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Overview of the Spanish fisheries in the Patagonian Shelf

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ABSTRACT

The fishing grounds of the Patagonian Shelf support some of the most important fisheries in the world. The great abundance of marine resources among parallels 35º and 54º South, is associated with the Subtropical Convergence formed by the Brazil and Falkland/Malvinas currents. The mixing of the flow of La Plata River and the western branch of the Falkland/Malvinas Current generates areas of high plankton production on the shelf.

Hakes (*Merluccius hubbsi* and *Merluccius australis*) and cephalopods (*Illex argentinus* and *Loligo gahi*) have been found the main commercial species, with important amounts of accompanying species in the catches such as Patagonian toothfish (*Dissostichus eleginoides*), Kingclip (*Genypterus blacodes*), Hoki (*Macruronus magellanicus*), Red cod *(Salilota australis*), Southern blue whiting (*Micromesistius australis*), etc.

These fisheries are currently among the most important to the Spanish bottom trawler freezing fleet that has around 40 vessels fishing in this area, besides another 20 that operate in joint ventures sailing Falkland flag. It is estimated that this fleet generates approximately 2,000 direct offshore jobs, and more than 10,000 indirect onshore jobs.

This paper presents results from the EC Study Project 99/016 "Data collection for stock assessment of two hakes (*Merluccius hubbsi* and *M. australis*) in international and Falkland waters of the SW Atlantic". Historical fishery and biological data series available from the Instituto Español de Oceanografía (IEO) and the Falkland Islands Fishery Department (FIFD) were used during the project to describe fishing patterns and spatio-temporal changes in the abundance and distribution of target and accompanying species, as well as to give an overview of these important fisheries.

Keywords: South West Atlantic, Spanish fishing fleet, hakes, cephalopods

INTRODUCTION

The EC Study Project 99/016 “Data collection for stock assessment of two hakes (*Merluccius hubbsi* and *M. australis*) in international and Falkland waters of the SW Atlantic” ran from January 2000 to December 2001. The main objective of the project was the collection and collation of already existing and newly acquired fishery and biological data needed for preliminary assessment of two hake species occurring in the study area. In addition to this basic remit, additional objectives included the creation of a common database, study of spawning seasons and areas, discard pattern and length-frequency composition of target and non-target species, estimation of annual by-catch rates, analysis of trophic relationships, marine mammals by-catch and sightings, morphometric analysis for stock differentiation, and developing GIS applications for analysis of the data collected.

On the northern Patagonian Shelf the fishery for hakes originated in the 1920s and was centred around Mar del Plata (Agnew *et al*., 2001). Until early 1960s the fishery resources in the Patagonian Shelf and more specifically hake (*Merluccius hubbsi*) were exploited by coastal states: Argentina, Uruguay and Brazil. this fishery was developed at 90 to 180 m depth in a range of 100 nautical miles from Mar del Plata. In successive years Argentinean fleet incorporated bigger vessels what allowed her to fish further to the south (Portela *et al*., 1997).

At the end of the 1960s fleets from the former Soviet Union and from other East and Far East countries increased their effort in the area, what in some way affected the state of the resources. Fishing activities on the southern Patagonian Shelf and slope and in Burdwood Bank, started in 1978 (Csirke, 1987) when long distance fishing fleets from Argentina, Japan and Poland began the exploitation of cephalopods, southern blue whiting and other demersal resources unexploited until there (FAO, 1979, 1981).

One of the first exploratory commercial surveys by Spanish vessels was made in 1961 and at the end of the 1970s some 40 Spanish vessels were transferred to joint ventures in Argentina. In the beginning of the 1980s fishing effort and total annual catches increased rapidly, as well as the number of countries and vessels operating in the area, with the subsequent concern about the risk of overexploitation, especially due to the foreseeable difficulties in the management of some of these fisheries (Csirke, 1987).

Fishing effort by Spanish vessels operating in the SW Atlantic increased since 1983, reaching a peak in 1990 with more than 80 boats flying Spanish flag. Since then, effort experienced a fluctuating reduction in number of vessels, mainly due to the development of new fisheries by this fleet in the North Atlantic and to a changing registration process to joint ventures based in the Falkland/Malvinas islands, leading to few more than 20 Spanish boats operating nowadays in these fishing grounds.

MATERIAL AND METHODS

The main objective of the project was the collection of fishery and biological information needed for hake assessment in international and Falkland waters, through a program of scientific observers on board Spanish commercial trawlers fishing in the Patagonian shelf. The presence of biological observers on board is the only way to obtain reliable information on catch, effort and biological characteristics of the catch in a fishery developed by big trawlers with fish processing and freezing capabilities. The project also aimed to obtain accurate information on the level of by-catch and discarding of non-target species, marine mammals and other non-commercial species, together with biological information of all the species present in the fishery, both in international waters and the FICZ and the FOCZ.

Historical fishery and biological data series available from several partners were provided to the project. New fishery and biological data were collected by scientific observers placed on board Spanish fishing vessels operating in the study area during the project period. Data on fishing activity included effort, catches and discards of target and non-target species on a haul-by-haul basis. Biological information (size, sex, maturity stage, etc) of target and non-target species was recorded on a daily basis. Data on landings and effort provided by commercial companies was collated and processed for estimation of total catch and effort of the whole Spanish fishing fleet in the area. Ancillary historical and new data on location, time of fishing, depth, SST, SBT, sea roughness, wind, etc, was recorded on a haul-by-haul basis for development of GIS to relate the species distribution to physical and environmental factors. Other information collected was about by-catches and sightings of small cetaceans and seabirds, and biological samples such as otoliths, stomachs and whole specimens of hakes for subsequent studies on growth, diet and morphometrics.

Biological samples to determine monthly length distributions by sex of target and non-target species were recorded daily. Size and weight of target and non-target species were recorded by stratified sampling to calculate length-weight relationships and their variation in time and space.

