Case studies of the local stock assessment in the Northwest Pacific: application of robust regression in estimating stock-recruitment relationship

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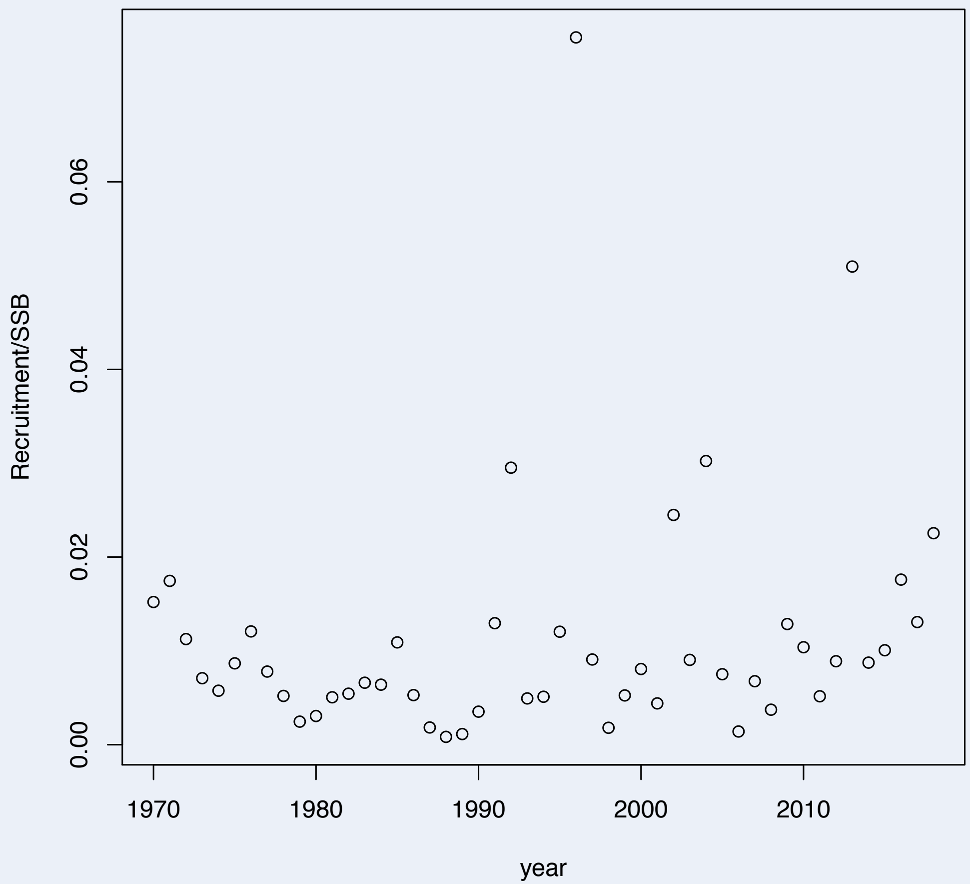
Strong year-classes in fisheries resources

- Strong year-classes occur everywhere in fisheries stock.

- Example in Japan;

The northwest pacific stock in Chub mackerel in 1992, 1996, 2004, and 2013.

[1970 – 2018]



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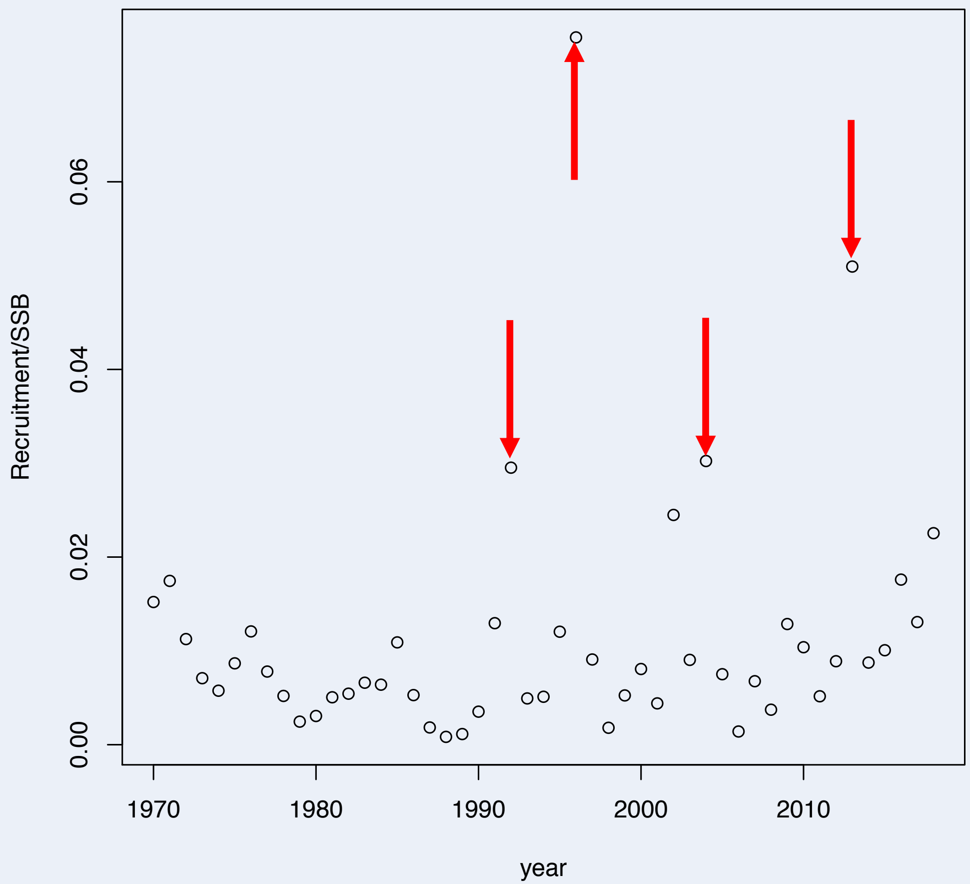
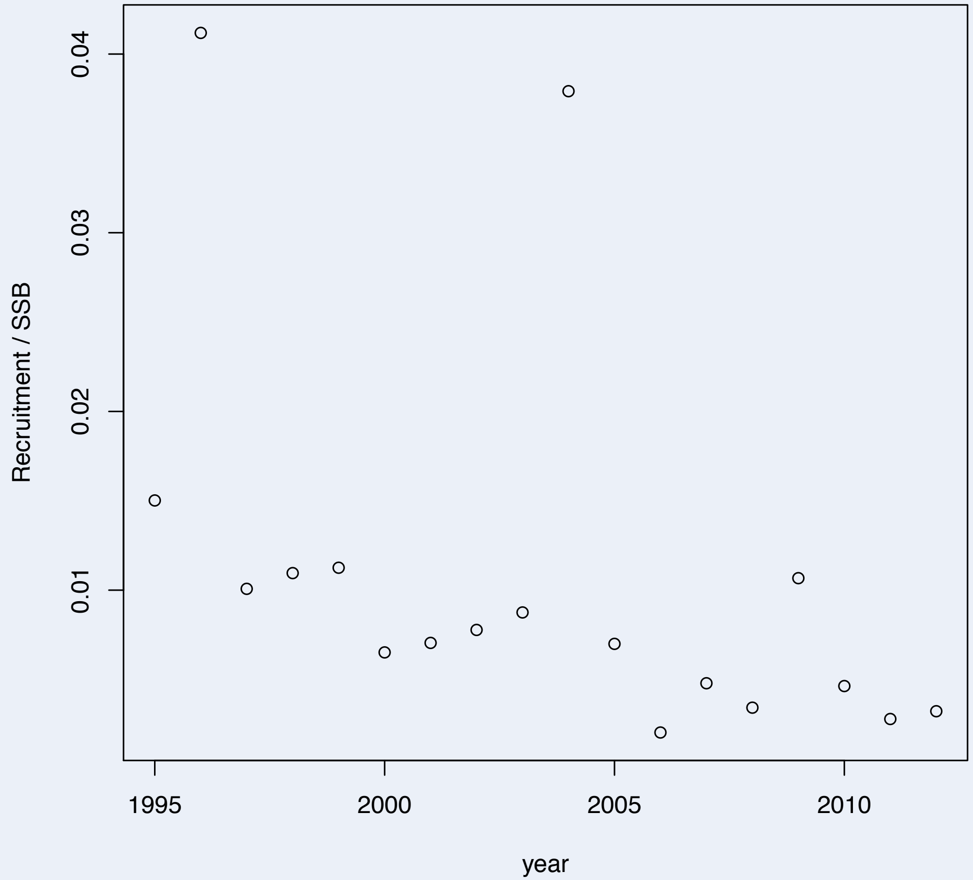


