk — M. Kishi
Preliminary observation of iron concentration in the northern North Pacific — K. Kuma
Introduction of LUCC (Land-Use and Land-Cover Change) — Y. Himiyama
Discussion on the sub-themes of Amur-Okhotsk Project — T. Shiraiwa

November 10-11 (Kyoto)

Foreword — T. Hara
Report on advancement of feasibility study — T. Shiraiwa
Structure and dynamics of phytoplankton in the northern North Pacific — K. Suzuki
Why the western part of the northern North Pacific is iron-limitation region? — J. Nishioka
Introduction of the project on "Vegetation changes in Siberia since the Last Glaciation" — H. Takahara
Atmospheric transport of Asian terrestrial materials to the Sea of Okhotsk — M. Uematsu
Discussion on backgrounds of anthropogenic impacts in the Amur River Basin — H. Kakizawa
Discussion of spatial variabilities of land-uses in the Amur River Basin — S. Haruyama
Discussion of mechanism on material transport in the Amur River Basin — H. Shibata
Discussion of material transport and flux in the Sea of Okhotsk — T. Nakatsuka
Discussion of natural variability assessment in the Far East — Y. Tachibana

5.2. Preliminary research trips

Two research trips to Russia and China were carried out during the feasibility stage in the fiscal year 2003. The first trip was made by T. Shiraiwa, T. Nakatsuka and Y. Tachibana who visited the following institutions in Russia from December 2 to 11, 2003; Far Eastern Branch of Russian Academy of Science (Vladivostok), Pacific Institute of Geography (Vladivostok), Far Eastern Regional Hydrometeorological Research Institute (Vladivostok), Institute of Water and Ecological Problems (Khabarovsk) and Far Eastern Administration of Hydrometeorology and Environmental Monitoring (Khabarovsk).

Second trip was made by T. Shiraiwa, T. Nakatsuka, H. Shibata, S. Haruyama and M.

Yoh who visited Northeast Institute of Geography and Agriculture Ecology, Chinese Academy of Sciences (Changchun); Northeast Forestry University (Harbin); Institute of Water and Ecological Problems, Russian Academy of Sciences (Khabarovsk); and Far Eastern Administration of Hydrometeorology and Environmental Monitoring (Kahabarovsk) from January 17 to 23.

We discussed with representative scientists from each institution about the way of collaborations, archived data and documents, available facilities, devices, vessels, and human resources. From the discussions as well as written communications with additional institutions, we have constructed an international collaboration frame work of this project as shown in the following table;

Table1. International collaborators

Name	Affiliation	Position	Role
SERGIRNKO, Valentine	Russian Academy of Sciences, Far Eastern Branch	Chairman	Atmospheric chemistry
VORONOV, Boris A.	Russian Academy of Sciences, Far Eastern Branch, Institute of Water and Ecologocal Problems	Director	Conservation of the Amur River basin
MAKHINOV, Alexey N.	Russian Academy of Sciences, Far Eastern Branch, Institute for Water and Ecologocal Problems	Deputy Director,	Hydrology of the Amur River
KONDRATJEVA, Lyubov	Russian Academy of Sciences, Far Eastern Branch, Institute of Water and Ecologocal Problems	Professor	Biogeochemistry of Amur River
SOROKIN, Anatoly P.	Amur Scientific Center, Branch of Regional Geology and Hydrogeology	Chairman, Director	Hydrogeology of Amur River
VOLKOV, Yuri N.	Far Eastern Regional Hydrometeorological Research Institute	Director	Physical Oceanography in the Sea of Okhotsk
GAVRILOV, Alexandr V.	Far Eastern Administration of Hydrometeorology and Environmental Monitoring	Head of administra tion	Hydro-meteorological data management
BAKLANOV, Peter Ya.	Russian Academy of Sciences, Far Eastern Branch, Pacific Geographical Institute	Director	Economic Geography
KACHUR, Anatoli N.	Russian Academy of Sciences, Far Eastern Branch, Pacific Geographical Institute	Professor	Atmospheric chemistry
GANZEI, Sergry S.	Russian Academy of Sciences, Far Eastern Branch, Pacific Geographical Institute	Deputy Director	Land-use changes in the Amur River basin
SHI Fuchen	College of Life Sciences, Nankai University	Professor	Forest ecology
Hu Haiqing	Northern Forestry University, College of Forest Resources & Environment, Forest Fire Institute	Director	Fore fire in the Heilongjyang River
GUO qingxi	Northern Forestry University , College of	Professor	Forest Hydrology and

