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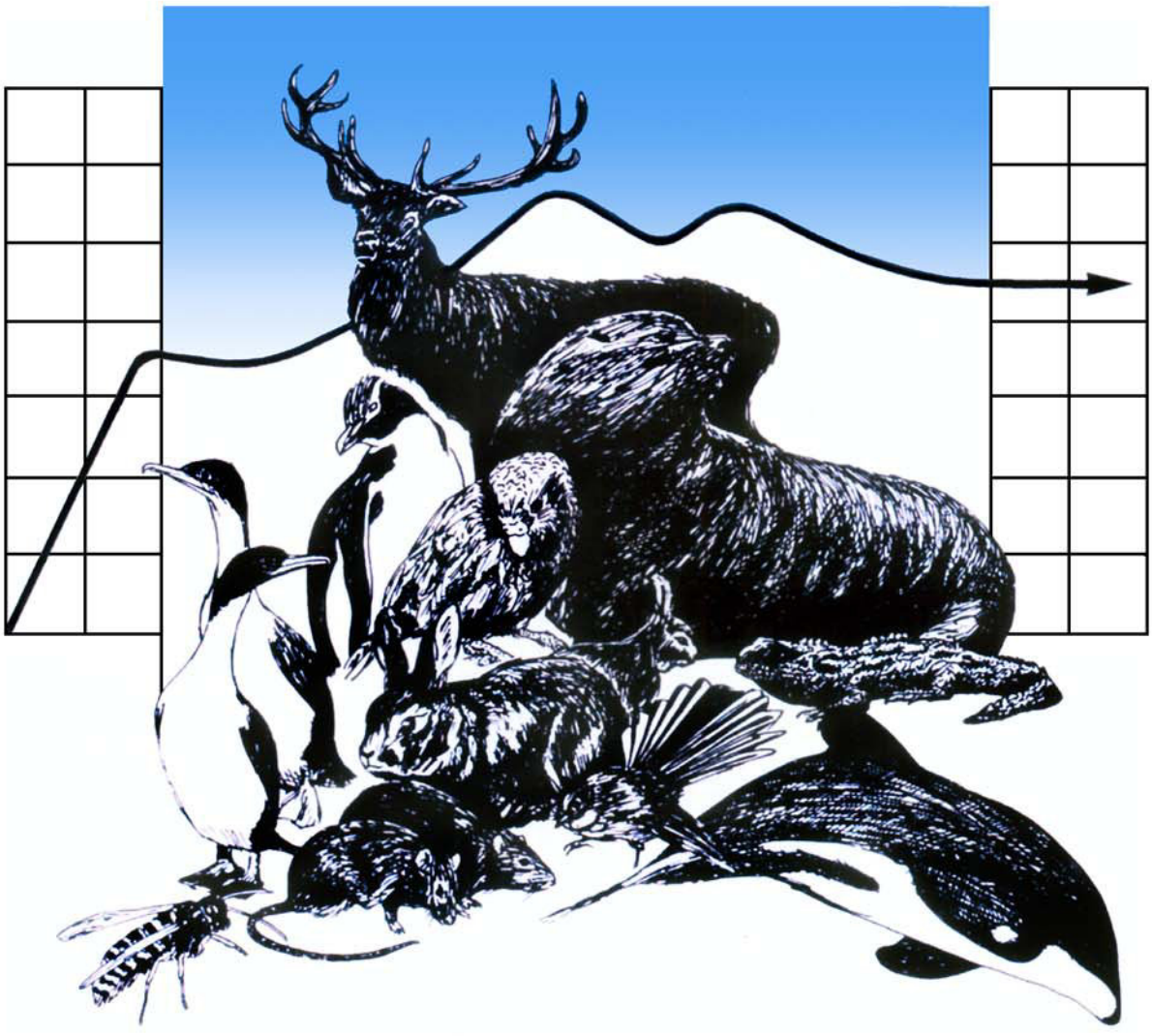
Te Whare Wānanga o Otāgo

NEW ZEALAND

DEPARTMENT OF ZOOLOGY



WILDLIFE MANAGEMENT

Distribution of Yellow-eyed Penguins (Megadyptes antipodes) on the Auckland Islands

November-December 2009

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A report submitted in partial fulfilment of the
Post-graduate Diploma in Wildlife Management

University of Otago

2010

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WLM Report Number: 235

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Report submitted in partial fulfilment of the requirements for WILM403: Practice of Wildlife Management.

March 2010

Word count: 11,169

EXECUTIVE SUMMARY

New Zealand's subantarctic islands have long been considered the stronghold of the yellow-eyed penguin (*Megadyptes antipodes*, YEP). In spite of this, little research has been done on the subantarctic populations, especially in the uninhabited Auckland Island group. Because of the recently identified unique management status of subantarctic YEPs, more baseline data is needed on this population. This document reports on the first comprehensive distribution survey of YEPs in the Auckland Islands beyond Enderby.

A team of six observers worked in the Auckland Islands from November 10 to December 1 2009, walking as much accessible coastline as possible to determine the range of YEP in the Islands. A previous survey in 1989 was restricted primarily to the northern and southern areas of the Island group and suggested that the eastern inlets could also have penguins. Hence these eastern bays were of particular interest during the present survey. Observers worked in pairs, searching the shoreline for evidence of YEP landings, such as faeces, scratch-marks, footprints and sightings of penguins. Accessibility in the eastern region was greater than anticipated, so that time was available to also search four further areas: Carnley Harbour, Adams Island, the Port Ross area/north coast and the northern islands (with the notable exception of Enderby). Other activities during the expedition included morning beach counts and a trial of nest searching.

During morning beach counts, 15 of 22 landings identified by observers were seen to be used by YEP. However a further 27 landings were identified during beach counts that were missed by observers during ground searches, which suggests that the total number of landings found is an underestimate and should be considered a minimum. In total, 306 YEP landings were identified. The northern islands and Adams Island appear to have the highest density of YEP landings, with 4.14 landings/km and 2.87 landings/km searched respectively. Both these regions are free of introduced predators, in contrast to the three other areas surveyed on the main Auckland Island. Localities with particularly

high densities of landings were Ewing Island, Frenchs Island, North Harbour, an unnamed bay south of Deep Inlet, and the north coast of Adams Island. Geographically, YEP appear to be clustered in the north and south of the island group, with fewer landings found in the eastern inlets and the upper reaches of Carnley Harbour.

This survey achieved better than expected coverage and as a result there is now a much better understanding of the distribution of this discrete YEP population. This knowledge will be informative for any future research and management trips to the Islands with the goal of working with YEP. In particular, when/if funding becomes available to complete a population survey, this report can help focus the aim of that expedition on areas where YEP are known to live, rather than wasting valuable resources monitoring uninhabited bays.

The key recommendation for future research is to focus survey efforts on areas where the highest densities of landings were found on this trip. Time and money spent in areas where few or no penguin landings were recorded will not be effective. Regarding management of this population, the results from this distribution survey suggest that there are differences between the main Auckland Island and outer islands that affect the densities of landings (and therefore penguins) that are found there. Eradication of predators from the main island could be a goal for YEP management. Finally, a possible population survey method is proposed based on nest-searching the areas were YEPs appear to be present in the highest densities, around the north and south of the Island group.

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1. INTRODUCTION

Under Department of Conservation (DOC) guidelines, the Yellow-eyed penguin (*Megadyptes antipodes*, hereafter hoiho or YEP) is classified as a nationally vulnerable species (Hitchmough et al. 2007, Miskelly et al. 2008). This classification reflects the instability in population numbers and susceptibility of the species to human induced impacts such as habitat destruction, introduced predators and disturbance by unregulated tourism (Moller & Alterio 1999, McClung et al. 2004, Ellenberg et. al. 2007, Hitchmough et al. 2007). Presently YEPs are known to breed at 51 sites on the New Zealand mainland (M. Young pers. comm.), Stewart and outlying islands, and the subantarctic Campbell Island and the Auckland Islands group. Total population estimates (including the subantarctic) number around 5000-7000 individuals (DOC 2009), but in reality very little is known about the subantarctic populations. YEP on Campbell and the Auckland Islands are assumed to be the stronghold of the species despite (in the Auckland Islands at least) never having had a full survey or regular monitoring (Moore 1992, McKinlay 2001).

Relative ease of accessibility and historic population declines (prior to 1980), mean that mainland hoiho (particularly on the Otago Peninsula) have been thoroughly studied in relation to diet, reproduction, foraging, habitat requirements, susceptibility to predation, climatic variation and tourism impacts (Darby & Seddon 1990, van Heezik & Davis 1990, Moore & Wakelin 1997, Moller & Alterio 1999, Moore 1999, Peacock et al. 2000, Ellenberg et al. 2007). Indeed these papers represent only a selection of the available literature. By comparison the publicly available literature on YEP on Campbell and the Auckland Islands is scant at best, although some research is in development (Young and Argilla, unpublished data). Geographic isolation has hampered efforts to collect data about the subantarctic hoiho, especially on the Auckland Islands where there has never been permanent long-term habitation by researchers. Previous surveys have usually been tied in with other species or management work and restricted only to Enderby Island, with one-off study in 1989 of some northern parts of Auckland and Adams Islands, Tagua Bay and some of the smaller islands (Moore 1990, Moore 1992, Young and Argilla unpublished data). In terms of conservation management, the lack of information available concerning hoiho on

the Auckland Islands is problematic for the species as a whole; a baseline understanding of Auckland Island hoiho is necessary as part of the overall species recovery plan. The need for this baseline data is pertinent now because of the potential threats facing the birds. Specifically, global climate change (Peacock et al. 2000), increased tourism (McClung et al. 2004, Ellenberg et. al. 2007) and/or fisheries disturbance (Moore & Wakelin 1997) and the presence of invasive predators (Moller & Alterio 1999) are all plausible candidates for negatively impacting the subantarctic YEP population in some way. Furthermore, recent research by Boessenkool et al. (2009a-c) has established the subantarctic hoiho (and particularly those on the Auckland Islands) as having significant genetic value and negligible rates of migration with their mainland counterparts, which necessitates the establishment of baseline monitoring in order to better understand their ecology.

1.1 The genetic importance of subantarctic YEPs

It has been known for some time that subantarctic and mainland hoiho are distinct genetically (Triggs & Darby 1989). However until recently, the YEP population found on the mainland was considered to be the remnant of a much larger population (Moore 1992). This theory was dispelled in recent papers produced by Sanne Boessenkool and colleagues (2009a-c). It had been suspected for some time that the mainland and subantarctic YEP populations did not readily mix, but using novel analysis of ancient DNA, Boessenkool et al. (2009a) provided evidence that mainland hoiho were in fact relatively recent colonisers of the South Island. Boessenkool et al. (2009a) propose that historically mainland YEP populations would have been virtually absent while a sympatric species, *Megadyptes waitaha*, would have dominated a similar ecological niche. The authors suggest that following Polynesian settlement, *M. waitaha* was rapidly exploited for food and went extinct within a few hundred years. This would have allowed for the range expansion of YEPs from the subantarctic. Evidence for this comes from discrepancies between the ancient DNA and morphometric measurements of penguin bones from middens dated 500 versus 100 years ago. The paper concluded that all mainland hoiho were probably descended from a group of subantarctic colonisers.

