Marine Space Use by Three Seabird Species of Blue Patagonia

Technical Report

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Summary

This report details the tasks carried out between November 2023 and December 2024 and the main results regarding the study of feeding behavior (diving) and marine space use of the Magellanic penguin, imperial cormorant, and southern giant petrel from Tova Island, Tovita Island, and Gran Robredo Island, respectively.

During two reproductive seasons (2023 and 2024), 44 and 25 breeding adults of Magellanic penguin and imperial cormorant were instrumented with two types of electronic devices (Axy-Trek and Axy-Trek Remote). Additionally, 10 breeding adults of southern giant petrel were instrumented with Axy-Trek Remote devices in January 2024. During both study seasons, the feeding trajectories ofMagellanic penguin and areas of highest use intensity during the reproductive period exceeded the limits of the current marine protected area —i.e., Patagonia Interjurisdictional Coastal Marine Park (PIMCPA). Even during the chick-rearing stage, when feeding trips are shorter, trajectories reach areas located more than 100 kilometers from the PIMCPA limits. In the case of imperial cormorant, feeding trips made during incubation and the chick-rearing stage occurred both within and outside (up to < 10 kilometers on average) the current marine protected area. In the case of southern giant petrels, clear spatial segregation between sexes was observed and all birds widely exceeded the PIMCPA limits, making extensive use of the continental shelf, from the coast to the continental slope. The data obtained and results presented constitute the first records of marine space use by Magellanic penguins and imperial cormorants from the Tova-Tovita complex. Additionally, the southern giant petrel records complement information recorded in previous years regarding marine space use by southern giant petrels.

Methodology

Magellanic penguin and imperial cormorant

During the early chick-rearing stage of 2023 (third and fourth week of November), electronic behavior and movement devices (Axy-Trek, www.technosmart.eu) with GPS, pressure sensors (i.e., depth), temperature, and triaxial acceleration (Fig. 1) were placed on 21 and eight breeding adults of Magellanic penguin (Tova Island) and imperial cormorant (Tovita Island), respectively. In all cases, the loggers were recovered after one or two successive feeding trips.

Additionally, during the 2024 reproductive season, 23 and 17 adults of Magellanic penguin (Tova Island) and imperial cormorant (Tovita Island), respectively, were instrumented with latest-generation devices (Axy-Trek Remote, www.technosmart.eu) with GPS and depth and triaxial acceleration sensors (Fig. 1).

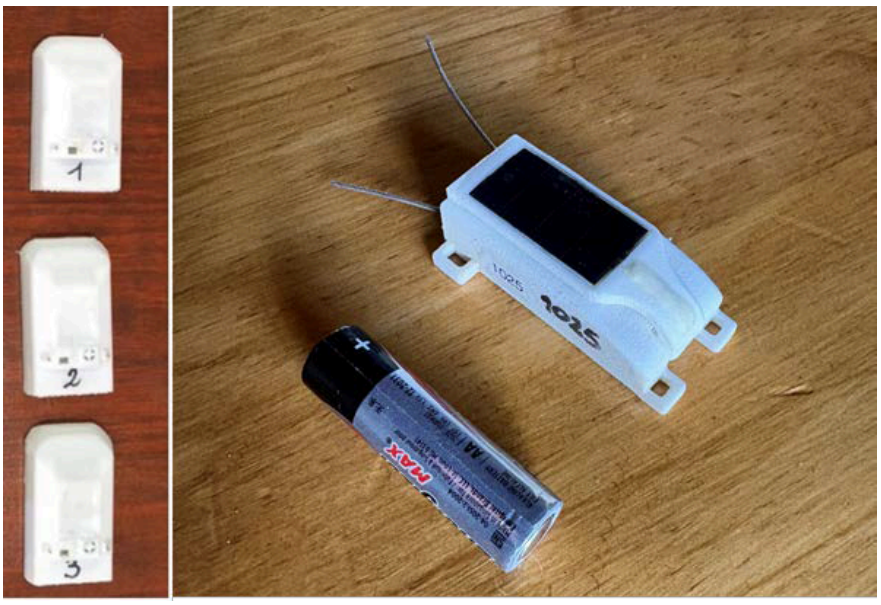

Figure 1. Electronic behavior and movement devices Axy-Trek (left) and Axy-Trek Remote (right).

In both species, birds were instrumented during both the incubation period (early November) and during the chick-rearing stage (early December) (Fig. 2).

Figure 2. Detail of instrumentation of a Magellanic penguin with an Axy-Trek device (left) and imperial cormorant with an Axy-Trek Remote logger (right).

Data from these instruments were downloaded automatically to data reception stations located near the nests for Magellanic penguins and at the colony periphery for imperial cormorants (Fig. 3). Data receptor bases were removed and replaced alternately throughout the reproductive stage to obtain complete records of at-sea trajectories and respective diving and feeding behaviors.

