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‘EMECS International Seminar In Osaka’

— Consider ways to preserve the environment of coastal regions in the Seto Inland Sea and Osaka Bay from the perspective of Preserving the environments of enclosed coastal seas throughout the world —

On Friday, January 8, 1999, the International EMECS Center sponsored a seminar entitled‘EMECS International Seminar In Osaka’ with the support of the Environment Agency of Japan, Osaka Prefecture. Hyogo Prefecture. Osaka City, the Global Environment Center, the Association for the Preservation of the Seto Inland Sea, the Governors and Mayors’ Conference on the Environmental Protection of the Seto Inland Sea and the Research Institute for the Seto Inland Sea.

The event was held at Primrose Osaka and was attended by more than 130 researchers, policy-makers and general citizens from universities, national and public research organizations, government agencies, local government organizations, citizen’s groups and private companies.

The objective of the seminar was to consider ways to preserve the environment of coastal regions in the Seto Inland Sea and Osaka Bay from the perspective of preserving the environments of enclosed coastal seas throughout the world, in advance of the joint Fourth International Conference on the Environmental Management of Enclosed Coastal Seas (EMECS ‘99) and Fourth International Conference on the Mediterranean Coastal Environment (MEDCOAST ‘99) held in November in Antalya, Turkey.

Three scientists from overseas were invited to talk about the present status of and efforts to preserve the environment in the Black Sea, Chesapeake Bay and the Baltic Sea: Dr. Erdal Özhan, professor, Middle East Technical University (Turkey), Dr. Wayne Bell, assistant director of the Environmental Science Center at the University of Maryland (USA.) and Dr. Bengt-Owe Jansson, professor emeritus, Stockholm University (Sweden).

Also participating in the seminar was Mr. Yoshihiro Natori, director of the Office of the Seto Inland Sea Environmental Conservation at the Water Quality Bureau of the Environmental Agency of Japan. Mr. Natori gave a talk entitled “New Measures for the Environmental Management and Restoration of the Seto Inland Sea” currently being studied by the National Council for the Environmental Management of the Seto Inland Sea.

Serving as coordinator for the seminar was Dr. Hiroshi Nakanishi, professor emeritus of Yamaguchi University and chairman of the National Council for the Environmental Management of the Seto Inland Sea, who has been involved in environmental research regarding the Seto Inland Sea for many years.

professor emeritus of Yamaguchi university
Chairman of the National Council for the Environmental Management of the Seto Inland Sea
Dr. Hiroshi Nakanishi

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Professor. Dr. Erdal Özhan, Middle East Technical university, Turkey / Chairperson, MEDCOAST

Introduction to the Black Sea

The Black Sea nowadays is considered to be one of the most polluted enclosed seas in the world and it is, in fact, the most enclosed sea in the world. The Black Sea is connected to the Mediterranean through two straits, the Bosporus and Dardanelles and the Sea of Marmara in between. The average water depth in the basin is about 1800 meters, but at the connection, the Bosporus is only 70 meters deep. The width of the straits is about one kilometer, so this clearly indicates how enclosed the basin is. When I was a student many years ago, we were told that only 200 meters from the top of the Black Sea was "alive". Below that it was all anoxic. Nowadays, reports say it is much less than before - only about 150 - 100 meters is alive and the rest is anoxic.

Environmental Problems

According to the Black Sea Environmental Program, the problems of the Black Sea are various, including the collapse of fisheries, the loss of habitats, endangered species, the problem of exotic species, degradation of the coast and basically the landscape, inadequate production of resources, and finally unsanitary conditions along many beaches.

The Black Sea is now suffering from severe environmental problems. However, the reason for this lies not with the countries that border this highly enclosed sea. The Black Sea is bordered by 6 countries, Turkey in the south, Bulgaria, Romania in the west, Ukraine and Russia in the north, and Russia and Georgia again in the east. The problem of the Black Sea is mainly due to 3 rivers, and one in particular - the Danube. The drainage basin of the Black Sea covers 17 countries occupying more or less one third of Europe. There are about 160 million people living in this area, so all the waste from the basin finally ends up in the Black Sea.

Sources of Pollution

Various countries and international rivers contribute to the bio-deload into the Black Sea basin. International rivers represent about 80% of the total, and the Danube almost 75%. And with regard to nitrogen, too, the situation is quite similar; there are just some differences in the percentages. And the same applies to phosphorus. So it is clear that much of the organic pollution which is the main problem of the Black Sea is due to international rivers and mainly due to the Danube.

Now while the Mediterranean is quite an oligotrophic basin, the Black Sea, on the other hand, is very rich in nutrients because of the inputs from the rivers. Now, this western part of the basin is shown in this slide and we can see the inputs from the Danube which discharges here, and here, and all the coast here more or less displays eutrophic conditions. Algar blooms occur quite often in the area, especially in the northwest basin, and the result of this is quite important. The algar blooms have caused significant damage to down-take habitats of the northwest basin. In the 1950s, there was an extensive area covered by red algae beds which gradually shrank, especially after the 1970s when the environmental crisis increased in the Black Sea. The shrinkage was even more pronounced and in the 1980s there were only a few patches of the phialophora beds.

Now, obviously, this is a very important consequence of organic pollution. The loss of phialophora beds illustrates itself very severely in the biodiversity of the area, in the status of the living resources.

Pollution in the Black Sea

In addition to the organic pollution of the basin, one other problem in the Black Sea is oil pollution. The Black Sea is an important place for tanker traffic; it's becoming even more important with the development of Caspian oil fields. There is quite a bit of traffic going through the Black Sea and much of it goes through the Bosporus. In 1995, there were about 1500 tankers per year going in and out. This is a large amount. This means every day, 3 tankers are moving up and 3 tankers moving down. The number is expected to double if the Caspian oil field is fully exploited. Obviously, this creates a great environmental risk to the whole Black Sea basin and especially to the Bosporus and to the city of Istanbul.

Another important problem of the Black Sea basin is the decline in fisheries. The increase in the fishing fleet in the Black Sea doubles in number about every 20 years, while on the other hand, we see the change of the fish catch from the basin. In the late 80's a sharp decline took place due to the accidental introduction of exotic species of jelly fish brought from Chesapeake Bay by ballast water. This introduction is first believed to have taken place in the early 80's. The jelly fish, finding no predators in their new home, thrived and reached huge numbers feeding on zoaplankton, etc., which are the food for the most important fish in the Black Sea, anchovies. So as the food for the anchovies declined, so did anchovies. The anchovy catch in the late '80s decreased by about 75% - the total fish catch was l/3 of the catch before this crisis. Now, obviously this meant other problems for the basin because there are many people around the basin who make their living on fishing.

Now luckily, due to some as yet unclear reason, in some way nature is trying to adjust itself to its former equilibrium and fishery is slowing picking up.

Strategies for Environmental Conservation

I'd like to give you some information about the efforts for improving the environmental conditions in the Black Sea. Now, before the l990s, there was almost no management effort for improving the environmental conditions along the Black Sea coast, and the basin as well.

Now the regional lack of efforts was basically due to the political system which existed over the area and with the change in the political system, efforts started to increase. In 1992, there was a convention signed by the 6 riparian countries of the Black Sea in Bucharest, known as the Bucharest Convention, for the protection of the Black Sea against pollution. This was rectified by all 6 countries by early 1994 subsequently enacted. There are 3 protocols included in the Bucharest Convention, all of them aiming against pollution, one on land-based sources of pollution, the second on dumping waste, and the last, joint action for emergencies, such as oil spills etc.

