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WCPO skipjack management procedure

WCPFC-SC19-2023/MI-WP-01

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Executive Summary

Following the adoption of the WCPO skipjack management procedure (MP) by WCPFC19 (CMM 2022-01), the MP is scheduled to be run in 2023 and the resulting management measures implemented in 2024. SC19 is scheduled to review the running of the MP and provide advice, as appropriate, to WCPFC20. The WCPFC's scientific services provider (SSP), the Pacific Community (SPC) is tasked with running the MP and reporting the outcomes to SC19.

The estimation method (EM) ran successfully and returned an estimate of spawning potential depletion ($SB_{latest}/SB_{F=0}$) in the terminal year (2022) of 0.42. Under the adopted management procedure for WCPO skipjack (CMM2022-01) this would set for the period 2024 to 2026: effort in the purse seine fisheries to 2012 levels; effort in pole and line fisheries to average 2001-04 levels and catch in the domestic fisheries of assessment region 5 to average 2016-18 levels.

As a whole, the data collection program has performed as anticipated and all necessary data to run the EM are available. However, the spatial and temporal coverage of some key data continue to raise concerns; in particular, the continued decline of pole and line fishing operations in equatorial regions. As these fisheries continue to contract their effort to restricted areas of the overall assessment region, their ability to index relative abundance becomes increasingly impaired. The continued reliance of the estimation method on pole and line indices of abundance is a cause for concern and it is recommended that alternative approaches be investigated. This may require the development and testing of a new estimation method for WCPO skipjack. This issue needs to be considered in the context of exceptional circumstances. Whilst it has not impacted on the running of the MP this year, diagnostic analyses indicate that it is likely to affect the future performance of the MP. We therefore recommend that further work be undertaken to develop and test an alternative estimation model for future use in the WCPO skipjack MP.

Revisions to historical data have also occurred since 2019, notably for pole and line fisheries in the northern regions of the model. This, amongst other factors, has resulted in quite significant changes to the standardised effort estimates and associated penalty terms for these fisheries. However, the overall impact of these changes on the region-wide estimates of stock status is less pronounced because the quantity of skipjack biomass in these regions is estimated to be low throughout the time series. Historical catch estimates for purse seine fisheries in regions 5 (S-ID-PH-5 and Z-PH-5) have also been updated. These changes were investigated last year and were found to have minimal impact on the outcomes of the MP.

A comparison of the expected performance of the MP and the 2022 skipjack stock assessment in terms of spawning potential depletion shows good correspondence in the terminal estimate from the two sources, but less overlap earlier in the time series. While this does not signal any exceptional circumstance, it may suggest there is still some uncertainty to be accounted for within the evaluation framework. This will be a focus of work over the coming period.

Throughout this report we highlight a number of data discrepancies and modelling issues that

Monitoring report summary for the WCPO SKJ management procedure.

Item	MP Element	Status & Comments	Priority
1	**Review MP performance**		
1.1	Comparison with stock assessment	Good - terminal estimates within prediction bounds - historical uncertainty	low
1.2	Data availability & quality	Pole and line CPUE in tropical regions	high
1.3	Other sources of data	No new information	
1.4	EM performance	Acceptable performance - longer term concerns	
2	**Review of the MP**		
2.1	Management objectives	No new information	
2.2	Scope of the MP	No new information	
2.2	Exceptional circumstances	None identified	
3	**Review MSE Framework**		
3.1	Operating model grid	Climate change scenarios	medium
3.2	Calculation of PIs	No new information	
3.3	Modelling assumptions	Pole and line CPUE for tropical regions	high
3.4	Data availability & quality	Generally good	

may require further investigation. These issues are summarised in the table below (and also in a proposed MP summary report (Appendix C) that can be drafted by SC and TCC for further consideration by the Commission) and may be considered further under the skipjack monitoring procedure with specific reference to the MSE modelling framework and the performance of the MP. Based on the information in this summary report, we assign a prioritisation of these issues for the consideraton of SC19.

We invite SC19 to:

- note the results of the estimation method and the outputs of the HCR with respect to the scheduled implemention of the WCPO skipjack MP, which indicates fishing for the period 2024-2026 should be at baseline conditions.

- while no serious issues are raised with respect to exceptional circumstances, note the ongoing concerns regarding key inputs to the estimation method, particularly with respect to the reliance on pole and line CPUE for equatorial regions.

- note the recommendation for a re-evaluation of the skipjack estimation method prior to the next implementation of the MP and to provide advice, as appropriate, on potential approaches.

- note the information provided regarding the monitoring of the skipjack MP and consider how this information might be advanced for the consideration of the Commission. In particular the proposal for SC and TCC to compile an MP summary report for the consideration of the Commission.

1 Introduction

Following the adoption of the WCPO skipjack management procedure (MP) by WCPFC19 (CMM 2022-01), the MP is scheduled to be run in 2023 and the resulting management measures implemented in 2024. SC19 is scheduled to review the running of the MP and provide advice, as appropriate, to WCPFC20.

A trial run of the MP, using data up to 2021, was presented to SC18 (Scott et al., 2022) to provide an indication of the procedures for running and implementing the MP. In this paper we update the inputs to the estimation method to include data to 2022. Based on the updated model, we consider the consistency of the input data and procedures for generating the inputs to the estimation method; the steps involved in running the estimation method and implementing the harvest control rule (HCR); how these and other data might be used as part of a monitoring strategy to check the overall performance of the MP, and the new requirements of CCMs under the havest strategy approach.

Input data for the estimation method will change over time due to the accumulation of new data as well as ongoing data management practices that may modify historical data holdings. In addition, inputs derived from external data analyses (e.g. standardised CPUE indices) will be updated as more data are added to the time series and these updates may modify the estimated values throughout the time period. Changes to data over time can be important, as significant changes might represent a deviation from the conditions assumed when testing the MP. Some allowance for potential changes in input data has been included in the evaluation framework where, for example, observation error has been applied to the simulated catch and effort data, tag recaptures and size composition data that were used to test the MP and evaluate its likely performance. As part of the monitoring strategy it will be necessary to identify where significant changes to the input data have occurred and to consider whether these changes might constitute exceptional circumstances. Throughout this document we highlight instances where changes to the estimation method (EM) input data have occurred and in particular where those changes have not been foreseen in the MP testing process.

2 Estimation method input data

The EM is based on a fixed implementation of a MULTIFAN-CL assessment that has very similar structure and settings to the 2019 skipjack diagnostic case assessment model (Vincent et al., 2019b). Data inputs to the EM comprise fishery-specific catch, effort and length-frequency data for the period 1972 to 2022 and tag release and recapture data from a number of tuna tagging programs between 1977 and 2021. The quarterly temporal stratification and 8-region spatial stratification (Figure 1) of the 2019 assessment has been retained as well as the fishery definitions that identify 31 relatively homogeneous fishing units representing purse-seine, pole and line and miscellaneous fisheries (gillnets, ringnets, handlines, etc.) as well as a number of longline fisheries that are included in the model primarily to provide length composition information.

A 'dry run' of the MP was presented to SC18 to demonstrate the procedures for running the EM and applying the HCR. Inputs to this dry run analysis were compiled as part of the work conducted to prepare the input data for the 2022 stock assessment of skipjack tuna (Teears et al., 2022; Castillo-Jordan et al., 2022). Changes to the modelling approach for the 2022 skipjack assessment necessitated a number of additional analyses to adjust the EM inputs to be in accordance with the procedures followed in 2019. The generation of input data this year has not been complicated by parallel efforts to produce stock assessment inputs for skipjack and, in general, closer correspondence to the 2019 assessment input data has been achieved.

2.1 Catch and effort data

Catch and effort data were compiled by year and quarter according to the fisheries defined in Vincent et al. (2019b) (Table 1). Catch for all fisheries was expressed in weight of fish, except for the longline fisheries for which a nominal catch of 500 individuals was set.

Historical catch estimates are consistent with the values used for the 2019 stock assessment (Figures 2 and 3). Instances where historical catches have changed (specifically for S-ID-PH-5) were identified during the 'MP dry run' exercise and sensitivity anlayses conducted to determine what impact on the MP they may have. Analyses indicated the historical changes in catch estimates for fishery S-ID-PH-5 had minimal impact on the outputs of the MP (Scott et al., 2022).

2.1.1 Purse seine

Purse seine catch for each set type (associated or unassociated) is determined from estimates of species composition from observer-collected samples raised to total catches estimated from raised log-sheet data (Hampton and Williams, 2016).

For the most part, effort data for purse seine fisheries are defined as number of sets, specified by set type (associated and unassociated). However, in assessment regions 5 and 6 where there is insufficient effort in pole and line fisheries to conduct CPUE standardisations, time series of standardised CPUE are generated from purse seine fisheries.

In region 5, CPUE for the Philippines domestic purse seine fishery was analysed using general linear models following the same approach as Bigelow et al. (2019) to produce a standardised index of abundance for the S-ID-PH-5 fishery between 2005 and 2022 (Figure 4). Estimates of time variant precision were implemented as time variant effort deviation penalties in MULTIFAN-CL.

In region 6, CPUE for the purse seine fishery operating largely within PNG archipelagic waters was analysed using GLMs following the approach of Vidal et al. (2019). These indices (Figure 4) were applied to the catches of the SA-ALL-6 fishery for the period 1997 to 2022 with estimates of time variant precision implemented as time variant effort deviation penalties in MULTIFAN-CL.

2.1.2 Pole and line

Standardised CPUE indices for pole and line fisheries in assessment regions 1, 2, 3, 4, 7 and 8 were provided by Japan. These standardised indices were estimated using spatio-temporal GLMs fitted to operational catch and effort data and followed the same procedure as Kinoshita et al. (2019). The uncertainty in each pole and line CPUE estimate, by fishery and year-quarter, was incorporated into the model as time-variant penalty weights for the effort deviations.

The unit of effort for the pole and line fisheries of PNG and Solomon Islands (assessment region 6) and of the mostly Indonesian pole and line fishery in assessment region 5 was nominal fishing-vessel-day.

Overall, standardised effort for pole and line fisheries corresponds relatively well with previous estimates (Figures 6 and 7) although, as for the MP dry run exercise, some differences remain, in particular for pole and line fisheries in regions 1 and 2 where both standardised effort indices and penalty terms show marked differences to the 2019 input values. These changes are further consiered under Section 5.1.1 of this report.

2.2 Size composition data

Length frequency data are included in the model and provide information on the size composition of the catch. The method employed for constructing size frequency data for purse seine fisheries, including weighting by catch for various set-type and spatial strata, was the same as that employed in previous years (Abascal et al., 2014; Vincent et al., 2019a). Samples were spatially weighted (5° x 5° squares) with thresholds applied to ensure small samples do not overly influence model estimates. Purse seine size frequency estimates show good correspondence to the 2019 assessment inputs (Figure 9).

Length frequency data for pole and line fisheries in assessment regions 1, 2, 3, 4 and 7 are available from the Japanese offshore and distant water fleets throughout the assessment time series. Length frequency data for pole and line fisheries in assessment regions 5, 6 and 8 are derived from observer data. Pole and line size frequency estiamates show good correspondence to the 2019 assessment inputs (Figure 10).

2.3 Tag release and recapture data

A substantial quantity of tag release and recapture data are available from 4 tagging programs (SSAP 1977-80, RTTP 1989-92, PTTP 2006-present and JPTP 1989-present). Procedures for compiling tag release and recapture data for the assessment are described in Peatman et al. (2022); Vincent et al. (2019a), including procedures for the adjustment of tag releases to account for tag loss that can occur as a result of tag shedding and tagging related mortality and to account for any non-usable recaptures due to a lack of adequately resolved recapture data. All procedures for compiling the tag release and recapture data were consistent with those followed for the 2019 skipjack stock assessment.

Historical data for tag releases and recaptures for all four tag programs showed good consistency with values used for the 2019 assessment (Figure 12).

In total, 34 new tag release events (21 JPTP; 13 PTTP) have been added to the tag release and recapture information for the MP. For the purposes of the assessment, a tag release event corresponds to all tags released for a given year, month, region and tagging program. Tag release length distributions (Figure 13) for tagged fish released after 2017 (the last year of tagging data used in the OM) for the PTTP and JPTP tagging programs, though variable, are consistent with historical releases and not outside the range of values assumed when testing the MP.

3 Running the estimation method

The estimation method is a simplified, fixed implementation of the 2019 skipjack stock assessment diagnostic case model and differs from a full stock assessment approach in a number of ways. The role of the EM is to provide a reliable and relatively unbiased estimate of stock status. In this instance, the skipjack EM is based on a stock assessment model and employs stock assessment software, however, the EM is effectively a fixed algorithm - a single model - that is applied consistently in each management period without change. The settings of the estimation method are outlined in Table 2 with all other settings, except for the weighting for the catch likelihood, based on the settings of the 2019 assessment diagnostic case model.

