REMOTE SENSING DATA ACQUISITION, ANALYSIS AND ARCHIVAL

by

William J. Stringer

FOURTH QUARTERLY REPORT

October 1 - December 31, 1986

OCSEAP Research Unit ~~267~~ 663

Submitted to

National Oceanic & Atmospheric Administration
Ocean Assessments Division
Alaska Office
PO Box 56
Anchorage, Alaska 9951"3

February 19S7

Geophysical Institute
University of Alaska
Fairbanks, Alaska 99775-0S00

FOURTH QUARTERLY REPORT
October 1 - December 31, 1986
OCSEAP Research Unit 267
Contract #50ABNC 600041

ACTIVITIES THIS QUARTER

1. Assistance to RU 625 (J. Brueggeman) . This study occupied the bulk of our activities during this quarter. The work consisted of providing ice-related data which could be usad in conjunction with Brueggeman's whale sightings in the Bering Sea. The whale sightings (about 3, 000) have been coded in terms of latitude and longitude. The objective of our efforts was to provide data which could be used to determine whether a meaningful statistical relationship could ba found between these sightings and ice parameters such as concentration, type (thickness) and ice edge location (including pol ynya boundaries) .

Fortunately the software which had been developed for our ongoing polynya analysis as well as some of the digital polynya boundaries could be used for this analysis. However, it was necessary to digitize additional data from the years already analyzed as well as data from years which had not yet been digitized for polynya analysis.

Specifically, the newly digitized data consisted of the following:

1. Data for the Anadyr Polynya was added. We had not previously digitized this polynya because it lies beyond the NOAA-OCSEAP O .S. study area. However, the whales are international travelers so this data set needed to be added. Data for January, February, March and April of 1978 and 19S3 were added to existing files and new files were created for data for January 1986.

2. The Bering Sea ice edge far January, February, March, and April of 1979 and 1983 was added mostly to existing files. However, for a few dates new files were created. Entirely new files were created for January 1986.

Material delivered to Brueggemen at the end of this quarter consisted of:

1) Magnetic tape captaining all files of Bering Sea ice and Anadyr, St. Lawrence Island, and St. Matthews Island polynyas.

2) Print-out maps of the data set described in 1) above.

3] Tabular print-outs of areal extent and perimeter lengths of polynyas listed above as well as other polynyas which occasional 1 y occur within the study area.

4) Tabular evaluation of ice conditions at 113 specified locations representing whale sightings and locations of no whale evidence. (This was essentially a trial run for a larger follow-on project which is described in "Next Quarter Activities. "

The above materials were delivered to Brueggeman's research unit during an on-site working visit by Richard Grotefendt, Brueggeman's assistant.

2. Polynya Analysis. Despite the diversion of effort to the whale studies, some progress was reads in the study of polynya size. Three additional years' data were digitized: 1977, 1979, and 1983, including the Anadyr pol ynya. In addition, the Anadyr polynya was added to the data for 1975 and 1986. Our previous work on the statistics of the Chukchi Sea resulted in tbe identification of 1979 and 1983 as relative maximum and minimum years of open water. Hence these are interesting years' data for comparison purposes.

Although we have not yet digitized all the years' data available to us, we decided to at least start examining the results in order to begin identifying the most useful and meaningful analysis functions. As a first step in this direction it was determined to calculate median polynya values for four major polynya systems as a function of month.

This has turned out to be a useful exercise because we have had to confront several concepts related to polynyas. As a background, it is instructive to first consider the World Meteorological Organization definition of a polynya - "an irregularly shaped opening enclosed by ice. As opposed to a fracture, the sides of a polynya could not be refitted to form a uniform ice sheet. Polynyas may contain brash ice or uniformly thinner ice than the surrounding ice. " Thus, areas of thin ice surrounded by thicker ice may be considered pol ynyas. Very often on satellite imagery polynyas can be seen with areas of obviously open water general 1 y surrounded by ice but on the down-wind side the transition f rom water to ice is often fairly uniform and it is difficult to determine where to draw the polynya boundary in this area. We have taken the boundary to be the transition between dark gray and light gray (an ice thickness of around 10cm) . However, in many cases this determination is a bit arbitrary. In any case, this is the definition we have used in determining what constitutes a polynya.

The size of polynyas is interesting from the consideration of salt and energy budgets for tbe water bodies which contain them. And, if one is considering the long term effects of these phenomena polynya size as a function of time is a critical measure. However, satellite measurements that depend on cloud-free conditions are by nature irregular in frequency and therefore, same scheme must be utilized to transform measurements made at irregular intervals into measures at regular intervals.

One logical approach to this transformation is to determine a measure of a central tendency far the quantity in question over periods sufficiently long to contain several measurements but sufficiently short to represent a characteristic period of time. In our case, we chose a month as a characteristic period, implying that any one measure within the month was as good as any other (i .e. statistical trends of less than a month's duration are not significant) . Of course there is another tacit understanding here; that each measure is statistically independent. To accomplish this, the measurements should be sufficiently separated that they da not essential ly represent two measures of the same value. The satellite data are inherently separated by one day at a minimum. Although we have assumed that this is sufficient temporal separation for an independent measurement, we may need to address this question in detail later.

The next topic for consideration is the measure of central tendency to be employed. Of the three, average, median and mode, we chose median for the following reasons. In some cases polynyas join to the open ocean or other polynyas for a while. What is their area then, and what does "area" mean in this case? The polynyas can 't be ignored in these cases and therefore simply deleting the observation f ram the data set is statistically unsound. On the other hand, so is adding an arbitrari ly large number to a set to be averaged. For this reason we did not take an average value. Mode is difficult to determine for a limited data set and would tend to emphasize values from strings of data from short time periods within the month - just the sort of data we would wish to reemphasize. Median values on the other hand, are not unduly influenced by a few arbitrarily large values at one end of the data set and tend to deemphasize the importance of continuous strings of data (provided they are short compared to the entire data set) . 'Therefore, we have chosen to determine median monthly values of polynya sizes.

However, this is not the end of the need for definitions. We soon realized that "polynya size" means size of an existing polynya. Thus one could argue that times when the polynya location was frozen or the polynya open to the ocean on one side could arguably be deleted from the data set if one is interested in the actual size of the polynya. On the other hand, as a measure of a process such as salt rejection during freezing, the fact that the polynya is frozen over or completely open is of great importance. Therefore, for this pilot study, we calculated median polynya sizes based on both data set definitions. Finally, we have listed the maximum polynya size observed during each month to give come indication of the variability in polynya size which occurred during the month. These results are shown in Table I.

Table I lists polynya median sizes by month for 1974 (except January and February) , 1975, 1977, 1979, 1983 and 1986 using both data set definitions for median determination, and maximum polynya size for the first 6 months of each year. The polynyas 1 isted are defined by Table 2 and Figure 1.

Figure 1 is a map showing the approximate location of persistent polynyas in the study area where they are given letter designations. Table II is the key between the letter designations and the name given each polynya. However, two of the polynyas for which areas are listed in Table I are actually aggregate po lynyas compiled in order to give an idea of tbe total polynya areas in the study area. "St. Lawrence" is the sum of St. Lawrence, North (E) and St. Lawrence, South (D) . (However, usually only one is open at a time.) Norton Sound (K) is the single polynya at the eastern end of Norton Sound. Kotzebue (Q) is the polynya which occurs between pack ice and fast ice in outer Kotzebue Sound. Chukchi is the sum of Cape Lisburne - Paint Lay (T), Pt. Lay - Icy Cape (U) and Icy Cape - Pt. Barrow (V] . (Often these polynyas join to form a single polynya - this phenomenon occurs within a number of pol ynya systems, making the tracking of the size of a designated polynya a tricky matter.)

These data have not been analyzed further. Our plan is to perform a multivariate analysis of polynya sizes versus time.

3. Data Acquisition and Projects Conducted for OCSEAP Management. We have provided enhanced AVHRR imagery in the vicinity of Kotzebue Sound and in the Beaufort Sea to OCSEAP management. The letters of transmittal - attached as Appendix 1, describe this work.

4. Data Received and Archived. We have continued to obtain and archive dai ly NOAA AVHRR satellite imagery of the OCSEAP study areas around Alaska. Because of the three-to-four times daily coverage of Alaska by these satellites, we cannot possibly afford to purchase a copy of each at the $10.00 per copy rate charged. Thus we select only the best images (approximately three per day and purchase them in positive transparency format directly from the receiving station at Gilmore Creek) . (our experience has shown us that positive transparencies retain the highest information content for analysis and reproduction purposes of all data formats other than digital tapes.)

NOAA AVHRR
positive transparency format

In addition to the positive transparency format data, we also receive hard copy facsimile transmission positive prints that have been used by the weather service. There 1s a great quantity of these prints as they represent at least one copy of

hard copy facsimile transmission positive prints each day' 3 image and sometimes digital enlargements and enhancements of particular areas. These are sent to us by the weather service about a month after they are transmitted from Gilmore Creek. We archive these data (although the image quality is considerably diminished from that of the positive transparency) because some feature of interest to OCSEAP investigators may be found on one of these images which did not appear on an image judged to be one of the day's "best" images. Following these criteria, we archived approximately 270 positive transparencies and 2700 positive facsimile prints this quarter.

Our "Quick-Look" ground station received a total of 66 images from Landsats 4 and 5. This relatively small data set is a result of cloudy weather in late fall and a conscious effort to obtain only useful (relatively cloud-free) imagery. These images are often digitally enhanced and enlarged with copies of these products archived as wel l as the standard 1: 1M scale print. In some instances we have obtained images at times when the sun was below the horizon - yet ice conditions are easily observed. This is an additional value of our ground station and image enhancement capability.

1 LANDSAT 4/5

We also continue to receive and archive the NOAA/NAVY ice charts published weekly and the drifting buoy data published monthly by the Polar Ocean Center in Seattle. Finally, this quarter we acquired Side-Looking Airborne Radar imagery of the Beaufort Sea as part of a data search (see Appendis II). Normally we only monitor the acquisition of this data because of its limited value and not so 1 imited expense.

1 ice charts
1 drifting buoy

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ACTIVITIES NEXT QUARTER

1. Assistance to Brueggeman (RO 625). We are creating a program to distinguish whether a given station is within or outside a polynya from the digitized data. When completed, al 1 3000 nf Brueggeman's whale/no whale data wi 11 be tested for correlation with polynyas.

2. Polynya Analysis. We will continue our analysis of polynya data. Emphasis this quarter will be applied to determining trends and significance of polynya extent data similar to and including the data reported here in Table I.

3. Data Acquisition. We will continue to acquire and archive Landsat and AVHRR satel 1 ite imagery as well as NOAA/Navy ice charts and ice drifting buoy data.

FUNDS EXPENDED

As of December 31, 1986 we have expended $101,940 of a total authorized $205,799.

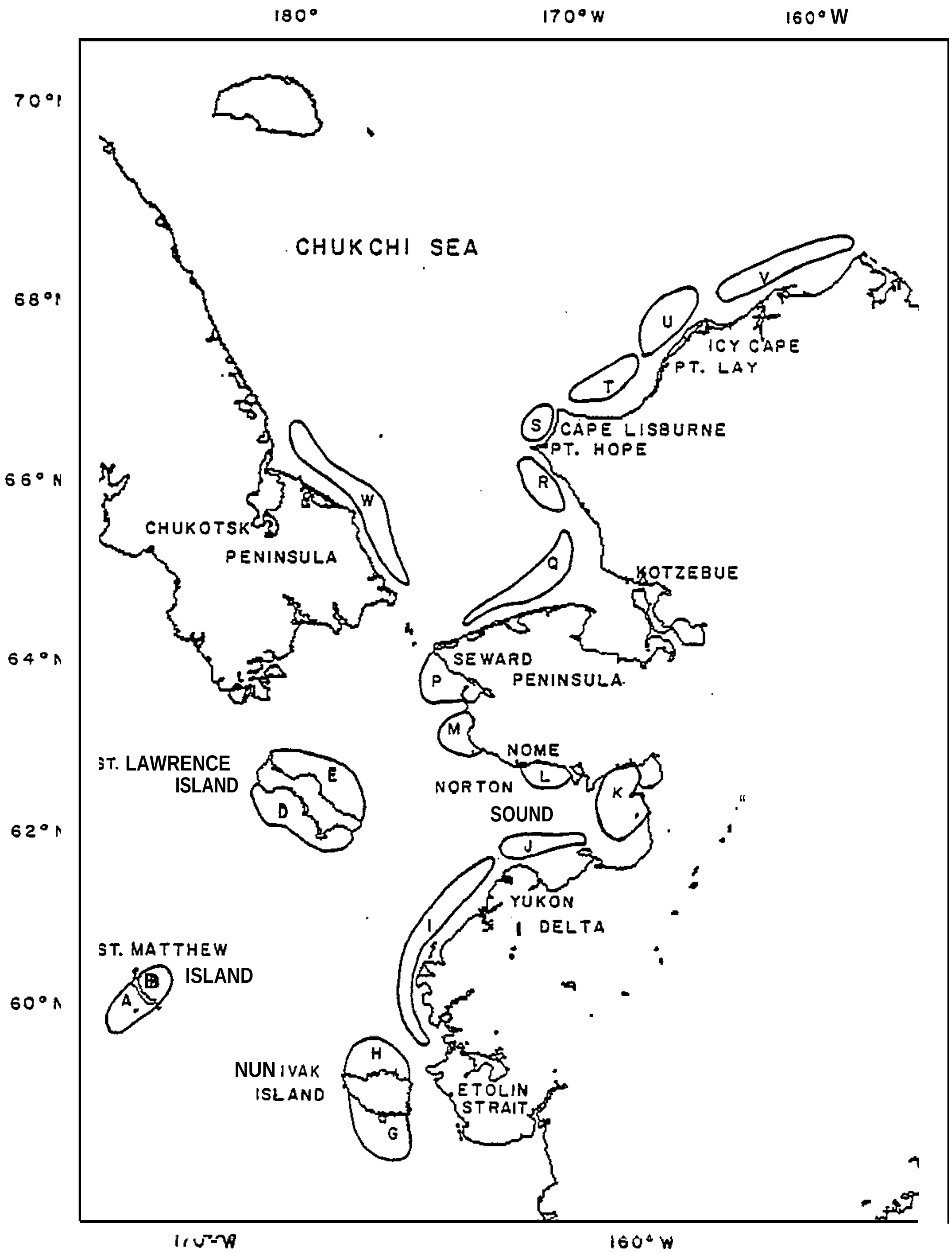

Figure 1. Map showing approximate location of persistent polynyas in the Bering Sea/ Chukchi Sea study area.

TABLE I. Tabulation of Polynya Area Medians for Six Months over Six Years.

JANUARY

Polynya	1975 Median Area*	1975 Median Area**	1975 Maximum Area	1977 Median Area*	1977 Median Area**	1977 Maximum Area
	km^2	km^2	km^2	km^2	km^2	km^2
St. Lawrence	3120	3120	27100	2260	2260	3140
Norton Sound	218	1610	2590	0	1400	3420
Kotzebue	360	3940	11 100	4520	5820	7860
Chukchi	0	0	1650	283	2500	18200

Polynya	1979 Median Area*	1979 Median Area**	1979 Maximum Area	1983 Median Area*	1983 Median fires**	1983 Maximum Area
	km	km	km	km	km	km
St. Lawrence	Open	Open	Open	1880	1940	3440
Norton Sound	1670	1700	7620	1630	1660	8950
Kotzebue	0	1490	1490	0	1550	4840
Chukchi	785	3800	15800	0	585	1920

Polynya	1986 Median Area*	1986 Median i%-es*++	1986 Maximum Area
	km	km	km
St. Lawrence	2000	2000	10500
Norton Sound	1380	1 SC10	4230
Kotzebue	452	620	1780
Chukchi	1050	1050	7410

FEBRUARY

Polynya	1975 Median Area* km	1975 Median Area** km	1975 Maximum (%-es km	1976 Median Area* km	1976 Median Area** km	1976 Maximum Area km
St. Lawrence	1720	3240	8550	740	820	2570
Norton Sound	8640	9280	30400	.564	708	6060
Kotzebue	10600	10600	14900	o	670	927
Chukchi	15700	15700	36100	0	0	0

Polynya	1 977 Median Area* km	1 977 Median Area** km	1 977 Maximum Area km	1979 Median Area* km	1979 Median Area** km	1979 Maximum Area km
St. Lawrence	1640	1640	2780	2350	4580	10200
Norton Sound	1130	1130	9120	788	853	17600
Kotzebue	0	0	0	1020	2260	7040
Chukchi	0	673	5640	1830	2150	3300

Polynya	1983 Median Area* km	1983 Median #W-es** km	1983 Maximum Area km
St. Lawrence	2 (:)&o	2060	3360
Norton Sound	1260	1260	1720
Kotzebue	o	4500	4500
Chukchi	0	2640	4340

MARCH

Polynya	1974 Median Area* km	1974 Median Area** km	1974 Maximum Area km	1975 Median Area* km	1975 Median Area** km	1975 Maximum Area km
St. Lawrence	1640	3680	9620	4280	4370	13200
Norton Sound	1420	2500	9220	1600	3110	25000
Kotzebue	0	458	458	2660	2850	7300
Chukchi	0	260	831	1020	1020	7440

Polynya	1976 Median Area* km	1976 Median Area** km	1976 Maximum Area km	1977 Median Area* km	1977 Median Area** km	1977 Maximum Area km
St. Lawrence	8790	9500	20200	1630	1720	6290
Norton Sound	1640	1670	7460	0	2090	11400
Kotzebue	0	1400	3030	0	0	0
Chukchi	0	925	1580	0	728	1440

Polynya	1979 Median Area* km	1979 Median Area** km	1979 Maximum Area km	1983 Median Area* km	1983 Median Area** km	1983 Maximum Area km
St. Lawrence	2200	2200	8180	2600	2600	11s00
Norton Sound	5780	5780	15500	9260	9260	16s00
Kotzebue	314	3350	9600	0	238	30s
Chukchi	1260	1680	4410	1020	2100	3900

APRIL

Polynya	1974 Median Area* km	1974 Median Area** km	1974 Maximum Area km	1975 Median Area* km	1975 Median Area** km	1975 Maximum Area km
St. Lawrence	5680	5680	90100	2770	3260	10900
Norton Sound	10300	10300	132C)CI	1080	2390	5920
Kotzebue	0	0	0	1170	3000	3910
Chukchi	0	331	4170	1290	5350	28200

Polynya	1976 Median Area* km	1976 Median Area** km	1976 Maximum Area km	1977 Median Area* km	1977 Median Area** km	1977 Maximum Area km
St. Lawrence	5180	5500	1 2000	2580	4040	14400
Norton Sound	2380	2380	5590	1440	2230	6560
Kotzebue	0	327	327	0	151	237
Chukchi	o	248	421	0	952	2690

Polynya	1979 Median Area* km	1979 Median Area** km	1979 Maximum Area i:m	1983 Median Area* km	1983 Median Area** km	1983 Maximum Area km
St. Lawrence	13600	5650	Open	4890	2230	Open
Norton Sound	16500	13soc)	Open	16300	103C)0	Open
Kotzebue	722	786	Open	221	960	1490
Chukchi	1360	17.?0	7200	1180	1310	9570

JUNE

Pol ynya	1974 Median Area* km	1974 Medi an Area** k m	1974 Maximum Area km	1975 Median Area* km	1975 Median Area** km	1975 Maximum Area km
St. Lawrence	Open	Open	Open	Open	Open	Open
Norton Sound	Open	Open	Open	34400	34400	Open
Kotzebue	o	0	Open	259	346	Open
Chukchi	10000	10000	25700	40300	40300	50500

Pol ynya	1 ?76 Median Area* km	1 ?76 Medi an &-es** km	1 ?76 Maximum Area km	1977 Medi an Area* km	1977 Median Area** km	1977 Maximum Area km
St. Lawrence	Open	Open	Open	Open	Open	Open
Norton Sound	Open	Open	Open	Open	Open	Open
Kotzebue	0	0	0	444	444	Open
Chukchi	7300	7300	14200	6600	6600	23000

Polynya	1979 Median Area* km	1979 Medi an Area** km	1979 Maximum Area km	1983 Median Area* km	1983 Median Area** km	1983 Maximum Area km
St. Lawrence	Open	Open	Open	Open	Open	Open
Norton Sound	Open	Open	Open	Open	Open	Open
Kotzebue	Open	Open	Open	542	572	Open
Chukchi	5710	8040	open	943	943	12000

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JULY

Polynya	1974 Median Area* km	1974 Median Area** km	1974 Maximum Area km	1975 Median (%-es* km	1975 Median Area** km	1975 Maximum Area km
St. Lawrence	Open	Open	Open	open	Open	Open
Norton Sound	Open	Open	Open	Open	Open	Open
Kotzebue	Open	Open	open	Open	Open	Open
Chukchi	18400	18400	Open	5460	5460	Open

Polynya	i 97.5 Median Area* km	i 97.5 Median 4h-es** km	i 97.5 Maximum Area km	1977 Median Area* km	1977 Median Area** km	1977 Maximum Area km
St. Lawrence	Open	Open	Open	Open	Open	open
Norton Sound	Open	Open	Open	Open	Open	Open
Kotzebue	Open	Open	Open	Open	Open	Open
Chukchi	1090c1	1 0900	Open	23100	23100	Open

Polynya	i 983 Median Area* km	i 983 Median Area** km	i 983 Maximum Area km
St. Lawrence	Open	Open	Open
Norton Sound	Open	Open	Open
Kotzebue	open	Open	Open
Chukchi	5440	5440	Open

*Median of all possible area determinations of the polynya. It includes those where the polynya was frozen over (area = 0), and those where the polynya has become part of the open ocean.

**Median of area determinations excluding those cases where the polynya was frozen over (area =0) as well as those where the polynya has become part of the open ocean.

TABLE II. IDENTIFICATION OF POLYNYI.

LOCATION OF POLYNYI	CODED DESIGNATION ON ALASKA BASE MAP
St. Matthew Island, South	A
St. Matthew Island, North	B
8St. Lawrence Island, South	D
St. Lawrence Island, North	E
Nunivak Island, South	G
Nunivak Island, North	H
Etolin Strait-Yukon Delta	I
Yukon Delta	J
Norton Sound	K
Nome	L
Seward Peninsual, South	M
Seward Peninsula, North	P
Kotzebue	Q
Cape Thompson-Pt. Hope*	R
Pt. Hope-Cape Lisburne	S
Cape Lisburne to Pt. Lay**	T
Pt. Lay to Ice Cape**	u
Ice Cape to Pt. Barrow**	v
Chukotsk Peninsula	W
Anadyr Polynya	Y

* Carleton (1975)

** Chukchi Polynya (Stringer, 19S2)

APPENDIX I

November 11, 1986

Dr. Jawed Hameedi
NOAA/Ocean Assessments Div.
Alaska Office
P.O. Box 56
Anchorage, AK 99513

Dear Jawed:

Enclosed with this Letter are copies of the data you requested. The latest moderately clear day in your study area before your cruise was August 26 (Julian day 238) and the earliest clear day afterward was September 28 (Julian daY 271). The data are all from northbound passes and therefore the images al ? appear upside down.

