Need for Stock Structure Information for Assessment and Management of WCPO Tuna Stocks

John Hampton
Oceanic Fisheries Programme, SPC

SPC Stock Structure Workshop

Noumea, New Caledonia, 9-12 October 2018

History

- MULTIFAN-CL – early 1990s
- Early integrated stock assessment model, with spatial structure – Fournier et al. 1998

MULTIFAN-CL: a length-based, age-structured model for fisheries stock assessment, with application to South Pacific albacore, *Thunnus alalunga*

David A. Fournier, John Hampton, and John R. Sibert

Abstract: We introduce a length-based, age-structured model, MULTIFAN-CL, that provides an integrated method of estimating catch age composition, growth parameters, mortality rates, recruitment, and other parameters from time series of fishery catch, effort, and length frequency data. The method incorporates Bayesian parameter estimation, estimation of confidence intervals for model parameters, and procedures for hypothesis testing to assist model development. We apply the method to South Pacific albacore, *Thunnus alalunga*, fishery data and demonstrate the incorporation of model structure such as spatial heterogeneity, age-dependent natural mortality and movement rates, time series trends and seasonal variation in catchability, and density-dependent growth. Consistency of the results of the albacore analysis with various exogenous sets of biological and environmental data gives credence to the model results.

Résumé : Nous présentons un modèle fondé sur la longueur et structuré par l'âge, le MULTIFAN-CL, comme méthode intégrée pour l'estimation de la composition de l'âge des prises, des paramètres de croissance, du taux de mortalité, du recrutement, et d'autres paramètres, à partir de séries chronologiques de données sur les prises, l'effort et les fréquences de longueurs des captures. On y fait appel à l'estimation bayesienne de paramètres, à l'estimation des intervalles de confiance des paramètres du modèle ainsi qu'à des procédures de test d'hypothèses pour faciliter l'élaboration du modèle. Nous appliquons la méthode aux données sur la pêche du germon du Pacifique sud (*Thunnus alalunga*) et démontrons l'incorporation de structures comme l'hétérogénéité spatiale, la mortalité naturelle dépendante de l'âge et les taux de déplacement, les tendances des séries chronologiques et la variation saisonnière de la vulnérabilité à la pêche, et la croissance dépendante de la densité. La cohérence des résultats de cette analyse avec d'autres séries de données biologiques et environnementales rend crédibles les résultats obtenus avec le modèle.

[Traduit par la Rédaction]

Introduction

Age-structured models are now the method of choice for many fisheries stock assessments. Models range from simple deterministic methods, such as virtual population (or cohort) analysis (Megrey 1989), to statistical models in which variability in the data and various population processes is acknowledged (Doubleday 1976; Paloheimo 1980; Fournier and Archibald 1982; Pope and Shepherd 1982; Dupont 1983; Deriso et al. 1985; Schnute and Richards 1995; McAllister and Ianelli 1997).

Received June 20, 1997. Accepted May 29, 1998.
J14072

D.A. Fournier.[1] Otter Research Ltd., P.O. Box 265, Station A, Nanaimo, BC V9R 5K9, Canada.
J. Hampton. Oceanic Fisheries Programme, South Pacific Commission, B.P. D5 98848 Noumea Cedex, New Caledonia.
J.R. Sibert. Pelagic Fisheries Research Program, Joint Institute for Marine and Atmospheric Research, University of Hawaii, Honolulu, HI 96822, U.S.A.

[1]Author to whom all correspondence should be addressed. e-mail: otter@island.net