For a full stock assessment, the model fits to the data over a number of assessment phases with initial parameter estimates set to default starting values. For the initial phases of the model fitting process many of the parameters are fixed and only a few are free to be estimated. With each successive phase more parameters are freed for estimation until the final phase when all parameters are freely estimated.

The estimation method takes a different approach. Rather than starting from default values it uses the estimates from the last full stock assessment as a starting point. The model is then fitted over three estimation phases, with all model parameters freely estimated in each phase. The only changes made to model settings between the phases is to set the number of function evaluations performed in each phase (100, 100, 1000), and progressively increase the catch errors penalty. For the first phase the catch errors penalty term (age flag 144) is set to a low value (100) allowing the model to have increased freedom to adjust to the new input data. For phases 2 and 3 the catch errors penalty is progressively increased (10,000, 100,000) so the model fits more closely to the observed catches. This approach reduces the number of phases necessary to fit the model but still allows it to adjust to the new input data and provide a reliable estimate of stock status. The development and testing of this EM formulation is detailed in Scott et al. (2020).

Recent stock assessments of WCPO tuna stocks have employed a jittering procedure to test whether the best model fit has been found rather than just convergence to a local minimum. No jittering has been performed for the MP estimation method. This is because the MP estimation method is essentially a fixed algorithm. As noted above, the esimation method has been tested to determine it's performance across a range of plausible stock and fishery scenarios to ensure that it performs adequately in all scenarios, however, it may not perform optimally in any one scenario.

3.1 Results and model diagnostics

As noted, the settings of the EM have been determined to ensure that it performs adequately well over a broad range of scenarios and it is therefore unlikely to perform optimally for any one specific scenario. This should be kept in mind when interrogating model diagnostics.

While the detailed interrogation of the EM diagnostics typically carried out as part of a full stock assessment may not be necessary, it is prudent to examine a number of key model outputs and diagnostics to ensure that the EM is performing well and is not subject to estimation failure. In this respect goodness of fit diagnostics such as the catch estimate deviates and effort deviates provide an overall indication of the performance and reliability of the estimation method. Similarly model estimates of fishery specific selectivity at age and time series of recruitment deviates can provide an indication of whether or not the model is performing to expectation (Merino et al., 2022). Evidence of significant failure might include distinct departures of residuals from zero (or 1 depending on how they are calculated), strong persistent trends over time and model estimates (e.g. selection patterns) that show unreasonable results.

There is no indication of significant failure of the estimation method from the diagnostics presented; the estimation method diagnostics indicate that the model is performing well.

Observed and predicted catches (Figure 14) match well for all fisheries across the time series. Similarly effort deviations (Figure 15) are centered around zero for all fisheries throughout the time series, although increased variability is apparent for the northern purse seine fisheries (S-ALL-1, S-ALL-2 and S-ALL-3). These fisheries have a strong seasonal fishing pattern resulting in a less clear catch and effort relationship. This issue is discussed further in Section 5 with reference to the monitoring strategy. Although more variable, effort deviations for these fisheries remain centered around zero and do not indicate a significant failure of the estimation method.

Time series of recruitment deviates (Figure 16) show some indication of long term temporal trends in some regions. Similar trends were also identified in the 2019 assessment. Long-term trends in recruitment do not always indicate a poor model fit but may warrant further investigation to determine their causes (Merino et al., 2022). Similarly the estimated fishery-specific selection patterns (Figure 17) are consistent with those estimated by the 2019 assessmnt. Both the recruitment trends and the estimated selection patterns are consistent with the modelling assumptions of the MSE framework and do not indicate failure of the estimation method.

The maximum gradient of the estimated parameters is often used as a general indication of model convergence, however, it is not considered to be a useful indicator of performance of the estimation method. This is because the estimation method is run for a fixed and pre-specified number of function evaluations. Prior testing has shown that the estimation method can produce reliable and relatively unbiased estimates of stock status without being run to full convergence (Scott et al., 2020). To illustrate this point the estimation method was run to convergence in a further 4th phase achieving a maximum gradient of 9.08 x 10^{-4}. Following this 4th phase the maximum gradient had reduced considerably but the estimate of stock status in the terminal year (0.417) remained almost identical to that of the 3 phase EM.

The estimates of stock status determined from running the MP this year differ from the estimates of last year from the dry-run analysis. The difference appears to be largely attributed to updates in the standardised pole and line indices, both for the historical time series (Figure 7) and for the most recent years. Pole and line indices for the terminal years were unavailable for the dry-run analysis and assumed values, based on extrapolations from historical values, were used instead. Whilst the updated pole and line indices generally correspond with previous estimates, values for the most recent years differ from the extrapolated values assumed last year.

4 Applying the harvest control rule

Once the estimation method has been run and an estimate of stock status ($SB_{latest}/SB_{F=0}$) has been obtained, the application of the HCR is a relatively straight forward process. The value of the scalar is determined corresponding to the estimated stock status and any additional meta-rules (e.g. that the value of the scalar cannot change by more than 10% from one management period to the next) applied.

The terminal estimate of stock status is measured as $SB_{latest}/SB_{F=0}$ where SB is the spawning potential biomass in the final year of the assessment and $SB_{F=0}$ is the average of the spawning potential biomass over the 10 preceding years (with a lag of 1 year, i.e. the last year of the assessment is not included). The estimate of $SB_{latest}/SB_{F=0}$ from the estimation method is 0.42 and the corresponding scalar from the HCR is 1.0 (Figure 19).

Under the adopted MP, this sets effort in the purse seine fisheries and catches in all other fisheries at baseline levels (PS 2012 effort; PL 2001-04 effort; Region 5 domestic fisheries 2016-18 catches) for the subsequent management period (2024 to 2026).

5 Monitoring strategy considerations

The monitoring strategy routinely evaluates the performance of the MP to check that it is working as expected. The monitoring strategy should consider all aspects of the harvest strategy including procedures for evaluating and testing the MPs; the scenarios that should be included in the OM grid; the preparation and application of the EM and the performance of the management procedure as a whole. In addition, it may identify changes in the dynamics of the fishery resulting from environmental, economic or social factors that may require a reconsideration of the management objectives and the testing of alternative MPs (Scott et al., 2023).

In this report we focus on aspects of the monitoring strategy relating to the application of the MP. We consider the consistency of data availability and the procedures for compiling and running the EM. Of primary concern is the consistency with which the actual implementation of the MP corresponds to the simulated conditions under which the MP was tested.

5.1 Data availability to run the MP

As a whole, the data collection program has performed as anticipated and all necessary data to run the EM are available. Some changes in data inputs have been noted. As highlighted above, some change is to be expected either due to ongoing data management processes or because inputs generated from model estimates (e.g. standardised CPUE) will be updated with the addition of new data. For the most part, however, the inputs to the EM showed good overall consistency with previous inputs and with the conditions assumed under the evaluation framework.

However, the spatial and temporal coverage of some key data continue to raise concerns, in particular, the continued decline of pole and line fishing operations in equatorial regions. During the 2019 assessment of skipjack (Vincent et al., 2019b) it was noted that the indices produced for the 8 region model were primarily as a result of the geostatistical method since traditional GLM methods were unable to estimate time series trends for some model regions. As these fisheries have continued to contract their effort to more restricted areas of the assessment region, their ability to index relative abundance becomes increasingly impaired. This is particularly so in the tropical regions that account for most of the catch and biomass. The 2022 assessment of skipjack (Castillo-Jordan et al., 2022) took measures to address this issue by, amongst other changes, removing the last 23 years of data from the region 8 pole and line CPUE time series, to account for poor data coverage, and adding a new unassociated purse seine index for regions 6, 7 and 8 starting from 2010. The reliance of the estimation method on pole and line indices of abundance is a continuing cause for concern and it is recommended that alternative approaches be investigated. This may require the development and testing of a new estimation method for WCPO skipjack.

5.1.1 Data revisions

As noted in the dry-run analysis conducted last year, the historical time series for some data sources has been modified; in particular, the catch estimates for the purse seine fisheries of Indonesia and Philippines in region 5 (S-ID-PH-5). Sensitivity analyses conducted during the dry-run analysis showed that these changes altered the historical estimates of stock status but had little impact on the terminal estimate used as input to the HCR. These sensitivity analyses have not been repeated here.

Sensitivity analyses were also conducted last year to investigate the impact of discrepancies in the estimated penalty terms for the associated purse seine fishery in region 6 (PS-ASS-6). For the current analysis, estimated penalty terms for PS-ASS-6 show much better correspondence with the values used in the MSE evaluations (Figure 5).

We also note that some inputs for the Japanese pole and line CPUE indices differ from those used for the OMs, particularly for the more northerly assessment regions (Figures 6, 7 and 8). The reasons for this remain unclear but could result from ongoing development to the VAST software package which was in fairly early stages of development at the time the 2019 assessment was conducted, or alternatively from changes in data filtering procedures. These changes mostly affect assessment regions 1 and 2 and the quantity of skipjack biomass estimated in these regions is small in comparison to other regions. Consequently any impact on the estimation of overall stock status resulting from these changes is relatively small.

5.2 Comparison of MP performance against latest assessment outcomes

A key input to the monitoring strategy is the updated full stock assessment which provides estimates of stock status based on the most recent data and the best available science. The full stock assessment is an important benchmark against which aspects of the harvest strategy should be judged. However, direct comparison of the results of the EM and the stock assessment would not be appropriate since they each perform different roles under the harvest strategy approach.

The results of the stock assessment should be used to check that stock status remains within acceptable bounds and is not deviating from the levels anticipated from the MSE testing process. In addition the full stock assessment will provide information on the sources of uncertainty included in the OM grid and can be used to identify any gaps in the range of scenarios that are used to evaluate the performance of candidate MPs.

A comparison of the expected performance of the MP and the 2022 stock assessment in terms of spawning potential depletion (Figure 20) shows good correspondence in the terminal estimate from the stock assessment and the results of the MSE analyses, but show less overlap of the estimates from the assessment and the MSE analyses throughout the time series. This may suggest there is still some uncertainty not accounted for in the evaluation framework. Further work will be required to determine the likely causes of these differences and whether any modifications to the OM grid will be required. We consider this to be a relatively minor issue that can be addressed through the ongoing development of the modelling framework under the monitoring strategy.

6 Conclusions

Sufficient data were available to generate the necessary inputs to run the EM and to apply the MP. Some changes to historical data are apparent but are not of sufficient magnitude to prevent the running of the EM or to invalidate the results. Standardised effort and associated penalty terms for some fisheries show changes to the OM vales and further work is required to resolve this issue, however, sensitivity analyses indicate this has minimal impact on the estimation of stock status and does not invalidate the results of the EM.

The EM ran successfully and returned an estimate of spawning potential depletion ($SB_{latest}/SB_{F=0}$) in the terminal year (2022) of 0.42. Under the adopted management procedure for WCPO skipjack (CMM2022-01) this would set effort in the purse seine fisheries to 2012 levels; effor in pole and line fisheries to average 2001-04 levels and catch in the domestic fisheries of assessment region 5 to average 2016-18 levels for the period 2024 to 2026.

The results of the most recent stock assessment indicate that stock status remains within the bounds predicted by the MSE analyses. Based on preliminary inspection, the results of the most recent assessment also indicate that the range of uncertainty included in the OM grid remains appropriate, although some aspects (e.g. historical uncertainty) may warrant further investigation.

Concern is raised regarding the spatial and temporal coverage of some key data, in particular, the continued decline of pole and line fishing operations in equatorial regions. As these fisheries continue to contract their effort to restricted areas of the overall assessment region, their ability to index relative abundance becomes increasingly impaired. The continued reliance of the estimation method on pole and line indices of abundance is a cause for concern and it is recommended that alternative approaches be investigated. This may require the development and testing of a new estimation method for WCPO skipjack. This issue needs to be considered in the context of exceptional circumstances. Whilst it has not impacted on the running of the MP this year, diagnostic analyses indicate that it is likely to affect the future performance of the MP. We therefore recommend that further work be undertaken to develop and test an alternative estimation model for future use in the WCPO skipjack MP.

Throughout this report we have highlighted a number of data discrepancies and modelling issues that may require further investigation. These issues are summarised in Table 3 and may be considered further under the skipjack monitoring procedure with specific reference to the MSE modelling framework and the performance of the MP. Based on the information in this summry report, we assign a prioritisation of these issues for the consideraton of SC19.

