Integrated stock assessment of the yellowfin tuna stock in the Indian Ocean

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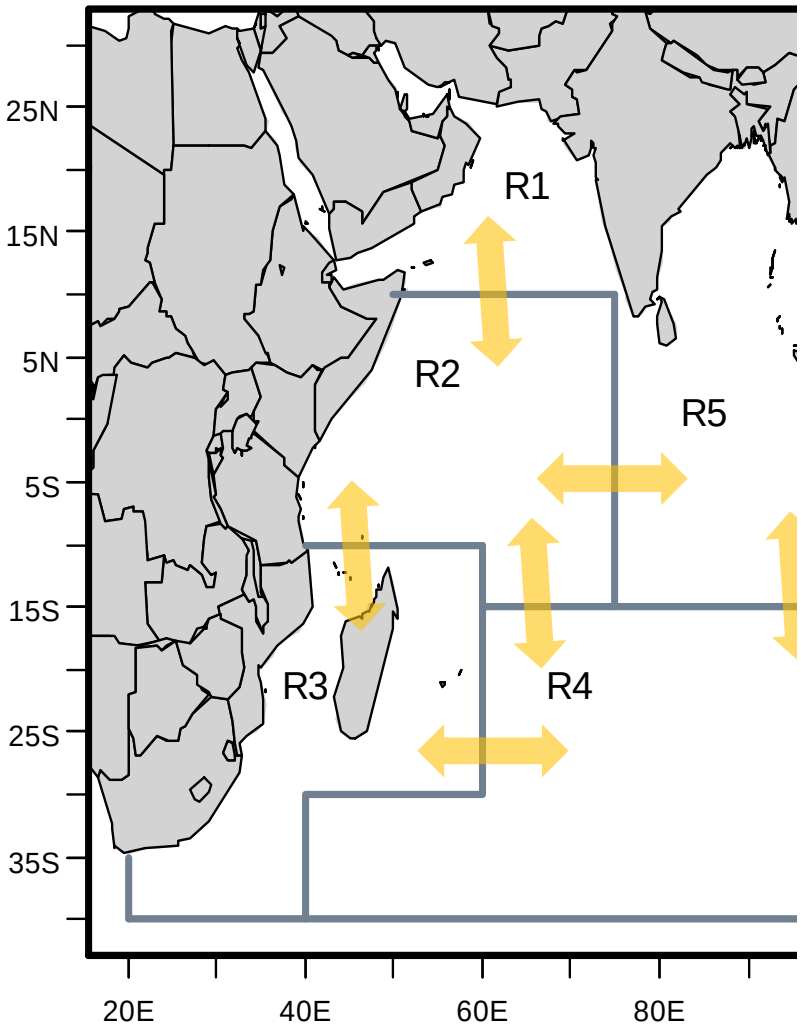
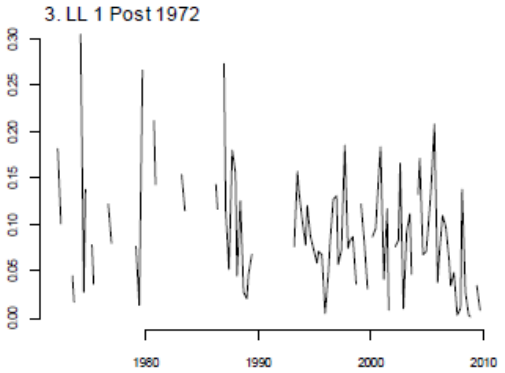
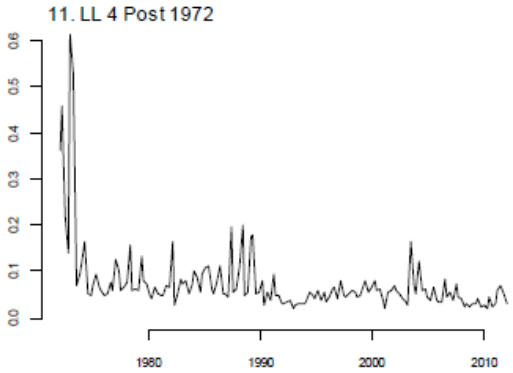
Introduction

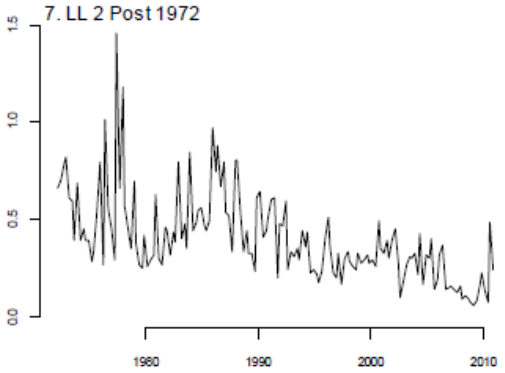
- Integrated age-structured stock assessment models. Incorporation of tag release/recoveries in likelihood.
- Spatial structure.
- Software platfoms MULTIFAN-CL and Stock Synthesis.
- Indian Ocean yellowfin assessments undertaken using MFCL (and SS) annually, since 2008.
- Tag dataset 54,393 releases (mostly 40-70 cm), 9961 recoveries.
- Tag data informative regarding stock size and natural mortality (and movement and selectivity).

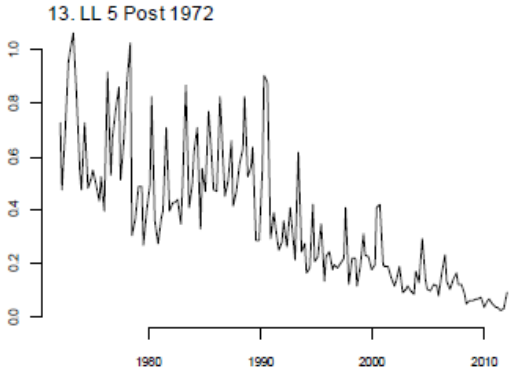
Key model elements

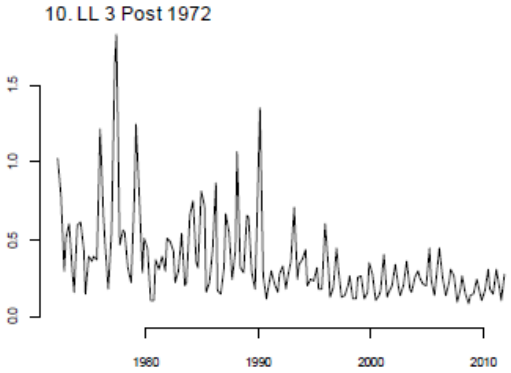












Model structure – tag component

- Correct tag recoveries for tag loss (initial, long-term).
- Release groups – Region, quarter (cohort).
- Assignment of tags to age at release (age) based on growth parameters.
- Mixing period (4 quarters).
- Predicted tag recoveries by cohort,age,fishery,time from fishery catch mediated by **fishery selectivity**, **reporting rate, natural mortality** and **movement**.
- Observed/predicted tag recoveries. Tag likelihood component in objective function. Negative binomial distribution, over dispersion parameter.

