SC-CAMLR-VIII/BG/11

COMMERCIAL KRILL FISHERIES IN THE ANTARCTIC, 1973 TO 1988

D.G.M. Miller

Abstract

STATLANT data reported to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) are used to discern observable trends in catch and effort for the Antarctic krill (*Euphausia superba*) fishery between 1972/73 and 1987/88. The annual krill catch rose gradually to a peak of some 500 000 tonnes in 1981/82 before dropping to a low level in 1983/84 and stabilizing at about 400 000 tonnes thereafter. In terms of both catch and effort the Soviet and Japanese krill fisheries in Subareas 48.1, 48.2 and 48.3 prevail in the CCAMLR Convention Area. Monthly fishing patterns (November to April) are similar in all areas, except in Subarea 48.3 where fishing is predominantly confined to the winter months (April to August). Trends in the fishery with respect to independent estimates of krill abundance and minke whale (*Balaenoptera acutorostrata*) catches are discussed.

Résumé

Les données STATLANT présentées à la Commission pour la conservation des ressources marines vivantes de l'Antarctique (CCAMLR) sont utilisées pour discerner les tendances apparentes de capture et d'effort pour la pêcherie du krill antarctique (*Euphausia superba*) entre 1972/73 et 1987/88. La capture annuelle du krill a augmenté petit à petit jusqu'à un maximum de quelques 500 000 tonnes en 1981/82 avant de baisser jusqu'à un niveau faible en 1983/84 et de se stabiliser par la suite, à environ 400 000 tonnes. Il semble qu'en termes de capture ainsi que d'effort, les pêcheries soviétiques et japonaises dans les sous-zones statistiques 48.1, 48.2 et 48.3 dominent l'exploitation du krill dans la Zone de la Convention de la CCAMLR. Les façons de pêcher, par mois (de novembre à avril), sont similaires dans toutes les zones, à l'exception de la sous-zone 48.3 où les activités de pêche sont limitées pour la plupart aux mois d'hiver (d'avril à août). Les tendances dans la pêcherie en ce qui concerne des estimations indépendantes de l'abondance du krill et les captures de petits rorquals (*Balaenoptera acutorostrata*) sont examinées.

Резюме

Данные по STATLANT, представленные в Комиссию по сохранению морских живых ресурсов Антарктики (АНТКОМ) используются для того, чтобы выявить очевидные закономерности изменений уловов и промыслового усилия при промысле антарктического криля (*Euphausia superba*) в течение периода 1972/73 - 1987/88 гг. Ежегодный вылов криля постепенно возрастал до максимума примерно в 500 000 т. в 1981/82 г.; затем вылов находился на низком уровне в 1983/84 г. и впоследствии стабилизировался на уровне около 400 000 т. Имеются свидетельства того, что как в отношении вылова, так и промыслового усилия советский и японский промысел в подрайонах 48.1, 48.2, и 48.3 играют главную роль в эксплуатации криля в зоне действия Конвенции АНТКОМ. Ежемесячный промысловый режим (ноябрь-апрель) подобен во всех районах за исключением Подрайона 48.3, где промысел ведется главным образом в течение зимних месяцев (апрель-август). Рассматриваются направления изменений промысла криля, определенные по независимым оценкам численности криля и размера уловов малого полосатика (*Balaenoptera acutorostrata*).

Resumen

Los datos notificados a la Comisión para la Conservación de los Recursos Vivos Marinos Antárticos (CCRVMA) en formularios STATLANT se utilizan para distinguir tendencias visibles en la captura y esfuerzo para la pesca de krill Antártico (*Euphausia superba*) entre 1972/73 y 1987/88. Hubo un aumento gradual en la captura anual de krill llegando a un máximo de 500 000 toneladas durante un tiempo en 1981/82, antes de disminuir a un nivel mínimo en 1983/84 para estabilizarse alrededor de 400 000 toneladas de ahí en adelante. En términos de captura y esfuerzo, las pesquerías de krill soviética y japonesa en las Subáreas 48.1, 48.2 y 48.3 predominan en el Area de la Convención de la CCRVMA. Los patrones mensuales de pesca (noviembre a abril) son semejantes en todas las áreas, excepto en la Subárea 48.3 donde la pesca es limitada principalmente a los meses de invierno (abril a agosto). Se debaten las tendencias en la pesquería con respecto a estimaciones independientes sobre la abundancia de krill y rorcual aliblanco (*Balaenoptera acutorostrata*).

1. INTRODUCTION

During the past three decades a growing demand for protein from the sea combined with increasingly restricted access to historical fishing grounds has resulted in the development of many "unconventional" fisheries (cf Robinson, 1982; Budzinski et al., 1985). In particular, such development has been focussed on the Antarctic krill (*Euphausia superba* Dana).

Krill has long been recognised as a key component of many Antarctic marine food webs (cf Marr, 1962; Everson, 1977; Knox, 1984 amongst others) and exhibits several attributes which enhance its potential as an exploitable resource. These include:

- high global abundance estimates (Everson, 1977; Gulland, 1983);
- high nutritional value (Grantham, 1977; Budzinski et al., 1985); and
- relative ease of capture arising from the species' tendency to aggregate (Eddie, 1977; El-Sayed and McWhinnie, 1979).

Exploratory fishing for krill as a commercial resource commenced in the early 1960's and initially catches were relatively small (Table 1). The build-up of annual catches was slow and it was not until the 1973/74 season that exploitation of krill could in any way be considered to have been on a commercial basis.

The primary aim of this paper is to review krill catches over the past fifteen years. Catch statistics will be used to indicate areas where the fishery has been most active and from which the largest catches have been taken. Discernible trends in the catches will be considered in the light of available theories on krill distribution and some attempt will be made to provide insights into possible relationships between krill fisheries and the species' distribution. As a secondary aim, some attempt will be made to assess possible links between the information provided by the fisheries data and available knowledge on krill predators. It is hoped that this approach will contribute to current efforts aimed at assessing the role of the minke whale (*Balaenoptera acutorostrata*) as an indicator of krill stock dynamics.

2. THE KRILL FISHERY

2.1 Available Data

Krill catches are reported from three major statistical areas in the Antarctic. Originally defined by the FAO, these areas have been subsequently adopted by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) (CCAMLR, 1988a). They are termed the Atlantic (Statistical Area 48), Indian Ocean (Statistical Area 58) and Pacific Antarctic (Statistical Area 88), and for convenience have been further subdivided into various subareas and divisions (Figure 1).

Summary catch and effort data are supplied annually to CCAMLR using the STATLANT A and B formats. For reporting purposes, catches are summarized by split-years; a split-year being the twelve month period from 1 July in one year to 30 June in the next. The catch year is designated according to the second of the two split-years. Krill STATLANT data contain information on catch with respect to year, month, major gear type, vessel type and geographical subarea.

Both STATLANT A and B data are considered in this paper, although only data where krill were specified as the target or only species caught have been used to analyze fishing effort. The bulk of catches taken during the period under consideration (1973 to 1988) were by the Soviet fishery (see below). Prior to 1983, however, Soviet catch data in all areas were not ascribed by month, and effort data (e.g. hours fished) are only available from that year onwards. Fine-scale catch and effort data (taken in groups by 10-day period and 0.5° latitude x 1° longitude) have been available since 1985/86 for Subareas 48.1 and 48.2 only. Such data have not been considered to any great extent in the analyses reported here.

2.2 Trends in Catches

2.2.1 Annual catch

During the period 1973 to 1988 (Figure 2) annual krill catches in the CCAMLR Convention Area rose steadily from 19 785 tonnes in 1973/74 (with a minor reduction of 28 891 tonnes, from 477 023 tonnes to 448 132 tonnes, between 1979/80 and 1980/81) to a peak of 528 201 tonnes in 1981/82. After 1982, catches declined sharply to a trough of 130 875 tonnes in 1983/84; a level close to that observed in 1977/78 (132 349 tonnes) during the early expansion of the fishery. Thereafter, annual catches gradually increased to a second peak of 445 673 tonnes in 1985/86 and subsequently levelled off at about 370 000 tonnes in the remaining years. From Figure 2 it is also apparent that the Soviet Union (±85% total) and Japan (±14% total) are by far the two major krill fishing nations, together accounting for about 99% of all catches.

2.2.2 Annual Catch By Area and Subarea

The annual catch in Statistical Area 48 is consistently larger (except for the 1975/76 season when no krill were taken in this area) than in Statistical Areas 58 and 88 for any one year (Figure 3). This trend has been especially obvious since the 1983/84 season.

Trends in the annual catch from the three areas (Figures 4 to 6) show slight differences, although Soviet and Japanese catches remain dominant. In Statistical Area 48 (Figure 4) the overall catch trend is similar to that for all three areas combined (Figure 3), which is not surprising given that Statistical Area 48 accounts for the major proportion of the annual catches. Gradually increasing catches in Statistical Area 58 peaked in 1980/81 (155 030 tonnes), at a much lower level than the 1985/86 peak (425 871 tonnes) in Statistical Area 48, before falling to consistently lower levels (±20 000 tonnes) thereafter (Figure 5). Sporadic catches in Statistical Area 88 reached a peak of 10 637 tonnes in 1982/83 and exhibited a subsequent decline similar to that in Statistical Area 58 (Figure 6). The 1983/84 season yielded the lowest post-peak catch levels in Statistical Areas 48 and 88 (104 680 and 641 tonnes respectively), which occurred (5 932 tonnes) in Statistical Area 58 two seasons later (1985/86).

Plots of cumulative catch by subarea (Figures 7 and 8) again illustrate the relatively large catches in Statistical Area 48 compared with the other two areas, despite the fact that both Statistical Areas 58 and 88 are substantially larger than Statistical Area 48. It is also apparent that prior to 1979/80 substantial catches in Statistical Area 48 were reported from subareas "unknown". These were predominantly taken by the Soviet fishery and suggest that the total catch from Statistical Area 48 over the years is substantially greater than that reflected in the designated subarea data presented.

The accumulated catches were greatest in Subareas 48.2 (1 161 678 tonnes) and 48.3 (977 118 tonnes) (Figures 7a and 7b) as were annual catches (Figure 9). Similarly, the pattern of both the underlying annual trend in catches and a low 1983/84 catch in these two subareas closely resembles the overall trend for Statistical Area 48 illustrated in Figure 4. Given the relative importance of catches from Statistical Area 48, therefore, the following analyses have tended to concentrate on Subareas 48.1, 48.2 and 48.3.

2.2.3 Catch By Subarea and Month

Although monthly Soviet catches are not available prior to 1983, it is possible to plot total catches by month for various subareas and time periods (Figure 10). Monthly catch trends are remarkably similar in Subareas 48.1 and 58.4 and Area 88 as a whole (Figures 10a, 10d and 10e). Fishing commences in early spring (i.e. October/November) and is followed by a gradual increase in catches until peak levels are reached in early to mid-summer (January/February). Catches then decrease until cessation of fishing in April/May. In Subarea 48.2, on the other hand, fishing commences at a similar time but large monthly catches are taken over a much longer period (January through to April) and peak slightly later (March/April) (Figure 10b). By contrast, the fishing pattern in Subarea 48.3 is entirely different (Figure 10c). Although catches may be taken the whole year round, the highest catch levels occur between April and August (i.e. in late autumn through winter) with peak catches in June. This observed trend has been independently confirmed by Dolzhenkov et al. (1988) and in the absence of further information it must by concluded that the observed pattern of fishing in Subarea 48.3 reflects a re-direction of effort northwards as a result of the seasonal encroachment of pack-ice in Subareas 48.1 and 48.2.

A further breakdown of catches by subarea, split-year and month is shown in Figure 11. Although data are scarce prior to 1983 in Statistical Area 48 (Figures 11a to 11c), both the annual and monthly tends described above are still observable. Similarly, even though catch data are far fewer and the underlying trend more erratic, this holds true for Subareas 58.4 (as illustrated by Division 58.4.1, Figure 11d) and 88.1 (Figure 11e).

2.3 Trends in Catch-Per-Unit of Fishing Effort

2.3.1 Annual Trend

Both Shimadzu (1985a) and Everson (1988) have concluded that the most appropriate index of catch-per-unit of fishing effort for krill (particularly for the Japanese fishery) is derived from catch/hour spent fishing. Using STATLANT B data, it is possible to calculate three annual indices of catch (tonnes)/hour fished (CPH). These are:

- total CPH/year (i.e. total catch/total hours fished/split-year);
- mean CPH/fishing season (i.e. mean monthly CPH for the months when fishing took place); and
- mean CPH/year (i.e. mean monthly CPH for a full 12 month split-year).

Values for the above three indices in Statistical Area 48 are shown for the period 1982 to 1988 (both Soviet and Japanese fishery combined) in Figure 12. Indications are that despite fluctuations from year to year, all three indices illustrate a gradual increase in CPH over the past seven years, particularly in Subareas 48.1 and 48.2 (see Figures 12a and 12b). (N.B. It must be noted that a large catch of 89 tonnes in one hour reported by the Japanese fishery in Subarea 48.2 during October 1982 (see below) has been omitted from this and, unless specifically mentioned otherwise, subsequent analyses. Although there are no indications that this particular result was invalid, its inclusion would serve to magnify fluctuations in CPH and would not conform with the underlying trend indicated by the total CPH/year (see Figure 12b)). It is also apparent that the greatest returns per unit of fishing effort were from these two subareas.

Plotting CPH for the Japanese fishery (Figure 13), including "mother ship" operations between 1977/78 and 1981/82 (cf Shimadzu, 1985a; Shimadzu and Ichii, 1985; Everson, 1988), it can also be seen that although there are wide year to year fluctuations the annual catch-per-unit of fishing effort has increased markedly, at least up until the three most recent seasons (i.e. 1985/86 to 1987/88). It must also be noted that there was a marked decline in CPH during the 1983/84 season which can be compared to the decline in total catch for that season (see Figure 2). Since 1985/86, catch rates have stabilized and this is probably attributable to the rigid operational characteristics of the Japanese fishery, particularly the commitment of a limited number of vessels to specific areas (cf Shimadzu, 1985b).

2.3.2 Trends By Area and Subarea

CPH indices for both the Japanese and Soviet fisheries by subarea are given in Table 2 for all years for which data are available. From this table and data presented in Figure 14, it would appear that the Japanese catch rate is markedly better than that of other nations. With respect to the Soviet fishery, however, two factors caution against unqualified acceptance of this conclusion. First, there is a marked difference between the operational characteristics of the two fisheries (cf Ichii, 1987; Dolzhenkov et al., 1988) and, second, Soviet effort data are only available from 1983 onwards. Nevertheless, it is apparent from the CPH values given in Table 2 that Subareas 48.1 and 48.2 are the most productive for both the Soviet and Japanese fisheries, an observation supported by the catch figures already discussed.

2.3.2.1 Japanese Fishery

Monthly CPH values for the Japanese fishery in Subareas 48.1 and 88.1, and Division 58.4.1 are plotted in Figures 15a to 15c for split-years 1977 to 1988. Overall trends in the fishing pattern are similar to that observed in the catches from each area (see Figure 11).

From comparison of Figures 16 and 15b, it can be seen that the fishery in Subarea 58.4 moves southwards as the season progresses. Everson (1988) has concluded that this is a consequence of the retreat of the pack ice into the East Wind Drift zone. In addition, it is apparent that individual monthly CPH values fluctuate widely and no dominant trend is visible. Everson (1988), citing Sugimito (1977), attributes the high CPH in Division 58.4.2 (see also Figure 16a) during December 1976 to the result of fishing on a large aggregation of krill or "super-swarm". A similar effect may have produced the high CPH observed in Subarea 48.2 for October 1982 (see below).

Shimadzu (1985a) showed that during 1977 Japanese operations extended eastwards into Statistical Area 88 (Figure 15c). Subsequently, monthly CPH values in this area and Division 58.4.1 are comparable, suggesting some similarity in the type of fishing operation being undertaken and in the catchability of the krill encountered.

The Japanese krill fishery moved into Statistical Area 48 from the 1980/81 season (Shimadzu, 1985a; Everson, 1988) and both Figure 15a and Table 2 indicate that CPH was very much higher here than elsewhere. Monthly CPH values from 1981 to 1988 for the Japanese fishery in Statistical Area 48 are shown in Figure 17. These tend to follow a similar pattern to the monthly catch figures (i.e. as shown in Figures 11a and 11b), although it can be seen that since 1985/86 the fishing season in Subarea 48.1 has been extended to include April (Figure 17).

Patterns in Japanese fishing effort to a large degree reflect trends in the catch, both within and between years, already discussed. Unlike the general trend in CPH shown in Figures 12 and 13, a gradual increase and levelling off of effort in both Subareas 48.1 and 48.2 during the past three years is not apparent (Figure 18). In fact effort has declined in Subarea 48.2 since 1984/85, while increasing effort in Subarea 48.1 from 1982/83 was broken by a marked decline in the 1984/85 season. In the absence of further information, this would tend to suggest some operational change in the fishing pattern during 1984/85. Based on a report contained in the official proceedings of the CCAMLR Scientific Committee (SC-CAMLR, 1985, paragraph 5.26), there does in fact appear to have been a reduction in the number of Japanese vessels operating in both subareas during that particular season.

Other than these general trends, it is not possible to discern any clear pattern in Japanese fishing effort in the two subareas under consideration. However, as Everson (1988) has noted, the presence of fishing activity in what are effectively two adjacent subareas should allow some comparison (both between and within seasons) to be made between Subareas 48.1 and 48.2. Comparing seasonal mean CPH in the subareas (Figure 19), however, indicated that they have little in common. Similarly, plotting mean CPH in Subarea 48.1 compared with Subarea 48.2 for all fishing months and for mid-season months alone (December to February) (Figure 10) supports this observation. On the other hand, if values from the same month are compared (Figure 21) there is a tendency for a high CPH in Subarea 48.1 to be associated with a high CPH in Subarea 48.2. Everson (1988) has concluded that this suggests some link between the catchability of krill in the two subareas and given the currently expanded data set (compared with that originally analyzed by Everson) probably indicated a "real effect".

2.3.2.2 Soviet Fishery

Available Soviet CPH data (1983 to 1988) from Area 48 are confined to Subareas 48.2 and 48.3, and as for the Japanese fishery, the seasonal mean indicates a gradual increase in CPH since data became available in 1983 (Figure 22). This increase was most marked, however, from 1985/86 onwards and especially in Subarea 48.3.

Trends in the mean monthly CPH for the Soviet fishery in Subareas 48.2 and 48.3 (Figure 23) indicate a similar pattern to that of the catches (Figures 10b and 10c), namely high CPH in Subarea 48.3 from April to October compared with high values in Subarea 48.2 from December through to May. This observation is borne out by both monthly fishing effort (Figure 24) and CPH values (Figure 25) over the past six seasons, particularly high catch-per-unit effort between January and April of the 1986/87 season. In this connection it should be noted that it was during 1986 that CCAMLR restrictions on directed fishing for *Notothenia rossii* in Subarea 48.3 came into force (CCAMLR, 1988a). Plotting monthly fishing effort on an annual basis indicates a substantive increase in effort for krill during January to April, 1987 (Figure 26). It is also interesting to note that 1986/87 was the only season during which fishing occurred all year round in Subarea 48.3 and subsequently the annual mean fishing effort was highest (Table 3).

As with the Japanese fishery in Subareas 48.1 and 48.2, comparison of Soviet CPH in Subareas 48.2 and 48.3 indicates little association between krill catchability in the latter two subareas (Figure 27). Furthermore, differences in the pattern of fishing limit a comparison of CPH values from similar months in Subarea 48.2 and Subarea 48.3. As such, similarities in krill catchability observed for the Japanese fishery in Subareas 48.1 and 48.2 were not evident (i.e. comparing Figures 21 and 28).

