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# Ecological and Economic Vulnerability of the Marginal Sea to the Global Climate Change - A Comparative Analysis of Regional Environmental Risks in the Japan Sea Rim

By

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**Abstract**

In this paper, we will present the results of a comparative analysis on societal responses to the degradation of environmental quality caused by global climate change and the globalization of regional economies in the area of the Japan Sea Rim. First, we will address both the ecological and socio-economic vulnerability in terms of resource management in this area. The interactions between the economy and environment are measured through an environmental accounting system, focusing on pollution loads from land-based sources. Then, we will discuss societal responses to environmental risks in these marginal coastal areas taking into account the experiences of the Mediterranean Sea and the Baltic Sea.

**Key words:** Climate Change, Global Warming, Environmental Risk, Marginal Sea, Japan Sea, Ecological Vulnerability

## 1. Introduction

The Sea of Japan is a semi-closed marginal sea enclosed by the north eastern coast of the Eurasian Continent, the Korean Peninsula and the Japanese archipelago. This marginal sea has three narrow straits which link it to the outer oceans: the East China Sea via the Korean Strait, the Pacific Ocean via La Perousa (Sôya), and the Tsugaru Strait. (North and South Korea do not accept the name of the sea, the Sea of Japan, because they find a connotation of Japanese colonialism in that name. Instead, they call the sea, "the East Sea" . However, in this paper, we follow the conventional custom for convenience the of average international reader.)

Until recently, the Japan Sea has been under severe political and military confrontations between the East and the West and between the North and the South due to the Cold War. A new trend of the introduction of a market economy to the former Soviet Union and to China has encouraged the Japanese local governments to promote the establishment of economic ties with the coastal areas of these countries as well as with South and North Korea. Also another new wave of global economic grouping in the late 1980's encouraged the local authorities to seek opportunities in forming an economic market across the Japan Sea

**Fig. 1** illustrates the geographical location of these regions surrounding the Japan Sea, which covers fourteen Japanese prefectures, ten Russian Divisions, three Chinese Provinces, and both Koreas. **Table 1** shows populations in each region at a year between 1985 and 1990. The total population in these regions amounts approximately to 300millions. The major socio-economic indicators of these coastal areas show that the area includes approximately 10 percent of the total Asian population and about 20 percent of the whole Asian lands. In that area, the total GNP amounts to approximately 3 trillion dollars in the late 1980's.

Advanced technology and capital in both Japan and South Korea, energy, mineral and wood resources in the Far East divisions of Russia, labor force, energy resource and agricultural products in the Northeast Provinces of China, labor force and mineral resources

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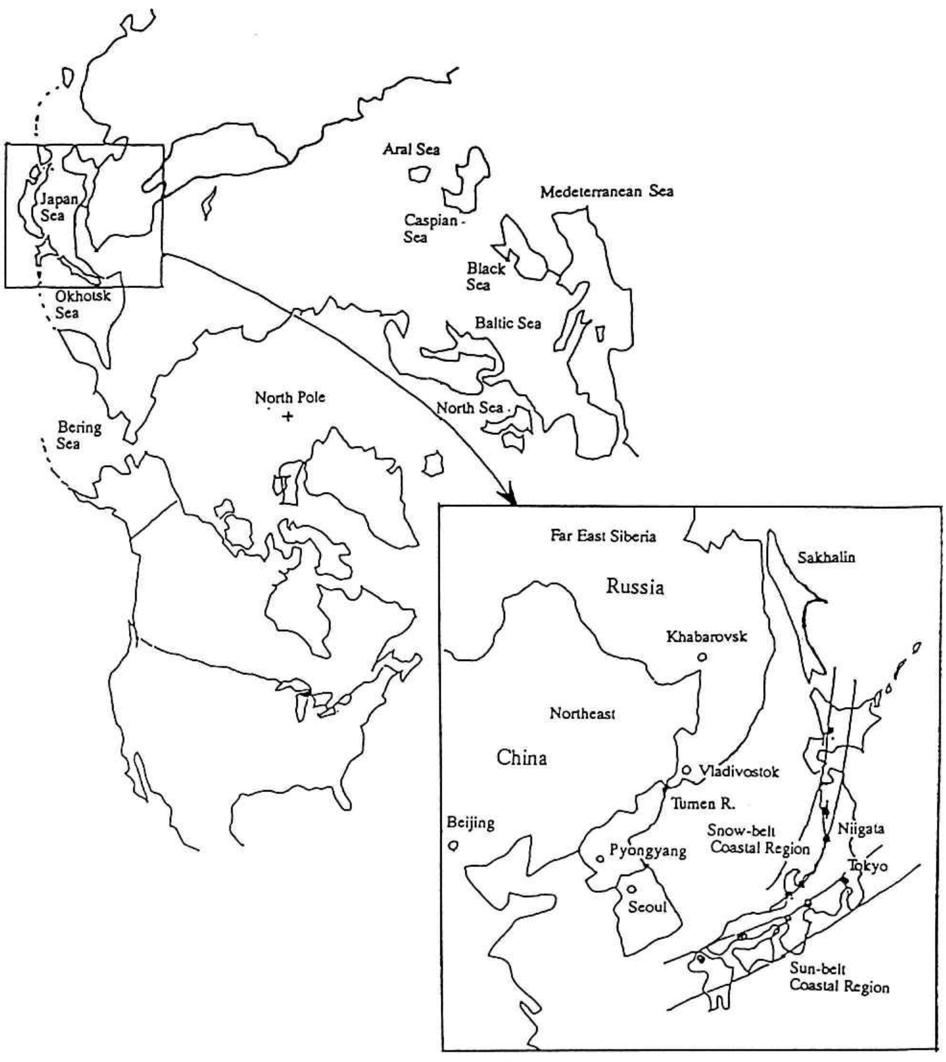


Fig. 1 Geographic location of the regions surrounding the Japan Sea.

in the North Korea : These are expected to become complementarily beneficial factors in promoting transregional interrelationships across the Japan Sea. If the political constraints to form the economic bloc is removed in future, such severe climatic conditions of hard frost and heavy snow could be overcome by introducing modern technology and by making investment to build industrial and civil infrastructures in these regions.

The potential environmental risks in these areas depend not only on development strategies which both the Japanese coastal areas and the outer continental areas will take, but also on the degree of global climatic changes, which is expected to be a warmer one, but with a higher degree of fluctuation to the ecological systems in the coasts, forests, rivers, lakes and the marginal sea. So far we have not got enough data and information so as to determine the levels of ecological and economic vulnerability of the resources in these areas (fishery, minerals, energies, forests etc.) under the global climatic changes and associated sea level rise. Rather, we are interested in assessing the direction of impacts which the expected environmental risks would bring about to the ecological and economic systems of that area through a global climatic change, in other words, our question is whether the regional society of this area would be vulnerable or resilient in future.

In the present context of potential environmental risks in the Japan Sea, our primary concern must be given on whether we could negotiate a fear that the marginal sea is going to be a huge grave yard of accumulating dumped wastes in excess to its purifying capacity of the Japan Sea. The combination of new economic globalization around the sea and potential rise in the sea level could accelerate a risky process before we see such concrete evidences that many other marginal seas (e. g. the Mediterranean Sea and the Baltic Sea) have had beyond their scope of environmental risk management.

