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Threats and threat status of the Westland Petrel

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SUMMARY

Threat status assessments provide a benchmark for identifying priorities for conservation and related research for special status species. We review data about an endemic New Zealand seabird, the Westland Petrel *Procellaria westlandica*, and provide information to assist future threat assessment reviews. A range of threats have potential in the future or have already contributed to reductions in population growth at a level that may exceed 10% over 10 yr (ranked High or High Potential threats). The realised (observed) threats include: landslips and extreme climate events degrading nesting habitat; bycatch mortality in commercial, recreational, and high-seas fisheries; attraction of fledglings to lights; and the potential encroachment of pigs *Sus scrofa* and dogs *Canis familiaris* into breeding areas. Low ranked threats (which may contribute < 10% to population reduction over 10 yr) include: habitat degradation by browsing introduced mammals and land development; death of individuals by striking wires or buildings; disturbance at colonies; the petrels' consumption of fisheries waste and plastics; human harvest; and naturally occurring mortality such as predation by native species or entrapment in tree branches and vines. Population size estimation, demographic modelling, and trend information indicate that the population is small (~2,800 breeding pairs) with very low productivity and therefore potential vulnerability to stochastic events. Recent surveys show that the area of breeding habitat occupied by the birds is only about 0.16 km^2. Storm events in 2014 severely reduced habitat quality, destroyed large parts of some colonies, and increased the likelihood of further erosion and landslip, for at least 75% of the global breeding population. Storm impacts at other colonies have not yet been assessed. In light of this information, we recommend immediate review of the threat status of the species, and initiation of mitigation activity to reduce the severity of threats. The information available indicates that a relisting to IUCN Endangered status may be warranted, and that the ACAP threat assessments should be revised to include two high level potential threats: pig predation and dog predation.

ANNEX 1. Waugh and Wilson (in press) manuscript Text.

THREATS AND THREAT STATUS OF THE WESTLAND PETREL *PROCELLARIA WESTLANDICA*

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ABSTRACT

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Threat status assessments provide a benchmark for identifying priorities for conservation and related research for special status species. We review data about an endemic New Zealand seabird, the Westland Petrel *Procellaria westlandica*, and provide information to assist future threat assessment reviews. A range of threats have potential in the future or have already contributed to eductions in population growth at a level that may exceed 10% over 10 yr (ranked High or High Potential threats). The realised (observed) threats include: landslips and extreme climate events degrading nesting habitat; bycatch mortality in commercial, recreational, and high-seas fisheries; attraction of fledglings to lights; and the potential encroachment of pigs *Sus scrofa* and dogs *Canis familiaris* into breeding areas. Low ranked threats (which may contribute < 10% to population reduction over 10 yr) include: habitat degradation by browsing introduced mammals and land development; death of individuals by striking wires or buildings; disturbance at colonies; the petrels' consumption of fisheries waste and plastics; human harvest; and naturally occurring mortality such as predation by native species or entrapment in tree branches and vines. Population size estimation, demographic modelling, and trend information indicate that the population is small (~2,800 breeding pairs) with very low productivity and therefore potential vulnerability to stochastic events. Recent surveys show that the area of breeding habitat occupied by the birds is only about 0.16 km^2. Storm events in 2014 severely reduced habitat quality, destroyed large parts of some colonies, and increased the likelihood of further erosion and landslip, for at least 75% of the global breeding population. Storm impacts at other colonies have not yet been assessed. In light of this information, we recommend immediate review of the threat status of the species, and initiation of mitigation activity to reduce the severity of threats. The information available indicates that a relisting to IUCN Endangered status may be warranted, and that the ACAP threat assessments should be revised to include two high level potential threats: pig predation and dog predation.

Key words: habitat degradation, New Zealand, predation, threat assessment, Westland Petrel

INTRODUCTION

Threat assessments are useful in prioritising conservation activities and research actions related to special status species. All threat assessment methods, however, have short-comings, and are difficult to apply across a broad range of taxa. Species may be of conservation concern but lack the data needed to assess the magnitude of specific threats, or are assumed to be in a healthy status because they are commonly seen or found in accessible localities. In general, seabirds are a highly therefore are vulnerable to stochastic or site-based threats (Ricketts *et al*. 2005). We review information relating to the conservation status of the Westland Petrel *Procellaria westlandica*, a species for which little quantitative population information was available until the 2000s. Recent research has provided the first detailed assessments of the population size, area of occupancy, population trends, productivity, and current and potential threats.

Paradoxically, for a species that nests close to human habitation, within a kilometre of a main highway, and on the mainland of New Zealand, its natural history is poorly known. It was first described as a species in 1945 (Falla 1946). Demographic research began in the 1970s, but was not published in detail until the 2000s (Waugh *et al*. 2006, 2015a), revealing that over that 40 yr period the population at the largest colony had: a) a stable or slightly increasing population (up to 1.8% increase per year), b) high adult survivorship (~95%), and c) low breeding frequency (an estimated 46% of adult birds breed annually). The population size was first assessed using quantitative analyses during the 2000s (Baker *et al*. 2011), although population trends across all surveyed colonies are unknown.