2.4 Comparison of Fishery Dependent Data With Other Sources of Information

A number of fishery-independent surveys of krill abundance have been undertaken in the same areas and at the same time as the fisheries data described above were collected. The two methods principally employed during these surveys were acoustics (i.e. using calibrated echo-sounders) and systematic net sampling with relatively small scientific nets (Table 4). As Everson (1988) has emphasized, the data in Table 4 indicate that incongruities between survey-based estimates of krill abundance are reflected in similar estimates based on catch and effort data from the fishery. As such, CPH indices do not exhibit any clear trend relative to acoustic or net estimates.

3. DISCUSSION

In terms of CCAMLR, knowledge concerning the amount(s) of krill removed by commercial fishing operations *per se* is unlikely to be of substantial application in the management of the fishery. As both Butterworth (1986) and Everson (1988) have emphasized, there are two major reasons for this. Firstly, the Convention requires that krill resources be managed on a sustainable basis and despite information on krill removed by the fishery, knowledge concerning the long-term proportionate mortality from fishing, predation and other natural causes is still incomplete. Such knowledge is vital in ascertaining whether particular stocks can sustain themselves in the face of exploitation. Secondly, the stipulation that krill harvesting should not prejudice the potential productivity of dependent species (i.e. predators) requires careful consideration of functional relationships between predator and krill population dynamics.

Krill's large-scale distribution has been extensively discussed by various authors and a number of theories for observed patterns exist (e.g. Marr. 1962; Makarov et al., 1970; Mackintosh, 1973; Lubimova et al., 1982; Miller and Hampton, 1989). The present analyses confirm that although major concentrations of krill may be distributed throughout the CCAMLR Convention Area, commercial fishing operations have tended to concentrate in so called "hot spots" in the Atlantic (Statistical Area 48) and Indian Ocean (Statistical Area 58) sectors. Of these, both catch and catch-effort statistics indicate Statistical Area 48 to have been the most productive for most of the fishery's available history. Both these observations do not substantially contradict any of the current theories on krill distribution.

Although there is little doubt that developments in the krill fishery have been closely governed by logistic (e.g. the possible connection between restrictions on finfish and increased krill harvesting discussed for Subarea 48.3) and economic constraints (cf Shimadzu, 1985a; Everson, 1988), it would appear from the catch/effort data analyzed here and from similar analyses undertaken by Everson (1988) that there is a large natural variation in the abundance of exploited krill stocks. As far as CCAMLR is concerned, the major difficulty is that such variability cannot be adequately quantified or separated from fishery-related variation. Nevertheless it would appear that a number of unifying principles link abundance, catch and fishing effort. Such factors are demonstrated by low catches and reduced CPH for the Japanese fishery during the 1983/84 season, the relatively high "catchability" of krill in the Atlantic sector (Statistical Area 48) and some anomalously high values for catch in terms of effort (e.g. during October 1982). These results tend to confirm one of the major conclusions of the CCAMLR sponsored Krill Simulation Study, namely that catch and effort data only provide a reasonable index of krill abundance in the immediate vicinity of the fishing fleet.

Both the Soviet (Dolzhenkov et al., 1988) and to some extent the Japanese (Ichii, 1987; Butterworth, 1988) fleets tend to focus their activities on krill concentrations and swarms[1]. In this context, fishing a super-swarm (such as observed in October 1982 or described in Sugimito, 1977) would represent an extreme case of such activity. Therefore, in order to realistically determine abundance over a wider area, some measure of "search time" by the fishery is necessary to assess the spatial heterogeneity of the krill stock(s) being fished (cf Butterworth and Miller, 1987; Butterworth, 1988; Mangel, 1988). According to recommendations forthcoming from the recently held Workshop on the CCAMLR

---

[1] For definition of what constitutes a krill "concentration" and "swarm" refer to Butterworth and Miller (1987) and the "patch-within-patch model" developed by Butterworth (1988).

Krill CPUE Simulation Study this would require documentation of the start and end times of fishing (specifically for the Japanese fishery) as well as classification of the type of krill aggregation being fished (CCAMLR, 1989). Only very detailed catch/effort data on a fine-scale are likely to provide such potentially important information. Similarly, crucial information on both krill swarms and concentrations (particularly for the Soviet fishery) would be best collected acoustically (CCAMLR, 1989).

As far as dependent species (i.e. krill predators) are concerned, Murphy et al. (1988) have emphasized that a first step in determining the effects of possible interactions between krill and other species requires definition of the temporal and spatial scales over which such interactions occur. An important consequence of this approach is that in a manner analogous to catch/effort data for the fishery, localized predator population processes are unlikely to provide a suitable index of krill abundance over a wide area (Everson, 1988).

Croxall et al. (1988) have fully discussed the problems inherent in monitoring warm-blooded predators to obtain some indication of variability in krill abundance. They make the point that even if krill harvesting was to increase markedly, it would be difficult to exclude the possibility that reductions in the rate of increase of seabird and seal populations are, independently of krill harvesting, attaining the natural carrying capacity of the environment. In addition, many monitoring programs are likely, for logistic reasons, to be confined to predators that are accessible at specific times (e.g. during breeding ashore). Such circumstances tend to restrict studies of krill variability as related to predator parameters within relatively confined temporal and spatial boundaries (i.e. the foraging ranges of land-based predators). This has been recognized by Bengtson (1984) as a major shortcoming in any attempt to assess possible relationships between krill and predators over the former's greater distributional range. For this reason the CCAMLR Ecosystem Monitoring Program (SC-CAMLR, 1986) has to come to recognize the potential importance of assessing the impact of feeding over a wide area by mobile krill predators. The minke whale is a specific example of such a predator.

Returning to the fisheries data analyzed in this paper, it can be seen that despite the fact that the fishery is essentially circumpolar it is predominantly confined to three major localities, of which Subareas 48.1, 48.2 and 48.3 appear to be most important. These particular subareas already contain a number of key monitoring sites for land-based krill predators (CCAMLR, 1988b) and it remains to be seen how important these specific subareas may be with respect to more wide-ranging krill predators, such as the minke whale.

The minke whale is one of the six rorqual (*Mysticeti*: family *Balaenopteridae*) species which has been least affected by commercial whaling (Tonnessen and Johnsen, 1982; Mizroch, 1984). Like the other species of the family, the minke whale is characterized by unique anatomical adaptations which facilitate filter-feeding on krill swarms by "gulping" or "engulfment" (Nemtot, 1959). In fact it is the swarming of krill which allows minke whales to feed on krill over almost the same spatial and temporal scales as those of its own habitat (cf Murphy et al., 1988). From this, it could be assumed that if the krill fishery is also geared towards exploiting swarms (see above), then some congruence between fisheries activities and minke whale distribution could be expected.

Information on the distribution of minke whale catches is shown (Figure 29) for the months of December to March and between 1972/73 and 1979/80. It can be seen, however, that there are only relatively few similarities between whale catches and data from the krill fishery.

To a large extent, whaling during the period under consideration was predominantly confined to the Indian Ocean (Statistical Area 58) and Pacific (Statistical Area 88) sectors. In contrast, krill fishing was primarily undertaken in the west Atlantic (Statistical

Area 48). Although there may be logistic reasons for this, the overall lower catch-per-unit of effort for the krill fishery in Statistical Areas 58 and 88 (Figure 15) suggest that (for whatever reason) minke whales were in fact being harvested in areas where krill were being fished. Such conclusions, however, are reached in the absence of detailed information from the major krill fishery (i.e. that of the Soviet Union) which only became available from 1983 onwards. In this connection, it is interesting to note that Ichii (1987) has reported considerable variability in observed associations between minke whale sightings and the presence of krill swarms.

Despite the above observations, some similarities exist between the geographic distribution of minke whale and krill catches by month. It can be seen that as the austral summer progresses, whale catches are taken farther south, particularly in the Indian Ocean (i.e. Statistical Area 58). This is directly analagous to the southward movement of the krill fishery in the same area (Figure 16). Furthermore, there is a steady decline in the number of whales caught between January and March which is similar to the decline in krill catches (Figures 10d and 10e) over the same period in Statistical Areas 88 and 58. Given the state of the available data, however, it is not possible to draw more specific associations between the distribution of krill fishing and minke whale catches.

It must be concluded therefore that in view of the demonstrated incompatibilities between the krill fishery and minke whale catch data, there is little to be gained in terms of understanding minke whale-krill interactions from coarse comparisons of the kind undertaken here. This is not to say that plotting the temporal and spatial associations of krill fishing and whale catches on a finer scale may not lead to some insight(s) into the form of the functional relationship(s) between krill distribution and whale feeding. It is difficult, however, to see how such information could be realistically applied in the absence of minke whale stomach contents data at a similar level of resolution as fine-scale information from the fishery. Finally, in attempting to monitor the recovery of whale stocks (also a requirement of CCAMLR) in the face of krill exploitation, considerably more information is required on the functional relationship(s) between krill aggregation and whale distribution at a variety of scales. In this connection, comparison of contemporaneous minke whale sightings (particularly on feeding animals) with both fisheries-dependent and independent survey data on krill distribution/abundance, especially acoustic information on aggregations, should be encouraged.

ACKNOWLEDGEMENTS

I would like to thank Dr L.D. Jacobson (Data Manager) and all the CCAMLR Secretariat staff for assistance in compiling the necessary krill fisheries data. The individual national ownership of such data is also gratefully acknowledged. Financial support was provided by the Sea Fisheries Research Institute.

REFERENCES

BENGTSON, J.L. 1984. Monitoring indicators of possible ecological changes in the Antarctic marine ecosystem. In: *Selected Papers Presented to the Scientific Committee of CCAMLR, 1982 to 1984. Part II.* CCAMLR: Hobart, Australia. (1985): 43-153.

BIOMASS. 1986. Post-FIBEX Acoustic Workshop. *BIOMASS Rept. Ser. No. 40*: 106.

BUDZINSKI, F., P. BYKOWSKI, D. DUTKIEWICZ. 1985. Possibilities of processing and marketing of products made from Antarctic krill. *FAO Fish Tech. Pap. 268*: 46.

BURUKOVSKIY, R.N. and B.A. YARAGOV. 1967. Studying the Antarctic krill for the purpose of organizing krill fisheries. In: BURUKOVSKIY, R.N. (Ed.). *Soviet Fishery Research on Antarctic Krill*: US Department of Commerce. Washington D.C. (TT 67-32683): 5-17.

BUTTERWORTH, D.S. 1986. Antarctic ecosystem management. *Polar Rec. 23*: 37-47.

BUTTERWORTH, D.S. 1988. A simulation study of krill fishing by an individual Japanese trawler. In: *Selected Scientific Papers, 1988 - Part I. SC-CAMLR-SSP/5*: Hobart, Australia.

BUTTERWORTH, D.S. and D.G.M. MILLER. 1987. A note on relating Antarctic krill catch-per-unit effort measures to abundance trends. *S. Afr. J. Antarct. Res. 17*(2): 108-112.

CCAMLR. 1988a. Basic Documents: Convention for the Conservation of Antarctic Marine Living Resources. CCAMLR: Hobart, Australia. pp. 117.

CCAMLR. 1988b. CCAMLR Ecosystem Monitoring Program: Standard methods for monitoring parameters of predatory species. SC-CAMLR: Hobart, Australia. pp. 61.

CCAMLR. 1989. Report of the Workshop on the Krill CPUE Simulation Study Workshop. SC-CAMLR-VIII, Annex 4.

CROXALL, J.P., T.S. McCANN, P.A. PRINCE and P. ROTHERY. 1988. Reproductive performance of seabirds and seals at South Georgia and Signy Island, South Orkney Islands, 1976-1987: Implications for Southern Ocean monitoring studies. In: SAHRHAGE, D. (Ed). *Antarctic Oceans and Resources Variability*. Berlin, Heidelberg: Springer-Verlag. pp. 261-285.

DOLZHENKOV, V.N., T.G. LUBIMOVA, R.R. MAKAROV, S.S. PARFENOVICH and V.A. SPIRIDONOV. 1988. Some specific features of the USSR krill fishery and possibilities of applying fishery statistics to studies of krill biology and stocks. In: *Selected Scientific Papers, 1988 - Part I. SC-CAMLR-SSP/5*: Hobart, Australia.

EDDIE, G.C. 1977. The harvesting of krill. Southern Ocean Fisheries Survey Program. Food and Agricultural Organization of the United Nations: Rome. *FAO GLO/SO/77/2*: 76.

EL-SAYED, S.Z. and M.A. McWHINNIE. 1979. Protein of the last frontier. *Oceanus 22*: 13-20.

EVERSON, I. 1977. The living resources of the Southern Ocean. Southern Ocean Fisheries Survey Program. Food and Agricultural Organization of the United Nations: Rome. *FAO GLO/SO/77/1*: 156.

EVERSON, I. 1978. Antarctic fisheries. *Polar Rec. 19*: 233-251.

EVERSON, I. 1988. Can we satisfactorily estimate variation in krill abundance? In: SAHRHAGE, D. (Ed.). *Antarctic Oceans and Resources Variability*. Berlin, Heidelberg: Springer-Verlag. pp. 199-208.

FAO. 1976. *FAO Yearbook of Fishery Statistics*. FAO: Rome. pp. 336.

GRANTHAM, G.J. 1977. The utilization of krill. Southern Ocean Fisheries Survey Program. Food and Agricultural Organization of the United Nations: Rome. *FAO GLO/SO/77/3*: 61.

GULLAND, J.A. 1983. The development of fisheries and stock assessment of resources in the Southern Ocean. *Mem. Natl. Inst. Polar Res. Spec. Issue 27*: 233-246.

HIGGINBOTTOM, I.R., K.R. KERRY, and S.E. WAYTE. 1988. Hydroacoustic surveys of the distribution and abundance of krill: Prydz Bay region - FIBEX, ADBEX II and SIBEX II, MV *Nella Dan*. *ANARE Res. Notes 62*: 47.

ICHII, T. 1987. Observations of fishing operations on a krill trawler and distributional behaviour of krill of Wilkes Land during the 1985/86 season. In: *Selected Scientific Papers, 1987. SC-CAMLR-SSP/4*: Hobart, Australia. pp. 335-368.

IVANOV, B.G. 1970. On the biology of the Antarctic krill. *Mar. Biol. 7*: 340-351.

KALINOWSKI, J. 1982. Distribution and stocks of Antarctic krill in the Drake Passage and the Bransfield Strait, during the BIOMASS-SIBEX expedition 1981. *Pol. Polar Res. 3:* 243-251.

KALINOWSKI, J., M. GODLEWSKA and L. KLUSEK. 1985. Distribution and stocks of krill in the Bransfield Strait and the Drake Passage during December 1983 to January 1984, BIOMASS-SIBEX. *Pol. Polar Res. 6*: 151-158.

KLINDT, H. 1986. Acoustic estimates of the distribution and stock size of krill around Elephant Island during SIBEX I and II in 1983, 1984 and 1985. *Arch. FischWiss. 37*: 107-127.

KNOX, G.A. 1984. The key role of krill in the ecosystem of the Southern Ocean with special reference to the Convention on the Conservation of Antarctic Marine Living Resources. *Ocean Management 9*:113-156.

LILLO, S. and O. GUZMAN. 1982. Study of the abundance, distribution and behaviour of krill in the Bransfield Strait and Drake Passage by means of hydroacoustic techniques. *INACH Sci. Ser. 28*: 17-45.

LUBIMOVA, T.G., R.R. MAKAROV, V.V. MASLENNIKOV, V.V. SHEVTSOV and K.V. SHUST. 1982. The ecological peculiarities, stocks and role of *E. superba* in the trophic structure of the Antarctic ecosystem. [Translation of report originally publish in Russian. Trudy VNIRO: Moscow]. In: *Selected Scientific Papers, 1982-1984. Part II*. CCAMLR: Hobart, Australia. 1985. pp. 391-505.

MACKINTOSH, N.A. 1973. Distribution of post-larval krill in the Antarctic. *Discovery Rept. 36*: 95-156.

MAKAROV, R.R., A.G. NAUMOV and V.V. SHEVTSOV. 1970. The biology and distribution of the Antarctic krill. In: HOLDGATE, M.W. (Ed.). *Antarctic Ecology, Vol. I*. London: Academic Press. pp. 173-176.

MANGEL, M. 1988. Analysis and modelling of the Soviet Southern Ocean krill fleet. In: *Selected Scientific Papers, 1988 - Part I. SC-CAMLR-SSP/5*: Hobart, Australia.

MARR, J.W.S. 1962. The natural history and geography of the Antarctic krill (*Euphausia superba* Dana). *Discovery Rept. 32*: 33-464.

MILLER, D.G.M. 1986. Results from biological investigations of krill (*Euphausia superba*) in the southern Indian Ocean during SIBEX-I. *Men. Natl. Inst. Polar Res. Spec. Issue 40*: 117-139.

MILLER, D.G.M. 1987. The South African SIBEX II Cruise to the Prydz Bay region, 1985. *S. Afr. J. Antarct. Res. 17*(2): 101-107.

MILLER, D.G.M. and I. HAMPTON. 1989. Biology and ecology of the Antarctic krill (*Euphausia superba* Dana): A review. *BIOMASS Sci. Ser. Vol. 9*: 166.

MIZROCH, S.A. 1984. The development of Balaenopterid whaling in the Antarctic. *Cetus 5*(2): 6-10.

MIZROCH, S.A. et al. 1985. Preliminary atlas of Balaenopterid whale distribution in the Southern Ocean based on pelagic catch data. In: *Selected Papers Presented to the Scientific Committee of CCAMLR, 1985*. CCAMLR: Hobart, Australia. pp. 113-193.

MURPHY, E.J., D.J. MORRIS, J.L. WATKINS and J. PRIDDLE. 1988. Scales of interaction between Antarctic krill and the environment. In: SAHRHAGE, D. (Ed.). *Antarctic Oceans and Resources Variability.* Berlin, Heidelberg: Springer-Verlag. pp. 120-130.

NAST, F. 1986. Changes in krill abundance and in other zooplankton relative to the Weddell Scotia Confluence around Elephant Island in November 1983, November 1984 and March 1985. *Arch. FischWiss. 37*: 73-94.

NEMOTO, T. 1959. Food of baleen whales with reference to whale movements. *Scient. Rep. Whale Res. Inst. 14*:149-290.

NEMOTO, T. and K. NASU. 1975. Present status of exploitation and biology of krill in the Antarctic. In: *Oceanology International.* London: BPS Exhibitions Ltd. 00353-360.

ROBINSON, M.A. 1982. Prospects for world fisheries to 2000. *FAO Fish. Circ. 722*: 16.

SC-CAMLR. 1985. Report of the Fourth Meeting of the Scientific Committee. CCAMLR: Hobart, Australia. SC-CAMLR-IV. pp. 1-54.

SC-CAMLR. 1986. Report of the Fifth Meeting of the Scientific Committee. CCAMLR: Hobart, Australia. SC-CAMLR-V, Annex 6: 145-190.

SHIMADZU, Y. 1985a. A brief summary of Japanese fishing activity relating to Antarctic Krill, 1972/73 to 1982/83. In: *Selected Scientific Papers, 1982-1984 - Part I.* CCAMLR: Hobart, Australia. 1985. pp. 439-471.

SHIMADZU, Y. 1985b. An updated information of the Japanese krill fishery in the Antarctic. CCAMLR: Hobart, Australia. CCAMLR Document Krill-WG/1985/Doc. 5: 7.

SHIMADZU, Y. and T. ICHII. 1985. Some considerations on the usefulness of CPUE data from Japanese krill fishery in the Antarctic. CCAMLR: Hobart, Australia. CCAMLR Document Krill-WG/1985/Doc. 4: 10.

