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FIRST STEPS IN THE ESTIMATION OF HARVEST RATIO REFERENCE POINTS FOR *NEPHROPS* FU 30 (GULF OF CADIZ)

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INTRODUCTION

The Norway lobster, *Nephrops norvegicus* is a one of the main commercial crustaceans exploited by a unique and highly multispecific bottom trawl fleet in the Gulf of Cadiz (Jiménez et al, 2004; Silva et al., 2007). Landings are clearly seasonal with high values from April to September. Discarding of *Nephrops* is negligible in this fishery. Despite annual catches of *Nephrops* are small compared with other Atlantic *Nephrops* stock (≈100 t annually in 2009-2013 periods), this species gives valuable revenues for the trawl fleet.

Nowadays, the ICES advice for the *Nephrops* stock in the Gulf of Cadiz (FU 30) is on the basis of a data-limited approach, meaning that no analytical stock assessment is conducted in this FU. According to this approach, FU 30 is considered as category 3.2.0 (ICES, 2012a) and it is assessed mainly by the analysis of the LPUE series which is used as an indicator of the stock size. Thus, the advice is based on a comparison of the most recent index value with the three preceding values, combined with recent catch or landings data. The catch recommendation is set at a long-term average, with and "uncertainty cap" or "change limit" of ± 20% comparing with recent catches.

Underwater television surveys to monitor the abundance of *Nephrops* populations were pioneered in Scotland in early 90's. The estimation of Norway lobster abundances using UWTV systems involves identification and quantification of burrow density over the known area of *Nephrops* distribution. This can be used to produce a raised abundance estimate for the stock. In last decade, this technique has received detailed attention in a series of ICES workshops aimed at standardising methodologies and quantifying the uncertainties associated with the method (Campbell et al., 2008; ICES, 2010). Currently, ICES considers this methodology as the most appropriate, and suggests that, the so-called UWTV surveys can be used in order to obtain an absolute estimate of the biomass of Norway lobster and can be use as the basis of the scientific advice (ICES, 2013). Works targeting to use the UWTV surveys in the provision of advice for *Nephrops* have been carried out (Dobby, 2007; Dobby et al., 2007). On the other hand, the methodology for production of catch options based on UWTV surveys have been established in different working groups (ICES, 2009; ICES, 2013; ICES, 2016).

UWTV surveys have been extended to many stocks in Atlantic waters and Mediterranean Sea resulting in about 18 stocks prospected with these surveys in 2015 (ICES, 2015a). The Spanish Oceanographic Institute (IEO) carried out an exploratory *Nephrops* UWTV survey on the Gulf of Cadiz fishing grounds in 2014 within the framework of a project supported by Biodiversity

Foundation (Spanish Ministry of Agriculture, Food and Environment) and European Fisheries Fund (EFF) (Vila et al., 2014). At the moment, two UWTV are available (2014 and 2015) and the next TV survey in FU30 will be carried out in June 2016 (ICES, 2015c).

In 2014, a Benchmark Workshop on *Nephrops* Stocks (WKNEP) was planned for 2016 with a data evaluation meeting in June and the Benchmark meeting in October. This WD shows the preliminary work carried out till the date about the *Nephrops* FU30-specific Harvest Ratio reference points estimation.

MATERIAL AND METHODS

The model used to generate catch options will be UWTV Based Approach. A SCA (Separable Cohort Analysis, model Bell) is used to estimate sustainable stock-specific Harvest Ratios (HR). Multiplying the HR by the assessed stock abundance in number obtained from the UWTV survey provides a recommended number of removals. This may be converted to landings by subtracting dead discard and then multiplying by the expected mean weight in landings in order to produce landings biomass (ICES, 2009; ICES, 2015b). No discards have been included in the calculating of catch options in FU 30 due to negligible discards on observed discards trips.

