Standardising composition data for non-representative sampling and climate influences:

Application to WCPFC sharks and tuna

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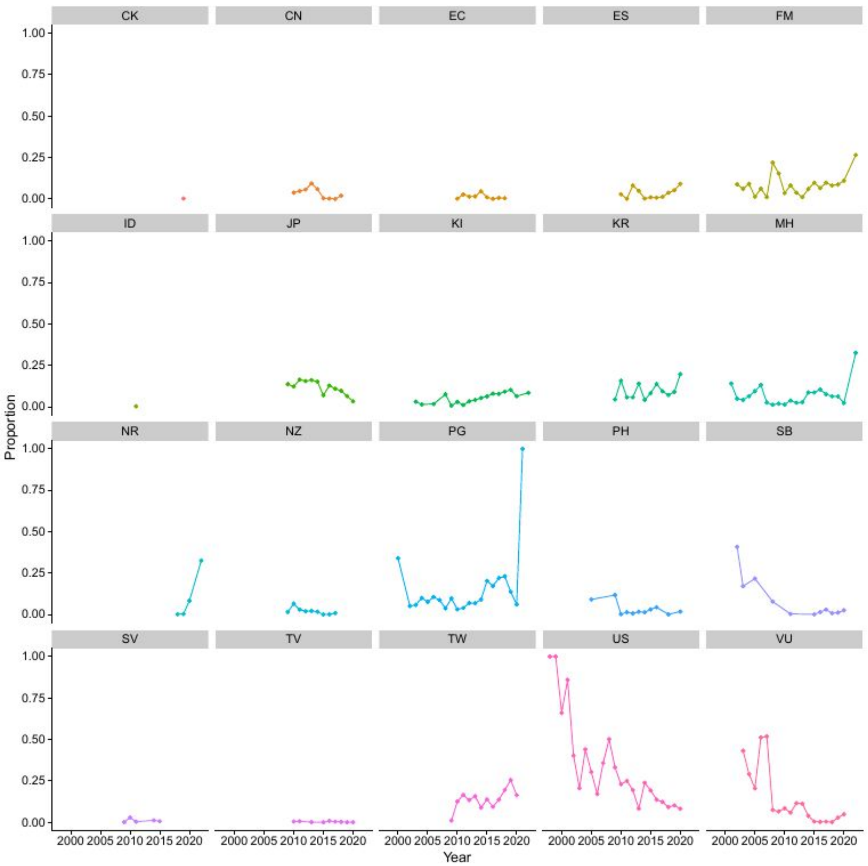
DRAGONFLY
Data Science

Motivation

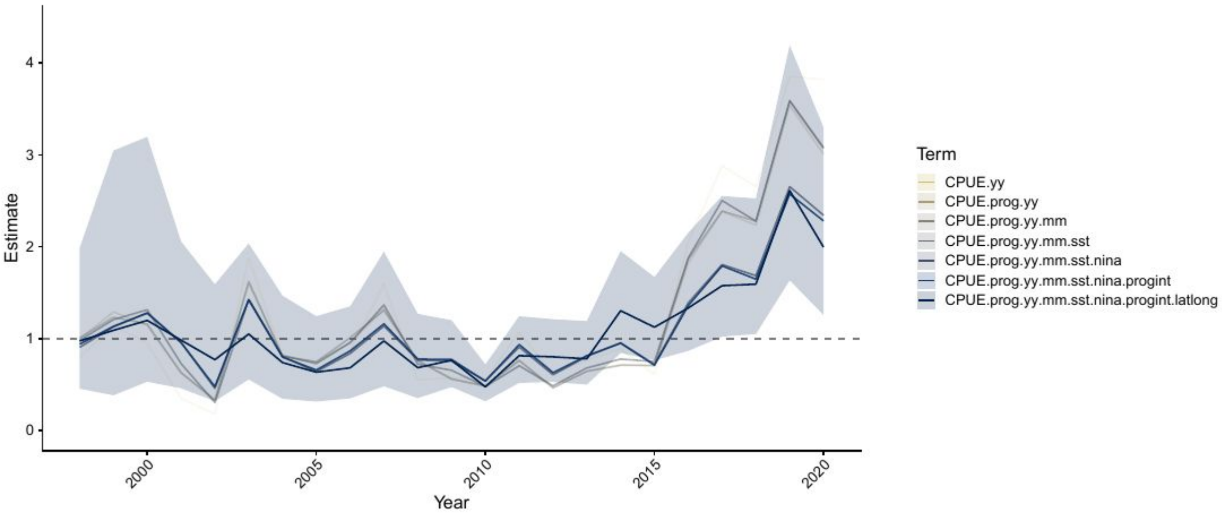
Using compositions (especially LFs) appropriately in stock assessments is hard:

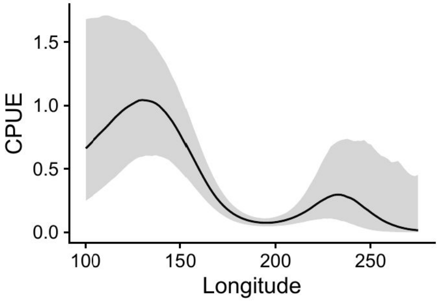
- Sampling often not representative, especially if not based on sampling design
- Ideally, compositions for the catch in models should reflect the removals of fisheries, including uncertainty
- Compositions for CPUE should reflect the composition of the relative abundance represented by the index

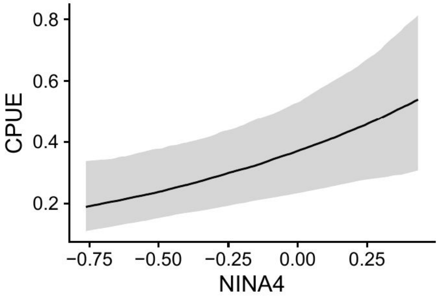


Motivation

- CPUE can "correct" for spatio-temporal influences, such as El-Nino.
- Need to do the same to LFs that reflect this index







Standardising length compositions

Multinomial decomposition provides a convenient way to standardise LFs using full compositional data:

Multinomial can be factorised into two independent poisson distributions:

i. Poisson over total samples N

ii. Poisson(λ_i) for each draw n_i in bin i - with $\pi_i = \lambda_i / sum(\boldsymbol{\lambda})$ - i.e., knowing N, we can formulate the poisson regression to give estimates for π_i

iii. Allows extension to over-dispersed models (i.e., integrating over random effects - e.g., sites within regions, sets within trips etc) - gives a negative binomial distribution for n_i given N

iv. Brings additional flexibility to models: smoothness can be forced by replacing length bins with smoothers (spline over length bins, e.g., if rounding is an issue), or modelling over-dispersion by length bin etc.

v. Can be implemented in standard modeling software (e.g., brms) as a glmm

Standardising length compositions

Multinomial decomposition provides a convenient way to standardise LFs using full compositional data

Standardising composition data can compensate for known influences on LFs

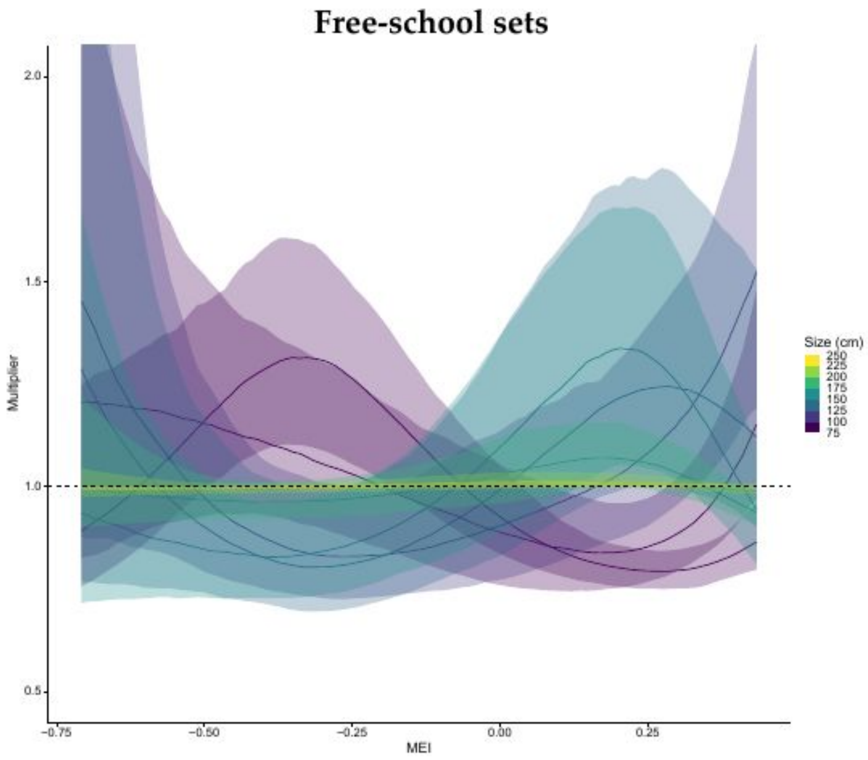
- Standardisation can mirror CPUE (for index LFs) to remove confounding variation
- Model can be used to scale LFs to total catch (don't remove variation, but use to scale LFs given catch by fleet)

