SCIENTIFIC COMMITTEE
TWELFTH REGULAR SESSION
Bali, Indonesia
3–11 August 2016

Potential implications of the choice of longline mitigation approach allowed within CMM 2014-05

WCPFC-SC12-2016/EB-WP-06 REV 1 (21 July 2016)

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Revision 1: 21 July 2016 The previous version included incorrectly transcribed mortality reduction rates for the two shark species within the Executive Summary, for the scenario where choice was removed and both techniques excluded. This has been corrected. All values in the main body of the original text and tables/figures were correct.

Executive Summary

This paper extends the analyses described in WCPFC-SC11-2015/EB-WP-02 on the potential impact of several longline gear restrictions of fishing-related mortality on oceanic whitetip shark and silky shark. Specifically, this paper attempts to assess the potential impacts of fleet choice that CMM2014-05 "Conservation and Management Measure for sharks" allows on longline mitigation approaches for these two shark species.

Using Monte Carlo simulations we compare the outcomes of "status-quo" fishing where use of (1) wire-trace material[3] and (2) shark-lines continues at currently observed levels, with scenarios where each are excluded, either individually or combined, and with scenarios where individual flag-states either choose to exclude the gear they use most frequently, or the gear they use least frequently.

The key conclusions of the analyses are:

1. The option for flag states to choose which fishing technique they exclude (either wire trace or shark-lines) has the potential to greatly reduce the benefits to silky shark and oceanic whitetip shark; and

2. If flag-states choose to exclude the technique **least used** by their vessels, the median predicted reductions in fishing-related mortality are 6% for silky shark and 10% for oceanic whitetip shark. This compares to reductions of 24% and 37% respectively if choice was removed and both techniques excluded.

We invite SC12 to consider these findings in their evaluation of the effectiveness of the shark CMM 2014-05. We also reiterate some of the important areas for knowledge improvement previously detailed in WCPFC-SC11-2015/EB-WP-02; e.g. further details of fishing gear configurations used, and research into likely rates of release mortality.

1 Introduction

In August 2015 SC11 reviewed WCPFC-SC11-2015/EB-WP-02 (Harley et al., 2015) which presented the results of analyses identifying the potential levels of mortality reduction arising from longline shark bycatch mitigation measures specified in CMM 2014-05 for oceanic whitetip shark (*Carcharhinus longimanus*) and silky shark (*Carcharhinus falciformis*). On the basis of those results, two specific areas of additional work were requested: 1) refine the evaluation of the potential impacts of the shark CMM 2014-05 (WCPFC, 2014) to include the provision for flag-states to choose which technique they exclude; and 2) extend the analysis to consider purse seine impacts, specifically how the transfer of effort between FAD and free-school modes of fishing may change

[3] defined here as either wire trace or wire leader.

the impact that purse seining has on these two tropical shark species. This paper focuses on the first request. Analyses of the second are presented in WCPFC-SC12-2016/EB-WP-03.

2 Methods

This analysis uses the same models, fleets, and data used and described in detail in Harley et al. (2015); we will not repeat that information here, but instead refer the interested reader to that paper.

To summarise, the model was separated into two components: catch (identifying factors that determined how many sharks would encounter and be at least briefly hooked on the gear); and fate (what happens to those sharks that are hooked). The analysis was comprised of several steps, which are briefly described below:

1. Development of a process model of how oceanic whitetip shark and silky shark can interact with a longline fishing gear ('catch component'), including the key factors likely to influence life status ('fate component') (see Figures 1 and 2);
2. Development of a spatial surface of total tropical (20°N - 20°S) longline fishing effort by flag in terms of hooks deployed associated with particular gear configurations, subsequently summarised across flags;
3. Development of a spatial surface of oceanic whitetip shark and silky shark abundance so that the location of deployment of fishing gear relative to the density of the two shark species can be taken into account. The surface, developed using available observer data, was taken from Harley et al. (2015), and represented an absolute latitude surface with relative abundance mirrored north and south of the equator (see Figure 3 of that paper). Through the application of the spatial surface of abundance, fishing patterns in areas of highest abundance will be more important to the overall longline impact than fishing in areas of low density;
4. Use information from previous analyses and the literature to parameterise the model in (1) in terms of values (or probability distributions) for catchability and survival, etc.;
5. Develop several management intervention scenarios, e.g. a total prohibition on the use of shark lines and wire traces (see next section); and
6. Evaluate management scenarios with the model and compare key outcomes.

2.1 Management scenarios examined

To better allow examination of the potential impact of choice within CMM 2014-05 we examined the following scenarios:

Status quo: no change in gear configurations.

Least-used: flag-states choose to exclude the technique least used by their vessels.

Most-used: flag-states choose to exclude the technique most used by their vessels.

Shark-lines: all shark-lines are excluded.

Wire trace: all wire trace[4] is excluded.

Shark lines and wire traces: both shark-lines and wire trace are excluded.

At the time of this analysis, we did not have knowledge on which approach flag-states had adopted. The information on gear deployed summarised in Table 1 was updated with available data through 2014[5], noting that CMM 2014-05 came into force on 1 July 2015. These data were used to identify which option would be associated with each flag. As an example, for Chinese vessels, wire trace would be excluded under the least used option and shark-lines under the most-used scenario, as wire trace use (14%) was lower than shark-line use (14.2%).

2.2 Monte Carlo simulations

The Monte Carlo simulations were implemented using R (R Core Team, 2013). The steps to undertake those simulations were:

- Apply the management scenario to the base fishing effort by flag to create a new effort layer. In each scenario, effort from an excluded gear category was redistributed to permissible gear categories, e.g., if wire trace was the category restricted under a flag choice, then all wire trace effort for that flag was transferred to monofilament leaders, and other characteristics were not changed.
- Apply the catch and fate models 5,000 times – each simulation has different draws from each input distribution.
- Keep track of catch, mortality and survival at every stage of the catch and fate models.