All the historical and new data collected during the project were collated and integrated into a common database referring to fishing activity (catch, effort, discards, landings, etc) and biology (length, sex, maturity stage, etc) of target and non-target species, for common analyses. The information was used for preliminary assessment of two hake populations. Monthly length-frequencies of hake were used for cohort analysis, using standard software. Assessment based on cohort analysis was carried out for the stocks in international waters. The suitability of a range of other possible approaches to stock assessment was reviewed. Environmental influences on CPUE were also investigated and spatial patterns of CPUE analysed. The data used for this analysis extend from the start of the fishery in the early 1980s to the present.

The raw data derived from the project comprised:

1. Time series for species composition in catches.
2. Time series of CPUE by species, season and geographical area.
3. Time series of size composition, sex ratio, mean body weights, length/weight relationships and recruitment indices for the target and non-target species of the fishery in each one of the fishing areas of the Patagonian shelf.
4. Estimates of proportion and composition of discards.
5. Time series of maturity stages, gonadal development and feeding indices for the target species.
6. Quantitative and qualitative description of the diet of the main fish predators.
7. Time series of catch and effort of the whole Spanish fleet.

These data were used to derive results on:

1. The description of the Spanish fisheries in the Patagonian shelf.
2. The temporal and spatial patterns of the fisheries and life-cycles of the fished stocks over the studied period, and retrospective analysis employing the already existing database.
3. Trophic relationships involving the target species.
4. Revised estimates of fishing mortality, incorporating amounts discarded.
5. Preliminary estimates of the size of the fished stocks of hake in international waters, and comparison of these estimates with those produced inside the FICZ and in Argentinean waters.

6. Preliminary species- and area-specific estimates of by-catch rates.
7. Existence of different stocks of hakes within the study area

MAIN RESULTS

Description of the Spanish fisheries in the Patagonian shelf

General description of the area

The fishing grounds off the Patagonian Shelf are actually one of the few areas around the world with important fishery resources but in which there is no effective regulation under any Regional Fisheries Organization (even local assessment and management is made inside the Falkland Islands Interim and Outer Conservation Zones (FICZ/FOCZ) and inside Argentinean EEZ). Fishery resources in the Patagonian Shelf occur and are exploited inside Argentinean EEZ, around the Falkland/Malvinas islands and in adjacent international waters, representing in many cases a typical example of what is known as straddling stocks.

These fishing grounds are currently among the most important to the Spanish long distance fleet mainly based in Vigo (NW Spain). This fleet is composed of about 40 vessels, besides another 20 and 100 that operate respectively in joint ventures with Falkland and Argentinean flags. It is estimated that vessels operating in the SW Atlantic flying Spanish flag, generate approximately 2,000 direct offshore jobs, and more than 10,000 indirect onshore jobs. The value at first sale of the catches of the Spanish fleet in this area is estimated at around 70,000 million pesetas per year (411 MEURO).

Sporadically commercial fishing by Spanish boats in the Patagonian Shelf started in early 1960s and had continued irregularly until 1983, from which its presence was regular in the area although alternating their activity with the fishing grounds in the South East Atlantic. The crisis on the Namibian fisheries at the end of the 1980s was the reason for the increase of the operations in the SW Atlantic, reaching the maximum activity in 1990. After that, the development of new fisheries by the Spanish fishing fleet in the North Atlantic represented a decline in the total effort in the Patagonian Shelf.

A fisheries regime for the management of the resources around the Falkland/Malvinas islands was implemented the first of February 1987, which followed the introduction of the Falkland Islands Interim Conservation and Management Zone (FICZ) in October 1986. The Falkland Islands Outer Zone (FOCZ) was introduced on 26th December 1990, extending the FICZ to the north, east and south of the Falkland/Malvinas islands to 200 miles, measured from coastal baselines. The South Atlantic Fisheries Commission (SAFC), composed of delegations from Britain and Argentina with participation of observers from the Falkland Islands as part of the British delegation was set up in 1991.

The argentine EEZ lies to the west of the Falkland Islands conservation zones. A number of important species have a transboundary distribution and of those the most important are the squid (*Illex argentinus*) and the Southern blue whiting (*Micromesistius australis*). Stocks of both species are shared between the Falkland Islands and Argentina, together with the high seas beyond 200 miles in the case of *Illex* (Anon., 1997).

Physical and oceanographic features in the Patagonian Shelf

The Patagonian Shelf is the widest in the Southern Hemisphere and one of the few areas in the world where the continental shelf extends beyond the 200 nautical miles limit; the continental shelf until 200 m depth has an area of 300,300 nautical square miles even in its majority is less than 100 m depth; the continental slope (200-1000 m) has an approximate surface of 58,000 nautical square miles (FAO, 1983).

In the northern part the platform is narrow increasing its width further to the south, reaching the maximum breadth (869 km) around parallel 51° S. In the northern part, the slope until 50 fathoms is smooth (0.5 m/km) being steeper between 50 and 100 fathoms; in the south, the slope is higher from 0 to 50 fathoms (1m/km) and smoother between 50 and 100 fathoms (0.3 m/km) at the latitude of Puerto Deseado (47° 45' S – 65° 55' W).

The Patagonian Shelf is greatly influenced by the Subtropical Convergence formed by the Brazil and Falkland/Malvinas currents. The Malvinas current is actually an offshoot of the Antarctic Circumpolar Current, a branch that veers northward along the South American continental shelf (Garzoli & Bianchi, 1987). The boundary between the cold Malvinas Current water and warmer inshore water parallels the coast until about the latitude of Buenos Aires, where the Malvinas encounters the Brazil Current (Deacon, 1937; Gordon., 1981; Legekis & Gordon. 1982). This interaction creates a very complicated fluid dynamics problem: the flow of the Malvinas Current is turned into the South Atlantic Ocean, while the warm Brazil Current waters are pushed toward the coast. The exact location of this boundary varies with the seasons, as seen in sea surface temperature imagery (Figure 1).