MFCL Tag Dynamics – single region example

Release 1

AGE **YEAR**

Release 2

AGE **YEAR**

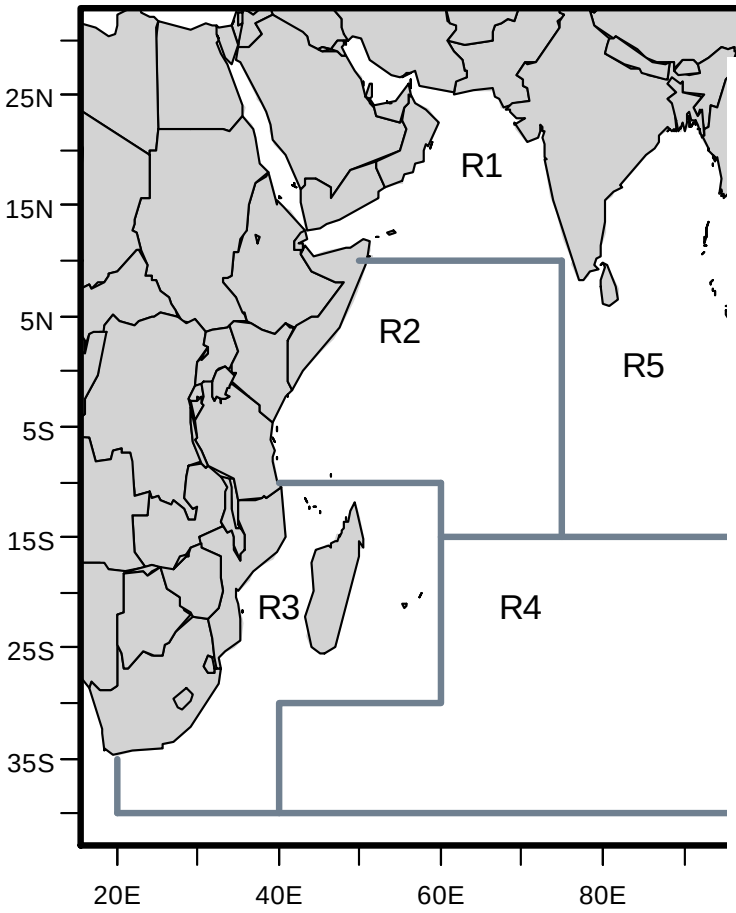
Release 3

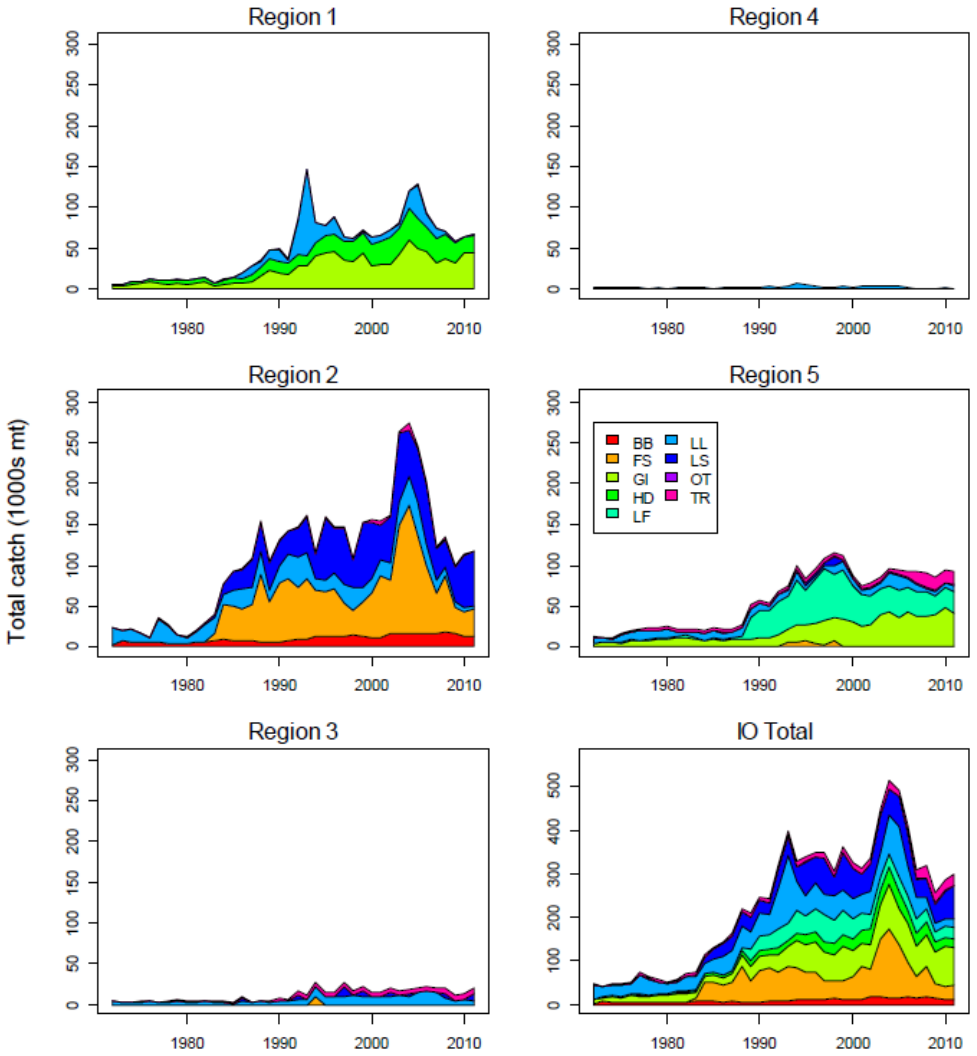
AGE **YEAR**

	2000	2001	2002	2003	2004	2005	2006	2007	2008
1									
2			32						
3			55	25					
4			32	65	20				
5				26	47	14			
6					18	46	11		
7						15	24	7	
8							10	19	5
9								6	13
10									6
11									
12									

Multiple tag release groups (cohorts).

Separable estimation of fishing mortality and natural mortality (in theory).



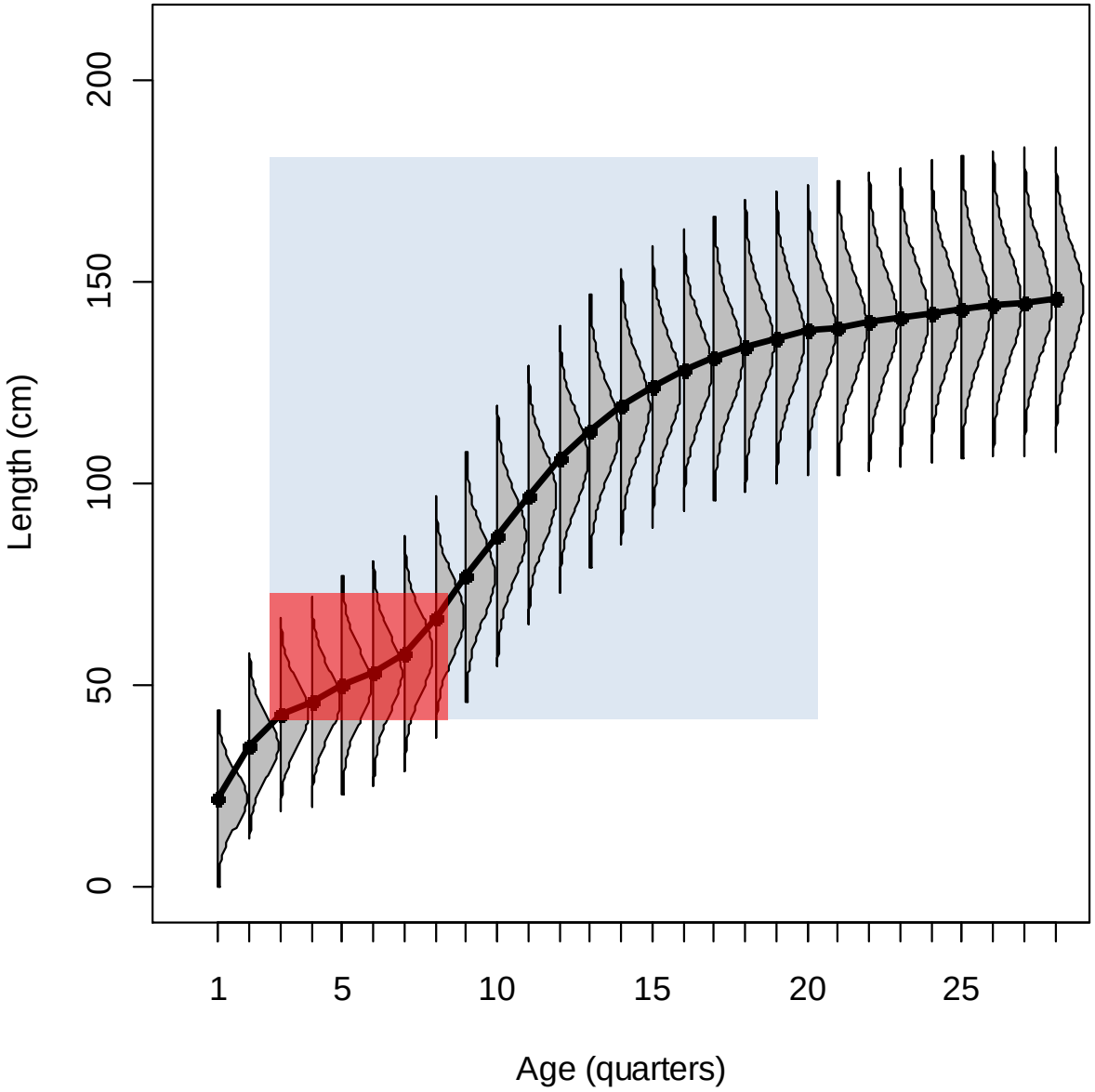


Spatial structure based on fishery structure and distribution of tag releases/recoveries.
Biogeographic regions.

Biological parameters

External analyses of tag data set to determine key parameters.