Strong year-classes in northwest pacific stock

- Example in Japan;

The northwest pacific stock in Blue mackerel in 1996, and 2004.

[1995-2012]



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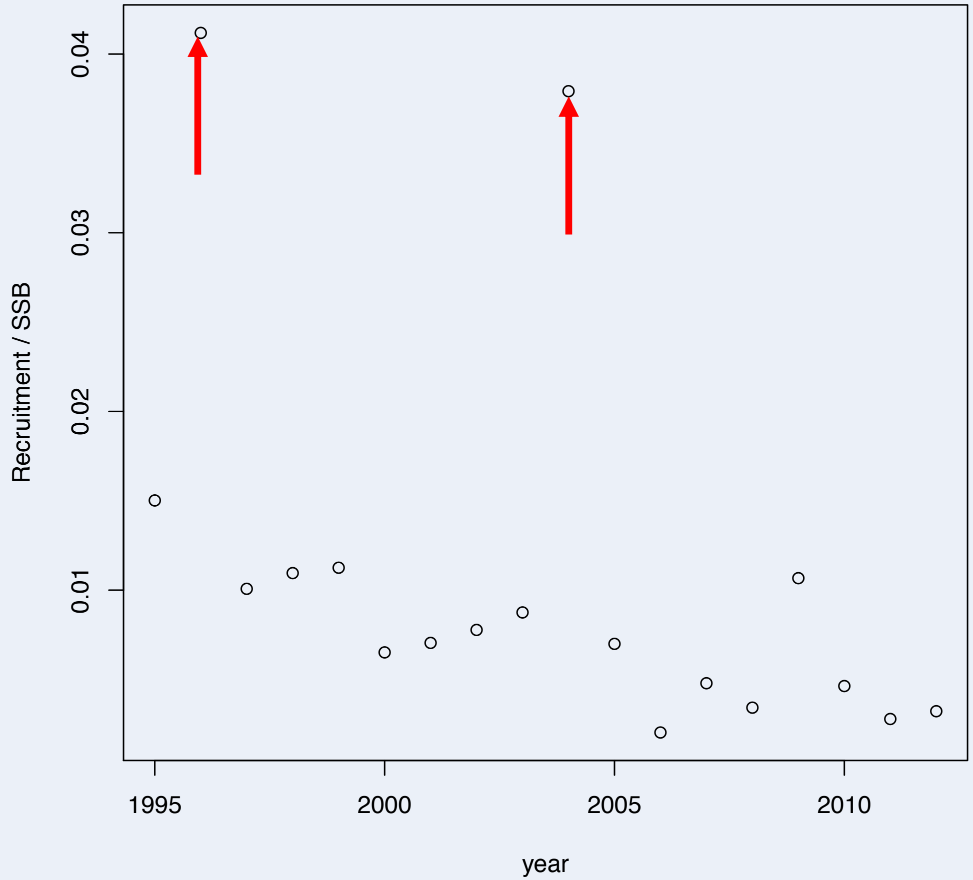
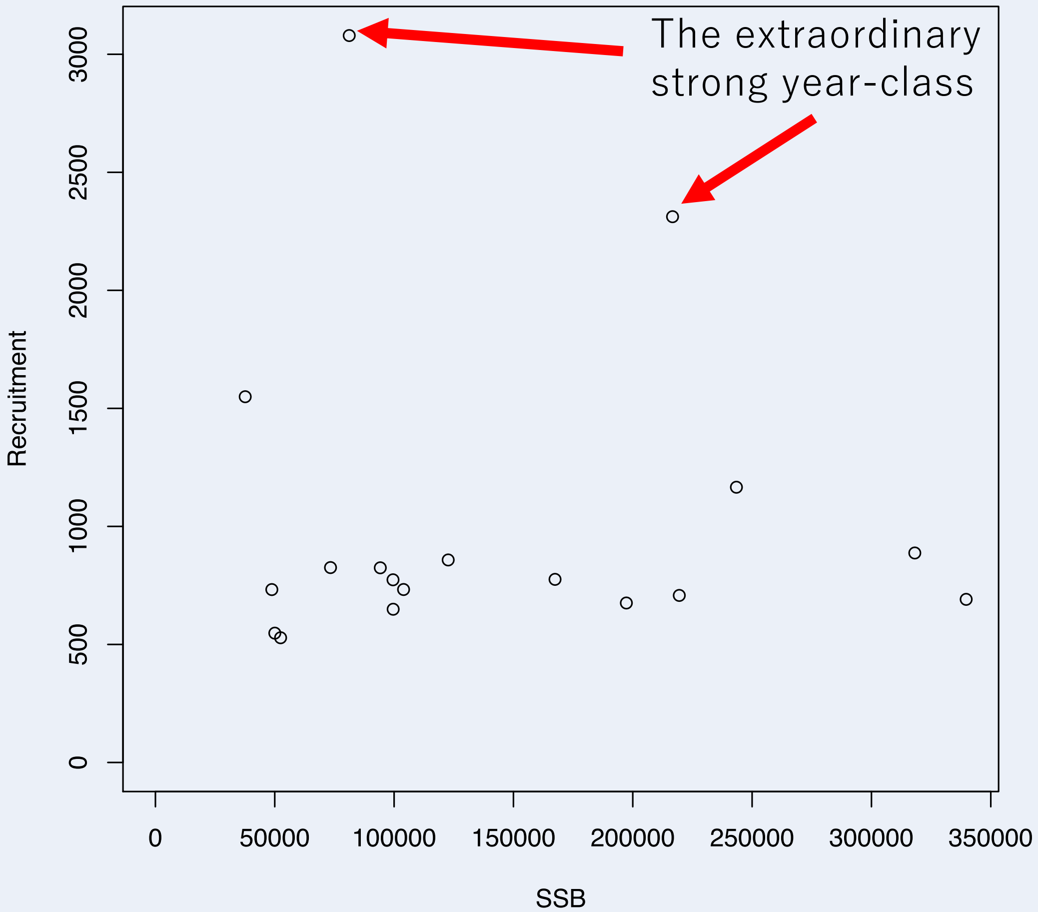


Bias in parameter estimation of SR function



- The recruitment deviating from the assumption of error distribution (lognormal dist.) occurs.
- Call here it “the extraordinary strong year-class”.
- The extraordinary strong year-class data causes a bias in parameter estimation.
- The biased parameter in SR function might fail in stock management and sustainable fishing activities.

