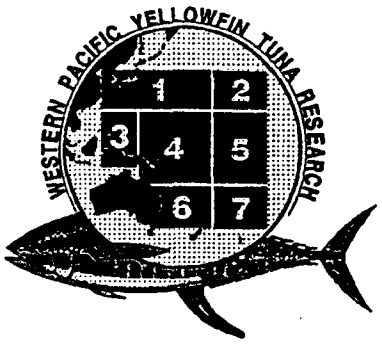

Koror, Palau
August 9 - 11, 1994

Report of WPYRG yellowfin assessment model development workshop, Honolulu, November 8-12, 1993

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Working paper for the 4th Meeting of the Western Pacific Yellowfin Tuna Research Group, Koror, Palau, August 9-11, 1994.

Report of WPYRG Yellowfin Assessment Model Development Workshop
Honolulu, November 8 – 12, 1993

At the behest of the Western Pacific Yellowfin Research Group (WPYRG), a workshop was convened to design a model capable of addressing management questions posed by WPYRG. Particular emphasis was placed on design of a model to make use of fishery and tagging data sets available to the WPYRG. The workshop was funded by University of Hawaii Pelagic Fisheries Research Program. The list of participants and agenda are given in Appendices A and B.

The structure of existing data was reviewed. WPYRG has attempted to assemble a complete yellowfin data set consisting of catch and effort by WPYRG area (Figure 1) and month with length-frequency samples consisting of counts by 1 cm size category for a large random sample of the catch. None of the data sets live up to that ideal. Length-frequency data are incomplete; effort data are often missing; sometimes only annual catch data available. A suitable model must recognize these limitations and be structured to use the data as they exist.

Management Questions

The WPYRG posed several management related questions. The workshop attempted to address these questions, and in addition, posed several others. The workshop participants felt that most of these questions were amenable to analysis by a suitable model.

1. What is a "safe" level of exploitation? — An appropriate model can be used to estimate the consequences of different levels and patterns of exploitation.

2. What factors contribute to local depletion? — An appropriate model can be used to estimate the degree of depletion in the WPYRG areas in response to changes in the fisheries.

3. Do purse seine catches adversely effect longline catch rates? — This question can be addressed by using a suitable model to simulate changes in purse-seine catches and note changes in longline catches.

4. Can trends in catchability be detected? — Suitably parameterized models may detect trends in catchability if there is sufficient information in the data.

5. Are surface stocks and subsurface stocks separate? — The workshop suggested that a single stock model with horizontal spatial heterogeneity be used to analyze existing data. The question of vertical stock separation would best be handled by a different analysis of tagging data. If the observed numbers of tag returns in subsurface fisheries from surface releases are significantly less than expected, then a model with more complex stock structure may be necessary. The workshop recommended that the

South Pacific Commission (SPC) and the National Research Institute of Far Seas Fisheries undertake a collaborative analysis of the SPC's Regional Tuna Tagging Programme tagging data as soon as possible.

6. What is an appropriate measure of fishing effort, particularly for purse seine fleets? — The effects of different effort measures on model performance will be tested.

7. What is the current level and history of exploitation? — The exploitation history would be estimated in the process of fitting an appropriate model to data.

8. How does one avoid the conclusion that stocks are lightly exploited when in fact they are heavily exploited? — Alternative stock histories can be generated by simulation and used to test model sensitivity to impending collapse. Also, the robustness of the stock trend estimates can be investigated by evaluating the sensitivity to structural constraints and assumptions used in fitting the model.

9. How can data collection be improved? — Alternate proposals for expanded data collection can be tested with the model to see which ones provide the best improvement in parameter estimation.

Existing Models

Several potential models for estimating parameters of yellowfin population dynamics were discussed. Some of these models contain spatial structure. Spatially structured models based on advection-diffusion capture movement very well but are computationally difficult and require fine-scale data. Simple transfer models are less realistic but much easier to implement. Current implementations of both general types of movement models lack age structured representations of the fish population.

The SPARCLE model contains a very general age-structured parameterization which has been successfully applied to southern albacore. The structure of the SPARCLE model contains representations for time trends in catchability and selectivity, but no explicit spatial heterogeneity.