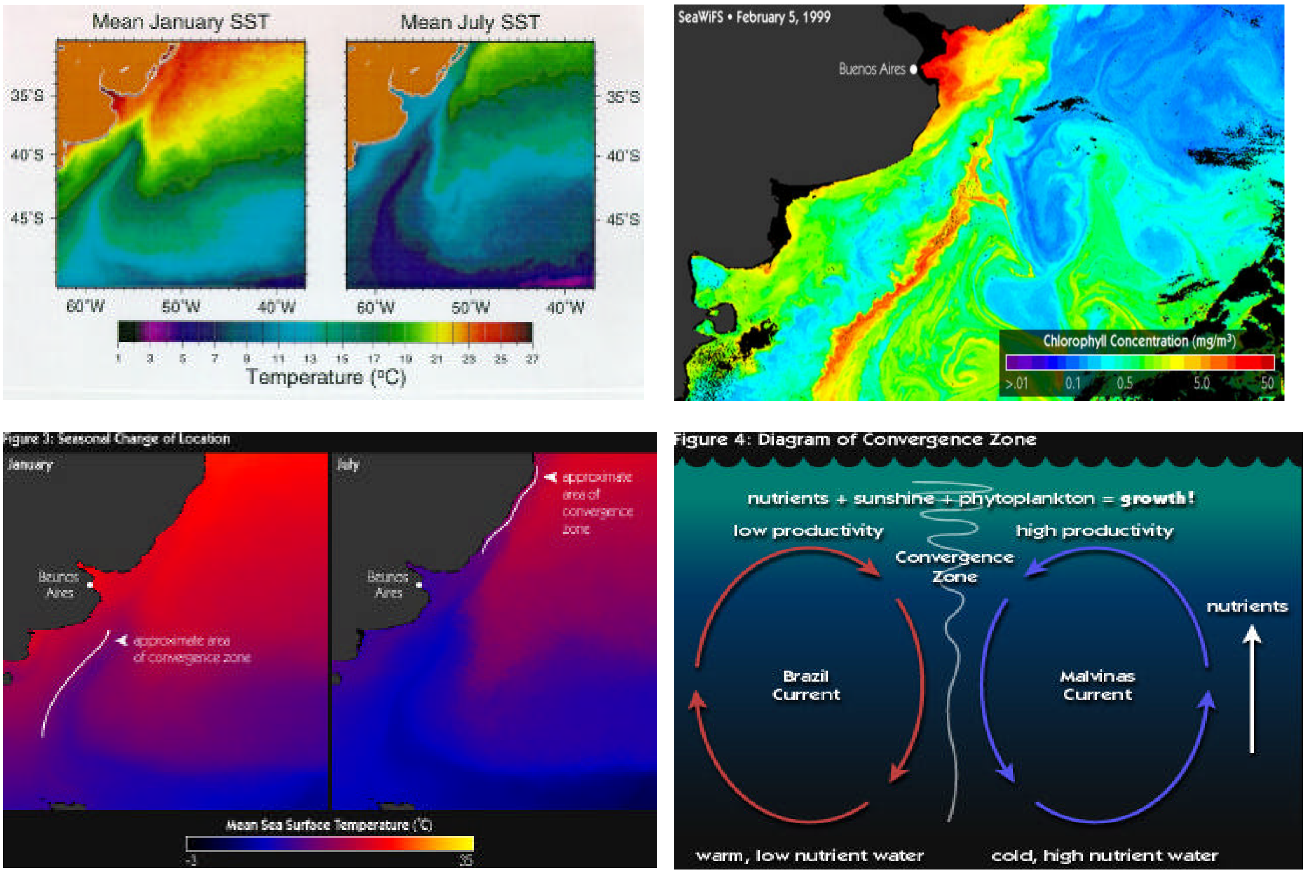

Figure 1. SST Distribution in summer (January) and winter (July). Note the Brazilian current and the Falklands current and the different position of the Convergence Zone.

All these species are highly influenced by the oceanographic conditions of the area including inter- and intra-annual variability. Shortfin squid (*Illex argentinus*) perform yearly large migratory movements from the South of Brazil to Falklands, maybe related to its life cycle.

Common squid (*Loligo gahi*) is more confined to a relative small area within Falklands waters, named Loligo-box, but with great explosions of abundance in Autumn (March to May). Finfish use to take advantage of the current dynamics, moving southward in summer together with the Brazilian current and northward in winter making use of the subantarctic current.

Spanish Fisheries in the SW Atlantic

These fisheries comprise target and by-catch species with different proportions of discards. Target species may be discarded due to several reasons such as size, bad conditions, etc; by-catch species experienced a reduction in discards since early 90s due to their introduction as marketable species to consumers.

The fishing grounds in the Patagonian Shelf in which vessels flying Spanish flag are operating can be divided in two main fishing zones, one of them around the Falkland/Malvinas islands in what are known as Falkland Islands Interim and Outer Conservation Zones (FICZ and FOCZ respectively) and the second one in the High Seas, outside the Argentinean EEZ .

The activity of the Spanish vessels in the High Seas is reduced to those portions of the continental shelf and slope sticking out of the Argentinean EEZ, i.e. a small patch around 42º S and a bigger area comprised between parallels 43º 30' and 48º S, namely "Area 42 and 46" respectively. The fishing grounds around the isles have been divided in three sub areas Malvinas North (MN), Malvinas West (MW) and Malvinas South (MS) (Figure 2).

