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Polynyas and Prehistoric Settlement Patterns

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ABSTRACT. In traditional Inuit society the availability of game resources must always have been one of the most important criteria for the determination of settlement locations. A number of ecological factors determine the availability of particular game species in the Arctic regions. The presence of open water areas known as polynyas is one of these factors. The relationship between polynya distributions and prehistoric settlement patterns in the High Arctic is explored, with particular reference to the Bache Peninsula region on the east coast of Ellesmere Island, N.W.T.

RÉSUMÉ. Dans la societé Inuite traditionelle, un des principaux criteres de localisation des colonies a toujours été, semble t'il, la présence de ressources en gibier. Les facteurs écologiques sont nombreux pour permettre l'abondance d'espáces giboyeuses particulieres dans les regions arctiques. Un de ces facteurs est la présence de zones à eau libre, qu'on appelle des polynias. L'auteur explore le type de rapport entre la localisation des polynias et celle des colonies préhistoriques dans l'Arctique Septentrional et met l'accent sur ia Peninsule de Bache, située sur la côte est de l'ile d'Ellesmère - N.W.T.
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INTRODUCTION

For a prehistoric population existing almost exclusively on food resources obtained through hunting, a close association usually existed between the location of settlements and a reasonable proximity to game. The access to game resources in any given region shifts with the seasons and the distribution of human settlements usually reflects these changing conditions. This paper explores the relationship between particular areas of food resource concentrations created by the presence of open water occurrences, known as polynyas, and prehistoric settlement patterns in the High Arctic. Special emphasis is placed on data from the Bache Peninsula region on the east coast of Ellesmere Island. This latter area has been the centre of extensive archeological investigations during the past two summers resulting in the location of over 180 sites spanning at least 4000 years of periodic human occupation.

POLYNYAS

In the World Meteorological Organization's official glossary (1970), a polynya is defined as "any non-linear shaped opening enclosed in ice. Sometimes the polynya is limited on one side by the coast and is called a shore polynya, or by fast ice and is called a flaw polynya. If it occurs in the

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FIG. 1. Polynya locations in the Canadian High Arctic.

same position every year it is called a recurring polynya." This paper deals principally with the recurring polynyas although a few statements are made regarding what I have termed secondary polynyas for lack of better terminology. By secondary polynya is meant an area which appears to become ice-free several weeks earlier than the occurrence of regular regional breakup. Obviously the distinction between these two types of polynya may in some instances be difficult to define, but as a rule the primary recurring polynya is established one or two months prior to general breakup of the fast ice whereas the secondary polynyas appear only a few weeks before this event.

There are a number of recurring polynyas in the High Arctic. Figure 1 shows the distribution of these areas based on information obtained from a letter by W.J. Sowden, personal observations, and correspondence with R.A. Lake, Institute of Ocean Sciences in Victoria, British Columbia. Vibe (1950, Fig. 3) has identified additional polynyas in the Kane Basin region and states that some of these may open up during new and full moon throughout the winter (Vibe, 1950:12). Several investigators, notably Dunbar (1958), Sadler (1974), Kupetskiy (1962) and others, have published works dealing with these open water phenomena.

The physical mechanisms involved in the formation of a polynya have been discussed by R.A. Lake (1979, personal communication). These mechanisms are:

1) mechanical removal of new ice usually attributed to strong currents such as one finds in a narrow channel. If an ice cover is able to

establish itself its rate of growth may be inhibited by the mechanical removal of ice platelets growing into the water from the sea ice. Wind can also mechanically remove young ice by breaking it up and causing surface currents which carry the ice down wind. In general, strong tidal currents would be more effective than wind as they are more regular thus sweeping the area clean during each tidal cycle before stronger ice can be established.

2) If the water at the surface is above its freezing point the thermodynamic balance will be unfavourable to ice formation. Water having a temperature above its freezing point may reach the surface when it is mixed or carried upward as water accelerates through a narrow passage or where two water masses of different densities meet.