Implemented as R package (ComPoM - composition standardisation using poisson-factorised multinomial GLMMs, still in beta); publication in prep. with Darcy Weber (CCSBT, NZRL)

Full Bayesian implementation using BRMS under the hood. Current trials with TMB backend too (D. Weber).

Example: Silky shark

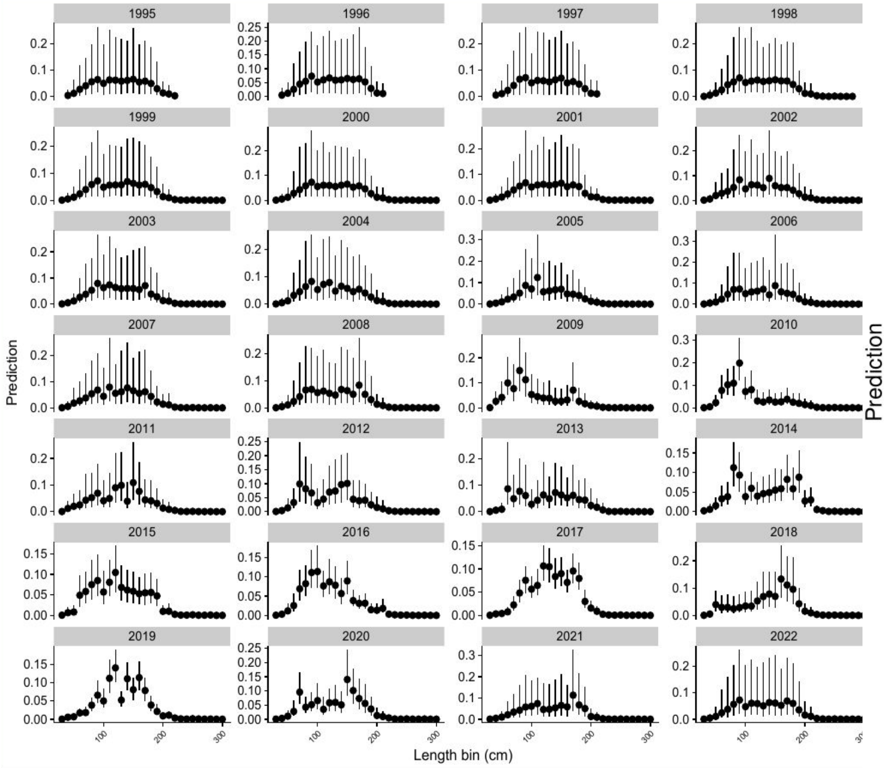
- Standardising CPUE to remove spatio-temporal influences on Silky shark availability in purse seine
    - Corresponding model for LFs
    - Clear effect of ENSO (MEI-V2 index)
- Scaling model for capture fleet LFs, scaling flag-year effects by catch



