PROGRESS REPORT OF THE AMUR-OKHOTSK PROJECT 2006

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1. OBJECT AND CONTENTS OF THE PROJECT

The object of the project is to elucidate role of the Amur river on the primary productivity in the Sea of Okhotsk and northern North Pacific, then to evaluate possible human impacts such as land surface disturbances in the Amur river basin on the marine ecosystem of the ocean (Narita and Shiraiwa, 2003, 2004; Shiraiwa, 2005a, 2005b, 2006a, 2006b). In this study, we try to answer following five questions; 1) How the dissolved iron is transported from the Amur river basin to the Sea of Okhotsk and the northern North Pacific through the Amur river and by ocean current ?; 2) To what extent the supply of dissolved iron is regulating the primary production in the Sea of Okhotsk and the northern North Pacific ?; 3) How the land surface disturbance affects on the material circulation in the Amur-Okhotsk system ?; 4) How the human impacts will change the system in the future ?; and 5) How we can conserve this environmental system which expands across the international boundaries ? By solving these five questions, we will propose a new global environmental concept "*Giant" Fish-Breeding Forest*" to conserve the system as collaborative efforts between China, Russia, Mongolia and Japan (Shiraiwa, 2006b).

The Amur-Okhotsk Project consists of nine research groups; 1) physical oceanographic processes; 2) chemical and biological oceanographic processes; 3) biogeochemical process in river; 4) biogeochemical process at land surface; 5) sociological and economical background behind land-use changes; 6) land-use monitoring; 7) atmospheric transport; 8) hydrological processes; and 9) numerical modeling of marine ecosystem. Research groups 1-4 and 7-9 study the production, transport and utilization of the dissolved iron. The groups 5 and 6 analyze historical processes in the land-use changes and background behind the land-use changes occurring in the Amur river basin.

The main target of the project is lower half of the 2.05 million km^2 basin of Amur river and the Sea of Okhotsk plus western part of the northern North Pacific (so-called Oyashio region). The project conducts various types of field observation/research, analyses on biogeochemical samples, satellite monitoring and image interpretation, analyses on historical data, and interviewing from local residents. The collected data will be used for terrestrial hydrogeochemical and marine ecosystem models to simulate how the changing land use affects on the marine ecosystem through iron flux for the future.

The Amur-Okhotsk Project is trying to create a new global environmental concept "Giant" Fish-Breeding Forest by expanding Japanese indigenous idea called "Uotsuki-Rin (Fish Breeding Forest)" which relates upstream forest with coastal ecosystem both physically and spiritually. The idea called "Uotsuki-Rin" has been developed in Japan first as material

linkage between the upstream forest and the coastal ecosystem. The idea was then expanded further to the linkage in humanities inside the system which included fishermen in the coast and foresters and farmers in the upstream. With this idea in mind, fishermen started afforestation in their drainage basin to protect their fishery zone. This movement expanded all over Japan and now it is well known as one of the social movement to conserve local environment.

The physical linkage inside the "Uotsuki-Rin" has not fully established yet, although the humanistic aspects of "Uotsuki-Rin" has been developed further since 1970s. The Amur-Okhotsk Project tries to establish the physical linkage between the Amur river basin and the Sea of Okhotsk and the northern North Pacific with respect to the transport of dissolved iron. The outcome of the project is significant because this will be the first attempt to relate nearly 2 million square km of land surface with open ocean ecosystem much beyond the scale of "Uotsuki-Rin". The proposed system encompasses international boundaries such as Russia, China, Mongolia and Japan. People living in and depending on the system have deferent perspectives on their natural environment. Our project will seek a way how we conserve this vast linkage by studying various flows in the system, which include export and import in economics, cultural interaction, information, and governmental regulations.

