Polar Bear—Sea Ice Relationships

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INTRODUCTION

The population status of polar bears (*Ursus maritimus* Phipps) throughout their circumpolar range is unknown. Scientists and informed laymen differ in their estimates of relative abundance, expressing opinions ranging from the possibility of extirpation because of over hunting to the assumption of near normal abundance. Unfortunately, little effort has been directed at determining the influence of climatic change on potential polar bear habitat and in turn the bear population. Climatic change is directly manifested by sea ice conditions. I intend in this discussion to relate polar bear occurrence and patterns of movement to occurrence and movements of the various types of sea ice, with emphasis on observations made off the west and north coast of Alaska.

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CHARACTERISTICS AND MOVEMENTS OF SEA ICE

Arctic sea ice can be classified into three types—land fast ice, drifting pack ice, and polar pack ice.

Land fast or fast ice is ice which is anchored to the shore. In protected bays, fast ice generally forms in place along the shore in the fall. Along open shorelines, ice which eventually becomes land fast ice generally forms at sea and is brought to the coast by currents and winds. In some areas, fast ice is mainly newly frozen ice that forms with a smooth surface. Along other shorelines, including the north coast of Alaska, old ice is interspersed with the newly formed ice causing the surface in some areas to be quite rough. The fast ice belt is narrow along coasts with deep water and offshore winds and currents, and extends offshore the farthest where shallow water permits ice to freeze to the bottom, and where winds and currents do not tend to move ice offshore. Along the Alaska coast, the first fast ice forms during the fall in the area to the east of Point Barrow and then from Point Barrow southwestward toward Cape Lisburne. Most fast ice melts during the summer or breaks loose from shore and joins the drifting pack ice.

Drifting pack ice extends as a belt of ice in motion between shore fast ice and the heavier ice of the polar pack in the central polar basin. There is more open water in the drifting pack ice zone, especially in early winter, than in the polar pack zone. This open space allows winds and currents to move ice masses relative to one another. Openings in the ice, known as leads, and pressure ridges are formed as the ice is moved within the confines of the more immovable polar pack ice and the stationary fast ice. During winter, leads freeze over as they are formed.

Polar pack ice covers the central part of the polar basin. It is a year or more old, and pressure ridges have been eroded so the surface is fairly smooth. Thickness is fairly uniform with freezing on the bottom in winter generally in equilibrium with destruction of the upper ice surface in summer. Polar pack ice is packed together so there is not much movement of ice masses relative to one another, and leads and pressure ridges are not formed to the extent that they are in drifting pack ice. North of the Alaska coast there does not appear to be a sharp delineation between drifting pack ice and polar pack ice. Some areas of heavy unbroken flat ice occur within the drifting pack ice zone; the extent varies from year to year.

Off the coast of Alaska, ice cover is at its maximum in February and March and at its minimum in August and September (Wittman & MacDowell 1964) (Fig. 1). Ocean currents and winds cause both the drifting pack ice and the polar pack ice to move in fairly well defined patterns. The earliest comprehensive reports on ice movement are from the drift of the Norwegian ship 'FRAM' as reported by Nansen (1902) and the drift of the Russian ship 'SEDOV' as reported by Zubov (1943). More recent information has come from Soviet and United States drifting ice stations. Fig. 2 shows the most widely accepted pattern of surface current movement.

Changes in ocean currents and climate affect sea ice. Vibe (1967) states that the relative strengths of the Canadian, the East Greenland and the Irminger Currents in Davis Strait off the southwest coast of Greenland determine sea ice distribution which in turn influences climatic conditions and the composition, distribution and stability of plant and animal communities on and adjacent to Greenland. He distinguishes three different climatic periods, each about 50 years long, between 1810 and 1960, reflecting three stages of penetration of East Greenland ice into Davis Strait. He believes that conditions of 1810-1860 are now repeating themselves. He designates this as a drift ice stagnation stage where the Canadian current has a dominating influence, and east Greenland ice does not penetrate far north into Davis Strait. The climate is cold, dry, and stable.