Following the Bucharest Convention, there was an important document signed by these countries known as the Odessa Declaration. This is a Polish document, a short document, describing the types of action to be implemented for realizing the Bucharest Convention, and this

was signed a year later, in 1993. And the last important document is the Black Sea Strategic Action Plan. This was signed in October 1996. The Black Sea Strategic Action Plan is quite a comprehensive document, which was prepared as the result of a very important international program called the Black Sea Environmental Program. The Black Sea Environmental Program was a GEF, Global Environmental Facility, funded program, an international program, which started in June 1 993. It was initially funded by GEF, but later the European Union also started putting some money into it. The duration was initially three years, and it was extended by another year, later on. This program is now over. The program was administered from an office in Istanbul called the Program Coordinating Unit, which is, incidentally, the same unit as the Secretariat of the Bucharest Convention.

The Black Sea Environmental Program had different lines of action, which were administered by 6 activity centers located in 6 riparian countries. Emergency response was in Varna, Bulgaria; routine pollution monitoring was in Istanbul, Turkey; special monitoring was in Odessa, Ukraine; protection of biodiversity was in Batumi, Georgia; integrated coastal zone management was in Novorossiysk, in the Russian Federation, and, finally, the fisheries activity center was in Constanta, Romania.

MEDCOAST

Now, at the end of my talk, I would like to very briefly introduce my organization and what we have been doing to help the improvement of environmental management in the Black Sea and the Mediterranean.

MEDCOAST is a scientific network of scientific institutions. It's a totally non-governmental network, which became operational in 1 992 with the first conference, which was organized incidentally in Antalya, which will be the place of the joint conference with EMECS in 1999.

Now since 1993, MEDCOAST has been active in 3 directions; scientific meeting organizations, human resource development programs and collaborated research at a regional level. I'll just show you what we have done in 2 of these.

Under scientific meetings, we have already organized 3 conferences called the MEDCOAST International Conference and Mediterranean Coastal Environment Series.

In human resource development, we organize and run short-term training programs and we have so far held 2 courses. One, the more comprehensive one, is a 3-week course called the 'MEDCOAST Institute' and the theme is integrated coastal management. The shorter one is 'Beach Management in the Mediterranean and the Black Sea'. We are organizing the fifth MEDCOAST Institute this year and the fourth Beach Management course once again in Malta, this year. Though it is not operational yet, MEDCOAST is aiming to operate an international degree program, with input from all cooperating academic institutions.

We are proud to have almost 180 alumni representing 33 countries which have been active in management efforts. And the impact of MEDCOAST so far on management of the Mediterranean and the Black Sea has been in these 3 directions - enhancing scientific research, data and information exchange, basically through conferences; training key people for coastal management in our training courses, and improving coastal development and coastal engineering. Because of our past efforts since 1993, MEDCOAST in 1997 was selected as one of the top ten efforts in the world for marine conservation by the Pew Fellows program, Boston USA, and was given the prestigious Pew Fellow Award.

The Conservation of the Coastal Area Environment of Chesapeake Bay

Dr. wayne H.Bell, Center for Environmental studies, university of Maryland (UMCES), USA

The Chesapeake was first explored well by the English Captain, John Smith in 1612, who wrote that, "in fact the heavenly earth never agreed better to frame a place for men's habitation". We still agree! Chesapeake Bay is more than an estuary and it is more than a habitat. It is a way of life for millions of people, and we recognize it today in Maryland as "The Land of Pleasant Living". It is located on the eastern shore of North America and on the western boundary of the North Atlantic Ocean.

There are many ways to measure Chesapeake Bay, but there are two features that are extremely important. One is that the Bay is relatively shallow, with an average depth of only 7 meters. This makes it extremely susceptible to changes in wind and weather. Historically, the shallow bottom was host to extensive seagrass beds and oyster reefs so massive that they were once hazards to ship navigation. While there are more than 7000 km of shoreline, there is an even more impressive watershed. That watershed drains 6 states, plus the District of Columbia, that is, the city of Washington. The ratio for Chesapeake Bay is typically, in order of magnitude, greater that for other large coastal systems. There are 4 rivers, which will come up on this slide in a moment, that contribute 80-90% of the freshwater flow in the Chesapeake.

My point is this. Processes on the land have a tremendous potential influence on what happens in the estuary. And this is a principal theme which I will return in this talk. The principal driving force is fresh water from the tributaries. Being less dense, it tends to flow out in the upper portions of the water column. But in doing so, it entrains some saltier, denser water from below. This water must be replaced, and that replacement comes from the ocean. The result is a basic bi-layered flow: fresh water out, and deeper, saltier water in. This creates a "wedge" of saltier water that increases in height until it occupies the entire water column near the mouth of the estuary. A cross-section through this wedge shows a well-defined pycnocline where salinity rapidly increases and, in the warmer months, there is a corresponding thermocline as well. These differences in density retard mixing across this boundary.

Here the cross-section is shown, and this is the pycnocline area where density rapidly increases with depth, and temperature decreases in the summer. The upper end of this wedge is where fresh water and salt water first meet. Mixing processes in this area often create a zone of maximum turbidity where suspended sediments and other materials

congregate.

I'll return to my point though: the driving

force for the salt wedge circulation is freshwater runoff from the land. It is nothing trivial about being located at the edge of the sea. Land use is not uniform on Chesapeake Bay watershed. The upper regions are forested. There are extensive tidal marshes in the lower reaches, particularly on the eastern side of the Bay, as we call it the Eastern Shore. Between are local regions of highly productive farmland. More than 80% of the bay watershed is, in fact, forest and agricultural land. But land use is also changing. In Maryland, 100 square kilometers per year are being converted to urban land, and that trend is coming.

Where did the Chesapeake Bay policy come from? The restoration and conservation effort is a relatively recent program. It is possible to trace its roots to several comprehensive scientific studies. Perhaps the most significant was a 7-year project funded by the US Environmental Protection Agency, USEPA, in the late 1970's. Here are some of most influential factors that led scientists, citizens, and elected officials together to conclude that something is very wrong with their Chesapeake. There was a precipitous decline in several resources, but none was as striking as that of the Eastern Oyster. Through at least the 1800's, oysters were so abundant that scientists estimate they could have filtered a volume of water equal to the Bay itself every 3 days. This picture, the postcard picture, in the upper corner here, that picture from an early 1900 postcard shows 200,000 bushels of oyster shell at a seafood packing plant near Norfolk. Virginia.

Overfishing was joined in the 1950's by 2 protozoan diseases, locally called MSX and Dermo. While not harmful to humans, the results have decimated oyster populations. Today's oyster populations would require more than a year to filter a volume of water equivalent to that of Chesapeake Bay.

Seagrasses comprise several species of submerged aquatic vegetation (SAV). The extensive SAV beds began to disappear from the Chesapeake, the northern portions of the Bay in the late 1960's and that disappearance proceeded southward. The historic low was about 15,600 hectares in 1984. That was less than 10% of the historic extent of these grass beds.The salt-wedge pattern of estuarine circulation promotes the loss of oxygen from deeper waters, particularly during the summer months. However, there is evidence that the amount of water that is essentially oxygen-free was increasing in both volume and duration as well. Since oxygen-free water does not support life, newspaper headlines from the late 1970s announced, "The Bay is Dying." Scientific or not, this aroused a great amount of public concern. Until the early 1980's, our understanding of nutrient pollution in estuary was dominated by studies derived from freshwater lakes. In these systems, phosphorus or P was the limiting nutrient that was supposed to stop primary production by plants and algae. Chesapeake Bay researchers clearly established that nitrogen, not phosphorus, was the limiting nutrient in estuaries like this bay. These are some of the chemical forms that these nutrients take and in addition, managers and scientists also differentiate between point source pollution derived from sewage and industrial pipes or outfalls and not point pollution derived from agricultural urban runoff in atmospheric deposition.