- Growth
- Natural mortality



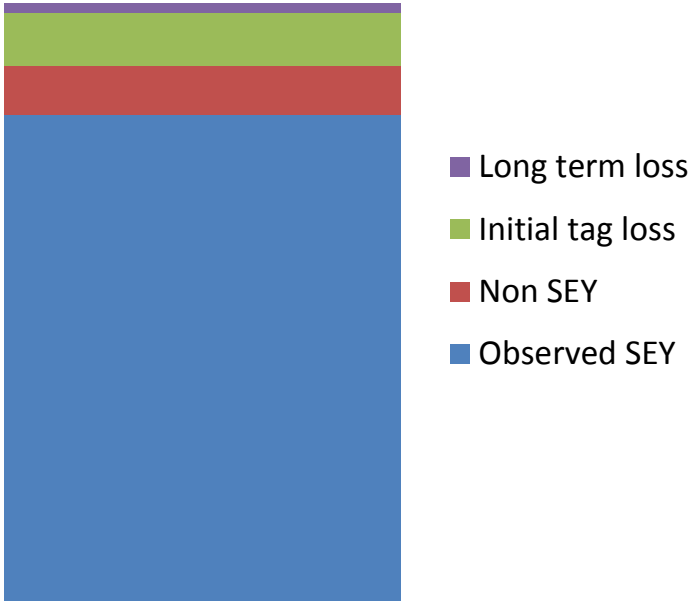
Tag dataset

Releases

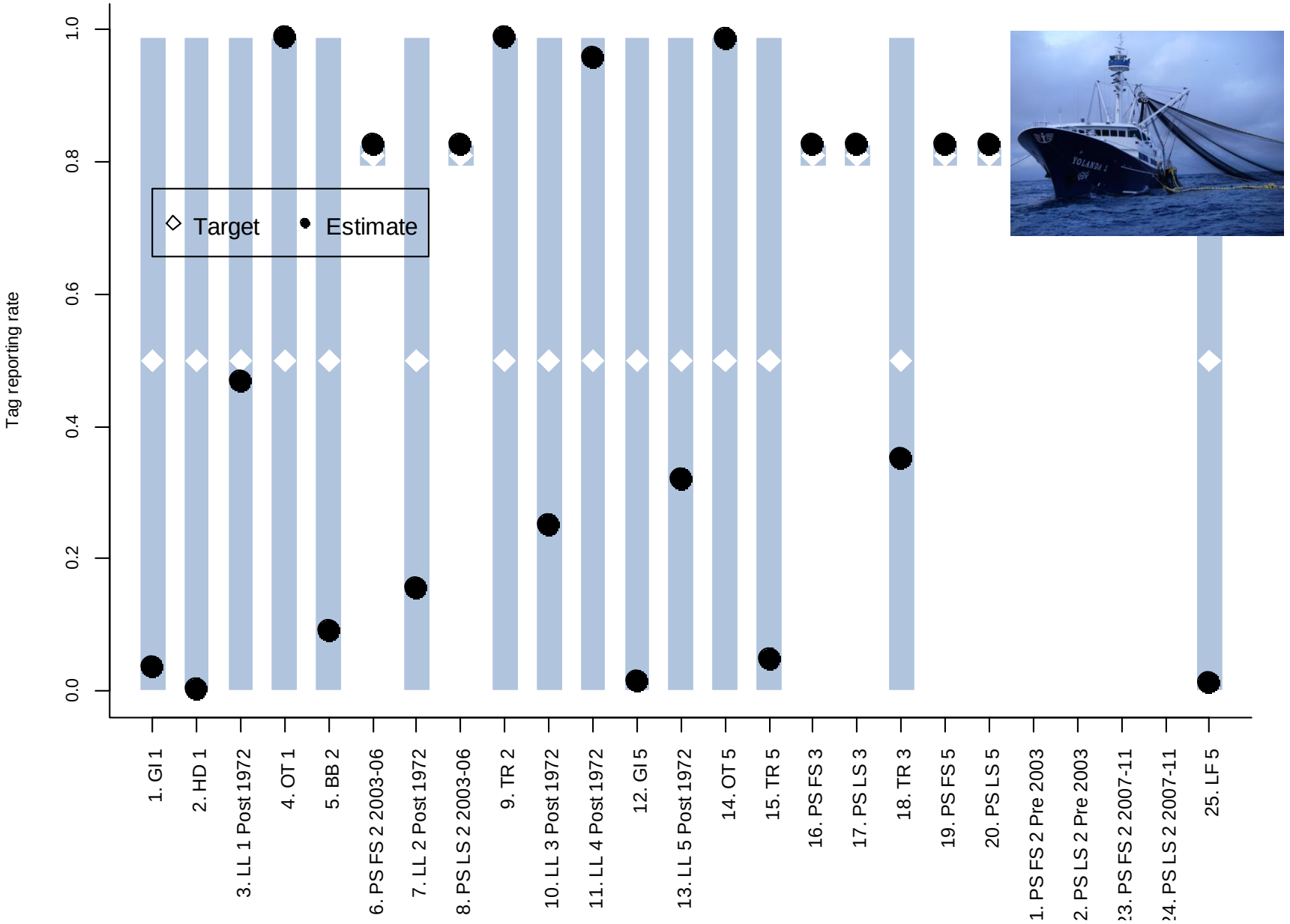
Region, quarter, length

Recoveries

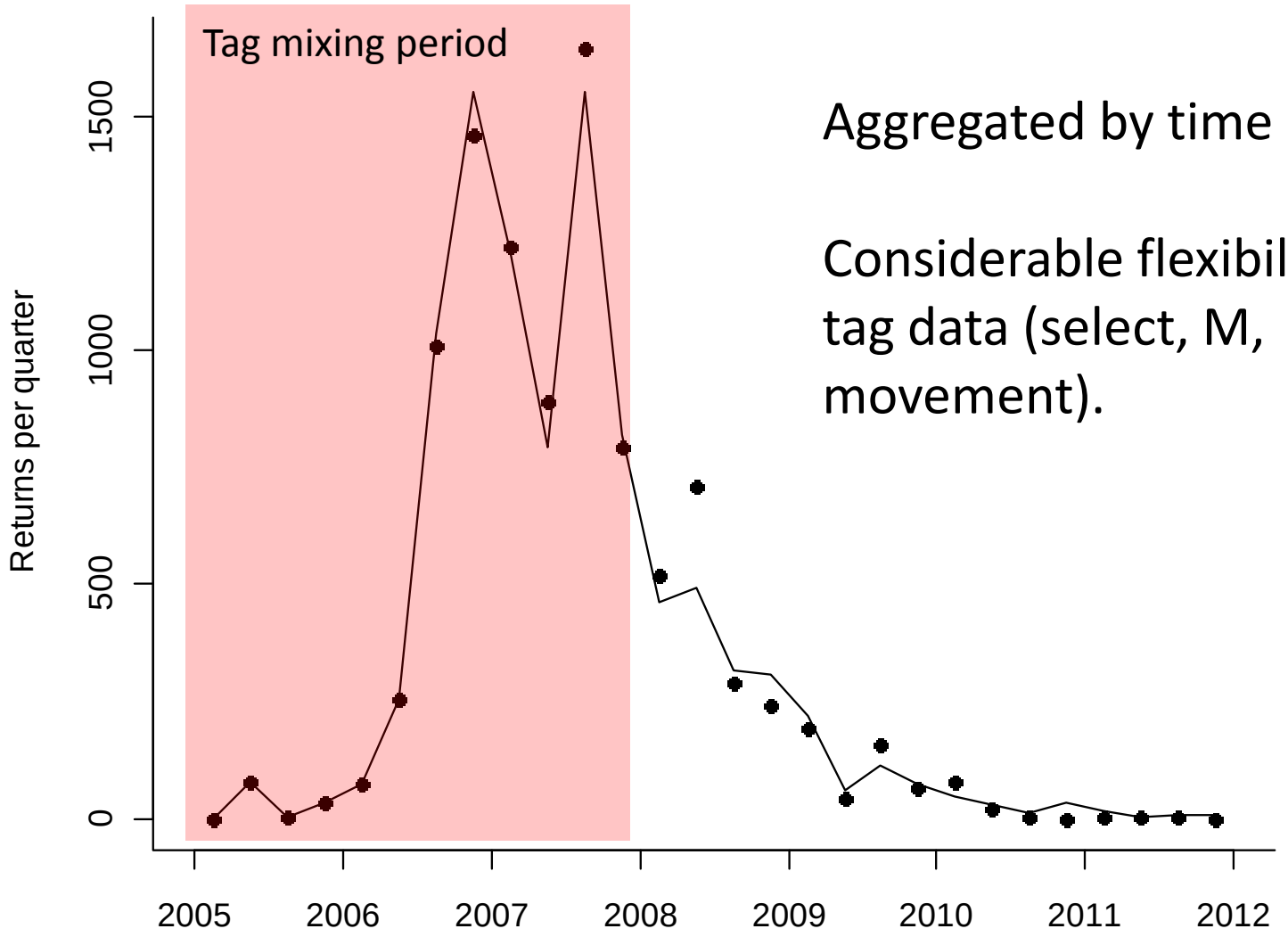
Fishery (region), quarter



Tag reporting rates – fishery specific



Tag recoveries 1

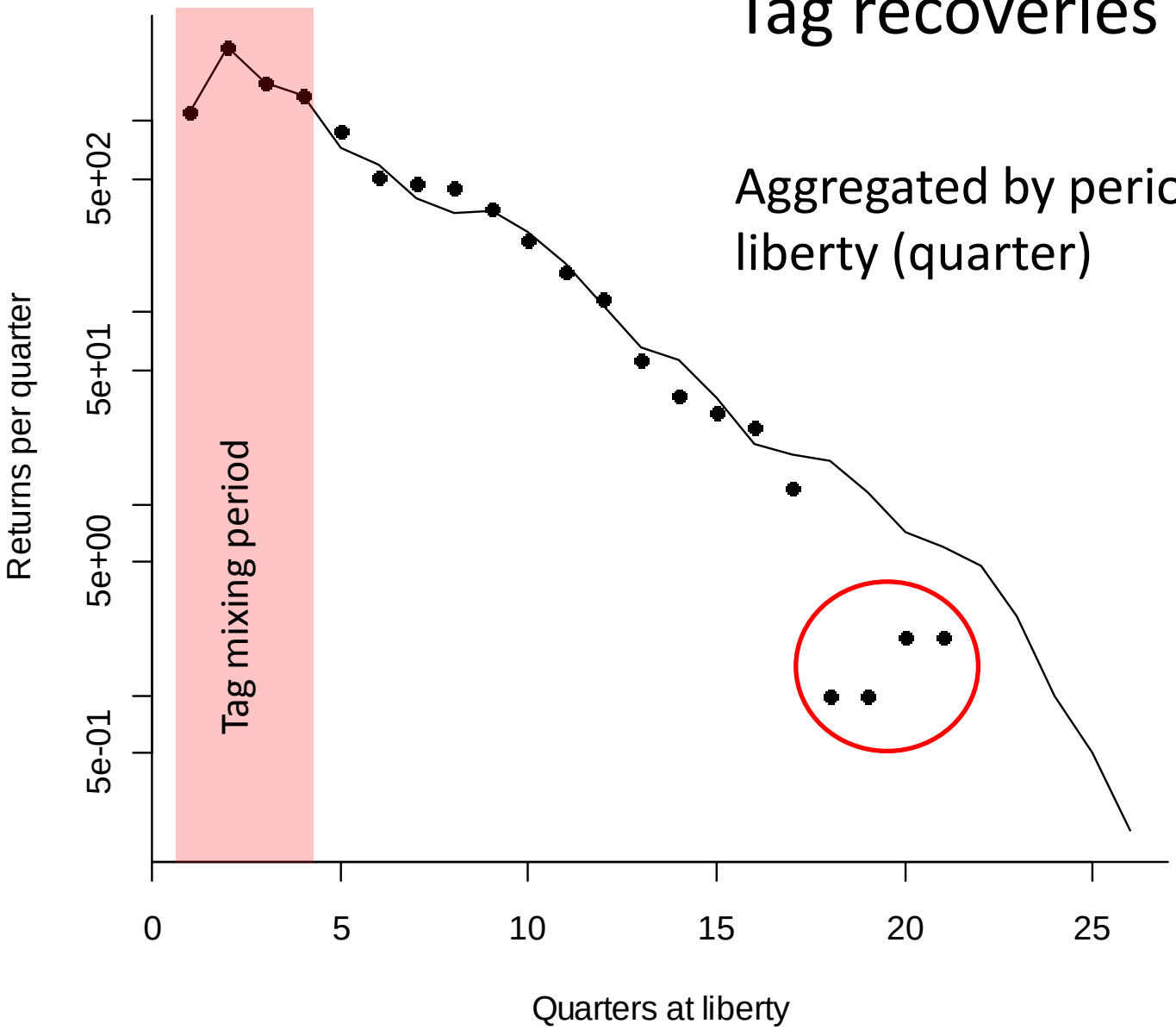