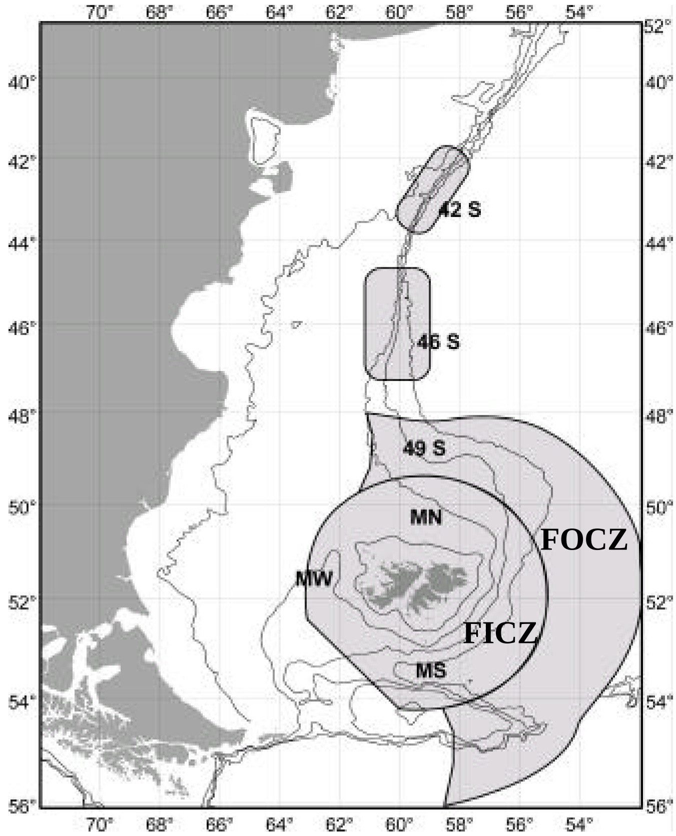

Figure 2. - Main fishing areas in the Patagonian Self for the Spanish fishing fleet

- *Target fisheries:*

Three main fisheries could be defined in the Patagonian Shelf for the Spanish fleet. The first target fishery and also the most important is that of hake, comprising *Merluccius hubbsi* and

Merluccius australis. Although *M. australis* is more appreciated in the market, it is much more scarce and restricted to southern areas. The second fishery is that directed to Illex squid (*Illex argentinus*) and the third one is the Loligo fishery (*Loligo gahi*).

The fishing pattern is thought to be directed by a number of fishing market criteria to target one or another species. There is also a seasonal effect of abundance and fishing aims to take advantage of the seasonal abundance of each group. Depth is a factor clearly affecting distribution and abundance of all fished species.

- *By-catch fisheries:*

The most important by-catch species are patagonian toothfish (*Dissostichus eleginoides*), kingclip (*Genypterus blacodes*), hoki (*Macruronus magellanicus*), red cod (*Salilota australis*) and southern blue whiting (*Micromesistius australis*). All these fisheries comprise both retained catch and discard for all species. Target species may be also discarded due to several reasons. In recent years discard percentages have decreased below 15%, except for *Patagonotothen* spp (100% discarded). This should be analysed in further works in order to understand possible changes in fishing patterns as well as to evaluate possible emerging target species and their fishery potential.

Catch and effort

The fishing grounds in the SW Atlantic support some of the most important fisheries worldwide, with hakes and cephalopods being the main commercial species and accounting a mean of 500,000 and 700,000 tons per year respectively in recent times; important quantities of by-catch species are also caught and used for human consumption. These fisheries are very important to the EU fishing fleet, since more than 160 big EU freezing trawlers have been operating in this region from 1983 onwards (60 of them around the Falkland/Malvinas waters and in the High Seas, and a further 100 vessels owned by EU companies are operating in joint ventures inside the Argentinean EEZ) to provide the EU seafood industry with important amounts of finfish and cephalopods.

An increase of the catches and effort was observed from 1983 to a maximum in 1990 coinciding with the closure of Namibian fisheries. After that, catches and effort decreased corresponding with the development of the Greenland halibut fishery in the NW Atlantic, until its stabilisation from 1993. CPUE showed different patterns of fishing activity by area and season.

For a more detailed insight on this section, please have a view to the paper ICES ASC 2002/L: 05

Distribution, maturity and migratory patterns of hakes (*Merluccius hubbsi* and *M. australis*) in Falkland waters

The overall distribution of both *Merluccius hubbsi* and *M. australis* in the southern part of the Patagonian Shelf is quite similar, although *M. australis* tends to occur deeper and further south than *M. hubbsi* (Cousseau and Perrotta, 2000). Both species undertake seasonal migrations from their inshore spawning grounds to offshore feeding grounds (Bezzi et al., 1995) but the patterns of their migrations have only been studied in detail for the northern populations of *M. hubbsi* (Podesta, 1990, Aubone et al., 2000). Shelf and continental slope waters around the Falkland Islands are used as adult feeding grounds by both *M. hubbsi* and *M. australis* - juvenile fish have only been encountered there on a few occasions (Tingley et al., 1995). The maturity status and patterns of monthly CPUE of *M. hubbsi* and *M. australis* gave a basis for the construction of a preliminary scheme of their seasonal migrations in Falkland's waters (Figure 3).

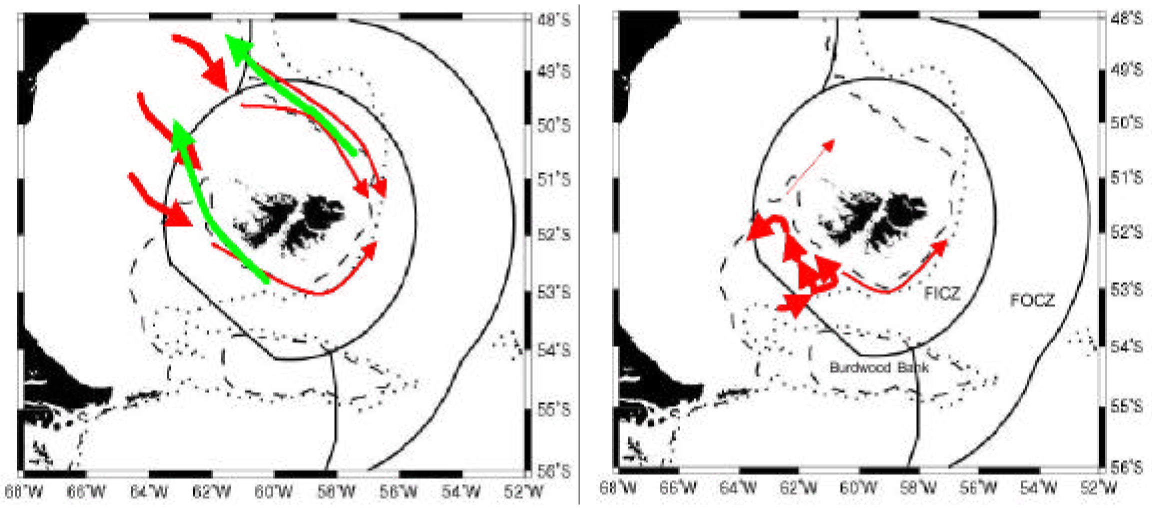

Figure 3. Scheme of possible seasonal migrations of *M. hubbsi* and *M. australis* in Falkland waters. For *M. hubbsi*, autumn migrations in bold red arrows, winter migrations in red arrows and spring migrations in bold green arrows.