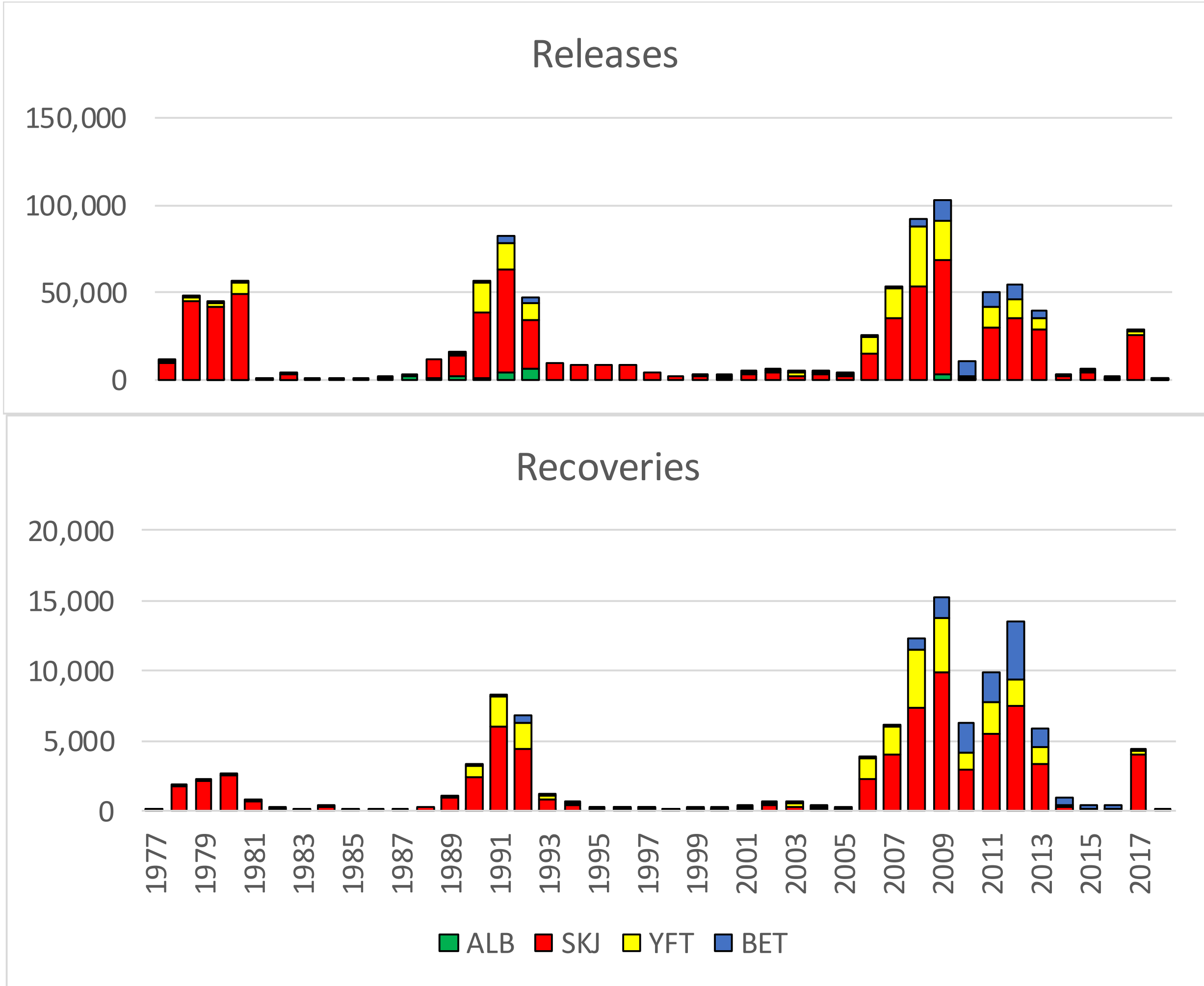
Statistical age-structured models are superior to deterministic models in that they permit the estimation of confidence intervals for the parameter estimates. This allows uncertainty in stock assessments to be incorporated into management advice through decision or risk analysis. Bayesian approaches to age-structured models (McAllister and Ianelli 1997; Punt and Hilborn 1997) now provide a powerful framework for undertaking integrated analysis of fish stocks and for expressing the full range of uncertainty in the resulting advice given to fisheries management authorities.

A second advantage of statistical age-structured models is that they provide an objective means of comparing model hypotheses regarding alternative "states of nature". In a maximum-likelihood framework, the usual frequentist approach of testing nested models using likelihood-ratio tests can be applied. In the Bayesian framework, the posterior odds of competing models can be computed. In either case, statistical guidance can be obtained regarding an appropriate model structure for the case at hand.