Aggregated by time (quarter)

Considerable flexibility to fit tag data (select, M, movement).

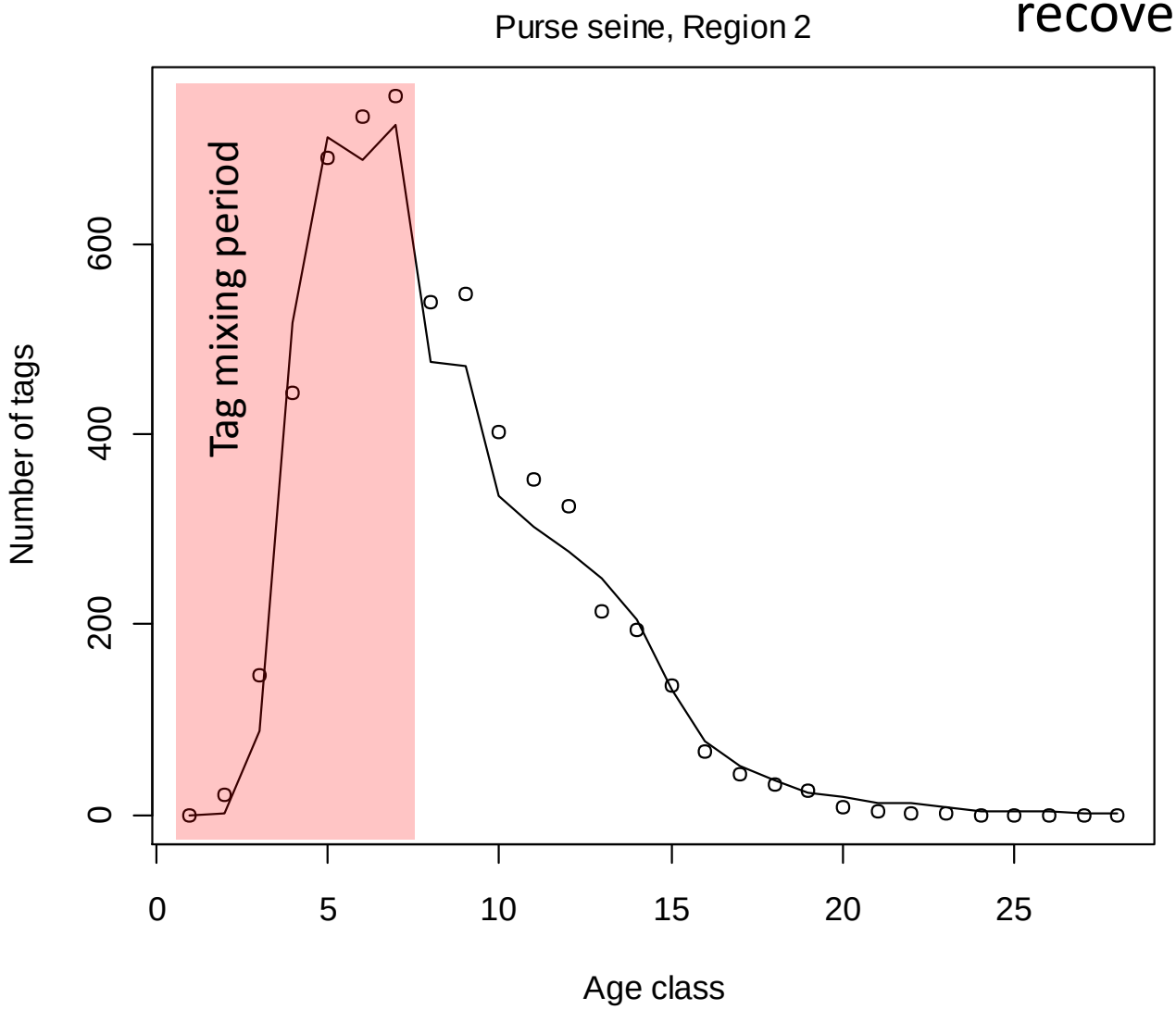
Tag recoveries 2

Aggregated by period at liberty (quarter)

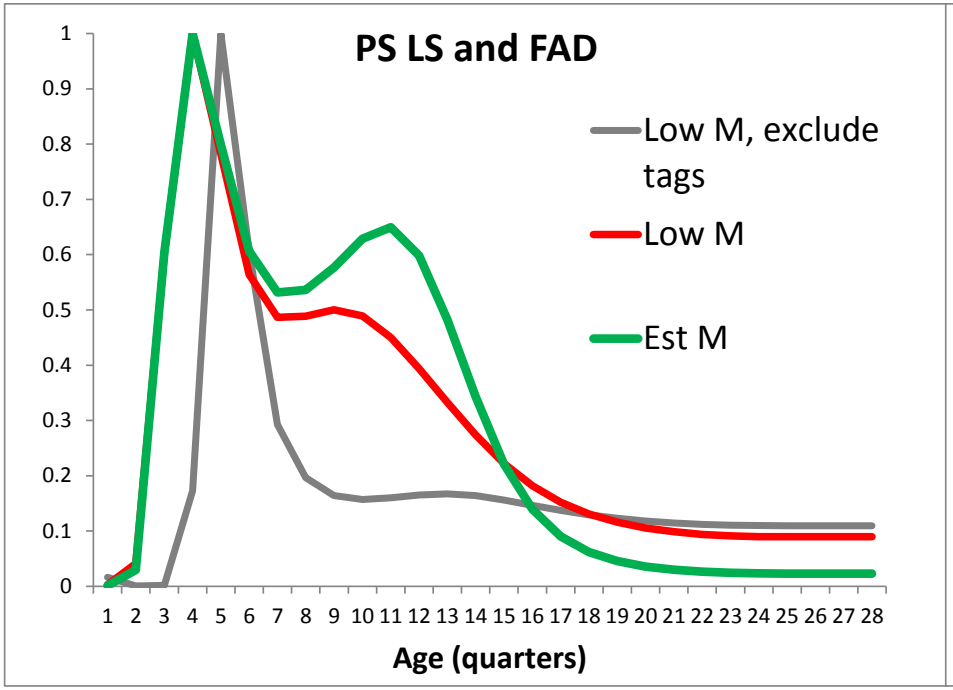


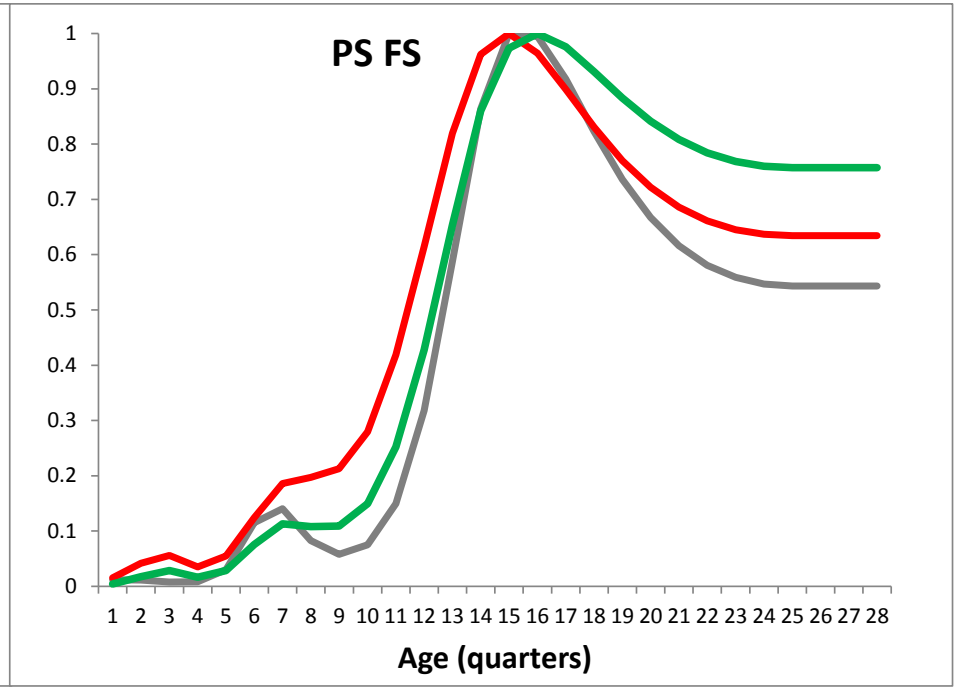
Tag recoveries 3

Aggregated by age at recovery (quarter)