Historically all vessels licensed to fish in the Falkland Conservation Zones have reported the total catch of both hakes together, making it difficult to separate catches by species. To investigate the monthly patterns in the distribution of the hake species we therefore used only the data collected by scientific observers. Catches were plotted for each month over the years 1988 – 2000. Data collected by FIFD and IEO observers were analysed separately to avoid possible bias in sampling protocols etc. The proportion of individuals at each maturity stage was also assessed on a monthly basis, separately for males and females, using aggregated data from 1988 to 2000.

Aggregated (over all years) plots of haul by haul CPUE of both sets of data show similar monthly patterns. Thus the IEO data is broadly in line with the suggested migration patterns based on the FIFD observer data. CPUE on the shelf area east of the Argentine EEZ at 45 – 46°S shows a similar monthly pattern to that seen in the FICZ, in particular lower CPUE in December/January, suggesting that migration patterns to and from these areas are quite similar.

The majority of records of *M. australis* are from the deeper shelf area between the 200m and 500m contours in the south-west of the FICZ. However, *M. australis* is also encountered in small numbers over the shallower shelf in the north-west of the FICZ and right round the 200m contour, including some recorded occurrences in international waters as far north as 45°S.

M. hubbsi is abundant between the 150 and 300 m depth contours everywhere on the shelf and shelf edge around the Falkland Islands, and on the High Seas. Significant number of animals occur in the area southeast of the Islands (*Loligo* box) and there are also some records of *M. hubbsi* occurrence in shallow waters (<150 m).

Conclusions on distribution, maturity and migratory patterns of hakes

1. Both hake species utilise Falkland's waters as their feeding grounds and are most abundant in the ecotone zone to the west of the Islands.

2. Their feeding seasons, however, are different: M. australis appear in the FICZ in August, feed in summer-autumn, with highest catch rates in February-May prior to their departure to spawn, whereas M. hubbsi appear in the FICZ in February and feed in autumn-spring.
3. M. hubbsi utilise the Falkland shelf more extensively than M. australis, being abundant over the entire shelf area including south-east of the Islands, whereas M. australis tend to occur in the western part of the FICZ.
4. Their spawning seasons are also different – the austral winter for M. australis and the austral summer for M. hubbsi.

Growth of hake from Falkland Islands waters.

The two hake species caught in Falkland Islands' waters have very different size distributions. *M. australis* are commonly 60 – 80 cm total length whilst *M. hubbsi* are usually 30 – 60 cm.

Using ages from otoliths collected in November the difference in size at age in male and female *M. australis* is not quite significant at the 5% level (F = 1.8219, p = 0.05264). In contrast, the difference in size at age in male and female *M. hubbsi*, using otoliths sampled in April, is highly significant (F = 17.163, p < 2.2e-16).

Standard von Bertalanffy growth curves were fitted to the size at age data to summarise the pattern of growth in the two hake species (Figure 4). All otolith readings in the period 1988 – 2000 were used. Assuming a birth date of 1 July, the sampling date of the otoliths was used to adjust the fitted age to take account of growth since the last growth marker was laid down.

