SCIENTIFIC COMMITTEE
SIXTEENTH REGULAR SESSION
Online
11–20 August 2020

Simulating future data for WCPO skipjack harvest strategy evaluations.

WCPFC-SC16-2020/MI-IP-10

R. Scott[1], F. Scott, G. M. Pilling, P. Hamer and J. Hampton

[1]Oceanic Fisheries Programme, The Pacific Community

Contents

Executive Summary

A primary consideration when conditioning operating models (OMs) is to identify the most important sources of uncertainty regarding the dynamics of the stock, the operations of the fishery and the quality of the data that will be used as inputs to the management procedure The OM must capture the overall dynamics of the underlying system and be capable of generating data, to be passed to the management procedure, that sufficiently represent that system, and have appropriate variability to reflect important sources of uncertainty. In this brief paper we describe the settings and procedures to simulate catch, effort, length frequency and tag recapture data from the WCPO skipjack OM grid of models and compare the historical observed data to the simulated data. These comparisons are largely based on visual inspection.

The simulated catch, effort, size composition and tag recapture data generated within the evaluation framework are, for the most part, a close approximation to their real-life counterparts. Although some deficiencies have been identified in, for example, modal variation in length compositions and the spread of their distributions, and in the length distribution of tag releases and the overall quantity of tag returns, the results presented here and also in SC16-MI-IP09 show that these deficiencies do not unduly affect the ability of the estimation model to reliably estimate stock status.

The methods and settings for simulating data within the evaluation framework are considered sufficient for the purpose of testing candidate management procedures for WCPO skipjack. However, further investigation into more appropriate methods to generate simulated catch and effort data, tag recapture data and for incorporating greater modal variability in length composition data will be conducted as part of the ongoing work to further develop and refine the evaluation framework.

We invite WCPFC-SC to note the following:

- The approach for generating simulated catch and effort data described in this paper is unchanged from previous analyses.
- The simulated catch, effort, size composition and tag recapture data generated within the evaluation framework are, for the most part, a close approximation to their real-life counterparts.
- Where deficiencies have been identified in the simulated data, they do not unduly affect the ability of the estimation model to reliably estimate stock status.

1 Introduction

An updated grid of operating models (OMs) for WCPO skipjack is presented in SC16-MI-IP08. The updated grid is based on a repeat of the OM conditioning process, now based on the more recent 2019 stock assessment of WCPO skipjack tuna (Vincent et al., 2019). A primary consideration when conditioning OMs is to identify the most important sources of uncertainty regarding the dynamics of the stock, the operations of the fishery and the quality of the data that will be used as inputs to the management procedure. The OM must capture the overall dynamics of the underlying system and be capable of generating data, to be passed to the management procedure, that sufficiently represent that system, and have appropriate variability to reflect important sources of uncertainty.

Methods for generating simulated data from MULTIFAN-CL have previously been described (Scott et al., 2018). The methods employed here are broadly similar but are applied to the updated grid of OMs. The refitting of MULTIFAN-CL to simulated data and its performance as an estimation model is described in SC16-MI-IP09. In this paper we briefly describe the settings and procedures to simulate catch, effort, length frequency and tag recapture data from the WCPO skipjack OM grid of models and compare the historical observed data to the simulated data. We identify any deficiencies in the simulated data and consider their consequences for the evaluations as well as potential future developments to generate simulated data that more accurately represent real observations.

2 Generating simulated data for WCPO skipjack

For the initial investigations into developing harvest strategies for WCPO skipjack, model based management procedures (MPs) are being considered. The model used within the MP to determine stock status is based on MULTIFAN-CL and relies on fishery specific inputs of catch, effort, length composition and tag release and recapture information.

2.1 Catch and effort data

Methods for generating future data with observation error in MULTIFAN-CL are described in Davies et al. (2017). Observation error for catch and effort data are derived assuming a lognormal error distribution. A single, user defined, coefficient of variation (CV) is specified for either catch, or effort, which applies across all fisheries and to all periods in the model.