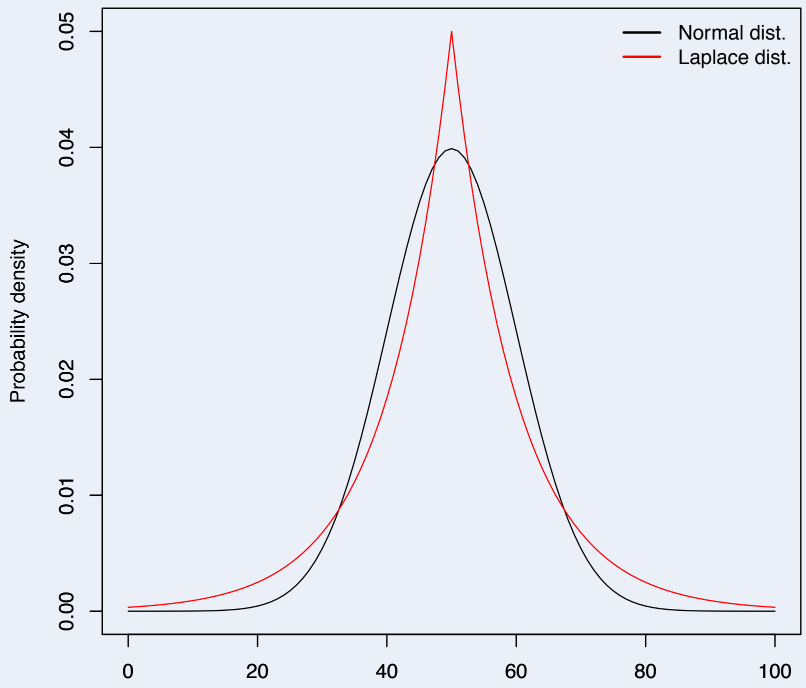
Need the robust estimation

- The Least Mean Square (LMS) method is adopted to estimate the parameters in SR function by assuming the residuals follow the lognormal distribution.

- The extraordinary strong year-class is notoriously influential to estimate parameters in SR function.

- To avoid such an unfavorable effect in estimating parameters, the robust estimation could be useful in stock assessment.

Least Absolute Deviation (LAD) method as robust estimation



- In most cases, LSM assumes a normal distribution for the residuals, which is hard to accept outliers .
- LAD uses the median as the center of the distribution and assumes a Laplace distribution for the residuals. The distribution tends to tolerate outliers.
- Hereafter, the estimation by LAD is described as L1 and by LMS as L2.

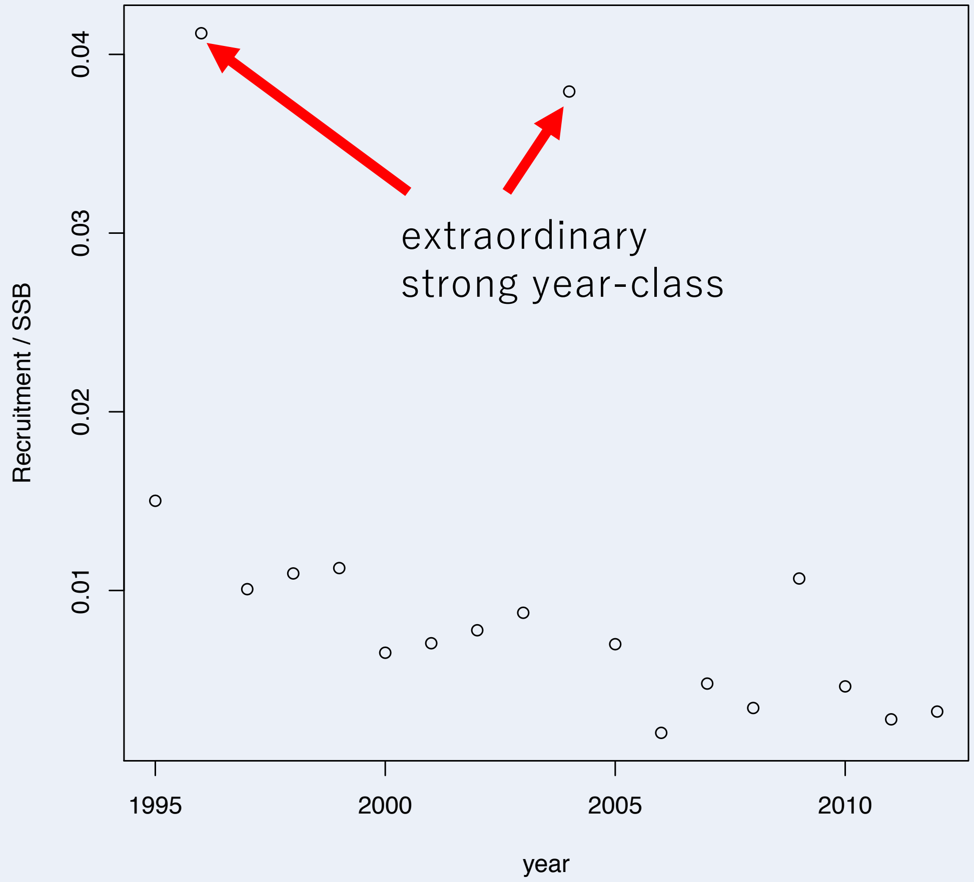
Estimating parameters in SR function by simulations

- To compare the accuracy of estimated parameters in SR function by L1 or by L2 methods, we generated the SR data by simulation with lognormal errors in recruitment.

- The ordinary and extra-ordinary SR relationships were generated based on the Hockey-Stick type SR function.

- Following the past SR pattern, the extraordinary strong year-class is assumed to occur about once every 10 years (p=0.1).

- The recruitment was multiplied 10.

