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LONG-TERM CHANGES IN POPULATIONS OF SEABIRDS ON PETERMANN ISLAND AND SURROUNDING ISLANDS IN GRAHAM LAND, ANTARCTIC PENINSULA

The comparison of new and historic census counts of pygoscelid penguins and other seabird populations on Petermann Island (65°10′S, 64°10′W) and neighboring islands shows several trends consistent with theories of climate-mediated change in the Antarctic Peninsula. Long-term data on the number of gentoo nests on Petermann Island show that their abundance has increased about 30 times from beginning of the 20th century, 3–4 times from 1970–80, and has doubled since 1990. In contrast, the abundance of Adélie penguin nests on Petermann Island diminished about four times since 1970 and two times since 1997. The newly discovered gentoo penguin rookeries on Moot Point, the Yalour Islands, Galindez Island and Cape Tuxen represent the southernmost locations where this species has been found breeding in the Antarctic Peninsula. Booth Island, the southernmost place where all three pygoscelid penguins currently breed, also remains the southernmost point where chinstrap penguins breed.

Key words: censuses, long-term changes, pygoscelid penguins, blue-eyed shag, Antarctic Peninsula, Petermann Island

One focus of modern biological research in Antarctica is the study of bird population dynamics, especially of pygoscelid penguins, which serve as bio-indicators of long-term physical and biological change in the Antarctic ecosystem [7, 12, 13, 27]. For example, from the mid-1980 to early 1990's, the abundance of some species of penguins in many breeding colonies found on the western Antarctic Peninsula noticeably increased. This has been explained by a decrease in food competition (as a result of the reduction of whale numbers; reviewed in [4]), an increasing of number of krill, a decline in the amount of snow cover (due to global warming) [14], and an increase in the length of the breeding season due to higher average temperatures [19]. Conversely, since 1990 the numbers of some penguin species in the region of the western Antarctic Peninsula have diminished [33, 34]. This has been explained as being a result of climate change, which has been linked to both the timing and extent of sea ice [30, 31], factors which, in turn, play an important role in the recruitment of krill, the principle food source for the pygoscelid penguins [6, 10, 16].

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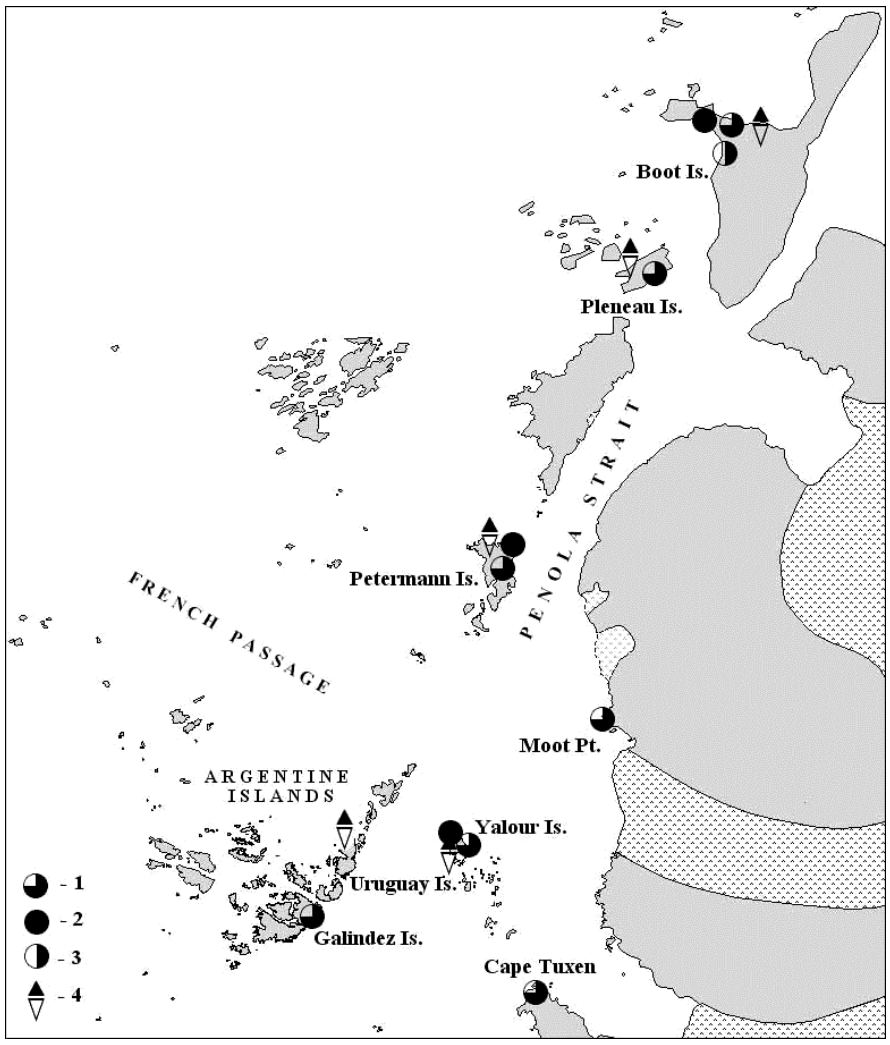
At some locations in Antarctica, there is a long census record for penguins. First estimates of the numbers of penguins breeding on Petermann Island (65°10' S, 64°10' W), in the southwest Antarctic Peninsula, were conducted in 1909 during the expedition of Jean-Baptiste Charcot [26]. In the 1970's and 1980's, English and German researchers performed censuses of penguins on Petermann Island and the Yalour Islands [9, 19, 20, 33]. Since 1994, American researchers under the leadership of Ron Naveen began monitoring penguin, blue-eyed shag, and Southern giant petrel colonies throughout the Antarctic Peninsula [17, 21–24]. Since 1998 the studies of the bird composition, reproduction, behavior, population dynamics, and distribution have been conducted by Ukrainian researchers based at Akademik Vernadsky Station (formerly, the UK Faraday Station) which is located on Galindez Island, Argentine Archipelago, some 10 km south of Petermann Island.

