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WORKING DOCUMENT ABOUT MATURITY OGIVES ANALYSIS OF EUROPEAN HAKE FROM SOUTHERN STOCK

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INTRODUCTION

The Data Collection Regulation (DCR) programme covers extensive sampling of maturity data (Reg EC No1639/2001). The maturity stage is an important biological parameter to be used in the calculation of maturity ogives (and therefore of Spawning Stock Biomass), for the definition of the spawning season of a species, for the monitoring of long-term changes in the spawning cycle, and for many other research needs regarding the biology of fish. Taking into account that the proportion of resting females during the peak of the spawning season is lower than the rest of the year, in the Workshop on Sexual Maturity Staging of Hake and Monkfish, held in Lisbon (Portugal), 21–24 November 2007 it was agreed that maturity ogives should only be based on data collected during the peak of the spawning season (ICES, 2007). Since then, sampling effort has been focused between December and March.

On the other hand, maturity ogives has been traditionally estimated considered both sex together. Nevertheless, it is known that males mature earlier than females, at lower sizes and probably at lower ages too (Alheit and Pitcher, 1995; Ungaro, 2001; Piñeiro and Saínza, 2003).

Overestimation of L_{50} leads to underestimation of SSB with the consequent impact on assessment and management measures. Because of these, the aim of this study is to estimate maturity ogives using different pool of data (sex combined and only females) from the peak of spawning and from all year around to study effect on L_{50} estimates and impact on assessment and management.

SAMPLING

All specimens included in this study came from Galician Shelf. The Bay of Biscay, Portugal and the Gulf of Cadiz data were excluded because historical data series are short and/or incomplete. Besides, in the case of the Gulf of Cadiz, historical data presents inconsistent results.

35,598 European hake specimens were caught and sexed during the period 1982-2008 (16,746 males and 18,852 females. Annual distribution of samples was not homogeneous, fluctuating between 143 individuals caught in 1987 and 3067 individuals caught in 2008 (Table 1). Length distribution was not homogeneous either between or within years. In some years most of specimens belongs to the same length range and some sizes were undersampled (Table 2 and 3).

Length-weight relationship was plotted for all year, excepting for those year when weight information was not available. No important differences between annual curves were observed (Figure 1) that means there are no relevant changes between studied years.

Table 1: Number of mature and immature males and females sampled per year .

Year	Males		Females		Total
	Immature	Mature	Immature	Mature	
1982	40	168	61	159	428
1983	69	99	103	46	317
1984	216	252	264	277	1009
1985	648	473	628	386	2135
1986	82	154	108	141	485
1987	54	55	32	2	143
1988	456	193	369	80	1098
1989	384	238	322	243	1187
1990	1011	572	1138	186	2907
1991	299	254	406	186	1145
1992	496	131	528	20	1175
1993	170	48	160	21	399
1994	407	160	478	67	1112
1995	591	571	526	106	1794
1996	225	266	369	238	1098
1997	505	158	652	134	1449
1998	330	176	491	55	1052
1999	239	261	369	64	933
2000	179	202	270	124	775
2001	175	96	259	52	582
2002	282	208	603	237	1330
2003	364	585	933	927	2809
2004	170	458	763	930	2321
2005	415	537	772	472	2196
2006	588	496	927	247	2258
2007	95	67	214	18	394
2008	539	839	1203	486	3067
Total	9029	7717	12948	5904	35598

Table 2: Sampled males length distribution per year.