There appear to be no suitable parameter estimation models containing both age structure and spatial structure.

Strategy for Model Development

The group recommended adaptation of the SPARCLE paradigm to include a representation of fish movement between the WPYRG zones. The SPARCLE model is explicitly parameterized to address most of the questions posed above (Fourier and Sibert 1993). Trends in catchability are directly estimated (question 4). Fishing mortality is parameterized in terms of fishing effort so that alternative effort estimates could be evaluated (question 6). The SPARCLE paradigm can be used to simulate alternative fishery development

scenarios to determine "safe" levels of exploitation (questions 1 and 8). The time trends in fishing mortality are directly estimated (question 7) and are area specific (question 2). Proposals for enhanced future data collection can be simulated and tested with this model (question 9).

The recommended model would essentially consist of parallel versions of SPARCLE running in each WPYRG zone with transfer coefficients for movement among the zones. Spatial structure will be implemented by assuming that a proportion of the individuals in each WPYRG zone move to another zone in each time step. Let N_k be the number of individuals in region k, $k = 1, 2, \ldots m$. (For the current WPYRG zones, $m = 7$.) Let T_{ij} be the proportion of individuals which move from region i to region j in one unit of time and $T_{kk} = 0$. Then

$$\frac{dN_k}{dt} = -(F + M + \sum_{j=1}^{m} T_{kj})N_k + \sum_{i=1}^{m} T_{ik}N_i$$

where F is the SPARCLE parameterization of fishing mortality and M is the natural mortality. The parameters in the transfer equation above can be made age, time, and area specific where appropriate. There are closed form solutions to this equation, but the group concluded that a fully implicit finite difference approximation with a time step of about 1 month might be computationally more practical. Figure 2 shows how the components of the proposed model are related and how the expected outputs relate to the management questions posed above.

The group recognized that the WPYRG data base will probably need to be reprocessed from time to time in parallel with the model development. For example, it may be necessary to pool data from different fishing fleets or to revise effort calculations. A suitable mechanism needs to be implemented for refinement of the data base and communication with the model developer. The group recommended that collaboration between workshop participants be maintained to provide technical input into model development and data processing.

The group recommended that Dr. David Fournier be contracted to adapt the SPARCLE model and that SWFSC serve as data custodian for catch, effort and size composition data.

The group tried to anticipate various technical problems that might arise in the development of the model. The most serious issue was the large number of parameters that would need to be estimated, ranging from 2,000 to 10,000 depending on various assumptions and constraints. The larger number of parameters is feasible but might require a super-computer. The lower number of parameters could be handled on a work station or powerful PC. The group recommended that the feasibility of implementing SPARCLE on more powerful computers be investigated.

The group estimates that the total cost of model development (including salary, telecommunications and computing) would be approximately US$100,000. Several potential funding sources were discussed. It may be possible to secure funds from the FAO

Expert Consultation on Interaction in Pacific Tuna Fisheries, provided that significant progress could be achieved prior to the next meeting of the Consultation in December 1994. It is also possible that the University of Hawaii Pelagic Fisheries Research Program could provide a portion of funding.

Summary of Recommendations

1. A suitable model for analysis of the WPYRG data would be an adaptation of the SPARCLE paradigm to include a representation of fish movement between the WPYRG zones. The model would have the capacity for time, area, and age specific parameters, but the parameters should be capable of being constrained in various ways (equal across area or across time, for example).

2. Collaboration between workshop participants should be maintained to provide technical input into model development and data processing.

3. Dave Fournier should be contracted to adapt the SPARCLE model, and SWFSC should serve as data custodian for catch, effort and size composition data.

4. The feasibility of implementing SPARCLE on more powerful computers should be investigated.

5. The South Pacific Commission (SPC) and the National Research Institute of Far Seas Fisheries should undertake a collaborative analysis of the SPC's Regional Tuna Tagging Programme tagging data as soon as possible.

