

Evaluation of the Effects of Uncertainty in Recreational Harvest Estimates on Fisheries Assessment and Management

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Survey

CPUE

Size / age comp

Life history

Growth

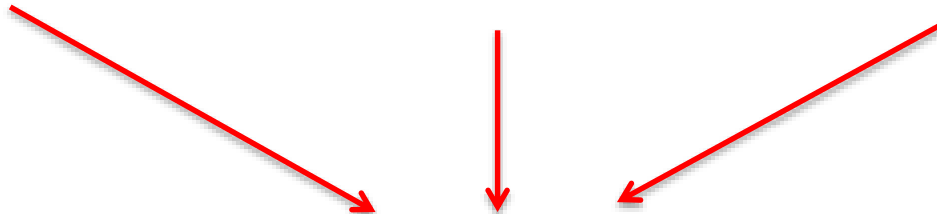
Mortality

Maturity

Fishery

Landings

Size / age comp



Stock assessment model

Production

Virtual population analysis (VPA)

Statistical catch at age (SCAA)



Population estimates

Management reference points

Catch limits

Objective

Understand the impacts of uncertainty in recreational fishery harvest estimates on the assessment and management of a population

Survey

CPUE

Size / age comp

Life history

Growth

Mortality

Maturity

Commercial Fishery

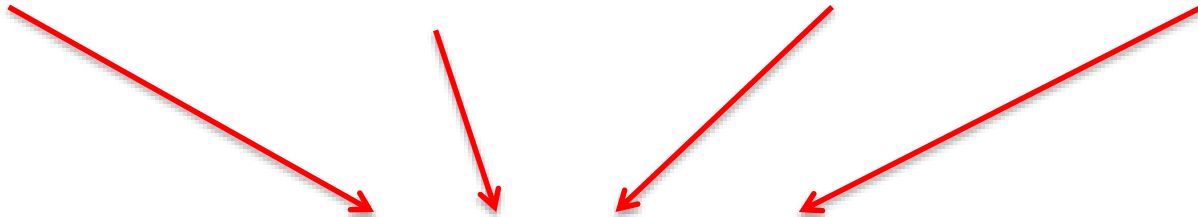
Landings

Size / age comp

Recreational Fishery

Landings

Size / age comp



Stock assessment model

Production

Virtual population analysis (VPA)

Statistical catch at age (SCAA)



Population estimates

Management reference points

Catch limits

Management Strategy Evaluation (MSE)

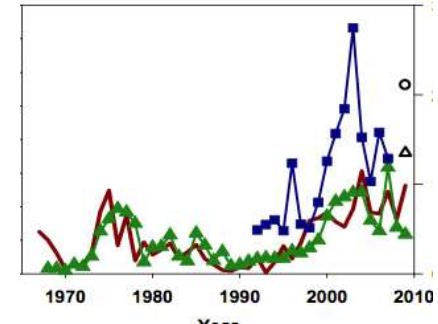
Population Dynamics



Management Process



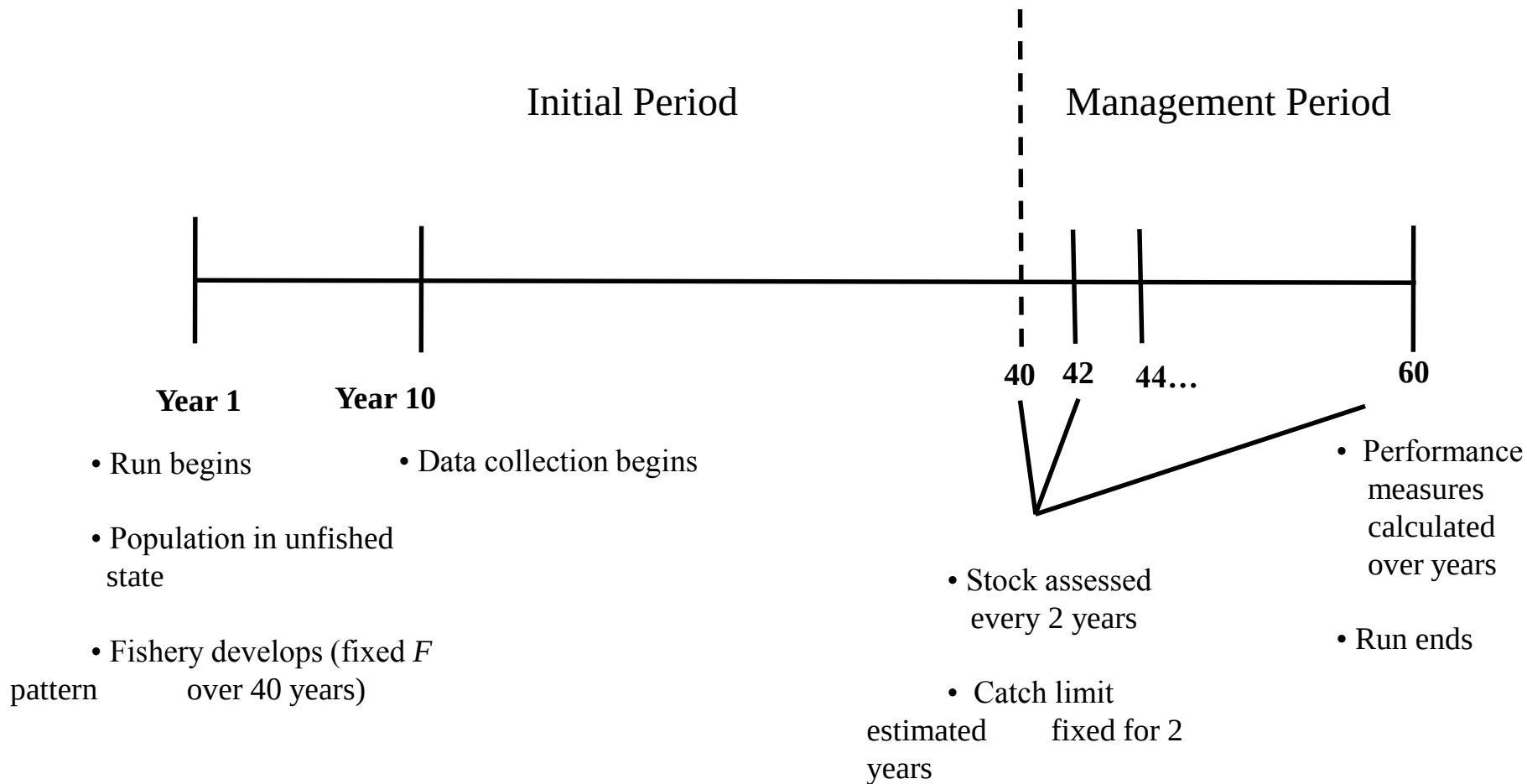
Generate Data



Stock Assessment



Evaluate Performance of Management Actions



Model Dynamics

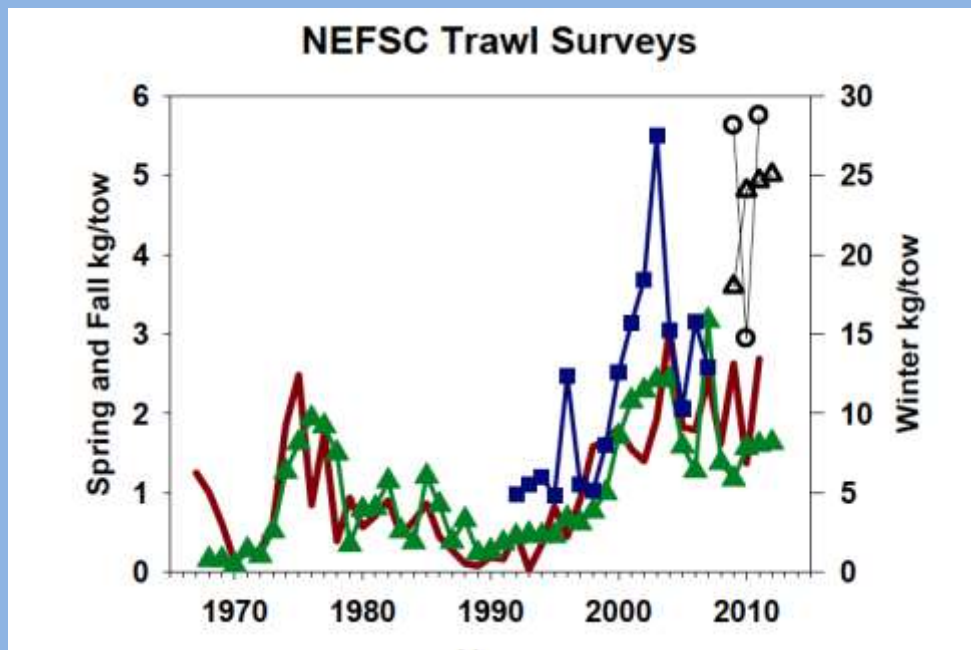
- Age-structured model
 - Variable recruitment (Beverton-Holt SR relationship)
 - Fixed M , steepness, selectivity (although both can vary), weight and maturity at age
 - 2 fisheries, 1 survey

Model Dynamics

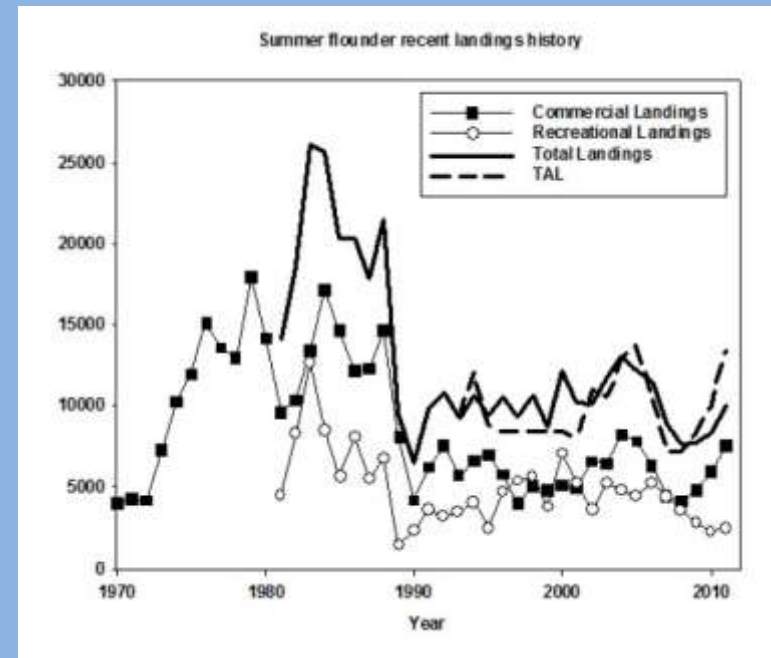
- Data generating model
 - “estimates” based on “true” values + some error
 - Annual estimates = true * lognormal error
 - PSE of recreational estimates varies (0.2 , 0.3, 0.4, 0.5, 0.6, 0.8, 1.0)
 - PSE of survey + commercial landings fixed (0.25 and 0.1, respectively)
 - Estimates at age = sample from multinomial
 - Sample size decreases with increasing PSE in recreational fishery
 - Samples fixed for survey + commercial fishery

Information in the Data

CPUE: Trend



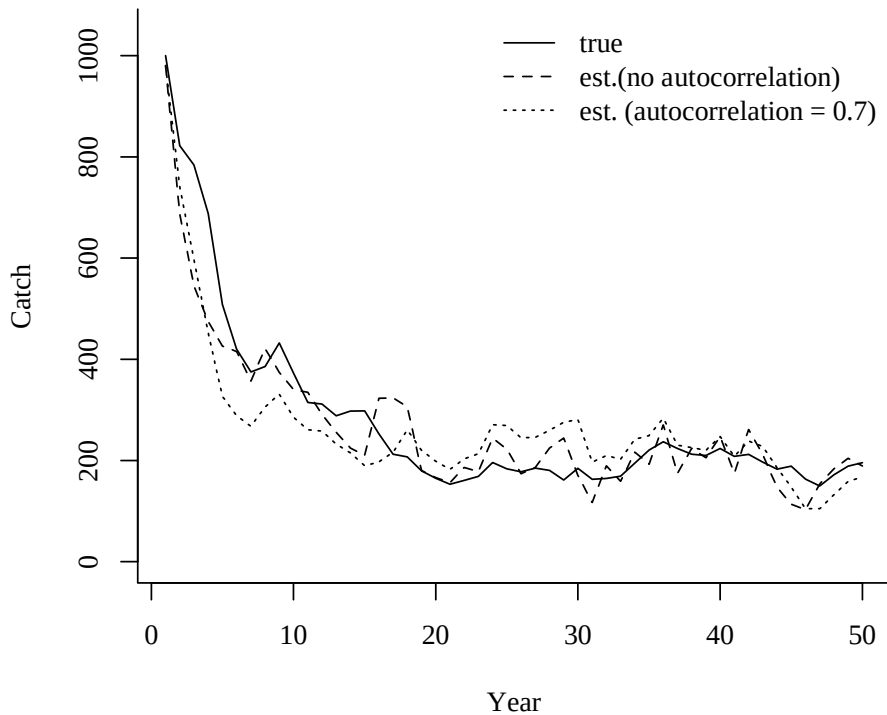
Catch: Scale



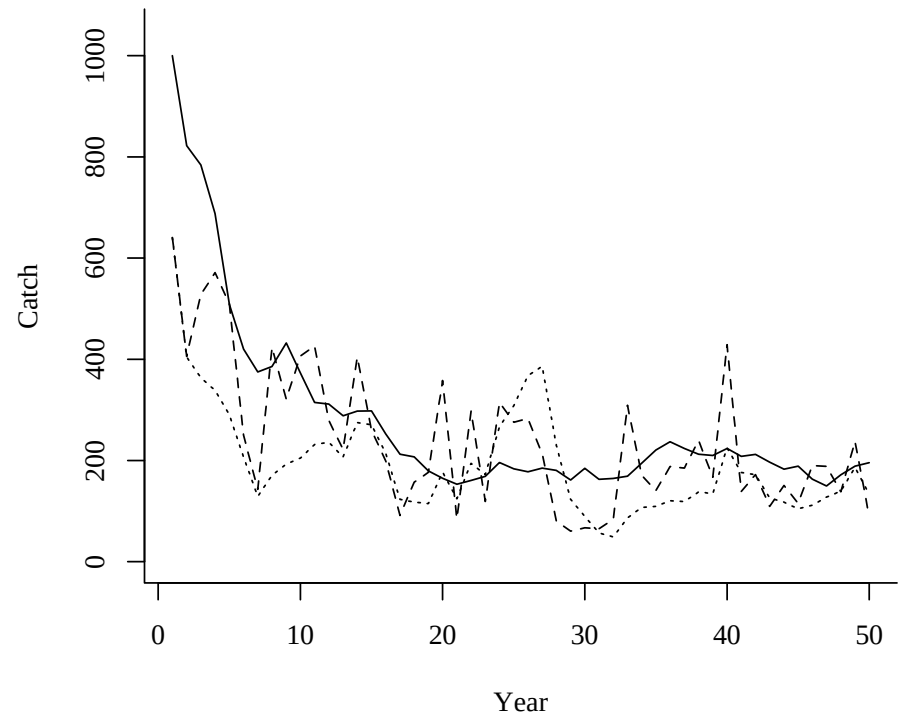
Terceiro 2012

Generating Catch Estimates

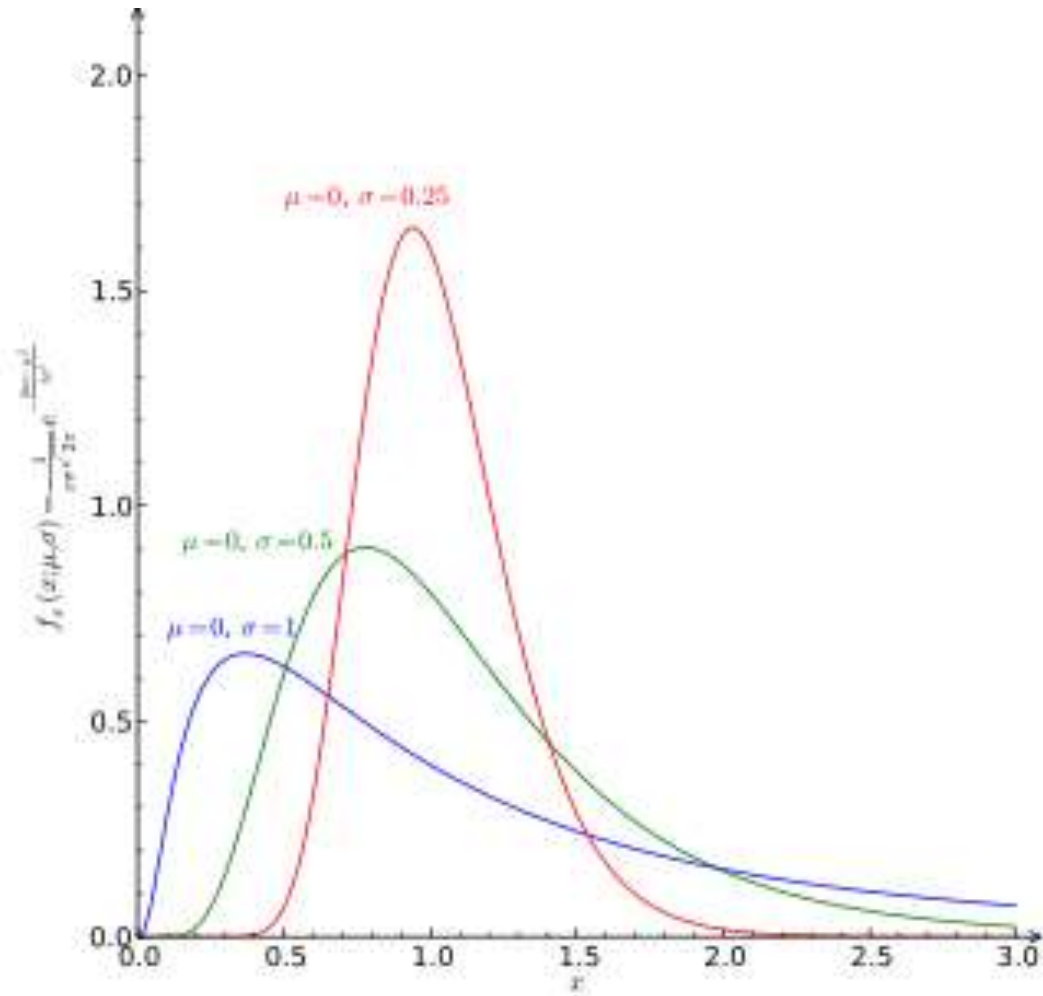
PSE = 0.2



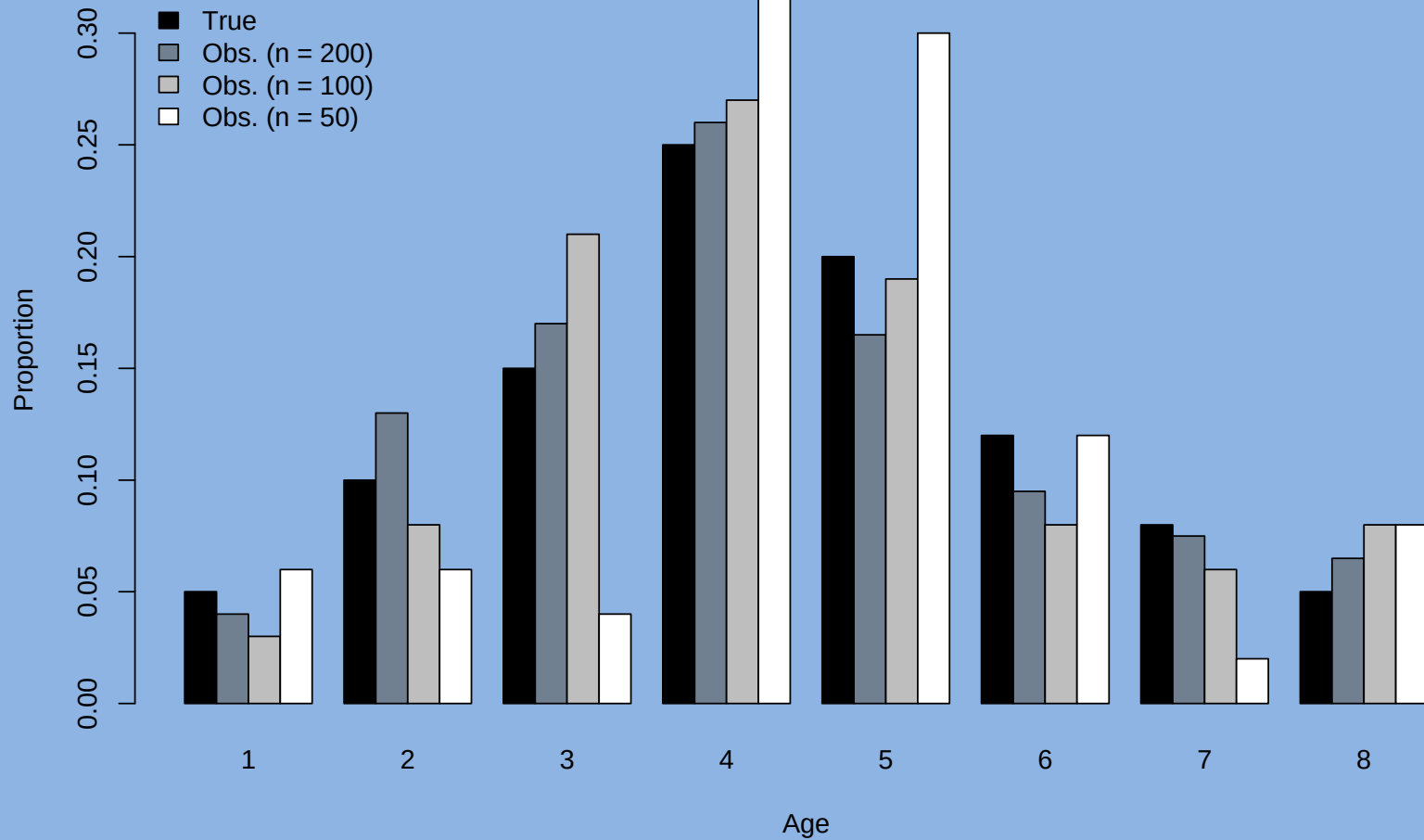
PSE = 0.5



Lognormal Distribution



Age Information



Model Dynamics

- Assessment model
 - Estimates recruitments and F in both fisheries
 - All other inputs fixed at “true” values,
 - Given the true values as starting points in the estimation
 - Estimates SPR-based BRPs and the OFL based on the final year
- Management model
 - OFL = catch @ $F_{x\%}$ corresponding to F_{MSY}
 - Catch target = catch @ $F_{lim-5\%}$ (e.g., $F_{40\%}$ if $F_{lim} = F_{35\%}$)

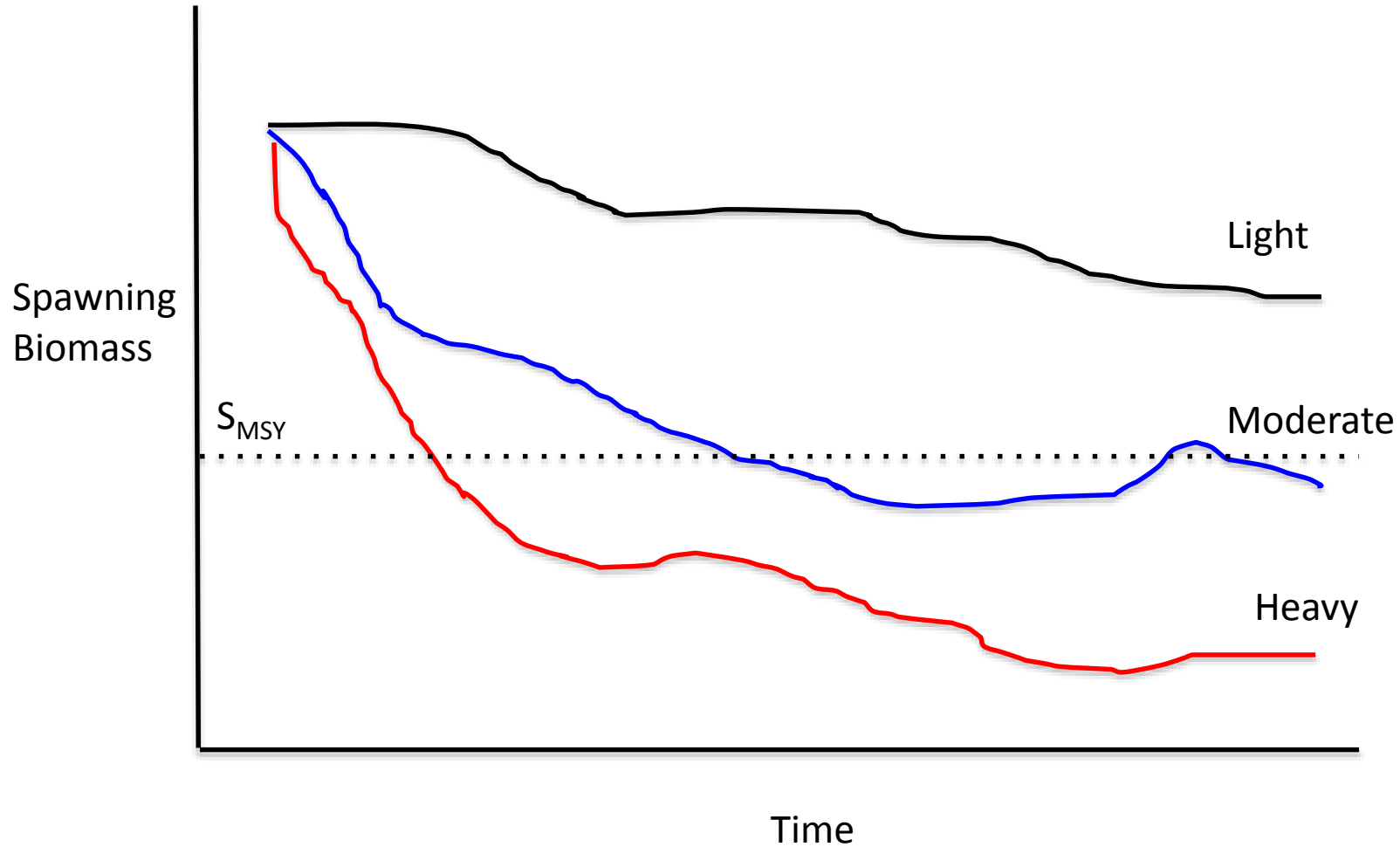
Assessment Fitting Details

- Maximum Likelihood Estimation
 - Lognormal likelihood (CPUE and fishery landings)
 - Multinomial likelihood (proportions at age)
 -
- Variance used in fitting of lognormal component
- True ESS used in fitting multinomial component
- Uncertain data are treated as such in the model and have less “weight” in the overall fitting

Scenarios

- 3 life histories (slow, medium, fast)
- 3 exploitation histories (light, moderate, heavy)
- 3 rec:total landings (30, 60, 90%)
- 7 PSE levels (0.2, 0.3, 0.4, 0.5, 0.6, 0.8, 1.0)
- 189 scenarios in base model run

Exploitation Levels



Sensitivity Run

- Base model runs do not include model misspecification
- Sensitivity run
 - M varies in the operating model but is fixed in the assessment
 - Moderate exploitation only

Life History Parameters

Parameter	Description	Life History		
		Slow	Medium	Fast
Specified				
a_r	Age at recruitment (to population)	3	1	1
a_{max}	Maximum age	20	12	8
M	Natural mortality rate	0.1	0.2	0.4
R_0	Virgin recruitment	1x10 ⁶	1x10 ⁶	1x10 ⁶
h	Steepness	0.45	0.65	0.85
a_0	Age at length=0	0	0	0
L_∞	Maximum length	105	90	50
k	Growth rate	0.15	0.25	0.35
b_1	L-W scalar	2.98x10 ⁻⁷	3.5 x 10 ⁻⁶	4.27 x 10 ⁻⁵
b_2	L-W exponent	3	3	3
m_{50}	Age at 50% maturity	4	2.5	1.5
m_{slope}	Slope of maturity function	1	0.5	0.25
s_{50}	Age at 50% selectivity (commercial,recreational,survey)	5.5, 5.5, 3	3.25, 3.25, 1.75	2.5, 2.5, 1
δ	Slope of selectivity function	0.5	0.5	0.5

Measuring Assessment Error

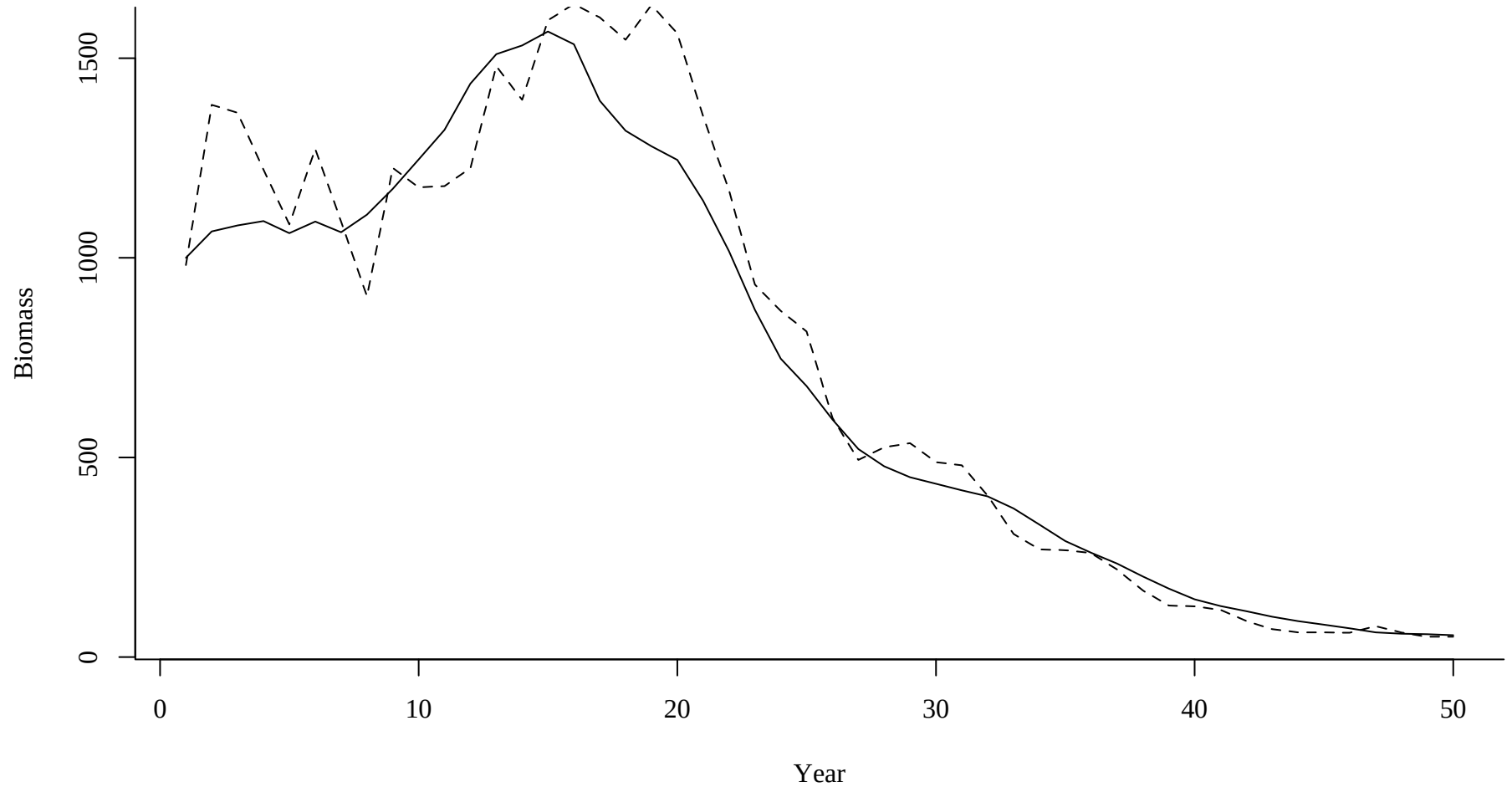
- Relative error (RE) of estimates in terminal year in each assessment

$$RE = 100 * (\text{estimated} - \text{true}) / \text{true}$$

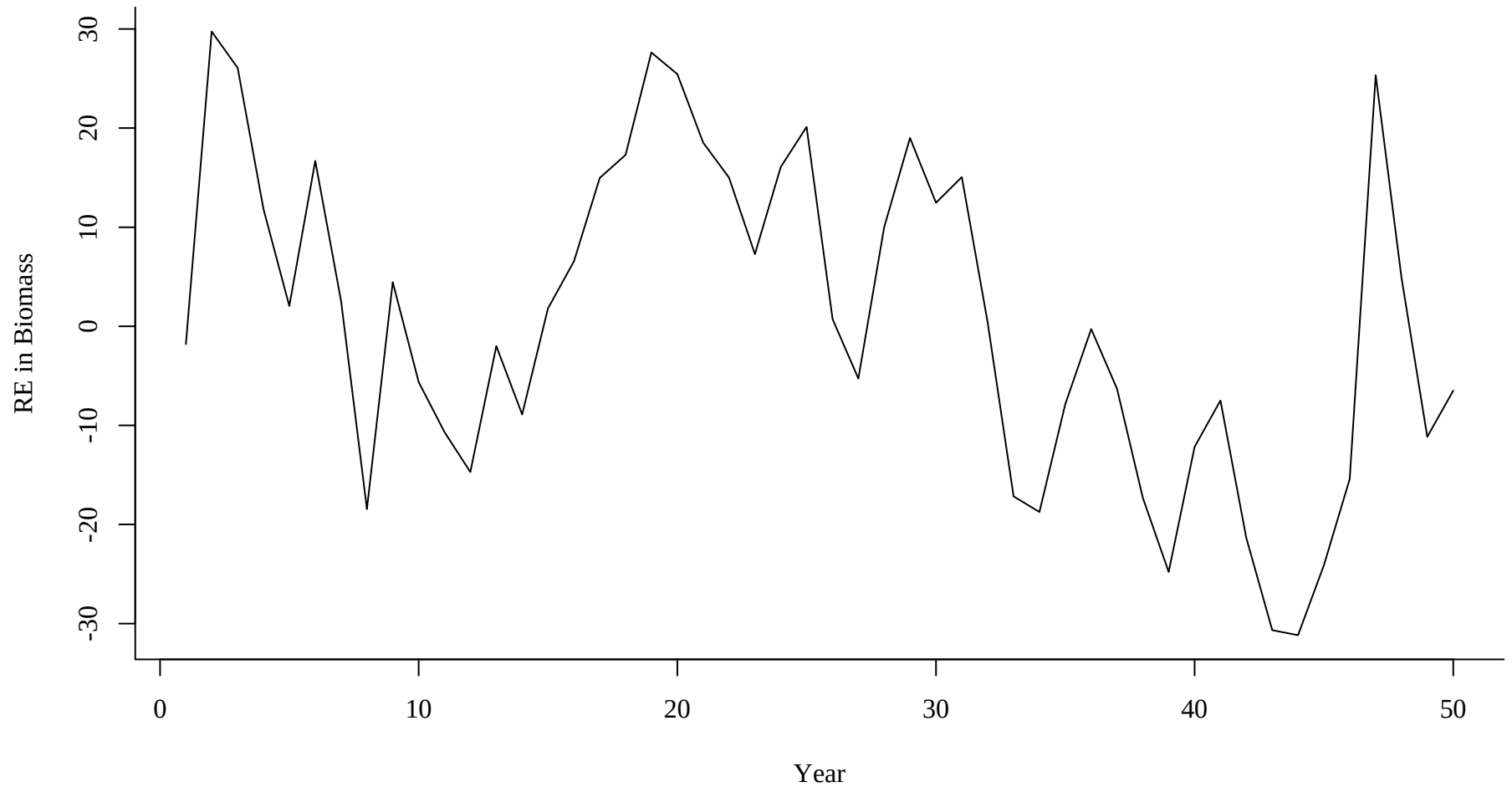
MRE = median of RE estimates from a single run

MARE = median of *absolute* estimates of RE

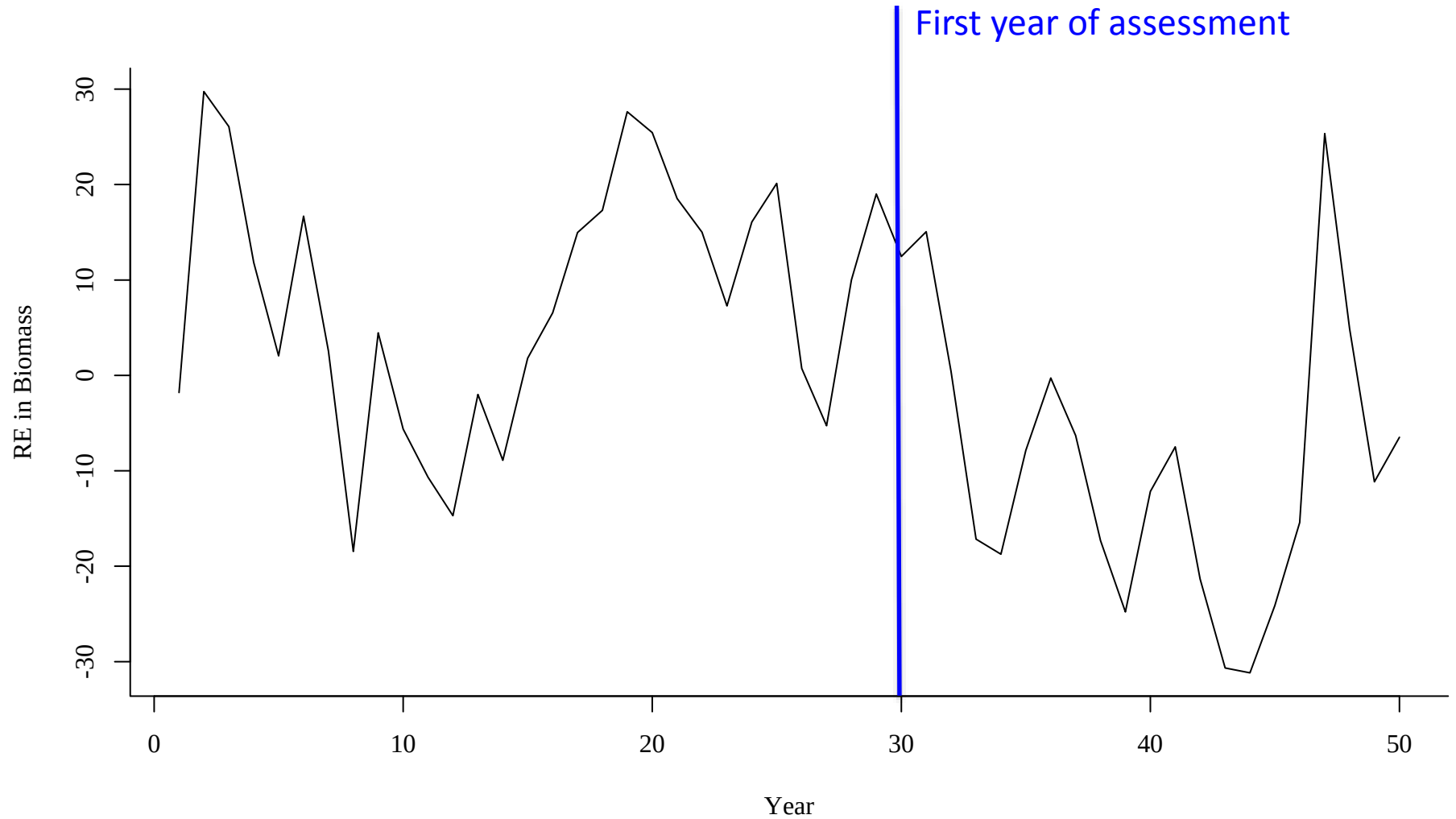
True vs. Estimated Biomass



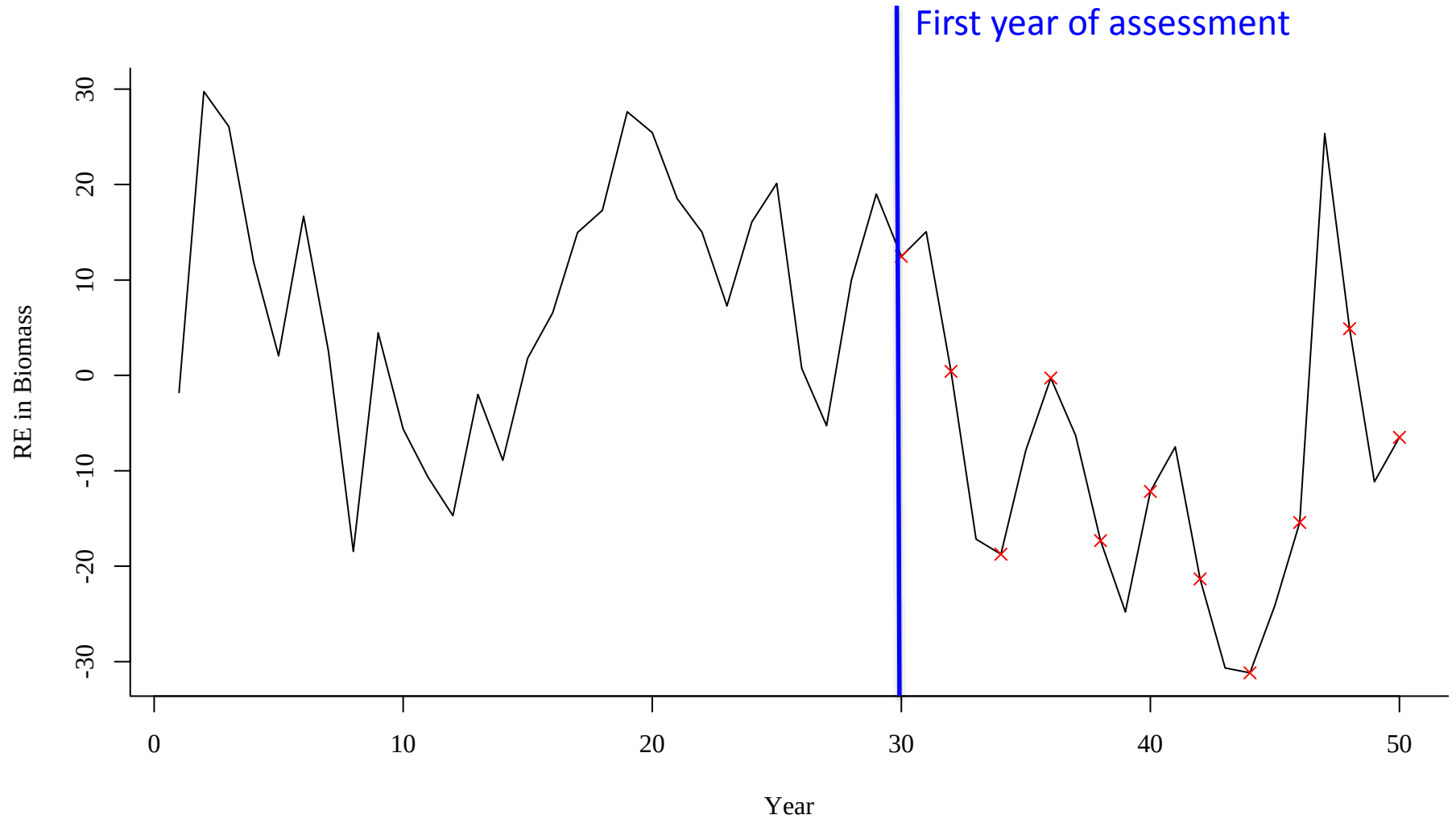
Relative Error (RE) in Biomass Estimates



