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Trends in the pattern of discarding in the hake (*Merluccius hubbsi* and *Merluccius australis*) fishery in the SW Atlantic

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ABSTRACT

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 IEO (1988 onwards) were used to describe and quantify patterns and spatio-temporal changes in catches and discards in the hake fishery. Data were collected by scientific observers on board Spanish fishing vessels operating in the study area. Data collected 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, etc) on target species was recorded on a daily basis, while biological data on non-target species was recorded periodically. The "discards ratio" was calculated by each haul, defined as the total weight of fish discarded divided by the total catch weight. The most important by-catch species are hoki or whiptailed hake (*Macruronus magellanicus*), red cod (*Salilota australis*), southern blue whiting (*Micromesistius australis*), Patagonian toothfish (*Dissostichus eleginoides*) and kingclip (*Genypterus blacodes*),.

Discards included both target and non-target species. The most commonly discarded species were *Patagonotothen* spp. (almost 100% of the catch is discarded), whiptailed hake (*Macruronus magellanicus*) (25% discarded), southern blue whiting (12%) and red cod (6%). These percentages vary with area, year and fishing season. The four target species (*Merluccius hubbsi, Merluccius australis, Illex argentinus* and *Loligo gahi*) have discard ratios below 5%. In recent years discard ratios for all species except *Patagonotothen* spp. have fallen below 15%.

Keywords: discards, fishing pattern, hake, SW Atlantic.

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.

The project provided an opportunity to collect and integrate for the first time at European level the necessary fishery and biological data for the development of partial stock assessment for the future rational management of the fisheries in the area. Such management is needed for the sustainability of the commercial fisheries, the conservation of the onshore and offshore jobs and the supply of fish to the most important markets worldwide.

Historical fishery and biological data series available from IEO and FIGFD (since 1988 and 1987 respectively) were utilised. New fishery and biological data were collected by scientific observers provided by IEO, ANAMER and FIGFD, and 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 haul-by-haul basis. Ancillary data on location, time of fishing, depth, SST, SBT, sea roughness, wind, etc, were also recorded on a haul-by-haul basis.

The fishing grounds of the Patagonian Shelf support some of the most important fisheries in the world, with hake (*Merluccius hubbsi* and *Merluccius australis*) and cephalopods (*Illex argentinus* and *Loligo gahi*) being the main commercial species for fleets from coastal states, EU and Far East countries. Just in an European context, these fishing grounds are currently one of the most important to the Spanish bottom trawler freezing fleet, mainly based in Vigo (NW Spain). This fleet is composed of about 40 vessels, besides another 20 and 100 respectively that operate in joint ventures with Falkland and Argentinean flags.

It is estimated that this fleet generates 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 411 million Euros per year. The annual mean catch of the different fleets is around 600,000 tons of hake. These fleets also catch important amounts of squid and accompanying species such as Hoki or whiptailed hake (*Macruronus magellanicus*), Red cod (*Salilota australis*), Southern blue whiting (*Micromesistius australis*), Patagonian toothfish (*Dissostichus eleginoides*) and Kingclip (*Genypterus blacodes*),

Short description of the fisheries.

- **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 also a factor clearly affecting distribution and abundance of all fished species.

- **By-catch fisheries:**
  The most important by-catch species are Hoki (*Macruronus magellanicus*), Red cod (*Salilota australis*), Southern blue whiting (*Micromesistius australis*), Patagonian toothfish (*Dissostichus eleginoides*) and Kingclip (*Genypterus blacodes*). 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 will be analysed later in order to understand possible changes in fishing patterns as well as to evaluate possible emerging target species and their fishery potential.

Table 1 shows the most important species of the fishery. The four firsts are considered target species whilst the remain are main bycatch species.

Table 1. Main species of the fishery.

SCIENTIFIC NAME	SPANISH NAME	ENGLISH NAME
Merluccius hubbsi	Merluza común argentina.	Common hake
Merluccius australis	Merluza austral	Southern (austral) hake
Illex argentinus	Pota	Shortfin squid
Loligo gahi	Calamar	Common squid
Macruronus magellanicus	Merluza de cola	Hoki or whiptailed hake
Micromesistius australis	Polaca	Southern blue whiting
Genypterus blacodes	Rosada	Kingclip
Salilota australis	Bertorella, Brótola	Red cod
Dissostichus eleginoides	Merluza negra, Robalo	Patagonian toothfish
Patagonotothen spp	Marujito	Rock cod

Discard rates of target species were generally low in all areas and seasons with the highest discard rate for Notothen sp. (around 100% of the catch). *Illex* squid was found to be the major by-catch for hake fishery in the 46 S area.

IEO observers reported data on incidental catches of marine mammals and sea birds since 1993 and the analysis of this information was made by AU. The observed mortality in the fishing gears comprised small numbers of black-browed albatross, gentoo penguin and the hourglass dolphin. The species most frequently sighted was the Peale's dolphin, although this species did not appear in by-catches, followed by the hourglass dolphin.

All these species are highly influenced by the oceanographic conditions of the area. Shortfin squid perform yearly large migratory movements from the South of Brazil to Falklands, maybe related to its life cycle. Common squid 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 (see Fig. 1).

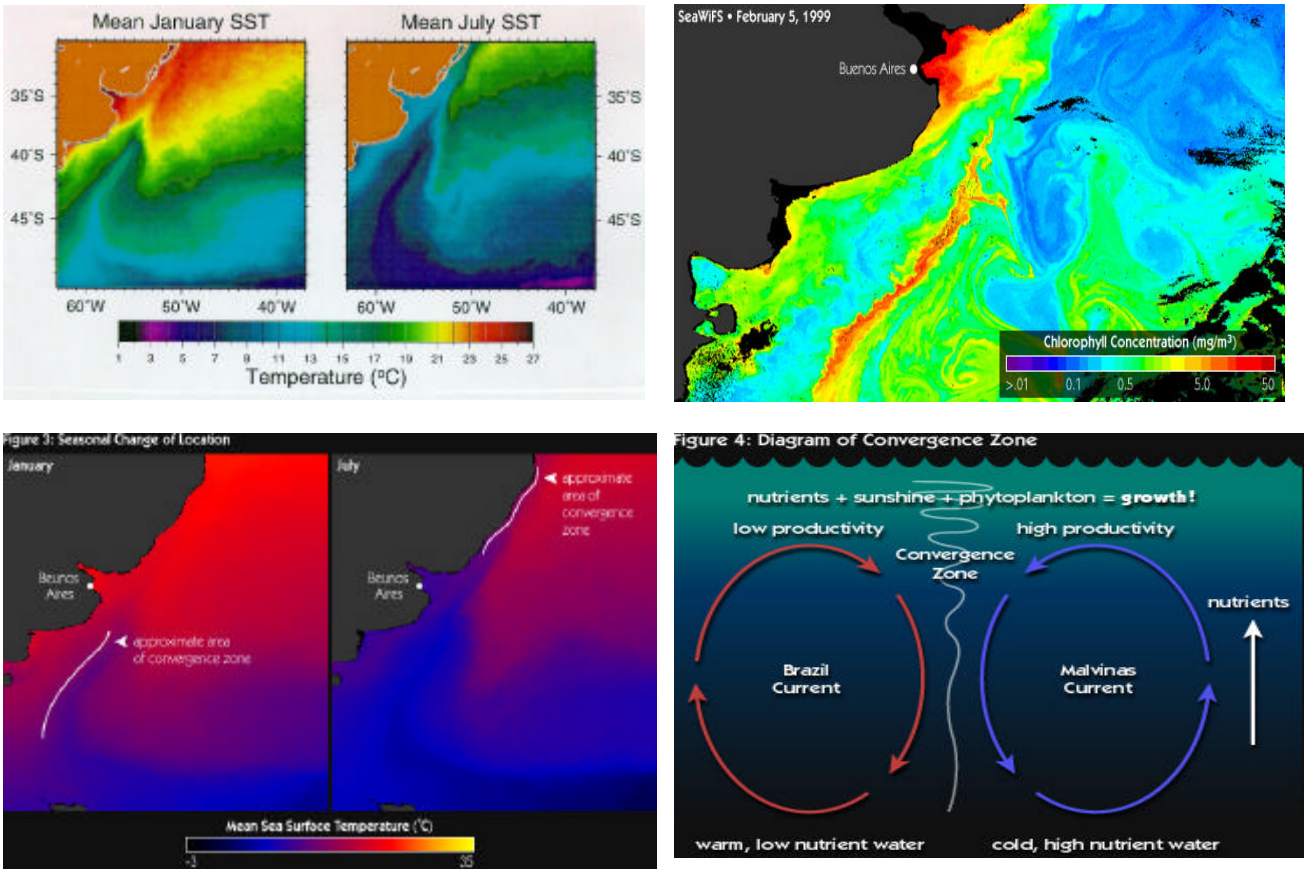

Figure 1. SST Distribution in summer (January) and winter (July). Note the Brazilian current and the Falklands current.

