Albatross Research

Antipodean wandering albatross census and population study 2018

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ABSTRACT

Antipodean wandering albatross *Diomedea antipodensis antipodensis* breed almost exclusively on Antipodes Island and following a dramatic population crash in 2006, males have been declining at about 6% per annum and females at about 12% per annum. The decline appears to be driven mainly by high female mortality, with a marked sex imbalance now conspicuous in the breeding population.

There is a significant negative relationship between La Nina conditions (which bring warmer sea temperatures to the western Pacific) and the survival of breeding female Antipodean wandering albatrosses. However, while breeding success dropped from a mean 74% prior to the crash to 60% after it, poor nutrition of breeding females in La Nina summers appears unlikely to be the proximate cause of their high mortality as birds usually abandon breeding if their condition is too poor. The main preventable cause of high female mortality is likely to be fisheries bycatch north of New Zealand and in the central and eastern Pacific between 20-35°S, occurring in late winter and spring.

Antipodean wandering albatross are now assessed by the New Zealand Threat Classification System as "Nationally Critical" (Robertson et al 2017) and understanding the causes of and solutions to the high female mortality is urgently required. Extensive real-time satellite tracking should be used to better define problems the birds are encountering at sea.

INTRODUCTION

Antipodean wandering albatross (*Diomedea antipodensis antipodensis*) are endemic to the Antipodes Islands, with approximately 99% of the population breeding there and a few pairs nesting on both Campbell Island and at the Chatham Islands. They forage mainly in the Pacific Ocean east of New Zealand, and to a lesser extent in the Tasman Sea (Walker & Elliott 2006).

They are a regular by-catch in New Zealand long-line fisheries, with small numbers annually caught on observed domestic and chartered vessels (Abraham *et al.* 2015). Numbers caught are likely to be considerably higher than those reported, as many long-line hooks set in New Zealand waters are from small unobserved domestic vessels, and there are substantial unobserved long-line fleets in international waters in the south Pacific Ocean where the birds mostly forage (Walker & Elliott 2006).

Due to the vulnerability of this long-lived and slow breeding species to fisheries bycatch, their survival, productivity, recruitment and population trends have been monitored during almost annual visits to Antipodes Island since 1994. In the 1990's the population increased following a major, presumably fisheries-induced, decline during the 1980's (Walker & Elliott 2005, Elliott & Walker 2005 and Walker & Elliott 2006). However, about 2006 there was a sudden drop in the size of the breeding population, and it has continued to decline since then.

This report summarises the most recent findings on the survival, productivity, population trends and at-sea distribution of Antipodean wandering albatrosses, collected during a seven-week trip to the island during the 2017/18 summer.

METHODS

Details of the methods used, study area locations and earlier results are given in Walker & Elliott 2005, Elliott & Walker 2005 and Walker & Elliott 2006.

In brief, summer visits are made to Antipodes Island and all birds found within or near a 29 ha "Study Area" (Figure 1) are checked for bands. An attempt is made to identify both birds at every nest in the Study Area, and any breeding birds that have no bands are banded. All nests are labelled and mapped, the outcome of the previous year's nesting attempts are assessed, and the chicks banded. This data enables calculation of survivorship, productivity, recruitment, and attendance on the breeding grounds.

In addition, the number of active nests in 3 different parts of Antipodes Island (Figure 1) are counted each year (only 2 of these areas were counted in the period 2007–11). These 3 areas comprised 14.9% of all the nests on Antipodes Island between 1994 and 1996 (Walker & Elliott 2002), and the annual census of these blocks provides a reliable estimate of population trends.

Survival is estimated from the banded birds using mark-recapture statistical methods in the statistical software M-Surge (Choquet *et al.* 2005), and population size is estimated from the actual counts of birds and the sighting probabilities produced when estimating survival.

Figure 1. Location of the Antipodean wandering albatross study area on Antipodes Island, the two census blocks and the area (shaded green) in which albatrosses do not nest.

Changes in the at-sea distribution

Since 2011 data has been recovered from 63 geolocator dataloggers deployed on and retrieved from Antipodean wandering albatrosses to compare their foraging locations when the population was declining with those used a decade earlier when the population was growing.

Locations of the birds were calculated from light data using BASTRak software supplied by British Antarctic Survey (Fox 2007) and Intiproc provided by Migrate Technology (http://www.migratetech.co.uk/). More "reasonable" flight paths were obtained from the estimated longitude from the logger's light data and estimated latitude by matching the sea temperature data recorded by the logger with the nearest sea-surface temperature at the estimated longitude. The monthly sea-surface temperature data used to make this calculation was obtained from http://dss.ucar.edu.

Tracking data collected using geolocator loggers in 2011–2018 and tracking data collected using satellite transmitters in 1996-2001 was compared with kernel density plots. Kernels were estimated using the function kde2d in the MASS package (Venables & Ripley, 2002) in the statistical language R (R Development Core Team, 2017). Bivariate normal kernels were used, with a normal reference band-width (Venables & Ripley, 2002). Longitudes were transformed by the cosine of latitude to make units of latitude and longitude approximately equal.

RESULTS

Population size estimate from mark-recapture

The size of the breeding population as estimated by mark-recapture was increasing up until 2005 at a rate of about 8% per annum for both sexes. Between 2004 and 2014 the number of breeding pairs declined at about 12% per annum. Females were declining at a faster rate (12% per annum) than males (6%), resulting in a sex imbalance with more than 2 adult males for every one adult female. Between 2014 and 2017 the rate of female decline eased to around 7% per annum (Figure 2).