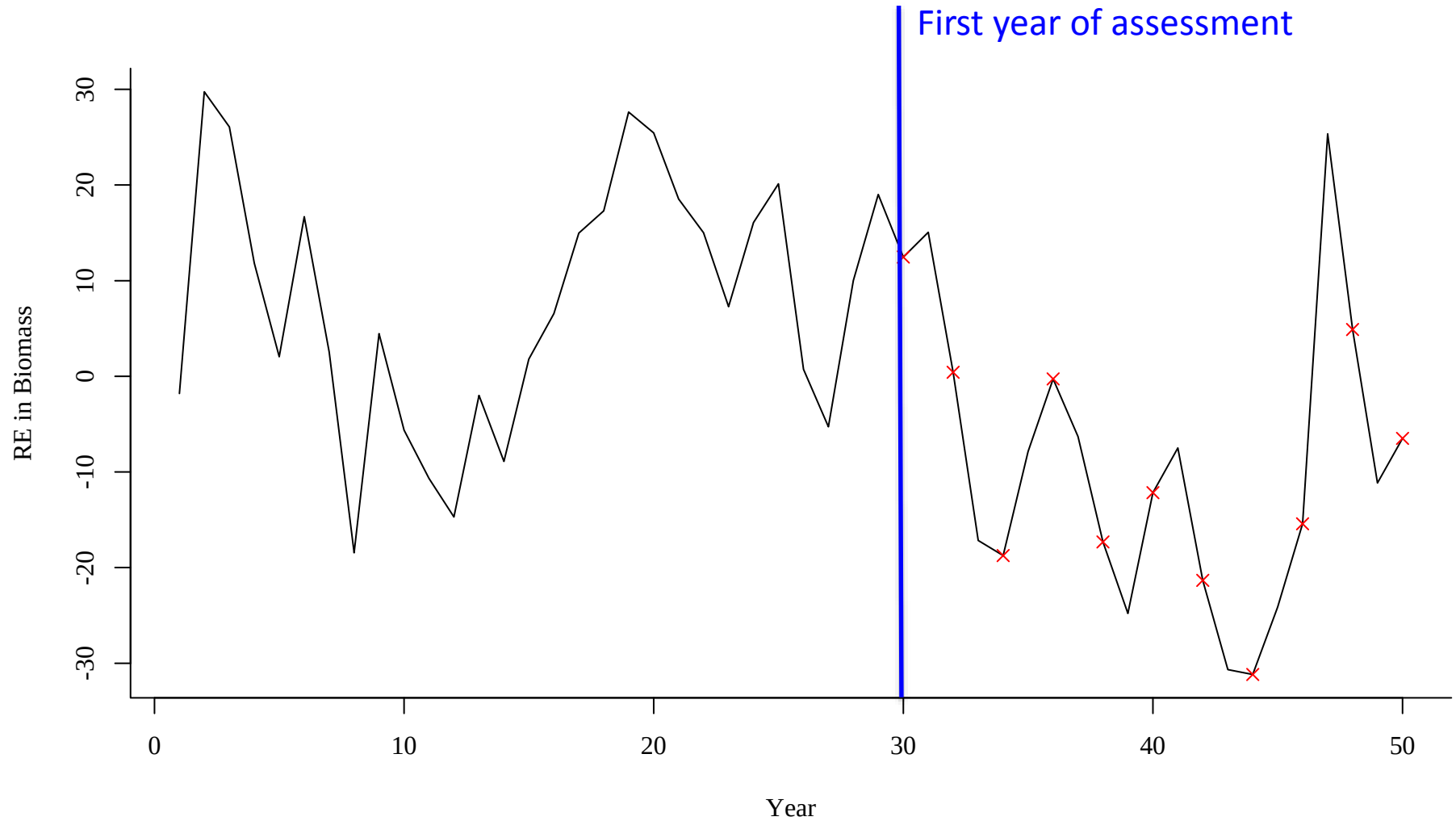
Relative Error (RE) in Biomass Estimates



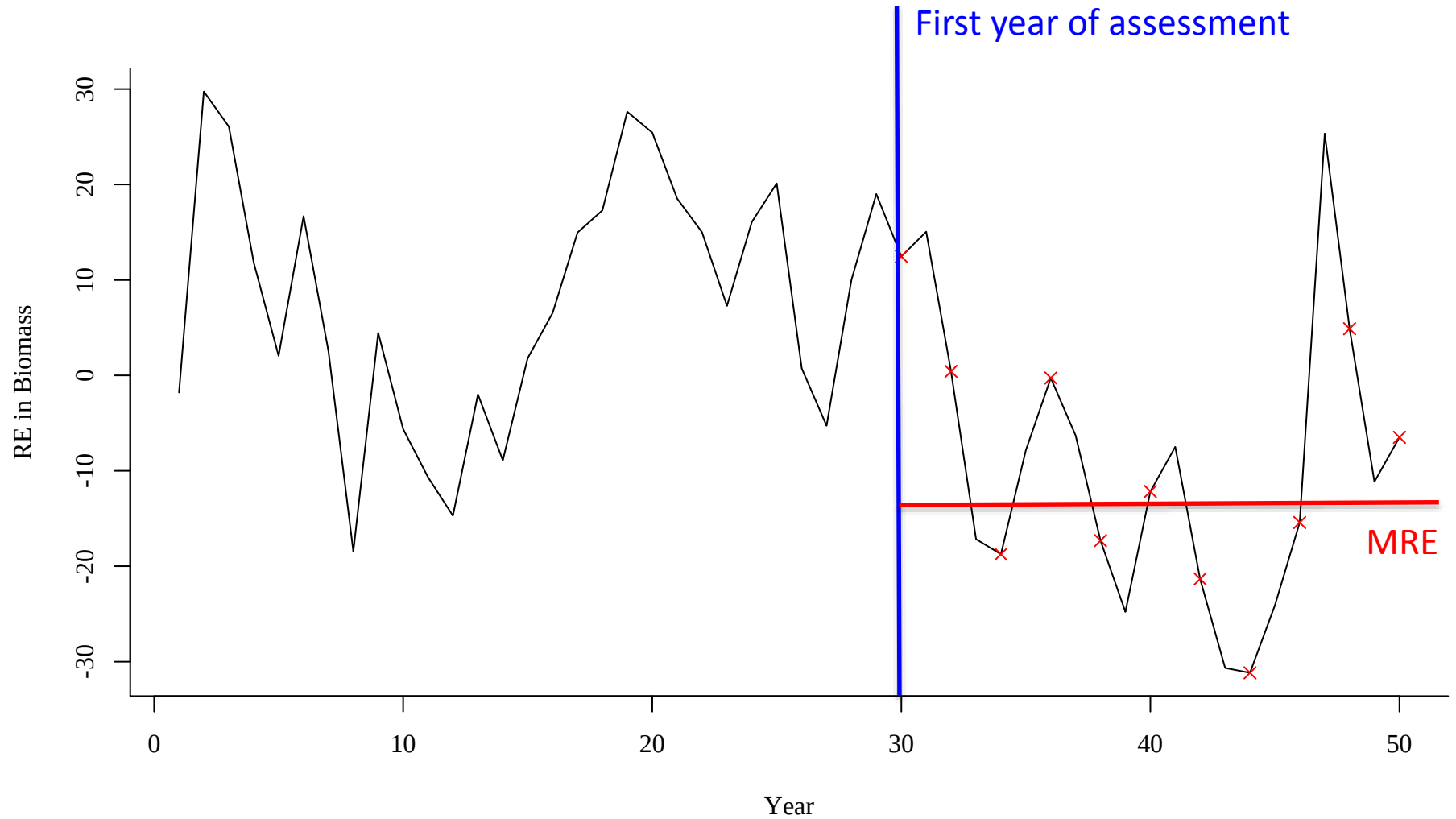
Relative Error (RE) in Biomass Estimates



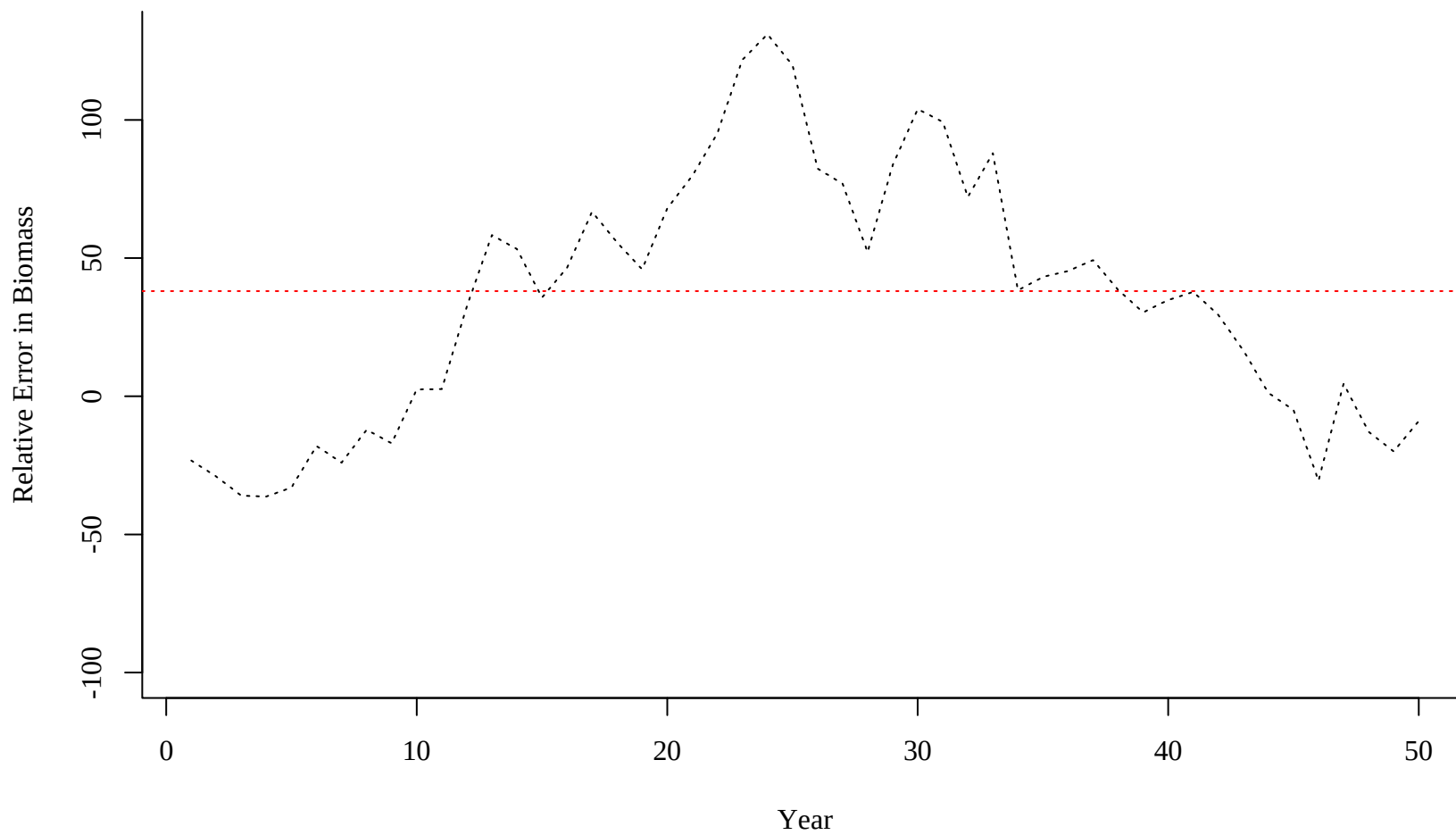
Relative Error (RE) Estimates of: *S*, *R*, *F*, and *OFL*



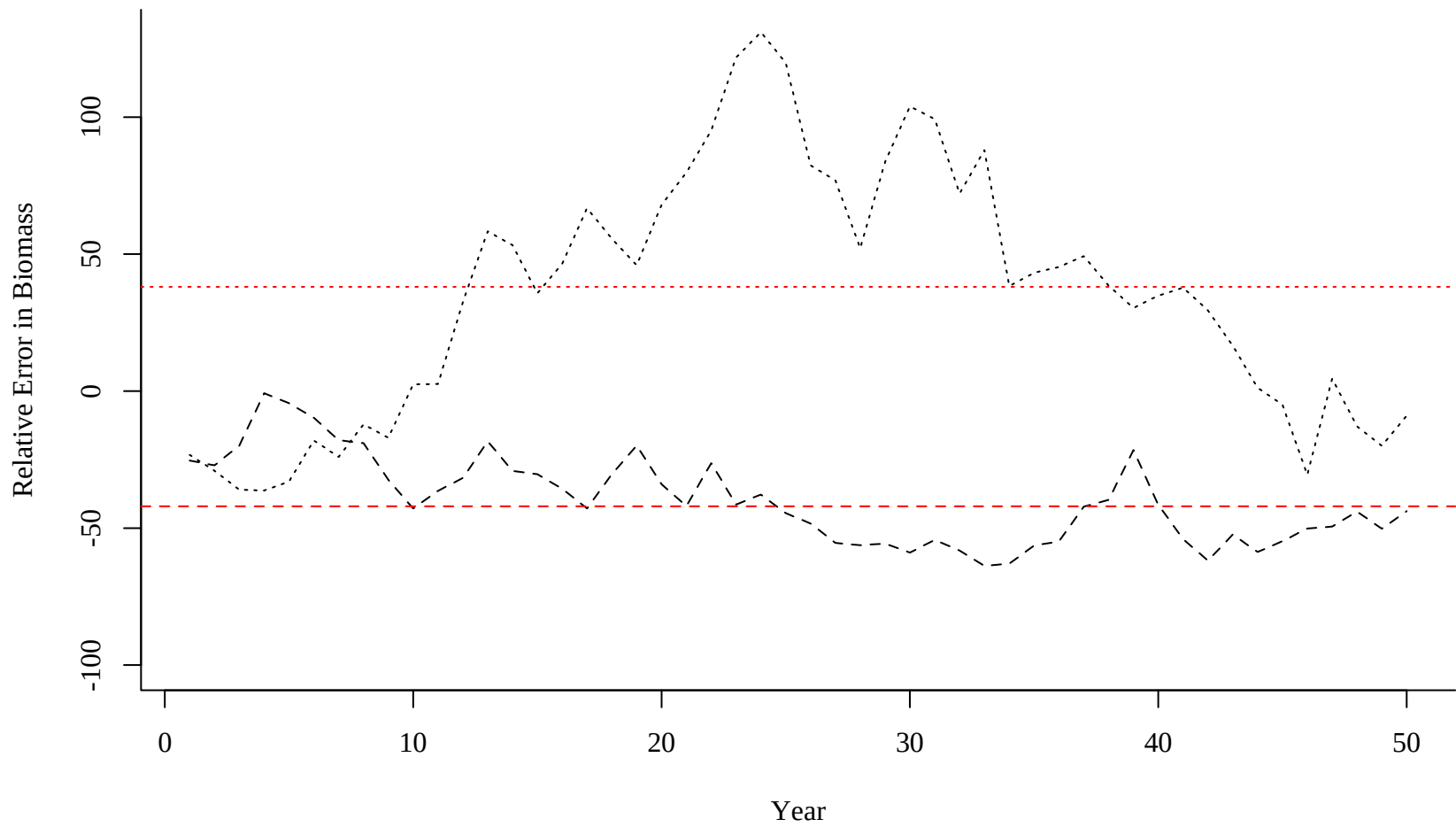
Median Relative Error (MRE)



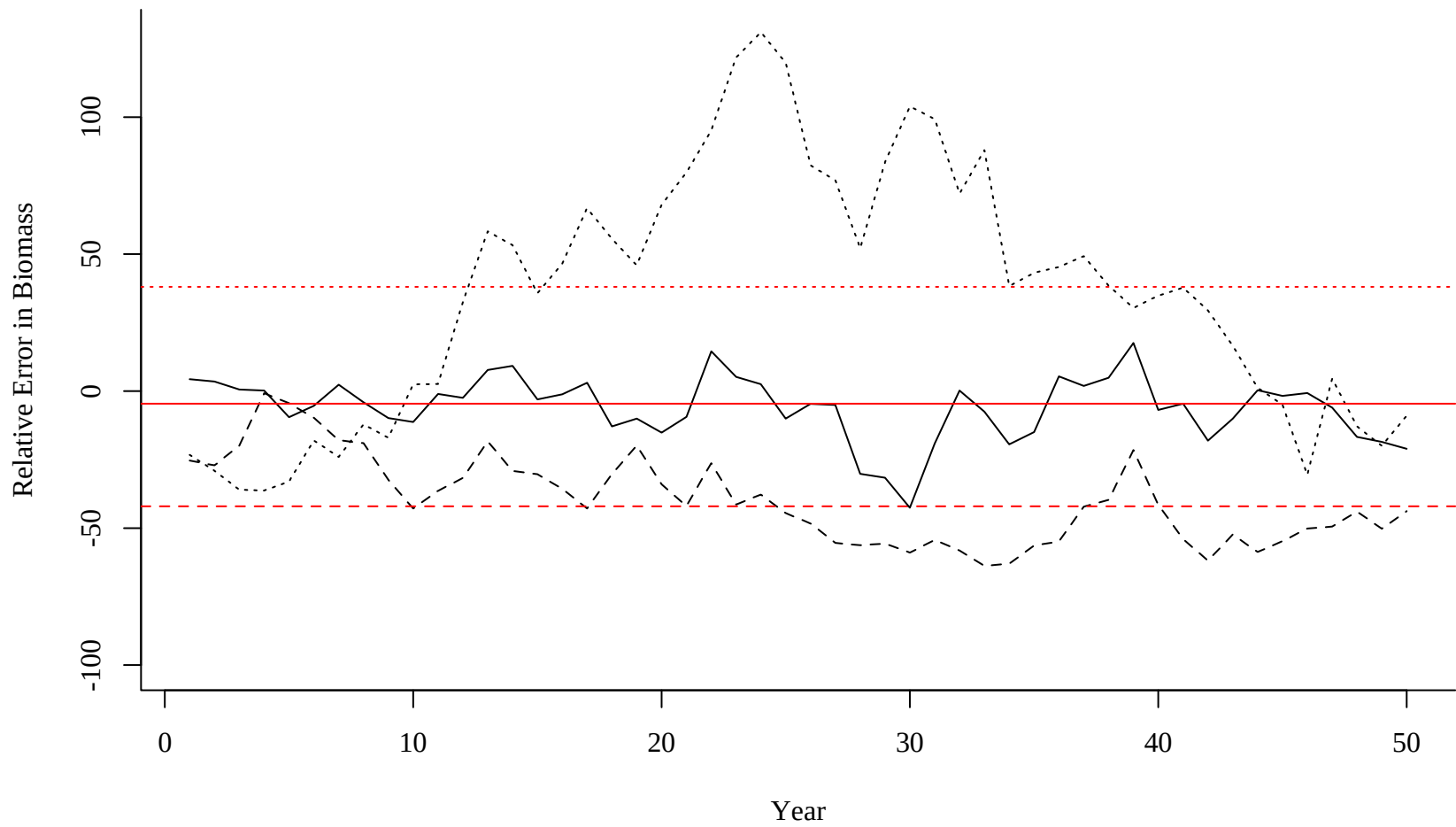
MRE



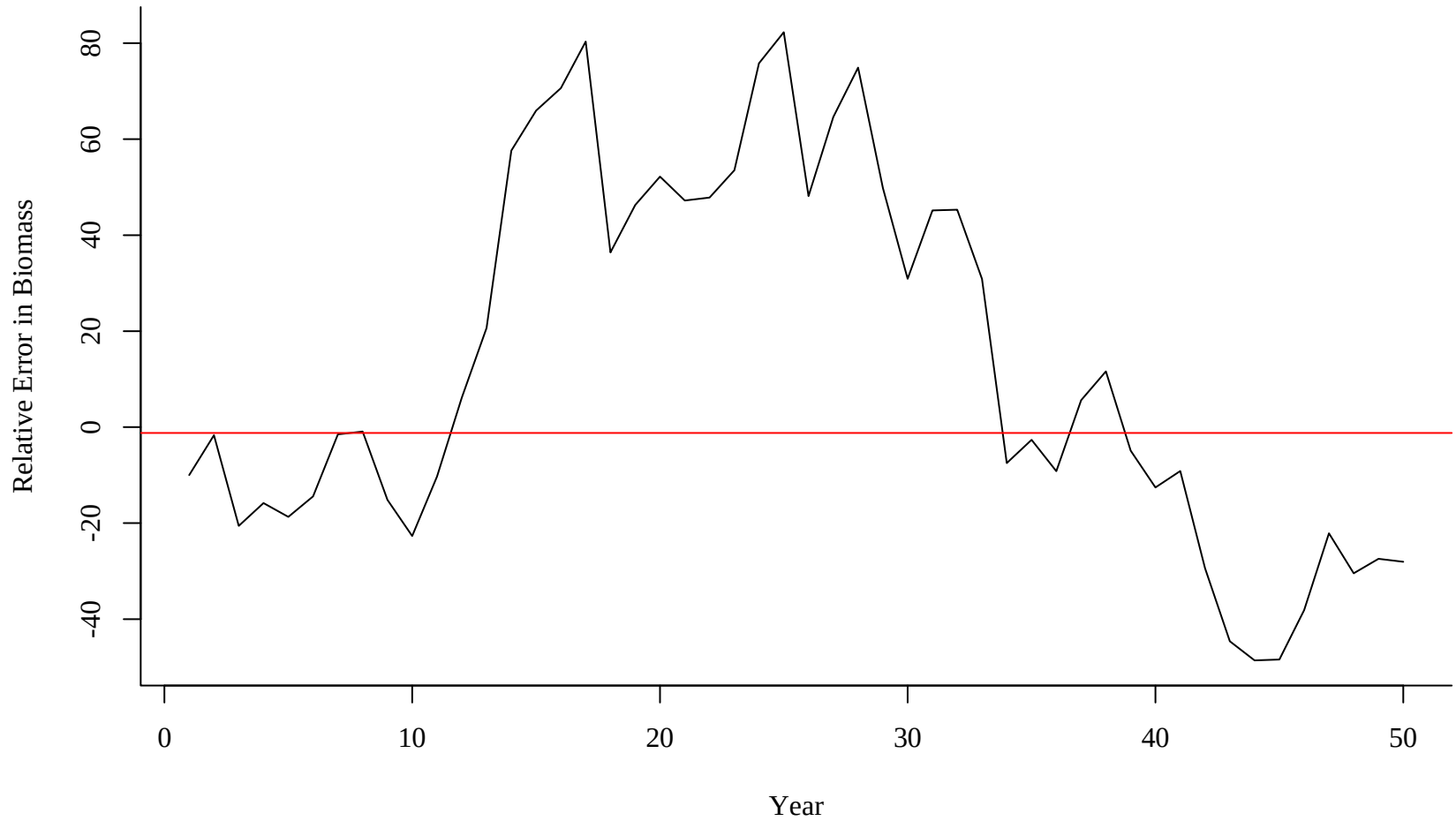
MRE



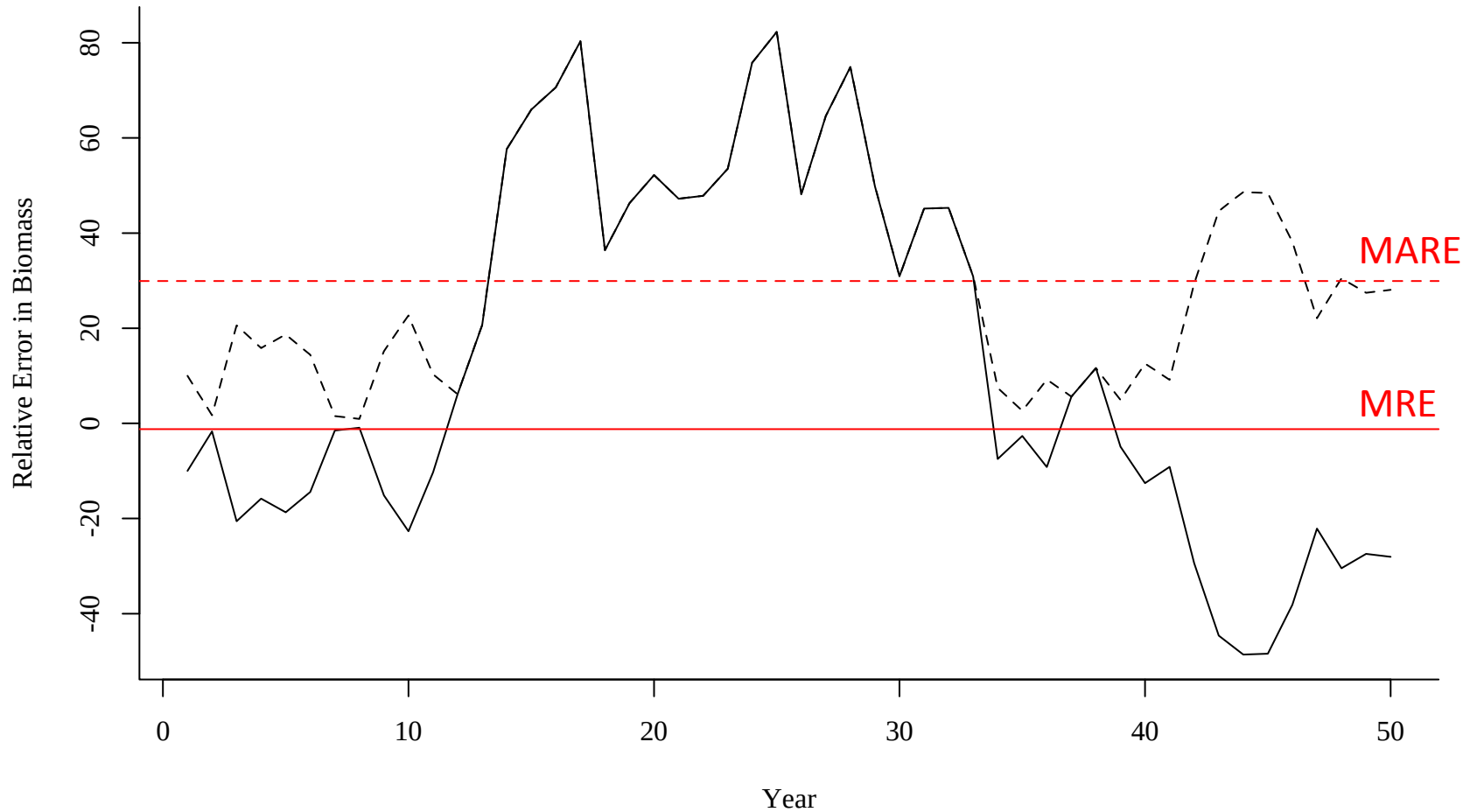
MRE



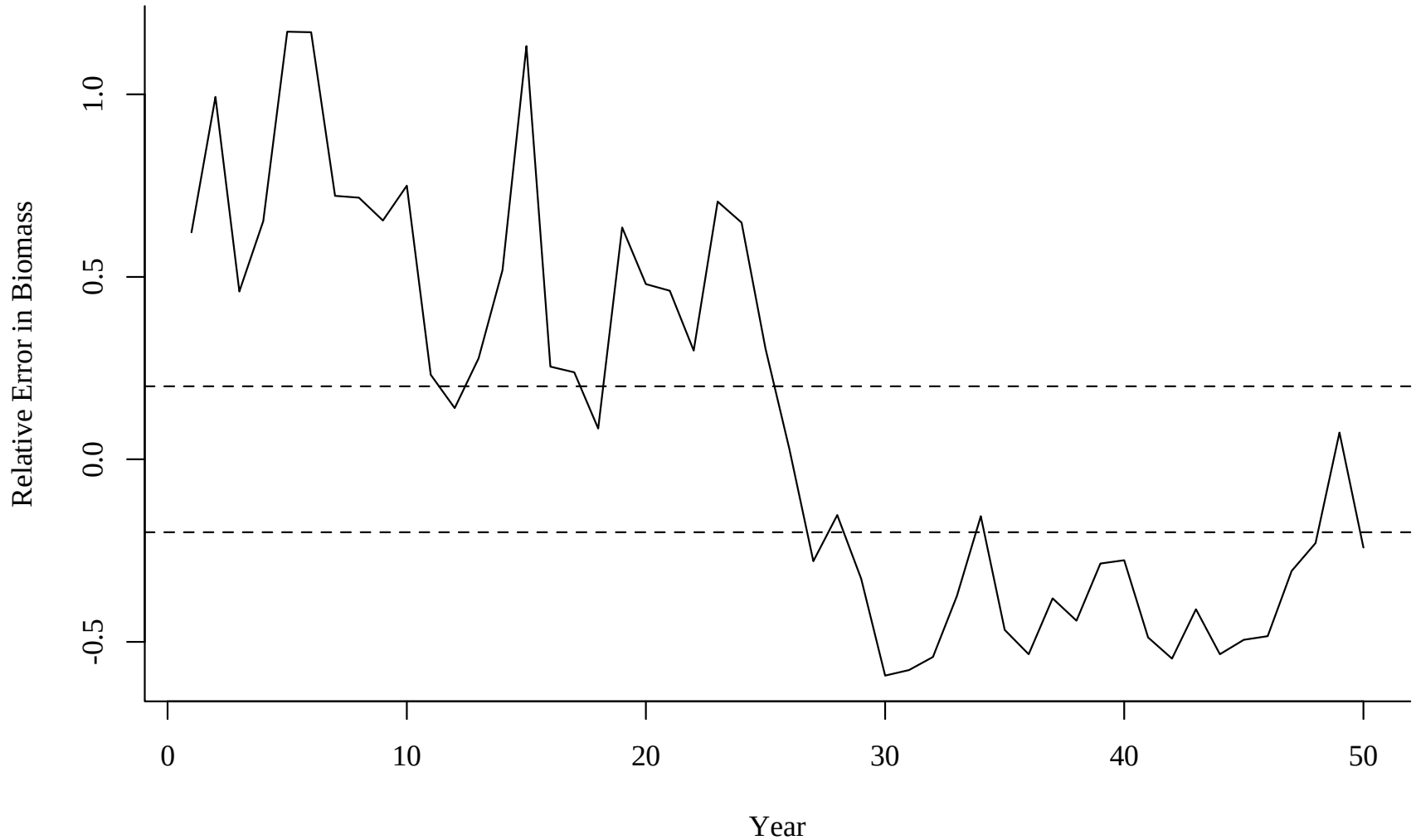
MRE vs. MARE



MRE vs. MARE



Proportion of Years More Extreme than + / - 20%



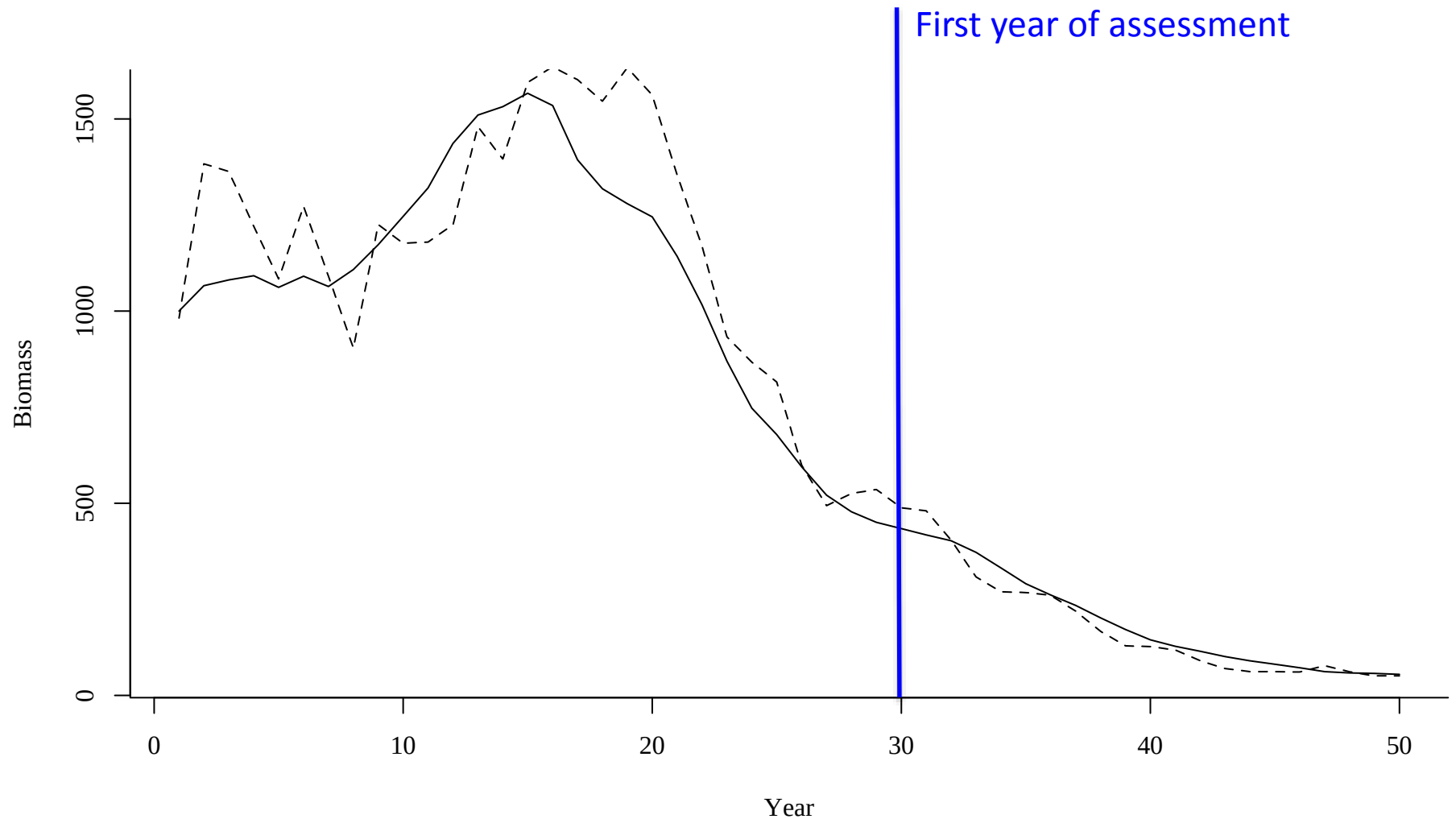
Measuring Assessment Performance

- MRE / MARE
 - Biomass
 - Recruitment
 - F
 - OFL
- Proportion of years $\pm 20\%$ of true value
 - Biomass
 - OFL
- Overfishing false positives and false negatives

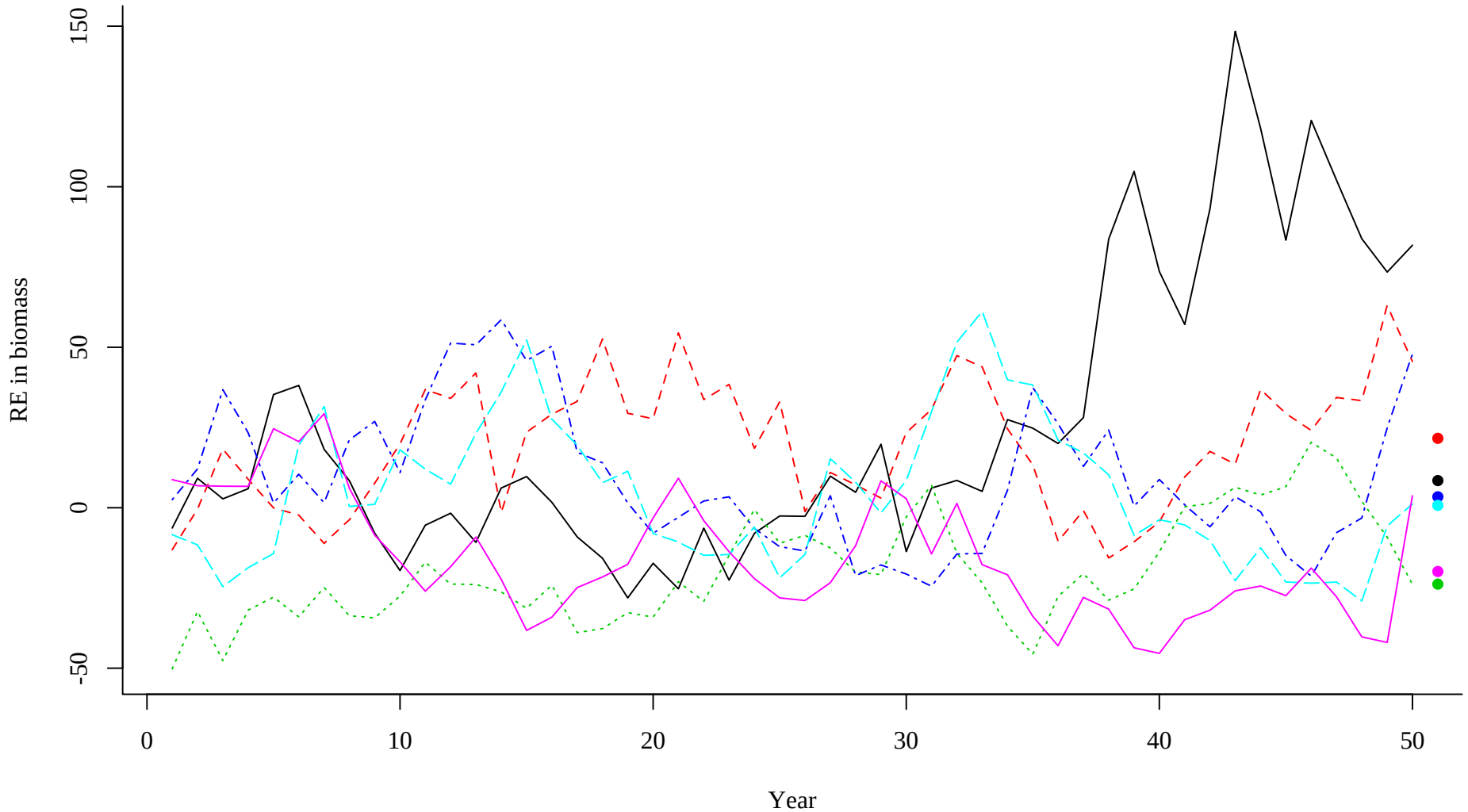
Measuring Population and Fishery Status

- Mean catch relative to MSY (C / MSY)
- Mean catch relative to true OFL (C / OFL)
- Mean spawning biomass (S)
- Proportional change in spawning biomass over time period(S)
- Proportion of years when population is overfished
- Proportion of years with overfishing

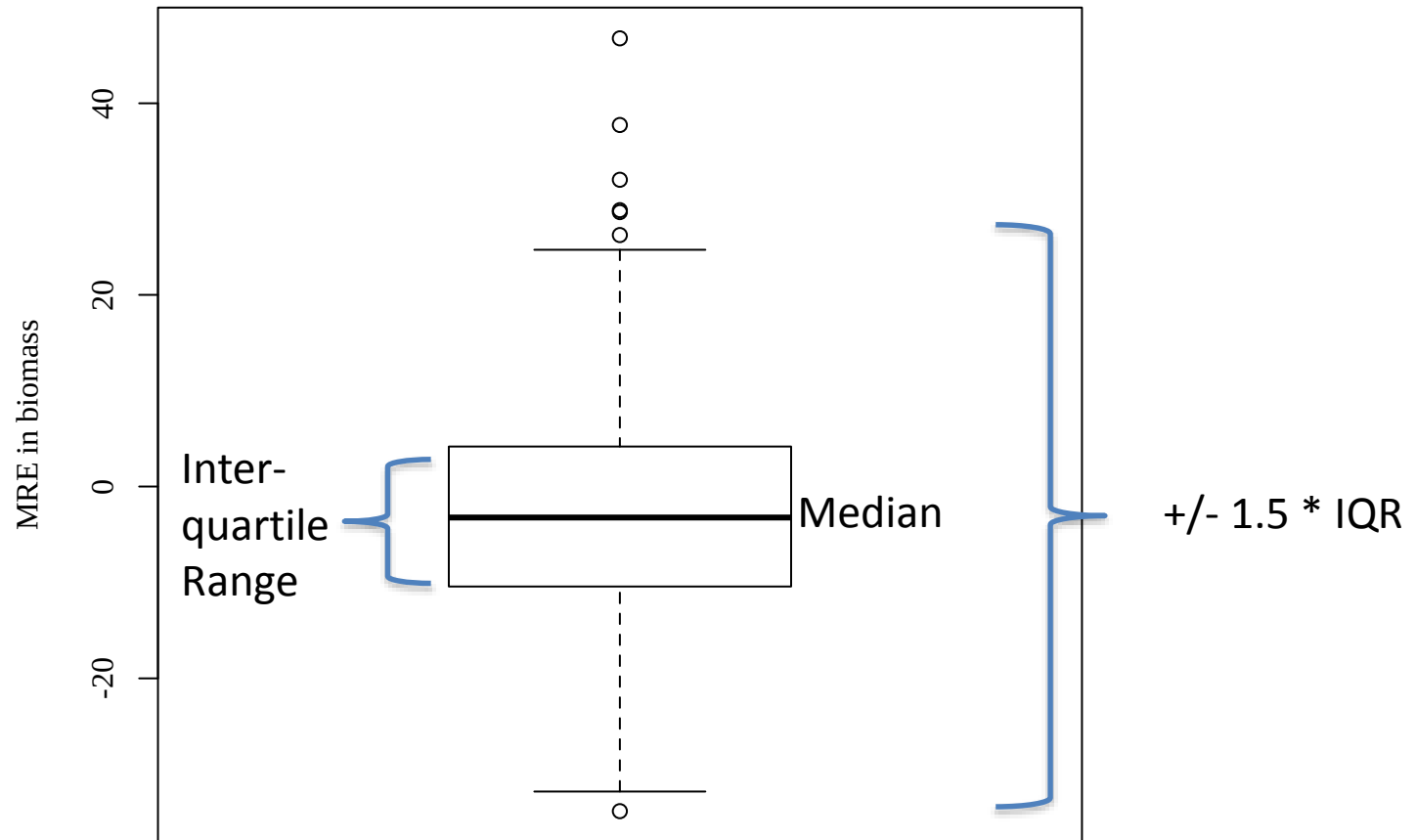
Population / Fishery Performance Measures