METHODOLOGY AND RESULTS

One important fact when dealing with this type of data is the lack of a complete spatial coverage. The own exploitation pattern, which looks for the highest fishing yields, did not allow us to sample all areas and months. As a result we obtain a patchy sample, possibly biased by the commercial activity

Observers record every single haul, performing biological samples, length distributions for both retained catch and discard. A summary of this information is presented in Table 2 and the location by year of the observed hauls is shown in Figure 2.

Table 2. - Summary of the information collected by Spanish observers from 1989 to 2001

Year	Observers	Hauls observed	Length samples	Biological samples
89	15*	3127	1229	1296
90	8*	1494	828	786
91	7*	1332	797	841
92	7*	1453	710	557
93	4*	1278	683	515
94	4*	1126	606	383
95	4*	1148	401	291
96	4*	1330	633	410
97	4*	1129	584	380
98	4*	1126	606	362
99	6*	1238	692	420
00	3* + 2**	1553	813	510
01	3* + 4**	1837	1082	895
Total	**79**	**19171**	**9664**	**7646**
***IEO observers, ** Project observers (ANAMER)**				

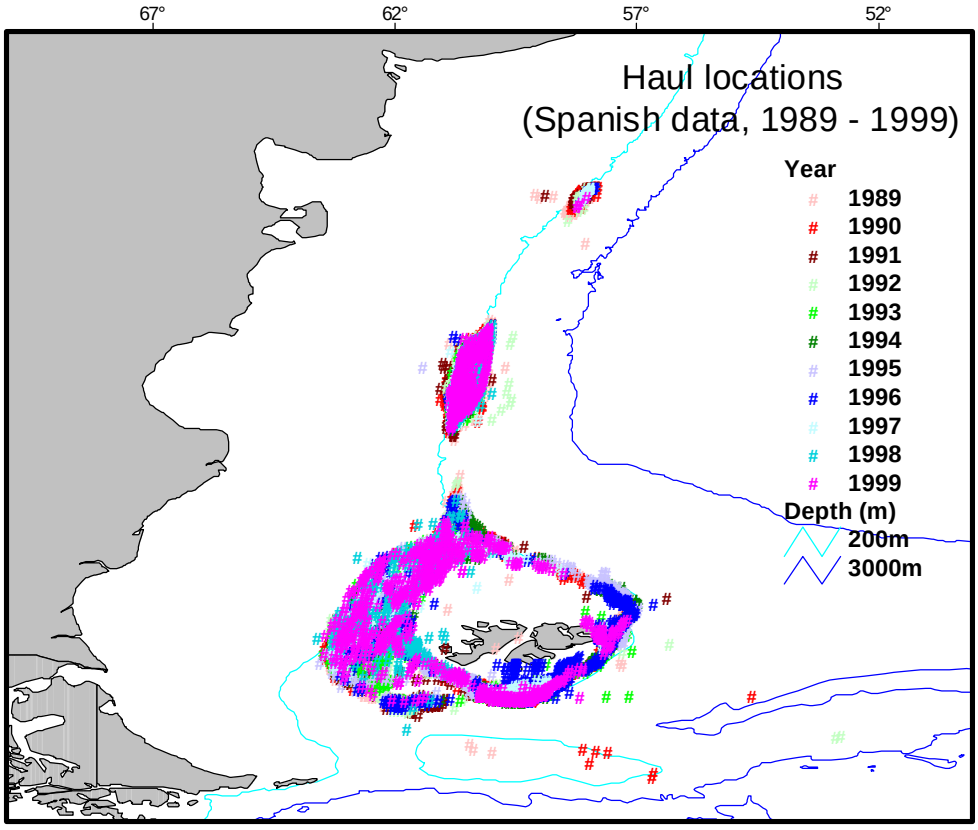

Figure 2. - Geographical position of hauls recorded by Spanish observers

Analysis of the discard pattern of target species by the Spanish fleet from historical data on a haul by haul basis from 1989 to 2001 was made. These analyses were made jointly by AU and IEO to describe the proportion of target species in the total catch and the amount of discards.

The discards ratio was calculated for each haul, defined as the ratio of total discards to the total catches. In Figure 3 and 4 can be seen the locations of hauls with different *Merluccius hubbsi* discard ratios, by "hake target" hauls and "non-hake target", respectively. Figure 5 also shows monthly total discards by "hake target" and "non-hake target" hauls. It can be seen that the lowest proportion of discards was seen in 1990 and 1991. In the north area (from 44°S northwards), hake discarding was recorded in 1989 and 1990 (Fig 6). Both hake target and non-hake target fishing have discards records. Figure 7 shows numbers for the middle area (between 44°S and 47° 30'S), high discards were seen in July 1996. Over 250 t of *Merluccius hubbsi* were discarded. Hake target fishing made the major contribution to discards in this area. Fig 8 shows the south area, which goes from 47° 30'S southwards, where nearly 120 t *Merluccius hubbsi* were discarded in April 1989. High discarding also occurred in 1995 and 1996. Discards are mainly from non-hake target fishing hauls in this area.

Figure 9 shows the seasonality of the fishery, notably marked in the austral winter from May to September, what also reflect the major the discard pattern in the season of high exploitation.

This could be also seen in tables 3 and 4. In table 3 a fishing pattern by bathymetry strata could be seen, in shallower waters hake are more abundant whilst in deeper waters Illex is more abundant. Table 4 shows monthly catch and effort for the different target and bycatch species of the fishery. A strong seasonal pattern could be also seen, maybe addressed by the strong hydrodynamic characteristics of the South West Atlantic as aforementioned. Analysis of the discard pattern of the by-catch species was also made. Percentages of discard in relation to total catch are shown in Table 5. The most discarded species are *Patagonotothen* spp, with around the 100% discarded, second is *Macruronus magellanicus*, with around 25% discarded, then *Micromesistius australis* (12%) and *Salilota australis* (6%). These percentages once vary depending on the division, year and fishing season. The four target species have percentages of discards below 5%. In recent years percentages have decreased below 15%, except for *Patagonotothen* spp (100% discarded).

