# Application of SPiCT to produce MSY advice for *Nephrops* Funcional Unit 25 (North Galicia)

González Herraiz, I.[1], Morlán, R. [1], Vázquez, A. [1], Gómez Suárez, F.J.[1], Fariña, A.C.[1].

[1]Instituto Español de Oceanografía. Centro Oceanográfico de A Coruña. Paseo Marítimo Alcalde Francisco Vázquez, 10. A Coruña, 15001. Spain

## INTRODUCTION

*Nephrops* landings in FU 25 (ICES Division 8c, North Galicia) have decreased a 98% from 1977 to 2016. Due to the low catches, no analytical stock assessment has been conducted in this FU since 2006, therefore ICES advice for this stock is on the basis of a data-limited approach since then. According to this approach, FU 25 is considered as category 3.1.4 stock (ICES, 2012) and it is assessed mainly by the analysis of the catch and LPUE series trends. Until 2019 there were no *Nephrops* discards in this FU, therefore catches were equivalent to landings (ICES, 2018a). In the FU 25 trawl fleet trips that catch *Nephrops* there are hauls directed and not directed to *Nephrops*. ICES recommendation for this FU has been zero catch since 2002. Results of the assessment in 2016 indicated an extremely low abundance level in the division 8c (that includes FU 25 and FU 31) and a zero TAC was recommended for 8c in 2017, 2018 and 2019. Following this recommendation, the *Nephrops* TAC zero was established for that triennium (EU, 2017). The 2019 assessment obtained the same conclusions and the zero TAC was extended for 2020, 2021 and 2022 (EU, 2020).

ICES has planned a Benchmark Workshop on the application of SPiCT to produce MSY advice for selected stocks (WKMSYSPiCT) that will be held from 15th to 19th of February 2021. Previously, two preparatory meetings were planned. The first consisted in two SPiCT model learning sessions the 26th and 28th of October 2020. In these sessions the preliminary work with SPiCT carried out in FU 25 was presented and the group recommended only use the Demersales survey CPUE as biomass index for this stock. The second preparatory meeting, a Data evaluation meeting, will be held since 17th to 19th of November 2020. The last results obtained with SPiCT in FU 25 and the related work in progress are described in this working document.

## METHODS

FU 25 *Nephrops* catch data has been collected on monthly basis by sex since 1975 by personnel on ports and also by data provided by the different ports authorities. Demersales bottom trawl survey has been carried out each year in October since 1983. Both activities were done by the Spanish Institute of Oceanography (IEO). There was no Demersales survey in 1987.

### *Study area*

Figure 1 shows FU 25 location (ICES statistical rectangles 15E0-E1 and 16E1).

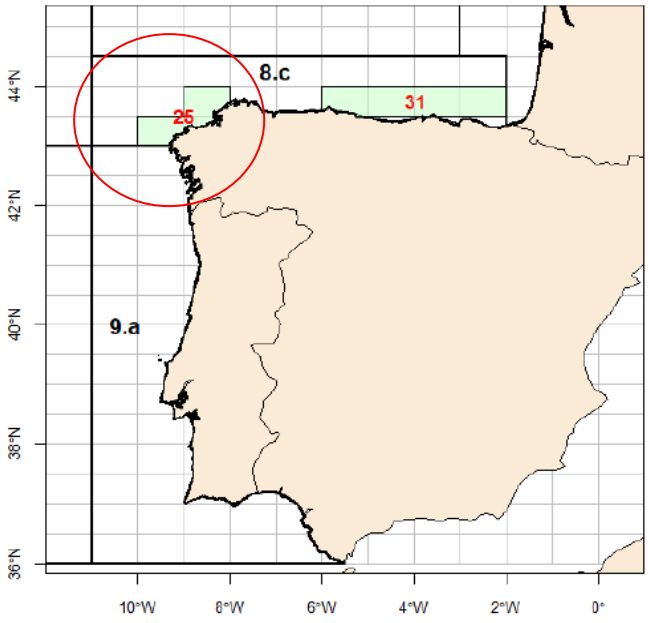



**Figure 1.** *Nephrops* Functional Unit 25 (North of Galicia) in red. FU statistical rectangles in green.

**RESULTS**

After many trials with different periods of the *Nephrops* catch and CPUE time series and different combination of indices, four different trials are presented in this document (Table 1).