Summarizing Performance Over Runs



Summarizing Performance Over Runs



Scenario

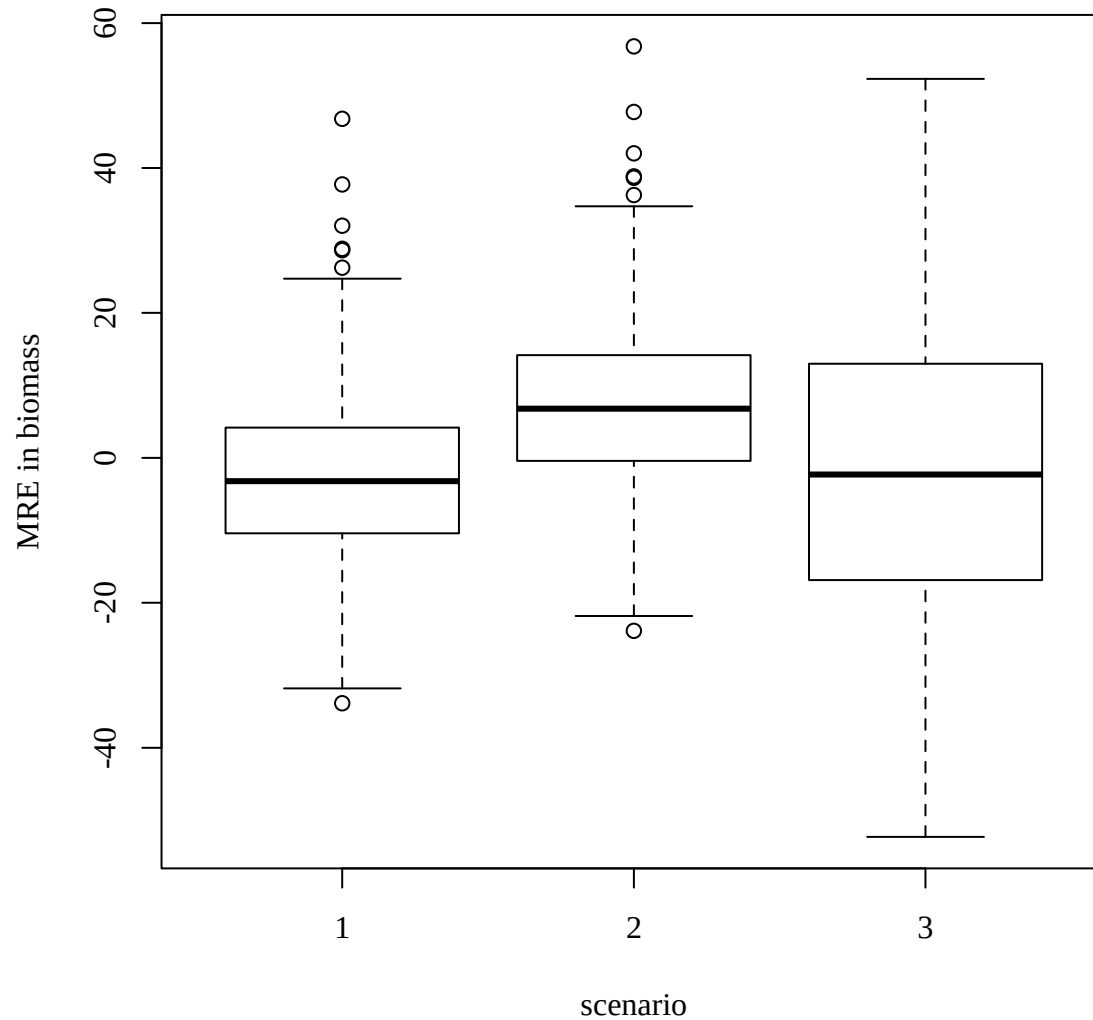
PSE = 0.3

Rec:Com = 0.3

Medium LH

Moderate Exploitation

Comparing Performance Across Scenarios

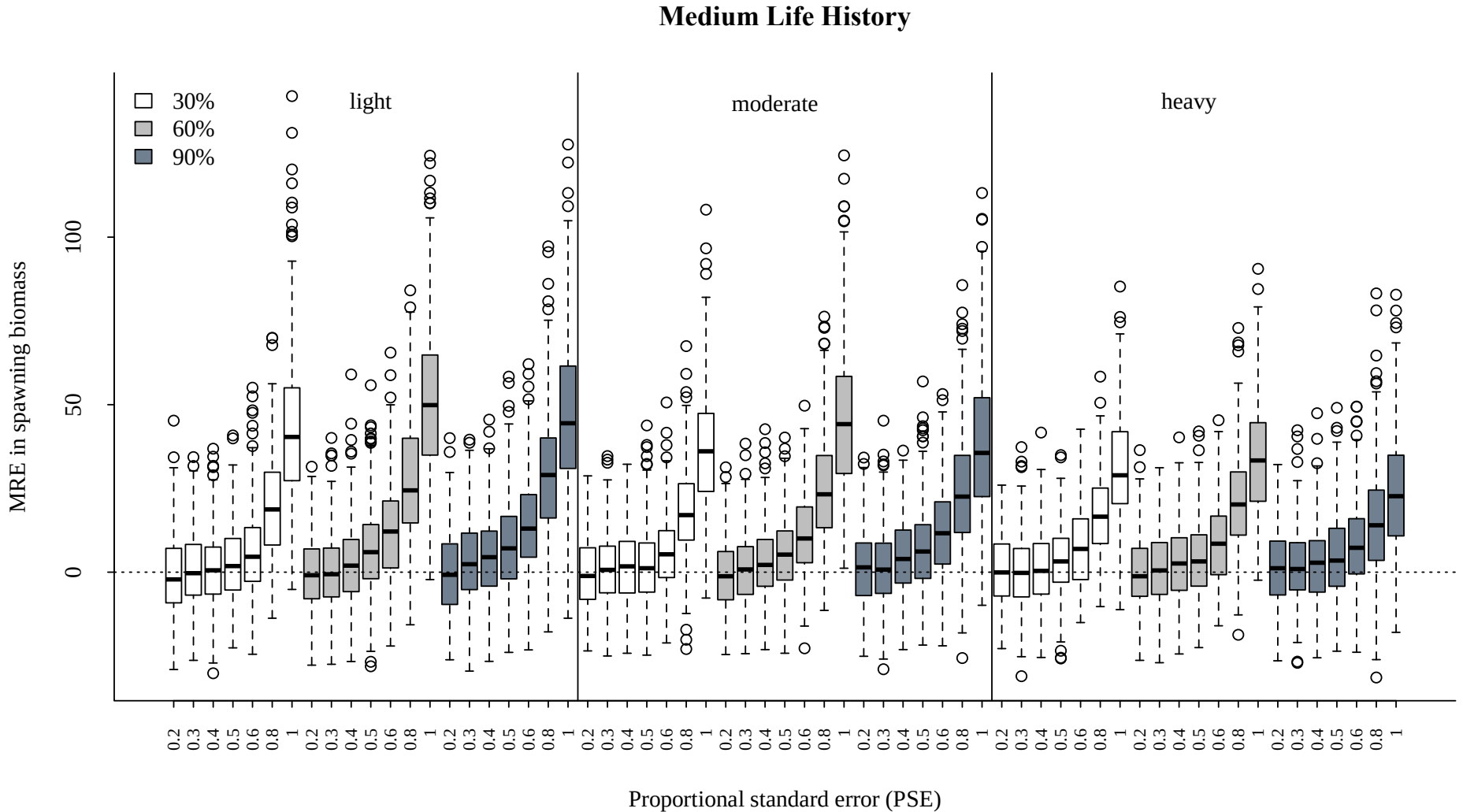


Results

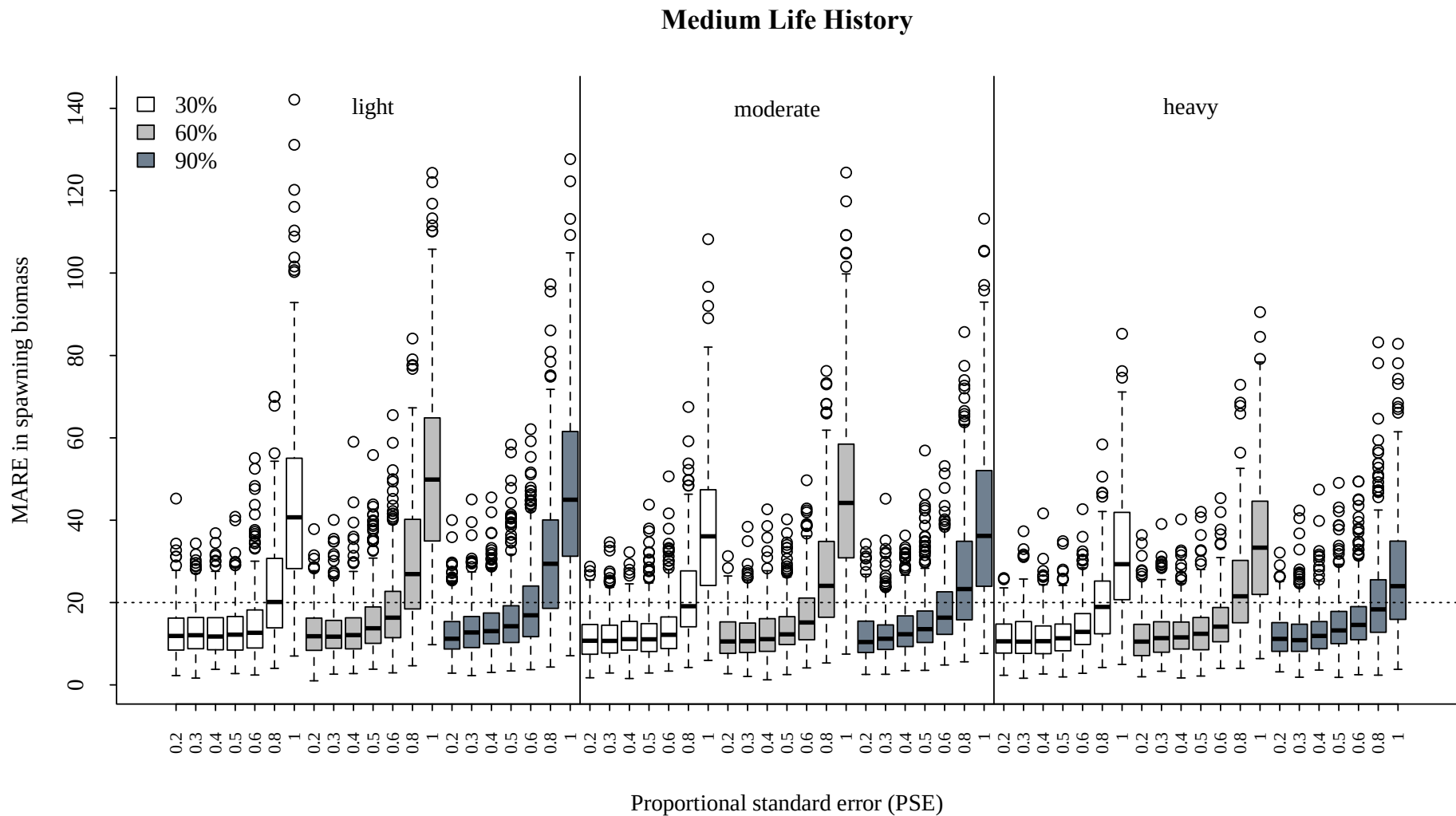
- Assessment error performance measures
- Population / fishery status measures
- 72 figures of model output in report
 - sample of the output shown here

Assessment Error Performance Measures

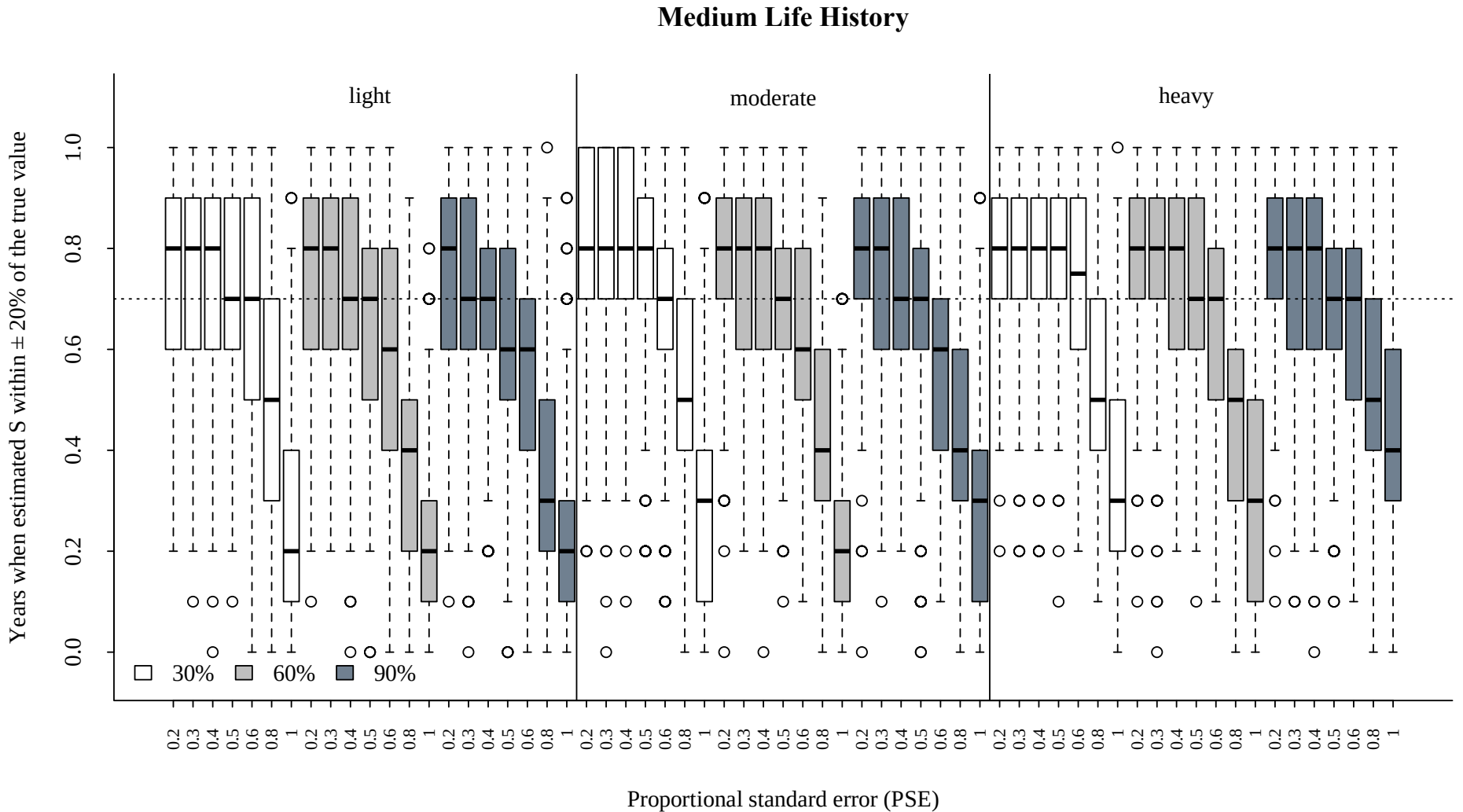
MRE in Biomass: Medium LH



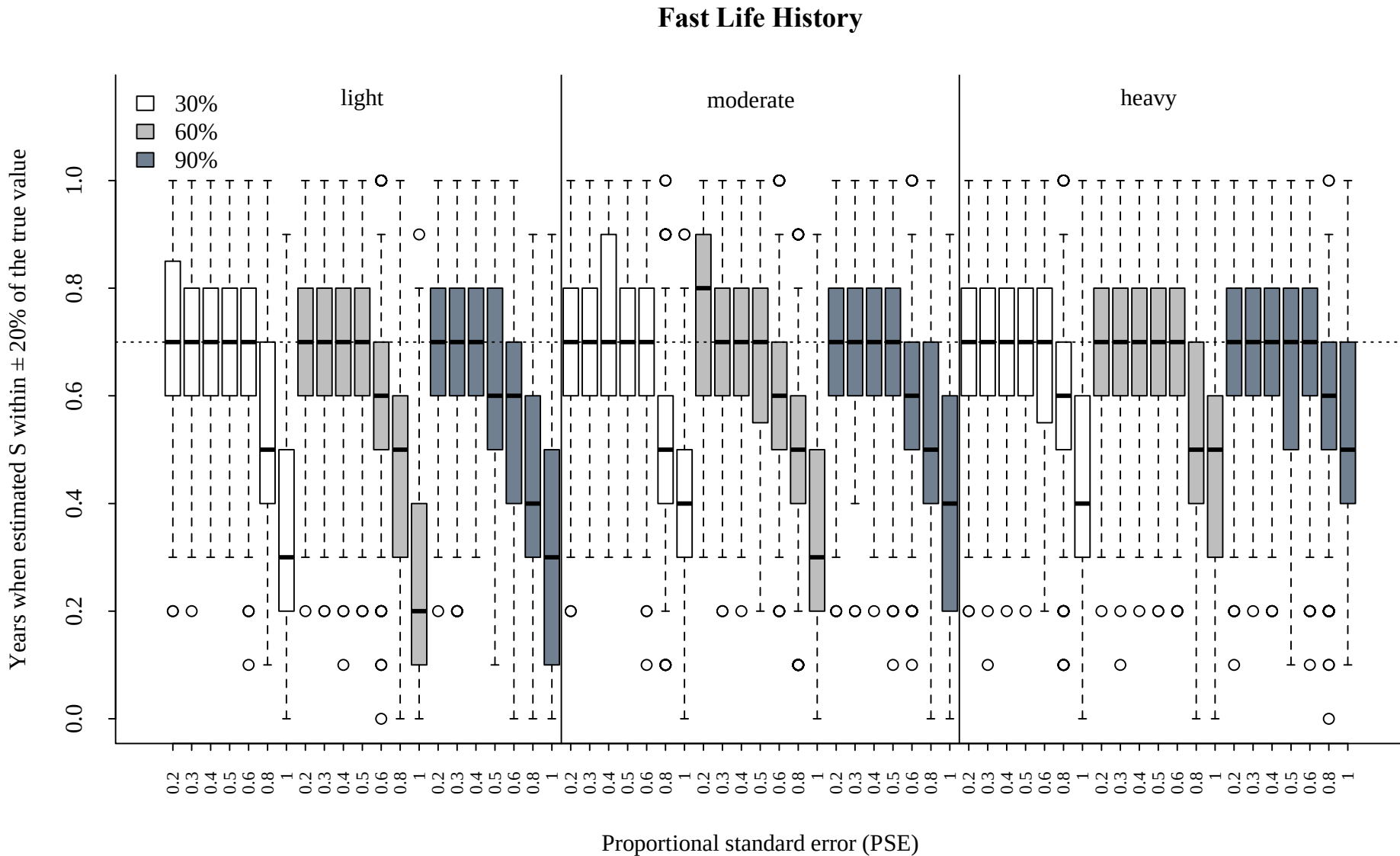
MARE in Biomass: Medium LH



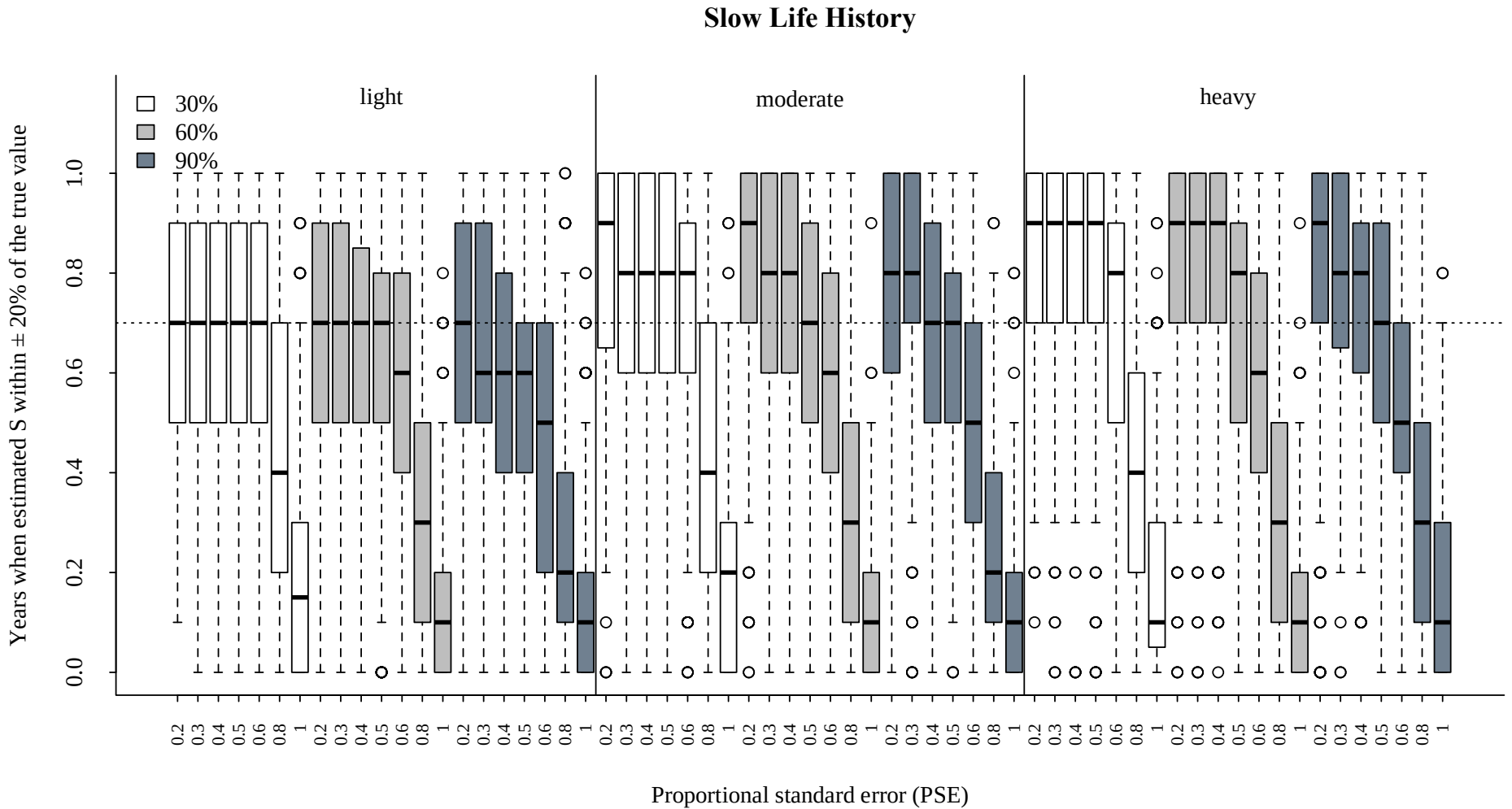
Biomass Estimates +/- 20% (Prop.) : Medium LH



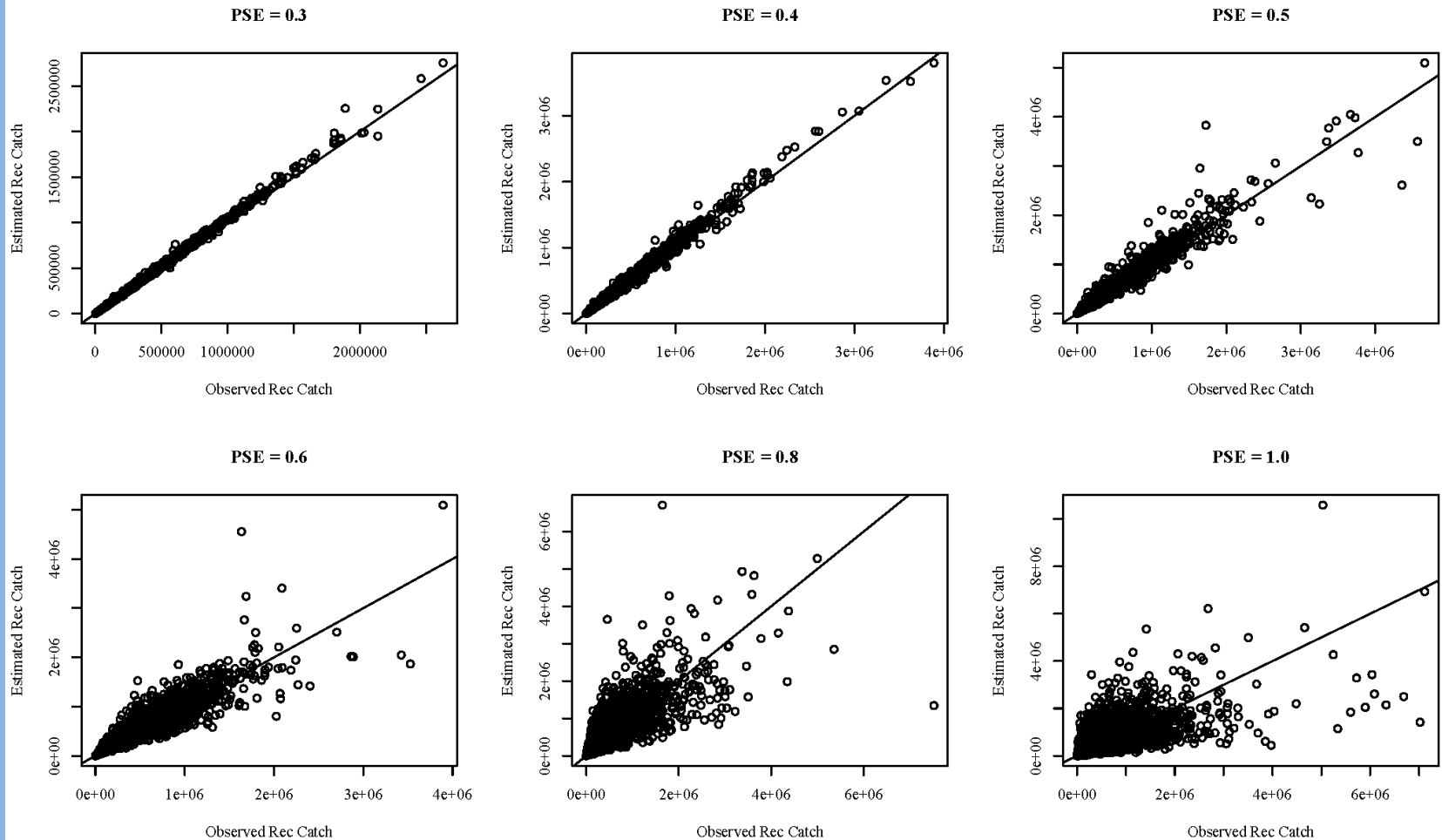
Biomass Estimates $\pm 20\%$ (Prop.) : Fast LH



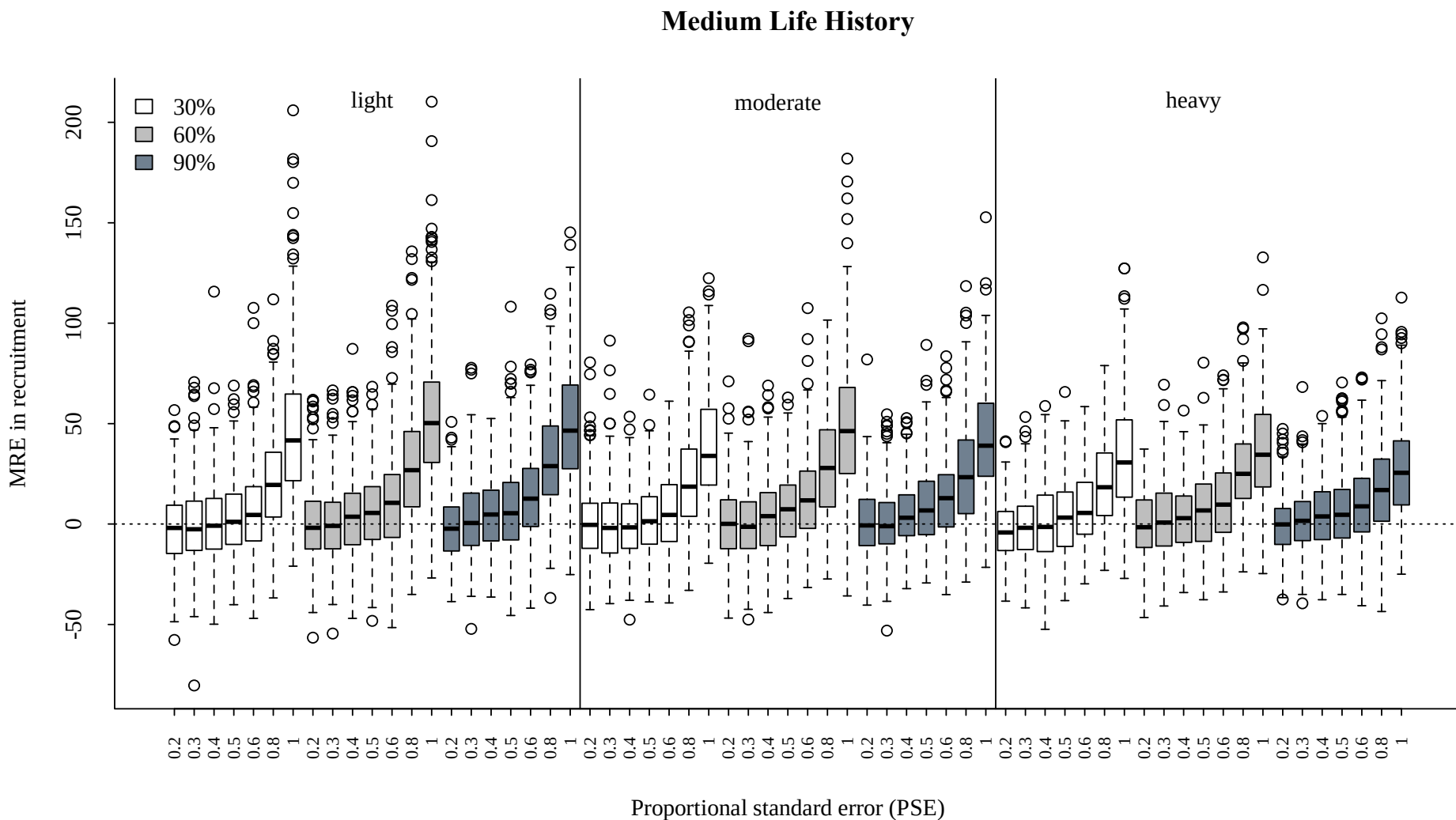
Biomass Estimates $\pm$ 20% (Prop.) : Slow LH



