ISSN, 0327-9332

INIDEP Documento Científico 3
Mayo 1994

# REPORT OF THE INIDEP WORKING GROUP ON ASSESSMENT OF HAKE (*Merluccius hubbsi*) NORTH OF 48° S (SOUTHWEST ATLANTIC OCEAN)

por

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ISSN N° 0327-9332

Primera edición: mayo 1994
Primera impresión: 700 ejemplares
Impreso en Argentina

Autoedición y diseño digital: Ricardo A. Dorr

Impresión: Offset Vega - Norberto J. Vega
Bolívar 3715 - 7600 Mar del Plata

INIDEP Documento Científico, 3
Mar del Plata, República Argentina

Citada en: Aquatic Sciences and Fisheries Abstracts (ASFIS); Agrindex (AGRIS).

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# REPORT OF THE INIDEP WORKING GROUP ON ASSESSMENT OF HAKE (*Merluccius hubbsi*) NORTH OF 48° S (SOUTHWEST ATLANTIC OCEAN) *

por

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## RESUMEN

**Informe del grupo de trabajo del INIDEP sobre la evaluación de la merluza (*Merluccius hubbsi*) al norte de 48° S (Océano Atlántico Sudoeste).** Este informe fue producido por el Grupo de Trabajo de Evaluación de Merluza. Se evaluó el recurso entre los 34° y 48°S (Argentina y Uruguay) sin incluir el Golfo San Matías. La evaluación analítica de la captura por grupo de edad fue realizada para el período 1983-1991, sobre la base de datos disponibles de Argentina. El modelo de VPA fue ajustado mediante las técnicas de Laurec-Shepherd y de Extended Survivor Analysis. Los resultados de estos análisis fueron congruentes con la información conocida hasta este momento del estado de la pesquería. Las estimaciones de biomasa por VPA se mantienen entre 2,1 y 2,7 millones de toneladas, similares a las estimadas a partir de campañas de investigación. La biomasa desovante estimada por VPA para el año 1991 se considera dentro de los niveles aceptables para la conservación del reclutamiento y la prosecución de la pesquería. Los valores actuales de esfuerzo permiten obtener, con relativa estabilidad, altos rendimientos y mantener la biomasa desovante. Se discuten además, estrategias de manejo.

## SUMMARY

**Report of the INIDEP working group on assessment of hake (*Merluccius hubbsi*) north of 48° S (Southwest Atlantic Ocean).** This Report was written by the Working Group on Assessment of Hake. The assessment covers hake between 34° and 48°S (Argentina and Uruguay), excluding Golfo San Matías. Total international landings and Argentine catch-at-age and effort data available for the 1983-1991 period allowed an analytical assessment. Tuning of the VPA was made using Laurec-Shepherd analysis and Extended Survivor analysis. The results of these analysis are congruent with the information about the state of the stock. VPA biomass estimates are around 2.1 and 2.7 mill. Tonnes, which are similar to those calculated through surveys. The Spawning Stock Biomass estimated for 1991 is considered to be within limits where the stock shows stable recruitment.. At the present effort level, yield and Spawning Stock Biomass appear to remain stable. Management measures are also discussed.

**Key words:** Stock assessment, fishery management, yield, *Merluccius hubbsi*, hake, PSW, Argentina.
**Palabras clave:** Evaluación, manejo de pesquerías, rendimiento, *Merluccius hubbsi*, merluza, PSW, Argentina.

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* Contribución INIDEP N° 870.

# 1. INTRODUCTION

## 1.1 Participation, Venue and Terms of Reference

The Working Group on Assessment of Hake north of 48°S met between April 26 and May 14 1993 in Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), Mar del Plata. The participants were Hans Lassen from Danish Institute for Fishery and Marine Research (DIFMAR), Charlottenlund, Denmark and the following scientists from INIDEP: Susana Bezzi (Chairperson), Guillermo Cañete, Marcelo Pérez and Marta Renzi. Guillermo Verazay, Administrative Secretary of Comisión Técnica Mixta del Frente Marítimo, participated part time at the invitation of the Director of INIDEP, Dr. Fernando Georgiadis.

This was the first phase of cooperation between INIDEP and DIFMAR on fishery biology science.

During this meeting the following topics were discussed

- Analysis of biological data for establishing background information for an assessment.
- VPA assessment based on 1978 - 1991 data and evaluation of appropriate biological reference points.
- The effects of technical measures, closed areas and seasons and mesh changes.
- Control problems, enforcement from a biological point of view.

## 1.2 Quality of the Assessment and Research Recommendations

Total international landings and Argentine catch-at-age and effort data available for the 1983-1991 period allowed an analytical assessment. The results of this analysis agree with the available information from the fishery, and the assessment is considered pertinent to management. However, the assessment of the optimal mesh size is not reliable before better data become available.

This analysis demonstrates the applicability of VPA assessment methods for hake. General Production Models which have hitherto been used, provide less detailed information on the status of the stock.

There are some data deficiencies in the assessment. Only Argentinean landings of those vessels landing fresh fish are sampled regularly; discards data, crucial to the mesh assessment, are scarce; and there is no regular survey covering the entire area of distribution.

The research needed to provide such data includes:

- A comparable set of data to that supplied by Argentina is required covering Uruguay, Spain and all other fleets fishing on these hake stocks.
- Sampling in other Argentinean ports (*e.g.* Puerto Madryn) than Mar del Plata is required.
- An observer program covering the entire fleet. Such a programme could give estimates of age and length distributions of the catch and discards by area and season.
- An annual survey over the total distribution area could estimate the length and age distribution of the stock, total biomass, total abundance and recruitment. Such a survey would also provide biological information such as the maturity ogive both in length and by age.

There are data available which need to be reinvestigated before the next assessment

- The effort data from 1991 should be reinvestigated because of the possible overestimate of the fishing mortality for this year.
- The limited data available from Uruguay and Spain should be compared with the Argentinean data.
- The entire effort time series should be studied to obtain the seasonal and area behaviour of the fleets. Also the age length keys should be disaggregated to provide a time and area breakdown matching that of the effort data. This breakdown would also improve the mesh assessment.

- An estimate of the natural mortality may be obtained from catch-at-age data available for the period 1968-1971 when the fishery was at a lower level than at present. Because changes in the ageing procedure, otoliths from these samples need to be reinvestigated.

In the discussion of the closure around Isla Escondida it was recognized that an observer program to be conducted on board the commercial fleet (2 observers per fishing vessel and per stratum) would improve the knowledge about the presence in this area of juveniles and of spawners during the entire closed season.

It is discussed which mesh is actually used by the fishing fleet. A survey of the fishing fleet possibly in connection with an observer programme would provide data to clarify the current situation. The connected problem of the selection factor applicable to commercial trawls could be studied by a selectivity survey using a fishing vessel. To ensure that the results are applicable also in the near future, a vessel as new as possible should be used for this study.

The priorities of the tasks listed above are:

For immediate action
- The effort data from 1991 should be reinvestigated
- The limited data available from Uruguay and Spain should be compared with the Argentinean data.
- Sampling in other Argentinean ports (*e.g.* Puerto Madryn) than Mar del Plata.
- A survey of the fishing fleet to clarify which mesh is actually used.
- An annual survey over the total distribution area.

For long term action
- An observer program covering the entire fleet.
- The entire effort time series should be studied to obtained the seasonal and area behaviour of the fleets.
- Estimate the natural mortality from catch-at-age data available for the period 1968-1971.

Manpower and facilities are required in order to complete and improve the information analysis as mentioned above. Therefore, these activities will be partially concluded when the next assessment takes place.

## 2. THE HAKE (*Merluccius hubbsi*) STOCK

Hake is a temperate-cold species living in subantarctic waters related to the Malvinas current system. Three main waters bodies define hakes hydrological habitat: 1) Brazilian current, 2) Malvinas current and 3) shelf waters.

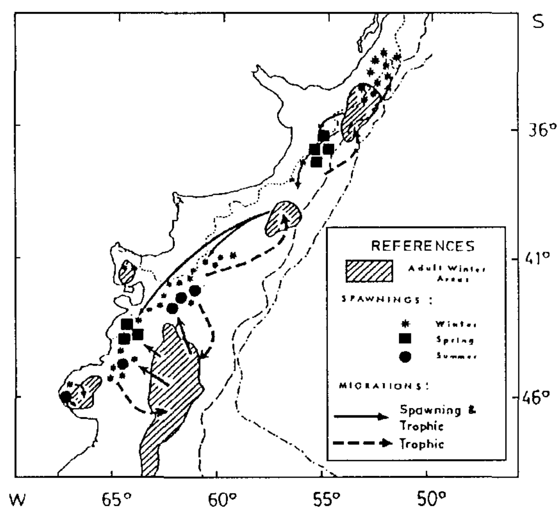


*Figure 1. Distributions and migrations patterns of hake* (Merluccius hubbsi).
Areas de concentración y migraciones de la merluza (*Merluccius hubbsi*).

The hake in the Southwest Atlantic is found on the Argentinean and Uruguayan continental shelves, mainly between 80 and 800 m depth, and between 34° and 54°S. Hake sometimes reaches Brazilian waters (23°S) due to subantarctic upwelling along the southern coast of Brazil.

Distributions and migration patterns are shown on Figure 1 (from Pérez Comas, 1990).