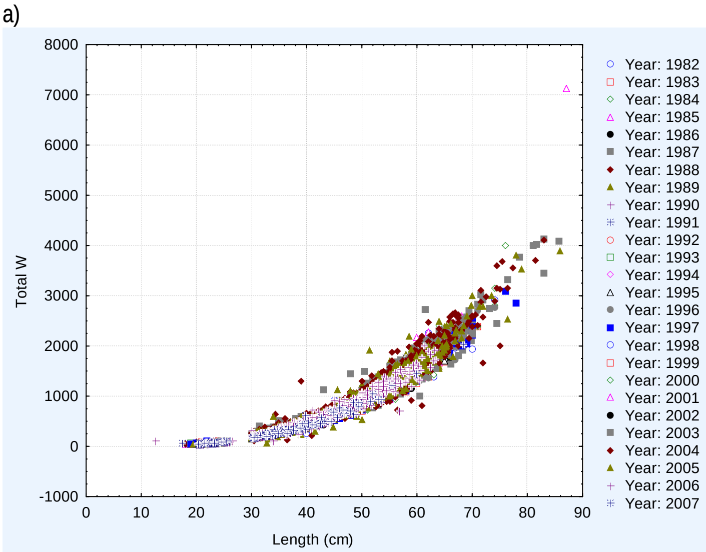
	Length (cm)									
Year	<5	5-15	15-25	25-35	35-45	45-55	55-65	65-75	75-85	>85
1982	0.00%	0.00%	0.00%	9.50%	58.60%	31.00%	1.00%	0.00%	0.00%	0.00%
1983	0.00%	0.00%	3.00%	41.10%	39.90%	15.50%	0.60%	0.00%	0.00%	0.00%
1984	0.00%	0.00%	4.70%	41.90%	23.50%	27.60%	2.40%	0.00%	0.00%	0.00%
1985	0.00%	0.10%	14.50%	38.20%	38.50%	7.90%	0.70%	0.00%	0.00%	0.00%
1986	0.00%	0.00%	1.30%	32.20%	47.50%	18.60%	0.40%	0.00%	0.00%	0.00%
1987	0.00%	0.00%	0.00%	26.10%	55.90%	16.20%	1.80%	0.00%	0.00%	0.00%
1988	0.00%	1.50%	30.40%	43.90%	20.90%	3.20%	0.00%	0.00%	0.00%	0.00%
1989	0.00%	0.00%	32.30%	30.70%	23.60%	13.00%	0.30%	0.00%	0.00%	0.00%
1990	0.00%	0.50%	37.10%	34.70%	22.10%	5.40%	0.30%	0.00%	0.00%	0.00%
1991	0.00%	0.00%	28.20%	30.60%	27.50%	13.50%	0.30%	0.00%	0.00%	0.00%
1992	0.00%	0.00%	31.80%	40.20%	22.20%	5.40%	0.50%	0.00%	0.00%	0.00%
1993	0.00%	0.20%	37.50%	35.10%	22.00%	5.20%	0.00%	0.00%	0.00%	0.00%
1994	0.00%	12.20%	24.60%	33.60%	26.40%	3.00%	0.10%	0.00%	0.00%	0.00%
1995	0.00%	0.00%	22.20%	40.60%	32.00%	4.90%	0.20%	0.00%	0.00%	0.00%
1996	0.00%	0.20%	18.70%	26.80%	42.50%	11.70%	0.20%	0.00%	0.00%	0.00%
1997	0.00%	1.10%	32.20%	35.10%	26.10%	4.90%	0.60%	0.00%	0.00%	0.00%
1998	0.00%	0.00%	31.50%	39.00%	24.80%	4.50%	0.20%	0.00%	0.00%	0.00%
1999	0.00%	1.50%	18.10%	32.90%	44.80%	2.70%	0.00%	0.00%	0.00%	0.00%
2000	0.00%	2.00%	24.90%	34.50%	34.60%	3.40%	0.50%	0.00%	0.00%	0.00%
2001	0.00%	0.00%	32.50%	35.00%	27.50%	5.00%	0.00%	0.00%	0.00%	0.00%
2002	0.00%	0.00%	32.40%	30.40%	33.20%	3.80%	0.20%	0.00%	0.00%	0.00%
2003	0.00%	0.20%	10.60%	38.30%	42.10%	8.30%	0.50%	0.00%	0.00%	0.00%
2004	0.00%	0.00%	12.80%	39.40%	38.20%	7.70%	1.80%	0.10%	0.00%	0.00%
2005	0.00%	0.00%	10.90%	41.90%	42.30%	4.40%	0.40%	0.00%	0.00%	0.00%
2006	0.00%	0.10%	24.70%	35.90%	30.30%	8.80%	0.30%	0.00%	0.00%	0.00%
2007	0.00%	0.00%	39.30%	35.00%	21.50%	4.30%	0.00%	0.00%	0.00%	0.00%
2008	0.00%	0.00%	19.30%	37.40%	29.00%	13.10%	1.10%	0.00%	0.00%	0.00%

Table 3: Sampled females length distribution per year.