An exploratory length frequency distribution analysis by sex was carried out for the time series available (2001-2015) in *Nephrops* FU30. An LCA should be fitted to recent observed removals length distributions. Normally a three year average is used but this is depended on the quality of the available data (ICES, 2013WKNEPH). The SCA model was fitted to a moving three year window of average length frequency distributions (2012-2014, 2011-2013, 2010-2012, 2009-2011, 2008-2010).

First explorations for FU30 were carried out in February 2016 with a R script used for carried out the SCA model in FU28-29 in the 2015 ICES WKLIFE V (ICES, 2015c). This script was complicate and the following trials were made with a new version of the script from 2015 ICES WKNeph (ICES, 2015).

Only 2015 UWTV abundance estimation was used because 2015 UWTV survey has many more stations than 2014 survey.

Settings

Discard survival
FemMature: (L_{25} and L_{50}) for female maturity
MalMature: (L_{25} and L_{50}) for males maturity
n. indivs: TV survey index
surv.time: Fraction of year survey occurs
TV.sel: TV selectivity
Alpha: Survey weighting
f.range: F.range for estimating the Yield per Recruit
discard.weight: Discard weighting

Initial parameters that the model has to estimate:

1) Initial population size at the smallest length class equal sex distribution assumed
2) Length at 25% selection
3) Multiplier on L_{25} to give L_{50}

4) Fishing mortalities at full selection for males and immature females
5) Fishing mortalities at full selection for mature females

Additional parameters as the von Bertalanffy growth parameters, natural mortality and weight-length parameters by sex are required for the model.

RESULTS AND DISCUSSION

Annual *Nephrops* length distribution series by sex from the bottom trawl fishery for the 2001-2015 periods in FU 30 is showed in Figure 1. Length composition of landings is biased for the period 2001-2005 since the sampling of landings was not stratified by commercial categories (Silva, et al., 2006). In 2006-2008, sampling was improved and covered all categories and a higher number of ports. Since 2009, concurrent sampling is carried out, as required by DCF (DC 2010/93/UE). The sampling since then is onboard. Outside of the *Nephrops* fishing season, a higher proportion of observed trips are likely to not cover *Nephrops* catches whereas when *Nephrops* sampling were carried out in harbor in the past, the length distribution of landings were covered in all months. This fact together with the low number of individuals sampled by sex in the last years could be insufficient to get robust and accurate length structure data of landings. The global sex-ratio remained stable about 50% in the time series, when the percentage of males should be much higher (more than 70% according to what was found in the 2013-2015 bottom trawl surveys in the area). The percentage of females by length class is often higher than the percentage of males; the opposite of what it should be expected.

The length distributions quality problems provided fits of SCA model not great for all the three years periods except 2009-2011 (Figure 2) even after several trials changing different settings (survey weighting, multiplier on L25 to L50, F range for estimating the yield-per-recruit, etc.). It was not possible to estimate the reference points HR35 for males, females and comb for any period except 2009-2011. HR01 for males, females and comb and HRmax for males, females and comb were the same within each year (*i.e.* 5.6 for the six reference points in the period 2010-2012, etc) except in 2009-2011.
Several runs were made with the 2009-2011 average length distribution. Figure 3 shows the results of the best fit obtained until the date, Table 1 present the settings and parameters used and Table 2 the Harvest Ratio obtained.

For obtaining this result we were decreasing the F of males and females (as our data suggested) just until before obtaining the same value for all the HR. So, the F obtained was 0.45 for both sexes. The problem at these values of F is that the model estimated abundance ten times lesser than the one estimated by the UWTV survey. Smaller F provided abundances similar to the UWTV survey abundance, but all HR had the same value.

There are doubts about how can affect using the first maturity length for females also for males for the model.

Possible next steps

The 3 year period of 2009-2011 seems to be the only with suitable lengths distributions at this step, nevertheless, 2010 and 2011 distributions have not a high quality. 2013 length distribution could be tested also. After some actions over length sampling methodology, a high quality 2016 summer length data are expected. According to that, more trials will be made at

list with only year 2009, 2013 and 2016 summer length data separately with the 2016-2015 UWTV average abundance estimation.

