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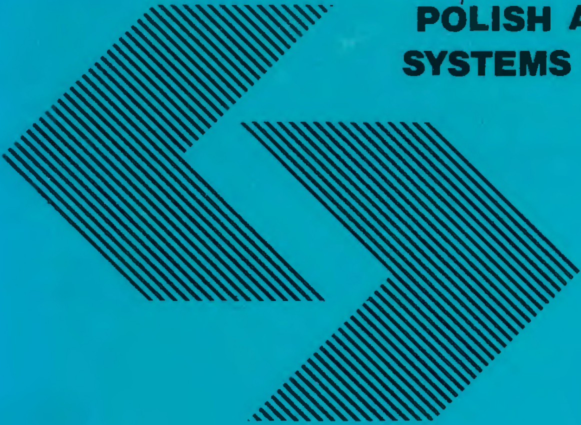

STRATEGIC REGIONAL POLICY

A. STRASZAK AND J.W. OWSIŃSKI
EDITORS

PART II

WARSAW 1985

SYSTEMS RESEARCH INSTITUTE
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STRATEGIC REGIONAL POLICY

Paradigms, Methods, Issues and Case Studies

A. Straszak and J.W. Owsiński
editors

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V. ENVIRONMENT

AN INTEGRATED MODEL OF ECONOMIC-ECOLOGICAL SYSTEM IN REGIONAL FRAMEWORK

- Japanese Experiences in Modeling Regional Environmental Management Programs

Saburo Ikeda

Institute of Socio-Economic Planning
University of Tsukuba
Sakura, Ibaraki 305, Japan

1. INTRODUCTION

This paper deals with the "Economic-Ecological Models" in the regional framework which are concerned with analysis of complexity in the interrelated processes among socio-economic, biological, chemical and physical components in the spatial setting at regional scale. The scope of regional framework includes such development and conservation problems associated with ecological components as:

(1) land use management
(2) ecological resource management
(3) pollution control
(4) conservation (open space, landscape, wildlife, vegetation, historical heritages and so on).

Most decision-makers in the regional levels are much more concerned with a spatial distribution of development impacts in terms of both equity and efficiency of social welfare and resource allocation schemes (Russel and Spofford 1977, Nijkamp 1980). This is especially true where public goods are involved in the planning or management models. A rise in the level of environmental amenity in some region may cause disamenity or impaired environment in other region, if there is a lack of total system's viewpoints in the policy evaluation issues. For example, inter-regional transfer of toxic wastes or pollutants from socio-economic activities including those with pollution abatement facilities, has been one of the most conflicting issues over regional and international boundaries (Thoss and Wiik 1974, OECD 1980). The conflict between beneficiaries and losers within the region gives increasing importance to the distributional consideration in the planning models in view of diverse nature of ecological responses to the developemt activities depending on the very local specific circumstances.

Thus we cannot provide practicable policy alternatives to the decision-makers without showing possible distributional outcomes of these altenatives on the basis of regional spatial conditions.

Kinds of models and modeling approaches examined in this paper are primarily selected on the basis of the Japanese experiences in this field which would be served as one of the typical examples undertaken in the countries under rapid industrialization and urbanization for the recent quater century. Because of urgent necessity of having policy evaluation tools for pollution abatement and nature conservation control in the days of environmental awareness of 1970's, some hundreds of models have been produced so far in the field of environmental pollution problems in Japan. These models include at least either economic or ecological components associated with pollution phenomena. Typical use of these models was primarily to simulate or forecast such possible pollution processes that are generated by industrial and urban wastes discharged from both public and private sectors.

There are, however, a few cases which dealt with comprehensively both economic and ecological elements in the sense of regional total system's viewpoints. Examples of these modeling efforts are:

(1) "Industrial-Ecological Models for evaluation of industrial policy" supported by "Ministry of International Trade and industry.

(2) "Environmental management Models in the special research programs on environmental sciences" supported by Ministry of Education, Culture and Science.

(3) "Eutrophication Management Models of Fresh-Water Area on Lake Kasumigaura Basin" supported by "Environment Agency".

In the following section, model structure, modeling approaches and policy issues developed by these models will be surveyed, and then comparative evaluation of these models will be conducted together with discussion on the future improvement of the "E-E Models" in the regional framework.

2. CONCEPTUAL STRUCTURE OF ECONOMIC-ECOLOGICAL MODELS IN REGIONAL FRAMEWORK

In order to facilitate a comparative evaluation of the models in the regional framework let us first set up a conceptual structure of the "E-E Models" in the regional total system's framework. Figure 1 is an example of such conceptualization of the existing Japanese models with reference to world-wide works in this field.

Socio-economic model in the left-hand side consists of a "macro-submodel" and a "micro-submodel" that are to be hierarchically connected. The macro-submodel describes the economic, social and demographic indicators by aggregating various human activities resulting by the interacting social units (actors) residing in the concerned area. The whole area could be devided into a several sub-regions from geographical, administrative and other reasons in accordance with the availability of macro data on these indicators. The aggregated value of these indicators are transferred to the "micro-submodel" as the exogeneous conditions.

The micro-submodel gives the levels of socio-economic activities assciated with the following fundamental social units:

i) production sectors
ii) public sectors
iii) consumption sectors.

It is in this submodel that the land use pattern, levels of public investment for social-infrastructure or pollution control, recreational demand by household, etc. are estimated either in "monetary" term or "resource" term (material balance or energy balance) (Kneese, Ayres and d'Arge 1970). The demand and supply of private or public goods are subject to environmental/ecological constraints in the spatial dimensions of the concerned region.

The "Ecological Model" in the right-hand side of Figure 1 simulates the biological, chemical and physical interactions between ecological components taking place in such a spatial environment as airshed, river-basin, lake, reservoir, coastal zone or the combination of these environments, where the ecological goods are not only utilized by human activities but also impacted by receiving wastes and pollutants discharged from socio-economic activities. It is this ecological model that needs a great deal of consideration on non-homogeneous nature and non-linearity in the dynamic behaviors of ecological components. For example, the recent deterioration of water quality (eutrophication of water body) in semi-closed basins, bay or coastal zones surrounding urbanized area requires further consideration about nutrients loadings (nitrogen, phosphorus and other organic matters) with respect to:

- o where nutrients come into and flow out, and
- o from what sources they originate:

This information is essential for the economics ecological models not only to predict a degree of water eutrophication but also to estimate the control cost and the damage cost to the fishery, recreation, irrigation as well as municipal or industrial water use, incurred by the frequent occurrence of phytoplankton blooms (red tides).

The middle section in Figure 1 is composed of:

(1) resource demand model,
(2) wastes (pollution) emission model and
(3) environmental constraints model,

that work as an interface between the economic and eclogical models.

The first one is to calculate the demand for ecological resources or commodities which are to be utilized by socio-economic units when the production and consumption levels are given by the "macro-economic model". The second one is to estimate the amount of wastes and pollutants to be generated and to be discharged into the spatial environment after cutting down by means of adequate control scheme. The third one is to evaluate regional environmental capacity of each ecological commodity to maintain a sustainable level in the prescribed regional area.

