AUSTRALIAN NATIONAL ANTARCTIC RESEARCH EXPEDITIONS

ANARE RESEARCH NOTES 13

A Computer Data Base for Antarctic Sea Ice Extent

T.H. Jacka

ANTARCTIC DIVISION
DEPARTMENT OF SCIENCE AND TECHNOLOGY

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N O T E S

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CONTENTS

ABSTRACT 1

1. PAST OBSERVATIONS OF SEA ICE EXTENT 3

2. THE SATELLITE ERA 3

3. ANALYSIS TECHNIQUES 5

   3.1 AIMS 5

   3.2 MAP DIGITISATION 6

   3.3 MAP INTERPRETATION 7

   3.4 SPATIAL RESOLUTION OF THE DATA BASE 7

   3.5 ICE EXTENT AND AREA CALCULATIONS 7

   3.6 CALCULATIONS OVER THE TIME DOMAIN 12

4. RESULTS 12

   4.1 MEAN SEA ICE EXTENT 12

   4.2 MAXIMUM SEA ICE EXTENT 20

5. DISCUSSION 22

REFERENCES 53

ACKNOWLEDGEMENT 54

APPENDIXES

I Conversion of digitiser coordinates to latitude and longitude ... 24

II Calculation of sea ice area 26

III Computer program output of mean sea ice latitude and variations for months, January through December 27

IV Computer output of sea ice latitude for each 10° longitude each year for months, January through December 40

FIGURES

1. Sea ice positions noted by Captain James Cook 2

2. The Navy-NOAA Joint Ice Centre map for 15 April 1982 4

3. The digitiser and computer terminal used for analysis of sea ice maps 6

4. Mean ice distribution for each month 13

5. Monthly means of Antarctic sea ice extent 19

6. Annual variation in mean sea ice extent as a function of latitude 19

7. Mean maximum sea ice extent 20

8. Plots of sea ice latitude each week for the maximum period ... 21

9. Maximum latitude of the sea ice edge for the period 1973 - 1982 .. 21

10. Schematic diagram of sea ice map on digitiser tablet 25

11. Parameters used for calculation of sea ice area 25

TABLES

1. Digitiser data for the Joint Ice Centre map dated 15 April 1982 .. 8

2. Sea ice longitude, distance from South Pole and latitude resulting from analysis of the data of Table 1 9

3. Computer program output of sea ice extent 10

4. Computer program output from area calculations 11

A COMPUTER DATA BASE FOR ANTARCTIC SEA ICE EXTENT

by

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ABSTRACT

A computer technique is described for digitising data from the sea ice maps distributed weekly by the U.S. Navy-NOAA Joint Ice Centre. Monthly maps of the Antarctic region outlining extent of sea ice cover have been available from this source since January 1973. Computer programs for the analysis of this data are described. Maps are presented which illustrate the mean, over ten years, of the extent each month and at maximum. These data have been used as a climate monitor using the relation between sea ice extent and the distribution of anticyclones, Antarctic and ocean temperatures, and atmospheric CO_2 levels which have been the topics of many recent studies.

The data are also of relevance to polar transport studies. Ships may need to penetrate, and aircraft may need to overfly, many kilometre of sea ice in order to carry out scientific programs or to gain access to Antarctic stations.

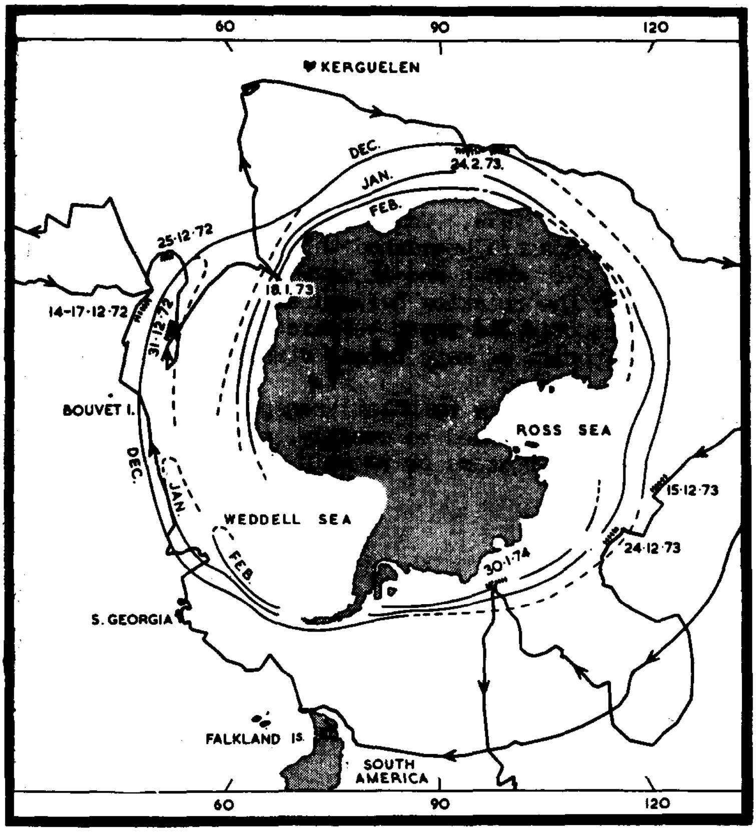


Figure 1. Sea ice positions noted by Captain James Cook are plotted along with voyage tracks. Also shown are December, January and February sea ice limits from Mackintosh and Herdman (1940).

1. PAST OBSERVATIONS OF SEA ICE EXTENT

The earliest observations of the Antarctic sea ice were made by the expeditions of Captain James Cook from 1772 to 1774. Herdman (1959) has given an account of Cook's sea ice records, while Rubin (1982a) has carried out a detailed study of all the scientific investigations of the expedition. Figure 1 (after Herdman, 1959) shows positions and dates of Cook's sightings of sea ice, superimposed on curves indicating the average sea ice limit for December, January and February, 1929-1936 (Mackintosh and Herdman, 1940). The scientific results, including sea ice observations, of Cook and of Bellingshausen have been examined in detail by Rubin (1982a and 1982b).

The earliest estimates of apparent mean monthly position of the sea ice edge for all months are for the period 1929-1936. They have been compiled by Mackintosh and Herdman (1940) and include data from scientific expeditions, in particular, those of the Discovery, and from whaling expeditions (Hansen 1934, 1936).

These same sources were later used to compile the British Admiralty (1943) "Ice Chart of the Southern Hemisphere", and still later, with more modern shipboard, aerial and land-based observations from Soviet, U.S. and Japanese expeditions, to give the sea ice data for the U.S. Navy Hydrographic Office (1957) "Oceanographic Atlas of the Polar Seas" and for the Soviet "Atlas Antarktiki" (Tolstikov et al., 1966 and Yeskin, 1969). In the compiling of these maps preference was given to later observations comprising principally, for the "Atlas Antarktiki", of data collected during the period 1947-1962.

2. THE SATELLITE ERA

Since 1967, various forms of satellite monitoring of sea ice extent have become available. Minimum brightness composite photographs (Booth and Taylor, 1969) for the period 1967-1972 provided the first regular description of the broadscale sea ice characteristics while from 1973 to the present, the U.S. Navy Fleet Weather Facility's Ice Forecasting Group, now called the Navy-NOAA Joint Ice Centre, have consistently provided a weekly map not only of the Antarctic sea ice, but also of the concentrations, and occasionally gives the location of the larger icebergs. Figure 2 is a sample map from this source for 15 April 1982. Note the iceberg near South Georgia and the notation describing concentrations.

The Joint Ice Centre uses several data sets in order to compile the weekly maps (Godin, 1979). Onboard NOAA polar orbiting satellites, Very High Resolution Radiometers which sense visible and infrared wavelengths, can resolve features to 1.0 km. Defence Meteorological Satellite Program satellites, also sensing visible and infrared wavelengths, can resolve features to 4.0 to 5.0 km. Due to darkness and extensive cloud cover, particularly in the winter months these satellites provide only data detectable in the infrared wavelengths much of the time.

Passive microwave images from the Electrically Scanning Microwave Radiometer onboard NASA's NIMBUS V satellite, and from the Scanning Multichannel Microwave Radiometer on NIMBUS VI are especially valuable for sea ice monitoring,

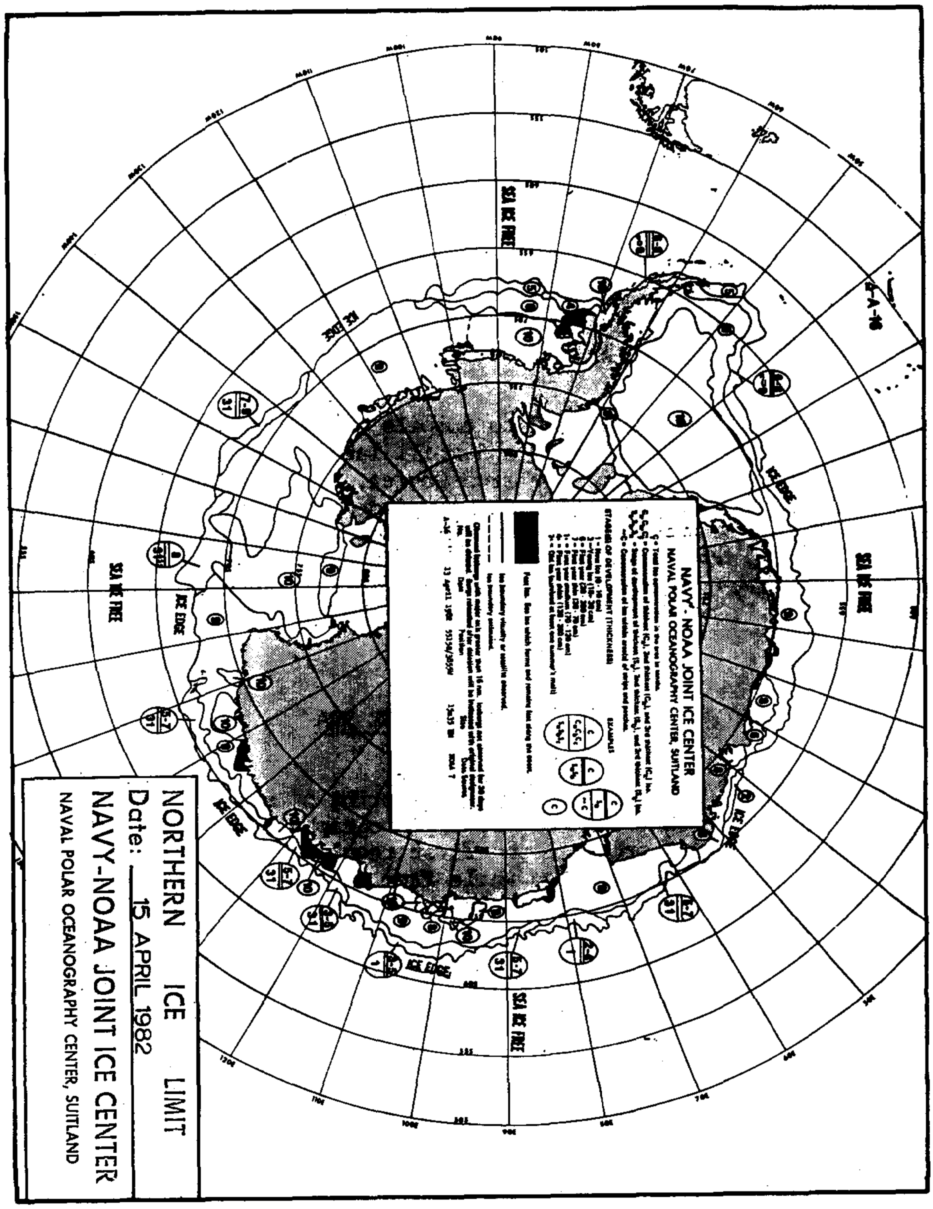


Figure 2. The Navy-NOAA Joint Ice Centre map for 15 April 1982. Note the iceberg (designated A16) and the ice concentration notations. For this paper the northern edge of the sea ice is digitised.

particularly during the winter months since they are not affected by cloud cover. The resolution of these sensors is approximately 32 km (Zwally and Gloerson, 1977).

Sharply contrasting microwave emissivities for sea ice (0.80 to 0.95) against sea water (0.40) allow ocean/sea ice definition from passive microwave imagery (Gloerson, et al., 1978). Ice temperature, concentration and type, snow cover, atmospheric temperature, and water content also affect the sensor received signal.

The Joint Ice Centre maps are produced in near real time from the analysis of microwave brightness temperature data, from the infrared and visible data, and from aerial and shipboard observations when available. From the microwave data, Zwally et al. (1982) have carried out subsequent numerical analyses of the raw data, providing a more accurate estimate of the ice characteristics.

Although a near continuous record is available from the weekly sea ice charts for the period 1973 to present, the quality of data has not been consistent. Some satellite data for 1973 and 1975 are unavailable due to equipment malfunction, and data for 1976 to 1978 suffer from equipment deterioration. In October, 1978 however, NIMBUS VII was placed in orbit, with a new Scanning Multifrequency Microwave Radiometer, and this has improved data reliability.

The provision of a weekly map detailing Antarctic sea ice distribution is a valuable asset for climatological, glaciological and geographical applications. The large amount of data however, requires a more refined storage and analysis technique. This report describes computer programs for the interpretation and analysis of these data. Some results from the analysis are given in both map form and as tabulated computer output.

3. ANALYSIS TECHNIQUES

3.1 AIMS

The computer technique described allows digitisation of the Navy-NOAA sea ice maps at every 10° longitude. Analysis has so far been concerned with the extreme northern edge of the Antarctic sea ice as shown by the weekly maps, and thus includes sea ice of concentrations greater than one tenth. The analysis has not included sea ice thickness or concentration data, and excludes the existence of polynyas. Zwally et al. (1979) have shown that as much as 50% of the Antarctic sea ice region can have an ice concentration of less than 85%. The measurement used however, is thought to give a reasonable measure of the hemispheric ice extent (Streten and Pike, 1980).

Once digitisation of a sea ice map is completed, computer programs are used to calculate the position of the ice edge, the ice extent at different longitudes, the area of sea ice in 10° sectors, and the total sea ice area. Further analysis includes calculation of means of ice extent and area over the time domain.

3.2 MAP DIGITISATION

Map interpretation is carried out using a computer linked digitiser. The digitiser is linked in parallel with an input/output terminal so that data may be transmitted from both the digitiser and the terminal.

The computer used for the analysis at the University of Melbourne is a VAX-II. The digitiser is a Summagraphics Bitpad, which has an active digitising area of 280 x 280 mm. The speed of the digitiser output is optional, but is usually set at 300 baud. A range of terminals are available at the University, each of them compatible with the digitiser. Figure 3 shows the set up of the equipment used at the University.

Input data files are created from the Navy-NOAA maps for later analysis by the computer programs. An input file consists of data pertaining to one or more maps. Data for each map consists of first, the date of the map, and second x-y coordinates from the digitiser defining the sea ice edge.

The digitiser is set such that coordinates are transmitted to the computer at discrete points when the digitiser stylus is activated. To initiate map digitisation, three data points are read which are used by the interpretation/analysis programs to orient and scale the map.

The first three map points digitised are the South Pole, the point at 65°S, 0° longitude, and the point at 65°S, 90°E respectively. This allows the map to be placed at any position and orientation on the digitiser tablet, and the map to be drawn at any scale.

By activating the stylus on the sea ice edge at each 10° of longitude, 36 points are then entered to the data file.

Finally, to indicate the end of the data set, the point at the South Pole is redigitised.

Figure 3. **The digitiser and computer terminal used for analysis of sea ice maps.**

At the University of Melbourne, a single data file contains all the digitised sea ice information, arranged in chronological order. Table 1 shows the section of the input data set representing the digitisation of the map of Figure 2.

3.3 MAP INTERPRETATION

The raw sea ice data file created as described in the preceding section consists of coordinates of the stylus on the digitiser tablet. These coordinates need now to be interpreted in terms of latitude and longitude of the ice edge. A computer program has been written to perform this task. Appendix I outlines the calculations involved.

The program begins by selecting the date and map sets to be analysed from the total data file. After scaling and orienting each map, longitudes and latitudes of the ice edge are output on computer file for use by further analysis programs. The program also outputs longitude, latitude and distance of the ice edge from the south pole to a file for paper printing. An example of this output, again pertaining to the map of Figure 2, is shown in Table 2.

