

Management strategy evaluation for the Indian Ocean tuna fishery : development of operating model

IOTC Working Party on Methods
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JRC, Ispra, Italy

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Progress

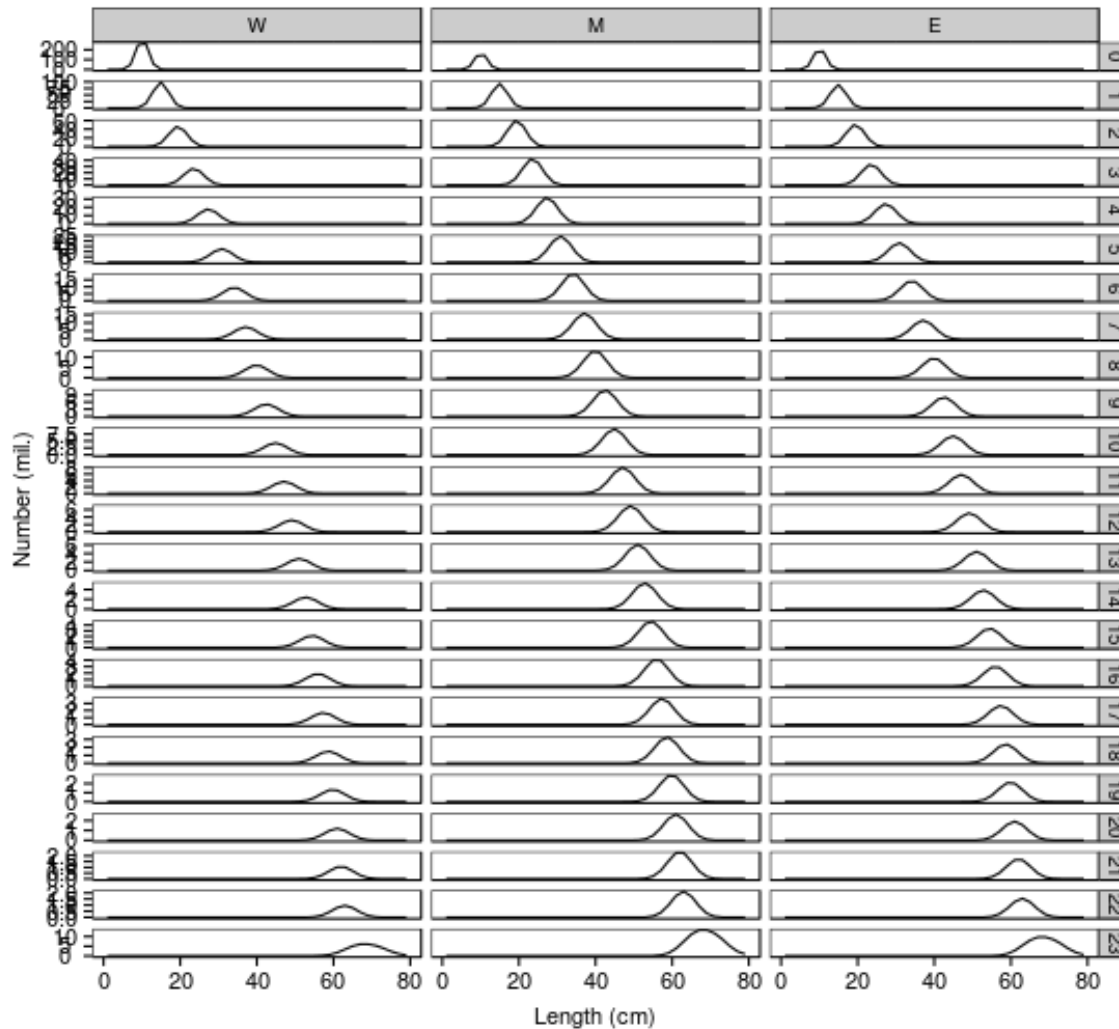
- Initial model development presented to WPM in October 2013
- Further development:
 - Refinements to model dynamics (C++)
 - Incorporation of data for conditioning (R/C++)
 - Presentation of conditioning fits (R)
- Code repository moved to:
 - <https://github.com/iotcwpm/SKJ>
- Issue tracking and to do list:
 - <https://github.com/iotcwpm/SKJ/issues>
- Documentation published at:
 - Text and equations: <http://iotcwpm.github.io/SKJ/>
 - Doxygen:
<http://iotcwpm.github.io/SKJ/doxygen/html/index.html>

Model dimensions

- Quarterly **time step**:
 - 1950-2013 (conditioning model to observed data)
 - 2014-2038 (evaluating alternative harvest control rules)
- Three **regions**:
 - Western
 - Maldives
 - Eastern
- Five **methods**: Purse seine (PS), Pole and line (PL), Gillnet (GN), Line (LI), Other (OT)
- Twenty four quarterly **ages**: 0-23
- Forty 2cm **size bins**: 0-2, 2-4, ..., 78-80cm

Population structure

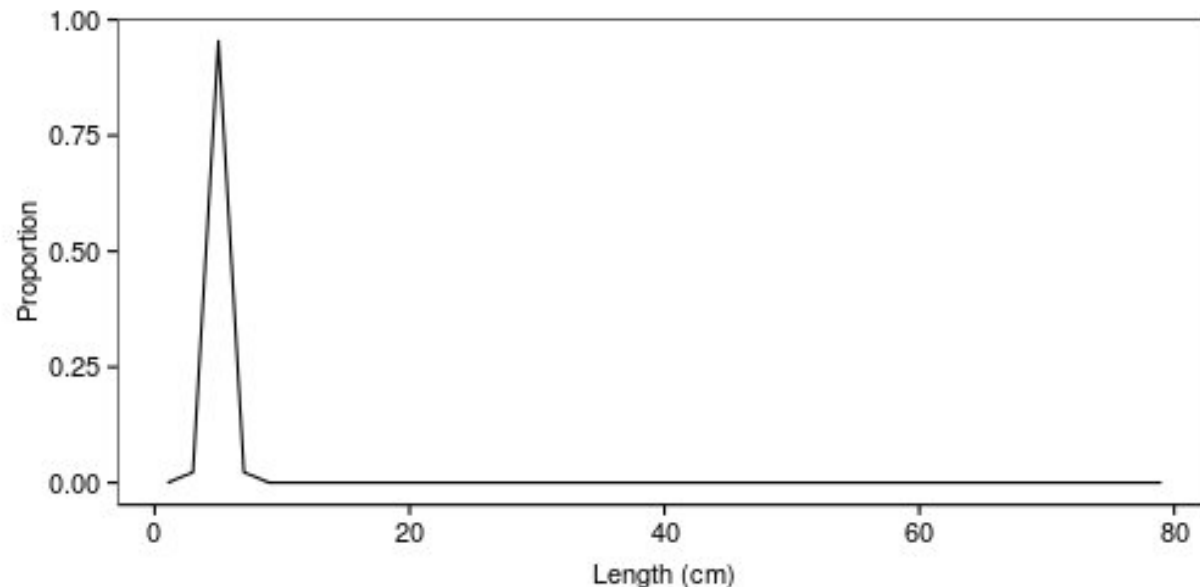
- Numbers by **region**, **age**, **size**
- Accounting for numbers-by-size (i.e. age x size matrix in each region): allows proper **modelling of size-based selectivity**; may provide advantages in simulating tagging programs