In the early 1980's, scientists began to connect many Chesapeake Bay problems with nutrient pollution from the land. Algal blooms were the direct consequence of nutrient pollution into the surface waters. Major blooms develop in early spring following fresh water runoff from rainfall and melting snow on the watershed. This brings major nutrient loads to the system. When the spring blooms exhaust the available limiting nutrient, the algal cells die, sink, and decompose below the pycnocline. Decomposition consumes oxygen, and in the extreme case producing summer anoxic waters.

Nutrients also stimulate the growth of attached algae, sometimes called epiphytes, on the emerging leaves of growing sea grasses. The epiphytes become dense enough to shade the leaves, reducing their ability to conduct photosynthesis. The SAV eventually dies. This shading phenomenon has given rise to the concept of Chesapeake Bay as a "Twilight Estuary."

The first Chesapeake Bay Agreement was signed in 1983. The signatories to this voluntary commitment to restore and protect the Bay were as follows: The Governors of the States of Maryland, Virginia, and Pennsylvania, Mayor of District of Columbia, that is Washington DC, the Chair of the Chesapeake Bay Commission an inter-state agency of Legislators, and the administrator of the USEPA, who represented a large number of agencies in the Federal Government.

The Federal Government through the USEPA contributes approximately $20 million annually to the Chesapeake Bay Program. This is more than matched, far more than matched, by additional funds from the participating states and federal agencies. Since 1984 the states have cooperated in an extensive water quality monitoring program, comprising over, more than 150 stations occupied every 2 weeks of the year. Representative data can be accessed through the Chesapeake Bay Program home page.

The Chesapeake Bay Program is supported in part by modeling and there is an extensive modeling effort, but it will take a long time to go through these! But the original Hydrodynamic and Water Quality models and pink were used to set a 40% nutrient reduction goals that I will be talking about in a moment, by predicting that this would eliminate deep water anoxia from the bay. Model refinements no longer support this specific prediction, but output from the Water Quality model, particularly with regard to effects on living resources, remains a central objective to predicting the consequences of changes in nutrient loads to the Chesapeake. The Watershed Model is still under development, but when completed, it will attempt to relate nutrient inputs to changes in weather and land use that are critically important.

Reduce controllable nutrient loading by 40%; restore submerged aquatic vegetation, you can see why that is important; increase wetland restoration, so there's a net increase instead of decrease in the wetlands; restore forested stream buffer to help control nutrient runoff from fields; remove dams to fish passage so that fish can migrate upstream to breathe; effect multi-state, cross-jurisdictional fishery management; and promote, achieve and maintain a toxics-free bay. I am going to return to only one of these, the nutrient downloading, reduction goal of 40% by the year 2000. I will talk about how we are doing and where we are going. The fundamental approach to nutrient control being used in the Chesapeake Bay system. The Executive Council commitment is a 40% reduction in the controllable loads of nitrogen and phosphorus by the year 2000 relative to the loads that were calculated in 1985.

Based on models as well as scientific measurements, the total nitrogen load, we'll use that example, nitrogen, the total nitrogen load in 1985 was 365 million lbs/year. It is estimated that only 185 million pounds can actually be controlled through technology and through best management land use practices. For example, nitrogen leaving forests is not considered a controllable load, even though it is a major load

in the Chesapeake, because the forest is still so extensive. Forty percent of the 185 yields a reduction of 74 million lbs/year. Subtracting this from 365 yields a total final load of 291 million lbs/ year. This is both the goal for the year 2000 and a cap that is not to be exceeded again. Progress toward the 40% reduction goals was evaluated in 1996. In fact, what the original goal was, what the original loading was in 1985, where we thought we were in 1996 and where we predicted to be in the year 2000. Regarding the moment from nitrogen reduction, we will not quite achieve that goal, although we will get close. In addition, I have gone into some data and indicated what the point source loads are, so the difference between these two would be point source at the top and non-point at the bottom. You can see that for the most part in our reduction of loads in 1996 that, in fact, we achieve this largely through point source control.

Phosphorus can be analyzed the same way. Again, we have major points source loadings calculated in 1995, we substantially reduced the overall load in 1996, largely through point source control, that means sewage treatment plant upgrades. We anticipate that we are actually going to make our goal by the year 2000. In the case of phosphorus, most of the point source load reductions came from the implementation of a phosphate detergent ban, which was implemented originally in Maryland in 1995 and the other states followed later. At the same time that argument was being argued in the State Legislature, a spokesman for the detergent industry said, and I quote “I can tell you that a phosphate ban in Maryland will have almost no impact on the water quality of the Chesapeake Bay. We told you so.

How are we doing? There is no statistical evidence unfortunately that the nutrient concentrations in the main portion of Chesapeake Bay have changed. The good news is that the concentrations of nitrogen and phosphorus are not increasing. The bad news is, I guess you would call it, “environmental inertia.” The sum of natural processes that continue to release nutrients that have built up over years of pollution. Among those sources may be the sediments themselves and ground water. Since again we have such an extensive watershed to deal with.

SAV acreage is determined annually by aerial surveys in the summer of each year. The interim goal of 114,000 acres represents the total area that exhibited at least some SAV growth during the 1970’s. The long-term goal of 600,000 acres represents the total area of suitable bottom for SAV growth down to a depth of 2 meters. As you can see we are barely making progress toward the interim goal. We have a long way to go, but in fact again, there is no evidence that there is still precipitous decline.

The restoration of striped bass to a valuable sport and commercial fishery is one of our great success stories. This is reflected not only in the size and number of fish caught as this happy angler can certainly show, but also in annual recruitment survey done by the Departments of Natural Resources in Maryland and Virginia. The Maryland Young-of-Year index is calculated simply by sampling some 22 sites around the Bay with a 30 meter net and counting the number of fish, in this case, juvenile striped bass that are caught. And an index above 8 is considered to be a good year. Some indices of recent years have been much higher than that.

This slide summarizes the nutrient concentrations in the waters of Chesapeake Bay and its tributaries. Decreasing, trends are found mainly on the western shore, that is on the left of the graph, and bad, increasing trends still remain in the eastern shore. Those are areas dominated by agriculture. So non-point pollution remains one of our great challenges. For example, in the Choptank River watershed, represents largely agricultural land, and you can see how dominant it is in that particular watershed. Controlling that is a major concern for us. It represents over half of the watershed’s acreage. To approach this problem, the Chesapeake Bay Council has issued a declaration to break the bay up into the tributaries. These are the 10 tributaries for Maryland.

The Choptank watershed, for example, now can address its local pollution problems, but Patapsco/Back Bay watershed is near Baltimore and is dominated by sewage treatment plants and their concern is much more point-source pollution control. Maryland is also undergoing rapid population growth changes and those represent changes in our watershed as well. The population in 1990 was 4.7 million, and is now about 5 million. It has increased 22% since 1970. At the same time in areas of growth shown by yellow and orange, it had increased by 86%, and in our cities it had declined by 21%. We have doughnuts surrounding holes of declining population in our cities. This represents some very interesting changes in what we are doing with the 28% increase in population from 1970 to 1997. Vehicle miles driven by Marylanders increased 117%. But what we have is farmland being encroached upon now by 2 or 3 acre lots of development. As John Hanson Mitchell wrote, ‘I have done enough homework in land-use patterns to know that where there is a highway, no matter how rural the place may seem, there is certain to be development in the future’.

