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Consultant's Report:

Ecological Modelling and the Orientation and Integration of Fishery Research by KISR/MFD

by

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Executive Summary

- Until now, stock assessment performed by MFD staff have been, for compelling reasons, largely single-species "tactical" assessments, aiming at answering specific, short term questions of the fishing industry.

- The data base now exists at MFD for a transition toward multispecies "strategic" assessment possibly leading to a long-term reorientation of the fishing sector, particularly with regards to the shrimp/fish (by-catch) fishery.

- Such transition will involve (a) a stronger integration of the separate projects now dealing with shrimp and finfish management and (b) a computerization of the data collected in the last 5 years by these two projects and/or their predecessor(s). Item (b) should be given the utmost priority.

- The computerization and hence direct accessibility of the data fishery-related base held at MFD will allow within one year the construction of a preliminary model of the marine ecosystem off Kuwait.

- Emphasis should be given in the next Shrimp and Fin Fisheries Management Workshop to the potential usefulness of ecosystem models for the purposes of fishery management, and to a discussion of a preliminary model to be developed in the course of 1986.

- An international conference should be noted in Kuwait by KISR in Spring 1987 on multispecies models and their use in fishery management.

Introduction

The terms of reference of this consultancy to KISR/MFD * were:

i) To advise on the application of the ecological approach to multispecies interactions in Kuwait's fisheries.

ii) to review on-going work on stomach content analysis.

iii) To advise on the possibility of applying the ECOPATH Model to Kuwait's fisheries.

iv) To prepare a report for presentation at the 1985 Shrimp and Fin Fisheries Management Workshop covering these topics.

Since its start in the late 70's, the research on Kuwait's marine fishery resources has been single-species oriented, and geared toward provision of predominantly short-term management advice. This is understandable, since most fishing effort in Kuwait is aimed at a relatively small number of high-value species, such as the shrimps (Peneaeus semisulcatus) and fish such as hamoor or hamra. Moreover, the absence of quantitative information on the marine resource of Kuwait for the period prior to the late'70 precluded, until recently, any assessments requiring a long time series of data, as well as any long-term management plan.

This situation has now changed, however, and this report consequently addresses the question how the data collected since the inception of the Shrimp Management, and of the Fin Fish Management Projects could be integrated and analyzed to allow for:

i) improved single-species assessment,

ii) the identification of gaps in the present data collection systems, and

iii) the construction of a preliminary ecological model of the fishery resource system off Kuwait.

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The pre-requisite for these three items is computerization of all fishery resource data available at KISR/MFD, and this report shall therefore deal with this item first.

Computerization and analysis of the fishing resource data available at KISR/MFD:

The following basic type of fishery resource information are available at MFD:

i) trawl survey data (catch per effort data, length-frequency data by species plus miscellaneous related information),

ii) catch, landing, effort, price and size composition data,

iii) oceanographic data, and

iv) miscellaneous information (e.g. on shrimp juveniles in mudflats, stomach composition data, etc).

Parts of this data sets have already been computerized, notably the catch and effort data from various fisheries, and catch per effort data (plus related information) from the inshore shrimp nurseries.

The trawl survey data should now be filed using Data Base II, III or a similar program using the Columbia computers available at MFD. Relying on the Computer Centre of KISR headquarters would probably involve delays and reduce the quality of the data entered, because it would have been entered and edited by a third party . Also, the data would not be available for immediate retrieval and analysis in interactive mode by MFD staff.

It was estimated that entering the backlog of accumulated trawl survey data held at MFD would involve between 6 and 12 months of keypunching by one person (who would not necessarily need to have any substantive previous training in computer use) as well as one month (at most) for an experience programmer to set up the templates (i.e. "forms") needed.