Interactions between Westland Petrels and fisheries were identified as being problematic by the 1990s, when diet and tracking studies revealed frequent interactions with the nearby trawl fishery for hoki *Macruronus novaezelandiae* (Freeman 1998). Soon thereafter, DoC has developed a Threatened Species Recovery Plan (Lyall *et al*. 2004), which identified a range of threats and conservation priorities, though few attempts have since been made to address those threats. A recent, comprehensive review of the threats affecting the species documented actual and potential possible causes of habitat degradation, mortality, and indirect threats to the population (Wilson 2016). That assessment prioritised management and research actions. Here we provide an assessment of the severity and likelihood of the threats, and other information pertinent to a review of the threat status for Westland Petrels. On the basis of threat classification systems of the Department of Conservation (DoC), Agreement on the Conservation of Albatrosses and Petrels (ACAP), and International Union for the Conservation of Nature (IUCN), we recommend up-listing of the species to the endangered category.

METHODS

We reviewed information about the threats to Westland Petrels, from both published and unpublished sources. Using DoC criteria for threat classification (Townsend *et al*. 2008), IUCN assessment criteria for threat status (IUCN 2012), and the threat matrix developed by ACAP (2011, 2014, Phillips *et al*. 2016), we reviewed all available information, presenting an assessment in a format suitable for any upcoming review of the species' conservation status by these agencies. The threat matrix developed by ACAP (2014), modelled on the IUCN threat assessments (2012; summarised in Table 1), ranked threats identified in our earlier publications (Waugh *et al*. 2015 a,b; Wilson 2016). This methodology assesses the scope of each threat in relation to the proportion of the population exposed, and the severity, indicative of the likely reduction in population that would result from the actual or potential threat. The scope and severity were assessed by expert opinion. Threats were ranked as High, where they were considered to have a probability of causing a >10% reduction in population size over 10 yr (High severity) or affect > 10% of the population (High Scope); or low, if their effect was likely to be <10% reduction in population over 10 yr or affect <10% of the population. We added "High Potential", for both scope and severity, where a threat was not known to be operating currently, but had a high likelihood to be evident within a 10-yr time frame. Threats assessed as negligible were likely to be affecting only a very small number of individuals.

We present some demographic data (e.g., breeding success) based on visits to two research colonies, Rowe and Study Colony, 3 times per year during 2014-2016. Pairs with eggs, chicks, and fledglings were identified in marked, lidded burrows, from a total of 8-11 burrows at Rowe and 24-31 burrows at Study Colony each year in which eggs had been laid. Greater numbers of burrows at each colony (n = 50 at Rowe, n = 130 at Study Colony) were monitored in these and previous years, but many were not used by breeding pairs; unfortunately 42% and 27%, respectively, of study nests at the two colonies were destroyed in a major storm in 2014, leading to this small sample size. Breeding success was defined as the number of eggs present in early July that led to fledgling young in September of the same year. Between-colony differences in breeding success were tested using paired t-tests, with $\alpha = 0.05$.

Colonies at which our demographic research was conducted within the Scotsman Creek catchment (42.147°S, 171.339°E; Fig. 1) were resurveyed in 2016 following the methodology of Baker *et al*. (2011). In addition, the colony boundaries were mapped following our transect surveys, once the researchers had a clear understanding of each colony's extent. Mapping was accomplished using Quantum GIS (QGIS Development Team 2016), and results were compared with those defined by Baker *et al*. (2011) based on the end points of all transects that contained burrows in the earlier survey series (Baker, unpubl. data). Two areas covered in 2008-2011 were not resurveyed in 2016 as they presented a risk of landslide, with overhanging, unsupported mud cliffs, or soil cracks indicating possible land movement. The areas that had been subject to landslip in 2014 were partially mapped, including edges safely accessible using GPS points (Garmin GPS Map 64), as well as inaccessible edges estimated based on knowledge of the terrain. The spatial extent of each colony was estimated using the QGIS "identify features" tool to estimate the area of mapped polygons, and does not take into account slope. Data relating to colony extent from 2016 are provisional and included as indicative values to show where slips and changes to colony boundaries have occurred. Further detailed surveys are desirable to confirm these preliminary assessments.

RESULTS & DISCUSSION

We reviewed all available data on population size, area of occupancy, and threats, using those identified by Wilson (2016), with additional demographic information from Waugh *et al*. (2015a). See Table 2 for assembly of terrestrial threats and Table 3 for marine threats.

Species population size

The estimated population size in 2011 was 2,827 breeding pairs in 26 colonies (95% CI = 2,143 - 3,510; Baker *et al.* 2011). The population size assessment from this comprehensive quantitative survey was broadly similar to that provided by more qualitative surveys (Wood & Otley 2013), which estimated 3,000-5,000 breeding pairs in 2005, in 29 colonies. The difference in colony number may be a result of variation in colony boundary definition and does not indicate that Baker *et al.* (2011) missed three colonies, but as Wood & Otley (2012) did not provide accurate maps it is difficult to assess where these differences occurred.