Then, we have the unknowns that have come to us, Pfiesteria piscicida. This was first described in 1988 from cultures in North Carolina of fish. It is a dinoflagellate and it is becoming more and more responsible for harmful algal blooms and fish kills along the Atlantic coast, and perhaps elsewhere. These kills are manifested by overt legions or sores on the fish. It also turns out, in addition to just killing the fish, it causes distressed behavior, that is quite noticeable shortly before the fish die. Humans exposed to water containing toxic Pfiesteria can develop skin sores and various neurological problems, especially short-term memory loss. There is no evidence that humans are at risk from eating sea food from Pfiesteria-infested waters, even when Pfiesteria is not causing fish kills. Nevertheless, the Governor closed 3 rivers in Maryland as a result of these kills and seafood consumption in the State of Maryland in 1997 declined by 40%. We formed a consensus to try to get at the point of what is causing Pfiesteria outbreaks, and the best we could do is to link it to other harmful argal blooms to nutrient pollution. We do not know the absolute cause and effect, but that consensus has led to the formation of new legislation to basically force agriculture to develop nutrient control strategies on the farms beginning in the year 2002.

I am approaching the importance of science from the perspective of my institution which has 3 laboratories located crucially across the Chesapeake Bay watershed. What I want to point out is that science is not a huge investment in the Chesapeake Bay Voluntary Program; that is not what is for, that program is for program implementation. The science is funded in other ways. At our institution, federal funding through grants and contracts to our faculty account for almost 60% of our total grant expenditures for Chesapeake Bay research. One of the dominant supporters has been the National Science Foundation which, in the US, is not a signatory to the Bay Program, but is a nationally competitivescientific research

funding agency. My point is that this is research that is independent of the Bay Program, but that independence assures that the science is nationally competitive. This research can still be relevant to Chesapeake Bay management needs. Independent and relevant research assures that future Chesapeake Bay policy will be based on the best science possible. One example to give you, because it is a new way of looking at a coastal sea, involves this project called TIES, which is again available over the internet. TIES basically is looking at why the Chesapeake Bay is so productive, and its testable hypothesis is that it's due to the fact that fresh water and salt water do not mix uniformly in the estuary. To sample the bay on such a fine scale, we use an instrument called Scanfish, basically a flying wing towed behind a boat about 4-6 knots, which is programmed by computer to undulate in the water column, while an array of instruments measure such things as temperature, salinity, chlorophyll, dissolved oxygen, turbidity, particle size and even abundance of particles. The acoustics are also used to locate large fish populations. A TIES cruise can cover the entire Chesapeake Bay in a week and gather so much data that it's almost hard to manage and actually process it. It is an incredibly rich resource and the data are sometimes posted to the internet.

I conclude by simply looking at a couple of new ways to approach education to involve the people in the Chesapeake Bay Program and hopefully for other things as well, including EMECS.

That ends my talk. Why do we do this and why do I think this is something EMECS could really take the leadership in? Because as a Senegalese ecologist said, "In the end we will conserve only what we love, we will love only what, we understand; and we will understand only what we are taught."

Environmental Conservation in the Baltic Region

prof. Emeritus Dr. Bengt-Owe Jansson, Stockholm University, Sweden

Introduction to the Baltic Sea

The Baltic Sea is a fairly large sea. It's very long from north to south, and there's a very narrow connection to the North Atlantic outside. It has a large catchment or drainage area about four times as large as the sea itself, which means that what really drives the water quality in the Baltic Sea is the type and intensity of land use in the catchment area.

Environmental Problems in the Baltic Sea

A typical feature of the Baltic Sea is the large archipelago along the rocky coast of Sweden, Finland and Estonia, offering important, and also very beautiful scenery as in this slide. The Stockholm archipelago alone has more than 30,000 rocky islands covered under water by luxurious growth of seaweeds, which are important both as nursery grounds and as spawning grounds for fish - even commercially important fish like herring - but which also act as a chemical-biological filter for the nutrient-rich water coming from land run-off and ending up being caught in the archipelagos.

Environmental Conditions in the Baltic Sea

Some parts of the archipelagos are still fairly pristine, and actually constitute a very important natural resource for tourism, which is becoming a big industry for the future. You can have very cold winters. The water is crystal clear and there is a spring bloom of both green and brown seaweed. The water translucency in the total Baltic was excellent back in the '40s. But now, due to nutrification, in many areas the water translucency has decreased by two to three meters.

There are some 85 million people living in the watershed in Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Poland, Germany, and Denmark. The population density is highest in Poland, the large Nordic countries having actually quite small populations. This number of people, however, has had a large impact on the Baltic Sea and, in fact, the Baltic basin has around 50% of the total industrial production in the whole world. Energy use since the Second World War has increased by some 300% - so it's a growing area and we have to be careful in the exploitation of natural resources.

Land in the north is usually forested, but also with some small-scale agriculture to maintain the sparse human population in northern Sweden and northern Finland. There are also several big rivers like the River Dalalven, which integrates the water quality in the soil and transports lots of material to the Baltic Sea, affecting the water quality.

The forestry dominates in the north, and arable land is concentrated in the south, here. Poland has a large agriculture, like Lithuania, too. There are several big rivers which transport and imprint the effects of agriculture on the Baltic marine systems.

Fisheries

Another important natural resource is, of course, the fisheries. They have been very productive - if we look at the early '80s. But schools of fish come and go. We have been over-harvesting, both herring, sprat and cod. But cod also has another story - it is very sensitive to pollution.

In the early '80s though, close to 1 million tons of fish was landed, which is 1% of the total world catch from a sea with a surface area only 1/1000th of the total oceans in the world. So the Baltic has a big potential for being productive if we can manage it well.

In talking about nature conservation, I feel very strongly that this is a kind of concept that should be spelled out much more clearly than it has been. Maybe it started out as just a strong feeling for a clean nature in Sweden. The strong debate now around one of the biggest buzzwords, 'biodiversity,' has also pointed out the importance of putting more power behind our work when we are talking about environment conservation. One of the important questions there is of an ethical origin - surely we don't have any right to kill off so many organisms in the highly diverse systems all over the world, unless we really need to do so for our own survival, which is not actually true right now. So ethics has been in the focus of destruction fairly long.

The Ecosystems

Ecosystems are truly life-support systems of human beings. It is becoming even more strongly said now that to be able to survive we need to have a surviving life-support system, of course. This goes back to the fact that the ecosystem provides services to society. Services like production of clean air, clean water and healthy food. We thought for a long

time that clean water was for free until now when there is getting less and less of it on a global scale.

The ecosystem absorbs and detoxifies to a fairly large extent waste from society - that's another important service. It produces fuel and building materials. It produces medicine. There are lots of examples of important plants used for human health which even now medical doctors have started to get interested in.

The ecosystems maintain a healthy and, for the mind, stimulating scenery for human beings. The forest is a typical ecosystem. The forest is fixing solar energy, in the forest there live lots of birds, and mushrooms, not for our pure delight, but because they are very important for the maintenance of the system. Birds disperse seeds unconsciously planting trees for our sakes, for example. The mushrooms we like to pick in the autumn in our country are very important; they are fixing nitrogen from the atmosphere and deliver it to the trees, and as a 'reward' they get the sugar from the photosynthesis of the tree. So they are very important in nature's 'web' in the forest, which cleans the soil water by taking up minerals - producing important ground water, which we use in our society. It produces timber and other building materials and it also is also able to absorb some of the pollutants like NOx, dioxins and sulfuric acid.

These ecosystem services, then, constitute the basis of what we are talking about when we talk about 'sustainable society' and 'sustainable development'. We have to have lots of working ecosystems. We have to explain this to people who, unlike you, are not so familiar with these things.