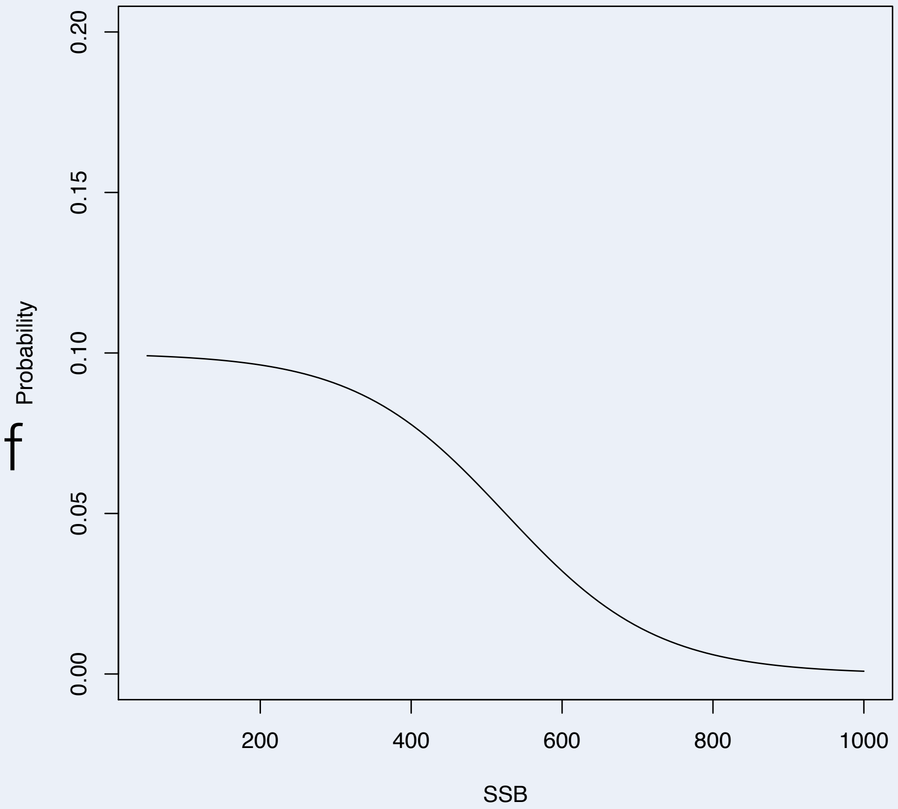


Extraordinary strong year-class occurs depending on the size of SSB

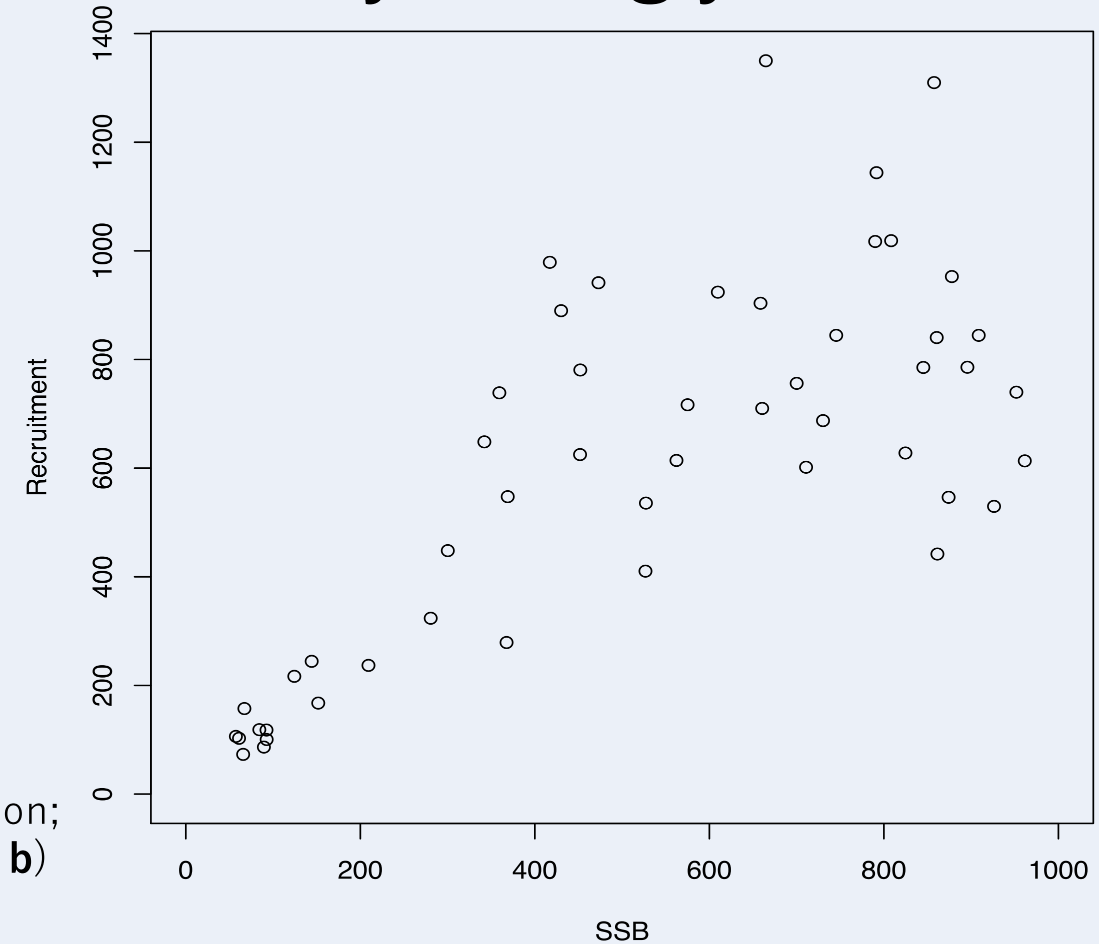
- The extraordinary strong year-class occurs where the SSB is small.

  $p/(1+\exp(\beta*(\mathrm{SSB}-\mathrm{mSSB}))$

- where β and mSSB are the slope coefficient (0.01) and the mid-value of SSB range ((50+1000)/2).



Realistic value in variance (sd.lognorm=0.4) without extraordinary strong year-class



Hokey Stick type SR function;
Recruitment = **a** min(SSB, **b**)

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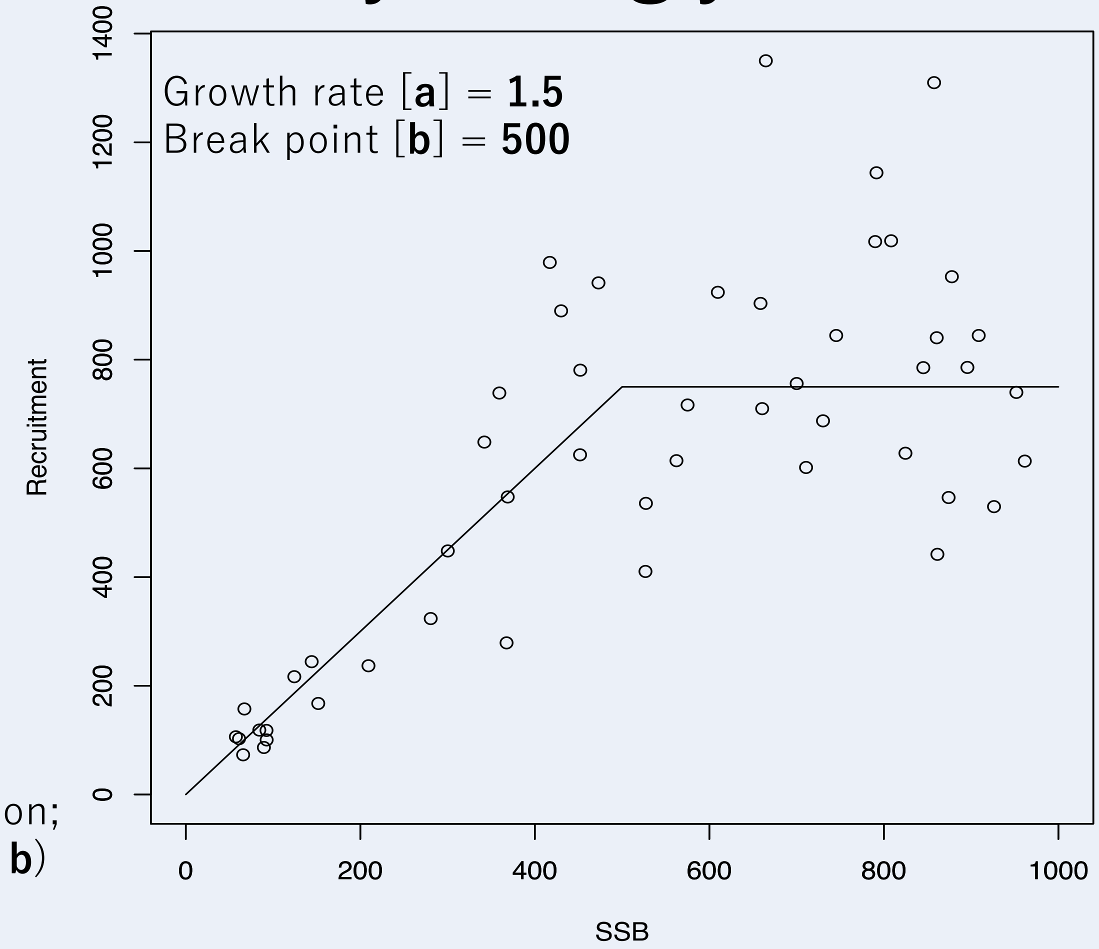