The focal point is how to set such threshold levels of sustainability or ecological stability in the regional setting. It seems to be clear that we need again enough scientific and technological information on the spatial distribution of ecological components to determine these levels of the environmental constraints. Table 1 illustrates an example of ecological components which are taken into consideration in this interface section in the case of coastal resource management model (Ikeda and Nakanishi 1982).

The major policy issues to be addressed in the present model framework are:

(1) to predict primary and secondary effects or responses which might be brought about both by the utilization of ecological resources and by the discharge of wastes and pollutants.
(2) to estimate the benefits and damages incurred by adopting alternaive combinations of control instruments in terms of economic or ecological indicators.

(3) to bring the comprehensive or total systems views into the regional environmental management plans beyond a traditional economic or ecological evaluation with spatially aggregated costs or efficiency.

3. INDUSTRIAL-ECOLOGICAL MODEL

3.1 Introduction

This research project was initiated in 1971 by the Ministry of International Trade and Industry (MITI) to respond to the national need of achieving harmonious industrial development with the environmental preservation being confronted with severe pollution problems during the latter half of 1960's (MITI 1972). To mitigate the heavy burden to the Japanese environment, the MITI needed to develop adequate industrial policies or guidelines of shifting gradually towards such an industrial structure that generate less wastes and pollutants. The primal purposes of this project were (Research Institute for Industrial Policy 1976-1980):

(a) What should be industrial activities in accordance with ecological principles in the natural environment?

(b) How should such industrial-ecological models be built?

(c) What are the industrial policies that comply with various demands in pluralistic society in reference to the objectives of (a) and (b)?

A multi-disciplinary team was formed with the members from the fields of ecology, economics, earth-science, medical science, systems engineering, urban planning and so on, and they reached a fundamental concept called "industrial ecology", which was stated as:

"Comprehensive analysis and evaluation of dynamical interrelation between human-activities of industrial development and environment."

This was quite a new idea at that time, particularly in the authorative body responsible for industrial development, although it is not clear whether or not their idea and philosophy have finally been implemented in the actual administrative decision making.

However, their initiated concept has been elaborated in developing various regional models within the original total system and found reasonable places not only in the multi-regional models of macro-type, but also ecological models in regional setting (Industrial Policy Research Institute 1976-1980).

3.2 Model Structure and Modeling Approach

Figure 2 illustrates the overall structure of the "Industrial-Ecological Model" which consists of multi-layered system of models (MITI 1972).

The macro model in regional setting utilizes energy and material flow in the form of "input-output table". The particular feature is to include explicitly not only natural and ecological resource but also pollutants in its input-output table as is now common in "Leontief's Model" for pollution control (Leontief 1970):

Production $X = \underline{A}X + F$ (to be produced for intermediate or final use)

Resource $Z = \underline{B}X + W$ (to be used for production or consumption)

Pollution $Y = \underline{C}X + G$ (to be discharged into the environment)

Here, X, Z and Y are vectors of industrial outputs, consumed resources and generated pollutants, respectively. F, W and G are vectors of final demands, recreation or amenity demands by households, and wastes disposals by housholds, respectiely. The matrices A, B and C represent consumption or generation coefficients by production sectors.

Then, the amount of ecological resource Z and pollutants Y are taken into consideration in the ecological models at the lower layer of Figure 2. Finally the pollution levels in air, water, soil and other environmens are to be analyzed in reference to some "Environmental Quaity Standards" set as constraints for industrial development policies.

3.3 Model Evaluation

It seems that the initial plan to develop the "Industrial-Ecological Model for Industrial Policies" is quite ambitious in terms of its scale and depth. We do not have enough measures to evaluate performance and practicability of the Industrial-Ecological model when they are actually applied to industrial policy formulation. But, some simulation results by using such macro models of "Kanto Region" or "Kansai Region" (these are two major industrial centers in Japan) were in fact taken into consideration in determining their industrial policy on the regional industrial structure.

Table 2 illustrates an outcome of the model simulation for the following industrial policy issues:

(1) increase of the ratio B/A between private investment-(A) and public investment-(B) for construction of social overhed capitals,
(2) shift of industrial structure from the resource-oriented type to the knowledge-intensive type,
(3) shift of consumer's behaviors from goods to services,
(4) tightening pollution control measures, and
(5) steady or stabilized population migration from other regions.

These policy questions are summarized by the order of favorability to the six scenarios in terms of "economic growth", "environmental quality level", and "required investment for pollution control" in which "standard type of industrial policy" was shown to be the most visible course during the first half of 1970s.

This project has recently concentrated its effort to the elaboration of detailed ecological submodels on the basis of "ecological database" or "ecological maps" rather than to the further development of large-scale macro-models in order to explore a dynamic harmonization between natural environment and highly industrialized society (Industrial Policy Research Institute 1980). In views of the recent concern with regional distribution problems of environmental pollution and amenity, it is quite understandable for this project to attempt to get more precise and quantitative information with respect to the ecological responses to the industrial policies in the regional framework.

4. ENVIRONMENTAL MANAGEMENT MODELS IN REGIONAL SETTING

4.1 Introduction

The "Special Research Program on Environmental Science" was created in 1977 by the Ministry of Education, Culture and Science to support the basic and comprehensive studies in various fields of environmental science. The scale of the grant to aid the research was, for example, about 950 million Japanese yen (about 4 million US$) in 1982 with over a thousand participants from public and private universies and research institutions. One of the specific purposes of this research program is to promote interdisciplinary research efforts and discussions on the issues associated with the relationship among the environment and human activities, the dynamics of natural environment and the technology of environmental pollution control. There are a number of researches concerning with the "Economic-Ecological Models" involved in the following fields of the special research program (Takahashi 1982):

(1) Ecosystem research
(2) Human health effects
(3) Technology for environmental management
(4) Concepts and methodologies in environmental studies
(5) Environmental monitoring

However, there has been so far a few studies on "E-E Models" in the regional total system's framework. Since the major purpose of the model building is directed to the scientific analysis and evaluation between socio-economic activities and their impacts on ecological environment, it requires a great deal of work for the scientists in academism to collect the empirical data and information that are to be used for for validating their models. Thus, some of the examples described in the next section are rather conceptual and have not yet been applied directly to policy formulation in the actual decision-making bodies.

The first and second examples are concerned with the models of the land-marine integrated development in the semi-closed sea area (Nishikawa et al. 1980, Ikeda and Nakanishi 1982). The objectives of these models are:

i) to understand the interactions between coastal land-use plans and marine-use plans which used to be implemented or administrated separately by different organiztions scattered in various levels of policy formulation bodies.

ii) to assess the dynamic behaviors of marine resources in terms of social costs (benefits and damages) for their utilization and preservation.

iii) to aid for desicion-makers to understand distributional figures of ecological components in space and sectors.