Cyclic variations in tidal currents (14-day periods typically) may result in periods of weak currents when the surface water can reach its freezing point and an ice cover of sufficient strength is established to close over the polynya. The return of stronger currents may only inhibit ice growth but may not be sufficient to remove the ice which may persist for several of the winter months. The ice will remain anomalously thin, and the polynya reforms early in the spring as the thermodynamic balance shifts with an increase in solar radiation.

The mechanisms involved in the establishment of secondary polynyas are undoubtedly of a similar nature although the effects are weaker. During three seasons of observation in the Bache Peninsula region, on the east coast of Ellesmere Island, these secondary polynyas (Fig. 2) have appeared in the same locations in varying degrees of expansion. During the 1979 field season which was marked by a very late snow melt and ice breakup, one of the secondary polynya areas along the north coast of Johan Peninsula was still ice-covered by mid-August when the field party left the area. This event suggests that the secondary polynya areas are much more sensitive to minor environmental and climatic fluctuations than the primary recurring polynyas. It also suggests that the secondary polynyas need not be recurring, and may therefore have been a less predictable food resource harvesting area for prehistoric hunting groups.

POLYNYA RESOURCES

The factor linking polynyas and human settlement is the presence of available and potential food resources in the open water area. As Kane (1856: 244) noted "To these spots, the seal, walrus, and the early birds crowd in numbers". Observations of the wildlife attracted to the Flagler Bay polynya in the Bache Peninsula region (Fig. 3) were carried out during the summers of 1978 and 1979. During the latter season the Flagler Bay polynya was observed in early June in order to determine the general time of arrival of walrus, which were observed in large numbers (300-plus) in July of 1978. Observations of the bird population in the polynya were carried out by H. Ouellet of the National Museum of Natural Sciences and his assistant at spaced intervals