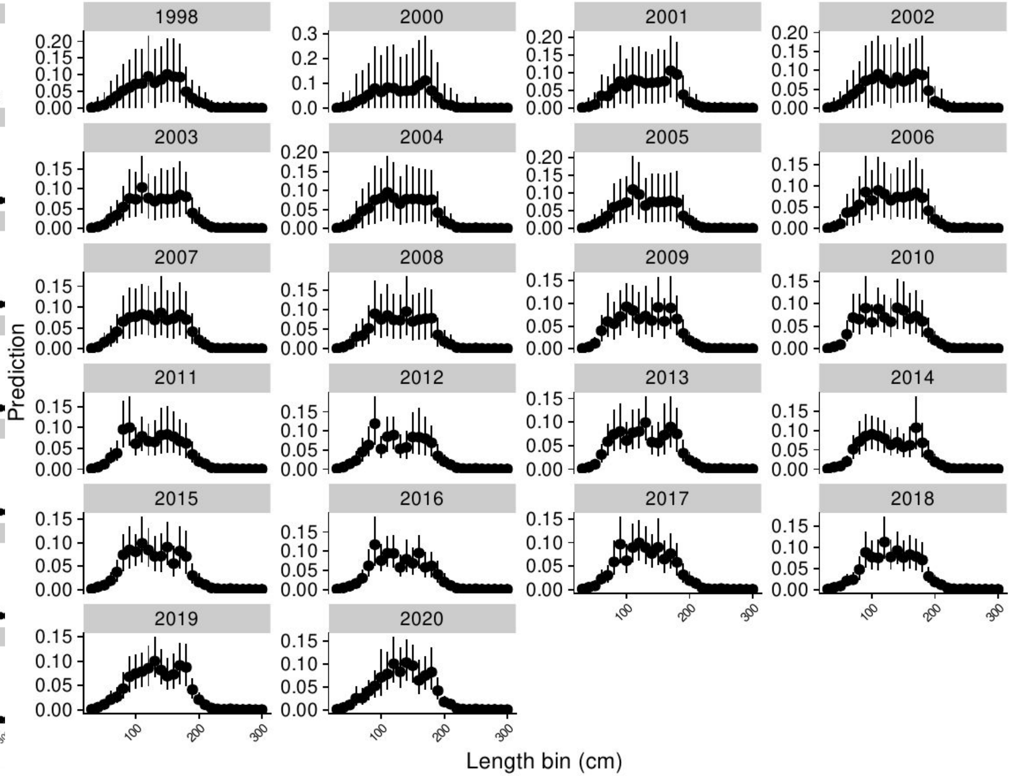
Silky shark: Scaled LFs

Purse-seine: Free-school

Catch LFs

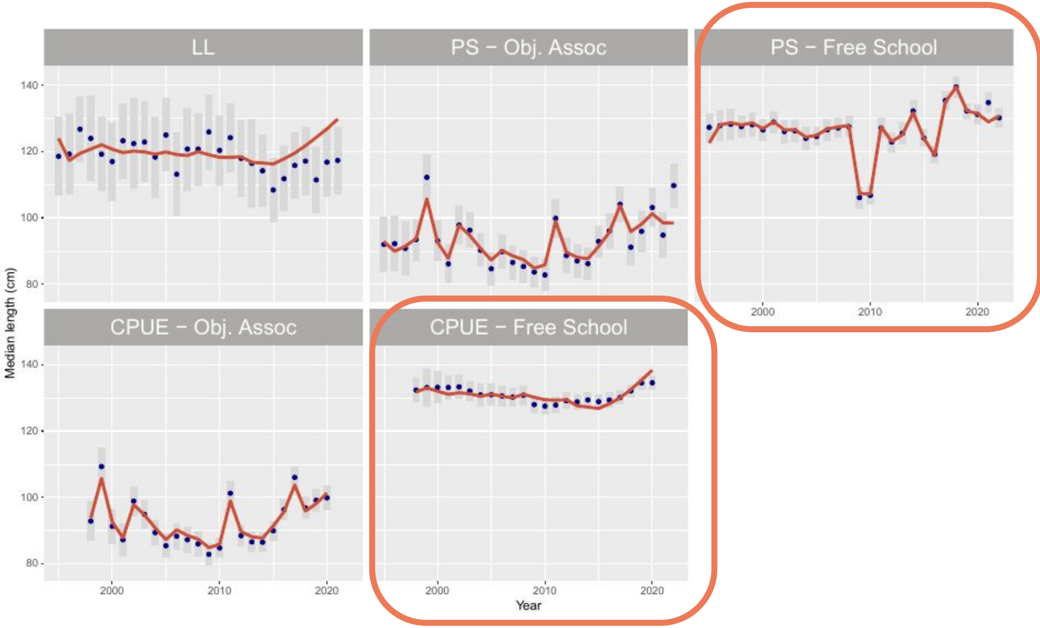


CPUE LFs



Silky shark: Impact on assessment

- Uncertainty is scaled using the trace of the posterior composition covariance matrix
- Smoother trends in CPUE after standardisation: single selectivity for CPUE LFs in assessment
- Highly variable LFs by year after predicting captures by the full fleet



