

 <p data-bbox="250 514 490 556">Agreement on the Conservation of Albatrosses and Petrels</p>	<p data-bbox="581 237 1429 325">First Meeting of the Population and Conservation Status Working Group</p> <p data-bbox="813 342 1429 380"><i>La Rochelle, France, 29 – 30 April 2013</i></p> <p data-bbox="537 455 1408 548">Use and exploitation of channel waters by the black-browed albatross</p> <p data-bbox="570 573 1377 703"><i>Javier A. Arata, Alejandro R. Vila, Ricardo Matus, Daniela Droguett, Carlos Silva-Quintas, Valeria Falabella, Graham Robertson</i></p>
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SUMMARY

Black-browed albatrosses are the most abundant albatross species of the southern hemisphere, breeding on sub-Antarctic and Antarctic oceanic islands around the globe. Their breeding foraging habitat is reasonably well known along its distributional range, indicating a preferred use of waters <500 m during breeding. The discovery of a colony insert within the Admiralty Sound, Tierra del Fuego, poses an interesting challenge to the known precepts on foraging behaviour for the species. In this study we present the first record on the foraging distribution of the only known inner-channel colony of albatrosses in the world, using high-resolution GPS loggers. Black-browed albatrosses breeding at the Albatross Islet used exclusively inner channel waters, at least during the chick guard stage. Results indicate a very small foraging range during chick-guard, with a significant use of sit-and-wait or 'drifting' behaviour during foraging.

Uso y explotación de aguas de canales por parte de albatros de ceja negra

Los albatros de ceja negra son la especie de albatros más abundante del hemisferio austral, que se reproduce en las islas oceánicas subantárticas y antárticas de todo el mundo. Se conoce razonablemente bien su hábitat para la reproducción y alimentación a lo largo de todo su rango de distribución, que indica que prefieren el uso de aguas <500 m durante la reproducción. El descubrimiento de una colonia ubicada dentro de Admiralty Sound, Tierra del Fuego, representa un desafío interesante para los preceptos conocidos sobre el comportamiento de búsqueda de alimentos de la especie. En este estudio, presentamos el primer registro de la distribución de zonas de alimentación de la única colonia conocida en el mundo de albatros ubicada dentro de un canal, con el uso de registradores de GPS de alta resolución. Los albatros de ceja negra que se reproducen en el islote Albatros usaron exclusivamente las aguas internas del canal, al menos durante la etapa de protección de los pichones. Los resultados indican una zona de alimentación muy pequeña durante la protección de los pichones, con un importante uso de comportamiento de espera o desplazamiento a la deriva durante la alimentación.

Utilisation et exploitation des eaux des canaux par les albatros à sourcils noirs

L'espèce d'albatros la plus peuplée de l'hémisphère sud est celle des albatros à sourcils noirs. Ces albatros se reproduisent sur les îles antarctiques et subantarctiques. Leurs zones de reproduction et de ravitaillement dans leur aire de répartition sont relativement bien connues. En période de reproduction, ces albatros privilégient les eaux <500m. La découverte d'une colonie dans le canal Admiralty Sound, Terre de Feu, remet en question les informations dont nous disposons sur les modes de recherche alimentaire de cette espèce. Cette étude présente les premières données disponibles sur l'aire de répartition alimentaire de la seule colonie d'albatros au monde située dans un canal. Ces données ont été collectées à l'aide de systèmes de géolocalisation. Les albatros à sourcils noirs qui se reproduisent sur Albatross Islet ont utilisé exclusivement les eaux du canal, du moins durant la période d'élevage des poussins. Les résultats de cette étude indiquent que la zone de recherche alimentaire des albatros est très restreinte durant la période d'élevage des poussins. Ils adoptent principalement un comportement attentiste ou "à la dérive".

INTRODUCTION

Black-browed albatrosses are the most abundant albatross species of the southern hemisphere, breeding on sub-Antarctic and Antarctic oceanic islands around the globe (Gales 1998). Recent population estimates have showed that about 96% of their world population is confined to the waters around the southern tip of South America (Wakefield et al. 2011). On the light of this fact, it should not be surprising the discovery of new colonies for science in southern Chile during the recent years (Arata et al. 2003, Aguayo et al. 2003, Marin and Oehler 2007). Nonetheless, it is remarkable the existence of a small colony at the dead end of a channel in Tierra del Fuego, more than 275 km from open ocean (Aguayo et al. 2003).

At-sea distribution of breeding black-browed albatrosses is well known for 8 major groups of islands (Wakefield et al. 2011). Home range analyses from these colonies indicates that black-browed albatrosses forage preferably on waters <500 m during breeding, with marked reductions in trip duration and distance during chick-rearing, particularly during brooding (Wakefield et al. 2011).

The understanding of the activity patterns of albatrosses during foraging trips, particularly when and where they actually capture their prey, has evolved slowly. In general terms, mollymawks are very efficient gliders, undertaking long foraging trips in search for food. Once a prey aggregation is detected, they engage in intensive foraging behaviour, with recurrent landing and take-off (Catry et al. 2004, Phalan et al. 2007). Albatrosses are also known to spent night hours sitting on the sea-surface, where they apparently can forage using a sit-and-wait technique (e.g., grey-headed albatross; Huin and Prince 1997, Catry et al. 2004); however, it is likely that this activity has a lower intake reward compare with active foraging, flight-landing, behaviour, with most food intakes occurs actually during daylight (Catry et al. 2004, Phalan et al 2007).

In this study we provide the first description of the distribution and activity patterns of the only known inner-channel colony of albatrosses in the world, using high-resolution GPS loggers. Results indicate a very small foraging range during chick-guard, with a significant use of sit-and-wait or 'drifting' behaviour during foraging.