3.4 SPATIAL RESOLUTION OF THE DATA BASE

The resolution of the data maps received from the Navy-NOAA Joint Ice Centre is limited by the lowest resolution satellite used, i.e. 32 km (NIMBUS VI microwave radiometer). Further unknown errors may arise in the interpretation of the satellite data for map production. Zwally et al. (1982) calculated sea ice areas by numerical analysis of the raw microwave data only, without reference to the Joint Ice Centre maps. Comparison between total hemispheric ice areas calculated by Zwally et al. and those calculated for the data base described here, for the months of maximum extent (August, September and October) and for the years 1973 to 1976, reveal discrepancies of less than 10%.

In producing the data base discussed in this paper, inaccuracies may be due to distortion of the plain paper copier versions of maps received and to the resolution limits of the digitising system. These may be of the same order as the resolution limits of the satellite system. Hence, computer output results in the Tables and Appendices quote latitudes only to the nearest 0.1°, distances to 10 km and areas to $10^3 km^2$.

3.5 ICE EXTENT AND AREA CALCULATIONS

By using the computer linked digitiser and the interpretation program to analyse a map of Antarctica (i.e. with no sea ice), a data file describing the Antarctic coastline may be created. Such a data file is used along with the output data file created by the interpretation program to calculate the distance from the coast to the sea ice edge (i.e. the sea ice extent). This calculation is done by another program which first selects the maps to be analysed, then checks that longitudes of the Antarctic coast and of the ice edge match. Given this is the case, the extent is calculated by a simple subtraction of distances from the pole at each longitude. The mean ice extent over the 36 digitised longitudes is also calculated for each map. A sample output, for the map of Figure 2, is shown in Table 3.

With the latitude of the Antarctic coast and of the sea ice edge both defined at 10° longitudinal intervals it is possible to estimate the area of the sea

Table 1. Digitiser data for the Joint Ice Centre map dated 15 April 1982.

150482	
1296	1448
1297	2241
2068	1446
1297	2128
1420	2163
1533	2116
1649	2075
1745	1994
1874	1945
1959	1841
2065	1736
2079	1591
2118	1449
2144	1293
2088	1149
1983	1043
1882	945
1791	840
1684	759
1555	708
1409	762
1290	752
1176	765
1062	798
947	833
877	940
794	1027
708	1112
647	1211
614	1329
592	1453
628	1575
654	1692
590	1872
647	2013
847	2003
967	2038
1081	2058
1179	2130
1295	1450

Table 2. Sea ice longitude, distance from South Pole and latitude resulting from analysis of the data of Table 1.

DATE IS 150482

LONG °E	DIST. km	LAT. °S
0	2410.	68.3
10	2570.	66.9
20	2510.	67.4
30	2550.	67.1
40	2500.	67.5
50	2700.	65.7
60	2730.	65.4
70	2910.	63.8
80	2820.	64.6
90	2910.	63.8
100	3050.	62.5
110	3000.	63.0
120	2820.	64.6
130	2730.	65.4
140	2770.	65.0
150	2800.	64.8
160	2770.	65.0
170	2460.	67.8
180	2460.	67.8
190	2450.	67.9
200	2440.	68.0
210	2500.	67.5
220	2330.	69.0
230	2320.	69.1
240	2400.	68.4
250	2440.	68.0
260	2450.	67.9
270	2490.	67.6
280	2410.	68.3
290	2430.	68.1
300	2910.	63.7
310	3050.	62.6
320	2530.	67.2
330	2390.	68.5
340	2290.	69.4
350	2450.	67.9
MEANS	2600.	66.5

Table 3. Computer program output of sea ice extent.

15Ø482

LONG 0 E	EXTENT km
Ø	15Ø.
1Ø	32Ø.
2Ø	27Ø.
3Ø	25Ø.
4Ø	14Ø.
5Ø	14Ø.
6Ø	22Ø.
7Ø	51Ø.
8Ø	39Ø.
9Ø	35Ø.
1ØØ	38Ø.
11Ø	44Ø.
12Ø	28Ø.
13Ø	14Ø.
14Ø	2ØØ.
15Ø	41Ø.
16Ø	54Ø.
17Ø	43Ø.
18Ø	115Ø.
19Ø	118Ø.
2ØØ	112Ø.
21Ø	1Ø2Ø.
22Ø	71Ø.
23Ø	57Ø.
24Ø	6ØØ.
25Ø	7ØØ.
26Ø	46Ø.
27Ø	57Ø.
28Ø	55Ø.
29Ø	11Ø.
3ØØ	2Ø.
31Ø	162Ø.
32Ø	119Ø.
33Ø	93Ø.
34Ø	46Ø.
35Ø	33Ø.

MEAN SEAICE EXTENT = 52Ø. km.

Table 4. Computer program output from area calculations.

DATE IS 15 482

LONG. ^{o}E	AREA 10^{6} km^{2}.
0 - 10	0.095
10 - 20	0.120
20 - 30	0.106
30 - 40	0.081
40 - 50	0.059
50 - 60	0.080
60 - 70	0.163
70 - 80	0.201
80 - 90	0.168
90 - 100	0.172
100 - 110	0.195
110 - 120	0.166
120 - 130	0.095
130 - 140	0.077
140 - 150	0.136
150 - 160	0.205
160 - 170	0.195
170 - 180	0.269
180 - 190	0.375
190 - 200	0.369
200 - 210	0.355
210 - 220	0.294
220 - 230	0.220
230 - 240	0.207
240 - 250	0.233
250 - 260	0.213
260 - 270	0.195
270 - 280	0.208
280 - 290	0.123
290 - 300	0.023
300 - 310	0.314
310 - 320	0.502
320 - 330	0.351
330 - 340	0.235
340 - 350	0.145
350 - 360	0.094

TOTAL ICE AREA IS 7.038 * 10^{6} km^{2}

ice within each 10° sector. Appendix II gives an outline of the method of calculation of sea ice area. Table 4 is a sample output, again for the map of Figure 2.

3.6 CALCULATIONS OVER THE TIME DOMAIN

Another computer routine brings together all the data for each of the 12 calendar months, and calculates average sea ice latitudes for each month, at each 10° longitude. In addition, the standard deviation of the ice latitude at each 10° longitude over the years is calculated, along with the greatest and least ice latitude. Input data for this program is the computer file created by the interpretation program.

Appendix III shows the output from this program where one map for each month for each year from 1973 to 1982 inclusive, forms the initial data set. This program also produces a monthly computer file containing the output from the interpretation program in a condensed form so that for a particular year, month and longitude, the sea ice latitude can quickly be obtained. This output is shown in Appendix IV.

4. RESULTS

4.1 MEAN SEA ICE EXTENT

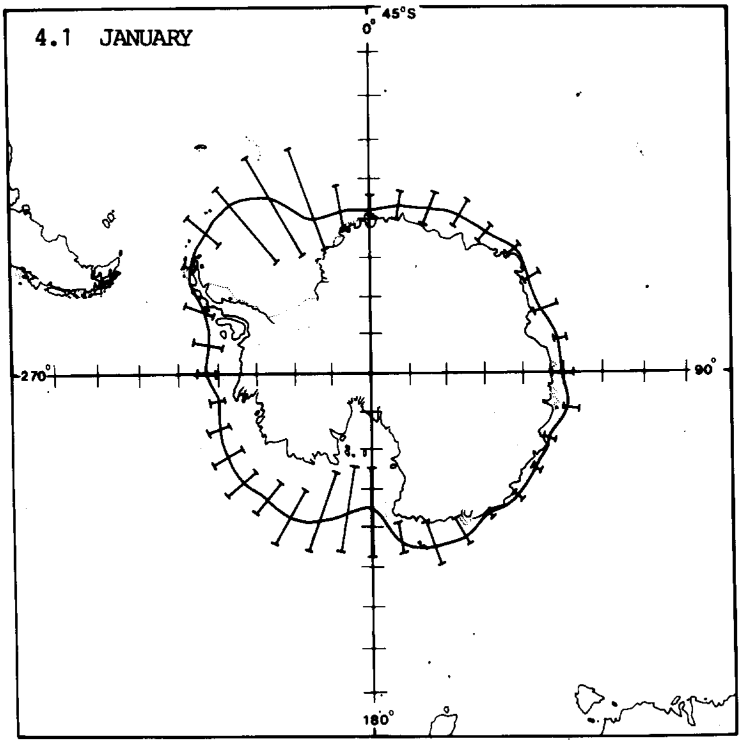
The analysis to date has included data from: (a) one map for each month (where possible, near the middle of the month) for the whole 10 year period for which the Navy-NOAA maps have been available, i.e. 1973 to 1982 inclusive; and (b) every map (i.e. one per week) for the months of August, September and October; the period of maximum ice extent.

Figures 4.1 - 4.12, drawn from the output of Appendix III, shows the mean monthly position of the Antarctic sea ice. The range bars indicate extreme sea ice positions over the 10 year analysis period. They are calculated for each 10° longitude, independently of the other longitudes, so that the greatest or least extent at one longitude does not necessarily correspond on the time domain to the greatest or least at other longitudes.

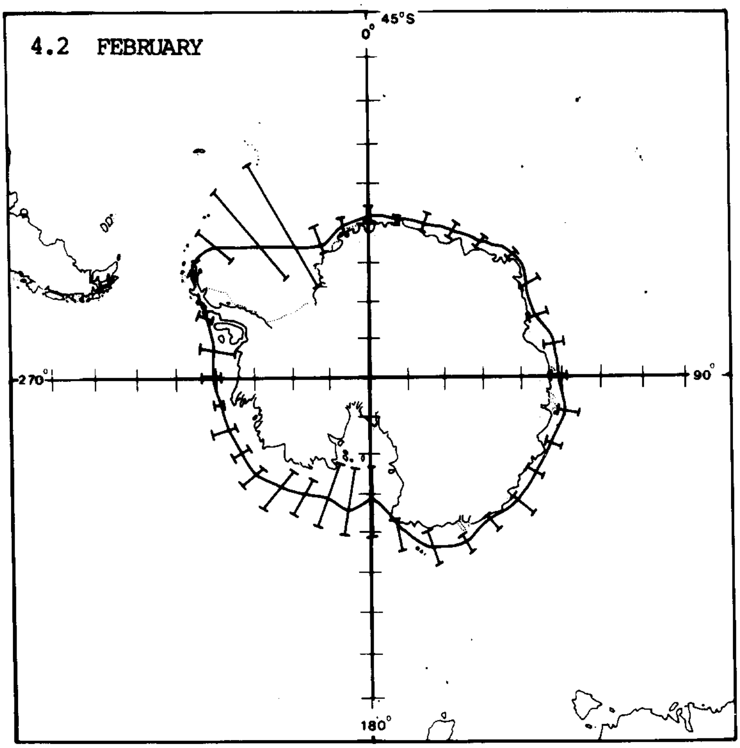
Figure 5 summarises Figures 4, by showing the mean sea ice extent on just two maps, one respresenting the sea ice advance from March to August, and the other, the sea ice retreat from September to February. The mean annual variation in the latitude of the sea ice extent, averaged over all longitudes, is shown in Figure 6, which also includes an area scale. It is evident that the mean minimum sea ice extent occurs during late February to early March, while the longer lived maximum occurs during August to October. Although there is more total sea ice during September than during August or October, from Figure 5, this is not true at all longitudes. From Figures 4, it is seen that at minimum, a large portion of East Antarctica may be sea ice free, while the Weddell Sea is rarely completely ice free. Also, during the months of near minimum sea ice cover, there is often an ice build up off the coast of George V Land.

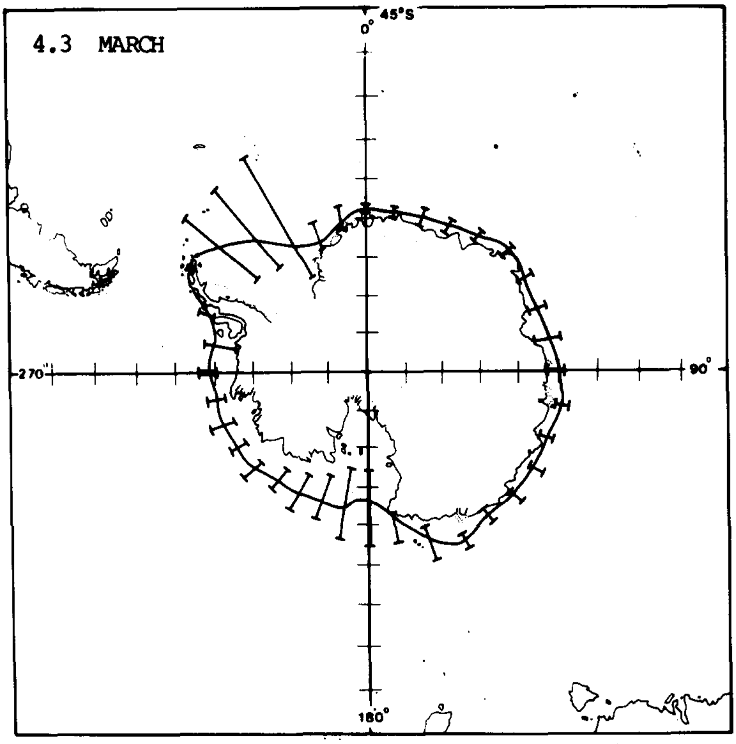
Figure 4 (on following pages). Mean ice distribution for each month, plotted at 10° longitudinal intervals with range bars indicating, independently at each longitude, the greatest and least ice extent over the 10 year period.