Table 1 Population in the nations and regions surrounding the Japan Sea.

| Nation / Region | Population |
|---|---|
| Russia, Far East Divisions (1985) | 9,865,000 |
| Yakut Autonomous Republic | 1,333,000 |
| Buryat Autonomous Republic | 1,000,000 |
| Primorsky Territory | 2,136,000 |
| Khabarovsk Territory | 1,728,000 |
| Amur region | 1,031,000 |
| Kamchatka region | 428,000 |
| Magadan region | 532,000 |
| Sakhalin region | 693,000 |
| China, North East Provinces (1988) | 96,590,000 |
| Heilongjiang | 34,660,000 |
| Jilin | 23,730,000 |
| Liaoning | 38,200,000 |
| Republic of Korea (South Korea) (1988) | 42,593,000 |
| Democratic People's Republic of Korea (North Korea) (1988) | 21,153,000 |
| Japan, 14 Prefectures along the Japan Sea (1990) | 30,983,731 |
| Hokkaido | 5,643,715 |
| Aomori | 1,482,935 |
| Akita | 1,227,491 |
| Yamagata | 1,258,404 |
| Niigata | 2,474,602 |
| Toyama | 1,120,182 |
| Ishikawa | 1,164,627 |
| Fukui | 823,595 |
| Kyoto | 2,602,520 |
| Hyogo | 5,405,090 |
| Tottori | 615,741 |
| Shimane | 781,005 |
| Yamaguchi | 1,572,645 |
| Fukuoka | 4,811,179 |

In this paper, we use a systems analytical framework in order to examine a set of scenarios on global environmental impacts, which is based on the Coastal Economic-Ecological Models (Ikeda, 1987) and is elaborated in detail in section two. The third section is devoted to an overview of the marginal sea in connection to the possible global climate change. The major risk issues are analyzed in sections four and five, which focus on the ecological and economic vulnerability of the Japan Sea. The final section will discuss the societal responses to the potential risks for implementing an international management scheme in this region.

## 2. A Framework of this Study : Regional Vulnerability and Resilience to the Climate Change as Indicators of Environmental Risks

In the beginning, we define vulnerability and resilience of a regional society to external disturbances. The concept of "vulnerability" can be explored in various ways, as biophysical conditions of the living environment, as social and political conditions of the social institutions, and as health and demographic conditions of the regional society. The definitions we use in this paper are based on systems analytic approach to hazard and risk management (Timmerman, 1981) :

**Regional vulnerability** : a degree of inability for a regional society to cope with the occurrence of a hazardous event,

**Regional resilience** : a degree of ability for a regional society to absorb and recover from the occurrence of a hazardous event.

In order to carry out such risk analysis of regional vulnerability and resilience to global environmental risks in the coastal areas, we need a conceptual model of regional society which includes at least economic system of utilizing coastal resources, and ecosystem to be exploited or preserved. **Fig. 2** presents such a conceptual model that formulates multifarious actions and responses between economic and ecological systems as a framework of risk analysis on regional vulnerability and resilience. In this conceptual model, we suppose that economic system seeks to maximize utility and efficiency of the regional society by utilizing marine resources, and ecological system pursues dynamic resilience in material and energy flows within the system. Major regional responses to the global environmental risks are analyzed through the following three submodels, which work as an interface between economic and ecological models. These submodels are :

1) Resource and environmental constraint model,
2) Waste (pollution) control model,
3) Multiple resource demand model.

The first model is concerned with resource sustainability or environmental capacity of purification services in ecological system as a critical factor of evaluating regional vulnerability and resilience. The regional vulnerability will be understood in a way that

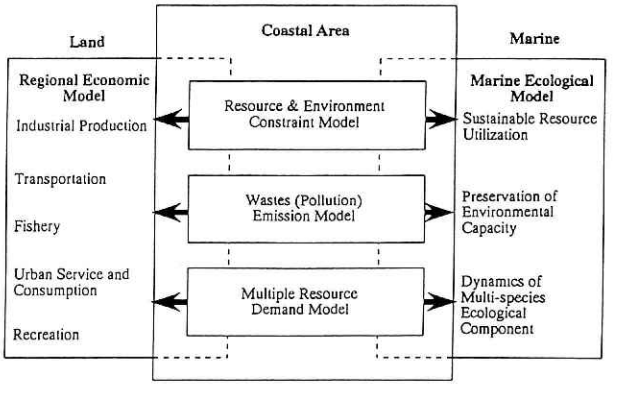


Fig. 2 A Conceptual structure of economic-ecological model for comparative analysis of regional environmental risks.

the interface between these two systems does not work adequately in order to respond the outer disturbances. The second model aims at estimating the amount of wastes to be discharged into the ecological system. The last model seeks to estimate various resource exploitation demanded by multiple sectors in a regional economic system. Water and fishery resources are the typical ones in which both quantity and quality of the resources, such as clean water or fishes of toxicity free, will be required.

In building such a regional economic-ecological model, we have some important systems management issues of environmental risks (Ikeda, 1987). The first issue is the way to structure a regional vulnerability in the context of the three submodels discussed above which link economic and ecological systems: the resource demand, wastes discharged and resource constraints. Here, for simplicity, we focus only two vulnerability issues: ecological and economic vulnerability that Kasperson and Dow (1991) elaborated in discussing their spatial equity problem.

Secondly, risk information, that is, a detailed context of uncertainty about resource demand or consumption play a critical role in the conceptual model, but in a different way in economic and ecological system. The economic system in either market mechanism or planned one does not adequately carry risk information on environmental goods and services to the society, which includes a limitation of environmental purifying capability of the coastal water. Rather, such information is asymmetrically owned between beneficiary and victims of environmental degradation, and between the supply side and the demand side of environmental goods and services. Such asymmetry on risk information gives biases to various economic actors (industries, consumers, and administrators) for their decision-making to negotiate a societal response to regional environmental risks. In the ecological system, a kind of risk information as a form of biodiversity or entropy, has a high degree of heterogeneity and uncertainty in its space and time. Each ecological component has a wide variety of efficiency of utilizing energy or biomass that is hard to be explicitly transmitted.

The third issue is accountability of system agents or decision-makers in the regional society to respond the fear of total ecological collapse of the regional society in future. The role of economic actors and ecological agents are widespread in the complex reality of the pluralistic society: From a rational economic man who seeks to maximize economic utility, socially active existence which pursues innovation through creative activities and up to biological man who acts passively in natural food linkages. We often find technological optimism which assumes man's limitless ability in solving environmental risk problems through technological innovations and economic growth.

For example, developing countries sometimes adopt economic development strategy which does not take the environmental risk seriously into account, assuming that economic growth will solve various problems, including environmental disruption eventually in future. On the contrary, some take a pessimistic view to the technological progress, arguing that it inevitably brings about irreversible changes in global environment toward catastrophic results. Hence, some of institutional mechanisms of disseminating and integrating risk information throughout the economic and ecological systems is indispensable.