Table 1.- SPiCT trials presented in this document.

| | FU 25 Catch series (t) | | | Index: Scaled FU 25 Demersales trawl survey (kg/haul) 1983-2019 |
|---|---|---|---|---|
| Trial 1 | 1975-2019 | Males and females together | Annual | Males and females |
| Trial 2 | | Males | Monthly | Males |
| Trial 3 | | | Quarterly | |
| Trial 4 | 1997-2019 | | Monthly | |

There were made trials with the whole time series of catch and since 1997 because in both catch and index series there are two phases until middle nineties and from middle nineties. Some trials were made only with males because this part of the stock is more vulnerable to the fishery since, unlike the females, they are out of the burrow most of the time.

Different units of time (annual, month, quarter) were used because there are differences in the FU 25 *Nephrops* yield among the different months of the year, with the highest yields in July (Figure 2, ICES, 2018).

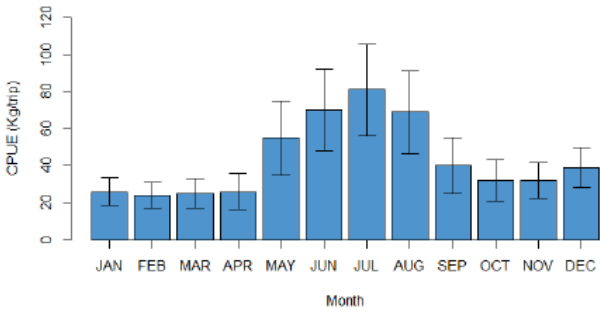



**Figure 2.** *Nephrops* CPUE in FU 25 (1980-2008) from commercial fleet (ICES, 2018).

*Data*

In Figure 3 the available series and the series that were used are shown. By recommendation from the WKMSYSPiCT learning sessions, only Demersales survey was used as index. Sentinel series was not used because has only 3 years.