For day 238 we have a regional scale band 1 (visual wavelengths) image. Perhaps the greatest value of this image is that it shows the location of cloud-free data. Next, we have the band 1 digital enlargement and enhancement, and final ly, the band 4 (thermal IR) digital enlargement and enhancement. Here each l°C temperature increment is denoted by a *separate* gray value.

For day 271 we bare again a regional image--only this time it is band 4 (thermal IR) . One interesting feature of this image is the temperature difference between the two separate cloud regimes. Following this is a band Z (near IR) band digitally enlarged *image* (a band 1 image will be requested-- I am not sure why they provided this image, as band 1 shows sediment plumes best). Finally, we have a band 4 digital enlargement and enhancement with 1°C temperature increments.

It's interesting to me that the surface temperature pattern appears to have remained somewhat *constant over this* period. It would also be interesting to monitor the surface temperature pattern over an entire open water season.

Please tel 1 Erdogan we are starting on his Beaufort Sea data and hope to have results for him soon.

Best regards.

Bill *Stringer*

BS:jd

December 5, 1986

Dr. Jawed Hameedi
NOAA/Ocean Assessments Div.
Alaska Office
P.O. Box 56
Anchorage, AK 99513

Dear Dr. Hameedi:

Enclosed wick this letter is the visible band image of the southern Chukchi Sea I promised. As you can see, the land is almost as dark as the ocean and some sediment can be seen as a gray level between these two (and in most cases, physically between them as well). I don't think we would see any more detail here regardless of how much contrast stretch was applied. However, I am willing to attempt it if you chink it worthwhile.

Meanwhile, I have acquired transparencies of the thermal band images and am prepared to produce as many copies of them as might be ==@=f-

1 should also let you knew that I am pulling some materials together as per a request from Dale Kinney for an MMS publication. It isn't a big project and I'm sore than happy to da it.

Finally, I should express our (myself, Jan, Joanne and Mark) appreciation to OCSEAP for the contract extension. It has done a lot for our morale in au otherwise uncertain time.

Sincerely,

Bill Stringer

BS:jd

December 5, 1986

Erdogan Ozturgut
NOAA/NOS/OAD
701 C Street
PO Box 56
Anchorage, AK 99513

Dear Dr. Ozturgut:

Enclosed with this letter is the first attempt to obtain Beaufort Sea imagery during this October. Please don't be depressed and don't throw them out just yet. These images were obtained on Julian days 276 (Oct. 3), 279 (Oct. 6) and 282 (Oct. 9). They are from the thermal band and have the same grey scale versus temperature that was used for the images of the Chukchi Seas sent earlier. White is the freezing temperature of seawater and the grey steps are in 1 °C increments warmer. As you can see, it was mostly colder than that.

Before I go any further I should tell you that I have another grey scale version in the works that should show more detail and that will be sent along shortly.

Meanwhile we might look at these images for a minute. The pair from Oct. 9 shows the most detail and I will discuss it first. I have indicated the location of Barrow and Harrison Bay on this image. Note that the data ber 1s upside down at the top. This results from the happenstance that these data came from a northbound satellite. Also, I have indicated on the more southerly image approximately where the second image overlays it. (Mackenzie Bay is in the more southerly image but it was too cold to see any detail here.) Once you become oriented to this image you can see quite a bit of temperature structure in the open water/partially frozen area of the Beaufort Sea. This is worth saving because the next version will most likely show a lot more structure in the ice, but less in this area. Thus, together they should give a more complete picture of ice conditions in the region.

The other two sets of images have me puzzled for the moment. It is possible that they were accidently obtained from an area further offshore. For the time being I can say no more about them. The mystery may become solved when we see the next set of images.

Sincerely,

Bill stringer

BS:jd

P.S. Just in case they may have taken Beaufort Sea radar data at this time, I have placed an inquiry with Canada's Ice Centre for a catalog of their data. A comparison of radar and thermal IR data might be very useful.

APPENDIX II

GO AHEAD FOR NEW CALL
ETT GA 0053376I/*
GEOPH INST FBK

IZ 03 I828V
DOE AESICE OTT

GEOPH INST FBK
ZCZC 09 FAIRBANKS, ALASKA USA, 03, DECEMBER, 1986

TO: F.E. GEDDES
SENIOR ICE CLIMATOLOGICAL TECHNICIAN
ICE CENTRE ENVIRONMENTAL CANADA
365 LOURIER AVENUE WEST
JOURNAL TOWER SOUTH
OTTAWA, CANADA KIA OH3
TELEX: 053-3761 DOE AES ICE OT

DEAR MR. GEDDES:
WE WOULD LIKE TO PURCHASE COPIES OF RADAR IMAGERY OF THE ALASKAN/CANADIAN COAST FROM MACKENZIE BAY WESTWARD. COULD YOU PLEASE ADVISE US OF COVERAGE WHICH HAS OCCURED BETWEEN SEPTEMBER, 1985 AND PRESENT. ALSO PLEASE ADVISE US OF YOUR CURRENT COST SCHEDULE.

THANK YOU.

WILLIAM J. STRINGER
UNIVERSITY OF ALASKA - FAIRBANKS
GEOPHYSICAL INSTITUTE
TELEX: 35414
DOE AESICE OTT

I830EST 002.40

TIME 005.2 MINS

RCV20453 08:56 12/17/86

GEOPH INST FBK

DOE AESICE OTT
FOLLOWING FOR WILLIAM J STRINGER
UNIVERSITY OF ALASKA
GEOPHYSICAL INSTITUTE

REUR TELEX 041286

THERE HAVE BEEN 45-50 FLIGHTS ALONG THE ALASKAN COAST FROM SEPTEMBER 1985 TO PRESENT, THE MAJORITY OF WHICH ARE IN THE JUNE TO SEPTEMBER PERIOD. THE COST PER NEGATIVE DUPLICATE IS 140 DLRS CDN PLUS COURIER CHARGES. A LISTING OF ALL FLIGHTS CAN BE MAILED IF SO DESIRED.

GEDDES
ICE CLIMATOLOGY OTTAWA
161840
GEOPH INST FBK

DOE AESICE OTT

TOD DEC 17 86

CONVERS2 034 ... 12/18/86

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18 86 1543 02749F

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C 027 FAIRBANKS ALASKA USA 18 DEC 1986

N. GEDDES

CLIMATOLOGY OTTAWA

EX 0533761 DOE AESICE OTT

YOUR TELEX 12/17/86

ASE MAIL LISTING OF ALL FLIGHTS ALONG ALASKAN COAST
WEEN SEPT 85 TO PRESENT AS YOU OFFERED. IF YOU
A FLIGHT BETWEEN OCT 1 AND OCT 20, 1986 WE WISH TO
ER IT NOW AND WILL FORWARD $120 DOLLARS CANADIAN PLUS
URIER CHARGES VIA ANY MEDIUM YOU SUGGEST

ANK YOU,
STRINGER
LEX 35414 GEOPH INST FBK

E AESICE OTT

ME 001 X MINS

Bill —
What shall I
charge for this?
Doug

Environment Canada / Environnement Canada
Atmospheric Environment Service / Service de l'environnement atmosphérique

Ice Centre Environment Canada
365 Laurier Avenue Weet
Journal Tower South, 3rd Fir.
Ottawa, Canada KIA 0H3

Your file Voire référence

Our file Notre référence
8280 -6(ACIC)

12 September, 1985

Geophysical Institute
University of Alaska
C.T. Elvey Building
Room 608
Fairbanks, Alaska 9977 S-0800
ATTN: Mr. Bill Stringer

Dear Mr. Stringer:

Aug 8, 1985

Enclosed, as requested in your telex and purchase order (51771-4912) dated 14 August 1985, please find the following:

A. NegaCive Duplicate and logs for NDZ flight 1464 - 19 June 1985

B. Negative duplicate and logs for NDZ flight 1475 - 07 July 1985

C. Negative duplicate and logs for NDZ flight 1476 - 08 July 1985

Positive paper prints can also be obtained if so desired. An invoice will be forwarded as soon as costs have been determined.

Yours truly,

F.E. Geddes
Senior Ice
Climatological Technician

Enclosure

ICEC086STRINGER

RCV20465 07:01 12/19/86

30 DEC 19 86

RCV20466 07:03 12/19/86

DOC ASIGE OTT

GEOPH INST FBK

ATTN: W. STRINGER

FOLLOWING IS A LIST OF DATES FOR FLIGHT SLAR IN YOUR AREA OF INTEREST

1985

SEPT 7 14 16 20 22 24 29
OCT 2 3 4 5 7 9 11 19 20
NOV 12

1986

FEB 14
MAY 17
JUNE 28
JULY 1 4 7 12 17 20 22 23 28 31
AUG 3 6 7 9 17 21 26 27 30
SEPT 5 11 14 16 19 21 23 29
OCT 27

REGARDS
CEDDES
ICE CLIMATOLOGY
1910SSEST

GEOPH INST FBK

DOC ASIGE OTT

30 DEC 19 86

Reply

Ref your telex of 12/19/86 please send copies of radar imagery from Sept 29 and Oct 27 1986. I have generated a purchase order for $240 for imagery plus $60 for courier costs payable to Ice Centre, Canada. PO number is 54225-4610, Geophysical Institute, University of Alaska. Payment will be by check unless you specify otherwise. Thank you. Bill Stringer

54225-4610

CONVER82 149 08:35 12/22/86

EL SEC
0053776I
DEC 22 86 0829 008191
GEOPH INST FBK

DOE AESICE OTT

UNABLE TO TRANSMIT FOLLOWING MESSAGE TO YOU ON 12/19/86. YOUR
TELEX KEPT REGISTERING A NF OR NC. LOOKS OK NOW.

ZCZC 032 FAIRBANKS ALASKA USA 19 DEC 1986
ATTN: GEDDES
ICE CLIMATOLOGY
TELEX: 053-3761
BT
REF: YOUR TELEX OF 12/19/86

PLEASE SEND COPIES OF RADAR IMAGERY FROM SEPT. 29 AND OCT. 27 1986.
I HAVE GENERATED A PURCHASE ORDER FOR $240 FOR IMAGERY PLUS $60
FOR COURIER COSTS PAYABLE TO ICE CENTRAL, CANADA. P.O. NUMBER IS
54223-4610. GEOPHYSICAL INSTITUTE, UNIVERSITY OF ALASKA. PAYMENT
WILL BE BY CHECK UNLESS YOU SPECIFY OTHERWISE. THANK YOU.

BILL STRINGER
TELEX 35414 GEOPH INST FBK
K
DOE AESICE OTT

TIME 002.7 MINS

Dee
Finally got
this out —
Doug

RU 663

AK - OCSEAP

RE MOTE SENSING

Rec - 1/4/88

REMOTE SENSING DATA ACQUISITION
ANALYSIS AND ARCHIVAL

SIXTH QUARTERLY REPORT

April 1, '19S7 - June. 30, 1987

OCSEAP Research Unit 663

by

William J. Stringer
Geophysical Institute
University of Alaska Fairbanks
Fairbanks, Alaska 99775-0800

Submitted to

National Oceanic & Atmospheric Administration
Ocean Assessments Division
Alaska Office
PO Box 56
Anchorage, Alaska 99513

September 1987

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SIXTH QUARTERLY REPORT
April 1 - June 30, 1987
OCSEAP Research Unit 663
Contract #50ABNC 600041

ACTIVITIES THIS QUARTER

1. Assistance to MSS. Everett Tornfelt of the Anchorage MMS Office requested a data search and copies of appropriately selected imagery. This was accomplished (see our letter of transmittal and response from MMS attached as Appendix 1).

2. Polynya Analysis. Last quarter we supplied plots of polynya data for the Bering and Chukchi Sea polynyas we are analyzing. These plots gave the measured areas for the polynyas as a function of time. Since these plots show all the measured values for extent as measured from archived satellite data, they also serve as a record of available imagery of these polynyas including the existence of sets of time series data for later detailed analysis relating polynya behavior with meteorological and oceanic parameters.

This quarter we have condensed these data into a statistical summary (attached as Appendix 2) giving a wide range of statistical parameters for each polynya on a monthly basis.

3. Data Received and Archived. We have continued to obtain and archive daily NOAA AVHRR satellite imagery of the OCSEAP study areas around Alaska. Because of the three-to-four times daily coverage of Alaska by these satellites, we cannot possibly

afford to purchase a copy of each at the $10.00 per copy rate charged. Thus we select only the best images (approximately three per day and purchase them" in positive transparency format directly from the receiving station at Gilmore Creek). (Our experience has shown us that positive transparencies retain the highest information content for analysis and reproduction purposes of all data formats other than digital tapes.)

In addition to the positive transparency format data, we also receive hard copy facsimile transmission positive prints that have been used by the weather service. There is a great quantity of these prints, as they represent at least one copy of each day's image and sometimes digital enlargements and enhancements of particular areas. These are sent to us by the weather service about a month after they are transmitted from Gilmore Creek. We archive these data (although the image quality is considerably diminished from that of the positive transparency) because some feature of interest to OCSEAP investigators may be found on one of these images which did not appear on an image judged to be one of the day's "best" images. Following these criteria, we archived approximately 517 positive transparencies and 3998 positive facsimile prints this quarter.

Our "Quick-Look" ground station received a total of 184 images from Landsats 4 and 5. These images are often digitally enhanced and enlarged with copies of these products archived as well as the standard 1:1M scale print. In some instances we have obtained images at times when the sun was below the horizon - yet ice conditions are easily observed. This is an additional value of our ground station and image enhancement capability.

We also continue to receive and archive the NOAA/Navy ice charts published weekly and the drifting buoy data published monthly by the Polar Ocean Centsr in Seattle.

ACTIVITIES NEXT QUARTER

1. We are anticipating providing remotely sensed data to OCSEAP investigators performing field work aboard the NOAA Ship, Surveyor.

2. We will continue to collect remotely sensed AVHRR and Landsat data.

3. We will monitor the availability of the SSMI passive microwave data which should become available in September or October.

4. Continuing Polynya Analysis. Our earlier efforts to relate polynya size with local winds on a monthly basis did not yield many positive correlations. In order to test whether monthly sorting is too "coarse'" we will divide the data set into hi-monthly sets and perform the analysis on that basis.

On the other hand, we note Robert Pritchard's recent OCSEAP-sponsored research which reports poor correlation between ice motion and geostrophic winds. We want to investigate these results for their implications to polynya formation and size.

APPENDIX 1

February 18, 1987

Everett Tornfelt
Minerals Management Service
949 E. 36th Avenue
Room 110
Anchorage, Ak 99508-4302

Dear Mr. Tornfelt:

Enclosed with this letter are three enlargements of AVHRR images from September 15, 18 and 28, 19S3. We conducted a search of imagery available since 1973 and found that this set of images illustrates best the conditions encountered by the whaling fleet. However, the conditions shown here may be one "cape" northward of the location where the fleet was caught. (See dates on back of images.) The September 15/18 pair shows how fast the ice can move shoreward. The ice remained there and can be seen "freezing in" on the 28th. (Notice that Elson Lagoon North of Barrow has frozen over.)

Best regards,

Bill Stringer
Associate Professor of
Geophysics

BS:jd

encl .

cc : Jawed Hameedi ,

Hello Bill

27 Mar 87

Just wanted to drop a brief note thanking you for the photos.. just what we wanted.

again, thanks

Dale Kenney
MMS

APPENDIX N

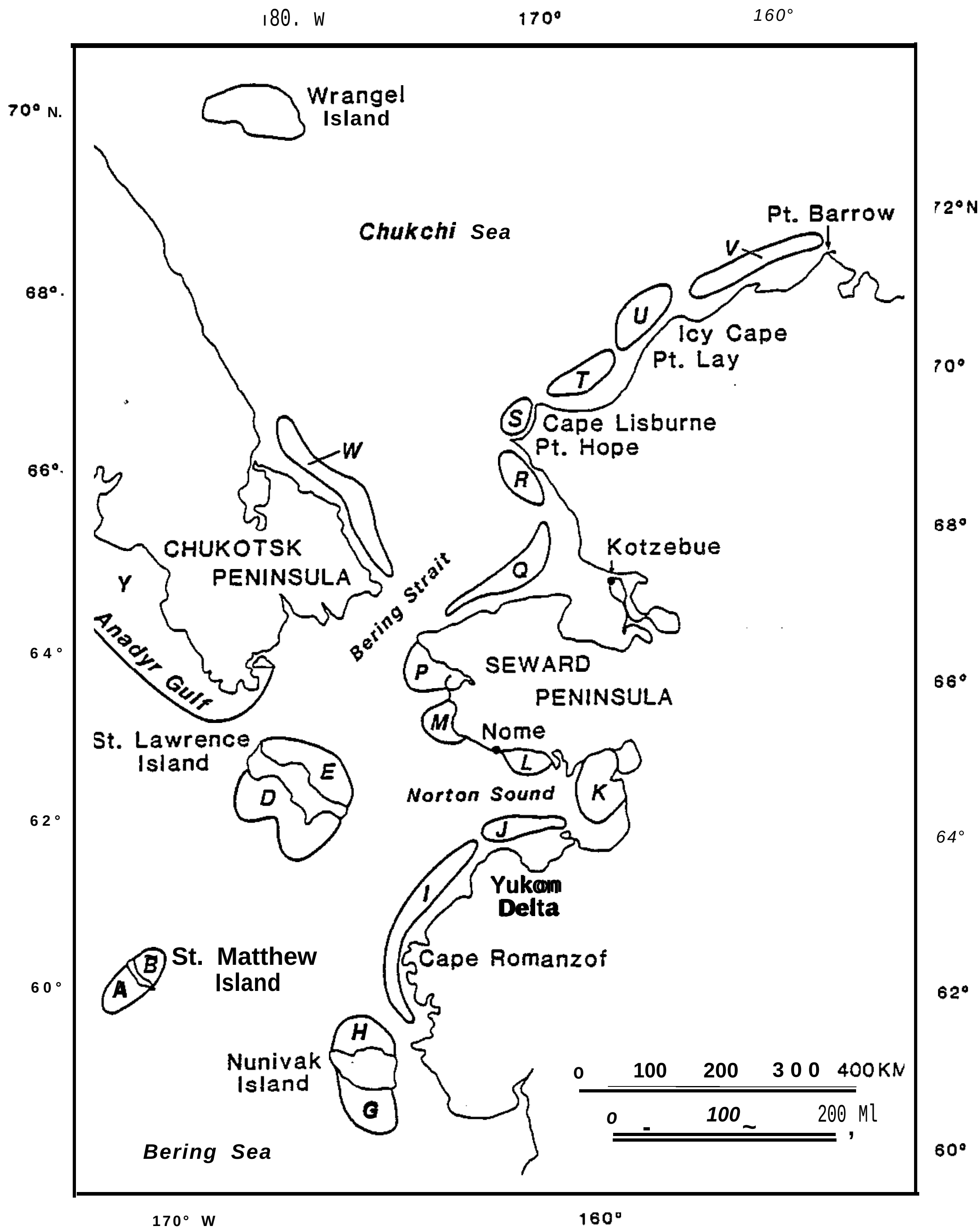

Figure 1. Map showing approximate location of persistent polynyas in the Bering Sea/ Chukchi Sea study area.

TABLE 1

IDENTIFICATION OF POLYNYI

LOCATION OF POLYNYI	CODED DESIGNATION ON ALASKA BASE MAP
St. Matthew Island Polynya, South	A
St. Matthew Island Polynya, North	B
St. Lawrence Island Polynya, South	D
St. Lawrence Island Polynya , North	E
Nunivak Island Polynya, South	G
Nunivak Island' Polynya, North	H
Cape Romanzof Polynya	I
Yukon Delta Polynya	J
Norton Sound Polynya	K
Nome Polynya	L
Seward Peninsula Polynya, South	M
Seward Peninsula Polynya, North	P
Kotzebue Sound Polynya	Q
Cape Thompson-Pt. Hope Polynya *	R
Pt. Hope-Cape Lisburne Polynya	S
Cape Lisburne to Pt. Lay Polynya **	T
Pt. Lay to Icy Cape Polynya *'	U
Icy Cape to Pt. Barrow Polynya **	V
Chukotsk Peninsula Polynya	W
Anadyr Gulf Polynya	Y

* Carlton, 1975
** Chukchi Polynya (Stringer, 1982)

Table 55: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, South (A) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	6	14
Average	0	5690	
Median**	0	7220	3040
Mode	0	1140	OPEN
Geometric mean		3660	
Standard deviation	0	3900	
Standard error	0	1590	
Minimum	0	497	436
Maximum	0	9110	OPEN
Range	0	8610	

	MAY	JUNE	JULY
Sample size	31	30	5
Average	OPEN	OPEN	OPEN
Median**	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean	OPEN	OPEN	OPEN
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	OPEN	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range	0	0	0

Table 56: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, North (5) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	6	11
Average	0	0	
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	0	
Standard error	0	0	
Minimum	0	0	0
Maximum	0	0	OPEN
Range	0	0	

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 56: Monthly **Summary Statistics** of Polynya Areas* for St. Matthew Island Polynya, North (B) **in** 1974.

	MAY	JUNE	JULY
Sample size	31	30	5
Average	OPEN	OPEN	OPEN
Median**	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean	OPEN	OPEN	OPEN
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	OPEN	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range	0	0	0

Table 57: Monthly Summary Statistics of Polynya Areas* for St. **Lawrence** Island Polynya, South (D) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	11	14
Average	0	2660	
Median**	0	2770	6200
Mode	0	0	
Geometric mean			
Standard deviation	0	2960	
Standard error	0	894	
Minimum	0	0	2680
Maximum	0	9620	OPEN
Range	0	9620	

	MAY	**JUNE**	**JULY**
Sample size	31	30	5
Average	OPEN	OPEN	OPEN
Median**	OPEN	**OPEN**	OPEN
Mode	**OPEN**	OPEN	OPEN
Geometric mean	OPEN	OPEN	**OPEN**
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	OPEN	OPEN	OPEN
Maximum	**OFEN**	OPEN	OPEN
Range	0	0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 58: Monthly Summary Statistics of Polynya Areas* for St. Lawrence Island Polynya, North (E) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	11	9
Average	0	0	
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	0	
Standard error	0	0	
Minimum	0	0	0
Maximum	0	0	OPEN
Range	0	0	

	MAY	JUNE	JULY
Sample size	31	30	5
Average	OPEN	OPEN	OPEN
Median**	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean	OPEN	OPEN	OPEN
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	OPEN	OFEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range	0	0	0

Table 59: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, South (G) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	9	11
Average	0	3720	
Median**	0	4460	41400
Mode	0	0	OPEN
Geometric mean			
Standard deviation	0	3810	
Standard error	0	1270	
Minimum	0	0	1030
Maximum	0	9200	OPEN
Range	0	9200	

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 59: Monthly **Summary Statistics** of Polynya Areas* for Nunivak Island Polynya, South (G) in 1974.

