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AGREEMENT 02/2005 REPORT

DEVELOPMENT OF THE PACIFIC WALRUS AERIAL SURVEY METHODOLOGY

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ABSTRACT

40 pages, 7 tables, 14 figures, 9 appendices, 42 references. Key words: Pacific walrus, aerial survey, tagging, distribution, population numbers, sex-age composition, dynamics, behavior, Bering Sea.

This is an overview of data available on population numbers, distribution, and sex-age composition of Pacific walrus in the Bering Sea during spring. Ice and climatic conditions for the period of time of the prospective walrus aerial survey are described. The possible influence of various factors on daily and seasonal dynamics and activity of walrus on ice is evaluated. Recommendations on conducting spring instrumental aerial survey and satellite tagging of walrus are offered.

INTRODUCTION

Pacific walrus has been a foundation for the existence of aboriginal peoples of Chukotka and Alaska since ancient times. Chukotka marine mammal hunters harvest about 1,500 walrus for their traditional needs each year. Walrus harvest exceeds any marine mammal harvest by the number of harvested animals, and by cumulative weight is second only to gray whale harvest. Pacific walrus population numbers were reduced to minimum as a result of overharvest in the 1960's; however, conservation measures helped restore the optimal size of the population by the early 1980's.

Rational use of any resources, including Pacific walrus, implies estimation of harvest limit based on population estimate of the species. The latest Pacific walrus population estimate was made in 1990 based on the results of joint Russian-American aerial survey. Total population numbers were estimated at 190-200,000 animals (Gilbert et al., 1992). Since then, no reliable Pacific walrus surveys have been conducted that would provide data for accurate population estimate. At the same time, there are indications of negative processes occurring in the population. This tendency was first observed in the first half of the 1980's, when surveys of sex-age composition of the walrus haulouts in the Chukchi Sea showed alarmingly low population productivity and survival rate of the young (Fay, Kelly, 1989). Aerial survey data during 1980-90 also indicated slow decline of walrus numbers (Федосеев, 1981; Федосеев, Разливалов, 1986; Gilbert et al., 1992). The ratio of adult females and young 0-3 years old estimated for the Chukchi Sea in summer in 1998-99 indicated that the rate of recruitment was still very low (Kelly et al., 1999). Over the last few years, several haulouts along the coast of Kamchatka and Koryakiya ceased to exist, and on those sites where walrus continue to haul out, the number of animals reduced significantly (Тестин, 2004). Compared to the mid 1980's, the number of walrus in the aggregation that spends summer in the northern part of Anadyr Bay reduced almost two fold (Смирнов и др. 2002; our data). All of the above points to a continuing decline in the Pacific walrus population.

Thus, walrus harvest in the absence of current data on population numbers may have a serious negative impact on the state of this resource and as a result, on the economy and social situation in Native communities of Chukotskiy Autonomous District. In order to estimate the current population numbers of Pacific walrus, it is necessary to conduct a simultaneous aerial survey in the Russian and American coastal waters, since at present, this is the only operational and sufficiently accurate method of estimating numbers of pagophilous species of marine mammals.

This report includes an overview of the information on hydrology, distribution and behavior of Pacific walrus available in publications that must be taken into account when conducting aerial photographic survey in spring.

OVERVIEW OF PREVIOUS SURVEYS

The first attempts to estimate Pacific walrus population numbers using aerial visual surveys were undertaken in 1958 both in the USSR (П.Г. Никулин, по: Федосеев, 1962), and in the USA (Buckley, 1958). Those efforts were not coordinated; they were conducted using different techniques and in different seasons. Since 1960, aerial photography has been used for survey purposes and the survey system became regular in the Russian waters.

Table 1.

Pacific walrus population estimates based on the results of fall aerial surveys

Year	Period	Zone	Estimated number of animals, thousands of individuals		Number of animals in the population with the correction according to G.A. Fedoseev (1984), Fay et al. (1997)	Number of animals in the population with the correction according to G.A. Fedoseev (2000)	Source
			Lim	M			
1958	August-September	Russia		40			P.G.Nikulin (In: Fedoseev, 1962)
1960	September-October	Russia		50	83	90	Fedoseev, 1962
1964	September	Russia	47-71	59	98		Gol’tsev, 1968
1970	September-October	Russia		101	168		Gol’tsev, 1972
1975	September-October	Russia and USA	140-200	170	220-248	238	Estes, Gol’tsev, 1984
1980	September-October	Russia and USA	250-300	275	291-311	386	Fedoseev, 1981; Johnson et al., 1982
1985	September-October	Russia and USA		233	244	334	Fedoseev, Razlivalov, 1986; Gilbert, 1989
1990	August-October	Russia and USA		201		296	Gilbert et al., 1992

Surveys were conducted approximately once in five years (Федосеев, 1962; Table 1). Surveys were conducted in September-October, since that is the time when autumn migration of walrus from the Chukchi Sea into the Bering Sea starts and when walrus fill haulouts along the Russian coast to their maximum capacity.

In the USA, walrus surveys were conducted in spring, usually in April (Table 2), since, during that time, the larger part of the population occurs on ice in the American part of the Bering Sea. Spring surveys were conducted in Russia in 1961, 1976, 1979, and 1987, however, only autumn survey data were used for population estimates.

Table 2.

Pacific walrus population estimates based on the results of the spring aerial surveys

Year	Period	Zone	Estimated number of animals		Number of animals in the population with the correction according to Fay et al. (1997)	Source
			Range	Mean		
1958	May	USA	7.5-12.5	10		Buckley, 1958
1960	February -March	USA	59-85	72	66-95	Kenyon, 1960
1960	April	USA	70-100	85		Kenyon, 1960
1961	March	USA	70-100	85	75-108	K.W.Kenyon (In: Fay, 1982)
1961	May	Russia		30		Крылов, 1968
1968	April	USA	73-110	92	106-160	K.W.Kenyon (In: Fay, 1982)
1972	April	USA	85-162	123	98-186	Kenyon, 1972
1976	April	Russia and USA		147		Fedoseev, 1984; Braham et al., 1984
1979	April-May	Russia				Fedoseev, 1979
1987	March	Russia	47-51	49		Mymrin et al., 1990
1987	April	Russia and Central Bering Sea		89		Fedoseev et al.., 1988
1987	May	Russia and Central Bering Sea		208		Fedoseev et al., 1988

The first coordinated Pacific walrus population survey in Russian and American zones (Estes, Gol’tsev, 1984) was conducted in 1975 within the framework of the project 02.05-61 “Marine mammals” of the Agreement on Cooperation in the Environmental Protection between the USSR and the United States. The survey was conducted in September-October by each side within its zone. From then on, coordinated surveys were conducted once every five years and resulting population estimates were used for population modeling and walrus population management both in the United States and the USSR. However, the survey and data processing methods used by each side remained different.

The last survey of Pacific walrus in 1990 was conducted in the most coordinated way. In 1989, Russian and American scientists conducted preliminary joint flights and developed detailed survey plans. American scientists participated in the flights over the Russian waters, and data processing and report writing were also accomplished jointly (Gilbert et al., 1992). However, unusual ice conditions in the fall of the 1990 did not allow statistically reliable data to be obtained, and the validity of the results was questionable. J. Gilbert (Gilbert, 1999) made a detailed analysis of the previous surveys, and found that the ice surveys produce more reliable data; he therefore recommended conducting surveys during the spring period (March-April). In 2000, the working meeting of the Pacific Walrus Survey Group was held in Anchorage, Alaska, where various possible methods of estimating population numbers and trends were discussed (Garlich-Miller, Jay, 2000). The opinions on what season the surveys should be conducted in were divided; nevertheless, after considering financial and organizational circumstances, the preparation for the spring survey was started.

ICE CONDITIONS

Maximum ice distribution in the Bering Sea occurs in March. In March, southern ice edge in the central part of the sea is located usually between 57°N and 60°N, shifting north as far as Cape Navarin in the western part of the sea, and as far south as St. Mathew and Nunivak islands and northern portion of Bristol Bay in the eastern part of the Bering Sea. In the Russian waters, ice gradually narrows from Cape Navarin, along the Koryak coast and includes Karaginskiy Bay. In April, the ice edge recedes to the north; ice drift in the ice edge zone is usually directed westwards and northwards in the first half of April, and from north to south in the Bering Strait area. Fast ice is little developed along the shore, but in some years, it can reach 30-40 km in width in Anadyr Lagoon area (Плотников, Якунин, 1999). Solid fast ice covers the entire Anadyr lagoon and the northern portion of Kresta Bay. Due to the impact of northern winds along the southern coast of Chukotskiy Peninsula, the extensive Sireniki Polyn'ya is formed.

Ice conditions in the Bering Sea in the first half of April in 1997-2005 are presented in the Appendix.

CLIMATIC CONDITIONS

In spring, northern winds prevail throughout the entire Bering Sea; however, their frequency gradually decreases from April to May. Mean wind force does not exceed 4-5 points of wind force scale; however, it reaches up to 9 points near islands and capes (Cape Navarin). Maximum frequency of calms is characteristic of Karaginskiy Bay (Карпова, 1963).

Mean April temperatures in the northern part of the Bering Sea range between 4° and 10°C, and can drop as low as - 32°C during the periods of cooling temperatures (Карпова, 1963).

Visibility in spring usually reaches 5 miles and more, due to improved light conditions. Recurrence of fogs and the number of overcast days increases from March to May. Total precipitation in the northern part of the Bering Sea is minimal during that time (Карпова, 1963).

WALRUS DISTRIBUTION

The walrus breeding season is over in March-April and then the calving season begins. Walrus distribution doesn't change much during those months, except for a slight tendency towards some increase in the number of animals occurring in the Bering Strait area and in Anadyr Bay in April (Fig.1) The main part of the population is localized in two regions at that time: Bristol Bay together with the area to the north of Bristol Bay, and the area around and south of St. Lawrence Island. In May, the animals start moving toward the Bering Strait and into the south-eastern portion of the Chukchi Sea as a result of seasonal migration. Some of the walrus remain in Bristol Bay and in coastal waters of Anadyr Bay and the Koryak coast.

Population distribution in early spring in many ways depends on the ice conditions. In the case of low ice coverage of the Bering Sea, the main concentration of walruses forms a single group oriented in the southeast-northwest direction along the ice edge (Fig.2). If the level of ice coverage is high, walrus concentrate in two areas - Bristol Bay and St. Lawrence Island - separated by a distinct gap.

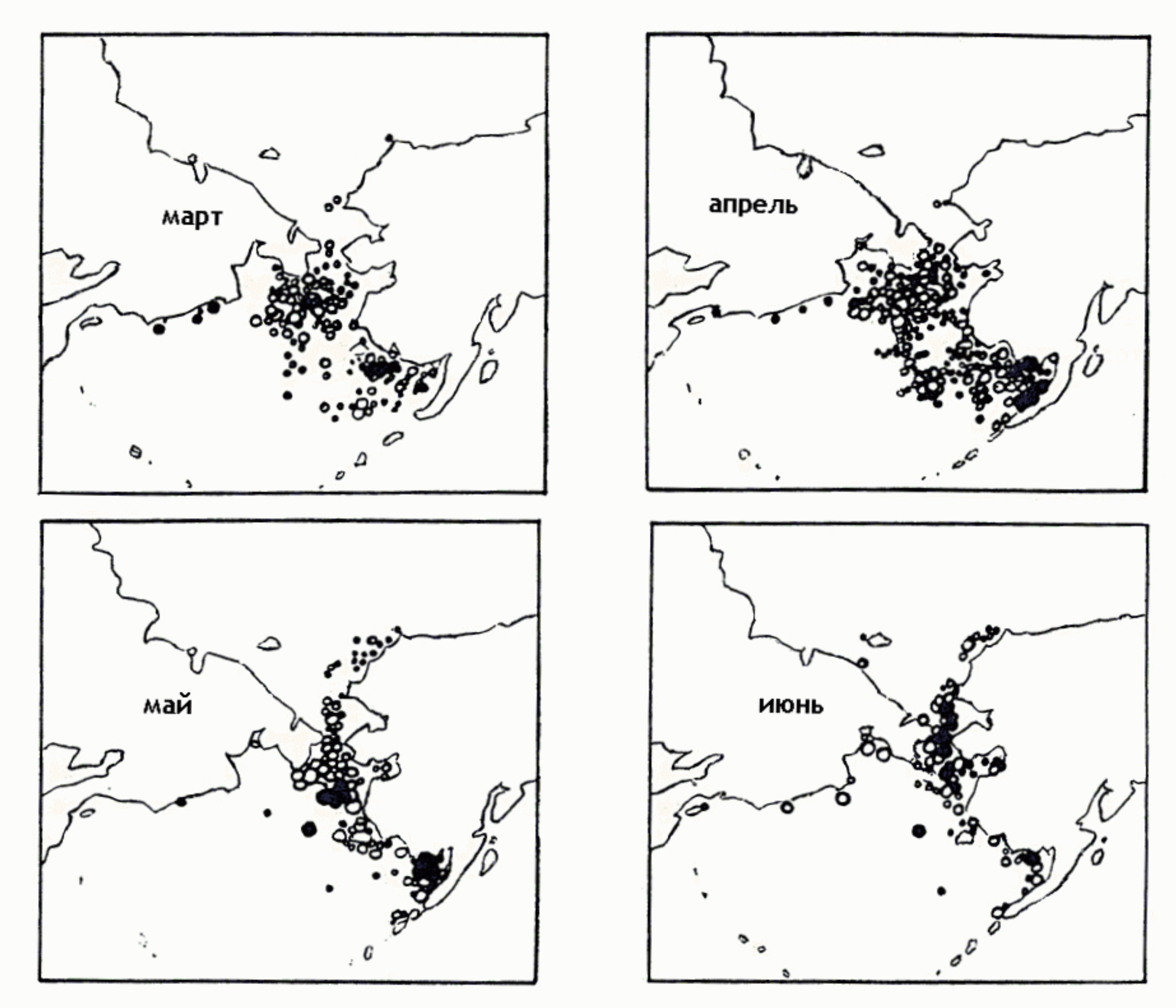


Fig. 1. Distribution of the Pacific walrus population during the period of March through June. Light circle – F. Fay's data (Fay, 1982)**; black dots – new data from various sources. Symbol size corresponds to group size** (according to: Fay et al., 1984a)

Thus, in spring, the majority of walruses aggregate in the American waters of the Bering Sea. There have been fewer observations conducted in Russian waters; however, there is no doubt that in spring, not more than 15-25% of the population stays in the western part of the Bering Sea. Coordinated Russian-American survey in April 1976 showed that walruses were practically absent along the coast of Chukotka and Kamchatka, and within Russian waters, formed aggregations only along the border between Anadyr Bay and open waters of the Bering Sea. The largest concentrations were found near St. Lawrence Island (Fig. 3a). In the American waters, walruses concentrated in traditional areas of Bristol Bay and in the vicinity of St. Lawrence Island (Fig. 3b). It is important to point out, that the total length of survey transects in Anadyr Bay in 1976 was relatively small (Fig.3a).