Previous investigations of appropriate values for observation error in catch and effort data (Scott et al., 2018) used an approach that compared the standard error of residuals about simple linear regressions of observed catch and effort pairs with those of simulated catch and effort pairs. From this, user defined input CVs were determined that generated future catch and effort data with similar levels of variability to historical observations. An input CV of 20% for both catch and effort resulted in a median CV for the simulated CPUE of 0.36 which was close to that observed for the historical period (0.38, see Scott et al. (2018)). Based on these results CVs of 20% and 30% were considered appropriate values for the generation of catch and effort observation error to include in the reference set of OMs.

Comparative plots of observed catch and effort pairs and corresponding simulated data for pole and line fisheries (Figure 1) and for purse seine fisheries (Figure 2), based on input CVs of 20% for both catch and effort, show that, in general, the simulated data have similar range and variability to observed catch and effort.

2.2 Size composition data

Observation error in size composition data is generated by MULTIFAN-CL from a multinomial distribution (Davies et al., 2017). The variability in the simulated data is controlled through the effective sample size (ESS) which is specified by the user for each individual size composition. As such, there is considerable flexibility for the specification of size composition observation error between fisheries and across time.

As a first choice of appropriate values we have taken the fishery specific estimated ESS as determined from a MULTIFAN-CL model fit using the self-scaling multinomial fitting option (Davies et al., 2018). In previous analyses ESS values were determined from a single model (diagnostic case assessment) and applied across the grid to each of the OMs. In this analysis, the ESS has been estimated for each individual OM (i.e. 24 separate estimates).

For the majority of fisheries, ESS values are very consistently estimated (Figure 3), however, estimates for the domestic fisheries in assessment region 5 show considerable variation in estimated ESS. The variation arises depending on the assumed growth model. These fisheries typically catch smaller individuals and model estimates are more sensitive to growth assumptions.

A small subset of comparative plots of observed vs simulated length frequency data are shown for purse seine fisheries in region 7 of the assessment in 2006 and for pole and line fisheries in regions 1 and 2 of the assessment in 2018 (Figure 4). Note that these figures are for a small number of selected fisheries and years, and show only one iteration of simulated data. In general, across all fisheries and years, the simulated data show similar modal lengths to the observed data but typically show a wider distribution with greater proportions of small and large fish represented.

Comparative plots are also shown for fisheries in region 5 of the assessment for which ESS estimates varied depending on the growth model assumed in the assessment (Figure 5). In some cases (e.g. for the Z-VN-5 fishery) the overall shape of the length distribution changes very little for the two growth models but the total number of fish in the distribution are scaled up or down according to the estimated ESS. However, in other fisheries (e.g. S-ID.PH-5) the change in growth model can impact the simulated size composition with the high growth model under-estimating (and the low growth model over-estimating) the proportion of small fish in some seasons.

2.3 Tag release and recapture data

Observation uncertainty is introduced into the tag recapture data based upon the OM estimation of the multinomial probability of recapture given the release samples. In this sense the probability of recapture of tagged fish is determined from the internal calculations of MULTIFAN-CL and cannot be specified by the user. The user must, however, specify the quantity of tags to be released, the regions from which those releases will be made, the fishery selectivity from which the length distribution of the releases will be generated and the assumed tag reporting rate. A tag reporting rate of 0.6 has been assumed for all fisheries. This value is slightly lower than the tag reporting rates estimated historically but was chosen to ensure that model estimates were not unduly constrained by the maximum tag reporting bound set at 0.9.

A summary of historical tag releases is shown in Table 1. Under the assumption that existing tagging programmes (PTTP and JPTP) will continue in their current form, the future tag releases in each region are set to the sum of the average regional releases for these two programmes. Consistent with the current tagging programmes, tags were assumed to be released at two year intervals. The release period was set to the second quarter and the length distribution of the released fish was determined from the selection pattern of the pole and line fishery in the corresponding region (Table 2).