Appendix C of this report outlines a proposed MP summary report that can be drafted by SC and TCC and submitted to the Commission for further consideration of the status of the skipjack MP and any issues that have been identified. The basis of the MP summary report is outlined in Scott et al. (2023).

7 Acknowledgments

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References

Abascal, F., Lawson, T., and Williams, P. (2014). Analysis of purse seine size data for skipjack, bigeye and yellowfin tunas. WCPFC-SC10-2014/SA-IP-05, Majuro, Republic of the Marshall Islands, 6–14 August 2014.

Bigelow, K., Garvilles, E., Bayate, D., and Cecilio, A. (2019). Relative abundance of skipjack tuna for the purse seine fishery operating in the Philippines Moro Gulf (Region 12) and High Seas Pocket 1. WCPFC-SC15-SA-IP08, Busan, Korea, 10-18 August 2019.

Castillo-Jordan, C., Tears, T., Hampton, J., Davies, N., Day, J., Magnusson, A., Scott, R., Pilling, G., Scott, F., and Hamer, P. (2022). Stock assessment of skipjack tuna in the western and central Pacific Ocean: 2022. WCPFC-SC18-2022/SA-WP-01, Online, August 10-18 2022.

Hampton, J. and Williams, P. (2016). Annual estimates of purse seine catches by species based on alternative data sources. WCPFC-SC12-2016/ST-IP-03, Bali, Indonesia, 3–11 August 2016.

Kinoshita, J., Aoki, Y., Ducharme-Barth, N., and Kiyofuji, H. (2019). Standardised catch per unit effort (CPUE) of skipjack tuna of the Japanese pole and line fisheries in the WCPO. WCPFC-SC15-2019/SA-WP-14, Pohnpei, Federated States of Micronesia - 12-20 August 2019.

Merino, G., Urtizberea, A., Fu, D., Winker, H., Cardinale, M., Lauretta, M., Murua, H., Kitakado, T., Arrizabalaga, H., Scott, R., Pilling, G., Minte-Vera, C., Xu, H., Laborda, A., Erauskin-Extraminiana, M., and Santiago, J. (2022). Investigating trends in process error as a diagnostic for integrated fisheries stock assessments. *Fisheries Research*, (In prep).

Peatman, T., Scutt Phillips, J., Potts, J., and Nicol, S. (2022). Analysis of skipjack tagging data for the 2022 skipjack tuna assessment: corrections for tagging conditions. WCPFC-SC18-SA-IP-20, online, 10-19 August 2022.

Scott, R., Scott, F., Pilling, G., and Hampton, J. (2020). Developing management procedures for WCPO skipjack: the estimation model. WCPFC-SC16-2020/MI-IP-09, Online.

Scott, R., Scott, F., Yao, N., Natadra, R., Williams, P., and Pilling, G. (2023). Monitoring the WCPO skipjack management procedure. WCPFC-SC19-2023/MI-WP-02, Koror, Palau, 16-24 August 2023.

Scott, R., Yao, N., Scott, F., Teears, T., Peatman, T., Hampton, J., Hamer, P., and Pilling, G. (2022). WCPO skipjack management procedure: dry run. WCPFC-SC18-2022/MI-WP-03, online, 10-18 August 2022.

Teears, T., Aoki, Y., Matsubara, N., Tsuda, Y., Castillo Jordan, C., Hampton, J., Schneiter, M., Scutt Phillips, J., Peatman, T., and Hamer, P. (2022). Background analyses and data inputs for the 2022 skipjack tuna stock assessment in the western and central Pacific Ocean. WCPFC-SC18-SA-IP-05, online - 10-18 August 2022.

Vidal, T., Pilling, G., Tremblay-Boyer, L., and Usu, T. (2019). Standardised CPUE for skipjack tuna katsumonus pelamis from teh Papua New Guinea archipelagic purse seine fishery. TechReport WCPFC-SC15-2019/SA-IP-05, Pohnpei, Federated States of Micronesia: 11-19 August 2019.

Vincent, M., Aoki, Y., Kiyofuji, H., Hampton, J., and Pilling, G. M. (2019a). Background analyses for the 2019 stock assessment of skipjack tuna. WCPFC-SC15-2019/SA-IP-04, Pohnpei, Federated States of Micronesia. 12-20 August, 2019.

Vincent, M., Pilling, G. M., and Hampton, J. (2019b). 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.

A Tables

Table 1: Skipjack fishery definitions.

Gear	number	category	Code	Flag	Region
Pole and line	1		P-ALL-1	ALL	1
Purse seine	2	combined	PS-ALL-1	ALL	1
Longline	3		LL-ALL-1	ALL	1
Pole and line	4		P-ALL-2	ALL	2
Purse seine	5	combined	PS-ALL-2	ALL	2
Longline	6		LL-ALL-2	ALL	2
Pole and line	7		P-ALL-3	ALL	3
Purse seine	8	combined	PS-ALL-3	ALL	3
Longline	9		LL-ALL-3	ALL	3
Domestic	10		Z-PH-5	PH	5
Domestic	11		Z-ID-5	ID	5
Purse seine	12	combined	S-ID-PH-5	ID-PH	5
Pole and line	13		P-ALL-5	ALL	5
Purse seine	14	associated	PS-ASS-5	DW	5
Purse seine	15	unassociated	PS-UNASS-5	DW	5
Domestic	16		Z-VN-5	VN	5
Longline	17		LL-ALL-5	ALL	5
Pole and line	18		P-ALL-6	ALL	6
Purse seine	19	associated	PS-ASS-6	ALL	6
Purse seine	20	unassociated	PS-UNASS-6	ALL	6
Longline	21		LL-ALL-6	ALL	6
Pole and line	22		P-ALL-4	ALL	4
Longline	23		LL-ALL-4	ALL	4
Pole and line	24		P-ALL-7	ALL	7
Purse seine	25	associated	PS-ASS-7	ALL	7
Purse seine	26	unassociated	PS-UNASS-7	ALL	7
Longline	27		LL-ALL-7	ALL	7
Pole and line	28		P-ALL-8	ALL	8
Purse seine	29	associated	PS-ASS-8	ALL	8
Purse seine	30	unassociated	PS-UNASS-8	ALL	8
Longline	31		LL-ALL-8	ALL	8

Table 2: Skipjack estimation method settings.

Model setting	Value		
Region structure	**8 regions**		
SRR steepness	**0.8**		
Size comp. weighting	**100**		
Tag mixing period	**1 qtr**		
Growth	**Lmin=25.7051**	**Lmax=78.0308**	**k=0.212**
Hyperstability in CPUE	**0**		

B Figures

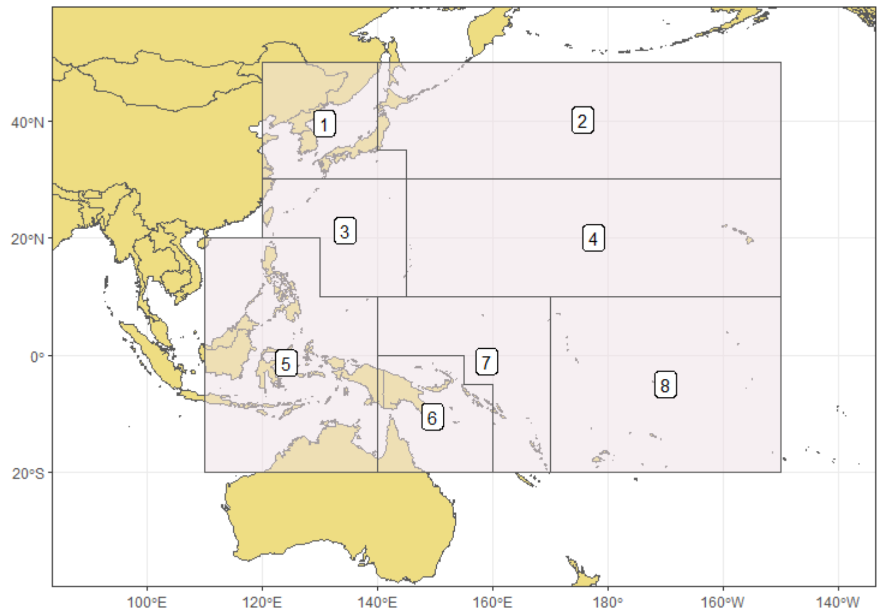

Figure 1: Regional structure of the skipjack estimation method.

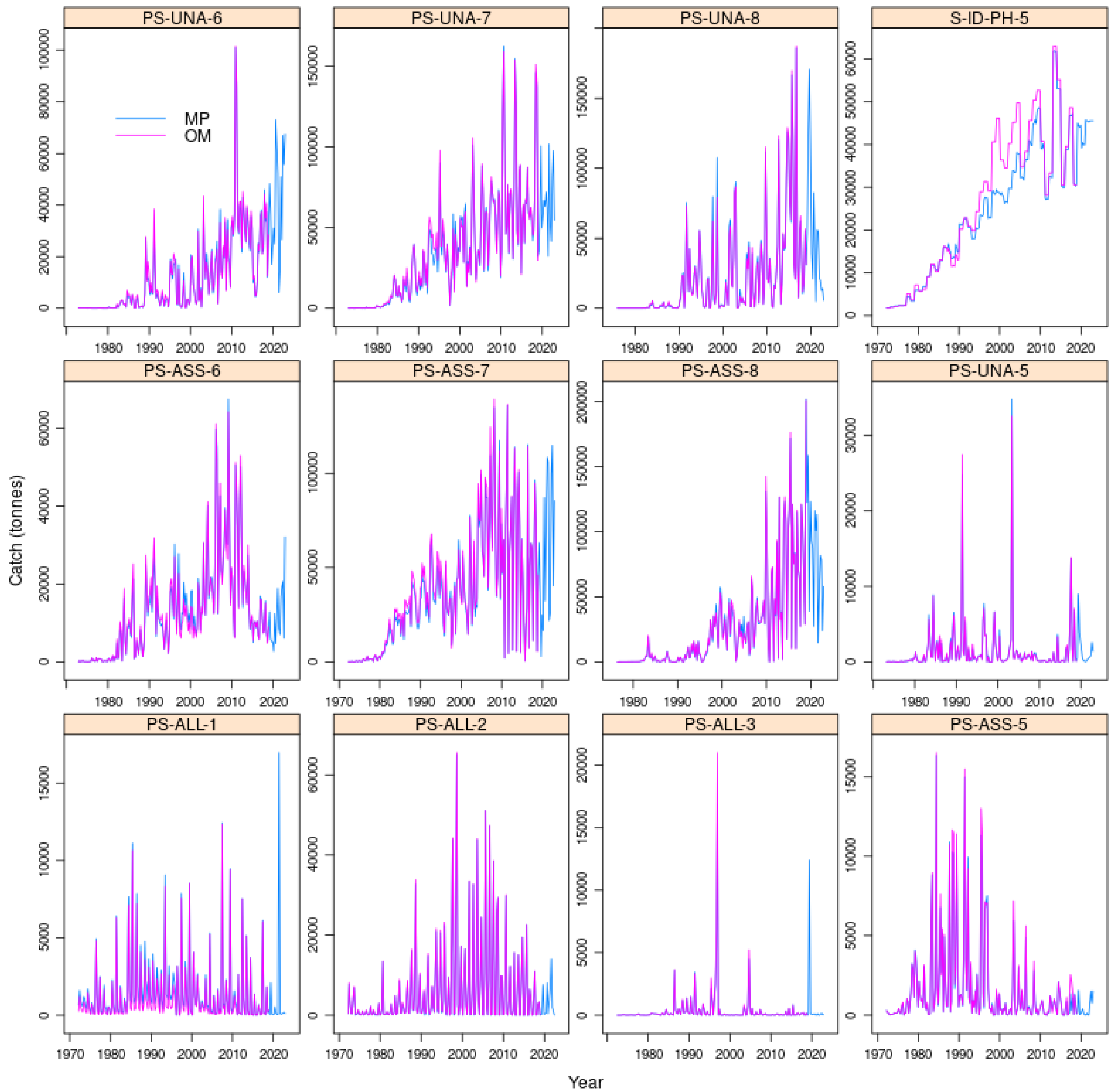

Figure 2: Comparison of historical purse seine catch estimates for the MSE evaluation framework (1972:2018, labelled OM) and the 2023 MP estimation method (1972:2022, labelled MP) inputs.