Systems approach adopted in this study takes a cybernetic view in managing environmental risks, which posits that we should look for responses to keep dynamic resilience of the system through feedback of available information even if it accompanies with high level of uncertainty. Here, the "vulnerability" of the system could be overcome provided if we could have increased our effort of not only monitoring and research to reduce uncertainty, but also of expanding the resource allocation to social infrastructure to provide an adequate level of accountability.

## 3. The Japan Sea and its Coastal Areas-A Breif History of its Formation

The Japan Sea was formed by extension as a result of collision and subduction by the hypothetical Kula-Pacific Ridge from the late Cretaceous to Oligocene period. Since then, that marginal sea experienced at least several important climatic and oceanographic changes in relation to human settlements in the Japanese islands. The remarkable change occurred about 6000 years ago -- at the period of transgression. At that time, the sea level was several meters higher than the present one, and the early aborigines called the Jômon people settled over coastal areas in the Japanese islands. For example, there found a number of shell mounds scattered in the heart of Tokyo and Osaka alluvial basins.

The weather was warmer, coincided with the Hypsithermal period, due to the melting of ice beds and other geological reasons (Kaseno, 1989). However, about 10000 years ago, the sea level was about 40 meters lower than the present one as illustrated in **Fig. 3.** Recent paleogeological study on the test pieces of bottom core samples will provide how the oceanographic conditions in the marginal sea and biological environment in the coastal zone were changed during the ice age and the period of Jômon transgression.

One of the important lessons that we could learn from these paleogeological and paleoclimatic data is that these changes in the sea level resulted in the shift of the dominant current due to the narrow and shallow straits, which connected the marginal sea with the outer oceans. As shown in **Fig. 4,** there are two major currents in the sea : the Tsushima Current, which is the prevailing warm current flew from the southern Pacific Ocean via the Korean Strait, and the Leeman Current, which is supplied from the northern Pacific Ocean via the Tatar Strait between Sakhalin and the Eurasian Continent. The presently dominant warm current, the Tsushima current, has furnished a variety of marine biological species and their high productivity in the sea.

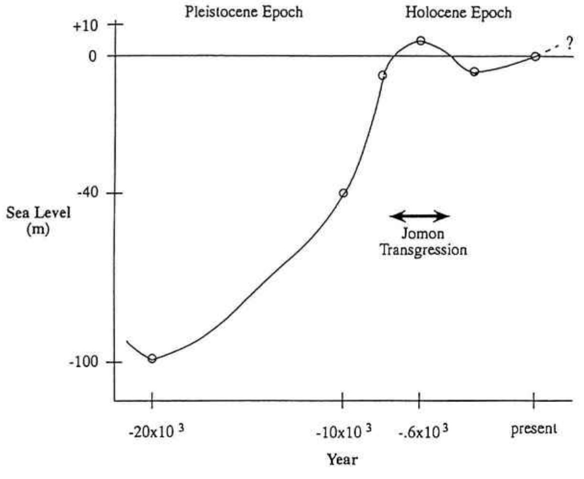


Fig. 3 Paleogeological estimation of sea level in the Japan Sea. (Source : Kaseno, 1989).

When the cold current from the northern strait was dominant around 20 thousands years ago, the fish species migrated from the northern Pacific Ocean to the sea and caused an ecological change in the sea. Hence, it is so critical for such a semi-closed marginal sea to have a slight increase in the sea level (several meters high) that might bring a drastic ecological change in terms of marine structure and biological productivity.

### 3.1 Meteorological characteristics and natural hazards

Asian summer monsoons bring about humid air over the Japanese archipelago, and that air flow strongly characterizes the regional climate and as-

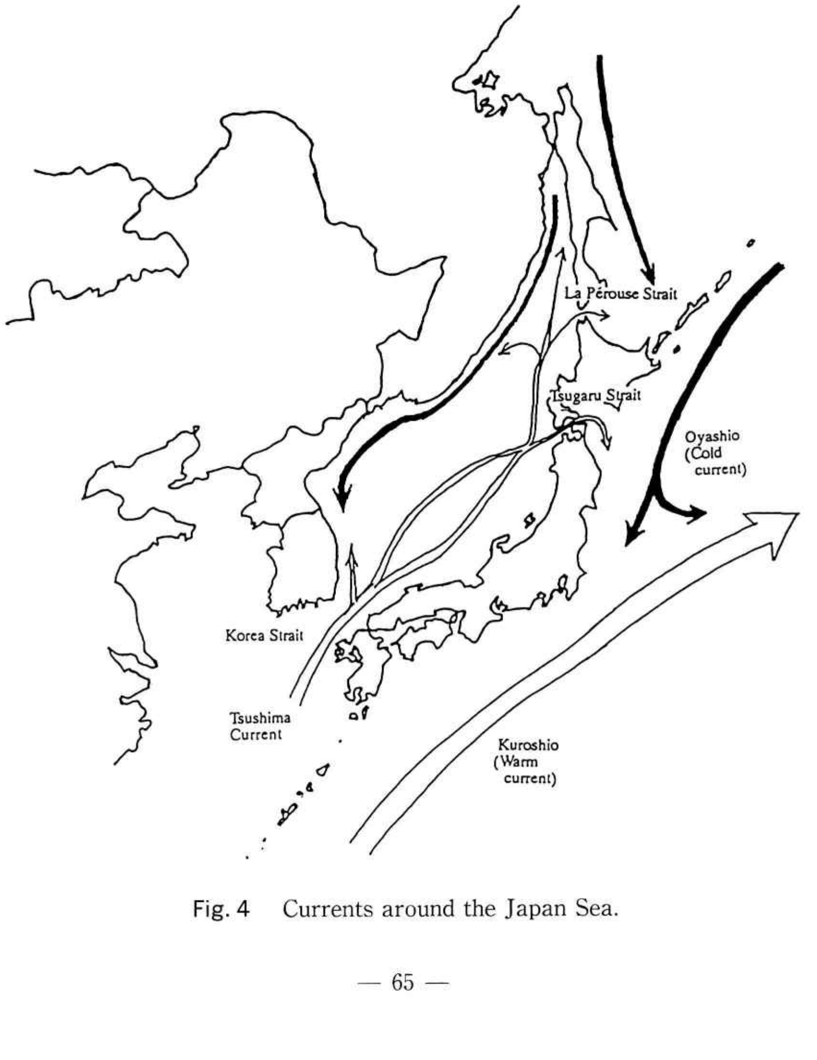


Fig. 4 Currents around the Japan Sea.

sociated agricultural activities. In general, southern Japan and the Pacific coasts obtain enough water to cultivate rice during the summer monsoon season. However, northern Japan and the Japan Sea coasts have a different hydrological character from the south and the Pacific coasts in terms of annual water balance for agricultural and industrial production. The winter monsoons (the Westerlies) from the northern hemisphere catch vapor over the Japan Sea generated by the Tsushima Current, and then, bring about heavy snow over northern Japan and the Japan Sea coasts. The snowfall in winter contributes about 30 percent of the water resource in these regions, which is used for cultivating paddy rice fields.

