The 2nd review of the stock assessment of bigeye tuna in the eastern Pacific Ocean

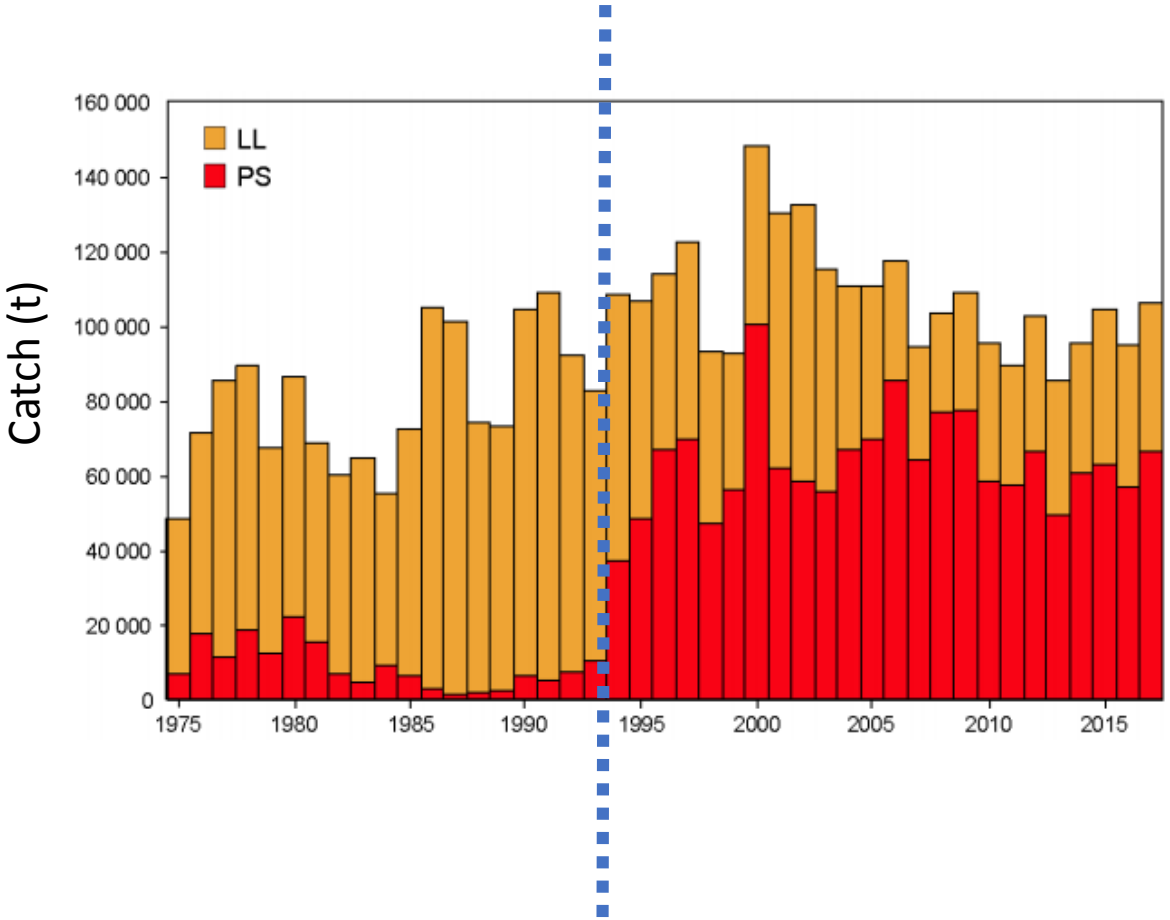
11-15 March 2019, La Jolla, CA.

