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# Trawl Anglerfish Discard Estimates and Patterns in the Spanish Northeast Atlantic Fisheries

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## Abstract

Discards estimates from Spanish bottom otter trawl of anglerfish, *Lophius budegassa (*black anglerfish*)* and *L. piscatorius (*white anglerfish*)*, in Northeast Atlantic Ocean (ICES Sub-areas VI, VII and Divisions VIIIabd) are presented in this paper. Information was obtained by observers on board in different discard programs carried out by Spanish Research Institutes. Total discards obtained by the different raising procedures were very similar and total discard raised by effort (number of trips) as a simple estimator was assumed as the adequate value. Values in weight range from 4 t to 590 t, and from 4 t to 320 t for white and black anglerfish respectively in Sub-areas VI and VII. Length distributions of discarded anglerfish (Sub-areas VI and VII) show that most of the specimens are juvenile individuals. Discards estimations show a high variability in weight and number along the period studied. Yearly abundance of juveniles in the area is a factor to understand the variability of discard quantities. This trend in Sub-areas VI and VII is reflected by similar pattern between juveniles (length < 31cm) discards estimations and recruitment indices (age 0) obtained by French (FR-EVHOES) for black anglerfish, and Irish (IR-IGFS) for white anglerfish. Inter-annual variation may also be explained by legal restriction on minimum weights (DCR) laid down in 2000 due to change in onboard sorting procedures.

*Keywords: Anglerfish, Discards, Northeast Atlantic waters, Bottom Otter Trawl*

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## 1. Introduction

The growing importance of discards in fishery management is further reflected by the increasing attention paid to this topic by international research organisations since the 1990´s. Focusing on stock assessment the 2007 WGHMM Report points out that lack or unreliable discard data is one of the causes to reject analytical assessment on northern anglerfish stocks. Anglerfish, *Lophius budegassa* (Spinola 1807) and *L. piscatorius* (Linnaeus 1758), are ones of the most

valuable fresh white fish caught in Northeast Atlantic waters, ICES Sub-areas VI and VII, and landed to the Spanish markets (Lart et al., 2002). In a lesser extent, anglerfish is also caught in the Bay of Biscay (Divisions VIIIabd) by "baka" otter trawls.

Since 1990, and related to its increasing fishery relevance, studies on European anglerfish species have been focused on biological characteristics relevant to stock assessment, however, aspects as discard patterns still are far to be understood.

Discard data from Spanish bottom otter trawl (OTB) fleets, operating in ICES Northern stock, are presented. The information contained in this paper may be a step-forward into the improvement of the quality and reliability of data used for stock assessment of these species in the area.

## 2. Material and methods

Discard information has been obtained in a program of observers on board set up and monitored by the Instituto Español de Oceanografía (IEO) (years 1988-1989, 1994, 1999-2000 and 2003-2007) and Azti-Tecnalia (years 2003-2007). The "Spanish Discard Sampling Programme" started in 1988 in Sub-areas VI and VII and in 2003 in Divisions VIIIabd, however there are time-gaps as this research was funded by "with-an-end" research projects. Although sampling level has varied along the time series, it was stabilised since 2003 (Table 1), when the "Community Sampling Fishery Programme" was fully implemented in Spain by the EU (DCR). This sampling coverage supposes to be around a 1% of the total effort.

Sampling was carried out to estimate discards of the most important Spanish trawler fleets, ICES Sub-areas VI and VII, and Divisions VIIIabd (Figure 1). Two Spanish's bottom-otter-trawl fleets operate in Porcupine and Grand Sole areas and have anglerfish as a target species, and one in Divisions VIIIabd:

i) a fleet targeting megrim, that also catches two species of anglerfish and hake. It operates mainly in Grande Sole and southern Porcupine area.
ii) a fleet that operates at the shelf break, targeting hake and also anglerfish, witch and Norway lobster as associated species.
iii) a very mixed fishery (hake, anglerfish, megrim, red mullet, cephalopods, etc.) that operates in Divisions VIIIabd. Most of the species present seasonality.

The sampling recorded discards in weight and numbers, and length distribution of target species as was suggested by DCR. Estimates of the discard weight of species were calculated from length distribution using length-weight relationships (Dorel, 1986; Cull et al., 1989; Pereda and Pérez, 1995) and raised to the total discard by haul. The haul-raised data were further raised to total hauls in the trip (total hauls in trip/sampled hauls in trip).

### *2.1 Quantification of discards*

The anglerfish discard estimates follow the agreed protocol of raising discard procedures and were those given in the Charlottenlund workshop report (ICES, 2004). Two methods to estimate discards were considered, a ratio estimator and a simple estimator (Borges, 2005b; ICES, 2007b). The auxiliary variables considered in the analysis were chosen based both on the accuracy they might give, and also on their availability. Therefore, three main variables were used: landings of species and landings of target species, considering as ratio estimators, and a simple estimator, number of fishing trips. In Sub-areas VI and VII species considered as "target" for raising purposes were megrim for the OTB targeting megrim and hake for the OTB targeting hake. In Divisions VIIIabd total landings were used instead of "target landings" due to the wide range of target species caught by this fleet.

### *2.2 Discards length composition*

Box plots with data of Sub-areas VI, VII were used to study the variability along time in the length distribution of the discards. The yearly median length size, IQR (Inter Quartile Range) and extreme values are displayed. Due to the short discard series from Division VIIIabd this information was not presented.