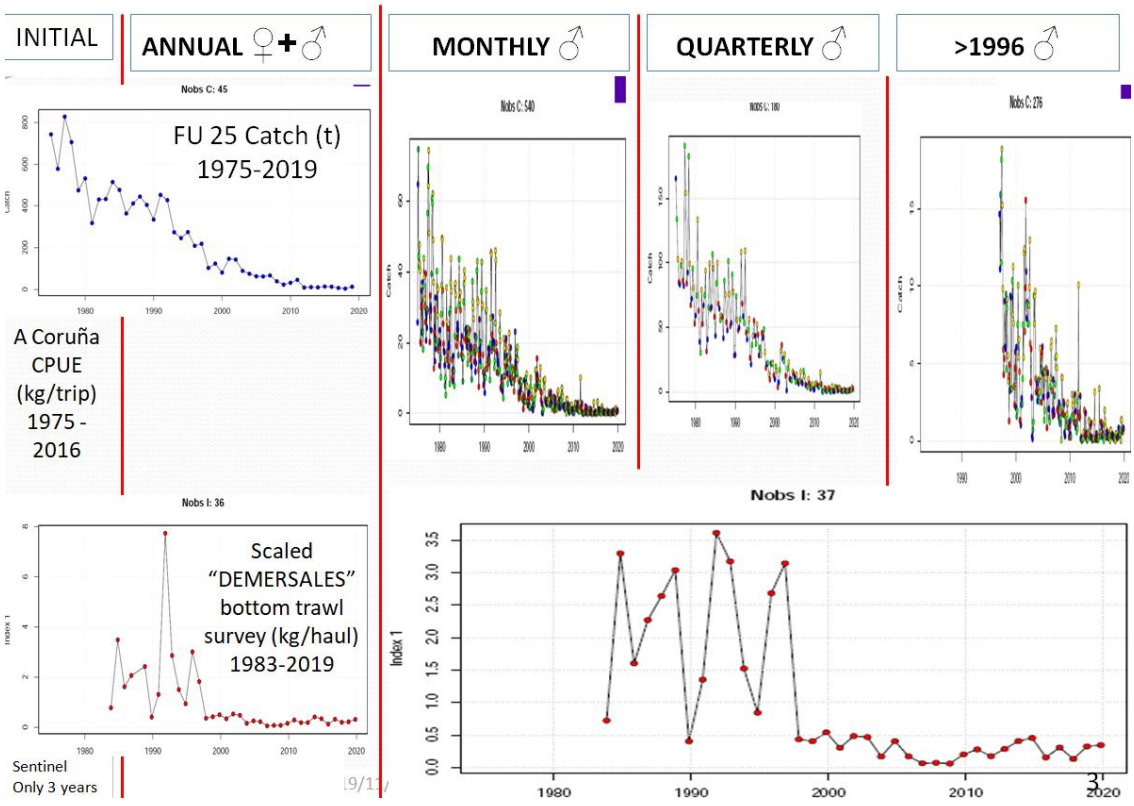



Figure 3.- Time series used in each trial.

*Procedure*

In all of the trials the survey index was scaled to mean 1 for better numerical stability, the number of iterations was increased to 1e6 and stronger priors were add (inp$priors$logbkfrac=c(0,1,1) , inp$priors$logn=c(log(2),0.5,1)) in order to obtain convergence and decrease the residuals problems.

The results of the function plotspict.ci(inp) are shown in Figure 4.

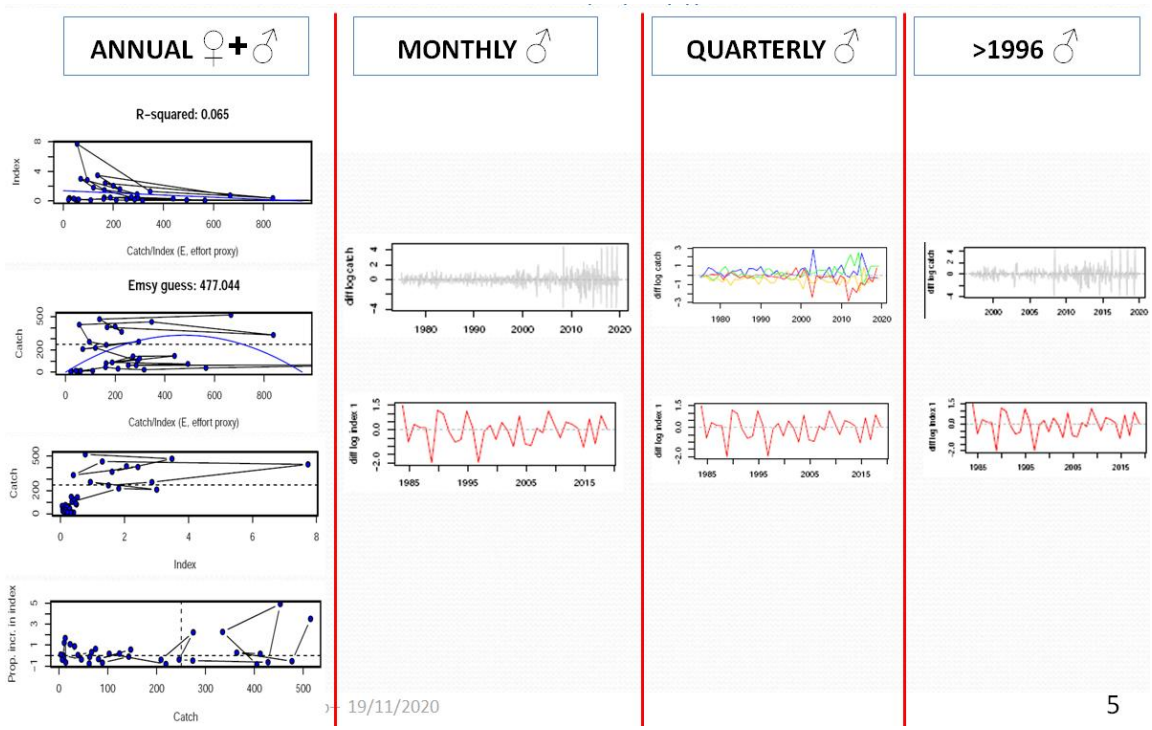



Figure 4.- Results of the function plotspict.ci(inp).