SUGIMOTO, S. 1977. On the status of the Antarctic krill fishery in 1976/77 season. *Rep. Meet. Fish.Top. Japan Soc. Sci. Fish. No. 11.* (In Japanese).

STASENKO, V.D. 1967. Determining the rational krill fishing methods and the commercial effectiveness of the chosen fishing gear. In: BURUKOVSKIY, R.N. (Ed.). *Soviet Fishery Research on Antarctic krill.* US Department of Commerce: Washington DC. (TT 67-32683): 61-78.

TONNESSEN, J.N. and A.O. JOHNSEN. 1982. The History of Modern Whaling. Berkley: University of California Press. pp. 798.

Table 1: Annual krill catches prior to 1973/74 (from Everson, 1978 and Bengtson, 1984).

Season	Catch (t)	Comments	Reference
1961/62	4	krill	Burukovskiy and Yaragov (1967)
1963/64	70	krill	Stasenko (1967)
1964/65	306	krill	Nemoto and Nasu (1975)
1966/67	?	krill	Nemoto and Nasu (1975)
1967/68	>140	krill	Ivanov (1970)
1969/70	100	UMC*	FAO (1976)
1970/71	1300	UMC*	FAO (1976)
1971/72	2100	UMC*	FAO (1976)
1972/73	7459	krill	FAO (1976) Nemoto and Nasu (1975)

* Catches of "Unspecified Marine Crustacea" for areas closely adjacent to the Antarctic are assumed by Everson (1978) to be krill.

Table 2: Total catch/hour fished/year (1), mean catch/hour fished/fishing season (2), and mean catch/hour fished/year (3) for the Soviet and Japanese krill fisheries by subarea. All data are given in t/hr; for explanation of indices of effort refer to text.

	48.1	48.2	48.3	58.4	58.4.1	58.4.2	88.1
Japanese fishery							
1	12.13	18.89	- - - -	- - - -	5.81	5.73	5.32
2	12.96	14.80	- - - -	- - - -	4.18	4.67	5.54
3	4.55	5.62	- - - -	- - - -	1.97	1.71	1.21
Year*	81-88	82-88	- - - -	- - - -	76-87	74-83	77-87
Soviet fishery							
1	- - - -	6.20	5.69	3.88	- - - -	- - - -	- - - -
2	2.44	5.20	4.85	4.05	- - - -	- - - -	3.43
3	- - - -	3.44	3.16	1.55	- - - -	- - - -	- - - -
Year*	83	83-88	83-88	83-88**	- - - -	- - - -	87

* Split-year
* * Excluding 1986 (no data)

Table 3: Mean annual (/12 month period) and seasonal (/months fished) fishing effort (hours fished) for the Soviet krill fishery in Subarea 48.3, 1983 to 1988.

Year	Mean annual effort (hours fished)	Mean seasonal effort (hours fished)
1983	170.92	683.67
1984	576.50	1383.60
1985	726.92	1744.60
1986	2233.50	2978.00
1987	3635.83	3635.83
1988	2913.92	3885.22

Table 4: Updated version of Table 3 in Everson (1988) comparing CPH and independent survey estimates of abundance during the same months and in approximately the same areas. Data pairs in brackets are the result of different analyses on the same data sets.

Date	Location of study	Subarea	Biomass (tonnes)	Density (published)	Density estimated (g/m^2)	CPUE (Japan)	Ref for survey
Acoustic surveys (FRG)							
Oct/Nov 1983	SIBEX I	48.1	51680	$7.2 g/10^3 m^3$	0.72	10.25, 13.75	Klindt 1986
Nov/Dec 1984	SIBEX II	48.1	379750	$54.8 g/10^3 m^3$	5.48	9.89, 18.15	Klindt 1986
Mar/Apr 1985	SIBEX II	48.1	16490	$2.6 g/10^3 m^3$	0.26	(9.46 Feb)	Klindt 1986
Acoustic surveys (Poland)							
Feb/Mar 1981	FIBEX (Drake Pass.)	48.1	(1195572	$28.9 t/nm^2$	8.40*)	20.08 -	Kalinowski 1982
			(62000		)	20.08 -	BIOMASS 1986
	FIBEX (Drake Pass.)	48.1	(70827	$34.0 t/nm^2$	9.93*)	20.08 -	Lillo & Guzman 1982
			(182000	$7.2/m^3$	715.00)	20.08 -	BIOMASS 1986
	FIBEX (Bransfield St)	48.1	(2271000	$346.0 t/nm^2$	100.00*)	20.08 -	Kalinowski 1982
			(136000	$4.7 g/m^3$	468.00)	20.08 -	BIOMASS 1986
	FIBEX (Bransfield St)	48.1	(448795	$76.2 t/nm^2$	22.26*)	20.08 -	Lillo & Guzman 1982
			(800000	$32.2 g/m^3$	3225.00)	20.08 -	BIOMASS 1986
Dec/Jan 1983/84	SIBEX I (Drake Pass.)	48.1	122470	$4.0 t/nm^2$	1.17*	18.15, 10.70	Kalinowski et al. 1985
	SIBEX I (Bransfield Strait)	48.1	70593	$3.0 t/nm^2$	0.88*	18.15, 10.70	Kalinowski et at. 1985

* Assumes one tonne per nautical square mile = 0.292 g/m^2. All density values assume a depth range of 100 m.

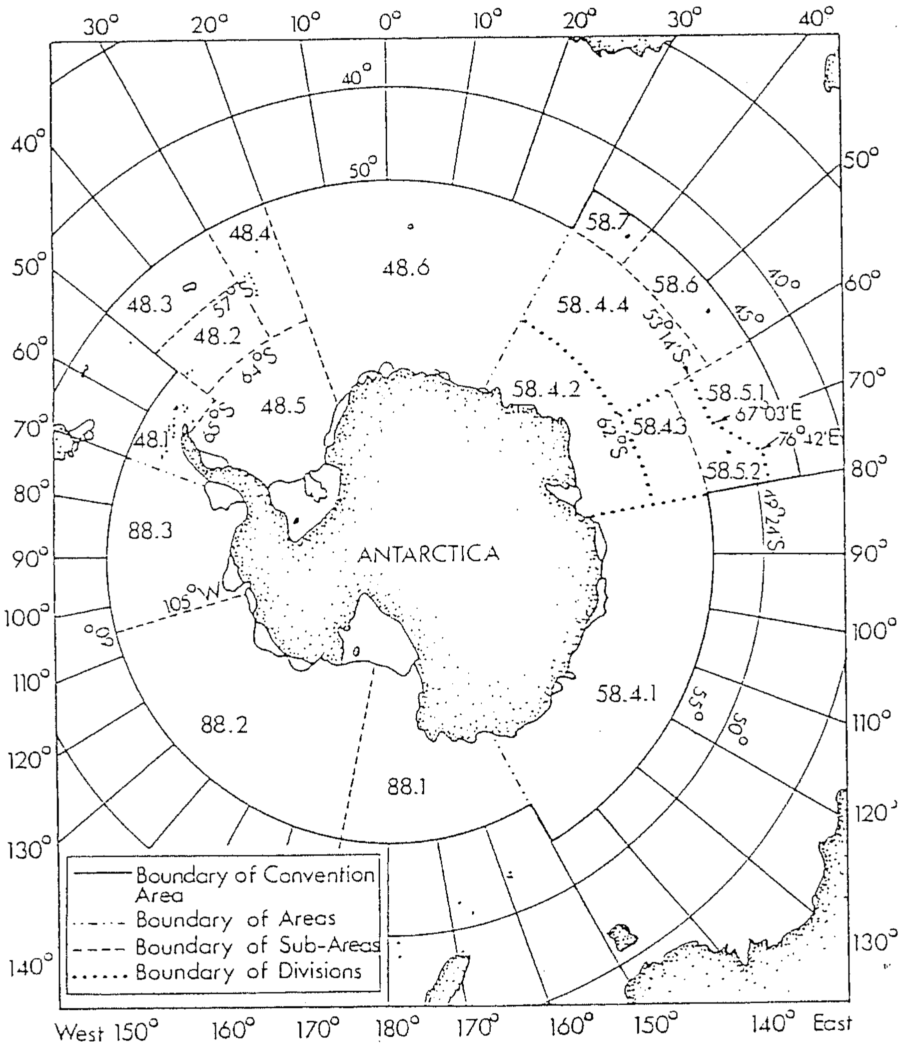
** Daytime data only.

Table 4 (continued)

Date	Location of study	Subarea	Biomass (tonnes)	Density (published)	Density estimated (g/m^2)	CPUE (Japan)	Ref for survey
Acoustic surveys (Australia, France, Japan, South Africa)							
Feb/Mar 1981	FIBEX (Prydz Bay Bouvet Is.)	58.4.2 48.6	4512000	-	1.97	4.24, 3.60	BIOMASS 1986
Feb/Mar 1985	SIBEX II (Prydz Bay)	58.4.2	124000	$48.0 g/m^3$	0.48	- -	Miller 1987
Jan/Mar 1981	FIBEX (Prydz Bay)	58.4.2	**1600000	$1.1 g/m^2$	-	3.30, 4.24, 4.60	Higginbottom et al. 1988
Jan/Feb 1984	ADBEX (Prydz Bay)	58.4.2	**3500000	$2.7 g/m^2$	-	-	Higginbottom et al. 1988
Jan 1985	SIBEX II (Prydz Bay)	58.4.1	**3700000	$2.9 g/m^2$	-	5.04	Higginbottom et al. 1988
Net haul surveys							
Oct/Nov 1983	SIBEX I	48.1	723000	$103.2 g/10^3 m^3$	10.32	10.25, 13.75	Nast 1986
Mar/Apr 1984	SIBEX I	58.4.2	550000	$34.8 g/10^3 m^3$	3.48	- -	Miller 1986
Nov/Dec 1984	SIBEX II	48.1	25200	$36.0 g/10^3 m^3$	3.60	- , 106	
Mar/Apr 1985	SIBEX II	48.1	164000	$23.4 g/10^3 m^3$	2.34	(9.46 Feb)	Nast 1986

* Assumes one tonne per nautical square mile = $0.292 g/m^2$. All density values assume a depth range of 100 m.

* * Daytime data only.



AREA 48	ATLANTIC ANTARCTIC AREA		
	48.1	Peninsula Subarea	
	48.2	South Orkney Subarea	
	48.3	South Georgia Subarea	
	48.4	South Sandwich Subarea	
	48.5	Weddell Subarea	
	48.6	Bouvet Subarea	
AREA 58	INDIAN OCEAN ANTARCTIC AREA		
	58.4	Enderby-Wilkes Subarea	
		58.4.1	Enderby-Wilkes Division 1
		58.4.2	Enderby-Wilkes Division 2
		58.4.3	Enderby-Wilkes Division 3
		58.4.4	Enderby-Wilkes Division 4
	58.5	Kerguelen Subarea	
		58.5.1	Kerguelen Division
		58.5.2	McDonald-Heard Division
	58.6	Crozet Subarea	
	58.7	Marine-Prince Edward Subarea	
AREA 88	PACIFIC ANTARCTIC AREA		
	88.1	Eastern Ross Subarea	
	88.2	Western Ross Subarea	
	88.3	Amundsen Sea Subarea	

Figure 1: Statistical areas, subareas and divisions of the CCAMLR Convention Area (CCAMLR, 1988a).

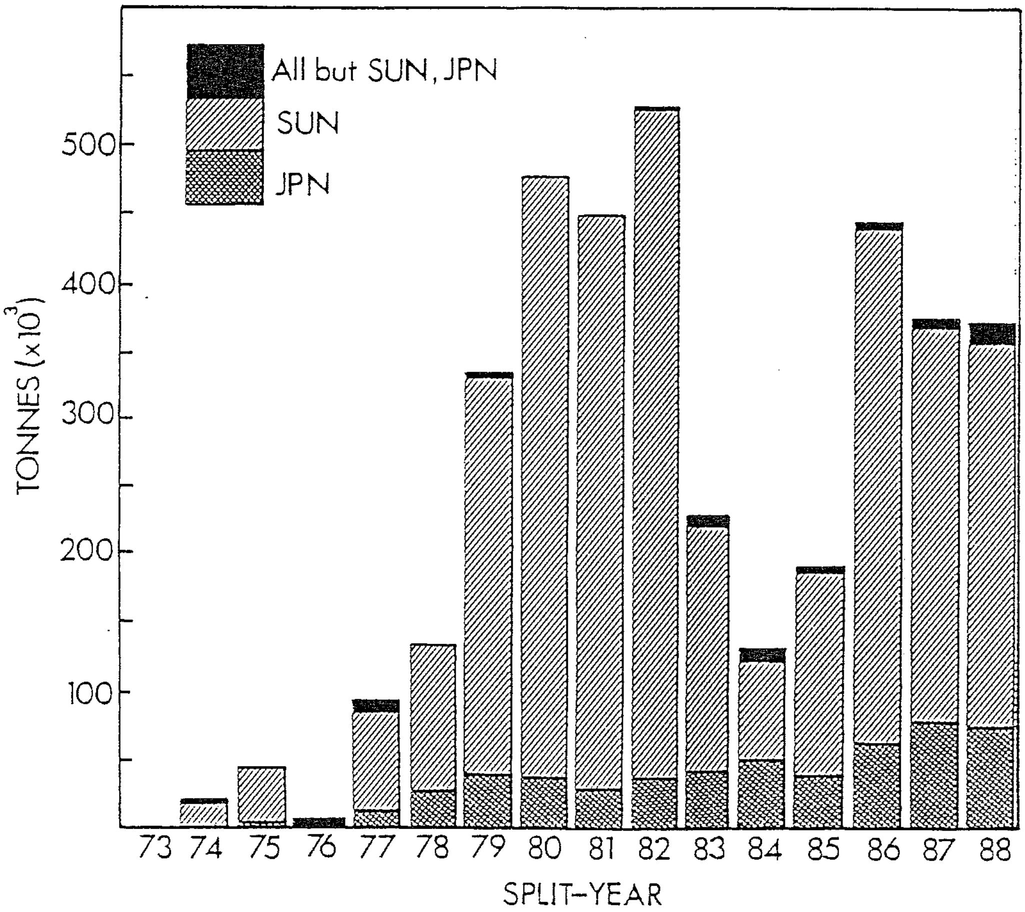


Figure 2: Reported annual krill catches by country from the CCAMLR area (SUN = Soviet Union, JPN = Japan. All but SUN, JPN = Brazil, Chile, GDR, Korea and Poland).

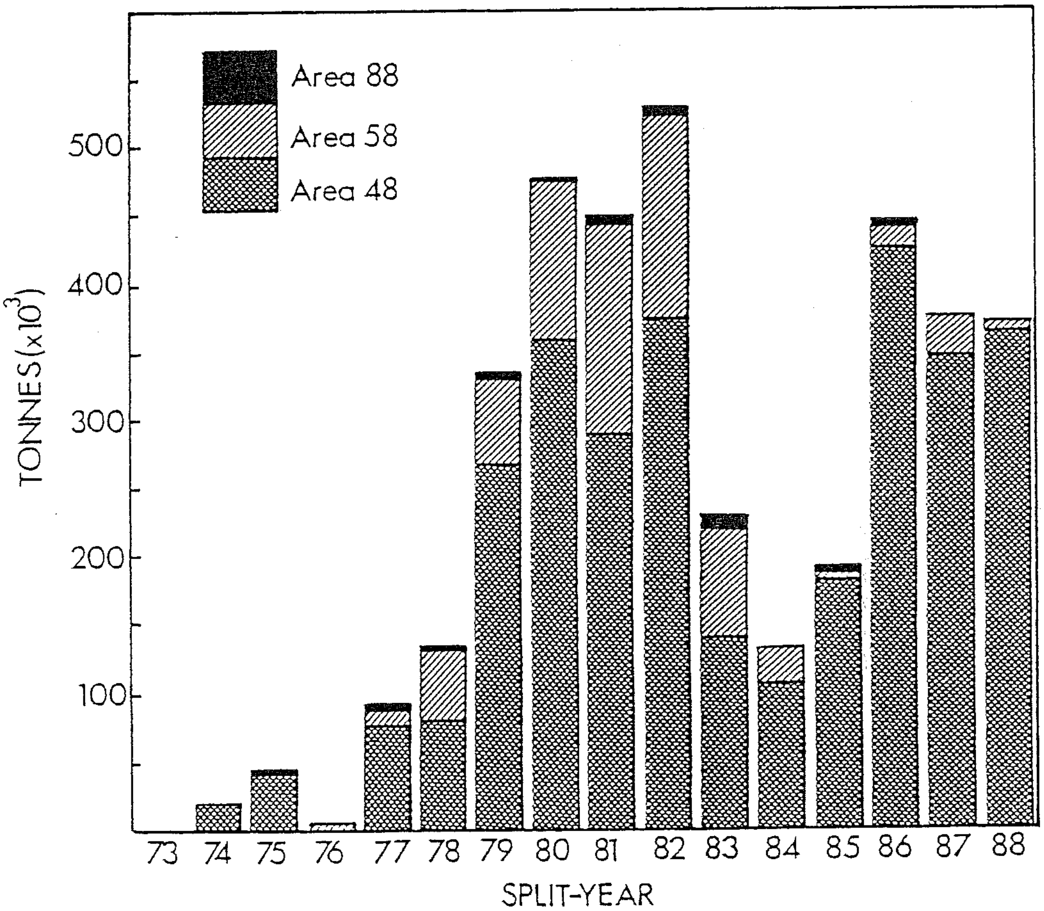


Figure 3: Reported annual krill catches by statistical area from the CCAMLR Covention Area.

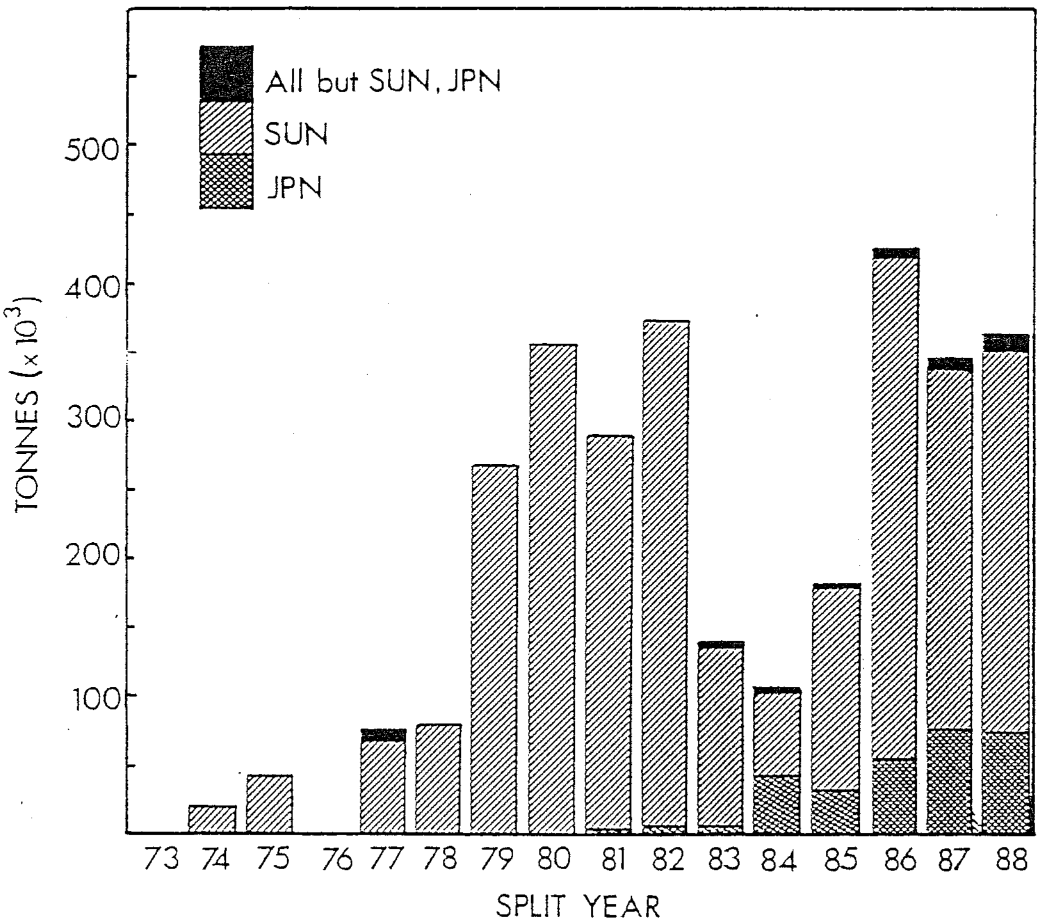


Figure 4: Reported annual krill catches by country in Statistical Area 48.

