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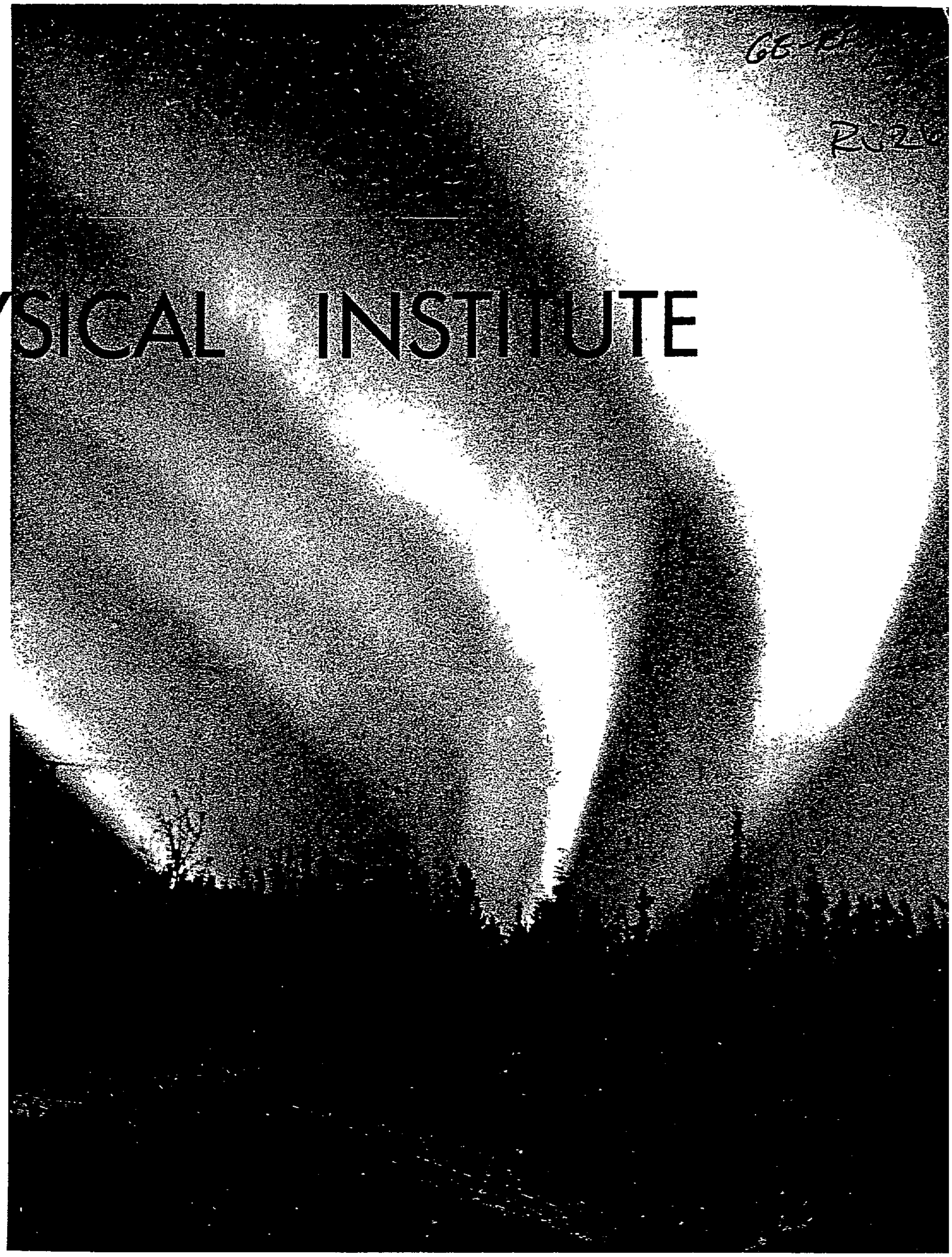