Civil infrastructure in preventing hazards caused by the heavy snowfall has gradually built up in the recent years. In particular, major streets in cities are now equipped with facilities which melt snow in order to keep smooth traffic. In addition, lifelines and utilities for citizen have been remarkably improved. Accumulated snow, which used to be the hazardous one, may be reevaluated as a stocked water resource for electricity generation, irrigation, a source of underground water and thermal heat pump in summer, and so on. Despite the potential use of accumulated snow, it is no doubt that both heavy snowfall and less sunshine are still major obstacles for these coastal areas to compete with the Pacific sun-belt region in terms of industrial development.

As for other types of natural hazards, the Japan Sea coastal area has less risks of being attacked by typhoons, earthquakes, high tides, and tsunami (earthquake-driven high waves) than the Pacific coastal area. However, when both coastal areas were to be under the same degree of natural hazards induced by the potential rise in the sea level, the Japan Sea coasts could have more risks of being damaged because the civil infrastructure in preventing natural hazards has not caught up the protection levels implemented in the sun-belt areas.

### 3.2 Environmental risks in the coastal area

So far, in Japan, industries have been developed along bays or coastal zones which are open to the outer oceans, but mostly along the Pacific Ocean since the end of World War II. Having been a local economic center, economic activities of major cities facing the Japan Sea (e. g. Kanazawa, Toyama, Niigata and Akita ; the population of these cities ranges from 30 to 500 thousands) are limited within their surrounding local areas. A classical set of industrial and urban pollution has not emerged as a salient political issue in the region except for a couple of pollution tragedies caused by toxic heavy metals (mercury and cadmium pollution). **Fig. 5** shows a map of industrial cities which are legally required to make pollution control plans by establishing preventive and remedial measures for air and water pollution, noise, vibration, soil pollution, and ground subsidence in order to meet the national environmental quality standards (Ikeda, 1986).

Among the 39 cities designated as the zones of mandated pollution control, only three cities are located along the Japan Sea. However, in the late 1980's, new types of environmental pollution have appeared beyond the local, regional, and national boundaries. The new problems include air pollution by acid rain and oil pollution from both national and international sources. **Fig. 6** shows the monitoring data on acidity of precipitation (Central Res. Inst. of Elect. Power Indust., 1989). Clearly we can see the difference of acidity between two coastal areas in terms of seasonal variation. The acidity ($SO_4$ $g/m^2$) in the Japan Sea coastal area is dominant in winter due to the winter monsoons, possibly because the pollutant were originated from the continental nations, although the long distance transportation of pollutants in the Far East is not fully studied.

The water and soil pollution from dumping of hazardous industrial wastes are also the critical issues from the view point of inter-regional transfer of pollution externality. The excessive hazardous wastes which are generated beyond the treatment

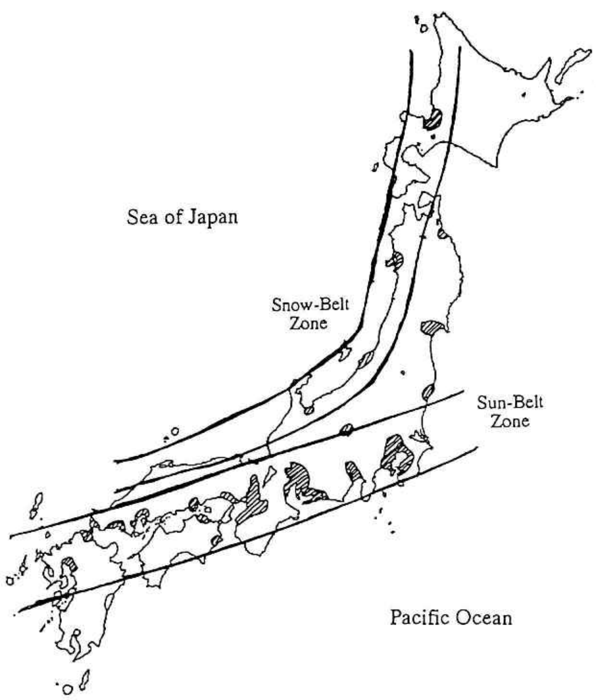


Fig. 5 Industrial sites in Japanese coastal zones.

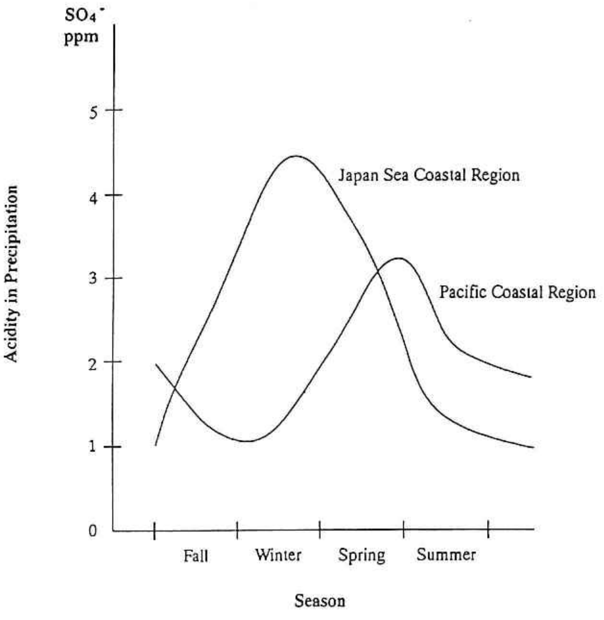


Fig. 6 Acidity in rainfall over Japanese coasts. (Source: Central Res. Inst. of Eleco. Power Indust., 1991)

capacity in the sun belt region are transferred to the depopulated region. Locations of nuclear power stations have been concentrated mostly in the coast lines of the Japan Sea (e. g. Fukui, Niigata and Kashiwazaki). This could add another source of the risk of possible radio-active wastes to the Japan Sea. At the same time, as we described before, the globalization of regional economy beyond the national border makes it possible to develop industrial activities in the coastal areas facing the marginal sea, which used to be less attractive in the sense of the national market. Thus the risks of sea water pollution by dumping industrial wastes, oils, and household wastes are anticipated to be dramatically increased in that marginal sea unless there are adequate inter-regional instruments for the risk management.

## 4. Scenarios of the Global Climate Change around the Japan Sea

### 4.1 The climate change and the Japan Sea

Several models have been developed for prediction of the global climate change caused by the carbon cycle in the atmosphere and ocean. It is an important common assumption for such numerical models that global equilibrium concentration of $CO_2$ gas in the atmosphere, which has the largest greenhouse effect, will double from the present equilibrium by 2100. So far, most of the simulation models on the global warming provide a wide range of predictions with respect to the climatic impacts on the Far East as a whole. Nevertheless, there exists a fairly good degree of consensus in terms of annual mean temperature, precipitation and atmospheric pressure patterns, and other climatic factors. (Tokioka, 1990). These estimates include the following:

1) Rainfall will decrease in the subtropical area, and increase in the Northeastern Continent, but will not change so much on Japanese islands,

2) temperature at the cold outbreak region (the Northeastern Continent) will increase over 10°C, and the mild increase around 2-3°C on Japanese islands,

3) the summer monsoons in the subtropical area will be stronger, and the rainfall will follow the tropical pattern, and become instable in scale and time,

4) the winter monsoons from the Northeastern Continent will be weaker. Therefore, less snowfall is expected in the coastal area of the Japan Sea.