We compared absolute values of total catch and total mortality across scenarios, the different mortality options (i.e., where a shark could die in the process) and the relative change in fishing related mortality from the status-quo option.

[4]defined here as either wire trace or wire leader

[5]For Japan we assumed the same gear characteristics as for Korea due to the lack of observer data for Japanese DW vessels, and values for the United States were kindly provided by Keith Bigelow.

3 Results

The results focus on the relative total mortality arising from the choice of mitigation option (shark-lines or wire trace) at the fleet level. We note that the inclusion of additional data has led to small differences in the results of some management scenarios in terms of mortality rate reduction compared to Harley et al. (2015), but that overall patterns remain comparable. For both species, as noted by Harley et al. (2015), excluding shark lines reduces the level of catch of silky sharks, while the exclusion of wire trace has no effect on this part of the process. The main impact of the latter mitigation is the reduction in subsequent mortality (e.g. Figures 3 and 6).

Silky shark

Under either choice scenario (least-used or most-used), the overall mortality rate (deaths/catch) was reduced compared to the status quo (Tables 2 and 4. See also Figure 5). Comparing the median rates, choosing to exclude the least used option reduced the mortality rate by 6%, a lower reduction seen than under the total exclusion of either shark lines or wire trace. Excluding the most used option reduced the mortality rate by 21%, and hence was more effective than excluding either shark-lines or wire trace individually, and slightly less effective than excluding both shark-lines and wire trace (which led to a 24% reduction). The corresponding mortality components are presented in Figure 4.

Oceanic whitetip shark

Under either choice scenario (least-used or most-used), the overall mortality rate (deaths/catch) was reduced compared to the status quo (Tables 3 and 5. See also Figure 8). Comparing the median rates, choosing to exclude the least used option reduced the mortality rate by 10%, again a lower reduction seen than under the total exclusion of either shark lines or wire trace. Excluding the most used option reduced the mortality rate by 30% relative to the status quo, again this was more effective than excluding either shark-lines or wire trace individually, and slightly less effective than excluding both shark-lines and wire trace (which led to a 37% reduction). The corresponding mortality components are presented in Figure 7.

4 Discussion

While CMM 2014-05 includes limits on two longline gear features strongly related to interactions with silky shark and oceanic whitetip shark, that CMM allows the flag-state flexibility to choose **at least one** of the measures to exclude – while in theory allowing them to continue to use the other.

The levels of fishing mortality experienced by these two species are well in excess of F_{MSY} and the analysis conducted here clearly demonstrates that giving the option of prohibiting shark lines **or** wire traces is likely to result in considerably less benefit in terms of mortality reduction than excluding both. WCPFC should consider whether the likely negative impact of this flexibility is consistent with the expectations of protection to be offered to these two species when the CMM was adopted.

This analysis assumes that **all** vessels within a specific fleet will choose one option or the other. However, CMM 2014-05 states only that "CCMs shall ensure that their vessels comply with at least one of the... options". Therefore individual vessels within a fleet have the potential to choose to not use wire trace as branch lines or leaders, and/or not to use 'shark lines'. While modelling individual vessel choice was beyond the scope of the current analysis, the resulting reductions in mortality will likely be lower than estimated here.

4.1 Data and information

The model outputs remain reliant upon the information used to parameterise it. Model outputs would be enhanced through greater observer coverage of longline fleets throughout their range and across fleets, to allow the development of more fine-scale abundance surfaces. This would also allow consideration of spatial management measures. In turn, the collection of specific information to better determine the potential fishing-related mortality of the two shark species post release (as per CMM 2014-05) is needed. To repeat from Harley et al. (2015) we recommend that, where practical, observers on longline vessels collect hooking location – specifically whether the hook is visible (i.e. lip-hooked) or not-visible (i.e., gut-hooked) – as this is an important factor in release mortality. We also recommend that information be collected on how these two species are released, specifically whether they were released while in the water or whether they were brought on-aboard the vessel first, and whether an attempt was made to remove the hook. In conjunction with this information, it is recommended that a set of experiments be undertaken to estimate release survival under the types of conditions of pre-release 'treatment' received (e.g., after Campana et al., 2009).

4.2 Model

The two-step model developed built on previous studies of factors impacting shark catch rates and mortality (Clarke, 2011; Bromhead et al., 2013; Caneco et al., 2014) and other models (Patterson et al., 2014). The model made quite strong assumptions about what factors impact catch rates (e.g., location and hook depth) and what influences release mortality (e.g., hooking location and how released). This model can be expanded to include new processes and factors that are likely to be important. These could include shark size, sex, bait type, location/water temperature (for release survival), but the main limitation will be the development of the effort surface that contains these characteristics.

Further development of the model and/or the results of any experiments could result in new potential data needs. One benefit of a model such as this is that it can be used to assess the sensitivity of mortality estimates to uncertainty in particular parameters and processes. Such analyses could be used to help prioritize observer data collection and research experiments.

Acknowledgements

This work was funded by WCPFC Project 54 ("Shark Monte Carlo mitigation analysis for purse seine, and extension of the longline analysis"). Thanks go to Drs Alex Tidd, John Hampton and Steve Brouwer for helpful comments on an earlier draft of this paper.

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Table 1: Proportion of use for key longline gear characteristics by vessel flag.