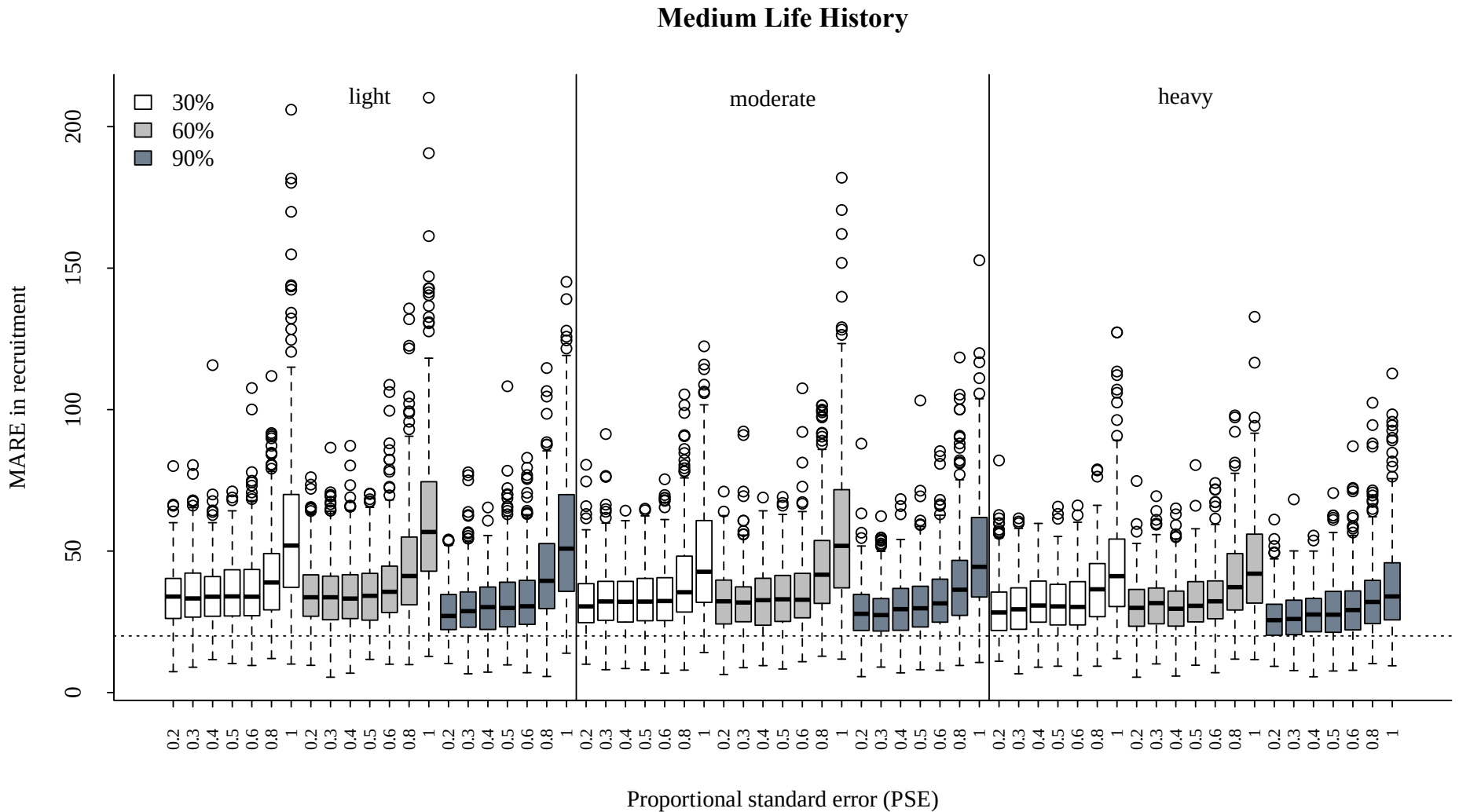
Replicating Observed Catches



MRE in Recruitment: Medium LH

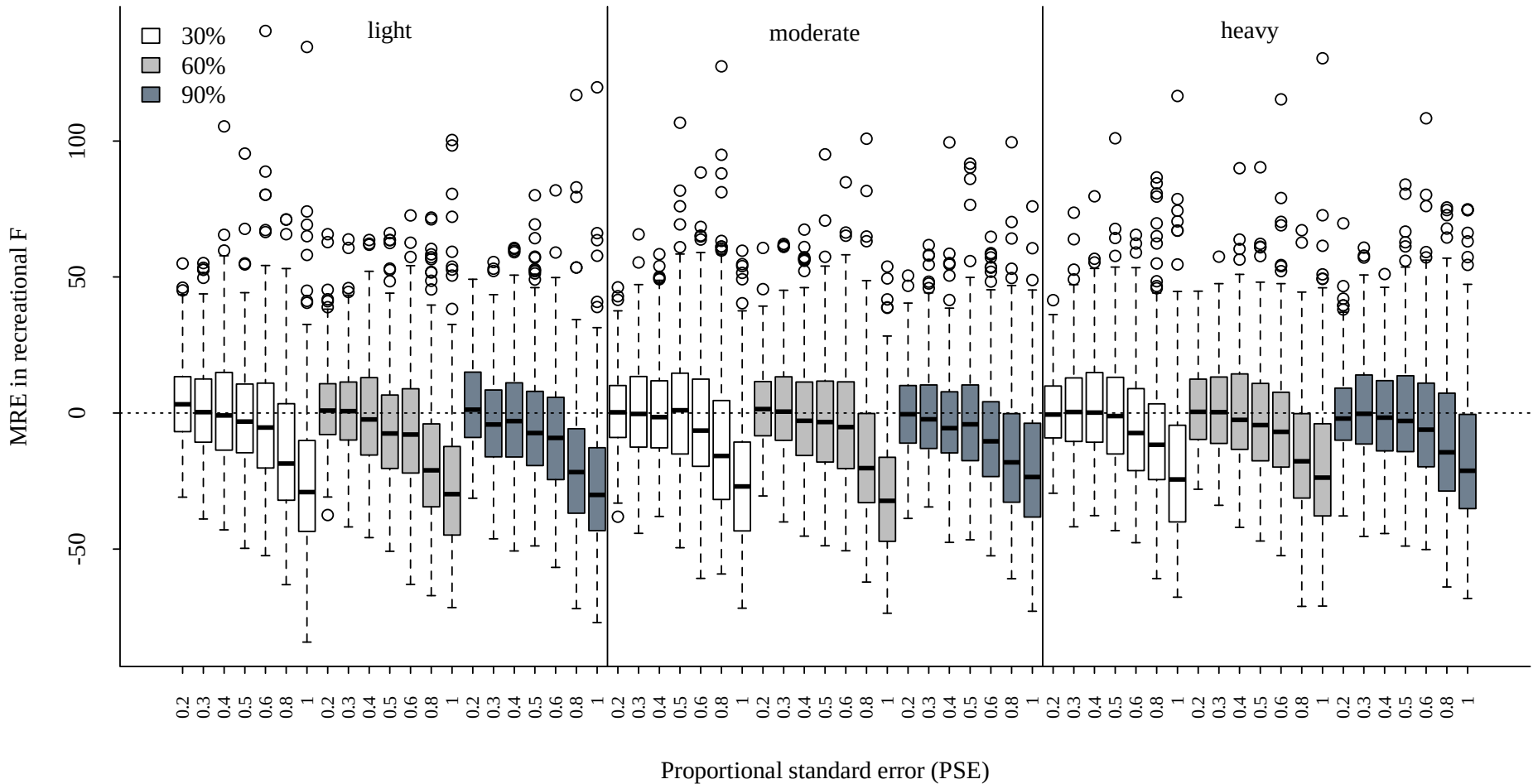


MARE in Recruitment: Medium LH

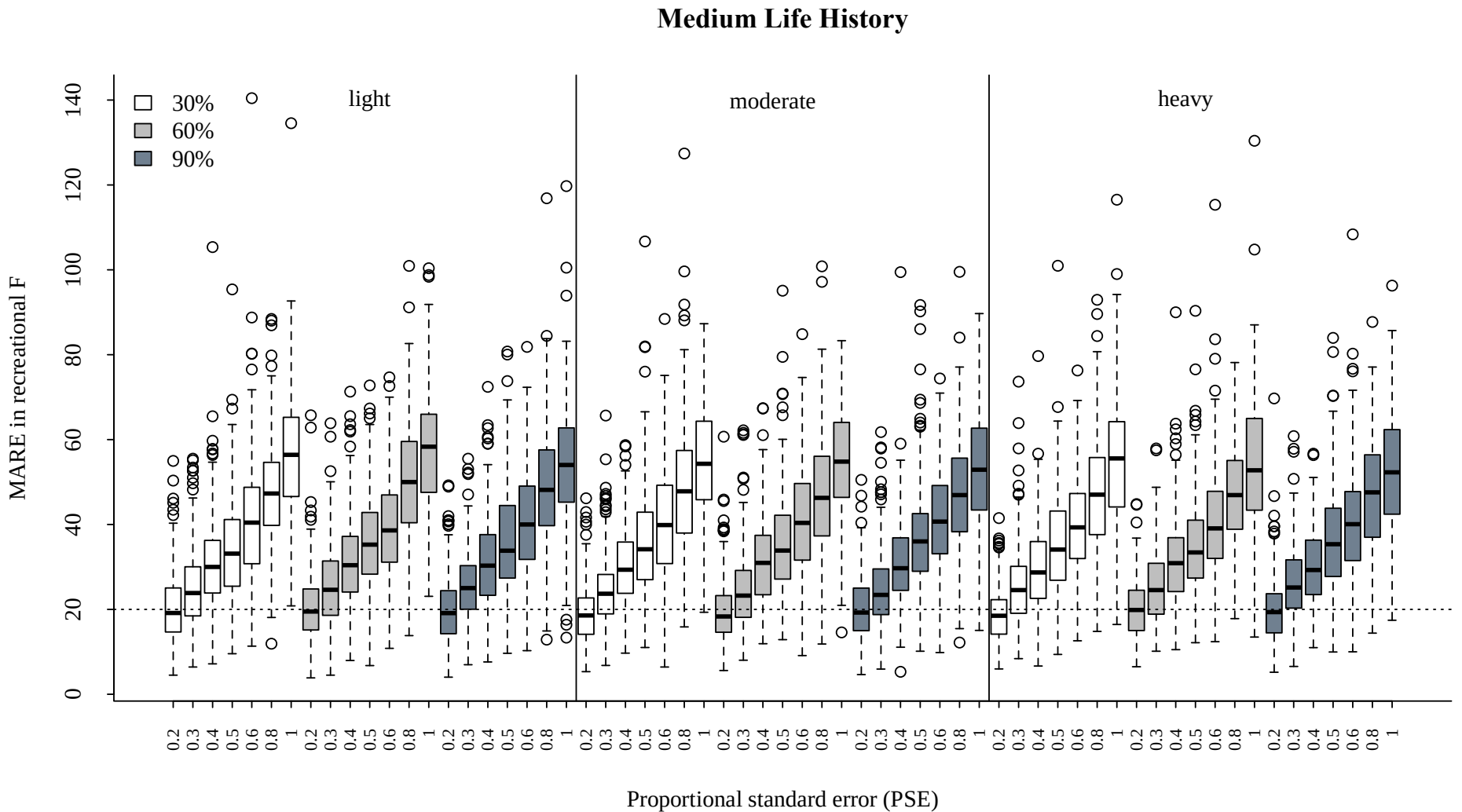


MRE in F_{Rec} : Medium LH

Medium Life History

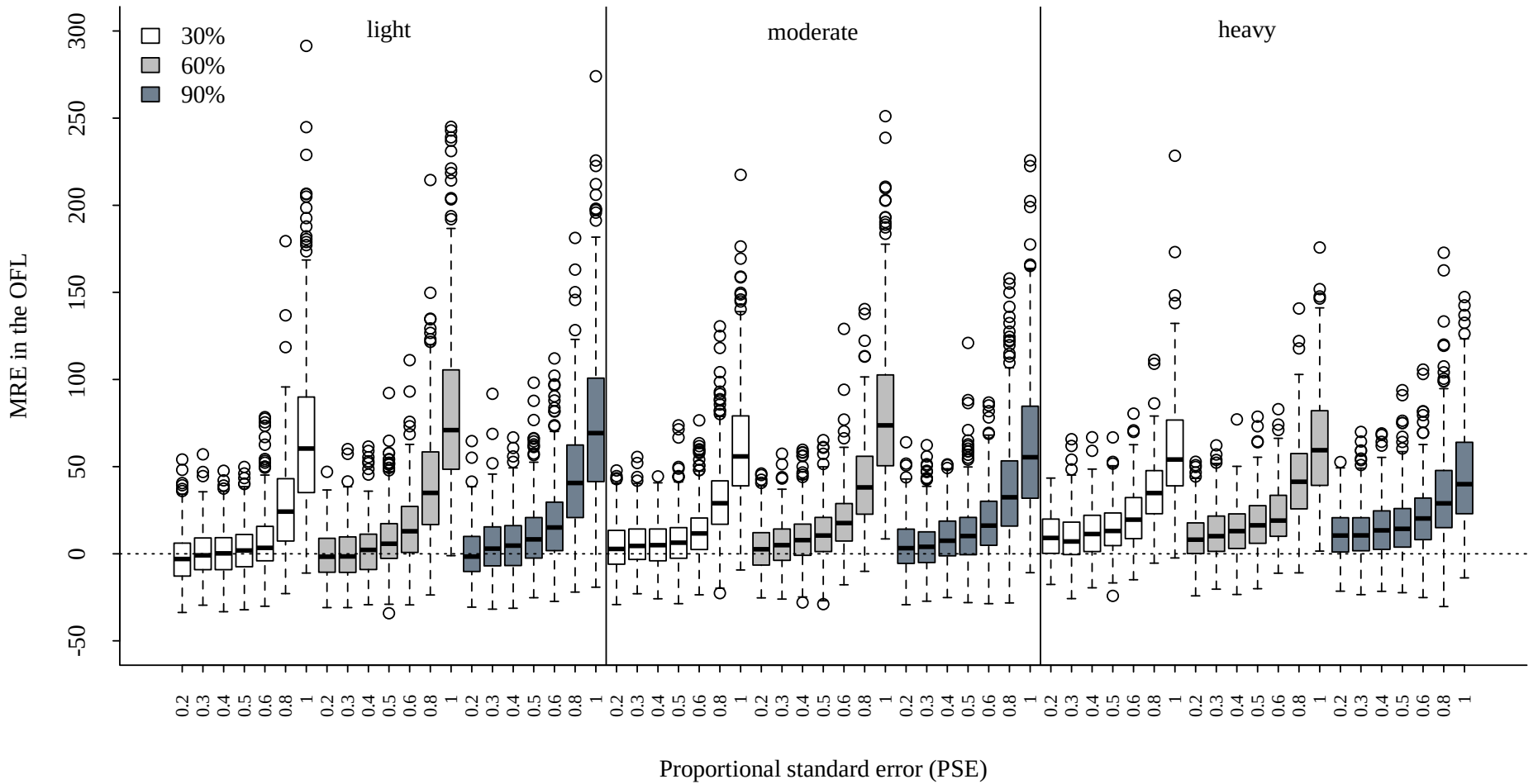


MARE in F_{Rec} : Medium LH

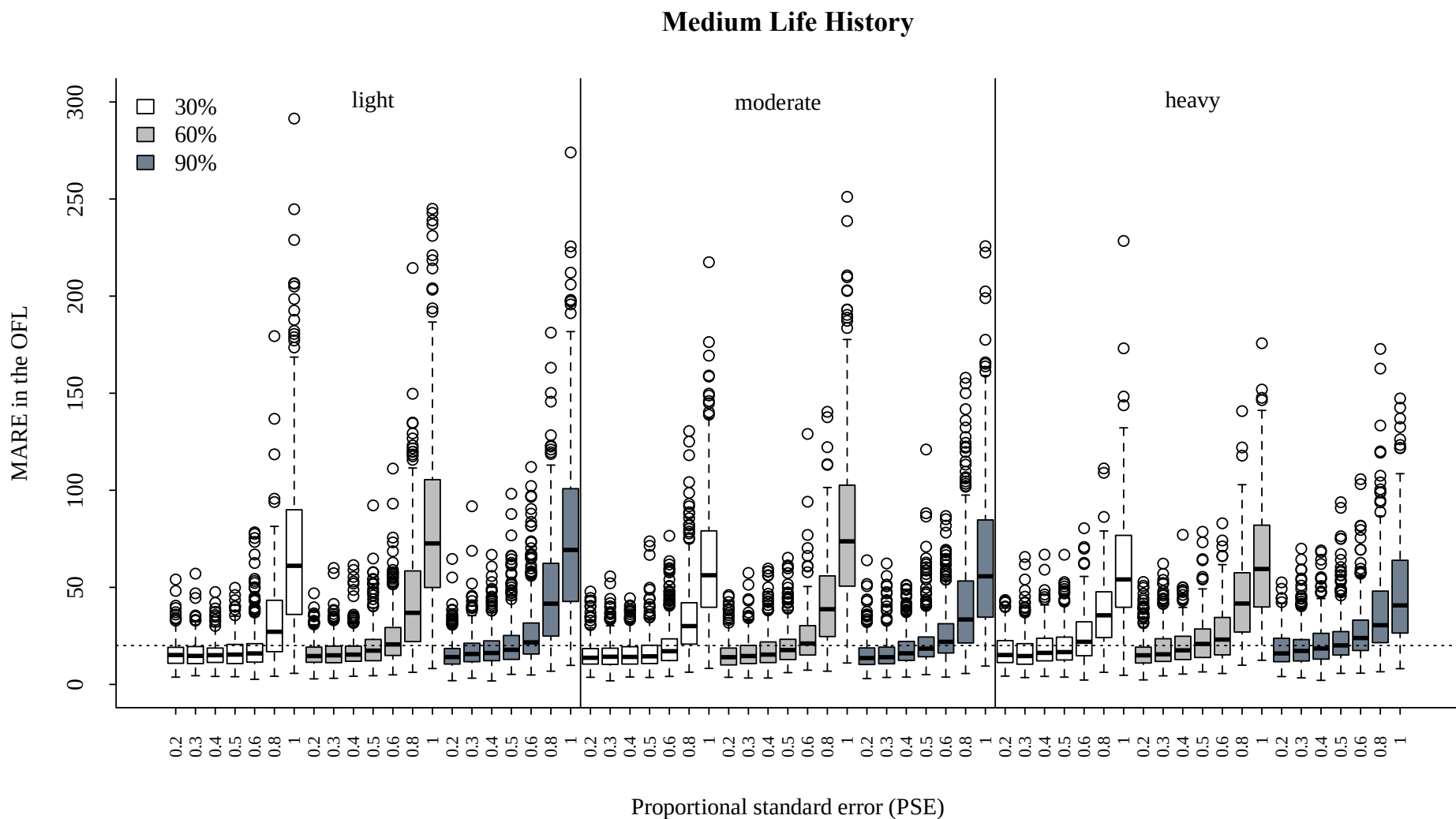


MRE in OFL: Medium LH

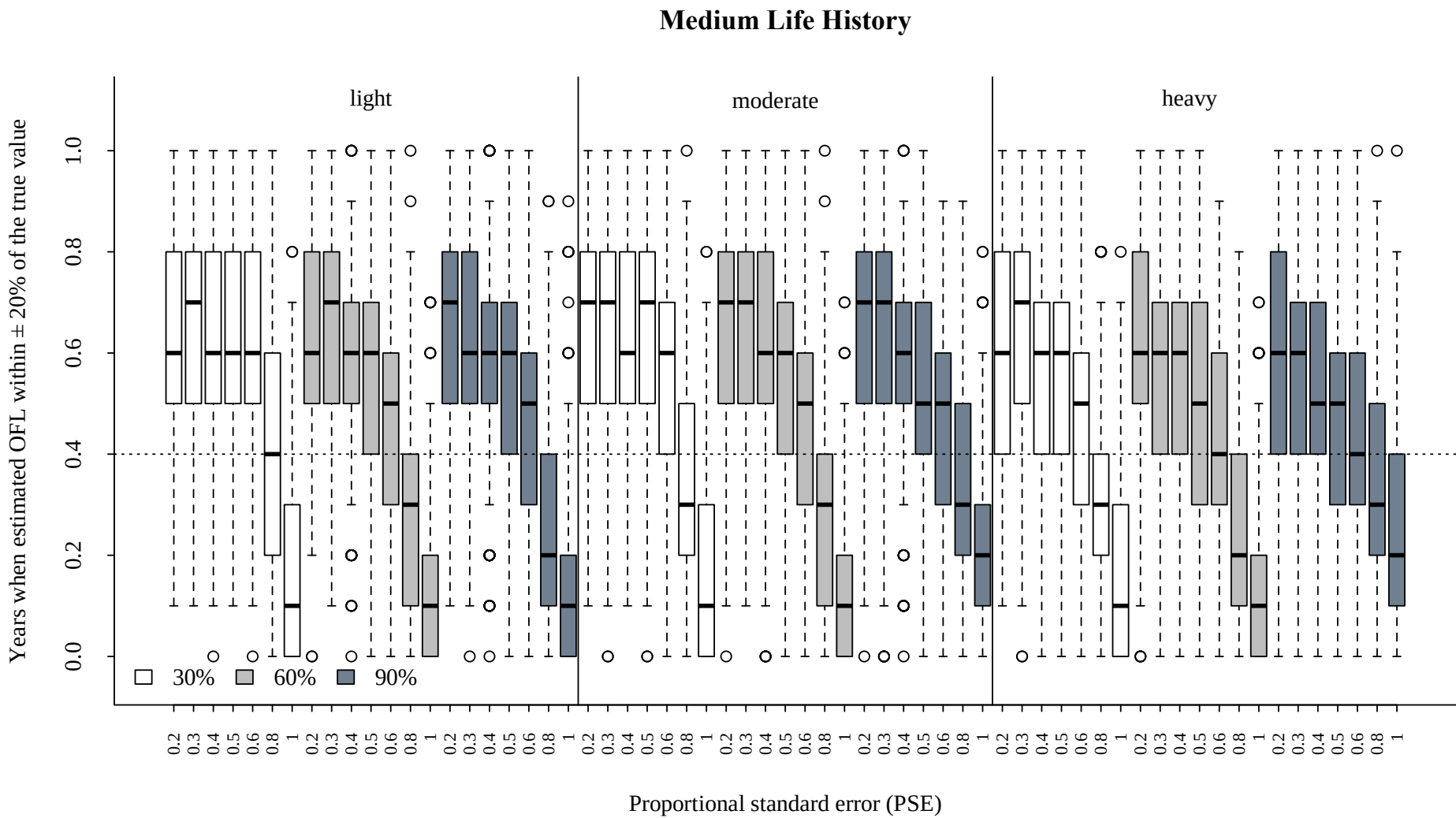
Medium Life History



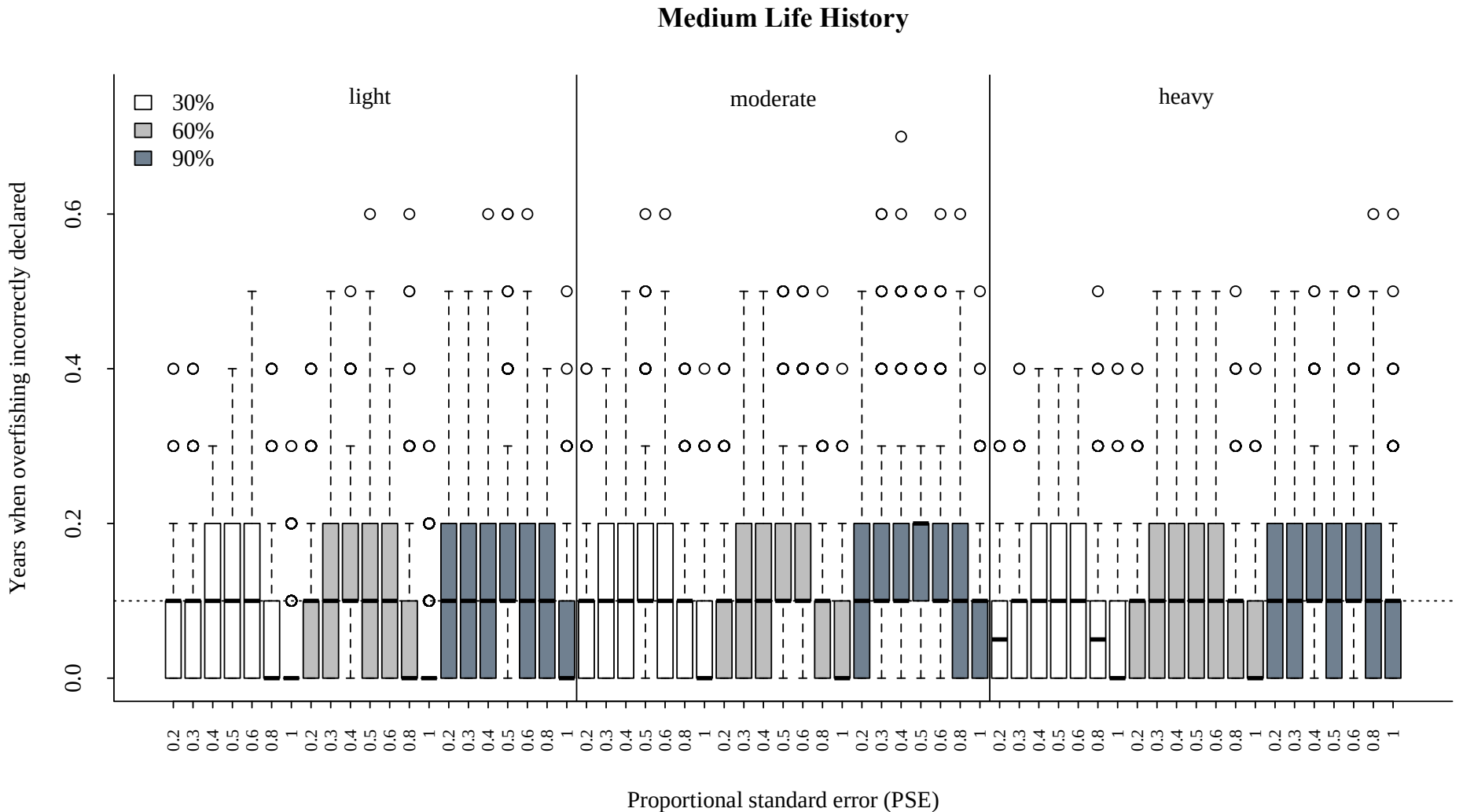
MARE in OFL: Medium LH



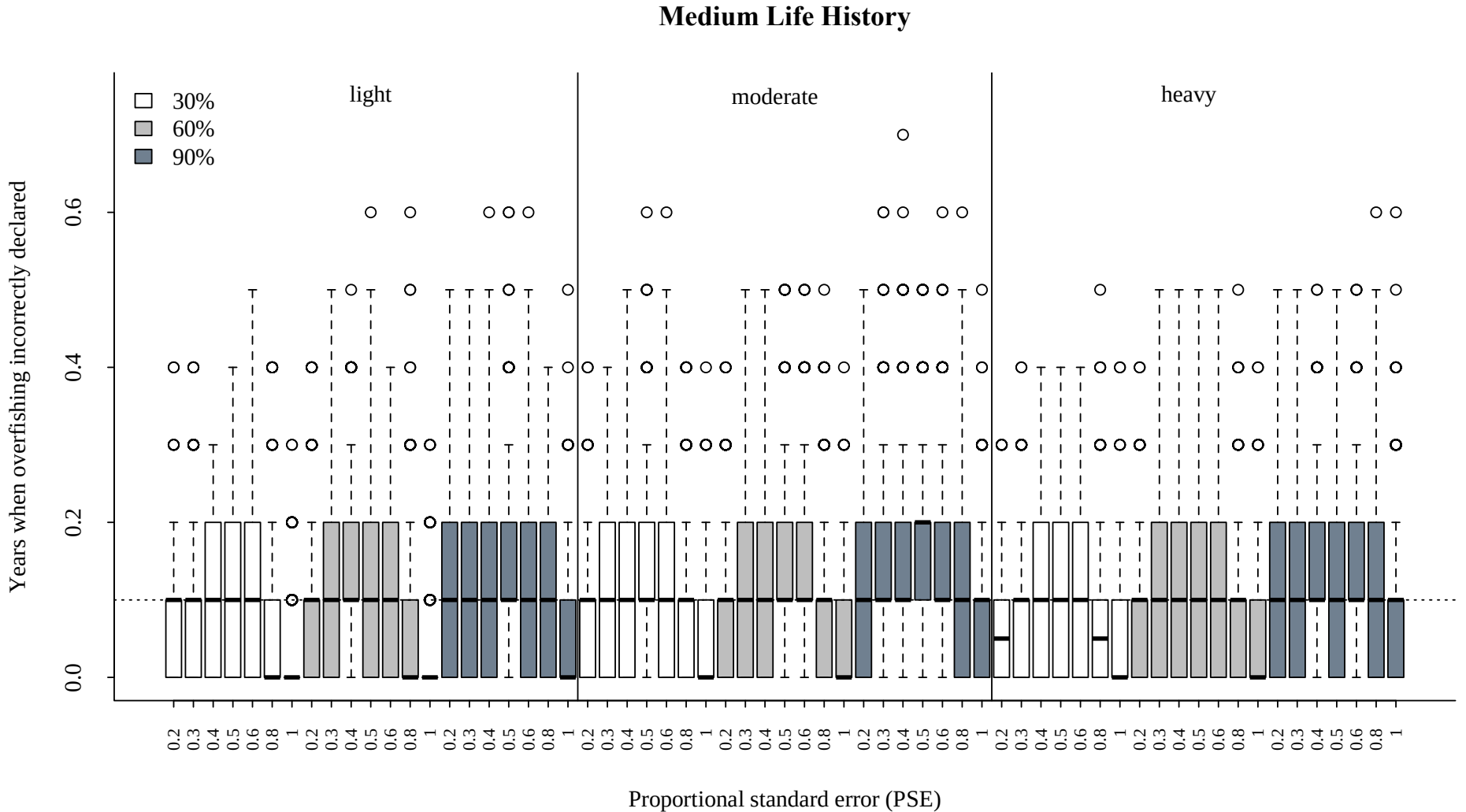
OFL Estimates +/- 20% (Prop.) : Medium LH



Overfishing False Positives (Prop.) : Medium LH



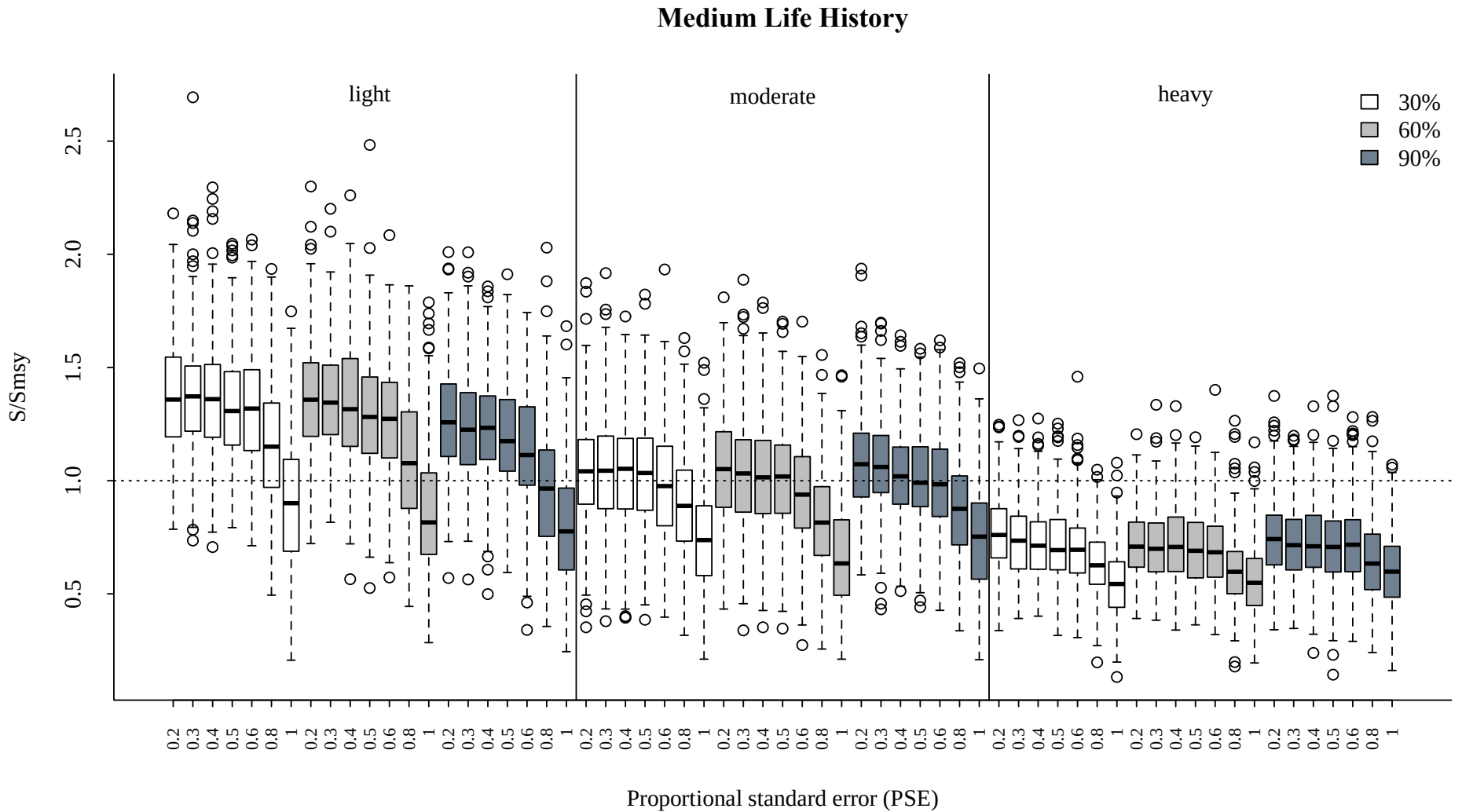
Overfishing False Negatives (Prop.) : Medium LH