METHODS

Black-browed albatrosses were tracked at Albatross Islet (54°27'25"S, 69°01'12"W) during breeding seasons 2011 (2011/12) and 2012 (2012/13) using Mobile Action model GT-120 GPS loggers. These are 44.5x28.5x13 mm, 20 g, 16 Mb units built for trekking sports but not waterproof. In order to install these GPSs on albatrosses, we weatherproof the instruments using silicone gel and two rubber-thumbs cut off from domestic cleaning gloves. Instruments were set to record every 30 minutes with a battery-life expectation of about 5 days. The GPSs were attached to the long feathers of the back, between the

wings, using TESA tape 4651. The frequency of locations obtained suggests a good performance of the instrument during the short foraging trips sampled (Fig. 1).

Eight albatrosses were tagged during 7 to 11 January 2012, obtaining a total of 13 foraging trips from 7 of the birds; one instrument was not recovered. During the 2012 season a total of twelve albatrosses were tagged from 7 to 14 December 2012, obtaining a total of 15 foraging trips from 9 birds; one bird never left the nest and two instruments were not recovered. Not a single nest failed due to desertion during the duration of both field works.

Albatross distribution was modelled using kernel density analysis, with a grid size of 5 km and a search radius of 0.5 km. Maps presented correspond to density distributions of 50, 75 and 95% utilisation distribution contours (Fig. 2).

Behaviour of albatrosses during the foraging trips was described by using speed and distance travelled as proxies. We estimate the instantaneous speed from consecutive GPS locations by using the distance and time provided by the manufacturer software. Data was categorized in 'day', 'twilight' and 'night' according to the local dawn, sunrise, sunset and dusk times for the Albatross Islet during the study period, using TerraTime software. Frequency distribution analyses for each daylight period indicated that albatrosses spend >75% of its time moving at speeds <6-8 km/h (Fig. 3). Activity patterns were defined accordingly, following examples from other studies (Weimerskirch et al. 2002, Zavalaga et al. 2011). Three movement patterns were identified: '*travelling*' if speed >8 km/h and distance >4km between points; '*foraging*' if speed between consecutive points is ≤4 km/h and distance ≤2 km; or '*prospecting*' if fail to fulfil any of the two former categories. Furthermore, ground speed during 'travelling' and 'foraging' was analysed depending on the bearing of the movement, estimated using the azimuth function in Octave.

Results presented are mean ± 1 SD, unless otherwise indicated.

RESULTS

Breeding black-browed albatrosses from Albatross Islet were tracked during two consecutive seasons, during early (2012) and late (2011) chick guard stage. During both seasons, albatrosses exploited exclusively inner waters from Admiralty Sound and the Magellan Strait (Fig. 2), no farther than 173.6 km from the colony (mean ± SD: 52.1 ± 46.4 in 2011 and 47.1 ± 22.9 km in 2012), travelling a total distance of 137.6 ± 111.4 km (2011) and 115.9 ± 56.3 km (2012), a trip duration of 29.8 ± 15.3 h (2011) and 19.5 ± 9.8 h (2012) (see Tables 1 and 2). In addition to the typical foraging trips, three birds undertook trips of 3-6 h, close to the colony (<4 km), most likely for resting far from the nest.

Birds tracked multiple trips showed a long-short-long pattern. Short trips seem unrelated to foraging activity, remaining close to the colony (Table 1 and 2).

Albatrosses showed a distinct flying and behaviour pattern according to light conditions. Activity patterns of albatrosses tracked were assessed according to their distance and speed during two consecutive locations. Most movements were ≤ 1 km and at a speed ≤ 2 km·h⁻¹ (Fig. 3). Accordingly, activity patterns were defined as 'foraging' (< 2 km or < 4 km·h⁻¹), 'travelling' (> 4 km or > 8 km·h⁻¹) or 'prospecting' (neither 'foraging' nor 'travelling'). This distinction is in agreement with observations for other albatrosses (*Diomedea exulans*, sitting-on-water < 9 km·h⁻¹ and travelling > 18 km·h⁻¹; Weimerskirch et al. 2002) and seabirds (*Pelecanus thagus*, Zavalaga et al. 2011). Albatrosses undertook 'travelling' almost exclusively during day and twilight conditions, when the highest speeds were recorded (Fig. 3 and 4). By contrast, 'foraging' was the dominant behaviour during night conditions (Fig. 4). These differences were significant (foraging: $P=0.0038$ [2011], $P=0.0001$ [2012]; travelling: $P=0.0056$ [2011], $P<0.0000$ [2012]).

Black-browed albatrosses tracked during both seasons showed distinct patterns while 'foraging' (Fig. 5): they either had isolated or clusters 'foraging' spots or spent long hours apparently sitting on the sea surface. During the 2011 season, 10 of the 13 foraging trips presented a series of consecutive 'foraging' locations, in an almost linear direction, lasting 3.14 ± 1.99 h. Likewise, 13 of the 15 foraging trips tracked in 2012 presented this behaviour, lasting 4.65 ± 2.13 h. These periods were characterized by linear displacement of the birds (Fig. 5) at ground speed of 1.05 km·h⁻¹ (2011) and 0.98 km·h⁻¹ (2012) (Fig. 6), on an almost unidirectional axis (Fig. 7), reason for which we named them 'drifting' behaviour.

These events were usually oriented NW-SW (24 out of 38 events; Fig. 7) during 2011 season and NE-SE (13 out of 16 events; Fig. 7) during 2012. This 'drifting' behaviour occurred with a median of 3 events per foraging trip during 2011 and 1 event (range: 0-3) in 2012. 'Drifting' events occurred mostly during night hours (84% and 84% of the time during night in 2011 and 2012), but they were also observed during daylight (Fig. 8). By contrast, 'active foraging' events, characterised by short periods of 'foraging', preceded and followed by prospecting or travelling events, occurred mainly during day hours (Fig. 9).

