The ECOPATH II Software or How We can Gain from Working Together

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Throughout the world the use of traditional single-species models to provide management options for fisheries has become increasingly problematic. Species in an ecosystem interact and single-species models can be applied with reasonable confidence only when the stocks are in a relatively stable condition. The solution to the problems is multispecies modelling.

During the last decade several groups of researchers have developed multispecies models for management purposes, e.g. in the North Atlantic, and the Northeast and Southeast Pacific regions. The development of these models has shown that multispecies modelling is a task far from trivial, and the models have not yet been of real use for management purposes. One of the problems has been that in some instances the multispecies models have led to completely opposite management advice than that obtained from traditional single-species models, leaving the managers with a difficult choice.

These simulation models are promising though, and they will probably prove to be very useful in the course of the present decade. However, they demand a large data input, which makes it unlikely that the experience from the present few models will provide us with the shortcuts needed if multispecies models are to become the standard management tool in hundreds of management areas throughout the world. In consequence, we may have to look for something simpler to give us a 'picture' of a certain ecosystem.

The first steps can be to group the hundreds or thousands of species in the system into a manageable number of ecologically related groups in "boxes", and then try to describe the flows between them.

Box Models

When trying to model the energy balance of a plant, a fish or perhaps a pond system, the most used method is to study (only) the organism/group of special interest, trying to estimate all the parameters that add together to give the energy balance. The procedure is to express that input equals output, e.g.,

Consumption + Import = Production + Excretion + Egestion + Respiration

This balanced equation can, when applied to all groups of the system, be used to model nearly everything, from a coral reef to the cash flow of a nation's economy.

For the biologist trying to express the energy budget, the main problem is to estimate the components, e.g. consumption, or respiration and in consequence he or she may choose to disregard the rest of the system.

An alternative approach is to study the whole system. J.J. Polovina of the Southwest Fisheries Center, Hawaii, has suggested a model where a single element of the energy balance (i.e., the production) is studied in detail for *all* groups in the system. Thus production can be expressed as:

Production = Export + Predation + Flow to Detritus

The term "predation" links the groups of the system with each other. If for instance the predation rates are unknown for all the, say, ten groups in the system, we end up with ten equations like the one just above, all of which have the same ten unknowns. Such a system of equations can be solved, and we thus get estimates of all the ten unknown predation rates.

As this example shows, it is possible to estimate a missing parameter for each box by combining the information on all the groups in the system. The message thus is: Let us combine our incomplete knowledge of the individual groups to gain additional information. In this case, the whole becomes more than the sum of its parts (see also Pauly, p. 11).

The first application of the method described here was carried out by J.J. Polovina and coworkers on a coral reef ecosystem, the French Frigate Shoals, Hawaii.[1] The French Frigate Shoals team developed a software called the ECOPATH Model which could be used to calculate the biomasses of the groups in the system from estimates of diet compositions, consumption and production rates, as well as biomasses of the top predators.

Concurrently with the development of the original ECOPATH Model where the emphasis was on biomasses, theoretical ecosystem modelers have concentrated their effort on describing the network of flows in ecosystems, and on methods for comparing ecosystems. What must so far be considered a culmination of this work was presented by R.E. Ulanowicz.[2] He gives a set of network flow indices, the theoretical basis of which appears to provide a tool for describing the flow characteristics of an ecosystem. The new tool makes it possible to *compare* ecosystems, e.g., a coral reef, a polyculture pond, and a lake system, or for that matter a single ecosystem as it matures through development.

The Software

The ECOPATH II model marries the approaches by Polovina and Ulanowicz. A first version of the new model was

presented by Pauly et al.[3] (in press), and the model has since been further developed and refined so that Version 1.0 is now available as Software 6 from the ICLARM Software Project[4]. The ECOPATH II program is supplied on one 5 1/4" floppy diskette and can be run on any IBM compatible PC, without need for additional software.

The ecosystems that are analyzed with the ECOPATH II must be in steady-state, which means that the flows in and out of each of the components (boxes) must be balanced over the time period studied. This may seem a tricky requirement but it can be met for most ecosystems, even for rapidly developing systems as pond cultures, by either averaging over the total production period, or by taking "snapshots" of the system, i.e., by looking at short time intervals.

For each of the groups any one of predation rate, consumption rate, biomass, or ecotrophic efficiency ((Predation + Export)/Production) may be unknown. In some cases, consumption may be unknown in addition to one of the three other variables. The diet composition, imports and exports (which include catches/harvests) must be known.

The model will estimate the missing parameters and the flows between the boxes. In addition, it is possible to get all the cycles and the flow pathways of the system printed. Finally, the network flow indices mentioned above are calculated.