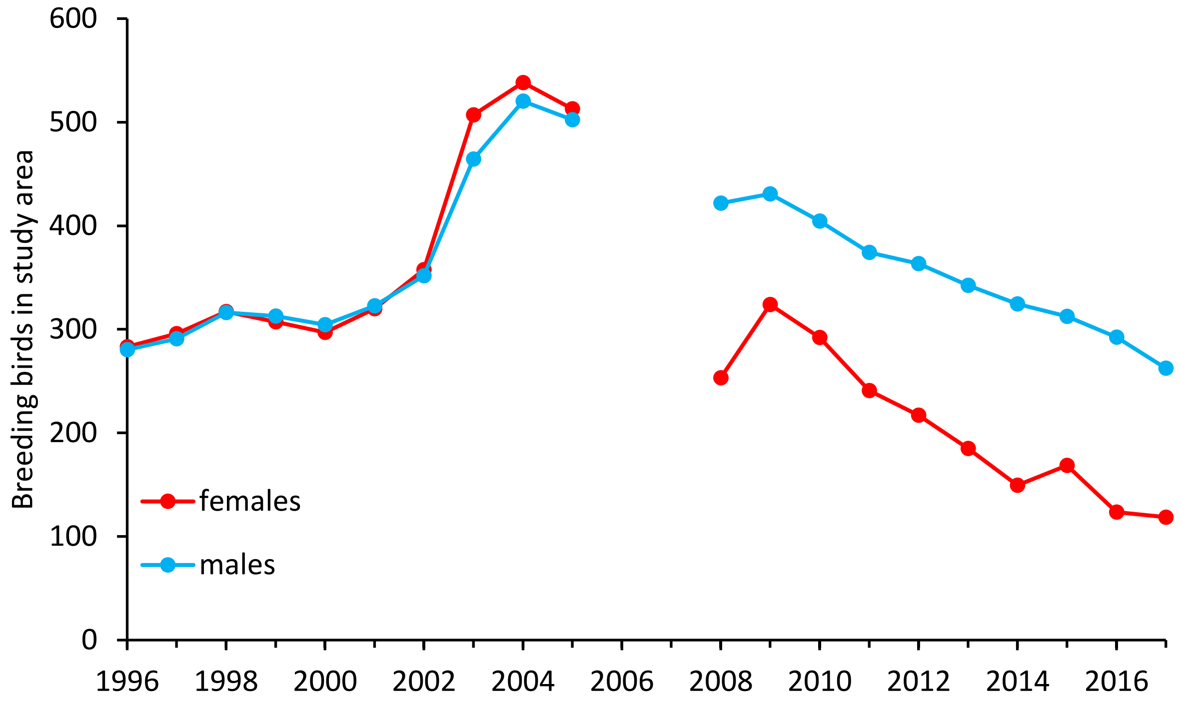


Figure 2. The number of breeding birds in the study area on Antipodes Island estimated by mark-recapture.

Survivorship

Adult survival varied around a mean value of about 0.96 up until 2004 and during this period male and female survival was not significantly different. Since 2004 both male and female survival has declined, with female survival significantly lower than that of males (Figure 3).

Close examination of the survival data suggests that between 2008 and 2010 breeding birds of both sexes had much lower survival than non-breeding birds (Figure 4). However, since then survival of breeding males has returned to more normal levels and is now only a little lower than that of non-breeding males (Figure 4). In contrast, survival of breeding females was high in 2015 but low for the rest of the period, while survival of non-breeding females has been low since 2011 (Figure 4).

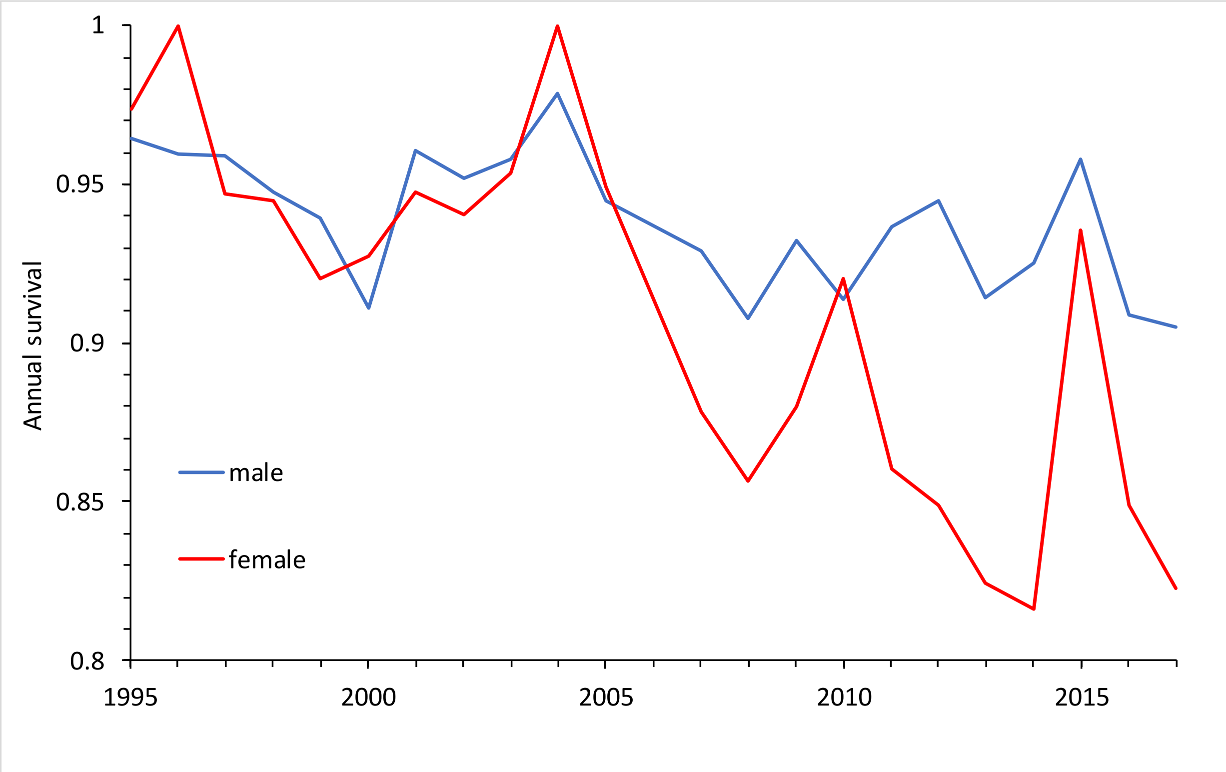


Figure 3. Estimated annual survival of Antipodean wandering albatross on Antipodes Island since 1994. Note that as the island wasn't visited in 2006, survival estimates for 2006 and 2007 were estimated from the survival over a 2-year period and then equally apportioned amongst the 2 years.