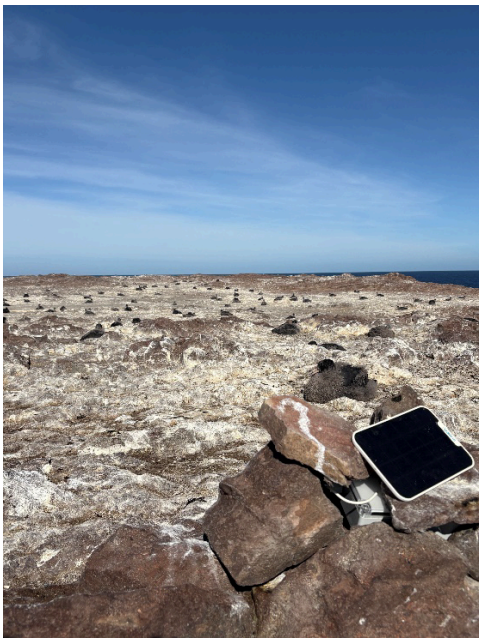

Figure 3. Automatic data reception station placed in the southern giant petrel colony of Gran Robredo Island.

Southern giant petrel

In January 2024, 10 breeding adults (five males and five females) of southern giant petrel were instrumented with Axy-Trek Remote devices, www.technosmart.eu (see above) (Fig. 4). Adult instrumentation was performed during the first week of chick life (early January) to reduce any potential impact on birds that were incubating. Data from these instruments were downloaded automatically to a base station located at the periphery of the Gran Robredo Island colony (Fig. 3). Data receptor bases were removed and replaced alternately throughout the year to have complete routes to feeding areas of each instrumented adult over 12 months (reproductive and non-reproductive period).

Figure 4. Breeding adult southern giant petrel instrumented with an Axy-Trek Remote location and movement device.

Results

Feeding behavior, diving and marine space use

Magellanic penguin - Tova Island

Feeding trips at sea were recorded from 41 of the 44 instrumented penguins in both seasons. During 2023, only 1 or 2 feeding trips per individual were recorded (16 and 3 penguins with one and two trips, respectively) within the early chick-rearing period. During 2024, the change in technology (see above) allowed recording up to 15 feeding trips per individual, covering both incubation and the chick-rearing stage.

In their feeding trips during incubation (2024 season), penguins remained at sea for an average of almost two days, although the longest trip lasted eight days (Table 1). On average, feeding routes presented total distances greater than 120 kilometers in marine areas located more than 100 kilometers from the colony (Table 1).

During chick rearing (2023 and 2024 seasons), the average time at sea was 14-22 h and total distances traveled per trip were 48 and 73 kilometers for the 2023 and 2024 seasons, respectively. During the 2024 chick-rearing stage, penguins moved on average more than 30 kilometers from the colony, although they reached maximum distances exceeding 100 kilometers (Table 1).

Table 1. Characteristics of feeding trips of Magellanic penguins from Tova Island during reproductive seasons 2023 (chick rearing) and 2024 (incubation and chicks). Values for the 2024 season represent the mean and standard deviation of individual averages (N=8 and 18 individuals for incubation and chicks, respectively). For the chick-rearing stage of the 2023 season, the mean and standard deviation of total recorded trips is shown (N=22 trips).

	Incubation				**Chick Rearing**							
	2024				2023				2024			
Feeding Trips	*Average*	*SD*	*Min*	*Max*	*Average*	*SD*	*Min*	*Max*	*Average*	*SD*	*Min*	*Max*
Duration (h)	47,5	42,0	1,5	201,8	13,9	6,8	2,3	25,6	21,9	7,4	1,4	82,2
Distance traveled (km)	122,5	99,7	3,7	419,4	47,7	25,6	5,2	99,7	72,9	29,3	7,0	272,5
Maximum distance to colony (km)	38,1	22,5	2,1	118,1	14,2	7,4	1,9	31,8	30,8	13,0	3,1	116,4
Number of dives/trips	1000	875	12	3884	304	187	46	738	552	211	32	1963

During both study seasons, the feeding trajectories of Magellanic penguins exceeded the limits of the current marine protected area (i.e., PIMCPA) (Fig. 5).

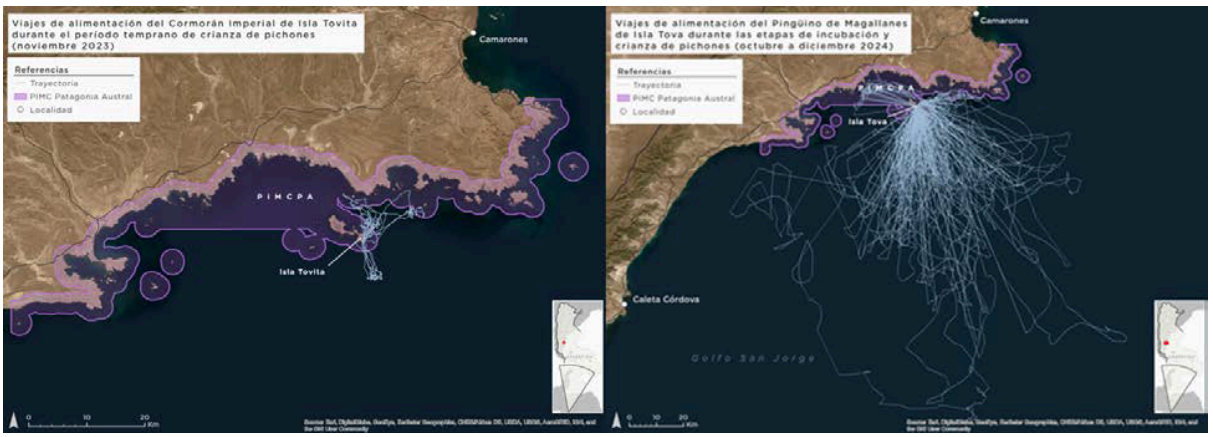

Figure 5. Feeding trajectories of Magellanic penguins from Tova Island during reproductive seasons 2023 (chick-rearing stage) (left) and 2024 (incubation and chick rearing) (right). 21 and 23 breeding adults instrumented during 2023 and 2024, respectively.

