The need for spatial-temporal modeling of catch-per-unit-effort data when used to derive indices of relative abundance to include in stock assessment models

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The issue

- The bluefin tuna assessment model depends on indices of abundance derived from the CPUE of the Japanese and Taiwanese longline fleets
- The spatial distributions of the Japanese and Taiwanese longline fleets change over time
- Different areas have different size bluefin tuna
- The current CPUE standardization does not adequately take the spatial distribution into consideration
- The same composition data is used both for the index of abundance and the catch, but these represent different components of the population.

Spatial distribution of Bluefin tuna

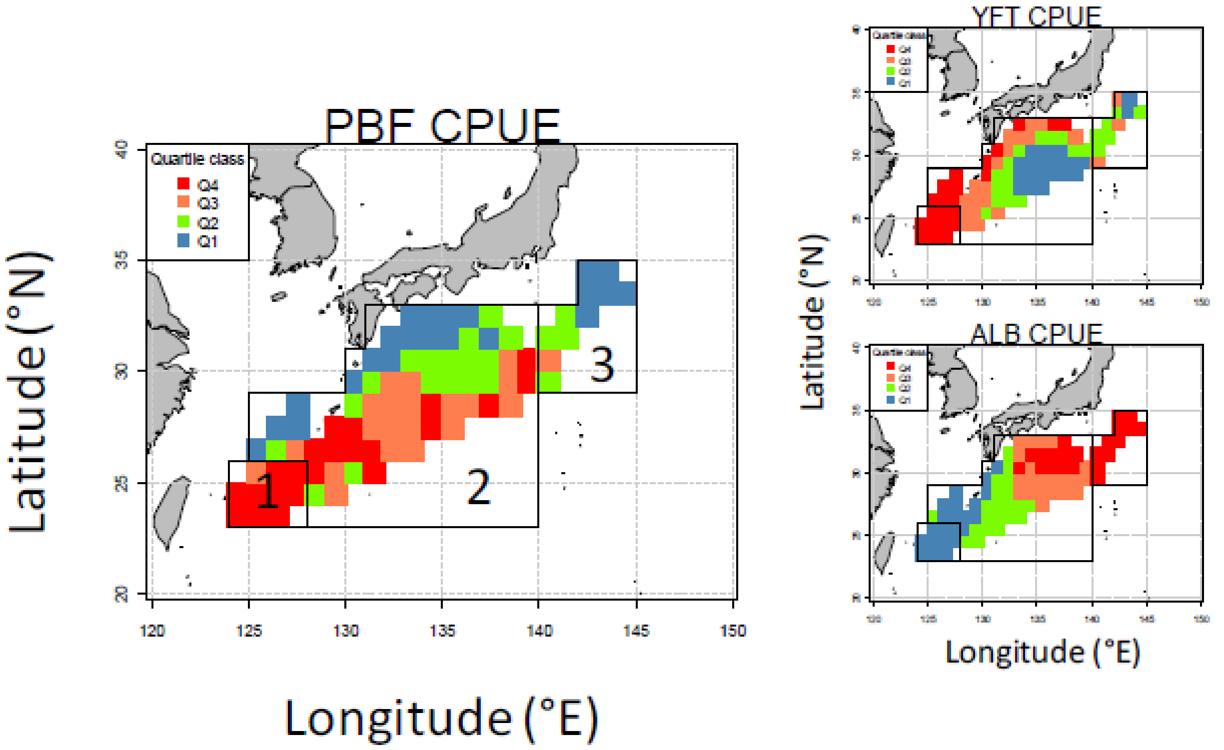


Fig. 3 Geographic distribution of standardized CPUE by 1x1 degree grid in latitude and longitude for PBF, YFT and ALB. Colors in each grid indicate quartile classes of CPUE for each species. Q1, lowest CPUE class; Q2, second lowest CPUE class; Q3, second highest CPUE class; Q4, highest CPUE class. Blue, green, orange and red indicates Q1, Q2, Q3 and Q4, respectively.