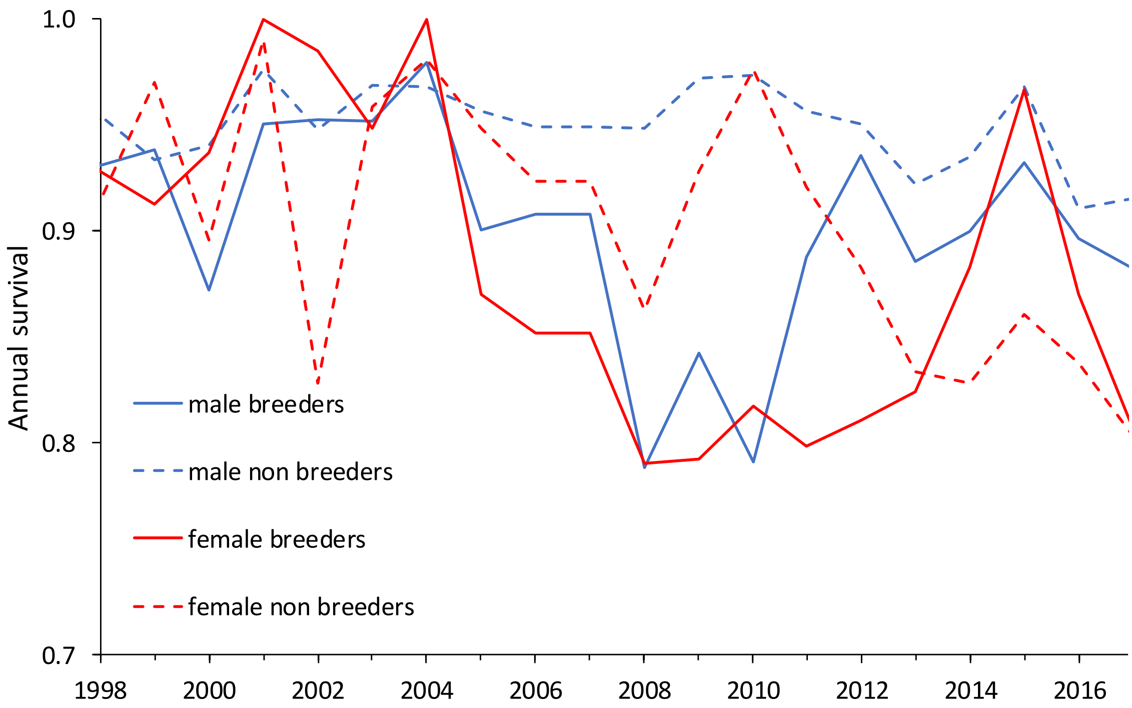


Figure 4: Survival of breeding and non-breeding male and female Antipodean wandering albatrosses in 1995–2017.

Recruitment

The number of birds breeding for the first time in the Study Area in 2018 was near the mean of the previous 6 years, but much higher than the very low recruitment recorded in 2017 (Figure 5). The number of females newly recruiting to the breeding population continues to be higher than that of males due to the marked sex imbalance: with the abundance of partner-less males, any available female rapidly finds a male partner.

Figure 5. Number of birds recruiting to the breeding population in the study area on Antipodes Island since 1997

Productivity

Nesting success averaged 74% before 2005 but dropped to an average of 60% between 2006 and 2016. In 2017 nesting success was 80.4%, suggesting a recovery to the high nesting success typical prior to 2006. However, while nesting success was high in 2017, few chicks were produced in the study area as the numbers nesting in 2017 was so low (Figure 6). Since the population crash in 2006, the number of chicks produced has consistently declined at a faster rate than the reduction in breeding success due to the combined effect of fewer birds nesting and reduced nesting success.

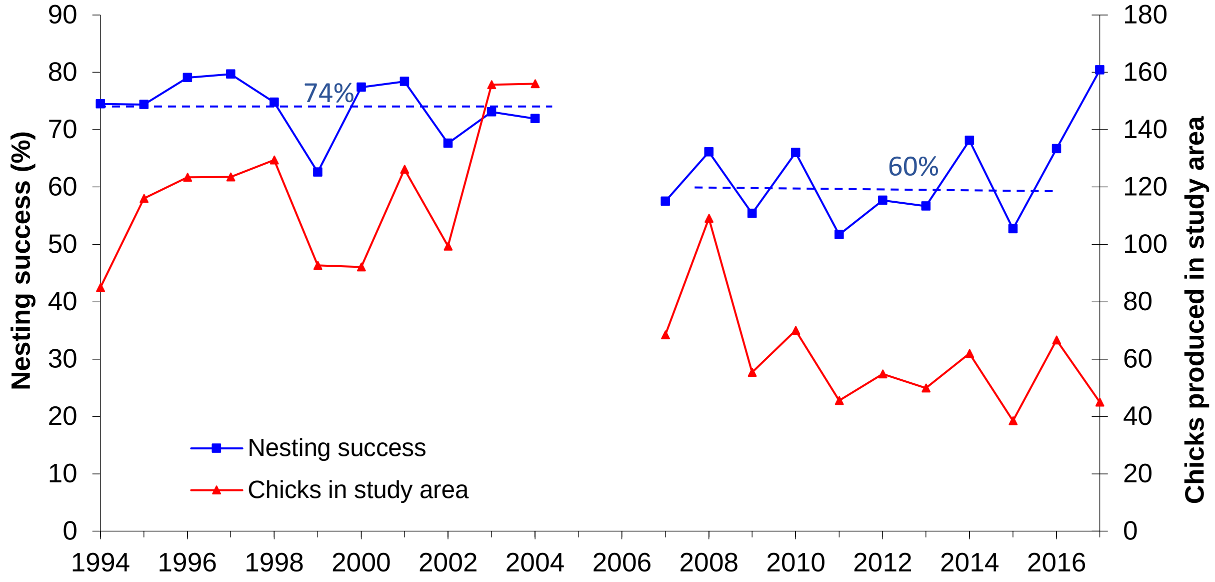


Figure 6. Nesting success and the number of chicks fledged from the study area on Antipodes Island since 1994. The dashed lines indicate average nesting success in two periods, 1994-2004 and 2007-2016.