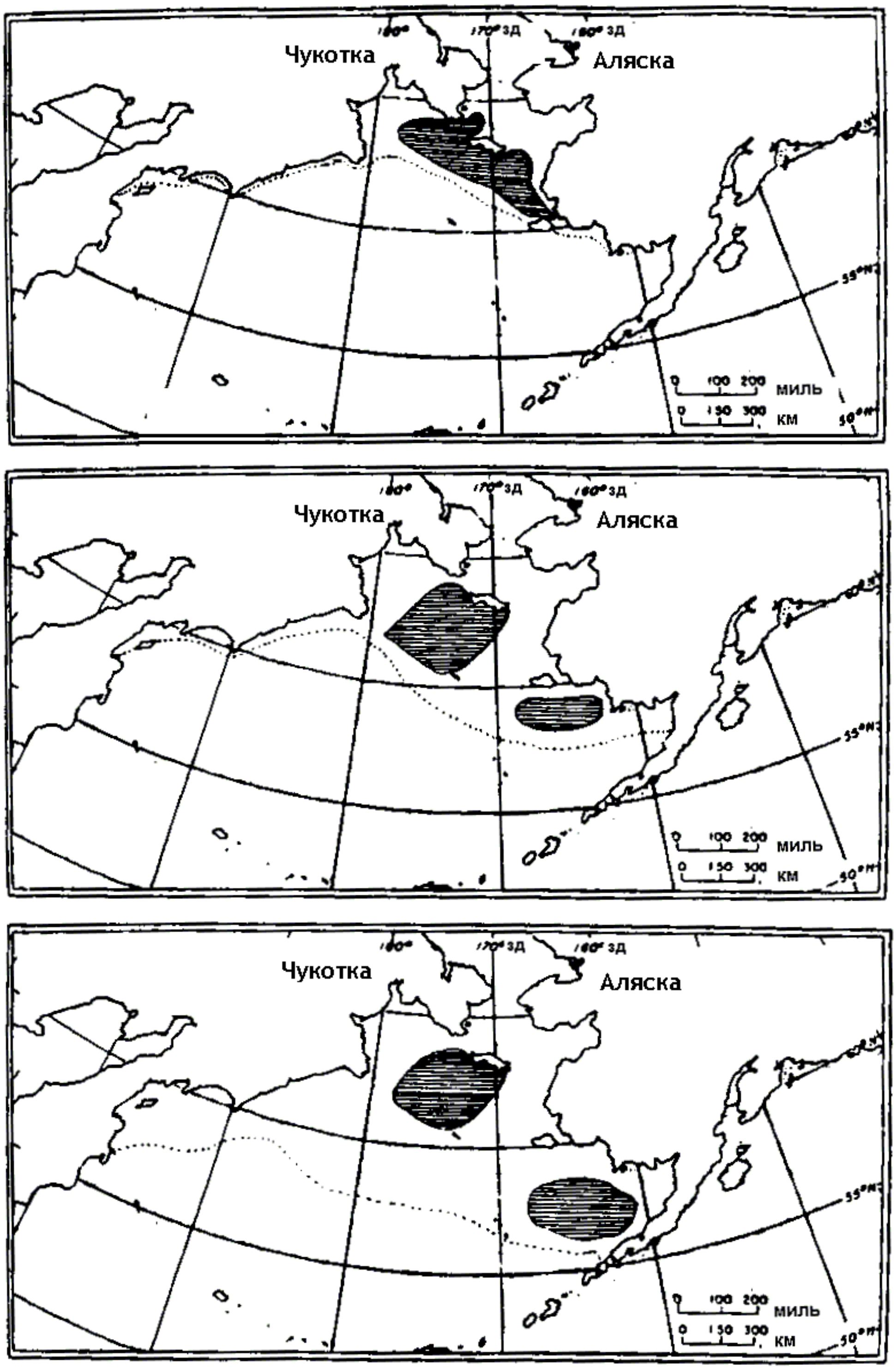


Fig. 2. Locations of reproductive groups of walrus (hatched areas**) in January-March at the maximum (**top picture**), average (**middle picture**) and minimum (**bottom picture**) levels of ice coverage. Ice edge is shown as dotted line** (according to: Fay et al., 1984a)

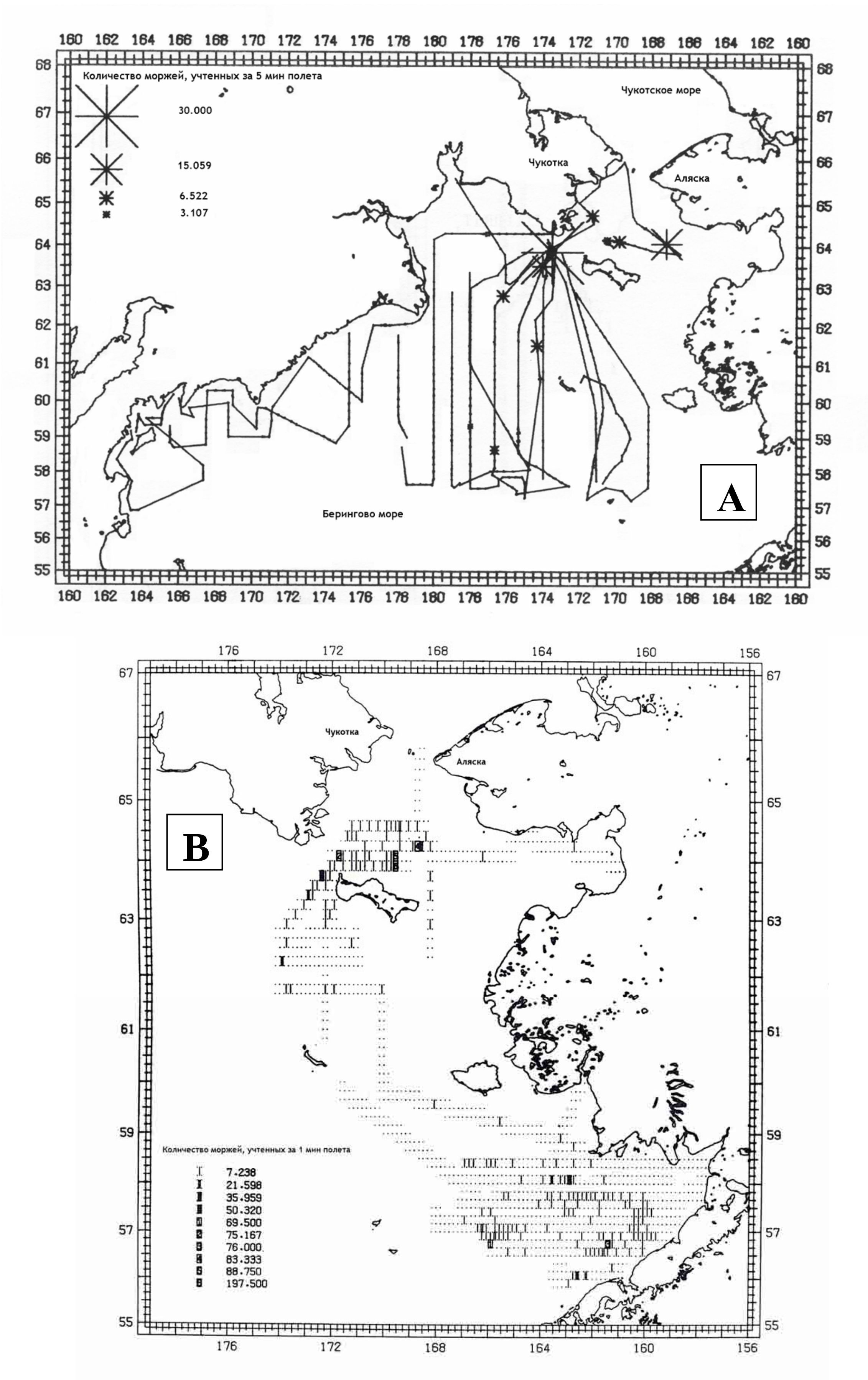
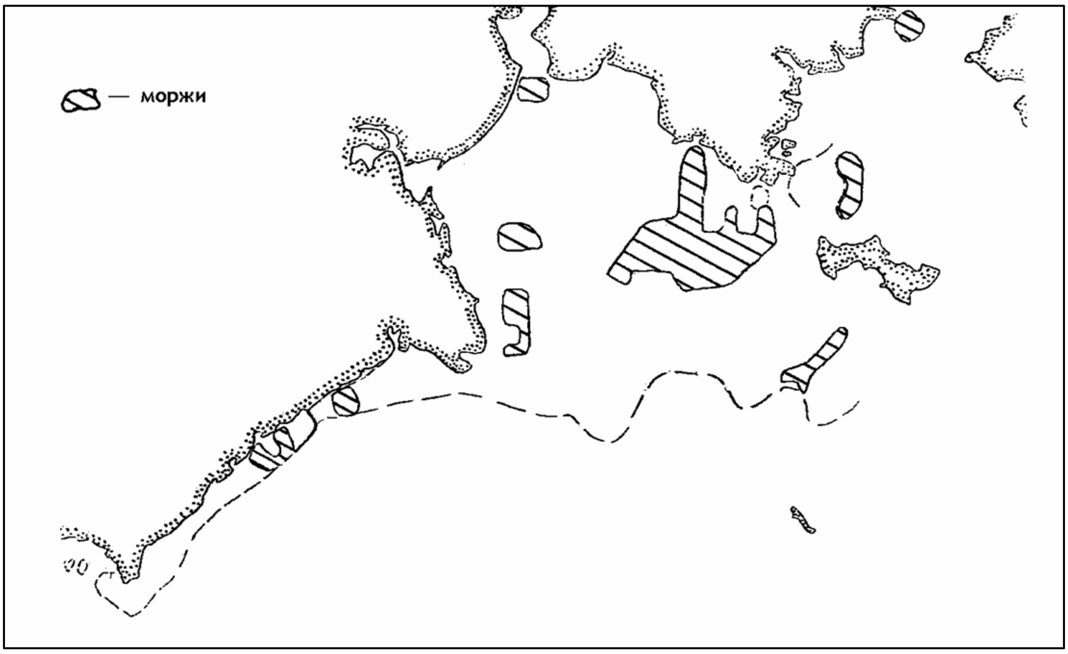


Fig. 3. Walrus density estimated on transects during aerial surveys in 1976 (According to: Braham et al., 1984):

A) TINRO (12-26 April). Walrus encounters (sightings) **marked as stars B) NMFS 6-23 April.**

Aerial surveys in 1979 and 1987 found that the number of walruses in the western part of the Bering Sea in spring increased. In April-May of 1979, walrus aggregations were along the Koryak coast in the area of Cape Navarin at the entrance to Kresta Bay and the largest concentration was located in the northeastern part of Anadyr Bay south of Cape Chaplin and Cape Bering (Fig.4). It was likely due to the lower ice coverage of the Bering Sea. (Федосеев, 1979).



Pic. 4. Distribution of walrus in the Bering Sea in April-May 1979 (according to: Fedoseev, 1979)

In 1987, a more detailed survey of walrus distribution in the western part of the Bering Sea during the period of March through May was conducted (Fig. 5). In March, walruses were distributed throughout the entire Anadyr Bay and in small numbers south of Cape Navarin along the Koryak coast. The total number of walruses inhabiting Anadyr Bay was estimated at 46-51,000 animals. The majority of those walruses were aggregated to northeast of Cape Navarin (Fig.6). In April, walruses were distributed more evenly and their numbers in the Russian waters were approximately 10,000 animals. At that same time, the eastern portion of a large aggregation of 22,000 animals extended into the Russian waters in the area of Cape Chaplino, south of St. Lawrence Island (Fig. 7a). In May, a general tendency of walruses moving northwards and eastwards was observed; nevertheless, close to 37,000 animals were counted in the Russian zone (mostly in Anadyr Bay)(Fig.7b).

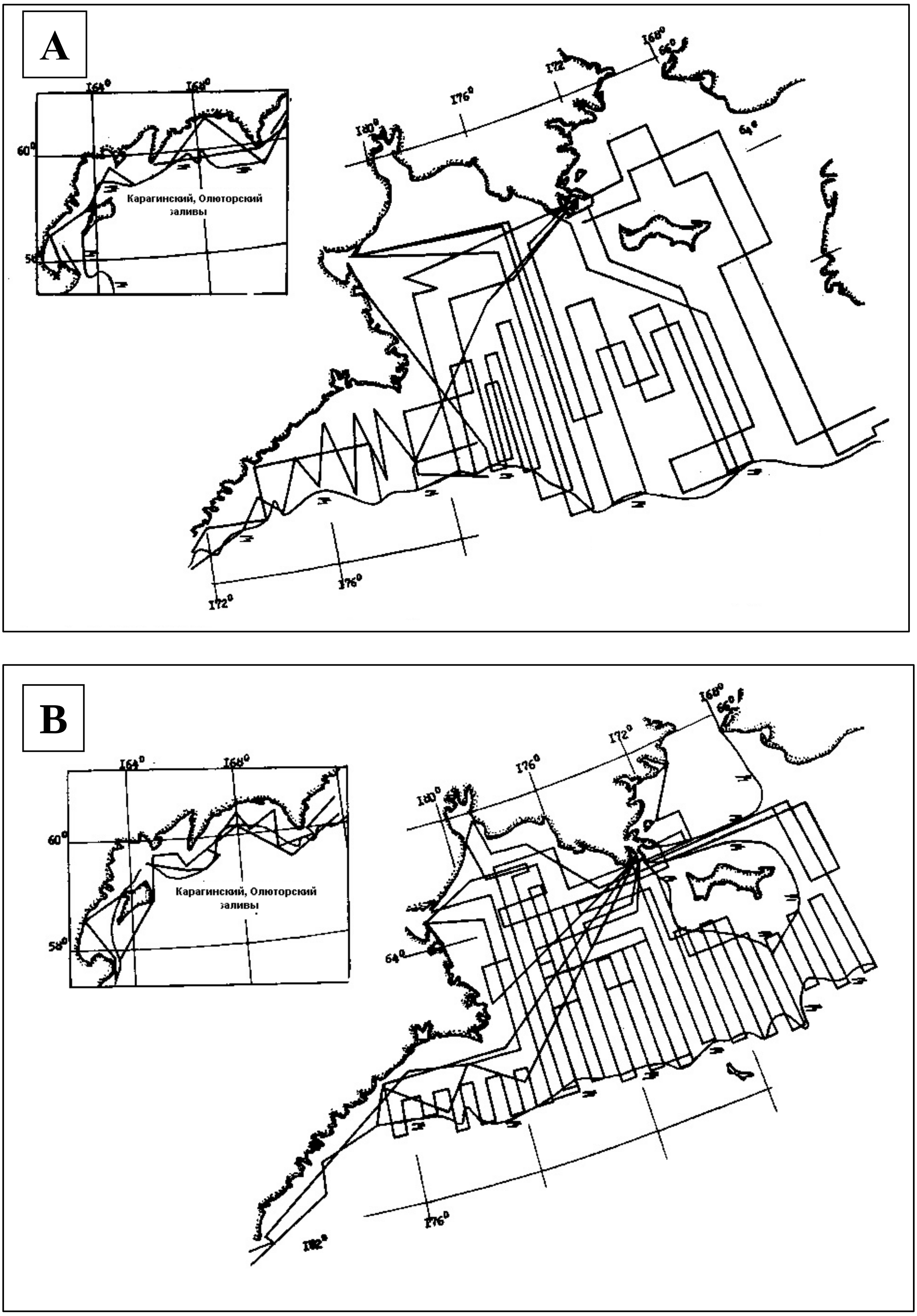


Fig. 5. Survey transect scheme in April (A) **and in May** (B**) 1987**
(according to Fedoseev et al.., 1988)