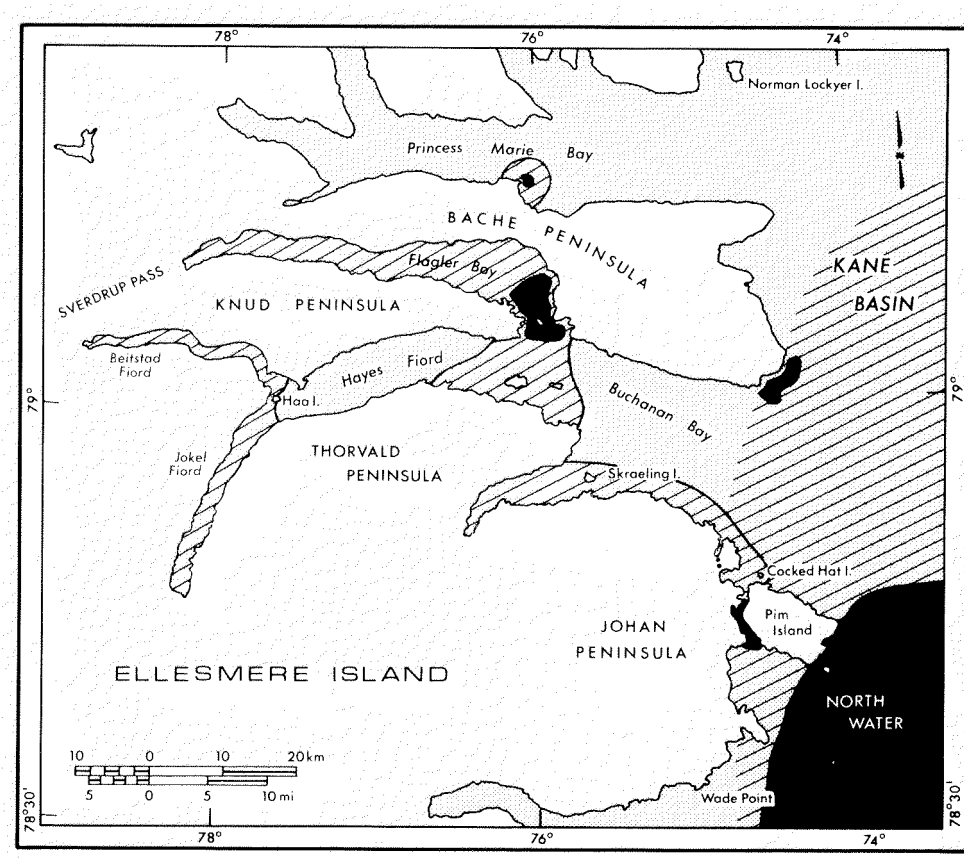

Fig. 2. Primary and secondary polynyas in the Bache Peninsula Region; ● - primary, ◐ - secondary.

during June and July. The following table based upon information kindly provided by Ouellet illustrates the potential economic importance of the Flagler Bay polynya in terms of available bird species (Table 1).

Many of the smaller islands in the polynya contained large numbers of nests and the gathering of eggs undoubtedly has provided an important food source in the past. The most important food to be obtained in the polynya was probably always the walrus (*Odobenus rosmarus*). Although large numbers of ringed seals (*Phoca hispida*) are present in the general region, their presence in the polynya seems to be limited to a time period prior to the arrival of the walrus. The arrival of the walrus, which in 1979 occurred about the middle of June, provides an interesting insight into their migratory habits. In order to reach the feeding grounds of the Flagler Bay polynya the walrus had to travel along a relatively narrow tidal cracked ice zone along the coast for at least 10 - 12 km, the distance between the polynya and the open North Water in Smith Sound. The snow melt and ice breakup was delayed two to three weeks in 1979 and it is quite possible that a less severe spring season would have enabled the walrus to enter the polynya at an earlier date. In 1978, walrus