This idea was further established by another 2009 paper showing not only are mainland (including Stewart Island and surrounds) YEPs genetically distinct from subantarctic YEPs, they also appear to have less total genetic variability than their southern counterparts, indicating that the founding group was probably small (Boessenkool et al. 2009b). It was shown that subantarctic hoiho have 18 alleles unique to their genotype, while the South Island birds only have 2 unique alleles (which were also extremely rare within the sample). The subantarctic population – and the Auckland Island subpopulation in particular – also has greater levels of heterozygosity (Triggs & Darby 1989), which is generally considered indicative of a healthy population with low levels of inbreeding (Scribner et al. 2006). Ultimately, because of their more diverse genetic status, subantarctic hoiho represent the greatest evolutionary potential for any group of hoiho alive today (Boessenkool 2009c). It was suggested by Boessenkool et al. (2009b) that the differences in these two populations are marked enough that the two locations should be considered independent management units. This finding has important implications for the overall conservation and management of hoiho; it is not the first time such a situation has arisen in New Zealand species conservation. For example the Tokoeka species of kiwi (*Apteryx australis*) was split into four distinct management units after genetic research found considerable differences between geographically independent populations (Burbidge et al. 2003, Shepherd & Lambert 2008, Holzapfel et al. 2008). Similarly, the findings of Boessenkool et al. (2009) suggest that gene flow between the South Island and subantarctic populations is minimal (effectively nil) and the difference between populations is large enough that they should be considered functionally separate, requiring independent management. Boessenkool et al. (2009) supports McKinlay (2001) by reiterating the necessity of a survey of the subantarctic population, especially on the Auckland Islands, given that present data is *"either incomplete or out of date"* (p. 2399).

1.2 What is already known at the Auckland Islands?

The existing knowledge of YEPs in the subantarctic is relatively poor when compared with those living on the mainland; this is especially true of the Auckland Islands (Moore 1992). Since subantarctic hoiho now warrant

independent management unit status, baseline data of the subantarctic populations is urgently required. Research and monitoring trips to the subantarctic are expensive and require considerable resources in terms of expertise and technical support (because of often adverse working conditions). Because of this, reports on YEPs in the subantarctic are few and far between.

The early work was conducted by Peter Moore of DOC and associated colleagues (Moore 1990, Moore 1992). At the end of 1989 Moore spent approximately five weeks mainly in the northern part of the Auckland Island group, conducting beach counts of YEPs at landing sites along the north coast of the main Auckland Island, Tagua Bay, and on Enderby, Ewing, Rose and Adams Islands. After adjusting for likely landings outside of survey times, and pairs without a daily rotational routine, Moore suggested that around 470 breeding pairs were living in the area covered by the survey. He goes on to note that the unsurveyed eastern coast of the main island has many bays that could accommodate YEPs and "a very conservative estimate would be perhaps another 100 pairs, raising the Auckland Islands total to 520-570 pairs" (p. 12). Moore himself labels the 1989 survey as "brief and incomplete" and "provisional", a view reiterated in the current species recovery plan (McKinlay 2001). Based on experiences with a similar survey on Campbell Island, Moore suggests that his data is likely to be an underestimation of the true population number. He concludes that "Further surveys are needed." According to the current Hoiho Recovery Plan, Moore's twenty year-old recommendation for further surveys were yet to be acted upon (McKinlay 2001). The present survey should go some way toward rectifying this, at least by confirming the presence/ absence of hoiho around the rest of the Auckland Island coastline.

1.3 Aim of the present expedition

Our expedition aims to complete the first comprehensive survey of the distribution of hoiho on the Auckland Islands beyond Enderby Island. Before actual population number can be estimated such as Moore called for, we need to know exactly where hoiho are found throughout the islands. Once this is established, an estimate of density (ie. population estimate by nest counting) can be a subsequent goal. This data is a crucial input for hoiho management; as

observed by the current DOC hoiho recovery plan, *"Data on abundance and population trend are still lacking for Stewart Island and its outlying islands, and the main Auckland Island. Completion of survey work and establishment of basic monitoring would provide a clear picture of the national status of hoiho and, in the case of these islands, a baseline for future comparisons of abundance"* (McKinlay 2001 p. 15). The present distribution survey was based upon searches of accessible shoreline to determine where YEP landings can be found. Primarily using indicators of presence (birds, tracks, faeces, scratch-marks etc.) we aimed to survey as much coast as conditions allow so that the distribution (presence/ absence) of YEPs in the Auckland Islands can be accurately recorded. This will provide the basis for a future survey of abundance ie. a true population density survey by nest counting in areas where YEP are known to live.

2. METHODS

2.1 Expedition structure

The survey was completed over 21 days of fieldwork at the Auckland Islands (between 50° 29' and 50° 56' S and longitude 165° 52' and 166° 22' E) during November 10 and December 1 2009 (see Appendix 1 for details). Based on the small amount of previously recorded presence/absence information on yellow-eyed penguins in the Auckland Islands (and as the accessibility of coastline was largely unknown), the islands were searched following a prioritised route: eastern bays and inlets (high priority); Carnley harbour and Adams Island (medium priority); north coast, Port Ross and outlying islands (lower priority). No attempt was made to search other areas of the islands, notably the west coast of Auckland Island and south coast of Adams Island where tall cliffs dominate the landscape. Enderby Island was not surveyed either as YEP there were monitored in the previous summer.

The expedition team of eight was comprised of six observers and two boat crew members. The observers had a range of backgrounds and experience working with hoiho, coming from the Department of Conservation (JH, JL, CL), the Yellow-eyed Penguin Trust (SK, LT) and the University of Otago (KB). The chartered vessel for the trip was *Tiama,* a 50-ft steel hulled yacht designed and equipped for working in high-latitude conditions.

2.2 Searching for landings

The accessibility of coastline was assessed using binoculars from *Tiama*. Areas of coast accessible by foot (and therefore deemed possible for YEPs to land) were searched methodically with observers walking in teams of two. In some areas, especially at high tide, walking directly on the coast was not feasible so teams walked further (20-40m) upshore, usually through scrub or rata forest. In a small number of areas not accessible by foot or where good visibility allowed, landings could be located while a team cruised past in an inflatable naiad-type tender. For the purposes of this trip, a landing was defined as the point of access to land, above the high-tide mark.

Where initial sign indicative of penguins (for example, scratches or a track) was observed, this would be followed up to obtain a second type of sign

(such as faeces or footprints). Where other species were not implicated (such as scratches from pigs or sea lions, faeces from other birds), the site would be recorded as a landing. Landings within 20m of another landing were recorded as one. All landings were recorded with a hand-held GPS unit, as well as co-ordinates being noted in a log-book with a general description of the site including the type and amount of sign seen, vegetation, slope, aspect, terrain and other wildlife present. Generally sign was not followed until a nest was found, although nests within 25-30m of the landing were often noted opportunistically. The survey dates corresponded with the late egg incubation/hatching stage where it is expected one adult will be in attendance of the nest at all times.

In other areas where the coast was inaccessible (with overhangs, bluffs, or at high tide) searching was conducted inland and any penguin sign noted and attributed to the nearest possible landing site. At all times the search teams were using an active track function (and recording start/stop times) on their GPS to allow for search effort to be recorded and mapped.

Bluffs or cliffy areas deemed too steep for penguin access were not searched by walking or from the water and were recorded as 'not searched'. It is almost certain that a small number of landings were missed in these areas, however the excessive effort and risk required to search these sections would have quickly consumed the limited time available so the decision was made to focus on areas that could be reliably searched. Similarly there are some areas of coast that would likely have had YEP landings but sea/weather conditions meant putting a search team ashore would be too risky.

2.3 Morning beach counts

On most mornings a beach count was conducted from the cockpit of *Tiama*. These counts were typically one-off at each location and were primarily completed for the purpose of verifying the accuracy of shore-searches and to look for juvenile birds. We developed a system of watching areas during the early morning that had been searched on foot the day before. This allowed us to note any landings that may have been missed, keeping in mind this is not a fool-proof system since hoiho do not necessarily use their landings daily, especially in November while incubating eggs.

All counts started between 5-5.30am and finished at 9am. Teams of two observers would sit quietly aboard *Tiama* with binoculars watching for penguins leaving or going ashore, and any new landings were noted as GPS waypoints at the end of the count.

2.4 Nest searching

Toward the end of the trip it was decided to conduct one day of nest searching around Laurie Harbour and Erebus/Terror Coves to assess the feasibility of using this technique, as it could provide a way of estimating population abundance on future expeditions. This involved teams of two people walking the coast as usual but when sign was encountered they would endeavour to follow it until a nest was found. In most instances the landings were known as they had been located during previous search efforts. Teams were paired so that each team had a member with at least some experience nest-searching. A trial of nest-searching was of particular interest because of the presence of pigs and sea lions in the area sometimes making it difficult to recognise sign accurately and we wanted to see how difficult it would be to follow sign and tracks from the suspected landings/coast to the nest.

2.5 Data analysis

GPS waypoints of landings were logged in *MapSource* (version 6.13.7) and later *Google Earth* (version 5.1) to produce a distribution 'map' showing the location of landings and nests found through shore searches or counts. The *Google Earth* imagery of the Auckland Island area was updated 20/02/10 so some images in this report are showing the old (November 2005) image while others show the new image taken in January 2009. The contrast of some Google Earth images was improved using *Picasa 3.* All landings were also recorded manually in *Microsoft Excel 2003* with data from the logbooks describing site characteristics.

3. RESULTS

3.1 Accessibility for searching & summary of search effort

Fortunately, accessibility in the high priority eastern bays was better than anticipated so the team ended up being able to search all areas of interest for around the same number of days: 6 days in the eastern bays and inlets; 8 days around Carnley harbour and Adams Island; and 7 days on the north coast, Port Ross and outlying islands. In total, 185km (40.7%) of the total ~454km (not including Enderby) coastline was searched either by foot (142km, 31.2%) or by boat (43km, 9.0%).

There was considerable variation in the density of landings throughout the five regions (Table 1) and in the hours spent searching per landing found (Table 2). For example, 94 landings were identified on Adams Island, which translates to 2.87 landings per kilometre searched, at a rate of approximately one landing per every half hour of searching (Tables 1 and 2). Across Carnley Harbour on the south coast of the main island, only 10 landings were found over the 55.7km that were searched. This means 0.18 landings were found per kilometre searched, at a rate of 10.8hrs searching per landing (Tables 1 and 2).

Table 1. Distance of coastline searched as a percentage of the total, YEP landings found and density of landings per kilometre searched for five regions of the Auckland Islands.Note that for all tables, *"YEP* landings found*" refers* only to those found during ground searching, and not those found during beach counts, unless specified.

Area	Total distance	Distance searched, km (% of total)	YEP landings found	Landings per km searched
East coast inlets	164.0	59.0 (36%)	75	1.27
Carnley Harbour	91.8	55.7 (61%)	10	0.18
Adams Island	77.7	32.7 (42%)	94*	2.87
North coast, Port Poss	39.0	25.7 (66%)	54	2.10
Outlying islands	15.7	11.1 (71%)	46	4.14
TOTAL	**388.2**	**184.6**	**279**	**1.51**

* another 11 possible landings were noted on Adams Island but could not be confirmed due to weather conditions meaning it was too dangerous to put a team ashore.

Table 2. Time spent searching per landing found, for five regions of the Auckland Islands

Area	Hours searched	YEP landings found	Hours searched per landing
East coast inlets	137.0	75	1.80
Carnley Harbour	107.5	10	10.80
Adams Island	44.5	94*	0.47
North coast, Port Poss	62.9	54	1.16
Outlying islands	37.7	46	0.82
TOTAL	**389.6**	**279**	**1.40**

* another 11 possible landings were noted on Adams Island but could not be confirmed due to weather conditions meaning it was too dangerous to put a team ashore.

3.2 Distribution of yellow-eyed penguins from landing searches

In total, 184.6km of Auckland Island coastline was actively searched for hoiho landings (see Appendix 2 for maps showing areas searched). 76.8% of this distance (141.7km) was searched on foot, with the other 23.3% (42.9km) searched from a tender travelling close to the shoreline. In all, 279 landings were recording during searches, and a further 27 found during morning counts (Figure 1). These figures must be considered minimums as some landings were certainly missed (this is elaborated on in section 3.5).