Area of occupancy

The area occupied by the species for nesting is variously reported: 16 km^2 by Lyall *et al*. (2004) and 3 km^2 by BirdLife International (2016), but with no explanation of the method of survey for either record. However the species only occupies a small proportion of the 16 km^2 protected area identified by Lyall et al. (2004), with concentrations of burrows in localised areas (termed: colonies) within a rugged, heavily dissected landscape. The petrel's occupancy of the 16 km^2 protected area is best described as fragmented. Few burrows (perhaps only a few dozens) are found outside the protected area boundaries.

The area of occupancy reported by Wood & Otley (2012) was 73 ha, but this figure is difficult to reconcile with data from GPS mapped transect surveys (Baker *et al*. 2011), in which the total area of burrowed terrain was reported as 0.16 km^2, made up of 26 discrete colonies. Baker *et al*. (2011) reported on the first rigorous and repeatable transect survey, which estimated colony surface areas, and conformed to a recognised survey methodology (ACAP 2011). We consider that 0.16 km^2 is the most robust, global estimate of the actual area of breeding habitat that Westland Petrels occupied in 2011. No subsequent all-colony surveys have been conducted.

Our own GPS mapping and transect surveys conducted in 2016 of four colonies in Scotsman Creek catchment (Study Colony, Rowe, and two others: Middle and Noisy Knob) showed that the petrels occupied 26,860 m^2. Two additional areas that could not be surveyed due to land instability covered an estimated 7,073 m^2. The areas surveyed were comparable to those mapped by Baker *et al*. (2011), and based on our GPS mapping totalled 41,713 m^2. The differences between the Baker *et al.* (2011) estimate and our own survey was 7,780 m^2. This provisional estimate provides an indication of the minimum area of burrowed terrain lost in 2014 as a result of storm damage and attendant land slips at these four colonies (Fig. 1). Aerial surveys by DoC showed that slips and tree-falls occurred across the whole area containing the Westland Petrel colonies (DoC Unpublished data *in* Wilson 2016). Landslips and ongoing erosion remain a concern. Landslips have occurred about once each decade, but prior to 2014 probably impacted just one colony on each occasion (Wilson 2016). Estimates of the population size, the extent of colonies, and density of burrows following the 2014 storm event are needed to assess the stability of the population and its current zone of occupancy. The ongoing erosion caused by landslips and uprooting of trees also needs to be considered when determining the level of ongoing habitat degradation, or if mitigation actions can be put in place to avoid further erosion of nesting areas. More detailed assessments of the survey data and additional surveys are required to provide estimates of the changes in colony size and habitat stability.

Population trends and demographic information

Surveys of burrow density and burrow occupancy were conducted at Study Colony, whose numbers contribute ~27% of the petrel's global population; both measures indicated a slow increase (density at 0.67%/yr during 2007-2014, and occupancy at 0.95%/yr from 2001 to 2014; Waugh *et al*. 2015a). Demographic modelling of mark-recapture data from Study Colony indicated an average increase in population size of ~1.8%/yr since 1970. Key parameters for examining the impact of threats for the species were adult survivorship (0.917 and 0.954 for non-breeding and breeding birds, respectively) and breeding frequency (averaging 0.46 of adult birds breeding in a given year).

The large Study Colony may not be representative of the other, smaller colonies, which may be subject to different predation or habitat quality pressures. Surveys in colonies of different sizes and habitat features are needed. Preliminary analyses indicate that breeding success did not differ significantly in 2014-2016 between Rowe (n = 8-11 pairs, average 0.72 ± SD 0.13) and the Study Colony (n = 24-31 pairs, average = 0.64 ± 0.11), albeit with small sample sizes. Many more nests (n = 50 at Rowe, n = 130 at Study Colony) are currently monitored, but due to low breeding frequency in study burrows (only ~0.33 of burrows are used for breeding; Waugh *et al*. 2015a), few eggs are laid annually. Further, major landslips at both colonies in 2014 reduced the number of study nests dramatically (Waugh *et al*. 2015 b). Other small colonies should be monitored for breeding success. The low breeding frequency across colonies should be monitored to understand why productivity from the species is so low, and to assess the ongoing impact of this on population growth. In addition, site- and pair-fidelity should be assessed to determine if meta-population dynamics might explain the apparent low frequency of breeding.

Threats

In the following sections we detail the threats that have greatest potential to cause mortality and influence population growth rates (see Tables 2 and 3).

Terrestrial threats. The Westland Petrel nests on steep, densely forested hills 20-250 m altitude. Burrows are usually concentrated in areas where the ground is relatively open, with adjacent take-off areas (Waugh & Bartle 2013). This is one of the few petrels that still nest on mainland New Zealand, possibly due to these large birds aggressively resisting attacks from land-based predators.

