PACIFIC FISHERIES RESOURCE CONSERVATION COUNCIL
Conseil pour la conservation des ressources halieutiques du pacifique

PUBLIC SUMMARY—COMPUTER MODELLING OF MARINE ECOSYSTEMS

Applications to Pacific Salmon Management and Research

OCTOBER 2008

PREPARED FOR
Pacific Fisheries Resource Conservation Council
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PUBLIC SUMMARY

This is a Pubic Summary of a 29 page report of the same title. The full report is available at www.fish.bc.ca.

OVERVIEW

This paper discusses how ecosystem modelling could be a valuable tool in the management and conservation of Canada's west coast fisheries and salmon stocks. In this study ecosystem modelling refers to a computer application that examines aquatic ecosystems, and species therein, with the ability to simulate biological changes, such as biomass, mortality, catch, feeding and competition, as influenced by factors like environment, predation, competition or fisheries. By emulating both ecosystem and species changes over time, such models can help guide pro-active responses to potential future changes.

This study shows that ecosystem modelling has progressed to a level of sophistication which justifies its use in the management and conservation of Canada's west coast fisheries and salmon stocks. The full report titled "Computer Modelling of Marine Ecosystems: Applications to Pacific Salmon Management and Research" by Dave B. Preikshot Ph.D., is available at www.fish.bc.ca.

DEVELOPMENT AND CAPABILITIES OF ECOSYSTEM MODELS

Researchers have used ecosystem models for many decades. Many early models were useful as a way to organise general knowledge about ecosystem-level processes. Ecosystem models are commonly thought of as computer-based applications because computers can take on the cumbersome task of executing the algorithms and calculating the output data that characterise present-day models. However, even a flow diagram is a model, if merely a representational one, which helps visualise features deemed important to the modeller.

Many early, pre-personal computer, models were focused on very simple representations of an ecosystem—with few species and select dynamics which could be calculated manually by the researcher. As the ability to use personal computers became more widespread, the scope of ecosystem models increased to include more species and capture a greater variety of ecosystem mechanisms. The development of fisheries ecosystem models has paralleled this history, so it is not surprising that the foundations to much of the extant research is found in the mid 1980s.

Through the latter 20th century, the majority of planning for fisheries management was based upon research on single species or certain 'stocks' of a given species. This single species approach and the resulting single species stock assessment models generated some successes in managing fisheries like Pacific halibut. Unfortunately, overconfidence in our ability to cope with uncertainties in parameters and predictions of many single species models may have helped generate misleading views of fish populations and their dynamics. Such problems have contributed to the collapses of fisheries on valuable species and stocks, such as Atlantic cod.

One value of ecosystem models that has been observed is serving as an inventory of species and their known populations and interactions. When used as a reference, fisheries ecosystem models could, at the very least, provide fisheries scientists, managers and stakeholders with boundaries within which changes to any species can be thought to be possible.

If used as a reference for research, ecosystem models could help identify knowledge gaps that would be effective in addressing questions facing management of many species. If used as a reference for management, ecosystem models could help explore likely consequences of different fisheries management policies. In a more sophisticated approach, feedback between ecosystem models, field research and single species models becomes

mutually informative rather than competitive. Thus, while some fear (or advocate!) that fisheries ecosystem models could replace single species models, it seems more likely that the two approaches will be complementary rather than competitive in the future.

Computer models have advanced to a stage at which they can be built to examine most issues facing research and management. However, it must be stressed that no ecosystem model is ever going to be able to precisely answer all issues in any ecosystem. Indeed, the point of any model is to capture processes which are deemed interesting or of value. An everything model is neither possible nor desirable because the very elegance of a model lies in its ability to simplify, where possible, to observe processes and results valuable to the researcher.

No ecosystem model is ever finalised and they should always be put to the scrutiny of a variety of experts and users to validate their inputs and outputs. No ecosystem model would be of use without collaboration and modellers are dependent on information from other scientists collecting data in the field or working with single species models.

Lastly, results from one ecosystem model, like any other modelling process, need to be challenged with results from parallel ecosystem modelling work. When models agree, it is a good sign that we are more accurately reproducing observed data. When models disagree, it is a good sign that we need to re-examine the assumptions of probably one, and even perhaps both, of the models.