Oshima et. al. 2012. Shift of fishing efforts for Pacific bluefin tuna and target shift occurred in Japanese coastal longliners in recent years. ISC/12/PBFWG-3/05

Changes in spatial distribution over time

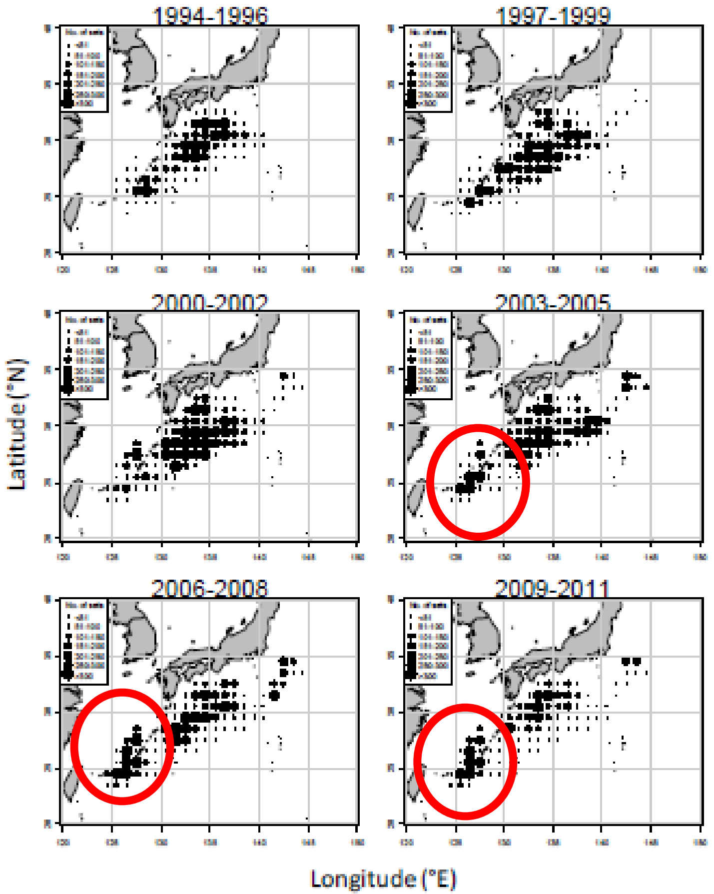
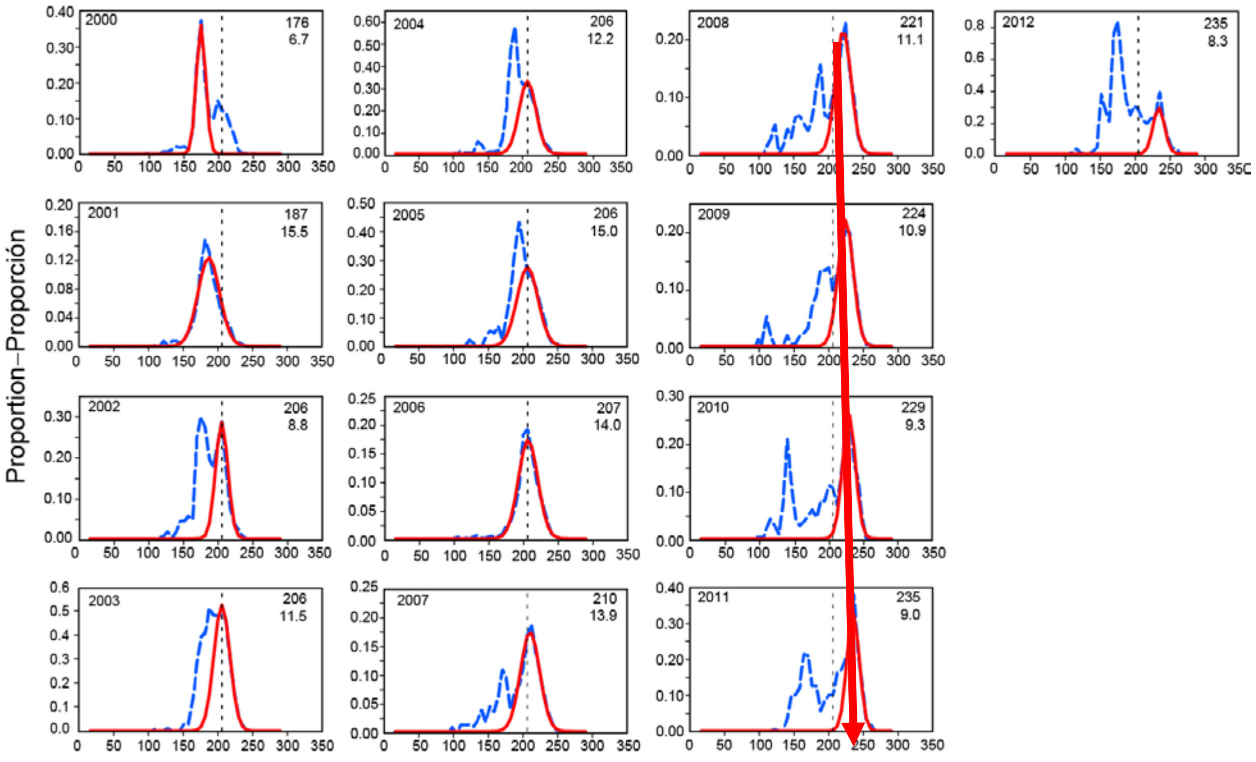
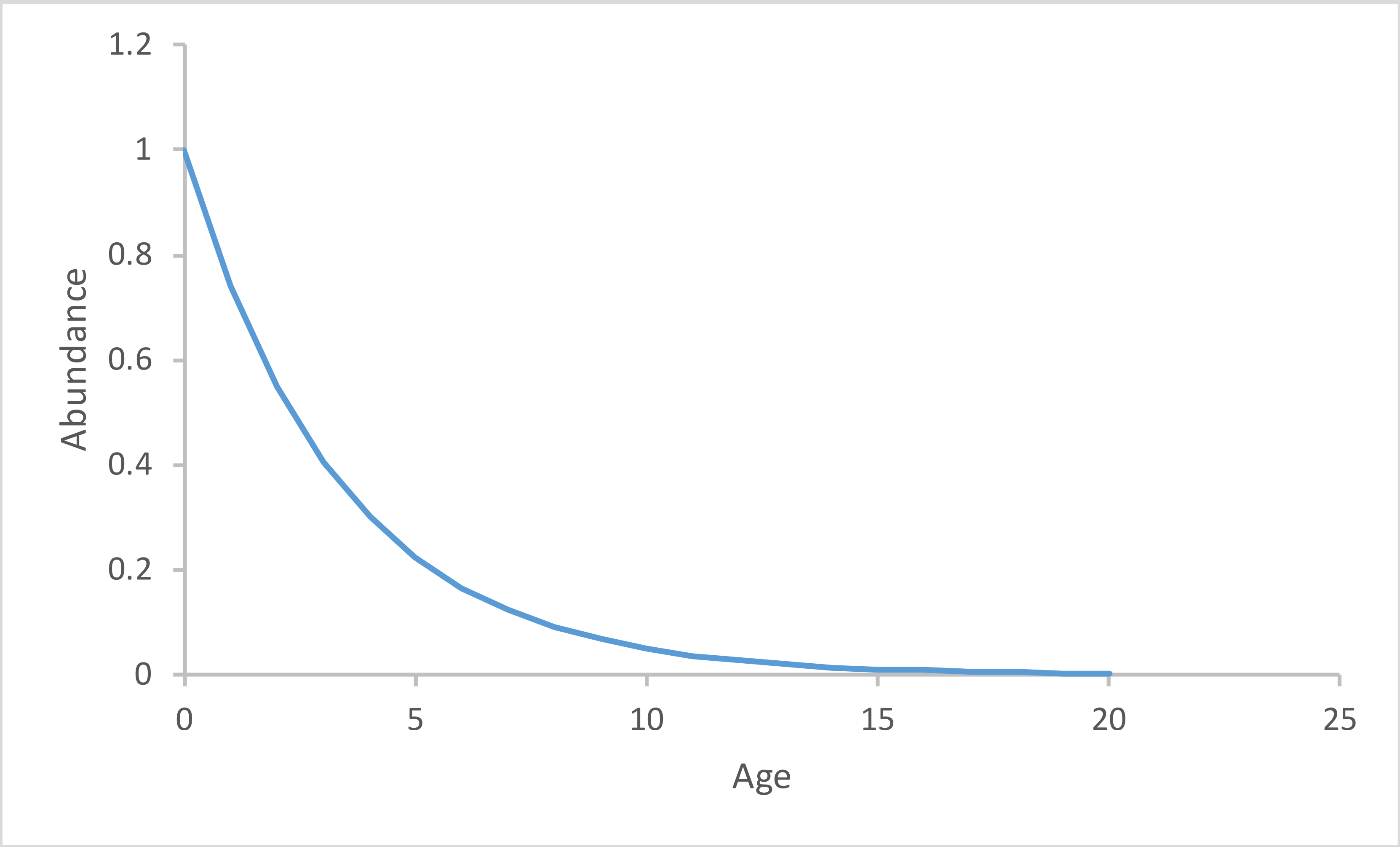