The feeding trajectories and areas of highest use intensity during the reproductive period were found outside these limits, for both females and males (Fig. 6). Even during the chick-rearing stage, when feeding trips are shorter (i.e., duration and distance to colony), trajectories reach areas located more than 100 kilometers from the current protected area limits (Fig. 7).

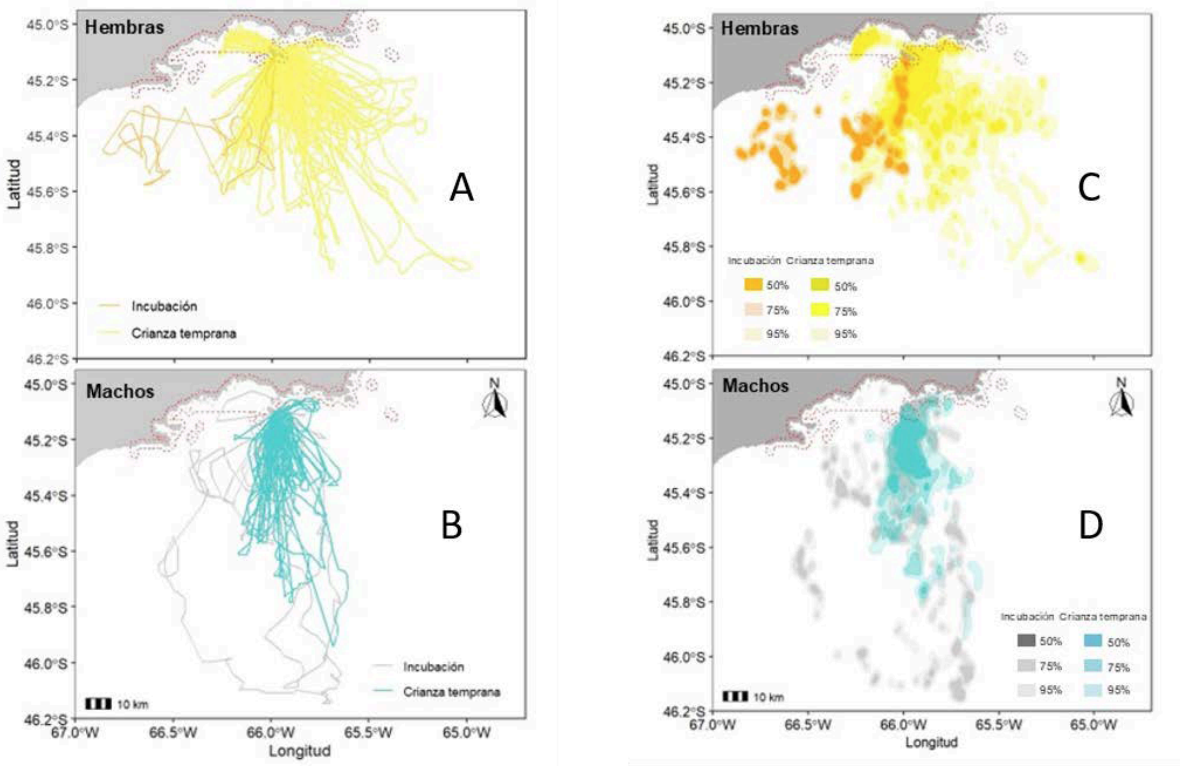

Figure 6. Feeding trajectories (A and B) and marine area use intensity (C and D) of Magellanic penguins from Tova Island during the 2024 reproductive period (incubation and chick rearing).