	Forest Resources & Environment, Forest Fire Institute		GIS modeling
CAI Tijiu	Northern Forestry University , College of Forest Resources & Environment, Forest Fire Institute	Professor	Forest Hydrology
GU Jinfeng	Northern Forestry University , College of Forest Resources & Environment, Forest Fire Institute	Master	Forestry
LI Tao	Heilongjyang Hydrological Agency	Mr.	Hydrology
WO Wenwei	Heilongjyang Hydrological Agency	Mr.	Hydrology

6. TIME SCHEDULE

6.1.Pre-Research (PR) the fiscal year **2004**

Two workshops are planned during the fiscal year 2004. One will be held in Kyoto in April to discuss the problems related to Sungari River (Songhua Jyang) with Chinese colleagues. The other will be held in Kyoto in January 2005 to summarize the activities and discuss future plan with Russian and Chinese colleagues. The other activities are follows;

Group 1-2: Research strategy will be discussed between the Japanese members and Far Eastern Regional Hydrometeorological Research Institute at Vladivostok. Analyses of dissolved iron and the related organic matters will be made by using pre-sampled water from the study region.

Group 3: Collection of geochemical data in the Amur River, which was monitored by Far Eastern Administration of Hydrometeorology and Environmental Monitoring. A preliminary research expedition to the Amur River and its estuary will be planned.

Group 4: Selection of the experimental drainage basins is planned. At least four basins will be assessed by Japanese, Russian, and Chinese members; Amur River basin to test forest fire impact, Khabarovsk Peat land to test peat fire impact, Sang Jyang Plain to test agricultural impact, Panku-chin River to test deforestation impact.

Group 5: Data collection on Russian and Chinese logging operation and forest fire.

Group 6: Data collection on satellite images (MODIS, NOAA, LANDSAT) covering Amur River drainage, and their interpretations.

Group 7: Selection of the aerosol monitoring sites is planned. At least four sites will be assessed by Japanese and Russian members in the coastal area surrounding the Sea of Okhotsk. An ice core of 300-m in length will be drilled at Mt. Wrangell, Alaska, in order to quantify the flux of air-borne iron into the ocean.

Group 8: Data collection will be planned. These include discharges of various tributaries and main stream of the Amur River drainage.

Group 9: Development of the comprehensive marine ecosystem model of the Sea of Okhotsk.

6.2.Full-scale Research the fiscal year **2005**

Group 1 and 2: Preliminary study on iron isotopes in sea water will be planned in order to distinguish riverine from atmospheric dissolved iron. Assessment of the research vessel will be done by Japanese members at Vladivostok.

Group 3: A research expedition will be planned by using vessels of Institute of Water and Ecological Problems to study the balances and fluxes of dissolved iron and fluvic acids in the Amur River. In situ and laboratory analyses on the water sample will be conducted. Routine water sampling will be conducted by Far Eastern Administration of Hydrometeorology and Environmental Monitoring and by Heilongjyang Hydrological Agency.

Group 4: Installation of automatic hydrometeorological and water sampling stations will be established in the four experimental sites. Continuous water chemistry monitoring will be started in four different experimental basins.

Group 5: Field work on the situation of forest logging and forest fire will be planned. Hearing from local and central organizations will be conducted both in Russia and China.

Group 6: Compilation of the time-series of satellite images will be attempted to produce a large-scale historical land-surface changes in the Amur River basin.