Nest counts

A total of 509 nests were counted in the 3 census blocks in 2018, from which we estimate there were 3,402 pairs nesting on Antipodes Island, an improvement on the 2,466 pairs estimated to be nesting in 2017 (Table1, Figure 7).

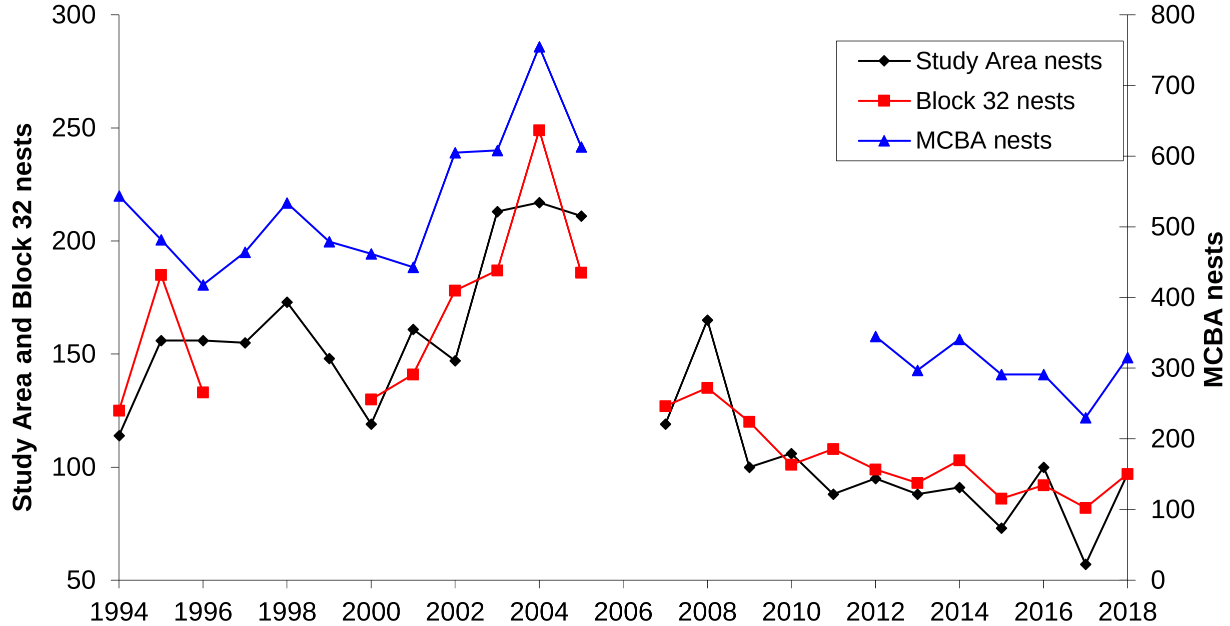


Figure 7. The number of Antipodean wandering albatross nests in three blocks on Antipodes Island since 1994.

After increasing for five years between 2000 and 2005, the number of nests in the study area and Block 32 declined between 2005 and 2007 by about 38% and has continued to decline since then, albeit more slowly.

Table 1: Antipodean wandering albatross nests with eggs in February in three areas on Antipodes Id in 1994– 2018.

Year	Study area	Block 32	Subtotal	MCBA	Total counted	Estimated nests on island
1994	114	125	239	544*	783	5233
1995	156	185	341	482*	823	5500
1996	154	133	287	418*	705	4712
1997	150			464*		5463
1998	160			534		5827
1999	142			479		5172
2000	119	130	249	462	711	4752
2001	160	141	301	443	744	4972
2002	148	178	326	605	931	6222
2003	214	187	401	608	1009	6743
2004	216	249	465	755	1220	8153
2005	211	186	397	613	1010	6750
2006						
2007	119	127	246			4368
2008	165	135	300			5327
2009	98	120	218			3871
2010	106	101	207			3676
2011	88	108	196			3480
2012	95	104	199	345	543	3629
2013	88	93	181	297	478	3195
2014	91	103	194	341	535	3576
2015	73	86	159	291	450	3007
2016	100	92	192	291	483	3228
2017	57	82	139	230	369	2466
2018	97	97	194	315	509	3402

- estimated (see Walker and Elliott 1998).

Plumage of birds as they finish rearing a chick

No moult occurs during the year spent rearing a chick so towards the end of a breeding cycle the feathers of both male and female breeding birds becomes very worn. Efforts were made in January 2018 to photograph these breeding birds during the very brief visits they make to feed their chick on Antipodes Island just prior to chick fledging, to improve identification of adult Antipodean wandering albatrosses at sea. The appearance of female plumage at the end of breeding was found to be noticeably different to the evenly-dark chocolate-brown plumage of females ready to start breeding. By the end of a year spent raising a chick, the tips of most brown feathers had worn off, giving such females a mottled, leopard-spot, appearance as the white of the inner part of the feather showed through (Figure 8).