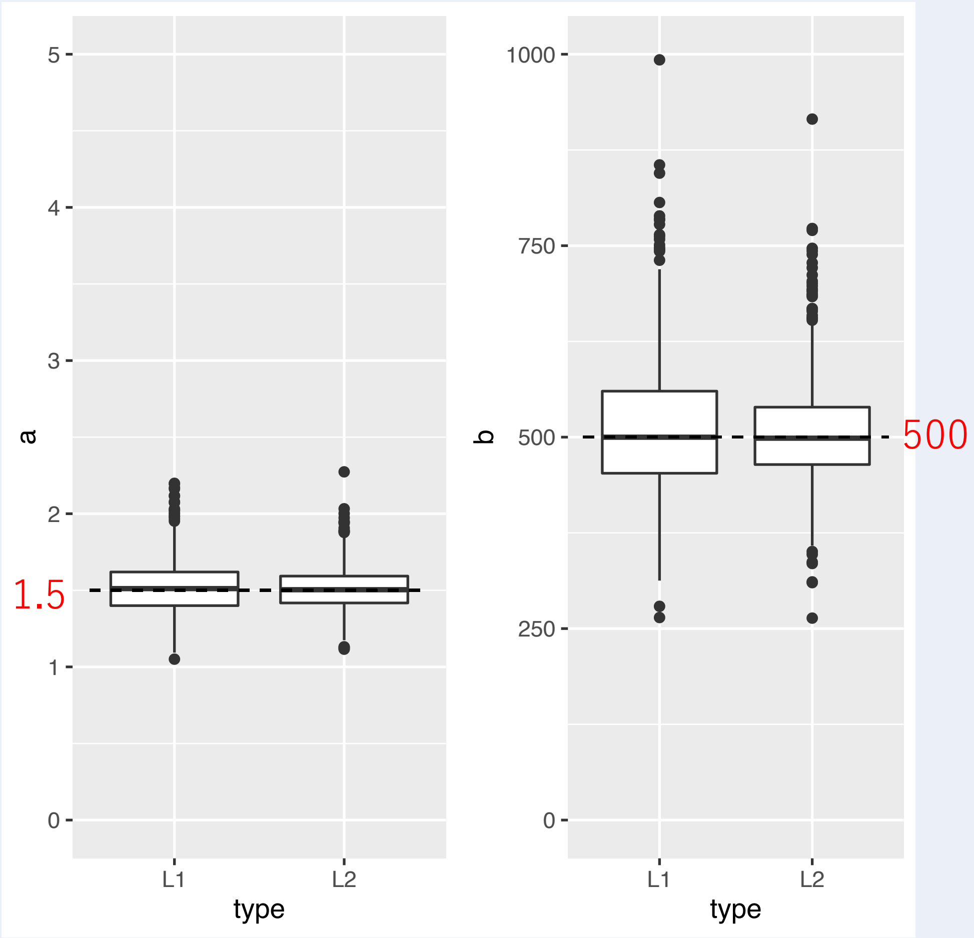
Hokey Stick type SR function;
Recruitment = **a** min(SSB, **b**)

L2 estimates work better than L1.

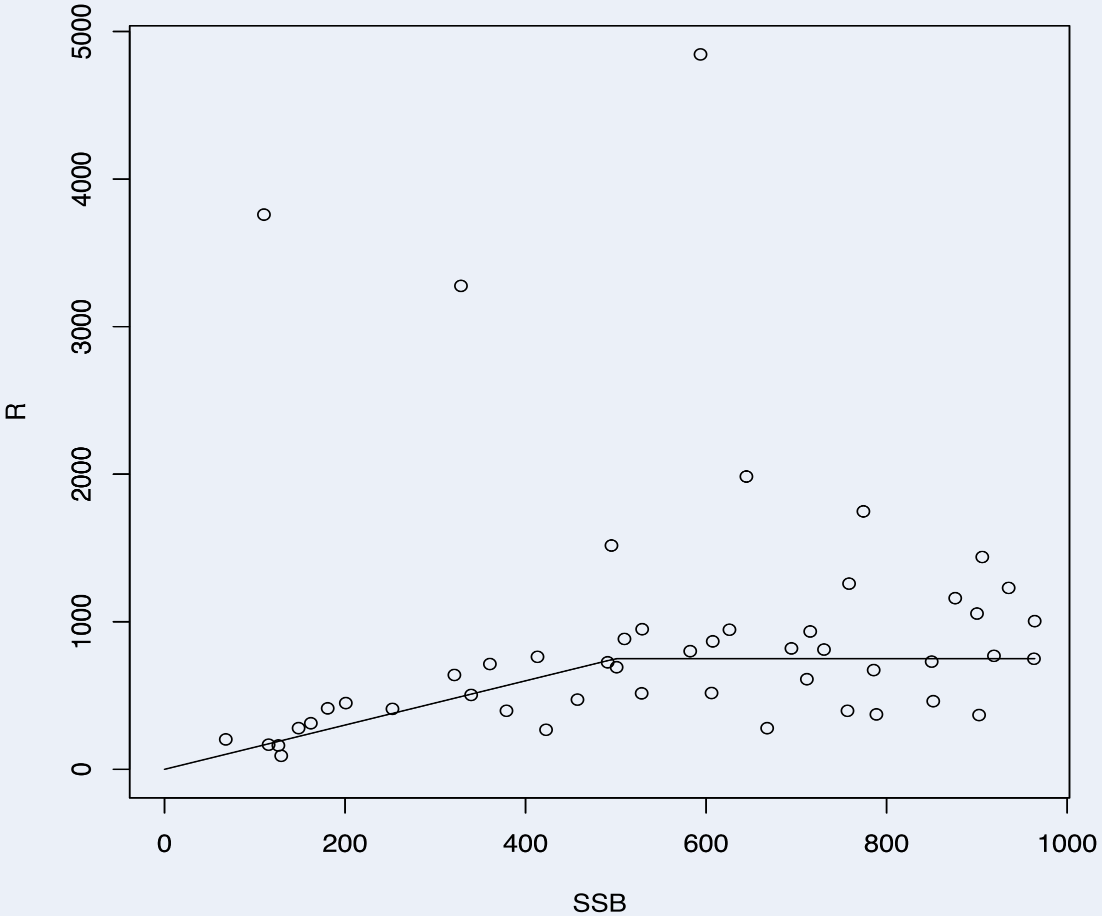
- Result of 1000 simulation trials.