2. PROGRESS REPORT

The project aims at clarifying linkage between the Amur river basin and the ocean ecosystem with respect to dissolved iron transport. Role of humanities is essential to conserve this system. We discussed this point in 2006 and decided to consider this topic under the new concept "Giant" Fish-Breeding Forest. Because the materials including dissolved iron flow downward only and there is no transport towards reverse direction. Therefore, the lower end of this system suffers every impact from upward regions. In such one-way flows system, benefit and risk tend to be distributed unevenly. Such inequality can be compensated by introducing different flows beside materials. By looking at various flows among stakeholders in the system, we will propose a conceptual background on which every stakeholder can collaborate for the conservation of the system.

Followings are individual progresses of each group in 2006.

a) Groups 1 and 2

These groups conducted a research cruise in the Sea of Okhotsk in August/September. They succeeded in measuring concentrations and distributions of various types of iron in the Sea of Okhotsk. The observed results showed that "Intermediate-Water Iron Hypothesis" was basically the main mechanism how the dissolved iron from the Amur river was transported to the Sea of Okhotsk and even to Oyashio region. It was supposed in the beginning that transported iron was once deposited in the estuary area of Amur river. However, our bottom-sea coring showed that the transported iron can hardly deposit on the estuary and continental shelf region due to strong tidal current there. This suggests that the transported

iron through the Amur river can immediately be transported into intermediate water layer in offshore region of the Sea of Okhotsk together with dense shelf water.

It was also confirmed that most of the dissolved iron in the Amur river was actually precipitated in the estuary area before penetrating into offshore intermediate layer as particulate iron. We speculated that some part of dissolved iron could be transported to the surface water of the Sea of Okhotsk directly as a complex with terrestrial organic matters, but this direct input of riverine dissolved iron into surface water of the Sea of Okhotsk might not be significant as we anticipated at least in the southern region of the Sea of Okhotsk. Long-range transport into the North Pacific Intermediate Water (NPIW) was found to be the most important process carrying the iron from Amur river to the Sea of Okhotsk and Oyashio region.

b) Groups 3 and 4

These groups conducted routine measurements on the concentration of iron in river water, soil water and ground water at Great and Little Khingan Mountains, Sanjiang Plain, Gassi Lake basin, and Anuy river basin, respectively. Spatial distribution of the concentrations in the dissolved iron was also measured in the Gassi Lake drainage basin where the concentrations of the dissolved iron in the lake and the adjacent wetland was significantly higher than those observed in nearby streams in forested area.

We studied the impact of land-use changes on the production of dissolved iron. In Sanjiang Plain, concentrations of dissolved iron in the interstitial water in the soil horizons were measured repeatedly from May to November in 2006. The highest concentration was always found in natural wetland whereas the lowest was in cultivated dry land. Paddy field showed intermediate concentrations. The concentration of dissolved iron was found to be related with water table too even in the same land-use type. In paddy field, water table solely decides the concentration.

We succeeded in carrying out a research cruise at Amur Liman (mouth of the Amur river) for the first time for foreigners since the beginning of 1800. The team collected water samples at various points of the Amur Liman and Sakhalin Bay. The samples are stored at the Institute of Water and Ecological Problems at Khabarovsk for future analyses.

c) Group 5

Group 5 studied mechanism on forest management and forest industry in Russia and their impacts on the present situation of the mixed forest in the Far East. It was found that the Far Eastern timber cutting is now accelerated by investments both from Russia and overseas and the illegal cutting of deciduous forest was still a serious problem. They also compiled a statistics on export of timber at trading stations between China and Russia.