A comparison of the length distribution of tagged fish released under the JPTP and PTTP and the simulated tag release data (Figure 6) shows the simulated tag releases (determined from the selection pattern of the pole and line fisheries in each region) have larger modal length than those for either of the current tagging programmes. A corresponding plot of tag recaptures for the JPTP, PTTP and simulated releases (Figure 7) shows the JPTP to have a smaller number of recaptures, consistent with the smaller number of releases from this program. It also shows a smaller number of recaptures for the simulated data as compared to the PTTP in spite of similar quantities of tags being released. The smaller number of recaptures will occur mostly as a result of the tag reporting rate assumed when simulating the tag recaptures although differences in the length composition of the released fish will also impact on the probability of recapture since several biological and fishery processes (natural mortality, movement and selection) vary with age and length.

Further work to investigate options for simulating tag release and recapture information is planned as part of the science plan to support the PTTP. This may allow for alternative approaches to simulating tagging data to be explored, including through individual based modeling approaches such as SEAPODYM and Ikamoana.

Although the quantities of tag recaptures from each program (JPTP, PTTP and simulated data) differ, the decline in recaptures with time at liberty (Figure 7) appears quite consistent at least for time at liberty of 1 year or less (the period during which the majority of recaptures are made). At time of liberty greater than 1 year the PTTP recapture rate declines at a slower pace. This characteristic is also evident in the simulated tag recapture data.

3 Discussion

Although the operating models have been updated, the approaches for generating simulated catch, effort, size composition and tag recapture data described in this paper are largely unchanged from previous analyses.

For simulating catch and effort data, a level of observation error is specified, for both catch and effort, that results in variability in CPUE comparable to that observed in reported data. It has previously been noted, however, that there are well established procedures for monitoring and reporting catch and effort in most of the fisheries targeting skipjack and that it is unlikely that error in the observation of these quantities will be as high as 20% or 30%. The CV estimated through this approach represents a combination of observation error in the reported values of catch or effort and also process error in the underlying relationship between catch and effort. This process error is captured by the MULTIFAN-CL fitting process in the estimation of effort deviations. Stochastic projections that incorporate re-sampling from the effort deviations (in the same way that recruitment deviations are currently re-sampled) would provide a more comprehensive simulation approach and would separate the sources of error more appropriately into their constituent components. A similar capability to re-sample the selectivity deviations estimated within MULTIFAN-CL may also allow the generation of size composition data that exhibit greater modal variability and more closely resemble actual observations. These features for MULTIFAN-CL projections are currently under development but once implemented would likely represent the preferred approach for simulating data within the evaluations.

The data simulated within the evaluation framework are required for input to the estimation model. The estimation model, in this case, is based on MULTIFAN-CL and uses the input data to estimate the status of the stock. The quantity, quality and general characteristics of the simulated input data will affect the performance of the estimation model in its ability to reliably estimate stock status. Some characteristics of the data will be more influential than others. The refitting of MULTIFAN-CL to simulated data has previously been considered in Scott et al. (2018) with regard to the generation of pseudo data, and is further considered in SC16-MI-IP09 with regard to the performance of the estimation model, the results of which indicate that the estimation model when fit to simulated data as described in this paper provides a relatively unbiased and reliable estimate of stock status.

4 Conclusion

The simulated catch, effort, size composition and tag recapture data generated within the evaluation framework are, for the most part, a close approximation to their real-life counterparts. Although some deficiencies have been identified in, for example, modal variation in length compositions and the spread of their distributions, and in the length distribution of tag releases and the overall quantity of tag returns, the results presented here and also in SC16-MI-IP09 show that these deficiencies do not unduly affect the ability of the estimation model to reliably estimate stock status.

The methods and settings for simulating data within the evaluation framework are considered sufficient for the purpose of testing candidate management procedures for WCPO skipjack. However, further investigation into more appropriate methods to generate simulated catch and effort data, tag recapture data and for incorporating greater modal variability in length composition data should be considered.