DISCUSSION

Black-browed albatrosses breeding at Albatross Islet, Admiralty Sound, Tierra del Fuego, used exclusively inner channel waters, at least during the chick guard stage. This is the first record of such behaviour described for an albatross colony.

The Albatross islet is located at the East end of the Admiralty Sound and about 275 km from the Pacific Ocean and 385 km from the Atlantic Ocean, well within foraging range of black-browed albatrosses from other colonies studied (Fig. 10). However, black-browed albatrosses breeding at the Albatross Islet undertook significant shorter foraging trips (range: 52 and 47 km; duration: 30 and 20 h; in 20011 and 2012, respectively) during the

guard stage than conspecific from Diego Ramirez (JA Arata, unpubl. data) and Falkland Islands (Islas Malvinas)¹ (Granadeiro et al. 2011) during the same breeding stage (Albatross Islet vs Falkland Islands (Islas Malvinas)¹ *t*-test: $P < 0.0000$; Albatross Islet vs Diego Ramirez *t*-test: $P < 0.0000$, for all years), suggesting a predictable and available food source in the channels exploited.

Furthermore, an interest pattern emerged from all locations characterized as 'foraging'. Birds tracked usually left the colony and after a short searching period (2011: 5.00 ± 4.23 h; 2012: 7.09 ± 6.26 h), they sat on the sea-surface and spent 3.14 and 4.65 h (2001 and 2012, respectively) 'drifting' away, likely carried by waves and wind (Fig. 5). Almost all birds tagged undertook this behaviour, which compose 33% (2011) and 25% (2012) of the total duration of the foraging trips. This activity pattern was most common during night time (84% of time), similar to black-browed albatrosses from South Georgia Islands (Islas Georgias del Sur)¹ (70%; Phalan et al. 2007). Albatrosses floating on the sea-surface are believed to forage using a sit-and-wait technique, although the overall significance of this behaviour on their energy budget is thought to be minor (Catry et al. 2004, Phalan et al 2007). Other seabird species had been described to rest and sleep while floating adrift (e.g., Lesser black-backed gulls, *Larus fuscus*; Shamoun-Baranes et al. 2011).

Although similar to the activity pattern described for other mollymawks from South Georgia Islands (Islas Georgias del Sur)¹ (Phalan et al. 2007), the 'drifting' behaviour detected in black-browed albatrosses in this studied seems a well-defined, more constant pattern or strategy during foraging. If we considered the lower energy cost of siting-on-water versus actively flying and landing for catching preys, being the take-off one of the most energy cost activities involved during foraging, it may be that the average cost-intake energy balance of this behaviour could be positive and rewarding.

In this case, we proposed that the vertical diel migration of local prey items, such as the lobster-krill *Munida gregaria* and the fuegian sprat *Sprattus fuegensis*, which are abundant food sources in these channels (Tapella et al. 2012, Diez et al. 2012), could be a driven factor for the behaviour described. Black-browed albatrosses from Diego Ramirez are known to exploit the outer channels off Southern America during incubation and brooding, and even enter the Beagle Channel, Magellan Strait and Admiralty Sound waters during postguard (Wakefield et al. 2011, JA Arata, unpubl. data), from where they may have capture lobster-krill and clupeidae fish (Arata and Xavier 2003), among other prey items. In the Magellan Strait and Admiralty Sound there is almost no long-line or trawl fisheries so availability of fishing discards in the area are null. Clupeid fish and lobster-krill are found close to the sea surface intermittently, where they could become accessible to albatrosses (Diez et al. 2012). We hypothesise that the unpredictable occurrence of this prey item near

¹ "A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Islas Malvinas), South Georgia and the South Sandwich Islands (Islas Georgias del Sur e Islas Sandwich del Sur) and the surrounding maritime areas."

surface but their aggregated behaviour while forming pelagic swarms could favoured the development of the 'drifting' behaviour by albatrosses tracked from the Albatross Islet.

Finally, it is interesting to notice that black-browed albatrosses tracked from other colonies in Chile are known to use inner fjord and channel waters during breeding. By contrast, albatrosses from Falkland (Malvinas)¹ and South Georgia Islands (Islas Georgias del Sur)¹, the other two closest colonies, do not venture into the Magellan Strait or Beagle Channel during breeding (BirdLife International 2004, Wakefield et al. 2011). Accordingly, we suggest that albatrosses from the Albatross Islet could be related to the Chilean population, which should be confirmed through genetic analysis. The question on the origin of the founders could have implications for the conservation status of this colony, considering that black-browed albatrosses from Chile and the Atlantic (Falklands (Malvinas) and South Georgias (Georgias del Sur))¹ have a different non-breeding distribution and face very different risks from fishing fleets (Chile: Moreno et al. 2006, Moreno et al. 2008; Argentina-Uruguay-Brazil: Bugoni et al. 2008, Jiménez et al. 2010, Favero et al. 2013) which is reflected in different population trends in Chile respect to the Southwest Atlantic populations of black-browed albatrosses (Huin 2001 in Robertson et al. 2007, Poncet et al. 2006).