Panel Members

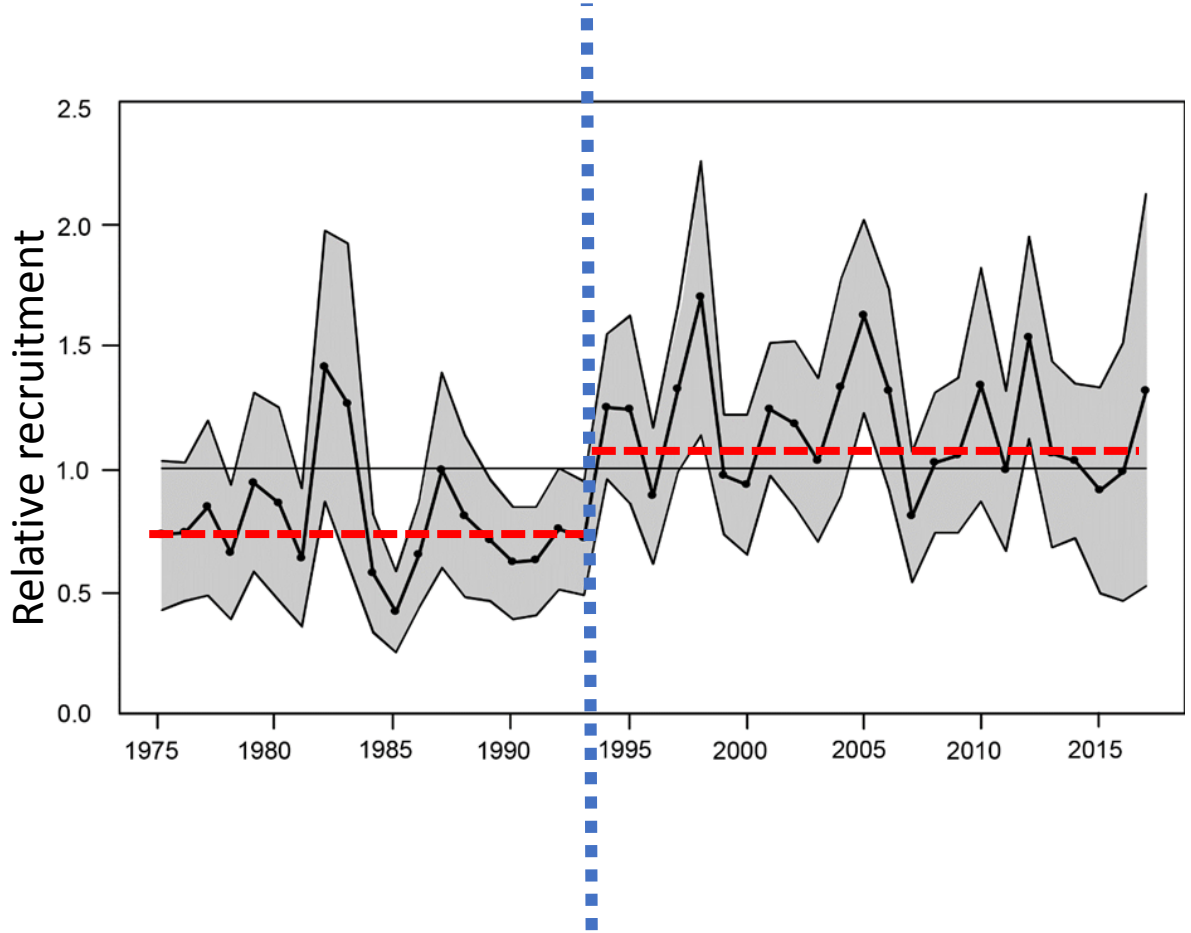
- **André Punt** (**Chair**), Director and Professor at the School of Aquatic and Fishery Sciences at the University Washington
- **Steven Cadrin**, Professor at the University of Massachusetts School for Marine Science and Technology, and chair of the Department of Fisheries Oceanography, and Educational Director of the Massachusetts Marine Fisheries Institute
- **Dan Fu**, Stock Assessment Officer at the Indian Ocean Tuna Commission
- **Kai Lorenzen**, Associate Director and Professor in the Fisheries and Aquatic Sciences, School of Forest Resources and Conservation, University of Florida
- **Richard Methot**, Senior Stock Assessment Scientist for the United States National Marine Fisheries Service and President of the American Fishery Society's Marine Fisheries Section and an affiliate professor at the University of Washington
- **Kevin Piner,** Research Fishery Biologist for United States National Marine Fisheries Service, Southwest Fisheries Science Center
- **John Walter**, Acting Chief of the Gulf and Caribbean Branch and Research Fishery Biologist of the United States National Marine Fisheries Service, Southeast Fisheries Science Center