There is a fairly new concept, which is called the 'ecological footprint'. A 'footprint' of an activity in pristine nature. A city needs a certain amount of clean water, a certain amount of building materials, and an ecosystem around it that can absorb all the toxins and other types of pollutants. The potential of that can be described on a square kilometer basis; how many cubic meters of water per square kilometer it can produce, how many pollutants per square kilometer it can absorb, etc. So, by some very rough mathematics, you can describe how large an area a certain city needs for its maintenance. Our colleagues in Stockholm have made a calculation as to how large a footprint the 29 largest cities in the Baltic basin make. It turns out to be 75 - 150% of the total drainage area! So the Baltic society already overuse their natural resources and have to 'export' pollution and import goods and services.

Effects on the Baltic Resources

Now let's look at just a few examples of the effects on the Baltic resources by man's activities. The deposition of nitrogen through rainfall over the Baltic drainage area has a maximum in the south and a minimum in the north. It tells us that there is some kind of large production center in the south. This, of course, is the industrial part of northern Europe - mainly Germany, the Czech Republic, Slovenia, Hungary, etc., which are actually outside the drainage area. But through the winds, the nitrogen is transported northwards over the water. Deposition from air amounts to close to 40% of the total nitrogen. Some 50% of that total load comes from land runoff produced mainly through agriculture, forestry, and urban areas, while the nitrogen from the atmospheric fallout comes to a large extent from transportation - cars, trucks, etc., and industry. The nitrogen is one of the key nutrients for the Baltic Sea. The effect of this nitrification is now clearly seen. The masses green algae due to this fertilization with nitrogen are accumulating in the bays. They are decomposed - lots of oxygen is consumed by these processes. This is not a nice place to be for lots of tourists or for those who have their summer houses here!

Another large impact we have in the Baltic Sea, is the summer plankton blooms - some of them poisonous, like yours in the Seto Inland Sea. When these algae die off and settle down to the bottom they consume all the oxygen and we get production of hydrogen sulfide over a large area. Large areas have hydrogen sulfide; or have an oxygen concentration of less than 2ml/l, which is too little for fish. But outside the area it is fairly healthy, with food for fish like cod, for example. So the algal blooms and the hydrogen sulfide areas have been very important alarm clocks that started to ring in the mid-1960s.

Another warning that occurred at about the same time, came from the chlorinated hydrocarbons like PCB and DDT. PBC struck very heavily at the populations of gray seals, which in 1900 were in the order of 100,000 animals, but by the 1970s were down to less than 1,000. The DDT also accumulates in the upper, what we call, trophic layers; the auks, like the seals, are heavy fish-eaters and they have large amounts of DDT in their eggs, which negatively affected the population.

Organizations for the Environmental Conservation

What started the more planned organization of the conservation processes in the Baltic area was firstly the ordinary people, so to speak, who couldn't stand to see our clean, natural environment more and more polluted and dirty. The non-governmental organizations also started to have an effect on the politicians. This activity, which more or less started in Sweden, created the Swedish Environment Protection Board, the first one of its kind, at least in the Baltic area, which not only tried to regulate what was allowed to be done in Swedish waters but also financed important research and monitoring of the Baltic Sea. A big step was taken in 1972 when the Helsinki Commission, HELCOM, was created, because this was based on an international agreement- the first of its kind in the whole world. It was a convention on the protection of the marine environment of the Baltic Sea. Despite having very little money, this organization did a lot of good, even during the Cold War because it was a very difficult time just to get the Soviet Union to agree to strong measures against pollution. Now it's much easier.

Environmental Action Programs

The '90s have been very active. It was now that the Prime Ministers around the Baltic were starting to get more active by creating the Baltic Sea Joint Comprehensive Environment Action Programme in 1 990 with the creation of a task force. That was an organization that also included a financing organization like several large European environmental banks and the World Bank and also several non-government local organizations, which was very important and very wise. They are acting on the concepts of 'precautionary principle' and on the 'best environment practice.' As one of the results, they produced an overview of 132 'hot spots' all over the Baltic area.

The Agenda 21 for the Baltic Sea is another recent activity, started by the Prime Ministers in May 1996. It's a very detailed program about what should be done with the Baltic Sea. And at the same time, the Council of Baltic States had a meeting in 1996, where, among other things, they discussed agricultural policy which we, some of the researchers around the Baltic, had discussed at a Royal colloquium the day before. Many of our talks on agricultural problems and their effect on the Baltic are published in the scientific journal, Ambio, Vol. 26, No. 7, 1997.

Within the Baltic Agenda 21, different countries around the Baltic were given a kind of 'homework' to investigate what could be done in different activities. Responsible for

energy was Denmark, for agriculture Poland, for forestry Finland, etc. They proposed what should be done to the Baltic Sea. Vision and Strategies for the Baltic Region (VASAB) is a planning project of the total drainage area based on transport development.

And some funds were provided by the Nordic Environment Finance Corporation, by the Nordic Ministers of Finance, and not only in the Nordic countries but also in the southern countries around the Baltic Sea. Some 60 cities around the coast of the Baltic Sea have also created a union to help each other in the planning, for example, of harbors, taking care of the environmental problems. So the activities have been really dynamic.

Also from the NGOs, who have come together in Coalition Clean Baltic, an umbrella association, which issues a periodic journal.

On the education side, we have very interesting projects which are still running, based at Uppsala University, the Baltic University, which runs a satellite program, an educational program for undergraduates; it seems to be very much appreciated and close to 1,035 universities have used that. Initially starting with natural science, they are now also incorporating economics.

Toxic Substances

Now, what has all this accomplished? We have seen some encouraging examples. Since banning PCB in several countries in 1976 - and now nearly all of them have banned PCB - the seal population has started to increase, starting in ‘82 from some 500 animals, they are now up to around 2000, and fishermen are complaining that seals are taking fish from them, which is a good sign for the seal.

Concentrations of DDT and PCB were very high in the eggs of the auks in ‘68. If we take that concentration as a base of 100%, then we can see that through banning DDT in 1974 and PCB in 1 976, the concentration has rapidly gone down, close to the original level in the 1950s. This tells us, and this is important, that when we really start do anything on a large scale, we get results.

And let me end with this picture, this diagram, showing the ‘king and queen of the Archipelagos’, the wild sea eagle, which was also badly hit by DDT. At first, in the 1800s, they were severely hunted. They were seen as a competitor, on a small-scale, to small wild animals like hares, pheasants and fish. Hunting was forbidden in the 1920s, and then it came back fairly rapidly, but then DDT struck again. But it was banned in 1975, and at that time also, the Swedish Society for Nature Conservation, started to feed eagles during winter time. This is a very hard time for them to get something to eat. But now they are up again, and in summer 1997, we had the great pleasure of finding 177 chicks along the Swedish east coast, which is a very high figure, so the population is now coming back again.

Final Remarks

These success stories are the kind of information which is very important to get out to the news media, but the trouble is, only bad news is good news for most journalists! We have tried to encourage people to help with the restoration and redevelopment of the Baltic Sea. Good organizations are there, the information is there, we know a lot about the Baltic system, we even know what to do. The problem is to get the message across. Maybe one of the most important things is the individual level. If, for example, many people are willing to leave their car at home and take the train instead, that would help a lot.

New measures for the environmental conservation and restoration of the Seto Inland Sea

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Last September, the Director-General of the Environment Agency requested the National Council for the Environmental Management of the Seto Inland Sea to study new measures for the environmental management and restoration of the Seto Inland Sea. The Council has spent more than a year deliberating this issue and soliciting the views of the general public and is due to release its recommendations in the near future. Today I would like to summarize the gist of these recommendations.

First I would like to cover the events leading up to the study. As you know, the Seto Inland Sea is the largest enclosed coastal sea in Japan. Once it was renowned for the scenic beauty of its countless islands floating in the sea. It was also a rich source of fish and other marine products.