Both deterministic and statistical age-structured models rely on catch-at-age data. These are sometimes derived from the analysis of annuli on various body parts of individual fish. Perhaps more commonly, age composition is derived from length frequency samples using an age–length relation-

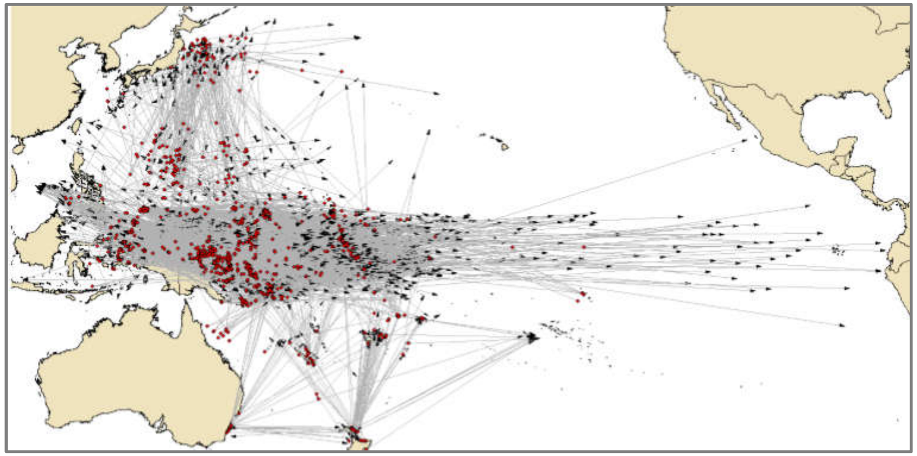
Why Spatial?

- Rich history of tuna tagging data
- SKJ assessment not possible without tagging → spatial approach is essential

