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THE SOVIET KRILL FISHERY IN THE ATLANTIC SECTOR OF THE ANTARCTIC FROM 1977 TO 1991: FISHING EFFORT DISTRIBUTION AND INTERANNUAL PATTERNS

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Abstract

Data on the Soviet krill fishery in the Atlantic Sector of the Antarctic from 1977 to 1992 are discussed. The total fishing effort from 1977 to 1991 was 50 086 vessel-days fished, in Subareas 48.3 (45% of the total for the period), 48.2 (36%) and 48.1 (19%). Three distinct patterns in the distribution of monthly fishing effort between subareas were recognised: Type I covered the period 1981–1982, Type II 1983–1986 and Type III 1987–1988. It is likely that environmental conditions and operational constraints influenced the distribution of fishing effort. The three types of distribution correspond to the spatial and temporal variability of the meridional atmospheric processes. Retrospective data analyses show that the fishing effort is most intense in the subarea where air transfer from the south is greatest. The phenomenon occurs in Subareas 48.1 and 48.2 under conditions of increased westward component of the zonal air exchange and in Subarea 48.3 of decreased westward component.

Résumé

Les auteurs examinent les données de la pêche soviétique de krill dans le secteur Atlantique de l'Antarctique de 1977 à 1992. L'effort de pêche total de 1977 à 1991 comptait 50 086 jours de pêche-navire, dont 45% dans la sous-zone 48.3, 36% dans la sous-zone 48.2 et 19% dans la sous-zone 48.1. La répartition de l'effort de pêche mensuel dans ces sous-zones affiche trois tendances distinctes : de type I pour la période 1981–1982, de type II pour celle de 1983–1986 et de type III pour celle de 1987–1988. Il est probable que les conditions environnementales et les contraintes opérationnelles aient influencé la répartition de l'effort de pêche. Les trois types de répartition correspondent à la variabilité spatio-temporelle des processus atmosphériques méridiens. Les analyses rétrospectives des données indiquent que l'effort de pêche le plus intense est déployé dans les sous-zones où le déplacement d'air en provenance du sud est le plus important. Ce phénomène se produit dans les sous-zones 48.1 et 48.2 lorsque l'échange d'air zonal vers l'ouest est accru et dans la sous-zone 48.3 lorsqu'il diminue.

Резюме

В статье рассматриваются данные по советскому промыслу криля в атлантическом секторе Антарктики с 1977 по 1992 г. Суммарное промысловое усилие с 1977 по 1991 г. составило 50 086 судо-суток лова в подрайонах 48.3 (45% от общего за этот период), 48.2 (36%) и 48.1 (19%). Выделено три характерных типа распределения ежемесячного промыслового усилия между подрайонами: тип I охватывает период 1981–1982 гг., тип II – 1983–1986 гг. и тип III – 1987–1988 гг. Вероятно, на распределение промыслового усилия влияли условия окружающей среды и ограничения практического характера. Эти три типа распределения соответствуют пространственно-временной изменчивости меридиональных атмосферных процессов. Анализ ретроспективных данных показывает, что промысловое усилие выше всего в том подрайоне, где преобладает перенос воздуха с юга. Это явление имеет место в подрайонах 48.1 и 48.2 в условиях усиления западной составляющей зонального атмосферного переноса и в Подрайоне 48.3 в условиях ее ослабления.

Resumen

Se analizan los datos de la pesquería soviética de kril que operó en el sector atlántico de la Antártida entre 1977 y 1992. El esfuerzo total de pesca en el período de 1977 a 1991 en las Subáreas 48.3 (45% del total para el período), 48.2 (36%) y 48.1 (19%) fue de 50 086 días de pesca/barco. Se observaron tres patrones definidos en la distribución del esfuerzo de pesca mensual entre las subáreas: el Tipo I cubrió el período de 1981 a 1982, el Tipo II de

1983 a 1986 y el Tipo III de 1987 a 1988. Es probable que las condiciones del medio ambiente y las limitaciones operacionales hayan afectado la distribución del esfuerzo pesquero. Los tres patrones de distribución están asociados con la variabilidad espacial y temporal de los procesos atmosféricos meridionales. Análisis retrospectivos de los datos demuestran que la intensidad del esfuerzo pesquero es mayor en la subárea que experimenta una mayor transferencia de aire del sur. Este fenómeno ocurre en las Subáreas 48.1 y 48.2 cuando la zona de intercambio del aire tiene un componente mayor del oeste, y en la Subárea 48.3 donde el componente del oeste es menor.

Keywords: Antarctic krill fishery, Atlantic Sector of the Antarctic, fishing effort, atmospheric air movements, CCAMLR

INTRODUCTION

Information on the Soviet krill fishery is rather scarce in the literature. Some data on the earlier krill fishery are given in Lubimova et al. (1985), which discusses the role of krill in the trophic structure of the Antarctic ecosystem. Limited data on the deployment of the Soviet krill fishing fleet from 1972 to 1985 are presented by Maklygin (1987), while information on the Soviet krill fishery is also given in the FAO review of the world krill fishery (Nicol and Endo, 1997). In describing the history of Soviet scientific research on the Antarctic ecosystem, Sushin and Litvinov (1999) also provided some information on the krill fishery.