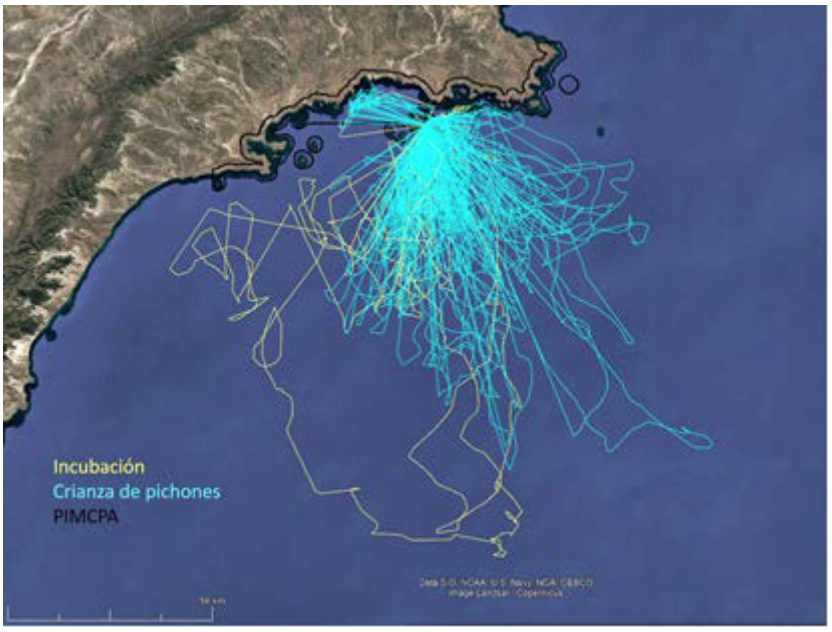

Figure 7. Feeding trajectories of Magellanic penguins from Tova Island during the 2024 reproductive season (incubation and chick rearing). Eight and 18 breeding adults instrumented during incubation and chicks, respectively (there were three same individuals instrumented in both periods).

During their sea excursions, penguins performed about 1000 and 300-500 dives per trip during incubation and chick-rearing periods, respectively (Table 1). Average maximum duration and depth were less than 1 min and 18 m, respectively (Table 2).

Table 2. Characteristics of dives performed by Magellanic penguins from Tova Island during the chick-rearing stage of the 2023 season and incubation and chick-rearing periods of the 2024 season. Values for the 2024 season represent the mean and standard deviation of individual averages (N=8 and 18 individuals for incubation and chicks, respectively). For the chick-rearing stage of the 2023 season, the mean and standard deviation of total recorded trips is shown (N=22 trips).

Dives	**Incubation**			**Chick Rearing**					
	2024			2023			2024		
	Average	*SD*	*Max*	*Average*	*SD*	*Max*	*Average*	*SD*	*Max*
Duration (s)	44,5	8,6	164	49,1	20	88,8	49,7	7,2	179,0
Maximum depth (m)	13,7	5,3	87,9	17,8	8,4	38	15,4	3,2	94,2
Time at maximum depth (s)	17,4	3,0	103,0	18,1	5,2	29,6	20,0	3,8	124,0

Imperial cormorant - Tovita Island

Feeding trips at sea were recorded from 16 of the 25 instrumented cormorants in both seasons. During the early chick-rearing period of the 2023 season, animals were instrumented for only less than 48 h (see above), within which a total of 14 feeding trips were recorded (six and two individuals with two and one trip, respectively). As in the case of penguins, the use of data receptor bases in the 2024 season allowed recording between 13 and 64 feeding trips per individual, covering both incubation and the chick-rearing stage.

In their feeding trips during incubation (2024 season), cormorants remained at sea for an average of about five hours (Table 3). During feeding trips, breeding adults of both sexes traveled an average of about 25 kilometers. The maximum distance to the colony was almost 22 kilometers, but on average these distances did not exceed eight kilometers (Table 3). During the chick-rearing stage (2023 and 2024 seasons), the average time at sea was 3-4 h and total distances traveled per trip were around 30 kilometers. The maximum distance from the colony was less than 22 kilometers, although the average did not exceed nine kilometers (Table 3).

Table 3. Characteristics of feeding trips of imperial cormorant from Tovita Island during reproductive stage 2023 (chick rearing) and 2024 (incubation and chick rearing). Values for the 2024 season represent the mean and standard deviation of individual averages (N = eight individuals, four for incubation and four for chicks). For the chick-rearing stage of the 2023 season, the mean and standard deviation of total recorded trips is shown (N=14 trips).

Feeding Trips	**Incubation**				**Chick Rearing**							
	2024				**2023**				**2024**			
	Average	***SD***	***Min***	***Max***	***Average***	***SD***	***Min***	***Max***	***Average***	***SD***	***Min***	***Max***
Duration (h)	4,7	1,8	0,3	9,3	2,8	2,2	0,3	8,1	4,3	2,6	0,3	9,9
Distance Traveled (km)	25,4	7,9	0,3	78,9	33,3	27	1,0	87,9	27,1	14,0	2,8	85,4
Maximum distance from the colony (km)	7,1	2,6	0,5	21,6	7,8	5,9	0,3	21,5	8,6	4,3	0,7	20,7
Number of dives/ trips	51	30	1	177	43	42	5	151	94	82	2	343

During both study seasons, feeding trips made during incubation and the chick-rearing stage occurred both within and outside the current marine protected area (Patagonia Austral Coastal Marine Interjurisdictional Park, PIMCPA) (Fig. 8).