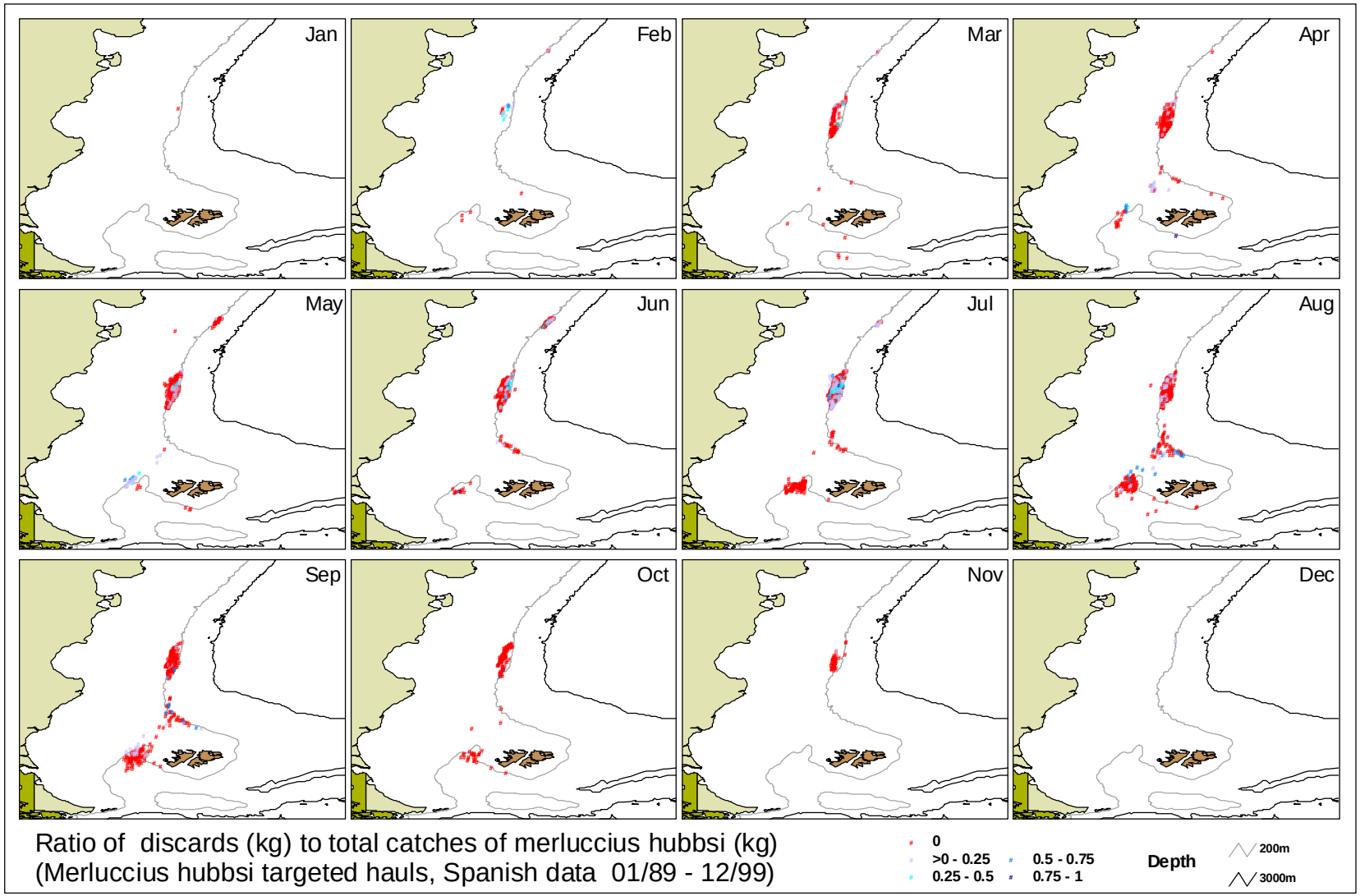

Figure 3. Ratio of discards to total catches of *M. hubbsi* in hake targeted hauls.

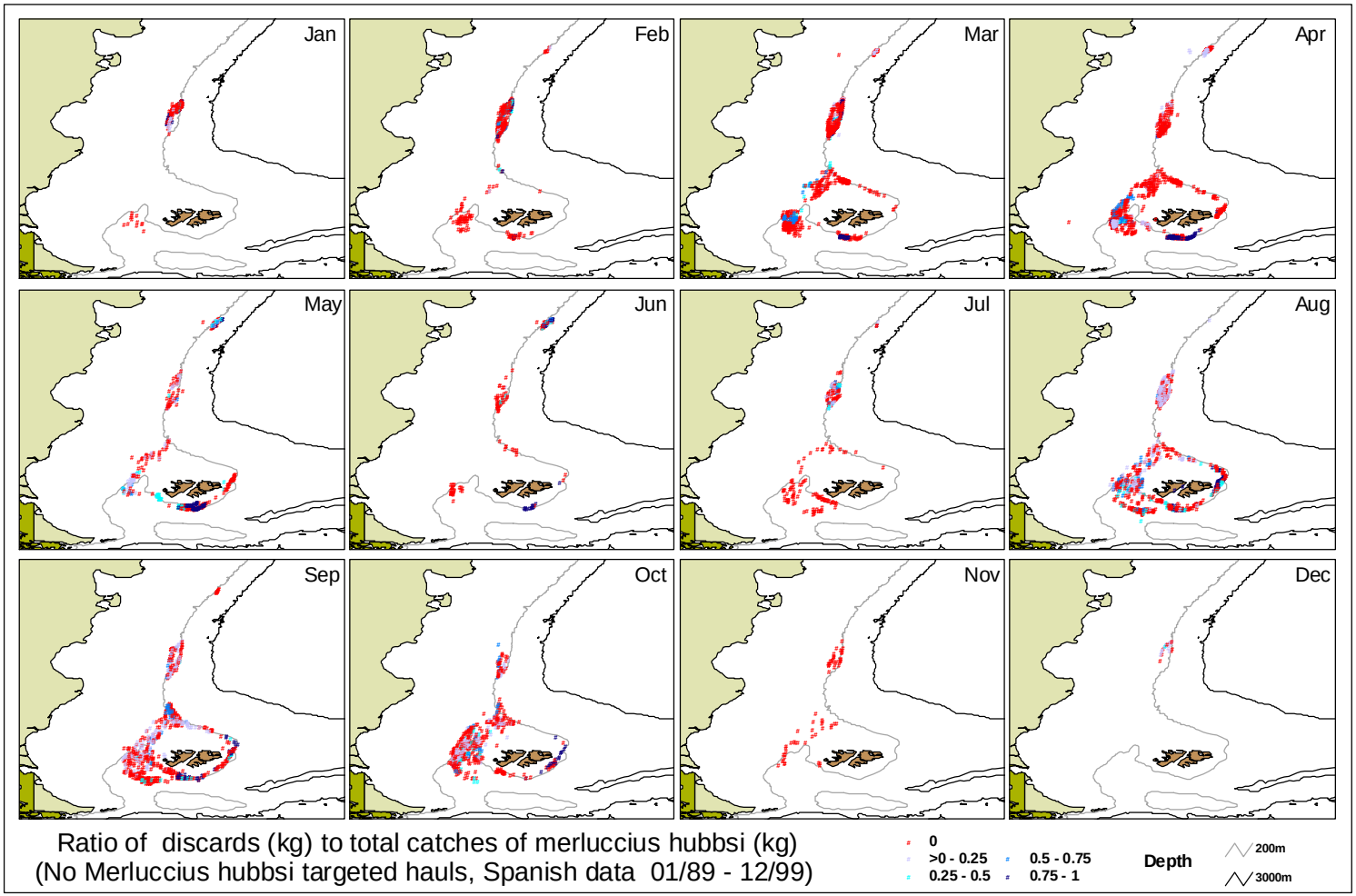

Figure 4. Ratio of discards to total catches of *M. hubbsi* in non-hake targeted hauls

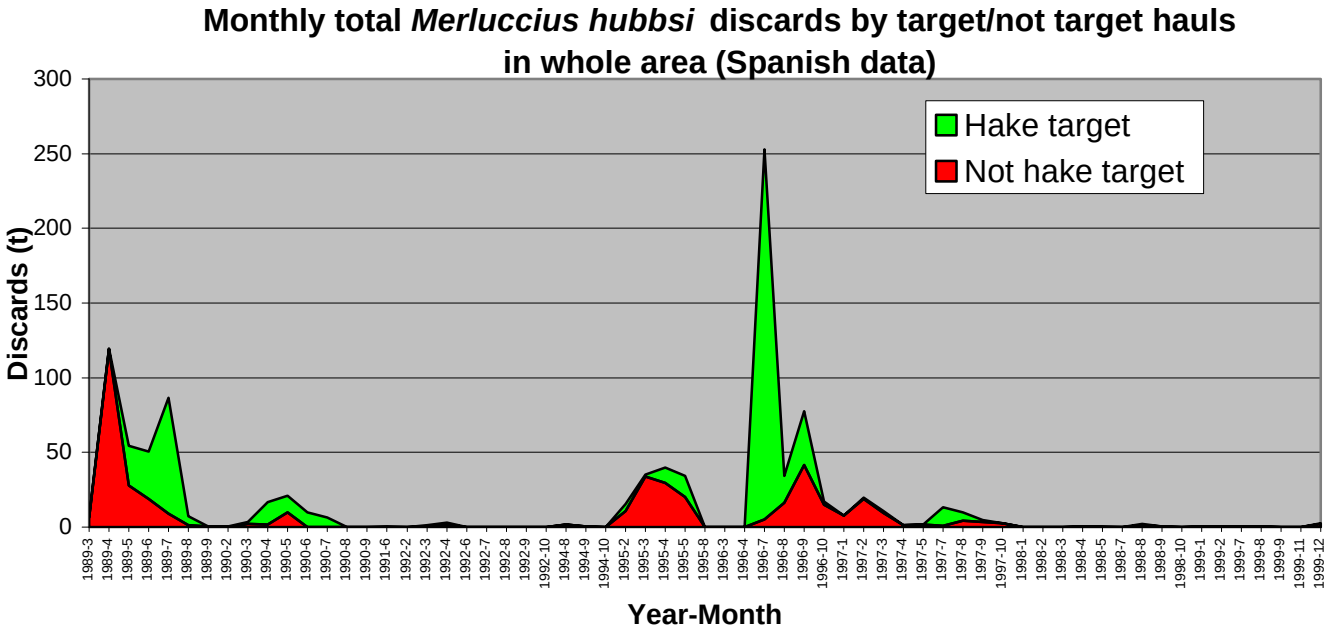

Figure 5. Monthly total *Merluccius hubbsi* discards by target/not target hauls in the whole area (Spanish data).