The main purpose of the present paper is to describe the distribution of fishing effort (vessel-days fished (VDF)) in Subareas 48.1, 48.2 and 48.3 from 1977 to 1992 and to discuss factors that may influence patterns in the distribution of the fishing fleet.

MATERIAL AND METHODS

Data on vessel type and days of fishing by month and subarea that had been annually compiled in the *Atlas of Fisheries in the Southwestern Atlantic* (Anon., 1978–1992) were used in the analysis. These data were computerised, allowing their further sorting and processing.

Data on monthly VDF were analysed to investigate variations in seasonal, interannual and spatial distribution between subareas in the 15-year period from January 1977 to December 1991, the period during which the Soviet krill fishery reached its peak. Therefore, it is the most complete compilation of data for this period. It should be noted that the VDF data presented in this paper were collected by observers and may differ from fishery statistics officially published in the USSR. For a comparative analysis of the distribution of the krill fleet and environmental conditions, mean monthly values of atmospheric pressure at sea level were used, each value representing an area of 5° latitude x 10° longitude. These data were obtained from the Russian Hydrometeorological Centre (Moscow). The interannual variability of atmospheric pressure gradients in Subareas 48.1, 48.2 and 48.3 from 1970 to 2000 were analysed. An evaluation of these gradients gives an initial approximation of the geostrophic movements of air masses in the zonal (along longitude) and meridional (along latitude) directions (Kats, 1960). In the southern hemisphere the positive values of the latitudinal and longitudinal gradients correspond to movements to the south and east respectively.

RESULTS AND DISCUSSION

The Soviet krill fishery recorded the highest catches between 1977 and 1991 (Sushin and Litvinov, 1999) with a total catch of 3 538 229 tonnes of krill, corresponding to a total of 50 086 VDF in the Atlantic Sector (Table 1). During that period the fishing gear generally described as 'pelagic midwater rope-trawl' was most commonly used. Anon. (1978–1992) recorded 16 different types of krill vessels in use during that period (Table 2). Unfortunately there were no standard abbreviations for some of the vessel types in use at that time. A detailed description of different vessel types is given in *The Fleet of the Fishing Industry* (Anon., 1990), but in certain cases it is difficult to match the descriptions from this publication with the abbreviations given in Anon. (1978–1992). Table 2 presents an interpretation of these abbreviations based on advice from Sundakov, Boronin and Milavsky (pers. comm.).

Large freezer trawlers for the production of frozen products and meal which are summarised as BMRT vessels (miscellaneous projects, Table 2) accounted for over 33% of the total fishing effort, while the even larger freezer trawlers (PPR, projects 'Grumant' and 'Rembrant', Table 2) accounted for over 25%. The proportions of other types of fishing vessel were significantly less, with large freezer trawlers (BMRTM, project 'Luchegorsk') accounting for 8.3% and all other types, less than 6% (Table 2).

Table 1: Antarctic krill catches and former Soviet Union (FSU) fishing effort in the Atlantic Sector from January 1977 to December 1991.

Years*	Total Krill Catches in the Whole Antarctic, all Countries (tonnes)	Total Krill Catches in the Atlantic Sector of Antarctic, all Countries (tonnes)	Krill Catches in the Whole Antarctic by FSU Countries (tonnes)	Krill Catches in the Atlantic Sector of Antarctic by FSU Countries (tonnes)	Fishing Effort (vessel-days fished)
1977	122 534	106 794	105 049	99 828	2 571
1978	142 803	89 923	116 637	89 820	1 890
1979	386 256	321 344	349 825	321 196	4 516
1980	477 186	356 978	440 516	356 752	3 899
1981	448 132	288 868	420 434	285 117	3 815
1982	528 699	374 080	491 656	368 182	3 212
1983	229 771	139 489	180 290	128 751	2 170
1984	128 218	104 680	74 381	62 321	1 296
1985	191 472	180 819	150 538	146 855	2 867
1986	445 673	425 871	379 270	366 738	3 902
1987	376 453	346 531	290 401	264 530	4 364
1988	370 663	363 234	264 190	262 736	4 548
1989	395 860	394 406	263 031	263 006	3 634
1990	374 856	350 213	273 409	272 751	4 209
1991	356 439	354 249	250 392	249 646	3 193
Total	4 975 015	4 197 479	4 052 009	3 538 229	50 086

*Annual catches are presented by split-year according to CCAMLR statistics (CCAMLR, 1991) and fishing effort is shown by calendar year.

Table 2: Fishing effort (vessel-days fished) deployed by the former Soviet Union (FSU) krill fishing fleet in the Atlantic Sector by vessel type, from January 1977 to December 1991.