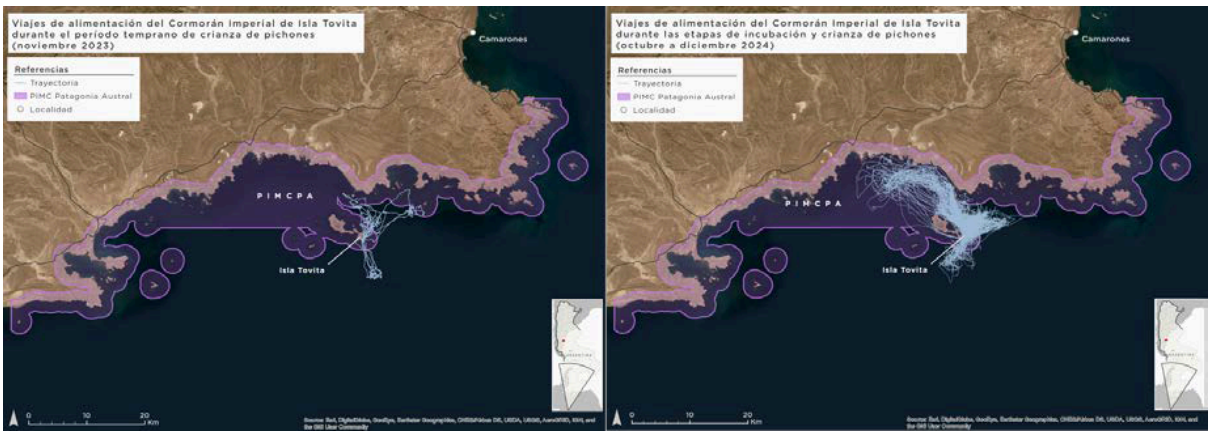

Figure 8. Feeding trajectories of imperial cormorant from Tovita Island during reproductive seasons 2023 (chick-rearing stage) (left) and 2024 (incubation and chick rearing) (right). Data correspond to records from 16 breeding adults in both seasons.

The feeding trajectories and areas of highest use intensity during the reproductive period (i.e., incubation and chick rearing) were found within these limits fundamentally for females. Some of the trajectories and feeding areas of males took place outside the protected area, although at distances less than seven kilometers from the PIMCPA limits (Fig. 9 and 10).

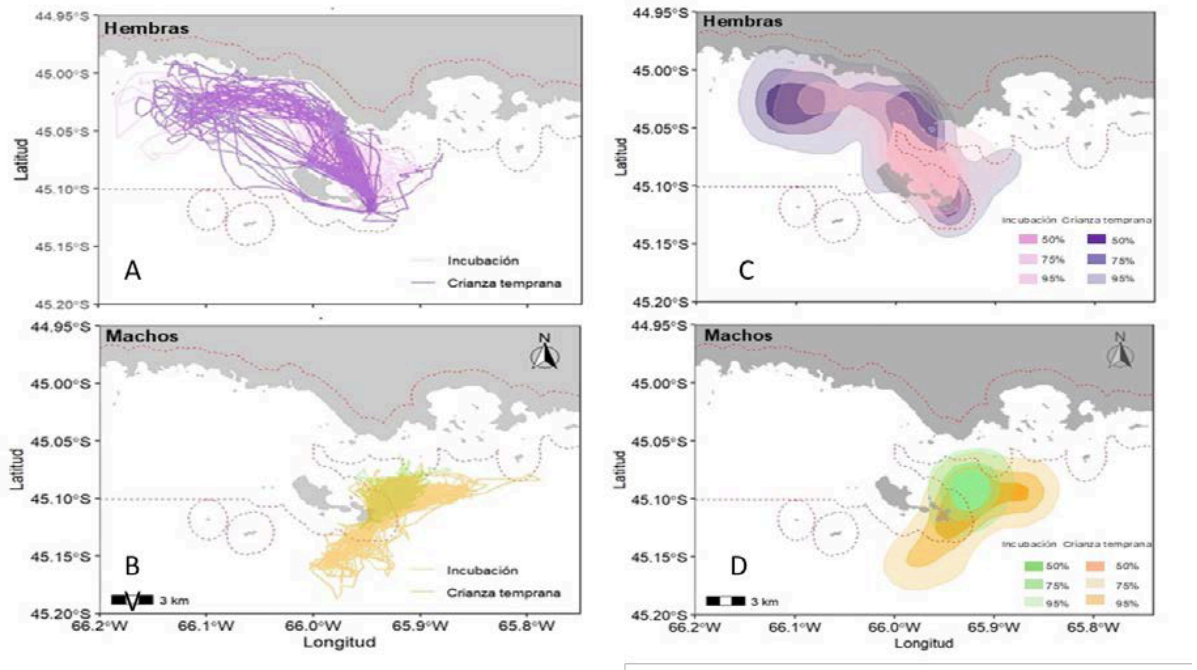

Figure 9. Feeding trajectories (A and B) and marine area use intensity (C and D) of imperial cormorants from Tovita Island during the 2024 reproductive period (incubation and chick rearing).