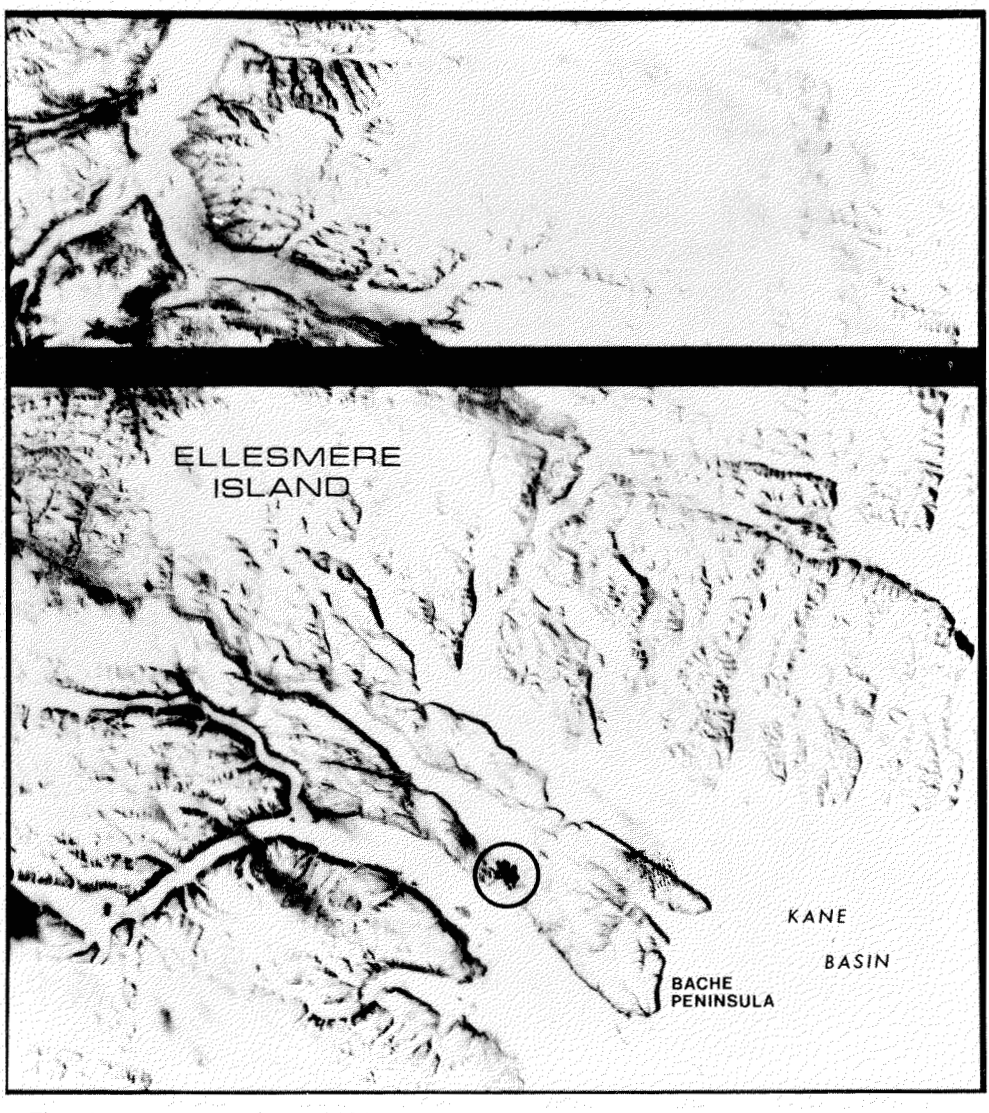

Fig. 3. Flagler Bay Polynya, 24 May 1975.

were observed at the Dundas Island polynya (Fig. 1) in early April (R. A. Lake, personal communication, 1980). Unfortunately, there are no exact data on the time of departure of these animals in the fall or on the interesting question of whether any of the walrus remain in the area during the winter. According to officers who were stationed at the Alexandra Fiord RCMP detachment in the early 1950's (F. Stiles and B. Sawyer, personal communication, 1980) small areas of open water persisted throughout the winter in the Flagler Bay area. Approximately 250 animals were noted during the summer of 1979, slightly below the figure of 300 observed in 1978. A number of bearded seals (*Erignathus barbatus*) were observed in the polynya

TABLE 1. Observations and estimates of bird populations in the Flagler Bay polynya 1979

	15 June	18 June	8 July	10 July
Red throated Loon (*Gavia stellata*)		3		4
Snow Goose (*Chen hyperborea*)				
Old Squaw (*Clangula hyemalis*)	30	300-400		20
Common Eider (*Somateria mollissima*)	300	400-500		350-400 (nesting)
King Eider (*Somateria spectabilis*)	20	100		
Gyrfalcon (*Falco rusticolus obsoletus*)				
Long Tail Jaeger (*Stercorarius longicaudus*)		10		1
Parasitic Jaeger (*Stercorarius parasiticus*)				1
Glaucous Gull (*Larus hyberboreus hyperboreus*)		50 + nests		1 colony (75 birds) 50-60 nests
Thayer Herring Gull (*Larus argentatus*)				1
Ivory Gull (*Pagophila eburnea*)		3		
Arctic Tern (*Sterna paradisea*)		60		200
Thick-Billed Murre (*Uria lomvia*)		1 (maybe later)		
Black Guillemote (*Cepphus grylle*)	60	250	300	350-400
Dovekie (*Plautus alle alle*)	15			
Snow bunting (*Plectrophenax nivalis nivalis*)		8	10	

Observations did not take place during the month of August.

although not in great numbers. Large numbers of white whales (*Delphinapterus leucas*) and narwhals (*Monodon monocerus*) have been noted in the Bache Peninsula region but not in the polynya prior to overall breakup of the regional fast ice. From faunal evidence obtained in the old Thule culture dwellings it is clear that the latter two whale species as well as the bowhead whale (*Balaena mysticetus*) were present in Flagler Bay. With an ameliorating shift in climate and ice patterns allowing for a more extensive open water period a similar situation would probably be evident today.