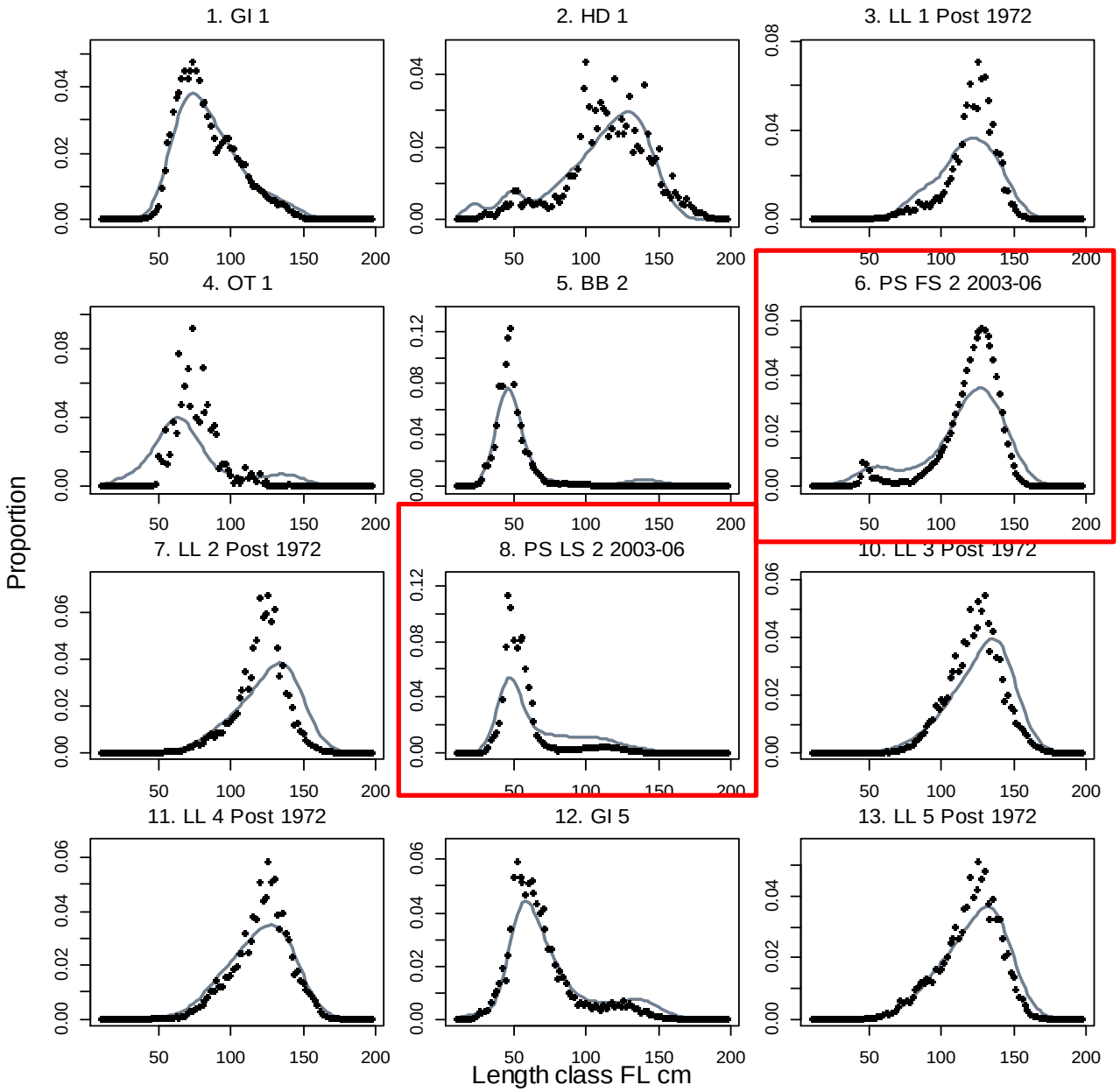


Fishery selectivity





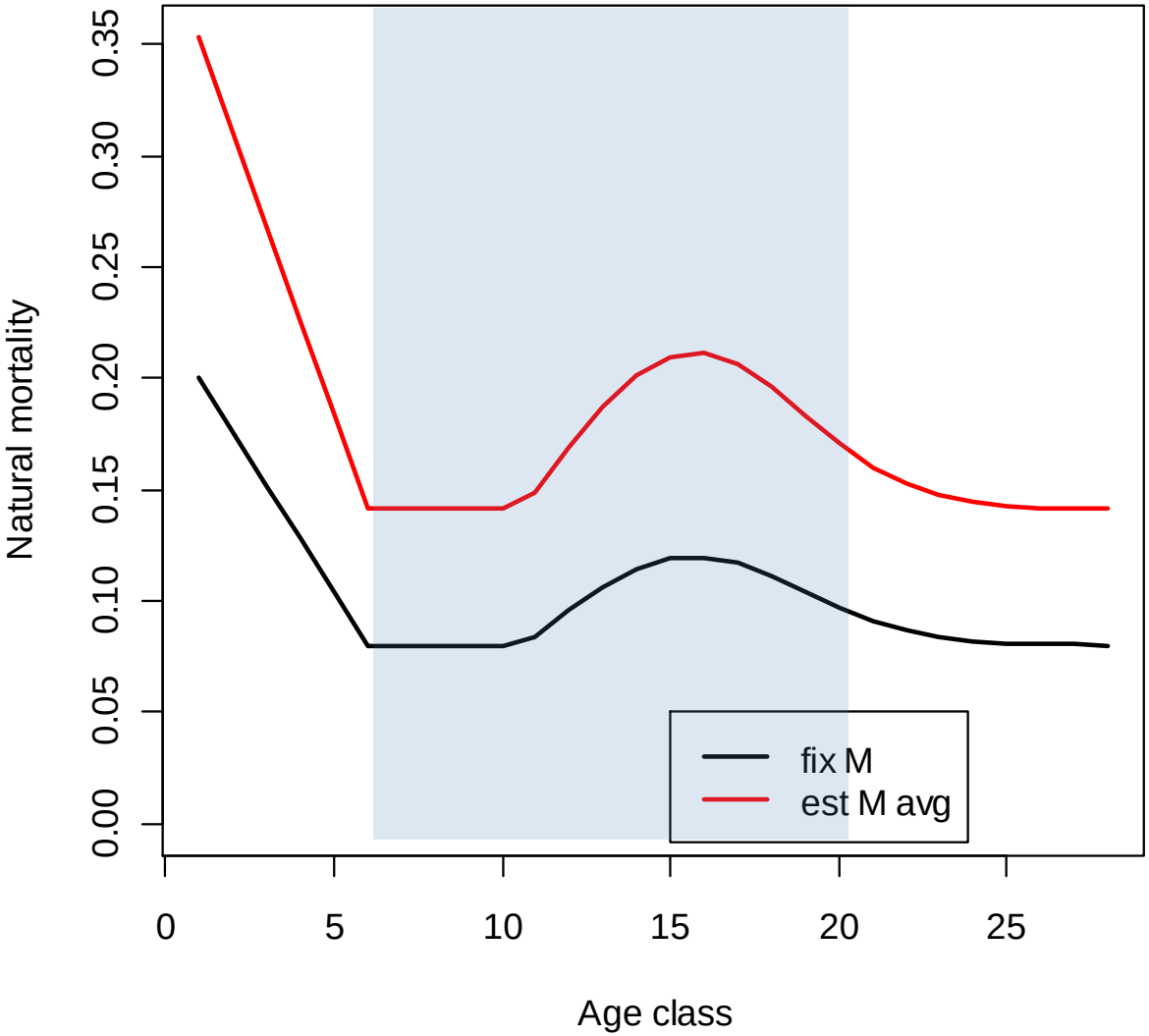
Tagging data highly influential in selectivity estimates for key fisheries.
However, small time window during recovery period.



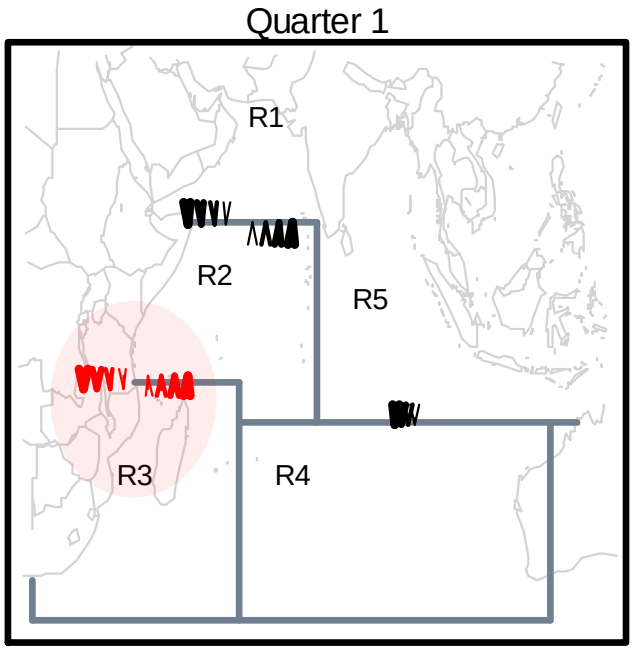
Degradation of the fit to the length data.