This paper presents data on the distribution and long-term dynamics of penguin and shag populations in the vicinity of Petermann Island as a part of the environmental baseline study which seeks to describe trends and possible causes of variability in bird populations in this region. We also suggest that continuing monitoring and reporting of seabird population trends, as well as other potential bioindicators of climate-mediated change in the southern Antarctic Peninsula, should be an important part of the Ukrainian scientific program at Akademik Vernadsky Station.



Materials and methods. The abundance and distribution of penguin and shag colonies were studied on the Petermann Island, Yalour Islands, Pléneau Island, Booth Island, and Uruguay Island from 1994 – 2008 by researchers with Oceanites and from 2003 – 2008 by personnel from Vernadsky Station and Oceanites, Inc. (Fig. 1).

Fig. 1 Locations of seabirds rookeries: 1 – gentoo penguin, 2 – Adélie penguin, 3 – chinstrap penguin, 4 – blue-eyed shag
Рис. 1 Расположение колоний морских птиц: 1 – ослиный пингвин; 2 – пингвин Адели; 3 – антарктический пингвин; 4 – голубоглазый баклан

Breeding groups were mapped (either by GPS or hand-drawn maps) and individual nests counted during the peak of egg laying, when access to the islands was possible. Observers attempted to use protocols consistent with Standard Methods established by the Scientific Committee for the Conservation of Antarctic Marine Living Resources (CCAMLR) Ecosystem Monitoring Program (CEMP) [29] to obtain the total number of nests by repeated counts. Essentially this involves individual nest enumeration in entire colonies, counted about the estimated time for peak nesting, and employing multiple recounts to obtain an average at each subcolony where enumeration is difficult due to the number of nests present or obstacles to the observer. Census methods are described in more detail in Naveen [21, 22, 24] and Lynch et al. [17].

Each of the islands compared in this paper were surveyed in whole as the breeding populations in each of the islands is discrete and can be easily counted. Methods for earlier censuses are not described so it is unknown how these censuses were obtained. However, to the extent that these counts represent a reasonable approximation of the population size, they are included here.

Results. Gentoo penguin (*Pygoscelis papua* Forster, 1781) occurs regularly on the studied islands in the austral summer. The largest colonies are situated on the islands of Petermann, Booth and Pléneau.

It was earlier noted that the gentoo colony on Petermann Island was the southernmost for this species [8, 23, 32], but recently we found more southerly rookeries of gentoo penguins on Moot Point (65°12' S, 64°06' W), Yalour Island (65°14' S, 64°10' W), as well as Galindez Island in the Argentine Islands (65°15' S, 64°15' W) and Cape Tuxen (65°16' S, 64°08' W) (fig.1).