References

Davies, N., Fournier, D. A., Takeuchi, Y., Bouye, F., and Hampton, J. (2017). Developments in the MULTIFAN-CL software 2016-2017. WCPFC-SC13-2017/SA-IP-05, Rarotonga, Cook Islands, 9–17 August 2017.

Davies, N., Fournier, D. A., Takeuchi, Y., Bouye, F., and Hampton, J. (2018). Developments in the MULTIFAN-CL software 2017-2018. WCPFC-SC14-2018/SA-IP-02, Busan, South Korea, 9–17 August 2018.

Scott, R. D., Scott, F., Davies, N., Pilling, G., and Hampton, S. (2018). Generating pseudo data in MULTIFAN-CL. WCPFC-SC14-2018/MI-IP-03, Busan, South Korea, 5–13 August 2018.

Vincent, M., Pilling, G. M., and Hampton, J. (2019). Stock assessment of skipjack tuna in the western and central pacific ocean. WCPFC-SC15-2019/SA-WP-05 (rev 2), Pohnpei, Federated States of Micronesia. 12-20 August, 2019.

Assessment Region	Tag Release Programmes SSAP 1977-1980		RTTP 1989-1992		PTTP 2006-2018		JPTP 1998-2018	
1	0		0		0		19	(154)
2	0		0		0		47	(384)
3	1	(82)	0		0		55	(578)
4	1	(162)	0		0		30	(287)
5	2	(2662)	6	(2179)	3	(7332)	2	(205)
6	3	(3875)	10	(2414)	16	(5652)	2	(56)
7	7	(1084)	8	(934)	12	(1406)	20	(590)
8	9	(3972)	5	(2021)	2	(3424)	9	(506)

Table 1: Tag release summary: Number of tag release events by region and tagging program. The average number of fish tagged and released is shown in brackets.

region	year	month	fishery	n releases
1	2020	5	P-ALL-1	154
2	2020	5	P-ALL-2	384
3	2020	5	P-ALL-3	578
4	2020	5	P-ALL-4	287
5	2020	5	P-ALL-5	7537
6	2020	5	P-ALL-6	5708
7	2020	5	P-ALL-7	1996
8	2020	5	P-ALL-8	3433
1	2022	5	P-ALL-1	154
2	2022	5	P-ALL-2	384
3	2022	5	P-ALL-3	578
4	2022	5	P-ALL-4	287
5	2022	5	P-ALL-5	7537
6	2022	5	P-ALL-6	5708
7	2022	5	P-ALL-7	1996
8	2022	5	P-ALL-8	3433
	...			...

Table 2: Future tag release numbers by year and region. Tags are assumed to be released every second year in the second quarter with the length distribution of the released fish assumed to be that of the pole and line fishery for that region.

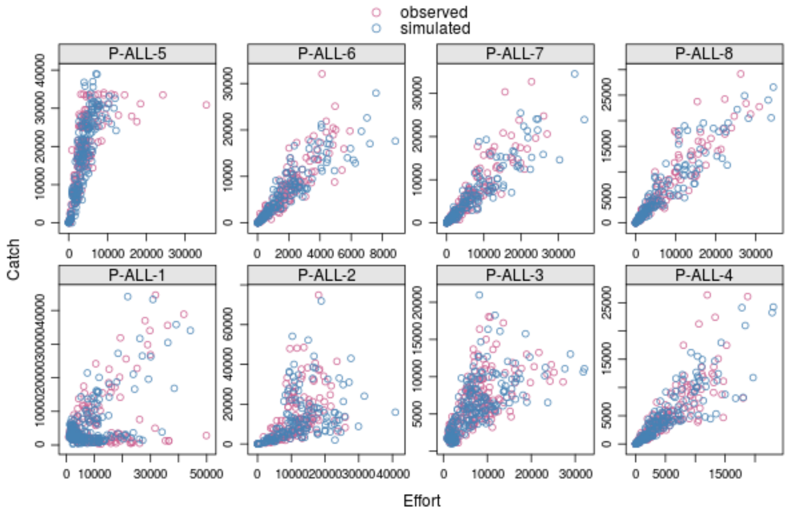

Figure 1: Observed and simulated catch and effort data (1972 to 2018) for pole and line fisheries. Simulated data are generated from input CVs of 20% for both catch and effort