Example: ALB in NZ troll

Correcting for oceanographically mediated availability of juvenile ALB in NZ waters (compositions caused issues in previous assessment)

- Modeled impact of MEIV2 on compositions
- Nuisance effects for month, year, statistical area, Vessel ID
- All modeled as random effect deviations from a mean composition

```
log(n) ~ (1|bin) +
    s(bin, MEIV2) +
    (1|bin:month) +
    (1|bin:fishing-year) +
    (1|bin:fishing-year:month) +
    (1|bin:statistical-area) +
    (1|bin:vessel_id) +
    offset(log(N)))
```

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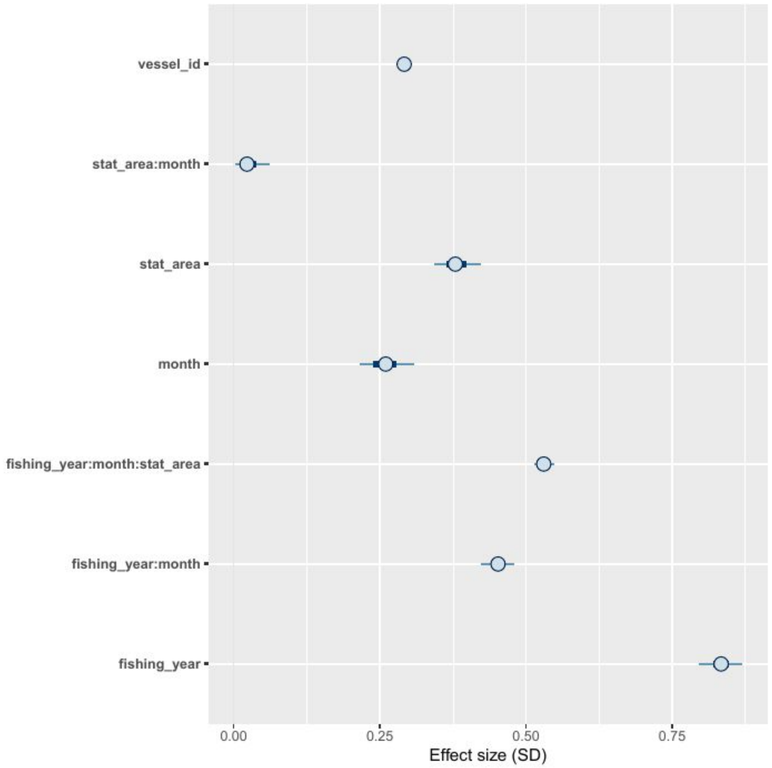
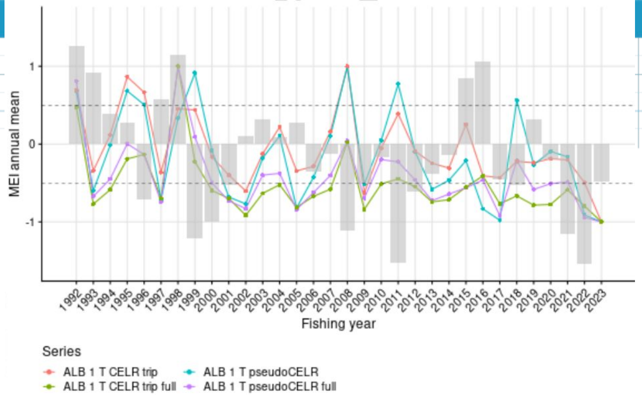
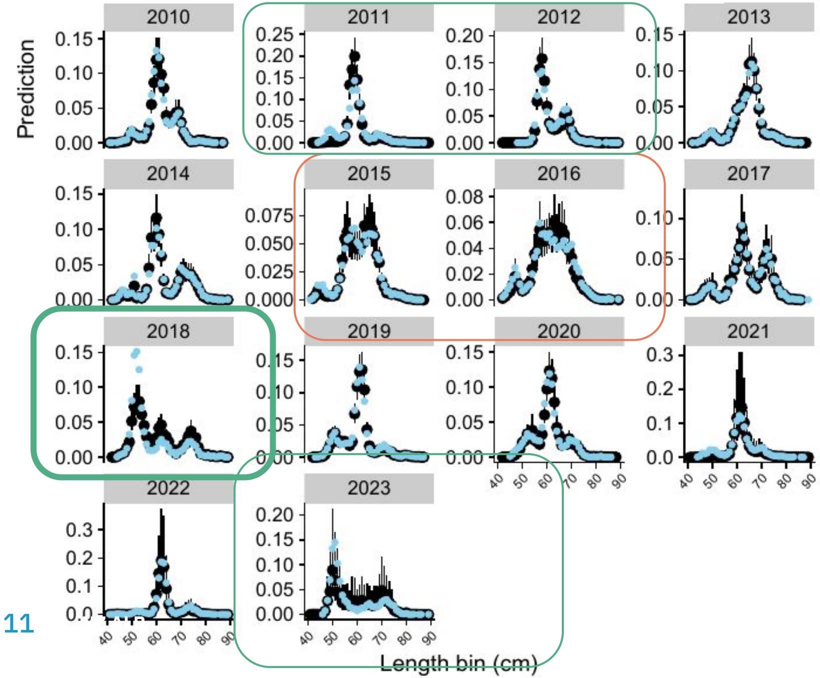
