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G. Barry Baker
University of Tasmania

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Keith Reid, G. Barry Baker & Richard Wells

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Mitigation of seabird bycatch in New Zealand squid trawl fisheries provides hope for ongoing solutions

Keith Reid[a,b], G. Barry Baker[b,c] and Richard Wells[d]

[a]Ross Analytics Pty Ltd, Bonnet Hill, Tasmania, Australia; [b]Institute of Marine and Antarctic Studies, University of Tasmania, Hobart, Australia; [c]Latitude 42 Environmental Consultants Pty Ltd, Kettering, Tasmania, Australia; [d]Resourcewise Ltd, Richmond, New Zealand

ABSTRACT

Although there is an increasing awareness of the high rates of seabird bycatch in trawl fisheries globally, there is relatively limited implementation of effective mitigation measures. Seabirds that are attracted to the stern of the trawl vessel to feed on fish-waste can be drowned or injured when they collide with warps/cables or when they become entangled in nets. Managing fish-waste discharge (processing offal and discards) and limiting access to it by scaring birds have been identified as the most effective measures to reduce seabird mortality from collisions with warps. New Zealand's arrow squid (*Nototodarus* spp.) trawl fishery occurs during the austral summer and autumn when there is significant overlap with large numbers of foraging seabirds due to the proximity of breeding areas. Regulations introduced by the New Zealand government in 2007 requiring the use of devices to reduce warp strikes and operational procedures to manage fish-waste were independently implemented by the fishing industry in 2007 with the support of fishery regulators. The rate of capture of albatrosses by warps decreased from a mean of 2.9 birds per 100 tows during the period 2003 to 2006 to a mean of 0.7 birds per 100 tows after 2007. Long-term ownership of squid fishery quota catalysed the proactive engagement of the industry and has been reflected in a positive cultural shift in the attitude of fishers towards managing the risk of the capture of seabirds. Multi-sector collaboration and engagement allowed for the translation of experimental mitigation results into long-term, industrial-scale operational practices.

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Introduction

Seabirds are incidentally captured and killed (known as bycatch) in a range of fisheries throughout the world, and there is evidence that fisheries-related mortality is responsible for population decreases in many species, particularly the albatrosses and petrels (Families Diomedeidae and Procellariidae) (Alexander *et al.* 1997; Croxall 1998; Gales 1998; Baker *et al.* 2002; Dias *et al.* 2019). This threat to seabirds has been particularly well documented for longline fisheries, but significant mortality of seabirds is also associated with trawl, gillnet and purse-seine fisheries (Phillips *et al.* 2016). A recent global assessment of threats to seabirds found that large-scale fisheries are causing declines in more than 80 species, with trawl and longline gear having the greatest impact in terms of the scope and severity of threat (Dias *et al.* 2019).

Proven measures to mitigate seabird bycatch exist for longline and trawl gears, in particular (ACAP 2021), but information on successful implementation and uptake of mitigation is generally lacking. While there are numerous examples of experimental work to verify the efficacy of mitigation measures (e.g. Bull 2009; Løkkeborg 2011; Melvin *et al.* 2014; Robertson *et al.* 2014), these are mostly short-term trials that are undertaken on a few vessels, do not span entire fishing seasons or multiple years, nor necessarily reflect normal, commercial operational practice. There are relatively few multi-year studies that report on mitigation efficacy at the fleet or fishery level in a commercial operating context and span periods of time exceeding 10 years. Those that do exist are all for longline fisheries; in Australian pelagic longline fisheries (Baker and Robertson 2018) and for demersal longline fisheries in Alaska (Melvin *et al.* 2019) and around South Georgia in the South Atlantic (Collins *et al.* 2021).

Such long-term case studies are important because both seabird foraging and fishing are dynamic processes, with changes in seabird abundance and behaviour, fishing effort, gear and operating practices exposing mitigation measures to testing under a range of conditions that are rarely represented in short-term experimental work (Baker and Robertson 2018).

Mitigation development for seabirds in trawl fisheries is yet to reach the widespread application and maturity seen for longline gears. This may reflect the

CONTACT Keith Reid keith.reid@rossanalytics.com.au

higher visibility of seabird mortalities in longline gear as dead birds are landed individually on a vessel.

This has meant that seabird bycatch in trawl fisheries took longer to be acknowledged as a serious and widespread problem (Baker *et al*. 2007). Under current knowledge and operations, some level of bycatch is inevitable and understanding its causes, and finding effective and implementable approaches to manage them, will require good data collection and analyses as well as ongoing collaboration among those with a statutory mandate to manage fishing operations, fishers, gear technologists, and seabird biologists.