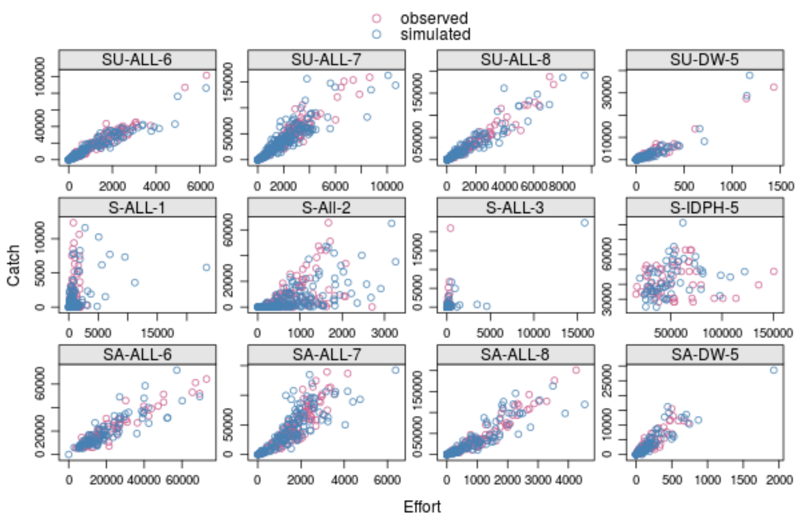

Figure 2: Observed and simulated catch and effort data (1972 to 2018) for purse seine fisheries. Simulated data are generated from input CVs of 20% for both catch and effort

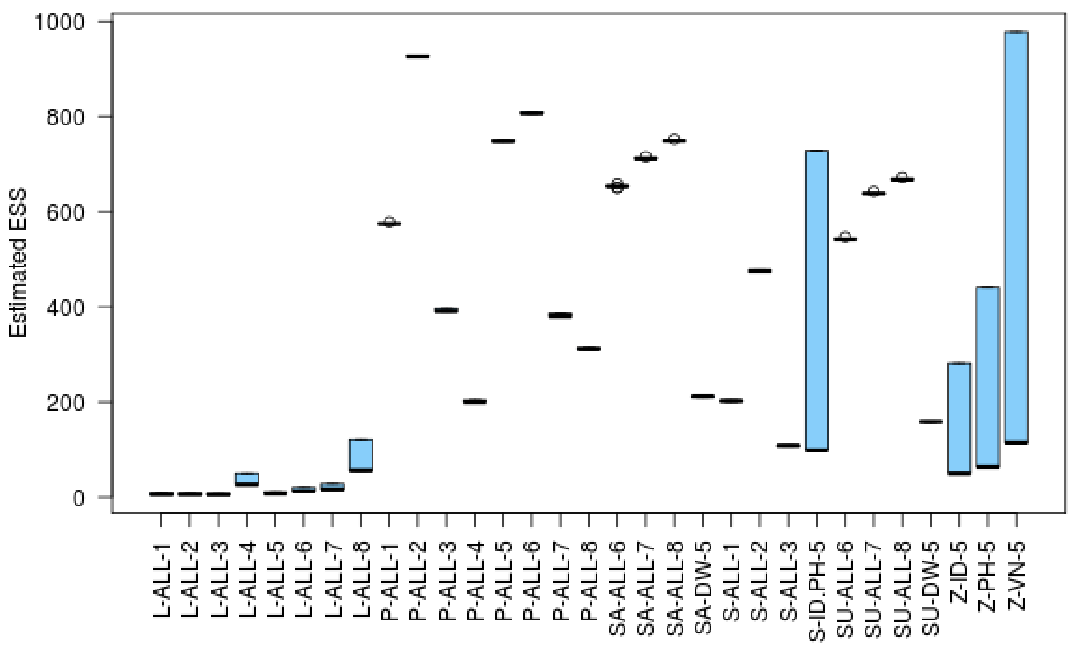

Figure 3: Fishery specific estimated effective sample size across the grid of 24 models.

