CHILEAN KRILL FISHERY: ANALYSIS OF THE 1991 SEASON

Victor H. Marín*, Armando Mujica** and Patricio Eberhard***

Abstract

This paper summarises Chilean catch data for 1991. Special emphasis is given to the analysis of haul-by-haul data and its use in studying small-scale spatial distribution of catches. The results show that krill fishing in Subarea 48.1 is particularly intense near CEMP sites. Other ways of using of haul-by-haul data are suggested.

Résumé

Le présent document récapitule les données de capture chiliennes de 1991. Il met l'accent sur l'analyse des données par trait et son utilisation dans l'étude de la distribution spatiale à petite échelle des captures. Les résultats mettent en évidence l'intensité particulière de la pêche de krill à proximité des sites du CEMP de la sous-zone 48.1. Quelques suggestions sont avancées sur les autres utilisations possibles des données par trait.

Резюме

В настоящей работе суммируются данные по промыслу Чили за 1991 г. Особое внимание уделено анализу данных за каждое отдельное траление и их использование в изучении мелкомасштабного пространственного распределения уловов. Результаты показывают на то, что промысел криля в Подрайоне 48.1 особенно интенсивен вблизи участков CEMP. Также предложены другие способы использования данных за каждое отдельное траление.

Resumen

Este documento resume la información de las capturas de krill en 1991 realizadas por Chile. Se destaca la importancia del análisis de información de lances individuales y su utilidad en el estudio de la distribución espacial de las capturas a escala fina. Los resultados muestran que la pesca de krill en la Subárea 48.1 es intensa cerca de las localidades del CEMP. También se sugieren otras formas de utilizar los datos de lance por lance.

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* Depto. de Cs. Ecológicas, Facultad de Ciencias, Universidad de Chile, Casilla 653, Santiago, Chile
** Depto. Biol. Marina, Facultad Ciencias del Mar, Universidad Católica del Norte, Casilla 117, Coquimbo, Chile
*** Instituto Antártico Chileno, Casilla 16521, Correo 9, Santiago, Chile

1. INTRODUCTION

The main objective of CCAMLR, by definition, is the conservation of the Antarctic marine living resources. Krill is by far the most abundant resource. The analysis of the krill fishery is the major task of the Working Group of Krill (WG-Krill) including among other jobs to review and evaluate information concerning the size, distribution and composition of commercial krill catches, including likely future trends in these catches (SC-CAMLR 1988, paragraph 2.26). At its 1989 meeting, WG-Krill agreed that analyses of haul-by-haul data should commence as soon as possible (SC-CAMLR 1989, Annex 5, paragraph 78). During the second meeting of WG-Krill in 1990 there was some discussion on the use of haul-by-haul data (SC-CAMLR 1990, Annex 4, paragraphs 114 and 115) and WG-Krill felt that some preliminary analyses are needed. Accordingly, the Chilean National Fisheries Service (CNFS) produced a form to collect haul-by-haul information. The main objective of this article is to present a preliminary analyses of the haul-by-haul data.

2. GENERAL CHARACTERISTICS OF THE CHILEAN FISHERY

The Chilean krill fishery has operated, except for the year 1983, only in the Subarea 48.1, comprising from 5% to 100% of the krill fishery in that subarea (Figure 1). The catch is used in the production of feed either as frozen krill or meal. For that reason, quality is a substantial component in the fishing operation. The personnel operating the vessels recognise three categories of krill with respect to colour: red, pink and white. Their target is the red krill, since the product is sold, among others, to the salmon industry. In this regard the product being sold is the carotenoid of either the frozen krill or the krill meal. For the same reason, green feeding krill and gravid females are avoided by the fishery.

In producing frozen krill, the whole animal is frozen without any additional processing. The size of the catch (haul-by-haul) is regulated by the processing capability of the vessel and as a rule does not exceed 10 tonnes at the time. The total catch is regulated by the capacity of the freezers.

3. CHILEAN KRILL FISHERY DURING 1991

3.1 General Overview

During the 1991 fishing season Chile sent one factory vessel to fish for krill in Antarctic waters. The total catch for the season was 3 679 tonnes. This catch level is about 19% lower than the 1990 level when two vessels were fishing. The products from 1991 were 251 tonnes of krill meal and 1 265 tonnes of frozen krill. These quantities correspond to the maximum transportation capacity of the vessel.

Figure 2 shows the total catch-per-day during the season. The average total catch-per-day was 108 tonnes, a maximum of 160 tonnes was obtained at the end of the season. A total of 419 hauls were taken. The number of hauls-per-day remained between 12 and 14 for the whole season except for three days (Figure 3). The total effort-per-day, measured as total towing time, ranged between 3 and 14 hours (Figure 4). During the first 20 days the effort ranged between 6 and 12 hours, decreasing to a lower level during the last 14 days. This shift in effort had a major effect, as it is shown below, in the CPUE values. The reason for this is that due to processing constraints the catch (haul-by-haul) is maintained at relatively low values (9 000 tonnes on average), adjusting the effort accordingly.

The fact that the Chilean krill fishery operates only in Subarea 48.1 and takes a consistent portion of the total catch in the subarea, allowed us to study interannual changes in CPUE from 1987 to 1991. Average and maximum (haul-by-haul) CPUE values, expressed as catch-per towing time were calculated and are shown in Figure 5. Both the average value and the maximum show the same trend: an increase from 1987 to 1988, followed by a decrease during 1989-1990 and a further increase in 1991. The increase during 1987-1988 agrees with data from Miller (1989).

3.2 Spatial Distribution of Hauls

In 1991, fishing took place in the northern shelf of the South Shetlands. The season started 20 February near Livingston Is. and ended 25 March near Elephant Is. (Figure 6). This pattern of movement is similar to that described by Endo and Ichii (1989) for Japanese trawlers in the same area.

