

Predator Effect and Behavioral Patterns in Arctic Terns (*Sterna paradisaea*) and Sabine's Gulls (*Xema sabini*) During a Failed Breeding Year

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Abstract.—Little is known about the factors influencing the breeding decisions of Arctic breeding seabirds and their behavior in a failed breeding year. Here we present the behavioral patterns observed in a year with late sea ice break-up and regular predator visits to the colony. We found that breeding initiation of Arctic Terns and Sabine's gulls was delayed until the breeding attempt was given up and the colony abandoned. However, the birds did not leave the region but returned to the colony soon after sea ice break-up continuing bonding behavior although egg-laying was not initiated. In 2006, the period 11-15 July seemed important for the breeding decision, as birds gradually gave up breeding and left the colony during that period. Received 12 December 2006, accepted 20 April 2007.

Key words.—*Alopex lagopus*, behavior, High Arctic, failed breeding, Northeast Greenland, predator effect, *Sterna paradisaea*, Young Sund, *Xema sabini*.

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Arctic Tern (*Sterna paradisaea*) and Sabine's Gull (*Xema sabini*) are long-lived monogamous seabirds expressing a strong breeding association in colonies along the coast of Northeast Greenland. Of the 24 known Sabine's Gull colonies in Greenland, 21 are located in the vicinity of an Arctic Tern colony (GSCD 2006). In Greenland, the population of Arctic Tern is estimated to 65,000 breeding pairs (Egevang and Boertmann 2003); while Sabine's Gull numbers 100-500 breeding pairs (Birdlife 2004).

Breeding success of Arctic seabirds is affected by the timing of sea ice break-up (de Korte 1988; Gaston *et al.* 2005), food availability (e.g., Suddaby and Ratcliffe 1997), accessibility of terrestrial predators to islands with breeding colonies (Marshall 1952; Nordström *et al.* 2003) and extreme natural events (Ganter and Boyd 2000). In the Arctic, where environmental conditions fluctuate largely from year to year, failed breeding seem to be a regular phenomenon. However, little is known about the behavioral patterns of Arctic Terns and Sabine's Gulls during a failed breeding year. Here we present a study of fluctuations in pair numbers, colony structure and behavior during a year of failed breeding in Northeast Greenland.

METHODS

The study was conducted on Sandøen (74°18'N; 20°15'W) near Daneborg in Young Sund, Northeast Greenland from 7 July to 3 August 2006. The island holds one of the largest Arctic Tern colonies in Northeast Greenland reported to hold up to 2,000 individual birds while the number of Sabine's Gulls ranged from 40 to 300 individual birds (Meltøfte 1997-2006; Table 1).

Sandøen is composed of sand, gravel, and scattered rocks and has an approximate area of 0.24 km² with a perimeter of 2.2 km. The sea ice break-up in Young Sund is known to follow regular yearly patterns and the ice-free period in Young Sund normally ranges from mid July to the beginning of October (Rysgaard *et al.* 2003). In 2006, the sea ice disappeared on the 23 July which is late compared to previous years (Table 1). An Arctic Fox (*Alopex lagopus*), a known predator of eggs and nestlings, made regular visits to the breeding colony by use of the sea ice connecting the island to the mainland.

Arctic Terns and Sabine's Gulls were counted each day between 9.00 and 11.00 h. Pairs standing in the colony showing clear signs of breeding preparations during the entire study period, e.g. digging nest bowls, courtship feeding, aggressions against neighbors, flying in pair-wise formations and copulations were regarded as breeding birds. Birds gathered in flocks, either on the island or on the sea ice were regarded as non-breeding birds. Trends over time in numbers of breeding birds and the relation between date of sea ice break-up and the total number of individual birds (1996-2006) was analyzed using Spearman's rank correlation coefficient (r_s) (SAS Institute 2002-2003).

RESULTS

Figure 1 presents the number of pairs and total number of individual Arctic Terns

Table 1. Numbers (N) of individual Arctic Terns and Sabine's Gulls, and breeding status on Sandøen, Northeast Greenland from 1996-2006 (Meltøfte 1997-2006; P. Jessen, pers. obs.; N. Levermann pers. obs.; "100s" in 1996 indicates the reported "hundreds"), including date of sea ice break-up in Young Sund (ZERO 2006). NA: data not available.

Year	Arctic Tern		Sabine's Gull		Date of sea ice break-up
	N	Eggs/Chicks	N	Eggs/Chicks	
1996	100s	Yes	40	Yes	18/7
1997	450	Yes	150	Yes	18/7
1998	400-500	Yes	50-100	Yes	21/7
1999	2000	Yes	300	Yes	19/7
2000	1000	Yes	100	Yes	11/7
2001	800-1000	Yes	100	Yes	20/7
2002	600-800	Yes	100	Yes	12/7
2003	600-800	Yes	100	Yes	3/7
2004	1100	Yes	200	Yes	8/7
2005	NA	Yes	NA	NA	7/7
2006	775	No	180	No	23/7

on Sandøen during the study period. Numbers decreased from 10 July to complete desertion two days before sea ice break-up on 23 July ($r^2 = 1.0$, $P < 0.001$, $N = 5$). As soon as the remaining ice in Young Sund broke, the colony was gradually re-established towards the initial level of pair numbers ($r^2 = 0.76$, $P < 0.01$, $N = 10$), but egg-laying was not initiated. The total number of birds in the colony was not fully re-established until 29 July and this level was maintained until the end of the study period. The highest number of Arctic Terns was observed 2 August with 311 pairs and a total of 775 individuals.