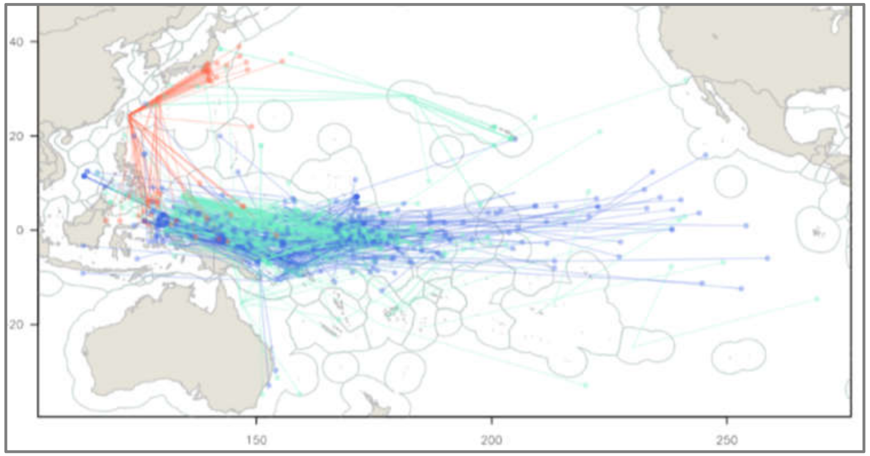


Movements

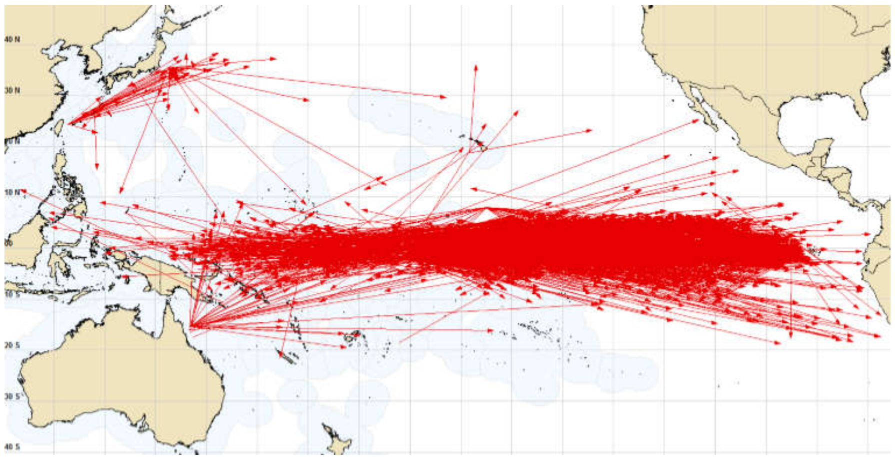
Skipjack



Yellowfin

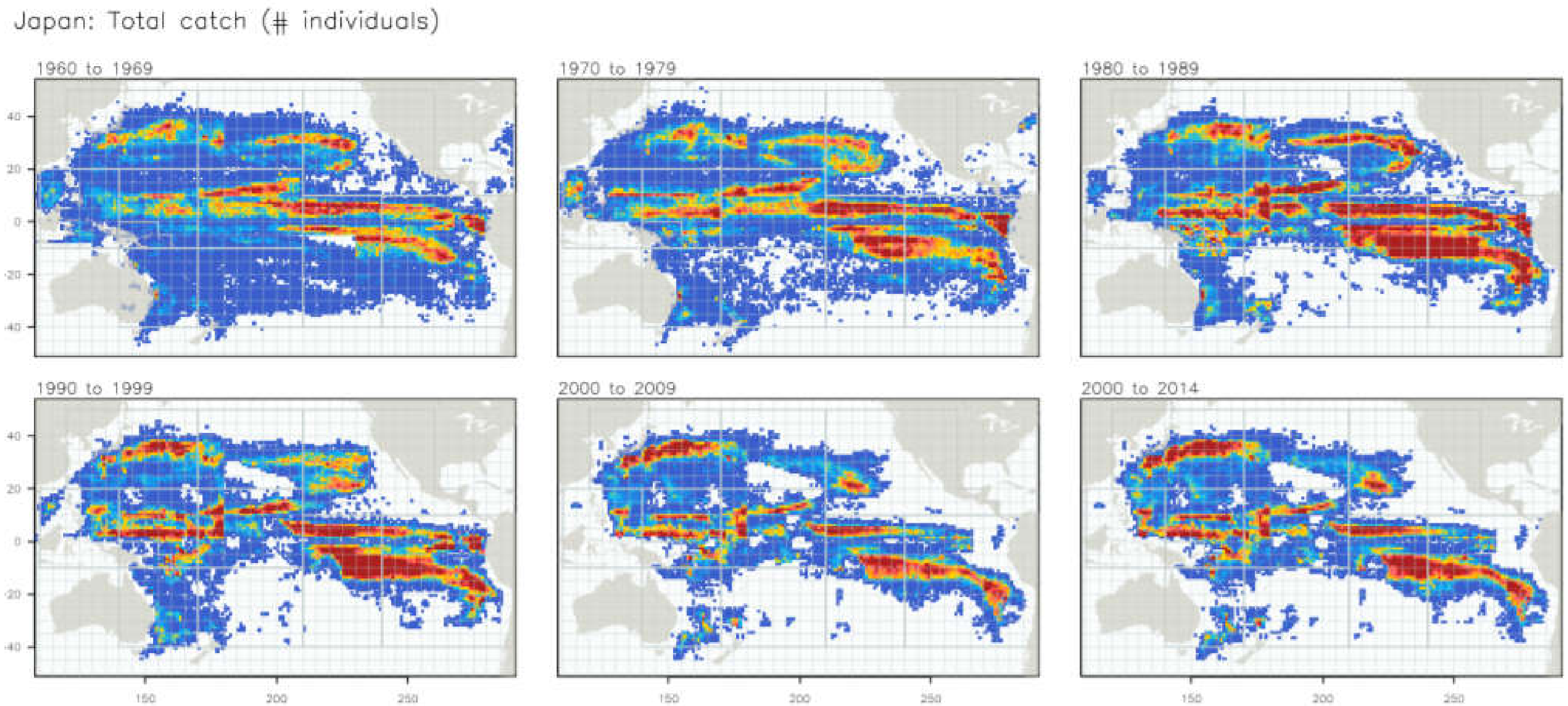


Bigeye



Why Spatial?