Figure 8: Female Antipodean wandering albatrosses at the end of a year spent rearing a chick, with their plumage worn, giving a "mottled" appearance where the brown tips have worn off exposing white feathers beneath. Compare this plumage with that of a female with freshly moulted plumage in the cover photo (all images by Kath Walker)

At-sea distribution of Antipodean wandering albatrosses

Dataloggers were retrieved from 10 albatrosses in 2018 bringing the total of birds tracked since 2012 to 60 comprising 31 females and 29 males. The 10 dataloggers were re-deployed on a new set of birds. The foraging patterns of the 10 newly-tracked birds (Figure 9) did not change the general pattern of at-sea distribution of birds that we reported in 2017 (Elliott & Walker 2017) but did reinforce the seasonality of foraging patterns. Almost all non-breeding birds—both male and female— left New Zealand waters in late summer, spent around a month off southern Chile in autumn, moved northwards in early winter to waters near Juan Fernandez Island, returned to forage off north-east New Zealand in mid-winter to early spring, then in late spring often returned to southern Chile. Both female and—more surprisingly— male non-breeders spent some time at latitudes between 25^0 and 30^0 degrees south, particularly while off the coast of South America and north of New Zealand.

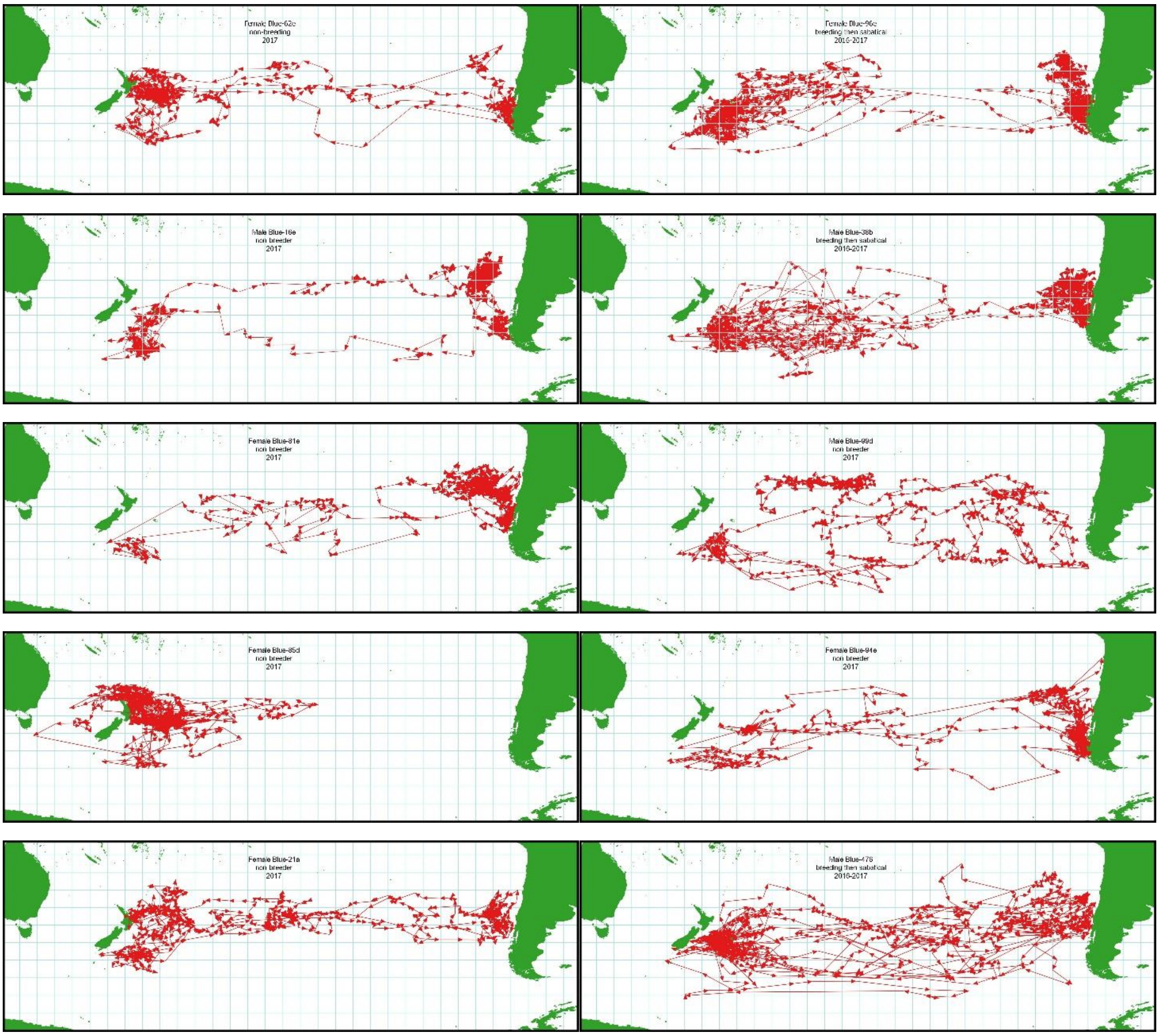


Figure 9: Tracks of 10 Antipodean wandering albatrosses tracked in 2016 and 2017.

Threats from fisheries

To try and better identify ocean regions and fisheries that might be responsible for the decline of Antipodean wandering albatrosses, we added new data from birds tracked in 2016 and 2017 and re-analysed the entire tracking database for the period 2011–2017. We extracted long-line fishing activity from Global Fishing Watch (www.globalfishingwatch.org) and overlaid kernels of all tracking data from females since 2011 (Figure 10). Both fishing effort and female Antipodean wandering albatross density were found to be relatively high in the central Tasman Sea, north-west and north-east of northern New Zealand and around Juan Fernandez archipelago (Figure 10).

