SCIENTIFIC COMMITTEE
FOURTH REGULAR SESSION

11-22 August 2008
Port Moresby, Papua New Guinea

PRELIMINARY RESULTS OF AN ECOLOGICAL RISK ASSESSMENT FOR NEW ZEALAND FISHERIES INTERACTIONS WITH SEABIRDS AND MARINE MAMMALS

WCPFC-SC4-2008/EB-WP-2

Waugh, S.[1], D. Filippi[1], N. Walker[2], and D. Kirby[3]

---

[1] Sextant Technology, 116 Wilton Road, Wellington 6012, New Zealand.
[2] Ministry of Fisheries, PO Box 1020, Wellington, New Zealand
[3] SPC, Noumea, New Caledonia

Preliminary results of an Ecological Risk Assessment for New Zealand fisheries interactions with seabirds and marine mammals

Susan Waugh[1], Dominique Filippi[1], Nathan Walker[2], David Séan Kirby[3]

[1]Sextant Technology, 116 Wilton Road, Wellington 6012, New Zealand

[2]Ministry of Fisheries, PO Box 1020, Wellington, New Zealand

[3]Secretariat for the Pacific Community, BP D5, Noumea Cedex, New Caledonia 98848

23 July 2008

Author for Correspondence:

Susan Waugh
116 Wilton Road
Wellington 6012
New Zealand
Ph: +6449764227
Email: s.waugh@sextant-technology.net

1 Executive Summary

An analysis was undertaken of the risk of adverse effects on populations of protected species due to fisheries interactions in New Zealand waters. The Ecological Risk Assessment (ERA) methodology developed as part of the work of the Western and Central Pacific Fisheries Commission was used as a guide to the work reported here. The report presents a preliminary Productivity-Susceptibility Analysis (PSA) depicting the likely encounters and relative likelihood of population effects due to interactions between fisheries (pelagic longline and troll) and 26 seabird and 2 marine mammal species. We derived species distributions from a pre-existing database which incorporates available sightings data, breeding localities, incidental catch records, and remote-tracking studies. Species distributions were then scaled by population size to give a relative estimate of density. We used these density distributions and maps of fisheries effort data to develop indices of species' susceptibility to fisheries capture. Indices of productivity were then developed from biological information: lifetime reproductive output was calculated from age-at-first breeding, breeding frequency and clutch size; lifespan and age-at-first breeding were again used as indicators of natural mortality and inherent risk due to delayed maturity. The indicators of productivity and susceptibility were then plotted and the risk scores ranked, so as to describe the relative risk among species due to pelagic longline and troll fisheries.

2 *Introduction*

In international fisheries management contexts, Ecological Risk Assessment (ERA) has been used to examine the likelihood of fisheries effects for both target and non-target species (Standards New Zealand and Standards Australia 2006). Such analyses allow the targeting of more detailed monitoring, research, and caution to be applied in managing effects of fishing, where information is incomplete or uncertain. Three levels of ERA have been identified: Level 1 analysis is designed to identify hazards to species and systems using qualitative data and expert opinion, such as that undertaken for Convention for the Conservation of Marine Living Resources (CCAMLR) fisheries (Waugh et al. 2007); Level 2 is based on the biological characteristics of species caught in the fishery concerned, and the degree of interaction between that fishery and those species. The Level 2 methodology considered to be the most appropriate and robust for fisheries ERA is termed Productivity-Susceptibility Analysis (PSA) (Hobday et al. 2006 a,b). This method has been most developed in the management of Australian fisheries by Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) and was recently applied to Western and Central Pacific Fisheries Commission (WCPFC) fisheries assessments for bycatch species (Kirby 2006, Kirby and Hobday 2007, Kirby and Molony 2007); Level 3 analysis is analogous to detailed stock assessment research. Several analyses examining fisheries effects on marine mammal and seabird interactions have been developed at this level (e.g. Maunder et al. 2000, Tuck et al. 2002). Level 3 analyses typically require detailed data and relatively long time-series of catch- and or life-history information for these species.

The research reported here addresses risk assessment using a Level 2 PSA, for protected seabird and marine mammals only. A wide range of species from these two groups were considered in the original analyses, but several were excluded as it was considered that they had little probability of interacting with the fishing methods included or data were lacking to describe their ranges. This ERA method examines the likely consequences of removals through accidental fishing mortality on populations (their susceptibility to population effects of fishing) and recognizes that the differing fecundity and life-history attributes of populations (their productivity) play a role in determining likely population responses. The focus of the study was on native or commonly-occurring species in the New Zealand Exclusive Economic Zone (EEZ). In the analyses reported here, we examined only pelagic longline and troll fisheries and the interaction with 25 species of protected seabirds and two seal species. These species ranged in IUCN rank from Least Concern to Critical.

3 Methodology

In order to deal with patchy data availability, or inconsistent measures of either susceptibility or productivity, the CSIRO model uses several sorts of data to contribute to each of the two main indices (e.g. for *P* or Productivity indices, it uses many variables including clutch size, breeding frequency, age-at-first breeding, and average lifespan). For groups of species with conservative life-history traits, it is valid to use values from another species to complete details for those with missing information. These were reviewed by an expert panel and revised where incongruous values were identified.