However, its prime geographical location, and its shallow depth and calm waters, spurred the development of industry along its shores during the period of rapid economic growth in the postwar period. The resulting factory waste water, combined with the wastes from ordinary households, landfills and so on, brought about the degradation of the environment in the Seto Inland Sea. One manifestation of this worsening environment was the so-called "red tides." Red tides frequently caused serious harm to the fishing industry, including the decimation of yellowtail cultivation. During the worst period, there were nearly 300 incidences of red tides in a single year. In 1970 and 1975, red tides occurred not only in Osaka Bay but throughout the entire Seto Inland Sea region.

Landfills have also been a major cause of environmental degradation in the Seto Inland Sea. The shallowness of the Seto Inland Sea led to the idea that additional land could be obtained easily through reclamation. In some years as many as nearly 4,000 hectares of landfill were created in a single year.

The result of all of these factors was that, by 1970, the Seto Inland Sea was being called a "dying sea." Calls from the community for action resulted in the enactment of the Provisional Law for the Environmental Conservation of the Seto Inland Sea in 1973. Five years later, in 1978, this law was made permanent as the Law for Special Measures for the Environmental Conservation of the Seto Inland Sea. Last year marked the 25th and 20th anniversaries of the provisional and permanent laws, respectively.

Let me give a few examples of the restrictions codified in these laws. To limit the COD load, limits were placed on total COD. Another was to reduce the amount of reclamation. The basic policy on landfills is determined by the National Council for the Environmental Management of the Seto Inland Sea, and there were guidelines to be applied in the event that reclamation needed to be carried out. And the law also included guidelines for reducing nitrogen and phosphorous in order to prevent eutrofication.

So how has the environment in the Seto

Inland Sea changed since the law was created? Well, since the provisional law was enacted in 1973, the COD load from industrial sources has been reduced to less than half its previous level. This is a graph of the COD level in Osaka Bay over time. As you can see, the environment in Osaka Bay is gradually improving.

Environmental standards have been determined for the Seto Inland Sea. This graph shows the level of achievement of these environmental standards. The level for all sea regions is shown at the top and the level for the Seto Inland Sea is shown below that. The figures show a gradual improvement since the law was enacted, though in recent years they have leveled off. However, the figures for the Seto Inland Sea are better than those for Tokyo Bay and Ise Bay. Moreover, the number of occurrences of "red tides" each year was very high when the provisional law was enacted in 1973, but these have been reduced dramatically. However, even now about 100 red tides occur each year.

Before the year in which the provisional law was enacted, the amount of reclamation performed amounted to approximately 2,000 hectares each year. Since the law was enacted, that figure has been reduced to an average of about 400 hectares per year. Looking at this from a different angle, however, this means that landfills are still being created at the rate of 400 hectares per year.

Due to the ongoing reclamation and other factors, seaweed beds in the Seto Inland Sea continued to decrease even after the enactment of the provisional law. Tidal flats have continued to decrease as well. Natural shoreline has decreased drastically while man-made shoreline has increased. So there has been a steady decrease in the number of seaweed beds and tidal flats and necessary natural environments, as well as in the number of places where people can come in contact with the ocean.

Before the period of postwar economic growth, the quality of water in the Seto Inland Sea was good, and other environmental factors were favorable as well. However, with the environmental destruction that occurred during the period of economic growth, water quality and other environmental factors deteriorated until they were at their worst around 1970, leading to the establishment of the Seto Inland Sea law. The law was established to restore the environment of the Seto Inland Sea that had existed before the period of economic growth. However, although there was some improvement in water quality following the enactment of the law, due to the ongoing reclamation and other factors, other environmental factors have continued to worsen. And in recent years even the improvement in water quality has leveled off.

It was the problem of how to achieve the objectives of the Seto Inland Sea law, namely, to restore the environment of the Seto Inland Sea to its status before the period of economic growth, that led to the present study.

Future policy measures for the environmental conservation of the Seto Inland Sea will be based on several basic premises. One is the need to achieve coexistence between the natural environment of the Seto Inland Sea and the lifestyles of the 30 million people who live in the region. Another is the fact that the Seto Inland Sea, while it is a single enclosed coastal sea, has very different characteristics from, say, east to west, and these must be taken into account.

As a result, the basic approach to future policy measures concerning the environmental conservation of the Seto Inland Sea can be summarized in the form of three main objectives.

The first is conservation, the necessity, above all, for conservation brought about primarily by restrictions. This leads to a second objective: restoration, the need for a shift toward restoring the environment that has been lost. And achieving these two policy objectives will lead to the need for wide-ranging partnership and participation.

The first objective, an improvement in conservation policies, will involve preserving, to the greatest extent possible, those natural environments that still remain, and both restricting the generation of pollutant loads and promoting substance recycling in order to reduce as much as possible the burden placed on the environment by the activities of human beings. I would like to discuss four of the measures that should be implemented in an integrated manner to achieve these goals.

First is the issue of water quality. Although restrictions on total COD currently exist, we must change these to comprehensive measures to preserve water quality, including a reduction of the load from such substances as nitrogen and phosphorous.

Second is the matter of landfills. As I mentioned earlier, a basic policy on reclamation does exist. However, we need to conduct a wide-ranging study of the reasons why reclamation is needed and of the measures designed to restrict reclamation. For example, the need to get rid of wastes was once a primary reason for constructing landfills. However, this can also be accomplished by placing restrictions on the generation of wastes, and by reducing waste quantities and recycling wastes. In cases where, even after various means to eliminate the causes of landfills have been devised, reclamation is still unavoidable, the reclamation must make every effort to avoid adversely affecting the environment. For this reason, a thorough study of restrictions and ways to avoid affecting the environment must be conducted from the planning stage onward. In the event that the environment is adversely affected even after all of these steps have been taken, suitable means of undoing the damage (mitigation)

must be studied. The policy regarding reclamation must emphasize in particular the importance of the shallows, the shallow areas in the Seto Inland Sea.

Third is the need to preserve existing seaweed beds and tidal flats to the greatest extent possible, as well as to preserve areas where human beings can come in contact with nature in general (and the sea in particular) and to conduct activities that will encourage such contact. Here it should be noted that it is also important to preserve man-made scenic beauty such as fishing ports, terraced hillsides, historical towns and so on, the kinds of scenery that one used to be able to see everywhere in the Seto Inland Sea region. Such places have long been neglected and the regional character is fast disappearing from many areas. Suitable measures must be taken to preserve such man-made scenic beauty as well.

Fourth, and lastly, is the current problem of excavating gravel and pebbles from the ocean floor. For the past four years, the Environmental Agency has been conducting a study of the environmental impact of excavating gravel and pebbles from the ocean floor. However, we still have insufficient knowledge of the ecological impact and the effect on the ecosystem of these activities. For this reason, we must continue to study the effect of these activities on the environment, and we should begin to study suitable measures at the point where we have sufficient knowledge to proceed. We must also develop substitute materials or technologies that we can use in place of such activities.

Let me turn now to the second policy objective, that of devising measures to restore the lost environment of the Seto Inland Sea. Policies to actively restore these environments were judged to be necessary because it was determined that the preservation policies alone

would not be sufficient to restore the seaweed beds and tidal flat environments that have already been lost. Restoration is an approach that is relatively new to Japan, and so basic efforts to coordinate this policy are currently underway. One such effort is to identify the areas in which good environments have been lost. Another is the organization for implementing restoration; the national government and local public organizations must play a leading role with the cooperation of companies, local citizens and private organizations. There is also the question of planning. Such environments will not be restored overnight but must be restored in an organized manner with a medium- to long-term perspective.