### *2.3 Discard causes*

Inter-annual variation of discards may be linked to the presence of strong year classes of smaller less-marketable fish (FAO, 2005). Therefore, we compare anglerfish from Sub-areas VI, VII: number of juveniles (length < 31cm) discarded in Sub-areas VI-VII *versus* recruitment indices of juveniles (length < 31cm) in Spanish (SP-PGFS) survey (time series from 2003 to 2007) (Velasco, *pers. comm.)* and also the 0 ages indices, obtained by French (EVHOES) and Irish ( IR-IGFS) (time series from 2003 to 2006) (ICES, 2007a). Annual surveys are carried out in the same area where fleet operates. Pearson´s correlation coefficient was used to assess the correlation between juveniles discarded and the three survey indices. Due to the short discard series form Division VIIIabd information was not used in the analysis.

Pooled data of discard quantities in Sub-areas VI, VII from years before and after the implementation of the Council Regulation on minimum weight (year 2000), Council Regulation

(EC) No 2406/96, were used to test the effect of the ban on discard activities. Bi-histograms together with $DL_{50}$ parameters were the analytical techniques used to show temporal variation in discard procedures onboard.

## 3. Results

### *3.1 Quantification of discards*

Total fleet discards estimations obtained by the three different raising procedures were very similar and coefficients of variation (CVs) of discard variable didn't show a clear pattern, giving similar results. As a consequence, total discard raising by effort (number of trips) as a simple estimator was assumed as the adequate value (ICES, 2007b) (Figure 2).

Results show a high variability in discard value along the period (Table 2). An increasing trend in the weight discarded in black anglerfish till 2006 and a pick of high discard in 2004 in white anglerfish were observed. Discards in weight ranged from 4 to 320 t, and from 4 to 590 t, for black and white anglerfish respectively (Table 2) (raising to effort value). Mean discard values in weight in Sub-areas VI, VII during the 80' and 90' are much lower than those obtained after year 2000 (Figure 2), nevertheless, this increase is mainly apparent for black anglerfish. In white anglerfish discard weight started decreasing again after 2004.

Percentages of anglerfish discarded in Sub-areas VI and VII related to total catch (weights) present also high inter-annual variations in the analysed fisheries (Table 2). In Sub-areas VI and VII weight percentage discarded range between 0.1 and 13% and it is quite similar for both species. The highest value found in weight was around 11% for black anglerfish (year 2006) and 13% for white anglerfish (year 2004). In Divisions VIIIabd, 2007 was the year with higher discard percentage in weight, both for white and black anglerfishes.

### *3.2 Discards length composition*

Number and length composition of discard of these species presented a high variability along the period (Table 2 and Figure 3). The percentage in number discarded varied between 2% and 65% and between 2% and 76%, for black and white anglerfish respectively.

In Sub-areas VI, VII, the Spanish trawl discard for both anglerfish showed a gradual increase in number since 1999-2000 (Table 2). However, a reduction in number was observed in white anglerfish since 2006.

Both anglerfish species have showed a similar discard pattern (Figure 4). The average discard length was estimated in 16 cm for both species. The smallest size of discarded individuals' drops is 5cm for both species and the largest discarded individuals are around 35 cm. Black anglerfish discards presents a skewed distribution to the larger sizes and the modal size increased from 12 cm to 14 cm along the period. No clear differences were found in the modal size variation, but graphs show a slight increase to larger sizes discarded since 2000.

### *3.3 Discard causes*

French, Irish and Spanish surveys are directed to demersal and benthic species as well to detect the strength of the recruitment. Hence abundance indices for small anglerfish could probably reflect estimates of recruitment that can be correlated with the discard estimates. A significant positive correlation was found between black anglerfish discard quantities and abundance estimations obtained by the Irish and French Groundfish surveys (R = 0.76). On the other hand, negative correlation is found with the Spanish survey (R = -0.77). A very high correlation was found between white anglerfish discard quantities and the Irish (IR-IGFS) abundance estimation for the same specie (R = 0.95). Spanish and French (FR-EVHOE) white anglerfish abundance data are also correlated with discard information (R = 0.61 and R = 0.48) (Figure 5).

Figure 6 summarizes the discard lengths distribution from pooled data (all years available, before and after Council Regulation) and the $DL_{50}$ parameter (50% discard length) related with each period. There was a slight increase in $DL_{50}$ value for both species after Council Regulation implementation. For black anglerfish, a positive correlation was found between annual $DL_{50}$ and total catch (in weight and number) (Figure 7). No correlation was found for white anglerfish.

## 4. Discussion

In recent years a number of studies have shown that discard may be of considerable importance in stock assessment (Borges et al., 2005a; Punt et al., 2006) specially when high variability in discard rates is found along the period studied. Our results indicate that there is a high variability in the volume of discard for anglerfish and, in recent years, how discarding of both anglerfish species has increased in the Spanish Northeast Atlantic Fisheries.

The three methods used to estimated the weight and numbers of the fish discarded annually by the trawl fleet have provided estimates of the same order of magnitude for a given species, so the bias of estimation could be considered enough efficient, and indicate that the sampled level is considered representative and the data qualitative (Vigneau, 2006). The high CV values found

for both species in year 2000 were probably due to the different implementation by vessel of the Council Regulation Minimum Weight.