UNIVERSITY OF ALASKA

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UAG R-236

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SCIENTIFIC REPORT

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Report Approved By

Keith B. Mather
Director

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ABSTRACT

Imagery from the ERTS-1, DAPP and NOAA 2/3 VHRR satellite systems were used for identification of recurring features of the movement and distribution of sea ice in the Bering and Chukchi seas during late winter. Data acquired during March and April of 1973 and 1974 show several such features including: 1) a shear zone of variable width along the west coast of Alaska which separates landfast ice from drifting sea ice; 2) an area of generally broken pack ice between Bering Strait and Point Hope; 3) persistent polynya off south-facing coasts, such as that east of Point Hope, south of the Seward and Chukchi Peninusla and south of the larger islands; 4) convergence zones on the north sides of St. Lawrence and Nunivak Isands, and 5) narrow shear zones extending generally southward from the boundaries of Bering Strait and from the east and west ends of St. ‘Lawrence Island. The pattern observed is consistent with a general southward drift of sea ice under the influence of the prevailing northerly winds present in the area during this time of year. Closure of ice against south-facing coasts, reflecting northward ice drift, occurred about 10% of the time. These episodes probably correlate either with short periods of dominately south winds or drift under the influence of north setting currents when prevailing north winds were light.

ACKNOWLEDGMENTS

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INTRODUCTION

In this brief discussion, we shall attempt to describe the major, recurring features of sea ice movement and distribution patterns in the Bering and Chukchi seas (Figure 1) during the months of March and April, with the exception of changes in position of the ice edge. Our analyses are based upon examination of all available imagery from the ERTS-1, DAPP, and NOAA 2/3 satellite systems for these months in 1973 and 1974. Imagery was interpreted visually, and ice features, movements, and distribution patterns were traced directly from ERTS-1 imagery. DAPP and NOAA satellite imagery were utilized to monitor ice characteristics at selected localities, to provide synoptic views of sea ice conditions during the periods for which ERTS imagery was available, and to supply data for areas not covered by suitable ERTS-1 imagery.

The system we are describing extends over 14 degrees of latitude (roughly from 58°N to 72°N) with constraining boundaries and obstructions formed by land masses, and generally shallow water over a continental shelf. The influence of seasonally prevailing meteorological conditions which operate on this system produces a variety of ice conditions which in a broad sense are predictable in that they are annually recurring, As examples, landfast ice in particular areas, the edge zone of the ice pack, and certain polynya are developed each year. Superimposed upon these predictable conditions are variations which result from deviations from average meteorological and (probably) current conditions over the winter or from the timing, intensity, and distribution of shorter-term meteorologic events, In this discussion, we have not attempted to correlate ice conditions with local meteorological conditions at the time imagery was acquired, nor in general, to account for short-term effects. Instead, we have concentrated on defining an "average" configuration for sea ice in this area. This is in keeping with our present, limited objective of describing major causative factors producing the general array of conditions observed in sea ice of the Bering and Chukchi seas during March and April.

DESCRIPTION OF ICE DISTRIBUTION

Between Barrow and Point Hope, the main body of drifting ice is separated from the landfast ice by a broad shear zone which is narrow in the north, but widens to about 60-80 kilometers in the south. Figure 2, taken from an ERTS image acquired in March of 1973, shows this feature in the area of Cape Lisburne. The ice within the zone consists of broken floes of heavier seasonal ice, and probably occasional pieces of multi-year ice, in a matrix of thinner, new ice.

The fracturing of the ice within this shear zone probably results from interaction of the pack ice with the coastline during periods of south to southwesterly movements of ice along the coast. In contrast, a flaw lead tends to develop along the coast in association with northerly movements.

The coastline southeast of Point Hope is oriented at a high angle to prevailing winds (Figure 1) and as a result, an open lead is often present resulting from the southerly drift of the ice away from this coast. Figure 3, taken from an ERTS image of this area acquired on March 19, 1974, shows a new lead along the coast resulting from the initiation of southerly movement. This follows a two-day period of slow northerly drift of the ice during which the polynya, which usually occurs along this coast, was partially closed. Figure 4 shows the area on the following day after approximately 15 kilometers of southerly drift had occurred; and Figure 5 is the same area on April 7, 1974, when the polynya had widened by an additional 7 kilometers, while west of the polynya the ice had displaced about 20 kilometers to the south. These figures indicate the general stability of this polynya, which attained a width of 50 kilometers during March 1973.