Spawning and recruitment

- Seasonal spawning fraction:
 - Priors based on Grande (2013)
- Stock-recruitment relationship: Beverton-Holt based on pooled, total spawning biomass
- Recruits distributed proportionally to each region and over sizes,

$$R_{r,s} = \bar{R} \cdot \chi_r \cdot A_s$$



Growth

- Von Bertalanffy growth
- Variability in increments: **constant s.d. + c.v. on increment**
- Converted to a quarterly size transition matrix
- Priors based on Hillary (2011) based on tagging data

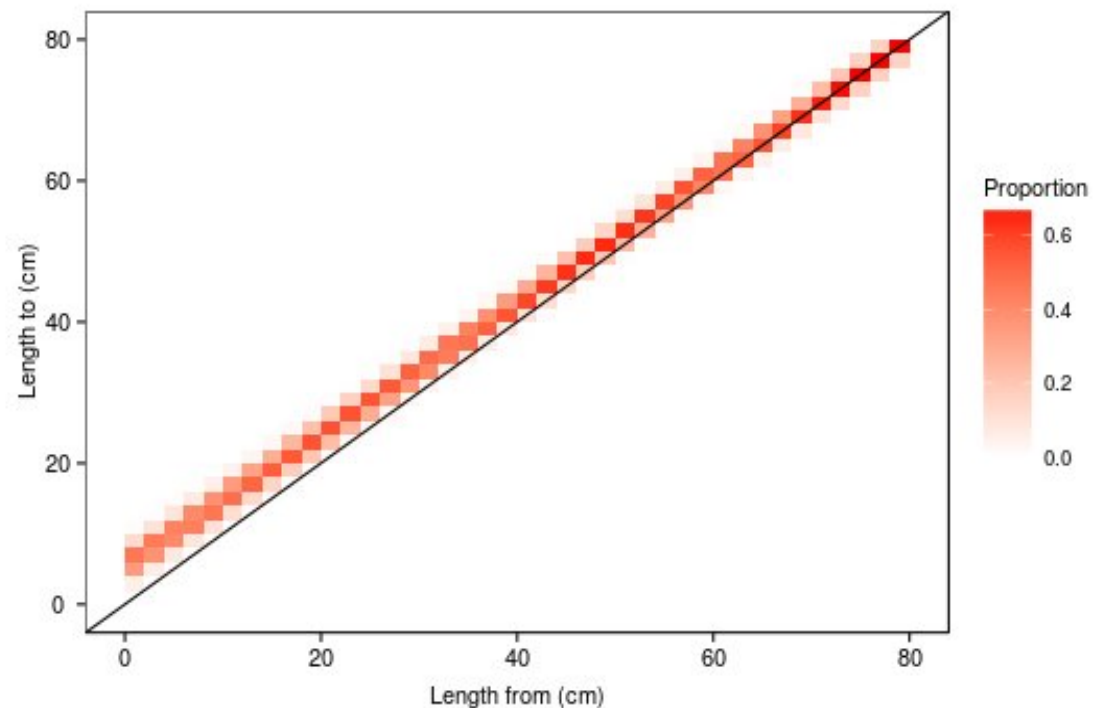
$$I_s = (\lambda - L_s) \left(1 - e^{-0.25\kappa} \right)$$

normal distribution with a constant standard deviation
 of the growth increment for a fish of size s is then

$$J_s = \sqrt{\epsilon^2 + (\phi I_s)^2}$$

size \dot{s} to size s in one quarter is thus,

$$G_{\dot{s},s} = \int_{l=2s}^{l=2(s+1)} \frac{1}{\sqrt{2\pi} J_{\dot{s}}} \frac{e^{-\left(L_{\dot{s}}+I_{\dot{s}}-l\right)^2}}{2(J_{\dot{s}})^2}$$

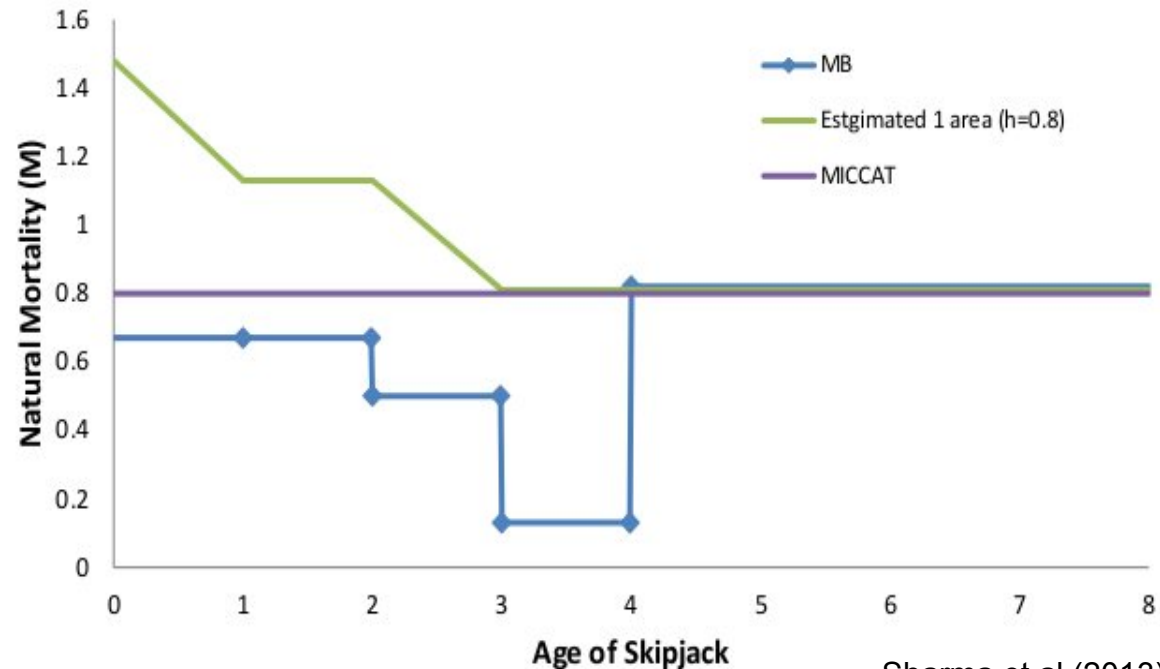
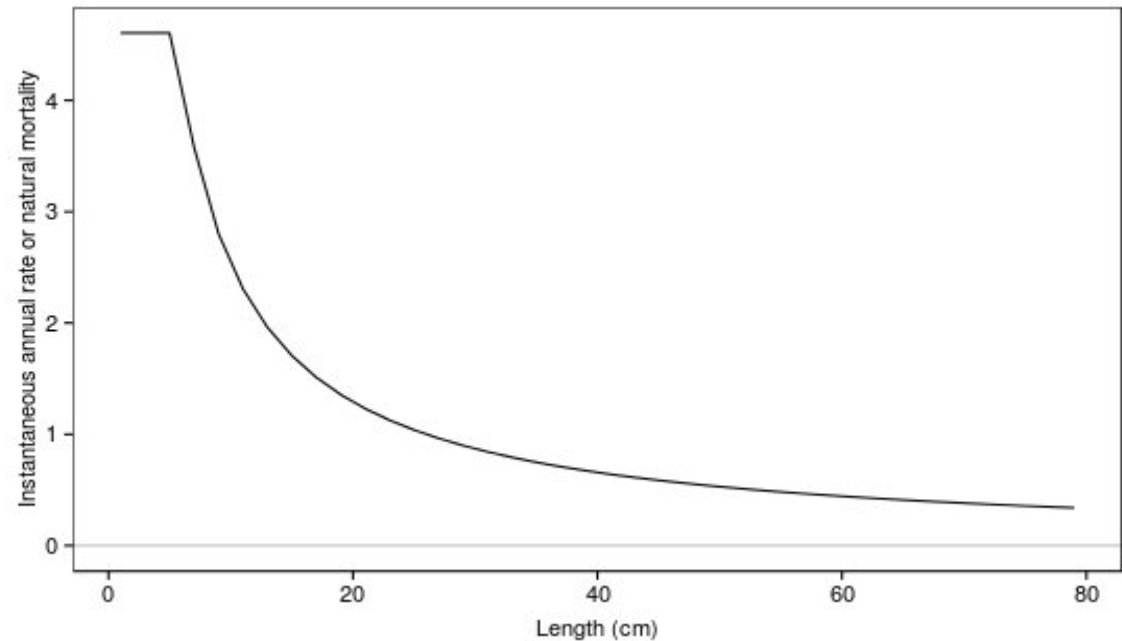