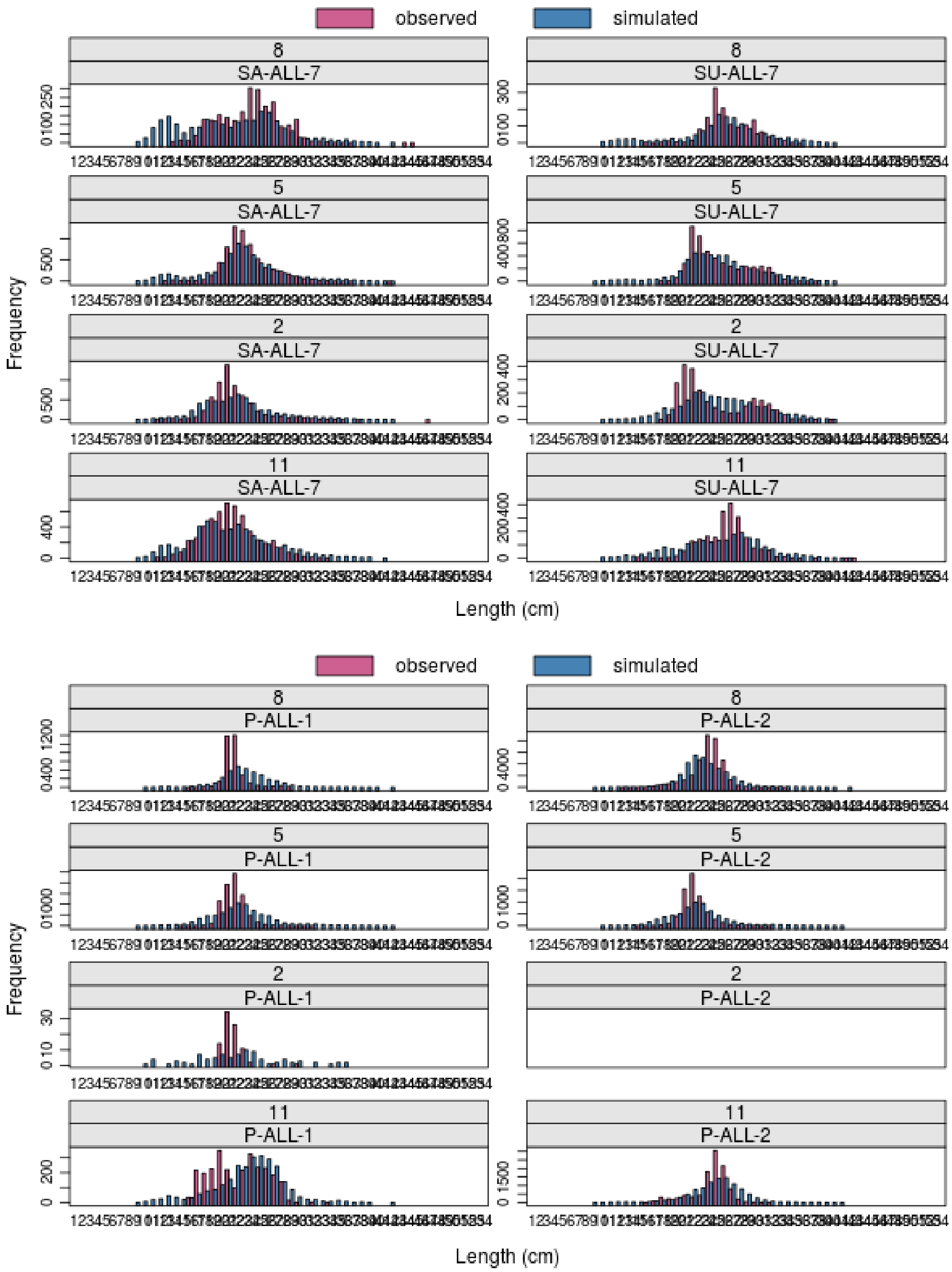

Figure 4: Observed and simulated length compositions for purse seine fisheries in assessment region 7 in 2006(SA-ALL-7 and SU-ALL-7, top) and pole and line fisheries in assessment regions 1 and 2 in 2018 (P-ALL-1 and P-ALL-2, bottom) by season (month= 2,5,8,11).