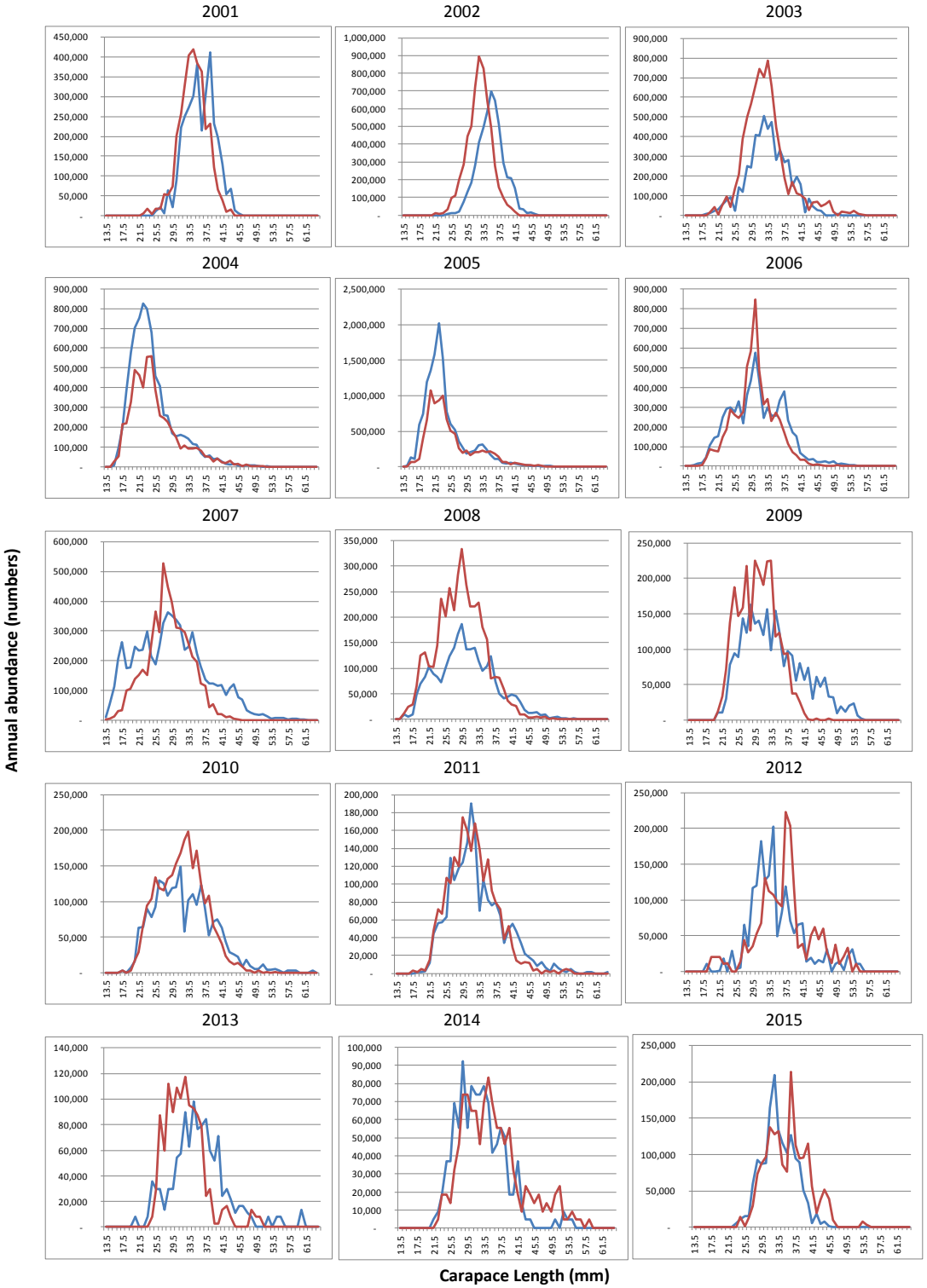

Figure 1.- 2001-2015 *Nephrops* length data by sex from Gulf of Cádiz (FU 30). Blue line (males) red line (females). The X-axes is different in the time series in order to view better the length distributions in the last period.