PREHISTORIC SETTLEMENTS

Research in the Crozier, Berkeley and Pullen Straits region, between Bathurst, Cornwallis and Devon Island, has indicated a strong relationship between the presence of several recurring polynyas (Fig. 1) and the location of extensive prehistoric settlements; Ruffman, 1974; McGhee, 1976; Schledermann, 1978b and c; Helmer, 1979). In most cases the site areas yielded evidence of periodic occupation spanning three to four millenia, suggesting a considerable longevity of the associated polynas. Other areas of known polynya occurrence have been investigated to a lesser degree, or not at all, and may in the future provide evidence of prehistoric activities.

A closer examination of the relationship between primary and secondary polynyas and prehistoric settlement locations is based on the present results of archaeological research in the Bache Peninsula region on the east coast of Ellesmere Island (Schledermann, 1977; 1978a). The primary polynyas in this region (Fig. 2) range in size from the relatively large Flagler Bay polynya (Fig.

3), a primary recurring open water area, to smaller primary polynyas in Rice Strait and off Cape Camperdown on the southeast tip of Bache Peninsula. Secondary polynya areas occur primarily at the mouth of Alexandra Fiord, along the north shore of Johan Peninsula, in the inner fiord areas, on the north shore of Bache Peninsula, on the north shore of Norman Lockyer Island, and as a general expansion of the Flagler Bay polynya (Fig. 2). Even a preliminary study of settlement locations in this region indicates a strong correlation between settlements and the presence of primary as well as secondary polynyas.

Archeological investigations along the northeastern shore of Knud Peninsula, an area bordered on the Flagler Bay polynya, shows prehistoric settlements to extend back 2500 to 3000 years before present. Late pre-Dorset, transitional and early Thule occupations indicate similar periods of intensive prehistoric land use activities in the area. During the late Dorset culture occupations the polynya served as a major spring and summer gathering place as evidenced by the construction of large communal gathering structures and associated cooking rows (Schledermann, 1978a). The Thule culture occupation, spanning both summer and winter, is represented by at least 25 sod, stone and whalebone house ruins, numerous tent ring structures and cache remains. One of the islands in the polynya contained a number of sites from various prehistoric time periods. Additional sites have been noted along the Bache Peninsula coast on the north shore of the polynya. The cultural evidence, particularly the faunal remains in dwellings and middens, leaves no doubt about the importance of this area for human settlement and hunting activities in the past. The attraction was clearly the potential food resources available on a seasonal basis in the polynya. An analysis of the excavated faunal materials is in progress. However, preliminary results indicate the prehistoric utilization of most of the bird and sea mammal species presently known from this area.

As stated earlier, the presence or absence of these open water areas is dependent upon a number of physical and thermodynamic factors. It is reasonable to assume that significant changes in these factors could result in the disappearance or, for that matter, in the creation of a polynya. The archaeological site investigations in the Flagler Bay area, particularly on the northeastern tip of Knud Peninsula, revealed a curious lack of sites older than *ca.* 3000 B.P., in spite of the existence of a number of sites in the 4000 - 4500 B.P. time range found elsewhere in the general Bache Peninsula region. It is possible to suggest that a causal relationship exists between the lack of old site remains and the possible non-existence of the polynya prior to *ca.* 3000 B.P. One of the dynamic factors which could have influenced the polynya occurrence would be land rise due to isostatic rebound. Deglaciation and associated land movements have been in operation during the past 8000 or more years in this region (W. Blake, personal communication, 1979). Two of the principal factors resulting from a general land rise, as far as a polynya is concerned, would be changing water depth and altering velocity of tidal currents brought about by changes in structural confinement.