The breeding habitat was severely impacted by tropical storm *Ita* in 2014, leading to the damage or destruction of up to half by area of those colonies inspected, together containing up to 75% of the breeding population (Waugh *et al*. 2015 b). Surveys to quantify the impacts are needed, with aerial photography showing damage across the entire petrel habitat (DoC, unpubl. data). The most accessible colonies were surveyed for colony area, burrow density, and occupancy in 2015 or 2016, with analysis ongoing. Tropical storm *Ita* occurred prior to the laying period, so only those adults visiting their burrows at the time would have been killed. A variable number of breeding birds night-to-night do visit burrows during the pre-laying period.

It would be beneficial to assess whether birds were killed during the storm. This would obviously increase the population impacts of the event. From our field observations, we consider that it is probable that breeding birds, on the ground at night, were killed in the landslips because these occurred during months when birds attend colonies. We don't have direct evidence that birds were killed, or the time of day that the land damage occurred, and thus can't estimate the mortality. The debris fields have not been accessed to identify any bird remains, as these areas remain dangerous to visit.

One could ask whether birds that were not killed, but which lost their burrows and surrounding segment of colony, could adjust to habitat loss. It seems clear that such long-lived birds could relocate and establish new territories. Indeed, two individual banded birds that had previously bred at a heavily impacted small colony (Rowe) were recovered at the larger Study Colony, some 2 km from their previous nesting areas. However, the impact on breeding frequency for affected birds is likely to be substantial, with up to 50% of the area of at least three major colonies affected by severe erosion (where all substrate was removed), or by uprooted trees destroying or reducing access to burrows. From our observations to 2017, many of these areas have not become accessible to the petrels, as the resulting massive volumes of tree trucks and rotting vegetation completely obstruct the bird's access to the soil, and upturned tree-root systems have removed all substrate in areas. This environment also provides a hazardous landscape in which to land or move about for the petrels. The lowland podocarp forest present in the colonies is composed of canopy trees of around 15 species, each of which can measure 20 - 60 m in height and 1 - 4 m in diameter (Plant Conservation Network 2017); each tree in this sub-tropical rain forest could almost be called an ecosystem, with many hanging vines and epiphytes. The volume of the tree, its foliage, branches and root system, once toppled, is huge, and in the affected colonies we have visited, very large volumes of plant material and soil are disturbed and unable to be used by nesting petrels.

The ongoing nature of the erosion is a cause for concern. The 2014 storm caused severe erosion including part of some colonies being reduced to exposed bedrock. As most canopy trees were removed from the two monitored colonies future heavy rainfall events, common in this region with over 2 m rainfall per annum, are causing further soil erosion, which threatens a significant proportion of remaining burrows. During the 2014 storm, over 200 mm of rain fell in 24 h, but this is not an uncommon event in this region.

We have yet to find any indication that the number of birds breeding at the two closely monitored colonies has increased, due to within-colony movement. Monitoring the response of the population, in terms of the distribution of nests, the nest density, and the breeding frequency and reproductive output of birds, should be a high priority for data collection in the future.

Predation by pigs and dogs remain potentially high-risk threats due to the proximity of these two invasive species to the petrels' nesting habitat. Vagrant dogs have killed petrels at the colonies in the past, and pigs have been liberated nearby by people seeking to establish a pig population for hunting. Dogs killed all Little Penguins *Eudyptula minor* monitored at a small colony 2.5 km from Study Colony in 2016 (K.-J.W., pers. obs.). In 2016, there was an established population of feral pigs within 20 km (J. Washer, pers. comm.; Wilson 2016). Either of these predators has the potential to extirpate entire colonies and should be considered a major threat to the petrel population. Pig invasion is considered more severe than dog predation as pigs are likely to be more pervasive, more persistent, and harder to eradicate than vagrant dogs. Monitoring at Study Colony only is being undertaken on a monthly basis by DoC to check for the presence of these introduced species (S. Freeman, pers. comm. in February 2017), but additional solutions, such as fencing, toxic bait stations, or management of buffer land to avoid the arrival of pigs and dogs should be implemented without delay. These threats remain the most pervasive and potentially destructive that we have documented.

The attraction of petrels to lights at night (also called fallout; Rodrigez *et al*. 2017), and striking of powerlines may be important threats for the species. The fallout of fledglings appears to lead to a higher mortality than powerline collisions. These are assessed as being of low risk, with unquantified scope for fallout, as the extent of mortality is unknown (Wilson 2016). Awareness-raising among the local residents is ongoing (Wilson 2016, Westport News 2017) so that many downed petrels may be recovered and released. However, robust planning of housing or industrial development, and enforcement of standards around lighting and structures, are necessary to avoid mortalities from these sources increasing.

Human harvest may have occurred since 2010 (Wilson 2016), and it is unknown whether unauthorised visits to monitored colonies were by curious local residents, or to harvest birds at the end of their fledging period. Equipment used to extract chicks from burrows was found at Study Colony in 2011. Ongoing monitoring, for example by surveillance cameras, is warranted to assess whether unpermitted access is occurring. As this threat affects only the most accessible (albeit, large) colonies, and is not likely to cause a >1% per annum population decline, it is assessed as low severity and low scope.