Several authors have presented data indicating that sections of the Arctic have experienced warming trends prior to about 1950 and have experienced cooling trends since that time. Zubov's (1943) data show a warming of the Arctic for approximately 100 years prior to publication in 1943. He shows that Arctic glaciers have receded and the southern boundary of Siberian permafrost has moved northward. Zubov also present comparative data obtained during the drift of the 'FRAM' and the drift of the 'SEDOV', 43 years later, over similar tracks in the Eurasian sector of the Arctic Ocean. The mean ice thickness was one-third less and the mean air temperature 4°C higher in 1937-40 than in 1893-96. Dorf (1960) quotes Willett (1950) who states that in Spitsbergen mean winter temperatures have risen about 8~ between 1910 and 1950. Dorf (1960) also quotes Ahlmann (1953) who reports ice free ports in Spitsbergen to be open to navigation about 7 months of the year as compared with only 3 months 50 years earlier. Mitchell (1965) states that world climate during the past century has been characterized by a warming trend from the 1880's to the 1940's. Thereafter, the warming trend appears to have given way to a cooling trend that has continued to at least 1960 with some evidence that it was continuing in 1965. Budyko (1966) says that polar ice cover is so sensitive to temperature that a summer anomaly of plus 4°C would cause the entire ice pack to melt in 4 years; an anomaly of plus 2°C would produce the same effect in a few decades. Once the ice pack had disappeared, negative temperature anomalies could re-establish it.

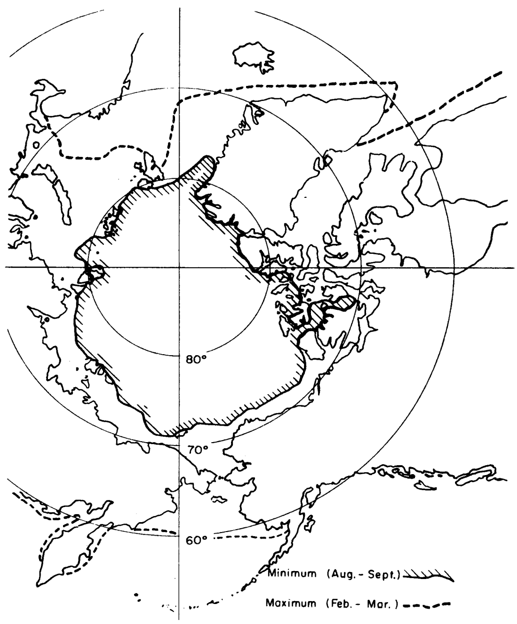

Fig. 1 Ice cover, North Polar Basin

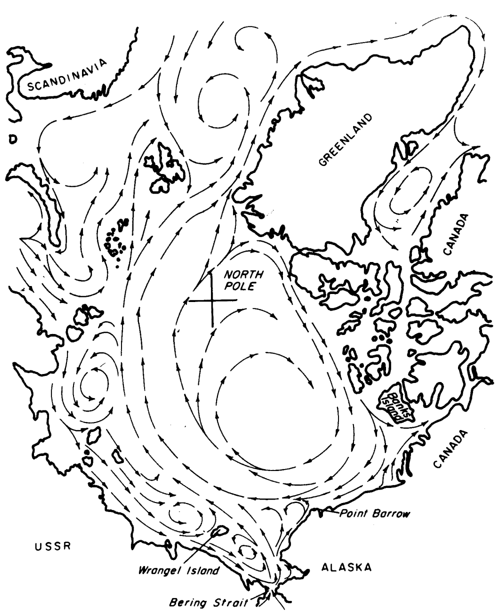

Fig. 2 General surface circulation, North Polar Basin (adapted from Oceanographic Atlas of the Polar Seas, 1958. U.S. Navy Hydrographic Office, Washington, D.C.).

POLAR BEAR DISTRIBUTION IN RELATION TO TYPE OF ICE

Polar bears generally first appear along Alaska's north coast in October, when shore fast ice enables them to travel from drifting pack ice to the beach.

The first bear sightings are reported to the east of Point Barrow and then to the southwest in the same sequence that fast ice forms. Eskimos indicate that polar bears travel from north to south in the fall, along the coast between Point Barrow and Cape Lisburne. Considering the two most productive bear hunting areas along this section of coast, bears are first taken by Eskimos in the northernmost Point Franklin area and then in the Icy Cape area to the south. Eskimos also report that, traditionally, bears are more numerous along the coast in years when winds from the north and west bring old ice to the coast than in years when newly frozen ice drifts in. Bailey & Hendee (1926) verify this and report that in the fall of 1921, old ice failed to come in and new ice formed for miles out from the shore. Consequently, few polar bears were killed between Barrow and Point Hope. In the fall of 1967, Alaska Department of Fish and Game personnel observed that winds brought more heavy ice further south than usual, and there were more bears along the coast than usual. This situation appears to be repeating itself in 1970.