In order to know the present situation of farming in the Sanjiang plain, group 5 made extensive interview to 76 farmers in Sanjiang plain. Preliminary results show that the farming in this region is not fully sustainable due to shortage of irrigated water, lowering of ground water table, and employment problems. These factors will be examined when we simulate how possible land-use changes affect on the marine ecosystem for the future.

d) Group 6

This group succeeded in compiling electric layers on landform, geology, hydrology, vegetation and land-uses for the whole Amur river basin with a scale of 1/1,000,000. The basic GIS products tell us the present situation of the land surface of the basin. It also shows anthropogenic land-surface disturbances such as dry lands, paddy fields, deforestation, forest fires, huge dams all of which may affect the production of dissolved iron. They also made several field observations as ground-truth for their monitoring of land-use changes by satellite data interpretations. By combining the GIS products and satellite observations, we were able to show recent land-use changes in the Amur river basin.

e) Group 7

Atmospheric transport of iron was quantified from the continuous monitoring by Automatic Aerosol sampler installed at Kamchatka peninsula. We also made an 131-m ice core drilling at the summit of Ichinsky volcano in Kamchatka to reconstruct a longer time record of iron deposition from the atmosphere over the Sea of Okhotsk. The samples are under analyses at present.

f) Group 8

This group started to construct a numerical model to simulate the production and transport of dissolved iron in the Amur river basin. The model consists of three sub-models describing soil water movement, solutes transport and chemical equilibrium. In 2006, we started to develop the sub-model of soil water movement by using a commercial software "GETFLOWS". This model simulates both water velocity and residence time in the Amur river basin.

g) Group 9

Group 9 developed a numerical model to simulate primary production in the Sea of Okhotsk and Oyashio region with special reference to the dissolved iron. They succeeded to simulate distribution of biomass productivity in these regions. However, the ocean model lacks the process of intermediate water transport of iron and thereby the model failed to simulate the actual distributions which are mainly determined by the contributions of intermediate water transport of iron. They will revise the model by including the process in the following years.

We have been carrying out this project as we planed initially but there is a major concern with respect to transport of samples from Russia to Japan. Russian Federation prohibits foreigner to take any samples out from their territory since 2005. We collected so many samples from river, land-surfaces and glacier in 2006. They are currently stocked in our collaborative research institutes. In spite of serious arrangement between Russia and Japan, we have not solved this problem yet. There was no good sign for this issue so far, and we decided last year that we asked related Russian institutes to analyze these samples in Russia.

This will increase our project expenses but we will mange it by reducing other expenses for the future.

3. FUTURE SCHEDULE

As we already mentioned in the previous section, our project is currently carried out as we planed initially. In the remaining 3 years from 2007 to 2009, we will attempt;

1) to quantify the flux of iron from wetlands extending at the middle reach of the Amur river. We need to clarify the present mechanism "how" and "how much" iron is produced in the Amur river basin and "how much" iron is discharged to the Sea of Okhotsk. Then we will predict how human impact will affect on this mechanism;
2) to clarify the mechanism how dissolved iron is incorporated in the river water from various types of land cover. We will conduct several intensive observations in relation to flooding in the Amur river. It is also important to clarify the biogeochemical processes occurring in the river water with respect to dissolved iron. We will quantify the fluxes not only of dissolved iron but also labile iron in the river;
3) to quantify the biogeochemical processes such as aggregation and precipitation in the estuary region of the Amur river;
4) to quantify the mass balance of iron in the continental shelf in the Sea of Okhots;
5) to quantify the transport, precipitation and dissolution of iron in the intermediate water layer in the Sea of Okhotsk and Oyashio regions. This will be an important issue related to solution chemistry controlling solubility of iron by organic ligand in the Intermediate water;
6) to quantify fluxes of iron input through atmospheric transport;
7) to unveil the relationship between dissolved iron and primary production in the Sea of Okhotsk and Oyashio region;
8) to conduct numerical simulations to evaluate the impacts of land-surface disturbance on oceanic primary productivity by means of a terrestrial iron transport model and a ocean ecosystem model including dissolved iron cycle;
9) to compile historical GIS on the land-use changes in the Amur river basin;
10) to unveil background behind intensive land-use changes in the Amur river basin in the 20th century;
11) to construct a framework of *"Giant" Fish-Feeding Forest* to better understand the conservation strategy of the Amur-Okhotsk system;
12) to find a way to conserve the Amur-Okhotsk system for the sustainable use of the marine and terrestrial ecosystems.

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