The assessment presented in this report covers hake between 34° and 48°S, excluding Golfo San Matías. Several hake stocks occur in this area, however stock boundaries are not well defined, there is mixing between stocks and the fisheries exploit several stocks. Therefore as a first approximation a combined assessment was investigated rather than a split based on uncertain data.

For a detailed summary of information available on hake stocks off Argentina and Uruguay, see Bezzi *et al.* (1993).

## 3. DESCRIPTION OF THE FISHERIES

### 3.1 Fleets

#### 3.1.1 Argentinean fleet

Fishing activities in Argentina are divided in two main categories: coastal and offshore. The coastal fleet is composed by small trawlers (< 25 m). Only a small part of this category operates on hake.

The offshore fleet can be divided in two groups. One group mainly landing hake and squid (Table 1) and the other principally target on shrimp. The shrimp fleet operates in an area which overlaps with the hake nursery ground and for this reason could take hake as by-catch. The main shrimp fishery season is from October to March.

#### 3.1.2 Uruguayan fleet

There are 34 trawlers in the hake fishery. They are all less than 40 m and with engine power between 600-900 HP. The fleet catches hake and occasionally squid. All these vessels land whole fresh fish (ungutted).

#### 3.1.3 Other Fleets

These are large factory vessels processing hake on board. The main part of this fleet is Spanish. Also occassionally former USSR participated in this fishery.

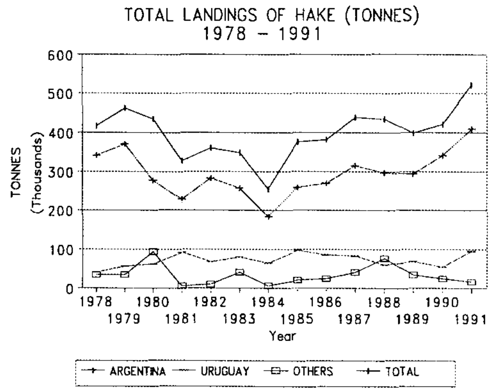


*Figure 2. Landings of hake by country (Tonnes).*
Desembarques de merluza por país (toneladas).

### 3.2 Landings

Landings by Argentina, Uruguay and other countries, mainly Spain, between 1978 and 1991 are given in Table 2 and Figure 2.

Argentina hake landings between 1970 and 1976 were below 200,000 Tonnes. After 1977 landings increased and were in 1991 409,000 Tonnes.

Uruguayan landings increased between 1976 and 1980. Landings were below 70,000 Tonnes. After 1980 the average landing is approximately 78,000 Tonnes, with more than 95,000 Tonnes in 1985 and 1991.

### 3.3 Discards

No regular monitoring of discards took place. However observations made in 1973-1974 from the Argentinean fleet showed discards between 10-30% in weight and about 25-40% in number caught (Cousseau and John, 1976).

*Table 1. The Argentine fishing fleet around 1990, from Bertolotti (1991).*
La flota pesquera argentina en 1990 (Bertolotti, 1991).

| Type<br>Trawlers | N. ships | Catch Capacity<br>'000 t | Length<br>m | GRT<br>HP |
|---|---|---|---|---|
| Whole fish, ice chilled | 114 | 445 | 25-45 | 300-350 |
| Gutted without head and ice chilled | 13 | 69 | 25-45 | 300-350 |
| Gutted without head and frozen | 21 | 174 | > 45 | 1500 |
| Fillet and frozen product | 27 | 265 | > 45 | 1500 |

*Table 2. Landings (Tonnes) of hake by country for 1978-1991.*
Desembarques (toneladas) de merluza por país entre 1978 y 1991.

| YEARS | ARGENTINA | % | URUGUAY | % | OTHERS | % | TOTAL |
|---|---|---|---|---|---|---|---|
| 1978 | 341,161 | 81.86 | 41,326 | 9.91 | 34,293 | 8.23 | 416,777 |
| 1979 | 370,905 | 80.28 | 57,057 | 12.35 | 34,077 | 7.38 | 462,039 |
| 1980 | 277,350 | 63.80 | 62,309 | 14.33 | 95,049 | 21.87 | 434,708 |
| 1981 | 228,729 | 70.05 | 92,268 | 28.26 | 5,524 | 1.69 | 326,521 |
| 1982 | 281,909 | 78.22 | 68,024 | 18.88 | 10,452 | 2.90 | 360,385 |
| 1983 | 257,100 | 73.95 | 79,692 | 22.92 | 10,896 | 3.13 | 347,688 |
| 1984 | 183,244 | 71.90 | 65,051 | 25.53 | 6,556 | 2.57 | 254,851 |
| 1985 | 259,334 | 68.88 | 97,150 | 25.80 | 20,012 | 5.32 | 376,496 |
| 1986 | 270,558 | 70.97 | 86,213 | 22.61 | 24,467 | 6.42 | 381,238 |
| 1987 | 314,220 | 71.59 | 83,693 | 19.07 | 41,008 | 9.34 | 438,921 |
| 1988 | 296,026 | 68.15 | 60,736 | 13.98 | 77,501 | 17.86 | 434,343 |
| 1989 | 294,333 | 73.89 | 69,329 | 17.41 | 34,655 | 8.70 | 398,317 |
| 1990 | 341,042 | 81.01 | 55,751 | 13.24 | 24,101 | 5.74 | 420,974 |
| 1991 | 409,250 | 78.50 | 95,890 | 18.39 | 16,172 | 3.10 | 521,312 |

Observations made in 1979-1980 showed discards between 2-5% in weight and 1-15% in number. Most fish discarded were below 35 cm, (Perez Comas *et al.*, 1986).

In spring 1988, observations from the Uruguayan fleet suggested that only about half of the catch in number (70% in weight) is actually landed. Most of the discard is fish below 35 cm with an average size of 25 cm (Rey y Menéndez, Ms). Hence the estimate of the stock of hake below 35 cm is an underestimate. The fish discarded were mainly of age groups 1 and 2.

## 4. CATCH AT AGE

### 4.1 Biological data

Hake landings have been sampled regularly in Mar del Plata Port since 1968. However in 1984 and 1989-90 sampling was very poor.

Historically, this port has accounted for almost 80% of the annual landings of hake in Argentina, but since 1985 landings to Patagonian Ports increased because of a southward movement of fishing effort. Also the absolute landings to Mar del Plata decreased. In 1990 Mar del Plata Port accounted for approx. 57% of the total Argentinean hake landings.

Only vessels landing ice chilled fish (whole ungutted) were sampled. Freezing and factory vessels process fish on board, and it is not possible to obtain length samples in port from these vessels. In 1990, 212,938 Tonnes were landed as ice chilled hake, representing 66% of the total landings or 90% of landings in Mar del Plata Port. Puerto Madryn is the second most important port.

The vessels sampled are considered to be representative of the whole operation of the hake fleet and it is assumed that the sampling in Mar del Plata Port is still representative of the total landings.

Data from a regular sampling of the Uruguayan fishery for hake have only been provided for the period 1980-1987 and only length compositions and no age-length keys were provided. These data only became available very recently and were not included in the construction of the catch-at-age matrix.

Length distributions by month for Spain were available for 1989 only, and were not used in the assessment. These data were obtained by observers. No biological data representing the catches of other countries were available.

It was considered preferable to obtain a time series of catch-at-age data on a comparable basis for the entire period. Hence the catch-at-age matrix presented in Table 3 is based on Argentinean data only.

### 4.2 Raising procedure of samples

Length, and sex were determined for all hake in the samples. Periodically, subsamples was taken and these fish were weighted and otoliths removed.

Until 1985, otoliths were taken at random (fixed number of individuals). From 1985 to 1989 a systematic sample was taken (1 each 5 individuals per length class and sex); and after 1989 a fixed number of 2 individuals per length class and sex was obtained.

Annual age-length keys were constructed as follows: the subsamples of otoliths obtained on a monthly basis were pooled by year. From this pool a fixed number of otoliths for each length/sex class was extracted at random for ageing. For each length/sex class below 35 cm, 20 otoliths were sampled, while 35 otoliths were taken from larger hake. The procedure is based on consideration of coefficient of variation (Baird, 1983).

In 1982 and 1989 the otolith subsamples were very poor. Therefore, an age composition for the landings was obtained from the length distribution for these years and the age-length keys of the previous years (Clark, 1981).