Several things attract polar bears to shore fast ice. One is beach carrion which includes carcasses of walrus *Odobenus rosmarus*, bowhead whales *Balaena mysticetus*, beluga whales *Delphinapterus leucas*, ringed seals *Pusa hispida* and bearded seals *Erignathus barbatus*. Ringed seal pupping dens in fast ice attract bears in the spring. Bears also travel on fast ice to find suitable denning sites. Polar bear dens have been reported along river banks in northeast Alaska and on fast ice close to the islands east of the mouth of the Colville River. Quantitative data on the number of dens along the north coast of Alaska have not been obtained, but dens are less concentrated than in many denning areas elsewhere in the polar basin.

During the winter, drifting pack ice off the Alaska coast probably supports greater concentrations of polar bears than either shore fast or polar pack ice. This is probably because juvenile ringed seals and bearded seals, the bears' main food, are more numerous in drifting pack ice than in fast or polar pack ice. Seals probably prefer drifting pack ice because of open water and the relative ease of keeping breathing holes open where leads have recently frozen over. Intensive studies have not been conducted off the Alaska coast in the summer, but it is assumed that seals and therefore bears are more numerous in drifting pack ice than in the more stable polar pack ice. Bears may be more concentrated in drifting pack ice in the summer than in the winter because there is less ice on which to disperse during the summer. T. Larsen of the Norwegian Polar Institute (pers. comm.) found bears quite concentrated in the drifting pack ice east of Spitsbergen in the summer.

There is not much information on polar bear abundance and distribution on polar pack ice. Bears have been sighted close to the North Pole, and at several locations on polar pack ice between Alaska and the North Pole, by personnel of United States drifting ice stations and the British Transarctic Expedition (data on file at Naval Arctic Research Laboratory, Barrow, Alaska). The number of sightings, however, suggests that bears are sparsely distributed The area where drifting pack ice occurs north of Point Barrow sometimes has extensive heavy ice without open leads or thin ice, and observations here might give some insight into bear abundance on polar pack ice. Some bears travel through these areas, but they apparently do not spend appreciable amounts of time in them.

HARVEST

It appears that the pattern of ice formation and movement in any year can affect the Alaskan harvest of polar bears for that year. More bears occur and are taken by Eskimo hunters along the coast in years when winds bring drifting pack ice close to the beach and shore fast ice forms early in the fall. Nearly all Eskimo hunting is on the beach or on fast ice. The mode of travel is snow machine or dog team. Nearly all bear hunting for trophies is accomplished with the aid of aircraft on drifting pack ice. Hunter selectivity of bears, in years when there is much rough ice and relatively few areas suitable for landing an airplane, is low. The differing degrees of selectivity can affect the total kill and contribute to variations in sex and age structure of the harvest from year to year. In Greenland Vibe (1967) relates changes in distribution of the polar bear harvest to changes in ice conditions.

DENNING RELATED TO ICE MOVEMENTS AND CLIMATE

In polar bears, the pregnant females appear to be the only animals that routinely go into dens in the fall for extended periods. Young are born in the den. Most known areas that have high concentrations of denning animals around the polar basin are on large offshore islands. There are little data on fluctuations in the numbers of denning females from year to year in these areas, but there are reports that numbers of bears visiting islands where denning occurs vary from year to year, depending on ice conditions (Harington 1968; Kistchinski 1969; Lønø 1970). In years when relatively few pregnant females reach denning areas on land, some may be forced to den on sea ice. It is quite possible that ice provides a less stable platform for denning than does land. This could cause the segment of the population denning on the ice to be less successful in raising cubs and therefore to have a lower reproductive rate than the segment denning on land.