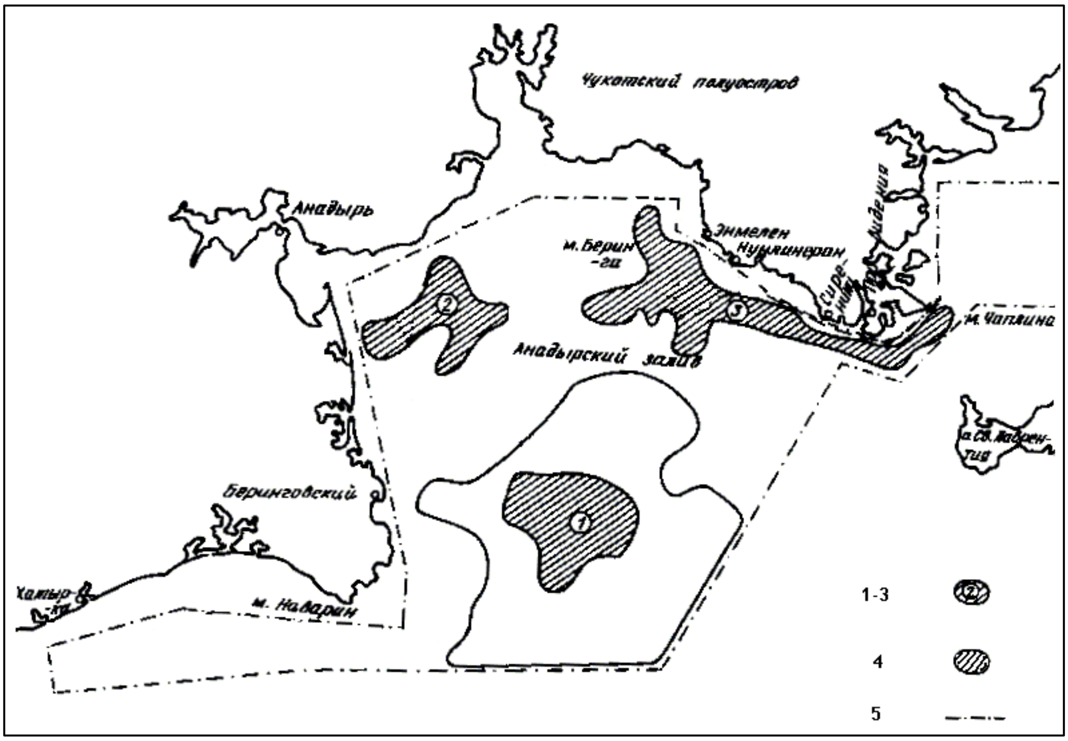


Fig. 6. Areas of walrus distribution on ice in March of 1987 (according to: Mymrin et al., 1990):

1 – central core and boundaries of the Anadyr reproductive group;
2 – walrus group in the Cape Geka area;
3 – walrus group in Syreniki polynia area;
4 – areas of winter distribution;
5 – boundaries of the surveyed zone (area)

Thus, during the period of population growth in 1970's and 1980's, the expansion of the winter-spring range of distribution of Pacific walrus took place mainly in the western part of the Bering Sea. It is likely that at the currently observed stage of population decline, numbers and range of distribution of Pacific walruses in the Russian waters may reduce again. In any case, the number of walruses in the western part of the Bering Sea in spring does not exceed 15-25% of the total population.

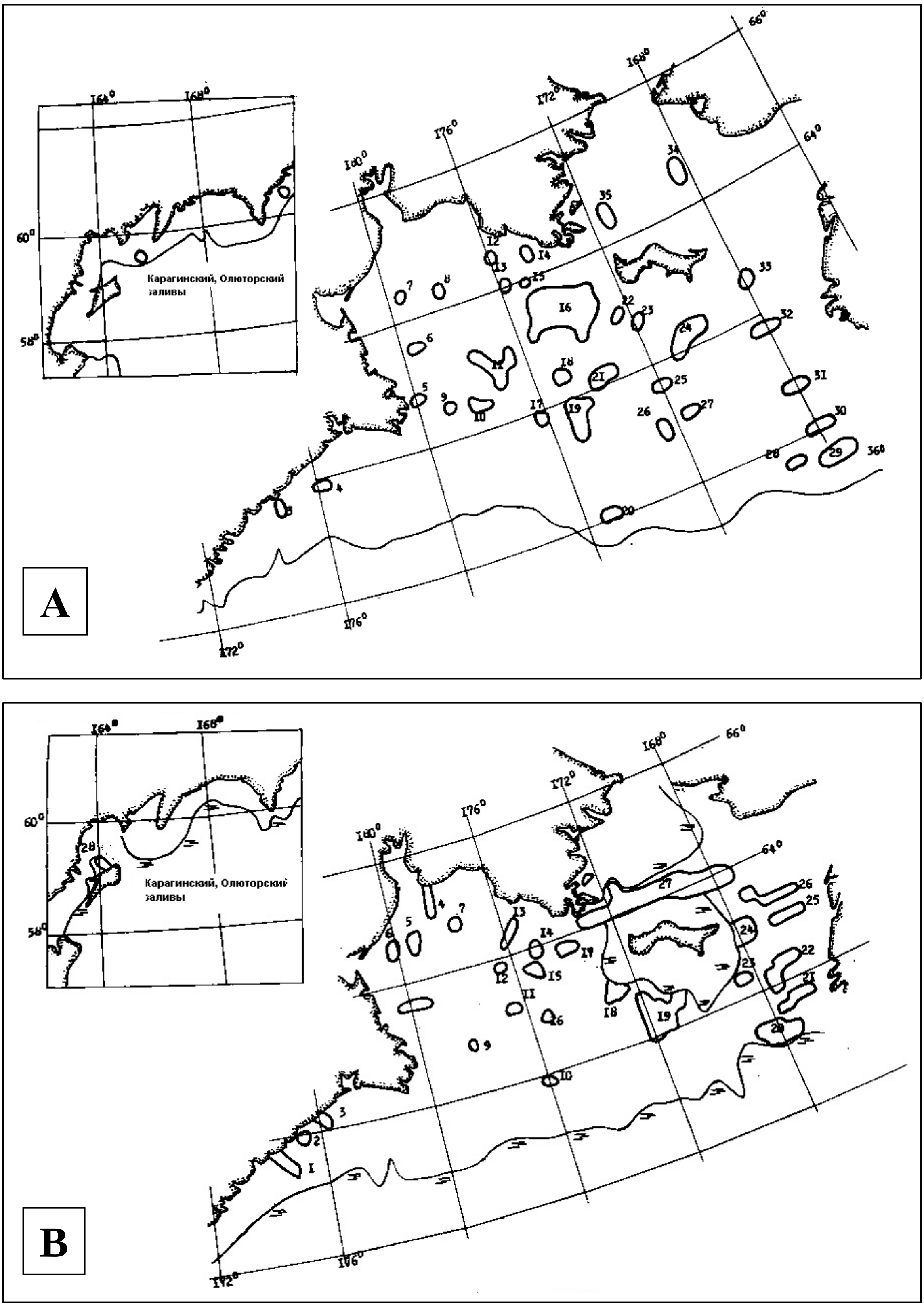


Fig. 7. Walrus distribution in April (A**) and May** (B) **of 1987**
(according to: Fedoseev et al., 1988)

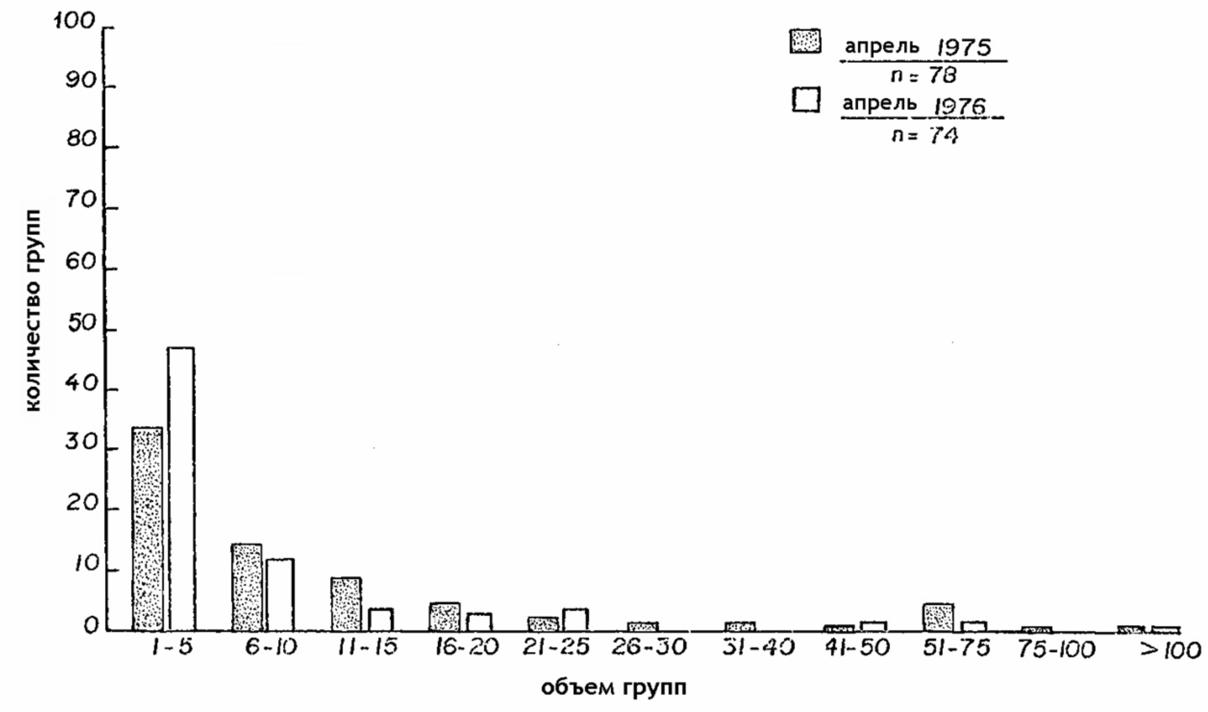


Fig. 8. Size composition of walrus groups on ice in April of 1975 and 1976. (According to: Wartzok, Ray, 1980)

SIZE COMPOSITION OF THE ICE HAULOUTS

In spring, the average size of haulouts tends to increase. In the first half of March, the number of haulouts counting one or two animals constitutes about 65.3% and only 46.9% in April. At the same time the number of groups counting more than 30 animals increases from 4.8% in March to 8% in April, and most of such haulouts are recorded beginning from mid April (Table 3). However, in general, smaller haulouts (less than 15 animals) prevail in April constituting about 60% of all the observed walrus groups (Fig.8).

Table 3

Seasonal dynamics of occurrence frequency of walrus ice haulouts of four size classes (according to: Fay, Kelly, 1989)

Place and year of observation	**Date of observation**	**Number of animals in a group**	**Group size**			
			1–2	**3–15**	**16–30**	**> 30**
Zvyagino, 81	25 Feb. – 15 Mar.	336	74.7	17.3	4.5	3.6
Aerial, 60	23 Feb. – 2 Mar.	512	51.8	42.2	2.7	3.3
Barton 1, 72	27 Feb. – 24 Mar.	72	69.4	20.8	4.2	5.5
Zakharovo, 85	17 – 30 Mar.	32	71.9	28.1	0.0	0.0
Aerial, 61	21 – 30 Mar.	410	52.0	31.5	4.9	11.7
Zagoryany, 76	17 Mar. – 18 Apr.	115	51.3	39.1	7.0	3.5
Glyatsir, 71	31 Mar. – 20 Apr.	88	61.4	35.2	2.3	1.1
Aerial, 72	11 – 16 Apr.	525	33.3	36.8	12.8	17.3
Aerial, 68	16 –23 Apr.	515	41.6	39.4	8.7	10.3
Polar Star, 80	17 –21 May	113	34.5	41.6	13.3	10.6
Polar Star, 80	5 –16 June	52	30.8	59.6	5.8	3.8

SEX-AGE COMPOSITION OF HAULOUTS

The walrus breeding season is over in March-April and then the calving season begins, therefore mixed reproduction groups consisting mostly of females and subadults prevail in central and eastern parts of the Bering Sea. Males are represented by large adult animals-breeders in such groups. Subadults and old males form separate haulouts on the periphery of the reproduction groups (Table 4).

Springtime sex-age composition of walrus haulouts in the western part of the Bering Sea is less studied in the western part of the Bering Sea. Walruses occurring in March-April in the waters adjacent to the Koryak coast are almost exclusively adult males 20±6 years old (Садовов, 1986; Кибальчич, 1988). It is assumed to be a group of non-breeding (bachelor) males (Кибальчич, 1988), although, it is also possible that males observed in Koryak coastal area already participated in a rut in January-February. Females were also observed in this are during spring survey of 1979 (Федосеев, 1979).

It is likely that a reproductive group consisting mostly of females and young animals remains in Anadyr Bay. (Мымрин и др., 1990).

Table 4.

Sex-age composition of walrus aggregations on Bering Sea ice in March-April of 1971-1976 (according to: Fay et al., 1984б)

Region	Period	Number of animals	Immature animals of both sexes	Subad + ad	
				Males	Females
North-Center	March	907	251	90	566
North-Center	Early April	332	131	13	188
North-Center	Mid April	1171	459	40	672
East-Center	Mid April	255	4	240	8
East-Center	March-April	73	11	54	8
South-East	Mid April	621	237	38	346

SEASONAL DYNAMICS

There are no data on seasonal dynamics of walrus on ice during spring, except for the knowledge that the number of animals on ice varies significantly throughout the season. There is a lot more information accumulated on seasonal dynamics of walrus as a result of many years of surveys of coastal haulouts in summer and autumn. Those data shows that regular increases and declines of numbers are characteristic of walrus on shore. In 1983-99, peak numbers on male, female, and mixed haulouts on average occurred every 5.8 days (range 4.25-8) (Table. 5) regardless of weather conditions. Intervals between peak numbers on male haulouts in Bristol Bay were 6 to 10 days (Hills, 1992).

Table 5.

Data on walrus abundance dynamics in the coastal haulouts of the Bering Sea during summer-fall periods of 1983-1999.

