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Updated abundance indicators for New Zealand blue, porbeagle and shortfin mako sharks

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Contents

Executive summary

This study updates several abundance indicators for blue, porbeagle and mako sharks, the main shark species caught in New Zealand's tuna longline fishery. Distribution indicators for all three species were extended by two years, and standardised catch per unit effort (CPUE) indices for porbeagle sharks were extended by two years. The distribution indicators were consistent for all three species in showing either increasing trends throughout the period 2005–2015, or an increasing trend followed by stabilisation at a constant level.

CPUE indices for porbeagle shark from the Japanese charter tuna longline fishery in southern New Zealand (the Japan South fishery) showed a strong increase in the last two years, whereas in northern New Zealand the indices for domestic and Japanese vessels combined (the North fishery) were relatively flat. The longer time series of the Japan South observer indices showed little change since the early 2000s apart from a small increase since 2013. A large peak in 1998–2000 was anomalous and cannot currently be explained, but it is independently corroborated by a peak in reported commercial landings during 1998–2000. The North fishery observer data suggest that porbeagle abundance declined to low levels during the early 2000s but has since increased substantially, although since 2008, the indices have been variable without any clear trend.

Thus, there is some inconsistency among trends identified for porbeagle shark by the distribution and CPUE indicators, and by the standardised CPUE indices for the North and South fisheries. Some year-to-year CPUE variations were too large to represent changes in population biomass, and may instead reflect changes in availability to the fishery. Furthermore, some CPUE models fitted the data poorly and may be unreliable. Nevertheless, when taken as a group, the indicators suggest that the porbeagle population around New Zealand has been stable or increasing during the last decade.

1 Introduction

Recognizing the data-poor nature of many of the world's shark fisheries, scientists have recently turned to alternative methods for assessing threats to the sustainable utilisation of chondrichthyan resources. These methods have the advantage of being more forgiving of data gaps, less reliant on assumptions structuring population dynamics, and more readily updated than traditional stock assessments. One approach is to develop a series of stock status indicators to assess the response of the population to fishing pressure. Such indicators are usually straightforward to compute (except for standardised CPUE) and track over time, thus providing the opportunity to observe trends that can serve as early signals of overexploitation. Indicators of stock status can be useful for initial assessments and/or for prioritising future data collection or analytical work (Clarke et al. 2013).

The main shark species caught in New Zealand's tuna longline fishery are blue shark (*Prionace glauca*), shortfin mako shark (hereafter abbreviated to 'mako shark'; *Isurus oxyrinchus*), and porbeagle shark (*Lamna nasus*) (Francis 2013; Griggs & Baird 2013). In a previous study using New Zealand fishery data up to 2013, four types of indicators were developed for the three shark species: distribution, percentage catch composition, standardised catch per unit effort (CPUE), and median size/sex ratio (Francis et al. 2014). The present project extends that study by updating the distribution time series for all three species by two more years, and updating the CPUE time series for porbeagle sharks by two more years.

2 Methods

2.1 General methods

The methods used in this study were a subset of those used in the previous study by Francis et al. (2014), and further details of the methods were provided there.

The main data sources used for this study were the Ministry for Primary Industries (MPI) catch-effort database *warehou*, and the MPI observer database *COD*. Data were extracted for relevant periods, i.e. the 2004−05 to 2014−15 fishing years for *warehou* and the 1992−93 to 2014−15 fishing years for *COD*. Hereafter, all years are reported as fishing years (1 October to 30 September), and they are labelled after the second of the two years (e.g. 2004−05 is referred to as 2005). Our analyses are restricted to the surface longline fishery that targets mainly southern bluefin tuna, bigeye tuna, and broadbill swordfish (Griggs & Baird 2013). This fishery accounted for 98−99% of the New Zealand blue shark catch, 92−95% of the mako shark catch, and 74−84% of the porbeagle shark catch between 2008 and 2011 (Francis 2013).

Tuna longline fishing effort is concentrated in two distinct regions of the New Zealand Exclusive Economic Zone (EEZ) – off the north-east coast of North Island and off the west coast of South Island. As in previous studies (Francis 2013; Francis et al. 2014), we analysed data from these two regions separately: the North region comprised Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and the South region comprised FMAs 5 and 7 (see Appendix 1). Effort and catches were very low in the remaining FMAs.

2.2 Distribution indicators

The dataset used for distribution indicators omitted rectangles with fewer than 5000 hooks of fishing effort in a given fishing year, to reduce the risk that extreme catch rates from a single set could bias results. A limit of 5000 hooks ensured that each included rectangle had at least three domestic sets or two foreign charter vessel sets.