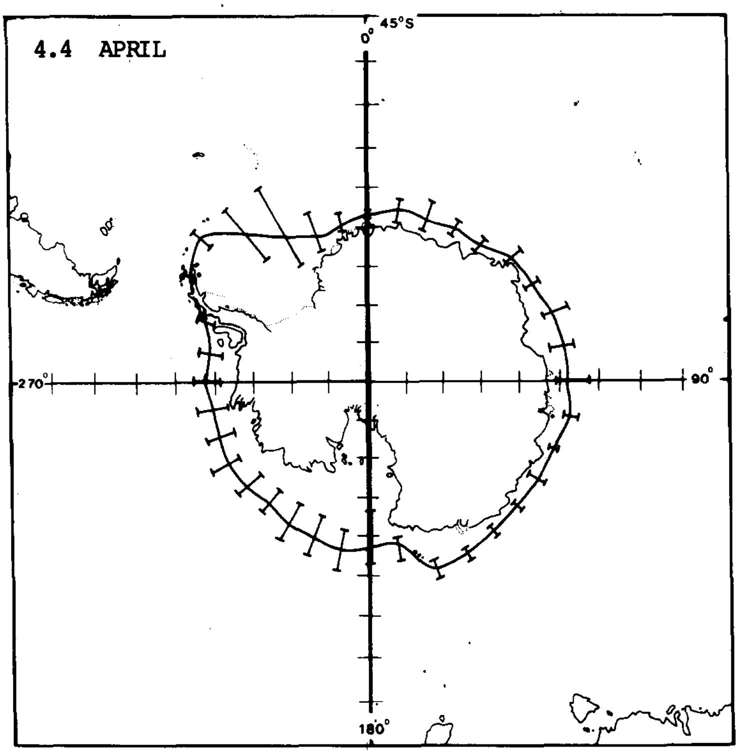
4.1 JANUARY

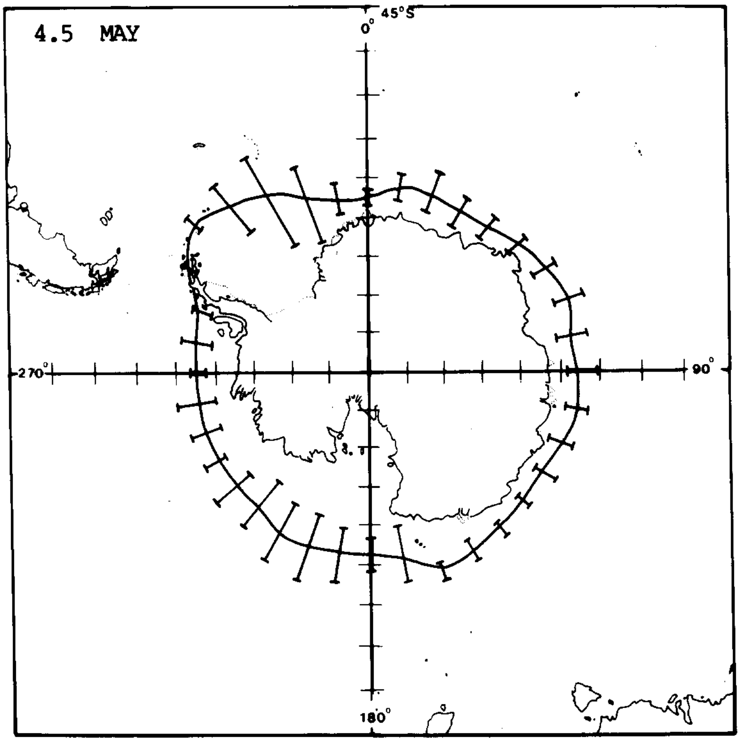


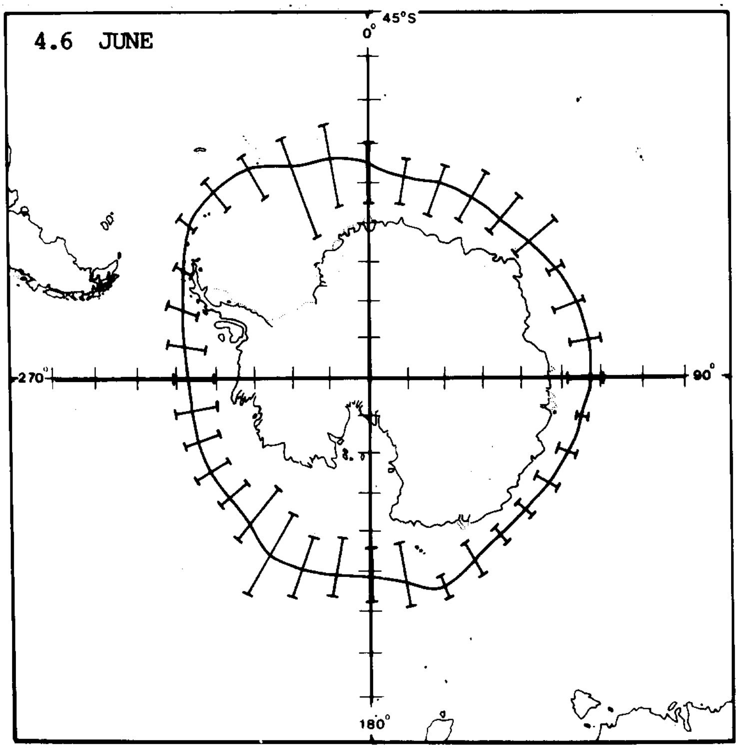
4.2 FEBRUARY

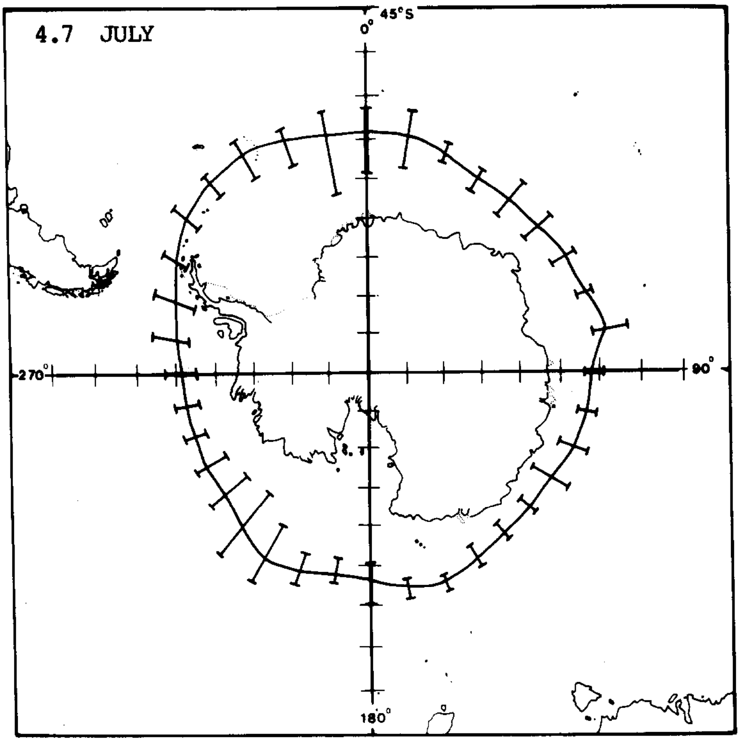



4.3 MARCH
0°
45°S
270°
90°
180°

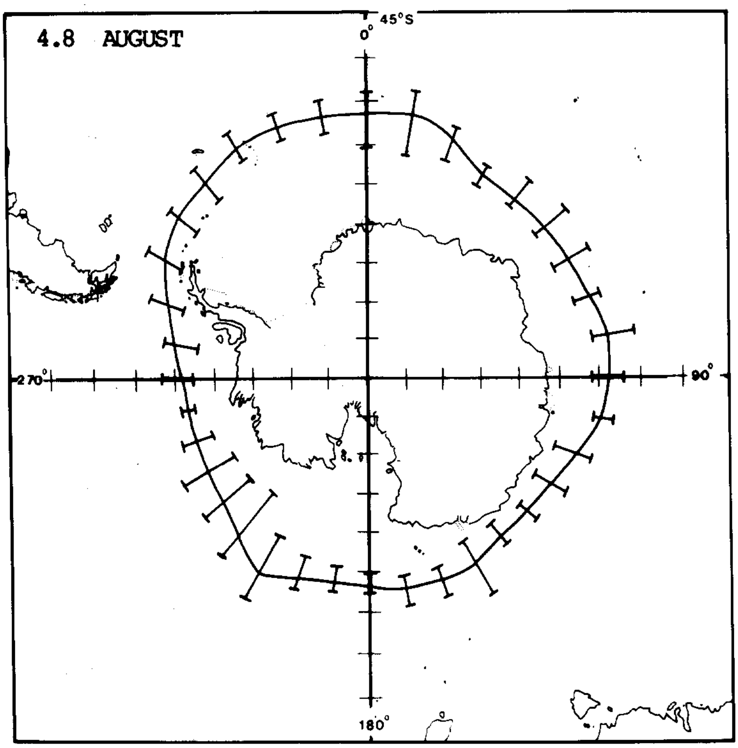

4.4 APRIL
0°
45°S
270°
90°
180°


4.5 MAY
0°
45°S
270°
90°
180°


4.6 JUNE
0°
45°S
270°
90°
180°

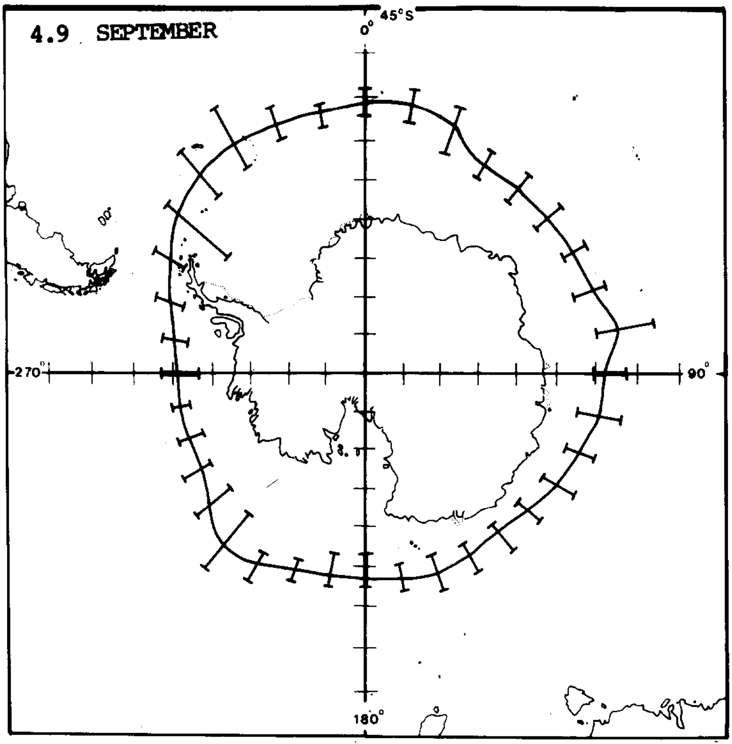


4.7 JULY
0°
45°S
270°
90°
180°

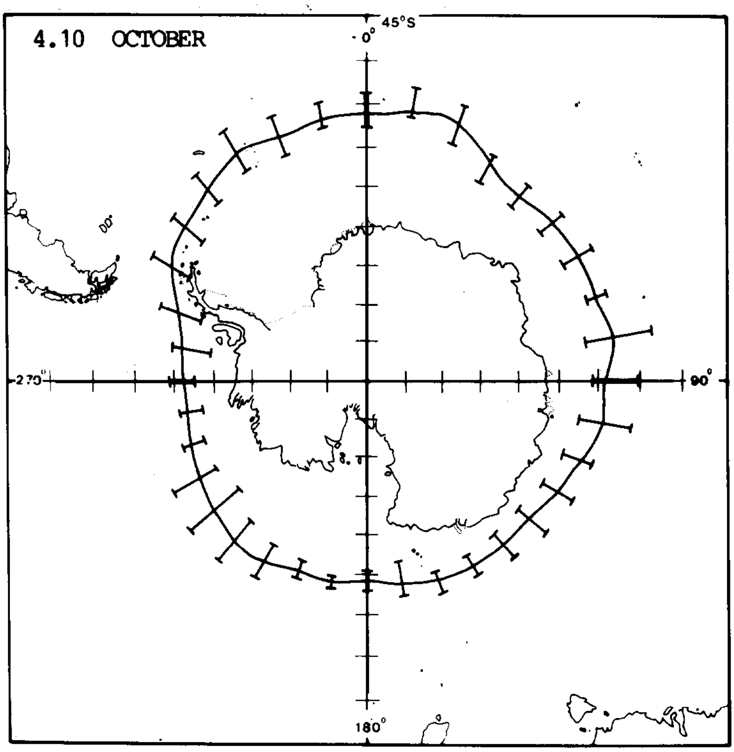


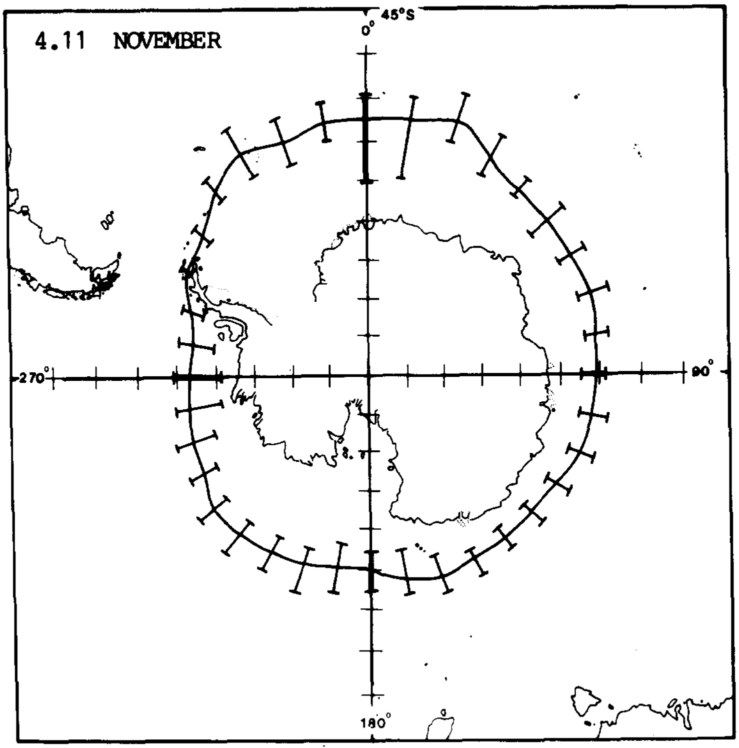
4.8 AUGUST
0°
45°S
270°
90°
180°

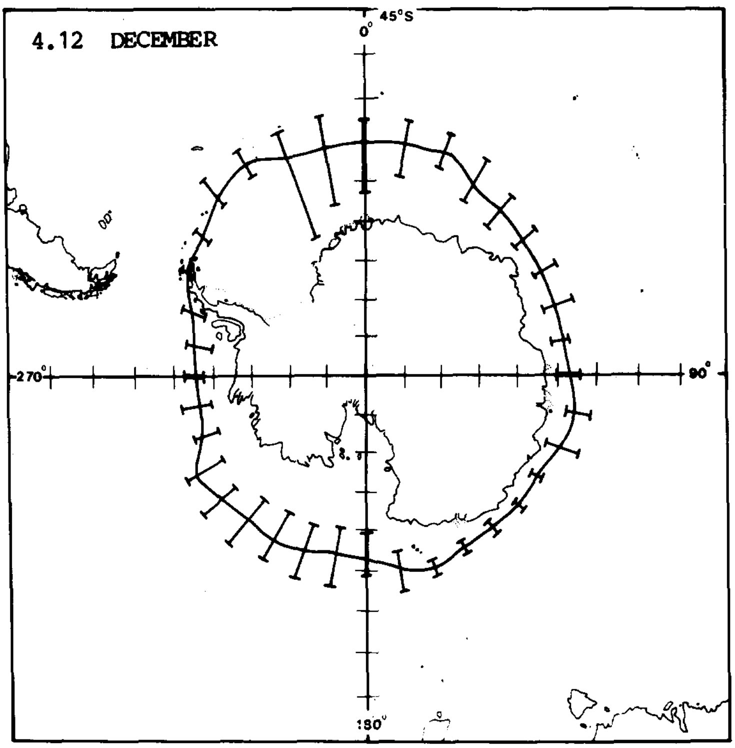
4.9 SEPTEMBER



4.10 OCTOBER




4.11 NOVEMBER
45°S
0°
270°
90°
180°


4.12 DECEMBER
45°S
0°
270°
90°
180°

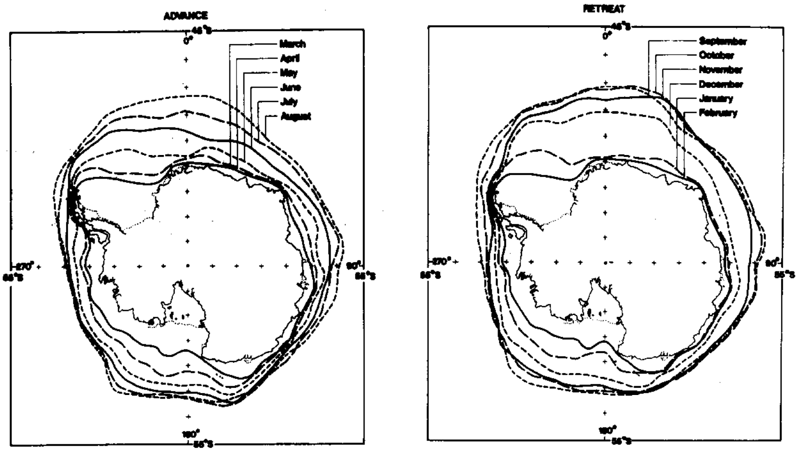


Figure 5. Monthly means of Antarctic sea ice extent showing the advance from March to August and the retreat from September to February.

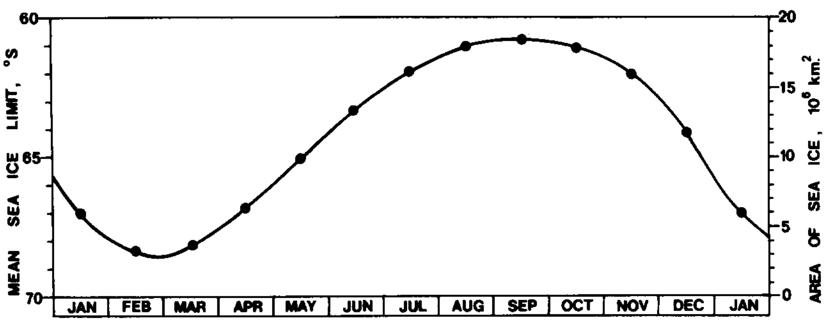


Figure 6. Annual variation in mean sea ice extent as a function of latitude. Also shown is an approximate total area scale.

4.2 MAXIMUM SEA ICE EXTENT

Particular attention has been given to the maximum ice extent as this parameter is more indicative of annual climatic trends rather than shorter lived, localised events (Budd, 1980; Jacka, 1981).

Figure 7 shows the 10 year maximum ice extent, calculated independently at each 10° of longitude. Range bars indicate the size of the interannual variations in the maximum extent.