Flag	Trace		Hook			Shark line		Hook position	
	Wire	Mono	J	Tuna	Circle	ShkLn	NoShkLn	Shllw	NoShllw
CK	0.005	0.995	0.383	0	0.617	0	1	1	0
CN	0.140	0.860	0.369	0	0.631	0.142	0.858	1	0
FJ	0.269	0.731	0.198	0	0.802	0.264	0.736	1	0
FM	0.129	0.871	0	0	1	0.289	0.711	1	0
JP	0.834	0.166	0.503	0	0.497	0.018	0.982	1	0
KR	0.834	0.166	0.503	0	0.497	0.018	0.982	1	0
MH	0.608	0.392	1	0	0	1	0	1	0
PF	0.418	0.582	0.680	0	0.320	0.002	0.998	1	0
PG	1	0	1	0	0	0.943	0.057	1	0
TW	0.150	0.850	0.870	0	0.130	0.080	0.920	1	0
US	0.900	0.100	0	0	1	0	1	1	0
VU	0.350	0.650	0.867	0	0.133	0.868	0.132	1	0
WS	0	1	0	0	1	1	0	1	0

Table 2: Overall mortality rate (deaths/catch) for silky shark for the status quo (Base.SQ) and each management scenario in terms of percentiles from Monte Carlo distributions.

	10th percentile	median	90th percentile
Status-quo	0.31	0.34	0.38
Least-used	0.29	0.32	0.36
Most-used	0.24	0.27	0.31
No Shark-lines	0.28	0.31	0.35
No wire trace	0.25	0.28	0.33
No Shark-lines or wire trace	0.23	0.26	0.29

Table 3: Overall mortality rate (deaths/catch) for oceanic whitetip shark for the status quo (Base.SQ) and each management scenario in terms of percentiles from Monte Carlo distributions.

	10th percentile	median	90th percentile
Status-quo	0.27	0.3	0.33
Least used	0.24	0.27	0.3
Most used	0.18	0.21	0.24
No Shark lines	0.22	0.25	0.28
No wire trace	0.19	0.23	0.26
No Shark lines or wire trace	0.16	0.19	0.22

Table 4: Percentage reduction in overall mortality rate for silky shark for each management scenario in terms of percentiles from Monte Carlo distributions.

	10th percentile	median	90th percentile
Least used	6	6	5
Most used	23	21	18
No Shark lines	10	9	8
No wire trace	19	18	13
No Shark lines or wire trace	26	24	24

Table 5: Percentage reduction in overall mortality rate for oceanic whitetip shark for each management scenario in terms of percentiles from Monte Carlo distributions.

	10th percentile	median	90th percentile
Least used	11	10	9
Most used	33	30	27
No Shark lines	19	17	15
No wire trace	30	23	21
No Shark lines or wire trace	41	37	33

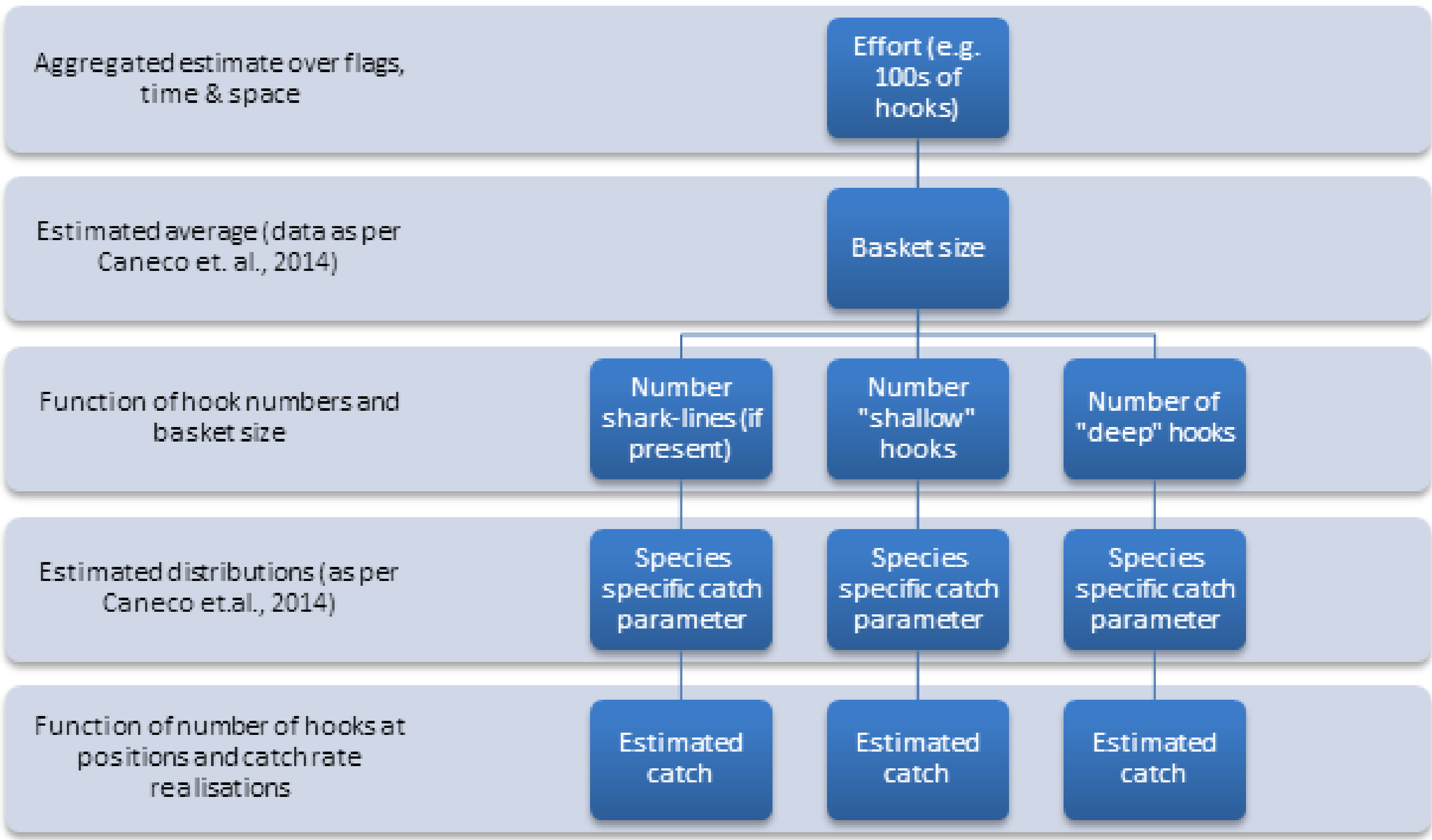


Figure 1: Part 1 of the theoretical model: the catch component.