All comments/complaints should be sent to the Chair

Recruitment regime shift



Increase in PS catch

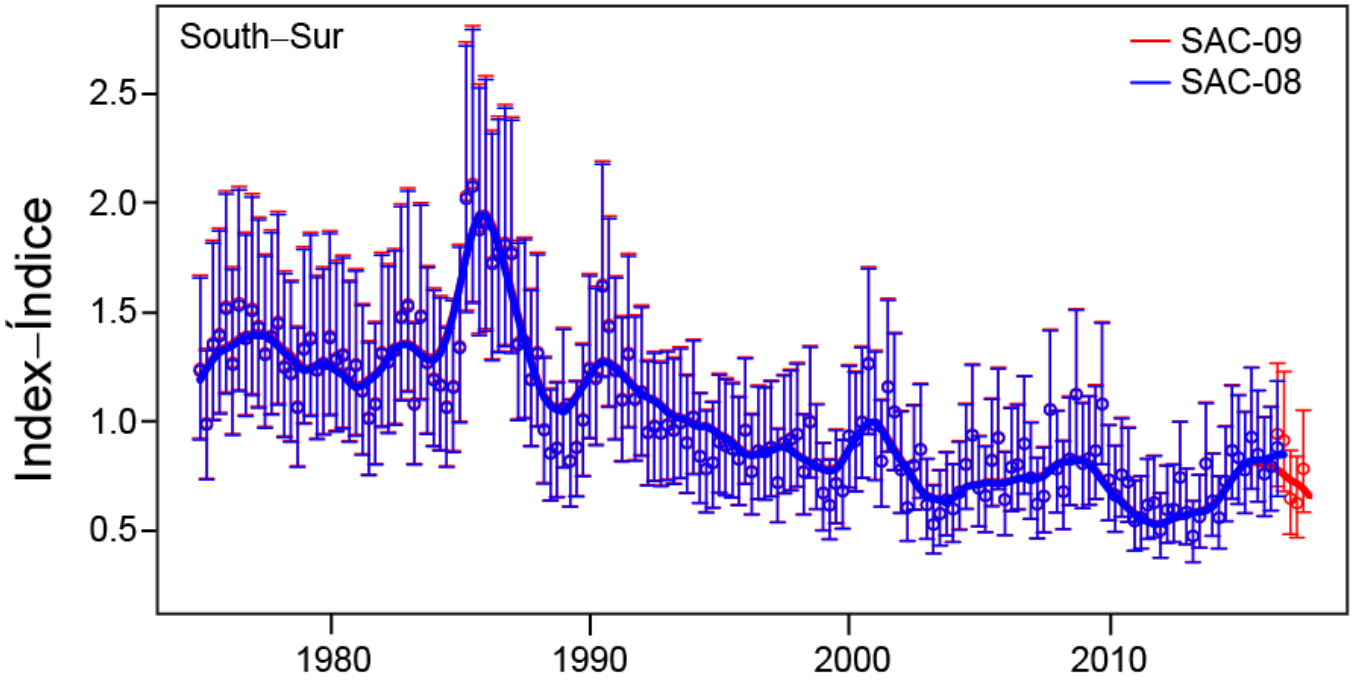


increase in model recruitment

Change in perception of relative exploitation (Fmult)

2017 Full Assessment Fmult 1.15

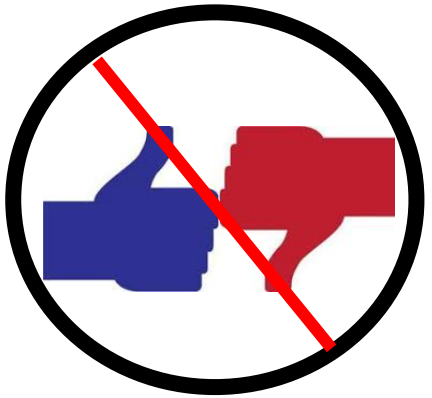
2018 Updated Assessment Fmult 0.87



Retrospective Pattern in Fmult

Objectives

- Identify the best available science for use in the assessment
- Provide an independent review of the assessment approach
- Provide advice on future research and data collection that will improve the assessment and the provision of management advice.
- **Not a review of the assessment in relation to the provision of management advice in the short-term**



- **A focus was an apparent “recruitment regime shift”, where the assessment model estimates an increase in average recruitment in the mid-1990s coincident with the increase in purse seine catches in the EPO**
- **Two general approaches to modelling evaluated**
  - **The 2018 base-case model- fleets as areas**
  - **A new area-specific model with four re-defined areas**

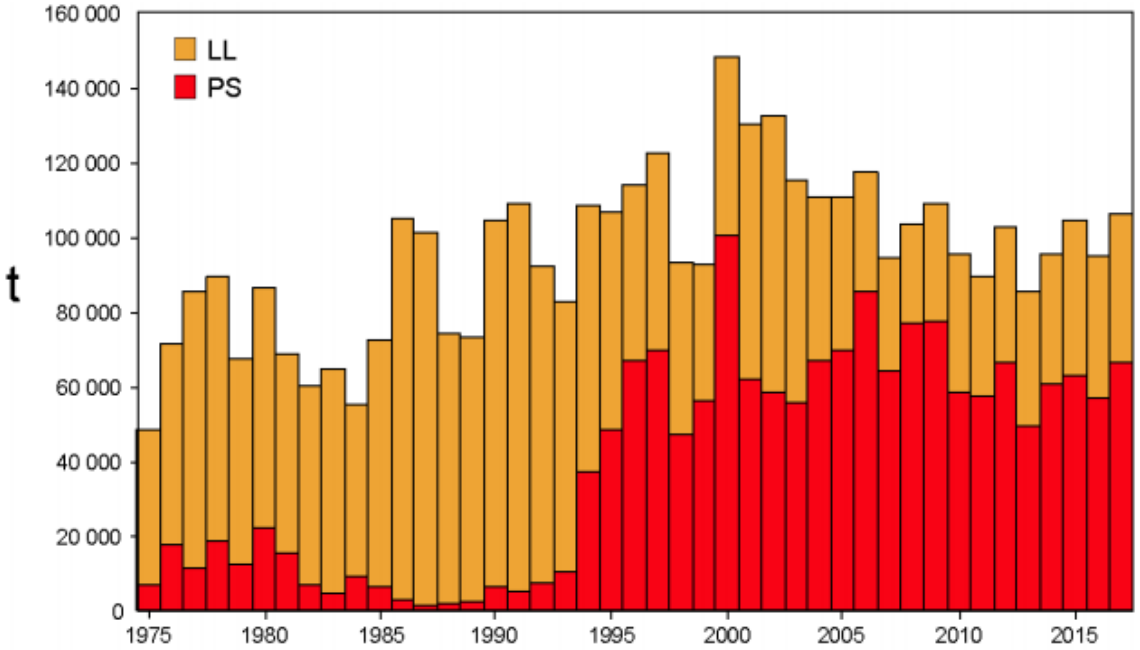
Logistics

- IATTC staff provided
  - Background documents
  - Documents prepared specifically for the review
  - Presentations
- IATTC staff responded to requests by the Panel that addressed topics related to data, biology, and modelling
- IATTC staff ran model requests from the Panel