*Could discard data reflects annual recruitment?*

Discards numbers show the importance of juveniles discard for both species and areas. Values have increased, both in weight and in number, after year 2000 according to total discard values estimated. Year class strengths, as shown by an increase in discarding in a particular years, are in accordance with the extreme recruitments reported by the number of juveniles anglerfish specimens for some scientific surveys indices. That is the case of FR-EVHOES / IR-IGFS surveys for black anglerfish, and IR-IGFS, for white anglerfish numbers. The same pattern in the increase in juveniles has been detected from the Icelandic groundfish survey (Solmundsson, 2007).

*Has the MLW restriction conditioned discard patterns onboard?*

The implementation of Council Regulation (2406/96) that set a minimum weight of first sale of 500 g. might imply changes on sorting procedures of the catch. Since 2000 lower sizes are not allowed to retain onboard, hence this restriction could be a strong motive for the discard increase in recent years. In relation to the minimum weight (MWL), the $DL_{50}$ comparison between both periods (before and after 2000) results in an unsubstantial increasing trend for both species. This slight increase in the selection parameter could be better explained under the light of the positive correlation between discard abundance and $DL_{50}$ estimation, rather than changes imposed by the ban.

The main reason, provided by skippers interviewed on board, for discarding anglerfish, is the low commercial value of small fish (Lart et al., 2002). The discard pattern also reflects a response of the fishermen to changes in resource conditions, as for instance seasonality and inter-annual availability of the resource (FAO, 2005b).

The failure to account a substantial portion of the total catch (juveniles) due to the lack of discard information, can result in poor estimation of recruitment levels, where the crew discard pattern varies with the abundance of juveniles (Borges et al., 2005a). The inclusion of discard data in assessment would improve the ability to detect strong year-classes prior to their recruiting to the fishery and hence provides the industry an improved ability to plan their operations (Punt et al., 2006). Consequently discard data could be a complementary index to determine the strength of annual recruitment. The inclusion of discard data in the assessment would produce remarkable variations in the perception of the *status* of the stock and would have an important impact in short term projections, and recommendations for TAC constrictions.

## 5. References

-Borges, L., Rogan, E. and Officer, R. 2005a. Discarding by the demersal fishery in the waters around Ireland. Fisheries Research 76: 1-13.

- Borges, L., Zuur, A.F., Rogan, E. and Officer, R. 2005b. Choosing the best sampling unit and auxiliary variable for discard estimations. Fisheries Research 75: 29-39.

- Cull, K.A., A.S. Jeremyn, A.W. Newton, G. I. Henderson, and W.B Hall. 1989. Length/Weight relationships for 88 species of fish encountered in the North East Atlantic. Scottish Fisheries Research. 43: 1-81.

- DorelL, D. 1986. Relations taille/poids pour l' atlantique nord-est. IFREMER DRV/86-001/RH Nantes.

- FAO. 2005. Discarding in the world's marine fisheries: an update, K. Kelleher. FAO Fisheries Technical Paper No. 470. Roma.

- ICES. 2004. Workshop on Discard Sampling Methodology and Raising Procedures. ICES CM 2004.

- ICES. 2007a. Report of the Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim (WGHMM). ICES CM 2006/ACFM:21

- ICES. 2007b. Report of the Working Group on Discard Raising Procedures, 6-9 February 2007, San Sebastian, Spain. ICES CM 2007 ACFM:06. 58pp.

- Lart, W., R. Caslake, M. Allen, R. Briggs, A. Kingston, E. Hugues-Dit-Ciles, P. Lucio, N. Pérez, M. Santurtún, y I. Quincoces. 2001. Monitoring of discarding and retention by trawl fisheries in Western Waters and the Irish sea in relation to stock assessment and technical measures. Final Project 98/095.

- Pereda, P. and N. Pérez. 1995. Relaciones talla-peso de peces capturados en las campañas de arrastre demersal "Demersales 0993 y Demersales 0994". Inf. Téc. Inst. Esp. Oceanogra., 159:1-16.

- Punt, A.E., David C. Smith, Geoff N. Tuck and Richard D. Methot. 2006. Including discard data in fisheries stock assessments: Two case studies from south-eastern Australia. Fisheries research 79: 239-250.

- Solmundsson, J., Jonsson, E. and Bjornsson J. 2007. Recent changes in the distribution and abundance of monkfish (Lophius piscatorius) in Icelandic waters. ICES Document CM 2007/ACFM K:02.

- Vigneau, J. 2006. Raising procedures for discards: sampling theory. ICES ASC CM 2006/K:16. 9 pp.

Table 1. Total number of vessels, trips and hauls sampled by fleet and years for Spanish Discard Programs.

| | Sub-Area VI, VII | | | Divisions VIII a b | | |
|---|---|---|---|---|---|---|
| | **Vessels** | **Trips** | **Hauls** | **Vessels** | **Trips** | **Hauls** |
| 1988 | 14 | 14 | 371 | - | - | - |
| 1989 | 7 | 8 | 236 | - | - | - |
| 1994 | 15 | 20 | 703 | - | - | - |
| 1999 | 6 | 6 | 230 | - | - | - |
| 2000 | 9 | 14 | 388 | - | - | - |
| 2003 | 9 | 9 | 370 | 4 | 6 | 96 |
| 2004 | 11 | 11 | 400 | 3 | 4 | 104 |
| 2005 | 10 | 10 | 337 | 7 | 11 | 264 |
| 2006 | 13 | 13 | 377 | 5 | 10 | 219 |
| 2007 | 12 | 12 | 367 | 5 | 12 | 282 |