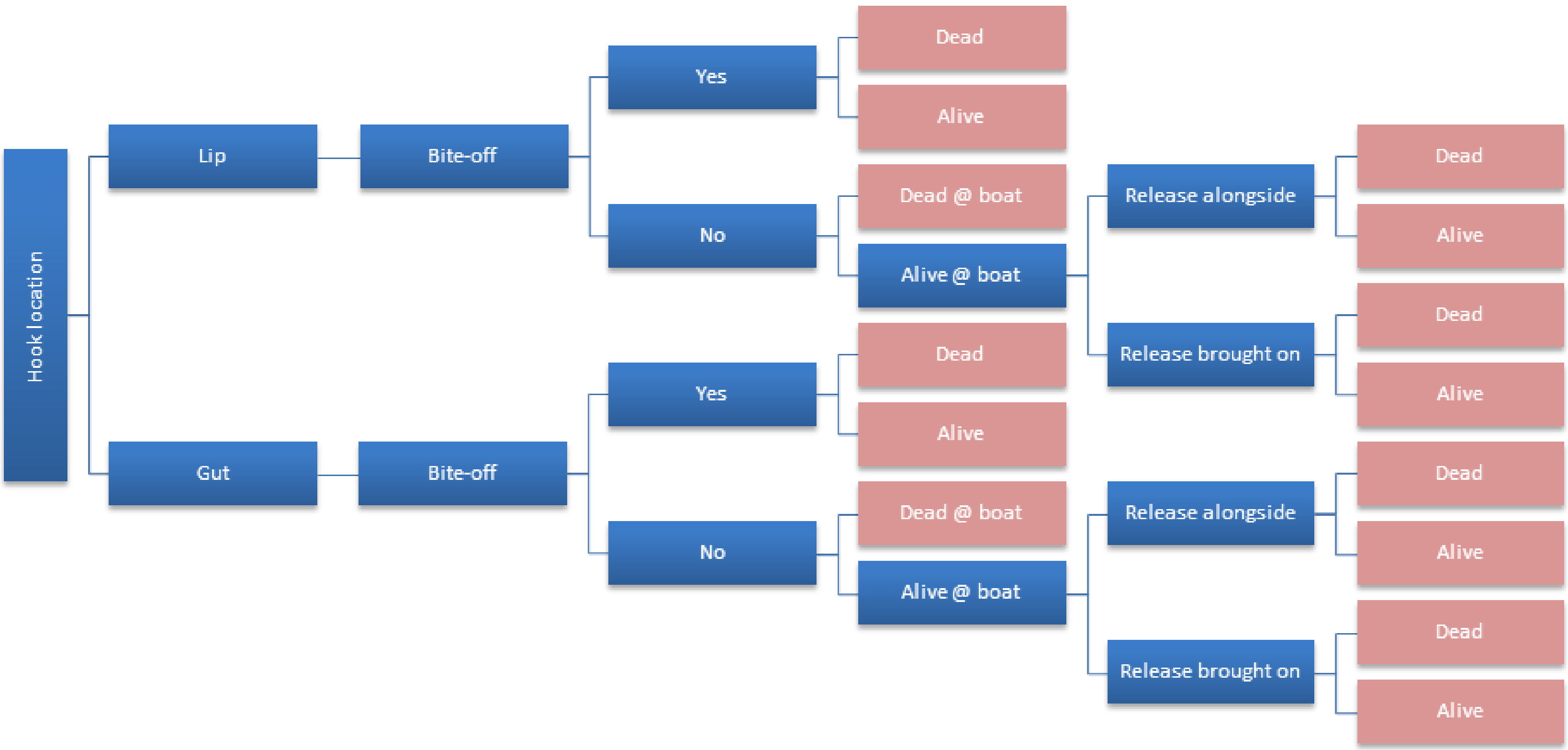
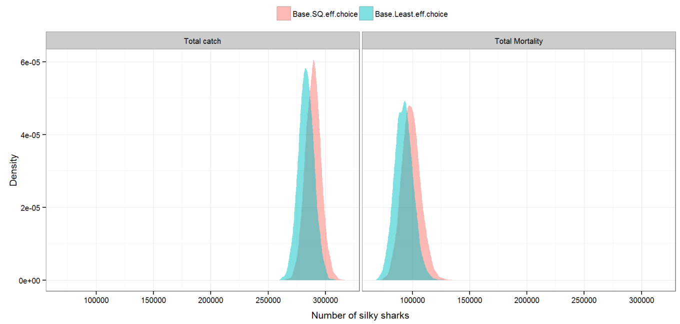
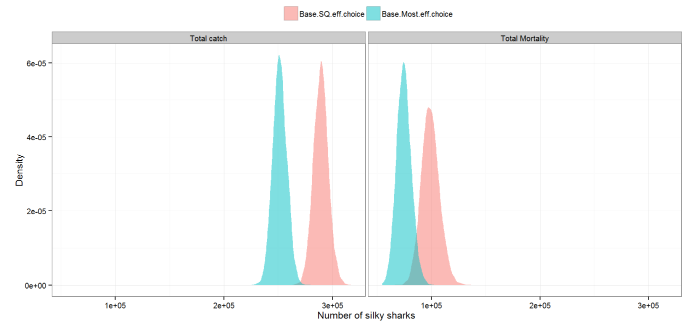