In trawl fisheries, seabirds are attracted to vessels to feed on the waste products from fishing operations; here we use the term 'fish-waste' to include all fish and non-fish discards and offal resulting from fish processing. Seabirds congregating at the stern of the vessel may be dragged underwater and drowned when their wings become entangled as a result of collisions with netsonde cables (also referred to as net-monitoring cables or third wires) and trawl cables towing the net (hereafter warps), these collisions are collectively referred to as warp strikes; seabirds also become entangled/retained in nets when they are at or near the surface (Phillips *et al.* 2016). While the risk to seabirds of net capture is limited to the period that the net is at or near the surface, the risks to seabirds posed by collisions with warps exist throughout almost the entire period of each fishing event (tow). These differences are also reflected in the likelihood of mortalities being observed as birds captured in the net are more likely to be retained compared to birds killed by warp strikes. The implicit underestimate of the number of birds killed but not retained is referred to as cryptic mortality (Parker *et al*. 2013). Bycatch in trawl fisheries is also influenced by species-specific differences in size, foraging and flight behaviour of seabirds, with large species such as albatrosses particularly susceptible to injury on warps (Sullivan *et al.* 2006a, 2006b; Watkins *et al*. 2008; Favero *et al*. 2010).

New Zealand's arrow squid (*Nototodarus* spp.) trawl fishery occurs in high latitudes (48°S-51°S) mostly during the austral summer and autumn months and has been operating since the early 1980s. The fleet uses both bottom and midwater trawls, on well-defined and relatively small grounds on the shelf edge (180–220 m depths) of the Southern Snares shelf as well as north and east of the Auckland Islands. The fishery has historically been comprised of predominantly foreign-flagged vessels, from, for example, the former USSR, Japan and Korea, that were chartered by New Zealand quota owners to reduce their economic risk associated with the highly variable nature of squid abundance and to increase capacity in the New Zealand fleet. At its height (in the 1980s) the fleet numbered 50–60 vessels, however, a range of policy (e.g. requiring vessels to be flagged to New Zealand) and economic drivers have meant that the size of the fleet (now annually in the range of 15–20 vessels) and effort has significantly declined since then.

There is significant overlap with the fishery and large numbers of foraging seabirds due to the proximity of breeding areas of sooty shearwaters (*Ardenna grisea* approximately 4–5 million pairs Waugh *et al*. 2013) white-chinned petrels (*Procellaria aequinoctialis* c250 000 pairs (Rexer-Huber *et al*. 2016) and white-capped albatross (*Thalassarche steadi*– approx. 95 000 pairs 95 000 pairs Baker *et al*. 2023) and Buller's albatross (*T. bulleri* 30 000 pairs ACAP 2009). Since its development in the early 1980s, there has been a recognition of the fisheries' interactions with all of these species, which has been amplified by the increased awareness of the negative conservation status of albatrosses and petrels globally. Recognition of the impact of fisheries related mortality on seabird populations that breed in New Zealand resulted in the use of a systematic risk assessment framework that used seabird and fisheries distribution data to determine the extent of overlap and fisheries observer data to determine the probability of death when a bird encounters a particular fishery (Richard *et al*. 2020). The risk-based approach of Richard *et al*. (2020) compared the estimated total fishery-related deaths with an estimate of the maximum number of fisheries deaths that the population can sustain under the prevailing management arrangements.

Bartle (1991) presented observer data from Soviet vessels fishing in the New Zealand squid fishery and reported a mean rate of white-capped albatrosses being killed in the fishery of 26 birds per 100 trawls (range 9–42), predominantly associated with capture on netsonde cables. Netsonde cables are relatively thin but strong electrical cables connected to the net monitoring equipment that are at low tension and have a central and higher attachment point than warps on the vessel. Based on these estimates and a multiplier to account for cryptic mortality, Bartle (1991) suggested that the number of white-capped albatrosses killed in the squid fishery each year was of the order of 2 300 birds, representing a 2% increase on the natural mortality rate for the species. The use of netsonde cables on trawl vessels in New Zealand was prohibited in 1992 (Bull 2007), and this was associated with a marked decrease in the estimated mortality of albatrosses (J.A. Bartle pers comm in Gales 1993). In the 1990s, the focus of attention on non-target catch in the squid fishery switched to marine mammals, in particular, the New Zealand sea lion (*Phocarctos hookeri*), resulting in increased levels of observer coverage on vessels

(Wilkinson *et al.* 2003; Thompson *et al.* 2013). The increase in data from observers revealed an ongoing problem with albatross capture on trawl warps and in the nets.

