Survival and breeding response of a sea-ice obligate seabird following the unprecedented low extent of winter ice in the Bering Sea

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Background

Mandt's Black Guillemot (*Cepphus grylle mandtii*) (Figure 1) is one of the few Arctic sea ice obligate seabirds, breeding at colonies adjacent to pack ice from June to early September and wintering in the Marginal Ice Zone in the nonbreeding period.

The breeding biology and demography of a nesting colony on **Cooper Island, Alaska** (Figure 2) has been studied annually since 1975, with most breeding birds color-banded (see Figure 1) for individual recognition allowing estimates of annual breeding status and overwinter survival. Decreases in prey abundance from reductions in summer sea ice extent have reduced the breeding success and size of the colony (Divoky et al. 2015).

Figure 1. Mandt's Black Guillemot, an Arctic ice-obligate seabird.

Figure 2. Map of Alaska, and adjacent Bering Sea and Arctic Ocean, showing locations referenced in text and graphs.

For the past seven years nonbreeding movements of birds breeding at the colony were monitored with light-sensitive data loggers (Figure 3) attached to birds' legs at the end of the breeding season and retrieved the following year. The data logs of sunrise and sunset times provide information for estimating daily locations for the nine-month nonbreeding period and also information on activity (Figure 4). Initial analysis (Divoky et al. 2016) found the species winters at the southern edge of the Bering Sea (Figure 5) in areas that provide sufficient ice for roosting and open water for feeding.

Figure 3. Light-sensitive data logger on leg of Black Guillemot.

Figure 4. Black Guillemots spend >5 hours on sea ice each day.

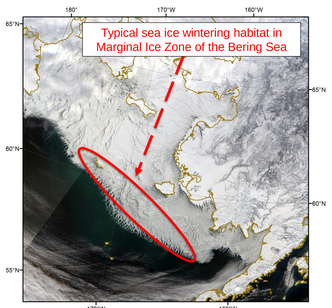

Figure 5. Satellite (MODIS) image of Bering Sea February 5 2008 showing typical wintering habitat.

2017-18 Nonbreeding Season

In the winter of 2017-18, sea ice in the Bering Sea, the primary wintering habitat for Black Guillemots, was at its lowest extent on record from early December to April (Figure 6).

While there was a slow rate of increase in December, January saw a doubling of ice extent. In early February, however, south winds and warm (>0° C) air temperatures caused a sharp decrease in ice extent. Ice extent increased again in mid-March but only reached half of the normal extent for that month. By the end of April ice extent was only one-tenth of normal.

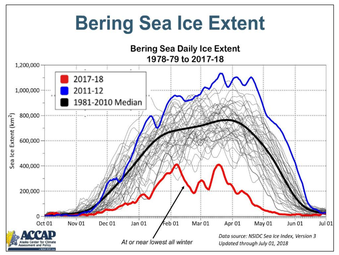

Figure 6. Bering Sea ice extent 1978-79 to 2017-18.

The warm air temperatures and winds in early February also reduced ice extent north of the Bering Strait. This resulted in the Marginal Ice Zone (sea ice fraction <0.75 percent) extending into the Arctic Ocean in winter, rather than being exclusively over the Bering Sea shelf as is in typical years.

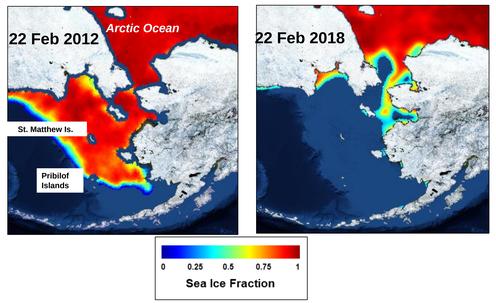

Figure 7. Bering Sea ice cover on 22 February 2012 and 2018

Literature Cited

Divoky, G. J., P. M. Lukacs and M. L. Druckenmiller (2015). Effects of recent decreases in arctic sea ice on an ice-associated marine bird. Progress in Oceanography 136: 151-161.

Divoky, G. J., D. C. Douglas and I. J. Stenhouse (2016). Arctic sea ice a major determinant in Mandt's black guillemot movement and distribution during non-breeding season. Biology Letters 12(9)

Impacts on Movements and Distribution

Movements in the 2017-18 nonbreeding season differed markedly from the six previous years as birds entered the Bering Sea in mid-January rather that early December and then had only a minor southward movement before moving back to the Arctic Ocean (Figure 8).