However, the grid scale adopted in these models is too rough to interpolate their estimated results into the regional scale of the climate effects surrounding the Japan Sea. For example, the model developed by the Meteorological Research Institute of Japan adopts 400 to 500km grid scale. However, for accurate predictions of the climate effects, we need at least the 100km grid scale. Therefore, it is extremely difficult to predict the future climate in that area by applying these global warming models. One of the possible ways by which we could make reasonable predictions for the regional climate changes is to design an adequate set of scenarios concerning the regional climate impacts, taking account of available scientific knowledge and data, including paleoclimatic and meteorological monitoring data.

### 4.2 Scenarios of climatic impacts to the coastal area

The following are such typical scenarios of regional climate impacts on the Japanese islands summarized by Yoshino (1991):

(A) In summer, Asian monsoons will become stronger, and rainfall is expected to decrease and become like tropical areas, sometimes torrential. When it pours, water will not be kept due to the steep terrain in mountain topology of Japanese river basins. That will cause not only loss of water resource but also erosion of moisture in soil, particularly in the southern part of the Japanese islands.

(B) In winter, the atmospheric pressure pattern of the cold and high anticyclone over the northern continent is expected to weaken, accordingly, the snowfall will decrease in the coastal areas facing the Japan Sea and the northern part of the Japanese islands. However, rainfall in the mountainous area will increase about 30 percent or more.

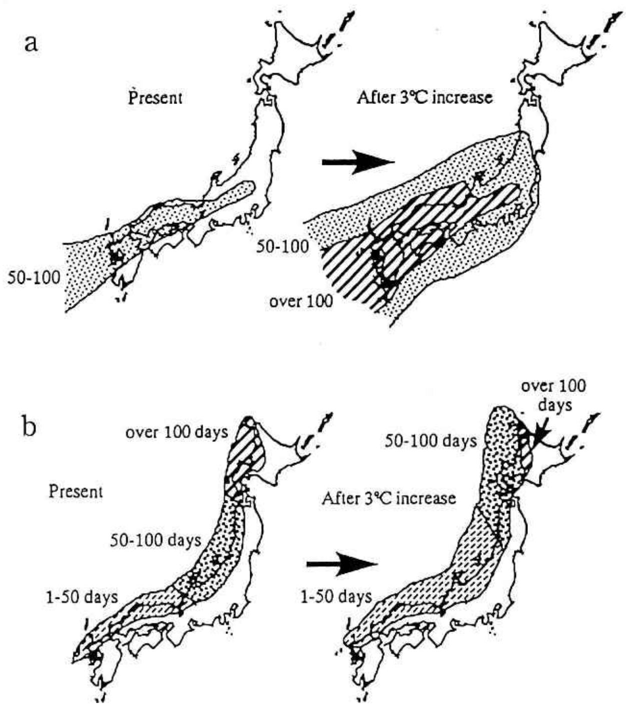


Fig. 7 Possible climate changes on Japanese islands.
(a) A number of days over 30°C in a year.
(b) A number of days with snowfall in a year.

**Fig. 7** displays an example of such estimations in terms of the number of days which the mean temperature exceeds 30°C in summer and the number of snowing days in a year projected by the Central Research Institute of Electric Power Industry (1991). The data shows that a favorable trend is predicted in the Japan Sea coastal area. Because of larger fluctuations in climate changes, i. e. rainfall and dry days, heavier snowfall and later frost, we may have more risks of potential natural hazards than those the present climatic pattern has provided.

### 4.3 Scenarios of the sea level rise

As to the sea level rise, there exists no detailed study to forecast a possible rise in the sea level in the Japan Sea. In the global sense, the sea level is considered to have gone up by 10 to 20cm over the last century because of the thermal expansion of sea water and possibly by melting ice bed. However, according to the monitoring data at the Japanese coasts, the sea level in the coastlines along the Pacific Oceans was at its peak in 1950, and has been going down since then (Sugimura, 1989). Therefore, the possible rise of the sea level depends not only on the degree of the global warming effects on the sea water at the time of doubling $CO_2$ concentration, but also the long-term coastal land movement in Japanese islands.

By and large, it seems to be reasonable to take the assumption of the possible rise in the sea level from 80cm to 120cm by the year of 2100 along the Japan Sea, which the IPCC working group reached consensus (Miura et al, 1992). If we take the scenario of 100cm rise in the sea level, it is obvious that a considerable portion of major Japanese metropolitan areas, such as Tokyo, Osaka and Nagoya, might be under water. For example, in Tokyo, approximately 30 percent of the urbanized districts with over two millions of residents will sink under the sea level, without any defensive measures (Environment Agency Japan, 1989b). However, this submerging process will go slowly for over 100 years, and be mixed up with the other effects of tidal waves and high tides caused by monsoons, typhoons and tsunami.

The countermeasures in preventing such tidal waves and high tides from the natural causes have been implemented in particular for the recent 50 years, mostly in the major urbanized regions in Japanese coastlines. However, the potential damage by these high waves and high tides will surely increase in the minor urban areas along the Japan Sea.

## 5. Vulnerability Analysis

Following the conceptual framework of regional vulnerability described in Section 3, we will discuss two types of vulnerability triggered by the expected climate changes. First, we will examine possible impacts on ecological system of the Japan Sea and the coastal area along the sea. Second, we will explore impacts on social and economic system of the regional society by the climate changes and economic development. In our conceptual framework, we consider the following three aspects in the analysis of ecological, social and economic vulnerability :

1) Environmental constraints of the marginal sea,
2) Wastes discharged into the sea and in atmosphere,
3) Resource demands (water, fishery, mineral, and amenity resources).

The distributional aspect of the environmental risks, such as potential damages and benefits in space and time dimensions, are also important so as to reach better understanding for future scenario of regional sustainability around the Japan Sea.

### 5.1 Ecological vulnerability

Based on a paleogeological and oceanographic study (Nishimura, 1990 ; Matsuno, 1989) with respect to the environmental constraints of the sea, we can come up with the following hypothetical scenarios :

(1) First of all, the global climatic changes by the rise

in atmospheric temperature may bring about changes in water flow patterns within the Japan Sea. In the beginning, the temperature of surface water will rise. Then, thermal expansion of water body may result in rise in the water level in the marginal sea. At the same time, the mixing and upwelling capacity between the surface water (8–17°C) and cold bottom water (about 0.5°C) may decline.

(2) The cold bottom water, which used to be adherently confined in the deep bottom layer (approximately 2,000 m to 3,000 m in depth) for many years, may have more difficulty in water exchange by getting less water supply from the upper layer. Finally, in the long run, it may induce a change in the flow pattern of the prevailing warm current in the surface layer which provides a various species of pelagic fishes, such as pollack, cuttlefish, sardine, saurel, in this marginal sea.

