ECOSYSTEM BASED MANAGEMENT: MODELS AND MARICULTURE [1/]

Introduction

Conceptual and numerical models are essential tools in managing and protecting coastal ecosystems. Models may be used in economic, social, and ecosystem simulations for many purposes, including aquaculture design, siting, and operation; ecosystem management and risk assessment; and integration of sustainable mariculture into restoration and management of coastal ecosystems.

At the Ecosystem workshop, particular emphasis was placed on the application of ecosystem models to understand the influence of fed and extractive forms of mariculture and their interactions with the natural environment. Participants recognized the limitations of existing models, i.e., they are typically more useful to assist in the prediction of the possible directions and types of interactions rather than predicting absolute or precise quantitative changes.

Waste products from fed mariculture systems may have a range of effects from nutrient enrichment of the water column and benthos to neutral effects where assimilation by the natural biota is equal to the rate of input. There may even be positive effects, such as food web enhancement of diversity and abundance of benthic organisms in more ideal situations where fish mariculture is sized appropriately and strong currents disperse organic and inorganic wastes.

In less than ideal physical conditions or where nutrient sensitivity is an issue, mariculture of species receiving a food ration (e.g., fish or shrimp) may be coupled with shellfish and/or seaweed capable of extracting nutrients from consumption of enhanced phytoplankton stocks or directly through nutrient removal. This is termed “integrated mariculture” in the literature, or more precisely, "integrated multi-trophic aquaculture,” and may be designed to eliminate adverse effects of fed finfish culture. Organic matter and nutrient additions by cultured fish do not have to be perfectly balanced with nutrient removal in space and time as long as the biological communities can assimilate the nutrient loads without adversely changing the composition and character of these communities.

Extractive shellfish and seaweed mariculture offers significant benefits to coastal ecosystems through reduction of excess nutrient loading known as coastal eutrophication. Worldwide, many coastal seas are suffering from adverse effects of eutrophication which can include oxygen depletion, changes in species composition and in some case harmful algae events. Although not typically defined as such, integrated mariculture could also include directing finfish facilities to areas where companion, extractive crops are not needed due to certain local characteristics.

Some areas with strong tidal current that prevent permanent solids deposition and concurrently that are not nutrient sensitive would not benefit from integrated mariculture to mitigate the effects of fed finfish culture. Algae and nutrients do not limit primary production in high current velocity, deep water, and nutrient insensitive areas (e.g., Cobscook Bay in Northern Maine, USA, and main channels of Puget Sound and the Strait

of Juan de Fuca in Washington State that experience light limitation of phytoplankton). Solid wastes from fish mariculture in these areas are periodically resuspended until they are incorporated aerobically into the food web. In general, other areas may be desirable for mariculture if its scale remains within the carrying capacity of the water body so that byproducts enhance, rather than degrade, existing marine resources. In the context of ecosystem-based mariculture, coastal resource managers may achieve protection of sensitive areas while addressing the larger need for food production and coastal economies. Worldwide, only limited coastal areas qualify as physically and chemically optimal for fish mariculture when all siting requirements are considered. In tropical or subtropical areas, especially those near shore, nutrient enrichment may have negative effects, and integrated mariculture would be beneficial in some cases. Initial observations of offshore cages in tropical areas indicate that there may be a food web response to mariculture discharge resulting in increased numbers of invertebrates and fish near the cages. These effects can be positive as long as the enrichment does not flow onto coral reefs and it is aerobically assimilated into the biological community in the surrounding area.

Although mariculture is often believed to have undesirable impacts on coastal ecosystems, the modeling session participants recognized that some forms of mariculture can become part of a solution to coastal problems caused by non-mariculture activities such as point and non-point source nutrient inputs, habitat destruction, and over-fishing. There was consensus among the international participants that models should describe levels and types of effects from mariculture. After some discussion, however, it was agreed that determining “what is acceptable” in terms of end point impacts or benefits is a separate informed political decision made on the basis of each country’s local customs, policies, and laws.

[1/] Rensel, J.E., A.H. Buschmann, T. Chopin, I.K. Chung, J. Grant, C.E. Helsley, D.A. Kiefer, R. Langan, R.I.E. Newell, M. Rawson, J.W. Sowles, J.P. McVey, and C. Yarish. In press. **Ecosystem based management: Models and mariculture**. J.E. Rensel, editor. Pages xx-xx *in* J.P. McVey, C-S. Lee, and P.J. O'Bryen, editors. The Role of Aquaculture in Integrated Coastal and Ocean Management: An Ecosystem Approach. The World Aquaculture Society, Baton Rouge, Louisiana, 70803.