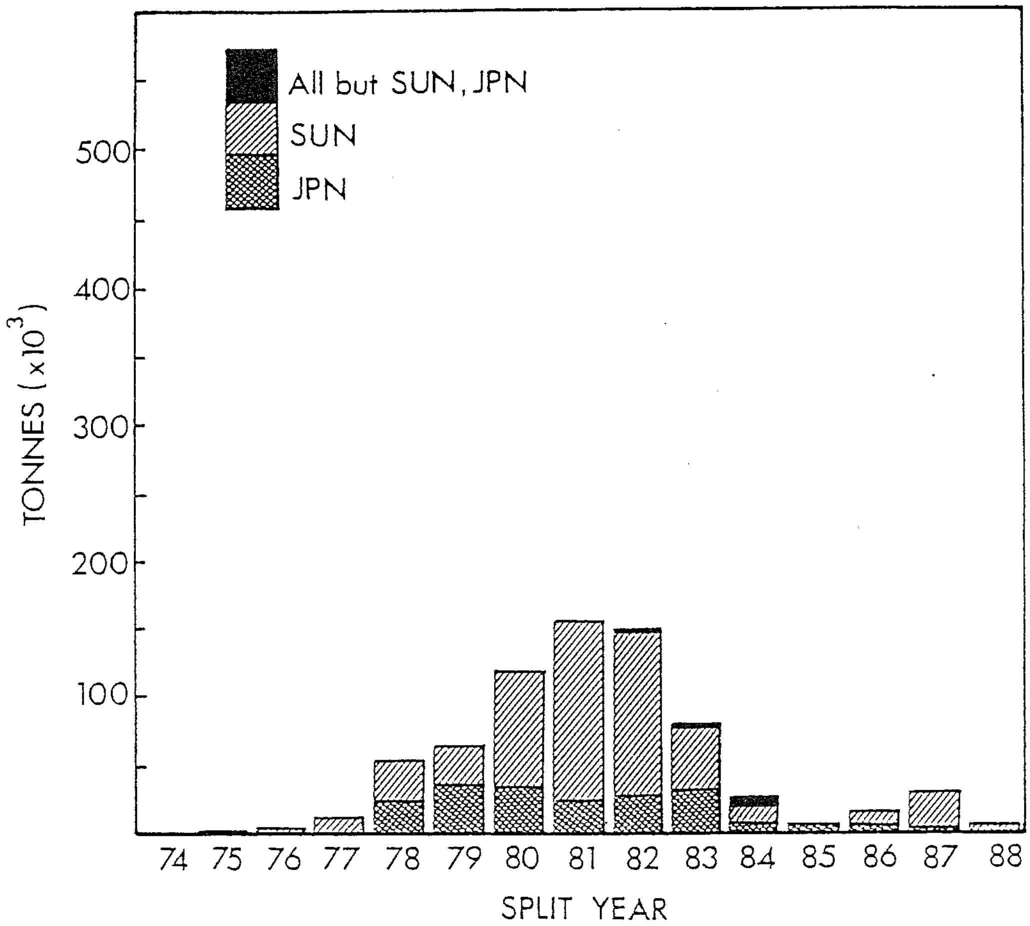


Figure 5: Reported annual krill catches by country in Statistical Area 58.

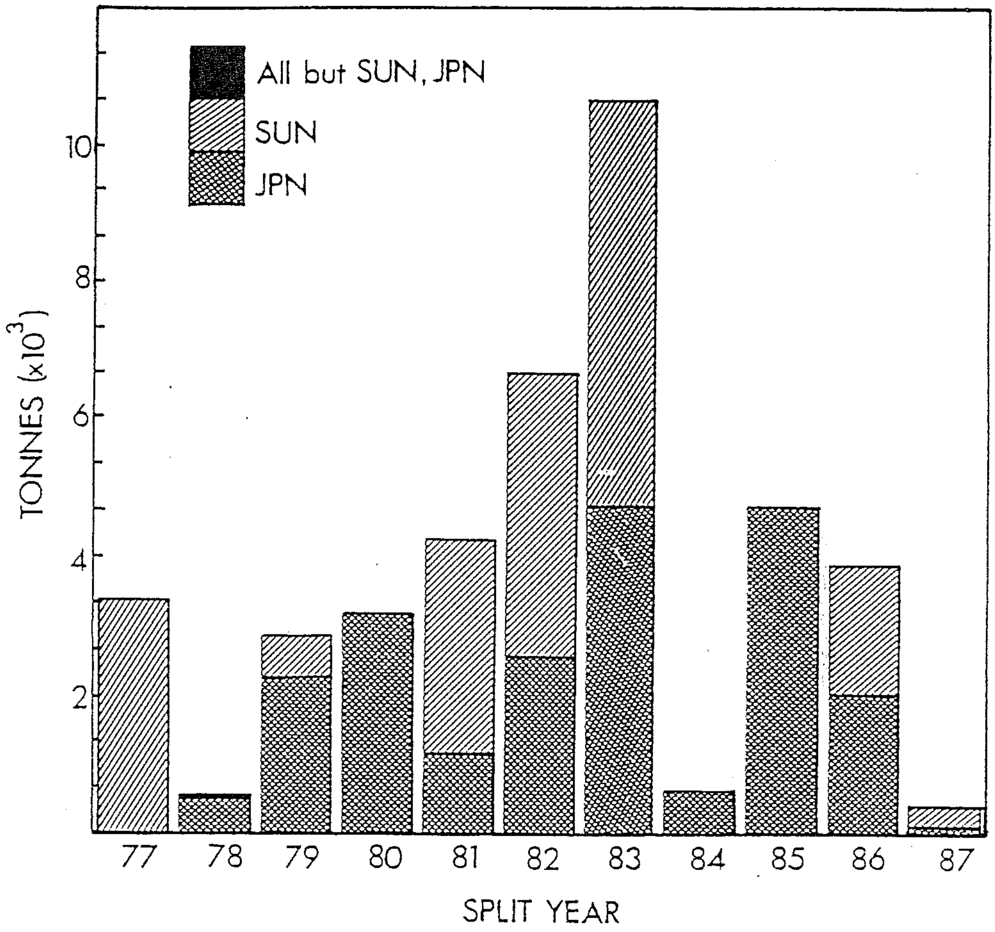


Figure 6: Reported annual krill catches by country in Statistical Area 88.

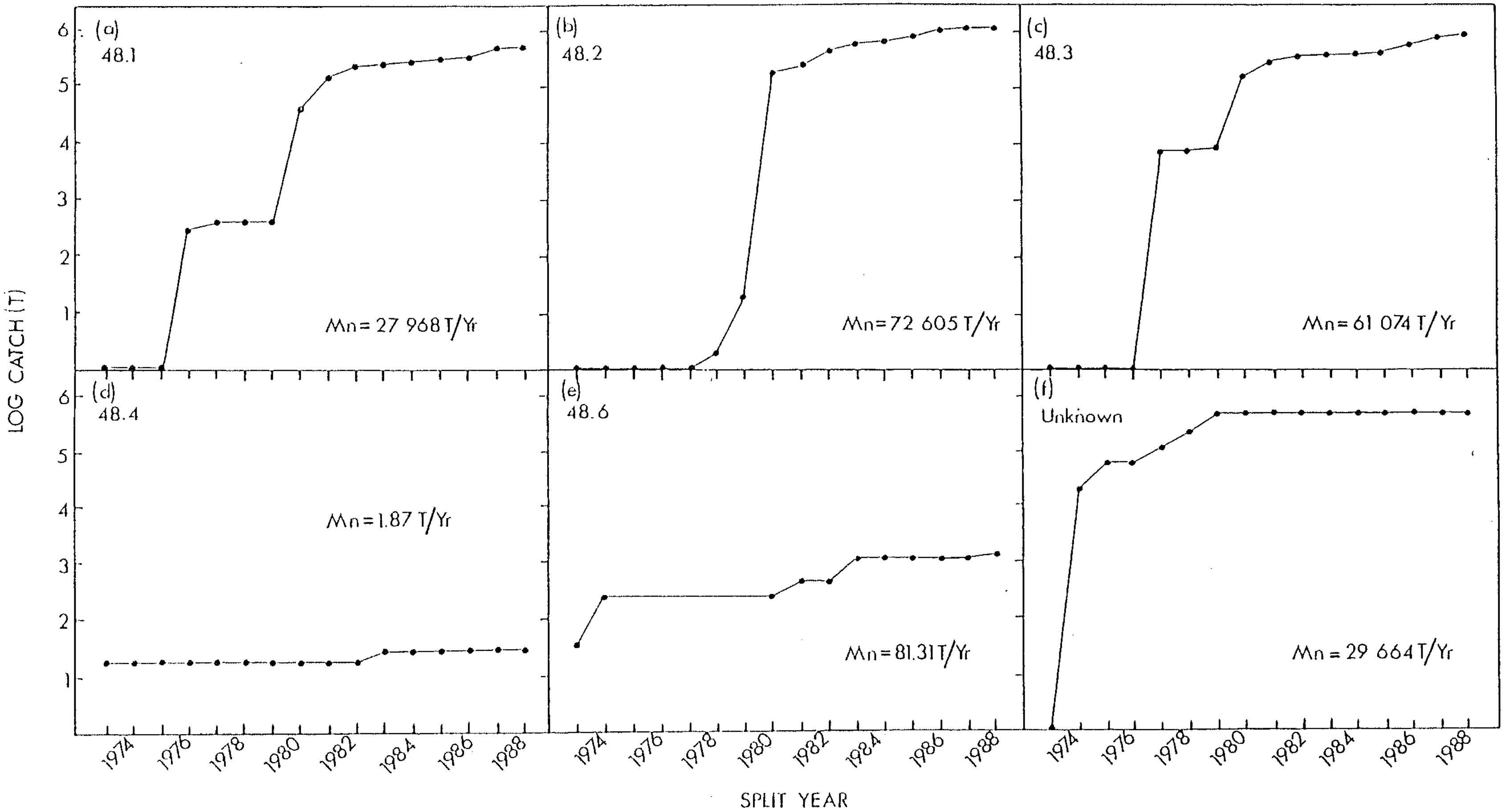


Figure 7: Cumulative krill catches from Subareas (a) 48.1, (b) 48.2, (c) 48.3, (d) 48.4, (e) 48.6 and (f) "unknown".

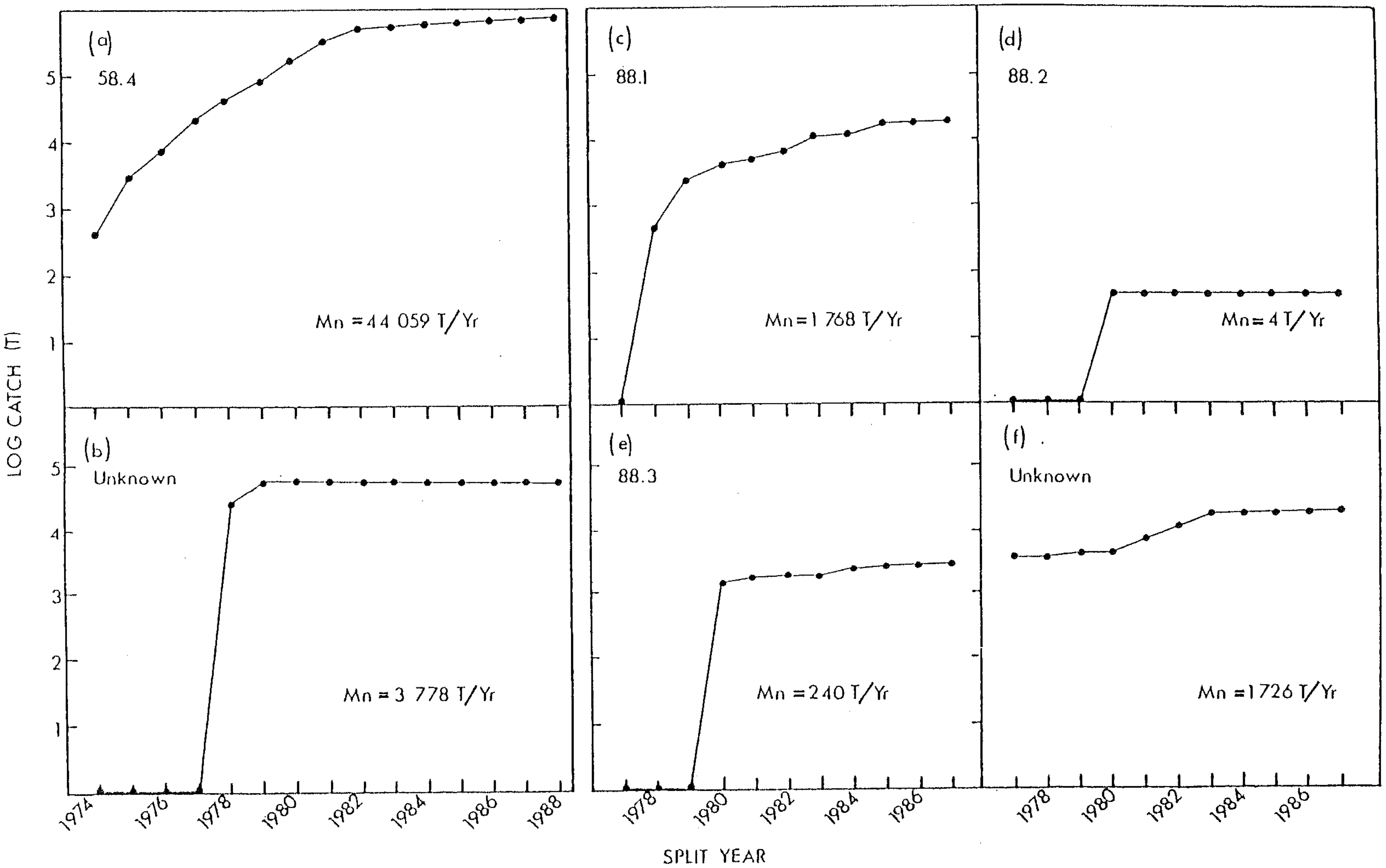


Figure 8: Cumulative krill catches from Subareas (a) 58.4, (b) 58 "unknown", (c) 88.1, (d) 88.2, (e) 88.3, and (f) 88 "unknown".

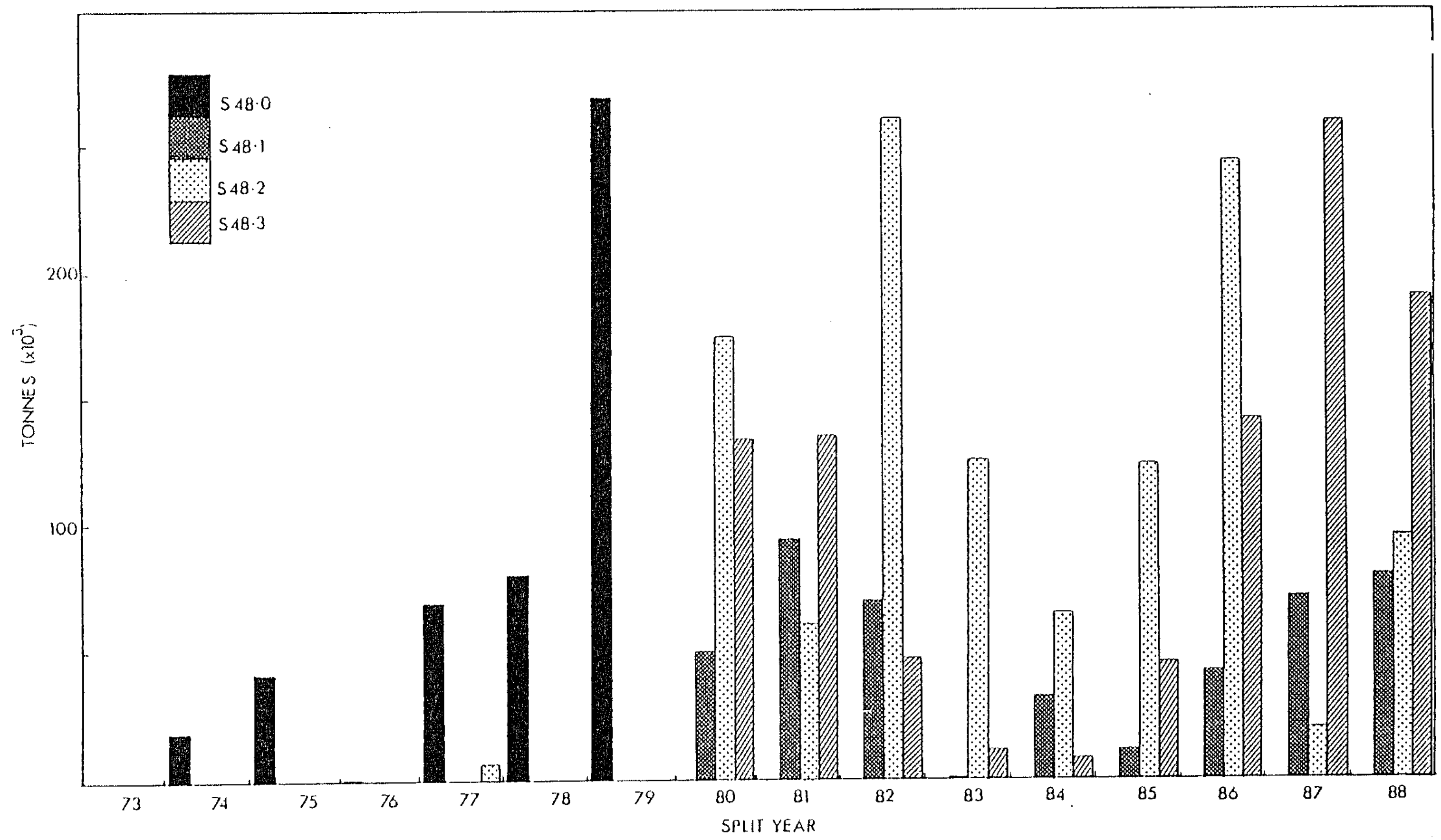


Figure 9: Annual krill catches from Statistical Area 48 by selected subarea.