Table 2.- Results of the models.

| | ANNUAL ♀+♂ | MONTHLY ♂ | QUARTERLY ♂ | > 1996 ♂ |
|---|---|---|---|---|
| CONVERGENCE | Convergence: 0 MSG: relative convergence (4) | Convergence: 0 MSG: relative convergence (4) | Convergence: 0 MSG: relative convergence (4) | Convergence: 0 MSG: relative convergence (4) |
| K | 6300 t | 4813 t | 3214 t | 1100 t |
| Bmsy | 3172 t | 2437 t | 1417 t | 164 t |
| Fmsy | 0.05 | 0.05 | 0.07 | 0.2 |
| MSY | 148 t | 126 t | 94 t | 33 t |
| B_2019.75 | 311 t | 320 t | 281 t | 271 t |
| F_2019.75 | 0.03 | 0.02 | 0.03 | 0.03 |
| B_2019.75/Bmsy | 0.1 | 0.1 | 0.2 | 1.7 |
| F_2019.75/Fmsy | 0.7 | 0.4 | 0.4 | 0.1 |

The results of the models are shown in Table 2. In terms of reference points, present biomass is always below the Bmsy except in the model with the catch series since 1997. Present fishery mortality is always below the Fmsy.

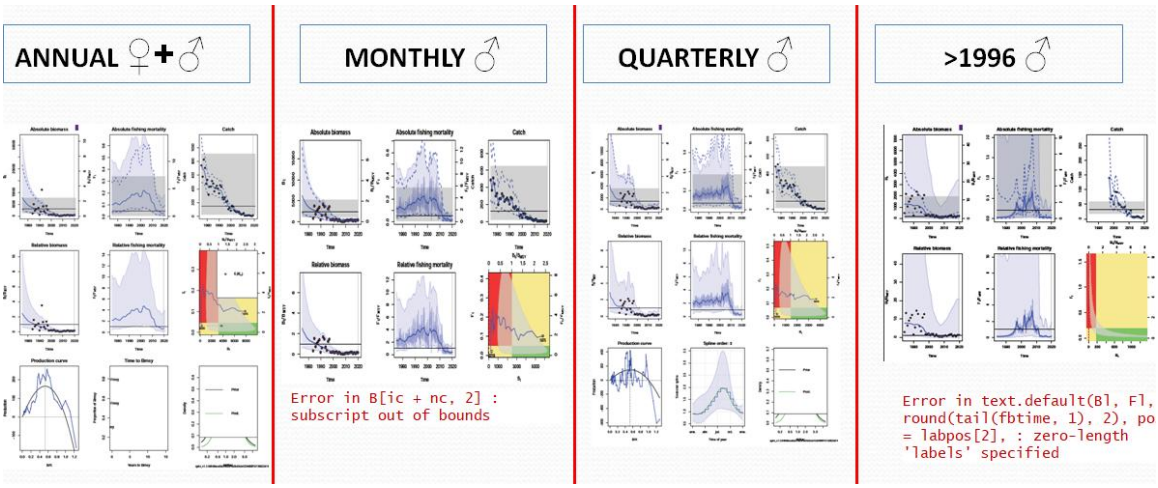



Figure 5.- Plots of the models.

The plots of the three first models (using the catch whole series) identify 3 periods in the fishery (Figure 5). In the first period, there were high biomass and fishing mortality (yellow), in the second period there were low biomass and high fishing mortality (red), and in the last period there were very low biomass and fishing mortality (yellow). In the last model, that uses only catch series since 1997, there are problems with the plot but it seems that there were a period with high biomass and low F (green) and other period with low biomass and high F (red).