Moot Point previously was connected with the Antarctic Peninsula by a glacier, but in 2004 it melted and two new small islands were formed which were quickly occupied by gentoo penguins. About 200 adult gentoos and 74 nests were counted on these islands in November 2005 and in December 2006 there were 101 nests; new rookery of gentoos, containing 15 nests was registered also on Yalour Island in December 2006 [17]. In recent years gentoos formed a new rookery on Galindez Island, where a dozen nests were built but just one chick was born in 2002 (Ignatyev, pers. comm.). However, in January 2008, 26 nests and 19 chicks were produced. In addition, about 200 adult gentoos and 100 nests were found on the Cape Tuxen in November 2007, which is the southernmost point for breeding of the species at present.

Gentoos return to their colonial breeding grounds – flat areas on rocky coasts with easy access to the sea by way of shelving beach – at the southern end of the Antarctic Peninsula, including the region of Petermann Island, from October – November. Birds begin to build nests first on elevated snow-free areas up to 50–100 m above sea level, while later arrivals are disposed to occupy lower sites.

We have not collected adequate data to document earlier egg-laying in gentoos on Petermann or nearby islands since inception of our studies. In 2006 we documented first egg-laying in gentoo penguins on Petermann Island on 9 November. In 2005, first chick hatch was 19 December, so the extrapolated laying date, based on an incubation period of 37 days [25], is 12 November. It was found that all three species of pygoscelid penguins advance their breeding phenology in years of warm October temperatures [18], and therefore we expect that the date of first egg laying will advance as temperatures continue to rise in vicinity of Vernadsky Station.

During the last six years there have been more than 5000 adult gentoos on Petermann Island and 2212–2438 nests (table 1). Numbers of chicks were: 2003/04 – 3260, 2004/05 – 2781, 2005/06 – 3453, 2006/07 – 3344 [17]. The ratio between number of chicks at creche and nests at the peak of egg laying varied from 1.21 to 1.47.

Year, Month	Island				Reference
	Petermann	Booth	Pléneau	Moot Point	
1909_J	75				[26]
1971_D	480				[20]
1982	375				[26]
1982_D			500		[33]
1988	755				[33]
1997	850–1000				[2]
1997_D	1224				
1999_N			1577		
2000_D			1579		[23]
2001_D		377			
2003_J			1639		
2001_J		1200			
2003_D			2170		
2004_J	2212				
2004_D	2301				
2005_J			2135		
2005_N				74	[17]
2005_D	2438				
2006_J		1151			
2006_D	2293			101	
2007_J			1574		

The comparison of our data on the number of gentoo nests on Petermann Island with previous data show that their abundance has noticeably increased: about 30 times from beginning of the 20th century, 3–4 times from 1970-80, and approximately doubling since 1990. Similar trends were noted on other nearby gentoo colonies (Pléneau Is., Booth Is.) and new rookeries formed on the southern range of this species.

Table 1 Inter-annual dynamics of gentoo nests at the southern limits of their range near Antarctic Peninsula (N – November, D – December, J – January)
Табл. 1 Межгодовая динамика количества гнезд ослиного пингвина в южной части его ареала у Антарктического п-ова ((N – ноябрь, D – декабрь, J – январь)

Adélie penguin (*Pygoscelis adeliae* Hombron et Jacquinot, 1841) also occurs in the study region. In early spring (September – October) Adélies begin the migration south and first arrive on the breeding grounds. They occupy upland areas of islands which are rid of snow early and begin to build nests. The nests of Adélies are simpler than those of gentoo penguins – we count around 300 stones, compared to the 3,000 stones in gentoo nests.

According to behavioral observations of the Adélies, males and females by turns incubate the eggs, while the other parent may leave to feed for several days [3].

Adélie colonies are located on Booth, Petermann and Yalour Islands. Adélie penguins nest together with gentoo penguins on Petermann Island and Booth Island. Egg laying occurs from the end of October to beginning of November.

The most abundant rookery of Adélie penguins locally is situated on the Yalour Islands. According to counts reported by Woehler [33], about 8,000 breeding pairs spread among 13 colonies were present here in the 1980s. This number had dropped to 4246 nests in 2003 [17], and 3620 nests in 2005 (table 2). Just 324 nests were counted in December 2006, but the following year there are about 2300 adult birds were found here.