	MAY	JUNE	JULY
Sample size	31	30	5
Average**	OPEN	OPEN	OPEN
Median	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean	OPEN	OPEN	OPEN
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	OPEN	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range	0	0	0

Table 60: Monthly **Summary Statistics** of Polynya Areas* for Nunivak Island Polynya, North (H) in 1?74.

	FEBRUARY	MARCH	APRIL
Sample size	1	9	8
Average**	0	4440	
Median	0	0	77300
Mode	0	0	OPEN
Geometric mean			
Standard deviation	0	7620	
Standard error	0	2540	
Minimum	0	0	16600
Maximum	0	22100	OPEN
Range	0	22100	

	MAY	JUNE	JULY
Sample size	1	30	5
Average**	OPEN	OPEN	OFEN
Median	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean	OPEN	OPEN	OPEN
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	OPEN	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range	0	0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 61: Monthly Summary Statistics of Polynya Areas* for Cape Romanzof Polynya (I) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	15	9
Average	0	9720	
Median**	c)	2000	54600
Mode	0	0	OPEN
Geometric mean			
Standard deviation	0	140 00	
Standard error	0	3620	
Minimum	0	0	529
Maximum	0	42200	OPEN
Range	0	42200	

	MAY	JUNE	JULY
Sample size	31	30	5
Average	OPEN	OPEN	OPEN
Median**	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OFEN
Geometric mean	OPEN	OPEN	OPEN
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	OPEN	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range	0	0	0

Table 62: Monthly Summary Statistics of Polynya Areas* for Yukon Delta Polynya (J) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	14	15
Average	0	0	4800
Median**	0	0	0
Made	0	0	0
Geometric mean			
Standard deviation	0	0	5430
Standard error	0	0	1400
Minimum	0	0	0
Maximum	Cl	0	12400
Range	0	0	i2400

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

***Median is equivalent to median size recorded in Tables 44-50.*

Table 62: Monthly Summary Statistics of Polynya Areas* for Yukon Delta Polynya (J) in 1974.

	MAY	JUNE	JULY
Sample size	18	30	5
Average		OPEN	OPEN
Median**	0	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	0	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

Table 63: Monthly Summary Statistics of Polynya Areas* for Norton Sound Polynya (K) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	14	25
Average	0	3630	10100
Median**	0	2500	9800
Mode	0	771	9740
Geometric mean			10000
Standard deviation	0	3510	1500
Standard error	0	937	300
Minimum	0	0	7920
Maximum	0	9220	13200
Range	0	9220	5280

	MAY	JUNE	JULY
Sample size	19	30	5
Average		OPEN	OPEN
Median**	17200	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	10100	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 64: Monthly **Summary** Statistics of Polynya Areas* for *Nome Polynya (1-)* **in** 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	14	25
Average	0	3430	10100
Median**	0	2240	9800
Mode	0	0	9740
Geometric mean			10000
Standard deviation	0	3680	1500
Standard error	0	984	300
Minimum	0	0	7920
Maximum	0	9220	13200
Range	0	9220	5280

	MAY	JUNE	JULY
Sample size	19	30	5
Average		OPEN	OPEN
Median**	172!:10	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OFEN
Standard deviation		0	0
Standard error		0	0
Minimum	10100	OPEN	OPEN
Maximum	OPEN	OFEN	OPEN
Range		0	0

Table 65: Monthly Summary Statistics **of** Polynya Areas* for Seward Peninsula Polynya, South (M) **in** 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	13	21
Average	0	901	2120
Median**	0	623	2220
Mode	0	0	1720
Geometric mean			
Standard deviation	0	876	1390
Standard error	0	243	304
Minimum	0	0	0
Maximum	0	2430	5240
Range	0	2430	5240

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 65: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, South (M) in 1974.

	MAY	JUNE	JULY
Sample size	21	30	5
Average**		OPEN	OPEN
Median	1650	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	0	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

Table 66: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, North (P) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	12	20
Average**	0	781	2100
Median	0	0	2270
Mode	0	0	0
Geometric mean			
Standard deviation	0	985	1470
Standard error	0	284	330
Minimum	0	0	0
Maximum	0	2430	5240
Range	0	2430	5240

	MAY	JUNE	JULY
Sample size	17	31	5
Average**		OPEN	OPEN
Median	1440	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	0	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 67: Monthly Summary Statistics of Polynya Areas* for Kotzebue Sound Polynya (Q) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	12	18
Average	0	38	0
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	132	0
Standard error	0	38	0
Minimum	0	0	0
Maximum	0	458	0
Range	0	458	0

	MAY	JUNE	JULY
Sample size	28	15	5
Average	0		OPEN
Median**	0	0	OPEN
Mode	0	0	OPEN
Geometric mean			OPEN
Standard deviation	0		0
Standard error	0		0
Minimum	0	0	OPEN
Maximum	0	OPEN	OPEN
Range	0		0

Table 68: Monthly Summary Statistics of Polynya Areas* for Cape Thompson-Pt. Hope Polynya (R) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	17	22
Average	0	1050	1690
Median**	0	954	2080
Mode	0	0	0
Geometric mean			
Standard deviation	0	933	1240
Standard error	0	226	265
Minimum	0	0	0
Maximum	0	2360	3740
Range	0	2360	3740

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 68: Monthly Summary Statistics of Polynya Areas* for Cape Thompson-Pt. Hope Polynya (R) in 1974.

	MAY	JUNE	JULY
Sample size	27	17	3
Average	149	1550	
Median**	121	155	17500
Mode	0	0	0
Geometric mean			
Standard deviation	151	4650	
Standard error	29	1130	
Minimum	0	0	0
Maximum	572	19400	OPEN
Range	572	19400	

Table 69: Monthly Summary Statistics of Polynya Areas* for Pt. Hope-Cape Lisburne Polynya (S) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	15	21
Average	0	228	236
Median**	0	36	268
Mode	0	0	0
Geometric mean			
Standard deviation	0	375	135
Standard error	0	97	29
Minimum	0	0	0
Maximum	0	1270	442
Range	0	1270	442

	MAY	JUNE	JULY
Sample size	30	15	3
Average	4990	11400	
Median**	648	10900	19400
Mode	0	10700	
Geometric mean		6830	
Standard deviation	7760	[illegible]	
Standard error	1420	1990	
Minimum	0	261	[illegible]
Maximum	20300	25700	OPEN
Range	[illegible]	25400	

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 70: Monthly Summary Statistics of Polynya Areas* for Cape Lisburne to Pt. Lay Polynya (T) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	17	19
Average	0	98	333
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	229	953
Standard error	0	55	220
Minimum	0	0	0
Maximum	0	831	4170
Range	0	831	4170

	MAY	JUNE	JULY
Sample size	27	18	.
Average	7600	11300	
Median**	5990	10400	OPEN
Mode	0	9140	
Geometric mean		9400	
Standard deviation	7140	6430	
Standard error	1370	1520	
Minimum	0	1300	17500
Maximum	[illegible]	25700	OPEN
Range	20300	24400	

Table 71: Monthly Summary Statistics of Polynya Areas* for Pt. Lay to Icy Cape Polynya (U) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	19	20
Average	0	125	586
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	236	1070
Standard error	0	54	239
Minimum	0	0	0
Maximum	0	658	4170
Range	0	658	4170

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 71: Monthly Summary **Statistics** of Polynya Areas* for Pt. Lay to Icy Cape Polynya (U) in 1974.

	MAY	JUNE	JULY
Sample size	27	17	2
Average	7960	11500	
Median**	5990	10700	58700
Mode	5920	10000	OPEN
Geometric mean		8570	41800
Standard deviation	6770	6620	
Standard error	1300	1610	
Minimum	0	186	17500
Maximum	20300	25700	OPEN
Range	20300	25500	

Table 72: Monthly Summary Statistics of Polynya Areas* for Icy Cape to Pt. Barrow Polynya (V) in 1974.

	FEBRUARY	MARCH	APRIL
Sample size	1	18	18
Average	0	0	309
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	0	1020
Standard error	0	0	240
Minimum	0	0	0
Maximum	0	0	4170
Range	0	0	4170

	MAY	JUNE	JULY
Sample size	24	14	2
Average	6920	3590	0
Median**	2320	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	7980	8600	0
Standard error	1630	2300	0
Minimum	0	0	0
Maximum	20300	25700	0
Range	20300	25700	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 73: Monthly Summary Statistics of Polynya Areas* for Chukotsk Peninsula Polynya (W) in 1974.

	MARCH	APRIL	MAY
Sample size	6	20	6
Average	468	0	0
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	1150	0	0
Standard error	468	0	0
Minimum	0	0	0
Maximum	2810	0	0
Range	2810	0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 74: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, South (A) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	1	5	4
Average	0	684	230[illegible]
Median**	0	549	2770
Mode	0	478	2770
Geometric mean		601	2930
Standard deviation	0	418	769
Standard error	0	[illegible]	384
Minimum	0	312	2340
Maximum	0	1.390	4110
Range	0	1080	1770

	APRIL	MAY	JUNE
Sample size	2	2	30
Average	1060	OPEN	OPEN
Median**	1060	OPEN	OPEN
Mode	1510	OPEN	OPEN
Geometric mean	952	OPEN	OPEN
Standard deviation	643	0	0
Standard error	455	0	0
Minimum	600	OPEN	OPEN
Maximum	1510	OPEN	OPEN
Range	910	0	0

Table 75: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, North (B) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	1	4	4
Average	0	0	0
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	0	0	0
Maximum	0	0	0
Range	0	0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 75: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, North (B) in 1975.

	APRIL	MAY	JUNE
Sample size	4	2	30
Average	238	OPEN	OPEN
Median**	0	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation	475	0	0
Standard error	238	0	0
Minimum	0	OPEN	OPEN
Maximum	950	OPEN	OPEN
Range	950	0	0

Table 76: Monthly Summary Statistics of Polynya Areas* for St. Lawrence Island Polynya, South (D) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	7	7	14
Average	8760	3260	4380
Median**	4110	2570	4310
Mode	2120	0	0
Geometric mean	5340		
Standard deviation	9560	3400	3760
Standard error	3610	1280	1000
Minimum	2020	0	0
Maximum	27100	8550	[illegible]
Range	25100	8550	13720

	APRIL	MAY	JUNE
Sample size	18	8	30
Average	3990		OPEN
Median**	2920	15900	OPEN
Mode	0		OPEN
Geometric mean			OPEN
Standard deviation	3560		0
Standard error	840		0
Minimum	0	8990	OPEN
Maximum	10900	OPEN	OPEN
Range	10900		0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 77: Monthly Summary Statistics of Polynya Areas* for St. Lawrence Island Polynya, North (E) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	3	6	14
Average	0	510	475
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	1250	1130
Standard error	0	510	302
Minimum	0	0	0
Maximum	0	3060	3610
Range	0	3060	3610

	APRIL	MAY	JUNE
Sample size	16	7	30
Average	456		OPEN
Median**	0	0	OPEN
Mode	0	0	OPEN
Geometric mean			OPEN
Standard deviation	821		0
Standard error	205		0
Minimum	0	0	OPEN
Maximum	2320	OPEN	OPEN
Range	2320		0

Table 78: Monthly **Summary** Statistics of Polynya Areas* for Nunivak Island Polynya, South (G) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	5	6	8
Average	4830	1880	2470
Median**	3980	1210	1640
Mode	3110	0	0
Geometric mean			
Standard deviation	4350	2180	2760
Standard error	1950	890	976
Minimum	0	0	0
Maximum	11800	4440	5990
Range	11800	4440	5990

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 78: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, South (G) in 1975.

	APRIL	MAY	JUNE
Sample size	11	5	30
Average	1940		OPEN
Median**	1510	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean			OPEN
Standard deviation	2110		0
Standard error	636		0
Minimum	0	3760	OPEN
Maximum	4860	OPEN	OPEN
Range	4860		0

Table 79: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, North (H) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	4	6	9
Average	114	2270	2310
Median**	0	2090	2130
Mode	0	0	0
Geometric mean			
Standard deviation	228	2500	2110
Standard error	114	1020	704
Minimum	0	0	0
Maximum	455	5020	5990
Range	455	5020	5990

	APRIL	MAY	JUNE
Sample size	12	5	30
Average	1610		OPEN
Median**	1110	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean			OPEN
Standard deviation	1710		0
Standard error	493		0
Minimum	0	0	OPEN
Maximum	4500	OPEN	OPEN
Range	4500		0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 80: Monthly Summary Statistics of Polynya Areas* for Cape Romanzof Polynya (I) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	7	11	16
Average	286	9490	5330
Median**	0	1040	1770
Mode	0	0	0
Geometric mean			
Standard deviation	756	12[illegible]	7250
Standard error	286	3620	1810
Minimum	0	0	0
Maximum	7000	30400	25000
Range	7000	30400	25000

	APRIL	MAY	JUNE
Sample size	17	7	30
Average	237	2930	OPEN
Median**	0	1590	OPEN
Mode	0	0	OPEN
Geometric mean			OPEN
Standard deviation	466	3900	0
Standard error	113	1480	0
Minimum	0	0	OPEN
Maximum	1430	11300	OPEN
Range	1430	11300	0

Table 81: Monthly Summary Statistics of Polynya Areas* for Yukon Delta Polynya (J) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	3	12	13
Average	221	7630	4520
Median**	0	3020	976
Mode	0	0	0
Geometric mean			
Standard deviation	626	9680	7560
Standard error	22[illegible]	2790	2100
Minimum	0	0	0
Maximum	1770	30400	25000
Range	1770	30400	25000

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 81: Monthly Summary Statistics of Polynya Areas* for Yukon Delta Polynya (J) in 1975.

	APRIL	MAY	JUNE
Sample size	21	8	30
Average	1650	0	
Median**	549	0	OPEN
Mode	0	0	OPEN
Geometric mean			
Standard deviation	1930	0	
Standard error	422	0	
Minimum	0	0	0
Maximum	5780	0	OPEN
Range	5780	0	

Table 82: Monthly Summary Statistics of Polynya Areas* for Norton Sound Polynya (K) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	8	12	15
Average	1030	9780	4550
Median**	960	8960	1630
Mode	0	0	0
Geometric mean			
Standard deviation	1020	8670	6220
Standard error	359	2500	1610
Minimum	0	0	0
Maximum	2590	30400	25000
Range	2590	30400	25000

	APRIL	MAY	JUNE
Sample size	23	16	30
Average	1990	16800	
Median**	1180	13600	OPEN
Mode	0	13300	OPEN
Geometric mean		13400	
Standard deviation	2200	11000	
Standard error	458	2750	
Minimum	0	5010	30000
Maximum	6140	35500	OPEN
Range	6140	30500	

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 83: Monthly Summary Statistics of Polynya Areas* for Nome Polynya (L) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	7	11	10
Average	312	3940	1100
Median**	117	0	570
Mode	0	0	0
Geometric mean			
Standard deviation	379	4570	1940
Standard error	143	1380	614
Minimum	0	0	0
Maximum	954	9870	5500
Range	954	9870	6500

	APRIL	MAY	JUNE
Sample size	16	16	30
Average	1590	16400	
Median**	342	13600	OPEN
Mode	0	13300	OPEN
Geometric mean		11800	
Standard deviation	2400	11400	
Standard error	600	2840	
Minimum	0	669	30000
Maximum	6140	35500	OPEN
Range	6140	34800	

Table 84: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, South (M) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	5	9	10
Average	7110	5060	4980
Median**	6240	5370	5840
Mode	5550	0	5370
Geometric mean	6650		2820
Standard deviation	2862	4940	2990
Standard error	1280	1640	945
Minimum	3840	0	104
Maximum	11100	14900	7890
Range	7260	14900	7790

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 84: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, South (M) in 1975.

	APRIL	MAY	JUNE
Sample size	15	16	30
Average	2590	17900	
Median**	1460	13600	OPEN
Mode	0	13300	OPEN
Geometric mean		15600	
Standard deviation	2860	9920	
Standard error	738	2480	
Minimum	0	6830	30000
Maximum	8790	35500	OPEN
Range	8790	28700	

Table 85: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, North (P) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	6	7	10
Average	6250	5430	4290
Median**	5900	5370	5380
Mode	3840	0	0
Geometric mean	5430		
Standard deviation	3310	5260	3210
Standard error	1352	1990	1020
Minimum	1960	0	0
Maximum	11100	14900	7890
Range	9140	14900	7890

	APRIL	MAY	JUNE
Sample size	15	16	30
Average	2510	17100	
Median**	1460	13350	OPEN
Mode	0	13000	OPEN
Geometric mean			
Standard deviation	2920	10900	
Standard error	753	2710	
Minimum	0	0	30000
Maximum	8790	35500	OPEN
Range	8790	35500	

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 86: **Monthly** Summary Statistics of Polynya **Areas*** for Kotzebue Sound Polynya (Q) i n 1975.

	JANUA1?Y	FEBRUARY	MARCH
Sample size	9	9	11
Average	1220	13700.	2880
Median**	0	10900	2950
Mode	0	10400	0
Geometric mean		123(M2	
Standard deviation	1770	8640	2500
Standard error	590	2880	755
Minimum	0	8010	0
Maximum	4720	36100	7300
Range	4720	28100	7300

	APRIL	MAY	JUNE
Sample size	15	8	28
Average	1720	0	
Median**	1760	0	OPEN
Mode	0	0	OPEN
Geometric mean			
Standard deviation	1660	0	
Standard error	430	0	
Minimum	0	0	0
Maximum	3910	0	OPEN
Range	3910	0	

Table 87: Monthly Summary Statistics of Polynya Areas* for Cape Thompson-Pt. Hope Polynya (R) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	12	12	8
Average	1750	9570	1870
Median**	436	8900	1600
Mode	0	0	825
Geometric mean			
Standard deviation	2160	9730	1580
Standard error	623	2810	558
Minimum	0	0	0
Maximum	5070	36100	4710
Range	5070	36100	4710

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 37: Monthly Summary Statistics of Polynya Areas* for Cape Thompson-Pt. Hope Polynya (R) in 1975.

	APRIL	MAY	JUNE
Sample size	18	16	13
Average	975	315	17400
Median**	433	0	345
Mode	0	0	0
Geometric mean			
Standard deviation	1350	373	22800
Standard error	317	93	6330
Minimum	0	0	0
Maximum	3860	863	50500
Range	3860	863	50500

	JULY
Sample size	17
Average	
Median**	OPEN
Mode	OPEN
Geometric mean	
Standard deviation	
Standard error	
Minimum	0
Maximum	OPEN
Range	

Table 88: Monthly Summary Statistics of Polynya Areas* for Pt. Hope-Cape Lisburne Polynya (S) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	12	12	5
Average	95	8960	121
Median**	0	5080	0
Mode	0	0	0
Geometric mean			
Standard deviation	168	11300	270
Standard error	48	3270	120
Minimum	0	0	0
Maximum	569	36100	604
Range	569	36100	604

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 88: Monthly Summary Statistics of Polynya Areas* for Pt. Hope-Cape Lisburne Polynya (S) in 1975.

	APRIL	MAY	JUNE
Sample size	17	15	11
Average	268	10200	39600
Median**	109	518	42000
Mode	0	0	39600
Geometric mean			39000
Standard deviation	357	14600	7310
Standard error	87	3780	2200
Minimum	0	0	27400
Maximum	1110	33300	50500
Range	1110	33300	23100

	JULY
Sample size	17
Average	
Median**	OPEN
Mode	OPEN
Geometric mean	
Standard deviation	
Standard error	
Minimum	0
Maximum	OPEN
Range	

Table 89: Monthly Summary Statistics of Polynya Areas* for Cape Lisburne to Pt. Lay Polynya (T) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	12	12	7
Average	138	16500	3240
Median**	0	15600	1030
Mode	0	14900	1020
Geometric mean		14800	1950
Standard deviation	476	7920	3100
Standard error	138	2290	1170
Minimum	0	5430	557
Maximum	1650	36100	7440
Range	1650	30700	6880

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 89: Monthly Summary Statistics of Polynya Areas* for Cape Lisburne to Pt. Lay Polynya (T) in 1975.

	APRIL	MAY	JUNE
Sample size	21	16	13
Average	10200	21400	37500
Median**	1380	22600	39600
Mode	0	21100	38600
Geometric mean			35700
Standard deviation	12200	10100	10000
Standard error	2660	2520	2780
Minimum	0	0	12600
Maximum	28200	33300	50500
Range	28200	33300	37900

	JULY
Sample size	18
Average	
Median**	OPEN
Mode	OPEN
Geometric mean	
Standard deviation	
Standard error	
Minimum	1000
Maximum	OPEN
Range	

Table 90: Monthly Summary Statistics of Polynya Areas* for Pt. Lay to Icy Cape Polynya (U) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	13	13	15
Average	594	13800	4340
Median**	0	15500	5040
Mode	0	0	0
Geometric mean			
Standard deviation	1040	10100	3150
Standard error	287	2800	813
Minimum	0	0	0
Maximum	2480	36100	8950
Range	2480	36100	8950

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 90: Monthly Summary Statistics of Polynya Areas* for Pt. Lay to Icy Cape Polynya (U) in 1975.

	APRIL	...	JUNE
Sample size	24	20	13
Average	8970	17200	37500
Median**	1280	20000	39600
Mode	0	0	38600
Geometric mean			35700
Standard deviation	11800	12300	10000
Standard error	2410	2750	2780
Minimum	0	0	12600
Maximum	28200	33300	50500
Range	28200	33300	37900

	JULY
Sample size	18
Average	
Median**	OPEN
Mode	OPEN
Geometric mean	
Standard deviation	
Standard error	
Minimum	1450
Maximum	OPEN
Range	

Table 91: Monthly Summary Statistics of Polynya Areas* for Icy Cape to Pt. Barrow Polynya (V) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	15	17	17
Average	1210	10400	4640
Median**	834	9210	5040
Mode	0	0	0
Geometric mean			
Standard deviation	1700	10400	2740
Standard error	439	2530	664
Minimum	0	0	0
Maximum	6000	36100	8950
Range	6000	36100	8950

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 91: Monthly Summary Statistics of Polynya Areas* for Icy Cape to Pt. Barrow Polynya (V) in 1975.

