

Current ecological understanding admits of substantial unpredictability in how individual and population components of food webs, their spatial and temporal distributions and their trophic links to other components respond to both bottom-up and top-down perturbations. Unexplained variance in food web dynamics stemming from bottom-up signals (e.g., nutrient perturbations, temperature fluctuation, habitat alteration) probably exceeds that of top-down signals (e.g., recruitment pulses, habitat expansion), but the potential for surprise in even well-controlled experiments is still disturbingly high.

Further, the variances in effects of both bottom-up and top-down processes at each trophic level are likely to be greatest and structured least at intermediate biomass ranges which are required to maximize trophic transfer efficiency from 1st to nth trophic level. Unfortunately, the scope for uncertainty is probably also greatest when system productivity and biodiversity are high. Given current knowledge, predicting, regulating, or at least tolerating large variance in food web responses become necessities if fisheries are to be managed near maximal production capacity using ecosystem Constraints on the intensity of trophic linkages in lake food webs approaches.

Discussion

John Schnute

In one of your figures there is a response curve that was flat at one end, rose and became flat again, so that we have a low-end threshold, and a high-end threshold and something in between. If you put together a series of such responses then the theory is that the net effect will be that fairly large changes in the bottom will cancel out, am I right?

Bill Neill

That is certainly one of the consequences. If you put together a series of these kinds of things, it becomes extremely unpredictable in the middle ranges. It is easily predictable at the extremes, and it is in the middle where uncertainty exists. Unfortunately it turns out that 95% of all lakes on the planet follow this pattern.

John Schnute

That model is also how a neural net works, you have nodes and transfer functions like that from one to the other, and of course a characteristic of the neural net is it does have those kinds of threshold responses. It is almost like flipping a coin at each of those levels, and you flip all the coins from the bottom to the top. What you end up with is pretty unpredictable. That curve can be horizontal, then vertical, and then horizontal, that is a very sharp shift from one level to the next and that is your real point.

David Policansky

I am unsure if this question is for Bill or Jim. Bill, you said that 95% of the lakes on the planet are unpredictable. Is that the same middle ground that Jim was talking about that was dominated by copepods, where he wasn't going to look for tight relationships?

Bill Neill

That middle ground where there is so much uncertainty occurs as a consequence of both bottom up and top down processes. One of those alone does not explain things. The middle ground is the zone of interaction in which a whole variety of life history strategies, shapes, sizes, of organisms can make a go of it at some times under those conditions as a consequence of the interactions that are going on and so I am a very firm believer that top down processes can have very strong consequences in there, as well as bottom up consequences.

Jim Kitchell

Note that 95% of the world's lakes are fished.

Ecosystem Management-The Next Step

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Abstract

Fisheries science has long been split between those who emphasized environmental causes for stock fluctuations

(e.g. J. Hjort) and those who emphasized the impact of fishing itself (e.g. F. I. Baranov). The insights recently generated by multispecies modelling may lead to a consensus because they reinforce the need for a form of fisheries management that explicitly accounts for ecosystem effects, inclusive of predator-prey interactions. (see also Abstract by Walters *et al.*, this volume, page 26).

Marine protected areas, also known as marine reserves, would be at the core of such ecosystem management, because they - alone among fisheries management tools - allow reconciliation of the different natural time scales with those of fishers and markets. The latter point is illustrated by a comparison of two contemporary (and relatively depleted) marine ecosystems with their reconstructed earlier states, interpreted through O. D. Odum's theory of ecosystem development

Discussion

Uli Reinhardt

For your prediction that an ecosystem may return to a state where it is in balance, on what time scale do you predict that this will occur? For example, in systems that are really disturbed by fishing pressure, will they ever come back in a reasonable time scale, to the stable state that you predict?

Daniel Pauly

I am afraid I must talk coral reefs because these are places where several marine protected areas have been set up and monitored for a few years. I would rather discuss a temperate shelf but there are no marine protected areas on the temperate shelf.

It seems that for some coral reefs that have been closed to fishing for over a decade or so, within 2-3 years the number of fish have increased tremendously and the numbers of small fish have increased enough to have offset the half of the loss due to fishing.

After 5-6 years, Gary Russ from Australia has noticed an increase in the groupers but even after 10 years they have not re-established the biomass known to have been there before.