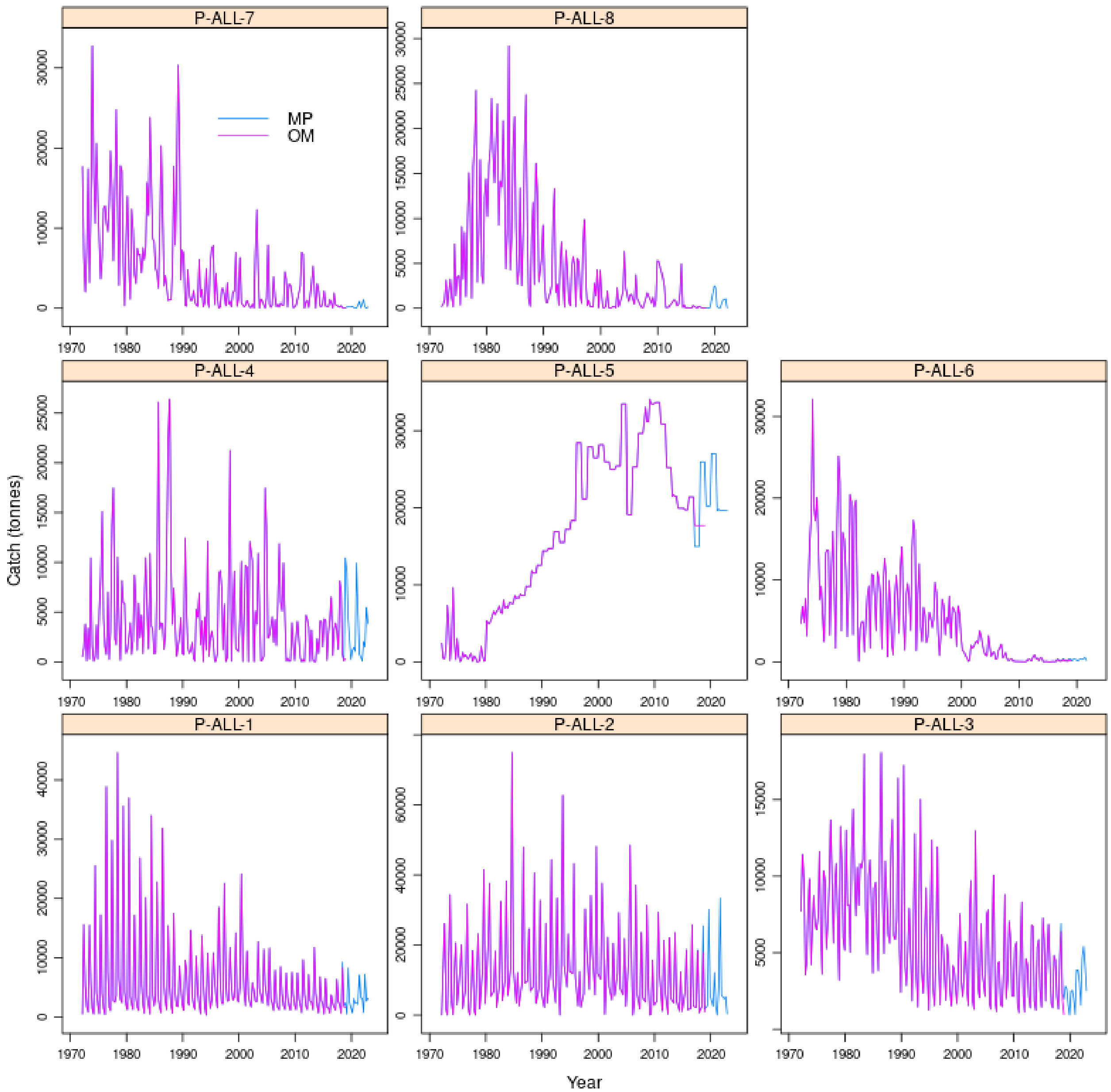

Figure 3: Comparison of historical pole and line catch estimates for the MSE evaluation framework (1972:2018, labelled OM) and the 2023 MP estimation method (1972:2022, labelled MP) inputs.

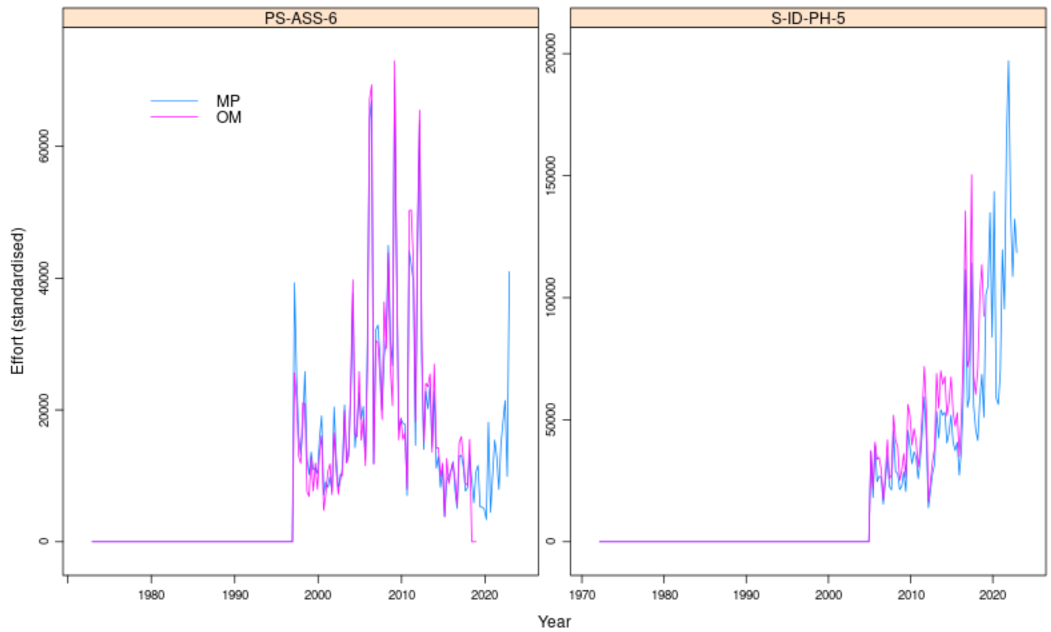

Figure 4: Comparison of purse seine standardised effort for fisheries S-ID-PH-5 (region 5) and PS-ASS-6 (region 6) for the MSE evaluation framework (1972:2018) and the 2023 MP estimation method (1972:2022). Terminal OM values are set to -1 to facilitate projections and do not affet the model fit.

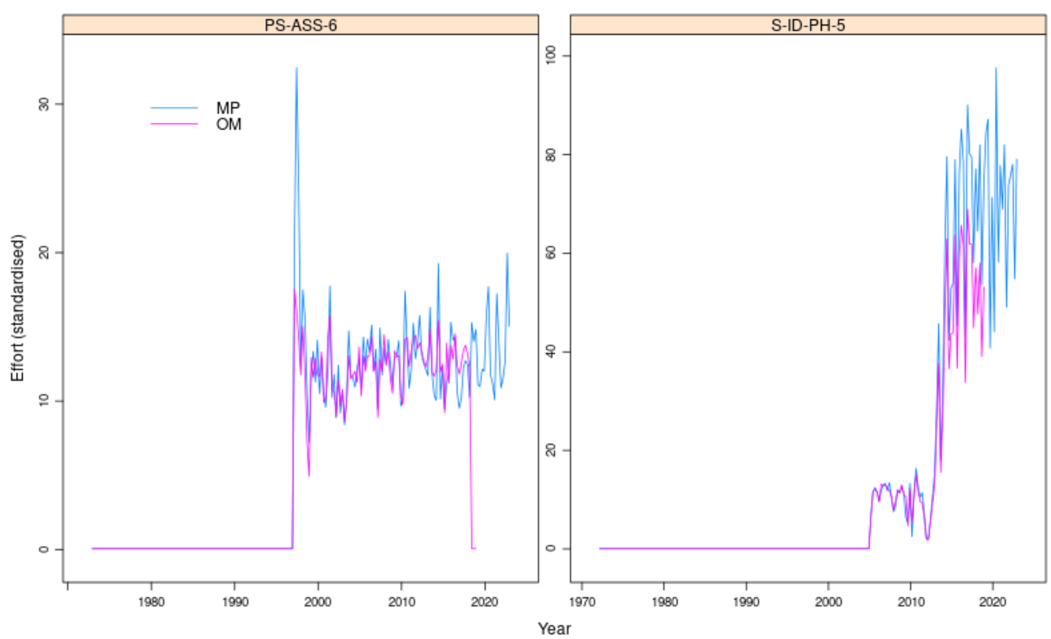

Figure 5: Comparison of purse seine standardised effort penalty terms for fisheries S-ID-PH-5 (region 5) and PS-ASS-6 (region 6) for the MSE evaluation framework (1972:2018) and the 2023 MP estimation method (1972:2022). Terminal OM values are set to -1 to facilitate projections and do not affet the model fit.

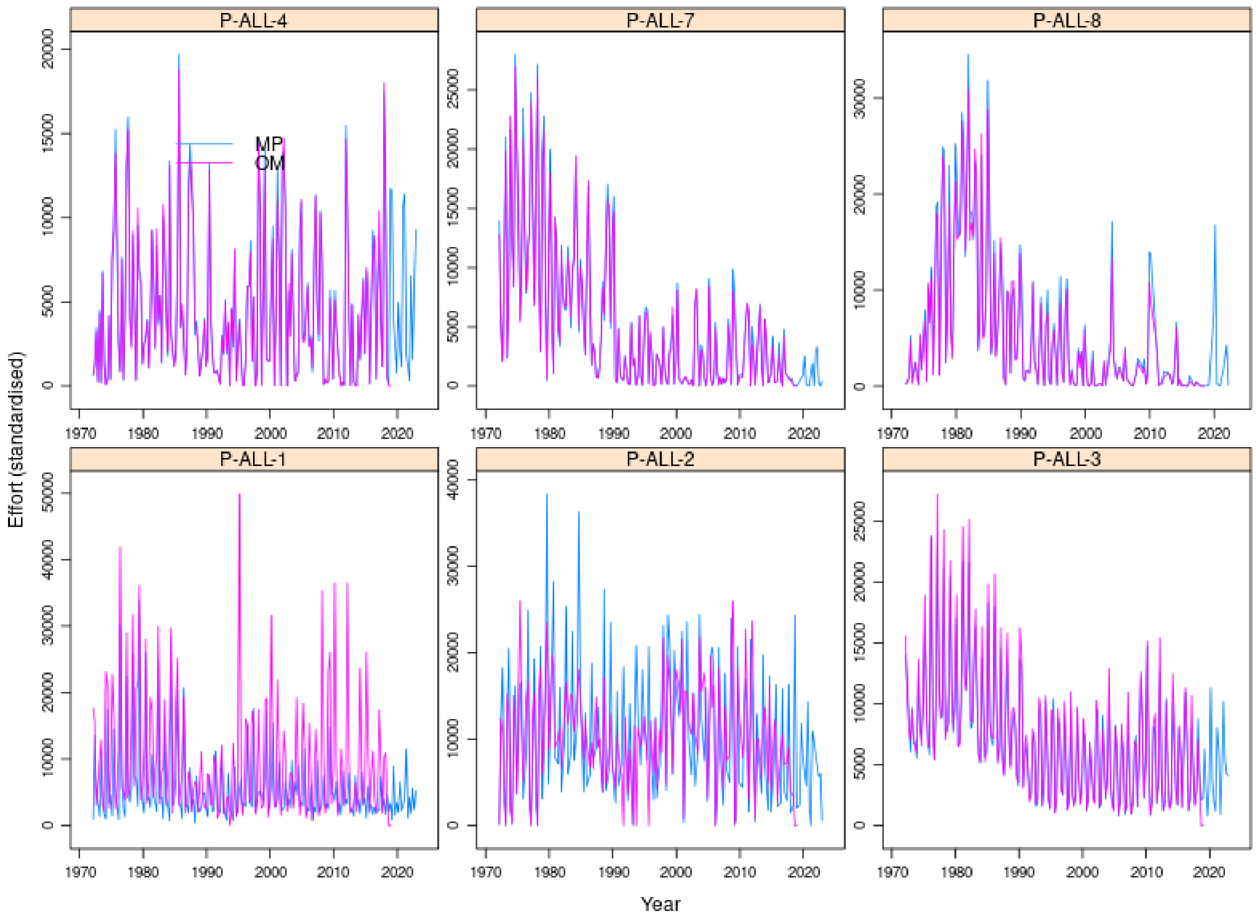

Figure 6: Comparison of standardised effort time series for pole and line fisheries for the MSE evaluation framework (1972:2018) and the 2023 MP estimation method (1972:2022) inputs.