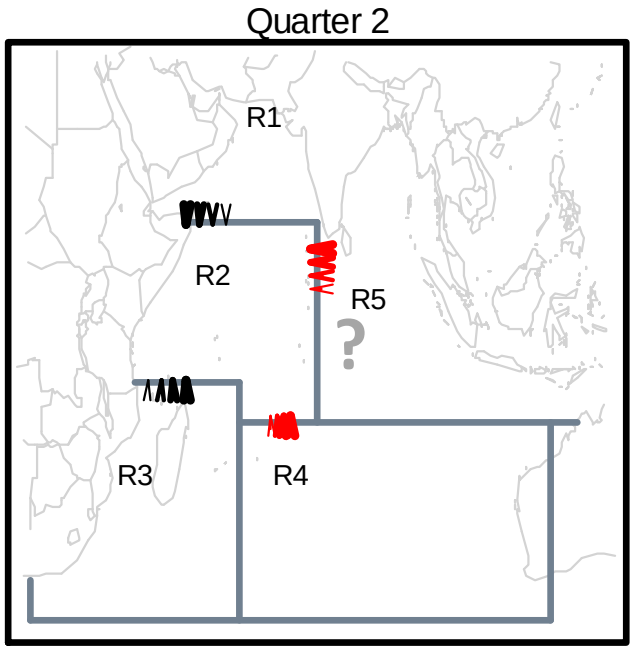
Tag data highly influential

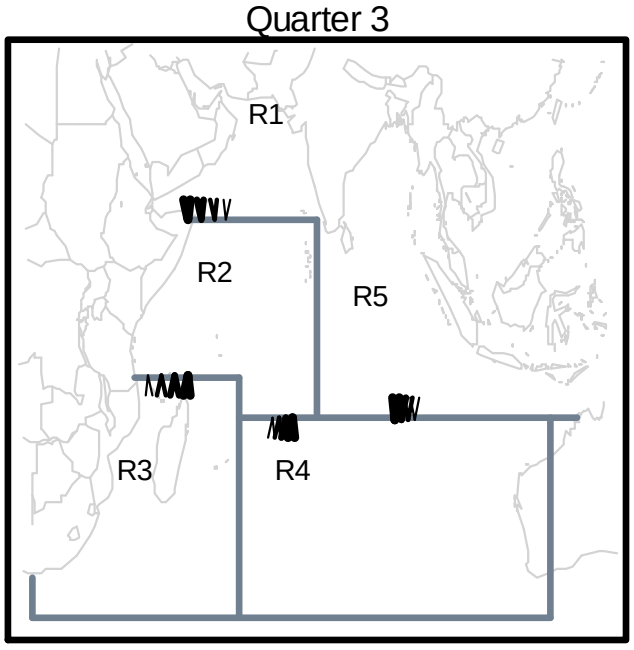
Natural mortality

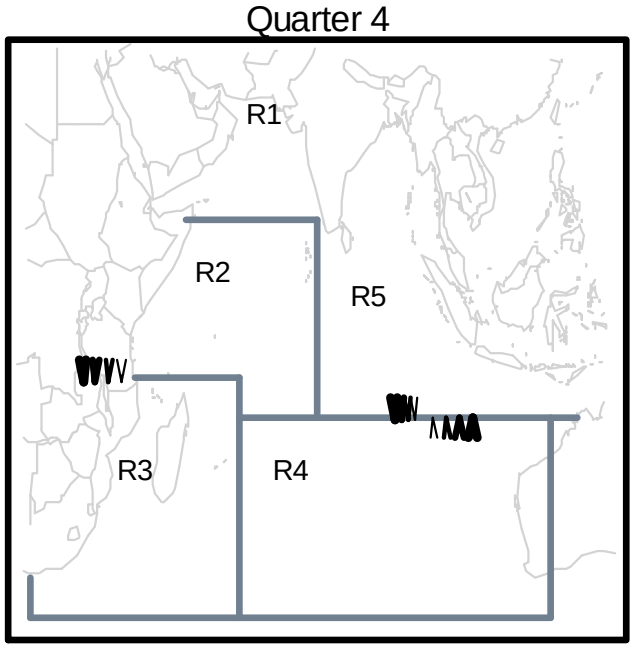


Estimation of average level of natural mortality; interaction with estimation of fishery selectivity and movement.