From the methodological viewpoint, these models consider explicitly dynamics of the socio-economical changes, and bring nonlinearity of eutrophication dynamics into the coastal ecosystem (Ikeda and Yokoi 1980). A variety of mathematical methods such as "Systems Dynamics (SD)", "Dynamic Programming (DP)" and "Linear Programming(LP)" are used in this ecological modeling based on the "material balance" (Kneese, Ayres and d'Arge 1970) or "energy balance" (Zuccetto and Jansson 1979).

4.2 Model Structure

As to coastal ecological model in Figure 3, the importance of nonlinear characteristics of eutrophication process urges us to construct a "system dynamic (SD)" model or a system of differential equations components rather than to use a static model of the "input-output table" type. Figure 4 illustrates a conceptual structure of a marine ecological model for the "Seto Inland-Sea" which consists of ten compartments (E1-E10) in the three trophic levels. They (E1-E10) are measured by the "organic carbon" contained in each compartment (biomass) that are originated from the primary production by phytoplanktons. Although the increase of nutrient loading into the coastal zone brings an increase of the primary production by phytoplanktons which uptake nutrients for their photosynthesis, the excess nutrients may destroy the stable structure of marine ecological system with a variety of fish species.

The inland-sea used to be one of the most affluent fishing bank in terms of productivity and variety of fish populations, but has been eutrophicated up to such a vulnerable level that has a frequent occurrence of "red-tides" (phytoplankton bloom) which happens to cause mass death of fish under cultivation and a drastic decrease of fish population with the high economic value.

The interaction between the socio-economic model and marine ecological model is analyzed by a relatively small number of elements in the interface of the "E-E Model", i.e. "Pollution Emission Model" and "Coastal Resource Demand Model" in Figure 3:

(1) Inflows of the nutrients (nitrogen and phosphorus) and pollutants such as COD or spilled oil.
(2) Physical destruction of the coastal zone by land reclamation and dredging for the extension of land area for industrial bases or urban uses, and construction of harbors, marine sports bases, etc.
(3) Harvest of marine products, both by fishery and by farming.
(4) Recreational use of coastal resource.

The overall resource allocation is carried out by the socio-economic model. The socio-economic model of coastal zone is a kind of LP model which has a multi-objective function associated with the social welfare in regional framework. It has two types of constraints, that is, hard and soft ones, attached to the LP model. The hard constraint is the one which is fixed rigidly concerning physical capacity of resource or exogeneous conditions. The soft one, on the contrary, can be set in accordance with human or societal preference due to a variety of demands by sectors. These are, for examples, income, public services, demand for amenity or recreation, which are calculated on the basis of the "SNA", a System of National Account proposed by the United Nations in 1968.

4.3 Modeling Approach

From the theoretical viewpoint of environmental economics, our ecoomic-ecological model of coastal resource use can be formulated by the following equations with respect to societal utility maximization (Fischer 1980):

Maximize

$$U(u_1, u_2, u_3, u_4, \underline{Q}) \text{: societal utility in regional coastal system} \qquad \text{(A)}$$

$$\left.\begin{aligned}
u_1 &= u_1(x_{11}, x_{21}, \ldots\ldots, x_{i1}, \ldots\ldots, \underline{Q}) &&\text{: utility of fishery industry}\\
u_2 &= u_2(x_{12}, x_{22}, \ldots\ldots, x_{i2}, \ldots\ldots, \underline{Q}) &&\text{: utility of recreation and amenity services}\\
u_3 &= u_3(x_{13}, x_{23}, \ldots\ldots, x_{i3}, \ldots\ldots, \underline{Q}) &&\text{: utility of industrial production}\\
u_4 &= u_4(x_{14}, x_{24}, \ldots\ldots, x_{i4}, \ldots\ldots, \underline{Q}) &&\text{: utility of urban services}
\end{aligned}\right\} \text{(B)}$$

subject to

$$u_j = u_j(x_{1j}, x_{2j}, \ldots\ldots, x_{ij}, \ldots\ldots, \underline{Q}) \geq u_j^* \text{ : minimum utility of the j-th sector } (j=1,..,m) \qquad \text{(C)}$$

$$f^k(y_{1k}, y_{2k}, \ldots\ldots, y_{ik}, \ldots\ldots, \underline{Q}) = 0 \text{ : production function of the k-th sector } (k=1,..,p) \qquad \text{(D)}$$

$$\sum_j x_{ij} - \sum_k y_{ik} \leq R_i(\underline{Q}) \text{ : constraint for i-th resource } (i=1,\ldots,n) \qquad \text{(E)}$$

where x_{ij} is the amount of resource or good consumed by the j-th sector, y_{ik} is the amount of resource or good i produced ($y_{ik}<0$) or used ($y_{ik}>0$) by k-th sector, u_j^* is a minimum requirement for j-th sector's utility function u_j, and $f^k(.)$ is a production function of k-th sector. The variable $\underline{Q}$ in (A)-(E) is a vector of environmental pollutants that brings the environmental externality into each sector's utility, production and constraint functions.

However, since we have not yet established a workable and practicable measures for evaluating societal utility which includes the values of environmental goods or services such as recreation and amenities of landscape, wildlife and vegetation, it is almost impossible to carry out such maximization scheme as defined by (A)-(E). Even if we could succeed in identifying the utility functions (A)-(C) by any means, it would be misleading for us to determine a resource allocation policy by undertaking some mathematical optimization algorithm under such a condition that there is a great deal of discrepancy in utility value between industrial products and recreational services in the current monetary masure.

The second model is a simplified version of the former model, and aims not only to work so efficiently as to reach a practical result, but also as to stand on a simpler theoretical basis of environmental economics in terms of cost efficiency of model building. Figure 5 shows the overall structure of this simplified version of economic-ecological model for the coastal resource utilization and management of eutrophication. This model attempts to construct an empirical and practicable model from the currently available data based on the theoretical framework of (A) -(E) as much as possible. In addition, the maximization procedure in (A)-(E) would be replaced by making the conventional "trade-offs" by means of the man-machine conversation between decision-makers and computer simulations.

The major simplifications in Figure 5 are as follows:

i) Instead of having explicit forms of utility or production functions, a kind of input-output table is set up to assess the economic activities associated with coastal marine resource utilization which includes specifically, fishery, recreation and transportation as well as industrial and urban activities.

ii) The evaluation of such policy issues of societal utility maximization by (A)-(E) will be carried out by the conversation type of communication between scenario writing on policy alternatives and the computer simulations for them. This evaluation process is based on the conceptual framework of "Environmental Economics" which takes into consideration the possible environmental externality Q in terms of environmental capacity R(Q).

4.3 Model Evaluation and Case of the Harima-Nada

In order to map out the basic interdependence among four major sectors; (1) fishery, (2) recreation and amenity, (3) industry and (4) urban service, we conduct a preliminary study of constructing an input-output table in the coastal region surrounding the "Harima-Nada" (see Figure 7). Specific features of this sea area are:

(1) Geographycally, it is a semi-closed sea whose water is exchangeable only by a couple of channels with that of the outer sea. The sea is relatively shallow , i.e., the average depth is about 30 meters.

