Shedding & reporting rate analyses for Indian Ocean tuna spp.

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Shedding rates

- Double tagging of yellowfin (10,659), bigeye (7,576) and skipjack (9,633) has been undertaken in reasonably high numbers
- We used on Seychelles or ’at Sea’ recoveries, which gave us the most reliable estimates of time-at-liberty and length at release/recapture
- In terms of fish recaptured that were double-tagged, we have 1089 yellowfin, 585 bigeye and 932 skipjack
- One major issue is that we lack the number of fish recaptured with a tag missing to be able to separate the data into tagger and size categories
- Really all we can attempt is to estimate a species-specific shedding rate

Process of tag shedding

- Usual assumption is that there are two types of shedding of tags of this kind: **Type I**: initial, near-instantaneous shedding of improperly placed tags; **Type II**: a more gradual shedding of tags over time
- One approach has been to model this as an instantaneous tag loss followed by a (usually) decreasing probability of tag retention with time-at-liberty, τ:

$$\pi^{\mathrm{ret}}(\tau) = \varphi \exp(-\eta\tau) \tag{1}$$

- A second approach is to define a partition of the time-at-liberty and estimate the tag retention probability for each element of this partition
- We chose the latter method

Tag retention model

- Assume that we have a time-at-liberty partition: $\tau \in \{\tau_1, ..., \tau_N\}$
- For each of these time-at-liberty 'bins' we would have a number of tags retaining both tags (DT), a number of tags with one tag still attached, (ST) and (in theory) a number of fish recaptured with no tags still attached (NT)
- Assuming each of these events has its own probability ($\pi_{D,S,N}$) then we can model the process multinomially:

$$p\left(DT, ST, NT \,|\, \pi_D, \pi_S, \pi_N\right) = \frac{(DT + ST + NT)!}{DT!ST!NT!}\pi_D^{DT} \times \pi_S^{ST} \times \pi_N^{NT} \quad (2)$$

- To simplify things we make some assumptions...

Tag retention model

- We assume that losses of animals to natural or fishing mortality is not influenced by having tags attached (or not)
- We assume that an animal with two tags is just as likely to be reported as an animal with one tag
- For a double-tagged fish, the loss of one tag or the other is independent
- We never observed fish recaptured with no tags attached $(NT = 0)$
- This really collapses the model down into a simple binomial model:

$$p\left(DT, ST \mid \pi^{\text{ret}}\right) = \frac{(DT+ST)!}{DT!ST!}\left(\pi^{\text{ret}}\right)^{DT} \times \left(1-\pi^{\text{ret}}\right)^{ST} \quad (3)$$

Tag retention model

- So we can define the probability of tag retention to time-at-liberty τ in terms of the individual partition elements:

(4) $$\pi^{\rm ret}(\tau) = \prod_{i=1}^{\tau-1} \pi_i^{\rm ret}$$

- Use Bayesian estimation techniques and we model retention probabilities as being *a priori* beta-distributed: $p(\pi^{\rm ret}) = B(\alpha,\beta)$ with $\alpha=\beta=1$ which defines a uniform/quasi non-informative prior on the unit interval - let the data define the answer
- Beta distribution *conjugate* to binomial distribution which gives us a simple closed form posterior for the tag retention:

(5) $$p\left(\pi^{\rm ret} \,|\, DT, ST, \alpha, \beta\right) = B\left(\alpha + DT, \beta + ST\right)$$

