Long-term changes in habitats associated with polar bear sightings during fall in the Alaskan Beaufort Sea; 1979-2005

Jeffrey S. Gleason, Charles Monnett, and Cleveland J. Cowles

Minerals Management Service, Alaska OCS Region, Environmental Studies Section, 3801 Centerpoint Drive, Suite 500, Anchorage, Alaska 99503-5823, USA

Photo by Suzanne Miller, USFWS

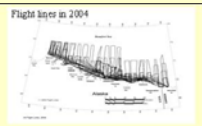
Abstract: A growing body of evidence suggests that seasonal characteristics of arctic sea ice, including timing of ice formation and ablation, sea-ice thickness, and aerial extent of sea ice, are changing on a broad scale. Concerns have been raised that polar bear (*Ursus maritimus*) populations may be negatively affected by recent trends in sea ice conditions. The Minerals Management Service fall Bowhead Whale (*Balaena mysticetus*) Aerial Survey Project has been conducting aerial flights over the Alaskan Beaufort Sea and associated coastlines since 1979. We used polar bear sighting data ($n = 337$ sightings, $n = 900$ bears) to address questions regarding polar bear habitat associations relative to sea-ice conditions. During the early (1979-87) and mid- (1988-96) periods of the survey, approximately 83% of polar bear sightings were associated with ice compared to just 31% of sightings associated with ice during the latter period (1997-2005). During the latter period (1997-2005), frequency of polar bear sightings associated with land and open water increased, whereas sightings associated with ice decreased. Less than 20% of polar bear sightings were associated with land during the early and mid-periods of the survey. In comparison, >58% of polar bear sightings were associated with land during the latter period. Polar bear sightings associated with ice type and ice percent differed among year periods. During the early and mid-periods, polar bears were largely associated with old ice (i.e., large and broken floes), whereas more recently, the majority of sightings were associated with ice-free conditions. Percent of ice visually estimated at polar bear sightings declined over the period of this study. Ice types and ice percents generated from within 50 x 50km blocks near Barrow and Kaktovik differed among year periods in both September and October. Results from this long-term aerial survey indicate significant changes in seasonal characteristics of ice in the Alaskan Beaufort Sea, as well as changes to polar bear distribution and concomitant changes in habitats associated with polar bear sightings.

Photo by Scott Schliebe, USFWS

INTRODUCTION

Potential adverse affects to polar bears from advanced breakup of sea ice in the spring or later onset of sea ice in the fall including physiological, energetic, and behavioral responses, may already be occurring (Stirling et al. 1999, see also Derocher et al. 2004, Amstrup et al. 2006, Monnett and Gleason 2006). In western Hudson Bay, for example, radio-collared female polar bears came ashore 25 days earlier and in poorer condition in 1998 than in 1981 (Stirling et al. 1999). A decline in natality also was documented over the same period (Stirling et al. 1999). The major implication to earlier spring breakup and a later fall freezeup is that females tend to be in poorer condition and may not be energetically capable of producing and successfully weaning cubs (Stirling et al. 1993, Stirling and Derocher 1993, Derocher et al. 2004).

Herein, we present observations of polar bears from a long-term (1979-2005) fall (Sept-Oct) aerial survey in the Alaskan Beaufort Sea. Objectives were to: (1) assess intra- and inter-annual variation in percent ice cover and ice types in the Alaskan Beaufort Sea, (2) describe temporal variation in percent ice cover and ice types associated with polar bear sightings, and (3) describe temporal variation in habitats associated with polar bear sightings.