Type of Vessel	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Total	%
BAT	34	43	1	49	0	0	47	0	181	434	306	17	0	59	184	1 355	2.7
BATKRR	0	0	0	0	0	0	0	0	0	0	0	468	0	504	417	1 389	2.8
BATM	0	0	0	0	0	0	0	0	0	0	24	184	183	106	125	622	1.3
BMMT	71	46	119	122	211	221	0	0	0	0	0	51	0	0	0	841	1.7
BMRT	1 491	1 239	2 198	1 890	1 528	1 204	458	469	816	1 016	1 081	1 443	187	892	628	16 540	33.2
BMRTA	0	7	61	153	206	0	22	80	36	174	214	88	0	70	35	1 146	2.3
BMRTV	0	0	0	0	0	0	30	0	0	0	102	237	0	5	170	544	1.1
BMRTIB	0	0	0	0	0	0	0	0	0	0	0	36	0	0	30	66	0.1
BMRTM	0	0	6	105	31	39	32	152	79	165	166	427	968	1 222	761	4 153	8.3
BMRTPT	0	0	0	0	0	0	279	47	545	581	326	0	729	694	178	3 379	6.8
RKT	0	0	0	0	0	0	0	0	0	0	344	45	0	0	0	389	0.7
PPR	516	361	1 701	869	1 257	302	333	446	893	1 033	1 317	1 453	881	656	635	12 653	25.4
RKTS	0	0	0	0	0	0	0	0	0	0	0	0	686	1	0	687	1.4
RTMA	44	108	126	57	376	183	10	13	0	0	0	0	0	0	0	917	1.8
RTMS	92	86	304	396	206	202	116	89	317	499	484	99	0	0	30	2 920	5.9
STR	0	0	0	258	0	1 061	843	0	0	0	0	0	0	0	0	2 162	4.3
Total	2 248	1 890	4 516	3 899	3 815	3 212	2 170	1 296	2 867	3 902	4 364	4 548	3 634	4 209	3 193	49 763	99.8

BAT – large autonomous trawler, project 'Horizont', gross registered tonnes (GRT) 5340, maximum length (ML) 111.3 m, main engine power (MEP) 2x2570 KWT.
BATKRR – large autonomous trawler for fish and krill, project 'Antarctida', 6394 GRT, ML 114.49 m, MEP 2x2580 KWT.
BATM – large autonomous trawler for frozen and canned production, project 'Pulkovskiy meridian', 4407 GRT, ML 103.7 m, MEP 2x2580 KWT.
BMMT – large fishing trawler for meal and frozen production, 3140 GRT, ML 84.7, MEP 1x1470 KWT.
BMRT – large freezer trawler for production of frozen products and meal, various projects, 2973–4407 GRT, ML 83–103 m, MEP 1x1470–2x1600 KWT.
BMRTA – large freezer trawler, project 'Altay', 3390 GRT, ML 107.50 m, MEP 5x735 KWT.
BMRTV, BMRTIB – large freezer trawlers, project 'Ivan Bochkov', 3144 GRT, ML 93.84 m, MEP 1x3820 KWT.
BMRTM – large freezer trawler, project 'Luchegorsk', 2973 GRT, ML 83.57 m, MEP 1x1470 KWT.
BMRTPT – large freezer trawler, various projects, 2326–2666 GRT, ML 83 m, MEP 1x1470 KWT.
PPR – large freezer trawlers, projects 'Grumant' and 'Rembrandt', 4699–5019 GRT, ML 102.7–103.59 m, MEP 1x2205–1x2280 KWT.
RTMA – freezer trawler, project 'Atlantic', 2657 GRT, ML 82.20 m, MEP 2x855 KWT.
RTMS – large freezer trawler, project 'Prometey', 3017 GRT, ML 101.8 m, MEP 1x2850 KWT.
STR – refrigerating seiner-trawler, project 'Alpinist', 710 GRT, ML 53.7 m, MEP 1x970 KWT.
RKTS, RKT – large autonomous trawler for fish and krill, similar to project 'Antarctida', 6394 GRT, ML 114.49, MEP 2x2580 KWT.

Table 3: Fishing effort (vessel-days fished) deployed by the krill fishing fleet of the regional fishery associations of the former Soviet Union (FSU).

Years	Azcherryba (Kerch)	Zapryba (Riga)	Sevryba (Murmansk)	Dalryba (Vladivostok)	Total
1977	271	1 637	663	0	2 571
1978	153	1 155	582	0	1 890
1979	1 165	1 177	2 174	0	4 516
1980	785	1 613	1 501	0	3 899
1981	1 219	1 054	1 542	0	3 815
1982	760	993	398	1 061	3 212
1983	727	307	386	750	2 170
1984	703	226	367	0	1 296
1985	1 171	785	911	0	2 867
1986	1 434	718	1 750	0	3 902
1987	1 398	549	2 417	0	4 364
1988	1 056	882	2 610	0	4 548
1989	1 112	930	1 592	0	3 634
1990	1 140	1 149	1 920	0	4 209
1991	833	743	1 617	0	3 193
Total	13 927	13 918	20 430	1 811	50 086

The fishery for Antarctic krill was operated by three regional Soviet fishery associations: the Azov and Black Sea Fishery Association (Azcherryba, based in Kerch), the Western Fishery Association (Zapryba, based in Riga) and the Northern Fishery Association (Sevryba, based in Murmansk) (Table 3). In 1982 and 1983, vessels of the Far East Fishery Association (Dalryba, based in Vladivostok) also took part in the krill fishery, accounting for 1 811 VDF in total. During that period the levels of fishing effort deployed by Zapryba and Azcherryba were similar (13 918 and 13 927 VDF respectively), while those deployed by Sevryba were higher (20 430 days).