We calculated two distribution indicators:

- The high-CPUE indicator was the proportion of half-degree rectangles with unstandardised CPUE greater than a specified threshold in the commercial data. It was calculated as the number of high-CPUE rectangles divided by the total number of rectangles with reported effort. This indicator acts as a measure of the spatial extent of high abundance areas. CPUE was calculated for each fishing year as the total number of sharks caught per rectangle divided by the total number of hooks set in the rectangle (in thousands). Following preliminary tests using a range of potential thresholds, indicator thresholds were arbitrarily set at 25 sharks per 1000 hooks for blue shark, and at one shark per 1000 hooks for porbeagle and mako sharks.
- A proportion-zeroes indicator was calculated as the number of half-degree rectangles with zero reported catches in a fishing year divided by the total number of rectangles with reported effort in that year.

Commercial fishing returns have separate panels for recording catch that is processed (with some part of the shark being retained), and catch that is discarded or released. Total catch weights were calculated by summing the processed and discarded values.

2.3 Porbeagle shark standardised CPUE

Catch data were groomed as described in the earlier study (Francis et al. 2014). Most fishing effort in the South region was applied by chartered Japanese longliners, which use different fishing methods and fish in different areas from New Zealand domestic vessels, so the analysis of commercial data in that region was restricted to Japanese vessels. CPUE standardisation models were fitted to (a) two commercial logbook datasets: the Japan South fishery (2006–2015), and the North fishery (all fleets combined; 2006–2015); and (b) two observer datasets: the Japan South observer data (1995–2015), and the North fishery observer data (all fleets combined; 1995–2015). This stratification of observer data by region and fleet differs from the approach used earlier in which all observer data were analysed with one model (Francis et al. 2014). The observer datasets are based on subsets of the fishing trips represented in the commercial logbook datasets, but the observer and logbook data were collected independently by observers and crew respectively. The observer datasets extend back to 1995 compared with only 2006 for the commercial datasets.

Both the negative binomial model and the zero-inflated negative binomial model as described in the previous study were fitted to each dataset, with the same sets of predictors offered (Francis et al. 2014).

Model equations:

1. Negative binomial model
Catch of porbeagle shark ~ year + month + area + target strategy + vessel + bait type + SST + soak time + catch of southern bluefin tuna + catch of swordfish + number of hooks

2. Zero-inflated negative binomial model
Counts: Catch of porbeagle shark ~ year + month + area + target strategy + vessel + bait type + SST + soak time + catch of southern bluefin tuna + catch of swordfish + number of hooks
Zeroes: Catch of porbeagle shark ~| year + month + area + target strategy + vessel + bait type + SST + soak time + catch of southern bluefin tuna + catch of swordfish

3 Results

3.1 Fishing effort and catch trends

Annual fishing effort in the New Zealand tuna longline fishery has declined slowly from about 3.7 million hooks in 2005 to 2.4 million hooks in 2015 (Figure 1). These values are an order of magnitude lower than in the early 1980s when a large foreign licensed fleet operated in New Zealand waters, and set about 25 million hooks per year (Ministry for Primary Industries 2016). Fishing effort in recent years has been concentrated off the north-east coast of North Island and the west coast of South Island (Appendix 1).

The total weight of all three pelagic sharks reported by tuna longliners on Tuna Longline Catch Effort Returns (TLCERs) increased slowly through the late 2000s to peak in 2012, followed by small declines or fluctuating levels (Figure 2). These reported weights include discarded dead sharks, but not sharks that are released alive, some of which will subsequently die, so they probably under-estimate true fishing mortality. Allowing for some post-release mortality, total mortality levels in the last few years were probably near the current Total Allowable Commercial Catches of 1860 t for blue shark, 200 t for mako shark and 110 t for porbeagle shark (Ministry for Primary Industries 2016).

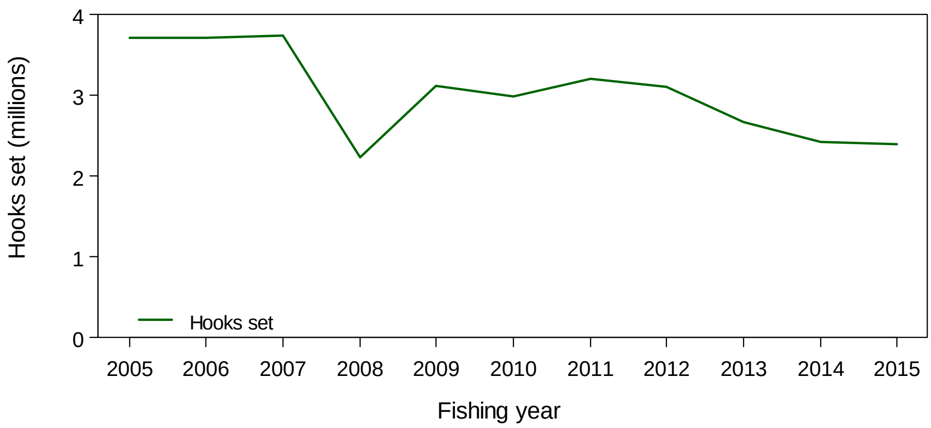

Figure 1: Number of hooks set in New Zealand waters by surface longline vessels.