Fig. A2-1 Geographic distributions of longline sets by three years interval from 1994 through 2011. Size of filled circles indicates class of number of longline sets by one-by-one degree grid in latitude and longitude.

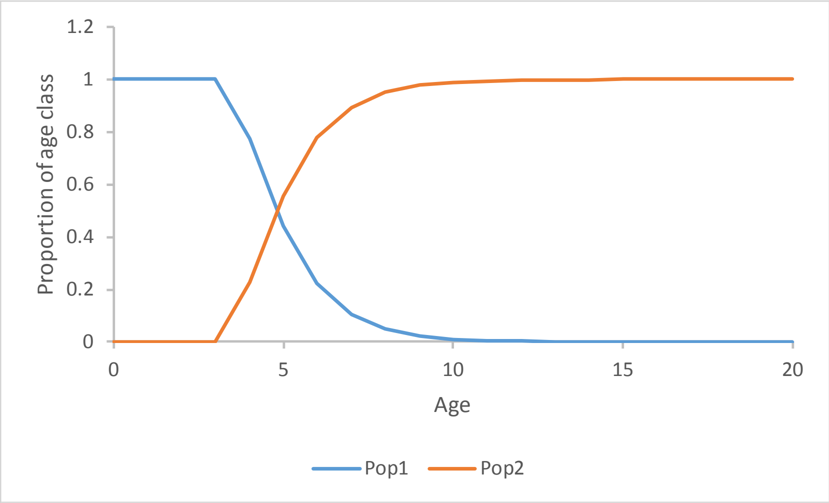


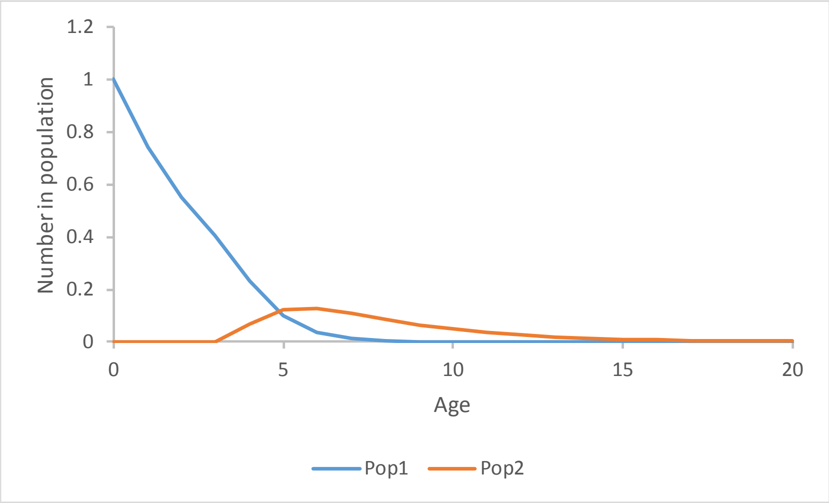
Oshima et. al. 2012. Shift of fishing efforts for Pacific bluefin tuna and target shift occurred in Japanese coastal longliners in recent years. ISC/12/PBFWG-3/05