- Spatial heterogeneity in fisheries

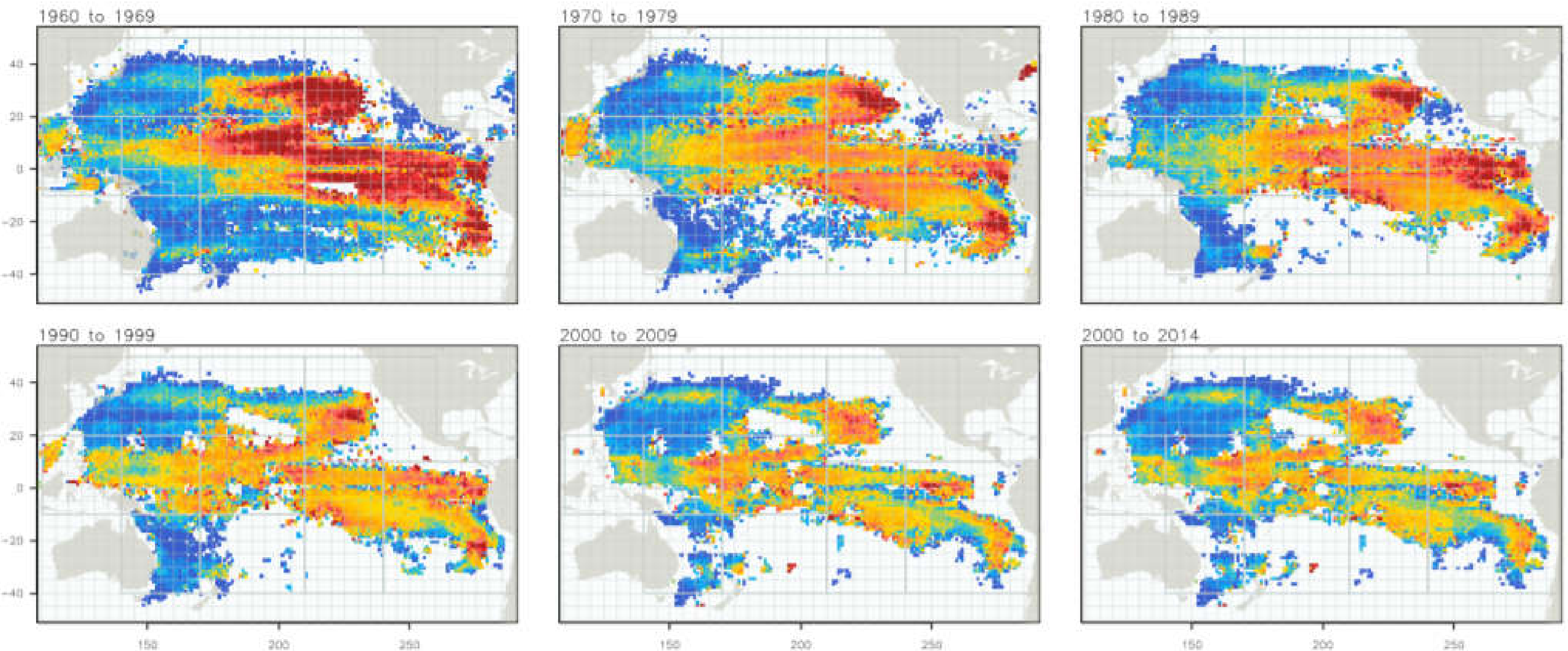


Why Spatial?

