

Seabird, marine mammal and surface fish surveys of Tasman and Golden Bay, Nelson

Part B: Stable isotopes of seabirds and prey-fish

Prepared for AWE New Zealand Pty. Ltd. and Friends of Nelson
Haven and Tasman Bay Incorporated

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Authors/Contributors:

Sean Handley, NIWA
Paul Sagar, NIWA
Rob Schuckard, FNHTB

For any information regarding this report please contact:

Sean Handley

Marine Ecology and Aquaculture
+64-3-548 1715
s.handley@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd
217 Akersten Street, Port Nelson
PO Box 893
Nelson 7040
New Zealand

Phone +64-3-548 1715
Fax +64-3-548 1716

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Reviewed by

Approved for release by

... R. G. L.

... K. R. Grange

1 Executive summary

Stable nitrogen isotopes have been shown to be valuable indicators of trophic level and carbon isotopes have been used to show how far from shore or in which oceanographic regions seabirds have fed. Stable carbon and nitrogen isotopes were compared between chicks of Australasian gannet sampled at Farewell Spit, spotted shag sampled at Tata Island and little penguin sampled at Fisherman Island and at Nelson to investigate the significance of Tasman and Golden Bays to their feeding and breeding. Significant breeding populations of Australasian Gannet, spotted shag and little penguin are known to feed and breed in these bays (see Part A – Handley & Sagar 2011 and Part C – Handley et al. 2011)

Analyses of data indicate:

- Tight clustering of nitrogen and carbon isotope signatures of all three seabird species, indicating that the birds fed at the same trophic level and from geographically similar diets.
- Spotted shag and little penguin are unlikely to range far from their rookeries in Tasman and Golden Bays during breeding, but their chicks had similar isotopic signatures to Australasian gannets that are capable of ranging several hundreds of kilometres.
- Australasian gannets, spotted shag and little penguin have all been previously recorded foraging throughout the bays (see Part A and C).

Comparison of blood and feather nitrogen isotope concentrations showed enrichment of feathers from Australasian gannets and spotted shags, a result which is supported by overseas literature.

2 Introduction

This research was undertaken in response to an approach from Friends of Nelson Haven and Tasman Bay Inc. (“FNHTB”). AWE Limited (“AWE”) and FNHTB jointly agreed to commission a study to obtain more information and baseline data about the distribution of prey fishes, seabirds and marine mammals within Tasman Bay, Golden Bay, and French Pass so as to better understand the ecology of this area.

Tasman Bay is considered an important area for prey fish such as pilchards *Sardinops neopilchardus* and, to a lesser extent, anchovies *Engraulis australis*, and yellow-eyed mullet *Aldirichetta forsteri* (Young & Clark 2006, Argue & Kearney 1983, Baker 1972). The presence of these sources of food, allows seabirds such as the fluttering shearwater *Puffinus gavia*, Australasian gannet *Morus serrator*, spotted shag *Stictocarbo punctatus* and little penguin *Eudyptula minor* to feed and breed in and around Tasman and Golden Bays (OSNZ- Rob Schuckard). Information about the distribution and numbers of prey fish and seabirds is considered essential for future RMA consent applications in Tasman/Golden Bay (R. Schuckard pers. com.), and/or valuable for territorial authorities and the Department of Conservation.

“Stable isotopes” are isotopes or chemical signatures of an element, such as carbon or nitrogen, which show no tendency to undergo radioactive breakdown¹. An isotope is a naturally occurring element having the same atomic number as another (i.e. the same number of nuclear protons), but having a different atomic mass (i.e. a different number of nuclear neutrons). Stable isotopes are useful to animal ecologists because of variations in their ratios, and changes in these ratios arising from physical and biological processes. The incorporation of dietary stable-isotope signatures into animal tissues means that analyses of these isotopes can be used to track changes in diet, and so movements between isotopically distinct food webs. This approach to identifying migratory connections has become widespread, particularly in studies of avian migration.

Stable isotope ratios of nitrogen ($^{15}\text{N}/^{14}\text{N}$ or $\delta^{15}\text{N}$) and carbon ($^{13}\text{C}/^{12}\text{C}$ or $\delta^{13}\text{C}$) in tissues pass from prey to predator in a predictable manner. For nitrogen, the ratio of the heavier (and rarer) isotope to the lighter one increases at a rate of 3–5 parts per thousand between trophic levels in marine systems, such that the method can be used to indicate the trophic level of the predator, though not the specific items in the diet (Petersen & Fry 1987, Forero & Hobson 2003, Barrett et al. 2007). Although carbon isotope ratios change less between trophic levels than those of nitrogen, they are useful in providing a general idea of how far from shore or in which oceanographic regions the bird has fed (Hobson et al. 1994, Barrett et al. 2007, Bond & Jones 2009).

The aim of this study was to examine the trophic linkages between Australasian gannets, spotted shags and little penguins and their prey in Tasman and Golden Bay area using stable isotopes to corroborate aerial and boat survey data (see Part A and C).

¹ For a beginners guide to isotopes, consult: http://www.iso-analytical.co.uk/what_are_isotopes.html

3 Methods

3.1 Seabird isotope collections

Trips to various bird colonies were undertaken by members of the Ornithological Society of New Zealand to collect feather and blood samples for stable isotope analyses to compare with prey fishes isotopic signals. In order to undertake these studies we obtained a High Impact Permit from the Department of Conservation (DoC permit No. NM-29023-FAU) and NIWA Animal Ethics Approval (permit No. 136).

3.1.1 Single feather trimming

Stable isotope analysis of feathers provides information about the diet of the birds when the feather was grown i.e. during moult which usually occurs after the breeding season. For chicks near fledging, a small portion (2 mg) of body or covert feathers was trimmed from the back of the birds and stored in a labelled bag for stable isotope analysis by NIWA in Wellington. The intention was to compare isotope signatures with marine prey fish species to establish the contribution of prey fishes to the diet of growing chicks. No gaps in the plumage were created by the feather trimming. Down feathers were not collected (with the exception of some Australasian gannets – see below) as the SI signatures can reflect what the parent birds have been eating before egg laying (Dr Matt Rayner, NIWA pers. comm., Inger & Bearhop 2008) and the isotopic turnover rate of natal tissue including unformed down is undescribed for these species.

3.1.2 Blood samples

Stable isotope analysis of blood provides more of a snap-shot of the diet of the bird during the previous few days. From each of the same individuals above, 2 millilitres of blood was extracted from the tarsal leg vein by pricking the vein with sterile needle and extracting blood using glass capillary (Thermo Fisher Scientific No.CSE2502) which were drained into sterile glass vials containing 99% ethanol. The wound was cleaned and cotton wool held over until blood flow ceased (clotting) and the chick released.

Australasian gannets were sampled from Farewell Spit, spotted shags were sampled at Tata Island, and little penguins were sampled at Fisherman Is. (Figure 1).