Topics covered

- DATA ISSUES
  - **Catch and discards**
  - Catch and discard composition data
  - **Indices of abundance**
- STOCK STRUCTURE AND SPATIAL STRUCTURE
  - **Stock structure hypotheses**
  - Movement
  - **Modelling**
- BIOLOGY
  - **Growth**
  - **Natural mortality**
  - **Recruitment and Spawner-Recruitment Relationship**
  - **Fishery structure and selectivity**
- DATA WEIGHTING, UNCERTAINTY, AND DIAGNOSTICS
  - **Data weighting**
  - **Diagnostics**
  - **Uncertainty**

DATA ISSUES: Catch



Issues of catch accounting discards leads to the Rshift

Catch

Findings:

Unlikely that underestimated PS catch (or discards) in the pre-1990s
or overestimated recent catches causes the Rshift.

Recommendations:

Apply retrospective approach to evaluate method used to split PS catch to species

Evaluate use of the difference in PS selectivity (pre/post 2000) to estimate the retention function after the implementation of the ban of discard.

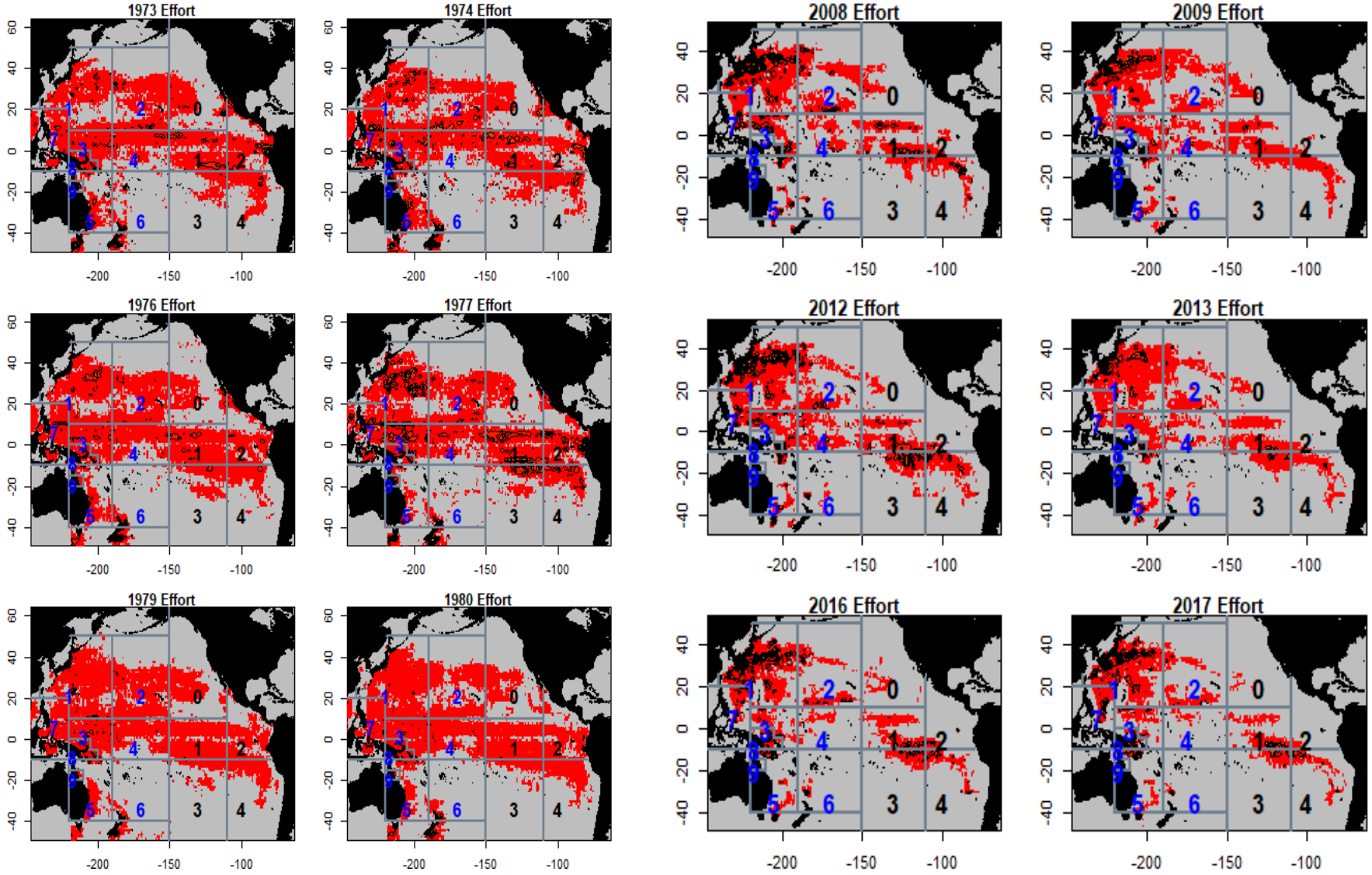
Re-evaluate the zero discard assumption in the LL fleet. Observers considered