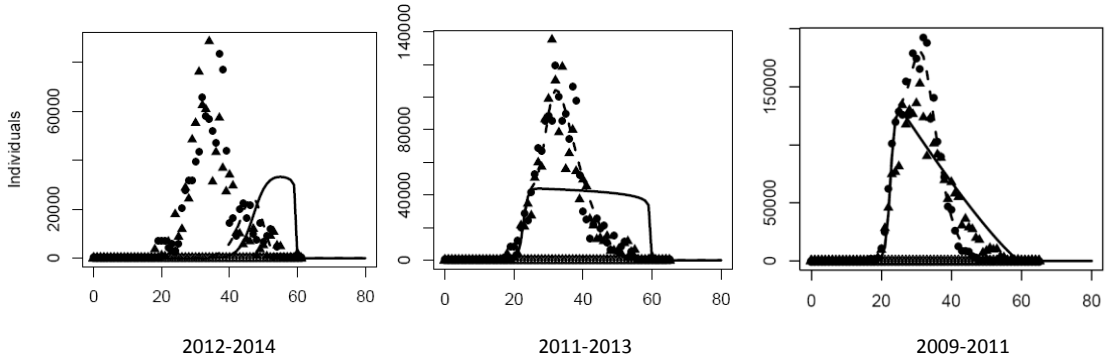

Figure 2.- Examples of unreasonable (left and center) and reasonable (right) SCA model catch in numbers at length fits.

Table 1.- Settings and initial parameters of the model.

K males	**0.2**
Linf males	60
A males	0.0004
B males	3.1018
M males	0.2
K females	0.065
Linf females	60
A females	0.0007
B females	2.9657
M females	0.2
Discard Survival (discard is zero)	0%
MAD Fe L25	27.3
MAD Fe L50	29.4
MAD Ma L25	27.3
MAD Ma L50	29.4
2015 UWTV abundance (number of individuals)(n.indiv)	384,000,000
2015 UWTV date (surv.time)	0.5
TV.sel	16.5, 17
alpha Survey weight	0.001
f.rangeYPR	0, 0.01, seq(0.05, 4, 0.05)
discard.weight (discard is zero)	1
Initial population size at smallest length class equal sex distribution	0.3
Length at 25% selection	26
Multiplier L25 L50	1.19
F males and immature fem	0.45
F mature fem	0.45