Pacific Community
Communauté du Pacifique

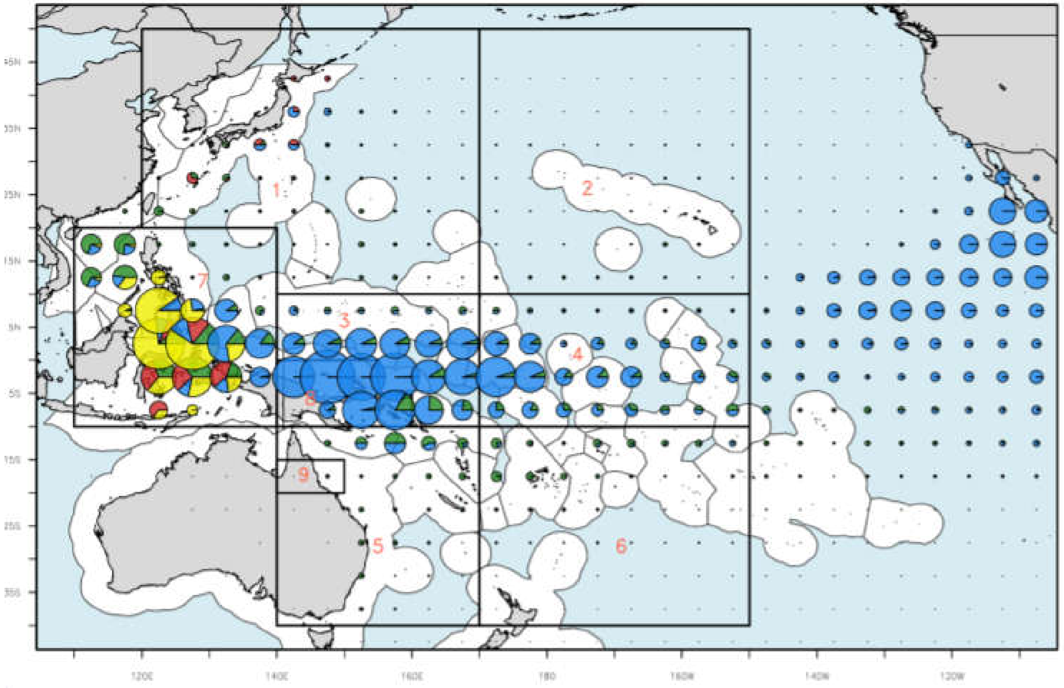
- Spatial heterogeneity in populations

Japan: BET CPUE (#indivs/100 hooks)