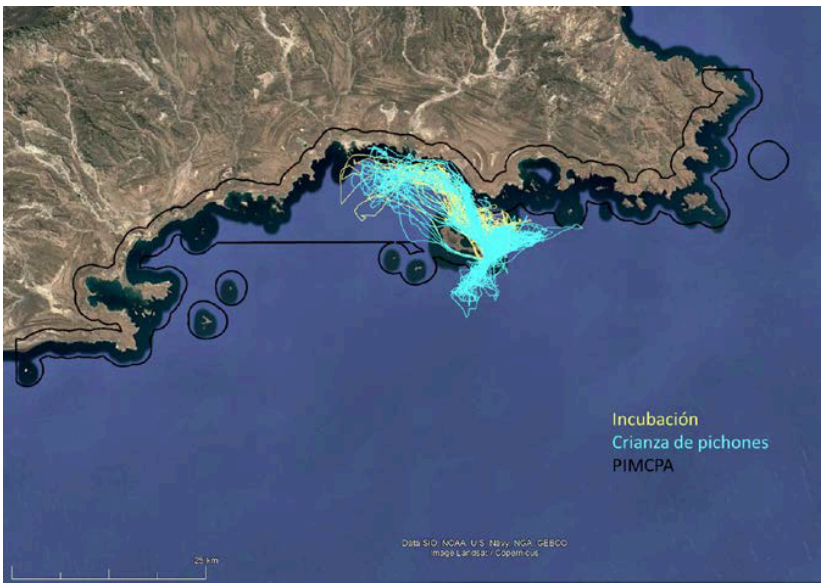

Figure 10. Feeding trajectories of imperial cormorant from Tovita Island during the 2024 reproductive season (incubation and chick rearing). Data correspond to eight breeding adults (four and four for incubation and chicks, respectively).

During feeding trips, cormorants performed between 40 and 90 dives per trip (Table 3), of approximately one minute average duration and shallow (max. average: 15-20 m) (Table 4). Time spent at the bottom corresponded to more than 60% of total immersion time.

Table 4. Characteristics of dives performed by imperial cormorants from Tovita Island during the chick-rearing stage of the 2023 season and incubation and chick-rearing periods of the 2024 season. Values for the 2024 season represent the mean and standard deviation of individual averages (N = eight individuals, four for incubation and four for chicks). For the chick-rearing stage of the 2023 season, the mean and standard deviation of total recorded trips is shown (N=14 trips).

	Incubation			Chick Rearing					
Dives	**2024**			**2023**			**2024**		
	Average	*SD*	*Max*	*Average*	*SD*	*Max*	*Average*	*SD*	*Max*
Duration (s)	74,2	8,7	235.0	56,7	28	112	72,1	25,3	309,0
Maximum depth (m)	20,9	2,0	58,9	15,9	6,0	26,0	19,6	10,8	74,2
Time at maximum depth (s)	49,4	9,1	140,0	37,5	22	83,6	47,7	15,7	217,0

Southern giant petrel - Gran Robredo Island

Sea positions were obtained over a complete year for southern giant petrel adults that were instrumented with Axy-Trek Remote devices on Gran Robredo Island (see above). This allowed analysis of marine space use and feeding trip characteristics during both the reproductive period (October to

April) and the non-reproductive stage (May to September). Between January and December 2024, a total of 510 feeding trips were obtained (between 15 and 101 per individual) (Table 5). southern giant petrel adults alternated feeding periods at sea with colony residence times throughout the entire year. Figure 11 shows, as an example, the pattern of trips and colony presence throughout the year for one of the studied individuals.

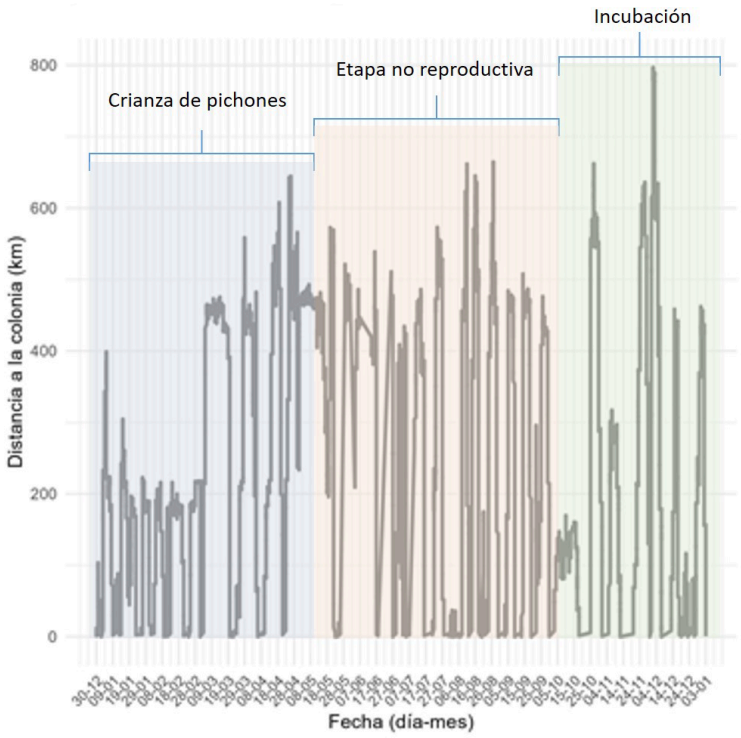

Figure 11. Pattern of feeding trips at sea and colony residence periods of a southern giant petrel from Gran Robredo Island. Colony residence periods are observed for those days when distance to the island is zero or very close to zero.