An Outlook

The approach described in this article is part of one of the more holistic projects (see Pauly, p. 11) that we are presently emphasizing at ICLARM. The project, called "Global Comparisons of Trophic Aquatic Ecosystem Models", is designed to support modelling efforts of research groups throughout the world (see box). The ECOPATH II Model will be further developed to include management options. The Global Comparisons Project is funded fully by the Danish International Development Agency (DANIDA).

For more information, see p. 16.

Further Reading

[1]Polovina, J.J. 1984. Model of a coral reef ecosystem. I. The ECOPATH model and its application to French Frigate Shoals. Coral Reefs 3(1): 1-11.

[2]Ulanowicz, R.E. 1986. Growth and development: ecosystem phenomenology. Springer Verlag, New York. 203 p.

[3]Pauly, D., M. Soriano and M.L. Palomares. Improved construction, parametrization and interpretation of steady-state ecosystem models. Kuwait Bull. Mar. Sci. 11. (In press).

[4]Christensen, V. and D. Pauly. 1990. A draft guide to the ECOPATH II program (ver. 1.0). ICLARM Software 6, 22 p.

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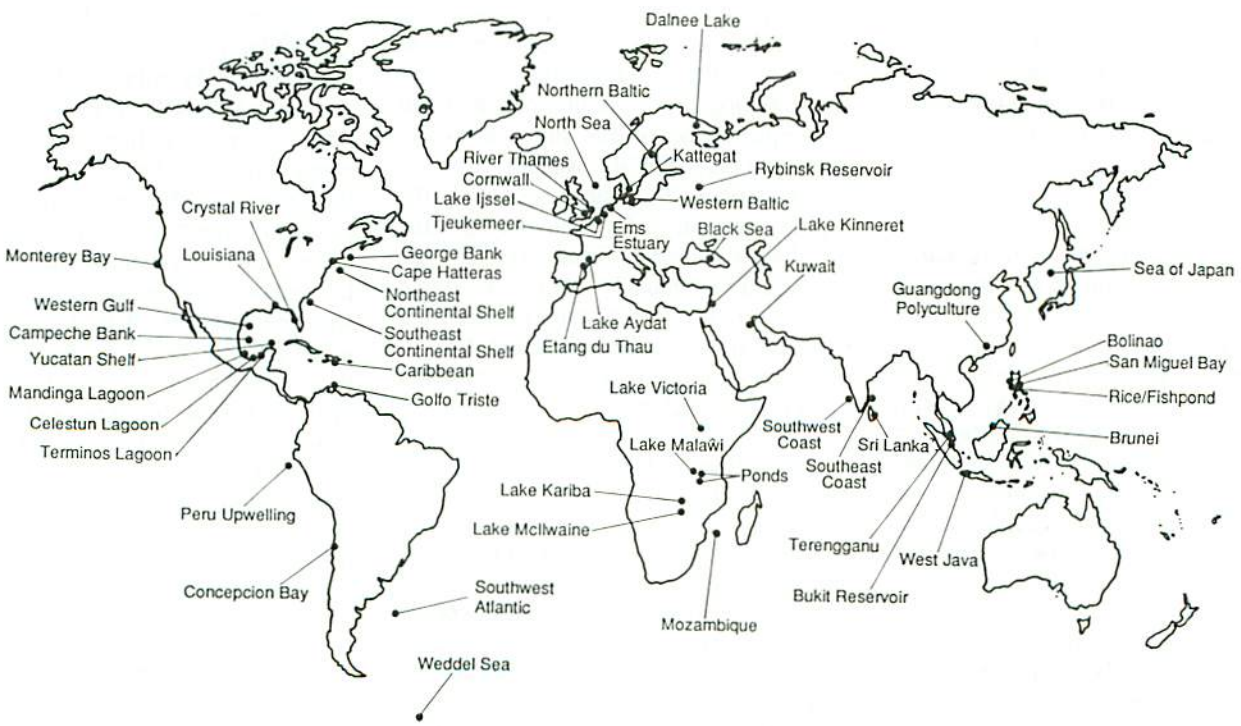
Trophic Models of Marine Ecosystems: Construction and Comparison

Poster Theme Session of the 1990 Statutory Meeting of the International Council for the Exploration of the Sea, October 1990, Copenhagen, Denmark.

This Theme Session, which will be convened by Daniel Pauly and Villy Christensen of ICLARM, has been designed to encourage the development of multispecies trophic or "box" models. The reaction has been good with close to 50 posters from ecosystems worldwide (covering all continents, latitudes, salinities, and sizes of ecosystems, as shown below).



At the forthcoming ICES Theme Session on Trophic Models, analysis of the ecosystems indicated on the world map is to be presented either as separate analysis or as part of comparisons.