In this context, this marginal sea has a high degree of vulnerability not only in possible change of warm current flow patterns due to the sea level rise, but also in possible increase in industrial wastes at the sea bottom due to the less exchangeability of the sea water. **Fig.** 8 illustrates this scenario in order to show the difference of oceanographic structure with the Okhotsk and Bering Sea. In the Japan Sea, warm water flows in and out through the narrow and shallow Korea and Tsugaru strait, which are 70 and 180m in depth, respectively. Warm water flows only in the upper layer, while cold water in the deep bottom layer is confined for a rather longer period with the decreased upwelling force. Hence, the peril of pollution is the highest among the seas stated above.

Other issue to be addressed in the ecological vulnerability is the environmental nature of the coastal areas. One of the critical risks is dispersion of acid rain by crossing the Japan Sea. **Fig.** 9 illustrates the long-rage transportation routes in winter, when the winter monsoons from northwest carries suspended particles more than several hundred kilometers per

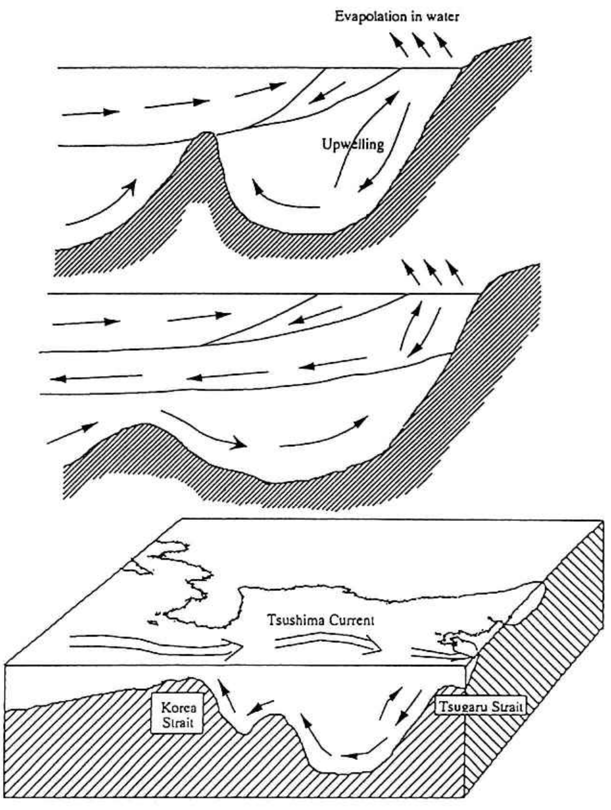


Fig. 8 Water circulation in the Japan Sea : A schematic illustration.

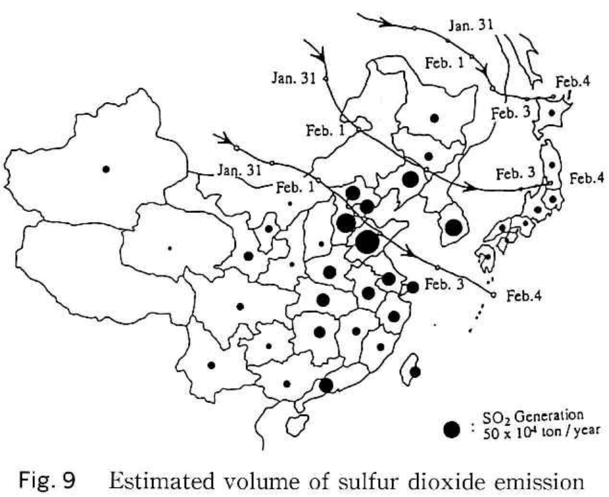


Fig. 9 Estimated volume of sulfur dioxide emission by regions and long-range transportation routes over the Japan Sea.

Table 2 Estimated anthropogenic sulfur dioxide emissions in northeast Asia.

| Region | Population ($\times 10^6$) | Area ($\times 10^9$ m$^2$) | Primary Energy Consumption ($\times 10^6$ ton/Yr.) | Total Annual Emissions ($\times 10^{12}$gS/Yr.) | Year |
|---|---|---|---|---|---|
| Japan | 120 | 372 | 314 | .55 (.85)* | 1983 |
| China | 1,052 | 9,597 | 504 | 9.85 (.97) | 1986 |
| Taiwan | 19 | 36 | - | .17 (.87) | 1986 |
| South Korea | 41 | 98 | 47 | .50 (.92) | 1985 |
| North Korea | 20 | 121 | 38 | .44? ( - ) | 1986 |
| Total | 1,244 | 10,224 | - | 11.54 (.95) | |

* Estimated ratio of emissions from stationery sources.

day. The recent study by the Central Research Institute of Electric Power Industry (Fujita et al., 1991) estimated the amount of sulfur dioxides generated by the Northeast Asian countries. **Table 2** shows its estimates of annual emissions in Japan, China, Taiwan, South and North Korea. The total amount is about 11 million ton per year by sulfur content, which equals to the amount generated by the North-European countries or the Northeastern part of the U. S.. Among the countries, China contributes the most, which shares 85 percent of the total generation. While we see a clear sign of increased acidity in rainfall and soils, so far, actual damages to the forest or fresh water have not clearly appeared in the Japanese coastal areas because it is said that Japanese soil is more resilient to sulfur acidity in terms of neutralizing capacity than continental soil. It is, however, a matter of time for Japanese trees and soil ecosystems to suffer the fatal damage.

**5.2 Social and economic vulnerability**

People in the coastal society begin to be aware of their vulnerability in the climatic changes and sea level rise, or at least, of direct impacts which include damages to urban river system, harbors, coastal low land and scenic views, setback of coastlines by erosion and high waves, etc.. These problems can cause a number of vulnerability to urban life lines, transportation and industrial and agricultural infrastructures by the increasing hazard potential.

As to the direct impacts on the regional economic system, we will have a various degree of impacts on industries, primarily on agriculture and climate-dependent industries such as brewing and fermentation, recreation and tourism, construction and transportation. However, in the global economic sense, we will have the following indirect social and economic vulnerability to the climatic changes :

1) urban infrastructure of life lines : vulnerable to the increasing hazard potentials,

2) industrial structure : vulnerable to high energy consumption with low recycle rate,

3) trade structure : vulnerable to export and import of pollution loads which will be transferred through the various types of media such as atmosphere, river, sea, and ecological components.

One of the major impacts associated with urban infrastructures is the risk of water pollution originated from urban non-point sources, such as garbage and wasted consumer products from households, hazardous wastes from commercial and transportation facilities and other urban activities. Because of fewer rainfall and higher temperature of its freshwater, the quality of river and ground water will be generally deteriorated. In addition, because of decreasing water storage and lower flow rate in sloped river basins in Japanese islands, the sea level rise will accelerate salinity intrusion not only into rivers and ground water system, but also into water supply and sewage systems. This means that, if the infrastructure of the urban life lines are not well prepared for the sea level rise, such urban water systems, which used to be the recycled type from upper to down stream, are more vulnerable to the risk of contamination by hazardous and toxic wastes from non-point sources.

Considering the regional context stated above, it is important to promote lower energy consumption and to create resource-sustainable society by developing an ecologically sound way of life and new technologies. Fortunately, the Japanese coastal area facing the Japan Sea has kept such appropriate technologies which could provide lower energy consumption and self-preventive systems in the frost and heavy snow environment. Technology in utilizing low entropy of accumulated snow is now under development as one of the clean energy sources.