Year	Length (cm)									
	<5	5-15	15-25	25-35	35-45	45-55	55-65	65-75	75-85	>85
1982	0.00%	0.00%	0.00%	8.60%	7.20%	26.70%	52.90%	4.50%	0.00%	0.00%
1983	0.00%	0.00%	2.00%	61.70%	5.40%	6.70%	22.10%	2.00%	0.00%	0.00%
1984	0.00%	0.00%	2.20%	43.30%	9.10%	17.60%	26.40%	1.30%	0.20%	0.00%
1985	0.00%	0.00%	15.50%	30.20%	15.70%	21.20%	16.70%	0.70%	0.00%	0.10%
1986	0.00%	0.00%	1.60%	25.70%	14.10%	32.50%	23.70%	2.40%	0.00%	0.00%
1987	0.00%	0.00%	0.00%	32.30%	21.00%	1.60%	21.00%	16.10%	6.50%	1.60%
1988	0.00%	0.70%	27.60%	45.20%	17.10%	7.10%	2.20%	0.00%	0.00%	0.00%
1989	0.00%	0.20%	25.50%	23.50%	9.40%	28.50%	11.90%	1.10%	0.00%	0.00%
1990	0.00%	0.10%	38.90%	35.90%	16.80%	5.90%	1.90%	0.40%	0.00%	0.00%
1991	0.00%	0.00%	25.90%	31.20%	15.30%	21.90%	5.80%	0.00%	0.00%	0.00%
1992	0.00%	0.00%	37.80%	40.10%	17.30%	2.70%	1.60%	0.40%	0.00%	0.00%
1993	0.00%	0.00%	36.70%	36.50%	16.70%	7.30%	2.40%	0.20%	0.00%	0.00%
1994	0.00%	0.20%	22.00%	38.30%	27.20%	9.30%	2.90%	0.00%	0.20%	0.00%
1995	0.00%	0.00%	17.70%	39.80%	29.50%	6.90%	4.70%	1.40%	0.10%	0.00%
1996	0.00%	0.00%	15.10%	18.50%	33.60%	22.50%	8.50%	1.80%	0.00%	0.00%
1997	0.00%	0.70%	23.10%	30.70%	22.80%	14.00%	6.50%	1.60%	0.50%	0.00%
1998	0.00%	0.20%	19.40%	37.20%	26.40%	12.60%	3.40%	0.90%	0.00%	0.00%
1999	0.00%	0.40%	22.40%	21.70%	40.70%	11.20%	3.40%	0.20%	0.00%	0.00%
2000	0.00%	1.00%	22.00%	30.40%	25.50%	15.20%	5.30%	0.80%	0.00%	0.00%
2001	0.00%	0.00%	32.80%	29.80%	21.40%	11.40%	3.60%	0.90%	0.00%	0.00%
2002	0.00%	0.00%	17.00%	23.50%	28.40%	26.80%	4.20%	0.00%	0.10%	0.00%
2003	0.00%	0.10%	7.90%	16.70%	22.00%	26.50%	24.90%	1.90%	0.10%	0.00%
2004	0.00%	0.00%	4.80%	17.10%	21.50%	32.50%	20.80%	2.90%	0.50%	0.00%
2005	0.00%	0.00%	9.50%	31.10%	22.10%	21.00%	14.20%	1.80%	0.20%	0.10%
2006	0.00%	0.10%	21.30%	35.70%	18.00%	18.60%	6.20%	0.00%	0.10%	0.00%
2007	0.00%	0.00%	39.40%	12.30%	11.20%	26.40%	9.90%	0.80%	0.00%	0.00%
2008	0.00%	0.10%	16.20%	27.60%	21.10%	23.40%	10.40%	1.10%	0.10%	0.10%

Figure 1: Annual length-weight relationships (1982-2008) both sexes combined.

a)



MATURITY OGIVES (1982-2008)

To estimate maturity ogives all data were checked and those outliers considered sampling errors were removed. Maturity ogives were estimated considering different pools of data:

- Maturity females data from all year around whose length was extrapolated to length at 1st January using growth parameters estimated with tagging data from IFREMER:

L_∞	128.35
K	0.168
t_o	-0.215
b	-0.1544298
a	19.8215949

- Maturity females data considering only specimens caught between December of year *i-1* and March of year *i*.