The area behind the trawl vessel where discharged fish-waste is available is also the area where trawl warps enter the water and so represents a dynamic and dangerous foraging environment for seabirds. Limiting access by scaring birds away and reducing the attractiveness through limiting fish-waste discharge, have been identified as the most effective seabird mitigation measures for trawl fisheries (Pierre *et al.* 2012; ACAP 2021). Regulatory measures for warp strikes were implemented in New Zealand's squid trawl fishery in 2006–07 with the mandatory use of seabird scaring devices (Fisheries New Zealand updated Regulation https://gazette.govt.nz/notice/id/2010-go1762). However, due to the operational, processing and engineering complexities involved, as well as cost and safety issues, the introduction of mandatory regulation of fish-waste management was not considered practicable. Eliminating fish-waste discharge, by retaining all waste on the vessel, is rarely practicable as many vessels do not have enough space on board to hold waste for long periods of time and would require substantial modification (as well as ongoing added operational costs) to permit this to occur. Despite the challenges in implementing mandatory requirements, specific operational procedures, to either make all fish-waste into meal or to use batching and mincing, were independently implemented by the fishing industry in 2007 and are ongoing (https://deepwatergroup.org/newsresources/op-manual).

In this paper, our objective is to take a holistic approach to review the modalities and impact of implementing a suite of technical and operational approaches to address seabird conservation objectives in the New Zealand squid trawl fishery. In doing so, we aim to identify those measures and approaches that might further improve seabird conservation in trawl fisheries, both in New Zealand and globally. This review combines publicly available government scientific observer data for the period 2003 to 2019 with detailed operational knowledge of the fishery to review the long-term implementation of mitigation approaches in an industrial fishery.

Methods

Fishery

In New Zealand, the seasonal squid trawl fishery targets southern arrow squid *Nototodarus sloanii* between January and June on the Snares Shelf, the Auckland Island's Shelf and on the Chatham Rise. The vessels involved target squid preferentially, generally in the austral summer and autumn, with effort mostly influenced by abundance (squid stocks are annually highly variable) and market price. The vessels are mostly in the range of 48–104 m length overall and freeze all products onboard, noting that the level of processing varies from packing whole to headed and gutted squid products.

Data collection and analysis

We used publicly available data on seabird bycatch collected by Government scientific observers deployed on trawl vessels targeting arrow squid fishing in New Zealand from 2003 to 2019 (downloaded from Dragonfly Data Science https://www.dragonfly.co.nz/ on 7 July 2021[1]). For seabirds, each taxon recorded in the data was allocated to a taxon group of albatrosses, petrels and other. The two main sources of seabird mortality associated with trawl fisheries are birds caught in nets or on warps (including paravanes that are used occasionally in bad weather to supplement acoustic monitoring of the net when hull-mounted transducers lose signal due to aeration). Therefore, the analysis is limited to data related to these two types of gear interactions. All birds reported caught, including those released alive, have been included as they provide an index of interactions with gear and hence risk exposure.

The number of seabirds caught each year (N_{total}) was estimated as the total number reported ($n_{reported}$) scaled by the proportion of tows observed ($p_{observed}$) where

$$N_{total} = n_{reported} * \frac{1}{p_{observed}}$$

Results

Fishing effort (number of tows per year) was of the order of 8–10 000 during the period 2003–2006, reducing to c.4 000 in 2008; there was a further decrease (<3 000 tows) between 2014 and 2018 with a subsequent increase such that the effort in 2019 (4 456 tows) was comparable to that during 2008–2011 (Figure 1). Over the same period, the number of observed tows increased gradually such that, combined with the decrease in effort, the % of hauls observed increased from less than 30% prior to 2013 to greater than 80% from 2013 onwards.

There were 3 749 records of interactions with trawl gear involving albatrosses and petrels in the squid fishery for the period 2003 to 2019. The dominant species reported by observers were white-chinned petrels (total = 1 512, n_{net} = 1 501, n_{warp} = 11), white-capped albatross

[1]This database is now hosted at https://www.stats.govt.nz/indicators/bycatch-of-protected-species-seabirds/.

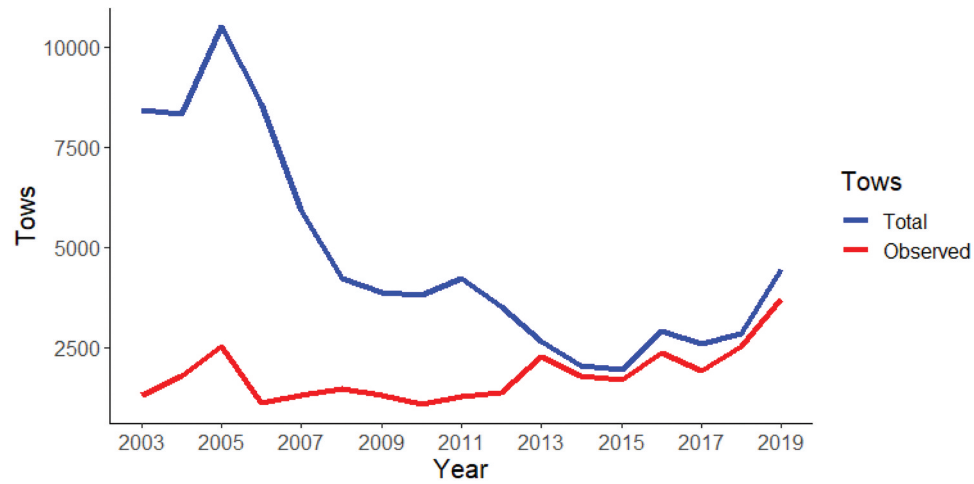

Figure 1. Total fishing effort (tows – blue) and observed tows (red) in New Zealand squid trawl fisheries from 2003 to 2019.

