LARGE MARINE ECOSYSTEMS :

EXPLORATION AND EXPLOITATION FOR SUSTAINABLE DEVELOPMENT AND CONSERVATION ON FISH STOCKS

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FISHERY FORECASTING – PRESENT STATUS AND FUTURE PROSPECTS

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ABSTRACT

A review of the approaches, procedures and models for fishery forecasting has been presented. The relative performance of some of the predictive models has been indicated. Applicability of some of the methods is demonstrated with help of a real life data. The future directions of the methodological approaches have also been outlined.

Introduction

Model formulation is an important exercise in fish stock assessment. The purpose is not only to evaluate the magnitude and variations in the various parameters of the fishery but also formulate guidelines for harvesting strategies for rational exploitation of the stocks on a short term and long term basis. Traditionally, the approach to modeling in fisheries focused on the inter-relationship of fishery dependent factors and the yield. The other factors are clubbed with 'random noises' or assumed in the long run to cancel out each other. The goal of model formulation in fisheries is not only to describe the input-output relationship to develop suitable exploitation options but also to make predictions in the short term and long term basis. The classical models in fisheries mainly deal with the long term aspects. These 'deterministic' models are based on 'a priori' assumptions about the nature of population growth, the relationship between fishing effort and the population size and form of relationship between yield and fishing effort. The major responsibility of fisheries managers is to determine the long term policies that will provide sustainable and near optimum return from the stocks. In contrast, the users of the resources presently want short term forecasts to make decisions regarding investment, fleet size, gear type etc. It is well known that the variations in the exploited stock size not only depend on the fishery dependent factors such as fleet size, type of gear and mesh used etc. but also depends on the fluctuations in the fishery independent variables such as the sea surface temperature, upwelling, wind speed, wind direction and other biophysical and ocean related parameters. An ideal model will be the one which is built around all the fishery dependent and fishery independent factors. Obviously such an ideal formulation of fisheries model is a difficult proposition because of its obvious complexity and exorbitant cost involved in the collection of data on all the relevant parameters.

Marine fishery forecasting

Time-series analysis is an economical method for forecasting catches that could be widely applied as one of several methods in fishery forecasting. Its applicability in economics is well recognized and in fisheries it is slowly gaining importance. Some of the studies on fisheries forecasting are mentioned hereunder.

Dyer and Gillooly (1979) studies the variations over time of the total annual production of pelagic fish for South Africa and the United Kingdom quantitatively using the exponential smoothing technique. The exercise was repeated on annual mackerel landings for the same two countries. Van Winkle *et. al.* (1979) used autocorrelation and spectral analysis techniques to examine the periodicity in the dominant year classes of Atlantic coast striped bass (*Morone saxatilis*) commercial fisheries data. Saila *et. al.* (1980) compared some time-series models for analysis of fisheries data. The three procedures, monthly averages, harmonic regression analysis and autoregressive integrated moving average models were briefly described and evaluated using the variance of the residuals of the original observations and forecasts compared with actual data not used in developing the models. An ARIMA (Auto Regressive Integrated Moving Average) model was found to be the most suitable in terms of producing forecasts upto 12 months ahead. The predictive power of stock production models and some time-series methods were considered for five marine fish stocks by Stocker and Hilborn (1981). The distinction between model fitting and forecasting future short term catch was discussed as was the difference between techniques to forecast short term yield and techniques to calculate long term management practices.