The length composition of the annual landings was estimated from the raising factors associated with the samples as follows:

*Table 3. Catch in number at age. Numbers*10**3.*
Captura en número por edad (N*10**3).

| YEAR AGE | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11368 | 4540 | 13468 | 31780 | 23150 | 26633 | 7451 | 12297 | 6846 | 13836 | 29053 | 7983 | 36316 | 26227 |
| 2 | 279822 | 115398 | 182135 | 121421 | 206496 | 240031 | 120820 | 165340 | 183408 | 222421 | 274416 | 230668 | 364926 | 393275 |
| 3 | 203531 | 330272 | 176906 | 125612 | 181065 | 197790 | 158151 | 235927 | 206738 | 202276 | 224580 | 212195 | 215466 | 336327 |
| 4 | 129667 | 176134 | 276463 | 98574 | 102050 | 86109 | 77137 | 124402 | 163239 | 116160 | 118214 | 48706 | 127894 | 162158 |
| 5 | 52300 | 103043 | 78704 | 107521 | 91995 | 45555 | 30687 | 67991 | 59900 | 76966 | 54669 | 42728 | 42759 | 56536 |
| 6 | 26401 | 47619 | 44579 | 40736 | 38212 | 17388 | 16847 | 23841 | 33748 | 52991 | 74477 | 97518 | 32413 | 17484 |
| 7 | 14589 | 17574 | 20071 | 20885 | 6530 | 23706 | 17159 | 19223 | 7383 | 23345 | 29404 | 40689 | 10567 | 5615 |
| 8 | 11819 | 10207 | 6775 | 10666 | 4171 | 8528 | 14445 | 7051 | 3571 | 7353 | 8453 | 11396 | 5238 | 1995 |
| 9 | 1028 | 5303 | 2892 | 9522 | 1904 | 2019 | 6020 | 6614 | 1991 | 2002 | 3302 | 1052 | 45 | 3204 |
| 10 | 1386 | 3844 | 2132 | 1807 | 2467 | 356 | 1824 | 2694 | 2333 | 1250 | 936 | 864 | 0 | 96 |
| 11 | 373 | 417 | 273 | 0 | 0 | 366 | 1872 | 605 | 1478 | 2104 | 1646 | 2200 | 0 | 509 |
| 12 | 0 | 263 | 417 | 0 | 0 | 0 | 0 | 320 | 72 | 0 | 0 | 0 | 0 | 78 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 52 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 4. Mean weight at age (grms).*
Peso medio por edad (gramos).

| YEAR AGE | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 223.40 | 205.73 | 232.87 | 255.01 | 0.00 | 219.66 | 171.92 | 214.24 | 244.16 | 234.71 | 227.41 | 0.00 | 237.6 | 252.02 |
| 2 | 398.46 | 362.71 | 384.73 | 367.11 | 0.00 | 387.54 | 365.93 | 386.57 | 394.04 | 391.06 | 381.36 | 0.00 | 405.74 | 393.16 |
| 3 | 554.35 | 450.21 | 513.98 | 450.56 | 0.00 | 529.41 | 494.50 | 506.53 | 515.99 | 523.77 | 507.69 | 0.00 | 545.27 | 539.21 |
| 4 | 653.41 | 587.30 | 591.69 | 543.39 | 0.00 | 670.99 | 638.87 | 602.17 | 618.39 | 633.61 | 621.91 | 0.00 | 654.31 | 647.32 |
| 5 | 783.18 | 687.95 | 700.43 | 604.91 | 0.00 | 745.15 | 726.18 | 735.61 | 757.42 | 678.87 | 707.07 | 0.00 | 773.02 | 772.37 |
| 6 | 853.02 | 812.20 | 848.72 | 695.31 | 0.00 | 821.18 | 848.87 | 857.29 | 902.17 | 876.09 | 783.66 | 0.00 | 860.73 | 928.68 |
| 7 | 984.04 | 985.72 | 791.08 | 715.81 | 0.00 | 852.73 | 985.62 | 1021.35 | 1049.84 | 1043.66 | 932.61 | 0.00 | 896.45 | 1013.2 |
| 8 | 972.20 | 976.43 | 1190.23 | 738.16 | 0.00 | 1215.59 | 1092.90 | 1285.64 | 1194.81 | 1243.16 | 1114.00 | 0.00 | 946.98 | 904.33 |
| 9 | 1965.49 | 1282.02 | 1181.74 | 893.67 | 0.00 | 1408.99 | 1313.72 | 1219.90 | 1405.81 | 1408.62 | 1063.68 | 0.00 | 4192.19 | 1042.81 |
| 10 | 915.23 | 1289.39 | 891.18 | 710.53 | 0.00 | 3009.53 | 1137.49 | 1751.10 | 1695.12 | 1238.36 | 1377.76 | 0.00 | 0.00 | 1452.96 |
| 11 | 784.35 | 1509.84 | 2081.57 | 0.00 | 0.00 | 1995.10 | 1586.16 | 1201.20 | 2144.04 | 1135.53 | 1204.68 | 0.00 | 0.00 | 2022.71 |
| 12 | 0.00 | 2230.76 | 1354.31 | 0.00 | 0.00 | 0.00 | 0.00 | 2100.14 | 2218.51 | 0.00 | 0.00 | 0.00 | 0.00 | 1733.33 |

$$F_i = \frac{C_1 * C_2 * C_3 * C_4}{PM * SC_1 * SC_2 * SC_3}$$

$F_i$ : Raising factor for the i sample.
PM : Sample weight.
$C_1$ : Landing of the sampled boat.
$C_2$ : Landing by month from the statistical square where the sample have been taken.
$SC_1$ : Total landing of the sampled boats in the statistical square.
$C_3$ : Landing by month.
$SC_2$ : Total landing reported from the statistical square where samples have been taken.
$C_4$ : Total annual landing.
$SC_3$ : Total landing during the months where samples have been taken.

These factors were applied to the total landing by geographical areas as provided by fishery statistics and the total length distributions for the annual landing 1978-1991 were obtained for both sexes combined. These length distributions were then applied to the age-length keys. The estimated catch-at-age matrix is shown in Table 3.

## 5. MEAN WEIGHT AND MEAN LENGTH AT AGE

A length-weight relationship was estimated for each year from the landing subsamples (total length and weight per individual).

$$\log W = \log a + b \log L$$

This relationship was used to estimate the sample weights. The mean weight-at-age matrix were derived from the mean weight per length class, the age-length keys and the length distribution of the annual total landings (Table 4).

Figure 3 shows the mean weight for age groups 2, 3 and 4 for 1978-1991. No marked trends were observed.

Figure 4 shows the mean length for age groups 2, 3 and 4 for the entire period and also this figure shows no clear trend.

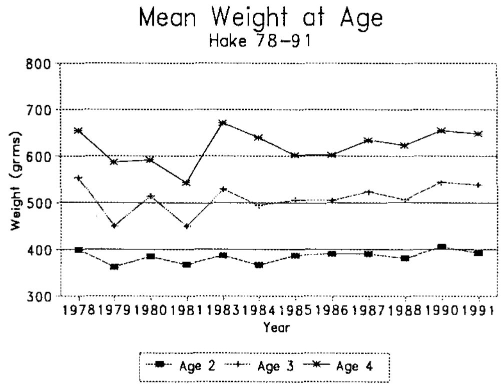


*Figure 3. Mean weight (grams) for age groups 2, 3 and 4. Period 1978-1991.*
Peso medio (gramos) para los grupos de edad 2, 3 y 4. Período 1978-1991.

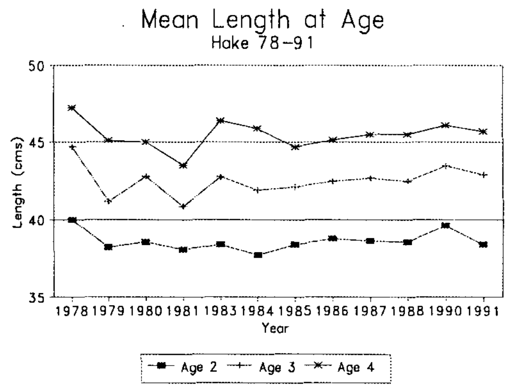


*Figure 4. Mean length (cm) for age groups 2, 3 and 4. Period 1978-1991.*
Largo medio (cm) para los grupos de edad 2, 3 y 4. Período 1978-1991.

Between 1978 and 1983 mean weight-at-age and mean length-at-age fluctuated. After 1985 these fluctuations were less marked, possibly as a result of increased sampling.

For the assessment, the average 1985-1991 of both mean weight-at-age and mean length-at-age were applied.

## 6. MATURITY OGIVE

The age of first maturity was found by Simonazzi y Otero (1986) as 3.6 and 3.5 years for males and females, respectively. However they did not consider age group 0 and they included all rings in the otoliths in the age determination. The procedure used at present, assigns age groups *i.e.* ignores the winter ring until after 1st January. Therefore, the results of Simonazzi y Otero (1986) correspond approximately to 2.5 years old.

The age-maturity ogive was re-estimated, based on the length-maturity ogive estimated by Simonazzi (Informe 4/89/GTD). His data were obtained from four hake surveys in 1986-1987 in the Argentine-Uruguayan Zona Comûn de Pesca, one survey in each quarter of the year.

The 1986 annual age-length key was applied to the length-maturity ogive. The results are shown in Table 5.1 and suggest that a significant proportion of age group 1 males are mature. However poor otolith sampling in 1986 make this result uncertain. Instead an average (1978-1991) age-length key by sex was constructed to minimize sampling errors. This average age-length key was applied to the length-maturity ogive and the maturity proportion for each age group calculated. The results are shown in Table 5.2.

For the assessment, it was assumed, that 60% of the individuals of age group 2 have reached maturity. No individuals of age group 1 were considered mature, while all individuals of age 3 and older were assumed to be mature. Even though the data suggest minor differences in age at first maturity between sexes this was ignored for the assessment.

## 7. SURVEY RESULTS

Table 6 summarizes biomass estimates from bottom trawl surveys conducted between 1978-1991 (see Bezzi *et al.*, 1993). The 1978 and 1979 surveys collected eggs and larvae on the spawning grounds. These data were used to estimate the spawning stock biomass at 1.1 mill Tonnes (Ciechomski *et al.*, 1981). The authors considered that "this evaluation which refers only to the adult spawning stocks of hake of lengths over 33-34 cm., may be underestimated as the sampling grid might not have covered the whole reproduction area during summer". Therefore this value was not used in the present assessment.

## 8. COMMERCIAL CATCH RATES

Before 1973, the offshore fleet consisted of a few vessels with similar characteristics and the fleet was considered homogeneous.