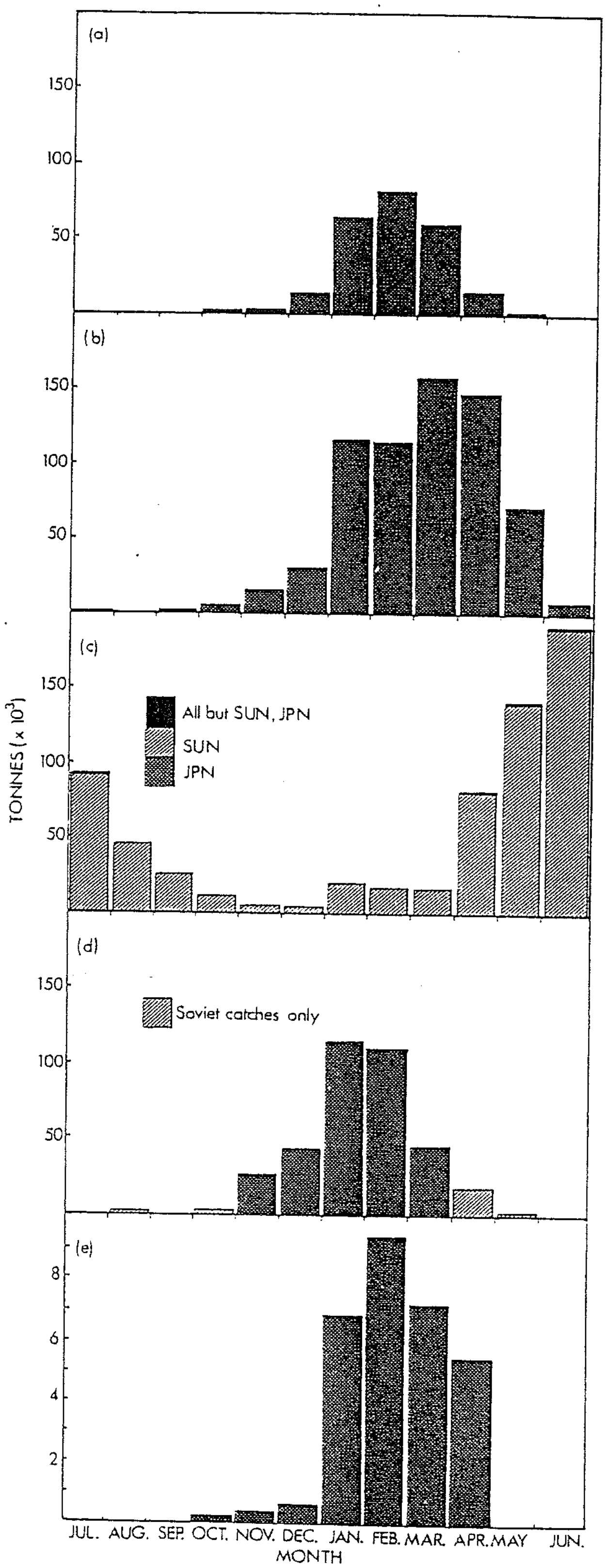


Figure 10: Krill catches by month in Subareas (a) 48.1, (b) 48.2 and (c) 48.3 (1982/83 to 1987/88), and in Areas (d) 58 (1973/74 to 1987/88 - Soviet data from 1982/83 only) and (e) 88 (1976/77 to 1986/87 - Japanese data only).

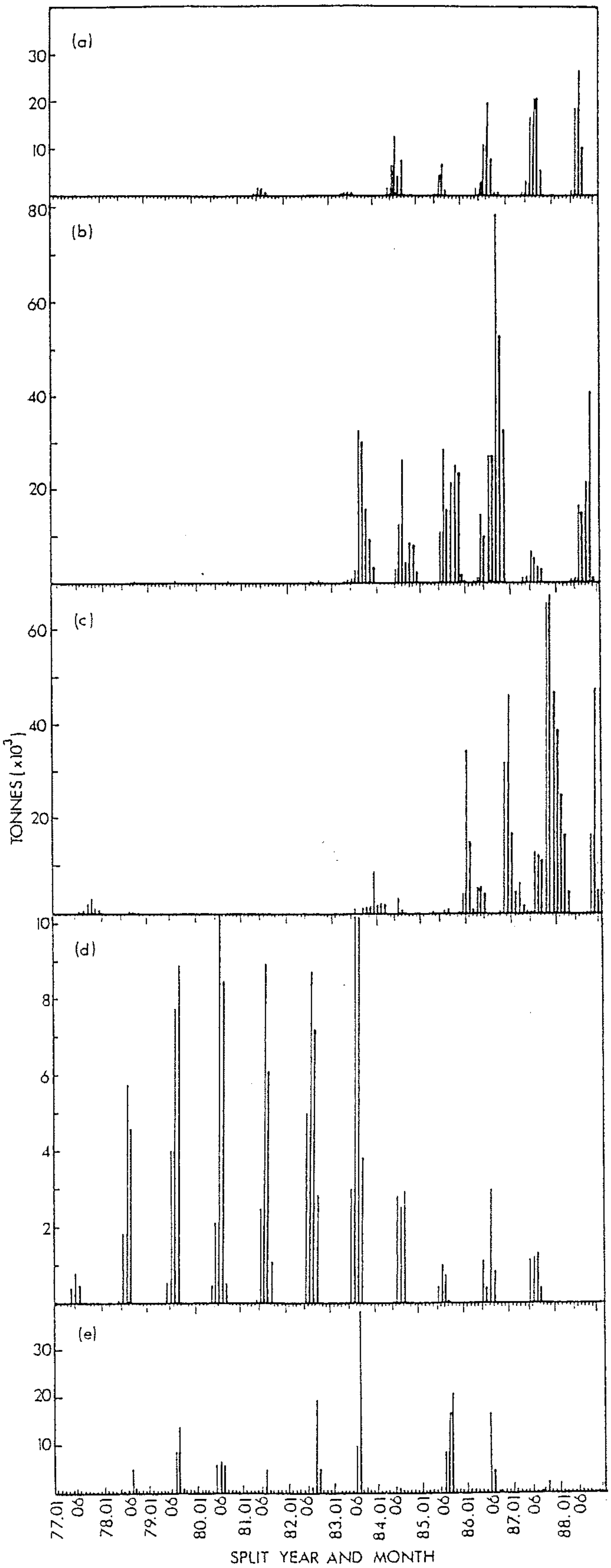


Figure 11: Krill catches by split-year and month for the period 1976/77 to 1987/88 in Subareas (a) 48.1, (b) 48.2 and (c) 48.3, (d) Division 58.4.1 (Japanese data only) and (e) Subarea 88.1 (Japanese data only). Months are numbered according to split-year (e.g. 88.03 on the horizontal axis means the third month of the 1987/88 split-year, i.e. September) - see text for further details.

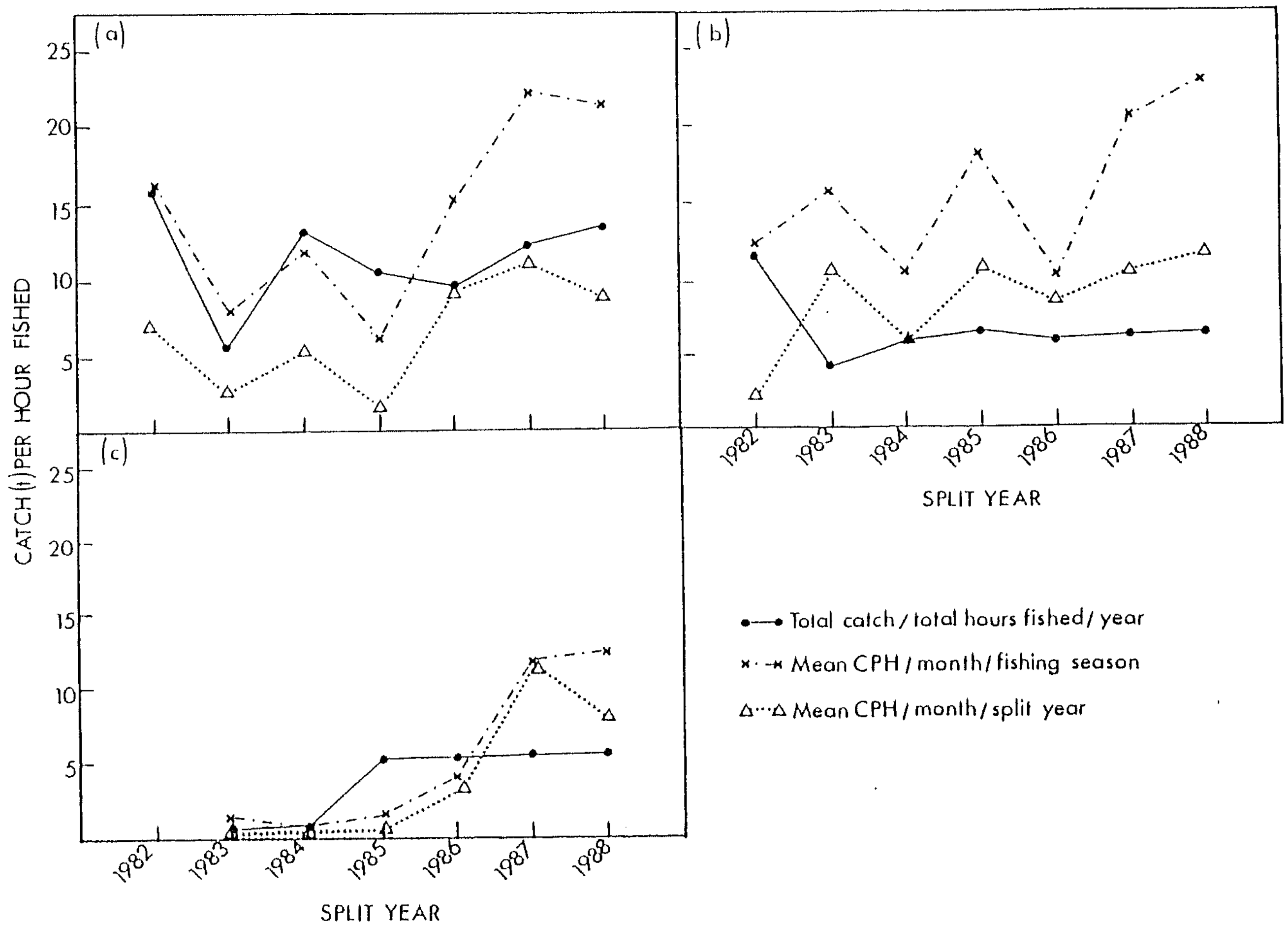


Figure 12: Krill catch (tonnes) per hour fished (CPH) indices in Subareas (a) 48.1, (b) 48.2 and (c) 48.3.

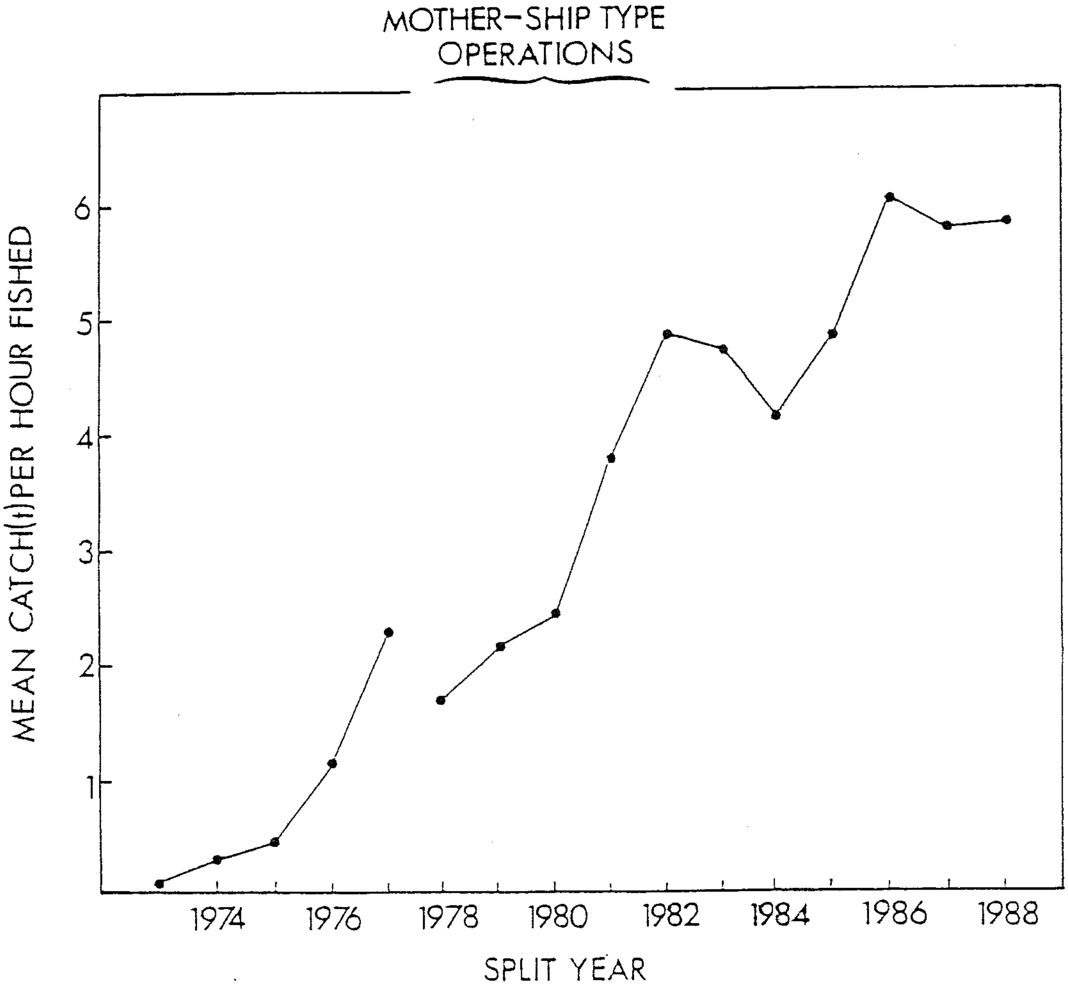


Figure 13: Mean CPH for the Japanese krill fishery between 1972/73 and 1987/88.

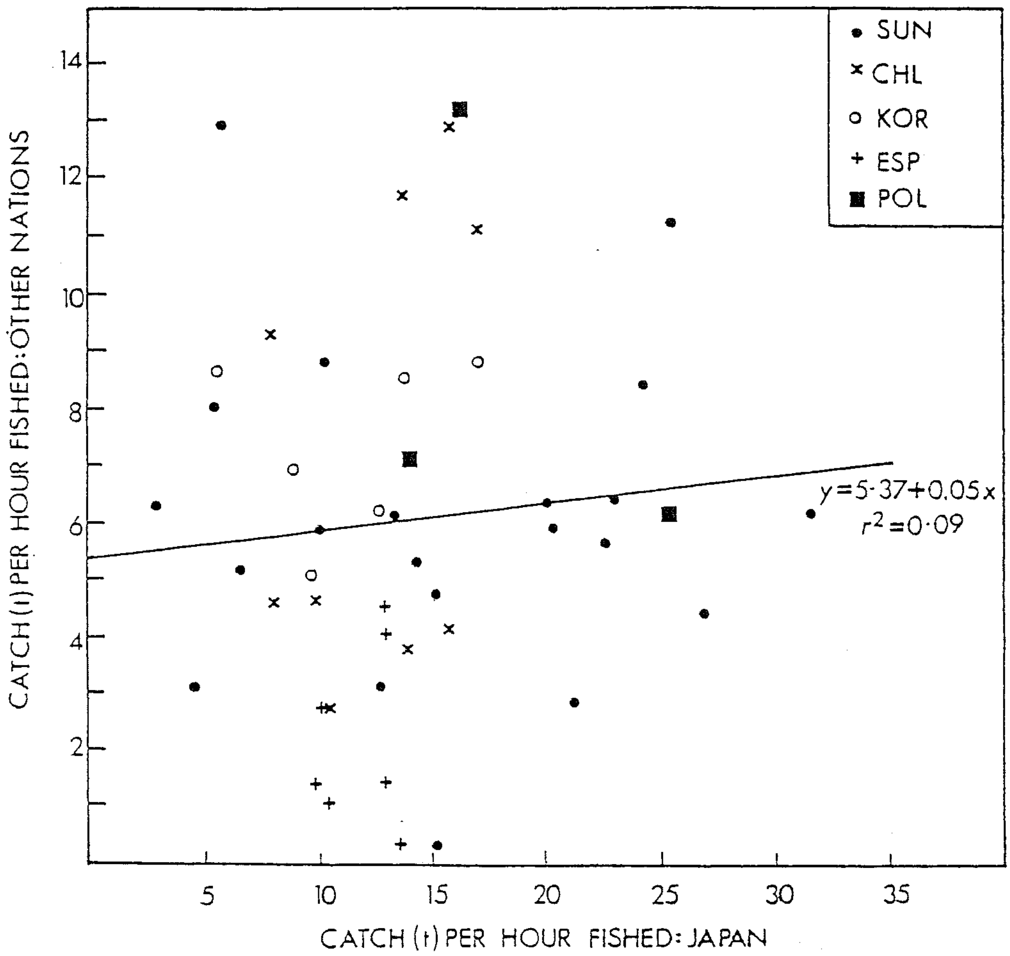


Figure 14: Comparison of CPH values for the Japanese fishery with those for other nations in the same subarea and during the same month.

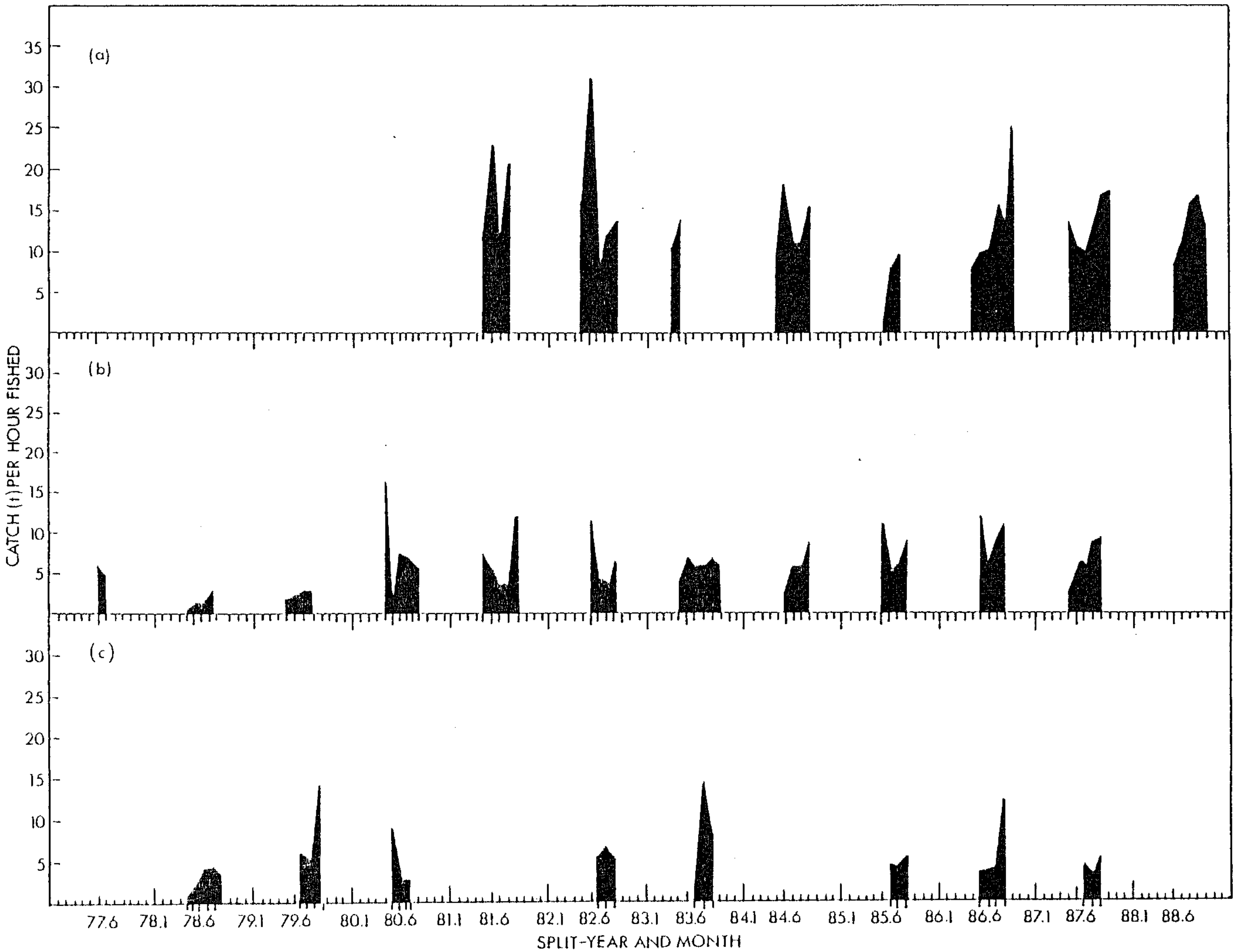


Figure 15: Monthly CPH values for the Japanese krill fishery in (a) Subarea 48.1 (1980/81 to 1987/88), (b) Division 58.4.1 and (c) Subarea 88.1 from 1976/77 to 1987/88.