Fisheries data for the PSA analyses were treated separately for pelagic longline and troll fisheries, which are of particular relevance to the WCPFC. We did not consider target-species differences in susceptibility within a fishing method. As we were unsure to what degree susceptibility to capture might vary between these fishing methods for any one species, we did not consider it valid to compare between the outputs for the different fishing methods. Thus a PSA value for each species and fishing method combination was generated, being the distance to the origin for any species, based on the intersection of the susceptibility and productivity indices for that species. This overall index is described as the ‘distance’ (DIST) for each species.

This report focuses only on the marine species likely to interact with pelagic longline and troll fisheries. We considered a total of 90 seabird and 15 marine mammal taxa native to, or commonly occurring within the New Zealand EEZ. When we considered the distribution and life-history data available for this group of candidate species, we retained 28 species, spread across the major taxonomic groups likely to be captured by troll and pelagic longline fishing methods (Table 1). Other groups that we considered (e.g. terns, cormorants, penguins, and marine mammals aside from sea lions and seals) where data were available were excluded as information on fisheries captures indicated that there was a very low probability of their capture with these fishing methods.

Table 1 Seabird and marine mammal species included in the PSA analysis, listed by family.

Family	**Total candidate species native to NZ or frequently occurring in the NZEEZ**	**Species included in Outputs of the Analyses**[1]
Seabirds[2]		
Diomedeidae	15	11
Hydrobatidae	6	1
Laridae	16	0
Pelecanoididae	3	1
Phaethontidae	2	0
Phalacrocoracidae	10	0
Procellariidae	37	12
Spheniscidae	7	0
Stercorariidae	3	0
Sulidae	3	1
Marine Mammals		
Balaenidae	1	0
Balaenopteridae	2	0
Delphinidae	11	0
Globicephalidae	4	0
Otariidae	3	2
Phocidae	1	0
Physeteridae	2	0
Total	126	28

---

[1] The following numbers of species were considered, but due to the low probability of interaction with either Pelagic Longline or Troll methods, they do not appear in the results. Terns 3, cormorants 5, marine mammals 7, penguins 2. Incomplete distribution data only were available for species which were 'considered' but not included in the analyses.

[2] All seabird species considered in this analysis nest in New Zealand, while marine mammals included several species that are considered migratory to New Zealand waters, but spend a significant portion of their life-cycle in the New Zealand EEZ.

Calculating Productivity

The data used for calculating Productivity (*P*) values for species were general 'life-history' parameters for species. Where available these included:

- Average Annual Adult Survival
- Average maximum lifespan
- Clutch size
- Breeding frequency (average number of breeding attempts per year)
- Age-at-first breeding

Where there were missing values for species, we took values from congeneric species, or where these were unavailable, we used average values from the lowest taxonomic level available (based on Hamer et al. 2002 for seabirds and Perrin 2000. or A. van Helden, pers. comm. for marine mammals).

From the basic life-history parameter values above, we calculated Average Lifespan (Lifespan) and Lifetime Reproductive Output (LRO):

$$\text{Lifespan} = -1/(\ln(\text{Average Annual Adult Survival}/100))$$

$$\text{LRO} = (\text{Lifespan} - \text{Age-at-Maturity}) \times \text{clutch size} \times \text{breeding frequency}$$

The Productivity Index (*P*) was calculated, and normalized by:

$$P = (\text{Lifespan} / \max \text{Lifespan}) + (\text{LRO} / \max \text{LRO}) + ((1/\text{Age-at-Maturity}) / (\max 1/\text{Age-at-Maturity}))$$

In one case (white-chinned petrel), where the estimated population parameters resulted in a LRO that had a negative value, we adjusted the average annual survival parameter to the level of congeneric species (i.e. from 79% per annum to 89% per annum). For all species, the *P* index ranged between 0.4 and 1. They were therefore normalized by:

$$P\ (\text{tabulated}) = (P1-0.4)/0.6$$

Calculating Susceptibility

To generate the index of susceptibility for each species, we generated a matrix of the overlap of fishing effort and each species distribution. We diverged from the method of Hobday and Kirby (2007) by considering the overlap on the horizontal plane as an indication of the potential for risk of fisheries interactions (here we consider interactions to be captures, including those involving live releases of captured individuals).

For the average annual species distribution we used the information in the New Zealand National Aquatic Biodiversity Information System (NABIS) (New Zealand 2008). See Appendix 2 for details of the compilation and definition of these layers. The three layers described for each species in the NABIS system were the 100% annual distribution, the 90% distribution and “HotSpots”. We weighted the species distribution in each species matrix against the three NABIS layers: NABIS 100% distribution - a relative weight of 0.2; NABIS 90% distribution, 4.8; and NABIS ‘HotSpot’, 100. The layers generated were weighted by an estimated population size for each species (breeding pairs for seabirds and total individuals for marine mammals). This way, relatively rare species were less ‘available’ for capture than common species, if they spent time over equal-sized ranges. Currently our base case considers that species risk is relative to its availability to interact with fishing events. Following this logic, we considered that this weighting was necessary as a rare species of wide distribution could have a disproportionately high risk value, relative to its probability of capture[3]. We their did not weight species on the basis of their vulnerability to extinction as determined by International Union for the Conservation of Nature (IUCN) ranking.

Individual fishing locations (start positions), were treated at ‘set’ level for positioning, weighted by the number of hooks per set. Fisheries catch and effort data for four years (1 October 2003 to 30 September 07) were used to describe the distribution and intensity of pelagic longline (PLL) and troll (TRO) fishing effort. The number of fishing events considered in the interaction zone for each species was calculated for

---

[3] Note that this report presents a preliminary analysis, and that we intend to examine this aspect further as the work develops.

the area under the species distribution only. The data were available with latitude and longitude details to a level of 0.1 degrees for the two fishing methods considered.