Processed weights of all three shark species have declined steeply to zero or near-zero following the banning of shark finning in 2014 (Figure 2). This has resulted in a rapid increase in discarding of sharks (Figure 2), and also live releases (not shown). For blue shark, processed weights were very close to the Monthly Harvest Return (MHR) values obtained independently from actual landed weights reported to MPI by quota holders, indicating that the TLCER processed weights were probably accurately reported overall. For mako and porbeagle sharks, processed weights were lower than MHR weights because the latter include sharks caught by methods other than tuna longlines.

3.2 Distribution indicators

In the North fishery, the high-CPUE indicators for all three species reached their highest recorded levels in the last two years (2014 and 2015) (Figure 3), thus extending the overall increases for all species since 2005. In Japan South fishery, the high-CPUE indicators for blue and porbeagle shark increased to 2011 or 2012 respectively, and have remained relatively stable since then. Mako shark is uncommon in the cooler waters of the South region and the high-CPUE indicator there has fluctuated around a low level.

Blue shark is common around New Zealand, resulting in the proportion-zeroes indicators for both regions being effectively zero (Figure 3). The proportion-zeroes indicators for mako and porbeagle sharks declined steadily through the first half of the time series in both regions, but have stabilised in the last three years (2013–2015) (Figure 3).

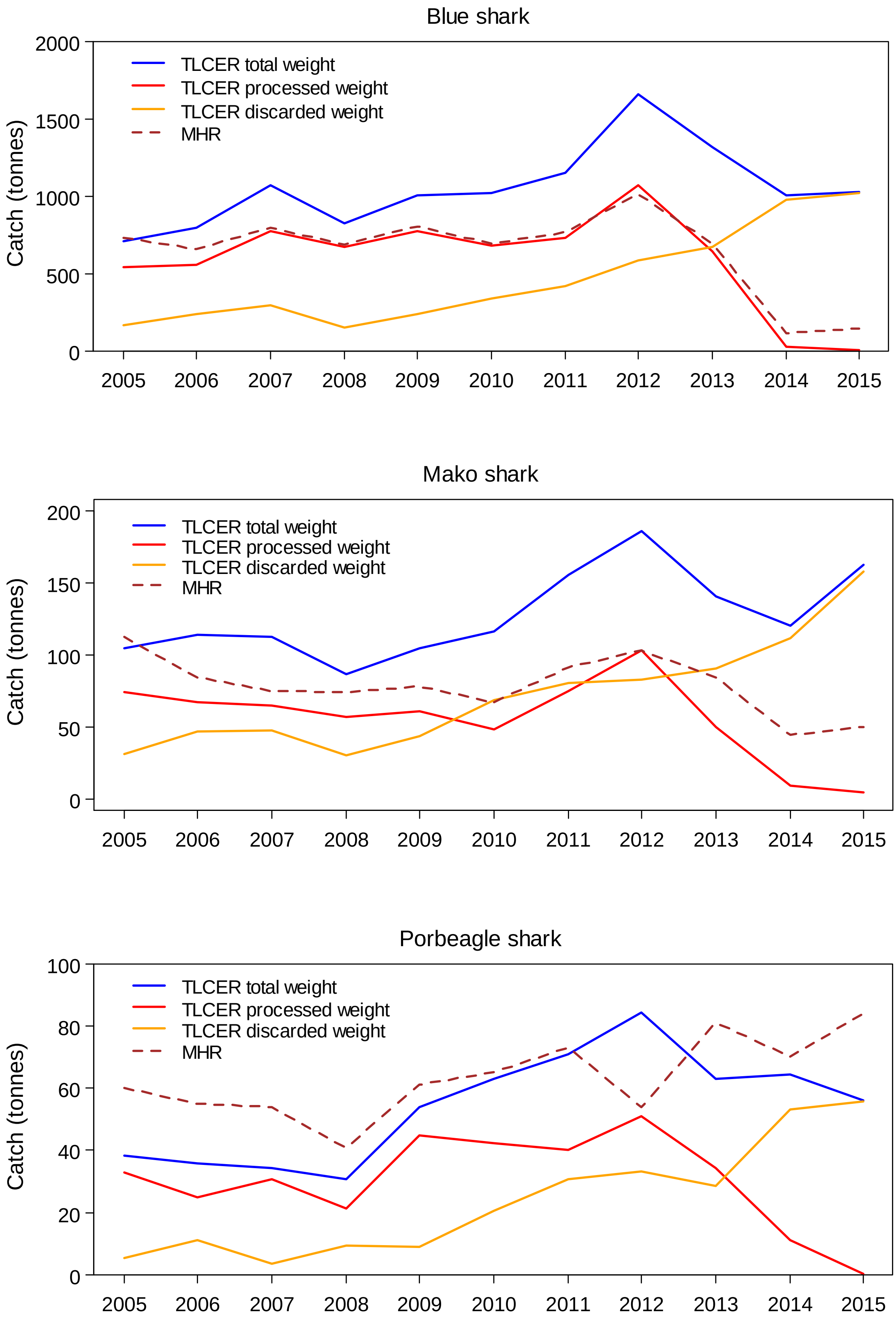

Figure 2: Estimated pelagic shark catches (whole weight) in the surface longline fishery for the 2005 to 2015 fishing years as reported on Tuna Longline Catch Effort Returns (TLCERs). A breakdown of the total weight by processed and discarded categories is also provided. Monthly Harvest Return (MHR) landings for all fishing methods are also shown (source: (Ministry for Primary Industries 2016)).