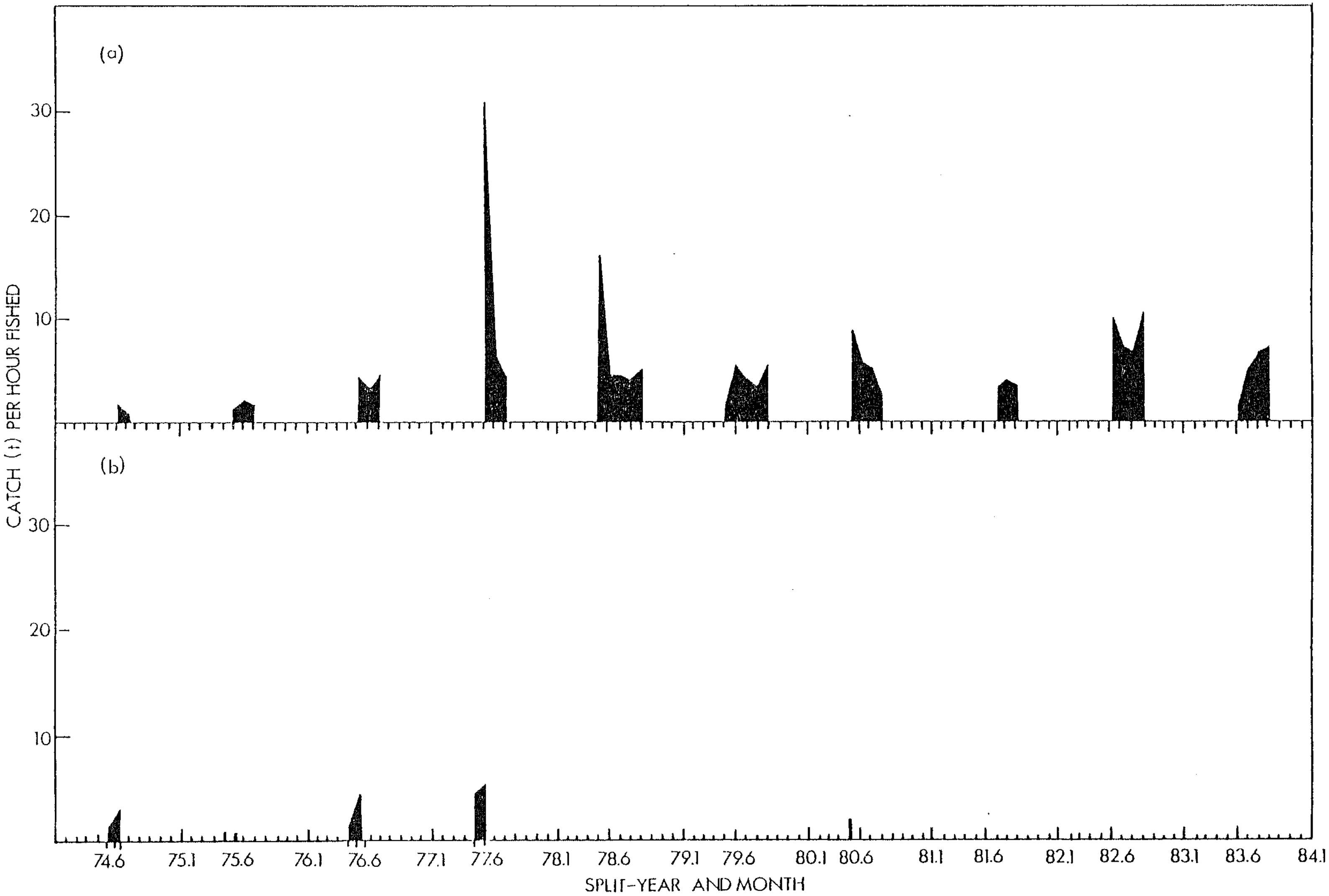


Figure 16: Monthly CPH values for the Japanese krill fishery in Divisions (a) 58.4.2 and (b) 58.4.4 from 1973/74 to 1982/83.

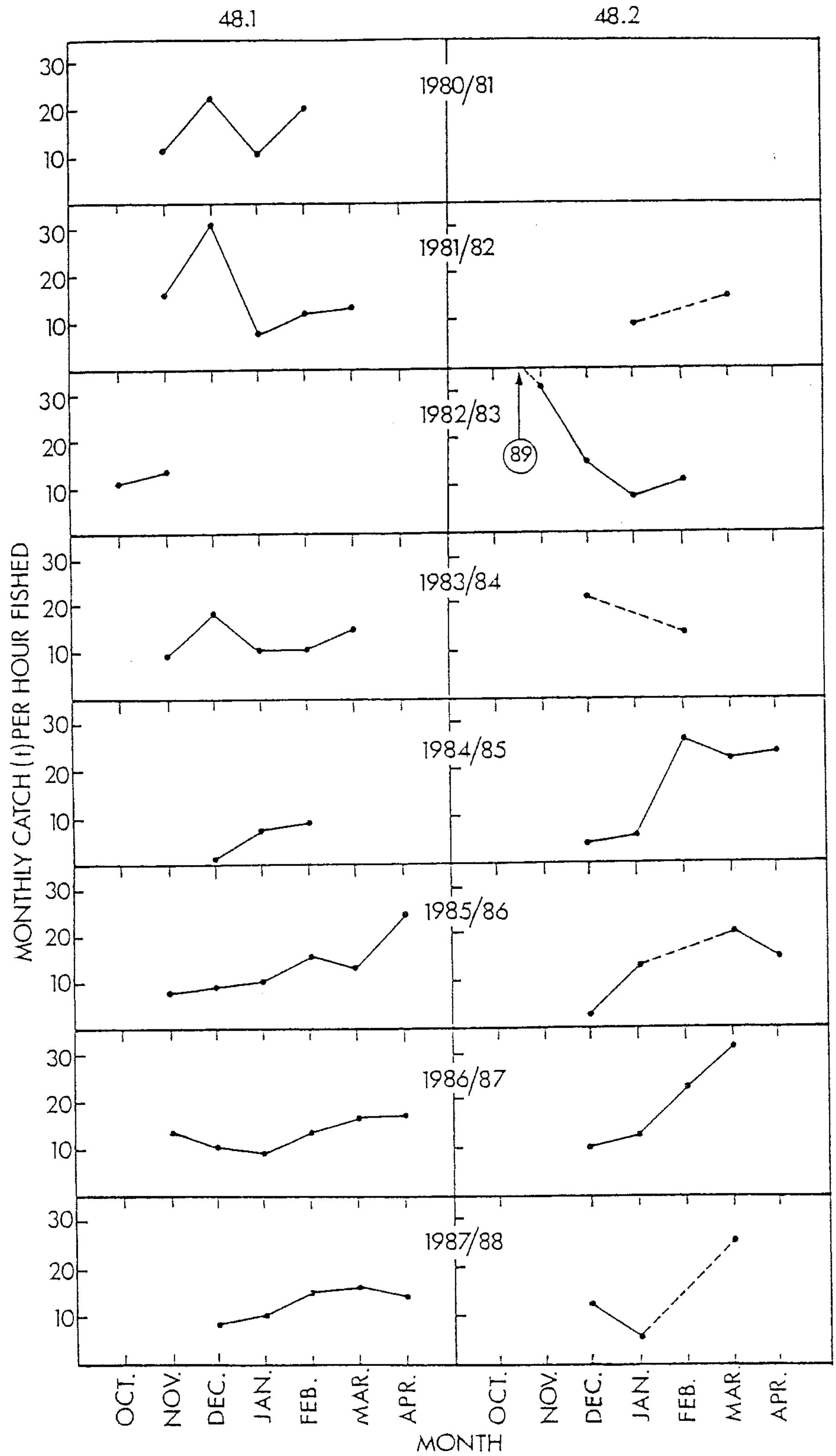


Figure 17: Monthly CPH values for the Japanese krill fishery in Subareas 48.1 and 48.2 for the period 1980/81 to 1987/88.

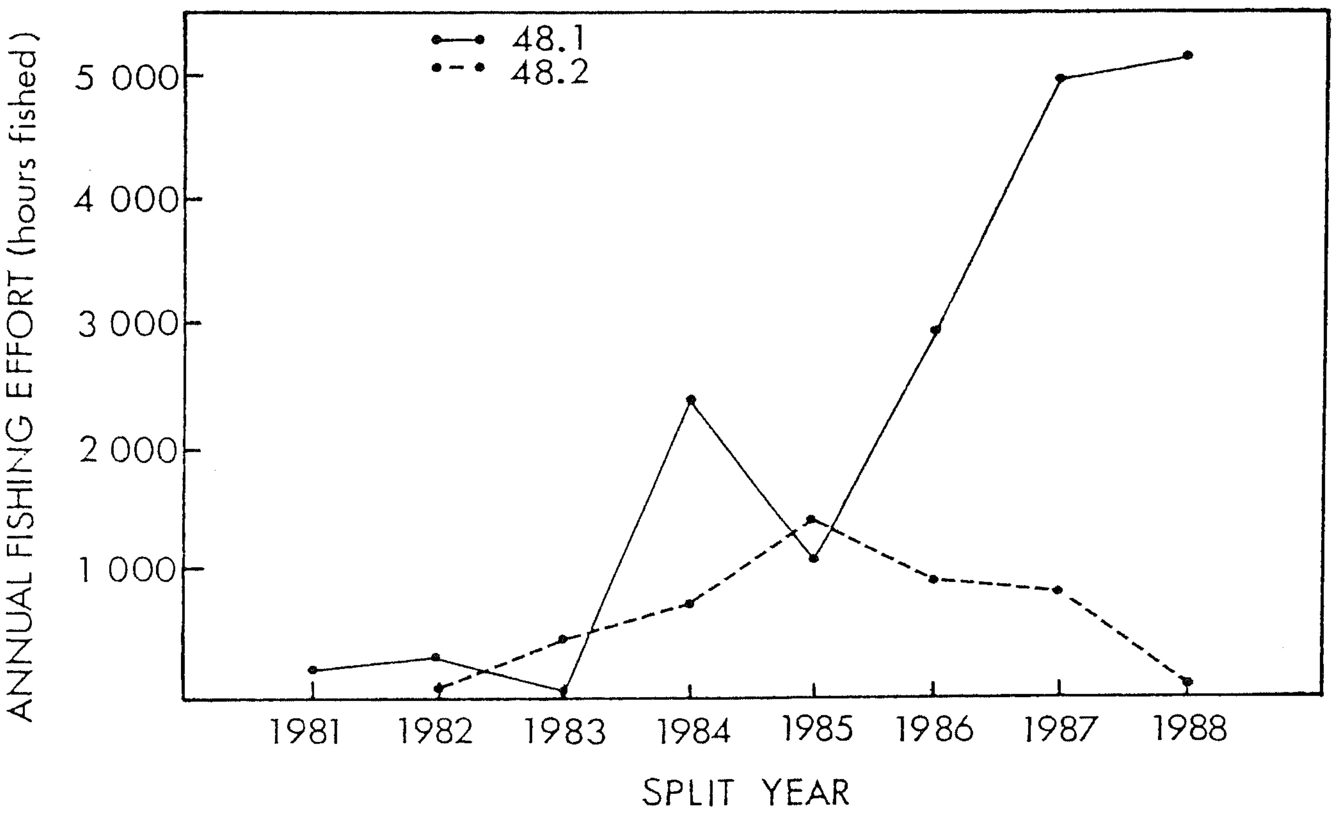


Figure 18: Annual fishing effort (hours fished) by the Japanese krill fishery in Subareas 48.1 and 48.2 (1980/81 to 1987/88).

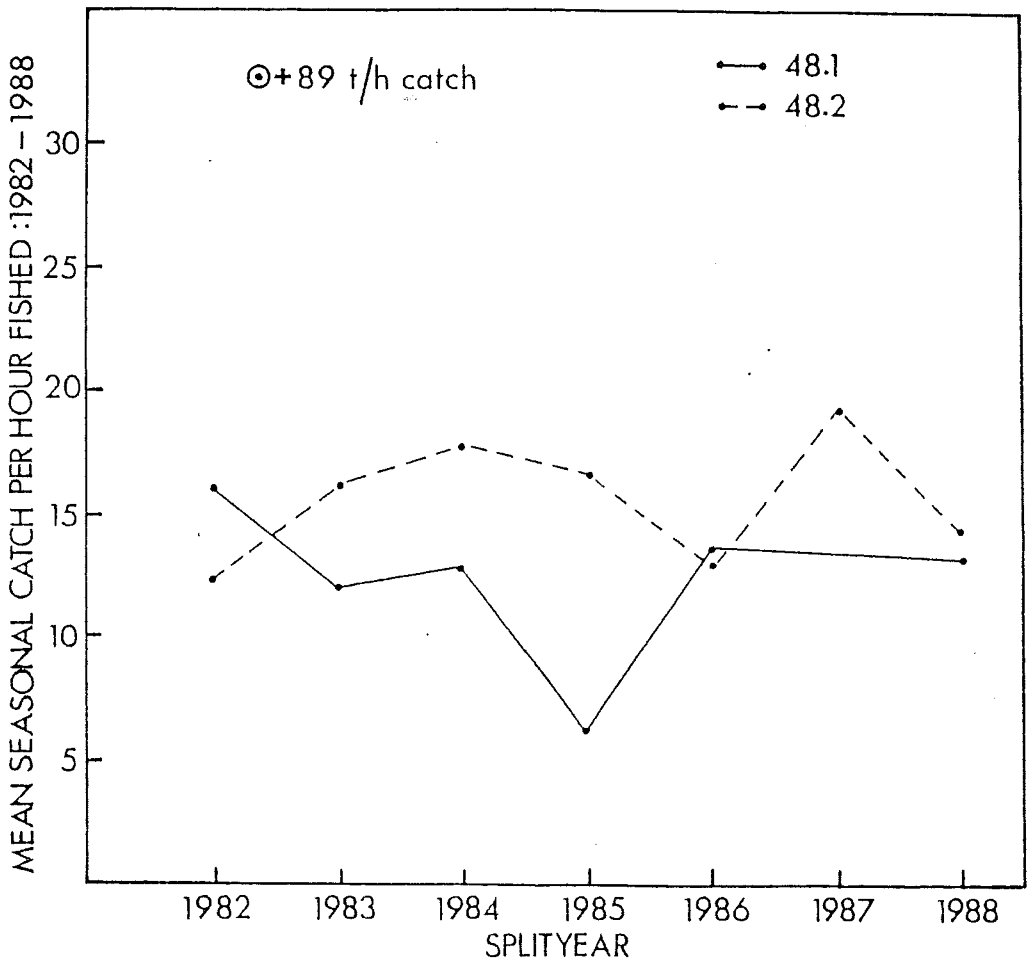


Figure 19: Seasonal mean CPH of the Japanese fishery in Subareas 48.1 and 48.2 (1980/81 to 1987/88).

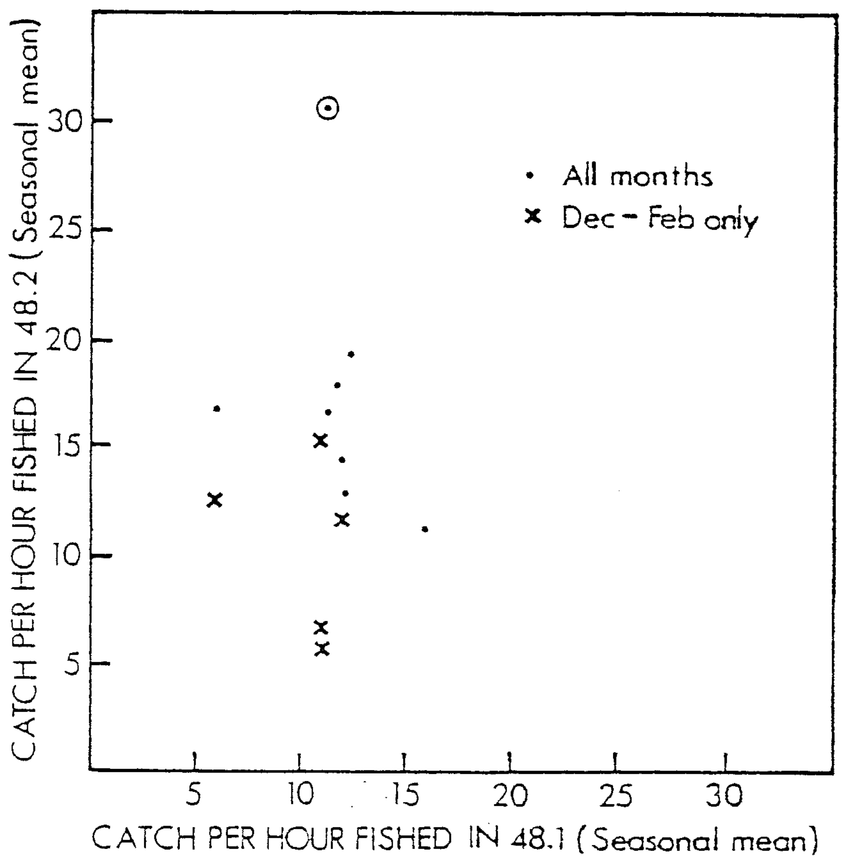


Figure 20: Comparison of seasonal mean CPH for the Japanese krill fishery in Subarea 48.1 versus Subarea 48.2.