Mortality

- On suggestion of WPTT use Lorenzen function:

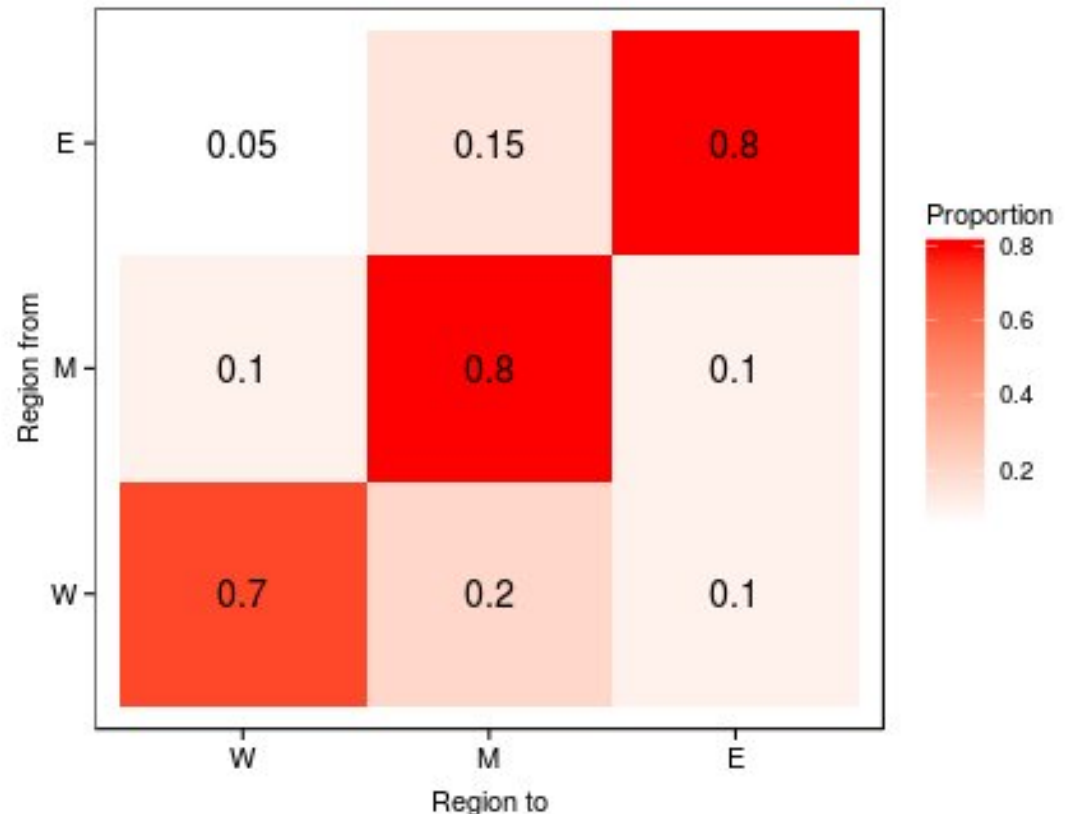
$$M_s = \nu W_s^\gamma$$

- ν (M at 1kg) = 0.7
- γ (exponent) = -0.29 = estimated by Lorenzen
- Modified so there is a maximum M