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Table 1. December 2012

BIRD	Breeding Stage	TRIP No.	START TRIP Date	START TRIP Time	END TRIP Date	END TRIP Time	Trip Duration (h)	Time at nest (h)	Total Distance Travelled (km)	Max. Distance (km)
X00159	Guard	1	08-12-2012	16:40:12	09-12-2012	11:17:34	18.62	4.01	99.1	43.5
		2	09-12-2012	15:18:03	10-12-2012	9:24:51	18.11	--	185.1	44.7
X00072	Guard	1	08-12-2012	6:12:59	09-12-2012	6:05:03	23.87	--	196.1	84.2
X00056	Guard	1	07-12-2012	22:16:17	08-12-2012	11:33:34	13.29	5.17	97.3	44.8
		2	08-12-2012	16:44:02	09-12-2012	11:17:34	18.56	9.26	99.2	43.5
		3	09-12-2012	20:33:16	10-12-2012	11:20:04	14.78		87.7	40.5
X00181	Guard	1	08-12-2012	7:45:13	08-12-2012	15:50:24	8.09	23.28	40.2	17.4
		2	09-12-2012	15:07:01	10-12-2012	9:24:51	18.30		124.0	44.7
X00206	Guard	1	12-12-2012	11:58:40	12-12-2012	18:02:53	6.07	3.51	5.4	1.5
		2	12-12-2012	21:33:42	14-12-2012	17:07:06	43.56		144.3	51.0
X00197	Guard	1	12-12-2012	11:41:30	13-12-2012	3:36:50	15.92	--	30.1	11.8
X00168	Guard	1	12-12-2012	20:02:37	13-12-2012	4:22:22	8.33	--	29.1	14.5
X00075	Incubation	1	07-12-2012	21:38:58	09-12-2012	8:20:23	34.69	--	165.3	64.3
X00207	Guard	1	11-12-2012	23:18:43	12-12-2012	11:06:05	11.79	8.75	162.7	80.3
		2	12-12-2012	19:51:18	13-12-2012	20:49:23	24.97	--	162.0	74.1

Table 2. January 2012

BIRD	Breeding Stage	TRIP No.	START TRIP		END TRIP		Trip Duration (h)	Time at nest (h)	Total Distance Travelled (km)	Max. Distance (km)
			Date	Time	Date	Time				
X00175	Post-guard	1	08-01-2012	8:55:01	10-01-2012	6:47:49	45.88	6.67	111.2	37.1
		2	10-01-2012	13:28:13	11-01-2012	5:05:45	15.63		38.4	13.5
X00131	Post-guard	1	08-01-2012	0:13:00	09-01-2012	12:16:54	36.07		103.5	27.5
X00174	Guard	1	08-01-2012	4:21:18	10-01-2012	8:06:18	51.75		432.1	173.6
X00111	Guard	1	08-01-2012	22:50:58	10-01-2012	5:47:59	30.95	8.16	121.2	54.1
		2	10-01-2012	13:57:28	10-01-2012	17:22:40	3.42	0.50	8.1	3.5
		3	10-01-2012	17:52:39	11-01-2012	12:33:05	18.67		127.3	50.4
X00173	Guard	1	08-01-2012	6:43:48	10-01-2012	5:51:24	47.13	6.09	237.4	97.4
		2	10-01-2012	11:56:59	10-01-2012	16:53:10	4.94	4.89	27.3	12.4
		3	10-01-2012	21:46:34	11-01-2012	11:41:35	13.92		105.4	40.2
X00157	Guard	1	07-01-2012	18:10:34	08-01-2012	19:45:47	25.59		111.2	35.7
X00075	Guard	1	07-01-2012	18:41:36	07-01-2012	21:49:58	3.14	0.91	10.8	2.8
		2	07-01-2012	22:44:34	09-01-2012	12:20:35	37.60		98.7	31.1

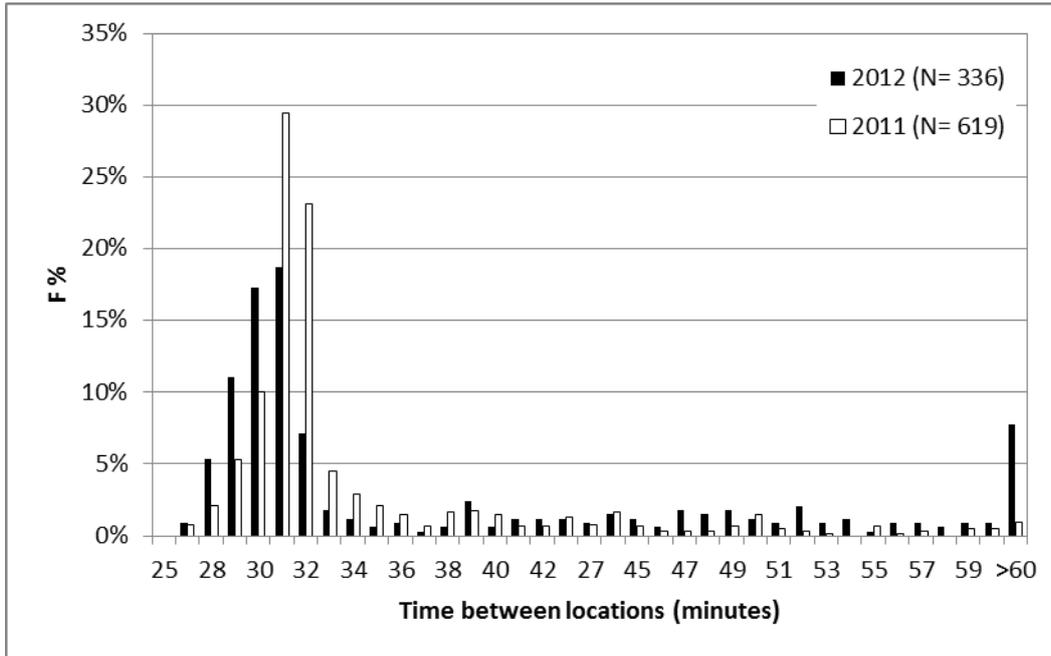


Figure 1. Frequency distribution of time interval (minutes) of GPS locations recorded by the Mobile Action model GT-120 GPS units.