And, lastly, there is the matter selecting appropriate technologies. Technologies for restoring these environments are still in the process of being developed, although they are gradually beginning to take shape. As a result, several issues need to be considered based on the status of these technical development efforts. One is suitable study of the environments that used to exist. Another is the need to restore biodiversity and give priority to the use of technologies that help promote material cycles. Still another is the need to restore the regenerative capacity of the natural environment. Ultimately human beings can only provide the setting; from that point on, we must make as much use as possible of the regenerative powers of nature to restore itself. Another consideration is that we cannot simply restore one place and destroy the natural environment surrounding that place. In addition, we need to consider technologies to be used taking into consideration the views of local residents and the selection of locations to be restored. And our efforts must include not only creating environments but conducting suitable monitoring and maintenance as well. Specific efforts should include improving the natural cleansing properties of the ocean, providing places where people can come in contact with the sea, and improving the scenic beauty of the region.

This leads us to the third policy objective: that of promoting wide-ranging partnership and participation. This will involve strengthening three areas of cooperation. The first is the local partnership involving each of the regions in the area. This should include both lateral cooperation among each of the prefectures, cities and towns bordering the Seto Inland Sea and what one might call "vertical" cooperation with the cities, towns and villages located on rivers that feed into the Seto Inland Sea. A second type of partnership is organizational. Many different people are involved in the effort to preserve the environment of the Seto Inland Sea. There must be cooperation among all entities involved in this effort: the national government, local public organizations, companies, fishermen, local residents, researchers and so on. Particularly indispensable will be the understanding and cooperation of local residents. And a third type of partnership is generational. An effort must be made to educate both young and old about the environment and promote greater awareness and understanding of environmental issues.

One additional type of partnership will be of crucial importance: cooperation among enclosed coastal seas throughout the world, or what one could call international partnership. EMECS, the International Conferences on the Environmental Management of Enclosed Coastal Seas, and the International EMECS Center, communicate to the world the efforts being made to preserve the environment of the Seto Inland Sea, while also providing a forum that allows people to learn from the experience of efforts in enclosed coastal seas throughout the world.

In conclusion, in our capacity as the secretariat for the National Council for the Environmental Management of the Seto Inland Sea, we have monitored the status of deliberations for more than a year. I would like to close my remarks by emphasizing that I have been made keenly aware of the importance of obtaining the cooperation and participation of the local community in these efforts.

「The Gulf of Thailand」

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Thailand has two coasts. One curves around the scooped out shore of the Gulf of Thailand and has a length of 1,870 kilometers. The other lines the shore of the Andaman Sea of the Indian Ocean and has a length of 800 kilometers extending northwards from the Malaysian border to the Burmese border.

The Gulf of Thailand (figure 1.) extends northwest from the southern part of the South China Sea. It is approximately 835 kilometers long on its northwest axis. The maximum width is approximately 555 kilometers. The mouth of the Gulf, as indicated by the dotted line, is about 370 kilometers. The Gulf of Thailand covers an area of approximately 350,000 km2.

Being a part of Sunda Shelf, the Gulf is relatively shallow, with a mean depth of approximately 45 meters and a maximum depth of approximately 80 meters. The deepest part is located in a central basin between latitude 9°N and longitude 101° and 102°E. This deep basin extends northward to the vicinity of Ko Chuang off Sattahip, Rayong province, and is separated from the South China Sea by two ridges, One of there ridges extends southwest from Cape Camau at various depths of less than 25 meters for more than 110 kilometers and the other extends northeast off the Thai-Malaysian border for a distance of 167 kilometers at various depths of less than 50 meters. Between these two ridges, there exists a deep channel with a sill depth of 67 meters (Robinson, 1974).

Another general characteristic of the Gulf, which is typical of the Sunda Shelf, is the lack of an extensive distribution of coral reefs like those in Philippines waters. The corals that exist are located around some small island in the Gulf, usually far from the coast.

The Gulf of Thailand is an integral part of the Asian Continent. The sediments deposited on the bottom of the shelf are largely muddy, with sandy components brought in during the Pleistocene. Studies of the sediments at different parts of the Gulf during a series of exploratory trawling and resources surveys carried out by the Department of Fisheries revealed that the bottom was covered with ooze, or mud mixed with sand or shells (Pasuk, 1969 ; Ritraksa, Thamaniyom and Sittichaikasem, 1968). The bottom of the inner Gulf, into which four rivers drain a considerable amount of sediment annually, is covered with loose mud. In the

central basin, where the sediments are deposited, the bottom is again covered with soft mud.

Robinson (1974), in summarizing the results of the NAGA Expedition, concluded that the Gulf is a two-layered shallow water estuary. This means that low salinity water which has been diluted by rainfall and freshwater runoff flows out of the Gulf at the surface, while high salinity and relatively cooler water from the South China Sea flows into the Gulf over the 67-meter sill at the mouth of the Gulf. Various forces arising from monsoon winds, heavy precipitation and tidal currents create complex circulation in the Gulf. There exists localized areas of divergence of upwelling, downwelling or convergence of waters.

Robinson (1974) further observed that the general circulation and physical properties of the water mall varied to some extent both during seasonal periods, and that the monsoon winds play a major role influencing the circulation in the Gulf of Thailand. In the inner Gulf area where four major rivers drain, there is a rapid confluence of river and Gulf waters.

The southwest monsoon, starting in March or April, is usually well established in May and ends in September. This wind, after having blown across the India Ocean and the Bay of Bangal, brings rainfall to Thailand, Kampuchea and Vietnam between July and October. October is the lull between the southwest and the northeast monsoons. From November to February, the northeast monsoon winds, after having blown across the continent, bring low-moisture, cool are to Thailand and over the Gulf. March and April are the inter-monsoon months.

(Figure 1) Gulf of Thailand

In general, surface salinities in the Gulf are between 30.5 and 33 parts per thousand (ppt). Salinities at the deepest part of the central basin, where South China Sea water flows in, are higher ranging, i.e., between 33 and 34 ppt or above. Low oxygen concentrations (less than 2.5 mg/l) and high salinity of surface water in certain areas indicate localized areas of divergence or upwelling. Likewise, high oxygen concentrations and low salinity found at lower depths indicate localized areas of convergence or downwelling.

From a study of horizontal charts of temperature, salinity and sigma-t, it was concluded that in October the surface water flowed into the Gulf in a counter-clockwise direction, i.e., inflow along the east coast and outflow along the west coast of the Gulf; while at the central part, there was sluggish circulation. During the peak of the northeast monsoon, water of low temperature and high salinity moved into the Gulf around Cape Camau, but did not penetrate deep into the Gulf; instead, the water flowed out of the Gulf, slightly west of its mouth. During the peak of the northeast monsoon (August), there was a strong flow into the Gulf along the east coast. The survey carried out during 1970 and 1971 by H.T.M.S. Chanthara of the Hydrographic office of the Royal Thai Navy indicated that there was an intrusion of water mass from the South China Sea along the western coast of the Gulf and an outflow of less saline, but cooler, water along the eastern coast of the Gulf (Pongsapipatt and Sapsomwong, 1 973).

The circulation in the inner Gulf was influenced more of less by tidal currents and the circulation of surface water was clockwise in direction at the beginning and at the end of the year (during the northeast monsoon period) and counter-clockwise in the middle of the year (southwest monsoon period). The average surface salinity was 27.1 to 29.8 ppt. In estuaries during the peak of freshwater runoff (November to December), the salinity was quite low. Oxygen concentration at he surface was more than 4 mg/l but at the bottom it was very low, being 2.9 mg/l or less. The concentration of phosphate varied from 0.1 to 0.9 g-at P/1 and of nitrite from 0.05 to O. 14 ug-at N/1. The increasing trend of biochemical oxygen demand (BOD) in this area indicated that the water quality was becoming increasingly poor.