	APRIL	MAY	JUNE
Sample size	23	21	13
Average	9350	16400	37500
Median**	1370	18800	39600
Mode	0	0	38600
Geometric mean			35700
Standard deviation	12000	12600	10000
Standard error	2500	2700	2780
Minimum	0	0	12600
Maximum	28200	33300	50500
Range	28200	33300	37900

	JULY
Sample size	16
Average	
Median**	OPEN
Mode	OPEN
Geometric mean	
Standard deviation	
Standard error	
Minimum	0
Maximum	OPEN
Range	

Table 92: Monthly Summary Statistics of Polynya Areas* for Chukotsk Peninsula Polynya (W) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	8	9	3
Average	0	1400	1800
Median**	0	0	2110
Mode	0	0	0
Geometric mean			
Standard deviation	0	2740	1690
Standard error	0	913	975
Minimum	0	0	0
Maximum	0	6510	3340
Range	0	6510	3340

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 92: Monthly Summary Statistics of Polynya Areas* for Chukotsk Peninsula Polynya (W) in 1975.

	APRIL	MAY	JUNE
Sample size	3	4	0
Average	0	0	
Median**	0	0	
Mode	0	0	
Geometric mean			
Standard deviation	0	0	
Standard error	0	0	
Minimum	0	0	
Maximum	0	0	
Range	0	0	

Table 93: Monthly Summary Statistics of Polynya Areas* for Anadyr Gulf Polynya (Y) in 1975.

	JANUARY	FEBRUARY	MARCH
Sample size	6	9	16
Average	13200	3570	6420
Median**	11800	3140	4490
Mode	7830	2600	3670
Geometric mean	12200	2960	4600
Standard deviation	5720	2030	5050
Standard error	2340	677	1260
Minimum	7590	986	880
Maximum	21600	6590	17800
Range	14000	5600	16900

	APRIL
Sample size	20
Average	7330
Median**	5550
Mode	4060
Geometric mean	
Standard deviation	5670
Standard error	1270
Minimum	0
Maximum	19600
Range	19600

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 94: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, South (A) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	16	14	15
Average	554	1770	1120
Median**	402	1560	1060
Mode	648	850	752
Geometric mean		1180	
Standard deviation	573	1340	826
Standard error	143	358	213
Minimum	0	236	0
Maximum	2420	3620	2560
Range	2420	3380	2560

	MAY	JUNE	JULY
Sample size	4	22	31
Average	120	OPEN	OPEN
Median**	0	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation	241	0	0
Standard error	120	0	0
Minimum	0	OPEN	OPEN
Maximum	482	OPEN	OPEN
Range	482	0	0

Table 95: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, North (B) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	17	16	10
Average	0	402	0
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	647	0
Standard error	0	162	0
Minimum	0	0	0
Maximum	0	1890	0
Range	0	1890	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 95: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, North (B) in 1976.

	MAY	JUNE	JULY
Sample size	3	22	31
Average	1500	OPEN	OPEN
Median**	2100	OPEN	OPEN
Mode	180	OPEN	OPEN
Geometric mean	942	OPEN	OPEN
Standard deviation	1140	0	0
Standard error	659	0	0
Minimum	180	OPEN	OPEN
Maximum	2210	OPEN	OPEN
Range	2030	0	0

Table 96: Monthly Summary Statistics of Polynya Areas* for St. Lawrence Island Polynya, South (D) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	20	12	18
Average	886	9940	4730
Median**	775	9500	5340
Mode	0	7720	0
Geometric mean			
Standard deviation	838	7230	3650
Standard error	187	2090	859
Minimum	0	0	0
Maximum	2570	20200	12000
Range	2570	20200	12000

	MAY	JUNE	JULY
Sample size	6	22	31
Average	42400	OPEN	OPEN
Median**	40000	OPEN	OPEN
Mode	742	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation	45100	0	0
Standard error	18400	0	0
Minimum	0	OPEN	OPEN
Maximum	91700	OPEN	OPEN
Range	91700	0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 97: Monthly Summary Statistics of Polynya Areas* for St. Lawrence Island Polynya, North (E) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	18	13	11
Average	0	1040	222
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	1810	736
Standard error	0	503	222
Minimum	0	0	0
Maximum	0	4640	2440
Range	0	4640	2440

	MAY	JUNE	JULY
Sample size	4	22	31
Average	1500	OPEN	OPEN
Median**	0	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation	3000	0	0
Standard error	1500	0	0
Minimum	0	OPEN	OPEN
Maximum	6000	OPEN	OPEN
Range	6000	0	0

Table 98: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, South (G) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	12	14	16
Average	961	2700	3240
Median**	950	2360	1930
Mode	820	1780	1470
Geometric mean			2040
Standard deviation	675	2080	2850
Standard error	195	556	713
Minimum	0	0	271
Maximum	2670	6380	9190
Range	2670	6380	8920

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 98: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, South (G) in 1976.

	MAY	JUNE	JULY
Sample size	13	[illegible]	31
Average		OPEN	OPEN
Median**	OPEN	OPEN	OPEN
Mode	OFEN	OPEN	OPEN
Geometric mean		OFEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	508C)	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

Table 99: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, North (H) in 1976.

	FEBRUARY	MARCH	APRIL
Samp size	9	18	13
Aver e	0	1820	142
Medi**	0	258	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	2290	351
Standard error	0	539	97
Minimum	0	0	0
Maximum	0	6150	1070
Range	0	6150	1070

	MAY	JUNE	JULY
Sample size	9	22	31
Average		OPEN	OPEN
Median**	18400	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	0	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 100: Monthly Summary Statistics of Polynya Areas* for Cape Romanzof Polynya (I) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	16	19	15
Average	147	690	1270
Median**	0	0	902
Mode	0	0	0
Geometric mean			
Standard deviation	416	1580	1350
Standard error	104	362	350
Minimum	0	0	0
Maximum	1640	6940	3590
Range	1640	6940	3590

	MAY	JUNE	JULY
Sample size	9	21	31
Average	7120	OPEN	OPEN
Median**	6970	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation	6100	0	0
Standard error	2030	0	0
Minimum	0	OPEN	OPEN
Maximum	18400	OPEN	OPEN
Range	18400	0	0

Table 101: Monthly Summary Statistics of Polynya Areas* for Yukon Delta Polynya (J) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	23	22	17
Average	0	1770	238
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	2570	844
Standard error	0	547	205
Minimum	0	0	0
Maximum	0	6940	3490
Range	0	6940	3490

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 101: Monthly Summary Statistics of Polynya Areas* for Yukon Delta Polynya (J) in 1976.

	MAY	JUNE	JULY
Sample size	12	9	31
Average	3500		OPEN
Median**	0	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean			OPEN
Standard deviation	6550		0
Standard error	1890		0
Minimum	0	0	OPEN
Maximum	18400	OPEN	OPEN
Range	18400		0

Table 102: Monthly Summary Statistics of Polynya Areas* for Norton Sound Polynya (K) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	23	14	24
Average	1790	2410	2440
Median**	675	1660	2490
Mode	654	1560	2300
Geometric mean			1950
Standard deviation	1960	2410	1230
Standard error	409	644	251
Minimum	0	0	148
Maximum	6060	7460	5590
Range	6060	7460	5440

	MAY	JUNE	JULY
Sample size	17	11	31
Average	8920		OPEN
Median**	5150	17500	OPEN
Mode	4860	OPEN	OPEN
Geometric mean	6660		OPEN
Standard deviation	7880		0
Standard error	1910		0
Minimum	2400	10800	OPEN
Maximum	27200	OPEN	OPEN
Range	24800		0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 103: Monthly Summary Statistics of Polynya Areas* for Nome Polynya (L) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	21	11	19
Average	1260	2020	904
Median**	206	154	0
Mode	0	0	0
Geometric mean			
Standard deviation	1970	3030	1740
Standard error	431	913	399
Minimum	0	0	0
Maximum	6060	7460	5590
Range	6060	7460	5590

	MAY	JNE	JULY
Sample size	15	11	31
Average	8130		OPEN
Median**	7380	500	OPEN
Mode	0	EN	OPEN
Geometric mean			OPEN
Standard deviation	9410		0
Standard error	2430		0
Minimum	0	10800	OPEN
Maximum	27200	OPEN	OPEN
Range	27200		0

Table 104: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, South (M) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	23	15	16
Average	1990	4020	822
Median**	455	3950	840
Mode	0.	0	0
Geometric mean			
Standard deviation	3990	3900	654
Standard error	832	1010	164
Minimum	0	0	0
Maximum	13800	10800	2560
Range	13800	10800	2560

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 104: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, South (M) in 1976.

	MAY	JUNE	JULY
Sample size	18	11	31
Average	5690		OPEN
Median**	2160	17500	OPEN
Mode	0	OPEN	OPEN
Geometric mean			OPEN
Standard deviation	8960		0
Standard error	2110		0
Minimum	0	10800	OPEN
Maximum	27200	OPEN	OPEN
Range	27200		0

Table 105: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, North (P) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	20	14	15
Average	2330	3260	735
Median**	744	2480	688
Mode	0	0	0
Geometric mean			
Standard deviation	4180	3660	730
Standard error	936	979	188
Minimum	0	0	0
Maximum	13800	10700	2560
Range	13800	10700	2560

	MAY	JUNE	JULY
Sample size	19	11	31
Average	5410		OPEN
Median**	1790	17500	OPEN
Mode	0	OPEN	OPEN
Geometric mean			OPEN
Standard deviation	8790		0
Standard error	2020		0
Minimum	0	10800	OPEN
Maximum	27200	OPEN	OPEN
Range	27200		0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 106: Monthly Summary Statistics of Polynya Areas* for Kotzebue Sound Polynya (Q) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	19	14	13
Average	159	674	25
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	320	1020	91
Standard error	73	272	25
Minimum	0	0	0
Maximum	927	3030	327
Range	927	3030	327

	MAY	JUNE	JULY
Sample size	9	9	31
Average	12	0	OPEN
Median**	0	0	OPEN
Mode	0	0	OPEN
Geometric mean			OPEN
Standard deviation	37	0	0
Standard error	12	0	0
Minimum	0	0	OPEN
Maximum	111	0	OPEN
Range	111	0	0

Table 107: Monthly Summary Statistics of Polynya Areas* for Cape Thompson-Pt. Hope Polynya (R) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	18	19	18
Average	2160	3000	400
Median**	1840	3200	0
Mode	0	0	0
Geometric mean			
Standard deviation	1680	2070	1180
Standard error	396	474	279
Minimum	0	0	0
Maximum	5960	5450	5100
Range	5960	5450	5100

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 107: Monthly Summary Statistics of Polynya Areas* for Cape Thompson-Pt. Hope Polynya (R) in 1976.

	MAY	JUNE	JULY
Sample size	17	14	24
Average	717	684	OPEN
Median**	405	130	OPEN
Mode	0	0	OPEN
Geometric mean			OPEN
Standard deviation	685	1290	0
Standard error	166	344	0
Minimum	0	0	OPEN
Maximum	2320	4850	OPEN
Range	2320	4850	0

Table 108: Monthly Summary Statistics of Polynya Areas* for Pt. Hope-Cape Lisburne Polynya (S) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	16	20	17
Average	136	267	91
Median**	0	141	0
Mode	0	0	0
Geometric mean			
Standard deviation	293	358	152
Standard error	73	80	37
Minimum	0	0	0
Maximum	785	1080	593
Range	785	1080	593

	MAY	JUNE	JULY
Sample size	15	15	24
Average	1560	5030	
Median**	346	364	OPEN
Mode	214	0	OPEN
Geometric mean			
Standard deviation	2920	5920	
Standard error	754	1530	
Minimum	0	0	590
Maximum	8860	14200	OPEN
Range	8860	14200	

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50

Table 109: Monthly Summary Statistics of Polynya Areas* for Cape Lisburne to Pt. Lay Polynya (T) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	13	21	15
Average	0	346	61
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	557	133
Standard error	0	122	34
Minimum	0	0	0
Maximum	0	1570	421
Range	0	1570	421

	MAY	JUNE	JULY
Sample size	25	18	17
Average	5650	7880	
Median**	4950	7250	OPEN
Mode	10800	6940	OPEN
Geometric mean		7230	
Standard deviation	3010	3380	
Standard error	601	796	
Minimum	0	3220	4490
Maximum	10800	14200	OPEN
Range	10800	11000	

Table 110: Monthly Summary Statistics of Polynya Areas* for Pt. Lay to Icy Cape Polynya (U) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	14	17	13
Average	383	441	100
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	638	688	162
Standard error	170	167	45
Minimum	0	0	0
Maximum	1530	1710	456
Range	1530	1710	456

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 110: Monthly Summary Statistics of Polynya Areas* for Pt. Lay to Icy Cape Polynya (U) in 1976.

	MAY	JUNE	JULY
Sample size	24	18	18
Average	5860	7490	
Median**	5150	7250	57300
Mode	10800	6940	OPEN
Geometric mean		5420	
Standard deviation	2870	4000	
Standard error	586	942	
Minimum	0	140	2560
Maximum	10800	14200	OPEN
Range	10800	14100	

Table 111: Monthly Summary Statistics of Polynya Areas* for Icy Cape to Pt. Barrow Polynya (V) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	13	19	13
Average	0	1050	106
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	2570	383
Standard error	0	589	106
Minimum	0	0	0
Maximum	0	11200	1380
Range	0	11200	1380

	MAY	JUNE	JULY
Sample size	19	19	15
Average	897	474	1060
Median**	193	105	488
Mode	0	0	0
Geometric mean			
Standard deviation	2440	948	1370
Standard error	560	217	353
Minimum	0	0	0
Maximum	10800	4100	4060
Range	10800	4100	4060

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 112: Monthly Summary Statistics of Polynya Areas* for Chukotsk Peninsula Polynya (W) in 1976.

	FEBRUARY	MARCH	APRIL
Sample size	19	11	11
Average	446	591	0
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	1260	1200	0
Standard error	288	362	0
Minimum	0	0	0
Maximum	5380	3740	0
Range	5380	3740	0

	MAY	JUNE	JULY
Sample size	7	22	0
Average	0		
Median**	0	OPEN	
Mode	0	OPEN	
Geometric mean			
Standard deviation	0		
Standard error	0		
Minimum	0	0	
Maximum	0	OPEN	
Range	0		

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median size recorded in Tables 44-50.

Table 113: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, South (A) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	3	3	20
Average**	1950	403	490
Median	1460	212	300
Mode	144	0	0
Geometric mean	962		
Standard deviation	2090	525	555
Standard error	1210	303	124
Minimum	144	0	0
Maximum	4240	996	2360
Range	4100	996	2360

	APRIL	MAY	JUNE
Sample size	17	17	30
Average**	676		OPEN
Median	582	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean			OPEN
Standard deviation	748		0
Standard error	181		0
Minimum	0	355	OPEN
Maximum	2710	OPEN	OPEN
Range	2710		0

Table 114: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, North (B) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	3	4	18
Average**	0	0	21
Median	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	0	65
Standard error	0	0	15
Minimum	0	0	0
Maximum	0	0	251
Range	0	0	251

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 114: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, North (B) in 1977.

	APRIL	MAY	JUNE
Sample size	18	16	30
Average	376		OPEN
Median**	0	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean			OPEN
Standard deviation	807	25000	0
Standard error	190	6250	0
Minimum	0	0	OPEN
Maximum	2340	OPEN	OPEN
Range	2340		0

Table 115: Monthly Summary Statistics of Polynya Areas* for St. Lawrence Island Polynya, South (D) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	4	6	20
Average	2000	1780	2270
Median**	2440	1760	1620
Mode	0	1160	1570
Geometric mean		1580	
Standard deviation	1380	848	1890
Standard error	692	346	422
Minimum	0	592	0
Maximum	3140	2780	6290
Range	3140	2190	6290

	APRIL	MAY	JUNE
Sample size	22	8	29
Average	3590	12500	OPEN
Median**	2210	7280	OPEN
Mode	0	0	OPEN
Geometric mean			OPEN
Standard deviation	4050	13100	0
Standard error	864	4620	0
Minimum	0	0	OPEN
Maximum	14400	29100	OPEN
Range	14400	29100	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 116: Monthly Summary Statistics of Polynya Areas* for St. Lawrence Island Polynya, North (E) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	5	6	19
Average**	0	0	48
Median	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	0	195
Standard error	0	0	45
Minimum	0	0	0
Maximum	0	0	852
Range	0	0	852

	APRIL	MAY	JUNE
Sample size	24	9	29
Average**	886	891	OPEN
Median	0	0	OPEN
Mode	0	0	OPEN
Geometric mean			OPEN
Standard deviation	1960	2020	0
Standard error	400	672	0
Minimum	0	0	OPEN
Maximum	7680	5950	OPEN
Range	7680	5950	0

Table 117: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, South (G) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	3	4	17
Average**	2340		1630
Median	1930	54700	1150
Mode	1610	OPEN	1300
Geometric mean	2210		
Standard deviation	1000		1870
Standard error	581		453
Minimum	1610	962	0
Maximum	3490	OPEN	7100
Range	1880		7100

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 117: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, South (G) in 1977.

	APRIL	MAY	JUNE
Sample size	19	31	30
Average**		OPEN	OPEN
Median	5400	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	0	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

Table 118: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, North (H) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	4	4	16
Average**	0	0	385
Median	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	0	878
Standard error	0	0	219
Minimum	0	0	0
Maximum	0	0	2890
Range	0	0	2890

	APRIL	MAY	JUNE
Sample size	20	31	30
Average**	5390	OPEN	OPEN
Median	0	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation	22300	0	0
Standard error	4980	0	0
Minimum	0	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 119: Monthly Summary Statistics of Polynya Areas* for Cape Romanzof Polynya (I) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	8	6	16
Average	860	2430	279
Median**	371	1890	0
Mode	0	1080	0
Geometric mean			
Standard deviation	1050	2390	670
Standard error	370	974	167
Minimum	0	0	0
Maximum	2500	6870	2420
Range	2500	6870	2420

	APRIL	MAY	JUNE
Sample size	21	29	30
Average	5340		OPEN
Median**	486	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean			OPEN
Standard deviation			0
Standard error			0
Minimum	0	5640	OPEN
Maximum	OPEN	OPEN	OPEN
Range			0

Table 120: Monthly Summary Statistics of Polynya Areas* for Yukon Delta Polynya (J) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	8	4	19
Average	349	120	639
Median**	0	124	0
Mode	0	0	0
Geometric mean			
Standard deviation	844	97	874
Standard error	298	48	200
Minimum	0	0	0
Maximum	2420	230	3200
Range	2420	230	3200

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 120: Monthly Summary Statistics of Polynya Areas* for Yukon Delta Polynya (J) in 1977.

	APRIL	MAY	JUNE
Sample size	23	29	30
Average	298		OPEN
Median**	0	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean			OPEN
Standard deviation	567		0
Standard error	118		0
Minimum	0	0	OPEN
Maximum	1720	OPEN	OPEN
Range	1720		0

Table 121: Monthly Summary Statistics of Polynya Areas* for Norton Sound Polynya (K) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	8	10	20
Average	966	3040	1510
Median**	675	1880	145
Mode	0	875	0
Geometric mean		1630	
Standard deviation	1220	3110	2640
Standard error	432	984	591
Minimum	0	196	0
Maximum	3420	9120	11400
Range	3420	8920	11400

	APRIL	MAY	JUNE
Sample size	22	16	17
Average	1680		OPEN
Median**	1450	4840	OPEN
Mode	0	OPEN	OPEN
Geometric mean			OPEN
Standard deviation	1880		0
Standard error	400		0
Minimum	0	534	OPEN
Maximum	6560	OPEN	OPEN
Range	6560		0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 122: Monthly Summary Statistics of Polynya Areas* for Nome Polynya (L) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	10	9	21
Average	810	2900	1350
Median**	501	856	369
Mode	0	828	0
Geometric mean		1490	
Standard deviation	937	3340	2580
Standard error	296	1110	564
Minimum	0	360	0
Maximum	2480	9120	11400
Range	2480	8760	11400

	APRIL	MAY	JUNE
Sample size	21	13	18
Average	1220	421	
Median**	160	266	OPEN
Mode	0	0	OPEN
Geometric mean			
Standard deviation	2010	701	
Standard error	438	194	
Minimum	0	0	2710
Maximum	6560	2590	OPEN
Range	6560	2590	

Table 123: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polyn ya, South (M) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	6	10	21
Average	3170	1170	507
Median**	2480	906	0
Mode	1520	849	0
Geometric mean		1030	
Standard deviation	2690	602	911
Standard error	1100	190	199
Minimum	0	428	0
Maximum	7510	2280	3470
Range	7510	1850	3470

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 123: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, South (M) in 1977.

	APRIL	MAY	JUNE
Sample size	22	10	19
Average**	1450	433	
Median	668	261	,OPEN
Mode	0	0	OPEN
Geometric mean			
Standard deviation	1990	768	
Standard error	424	243	
Minimum	0	0	0
Maximum	6560	2590	OPEN
Range	6560	2590	

Table 124: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, North (P) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	6	8	21
Average**	3170	1230	500
Median	2480	1180	0
Mode	1520	849	0
Geometric mean		1020	
Standard deviation	2690	686	915
Standard error	1100	242	200
Minimum	0	266	0
Maximum	7510	2280	3470
Range	7510	2010	3470

	APRIL	MAY	JUNE
Sample size	23	9	18
Average**	1440	1160	
Median	921	496	OPEN
Mode	0	0	OPEN
Geometric mean			
Standard deviation	1950	1470	
Standard error	406	490	
Minimum	0	0	0
Maximum	6560	4310	OPEN
Range	6560	4310	

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 125: Monthly Summary Statistics of Polynya Areas* for Kotzebue Sound Polynya (Q) in 1977.

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
Sample size	11	8	15	21	15	17
Average	3890	0	0	63	48	
Median**	5440	0	0	0	0	446
Mode	0	0	0	0	0	
Geometric mean						
Standard deviation	3290	0	0	88	66	
Standard error	992	0	0	19	17	
Minimum	0	0	0	0	0	120
Maximum	7860	0	0	237	236	OPEN
Range	7860	0	0	237	236	

Table 126: Monthly Summary Statistics of Polynya Areas* for Cape Thompson-Pt. Hope Polynya (R) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	15	15	17
Average	2800	435	47
Median**	1580	0	0
Mode	1500	0	0
Geometric mean			
Standard deviation	2780	687	139
Standard error	718	177	34
Minimum	0	0	0
Maximum	7860	2200	513
Range	7860	2200	513

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 126: Monthly Summary Statistics of Polynya Areas* for Cape Thompson-Pt. Hope Polynya (R) in 1977.