Figure 6, part of an ERTS image acquired in March 1973, shows the area north of the Bering Strait where an approximately square arm of the Chukchi Sea is bounded by the north coasts of the Chukchi and Seward peninsulas, the ice of Kotzebue Sound, and the boundaries of Bering Strait proper. The geometry of these coastlines (as modified by the distribution of fast ice) exerts a strong influence on the pattern of deformation. Under conditions of rapid southerly drift, pack ice enters this region in a relatively wide stream, but can exit southward only through the Bering Strait. As a result, the ice is driven against the north coasts of the Chukchi and Seward peninsulas, which causes a funneling of the ice towards Bering Strait. This in turn produces a series of long leads extending northward from headlands or corners of shorefast ice on the north side of the Chukchi and Seward peninsulas toward Point Hope. The pattern of displacement vectors indicates that these leads have a significant shear component of motion across them. In addition to these long leads, shorter leads occur approximately normal to the direction of drift. These are most closely spaced just north of the Bering Strait, and tend to be wider apart with increasing distance to the north,

The mechanisms producing these two fracture systems are different. The long leads probably reflect an internal stress system which arises from the interaction of the drifting pack ice with the coastlines, as suggested by the observation that the fracture geometry has many of the properties of a plastic flow field, In contrast, short leads normal to the drift direction appear to result from local tensile failure of the ice under wind stress,

A similar pattern of movement in this area is shown in Figure 7, which was acquired in April 1974. In this case, the long shear leads are not developed. This is attributed to the absence of large-scale movements of the pack ice surrounding the broken zone, with the accompanying lack of an internal stress field of sufficient magnitude to cause fracturing.

Finally, under conditions of northerly drift, a few long east-west leads tend to occur in these areas.

The Diomede Islands and the fast ice which forms between them create a barrier, centrally situated in Bering Strait. Southward drifting ice is deflected to both sides of this barrier and very large floes are also fragmented. The impingement of southward drifting ice against this barrier creates a small zone of convergence extending north from the islands, and a polynya on the south side.

The effects of Fairway Rock and King Island on the general flow pattern are negligible on the scale being used in this study.

The south side of the Seward Peninsula, from Cape Prince of Wales to Cape Rodney, is generally marked by a polynya. Under conditions of active southerly drift in Bering Sea proper, a shear zone, extending south to southeast from Cape Rodney usually separates the drifting ice in Bering Sea from that in Norton Sound.

The coast of Siberia south of Bering Strait is marked by numerous bays and inlets, but distribution of fast ice along this coast tends to smooth the coastline to some extent. In general, the orientation of the fast ice edge is such that the prevailing winds tend to continually move the ice away from this coast so that heavy pack ice does not accumulate. During periods of southerly ice drift through Bering Strait, a shear zone trom the west side ot the strait to Cape Chaplin separates the moving pack ice from the thinner or fast ice closer to shore. Note also that the Gulf of Anadyre appears to be dominated by thin ice continually moving away from the coast in a southerly direction. Only minor incursions of heavy ice in this area were noted in the imagery.

Figure 8 shows the north side of St. Lawrence Island, a zone of strong convergence. Sea ice drifting south from Bering Strait impinges in a wedge-shaped area with the base extending across the entire 160 kilometer length of the island, with the vertex located at distances of up to 100 kilometers to the north. The margins of the wedge are marked by shear zones which separate the nearly stationary ice of the wedge from the deflected and southerly-moving pack.

Zones of intense ice deformation occur at the east and west ends of the island, while a polynya up to 100 kilometers wide is generally present off the south coast.

Ice movements in the vicinity of St. Matthew and Nunivak Islands are similar to those described above, though on a smaller scale.

RESULTS

The results are summarized in Figure 9 which shows the average distribution of major features of the ice during March and April of 1973 and 1974. In general, the pattern shown is consistent with that which would be deduced from knowledge of the prevailing winds shown in Figure 1, and the configuration of the coastlines as modified by the landfast ice boundary. That is, the pattern reflects southerly movements of the ice with polynya off south-facing coasts and convergence on north-facing coasts. This is not meant to imply that drift is continuous to the south, but rather that episodes of northward movement, which would tend to change this pattern, seldom occur. Further, when they do occur, ice displacements tend to be on the order of only a few kilometers over relatively small areas, and the effects of these movements on the pattern are short-lived. For the four months of satellite imagery examined for this study, evidence of active northerly drift of ice could be identified for about 10 percent of the time, In contrast, evidence of active southerly drift was found for about 50 percent of the time, with displacements ranging up to tens of kilometers, and ultimately involving movement of ice over the entire study area.