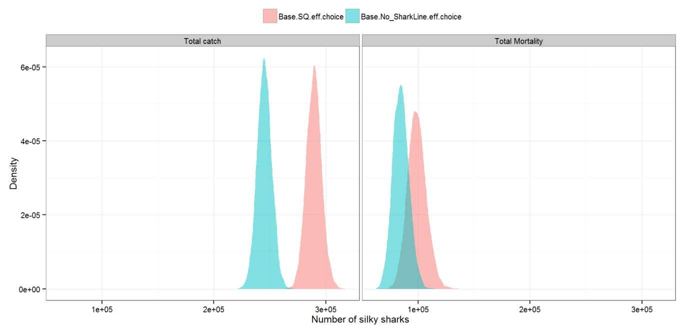
Figure 2: Part 2 of the theoretical model: the fate component.



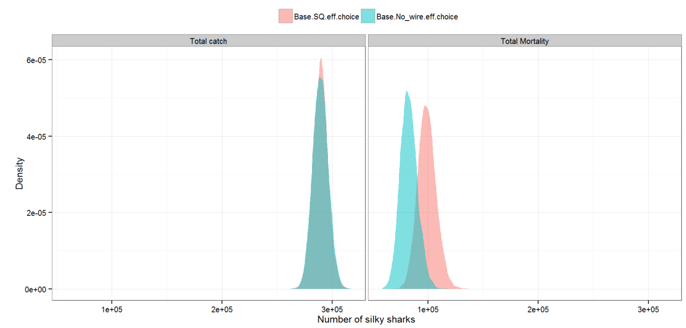
(a) Ban least-used method



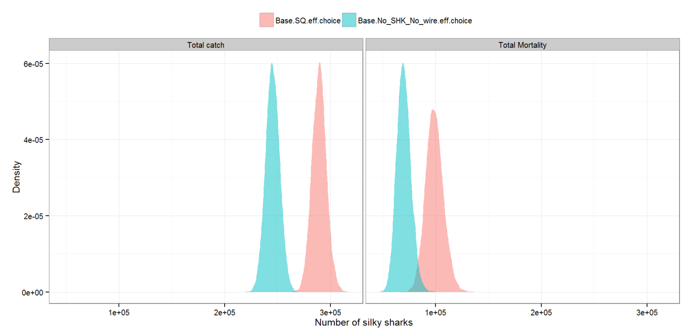
(b) Ban most-used method



(c) Ban shark lines



(d) Ban wire trace



(e) Ban both

Figure 3: One-off comparisons for silky shark between the status quo (Base.SQ) and each scenario in terms of the Monte Carlo distributions of catch (left side of the individual panels) and mortality (right side of the individual panels).