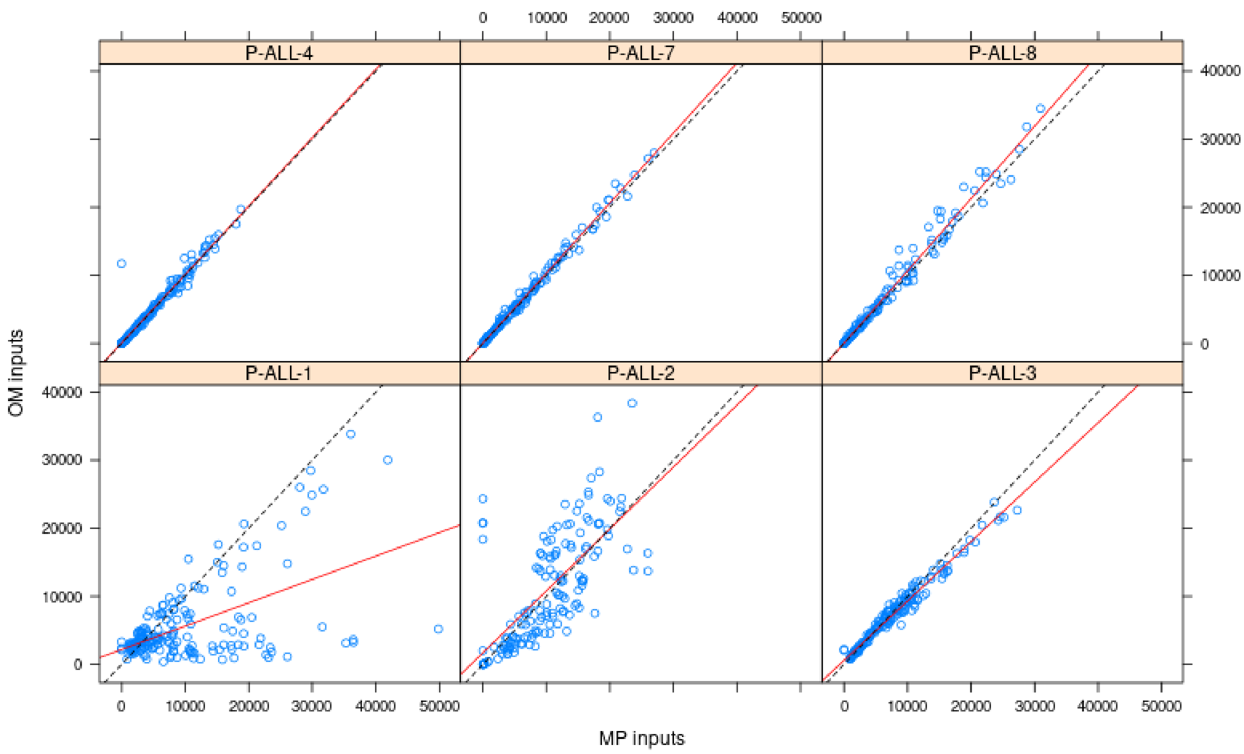

Figure 7: Pairwise comparison of standardised effort time series for pole and line fisheries for the MSE evaluation framework (1972:2018) and the 2023 MP estimation method (1972:2022) inputs. Each point on the graph represents standardised effort observation for the OM (y-axis) and EM (x-axis) for the same year, season and fishery. Points on the dotted line indicate identical values. Red line shows a linear regression through all points with intercept set to zero.

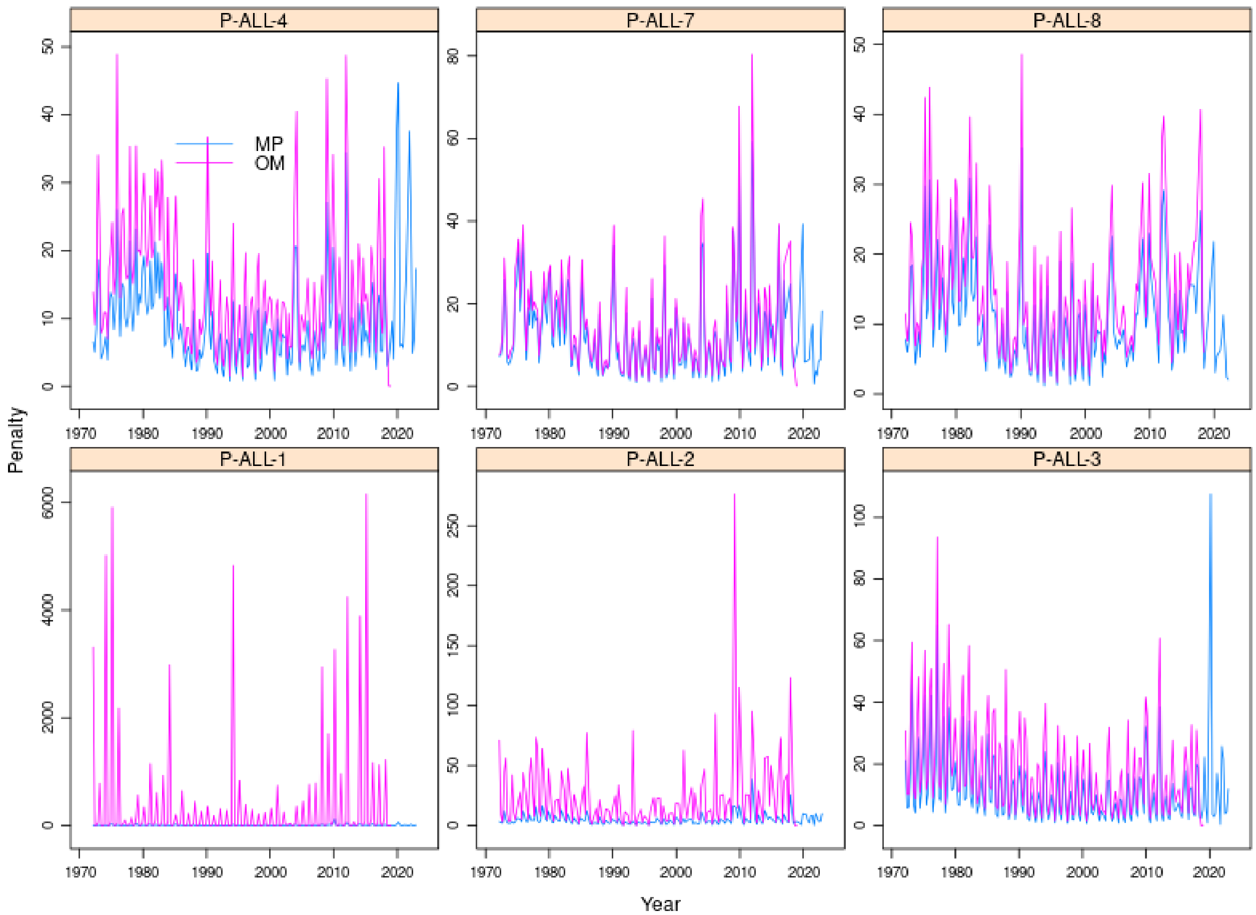

Figure 8: Comparison of time varying penalty terms for pole and line fisheries for the MSE evaluation framework (1972:2018) and the 2023 MP estimation method (1972:2022) inputs.

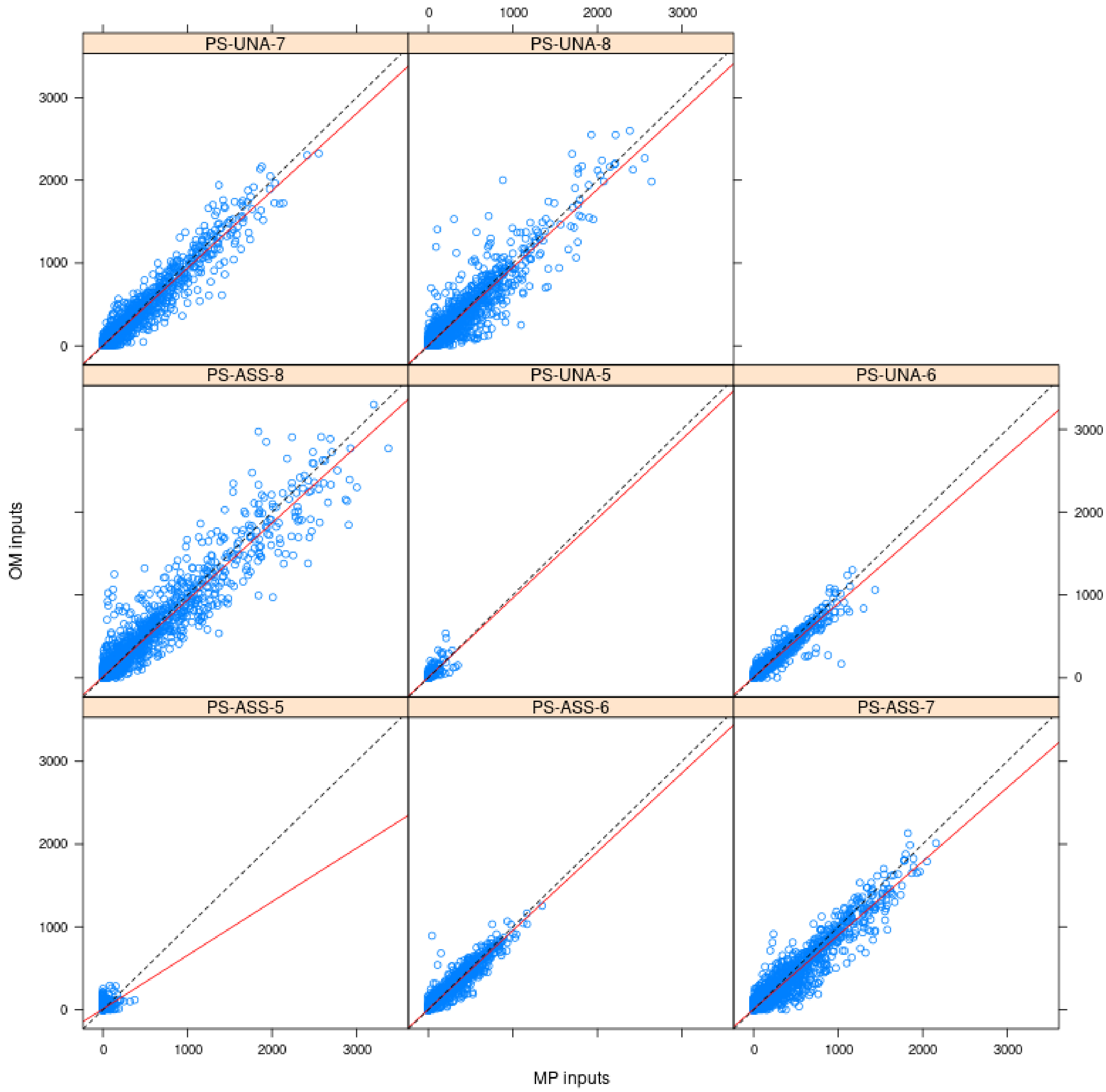

Figure 9: Pairwise comparison of re-weighted size frequency at length for purse seine size composition data for the MSE evaluation framework (1972:2018) and the 2023 MP estimation method (1972:2022) inputs. Each point on the graph represents a re-weighted length observation for the OM (y-axis) and EM (x-axis) for the same year, season, fishery and length. Points on the dotted line indicate identical values. Red line shows a linear regression through all points with intercept set to zero.