	APRIL	MAY	JUNE
Sample size	20	19	20
Average	5	781	3710
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	21	976	7830
Standard error	5	224	1750
Minimum	0	0	0
Maximum	96	2320	23000
Range	96	2320	23000

	JULY
Sample size	29
Average	
Median**	OPEN
Mode	OPEN
Geometric mean	
Standard deviation	
Standard error	
Minimum	1080
Maximum	OPEN
Range	

Table 127: Monthly Summary Statistics of Polynya Areas* for Pt. Hope-Cape Lisburne Polynya (S) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	14	13	18
Average	293	105	0
Median**	161	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	344	163	0
Standard error	92	45	0
Minimum	0	0	0
Maximum	1110	476	0
Range	1110	476	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 127: Monthly Summary Statistics of Polynya Areas* for Pt. Hope-Cape Lisburne Polynya (S) in 1977.

	APRIL	MAY	JUNE
Sample size	24	21	22
Average**	82	1240	5970
Median	0	148	2200
Mode	0	0	1160
Geometric mean			2420
Standard deviation	163	3311	7820
Standard error	33	722	1670
Minimum	0	0	302
Maximum	504	12700	23000
Range	504	12700	22700

	JULY
Sample size	29
Average**	
Median	OPEN
Mode	OPEN
Geometric mean	
Standard deviation	
Standard error	
Minimum	21800
Maximum	OPEN
Range	

Table 128: Monthly Summary Statistics of Polynya Areas* for Cape Lisburne to Pt. Lay Polynya (T) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	11	14	21
Average**	3210	634	187
Median	566	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	5550	1560	416
Standard error	1670	417	91
Minimum	0	0	0
Maximum	18200	5640	1440
Range	18200	5640	1440

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 128: Monthly Summary Statistics of Polynya Areas* for Cape Lisburne to Pt. Lay Polynya (T) in 1977.

	APRIL	MAY	JUNE
Sample size	22	28	23
Average	477	7720	7840
Median**	0	7920	4600
Mode	0	7780	4110
Geometric mean		6430	
Standard deviation	812	4030	7140
Standard error	173	761	1490
Minimum	0	1350	0
Maximum	2690	13800	23000
Range	2690	12400	23000

	JULY
Sample size	29
Average	
Median**	OPEN
Mode	OPEN
Geometric mean	
Standard deviation	
Standard error	
Minimum	21800
Maximum	OPEN
Range	

Table 129: Monthly Summary Statistics of Polynya Areas* for Pt. Lay to Icy Cape Polynya (U) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	12	14	22
Average	4310	1570	135
Median**	1540	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	6140	2860	350
Standard error	1770	765	75
Minimum	0	0	0
Maximum	18200	9630	1440
Range	18200	9630	1440

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 129: Monthly Summary Statistics of Polynya Areas* for Pt. Lay to Icy Cape Polynya (U) in 1977.

	APRIL	MAY	JUNE
Sample size	22	26	21
Average	424	8100	6700
Median**	0	8100	4600
Mode	0	7900	0
Geometric mean		6780	
Standard deviation	877	3920	7930
Standard error	187	769	1730
Minimum	0	645	0
Maximum	2720	13800	23000
Range	2720	13200	23000

	JULY
Sample size	29
Average	
Median**	OPEN
Mode	OPEN
Geometric mean	
Standard deviation	
Standard error	
Minimum	21800
Maximum	OPEN
Range	-

Table 130: Monthly Summary Statistics of Polynya Areas* for Icy Cape to Pt. Barrow Polynya (V) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	12	14	20
Average	4310	1580	72
Median**	1630	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	6140	2860	322
Standard error	1770	764	72
Minimum	0	0	0
Maximum	18200	9630	1440
Range	18200	9630	1440

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 130: Monthly Summary Statistics of Polynya Areas* for Icy Cape to Pt. Barrow Polynya (V) in 1977.

	APRIL	MAY	JUNE
Sample size	22	25	23
Average**	396	8080	1020
Median	0	8260	0
Mode	0	7940	0
Geometric mean		6100	
Standard deviation	880	4180	1960
Standard error	188	836	408
Minimum	0	172	0
Maximum	2720	13800	6170
Range	2720	13600	6170

	JULY
Sample size	5
Average**	
Median	2010
Mode	
Geometric mean	
Standard deviation	
Standard error	
Minimum	0
Maximum	OPEN
Range	

Table 131: Monthly Summary Statistics of Polynya Areas* for Chukotsk Peninsula Polynya (W) in 1977.

	JANUARY	FEBRUARY	MARCH
Sample size	2	3	17
Average**	0	0	0
Median	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	0	0	0
Maximum	0	0	0
Range	0	0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 131: Monthly Summary Statistics of Polynya Areas* for Chukotsk Peninsula Polynya (W) in 1977.

	APRIL	MAY	JUNE
Sample size	20	7	29
Average	0	737	
Median**	0	0	OPEN
Mode	0	0	OPEN
Geometric mean			
Standard deviation	0	1060	
Standard error	0	403	
Minimum	0	0	1780
Maximum	0	2690	OPEN
Range	0	2690	

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 132: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, South (A) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	5	12	13
Average**	OPEN	OPEN	
Median	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean	OPEN	OPEN	
Standard deviation	0	0	
Standard error	0	0	
Minimum	OPEN	OPEN	305
Maximum	OPEN	OPEN	OPEN
Range	0	0	

	APRIL	MAY	JUNE
Sample size	30	31	30
Average**	OPEN	OPEN	OPEN
Median	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean	OPEN	OPEN	OPEN
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	OPEN	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range	0	0	0

Table 133: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, North (B) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	5	11	13
Average**	OPEN		
Median	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean	OPEN		
Standard deviation	0		
Standard error	0		
Minimum	OPEN	0	0
Maximum	OPEN	OPEN	OPEN
Range	0		

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50

Table 133: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, North (B) in 1979.

	APRIL	MAY	JUNE
Sample size	30	31	30
Average	OPEN	OPEN	OPEN
Median**	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean	OPEN	OPEN	OPEN
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	OPEN	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range	0	0	0

Table 134: Monthly Summary Statistics of Polynya Areas* for St. Lawrence Island Polynya, South (D) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	3	17	17
Average	OPEN	3270	2840
Median**	OPEN	2640	2220
Mode	OPEN	0	2180
Geometric mean	OPEN		2420
Standard deviation	0	3140	2010
Standard error	0	761	487
Minimum	OPEN	0	1190
Maximum	OPEN	10200	8180
Range	0	10200	6990

	APRIL	MAY	JUNE
Sample size	14	31	30
Average		OPEN	OPEN
Median**	15900	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	2420	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 135: Monthly Summary Statistics of Polynya Areas* for St. Lawrence Island Polynya, North (E) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	4	15	14
Average		1270	901
Median**	50000	0	0
Mode	OPEN	0	0
Geometric mean			
Standard deviation		2210	2330
Standard error		570	623
Minimum	0	0	0
Maximum	OPEN	5520	7400
Range		5520	7400

	APRIL	MAY	JUNE
Sample size	14	31	30
Average		OPEN	OPEN
Median**	0	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	0	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

Table 136: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, South (G) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	5	15	16
Average	OPEN	1780	
Median**	OPEN	1130	2520
Mode	OPEN	0	OPEN
Geometric mean	OPEN		
Standard deviation	0	1970	
Standard error	0	509	
Minimum	OPEN	0	574
Maximum	OPEN	6950	OPEN
Range	0	6950	

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 136: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, South (G) in 1979.

	APRIL	MAY	JUNE
Sample size	30	31	30
Average	OPEN	OPEN	OPEN
Median**	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean	OPEN	OPEN	OPEN
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	OPEN	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range	0	0	0

Table 137: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, North (H) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	5	15	14
Average	OPEN	851	
Median**	OPEN	0	0
Mode	OPEN	0	0
Geometric mean	OPEN		
Standard deviation	0	1660	
Standard error	0	428	
Minimum	OPEN	0	0
Maximum	OPEN	5150	OPEN
Range	0	5150	

	APRIL	MAY	JUNE
Sample size	30	31	30
Average	OPEN	OPEN	OPEN
Median**	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean	OPEN	OPEN	OPEN
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	OPEN	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range	0	0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 138: Monthly Summary Statistics of Polynya Areas* for Cape Romanzof Polynya (I) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	4	21	18
Average		3740	
Median**	2490	3060	4550
Mode	1310	0	OPEN
Geometric mean			
Standard deviation		3570	
Standard error		780	
Minimum	1310	0	0
Maximum	OPEN	14200	OPEN
Range		14200	

	APRIL	MAY	JUNE
Sample size	30	31	30
Average	OPEN	OPEN	OPEN
Median**	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean	OPEN	OPEN	OPEN
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	OPEN	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range	0	0	0

Table 139: Monthly Summary Statistics of Polynya Areas* for Yukon Delta Polynya (J) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	4	19	16
Average	0	825	812
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	2230	1680
Standard error	0	512	420
Minimum	0	0	0
Maximum	0	9370	4700
Range	0	9370	4700

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 139: Monthly Summary Statistics of Polynya Areas* for Yukon Delta Polynya (J) in 1979.

	APRIL	MAY	JUNE
Sample size	25	31	30
Average		OPEN	OPEN
Median**	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	1180	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

Table 140: Monthly Summary Statistics of Polynya Areas* for Norton Sound Polynya (K) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	9	24	17
Average	3100	2400	6590
Median**	1700	792	6970
Mode	1630	0	4700
Geometric mean			4510
Standard deviation	3140	4750	4580
Standard error	1050	970	1110
Minimum	0	0	468
Maximum	7620	17600	15500
Range	7620	17600	15000

	APRIL	MAY	JUNE
Sample size	23	31	30
Average		OPEN	OPEN
Median**	16600	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	5040	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50

Table 141: Monthly Summary Statistics of Polynya Areas* for Nome Polynya (L) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	8	25	16
Average**	359	1760	6420
Median	222	123	7040
Mode	0	0	4560
Geometric mean			3880
Standard deviation	600	4740	4940
Standard error	212	948	1240
Minimum	0	0	314
Maximum	1820	17600	15500
Range	1820	17600	15200

	APRIL	MAY	JUNE
Sample size	21	31	30
Average**		OPEN	OPEN
Median	16600	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	676	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

Table 142: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, South (M) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	5	24	22
Average**	1070	1500	2120
Median	861	0	1730
Mode	649	0	1690
Geometric mean	904		
Standard deviation	650	2280	1620
Standard error	290	465	346
Minimum	360	0	0
Maximum	1920	6960	6040
Range	1560	6960	6040

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 142: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, South (M) in 1979.

	APRIL	MAY	JUNE
Sample size	22	31	30
Average		OPEN	OPEN
Median**	10800	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	0	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

Table 143: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, North (P) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	6	25	21
Average	813	1470	2200
Median**	755	0	1770
Mode	412	0	1690
Geometric mean	628		
Standard deviation	608	2240	1620
Standard error	248	448	354
Minimum	158	0	0
Maximum	1920	6960	6040
Range	1760	6960	6040

	APRIL	MAY	JUNE
Sample size	22	31	30
Average		OPEN	OPEN
Median**	10800	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	0	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 144: Monthly Summary Statistics of Polynya Areas* for Kotzebue Sound Polynya (Q) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	4	25	23
Average	372	1870	1930
Median**	0	1070	628
Mode	0	0	0
Geometric mean			
Standard deviation	745	1960	2500
Standard error	372	392	520
Minimum	0	0	0
Maximum	1490	7040	9600
Range	1490	7040	9600

	APRIL	MAY	JUNE
Sample size	21	22	30
Average			OPEN
Median**	766	1170	OPEN
Mode	0	OPEN	OPEN
Geometric mean			OPEN
Standard deviation			0
Standard error			0
Minimum	0	835	OPEN
Maximum	OPEN	OPEN	OPEN
Range			0

Table 145: Monthly Summary Statistics of Polynya Areas* for Cape Thompson-Pt. Hope Polynya (R) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	9	19	18
Average	1160	1330	2870
Median**	0	0	3000
Mode	0	0	2100
Geometric mean			1860
Standard deviation	1780	2740	2300
Standard error	594	629	542
Minimum	0	0	67
Maximum	4970	10100	9600
Range	4970	10100	9530

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50

Table 145: Monthly Summary Statistics of Polynya Areas* for Cape Thompson-Pt. Hope Polynya (R) in 1979.

	APRIL	MAY	JUNE
Sample size	14	28	30
Average	2790		
Median**	3040	1120	OPEN
Mode	0	OPEN	OPEN
Geometric mean			
Standard deviation	2370		
Standard error	633		
Minimum	0	0	74
Maximum	6140	OPEN	OPEN
Range	6140		

Table 146: Monthly Summary Statistics of Polynya Areas* for Pt. Hope-Cape Lisburne Polynya (S) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	11	19	20
Average	786	1720	350
Median**	0	1880	238
Mode	0	0	0
Geometric mean			
Standard deviation	1550	1160	530
Standard error	468	265	119
Minimum	0	0	0
Maximum	4010	3300	2340
Range	4010	3300	2340

	APRIL	MAY	JUNE
Sample size	19	24	30
Average	148	700	
Median**	126	398	OPEN
Mode	0	0	OPEN
Geometric mean			
Standard deviation	144	837	
Standard error	33	171	
Minimum	0	0	0
Maximum	512	3680	OPEN
Range	512	3680	

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 147: Monthly Summary Statistics of Polynya Areas* for Cape Lisburne to Pt. Lay Polynya (T) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	10	20	23
Average	3120	1670	1560
Median**	1410	1860	1480
Mode	0	0	0
Geometric mean			
Standard deviation	4840	1160	1440
Standard error	1530	260	301
Minimum	0	0	0
Maximum	15800	3300	4410
Range	15800	3300	4410

	APRIL	MAY	JUNE
Sample size	21	25	25
Average	830	5690	
Median**	430	3240	OPEN
Mode	0	2590	OPEN
Geometric mean		3380	
Standard deviation	970	5760	
Standard error	430	1150	
Minimum	0	382	0
Maximum	7200	20700	OPEN
Range	7200	20300	

Table 148: Monthly Summary Statistics of Polynya Areas* for Pt. Lay to Icy Cape Polynya (U) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	9	18	22
Average	2520	573	1670
Median**	0	0	1310
Mode	0	0	0
Geometric mean			
Standard deviation	5230	1460	1650
Standard error	1740	345	351
Minimum	0	0	0
Maximum	15800	4920	4830
Range	15800	4920	4830

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 148: Monthly Summary Statistics of Polynya Areas* for Pt. Lay to Icy Cape Polynya (U) in 1979.

	APRIL	MAY	JUNE
Sample size	19	26	21
Average	1820	4330	
Median**	1430	672	15500
Mode	0	0	OPEN
Geometric mean			
Standard deviation	2040	6290	
Standard error	469	1230	
Minimum	0	0	0
Maximum	7200	20700	OPEN
Range	7200	20700	

Table 149: Monthly Summary Statistics of Polynya Areas* for Icy Cape to Pt. Barrow Polynya (V) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	11	18	20
Average	2550	588	1170
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	4830	1460	1680
Standard error	1460	345	377
Minimum	0	0	0
Maximum	15800	4920	4410
Range	15800	4920	4410

	APRIL	MAY	JUNE
Sample size	18	27	21
Average	1660	3960	3930
Median**	536	679	479
Mode	0	0	0
Geometric mean			
Standard deviation	2160	6300	5450
Standard error	509	1210	1190
Minimum	0	0	0
Maximum	7200	20700	15900
Range	7200	20700	15900

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 150: Monthly Summary Statistics of Polynya Areas* for Chukotsk Peninisula Polynya (W) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	4	15	19
Average	3400	510	188
Median**	0	183	0
Mode	0	0	0
Geometric mean			
Standard deviation	6800	728	525
Standard error	3400	188	120
Minimum	0	0	0
Maximum	13600	2700	1710
Range	13600	2700	1710

	APRIL	MAY	JUNE
Sample size	9	16	30
Average	0		
Median**	0	0	OPEN
Mode	0	0	OPEN
Geometric mean			
Standard deviation	0		
Standard error	0		
Minimum	0	0	5160
Maximum	0	OPEN	OPEN
Range	0		

Table 151: Monthly Summary Statistics of Polynya Areas* for Anadyr Gulf Polynya (Y) in 1979.

	JANUARY	FEBRUARY	MARCH
Sample size	7	13	23
Average	3220	2570	3360
Median**	2640	2350	3180
Mode	2280	722	2070
Geometric mean	2780		2980
Standard deviation	2240	2050	1460
Standard error	847	569	305
Minimum	1650	0	464
Maximum	8120	5890	6320
Range	6470	5890	5860

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 151: Monthly Summary Statistics of Polynya Areas* for Anadyr Gulf Polynya (Y) in 1979.

	APRIL
Sample size	17
Average	19700
Median**	15600
Mode	14800
Geometric mean	14300
Standard deviation	19200
Standard error	4670
Minimum	2640
Maximum	86700
Range	84100

*Polynya areas are in square kilometers. All possible area determinations are used for the calculations.

**Median is equivalent to median area in Tables 44-50.

Table 152: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, South (A) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	8	6	10
Average	OPEN	703	1300
Median	OPEN	662	455
Mode	OPEN	635	400
Geometric mean	OPEN		
Standard deviation	0	455	2290
Standard error	0	186	723
Minimum	OPEN	0	0
Maximum	OPEN	1420	7660
Range	0	1420	7660

	APRIL	MAY	JUNE
Sample size	6	31	30
Average		OPEN	OPEN
Median	5760	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	136	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

Table 153: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, North (B) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	8	6	6
Average		0	46
Median	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation		0	113
Standard error		0	46
Minimum	0	0	0
Maximum	OPEN	0	276
Range		0	276

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50.

Table 153: Monthly Summary Statistics of Polynya Areas* for St. Matthew Island Polynya, North (B) in 1983.

	APRIL	MAY	JUNE
Sample size	7	31	30
Average	0	OPEN	OPEN
Median	0	OPEN	OPEN
Mode	0	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	0	OPEN	OPEN
Maximum	0	OPEN	OPEN
Range	0	0	0

Table 154: Monthly Summary Statistics of Polynya Areas* for St. Lawrence Island Polynya, South (D) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	15	11	15
Average	2000	2290	4220
Median	1940	2120	2700
Mode	1820	1430	2500
Geometric mean		2200	3200
Standard deviation	842	683	3360
Standard error	217	206	869
Minimum	0	1430	893
Maximum	3440	3360	11800
Range	3440	1930	10900

	APRIL	MAY	JUNE
Sample size	16	28	30
Average			OPEN
Median	4760	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean			OPEN
Standard deviation			0
Standard error			0
Minimum	686	0	OPEN
Maximum	OPEN	OPEN	OPEN
Range			0

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50.

Table 155: Monthly Summary Statistics of Polynya Areas* for St Lawrence Island Polynya, North (E) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	16	10	11
Average	0	0	328
Median	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	0	0	1090
Standard error	0	0	328
Minimum	0	0	0
Maximum	0	0	3610
Range	0	0	3610

	APRIL	MAY	JUNE
Sample size	15	27	30
Average		OPEN	OPEN
Median	487	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	0	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

Table 156: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, South (G) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	11	6	16
Average	1440	1180	
Median	1440	1190	7820
Mode	702	854	OPEN
Geometric mean	1280	1130	
Standard deviation	714	394	
Standard error	215.	161	
Minimum	506	665	0
Maximum	3040	1720	OPEN
Range	2530	1060	

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50

Table 156: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, South (G) in 1983.

	APRIL	MAY	JUNE
Sample size	19	31	30
Average	OPEN	OPEN	OPEN
Median	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean	OPEN	OPEN	OPEN
Standard deviation	0	0	0
Standard error	0	0	0
Minimum	OPEN	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range	0	0	0

Table 157: Monthly Summary Statistics of Polynya Areas* for Nunivak Island Polynya, North (H) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample si	12	7	17
Average	0	0	
Median	0	0	6840
Mode	0	0	OPEN
Geometric ean			
Standard :viation	0	0	
Standard e.rror	0	0	
Minimum	0	0	0
Maximum	0	0	OPEN
Range	0	0	

	APRIL	MAY	JUNE
Sample size	19	31	30
Average		OPEN	OPEN
Median	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	0	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50.

Table 158: Monthly Summary Statistics of Polynya Areas* for Cape Romanzof Polynya (I) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	13	7	19
Average	1770	709	
Median	1220	726	13600
Mode	1150	610	OPEN
Geometric mean	1080	692	
Standard deviation	1760	164	
Standard error	489	62	
Minimum	122	508	739
Maximum	6730	962	OPEN
Range	6610	454	

	APRIL	MAY	JUNE
Sample size	19	31	30
Average		OPEN	OPEN
Median	OPEN	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	475	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

Table 159: Monthly Summary Statistics of Polynya Areas* for Yukon Delta Polynya (J) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	20	10	20
Average	41	0	26
Median	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	157	0	79
Standard error	35	0	18
Minimum	0	0	0
Maximum	699	0	266
Range	699	0	266

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50.

Table 159: Monthly Summary Statistics of Polynya Areas* for Yukon Delta Polynya (J) in 1983.

	APRIL	MAY	JUNE
Sample size	19	31	30
Average		OPEN	OPEN
Median	9130	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	0	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

Table 160: Monthly Summary Statistics of Polynya Areas* for Norton Sound Polynya (K) in 1983.

	JANUARY	FEBRUARY	MARCH
mple size	21	10	23
erage	2190	1330	8300
dian	1620	1340	9020
de	0	1230	1730
ometric mean		1310	5940
andard deviation	2630	239	5570
Standard error	574	75	1160
Minimum	0	1000	841
Maximum	8950	1720	16800
Range	8950	720	16000

	APRIL	MAY	JUNE
Sample size	19	31	30
Average		OPEN	OPEN
Median	16300	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	2310	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50.

Table 161: Monthly Summary Statistics of Polynya Areas* for Nome Polynya (L) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	20	8	21
Average	1720	1030	8530
Median	422	582	9500
Mode	0	221	9020
Geometric mean		592	5330
Standard deviation	2860	1050	5820
Standard error	640	371	1270
Minimum	0	140	350
Maximum	8950	3050	16800
Range	8950	2910	16400

	APRIL	MAY	JUNE
Sample size	18	31	30
Average		OPEN	OPEN
Median	17000	OPEN	OPEN
Mode	OPEN	OPEN	OPEN
Geometric mean		OPEN	OPEN
Standard deviation		0	0
Standard error		0	0
Minimum	0	OPEN	OPEN
Maximum	OPEN	OPEN	OPEN
Range		0	0

Table 162: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, South (M) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	19	12	22
Average	2680	2300	1720
Median	271	771	1710
Mode	0	0	1650
Geometric mean			1560
Standard deviation	4190	3340	680
Standard error	960	964	145
Minimum	0	0	410
Maximum	12600	10400	3130
Range	12600	10400	2720

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50.

Table 162: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, South (M) in 1983.