In order to test the hypothesis that a general lack of archaeological sites pre-dating *ca.* 3000 B.P. is related to the non-existence of the polynya prior to that time, Robert Lake of the Institute of Ocean Sciences kindly agreed to conduct a computer simulation of past hypothetical conditions in the Flagler Bay area. The basic assumption involved in the development of the simulation model was that of general land rise. Several radiocarbon assessments from the study area (Schledermann, 1978b) have indicated an approximate rebound in the order of 25 - 30 m over the past 4000 years. Lake computed tidal currents off Koldewey Point on Knud Peninsula for present water levels, again using the assumption that land had subsided by *ca.* 30 m, in order to simulate the suggested conditions prior to 3000 B.P. The currents for a 30-day period were used in order to encompass variations in current rate resulting from major diurnal and semi-diurnal tidal constituents. The projected subsidence resulted in average currents being reduced to 3 cm/sec. from 6 cm/sec., or about 50%. The numerical values should be considered as estimates only although the degree of speed reduction is probably realistic (Lake, personal communication, 1978). Although by no means conclusive, the computations of the tidal currents at the entrance to Flagler Bay suggest that the present polynya did not exist prior to 3000 B.P., at least not as prominently as today. The lack of sites pre-dating this time period could therefore be explained by a reduction or absence of major food resource concentrations. An alternate explanation or perhaps a contributing factor relates to the question of resource concentration. It is generally agreed that the High Arctic experienced a warm climatic period between approximately 3500 and 4500 B.P. The probable causality between this climatic situation and the initial pioneering human migrations into the High Arctic is also a point of general agreement among arctic archaeologists. It could be argued that during a period of warmer climatic conditions, more extensive open water areas of longer seasonal duration would affect the degree of animal concentration by allowing an expansion of the potential habitat availability. Settlement locations would, perhaps, be more dispersed under such conditions. In the Bache Peninsula region there is some evidence to suggest that settlements were less geographically restricted during the early, as well as during the later (*ca.* 1100 to 900 B.P.), climatic warming periods. However, it is the extensive use of the Flagler Bay polynya during the early part of the latter climatic warming trend, indicated by the large spring and summer settlements on Knud Peninsula, which detracts from the alternative explanation of polynya resource use or lack thereof prior to 3000 B.P. Obviously, the people of the late Dorset culture found the Flagler Bay polynya sufficiently economically attractive to congregate, even during a warmer climatic period, in relatively large numbers on its shores.

There is one apparent difference between the two climatic warming periods which could explain the late Dorset culture occupation of the Flagler Bay polynya shores. According to many paleoclimatic investigations (Nichols, 1975; Paterson *et al.*, 1977) the earlier of the two periods of climatic optimum was not only longer in duration but also was a climatic episode which

exhibited an average temperature several degrees C above the second optimum. Based on this factor the alternative explanation may be valid, or at least have been a contributing element in the lack of pre-3000 B.P. settlements in the area.

DISCUSSION

Not all polynya areas in the High Arctic have been equally attractive for human hunting activities and settlements. It must be emphasized that polynyas do not by their mere presence result in the establishment of seasonal human settlements. Other factors such as available and dependable food resources, distance from alternative resources and central base will to a large degree determine the human activities, if any, in a polynya area. The Hell Gate/Cardigan Strait polynya may belong to the "limited use" category although considerably more survey work has to be carried out in order to verify this assumption. A brief site survey on the west side of Cardigan Strait by McGhee and Schledermann (1974), revealed only a small number of sites. Several other polynya areas noted on Figure 1 have yet to be investigated from an archaeological point of view.