Haulout	Year	Composition	Number of abundance peaks	Average interval, days	Source
Arakamchechen	1983	males	12	5.77	Mymrin et al., 1988
Arakamchechen	1984	males		5.75	Mymrin et al ., 1988
Arakamchechen	1985	males	9	5.70	Mymrin et al., 1988
Retkyn	1984	mixed		5.10	Mymrin et al., 1988
Retkyn	1985	mixed	7	6.00	Mymrin et al., 1988
Retkyn	1992	mixed	8	4.7	Unpublished data ChOIP? (ЧОИР)
Retkyn	1999	mixed	3	5.5	Kochnev, unpublished data.
Meechkyn	1985	mixed	10	6.10	Mymrin et al., 1988
Meechkyn	1987	mixed	5	4.25	Unpublished data of “Okhotskrybvod”
Meechkyn	1989	mixed	4	4.67	Unpublished data of “Okhotskrybvod”
Meechkyn	1996	mixed	4	6.33	Unpublished data of ChukotTINRO
Meechkyn	1997	mixed	3	6.5	Unpublished data of ChukotTINRO
Russkaya Koshka	1985	males	4	7.6	Mymrin et al., 1988
Galinvilan	1987	males	3	5.5	Semyonov et al., 1988
Verkhoturova	1987	males	2	8.00	Semyonov et al., 1988
Verkhoturova	1990	males	11	5.27	Chugunkov, 1991

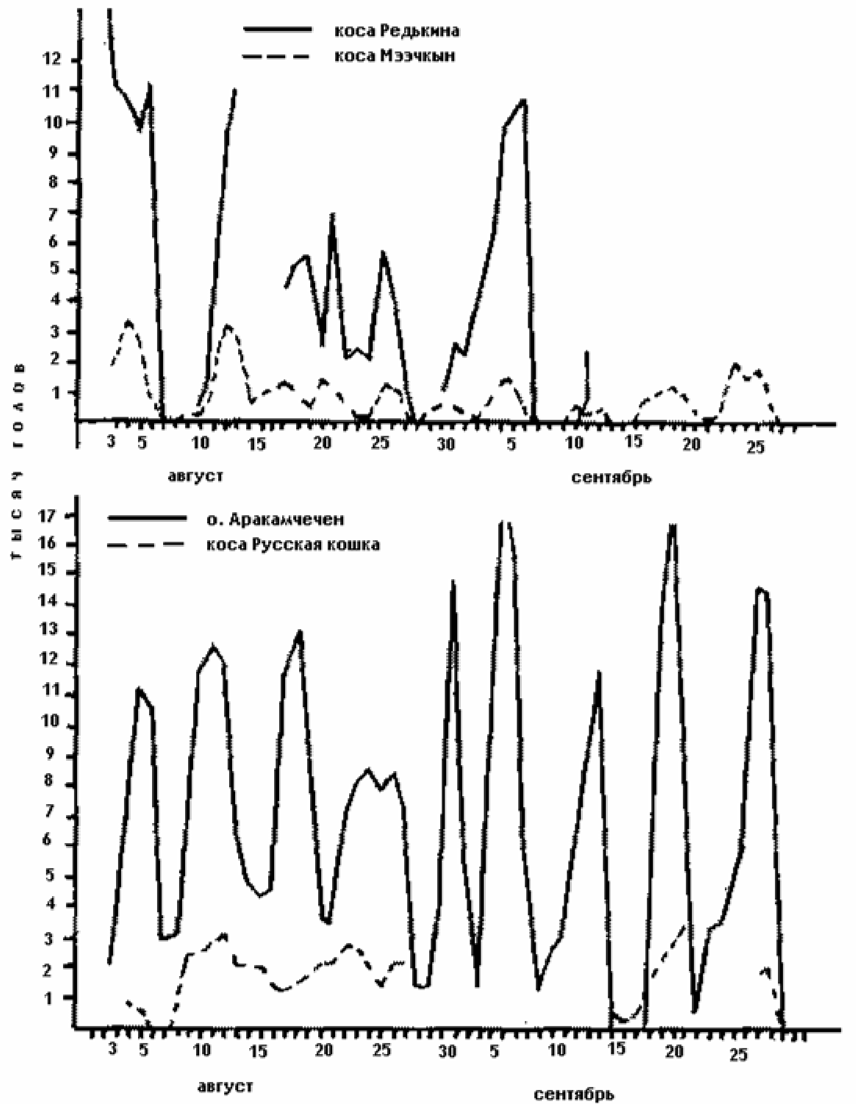


Fig. 9. Dynamics of walrus abundance in Bering Sea haulouts in August-September 1985. (according to Mymrin et al., 1988)

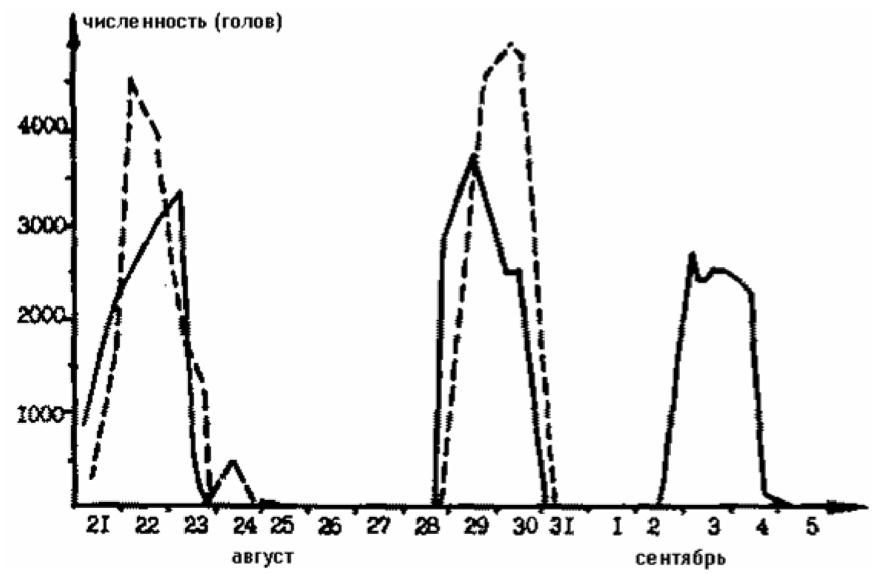


Fig. 10. Dynamics of walrus abundance in Cape Galinvilan (solid line) and Verkhoturov I. (dashed line) haulouts during 21 August-4 September 1987. Distance between haulouts – 80 km (according to: Semyonov et al.., 1988)

Abrupt fluctuations of walrus numbers on shore and their relatively consistent periodicity most likely can be explained by walrus leaving for feeding (Семенов и др., 1988) and by weather conditions (Кибальчич, 1988), although some scientists do not find correlation between weather changes and dynamics of walrus numbers (Чугунков, Калиниченко, 1996).

Many authors point out that fluctuations of walrus numbers are somewhat synchronized, even between haulouts that are located a long distance apart (Fig. 9-10). However, D.I. Chugunkov and E.N. Kalinichenko (1996) did not observe synchronicity when studying dynamics of walrus numbers on walrus haulouts of Kamchatka and Koryak coasts. Dynamics of walrus numbers on haulouts that form in the Chukchi Sea during the period of autumn migrations depend totally on weather conditions and disturbance factors (Кочнев, 1991, 1999), therefore the data indicating rhythmic processes can be extrapolated (with substantial reservations) to spring period only based on the results of summer observation on permanent Bering Sea haulouts.

IMPACT OF WEATHER CONDITIONS

There are no data on how walruses react to weather changes on spring haulouts. Observations of walrus behavior on the coastal haulout of Baturst Island showed that walrus numbers dynamics on shore depended to a high degree on air temperatures, precipitation, and wind speed and duration (Table 5-6). Walruses abruptly moved into water after prolonged strong winds, the numbers of walruses on shore decreased more gradually when temperatures dropped, the number of walruses on shore remained the same or decreased under drizzling rain, and if snow fell the numbers decreased (Salter, 1979). Captive walrus avoided strong winds (even in sunny weather) and haul out on solid surface when precipitation was less than 0.5 mm/hour (Fay, Ray, 1968).

A.A. Kibal’chich (1988) found that on Arakamchechen Island in 1977, there was correlation between walrus behavior on the island haulout and wind speed and abrupt changes in atmospheric pressure (Fig. 11). If atmospheric pressure dropped and wind increased, walrus as a rule abandoned the haulout. The reaction to pressure decrease must have developed in association with unfavorable conditions that follow that decrease: wind strengthening, increase of wave splashing on haulout, decrease of temperature, and increase precipitation. A.A. Kibal’chich also suggests that walruses are forced to go into water because the conditions of sound transmission deteriorate with the increasing surf noise.

Table 5.

Fluctuations of weather conditions, under which the number of walrus on shore decreased, increased or remained stable (according to: Salter, 1979)

6-hour trends in walrus numbers						
	Decrease (n = 22)		Stability (n = 25)		Increase (n = 27)	
Weather changes	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Wind, km/hour	0	32	0	29	0	35
Air temperature, °C*	0.5	8.5	0.0	10.0	1.0	14.0
Humidity, %	63	90	64	90	68	90
Atmospheric pressure, mbar	989	993	980	998	986	995
Cloud cover, points	0	11*	0	11*	0	10
Precipitation	No	Snow	No	Rain	No	No

- Temperature varied from +1 to + 15° during the haulout period (season)
- 100 pa = 1 mbar
- 11 – fog

Table 6.

Variation of walrus abundance on shore (during 6 hour periods) with time, and depending on weather conditions (according to: Salter, 1979)

Variable	Correlation coefficient (n=74)	Step	Step-by-step regression analysis		
			Determination coefficient values R^2 [1]	Accumulated values of R^2	Importance at the 4 step [2]
Data [3]	- 0.02	1	0.0005	0.0005	ns
Data [3]	- 0.01	2	0.0060	0.0055	ns
Precipitation	- 0.29 [4]	3	0.0918	0.0857	p<0.05
Temperature trend	0.25 [4]	4	0.1418	0.0501	p<0.05
Wind speed	0.18	5	0.1732	0.0314	-
Temperature	0.15	6	0.1819	0.0087	-
Cloud cover	- 0.11	7	0.1849	0.0029	-
Wind direction	- 0.03	8	0.1858	0.0009	-
Time	- 0.08	9	0.1862	0.0004	-
Humidity	- 0.07	10	0.1864	0.0002	-

1 - R^2 – value of explained variance
2 – Variable in lines 5 and 10 are not reliable predictors ($p<0.05$); ns – the result is not significant
3 – Variables included in the analysis; other variables introduced in order of decreasing of their significance
4 – values of bilateral (two-sided) criteria $p < 0.05$, but > 0.01

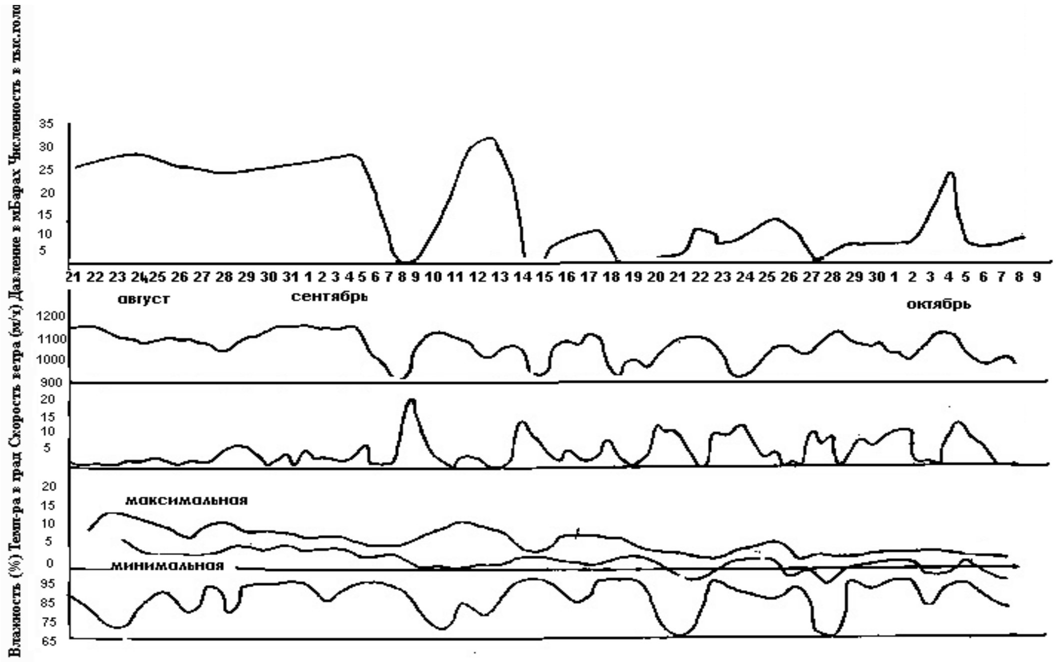


Fig. 11. Correlation between walrus abundance at the Arakamchechen haulout and atmospheric pressure, wind speed, air temperature and humidity
(According to: Kibal'chich, 1988).

More recent observations on the haulouts of Kamchatka and Koryak coast did not confirm any correlation between walrus numbers on shore and changes in weather conditions (Чугунков, Калиниченко, 1996). Establishing correlations between walrus numbers on haulouts and meteorological conditions requires accumulation of large volumes of data on haulouts with different haul out conditions and different sex-age composition during all the seasons and subsequently, appropriate statistical processing of those data.

DIURNAL DYNAMICS

Walrus departure from solid substrate (ice or shore) is determined primarily by their need to forage. Available data leads to that conclusion, and there is no expressed diurnal rhythm in walrus foraging. F. Fay and C. Ray (Fay, Ray, 1968) observed peaks of activity in the water in captive walruses primarily in early mornings and late evenings. During the period of March through June in the area of St. Lawrence Island, F. Fay (Fay, 1982) recorded walrus in the water most frequently in early mornings and late at night; at those same hours, collected walruses usually had full stomachs. However, after analyzing the ratio of walrus encounters in water and on ice during both boat and aerial surveys, Fay had to acknowledge the absence of diurnal rhythmic pattern in walrus foraging behavior (Fig. 12).

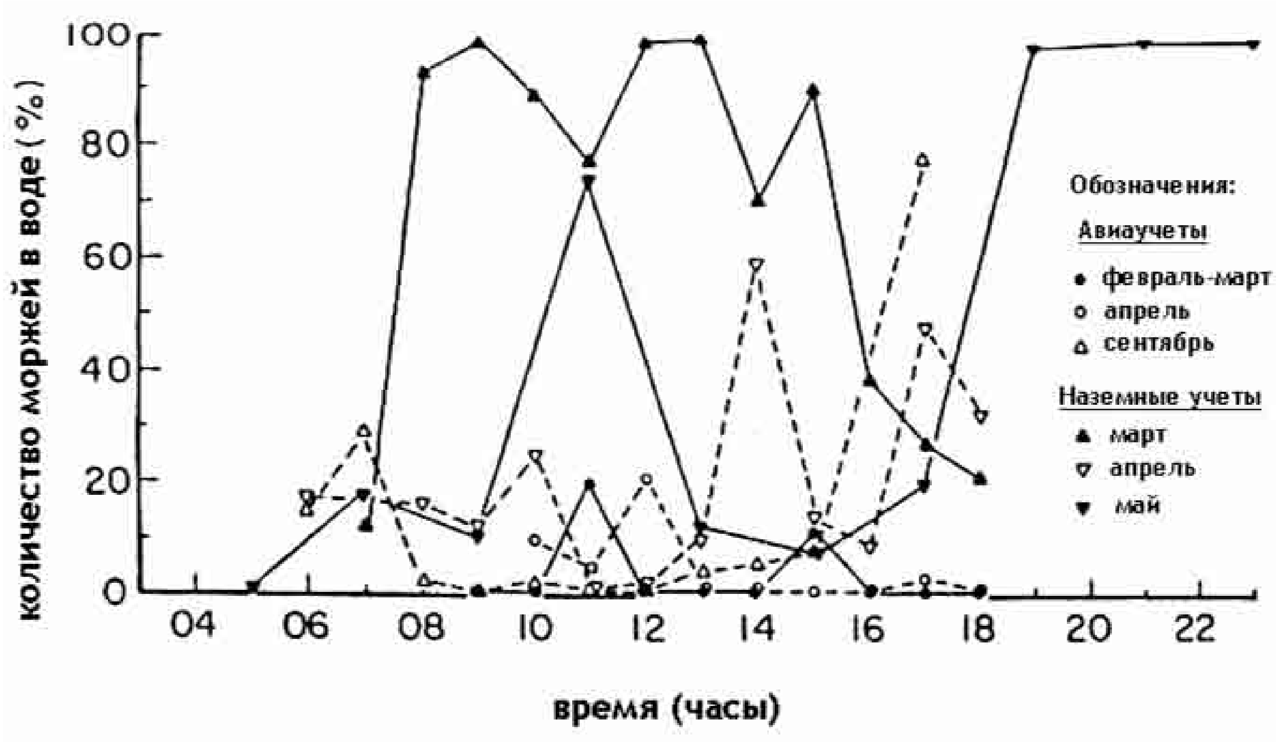


Fig. 13. Frequency (%) of walrus occurrence in the water (versus animals sighted on ice). Data obtained in the course of aerial and ground surveys in the Bering Sea (February-May) and aerial survey in the Chukchi Sea (September). Group sizes: aerial surveys in February-May – 14814, in April – 23550, in September – 11094 individuals; ground-based surveys in March – 2718, April – 3478, May – 2721 individuals (according to: Fay, 1982).