Figure 1. Overview of YEP presence/absence in the Auckland Islands. White points indicate landings found by searching; red points are landings missed in searching but found during morning counts; and blue points indicate nest sites. Note that YEPs are found in high densities on Enderby Island, but this area was not searched. More detailed images of specific areas are in Appendix 3.

The YEP landings found during this expedition can be grouped into five general geographic regions:

3.2.1 Eastern inlets and bays

This region covered from Ranui Cove in the north to Cape Farr in the south, including Webling Bay, Kekeno Bay, Haskell Bay, Chambres Inlet, Granger Inlet, Griffith Inlet, Musgrave Inlet, Tandy Inlet, Smith Harbour, Norman Inlet, Hanfield Inlet, Deep Inlet, McLennan Inlet, Waterfall Inlet, and two unnamed bays (Table 3; figures 1.1-1.6, Appendix 3). Worth Inlet was not searched. In this region, 48.9km were searched by walking, and 10.98km were searched from a tender.

Table 3. Search effort and YEP landings for eastern inlets and bays. Bays are listed ranked by areas of highest density of landings per kilometre searched.

Area	Distance searched (km)	Observer effort (hrs)*	YEP landings	Landings per km searched
Unnamed bay [1]	0.20	0.75	1	5.13
Waterfall Inlet	2.62	8.50	8	3.05
Chambres Inlet	6.69	15.67	20	2.99
Unnamed bay [2]	2.70	6.33	8	2.96
Kekeno Bay/Point	4.20	13.00	11	2.62
Ranui Cove	4.10	7.83	6	1.46
Deep Inlet	6.32	17.33	8	1.27
Haskell Bay	10.00	18.73	9	0.90
Tandy Inlet	1.33	4.00	1	0.75
Webling Bay	4.87	4.33	2	0.41
Musgrave Inlet	4.66	13.90	1	0.21
Granger Inlet	0.96	2.17	0	0
Griffith Inlet	0.18	0.60	0	0
Smith Harbour	2.64	5.67	0	0
Falla Peninsula	1.04	2.00	0	0
Norman Inlet	5.27	11.33	0	0
Hanfield North	1.01	1.67	0	0
Hanfield South	0.24	0.67	0	0
McLennan Inlet	0.07	0.17	0	0
TOTAL	**59.08**	**134.70**	**75**	**1.27**

*Observer effort is the time spent by team/s in a given area, accounting for the number of people. So for example Waterfall Inlet may have been searched for 4.25 hours by 2 people, or just over 2 hours by 4 people. This rule hold true for all other tables in this section.
Unnamed bay [1] – south of Deep Inlet; Unnamed bay [2] – south of Cape Bennett

3.2.2 Carnley Harbour

This area includes all of Carnley Harbour except Adams Island, so the entire accessible south coast of the main Auckland Island (Table 4; figure 2.1, Appendix 3). This region had by far the lowest density of landings from any of the five regions searched. Of the 55.7km searched here, 44.46km were walked, and 11.25km were boated.

Table 4. Search effort and YEP landings for Carnley Harbour. Areas are ranked by highest density of landings per kilometre searched.

Area	Distance searched (km)	Observer effort (hours)	YEP landings	Landings per km searched
Carnley east	4.70	10.83	2	0.43
Musgrave Harbour	15.61	29.33	5	0.32
Tagua Bay	8.00	6.00	2	0.25
Camp Cove	9.15	17.67	1	0.11
Coleridge Bay	2.45	3.50	0	0
North Arm	16.45	23.83	0	0
Musgrave Peninsula	3.65	3.67	0	0
Camp Cove west	7.50	11.17	0	0
Western Harbour	3.80	5.00	0*	0
TOTAL	**55.70**	**111.00**	**10**	**0.18**

3.2.3 Adams Island

All accessible areas of Adams Island were covered: the north coast, Fly Harbour and Bollon's Bay (Table 5; figure 3.1, Appendix 3). On Adams Island, 12.86kms were walked and 19.96kms were boated.

Table 5. Search effort and YEP landings for Adams Island. Areas are ranked by highest density of landings per kilometre searched.

Area	Distance searched (km)	Observer effort (hrs)	YEP landings	Landings/ km searched
North coast	26.10	35.42	83	3.18
Fly Harbour & Bollons Bay	6.73	9.08	11	1.63
TOTAL	**32.8**	**44.50**	**94**	**2.86**

3.2.4 Port Ross and north coast

This region includes all accessible coast between Ranui Cove and North West Cape, including Laurie Harbour, Hardwicke (covers Erebus Cove, Terror Cove,

Dea's Head), Matheson Bay and North Harbour (Table 6; figures 4.1-4.3, Appendix 3). In this region 25.08kms were walked and 0.72km was boated.

Table 6. Search effort and YEP landings for north coast bays. Areas are ranked by highest density of landings per kilometre searched.

Area	Distance searched (km)	Observer effort (hours)	YEP landings	Landings per km searched
North Harbour	3.70	10.77	20	5.41
Matheson Bay	1.10	2.17	4	3.65
Laurie Harbour	13.60	35.00	26	1.91
Hardwicke	7.40	15.00	4	0.54
TOTAL	**25.80**	**62.93**	**54**	**2.09**

3.2.5 Outlying predator free islands

This area covers the smaller islands around Port Ross, believed to be free of the feral pigs (*Sus scrofa*), cats (*Felis catus*) and mice (*Mus musculus*) found on the main island (Harper 2010). Ewing Island, Rose Island, Ocean Island, Frenchs Island, Shoe Island and Davis Island were surveyed (Table 7; figures 5.1-5.5, Appendix 3). These islands had the highest density of landings out of any of the regions searched. Islands not surveyed include Enderby, Disappointment, Figure of Eight, Dundas, Green, and Friday Islands. All 11.14kms were covered on foot.

Table 7. Search effort and YEP landings for the northern islands. Islands are ranked by highest density of landings per kilometre searched.

Area	Distance searched (km)	Observer effort (hours)	YEP landings	Landings per km searched
Frenchs Island	0.31	0.83	2	6.47
Ewing Island	5.51	21.33	30	5.44
Shoe Island	0.39	1.17	2	5.19
Rose Island	3.00	9.00	9	3.00
Ocean Island	1.80	5.00	3	1.67
Davis Island	0.14	0.33	0	0
TOTAL	**11.14**	**37.67**	**46**	**4.13**

3.3 Main island vs. predator free outlying islands

There was nearly a perfect 50:50 split in the number of landings found on the main island compared to the outlying islands, including Adams. This is despite considerably more time being spent searching the main island than the others (307.4hrs vs. 82.2hrs). The outlying islands equal just 22% of the searched area. This suggests that YEPs are living at higher densities on these islands. Indeed, we found 1.17 landings per km on the mainland versus 3.51 landings/km on the offshore islands including Adams.

3.3.1 The presence of feral pigs at landing sites

Of the 279 landings found by searching, 141 (50.5%) were found on the smaller northern islands and Adams Island where pigs are not found. Many incidental observations were made about the amount of pig sign (rooting, scats, footprints, actual pigs, and even what appeared to be pig scat with penguin feathers in it – photo in Appendix 4) seen while walking the coast of the main island. Observers were specifically asked to note if they saw pig sign when they recorded landings. Of the 138 (49.5%) landings found on the main island, 65 (47.1%) were found in areas where there was no noticeable pig sign.

3.4 Characteristics of landing sites

At each recorded landing, observers were asked to note what sign had alerted them to the presence of a landing, and describe basic characteristics of the site in a specially created logbook.

3.4.1 Sign indicating landings

Landing sites were typically identified by two types of penguin sign. All sites had one type of sign, 89.6% were identified using two types of sign, 35.8% three types, and only 2.9% had four types of sign. Scratch-marks were the most common type of sign identified first at landing sites (48.4% of all landings) while faeces were the most common second sign type (39.4%) (Table 8).

Table 8. Types and number of YEP sign encountered at landings.

Sign type	1st sign (%)	2nd sign (%)	3rd sign (%)	4th sign (%)
Scratch-mark	135 (48.4)	92 (33.0)	16 (5.7)	0
Faeces	71 (25.4)	110 (39.4)	47 (16.8)	1 (0.4)
Track	52 (18.6)	24 (8.6)	19 (6.8)	2 (0.7)
Penguin	9 (3.2)	0	0	0
Footprint	7 (2.5)	14 (5.0)	8 (2.9)	1 (0.4)
Smell	3 (1.1)	3 (1.1)	0	0
Nest	0	5 (1.8)	4 (1.4)	1 (0.4)
Other*	2 (0.7)	2 (0.7)	6 (2.2)	3 (1.1)
None	0	29 (10.4)	179 (64.2)	271 (97.1)
TOTAL	**279**	**279**	**279**	**279**

*Other includes: penguin feathers, dead YEP, penguin regorge/bolus, sound/calls, roost mounds and gastroliths.

This data indicates a search pattern where in most instances the observers would come across a suspected landing site, noticing scratch-marks (of a size, depth and location consistent with regular penguin activity) and on closer inspection come across penguin faeces.

3.4.2 Penguins seen

Forty-five YEP were physically noted at 36 (12.9%) landings found during shore searches. This figure was expected to be low as tracks were not typically followed up to find nests, because of time constraints. Most of these individuals were adults (33) with the rest being chicks (10) or juveniles (2).

3.4.3 Terrain, access, aspect and wave exposure

Basic comments on slope, access and aspect were recorded. Nearly half of landings were recorded at sites of 'moderate' (definite uphill) steepness (47.0%); 23.3% were recorded as 'steep' (hands required to climb); 26.2% were 'slight' and 3.2% were 'flat'. Rock platforms dominated the classification for access points (37.3%). Rocky beaches, meaning a combination of large (>50cm) and small (<50cm) boulders were also common (26.5%). Beaches/coast with only large boulders were also common (19.4%) with the remaining landings to be found at sites with only small boulders (9.0%), rock platforms with boulders (7.2%), or sandy beaches with rock platforms (0.7%). As might be expected,

north, nor-west and nor-east were the most common aspects for landing sites (22.6%, 20.8%, 15.4% respectively). Each landing was assigned a category for wave exposure. In hindsight these categories should have been more detailed to reduce the arbitrary differences in opinion between observers. As it was, we noted 45 (16.1%) of landings at sheltered sites, 213 (76.3%) landings exposed to some wave action, and 21 (7.5%) exposed to constant wave action.

3.4.4 Vegetation and cover

Observers were asked to note the dominant vegetation type at each landing. The most prevalent vegetation type where landings were found was scrubland, typically dominated by dracophyllum and hebes. Number of landings in each vegetation type are summarised below (Table 9).

Table 9. Vegetation types noted at YEP landings.

Vegetation type	Number of landings	Percent
Scrubland	80	28.7
Scrub/tussocks	46	16.5
Rata forest	41	14.7
Rata/scrub	35	12.5
Olearia	30	10.8
Tussock	20	7.2
Tussock/megaherbs	7	2.5
Scrub/megaherbs	7	2.5
Rata/scrub/tussock	4	1.4
Megaherbs	4	1.4
Scrub/turf	2	0.7
Rata/tussock	2	0.7
Turf	1	0.4
TOTAL	**279**	

In terms of cover, the vast majority of landings (230, 82.4%) had vegetation cover to the edge of the foreshore, and a further 26 (9.3%) had cover to the water's edge. Some 21 landings (7.5%) had 20-39 metres of uncovered terrain between the landing and vegetation, and just 2 (0.7%) had between 40-59m of uncovered terrain.