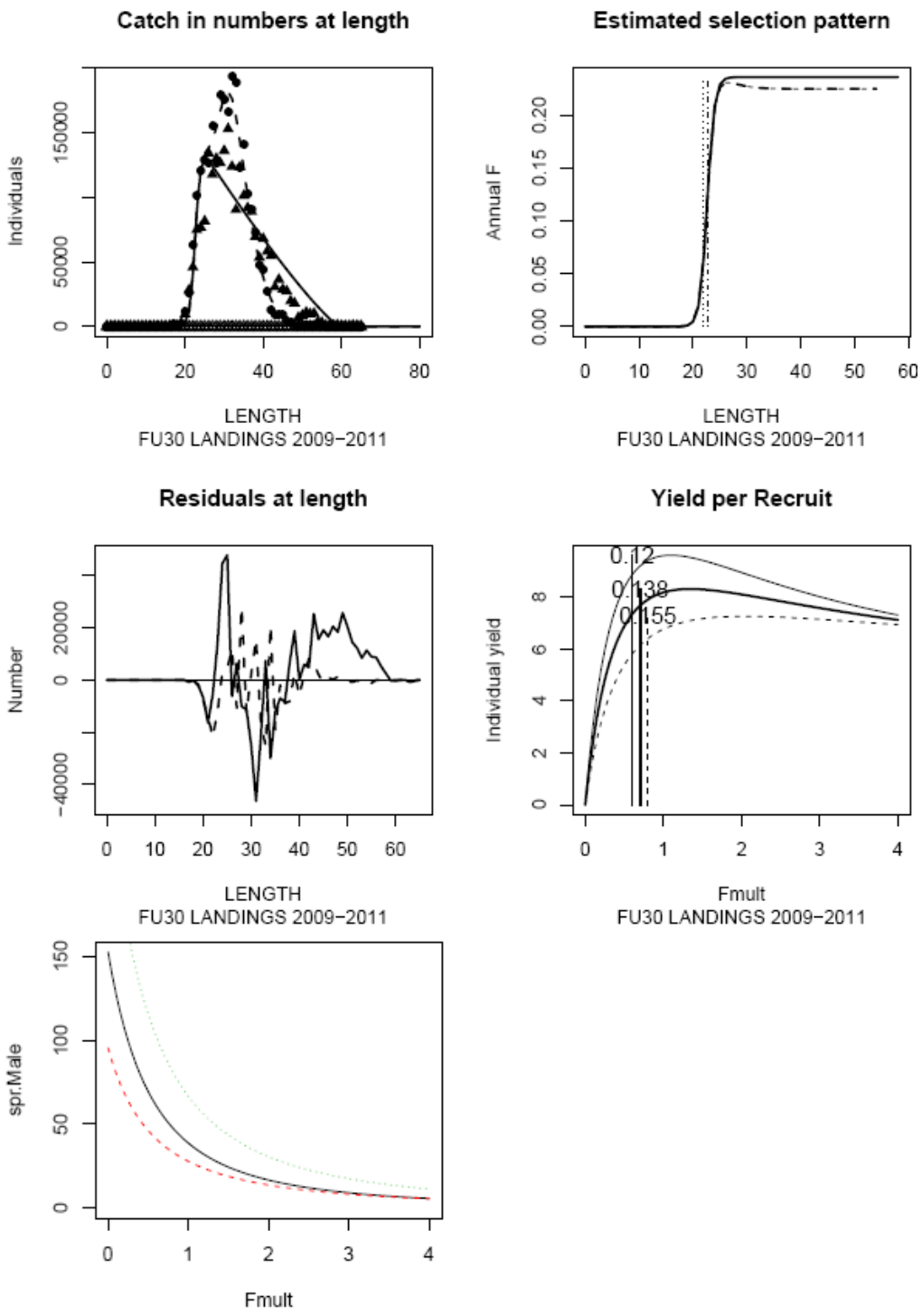

Figure 3 shows the results of the best fit obtained until the date. Gulf of Cadiz (FU 30): Separable Cohort Analysis (SCA) model fit to average length-frequency distributions 2009-2011. Solid lines are for males, dashed lines are females, thick lines represent the landings component, and the thin lines represent the discarded component (zero in this fishery). The top left panel gives observed and predicted numbers-at-length in the discards and landings, top right gives the fishing mortality-at-length with the vertical lines representing length at 25% selection and 50% selection. Bottom left shows residual numbers (observed-expected) at length. The bottom right gives the Yield-per-recruit against fishing mortality, the thick solid line gives the combined value and vertical lines represent $F_{0.1}$ for the three curves.

Table 2.- SCA reference point estimates for 2009-2011 average length distribution.

Ref Point	2009-2011
HR 0.1 Male	10.9
HR 0.1 Female	14.2
HR 0.1.Comb	12.6
HR max Male	18.8
HR max Female	31.3
HR max Comb	22.3
HR 35 Male	13.4
HR 35 Female	15.0
HR 35 Comb	13.4

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