Table 2. Anglerfish discard data in weight (t) and in number of individuals. Absolute values and their percentage regarding to the total catch are indicated. Discard estimations were obtained by raising to fleet effort.

| | Black Anglerfish | | | | White anglerfish | | | |
|---|---|---|---|---|---|---|---|---|
| | Sub area VI-VII | | | | | | | |
| | **Weigth (t)** | | **Number (*1000)** | | **Weigth (t)** | | **Number (*1000)** | |
| year | Absolute values | % Total Catch | Absolute values | % Catch | Absolute values | % Catch | Absolute values | % Catch |
| 1988 | 4.3 (64.9) | 0.2 | 27.7 | 1.8 | 4.4 (48.7) | 0.1 | 40.6 | 1.7 |
| 1989 | 8.9 (49.6) | 0.5 | 114.2 | 5.1 | 6.6 (38.3) | 0.2 | 70.8 | 5.1 |
| 1994 | 31.2 (23.8) | 2.4 | 557.5 | 29.2 | 27.2 (23.4) | 0.8 | 306.8 | 22.2 |
| 1999 | 43.1 (23.9) | 2.0 | 551.3 | 25.9 | 104.0 (22.7) | 4.1 | 1574.8 | 63.4 |
| 2000 | 30.7 (53.0) | 2.0 | 358.9 | 23.1 | 37.2 (39.8) | 2.2 | 288.9 | 27.9 |
| 2003 | 68.0 (32.7) | 2.0 | 1070.8 | 26.6 | 250.0 (35.4) | 5.9 | 2859.2 | 51.9 |
| **2004** | 238.3 (35.5) | 8.2 | **3479.1** | **65.4** | **587.0 (42.6)** | **12.9** | **7088.3** | **75.8** |
| 2005 | 186.1 (28.9) | 6.2 | 2370.6 | 53.2 | 279.0 (36.1) | 6.2 | 3313.7 | 59.7 |
| **2006** | **320.0 (46.2)** | **10.8** | 2775.2 | 52.7 | 89.2 (42.3) | 2.1 | 671.6 | 22.8 |
| 2007 | 248.2 (45.5) | 9.4 | 1848.4 | 43.5 | 15.6 (26.2) | 0.3 | 187.3 | 9.7 |
| | **Sub area VIIIab** | | | | | | | |
| | **Weigth (t)** | | **Number (*1000)** | | **Weigth (t)** | | **Number (*1000)** | |
| year | Absolute values | % Catch | Absolute values | % Catch | Absolute values | % Catch | Absolute values | % Catch |
| 2003 | 3.6 (99.4) | 1.8 | 57.1 | 17.9 | 2.3 (99.4) | 1.0 | 28.3 | 3.5 |
| 2004 | - | - | - | - | 5.8 (63.8) | 1.7 | 74.1 | 6.5 |
| 2005 | - | - | - | - | - | - | - | - |
| 2006 | 2.9 (69.0) | 1.6 | 18.1 | 5.9 | 4.1 (81.9) | 1.8 | 12.1 | 3.1 |
| **2007** | **9.3 (67.0)** | **4.7** | **26.8** | **6.4** | **33.1 (72.0)** | **14.3** | **201.2** | **29.9** |

Brakets: Coeficients of variation of the estimations.

Table 3. Pearson´s correlation coefficient matrix for all possible pairs between anglerfish discards estimations and juveniles abundance (Age 0) obtained by Irish, French and Spanish scientific surveys.

Black Anglerfish

| | *Discards data* | *SP-PGFS* | *FR-EVHOE* | *IR-IGFS* |
|---|---|---|---|---|
| Discards data | 1 | | | |
| SP-PGFS | -0.771387899 | **1** | | |
| FR-EVHOE | **0.764779071** | -0.703497612 | **1** | |
| IR-IGFS | **0.769108671** | -0.554349344 | 0.971134797 | **1** |

White Anglerfish

| | *Discards data* | *SP-PGFS* | *FR-EVHOE* | *IR-IGFS* |
|---|---|---|---|---|
| Discards data | 1 | | | |
| SP-PGFS | **0.607655054** | **1** | | |
| FR-EVHOE | **0.489581084** | 0.037831404 | **1** | |
| IR-IGFS | **0.949139014** | 0.58765488 | 0.714460443 | **1** |

Figure 1. Map of North East Atlantic Discard Observers Programs sampling area. Solid lines indicate the boundaries of the ICES Sub-areas and Divisions with their respective names where Spanish Trawl fishing fleets operate. Isobaths (200, 500 and 1000 m) are indicated.