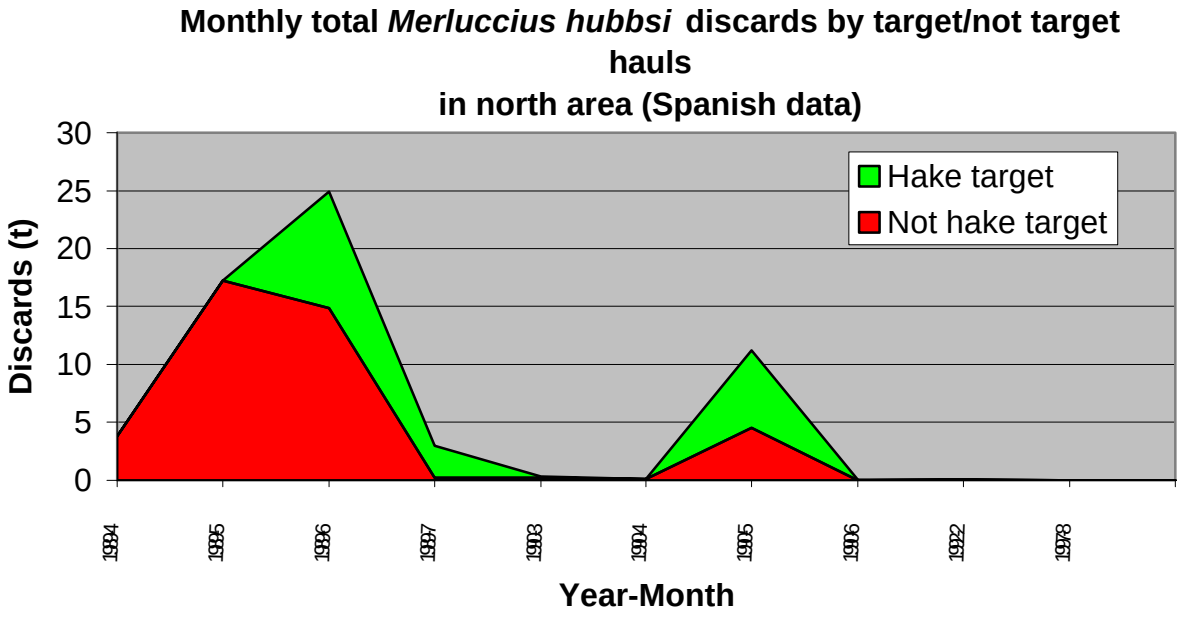

Figure 6. Monthly total *Merluccius hubbsi* discards by target/not target hauls in the north area (Spanish data).

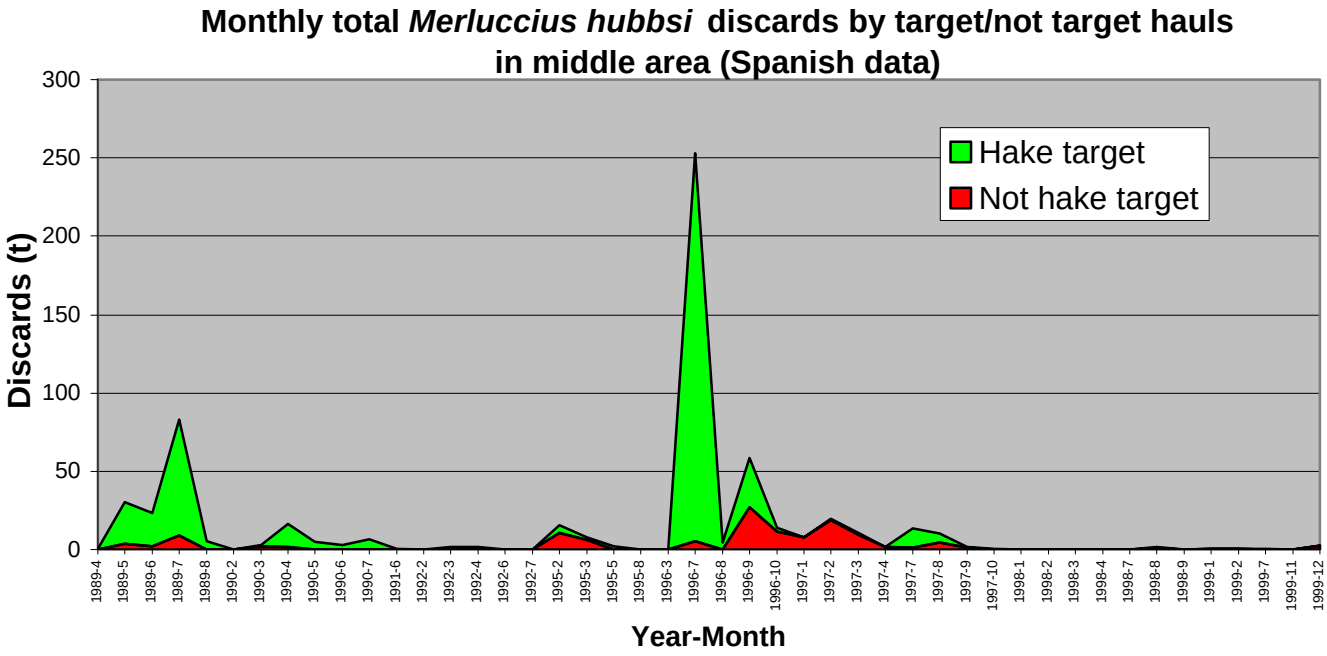

Figure 7. Monthly total Merluccius hubbsi discards by target/not target hauls in the middle area (Spanish data).