Reference

Fournier, D.A. and J.R. Sibert. 1993. SPARCLE: South Pacific albacore research catch-at-length estimator. SPC/SPAR 5/WP 12, Fifth South Pacific Albacore Research Workshop, Papeete, French Polynesia, 29 March - 1 April 1993.

Figure 1. Geographic region and subareas for WPYRG data base.

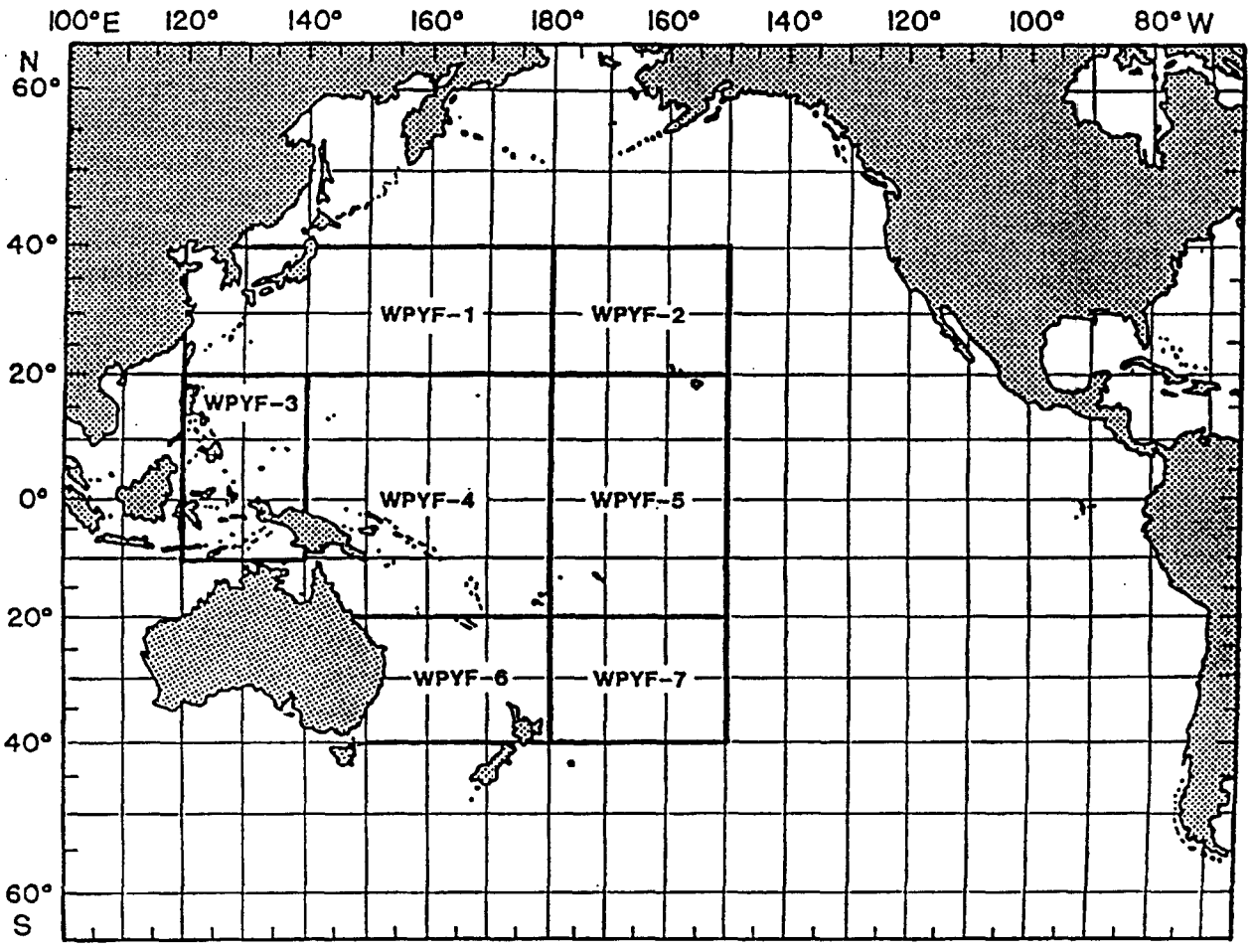
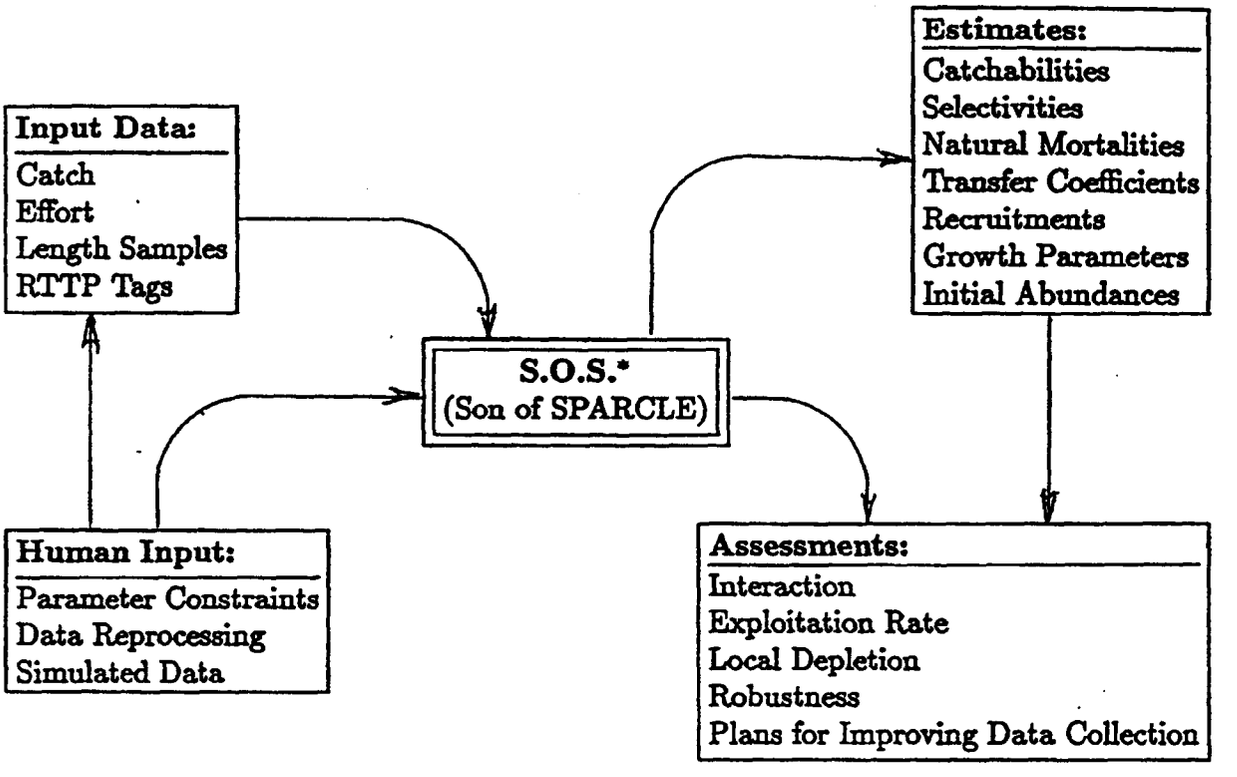


Figure 2. Inputs to and outputs from suggested model.



*For those in the know ... pronounced "souse".

Appendix A. List of Workshop Participants

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Appendix B. Agenda

WPYRG Yellowfin Assessment Model Development Workshop
November 8 — 12, 1993
Honolulu

Agenda

Meet in hotel lobby at 9:00Am Monday, November 8.

1. Housekeeping — John S.
2. Background: "Let the punishment fit the crime" — Pierre
3. Data Holdings:
   a. catch, effort, length-frequency, — WPYRG report
   b. tagging — John H., Sachiko
4. Types of models currently available.
   a. Movement — John S.
      transfer coefficients
      advection diffusion
      individual based models
   b. Age structured population model; e.g. SPARCLE — Dave
5. What kind of model is needed? What is it supposed to do? Is is practical and feasible?
6. Implementation