3.5 Beach count data & reliability of the search method

Beach counts were conducted on 21 mornings in 19 different locations (Table 10). The total number of independent landing sites seen by observers during the counts was 42. This compares with only 22 landing sites noted by teams searching the areas covered by the counts. We noted that 15 of the 22 searched sites were seen to be used on the given morning, meaning 27 of the 42 sites were identified as "new" sites, (ie. they were not one of the original 22 recorded during the searches)(Table 10). That 42 of 49 landings were seen to be used suggest approximately 15% of YEPs not leaving or returning to their nest/roost during the count morning count period. However, we have no way of knowing how many landings were missed by searches and not seen to be used during the count.

If we ignore the very real possibility of landings that are unknown and unused, and assume search landing sites were identified correctly 100% of the time (and this is unlikely) then there should actually be 49 landings in the areas covered by the beach counts, 22 (45%) found by searching, and an additional 27 (55%) found from counts. Following this logic, and given that searching was our main method of finding landings, one could propose 55% of all landings were missed during our searches. Given that we found 279 landings using this method, this would mean another 341 further landings went unnoticed.

In total, 151 YEPs were seen during morning beach counts; 51 (33.8%) were identified as adults and 2 (1.3%) were juveniles. However the majority (98, 64.9%) were too far away to positively identify their age class, even with binoculars (Table 10).

Table 10. Summary of beach count locations, duration and outcomes. Shaded rows indicate locations where more than one count was made.

Location	Date	Duration (hours)	Landings found by searching	Landings noted during count	New landings*	Adult YEPs seen	Juveniles	Unknown[§]	Total YEPs seen
Haskell Bay	10/11	3.5	4	2	0	2	0	0	2
Chambres Inlet	11/11	3.5	0	1	1	0	0	1	1
Granger Inlet	12/11	3.5	0	0	0	0	0	0	0
Smith Harbour	13/11	3.5	0	0	0	0	0	0	0
Hanfield North	14/11	3.0	0	0	0	0	0	0	0
Waterfall Inlet	16/11	3.5	2	6	6	13	0	1	14
Musgrave Harbour	17/11	3.5	1	0	0	0	0	0	0
North Arm	18/11	3.5	0	0	0	0	0	0	0
Tagua Bay	19/11	3.5	0	1	1	1	0	1	2
Survey Bay	20/11	3.5	4	6	2	11	0	8	19
Camp Cove	21/11	3.5	0	0	0	0	0	0	0
Coleridge Bay	22/11	3.5	0	0	0	0	0	0	0
Western Harbour	23/11	3.5	0	1	1	1	0	0	1
Waterfall Inlet	24/11	3.7	2	6	3	18	1	0	19
Webling Bay	25/11	4.0	2	7	7	0	0	14	14
Laurie Harbour	26/11	3.7	0	0	0	0	0	0	0
Erebus Cove	27/11	3.7	0	2	2	0	0	2	2
Terror Cove	28/11	3.8	0	2	2	1	1	0	2
Terror Cove	29/11	3.7	1	4	2	4	0	0	4
Dea's Head	30/11	4.1	0	0	0	0	0	0	0
North Harbour	01/12	4	6	4	0	0	0	71	71
TOTAL		**75.6**	**22**	**42**	**27**	**51**	**2**	**98**	**151**

* New landings are those identified during the beach counts that were missed during the shore search.
[§]Unknown = birds identified as YEPs but generally too far away to be positively identified as adult or juvenile

3.6 Feasibility of nest-searching

Nest searching took place for one day on 29 November, with one team working in the Erebus/Terror Cove area, and two teams on the south coast of Laurie Harbour. Key points from this day:

- The Erebus/Terror Cove team worked from 5 suspected landings but were only able to find 2 nests during 8 hours of searching.
- The two teams at Laurie Harbour worked in adjoining areas, where a total of 14 suspected landings had been identified. The search areas of these two teams overlapped to some degree. Both teams found 8 nests during 8 hours of searching.
- Because their search areas overlapped, the Laurie Harbour teams both found three of the same nests, meaning a total of 13 nests were found from the 14 suspected landings.

4. DISCUSSION

Despite the potential for a high number of missed landings, the results of this survey do still contribute valuable information concerning the distribution of YEPs at the Auckland Islands and the feasibility of future population surveys and research.

Distribution of hoiho in the Auckland Islands

Given the considerable variation in the density of landings found throughout the five regions searched, and in the hours spent searching per landing found, it appears YEP landings (and the effort required to locate them) are not uniformly distributed across the island group. Geographically, when we look at the overall pattern of distribution, hoiho appear to be clustered in the north and south of the Island group, with few landings found in the eastern inlets or upper reaches of Carnley Harbour. Before this trip, there was very little known about the distribution of YEPs anywhere at the Auckland Islands other than YEP could be found at Enderby and surrounding islands, and some parts of the north coast and Adams Island. However our extensive search effort suggests these areas are probably still the main areas where hoiho are found – search results from the eastern inlets and Carnley Harbour show the lowest density of landings in these two areas. In fact, no penguin sign was observed at all in eight out of 19 localities in the east coast region, and only ten landings were found in the whole Carnley Harbour area. Localities with particularly high densities of landings are Ewing Island, Frenchs Island, North Harbour, an unnamed bay south of Deep Inlet, and the north coast of Adams Island;

It is interesting to observe the inconsistency between landing density on the north coast of Adams Island and the south coast of the main island, despite both these regions sharing the same body of water, Carnley Harbour. Any number of possible factors may be contributing to the extremely low density of landings found on the main island side of Carnley Harbour: a) the potential for predation is much greater on the main island – pigs and cats were witnessed by team members in this area; b) poorer quality habitat and southerly aspect; c) the extra distance birds living in this area have to travel to forage (this hypothesis

assumes that hoiho are travelling beyond the limits of Carnley Harbour into deeper water in search of food; for example, if there is a good foraging area off Cape Bennett, an individual nesting in the upper reaches of Carnley Harbour has much further to travel than an individual nesting on the north coast of Adams Island).

There are a number of subjective errors that could have affected the reliability of our search data. In particular, the ability to pick-up and correctly identify sign may differ between teams or at least individual observers. Observers with years of YEP experience would be expected to pick up more subtle pieces of sign than relative newcomers. Similarly, freshness and amount of sign would likely make some landings easier to pick up than others.

The role of introduced predators

From the amount of rooting and predated seabirds around the main island, it appears there is a considerable population of pigs and cats there, although this is impossible to quantify from incidental observations. That just over half our recorded landings were found on islands free of introduced predators, despite considerably more time being spent on the main island, suggests that pigs and cats may be affecting the sub-population of hoiho that nest there. Where predators are not found, densities of landings were also greater. Cats are known predators of YEPs on the South Island (Moller & Alterio 1999) and as such there is no reason to believe the feral cats on Auckland Island are not preying on YEP. Indeed Harper (2010) noted Auckland Island shag (*Leucocarbo colensoi*) remains in the stomach of a cat trapped in the Port Ross area, a bird of comparable size to a YEP, although much lighter (Robertson & Heather 1999). Pigs are doubly problematic because not only could they be preying on hoiho (Challies 1975), they appear to be actively rooting up many coastal areas on the main island (pers. obs.), potentially destroying penguin habitat and generally disturbing the birds. The removal of these predators from the main island would likely prove desirable for the YEP population. If pig/cat eradication were to be achieved, it is entirely possible that the northern islands and Adams could act as a source of YEPs capable of repopulating the main island. Harper (2010) speculates that

excess seabirds from the surrounding islands could very well be attempting to nest on the main island, but are falling victim to cats and so fail to establish. Harper (2010) goes on to note that the eradication of pigs and cats from Auckland Island would "approximately double the area available for breeding seabirds that is free of large mammalian predators in the New Zealand subantarctic islands" and that eradication should be actively pursued, a stance supported by the present author.

Similarities between landing sites

Recording landing site characteristics did not reveal any real surprises regarding landing preferences, only confirming that subantarctic YEPs are an adaptable group of individuals and seem to be able to utilise a considerable range of habitat types, much like their South Island counterparts. It was interesting to note more often than not that landings (and presumably nests) had some degree of northerly aspect, presumably to make the most of the available sunlight/warmth.

Beach count data as a way of verifying search accuracy

The large number of landings missed during shore-searches that became known during beach counts of the same areas is worrying. Our record of landings can at best be considered a minimum for the area surveyed; at worst, we may have missed more than half the true number of landings. While it is disappointing to have such a high level of potential inaccuracy, it is not reasonable to expect that the situation at the 19 beach count locations can be accurately applied to the entire Island group. To take a more positive slant, at eight of the beach count areas, no landings were seen either searching or counting. While we cannot know for sure if there were in fact birds in these areas that did not using their landing that morning, this does tie in with four further beach count locations where searches produced zero landings, yet a low density of landings was revealed during the count. This suggests that the accuracy of our search method was better where no or very few landings were noted, compared to areas where several landings were noted, yet several were also missed. Put another way, it

seems to be easier to identify locations where penguins are not, than accurately identify how many landings exist in an area where a moderate number of penguins are living.

Beach counts have been used previously as a way of estimating abundance of breeding YEP (Moore 1992, Moore et al. 2001), and while this is indicative of total population abundance, the counts that we did are in no way suitable for estimating population abundance from. Using beach counts to estimate abundance requires that 1) Multiple counts are completed at each bay/inlet (which we were not able to achieve, being constantly on the move searching for landings meant we typically anchored only once in any given bay, the two exceptions to this being Waterfall Inlet and Terror Cove), and 2) A known number of the birds are either detectable or banded/otherwise identifiable so that mark-recapture analysis can be performed, in a similar vein to Moore's work on Campbell Island (Moore 1992, Moore et al. 2001). In order to make a rough guess at a population estimate, at the very least we would need to know how many landings were wrongly identified by our search method, and how many pairs on average were using each landing. Moore (1992) did produce a figure for mean number of birds per landing, but the variance around this number and the range upon which it is based do not make it suitable to apply to the rest of the islands, even more so because the data is now twenty years old.

Potential for nest-searching

Nest-searching was trialled for one full day toward the end of the trip, with mixed success. The two sites where nest-searching was trialled differ noticeably in certain characteristics that may help explain the mixed success of the teams. The area around Erebus/Terror Coves is much drier, flatter and more sparsely vegetated than Laurie Harbour, and the team working there had fewer landings to start from. This team also commented on how little sign there was to follow and that the nests they did find seemed to be more to chance. In contrast, one team at Laurie Harbour was able to follow sign nearly 230m from the coast directly to a nest that was positioned roughly 60m above sea-level.

In terms of using this method on future trips, it seems nest searching is certainly possible and worthwhile at least in some areas of the Auckland Islands, particularly in areas where moderate to high densities of landings are thought to exist.

Where to from here?

Using what we now know about the approximate presence/absence of YEPs around the Auckland Island coast, and density of landings as a crude measure of relative abundance, the next step will be to produce a population estimate and investigate the factors affecting distribution. In terms of how such a survey might work, it is not reasonable to expect that the Auckland Island population could be estimated using mark-recapture analysis as Moore and colleagues did at Campbell Island. The Auckland Islands cover a much greater area, there are no permanent inhabitants, and multiple trips to perform counts of banded versus unbanded birds would be prohibitively expensive and time consuming.

4.1 Conclusions

The yellow-eyed penguin is an iconic and vulnerable New Zealand species. Because of the recently established genetic status of hoiho on the subantarctic islands, there is a great need to collect baseline data on these populations. This survey was an important first step in the future management of hoiho in the Auckland Islands. While not without fault, our search method helped establish the approximate presence/absence of YEP around the Auckland Islands. Our survey provides an idea of the absolute minimum number of YEP landings we might expect to find at the Auckland Islands, and we can be fairly confident that we have identified areas where no or very few hoiho are found, indicating places where less monitoring effort will be needed in the immediate future.