Throughout the entire year, Giant Petrels made use of a very extensive space of the Argentine continental shelf. From the coast to the Continental Slope (approx. 60° W) and from southern Buenos Aires Province (approx. 41° S) to the Strait of Magellan (approx. 51° S) (Fig. 12).

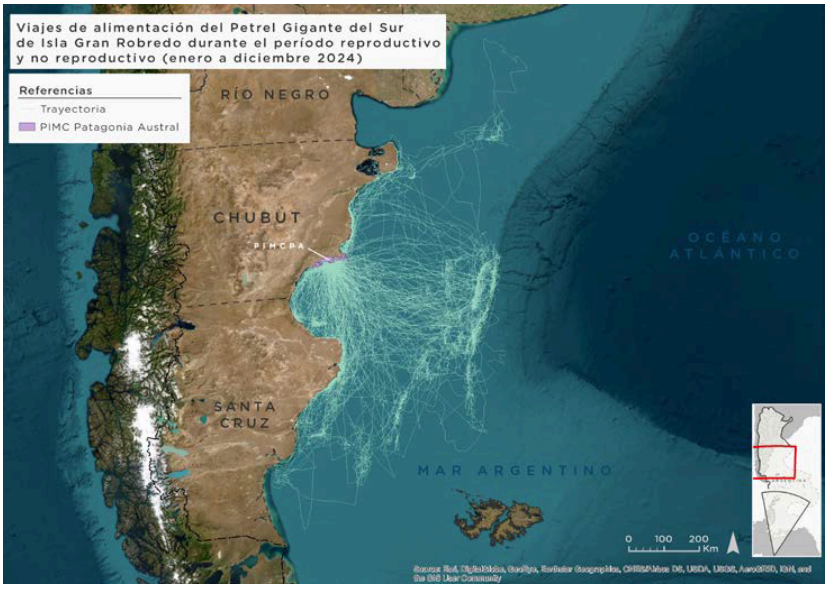

Figure 12. Trajectories corresponding to feeding trips (N = 510) of 10 adults (five males and five females) breeding southern giant petrels from Gran Robredo Island. Data correspond to the period January to December 2024. The area covered by the Patagonia Austral Coastal Marine Interjurisdictional Park is indicated in fuchsia.

Throughout the study period, Giant Petrels made, on average, feeding trips of more than 48 h (two days) during which they traveled distances of more than 7000 kilometers (average = 477 ± 249 kilometers) and moved up to almost 800 kilometers from the colony (average = 134 ± 53 kilometers) (Table 5).

Table 5. Characteristics of feeding trips of southern giant petrels from Gran Robredo Island during reproductive and non-reproductive periods (N = 10 individuals, 510 trips). Values represent the mean (and other descriptive statistics) of individual averages.

Feeding trips	Average	Deviation	Minimum	Maximum
Duration (h)	48.9	22.9	28.8	102.9
Distance traveled (km)	477.1	248.6	207.3	1075.8
Maximum distance to colony (km)	133.7	53.3	48.9	241.9
Number of trips (n)	54	33	15	101

In general terms, although clear spatial segregation between sexes was observed (Fig. 13), all birds used both coastal areas (north and south of Gran Robredo island) and middle shelf and continental slope areas (Fig. 13).