Other important but low-severity threats that are likely to affect the entire population (therefore having high scope) include browsing by introduced goats *Capra hircus* and brushtail possums *Trichosurus vulpecula*, reducing plant cover and increasing erosion potential. Goat trampling creates holes in burrows, and can increase access to nestlings for the native, but predatory, weka *Gallirallus australis.* Predatory introduced mammals sighted in and around the colonies during 2010-2016 include brushtail possums, stoats *Mustela erminea*, and rats *Rattus* spp., but breeding success (ca. 65% of eggs laid fledge chicks; Waugh *et al*. 2015 a, this study) suggest that their presence may not hinder breeding success at Study Colony. The effects of these predators and browsers at smaller colonies are unquantified.

“Naturally occurring” sources of mortality that may affect adult survival are the entrapment of adult birds in tree branches and vines, which kills a few birds at monitored colonies each year. Pathogens, and soil loss through the birds burrowing activities are considered low risk threats in both severity and scope. Human impacts on the colony, through visits by researchers and tourists are monitored, and while potentially damaging are managed through strict controls on access.

Marine Threats. Bycatch remains an important threat to Westland Petrel throughout its range in both breeding and non-breeding periods. It potentially affects all breeding stages and age-groups, so is considered of high scope. Fishing mortality occurs throughout the foraging range during breeding, April - October (Richard & Abraham 2015), and probably in their non-breeding range off South America, November - March (Landers *et al.* 2011, Brinkely *et al.* 2000; see below for more details). These fishing mortality threats are considered to be high risk, and due to their potential to increase adult mortality could lead to a decline of the population of >1%/yr (Tuck *et al.* 2001). Adult survivorship modelled for the Westland Petrel population differed between breeding and non-breeding birds, which are birds that had breed at least once but not engaged in breeding in a particular year. Non-breeders showed significantly lower survivorship (0.917) compared to breeders

(0.954; Waugh *et al.* 2015a). One possible explanation is that the non-breeding birds spend more time in a particular environment than breeders, either when they are in the out-of-breeding migration or when in New Zealand waters, and are exposed to factors that reduce their survivorship, such as high fishing mortality or low food availability. We therefore do not exclude the possibility that fishing mortality could have a significant impact on the species, to the level of 4%/yr on average, and higher in some years (Waugh *et al.* 2015).

The species feeds mainly within 200 km of the coast around central New Zealand during the breeding season (Landers *et al*. 2011). During the non-breeding season, they migrate to South America waters, where they occur as far north as Peru (Brinkley *et al*. 2000) and as far south as Patagonia (Landers *et al*. 2011). Westland Petrels are strongly attracted to fishing vessels and feed readily on baits and discards (Freeman & Smith 1998, Freeman 1998, Freeman & Wilson 2002). They may be captured in a range of commercial, artisanal, and recreational fisheries. Assessment of the likelihood of capture by New Zealand commercial fisheries indicates that trawl, bottom longline, and surface longline total 88 (95% CI = 37-183) fatalities annually (Richard & Abraham 2015). The species is considered to be at High Risk of adverse population effects from New Zealand commercial fisheries (Richard & Abraham 2015), ranking 10th among 80 species assessed. The level of capture in non-commercial New Zealand fisheries and fisheries outside of New Zealand is unquantified.

Other marine threats assessed to be of lower severity and scope include the possibility that storms are predicted to become more extreme in scale and more frequent (Rhein *et al.* 2013), and may lead to further erosion at breeding colonies. Through changes in the marine environment, storms may reduce foraging returns for breeding petrels (high potential severity and scope). Changing fisheries practices may lead to a reduction in food supply, with the petrels frequently feeding on discards from trawl fisheries during the breeding period. The possible impacts of future changes are unquantified, but may affect a large proportion of the population. These impacts remain potential and require complex data to interpret, but should be considered for future fishery-management and petrel threat assessment research. Plastic ingestion or entanglement has not been noted for Westland Petrels at their colonies to date, and is rated as low severity, but has high potential scope. Storm wrecks were assessed as having negligible severity, and low scope, as very few mortalities have been reported for Westland Petrels, while other species, such as prions *Pachyptila* spp have been heavily impacted by storm events in recent years in southern New Zealand (Miskelly 2011a, b, cited *in* Jamieson *et al.* 2016).

Threat assessments

Threat assessments for the species were undertaken by DoC in 2016 (Robertson *et al*. 2017), and a review was instigated of the IUCN Redlist in 2016, both within reviews of multiple species. These assessments are useful in providing a generic overview of conservation and research priorities when applied to many different taxa. As such, they may have limited scope in assessing the specific circumstances of particular species. For example, those with particular life-history traits, or particular spatial distributions may have additional vulnerabilities, not well captured by one-size-fits-all classification systems (Master *et al*. 2012).

Our analysis points to several threats that may result in population declines for Westland Petrel, and which are not included in threat assessments completed before 2017. Information used in these generic threat assessments relating to population distribution and size is out of date. This may influence the level of severity of threat recognised for the species. A final factor to consider is the potential threats to the species from two introduced predators – dogs and pigs – that have strong potential to quickly decimate the Westland Petrel population. While neither currently (in 2017) occur within the petrels' breeding colonies, both could reach the colonies unobserved at any time. The threat classification systems and conservation priority setting systems appear to deal poorly with potential threats, as opposed to measured or observed threats, regardless of how serious they may be.