At that time the main objective of the Soviet krill fishery was to maximise the quantity of catch rather than the quality of krill caught, so the pattern of Soviet krill fishing activities, although influenced by economic and political factors, tended to reflect the distribution of the most abundant and stable krill aggregations and their availability given the prevailing ice and weather conditions. Due to the distinctive characteristics of the socialist economy, it is very difficult to trace market demand during that period. The majority of the krill catch was destined for agriculture: whole frozen krill and krill meal were used as agriculture fertilizers and nutrient supplements for feeding animals. Only a relatively small part of the krill catch was directed for human consumption. The Soviet krill fishery operated principally in three South Atlantic subareas: the South Shetland Islands (48.1), the South Orkney Islands (48.2) and South Georgia (48.3). Between 1977 and 1991 most fishing effort occurred in Subarea 48.3 (45% of the total), followed by Subarea 48.2 (36%) and then Subarea 48.1 (19%). Annual and interannual changes in the distribution of fishing effort were significant (Figure 1). From 1977 to 1991, the fishing fleet tended to show similar patterns of distribution for several years at a time: the three major patterns in the distribution of fishing effort (FE) are described below.

Type FE-I: 1981 and 1982. The krill fishery operated in Subarea 48.1 from January to April, and then the fleet moved to Subarea 48.3 via Subarea 48.2. Between 1978 and 1982, the importance of Subarea 48.1 increased, with fishing effort reaching a maximum for that area in 1982 before ceasing abruptly in 1983. Such changes may be due to the fluctuations in krill biomass observed by Siegel (2000).

Type FE-II: 1983 to 1986. These years were quite different from the previous period, with the krill fishery occurring in Subarea 48.2 in the first half of the year. There were some differences between these years, notably the month during which the fishery moved from Subarea 48.2 to Subarea 48.3. This move occurred in June 1983 and 1985, and in May 1986, while in 1984 the krill fishery was conducted mostly in Subarea 48.2.

Type FE-III: 1987 to 1989. Fishing effort was concentrated mainly in Subarea 48.3, from March–April to September–November, with the importance of this subarea increasing from June 1985.

It is likely that the following three main factors have influenced the distribution of fishing fleet:

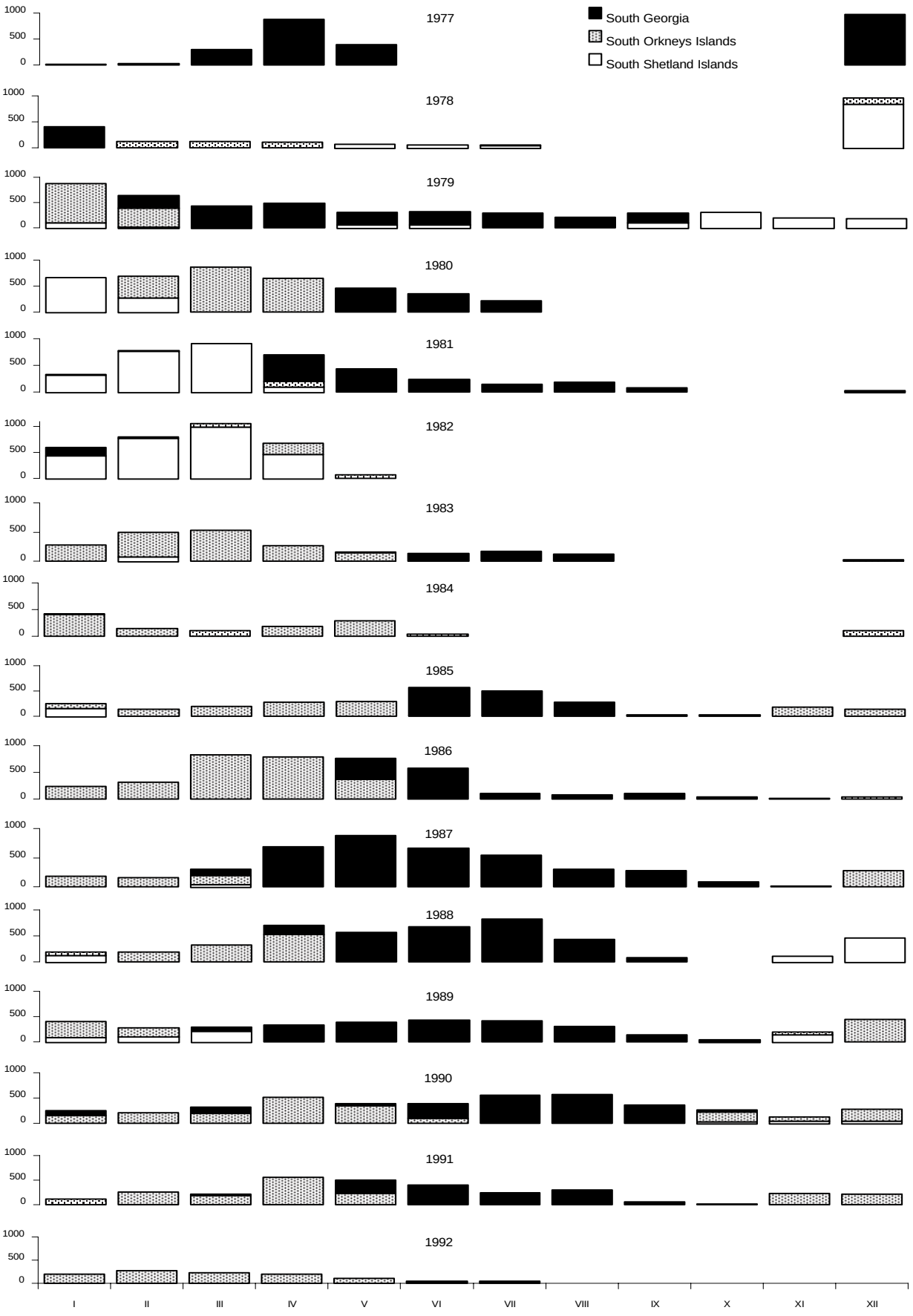

Figure 1: Distribution of fishing effort (vessel-days fished) by subarea from 1977 to 1992.

Table 4: Reasons for cessation of fishing in certain subareas, as described in Anon. (1978–1992).

Period	Shift between Subareas	Reason Indicated
1978 January	48.3–48.2	Stormy weather, poor catches.
1978 December	48.1–48.2	?
1979 February/March	(48.1+48.2)–48.3	?
1979 September	48.3–48.1	Poor catches, shortage of krill aggregations.
1980 February	48.1–48.2	Shortage of krill aggregations in the second half of February.
1980 April–May	48.2–48.3	Ice conditions.
1981 March/April	48.1–48.3 and 48.2	Unstable conditions of fishery.
1981 September	48.3–	?
1982 April	48.1–48.2	Poor catches: krill decrease in Subarea 48.1.
1982 May	48.2 – Patagonian shelf	Under orders from the Ministry of Fisheries of the USSR, the whole of the Soviet fleet in the area moved to the Patagonian shelf on 10 May 1982.
1983 May/June	48.2–48.3	Ice conditions.
1984 June	48.2–	Ice conditions.
1985 May/June	48.2–48.3	Ice conditions.
1985 September	48.3–48.2	Decrease in density of krill aggregations due to stormy weather.
1986 May	48.2–48.3	Ice conditions.
1986 October	48.3–48.2	Decrease in density of krill aggregations due to stormy weather.
1987 March	48.2–48.3	Decrease in catches.
1987 October	48.3–48.2	Fishing vessels changed target from krill to fish.
1988 April/May	48.2–48.3	Ice conditions.
1988 September	48.3–	Bad conditions for fishery.
1989 February	48.2–	Stormy weather, ice conditions.
1989 March	48.1–48.3	Decrease in catches.
1989 October	48.3–(48.1+48.2)	Bad conditions for fishery.
1990 June	48.2–48.3	Winter time.
1990 October	48.3–48.2	Decrease in catches.
1991 May	48.2–48.3	Ice conditions.
1991 September	48.3–48.2	Decrease in catches.
1992 May	48.2–48.3	Decrease in catches.

(i) the presence and stability of aggregations of krill of appropriate quantity and quality for the fishery. Krill quality is determined by its size and feeding status: very small and intensively feeding krill can only be processed into krill meal. In general the highest priority for the Soviet fleet as a whole was to maximise catches, i.e. FE reflected the presence of large, dense and stable krill aggregations rather than the quality of krill;

(ii) ice and weather conditions; and

(iii) economic and logistic factors such as availability of fuel and other fleet supplies, the political situation, management and selection of target species (e.g. krill or icefish).

Therefore, only the first and second factors are determined by environmental processes in the ocean and atmosphere. An attempt is made here to trace the connection between fishing fleet distribution and oceanic and atmospheric conditions. However it should be emphasised that all three factors may influence patterns of fishing activities, and even decision-makers may not be able to determine which factor was most important at any particular time.

The data from Anon. (1978–1992) show the following two main reasons for changing the subarea fished (Table 4):

(i) shortage of krill aggregations and bad ice conditions; and

(ii) stormy weather which negatively influenced the fishery, and dispersal of krill aggregations which usually had a short-term small-scale effect and rarely led to a change of subarea.