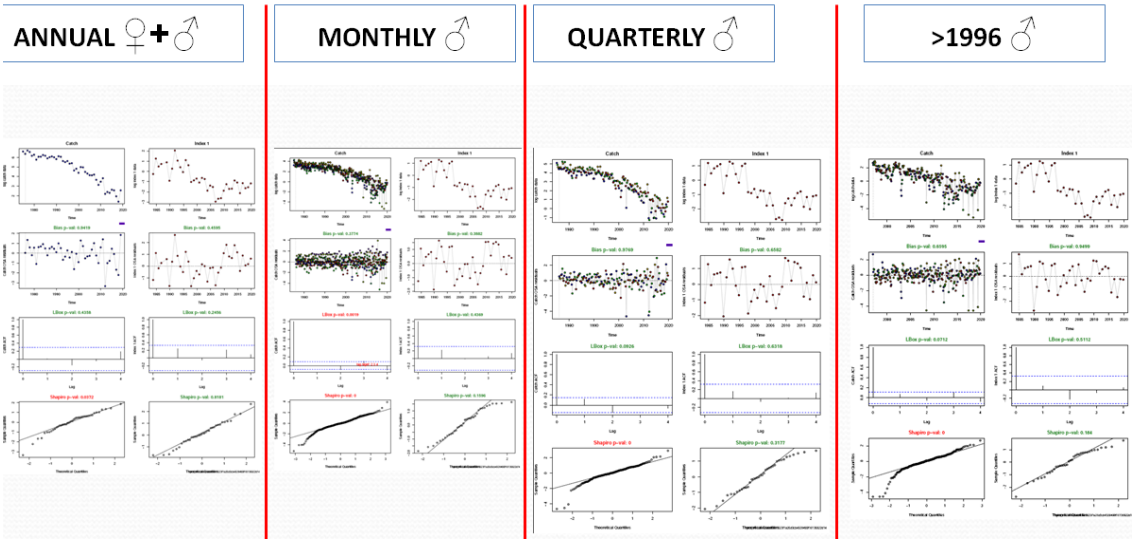



Figure 6.- Residual analysis of the models.

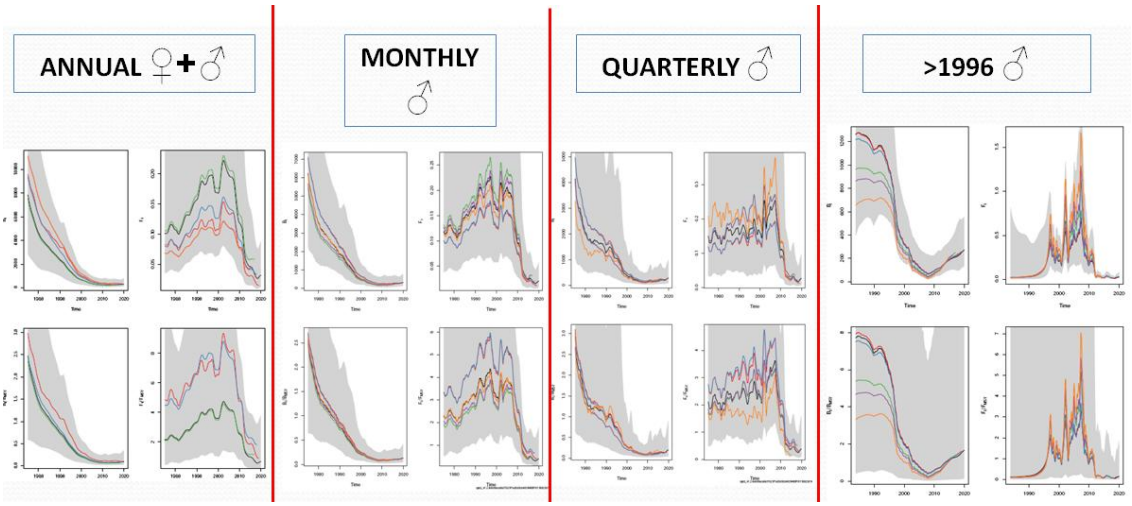



Figure 7.- Retrospective analysis of the models.