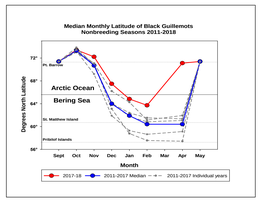

Figure 8. Median monthly latitude of Black Guillemots in 2011-18 nonbreeding seasons.

Movement and distribution of Mandt's Black Guillemot in the Bering Sea is highly correlated with sea ice extent. A comparison of 2017-18 with 2011-2012 shows later and slower sea ice formation was correlated with a later entry of guillemots into the Bering Sea in 2017-18. When sea ice extent decreased in early February 2018 birds moved northward into the Arctic Ocean, whereas in 2011, when sea ice extent increased into April, birds remained in the Bering Sea until flying north to breed in May.

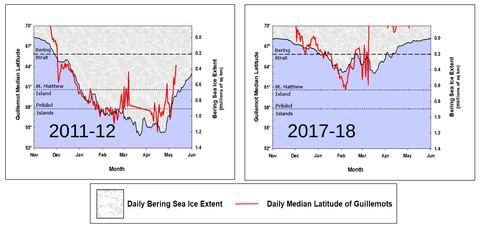

Figure 9. Daily median Bering Sea ice extent and median latitude of Black Guillemots in the nonbreeding seasons of 2011-12 and 2017-18.

The major (>1000 km) northward shift in the 2018 late winter and early spring distribution meant birds occupied the Arctic Basin, where prey densities are lower than the subarctic Bering Sea, during the period immediately before returning to the waters near Cooper Island and preparing to breed.

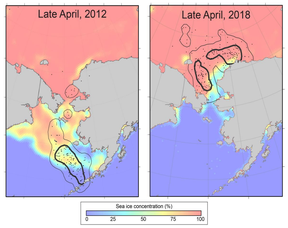

Figure 10. Locations (dots) of Mandt's black guillemots in late April 2012 and 2018 with sea ice concentration. Polygons depict 90% (thin) and 50% (thick) utilization distributions.

Demographic and breeding impacts

Preliminary demographic analysis found overwinter survival during the 2017-18 nonbreeding season to be the lowest recorded for the study (Figure 11). Of those birds that did return to breed, nearly one-third did not lay eggs, the first instance of colony-wide nonbreeding (Figure 12). While direct causative effects are unknown, the high overwinter mortality and the poor condition of surviving birds indicates prey availability was reduced for the birds in the 2017-18 nonbreeding season and may be related to due to the reduction in winter ice extent.

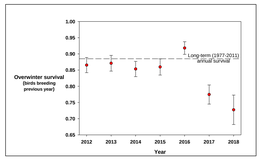

Figure 11. Annual survival breeding Black Guillemots, 2012-2018.

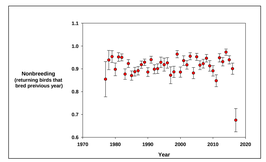

Figure 12. Annual occurrence of nonbreeding for Black Guillemots that bred preceding year.

The increased overwinter mortality and high incidence of nonbreeding contributed to a punctuated decline in the size of the breeding population, dropping to 50 pairs in 2018. This continued a trend that began in 1989-90 when a shift in the phase of the Arctic Oscillation increased regional temperatures resulting in reductions in summer ice extent.

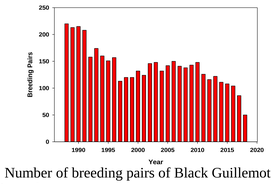

Figure 13. Number of breeding pairs of Black Guillemots at the Cooper Island nesting colony.

Conclusions

- **Unprecedented low ice extent in the Bering Sea caused a major northward shift in the nonbreeding distribution of Mandt's Black Guillemot in 2017-18**
- **The record low ice extent and anomalous distribution of Black Guillemots were correlated with the highest overwinter mortality and incidence of nonbreeding in the 44 years of study at the Cooper Island colony**
- **Reduced prey abundance in the Arctic Ocean, compared to the typical Bering Sea wintering area, may have caused the higher mortality and nonbreeding**
- **The abnormal winter ice in 2017-18 could be expected**
- **to have affected the entire Western Arctic population of Mandt's Black Guillemot, with an estimated >25 thousand breeding in Russia, Canada and Alaska**