With the entry into the fishery of new vessels with power more than 1,000 HP, two categories were identified with different efficiencies. Standardization of effort (Castello *et al.*, 1975) was made from:

$$U = (C_A / X_A) / (C_B / X_B)$$

where:

$C_A$ and $X_A$ are landing and effort of vessels less than 1000 HP

$C_B$ and $X_B$ landing and effort of vessels more than 1000 HP

After 1988, U was found to be close to 1. The estimated CPUE is raised to total effort by year (Table 7).

There has been changes in the number of vessels and in the distribution of fishing effort after 1988 (Giangiobbe *et al.*, 1993). However Irusta (MS) investigated the estimation procedure in 1992 and still found that for 1989 and later years there is no CPUE difference between the two fleet categories.

*Table 5.1. Maturity ogive. Based on age-length key for 1986.*
Ojiva de madurez. Basada en la clave largo-edad para 1986.

| Males | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Nø Mat. | 4694 | 13834 | 7287 | 4433 | 2260 | 2260 |
| Nø Tot. | 19335 | 17011 | 7663 | 4482 | 2285 | 2285 |
| Percent. | 0.24 | 0.81 | 0.95 | 0.99 | 0.99 | 0.99 |
| Females | 1 | 2 | 3 | 4 | 5 | 6 |
| Nø Mat. | 87791 | 1354094 | 912591 | 1150643 | 546998 | 335147 |
| Nø Tot. | 683536 | 2546222 | 933008 | 1156510 | 548202 | 335737 |
| Percent. | 0.12 | 0.53 | 0.98 | 0.99 | 1.00 | 1.00 |

*Table 5.2. Maturity ogive. Based on age-length keys for the period 1978-1991.*
Ojiva de madurez. Basada en las claves largo-edad para el período 1978-1991.

| Males | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Nø Mat. | 601841 | 1372530 | 702609 | 415960 | 264531 | 143296 |
| Nø Tot. | 4303178 | 2154819 | 751739 | 421686 | 267081 | 144670 |
| Percent. | 0.14 | 0.64 | 0.93 | 0.99 | 0.99 | 0.99 |
| Females | 1 | 2 | 3 | 4 | 5 | 6 |
| Nø Mat. | 143916 | 1209159 | 1088842 | 913048 | 550522 | 329281 |
| Nø Tot. | 4578739 | 2181035 | 1150251 | 919402 | 552123 | 330006 |
| Percent. | 0.03 | 0.55 | 0.95 | 0.99 | 1.00 | 1.00 |

*Table 6 . Bottom trawl surveys made between 1978 and 1991 with the objective of estimating abundance and stock biomass. The depth range covered was 50 - 400 m. The area "ZCP" is the Zona Común de Pesca.*
Campañas de pesca de fondo realizadas entre 1978 y 1991 para la estimación de abundancia y biomasa poblacional. El rango de profundidad cubierto osciló entre 50 y 400 m. "ZCP" es Zona Común de Pesca.

| Ship | Year | Season | Area | Biomass mill Tonnes |
|---|---|---|---|---|
| Shinkai Maru | 1978 | winter | 35-55°S | 3.9 |
| Shinkai Maru | 1979 | Summer | 35-55°S | 3.9 |
| Dr. Holmberg Cap. Cánepa | 1981 | Winter | 35-48°S | 1.6 |
| Dr. Holmberg Cap. Cánepa | 1982 | Summer | 35-48°S | 1.8 |
| Dr. Holmberg Cap. Cánepa | 1983 | Winter | 35-48°S | 2.3 |
| Dr. Holmberg Cap. Cánepa | 1983 | Summer | 35-48°S | 2.7 |
| Cap. Oca Balda | 1986 | Autumn | ZCP | 0.67 |
| Cap. Oca Balda | 1986 | Winter | ZCP | 0.41 |

| Ship | Year | Season | Area | Biomass mill Tonnes |
|---|---|---|---|---|
| Cap. Oca Balda | 1987 | Summer | ZCP | 0.42 |
| Cruz del Sur | 1987 | Spring | ZCP | 0.11 |
| Cruz del Sur | 1988 | Summer | ZCP | 0.15 |
| Cruz del Sur | 1988 | Autumn | ZCP | 0.20 |
| Cruz del Sur | 1988 | Winter | ZCP | 0.15 |
| Cruz del Sur | 1989 | Autumn | ZCP | 0.18 |
| Cap. Oca Balda | 1991 | Autumn | ZCP | 0.61 |
| Cap. Oca Balda | 1991 | Winter | ZCP | 0.29 |

*Table 7. CPUE and total effort by year. (CPUE observed for the Argentinean fleet, the total effort is calculated by dividing the total international landings by CPUE.*
CPUE y esfuerzo total por año. (CPUE observado en la flota argentina. El esfuerzo total se calculó dividiendo los desembarques internacionales totales por el CPUE).

| Year | CPUE | Total effort |
|---|---|---|
| 78 | 4.33 | 96.26 |
| 79 | 4.04 | 114.36 |
| 80 | 3.93 | 90.25 |
| 81 | 3.54 | 92.23 |
| 82 | 3.22 | 111.93 |
| 83 | 3.42 | 101.67 |
| 84 | 4.36 | 58.46 |
| 85 | 3.38 | 111.36 |
| 86 | 2.92 | 130.55 |
| 87 | 2.61 | 168.16 |
| 88 | 2.44 | 177.89 |
| 89 | 2.24 | 177.81 |
| 90 | 2.25 | 187.11 |
| 91 | 2.62 | 198.97 |

## 9. NATURAL MORTALITY

Otero and Kawai (1981) and Prenski y Angelescu (1991) have estimated the natural mortality rate for hake. Considering these estimations a value of 0.3 per year for the entire period and for all ages was assumed for this analysis.

Estimation of M could be based on the catch-at-age (Table 3) and the effort data (Table 7). Plotting the log of CPUE ratios for age 3/4 and 4/5 vs effort showed a very scattered picture and the regression parameters were obtained with large standard errors. M was actually estimated at 0.58 per year with a standard error of 0.31. This is not considered a better estimate than the 0.3 per year found by other authors. There are catch-at-age data available for the period 1968-1971 when the fishery was at a lower level than at present. Otoliths from these samples need to be reinvestigated before these data could be used for analysis.

## 10. VPA ANALYSIS

Preliminary runs of Separable VPA and Laurec-Shepherd (L-S) VPA were made using data from 1978-1991. Age group 7 and older age classes had large log residuals in both analyses. These age groups are not very abundant in the samples and for further analysis these ages were aggregated into a 7-plus group.
Residuals for the years 1978-1982 by age from L-S VPA showed high variation. In these years sampling was less compared to the present level. Therefore, only data from 1983-91 period were used in the assessment.

### 10.1 Laurec-Shepherd Analysis (L-S)

Tuning of the VPA was made using total effort data (Table 7) combined with the corresponding age compositions *i.e.* the total landings by age (Table 3). The effort data series is the only consistent time series available which allows tuning.

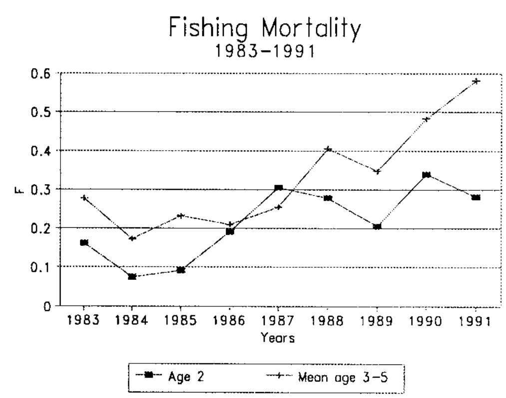


*Figure 5. Fishing mortalities (per year) for age groups 2 and 3-5. Period 1983-1991.*
Mortalidades por pesca (por año) para los grupos de edad 2 y 3-5. Período 1983-1991.

The estimated fishing mortalities, stock sizes and total stock biomass by age and year are shown in Tables 8, 9 and 10. Figure 5 shows the values of F for age 2 (partially recruited), and the mean value of F for ages 3 to 5 (fully recruited) for the 1983-1991 period.

The only surveys available, which covered the entire area of distribution and which provided estimates of the total biomass, are from 1983 summer and winter surveys (Table 6). These Total Biomass estimates are 2.7 and 2.3 mill. Tonnes respectively. The corresponding VPA estimates is 2.6 mill. Tonnes which agrees well with the observed biomass.

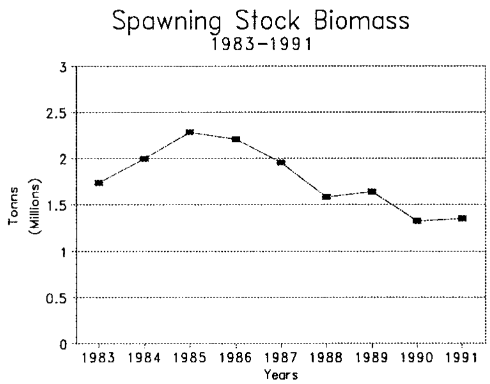


*Figure 6. Spawning stock biomass estimated by Laurec-Shepherd method. Period 1983-1991.*
Biomasa de la población desovante estimada por el método de Laurec-Shepherd. Período 1983-1991.