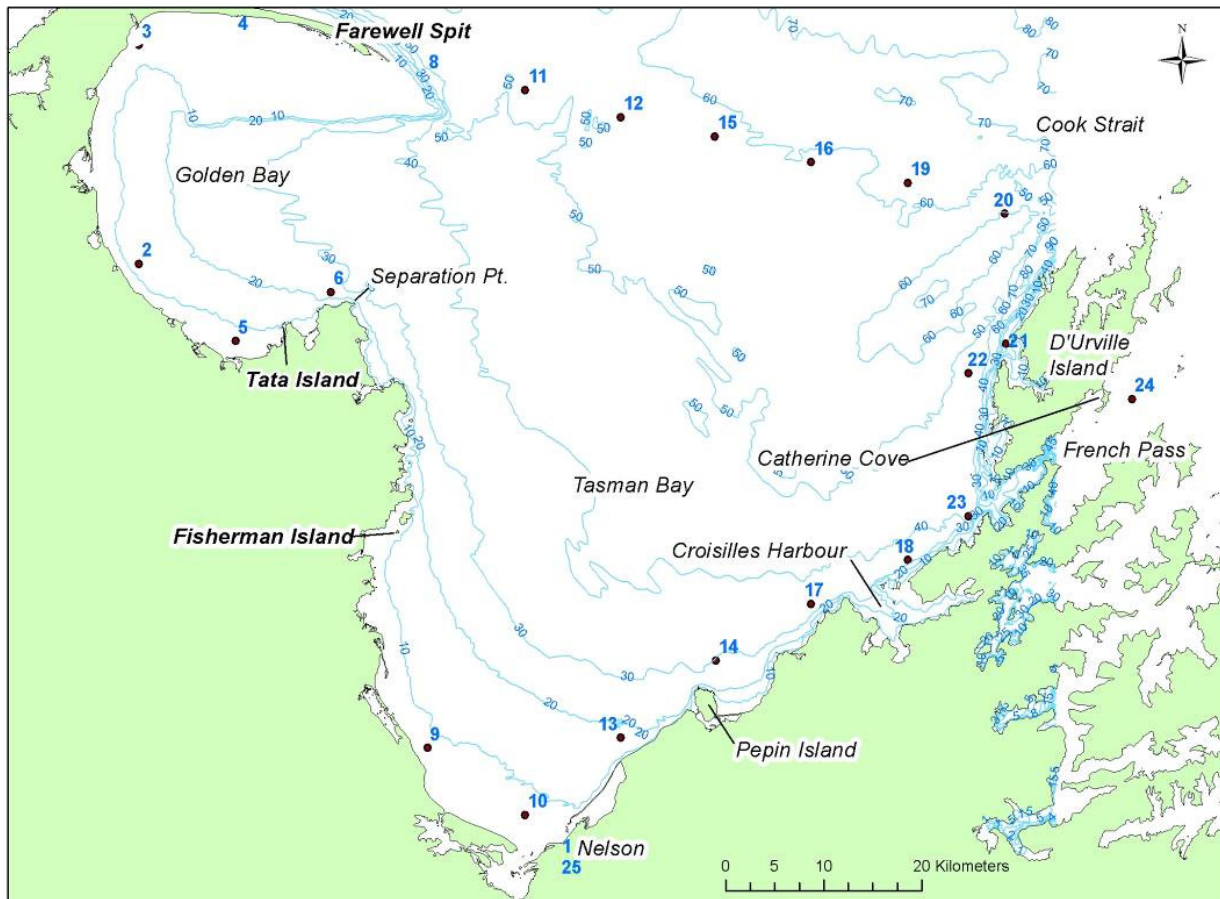


Figure 1: Study location indicating sites of seabird sampling (in Bold). Bird sampling sites are in bold.

3.1.3 Australasian gannet sampling, Farewell Spit

On 9 December 2010, members of the Ornithological Society of New Zealand (OSNZ)) and DoC Golden Bay visited the Australasian gannet colony at Farewell Spit. Timing was based on the previous visit to the colony (6 November 2010). At that time, all birds were sitting very tight on nests with eggs suggesting breeding was at an advanced stage. Early breeding can start at the end of July however, in recent years breeding has started later and now the first clutches of eggs appear between the end of September and the end of October (Schuckard unpub. data).

On arrival at the colony in December 2010 it became apparent that the majority of chicks were too immature, having their natal down and lacking feathers, and thus unsuitable for sampling. Small chicks in down are also vulnerable to disturbance and unable to thermoregulate, and so are not suitable for sampling under the protocols set out in our DoC High Impact permit. A subsequent visit to the colony was planned for January 2011.

On 21 January 2011 the colony had plenty of chicks. Fledglings of Australasian gannet ranged from 95 – 109 days (Nelson 1978). Most of the chicks were assessed to be older than two weeks based on the first sign of primary feather growth. This age was deemed suitable for sampling. In general, the colony appeared to have significant chick mortalities on nests lower down the shore presumably due to drowning, not starvation. Two regurgitations were collected; including possibly barracuta² (Schuckard pers. com.).

² These samples were heavily digested, missing their heads and otoliths, and were later deemed unsuitable for stable isotope analysis for the aims of this project due to uncertainty of their geographic origin, as they may have been eaten on the West Coast (c.f. Tasman. & Golden Bays).

The chicks sampled on the second site visit were estimated to be between 2 and 9 weeks old with weights varying between 1,090 and 2,840 grams. Chicks were sampled over an 8-hour period.

Problems were encountered bleeding the Australasian gannet chicks through the tarsal vein. Of the initial 13 chicks, sampled through the tarsal vein, 2 did not bleed at all and a number provided marginal quantities of blood. Therefore, a further 19 chicks were bled from the brachial vein to ensure an adequate sample size.

Coagulation of the blood took place in a matter of seconds and all birds were released without any apparent negative effects from the different sampling methods. Feather samples were taken either from the upper tail coverts or the wing coverts close to the body. Three chicks did not have feathers and down was sampled instead.

In conjunction with bird sampling, a beach seine was used to collect yellow-eyed mullet for SIA in the shallow water at the spit.

During a February 2011 visit, members of the OSNZ used a beach seine to collect additional fish samples. Only yellow-eyed mullet was collected for SIA in the shallow water on the northern part of Farewell Spit.

3.1.4 Spotted shag sampling, Tata Island

On 26 November 2010, OSNZ members (Rob Schuckard, Mike Bell and David Melville) and Manawhenua ki Mohua monitoring team (Chris Hill and Anya van Holten) landed at the southern island of Tata Islands. Weather conditions were sunny and warm. Assessment of the colony revealed many of the fledglings had already left the nest sites and were roosting on the shallow rocks encircling the island but enough birds were present for sampling. To minimise stress during bird handling it was decided to process the birds on the eastern part of the southern island which was shaded from the afternoon sun.

The shag catching went extremely well with no sign of disruption or neighbouring roosting juveniles taking flight. A condition of the special permit was to cease the catching of the birds if there was evidence of a significant disruption to nesting activity. Only the catcher was moved by boat along the island, while the samplers remained in one location to minimise disturbance to the colony. Birds were subsequently released at the ledge where they had been caught without difficulty. The birds were sampled over a 4.5 hours period, commencing at 11:15. Five birds were also sampled for whole blood which was later frozen to compare with ethanol preservation³. Three regurgitate pellets were collected⁴.

Adult spotted shag weights vary between 1.0 and 1.9 kg (Lalas 1983), wing length varies between 233 and 266 mm (Marchant & Higgins 1990) and bill length varies between 56 and 70 mm (Marchant & Higgins 1990). Juvenile wing lengths measured in this study varied from 115 to 260 mm, bill length varied between 39 and 64 mm and the weight varied between 0.43 and 1.2 kg. Based on the above information and a nesting period of 62 days, it was estimated the ages of the juveniles we sampled to be: 3 at ca. 5 weeks old, 15 between 6 and 8 weeks old, and 8 at ca. 9 weeks or older.

³ David Melville provided a reference (Barrow et al. 2008) that questioned the use of ethanol as a preservative 25/11/1010.

⁴ These regurgitates did not contain fish muscle tissue of identifiable species, and without bird tracking devices, we did not know their geographic origin. Thus, they were deemed unsuitable for stable isotope analysis given the aims of the project. Research also suggests that digestion can alter the isotopic signatures potentially confounding results (Pinnegar & Polunin 1999).

A number of dead chicks were noted in the colony, which is fairly typical of smaller colonies in the Marlborough Sounds (Mike Bell, OSNZ, personal observations). For every 7 living juveniles there were about 4 dead chicks smaller than 4 weeks old counted. It is likely, however, that a significant number of juveniles had already fledged. One of the regurgitations collected contained nematodes. Ectoparasites were also very abundant on the sampled birds including; multiple birds with swollen (well-fed) ticks on wings; multiple birds with feather mites; and most were heavily infested with fleas. One juvenile also had 20-30 smallish ectoparasites stuck to the naked skin of its gular region.

3.1.5 Little penguin sampling, Fisherman Island

On the 30 November 2010, OSNZ members (Rob Schuckard, Mike Bell and David Melville) and Peter Gaze (DoC Nelson) landed at the southern end of Fisherman Islands. Weather conditions were sunny and warm.