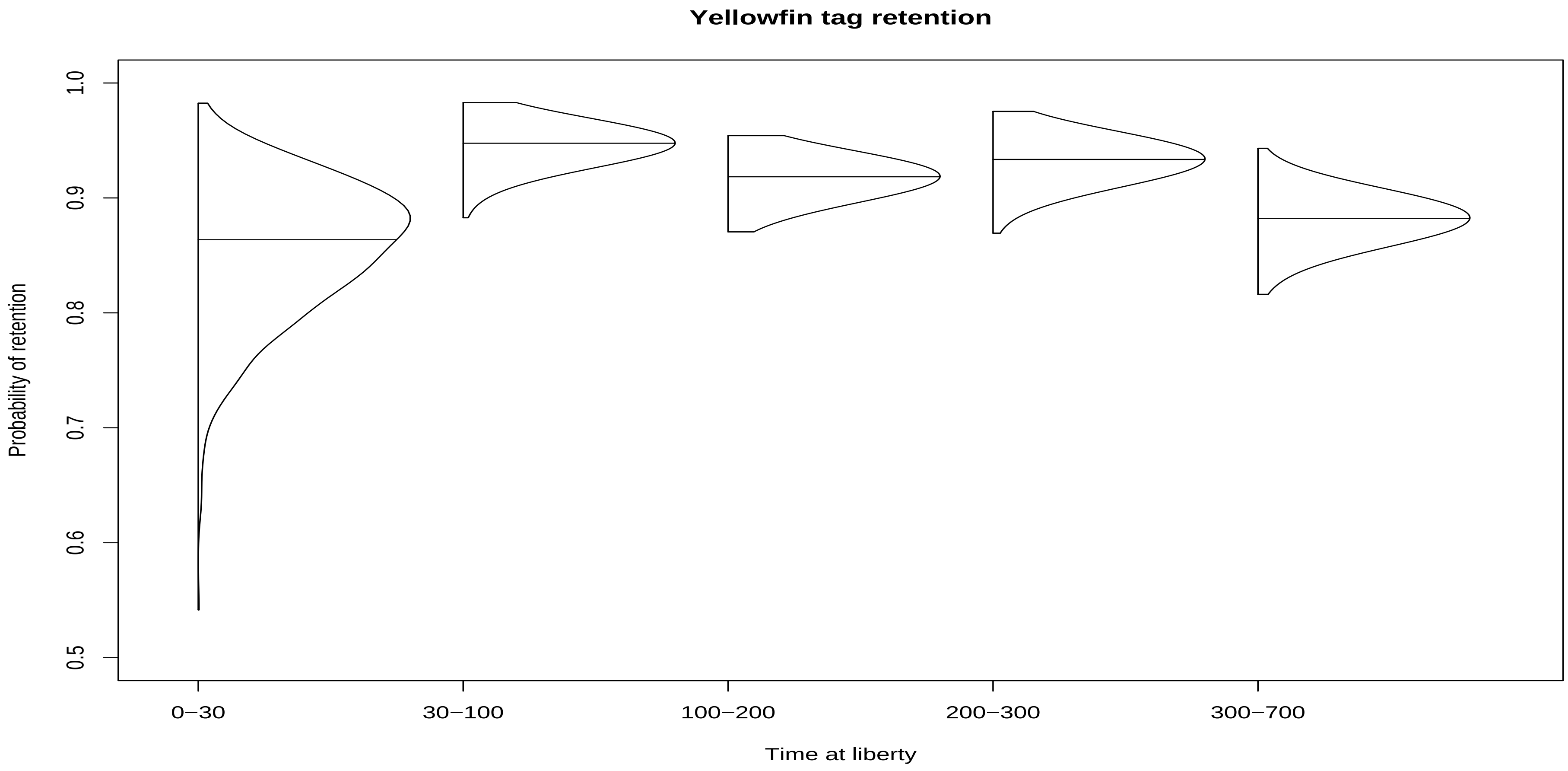
Data for pooled time-at-liberty

Data for yellowfin (Y), bigeye (B) and skipjack (S) the given time-at-liberty partition:

τ	0-30	30-100	100-200	200-300	300-700
DT (Y)	29	227	308	208	228
ST (Y)	4	11	28	14	30
DT (B)	19	104	183	155	110
ST (B)	0	1	7	2	4
DT (S)	50	183	275	198	190
ST (S)	2	6	8	4	4

Yellowfin tag retention

Posterior and median (horizontal line) retention probabilities for the yellowfin double-tagging data