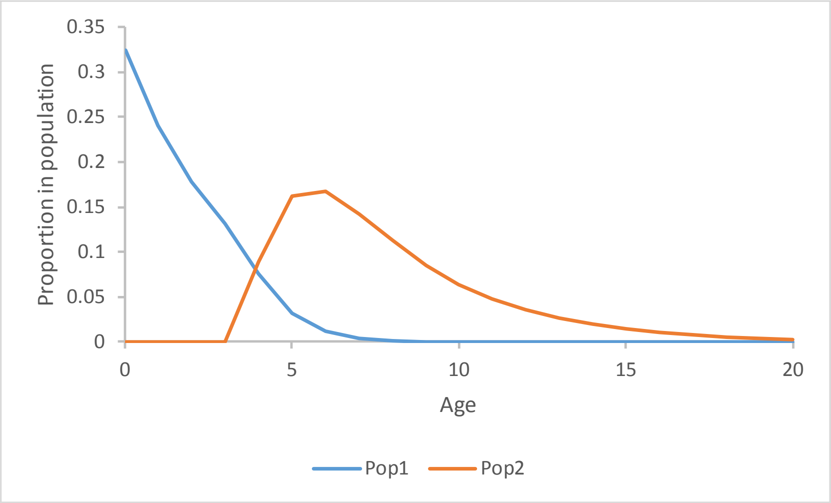
Simulation



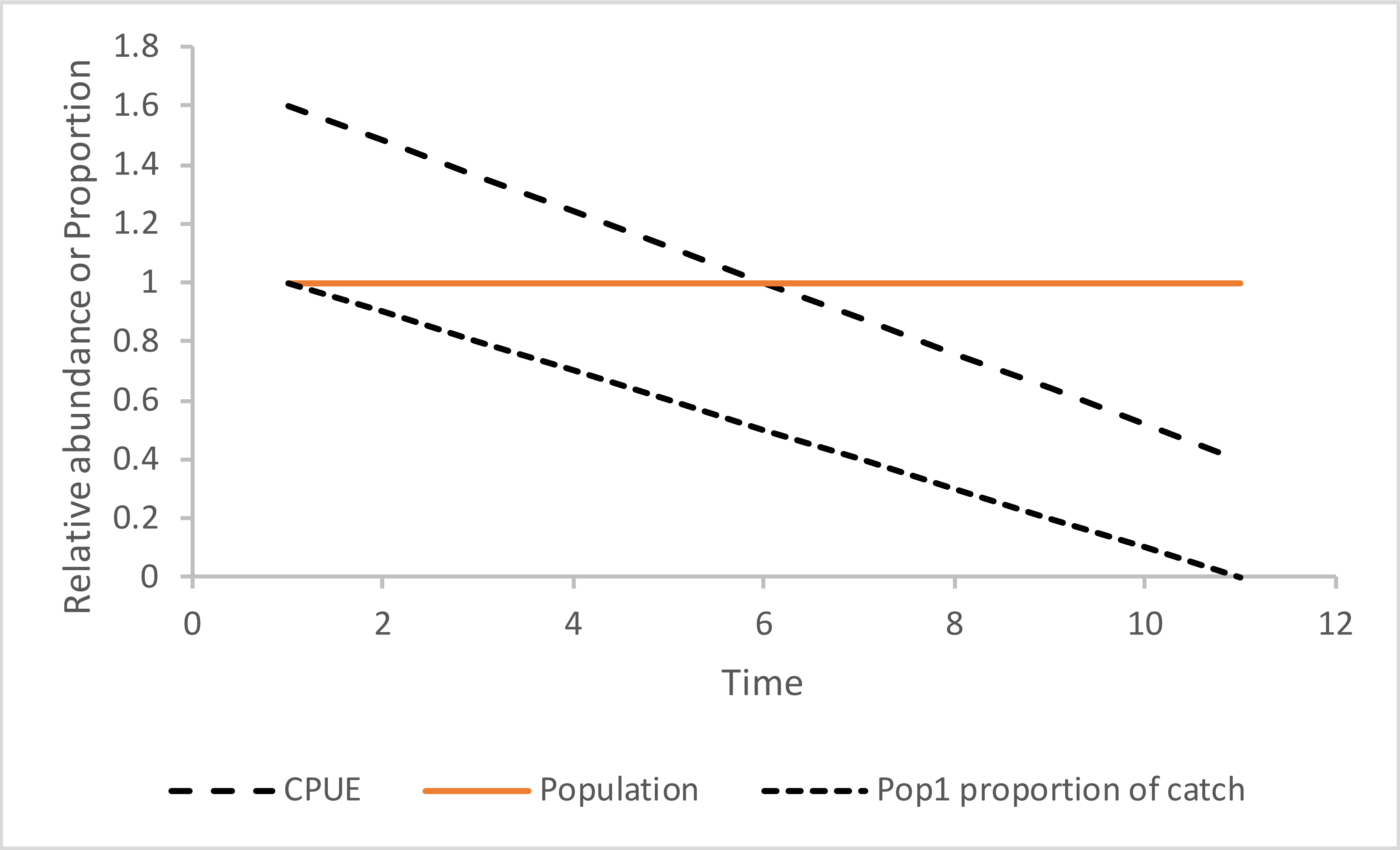
Two population model



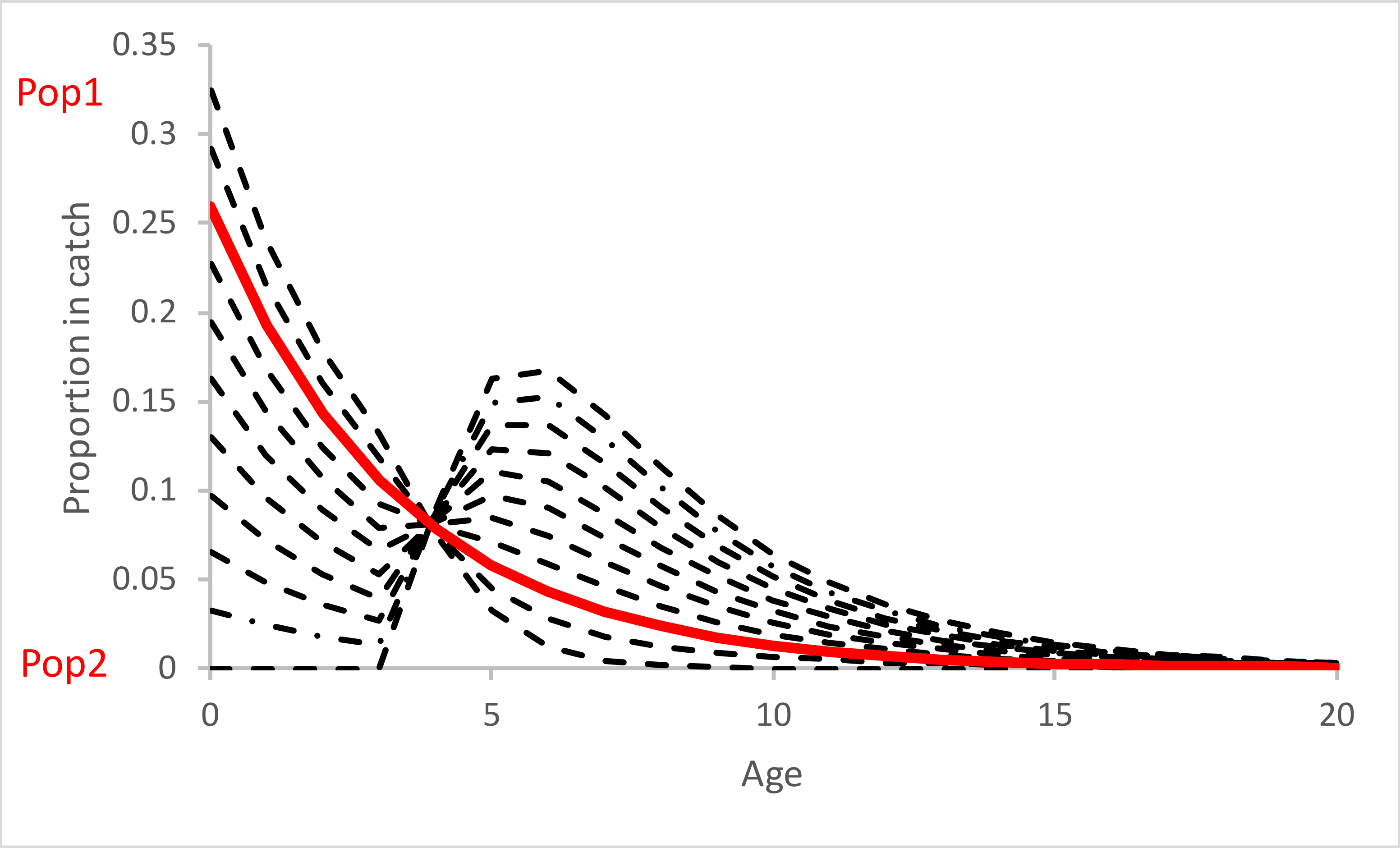




Abundance versus CPUE



Catch composition versus population composition



The concept

- Model a latitude x longitude x time interaction
- Predict the CPUE for each time and 1x1 square
- Sum the CPUE across 1x1 squares by time to create the index of relative abundance
- Add length

Suggested analysis

- Account for changes in the spatial distribution using a spatial-temporal model
- The parameters of the correlation function should be estimated separately for latitude and longitude (e.g., termed geometric anisotropy).
- Do not include season in the model.
- Use a zero-inflated model
- Sea surface temperature should be considered as a predictor of fish density
- Initial analyses should be based on sets with HPBs >= 16 HPB
- Do not include YFT and ALB catch rates and covariates
- Use one by one degree stratification
- Include length as a fourth dimension in the analysis is important.
- Data points should be the catch aggregated by year, 1x1 degree square, and 1 cm length interval
- To simplify the model, initial analyses should use a single likelihood could be used to fit the catch by strata and each strata-length bin given the same weight (variance).