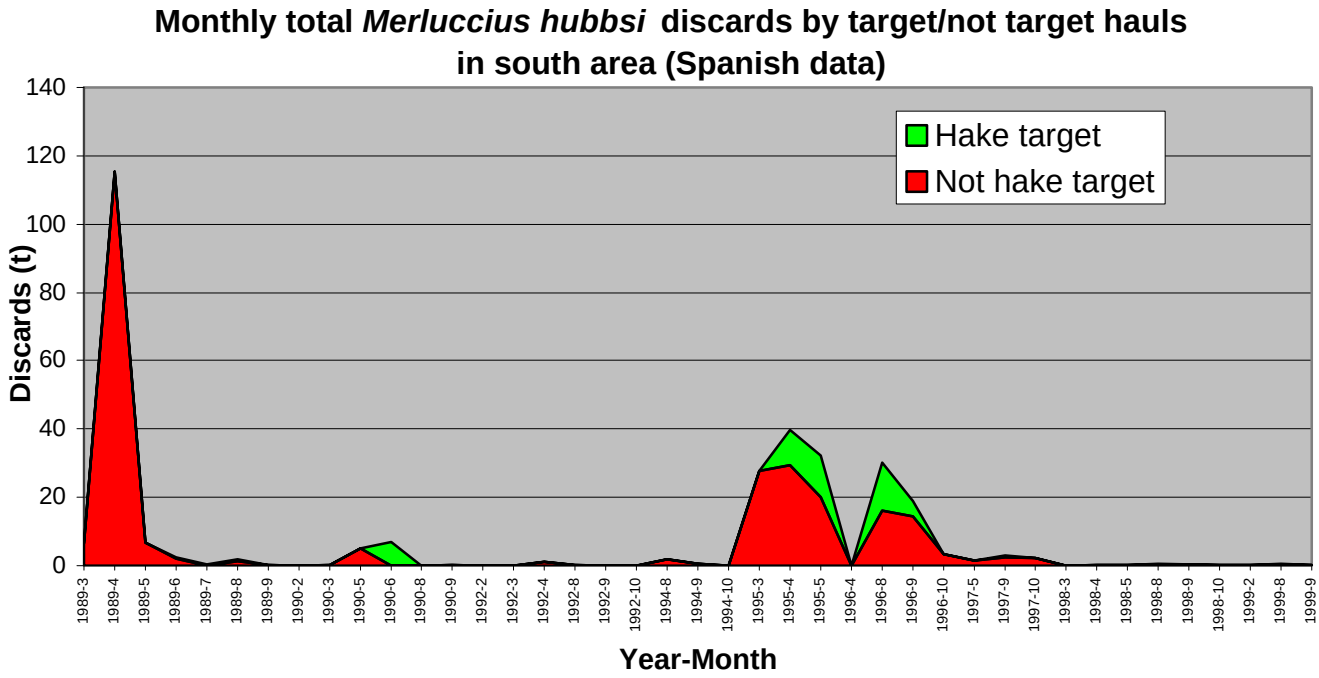

Figure 8. Monthly total Merluccius hubbsi discards by target/not target hauls in the south area (Spanish data).

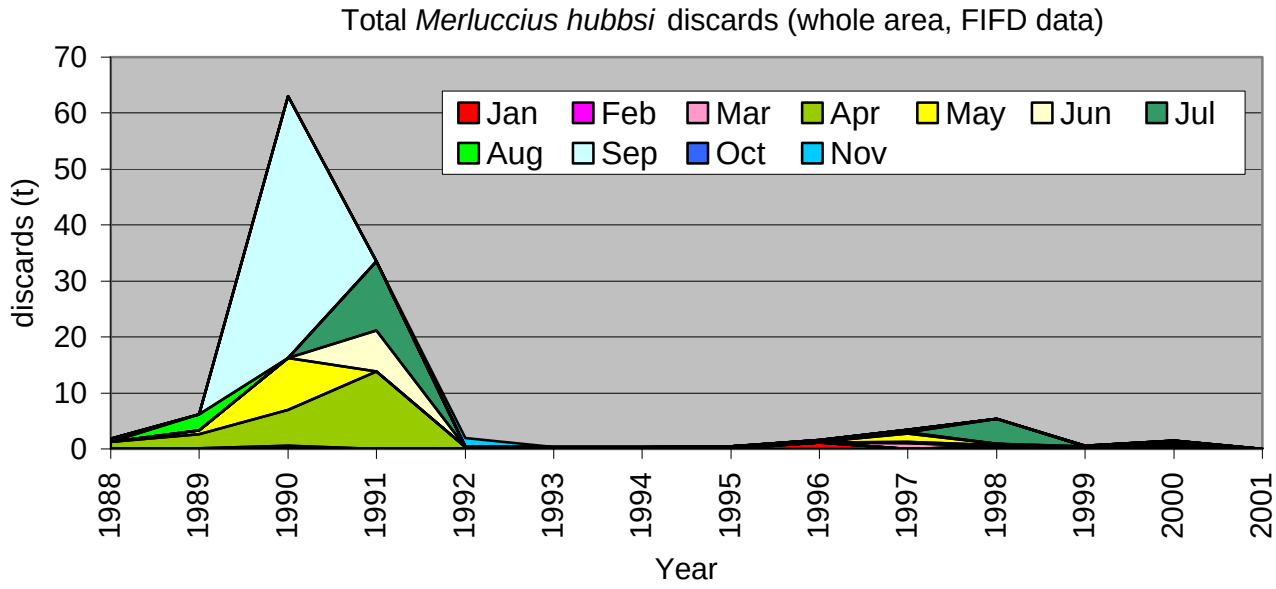

Figure 9. Seasonality of the discard pattern in *Merluccius hubbsi* and amounts from 1988 to 2001

Length distributions were done for catches and discard of eight considered species (fig 10 and 11). Although discard length samples show smaller lengths than those of catches, it seems not to have a clear length-discard pattern but discard is more directed by other causes, such as processing time and appearance of fish.

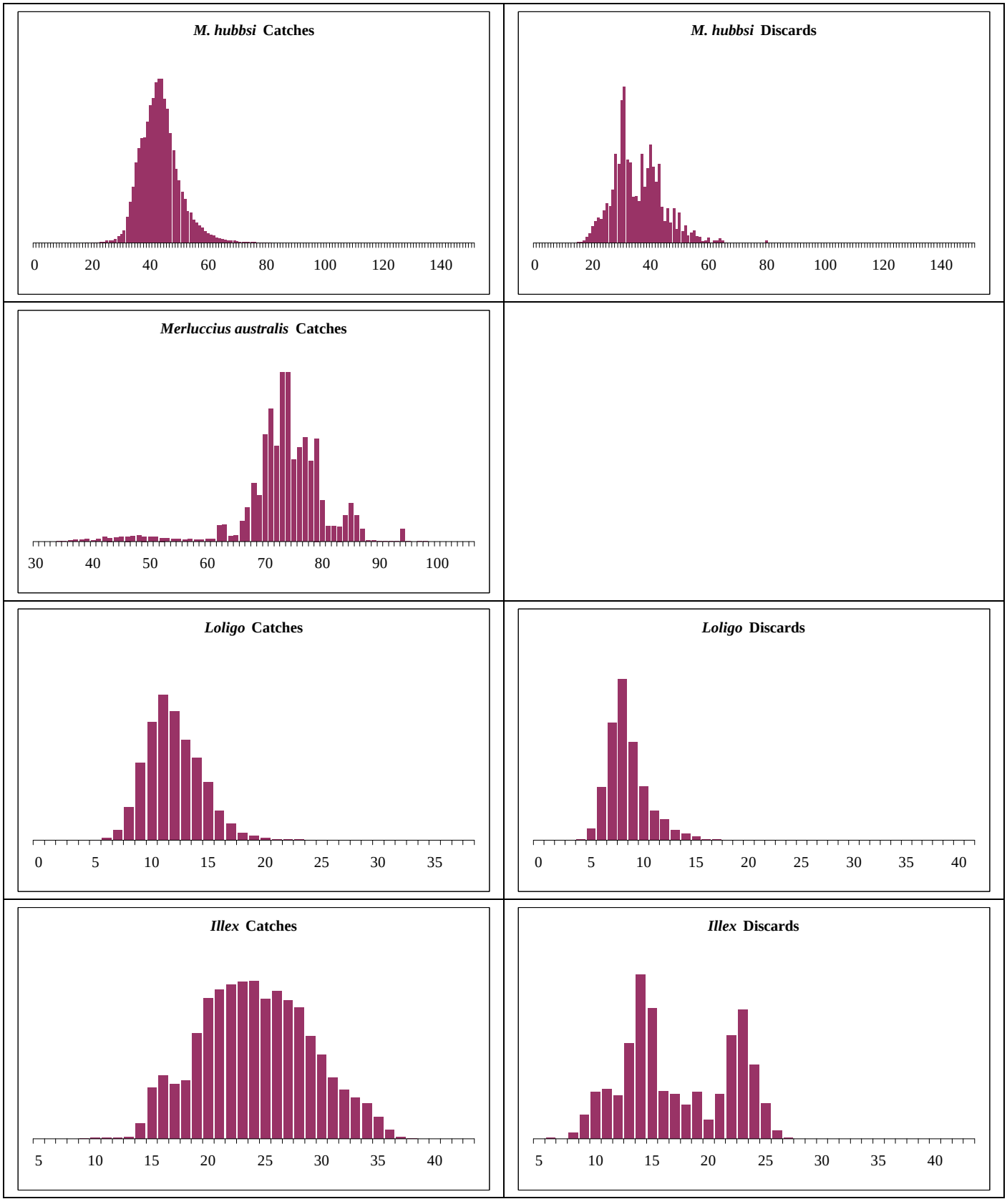

Figure 10. Length distributions and size range of the different target species of the fishery both for catch as discards.