Figure 6 shows a plot of SSB against year. From 1986 to 1991 the biomass decreased coinciding with an increase of the fishing mortality (Figure 5). The SSBs estimated for 1990-1991 are below those observed for other years. Surveys in 1978 and in 1979 estimated the SSB at 1.1 mill. Tonnes based on egg/larvae densities. This however is considered to be an underestimate, a provisional VPA analysis indicates a much higher SSB. Figure 6 indicates that recent recruitment is closed to the 1983-1991 average and the SSBs estimated for 1990-1991 are considered to be within limits, where the stock shows stable recruitment.

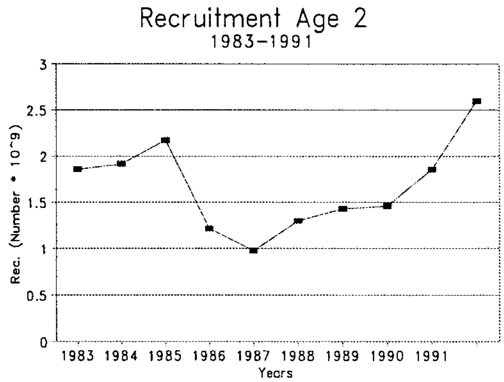


*Figure 7. Recruitment of age 2 estimated by Laurec-Shepherd method. Period 1983-1991.*
Reclutamiento para la edad 2 estimado por el método de Laurec-Shepherd. Período 1983-1991.

Figure 7 shows the estimated stock in number for age group 2 *vs.* year. Recruitment to the fishery takes place at age 2. The recruitment varies around 1,500 mill. ind. and no very strong year-class can be identified, but there appeared to be a period of good recruitment around 1985. Recruitment varies within a factor of two *i.e.* recruitment is fairly stable over the period.

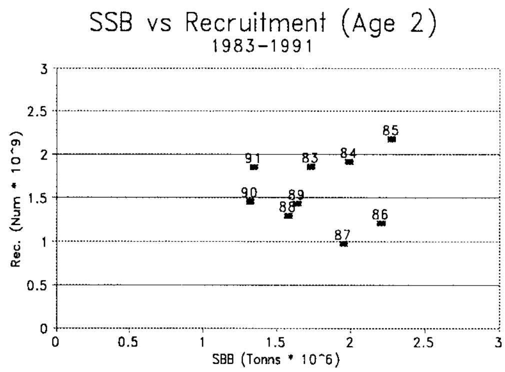


*Figure 8. Number of recruits against SSB for 1983 to 1991. The year is when the year-class recruits as age 2.*
Número de reclutas versus biomasa de la población desovante entre 1983 y 1991. El año corresponde a la clase anual de reclutas de edad 2.

There is no apparent relationship between SSB and recruitment (Figure 8).

*Table 8. Fishing mortality (F) at age.*
Mortalidad por pesca (F) por edad.

| YEAR AGE | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | .0118 | .0029 | .0087 | .0060 | .0091 | .0173 | .0047 | .0167 | .0086 |
| 2 | .1615 | .0756 | .0920 | .1914 | .3047 | .2788 | .2056 | .3400 | .2805 |
| 3 | .2591 | .1694 | .2310 | .1770 | .3749 | .6564 | .4074 | .3382 | .6920 |
| 4 | .2945 | .1696 | .2179 | .2777 | .1589 | .4434 | .3200 | .5242 | .5225 |
| 5 | .2759 | .1805 | .2478 | .1724 | .2281 | .1160 | .3190 | .5870 | .5296 |
| 6 | .2765 | .1732 | .2322 | .2090 | .2540 | .4053 | .3488 | .4831 | .5813 |
| 7+g | .2765 | .1732 | .2322 | .2090 | .2540 | .4053 | .3488 | .4831 | .5813 |
| Av3-5 | .2765 | .1732 | .2322 | .2090 | .2540 | .4053 | .3488 | .4831 | .5814 |

*Table 9. Stock number at age (start of year). Numbers*10**3.*
Número de individuos de la población por clase de edad al comienzo del año (N*10**3).

| YEAR AGE | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2617523 | 2942527 | 1651495 | 1321192 | 1765836 | 1962657 | 1970964 | 2536592 | 1968828 |
| 2 | 1855851 | 1916278 | 2173489 | 1212915 | 972894 | 1296302 | 1429070 | 1453281 | 1848027 |
| 3 | 996704 | 1169851 | 1316207 | 1468708 | 742027 | 531453 | 726642 | 861896 | 766329 |
| 4 | 387898 | 569864 | 731605 | 773925 | 911550 | 377864 | 204228 | 358184 | 455295 |
| 5 | 217186 | 214063 | 356300 | 435890 | 434326 | 576081 | 179670 | 109862 | 157095 |
| 6 | 82750 | 122099 | 132386 | 206011 | 271772 | 256133 | 380028 | 96753 | 45250 |
| 7+g | 166446 | 299468 | 202718 | 102724 | 184908 | 150428 | 219015 | 47312 | 29755 |
| TOT | 6324357 | 7234150 | 6564200 | 5521366 | 5283312 | 5150917 | 5109616 | 5463881 | 6834047 |

*Table 10. Stock biomass at age (start of year). Tonnes*10**3.*
Biomasa de la población por clase de edad al comienzo del año (toneladas*10**3).

| YEAR AGE | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 574965 | 505879 | 353816 | 322582 | 414459 | 446328 | 458269 | 602694 | 890209 |
| 2 | 719216 | 701224 | 840206 | 477937 | 380460 | 494358 | 562411 | 589654 | 726570 |
| 3 | 527665 | 578491 | 666698 | 757839 | 388652 | 269813 | 382562 | 469966 | 413212 |
| 4 | 260275 | 364069 | 440551 | 478588 | 577567 | 234998 | 130320 | 234363 | 294721 |
| 5 | 161836 | 155448 | 262098 | 330152 | 294851 | 407329 | 132965 | 84925 | 121336 |
| 6 | 67952 | 103647 | 113493 | 185857 | 238097 | 200721 | 312459 | 83278 | 42023 |
| 7+g | 282358 | 366304 | 289865 | 166210 | 224454 | 171270 | 344994 | 95186 | 40514 |
| TOTBIO | 2594268 | 2775061 | 2966727 | 2719164 | 2518539 | 2224817 | 2323980 | 2160068 | 2528585 |

### 10.2 Extended Survivor Analysis (XSA)

This analysis is based on the same assumptions and data as the Laurec-Shepherd analysis discussed above. However the XSA analysis do not treat the terminal year different from others years as do the L-S analysis.

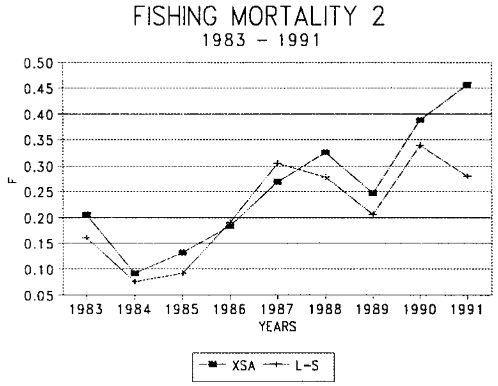


*Figure 9. Fishing mortalities (per year) of age group 2 estimated by Laurec-Shepherd method and Extended Survivor analysis for 1983-1991.*
Mortalidades por pesca (por año) para el grupo de edad 2 estimado por los métodos de Laurec-Shepherd y Análisis de Sobrevivientes para 1983-1991.

A comparison between the estimated fishing mortalities from XSA with those estimated from the L-S analysis (Figures 9 and 10) shows that these are similar except for 1991, slightly higher for XSA. Both analyses indicate an upward trend during the later years, this trend being more pronounced in the XSA analysis, with extremely high values in 1991.

No new vessels were introduced in the fishery in 1991 and general indications from the fishery are that no show any major changes occurred between 1990 and 1991. The XSA results for 1991 are considered overestimates of the current level of exploitation and the catch projections are based on the L-S results.

### 10.3 Retrospective Analysis

As discussed in section 10 the data analysis was restricted to age groups 1-7+ and to the time period 1983-1991. To investigate the accuracy of the estimated fishing mortalities, a retrospective analysis focusing on 1987 and later years was conducted. The F-at-age array for 1987 was obtained first by restricting the analysis to 1983-1987 and then successively include year by year up to 1991. The estimated fishing mortalities for age groups 2, 3, 4 and 5 were plotted in the figures 11, 12, 13 and 14. These indicates, that the fishing mortality from the last year in the assessment will change when more data later becomes available and that this change appears to be within 0.1-0.2. There do not appear to be any systematic either over- nor underestimation.

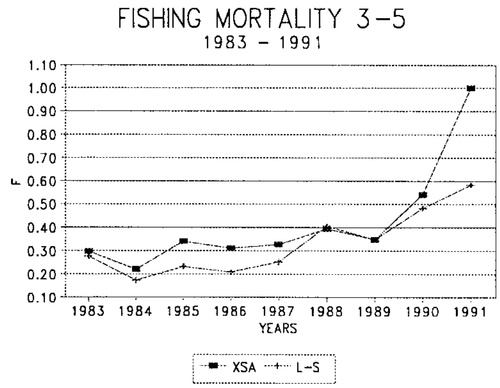


*Figure 10. Fishing mortalities (per year) of age groups 3-5 estimated by Laurec-Shepherd method and Extended Survivor analysis for 1983-1991.*
Mortalidades por pesca (por año) para los grupos 3-5 estimadas por los métodos de Laurec-Shepherd y Análisis de Sobrevivientes para 1983-1991.