METHODS

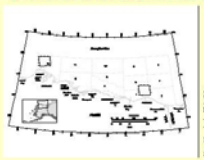
Field

-- fixed-wing aircraft surveys
-- during September and October
-- from 1979 - to present
-- 2 observers; bubble windows
-- random transects in established survey blocks
-- includes transect, connect, and search segments
-- flown at ~457m and 200-250km/h
-- data in Microsoft Access and ArcGIS

Analytical

-- it was not our intent to quantify habitat-use *per se*, nor were we attempting to infer habitat-use decisions (neither "preference" nor "selection"; see Johnson 1980, Van Horne 1983, Arthur et al. 1996); rather, we simply wanted to describe the frequency of polar bear sightings as they related to broadly defined habitat categories over the 27-year period of this survey.
-- sea ice percent was visually estimated to the nearest whole percent when environmental conditions changed and also for all marine mammals sightings.
-- ice percents were reclassified into three broad categories: <25%, 25-75%, and >75%.
-- ice type was originally classified into 1 of 10 discrete groups including a "no ice" category.
-- ice types were reclassified into three broader categories: old, new, and no ice.
-- for each polar bear sighting, an ice-percent category (e.g., ≤50% and >50%; Stirling et al. 1999), ice type, and general habitat code (i.e., ice, land, or water) was assigned.
-- large-scale sea-ice dynamics were assessed within 50 x 50km blocks near Barrow and Kaktovik using goodness-of-fit test (i.e., χ^2).
-- year-period effects for ice percent, ice type, and general habitats associated with polar bear sightings were assessed using χ^2 with all data being separated within year (i.e., September and October).
-- significance level was set at $P = 0.01$ for contingency analyses to guard against committing Type I error (Johnson 1998).

STUDY AREA and 50 x 50km ICE SAMPLE BLOCKS

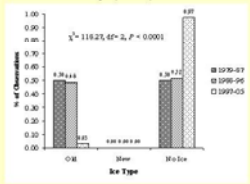


Study area, including aerial survey blocks (gray dashed lines) and important landmarks along the Alaskan Beaufort Sea coast. Darkened boxes represent 50 x 50km blocks used to assess large-scale changes in sea-ice conditions visually estimated during fall aerial surveys; 1979-2005.

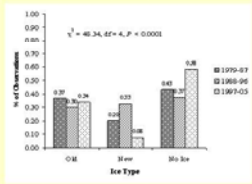
CHANGES IN SEA ICE CHARACTERISTICS

-- ice types (Figs. 1a-b) and ice percents (Figs. 2a-b) differed among year periods in both September and October (χ^2; $P < 0.0001$, old ice versus no ice) near Barrow.
-- an among-year period difference also was documented in ice types (Figs. 3a-b) and ice percents (Figs. 4a-b) for September and October (χ^2; $P < 0.0001$) near Kaktovik.
-- ice-free conditions were encountered more frequently and old ice encountered less frequently at both locations more recently (1997-05) (Figs. 1-4).

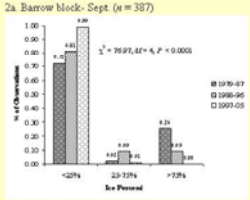
1a. Barrow block- Sept. ($n = 387$)



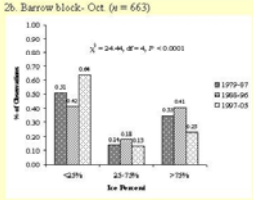
1b. Barrow block- Oct. ($n = 441$)



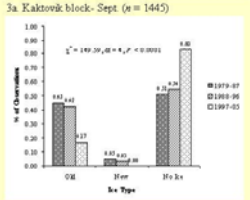
2a. Barrow block- Sept. ($n = 387$)



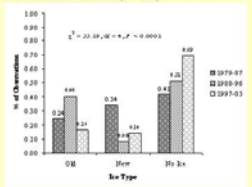
2b. Barrow block- Oct. ($n = 663$)



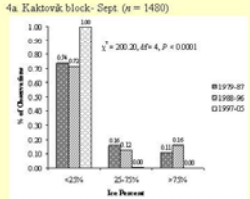
3a. Kaktovik block- Sept. ($n = 1445$)



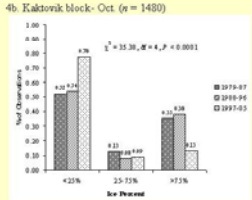
3b. Kaktovik block- Oct. ($n = 460$)



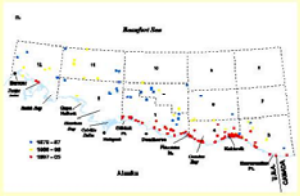
4a. Kaktovik block- Sept. ($n = 1480$)