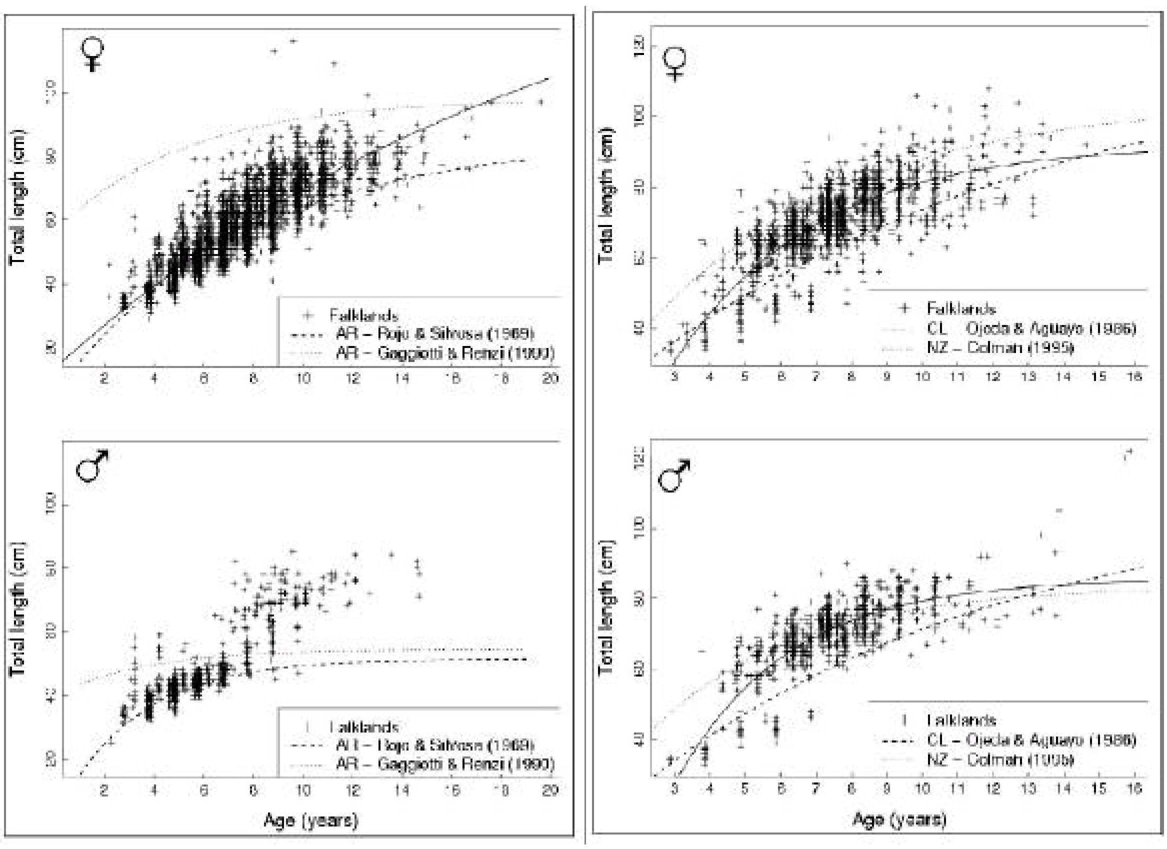

Figure 4. Size at age for *M. hubbsi* and *M. australis* from Falkland's waters using otoliths sampled in 1988 – 2000.

Fitted growth curves for *M. australis* were obtained and adjusted with the fitted coefficients for the von Bertalanffy growth curves. For both sexes size at age appears to be larger for fish from Falkland's waters than in Chilean waters. Size at age for males from Falklands waters is comparable with that in New Zealand waters but females in Falkland's waters are smaller.

Adjusted size at age data and the fitted growth curves for *M. hubbsi* were also found. Fitting the von Bertalanffy growth model using non-linear least squares does not yield especially good fits for either sex. The fitting process fails to converge for the male size at age data, whilst the fit to the female size at age data is acceptable but does not reach an asymptote within the size range sampled.

Two studies of the growth of *M. hubbsi* from the Argentine fishery have reported rather different growth curves. In females and smaller males, size at age for fish sampled in Falkland's waters is more or less bracketed by the two Argentine growth curves, though it is closer to the growth pattern reported by Rojo and Silvosa (1969). However all males larger than ~60cm total length fall outwith the size at age curves from Argentine waters.

Furthermore there is evidence of a discontinuity in the size at age data for fish sampled in Falklands waters. Male *M. hubbsi* greater than 60cm total length are very rare indeed. Otolith sampling by FIFD observers is non-random, so it is not unreasonable for extremely large (or small) fish to be over-represented in the size at age data in comparison to their real occurrence in the population. However, another possibility is that the large male *M. hubbsi* in the otolith data are actually mis-identified *M. australis*.

For both species there is considerable variability in size at age that limits the value of fitted growth curves. Raw age-length keys for the two species, based on all otoliths collected by FIFD observers from 1988 – 2000 were obtained.

Otolith readings and age-length keys for hake species made by FIGFD in previous years and during the current project were provided and used in the assessment workshop held in London in July 2001.

Stomach contents analysis

The trophic relationship between predatory fish and the trophic position of predatory fish in the South West Atlantic ecosystem are poorly understood, but are of great importance to fisheries management (Velasco and Olaso, 1998), where it is useful in understanding the patterns of resource use, intra specific competition and the influence of predatory fish on the abundance and recruitment of other marine organisms (Du Buit, 1996).

The migratory behaviour and trans-boundary distribution of many commercial finfish and squid species in the South West Atlantic make them vulnerable to both natural and man made variations in prey availability, where a decrease in prey availability either from natural fluctuations or over fishing, in one area can also result in a decrease in the predator population, thus resulting in a cumulative decrease in fish numbers throughout its region of distribution. Due to the trans-boundary distribution of several species this cumulative decrease can also be a result of poor management strategies in neighbouring countries.

An understanding of the diet of these migratory species (Figures 5a and b) will enable these fluctuations to be incorporated into fisheries management strategies resulting in better management of these migratory fish stocks.

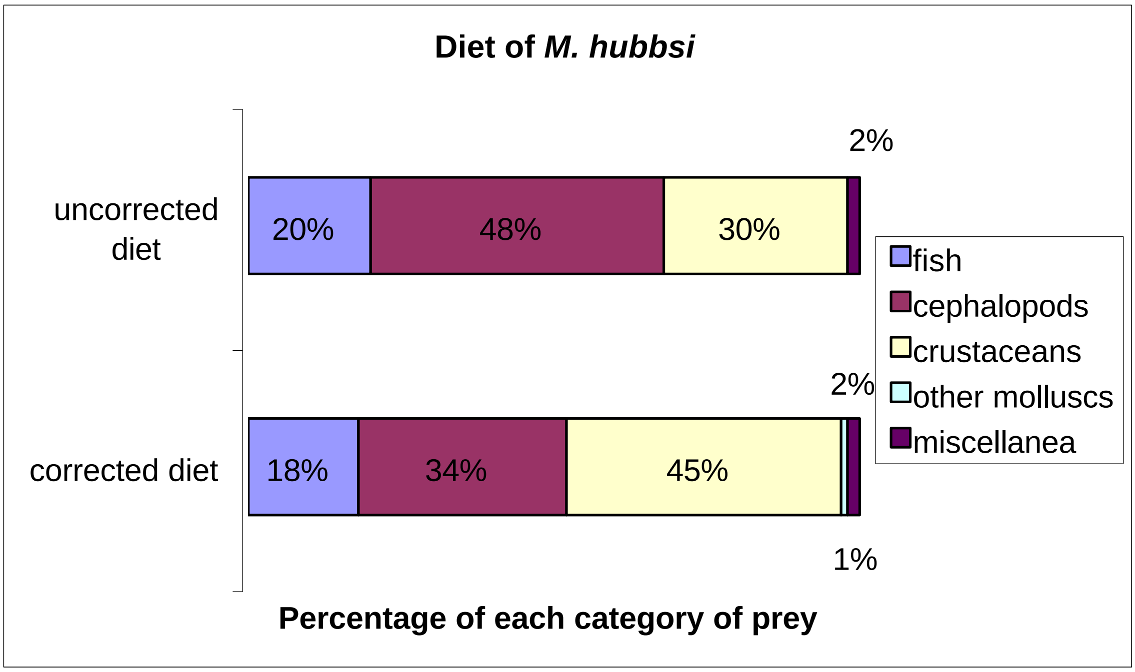

Figure 5a. Percentage frequency of each prey category in the diet of *Merluccius hubbsi*