Walrus counts on the coastal haulout on Arakamchechen Island in July-August 1985 conducted twice a day (in the morning and in the evening) showed that the number of walruses on shore was larger (64% of cases) than in the morning (36%) (Мымрин и др., 1988). Atlantic walrus on Baturst Island did not have any diurnal rhythmic activity, although there was a general tendency of walrus coming ashore during the day (6:00 to 18:00) and leaving the shore late at night (Salter, 1979).

Table 7

Walrus on ice surface and time of the day in July 1977 (according to: Wartzok, Ray, 1980)

Time intervals	**Number of observations of haulouts with the number of walrus exceeding 50 during the time interval**
0000-0300	5
0300-0600	5
0600-0900	5
0900-1200	6
1200-1500	6
1500-1800	7
1800-2100	7
2100-0000	6

During July 1977 observations in the Chukchi Sea, the maximum number of haulouts counting 50 and more walruses was detected between 15:00 and 21:00; however, the differences were not statistically confirmed (Table 7). Distinct diurnal rhythmic behavior also was not found on male haulouts in Kamchatka and along the Koryak coast (Чугунков, 1991; Чугунков, Калиниченко, 1996; Fig. 14).

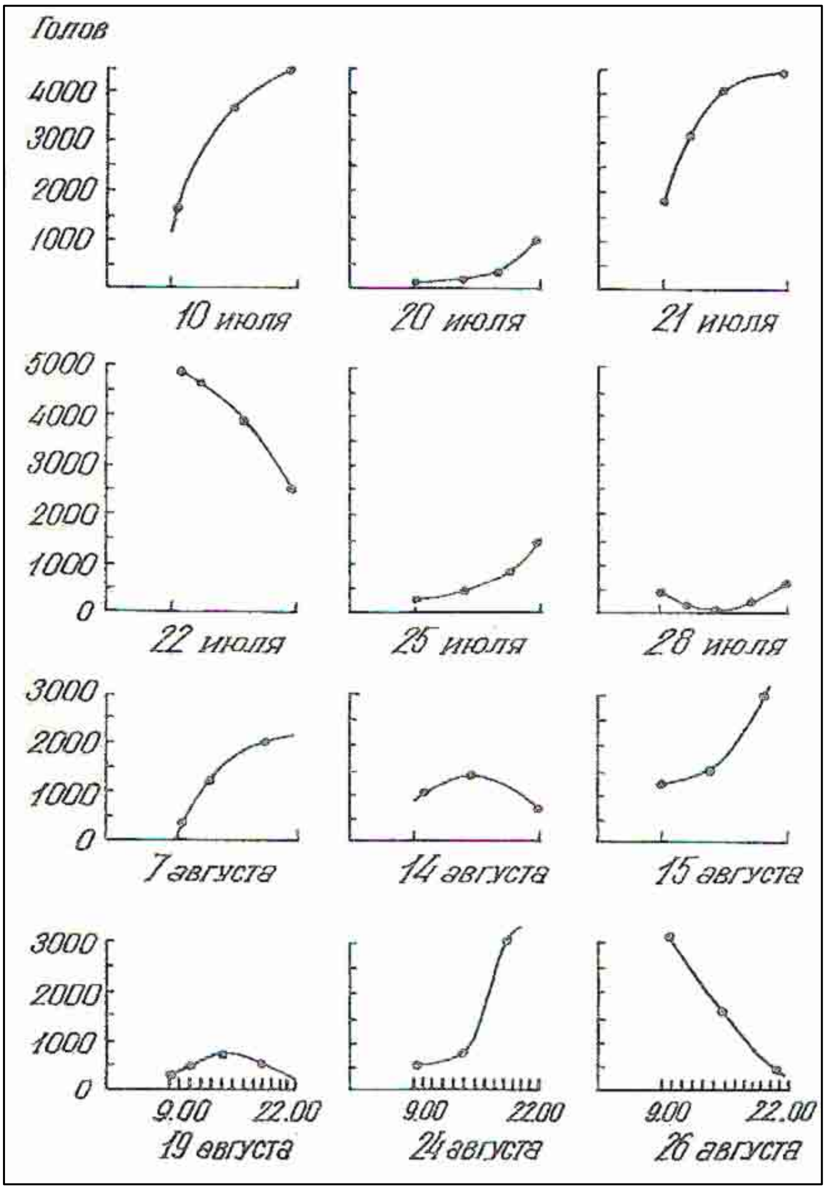


Fig. 14. Dynamics of walrus abundance during the light time of day (9:00 to 22:00) on Verkhoturov Island in summer of the 1990 (according to: Chugunkov, 1991).

CONCLUSION

In conclusion of the present overview, we have to admit that current knowledge of distribution and population dynamics of Pacific walrus as well as the factors that influence distribution and numbers are scant and fragmentary. Nevertheless, based on the understanding of biology and behavior of Pacific walrus presented above, we can make the following recommendations for conducting instrumental aerial surveys and satellite tagging:

Recommendation on conducting aerial survey.

Taking into consideration that the survey must be conducted in spring, the best time would be the first half of April, when no significant changes in walrus distribution compared to winter distribution take place and the majority of animals remain in the areas of breeding forming relatively dense aggregations. In the Russian part of the Bering Sea during that period of time, the stable aggregations of walrus that form every year in certain areas, have not yet formed and animals are scattered in small groups throughout the entire Bering Sea. For that reason, the network of survey transects should be relatively dense, and evenly cover the entire ice-covered water area from Karaginskiy Bay through Bering Strait, and also 20-40 km-wide clear water zone adjacent to the ice edge not to miss the groups moving by water (relocating by water). The survey must be conducted more than once, since there is a risk to survey during the time when the majority of walrus is in the water. Taking in consideration that the number of walruses on substrate surface (on ice) reaches maximum every 40-10 days, second survey should be conducted within next ten days. The best meteorological conditions for conducting a survey include the absence of fog; absence of low cloud ceiling; temperature at the sea surface is close or higher than mean temperature for that season (-4-10°C); wind speed does not exceed 3-5 m/sec; and atmospheric pressure is below 1008 Mbar. Ideally, surveys should be conducted on calm days after prolonged storm wind, when the maximum number of animals hauls out on the surface of substrate (on ice).

Recommendations for conducting satellite tagging.

Considering that only 25% of Pacific walrus population inhabits Russian waters of the Bering Sea in spring, and organizational and financial difficulties of entering Russian EEZ by a foreign vessel are extreme, we recommend conducting walrus tagging in the vicinity of St. Lawrence Island. Habitat conditions of walruses in that area are similar to those of Anadyr Bay and data on walrus in the water or hauled out on the surface of substrate (ice) could be used for correction of aerial survey data both in American zone and in Russian waters. The situation is different along the Koryak coast. Meteorological and hydrological (oceanographic) conditions there are very different from those in the American zone and in Anadyr Bay, and therefore it may be necessary to tag several walruses in the territorial waters of Russia (in Russian waters). There is no need to bring an ice-breaker to accomplish walrus tagging in the Koryak coast area; we can try to conduct the tagging using an ordinary fishing vessel.

However, in order to collect data on walrus relocations/redistribution and activity throughout the year, we consider it important to expand the tagging program beyond only calculating correction coefficients. It is necessary to conduct tagging of as many animals as possible throughout the year in different parts of their range including Kamchatka waters, Anadyr Bay, Chukchi and East-Siberian Sea.

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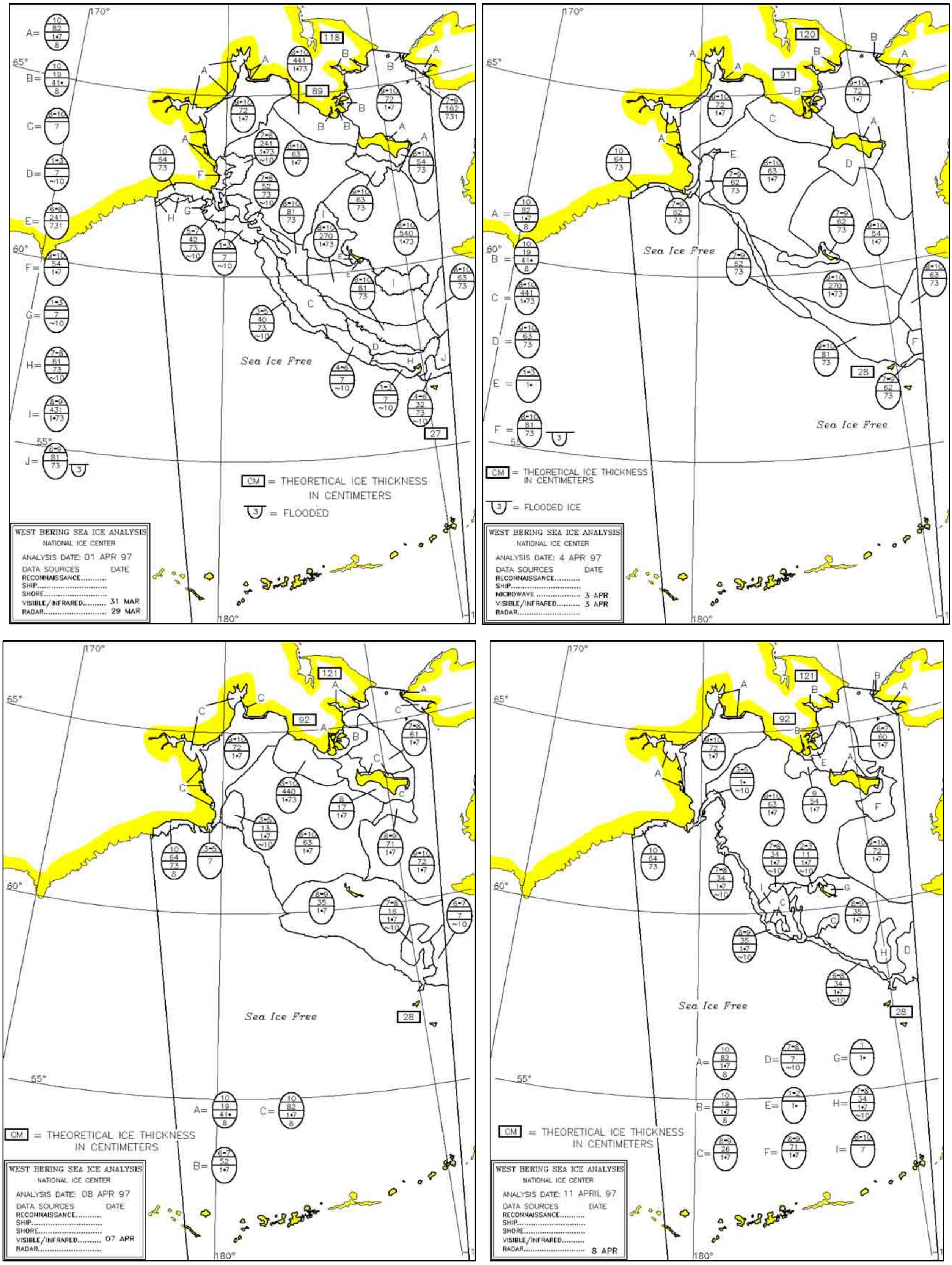
APPENDIX

Ice conditions in the western part of the Bering Sea in the first half of April (U.S. National Ice Center)



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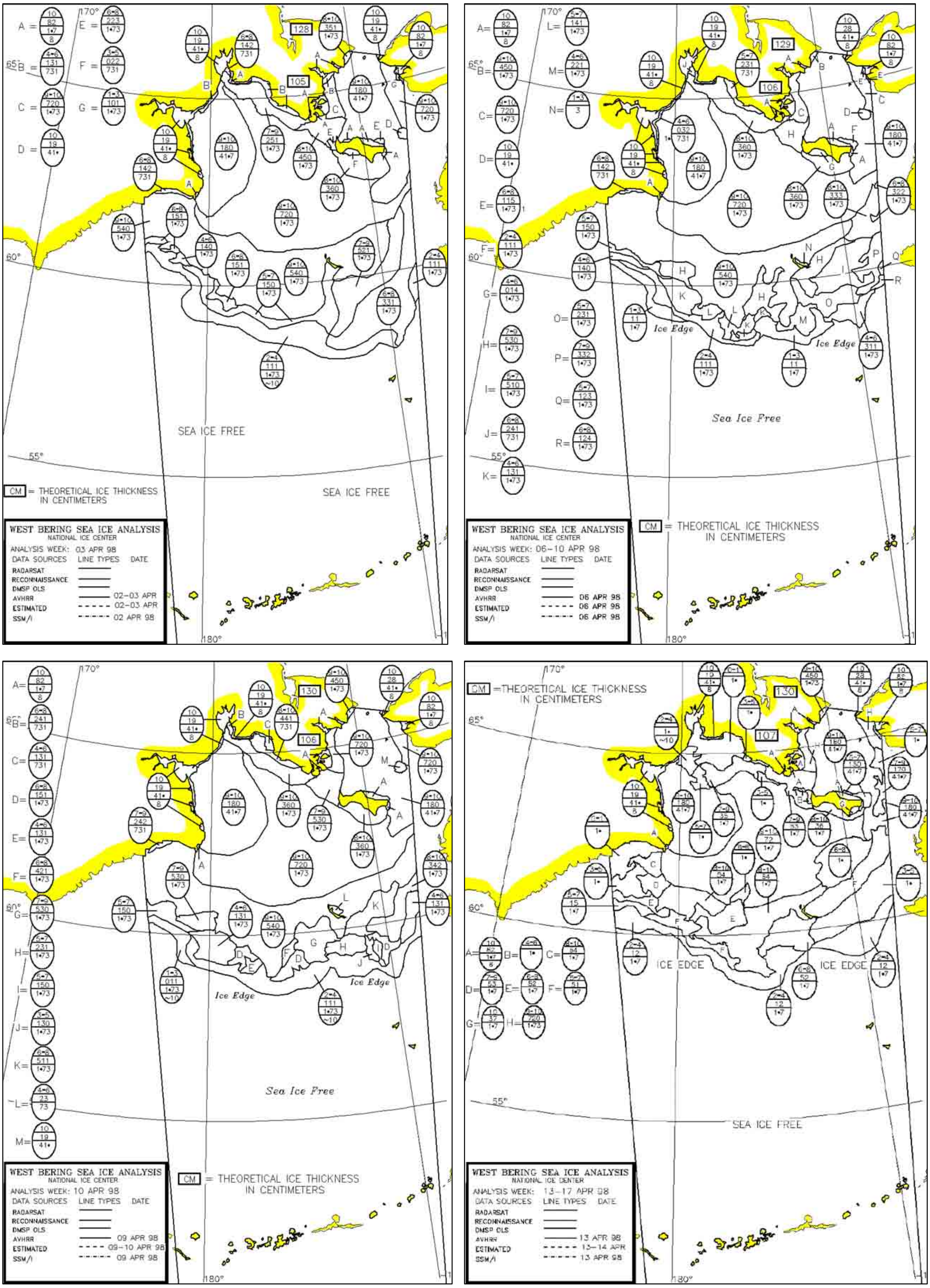