## 11. DYNAMIC POOL MODEL ANALYSIS

A non-equilibrium dynamic pool model (CEDA) was applied to CPUE and landing data for the 1978-1991 period. Application of this model requires constant mortality, but the effort has increased causing fishing mortality to increase and one of the basic assumptions in this analysis is therefore not satisfied. The analysis can only be

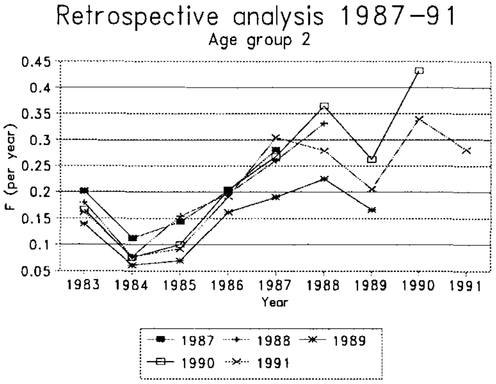


*Figure 11. Retrospective analysis 1987-1991. Age 2.*
Análisis retrospectivo 1987-1991. Edad 2.

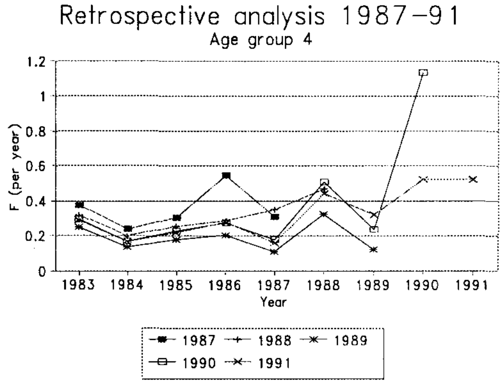


*Figure 13. Retrospective analysis 1987-1991. Age 4.*
Análisis retrospectivo 1987-1991. Edad 4.

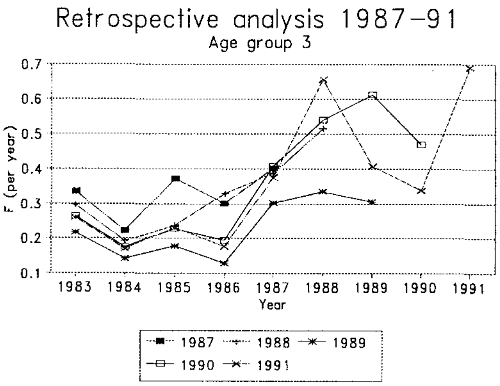


*Figure 12. Retrospective analysis 1987-1991. Age 3.*
Análisis retrospectivo 1987-1991. Edad 3.

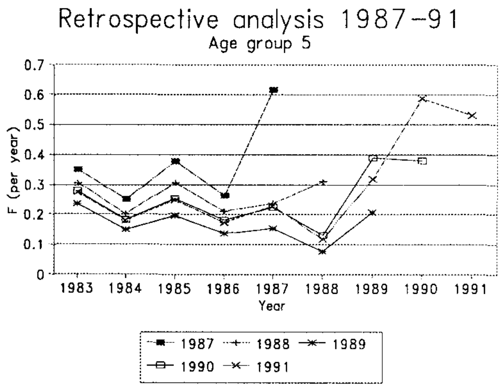


*Figure 14. Retrospective analysis 1987-1991. Age 5.*
Análisis retrospectivo 1987-1991. Edad 5.

used as a crude guide of MSY levels. Figure 15 shows the observed and fitted CPUE values and estimated biomass, all three decline steadily. Figure 15 further analyses the log residuals. The CPUE observations for 1984 and 1991 have large residuals, however removing these observations from the analysis did not change the conclusion that the present landing level is around or slightly below the MSY level.

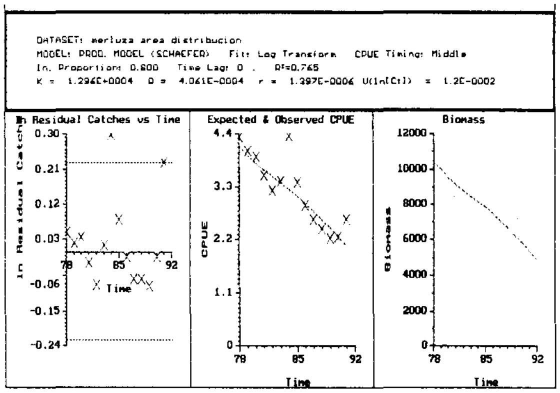

*Figure 15. Dynamic Pool Model analysis applied to CPUE and total landings for hake. A) Shows the ln residuals of CPUE, B) shows the observed CPUE (kg/hp*hr) and the fitted curve and C) shows the development of the biomass (arbitrary units) for the 1978-1991 period.*
Modelo dinámico aplicado al CPUE y a los desembarques totales de merluza. A) ln de los residuales del CPUE. B) CPUE observado ((kg/hp*hr) y la curva ajustada. C) Desarrollo de la biomasa (en unidades arbitrarias) para el período 1978-1991.

## 12. CATCH PROJECTIONS

### 12.1 Fishing mortalities and stock size for catch predictions

For short term projections, the results from the L-S VPA were used.

Very few age group 1 hake appears in the landings, as hake of this age group is discarded. These projections exclude age group 1 and do not account for the discards. The projections are therefore of landings.

The stock numbers were taken from the VPA estimate for 1991 projected to the beginning of 1992. The estimate of the recruiting age group 2 in 1992 is based on landings of age group 1 in 1991. This age group is very scarcely represented in the landings and because of this and because of an unknown amount discarded, this estimate is subject to a very large uncertainty and is not considered reliable. Instead for age group 2 (recruitment) in 1992 an average of 1983-1991 was used, 1,570 mill. ind.

As discussed in section 10.1, age 3 is the first fully recruited age group and these and older hake are considered to have the same fishing mortality. Hake older than 5 are few in the landings and as a estimate of the fishing mortality on the fully recruited age groups an average over age 3 to 5 was used. The VPA estimate of F on age group 2 is used for the projections.

The estimated fishing mortality for 1991 is higher than that for 1990 (Table 8 and Figure 5). However this increase may be overestimated and therefore two levels of fishing mortalities for age group 2 and for age 3-5 were investigated. The first option was obtained directly from the estimated 1991 F-at-age array and the second option is the average 1989-1991. These options probably represent extremes, either no change between 1990 and 1991 and the full estimated increase. This range is considered to incorporate the actual fishing mortality. As discussed below projections for 1992 compared with provisional landing data suggest this.

The mean weight-at-ages shows no trend with time (Figure 3). To project the yield for 1992-1994, an average array of mean weight-at-age covering the period 1985-1991 was used. To represent the 7+ group the average over ages 7 to 9 was used, as the mean weights of hake of age 10 and older show very large variation between years. The same mean weight-at-age array was used for estimation of Spawning Stock Biomass (SSB). The maturity ogive used, is presented in section 6.

### 12.2 Short term projections

Table 11 presents catch projections for three options:

1) F-0.1 ($F_{3\text{-}5} = 0.36$)
2) F for the average situation 89-91 ($F_{3\text{-}5}$ = 0.47)
3) F estimate for 1991 ($F_{3\text{-}5} = 0.58$).

Calculation of F-0.1 is explained in section 12.3 below.

The total landings for 1992 are not known precisely at present but preliminary data put this value at 480,000 Tonnes. This is higher than the projected landings based on the average 89-91 F, but below that projected, if the F estimated for 1991 is used (Table 11). Assuming that F for 1991 is equal to F for 1992, the F for the terminal year in the VPA (1991) is between 0.47 and 0.58. So the TAC for 1993 and 1994 was estimated as a mean between these landing values (Table 11). This value includes other countries than Argentina (Uruguay, Spain, etc.). Argentine average landings are 74 % of the total.

Table 11 shows that SSB is expected to remain stable at approximately 1.2 mill. Tonnes at the present level of effort. Figure 8 shows the SSB-recruitment relationship. From this figure it is not possible to derived a relationship and therefore it is not possible to predict recruitment with any confidence should the SSB decrease much below the present level.

### 12.3 Long term projections

The long term projection used the same average recruitment (age group 2) of 1,570 mill. ind. as in section 12.2 and the F-at-age array used was the average 1989-1991. Natural mortality, mean weights-at-age and maturity ogive were also as applied for the short term projections. Figure 16 shows the yield and SSB curves. The fishing mortalities on the x-axis are adjusted to the 1989-1991 average (set at 1) and the arrow shows the L-S VPA estimate for fishing mortality for 1991.

The F-0.1 level is the level where the slope of the yield curve is 10 % of the slope of the curve at F = 0. This reference point has been advocated as an appropriate effort level for a sound economic fishery and is found at 0.77 of the 89-91 level.

The F-max level corresponds to the maximum yield which can be taken from the stock. However, the yield curve is flat-topped and F-max is estimated to be at effort levels much higher than those seen at present. The yield curve at such high levels of exploitation is not realistic because the corresponding low SSB would have affected recruited adversely. Therefore F-max is not considered further.

At the present level of exploitation an increase of effort would increase the yield only slightly but decrease the SSB below historic low levels. *E.g.* a doubling of the effort would only increase the yield by about 10 % while the SSB at the same time would decrease by 35 %.