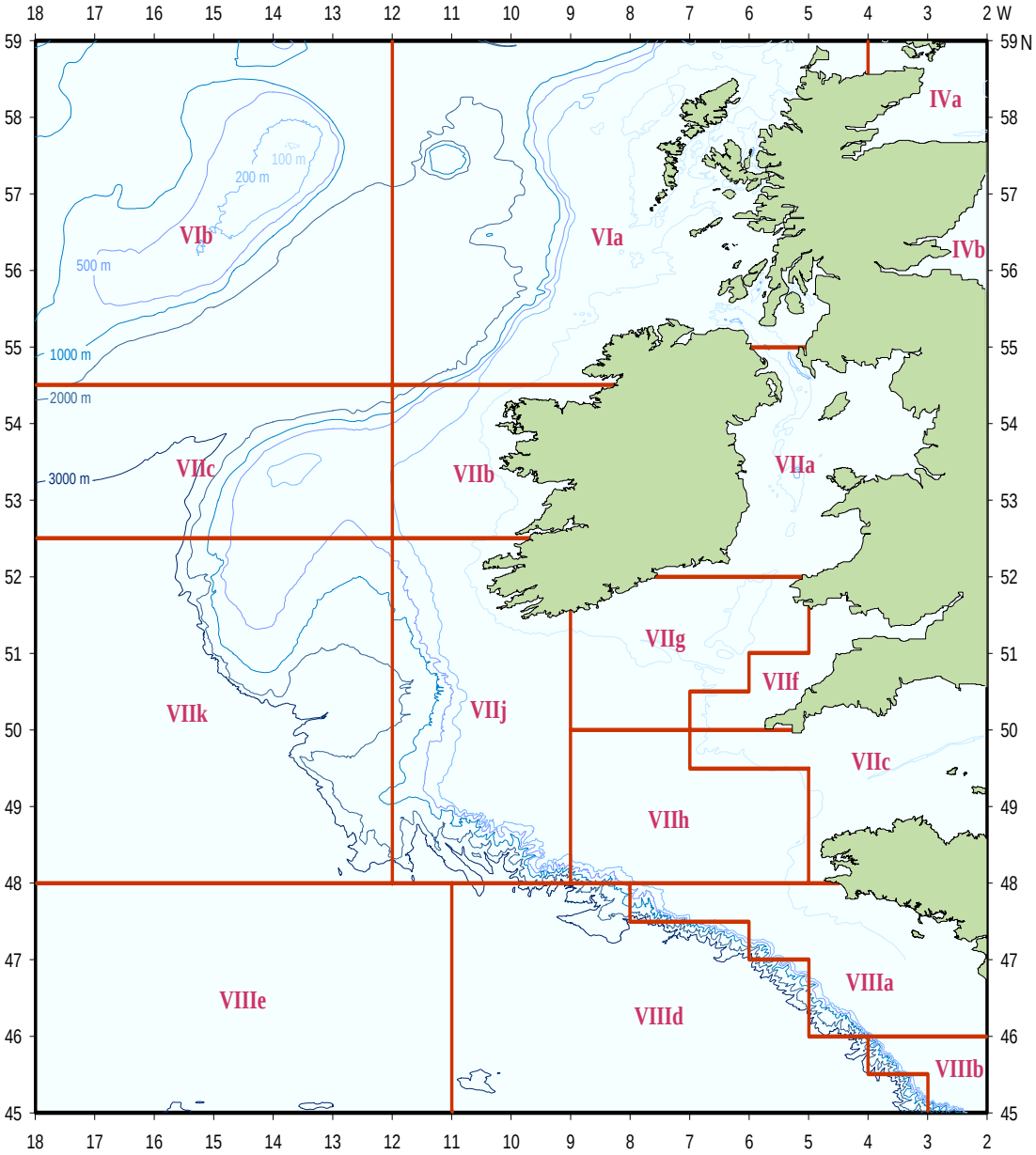


Figure 2.Evolution of discard values (t) in Sub-areas VI, VII. Bars represent discard estimations by the three different raising procedures tested (Effort, Landings and Target Species).