These templates are:

a) One form for the details of each haul or station, with spaces for position and time at start and end of each haul, water depth, bottom type, any oceanographic measurements (BT, salinity, etc) and total catch.

b) One form to enter, for each haul, the catch per hour (and the catch per haul in case the haul do not have a duration of one hour) per species (and species group in taxa not identified to species) as well as flags to indicate any subsample that may have been measured and/or counted.

c) One form to enter length-frequency distributions, or simple counts of subsamples and their weight, with a routine to raise the subsample to the catch per hour of the species in question.

All data entry routines should include logic checks and crude editing routines wherever possible (e.g. time at start of haul must be earlier then at end, or depth must be between some present range, respectively).

Suitable models for form (a) to (c) may be found in FAO publications, notably those pertaining to the trawl survey project conducted in the Gulf in the '70s.

Once all trawl survey data held by MFD have been entered, "hard copies" (i.e. printed copies) of the data entered should be made, and issued as Technical Reports; this will ensure (a) the data will be available to MFD staff without access to or experience with computers (b) that consultants to KISR/MFD or students at Kuwait University will be able to work on the data without having to be physically present at MFD and/or to use the same computer as used to log the data and (c) that the data will not be lost if the diskettes onto which the data have been stored are lost or destroyed. Making hard copies also has the advantage of allowing identification of errors.

The consultant knows of several multimillion $ trawl surveys which have left no record of ever having been conducted neither in the country where they took place, nor in the international literature. In a few of these cases, the data are available in hard copy, however, such that future generation of researchers will be able to reconstruct the state of the resource at the time these surveys were conducted. Where hard copies are missing, illegible tapes, missing punch cards or missing original records will doom any efforts at reconstructing the surveys and hence definitely preclude any benefits that may have resulted from them.

Once the available trawl survey data have been stored, analysis should proceed as follows:

i) computation of species specific density and/or biomass by stratum and season,

ii) reconstruction of population size-frequency distribution, by species, for the whole area of reference by season.

iii) miscellaneous other analyses.

The trawl surveys conducted in Kuwait waters have not been stratified random trawl surveys. However, a sensible post hoc sampling scheme might be to stratify the catch per hour data by the most important factor affecting demersal fis distribution, namely

i) depth (0-9, 10-19, 20-29 m, etc) and

ii) bottom type (sand, sandy mud, mud or "shrimping ground vs non-shrimping ground")

iii) time of the year (say: winter & spring vs summer & fall).

iv) major fishing grounds (e.g. Kuwait Bay, South Kuwait waters, North Kuwait waters, etc).

"Stratifying" means here that the data for any station within a certain depth range (say 20-29 m) bottom type (say sand) and season (say summer/fall) can be combined (added to or averaged) with those for the same stratum. A report by this consultant to the Government of Burma (see Attachment 1) gives the details on how overall biomass and its standard errors are computed using stratified trawl survey data.

Note that the attached report suggest a time period of 1 month for stratification of all trawl survey data; this short time scale will be, in Kuwait, appropriate mostly for the data pertaining to shrimp, as most other taxonomic groups, notably the fishes, do not require such narrow time scale.

The report mentioned above included here as Appendix I, as well as Appendix II give a standard procedure for converting mean density (i.e. mean catch per effort) into estimates of absolute biomass. It is imperative that such estimates be derived from the trawl survey data obtained to date; one reason for this is that biomass estimates (B) allow for estimates of annual fishing mortality (F) via

$$\frac{Y}{B} = F \qquad \ldots 1)$$

where Y is the annual catch. Thus, it is possible to compare estimates of F obtained by analytical methods (e.g. via detailed analysis of catch composition data) with values obtained by relating total catch and biomass. Such possibly of double-checking seems to this consultant particularly useful in view of the difficult in estimating effective fishing effort for some segments of the Kuwait fisheries sector.

Obviously, equation (1) will give proper results only if the "catch" figures used really refer to the fish that have been caught and killed, i.e. include landings + discards. Also, the biomass estimate will have to be based on realistic estimates of escapement (see Appendix I and II).