LIST OF FIGURES

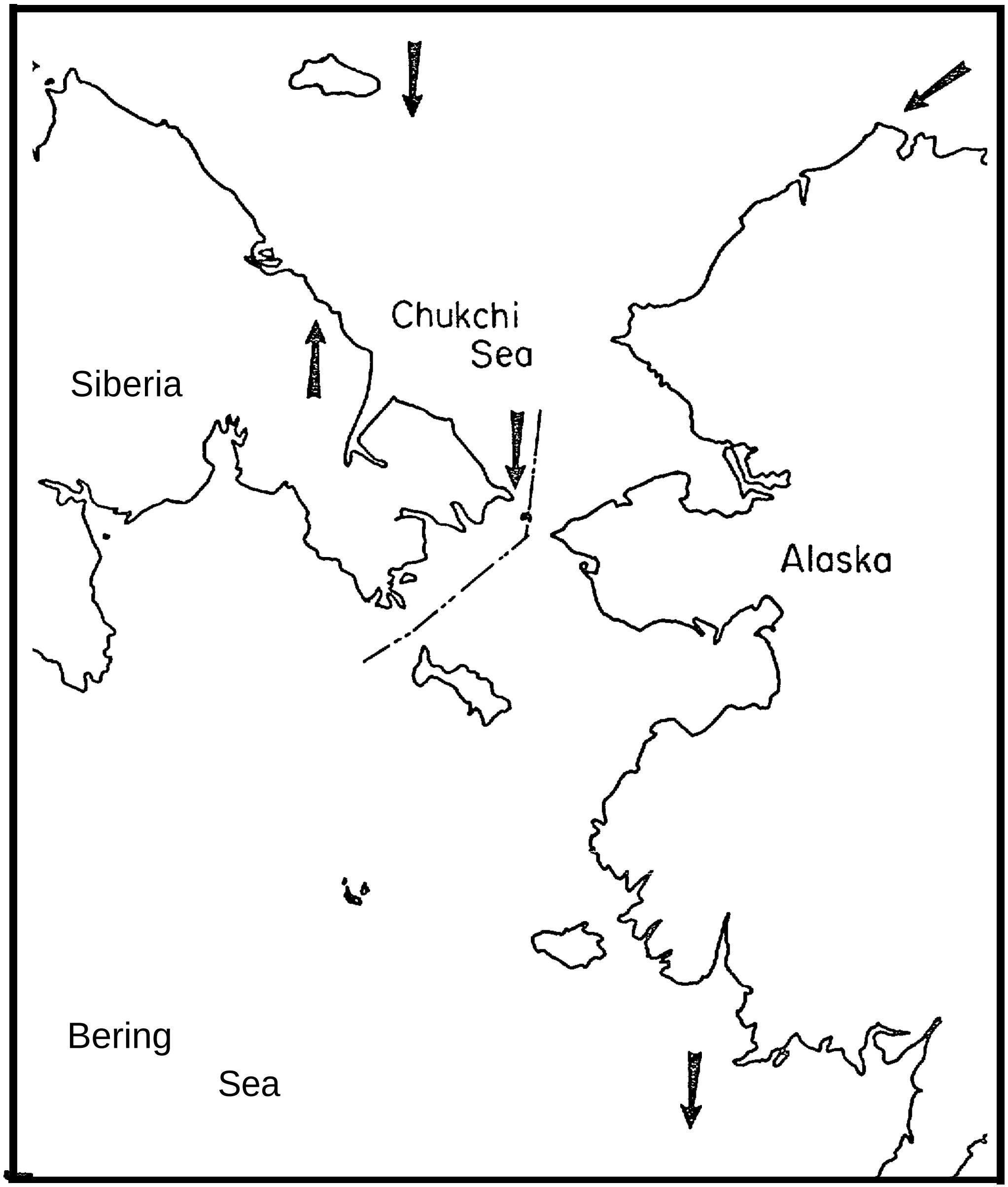


Figure 1. Location Map. Black arrows indicate prevailing wind direction during winter months, as given by Bilello (CRREL RR306, 1973).