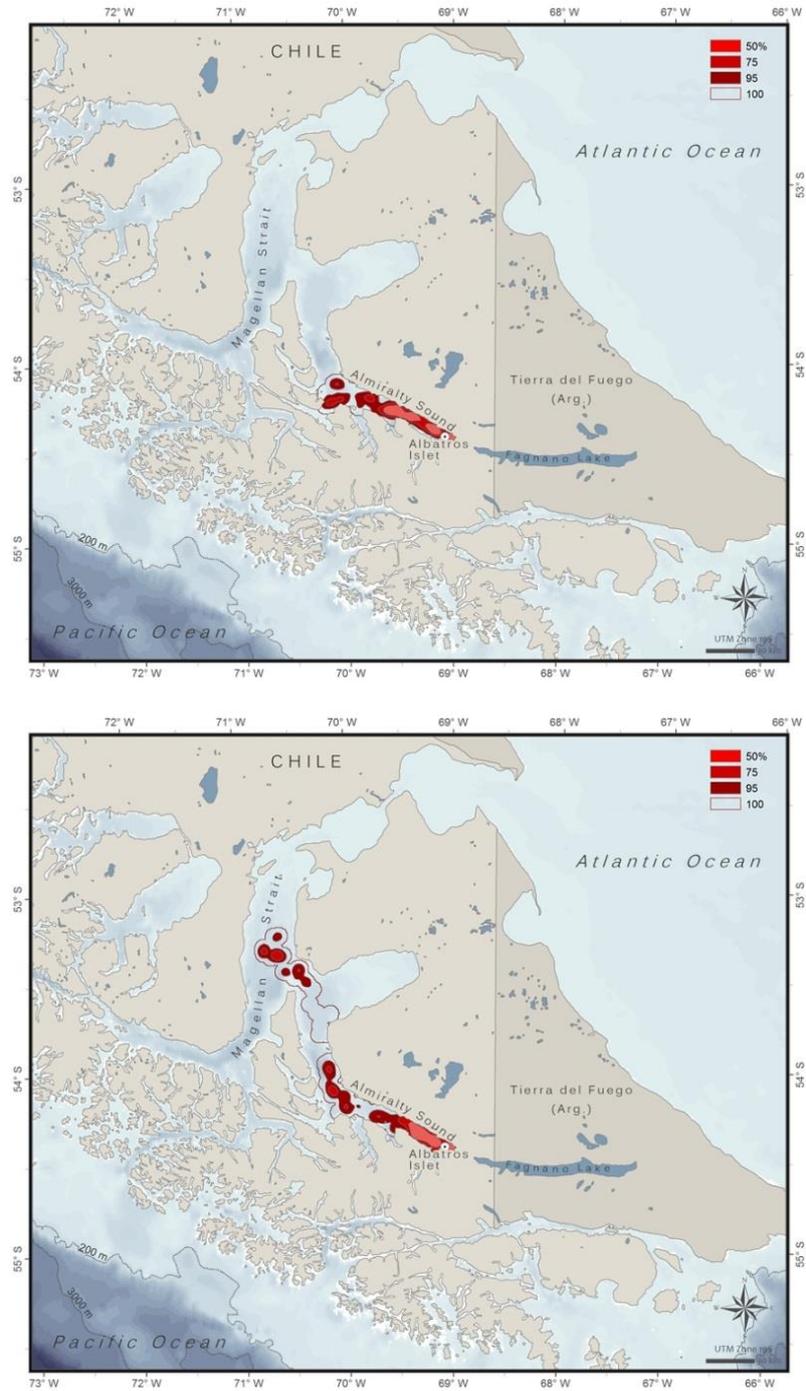


Figure 2. Distribution of breeding black-browed albatrosses tracked from Albatross Islet during early (December 2012; top) and late (January 2012; bottom) chick guard period.