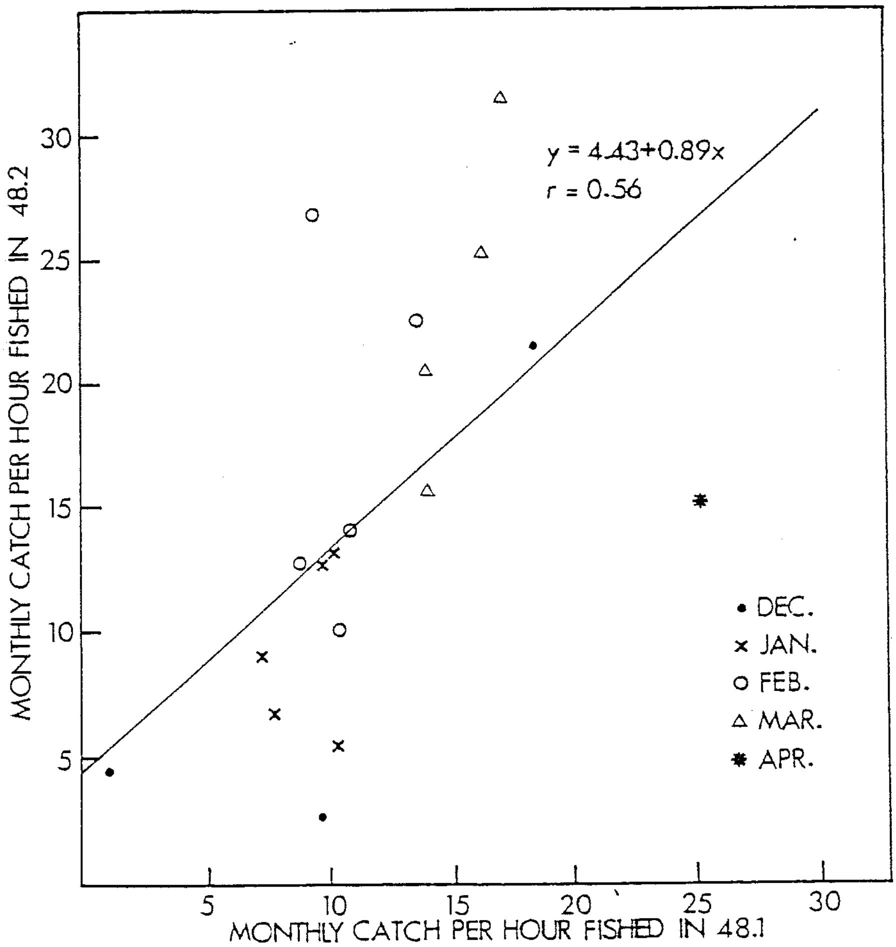


Figure 21: Comparison of CPH values for the Japanese krill fishery in the same months between December and April for Subarea 48.1 versus Subarea 48.2.

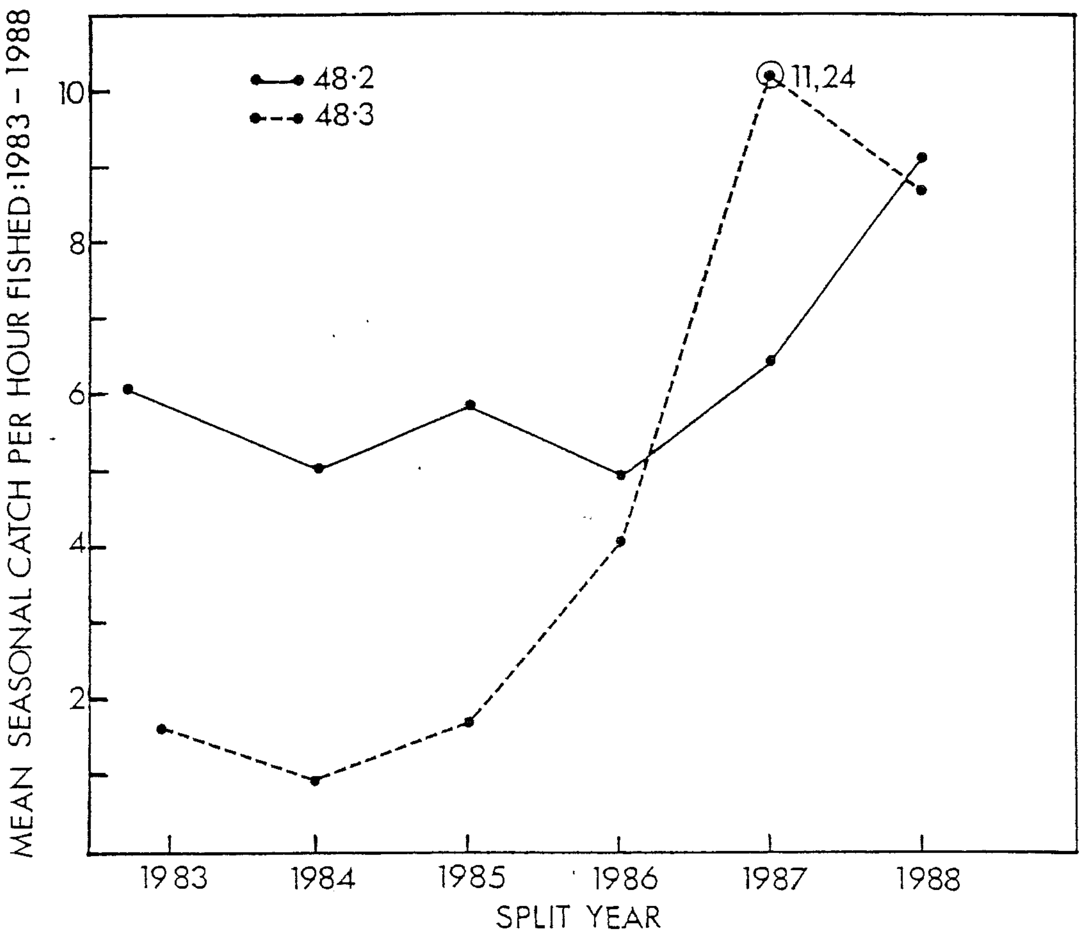


Figure 22: Seasonal mean CPH for the Soviet krill fishery in Subareas 48.2 and 48.3 (1982/83 to 1987/88).

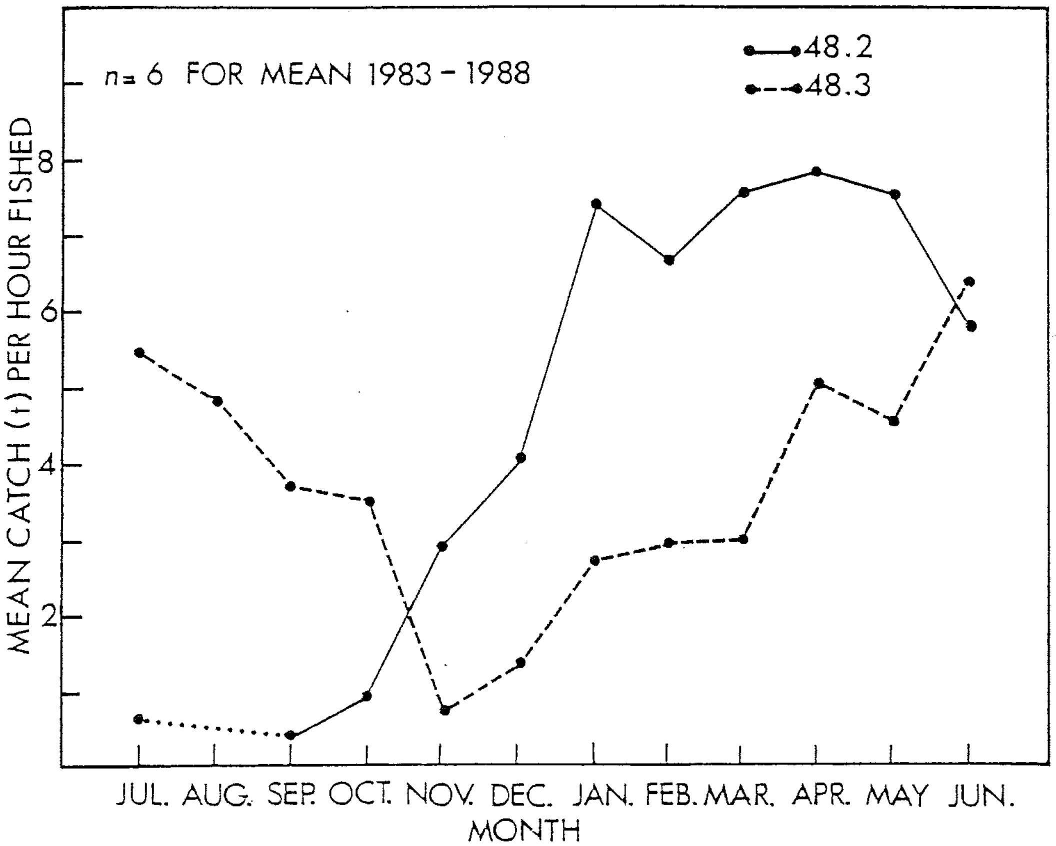


Figure 23: Mean monthly CPH for the Soviet krill fishery in Subareas 48.2 and 48.3 for the period between 1982/83 and 1987/88.

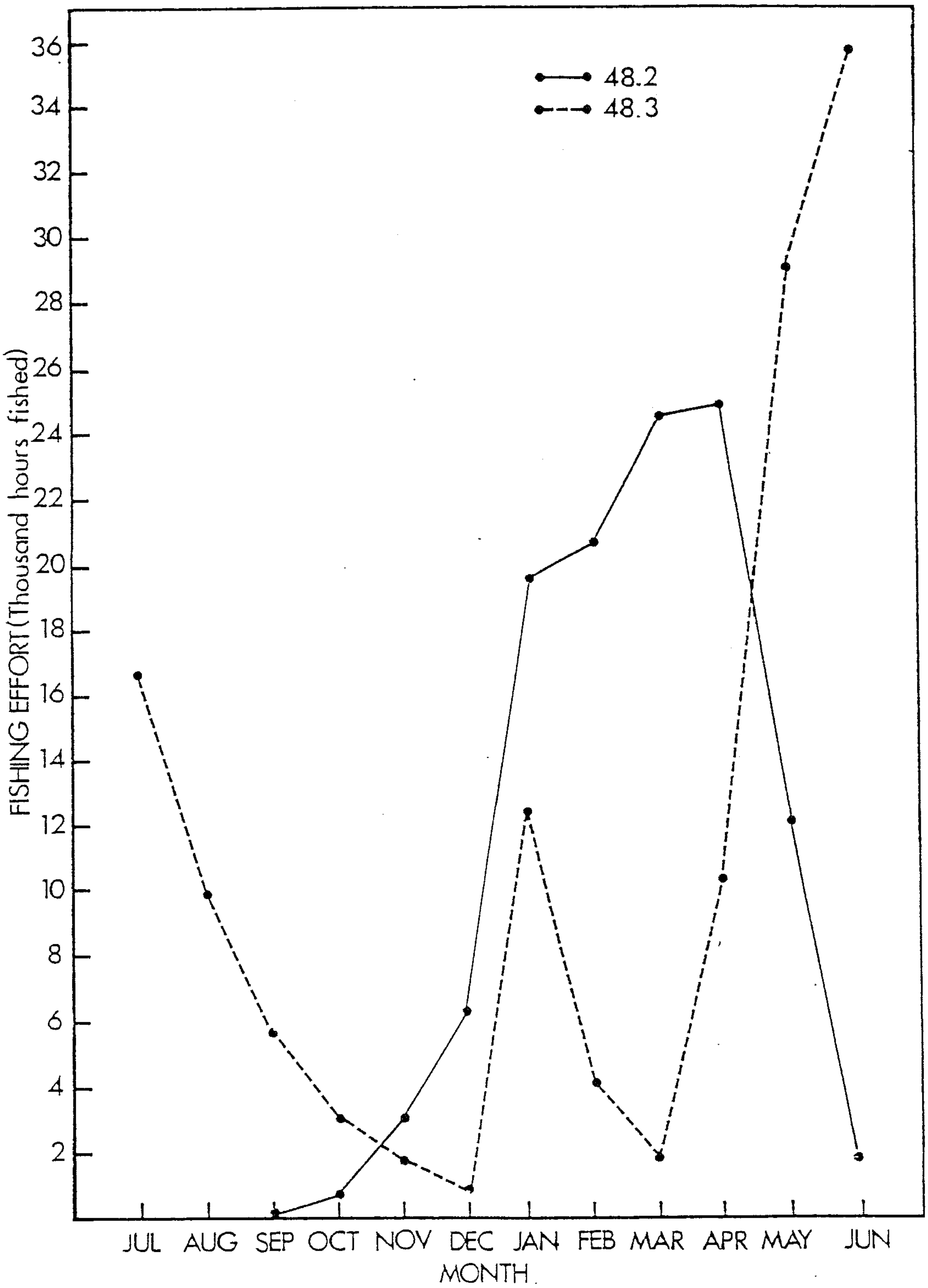


Figure 24: Fishing effort (hours fished) per month for the Soviet krill fishery in Subareas 48.2 and 48.3 (1982/83 to 1987/88).

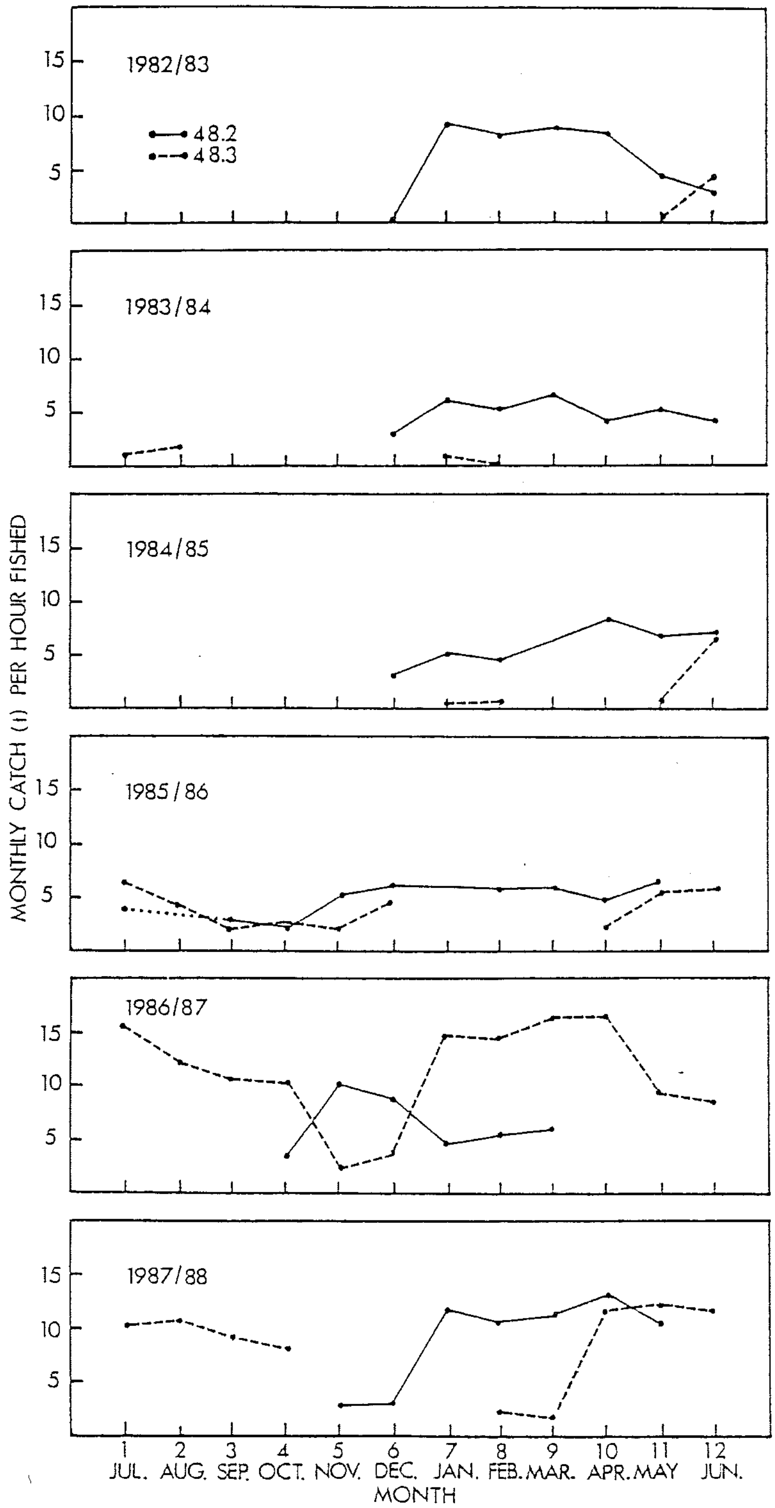


Figure 25: Monthly CPH for the Soviet fishery in Subareas 48.2 and 48.3 (1982/83 to 1987/88).

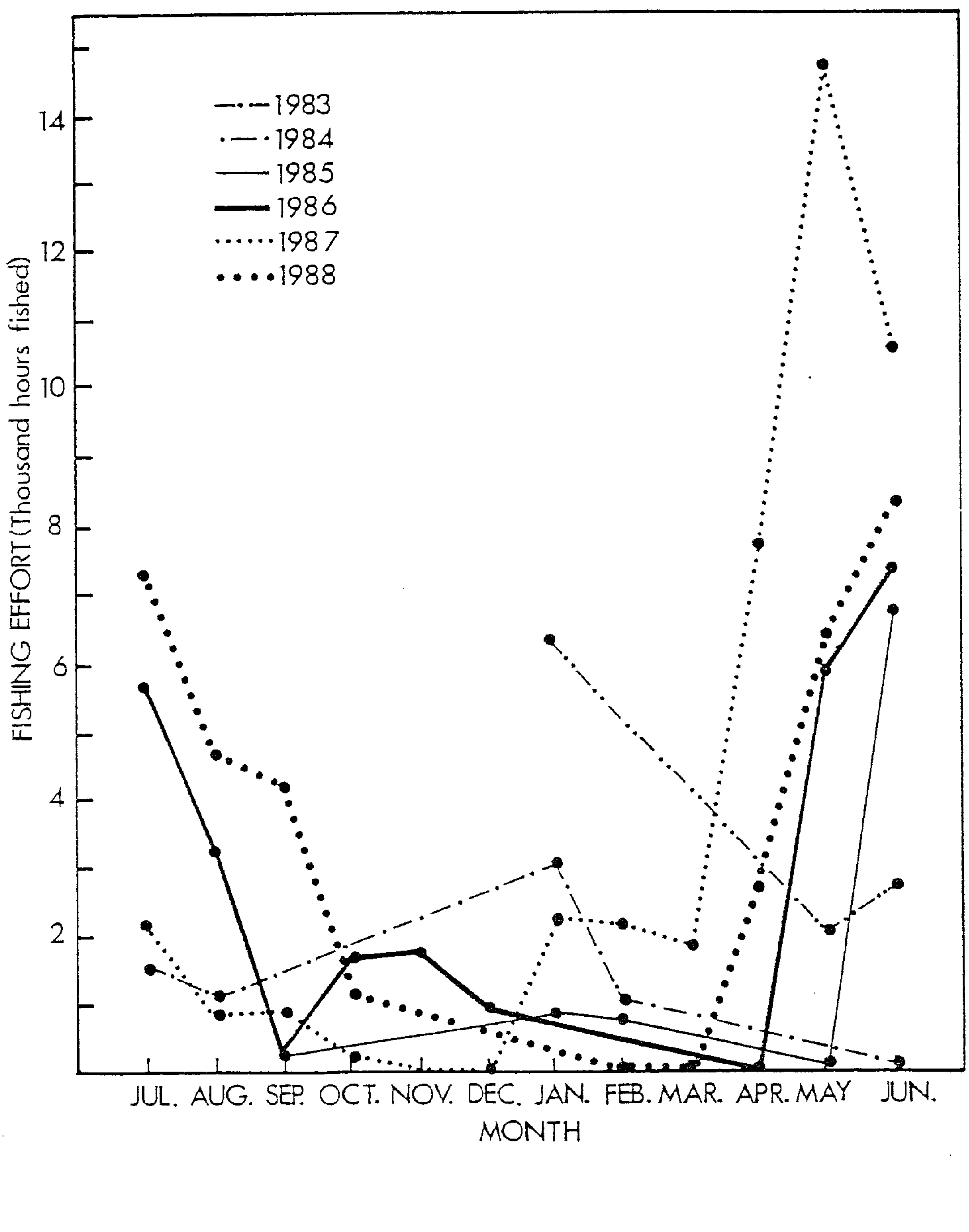


Figure 26: Monthly fishing effort (hours fished) by year for the Soviet fishery in Subarea 48.3 (1982/83 to 1987/88).