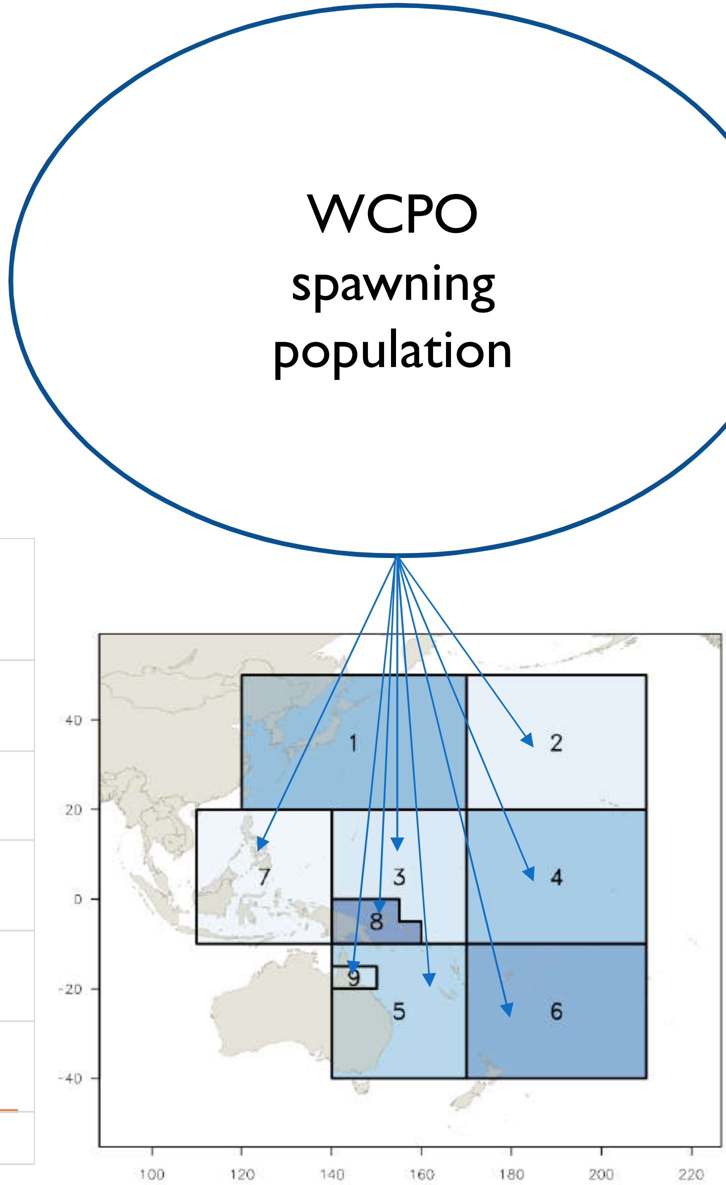
Method used in MULTIFAN-CL

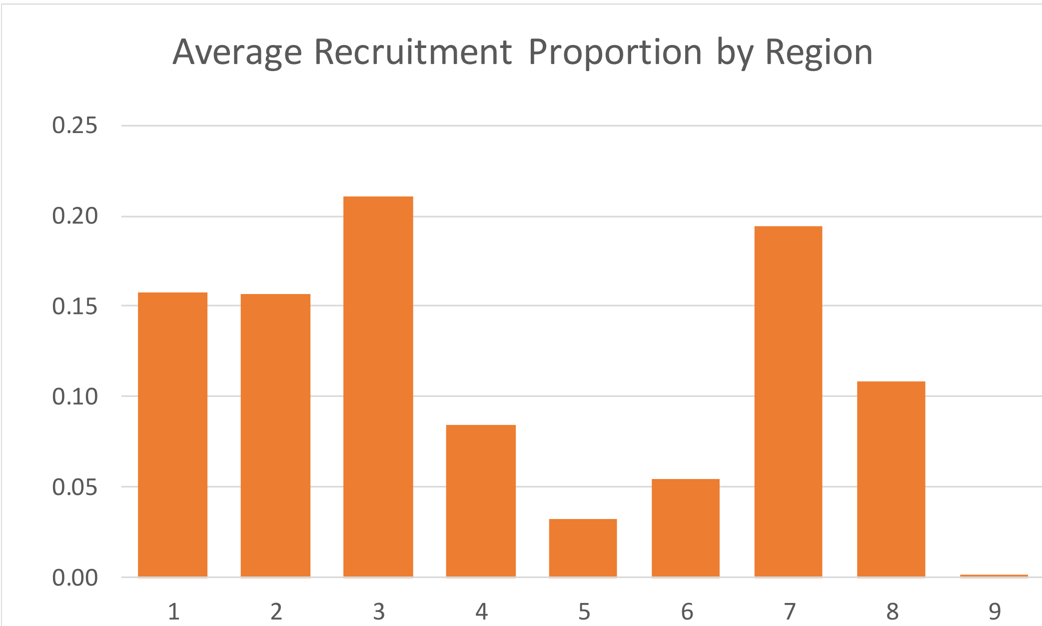
Pacific Community
Communauté du Pacifique