Similarly, counts have dropped at both Booth Island and Petermann Island during a similar time frame.

Numbers of Adélie chicks on Petermann Island varied in the following way: 2003/04 – 731, 2004/05 – 580, 2005/06 – 589, 2006/07 – 458 [17]. The ratio between number of chicks and nests varied from 1.09 to 1.32, which is lower than was observed for the gentoo penguin.

Thus, in contrast to gentoos, the abundance of Adélie penguin nests on the studied islands diminished about 4 times since 1970 and 2 times since 1997. Also numbers of Adélie chicks and their ratio to number of nests have decreased markedly.

Year, Month	Island			Reference
	Petermann	Booth	Yalour	
1909_D	925			[26]
1971_D	1540			[8]
1982_D	987			[26]
1982			~ 8000	[33]
1983		61		[33]
1988	1080			[33]
1998_D	650			[2]
1997_N	862			
2001_J		18		[23]
2001_D	926	34		
2002_D	485			
2003_N	553		4246	
2004_J			5558	
2004_N	532			[17], our data
2005_N	505	15	3620	
2006_J		17		
2006_N	410			

Table 2. Inter-annual dynamics of Adélie nests at some rookeries near Antarctic Peninsula

Табл. 2. Межгодовая динамика количества гнезд пингвина Адели в некоторых колониях возле Антарктического п-ова

Historic census data for Booth Island, reported by Woehler [33] show that three chinstrap chicks were found in 1983, and three chinstrap nests were counted in 1990, 12 nests were found here in January 2001, 24 nests in December 2001 [17, 23], nine nests were registered here in December 2005 and in January 2006, about 40 birds and 10 nests were in December 2007.

Numbers of chinstrap chicks on Booth Island were 17 in January 2001, 12 in January 2006 and 13 in February 2007 [17]. So, the ratio between number of chicks and nests were 1.42, 1.33 and 1.3, that higher than for Adélie and comparable with gentoo penguin.

At present the Booth Island (65°05' S, 64°00' W) is the southernmost location where chinstraps are found breeding and all three pygoscelid penguins breed together [17].

Emperor penguin (*Aptenodytes forsteri* Gray, 1844) appears in the region very rarely. Single emperors were registered in May – June 1998 [2], October – December 2003 [1], May, September – October 2004 (Manilo, pers. comm.). Since January to February 2006 one young moulting emperor was on Booth Island.

Chinstrap penguin (*Pygoscelis antarctica* Forster, 1781) occurs in the study region in small numbers. Just a few individuals appear among nesting gentoo and Adélie groups. The nearest known southern large colony of this species is located on Anvers Island (64°55' S, 63°58' W). But in recent years, the spread of this species to the south was noted, as in the case of gentoos. In particular, two chinstrap nests were found on the Yalour Island in November 1997 [2].

Blue-eyed shag (*Phalacrocorax atriceps* King, 1828) is one of the most conspicuous flying bird species in the region and one of those that occupies the region year-round. The largest flocks are formed during the austral winter (June – August). Flocks containing hundreds or several thousand individuals usually roost on Uruguay Island, leaving to forage in the daytime in the region of the Berthelot Islands, foraging in ice-holes on small pelagic fish and squids until they return toward evening. Shag nesting sites are located on the islands Petermann, Booth, Pléneau, Yalour and Uruguay (see Fig. 1).

A larger rookery is situated on Uruguay Island. There number of bird pairs here at the end of century was 35–45 [2]. In the mid-1990s the numbers of shag nests on Petermann Island ranged from 27 to 34 [23] (table 3). During the period of 2003–2007, the number of shag nests on Petermann Island declined about 50%. The same decline can be seen on Uruguay Island, where for last several years number of nests has diminished about in 1.5 times. Numbers of total shag chicks have also decreased. At the same time the number of shag nests has increased on the Pléneau Island and new rookery was formed on the Yalour Island.