(2) It is surrounded by highly industrialized and urbanized areas such as Osaka, Kobe, Himeji and Mizushima industrial bases as shown in Figure 7. Hence it has suffered from heavy inflows of nutrients and other pollutants.

(3) A number of Reclamations and dredgings have been carried out along the greater part of the coastal area.

(4) Due to the heavy sea traffic, the oil discharged from boats and ships has contaminated the sea.

Table 3 shows the result of the input-output table for the "Harimana-Nada". We used the data and statistics from the "Industrial I-O Table" of "Hyogo Prefecture" which occupies the northern part of the sea and shares more than ninety percent of total nutrient loadings into this sea area.

As to the recreational activity, only "swimming" and "sport fishing" are counted as the amount of services in "recreation and amenity sector". Other amenity services including leisure activities at the coastal resort area may be included in the "Urban Service Sector" as long as they consume the goods or other services. To estimate such input-output values for the recreation and amenity sector from the formal I-O table of Hyogo Prefecture (Planning Bureau, Hyogo Prefecture 1981), we used the field survey on the tourlists conducted by the Hyogo Prefecture (Commerce & Industry Bureau, Hyogo Prefecture, 1978 and 1982). This survey included the number of tourists by their purposes and amount of money spent in accomodation, transportation, food and drink, and so on. A part of this survey is shown in Tables 4 and 5. The input values into the sector of "recreation service" are to be reduced from the sector of "urban services" to keep consistent figures within the input-output table. The estimated final demand for "recreation service" in this coastal region is about 32,377 million Japanese yen which accounts for almost equal value of the "fishery sector".

In the part of "marine ecosystem model" in Figure 5, the specific emphasis is paid on the dynamic process of eutrophication phenomena and its impacts to the production structure of marine ecological compartments The basic elements and the relationship of their biological processes are illustrated in Figure 8, where the nutrients loads Q is to be fed in through "model of wastes and pollution loads", given the final demands of the production sectors by the input-output table.

The model consists of two parts. One is to determine hydraulic conditions of the tidal currents in the sea which is vertically devided into two layers. The tidal current is considered to be one of the key factors to obtain a spatial distribution of ecological compartments. The other is to calculate biological interactions among ecological compartments (nutrients, phytoplanktons, zooplanktons, benthos, fishes, etc.) together with the diffusive and advective transportation in the current field of two layers. The general dynamic equations which describe a horizontal or vertical distribution of a biomass of each components, P, is expressed by

$$\frac{\partial P}{\partial t} = \underbrace{-u\frac{\partial P}{\partial x} - v\frac{\partial P}{\partial y} - w\frac{\partial P}{\partial z}}_{\text{(advection)}} + \underbrace{K_x\frac{\partial}{\partial x}\left(\frac{\partial P}{\partial x}\right) + K_y\frac{\partial}{\partial y}\left(\frac{\partial P}{\partial y}\right) + K_z\frac{\partial}{\partial z}\left(\frac{\partial P}{\partial z}\right)}_{\text{(diffusion)}}$$
$$+ \{\text{Biological Dynamics}\}$$

where u, v, w are the tidal current velocities in x, y, z directions, respectively, and K is a turbulent diffusion coefficient. The term of biological dynamics represents such a relationship as is illustrated in Figure 8, and is given in details in our paper (Ikeda and Kishi 1982).

Figure 9 shows an example of the computed results of tidal residuals which is presumed to constitute a major part of "steady flow" in the "Harima-Nada". Given this current field and nutrients loading from rivers flowing into the sea which is to be estimated by the "wastes and pollution model"(see Figure 11), we are able to simulate the dynamic behaviors of ecological compartments in regional spatial dimensions.

Figures 10-15 are several examples of these similation results in two layers after six tidal cycles from the uniform initial state and from constant boundary conditions at both the "Bisan-Seto" and the "Kii-Channel". It is shown that there is a clear spatial difference between the distributions of two phytoplantons, "Diatom" and "Chattonella", which have different responses to the nutrients and physical conditions in this sea area (see Figures 13 and 14). The "Chattonella's bloom" in the summer season may cause a great damage not only to fish farming but also to the recreation service because of disamenity of their colors and smells. The details of these computation is given in the forthcoming paper (Kishi and Ikeda 1984).

5. EUTROPHICATION MODELS OF FRESH-WATER AREA IN REGIONAL FRAMEWORK

5.1 Introduction

This comprehensive study on the eutrophication of fresh-water basin area was started in 1977 as a special project in the National Institute for Environmental Studies (NIES) funded by Environmental Agency in Japan. The project focusses a specific attention on the quantitative analysis of eutrophication effects on man's utilization and presevation of lake water resource in regional total system, particularly in the case of Lake Kasumigaura (NIES 1977). Since Lake Kasumigaura is one of the major water resources for the Kanto-Region with over twenty million people, the deterioration of lake water quality causes a significant impact not only on municipal water supply, but also on other uses of the lake environment such as recreational activities, commercial fishing and fish firming.

The study topics related with "integrated model for prevention of eutrophication" within this comprehensive project are:

(1) production and consumption activities in regional society which include wastes trearment at source,
(2) man's utilization of lake water resource,
(3) supply of amenity and recreational services, and
(4) flood control function associated with the lake physical capacity of water reserves and flood plains.

The policy objectives of these modeling effort is primarily to establish some quantitative measures or indicators to be used in estimating benefits of eutrophication control or in estimating pollution-caused damages to the production activities in the lake-basin area (Nakasugi et al. 1979).

5.2 Model Structure and Modeling Approach

Figure 6 illustrate the interrelationship among the submodels in their model framework (Kitabatake 1981). Except the evaluation of amenity and recreational activities, the submodel are largely formulated in the framework of environmental economics, where a production function or a damage function is estimated empirically by means of econometric method. For example, the welfare cost for fish farming industry (mostly carp firming) is derived from the information on water quality, dose-response relationship such as "water quality" versus "amount of damages for the carp production" versus water quality, and other economic data on fisherman's household.

For example, the damage function D of carp farming by the opration with feed supply boxes is regressed in the form of

$$D = f(U, \underline{Q})$$

where $U=(u_1,u_2,u_3)$: (capital input, labor cost, feed cost)

$\underline{Q}=(q_1, q_2, q_3)$:(temperature, transparency, chlorophyll-a)

and has the following result by N=152 samples:

$$\begin{aligned} D/Y = -15.673 &+ \underset{(1.645)}{.006(u_1-u_1^*)} + \underset{(6.559)}{1.249(q_1-q_1^*)} \\ &- \underset{(-4.680)}{7.082(q_2-q_2^*)} \underset{(-3.331)}{-4.102\delta}, \qquad R^2=0.331. \end{aligned}$$

where Y is the production output of carps, u_1^*, q_1^*, q_2^* are sample means, and δ is the dummy variable of using aeration devices. The F values in parenthesis for inclusion and exclusion of variables in the regression equations are taken to be 2.0 (Kitabatake 1982).