This expedition achieved the first-ever wide-spread distribution survey of hoiho at the Auckland Islands. However it was not a population estimate and a follow-up trip will be needed at some point in order to achieve this. The present expedition has laid the groundwork for future trips, in that we have recognised areas that have higher densities of landings, and thus appear to have a larger

than expected population of YEP. Because of their unique ecology hoiho are an inherently difficult species to monitor accurately. Being secretive nesters and non-colonial, it is not possible to estimate population size in the same way as other penguin species. A possible method for completing a population survey of the key Auckland Island sites, based primarily on a nest searching method, is discussed in the next section.

5. RECOMMENDATIONS

To evaluate the conservation status of hoiho in the Auckland Islands, it is desirable that a population survey be completed in the near future, so that numbers of birds is established, and then possibly further monitoring trips could be made to assess the stability of the population numbers, and investigate the factors affecting their distribution and breeding productivity.

A couple of points to bear in mind when thinking about how a population survey might be approached: 1) Time of year is a critical factor to consider when planning an abundance survey of YEPs. Peter Moore's work on Campbell Island has shown that November is the least reliable time to survey hoiho because they are in the incubation phase and do not leave the nest as regularly as they do later in the season during the guard phase (Moore 1992, Moore et al. 2001) and 2) beach counts and mark-recapture analysis is time-consuming and requires seasonal counts based on a cohort of banded birds. Given the time scale on which YEP monitoring trips to the Auckland Islands are made (20 years currently), this is not a realistic option. Nest-searching would prove a better use of resources and would be easier to repeat say 5, 10 or 20 years apart as the case may be.

Keeping both these important points in mind, future researchers should aim to complete a population survey of Auckland Island hoiho by nest searching at some point during the early to mid-guard phase (Dec-January) when the movement of adults is most regular. If the survey team were to be boat-based, they could (weather permitting) stay multiple days at certain anchorages, using morning counts as a way of positively identifying landing sites, then conduct day-long nest searches from these starting points. Key areas to focus on would be those areas where we can expect for there to be reasonable numbers of penguins, ie. the areas where we found the greatest densities and absolute numbers of landings on our trip: Adams Island, the northern islands (especially the larger two, Ewing and Rose), Laurie Harbour, North Harbour, Waterfall Inlet, Chambres Inlet, Kekeno Point, Haskell Bay and so on (if pest eradication on the main island does ever go ahead then it might also be wise to monitor some of the less-inhabited eastern bays to see if YEPs return to these areas over time, however this is a secondary to the main goal of estimating the population). In terms of efficiency, it may be possible to take (based on the author's knowledge

of how the present trip worked) again a team of six people on a chartered boat like *Tiama*, and drop 2 or 3 team members on Adams Island, where there is centrally located accommodation available in the albatross researcher's hut on the north coast. They could then search the north coast of Adams while the rest of the team searches around the northern islands and key sites like Chambres Inlet, North Harbour and Laurie Harbour. Having all team members well versed in nest searching on the mainland before the expedition would also be beneficial. Such an approach could prove surprisingly time-efficient, depending on weather and the exact number of locations to be searched; by splitting the team in this way a large amount of data could be collected in just 2-3 weeks.

Key points:

- Working in the Auckland Islands is difficult, but not impossible.
- Time of year is critical to successfully finding YEPs. In the guard phase adult birds switch nest-minding duties on a regular basis, thus making true landings easier to locate, and it is easier to quantify breeding pairs.
- For practical reasons, a population estimate or survey of abundance would need to be primarily based on a nest-searching method.
- YEPs appear to be patchily distributed in the Auckland Islands, and there are many inlets where no or very few individuals are found – trip planners need to be aware of this and focus efforts where YEPs are known to live.
- Bearing this in mind, YEP distribution is not static and areas identified as low density by the current research should still be monitored every now and then.
- This is especially true if pig and cat eradication ever goes ahead; then 'before and after' type monitoring of these low density areas should be reconsidered, on a suitable timescale.
- Other directions for research further down the track include investigations of population biology, including questions about breeding productivity and fledging success; foraging range and diet; disease and parasite loads; key threats to adults and chicks; and potential differences in all of the above between the main island and offshore islands.

6. ACKNOWLEDGEMENTS

This work was funded by DOC Southern Islands and the Yellow-eyed Penguin Trust.

The Auckland Islands expedition was truly a team effort. Thanks are due for Jo Hiscock, team leader, for getting the team together and doing much of the planning and dirty logistical work. Above all I am indebted to Jo for taking a chance on me to fill the final berth.

The infallible Henk Haazen, owner and skipper of the trustworthy *RV Tiama*. His professionalism under trying conditions, coupled with the reliability of his boat and crew, was integral to the success and safety of this expedition.
Even when we were "just outside."

To Henk's right-hand man, first mate Steve Parsons, whose bare-footed boatmanship and penguin-spotting abilities were simply unparalleled.

Sandy King for your wealth of penguin knowledge, and the many brain-storming and bush-bashing sessions.

Leith Thomson for looking out for me. You shared your happy song, gave me knot-tying lessons, and had unfailing belief in my dismal rock-climbing abilities.

Callum Lilley for being our quasi-professional photographer, manning the tender in atrocious conditions, and whole-heartedly embracing the 5am haiku challenge.

Jo Ledington, for your positive outlook, and never failing to polish off the leftovers with me. Not to mention a well-timed kick in the back at 5.26am on one of my beach count mornings.

Melanie Young assisted me with the design of the logbooks and beach count sheets, commented on a draft copy of this report and freely gave many hours of laughs, support and advice, both before and after the trip.

Ronda Peacock did an incredible last-minute job putting six beautiful waterproof logbooks together. They lasted the distance!

Eric Shelton, for encouraging me to focus my special topic project for TOUR415 on background research for this trip. A lot of the ideas and information from that project have worked their way into the introduction of this report.

Phil Seddon and Yolanda van Heezik, for your reassurance and encouraging me to have faith in my work and abilities.

And finally, Avi Stein for being a willing (if a little short) shoulder on which I can depend. I would never have made it to the Auckland Islands if you hadn't stepped in to cover my original 403 project; there will never be enough thanks for you. This report wasn't quite a Beer & Stein production, but it is dedicated to you.

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APPENDICES

APPENDIX 1. Anchorages and daily search summary.
Courtesy of JH.

Monday 9th November
Arrived at the Auckland Islands, anchored in Haskell Bay.

Tuesday 10th November
Searched Haskell Bay and moved and anchored at the head of Chambres inlet in the evening.

Wednesday 11th November
Searched Chambres Inlet and started on Granger Inlet. Anchored at the head of Granger Inlet for the night.

Thursday 12th November
Finished Granger Inlet, Griffith Inlet, Musgrave Inlet and Tandy Inlet, and anchored at the head of Smith Harbour for the night.

Friday 13th November
Searched Smith Harbour, Norman Harbour and both the North and South Arms of Hanfield Inlet. Anchored in the North Arm of the Hanfield for the night.

Saturday 14th November
Blowing all day, gusts over 65kts in the harbour, didn't leave anchorage.

Sunday 15th November
Searched Deep Inlet, Worth Inlet, McLennan Inlet and Waterfall Bay. Anchored in Waterfall Bay for the night.

Monday 16th November
Searched the bays around to Carnley Harbour. Blowing through there so motored to Musgrave Harbour and anchored for the night. Searched a short section of the harbour.

Tuesday 17th November
Searched Coleridge Bay, the rest of Musgrave Harbour, Circular Head and most of North Arm around to Epigwaitt. Anchored on the west side of North Arm.

Wednesday 18th November
Completed North Arm, Musgrave Peninsula, and Tagua Bay. Anchored in Tagua Bay for the night.

Thursday 19th November
Searched Emergency Bay and the south coast east. Searched all of the North Coast of Adams Island. Anchored in Trinity Cove for the night.

Friday 20th November
Searched Bollons Bay and Fly Harbour. Anchored in Camp Cove for the night.

Saturday 21st November
Searched Camp Cove coast, didn't get far because of 60-70kt winds. Dropped team on Adams in the evening to do Albatross work. Anchored Western Harbour.

Sunday 22nd November
Visit to the SW Cape albatross colony. Searched Western Harbour and along towards Trinity Cove. Anchored in Trinity Cove.

Monday 23rd November
Searched Trinity Cove to Camp Cove, picked up team from Adams. Moved and anchored at Waterfall Bay.

Tuesday 24th November
Sailed to Kekeno Point, searched to Webling Bay, and started Ewing island. Anchored Webling Bay.

Wednesday 25th November
Searched Ranui cove to Sealers Ck, and French Island. Anchored in Laurie Harbour.

Thursday 26th November
Searched Laurie Harbour from Sealers Ck around the head of the bay to Erebus Cove and Deas Head to Friday Island. Anchored in Erebus Cove.

Friday 27th November
Searched Rose Island, Ocean Island, and completed Ewing Island. Anchored at Terror Cove.

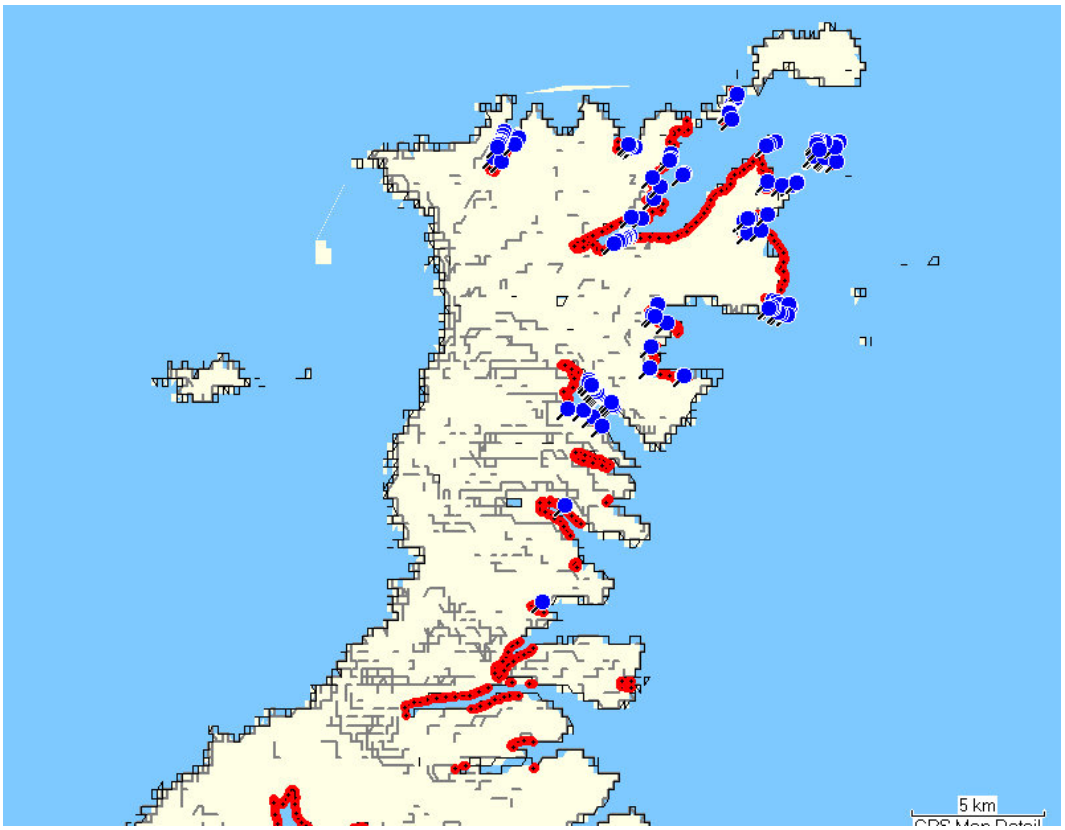
Saturday 28th November
Weather foul, short visit to Enderby Is. Anchored Terror Cove.