Group 7: Installation of automatic aerosol samplers will be conducted at least four sites surrounding the Sea of Okhotsk. An ice core will be drilled at Mt. Ichinsky, Kamchatka, to reconstruct a high-time resolution record on iron flux.

Group 8: Large-scale hydrological model will be developed to understand impact of discharge fluctuations on the balance and fluxes of dissolved iron and fluvic acids. Several river- and lake bottom sediments will be drilled in order to study historical changes in suspended sediment including particulate iron.

Group 9: Development of the comprehensive marine ecosystem model of the Sea of Okhotsk.

6.3.Full-scale Research the fiscal year **2006**

Group 1 and 2: Major research cruise will be operated in the Sea of Okhotsk and the northern North Pacific in autumn. These cruises will conduct hydrographical investigations using CTD and start long-term monitoring of water current and material transport using mooring systems. Main study topic during the cruises is the geochemical observation which include dissolved and suspended iron, dissolved organic matters, major nutrients, dissolved oxygen, chlorophyll-a, phytoplankton and zooplankton.

Group 3: Routine sampling of river water and its analyses.

Group 4: Maintenance of the experimental drainage basin and the analyses of water, groundwater, soil, peat samples.

Group 5: Field work at Sang Jyang Plain to study current agricultural activity. Discussion with governmental institutions will be planned to study the Chinese policy in developing and conserving the Sang Jyang Plain.

Group 6: Construction of GIS based database on the historical changes in the land-uses in the Amur River basin.

Group 7: Routine maintenance of automatic aerosol samplers. Analyses of ice cores.

Group 8: Analyses of atmospheric-ocean-land surface interaction in the Amur River basin and the Sea of Okhotsk. Sea sediment drilling during the course of research cruises in the Sea of Okhotsk and the northern North Pacific.

Group 9: Development of the comprehensive marine ecosystem model of the Sea of Okhotsk.

6.4.Full-scale Research the fiscal year **2007**

Group 1 and 2: Major research cruise will be operated in the Sea of Okhotsk and the northern North Pacific in spring. These cruises will conduct hydrographical investigations using CTD and start long-term monitoring of water current and material transport using mooring systems. Main study topic during the cruises is the geochemical observation which include dissolved and suspended iron, dissolved organic matters, major nutrients, dissolved oxygen, chlorophyll-a, phytoplankton and zooplankton.

Group 3: Routine sampling of river water and its analyses.

Group 4: Maintenance of the experimental drainage basin and the analyses of water, groundwater, soil, peat samples.

Group 5: Field work at Ta-Shin-Angring Mountains to study forest fire and deforestation. Discussion with governmental institutions will be planned to study the Chinese policy in conserving Ta-Shin-Angring Mountains.

Group 6: Construction of GIS based database on the historical changes in the land-uses in the Amur River basin.

Group 7: Routine maintenance of automatic aerosol samplers. Analyses of ice cores.

Group 8: Sea sediment drilling during the course of research cruises in the Sea of Okhotsk and the northern North Pacific. Palynological study in the Amur River basin to elucidate the vegetation changes in the last millennium.

Group 9: Sensitivity test of the comprehensive marine ecosystem model. Economical evaluation of historical changes in fish production from the Sea of Okhotsk.

6.5.Full-scale Research the fiscal year **2008**

Group 1 and 2: Analyses of data and samples

Group 3: A research expedition will be planned by using vessels of Institute of Water and Ecological Problems to study the balances and fluxes of dissolved iron and fluvic acids in the Amur River. In situ and laboratory analyses on the water sample will be conducted. Routine water sampling will be conducted by Far Eastern Administration of Hydrometeorology and Environmental Monitoring and by Heilongjyang Hydrological Agency.

Group 4: Intensive observation in four experimental drainage basins.

Group 5: Synthesis of political, economical, and sociological underlying causes behind changes in land-uses in the Amur River basin.

Group 6: Construction of GIS based database on the historical changes in the land-uses in the Amur River basin.

Group 7: Routine maintenance of automatic aerosol samplers. An ice core will be drilled at Mt. McKinley, Alaska, to reconstruct a high-time resolution record on iron flux.