	APRIL	MAY	JUNE
Sample size	13	25	30
Average	4630		OPEN
Median	1050	OPEN	OPEN
Mode	914	OPEN	OPEN
Geometric mean			OPEN
Standard deviation	7490		0
Standard error	2080		0
Minimum	0	314	OPEN
Maximum	19100	OPEN	OPEN
Range	19100		0

Table 163: Monthly Summary Statistics of Polynya Areas* for Seward Peninsula Polynya, North (P) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	17	12	22
Average	2550	2360	1720
Median	58	922	1710
Mode	0	0	1650
Geometric mean			1560
Standard deviation	4210	3300	680
Standard error	1020	952	145
Minimum	0	0	410
Maximum	12600	10400	3130
Range	12600	10400	2720

	APRIL	MAY	JUNE
Sample size	12	25	30
Average	5010		OPEN
Median	1080	OPEN	OPEN
Mode	914	OPEN	OPEN
Geometric mean			OPEN
Standard deviation	7690		0
Standard error	2220		0
Minimum	0	151	OPEN
Maximum	19100	OPEN	OPEN
Range	19100		0

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50.

Table 164: Monthly Summary Statistics of Polynya Areas* for Kotzebue Sound Polynya (Q) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	21	11	17
Average	1050	409	73
Median	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	1700	1360	118
Standard error	371	409	29
Minimum	0	0	0
Maximum	4840	4500	308
Range	4840	4500	308

	APRIL	MAY	JUNE
Sample size	14	28	21
Average	585		
Median	388	886	OPEN
Mode	0	OPEN	OPEN
Geometric mean			
Standard deviation	620		
Standard error	166		
Minimum	0	0	0
Maximum	1490	OPEN	OPEN
Range	1490		

Table 165: Monthly Summary Statistics of Polynya Areas* for Cape Thompson-Pt. Hope Polynya (R) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	23	16	22
Average	1090	435	521
Median	0	279	67
Mode	0	0	0
Geometric mean			
Standard deviation	1910	514	677
Standard error	398	128	144
Minimum	0	0	0
Maximum	8070	1660	1900
Range	8070	1660	1900

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50.

Table 165: Monthly Summary Statistics of Polynya Areas* for Cape Thompson-Pt. Hope Polynya (R) in 1983.

	APRIL	MAY	JUNE
Sample size	14	28	13
Average	340	364	2060
Median	0	0	1830
Mode	0	0	0
Geometric mean			
Standard deviation	570	532	1740
Standard error	152	100	482
Minimum	0	0	0
Maximum	1950	1580	5920
Range	1950	1580	5920

	JULY
Sample size	28
Average	OPEN
Median	OPEN
Mode	OPEN
Geometric mean	OPEN
Standard deviation	0
Standard error	0
Minimum	OPEN
Maximum	OPEN
Range	0

Table 166: Monthly Summary Statistics of Polynya Areas* for Pt. Hope-Cape Lisburne Polynya (S) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	20	14	25
Average	266	334	125
Median	192	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	389	515	190
Standard error	87	138	38
Minimum	0	0	0
Maximum	1570	1660	652
Range	1570	1660	652

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50

Table 166: Monthly Summary Statistics of Polynya Areas* for Pt. Hope-Cape Lisburne Polynya (S) in 1983.

	983 APRIL	983 MAY	983 JUNE
Sample size	18	27	15
Average	128	8160	733
Median	124	516	428
Mode	0	0	0
Geometric mean			
Standard deviation	116	11400	1490
Standard error	27	2200	384
Minimum	0	0	0
Maximum	357	31400	5920
Range	357	31400	5920

	JULY
Sample size	28
Average	OPEN
Median	OPEN
Mode	OPEN
Geometric mean	OPEN
Standard deviation	0
Standard error	0
Minimum	OPEN
Maximum	OPEN
Range	0

Table 167: Monthly Summary Statistics of Polynya Areas* for Cape Lisburne to Pt. Lay Polynya (T) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	20	14	28
Average	324	1140	1470
Median	0	0	1210
Mode	0	0	0
Geometric mean			
Standard deviation	552	1710	1640
Standard error	123	456	311
Minimum	0	0	0
Maximum	1920	4340	5900
Range	1920	4340	5900

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50

Table 167: Monthly Summary Statistics of Polynya Areas* for Cape Lisburne to Pt. Lay Polynya (T) in 1983.

	APRIL	MAY	JUNE
Sample size	21	29	14
Average	1630	21100	3560
Median	1180	21700	930
Mode	0	21700	775
Geometric mean		20200	1540
Standard deviation	2120	5920	4660
Standard error	463	1100	1250
Minimum	0	11100	149
Maximum	9570	31400	12000
Range	9570	20300	11800

	JULY
Sample size	30
Average	
Median	OPEN
Mode	OPEN
Geometric mean	
Standard deviation	
Standard error	
Minimum	4190
Maximum	OPEN
Range	

Table 168: Monthly Summary Statistics of Polynya Areas* for Pt. Lay to Icy Cape Polynya (U) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	19	13	26
Average	454	1210	1280
Median	0	0	375
Mode	0	0	0
Geometric mean			
Standard deviation	815	1760	1690
Standard error	187	487	332
Minimum	0	0	0
Maximum	2720	4340	5900
Range	2720	4340	5900

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50.

Table 168: Monthly Summary Statistics of Polynya Areas* for Pt. Lay to Icy Cape Polynya (U) in 1983.

	APRIL	MAY	JUNE
Sample size	19	29	14
Average	1520	21100	
Median	1060	21700	207
Mode	0	21700	0
Geometric mean		20200	
Standard deviation	2260	5920	
Standard error	519	1100	
Minimum	0	11100	0
Maximum	9570	31400	OPEN
Range	9570	20300	

	JULY
Sample size	12
Average	
Median	6620
Mode	OPEN
Geometric mean	
Standard deviation	
Standard error	
Minimum	4190
Maximum	OPEN
Range	

Table 169: Monthly Summary Statistics of Polynya Areas* for Icy Cape to Pt. Barrow Polynya (V) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	19	12	26
Average	578	1200	923
Median**	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	892	1830	1630
Standard error	205	529	320
Minimum	0	0	0
Maximum	2720	4340	5900
Range	2720	4340	5900

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50

Table 169: Monthly Summary Statistics of Polynya Areas* for Icy Cape to Pt. Barrow Polynya (V) in 1983.

	APRIL	MAY	JUNE
Sample size	19	28	15
Average	1100	20600	96
Median	306	21700	0
Mode	0	21700	0
Geometric mean			
Standard deviation	2280	7670	201
Standard error	522	1450	52
Minimum	0	0	0
Maximum	9570	31400	566
Range	9570	31400	566

	JULY
Sample size	14
Average	
Median	0
Mode	0
Geometric mean	
Standard deviation	
Standard error	
Minimum	0
Maximum	OPEN
Range	

Table 170: Monthly Summary Statistics of Polynya Areas* for Chukotsk Peninsula Polynya (W) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	12	5	7
Average	454	0	0
Median	0	0	0
Mode	0	0	0
Geometric mean			
Standard deviation	992	0	0
Standard error	286	0	0
Minimum	0	0	0
Maximum	2590	0	0
Range	2590	0	0

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-50.

Table 170: Monthly Summary Statistics of Polynya Areas* for Chukotsk Peninsula Polynya (W) in 1983.

	APRIL	MAY	JUNE
Sample size	6	15	23
Average	0	95	OPEN
Median	0	0	OPEN
Mode	0	0	OPEN
Geometric mean			OPEN
Standard deviation	0	367	0
Standard error	0	95	0
Minimum	0	0	OPEN
Maximum	0	1420	OPEN
Range	0	1420	0

Table 171: Monthly Summary Statistics of Polynya Areas* for Anadyr Gulf Polynya (Y) in 1983.

	JANUARY	FEBRUARY	MARCH
Sample size	11	10	16
Average	6200	3870	8080
Median	4950	3700	7060
Mode	0	3230	6510
Geometric mean			6980
Standard deviation	5570	2920	4430
Standard error	1680	923	1110
Minimum	0	0	2090
Maximum	16300	9650	18500
Range	16300	9650	16400

	APRIL
Sample size	11
Average	7660
Median	6180
Mode	6180
Geometric mean	6730
Standard deviation	3910
Standard error	1180
Minimum	2700
Maximum	14800
Range	12100

*Polynya areas in square kilometers. All possible area determinations are used for calculations.

**Median is equivalent to median area in Tables 44-60

RU 663

REMOTE SENSING DATA ACQUISITION ANALYSIS AND ARCHIVAL

SEVENTH QUARTERLY REPORT
July 1, 1987 - September 30, 1987
OCSEAP Research Unit 663

by

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Submitted to

National Oceanic & Atmospheric Administration
Ocean Assessments Division
Alaska Office
PO Box 56
Anchorage, Alaska 99513

December 1987

SEVENTH QUARTERLY REPORT
July 1, 1987- September 30, 1987
OCSEAP Research Unit 663
Contract #50ABNC 600041

ACTIVITIES THIS QUARTER

1. Assistance to OCSEAP **Investigators.** Walter Johnson, Sathy Naidu and Jim Raymund (RLJ 690) conducted a cruise aboard the Surveyor in the Chukchi Sea between September 17 and October 8. This RU provided support to that effort by monitoring NOAA AVHRR satellite images as they became available during this time and producing high quality photographic prints of the scenes which maybe of value to their study. It is anticipated that some of these images will be analyzed digitally in the future to show patterns of temperature distribution and suspended sediment in the region just north of Bering Strait. A high-resolution SPOT image was also acquired showing suspended sediment in the vicinity of Kotzebue.

coordination w/ RU690

At one point, when the surveyor was located at 670N, 168o12'W, we contacted the field party to give a verbal description of the Chukchi temperature regime as interpreted *from NOAA thermal* band imagery.

real time R.S → SHIP!

2. **Polynya Analysis.** Having completed our preliminary statistical analysis of polynyas, we are now beginning an attempt to correlate polynya size with extemrd factors, principally wind and temperature. We think that it would also be *useful* to be able to look for correlations with currents. This would seem to be particularly important in light of Dr. Robert Prichard's recent work performed for the Minerals Management Service and reported at the recent conference on Port and Ocean Engineering under Arctic Conditions held in Fairbanks. On the basis of buoy position and current (relative to the buoys), Prichard concludes that often currents are the major influence in ice

motion. We hope to be able to report some preliminary findings of this work at the upcoming Information Transfer Meeting to be held in Anchorage during November.

3. Reports and Papers Provided. During this quarter we provided Drde Kinney of MMS with 'Width and Persistence of the Chukchi Polynya," and "Statistical Description of the Summertime Ice Edge in the Chukchi Sea." Mr. Dick Ragle wanted information regarding ice conditions and related hazards in Stephenson Sound and Prudhoe Bay. It transpired that he already had most of our reports but did not have "Summertime Ice Concentration in the Harrison and Prudhoe Bay Vicinities of the Beaufort Sea." This seemed to be the kind of information he needed so it was sent to him.

who is he?

4. Data Acquired this Quarter. We have continued to obtain and archive daily NOAA AVHRR satellite imagery of the OCSEAP study areas around Alaska. Because of the three-to-four ties daily coverage of Alaska by these satellites, we cannot possibly afford to purchase a copy of each at the $10.00 per copy rate charged. Thus we select only the best images (approximately three per day and purchase them in positive transparency format directly from the receiving station at Gilmore Creek). (Our experience has shown us that positive transparencies retain the highest information content for analysis and reproduction purposes of all data formats other than digital tapes.)

3 AVHRR image per day are purchased! positive transparencies

In addition to the positive transparency format data, we also receive hardcopy facsimile transmission positive prints that have been used by the weather service. There is a great quantity of these prints, as they represent at least one copy of each day's image and sometimes digital enlargements and enhancements of particular areas. These are sent to us by the weather service about a month after they are transmitted from Gilmore

Creek. We archive these data (although the image quality is considerably diminished from that of the positive transparency) because some feature of interest to OCSEAP investigators may be found on one of these images which did not appear on an image judged to be one of the day's best images. Following these criteria, we archived approximately 555 positive transparencies this quarter.

Our "Quick-Look" ground station received a total of 37 images from Larrdsats 4 and 5. These images are often digitally enhanced and enlarged with copies of these products archived as well as the standard 1:1M scale print. In some instances we have obtained images at times when the sun was below the horizon - yet ice conditions are easily observed. This is an additional value of our ground station and image enhancement capability.

We also continue to receive and archive the NOAA/Navy ice charts published weekly and the drifting buoy data published monthly by the Polar Ocean Center in Seattle.

ACTIVITIES NEXT QUARTER

1. We arc anticipating taking part in the upcoming Information Transfer Meeting and Information Update Meeting in Anchorage, November 17-20.

2. We will continue to collect remotely sensed AVHRR and LandSat imagery.

3. We will continue to watch for the availability of SSMI passive microwave data which should become available shortly.

4. We will continue our polynya analysis attempting to relate polynya size with meteorological conditions.

FUNDS EXPENDED

As of September 30,1987, we have expended $169,372.83 of a total authorized budget of $205,799.00.

REQUEST FOR PERMISSION TO PUBLISH

Attached is a preprint of "Summertime distribution of floe sizes in the western Beaufort Sea," which was prepared under this contract. We seek permission to submit it to the Journal of Geophysical Research.

DRAFT

SUMMERTIME DISTRIBUTION OF FLOE SIZES IN THE WESTERN NEARSHORE BRAUFORT SEA

by

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Submitted to

Journal of Geophysical Research

December 1987

ABSTRACT

The areal extent of ice floes has been measured from Landsat imagery of the summertime Beaufort Sea, spanning the five months between break-up and freeze-up. In general, the distribution of floe size areas was found to obey a power law: $N(S) = N_1 S^{\lambda}$, where the counted number of floes per unit floe size interval, N(S), is related to the number of floes in the particular distribution at unit floe size (N_1), the floe size (S), and λ, a parameter found here to range between -1.33 and -2.06. The value of λ decreased from -1.33 in May to -2.06 in August and then increased to nearly -1.47 in September. An exponential relationship with λ was found among the values of N_1 from the various distributions: $N_1 = N_o e^{-15.14a}$. This relationship appears to hold regardless of the seasonal variation of λ. Thus, floe size distributions were found to obey $N (S) = NO (e^{-15'' \, 4}S)'$, with a value No = 1.23×10^{-6}, where No is tha projected number of floes per unit floe size at unit floe size for λ = 0.

Although not observed, a value of λ = -1 was found by theoretical considerations to produce a floe size distribution in which the apparent distribution of floe size is the same regardless of the scale at which it is viewed. Based on the observed variation of λ with season, it is hypothesized that such a distribution might appear earlier in the year than the observing period reported here. A value of λ = 0, also not observed, would describe a floe field where all floe sizee are found in equal numbers.

INTRODUCTION

The Beaufort Sea shear zone (see Figure 1) is a region of dynamic ice activity resulting from interaction between the static shorefast ice zone and the pack ice of the Arctic Ocean gyre. During winter and early spring the ice in this region is subjected to recurring large-scale stresses brought on largely by synoptic weather systems. During these events, the pack ice is both fractured and ridged. However, the fracturing at this time is largely limited to the creation of floes whose characteristic dimensions range between a few tens to hundreds of km. AS long as temperatures remain sufficiently below freezing, the leads between floes freeze quickly to such a thickness and strength that by the time of the next synoptic event an entirely new fracture pattern is created--in terms of the new fracture pattern, the ice has "forgotten" the previous fracturing.

Once tha freezing rate is diminished to the point that fractures formed during one dynamic event remain very weak at tha time of the next event, successive events will then continue to fracture the ice into smaller flees. Soon after that internal stresses are joined by other mechanisms of new floe formation; contact forces between floes in collision have been observed to cause floe division (Sackinger, 1985) and as fetches develop, waves also cause fracturing of floes (Wadhams and Squire, 1980).

Not only are there several mechanisms which can result in fracturing of flees, but in this region, the pack ice strength is very seldom uniform: there are partially frozen leads, rubble piles, pressure ridges, shear ridges and even fractures in otherwise unbroken floes resulting from asymmetric loading due to ice piled around edges (see Figure 2). Thus as the pack ice region begins breaking up, there are innumerable areae of relative strength and weakness in the ice field which can respond to applied forces. Hence, in the absence of simple applied stresses and uniform ice strength, One might anticipate that the creation of floes would result in a somewhat random size distribution but that in general, the sizes would become smaller with time.

There are various reasons to examine floe size distributions. Wadhams and Squire (1980) , and Dean (1966), for instance, heve investigated the relationship between floe size and wave attenuation. The study reported here was originally prompted by a hypothetical assessment of the release rate of spilled petroleum which had been entrained in ice following the spill.

ANALYSIS

Landsat imagery has been available since 1972. These data have , pixel area of 4.8 x 10^3m so that flees on the order of 10^4 m should be measurable. The optimum approach to a study of floe size distributions and their change over time would be to sample the size dis tribut ion of the same ice field as it changes. There are several operational

Description of LANDSAT! what it "sees" difficulties encountered trying to accomplish this ideal experiment: Landsat coverage at this latitude has usually been only four successive days every two weeks (although there was a brief period with two satellites operating one week apart) . However, cloudiness and operational interruptions make the data set much less regular than even this schedule would suggest. Furthermore, unless coverage is continuous, it is difficult to follow a particular ice field as it deforms due to currents and wind drift. Thus, unless one has the advantage of fortuitous circumstances, generally, the best that can be done is a sampling of data from the same region over a range of times. In this study we analyzed floe size data from 18 images of the western nearshore Beaufort Sea which yielded samples between May and September, 1972 through 1981. From these images 26 study areas were selected, each *20X20 km.*

Photographic enlargements of these study areaa were made to 1:50,000 scale and floe areas were measured by means of a digitizing table linked with a computer. Actual areas were computed as a cursor was manually directed around each floe on the enlargement. Each floe waa numbered for identification purposas and a computer-generated line drawing of each floe scaled was created for verification purposes (Figure 3). Floe sizes down to the order to $10^3 m^2$ were measured but the population of sizes less than $10^4 m^2$ were not considered valid for analysis. However, in the example which follows, theee data are plotted.

The data were found to fit a power law best and were all subsequently plotted using log-log coordinates. Figure 4 shows the plot of data taken from scene 1719-21031, 12 July 1974. A computer-generated least squares fit for these data is plotted as well. Despite the apparent closeness of this fit, the average deviation between measured data and the best fit is 52%. The reason for this apparent discrepancy is simply that the scales are logarithmic, compressing differences less than an order of magnitude to relative insignificance. However, correlation was found to be 98. 7% and the power law explained 97.5% of the variation. On this plot, the horizontal scale gives floe size in m^2 while the vertical scale gives the number of floes per unit floe size at a given size in the entire 400 km^2 study area. Thus, in Figure 4, to find the number of floes in the study area whose sizes range from $1x10^6 m^2$ to $2x10^6 m^2$, one notes that $1x10^6 m^2$ corresponds to approximately $3x10^{-5}$ floes/m^2 while $2x10^6 m^2$ corresponds to about $1x10^{-5}$ floes/m^2. Multiplying the mid range value of $2.0x10^{-5}$ floes/m^2 times $1x10^6 m^2$, one arrives at 20 floes. In the data actually scaled there were 17 floes whose sizes ranged between 1.05 and 2.10 x $10^6 m^2$.

The powar law found for the data displayed in Figure 4 is N = $4.8x10^4 S^{-1.53}$ where N is Number of floes per unit floe size and S is floe Size. The coefficient, 4.8X104, is the value Of this relationship when S = 1 m^2 and is the number of floes per unit floe size whose sizes would fall within the interval, 1 to 2 m^2. In all subsequent discussions, we will refer to this coefficient as N_1. Clearly, the extension of the distribution to m^2 floe sizes is hypothetical since the smallest floe measured was nearly four orders of magnitude larger. The small floe limit will be considered in more detail in our discussion.

RESULTS

Table 1 lists the datea, Landsat scene identification numbers, power law relationship, percent of variation explained arid correlation coefficient for all study areas analyzed. All study areas were 20x20 km in size. In the cases where two study areas were located on one Landsat image, a suffix A, or B is found after the date.

Power law relationships were found to be valid for all data sets. However, examination of the Durbin-Watson statistics indicates that a small cyclical variation of residuals remained. As can be seen from Table 1, the smallest correlation coefficient was .985. The value of λ ranged from -1.33 for 19 May 1974 to -2.06 for 5 August 1981, and N_1 ranged from 2.99×10^3 floes on 2 May 1978 to 1.20×10^8 floes for 5 August 1981. In general one would expect that both the absolute value of the power and the value of N_1 would increase as a floe field is broken up and more, smaller floes are generated. However, N_1 is also related to the fraction of the study area taken up by floes: consider two assemblages of floes in two equal study areas, each with the same distribution power but one with half as many floes as the other. The value of N_1 for the first assembly would be half that of the other. This study utilized study areas where the flees were reasonably compact yet sufficiently distinct to be identified and measured. Following this, using the summed floe area, N_1 was normalized to a perfectly compact condition. If the data are normalized for compactness, N_1 is directly related to the distribution!s power. This is because by compactness normalization we specify that the **total** floe area is conserved. Then for every power there is a unique value of N_1. The values of N_1 listed in Table 1 reflect this normalization. Figure 5 illustrates the relationship between N_1 and λ. A semi-log plot was chosen for display purposes because the N_1 values gave a linear fit in this representation. Thus the N_1 values can be **expressed** as an exponential law: $N_1(\lambda) = N_0 e^{-15.14\lambda}$ where N_0 = 1.37 X10-6 is the value of N_1 for the power law distribution, λ = 0. The correlation coefficient for this exponential fit was 99. 5%.

Returning to Table 1, it can be seen even at a glance, that these data appear to he ordered in terms of date versus A. Taking advantage of the five date groupings that occur in the data set, we obtain the relationship between power law exponent λ, and date shown in Figure 6. The bars on this plot represent one etandard deviation variance. This figure clearly shows a trend toward a higher negative power as summer progresses, followed by a sharp decline in mid to late September. It was thought that perhaps the relationship between N_1 and λ might be different for the September data when λ was increasing in value again. These data were plotted aa squares on Figure 5 rather than dots, as are all other data. It can easily be seen that the September data are not distinguished in this regard.