The analyses of the distribution of hauls in space showed three major fishing sectors (Figure 6): sector (1), the northern shelf of Livingston Is.; sector (2), the area north of Robert Is. and Nelson Is.; and (3) the northern shelf of Elephant Is. Fishing in sector (1) lasted for 19 days, 4 days in sector (2) and 11 days in sector (3). The three sectors had bottom depths shallower than 300 m. Figure 7 shows the depth of the hauls. The maximum daily average trawling depth was approximately 85 m, however, most of the time trawling depth was between 44 and 60 m.

Our data together with the data presented in Endo and Ichii (1989) and the CCAMLR fine-scale data information (SC-CAMLR, 1991) show that there are two consistent fishing grounds in Subarea 48.1: north of Livingston Is. and north of Elephant Is. Both areas correspond to shallow shelf waters. It is important to note that in both areas there are large colonies of land-based krill predators. In fact during 1990 Chile and USA submitted proposals for CEMP sites at Cape Shirreff (Livingston Is.) and Seal Is. (Elephant Is. sector) respectively (CCAMLR 1990, paragraph 6.3). Feeding grounds for land-based predators may extend 100 km from the colony. Thus, the most important fishing grounds in Subarea 48.1 occur well within feeding areas of these predators.

3.3 Haul-by-Haul CPUE Data

We have attempted a preliminary analysis of haul-by-haul data collected during 1991. The objective of this analysis was a comparison between Livingston Is. and Elephant Is. fishing grounds. We envisage that this preliminary treatment of haul-by-haul data will promote further analysis and discussions on the use of this data.

All analyses were conducted in terms of catch-per-unit-effort, using towing time as effort. Figure 8 shows the daily average and range of CPUE values during 1991. CPUE remained stable during the first 23 days increasing in the last 11 days. Haul-by-haul data were plotted against haul number in order to study CPUE changes in detail. Figure 9 shows the data for areas (1) and (2), Figure 10 shows the data for area (3).

In areas (1) + (2) only 0.8% of the hauls exceeded 1 tonne min^{-1}, in area (3) all hauls exceeded that level (ANOVA). We conducted a correlation analysis to study the spatial dimensions of the "krill patches" in terms of number of hauls-per-patch. An autocorrelation function was calculated for both the total catch-per-haul and CPUE (Figures 11 and 12). The point of interest in this analysis is the position of the first zero crossing. This point gives some idea on the spatial structure of the hauls. The results show that the autocorrelation function for both variables "dies out" after five hauls, suggesting that on average the vessel move away from a patch after five hauls. This result was independent of the area fished, suggesting that although there were differences in CPUE, the spatial structure did not change significantly.

Finally we analysed the detailed movement of the vessel in an attempt to study the advection of krill patches into the whole area. The vessel move to area (2) on 21 February finding a patch centre at around 62°10'S, 60°W. This patch was fished for two days (21 to

23 February) yielding 260 tonnes (CPUE = 12.9 tonnes hr $^{-1}$). Later in the season, on 10 March the vessel returned to area (2). This time finding a patch at about 62°S, 59°13'W. This patch was fished for another two days yielding 264 tonnes (CPUE = 9.3 tonnes hr $^{-1}$).

If we assume that the two patches in area (2) were the same, we could calculate the advection of krill into this area. Under this assumption the patch moved about 40 miles in 17 days which gives a drift speed of 5 cm s^{-1}. If we use that figure, we could then calculate the time that it would take for a patch to move from Livingston Is. to Elephant Is. (distance near 420 n. miles). According to our estimate it would take 179 days or six months for a patch to passively drift from one fishing area to another. Even if we consider doubling the drifting speed it would take about three months to move between these two areas. Fishing season lasted 34 days. Thus for a given season, both areas would be treated as independent fishing grounds. This analysis does not allow that krill could swim actively from area to area.

3.4 Scientific Observers and By-Catch

Scientific observers went on board the commercial vessel during 1991. Sampling comprised of two litre samples from each haul to analyse krill and a by-catch of fish. These data are currently being analysed. A total of 169 hauls were analysed for by-catch. Adult fishes of 13 species belonging to five families were found in 42 hauls (Table 1). Myctophids were the most abundant, especially in the area near Elephant Is. Juveniles were more abundant than adults, however, no species identification was possible at this time. This work is currently underway.

4. CONCLUSIONS

Analyses of haul-by-haul CPUE data could be an important tool in the study of small scale spatial distribution of fishing grounds. In this regard the results of such an analysis may be very applicable to CEMP studies. Here we have shown that fishing grounds and potential feeding grounds of land-based predators coincide in space. Furthermore, our data show that in Subarea 48.1 the largest fishing grounds are near CEMP sites. A study of ecological consequences of this type of fishing activity (shallow water) is a primary task for both WG-Krill and WG-CEMP. Haul-by-haul CPUE data from other fishing areas will be necessary in order to continue this analysis.

Haul-by-haul data are also valuable if they are combined with scientific observations on board commercial vessels. They can help in identifying "stocks" and also in providing a first insight on the advection of krill in some areas. All these studies require detailed data on vessel position for each haul; ie., latitude and longitude in degrees and minutes. In summary, analysis of haul-by-haul CPUE data may be an important way of analysing the potential impact of krill fishing on other components of the Antarctic ecosystem. For the review, a submission of haul-by-haul data to CCAMLR should be continued.

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Table 1: Species of fish found as by-catch during krill fishing in Subarea 48.1 (1991 season). Data from scientific observers on board of a Chilean commercial vessel.