Assessment of the colony of little penguin on Fisherman Island revealed a very poor breeding success. Many nests had been deserted, sometimes with eggs still in the nests, a number of fresh dead chicks (<24 hours old) were present and the small number of living chicks were very emaciated.

3.2 Prey fish isotope collections

Prey fishes were sampled on the 25 and 26 January 2011 in the region of eastern Tasman Bay previously identified via aerial survey to contain abundant schooling fish through French Pass to D'Urville Island (Handley & Sagar 2011). Methods used to obtain prey fishes were a plankton net, beach seine and capture of predatory fishes to analyse their stomach contents.

Fish were dissected with a scalpel and a portion of the left hand side of the muscle tissue behind the gut cavity was removed, individually bagged and frozen. Only whole intact prey fishes (skin intact) dissected from predatory fish were used for stable isotope analysis to minimise any chance of change in $\delta^{15}\text{N}$ isotopic concentrations resulting from acidification during digestion (Pinnegar & Polunin 1999).

3.3 Stable Isotope Analyses (SIA)

To establish background stable isotope signatures of pelagic and benthic primary producers, SI values were used from a previous project centred at Separation Point, Golden Bay (S. Handley, NIWA, unpublished data), and from another study at Horoirangi Marine Reserve (T Willis, NIWA, unpublished data). Suspended particulate organic matter (SPOM) was collected above the summer isotherm, and benthic microalgae (BMI) were scraped from the surface of sediments by SCUBA at Whariwharangi Bay, Golden Bay. To control for regional variation, SPOM and BMI were also collected from the West coast and Cook Strait regions at Punakaiki, Glenduan (south end of Horoirangi Marine Reserve), and at north east entrance to Port Hardy D'Urville Island. SPOM seawater samples were collected in 4 l acid washed bottles, were first filtered through 150 μm mesh to remove zooplankton, then filtered through pre-ashed (450°C x 4 h) 47 mm glass fiber filters (GF/F) at low pressure (<5 in. Hg vacuum) to achieve a dark green colour. Benthic microalgae were concentrated by a vertical migration technique modified from Carman & Fry (2002) whereby diatom scrapings collected on SCUBA were returned to the laboratory and incubated under fluorescent grow lights below a 63 μm Nitex mesh netting covered by 1-2 mm of GLC 0.4 mm glass beads for 18-24 hours. The mesh screens were then gently removed, and washed with 0.1 μm filtered seawater to

remove the diatoms which were then filtered through glass fibre filters as above. Samples for C isotope analysis were treated with 1N HCl to remove carbonates, and rinsed with reverse osmosis water. All glass filters were inspected microscopically and cleaned of any zooplankton or detritus with forceps. Terrestrial isotope signatures were established directly via concurrent sampling and analysis of river detritus and above-ground tissue of dominant vegetation (diatom mats, rushes and herb species) from Wainui River, Totaranui Stream, Awaroa Inlet stream and a stream at Nile Head D'Urville Island (Handley, unpublished data).

Fish muscle tissue was subsampled (tissue only, no skin, no bone) and freeze dried prior to SIA. Frozen "whole blood" was freeze dried and ground roughly (in the sample tube) using a stainless steel dissection probe prior to SIA. "Blood in ethanol" was dried at 60 °C then ground roughly (in the sample tube) using a stainless steel dissection probe prior to SIA. Heart muscle tissue stored in ethanol was subsampled from the heart wall, dried at 60 °C overnight prior to SIA. Feathers were air dried, and then one complete side (up to the shaft) was snipped into multiple small pieces, off one single feather. These pieces then mixed roughly, before subsampling for SIA.

Stable isotope analyses of samples were carried out on a ThermoQuest Finnigan Delta-Plus mass spectrometer (Bremen, Germany). Solid samples were prepared in tin boats and combusted in an NA 1500 elemental analyser (Fisons Instruments SpA, Strada Rivoltana 20090, Rodano, Italy) at 1020 °C in a flow of oxygen and He carrier gas. Oxides of N were reduced to N₂ gas in a reduction furnace at 640 °C. N₂ and CO₂ gases were separated on a Porapak Q gas chromatograph column before being introduced to the mass spectrometer detector via an open split. CO₂ and N₂ reference gas standards were introduced to the mass spectrometer with every sample run. ISODAT software calculated $\delta^{15}\text{N}$ values against atmospheric air, and $\delta^{13}\text{C}$ values against the CO₂ reference gas relative to PDB, correcting for ¹⁷O. The secondary acetanilide standard was calibrated routinely against international NIST standards (flour, DL-leucine and USGS40⁵). Accuracy of both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ estimates measured in relation to four environmental standards was $<\pm 0.25$.

4 Results

4.1 Australasian gannet sampling – Farewell Spit

A total of 34 Australasian gannet chicks was sampled, a greater number than planned, because of the number of unsuccessful blood samples or insufficient quantities through the tarsal vein. Of these, only 25 provided adequate samples for SIA.

4.2 Spotted shag sampling – Tata Island

In total 26 spotted shag was sampled. One more bird than permitted was sampled as the birds were very dehydrated, resulting in less blood than considered desirable under the protocol.

4.3 Little penguin sampling – Fisherman Island

From Fisherman Island 3 live chicks were sampled for blood, 3 for feathers, and 3 dead chicks for feathers and heart tissue as their blood had coagulated. A single moulting adult

⁵ <http://www.niwa.co.nz/our-services/instruments/instruments/masspec>

was also sampled. From the colony breeding boxes on Rocks Road in Nelson, adjacent to Guytons fish market a single dead chick was sampled for feathers and heart tissue.

4.4 Prey fishes

Many schooling fish were seen on the boat trip to the eastern side of Tasman Bay, but capturing them proved difficult. Most of the fish appeared to be very small (< 5 cm) with some almost translucent, making them difficult to see and therefore capture. A plankton net was trialled, but due to the fine mesh (100 μm), it appeared to create a pressure-wave in front of the net, which we assumed could be easily detected by the small fishes which escaped capture. The seine net we tried had too large a mesh size, so it was decided to sample the fishes by capturing predatory fishes. Kahawai (*Arripis trutta*) and albacore tuna (*Thunnus alalunga*) - a rare catch for inner Tasman Bay (Barrie Bird, Seabird Charters, pers. comm.) were caught and their stomachs dissected. From these we sampled the freshest prey items.

Prey items sampled included sprat (*Sprattus* sp.), anchovy, juvenile arrow squid (*Notodarus* sp.) and a single juvenile silver warehou (*Seriolella punctata*)⁶. Yellow-eyed mullet and piper (*Hyporhamphus ihi*) were sampled in the intertidal using the beach seine.

4.5 Stable Isotopes

The results of the SIA analysis show that terrestrial sources of nitrogen and carbon are depleted, and as expected as we move up the food-chain, the concentrations of these isotopes increased (Figure 2). At the base of the food chain, SPOM, which includes phytoplankton, was generally the most depleted, with benthic micro-algae (BMI) and then seaweeds from the reef being more enriched, especially for nitrogen which is a limiting nutrient in Tasman Bay (MacKenzie & Gillespie 1986, Zeldis et al. 2011). Carbon and nitrogen enrichment increased further up the food chain from zooplankton (which graze on SPOM and potentially BMI) and then to fishes. There was some separation of the isotope concentrations of the prey fishes, with those dissected from predatory tuna and kahawai more depleted than yellow-eyed mullet and piper (Figure 2). The exception to this trend was for the squid sampled from tuna which were only slightly depleted in carbon relative to freshly caught prey fishes. We cannot discern whether these differences were due to alteration of the isotope ratios from partial digestion inside the stomachs of tuna and kahawai, or due to these species feeding on more oceanic zooplankton, as the piper and yellow-eyed mullet were all collected in shallow locations compared to the anchovy and sprat. It was affirming that the juvenile yellow-eyed mullet showed depletion in nitrogen compared to adults as we expected to see older fish of the same species to become more nitrogen enriched as they grow. There was potential evidence of regional variation in isotope values, with the Farewell Spit yellow-eyed mullet showing more enrichment of nitrogen and carbon than those from D'Urville, but unfortunately these fish were sampled on the northern side of Farewell Spit, at the entrance to Golden and Tasman Bay, rather than inside Golden Bay.

