Pelagic Fisheries Research Program

Integrative modeling in support of the Pelagic Fisheries Research Program: spatially disaggregated population dynamics models for pelagic fisheries

Design of tag-recapture experiments for estimating yellowfin tuna stock dynamics, movement, and fishery interaction

Progress Report

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Background

The research reported here has two foci: (1) development of spatial models of pelagic fish population dynamics that explicitly include movement, mortality, and fisheries; (2) creation of an internally consistent conceptual framework for the research program of the Pelagic Fisheries Research Program (PFRP).

The pelagic fisheries operating within the various jurisdictions of the Western Pacific Regional Fishery Management Council (WPRFMC) are embedded in stocks of fish that extend over the entire Pacific Ocean basin. The dynamics of fish stocks inside of individual Extended Economic Zones (EEZs) are coupled to the dynamics of the larger stocks. Issues of how fisheries operating in one area influence fisheries operating in other areas, "interaction", depend on rates of movement, mortality and exploitation. Fisheries interaction questions are posed on all scales; interactions between fisheries operating on neighboring fishing grounds (as in the case of various components of the Hawaii tuna fleet) or between fisheries operating thousands of miles apart (as in the case of the impact of large-scale purse seine harvests of yellowfin tuna on the general availability of yellowfin in Hawaii). Methods to address these questions on the appropriate scale need to be developed.

The PFRP is a broadly multidisciplinary program. It supports many different research projects in the biology, social, and physical sciences. There is a risk that the PRFP will degenerate into a disconnected collection of individual research projects. The integrative modeling attempts to incorporate results from the suite of PFRP projects into a single conceptual framework.

Objectives

The general objective of the proposed research is to integrate the results of different PFRP components into spatially disaggregated models of pelagic fisheries which integrate knowledge of fish movement, the fishing process, economics and oceanography.

Specific objectives are:

1. Extend the large scale model of tagged skipjack, based on advection diffusion equations, to yellowfin tuna and to larger geographic areas in the Pacific

2. Develop flexible model parameterizations for relating movement parameters to geographic and oceanographic variables.

3. Develop small scale fisheries models applicable to the Hawaii region which explicitly include both movement and population dynamics.

4. Develop economic predictors of fishing effort usable in the context of spatially disaggregated population models.

General Project Status

The amalgamation of these two projects last year was very effective in increasing project efficiency. The work of Dr. Bills in improving the numerical techniques used in modeling fish movement that was required for the tag design study has been applied to the larger scale movement analysis. As a result we have two alternative approaches to the analysis of movement. One approach is more suitable for fish with high rates of directed or migratory movements and the other more suitable for fish which more dispersive movements. Dr. Bills is scheduled to leave the UH in August at the conclusion of the tag design study. Since his expertise is in the numerical solution of PDEs, his loss will slow further improvement along these lines.

Progress on 1995 Goals

1. Complete the analysis of SPC skipjack and yellowfin tag recaptures using the expanded large-scale model. Apply these results to the movement of tunas through the Hawaii EEZ and to the assessment of interaction between equatorial fisheries and fisheries in Hawaii.

The SPC tagging data were revised in April 1996 to include new tag returns and corrections to reported recapture positions. The corrected data is more amenable to the movement analysis procedures, and the current round of analyses appear to be progressing well for both skipjack and yellowfin. Additional model structure was introduced to accommodate age-dependent mortality in tagged fish released in specific regions (i.e. Philippines) and to control parameter estimation in specific region-season strata with low numbers of recaptures. The scope of the analysis was increased by inclusion of Japanese data from the Tohoku National Fisheries Research Institute (TNFRI). These data include skipjack releases from Japanese research and training vessels, recaptures from various

fleets, and fishing effort data from Japanese "offshore" (i.e. near Japan) purse seine and baitboat fleets. This development should be particularly useful in modeling movement of skipjack in the WPRFMC region.

2. Continue work on the problem of estimating movement from catch and effort data (tag-independent movement analysis).

Solution of this problem ultimately rests in better understanding of recruitment timing and distribution. Very little work was conducted toward this goal. The results of the YFT fecundity study will be helpful.

3. Complete the tag-release design study.

The tag-release design study is complete, and the second draft of a manuscript is in preparation. The general conclusion is that a combined yellowfin/bigeye (*ahi*) tuna tagging study for Hawaii would be practical, but only if a dedicated tagging vessel were chartered. Tagged tunas would need to be released at 4 periods during the year in three locations within the Hawaii EEZ. An important development to be derived from the small scale model is the importance of the differences between approximations to the advection-diffusion PDE.

4. Continue efforts to reparameterize the advection-diffusion model of tuna behavior in terms of environmental variables.

A large scale tuna movement simulation was developed in which the movement parameters of the advection-diffusion model were made to depend on features of the environment. An index of habitat suitability was computed from the sea surface temperature and the depth of the thermocline as determined from climatological means. The resulting distribution of tagged tunas was generally reasonable, but lacked the irregularities observed in real data. The overly regular distribution is attributable to the use of climatological means.

Goals for the next year

1. Complete analysis of SPC tuna tagging data and apply results to the analysis population exchanges within the WPRFMC area.

2. Continue collaboration with TNFRI scientists on analysis of north Pacific skipjack migration.

3. Include additional variables, i.e. oxygen, topography, into the habitat paramterization of tuna movement. If feasible, output from oceanographic models to simulate "real time" observations of temperature and oxygen fields.

4. Continue work on the problem of estimating movement from catch and effort data (tag-independent movement analysis). Use results of YFT fecundity study to model recruitment.

5. Test alternative numerical approximations to the advection-diffusion PDE used to model fish movement, such as the "FASTEST" 4-point approximation and single step implicit methods.