Sunday 29th November
Nest searched some of Laurie Harbour and Erebus and Terror Coves to assess feasibility of nest search method. Anchored Deas Head.

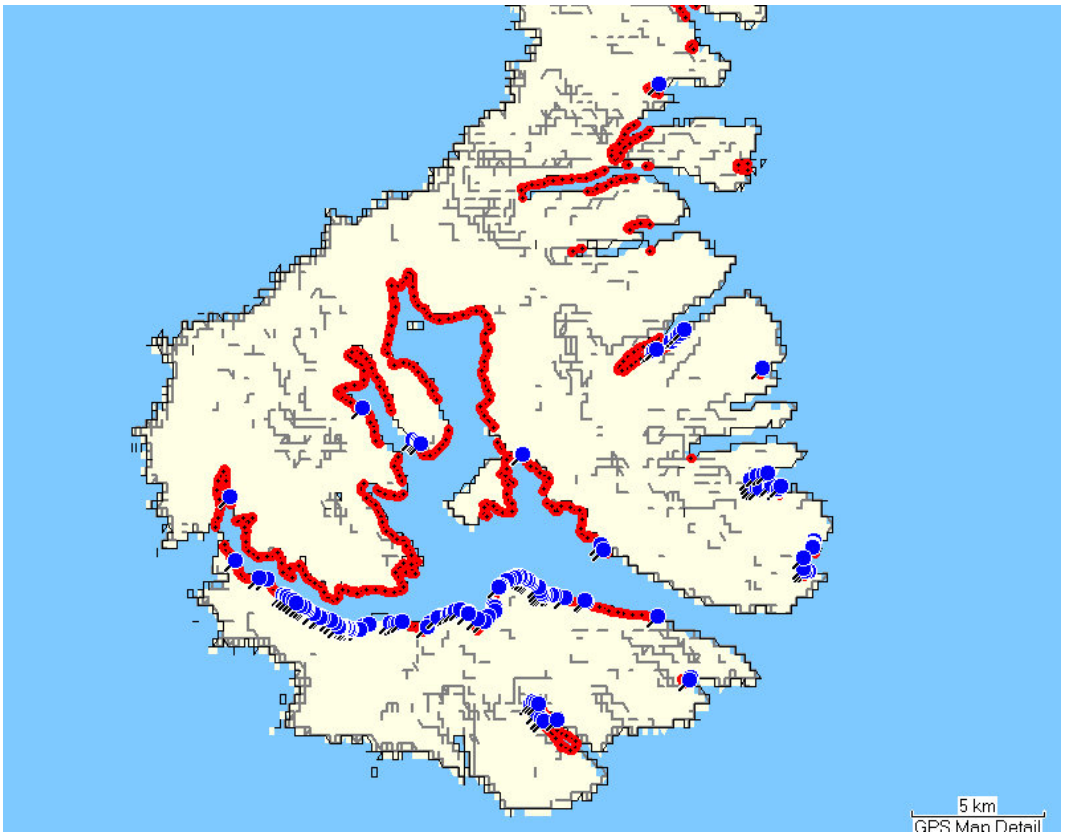
Monday 30th November
Searched Mathesons Bay, North Harbour. Also visited the Rockhopper colony briefly at NW Cape but hardly any penguins there so didn't go ashore to take samples. Anchored North Harbour.

Tuesday 1st December
Beach count, treated fingerposts and departed for NZ about midday. Arrived Bluff 6am Thursday.

APPENDIX 2. Maps showing summary of search effort.
Courtesy of JH.



Map 1. Northern half of the Auckland Islands, showing area searched in red, and landings found in blue.



Map 2. Southern half of the Auckland Islands showing area searched in red, and landings found in blue.

APPENDIX 3. Google Earth images showing locations of YEP landings.

Region 1: Eastern inlets

Figure 1.1 Tucker Point to Kekeno Bay. Red/medium grey landings indicate those missed during searches and subsequently noted during a morning count.