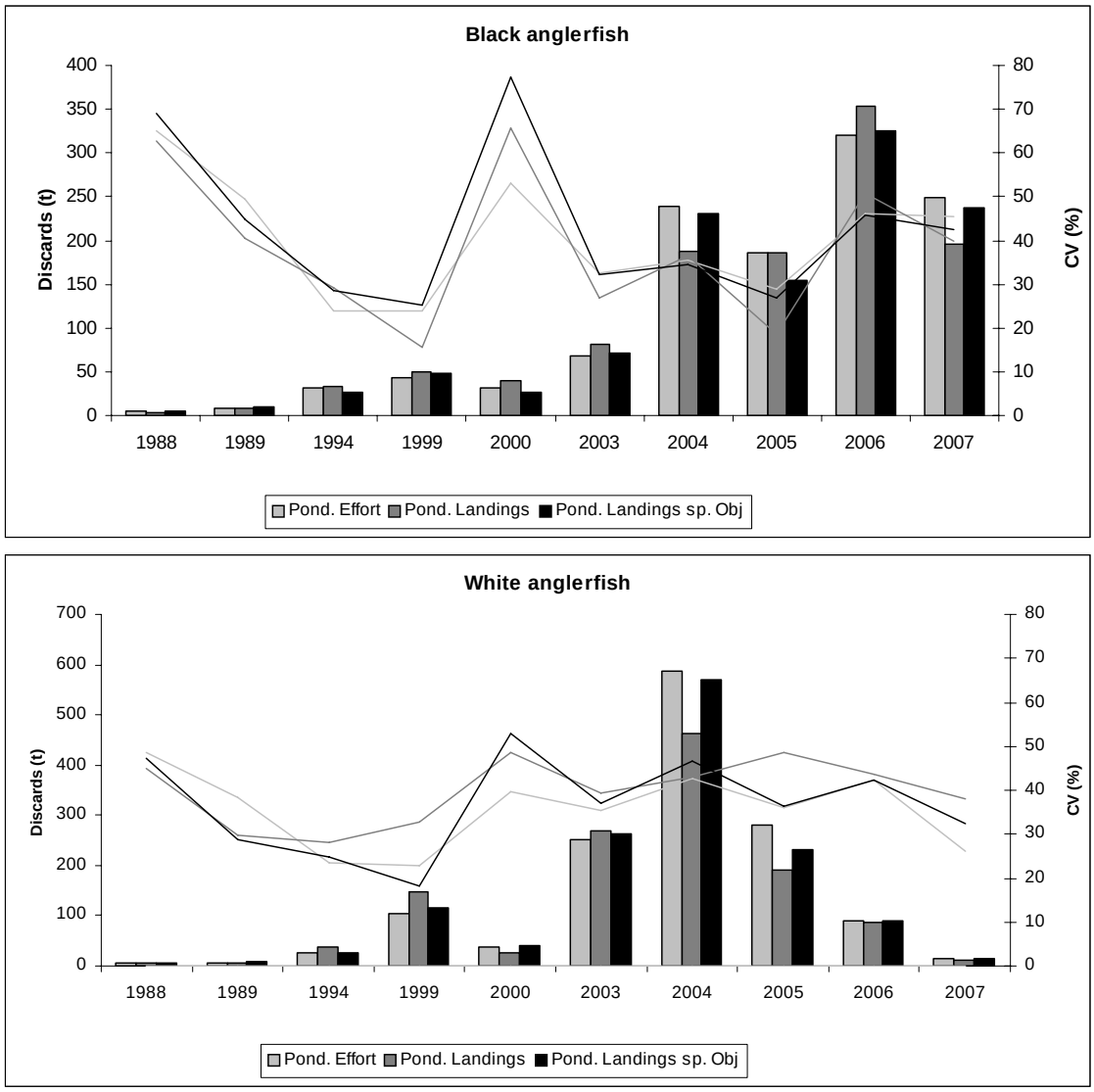
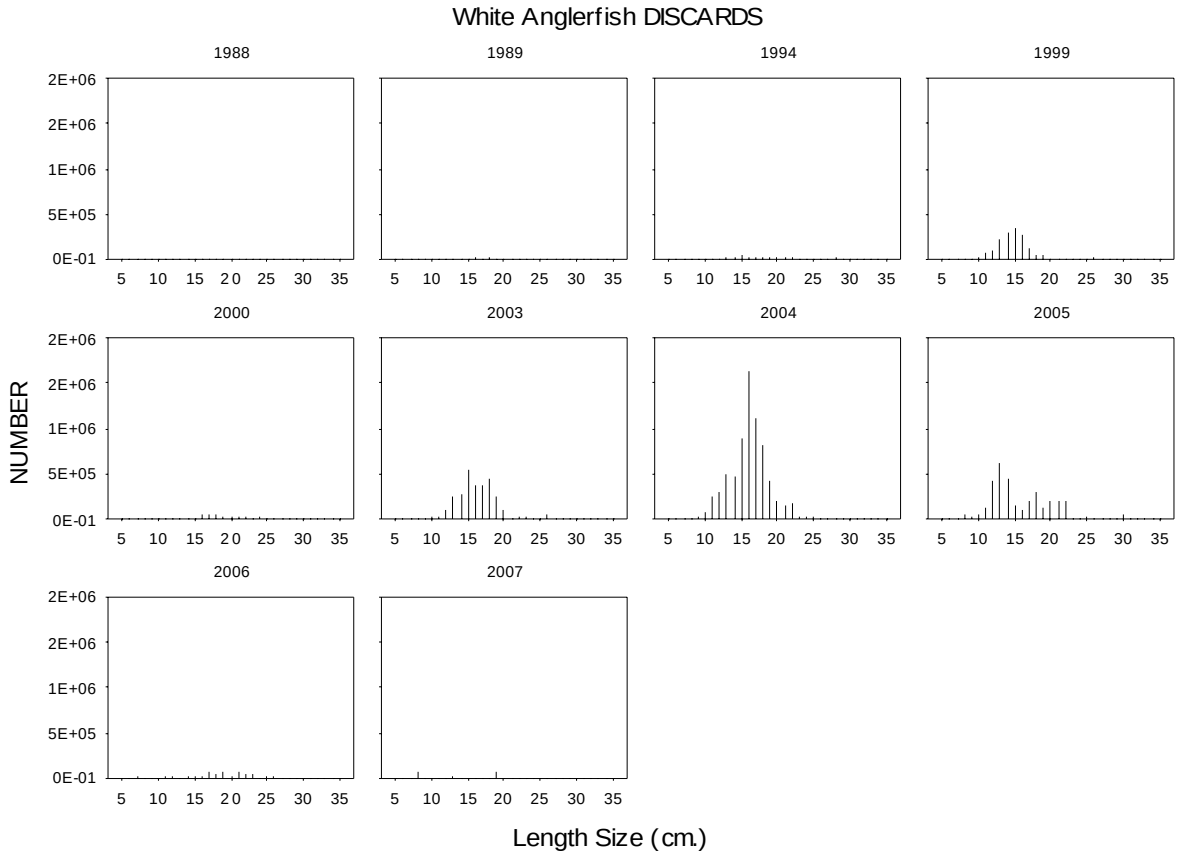


Figure 3. Annual length frequencies of discarded for black and white anglerfish in Northern stock.