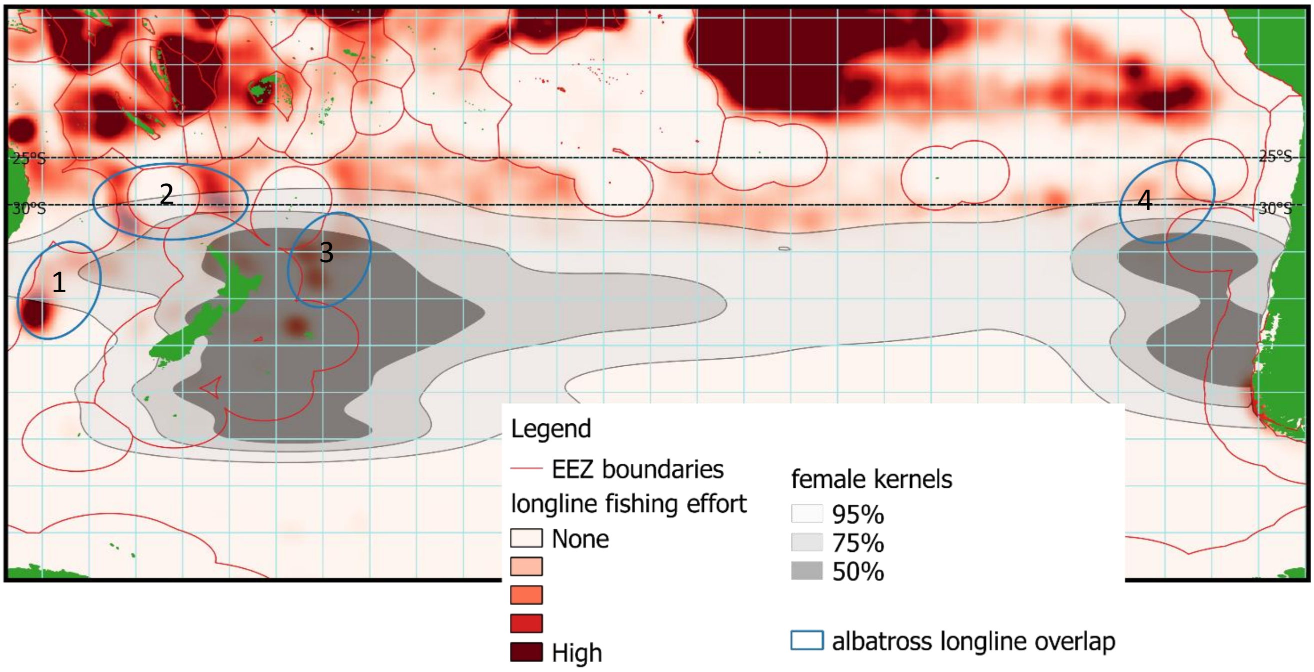
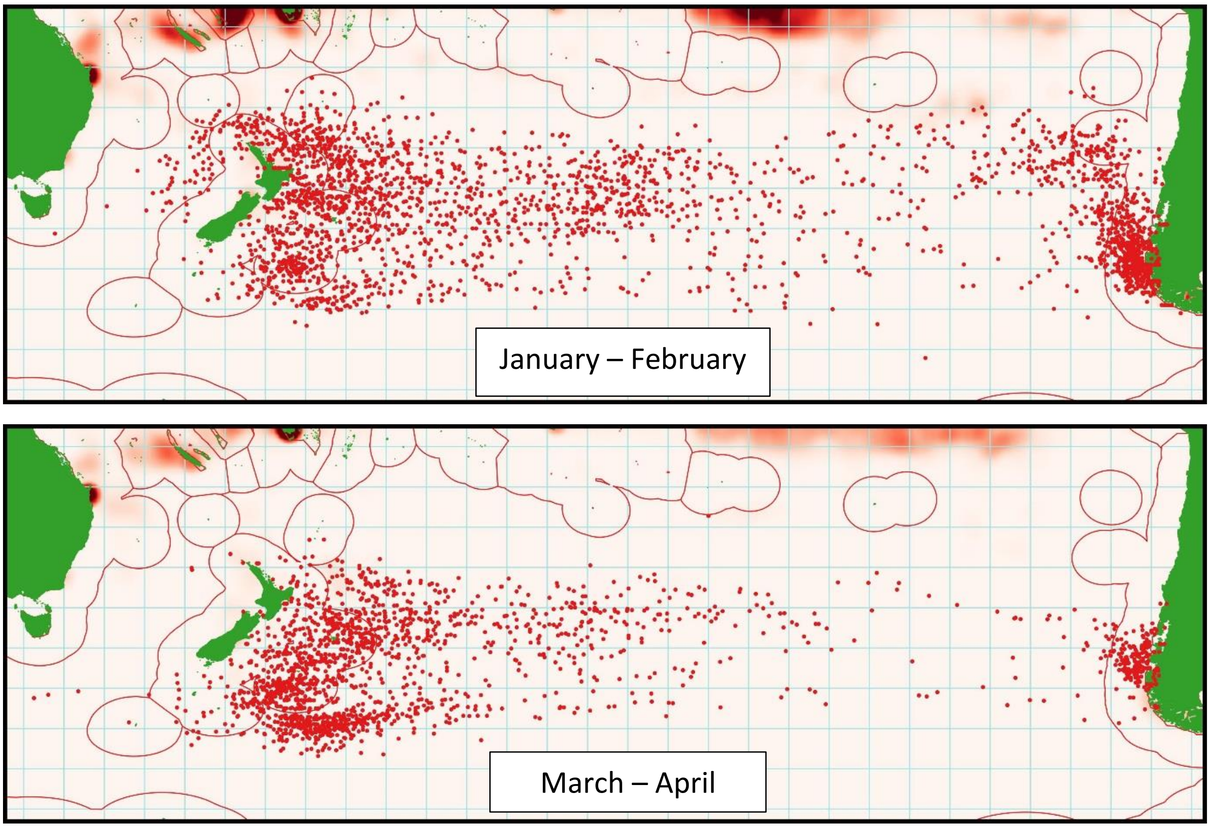


Figure 10: Foraging range of female Antipodean wandering albatrosses in the period 2011–2017 and overlap with long-line fishing effort. The blue ellipses identify areas of high albatross long-line fishing overlap.