DISCUSSION

The summertime floe size data fit a power law distribution over a range of several decades of floe sizes. From Figure 6 we see that the average power of this law changes from -1.34 to -1.80 between late May and early August. Examination of the actual floe counts shows that size of the largest floes in the distributions changed from the 10^7-10^8 m^2 range to tha 10^6-10^7 m^2 range over this period. At the same time N (S)= N(10^4), the number of floes at size 10^4 m^2, changed f rom a few to the 50-100 range. Clearly this is an indication of a process where many small floes are being created but large floes are not entirely eliminated. This suggests a probabilistic process where, in each unit of time, a given floe has a probability less than unity of undergoing a division. As a result, as smaller flees are created, large flees retain some chance for survival. An alternative to this, a mechanism under which every floe divided, say, by half during each unit of time, would produce a apiked distribution that grew exponentially in total number as its locus moved to smaller floe sizes. If a probabilistic process is taking place, then the change in the exponent of the power law over time reflects the process of random floe splitting as the summer season progresses. The decrease of the exponent in late September would result from the combining of floes as freezing temperatures reappear.

It is interesting to consider some of the implications imposed by convergence of the integral of a power law floe size distribution. Clearly the aggregate of the floe sizes cannot exceed the size of the study area. To investigate the implications of this boundary condition we note that starting with

$$N(S) = N_1 S^{\lambda}$$

as the form of the floe size distribution,

$$SN(S) = N_1 S^{\lambda+1}$$

is the number of flees whose sizes fall within one unit range of S, and if N_1 is normalized as if the study area A were completely covered with floes,

$$A = N_1 \int_{S_{min}}^{S_{max}} S^{\lambda+1} ds = \frac{'1}{(\lambda+2)} S^{\lambda+2} \Big|_{S_{min}}^{S_{max}}$$

unless λ = -2, then

$$A = \int_{S_{min}}^{S_{max}} S\text{-}i ds = N_1 \ln_S \Big|_{S_{min}}^{S_{max}}$$

gives the aggregate size of floes in the distribution whose sizes range from S_{max} to S_{min}.

These integrals converge under the following conditions:

1) $\lambda > -2$. This applies to all observed cases save one. In this casa the integral will converge even for a lower size limit of S_{min} - 0. Thus for this form the size of the floes decreases sufficiently faater than their numbers increase with the result that the aggregate area of floes smaller than any specified size is bounded, i.e. small floes do not catastrophically fill the study area.

However, the maximum floe size is bounded through convergence of the integral and therefore must be specified. Taking as an example the idealized form for the distribution of 12 July, 1974 (Figure 4), for a study area $A = 4x10^8$ m^2, we have S_{max} = $1\ 6x10^7$ m^2. This agrees well with the largest floe actually obeerved in this particular sample whose siza was 1.51 x 10^7 m^2. (Note that this floe occupies about 1/25 the study area.) Actually, since we have normalized the distribution to a totally compact condition, one would expect the largest floe to be somewhat larger than the largest floe actually observed because a compact distribution would contain more floes of all sizes and a greater chance of a larger largest floe.

It is instructive to consider the contribution to this integral from all floes smaller than those which we can effectively measure and count, $10^4 m^2$. Solving for this area yields approximately 10^7 m^2, or 1/40 the total study area. Similarly, the aggregate Of all floes whoee sizes would be less than 1 m^2 is approximately 10^5 m^2 or one four thousandth the a tudy area. Therefore, assuming there are no floes less than 1 m^2 has very little effect on the size of the largest permissible floe in the distribution. Even assuming there are no floes smaller than those we could measure, 10^4 m^2 only increases the size of the largest floe in the distribution by 2. 5%.

Hence, application of convergence criteria to determine a largest floe size in an idealized distribution yields a realistic result even assuming that the population of floes in the distribution does not extend below those sizes which we can actually observe.

2) $\lambda < -2$. This applies to only one observed case. In this case the integral will converge for any value of maximum floe size, including infinity, but *not* for arbitrarily small values for the minimum floe size. One way to visualize a floe field which allows arbitrarily large floes in the distribution yet whose integral converges for arbitrarily large floe size, is to imagine viewing a limited portion of an infinite floe field having such a distribution; if one views successively larger portions of the floe field, successively larger floes will come into view. However, the area observed is always larger than the largest floe in view.

In this case, the lower size limit must be examined; its value cannot be arbitrarily small. Figure 3 shows the floe field for which $\lambda = -2.06$.

In order to demonstrate the relative insensitivity of the size of the smallest floe to the specification of the size of the largest floe, the following comparative calculation was made: allowing the largest floe to be of infinite size results in a smallest floe of 0.91 m^2 while making the largest floe 10 m^2 results in a smallest floe of 0.32 m^2. Therefore the smallest floe will range between these two values for all realistic values of maximum floe size. (The actual largest floe observed in this distribution was approximately 4 x 106m2). On the other hand, the total number of floes in the distribution is far from insensitive to maximum floe size in this particular example because the smallest floe size is in the vicinity of 1 m^2 and N_1, the number of floes of unit floe size is 1.2×10^8. In other words, one can expect that many floes in the interval between floe sizes of 1 m^2 and 2 m^2. In the actual case the compactness of the distribution was 11% so that the actual number of floes of unit floe size would be around 1.1×10^7.

This number haa implications which require investigation. By the power law model used here, one quarter of the area covered with ice was covered with floes in the range between one and two meters square. This seems to account for an alarming fraction of the ice covered area. However, it must be pointed out that the number of floes per unit floe size falls off slightly faster than s^{-2}, which decreases quite rapidly. Hence the contribution to total ice covered area by small floes is not quite the problem it might appear at first. Another problem is related to the difference between the actual observed floe field and the idealized floe field represented by the power law. The normalized value of N_1 was obtained by summing the observed floes and adjusting the observed value of N_1 accordingly. In this case, the normalization factor was approximately 9. Clearly, however, no floes of unit floe size were included in this sum. As a result, the power law does not totally represent the distribution because it requires floes outaide the observable range for convergence of the integral to the observed total ice area. The actual distribution has more floe area in the observable range ($> 10^4 m^2$) than the power law representation. However, in actuality the floe size distributions observed are noisy - particularly at the large size end where small numbers of floes in each size category are found. One extra floe in the 10 km^2 range would have the same area as all the floes in the 1-2 m^2 range in the power law distribution. For this reason the small floe size limit of this distribution should not be taken as physically very meaningful in terms of numbers of floes because it is too sensitive to the variations in the total area covered by floes. However, its computation can yield an indication as to how completely the modeled power law represents the actual floe distribution. In this case, vast numbers of small floes were not required for convergence and as a result the power law represents the actual distribution reasonably well. On the other hand, the model representation should have had more floe area in the observable range. One would be tempted to change this by modifying λ or N_1. However, those parameters were calculated from a best fit to the observable data and the variation was explained to a high degree of precision. Therefore, the quantity of ice placed in the non-observable category by the model should .be regarded as a measure of the "noisiness" of the actual flow size distribution compared to the power law model.

The above argument should not be taken to mean that one should not expect floes in the actual distribution below the observation threshold. In this case, we were comparing the total area of flows in the observable range of the power law model with the total area of floes observed. . Nhen $\lambda > -2$, there is nothing to limit the extension of the distribution to very small floe sizes. The integral will still converge and the area covered by small floes will be finite. This is not true when $\lambda < -2$. Allowing the distribution to continue to very small floe sizes would catastrophically overfill the study area with slush ice - regardless of the compactness of the distribution. The ocean in figure 3 is not filled with ice and therefore the actual distribution must be truncated at some point. (In any case, the power law would have to end at the molecular diameter of water.) Nhen one observes a flea field in late summer, one does not see great quantities of floes smaller than a few meters in dimension. There are at least two mechanisms which would account for this: 1) small floes contain fewer flaws sufficiently weak to result in fractures from asymmetrical loading due to waves and collisions; 2) as flees become small, their removal rate dua to melting increases.

3) $\lambda = -2$. This is a special case where tbe integral is satisfied by the function $N_I \ln(S)$. Clearly this case represents the transition between the other two casee. This integral will not converge for either $s_{min} = 0$ or $s_{max} = \infty$, so that both limits must be specified.

The foregoing discussion can be summarized as follows. In general, assuming that one knows the actual total area of all floes under the convergence criteria discussed, for a specified smallest floe (even arbitrarily small) and constant total floe area, the maximum floe size specified by the distribution becomes larger as λ approaches -2 from smaller negative values (i. e. , $\lambda > -2$). When $\lambda < -2$, the largest permitted floe size is unlimited but the smallest floe size must be specified, and as λ decreases from -2, the size of the smallest floe specified through convergence increases (again, holding the total area of floes constant). However, if in the former case ($\lambda > -2$), one truncates the distribution at some small but finite size rather than allowing the size distribution to continue to arbitrarily small values, a larger maximum floe size is required. In the latter case ($\lambda < -2$), if a cut-off to large floe sizes ia imposed, than the smallest floe size must be decreased. On the other hand, if one knows the total floe area within a specified size range and has a measure of the largest floe within a particular distribution, the model distribution can be examined with cons iderably more detail.

If we assume that the floe size distribution is generated by the sequential disintegration of a few larger floes to many small onea, transient effects would be most noticeable if the initial fracturing resulted in just a few large floes which then begin the sequential disintegration process. On the other hand, transient effects would be least noticeable if the original distribution of floes in the study arsa just after the time of first fracturing approximated a power law. Since transients arising from initial conditions are not readily apparent in the actual distributions, this appears likely. In that case we would expect to find in early stages of the process the distribution of sizes described by large values of λ with large values of maximum floe size and relatively large values of minimum floe size.

Next, it is instructive to consider a special case, the distribution characterized by λ = -.1. In this distribution the aggregate area of all floes of size s_k is

$$'kNlsk^{-1} = N_1$$

Thus the area of floes at each unit floe size is constant and equal to '1', and the total area of floes is

$$A = N_1 \int_{S_{min}}^{S_{max}} dS = N_1(S_{max} - S_{min}).$$

If the minimum floe size is allowed to be zero, then

$$A = N_1 S_{max}$$

and N_1, the number of floes at unit floe size, can be determined by dividing total area of floes by the maximum floe size.

However, this distribution has an even more interesting property: consider viewing a general floe distribution at some particular scale. The population of floes in the field of view will have the came size distribution exponent regardless of the extent of the flow field viewed. However, a change of scale (for instance, by changing viewing altitude or by changing a photographic enlargement factor) should, in general, change the size distribution's power by changing the distribution of apparent sizes. (By apparent size we mean either the solid angle subtended by a floe when viewed by an observer at some altitude above the ice pack, or by the image area of the floe on a photographic print rather than the floe's scaled size which, of course, remains constant.) While generally true, this change of distribution exponent with scale does not occur for the distribution power $\lambda = -1$.

Consider a distribution in which the number of floes of area s_m is M and the number of floes whose areas are $1/K\ S_m$ is P:

$$N(S_m) = M$$

$$N(K^{-1}S_m) = P$$

We now enlarge this distribution by a factor K (i. e., a linear enlargement factor of $K^{1/2}$) so that floes which were originally of size P now have an area M. The total number of floes has not changed; however, the floes formerly of size class $1/K\ S_m$ are now of size class S_m and have correspondingly brought their population magnitude, P, along with them. However, the actual solid angle viewing area must be kept constant and as a result, we now only count floes which formerly inhabited an area of K^{-1} of the total area. If the distribution is invariant under change of scale, then the number of floes of size S_m remains constant:

$$N(S_m) = M = K^{-1}P, \quad = K^{-1}[N(K^{-1}S_m)].$$

If we now assume a power law form, $N(S) \cong S^{\beta}$, we can generalize the above requirement by noting that under this form

$$N(K^{-1}S) = [K^{-1}S]^{\beta}$$

and hence

$$S^{\beta} = K^{-1}[K^{-1}S]^{\beta}$$

which is only satisfied when $\beta = -1$. The result can be explained in a less rigorous way by noting that since the aggregate area of floes at each unit floe size is constant under this power law, their number is inversely proportional to their size, henca the increase in numbers of floes of a particular size caused by the enlargement of a greater number of smaller floes to the larger size is exactly cancelled by the requirement to keep the counting area constant (or viewing solid angle constant).

An assembly of floes having this distribution would appear similar regardless of the altitude from which it was viewed. No floe assemblies were measured here having this distribution. Yet it does not appear unreasonable that such distributions may exist. Based on extrapolation of tha curve of power law vs. date (Figure 6) one might expect to see such a distribution in the region studied in April or March. Such a distribution would appear generally the same regardless of the altitude from which it was viewed. This author has experienced this phenomenon when flying over the Beaufort Sea and adjacent Arctic Ocean pack ice in winter at night when only the outline of floes and no other distinguishing details can be seen in the moonlight.

Another interesting case is $\lambda = 0$. In this case,

$$N(S) = N_1$$

for all values of S and the number of floes at each unit floe size is constant. The area of all floes at each unit floe size is

$$SN(S) - N_1S$$

and is therefore proportional to floe size. The total floe area is

$$\int_{S_{min}}^{S_{max}} SN(S)ds = \tfrac{1}{2}N_1 \left(S^2_{max} - S^2_{min}\right)$$

Clearly this integral only converges if a finite maximum floe size is specified. This value of λ is so far from observed values that it appears unlikely to occur in sea ice. If it does occur, it would most likely occur very early in the floe disintegration process.

This work follows an earlier pilot study which concluded that spring and summer Beaufort Sea floe size spectra followed a power law distribution (Stringer et al., 1982; Stringer, 1983). Dean (1966) reported a gaussian distribution for measured floe size spectra in the Weddell Sea. Vinje (1977) reports a bimodal distribution in histogram of number vs. floe size distribution in the Spitsbergen-Greenland area. Weeka et al. (1980) present two floe diameter vs. frequency diagrams illustrating measurements performed from Side-looking Airborne Radar imagery. They stated that the histograms were negative exponential in form but it is not clear whether this was the result of numerical analysis or visual examination. No dates were given for the imagery.

Rothrock and Thorndike (1984) have written an extensive paper discussing theoretical considerations related to floe size spectra and have presented floe size spectra resulting from measurements performed by themselves from the AIDJEX study area. They display their data on a log-log format and take the resulting quasi-linear distribution of mean caliper diameter to a cumulative number as indicative of a power law distribution. No statistical tests were reported. They also re-plotted the Weeks et al. (1980) data showing that it, too, was quasi-linear in a log-log representation. Two Russian papers, Losev (1972) and Gorbunov and- Timokkov, are mentioned by reference only and no floe size data are reported.

Rothrock and Thorndike consider a number of problems related to sampling techniques and recommend that for manual measurements floe chord lengths be sampled along random lines. Hence their results are reported in terms of mean caliper diameter.

In the study reported here, actual floe areas were measured by means of a digitizing table. This technique has the advantages that normalization of the power law coefficients can be carried out and convergence of the integral of the resulting floe size distribution has physical meaning. It is possible to compare the results of these two studies in a general way because floe area should be linearly related to mean caliper diameter squared. Rothrock and Thorndike plotted cumulative number however, and this will result in λ values are slightly higher than values found by plotting the differential value as has been done here. The number of flees, NO, at mean diameter p is proportional to the number of floes whose areaa are equal to ρ^2. Thus, the range of powers found by Rothrock and Thorndike for the exponent, α, can be compared with λ by the following argument:

$$N_\rho \cong \rho^\alpha = (\rho^2)^{\alpha/2} = S^{\alpha/2} = S^\lambda, \text{ if } \alpha/2 = \lambda$$

The values of α are comparable with values of λ by dividing the α values by 2. Now we can compare the reported ranges of power law exponent:

range of $\alpha/2$: $-.85 < \alpha/2 < -1.25$ (comparable values of λ from other studies)

range of λ: $-1.33 < \lambda < -2.06$ (this study)

These values do not quite overlap. However, the Rothrock and Thorndike data were taken from aerial photography during summer at the AIDJEX site, well into the ice pack, while our data were taken very close to, or including the pack ice edge. The results reported here indicate that λ decreases at the pack ice edge with advance of season. It is not unreasonable to suggest that the ice at the AIDJEX study area was less dia integrated than ics at the pack ice edge at roughly the same time and therefore exhibited values of power law exponent that would occur at the ice edge much earlier in the spring.

CONCLUSIONS

1) Measured spring and summer floe size distributions taken from near the pack ice edge were found to follow a power law distribution:

$$N(S) = N_1 S^{\lambda}$$

where the power law exponent, λ, decreased from -1.33 in May to -2.06 in August and then increased to a value of -1.55 by October.

2) The power law coeff icients, N_1, (the number of floes at unit floe size in the distribution) are related to the power law exponent through an exponential relat ionship of the form:

$$N_1(\lambda) = N_0 e^{K\lambda}, \text{ where } N_0 = 1.23 \times 10^6 \text{ and } K = -14.4$$

Thus, each floe size distribution can be completely apecif ied through the power law exponent, λ. (This is for a perfectly compact distribution. For a real distribution, N_1 must be decreased by the compactness ratio.)

3) The exponential relationship of the power law exponents holds in both the case of decreasing and increasing values of λ as seasons change. Thus there appears to be no characteristic of flow size distribution which distinguishes between floe disintegration under summertime conditions and floe growth in the fall.

4) Examination of the observed power law spectra in terms of convergence criteria provide the following observation:

a) In the case of $\lambda > -2$, convergence of the flow size integral is not limited by the smallest floe size in the distribution, but the size of the largest floe must be specified. Requiring that the integral of floe sizes converged to the actual area covered by floes resulted in an upper limit floe size which agreed with the largest floe sizes observed in real distributions.

b) In the case of $\lambda < -2$, convergence of the floe size integral is not limited by the largest size in the distribution, but the size of the smallest floe must be specified. Requirement t that the floe size integral converge to the actual area covered by floes is very sensitive to the degree to which the power law models the area of floes within the observable range. The degree of match between power law representation and actual distribution is related to the "noisiness" of the actual floe size distribution.

5) Theoretical considerations show that a power law floe size distribution with an exponent value of $\lambda = -1$ would be self-similar under viewing scale changes: regardless of the scale at which it was viewed, the distribution of apparent floe sizes in a given angular field of view would remain constant. This distribution was not observed, but the variation of λ with date (Figure 6) suggests that such distribution might be found in the study area analyzed here in April or March. Considering the range of λ found by Rothrock and Thorndyke (1983), floes with this distribution may be found within the ice pack during the summer as well.

6) In the case of $\lambda = -2$, both the upper and lower limit floe sizes in a distribution would require specification in order for the integral to converge. The chance of a distribution occurring with precisely this exponent occurring is very small. The case is simply the mathematical transition between the caaes of $\lambda > -2$ and $\lambda < -2$.

Table 1. **Landsat** Scene Identification Number, Acquisition Date, Power Law Coefficient, Power, Percent Variation explained by power law model and correlation coefficient arranged in order of day of the year.

Scene ID	Date	N_1	$-\lambda$	Z variation explained	Correlation coefficient
2466-21114	2/5/78	2.99x10^{3}	1.35	98.3	.991
1665-21045	19/5/74	3.32x10^{3}	1.33	98.9	.994
2497-20421	2/6/76A	I.22X10^{5}	1.57	98.6	.993
2497-20421	2/6/76B	7.97X10^{4}	1.54	98.6	.993
2500-20592	5/6/76A	3.47x10^{4}	1.49	99.3	.996
2500-20592	5/6/76B	I.11X10^{4}	1.41	97.4	.987
1703-21151	26/6/74	4.89x10^{4}	1.49	99.3	.996
2157-20595	28/6/75	3.67x10^{5}	1.66	97.8	.989
2896-20434	6/7/77	1.26x10^{5}	1.56	97.1	.985
21993-20583	7/7/80	2.46x10^{6}	1.78	99.0	.995
1719-21031	12/7/74A	8.21x10^{4}	1.53	97.5	.987
1719-21031	12/7/74B	1.52x10^{5}	1.58	99.6	.998
1722-21202	15/7/74A	9.01X10^{4}	1.52	99.7	.997
1722-21202	15/7/74B	I.42x10^{7}	1.89	99.5	.997
22013-21095	27/7/80	5. 35x10^{6}	1.s3	97.8	.989
22387-20440	5/8/81A	1.20X10^{S}	2.06	99.7	.998
22387-20440	5/8/81B	4. 63x10^{7}	1.98	97.7	.988
30900-20490	21/8[80	9.529x10^{4}	1.57	98.1	.991
30901-20542	22/8/80	4. 3SX10^{5}	1.68	99.6	.998
30902-21001	23/8/80A	1.38x10^{6}	1.70	98.5	.993
30902-21001	23/8/80B	3.55X10^{6}	1.84	99.2	.996
22068-21160	20/9/80A	7.80x10^{5}	1.72	98.9	.995
22068-21160	20/9/80B	6.64x10^{5}	1.66	98.9	.994
1794-21170	25/9/74	3.20X104	1.47	98.9	.994
2249-21100	2819175A	1.37X10^{5}	1.60	98.5	.992
2249-21100	28/9/75B	9.07x10^{4}	1.55	98.8	.994

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FIGURE CAPTIONS

Figure 1. Map showing study area in the Beauf ort Sea Shear Zone, which is located between dynamic Beaufort Sea pack ice and static shorefast ice.

Figure 2. Oblique aerial photograph of Beaufort Sea pack ice showing non-uniformity of conditions related to ice strength on a local scale. In this example a lead has only frozen to a small fraction of the thickness of the surrounding floes. Numerous fractures can be seen, some of which follow this zone of weakness.