(total = 1 031, n_{net} = 677, n_{warp} = 354), sooty shearwater (total = 951, n_{net} = 945, n_{warp} = 6), and Buller's albatross (total = 183, n_{net} = 147, n_{warp} = 36).

Given the differences in the relative number of birds caught on nets and warps between the albatrosses and smaller petrels, these groups are treated separately in the subsequent sections.

Albatrosses

The rate of capture of albatrosses in nets (mean 2.7 birds per 100 tows, range 1.4–4.5) has remained relatively constant over the period 2003–2019 whereas for warps there was a distinct decrease from a mean of 2.9 birds per 100 tows during the period 2003 to 2006 to a mean of 0.7 birds per 100 tows after 2007 (Figure 2(a)). The estimated total number of albatrosses caught in nets and warps in squid trawl fisheries decreased from 785 in 2005 to 62 in 2014 with an increase to 130 in 2019; the overall trends over time were similar for nets and warps with the numbers caught in nets remaining higher than warps for all years after 2007 (Figure 2(b)).

Petrels

The rate of capture of petrels in nets (mean 8.2 birds per 100 tows, range 2–19) has been variable between years but has shown no trend over the period 2006–2019, the rate of capture for warps has been at or near zero during that period (Figure 3(a)). The estimated total number of petrels caught in nets in squid trawl fisheries decreased from a peak of 995 in 2006 and has been relatively stable at c.250 birds per year since 2010 (Figure 3(b)). The relative rate of birds caught for the two dominant petrel species (white-chinned petrels and sooty shearwaters) has changed over time, with the rate increasing for white-chinned petrels, from 3 birds per 100 tows in 2003 to a peak of 13 birds per 100 tows in 2015 (with a decline thereafter), whereas for sooty shearwaters there was an apparent step change decline from the period 2003 to 2009 (mean 4.3 birds per 100 tows) to 2010–2019 (mean 2.7 birds per 100 tows) (Figure 4(a)). This change is also reflected in the estimated numbers of birds caught with the sooty shearwaters being more numerous prior to 2009 but declining in catches since then, whereas the number of white-chinned petrels has remained relatively constant since 2009 (Figure 4(b)). Observer data on the number of birds counted near fishing vessels indicates a change in the relative abundance of white-chinned petrels and sooty shearwaters over the period 2008 to 2018 (Figure 5).

Discussion

To our knowledge, this is the first long-term study that describes the fleet and fishery-level processes to effectively introduce and maintain seabird bycatch mitigation measures in a commercially operating trawl fishery. From 2003 to 2019 there were substantial changes in the New Zealand squid trawl fishery in terms of the number and type of vessels, the operational/engineering characteristics of the fleet and also in the total effort (number of tows) in the fishery. An important aspect of this analysis is the availability and quality of public domain data collected on the vessels by scientific observers employed by the New Zealand government, particularly given the high level of observer coverage. The availability of this data is central to highlighting potential areas of concern and monitoring the continued efficacy of mitigation measures; there is little doubt that quantifying the level of seabird mortality in fisheries globally would be greatly enhanced if