Then, welfare cost of eutrophication which caused production losses for fish farming industry in Lake Kasumigaura is estimated based on the damage function D, given a marginal production cost function $Y=f(u_1, u_2, u_3)$ for operators. The same kind of analysis of eutrophication effect on the municipal water supply is carried out by taking account of a purification cost in short-term and a change of the intake point in long-term. As for a recreational use of the lake water resource, a kind of psychological method of evaluating the landscape at lakesites is attempted to have a quantitative relationship between residents' responses and phydical or biological features of the lakesite scenary.

5.3 Model Evaluation

The submodels of utilizing lake water resources are intended to quantify the economic values of the benefits or damages caused by the lake eutrophication in such sectors as fishery, fish firming, municipal water supply, and recreational use of lakesites. Besides the detailed studies on these submodels, there is a plan to develop a comprehensive economic-ecological models for controlling nutrients loading into the lake in the scale of the lake-basin area. Indeed, it is a quite difficult and time consuming task to get practicable data for building these empirical models in regional and spatial scale. But it is also true that without these empirical models based on the concept of the "E-E Model" in regional framework, any result of policy evaluation would become an illusion. The next issue the NIES project is going to tackle is how to integrate the demand or supply models of recreation and amenity into the "E-E Models" of the Lake Kasumigaura.

6. CONCLUSION

So far, most of Japanese models have not been directed toward a practicable use in the authoritative decision-making. They are rather assumed to be aids for policy evaluation of the long-term planning either in central or prefectural government bodies in order to have a scientific validation or critical information concerning with the proposed policies or projects. In this respect, we need further development of such a regional total system model of having more elaborate interface between economic and ecological submodels that facilitates the intermediate trade-offs in various regional decision-making bodies.

In this paper, we give the basic concepts of coastal economic-ecological models in regional framework and develop some methodological framework to evaluate both the utilization of marine resources and the control of eutrophication in coastal zone. It is, however, far from the goals of modeling objectives in terms of applicability and practicability of the economic-ecological models to the decison-making process in the context of the regional environmental management. This is partly due to the inconsistency of utility measures for economic and ecological goods or environmental services, respectively.

For example, the fish farming in the Seto Inland-Sea occupies not only a fairly large portion of water area in good water quality and in calm condition, but also it eutrophicates the sea water by itself due to excessive feeding or wastes from the dense fish population in the firm. The farming of sea weed which shares over one third of fishery production needs a relatively eutrophicated sea water to promote the primary production of photosynthesis. But, these areas that are suitable for the sea weed farming are also competitive for recreational or industrial uses. The recent increasing demand for recreation and amenity such as swimming, boating, sport fishing as well as picnicking along the marine coasts and resorts is raising a question whether or not we should promote such artificial farming of fishes and weeds. Instead we may be able to rely on natural farming in the Seto Inland-Sea as a whole by implementing an adequate eutrophication management plan for preserving a sustainable fish stock.

In order to explore such a policy issue, there is still a large gap between economic and ecological modelings. The gap, for instance, lies between eco-spatial information with respect to fish stocks, their dynamics and sustainability, and economic information on fishery industry, that is, supply and demand for a variety of fishes by consumption sectors. Nevertheless, given the recent progress in ecological modeling in regional total systems and in analysing eutrophication process taking place in the coastal or bay area, it would become more and more practicable and feasible to take the spatial distribution of ecological components in the economic evaluation of ecological resource management.

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Table 1 Illustrative Examples of Ecological Components of E-E Model in Coastal Management

Man's Activity for Resource Utilization	Fishery (fish catches, farming)	Recreation (swimming, picnicking, fishing)	Transportation (harbors, ship service)	Industry (industrial bases)
Ecological Resource Demand	fish population planktons feeds	fish populations coast vegetation		
	shoal water area underwater grass	natural coastline beach/shore water quality	bay/inlet open sea	coastline shallow open sea
Wastes and Pollution	nutrients	oil spill wastes	oil spill	wastes nutrients oil spill
Environmental Constraints	fish stock open sea	coastline beach	bay/inlet	coastline shallow open sea

Table 2. Comparative ranking of policy alternative (MITI, 1973)

Policy type	Policy issues (1)	(2)	(3)	(4)	(5)	Economic growth (GRD)	Environmental quality level	Required investment for pollution control
Standard	+	+	+	+	+	4	2	2
No pollution control	+	+	+	—	+	3	5	
Private sector	—	+	+	+	+	2	4	1
No migration	+	+	+	+	—	6	1	3
Industrial structure	+	++	+	+	+	4	2	4
Private sector and no pollution	—	+	+	—	+	1	6	

Notes: (+) means positiveness for each policy issue.

(−) means negativeness for each policy issue.

Table 3 Input- Output Table of Regional Economy in Coastal Zone,Hyogo Prefecture, 1978

	(1) Fishery (fishing, farming)	(2) Coastal Recreation Service	(3) Industry	(4) Coastal Water Transport.	(5) Transportation & Distribution	(6) Urban Service	(7) Unclassified activities	Total Intermediate sectors	Total Final Demand	Total Coastal zone Production
(1) Fishery	653 (354 299)	296	33,936	0	1	8,856	34	43,770	-14,054	29,772
fishing	(192 162)	(160)	(18,397)	(0)	(0.5)	(4,801)	(18)	(23,731)	(-7,619)	(16,112)
farming	(162 137)	(136)	(15,539)	(0)	(0.5)	(4,055)	(16)	(20,045)	(-6,435)	(13,510)
(2) Coastal Reacreation Service	0 (0 0)	0	0	0	0	0	0	0	32,377	32,377
(3) Industry (1st and 2nd)	6,080 (3,296 2,784)	9;230	3,906,584	20,329	249,635	502,991	84,139	4,778,988	2,739,801	7,518,789
(4) Coastal Water Transportation	64 (35 29)	133	24,133	2,833	29,661	.3,134	549	60,507	38,356	98,863
(5) Transportation & Distribution	592 (153 5)	1,730	160,580	1,730	77,554	104,516	40,776	387,022	329,917	716,939
(6) Urban Services	1,405 (762 643)	5,512	821,493	11,714	99,053	509,624	65,025	1,513,821	2,104,453	3,618,274
(7) Unclassified Activities	689 (373 316)	332	118,115	2,624	5,827	60,929	0	188,516	26,327	214,843
Total Intermediate sectors	9,483 (5,141 4,342)	16,777	5,064,841	39,230	462,731	1,190,050	190,518	6,972,630	5,257,177	12,229,807
Value Added	20,239 (10,971 9,268)	15,600	2,453,948	59,633	255,208	2,428,224	24,325	5,257,177		
Total Coastal-Zone Production	29,722 (16,112 13,610)	32,377	7,518,789	98,863	716,939	3,618,274	214,843	12,229,807		

(Unit: Million Yen)

Table 4. Survey of tourists in Hyogo Prefecture, 1978

sub-region in Hyogo Pref.	total tourists	swimming & fishing	day's tripper	lodged tripper
Kobe	14,706			
Hanshin	18,288	28	94.8 %	5.2 %
East Harima	10,868	434	95.8	4.2
West Harima	5,523	820	84.8	15.6
Awaji	6,360	1,772	74.7	25.3
Total	(thousand people)	3,054	2,458	593.