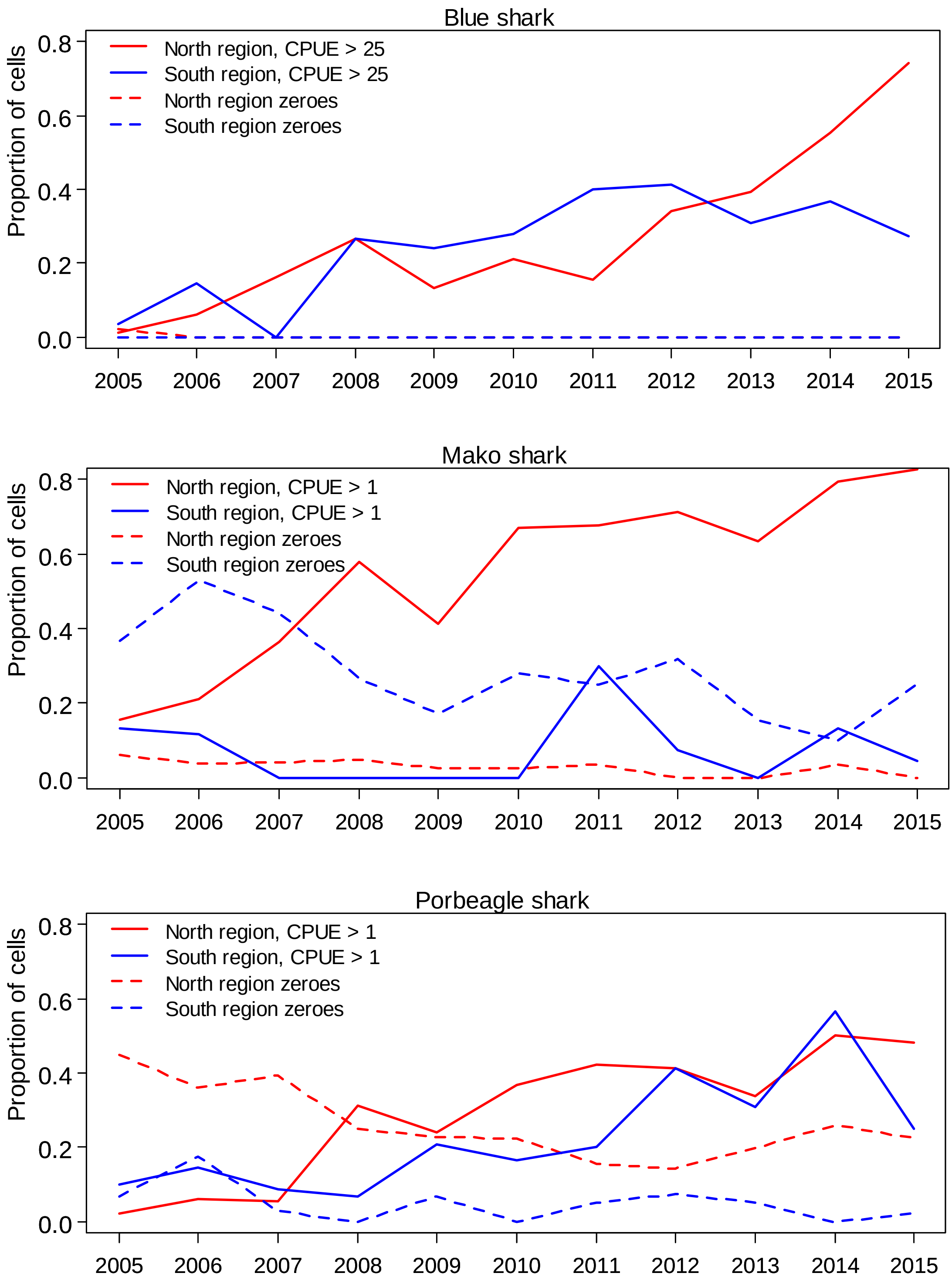

Figure 3: Pelagic shark distribution indicators. Proportions of 0.5 degree rectangles having CPUE greater than 25 per 1000 hooks (blue shark) and 1 per 1000 hooks (mako and porbeagle sharks), and proportions of rectangles having zero catches, for the North and South fishery regions by fishing year, based on estimated catches (processed and discarded combined) reported on TLCERs.