DATA ISSUES: Indices

Effort in the 1970'

JAPAN

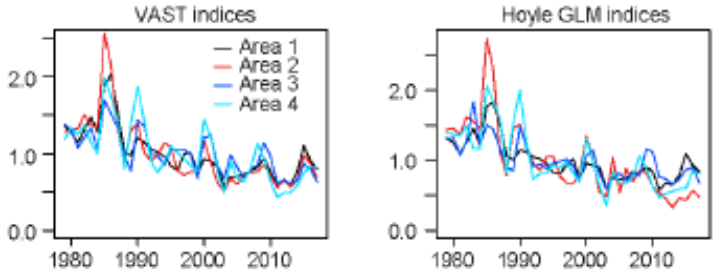
Effort in the 2010's



LL indices are the driver of changes in population abundance

Does standardization account for changes in targeting, catchability and spatial fishing patterns

Indices



Finding:

Joint modelling group making progress with the operational data and multiple fleets

GLM methods and newer spatial temporal models give similar series

Recommendations:

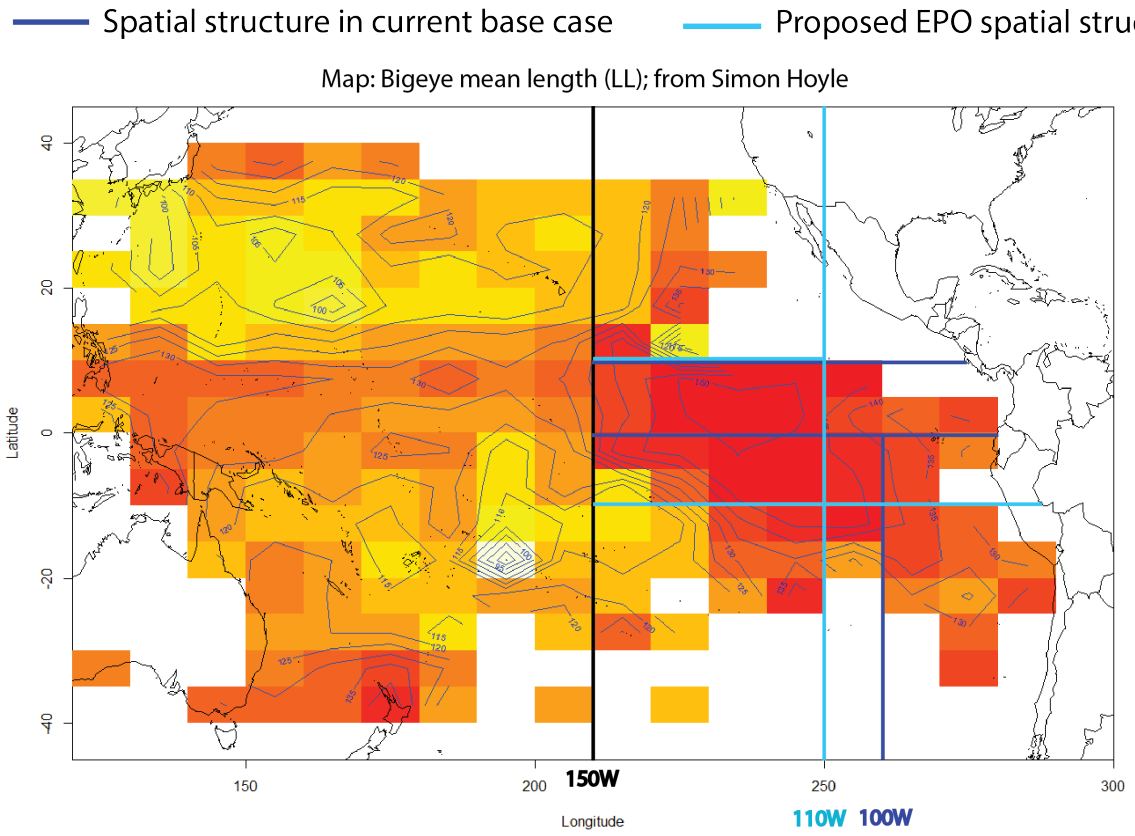
Operational-level CPUE data and fine scale composition data should allow use for longer periods of time.

The changing vessel ID over time in longline CPUE indices should be accounted for.

The pre-1975 longline CPUE data and for a larger area of the Pacific should be re-considered through spatio-temporal modelling approaches.

Mechanistic hypotheses of environmentally-mediated impacts on CPUE should be developed and tested with data.