Using these data we calculated an index of Susceptibility (*S*) for each species and fishing method in two stages. First, we generating a matrix of overlap between the species and the fishing effort by method.

$$\mathit{Overlap}\ \mathit{sp\_fishing\ method} = (\mathit{distribution\ of\ species} \times \mathit{distribution\ of\ fishing\ events})$$

Secondly, we summed the values for this matrix of overlap and corrected the resulting value by square-root function, so that we could compare the species between each other within a fishing method, such that:

$$S = \sqrt{\left(\sum_{lat}\sum_{long} \mathit{overlap}\ \mathit{sp\_fishing\ method}\right)}$$

4 Results

The pelagic longline fishery for a range of tunas and billfish during the period of the study (1 October 2003 to 30 September 2007) was distributed mainly around the northeast and to a lesser extent to the southwest of the New Zealand mainland. During this time over 16.5 million hooks in total were set for the fishery. The most intensive area of fishing effort for the four years combined was off the eastern extremity of the North Island of New Zealand (located around the East Cape and Hawke Bay areas; Figure 1). Seabird species occurring frequently in these areas include a wide range of albatrosses, which either forage in these areas during the breeding season, or visit this area in the winter prior to post-breeding migrations to the eastern Pacific and Atlantic Oceans. Several petrel species also frequent the East Cape area and north-eastern New Zealand, especially those with northern breeding grounds such as the Parkinson’s and great-winged petrels.

Troll fisheries (mainly for albacore tuna) for the same period were of much more limited distribution and total fishing effort than the pelagic longline fishery. Much of the fishing effort for this method is reported by New Zealand Statistical Area only (around 90% of troll effort), and is not included in this analysis. However, our preliminary review of findings showed that the outcomes in terms of species ranks in the analysis remained relatively unchanged with the different reporting regimes (these results are not detailed here). This fishery was distributed west of the New Zealand mainland, in particular off the coast of the northern North Island, extending as far south as the central western South Island (Figure 2). A total of 21,000 hooks were set during the four year period covered by the study. Seabirds occurring in these areas are typified by the sub-Antarctic albatrosses and petrels such as white-chinned and Westland petrels, and sub-tropical petrels such as great-winged petrels and sooty shearwaters.

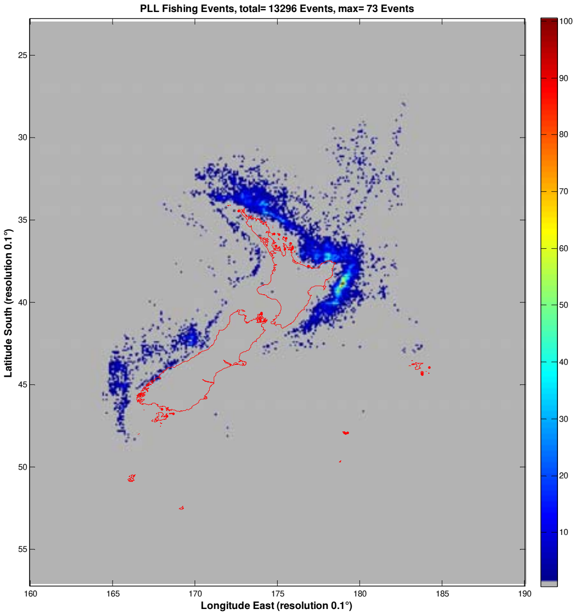

Figure 1. Distribution of fishing effort (number of hooks) by pelagic longline fisheries (from 1 October 2003 to 30 September 2007) around the New Zealand EEZ.

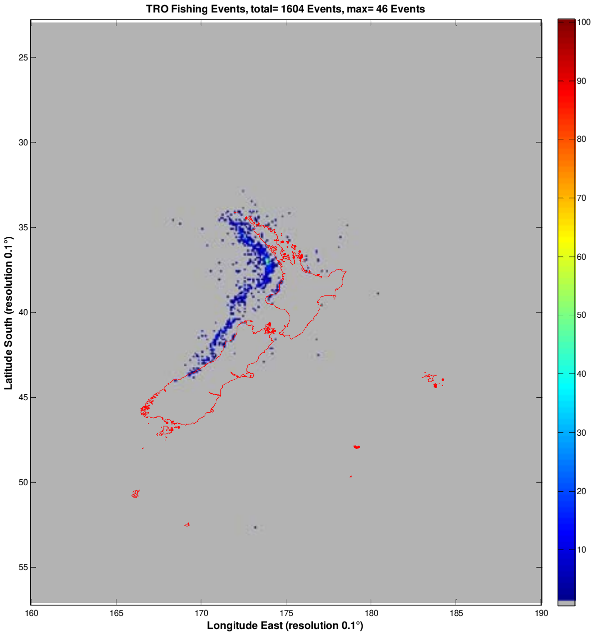

Figure 2. Distribution of fishing effort (number of hooks) by troll fisheries (from 1 October 2003 to 30 September 2007) around the New Zealand EEZ.

The PSA analysis for pelagic longline and troll fisheries (Figures 3 and 4 respectively) showed similar results in terms of the species ranked with highest and lowest risk. These fisheries showed the potential for greater population effects on petrels from the *Procellaria* genus (in particular Westland petrel (PCW), Parkinson's petrel (PRK), and white-chinned petrel (PRO)) compared with any other species-groups. A range of albatross (family Diomedeidae) and small petrel species (mainly from the genera *Puffinus, Pterodroma, Pelagodroma*) occurred in the species ranked 5 – 20 in the PSA analysis (Table 2).