The amount of plankton, ranging from 200 to 1,000 ml/1,000 m3, indicated that the inner Gulf of Thailand is one of the most productive areas of the world. The peak of the abundance of plankton was found to be in December. High plankton concentration areas are located in the inner Gulf of Thailand, at the estuaries of the four rivers and along the upper west coast of the Gulf. Along the west coast of the Gulf, plankton was most abundant during March to August. Hence, off the west coast several species of fish spawn, and their larvae and young feed in this area until October, when they move to a new feeding ground in the inner Gulf of Thailand.

The upwellings off the west coast, especially in the Gulf waters off Prachuab Kiri Khan and Chumphon province, have a very beneficial effect on fishery resources, because of the resulting high levels of nutrients in the area. The Department of Fisheries found that this area is the spawning area and larval rearing area of pla tu, or the Indo-Pacific mackerel (Rastrelliger neglectus), a staple item in the Thai diet.

The high productivity of the inner Gulf of Thailand was also revealed by a study on the primary production of the waters there. Luasinsap (1979) reported that the average primary production rate of sampled waters in the inner Gulf was 3.15 g-C/m2/day in 1978 and 3.45 g-C/m2/day in 1979.

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Scientific Report
International Joint Study on the Conservation of the Marine Ecosystem in the South China Sea

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National Institute for Environmental studies

Introduction The South China Sea is one of the world's foremost continental shelves, with a large population of living organisms. The Yangtze (Chang Jiang) River estuary has a particularly rich ecosystem, being a breeding ground for fish with abundant resources for the fishing industry. However, the construction of the Three Gorges Dam and other development efforts in the Yangtze basin have reduced the amount of fresh water and silt flowing into the South China Sea via the Yangtze River. This is expected to cause quantitative and qualitative changes in the load on the environment from the land, including an increase in the quantity of nutrient salts and pesticides and other harmful chemical substances. These environmental changes are affecting the environment of the ocean around Japan both directly and indirectly, and there is particular concern about the effect on the marine ecosystem, including the reduction in the fishing catch in the South China Sea. For this reason, the National Institute for Environmental Studies has begun conducting research into the effect on marine ecosystems of the environmental load brought by rivers into the Gulf of Chihli (Po Hai) and the South China Sea. The research has focused on the area of the Yangtze River estuary within Chinese territory in which non-Chinese researchers are not normally allowed to conduct research. However, China's rising population and economic growth are significant factors in global environmental research, and a true understanding of global environmental problems in East Asia is not possible without data on the environmental load from China. For this reason, tireless negotiations on joint international research were conducted with the Chinese National Maritime Bureau. Including the period of preparations for the start of this project, these negotiations went on for two years. The result was that, in March 1997, an agreement to conduct joint Japanese-Chinese international research was reached between the Global Environment Department of Japan's Environment Agency and the Chinese National Maritime Bureau.

On the Japanese side, the National Institute for Environmental Studies is playing a leading role in the joint international research effort in the Yangtze River estuary. There has also been participation from the Geological Survey Institute of the Ministry of International Trade and Industry (MITI), from the Western Sea Research Fisheries Research Center and from the National Research Institute of Aquaculture in the Fisheries Agency. From the Chinese side, the International Agreement officer at the National Maritime Bureau is playing a leading role, with the participation of the Bureau's No. I and No. 2 Marine Research Centers, the Eastern Seas Bureau and Aoshima Maritime University. The research consists of three major activities. Firstly, there is monitoring of the ocean near the mouth of the Yangtze River to measure the concentration of nutrient salts and the quantity of silt, phytoplankton and zooplankton, etc. flowing in from the Yangtze River, as well as the use of sediment traps to determine the progress of settling and decomposition and the analysis of ocean floor deposits in order to determine the change in the quantity of deposits supplied from past to present. Secondly, there are nutrient salts accumulation tests using a marine isolation test ecosystem(mesocosm) and an effort to determine the mechanism by which these phenomena change the marine ecosystem. Thirdly, there is the integration of this knowledge to develop a model of the marine ecosystem in order to determine the capacity of the ocean environment of the South China Sea. In accordance with the agreement for joint Japanese-Chinese international research, two joint surveys have been conducted, the first from October 11 to October 24, 1997 and the second from May 13 to June 4, 1998. The first joint survey in particular was conducted about a month before the main Yangtze River was blocked off for the construction of the Three Gorges Dam, so it will provide valuable basic data that can be used to verify the effect of this dam on the marine ecosystem. The survey voyages were made aboard the Chinese National Marine Bureau research vessel KAIKAN 49, which has a total length of 7 1 .4 meters and a total tonnage of about 1,000 t. Survey Results and Future Issues All-core boring samples were taken from the mouth of the Yangtze Delta, while in the coastal and continental shelf areas samples were taken of the top layer deposits on the ocean floor. These samples contained a record of the environmental changes for both the past several decades and for the past 10,000 years. An analysis of these samples showed that the Yangtze Delta area was formed at least six thousand years ago. Moreover, from the changes in the Cs-137 content of the core samples, it was determined that the average speed of deposition recorded each year in the coastal environment for the past 60 years was 1.5 cm. An analysis of particle settling using the sediment traps determined that a high percentage (74 - 78%) of the particles were of a diameter of 63 mm or smaller. DDT, BHC and other pesticides were detected in the deposits, indicating that the sources of the pollution load were land-based. After the water from the Yangtze River flows into the sea, it mixes with sea water; at an isolation experiment ecosystem (marine mesocosm) set up 100 kilometers off the coast of Shanghai, the following levels were recorded:

N03-N 24 mM
P04-P O.65 mM
Si 40 mM

The most noteworthy aspects of the data were the high N/P ratio, the fact that the rate for phosphorous was relatively limited, and the high silicon concentration. The phytoplankton in the ecosystem that formed consisted mainly of Diatomeae (principally Skeletonema and Chaetoceros), while the zooplankton consisted mainly of Pantopoda (mainly Paracalanus and Oithona). Due to the rate-limited phosphorous, we decided to conduct a phosphorous addition experiment corresponding to the increase in the amount of the phosphorous load supplied by way of the Yangtze River, in order to determine the changes in the ocean ecosystem. We defined the carbon transport efficiency to zooplankton as the percentage of 13C in particles larger than 100 mm with respect to the 13C in all particles. We were able to determine that the path of carbon circulation through the ecosystem of the Yangtze River estuary included both a photosynthesis loop, with carbon being transported from dissolved inorganic matter to phytoplankton, to zooplankton, as well as a bacteria loop in which carbon is transported from dissolved organic matter to microzooplankton, to zooplankton. In addition, the average transport efficiency was found to be 5% for the photosynthesis loop and about 1% for the bacteria loop, which were 5 and 2 times, respectively, the figures for the coastal regions of Japan. These results show the high propagation of living organisms in the ecosystem of the Yangtze River estuary by higher-order predators. Currently we are developing a model of the ecosystem in the South China Sea and using survey results and NOAA, SeaWiFS, LANDSAT and other satellite images to verify this model. The pesticides and other toxic chemical substances detected in the deposits, combined with the high biological production in the ecosystem of the Yangtze River estuary and the high efficiency of carbon transfer to the high-order predators, raise concern about the introduction of pesticides to the marine ecosystem and the effect of this phenomenon. We feel that this is one of the most important issues for environmental management in the ocean regions in East Asia.

Figure Marine Mesocosm Experiment near the Mouth of the Yangtze River(Left) On the Research Vessel(Right) In the Ocean

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