Issues: STOCK STRUCTURE AND SPATIAL STRUCTURE



Spatial Mismatch from assuming a single well-mixed stock (areas as fleets)

Does spatial structure in EPO that is not modelled contribute to the Rshift

Stock structure

Findings:

From a broad perspective evidence points to a single genetic pop across the tropical and temperate Pacific with sub-structure

Appears that CPUE and size structure and tagging data suggest sub-structure in EPO

Spatial EPO models did not eliminate Rshift

Recommendations:

Areas-as-fleets can be used for both the assessment and MSE operating model

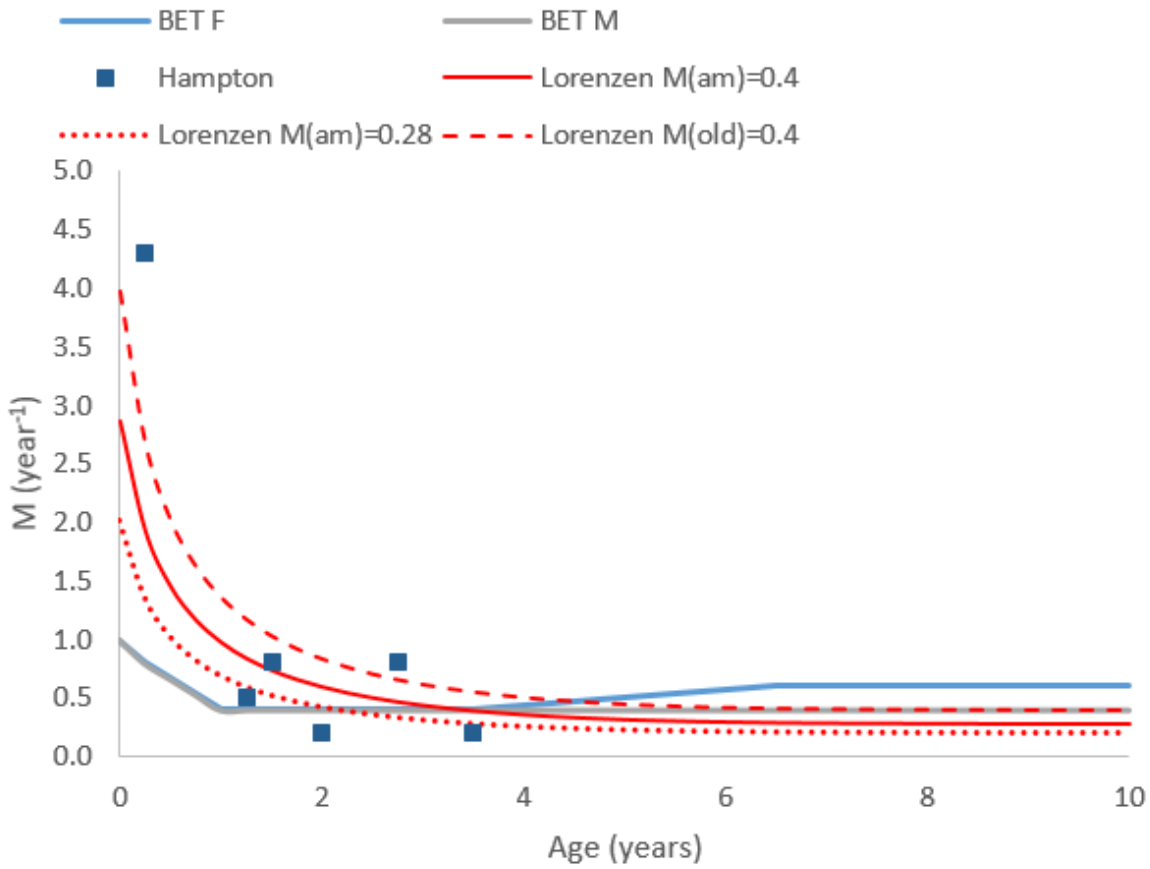
Spatially-structured assessment explorations should continue

Future explorations should consider tag-integrated methods, alternative movement models and explorations of geographic variation in growth.

Future tagging should be designed to represent all of the proposed areas and ages.

Continuing the collaboration with SPC on a Pacific-wide assessment of bigeye tuna,

Biology, Fisheries Structure and Selectivity



Is there a structural assumption in the model causing the Rshift

BIOLOGY, Fishery Structure and Selectivity

Findings:

Length at age: maximum length is uncertain and current value specified in model may be too large. Estimating growth in model eliminated Rshift.

The age-specific pattern in M used in the model is logical but adhoc. Higher juvenile M results in reduction to Rshift.

LL assumes asymptotic selectivity, allowing for a domed shape also reduces Rshift

Recommendations:

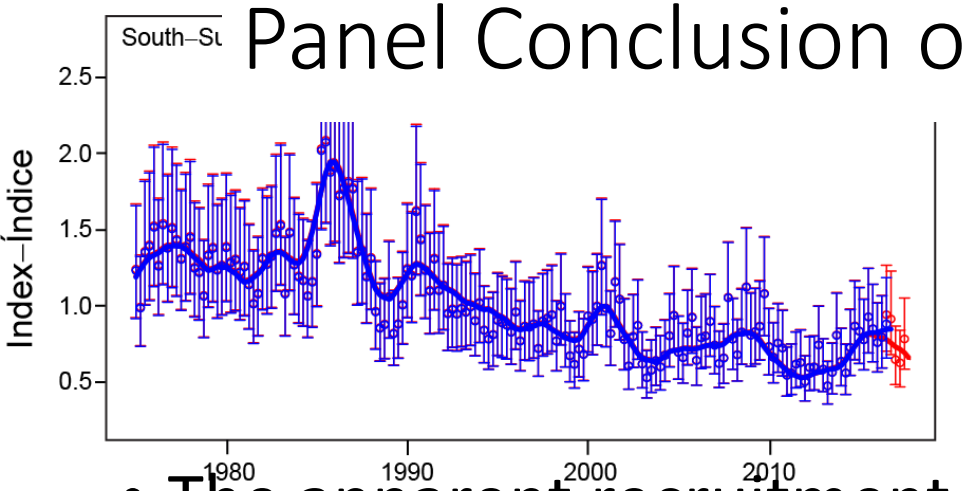
Continue evaluating the appropriateness of biological and fishery assumptions. consider estimating rather than specifying.