- Further research should be directed at separating the catch and composition components of the likelihood
- The catch-at-size data for use in the stock assessment model should be calculated simultaneously in the analysis.
- Consideration should be given to analyzing the Japanese and Taiwanese data simultaneously in the same model allowing for an “integrated” index of abundance to be developed.

Length composition issue

- Japanese longline length composition data, which is collected by port sampling, is not linked to a location.
- Attempts to link the length composition data to the logbooks, which contain location information, by date and port of landing are problematic.
- Training vessels may be an alternative source of length composition data, but their catches of Pacific bluefin tuna may be too small to be useful.
- Length composition data with location of capture is available for the Taiwanese longline fishery starting in 2010.
- Development of more creative methods might be needed to allow for modelling of the size composition of the data when creating the index of abundance.
- Other tuna stocks (e.g. albacore tuna in the north Pacific Ocean) show spatial differences by gender. Therefore, obtaining gender information in addition to length composition data should be considered.

Examples

- Kai, M., Thorson, J.T., Piner, K., and Maunder, M.N. 2017a. Predicting the spatio-temporal distributions of pelagic sharks in the western and central North Pacific. Fisheries Oceanography.
- Kai, M., Thorson, J. T., Piner, K. R. and Maunder, M. N. 2017. Spatio-temporal variation in size-structured populations using fishery data: an application to shortfin mako (*Isurus oxyrinchus*) in the Pacific Ocean. *Can. J. Fish Aquat. Sci.* doi:10.1139/cjfas-2016-0327

Fitting in the stock assessment model

- Joint likelihood for relative abundance by length and time
- Not available in SS
- Options
  - Separate index for each size
  - An overall index and composition data (more practical for length data)
- Catch data
  - Fit with flexible time varying selectivity

Proposed workshop

- CAPAM mini workshop
- La Jolla
- Feb 26 - March 2
- Two to three days will be designated to presentations and discussions
- Two days will be dedicated to applying the methods to one or more stocks.
- Format
  - Invited speakers (including one from outside fisheries)
  - Lots of time for discussion
  - Focus questions
- Topics
  - Statistic methodology (e.g. spatial correlation functions)
  - Practical implementation (e.g. algorithms and software)
  - Issues specific to CPUE analysis and stock assessment (e.g. length composition, targeting).
- Products
  - Workshop report