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Analysis of the ecosystem structure of Laguna Alvarado, western Gulf of Mexico, by means of a mass balance model

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Abstract

Alvarado is one of the most productive estuary-lagoon systems in the Mexican Gulf of Mexico. It has great economic and ecological importance due to high fisheries productivity and because it serves as a nursery, feeding, and reproduction area for numerous populations of fishes and crustaceans. Because of this, extensive studies have focused on biology, ecology, fisheries (e.g. shrimp, oysters) and other biological components of the system during the last few decades. This study presents a mass-balanced trophic model for Laguna Alvarado to determine it's structure and functional form, and to compare it with similar coastal systems of the Gulf of Mexico and Mexican Pacific coast. The model, based on the software Ecopath with Ecosim, consists of eighteen fish groups, seven invertebrate groups, and one group each of sharks and rays, marine mammals, phytoplankton, sea grasses and detritus. The acceptability of the model is indicated by the pedigree index (0.5) which range from 0 to 1 based on the quality of input data. The highest trophic level was 3.6 for marine mammals and snappers. Total system throughput reached 2680 t km^{-2} $year^{-1}$, of which total consumption made up 47%, respiratory flows made up 37% and flows to detritus made up 16%. The total system production was higher than consumption, and net primary production higher than respiration. The mean transfer efficiency was 13.8%. The mean trophic level of the catch was 2.3 and the primary production required to sustain the catch was estimated in 31 t km^{-2} yr^{-1}. Ecosystem overhead was 2.4 times the ascendancy. Results suggest a balance between primary production and consumption. In contrast with other Mexican coastal lagoons, Laguna Alvarado differs strongly in relation to the primary source of energy; here the primary producers (seagrasses) are more important than detritus pathways. This fact can be interpreted a response to mangrove deforest, overfishing, etc. Future work might include the compilation of fishing and biomass time trends to develop historical verification and fitting of temporal simulations.

Keywords: energy flows; trophic structure; Ecopath model; coastal lagoon; Mexico; Alvarado Lagoon

1. Introduction

Coastal lagoons are recognized as highly productive ecosystems that are used by numerous organisms for feeding, growth, reproduction and refuge (Allen and Horn, 1975; Day and Yáñez-Arancibia, 1982; Day et al., 1989). These ecosystems benefit humans in terms of food production (i.e. fisheries), transportation and recreation (NOAA, 1990). The annual economic value of coastal fisheries in the U.S. Gulf of Mexico stands around 650 million U.S. dollars (NOAA, 1990). The complexity of the oceanographic conditions that characterize coastal lagoons, as well as their multiple uses and biological diversity, necessitates a holistic approach to assess and manage their living resources.

In highly dynamic ecosystem, the resilience of the food web depends on how energy flows through the system (Hunter and Price, 1992). Many coastal lagoon food webs appear to be highly resilient, as they remain generally intact despite the challenges of an extremely dynamic environment (Day et al., 1989). Understanding how ecosystems react and recover from perturbations is a fundamental goal of ecology (Cottingham and Schindler, 2000). There are two approaches

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