However, in some cases, stormy weather might have coincided with the beginning of a longer-term dispersal of krill aggregations, which resulted in the reduction of krill densities below the threshold for a viable fishery. Most krill catches were taken under fishing conditions that were classified as 'satisfactory conditions', resulting in catch rates no higher than 7 tonnes/hour (Figure 2). Relatively few hauls were carried out under what was described

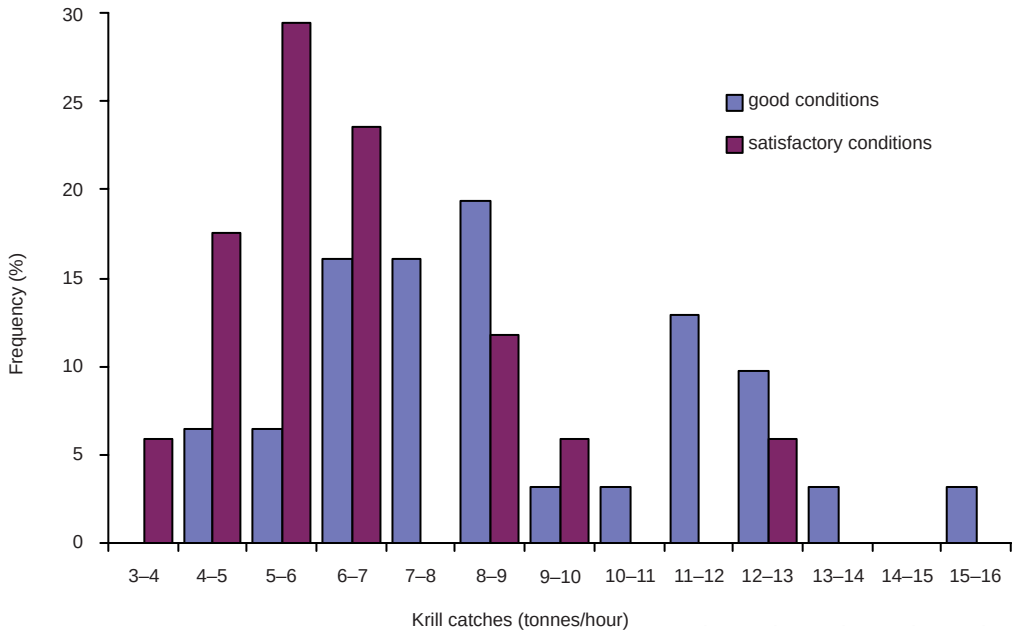

Figure 2: Distribution of Soviet krill catches under different fishery conditions from 1986 to 1990.

as 'good conditions' which led to catches higher than 10 tonnes/hour. It appeared that adverse ice conditions (extensive sea-ice) were the main reason for shifting the fleet from Subarea 48.2 to 48.3 in April–May. In other cases, the main reason for the shift was a deterioration in fishing conditions (decrease in the size, density and stability of krill aggregations), sometimes accompanied by stormy weather, which hampered fishing operations and dissipated krill aggregations.

On 10 May 1982, the entire USSR fleet stopped fishing in the Atlantic Sector and moved to the Patagonian Shelf; this was a unique operational move most probably due to the Falkland/Malvinas crisis. Before leaving, vessels worked in Subarea 48.2 and reported good fishing conditions with up to 10–20 tonnes of krill taken in 1–2 hauls during the day and 10–20 tonnes in 3–4 hauls at night. In January 1983, the krill fishery was restarted. From May to August 1983 fishing conditions in Subarea 48.3 were reported as either 'unstable' or 'satisfactory', and fishing effort was low (partly due to the fleet's involvement in the intensive icefish fishery). In 1984 conditions were not suitable for a winter krill fishery in Subarea 48.3 (Anon., 1978–1992). Heywood et al. (1985) reported an extremely low abundance of krill in Subarea 48.3 from July to October 1983 that could not be attributed to the environmental factors investigated. Siegel (2000) noted a more than 10-fold interannual variation in the kill biomass off South Georgia, but the 1983 austral winter period was very unusual in this respect and a similar situation was probably repeated in 1994. Fedoulov et al. (1996) observed some evidence that the Weddell–Scotia Confluence was located in the extreme south of the Scotia Sea during summer 1983/84. According to Latogursky et al. (1990), krill biomass near South Georgia in June 1983 and October 1984 were the lowest ever observed from 1974 to 1988. This low biomass in 1983 was attributed to the absence of any clearly discernible eddies in the current field, but due to lack of data, no reasons were offered for the low biomass in 1984. Siegel (2000) noted that changes in krill abundance and biomass in Subarea 48.1 seem to represent transient oscillations over a period of the order of at least 3–4 years.

In order to see how the distribution of fishing effort varied according to environmental conditions, the relationship between atmospheric gradients and the three types of fishing effort distribution observed above was examined.