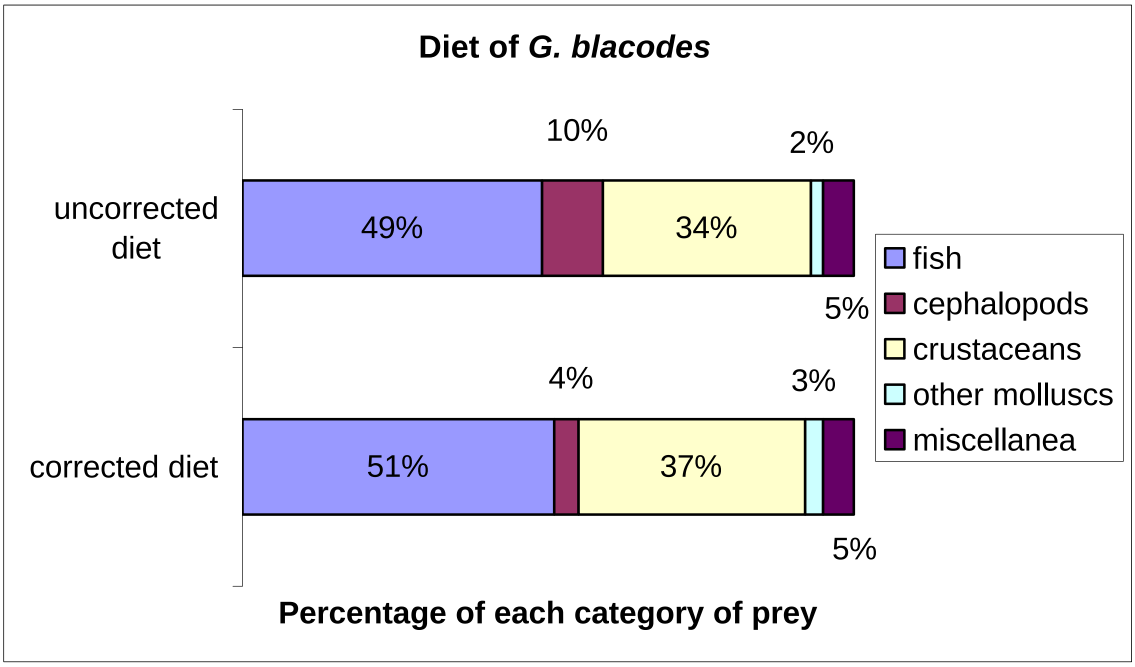

Figure 5b. Percentage frequency of each prey category in the diet of *Genypterus blacodes*

With the exception of *Merluccius hubbsi* little is known about the biology of these species in the South West Atlantic although studies on Hoki and Kingclip in New Zealand waters and South African waters have been carried out (Clarke, 1985,). Studies on common hake are limited to Argentine/Uruguayan waters (Ruiz and Fondacaro, 1997, Prenski and Bezzi, 1991, Ubal et al, 1987, Gaggiotti and Renzi, 1990, Arena et al, 1986, Otero et al, 1986). Data on the biology of commercial species found in Falklands waters is scarce (Norman, 1937, Wysokinski, 1974, Scott, 1982, Mouat et al, 2001, Arkhipkin et al, 2001, Janusz, 1986, Brickle et al, 2001,2001) although several studies are in progress.

Results and Conclusions

Prey identification indicated the presence of the squid *Loligo gahi* and *Illex argentinus*, the crustaceans *Munida gregaria*, *Cirriolus* sp. and the fish *Patagonotothen* spp.

Overall diet composition was not greatly affected by exclusion of data from stomachs thought to represent net or discard feeding. For *M. hubbsi*, the relative importance of crustaceans (which are unlikely to be taken during net feeding or discard feeding) increases in the adjusted diet.The diet of *M. hubbsi* consists of three main categories of prey: fishes, crustaceans and cephalopods. The fish taken include anchovies, hakes, notothenids, myctophids and southern blue whiting. The crustacean species eaten are macrozooplanktonic species, euphausids and amphipods. The cephalopods eaten were squids, including the two commercially important species, *Illex argentinus* and *Loligo gahi*. The diet of *G. blacodes* comprises nekton (more than 50%) and fish, e.g. *Patagonotothen* sp. (Figures 8a and b).

Of all species studied only Southern blue whiting showed no ontogenetic change in diet with predator length. This is probably due to the high abundance of its prey in the southwest Atlantic (Euphausiids and Hyperliid amphipods) pelagic region. The ontogenetic changes shown in all other species studied are thought to help regulate the competition between juveniles and adults for food (Ubal, 1986). The changes in diet between areas show that predatory fish are feeding on locally abundant prey items, with heavy reliance on a few species, such as Notothenid fish, *L. gahi* and *I. argentinus*. The cyclical migratory behaviour of many of the prey items either along the Patagonian shelf (such as *E. anchoita*, *S. fuegensis*, *I. argentinus*) or by depth (*L. gahi*, *M. ingens*) has resulted in the non-migratory and abundant notothenid fish being the dominant prey item for all species studied bar Southern Blue Whiting. Migratory species only occur in the diet when they become locally abundant and available to the predator. This results in predatory fish having narrow niche breadth ranges but with a few prey species having a high index of relative importance.