3.3 Porbeagle shark standardised CPUE

As in the previous study, a negative binomial model and a zero-inflated model were fit to each dataset with the best model fit to the data being determined by comparing AIC values and applying the Vuong likelihood ratio test. The fitted models were:

Japan South dataset, zero-inflated negative binomial model
Counts: Catch of porbeagle shark ~ year + month + vessel + SST + number of hooks
Zeroes: Catch of porbeagle shark ~ year + vessel + SST

North dataset, negative binomial model
Catch of porbeagle shark ~ year + target strategy + vessel + SST + number of hooks

Japan South Observer dataset, negative binomial model
Catch of porbeagle shark ~ year + area + vessel + SST + soak time + number of hooks

North Observer dataset, zero-inflated negative binomial model
Counts: Catch of porbeagle shark ~ year +area + target strategy + bait type + SST + catch of swordfish + number of hooks
Zeroes: Catch of porbeagle shark ~ year + target strategy + catch of swordfish + SST

For the North fishery dataset, five predictor variables explained 40.7% of the deviance, and for the Japan South observer dataset, six predictor variables explained 45.6% of the deviance. It is not possible to assess the percent deviance explained for the ZINB model, but for reference the negative binomial form explained 17% of the deviance for the Japan South fishery dataset and 36% for the North observer dataset.

In the Japan South fishery, standardised CPUE reached the highest levels ever recorded in 2014 and 2015 (Figure 4). Conversely, standardised CPUE in the North fishery has been variable with no overall trend since 2008. Observer CPUE for the same fishery subsets showed very similar patterns during for the time period in common (2006–2015), albeit with large confidence intervals in North fishery where observer coverage was low (Figure 4). The longer time series available in the observer data provide a better understanding of historical changes in porbeagle shark relative abundance in New Zealand waters. In the Japan South observer dataset, there was a large spike in 1998–2000, indicating a ca. 6-fold increase in availability or abundance of porbeagles. The spike was followed by a decline to low levels. In the North observer dataset, there was little indication of a peak in 1998–2000, and abundance seems to have declined until the early 2000s, followed by a variable but generally increasing trend since then (Figure 4).

The proportions of tuna longline sets which caught no porbeagles are shown in Figure 5. The Japan South fishery showed a declining trend, from about 0.5–0.6 zeroes in 2005–2006 to about 0.2–0.3 zeroes in 2014 and 2015. The Japan South observer data showed a similar but more exaggerated pattern of peaks and troughs, but no overall trend in zeroes, over the same period. The North fishery commercial data showed a slow decline in zero sets from about 0.9 in 2005–2006 to 0.75 in 2008, and remained at about that level until 2015. The North fishery observer data had a much lower proportion of zero sets than the commercial data, being mainly 0.3–0.7 except in 2001–2002 when it reached 0.8. There was no clear trend in observer North zeroes, although the proportions were generally lower in the second half of the time series than in the first.