When comparing the inter-species ratio of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotopic concentrations derived from the chick feathers of the three seabird species, it was evident that all species had relatively similar ratios, clustered higher up the food chain above the fishes (Figure 2). Chick $\delta^{15}\text{N}$ derived from the blood preserved in ethanol of the 3 seabird species ranged from 14.69 ± 0.08 ‰ (mean $\pm$ SE) from Australasian gannet to 15.07 ± 0.04 ‰ from spotted shag, and

⁶ Juvenile fishes were identified by Dr Trevor Willis, NIWA Nelson.

15.17 ± 0.29 ‰ from living little penguin (Figure 3). The feather $\delta^{15}\text{N}$ from Australasian gannets (15.88 ± 0.07 ‰) and spotted shags (15.93 ± 0.05) were all significantly⁷ more enriched than the $\delta^{15}\text{N}$ from their bloods (Australasian gannet = 14.69 ± 0.08, spotted shag = 15.07 ± 0.04).

The frozen whole bloods from spotted shags were not significantly different to ethanol preserved bloods for $\delta^{15}\text{N}$ but were significantly depleted for $\delta^{13}\text{C}$ ⁸. Live little penguin chick feathers had a $\delta^{15}\text{N}$ of 15.61 ± 0.16 ‰ were not significantly different than their blood⁹ (15.17 ± 0.29), but only 3 little penguin chicks were sampled for both tissues from the same comparable location at Fisherman Island.

Inter-species comparisons of $\delta^{13}\text{C}$ isotopes showed that live little penguin blood and feathers were depleted compared to the Australasian gannets and spotted shag chicks. The range of blood $\delta^{13}\text{C}$ was -19.55 ± 0.26 ‰ from live little penguins to -18.55 ± 0.12 ‰ from spotted shags, whereas feathers ranged from -18.48 ± 0.24 ‰ from live little penguins to -17.13 ± 0.11 ‰ for Australasian gannet feathers. There was no significant difference between feathers and down in the Australasian gannets sampled at Farewell Spit¹⁰.

For little penguin, the adult moulting bird sampled on Fisherman Island, as compared to live chicks, had depleted nitrogen for feathers and blood but not for carbon. Whereas the dead chicks sampled on Fisherman Island and in Nelson did not vary consistently possibly due to degradation of the isotopes after death.

When comparing the feather $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ isotope signatures of the different aged spotted shag and Australasian gannet chicks, no statistically significant differences were found between estimated age classes¹¹ or wing length respectively.

⁷ t-test results: Australasian gannet feathers vs blood: p=0.000001, spotted shag feathers vs blood: p=0.000001

⁸ t-test results: spotted shag $\delta^{15}\text{N}$ frozen whole blood vs ethanol preserved blood: p=0.14, $\delta^{13}\text{C}$ frozen whole blood vs ethanol preserved blood: p=0.0056

⁹ t-test result: penguin feathers vs blood: p=0.604

¹⁰ t-test result: Australasian gannet feather vs down: p = 0.014.

¹¹ Tukey-Kramer HSD tests of significance

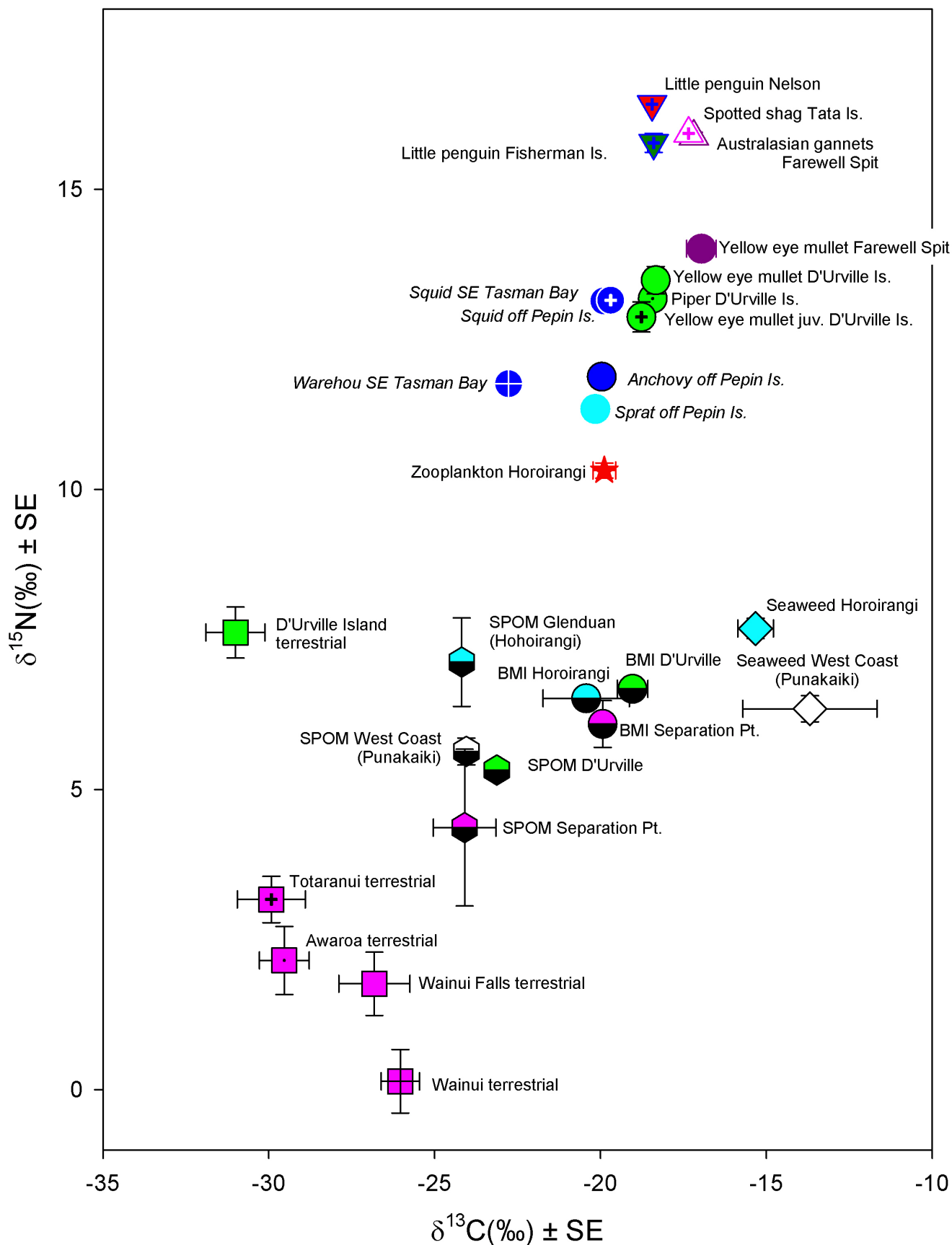


Figure 2: Stable-carbon and nitrogen isotope concentrations from the Nelson and West Coast region. Samples are colour coded by geographic location, and represent: “terrestrial” plants in freshwater waterways; suspended particulate organic matter (SPOM); benthic micro-algae (BMI); seaweeds; zooplankton, fishes (labels in italics are from gut content of predatory kahawai and albacore tuna); seabird chick feathers.