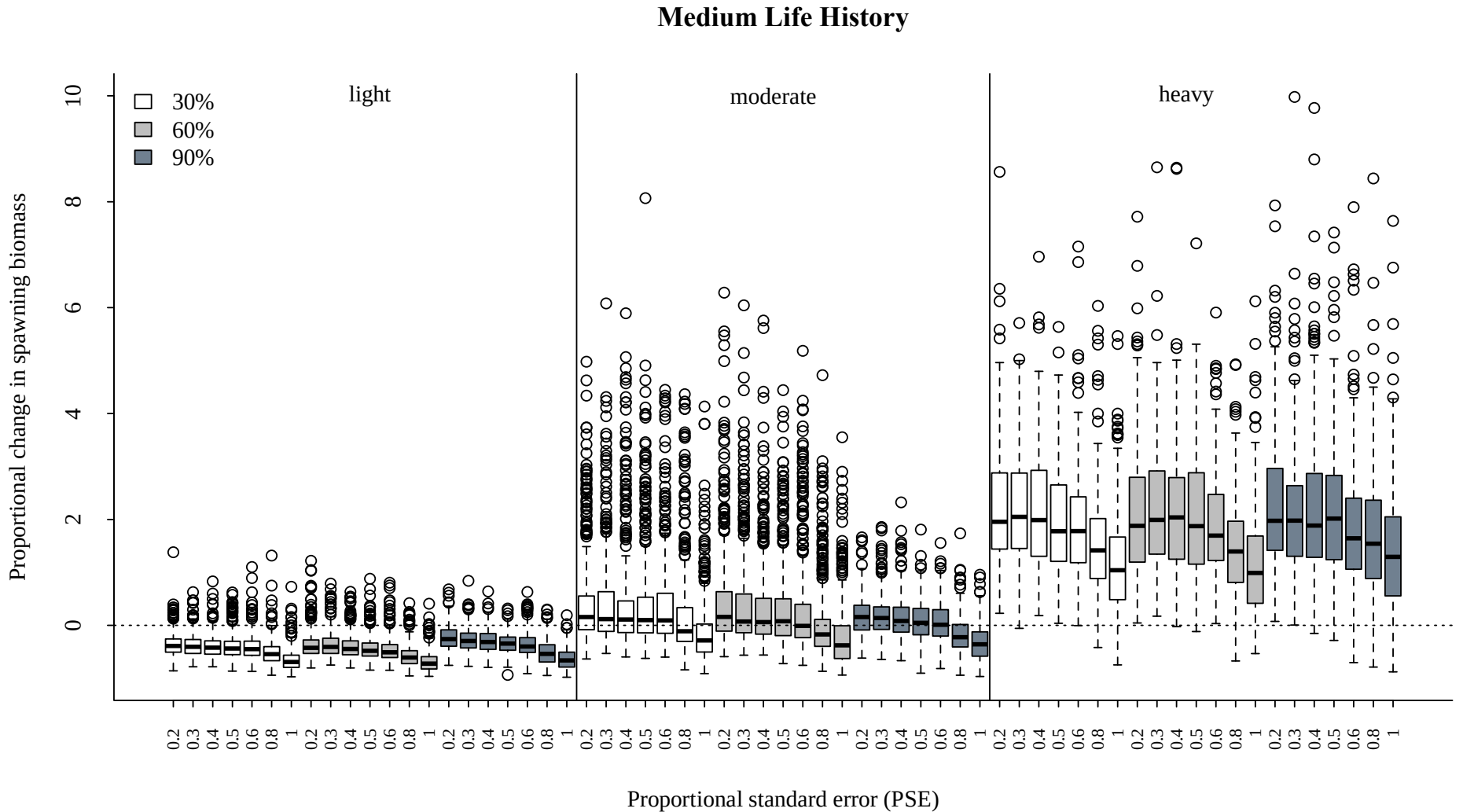
Population and Fishery Dynamics

Performance Measures

Mean S / S_{MSY} : Medium LH

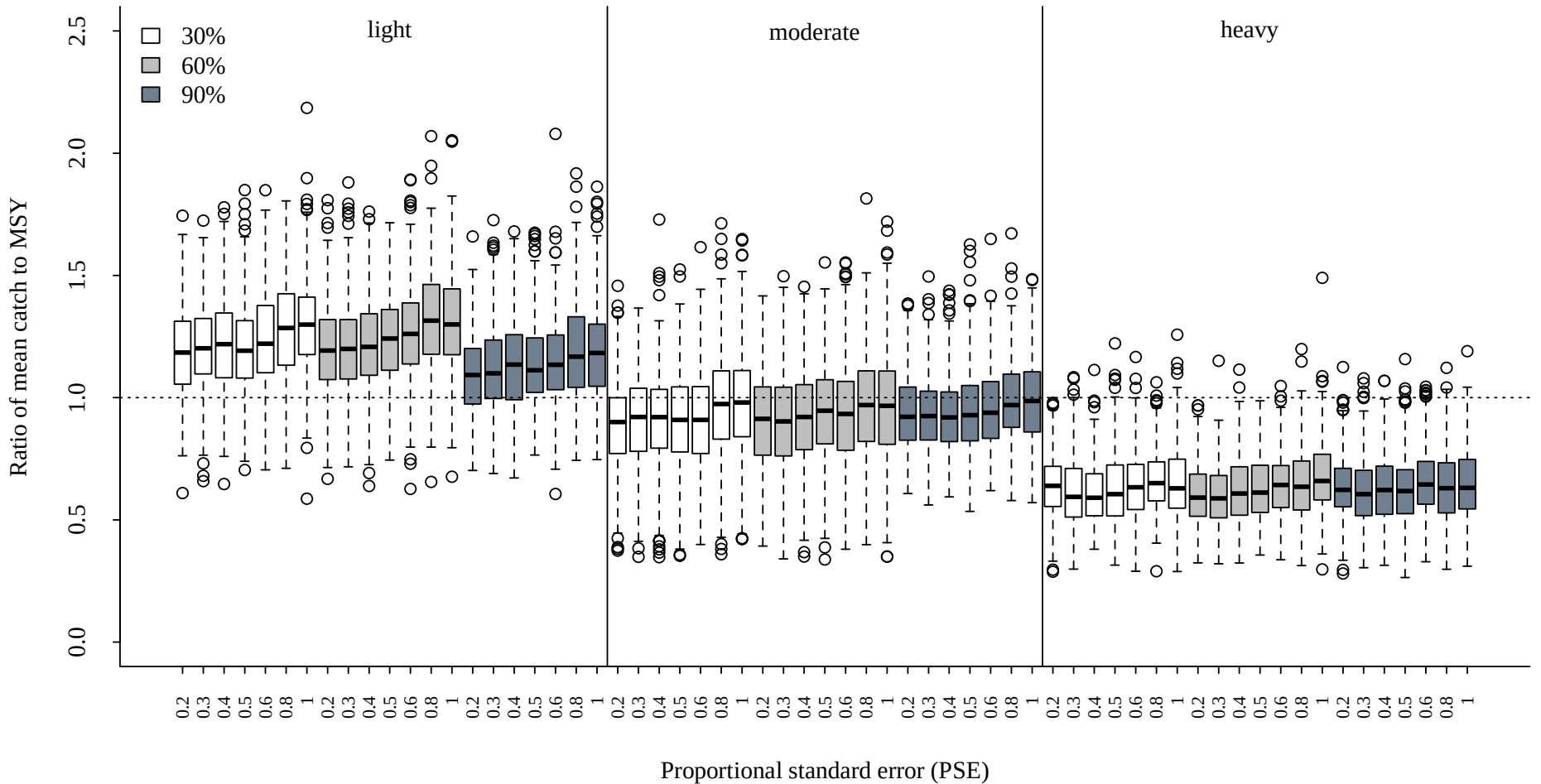


Change in Biomass (Prop.) : Medium LH

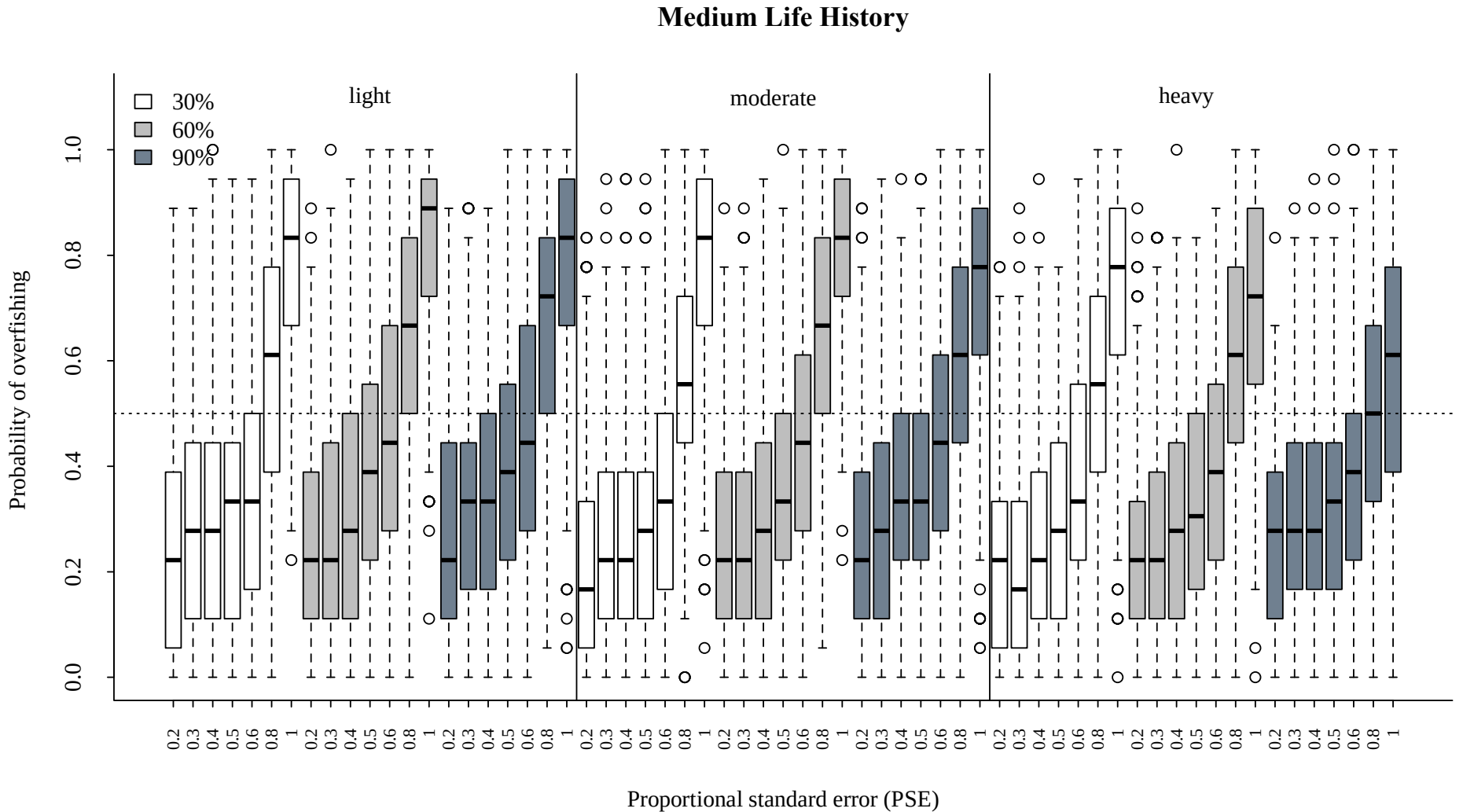


Mean Catch / MSY : Medium LH

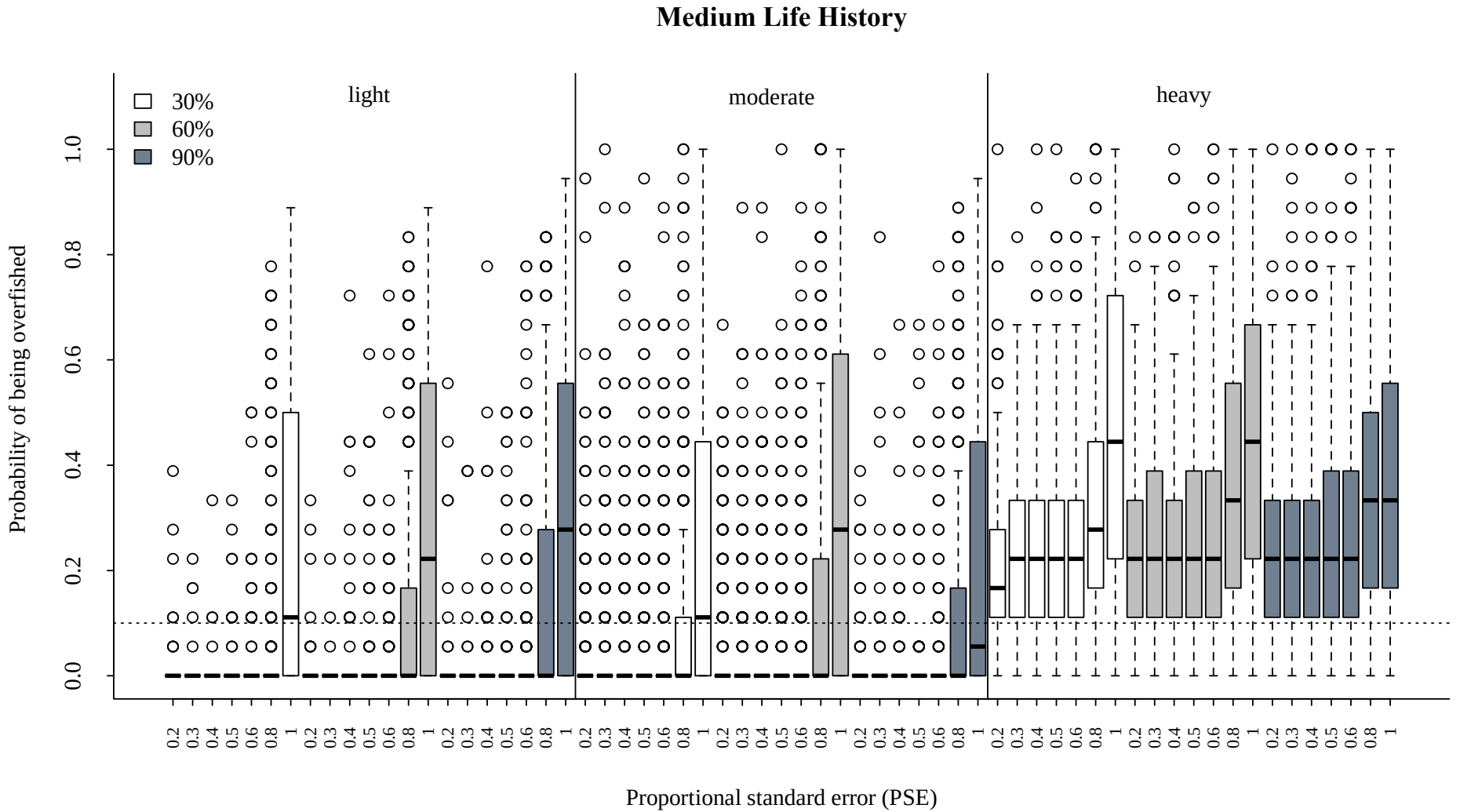
Medium Life History



Overfishing Probability : Medium LH



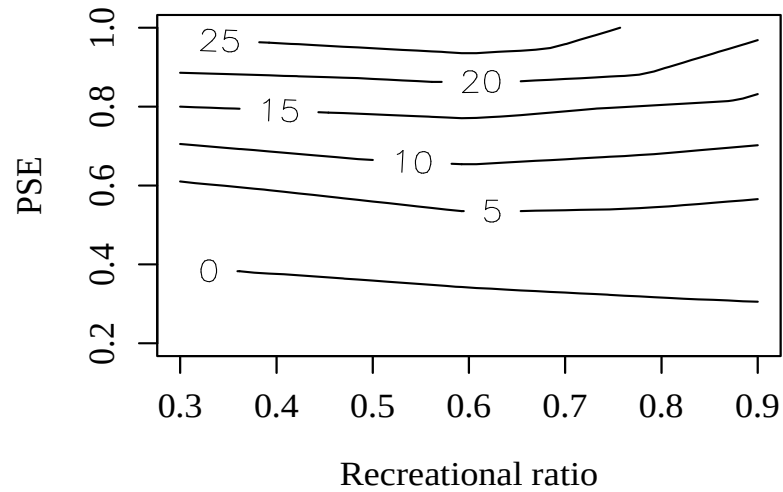
Overfished Probability : Medium LH



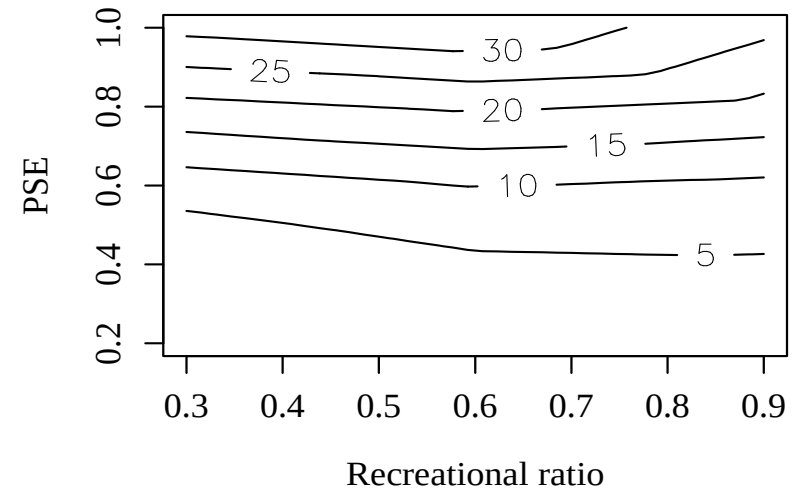
Beyond the Boxplot: Contours

MRE / MARE in Biomass and Recruitment : Fast LH

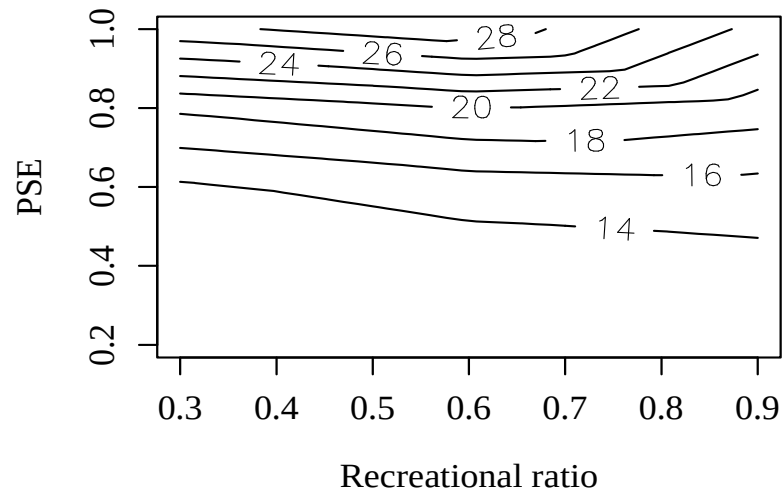
MRE of Spawning Biomass



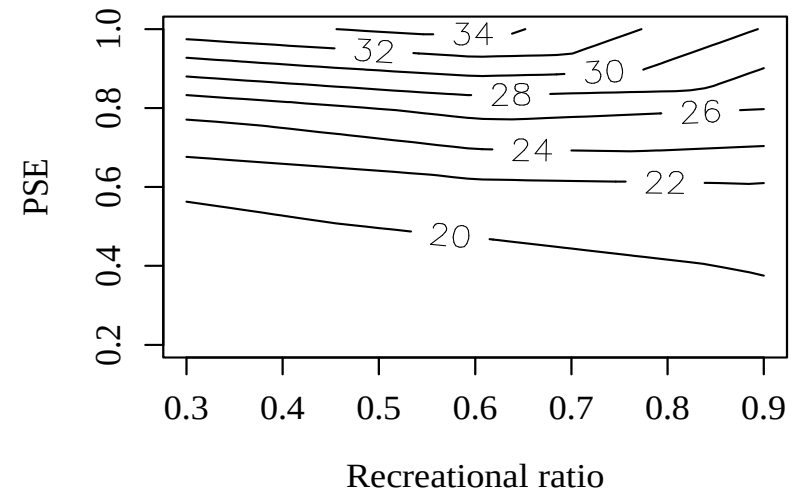
MRE of Recruitment



MARE of Spawning Biomass

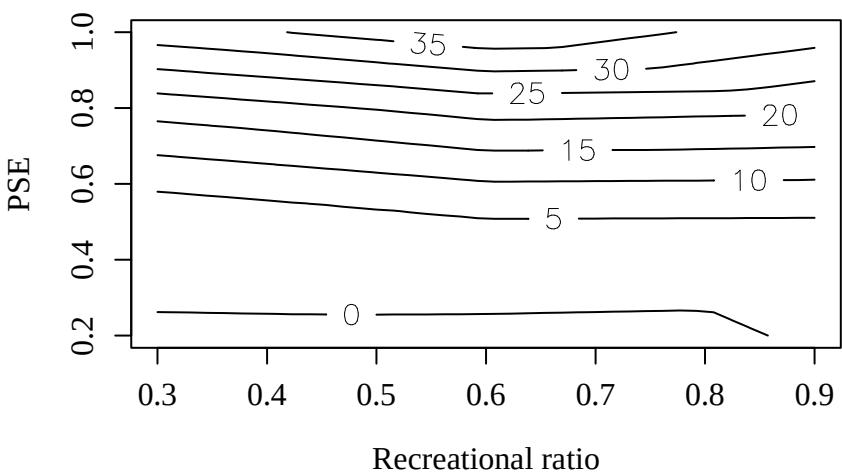


MARE of Recruitment

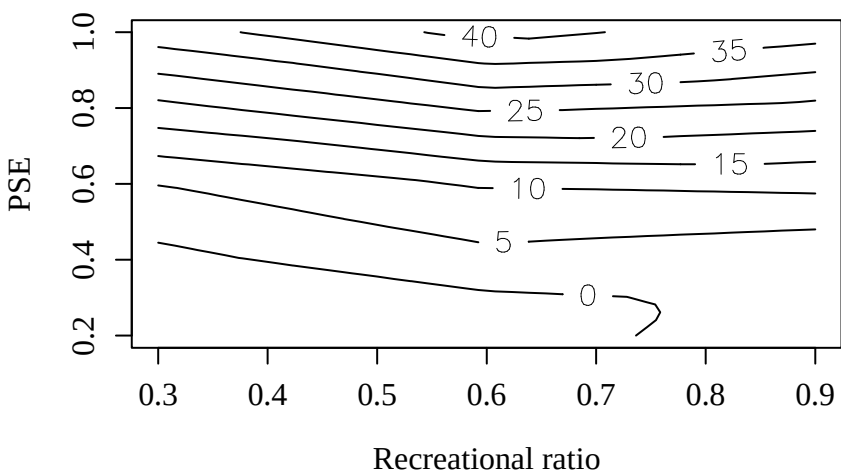


MRE / MARE in Biomass and Recruitment : Medium LH

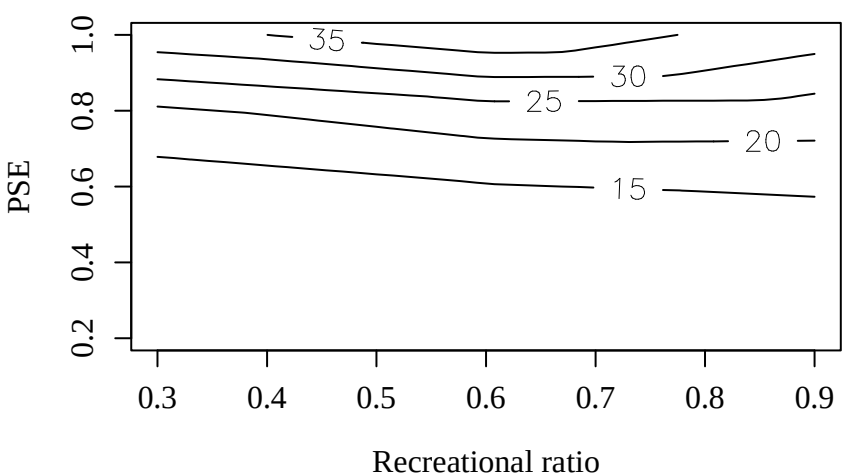
MRE of Spawning Biomass



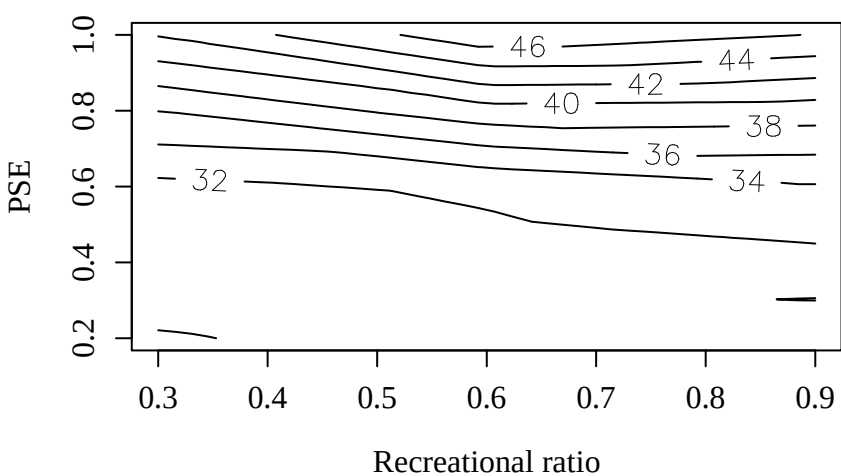
MRE of Recruitment



MARE of Spawning Biomass

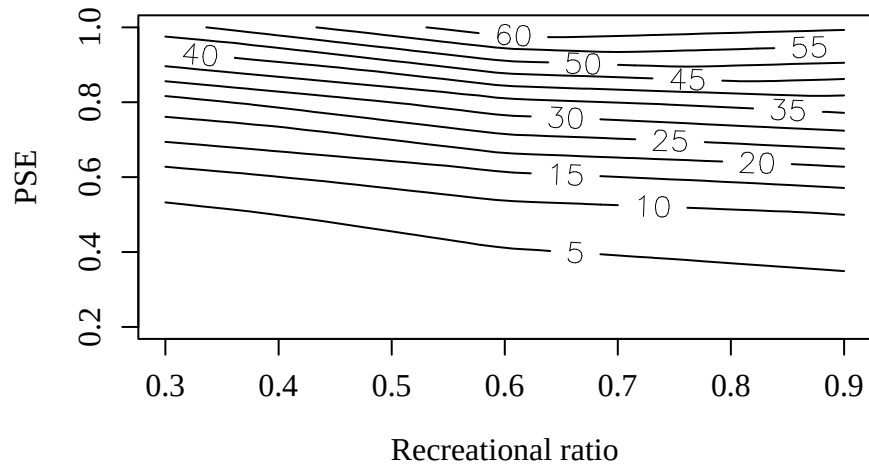


MARE of Recruitment

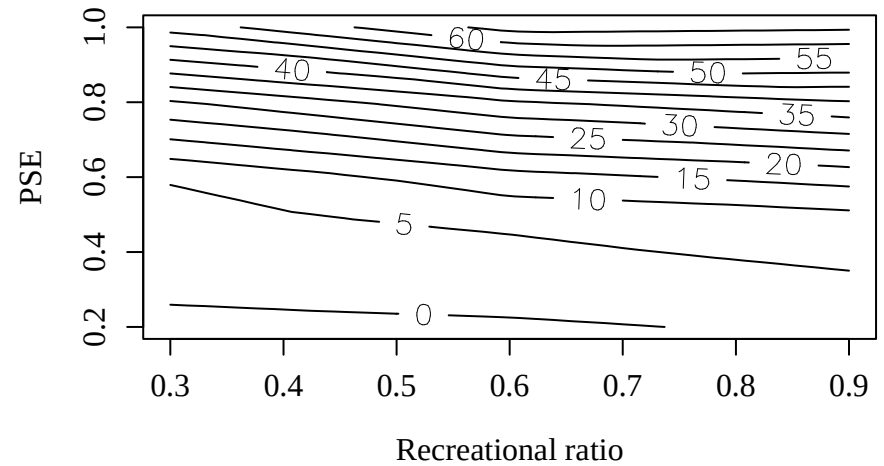


MRE / MARE in Biomass and Recruitment : Slow LH

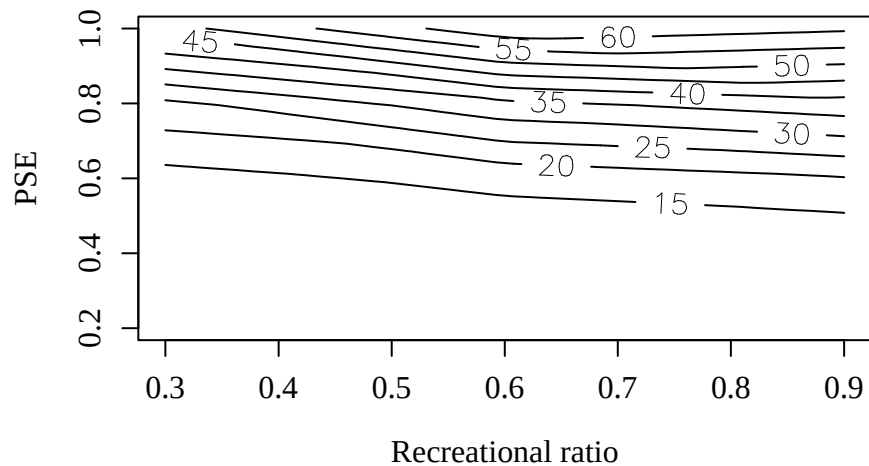
MRE of Spawning Biomass



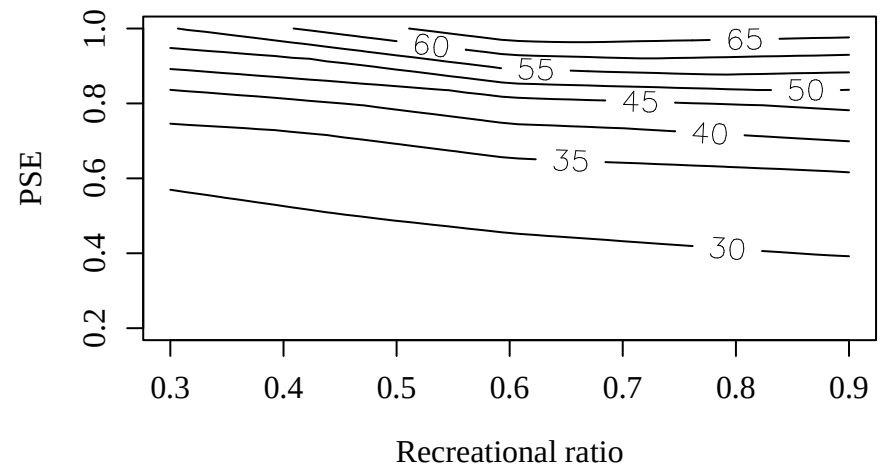
MRE of Recruitment



MARE of Spawning Biomass

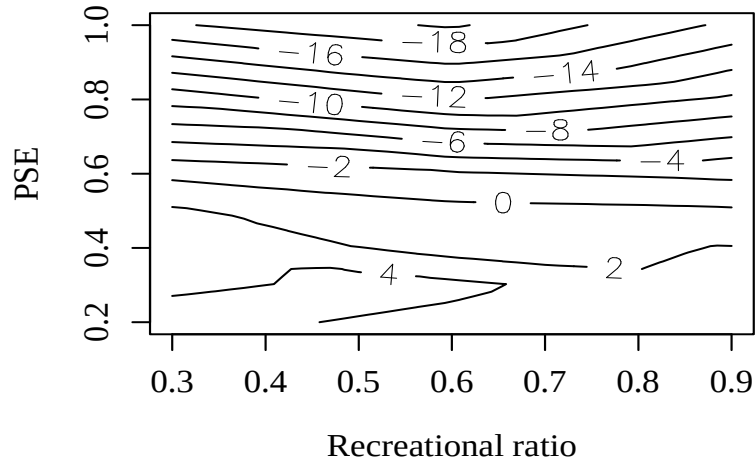


MARE of Recruitment

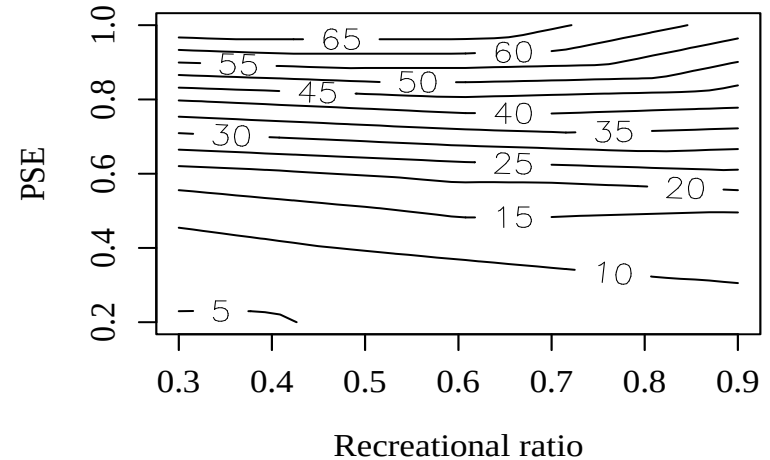


MRE / MARE in F and OFL: Fast LH

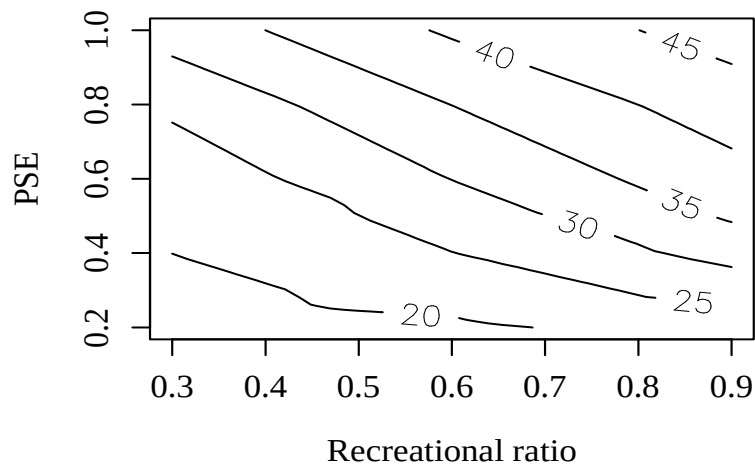
MRE of total F



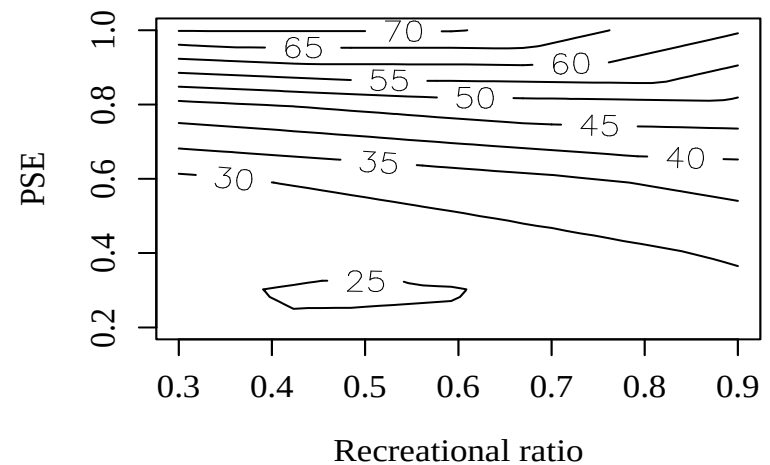
MRE of the OFL



MARE of total F

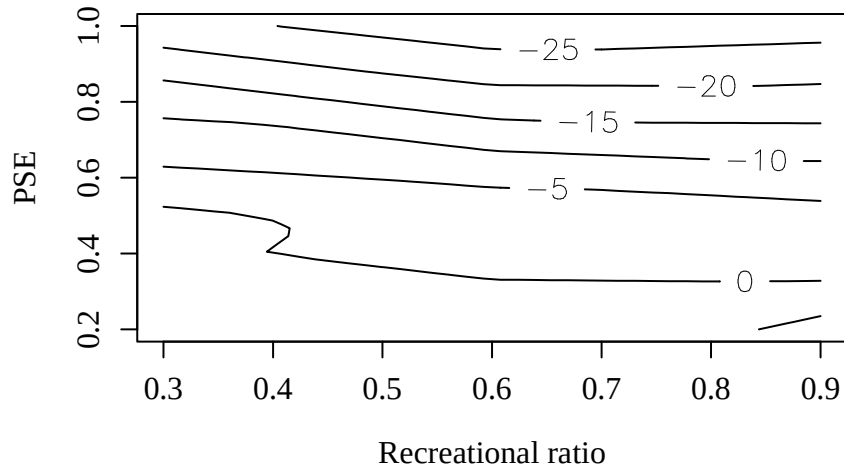


MARE of the OFL

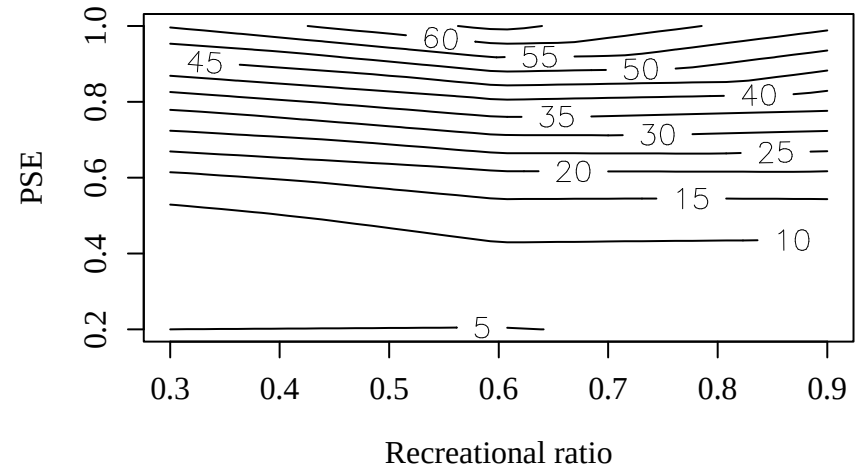


MRE / MARE in F and OFL: Medium LH

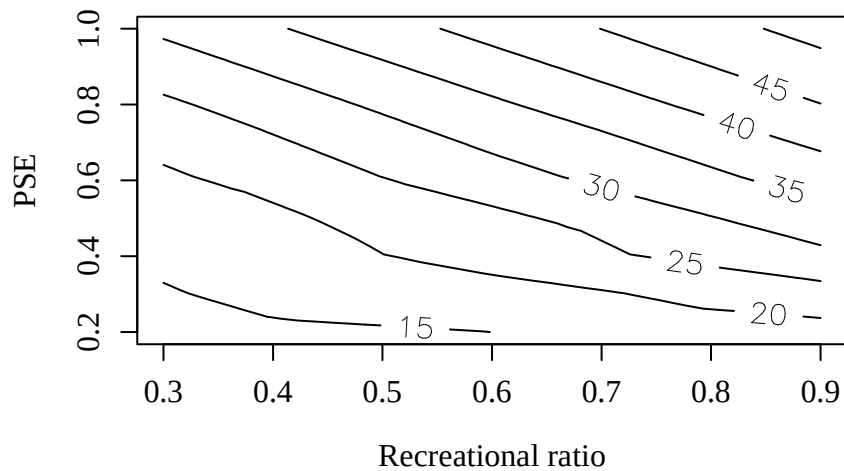
MRE of total F



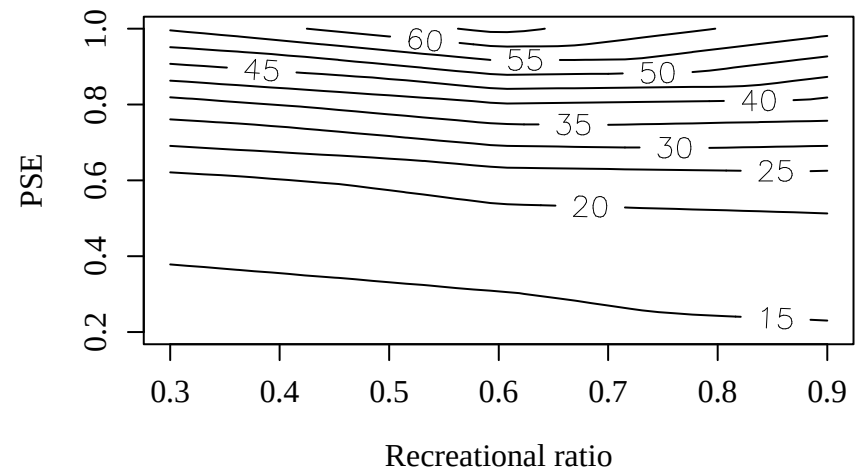
MRE of the OFL



MARE of total F

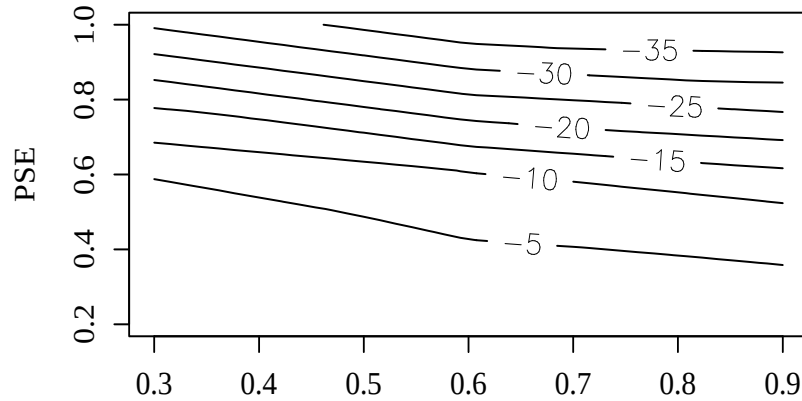


MARE of the OFL



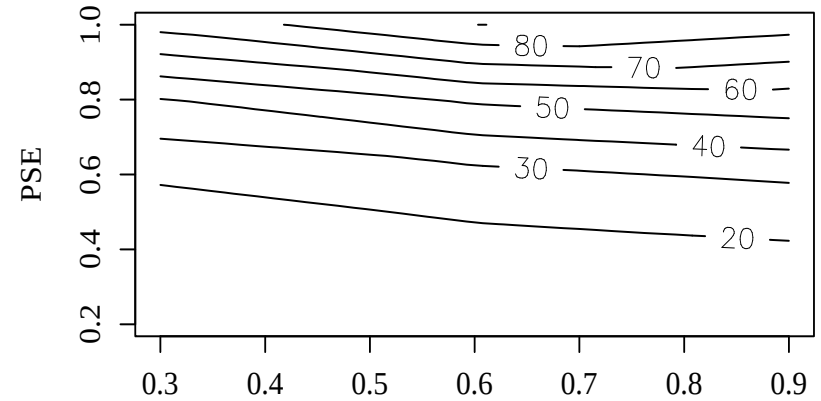
MRE / MARE in F and OFL : Slow LH

MRE of total F



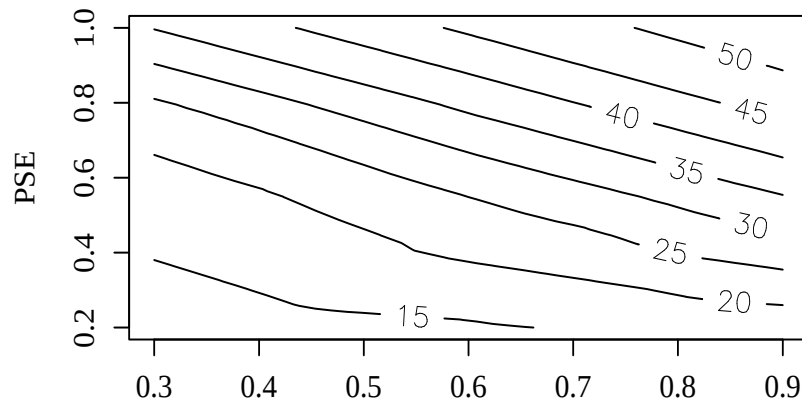
Recreational ratio

MRE of the OFL



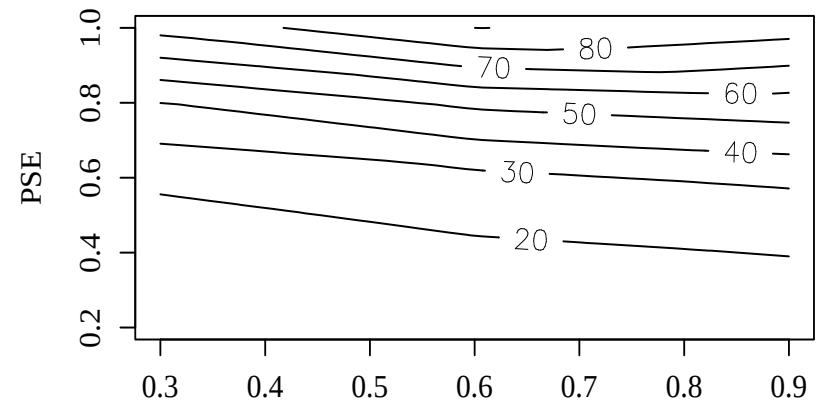
Recreational ratio

MARE of total F



Recreational ratio

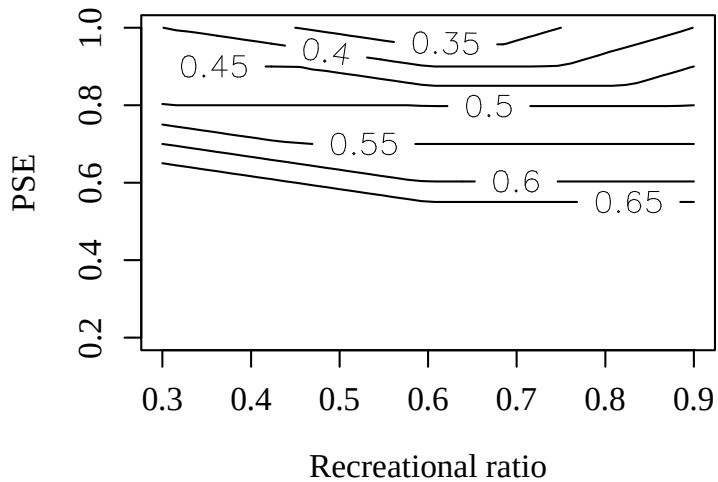
MARE of the OFL



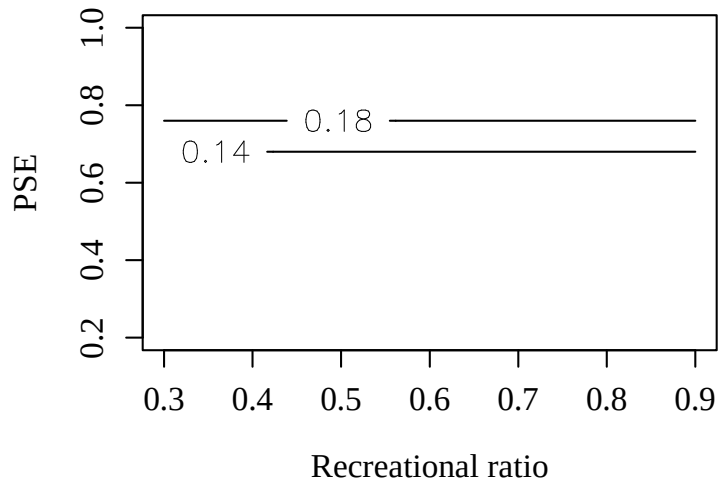
Recreational ratio

Fast LH

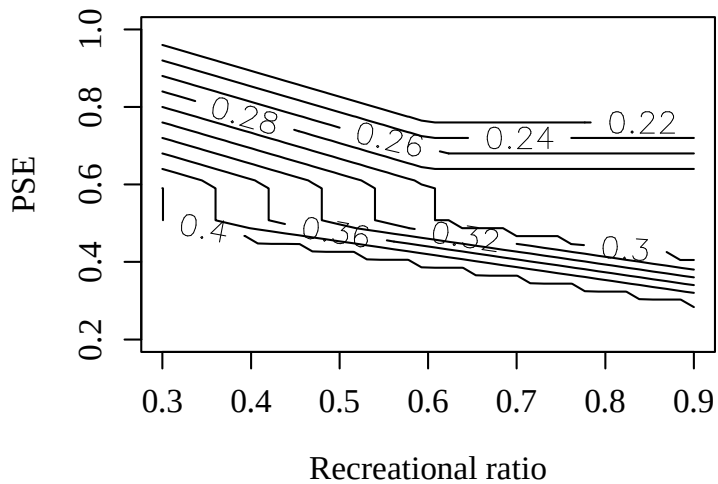
Years with S within $\pm 20\%$



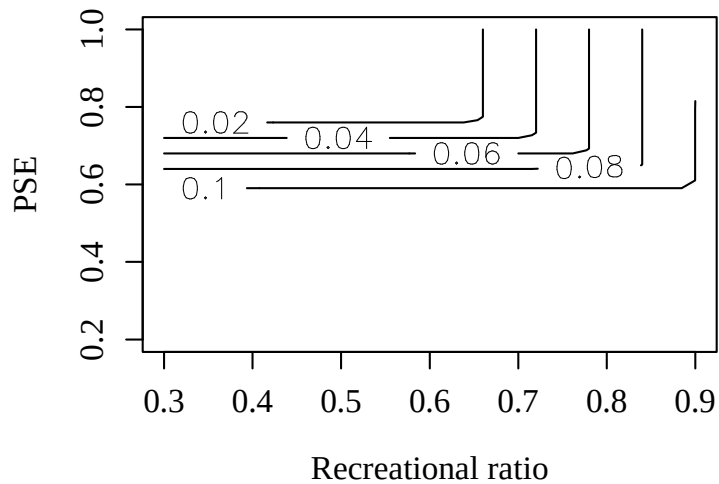
Years with Overfishing false negatives



Years with OFL within $\pm 20\%$

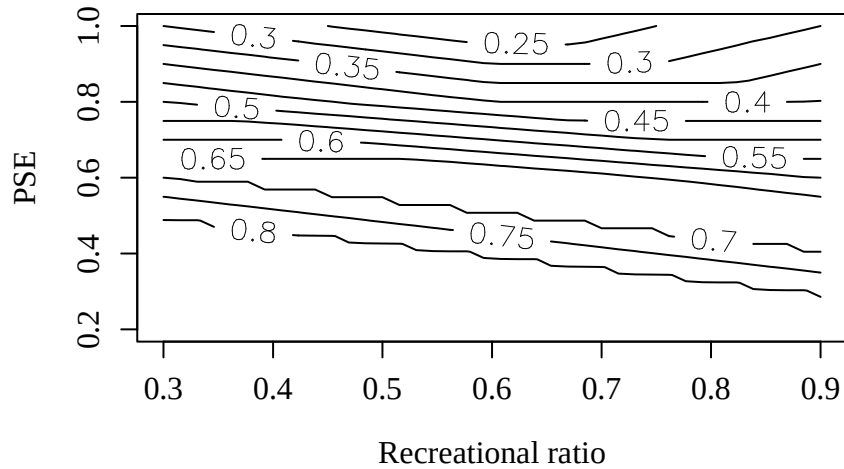


Years with overfishing false positives

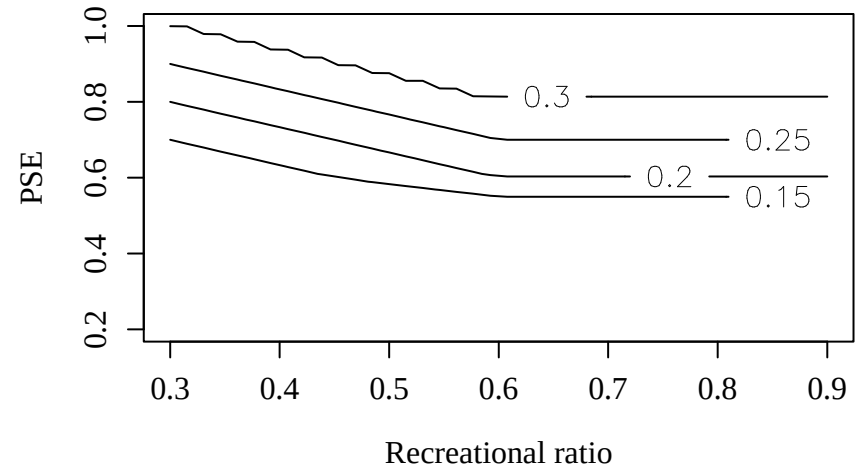


Medium LH

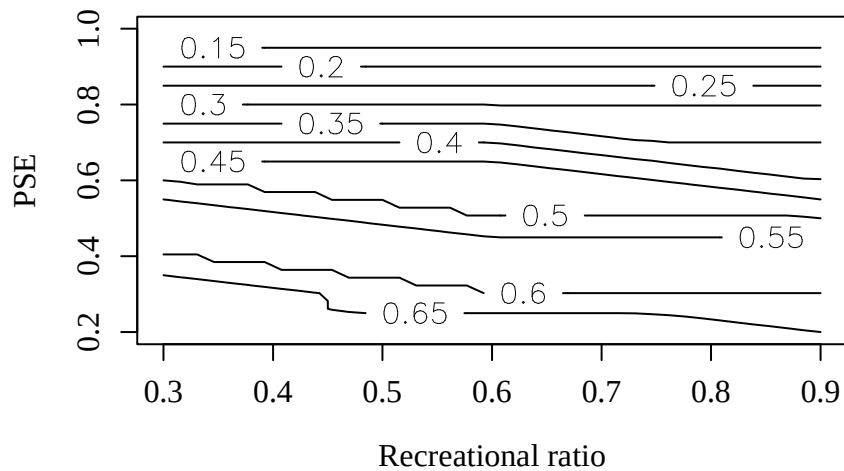
Years with S within $\pm 20\%$



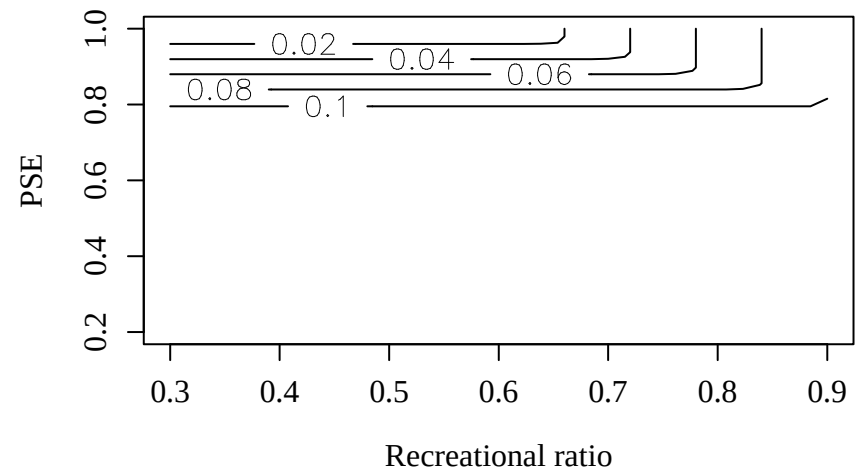
Years with Overfishing false negatives



Years with OFL within $\pm 20\%$

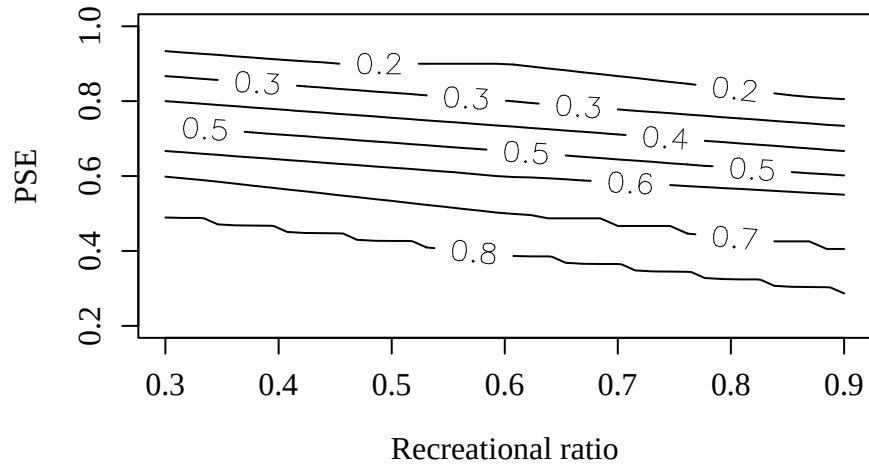


Years with overfishing false positives

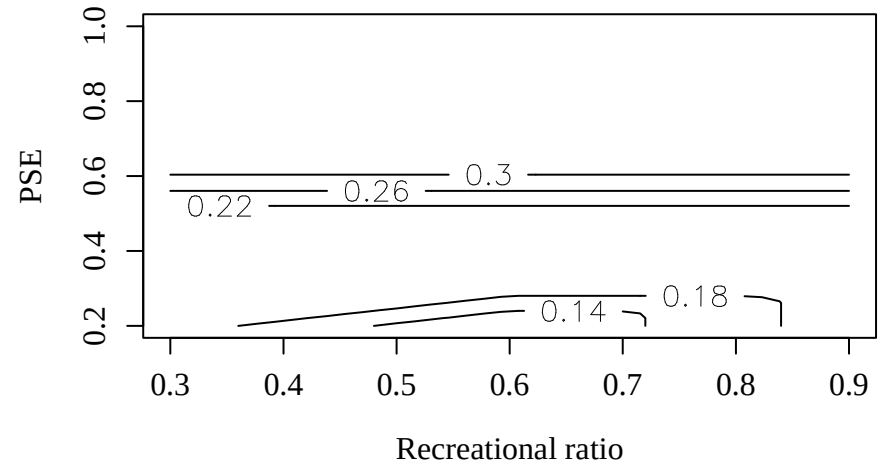


Slow LH

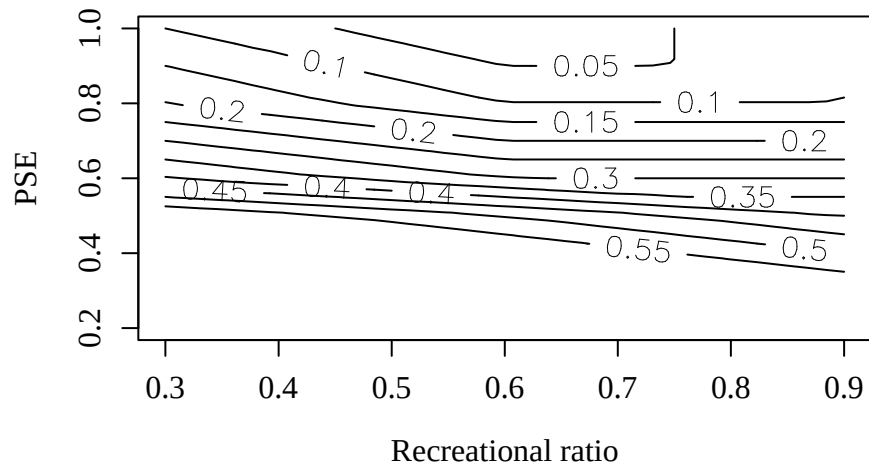
Years with S within $\pm 20\%$



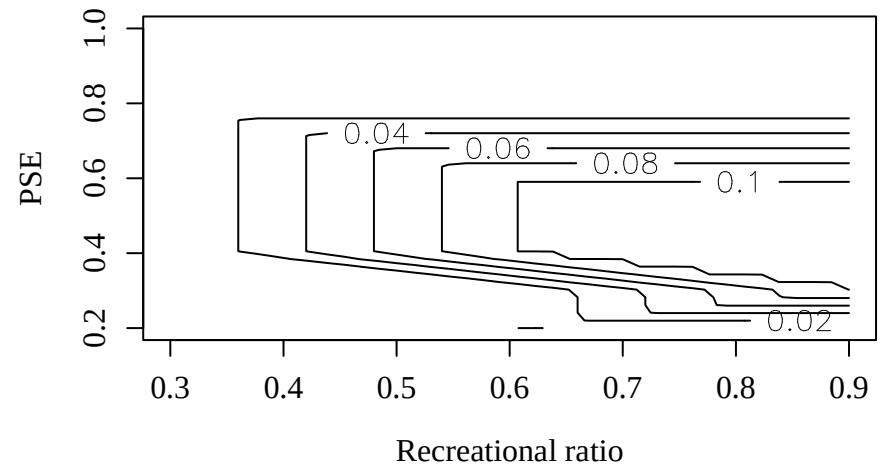
Years with Overfishing false negatives



Years with OFL within $\pm 20\%$



Years with overfishing false positives



Sensitivity Run: Model Misspecification

- M assumed fixed in assessment model
- Extreme error for PSEs > 0.6
- Increased overfishing risk for PSEs > 0.3

Conclusions

- PSEs ≥ 0.6 result in biased estimates across all model scenarios
 - Increasing bias with increasing PSE above threshold
- Thresholds for unbiased estimates $\leq 0.4 - 0.6$
 - Lower thresholds for heavy exploitation
 - Lower thresholds for recreational fisheries $\leq 60\%$
- Increased uncertainty going from fast to slow LH

Conclusions

- PSEs ≥ 0.6 result in biased estimates across all model scenarios
 - Increasing bias with increasing PSE above threshold
 - Exacerbated by model misspecification
- Thresholds for unbiased estimates $\leq 0.4 - 0.6$
 - Higher thresholds for heavy exploitation
 - Higher thresholds for recreational fisheries $\leq 60\%$
- Increased uncertainty going from fast to slow LH

Threshold PSEs May Be Lower Because...

- Increased recruitment variability
- Higher uncertainty in other assessment inputs
 - Survey
 - Commercial Landings
 - Ageing error
- Model misspecification
 - Changing catchability
 - Varying selectivity
 - Trends in M or steepness

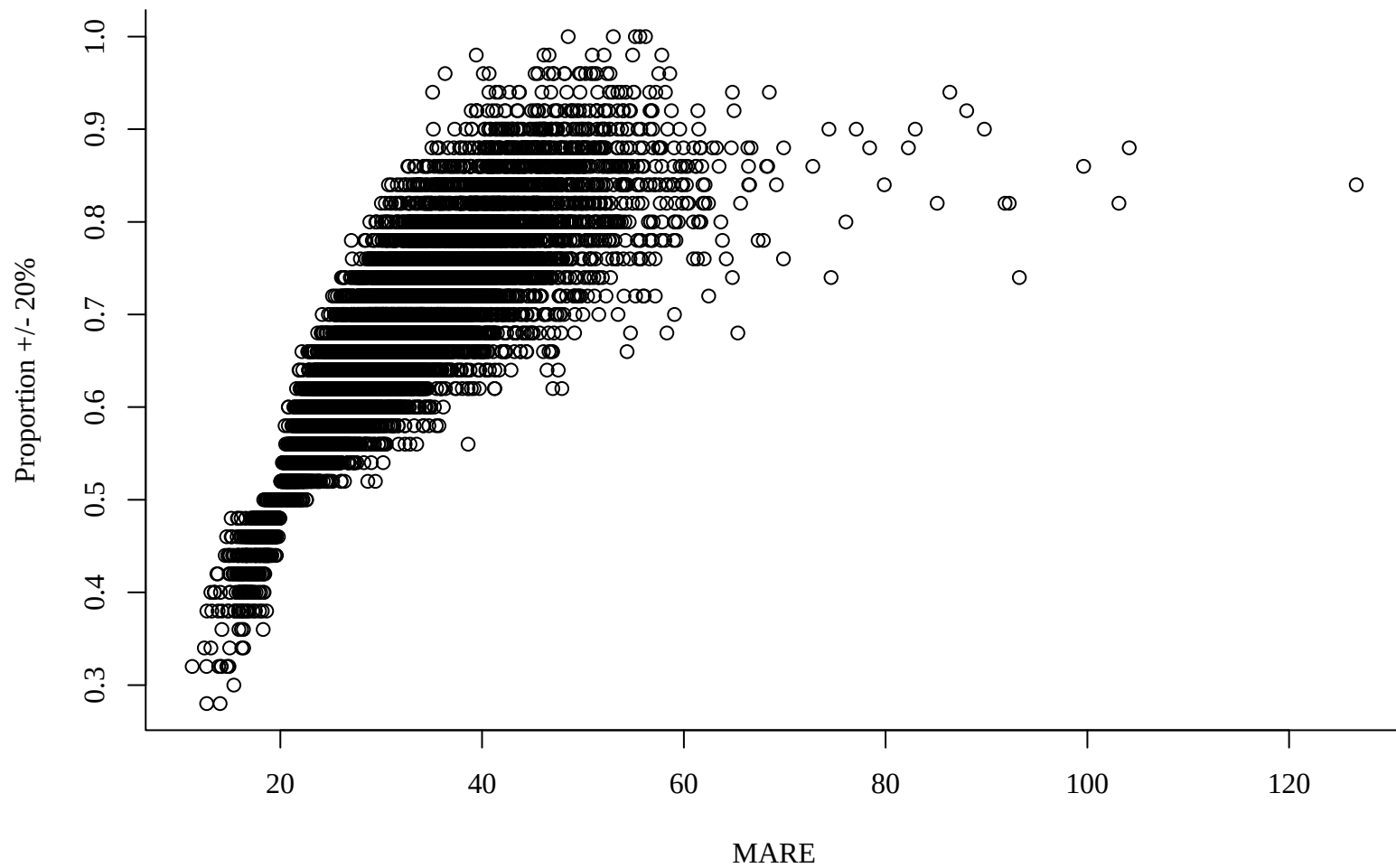
Threshold PSEs May Be Higher Because...