Department of Conservation threat classification. A review of the national threat classifications (Townsend *et al*. 2008) for New Zealand seabirds was conducted in 2016 (Robertson *et al*. 2017). The information available in July 2016 was reviewed, excluding detail provided by Wilson (2016). The DoC panel recommended that the threat assessment of At Risk, Naturally Uncommon be retained for the species.

IUCN threat assessment. The latest review of the threat status of Westland Petrels undertaken in 2016 (IUCN 2017) reused information from the 2012 assessment, without incorporating more recent information, and listed the threat status as Vulnerable. Based on our assessment of a revised area of occupancy (0.16 km^2) and significant ongoing degradation to the habitat, we submit that a revision of the threat status from Vulnerable to Endangered is warranted (IUCN 2012). This assessment is on the basis of criterion B (<500 km^2 of occupied area), B2a (fragmented occupancy, with 20 or more colonies totalling 0.16 km^2 within the single site), and 2biii (ongoing decline of habitat quality due to erosion at the slips and windfall sites documented following the 2014 storm). Data required to provide a population trend assessment are currently lacking, and should be a high priority.

ACAP threat assessment. The information presented herein has been assessed according to the ACAP threat severity and scope matrix (ACAP 2014). This information was presented in summary for all ACAP species by Phillips *et al.* (2016), but the information herein is more up-to date and accurate. Our assessments using the ACAP system are presented in Table 4. We included three terrestrial threats that present observed or potential risk to the population stability, at a severity level of High (Table 2). Two of these most severe threats relate to potential predation by dogs and pigs.

Some threats are known to kill 10s to 100s of individuals annually (e.g. fallout, fishing mortality), or adversely affect the breeding habitat (storm damage and ongoing erosion of nesting substrate at major breeding colonies).Currently, however, the data required to assess the impact of these threats to the petrel population are lacking to enable these to be included in the ACAP assessment.

CONCLUSIONS

We conducted a comprehensive review of the threats affecting the endemic Westland Petrel, restricted to breeding at one locality on the mainland of New Zealand. Our review showed that a number of threats have not been considered in the existing threat classifications for the species, prompting the need for reviews of the Westland Petrels threat status under the DoC, IUCN, and ACAP systems.

On the basis of the information reviewed, we suggest that the ACAP species threat assessment warrants revision, with some evidence of minor human take in the last five years, extensive degradation of limited breeding habitat, and potential predation all posing population level impacts. Indeed, the extinction risk of species occupying a single site is particularly high (Ricketts *et al*. 2005), with conservation action needed before these species reach the brink of extinction.

The New Zealand threat classification system places little priority on species that number >5,000 mature individuals, ranking the Westland Petrel as At Risk, Naturally Uncommon --- 7^{th} of the Threatened or At Risk categories of threat, and just one rank above “Not Threatened.” At a national scale, with many pressing priorities for conservation and species recovery, this ranking may be understandable. At a global scale, however, New Zealand has more threatened endemic seabirds than any other nation (Croxall *et al*. 2012). At an international scale it is irresponsible to wait until a species declines to <5,000 individuals, or suffers a 10-30% decline --- the criteria for up-listing to a more severe conservation status, before increasing its priority for monitoring, research, or recovery. The risk of allowing for a population to decline to such small numbers, for a species such as a petrel, which is long-lived and has slow population growth, increases the possibility of stochastic events leading to rapid population declines and problems associated with genetic bottlenecks negatively affecting the population productivity (Briskie & Macintosh 2004, Jamieson 2011).

The resources required for estimating population changes, range contractions, or habitat degradation, are difficult to obtain. Thus many important conservation priorities may be overlooked and remain undocumented for this species. An important aspect of the current knowledge base for Westland Petrel is that baseline estimates of population sizes have only recently been established, and further work is needed to understand whether the populations are stable, declining, or recovering. With good baseline surveys completed in 2011 for this species, the research and conservation management groups are in a good position to secure the species recovery to non-threatened status, using an evidence-based approach. We commend efforts to improve the knowledge base for this species, and encourage resource managers to continue the good work started 10 years ago, by completing repeat surveys and investigating locals where potential threats may be operating. It is crucial that we move beyond the “ambulance at the bottom of the cliff” approach, and create appropriate resource monitoring frameworks for the threatened and endemic wildlife of New Zealand.

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ANNEX 2. Waugh and Wilson (in press) manuscript Tables.

TABLE 1

Risk assignment criteria based on likelihood and consequence of threats as used by ACAP[a]

		Scope (% population affected)	
		High (11 – 100%)	**Low (1 – 10%)**
Severity (likely % reduction of affected population within ten years)	High (11 – 100%)	High & High Potential Unquantified	Low
	Low (1 – 10%)	Low	Low

[a]Definition of Scope and Severity follow those set out in ACAP (2016). Scope indicates the percentage of the population potentially affected by the threat and severity indicates the percentage of reduction in the affected population within 10 years, as a result of a current or potential threat.