Family:	Species:
Nototheniidae	*Notothenia gibberifrons* *Notothenia squamifrons* *Pleuragramma antarcticum*
Channichthyidae	*Neopagetopsis ionah* *Chaenocephalus aceratus* *Champsocephalus gunnari* *Chionodraco rastrospinosus*
Bathydraconidae	*Parachaenichthys charcoti*
Paralepididae	*Notolepis coatsi*
Myctophidae	(two unidentified species)

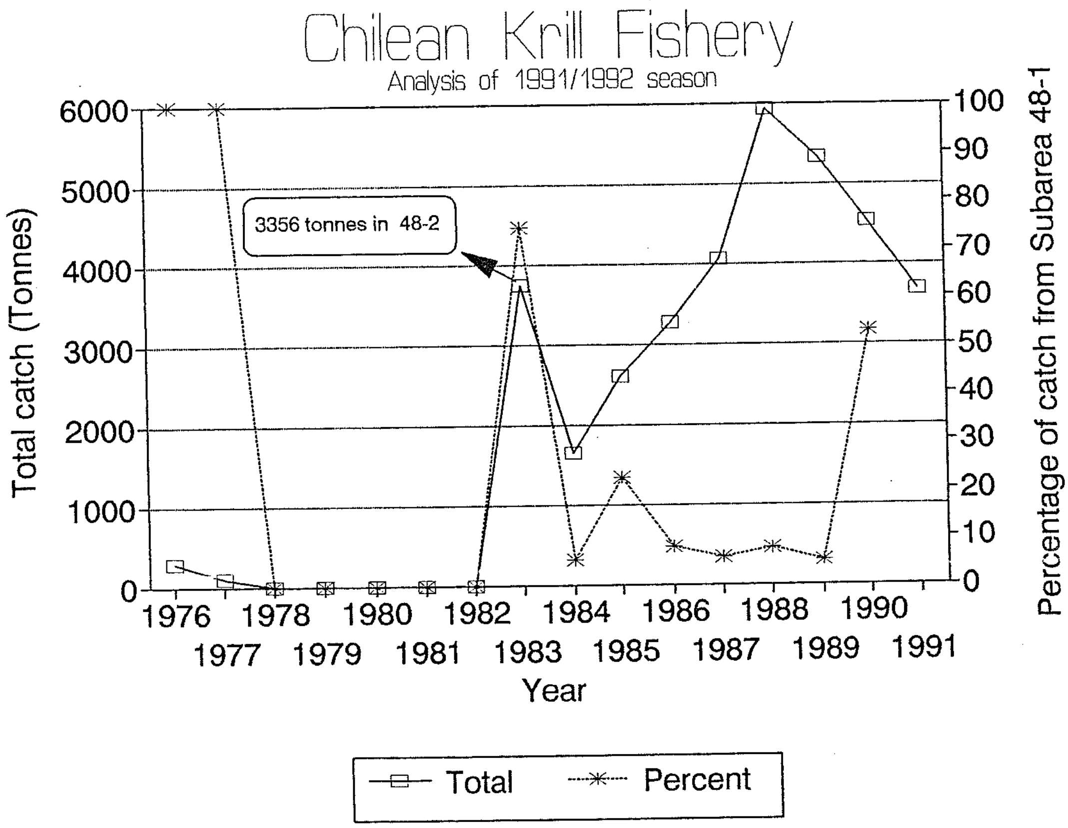

Figure 1: Total catch by Chilean trawlers in Subarea 48.1 from 1976 to 1991. The percentage of the Chilean catch with respect to total catch is also shown.

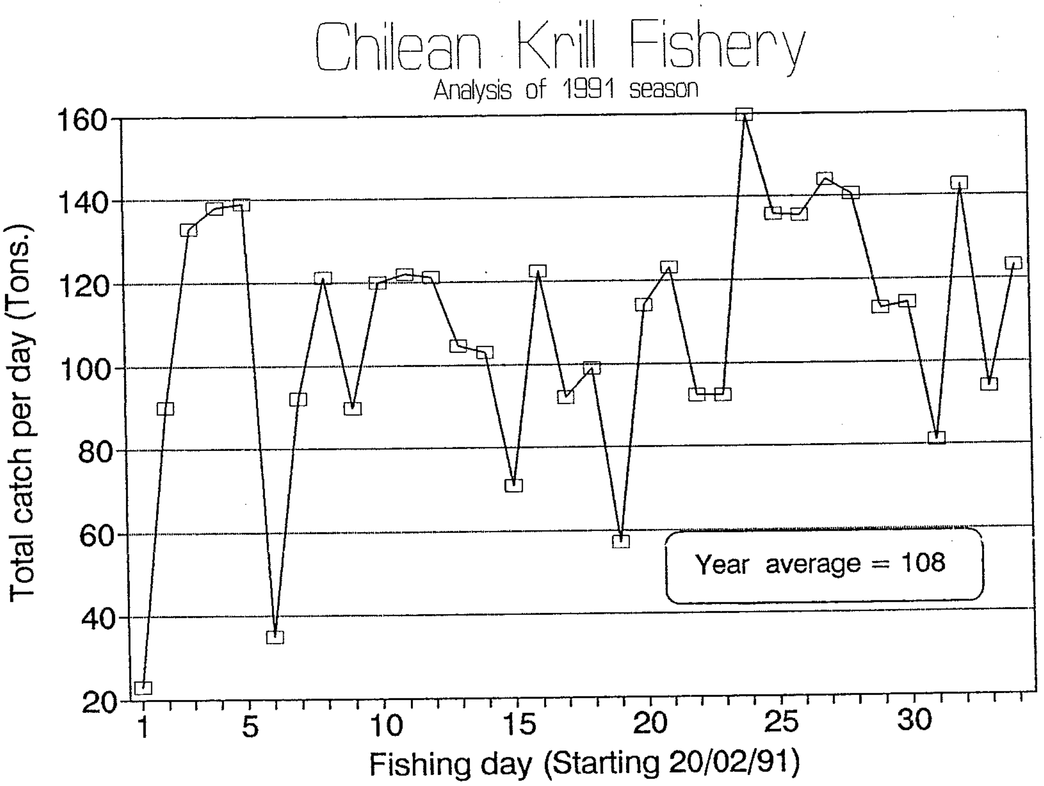

Figure 2: Total catch-per-day during 1991.