- Automated assessment process
 - Data filtering prior to assessment
 - Data weighting in assessment
 - Assessment diagnostics

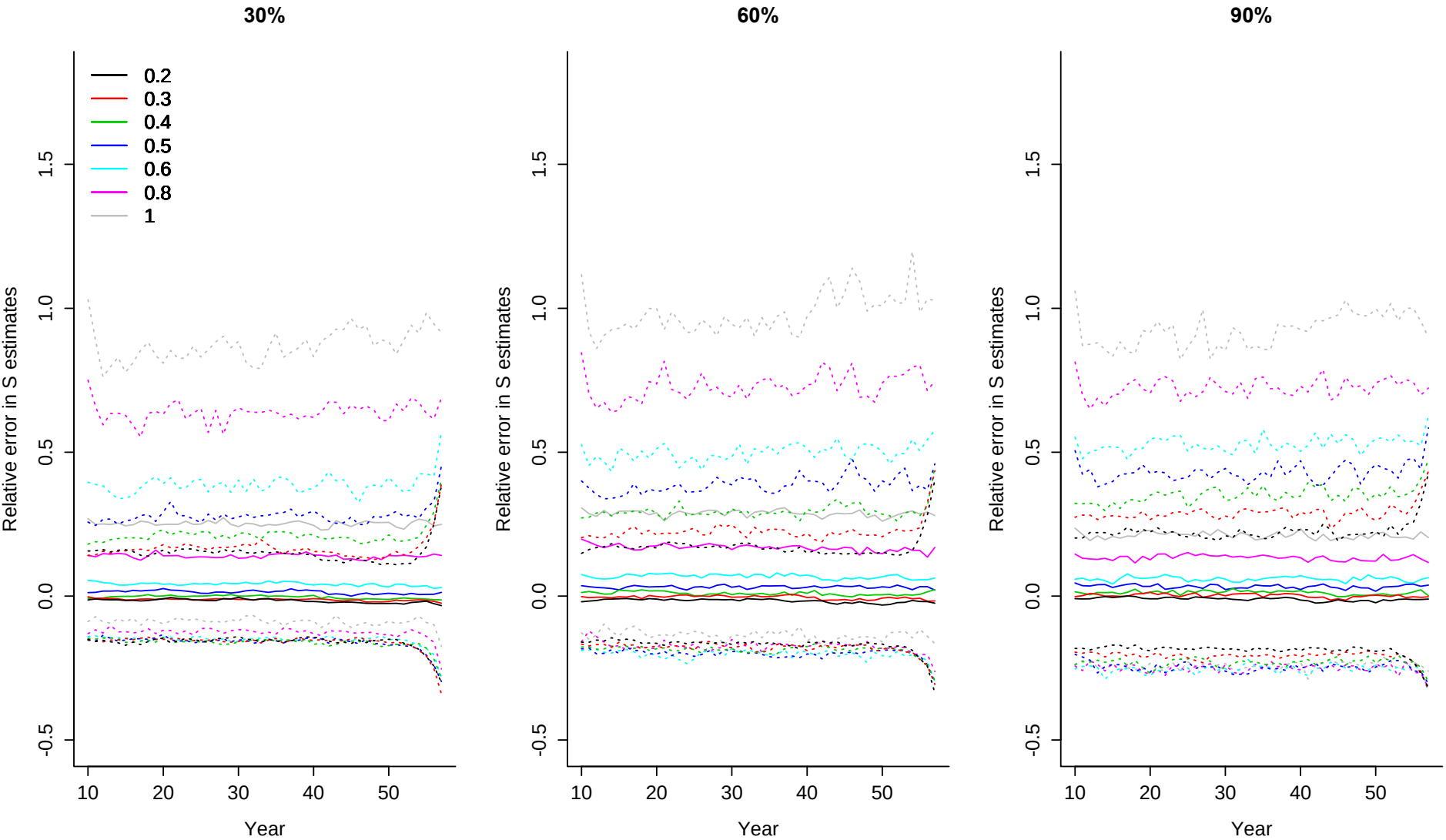
Caveats

- Population and fishery dynamics only explored for 20 years
- Same PSE value f across *all* years
- Effect of PSEs on interpretation of management success not explored
 - State-specific harvests relative to catch limit