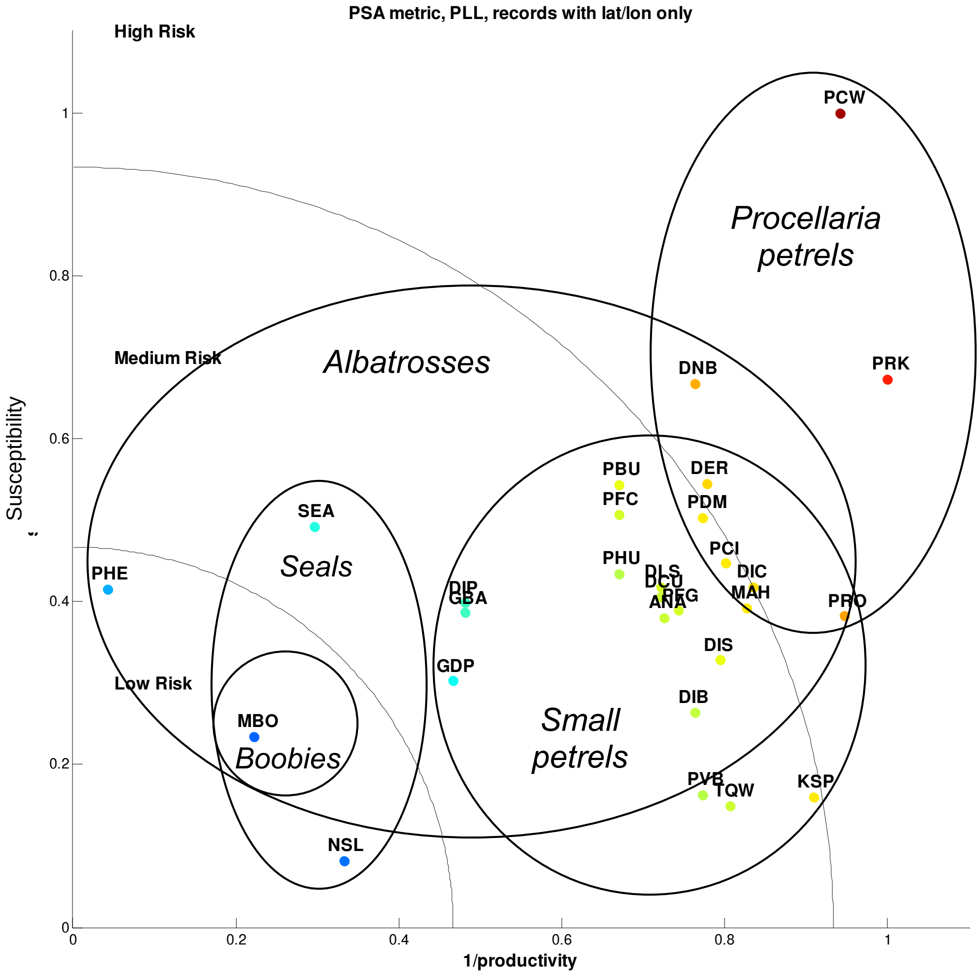

Figure 3. PSA output for pelagic longline fisheries within the New Zealand, showing relative productivity (x axis) and susceptibility to fishing mortality (y axis) for 25 seabird and 2 marine mammal species included in the analysis, and considered vulnerable to capture with this fishing method. See Appendix 1 for species codes.