It is therefore advisable not to increase effort appreciably over the present level. At the present effort level, yield and SSB appear to remain stable.

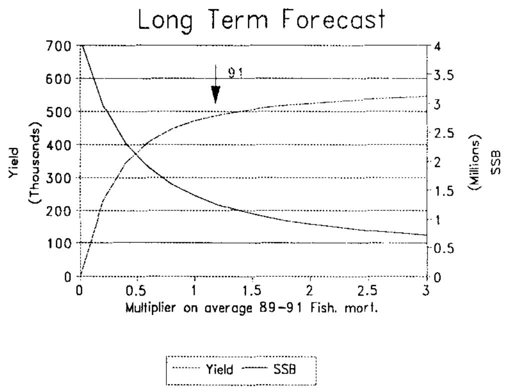


*Figure 16. Long term projection of yield and SSB.* Proyección a largo plazo del rendimiento y de la biomasa de la población desovante.

## 13. EFFECTS OF MESH SIZE CHANGES

### 13.1 Selection factor, selectivity range and mesh size used around 1990

The selection factor (SF) and length of first capture (L50) of the commercial fleet were used to estimate the effective mesh size from:

Mesh size = L50 / SF

Selection factors have been estimated up to 4.1 (Dahm, 1980) and the length of first capture ranged from 30 to 35 cm. The effective mesh size used by the commercial fleet was therefore found to be around 80 mm (= 32 cm / 4), well below the legal minimum mesh size of 110 mm. There are doubts about the relevant selection factor for trawl cod-ends used in the commercial fleet. Values as low as 2.1 have been observed (Verazay *et al.*, 1992). Whether fishing were done with illegal small meshes or the nominal mesh were effectively reduced through rigging is not known. The mesh assessment presented below assumes that the fishery is conducted with an 80 mm effective mesh size and the selectivity curve was calculated for a selection factor of 4 and a range of 15 cm.

### 13.2 Long term effects of a mesh change

Simulations were made for 80, 90, 100, 110 and 120 mm mesh size.

The basis for the simulations was

- The VPA stock numbers and fishing mortalities for 1991 (Tables 8 and 9).
- Mean weight-at-age and mean length-at-age were the averages for 1985-1991 (Table 12).
- A natural mortality of 0.3 per year, see Section 9.
- The maturity ogive given in Section 6.

The results were very dependent on whether account is made of discards or not. Excluding discards from the calculations indicates that even a decrease of the effective mesh size below 70 mm would not increase the mortality on age group 1 significantly and this is considered completely unrealistic. Data on discards are few, but demonstrate that large numbers of small hake are actually discarded.

Fishing mortalities of age groups 1 and 2 estimated from VPA, represent only landings and are underestimates of the mortality generated by fishing.

This additional discard mortality was calculated as the difference between F derived from the selectivity curve and the F estimated from VPA using the following formulae:

F-discard(age 1) =
F(VPA age 4)*Selectivity(age 1)-F(VPA age 1)

The F(VPA age 4) was chosen as an age group which is fully recruited *i.e.* selectivity = 1 for this age group. A similar calculation was made for age group 2. No other age groups were included in the discard calculations.

This assumption implies that small hake is caught proportional to their occurrence in the stock. While the assumption of no discards is unrealistic, the present calculations probably overestimates the potential gains from a mesh increase. However the simulations presented better represent the effects from a mesh increase than ignoring discards.

For the simulations, the average recruitment of age group 2 (approximately 1,500 mill. ind.) were used. This corresponds to a recruitment of 2,800 mill. ind. of age 1 using M = 0.3 per year and the 1991 fishing mortalities including the correction for discards as described above.

Mean weight-at-age per individual in the discards were derived for age group 1 assuming a mean length of 25 cm (which value was observed in the Uruguayan discard study) and 32 cm for age group 2. These lengths-at-age were converted to weight using an average weight-length relationship based on 1987, 1989-1991 data giving about half of the landing mean weight for ages 1 and 2.

The simulation results are given in Figure 17

*Table 11. Short term projection. Total Landings (Y) and SSB, both in '000 Tonnes with different options of fishing mortality for fully recruited age groups (3 and older).*
Proyección a corto plazo. Desembarques totales (Y) y biomasa de la población desovante, ambos en miles de toneladas, con diferentes opciones de mortalidad por pesca para los grupos de edad totalmente reclutados (3 y mayores).

| Year | | Options | | | |
|---|---|---|---|---|---|
| | | 91(3-5) | Mean | 89-91 (3-5) | F0.1 (3-5) |
| | F 92 | 0.58 | | 0.47 | 0.36 |
| 1992 | Y 92 | 516 | 487 | 458 | 363 |
| | SSB | 1279 | | 1335 | 1433 |
| | F 93 | 0.58 | | 0.47 | 0.36 |
| 1993 | Y 93 | 485 | 470 | 457 | 390 |
| | SSB | 1233 | | 1315 | 1472 |
| | F 94 | 0.58 | | 0.47 | 0.36 |
| 1994 | Y 94 | 473 | 465 | 457 | 407 |
| | SSB | 1196 | | 1287 | 1472 |

*Table 12. Mean weight at age (grammes) and mean lenght at age (cm), averages 1985-1991.*
Peso medio por edad (gramos) y largo medio por edad (cm) promedios para el período 1985-1991.

| AGE | MEAN WEIGHT (gr) | MEAN LENGTH (cm) | AGE | MEAN WEIGHT (gr) | MEAN LENGTH (cm) |
|---|---|---|---|---|---|
| 1 | 235.02 | 21.34 | 5 | 737.39 | 47.63 |
| 2 | 391.99 | 38.72 | 6 | 868.10 | 50.21 |
| 3 | 523.08 | 42.70 | 7+ | 1276.61 | 61.33 |
| 4 | 629.62 | 45.43 | | | |

*Table 13. Short term yield estimated for different mesh sizes. Tonnes*10**3.*
Proyección del rendimiento a corto plazo estimado para diferentes tamaños de malla (toneladas*10**3).

| MESH SIZE<br>YEAR | 80 | 90 | 100 | 110 | 120 |
|---|---|---|---|---|---|
| 1991 | 521.2 | 521.2 | 521.2 | 521.2 | 521.2 |
| 1992 | 515.5 | 466.8 | 401.8 | 324.9 | 245.4 |
| 1993 | 493.0 | 465.6 | 423.8 | 366.1 | 296.2 |
| 1994 | 477.4 | 461.3 | 434.4 | 393.2 | 336.7 |

which shows landings, discards in weight and SSB. The optimum yield was obtained with a 100 mm mesh size calculated with a selection factor of 4. From the graphs presented in Verazay *et al.* (1992) a selection factor of 2.8 for a 130 mm mesh can be derived. Using this value, the optimum mesh size is approximately 140 mm. This is above the legal mesh size in 1992 of 120 mm. Whether fishing were done with illegal small meshes or the nominal mesh size were effectively reduced through rigging is not known and should be investigated before any mesh change is introduced.

The optimal mesh size increases with increased effort. Section 12.2 consider two levels of fishing mortality (F for age 3-5 = 0.47 and 0.58). However, simulations made with both these levels did not change the optimal mesh size significantly.

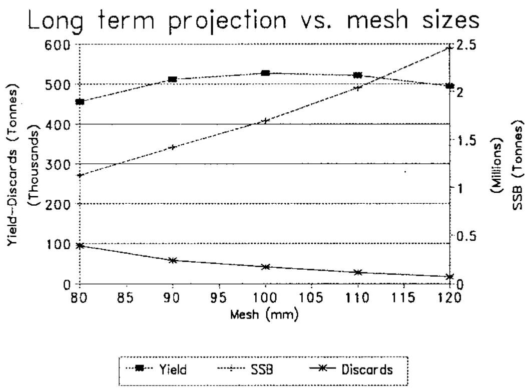


*Figure 17. Long term effects of a mesh size change.*
Efectos a largo plazo de un cambio en el tamaño de malla.

### 13.3 Short term effects of a mesh increase

The basis for the simulations was the same as for the long term mesh assessment and as above simulations were made for 80, 90, 100, 110 and 120 mm mesh size.

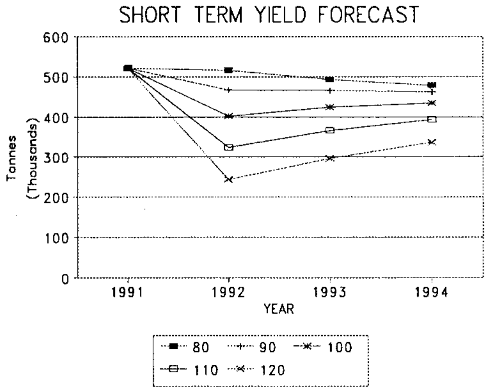


*Figure 18. Short term effects of mesh size change.*
Efectos a corto plazo de un cambio en el tamaño de malla.

The yield forecast for 80 mm is identical to the short term forecast for the $F_{3-5}$ = 0.58 presented in section 12.2. A major mesh increase causes the yield to diminish in the first year followed by a slow increase toward the new average situation (Table 13 and Figure 18).

The calculated SSB decrease slowly for 80 and 90 mm mesh size, while it increases for the larger mesh sizes (Table 14).

## 14. CLOSED AREAS AND CLOSED SEASONS

Some areas are closed to fishing to protect spawners and juveniles. These closed areas are on the nursery grounds of hake.