Table 3.- Models checklist.

| Checklist | ANNUAL ♀+♂ | MONTHLY ♂ | QUARTERLY ♂ | >1996 ♂ |
|---|---|---|---|---|
| 1.- Convergence *res$opt$convergence* | 0 | 0 | 0 | 0 |
| 2.- Variance parameters finite *all(is.finite(res$sd))* | TRUE | TRUE | TRUE | TRUE |
| 3.- No assumptions violation | See plot | See plot | See plot | See plot |
| 4.- Retro convergence | See plot | See plot | See plot | See plot |
| 5.- Realistic production curve *calc.bmsyk(res)* | 0.53 | 0.53 | 0.53 | 0.15 |
| 6.- Sensitivity to initial values *res$check.ini$resmat* | NULL | NULL | NULL | NULL |
| 7.- BBmsy, FFmsy IC *calc.om(res)* | 1 in both cases | 1 in both cases | BBmsy IC 1<br>FFmsy IC 2 | BBmsy IC 2<br>FFmsy IC 2 |



The residual analysis and the retrospective analysis of the models are shown in Figure 6 and 7 respectively and the checklist in Table 3. The four models checklist does not present big problems.

**DISCUSSION**

The FU 25 survey index time series has two marked periods, until 1996 and since 1997, which could arise certain doubts about this index.

A catch decrease in the middle nineties has also observed in the *Nephrops* divisions 9a and in the total 8c and it is even higher in the FU 31 (Figure 8), the FU 31 is the other FU of division 8c.

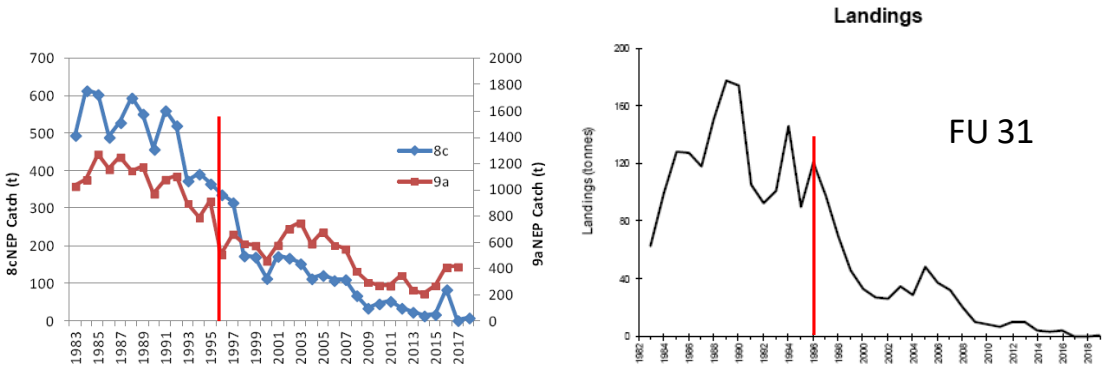



Figure 8. Divisions 8c and 9a (left) and FU 31 (right) landings time series.

Respect of the own survey index, the number and distribution of the survey hauls in FU 25 were similar in both periods (Figure 9; ICES, 2020). The information provided by the maps (Figure 9; available each year maps in Figures 12.1.6abcd in ICES, 2020) seems compatible with the survey index two periods. Getting more in detail, from the spatial point of view, the survey yield really had four periods. The first period, from 1983 to 1996, in which the yields are hig. A second period, from 1997 to 2002, with very  low yields. In the third period (2003-2008), Nephrops disappears from the south eastern part of the FU 25 and there are tiny yields in the North western part. In the last period (2009-2020), *Nephrops* remains out of the SE part and there is a slight increase in the NW part. This spatial information is corroborated by the 2009-2016 *Nephrops* CPUE maps from the commercial fleet (Figure 10, available each year maps in Figures 12.1.2ab in ICES, 2020) and also by the 2020 FU 25 *Nephrops* sentinel survey data, which are by 5 x 5 nautical miles strata, and also show absence of *Nephrops* in the major part of the FU. According to all the information, the two quantitative periods shown by the survey index seem to be reliable.