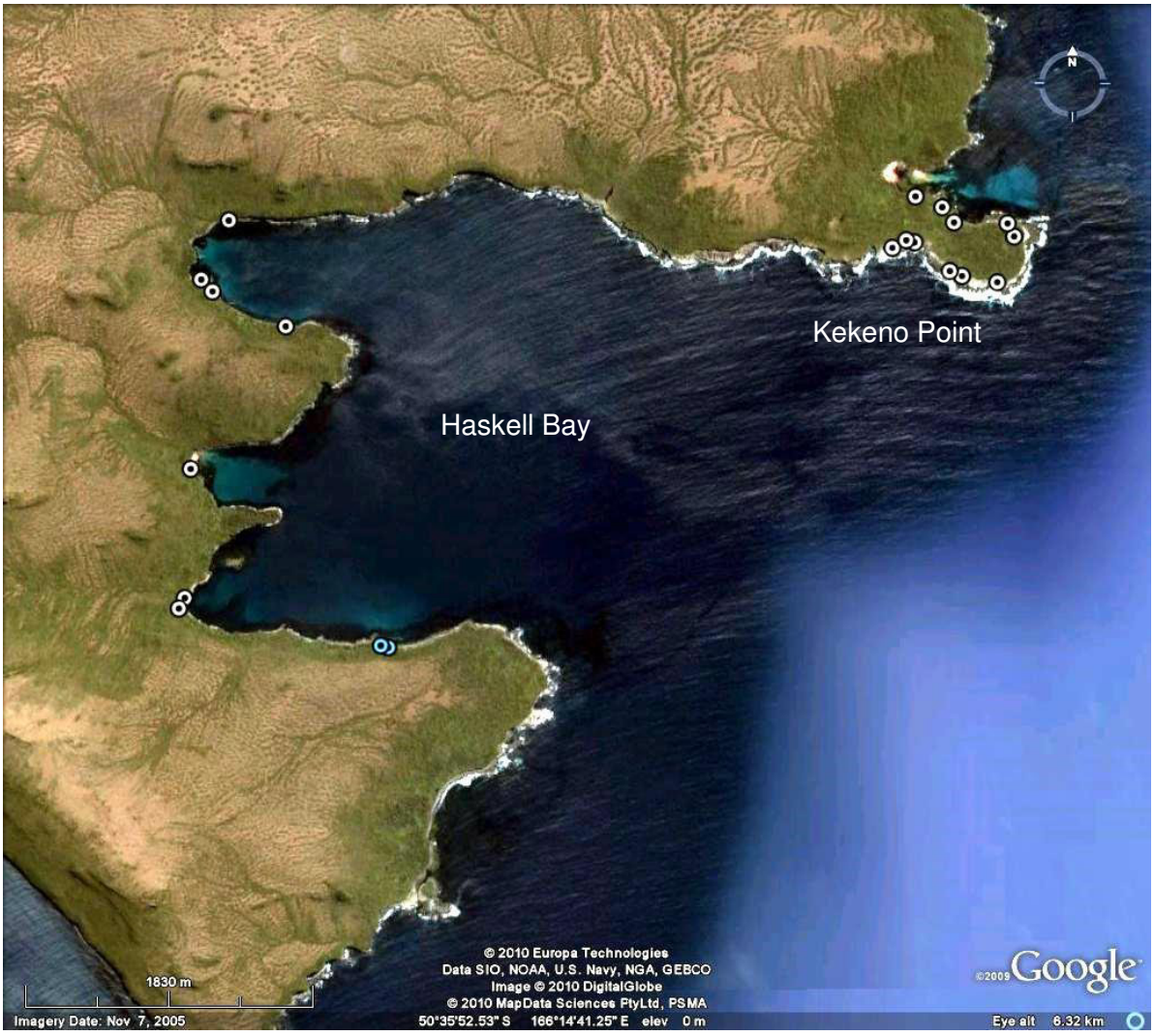


Figure 1.2 Kekeno Point and Haskell Bay

Figure 1.3 Chambres Inlet and Granger Inlet

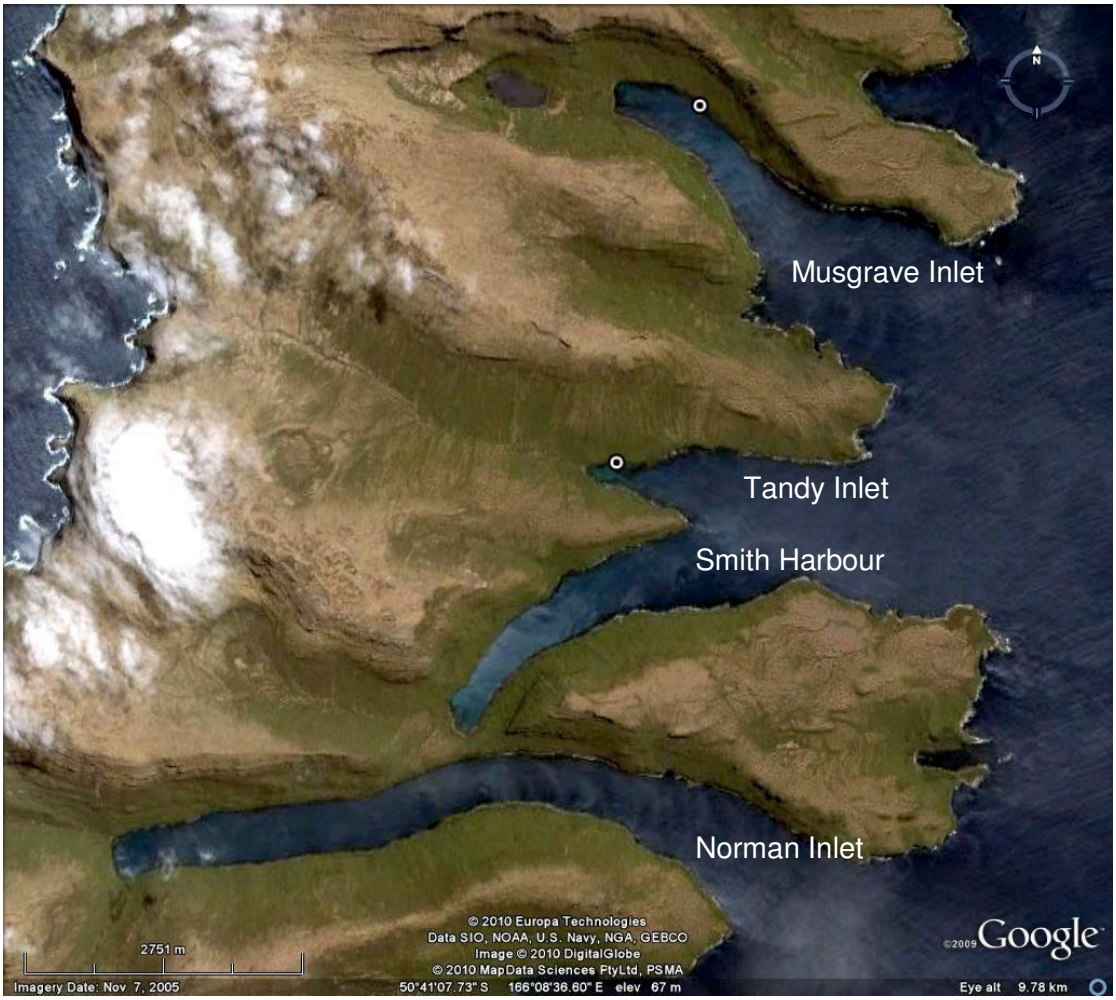


Figure 1.4 Griffith Inlet to Norman Inlet

Figure 1.5 Hanfield Inlet to McLennan Inlet

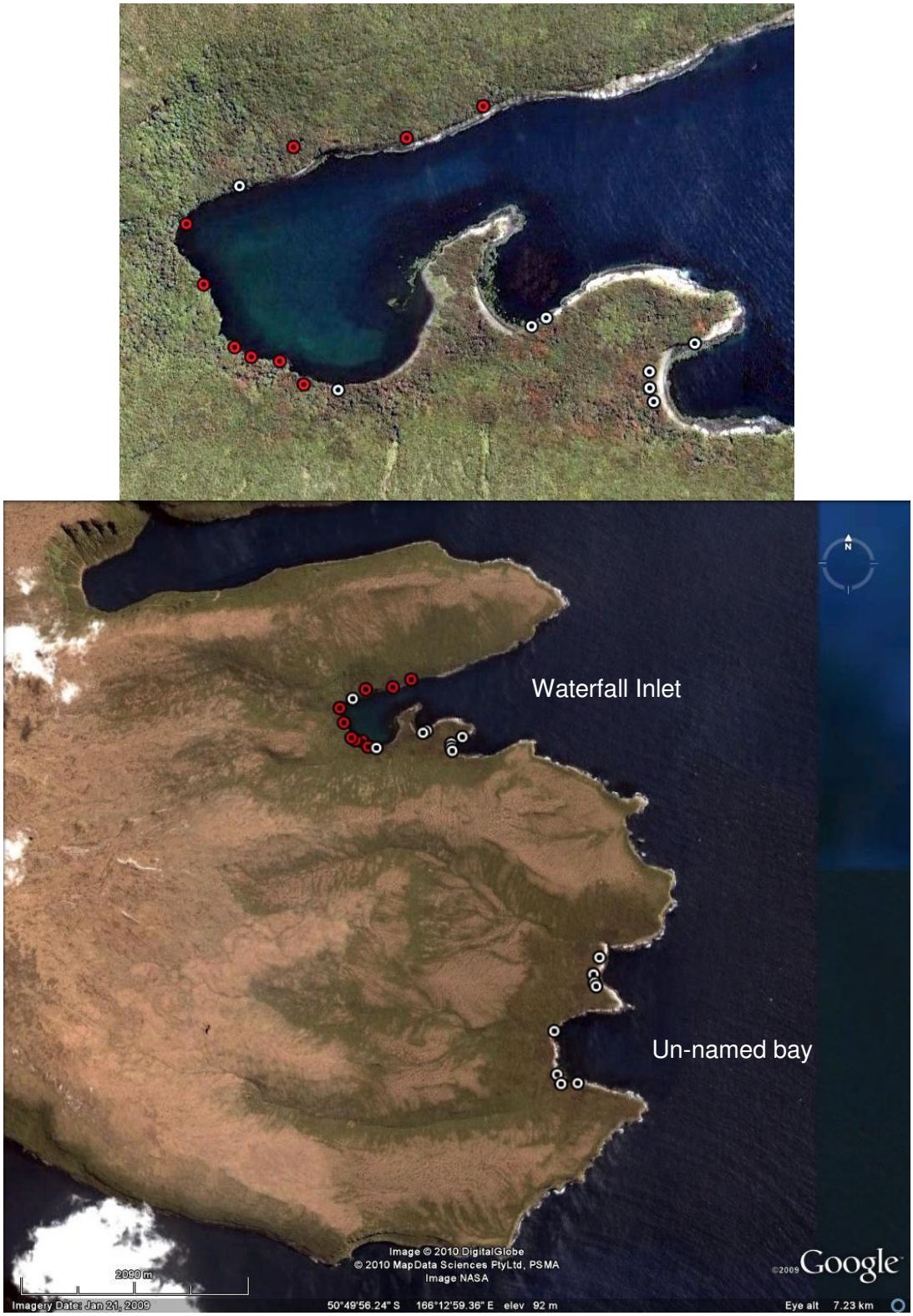


Figure 1.6. Above: Waterfall Inlet in detail. Below: Waterfall Inlet and unnamed bay. Red/medium grey landings indicate those missed during searches and subsequently noted during a morning count.

Region 2: Carnley Harbour

Figure 2.1 All of Carnley Harbour

Region 3: Adams Island

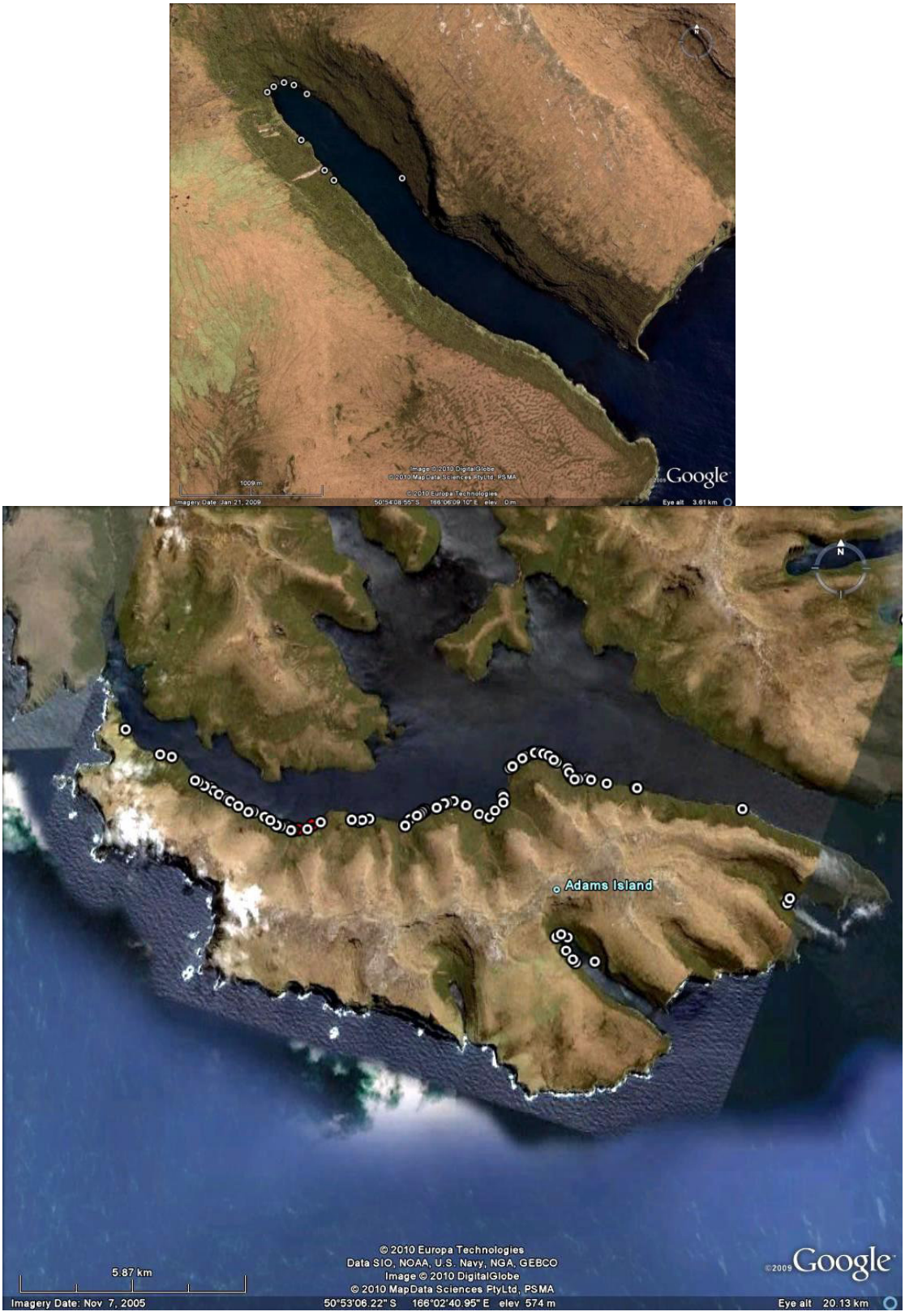


Figure 3.1 Above: Fly Harbour. Below: All of Adams Island including Fly Harbour and Bollons Bay

Region 4: North Coast & Port Ross area

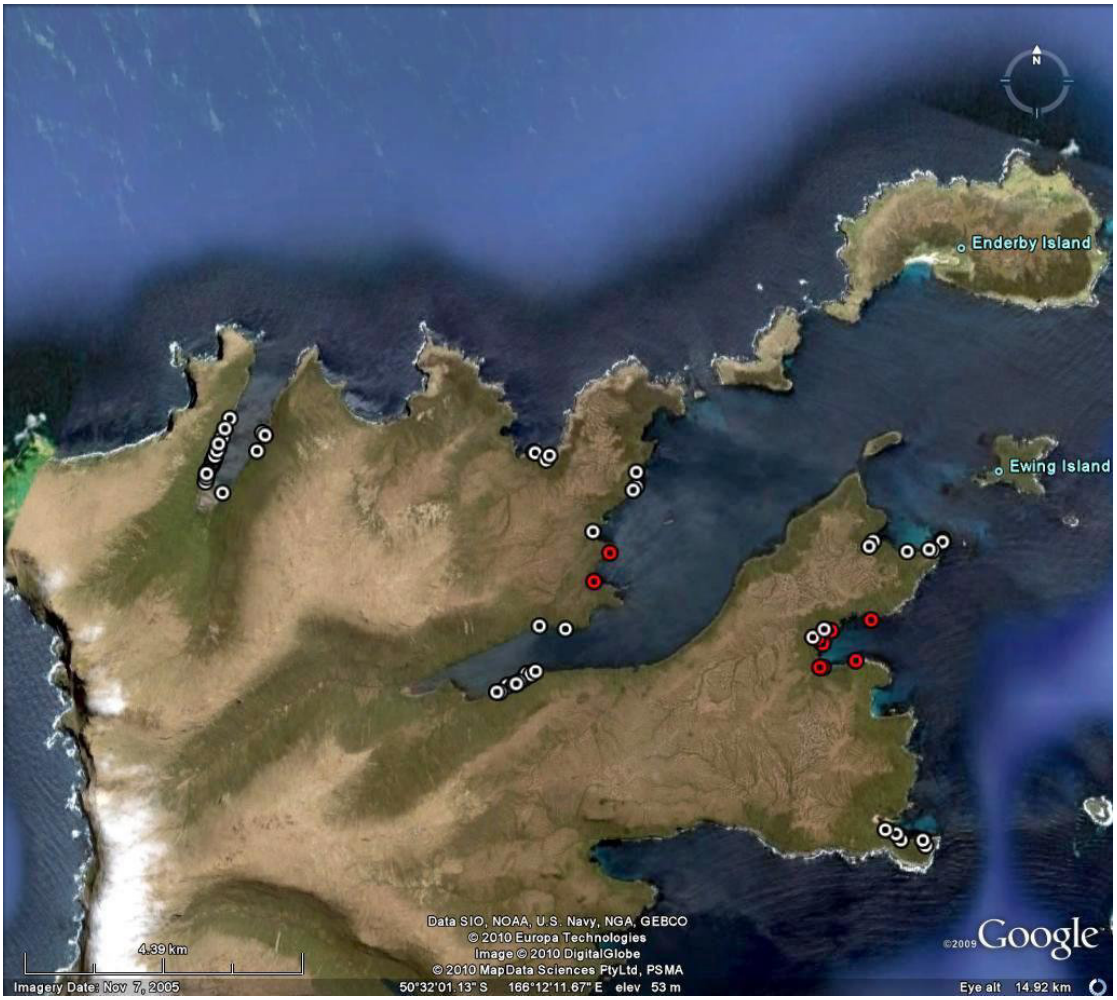


Figure 4.1 Overview of Port Ross and north coast. Red/medium grey landings indicate those missed during searches and subsequently noted during a morning count.