Group 8: Analyses of atmospheric-ocean-land surface interaction in the Amur River basin and the Sea of Okhotsk.

Group 9: Simulation of the impact of changing dissolved iron and fulvic acids fluxes on the biomass production in the Sea of Okhotsk and the northern North Pacific by using the comprehensive marine ecosystem model. The simulated results will be discussed by economical and social perspectives.

6.6.Full-scale Research the fiscal year **2009**

All the routine works will be withdrawn this year. Data and the analytical results will be summarized. At least two workshops will be planned to discuss the final outcomes from the present project. We will present the project outcomes and propose a guideline of sustainable land-use in the Amur River basin to maintain the present ecosystem in the Sea of Okhotsk by opening three major symposia in Japan, Russia and China.

7. BUDGETS

A. Total Budgets

(Unit: 1,000 yen)

	FY	Total	Breakdown of the Total					
			① Facility and Equipment	② Supplies	③ Domestic Travel	④ Travel Abroad	⑤ Personnel	⑥Others
PR	FY2004	33,000	5,500	8,500	2,600	5,800	3,100	7,500
Full-Scale Study	FY2005	169,788	78,732	27,248	5,070	10,012	8,258	39,468
	FY2006	143,341	42,151	25,348	5,070	6,630	8,708	55,434
	FY2007	98,993	2,300	20,448	5,070	7,033	8,708	55,434
	FY2008	86,217	2,300	25,448	5,070	11,523	8,258	33,618
	FY2009	65,121	2,300	20,448	5,070	8,736	8,033	20,534
Total		596,460	133,283	127,440	27,950	49,734	45,065	212,988

B. Major Expenses for Facility and Equipment

(Unit: 1,000 yen)

FY	Item	Price	Major Use
2005	3D fluorescence spectrophotometer	5,500	Characterization of dissolved organic matter in river and ocean waters
2005	Sediment corer	5,000	Sampling of sea-bottom sediments
2005	Acoustic releaser	2,500	Recovery of an ocean mooring system
2005	Clean water samplers	3,500	Sampling of clean water for Fe analysis
2005	Workstation	10.000	Numerical simulation of marine ecosystem model
2005	Automatic Hydro-geochemical Observation system	13,566	Automatic sampling and hydrological observations in rivers
2006	Cables for winches	10,000	Samplings of waters and sediments
2006	Cell counter	2,000	Monitoring of phytoplankton cell numbers
2006	Laser Particle Counter	25,000	Analysis on aerosol concentration in ice cores

8. PROJECT MEMBERS

	Name	Affiliation	Position	Role
○	WAKATSUCHI Masaaki	Institute of Low Temperature Science, Hokkaido Uni.	Professor	Physical oceanographic conditions
	KITAGAWA Hiromitsu	Faculty and Graduate School of Engineering, Hokkaido Uni.	Professor Emeritus	Physical oceanographic conditions
	YASUDA Ichiro	Department of Earth & Planetary Science, University of Tokyo	Associate Professor	Physical oceanographic conditions
	OOSHIMA Keiichiro	Institute of Low Temperature Science, Hokkaido Uni.	Associate Professor	Physical oceanographic conditions
	FUKAMACHI Yasushi	Institute of Low Temperature Science, Hokkaido Uni.	Assistant professor	Physical oceanographic conditions
○	NAKATSUKA Takeshi	Institute of Low Temperature Science, Hokkaido Uni.	Associate Professor	Oceanic geochemistry biogeochemical transport from riv to ocean
○	MATSUNAGA Katsuhiko	Yokkaichi Uni.	Professor	River-ocean interaction
	KUMA Kenshi	Graduate School of Fisheries Science, Hokkaido Uni.	Professor	Iron analyses in ocean
	SUZUKI Koji	Graduate School of Environmental Earth Sciences, Hokkaido Uni.	Associate Professor	Ocean biogeochemistry
	NISHIOKA Jun	Central Research Institute of Electric Power Industry, LTD	Researche r	Rare metal analyses in ocean