A general warming of the Arctic could adversely affect denning. Changing ice conditions because of a warming climate could result in fewer bears reaching some of the more favorable denning areas. Also, Vibe (1967) has pointed out that bears and ringed seals, their principal food, require a relatively stable Arctic or sub-Arctic climate without periods of thawing and melting of snow during winter, in order to successfully den and produce offspring. Warming of the Arctic would reduce the extent of such favorable areas. Disappearance of the ice cover because of air temperature anomalies, a possibility described by Budyko (1966), would have a severe impact on denning and, in fact, the food chain supporting the polar bear. Periods of cooling trends, during which the ice cover increased, should make more land areas, especially further south, accessible for denning.

DISCRETENESS OF POLAR BEAR POPULATIONS

Discreteness of bear populations is of primary concern from the standpoint of polar bear management. Effects of sea ice movements on distribution of bears must be considered in an analysis of tag returns and related data to determine if there are sub-populations of bears. Possible effects of ice movements are considered here primarily as they relate to bears off the Alaska coast. Fig. 2 shows that moving ice could transport bears in various ways. Bears could reach Bering Strait, normally the southern limit of their range off Alaska, by drifting on ice carried by the current moving to the southeast from the vicinity of Wrangel Island. Bears could then be carried north and then northwest toward Wrangel Island, or north and northeast past Point Hope and Cape Lisburne and then along the Alaska coast toward Point Barrow. Bears north of Point Barrow could drift west toward Wrangel Island, or north and then in a clockwise movement to the east and then to the south past the west side of the Canadian archipelago, and then northwest from the vicinity of Banks Island back toward Point Barrow.

Drifting ice could thus transport bears so as to prevent formation of isolated groups of animals off the coast of Alaska. Bears from the vicinity of Wrangel Island could be carried to Bering Strait and then past Cape Lisburne to Point Barrow and the Canadian archipelago. Bears from the northwestern section of Canada could drift past northeastern Alaska on their way toward Wrangel Island.

On the other hand, currents could tend to isolate sub-populations west and north of Alaska. Bears west of Alaska could drift back and forth between Wrangel Island and Bering Strait. Bears north of Alaska could be part of a population that remains in the area north of Alaska east to the Canadian islands.

Active movements of the bears themselves will have to be considered as well as their passive movements on drifting ice. Polar bears travel in their search for feeding areas, denning sites, mates, and more solid ice at time of spring breakup. Bears travel on their own, independently of ice movement, northward from the southern Chukchi Sea in March prior to ice breakup. Along the north coast of Alaska, there is a pronounced movement of bears to the east during the spring. This appears to be from an area where ice is breaking up, to an area where the ice is still quite solid.

It is interesting that bears tend to travel against the direction of prevailing ice drift along the north coast of Alaska in the spring and thereby tend to remain in a fixed position relative to the land. Recovery data have been obtained by re capture and hunter harvest for 26 of 202 bears marked off the Alaska coast prior to 1970. Most animals have been recovered 1, 2 or 3 years after tagging in the same general area where tagged. However, there have also been some recoveries a considerable distance from the tagging site. If bears can selectively navigate on changing sea ice with no constant reference points, the mechanisms for doing so would be most interesting to study.

INFLUENCE OF HUMAN ACTIVITY

With the expanding human population and attendant exploitation of natural resources, man will have a greater impact in the Arctic. The most immediate concern with regard to sea ice and polar bears is oil exploration, offshore drilling and the transport of oil by ships through ice covered seas.

Consideration should be given to limiting oil extracting activities in known polar bear denning areas throughout the polar basin. Human activity, including the use of large vehicles and explosive seismic charges, could keep bears away from denning areas. The effects of such activities when bears are in dens or emerging is unknown. Seismic exploration and drilling activities on fast ice could also affect seals, especially ringed seals when they are denning and pupping in the spring.

Oil spills would probably result if wells were drilled offshore and oil were transported by ship. From documentation of oil activity in Cook inlet in south-central Alaska (Evans 1970), it appears that spills would be inevitable. Moving ice would pose a threat to offshore drilling platforms, pumping facilities and transport ships. In the case of a leaking transport ship, ice would hamper or prevent repairs at sea and might delay travel to a docking area. Ice would hinder or prevent a mopping-up or containing of a spill, and currents could spread a large spill over a considerable area. Oil spills would affect polar bears by reducing the insulating value of their fur and adversely affecting species in the food chain below them.

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