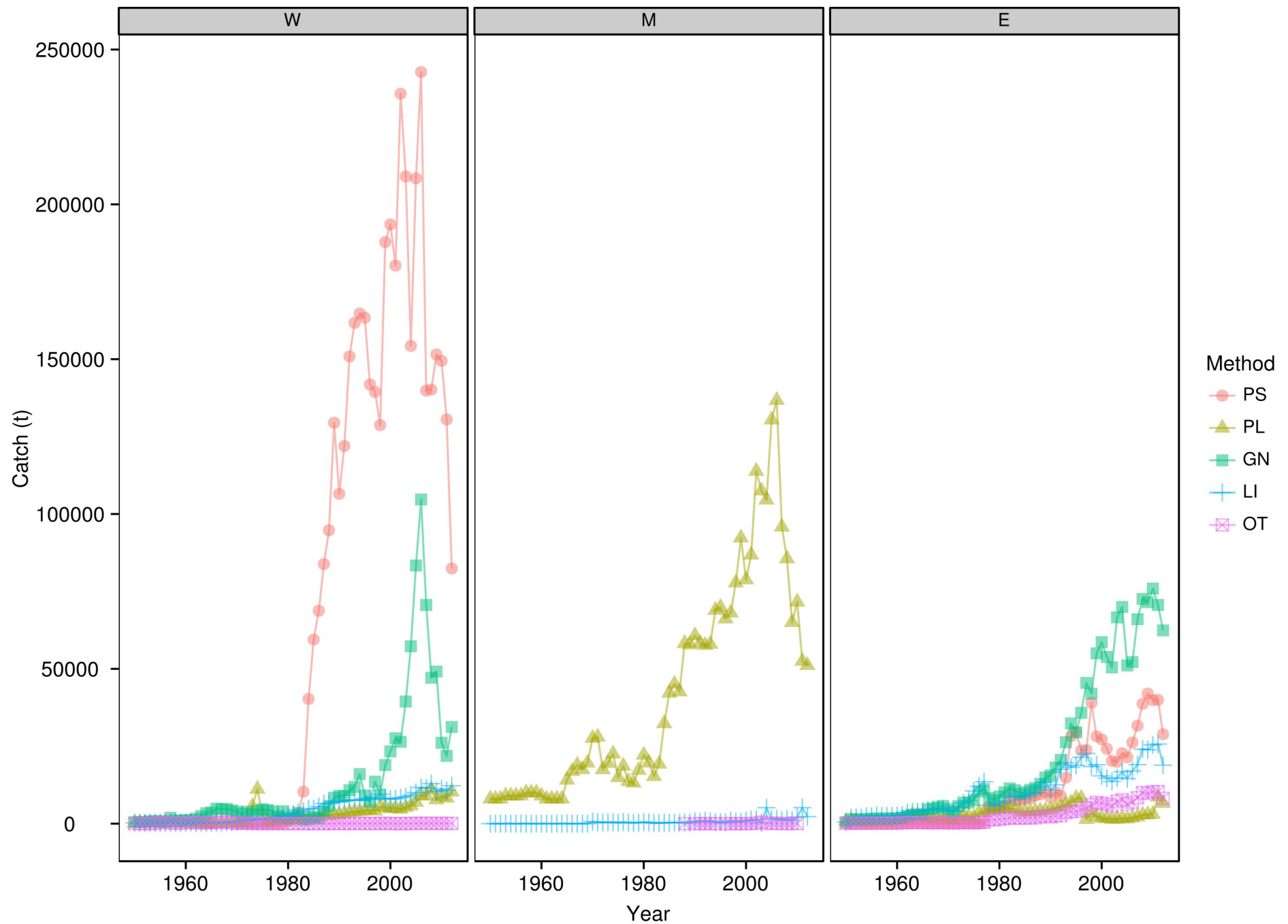


Movement

- Currently, movement between regions is **uniform across ages and sizes and quarters**
- Parameters represent **proportion of fish moving in a quarter**
- Unlikely to be information in data used in conditioning
- Move to different selectivity by size and/or quarter?
- Use of tagging data to define priors?

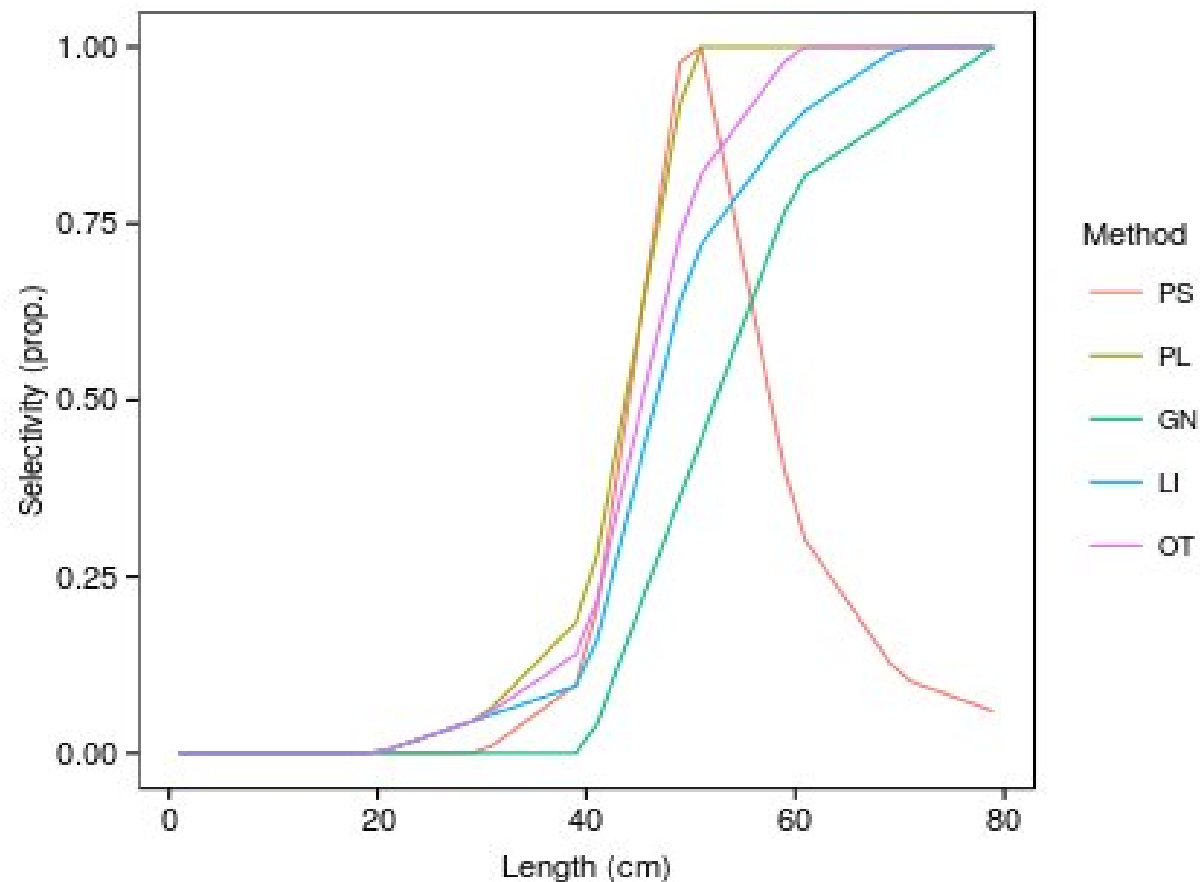


Catches : by region and method



Selectivity

- Piecewise spline for each **method**
- Currently no difference among regions
- May allow for some, perhaps penalised, differences in selectivity if fits suggest it is needed



Model conditioning

- Condition the model based on likelihood of fits to:
 - **Maldives** standardised **quarterly pole and line CPUE** 2004-2012 (Sharma et al 2014; IOTC-2014-WPTT16-XX)
 - **Western** standardised **annual purse seine CPUE** 1982-2011 (Soto et al 2013; IOTC-2013-WPTT15-32)
 - **Quarterly** size frequencies by **region and method** as available (see [data/size-frequencies.R](#) for processing of data provided by IOTC)
 - **Western** tagging-based Z estimates by **quarter** and **size group** 2005-2009 (Hillary & Everson in press)