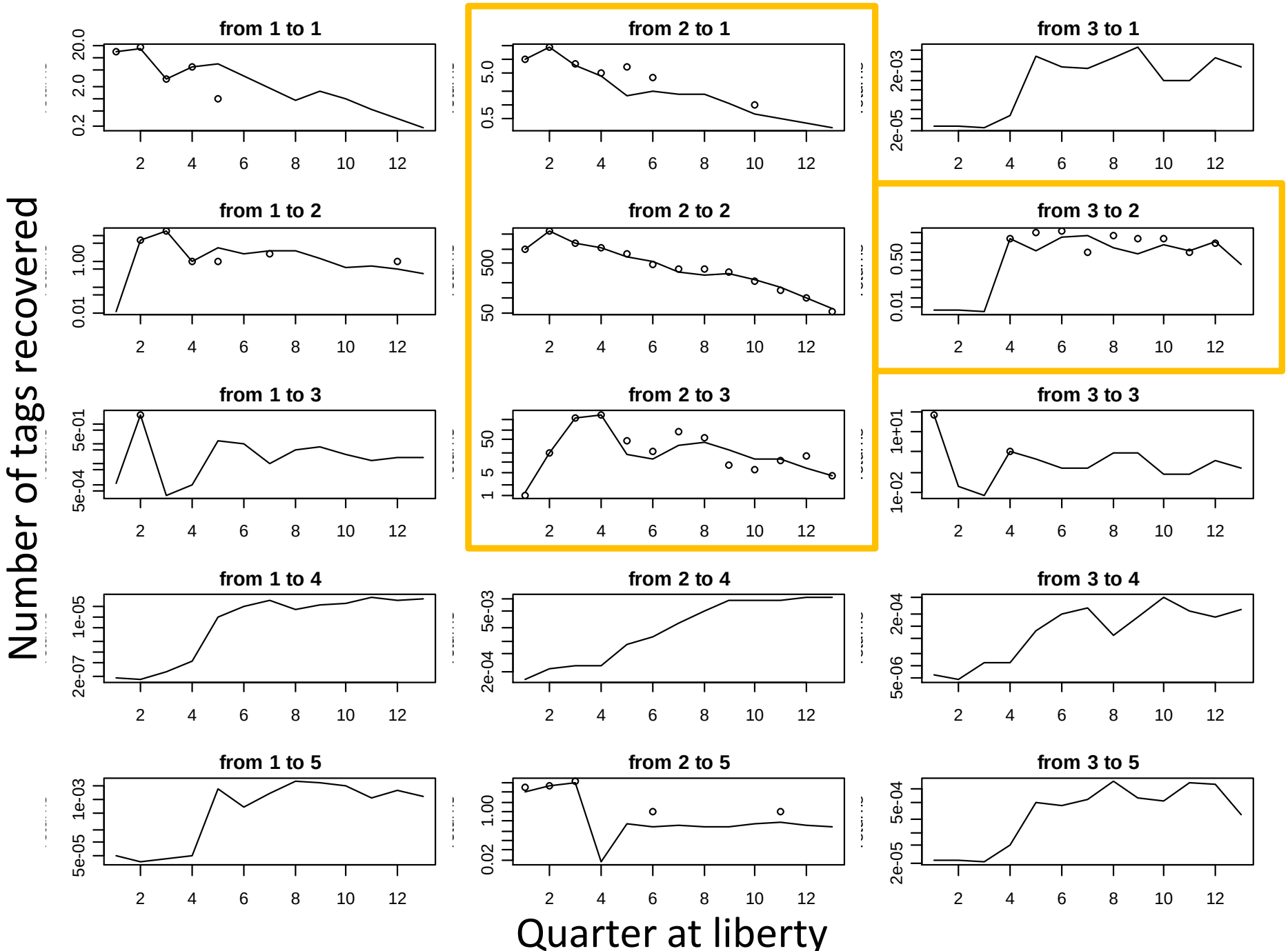


Movement

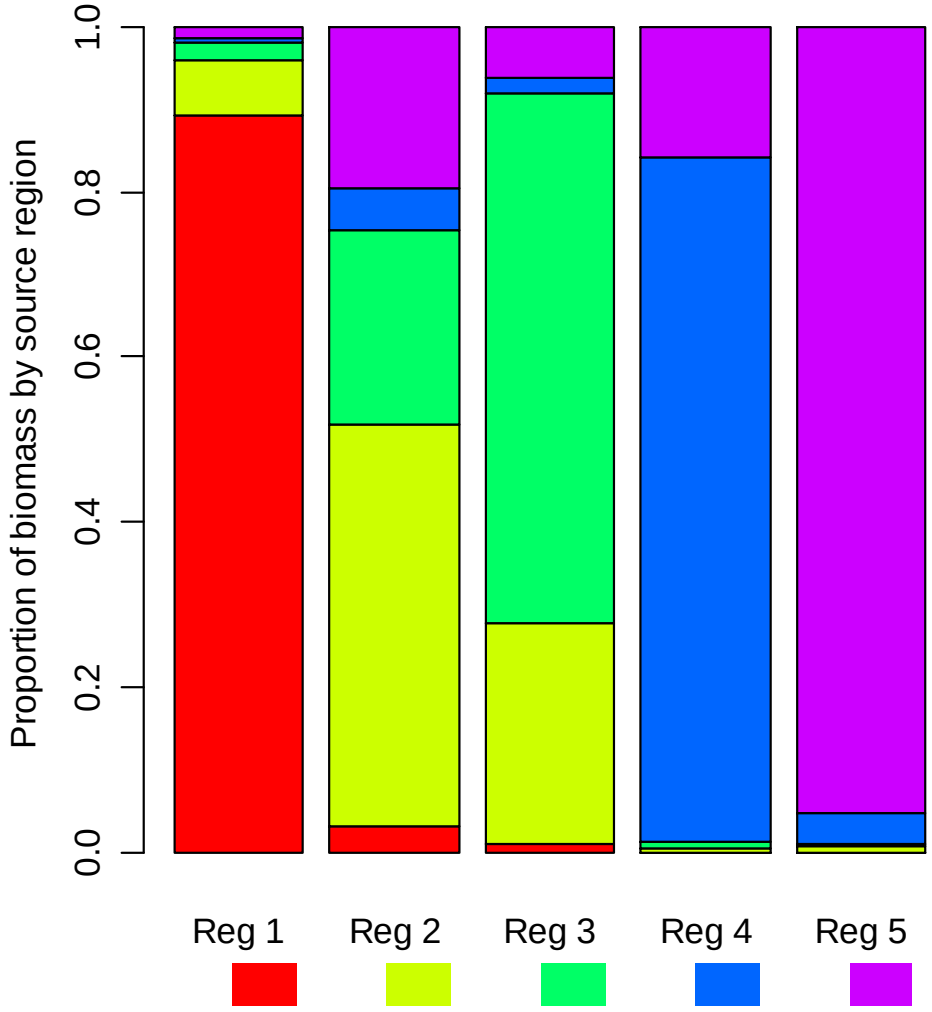
Quarterly movements. Invariant with age and year.

Tag data highly informative in estimation of movement parameters.

Max movement approx 10% per quarter (red).

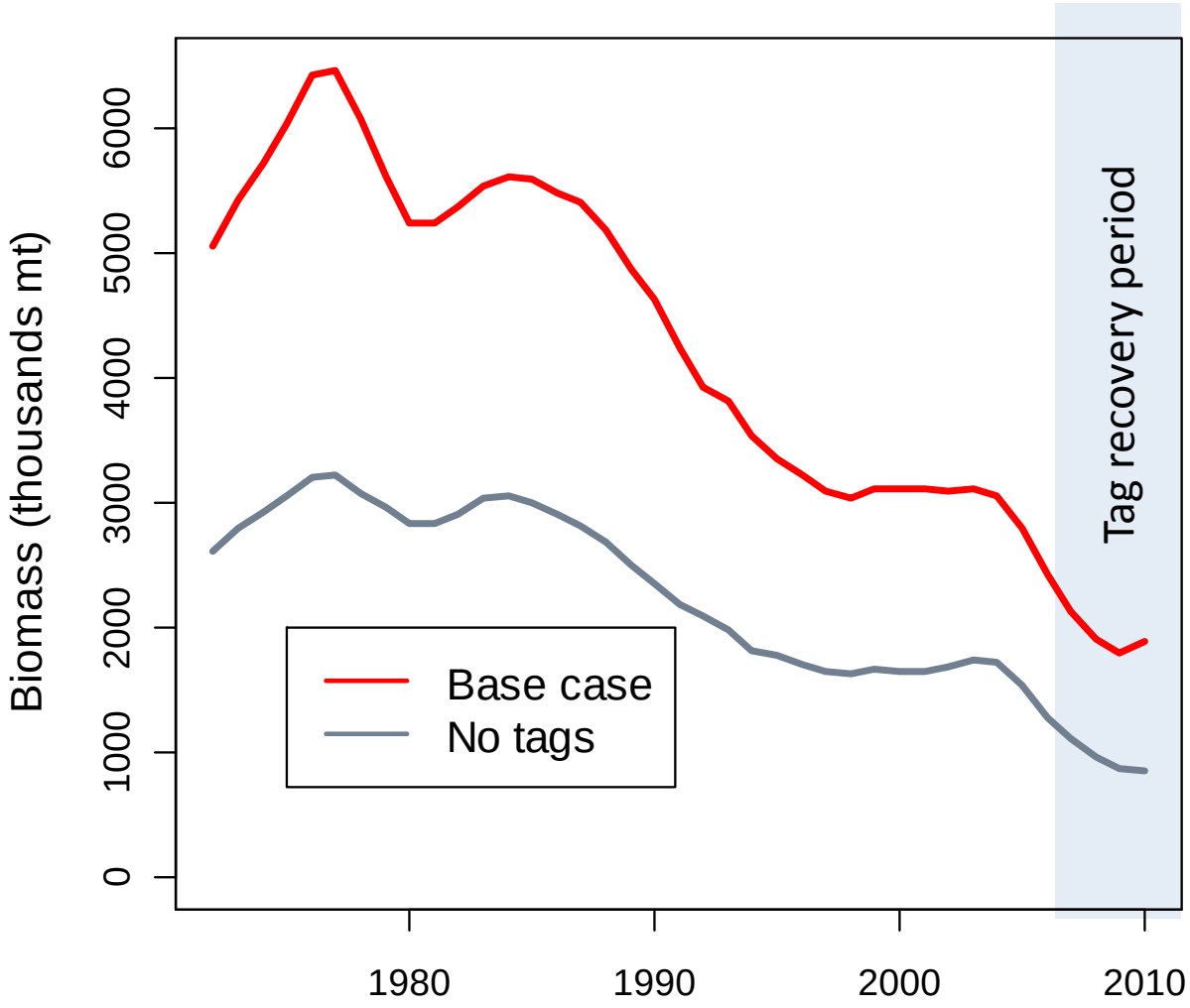

from 1 to 1
from 2 to 1
from 3 to 1
from 1 to 2
from 2 to 2
from 3 to 2
from 1 to 3
from 2 to 3
from 3 to 3
from 1 to 4
from 2 to 4
from 3 to 4
from 1 to 5
from 2 to 5
from 3 to 5
Number of tags recovered
Quarter at liberty

Movement



Recruitment source by region.

Biomass trajectory



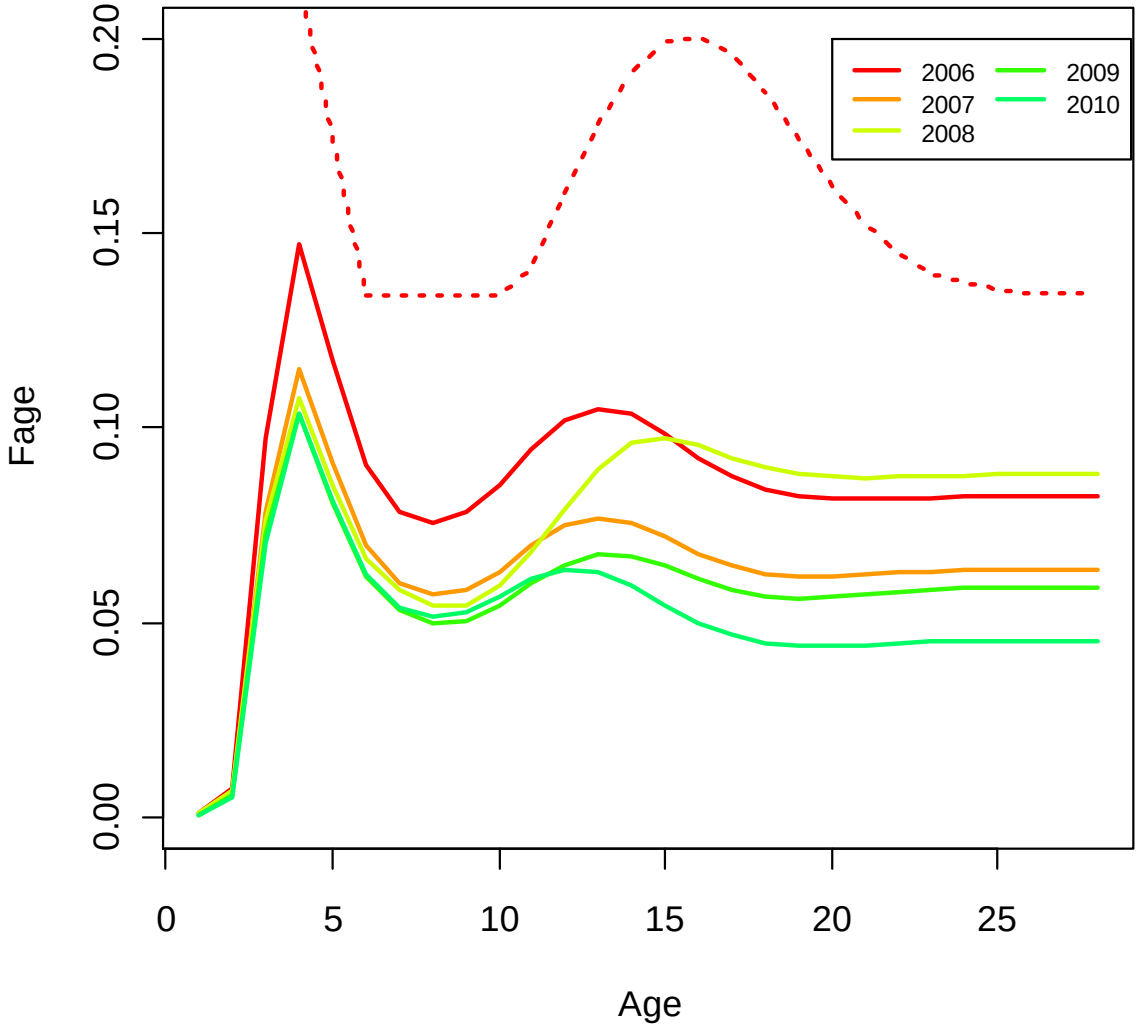
Decline in historical biomass driven by LL CPUE from each region.