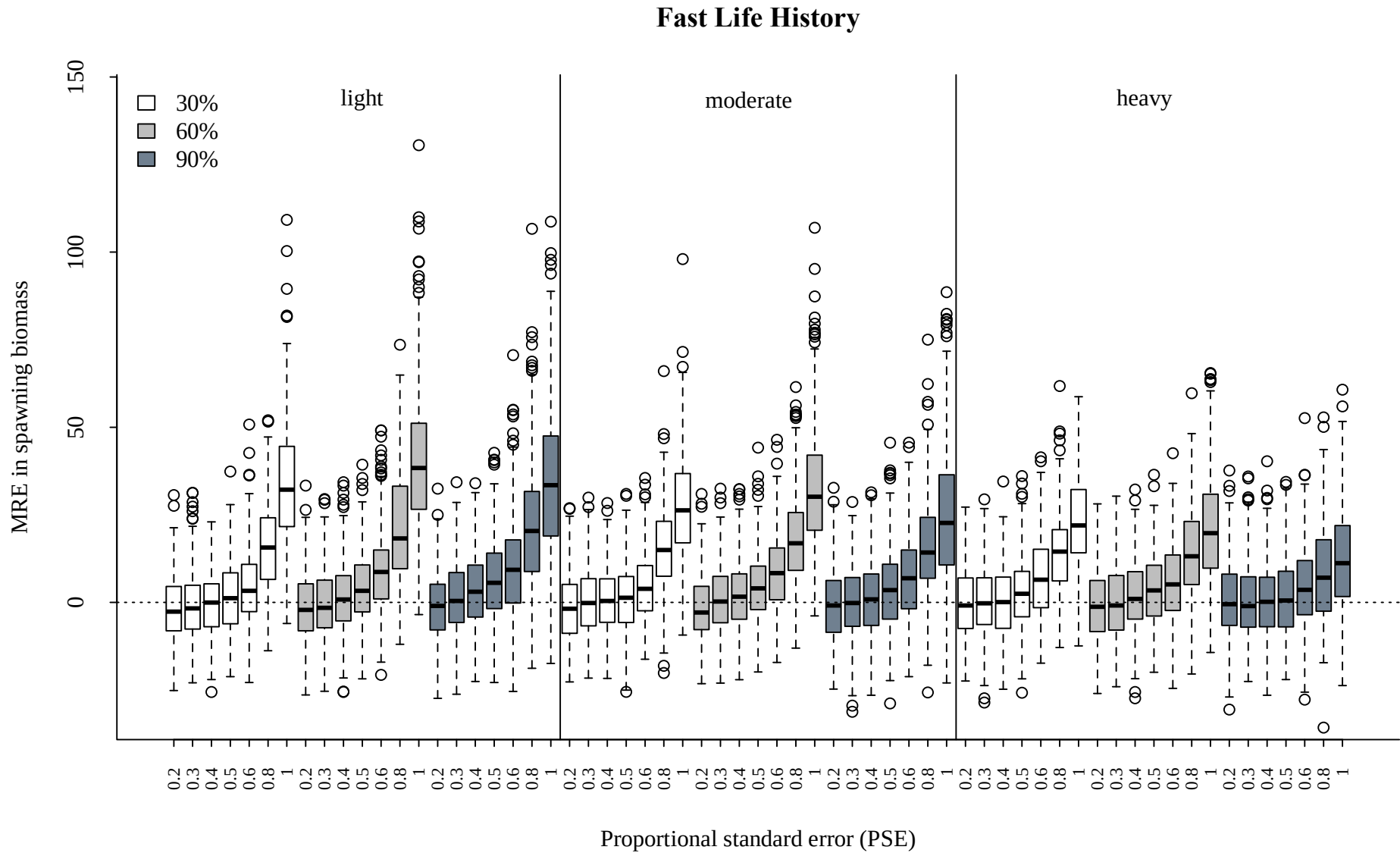
Extra Figures



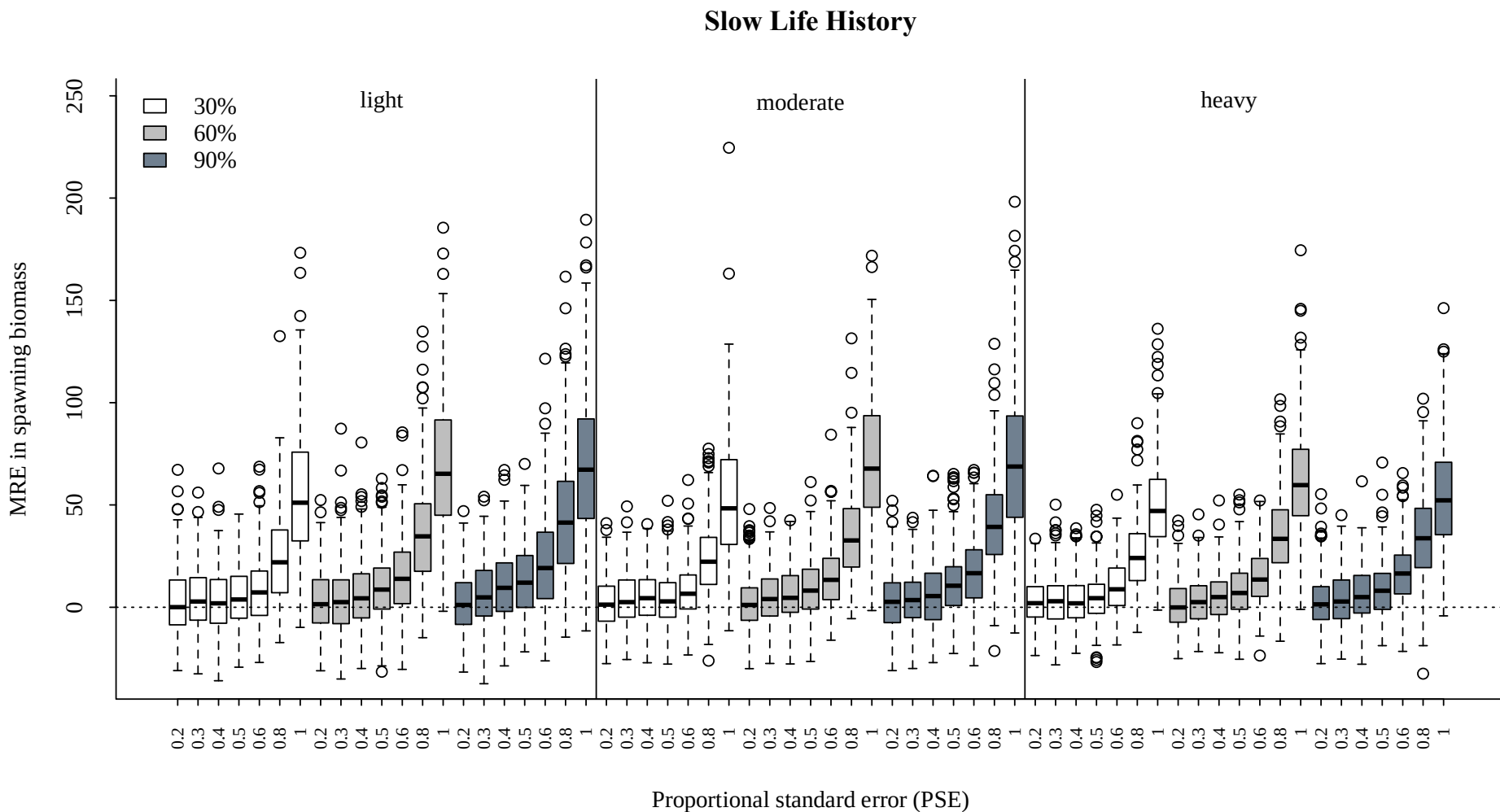
Error Over Time: Fast LH



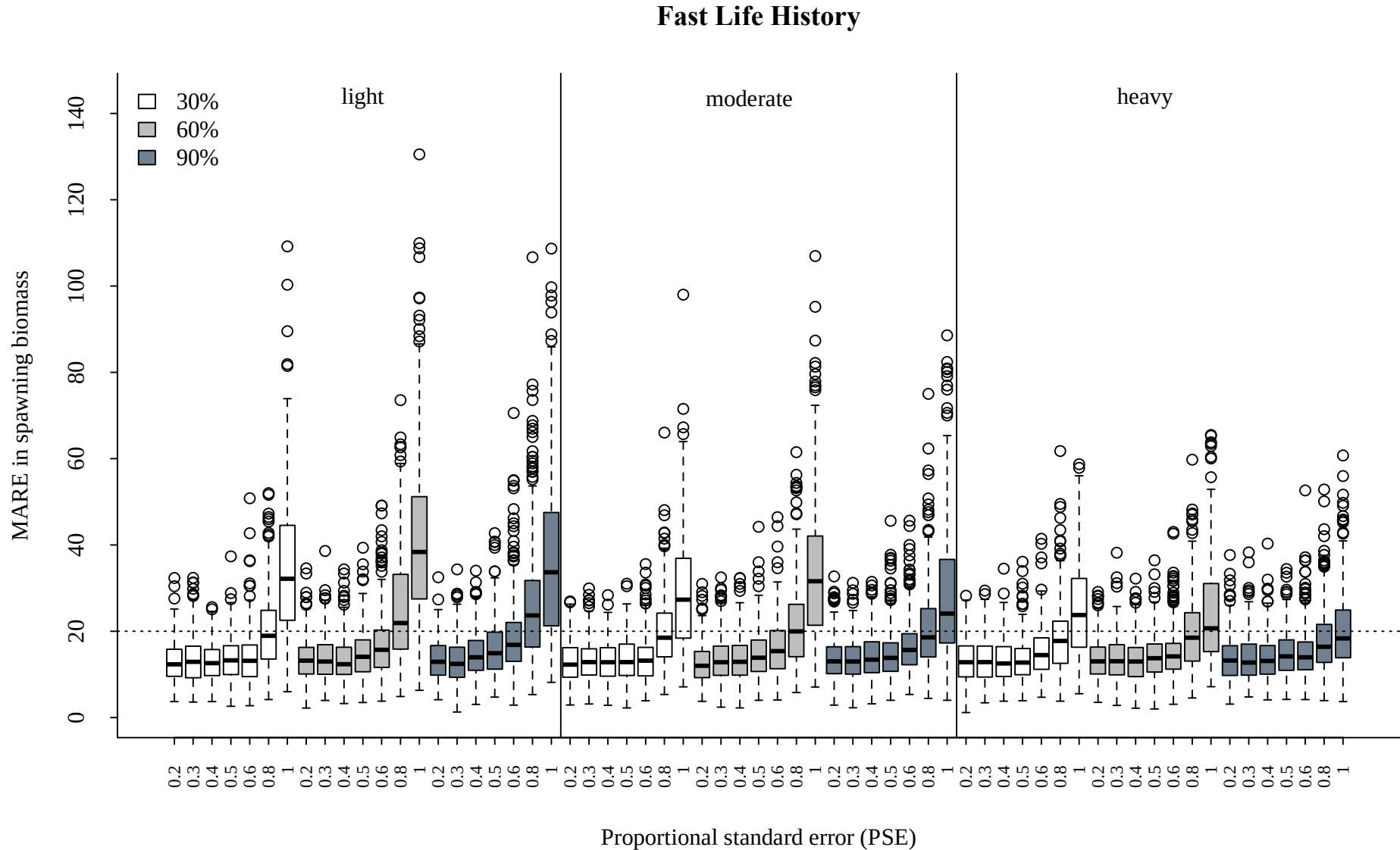
MRE in Biomass: Fast LH



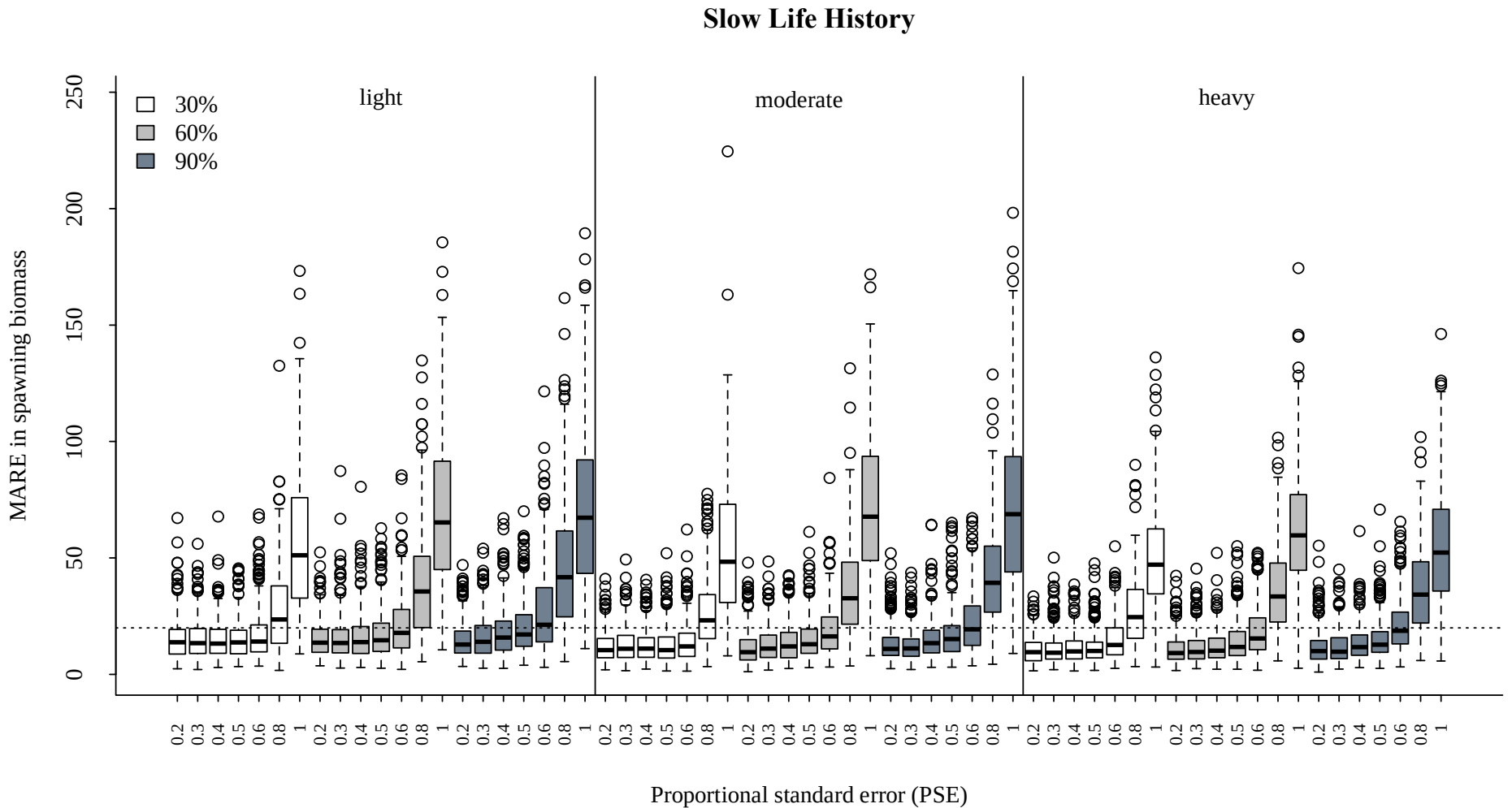
MRE in Biomass: Slow LH



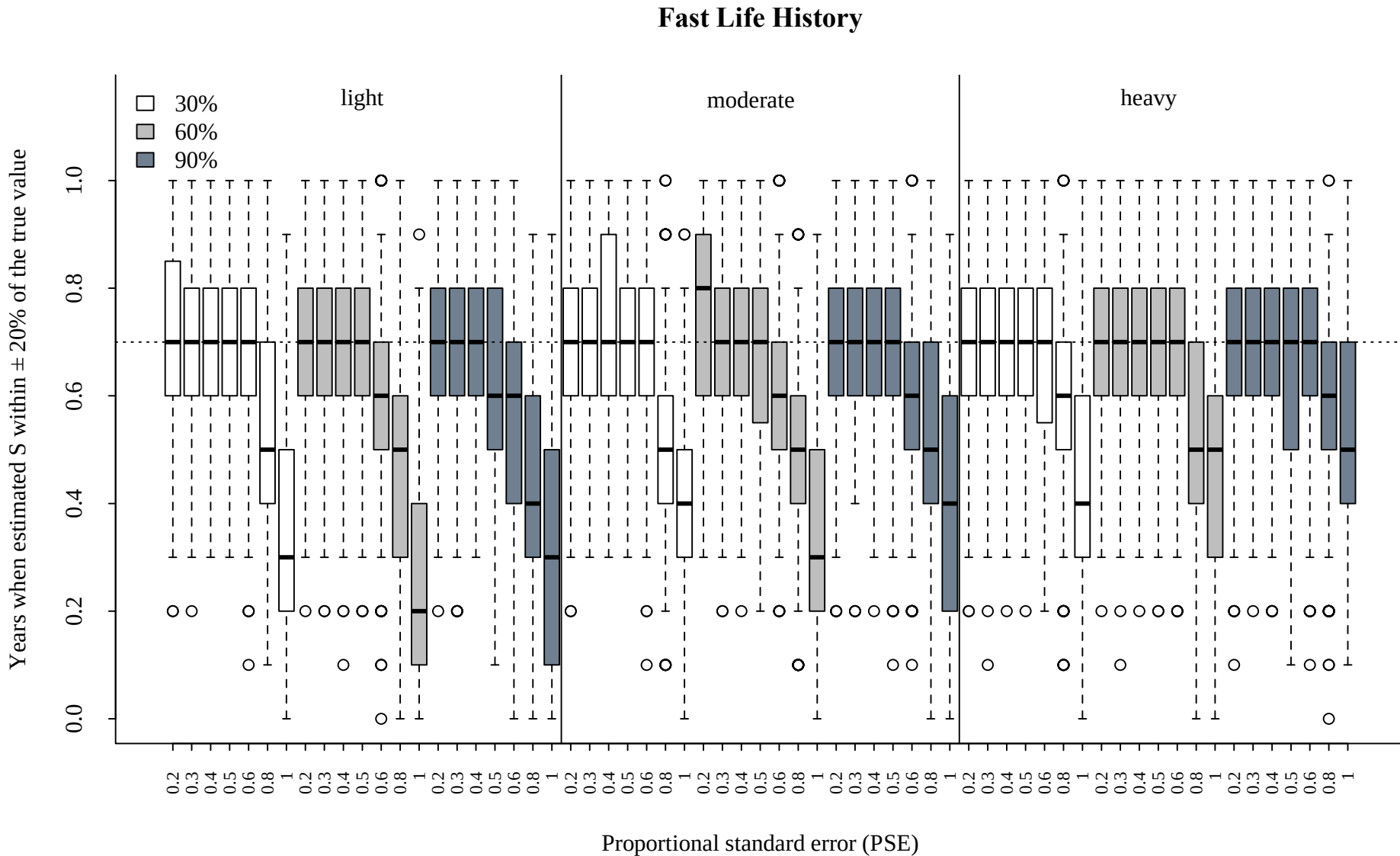
MARE in Biomass: Fast Life History



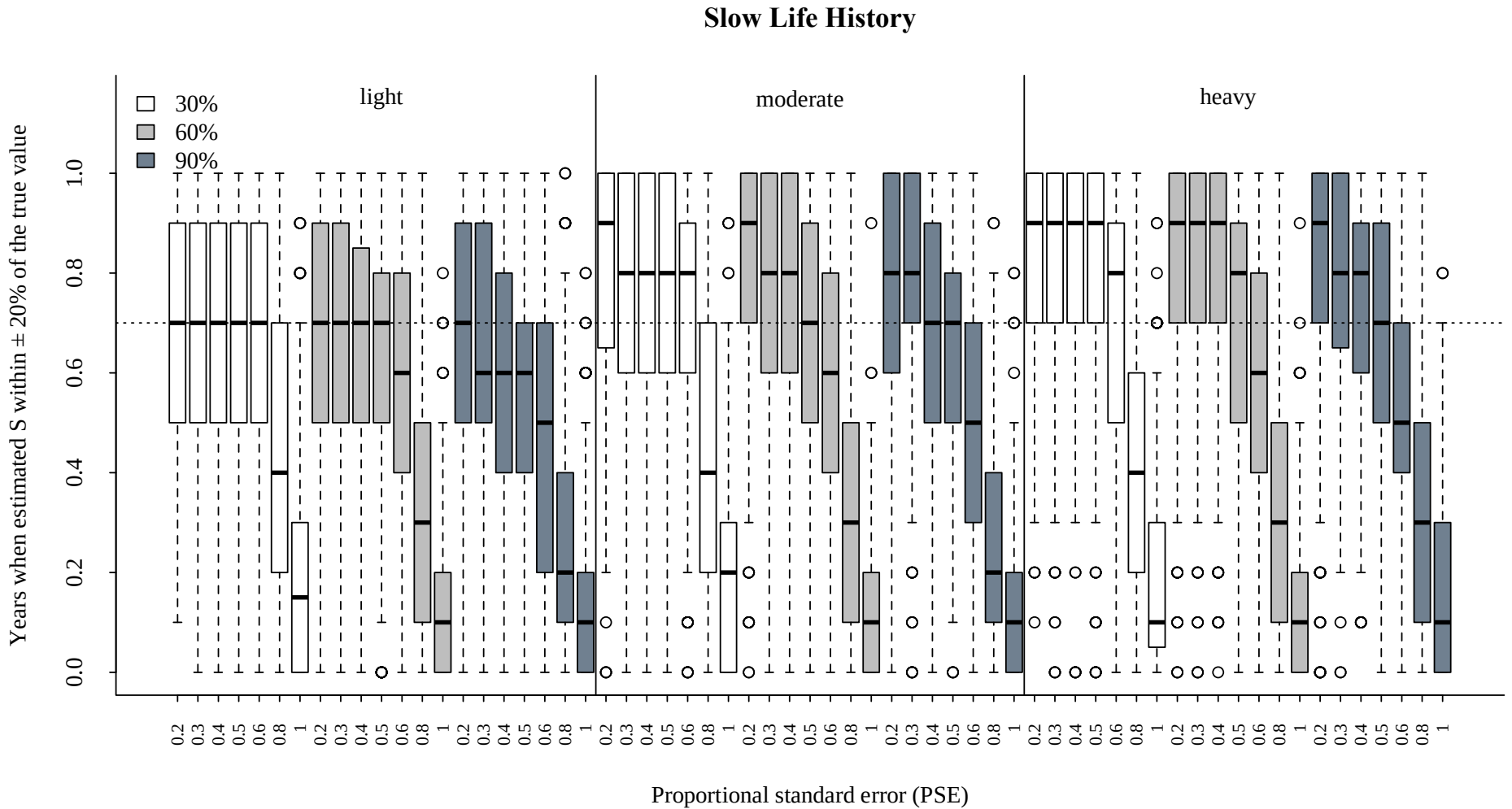
MARE in Biomass: Slow LH



Biomass Estimates $\pm 20\%$ (Prop.) : Fast LH

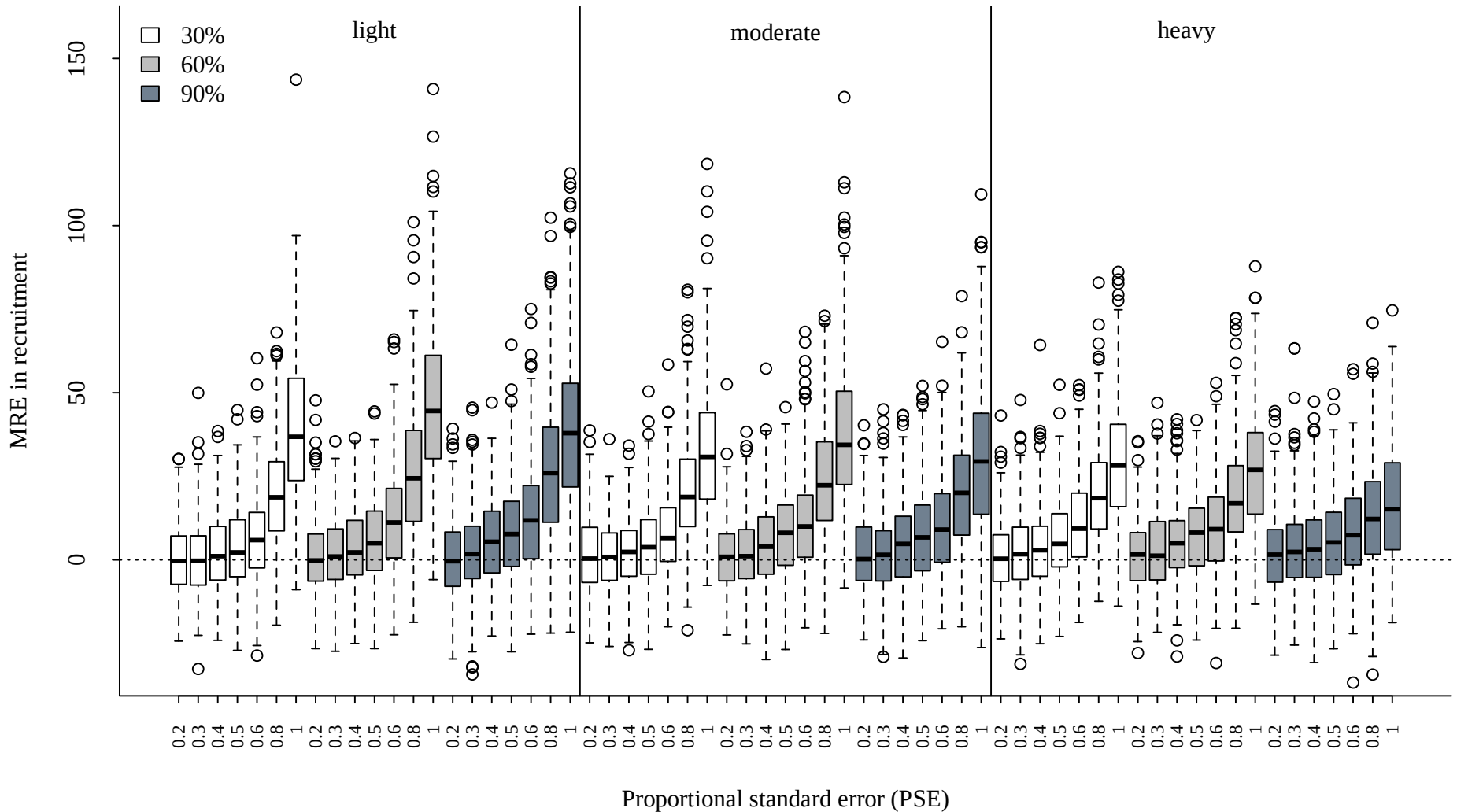


Biomass Estimates +/- 20% (Prop.) : Slow LH

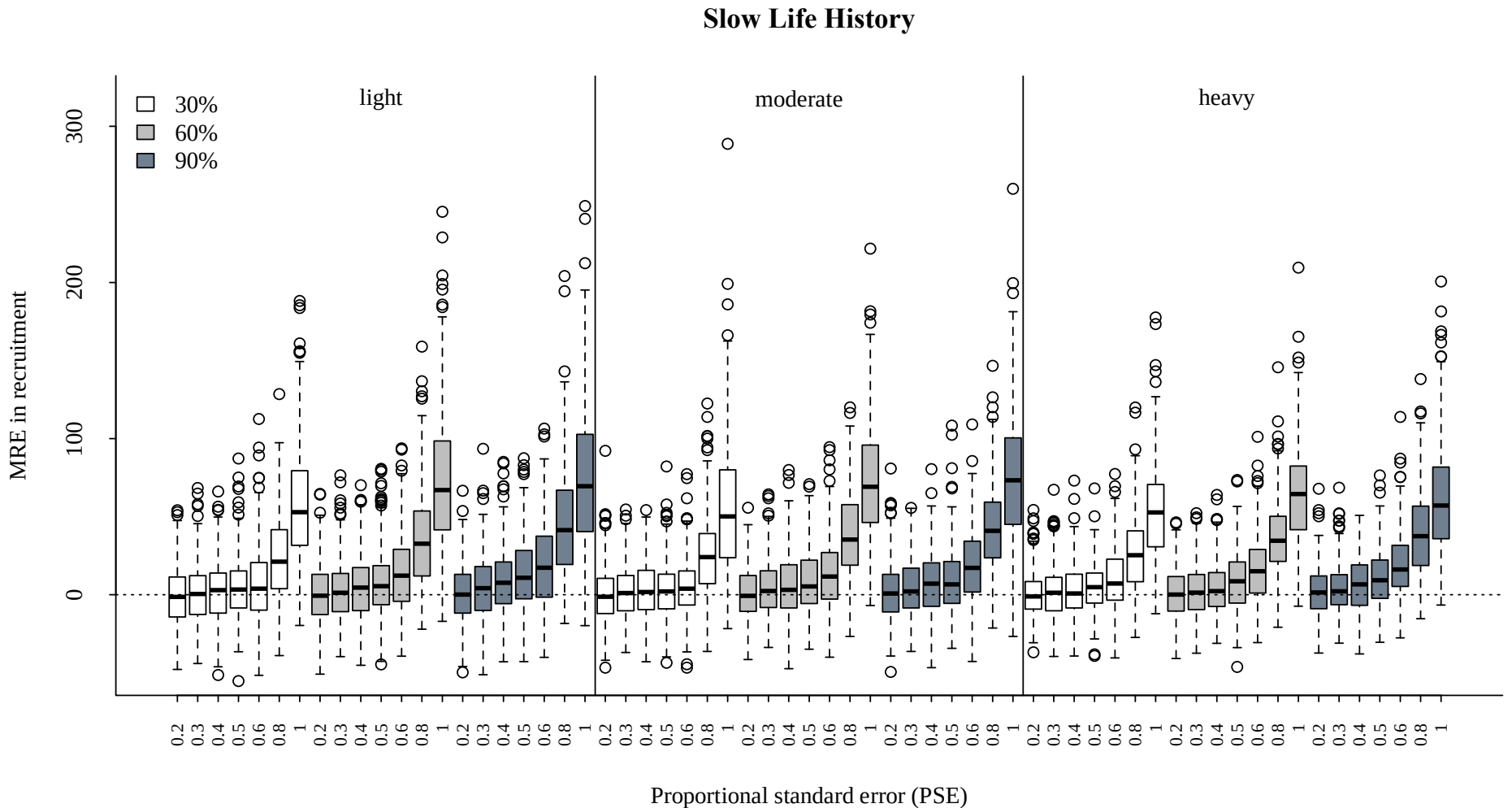


MRE in Recruitment: Fast LH

Fast Life History

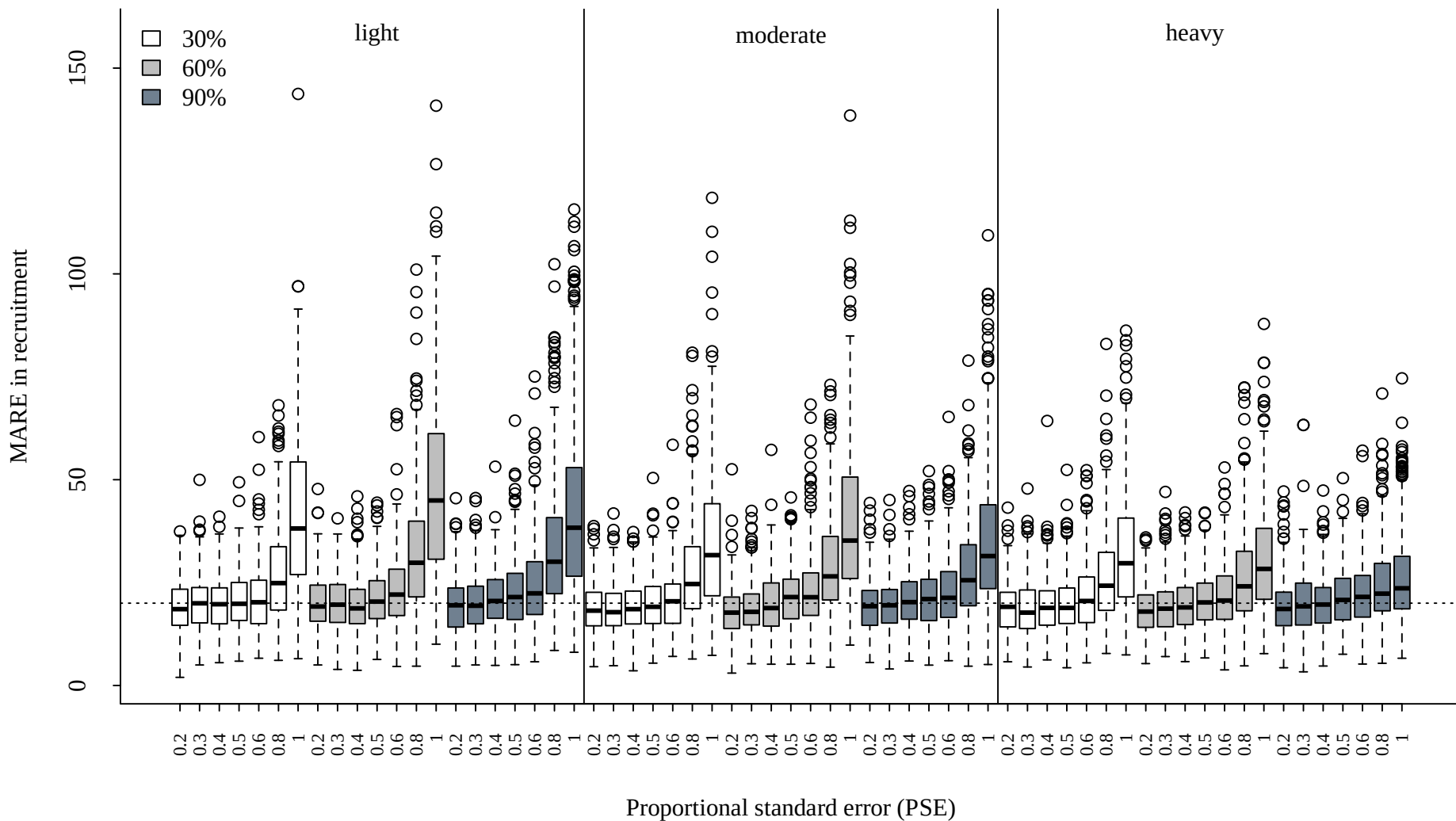


MRE in Recruitment: Slow LH

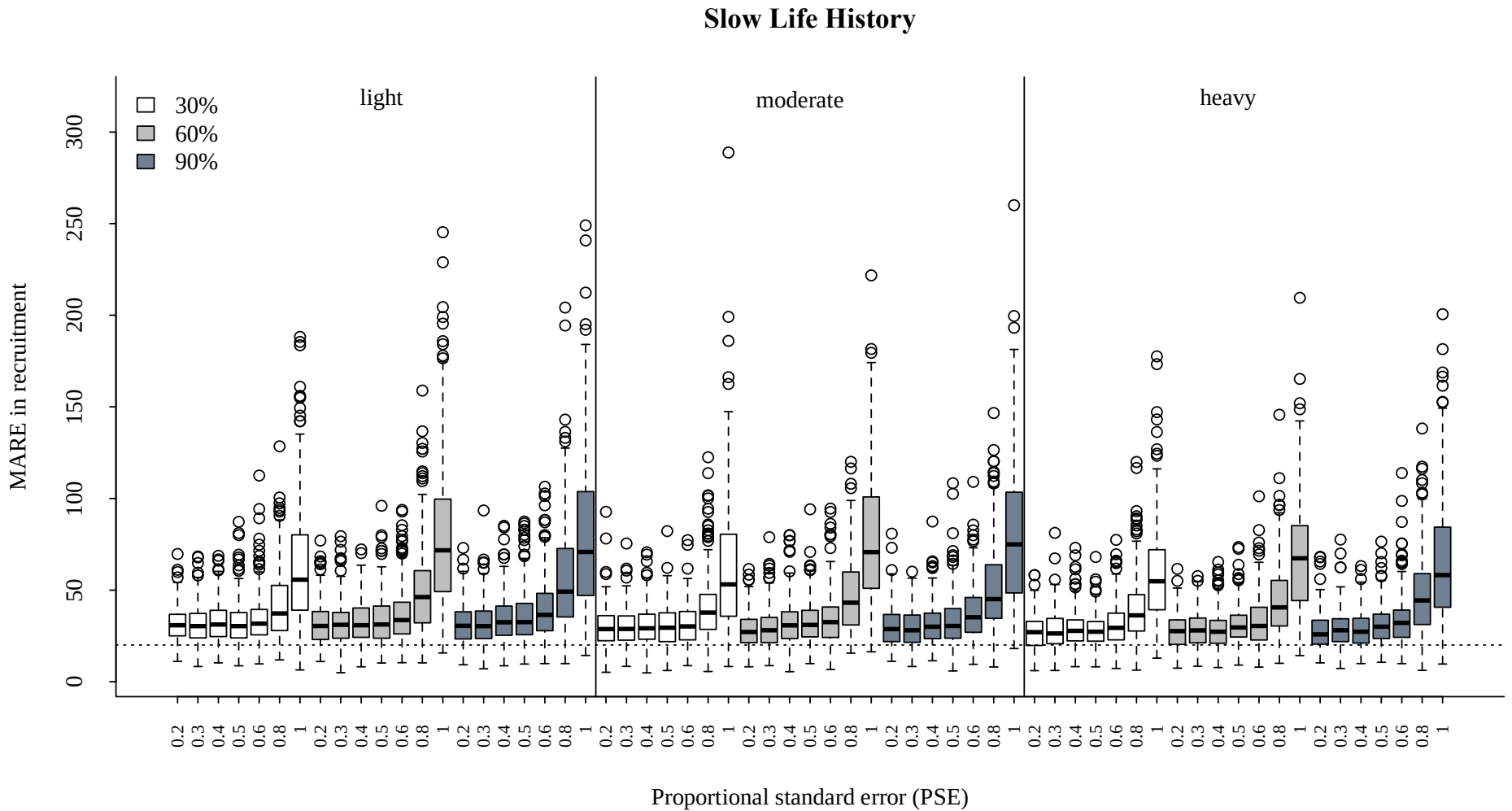


MARE in Recruitment: Fast LH

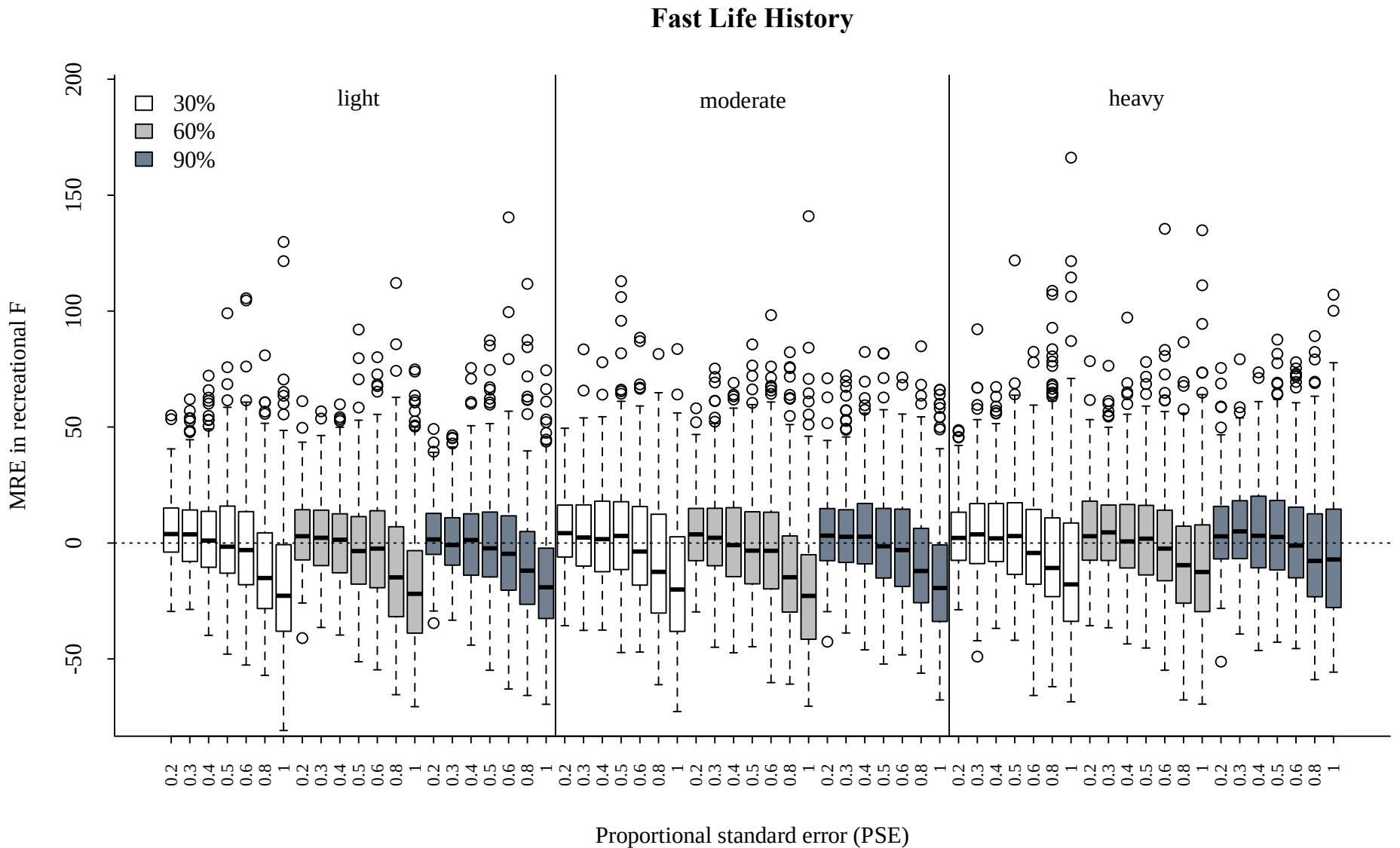
Fast Life History



MARE in Recruitment: Slow LH

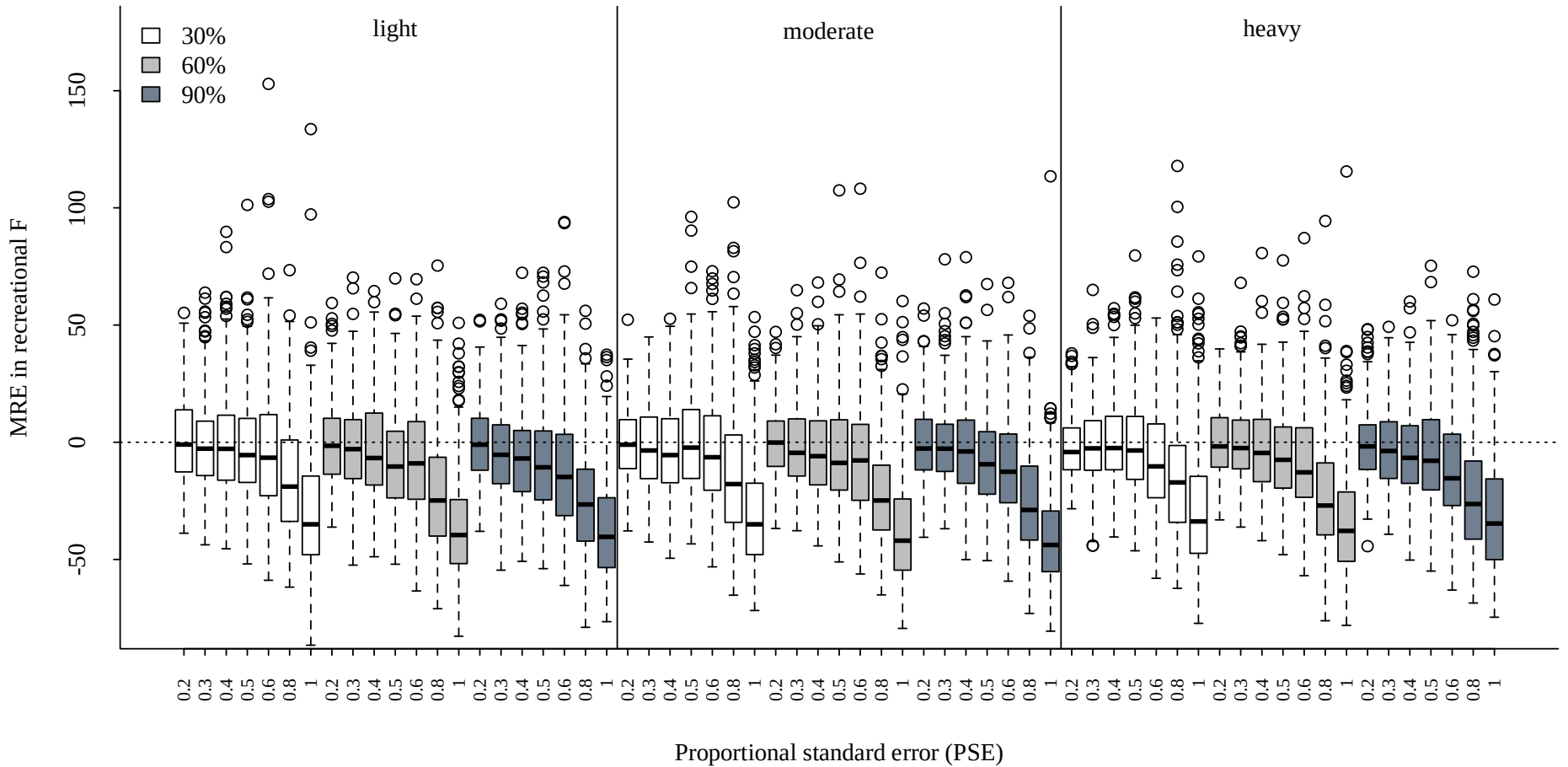


MRE in F_{Rec} : Fast LH



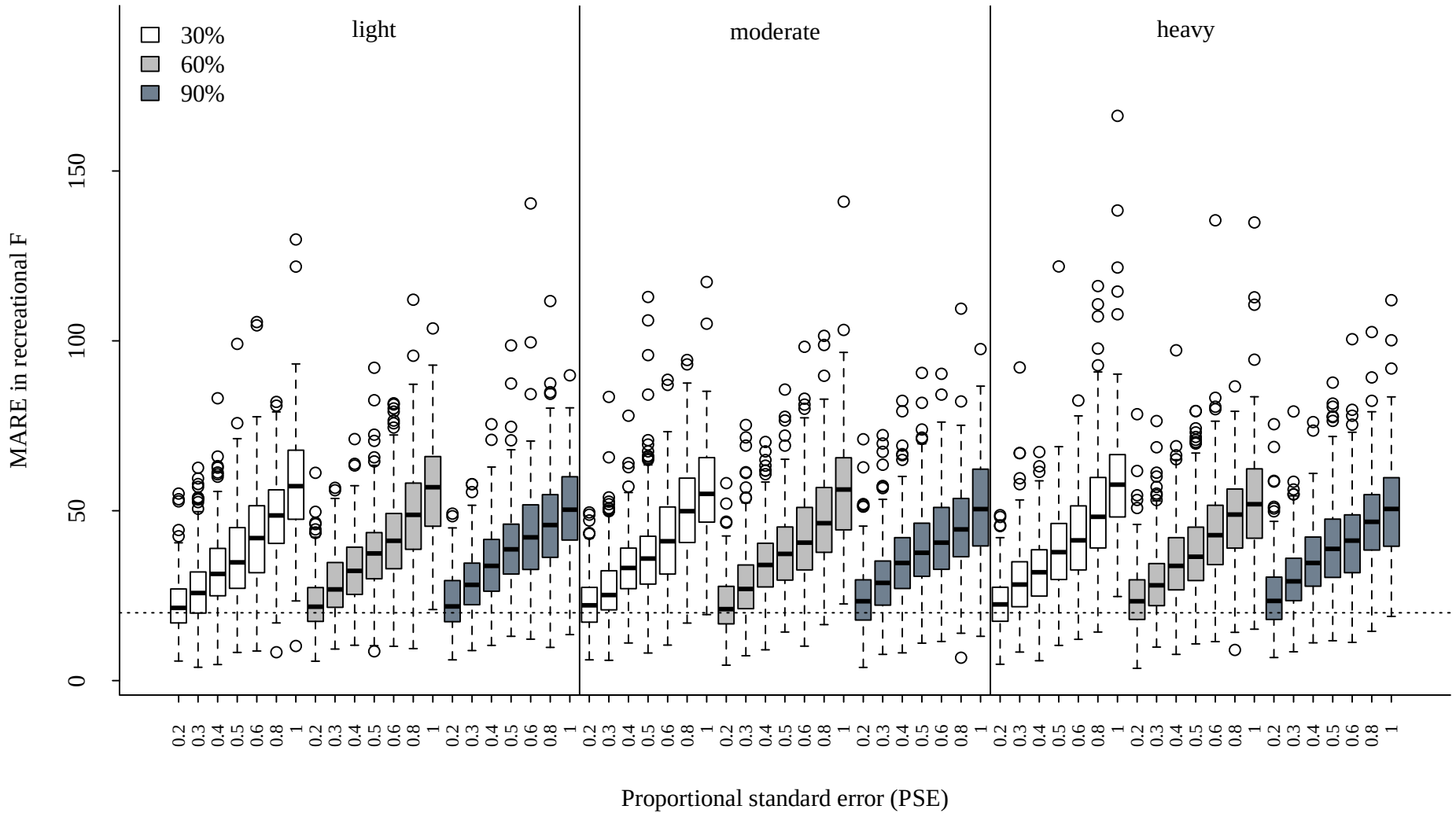
MRE in F_{Rec} : Slow LH

Slow Life History

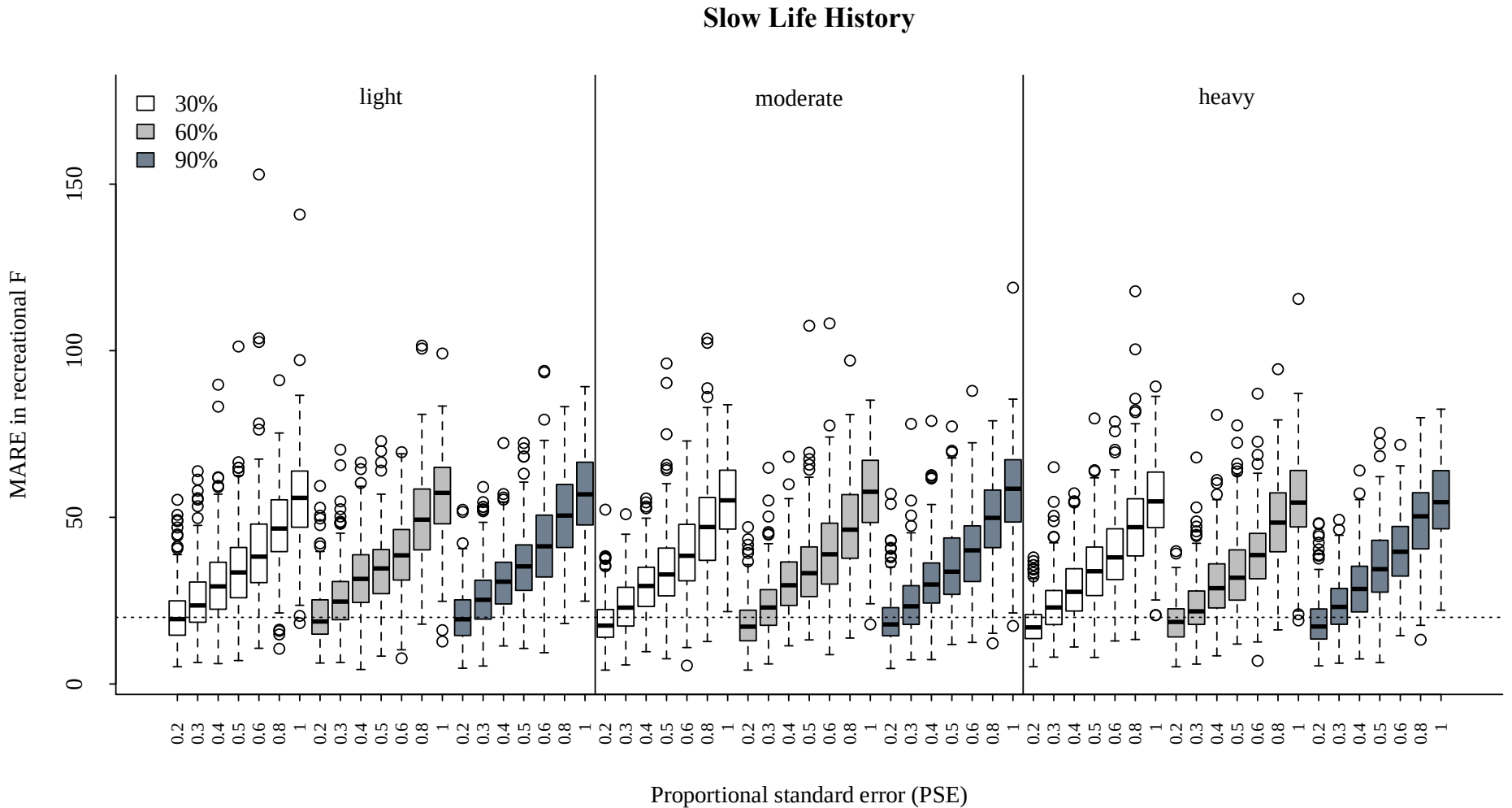


MARE in F_{Rec} : Fast LH

Fast Life History

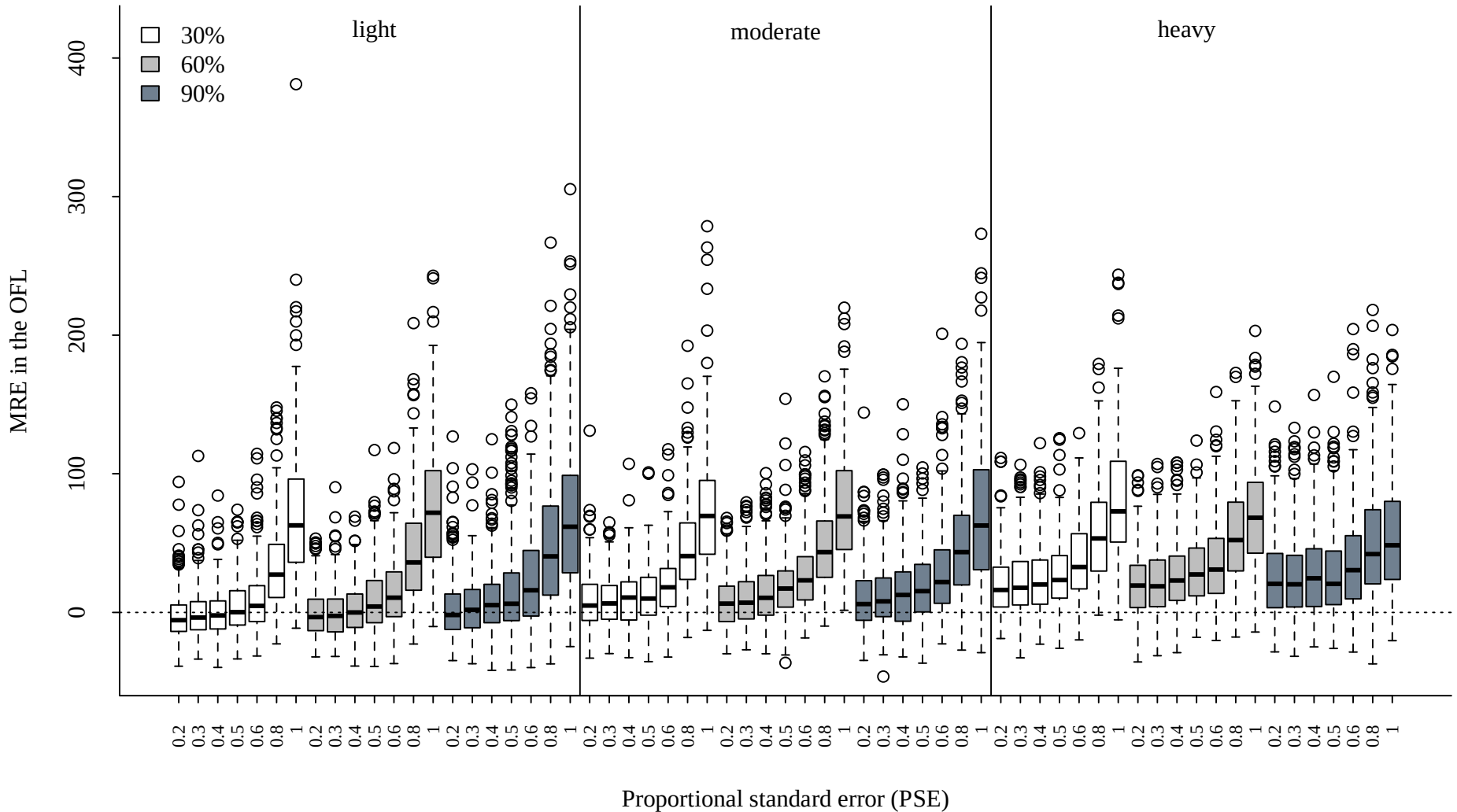


MARE in F_{Rec} : Slow LH

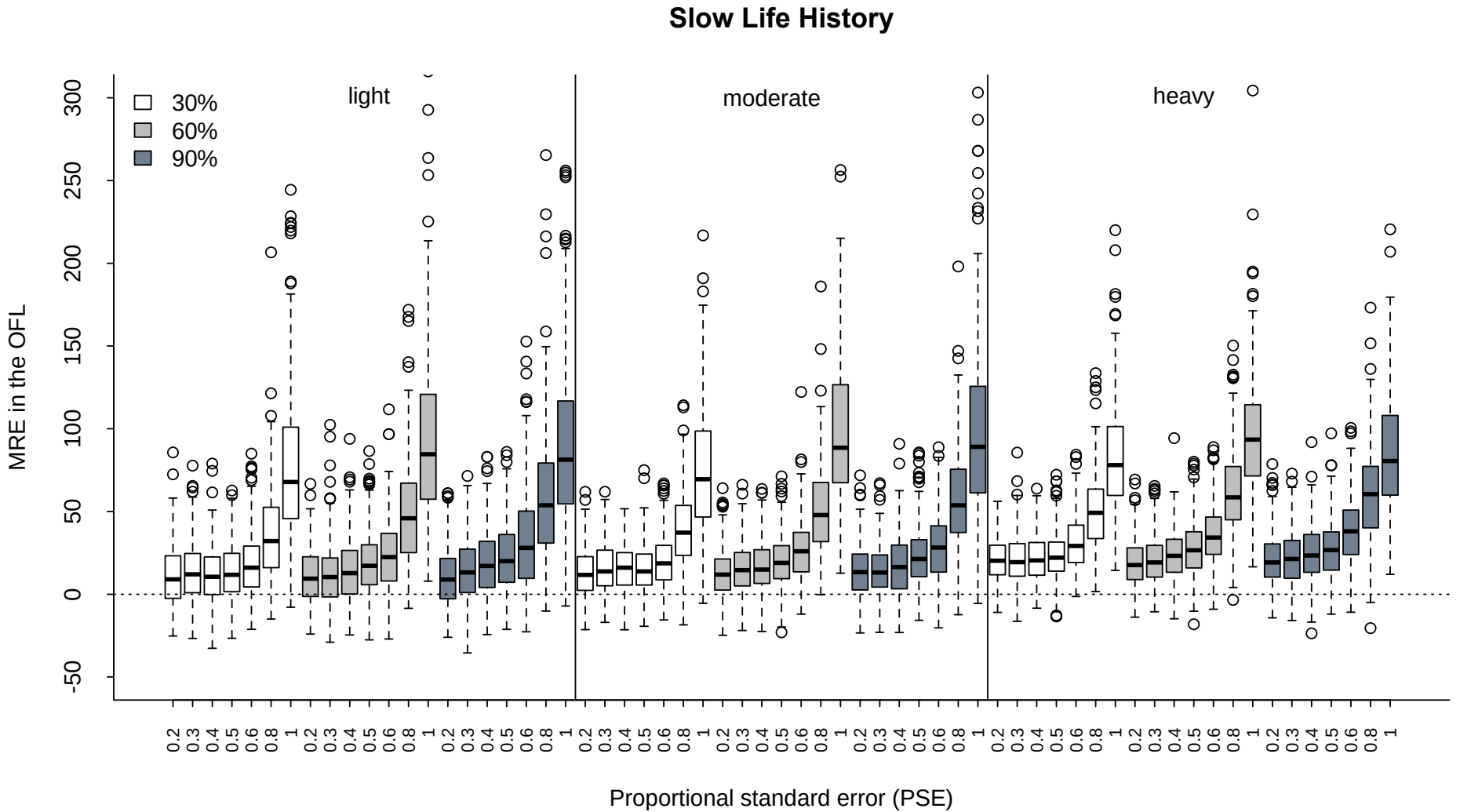


MRE in OFL: Fast LH

Fast Life History

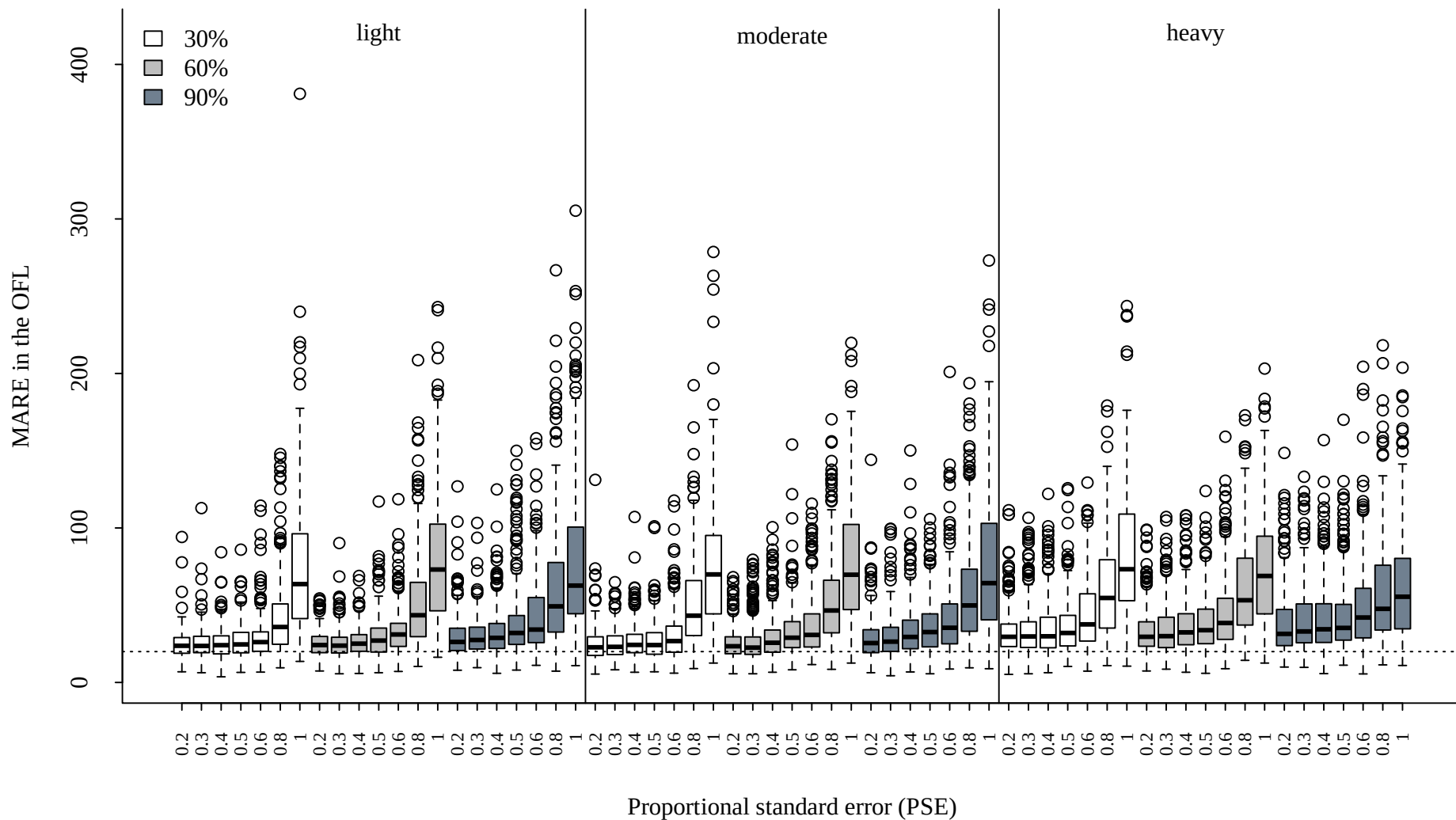


MRE in OFL: Slow LH



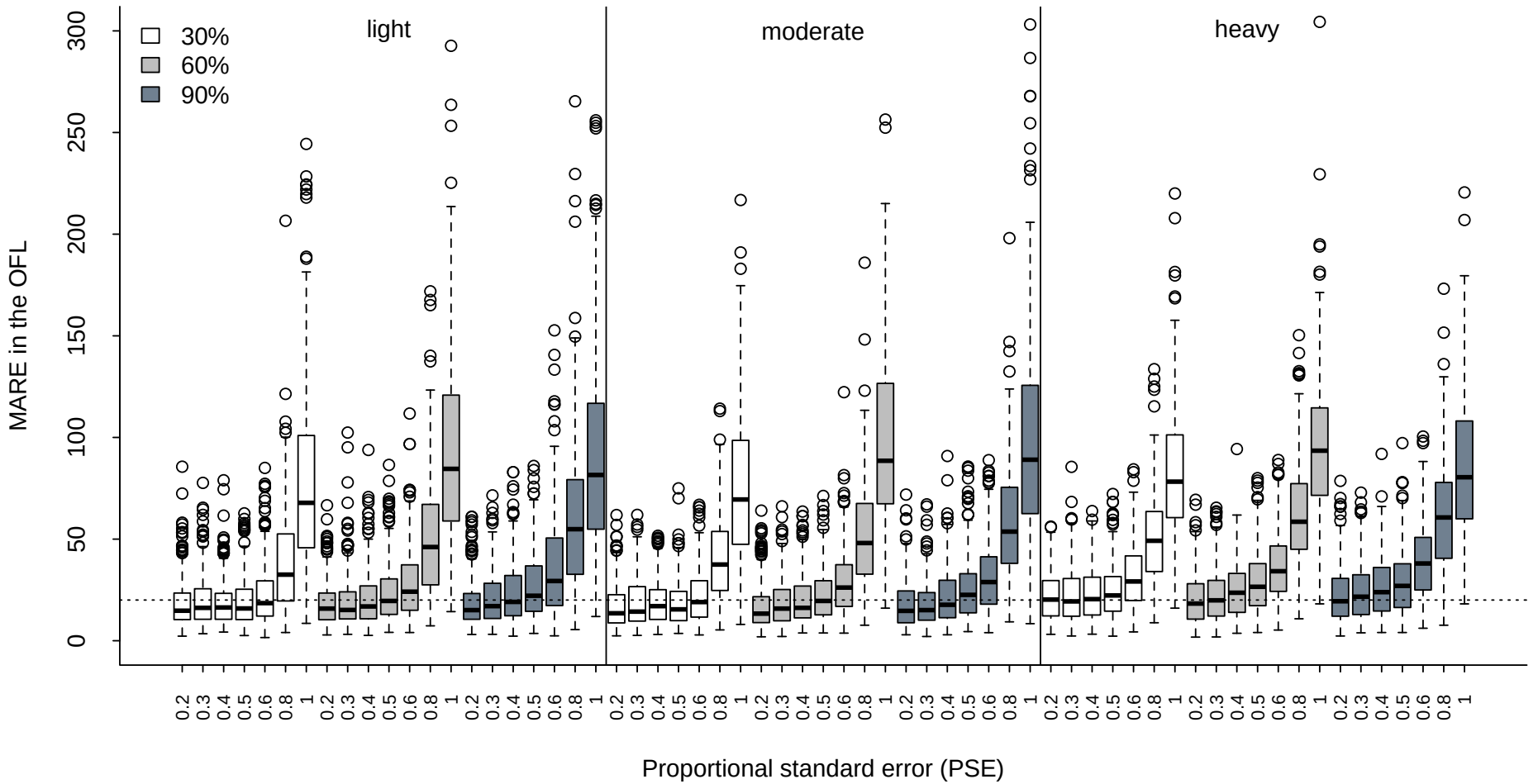
MARE in OFL: Fast LH

Fast Life History



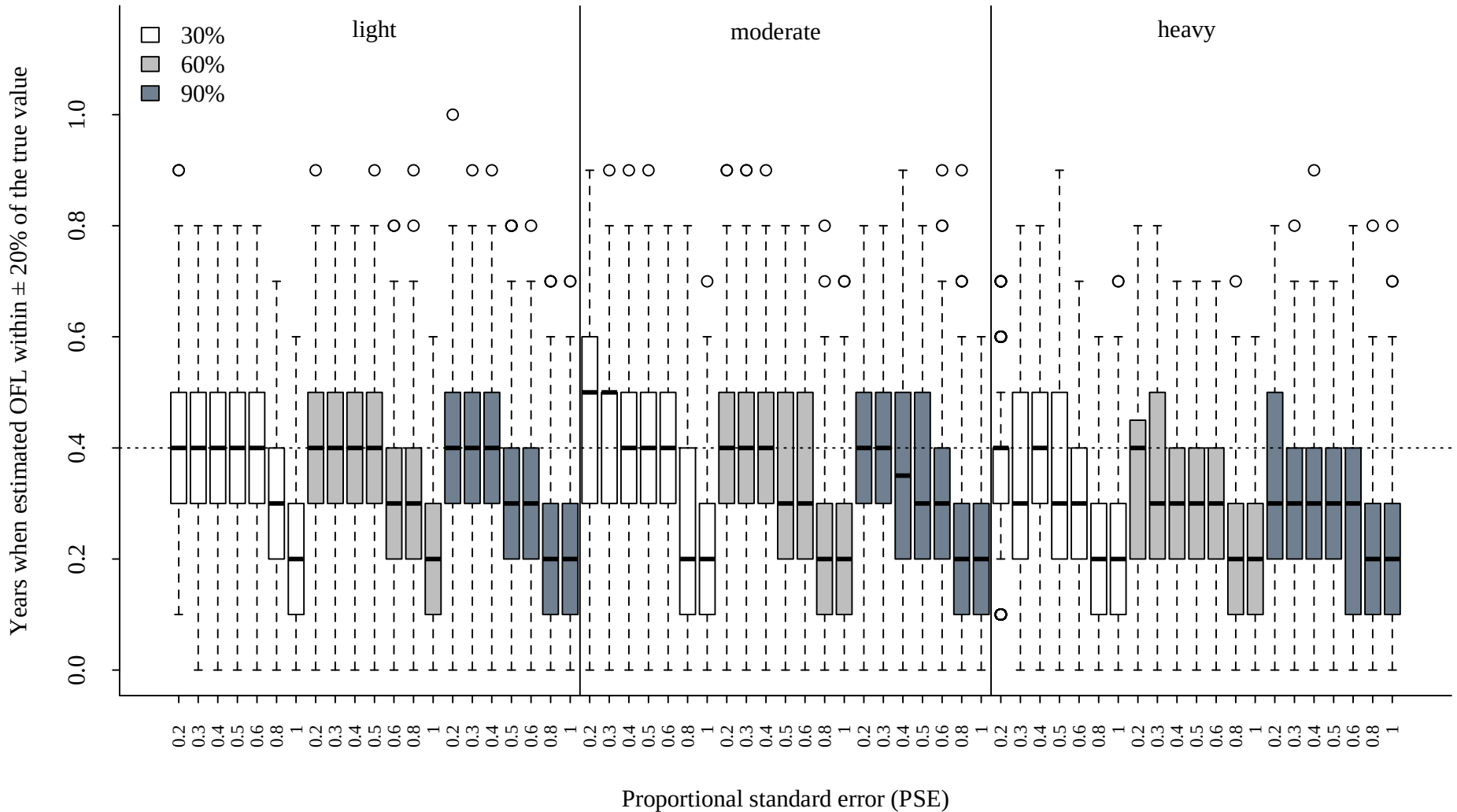
MARE in OFL: Slow LH

Slow Life History



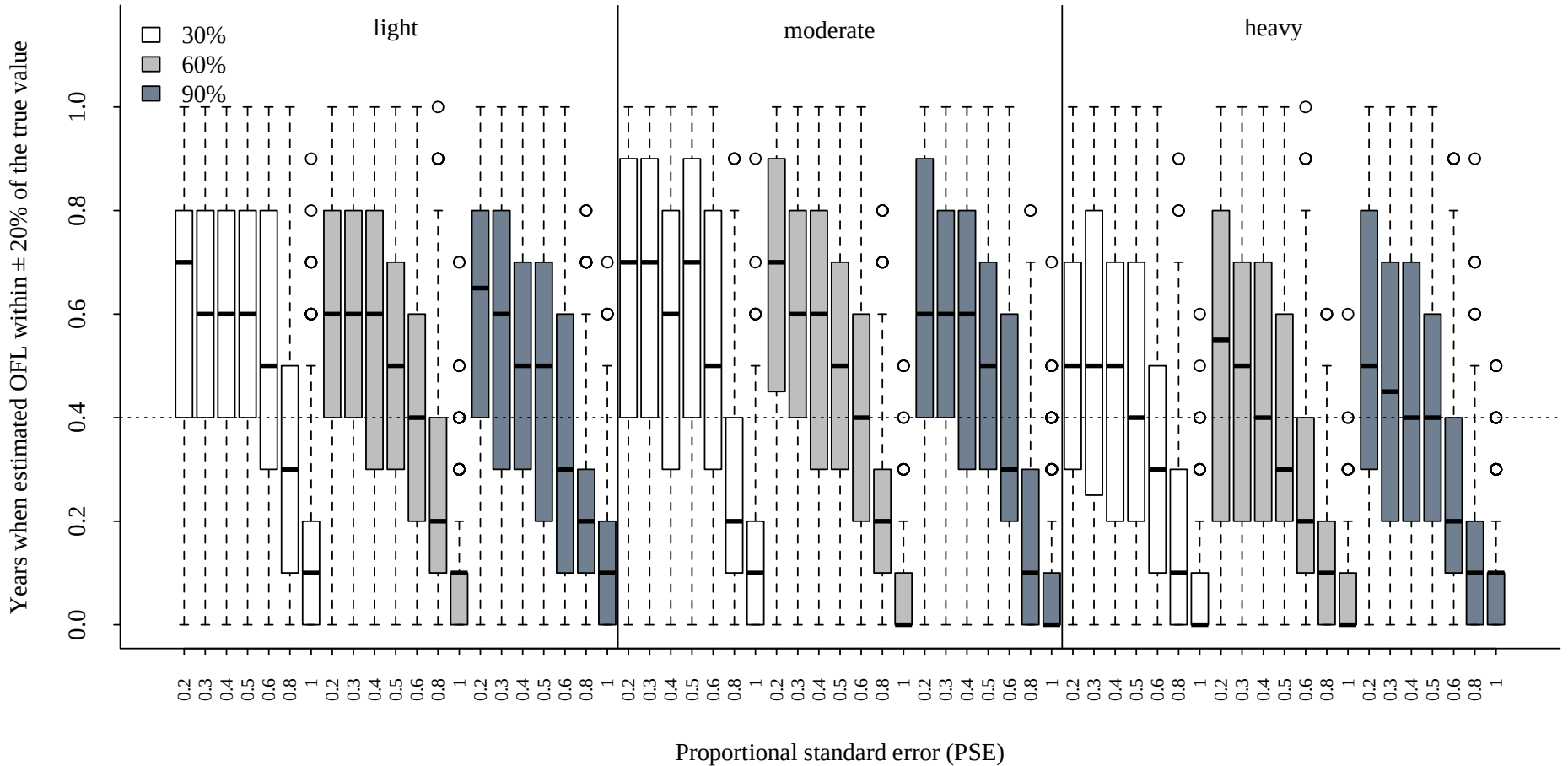
OFL Estimates +/- 20% (Prop.) : Fast LH

Fast Life History

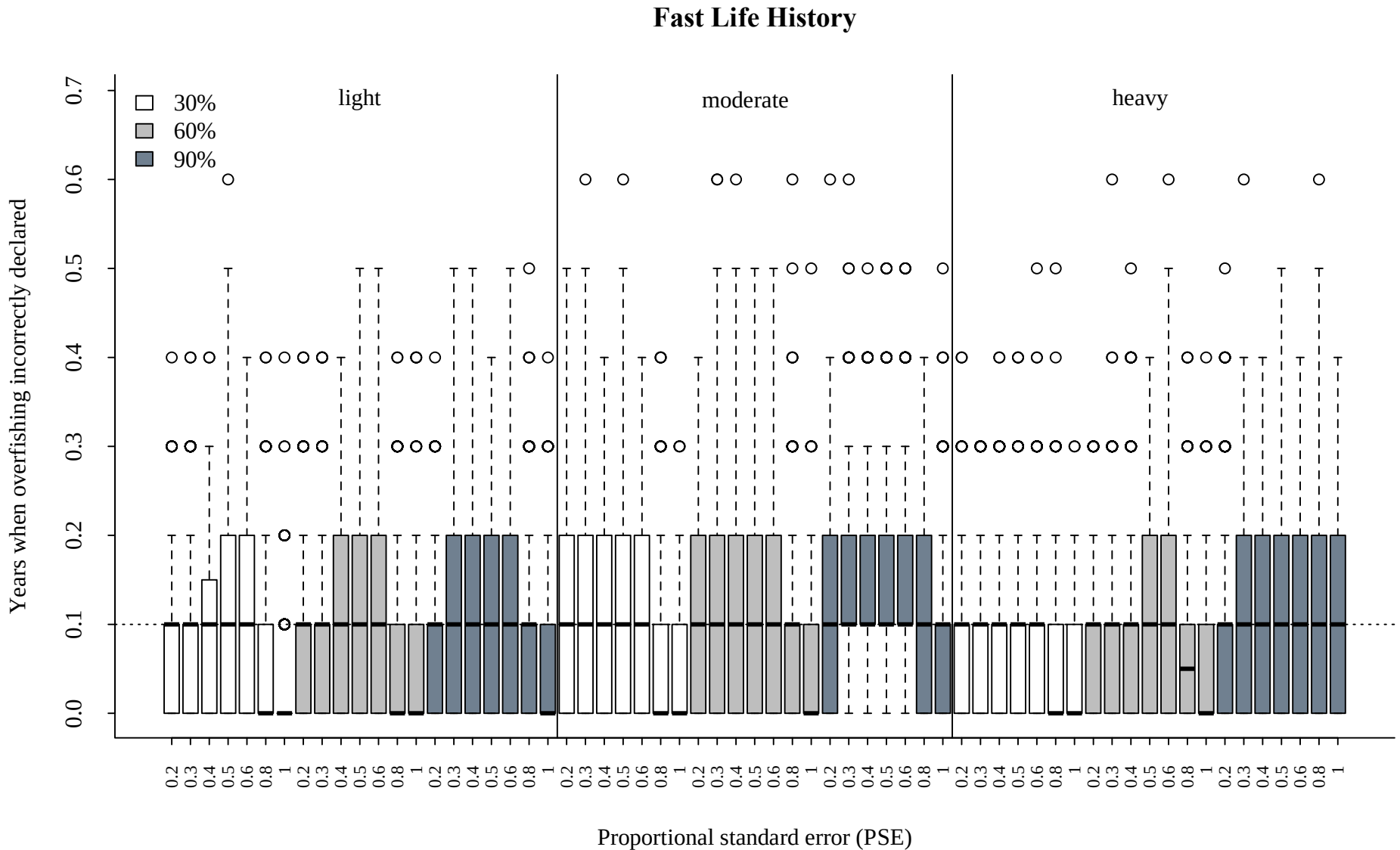


OFL Estimates +/- 20% (Prop.) : Slow LH

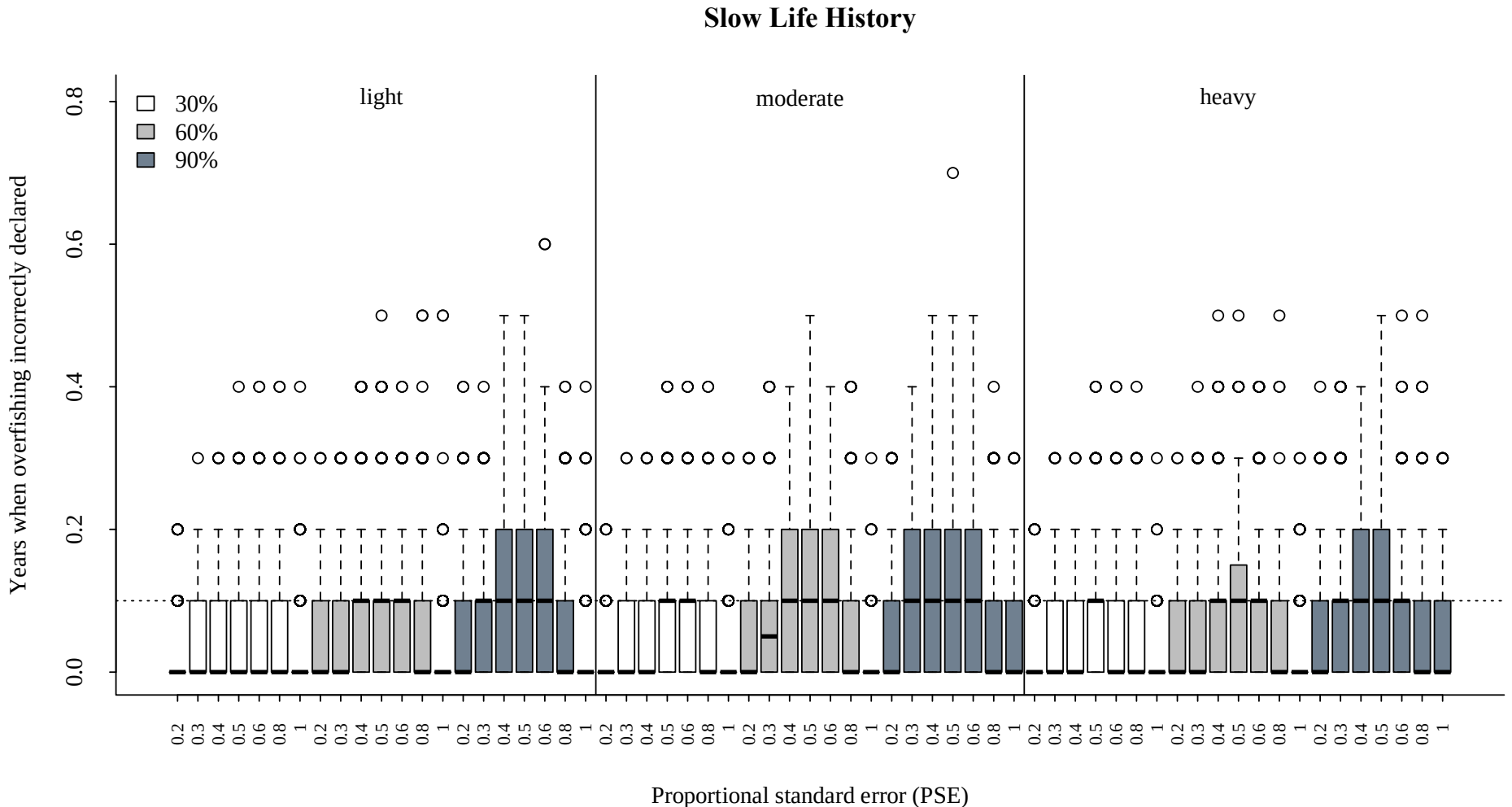
Slow Life History



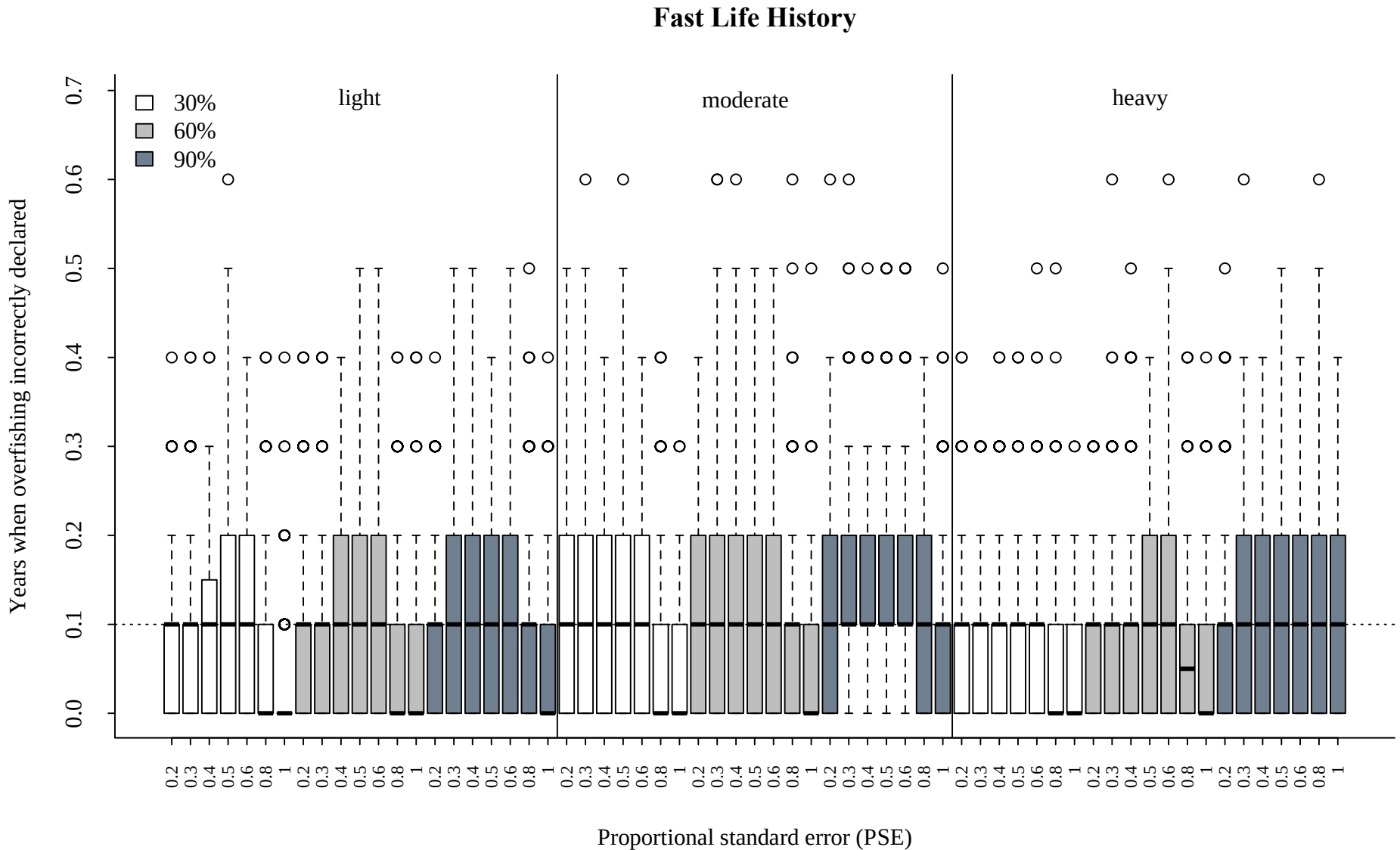
Overfishing False Positives (Prop.) : Fast LH