The impact of predation on the high seas and around the Falkland Islands is limited due to the fact that most predation mortality occurs in fish of a young age. Due to the distribution patterns of different year classes of common hake and other predatory fish within the southwest Atlantic. Immature fish tend to be found in shallow waters along the Patagonian shelf away from the targeted areas of commercial fishing vessels used in this study, thus resulting in little or no natural mortality in hake in these areas. Predatory interactions between these species (other than *M. australis* and *M. magellanicus*) are also small in the study area, however seasonal studies on the diet of predatory fish in and around the Falkland Islands may result in showing increased predation on commercial fish such as Southern blue whiting which use this area to spawn (as seen in the predation of southern blue whiting by *G. blacodes* in New Zealand waters).

A high level of dietary overlap seems to exist between different commercial fish species in the southwest Atlantic, this being a result of the dependency on few prey species. This report only shows a slight insight into the trophic relationships in the southwest Atlantic. Seasonal data may well reveal that although these fish are feeding on the same prey items they may well become available to them at different stages of there migration so that there is no direct competition for prey.

Morphological variability in the South Atlantic stocks of common Hake (*M. hubbsi)*.

The use of morphometric and meristic characters as a tool used for defining population units has been used successfully on several occasions, with meristics and morphometrics being used to identify or differentiate between genera, species, sub species, groups within species and individuals (e.g. Boetius, 1980, Fridriksson, 1958, Pierce et al, 1994, Tudela, 1999, Bolles and Begg, 2000). Meristic characters are enumerable morphological features such as fin rays, gill rakers and vertebrae, where as morphometric characters are those obtained by measurements of body parts.

Morphometric and meristic differences arise when populations are relatively discrete with relatively little genetic flow allowing the two populations to differ phenotypically, these differences can also arise from differing environmental conditions in each geographic area (Mamuris et al, 1998).

In the southwest Atlantic spawning of *M. hubbsi* is thought to take place in two areas. The Bonaerense spawning ground in the waters around Uruguay (Autumn spawning) and of the coast of Argentina (PLACE) (summer spawning) (Otero et al, 1986). *M. hubbsi* is a migratory species with migrations along the coast and into deeper waters linked to the Brazil/ Falklands confluence and areas of localised upwelling, where food is abundant.

Previous studies pertaining to the use of morphometric variability in *M. hubbsi* in Argentine/Uruguayan waters as a tool for stock distinction have resulted in the identification of 3 possible stocks existing in the south Atlantic (Perrotta and Sanchez, 1992), with stock one found above 42º S in the Rio Plata region, stock two found between 44-48º S in the Golfo san Matias region and stock three found below 48º S around the Falkland islands and southern Patagonia (spawning area unknown). Other studies have indicated the presence of only 2 stocks (Sardella, 1984) where the northern stock was found above 42º S and the southern stock was found below 42º S.

This study discusses the results of a morphometric and meristic study of common and Patagonian hake from the high seas of the southwest Atlantic and from around the Falkland islands, with the aim of determining the presence or absence of more than one stock of *M. hubbsi*.

Results and Conclusions of morphological variability.

The results of principle component analysis (PCA) for both the raw and standardised data show varying degrees of overlap, however there is enough separation to indicate a difference between those common hake collected from around the Falkland Islands and those collected from 42ºS and 46ºS. Patagonian hake also shows slight overlap with Common Hake although greater separation is observed.

Preliminary assessment of target species

A number of hypotheses were examined for the relationship of *M. hubbsi* caught around the Falkland Islands (Area A), in high seas waters (Area B) and in Argentine waters (Figure 6).

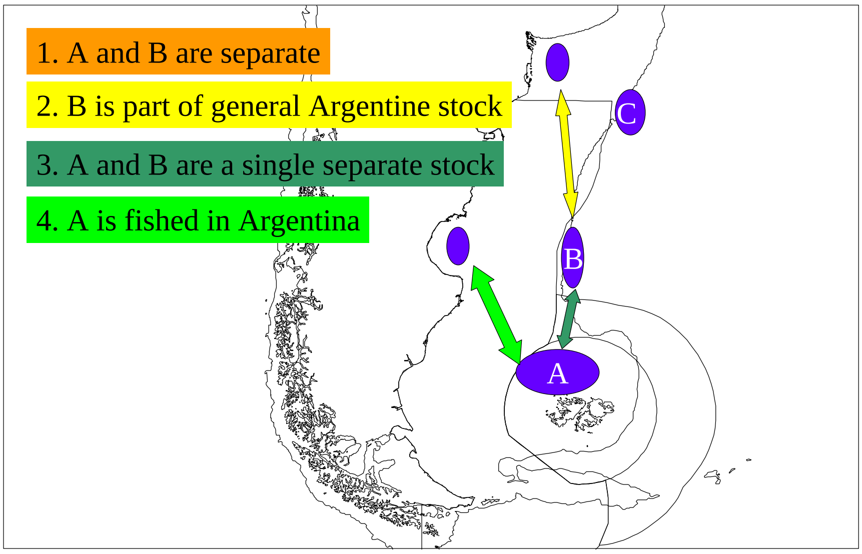

Figure 6. Schematic of the main hypotheses considered in the assessment.

These hypotheses were:

H1. A is a separate stock, unaffected by activities in Argentina or by stock B; the alternative hypotheses is that it is not a separate stock, and may be linked to either fish and fishing in area B (H3) or in Argentina (H4).

H2. B is a separate stock. The alternative hypothesis is that B is part of the general Argentine stock (considered here under H2) or that it is linked to fish from area A (H3).

H3. Fish from A and B are linked, and together form a single separate stock. This is one of the alternative hypotheses in H1 and H2. The alternative hypothesis is that they are not linked. A further alternative, that they are both linked to fish from Argentina is not considered here. However, if there proved to be confirmatory evidence that H3 was true, this further hypothesis might be worth investigating.

H4. A is linked to fishing in Argentina but not to fishing in area B. This is one of the alternative hypotheses to H1.

There are, of course a number of other possibilities, including those addressing area C. However, there are much fewer data from area C than the other areas, and it was considered by the workshop highly unlikely that fish in this area were separate from the general Argentine stock. These alternative hypotheses were therefore not considered further.

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