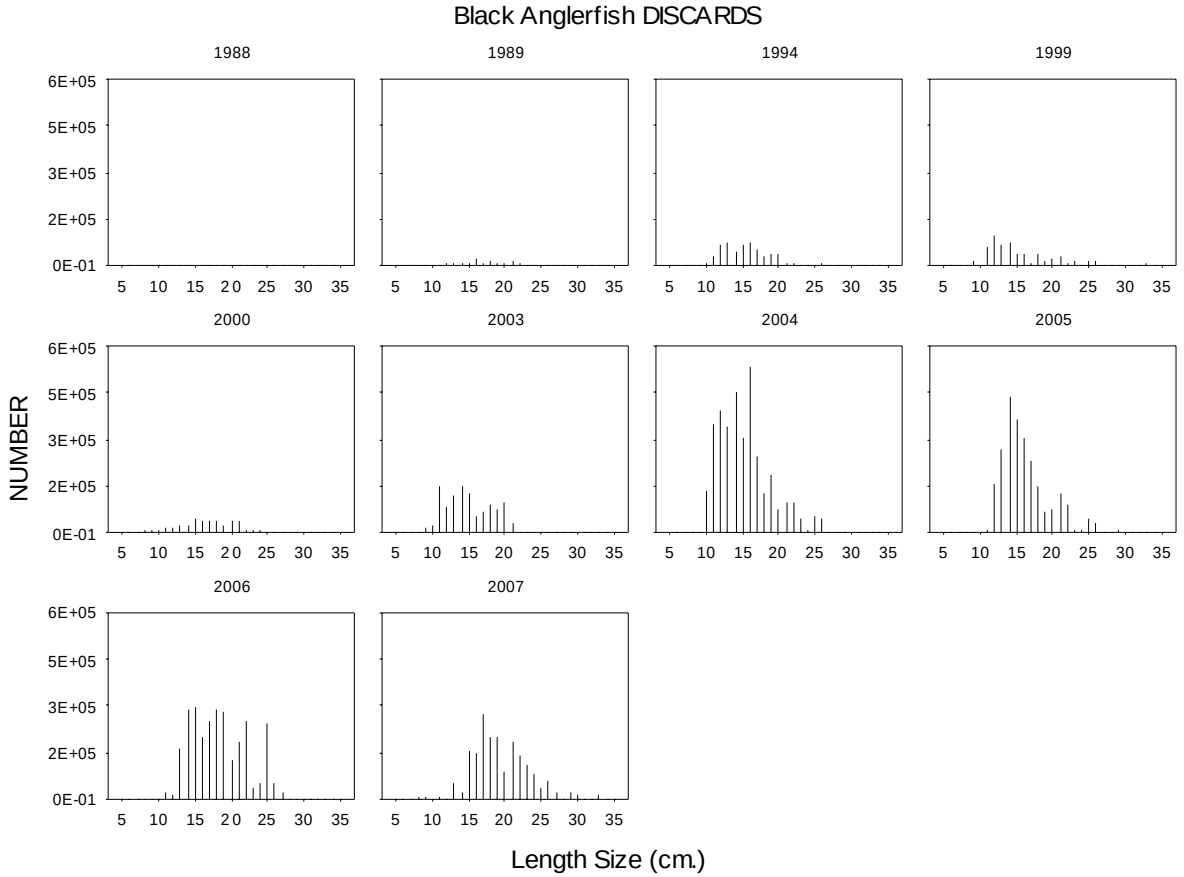



Figure 4. Box plots of annual discarded for black and white anglerfish in Northern Stock. Plots show median, inter-quartile range and extreme values for length distribution of individuals discarded.

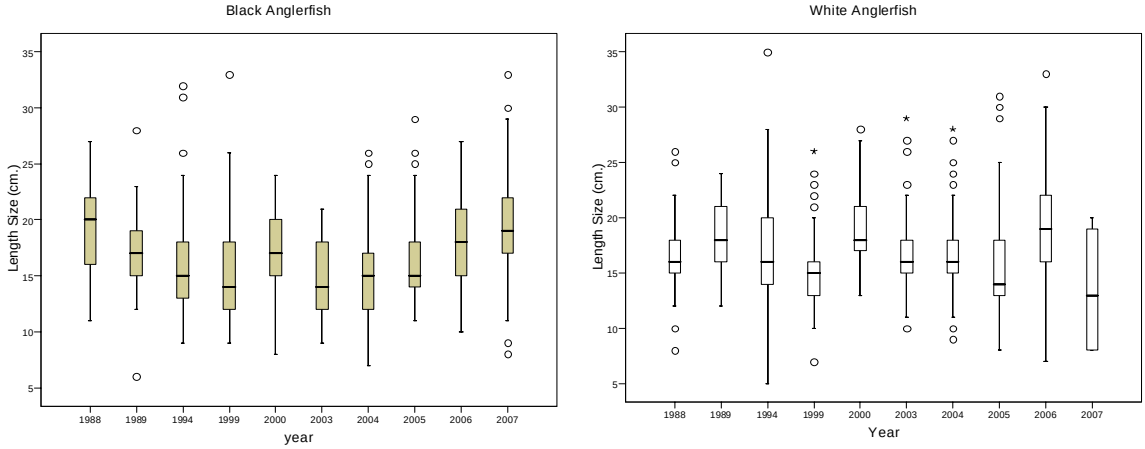



Figure 5. Annual estimates in number of juveniles discarded (right axes) compared to recruits abundance (left axes) obtained in the area by Irish, French and Spanish surveys.