The first closed area introduced is on the Patagonian coast in a zone around Isla Escondida. This closed area was established in 1974 in response to the increase of the offshore fleet and the high number of juveniles and spawners observed in the landings. In 1993, the limits of this area are 43°30'S - 44°30'S and between 64°W and the coast (Figure 19). This area is closed between October 1st and January 31st.

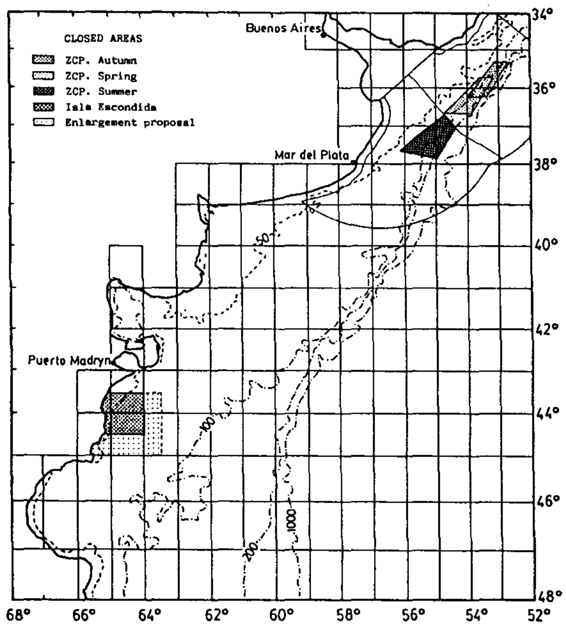


*Figure 19. Closed areas and closed seasons in effect in 1992-1993. The proposal for enlargement of closed area around Isla Escondida is shown as dotted.*
Areas y estaciones de veda en vigencia en 1992-1993. La ampliación propuesta para el área de veda de Isla Escondida se presenta punteada.

In 1984 it was proposed to enlarge this area with 30' both eastward and southward because spawners and juveniles are also abundant here (Figure 19).

In 1988 and in 1989 surveys conducted in this area confirmed these observations. Shrimp surveys also find high abundance of hake juveniles in this area, the most recent of these surveys were made in March 1993. Based on this information, it is still proposed to enlarge the closed area around Isla Escondida to protect juvenile hake.

Three closed areas in Zona Común de Pesca have been established in 1990-1991. The actual closed areas are decided upon each season, based on result of surveys. This decision is made for spring, summer and autumn separately. In winter there are no closures.

## 15. MANAGEMENT CONSIDERATIONS

### 15.1 Regulations required from a biological point of view

Fishing mortalities increased in recent years and are in 1991 25% above the average for the 1985-1991 period. The CPUEs have decreased as a result an increase in total effort during the period.

Spawning stock biomass (SSB) decreased between 1986 and 1991. The SSB for 1991 is still considered to be able to maintain recruitment but is at present at a historic low level and it is not known if recruitment would be adversely affected should the SSB decrease further.

Therefore, fishing mortality should not be allow to increase. This means that effort should be maintained around the present level and the increase seen in recent years should be halted.

A length of first capture around 25 cm was estimated for discards, which means that there is a significant mortality on immature hake. The length at first capture should preferably be above the length at first maturity (33 cm). Therefore management considerations should be given to protecting juvenile hake.

Shrimp fishing occurs on hake nursery grounds in Golfo San Jorge and the shrimp fishery here could be harmful to hake recruitment. However except for some surveys which demonstrate Golfo San Jorge as a nursery ground for hake little is known. This problem should be investigated.

Even though there are data deficiencies, the needs for halting the increase in effort and to protect juvenile hake are evident.

### 15.2 Legislation available for fisheries management

The relevant decree (Resolución 245/91 of Secretaría de Agricultura Ganadería y Pesca) provides for the following management measures

- Overall quota limitations
- Minimum mesh size (120 mm)

*Table 14. Short term SSB estimated for different mesh sizes. Tonnes*10**3.*
Proyección de la biomasa de la población desovante a corto plazo estimada para diferentes tamaños de malla (toneladas*10**3).

| MESH SIZE<br>YEAR | 80 | 90 | 100 | 110 | 120 |
|---|---|---|---|---|---|
| 1991 | 1347.7 | 1347.7 | 1347.7 | 1347.7 | 1347.7 |
| 1992 | 1279.3 | 1331.1 | 1399.7 | 1480.0 | 1562.2 |
| 1993 | 1232.8 | 1309.5 | 1415.6 | 1547.6 | 1692.4 |
| 1994 | 1196.2 | 1282.7 | 1405.6 | 1564.5 | 1747.6 |

- Prohibition of discarding
- Closed area and season
- Prohibition of new access to the hake fishery except with the following exceptions:
  - replacement of vessels which already possess a fishing permit
  - when accompanied with a proven reduction in the fleet
  - if fish available is above normal levels

### 15.2.1 Overall quota limitations

Total Allowable Catch (TAC) is a catch value, calculated on the knowledge of the present state of the stock and for a specified level of effort.

The TAC values of 470,000 Tonnes calculated for 1993 and 465,000 Tonnes for 1994 (Table 11) are based on maintaining the present effort level. These TAC values are the maximum landings to all countries fishing hake in the entire area.

A possible criteria for allocation by country of this total quota could be based on historic landing figures. If such a criteria was applied, Argentina would be allocated approximately 350,000 Tonnes of the total 470,000 Tonnes (74%, equal to the average landings 1986-1991).

Regulation of fisheries by a quota system has associated problems. These are mainly related to the "gold rush" *i.e.* that every fisherman tries to get as much catch as possible as fast as possible before the overall quota is fulfilled. This behaviour leads to significant overcapacity in the fleets. Quota systems must at least, in order to work, also include regulations of access to the fisheries and effort control *e.g.* by ensuring the withdrawal of comparable capacity (corrected for fishing power) when new vessels replace old or when vessels undergo major rebuilding.

### 15.2.2 Minimum mesh size

Data on discards suggest that juvenile hake suffer a significant mortality generated by the fishery. This mortality decreases hake recruitment to the fishery.

The current mesh regulation (120 mm minimum stretched mesh size) would allow for adequate protection of juvenile hake if the selectivity of commercial trawls is comparable to that used in the scientific studies. This, however, may not be the situation and an investigation of the selectivity of commercial gears is required before any evaluation of the current regulation can be made.

Regulations on minimum mesh size usually also include rules on minimum landing size and limitations on the allowed landing of undersized fish *e.g.* a 10 % rule. These regulations have no biological foundation, but are required for control purposes. The minimum landing size is set at or below the 50 % retention length of the gear. The ban on landing of undersized fish could lead to major discards, if the mesh regulation is violated and regulations which allows inspection at sea are needed.

### 15.2.3 Discard prohibition

Many species, including hake, have little survival when discarded and for that reason discarding represents a misused of the resource. While most mesh regulations still include that catches of undersized fish are discarded, Norway and Iceland have prohibited discarding and instead the fishermen are required to leave fishing grounds where major catches of undersized fish occurs. Regulation on discards should be considered together with the minimum mesh size regulation. Prohibiting discards create similar control problems at sea as for minimum mesh sizes regulations.

### 15.2.4 Closed areas and closed seasons

These measures are used to protect juvenile and spawning hake. It is recognized that such areas should be kept under review since distribution of fish are known to change between years. This measure is fairly simple to implement and enforce.

### 15.2.5 Limited access

At present, legislation only allow new access to the hake fishery either based on proven reduction in the fleet and if hake is available above normal levels.

However replacement of vessels now in the fishery with more modern types is at present discussed and therefore the following comments on this problem are offered.

New vessels will, for the same motor power and vessel size, be more effective than vessels now in the fishery. This is caused by development in vessel design, fishing techniques, fishing searching equipment, reduced required time for repairs and maintenance, etc. Since the aim is to maintain total effort at current levels, new boats can only be allowed if a comparable fishing capacity is removed *i.e.* more than one old vessel has to leave the fishery for each new. Therefore the relative fishing power between old and new vessels should be established as a prerequisite for a replacement scheme. This relationship can be established from the catch and effort data base, available at the Dirección Nacional de Pesca Marítima.

Proven reduction of the overall effort also requires knowledge on the relative fishing power between new and old vessels.

Increase of number of hake fishing vessels because of temporal high abundance of hake, would lead to overcapacity in the fishing fleets except if the resource is under-utilized and this is not the situation for hake. The Group advises against using this legal possibility. A possible high level of the hake stock is not likely to be maintained during the lifetime of a fishing vessel.

## 15.3 Possible by-catch of hake in the shrimp fishery

Hake is taken as by-catch in the shrimp fishery in Golfo San Jorge. Shrimp trawling uses small meshed gear (50 mm) and juvenile hake is part of the by-catches. However the magnitude of these by-catches is not known. Data cannot be obtained from the landings as most other species other than shrimp are discarded. Golfo San Jorge is known to be a nursery ground for hake and other species. Potentially the shrimp fishery could affect the hake recruitment adversely and investigations are required to clarify, if this is the case.

## 15.4 Experimental long line fishery

Two vessels are interested to fish hake with long line on the slopes of the continental shelf. The required landing allowance is 5000 Tonnes. Both because of the selectivity properties of the long line and because of the area in which the fishery is going to take place, catches of juvenile hake are expected to be minimal. The hake in this area are included in the assessment presented above and any long line landings should be counted against the overall quota.

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