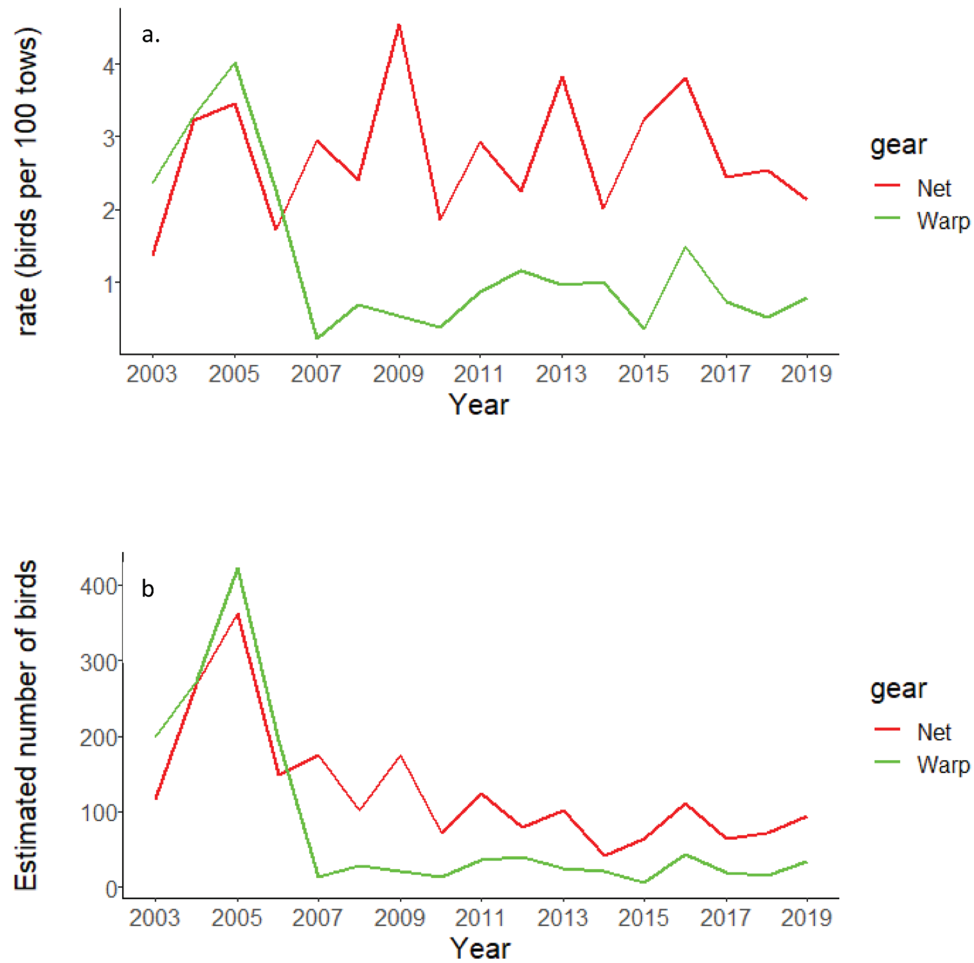

Figure 2. Capture rates (a) and scaled estimates of the numbers (b) of albatrosses caught in New Zealand squid trawl fisheries from 2003 to 2019.

this commendable level of transparency and data-sharing was widely adopted. Nevertheless, we recognise that there are limitations in the use of this publicly available data as there undoubtedly have been a range of technical, operational and legislative changes that may have impacted the way in which the data were collected and cannot be wholly accounted for in the analysis presented here. However, our aim in this paper was to review the outcome of the ensemble of technical, logistical and legislative actions taken to reduce seabird bycatch across the entire fishery (rather than describing a long-term experiment that examines the effectiveness of individual mitigation approaches). Notwithstanding these caveats, while the observed reduction in the total numbers of birds killed per year is, in part, a result of the reduction in fishing effort, it is apparent that the rate of albatross captures decreased from 26 birds per 100 tows in the early 1990s to less than 3 birds per 100 tows since 2007.

Effective bycatch mitigation is typically multi-factorial and depends on a suite of measures that address different elements of the risk associated with various aspects of a fishing operation, rather than a single element that is fully or primarily effective. In South African demersal trawl fisheries Maree *et al.* (2014) found that in the absence of offal discharge there were no warp strikes and when offal was discharged the rate of strikes was significantly reduced with the use of bird-scaring lines. In the case of the New Zealand squid trawl fishery, we have made no attempt to distinguish the effects of the fish-waste management and bird scaring device as these are integral parts of the overall mitigation approach. From an operational perspective, the overriding objective is to reduce seabird bycatch, such that measures are often not introduced according to an experimental design with the intent of determining their relative effectiveness. This includes the difficulty, both administratively and ethically, of including control experiments, in which a particular aspect(s) of mitigation is not used, to quantify its effectiveness when there is an expectation that this will result in an increase in bird mortality. This