Figure 2 shows the number of pairs and total number of individual Sabine's Gulls. Numbers decreased from 10 July towards the break-up of the sea ice ($r^2 = 0.90$, $P = 0.03$, N

$= 5$). The total number of Sabine's Gulls was re-established 23 July while the pairs were re-established 29 July ($r^2 = 0.91$, $P < 0.01$, $N = 10$). The highest number of Sabine's Gulls was seen 31 July with 67 pairs and a total number of 182 individuals.

Table 1 presents numbers of individual Arctic Terns and Sabine's Gulls, breeding status (Meltøfte 1997-2006), and date of sea ice break-up in Young Sund (ZERO 2006). We found no relationship between abundance and date of sea ice break up (Arctic Tern: $r^2 < 0.17$, $P = 0.67$ and Sabine's Gull: $r^2 = 0.03$, $P = 0.94$) and no effect of the ice situation the previous year (Arctic Tern: $r^2 = 0.01$, $P = 0.98$ and Sabine's Gull: $r^2 = 0.11$, $P = 0.77$).

Few birds tried to breed this summer. In total, 20 Arctic Tern eggs were found; four of

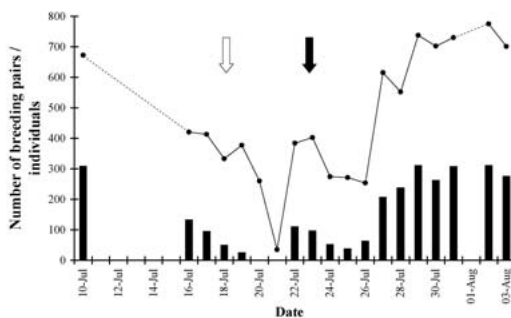


Figure 1. Number of pairs (bars) and total number of individual (dots) Arctic Terns in the breeding colony at Sandøen, Northeast Greenland in 2006. Dotted line indicates a period without observations. The open arrow indicates the last day an Arctic Fox visit was observed and the closed arrow indicates the day of sea ice break-up.

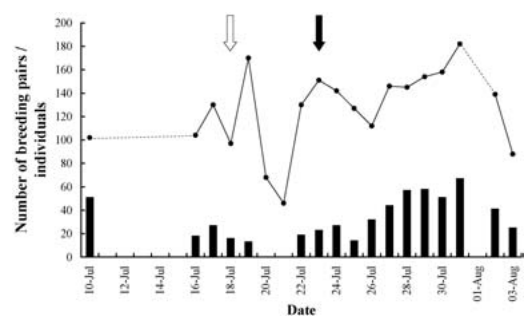


Figure 2. Number of pairs (bars) and total number of individual (dots) Sabine's Gulls in the breeding colony at Sandøen, Northeast Greenland in 2006. Dotted line indicates a period without observations. The open arrow indicates the last day an Arctic Fox visit was observed and the closed arrow indicates the day of sea ice break-up.

these were incubated and 16 were depredated. Two of the incubated eggs were later depredated and the remaining two were abandoned. The last Arctic Tern egg was laid 17 July and abandoned 19 July. No Sabine's Gull eggs were found.

During the re-establishment of the colony gradual occupancy of the breeding colony was observed; both species left the island in the afternoon and returning during the night hours. After 27 July the pairs occupied the colony the entire night indicating full occupancy.

On 7 August, the colony was still occupied by approximately the same number of birds as seen 3 August and both species were still present on Sandøen in high numbers 16 August this year (S. Rysgaard, pers. obs.).

DISCUSSION

In a year with late sea ice break-up and frequent colony visits by an Arctic Fox, we found that both Arctic Terns and Sabine's Gulls delayed egg-laying until the birds eventually gave up and abandoned the colony. However, failing to breed did not make the birds leave the region as the colony was re-established after sea ice break-up. The season of 2006 was the first record of completely failed breeding since systematic yearly recordings started in 1996 (Meltofte 1997-2006). The period 11-15 July seems important for the bird's "decision" to breed or not in the current year, as birds were gradually leaving the colony in this period.

In "normal" years, when breeding occurs, the hatching date for both species in Young Sund is the last week of July (Meltofte 1997-2006) indicating that egg-laying takes place in the first week of July when using an average incubation period of 20-22 days for both Arctic Tern and Sabine's Gull (Cramp 1985; Day *et al.* 2001). Adding an extra week for egg formation after copulation (Whittow 2002), this means that the decision of egg-laying in "normal" years is made around 1 July, i.e. prior to sea ice break-up (Table 1).

We found no indications that low food availability caused breeding failure because: 1) large areas of open water were accessible

during the entire study; 2) courtship feeding with large size "display" fish was one of the most frequent mating behaviors observed and; 3) the terns showed high success rate when feeding. The presence of a predator seems to make both Arctic terns and Sabine's Gulls skip breeding and thus, our study indicates that the accessibility of terrestrial predators determines the breeding success of these Arctic seabirds.

We found that Arctic Terns performed courtship feeding, mate guarding and copulations, and Sabine's Gulls upheld pair relations and breeding behavior until 3 August; long after breeding had failed. This indicates that both species are investing in the breeding success of the following year.

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