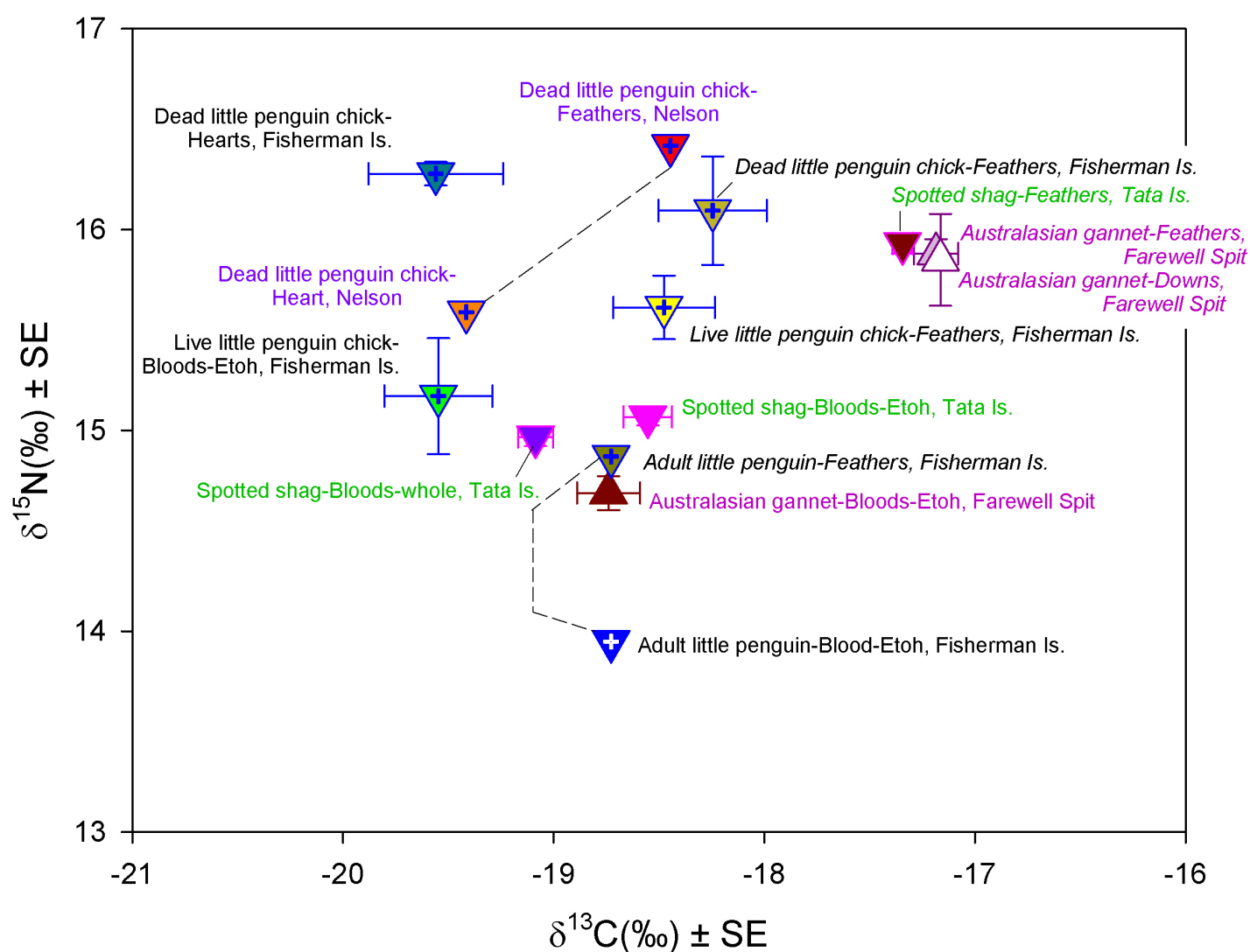


Figure 3: Stable-carbon and nitrogen isotope concentrations of Australasian gannets, spotted shags, and little penguins. Labels in italics are feathers and down, locations are colour coded, and symbols joined by dashed lines represent single individuals.

Table 4-1: Mean and standard error (SE) of Nitrogen and Carbon stable isotope concentrations for seabird species and prey fishes from Tasman and Golden Bays.

Common Name	Location	Age/mean size	Alive?	Tissue	N	Mean ($\delta^{15}\text{N}/^{14}\text{N}$)	SE	Mean ($\delta^{13}\text{C}/^{12}\text{C}$)	SE
Australasian gannet	Farewell Spit, Golden Bay	Chick	Alive	Blood in ethanol	5	14.69	0.08	-18.74	0.15
		Chick	Alive	Feather	29	15.88	0.07	-17.18	0.11
		Chick	Alive	Down feather	3	15.85	0.23	-17.16	0.01
Little penguin	Fisherman Island, Able Tasman, Tasman Bay	Adult	Alive	Blood in ethanol	1	13.95	.	-18.73	.
		Adult	Alive	Feather	1	14.87	.	-18.73	.
		Chick	Alive	Blood in ethanol	4	15.17	0.29	-19.55	0.26
		Chick	Alive	Feather	3	15.61	0.16	-18.48	0.24
		Chick	Dead	Heart muscle in ethanol	2	16.28	0.06	-19.56	0.32
		Chick	Dead	Feather	2	16.09	0.27	-18.25	0.26
	Rocks Rd, Nelson, Guytons fish shop	Chick	Dead	Heart muscle in ethanol	1	15.59	-	-19.35	-
Spotted shag	Tata Island, Abel Tasman, Golden Bay	Chick	Dead	Feather	1	16.42	-	-18.43	-
		Chick	Alive	Whole blood	5	14.97	0.05	-19.09	0.08
		Chick	Alive	Feather	26	15.93	0.05	-17.34	0.05
		Chick	Alive	Blood in ethanol	5	15.07	0.04	-18.55	0.12
Anchovy	Tasman Bay, off Pepin Is.	55 mm	Alive	Muscle	10	11.88	0.15	-19.96	0.21
Piper/Gar fish	Cherry Tree Bay, D'Urville Is.	193 mm	Alive	Muscle	10	13.18	0.08	-18.66	0.15
Silver warehou (juv)	Tasman Bay, off Pepin Is.	65 mm	Alive	Muscle	4	11.34	0.18	-20.16	0.12
Sprat	Tasman Bay, off Pepin Is.	56 mm	Alive	Muscle	2	13.15	0.01	-19.80	0.10
Squid (arrow squid?)	Tasman Bay, off Kokorua Bay Catherine Cove, D'Urville Is.,	150 mm	Alive	Muscle	7	12.87	0.25	-18.77	0.18
Yellow-eyed mullet	Kaiangawari Beach	135 mm	Alive	Muscle	10	13.48	0.23	-18.34	0.09
Yellow-eyed mullet	Farewell Spit, Golden Bay	165 mm	Alive	Muscle	10	12.87	0.25	-18.77	0.18
Yellow-eyed mullet (juv)	Cherry Tree Bay, D'Urville Is.	85 mm	Alive	Muscle	8	13.48	0.23	-18.34	0.09

5 Discussion

Stable isotopes of growing feathers and blood both represent assimilated diet, and both tissues are used to study the diet and foraging distribution of marine and terrestrial birds (Quillfeldt et al. 2008). The narrow feather $\delta^{15}\text{N}$ (15.61 ± 0.05 to 15.93 ± 0.16) and blood (15.17 ± 0.29 to 14.97 ± 0.05) isotope ranges from the three bird species chicks in this study indicates that all of their parents were feeding at the same trophic level within the region (c.f. Barrett et al. 2007), which suggests they all had a very similar diet. Comparable isotope methods have been used overseas to delineate sex differentiated food resource utilisation (Forero et al. 2002) and comparisons of trophic overlap of different seabird species (Forero et al. 2004). Comparisons between these studies and the isotopic signature ranges in this study show our results are accurate and robust. Due to the specific metabolic processes involved in tissue formation, different tissues may differ in their isotopic enrichment factor relative to the diet depending on the turnover rate of the tissue in question (e.g., Hobson & Clark 1992). Our initial NIWA advice for SIA methodology was that analysis of both blood and feathers may be unwarranted as the results from the different tissues is very similar (Sarah Bury, NIWA pers. comm.). Blood $\delta^{15}\text{N}$ isotope concentrations however can be depleted due to uric acid presence in the blood (Petersen & Fry 1987), and similarly, feather isotope ratios may also be biased by certain amino acids present in keratin in recently ingested food (Quillfeldt et al. 2008). From the three species of seabirds sampled in this study, Australasian gannet and spotted shag feathers had enriched $\delta^{15}\text{N}$ isotope concentrations over blood, a result which agrees with previous studies from other seabird species overseas (Quillfeldt et al. 2008). As Quillfeldt et al. (2008) also found similar $\delta^{15}\text{N}$ differences between both adult and chick tissues, with same differences between the tissues from both; it is unlikely that the differences seen between feather and blood tissues in our study are related to diet. Quillfeldt et al. (2008) recommended sampling both tissues, although in this study, the aim was to compare isotopic variation between species, and how that relates to signatures from potential diet fishes, rather than investigating differences between different tissues. The lack of differentiation between $\delta^{15}\text{N}$ in little penguin feathers and blood was likely the result of low sampling resolution.