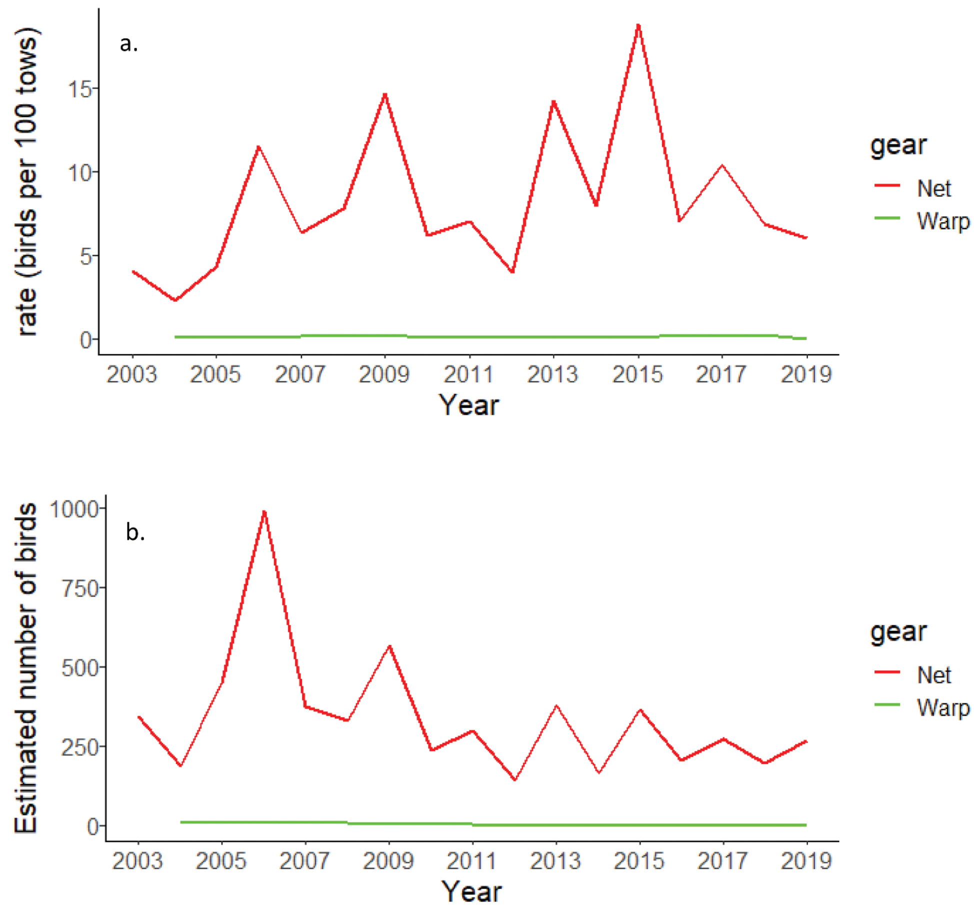

Figure 3. Capture rates (a) and scaled estimates of the number (b) of petrels caught in New Zealand squid trawl fisheries from 2003 to 2019.

creates an inevitable trade-off between the desire to quantify the relative contribution of different measures and the core objective of reducing seabird mortalities.

The reduction in the rate of birds caught on warps after 2007 indicates that the additional mitigation measures introduced at that time drove a reduction in the number of birds being killed on warps. The effectiveness of these measures to address warp captures is corroborated by the lack of a similar decrease in the rates of captures in nets; in the absence of any particularly effective measures specifically designed to reduce net captures, especially during hauling. Direct comparison between rates of net and warp captures was limited by the differences in the likelihood of birds being retained and brought onboard. In this analysis, we used the number of seabirds caught, including those reported to be released alive, to reflect the risk of interactions with fishing gear. While the pro-rata scaling used in this analysis does not explicitly account for spatial, temporal or vessel effects (cf. Richard *et al.* 2017, 2020) the high level of observer coverage in this fishery provides a level of confidence in the interpretation of the estimates. We recognise the challenges in estimating total mortality, including any correction for cryptic mortality, especially where gear modifications, such as the wrapping of splices in the warps, may impact the retention of dead birds and thus increase the rate of cryptic mortality. Experimental approaches to the estimation of cryptic mortality have been trialled (Sullivan *et al.* 2006a; Parker *et al.* 2013), and further work is required to provide estimates of mortality rates, including any consequential impacts of gear modifications.

Examining temporal trends in the rate of captures requires a consistent measure of the fishing effort as it relates to the time that birds are at risk. Using the number of tows provides a good measure of the risk periods for net capture of seabirds as the nets are at the surface twice on each tow, regardless of the duration of the tow. However, the risk period for warp collisions is dependent on the tow duration as birds are exposed to risk for all of the time that the net is in the water. Mean tow duration increased by approximately 20% over the period 2006 to 2010, but not thereafter (Fisheries New Zealand unpublished data). Therefore the reduction in