Table 5. Averaged consumption by tourists in 1978

	total	transportation	accomodation	miscelleneous (meal	etc)
Day's tripper	5,100	1,400	0		3,700
Lodged tripper	33,400	10,500	9,800	9,000	3,800

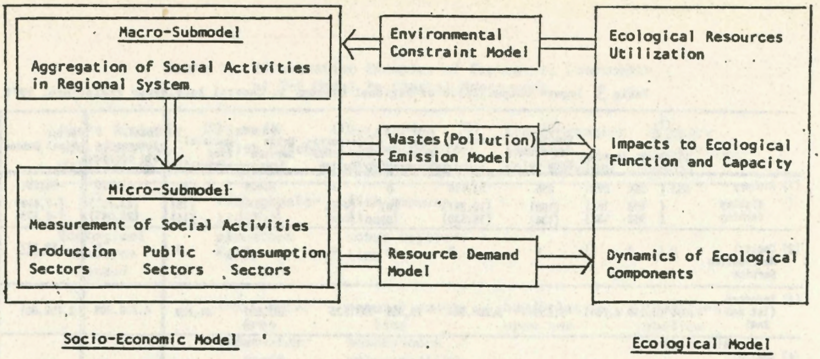
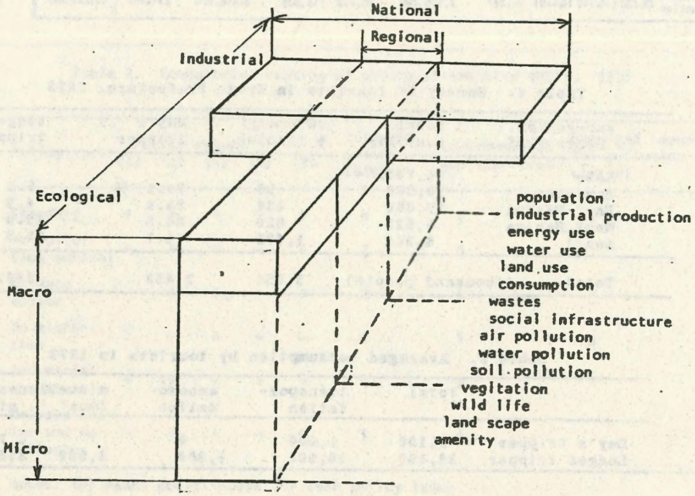


Figure 1 Conceptual Structure of Economic-Ecological Model in Regional Total System's Framework

Fig. 2. Multi-layered Structure of "Industrial-Ecological Model"



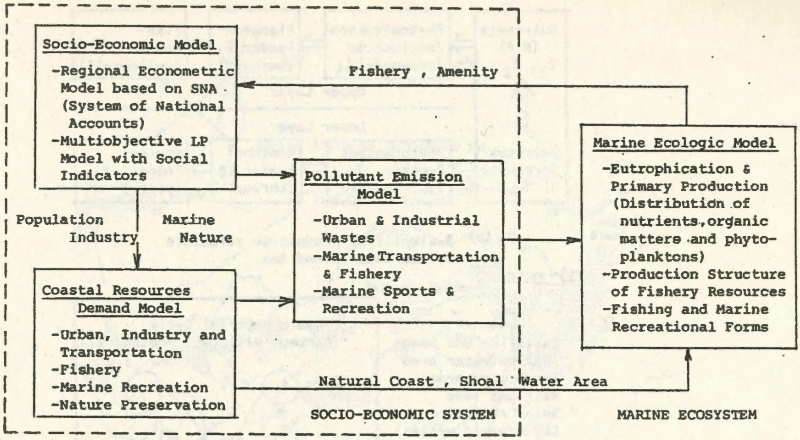


Fig. 3 Overall structure of the E-E model

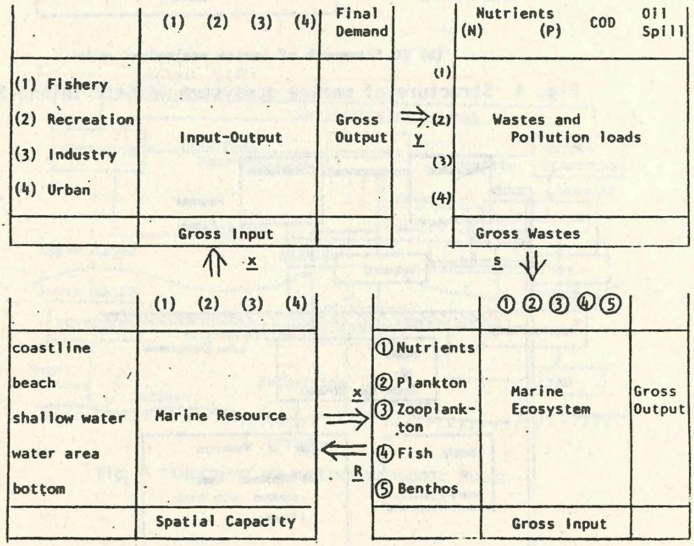
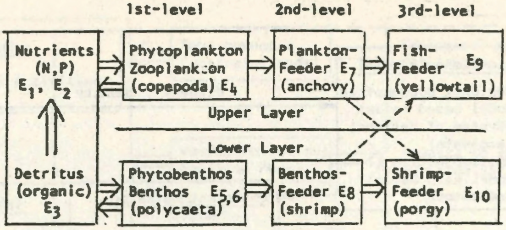
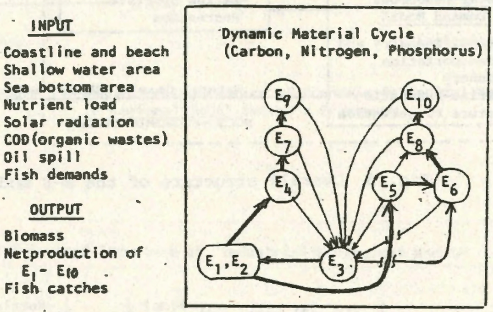