Reconstruction of the size distribution of the population of major species (shrimp and fish) would be rather straightforward - once the biomasses have been reconstructed, and the available length-frequency data have been computerized. Appendix I gives an outline of the procedure to be applied.

Only size-frequency distribution pertaining to the population as a whole (rather than to individual samples) should be used to estimate (population) parameters such as asymptotic length or mortality; hence it can be expected that reconstructed population size-distribution would help in improving the accuracy of growth such estimates for all stocks for which previous estimates were available.

The miscellaneous analyses that could be conducted, given time series of biomass (for species group and for the total stock) and population size-frequency distributions are numerous and involve:

i) behavioural (e.g. migration) studies, as well as studies on seasonal changes of availability and catchability of the resource,

ii) studies on biomass changes and changes in species composition of the exploited resources off Kuwait (e.g. have squids increased, as they usually do when their associated fish community is reduced?),

iii) relating species-specific catch and biomass through surplus production models,

as well as numerous other studies which could all be conducted using the existing data base, and hence provide, in a cost-effective fashion, some of the answer needed to predict the future state of Kuwait's fish resources.

Integration of research conducted by the Shrimp Management and Fish Management Projects

The major interaction between fish and shrimp in Kuwait waters is that most fish eat shrimps, whether they themselves are high value, exploited species or not.

The preliminary estimates of penaeid shrimp consumption by fish in Kuwait is of about 6 thousand tons annually, which is about three times the about 2,000 tons caught annually by the fishes (see Appendix II). However, no information are presently available to estimate the relative contributions of Penaeus semisulcatus, Metapenaeus affinis and other spp. to the predation estimate.

Preliminary information on the contribution by shrimp to the diet of Kuwait fishes have become available through the work of Mr. O. Euzen, who concentrated on this topic from May to December 1985 at the suggestion of this consultant. Mr. Euzen will complete his research on food and feeding of Kuwait fishes with experimental studies, to be completed in April-May 1986.

This consultant recommends that an MFD staff member be assigned to continue the studies on stomach contents of Kuwait fishes initiated by Mr. Euzen and to extend the array of species covered, such as to allow

more accurate estimation of shrimp consumption by fish than is possible now (see Appendix II). This study should be conducted over a period of one year, and be stratified by season, such as to allow for shrimp consumption over an annual cycle to be estimated. It is important that identifiable shrimps in fish stomachs be identified at the species level, and measured or weighted individually.

It may be mentioned in this context that the data collected in the frame of this study, and those already collected by Mr. Euzen should be reported in unagregated form (i.e. on a per-stomach basis) in one or several Technical Report(s). The first of these could contain (in addition to Mr. Euzen's original fish stomach data) tables including, in suitably rearranged form, the previously published results of feeding experiments conducted by the Mariculture group of KISR/MFD on fish occurring Kuwait waters (hamoor, newaiby, etc). Examples showing the format needed for such tables are given in Appendix II.

For his part, the consultant will continue his work toward estimations of the annual food consumption per biomass unit of fish such as those occurring in Kuwait.

The estimation of shrimp consumption by fish is not an idle academic matter; rather, combined with accurate fish biomass estimates such as discussed above, estimates of shrimp consumption by fish can be used to considerably improve understanding of the factors impacting on the recruitment of Kuwait shrimps, notably P. semisulcatus.

Indeed, implementation of the scheme for the detailed study of shrimp recruitment in Kuwait proposed earlier by the consultant requires that the major source of shrimp mortality be identified explicitly, and included in the virtual population or cohort analyses. Otherwise meaningless results will be obtained.

Or put differently: not accounting for such a large source of shrimp mortality as fish predation makes it improbable that (other) sources of pre-recruitment mortality will be identified using time-series analyses of mortality or annual recruitment estimates.

In this sense, integration of the data bases held at MFD relating to fish and to shrimp must precede their integration with the oceanographic data also collected by MFD.