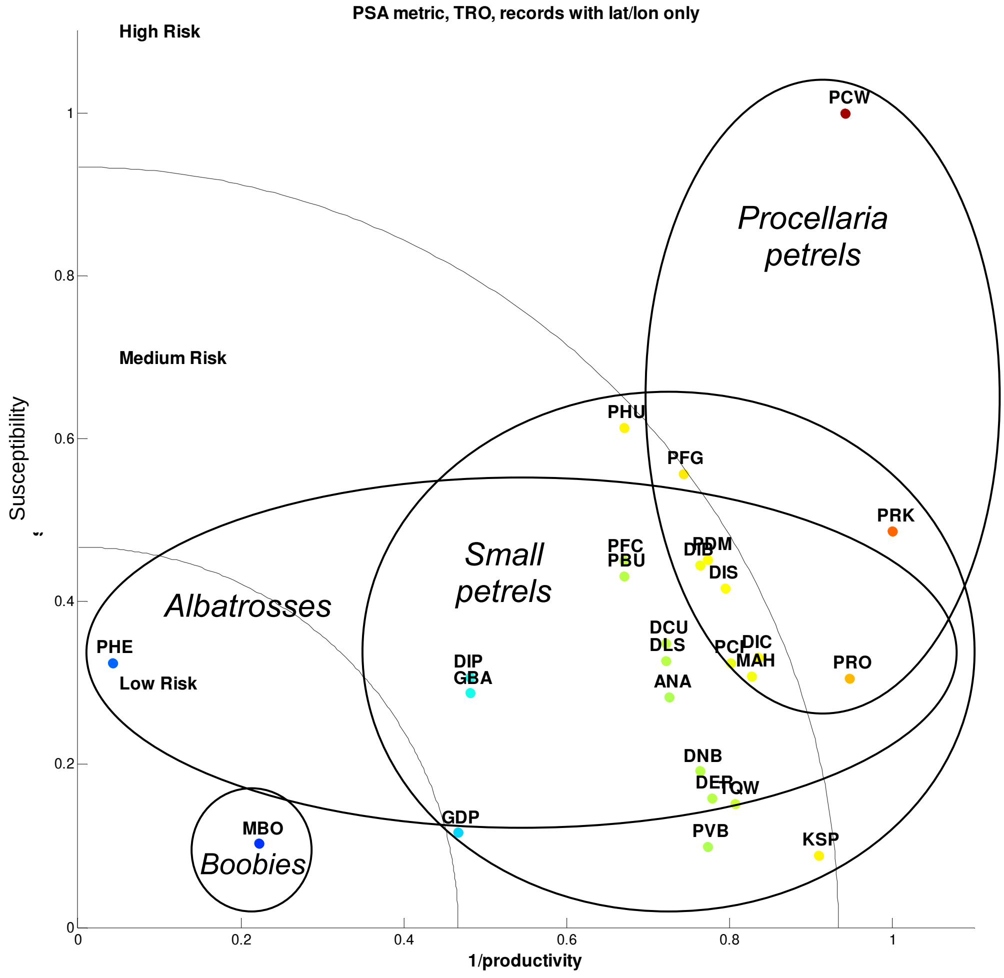

Figure 4. PSA output for troll fisheries within the New Zealand EEZ, showing relative productivity (x axis) and susceptibility to fishing mortality (y axis) for 25 seabird species included in the analysis, and considered vulnerable to capture with this fishing method. See Table 2 for species codes

Table 2. The PSA output showing the top 20 ranked species (on average) across pelagic longline (PLL) and troll (TRO) fisheries, for fisheries in the New Zealand EEZ, with distance calculated from the origin (Figures 3 and 4) for pelagic longline (DIST PLL) and troll (DIST TRO) fisheries. Species are listed by the average of the two ranks for PLL and TRO, and those ranked 1 – 5 for each fishing method are shown in red, 6 – 10 in orange, and 11-15 in yellow.

Species Code	Species name	Family	IUCN ranking	DIST PLL	Rank PLL	DIST TRO	Rank TRO
PCW	Westland petrel	Procellaridae (Procellaria spp)	VU	1.37	1	1.37	1
PRK	Parkinson's petrel	Procellaridae (Procellaria spp)	VU	1.20	2	1.11	2
PRO	White-chinned petrel	Procellaridae (Procellaria spp)	VU	1.02	3	0.99	3
KSP	Kermadec white-faced storm petrel	Procellaridae	LC	0.92	7	0.91	5
DIC	Grey-headed albatross	Diomedeidae	VU	0.93	6	0.89	7
PDM	Great-winged petrel	Procellaridae	LC	0.92	8	0.89	9
PFG	Sooty shearwater	Procellaridae	NT	0.83	14	0.92	4
DIS	Northern royal albatross	Diomedeidae	EN	0.85	12	0.89	8
MAH	Northern giant petrel	Procellaridae	NT	0.91	10	0.88	11
PCI	Grey petrel	Procellaridae (Procellaria spp)	NT	0.91	9	0.86	12
DER	Chatham albatross	Diomedeidae	CR	0.94	5	0.79	17
DNB	Northern Buller's albatross	Diomedeidae	VU	1.01	4	0.78	19
PHU	Hutton's shearwater	Procellaridae	VU	0.79	20	0.90	6
PBU	Buller's shearwater	Procellaridae	VU	0.86	11	0.79	16
PFC	Flesh-footed shearwater	Procellaridae	LC	0.84	13	0.80	14
DIB	Southern Buller's albatross	Diomedeidae	VU	0.80	19	0.88	10
TQW	Campbell albatross	Diomedeidae	VU	0.81	17	0.82	13
DCU	White-capped albatross	Diomedeidae	NT	0.82	16	0.80	15
DLS	Salvin's albatross	Diomedeidae	VU	0.83	15	0.79	18
ANA	Antipodean albatross (Antipodes Is)	Diomedeidae	VU	0.81	18	0.77	21

5 Discussion

The study demonstrated that the PSA methods developed by Kirby and Hobday (2007) can be applied to data sets for a wide range of taxonomic groups, including seabirds and marine mammals. We adapted the indices of productivity and susceptibility for the species and fisheries data available within our study zone (the New Zealand EEZ), and provided preliminary analyses of relative risk of fishing interactions (risk of capture) for 25 seabird and 2 marine mammal species considered vulnerable to capture by the pelagic longline and/or troll fisheries examined in this study.

Our study was limited by the availability of distribution data for different taxa considered. However, with increasing understanding of the ranges of seabird, marine mammal or other taxa through time, this methodology could be applied to address a range of research and management topics. We consider that this method could be used across a range of fishery scales, from within EEZ to major ocean basins. The analysis is not limited to using point (latitude-longitude) defined data, and we are currently adapting it to be used for statistical areas within the New Zealand EEZ context.

We are particularly interested in understanding the comparison between PSA analyses in the future, which may be possible if management interventions or fishing practices change through time, thus changing the susceptibility of species or degree of overlap of species and fishery distributions. Improved data on the biological characteristics of species is likely to lead to refinement, and possibly improve the accuracy of the productivity indices used. The current methodology does not allow for uncertainty to be incorporated into the indices of either productivity or susceptibility. Incorporating ways of dealing with uncertainty in the indices would be highly desirable.