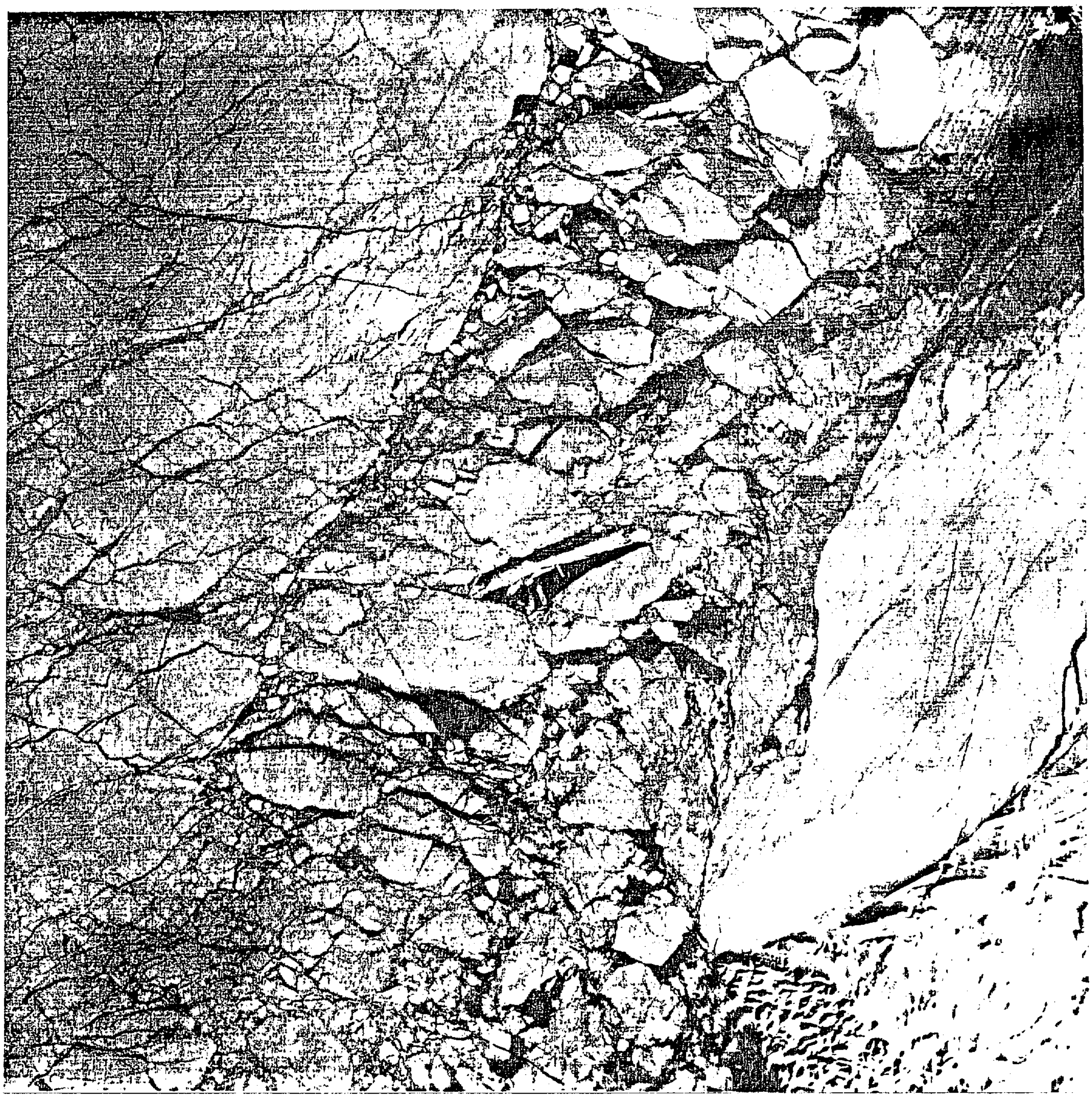