TABLE 2

Assessment of terrestrial threats to Westland Petrels considered to be at such a level to affect the survival of individuals, colonies, or to influence breeding habitat or feeding opportunities [a]

Terrestrial Threat	**Severity**	**Scope**	**Notes and References**
Predators (feral pigs)	High potential	High potential	Pigs have the ability to extirpate whole colonies or at worst the whole population. Feral populations currently occur about 20 km north of the Petrel Colonies, they may arrive at any time and on occasions during the last 20 years have been released by hunters close to the petrel colonies.
Predators (vagrant dogs)	High potential	High potential	Dogs have entered the petrel colonies infrequently over the last 20 years and killed petrels, but could invade at any time, with Punakaiki village only 2.5 kilometres from the colonies.
Landslide and windfalls leading to erosion of nesting substrate	High	High	Likelihood increased by storm damage in 2014, with erosion fronts currently at the periphery of major colonies leading to ongoing erosion of nesting areas (Waugh *et al*. 2015b).
Habitat damage by introduced mammals	Low	High	Possums and goats always present, degrading breeding habitat & destroying burrows
Predators (weka, possums, stoats, rats)	Low	High	Weka, possums, stoats and rats are all present at breeding colonies but do not appear to be affecting the colony dynamics in measurable ways.
Land development (mining, farming, housing)	Low	High potential	Currently land development adjacent to the colonies is not planned but development and changes in land use on and adjacent to flight paths remains possible. There is some housing intensification on the margins of the Specially Protected area.

Attraction to lights (fallout)	Low	Not quantified	Each year some young petrels are found grounded, near lights in Punakaiki and other West Coast settlements. Mitigation, low light levels and recovery and release of grounded birds may assist in reducing numbers of birds affected. There are restrictions on lighting in nearby Punakaiki village and developed areas near some flyways. The frequency is moderate, with birds recovered most years, but with high uncertainty around the numbers of individuals affected.
Powerline strikes	Low	Low	Mitigated by underground wires across the major flight path, but wires remain across all secondary flight paths.
Harvest (Human take)	Low	Low	Mitigated by restricted access, but occasionally appears to affect > 20% of chicks in monitored colonies. If unchecked this could lead to a > 10% reduction in population growth over 10 years, but is unlikely to be carried out at this severe level without being reported.
Tree captures	Low	Low	A natural threat affecting adults of breeding age, but ongoing at a low level annually.
Pathogens, parasites	Low	Low	Not identified for Westland petrels, although the potential exists.
Soil loss through burrowing	Low	Low	Ongoing occurrence of a natural process resulting from the birds nest building activity.
Human disturbance & trampling	Low	Low	Mitigated by restricted access.

[a] All threats are discussed in Wilson (2016) or Waugh *et al.* (2015a or b) except where otherwise noted. Threat levels are aligned to those described in Table 1, and are listed as High, High potential, Unquantified, Low, Negligible severity and scope.

TABLE 3.

Assessment of marine threats to Westland Petrels [a]

Marine Threat	Severity	Scope	Notes and References
Bycatch in commercial fisheries, NZ EEZ	High	High	Analyses for the Ministry for Primary Industries (Richard & Abraham 2015) place the species 10th most likely to suffer adverse population effects as a result of commercial fishing within the New Zealand Exclusive Economic Zone, with "High" risk ranking.
High-seas and out of NZEEZ fishery captures	Un-quantified	High	Possibly occurring during non-breeding migration, although data relating to Westland Petrels are sparse, capture of *Procellaria* petrels is common in the areas occupied between breeding seasons.
Bycatch in recreational fisheries	Un-quantified	High	The level of capture in recreational and customary fisheries within New Zealand waters is unknown, but some band returns from fishers indicate mortality occurs.
Climate change and consequent changes in the marine environment	High potential	High potential	May increase difficulty in finding food.
Fishery discards as food source	Un-quantified	High	Fishery changes within the Petrels foraging zone could lead to reduced chick production, but is unquantified. Analyses of the influence of fishery activity and climatic influences on diet indicate that climate has the greater influence (Waugh *et al.* unpublished data).
Plastic entanglement or ingestion	Low	High potential	No plastics have yet been reported in diet samples collected 20 years ago (Freeman 1998) nor have plastic debris been observed at the colonies. However, as the incidence of plastics in areas occupied by the Petrels will increase, the threat to the birds will

			increase.
Storm wrecks	Negligible	Low	Not considered to impact on Westland Petrel populations adversely at current levels, with no Westland Petrels observed killed in extensive storms that occurred in 2011 (Miskelly 2011a, b *in* Jamieson *et al.* 2016).

[a] Details as for Table 2.

TABLE 4

Suggested revision of threats for the ACAP assessment (ACAP 2011) showing a summary of known threats causing actual or potential population level changes of greater than 10% over 10 years at the breeding site of the Westland Petrel [a].