We questioned why one group of petrels in particular, the four species in the genus *Procellaria*, appeared to be particularly at risk from interactions with pelagic longline and troll fisheries. The three most highly ranked species were Westland petrel, Parkinson’s petrel and white-chinned petrel. All have an IUCN ranking of Vulnerable. These species have productivity rankings that are at the extremes of the species in their family (Procellaridae). It could be that the relatively poor understanding of the key life history parameters for the *Procellaria* petrels may be contributing to their high risk ranking. However, the relatively ‘high risk’ index for each of these species is largely due to their placement along the Y axis, with a high degree of overlap between the ranges of the species and the activity of both pelagic longline and troll fisheries in the New Zealand area. In particular, Westland petrel, a New Zealand endemic species with fewer than 2000 breeding pairs, is described as having a reasonably limited distribution around central New Zealand waters which coincides with an area of activity for both longline and troll fishery methods examined here. A similar situation exists for the Parkinson’s petrel, another New Zealand endemic species, which is described as having a limited at-sea distribution off north-eastern North Island of New Zealand, coinciding with an intensively fished area. Both of these species are observed caught in low numbers in observed fisheries in New Zealand (Fewer than 20 individuals for either species since 1996, Ministry of Fisheries, unpublished data). The lack of observed occurrence, however, in the incidental catch data may be due to the low observer cover in these fisheries in the northern and central parts of New Zealand EEZ.

Conversely, the white-chinned petrel, which nests in sub-Antarctic sites around 50 degrees south and is considered to number around 50,000 breeding pairs in its New Zealand breeding populations, has a wide distribution and high population numbers, and intersects with a large quantity of fishing effort throughout its range. The white-chinned petrel is the species the most commonly observed caught by fisheries observers in the New Zealand zone (around 1000 individuals have been observed caught since 1996, Ministry of Fisheries, unpublished data).

Troll fisheries have the additional potential to impact on populations of shearwaters, with the species most highly ranked for this fishing method being the Hutton’s and sooty shearwaters.

6 Conclusions

The study examined the utility of PSA analyses in assessing the relative risk of fisheries interactions across a range of protected seabirds and marine mammals, in relation to pelagic longline and troll fishing. *Procellaria* petrels, several albatross and shearwater species were identified as having highest potential risk of fisheries capture in these fisheries in the New Zealand EEZ. Species distribution data was the limiting factor in determining the number of species that could be included in the analysis. Further research will examine the utility of presenting analyses that will examine seasonal effects, and applying the method developed here across a wider range of fishing methods, in particular for trawl, set net and demersal longline fisheries.

7 Acknowledgements

We would like to thank the New Zealand Ministry of Fisheries for funding this study under Project IPA2007-09, and the following researchers who assisted in defining data input choices and in the formulation of the revised *P* and *V* indices used in the study: David Middleton, Martin Cryer, Robert Mattlin, Stephen Brouwer and Anton Van Helden. We thank the Ministry of Fisheries staff in the Research Data Management group, particularly Craig Loveridge, Marianne Sellers and Alana McArtney for extracting data and advice on distribution information. We thank Paul Sagar for allowing us to use data from the BirdLife Global Procellariiform Tracking Database on Buller's Albatross for comparative purposes in the study.

8 Bibliography

Birdlife International 2008. http://www.birdlife.org/action/science/species/seabirds/tracking.html. Sourced 3 July 2008.

Hamer, K.C., E.A. Schreiber and J. Burger. 2002. Breeding biology, life histories, and life-history environment interactions in seabirds. Pp 217-262. in Biology of Marine Birds. E.A. Schreiber and J. Burger (eds). CRC Press, Marine Biology Series. Boca Raton

Hobday, A. J., A. Smith, H. Webb, R. Daley, S. Wayte, C. Bulman, J. Dowdney, Williams, M. Sporcic, J. Dambacher, M. Fuller, T. Walker. 2006a. Ecological Risk Assessment for the effects of fishing: Methodology. WCPFC-SC2-2006/EB-WP-14.

Hobday, A. J., A. Smith, H. Webb, R. Daley, S. Wayte, C. Bulman, J. Dowdney, A. Williams, M. Sporcic, J. Dambacher, M. Fuller, T. Walker. 2006b. Ecological Risk Assessment for the Effects of Fishing: Methodology. Report R04/1072 for the Australian Fisheries Management Authority, Canberra)

Kirby, D.S. 2006. Ecological risk assessment for species caught in WCPO Tuna fisheries: inherent risk as determined by productivity-susceptibility analysis. WCPFC-SC2-2006/EB WP-1. Western and Central Pacific Fisheries Commission.

Kirby, D.S., and A. Hobday. 2007. Ecological risk assessment for the effects of fishing in the W3estern and Central Pacific Ocean: Productivity-Susceptibility analysis. WCPFC-SC3-EB SWG/WP-1.

Kirby, D.S., and B. Molony. 2007. Ecological risk assessment for the effects of fishing in the W3estern and Central Pacific Ocean: Research planning workshop report and draft research plan. WCPFC-SC3-EB SWG/WP-3.

Maunder, M. N., P. Starr, and R. Hilborn. 2000. Bayesian analysis to estimate loss in squid catch due to the implementation of a sea lion population management plan. Marine Mammal Science 16:413-426.

New Zealand 2008. National Aquatic Biodiversity Information System. www.nabis.govt.nz. Sourced 10 June 2008.

Perrin, W.F., B. Wursig, J.G.M. Thewissen. 2002. Encyclopedia of Marine Mammals. Academic Press, San Diego.