Plots of the circumpolar mean of the latitude of the ice edge during the maximum period (Figure 8) allow the Navy-NOAA map representing the maximum total ice cover in each year to be chosen. From Figure 8 a plot has been constructed of the mean latitude of the northern edge of the sea ice at maximum extent for each year form 1973-1982 (Figure 9). This type of plot has been used as a climate indicator (Jacka, 1981; Kukla et al. 1977; Ackley, 1981). The data exhibits a sharp decrease in the total amount of sea ice at maximum

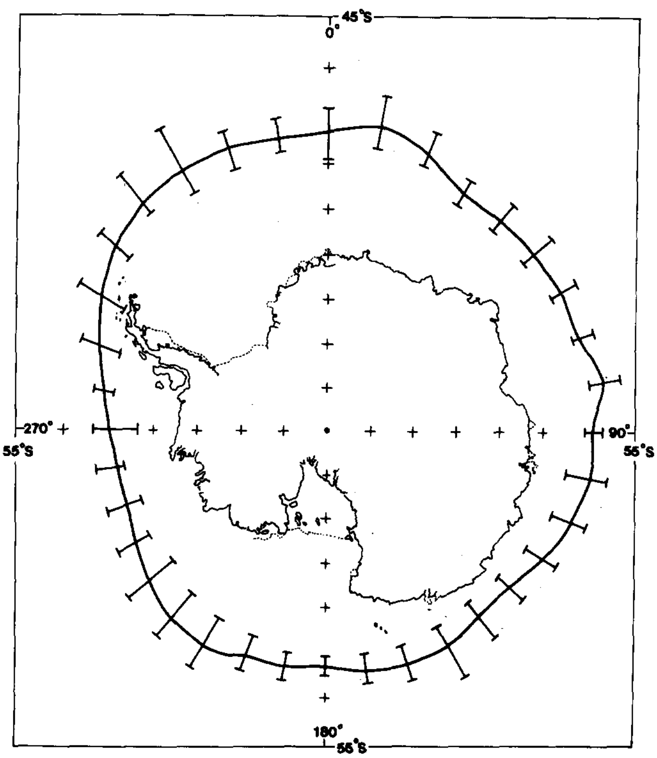


Figure 7. Mean maximum sea ice extent plotted independently at each 10° of longitude. Also shown are range bars indicating the largest and smallest maximum sea ice latitudes.

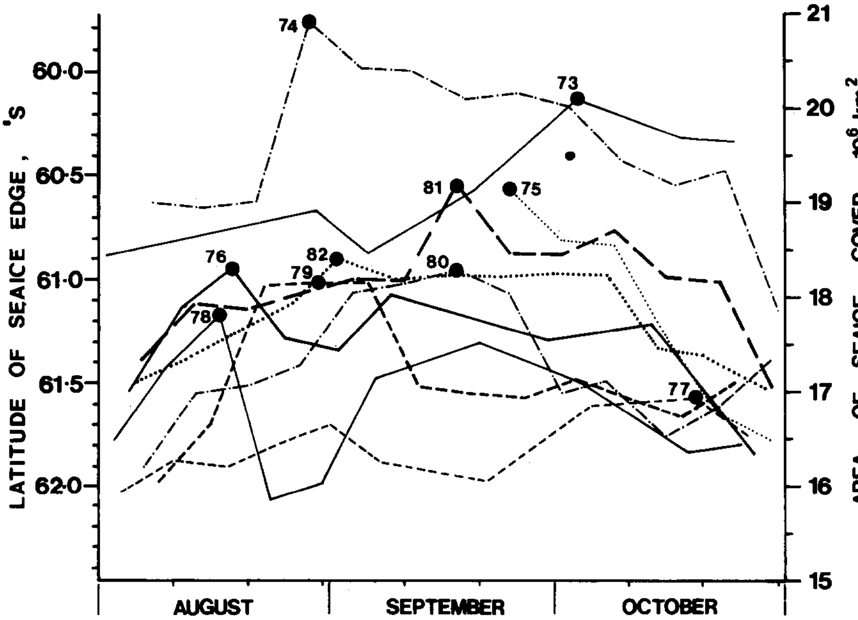


Figure 8. Plots of sea ice latitude each week for the maximum period. Points and numbers indicate the map of each year pertaining to the maximum extent that year.

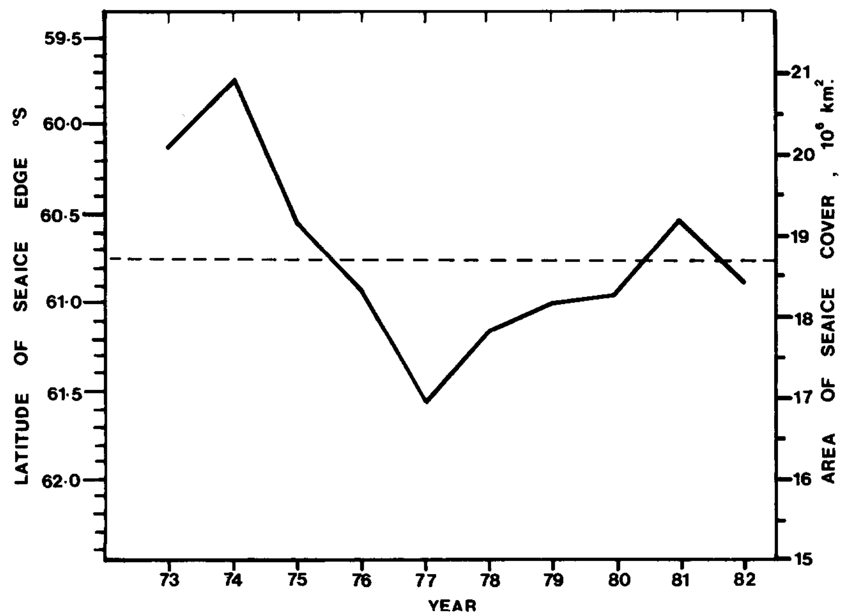


Figure 9. Maximum latitude of the sea ice edge for the period 1973-1982.

extent from 1974 to 1977, followed by an increase from 1977 to 1981. The mean maximum extent over the ten year period (dashed line of Figure 9) of 60.7° latitude (approximately 18.7 x $10^6 km^2$) is not significantly different from the maximum extents measured during the period 1967-1972. Variations in sea ice extent are considered sensitive indicators of both regional and global climatic change (Ackley, 1981; Allison, 1982). This parameter is therefore likely to be one of the earliest indicators of any significant climatic change, and the continuation of monitoring programs of the type described here is of particular importance.

5. DISCUSSION

The computer programs, instructions and data files presented are designed in the hope that other glaciologists, climatologists, geographers, transport engineers and others will make use of the data bank. Copies of the programs and input and output files are available on request.

The Antarctic sea ice extent has been monitored by others. Lemke et al. (1980) have digitised the ice edge at 5° longitudinal intervals, however they have included only areas of ice concentration greater than 5 octas. Streten and Pike (1980) have set criteria similar to those studied here, but have studied only the period 1972-77.

Zwally et al. (1982) have digitised contours of the ice edge such that, unlike this study, account has been taken for enclosed areas of open water, and for polynyas. They used only raw digital data from the Electrically Scanning Microwave Radiometer and while they do not use additional information, due to other measurement techniques utilized in the compilation of the Joint Ice Centre maps, use of raw data adds to the accuracy of their analysis. Kukla and Gavin (1981), using the Joint Ice Centre charts, integrate the sea ice to a resolution equivalent to a 2° latitude square, and also record five classes of sea ice concentration. Their analysis includes data to 1978 and they reported a decrease in the amount of total sea ice in summer months. This conclusion was based on their analysis to the mid 1970's and on the earlier data of Mackintosh and Herdman (1940). However, analysis of the sea ice distribution since 1977 has revealed that that decrease in sea ice extent was not representative of recent ice extent.

The data bank described in this paper supplies a measure of the most northern edge of the Antarctic sea ice. The computer programs and techniques described may, in exactly the same way, be used to detail the distribution of ice of various concentrations as indicated by the Navy-NOAA maps. The maps, however, do not supply information on sea ice thickness, and this parameter is of particular importance to climatologists and oceanographers. Allison (1982) has outlined where problems lie and has made recommendations for the collection of further, more useful data sets.

For the planning of future transport needs the above data base supplies information on the latitudes at which sea ice might be expected to exist. Analysis of the Navy-NOAA maps for higher concentrations would help to assess to what distances ships might be able to penetrate the sea ice. Again, however, the sea ice thickness is a particularly important parameter for the design and construction of ships intended for Antarctic waters.

APPENDIXES

APPENDIX I

CONVERSION OF DIGITISER COORDINATES TO LATITUDE AND LONGITUDE

Let the digitized coordinates at the South pole be (x_P, y_P); at 65°S, 0° longitude be (x_N, y_N); and at 65°S, 90°E be (x_E, y_E). Consider also a digitised point (x,y), as shown in Figure 10.

First, translate the system such that (x_P, y_P) is translated to (0,0);

$$\begin{aligned} x' &= x - x_P & y' &= y - y_P \\ x'_N &= x_N - x_P & y'_N &= y_N - y_P \\ x'_E &= x_E - x_P & y'_E &= y_E - y_P \end{aligned} \qquad (1)$$

Rotating the system through angle ϕ,

$$\tan\phi = \frac{-x'_N}{y'_N} = \frac{y'_E}{x'_E} \qquad (2)$$

Notice that if the map was exact and the digitising measurement exact, we would have

$$x'_E = y'_N$$

and $$y'_E = -x'_N$$

The digitising not being exact, the best measurement to take for ϕ will be from (2).

$$\tan\phi = \frac{\frac{1}{2}(-x'_N + y'_E)}{\frac{1}{2}(x'_E + y'_N)} \;;$$

and incidentally, the best value to consider in order to scale the map is

$$\tfrac{1}{2}(x'_E + y'_N) \qquad (3)$$

Now the expression

$$\tan\phi = \frac{y'_E - x'_N}{x'_E + y'_N} \qquad (4)$$

is used to calculate the angle ϕ, and rotation gives

$$\begin{aligned} x'' &= \cos\phi\, x' - \sin\phi\, y' \\ y'' &= \sin\phi\, x' + \cos\phi\, y' \end{aligned} \qquad (5)$$

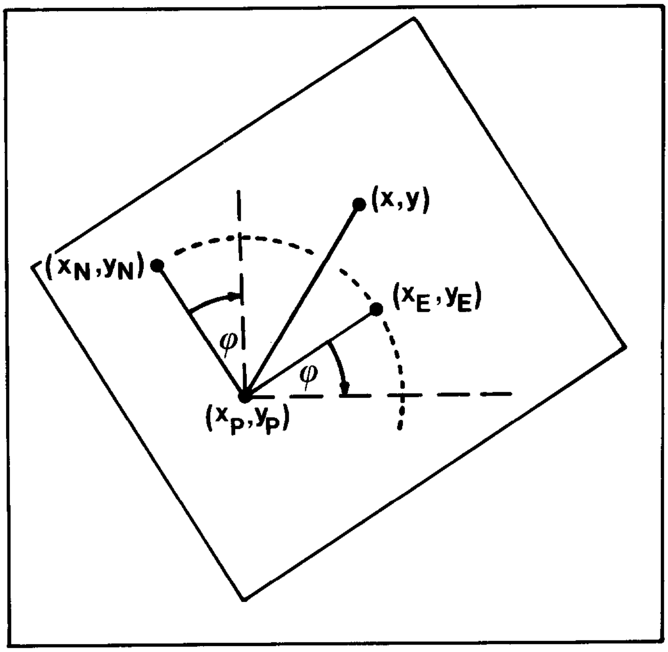


Figure 10. Schematic diagram of sea ice map on digitiser tablet.

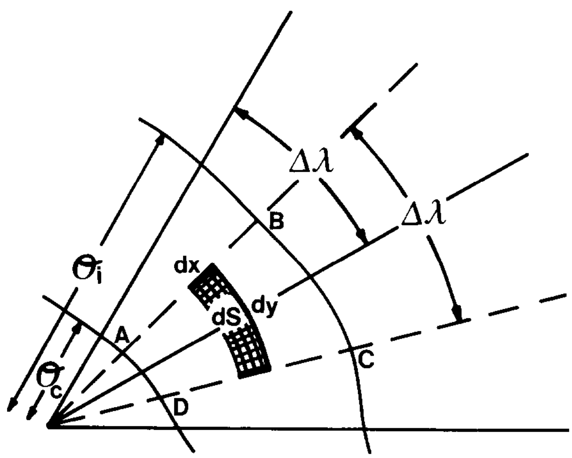


Figure 11. Parameters used for calculation of sea ice area.

APPENDIX II

CALCULATION OF SEA ICE AREA

Let θ_c and θ_i be the mean over the digitised interval of the angle of latitude from the South Pole to the Antarctic coast and to the sea ice edge respectively. Let ℓ_c and ℓ_i be corresponding distances respectively.

Generally, $\ell = R\theta$ (1)

and $\theta_c = \dfrac{\ell_c}{R}$; $\theta_i = \dfrac{\ell_i}{R}$

where R is the radius of the Earth, and θ_c and θ_i are expressed in radians. We wish to find the area of sea ice, S in the sector ABCD of Figure 11.

We have

$$dS = dxdy$$

where, from (1),

$$dx = R\,d\theta$$

and

$$dy = R\sin\theta\ \Delta\lambda$$

where $\Delta\lambda$ is the digitising interval.

Thus

$$dS = R^2 \sin\theta\, d\theta\ \Delta\lambda$$

and

$$S = \int_{\theta_c}^{\theta_i} R^2 \sin\theta\, d\theta\ \Delta\lambda$$

$$= -R^2\Delta\lambda \cos\theta \Big|_{\theta_c}^{\theta_i}$$

$$S = R^2\Delta\lambda(\cos\theta_c - \cos\theta_i).$$

For our purposes, $R \simeq 6371$ km and $\Delta\lambda = 10^\circ = 10\pi/180$.

APPENDIX III

COMPUTER PROGRAM OUTPUT OF MEAN SEA ICE LATITUDE AND VARIATIONS FOR MONTHS JANUARY THROUGH DECEMBER

Dates sampled for calculation of means are shown along with Longitude, mean Latitude, standard deviation, and greatest and least ice latitude, over the 10 year period, 1973 - 1982.