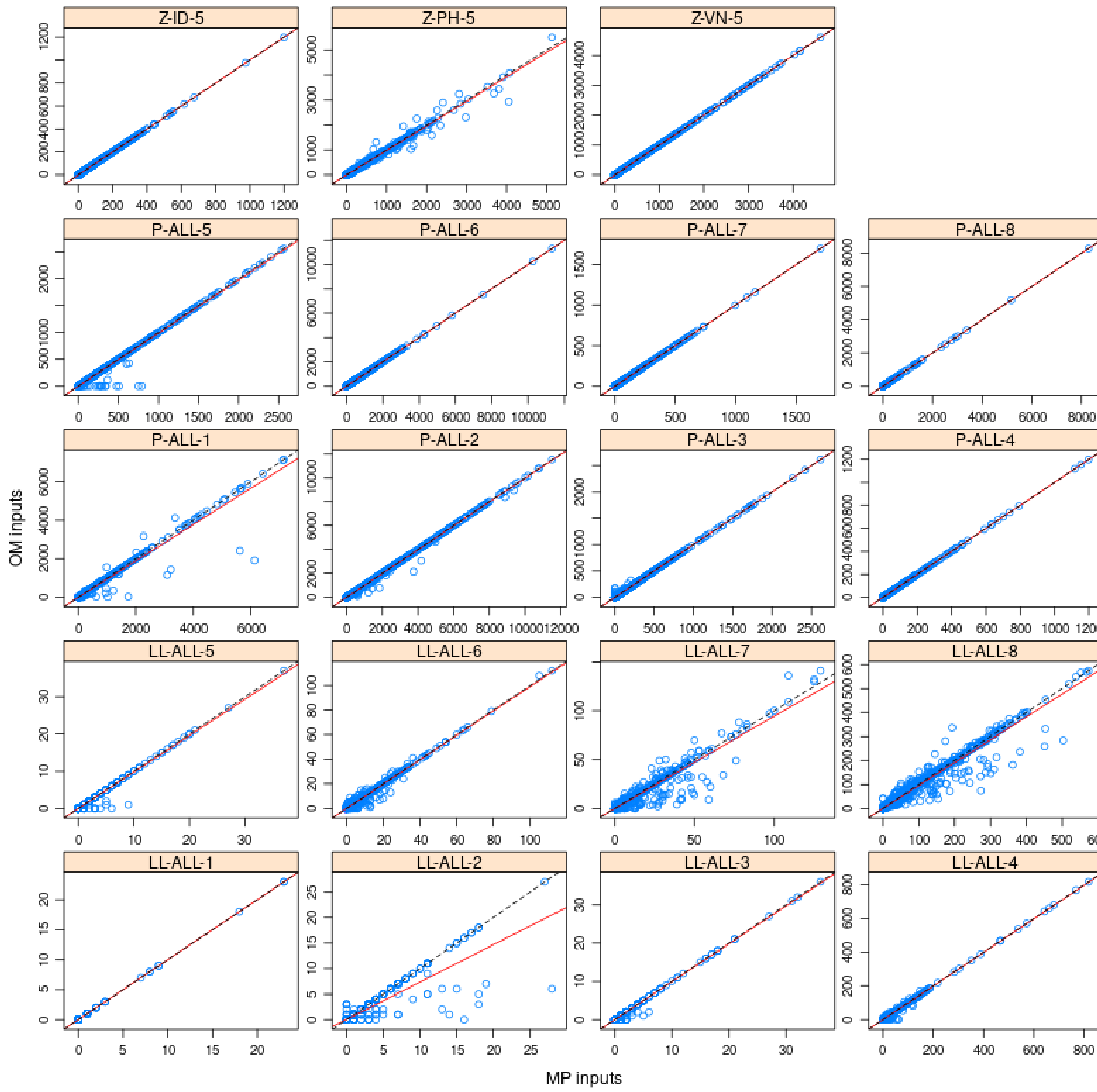

Figure 10: Pairwise comparison of size frequency at length for size composition data for non-purse seine fisheries for the MSE evaluation framework (1972:2018) and the 2023 MP estimation method (1972:2022) inputs. Each point on the graph represents a re-weighted length observation for the OM (y-axis) and EM (x-axis) for the same year, season, fishery and length. Points on the dotted line indicate identical values. Red line shows a linear regression through all points with intercept set to zero.

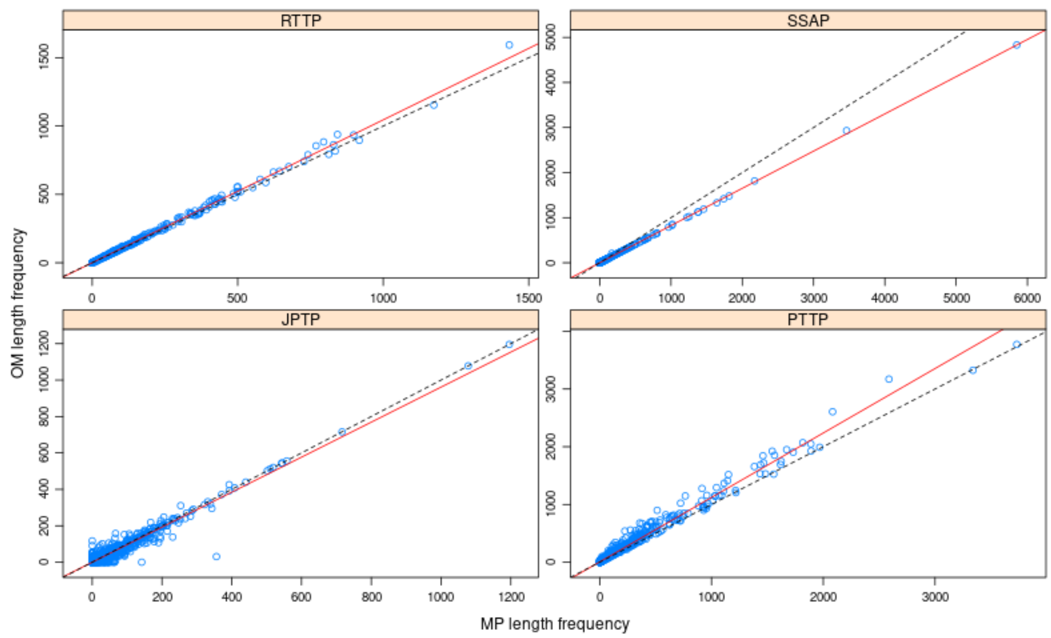

Figure 11: Pairwise comparison of tag release size frequency at length by tag program for the MSE evaluation framework (1972:2018) and the 2023 MP estimation method (1972:2022) inputs. Each point on the graph represents length at release observation for the OM (y-axis) and EM (x-axis) for the same year, season, region and program. Points on the dotted line indicate identical values. Red line shows a linear regression through all points with intercept set to zero.

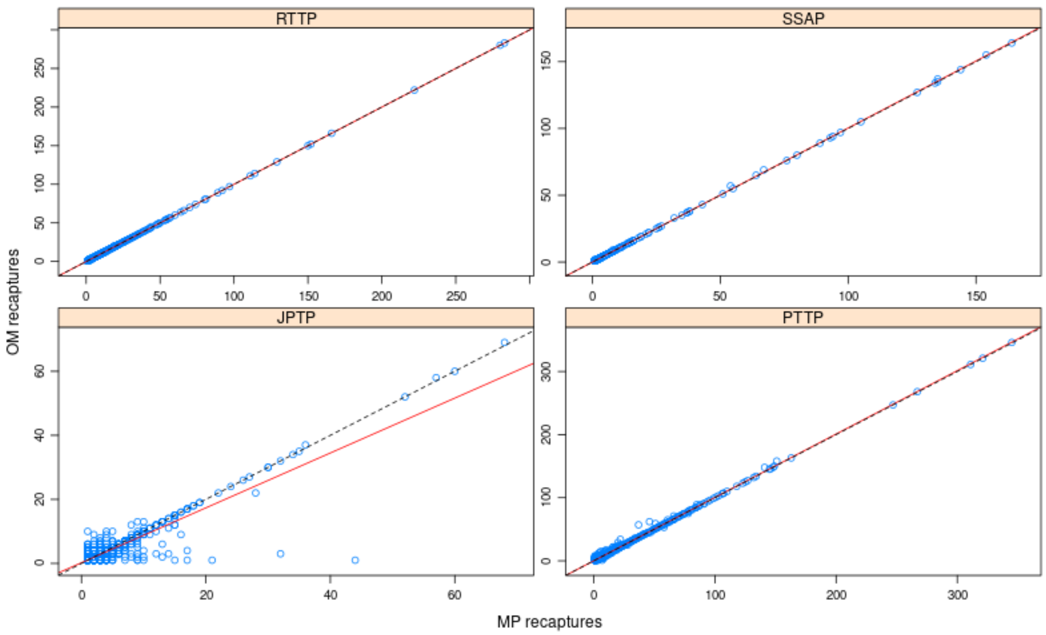

Figure 12: Pairwise comparison of tag recapture numbers by tag program for the MSE evaluation framework (1972:2018) and the 2023 MP estimation method (1972:2022) inputs. Each point on the graph represents recapture numbers for the OM (y-axis) and EM (x-axis) for the same year, month, recapture fishery, length and program. Points on the dotted line indicate identical values. Red line shows a linear regression through all points with intercept set to zero.

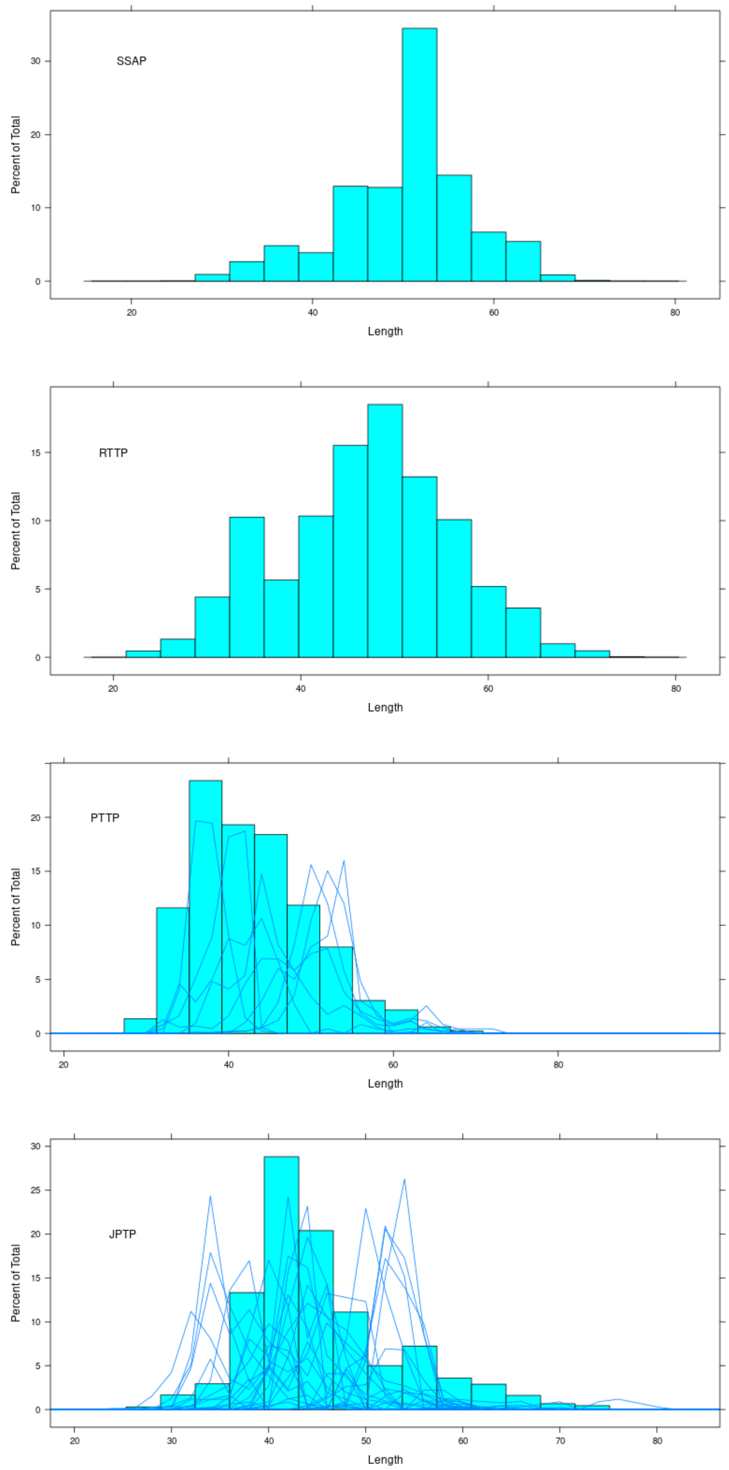

Figure 13: Tag release length compositions for release events used in the OM (all release events combined, bars) and release events since 2017 (individual release events, lines) for the SSAP, RTTP PTTP and JPTP tagging programs. Length distributions for recent releases have been scaled independently to aid comparison.