In relation to the $\delta^{13}\text{C}$ values which can give an indication of geographic region and onshore-offshore location where birds have been feeding (Hobson et al. 1994, Cherel et al. 2000, Barrett et al. 2007, Bond et al. 2010), the overlapping range of fishes and the seabirds indicate they are feeding in the same region. Conclusions regarding geographic movement are limited by our understanding of biogeographic isotopic regions ('isoscaples' or 'isotopic landscapes') and the identification of small-scale biogeographic isotopic gradients in food webs (Forero & Hobson 2003, Rubenstein & Hobson 2004, Jaeger et al. 2010). The power of $\delta^{13}\text{C}$ as a proxy of animal foraging habitats is related to the knowledge of the extent and pattern of its spatial variations in the environment (Jaeger et al. 2010). Although the range of pelagic and coastal feeding Australasian gannets from Farewell Spit may be several hundreds of kilometres (Wingham 1985), the feeding ranges of coastal feeding little penguins and spotted shags (Handley & Sagar 2011, Handley et al. 2011) from their rookeries in inner Tasman and Golden Bays are unlikely to take them outside the region, to an isotopically different foodweb or landscape. Thus, as all species share similar isotopic signatures with prey fishes sampled in the region, it is highly likely they are feeding in Tasman and Golden Bays. To confirm this hypothesis however, samples of prey-fishes from other regions bordering the study area would be needed. Prior to this however, it is recommended that

analysis of otoliths collected from seabirds via regurgitate is required to identify what species to capture and analyse for SI.

It was unfortunate that pilchard, which is considered an important diet component of these seabirds (Taylor 1997, Dann et al. 2000, Wingham 1985), was not collected during the fish collection trips. Parrish (1998) also report difficulties ground truthing their hydroacoustic survey of seabird forage fishes, where their nets clogged, and suggested the use of trawlers or a purse seine to capture prey fishes. Pilchards are a high-energy food source, typically of greater calorific value than other prey and consequently are considered a 'preferred' prey item in Australasian gannet diet (Batchelor & Ross 1982; Kirkham et al. 1985; Berruti et al. 1993). The highest mortality of Australasian gannets ever recorded in New Zealand occurred in 1995 and was attributed to a pilchard mortality event (Taylor 1997). Diet switching to compensate for a lack of pilchards is thought to increase foraging efforts and feeding frequency, deleteriously affecting reproductive success (Bunce & Norman 2000). In this study, the presence of poor breeding success and large numbers of dead and abandoned little penguin chicks at Fisherman Island, and in Nelson (Roberts 2010: Appendix A) possibly indicates a lack of pilchards in the region during this study. Pilchard and anchovy predominated in food samples from little penguin at Philip Island, Victoria, Australia (Montague 1982) and an increase in penguin mortality in northern Bass Strait and a significant reduction in breeding success were associated with widespread pilchard mortality (Dann et al. 2000). Also in New Zealand, large numbers of malnourished and dying little penguins were recorded during a pilchard die-off in 1995 (Smith et al. 1996). During this same pilchard mortality event, it was concluded that pilchard scarcity resulted in unusually long foraging trips of little penguin at Motuara Island, Marlborough Sounds, leading to increased risk of egg desertion (Numata et al. 2000). There was however no indication the Australasian gannet chicks were under any stress (R. Shuckard, pers. comm.), but gannets are capable of foraging farther than little penguins, suggesting pilchards or other high value forage fishes were available outside the range of the little penguins.

There did not appear to be a lack of schooling fish at the surface in Tasman and Golden Bays during the aerial survey carried out the week before samples were collected from the penguins (Handley & Sagar 2011) or the boat surveys carried out in December 2010 and January 2011 (Handley et al. 2011). Many of these fish schools could have been predatory kahawai or kingfish (*Seriola lalandi*) rather than small fishes suitable as food for penguins. Almost 2 months later, in late January, juvenile anchovy and sprat (average size of 55-56 mm) were the dominant gut contents of tuna and kahawai, but pilchard were absent as prey items of predatory fishes at that time. Given previous seabird diet records (Handley & Sagar 2011), our inability to catch pilchard from inner Tasman Bay to D'Urville Island, the lack of pilchards in the stomach contents of predatory fish caught, and the poor breeding success of little penguins on Fisherman Island all suggest that pilchard were scarce in inner Tasman Bay during this study. However, weight of Australasian gannet chicks and some adults did not allude to food stress. Greater sampling effort than allocated for fish across Golden and Tasman Bays would have been required to confirm this. However, given that pilchard are likely to have similar isotope signatures as the other pelagic fishes analysed herein (anchovy, yellow-eyed mullet, sprat and piper) as they feed on the same phyto- and zooplankton in Tasman and Golden Bays, the addition of pilchard to the isotope analysis would likely not have added any more strength to our conclusions.

5.1 Conclusions

In relation to the aims of this study to assess the importance of this region to the ecology of Australasian gannets, spotted shags and little penguins, three lines of evidence show that Tasman and Golden Bay are very important to the ecology of these species:

- (i) The results of this study showing tight clustering of nitrogen and carbon isotope signatures of all three seabird species were feeding at the same trophic level with some possible geographic differences;
- (ii) Observations from the previous aerial survey (Handley & Sagar 2011); and
- (iii) Previous documented research and observations of the distribution, feeding ranges and ecology of these species (see: Handley & Sagar 2011).

5.2 Recommendations

Future studies would benefit greatly by combining isotopes and tracking data in a spatial analysis (e.g. Rayner et al. 2010). By using GPS tracking devices and activity loggers a space model of marine hot spots in a region can be built especially when combined with prey-specific data using stable isotopes. Isotope data from prey species outside the region and collections across different seasons or climatic conditions (El Niño vs La Niña) would also provide regional and temporal data to better understand potential variability in isotopic signatures in this ecologically important region. Concomitant collection of seabird regurgitates/pellets analysed utilising an otolith library could also be used to quantify seabird diet and prey species preferences.

The decision about which tissues to sample; feather versus blood, or both, is complex. The keratin in feathers is metabolically inactive once formed so their derived isotope values reflect the period of time during which they are grown (Cherel et al. 2005). Whereas blood provides variable, short to medium term information (ca. 1-5 weeks, Cherel et al. 2005) but the nutrients for blood synthesis can come from stores (Bearhop et al. 2002). Discriminatory power or the relationship between isotope ratios in food and in consumer tissues has been found to be greater for feather $\delta^{15}\text{N}$ than blood in three species of penguin (Cherel et al. 2005). Although this study demonstrated that feather $\delta^{15}\text{N}$ values are enriched over blood for Australasian gannet and spotted shag (too few samples were collected from little penguin to comment), and this result confirms similar results from overseas bird species, we do not know why they differed. Specific research aimed at determining the range of isotopic variation of feathers and blood using controlled feeding of captive birds (e.g. Cherel et al. 2005) is required to quantify how a range of available diets affect tissue isotope values.

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Appendix A

Dead and ill penguins 'a concern'

ADAM ROBERTS - The Nelson Mail

Last updated 12:30 04/12/2010

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COLIN SMITH/Nelson Mail

UNWELL: Natureland Zoo vet nurse Lynn Cameron with a sick little blue penguin found on the Tahunanui Beach.