Schreiber, E.A. and J. Burger. 2002. Appendix 2: Table of seabird species and life history characteristics. PP 665-686. in Biology of Marine Birds. E.A. Schreiber and J. Burger (eds). CRC Press, Marine Biology Series. Boca Raton

Standards New Zealand and Standards Australia. 2006. Environmental risk management-Principles and process. Standards Australia/Standards New Zealand. Wellington: Standards New Zealand; 2006.

Tuck G, T. Polacheck, J.P Croxall and H Weimerskirch. 2001. Modelling the impact of fishery by-catches on albatross populations. Journal of Applied Ecology 38:1182–1196.

Waugh, S.M., G.B. Baker, R. Gales, and Croxall. 2008. CCAMLR process of risk assessment to minimize the effects of longline fishing mortality on seabirds. Marine Policy 32: 442–454.

9 Appendix 1. Species used in the analysis and their species codes

Data for species life-history parameter values were derived from Schreiber and Burger (2002) except where more recent estimates were available through the ACAP species accounts (see www.acap.aq) or from generic values for species groups (Hamer et al. 2002 for seabirds and Perrins et al. 2002 or A. van Helden, pers. comm. for marine mammals).

Table A1. The twenty-five seabird and two marine mammal species were reported in the ERA analysis, and the code used in graphic representation of the outputs.

Common name	Scientific name	Family	Code
Seabirds			
Antipodean Albatross	*Diomedea antipodensis*	Diomedeidae	ANA
White-capped Albatross	*Thalassarche steadi*	Diomedeidae	DCU
Chatham Albatross	*Thalassarche eremita*	Diomedeidae	DER
Buller's Albatross Southern	*Thalassarche bulleri*	Diomedeidae	DIB
Grey-headed Albatross	*Thalassarche chrysostoma*	Diomedeidae	DIC
Southern Royal Albatross	*Diomedea epomophora*	Diomedeidae	DIP
Northern Royal Albatross	*Diomedea sanfordi*	Diomedeidae	DIS
Salvin's Albatross	*Thalassarche salvini*	Diomedeidae	DLS
Buller's Albatross Northern	*Thalassarche bulleri*	Diomedeidae	DNB
Gibsons Albatross	*Diomedea antipodensis*	Diomedeidae	GBA
Light-mantled albatross	*Phoebetria palpebrata*	Diomedeidae	PHE
Campbell Albatross	*Thalassarche impavida*	Diomedeidae	TQW
Kermedec White-faced Storm-petrel	*Pelagodroma marina albiclunis*	Hydrobatidae	KSP
South Georgia Diving-petrel	*Pelecanoides georgicus*	Pelecanoididae	GDP
Northern Giant-petrel	*Macronectes halli*	Procellariidae	MAH
Buller's Shearwater	*Puffinus bulleri*	Procellariidae	PBU
Grey Petrel	*Procellaria cinerea*	Procellariidae	PCI
Westland Petrel	*Procellaria westlandica*	Procellariidae	PCW
Great-winged Petrel	*Pterodroma macroptera*	Procellariidae	PDM
Flesh-footed Shearwater	*Puffinus carneipes*	Procellariidae	PFC
Sooty Shearwater	*Puffinus griseus*	Procellariidae	PFG
Hutton's Shearwater	*Puffinus huttoni*	Procellariidae	PHU
Parkinson's Petrel (Black Petrel)	*Procellaria parkinsoni*	Procellariidae	PRK
White-chinned Petrel	*Procellaria aequinoctialis*	Procellariidae	PRO
Kermadec Petrel	*Pterodroma neglecta*	Procellariidae	PVB
Masked Booby	*Sula dactylatra*	Sulidae	MBO
Marine mammals			
New Zealand sea lion	*Phocarctos hookeri*	Otariidae	NSL
New Zealand fur seal	*Actocephalus forsteri*	Otariidae	SEA

10 Appendix 2. Derivation of species distribution – NABIS outputs

The New Zealand National Aquatic Biodiversity Information System (NABIS) contains data layers on around 40 marine species, defining their annual average distribution and hot-spots of at-sea activity (New Zealand 2008).

In the NABIS system, data layers were compiled by experts with knowledge of the distributions and ecology of a broad group of seabird taxa, supported by data from a variety of sources, including at-sea sightings, fisheries capture locations, satellite or other tracking data. HotSpots of activity for each species, and the areas of annual distribution were defined.

The HotSpots were defined by one of the following: areas around breeding colonies, where there was a considerable concentration of captures for the species, or where concentrations of foraging activity were identified from remote tracking studies. These distributions tended to be ‘conservative’ for species with poor data quality (i.e. HotSpots were likely to be larger than those for which very precise information was available). There was considered to be a reasonable level of consistency in the definition of HotSpots and annual distributions between species, due to the use of a single team of compilers for the data layers (P. Sagar, pers. comm.).

For three seabird species (white-capped albatross, black petrel and great-winged petrel), satellite- or other remote-tracking studies have been conducted subsequent to the creation of the NABIS layers and have indicated larger areas of concentrated use than appear on the current NABIS distributions. Thus there may be some tendency for the NABIS distributions to underestimate the extent of the range for some species.