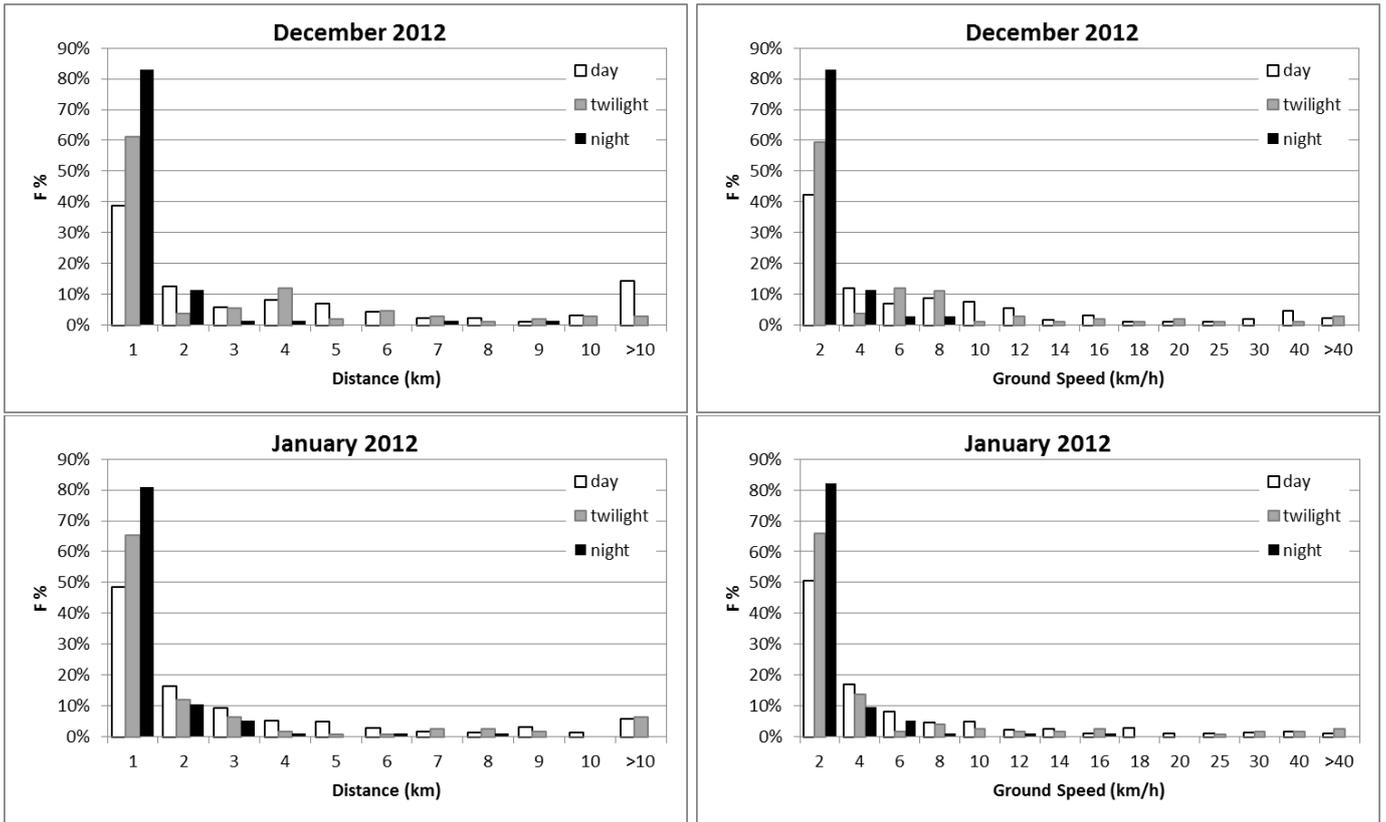


Figure 3. Frequency distribution of distance and ground speed for consecutive GPS locations, divided according to day, twilight and night.

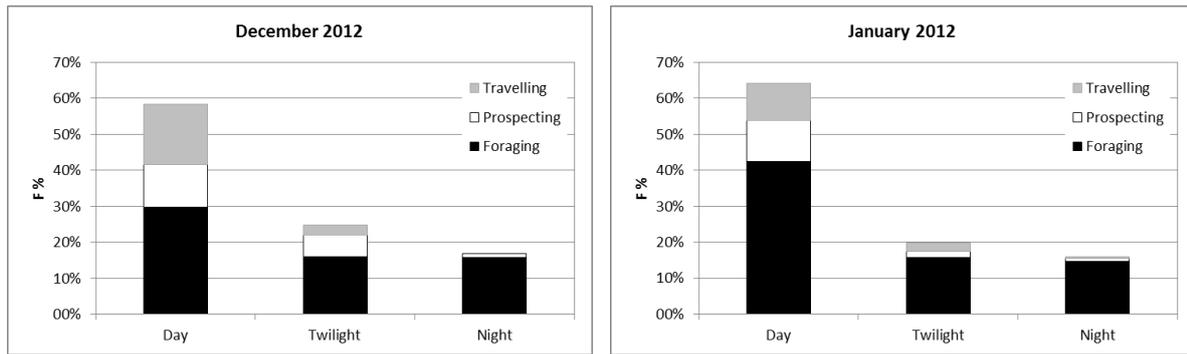


Figure 4. Frequency distribution of activities (*travelling, prospecting* and *foraging*) during foraging trips, according to daylight conditions.