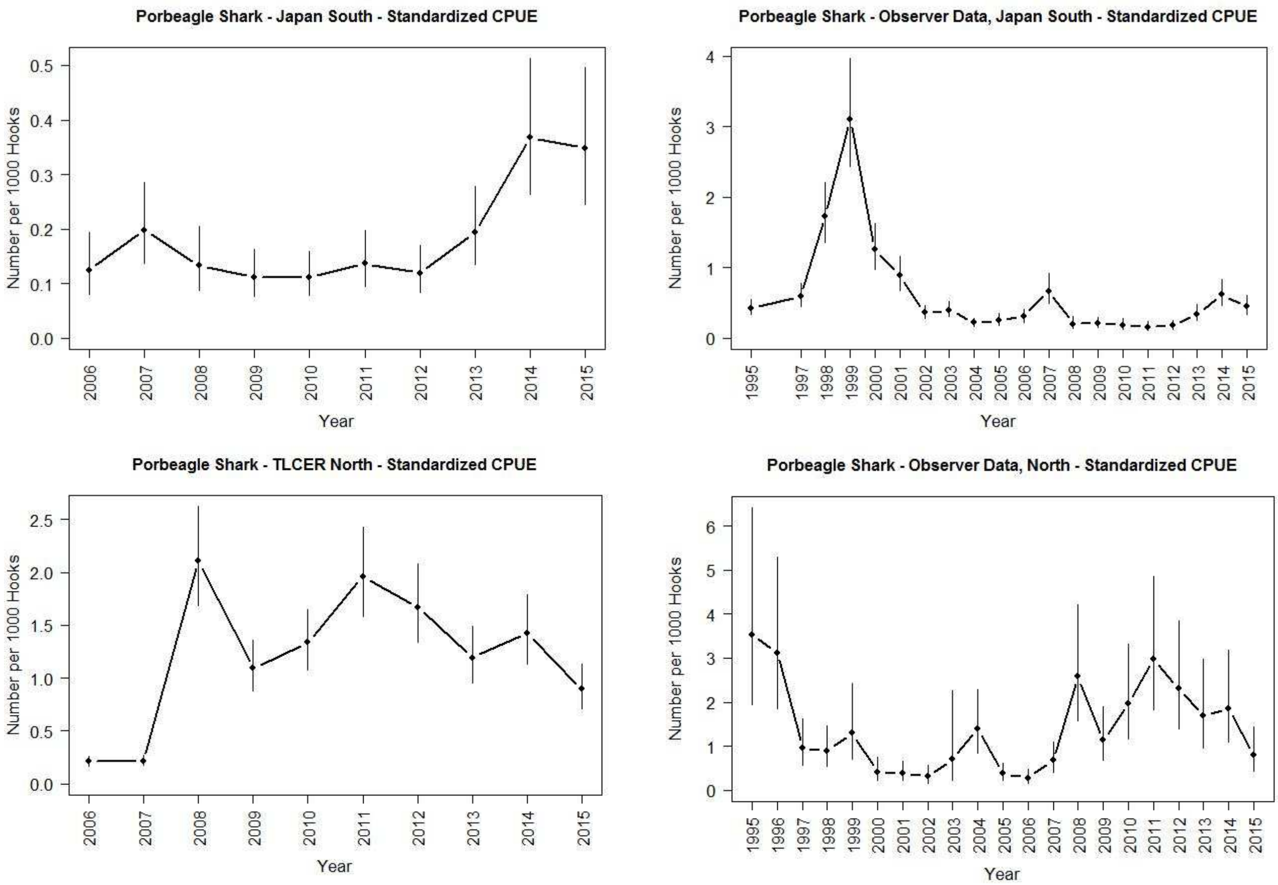

Figure 4: Standardised catch per unit effort with 95% confidence intervals for the Japan South fishery (top) and the North fishery (bottom), using commercial TLCER data (left) and observer data (right).