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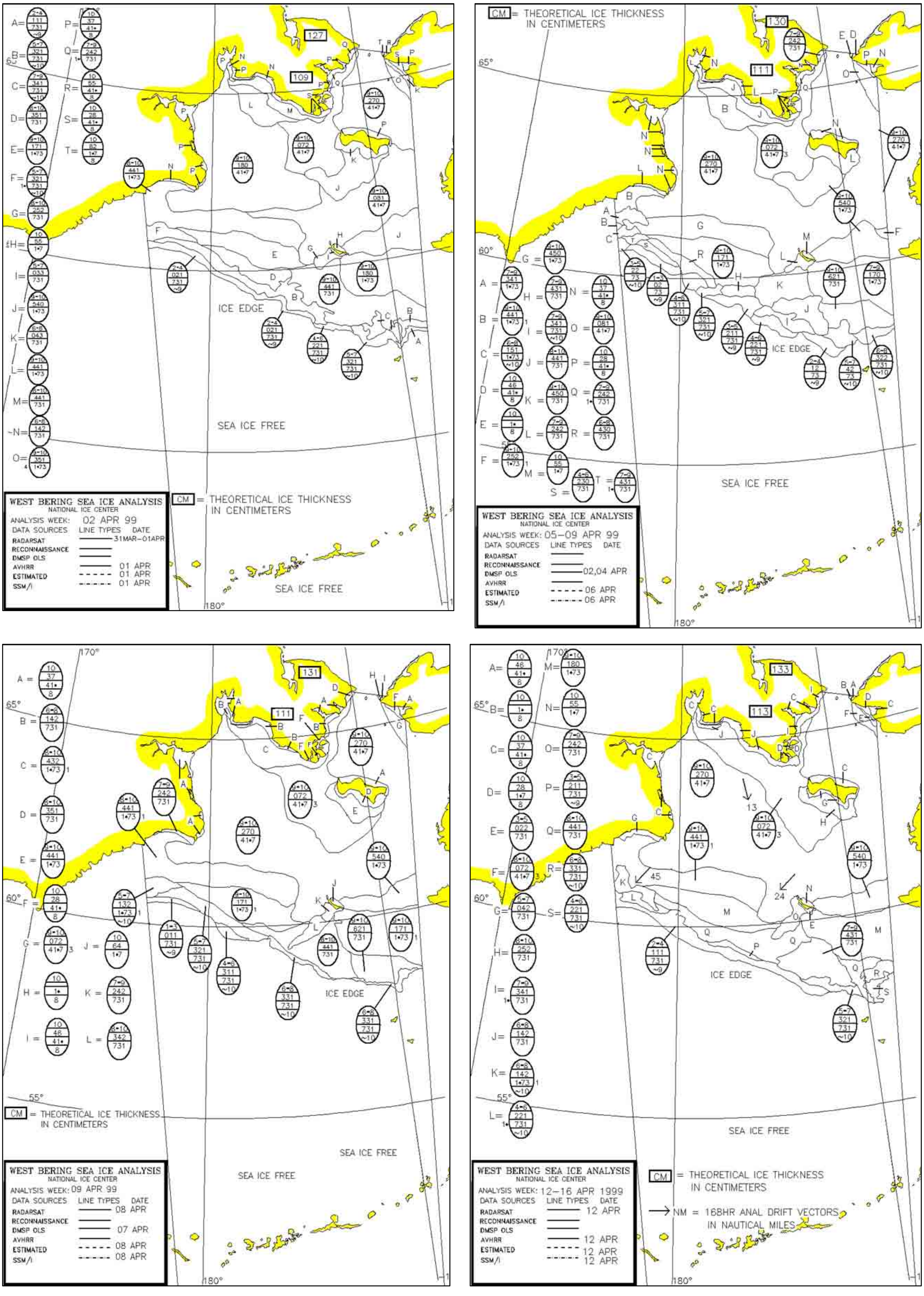
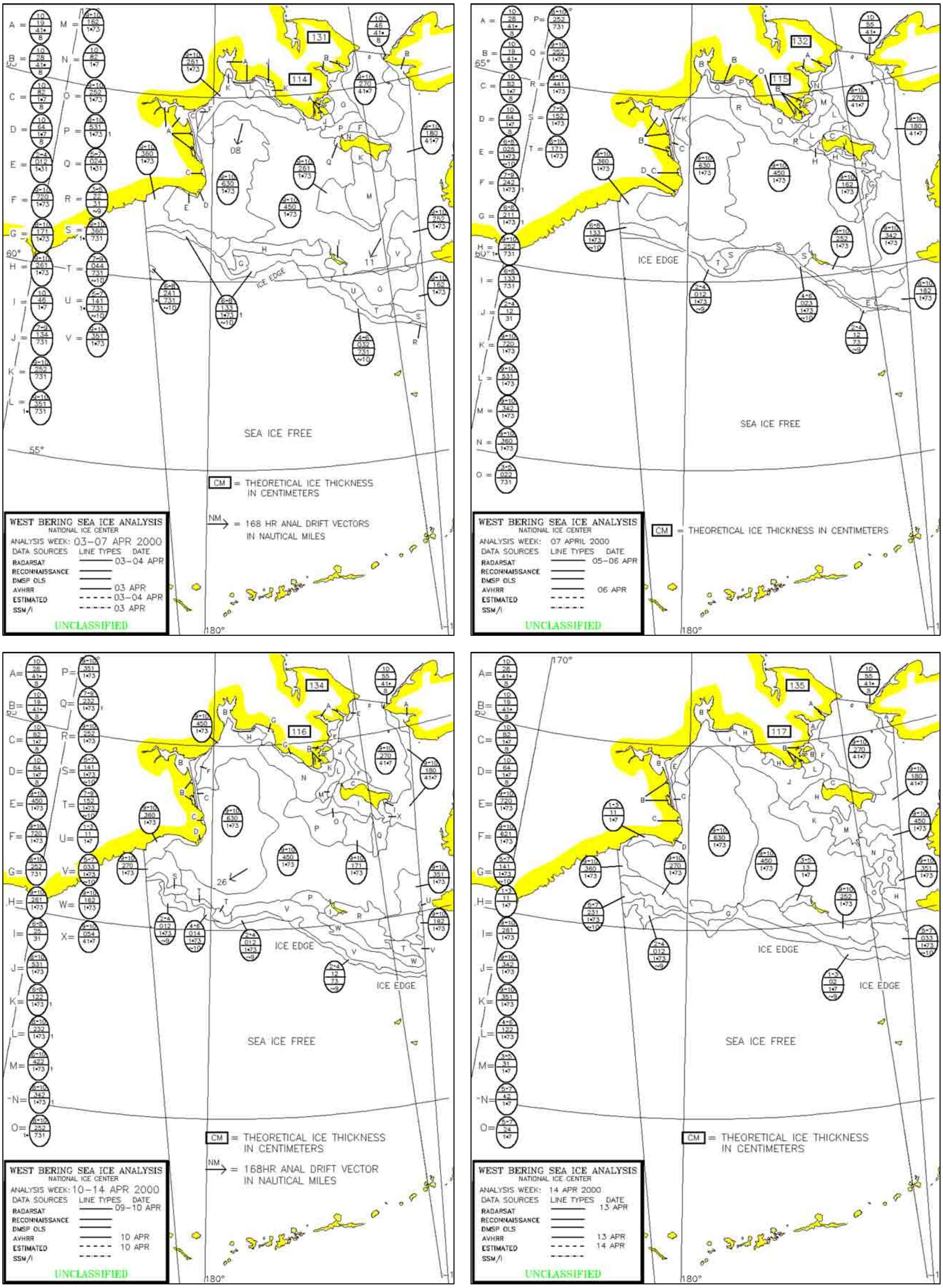
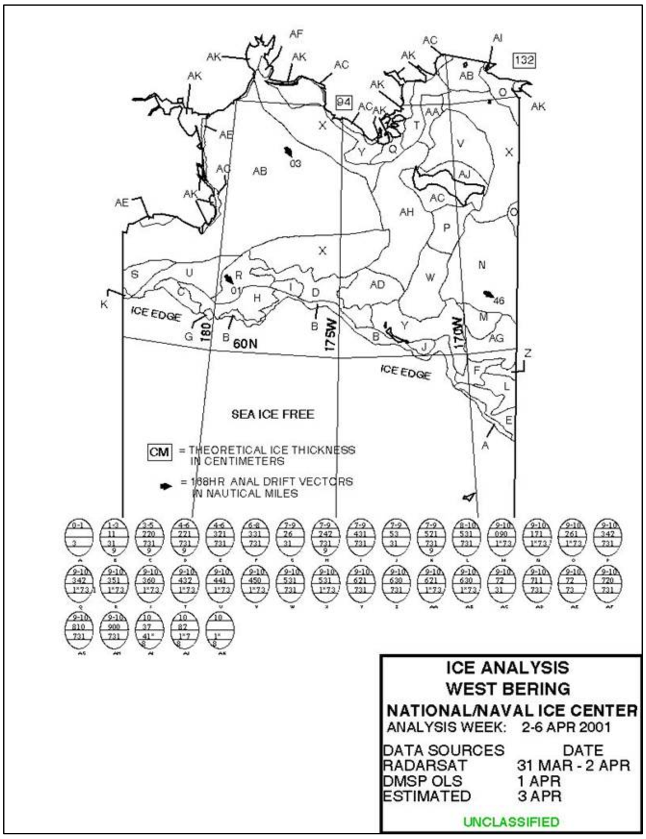
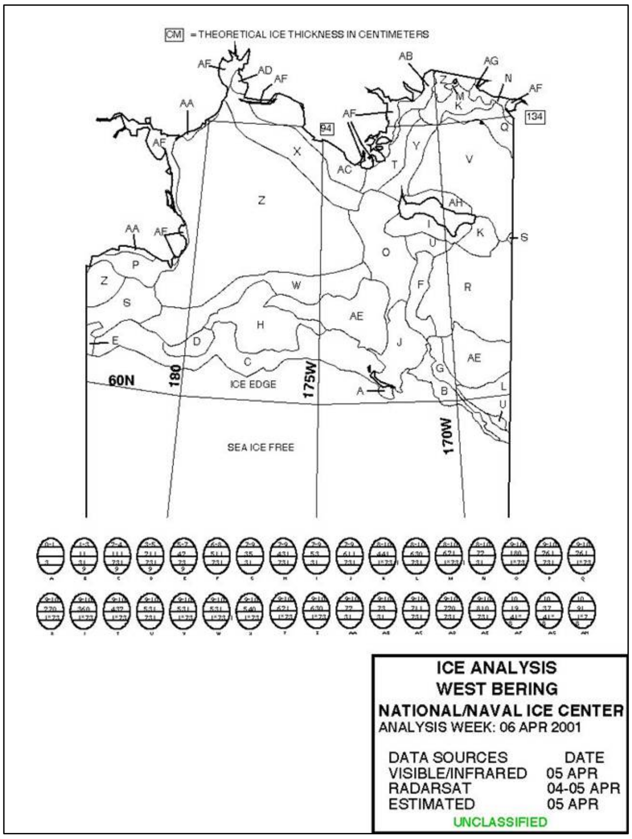


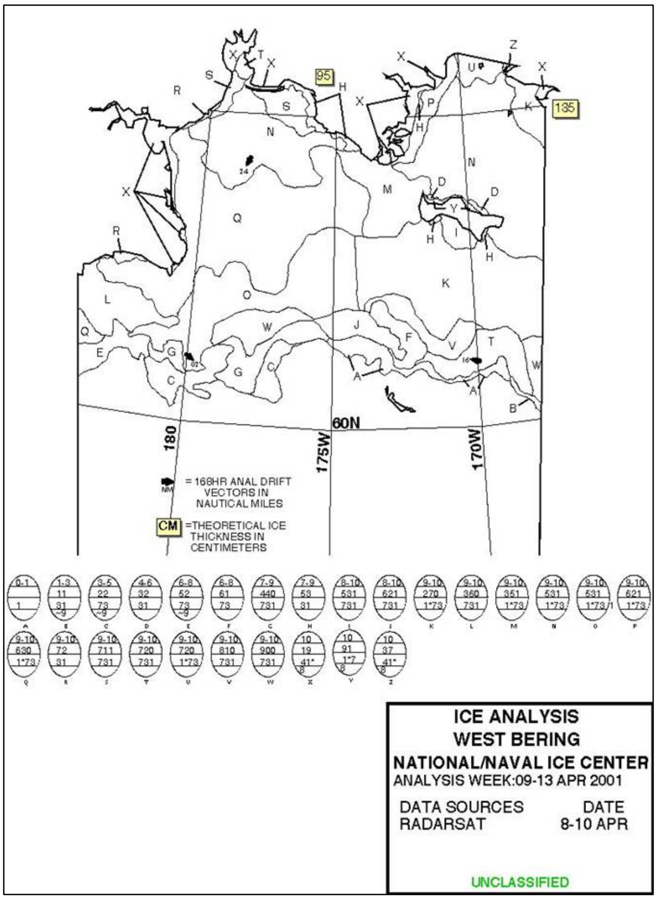
C. 2-12 April 1999.