Estimation method	L1	L2
Growth rate [a] (%)	1.21	0.711
Break point [b] (%)	1.88	0.94

(Est.mean-Sim.setting)/Sim.setting * 100

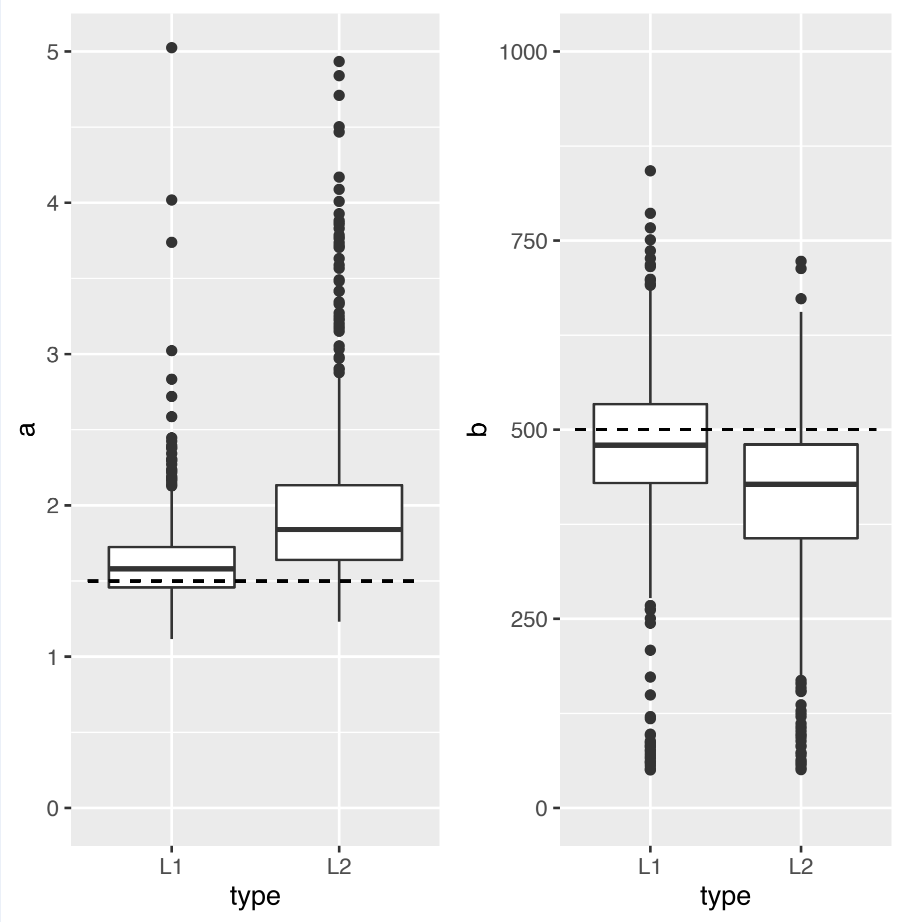


Realistic value in variance with the extraordinary strong year-class recruitments



L1 estimates work well

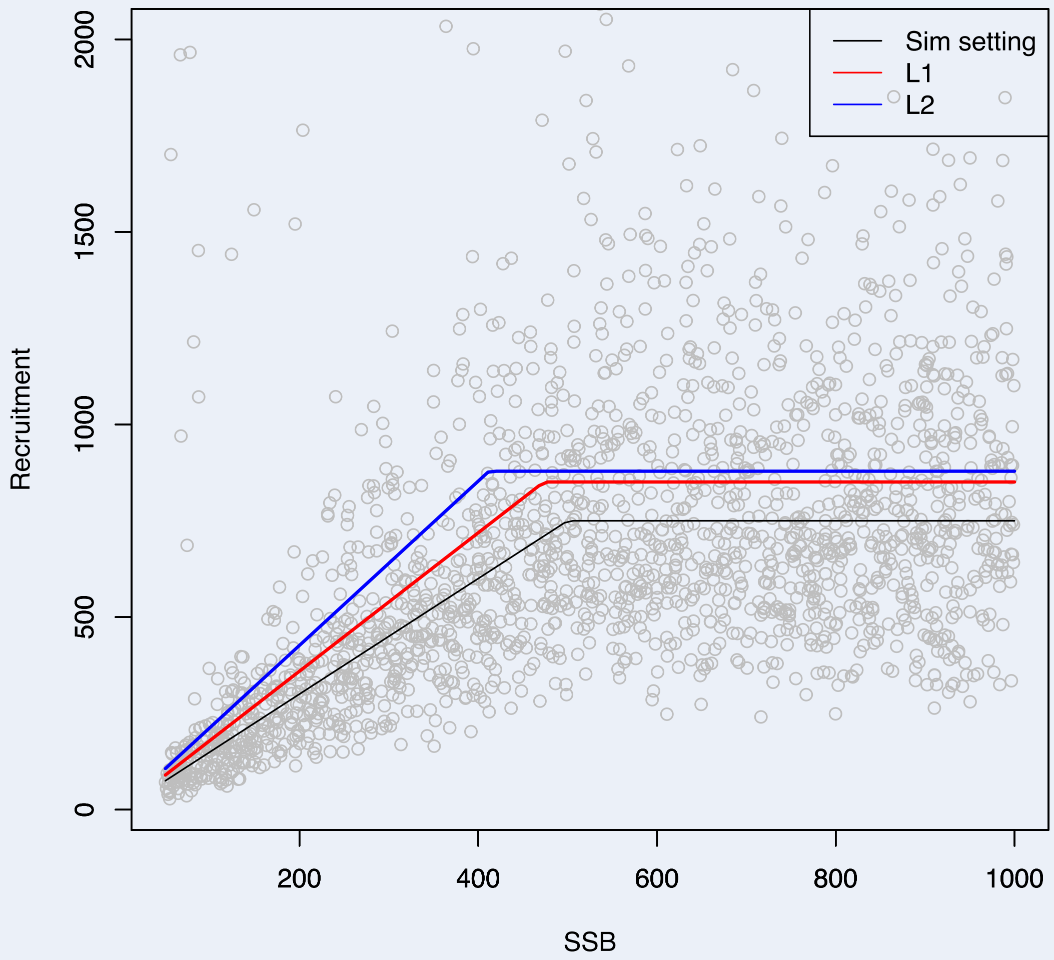
- L2 estimates have large biases.