The consultant is quite willing to provide detailed advice, in 1986 and beyond, on how the shrimp and fish data held at MFD can be analyzed simultaneously, and in conjunction with oceanographic data. However, this advice will be useful only if the presently available trawl/survey data are computerized as suggested above, and if the shrimp data be available in the form outlined in Pauly (1985, see footnote).

Toward a multispecies model of the fishery resources of Kuwait

The computerization of data and the analyses outlined above should provide, within about a year, the background necessary for constructing a preliminary version of an ecosystem model of Kuwait's major fishing grounds, and it is suggested that one day of deliberation at the next Shrimp and Fin Fish Management workshop, to be held in December 1986 be devoted to this and related topics.

Contributions to be prepared for this workshop would be:

- biomass estimates, by species and species groups, their relationship to bottom type, depth, and exploitation,

- studies on the size and age composition of the fish populations (high value as well as by-catch spp) and on the factors affecting these (migrations, fishing, recruitment changes, etc).

- studies on the food and feeding habits of Kuwait fish, with emphasis of shrimp species and sizes consumed,

- studies on the food consumption (i.e. energy requirements) of fish such as those occurring off Kuwait (could be contributed by consultant),

- a first attempt at constructing a trophic model of Kuwait's fishing grounds (could be contributed by consultant, working in cooperation with MFD staff).

The trophic model to be developed should take account, at least in preliminary fashion, of the results of the acoustic surveys to be conducted in 1986 and which should lead to the identification and quantification of Kuwait's resources in small pelagic fishes (sardines, mackerels, etc).

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[b] Pauly, D. 1985. A methodology for studying the recruitment into Kuwait's Shrimp stocks p. 32-44 In: C.P. Mathews (ed) Proceedings of the 1984 Shrimp and Fin Fish Fisheries Management Workshop, KISR, Kuwait.

The ECOPATH model of Polovina (1984*) probably provides the most rigorous algorithm for construction of an ecosystem model of Kuwait marine resources, although a more flexible approach is being developed by the consultant and will be presented at the next Shrimp and Fin Fish Management workshop.

The advantage for KISR/MFD of using a model such as ECOPATH are numerous, and include the following:

i) The need to assemble a comprehensive data base on and to estimate vital statistics for all abundant species (groups) will "force" MFD staff to assemble, review and edit all data presently available on Kuwait marine resources, and to extract a maximum of information from data that have already been collected, and hence lead to cost-effective data utilization,

ii) The biomasses, the consumption and the predation rate estimate obtained via ECOPATH will "balance out" only if the mortality rates entered on a per-species basis are realistic; this should lead in conjunction with item (i) to an increased reliability of the single species assessments (which to date have been performed independently of each other),

iii) Identifying the major predators and their preys within the Kuwait marine ecosystem will help envision and formulate management options involving active manipulations of the multispecied ecosystem (e.g. to reduce the biomass of shrimp predators (see Appendix II).

While displaying these and related features, steady state trophic ecosystem models remain easy to run, and no specialized ecological models are needed to implement them. Such cost-effective model, therefore, seem to be ideally suited to the need of KISR/MFD.

It is advised that the next Shrimp and Fin Fisheries Management Workshop be followed, after about 6 months, by an international conference/workshop, to be held in Kuwait and hosted by KISR, in which outside experts would contribute their knowledge and opinions as to the practical utilization of trophic models for the management of tropical multispecies fisheries. (A proposal on a conference of this type has already been developed by the MFD staff and the consultant, and should be read for details on the proposed conference).

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* Polovina, J.J. 1984. Model of a coral reef ecosystem. Part I. The ECOPATH model and its application to French Frigate Schools. Coral Reefs 3:1-11.

Appendices

I. Pauly, D. 1984. Methods for assessing the marine stocks of Burma, with emphasis on the demersal species. BUR/77/003/FAO Field Document 6, Rome, 22p.

II. Pauly, D. and M.L. Palomares. Shrimp consumption by fish in Kuwait waters: a methodology, preliminary results and their implications for management and research (MS).