The analysis of interannual variability in zonal and meridional air exchange observed in atmospheric circulation in Subareas 48.1, 48.2 and 48.3 shows that the western component of zonal exchange increased until the mid-1980s and com-pletely dominated zonal air exchange during the latter half of the 1990s in all three subareas (Figure 3). In the system of meridional air exchange over the islands, the southern component predominates for most of the time, with quasi-10-year, 4–6 year and quasi-2-year oscillations (Figure 4). The following

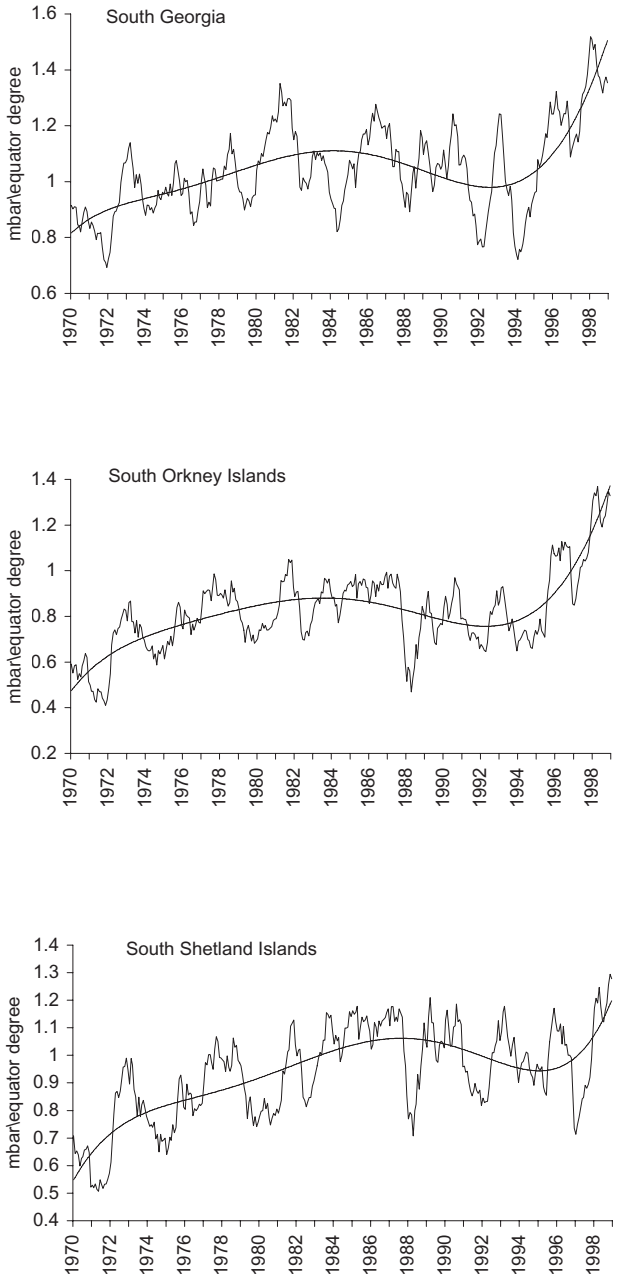

Figure 3: Interannual variability of zonal transfers in the principal krill fishing subareas. Solid line: 13-month running means. Dotted line: trend.

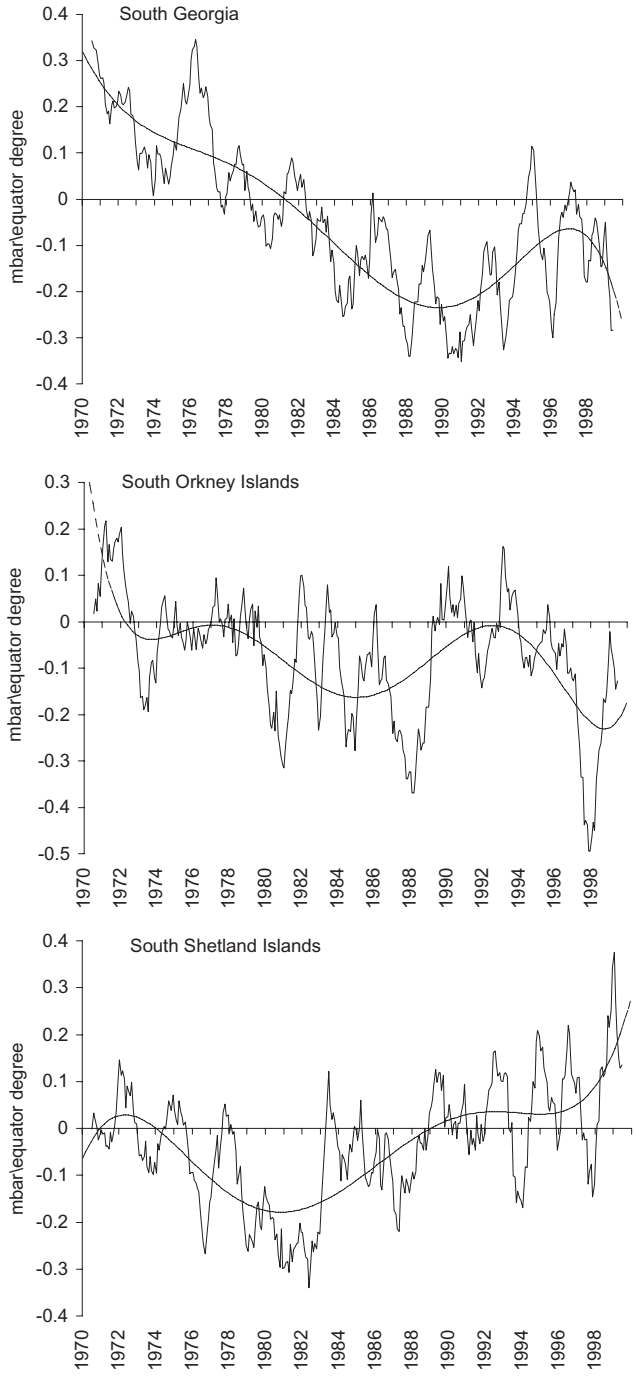

Figure 4: Interannual variability of meridional transfers in the principal krill fishing subareas. Solid line: 13-month running means. Dotted line: trend. Positive – north, negative – south.

features of the spatial and temporal variability of southern meridional air exchange in the Atlantic sector were identified.