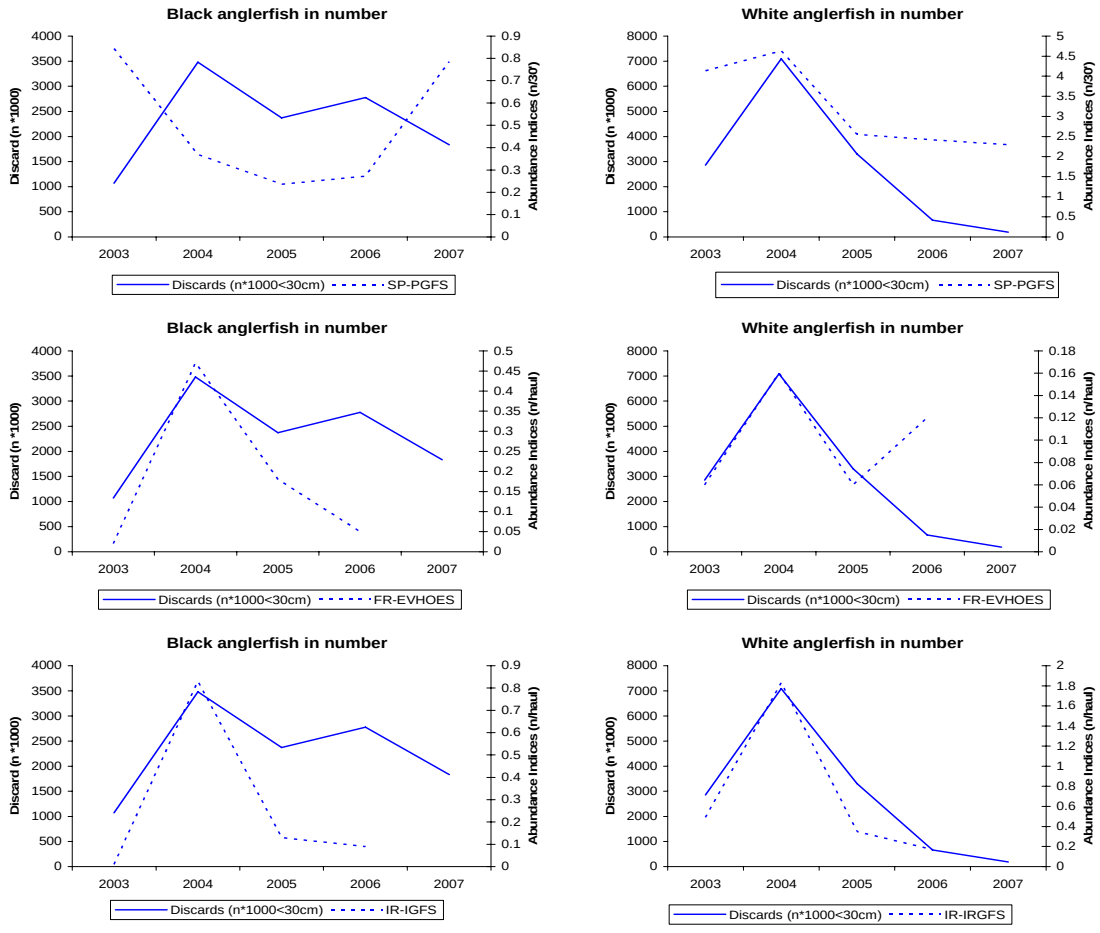


Figure 6. Length frequency distribution for both Species in Sub-areas VI, VII grouped by period (before and after minimum weight implementation, year 2000). Horizontal lines represent $DL_{50}$ obtained by pooling yearly discard data from both periods. Dot lines represent Confidence Intervals for the parameter estimation.

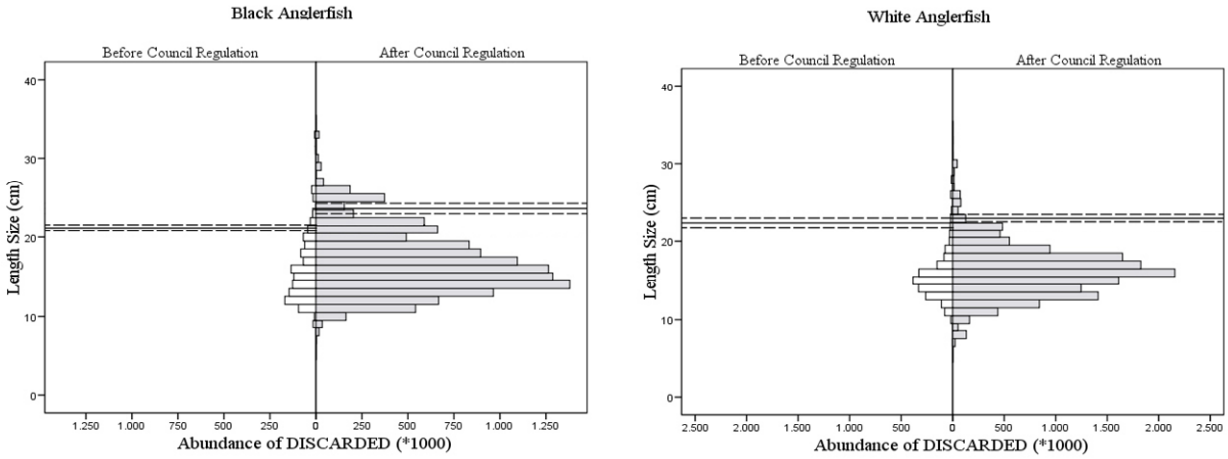



Figure 7. Correlation between annual $DL_{50}$ and total catch (top), and discard quantities (bottom) for both anglerfish species.