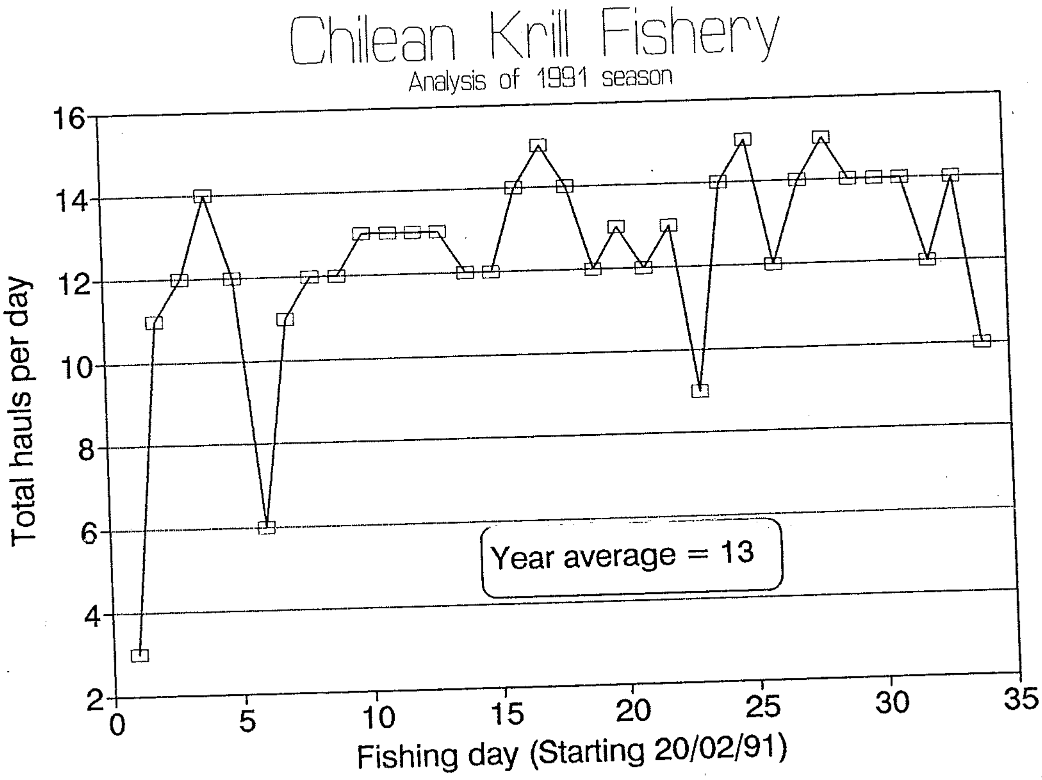

Figure 3: Total number of hauls-per-day during 1991.

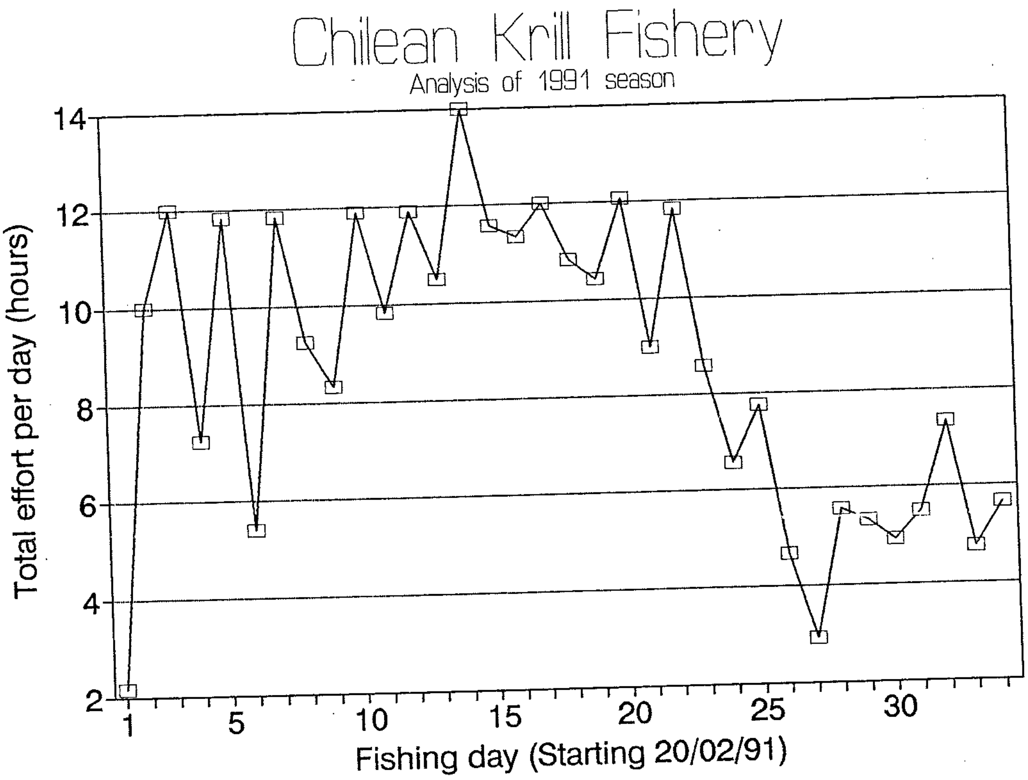

Figure 4: Total effort (measured as total towing time)-per-day during 1991.