A recent influx of sick little blue penguins is concerning staff at Natureland.

A dozen of the birds have been found on Nelson and Motueka beaches in the past week.

Three were found yesterday, with two dead and the other taken to a veterinarian.

Natureland staff have set up a 24-hour critical care unit to look after the penguins, many of which were extremely dehydrated, underweight and without food in their stomachs.

Natureland operations manager Gail Sutton said the trend was concerning.

"If there's this many being found, how many aren't? What sort of hole are they putting in the population?"

It was still not clear why the penguins were being washed up in such a bad state, she said.

Vet Mana Stratton said the birds' condition could be due to a lack of food in the unseasonably warm water, but that was just one possibility.

Many people did not realise that birds did not show visible signs of sickness until their condition was severe, she said.

"If it looks sick, it's very sick.

"If you can walk along and pick up a little blue penguin, it is in a critical condition and needs immediate treatment."

Mrs Sutton said the public should bring affected birds to Natureland immediately.

"Treating these birds is a specialist job, and the sooner the birds get into Natureland's care, the better the chance of success.

"Any protected wildlife can only be held and cared for by those permitted to do so."

People should also be careful to keep their dogs on a leash when walking them at the beach, as they could disturb penguin nests, she said.

Appendix B Stable isotope records

M = muscle tissue, F = feather, BW = whole blood, BE = blood in Ethanol, D = down, MH = heart muscle tissue, NR= not recorded.

SIA ID No.	Band No./Vial label	Age	Alive	Date	Common name	Species	Location	Tissue	d N	d C	Lat	Long
1				25/01/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Catherine Cove, D'Urville Is., Kaiangawari Beach	M	13.69	-18.60	S 40 51.480	E 173 53.428
2				25/01/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Catherine Cove, D'Urville Is., Kaiangawari Beach	M	13.50	-18.12	S 40 51.480	E 173 53.428
3				25/01/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Catherine Cove, D'Urville Is., Kaiangawari Beach	M	13.77	-18.63	S 40 51.480	E 173 53.428
4				25/01/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Catherine Cove, D'Urville Is., Kaiangawari Beach	M	13.778	-18.11	S 40 51.480	E 173 53.428
5				25/01/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Catherine Cove, D'Urville Is., Kaiangawari Beach	M	13.83	-17.89	S 40 51.480	E 173 53.428
6				25/01/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Catherine Cove, D'Urville Is., Kaiangawari Beach	M	13.79	-18.40	S 40 51.480	E 173 53.428
7				25/01/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Catherine Cove, D'Urville Is., Kaiangawari Beach	M	11.91	-18.53	S 40 51.480	E 173 53.428
10				25/01/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Catherine Cove, D'Urville Is., Kaiangawari Beach	M	13.62	-18.39	S 40 51.480	E 173 53.428
11				25/01/2011	Piper/Gar fish	<i>Hyporhamphus ihi</i>	Cherry Tree Bay, D'Urville Is.	M	13.22	-18.90	S 40 52.367	E 173 52.337
12				25/01/2011	Piper/Gar fish	<i>Hyporhamphus ihi</i>	Cherry Tree Bay, D'Urville Is.	M	13.11	-18.29	S 40 52.367	E 173 52.337
13				25/01/2011	Piper/Gar fish	<i>Hyporhamphus ihi</i>	Cherry Tree Bay, D'Urville Is.	M	13.44	-19.03	S 40 52.367	E 173 52.337
14				25/01/2011	Piper/Gar fish	<i>Hyporhamphus ihi</i>	Cherry Tree Bay, D'Urville Is.	M	12.89	-18.87	S 40 52.367	E 173 52.337
15				25/01/2011	Piper/Gar fish	<i>Hyporhamphus ihi</i>	Cherry Tree Bay, D'Urville Is.	M	13.35	-18.11	S 40 52.367	E 173 52.337
16				25/01/2011	Piper/Gar fish	<i>Hyporhamphus ihi</i>	Cherry Tree Bay, D'Urville Is.	M	13.05	-18.78	S 40 52.367	E 173 52.337
21				25/01/2011	Yellow-eyed mullet (juv)	<i>Aldrichetta forsteri</i>	Cherry Tree Bay, D'Urville Is.	M	13.38	-18.51	S 40 52.367	E 173 52.337
22				25/01/2011	Yellow-eyed mullet (juv)	<i>Aldrichetta forsteri</i>	Cherry Tree Bay, D'Urville Is.	M	13.40	-18.21	S 40 52.367	E 173 52.337
23				25/01/2011	Yellow-eyed mullet (juv)	<i>Aldrichetta forsteri</i>	Cherry Tree Bay, D'Urville Is.	M	12.91	-18.78	S 40 52.367	E 173 52.337
24				25/01/2011	Yellow-eyed mullet (juv)	<i>Aldrichetta forsteri</i>	Cherry Tree Bay, D'Urville Is.	M	13.40	-18.45	S 40 52.367	E 173 52.337
25				25/01/2011	Yellow-eyed mullet (juv)	<i>Aldrichetta forsteri</i>	Cherry Tree Bay, D'Urville Is.	M	11.54	-19.44	S 40 52.367	E 173 52.337
26				25/01/2011	Yellow-eyed mullet (juv)	<i>Aldrichetta forsteri</i>	Cherry Tree Bay, D'Urville Is.	M	12.73	-19.37	S 40 52.367	E 173 52.337
27				25/01/2011	Yellow-eyed mullet (juv)	<i>Aldrichetta forsteri</i>	Cherry Tree Bay, D'Urville Is.	M	12.77	-18.63	S 40 52.367	E 173 52.337
31				26/01/2011	Squid (arrow squid?)	<i>Notodarus sp.</i>	Tasman Bay, off Kokorua Bay	M	13.14	-19.90	S 41 04.895	E 173 30.770