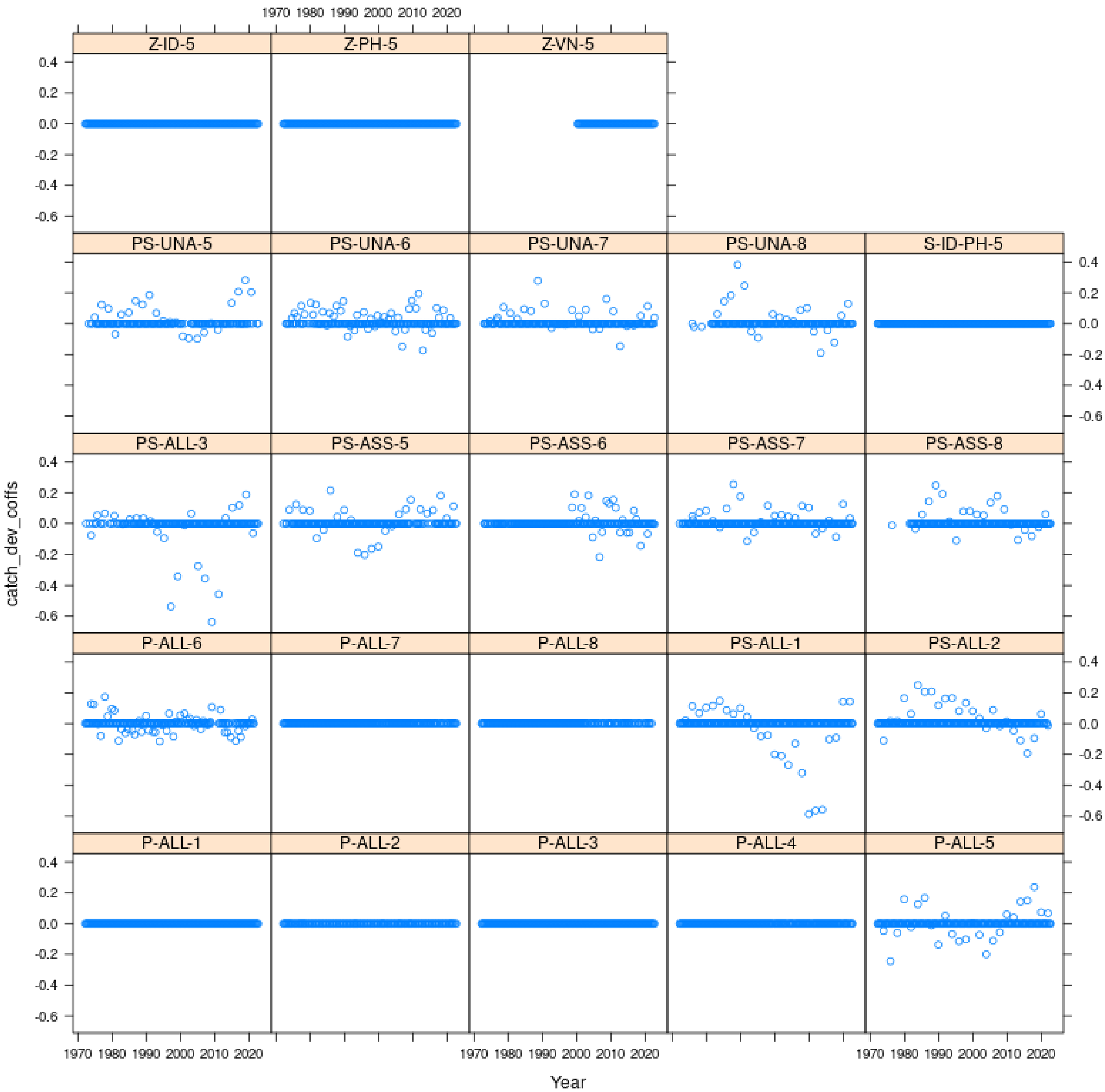

Figure 14: Catch deviations by time period from the final phase of the estimation method for all extraction fisheries except longline.

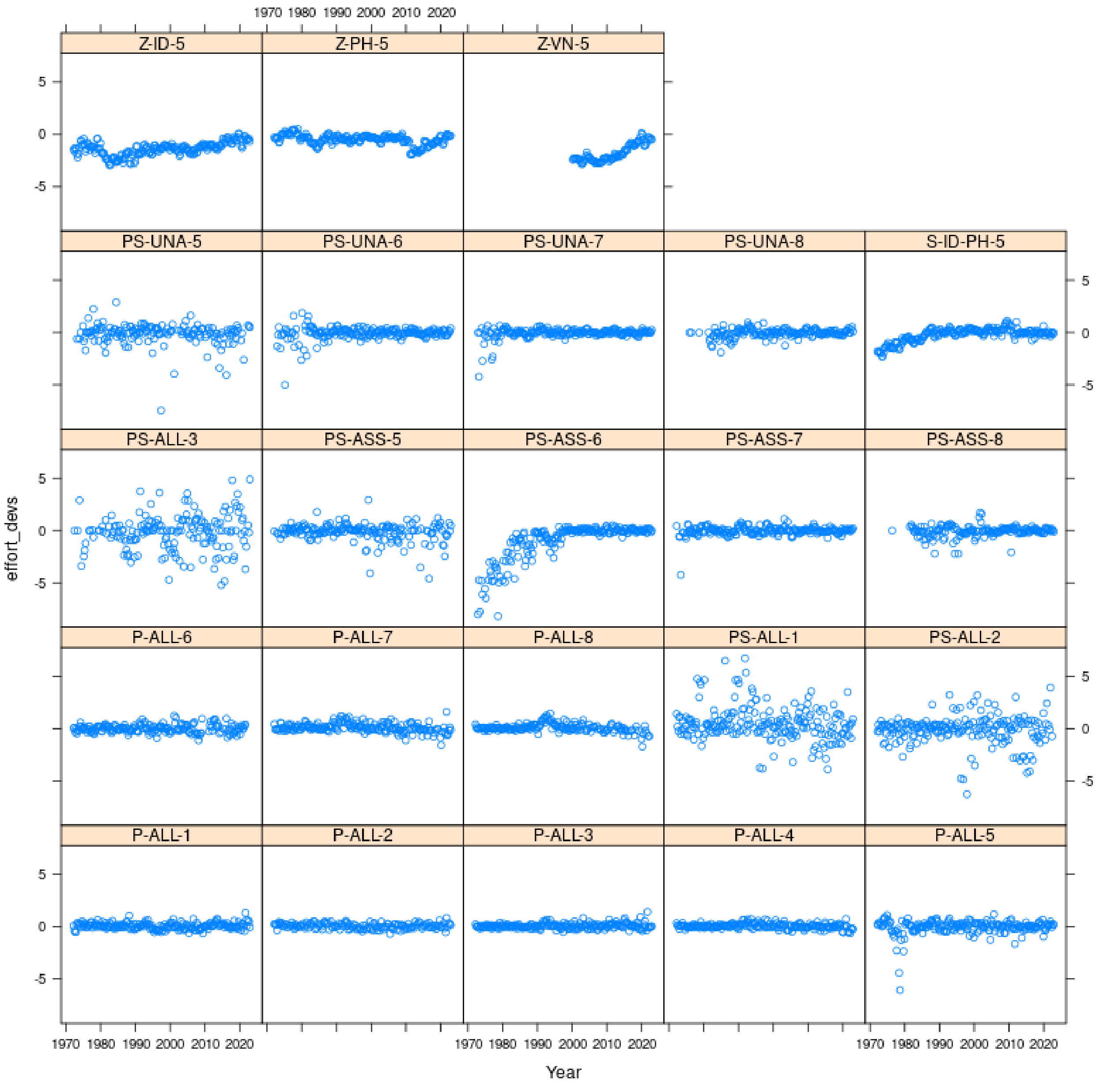

Figure 15: Effort deviations by time period from the final phase of the estimation method for all extraction fisheries except longline.

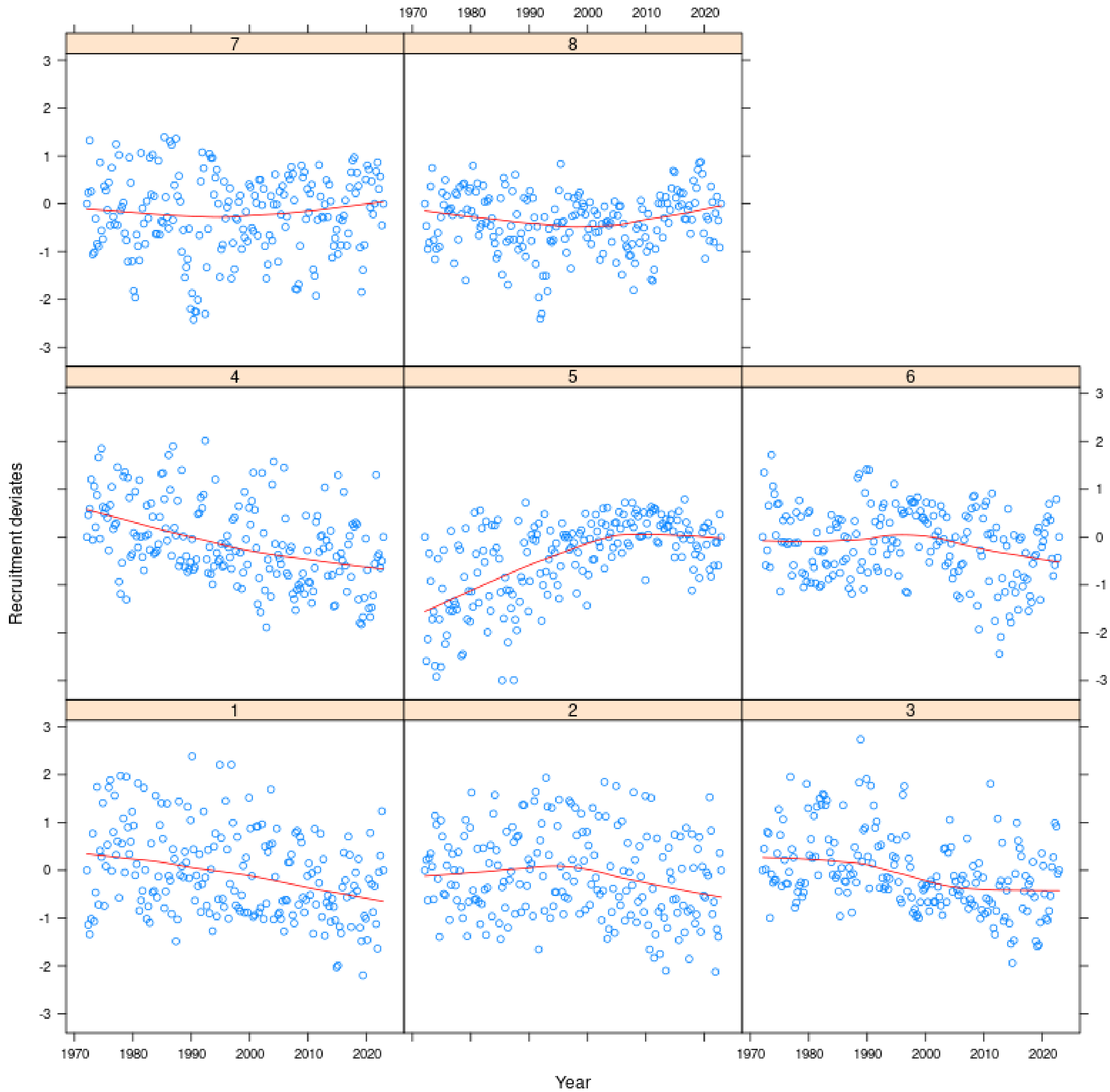

Figure 16: Recruitment deviations by assessment model region. Red line shows a loess smoother fitted to the full time series.