The trade structure is the critical one in Japanese economy in relation to the new program of economic globalization in the Japan Sea Rim. Japan has capabilities to supply only 20 percent of its energy consumption, and 30 percent of food demands. Such high dependency to the world ecosystem in terms of energy and food supply means that the climatic change is certainly a serious issue through the impacts to its trade structure (Nishioka, 1989). In this sense, social and economic vulnerability in the East Asian regions in the Japan Sea Rim are also a critical problem for the Japanese people as a whole. Although the new plan of stronger international economic ties with the continental countries is ambitious and is open to a number of uncertainties in future, we can set the following scenarios (Niigata Prefecture, 1991) :

**Scenario 1** : Mutually beneficial economic cooperation is going to start, which will be based on the complementary positions among the Northeast Asian countries. For example, a rather simple complementary relationship is found among the coastal countries for their economic development :

(a) Technology, Capitals : Japan, South Korea

(b) Energy Resource : China, Far East Siberia.

(c) Mineral Resource : China, Far East Siberia, North Korea

(d) Fishery Resource : Far East Siberia, North and South Korea, Japan

(e) Labor : China and North Korea.

**Scenario 2**: Shared specialization of industrial activities in this region will be in progress after investment for major infrastructure of transportation and production facilities in the Northeast Asian countries. Industrialized Japan and South Korea are already moving into such a relationship, which promote investment and relocation of their firms each other to form a common market.

**Fig. 10** illustrates such complementary relationships for the industrial development, together with the recent development of transportation and communication lines. There are a number of big projects with a good potential for resource and infrastructure development in this area. Some of these projects are already started, and some others are under serious consideration for start. For example, Russia has an ambitious plan to develop natural gas production in Yakutsk and oil and gas production in Sakhalin (the Vostok Plan).

In summer 1992, UNDP (United Nations Development Program) started a feasibility study for a development plan of an international port on the Tumen river (Tumen Jiang), which can guarantee China to have the only direct access to the Japan Sea at the international delta. These projects will guarantee the bright future of this area when they are successfully completed.

It is highly uncertain whether the scenario 2 may

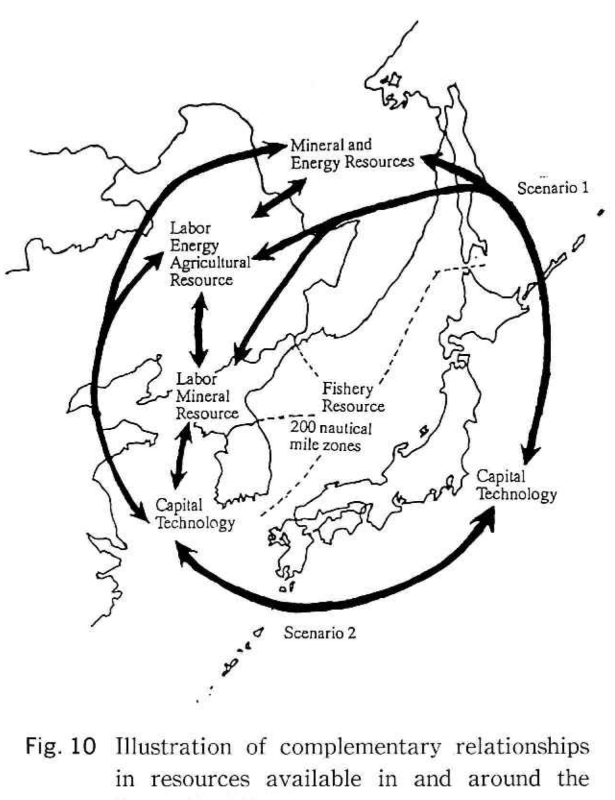


Fig. 10 Illustration of complementary relationships in resources available in and around the Japan Sea Rim.

get a real image or not in the current political situations of the Northeast Asia. In any case, it is the scenario 1 which actually is going to start for coming several years, when we need a regional risk management scheme of the marginal sea associated with the global climatic change and sea level rise.

Up to now, there is no estimated figures of how much of industrial wastes are discharged into the Japan Sea, and how much of ecological damages, primarily on fishery resource, the marginal sea has had. These questions are difficult to answer. The 1990 Annual Report by the Chinese Government describes that their industrial wastes to the water system amount to about 24.9 trillion tons, without counting local industries. The figure includes 2,189 ton of heavy metals (Nihon Keizai Shimbun, 1991). The Japanese Government reports that about 0.32 trillion tons of industrial wastes are generated for the waste processing in 1985 (Environment Agency, 1989b). There are no standardized indices to compare environmental risks in this particular region.

Surely, first of all, we have to set up an institution for monitoring the state of the Japan Sea, irrespective of the political situations which lasted for the past decades. Then, we could start to negotiate the future scenario of the risk management in this valuable marginal sea as a source of regional sustainability. The socio-economic vulnerability to the global climatic change depends not only on the economic development programs that each coastal country would adopt in future, but also on how much of information and monitoring data concerning to the ecological conditions of the marginal sea is distributed and shared among the regional society and people.

## 6. Toward Interregional Risk Management of the Japan Sea under the Global Climate Change

With increasing concerns toward the new economic globalization among the Northeast Asian countries in the Japan Sea Rim, what kind of environmental consequences could we see in this marginal sea after the economic globalization? Could the sea level rise which is associated with the global climate warming become the warning signal for the marginal sea to be deteriorated up to such a critical level, like the most industrialized nations have had in the course of industrialization at coastal zones?

In terms of the trade structure in this coastal area, Japan would be accused as responsible for the wastes if it does not transfer adequate technology of wastes processing with its trade transactions. **Table 3** gives some figures of the trade structure between Japan and

Table 3 International trade between Japan and northeast Asian nations surrounding the Japan Sea in 1989.

| | South Korea | China | Russia | North Korea |
|---|---|---|---|---|
| Japanese Export | | | | |
| Amount ($10^6$ dollars) | 16,561 | 8,516 | 3,082 | 197 |
| Share in Total Japanese Export (%) | 6.0 | 3.1 | 1.1 | .1 |
| Major Items | Machinery<br>Electro Machinery<br>Steel | Steel<br>Electro Machinery<br>Machinery | Machinery<br>Steel<br>Electro Machinery | Machinery<br>Electro Machinery<br>Transportation Machinery |
| Japanese Import | | | | |
| Amount ($10^6$ dollars) | 12,994 | 11,146 | 3,005 | 299 |
| Share in Total Japanese Import (%) | 6.2 | 5.3 | 1.4 | .1 |
| Major Items | Textiles<br>Electro Machinery<br>Steel | Crude Oil<br>Textiles<br>Fish Products | Non-ferrous Metals<br>Woods<br>Coals | Non-ferrous Metals<br>Fish Products<br>Steel |
| Share of Japanese Trade in each Nation | | | | |
| Export (%) | 20.8 | 21.2 | 2.8 | 19.2 |
| Import (%) | 26.9 | 14.4 | 2.8 | 7.8 |

the other Asian nations at the year of 1989. So far, the trade between Japan and the former USSR has been in the extremely low level, reflecting the hard political relationship up to now. However, if the new economic globalization may follow the course of scenario 1 which we described in the previous section, Japan's dependency on the energy, mineral, and woods resources will increase, in particular, to the Far East Siberia, and the Northeast provinces of China, and possibly the North Korea, primarily due to the location advantage in transportation.