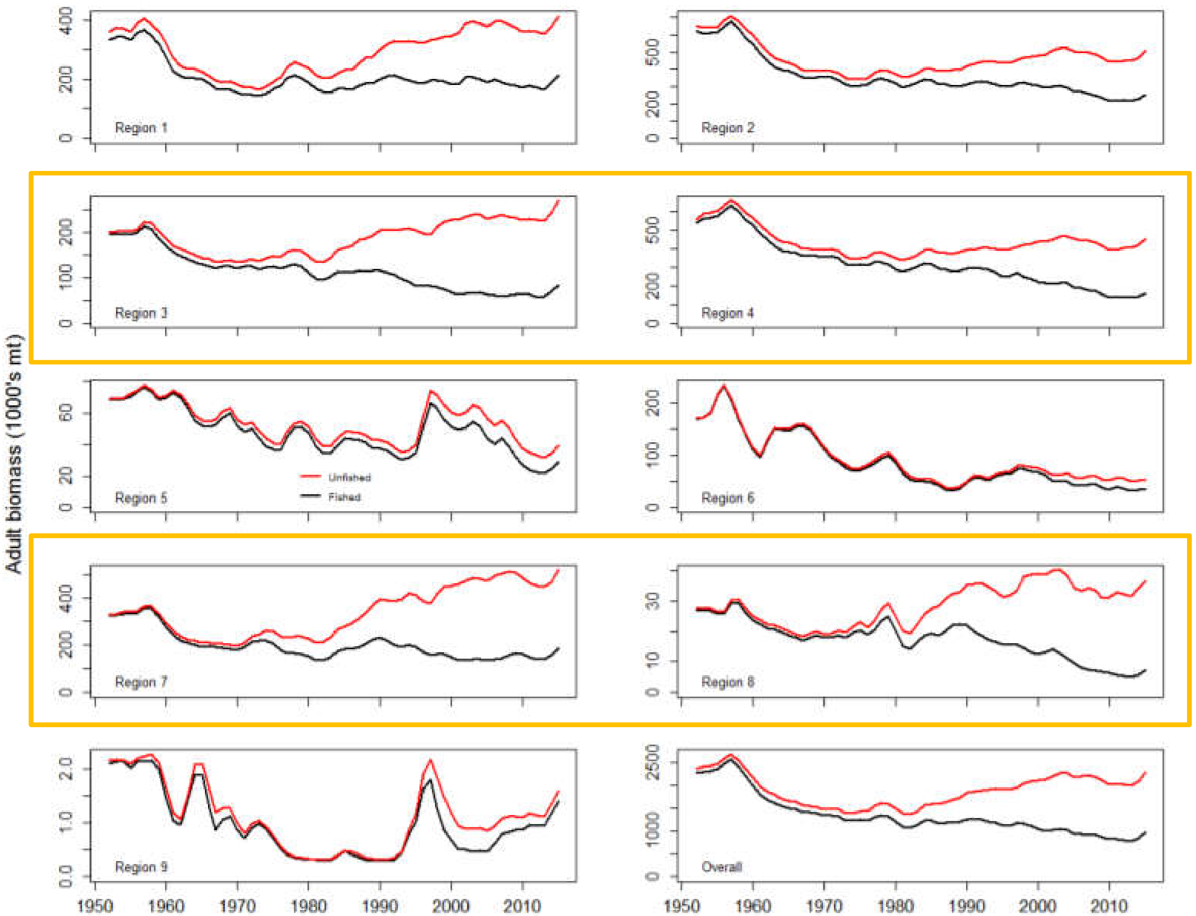
- Defined model regions with specific estimates of recruitment, abundance by region
- Most population dynamics (*M*, growth, etc.) shared across regions
- Region-specific populations linked by movement, may be age-specific, seasonal but no inter-annual variation

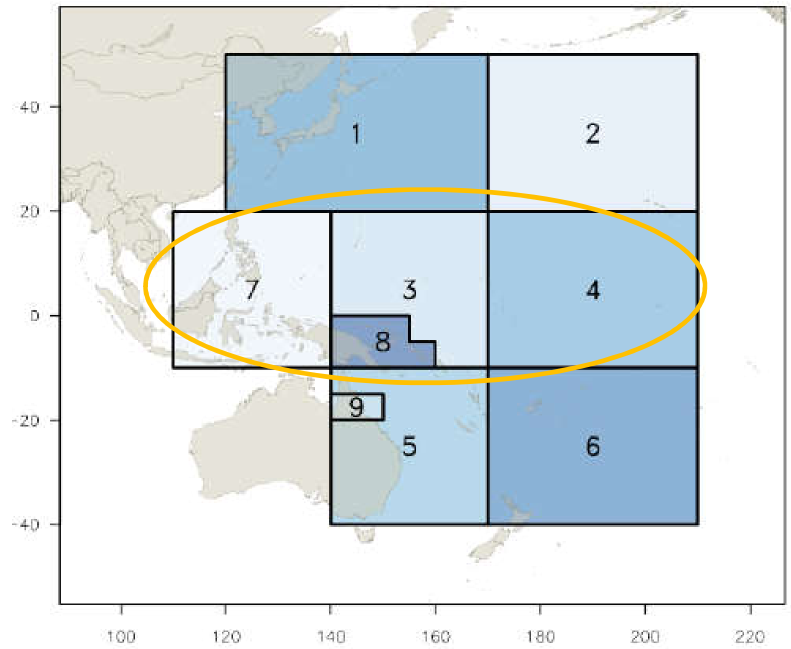
Recruitment (BET)





Region-specific estimates (BET)





Key Questions

Pacific Community
Communauté du Pacifique

- Is this simplistic stock structure appropriate for tunas in the WCPO?
  - Single stock, with recruitment allocated to regions
- What other possibilities need to be considered?
  - Local stock-recruitment dynamics, with post-recruitment mixing?
  - Spawning site fidelity / natal homing
  - Partial (e.g. resident/nomad) versions of the above