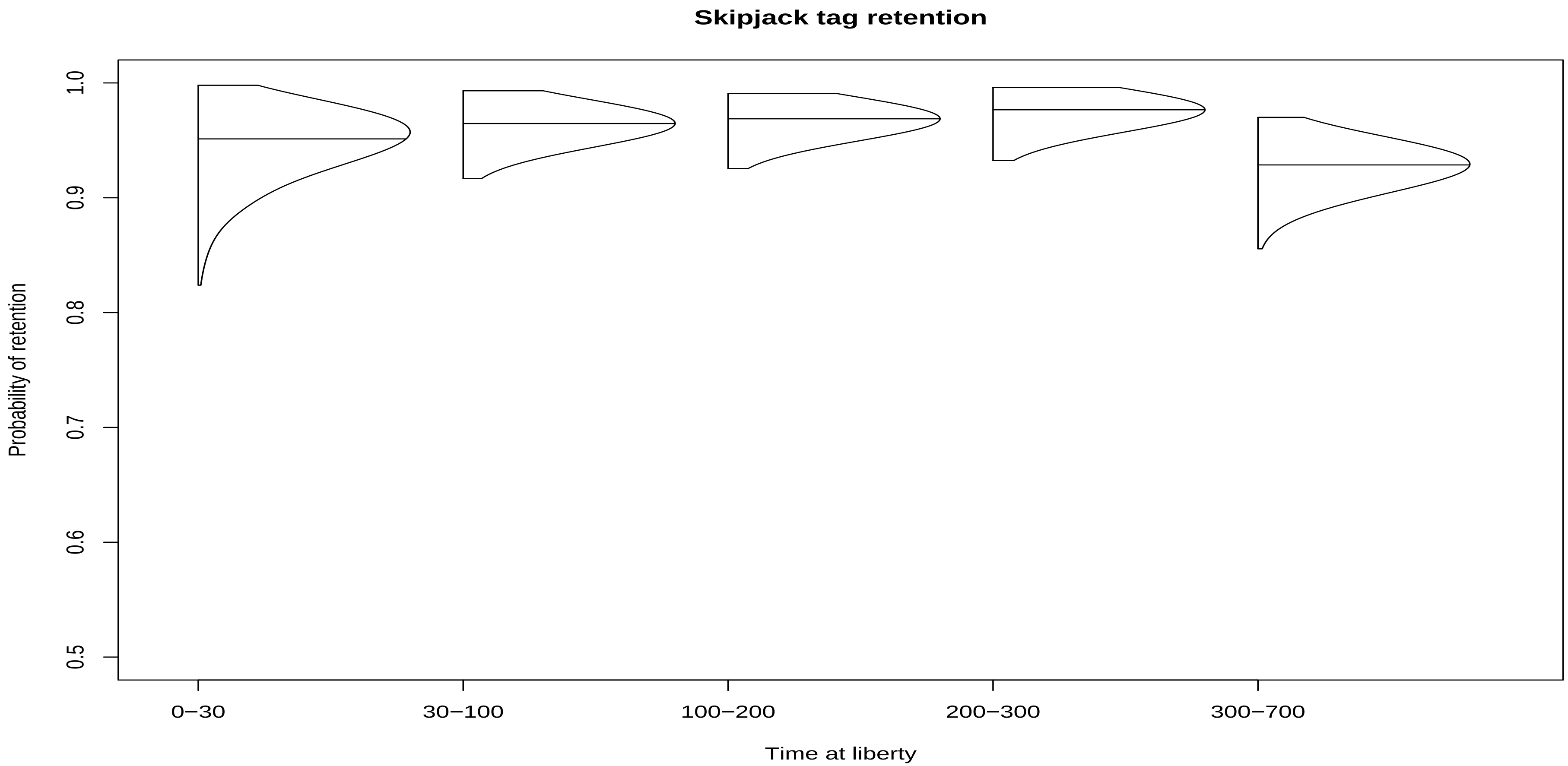


Bigeye tag retention

Posterior and median (horizontal line) retention probabilities for the bigeye double-tagging data

Skipjack tag retention

Posterior and median (horizontal line) retention probabilities for the skipjack double-tagging data



Observations

- All three species show evidence of type I and type II shedding - particularly yellowfin and bigeye
- Peculiar decrease in tag retention at 100-200 days, then an increase at 200-300 days, for yellowfin and bigeye, but not for skipjack
- Have no immediate answer as to why - we lack the data to look at size or tagger related effects
- Tag retention seemingly better for bigeye and skipjack than for yellowfin
- Given not all fish were double-tagged we will need to have some sort of rational approach to dealing with the fact that the tagged population, for assessment purposes, has differential ’drop-out’ rates due to shedding