- Maturity males and females combined data considering only specimens caught between December of year *i* and March of year *i+1*.

Data were fit to logistic model:

$$P = \frac{e^{a+bL}}{1+e^{a+bL}}$$

Where P is the probability to be mature and L is length in cm. Mean maturity length (L_{50}) was estimated as:

$$L_{50} = \frac{-a}{b}$$

Table 4 shows both logistic curve parameters and L_{50} estimated for each year using the four different pool of data. Differences of L_{50} estimated using different methods can be higher than 10 cm, depending on individuals size distribution, sex proportion and/or considered months and growth rates.

Figure 2 shows annual variation of L_{50} based on samples from December to March from both, sex combined and only females maturity data. As expected, due to earlier maturation of males, L_{50} was significantly lower if males were included in maturity ogives estimates.

When L_{50} based on female length data extrapolated to 1st January using both sets of growth parameters were compared to L_{50} estimated based on December to March female data, temporal trends were rather different.
The highest differences between L_{50} (> 5 cm in 8 years from 28 years serie) were observed when ogives estimated using female length at 1st January based on fast growth parameters and ogives estimated using only females caught between December and March were compared. Variations between other methods, in general, did not show differences higher than 5 cm. Differences might be due to sampling effort. Before 2007, sampling was not focused on the peak of spawning, so, in some years number of sampled females caught between December and March was scarce, length biased or even nonexistent. Since 2003, because of the existence of different research projects focused on hake, database is more exhaustive and complete; this may explain why data are more similar during this period.

Figure 3 shows that L_{50} based on females does not show the same trend when both methods are compared.

Table 4: Annual logistic curve parameters and L_{50} basing on different methods.

Year	Length at Jan-1 (fast growth)			Dec-Mar females			Dec-Mar mixed		
	a	b	L_{50}	a	b	L_{50}	a	b	L_{50}
1980	-13.696	0.273	50.3						
1982	-17.788	0.395	45.0	-41.742	0.942	44.3	-22.973	0.623	36.9
1983	-12.917	0.321	40.2	-13.567	0.332	40.9	-18.373	0.547	33.6
1984	-11.241	0.306	36.8	-19.513	0.455	42.9	-17.457	0.467	37.3
1985	-15.207	0.400	38.0	-27.787	0.663	41.9	-19.800	0.612	32.4
1986	-11.969	0.317	37.8	-25.621	0.579	44.3	-13.595	0.376	36.2
1987									
1988	-11.356	0.359	31.7	-63.354	1.623	39.0	-12.536	0.420	29.9
1989	-9.676	0.272	35.6	-58.744	1.517	38.7	-11.097	0.310	35.8
1990	-7.259	0.198	36.6	-14.603	0.357	40.9	-15.008	0.427	35.2
1991	-8.190	0.238	34.4	-57.894	1.505	38.5	-23.621	0.697	33.9
1992	-15.414	0.433	35.6	-12.684	0.295	42.9	-14.511	0.443	32.8
1993	-16.046	0.433	37.1						
1994	-9.137	0.232	39.4	-11.703	0.269	43.5	-11.820	0.330	35.8
1995	-8.952	0.218	41.1	-12.516	0.270	46.4	-9.243	0.250	36.9
1996	-4.905	0.123	40.0	-17.968	0.495	36.3	-12.423	0.378	32.9
1997	-10.089	0.225	44.9	-12.166	0.285	42.6	-9.502	0.276	34.4
1998	-7.253	0.156	46.6	-26.276	0.660	39.8	-18.349	0.521	35.2
1999	-7.567	0.187	40.5	-12.284	0.268	45.8	-5.361	0.178	30.2
2000	-18.276	0.459	39.8	-106.428	2.516	42.3	-14.059	0.377	37.3
2001	-11.942	0.277	43.1	-10.689	0.239	44.8	-10.269	0.249	41.3
2002	-5.752	0.148	38.9						
2003	-11.863	0.288	41.2	-24.466	0.555	44.1	-4.598	0.146	31.5
2004	-7.160	0.179	40.0	-10.031	0.207	48.5	-4.280	0.120	35.7
2005	-7.568	0.196	38.7	-33.343	0.765	43.6	-6.429	0.181	35.6
2006	-7.821	0.183	42.7	-12.170	0.281	43.4	-11.163	0.330	33.9
2007	-11.087	0.269	41.2	-9.259	0.201	46.1	-2.816	0.067	42.0
2008	-9.914	0.240	41.4	-29.431	0.686	42.9	-8.342	0.235	35.5