HOW MODELLING IS DONE

Ecopath with Ecosim (EwE) has become a popular computer-based modelling system to help address questions in fisheries research and concerns for fisheries management. The development of this software suite parallels the development of the discipline as a whole. Early models of the mid 1980s were mere static snapshots of a particular time, which only accounted for a dozen or so ‘functional groups’ of similar species with a very coarse resolution.

With the advent of increasingly powerful personal computers, EwE models became more detailed to accommodate particular species, as opposed to functional groups, and even life history stages of some species. More sophisticated versions included the ability to capture species changes through time and space as well as the capacity to simulate environmental forcing and fishing policy comparisons.

There are several other computer-based approaches to ecosystem modelling but EwE is by far the most used around the world. Canada can take particular pride in being home to the research group (the University of British Columbia Fisheries Centre) driving many of the advances in this globally relevant software.

STRAIT OF GEORGIA EXAMPLE

An example model of the Strait of Georgia is presented to show how such work can help visualise ecosystem processes and the relationships between managed species and the fisheries that depend on them. Using the Strait of Georgia model, it is possible for persons of various specialties to examine how biological changes across the ecosystem are represented and whether or not this is in accordance with their own knowledge. When the model’s input data or output predictions are judged incorrect, an opportunity is created to improve input data or to change simulated dynamics to more accurately represent expert opinion.

In the case of the Strait of Georgia model it was seen that the largest cause of changes in some species, e.g., lingcod, appear to be due to fisheries. This observation is in agreement with expert opinion on local lingcod dynamics. In the case of chinook salmon, however, the ecosystem model suggests that a combination of climate-derived, fishery and predation effects have contributed to population changes. While local experts had agreed there are different components of chinook population change, the model provides a way to synthesise their work.

The Strait of Georgia model also suggests that climate signals appear to be manifested throughout the food web, from fish species like herring to mammals and birds. The discovery of pervasive climate signals through an ecosystem could provide researchers and mangers with a better understanding or how different ecosystem states may exist and their capacity to sustain fisheries and other activities during these different times.

AGENCIES USING FISHERIES ECOSYSTEM MODELS

A survey of fisheries management agencies shows that ecosystem models are seen as an effective tool to help set research priorities and form management strategy. In particular, the National Marine Fisheries Service in the United States and the Commonwealth Scientific and Industrial Research Organisation of Australia have made extensive use of EwE, either alone or in conjunction with other ecosystem models.

In the case of the United States, ecosystem models are being tested to help develop proactive approaches and as a means to allow managers to quickly visualise important features of complex systems. In Australia ecosystem models are seen as a means of developing strategic, long-term, big-picture management plans. In both cases, it is hoped that ecosystem models will provide a qualitative framework within which specific quantitative and tactical research and management actions can be optimised.

The use of fisheries ecosystem modelling by fisheries research and management agencies with similar traditions and mandates to Canada's suggests a new course that Canada could easily adopt to great profit. Indeed, the existence of fisheries ecosystem modelling research in Canada in conjunction with learning from the experience of other agencies would facilitate the creation of a similar program. In the case of salmon in the Strait of Georgia it was seen that even a model assembled with a limited research staff (one PhD student!) provided useful insights for framing issues relevant to both research and management.

With the dedication of relatively modest resources it would, therefore, be possible to create a research team that could build a detailed salmon-focussed ecosystem model of the Strait of Georgia, or even larger salmon ecosystems in the North Pacific. All such work could be conducted with attention to Canadian interests, such as over the whole BC coast or as a part of Gulf of Alaska. Value can be added to such salmon models via guidance from local experts in salmon biology and the biology of the creatures with which they interact. Parallel research being done at the Pacific Biological Station (Nanaimo) and the Institute of Ocean Sciences (Sidney), in close collaboration with universities, would allow the incorporation of knowledge about effects from fisheries and environmental mechanisms.

Following the examples of other agencies, such modelling work could incorporate feedback between ecosystem modellers, single species stock assessment groups and field biologists, which would improve the quality and value of all three. In this vein, it is proposed that fisheries ecosystem modelling could help complement pre-existing research tools and create an informative framework within which sound strategic decisions could be made on research and management goals in complex and changing systems like the Strait of Georgia.

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