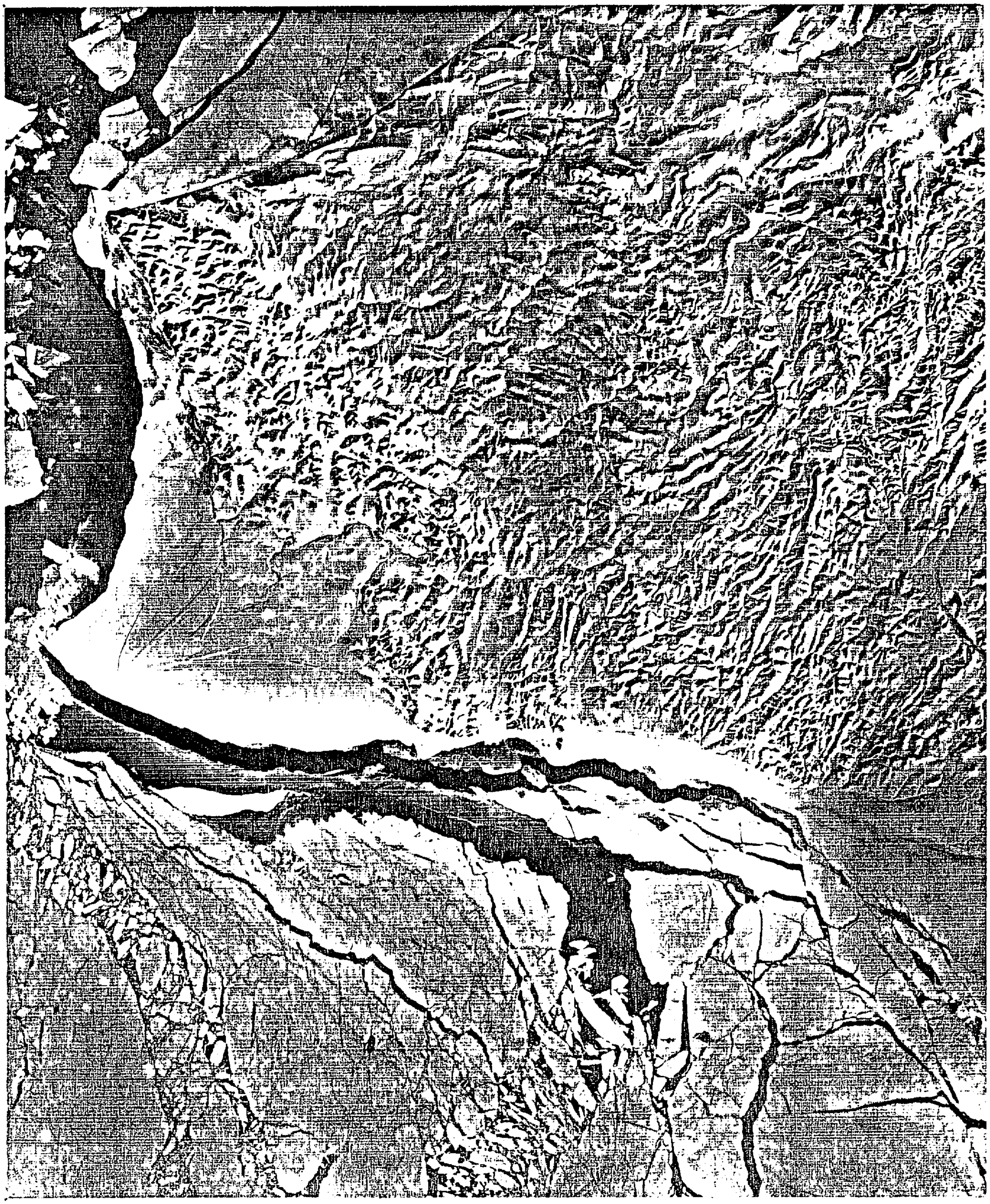