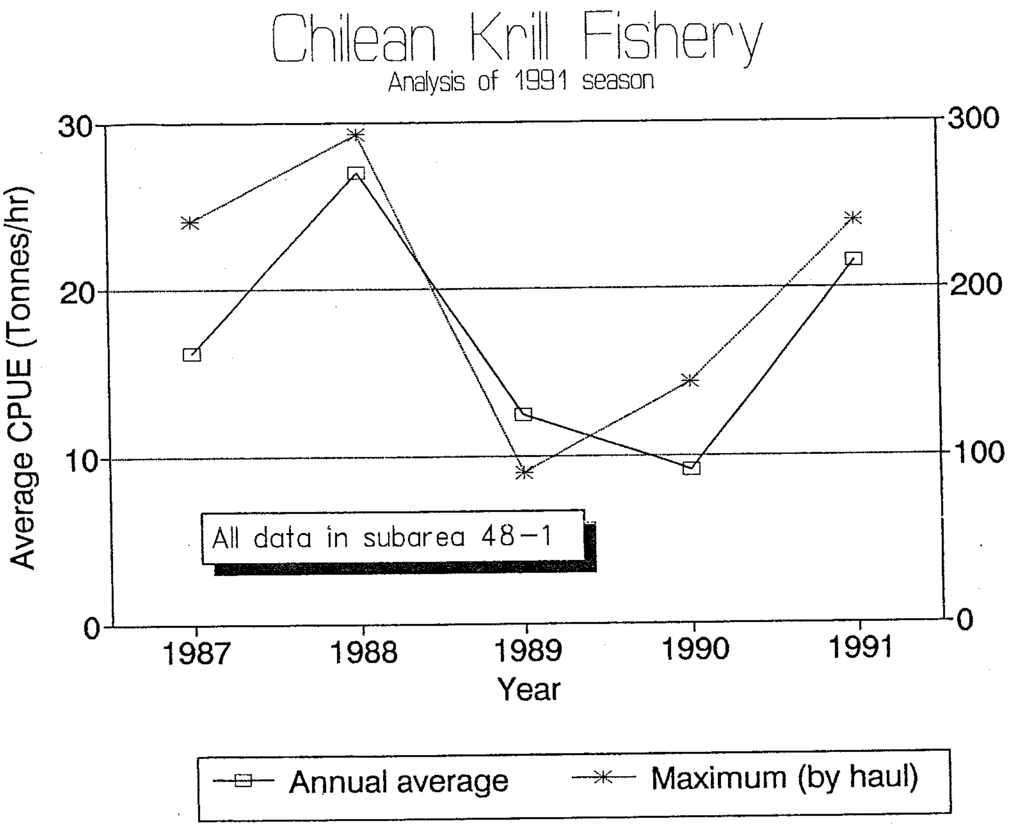

Figure 5: Mean CPUE for the Chilean krill fishery from 1987 to 1991. Data is presented by split-years and shown under the calendar year in which the split-year ends.

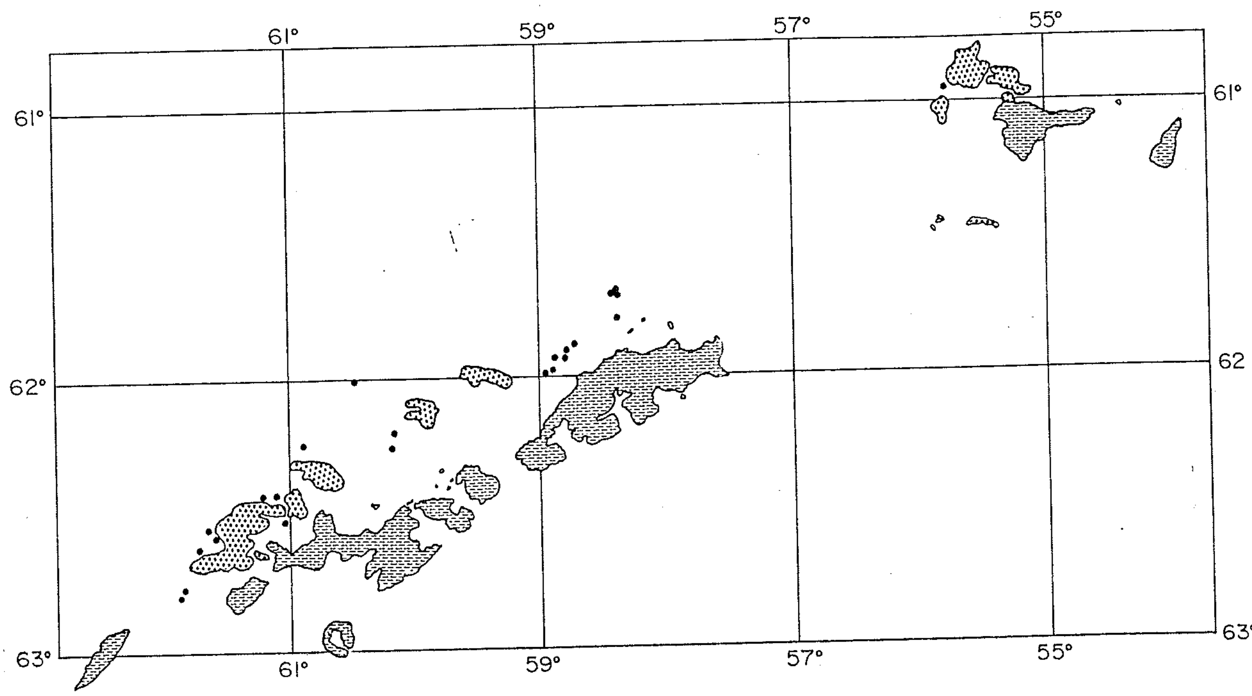

Figure 6: Spatial distribution of hauls during the 1991 season. Areas of high density of hauls have been encircled.