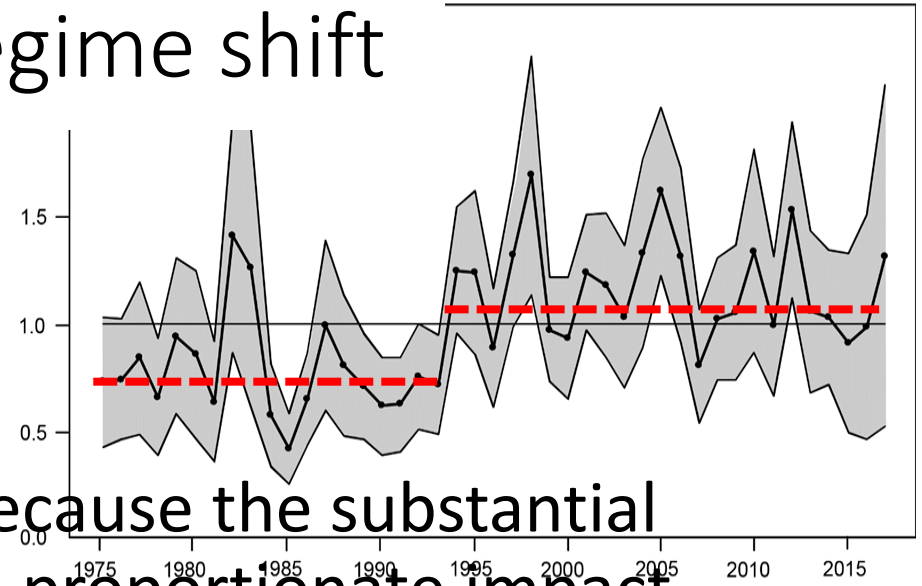
Maintaining h=1.0 should be revaluated along with bias corrections protocols and sigmaR used.

DATA WEIGHTING, UNCERTAINTY, AND DIAGNOSTICS

- Data weighting
  - The initial effective sample sizes for the composition data should be documented
  - Alternative approaches for setting the initial sample sizes should be explored in future assessments
  - A minimum of three iterations should be conducted to ensure convergence when applying the Francis (2011) method
- Diagnostics
  - Examine the pattern of residuals in the fit to the aggregated size-composition data as well as the fits to the time series of average length for each fleet.
  - Continue to use the ASPM analysis to explore the information content of the CPUE and length composition data, and any potential conflict between them.
  - Conduct retrospective analyses (including fishing mortality of reference ages as well as the F-multiplier).
  - Plot the aggregated fits to the size-composition data.
  - Construct profiles for R0 as well as other key quantities such as Linf, steepness, and initial depletion.
- Uncertainty
  - **As many parameters should be estimated as possible, with informative priors based on data, to better quantify estimation uncertainty.**
  - **Management procedures that do not require accurate estimates of probabilities should be considered in the MSE.**

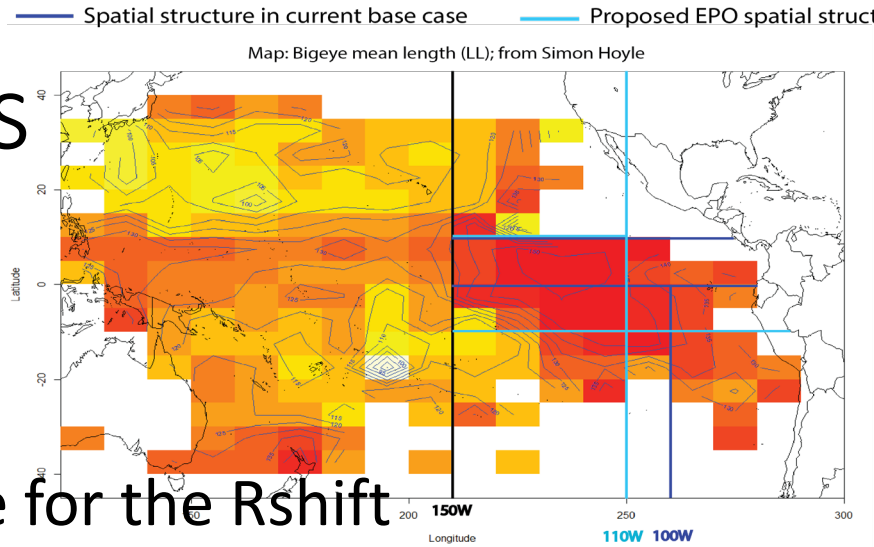
Panel Conclusion on recruitment regime shift