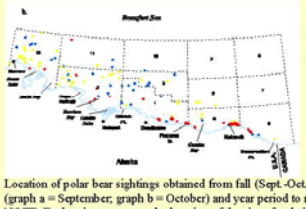


4b. Kaktovik block- Oct. ($n = 1480$)



LOCATIONS OF POLAR BEAR SIGHTINGS





Location of polar bear sightings obtained from fall (Sept.-Oct.) aerial surveys in the Alaskan Beaufort Sea, 1979-2005. Sightings were separated by month (graph a = September; graph b = October) and year period to reflect among- and within-year variation; 1979-87 (blue), 1988-96 (yellow), and 1997-05 (red).
NOTE: Each point represents the location of the aircraft relative to the animal when first detected with each point representing ≥1 polar bear.

-- for polar bear sightings on transect only, latitude (Adj. $R^2 = 0.69$) varied as a function of year ($F = 3.49$, df = 14, 54; $P < 0.0001$); date ($F = 12.67$, df = 1, 54; $P = 0.001$); and the year*date interaction ($F = 3.46$, df = 14, 54; $P < 0.0001$).

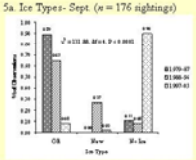
-- parameter estimates (+ SE) for year ($\beta = -2.15 + 0.68$) and date ($\beta = +1.29 + 0.37$) indicate that latitude declined (i.e., a north-south shift) over the period of this study, but increased (i.e., a south-north shift) as a function of date within year.

-- for polar bear sightings on transect only, longitude (Adj. $R^2 = 0.57$) varied as a function of year ($F = 2.53$, df = 14, 54; $P = 0.007$); date ($F = 13.52$, df = 1, 54; $P = 0.001$); and the year*date interaction ($F = 2.51$, df = 14, 54; $P = 0.008$).

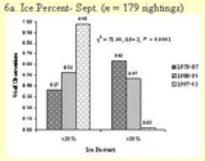
-- parameter estimates for year ($\beta = -6.34 + 5.93$) and date ($\beta = +13.73 + 3.24$) indicate that longitude declined (i.e., a west-east shift) over the period of this study, but increased (i.e., a east-west shift) as a function of date within year.

HABITATS ASSOCIATED WITH POLAR BEAR SIGHTINGS

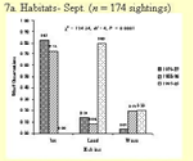
5a. Ice Types- Sept. ($n = 176$ sightings)



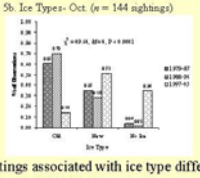
6a. Ice Percent- Sept. ($n = 179$ sightings)



7a. Habitats- Sept. ($n = 174$ sightings)

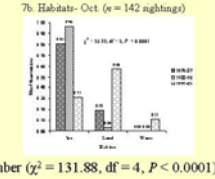


5b. Ice Types- Oct. ($n = 144$ sightings)



6b. Ice Percent- Oct. ($n = 147$ sightings)

7b. Habitats- Oct. ($n = 142$ sightings)



-- polar bear sightings associated with ice type differed among year periods in both September ($\chi^2 = 131.88$, df = 4, $P < 0.0001$) and October ($\chi^2 = 49.64$, df = 4, $P < 0.0001$) (Figs. 5a-b).

-- for both September ($\chi^2 = 71.00$, df = 2, $P < 0.0001$) and October ($\chi^2 = 39.92$, df = 2, $P < 0.0001$), differences were found for polar bear sightings related to ice percent (i.e., <50% versus >50%) (Figs. 6a-b).

-- for both September ($\chi^2 = 124.34$, df = 4, $P < 0.0001$) and October ($\chi^2 = 23.55$, df = 4, $P < 0.0001$), major differences were documented for habitats associated with polar bear sightings (Figs. 7a-b).

CONCLUSIONS

-- results from this long-term aerial survey indicate significant changes in seasonal characteristics of ice in the Alaskan Beaufort Sea, as well as changes in distribution of polar bears and concomitant changes in habitats associated with polar bear sightings.