Figure 2. Shear zone off Cape Lisburne. Photo from ERTS image E-1228-22270, March 8, 1973. Cape Lisburne at lower right. Scale 1:1,000,000



'Figure 3. Lead along the coast southeast of Point Hope. Photo from ERTS image E-1604-22102, March 19, 1974. Scale 1:1,000,000

Figure 4. Lead along the coast southeast of Point Hope. Photo from ERTS image E-1605-22154, March 20, 1974. Scale 1:1,000,000

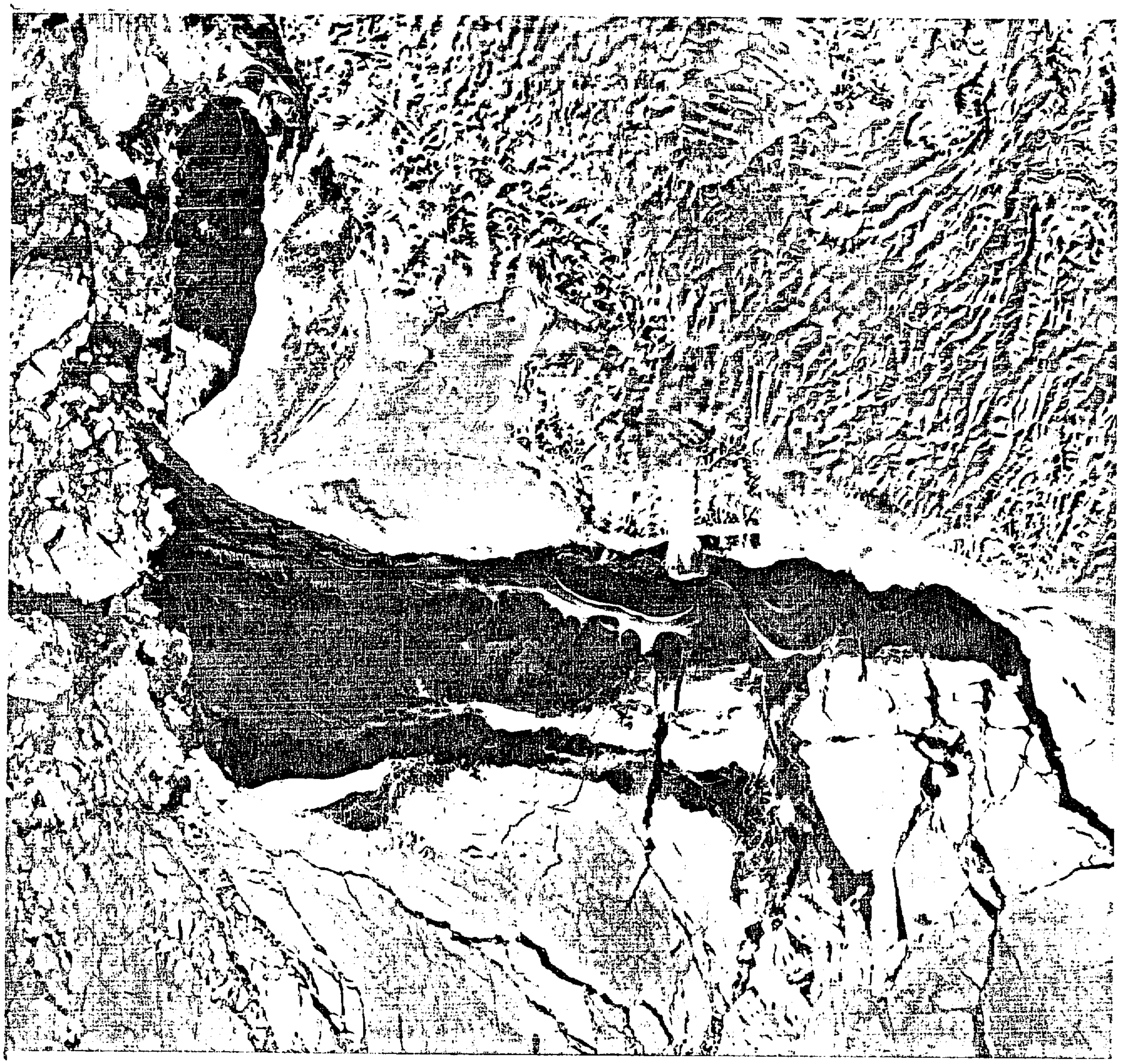


Figure 5. Lead along the coast southeast of Point Hope. Photo from ERTS image 1-1623-22154, April 7, 1974. Scale 1:1,000,000

Figure 6. Southern Chukchi Sea just north of Bering Strait. Chukchi Peninsula at lower left, Seward Peninsula at lower right. Photo of part of a mosaic of ERTS images E-1227-22214, 22221, 22223, March 7, 1973. Scale 1:1,000,000

Figure 7. Same area as shown in Figure 6. Chukchi Peninsula at lower left. Photo from ERTS image E-1623-22160, April 7, 1974. Scale 1:1,000,000