The beginning of the southern phase of meridional air exchange can be recognised by the sustained transition of circulation indices from positive to negative values. Similarly, periods of peak activity of the processes can be identified by inflection points. The timing of these processes varies between Subareas 48.1, 48.2 and 48.3, with a quasi-4-year lag between the South Shetlands, the South Orkneys and South Georgia. Periods of the dominant southern meridional air exchange in Subareas 48.1, 48.2 and 48.3 were observed in 1975, 1979 and 1983 respectively. These processes would have reached their peak in the early and mid-1980s and the early 1990s respectively. The years 1980, 1986 and 1991 corresponded to the observed maxima of three periods of extensive winter ice cover northwest of the Antarctic Peninsula (Hewitt, 1997). It is clear, from a comparison of Figure 1, Figure 4 and the description given above, that the peak of the southern phase of meridional air exchange was observed in Subarea 48.1 from 1980 to 1982 and corresponded to Type FE-I; in Subarea 48.2 it was observed from 1983 to 1986 and corresponded to Type FE-II, while in Subarea 48.3 it was observed from 1987 to 1991 and corresponded to Type FE-III. There is a clear correlation between peaks in southern meridional air transfer and the distribution of the krill fishing fleet, but this is difficult to account for. According to Sundakov (pers. comm.), the general requirement for the krill fishery in Subareas 48.1 and 48.2 was the absence of ice in the austral summer months because relatively dense krill aggregations were available there most of the time. Conversely, the primary condition for a krill fishery in Subarea 48.3 was the presence of krill aggregations, as this subarea is generally ice-free. One may speculate that both factors, i.e. the absence of ice in Subareas 48.1 and 48.2 and the presence of krill aggregations in Subarea 48.3 reflects the influence of the Antarctic Circumpolar Wave which has a periodicity of four to five years (White and Petersen, 1996).

CONCLUSIONS

From 1977 to 1991, the total effort deployed by the Soviet krill fishery was 50 086 days of fishing. The FE was unequally distributed between three subareas: 48.3 (45% of the total for the period), 48.2 (36%) and 48.1 (19%). The VDF distribution between subareas was, furthermore, very variable; three main patterns of VDF distribution were distinguished, corresponding to three major time periods: 1981–1982, 1983–1986 and 1987–1989. These general patterns of FE distribution correspond to spatial and temporal variability in the zonal and meridional atmospheric processes. While patterns in krill fishing distribution may be influenced by both environmental conditions and operational constraints, it was found that, in general, the VDF value was highest in the subarea where maximum southern atmospheric exchange took place.

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@inproceedings{Litvinov2004CPUEIU, title={CPUE INDICES USED IN SOVIET KRILL FISHERY STATISTICS FROM 1977 TO 1992 AND THEIR POSSIBLE UTILITY FOR EVALUATION OF RELATIVE CHANGES IN KRILL BIOMASS}, author={F. F. Litvinov and Alex Sundakov and V. I. Arkhipov}, year={2004} }. F. F. Litvinov, Alex Sundakov, V. I. Arkhipov. Key catch-per-unit-effort (CPUE) indices used in Soviet krill fi shery statistics, as well as the main sources of data and primary data for their calculations, were examined.Â The Soviet krill fi shery in the Atlantic Sector of the Antarctic from 1977 to 1991 : fi shing effort distribution and interannual patterns. M Mangel. CCAMLR Science. 2003. Antarctic krill has been fished commercially in the Southern Ocean since the 1970s and has been consistently the largest fishery, by tonnage, in the region since then. The fishery has seen changes in the nations involved, with early catches dominated by vessels from the USSR, Japanese vessels in the middle years and, more recently, most of the catch has been taken by vessels from Norway. A variety of products have emerged from the fishery with early efforts aimed at human consumption but latterly, the bulk of the catch has been used as high-end aquaculture feed with a small but valuable fracti Krill fisheries in the Southern Ocean may have immense longâ€term impacts on the marine ecosystem, disrupting the food web and blocking energy flows through the system. Currently two major finfish species are also exploited from Antarctic waters, the Patagonian toothfish and the Mackerel icefish. The convention is primarily focused on the conservation of living resources within the stated conservation area.Â species of the Soviet fishing fleets after the decline of the marbled rock cod in the 1970s. Although the annual mean catch of Mackerel icefish declined over the first 20 years of fishing, it is the only pre CCAMLR fishery to remain viable (Constable et al. 2000). 4 Antarctic Krillâ€fishery.