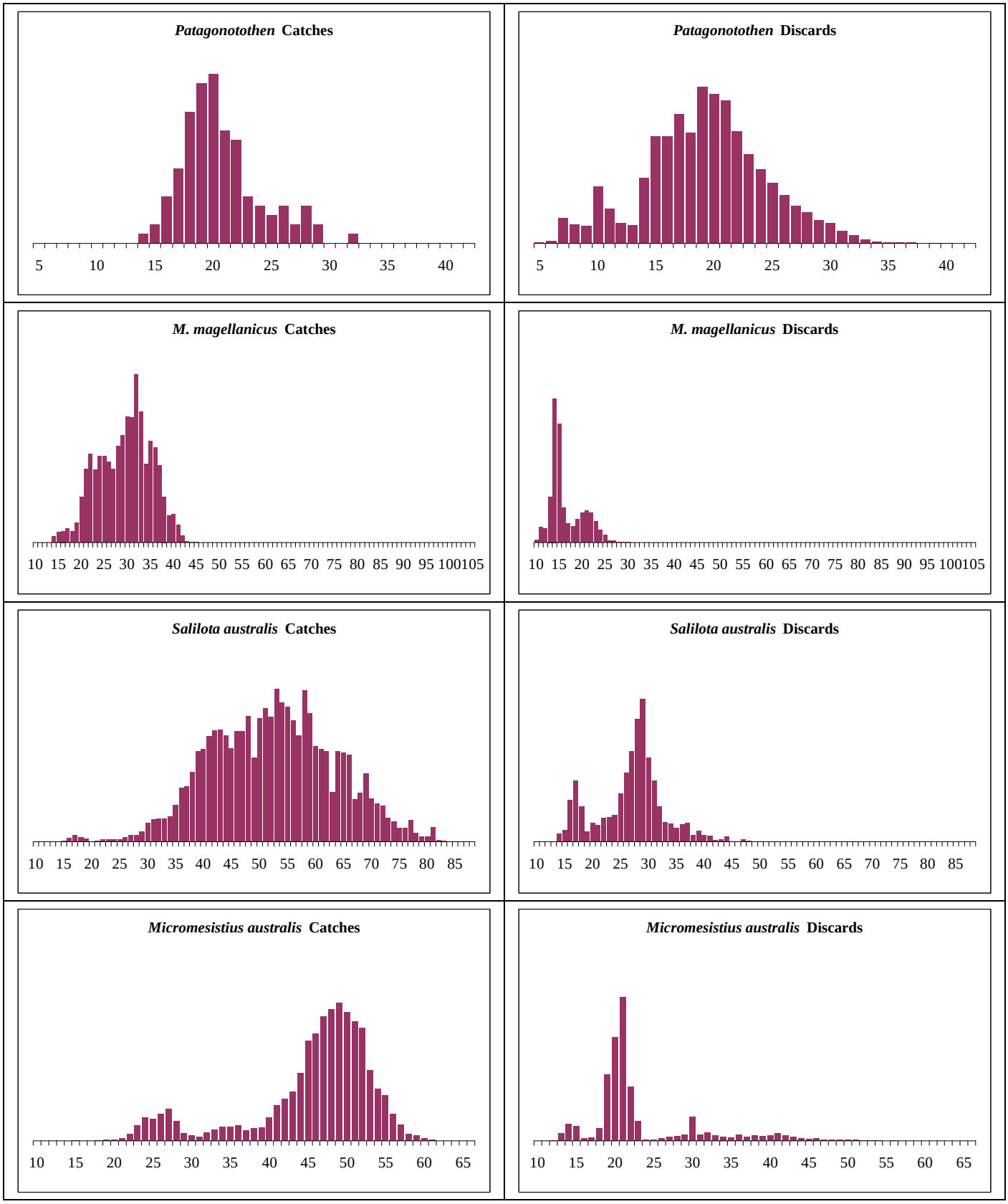

Figure 11. Length distributions and size range of the different bycatch species of the fishery both for catch as discards.

Table 3. Catch, effort and CPUE by bathymetric strata for all years.

year	(All)											
species		**strata**										
	Datos	51-100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	> 500	Total general
Merluccius hubbsi	CPUE	121	448	215	250	113	122	81	30	43	78	299
	total catch	12,266	12,346,762	5,082,844	2,747,954	361,018	187,460	55,556	32,754	23,285	33,315	20,883,214
	total effort	101	27,531	23,683	11,001	3,182	1,540	683	1,106	537	425	69,789
Merluccius australis	CPUE	7	55	45	84	110	86	76	127	118	91	79
	total catch	50	33,661	253,891	490,986	239,935	82,624	28,531	157,577	97,839	15,326	1,400,421
	total effort	7	615	5,604	5,854	2,181	957	377	1,237	832	168	17,832
Illex argentinus	CPUE	318	365	468	653	413	862	1,356	805	994	1,423	490
	total catch	84,754	6,788,190	5,147,458	2,852,772	397,777	545,130	749,453	205,217	49,123	1,769,581	18,589,455
	total effort	267	18,601	10,996	4,367	964	633	553	255	49	1,243	37,927
Loligo gahi	CPUE	2,699	716	1,418	1,014	820	408	45	27	23	35	1,058
	total catch	1,225,446	10,127,407	27,604,507	9,555,869	2,332,156	280,804	10,547	20,456	6,414	2,233	51,165,838
	total effort	454	14,135	19,468	9,422	2,843	688	235	769	275	64	48,351
Macruronus magellanicus	CPUE	187	103	384	245	198	192	123	70	107	66	246
	total catch	12,225	840,481	5,060,991	1,685,102	504,721	254,521	62,553	85,522	78,239	26,426	8,610,780
	total effort	66	8,155	13,183	6,875	2,547	1,326	510	1,217	728	402	35,007
Micromesistius australis	CPUE	725	623	361	608	1,720	3,050	2,034	251	356	116	883
	total catch	10,052	361,107	1,560,582	2,985,608	4,248,108	3,716,660	829,360	302,228	296,178	34,271	14,344,154
	total effort	14	580	4,317	4,912	2,469	1,218	408	1,203	832	296	16,250
Genypterus blacodes	CPUE	57	44	42	32	23	13	13	18	11	11	40
	total catch	3,674	960,175	798,438	326,772	58,195	6,284	1,441	1,923	237	742	2,157,880
	total effort	64	21,827	18,962	10,174	2,496	466	115	104	22	65	54,295
Salilota australis	CPUE	7	30	125	82	50	17	15	24	154	15	85
	total catch	402	306,850	2,619,852	983,592	162,716	18,832	4,904	9,445	16,582	1,552	4,124,727
	total effort	57	10,109	21,007	11,947	3,279	1,111	322	396	108	106	48,441
Dissostichus eleginoides	CPUE	23	5	15	14	24	31	35	65	132	84	21
	total catch	832	15,377	166,741	89,537	49,451	23,390	9,564	64,607	86,666	21,079	527,244
	total effort	36	2,945	11,150	6,253	2,086	749	276	991	658	251	25,395
Patagonotothen spp.	CPUE	35	149	162	93	112	97	101	66	42	58	138
	total catch	4,680	3,049,857	1,617,505	489,335	191,849	68,921	46,180	25,340	11,390	45,459	5,550,516
	total effort	135	20,484	9,970	5,273	1,708	711	459	385	270	778	40,171

Table 4. Monthly catch, effort and CPUE by month.