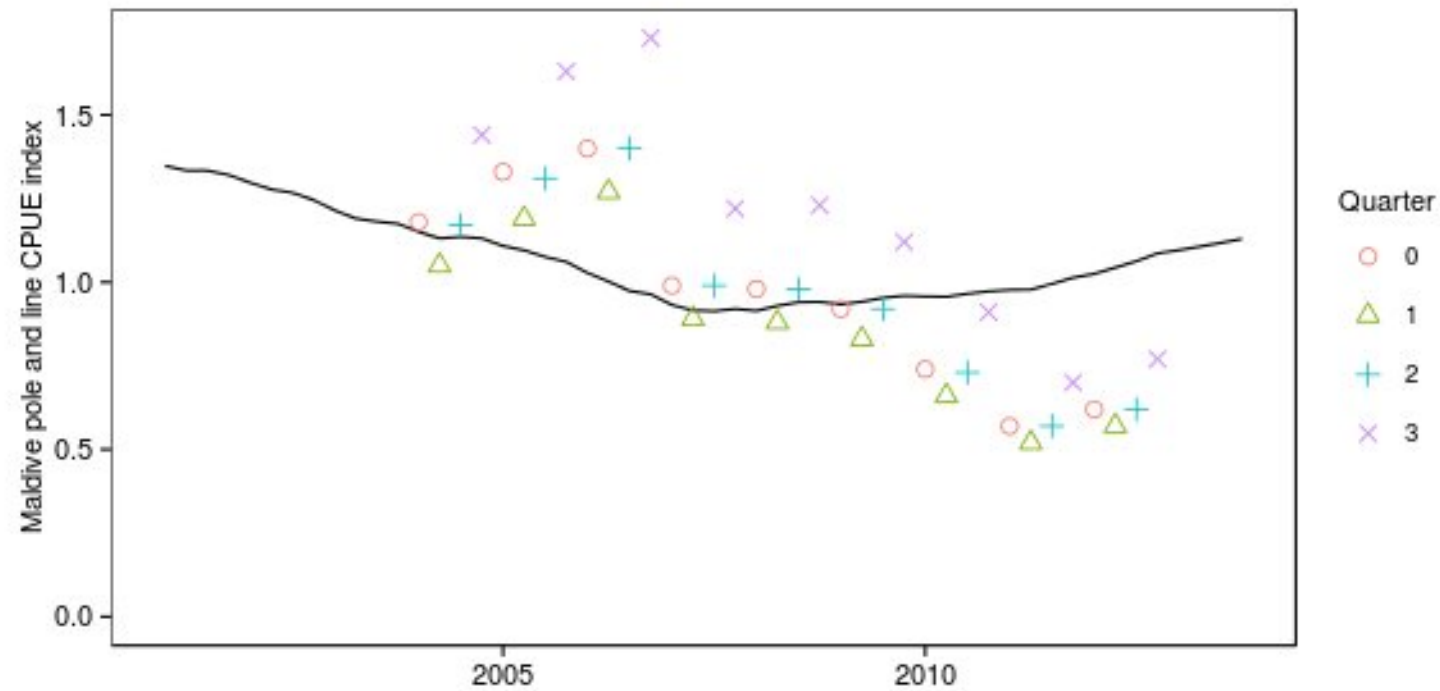
Model conditioning

- Plan to generate posterior distributions using a **population-MCMC algorithm** based on that of Ter Braak (2006):
 - Evolves posterior as a population of parameter sets - proposal distribution is self adapting
 - Appears to be a robust, efficient, easily parallel-izable means of generating posterior
 - Implemented but not yet hooked onto model – this week?
- The following fits to data are **very very preliminary**:
 - Uses a parameter set read in from file [parameters.tsv](#) - based on means of priors with some tuning “by eye”
 - Deterministic recruitment (all recruitment deviation parameters = 0)
 - Meant for discussion of options/issues with fitting