Year, Month	Island					Reference
	Petermann	Booth	Pléneau	Uruguay	Yalour	
1994_D	34					
1995_N	27					
1995_D	33					
1996_D	29					
1997_J	29					
1997_N	29					
1997_D	30					[23]
2000_D	23		28			
2001_J			25			
2001_D		19				
2002_D	28					
2003_J			28			
1998/99	30			35-45		[2]
2003_D	17		38			
2004_J					16	
2004_N	19					
2005_J			36			[17], our data
2005_N	11					
2005_D		18		24	16	
2006_N	13			28	17	
2006_D			58		18	

Table 3. Interannual dynamics of blue-eyed shag nests at some rookeries near Antarctic Peninsula
Табл. 3. Межгодовая динамика количества гнезд голубоглазого баклана в некоторых его колониях возле Антарктического п-ова

As blue-eyed shags are not highly site faithful, we cannot discount that observed changes in shag populations may reflect a redistribution of nesting sites to neighboring islands that are not censused. Hatching of chicks on the Petermann Island and Uruguay Island occurred in the first or second ten-day periods of December.

The observations of shag behavior during the incubation period showed that females flew away from the nest for feeding at dawn, while the males brooded at this time. Females fly along islands and dive in shallow water just offshore. They return in approximately in 10–11 h and change with the males, which then feed. The males appeared to fly farther from the nesting sites. We found more large fish in the pellets of male shags, possibly because males can dive deeper and feed in deeper layers of water. Both parents return to the nest at sunset.

The analysis of otoliths from shag pellets is dominated by small shallow-dwelling fish (e.g., *Trematomus bernachii* and juveniles of *Notothenia coriiceps*), with 5–10 individuals found/pellet. Squid beaks of *Brachioteuthis picta* and amphipods *Paraceradotus gibber* also were found in shag pellets.

Other birds. Among 25 species of birds occurring in the studied region [2], besides the above mentioned, the most abundant and most sensitive to environmental changes are the kelp gull, Antarctic tern, south polar skua, snow petrel, and snowy sheathbill.

During the last five years, the number of south polar skuas and the kelp gulls near Akademik Vernadsky Station on the Galindez Island slightly decreased. The numbers of the south polar skua nests on the island were: 2002 – 30 (Ignatyev, pers. comm.); 2005 – 14, 2006 – 9; the numbers of the kelp gull nests here were: 2002 – 8, 2005 – 9, 2006 – 4.

The south polar skua is mostly present in the austral summer while the snowy sheathbill also winters in the region. The shift of time of arrival and departure of skuas and snowy sheathbills was markedly distinct: skuas usually arrived on the islands in October – November (1 November 2005, 21 October 2006, 27 October 2007). The snowy sheathbills left Galindez Island on 15 November 2002 (Ignatyev, pers. comm.), 20 December 2004 (Manilo, pers comm.), but in 2005–2007 up to 10 birds remained near the Akademik Vernadsky Station during November–April and fed mainly on food waste from the station.

Discussion. The presented data are consistent with recent publications on population dynamics of pygoscelid penguins due to changes in the Antarctic ecosystem induced by climate warming [9, 11, 12, 17, 24, 28]. Gentoo and chinstrap populations have expanded southward along Antarctic Peninsula. Numbers of Adélie penguins which are dependent on sea ice for their survival, are rapidly declining, while number of subantarctic gentoo penguins are increasing dramatically.

Censuses of seabird populations near the Akademik Vernadsky Station provide support for several trends consistent with theories of climate-mediated change in the Antarctic Peninsula: 1) southerly range expansion in gentoo penguins consistent with earlier fast ice breakup in the vicinity of the Ukrainian station; 2) increasing gentoo penguin populations at established rookeries, indicating improved survivorship; 3) declines in Adélie penguins as a possible result of reduced inshore ice-dependent prey species. We have observed some change in breeding chronology (e.g., start of first reproduction) [18] that correlates with increasing temperatures observed at Akademik Vernadsky Station during the same period. Correlated with this, we have observed earlier open water and more extensive open water in the proximity to Galindez Island and regionally, which would allow gentoos access to the rookeries earlier to begin their breeding cycle.

The newly discovered gentoo penguin rookeries on Moot Point, Yalour Islands, Galindez Island and possibly on Cape Tuxen represent the southernmost location where this species has been found breeding in the Antarctic Peninsula.

Gentoos may have a relative advantage as given the changing environmental conditions. Gentoo penguins are larger in size (mean 81 cm and 6.2 kg) than the Adélies (70 cm and 5.0 kg). Gentoos also construct larger nests consisting of about in ten times as many stones. Gentoo eggs are thus elevated and less likely to be flooded by snow melt or rain, which is more frequent during the period we documented. The more general diet of the gentoo penguin relative to the Adélie penguin [32] may also be of great benefit as the balance of prey species changes in response to climate change [19].