JANUARY DATES USED ARE -

180173
170174
160175
150176
200177
190178
180179
170180
150181
140182

LONG o E	LAT o S	DEV o	MAX o S	MIN o S
0	69.1	0.8	69.8	67.2
10	68.5	1.1	70.0	66.6
20	68.2	1.1	69.6	65.7
30	66.8	1.0	68.3	64.9
40	66.8	0.8	68.1	65.6
50	65.7	0.5	66.7	64.9
60	66.3	0.7	66.9	65.0
70	66.5	1.0	67.5	64.2
80	65.5	0.7	66.6	64.2
90	65.2	0.9	66.8	63.8
100	63.9	0.8	64.7	62.4
110	65.2	0.4	66.0	64.8
120	65.3	0.3	65.7	64.7
130	65.3	0.4	65.8	64.8
140	66.5	0.7	67.2	64.7
150	65.7	1.2	68.8	64.9
160	66.2	2.0	69.8	63.9
170	67.7	1.6	71.1	66.1
180	71.5	6.3	78.4	61.3
190	71.0	4.5	78.6	66.7
200	69.5	3.0	76.7	65.8
210	68.2	2.2	72.5	64.9
220	68.6	1.8	71.7	66.7
230	68.3	1.8	70.1	65.5
240	68.6	1.4	70.7	66.2
250	68.8	1.1	70.4	67.6
260	69.8	0.6	70.7	68.9
270	68.8	0.9	70.0	67.4
280	68.8	1.0	70.3	66.8
290	67.1	1.2	68.2	64.4
300	63.6	0.5	64.1	62.4
310	62.7	1.6	64.7	59.3
320	62.7	3.9	71.0	59.2
330	64.6	5.8	72.7	58.4
340	68.8	4.9	73.0	59.8
350	68.7	2.0	71.1	65.6

MEANS ARE 67.1 1.7 OVER 10 YEARS

FEBRUARY DATES USED ARE -

150273
140274
200275
190276
170277
160278
150279
140280
190281
180282

LONG	LAT	DEV	MAX	MIN
o	o	o	o	o
E	S		S	S
0	69.3	0.6	70.0	68.0
10	69.4	0.4	70.2	69.0
20	69.0	0.8	70.1	67.8
30	68.3	0.8	69.3	67.1
40	67.5	0.7	68.5	66.7
50	65.9	0.6	66.8	65.1
60	66.7	1.0	68.2	64.8
70	67.3	1.1	69.1	65.7
80	66.2	1.1	68.2	64.7
90	66.0	0.7	66.8	64.9
100	64.5	0.8	65.4	62.7
110	65.2	0.9	66.7	63.9
120	65.5	0.9	66.7	63.4
130	65.2	0.9	66.1	62.9
140	66.2	1.0	67.0	64.5
150	65.3	0.9	66.4	64.0
160	66.8	1.4	69.0	64.6
170	70.6	1.5	71.7	67.2
180	74.8	4.1	78.2	69.3
190	72.4	3.4	78.5	69.3
200	73.0	2.9	78.0	69.7
210	72.6	1.7	74.7	69.7
220	72.0	1.8	74.1	68.1
230	70.7	1.1	71.8	68.4
240	70.7	0.9	71.9	69.4
250	70.3	0.9	71.3	68.0
260	70.3	0.5	70.9	69.4
270	69.2	0.9	70.7	68.0
280	69.4	1.2	72.3	67.8
290	67.6	0.5	68.2	66.4
300	64.0	0.2	64.2	63.7
310	63.9	1.6	67.0	61.2
320	67.9	4.3	73.2	59.0
330	70.7	6.3	77.0	59.0
340	71.9	1.3	73.1	69.3
350	70.2	0.7	71.1	69.2

MEANS ARE 68.5 1.4 OVER 10 YEARS

MARCH DATES USED ARE -

10373
140374
200375
180376
170377
160378
150379
130380
190381
180382

LONG °E	LAT °S	DEV °	MAX °S	MIN °S
0	69.3	0.4	69.8	68.8
10	69.1	0.6	69.9	68.1
20	68.7	0.7	70.3	67.8
30	68.2	0.7	69.4	67.0
40	67.3	0.5	68.2	66.7
50	65.7	0.6	67.1	65.0
60	66.2	0.7	67.3	65.1
70	66.4	0.7	67.6	65.1
80	66.1	1.2	67.8	64.5
90	65.1	0.7	66.5	64.3
100	64.3	0.7	65.2	63.5
110	65.2	0.6	66.1	64.2
120	65.3	0.8	66.7	63.7
130	65.2	0.8	66.9	64.0
140	65.8	0.9	67.4	64.7
150	64.8	0.6	65.7	63.8
160	66.8	1.6	68.7	64.2
170	70.5	1.4	71.6	67.6
180	73.2	3.5	77.2	67.3
190	71.5	3.4	77.6	68.0
200	71.9	2.3	76.1	69.8
210	71.7	1.4	74.4	69.4
220	71.8	0.9	73.5	70.4
230	70.3	0.9	71.7	68.9
240	70.3	0.9	71.8	69.1
250	69.8	0.9	71.3	68.0
260	70.0	0.7	71.1	68.9
270	69.2	0.8	70.4	68.0
280	69.8	1.2	72.7	68.5
290	68.1	0.6	68.7	66.9
300	63.9	0.3	64.5	63.5
310	64.0	3.3	71.4	59.5
320	67.7	4.2	72.2	59.5
330	71.2	5.0	75.8	58.7
340	71.9	1.5	73.6	69.5
350	69.9	0.9	71.0	68.3

MEANS ARE 68.2 1.3 OVER 10 YEARS

APRIL DATES USED ARE -

180473
180474
170475
150476
140477
200478
190479
170480
160481
150482

LONG	LAT	DEV	MAX	MIN
c	o	o	c	c
E	S		S	S
0	68.6	0.3	69.0	68.1
10	67.7	0.9	69.4	66.3
20	68.0	1.1	69.6	65.7
30	67.8	0.8	68.7	66.2
40	67.3	0.6	68.3	66.4
50	65.5	0.7	66.4	64.1
60	65.4	0.6	66.6	64.6
70	64.9	1.0	66.1	62.7
80	64.9	1.0	66.2	63.0
90	64.2	1.2	65.9	61.9
100	63.8	0.7	64.6	62.5
110	64.5	0.7	65.2	63.0
120	64.9	0.5	66.1	63.9
130	65.1	0.5	65.8	64.4
140	65.1	0.5	65.9	64.3
150	64.7	0.5	65.2	63.7
160	64.6	1.0	65.9	63.1
170	68.0	1.2	70.0	66.8
180	68.7	1.9	73.2	66.8
190	67.9	1.6	70.5	65.5
200	68.4	1.6	71.8	66.4
210	68.7	1.7	71.7	66.7
220	69.6	1.3	71.8	68.1
230	69.0	1.2	71.5	67.7
240	68.7	1.1	70.2	66.5
250	69.0	1.1	71.3	67.5
260	69.3	1.2	70.7	67.3
270	68.4	1.1	70.7	67.0
280	68.9	1.0	70.7	67.8
290	67.9	0.8	69.0	66.5
300	63.5	0.4	63.9	62.8
310	61.8	0.9	63.5	60.2
320	65.9	3.0	69.5	61.4
330	68.7	3.0	72.9	61.9
340	70.5	1.5	72.1	67.1
350	69.2	0.8	70.4	67.9

MEANS ARE 66.9 1.1 OVER 10 YEARS

MAY DATES USED ARE -

170573
160574
150575
200576
190577
180578
170579
150580
140581
130582

LONG °E	LAT °S	DEV °	MAX °S	MIN °S
0	67.7	0.9	68.5	65.9
10	66.0	1.0	67.8	64.2
20	66.1	1.8	68.1	63.0
30	66.1	1.6	68.7	64.4
40	65.8	1.6	67.9	62.9
50	64.6	0.8	66.1	63.4
60	63.6	0.9	65.3	62.6
70	62.5	1.2	64.7	60.8
80	63.4	1.4	65.5	61.2
90	62.8	1.3	64.5	60.9
100	62.7	1.0	64.3	61.4
110	63.6	1.0	65.4	62.1
120	64.3	0.9	65.8	62.9
130	64.4	0.6	65.2	63.3
140	64.4	0.8	65.6	63.0
150	63.9	0.8	65.0	62.5
160	63.2	1.0	64.4	61.7
170	65.7	1.9	70.0	63.2
180	65.8	2.3	68.7	60.5
190	66.2	2.0	69.6	62.8
200	65.9	2.7	70.7	61.9
210	65.9	2.1	70.4	62.6
220	67.4	2.2	71.7	64.5
230	67.1	1.5	69.8	64.5
240	67.1	0.9	68.5	65.9
250	67.2	1.3	69.3	65.4
260	67.8	1.4	69.7	64.9
270	67.6	0.6	68.7	66.9
280	66.6	1.1	69.1	65.1
290	66.4	0.8	68.5	65.6
300	63.2	0.6	64.3	62.4
310	60.9	0.8	62.0	59.5
320	62.2	2.6	66.7	59.1
330	63.6	3.8	71.1	58.9
340	66.1	3.4	72.5	62.3
350	67.0	1.8	69.2	63.6

MEANS ARE 65.1 1.5 OVER 10 YEARS

JUNE DATES USED ARE -

140673
200674
190675
170676
160677
150678
210679
120680
180681
170682

LONG o E	LAT o S	DEV o	MAX o S	MIN o S
0	62.8	2.4	67.6	60.0
10	64.2	2.1	67.1	61.7
20	63.3	2.0	67.9	61.7
30	63.2	2.0	66.8	59.7
40	63.9	1.9	65.6	60.0
50	63.1	1.8	65.2	58.9
60	62.1	0.8	63.3	61.3
70	61.4	1.3	64.9	60.7
80	60.9	1.3	63.8	59.1
90	61.4	1.4	64.6	59.7
100	62.0	0.8	63.0	60.1
110	62.6	0.7	64.2	61.7
120	63.4	1.0	65.2	62.2
130	64.1	0.8	65.4	62.8
140	64.0	0.9	65.2	62.7
150	63.4	1.5	65.7	61.0
160	62.0	1.3	64.8	60.4
170	63.7	2.3	68.7	60.7
180	64.3	2.5	68.1	60.1
190	64.7	1.9	69.1	62.0
200	64.0	2.4	68.5	60.3
210	64.1	3.2	70.1	58.5
220	66.0	2.2	71.4	63.4
230	66.2	1.4	69.1	64.9
240	66.2	1.4	68.9	64.2
250	66.6	1.4	69.1	64.6
260	67.0	1.7	69.9	64.6
270	66.5	1.5	69.6	64.6
280	65.6	1.6	68.4	63.7
290	64.2	1.4	66.3	62.3
300	62.6	0.9	63.7	61.1
310	59.6	0.8	60.9	58.2
320	59.4	1.2	61.7	57.2
330	59.2	1.9	63.4	57.6
340	61.3	3.6	70.8	57.6
350	61.5	3.6	67.8	57.5

MEANS ARE 63.3 1.7 OVER 10 YEARS

JULY DATES USED ARE -

190773
180774
30775
150776
140777
200778
260779
170780
160781
150782

LONG o E	LAT o S	DEV o	MAX o S	MIN o S
0	59.2	2.6	64.3	56.8
10	59.6	2.4	63.7	56.6
20	60.3	0.9	61.6	59.0
30	61.6	1.1	63.4	60.1
40	61.5	1.5	63.9	58.8
50	61.3	1.4	63.5	59.0
60	60.8	1.1	62.5	59.2
70	60.5	0.8	61.7	59.5
80	59.2	1.4	60.8	56.2
90	60.9	0.9	62.2	59.8
100	61.1	1.3	63.0	59.3
110	61.7	1.2	64.0	60.0
120	63.0	1.6	65.9	60.4
130	63.0	0.9	64.5	62.0
140	63.3	1.1	64.9	62.1
150	62.7	1.1	64.3	61.2
160	61.6	0.9	62.7	60.1
170	62.3	1.0	63.2	60.6
180	63.2	2.1	65.4	59.0
190	63.8	1.2	65.9	62.6
200	63.0	1.1	65.2	61.2
210	62.5	2.5	67.4	59.3
220	64.9	2.8	69.8	59.7
230	66.1	1.6	69.0	63.3
240	66.1	1.3	68.6	64.2
250	66.4	1.4	69.4	64.6
260	66.4	1.0	67.8	64.4
270	65.8	1.2	67.6	63.6
280	64.3	1.6	66.5	61.7
290	62.6	2.0	66.0	60.3
300	61.3	1.3	63.0	59.5
310	59.3	1.3	61.8	57.6
320	58.7	1.0	60.6	57.4
330	58.2	1.6	61.4	56.2
340	58.7	1.4	62.0	57.3
350	59.7	3.3	67.0	56.8

MEANS ARE 62.1 1.5 OVER 10 YEARS

AUGUST DATES USED ARE -

160873
150874
190876
170877
180878
90879
140880
130881
120882

LONG °E	LAT °S	DEV °	MAX °S	MIN °S
0	56.5	2.4	61.0	54.2
10	56.7	2.4	61.4	53.6
20	57.8	1.4	60.5	56.6
30	59.9	1.2	62.0	58.0
40	60.3	1.2	61.7	57.5
50	60.2	1.5	61.8	57.0
60	60.0	1.4	62.1	57.2
70	59.6	1.0	61.9	58.3
80	58.3	1.6	60.8	55.4
90	59.4	1.3	61.3	57.4
100	59.6	0.9	60.5	58.1
110	61.3	1.5	64.4	59.5
120	62.3	1.3	65.1	60.8
130	63.3	0.8	64.7	62.0
140	63.6	1.2	65.5	62.4
150	62.6	2.0	65.7	59.4
160	62.1	1.2	64.1	60.7
170	62.6	1.0	64.3	60.7
180	63.9	0.7	64.9	62.8
190	63.6	0.9	65.6	62.5
200	62.8	1.2	65.5	61.5
210	61.1	2.7	66.7	57.9
220	63.9	2.9	70.7	60.7
230	65.3	1.8	69.5	62.6
240	65.6	2.0	69.8	62.6
250	66.3	1.3	68.5	64.3
260	66.5	0.5	66.9	65.5
270	65.7	1.2	67.2	63.3
280	64.7	1.4	67.7	63.1
290	62.5	1.7	64.6	60.1
300	59.7	1.5	62.0	57.8
310	58.6	1.4	61.1	57.1
320	57.8	1.5	60.2	55.9
330	56.6	1.2	58.2	54.8
340	56.7	1.2	58.3	54.6
350	56.8	1.4	58.8	54.7

MEANS ARE 61.2 1.4 OVER 9 YEARS

SEPTEMBER DATES USED ARE -

200973
120974
250975
90976
220977
210978
130979
180980
170981
160982

LONG °E	LAT °S	DEV °	MAX °S	MIN °S
0	56.0	1.2	57.6	54.1
10	55.6	1.5	57.8	54.0
20	57.0	1.5	60.1	54.6
30	59.3	1.2	61.1	57.5
40	59.4	1.4	61.5	57.0
50	59.4	1.3	61.1	57.1
60	59.0	1.2	60.5	57.3
70	59.0	1.3	61.5	57.1
80	57.2	2.0	59.9	52.8
90	59.2	1.0	60.4	56.8
100	59.0	1.6	62.1	56.9
110	60.4	1.1	62.7	58.6
120	61.7	1.6	63.7	59.0
130	62.6	1.4	64.6	60.5
140	63.2	1.6	64.7	60.2
150	63.2	1.4	64.9	60.9
160	63.0	1.5	65.3	60.6
170	63.3	1.1	65.1	61.8
180	64.1	1.3	66.9	62.6
190	63.8	1.2	66.4	62.6
200	63.3	0.9	64.5	61.9
210	61.9	1.4	63.4	59.6
220	61.8	2.4	66.3	57.9
230	64.1	1.6	67.2	61.5
240	65.3	1.1	66.8	63.0
250	65.5	1.0	67.3	64.0
260	65.8	0.7	66.8	64.7
270	65.4	1.4	68.1	63.7
280	64.6	1.0	66.7	63.0
290	63.0	1.2	65.0	61.3
300	60.6	1.2	62.8	58.8
310	58.5	1.2	60.7	56.9
320	57.3	2.0	60.6	53.3
330	56.7	2.3	59.8	51.7
340	56.9	1.2	58.8	54.4
350	56.8	1.1	58.4	55.4

MEANS ARE 60.9 1.4 OVER 10 YEARS

OCTOBER DATES USED ARE -

181Ø73
171Ø74
161Ø75
141Ø76
2Ø1Ø77
191Ø78
181Ø79
161Ø8Ø
151Ø81
141Ø82

LONG o E	LAT o S	DEV o	MAX o S	MIN o S
Ø	56.3	1.2	57.9	53.9
1Ø	55.3	1.1	56.4	52.9
2Ø	55.5	1.5	58.Ø	53.6
3Ø	58.6	1.2	61.1	57.3
4Ø	59.1	1.4	61.2	57.3
5Ø	58.8	1.3	6Ø.8	57.2
6Ø	58.6	1.4	6Ø.9	56.7
7Ø	58.8	Ø.9	59.9	57.4
8Ø	57.9	2.Ø	61.3	53.4
9Ø	59.5	1.6	6Ø.9	55.6
1ØØ	59.Ø	2.Ø	62.1	55.9
11Ø	6Ø.3	1.3	63.1	59.Ø
12Ø	61.6	1.6	63.9	59.4
13Ø	62.4	1.4	64.6	59.9
14Ø	62.4	1.4	64.5	6Ø.7
15Ø	62.8	1.1	64.3	61.5
16Ø	62.9	Ø.9	64.1	61.7
17Ø	63.7	1.1	66.3	62.3
18Ø	64.5	Ø.8	65.5	63.3
19Ø	64.Ø	Ø.7	64.9	63.Ø
2ØØ	64.2	Ø.9	65.5	63.2
21Ø	63.6	1.4	65.6	61.1
22Ø	63.3	2.Ø	66.4	6Ø.1
23Ø	64.4	2.2	68.3	6Ø.2
24Ø	65.2	1.7	67.5	61.4
25Ø	66.1	1.2	68.6	64.9
26Ø	66.5	1.4	69.3	65.4
27Ø	66.2	1.2	67.9	64.4
28Ø	65.7	1.4	69.4	64.2
29Ø	64.2	1.4	67.3	61.8
3ØØ	61.7	1.5	63.9	58.3
31Ø	59.9	1.8	62.5	57.8
32Ø	58.1	1.1	6Ø.1	56.3
33Ø	56.8	1.8	59.4	53.9
34Ø	57.3	1.6	59.5	54.6
35Ø	56.8	1.1	57.7	54.6