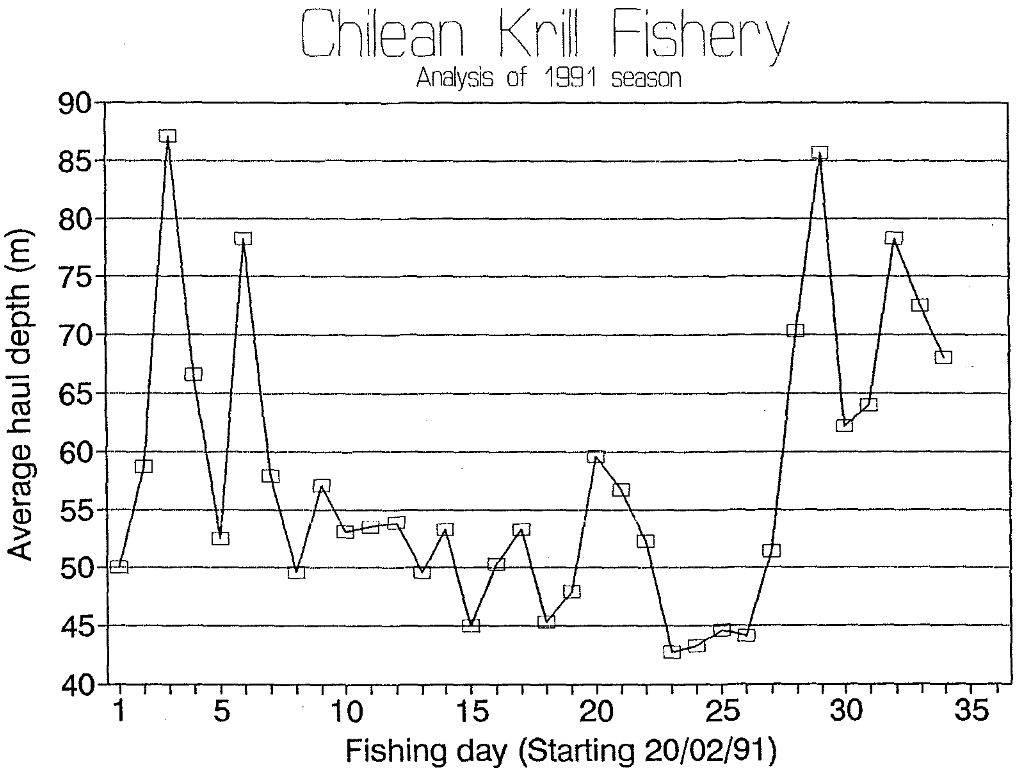

Figure 7: Daily average haul depth (m) during 1991.

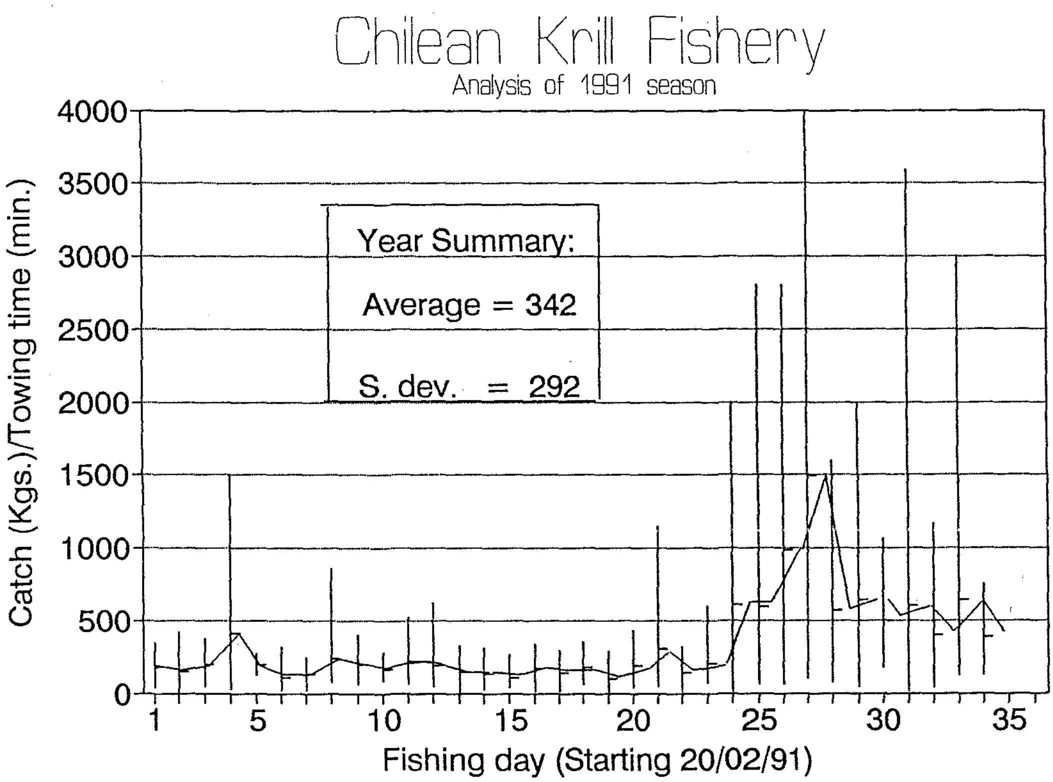

Figure 8: Daily average and total range of CPUE during 1991. Season average is shown as year summary.