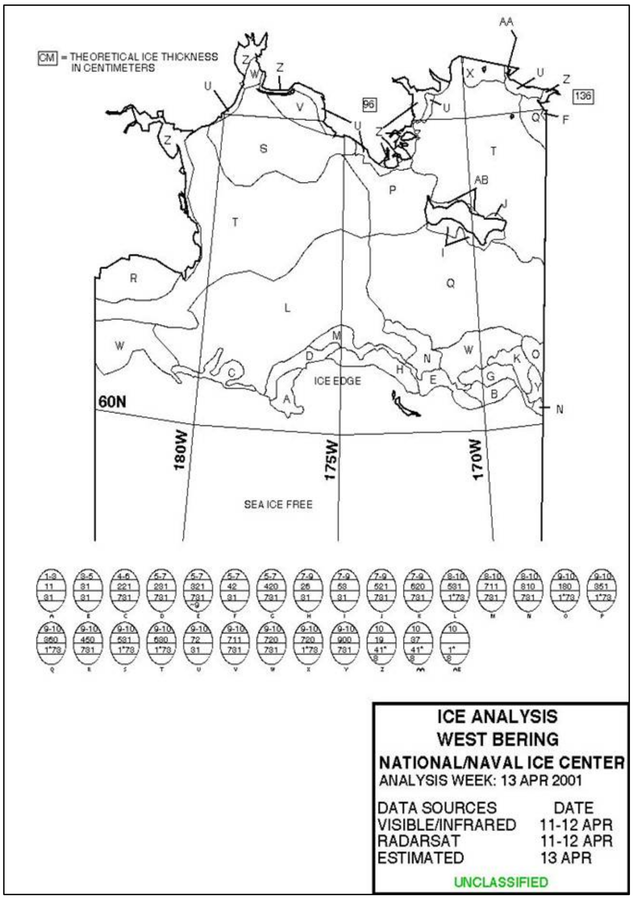


D. 3-14 April 2000.

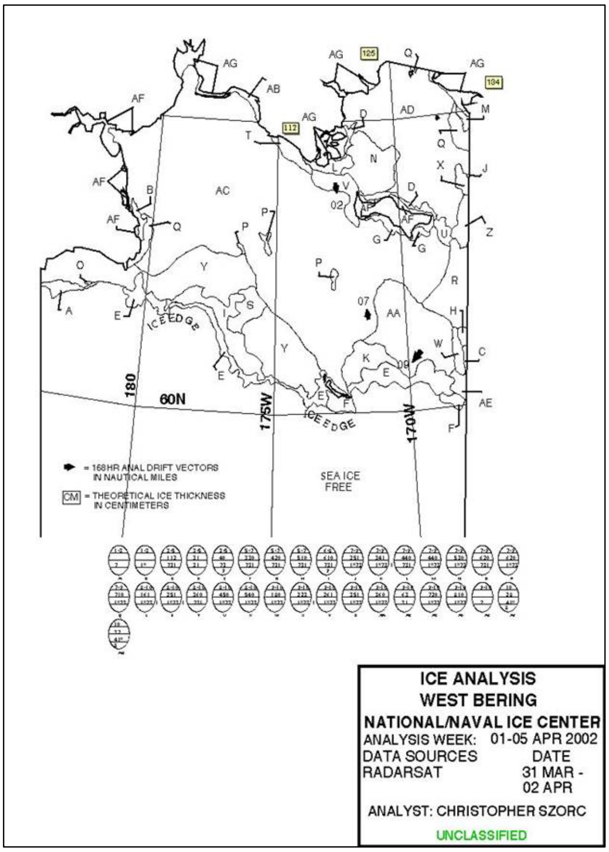


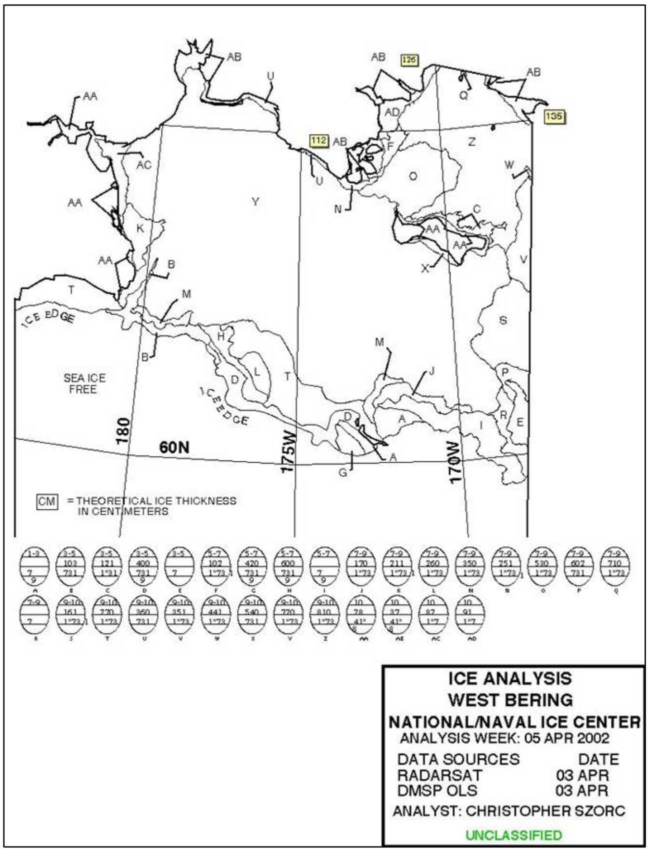


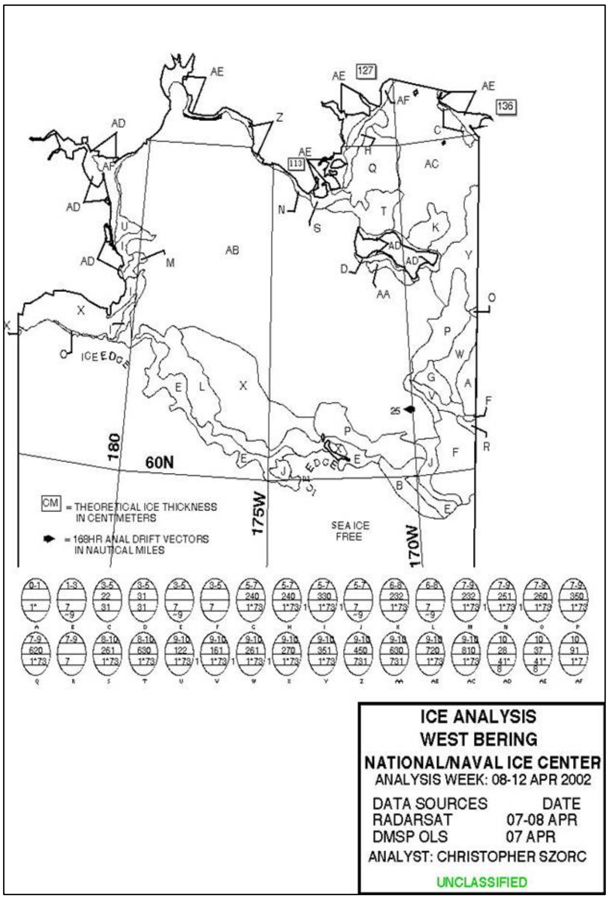


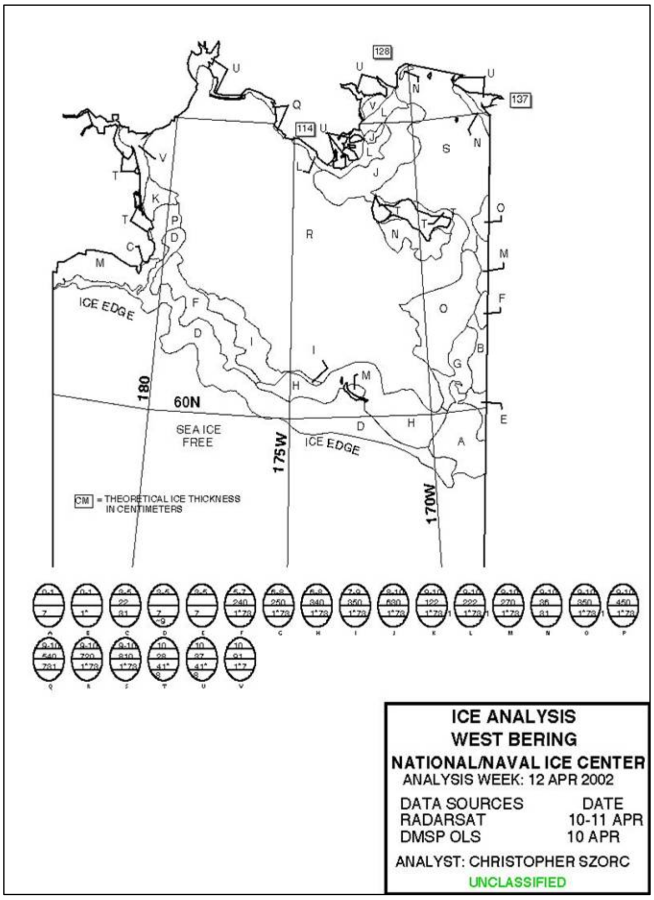


E. 3-13 April 2001

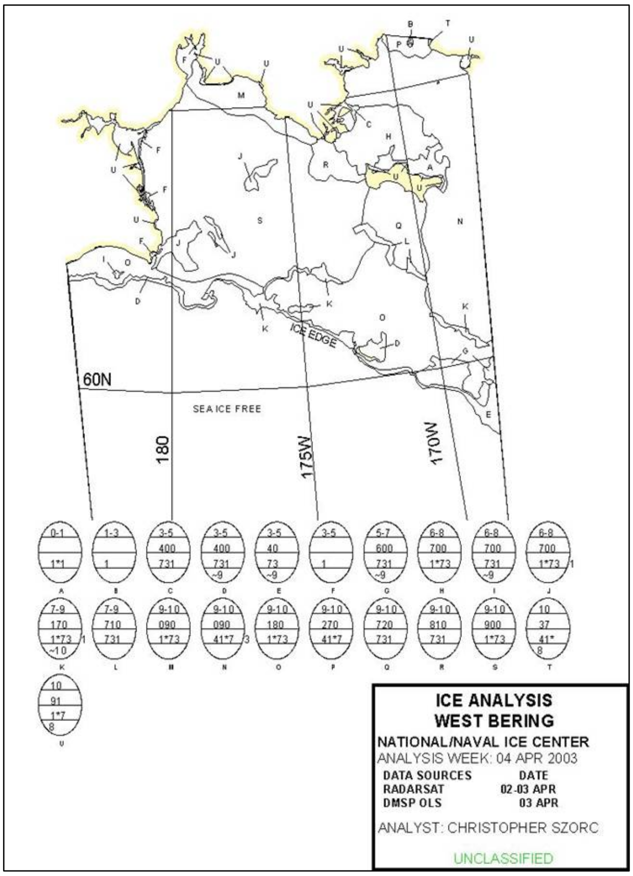


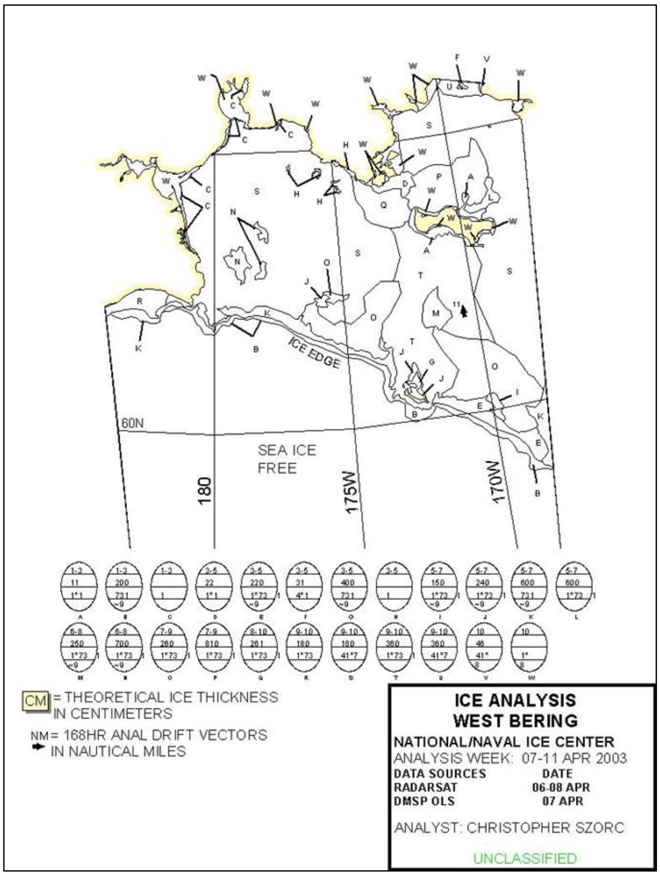


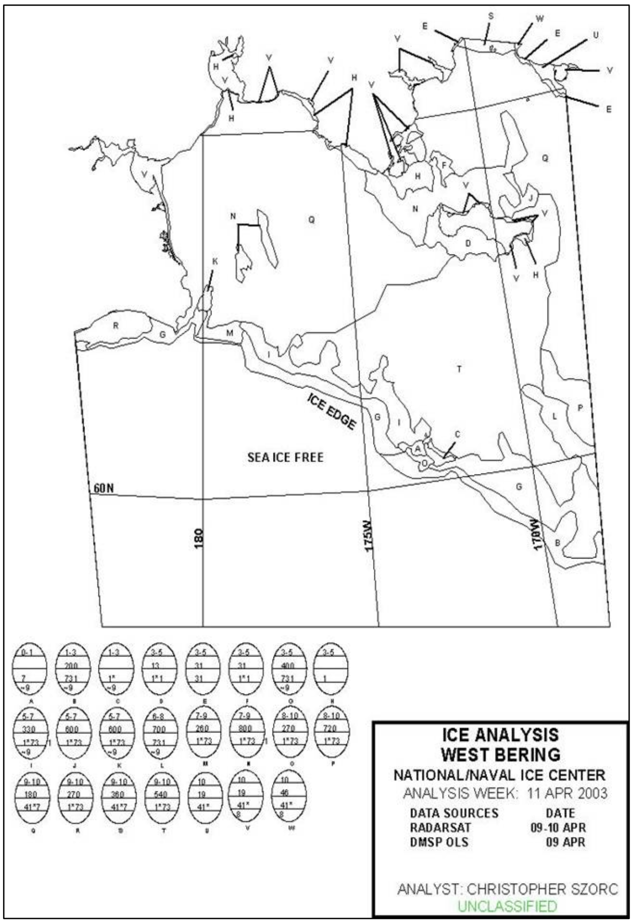


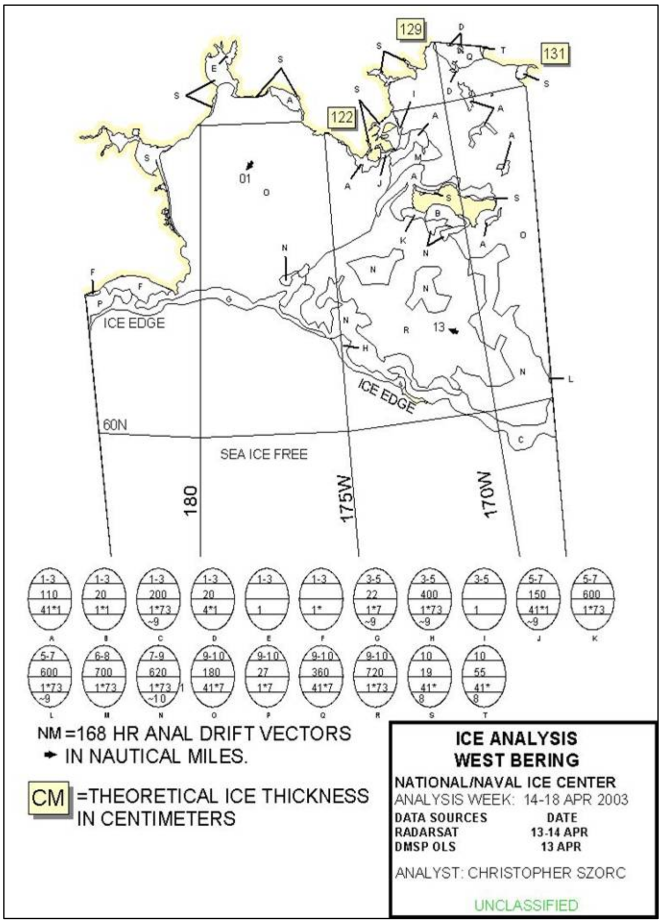