Estimation method	L1	L2
Growth rate (%)	19.81	42.15
Break point(%)	-5.32	-17.59

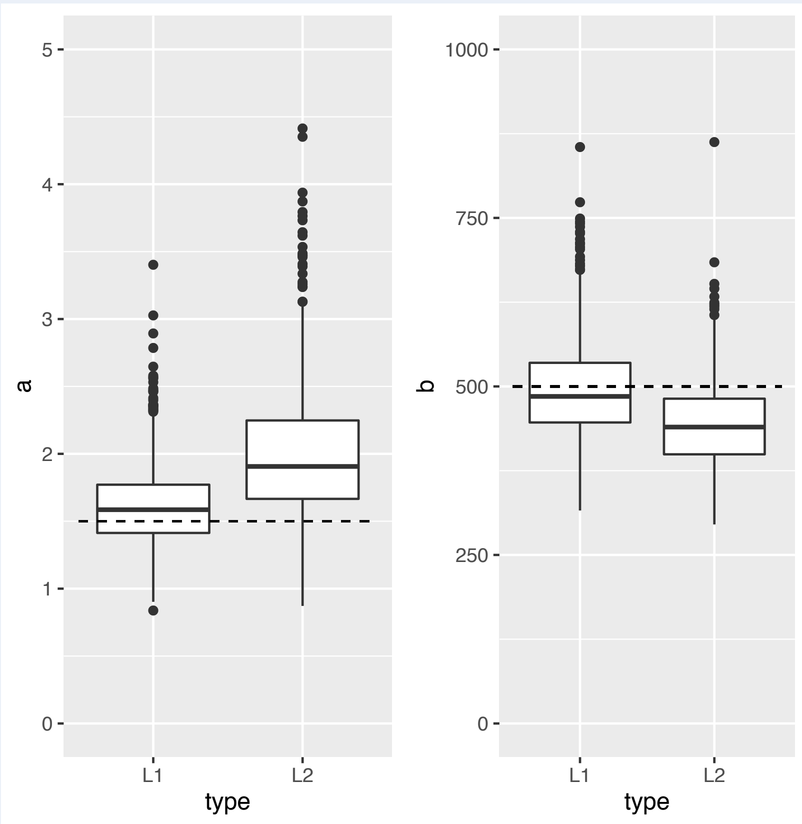
(Est.mean-Sim.setting)/Sim.setting * 100

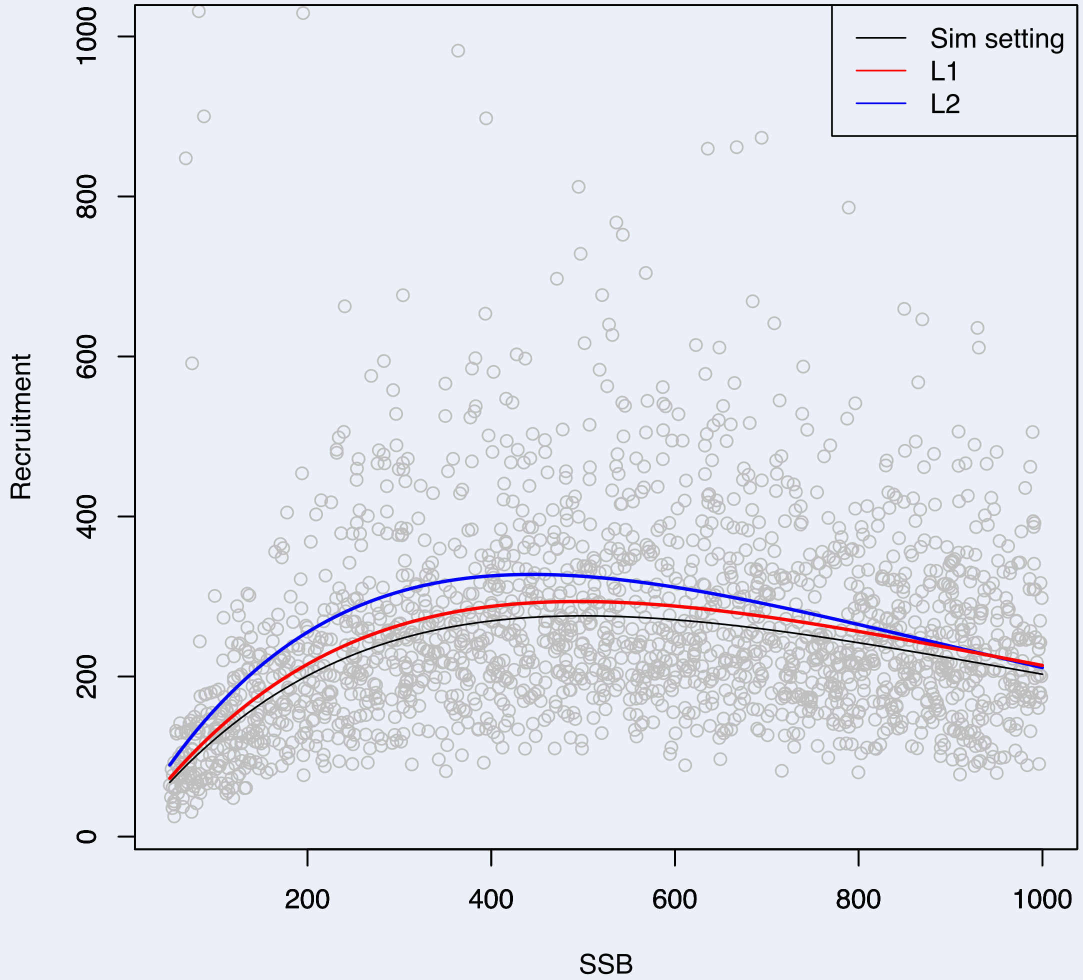
L1 methods less biased than L2



L1 estimates work for Ricker type SR function

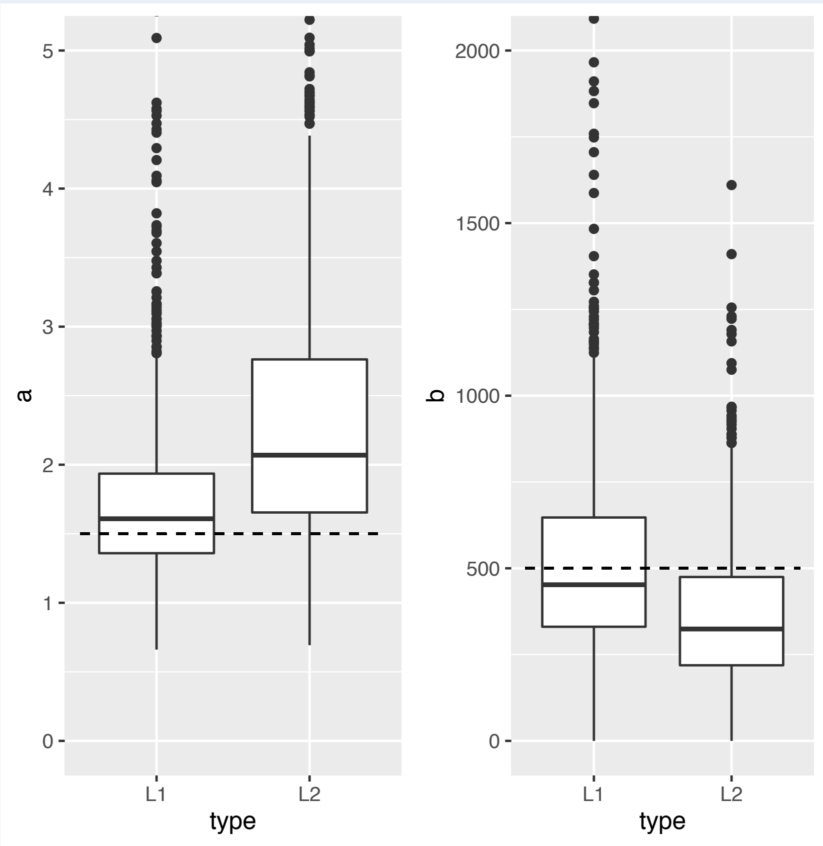
Recruitment = **a** SSB exp(-SSB/**b**)