Fig. 5 Structure of the simplified E-E Model



(a) A simplified production structure in the Seto Inland Sea



(b) SD framework of marine ecological model

Fig. 4 Structure of marine ecosystem in Seto Inland-Sea

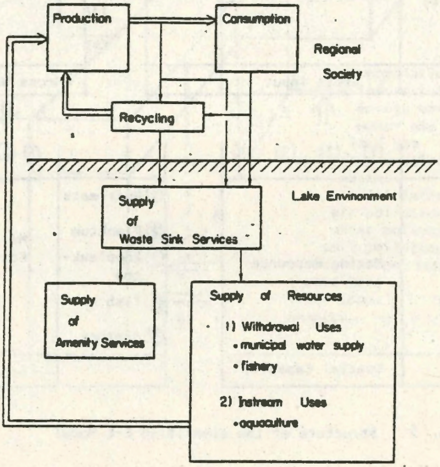


Fig. 6 Structure of lake utilization in regional total system

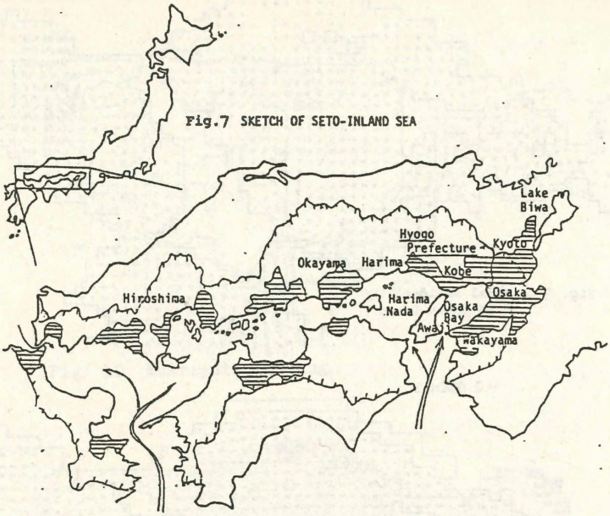


Fig.7 SKETCH OF SETO-INLAND SEA

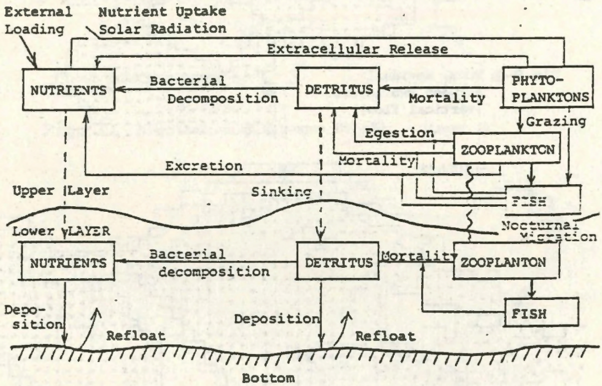


Fig. 8 STRUCTURE OF MARINE ECOLOGIC MODEL

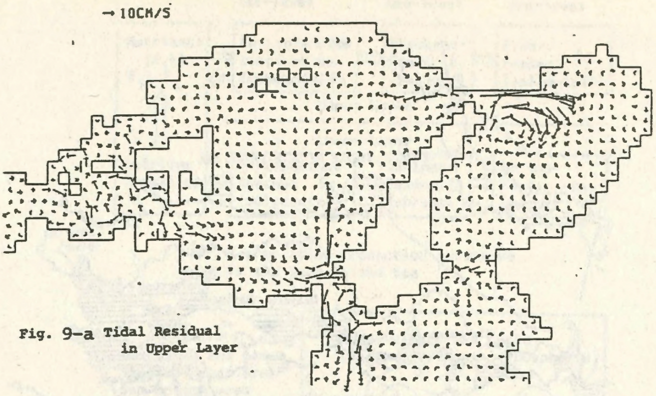


Fig. 9-a Tidal Residual
in Upper Layer

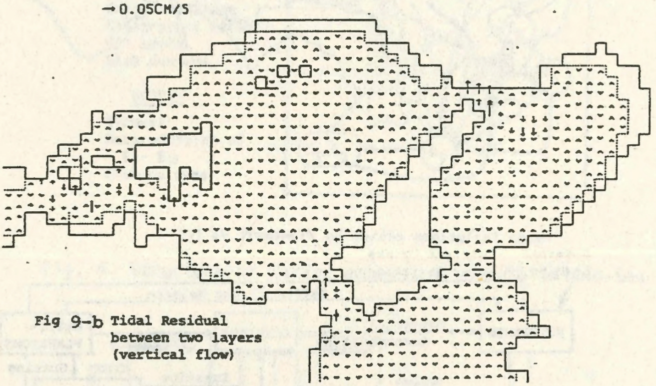


Fig 9-b Tidal Residual
between two layers
(vertical flow)

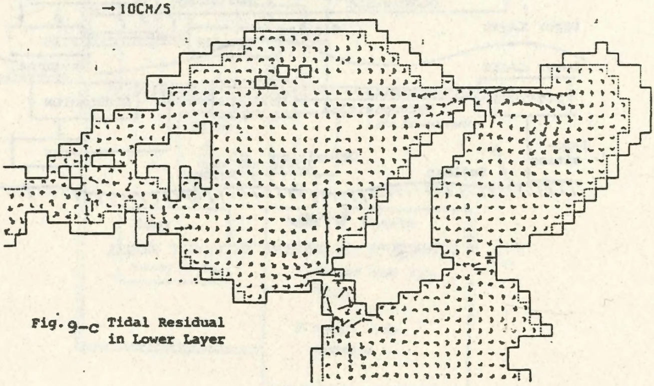
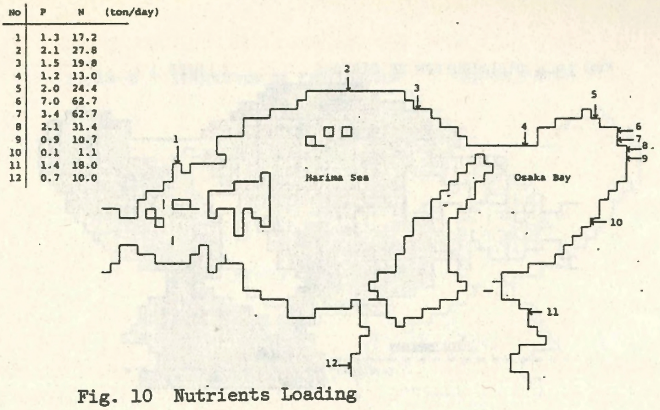


Fig. 9-c Tidal Residual
in Lower Layer



No	P	N (ton/day)
1	1.3	17.2
2	2.1	27.8
3	1.5	19.8
4	1.2	13.0
5	2.0	24.4
6	7.0	62.7
7	3.4	62.7
8	2.1	31.4
9	0.9	10.7
10	0.1	1.1
11	1.4	18.0
12	0.7	10.0

Fig. 10 Nutrients Loading

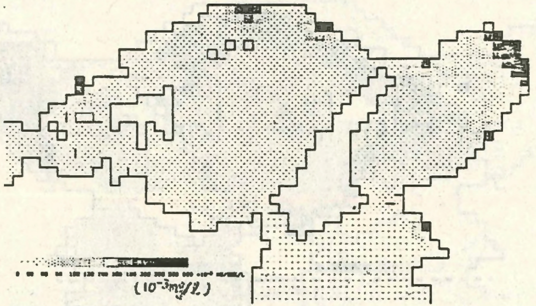


Fig. 11 Distribution of Nitrogen (NO_3-N) (Layer 1)