year	(All)													
strata	(All)													
		month												
species	Datos	1	2	3	4	5	6	7	8	9	10	11	12	Total general
Merluccius hubbsi	CPUE	43.12	88.05	196.73	406.35	392.33	425.04	571.46	299.16	188.20	116.21	106.95	92.70	301.42
	total catch	75,646	332,476	1,467,455	4,316,387	3,474,103	1,768,994	4,504,247	3,302,913	1,616,730	695,214	183,787	36,984	21,774,936
	total effort	1,754	3,776	7,459	10,622	8,855	4,162	7,882	11,041	8,590	5,982	1,718	399	72,242
Merluccius australis	CPUE	115.71	144.74	139.63	99.41	71.77	36.28	46.85	57.44	56.57	45.70	40.39	17.33	78.62
	total catch	81,237	209,516	285,377	255,704	93,154	12,091	28,569	148,937	148,138	97,511	58,673	5,396	1,424,303
	total effort	702	1,448	2,044	2,572	1,298	333	610	2,593	2,619	2,134	1,453	311	18,116
Illex argentinus	CPUE	1,123.66	664.77	688.42	592.10	467.98	527.83	22.72	25.50	58.97	8.82	29.56	244.34	510.90
	total catch	1,593,919	2,691,837	5,611,647	5,478,334	2,853,171	1,690,040	64,511	58,780	79,258	2,994	8,978	49,515	20,182,984
	total effort	1,419	4,049	8,151	9,252	6,097	3,202	2,839	2,305	1,344	339	304	203	39,505
Loligo gahi	CPUE	68.03	2,937.82	2,182.88	1,612.91	1,307.83	466.65	362.13	921.17	644.60	269.12	2.31	2.11	1,032.36
	total catch	11,871	5,305,605	9,129,825	9,349,791	9,082,176	671,818	1,169,756	8,814,956	6,029,788	1,564,687	2,725	79	51,133,077
	total effort	175	1,806	4,182	5,797	6,944	1,440	3,230	9,569	9,354	5,814	1,181	37	49,530
Macrurorus magellanicus	CPUE	55.95	215.74	218.18	273.92	193.69	170.55	108.97	164.28	246.88	450.60	364.74	199.22	244.71
	total catch	86,745	520,515	985,630	1,243,506	462,526	216,210	212,857	795,619	1,018,918	2,153,507	770,939	115,656	8,582,628
	total effort	1,550	2,413	4,517	4,540	2,388	1,268	1,953	4,843	4,127	4,779	2,114	581	35,073
Micromesistius australis	CPUE	1,813.44	1,660.79	301.39	228.25	90.54	11.79	27.19	304.81	624.83	741.81	1,638.38	5,953.92	881.05
	total catch	1,557,742	2,317,990	534,149	455,747	71,722	4,032	6,338	524,268	1,783,844	1,614,943	2,788,631	2,700,598	14,360,003
	total effort	859	1,396	1,772	1,997	792	342	233	1,720	2,855	2,177	1,702	454	16,299
Genypterus blacodes	CPUE	16.08	21.14	42.67	52.10	44.32	53.79	38.86	33.54	33.86	33.34	40.99	110.10	39.66
	total catch	28,153	77,808	303,600	464,254	257,008	149,603	227,133	261,660	190,869	167,455	70,292	39,746	2,237,581
	total effort	1,751	3,680	7,114	8,911	5,799	2,781	5,846	7,801	5,637	5,022	1,715	361	56,418
Salilota australis	CPUE	128.23	59.97	79.74	77.63	62.07	54.82	39.22	94.09	115.40	133.61	67.77	3.22	84.49
	total catch	128,162	174,896	478,136	624,333	402,338	118,412	127,000	613,275	685,821	712,272	104,454	582	4,169,682
	total effort	999	2,917	5,997	8,043	6,482	2,160	3,238	6,518	5,943	5,331	1,541	181	49,350
Dissostichus eleginoides	CPUE	16.76	24.12	15.43	20.21	9.70	14.20	13.08	30.11	28.65	15.58	17.79	10.46	20.82
	total catch	14,994	27,712	32,035	57,245	19,902	7,475	23,480	142,984	122,409	51,602	27,104	2,779	529,722
	total effort	895	1,149	2,076	2,833	2,051	527	1,795	4,749	4,273	3,312	1,524	266	25,448
Patagonotothen spp.	CPUE	234.57	161.20	190.03	135.06	94.40	67.30	114.15	122.38	136.17	150.90	134.56	131.06	135.63
	total catch	243,161	439,317	831,273	691,762	325,462	153,440	558,343	667,326	716,456	666,304	119,179	38,530	5,450,553
	total effort	1,037	2,725	4,375	5,122	3,448	2,280	4,891	5,453	5,261	4,416	886	294	40,187

Table 5. Catch, discard, effort and percentage of discarded by fishing areas.

year	(All)								
month	(All)	**division**							
species	Datos	Unknown	42	46	49	MN	MS	MW	Total
Merluccius hubbsi	total catch	8,978	745,165	13,684,464	371,999	506,868	383,594	6,083,910	21,784,978
	total discard	52	61,031	649,185	23,265	17,374	70,583	310,726	1,132,215
	total effort	68	2,906	29,566	1,730	4,556	11,822	22,599	73,246
	Percentage	0.58	8.19	4.74	6.25	3.43	18.40	5.11	5.20
	CPUE	132.97	256.47	462.84	215.05	111.25	32.45	269.21	297.42
Merluccius australis	total catch		3	5,170	11,422	25,847	27,046	1,354,813	1,424,303
	total discard		0	219	0	108	3,786	63,086	67,199
	total effort		10	205	133	723	2,653	14,392	18,116
	Percentage		0.00	4.24	0.00	0.42	14.00	4.66	4.72
	CPUE		0.33	25.17	85.68	35.77	10.19	94.14	78.62
Illex argentinus	total catch	23,717	4,964,931	8,996,737	338,602	3,044,048	345,533	2,470,419	20,183,987
	total discard	0	13,291	120,801	14,678	21,156	39,247	62,674	271,847
	total effort	42	4,302	20,584	623	2,376	3,790	6,787	38,503
	Percentage	0.00	0.27	1.34	4.33	0.70	11.36	2.54	1.35
	CPUE	563.57	1,154.14	437.07	543.63	1,281.07	91.18	364.00	524.21
Loligo gahi	total catch	332	36,002	766,540	208,644	5,912,235	44,118,443	742,402	51,784,597
	total discard	3	277	59,020	1,207	39,267	536,862	45,107	681,742
	total effort	26	291	10,246	1,157	5,144	22,999	9,667	49,530
	Percentage	0.84	0.77	7.70	0.58	0.66	1.22	6.08	1.32
	CPUE	12.57	123.86	74.81	180.34	1,149.45	1,918.25	76.80	1,045.51
Macruronus magellanicus	total catch	618	74,550	557,434	296,606	622,614	81,815	7,000,196	8,633,832
	total discard	222	21,286	225,389	111,916	135,528	38,417	1,607,914	2,140,672
	total effort	26	847	8,527	1,119	2,425	1,915	20,213	35,073
	Percentage	35.99	28.55	40.43	37.73	21.77	46.96	22.97	24.79
	CPUE	23.97	87.99	65.37	265.01	256.76	42.71	346.32	246.17
Micromesistius australis	total catch	1	10,081	90,645	166	2,148,299	2,054,380	10,056,432	14,360,003
	total discard	1	9,441	31,633	166	38,428	465,445	1,205,123	1,750,236
	total effort	1	492	543	35	719	3,465	11,043	16,299
	Percentage	100.00	93.65	34.90	100.00	1.79	22.66	11.98	12.19
	CPUE	0.77	20.48	166.81	4.74	2,989.70	592.90	910.62	881.05
Genypterus blacodes	total catch	1,553	37,525	1,128,876	53,016	85,211	49,279	883,124	2,238,584
	total discard	0	2,282	13,593	1,607	2,748	5,331	31,746	57,307
	total effort	43	1,520	25,330	1,383	2,884	5,648	19,609	56,418
	Percentage	0.00	6.08	1.20	3.03	3.23	10.82	3.59	2.56
	CPUE	35.77	24.69	44.57	38.33	29.54	8.73	45.04	39.68
Salilota australis	total catch	2,870	11,288	153,109	71,794	148,439	402,830	3,381,358	4,171,688
	total discard	27	1,391	6,580	4,086	8,735	29,120	219,153	269,092
	total effort	48	1,239	10,137	1,417	3,164	11,344	22,001	49,350
	Percentage	0.95	12.32	4.30	5.69	5.88	7.23	6.48	6.45
	CPUE	59.28	9.11	15.10	50.68	46.92	35.51	153.69	84.53
Dissostichus eleginoides	total catch	407	2,289	24,377	6,127	19,844	51,244	426,435	530,723
	total discard	0	1,034	1,504	362	3,616	9,682	10,698	26,896
	total effort	27	366	3,264	492	1,530	5,139	14,631	25,448
	Percentage	0.00	45.18	6.17	5.91	18.22	18.89	2.51	5.07
	CPUE	15.30	6.25	7.47	12.46	12.97	9.97	29.15	20.86
Patagonotothen spp.	total catch		227,027	3,445,276	128,383	346,619	411,302	992,509	5,551,116
	total discard		225,867	3,396,943	83,043	346,619	422,510	993,489	5,468,471
	total effort		2,734	21,656	920	2,024	4,471	8,382	40,187
	Percentage		99.49	98.60	64.68	100.00	102.73	100.10	98.51
	CPUE		83.02	159.09	139.57	171.26	91.98	118.41	138.13