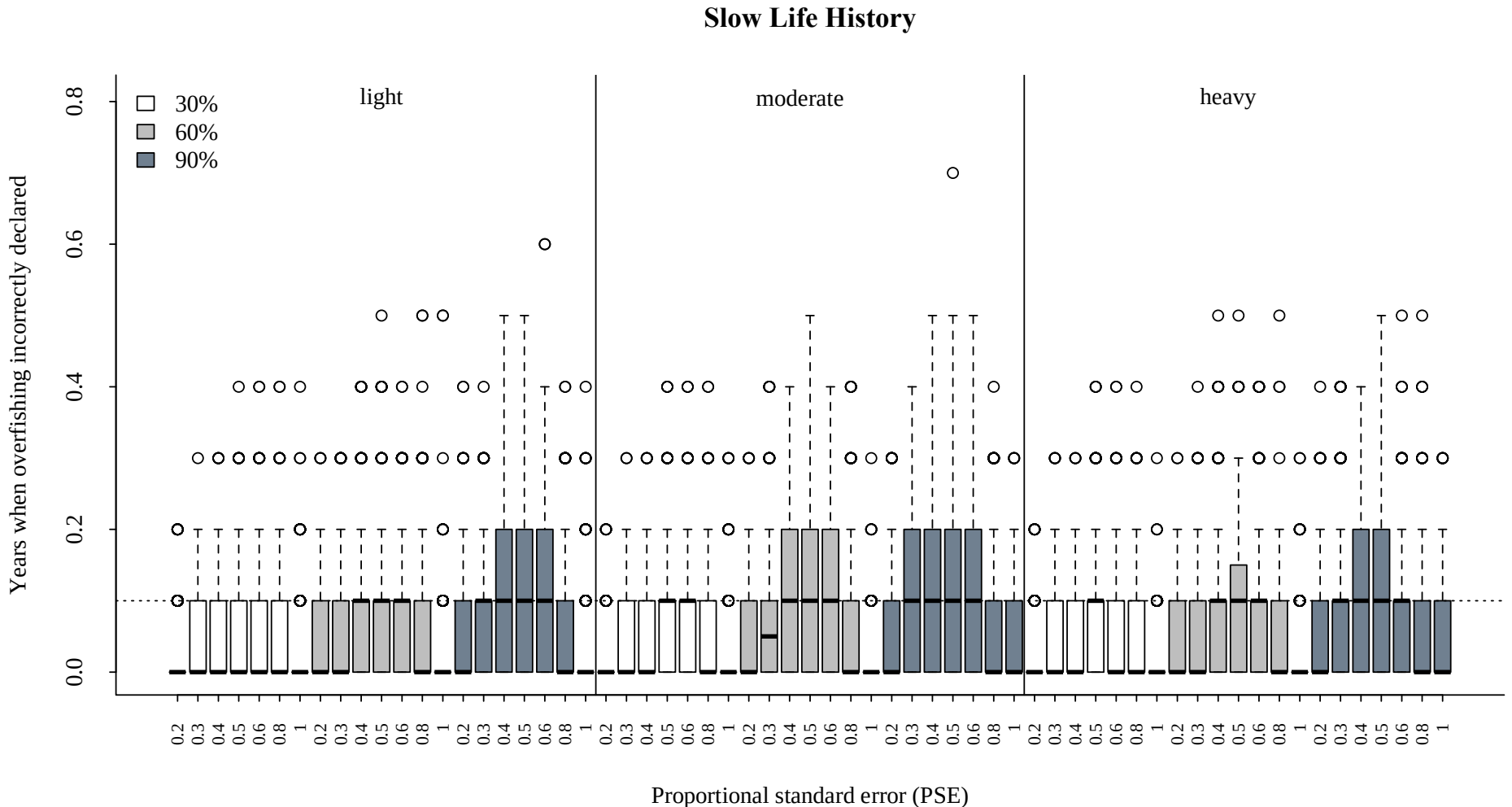
Overfishing False Positives (Prop.) : Slow LH



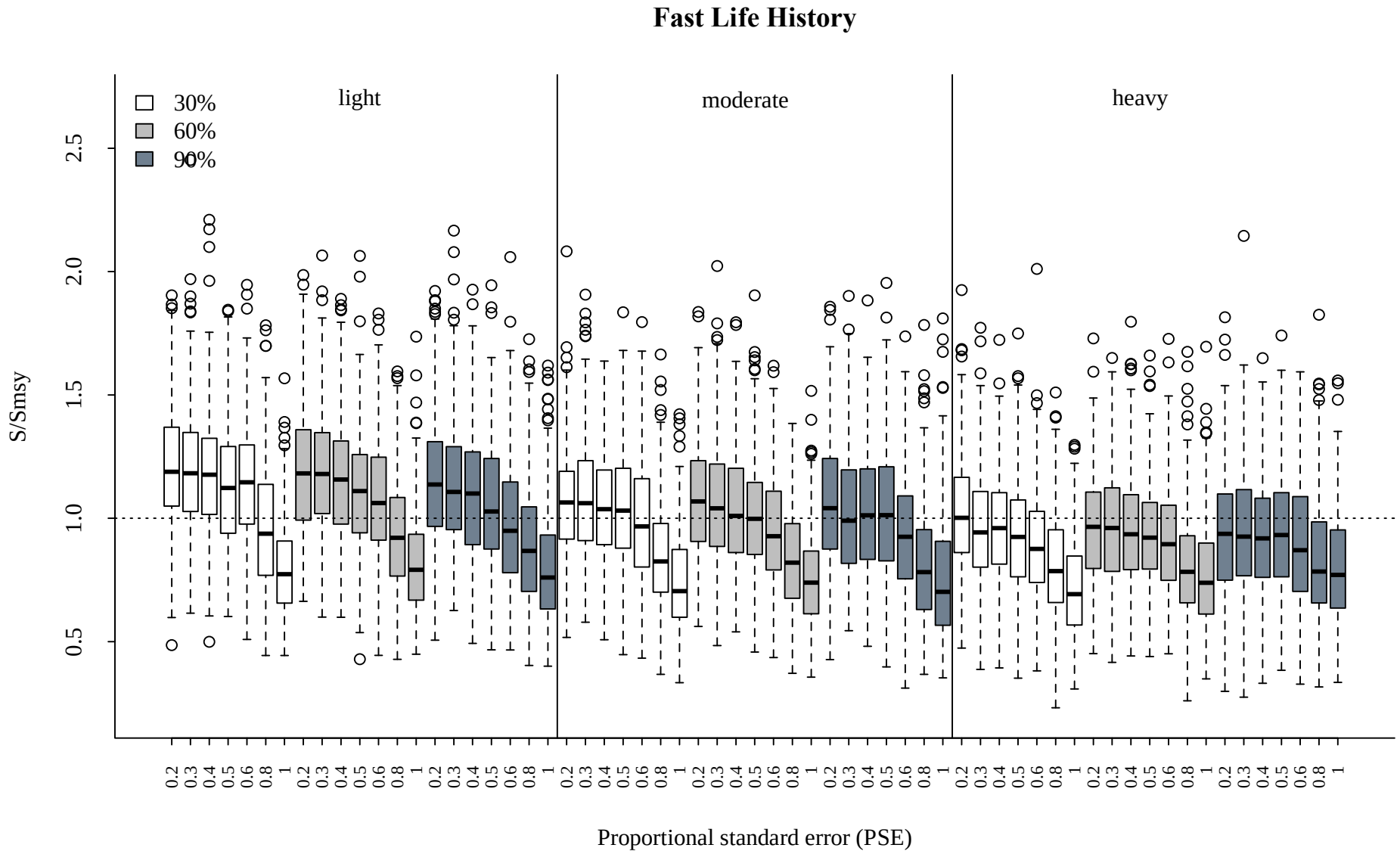
Overfishing False Negatives (Prop.) : Fast LH



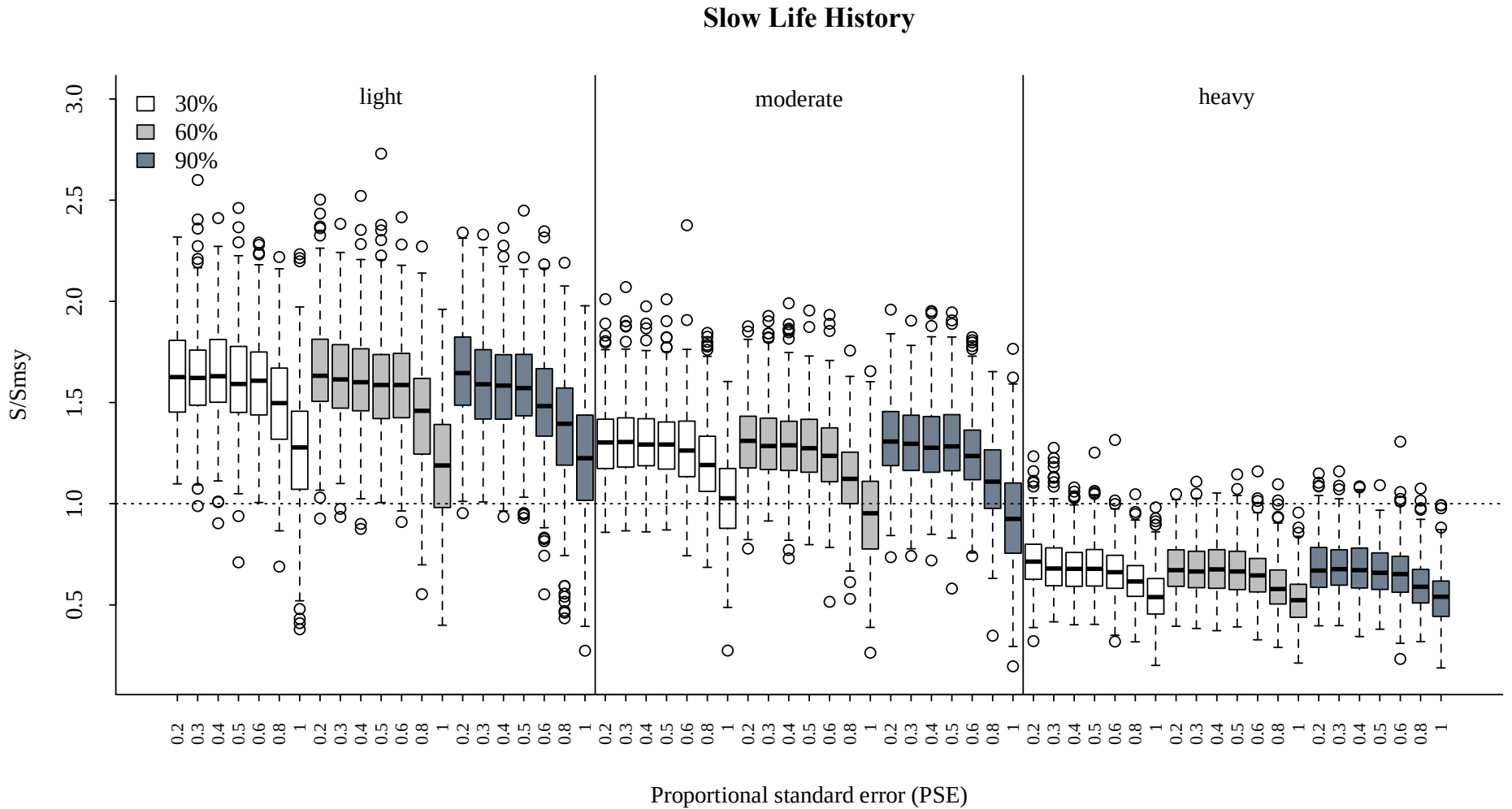
Overfishing False Negatives (Prop.) : Slow LH



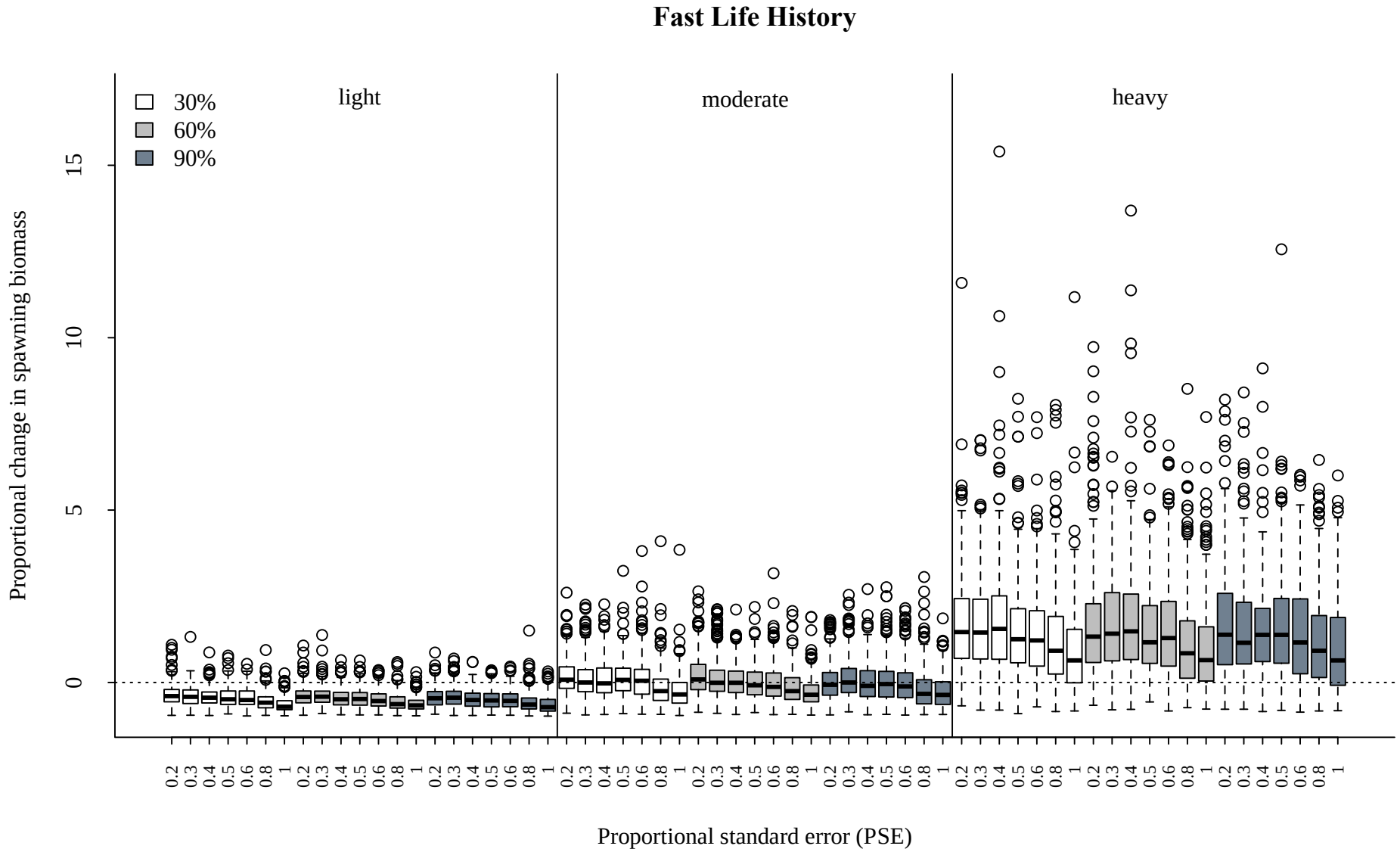
Mean S / S_{MSY} : Fast LH



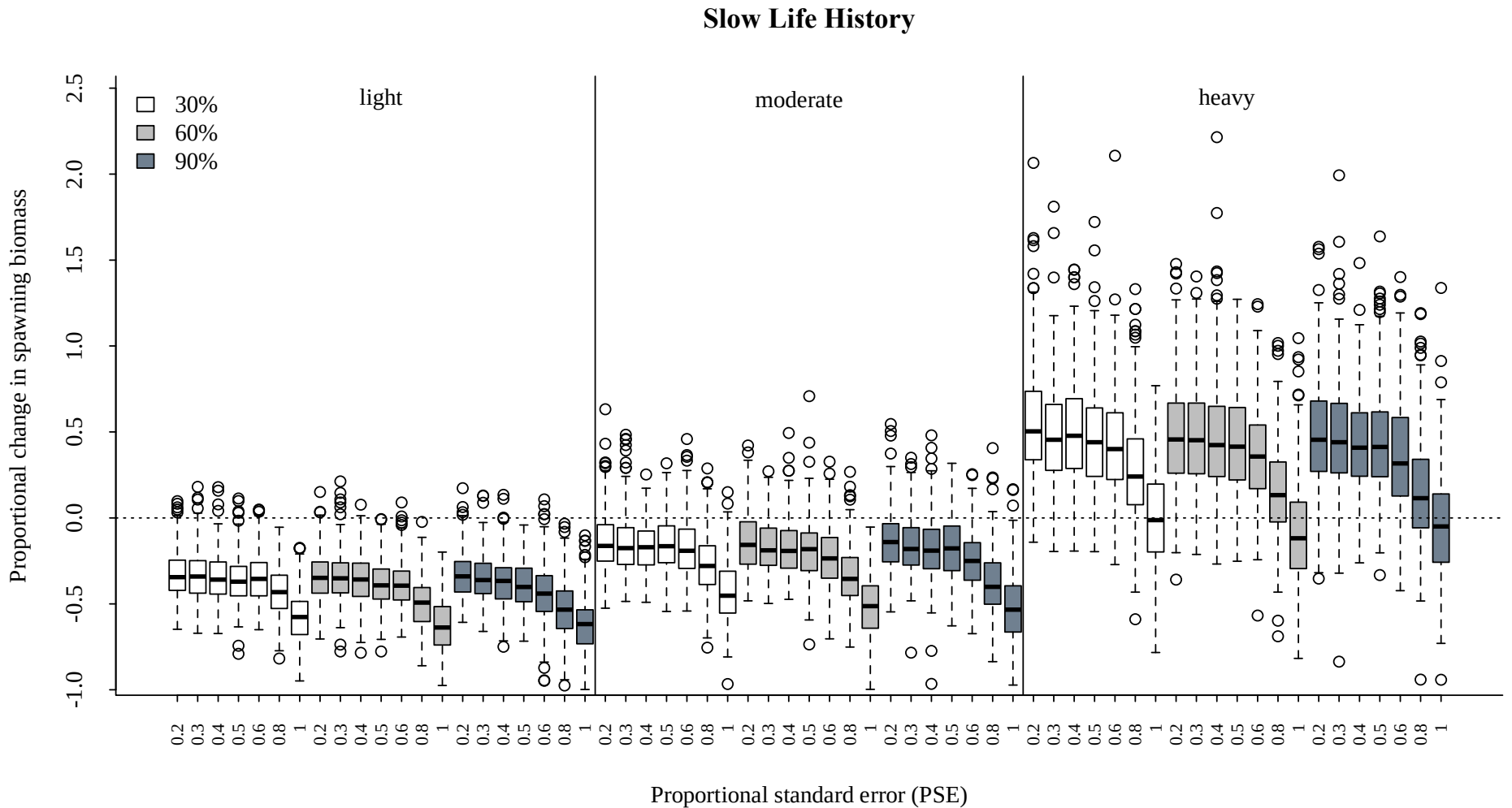
Mean S / S_{MSY} : Slow LH



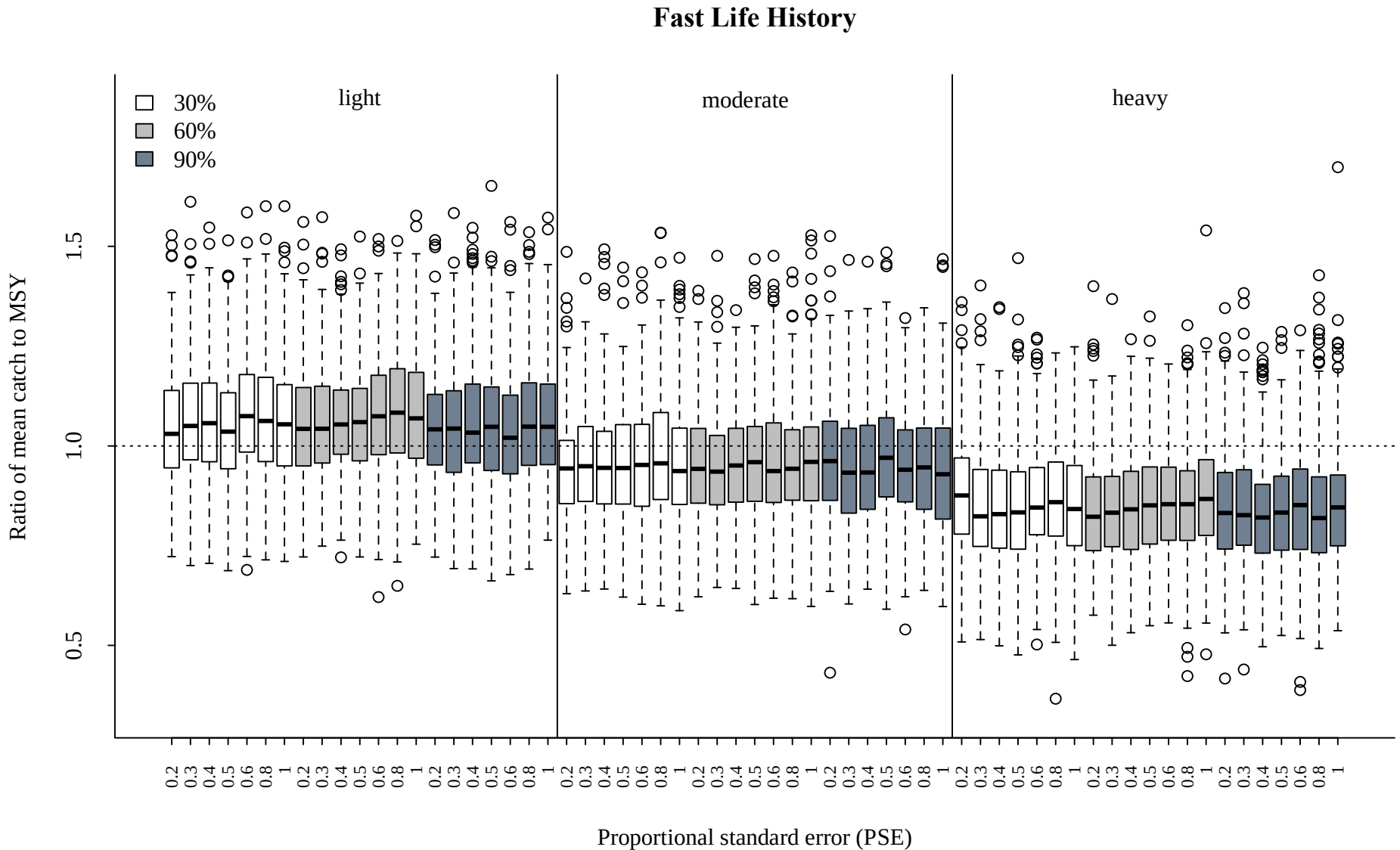
Change in Biomass (Prop.) : Fast LH



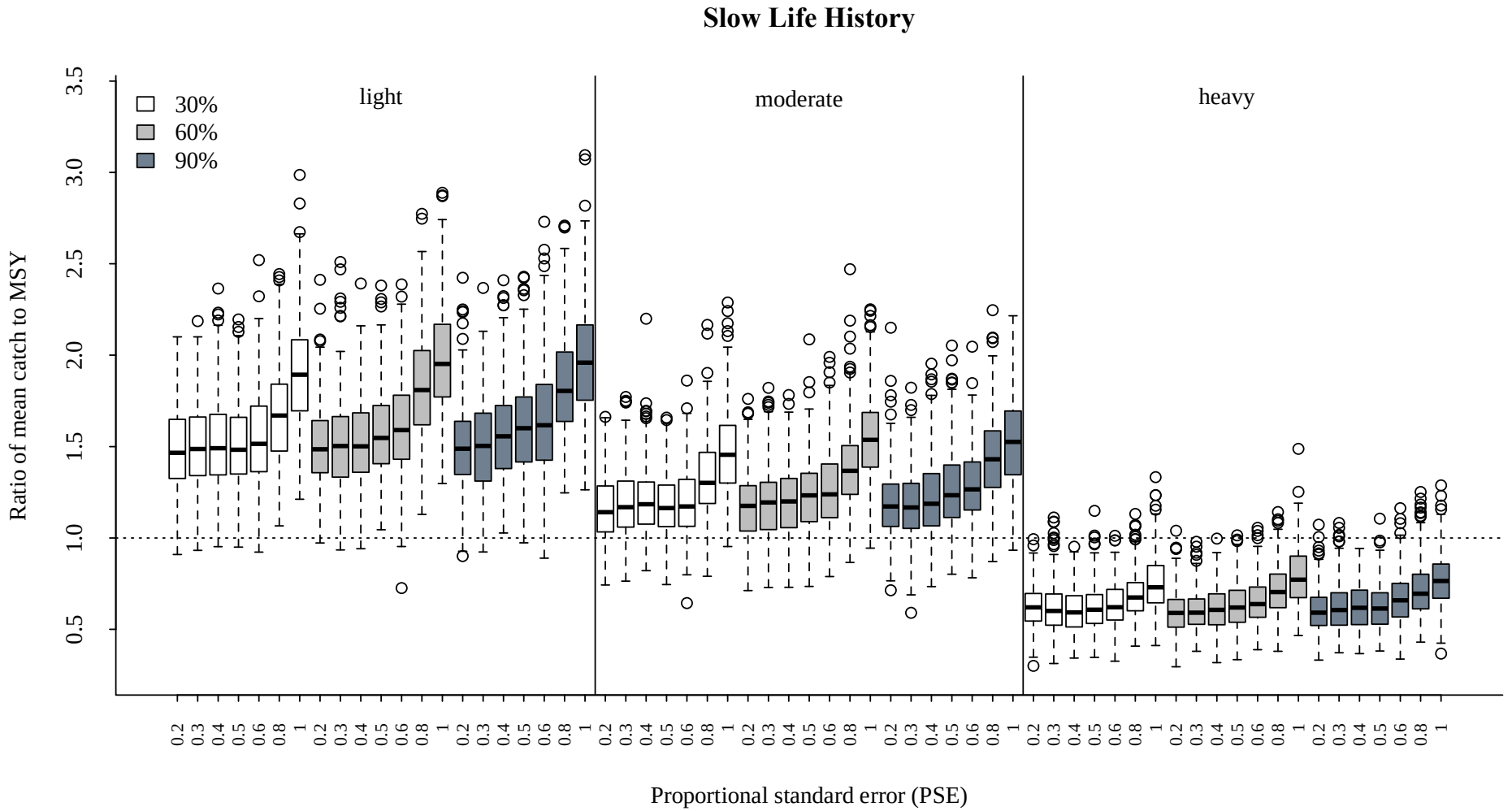
Change in Biomass (Prop.) : Slow LH



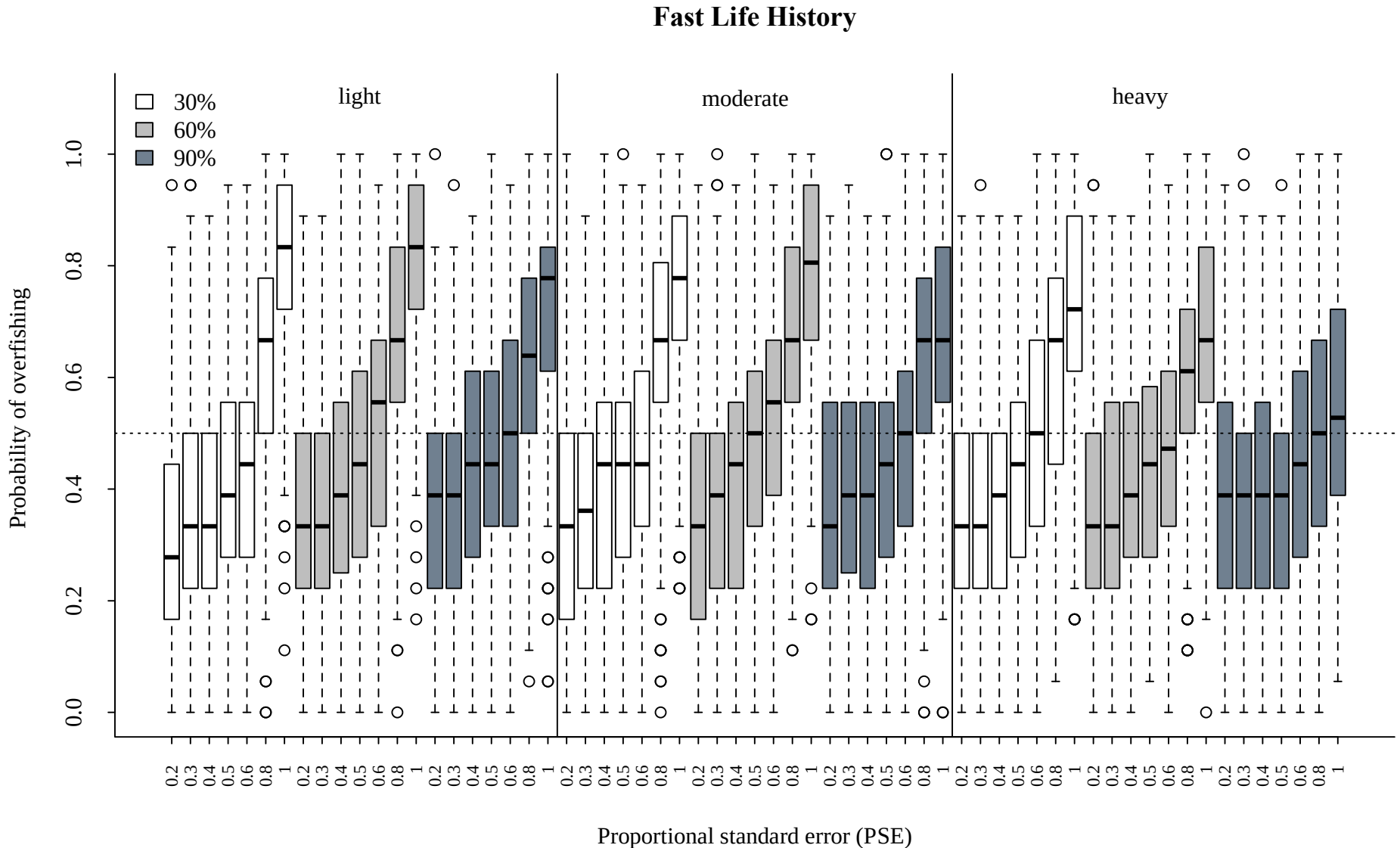
Mean Catch / MSY : Fast LH



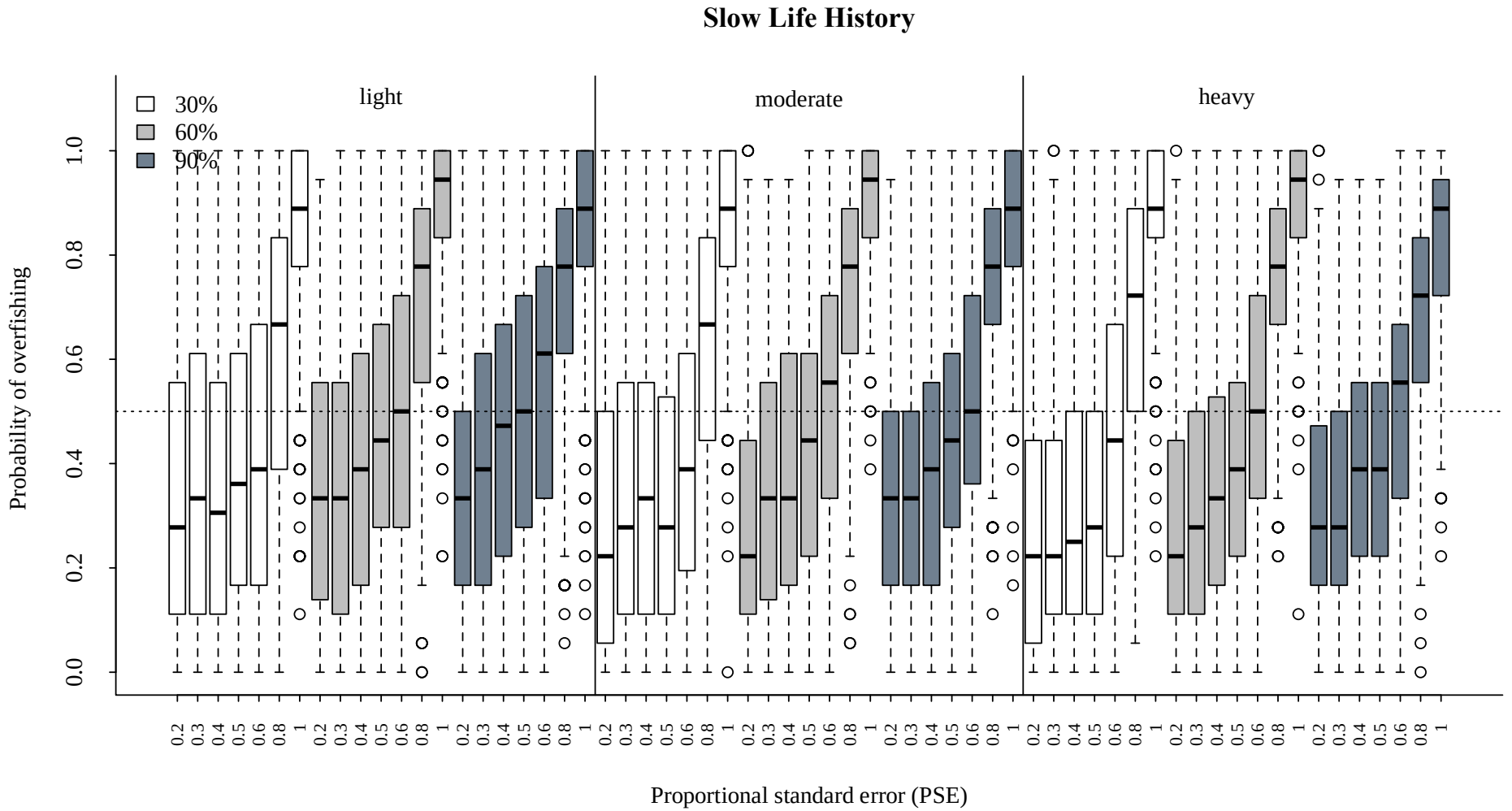
Mean Catch / MSY : Slow LH



Overfishing Probability : Fast LH

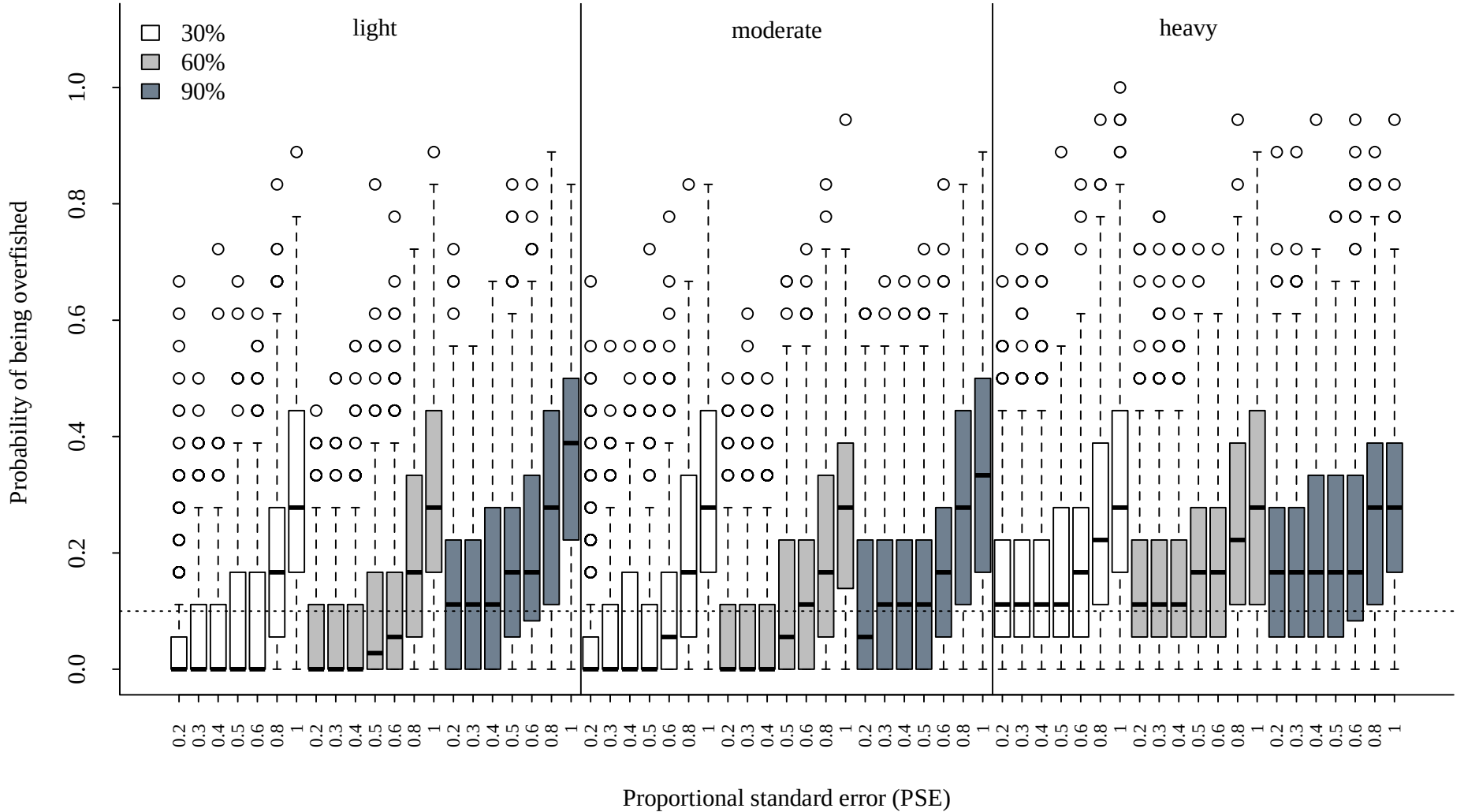


Overfishing Probability : Slow LH



Overfished Probability : Fast LH

Fast Life History



Overfished Probability : Slow LH