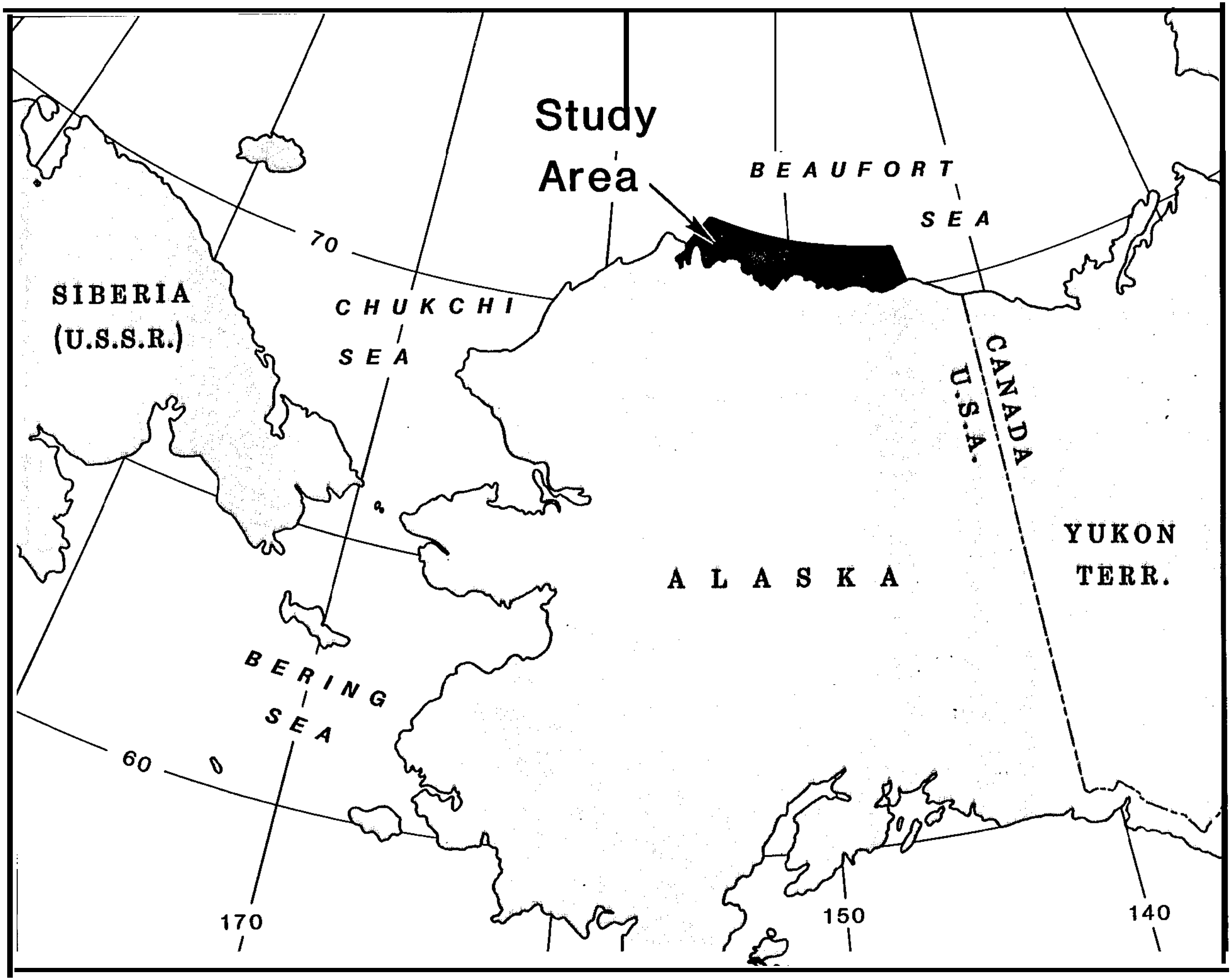
Figure 3(a) . Greatly enlarged portion of Landsat image, E-22387-20440, obtained 5 August, 1981.

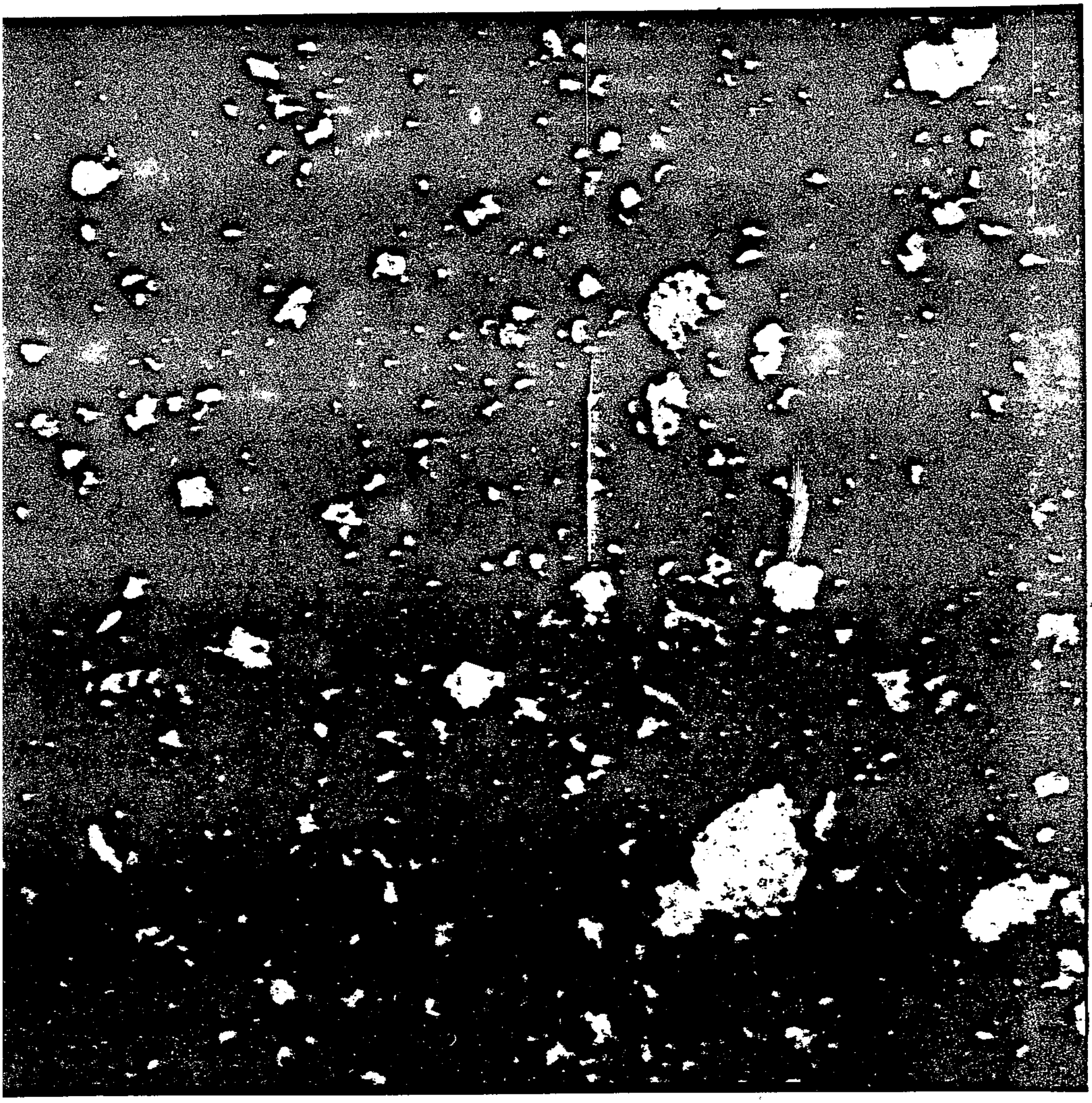
Figure 3 (b). Floe outlines obtained by digitizing floe boundaries from enlarged image. The largest floe in this field bas an area of 3.86 km^2.

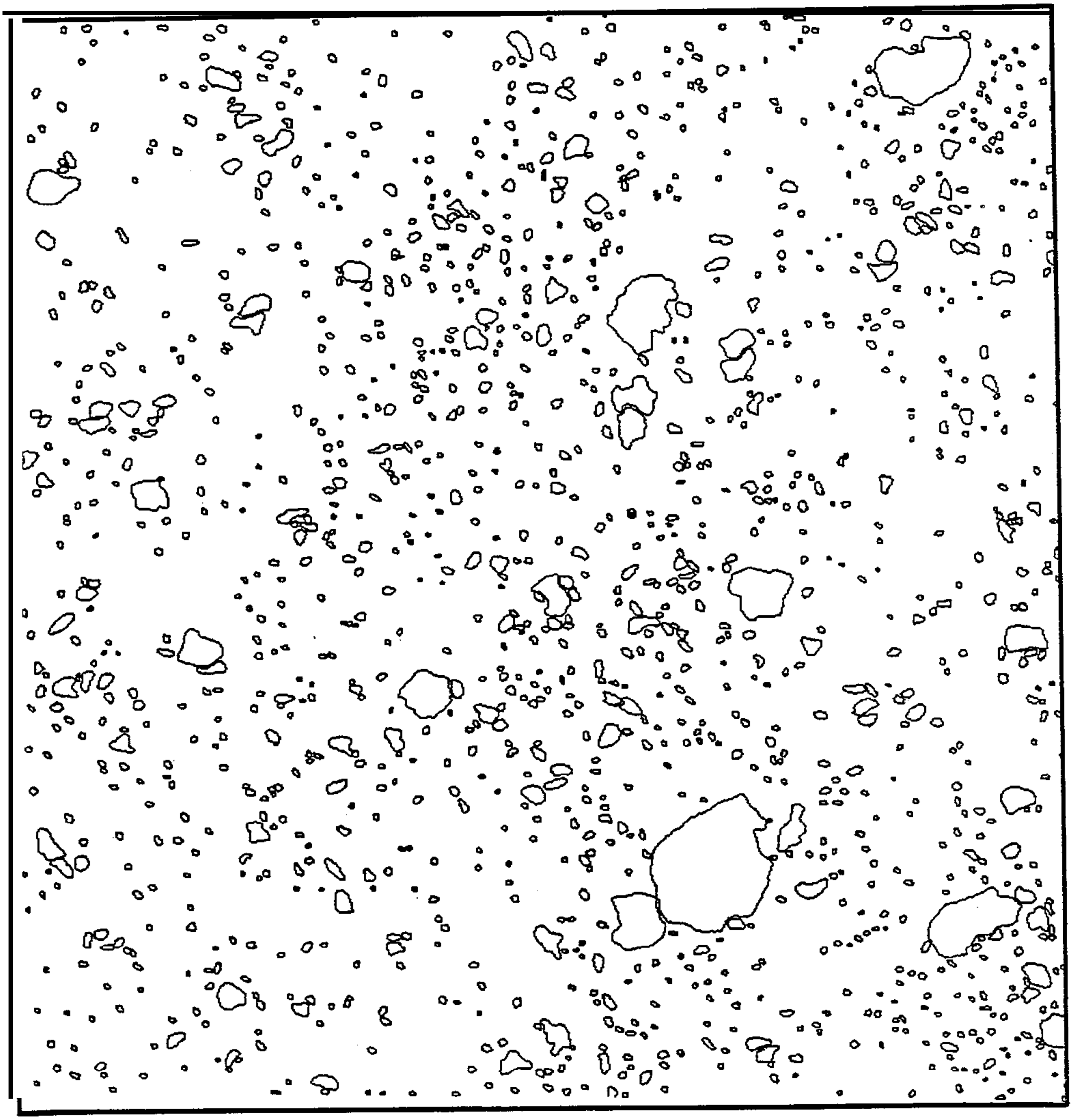
Figure 4. Distribution of normalized number of floes, N, per unit floe size as a function of floe size, S, measured from Landsat scene 1719-21031, obtained 12 July 1974. The straight line shows the locus of the power law best fit to these data, ignoring sizes smaller than $10^4 m^2$.

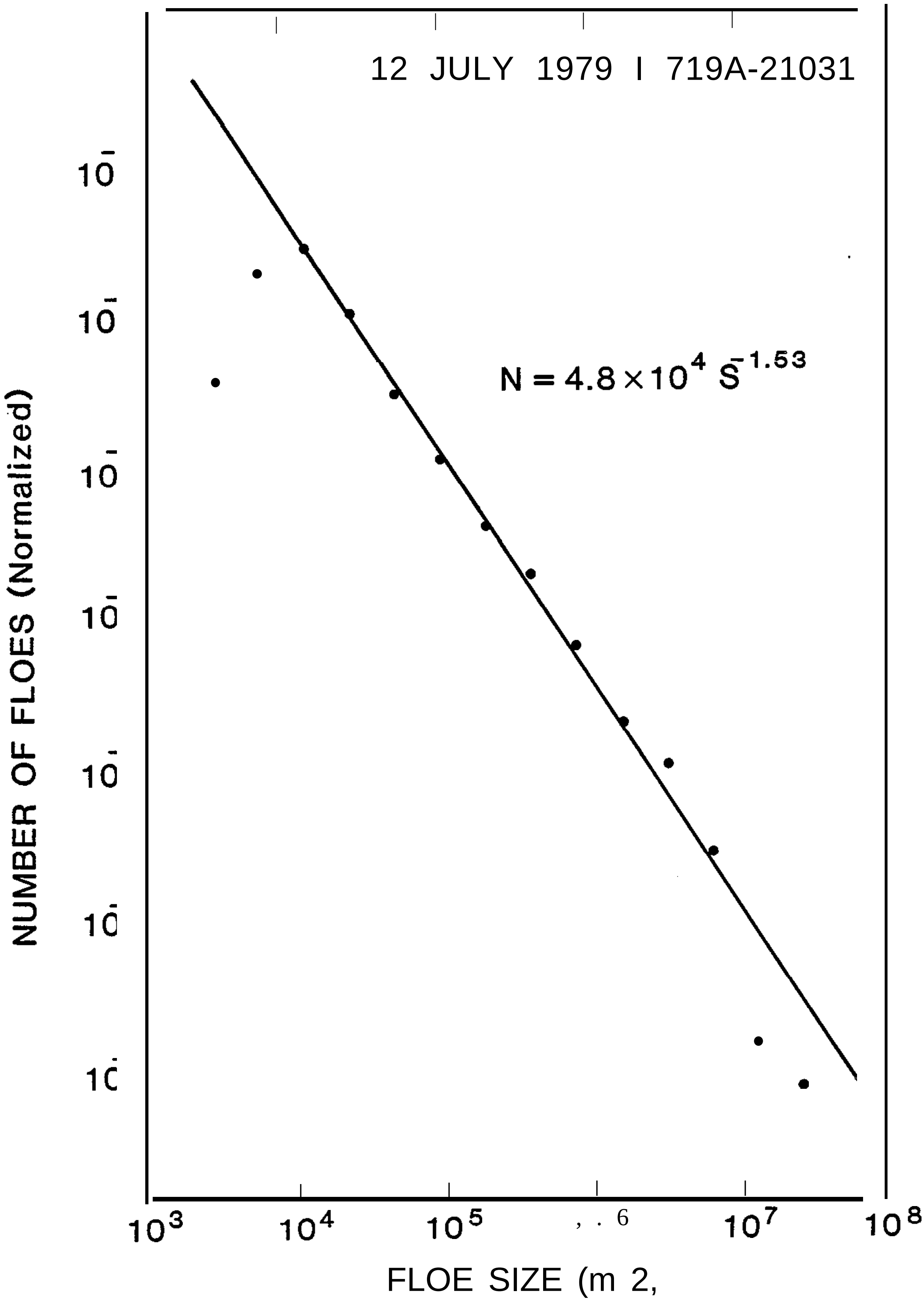
Figure 5. Relationship between power law coefficient (N_1) values, to power law exponent (A) values taken from Table 1. The straight line represents the best exponential law fit to these data. Dots represent power law coefficients and powers obtained through August when λ acquired increasingly larger negative values and the small squares represent power law coefficients and powers from September when this trend in λ values reversed (see Figurs 6) .

Figure 6. Relationship between observational period and power law exponent, λ, values taken from Table 1. Bars represent one standard deviation from mean values.

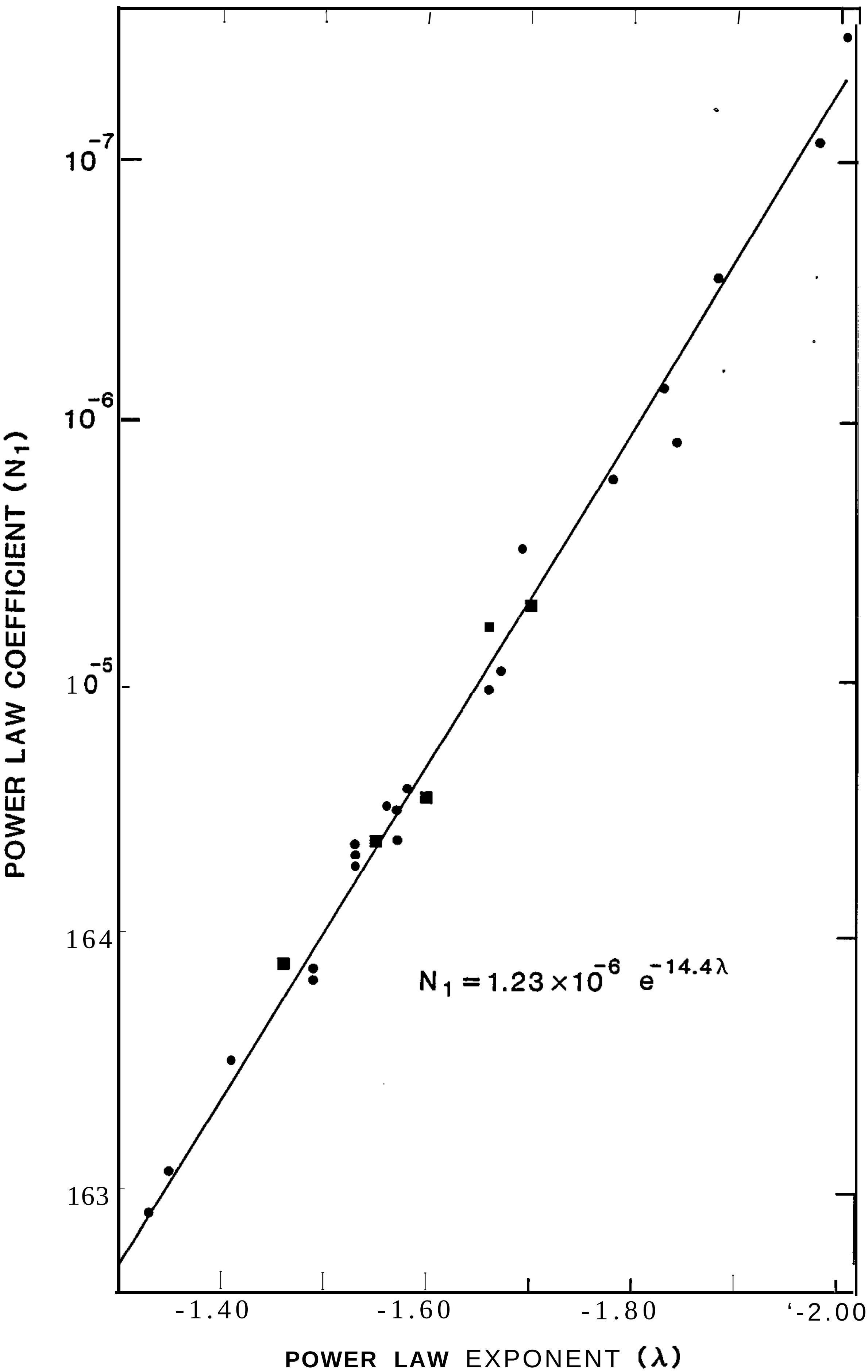

Study
Area
SIBERIA
(U.S.S.R.)
CHUKCHI
SEA
BEAUFORT
SEA
70
60
ALASKA
CANADA
U.S.A.
YUKON
TERR.
BERING
SEA
170
150
140



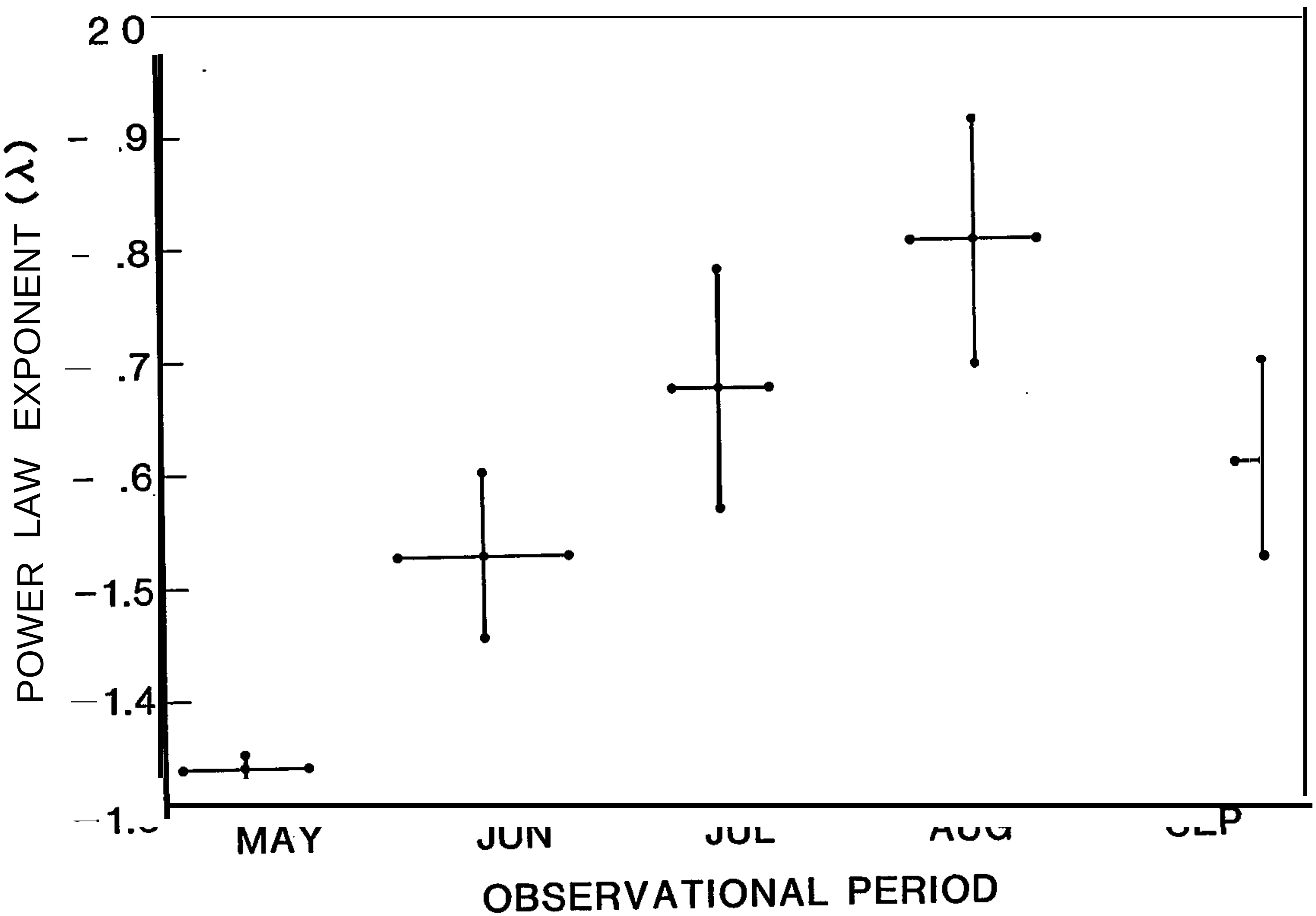




12 JULY 1979 I 719A-21031
$N = 4.8 \times 10^4 S^{-1.53}$
NUMBER OF FLOES (Normalized)
10^3
10^4
10^5
10^7
10^8
FLOE SIZE (m 2,



10^{-7}
10^{-6}
10^{-5}
164
163
POWER LAW COEFFICIENT (N_1)
$N_1 = 1.23 \times 10^{-6}\ e^{-14.4\lambda}$
-1.40
-1.60
-1.80
‘-2.00
POWER LAW EXPONENT (λ)



POWER LAW EXPONENT (λ)
2 0
.9
.8
.7
.6
-1.5
-1.4
MAY
JUN
OBSERVATIONAL PERIOD