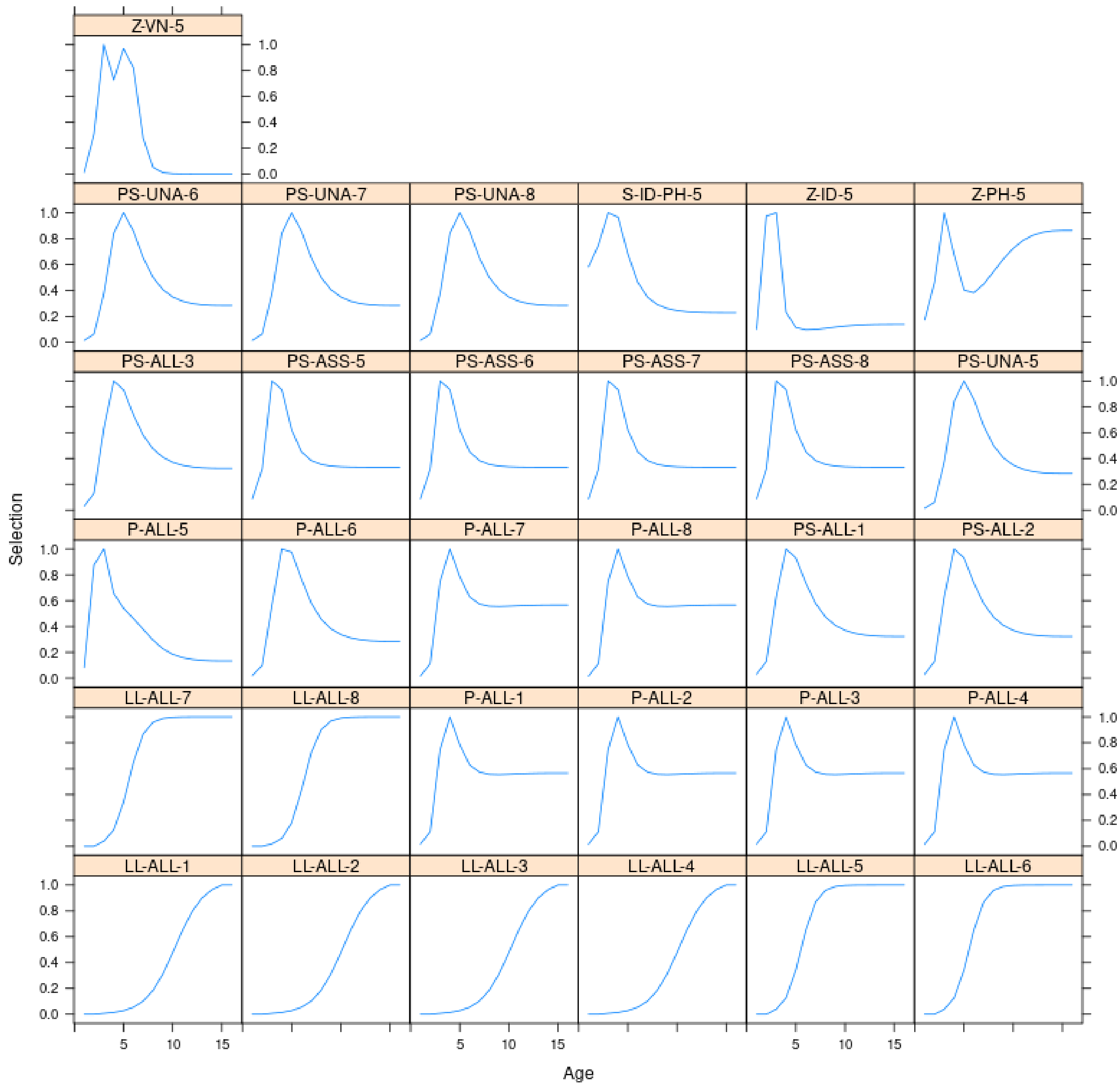

Figure 17: Estimated selection at age by fishery.

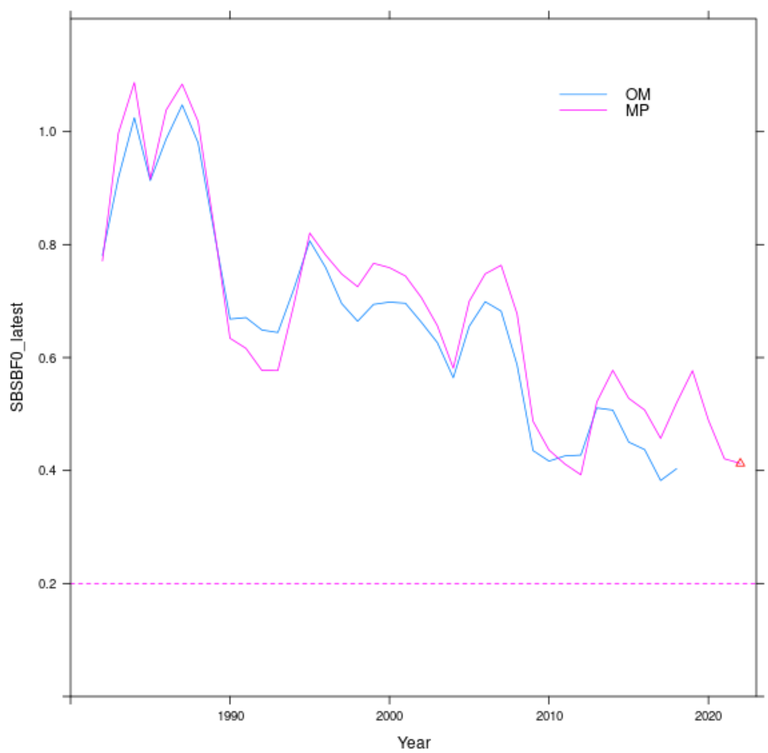

Figure 18: Estimated spawning potential depletion ($SB_{latest}/SB_{F=0}$, regions combined) as determined from the estimation method (where $SB_{F=0}$ is calculated over a 10 year window). The terminal estimate from the final estimation phase (red diamond) is used as the input to the harvest control rule. the OM in this instance represents the diagnostic case model from the 2019 stock assessment.

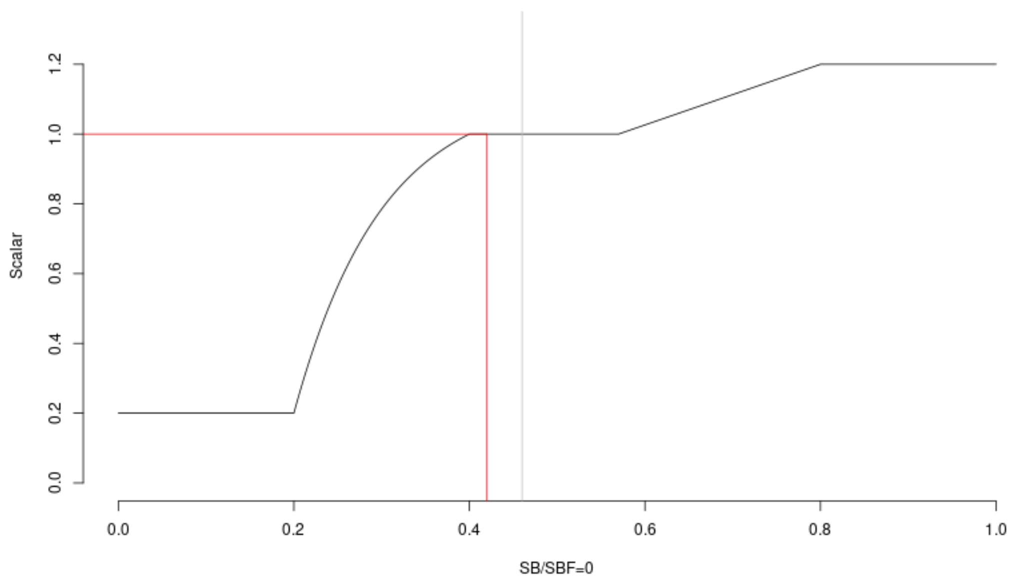

Figure 19: Application of the WCPFC19 agreed HCR. Red line shows the estimated spawning potential depletion ($SB_{latest}/SB_{F=0}$) in 2022 (0.42) as determined from the estimation method and the corresponding catch and effort scalar. Grey line shows the estimated spawning potential depletion ($SB_{latest}/SB_{F=0}$) determined by the 2022 stock assessment.

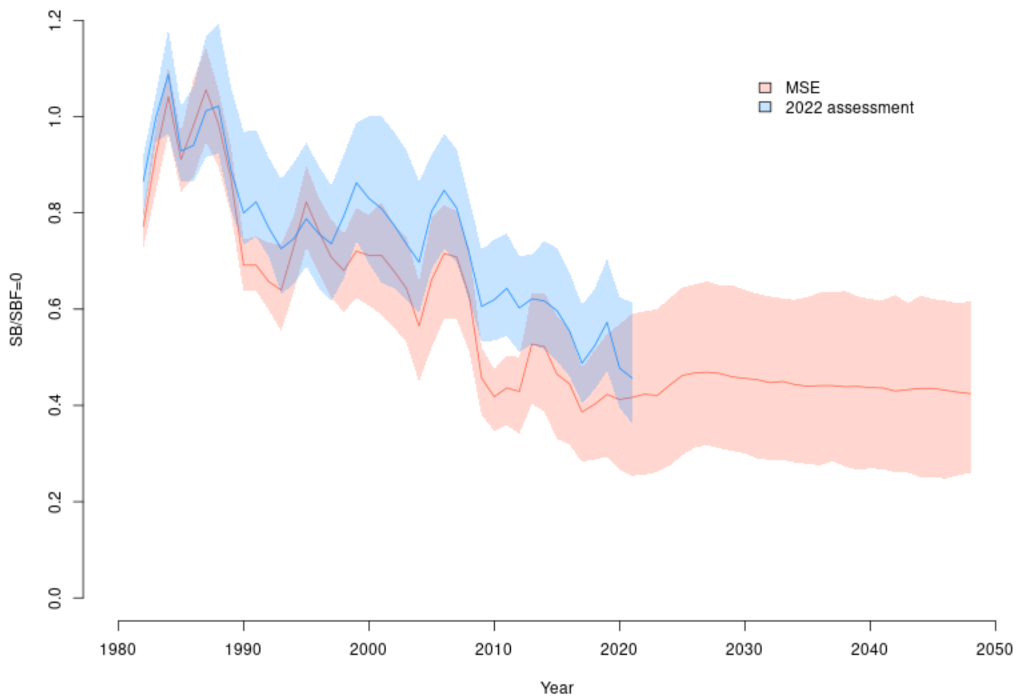

Figure 20: Distribution of predicted spawning potential depletion ($SB_{latest}/SB_{F=0}$) for the MSE evaluation of the WCPFC19 adopted MP and the estimated $SB_{latest}/SB_{F=0}$ from the 2022 stock assessment. Solid red and blue lines represent median $SB_{latest}/SB_{F=0}$ determined by the MSE and the 2022 stock assessment respectively.

C Outline SKJ MP monitoring report

To try to simplify and streamline the monitoring process as much as possible, a summary monitoring report can be compiled consisting of just a summary table that identifies the elements of the monitoring programme that may require additional work or through which major problems have been identified, along with a few short paragraphs to provide further details of the work required to address those issues. The priority of any issues identified can be determined based on the considered severity of the issue and the amount of work required to address it.

This short report is intended to provide an overview of the status of the MP and to allow for information to be collated progressively as elements of the MP are considered by different groups and Commission bodies. An example is shown below.

Summary Table

Table 3 provides a summary of the main issues identified for the WCPO skipjack MP arising from the analyses conducted this year to run the MP.

Table 3: Monitoring report summary for the WCPO SKJ management procedure.

item	MP Element	Status & Comments	Priority
1	**Review MP performance**		
1.1	Comparison with stock assessment	Good - terminal estimates within prediction bounds - historical uncertainty	low
1.2	Data availability & quality	Pole and line CPUE in tropical regions	high
1.3	Other sources of data	No new information	
1.4	EM performance	Acceptable performance - longer term concerns	
2	**Review of the MP**		
2.1	Management objectives	No new information	
2.2	Scope of the MP	No new information	
2.2	Exceptional circumstances	None identified	
3	**Review MSE Framework**		
3.1	Operating model grid	Climate change scenarios	medium
3.2	Calculation of PIs	No new information	
3.3	Modelling assumptions	Pole and line CPUE for tropical regions	high
3.4	Data availability & quality	Generally good	

Further Details

1. Review MP performance

   1.1 Comparison against stock assessment outcomes: A comparison of the MSE predicted outcomes of the adopted MP and the 2022 stock assessment shows good correspondence for the most recent years but shows some departure for the historical period. This is not considered a major problem affecting the MP but some further investigation of the OM grid may be required. This issue is considered to be a low priority.

1.2 Data availability and quality: Sufficient data were available to run the MP. However, it was noted that pole and line fishing effort in tropical regions continues to decline and this presents a potential problem for the future running of the MP. A re-evaluation of the estimation method is recommended prior to the next implementation of the MP. This issue is considered to be a high priority.

1.3 Other sources of data: No other sources of data have been identified.

1.4 EM performance: Overall the estimation method performed well and provided estimates of stock status within the prediction range of the MSE.

2. Review MP

2.1 Management objectives: No change

2.2 Scope of the MP: No change

2.3 Exceptional circumstances: None identified.

3. Review MSE framework

3.1 Operating Model Grid: OM grid to be extended to include climate change scenarios. In particular the effects of warm pool expansion in WCPO. These analyses require further analysis of the SEAPODYM outputs and may occur over an extended timeframe. This issue is considered to be of medium priority. Issues raised under 1.1 may also be considered here.

3.2 Calculation of performance indicators: No change

3.3 Modelling assumptions: no issues identified, however, re-evaluation of the skipjack EM (identified above) may require a re-evaluation of the modelling framework (for example the calculation of simulated data used to test the MP). This issue is considered to be of high priority.

3.4 Data availability and quality: Generally good - some changes may be required, however, depending on the approach adopted to address the decline in pole and line fishing in tropical regions.