One species distribution, the southern Buller’s albatross, used in the PSA analysis reported here is included below to illustrate the type of data used to derive species distributions for the study (Figure A2.1). We compared this distribution with distribution for the same species derived from a second database, the BirdLife Global Procellariiform Tracking Database (BirdLife 2008), which relies on the same original set of remote-tracking data (Figure A2.2). This comparison showed that the hotspots defined in the NABIS system equated to roughly the 50% Utility Distributions described by kernel analyses from the tracking data alone. We used a relative weight of 100 as the weighting on all NABIS hotspot areas for all the species we considered in the analyses, compared to a weight of 4.8 for 90% distributions, and 0.2 for the 100% distributions.

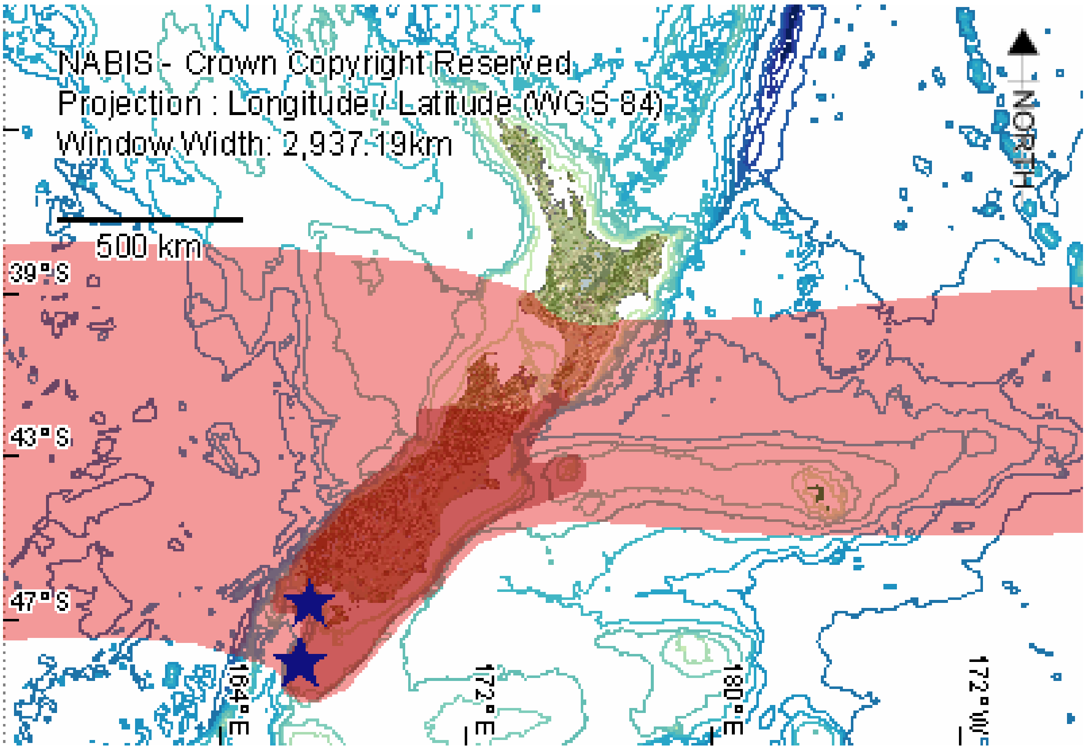

Figure A2.1 Southern Buller's Albatross distribution compiled in the NABIS database layer showing 100% distribution (pale pink), 90% distribution (medium pink) and hot spots (dark pink, mainly in proximity to breeding colonies), as well as breeding colonies (blue stars). Source: www.nabis.govt.nz

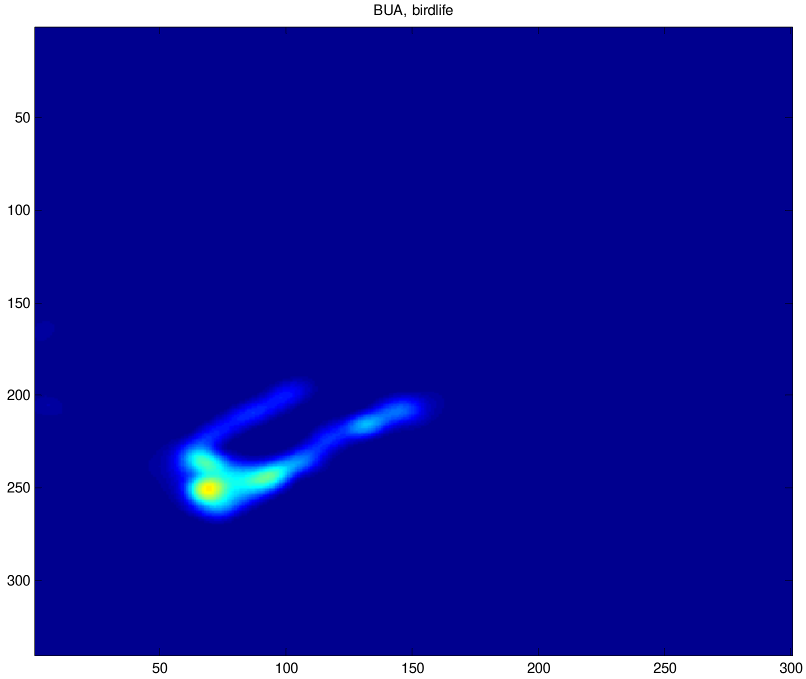

Figure A2.2. Distribution of Breeding and Non-breeding Southern Buller's Albatross from the BirdLife Global Tracking Database outputs (Data Paul Sagar pers. comm.) These data were used to calibrate the density of the NABIS maps, with NABIS hotspots equating to 50% utility distributions of the kernel analysis of the satellite tracking outputs.