Both fishing effort and albatross foraging location varies seasonally, with the greatest overlap in space and time between birds and fishers during the winter and spring months, July to October (Figure 11).



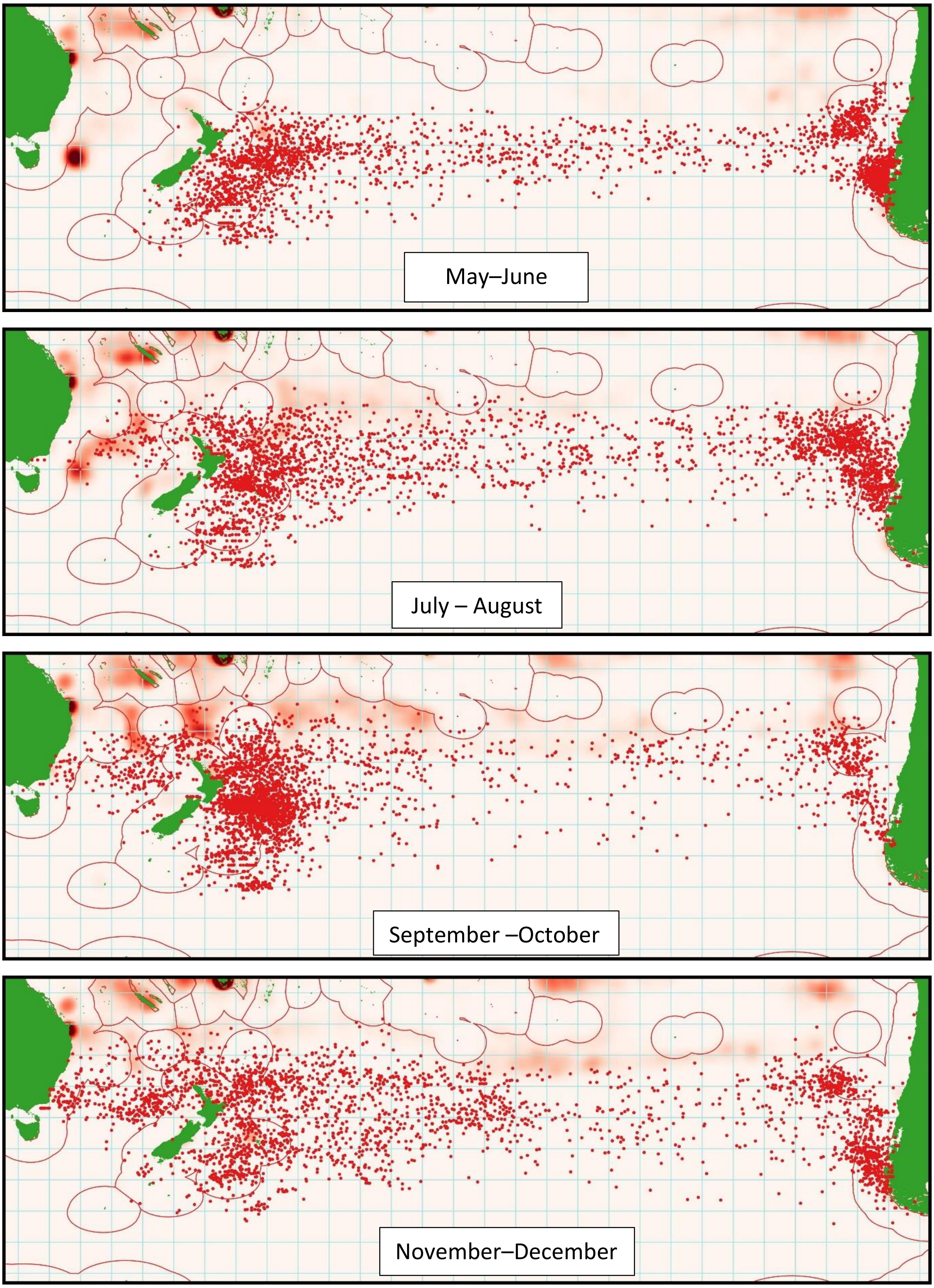


Figure 11: Overlap in space and time between long line fishing effort (light red smudges) from Global Fishing Watch and Antipodean wandering albatross foraging (solid red dots) from geolocator data loggers tracking birds in 2011–2017. Red lines indicate exclusive economic zones.

DISCUSSION

Breeding success of Antipodean wandering albatross in 2017 was much higher than it has been for many years, but despite this, relatively few chicks were added to the population as only small numbers attempted to nest that year. Approximately a third more pairs attempted to breed in 2018 than did in 2017, presumably because of very low numbers breeding in 2017. However, there was a much higher rate of early failure in those attempting to breed this year, with 11% of nests failed by mid-February compared to 0% failed by the same time the previous year and an average mid-February failure rate of 3% in the period 2012–2017. Sea surface temperatures were exceptionally high around New Zealand in the 2017/18 summer and may have contributed to this high failure rate. The breeding success of Gibson's wandering albatross nesting in the Auckland Islands was also markedly high in 2017 and breeding success was weakly related to the Southern Oscillation Index, with the proportion breeding significantly related to the SOI. In contrast, no significant relationship was found in Antipodean wandering albatross between SOI and breeding success ($P = 0.376$) or proportion breeding ($P = 0.715$) or survival of non-breeders ($P = 0.505$). However, a linear regression showed a significant ($P = 0.023$) relationship between annual survival of female breeders and SOI (Figure 12).

Detailed re-analysis of survival data suggests the previous interpretation of Antipodean wandering albatross decline as resulting entirely from low survival of non-breeding females has been too simplistic. Breeding birds of both sexes, as well as non-breeding females, have been subject to low survival in the last decade, but not at the same time. In the worst years, 2008, 2009 and 2010, both male and female breeders suffered very low survival while non-breeders did not (Figure 4). Male survival subsequently improved but non-breeding female survival fell and, with a notable exception in 2015 in female breeders, survival of both breeding and non-breeding females has remained low. As the different stages and sexes forage in different places, this re-analysis provides more information as to where any by-catch in fisheries contributing to this decline may be occurring.