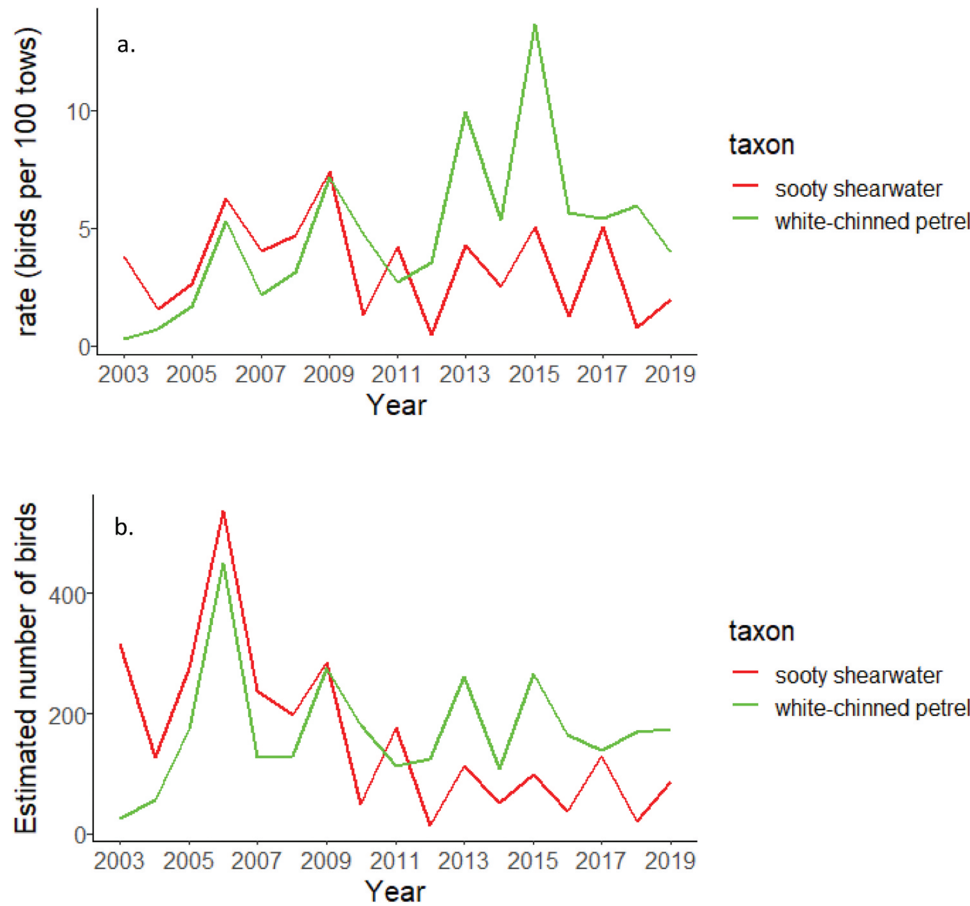

Figure 4. Capture rates (a) and scaled estimates of number (b) of sooty shearwaters and white-chinned petrels caught in New Zealand squid trawl fisheries from 2003 to 2019.

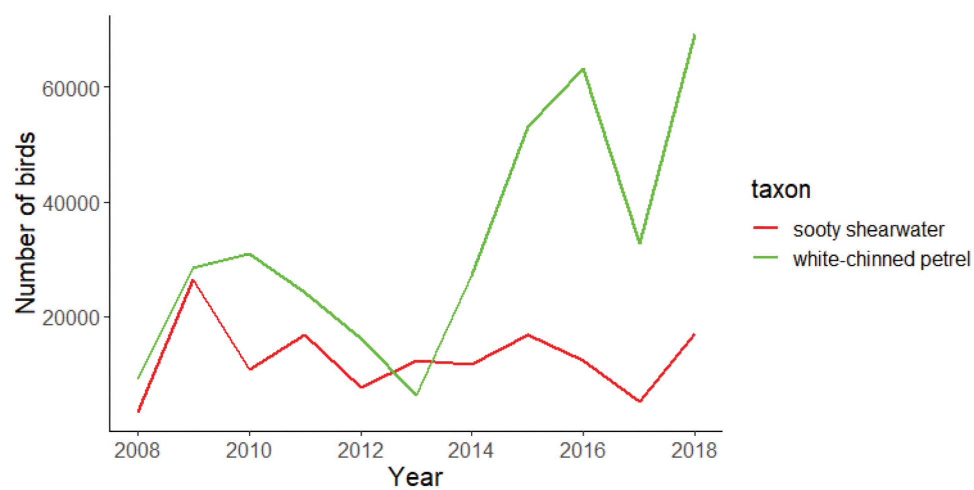

Figure 5. Number of sooty shearwaters and white-chinned petrels reported by observers near New Zealand squid trawl vessels each year from 2008 to 2018.

the number of tows may not reflect a similar level of reduction in the total time that warps are in the water. This suggests that the actual decrease in warp collisions during this period may be underestimated when using the rate calculated using the number of tows as the denominator.

The apparent changes in the relative numbers of white-chinned petrels and sooty shearwaters observed near vessels and captured in nets highlight the importance of the collection of data on the seabird assemblages in the areas in which fisheries are operating. These data are clearly important to understand the drivers of changes in relative capture rates and, in particular, where there are changes in the conservation status of the species involved, as this may require review and modification of any mitigation measures in place.

Fishing industry engagement is essential for effective design and uptake of mitigation, and it is instructive to review how this was achieved in the squid trawl fishery in New Zealand. One integral feature of New Zealand's fishery management, including the squid fishery, was the introduction of Individual Transferable Quotas (ITQs) in the 1980s (Lock and Leslie 2007). With the introduction of ITQs, key industry stakeholders with a history in the fishery had an increased incentive in ensuring the economic value of their quota share and hence the long-term future of the fishery. An important aspect of this long-term investment included addressing environmental risks where there was a potential for adverse effects as described by the New Zealand *Fisheries Act 1996* (https://www.legislation.govt.nz/act/public/1996/0088/latest/DLM394192.html), together with the indirect costs of negative public and political opinion (see, for example, Helson *et al.* 2010).