MEANS ARE 61.2 1.4 OVER 1Ø YEARS

NOVEMBER DATES USED ARE -

151173
141174
201175
181176
171177
161178
151179
131180
121181
181182

LONG o E	LAT o S	DEV o	MAX o S	MIN o S
0	57.9	3.0	65.3	54.9
10	57.2	2.9	64.6	54.6
20	56.0	1.7	58.6	53.0
30	58.5	1.7	60.7	55.1
40	59.5	1.0	60.9	58.1
50	59.5	1.5	62.4	57.3
60	59.7	1.5	61.5	57.8
70	59.6	1.2	61.2	57.2
80	60.3	1.2	62.4	58.9
90	61.0	1.1	62.6	59.4
100	60.6	1.1	62.6	59.0
110	61.1	1.2	62.9	59.2
120	62.1	1.3	63.7	60.1
130	62.8	1.0	64.0	61.0
140	62.7	1.0	64.3	61.3
150	62.8	1.2	64.3	60.8
160	62.9	1.3	65.4	60.7
170	63.9	1.6	67.4	61.8
180	65.2	1.5	67.6	62.6
190	65.0	1.8	68.0	62.0
200	64.2	1.7	66.3	61.0
210	64.0	1.6	66.2	61.9
220	63.8	1.7	65.8	60.9
230	63.9	1.6	65.9	61.3
240	65.4	1.2	67.0	63.6
250	66.0	1.5	68.5	63.7
260	66.6	1.7	70.4	64.7
270	66.6	1.7	70.5	64.4
280	66.9	1.7	69.6	65.0
290	65.6	0.9	67.2	64.4
300	63.1	0.5	63.6	62.1
310	62.0	1.0	63.3	60.2
320	59.6	0.8	60.7	58.0
330	57.9	1.8	60.4	54.0
340	58.7	1.6	61.5	55.5
350	57.8	1.3	59.5	55.1

MEANS ARE 62.0 1.4 OVER 10 YEARS

DECEMBER DATES USED ARE -

191273
121274
181275
161276
151277
141278
131279
111280
171281
161282

LONG o E	LAT o S	DEV o	MAX o S	MIN o S
0	60.4	2.7	66.8	57.8
10	60.7	3.1	66.6	57.5
20	60.1	2.0	63.6	57.6
30	62.5	1.7	64.9	58.5
40	63.1	1.8	65.4	60.3
50	63.2	1.3	64.8	61.4
60	64.0	1.0	65.0	61.8
70	64.1	1.0	65.5	62.5
80	64.3	0.9	65.7	63.2
90	63.8	1.0	65.3	62.3
100	62.7	1.1	63.8	60.3
110	63.7	1.4	65.2	60.9
120	64.6	0.5	65.1	63.6
130	64.4	0.4	65.2	63.6
140	65.0	1.0	67.4	63.8
150	65.0	0.7	66.4	63.9
160	64.0	0.6	65.0	63.1
170	65.0	1.5	67.1	62.2
180	66.9	1.6	69.7	64.9
190	67.0	1.9	70.1	63.0
200	66.2	2.1	69.6	62.8
210	65.9	1.9	69.9	63.2
220	65.9	2.1	69.1	62.0
230	65.8	1.8	67.8	62.6
240	66.5	1.5	68.6	63.2
250	67.4	1.1	69.4	66.1
260	68.1	1.3	69.6	65.8
270	67.9	0.8	68.9	66.6
280	67.8	1.1	69.7	66.1
290	66.4	0.9	67.9	64.6
300	63.8	0.5	64.3	62.8
310	62.6	1.0	63.8	61.0
320	60.3	1.1	61.8	57.7
330	59.2	1.1	60.9	57.3
340	60.8	3.8	71.1	57.4
350	60.9	3.2	69.0	56.8

MEANS ARE 64.2 1.5 OVER 10 YEARS

APPENDIX IV

COMPUTER OUTPUT OF SEA ICE LATITUDE FOR EACH 10° LONGTIUDE EACH YEAR FOR MONTHS JANUARY THROUGH DECEMBER

JANUARY

LONG	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	67.2	69.7	69.8	69.0	69.0	69.7	68.8	68.9	69.3	69.5
10	66.6	70.0	69.4	69.0	69.5	67.7	68.1	67.0	68.7	68.6
20	65.7	69.6	68.6	68.0	67.4	68.3	69.1	67.4	69.2	68.8
30	64.9	66.8	66.8	66.4	66.3	65.9	67.3	68.3	68.1	66.7
40	65.6	67.2	66.8	65.6	67.3	66.4	67.1	68.1	67.4	66.6
50	65.5	64.9	65.6	65.1	66.1	65.5	66.1	66.7	65.5	66.0
60	65.0	65.0	66.2	66.2	66.8	66.9	66.9	66.8	66.9	66.3
70	64.2	66.4	66.5	66.2	66.7	67.0	67.5	65.9	67.5	66.9
80	64.2	64.9	64.9	65.8	65.8	65.8	65.6	65.5	65.4	66.6
90	63.8	64.5	64.7	65.7	65.4	66.2	66.8	65.0	65.1	64.4
100	64.4	62.8	63.9	63.3	64.5	64.6	64.0	64.4	64.7	62.4
110	64.9	64.9	65.3	65.1	65.1	64.8	66.0	64.8	65.8	65.0
120	65.1	65.5	65.2	65.2	65.4	64.8	65.3	65.6	65.7	64.7
130	65.0	65.4	64.8	65.0	65.5	64.8	65.6	65.6	65.8	65.6
140	66.8	66.9	64.7	66.9	66.2	66.8	66.8	66.1	66.9	67.2
150	64.9	68.8	65.1	65.1	66.0	65.0	64.9	65.3	65.1	66.3
160	67.2	69.8	65.0	65.7	63.9	64.1	67.3	69.0	64.5	65.8
170	68.4	66.5	66.3	68.4	66.5	68.3	69.1	71.1	68.7	66.1
180	69.5	78.4	66.3	66.2	67.6	71.4	78.2	78.1	78.1	61.3
190	69.9	67.4	66.7	67.4	69.6	71.5	78.6	78.5	73.2	67.4
200	68.9	65.8	65.9	69.6	69.8	70.6	69.9	76.7	70.0	67.9
210	67.2	65.8	64.9	68.6	69.4	70.3	67.7	72.5	68.3	67.4
220	66.7	67.0	69.3	69.8	68.8	66.7	68.2	71.7	70.6	66.8
230	65.6	66.8	69.4	69.7	69.8	65.5	68.3	70.1	70.0	67.9
240	66.8	69.8	69.5	68.8	68.7	66.2	67.7	69.4	70.7	68.5
250	68.1	69.9	69.8	67.7	69.6	67.7	69.5	68.0	70.4	67.6
260	68.9	70.2	69.9	69.1	69.5	69.2	70.4	70.0	70.7	70.5
270	68.4	67.4	69.2	68.2	69.1	67.5	69.9	68.3	69.7	70.0
280	68.5	69.0	70.3	67.9	66.8	68.3	68.9	68.7	69.7	69.7
290	67.6	68.0	68.2	67.9	64.4	65.3	67.2	67.4	67.1	67.6
300	63.4	63.5	63.9	63.7	64.0	62.4	64.1	64.0	63.5	63.8
310	61.2	59.3	63.9	63.9	64.7	62.1	63.6	63.4	61.6	63.3
320	59.2	60.9	61.0	60.2	71.0	67.0	61.5	60.3	59.8	66.2
330	59.3	59.7	71.7	60.1	72.7	70.1	63.7	58.4	60.4	69.6
340	61.3	59.8	73.0	72.8	72.4	69.4	72.6	71.4	69.0	66.0
350	65.9	66.9	71.1	70.6	70.4	68.0	70.1	69.0	69.1	65.6

FEBRUARY

LONG	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	69.0	69.8	68.0	69.2	69.5	69.8	69.3	68.8	70.0	69.2
10	69.1	70.2	69.1	69.2	69.4	69.3	69.6	69.0	69.9	69.2
20	68.9	70.1	68.3	68.8	67.8	68.3	69.2	69.7	69.9	68.7
30	68.6	69.0	67.3	68.8	67.7	68.0	67.7	69.3	69.3	67.1
40	67.3	68.1	66.7	67.0	67.8	67.9	66.9	68.4	68.5	66.7
50	65.1	65.5	65.6	66.2	65.6	65.5	66.5	66.8	66.8	65.7
60	64.8	66.5	66.0	67.2	66.2	66.4	67.3	67.5	68.2	67.1
70	65.7	66.4	66.0	68.0	66.8	67.6	68.2	67.0	69.1	67.8
80	64.7	65.6	65.0	65.3	66.2	67.0	67.1	66.4	66.8	68.2
90	64.9	66.8	65.0	65.6	65.7	66.8	65.9	66.3	65.7	66.8
100	62.7	64.1	64.2	64.1	64.6	65.0	65.2	65.2	64.9	65.4
110	64.4	65.4	63.9	65.3	65.1	65.8	64.1	65.6	65.9	66.7
120	63.4	65.6	65.4	65.4	65.5	65.2	65.4	66.1	66.7	66.5
130	62.9	64.9	65.1	65.2	65.7	65.4	65.5	65.8	66.1	65.7
140	64.7	66.7	64.5	66.9	66.8	66.7	65.6	66.3	67.0	67.0
150	64.0	65.0	64.0	65.3	66.4	65.1	64.9	66.4	65.9	65.9
160	66.8	65.9	64.6	66.7	67.6	65.1	68.7	69.0	66.4	67.5
170	71.2	71.1	67.2	68.5	71.2	71.5	71.7	71.4	71.6	70.3
180	69.3	70.6	77.6	70.8	69.7	78.0	78.2	78.1	78.0	77.7
190	69.7	69.3	71.0	70.1	70.4	72.1	78.5	78.3	73.1	71.5
200	69.7	73.1	72.6	70.5	71.2	74.1	78.0	77.7	72.8	70.1
210	69.7	73.6	74.4	73.2	71.4	70.1	72.9	74.7	72.9	73.2
220	69.6	72.6	72.5	72.2	72.3	68.1	74.1	73.6	72.5	72.9
230	69.6	70.8	69.8	70.9	71.0	68.4	71.8	71.4	71.5	71.3
240	71.0	71.3	70.0	69.7	71.9	69.8	71.2	69.4	71.1	71.3
250	70.4	70.8	70.1	70.3	70.2	70.0	70.4	68.0	71.3	71.1
260	70.3	70.9	70.7	70.5	70.6	69.6	70.7	69.4	70.3	70.0
270	68.0	68.8	70.7	69.3	70.7	68.5	69.1	68.2	69.9	69.1
280	67.8	69.1	72.3	69.3	69.0	70.2	69.1	68.9	68.6	69.8
290	68.2	67.8	68.1	68.1	66.4	67.6	67.6	67.8	67.2	67.3
300	63.9	63.9	64.0	64.0	64.1	64.2	64.1	63.8	63.8	63.7
310	61.2	62.9	63.2	64.7	67.0	62.2	64.2	64.8	65.1	63.6
320	59.0	68.9	70.0	70.9	73.2	67.0	66.3	62.8	71.8	68.9
330	59.0	73.1	75.7	75.0	74.1	70.1	77.0	59.8	72.7	70.3
340	71.0	73.0	72.5	73.1	72.6	69.3	72.1	72.8	73.0	70.1
350	69.2	70.9	70.1	69.9	70.4	69.6	69.6	71.1	71.1	69.7

MARCH

LONG	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	69.2	69.8	69.8	69.1	68.8	68.9	69.5	69.4	69.4	68.9
10	69.6	69.9	69.4	68.5	69.1	68.5	69.4	69.5	69.2	68.1
20	68.6	70.3	68.0	68.6	68.6	67.8	69.0	69.2	69.0	67.9
30	67.9	69.4	67.7	68.8	68.9	67.6	68.6	68.6	67.9	67.0
40	66.9	67.7	67.0	68.2	67.7	66.8	66.7	67.8	66.7	67.0
50	65.5	66.0	65.4	66.0	65.0	65.8	65.9	67.1	65.1	65.5
60	65.1	66.0	66.5	65.5	66.3	66.6	67.3	66.9	65.6	66.6
70	65.1	66.2	66.4	66.8	65.9	67.4	67.6	66.4	66.2	65.9
80	64.5	65.0	65.3	65.1	66.5	67.8	67.8	66.4	65.2	67.2
90	64.5	64.3	65.2	64.9	64.7	66.5	64.6	65.8	64.4	65.9
100	64.5	63.7	63.9	63.9	63.5	65.2	65.2	64.8	63.6	64.6
110	64.4	64.5	65.0	65.2	65.4	65.5	64.2	66.1	65.4	66.0
120	63.7	65.2	65.0	65.1	65.4	64.4	65.8	65.9	65.8	66.7
130	64.0	64.9	64.6	65.0	65.6	65.1	64.7	65.3	65.9	66.9
140	64.7	66.9	65.8	66.0	65.0	66.1	64.8	65.8	65.7	67.4
150	64.3	65.6	64.7	63.8	65.0	65.1	64.3	65.0	64.9	65.7
160	68.7	66.2	66.8	64.5	68.3	68.4	64.2	67.7	65.5	67.2
170	71.6	71.3	70.2	67.6	71.0	71.3	71.6	71.1	71.0	68.2
180	69.2	72.0	75.5	67.3	69.9	75.9	77.2	76.7	73.6	75.1
190	70.1	69.1	68.5	68.0	69.9	73.0	77.2	77.6	71.0	70.8
200	70.2	72.2	70.3	69.9	70.6	73.8	76.1	75.2	69.8	70.8
210	69.4	72.7	71.0	70.8	70.9	72.1	72.4	74.4	72.2	70.7
220	71.2	72.5	70.8	71.4	71.8	70.4	72.1	73.5	72.7	72.0
230	69.2	70.6	70.1	70.4	69.8	68.9	71.5	71.2	71.7	70.0
240	70.3	70.4	70.3	69.6	69.7	69.1	71.6	69.8	71.8	70.1
250	68.8	69.7	70.4	69.7	69.6	68.0	70.7	69.8	71.3	69.7
260	69.5	70.2	70.4	70.2	68.9	69.7	70.8	70.1	71.1	69.3
270	68.7	70.4	70.3	69.7	68.0	69.3	68.8	68.4	69.4	69.2
280	68.6	70.6	72.7	70.3	68.5	69.1	69.5	69.3	69.2	70.4
290	68.2	68.4	68.5	68.7	66.9	67.2	68.3	68.1	68.0	68.3
300	63.7	63.7	64.5	63.8	64.0	63.6	64.1	63.6	64.0	63.5
310	59.5	63.1	63.5	63.4	67.6	62.0	64.0	62.4	71.4	62.8
320	59.5	66.8	70.4	72.2	71.9	66.0	67.1	62.6	71.3	69.5
330	58.7	72.2	75.0	73.3	74.3	68.0	70.0	75.8	73.8	71.3
340	71.5	72.7	72.8	72.8	73.2	69.5	70.6	73.6	72.9	69.7
350	69.2	70.5	70.2	70.5	70.4	69.9	68.3	71.0	70.1	68.8