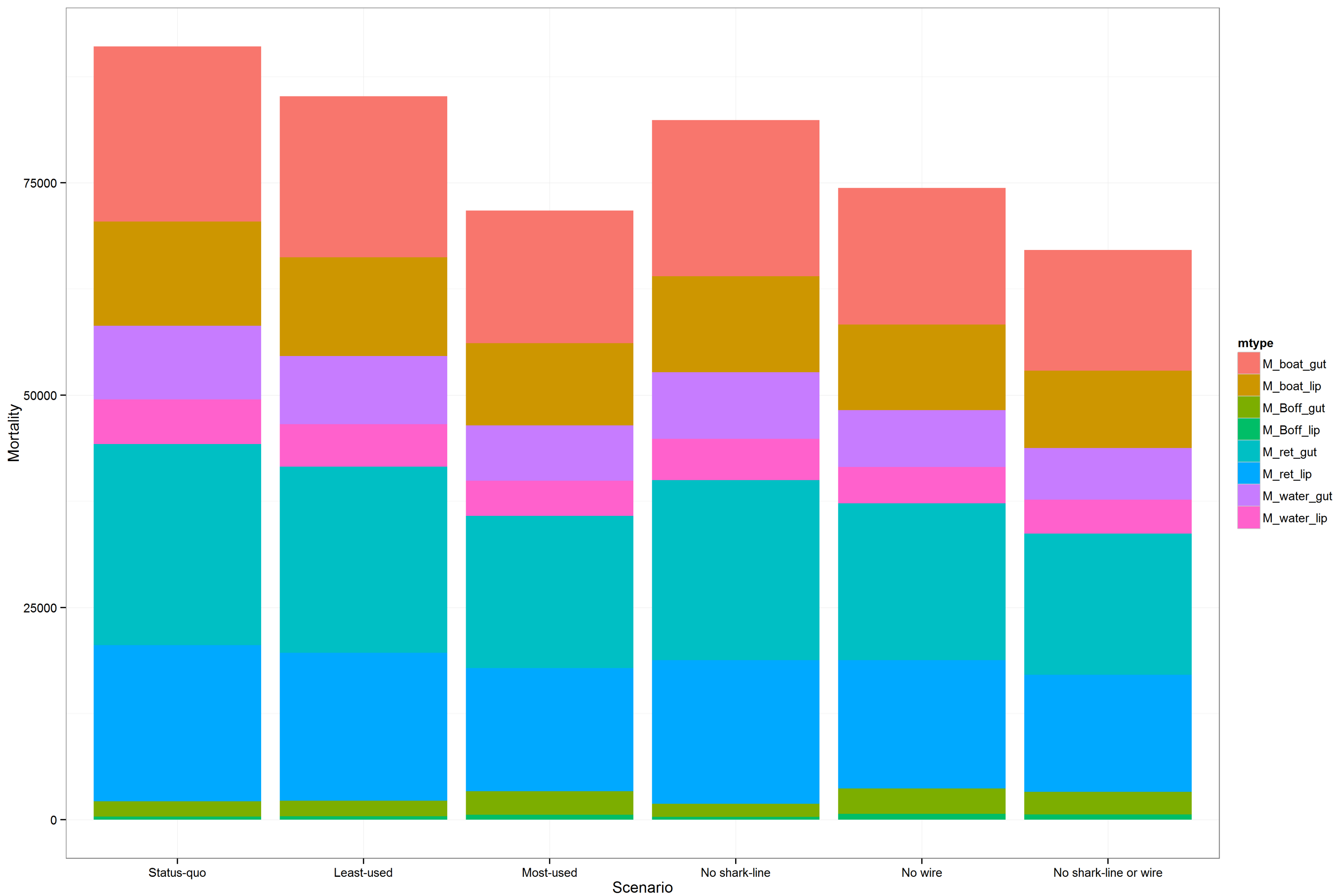


Figure 4: Median (across 5,000 simulations) mortality components for the status quo and each management scenario for silky shark. 'gut' = gut-hooked; 'lip' = lip-hooked; 'boat' = landed release; 'water' = water release; 'Boff' = bite off; 'ret' = retrieval

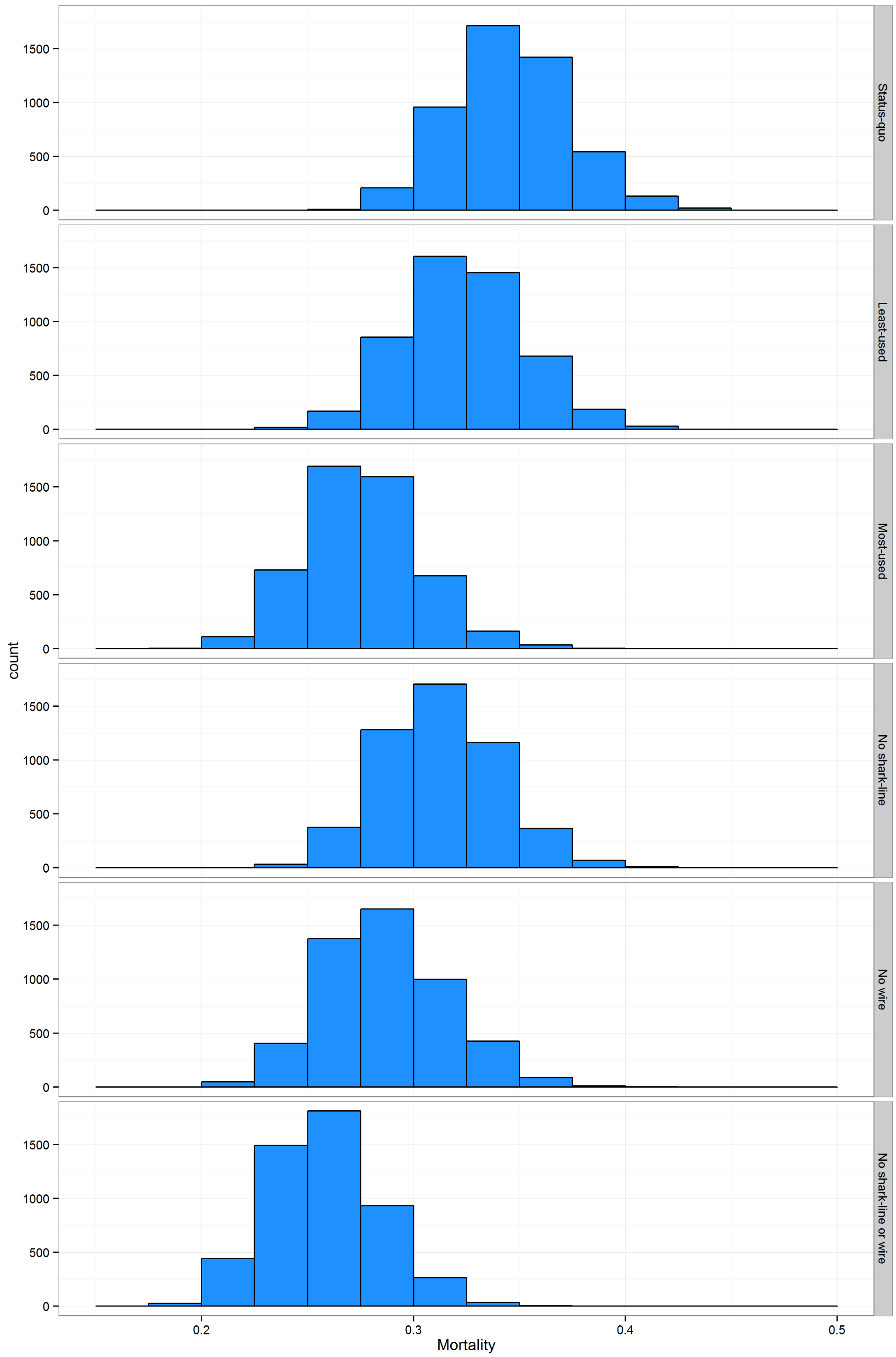
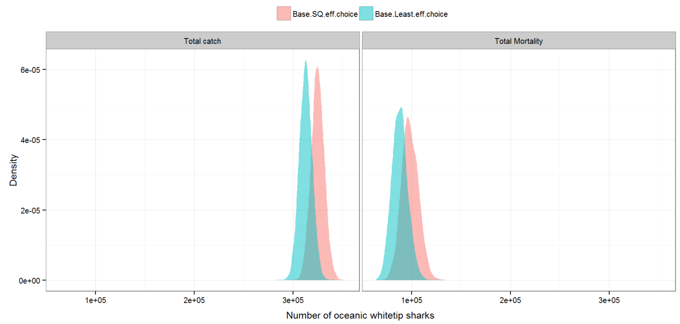
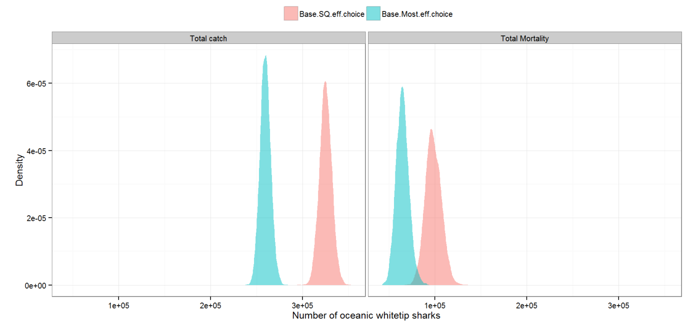