We can only speculate about the cause of the significant relationship between high mortality of breeding females and La Nina episodes. Poor nutrition is unlikely to be the cause of the relationship between survival and SOI in breeding females as birds can only breed if in reasonable condition and although breeding success has reduced since the crash, it is still relatively high.

La Nina brings warmer sea surface temperatures and stronger tropical cyclones to New Zealand and cooler sea surface temperatures and greater upwelling off the coast of Chile. El Nino conditions dominated the 1990's, with a switch to very strong La Nina in 1999/2000 before a return to El Nino in 2001–2004 (https://www.niwa.co.nz/climate/information-and-resources/elnino/el-nino-and-southern-oscillation). The

2005/6 crash in wandering albatross numbers is coincident with the onset of a long period (2006–201l) mostly dominated by La Nina. Breeding birds can only forage near New Zealand so presumably they were foraging in less productive warm waters during this 2006–2011 period and subject to stronger cyclonic winds, perhaps making chick provisioning trips more onerous. It is possible such conditions increase the likelihood of female albatrosses foraging further north in search of food or scavenging more around fishing vessels. However, La Nina is most intense over the summer months December–February when there is little long line fishing within the range of these albatrosses (Figure 12). In contrast to breeding birds, non-breeding birds can escape the warmer waters round New Zealand and travel to cooler waters off Chile which occur during La Nina; it was notable that females began regularly foraging there during this period. In the strong El Nino of 2015/16 the situation reversed and sea temperatures became cooler around New Zealand but warmer off Chile and survival of both non-breeding males and breeding birds of both sexes was higher that year.

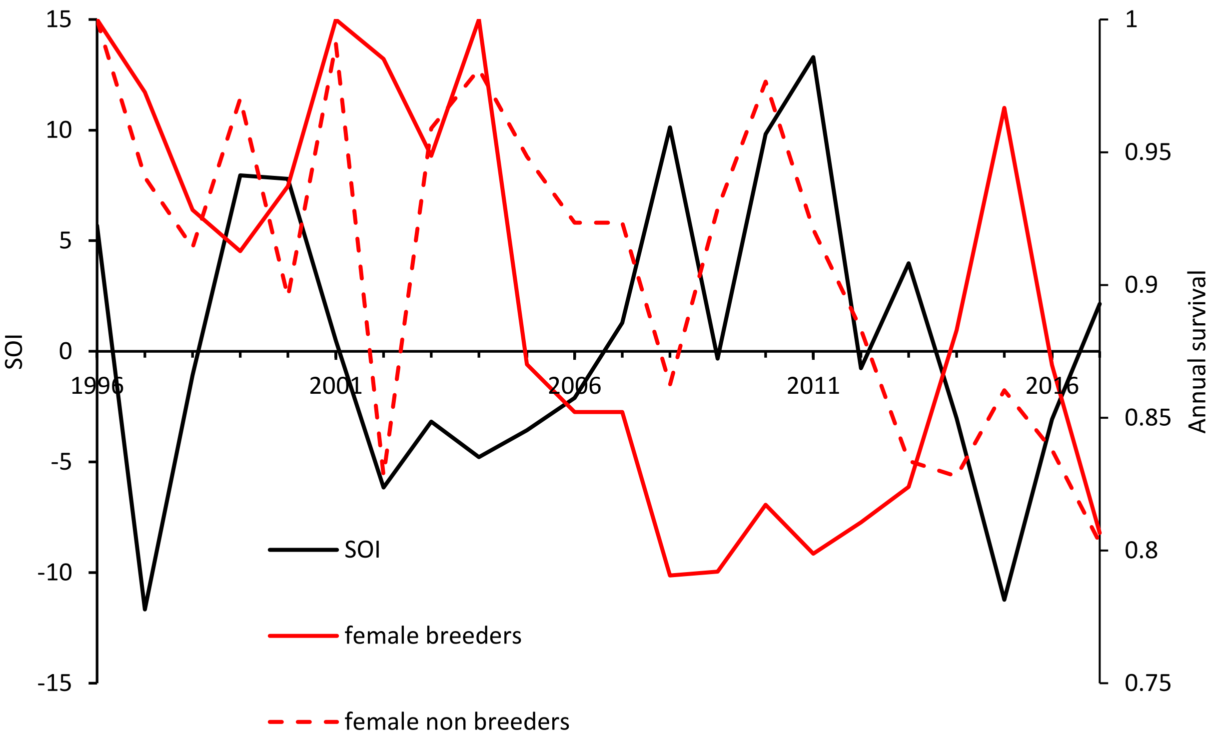


Figure 11: The relationship between the Southern Oscillation Index and annual survival of female Antipodean wandering albatrosses. The relationship of SOI with breeding females (but not with non-breeding females) is significant, with survival lower in La Nina (positive SOI) and higher in El Nino (negative SOI) conditions. All variables have been normalised, so they can be presented on the same scale.

Tracking in 2016–17 identified likely albatross/long-line fisheries interaction hot spots to the north, north-west and north-east of New Zealand, in addition to the previously identified hotspot for non-breeding birds north of

Chile. The at-sea tracking also revealed that albatrosses, like long-line fishers, use different parts of the ocean at different times. Most interaction between Antipodean wandering albatrosses and long-line fisheries is in the winter and early spring months, when breeding birds are working hard to feed large chicks and birds on sabbatical are moulting; both vulnerable conditions.

Larger-scale real-time tracking of both breeding and non-breeding females is urgently needed to determine if these "hot spots" are indeed the sites where Antipodean wandering albatrosses are dying. As inter-annual differences in sea surface temperatures seem to be involved, such tracking should be carried out over several breeding seasons.

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