32		26/01/2011	Squid (arrow squid?)	<i>Notodarus sp.</i>	Tasman Bay, off Kokorua Bay	M	13.15	-19.69	S 41 04.895	E 173 30.770
33		26/01/2011	Anchovy	<i>Engraulis australis</i>	Tasman Bay, off Pepin Is.	M	11.61	-20.21	S 41 07.084	E 173 25.202
34		26/01/2011	Anchovy	<i>Engraulis australis</i>	Tasman Bay, off Pepin Is.	M	11.93	-20.27	S 41 07.084	E 173 25.202
35		26/01/2011	Anchovy	<i>Engraulis australis</i>	Tasman Bay, off Pepin Is.	M	13.06	-18.27	S 41 07.084	E 173 25.202
36		26/01/2011	Anchovy	<i>Engraulis australis</i>	Tasman Bay, off Pepin Is.	M	11.55	-20.25	S 41 07.084	E 173 25.202
37		26/01/2011	Anchovy	<i>Engraulis australis</i>	Tasman Bay, off Pepin Is.	M	11.99	-20.04	S 41 07.084	E 173 25.202
38		26/01/2011	Anchovy	<i>Engraulis australis</i>	Tasman Bay, off Pepin Is.	M	12.09	-19.61	S 41 07.084	E 173 25.202
39		26/01/2011	Anchovy	<i>Engraulis australis</i>	Tasman Bay, off Pepin Is.	M	12.02	-20.33	S 41 07.084	E 173 25.202
40		26/01/2011	Anchovy	<i>Engraulis australis</i>	Tasman Bay, off Pepin Is.	M	11.49	-20.65	S 41 07.084	E 173 25.202
41		26/01/2011	Anchovy	<i>Engraulis australis</i>	Tasman Bay, off Pepin Is.	M	11.55	-19.85	S 41 07.084	E 173 25.202
42		26/01/2011	Anchovy	<i>Engraulis australis</i>	Tasman Bay, off Pepin Is.	M	11.48	-20.15	S 41 07.084	E 173 25.202
43		26/01/2011	Silver warehou (juv)	<i>Seriola punctata</i>	Tasman Bay, off Pepin Is.	M	11.76	-22.77	S 41 07.084	E 173 25.202
44		26/01/2011	Sprat	<i>Sprattus sp.</i>	Tasman Bay, off Pepin Is.	M	11.55	-19.89	S 41 07.084	E 173 25.202
45		26/01/2011	Sprat	<i>Sprattus sp.</i>	Tasman Bay, off Pepin Is.	M	11.68	-20.09	S 41 07.084	E 173 25.202
46		26/01/2011	Sprat	<i>Sprattus sp.</i>	Tasman Bay, off Pepin Is.	M	11.26	-20.47	S 41 07.084	E 173 25.202
47		26/01/2011	Sprat	<i>Sprattus sp.</i>	Tasman Bay, off Pepin Is.	M	10.88	-20.18	S 41 07.084	E 173 25.202
48		22/02/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Farewell Spit, Golden Bay	M	14.05	-16.13	NR	NR
49		22/02/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Farewell Spit, Golden Bay	M	13.98	-16.17	NR	NR
50		22/02/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Farewell Spit, Golden Bay	M	14.07	-17.59	NR	NR
51		22/02/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Farewell Spit, Golden Bay	M	13.44	-19.30	NR	NR
52		22/02/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Farewell Spit, Golden Bay	M	13.60	-15.57	NR	NR
53		22/02/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Farewell Spit, Golden Bay	M	14.41	-18.05	NR	NR
54		22/02/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Farewell Spit, Golden Bay	M	14.29	-18.65	NR	NR
55		22/02/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Farewell Spit, Golden Bay	M	14.16	-15.89	NR	NR
56		22/02/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Farewell Spit, Golden Bay	M	14.07	-17.13	NR	NR
57		22/02/2011	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	Farewell Spit, Golden Bay	M	14.02	-15.10	NR	NR
58	M67472	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	16.20	-17.24	NR	NR
59	M67473	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.77	-17.55	NR	NR
60	M67474	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.97	-17.48	NR	NR
61	M67475	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	16.18	-17.04	NR	NR
62	M67476	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.74	-17.88	NR	NR
63	M67477	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.92	-16.85	NR	NR
64	M67478	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.97	-17.36	NR	NR
65	M67479	26/11/2011	Spotted shag	<i>Phalacrocorax</i>	Tata Island, Abel Tasman	F	15.33	-17.33	NR	NR

				<i>punctatus</i>						
66	M67480	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	16.12	-17.23	NR	NR
67	M67481	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	16.02	-17.40	NR	NR
68	M67482	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.73	-17.60	NR	NR
69	M67483	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	16.02	-17.19	NR	NR
70	M67484	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.85	-17.06	NR	NR
71	M67485	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	16.23	-17.39	NR	NR
72	M67486	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.75	-17.37	NR	NR
73	M67487	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	16.29	-17.01	NR	NR
74	M67488	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.94	-17.31	NR	NR
75	M67489	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.84	-17.59	NR	NR
76	M67490	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	16.20	-17.14	NR	NR
77	M67491	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.61	-17.77	NR	NR
78	M67492	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	16.26	-17.10	NR	NR
79	M67493	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.79	-17.64	NR	NR
80	M67494	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	16.12	-17.46	NR	NR
81	M67495	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.49	-17.32	NR	NR
82	M67496	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	15.68	-17.23	NR	NR
83	M67497	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	F	16.13	-17.44	NR	NR
84	79	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	BW	14.83	-18.93	NR	NR
85	89	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	BW	15.07	-19.33	NR	NR
86	76	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	BW	15.05	-19.21	NR	NR
87	74	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	BW	14.99	-19.08	NR	NR
88	92	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	BW	14.91	-18.88	NR	NR
89	79	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	BE	15.12	-18.61	NR	NR
90	89	26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	BE	15.14	-18.97	NR	NR

91	76			26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	BE	15.15	-18.41	NR	NR
92	74			26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	BE	14.99	-18.30	NR	NR
93	92			26/11/2011	Spotted shag	<i>Phalacrocorax punctatus</i>	Tata Island, Abel Tasman	BE	14.95	-18.49	NR	NR
94	1 adult	Adult	Alive	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Fisherman Island, Able Tasman	F	14.87	-18.73	NR	NR
95	2	Chick	Dead	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Fisherman Island, Able Tasman	F	16.36	-18.50	NR	NR
96	3	Chick	Alive	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Fisherman Island, Able Tasman	F	15.50	-17.82	NR	NR
97	4	Chick	Alive	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Fisherman Island, Able Tasman	F	15.33	-18.96	NR	NR
98	5	Chick	Alive	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Fisherman Island, Able Tasman	F	16.06	-18.46	NR	NR
99	6	Chick	Dead	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Fisherman Island, Able Tasman	F	15.82	-17.99	NR	NR
100	7	Chick	Alive	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Fisherman Island, Able Tasman	F	15.56	-18.66	NR	NR
101	8	Chick	Dead	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Rocks Rd, Nelson, Guytons fish shop	F	16.42	-18.43	NR	NR
102	1 adult	Adult	Alive	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Fisherman Island, Able Tasman	BE	13.95	-18.73	NR	NR
103	2	Chick	Dead	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Fisherman Island, Able Tasman	MH	16.22	-19.24	NR	NR
104	3	Chick	Alive	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Fisherman Island, Able Tasman	BE	14.67	-19.31	NR	NR
106	5	Chick	Alive	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Fisherman Island, Able Tasman	BE	15.66	-20.06	NR	NR
107	6	Chick	Dead	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Fisherman Island, Able Tasman	MH	16.34	-19.88	NR	NR
108	7	Chick	Alive	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Fisherman Island, Able Tasman	BE	15.18	-19.27	NR	NR
109	8	Chick	Dead	30/11/2010	Little penguin	<i>Eudyptula minor</i>	Rocks Rd, Nelson, Guytons fish shop	BE	15.59	-19.35	NR	NR
110	M58863			21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	16.29	-17.85	NR	NR
111	M58864			21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.99	-17.47	NR	NR
112	M58865			21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.87	-16.25	NR	NR
113	M58866			21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.90	-17.61	NR	NR
114	M58867			21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.43	-17.77	NR	NR
115	M58868			21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.79	-17.64	NR	NR
116	M58869			21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.24	-17.40	NR	NR
117	M58870			21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.40	-17.98	NR	NR
118	M58877			21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.93	-17.63	NR	NR
119	M58878			21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	16.17	-15.53	NR	NR
120	M58879			21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	D	16.30	-17.18	NR	NR

121	M58880	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	16.33	-16.99	NR	NR
122	M58881	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.20	-17.21	NR	NR
123	M58882	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.78	-17.11	NR	NR
124	M58883	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	16.22	-16.72	NR	NR
125	M58884	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	16.63	-17.08	NR	NR
126	M58885	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	D	15.68	-17.16	NR	NR
127	M58886	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	D	15.56	-17.15	NR	NR
128	M58887	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	16.41	-16.88	NR	NR
129	M58888	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.45	-17.81	NR	NR
130	M58889	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.45	-17.49	NR	NR
131	M58890	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.75	-17.79	NR	NR
132	M58891	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.91	-17.05	NR	NR
133	M58892	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.72	-16.83	NR	NR
134	M58893	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.48	-17.75	NR	NR
135	M58894	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.72	-17.11	NR	NR
136	M58895	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	16.47	-17.20	NR	NR
137	M58896	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	16.12	-16.52	NR	NR
138	M58897	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.92	-16.46	NR	NR
139	M58898	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.78	-17.14	NR	NR
140	M58899	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	16.47	-16.53	NR	NR
141	M58900	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	F	15.71	-17.56	NR	NR
142	90	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	BE	14.49	-19.07	NR	NR
143	89	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	BE	14.65	-18.96	NR	NR
144	94	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	BE	14.76	-18.81	NR	NR
145	81	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	BE	14.56	-18.64	NR	NR
146	87	21/01/2011	Australasian gannet	<i>Morus serrator</i>	Farewell Spit, Golden Bay	BE	14.97	-18.22	NR	NR