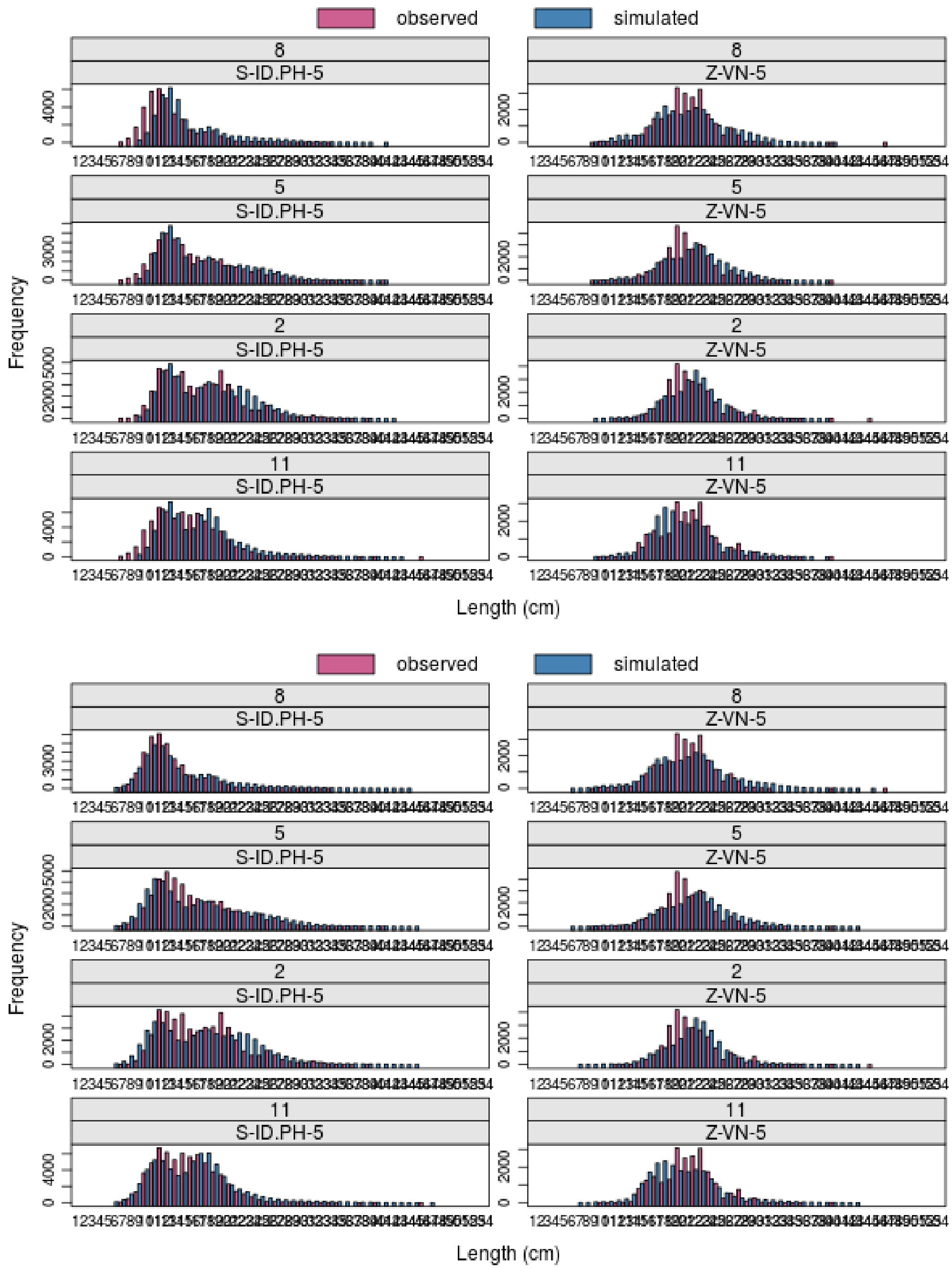

Figure 5: Observed and simulated length compositions for domestic and purse seine fisheries in assessment region 5 in 2016 (Z-VN-5 and S-IDPH-5) by season (month= 2,5,8,11), for the high growth scenario (top) and the low growth scenario (bottom).

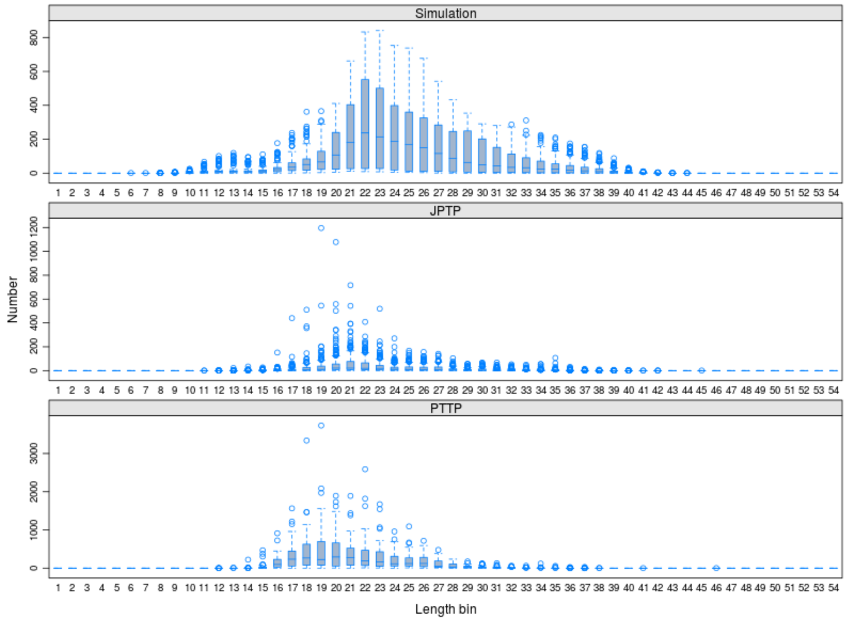