Jensen (1985) analyzed the catch and catch per unit effort data for Atlantic menhaden and the gulf menhaden of the Gulf of Mexico with the help of autocorrelation to test for time lags and to develop forecasting equations. Noakes (1985) demonstrated the efficiency of intervention analysis in fisheries science using the data from the Canadian Dungeness crab fishery. He opined that the selection of the most appropriate model from a set of models passing diagnostic checks could be made on the basis of an objective criterion. Rose *et. al.* (1986) proposed a time-series analysis method based on the use of categorized variables and ordinary least squares method. They contended that it had several advantages over the Box-Jenkins models and time-series regression with continuous variables. Aspects of model building, significance testing and interpretation of the results were discussed and illustrated with a fisheries example involving a measure of white perch (*Morone americana*) stock size in the Delaware River/Bay from 1928 to 1974. Fogarty (1988) used Box-Jenkins transfer function models to analyze the relationship between water temperature and marine lobster catch and catch per unit effort (CPUE). Stergiou (1989) analyzed 17 year record of monthly catch of pilchard from Greek waters using the ARIMA techniques. He proposed two models suitable to describe the dynamics of the fishery for forecasting catches upto 12 months ahead. He stated that ARIMA procedures were capable of describing and forecasting the complex dynamics of Greek pilchard fishery. A seasonal autoregressive model of the Anchovy fishery in the Eastern Mediterranean was also presented by him (Stergiou, 1990). He found that the seasonal autoregressive terms of the model seemed to be consistent with the biological/oceanographic observations. Stergiou and Christou (1996) and Stergiou *et.al.* (1997) compared the performance of regression, univariate and multivariate time-series models, harmonic regression models and exponential smoothing techniques (seasonal and non seasonal) in predicting the monthly fisheries catches of 16 species in the Hellenic waters. Shepherd (1984) proposed a simple method for catch forecasting when a few data other than the annual catches are available. The method calculates the expected catch level under the assumption that no change in fishing mortality will occur in the years covered by the forecast. Deriso (1980) suggested an equilibrium model which forecasts relative yields from biomass estimates in previous years and a stock/recruitment relation. Roff (1983) proposed short-term prediction model for prediction of demersal fish catches.

Chakraborty (1973) attempted polynomial regression in time-series of marine fish landings in India. Shastri (1978) also carried out a similar trend analysis. In India the first ever attempt on modeling marine fish production using the Box-Jenkins approach was by Indian Institute of Management (Anon 1984). In this study, the quarterly marine fish landings during 1960 to 1978 in each of the maritime states of India were considered for building up a multiplicative seasonal autoregressive models. The models were then used to forecast the fishery from 1979 to 1985. The forecasted values were found to be more or less in good agreement with the observed values.

At Central Marine Fisheries Research Institute (CMFRI), fishery forecasting forms an important part of fish stock assessment. The Institute has considerable expertise in marine fishery research, especially in the field of fish stock assessment. Besides the fish stock assessment using the conventional fishery models, the univariate and multivariate time-series analysis including the

ARIMA model, harmonic regression analysis and exponential smoothing techniques are employed for short term catch forecasting (Noble and Sathianandan, 1991; Sathianandan and Srinath, 1995; Venugopalan and Srinath, 1998; Srinath, 1998, MS). Currently greater thrust is put on development of appropriate predictive models for the commercially important marine fishery resources incorporating both the fishery dependent and fishery independent factors.

Future needs

Because empirical information will be insufficient to quantify the causal linkages, mathematical modeling will play a large role in any research aimed at fisheries forecasting. What types of models are appropriate? The interactions between the physical and biological processes are extremely complex and the consequences are unlikely to be demonstrated through simple correlations of stock size with one or many physical variables. The models that are proposed to be developed for marine fishery prediction should necessarily take into account, the climatic effect, hydrodynamics, water chemistry, ecosystem, the rate of exploitation the mode and the method of exploitation. This is quite a tall order. Attempting a unified approach or method for all the exploited fish stocks will be fruitless as different fish stocks react differently to the human induced or nature induced variations. Population models based on the life cycles of cohorts (cohort based models) may be most appropriate for describing the dynamics of a fish stock in terms of its environment. In particular growth and mortality of early life stages are related to short-term effects of weather, hydrology, water temperature and food availability. The rational incorporation of environmental conditions can be done only with models that operate on time steps consistent with the time scales of the significant weather, hydrologic and other events. Qualitative predictions on the future course of the fishery could also be attempted through application of Markov chains (Formacion and Saila, 1994 and Srinath, 1996).

Needless to say that the validity of the forecasts based on the predictive models largely depends on the database and its quality. In order that the fishery forecasting to be a viable continuous exercise, it is essential that there is regular inflow of the required data to the model building process. Thus data generation, acquisition and validation is an absolute necessity. There is an urgent need to strengthen and extend required support to the acquisition systems of the Institutes concerned with marine fishery research and fishery forecasting.

Although mathematical modeling is not a magic solution to the problem of fishery forecasting and predicting the effects of changes in climate on fish stocks, relevant models, together with estimates of their uncertainties, need to be developed as far as it is practical to do so because such a prediction is a societal problem of high priority.

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