Booth Island was found as the southernmost breeding point for chinstrap penguins at present.

Significant declines in the number of nesting blue-eyed shag were registered at Petermann and Uruguay Islands, but new breeding sites were found at Yalour Island, suggesting that a redistribution of breeding sites of this species may have occurred.

The location of Akademik Vernadsky Station near the current range limit of the gentoo penguin, and the fluid dynamics of population changes in Adélie and gentoo populations in this region, makes this station a potentially critical site for monitoring seabird populations on the Antarctic Peninsula.

The Ukrainian Antarctic program is especially well positioned to advance biological studies in conjunction with ongoing meteorological work. We recommend that national programs, particularly the Ukrainian Antarctic Program, can play a critical role in contributing to an expanded program of seabird monitoring in the area, as well as suggesting the need for increased bio-monitoring of other climatologically sensitive species in the area. This calls for continued support of a biological monitoring component to the Ukrainian Antarctic Program. Collaboration with other national programs, as seen by the excellent relationship with the Oceanites group, can serve as a model of expanding the work of the Ukrainian Antarctic Program along with international partners.

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Довготривалі зміни в популяціях морських птахів на острові Пітерман і довколишніх островах Землі Грейама, Антарктичний півострів. М. В. Чесалін, Р. Навін, Х. Лінч, І. Булок, М. Райдер, А. Міллер, С. Форест, Р. Дагит, І. В. Дикій, В. А. Тимофєєв. Порівняння нових і ретроспективних даних кількісних обліків популяцій антарктичних пінгвінів і інших морських птахів на острові Пітерман (65°10′ п. ш., 64°10′ з. д.) та сусідніх островах виявило декілька трендів, пов'язаних з кліматичною мінливістю в районі Антарктичного півострова. До теперішнього часу кількість гнізд вислюкового пінгвіна на острові Пітерман збільшилася приблизно в 30 разів у порівнянні з початком XX століття, в три-чотири рази з 1970-80-ми роками і подвоїлася з середини 1990-х років. Навпаки, кількість гнізд пінгвіна Аделі на о. Пітерман зменшилася приблизно в чотири рази з 1970-х і в два рази з 1990-х років. Виявлені нові колонії вислюкового пінгвіна на мисі Мут, островах групи Ялур, острові Галіндез і мисі Туксен, які є найпівденнішими місцями розмноження цього виду в районі Антарктичного півострова. Острів Бут, де відмічено розмноження всіх трьох видів з роду антарктичних пінгвінів, залишається найпівденнішою точкою розмноження справжнього антарктичного пінгвіна.

Ключові слова: кількісні обліки, багаторічна мінливість, антарктичні пінгвіни, блакитноокий баклан, Антарктичний півострів, острів Пітерман

Долговременные изменения в популяциях морских птиц на острове Питерман и близлежащих островах Земли Грейама, Антарктический полуостров. М. В. Чесалин, Р. Навин, Х. Линч, И. Булок, М. Райдер, А. Миллер, С. Форест, Р. Дагит, И. В. Дикий, В. А. Тимофеев. Сравнение новых и ретроспективных данных количественных учетов популяций антарктических пингвинов и других морских птиц на острове Питерман (65°10′ ю. ш., 64°10′ з. д.) и соседних островах выявило несколько трендов, связанных с климатической изменчивостью в районе Антарктического п-ова. К настоящему времени количество гнезд ослиного пингвина на о. Питерман увеличилось примерно в 30 раз по сравнению с началом XX века, в три-четыре раза с 1970-80-ми годами и удвоилось с середины 1990-х годов. Напротив, количество гнезд пингвина Адели на о. Питерман уменьшилось примерно в четыре раза с 1970-х и в два раза с 1990-х годов. Обнаруженные новые колонии ослиного пингвина на мысе Мут, островах группы Ялур, острове Галиндез и мысе Туксен, которые являются самыми южными местами размножения этого вида в районе Антарктического п-ова. Остров Бут, где отмечено размножение всех трех видов из рода антарктических пингвинов, остается самой южной точкой размножения настоящего антарктического пингвина.

Ключевые слова: количественные учеты, многолетняя изменчивость, антарктические пингвины, голубоглазый баклан, Антарктический п-ов, остров Питерман