One area outside the Bache Peninsula which has shown a strong association between the presence of polynyas and prehistoric activities is located between Bathurst and Cornwallis Islands and Grinnel Peninsula. Several hundred sites, spanning periodic occupations during the past 4000 years, have been recorded in this general region (Schledermann, 1978c) which apparently constituted one of the more heavily populated regions in the Islands. One of the economic attractions during the spring and summer was undoubtedly the walrus which still frequent this area in large numbers. This region is not too far removed from reasonably good musk-ox and caribou hunting territories, at least periodically. The location of a polynya in terms of an overall hunting orientation is very important. If a recurring polynya with its associated bird and sea mammal resources is located in reasonable proximity to other resources such as musk-ox and caribou, its attraction as a settlement area becomes obvious. If on the other hand the polynya is situated far from "regular" and dependable hunting territories it may not be of sufficient attraction to a hunting group in spite of its seasonal resource potential. The Makinson Inlet polynya (Fig. 1) may represent such an "isolated" situation and should provide an interesting test case for this discussion.

The largest of the open water areas, technically known as a "recurring polynya" is the North Water (Fig. 1). The importance of this area historically has been well documented (Dunbar and Dunbar, 1972). The significance of the North Water in terms of prehistoric hunting and settlement activities must be measured somewhat differently than has been the case with the much smaller polynyas in this discussion. Indirectly, the North Water has undoubtedly been very important to the occupants of northwest Greenland and eastern Ellesmere Island as a habitat for large numbers of sea mammals. This body of water, which varies in extent during the year, also seems to have

influenced human migration patterns by restricting most of the population movements between Ellesmere Island and Greenland to the area north of the Smith Sound narrows. In the past the North Water may have been an important factor in terms of providing fluctuating periods of greater economic abundance in the Bache Peninsula region. If, during warmer climatic periods, the northern boundary of the North Water extended further northward into the Kane Basin or did so during a greater part of the year than now, the fiord areas around Bache Peninsula may have been freed of ice earlier and to a greater extent than is the case today. Such a situation would have resulted in greater accessibility of sea mammals, particularly the larger species such as white whales, narwhals and bowhead whales. The location of large numbers of whalebone remains in and around the Thule culture sites indicate a fair degree of active bowhead whale hunting in the past. Fluctuating factors such as climatic conditions, open water areas, whether primary or secondary polynyas, sea ice conditions and available sea mammal resources have resulted alternately in periods attractive to human occupation and periods of abandonment, due to critical decreases in economic resources, as illustrated by the comparatively recent abandonment of the ancestral Polar Eskimo population from the Bache Peninsula region. It may be postulated that the economic importance of polynyas in the High Arctic increases, at least initially, during cooler climatic conditions. However, if these conditions become too severe, human occupation of a region may become disrupted to the extent that even seasonal hunting excursions to polynya areas are abandoned. During warmer climatic episodes when habitats, particularly for migratory species, are less restricted, polynya areas may be of lesser importance, resulting in a less restricted settlement pattern.

SUMMARY

Open water areas known as polynyas have in a number of cases been shown to be of great importance for the concentration of various economic food resources such as birds (eggs), several species of seals and walrus. These resources have in turn attracted human hunting groups during several millenia of High Arctic occupation. Not all polynyas have been equally attractive to human settlers whose survival depended upon a number of factors evolving around seasonal hunting pursuits, often regulated by geographical distances within which a shifting but generally centrally-based wandering society could operate.

Evidence from two regions (Bache Peninsula and Crozier/Pullen/Berkeley Straits) which contain several primary polynyas as well as extensive prehistoric settlements, suggests that the present polynyas have existed more or less *in situ* for at least 2000 to 3000 or more years. A discussion of the mechanisms involved in the development and recurrence of polynyas has been forwarded with particular attention placed on the potential reasons for the appearance and disappearance of polynyas. The fact that sites older than about 3000 B.P. are practically non-existent in the Flagler Bay area may be

related to the possible absence of the polynya prior to that time. As an alternative explanation, the importance of polynya areas for human hunting activities and seasonal settlement may have decreased during warmer climatic periods, particularly the climatic optimum prior to 3500 B.P.

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