There is a bay close to Manila where I have been diving over several years. The USA in its benevolence constructed a road along this part of the coast and the road was built such

that the mountain came down and landed on top of the reef. It was a classic ecological catastrophe straight out of a textbook. After a few years you see coral reefs replanting themselves on those parts of the reef that are free of mud, that have been washed out.

So in that sense there is always hope, at least for connected systems such as marine systems, if you give them a break. I do not know if that is true in a terrestrial system. Deforestation has led to a loss of the topsoil and of the subsoil in some areas in the Philippines so you have desert in the middle of a monsoon system. In these terrestrial systems you have, on any reasonable time scale, irreversible change. You don't have that on coral reefs. That is my answer.

Michael Bauman

Did you ever estimate the necessary size for a marine protected area under water?

Daniel Pauly

Some work has been done on what would be a reasonable size and you end up saying that you will not be able to protect large species, but you certainly can protect snappers, groupers, which on reefs stay in the same place once they have settled. I think this is a big problem in marine protected areas, to size them. It is an important area of research, not their usefulness but their size, and it is one of the most important in future.

Kevern Cochrane

I would like to follow up on that point. I don't think you can go from saying the big question is how big to make them and that their usefulness is assured. The two sides are totally interdependent and what I would like to suggest with marine reserves is two big questions. First, how long is a particular species resident in a reserve, and hence is that reserve effective in preserving that species? The other question is: what leakage is there from the reserve to adjacent areas and is that effectively supporting local fisheries?

For those two questions, ECOPATH is not the tool to use, unless you develop a spatial version of ECOPATH.

Daniel Pauly

Obviously ECOPATH is not the definitive tool, but it has shown that Odum's theory is compatible with what we think happens in a marine reserve and that is kind of neat.

The Understanding and Prediction of Marine Production: Considerations for the Future

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Abstract

It is often assumed that the best method to predict the behaviour of a system is to understand the processes operating within it. Although this assumption has proved extremely effective in the analysis of certain types of systems, the unconditional acceptance of such an assumption in the study of large marine ecosystems may be misleading. This Point of View focuses upon what methods we can use to refine our concept of an understanding so that we might make predictions of more applicability to management. I suggest scientists need to revisit three areas of production research. These are to:

1. Study the role and analysis of physical and biological scale in production. Variability and uncertainty are enmeshed with scale. Are scales of measurement that are convenient, or cost effective, for scientists the important scales of interest in production processes? What modelling methods are most suitable for dealing with changes in scale within production? What scale invariant tools have proved successful in other disciplines?
2. Quantify the consequences of animal behaviour on production. Production processes will be impacted not only by metrics such as weight and water temperature, but also by individual behaviour. Organisms will behave in response to conspecifics, physical conditions, prey and predators. Furthermore behavioural response will be dependent upon developmental stage. The emphasis should be on understanding the outcome of behaviour on production

variability.

3. Understand the relationship between understanding and prediction within science and management. Applicable process based understanding for management may not be formulated in terms that scientists find familiar. For example: a process-based model that yields a statistical distribution of expected production will be more applicable than the correct prediction of the maximum carrying capacity on any particular year, yet both studies are based upon valid scientific queries. The understanding of production processes should be focused upon predicting uncertainty. Let us ask when, where and how do rare events arise? With such information managers can design plans and policies that are robust to such variation.

Discussion

John Schnute

I was interested in your comment about understanding vs. prediction. I have often thought about the similarity between fish stocks and mutual funds. If you are a manager of a mutual fund and you report to your fund holders that our research staff really understand the stock market but it is not very predictable and your fund just dropped 15%, doesn't this make the point that what matters is predictability?

James Scandol

No, because management occurs over two time scales - setting up policy to deal with variability, and the short term dealing with trends and discrepancies. A general probability distribution can effectively design management policies to take this into account. These policies can be designed such that it doesn't matter that you don't know what is going to happen in any particular year and you can still essentially manage it. But if you know underlying variability might be reduced, then that is going to help you over the long term. So a view that you make - to think that you know what is going to happen -- might lead to worse management than saying that you don't know what is going to happen. Because if you get it wrong, then that is when you really get into trouble. Any