APRIL

LONG	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	69.0	68.1	68.6	68.7	68.5	68.7	69.0	68.5	68.2	68.3
10	67.6	69.4	66.9	67.6	67.8	66.3	68.1	68.4	67.8	66.9
20	68.8	69.5	68.2	67.7	67.9	65.7	67.6	69.6	67.5	67.4
30	67.9	68.4	67.5	67.3	68.7	67.4	66.2	68.7	68.6	67.1
40	66.7	67.5	66.4	67.2	68.0	67.5	66.7	68.3	67.2	67.5
50	66.3	64.9	65.2	64.1	65.3	65.7	65.4	66.4	65.6	65.7
60	65.0	65.3	64.9	65.3	65.0	66.0	64.6	66.6	65.7	65.4
70	62.7	64.9	65.1	65.8	64.8	65.7	64.9	66.1	65.1	63.8
80	63.0	65.1	65.2	64.6	65.2	66.2	63.9	66.1	65.0	64.6
90	61.9	63.7	63.8	63.9	65.1	65.9	64.5	65.9	63.9	63.8
100	63.6	62.9	64.0	63.3	64.2	64.6	64.6	64.1	63.9	62.5
110	64.5	64.2	65.2	64.1	65.2	64.4	65.0	65.2	64.1	63.0
120	65.2	64.8	64.8	63.9	64.9	64.9	64.9	66.1	65.0	64.6
130	65.3	64.7	64.8	64.4	64.7	65.3	65.0	65.8	65.7	65.4
140	65.0	64.6	64.9	64.3	65.1	65.1	65.7	65.9	65.0	65.0
150	65.2	64.7	65.2	64.1	64.6	64.7	63.7	65.1	64.9	64.8
160	64.6	63.8	64.0	63.5	65.9	65.0	63.1	65.1	65.6	65.0
170	67.3	67.3	67.3	66.9	67.9	70.0	66.8	69.6	69.2	67.8
180	68.1	67.5	67.4	66.8	67.4	69.7	69.8	73.2	69.5	67.8
190	67.5	67.2	65.8	65.5	67.1	69.5	68.7	70.5	69.3	67.9
200	67.3	68.1	66.6	66.4	68.0	69.9	69.0	71.8	69.3	68.0
210	68.7	68.3	66.7	67.0	67.1	70.6	69.1	71.7	69.9	67.5
220	68.1	70.2	68.1	69.6	68.9	70.2	68.7	71.8	71.2	69.0
230	68.0	68.5	67.7	69.0	69.1	68.2	68.4	71.5	70.4	69.1
240	66.5	68.5	68.3	69.4	69.0	68.6	68.1	70.0	70.2	68.4
250	67.5	68.9	68.6	71.3	70.1	68.8	68.5	68.3	69.9	68.0
260	67.3	70.7	69.3	70.6	70.2	69.0	70.4	68.1	70.0	67.9
270	67.0	69.8	68.4	70.7	69.2	67.7	68.1	67.8	67.8	67.6
280	67.8	70.1	70.7	69.7	68.9	68.2	68.2	68.1	68.9	68.3
290	67.6	69.0	67.7	68.9	68.4	67.3	67.7	66.5	67.4	68.1
300	62.8	63.9	63.8	63.9	63.6	62.8	63.7	63.6	63.5	63.7
310	60.7	61.8	61.5	61.7	63.5	61.8	61.7	60.2	62.5	62.6
320	69.5	65.1	63.3	67.6	69.0	64.9	61.4	62.1	69.2	67.2
330	70.0	66.4	68.8	69.5	72.9	68.7	61.9	71.3	69.2	68.5
340	71.3	69.8	72.1	70.8	72.1	71.4	67.1	70.9	70.1	69.4
350	70.3	69.5	70.4	68.8	69.2	69.7	68.9	68.2	69.4	67.9

MAY

LONG	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Ø	68.1	68.2	68.3	67.8	68.4	66.9	67.8	68.5	65.9	66.8
1Ø	66.3	66.4	65.8	64.2	64.9	65.6	67.3	67.8	65.9	66.Ø
2Ø	68.1	68.Ø	65.1	64.4	63.Ø	64.5	67.9	67.8	65.6	66.3
3Ø	67.5	66.6	65.3	64.4	64.8	64.4	67.9	68.7	66.9	64.8
4Ø	66.8	64.4	64.8	64.7	65.9	67.3	67.9	67.6	65.5	62.9
5Ø	64.9	64.Ø	63.9	64.3	64.5	65.5	66.1	65.1	63.4	64.7
6Ø	63.2	62.6	63.7	63.2	63.1	65.3	65.1	63.8	62.9	62.9
7Ø	61.4	62.6	61.8	62.8	62.6	64.7	63.2	63.5	6Ø.8	61.1
8Ø	61.7	62.4	64.4	63.8	63.9	65.5	63.7	64.7	62.6	61.2
9Ø	6Ø.9	62.7	62.4	62.3	63.3	64.5	64.1	64.2	63.Ø	61.Ø
1ØØ	61.5	62.4	62.4	63.1	63.1	63.2	64.2	64.3	61.8	61.4
11Ø	63.2	62.1	64.4	63.3	64.4	63.1	65.4	64.2	62.9	62.7
12Ø	63.5	62.9	65.Ø	63.9	64.3	63.5	65.8	64.6	64.8	64.6
13Ø	63.7	63.3	64.6	64.4	64.3	64.3	64.9	64.7	65.2	65.Ø
14Ø	63.Ø	63.1	64.2	64.8	64.2	64.8	65.Ø	64.9	64.7	65.6
15Ø	62.5	63.Ø	63.3	64.3	63.4	64.6	65.Ø	63.8	64.9	64.1
16Ø	61.7	61.7	62.Ø	63.5	63.1	64.2	63.5	64.Ø	63.7	64.4
17Ø	64.5	63.2	64.9	63.7	65.3	66.4	66.6	7Ø.Ø	66.9	65.1
18Ø	65.3	64.7	65.1	66.6	65.9	66.8	65.9	68.7	68.6	6Ø.5
19Ø	65.6	64.1	62.8	65.3	66.4	68.2	66.2	69.6	68.Ø	65.6
2ØØ	65.5	62.4	61.9	64.5	66.7	68.1	66.6	7Ø.7	67.6	64.8
21Ø	65.8	63.7	62.6	65.2	65.8	66.9	65.3	7Ø.4	67.5	65.3
22Ø	66.Ø	64.5	65.4	67.1	67.Ø	69.7	66.1	71.7	69.3	67.3
23Ø	66.Ø	64.5	66.7	67.3	67.Ø	67.3	66.6	69.8	69.3	66.5
24Ø	65.9	66.7	68.Ø	67.6	66.3	66.2	66.9	68.Ø	68.5	67.Ø
25Ø	65.8	67.3	68.3	67.5	66.1	67.5	65.4	68.7	69.3	65.9
26Ø	66.7	68.8	69.3	68.6	67.6	67.8	64.9	67.6	69.7	67.1
27Ø	67.2	68.7	67.2	67.7	67.7	66.9	67.1	68.Ø	68.4	67.3
28Ø	65.1	69.1	66.5	67.1	66.7	65.4	67.Ø	66.9	66.5	66.1
29Ø	66.2	68.5	66.9	66.2	66.3	65.6	65.8	66.3	66.Ø	66.Ø
3ØØ	63.3	63.4	62.7	64.3	63.1	63.6	62.5	63.8	62.4	63.3
31Ø	59.7	61.8	6Ø.5	6Ø.6	61.4	62.Ø	61.4	59.5	6Ø.8	61.3
32Ø	59.1	62.4	61.2	63.8	66.Ø	61.7	6Ø.5	6Ø.Ø	66.7	6Ø.4
33Ø	62.5	6Ø.2	62.3	67.3	71.1	63.9	6Ø.3	58.9	66.7	63.2
34Ø	65.1	62.4	69.Ø	7Ø.Ø	72.5	66.4	62.3	65.1	64.3	63.5
35Ø	68.2	65.5	69.2	68.7	69.2	67.5	66.2	66.4	65.8	63.6

JUNE

LONG	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	60.9	62.6	67.6	64.5	64.9	63.8	61.1	60.0	60.2	62.4
10	66.4	67.1	66.1	63.5	62.6	61.7	62.3	66.2	62.1	64.0
20	64.3	64.6	63.9	61.7	61.7	61.8	61.9	67.9	61.7	63.3
30	64.9	64.3	63.5	59.7	61.0	63.0	63.4	66.8	61.9	63.2
40	65.6	64.3	64.4	60.0	60.9	65.0	65.2	65.4	63.0	64.7
50	64.4	62.9	62.8	58.9	62.6	65.2	64.3	64.0	62.0	63.9
60	62.1	62.1	61.4	61.4	61.4	63.3	62.8	63.2	61.3	61.9
70	60.7	60.8	60.9	60.9	62.0	64.9	60.7	61.1	60.9	60.9
80	60.4	60.3	60.7	61.8	61.5	63.8	60.0	60.8	60.5	59.1
90	60.7	60.8	61.6	60.0	61.2	64.6	61.2	62.3	61.7	59.7
100	62.1	61.8	61.8	62.5	62.7	63.0	61.6	62.8	61.6	60.1
110	62.4	61.7	62.4	62.5	62.8	63.0	64.2	62.5	63.0	61.8
120	62.6	63.2	62.2	62.4	62.7	64.4	63.2	63.7	65.2	64.3
130	63.8	63.2	62.8	63.9	63.6	65.4	64.4	64.7	63.7	65.2
140	62.7	63.2	62.9	63.7	63.9	64.6	63.6	64.7	65.0	65.2
150	61.0	62.5	61.6	63.9	63.2	63.7	62.7	64.1	65.7	65.3
160	61.0	61.3	61.1	61.9	61.1	62.9	60.4	63.2	62.4	64.8
170	63.9	60.7	61.1	63.8	63.4	65.6	62.6	68.7	62.8	64.2
180	65.1	61.8	61.6	65.4	64.4	66.8	64.7	68.1	65.2	60.1
190	64.8	62.0	62.6	64.8	64.1	65.6	63.9	69.1	64.5	65.2
200	66.3	60.3	62.2	62.8	63.8	66.3	62.7	68.5	62.4	64.7
210	65.6	58.5	60.6	65.0	64.1	65.6	64.2	70.1	61.7	65.7
220	66.1	63.4	63.8	65.9	65.4	66.9	64.8	71.4	66.3	66.3
230	65.9	65.6	65.5	65.9	64.9	65.3	65.1	69.1	67.1	68.1
240	66.0	65.0	65.8	65.8	64.2	66.5	64.9	68.9	67.7	67.4
250	65.1	65.2	66.3	66.4	64.6	67.1	66.4	68.1	69.1	67.8
260	65.3	68.1	66.3	67.5	64.6	66.9	65.1	68.8	69.9	67.2
270	64.6	66.4	65.3	67.3	64.7	65.7	66.8	67.6	69.6	66.6
280	63.7	66.4	66.7	65.4	64.3	64.5	67.6	64.5	68.4	64.9
290	62.5	65.3	66.3	64.1	62.3	65.9	65.2	63.2	62.9	63.9
300	62.8	62.4	62.1	63.6	61.6	63.4	61.1	62.4	63.3	63.7
310	59.5	58.2	59.6	59.4	59.9	60.7	59.9	58.6	59.4	60.9
320	56.7	59.1	59.5	59.6	61.7	60.4	57.2	56.5	59.2	59.7
330	58.2	57.9	59.5	58.2	63.4	61.3	57.8	57.6	58.1	60.3
340	59.4	57.6	61.0	62.8	70.8	61.7	60.6	59.4	59.0	61.1
350	60.2	59.3	60.8	67.8	67.5	63.5	58.7	59.6	57.5	60.2

JULY

LONG	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	57.1	57.5	62.8	59.9	64.3	59.8	56.8	57.6	57.2	58.5
10	59.0	59.7	60.9	61.3	63.7	61.8	56.9	57.1	56.6	58.7
20	59.0	60.8	61.6	61.4	61.3	60.5	59.9	59.7	59.5	59.5
30	61.2	60.6	62.9	61.3	61.8	61.5	60.1	62.9	63.4	60.4
40	61.1	60.9	62.5	58.8	60.5	60.7	61.6	63.9	63.2	62.2
50	61.4	60.4	60.3	59.0	59.9	61.7	62.0	63.5	63.0	62.3
60	61.2	59.8	59.9	59.2	59.9	62.1	61.2	62.5	60.8	61.4
70	59.7	59.9	60.5	60.8	59.5	61.2	60.9	61.4	59.5	61.7
80	58.7	59.5	60.1	59.4	57.6	60.8	58.9	59.9	56.2	60.8
90	60.0	60.9	59.8	60.7	61.2	61.7	62.2	62.2	60.4	60.3
100	60.4	60.1	60.5	60.5	62.0	62.9	62.2	63.0	60.1	59.3
110	61.2	60.0	60.8	61.5	63.1	62.0	62.0	64.0	61.5	60.9
120	61.9	60.4	62.2	62.7	64.4	61.7	63.0	65.9	64.5	63.5
130	62.4	62.0	62.1	62.5	64.5	62.4	63.5	62.8	64.2	64.0
140	62.6	62.9	62.4	62.1	63.8	62.5	62.1	64.8	64.6	64.9
150	62.3	62.0	62.1	61.7	63.0	61.2	61.9	64.3	63.9	64.3
160	61.4	60.3	60.1	61.8	62.0	62.5	61.5	61.7	62.3	62.7
170	62.9	60.7	60.6	62.8	62.8	62.7	61.2	63.0	63.1	63.2
180	65.4	61.7	60.8	63.9	64.8	64.0	62.8	65.2	64.8	59.0
190	63.0	62.7	62.6	65.4	65.2	62.8	63.7	65.9	63.8	62.9
200	62.5	61.2	62.3	64.0	63.0	62.8	63.0	65.2	62.8	62.7
210	62.1	59.3	60.1	61.4	64.1	65.6	61.1	67.4	60.8	62.8
220	64.4	59.7	61.8	66.0	66.2	66.4	64.3	69.8	63.5	66.7
230	65.8	63.3	65.2	65.9	66.0	67.1	64.9	69.0	65.7	67.8
240	65.5	64.2	65.3	66.3	66.1	65.1	66.1	68.6	66.4	67.7
250	65.0	64.6	65.7	66.1	65.8	66.4	67.6	66.7	67.1	69.4
260	64.4	66.2	66.0	66.6	65.7	65.9	67.8	66.0	67.7	67.2
270	64.5	66.6	66.3	65.9	63.6	64.9	66.5	65.8	67.6	66.1
280	63.3	65.6	66.5	64.0	61.7	63.0	64.5	63.5	66.5	63.9
290	60.7	64.1	66.0	61.9	60.8	60.3	64.2	61.1	64.8	62.1
300	60.5	61.8	62.3	61.4	60.2	59.8	61.9	59.5	63.0	62.9
310	57.6	58.0	58.3	58.8	60.4	59.2	61.8	58.5	60.4	59.5
320	57.4	57.8	58.3	58.3	60.6	59.6	58.4	57.9	59.3	59.1
330	56.7	57.4	57.7	56.2	61.4	59.3	58.0	57.0	58.3	59.7
340	57.3	57.9	58.2	58.4	62.0	58.9	57.7	58.1	58.5	60.3
350	57.9	57.6	60.5	63.2	67.0	60.2	57.1	57.5	56.8	58.7

AUGUST

LONG	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	54.6	55.5		59.7	56.7	61.0	54.2	54.8	55.0	56.9
10	53.6	58.7		58.0	56.0	61.4	54.8	55.3	55.1	57.4
20	57.2	59.9		57.3	58.1	60.5	56.6	56.7	57.3	56.7
30	59.7	59.3		59.0	60.9	59.5	59.5	60.8	62.0	58.0
40	60.4	59.7		57.5	60.9	60.7	60.5	61.7	61.1	60.2
50	60.1	59.2		57.0	60.7	59.9	61.3	61.6	61.8	60.6
60	59.9	58.9		57.2	60.5	60.2	62.1	61.4	60.5	59.7
70	59.5	59.8		58.3	59.3	59.9	61.9	59.6	58.9	58.8
80	57.2	59.7		58.0	59.5	57.6	60.8	58.1	55.4	58.0
90	57.4	60.3		58.6	60.3	60.2	61.3	59.4	57.6	59.8
100	58.1	60.3		59.2	60.4	60.1	60.2	60.5	58.6	58.7
110	59.5	60.8		60.7	60.7	62.8	60.1	61.8	64.4	60.5
120	61.4	60.8		62.1	61.2	63.1	61.8	63.2	65.1	61.8
130	63.0	62.0		63.6	62.8	64.1	63.8	63.3	64.7	62.8
140	62.8	62.4		64.4	62.6	63.5	65.0	64.0	65.5	62.4
150	63.0	58.4		63.9	62.7	63.3	65.7	61.2	63.6	62.0
160	61.3	60.9		62.8	64.1	62.7	63.3	60.7	62.1	60.9
170	62.2	60.7		63.3	64.3	62.9	62.6	62.4	63.0	61.6
180	63.8	62.8		64.0	64.7	63.7	63.9	64.9	64.3	63.2
190	63.7	63.3		62.5	63.5	62.6	65.6	64.2	63.8	63.4
200	61.5	61.8		61.9	63.1	62.9	65.5	63.6	62.6	62.5
210	59.0	57.9		60.1	61.1	60.1	63.8	66.7	59.6	61.3
220	63.8	60.7		64.1	63.6	64.7	63.1	70.7	61.2	63.5
230	65.0	62.6		65.2	64.8	65.3	64.8	69.5	64.4	65.7
240	64.6	62.6		66.2	64.2	66.6	65.8	69.8	64.9	65.8
250	66.3	64.3		67.0	64.7	67.3	66.0	68.5	65.9	66.3
260	66.8	65.5		66.8	66.0	66.7	66.4	66.7	66.9	66.4
270	65.5	66.0		64.9	63.3	66.3	65.9	66.9	67.2	65.3
280	66.0	64.6		63.7	63.1	65.4	64.4	63.6	67.7	64.2
290	63.9	63.5		61.4	60.1	60.9	64.6	60.7	64.0	63.7
300	59.7	60.5		58.2	57.8	59.2	62.0	58.3	60.8	61.2
310	57.9	57.1		57.3	57.2	59.2	61.1	57.7	59.9	59.7
320	55.9	57.3		58.1	58.7	60.2	59.4	55.9	57.4	57.5
330	56.5	55.1		58.2	57.2	56.8	57.3	54.8	55.7	58.1
340	54.6	56.5		57.0	57.5	57.6	57.8	55.4	55.7	58.3
350	54.7	56.3		58.8	57.8	58.3	56.7	55.6	55.6	57.2