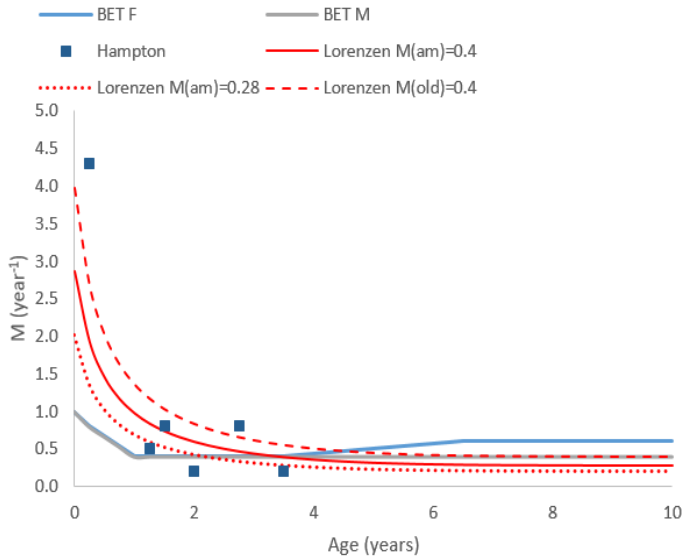
- The apparent recruitment regime shift arises because the substantial increase in purse seine catches does not have a proportionate impact on the trends in catch-rates or in the size-composition of the longline catches
- The model creates higher post 1995 recruitment so that the impacts of increased PS catches on longline catch rates are lessened.
- Thus, while it cannot be definitively rejected that an actual recruitment regime shift has occurred, the balance of evidence is that the apparent shift is an artefact of some aspect of the model or the way it has been parameterized.

Panel Conclusion on Spatial models



- Did not identify stock and spatial structure as the cause for the Rshift
- Spatial models could potentially allow an exploration of the use of the tagging data in the model to inform abundance and fishing mortality rates in areas where the assumption of full mixing is less likely to be violated
- The development of spatial models should be preceded by construction of a conceptual model
- The Panel does not consider the development of spatial model for the EPO a high priority in the short-term
- Developing a spatial model for the whole Pacific should take a staged approach, with the first step being implementation of a “simple” model with few areas.

Panel Conclusions on Data collection



- Longline discards
- Spatial and seasonal length-weight data
- Additional age-length to improve growth curves and time varying growth
- Tagging of juveniles and adults across the EPO
- Information from promising stock identification methods (e.g., genetics, otolith chemistry, morphology, parasites, larval dispersal)
- More tissue samples will enable application of genetic techniques (e.g., sex determination, stock origin, close-kin mark-recapture).
- Satellite pop-up tags to further explore movement dynamics, specifically focusing on estimating movements of large fish across major spatial boundaries.

Recruitment regime shift hypotheses considered

Hypothesis	Concept	Result
Spatial mismatch	Longline and purse seine areas not overlap	No
Growth issues	Don't see large fish	Yes
Length-Weight issues	Relationship is old	No
Model time span	Initial depletion inconsistent, start earlier	Partial
Selectivity issues	Dome shape selectivity for longline	Yes
Catchability issues	Temporal change in catchability and selectivity	No
LL Index issues	Spatial contraction of longline fleet	No
Environmental or ecosystem regime shift	Regime shift in recruitment is real	Some evidence for ecosystem change
Ricker stock recruitment	Reduced tuna abundance allows higher recruitment	Not evaluated
FAD early catch underestimation	Higher catch means higher recruitment estimates	Unrealistically high
FAD recent catch overestimation	Lower catch means lower recruitment estimates	Unrealistically low
Higher natural mortality rates	Higher M means catch has less impact on recruitments estimates	Yes
Density-dependent growth	Higher growth rates explains catch	Not evaluated
Changes in migratory patterns	Availability of fish influences impact of catch and indices	Not completely evaluated

Table 7.1

Areas of further development

Component	Detail
Growth	Alternative models, estimate in assessment with priors, density dependence
Natural mortality	Lorenzen, use sex ratio data
Selectivity for longline fleets	Dome shape for longline
Selectivity for the purse seine fleets	Discard regulations, non-parametric smoother
Initial conditions	Start earlier, equilibrium catch penalty
Stock-recruitment relationship	Bias correction factor, Estimate steepness
Size-composition data	Estimate weight, drop training vessel, consider other fleets
Catch-rate data	Annual CVs, Use VAST indices, consider purse seine catch per set
Diagnostics	Retrospective, ASPM, residual patterns, Likelihood profiles on several parameters

Table 7.2

Summary: main recommendations

- The reason for the recruitment shift was not definitively determined, but several potential hypotheses were identified
- The recommended order of investigation is to adjust M and growth before further extensively exploring spatial structure
- Operational-level CPUE data and fine scale composition data should be further investigated
- Areas-as-fleets should be used, but spatially-structured assessment explorations should continue

Finish

- The Panel wishes to thank IATTC staff for their hard work. We believe the IATTC staff are an exceptional group of analysts that will be able to develop a credible assessment of BET. The recommendation and conclusions of this panel should be the starting point and not the final word on those efforts