Figure 2: Annual L_{50} based on individuals sampled between December of year i and March of year i+1. Orange line represents L_{50} based just on females and red line represents L_{50} based on both sexes.

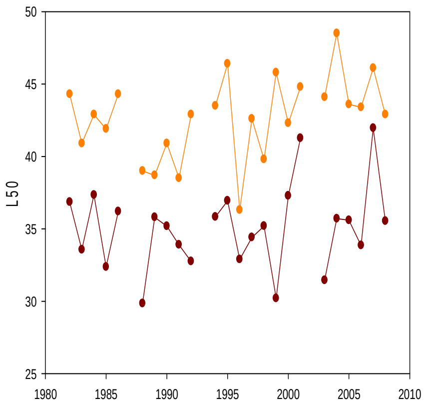
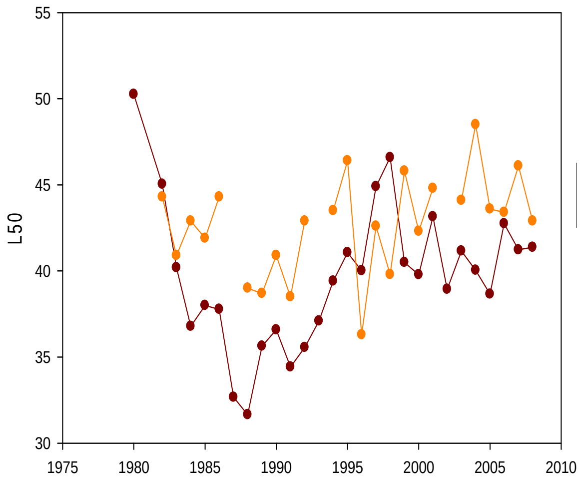


Figure 3: Annual L_{50} based on: a) female length at the 1st January calculated using fast growth parameters (red line) and length of females sampled between December of year i and March of year i+1 (orange line).



CONCLUSIONS

Differences in L_{50} (>10 cm) estimates has been observed depending on method. Historical data collecting was not focused on the peak of spawning, so, the reconstruction of data series based on this criteria is difficult. However, since 2003, when hake database was more complete, differences in L_{50} were lower.

- The use of new growth parameters leads to L_{50} decreasing between 3 and 5 cm depending on the year, affecting to SSB figures and trends.

-Two methods for female maturity estimation were tested. One with yearly maturation corrected to first of January and other, based on data collected during the peak of the spawning season following ICES (2007), recommendations. The second one has the disadvantage_ of scarce data some years. Preliminary results shows that both methods produce different trends. Further work is needed to decide the better one.

On the other hand, maturity ogives has been traditionally estimated combining both sex maturity data, but attending the present results, this proxy leads to different trends and a reduction of estimated L_{50}, that may bias SSB estimations.

Future Actions

Nowadays, the three laboratories involved in hake assessment: AZTI, IPIMAR and IEO, are taking histology samples to validate macroscopic maturity ogives. Even historical data series from the Bay of Biscay and Portugal are short and incomplete, this information is very important to improve maturity ogive estimates (Domínguez-Petit et al. In press).

Next step will be to repeat this study using data from the Bay of Biscay and Portugal in the framework of small scale project focused in data from the last 3-5 years. Considering that individuals from these two areas belong to the same stock that Galician specimens, results should be similar. If so, all combined data could be considered in the assessment. Different results would indicate spatial difference within the stock, and then, it would be necessary consider these areas separately. The objective of this work would be to compare L_{50} estimates between different calculation methods within and between areas, and to analyze their implications in the European hake Southern Stock assessment and management.

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