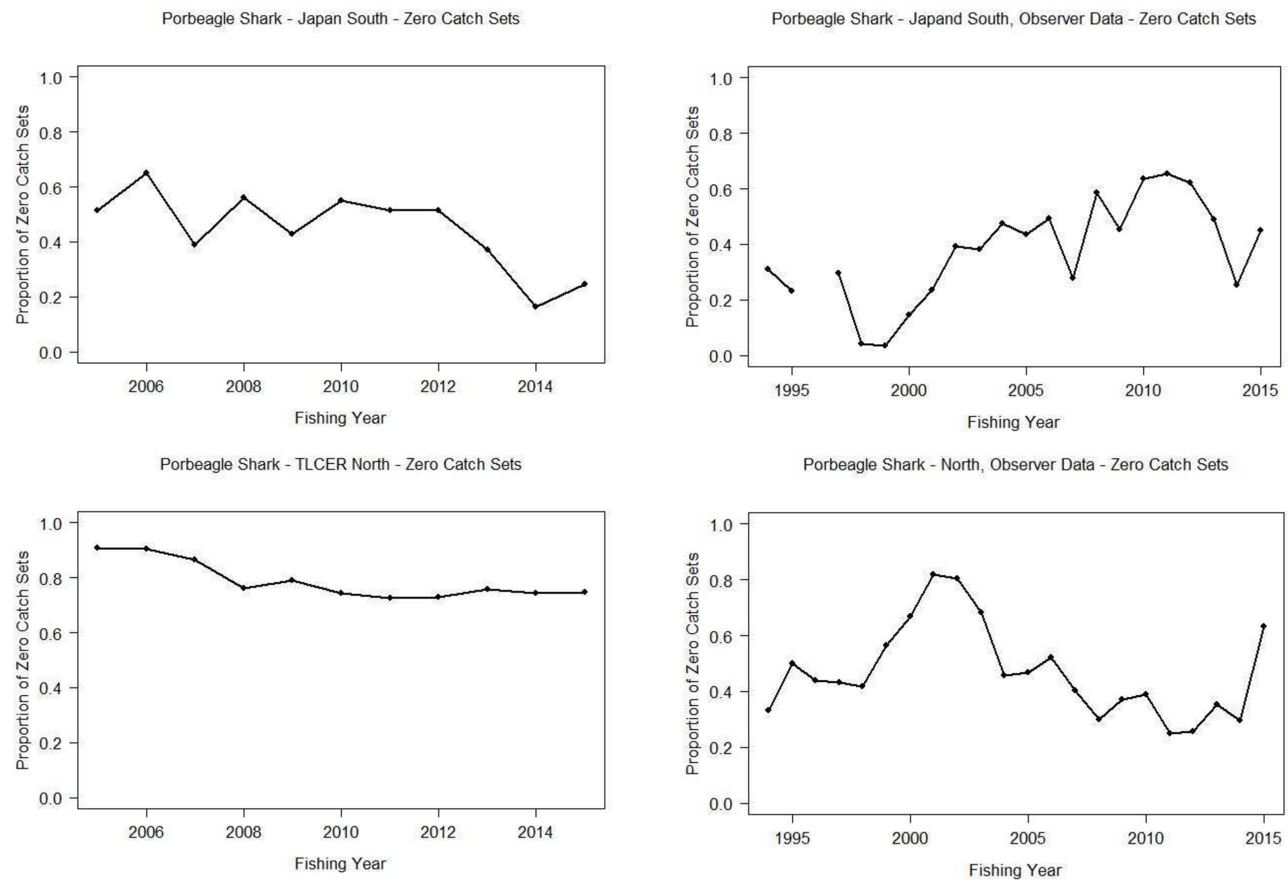

Figure 5: Proportion of sets with zero porbeagle sharks recorded by year in the Japan South fishery (top), the North fishery (bottom) using commercial TLCER data (left) and observer data (right).

4 Discussion

The revised indicators presented here update and reinforce the trends reported by Francis et al. (2014). The high-CPUE distribution indicators for the North fishery indicate that blue, porbeagle and mako sharks are increasing in abundance and/or availability, with the two latest years (2014 and 2015) being the highest in the time series. In the Japan South fishery, the high-CPUE indicators for blue and porbeagle sharks have stabilised following an earlier increasing trend. Mako shark is rare in South region so it is not well monitored by this indicator. The proportion-zeroes distribution indicators have stabilised for mako and porbeagle sharks in both regions following periods of decline. This indicator is not suitable for blue sharks for which zero catches in half-degree squares are virtually non-existent. The distribution indicators are therefore consistent for all three species in showing either increasing trends throughout the period 2005–2015, or an increasing trend followed by stabilisation at a constant level.

The standardised CPUE indices for porbeagle shark from the Japan South fishery were relatively stable between 2006 and 2013, and then showed a strong increase in the last two years, whereas the North fishery indices were relatively flat from 2008 onwards. The observer CPUE indices were generally consistent with the commercial logbook indices over the same time periods. Such concordance was expected for the Japan South fishery where observer coverage has been high (mean 73% of hooks observed per year, range 45–90%, in 2006–2013), but not for the North fishery where observer coverage has been much lower (mean 8% of hooks, range 4–14%, in 2006–2013 for all fleets combined) and unrepresentative of the spatial and seasonal distribution of the North fishery (Francis 2013; Griggs & Baird 2013; Francis et al. 2014).

The longer time series of the Japan South observer indices showed little change since the early 2000s apart from a small increase since 2013. The large peak in 1998–2000 was anomalous and cannot currently be explained, but it is independently corroborated by a peak in reported commercial landings during 1998–2000 (Francis 2017 in press). We note that 1999 was a strong La Niña year which resulted in higher than normal sea surface temperatures around New Zealand, and may have displaced porbeagles southwards (the North fishery did not show a corresponding peak). The North fishery observer data suggest that porbeagle abundance declined to low levels during the early 2000s but has since increased substantially, although since 2008 the indices have been variable without any clear trend.

Thus, there is some inconsistency among trends identified for porbeagle shark by the distribution and CPUE indicators, and by the standardised CPUE indices for North and South regions. Some year-to-year CPUE variations were too large to represent changes in population biomass, and may instead reflect changes in availability to the fishery. Furthermore, some CPUE models fitted the data poorly and may be unreliable. Nevertheless, when taken as a group, the indicators suggest that the porbeagle population around New Zealand has been stable or increasing during the last decade.

Further work to refine the standardised CPUE indices is desirable. Recommendations from our earlier study are still valid, and they include testing the effects of changes to model structure and predictors, and exploring the reasons for the large peak in CPUE in the Japan South observer data during the late 1990s (Francis et al. 2014). Additionally, the inclusion of variables such as the target strategy (which is based on the reported target species) requires further consideration. The spatio-temporal variation in catch rates of species such as swordfish and southern bluefin tuna has not been accounted for in models where these co-variates were included, and the effect of this variation should be explored. We also recommend a set-by-set comparison of data from commercial fishing returns (completed by vessel skippers) with observer data from the same vessels to validate the catch reporting by tuna longline vessels. The large difference between the proportions of zero porbeagle sets reported by fishers and observers in the North fishery suggest that porbeagles (and probably blue and mako sharks as well) may have been under-reported by the former.

5 Acknowledgements

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6 References

Clarke, S.C.; Francis, M.P.; Griggs, L.H. (2013). Review of shark meat markets, discard mortality and pelagic shark data availability, and a proposal for a shark indicator analysis. New Zealand Fisheries Assessment Report 2013/65. 74 p.

Francis, M.P. (2013). Commercial catch composition of highly migratory elasmobranchs. New Zealand Fisheries Assessment Report 2013/68. 79 p.

Francis, M.P. (2017 in press). Recalculation of historical landings of porbeagle shark. New Zealand Fisheries Assessment Report 2017/xx. 20 p.