While full fish-waste retention is required in some fisheries, such as in CCAMLR when vessels fish south of 60°S (CCAMLR 2021), the high-volume of fish-waste produced from processing meant that simply mandating fish-waste retention was not practicable. Trial data (Pierre *et al.* 2012; Kuepfer *et al.* 2022) have demonstrated the benefit of avoiding continual discharge of large pieces of fish-waste, and achieving this has become the objective of the industry-led mitigation strategy. However, fishery-wide uptake of new mitigation measures is often not as straightforward as simply transforming trial outcomes to specific practicable management measures (Eayrs and Pol 2018; Da Rocha *et al.* 2021). Industry experts engaged with fishery regulators to produce codified protocols and operational procedures for reducing the risk of bycatch of seabirds. Importantly, these operational procedures (OPs) were then formulated into vessel-specific Vessel Management Plans (VMPs) that were developed for both foreign owned and domestic vessels (see https://deepwatergroup.org/newsresources/op-manual/). These detailed the actions required on each vessel, based on its engineering and operational specifics, to achieve the objectives of the OPs for reducing seabird bycatch. These VMPs and OPs were modelled on existing vessel, crew and food safety systems in order for the format to be familiar to fishermen. The OPs created the requirement and instructions so that for those vessels that make fish meal the offal is macerated, cooked and dried so that the only discharge is 'stickwater' or species unable to be made into meal. Because the ability of a vessel to make fish meal must be part of the original vessel design and cannot be easily retrofitted, the OPs also outline how those vessels not equipped to meal fish-waste should produce a fine mince and/or discharged in batches depending on the vessel design and storage capabilities.

The proactive engagement of fishing industry leaders to achieve implementable and effective solutions represented a cultural shift in the fishery, especially in the attitude of fishers towards the capture of seabirds. This shift is reflected in the transition from the 1980s when catching seabirds was simply considered a normal part of doing business to a situation post-2010 when vessels report with pride about trips to sea in which few or even no birds were caught, as well as proactively reporting and seeking feedback when capture events occur (RW unpublished information).

Overcoming the inherent psychological inertia/conservative model of operation that often characterises fisheries (Eayrs and Pol 2018) required the leadership of quota owners as well as the engagement and participation of vessel operators, managers and crew. This process was catalysed by fishing industry liaison personnel who translated legislation and regulatory documents into a more amenable, vessel-appropriate format. Using industry personnel for this liaison brought credibility with vessel crews by being communicated from fishermen to fishermen and often required translating official requirements and specifications not only into 'crew friendly' terminology but also into the languages used on foreign-crewed vessels.

White-capped albatrosses, one of the major bycatch species in the squid fishery, are endemic to New Zealand but are known to be killed in both trawl and longline fisheries across a wide spatial scale in the Pacific and Atlantic oceans (Baker *et al.* 2021). The conservation status of the species has been recently assessed as Near Threatened with potential biological removal estimates suggesting that the scale of the loss across global fisheries is sufficient to cause a rapid decline (Baker *et al.* 2021). In South Africa, there are partnerships working to produce bird-scaring line designs and offal management approaches for the development of vessel-specific mitigation strategies (https://www.msc.org/what-we-are-doing/our-collective-impact/ocean-stewardship-fund/impact-projects/mitigation-measures-birdlife). Applying the same mitigation measures across all fisheries with which white-capped albatrosses interact, and thereby replicating the large and sustained reduction in warp captures of this species in the New Zealand squid fishery, would make a substantial contribution to improving the conservation status of this species. Hopefully, the identification of the key technical and cultural drivers that created positive changes in one fishery can accelerate the implementation of analogous approaches in other trawl fisheries (Adasme *et al.* 2019; Jiménez *et al.* 2022).

Notwithstanding the successes in reducing seabird bycatch in the squid fishery in New Zealand there remains a persistent level of seabird mortality in the fishery, particularly with the rate of captures in nets, which has remained at the same level for the last decade or more. Technical and operational approaches have been trialled to address net captures (e.g. Reid *et al.* 2010); however, broader development or uptake of these approaches has been limited. There is an increasing awareness of the extent of seabird mortality in trawl fisheries globally and also of the challenges of taking experimental mitigation results into industrial-scale operational solutions. Having achieved success previously in addressing these challenges, there is an opportunity for the fishing industry in New Zealand to apply those same positive attributes to deliver continued reductions in seabird mortality in New Zealand's squid trawl fisheries (see, for example, Edwards and Dunn 2021; Wells *et al.* 2021). Doing so, and exporting the solutions to other fisheries globally would improve the conservation status of a range of currently critically threatened and near-threatened seabird species.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Keith Reid http://orcid.org/0000-0002-6022-911X
G. Barry Baker http://orcid.org/0000-0003-4766-8182

Data availability statement

The data that support the findings of this study are openly available in Stats NZ Tatauranga Aotearoa at https://www.stats.govt.nz/indicators/bycatch-of-protected-species-seabirds/.

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