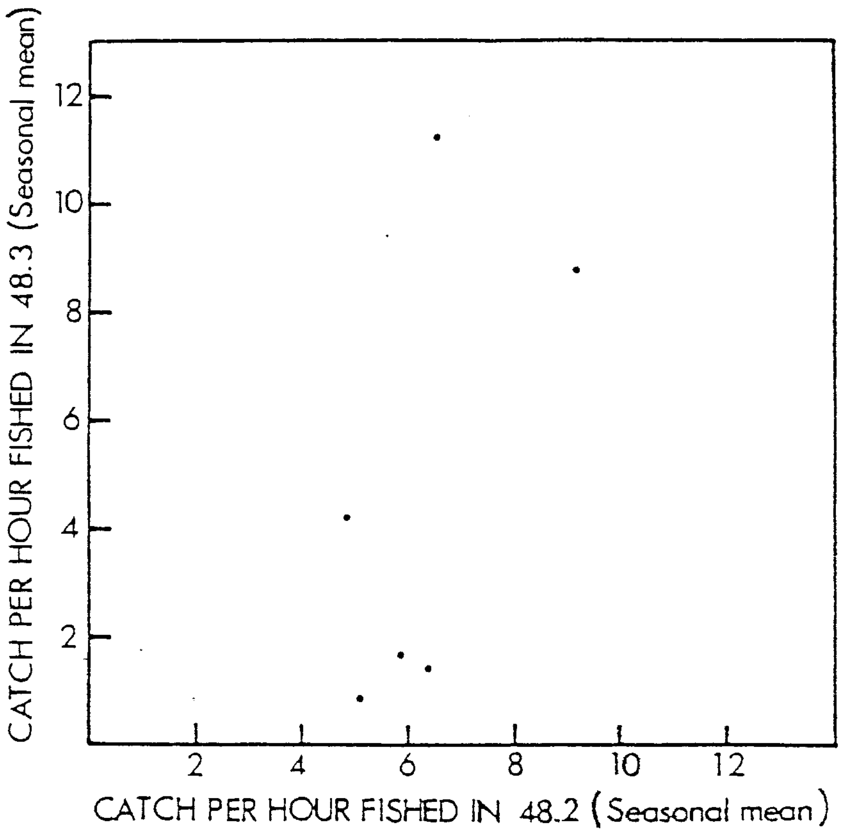


Figure 27: Seasonal mean CPH for the Soviet fishery in Subarea 48.2 versus Subarea 48.3.

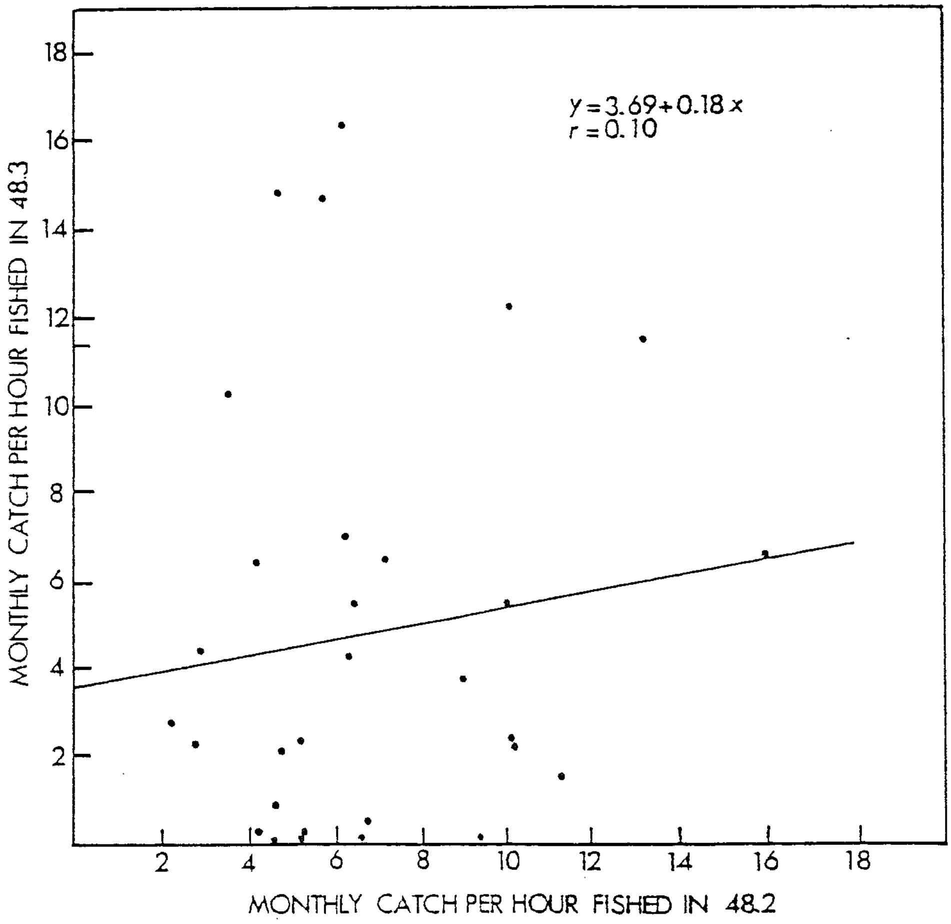


Figure 28: Comparison of CPH values in Subareas 48.2 and 48.3 for the Soviet fishery during the same months (1982/83 to 1987/88).

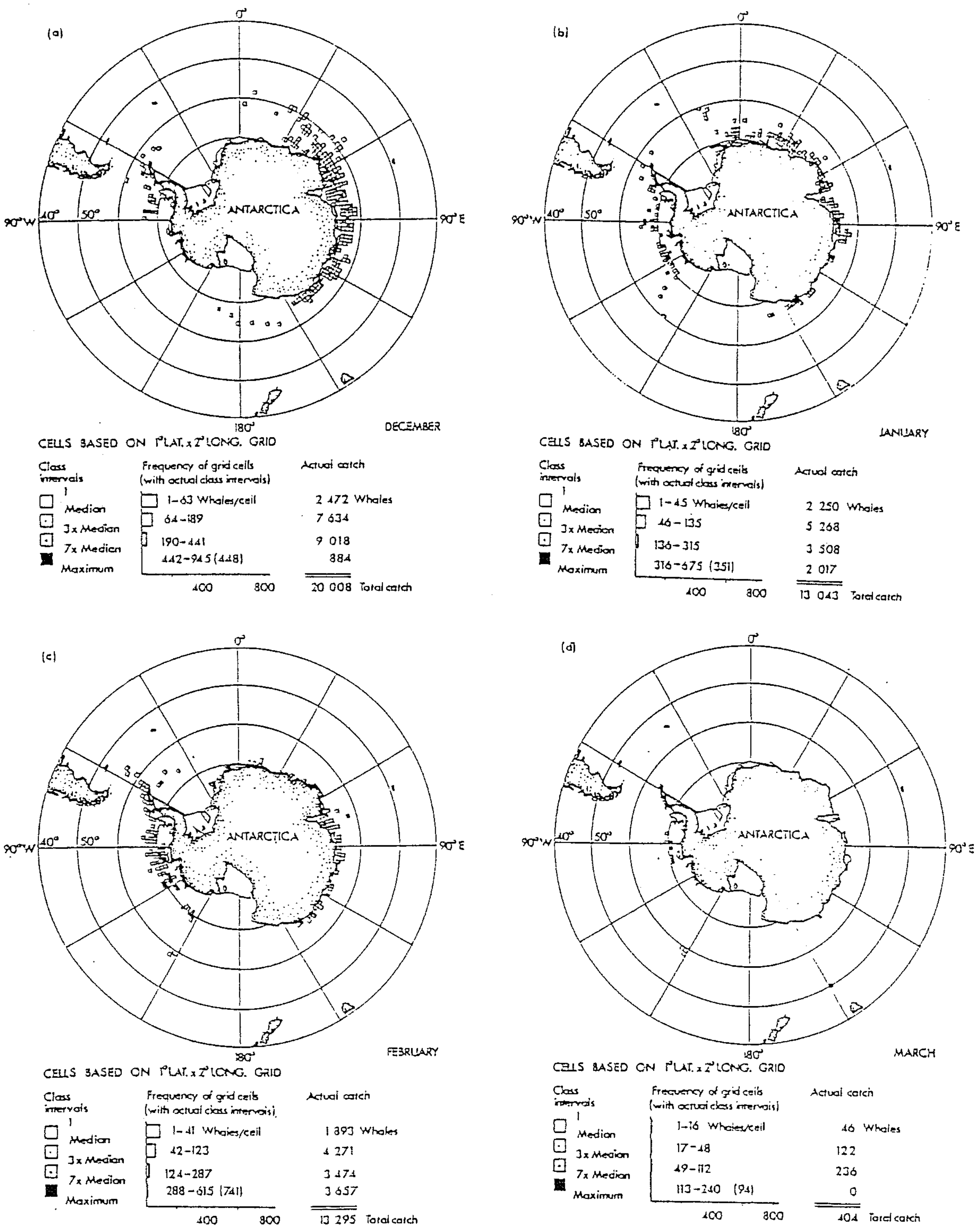


Figure 29: Minke whale catches in the Antarctic taken between 1972/73 and 1979/80 during (a) December, (b) January, (c) February and (d) March (from Mizroch et al., 1985).

Liste des tableaux

Liste des figures

Figure 11: Captures du krill par année australe et par mois pour la période 1976/77 à 1987/88 dans les sous-zones (a) 48.1, (b) 48.2 et (c) 48.3, (d) la division 58.4.1 (données japonaises seulement). Les mois sont numérotés selon l'année australe (c.-à-d. 88.3 représente septembre dans l'année australe 1987/88) - voir le texte pour des détails supplémentaires.

Figure 12: Indices de capture du krill (tonnes) par heure de pêche (CPH) dans les sous-zones (a) 48.1, (b) 48.2 et (c) 48.3.

Figure 13: CPH moyenne pour la pêcherie japonaise entre 1972/73 et 1987/88.

Figure 14: Comparaison entre les valeurs de CPH pour la pêcherie japonaise et celles pour les autres nations dans la même sous-zone et pendant le même mois.

Figure 15: Valeurs CPH mensuelles pour la pêcherie du krill japonaise dans (a) la sous-zone 48.1 (1980/81 à 1987/88), (b) la division 58.4.1 et (c) la sous-zone 88.1 de 1976/77 à 1987/88.

Figure 16: Valeurs mensuelles de CPH pour la pêcherie du krill japonaise dans les divisions (a) 58.4.2 et (b) 58.4.4 de 1973/74 à 1982/83.

Figure 17: Valeurs mensuelles de CPH pour la pêcherie du krill japonaise dans les sous-zones 48.1 et 48.2 pour la période 1980/81 à 1987/88.

Figure 18: Effort de pêche annuel (heures de pêche) par la pêcherie du krill japonaise dans les sous-zones 48.1 et 48.2 (1980/81 à 1987/88).

Figure 19: CPH moyenne saisonnière de la pêcherie japonaise dans les sous-zones 48.1 et 48.2 (1980/81 à 1987/88).

Figure 20: Comparaison entre la CPH moyenne saisonnière pour la pêcherie du krill dans la sous-zone 48.1 et celle dans la sous-zone 48.2.

Figure 21: Comparaison entre les valeurs de CPH pour la pêcherie japonaise du krill pendant les mêmes mois, entre décembre et avril, pour la sous-zone 48.1, et celles pour la sous-zone 48.2.

Figure 22: CPH moyenne saisonnière pour la pêcherie soviétique du krill dans la sous-zone 48.2 et 48.3 (1982/83 à 1987/88).

Figure 23: CPH moyenne mensuelle pour la pêcherie soviétique du krill dans les sous-zones 48.2 et 48.3 pour la période entre 1982 et 1987/88.

Figure 24: Effort de pêche (heures de pêche) par mois pour la pêcherie soviétique du krill dans les sous-zones 48.2 et 48.3 (1982/83 à 1987/88).

Figure 25: CPH mensuelle pour la pêcherie soviétique dans les sous-zones 48.2 et 48.3 (1982/83 à 1987/88).

Figure 26: Effort de pêche mensuel (heures de pêche) par année pour la pêcherie du krill dans la sous-zone 48.3 (1982/83 à 1987/88).

Figure 27: CPH moyenne saisonnière pour la pêcherie du krill soviétique dans la sous-zone 48.2 comparée avec celle dans la sous-zone 48.3.

Figure 28: Comparaison entre les valeurs CPH dans les sous-zones 48.2 et 48.3 pour la pêcherie du krill pendant les mêmes mois (1982/83 à 1987/88).

Список таблиц

Список рисунков

Рисунок 8: Кумулятивные уловы криля, полученные в Подрайонах (a) 58.4, (b) 58 "Неизвестен", (c) 88.1, (d) 88.2, (e) 88.3 и (f) 88 "Неизвестен".

Рисунок 9: Ежегодный вылов криля в Статистическом районе 48 по отдельным подрайонам.

Рисунок 10: Уловы криля по месяцам в Подрайонах (a) 48.1, (b) 48.2 и (c) 48.3 (1982/83 - 1987/88 гг.) и в Районах (в) 58 (1973/74 - 1987/88 гг. - советские данные только за 1982/83 г.) и (у) 88 (1976/77 - 1986/87 гг. - только японские данные).

Рисунок 11: Уловы криля по разбитым годам и месяцам за период 1976/77 - 1987/88 гг. в Подрайонах (a) 48.1, (b) 48.2 и (c) 48.3, (d) Участок 58.4.1 (только японские данные) и (e) Подрайон 88.1 (только японские данные). Месяцы пронумерованы в соответствии с разбитым годом (напр. 88.03 на горизонтальной оси - третий месяц разбитого 1987/88 года - т.е. сентябрь). См. объяснение в тексте.

Рисунок 12: Индексы уловов криля (т.) за час промысла (CPH) в Подрайонах (a) 48.1, (и) 48.2 и (c) 48.3.

Рисунок 13: Средний CPH при японском промысле криля в течение периода 1972/73 - 1987/88 гг.

Рисунок 14: Сравнение величин CPH при японском промысле и величин CPH при промысле других стран - в одном и том же Подрайоне в течение одного и того же месяца.

Рисунок 15: Ежемесячные величины CPH при японском промысле криля в (a) Подрайоне 48.1 (1980/81 - 1987/88 гг.), (b) на Участке 58.4.1 и (c) Подрайоне 88.1 с 1976/77 по 1987/88 гг.

Рисунок 16: Ежемесячные величины CPH при японском промысле криля на Участках (a) 58.4.2 и (b) 58.4.4 с 1973/74 по 1982/83 гг.

Рисунок 17: Ежемесячные величины CPH при японском промысле криля в Подрайонах 48.1 и 48.2 с 1980/81 по 1987/88 гг.

Рисунок 18: Ежегодное промысловое усилие (часы промысла) при японском промысле криля в Подрайонах 48.1 и 48.2 (с 1980/81 по 1987/88 гг.).

Рисунок 19: Сезонный средний CPH при японском промысле криля в Подрайонах 48.1 и 48.2 (с 1980/81 по 1987/88 г.).

Рисунок 20: Сравнение сезонного среднего CPH при японском промысле криля в Подрайонах 48.1 и 48.2.

Рисунок 21: Сравнение величин CPH при японском промысле криля за одни и те же месяцы с декабря по апрель в Подрайонах 48.1 и 48.2.

Рисунок 22: Сезонный средний CPH при советском промысле криля в Подрайонах 48.2 и 48.3 (с 1982/83 по 1987/88 г.).

Рисунок 23: Ежемесячный средний CPH при советском промысле криля в Подрайонах 48.2 и 48.3 с 1982/83 по 1987/88 гг.

Lista de las tablas

Lista de las figuras

Figura 6: Capturas anuales de krill notificadas por país en el Area Estadística 88.

Figura 7: Capturas de krill acumulativas de las Subáreas (a) 48.1, (b) 48.2, (c) 48.3, (d) 48.4, (e) 48.6 y (f) "desconocida".

Figura 8: Capturas de krill acumulativas de las Subáreas (a) 58.4, (b) 58 "desconocida", (c) 88.1, (d) 88.2, (e) 88.3 y (f) 88 "desconocida"

Figura 9: Capturas anuales de krill en el Area Estadística 48 por Subárea seleccionada.

Figura 10: Capturas de krill por mes en las Subáreas (a) 48.1, (b) 48.2 y (c) 48.3 (1982/83 a 1987/88), y en las Areas (d) 58 (1973/74 a 1987/88 - información soviética de 1982/83 solamente) y (e) 88 (1976/77 a 1986/87 - información japonesa solamente).

Figura 11: Capturas de krill por año dividido y por mes para el período de 1976/77 a 1987/88 en las Subáreas (a) 48.1, (b) 48.2, y (c) 48.3, (d) División 58.4.1 (información japonesa solamente) y (e) Subárea 88.1 (información japonesa solamente). Los meses están enumerados de acuerdo al año dividido (por ej. 88.03 en el eje horizontal corresponderá al tercer mes del año dividido 1987/88, esto es, septiembre) - refiérase al texto para mayor información.

Figura 12: Indices de captura de krill (t) por hora de pesca (CPH) en las Subáreas (a) 48.1, (b) 48.2 y (c) 48.3.

Figura 13: CPH media para la pesquería de krill japonesa entre 1972/73 y 1987/88.

Figura 14: Comparación de los valores mensuales de CPH para la pesquería de krill japonesa con aquellos para otras naciones en la misma Subárea y durante el mismo mes.

Figura 15: Valores mensuales de CPH para la pesquería de krill japonesa en (a) Subárea 48.1 (1980/81 a 1987/88), (b) División 58.4.1 y (c) Subárea 88.1 desde 1976/77 a 1987/88.

Figura 16: Valores mensuales de CPH para la pesquería de krill japonesa en las Divisiones (a) 58.4.2 y (b) 58.4.4 de 1973/74 a 1982/83.

Figura 17: Valores mensuales de CPH para la pesquería de krill japonesa en las Subáreas 48.1 y 48.2 para el período 1980/81 a 1987/88.

Figura 18: Esfuerzo de pesca anual (horas de pesca) de la pesquería de krill japonesa en las Subáreas 48.1 y 48.2 (1980/81 a 1987/88).

Figura 19: CPH media de temporada de la pesquería japonesa en las Subáreas 48.1 y 48.2 (1980/81 a 1987/88).

Figura 20: Comparación de CPH media de temporada para la pesquería de krill japonesa en la Subárea 48.1 versus Subárea 48.2.

Figura 21: Comparación de valores de CPH para la pesquería de krill japonesa en los mismos meses entre diciembre y abril para la Subárea 48.1 versus Subárea 48.2.

Figura 22: CPH media de temporada para la pesquería de krill soviética en las Subáreas 48.2 y 48.3 (1982/83 a 1987/88).

Figura 23: CPH media mensual para la pesquería de krill soviética en las Subáreas 48.2 y 48.3 para el período entre 1982/83 y 1987/88.

Figura 24: Esfuerzo de pesca mensual (horas de pesca) para la pesquería de krill soviética en las Subáreas 48.2 y 48.3 (1982/83 a 1987/88).

Figura 25: CPH mensual para la pesquería soviética en las Subáreas 48.2 y 48.3 (1982/83 a 1987/88).

Figura 26: Esfuerzo de pesca mensual (horas de pesca) por año para la pesquería soviética en la Subárea 48.3 (1982/83 a 1987/88).

Figura 27: CPH media de temporada para la pesquería soviética en la Subárea 48.2 versus Subárea 48.3.

Figura 28: Comparación de los valores de CPH en las Subáreas 48.2 y 48.3 para la pesquería soviética durante los mismos meses (1982/83 a 1987/88).

Figura 29: Capturas de rorcuales aliblancos en la Antártida entre 1972/73 y 1979/80 durante (a) diciembre, (b) enero, (c) febrero y (d) marzo (de Mizroch et al., 1985).