Figure 6: Length distributions for tag releases from the PTTP and JPTP tagging programs and simulated tag releases for the projection period. Note that y axes differ between the plots.

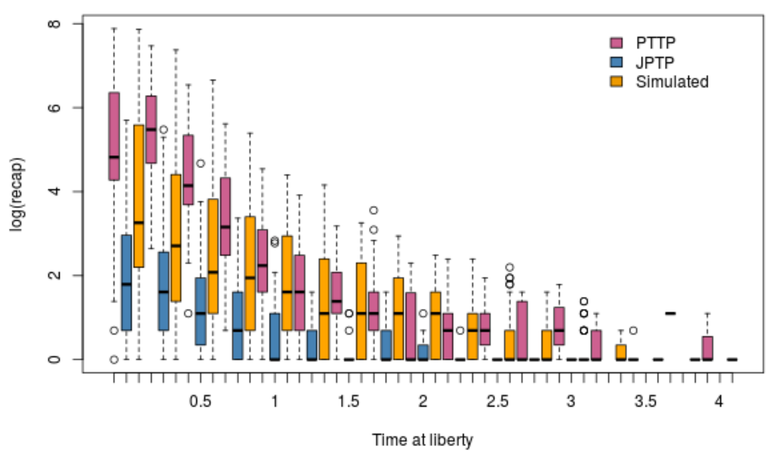

Figure 7: log recaptures against time at liberty (years) for the PTTP, JPTP and simulated tagging data for the historical time period.