Very large decline in absolute biomass – not consistent with catch history.

Trends in recruitment, biomass and F are credible for western equatorial region.

Fishing mortality estimates

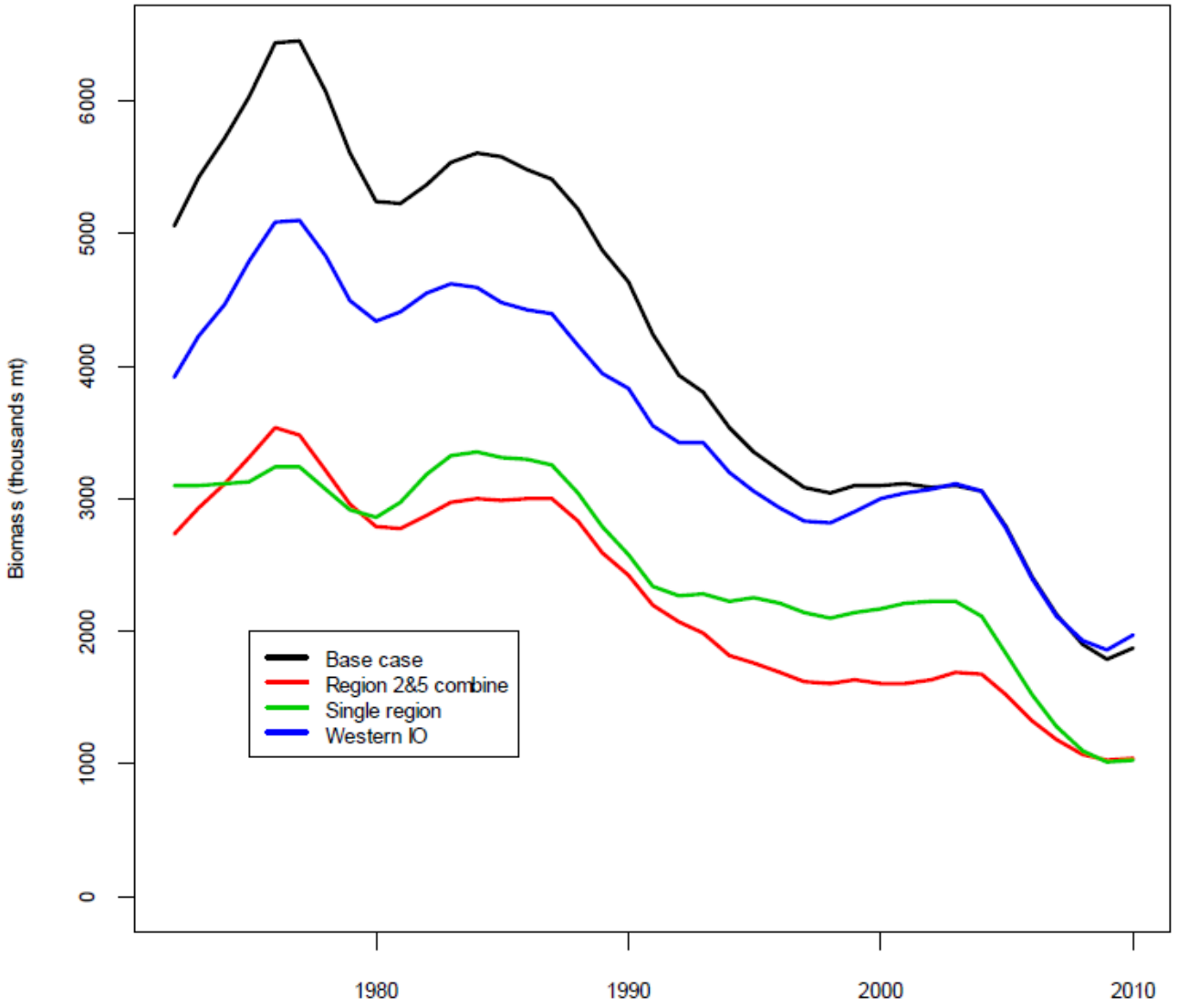
Age specific estimates for western equatorial region (2)



Model sensitivities

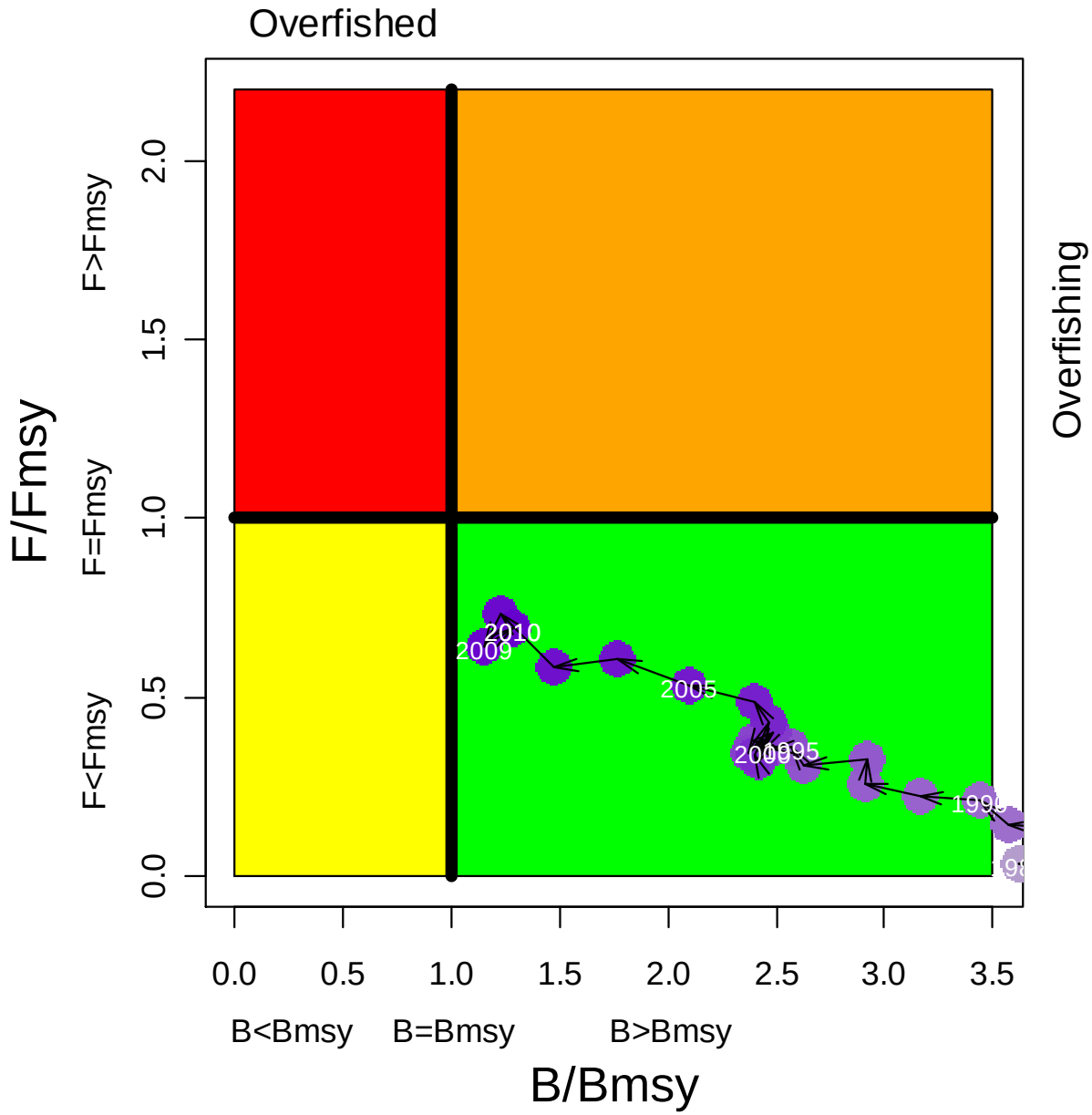
- Alternative regional structures. Sensitive to treatment of equatorial region. Component of the population linked to tag recoveries.
- Movement dynamics.
- Tag mixing period.
- Temporal changes in PS selectivity.

Regional structure



Summary

- Inclusion of tagging data highly informative in YFT assessment.
- Tag data limited to single region within model. Higher uncertainty with assessment for broader IO.
- Comparable assessments with and without tag data result in considerable different conclusions regarding stock status.
- Tag data: higher MSY, not overfished, not overfishing.
- Paradoxical to some scientists. Outstanding issues in assessment.
- Model structural assumptions; spatial structure, temporally invariant parameters. Tags represent a single snapshot.
- Limitations of other historical data sets (size freq, CPUE). Conflict with tag data set.


Overfished
Overfishing
F/Fmsy
F>Fmsy
F=Fmsy
F<Fmsy
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
B<Bmsy
B=Bmsy
B>Bmsy
B/Bmsy
2010
2009
2005
2000
1995
1990