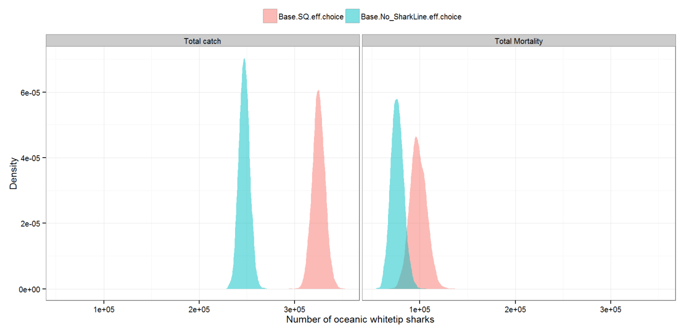
Figure 5: Monte Carlo distribution of mortality rates for the status quo and each management scenario for silky shark.



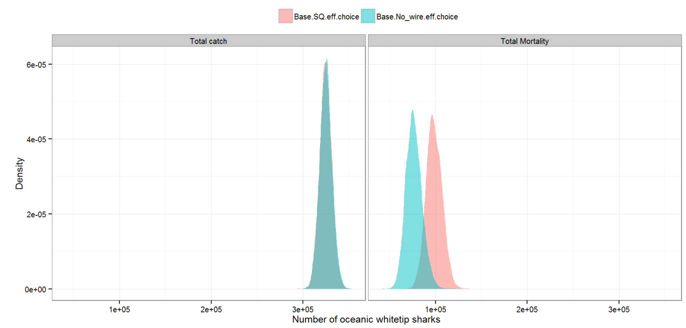
(a) Ban least-used method



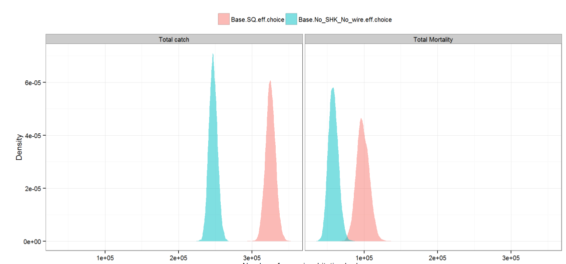
(b) Ban most-used method



(c) Ban shark lines



(d) Ban wire trace



(e) Ban both

Figure 6: One-off comparisons for oceanic whitetip shark between the status quo (Base.SQ) and each scenario in terms of the Monte Carlo distributions of catch (left side of the individual panels) and mortality (right side of the individual panels).