○	SHIBATA Hideaki	Field Science Center for Northern Biosphere, Hokkaido Uni.	Associate Professor	Biogeochemistry from land to river
○	NAGAO Seiya	Graduate School of Environmental Earth Sciences, Hokkaido Uni.	Associate Professor	Organic matters analyses
	YOH Muneoki	Environmental Conservation, Tokyo Uni. of Agriculture & Technology	Associate Professor	Biogeochemistry from land to river
	ISHII Yoshiyuki	Institute of Low Temperature Science, Hokkaido Uni.	Assistant professor	Hydrological analyses in Siberia
○	KAKIZAWA Hiroaki	Graduate School of Agriculture, Hokkaido Uni.	Associate Professor	Forest management analyses
○	IWASHITA Akihiro	Slavic Research Center, Hokkaido Uni.	Associate Professor	Political analyses on China/Russia
	HARA Toshihiko	Institute of Low Temperature Science, Hokkaido Uni.	Professor	Dynamics of Forest
	OONISHI Hideyuki	Research Institute for Humanity and Nature	JSPS Research Fellows	Minority people in Siberia
	SAKAMOTO Masahiko	Doshin Information Institute, LTD	Researcher	Economics and politics of Russia
	HARUYAMA Shigeko	Graduate School of Frontier Science, Uni. of Tokyo	Associate Professor	Land-use change monitoring
	HIMIYAMA Yukio	Hokkaido Uni. of Education, Asahikawa	Professor	Land-use changes and the background
○	SHIRAIWA Takayuki	Institute of Low Temperature Science, Hokkaido Uni.	Associate Professors	Ice core analyses
○	UEMATSU Mitsuo	Ocean Research Institute, Uni. of Tokyo	Associate Professor	Aerosol analyses
○	NARITA Hideki	Research Institute for Humanity and Nature	Associate Professor	Ice core analyses
	KOSHIMA Shiro	Tokyo Institute of Technology	Associate Professor	Biomass in ice core
	AZUMA-GOTO Kumiko	National Institute of Polar Research	Associate Professor	Chemistry of ice core
	NAKAWO Masayoshi	Research Institute for Humanity and Nature	Professor	Dust variation reconstruction
	TAKEUCHI Nozomu	Research Institute for Humanity and Nature	Assistant professor	Biomass in ice core
	HONDOH Takeo	Institute of Low Temperature Science, Hokkaido Uni.	Director	Ice core analyses
	MATOBA Sumito	National Institute for Environmental Studies		Trace metal analyses in ice cores
○	TACHIBANA Yoshihiro	Liberal Arts Education Center, Tokai Uni.	Associate Professor	Natural variability analyses
	OHATA Tetsuo	Institute of Low Temperature Science, Hokkaido Uni.	Professor	Water and Energy flux in Siberia
	YAMAGATA	Joetsu University of Education	Assistant	Land form development

	Kotaro		Professor	
	TAKAHARA Hikaru	Kyoto Prefectural Uni.	Professor	Pollen analysis
○	MATSUDA Hiroyuki	Graduate School of Environment and Information Sciences, Yokohama National Uni.	Professor	Biomass modelling
○	SAITO Seiichi	Graduate School of Fisheries Science, Hokkaido Uni.	Professor	Satellite monitoring of phytoplankton
○	ARAI Nobuo	Slavic Research Center, Hokkaido Uni.	Professor	Sea product analyses in the Far East
	KISHI Michio	Graduate School of Fisheries Science, Hokkaido Uni.	Professor	Marine ecosystem model
	MUKAI Hiroshi	Field Science Center for Northern Biosphere, Hokkaido Uni.	Professor	Marine ecosystem analyses

9. OTHERS

Appendices 1-2 are attached to this report.