Breeding Site	Human disturbance	Human take	Natural disaster	Parasite or Pathogen	Habitat loss or degradation	Predation by alien species	Contamination
2008 assessment (ACAP 2011)	No	No	No	No	No	No	No
2016 assessment (This study)	No	Occurring but No [b]	Yes [c]	No	Yes [c]	Yes [d]	No

[a] These ratings are based on the assessment of threats in this study, and those described in Wilson (2016), and Waugh *et al.* (2015a).

[b] Human take is suspected to have occurred in the past 5 years with burrow lids removed at 2 monitored colonies and muttonbirding equipment found at one colony

[c] Habitat loss through landslips and windfall of trees has resulted in the loss of breeding habitat, reduction in habitat quality and some adult mortality at two major colonies, with ongoing erosion at these and other

[d] There is a strong potential threat of dog and/or pig predation.

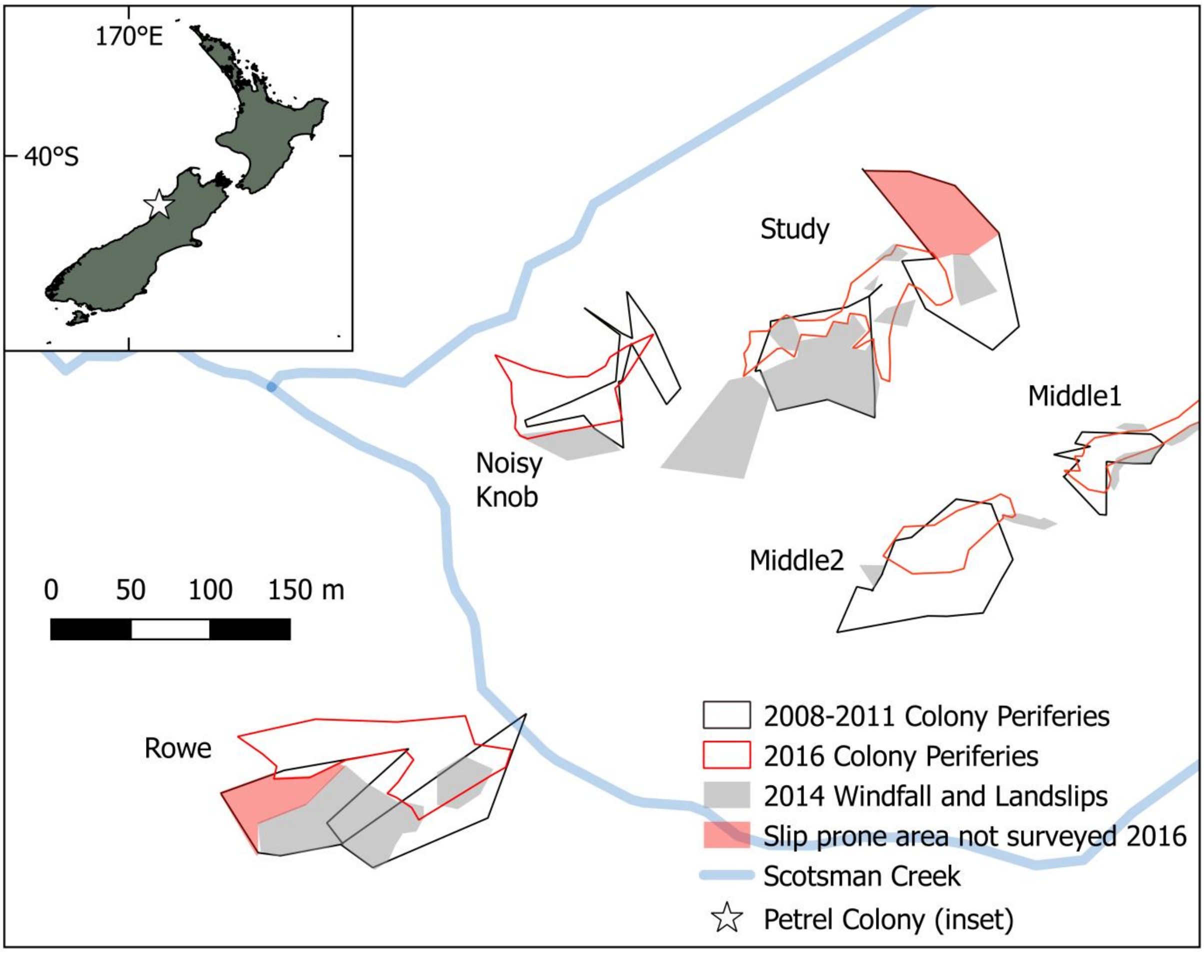

Fig. 1. Westland Petrel colonies in the Scotsman Creek Catchment (star on the inset map) mapped with GPS in 2008-2011 (black peripheries) by Baker *et al*. (2011) and in 2016 (red peripheries (this study, S. Waugh unpubl. data). The areas shown in grey shading are those that contained burrows in the 2008-2011, or earlier surveys, and were affected by landslips, erosion, and tree windfall following tropical storm *Ita* in 2014. No burrows or soil remain in these areas. Two areas (red shading) have not been eroded but were not surveyed in 2016 as they are considered too unsafe to enter due to the risk of landslips.