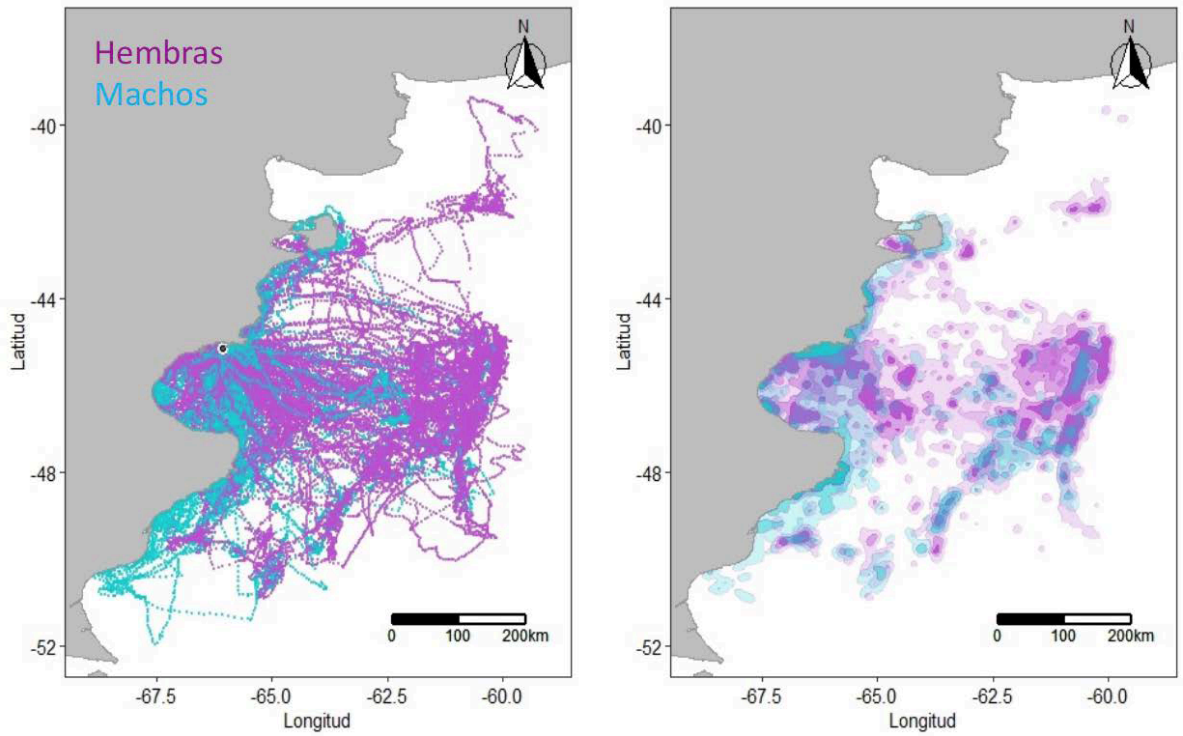

Figure 13. Feeding trajectories (left) and marine area use intensity (right) of adult male and female southern giant petrels from Gran Robredo Island throughout the entire year. In the right map, use intensity is shown with different color intensities.

Information analyzed for the first three months of chick rearing (early January to late March), when it is assumed that adult feeding trips are shorter (i.e., time and distances), indicates that in all cases, marine areas used by giant petrels widely exceed the PIMCPA marine protected area. Even in this stage, birds made, on average, feeding trips of more than 35 h (1.5 days) during which they traveled distances of up to almost 600 kilometers (Table 6). In general terms, females and males used both coastal areas (north and south of Gran Robredo island) and middle shelf and continental slope areas (Fig. 14). Marine areas of use during the chick-rearing period were found at maximum between 50 and 150 kilometers from the colony (Table 5 and Fig. 14), always outside the protected area limits. Coastal zones visited by petrels correspond fundamentally to South American sea lion (Otaria flavescens) rookeries and Magellanic penguin nesting colonies. The entire San Jorge Gulf corresponded to an important use area during the mentioned period (Fig. 14). For this stage, clear spatial segregation between sexes was also recorded, although these differences have not been statistically analyzed.

Table 6. Characteristics of feeding trips of southern giant petrel from Gran Robredo Island during the chick-rearing period (early January to late March) (N=159 trips).

Feeding trips	Average	Deviation	Minimum	Maximum
Duration (h)	36.6	17.1	18.4	78.2
Distance traveled (km)	350.1	123.4	201.5	588.4
Maximum distance to colony (km)	103.7	32.0	48.3	166.4
Number of trips (n)	26	12	15	53

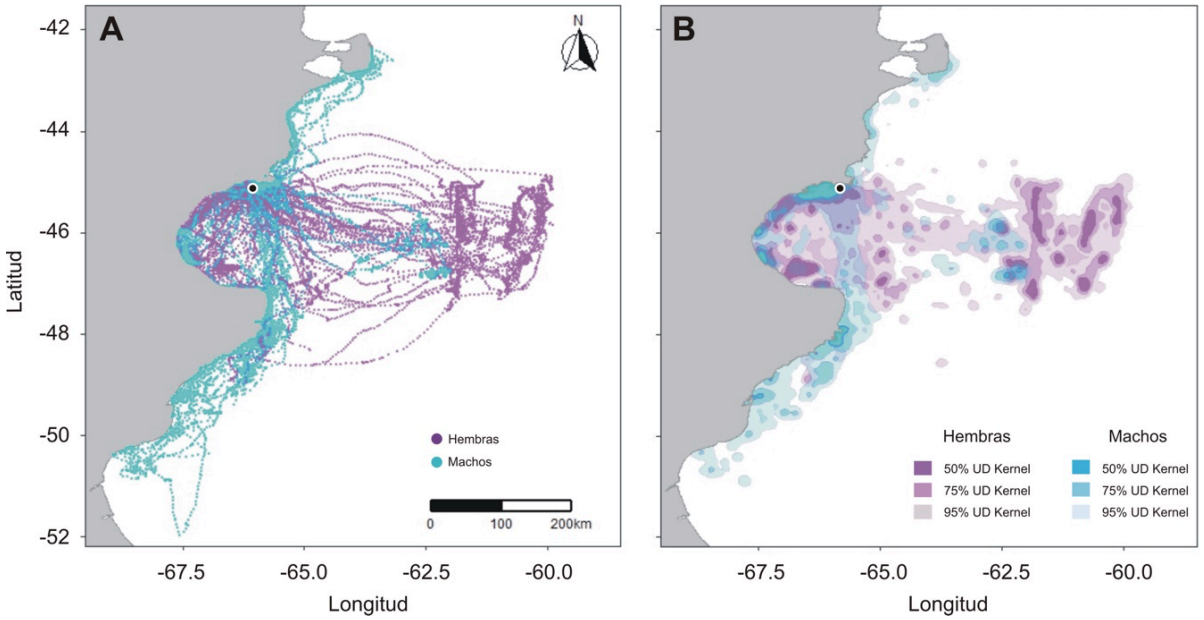

Figure 14. Feeding trajectories (A) and marine area use intensity (B) of giant petrels from Gran Robredo Island during the first three months of the chick-rearing period.