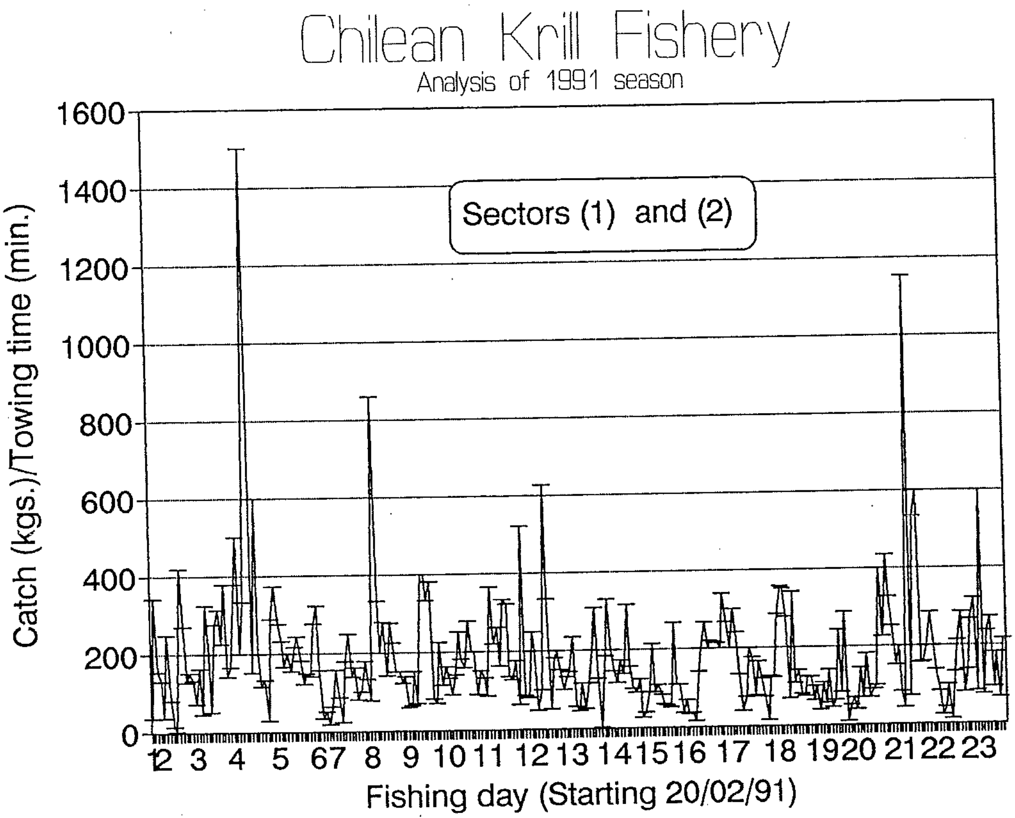

Figure 9: Haul-by-haul CPUE data for areas (1) and (2). Each small horizontal line corresponds to a haul.

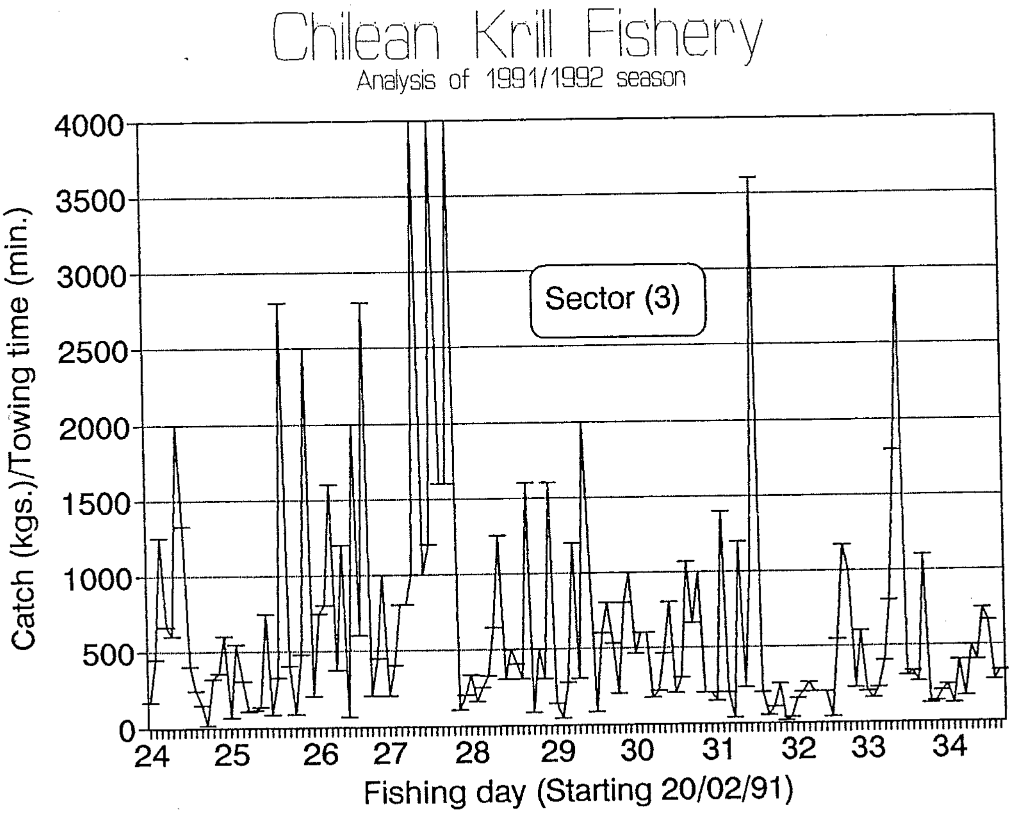

Figure 10: Haul-by-haul CPUE data for areas (1) and (2). Each small horizontal line corresponds to a haul.