Marine mammals

IEO also contributed to the project with historical data on by-catches and sightings of marine mammals collected since 1993 by observers trained to do this task by researchers of the Marine Mammals Project of the IEO with the following objectives:

– to record the interactions between fishing activities and marine protected fauna
– to advise national and international bodies with responsibilities in research and management of these species

Between 1993 and 2001, observers spent a total of 2540 days at sea on board Spanish fishing vessels. Their main task was to sample the fish and cephalopod catch and by-catch but they also recorded incidental sightings and by-catches of marine megafauna (seabirds and marine mammals). Sightings or catches of protected marine megafauna were recorded during 25 fishing trips. The information was processed, collated and checked before being integrated in the IEO project database for analysis.

Several species of sea birds and marine mammals were reported incidentally caught in the fishing nets. However, the 15 records over 9 years include three cetacean specimens in an advanced stay of decay when caught, and one bird (a seagull), which was released alive. Megafauna by-catch mortality recorded by fishery observers and sightings of cetacean are shown in table 6 and 7 respectively.

Table 6. "Megafauna" by-catch mortality recorded by fishery observers

			By-catch mortalities recorded								
Season	**No of Observers**	**Days at sea**	***Lagenorynchus cruciger***	***Otaria byronia***	***Lobodon carcinophagus***	***Arctocephalus australis***	"Grey seal"	***Pygoscelis papua***	***Diomedea melanophris***	**ALL**	**BY-CATCH RATE (No/day)**
1993	2	225	2	1	0	0	0	0	0	3	0.0133
1994	5	396	1	0	1	0	0	0	0	2	0.0051
1995	2	225	0	0	0	0	0	0	0	0	0.0000
1996	2	211	0	0	0	0	0	1	1	2	0.0095
1997	2	222	0	0	0	0	0	0	0	0	0.0000
1998	4	435	0	0	0	0	1	0	1	2	0.0046
1999	1	103	0	0	0	0	0	0	0	0	0.0000
2000	5	485	0	0	0	1	0	0	0	1	0.0021
2001	2	238	0	0	0	0	0	0	1	1	0.0042
SUM	25	2540	3	1	1	1	1	1	3	11	0.0043

Table 7. Sightings of cetaceans by fishery observers

(a) Number of groups

Season	**Observers**	***Days***	***Delfinus* sp.**	***Eubaleana australis***	***Globecephala* sp.**	***Physeter macrocephalus***	***Lagenorhynchus australis***	***Lagenorynchus cruciger***	**Unidentified**	**ALL**	Sightings rate (No/day)
1993	2	225								0	0.00
1994	5	396		1		1		15	3	20	0.05
1995	2	225			5		14		6	25	0.11
1996	2	211	1	1			6			8	0.04
1997	2	222		1			17		2	20	0.09
1998	4	435				1	8		3	12	0.03
1999	1	103								0	0.00
2000	5	485				2	3		7	12	0.02
2001	2	238					8		3	11	0.05
SUM	25	2540	1	3	5	4	56	15	24	108	

(b) Number of individuals

Season	**Observers**	***Days***	***Delfinus* sp.**	***Eubaleana australis***	***Globecephala* sp.**	***Physeter macrocephalus***	***Lagenorhynchus australis***	***Lagenorynchus cruciger***	**Unidentified**	**ALL**	Sightings rate (No/day)
1993	2	225								0	0.00
1994	5	396		2		5		120	19	146	0.37
1995	2	225			164		65		28	257	1.14
1996	2	211	8	1			36			45	0.21
1997	2	222		1			94		2	97	0.44
1998	4	435				1	55		42	98	0.23
1999	1	103								0	0.00
2000	5	485				2	31		31	64	0.13
2001	2	238					85		150	235	0.99
SUM	25	2540	8	4	164	8	366	120	272	942	

CONCLUSIONS

Main fisheries

Three main fisheries could be defined according to the different species distributions. On the other hand fishing pattern is directed by a number of fishing market criteria. Depth is a factor clearly affecting to distribution and abundance of all fished species as it is shown in table 3. Seasonal effects are also evident as it is shown in fig 9 and table 4, perhaps addressed by the oceanographic conditions of the area.

The first target fishery and also the most important is that of hake, comprising *Merluccius hubbsi* and *M. australis.* Although *M. australis* is more appreciated in the market, it is much more scarce and restricted to southern areas (table 5). Table 3 shows the different exploitation pattern, where red background highlight CPUE values between 100 and 500 kg/h and cyan highlight CPUEs greater than 500 kg/h. Common hake is more abundant in strata between 100 and 250 m depth, with CPUE values among 448 and 215 kg/h. However, short-fin squid becomes more abundant in depths greater than 250 kg/h, with high CPUEs even above 1000 kg/h.

There is a clear fishing market criterion to target one or another species, hake is always more appreciated and much more valuable than short-fin squid. However, sometimes the market is saturated of hake and skippers send instructions to vessels to target *Illex* (short-fin) squid, with the aim of maintaining the prices. As well there is a seasonal effect of abundance and fishing aims to take advantage of the seasonal abundance of each group (see table 4).

Hence, the second fishery is that directed to *Illex* squid. The third one will be the *Loligo* fishery, which target for common squid (*L. gahi*). It is restricted to a small area inside the FICZ, named as the Loligo-box, this area corresponds to “Malvinas Sur”.

Bycatch and discards:

All these fisheries comprise both retained catch and discard for all species. Target species may be also discarded if crew did not have enough time for processing when catches of a new haul come on board. Another reason could be bad looking of fishes caused by stress of trawling or any other reasons.

Length distributions were done for catches and discards of eight considered species. Although discard length samples show smaller lengths than those of catches, it seems not to have a clear length-discard pattern but discard is more directed by other causes, such as processing time and appearance of fish. This is very true particularly for the hake fishery. Regarding to the *Illex* and *Loligo* fishery, catch use to be single-species, with a very minor percentage of presence of other species, particularly in areas and season if high abundance.

Percentages of discard in relation to total catch are shown in table 5. The most discarded species are *Patagonotothen* spp, with around the 100% discarded, the second one is *Macruronus magellanicus*, with around 25% discarded, then *Micromesistius australis* (12%) and *Salilota australis* (6%). These percentage once vary depending on the division, year and fishing season. The four target species have percentages below 5%.

In recent years percentages have decreased below 15%, except for *Patagonotothen* spp (100% discarded). This should be must be analysed in further works in order to understand possible changes on fishing patterns as well as to evaluate possible emerging species and potential.

Marine mammals:

The 11 animals observed to be killed in the fishing gear included sea birds, pinnipeds and dolphins: three specimens of the black-browed albatross (*Diomedea melanophris*), one gentoo penguin (*Pygoscelis papua*), three hourglass dolphins (*Lagenorhynchus cruciger*),one crabeater seal (*Lobodon carcinophagus*), one South American sea lion (*Otaria byronia*), one South American fur seal (*Arctocephalus australis*) and one "grey seal". The overall by-catch mortality for seabirds and marine mammals was approximately 4 animals per 1000 observer days at sea, with the highest mortality (>1 animal per 100 days at sea) being seen in 1993 (Table 6). Thus the by-catch rate is apparently low.

Sightings of 108 cetacean groups (942 animals) were made, with the highest sighting rate (1.14 animals per day) in 1995 and no sightings in 1993 or 1999 (Table 7). The species most frequently sighted was the Peale's dolphin (*Lagenorhynchus australis*) followed by the hourglass dolphin. Other species of cetaceans observed were the common dolphin (*Delphinus* sp.), the pilot whale (*Globicephala* sp.), the sperm whale (*Physeter macrocephalus*) and the southern right whale (*Eubaleana australis*).