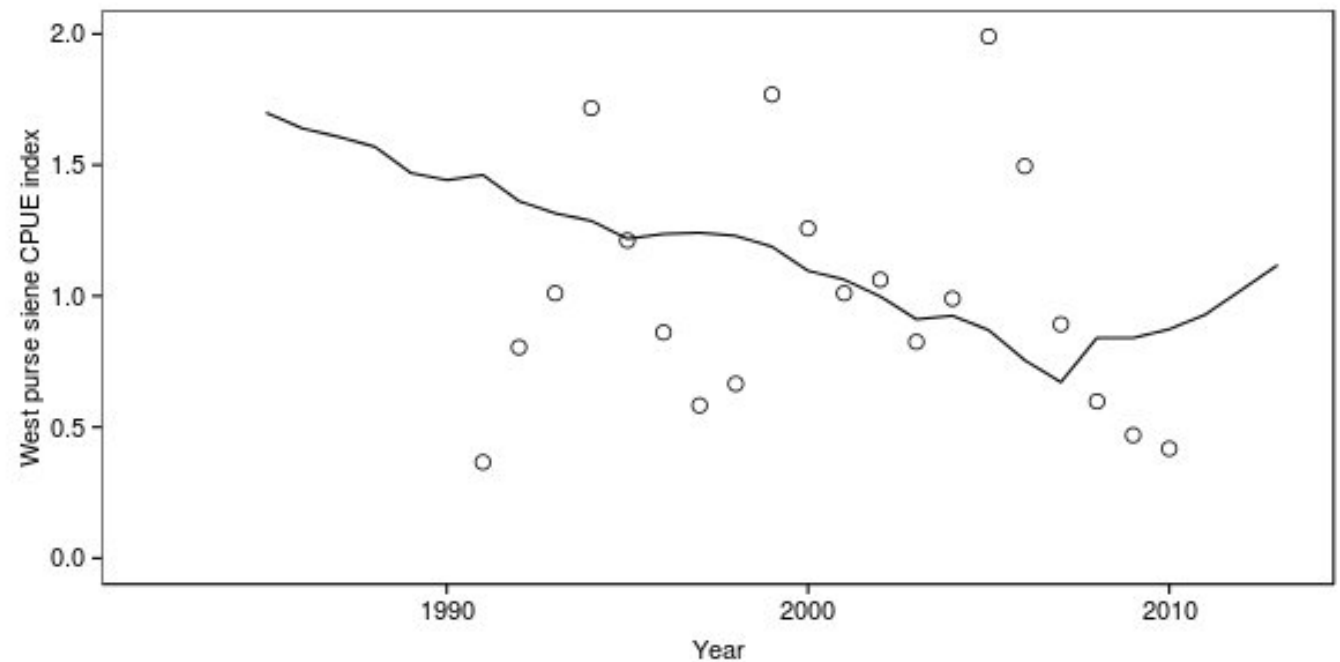
CPUE indices

Maldives PL CPUE

Need to estimate
relative q for
each quarter

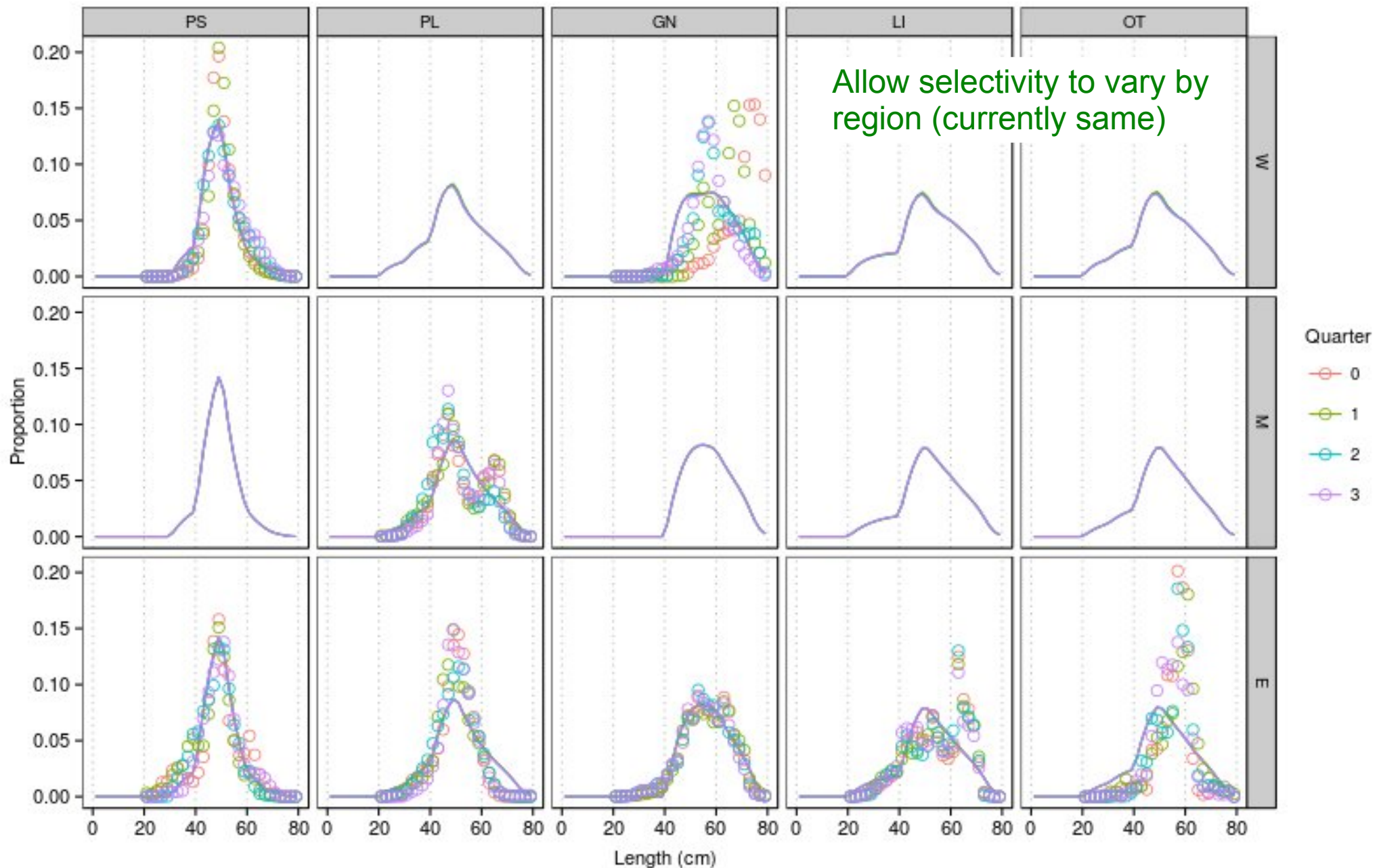


West PS CPUE



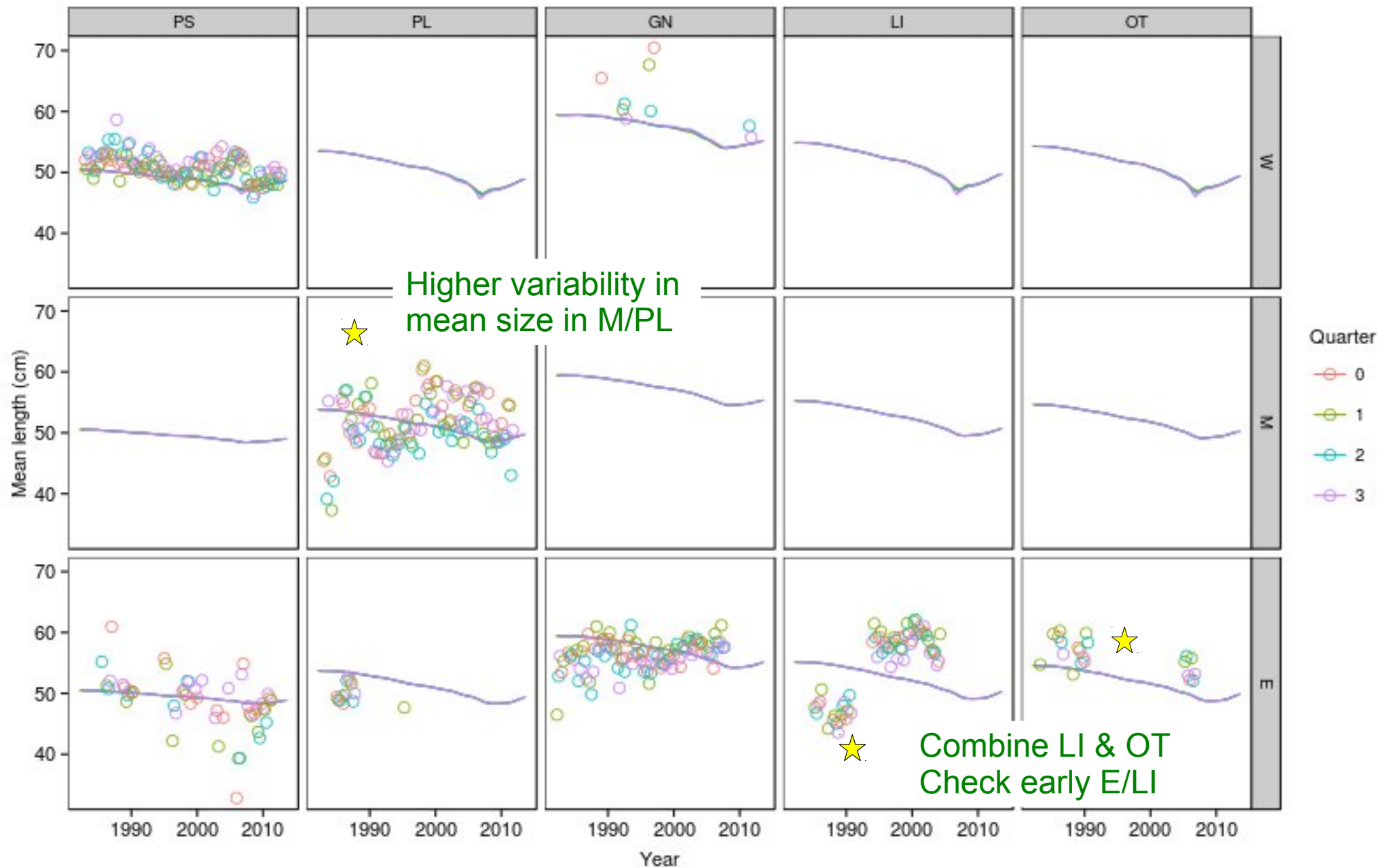
Size frequencies

Mean observed and expected proportions by **region**, **method**, **quarter** over years