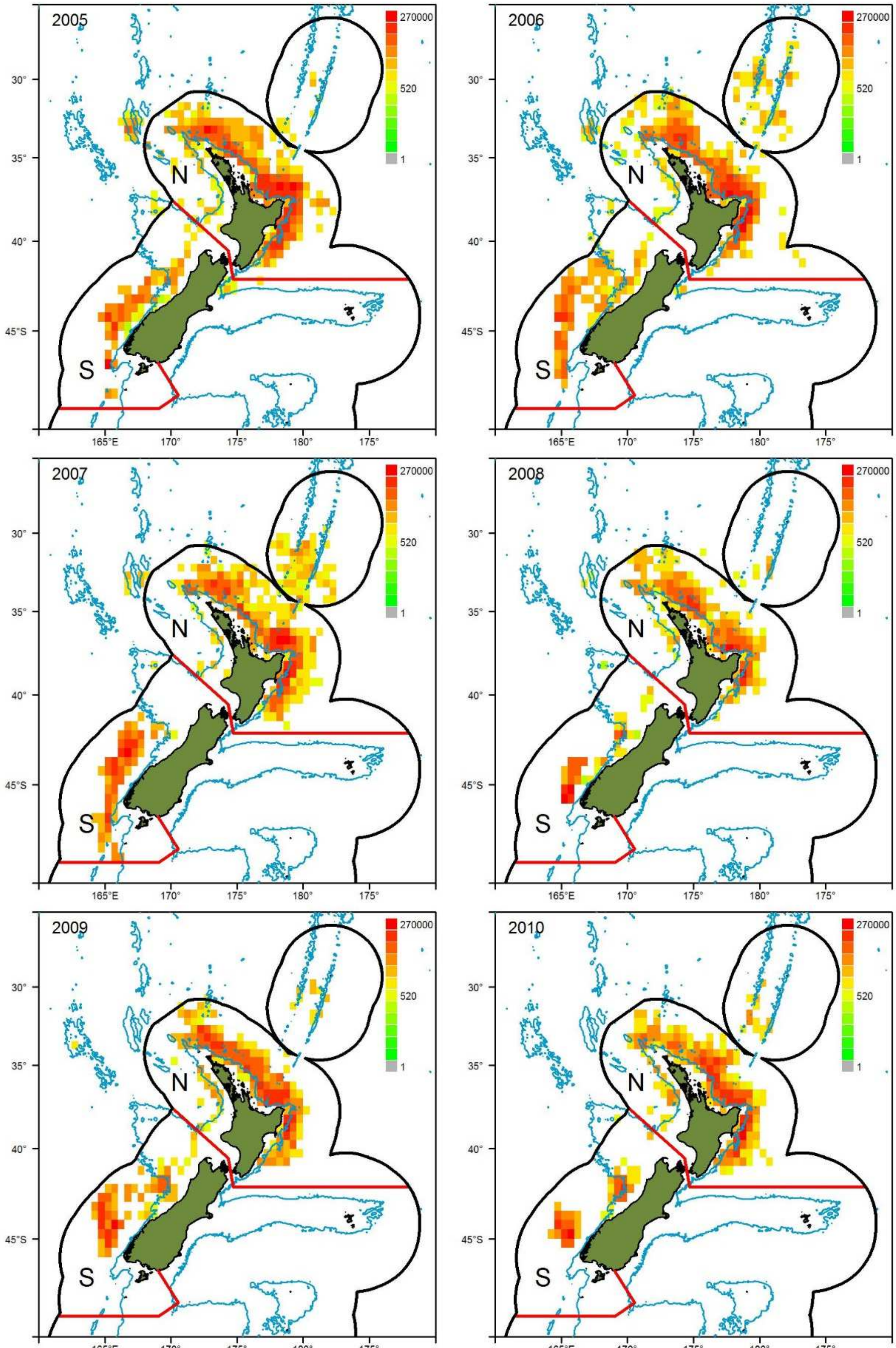
Francis, M.P.; Clarke, S.C.; Griggs, L.H.; Hoyle, S.D. (2014). Indicator based analysis of the status of New Zealand blue, mako and porbeagle sharks. New Zealand Fisheries Assessment Report 2014/69. 109 p.

Griggs, L.H.; Baird, S.J. (2013). Fish bycatch in New Zealand tuna longline fisheries 2006-07 to 2009-10. New Zealand Fisheries Assessment Report 2013/13. 73 p.

Ministry for Primary Industries. (2016). Fisheries Assessment Plenary: stock assessments and stock status, November 2016. Compiled by the Fisheries Science Group, Ministry for Primary Industries, Wellington, New Zealand. 459 p.

Appendix A

Number of hooks set by the surface longline fishery in 0.5 degree rectangles by fishing year. Red lines demarcate the North and South regions used for analysis. Note the log scale used for the colour palette. Depth contour = 1000 m.



Appendix 1 (continued):