SEPTEMBER

LONG	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	54.2	55.7	55.5	57.0	56.7	56.0	57.6	54.1	56.1	57.0
10	54.5	54.0	55.1	57.5	57.8	55.8	57.6	54.3	54.8	54.5
20	54.6	56.6	59.2	57.8	60.1	56.6	56.9	56.8	55.4	56.5
30	59.8	59.8	59.7	59.7	61.1	60.5	57.5	59.4	58.0	58.0
40	58.4	58.6	59.9	57.0	60.1	61.5	58.8	60.6	60.7	58.2
50	59.0	57.5	60.9	57.1	59.1	61.1	59.8	60.0	59.9	59.6
60	58.6	57.3	59.9	57.4	59.5	60.5	60.4	60.0	58.0	58.7
70	59.0	58.1	60.2	57.2	59.1	59.1	61.5	59.9	57.1	58.6
80	57.9	55.5	58.7	57.8	58.4	58.4	59.9	56.1	52.8	56.4
90	59.8	59.8	59.4	58.3	59.4	58.8	60.0	60.4	56.8	58.8
100	57.4	59.7	58.4	59.4	59.8	58.8	60.2	62.1	56.9	57.1
110	58.6	61.3	60.2	61.1	60.2	60.1	60.2	62.7	60.5	59.3
120	59.0	60.2	60.4	63.3	62.4	61.9	61.5	63.7	63.6	60.6
130	62.0	61.1	60.9	64.6	62.6	62.9	63.4	64.1	63.8	60.5
140	63.7	61.9	60.2	64.5	64.3	63.6	64.7	63.2	64.4	61.1
150	63.7	60.9	61.0	64.6	64.4	63.2	64.9	61.9	63.8	63.3
160	63.3	61.3	60.6	62.9	65.3	64.3	64.2	61.7	62.5	63.6
170	62.5	62.4	61.8	63.2	65.1	65.0	63.4	62.5	62.6	64.1
180	63.2	64.2	62.6	63.9	66.9	64.0	62.7	63.7	64.2	65.8
190	64.2	63.0	62.8	63.7	66.4	63.9	63.7	63.0	62.6	65.0
200	62.9	61.9	62.5	63.0	64.5	64.3	63.9	62.3	63.7	63.6
210	60.1	59.6	62.1	61.8	62.8	62.3	63.2	63.2	60.1	63.4
220	59.4	57.9	59.9	63.4	61.5	62.0	61.5	66.3	62.5	63.8
230	63.9	61.5	62.3	64.1	64.7	64.5	62.5	67.2	64.4	65.4
240	65.2	63.0	64.4	65.2	65.8	65.3	64.6	66.8	66.2	66.3
250	65.5	64.0	64.5	65.3	66.3	65.7	64.4	57.3	66.0	66.4
260	66.6	64.9	64.7	65.7	66.0	65.9	65.0	66.3	66.8	66.0
270	67.0	64.8	64.6	64.6	64.7	64.7	63.7	68.1	67.0	64.9
280	64.9	63.7	63.4	63.0	64.7	64.7	64.9	64.7	66.7	65.0
290	63.8	62.5	62.4	62.5	61.9	61.3	64.3	62.9	65.0	63.8
300	62.8	60.7	60.1	59.6	61.7	59.7	59.9	58.8	61.7	60.8
310	59.9	57.3	56.9	58.5	60.7	57.4	58.4	57.8	58.3	59.6
320	57.1	56.9	55.0	58.0	60.6	58.0	57.9	53.3	58.1	58.3
330	56.7	55.2	55.3	58.2	59.8	57.9	58.1	51.7	56.2	57.8
340	56.0	57.1	56.2	58.0	58.9	57.2	57.8	54.4	56.4	57.5
350	55.4	56.5	56.8	58.3	58.0	55.9	58.4	55.5	56.4	57.3

OCTOBER

LONG	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	53.9	55.6	57.9	57.3	57.3	56.1	57.2	55.2	55.7	56.4
10	52.9	56.3	56.4	55.6	54.0	56.0	55.7	54.9	55.8	55.7
20	53.6	58.0	56.9	54.9	57.4	55.1	54.0	56.0	54.5	55.0
30	57.7	58.0	59.8	58.3	59.4	58.9	57.3	61.1	58.4	57.5
40	57.9	57.9	60.6	58.2	60.1	60.2	57.9	61.2	60.1	57.3
50	57.2	57.7	59.3	57.5	58.9	60.5	58.2	60.1	60.8	57.7
60	56.7	57.0	58.6	56.9	59.0	60.6	58.9	60.9	58.8	58.7
70	57.4	58.2	59.6	57.9	59.9	59.2	58.5	59.9	58.3	59.2
80	57.3	57.6	58.9	58.2	59.1	57.9	61.3	56.4	53.4	58.5
90	59.3	60.0	60.9	60.2	59.1	58.6	60.8	60.3	55.6	60.5
100	58.2	57.7	60.5	59.5	58.6	57.1	61.8	62.1	55.9	58.4
110	59.3	60.1	60.5	61.7	59.3	59.0	60.2	63.1	60.7	59.5
120	59.4	62.0	61.8	62.3	59.4	59.9	62.2	63.7	63.9	61.1
130	62.6	62.5	62.9	63.5	62.8	59.9	61.2	64.6	63.4	61.0
140	62.1	61.0	62.7	64.5	63.6	60.7	61.8	64.0	62.9	60.8
150	61.8	61.7	62.4	64.0	64.3	61.5	64.1	63.8	62.4	62.4
160	62.3	61.7	62.3	63.5	63.4	62.9	64.0	64.1	61.8	62.8
170	62.3	63.4	62.9	63.0	63.8	63.2	66.3	63.6	63.7	64.3
180	63.3	64.5	65.2	63.3	63.8	64.4	65.4	65.5	64.7	65.1
190	63.0	63.2	63.2	63.7	64.8	64.9	64.2	63.7	64.6	64.7
200	63.2	63.2	63.6	64.4	65.5	64.2	65.0	63.5	64.0	65.4
210	62.0	61.1	63.3	64.4	65.6	64.8	64.3	63.2	62.8	64.5
220	61.4	60.1	61.3	62.9	65.0	63.8	64.4	66.4	63.0	65.2
230	62.4	60.2	64.9	63.9	64.5	65.8	63.0	68.3	64.9	66.4
240	64.8	61.4	65.1	65.3	64.9	66.2	64.0	67.5	65.8	66.9
250	65.4	65.2	65.5	65.3	66.2	65.6	64.9	67.7	66.2	68.6
260	65.9	65.4	65.4	66.5	66.2	65.5	65.8	68.5	66.0	69.3
270	67.7	66.4	65.8	66.1	64.4	65.0	66.0	67.9	65.4	67.3
280	69.4	65.5	66.0	64.2	64.5	65.1	65.8	66.0	65.3	64.9
290	67.3	64.4	64.0	61.8	63.1	64.9	65.2	63.7	63.8	63.6
300	63.9	62.0	61.1	58.3	61.0	62.6	62.2	61.2	62.4	61.8
310	61.6	60.1	57.8	57.8	60.4	62.5	61.7	58.2	58.4	60.9
320	57.6	58.7	57.0	57.8	58.6	60.1	59.4	56.3	58.4	57.5
330	55.1	57.0	55.2	56.6	59.4	59.0	57.0	53.9	58.5	56.3
340	55.2	57.5	57.4	56.9	58.9	59.5	57.8	54.6	58.6	56.4
350	54.9	57.1	57.1	57.7	57.4	57.5	57.4	54.6	57.1	56.7

NOVEMBER

LONG	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	55.3	57.0	58.9	65.3	58.7	57.9	56.9	55.4	54.9	58.3
10	54.6	57.0	57.9	64.6	56.6	55.5	56.9	54.6	56.5	58.0
20	53.0	56.5	57.6	57.6	58.6	55.4	56.2	54.1	55.1	55.8
30	55.1	60.7	59.8	59.0	59.6	58.0	56.4	57.8	58.5	59.6
40	58.1	60.3	60.9	58.2	60.1	60.1	60.0	59.2	59.9	58.6
50	57.3	59.0	62.4	57.5	60.1	59.9	60.1	60.0	59.8	58.7
60	57.8	58.0	61.5	58.6	61.0	61.1	60.3	60.1	61.0	57.8
70	58.8	57.2	60.9	59.8	60.2	60.2	61.2	60.3	59.5	58.3
80	58.9	59.3	60.5	59.5	61.0	61.1	61.6	59.9	59.2	62.4
90	60.6	61.1	62.6	59.5	60.4	60.8	61.1	61.9	59.4	62.3
100	60.8	61.6	62.6	60.7	59.5	59.6	60.5	61.2	59.0	60.1
110	59.9	62.9	61.6	61.6	60.2	60.3	59.2	62.3	61.8	60.8
120	60.7	63.7	63.3	62.8	60.4	62.5	60.1	62.6	63.4	61.6
130	61.7	64.0	64.0	64.0	61.0	62.4	62.4	62.8	63.4	62.7
140	61.4	64.1	63.0	64.3	62.8	62.5	62.5	62.3	62.7	61.3
150	60.8	62.6	63.3	64.3	63.5	63.9	63.5	62.3	63.1	61.0
160	61.3	62.5	60.7	62.7	63.8	65.4	63.8	63.0	63.1	62.3
170	61.8	63.1	63.0	62.5	64.5	65.3	67.4	64.5	63.5	63.2
180	62.6	64.2	64.0	63.9	66.0	66.3	67.6	56.8	65.0	65.7
190	62.0	62.8	65.3	64.7	66.6	66.4	68.0	64.0	65.2	65.0
200	61.0	63.0	63.8	64.4	66.3	66.1	66.1	62.9	64.2	64.1
210	61.9	62.0	63.3	65.1	66.2	65.1	65.6	62.6	64.9	63.4
220	61.5	60.9	63.6	64.3	65.8	64.8	65.8	64.4	62.7	63.9
230	62.1	61.3	62.1	63.5	64.0	65.0	64.9	65.9	64.5	65.6
240	65.6	64.5	66.1	63.6	63.8	66.3	64.9	67.0	65.4	66.6
250	66.1	65.0	67.0	64.2	63.7	67.2	65.7	68.5	65.7	67.3
260	65.8	66.3	65.8	66.9	65.0	65.7	64.7	70.4	66.7	68.6
270	66.8	65.5	66.7	65.5	66.0	66.3	64.4	70.5	66.6	68.0
280	69.6	65.9	66.2	65.0	65.0	68.4	65.9	69.3	66.9	67.0
290	67.2	66.5	66.3	64.8	64.6	66.1	65.7	64.4	64.9	65.3
300	63.6	63.5	63.5	63.4	62.1	63.5	62.6	62.4	63.4	63.2
310	61.7	62.4	62.0	63.3	63.2	62.5	61.9	61.5	60.9	60.2
320	59.8	59.9	59.2	58.6	59.9	60.7	59.7	58.0	59.8	60.0
330	57.0	56.7	57.6	58.3	59.7	60.4	58.6	54.0	58.3	58.2
340	59.8	58.5	57.3	58.5	61.5	59.4	58.1	55.5	59.0	59.8
350	56.2	58.0	57.9	58.8	59.5	58.8	58.2	55.1	56.9	58.6

DECEMBER

LONG	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	59.9	57.8	60.7	66.8	60.7	59.6	59.2	58.3	58.3	63.1
10	60.0	57.5	62.8	64.7	59.9	59.9	59.8	57.9	57.6	66.6
20	59.0	60.8	61.2	62.0	61.7	57.8	59.0	57.6	58.6	63.6
30	58.5	61.0	62.6	62.8	64.9	62.9	63.0	62.5	62.6	63.9
40	60.3	61.8	61.8	61.1	65.4	64.2	64.2	62.2	64.5	65.1
50	61.6	62.0	63.3	61.4	64.6	64.8	63.3	62.8	64.6	63.9
60	63.4	64.7	64.1	61.8	64.8	65.0	62.9	63.6	64.5	64.8
70	65.5	63.2	62.5	64.1	64.3	65.1	62.8	65.0	63.5	64.9
80	64.3	63.7	63.3	64.3	65.2	65.7	63.2	64.5	63.6	65.2
90	64.4	62.6	63.1	64.2	64.2	65.3	62.3	64.2	62.7	64.8
100	62.6	63.7	62.8	63.1	62.4	63.6	60.3	63.8	61.6	63.2
110	62.7	65.0	64.5	65.2	62.0	64.6	60.9	64.7	63.5	64.3
120	64.3	65.1	65.1	64.4	63.6	65.0	64.1	64.9	64.2	64.9
130	64.4	64.5	64.8	64.8	63.6	64.0	64.3	64.2	64.4	65.2
140	63.8	65.6	65.2	65.1	64.6	65.1	64.0	64.7	64.5	67.4
150	65.4	64.9	64.7	65.4	64.6	65.0	64.5	63.9	64.8	66.4
160	63.4	64.8	63.1	63.4	63.9	64.6	65.0	64.0	64.0	63.6
170	65.6	64.5	64.3	62.2	65.7	66.2	67.1	66.7	64.1	63.8
180	66.0	66.3	65.4	64.9	69.7	66.7	69.3	66.6	65.9	67.8
190	66.7	63.0	65.7	67.0	68.7	67.9	70.1	67.6	66.1	67.6
200	64.1	62.8	64.7	66.5	69.6	66.0	69.3	65.9	66.0	66.9
210	64.5	63.2	65.7	65.4	68.4	65.2	69.9	64.7	66.2	66.3
220	64.6	62.0	65.5	64.9	68.0	66.4	69.1	67.8	65.8	64.6
230	63.6	62.6	64.6	65.4	65.4	67.0	67.7	67.8	65.7	67.7
240	65.6	66.6	67.9	65.7	63.2	66.6	66.6	68.6	67.3	65.4
250	66.1	69.1	67.9	67.0	66.4	66.6	67.0	69.4	67.2	67.4
260	68.1	69.2	68.1	66.5	65.8	66.9	69.2	69.6	68.8	68.3
270	68.1	68.4	66.6	67.2	68.9	67.2	67.4	68.5	68.7	67.7
280	69.7	68.9	66.2	67.3	68.3	67.0	66.1	68.2	67.9	68.0
290	67.9	66.9	66.6	65.7	66.5	66.4	66.1	64.6	67.0	66.3
300	64.2	63.4	64.2	64.3	62.8	64.2	64.0	63.3	64.0	64.1
310	63.5	61.8	63.8	63.5	63.1	62.3	62.8	61.3	62.5	61.0
320	57.7	61.0	59.7	61.8	60.0	61.4	60.5	59.7	60.3	60.7
330	57.3	58.4	59.3	58.0	59.8	58.8	59.2	59.7	60.9	60.3
340	59.1	57.4	59.7	71.1	60.6	61.3	59.8	58.8	59.7	60.3
350	60.2	56.8	60.2	68.0	62.1	59.6	60.9	58.7	58.4	64.3

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ANARE RESEARCH NOTES (ISSN 0729-6533)

1. John M. Kirkwood (1982). A guide to the Euphausiacea of the Southern Ocean.

2. David O'Sullivan (1982). A guide to the Chaetognaths of the Southern Ocean and adjacent waters.

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