Appendix 1: Amur-Okhotsk Project Report No. 1 (In Japanese)

Appendix 2: Report on Preliminary Research Trip to Russia (In Japanese)

REFERENCES

Bishop, J.K., Davis, R.E., Sherman, J.T., Robotic observations of dust storm enhancement of carbon biomass in the North Pacific, *Science*, 298, 817-821, 2002.

Koizumi, I., K. Shiga, T. Irino and M. Ikehara, Diatom record of the late Holocene in the Okhotsk Sea. *Mar. Micropaleont.*, **49**, 139-156, 2003.

Martin, J. H., R. M. Gordon, S. Fitzwater, and W. W. Broenkow, VERTEX: phytoplankton/iron studies in the Gulf of Alaska. *Deep-Sea Research*, 36, 649-680, 1989.

Mizuta, G., Y. Fukamachi, K. I. Ohshima, and M. Wakatsuchi, Structure and seasonal variability of the East Sakhalin Current, *J. Phys. Oceanogr.*, **33**, 2430-2445, 2003.

Nakatsuka, T., C. Yoshikawa, M. Toda, K. Kawamura and M. Wakatsuchi, An extremely turbid intermediate water in the Sea of Okhotsk : Implication for the transport of particulate organic carbon in a seasonally ice-bound sea. *Geophys. Res. Lett.*, **29**, 10.1029/2001GL014029, 2002.

Nakatsuka, T., T. Fujimune, C. Yoshikawa, S. Noriki, K. Kawamura, Y. Fukamachi, G. Mizuta and M. Wakatsuchi, Biogenic and lithogenic particle flux in the western region of the Sea of Okhotsk: implications for lateral material transport and biological productivity, *J. Geophys. Res.* 2004 (in press).

Narita, H., M. Sato, S. Tsunogai, M. Murayama, M. Ikehara, T. Nakatsuka, and M. Wakatsuchi, Biogenic opal indicating less productive northwestern North Pacific during the glacial ages. *Geophys. Res. Lett.*, **29**, 10.1029/2001GL014320, 2002.

Ogi, M., Y. Tachibana, F. Nishio and M. A. Danchenkov, Does the fresh water supply from the Amur River flowing into the Sea of Okhotsk affect sea ice formation ?, *J. Meteorol. Soc. Jpn.*, **79**, 123-129, 2001.

Ohshima, K. I., M. Wakatsuchi, Y. Fukamachi, and G. Mizuta, Near-surface circulation and tidal currents of the Okhotsk Sea observed with the satellite-tracked drifters, *J. Geophys. Res*, **107**, 3195, doi:10.1029/2001JC001005, 2002.

Seki, O., M. Ikehara, K. Kawamura, T. Nakatsuka, H. Narita, T. Sakamoto, K. Ohnishi and M. Wakatsuchi, Reconstruction of paleoproductivity in the Sea of Okhotsk over the last 30 kyrs. *Paleoceanogr.* (in press).

Shiraiwa, T. and Yamaguchi, S., Reconstruction of glacier mass balances and climate changes in the Kamchatka Peninsula, *Journal of Geography*, 111 (4), 476-485, 2002.

Shiraiwa, T., Goto-Azuma, K., Matoba, S., Yamasaki, T., Segawa, T., Kanamori, S., Matsuoka, K. and Fujii, Y., Ice core drilling at King Col, Mount Logan 2002, *Bulletin of Glaciological Research* , 20, 57-63, 2003.

Shiraiwa, T., Kanamori, S., Benson, C.S., Solie, D. and Muravyev, Y. D., Shallow ice-core drilling at Mount Wrangell, Alaska, *Bulletin of Glaciological Research* , 21, 71-77, 2004.

Tsuda, A. and 25 others, A Mesoscale Iron Enrichment in the Western Subarctic Pacific Induces a Large Centric Diatom Bloom, *Science*, 300 (5621), 958-961, 2003.

Uematsu, M., Z. Wang and I. Uno, Atmospheric input of mineral dust to the western North Pacific region based on direct measurements and a regional chemical transport model, *Geophys. Res. Lett.*, **30**, 1342, doi:10.1029/2002GL016645, 2003.