Comparison with Maldivian skipjack shedding

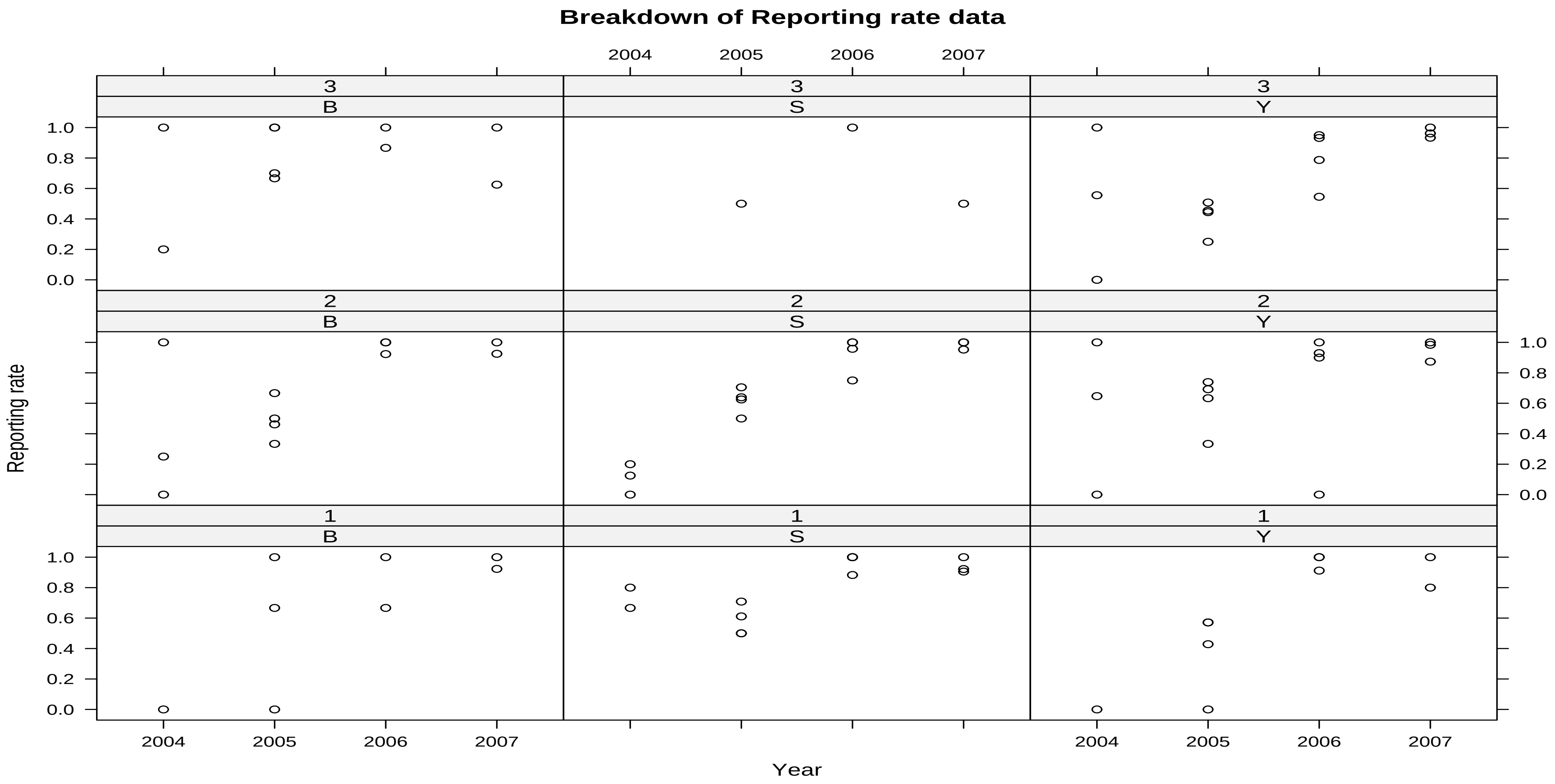
- Comparison with Maldivian skipjack shedding (Adam & Kirkwood, 2001)
- From Adam & Kirkwood (2001) the type I shedding was $\varphi = 0.97\,(0.91 - 1)$; from our 0-30 day period we have a median and 95% credible interval of 0.95 (0.88-0.99)
- For six months at liberty (roughly median time-at-liberty), the Maldivian skipjack retention was estimated to be 0.87 (difficult to infer the uncertainty in terms of SEs of φ and η); from our analysis we have a median and 95% credible interval of 0.89 (0.82-0.94)
- Seems to match reasonably well with the previous shedding analysis on skipjack

Reporting rates

- Tag seeding data are available for the Seychelles landed purse-seine catches
- For each species and three given commercial size-classes 15 tags were seeded over the species and size categories into the catch
- For each species and seeding event we have an estimate of the reporting rate by year, tagger and size-category
- Idea was initially to use GLMs to try and estimate reporting rates conditional on these three predictors

Reporting rate data

These are the fully-disaggregated raw reporting rate estimates:



Candidate GLMs for seeding

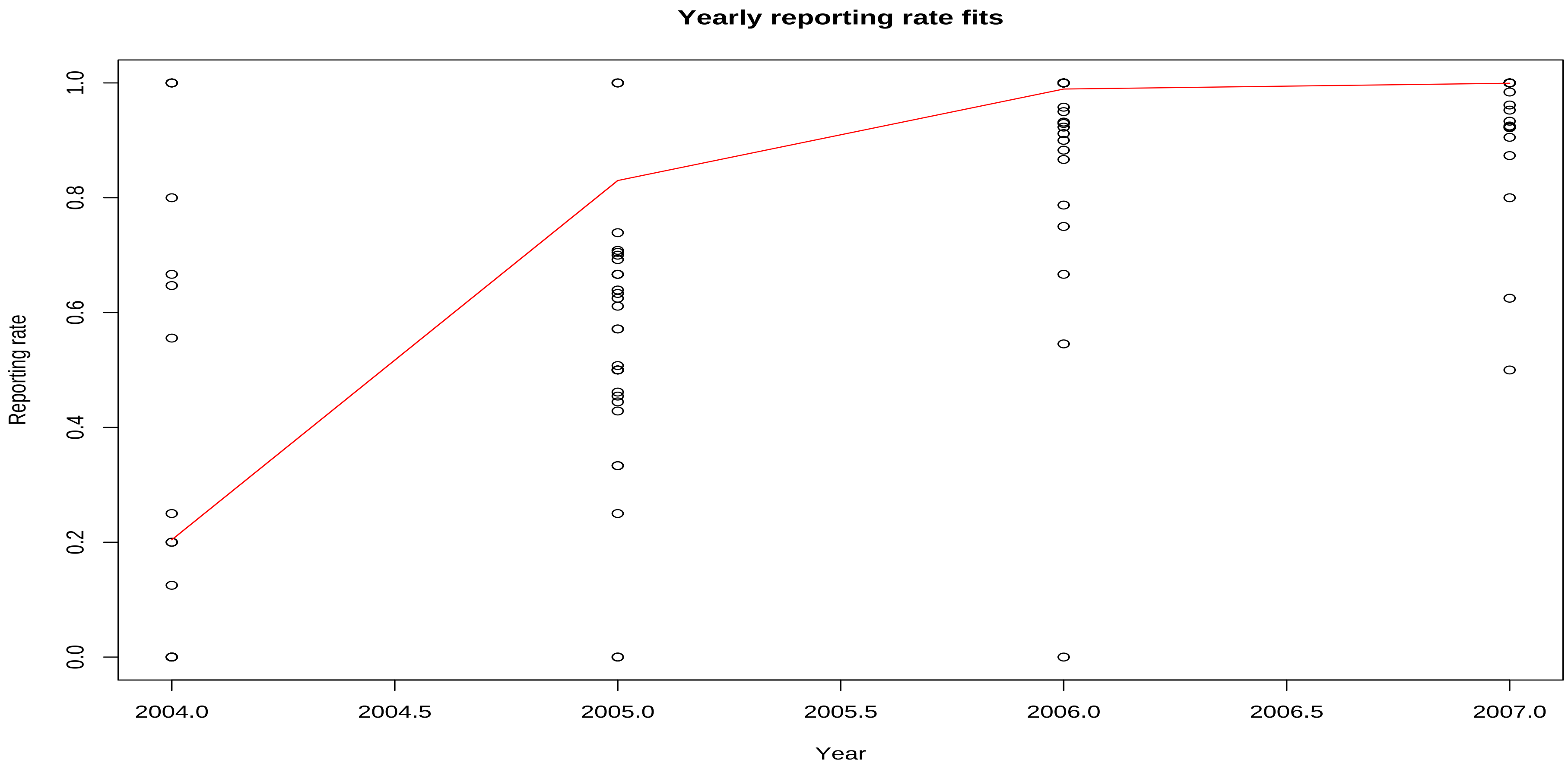
- The 'full' model for the reporting rate, π^{rep} was the following:

(6) $$\text{logit}\left(\pi^{\text{rep}}\right) \sim year + size + tagger + error$$

- For yellowfin and skipjack, only the year effect (and the intercept) were significant ($p < 0.05$); for bigeye only the tagger effect...
- We lack the data to be able to estimate the reporting rate down to this level of aggregation
- When aggregating all the species together only significant effects are the intercept ($p < 0.0005$), year ($p < 0.0005$) and tagger ($p < 0.05$)
- Using chi-squared likelihood ratio test model with year and tagger effects is just significantly ($p < 0.05$) better than year effect only model

Predicted reporting rate

Using LS means to average over the tagger effect we get the following species/size aggregated reporting rate-by-year:



Best approach?

- Fits using GLM are poor - we lack the data to inform on species or size-specific issues
- Some other methods could perhaps be used
- Would a structured jackknife bootstrap on the data be more informative as to both reporting rate estimates and the influence of the small data set and potential outliers?