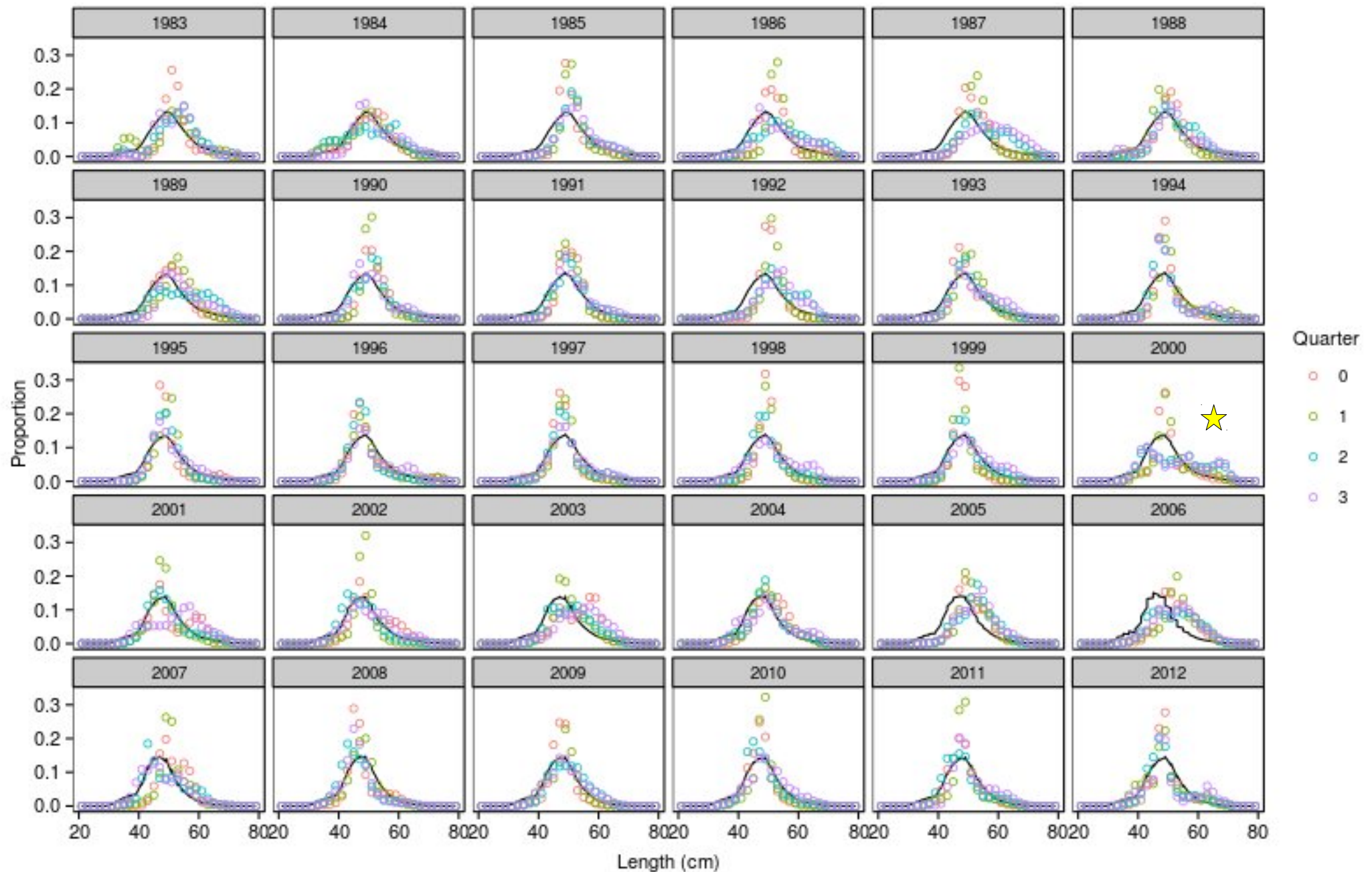


Mean lengths

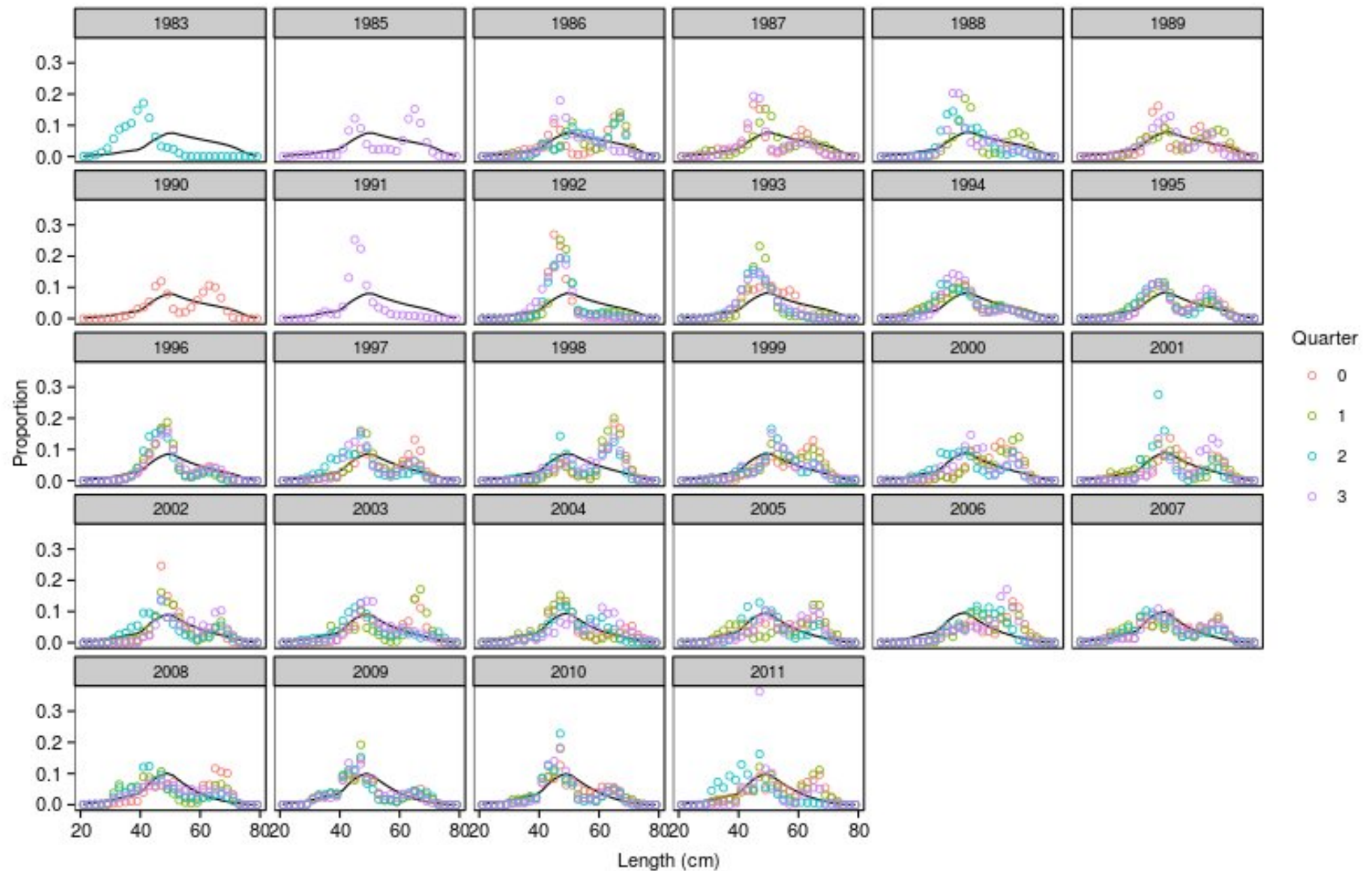
Observed and expected mean length by **region**, **method**, **year** and **quarter**



Size frequencies : W/PS

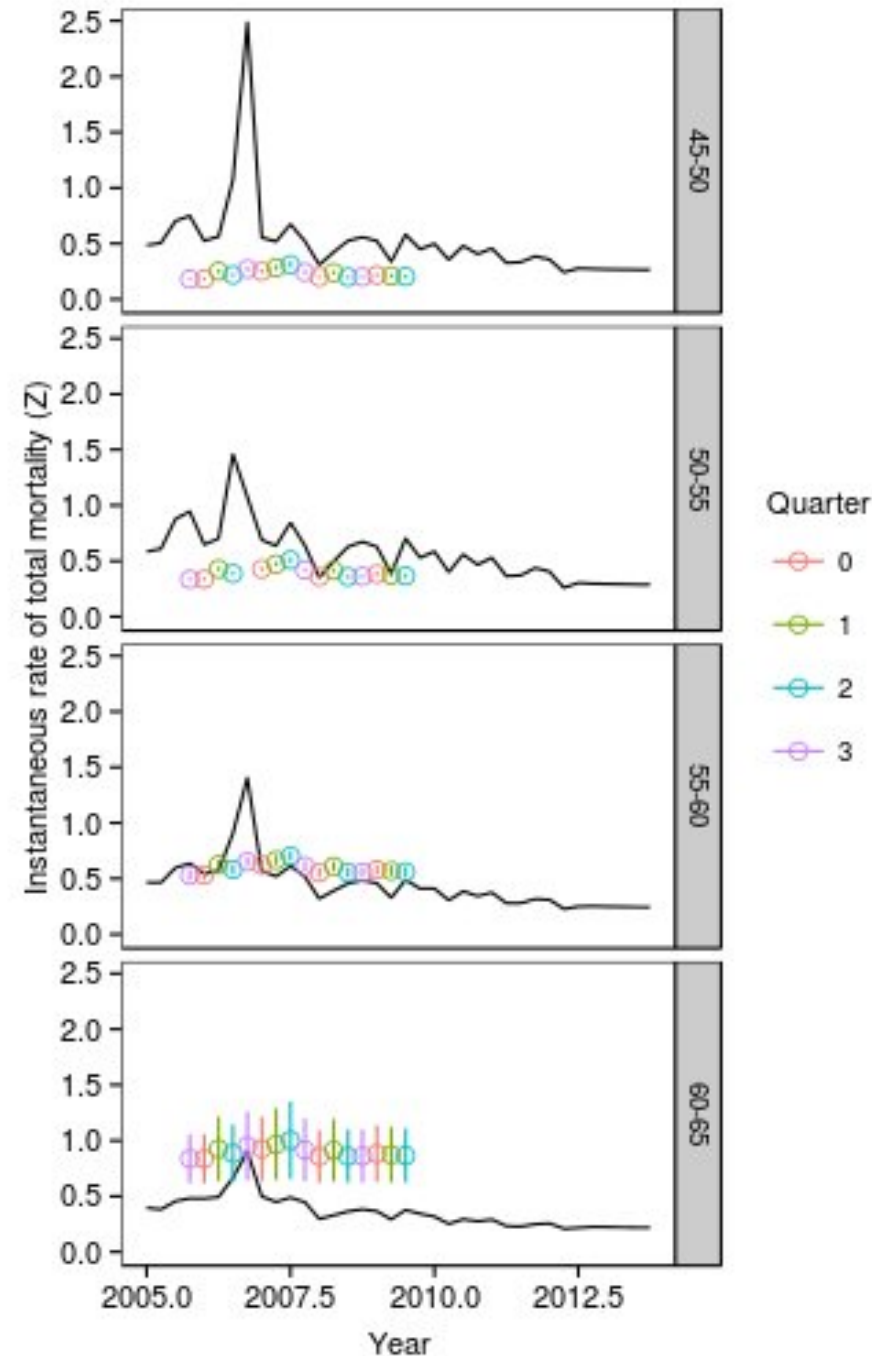


Size frequencies : M/PL



Z - estimates

- Fit to Z estimated from tagging for each quarter, for each of 4 size classes
- Expected Z generated for W only
- Differences in Z among size classes should help in estimating W/PS selectivity



Next steps

- April – June
 - Refinements to model dynamics and data as discussed here
 - Finalisation of model, data, priors and conditioning
 - Evaluation of simple harvest control rules
- July – September
 - Evaluation of simple management procedures – e.g. CPUE, mean length, tagging based
- October
 - meeting of project Advisory Committee
 - Changes as suggested by AC
- November and December
 - Meetings of WPTT and WPM