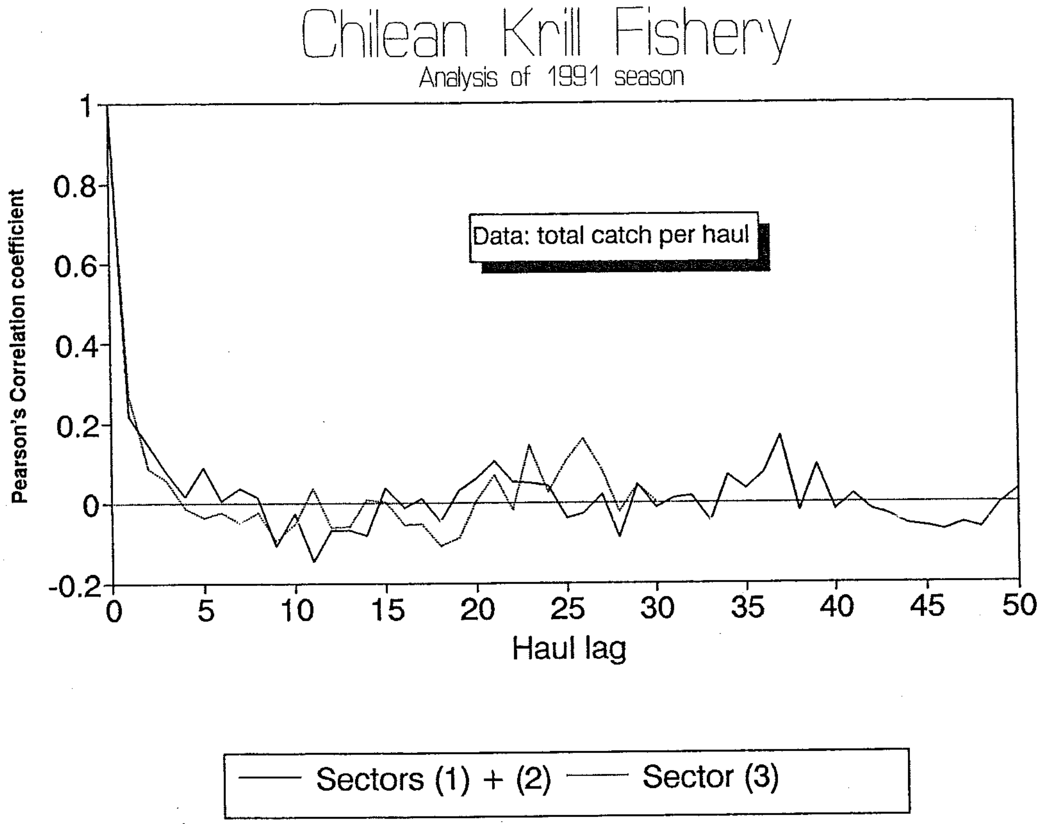

Figure 11: Autocorrelation function of the total catch-per-haul data for 1991.

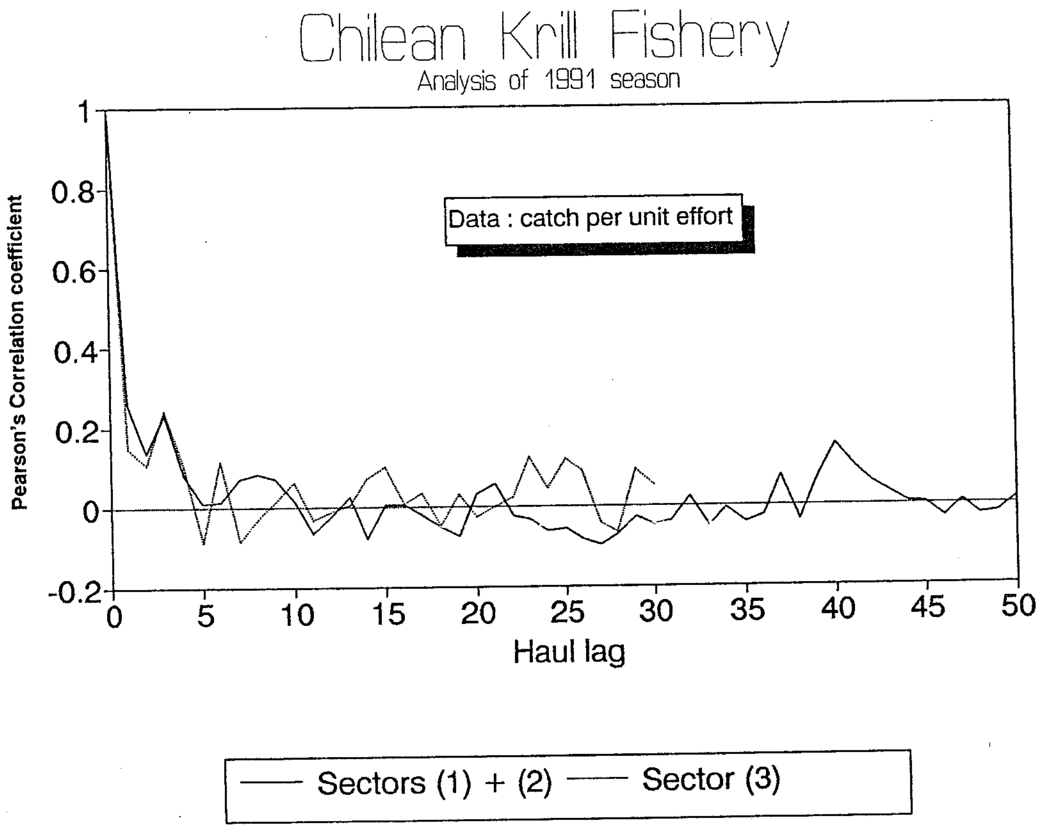

Figure 12: Autocorrelation function of the haul-by-haul CPUE data for 1991.

Liste des tableaux

Liste des figures

Список таблиц

Список рисунков

Lista de las tablas

Lista de las figuras

Figura 9: Datos de CPUE de lances individuales de las zonas (1) y (2). Cada línea pequeña horizontal corresponde a un lance.

Figura 10: Datos de CPUE de lances individuales de la zona (3). Cada línea pequeña horizontal corresponde a un lance.

Figura 11: Función de autocorrelación de los datos de captura total por lance en 1991.

Figura 12: Función de autocorrelación de los datos de CPUE de los lances individuales en 1991.