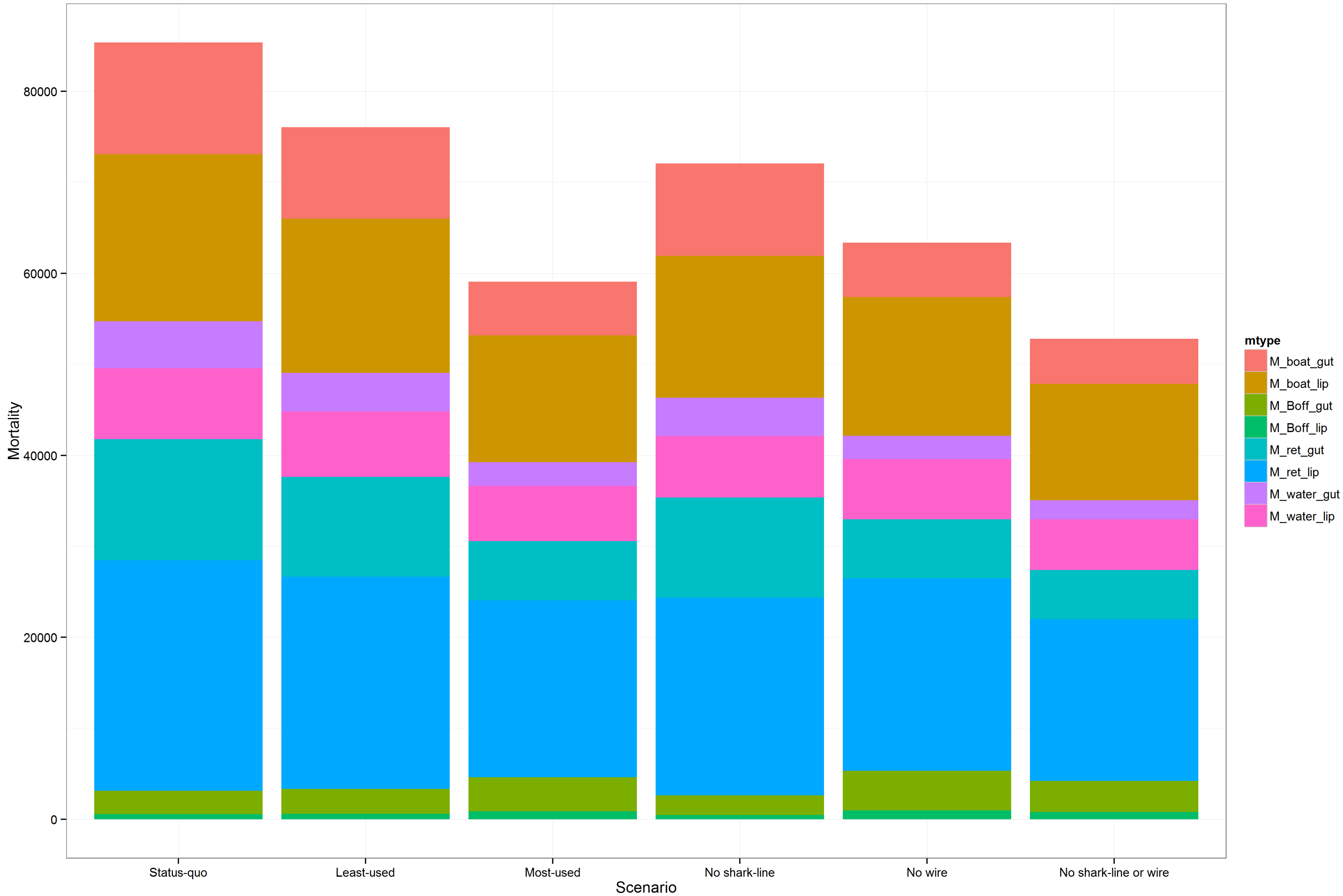


Figure 7: Median (across 5,000 simulations) mortality components for the status quo and each management scenario for oceanic whitetip shark. 'gut' = gut-hooked; 'lip' = lip-hooked; 'boat' = landed release; 'water' = water release; 'Boff' = bite off; 'ret' = retrieval

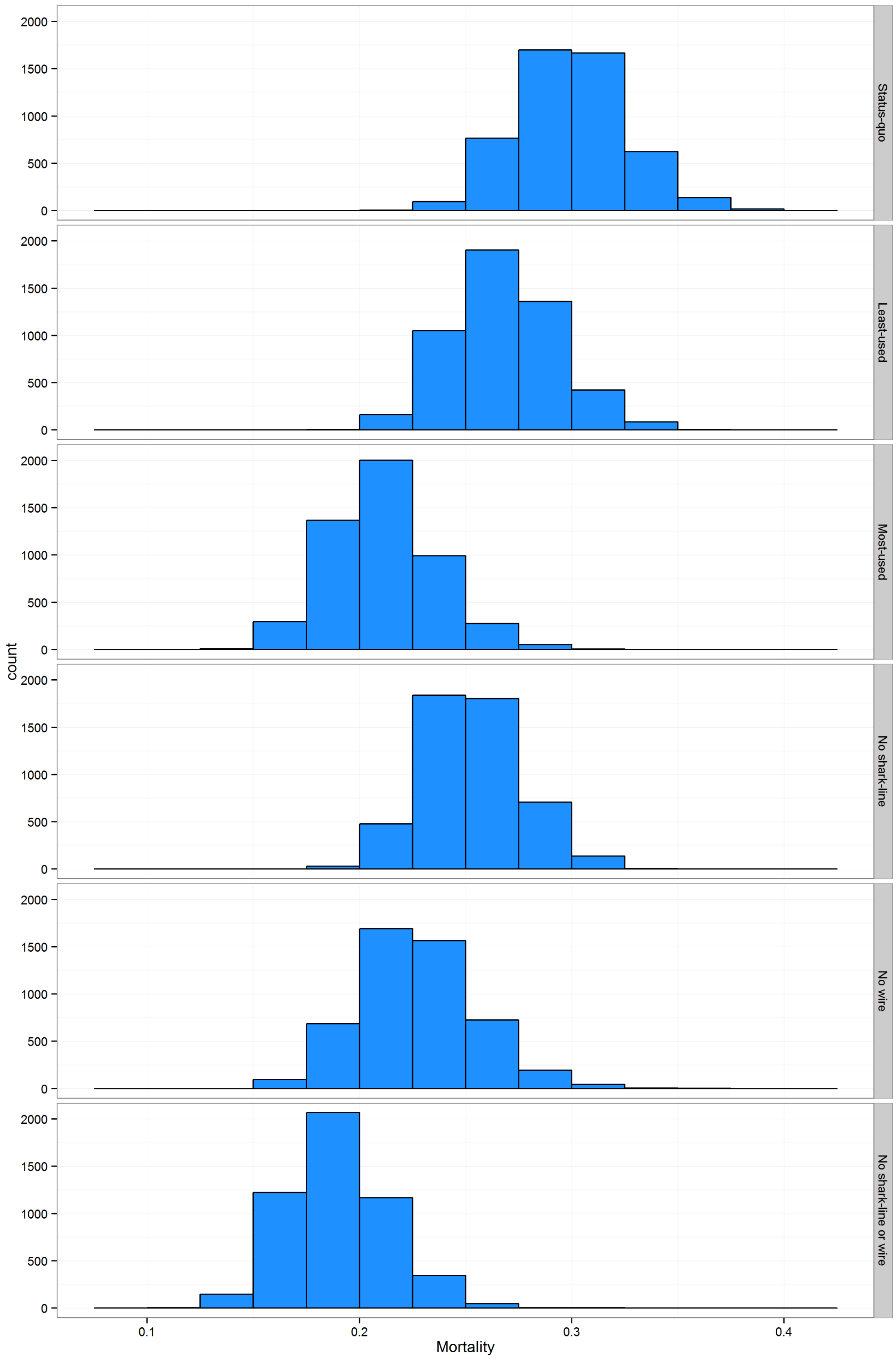


Figure 8: Monte Carlo distribution of mortality rates for the status quo and each management scenario for oceanic whitetip shark.