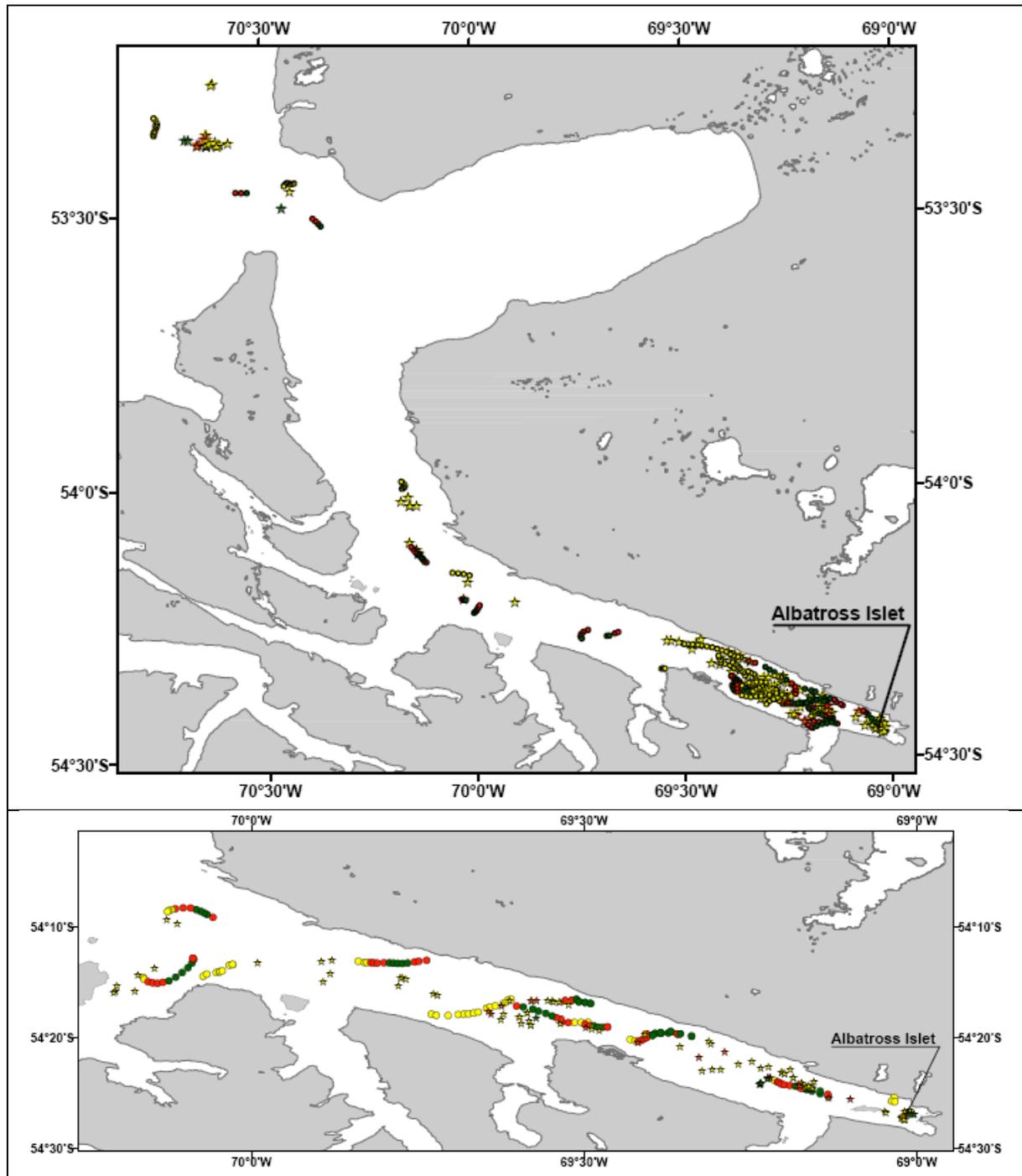


Figure 5. Distribution of locations categorized as representing “foraging” activities. Locations are divided by ‘drifting’ (circles) and ‘active’ (stars) events and by daylight periods: *green*: night; *orange*: twilight; *yellow*: day.

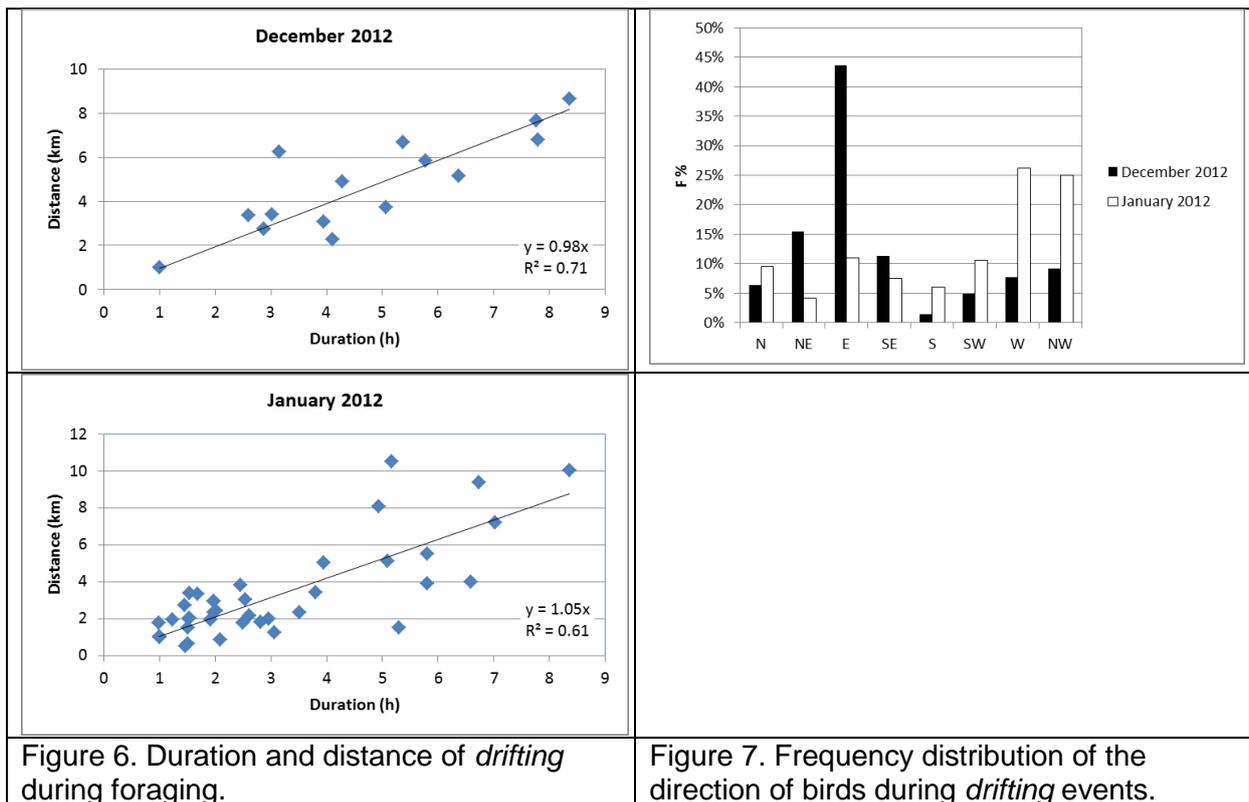


Figure 6. Duration and distance of *drifting* during foraging.

Figure 7. Frequency distribution of the direction of birds during *drifting* events.