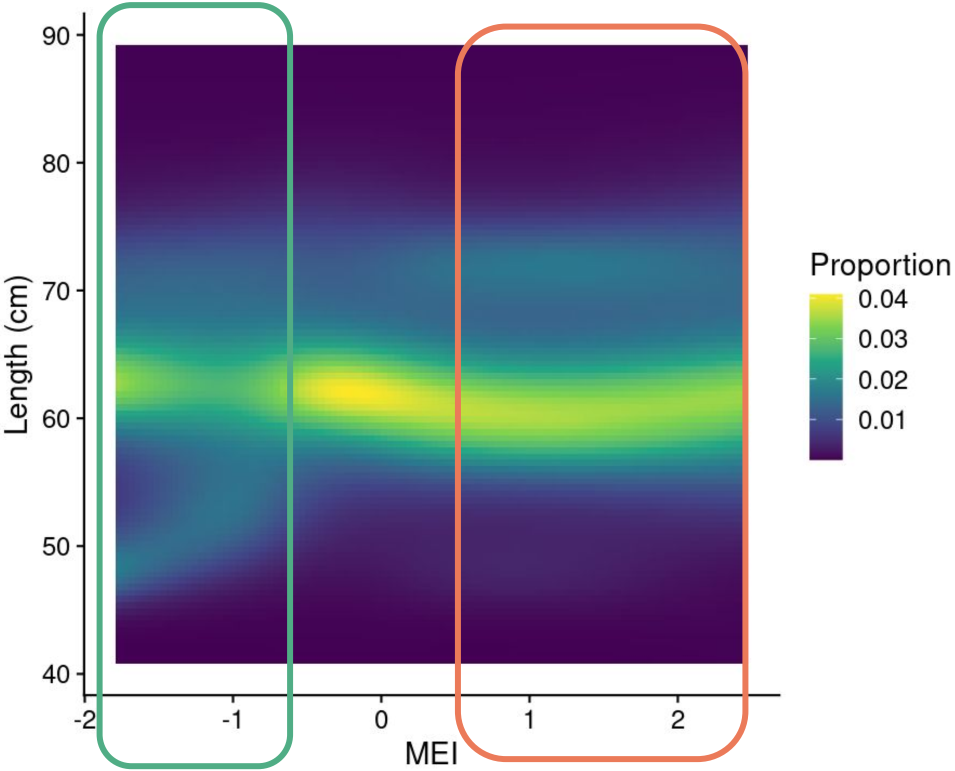



MEI annual mean
Fishing year
Series
ALB 1 T CELR trip
ALB 1 T CELR trip full
ALB 1 T pseudoCELR
ALB 1 T pseudoCELR full


Prediction
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Length bin (cm)


Length (cm)
MEI
Proportion

Recap

- Standardisation of compositions allows for more appropriate modeling of LFs in assessments
- Used (so far) in NZ shellfish stocks (Rock Lobster, abalone), WCPO sharks and NZ troll fishery for ALB
- Flexible modeling options for continuous (Lat/Long, ENSO; via 2D splines across effects and composition bins) and categorical effects (e.g., fleet, area)
- Most functionality (including model diagnostics, not shown) already implemented in ComPoM)

Thank you for your attention