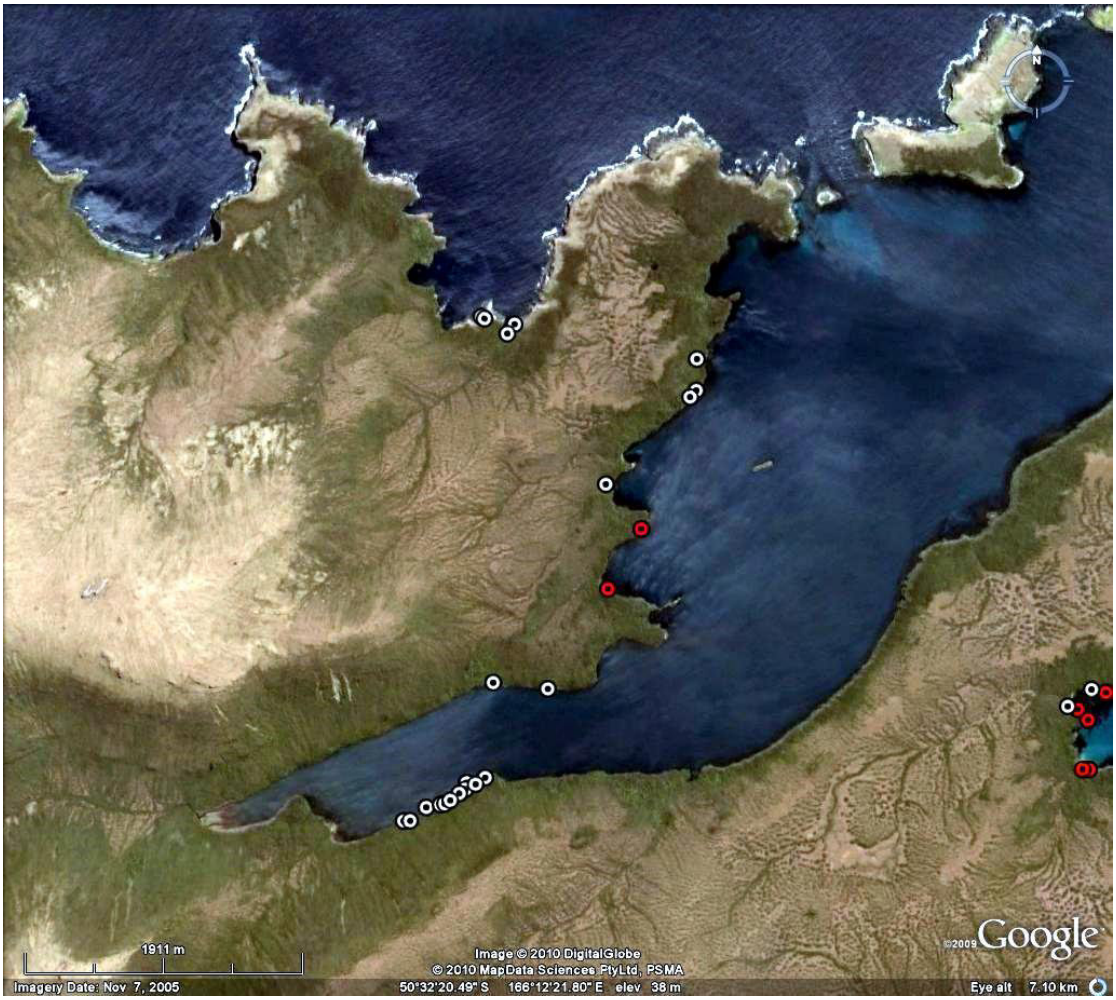


Figure 4.2 Matheson Bay, Hardwick and Laurie Harbour. Red/medium grey landings indicate those missed during searches and subsequently noted during a morning count.

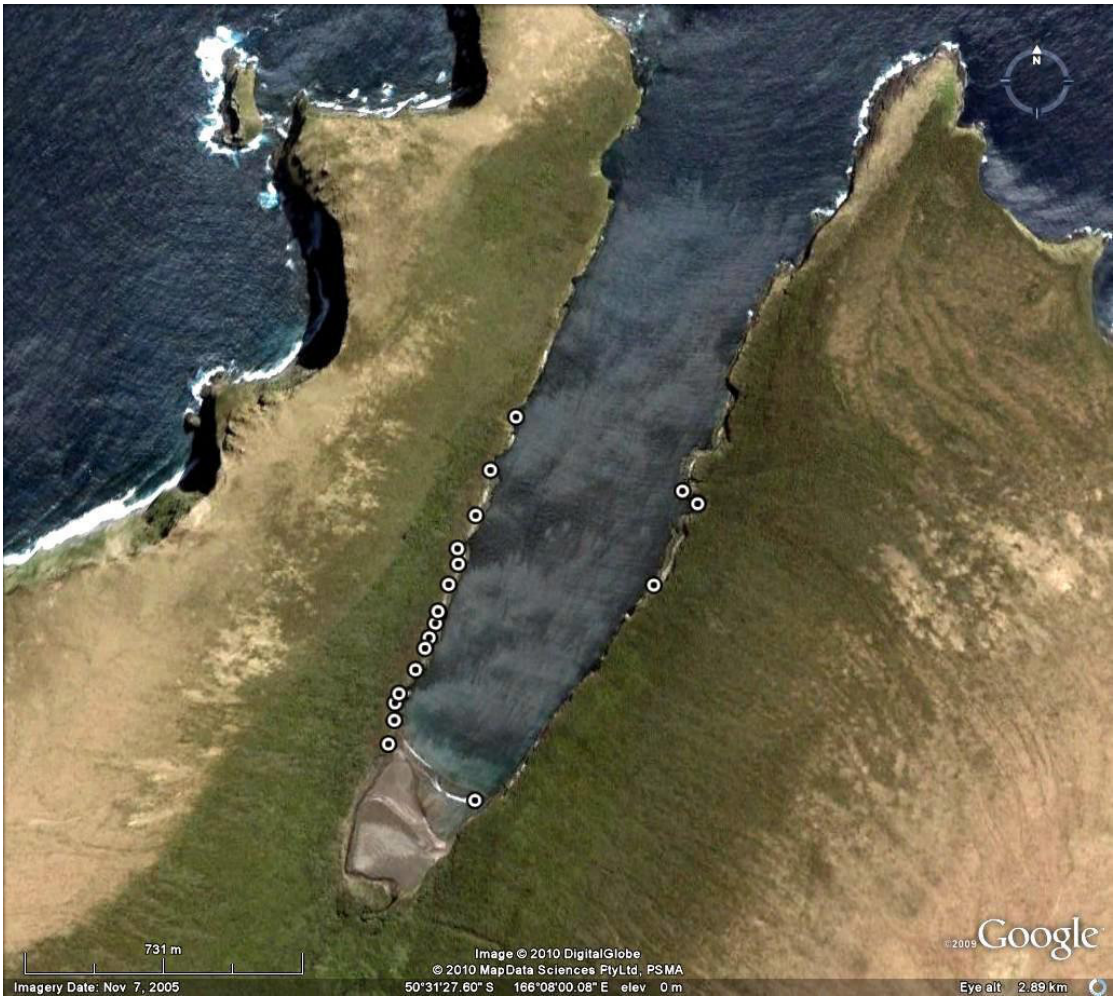


Figure 4.3 North Harbour

Region 5: Northern Islands

Fig 5.1 Ewing Island

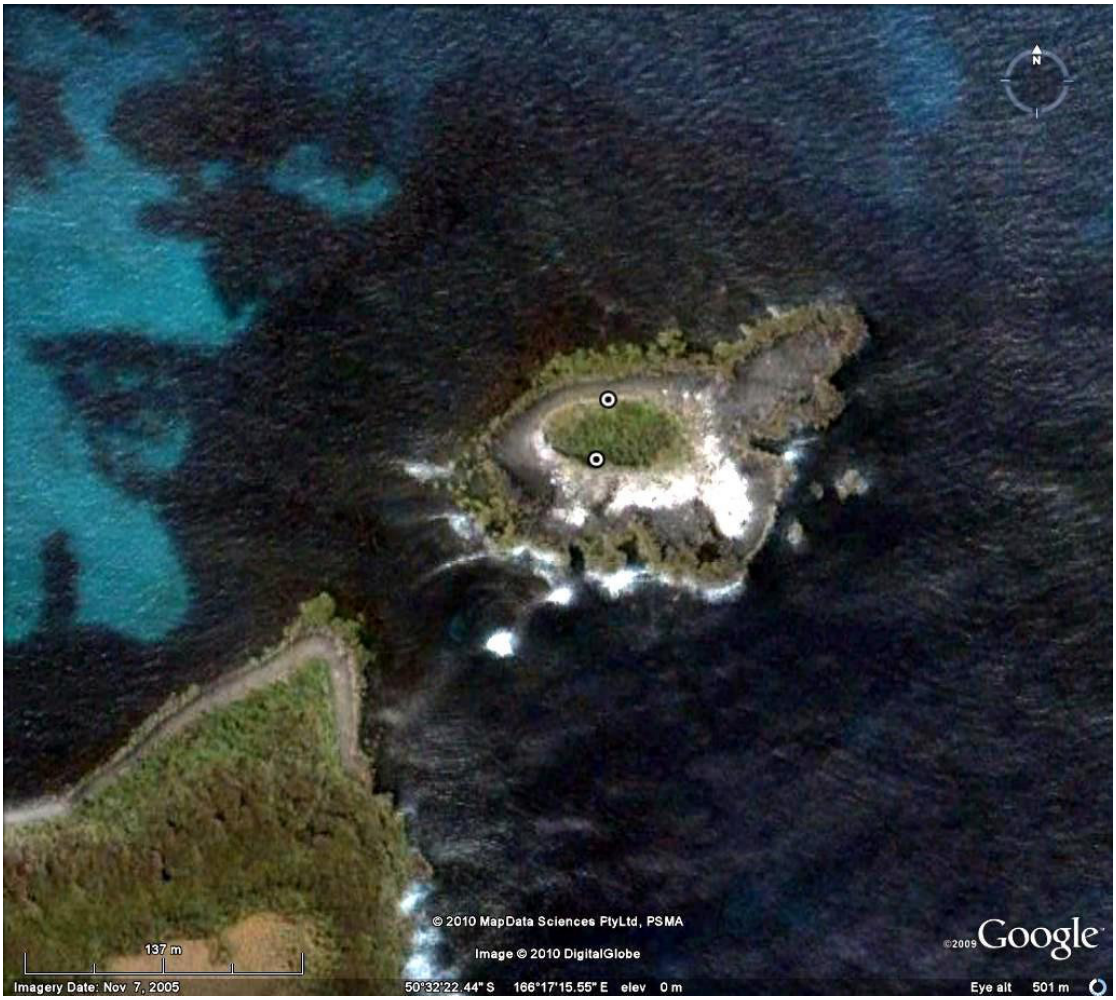


Figure 5.2 Frenchs Island

Figure 5.3 Rose Island

Figure 5.4 Ocean Island

Figure 5.5 Shoe Island

APPENDIX 4. Photos showing possible evidence of predation on YEP

This appears to be pig scat with penguin feathers in it. Found by SK while searching for landings on the south coast of Laurie Harbour. Scale is approximate; the piece shown above is roughly palm-sized.

~ 8 pellets within a 70cm x 70cm area