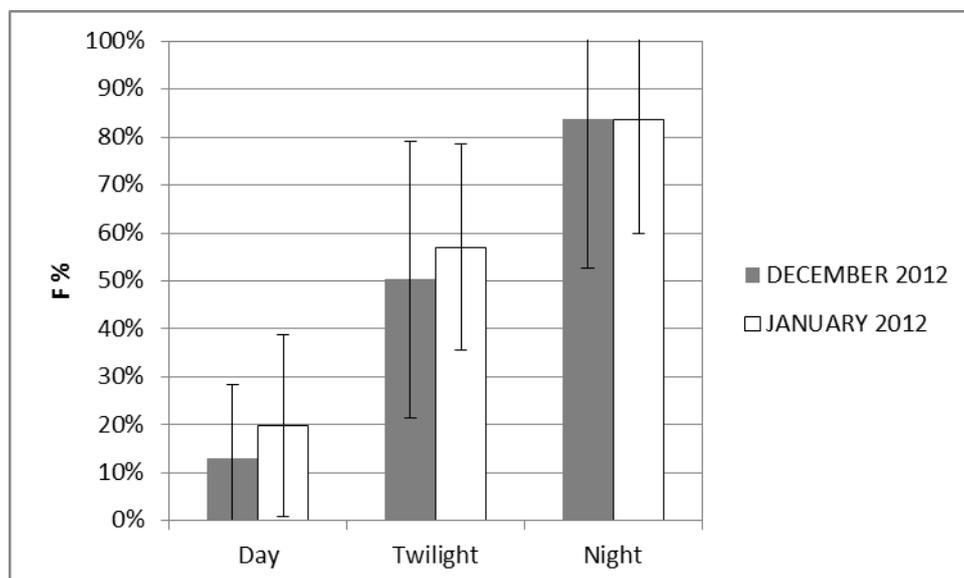


Figure 8. Mean ($\pm 1SD$) percentage of the time spent sitting-on-water (drifting), during day, twilight and night conditions.

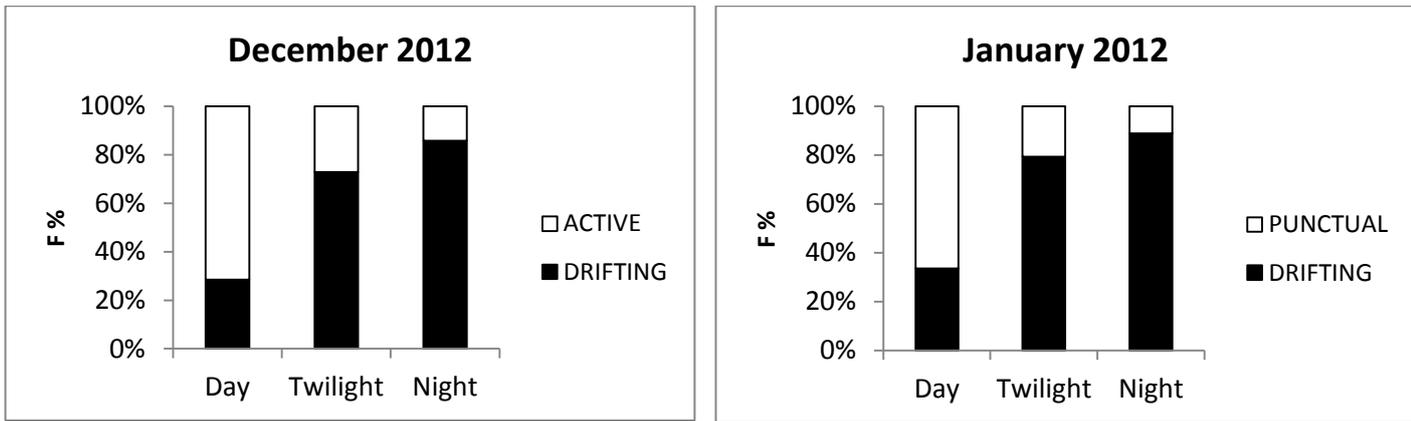


Figure 9. Proportion of the 'foraging' time spent in 'drifting' and 'active' behaviour.

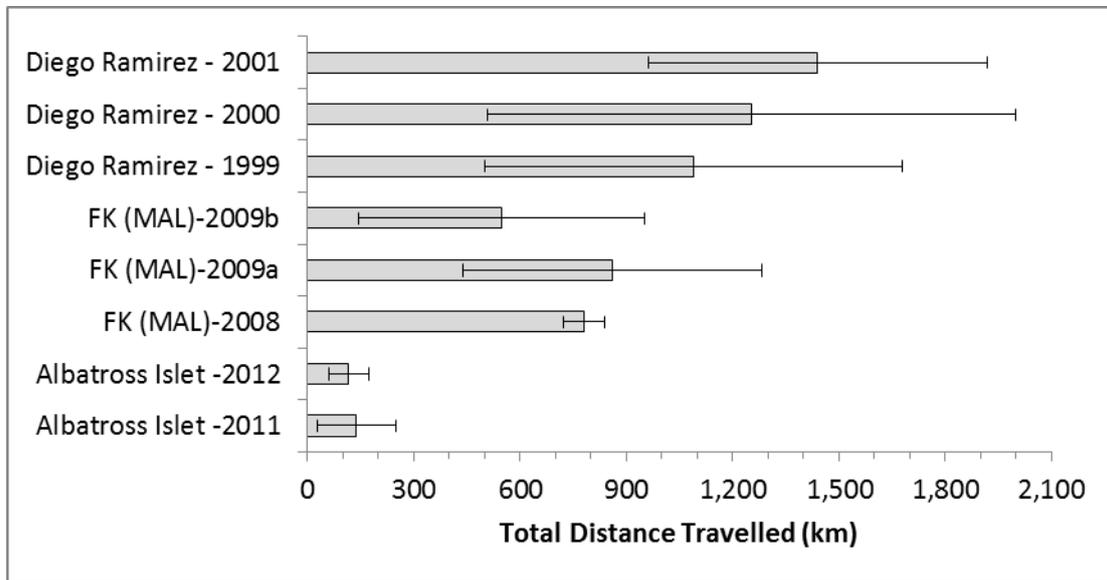


Figure 10. Total trip length (km) of breeding black-browed albatrosses tracked during chick guard stage at Albatross Islet (this study), Diego Ramírez Islands (JA Arata, unpubl. data) and Falkland Islands (Islas Malvinas)¹ (Granadeiro et al. 2011, Table 1).