The work in the future should be in the line of explore the annual model by sex and the monthly and quarterly model for females. It should be discussed if it would be suitable to analyse the time series from the point of view of a shift regime, but maybe this could affect only to the MSY but not to K. Other possibility would be work with the shortened series.

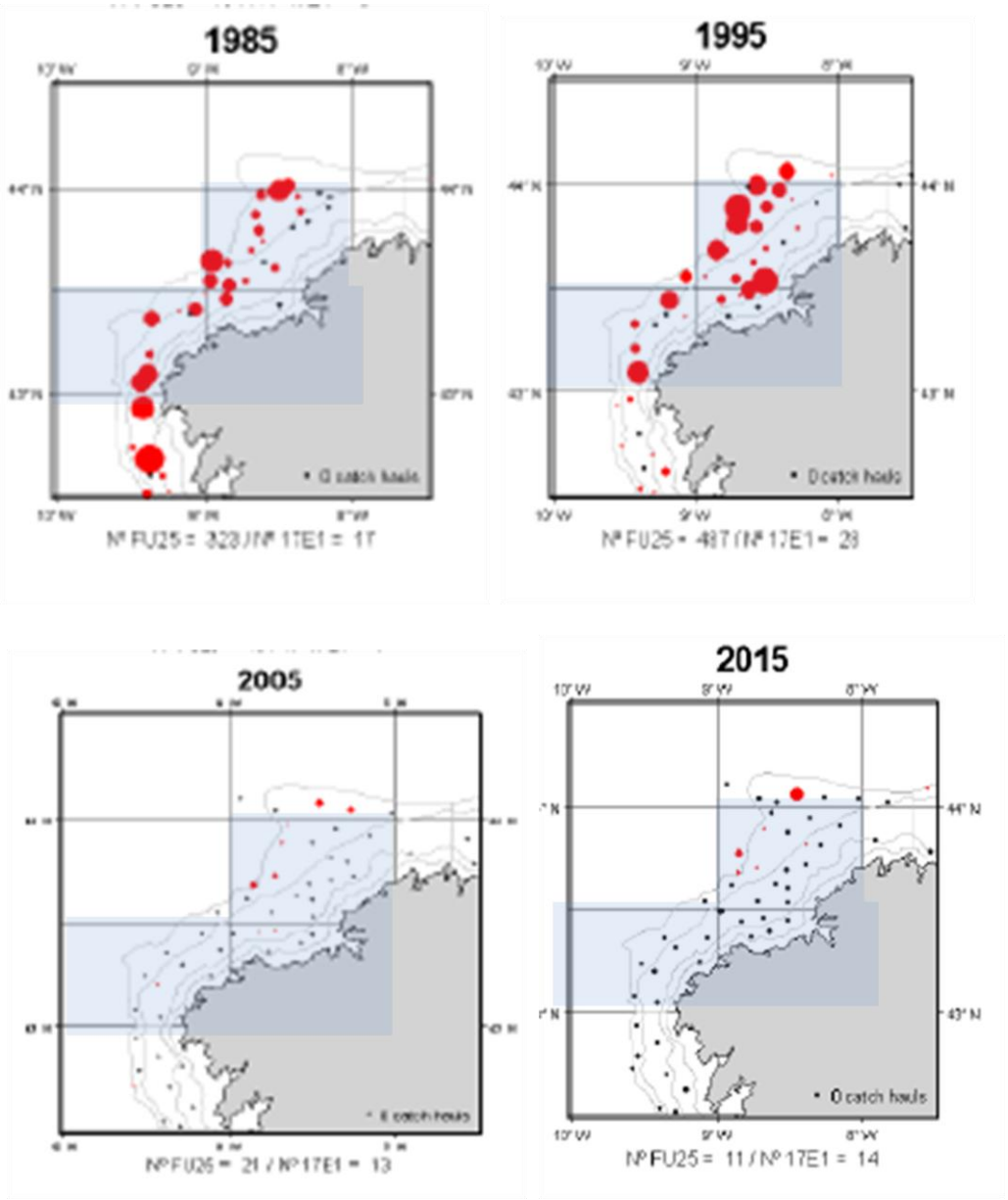



Figure 9.- Demersales survey hauls in FU 25. Red points: hauls with *Nephrops* catches. Black points: hauls with no presence of *Nephrops*. FU 25 rectangles in blue.

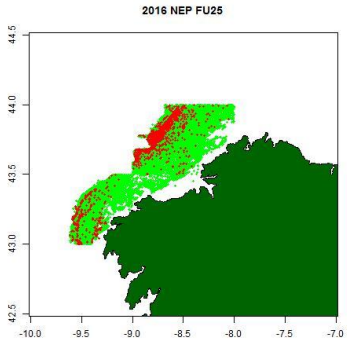



Figure 10.- 2016 FU 25 *Nephrops* CPUE from the bottom trawl commercial fleet allocated with the vessel monitoring system data. Red points: VMS points of fishing days with *Nephrops* catches. Green points: VMS points of fishing days with no presence of *Nephrops*.

**WK RECOMMENDATIONS TOWARDS THE FEBRUARY MEETING**

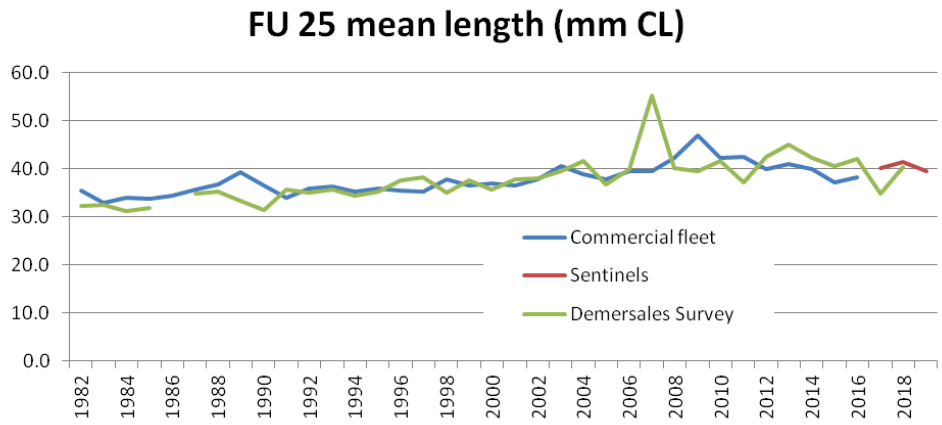
**A) Data – Survey index:**

- Check strange values in the first years of the time series, there has been differences in the sampling design? Has the gear change? Is the number and distributions of hauls similar? Are the maxima correct?

- Does the survey index take into account the swept area?

- Check the procedure to calculate Demersales survey index

- Show mean sizes of the survey and the fishery:




**B) Data – SPiCT analysis:**

- Carry out the forecast of each of the four runs presented.

- Log SD of biomass in relation to recruitment bias?

- Carry out an analysis only with the data of the area of the stock that remains nowadays in order to identify the MSY of this part.

- Try to correct the errors in plots that appear in the monthly runs (run 2 and 4)

- Improve the check "realistic production curve" (*calc.bmsyk(res)*) in run 4 (monthly males since 1997), since the result presented is very low, 0.15. Fix the parameter.

- Work in the normality problems of the four runs. Ping pong process. Outliers.

- Discussion about use the whole time series or only since 1997.

- Discussion about use priors or not in MSY to avoid negative values in the production curves? Standard deviation is very large.

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