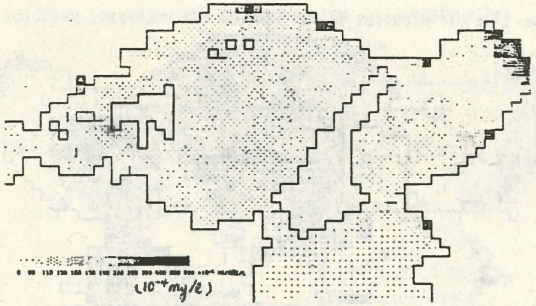


Fig. 12 Distribution of Phosphorous (PO_4-P) (layer 1)

Fig. 13-a DISTRIBUTION OF DIATOMS (LAYER 1)

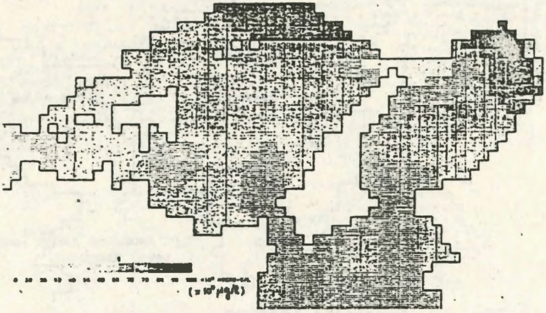


Fig 13-b DISTRIBUTION OF DIATOMS (LAYER 2)

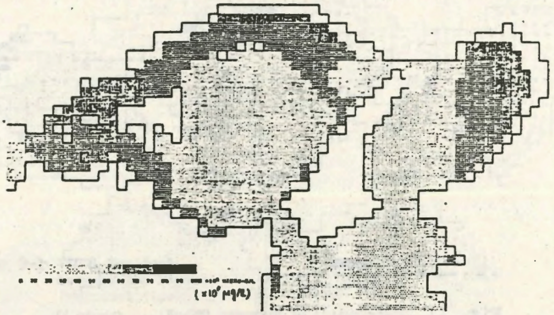


Fig. 14-a DISTRIBUTION OF CHATTONELLA (LAYER 1)

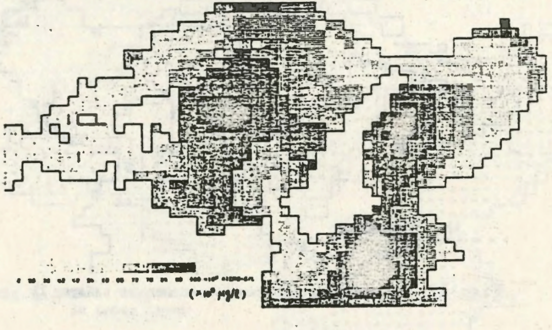


Fig 14-b DISTRIBUTION OF CHATTONELLA (LAYER 2)

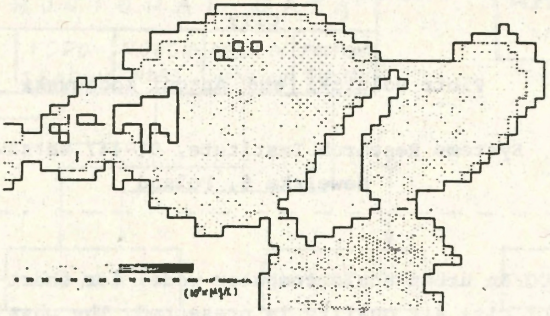


Fig 15-a DISTRIBUTION OF ZOOPLANKTON (LAYER 1)

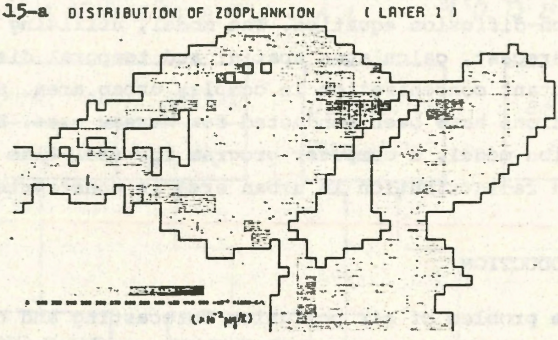
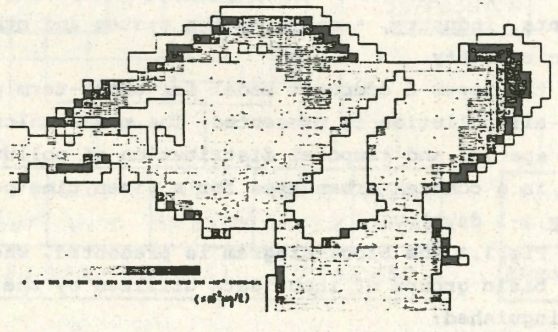


Fig. 15-b DISTRIBUTION OF ZOOPLANKTON (LAYER 2)



DISCUSSIONS

Paper by L. Kairiukštis

Discussion participants: A. Straszak, J. Owsiński, K. Polenske, R. Espejo, L. Kairiukštis.

Most of the questions were asked in order to obtain extra explanation as to the notions and structures used throughout the paper. These questions, related e.g. to the place of regions in the systemic structure outlined or to implementation and application of the comprehensive view presented, are satisfactorily answered in the text at hand.

Apart from that a question was asked in what way it is intended to influence policy makers - i.e. national and local governments - in order to increase the understanding of problems at hand. The answer pointed out that the only practicable means was to provide information to these who are resposible for activities influencing the biosphere, to make them aware of reasonable constraints connected with such activities.

Paper by S. Ikeda

Discussion participants: A. Kochetkov, K. Polenske, L. Kairiukstis, S. Ikeda.

Several explanations were asked for. First: the empirical basis for the input/output model - at the national level according to the international standard breakdown, i.e. approx. 200 categories, and at the regional level more aggregate tables synthesized from otherwise available information. Some activities, like fish processing industry, were left out because of lock of adequate data. Some other ones, like private sector investments, are treated through aggregates.

As to the formal side of the model development, it is provided by the three-year contract from the Ministry of Science and Education, and the model developers hope for an extension of another three year period in order to complete the work.

Paper by P. Holnicki and A. Żochowski

Discussion participants: T. Vasko, K.P. Moeller, D. Boekemenn,
A. Straszak, R. Bolton, P. Holnicki.

In response to questions one of the co-authors explained that: the control variable of the model was production level of a given factory, the sources located outside of the area considered had not been accounted for because of lack of appropriate data, and: location and time variables had not been used as control ones in the model, although this could be done within the same model structure. Many of the model features resulted directly from specifications made when accepting the contract.

On the policy side, in view of the preliminary nature of the model no experience could as of then be gained on the enterprises' reactions. In fact, the model builders were responsible solely for model development.

IBS Konf
38574/II
Bibl. podręczna

ADDRESS
6, NEWELSKA ST.
01-447 WARSAW
Tel. 36·44·14 , 36·81·50
Telex: 812397 ibs pl