F. 1-12 April 2002.

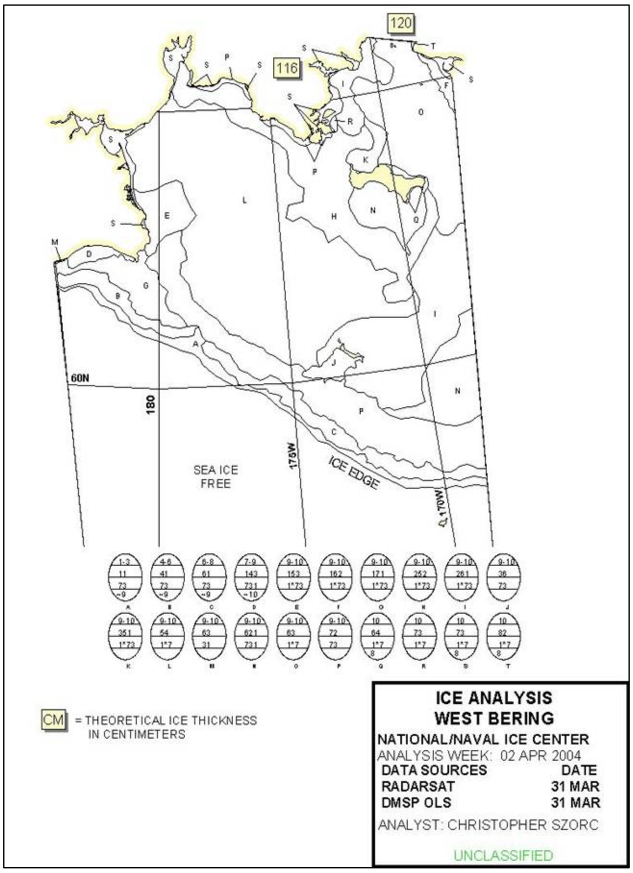


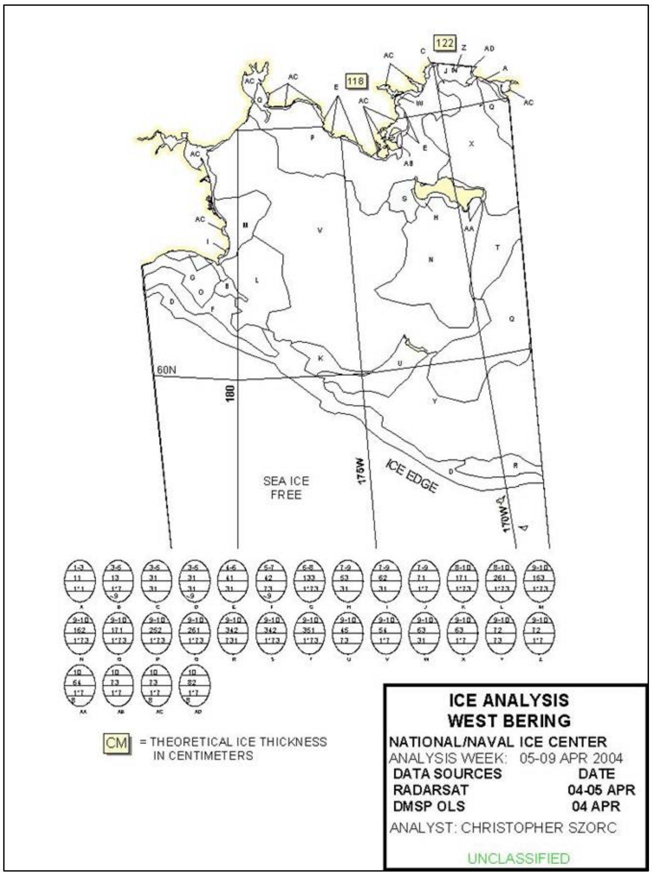


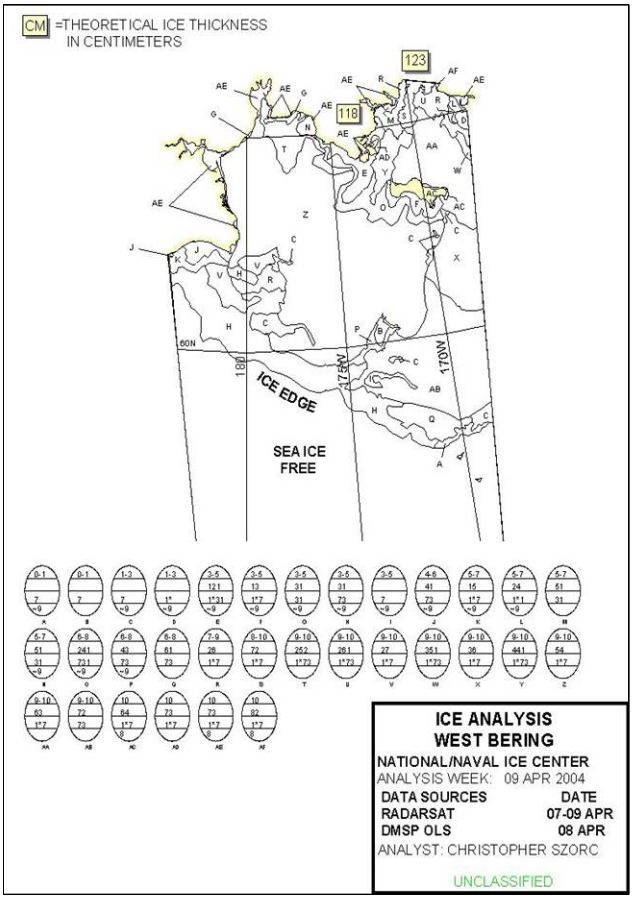


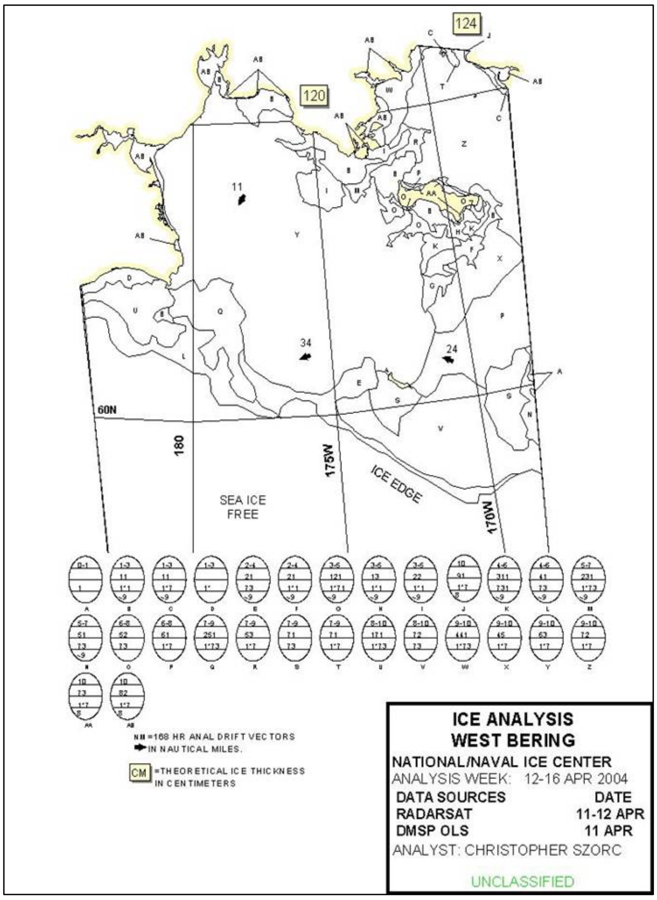


G. 4-14 April 2003

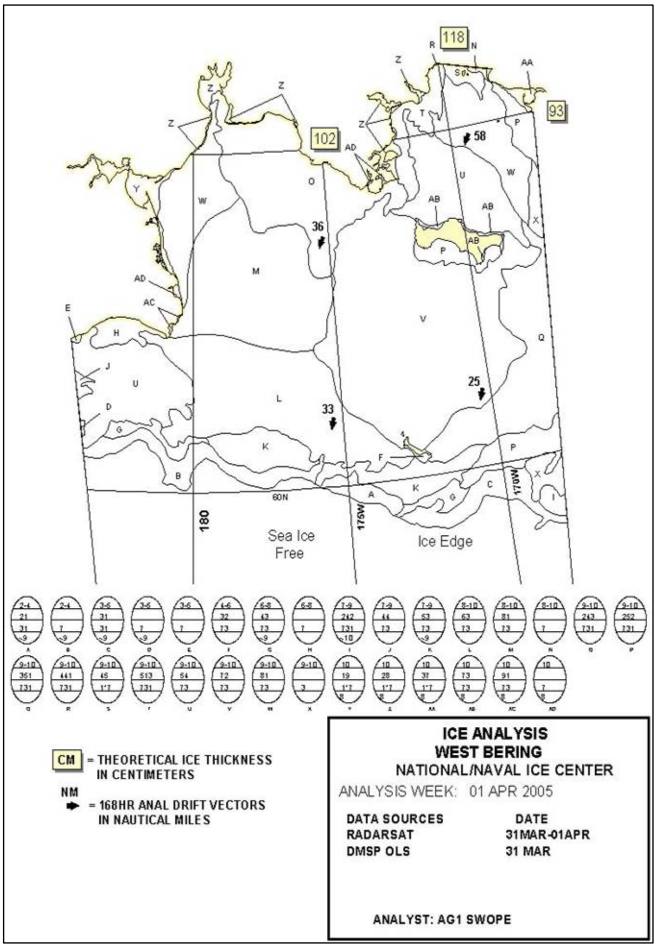


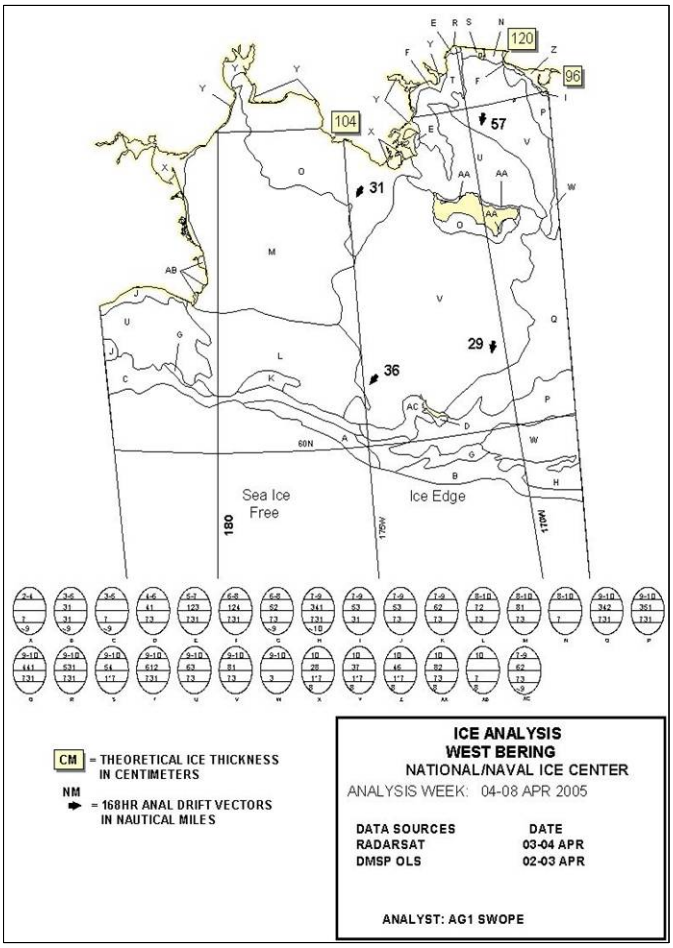


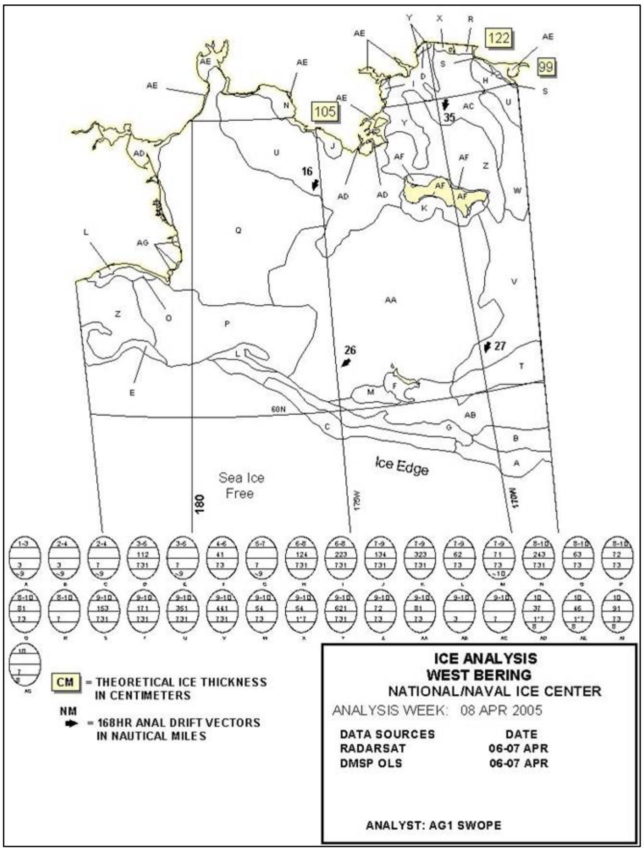


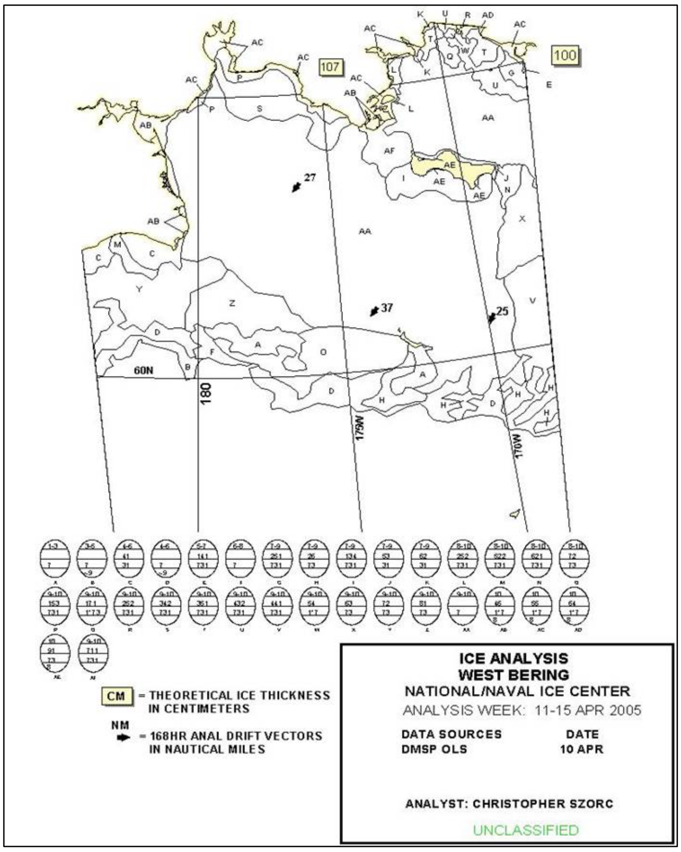


H. 2-12 April 2004









I. 1-11 April 2005