A number of recent reports have already been issued, which warns that the resource development activities in the major river basins in Siberia and the Northeast China could be a huge sources of industrial wastes flowing into the Japan Sea (Harries, 1991). In addition to the Pacific coastal area, not a few coastal places along the South Korea have had the frequent outbreaks of the red tide, toxic plankton blooms (Park et al, 1989).

There is indeed no definite solution to this problem. However, the Japanese experience of coastal environmental management, although it is actually remedial, not anticipatory, after the coastal sea has been deteriorated, may provide an example of such institutional mechanism. This regulation program called Areawide Total Pollution Load Control was enforced through the Water Pollution Control Law amended in 1978. Its target areas are major industrialized coastal zones : The Tokyo Bay, the Ise Bay, and the Seto Inland Sea including the Osaka Bay, which are the three industrialized megalopolis in Japan where the sea water is so eutrophicated and polluted by various inflows of hazardous materials that it brings about the frequent red tide (plankton bloom) and the blue tide (low oxygen water), both of which are toxic to fishes and shellfishes and gave damages not only to fish farming industry, but also to the coastal amenity and recreation.

The basic principles of the regulation scheme are :

(1) Determining the total pollution load to be reduced in terms of COD (Chemical Oxygen Demand) in order to attain a water quality standard designated by the government depending on the purposes of water use.

(2) Allocate the reduction load to each local government involved in the target area on the basis of their industrial activities, in essence, in the proportional way.

(3) Each local government shall take necessary steps to reduce the respective amount of pollution load by implementing the pollution control plan and by receiving various types of financial aids from the central government. The control measures include construction of sewage networks, tightening the effluent standards for industrial waste water, water quality monitoring and education.

Possibility of introducing such Areawide Total Pollution Load Control into the Japan Sea would have been blocked by the exactly the same problems as the $CO_2$ Emission Quota Policy might have in a more regional sense. However, a shared concerned the marginal sea would bring about more hope in creating such an inter-regional institutional mechanism, possibly linked with the fishery regulation purpose. In fact, several Japanese local governments facing the Japan Sea recently have proposed to establish the Inter-regional Committee or Forum for Marine Resource Research around the Japan Sea, which is based on the 200 sea-mile regulation zone (Asahi Shimbun, 1991).

This is the first initiative action to take into consideration of resource and environmental problems round the Japan Sea. We need various types of regulatory instruments and attempts, whichever governmental or non-governmental, to negotiate the way of managing the global risk of the potentially deteriorative marginal sea.

## 7. Conclusions

**(1) Ecological Vulnerability:** Patterns of Potential Environmental Risks to the Marine Ecosystem of the Japan Sea:

Historically, external pollution phenomena among industrial and public sectors (transfer of the pollution disutility to other industrial and public sectors without any compensation or transaction) have been one of the biggest environmental issues. The typical one is public hazards from industrial sources (kôgai in Japanese) as an indication of a variety of health risks and environmental disruptions. The other important externality is spatial or transfrontier pollution crossing over regional and national boundaries. In this particular coastal area, several international conflicts have already emerged, such as the issue of acid rains, hazardous wastes and oil pollution in the sea, over-exploitation of fish resources, and so on. Among them, the most critical one will be ecological risks in the Japan Sea which may be accelerated both by temperature rise and by associated increase in dumped industrial and household wastes.

**(2) Socio-Economic Vulnerability:** The Economic Globalization and Inter-regional Risks across the Marginal Sea:

Because of high degree of uncertainty involved in the spatial distribution of the global climate changes, it is extremely difficult to make any concrete estimations concerning potential socio-economic impacts on a particular regional society. Each region will suffer a variety of positive and negative impacts to important resources and social capital: these includes the following:

—Water resources for agricultural irrigation (rice production): A precipitation pattern may become instable due to the changes in global wind circulation with less snowfall and rainfall but torrential ones.

—Safety measures for natural hazards: Severer safety standards may be needed for infrastructure at estuaries, bays and rivers in urban areas for protecting facilities and human activities.

—Fishery resource: Possible changes of flow pattern may change the marine ecosystem through a food chain under the sea level rise, and the increased dumping of hazardous materials and various nutrients inflows may trigger large-scale toxic "red-tides" in coastal waters.

—Marine amenity resources: Floods and erosion of sea coasts may change coastal views and induce changes in vegetation at the coast.

Depending on the existing and future vulnerability of the coastal resources, various risk profiles will be required in the coastal resources management under the economic globalization around the Japan Sea.

**(3) The Accountable Responses to the Potential Risks:**

The regional strategies in forming the global economic group of the East Asian countries in the Japan Sea Rim may provide the critical condition of "becoming a huge dumping yard" by the increased utilization of mineral and natural resources in these regions. We surely need a careful and sound environmental management through regional and inter-regional collaborations. In fact, in the case of Japanese coastal management, we have had a number of severe industrial pollution and environmental disruption along the major coastal areas. The typical examples are the Minamata fish case, mercuric poisoning from industrial discharge to the Minamata Bay, blooming of the Red-Tide (toxic plankton) in the Seto Inland Sea, intrusion of the Blue-Tide (water of no oxygen mass) into river fronts of the Tokyo Bay.

The social responses toward the pollution control were called the Areawide Total Pollution Load Control Scheme in the case of the Japanese coastal zones (Environment Agency, 1989c). This regulatory instrument has been implemented for more than ten years to mitigate over-eutrophicated sea water due to the increased industrial and household wastes. The institutional setting in allocating both industrial wastes among the coastal areas involved in the Japan Sea would be the critical issue in the risk management for the marginal sea in future.

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# グローバル気候変動下における環日本海地域の生態的・経済的脆弱性の比較研究

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## 要　旨

本研究では,経済のグローバル化の傾向と相まって地球的規模の環境質変化が特徴的に出てくると思われる地域,すなわち,環日本海地域を取り上げて,気候温暖化や経済開発の進展による沿岸域の環境質の長期的変化を分析し,これら環境リスクに対してどの様な社会的な応答が可能であるのかを地域社会システムとしての脆弱性と適応性の観点から整理する.このために,まず日本海の環境質の歴史的変化と現状に対する定量的評価ならびに将来予測シナリオを策定し,日本海域の生態的脆弱性と沿岸地域の社会経済的脆弱性に関する具体的な考察を試みる.次に,日本海沿岸地域の地域社会システムとしての適応性の評価のために,まず沿海諸国の産業・環境政策の現状を評価し,続いて,地中海やバルト海など国際的な閉鎖性海域における国際環境協力成立過程を参考にして,環日本海地域における将来の国際環境協力の可能性を展望する.

**キーワード**：全地球気候変化,環境リスク,閉鎖性海域,日本海,生態的脆弱性