Figure 8. St. Lawrence Island and wedge-shaped convergence zone to the north. Photo from part of a mosaic of ERTS images 1226-22165, 22171, 22174, March 6, 1973. Scale 1:1,000,000

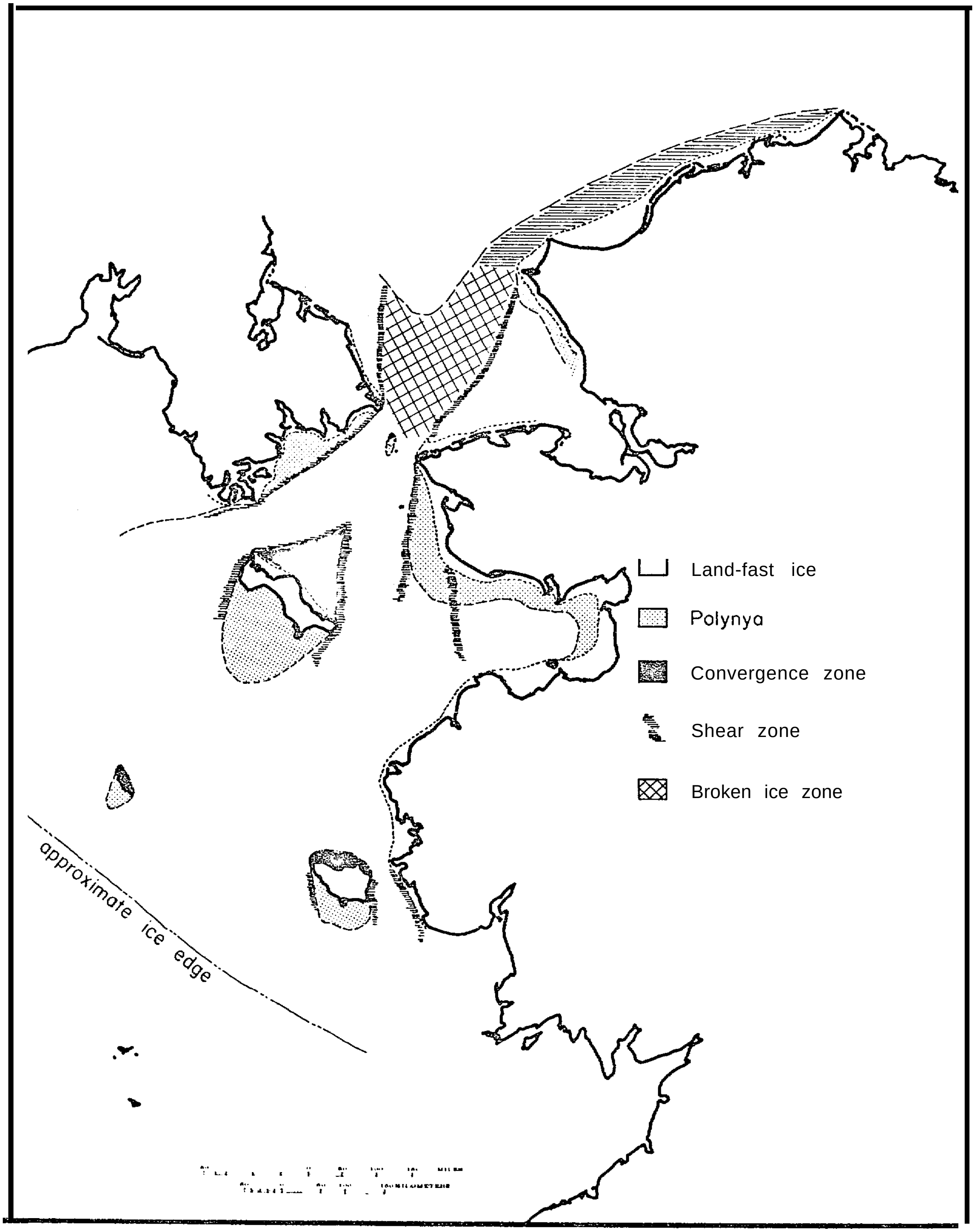


Figure 9. Summary of "average" distribution of major ice features for March and April of 1973 and 1974.