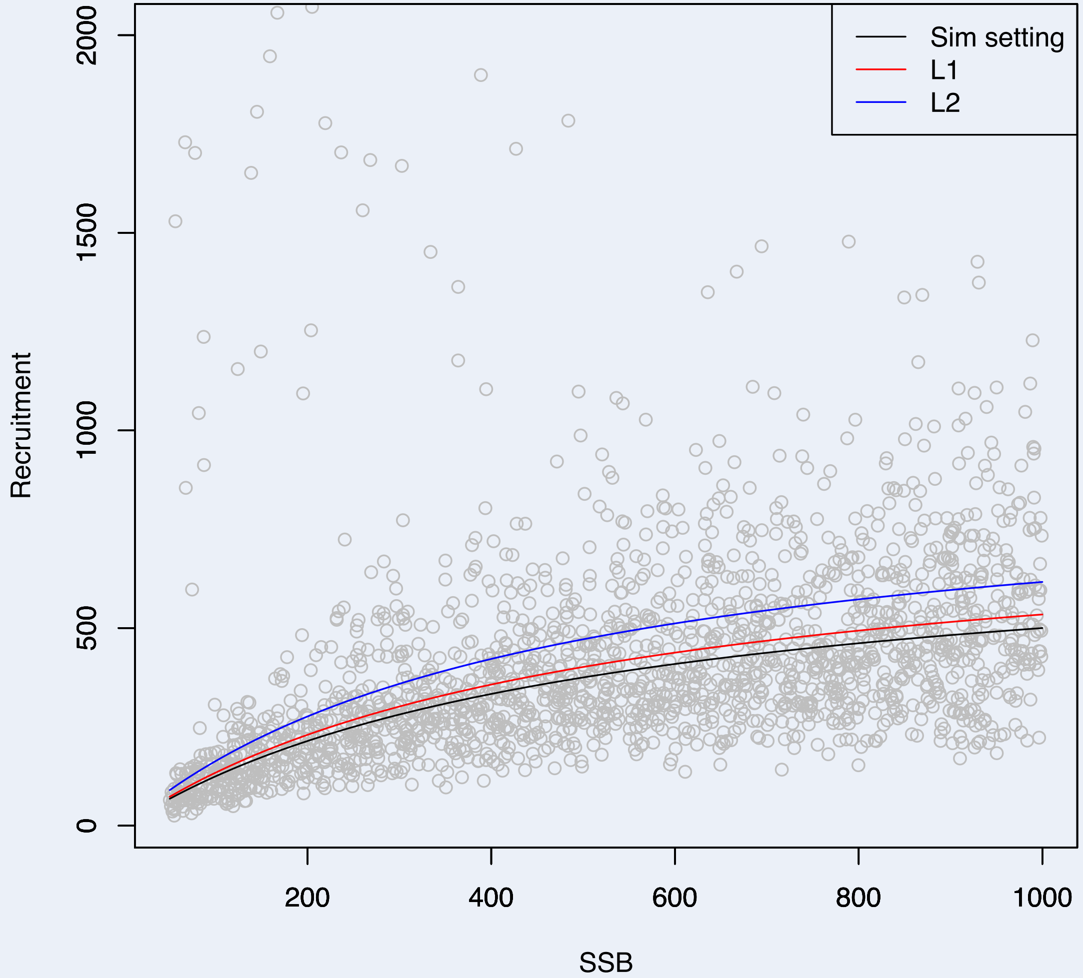




L1 estimates work for Beverton-Holt type SR function

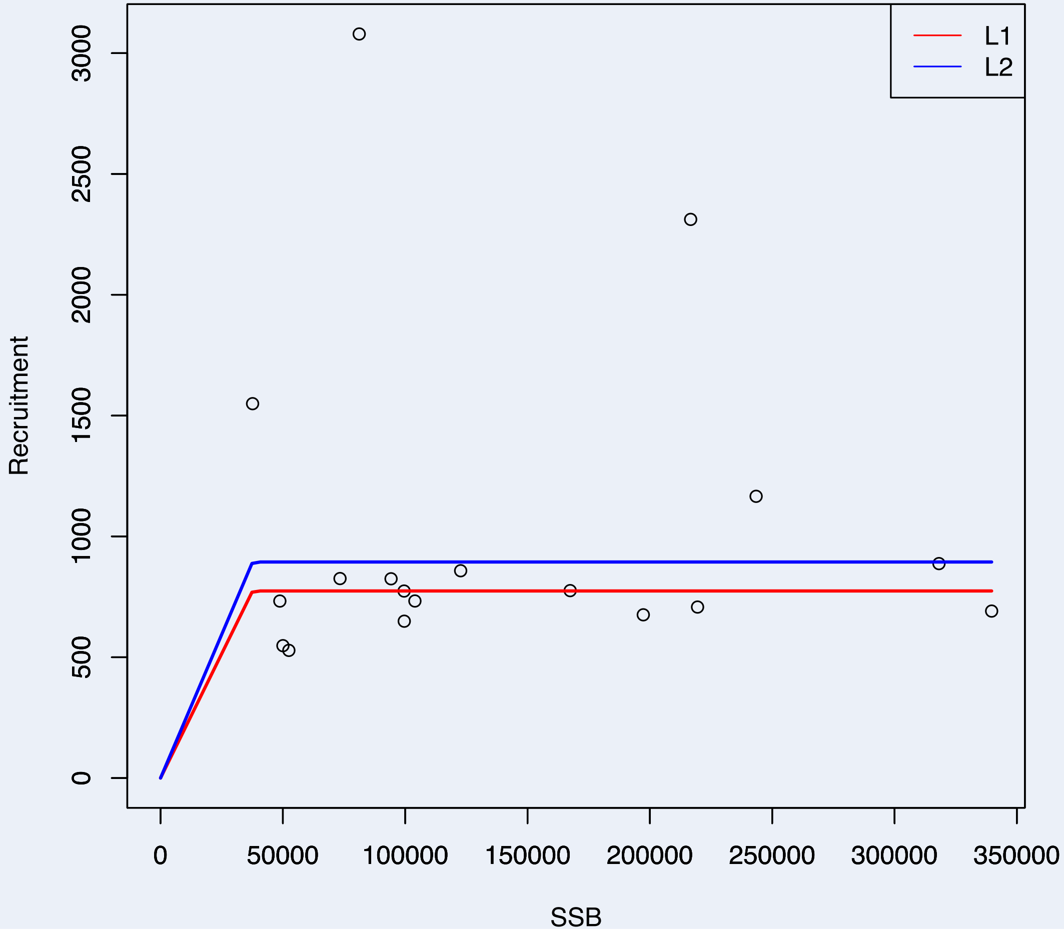
Recruitment = **a** SSB /(1+SSB/**b**)





L1 estimates of parameters in SR function of the northwest pacific stock of Blue mackerel

- The SR function by L1 estimation was less affected by the extraordinary strong year-class.
- Model diagnosis by AICc supports L1 estimates.
  - $AICc|_{L1} = 24.66$
  - $AICc|_{L2} = 30.60$
- What is nice to the stock management?



Need the robust estimation from viewpoint of stock management

- The growth rate and break point affect the stock prediction in future; hence it changes the target of stock management.
- In the upcoming harvest control rule in Japan, the target reference point will be fixed for 5 years. Thus, robust estimation of SR relationship would be preferable.
- Incorporating robust estimation would be an useful option in estimating parameters of stock-recruitment relationship, although the assumption of lognormal distribution for the error in recruitment has been standard in stock assessment.

Thank you.

Summary

- Robust estimation could avoid the bias on parameters of SR function, not affected by the extraordinary strong year-class.

- Robust estimation is useful to stock management for sustainable fisheries.

- The robust estimation by L1 method is implemented in FRSYR, a Japanese stock management calculation package of R.